

Recovery Strategy for the Copper Redhorse (*Moxostoma hubbsi*) in Canada

Copper Redhorse



2012

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PREFACE

The competent minister for the Copper Redhorse under the Species at Risk Act (SARA) is the minister of Fisheries and Oceans Canada (DFO). Because this species makes use of the Vianney-Legendre fish ladder, the minister responsible for the Parks Canada Agency (Parks Canada) is the competent minister for individuals located in the ladder. Section 37 of SARA requires the competent minister to prepare recovery strategies for listed extirpated, endangered or threatened species. The Copper Redhorse was listed as endangered under SARA in December 2007. Fisheries and Oceans Canada – Quebec Region led the development of this recovery strategy in close collaboration with the Copper Redhorse Recovery Team. This strategy meets SARA requirements in terms of content and process (Sections 39-41).

The successful recovery of the Copper Redhorse will depend on the commitment and cooperation of the many concerned parties who will participate in the implementation of the recommendations put forward in this strategy. Success will not depend solely on Fisheries and Oceans Canada or any one jurisdiction. In the spirit of the Accord for the Protection of Species at Risk, the ministers of Fisheries and Oceans Canada and Parks Canada invite all Canadians to join with Fisheries and Oceans Canada and Parks Canada in supporting and implementing the strategy, for the good of the species and of Canadian society as a whole. Fisheries and Oceans Canada and Parks Canada are committed to providing support for the implementation of the strategy, subject to the availability of resources and the various priorities regarding the conservation of species at risk. Other jurisdictions and agencies will participate in implementing the strategy according to their respective policies, allocated resources, priorities, and budgetary constraints.

The recovery goal, objectives and approaches identified in this document were developed based on the best available information and are subject to modification as new data become available. The ministers will issue a progress assessment report within five years.

One or several action plans presenting detailed descriptions of specific recovery measures required to ensure the conservation of the species will be added to the present strategy. Insofar as possible, the ministers will implement mechanisms to see that all Canadians directly interested in or affected by these measures will be consulted.

In 1987, The Committee on the Status of Endangered Wildlife in Canada (COSEWIC), initially designated the Copper Redhorse (*Moxostoma hubbsi*) as threatened; in November 2004 COSEWIC changed the designation to endangered. In December 2007, this species was listed as endangered in Schedule I of the Species at Risk Act. In 1999, it was designated threatened under the Quebec Act Respecting Threatened or Vulnerable Species. The present recovery strategy was developed following three five-year intervention plans (1995, 1999, 2004) developed and implemented by the Ministère des ressources naturelles et de la faune (MRNF) and its partners.

The above-mentioned intervention plans resulted in the creation of an important partnership network bringing together various government departments and levels, non-governmental agencies, and Quebec, Canadian and American universities.

ACKNOWLEDGMENTS

Fisheries and Oceans Canada and the Parks Canada Agency would like to thank the authors of this document, Andréanne Demers and Hugues Bouchard of DFO, and Nathalie Vachon, Pierre Dumont and Daniel Hatin of the MRNF. They are also grateful to all the members of the Recovery Team for their conscientious work in providing information, counsel and advice during the development of the recovery strategy. Thanks also go to Gilles Fortin of DFO and Lucie Veilleux of MRNF for their help with mapping.

And finally, DFO and Parks Canada Agency would like to acknowledge the critical contribution of all those who have offered comments on this document.

EXECUTIVE SUMMARY

The Copper Redhorse (*Moxostoma hubbsi*) is the only fish whose distribution is exclusively restricted to Quebec. This range is restricted even further to the St. Lawrence River and some of its tributaries. At the present time, the Richelieu River is the only body of water in which reproductive activity has been confirmed.

The Copper Redhorse population is in decline. Several threats to the recovery of the species have been identified: habitat degradation (sedimentation, degradation of riparian environment, eutrophication, organic pollution), construction of dams, contaminants, exotic or introduced species, recreational activities, commercial fishery, and low water levels. Certain biological characteristics of the Copper Redhorse such as the late age of sexual maturity, late spawning activities and specialized diet contribute to its vulnerability.

In November 2004, the Copper Redhorse population was designated endangered by the Committee on the Status of Endangered Wildlife in Canada. In December 2007, the population was listed as endangered in Schedule I of the *Species at Risk Act*. In 1999, it was designated threatened under the Quebec *Act Respecting Threatened or Vulnerable Species*.

The goal of this recovery strategy is to attain a population of 4,000 mature individuals over a period of 20 years. Five objectives have been identified to reach this goal:

Objective 1. Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse by:

- a. protecting known key habitat zones and creation of supplementary habitat;
- b. improving water quality and habitat, in the Richelieu and St. Lawrence River watersheds, to ensure conditions suitable for normal reproduction and growth;
- c. Maintaining connectivity between habitats used for the different stages of the life cycle.

Objective 2. Support the Copper Redhorse population through stocking until natural reproduction can ensure the long-term stability of the population.

Objective 3. Promote further research into the sub-adult component of the population (100–500 mm) to fill the gaps in our current knowledge of this stage of the Copper Redhorse life cycle.

Objective 4. Reduce the impact of anthropogenic pressures on the Copper Redhorse and its habitat.

Objective 5. Implement regular monitoring of the state of the population.

The Copper Redhorse is the focus of increasing interest on the part of the general public and different organizations. This recovery strategy aims to coordinate the various actions that must

be taken to complete the work already accomplished to prevent the disappearance of this species which is endemic to Canada. It also includes the identification of the critical habitat of the species: grass bed inhabited by adult Copper Redhorse in the St. Lawrence River, the littoral area along the Richelieu River used by juveniles and for migration, and the rapids of the Chambly and Saint-Ours dams, used for spawning.

RECOVERY FEASIBILITY

Recovery of the Copper Redhorse is considered possible because it meets the four criteria of technical and biological recovery feasibility.

1. Individuals present within the natural habitat are capable of reproduction.

Though natural reproduction is limited and juveniles have seldom been sampled, many mature individual fish have been observed in the spawning grounds of the Richelieu River. Furthermore, the residual population continues to exhibit a high level of genetic heterogeneity.

2. Habitats are available to permit the growth and reproduction of the Copper Redhorse.

Although many aquatic grass beds have been degraded, the protection of available habitat, together with bank restoration and other measures for the improvement of water quality, will increase the quantity of available habitats for the Copper Redhorse and consequently the chances of its recovery.

3. Threats to the species and its habitat can be avoided or mitigated.

Several conservation and outreach measures have already been implemented and various projects can be undertaken to mitigate the threats facing this species. Agricultural practices can be modified to diminish the effects of fertilizers and pesticides, soil erosion and sedimentation. The treatment of wastewater can be improved to reduce the introduction of contaminants into the natural environment. Important Copper Redhorse distribution areas can be protected from disturbance caused by pleasure boaters and fishermen.

4. The techniques necessary for the recovery of the species are available.

A reproduction plan was implemented in 2004 and stocking in the Richelieu River of larvae and fry was carried out every year between 2004 and 2009, in order to increase recruitment and to rebuild an aging spawner stock. Other techniques, such as annual monitoring of young-of-the-year abundance and genetic characterization of spawners and fry, permit the systematic monitoring of the population and the evaluation of population and distribution objectives.

TABLE OF CONTENTS

PREFACE	i
ACKNOWLEDGMENTS	iii
EXECUTIVE SUMMARY	iv
RECOVERY FEASIBILITY	vi
1. BACKGROUND	1
1.1 COSEWIC Species Assessment Information	1
1.2 Description	2
1.3 Needs of the Copper Redhorse	3
1.3.1 Biology and ecology	3
1.4 Population and Distribution	4
1.4.1 Limiting Factors	7
1.5 Threat: classification and description	7
1.5.1 Habitat Degradation	8
1.5.2 Introduced Organisms	11
1.5.3 Dams	12
1.5.4 Recreational activities	13
1.5.5 Contaminants	13
1.5.6 Fisheries	14
1.5.7 Water Levels	15
2. RECOVERY	16
2.1 Population and Distribution Objectives	16
2.2 Actions Already Completed or Underway	17
2.2.1 Conservation measures	17
2.2.2 Outreach and Public Education	19
2.2.3 Research and Monitoring	21
2.3 Recovery Objectives	23
2.4 Recommended Strategies to Meet Recovery Objectives	24
2.4.1 Recovery planning	24
2.4.2 Narrative to support Recovery Planning Table	31
2.5 Critical Habitat	31
2.5.1 Identification of critical habitat for the species	31

2.5.2	Information and methods used to identify critical habitat	32
2.5.3	Description of critical habitat	33
2.5.4	Schedule of studies to identify critical habitat	42
2.5.5	Examples of activities likely to result in the destruction of critical habitat	42
2.6	Knowledge Gaps.....	44
2.6.1	Reproduction and Spawning Grounds	44
2.6.2	Immature Fish	45
2.6.3	Adults.....	45
2.7	Existing and Recommended Approaches to Habitat Protection.....	46
2.8	Progress towards recovery	46
2.9	Activities Permitted by the Recovery Strategy	47
2.10	Statement on Action Plans.....	49
3.	REFERENCES.....	50
4.	RECOVERY TEAM	59
	APPENDIX A: Effects on the Environment and Other Species	60

LIST OF FIGURES

Figure 1. Pharyngeal apparatus of the adult Copper Redhorse. Photo: Yves Chagnon, MRNF.....	2
Figure 2. Distribution area of the Copper Redhorse. It ranges in the Richelieu River, Rivière Yamaska, Rivière Noire, Rivière L'Acadie, Rivière des Prairies and Rivière des Mille Îles, at the mouth of the Rivière Maskinongé and Rivière Saint-François, and in a few stretches of the St. Lawrence River, between Vaudreuil and the downstream sector of Lac Saint-Pierre.	5
Figure 3. Potential and known used spawning sites. The two known spawning sites are in the Richelieu River in the Chambly basin and the Saint-Ours dam. Île Hervieux, Lachine rapids, the channel downstream from the Rivière-des-Prairies hydroelectric facility, the Grand Moulin and Terrebonne rapids in the Rivière des Mille Îles, and the Dorion and Sainte-Anne-de-Bellevue channels at the head of Lac Saint-Louis are potential spawning sites.	6
Figure 4. Critical spawning habitat of the Copper Redhorse at the Saint-Ours dam	35
Figure 5. Critical spawning habitat of the Copper Redhorse at the Chambly dam.	36
Figure 6. Critical rearing and migration habitat in the upstream reaches of the Richelieu River. Identified critical habitat corresponds to the littoral zone between 0 and 4 m depth (coloured in red), from the Chambly basin (upstream) extending to the river mouth.	38
Figure 7. Critical rearing and migration habitat in the downstream reaches of the Richelieu River. Identified critical habitat corresponds to the littoral zone between 0 and 4 m depth (coloured in red), from the Chambly basin (downstream) extending to the river mouth.	39
Figure 8. Bounding area (in black) in which critical adult feeding habitat corresponds to grass beds presenting the attributes listed in Table 3. Coloured in green are the areas thought to possess adult feeding critical habitat attributes in the Montréal region of the St. Lawrence River, based on a model. Stretches of the Rivière des Prairies and the Rivière des Mille Îles containing critical habitat begins at longitude 73° 35' 31" W in the Rivière des Mille Îles and at longitude 73° 37' 11" W in the Rivière des Prairies.	40
Figure 9. Bounding area (in black) in which critical adult feeding habitat corresponds to grass beds presenting the attributes listed in Table 3. Coloured in green are the areas thought to possess adult feeding critical habitat attributes in the Contrecoeur region of the St. Lawrence River, based on a model.....	41

LIST OF TABLES

Table 1. Summary table of Copper Redhorse threats	8
Table 2. Recovery Planning: recovery strategies to mitigate the impact of threats are suggested for each recovery objective. These recovery strategies are grouped according to the corresponding approach (conservation, education, research) and are further described in the “measures” column. The recovery strategies are prioritized: beneficial: would aid in the recovery; necessary: of high value for recovery; essential: indispensable for recovery.....	24
Table 3. Summary of the attributes and functions of critical habitat	34
Table 4. Schedule of studies	42
Table 5. Examples of activities likely to destroy critical habitat	43

LIST OF ACRONYMS

COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COVABAR	Comité de concertation et de valorisation du bassin versant de la rivière Richelieu
DDT	Dichloro-diphenyl-trichloroethane
DFO	Fisheries and Oceans Canada
HSP	Habitat Stewardship Program
MDDEP	Ministère du développement durable, de l'environnement et des parcs du Québec
MRNF	Ministère des ressources naturelles et de la faune du Québec
NCC	Nature Conservancy Canada
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PBDE	Polybromodiphenylethers
SARA	Species at Risk Act
VHS	Viral Hemorrhagic Septicaemia

1. BACKGROUND

1.1 COSEWIC Species Assessment Information

Below is the COSEWIC assessment summary as it appeared in the 2004 Update Status Report (COSEWIC, 2004):¹

Date of assessment: 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.

¹ Available at http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=75

1.2 Description

The Copper Redhorse is a large-scaled catostomid fish of the genus *Moxostoma*, a group of relatively large fish, with an inferior,² protrusible mouth, lips with plicae³ 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,⁴ 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 18 to 21 molariform teeth per arch (Figure 1) are the main characteristics by which it can be distinguished from the other species (Scott and Crossman, 1974; Mongeau, 1984; Mongeau et al., 1986).



Figure 1. Pharyngeal apparatus of the adult Copper Redhorse.
Photo: Yves Chagnon, MRNF.

Certain characteristics of eggs and larvae have been described in various studies (Gendron and Branchaud, 1991; Beauchard, 1998; Grünbaum et al., 2003; Vachon, 2003a). 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 other redhorse species. Despite considerable efforts to develop other larval identification techniques, genetic analysis remains the most reliable method (Branchaud et al., 1996; Lippé et al., 2004).

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. Total length and weight average over 500 mm

² A fish is said to have an inferior mouth when the lower jaw is shorter than the upper jaw.

³ Folds located on the lips.

⁴ The part of the body located between the anal region and the caudal fin (tail).

and 5 kg respectively. Females are generally more corpulent than males (Mongeau et al., 1986; Mongeau et al., 1992).

1.3 Needs of the Copper Redhorse

1.3.1 Biology and ecology

The diet of the Copper Redhorse is based almost exclusively on small molluscs. Over 90% of the prey identified in the digestive tracts of adult Copper Redhorse are gastropods (snails) or bivalves (mussels) (Mongeau et al., 1986; Mongeau et al., 1992). In young-of-the-year, more than 50% (in number) of prey are microcrustaceans, the remainder being composed of worms, algae and insect larvae (Vachon, 1999a). Molluscs constitute part of the diet of several fish species in the streams of the St. Lawrence Plain. However, very few North American species are dependant upon this food source and none to the same extent as the Copper Redhorse. The particular configuration of the pharyngeal apparatus is well adapted to crushing shells and its level of specialization constitutes an evolutionary peak (Jenkins, 1970; Mongeau et al., 1986; Mongeau et al., 1992).

Compared to its congeners found in Quebec, this species reaches the largest size, is the most fecund, and has the longest lifespan, living for at least thirty years. The Copper Redhorse also takes the longest to reach sexual maturity, usually around the tenth year (Mongeau et al., 1986).

The reproduction period of the Copper Redhorse occurs later in the season than for its congeners in the St. Lawrence Plain. Spawning begins in mid June and lasts until the first week in July at which time water temperatures vary between 18°C and 26°C. Fecundity ranges from 35,000 to 112,000 eggs (Mongeau et al., 1986; Mongeau et al., 1992). The eggs hatch after 4 to 7 days of incubation and the larvae emerge and begin swimming 12 to 16 days after fertilization (Branchaud and Gendron, 1993; Branchaud et al., 1995). Known spawning sites are located in white waters, at depths varying between 0.75 m and 2.0 m. The heterogeneous substrate is composed of rocks, fine and coarse gravel, and, at times, fragments of bedrock embedded in clay (La Haye et al., 1992; Mongeau et al., 1992; Boulet et al., 1995; Boulet et al., 1996; Dumont et al., 1997). During the reproduction period, the Copper Redhorse, especially the females, will travel between the spawning site and areas of calmer water (Gariépy, 2008). Spawning occurs mainly at night (La Haye et al., 1992; Gariépy, 2008). Spawners appear to be capable of spawning in more than one site during the same season (Gariépy, 2008).

The growth of young-of-the-year is closely linked to the number of degree-days above 10°C during the growing season, which ends at the latest around the end of September, even if the fall is late. Juvenile Copper Redhorse remain associated with grass beds near the shore, where the substrate is fine, during their first growing season and at the beginning of the second (Vachon, 1999a, b, 2002). It is not known what habitats juveniles frequent after two years of age. Capture of juveniles is very rare. Specialization of the pharyngeal apparatus occurs at an early stage in the life cycle, making it possible for juveniles to leave the nursery area early on and travel to the grass beds where molluscs are plentiful, making their capture problematic.

Adult Copper Redhorse are found in the habitats of the St. Lawrence River, the Rivière des Prairies and the Rivière des Mille Îles, especially in the shallow grass beds around the islands and archipelagos (Vachon and Chagnon, 2004; Gariépy, 2008). In spring, the main variables defining habitat selection are vegetation, current velocity, turbidity and sphaeriid abundance (D. Hatin, MRNF, unpublished data). In summer, the Copper Redhorse chooses sites characterized by the presence of gastropods, a relatively fine substrate (clay, silt, and sand), low current velocity (<0.5 m/s) and presence of dreissenids (Gariépy, 2008). The grass beds of the St. Lawrence constitute a highly productive habitat with high density mollusc populations (Nilo et al., 2006). The gastropod-rich habitat zones preferred by the Copper Redhorse are generally less than 5 m in depth and have slow moving currents (Ferraris, 1984; Gariépy, 2008). In the winter, adult habitat is essentially characterized by shallow depths (< 4 m), slow water current (<0.3 m/s), relatively fine substrate, little or no vegetation density and little or no gastropod density (Comité ZIP des Seigneuries, 2006; Gariépy, 2008; DFO, 2010a; D. Hatin, MRNF, unpublished data).

Copper Redhorse movements vary according to season. Average distance traveled daily is low in the summer (0.13 km/d) and the winter (0.17 km/d), moderate in the fall (0.55 km/d) and highest in the spring (0.93 km/d), nearing the reproduction period (Comité ZIP des Seigneuries, 2006; Gariépy, 2008; D. Hatin, MRNF, unpublished data). Adults living in the St. Lawrence River migrate from 40 to 100 km over 4 to 40 days to reach the spawning grounds in Saint-Ours and Chambly. Adults living in the Richelieu River will migrate over a much shorter distance (average of 28 km) and time range (7 days on average) to reach the same spawning sites (D. Hatin, MRNF, unpublished data). Males of the Catostomidae family generally travel to the spawning grounds before the females (Page and Johnston, 1990). However, individuals of both sexes have been observed at spawning sites at Chambly and Saint-Ours several days before spawning (Gariépy, 2008; D. Hatin, MRNF, unpublished data). Size of territories also varies according to season. It is small in the summer (0.3 km²) and winter (<0.7 km²), medium in the fall (2.3 km²) and largest in spring, nearing the reproduction period (Comité ZIP des Seigneuries, 2006; Gariépy, 2008; D. Hatin, MRNF, unpublished data). In summer, adults concentrate and occupy a relatively confined area within their territory, corresponding approximately to the size of the grass beds in the area (Gariépy, 2008). The home ranges of individuals do not seem to overlap, but this may be due to the low population density.

1.4 Population and Distribution

The Copper Redhorse is the only fish endemic to Quebec. It was described by Vianney Legendre in 1942 (Legendre, 1942), but it appears to have been first identified by Pierre Étienne Fortin in 1866 under the name of an already known species of the genus *Moxostoma* (Branchaud and Jenkins, 1999).

Telemetric monitoring, genetic analysis of specimens, and studies conducted on contaminant levels present in the Copper Redhorse all indicate that the species now forms one single population (de Lafontaine et al., 2002; Lippé et al., 2006; Gariépy, 2008). Since 1942, specimens have been found in certain sections of the Richelieu River, the Yamaska, Noire, L'Acadie Rivers, the des Prairies River and des Mille Îles River, at the mouth of the Maskinongé and Saint-François Rivers, and in a few stretches of the St. Lawrence River, between Vaudreuil and

the downstream sector of Lac Saint-Pierre (Figure 2). Telemetric monitoring has shown that the distribution range of the Copper Redhorse has not changed since it was first discovered, except for the Yamaska and Noire Rivers where the species has likely disappeared (Mongeau et al., 1986; Boulet et al., 1995; Gariépy, 2008). The extirpation of the populations in the Yamaska and Noire Rivers, described by Mongeau et al. (1986), due to the significant degradation and fragmentation of habitat in this basin, is now confirmed (Boulet et al., 1995).

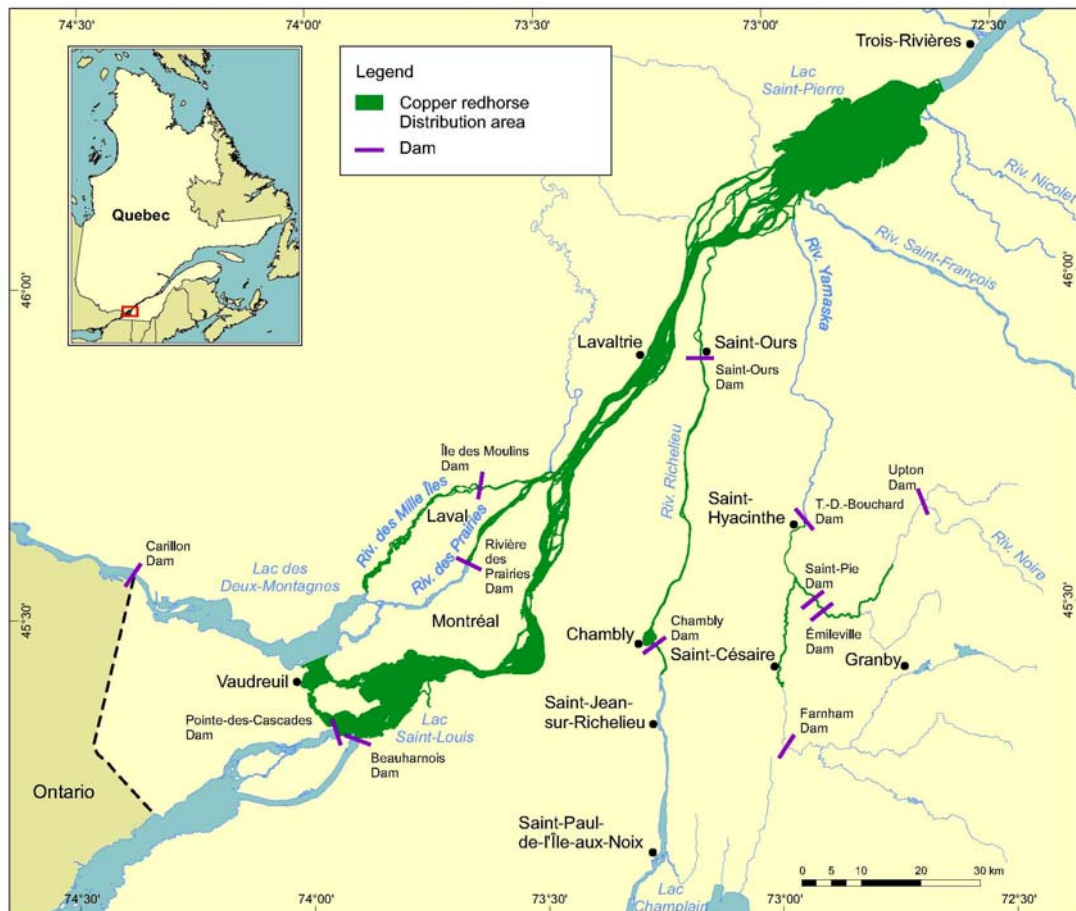


Figure 2. Distribution area of the Copper Redhorse. It occurs in the Richelieu River, Rivière Yamaska, Rivière Noire, Rivière L'Acadie, Rivière des Prairies and Rivière des Mille Îles, at the mouth of the Rivière Maskinongé and Rivière Saint-François, and in a few stretches of the St. Lawrence River, between Vaudreuil and the downstream sector of Lac Saint-Pierre.

To date, two spawning grounds have been identified in the Richelieu River: the main one in the Chambly rapids archipelago and another in the channel downstream from the Saint-Ours dam (Figure 3). Potential spawning grounds have been identified in the Lavaltrie-Contrecoeur (Île Hervieux) sector of the St. Lawrence River, though the use by Copper Redhorse of this stretch of river could not be determined (Vachon and Chagnon, 2004). Other areas within the distribution range of the species may offer suitable conditions for reproduction. These include the Lachine rapids, the channel downstream from the Rivière-des-Prairies hydroelectric facility, the Grand Moulin and Terrebonne rapids in the Rivière des Mille Îles, and the Dorion and Sainte-Anne-de-Bellevue channels at the head of Lac Saint-Louis (Mongeau et al., 1986; Comité ZIP des Seigneuries, 2006). The first reported Copper Redhorse observation was that of mature

individuals ready to spawn at the head of Lac Saint-Louis (Legendre, 1942). Reproduction activity has, however, never been observed outside of the Richelieu River spawning grounds (Jenkins, 1970; Massé et al., 1981; Mongeau et al., 1986; Vachon and Chagnon, 2004). An important nursery area has been located along the banks of the Richelieu River, downstream of Chambly, in the Île Jeannotte and Île aux Cerfs sectors (Vachon, 1999a, b, 2002).

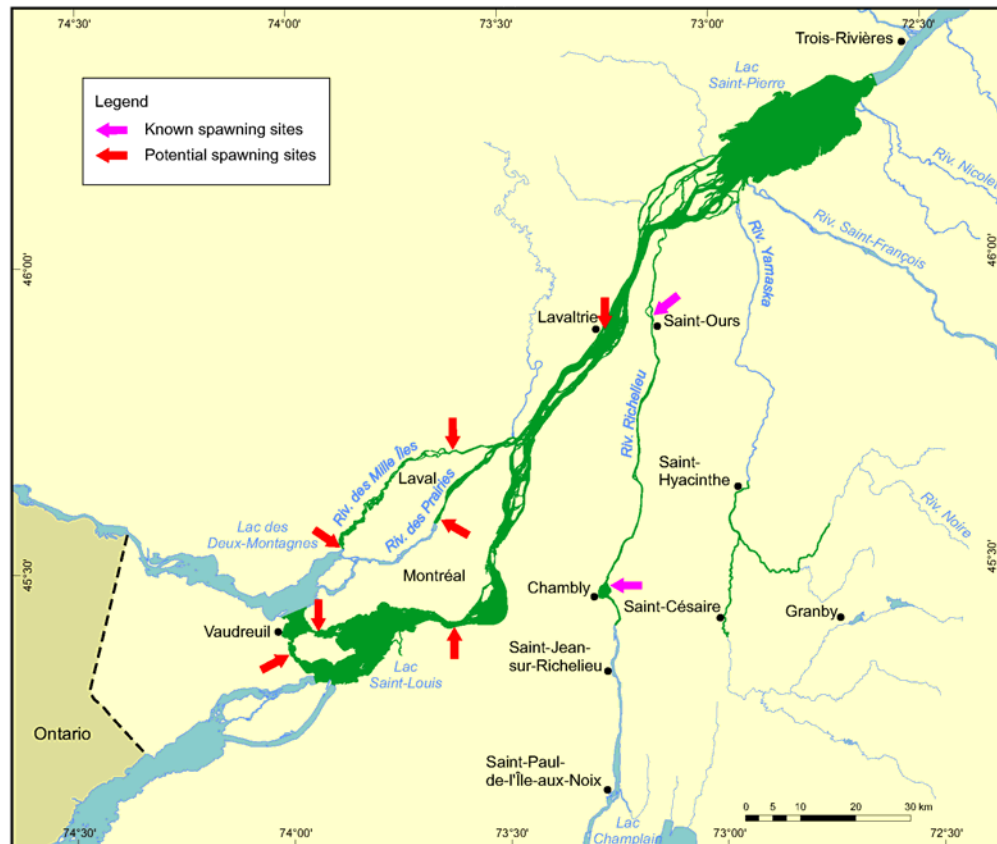


Figure 3. Potential and known used spawning sites. The two known spawning sites are in the Richelieu River in the Chambly basin and the Saint-Ours dam. Île Hervieux, Lachine rapids, the channel downstream from the Rivière-des-Prairies hydroelectric facility, the Grand Moulin and Terrebonne rapids in the Rivière des Mille Îles, and the Dorion and Sainte-Anne-de-Bellevue channels at the head of Lac Saint-Louis are potential spawning sites.

Examination of archeological remains dating from the 19th century from the banks of the Richelieu and St. Lawrence Rivers indicates the existence of a historically more abundant population, representing respectively 16.7% and 9.1% of all redhorse species (Osthéothèque de Montréal, 1984; Courtemanche and Elliot, 1985). More recently, in ichthyological inventories conducted in the Montréal area between 1965 and 1983, the abundance of Copper Redhorse was estimated at 2 and 3% compared to its congeners (Mongeau et al., 1986). The proportion dropped to 0.04% during the monitoring of the Vianney-Legendre fish ladder in 2003 (Fleury and Desrochers, 2004). Present population size is difficult to estimate given the rarity of the species and the mortality risk associated with handling individuals captured to estimate population size. A preliminary estimate, based on an assessment conducted with recaptured specimens made by one commercial fisherman in 2000, in the Lavaltrie-Contrecoeur sector of the St. Lawrence River, provides an abundance estimate of a few hundred (Vachon and Chagnon, 2004).

1.4.1 Limiting Factors

Several characteristics of the species' biology and ecology constitute factors that increase its vulnerability. The Copper Redhorse reaches sexual maturity at a relatively late age (around 10 years) which, when compared to other species, delays the contribution of recruits to the reproductive effort. Furthermore, spawning takes place late in the season, end of June to early July, exposing the Copper Redhorse to lower water levels and a shorter growing season for fry which are consequently smaller in size when confronting their first winter. The hypothesis of selective winter mortality according to size has not been clearly proven, but remains plausible (Vachon, 1999a, b, 2002). The spawning period of the Copper Redhorse coincides with the peak period of pesticide concentrations in rivers (See Section 1.5.3) and with a period of increased human activity associated with the Quebec and Canada national holidays (See Sections 1.5.4 and 1.5.6).

The specialized diet of the species also contributes to its vulnerability because it reduces its adaptability in its choice of possible prey. Finally, the limited distribution range of the Copper Redhorse, even historically, adds to its vulnerability when confronted with changes to its habitat.

On the other hand, the great longevity of the Copper Redhorse, which can extend to over thirty years, has until recently allowed the residual population to maintain a high level of genetic heterogeneity (Lippé et al., 2006).

1.5 Threat: classification and description

The numerous studies conducted since the beginning of the 1990s indicate that the species is having difficulty reproducing in its natural environment and that the population is aging (Branchaud and Gendron, 1993; Vachon, 2002; Vachon and Chagnon, 2004).

There is no doubt that anthropogenic activities are endangering the Copper Redhorse. Agricultural activities, urban development and recreational activities exert considerable pressure on the environment inhabited by this species. The 2004 COSEWIC Status Report identified several threats to the recovery of the species. The majority of threats were associated with habitat degradation, including the acceleration of erosion and increased turbidity resulting from agricultural activities, deforestation and urbanization, contamination of water by potential endocrine disruptors, and the eutrophication of watercourses. Other threats include the construction of dams which fragment the habitat and obstruct the passage of fish, lower water levels, invasive exotic species, and the intensive use of the Chambly rapids by pleasure boaters in summer, the main spawning ground of the Copper Redhorse. Incidental catch by sport and commercial fishermen and the input of pathogens were added to the list of threats identified by COSEWIC and presented in this Section. Each threat has been assessed by six parameters (Table 1). It is important to note that the severity of impact and level of concern associated with certain threats facing the species can vary locally depending on factors such as habitat type and threat intensity.

Table 1. Summary table of Copper Redhorse threats

Threats		Range	Occurrence	Frequency	Causal certainty	Severity of impact	Level of concern
Habitat Degradation	Erosion	General	Current	Ongoing	High	High	High
	Shoreline Hardening	General	Current	Ongoing	High	High	High
	Eutrophication	Local	Current	Ongoing	High	High	High
Introduction of Organisms	Species Introductions	Local	Anticipated	Ongoing	Low	Unknown	Moderate
	Pathogen Introductions	General	Anticipated	Seasonal	High	Low	High
Contaminants		General	Current	Ongoing	Moderate	Moderate	High
Dams		Local	Current	Ongoing	High	High	High
Recreational activities		Local	Current	Seasonal	Moderate	Moderate	Moderate
Sport Fishing		Local	Current	Seasonal	Low	Moderate	Moderate
Commercial Fishery		Local	Current	Recurring	Low	Moderate	Low
Flow Alteration		General	Anticipated	Seasonal	Low	Low	Low

Legend: **Range:** indicates whether threat is general throughout the distribution range or just present locally. **Occurrence:** indicates whether threat is historic, current, imminent or anticipated. **Frequency:** indicates whether threat occurrence is one-time, seasonal, ongoing or recurrent (not annual or seasonal). **Causal certainty:** indicates whether available knowledge about the threat and its impact on the viability of the population is of high, moderate or low quality. **Severity of impact:** indicates whether the severity of the threat is high, moderate or low. **Level of concern:** indicates whether threat management is, on the whole, of high, moderate or low concern. This may take into account the capacity to mitigate or eliminate the threat.

1.5.1 Habitat Degradation

The waterways that are used by the Copper Redhorse are located in the most densely populated areas of Quebec and the concomitant intensive agriculture and urban development are the main causes of habitat degradation.

1.5.1.1 Erosion

Although soil erosion is a naturally occurring phenomenon, it is significantly accelerated by human activity. The intensive agriculture carried out in the lowlands of the St. Lawrence contribute noticeably to soil and bank erosion (for a review, see Roy, 2002). Increases in drainage capacity, the channeling of watercourses, intensive agricultural techniques, and the loss

of riparian vegetation have accelerated sedimentation in the watersheds inhabited by the Copper Redhorse. It is estimated that 50,000 km of watercourses were modified in Quebec between 1944 and 1986, an average of more than 1,000 km per year (MEQ, 2003). Wide row monoculture,⁵ for crops such as corn and soybeans, requires yearly soil tillage and the cropping practices associated with it are believed to contribute most to water erosion. In the Richelieu River basin, where 70% of the land is used for agriculture, and 78% of that agricultural land consists of wide row cultures (Simoneau and Thibault, 2009). Despite policies and regulations currently in use, the trampling of banks by livestock and the absence of wind-breaks and adequate riparian vegetation contribute to soil erosion.

Along the St. Lawrence River, between Montreal and Lac Saint-Pierre, the banks have been receding 80 cm each year since the early 1980s and as much as 3 m in certain sectors such as the islands of Boucherville and Berthier-Sorel (State of the St. Lawrence Monitoring Committee, 2008). When water levels are sufficiently high to reach the banks, wave action from passing commercial vessels and recreational boats accelerates bank erosion. Wave action from commercial vessels using the St. Lawrence shipping channel can have an impact on banks at distances up to 800 m, especially between Montreal and Sorel (Dauphin, 2000). Massé and Mongeau (1976) demonstrated the negative impact of wave action from passing commercial vessels on the ichthyological fauna of the St. Lawrence, between Montreal and Sorel, especially through disruption of aquatic grass beds and exposed spawning grounds. During the summer, the Richelieu River is also becoming a busy waterway, used by recreational boaters. Another source of sedimentation and turbidity is the dredging of waterways and the release of sediments in the water.

Climate change is likely to impact on the ecosystems of the St. Lawrence Plain. From 1960 to 2003, the central and western portion of southern Quebec recorded a mean annual temperature increase between 0.5°C and 2.0°C (Yagouti et al., 2006). Climate forecast models predict warmer summers in southern Quebec with an accompanying increase in evaporation without, however, being able to establish whether precipitation will increase or decrease (Bourque and Simonet, 2008). Increases in frequency and scale of extreme weather events are also foreseeable, impacting directly on soil and bank erosion. Increases in precipitation or in severe rainfall events will create more runoff and accelerate the slumping of banks.

Soil and bank erosion lead to the acceleration of siltation and increases in turbidity. Siltation and increases in turbidity in watercourses lead to habitat loss and disrupt the entire food chain (reviewed in Vachon, 2003b). Sediments settle in the interstices in the gravel and rocks that form the substrate and can cover a spawning ground. Increased turbidity prevents penetration of sunlight into the water and impedes photosynthesis in plants while also reducing visibility for animal species that are visual predators. Fine sediments block the respiratory and digestive system of planktonic organisms that young Copper Redhorse feed on. Most fish in the family Catostomidae, specifically those in the genus *Moxostoma*, are extremely sensitive to turbidity, as are molluscs which constitute the principal prey of the Copper Redhorse (Vachon, 2003b).

⁵ Cultures where rows of crops are far apart to allow machinery to operate. Primarily corn, potato, soy and other vegetables.

1.5.1.2 Shoreline Hardening

Urbanization, industrialization and real estate development have brought significant changes in the riparian morphology and vegetation of the St. Lawrence River and its tributaries. Backfilling, deforestation, the installation of riprap,⁶ construction of walls and other infrastructure such as harbours, bridges and marinas have contributed to shoreline hardening and degradation of riparian and aquatic environments. A shoreline inventory conducted in 1995 showed that 45% of the shoreline between Cornwall and l'Île d'Orléans was covered by a protective structure, either a wall or riprap (Lehoux, 1996). A shoreline study of the municipality of Saint-Jean-sur-Richelieu showed that 75% of the shoreline was covered by a protective structure (CNC, 2008). It is estimated that over 75% of the north shore of Montreal has been developed, along with more than 65% of the Laval shoreline (Boutin and Lepage, 2009).

Mechanical stabilization activities on banks and littoral zones modify the physical characteristics of a watercourse (flow, current velocity, temperature) necessary for the maintenance of habitats such as aquatic grass beds. Moreover, hardened shorelines, devoid of vegetation, do not retain rainwater runoff as efficiently, contributing to increased sediment transport into the watercourses. Direct impacts on the Copper Redhorse are difficult to quantify, but since the young and the adults depend so heavily on the aquatic grass beds, degradation of the riparian environment is considered a threat to the species.

1.5.1.3 Eutrophication

Nitrogen and phosphorus are essential nutrients for the growth of living beings. The introduction of massive quantities of these elements into the rivers, through human activities, leads to the proliferation of algae and aquatic vegetation which may become excessive, invading aquatic environments and causing their premature aging.⁷

Since the early 1960s, when a pasture-based agriculture was changed to intensive cereal crops, phosphorus has been applied in progressively greater quantities to agricultural land in order to increase crop production. The level of nutrient input has, at times, been greater than the actual crop requirements and, in certain regions, the phosphorus level in agricultural land is consequently very high, and even critical (Gangbazo et al., 2005). Agricultural practices that contribute to erosion lead to the transport of phosphorus-laden soil into local watercourses. Degradation and loss of riparian environments and vegetation deprive watercourses of adequate buffer zones that can act as natural filters for sediments and fertilizers. The Ministère du développement durable, de l'environnement et des parcs (MDDEP) has set the limit for maximum total phosphorus concentration in rivers to prevent eutrophication at 0.030 mg/l (MEQ, 2001). From 2001 to 2003, the MDDEP calculated that average phosphorus concentration at the mouth of the Richelieu River was 0.037 mg/l, while the Rivière des Hurons, a tributary of the Richelieu, revealed a phosphorus concentration of 0.182 mg/l (Gangbazo et al.,

⁶ Riprap is rock or other material used to armor shoreline, streambeds, bridge abutments, pilings and other shoreline structures against scour, water or ice erosion.

⁷ Plant growth and the enrichment of watercourses is known as eutrophication. The phenomenon is generally accompanied by a reduction in dissolved oxygen in the water.

2005). Simoneau and Thibault (2009) estimate that 50% of the total phosphorus load transported into the Richelieu River annually comes from agricultural sources.

Residential and industrial wastewater also contribute to the eutrophication of surface water. Wastewater produced by approximately 60% of people living in Quebec are eventually dumped into the St. Lawrence River, after treatment. This wastewater is rich in organic matter, nitrogen and phosphorus. The organic matter requires high levels of oxygen in order to decompose, thus contributing to the reduction of dissolved oxygen. The sewage treatment facilities in Montreal, Longueuil, Laval and Saint-Jean-sur-Richelieu are physicochemical treatment plants that filter organic matter using coagulation and settling techniques that do not involve bacteriological decomposition. The resulting effluent has a high biological demand for oxygen.⁸ Many Quebec municipalities have dual-purpose sewage systems in which rainwater is combined with residential and industrial wastewater. During periods of high rainfall or snowmelt, untreated wastewater is regularly released into both the St. Lawrence and Richelieu Rivers.

Eutrophication leads to changes in the habitat. Biologically, this can signify a change in the resident species, and physicochemically this means reductions in dissolved oxygen. The enrichment of watercourses has created habitats which are beneficial to species that are more tolerant to eutrophication, such as pumpkinseed (*Lepomis gibbosus*), brown bullhead (*Ameiurus nebulosus*) and yellow perch (*Perca flavescens*). A water quality assessment of the Richelieu River basin, conducted in accordance with the Bacteriological and Physicochemical Quality Index, has shown increased degradation in water quality, progressing downstream along the Richelieu River, and very poor water quality in two of its tributaries, the Rivière L'Acadie and Rivière des Hurons (Simoneau and Thibault, 2009).

1.5.2 Introduced Organisms

1.5.3 1.5.2.1. Invasive Species

The St. Lawrence River is a busy shipping channel used by vessels from all the continents of the world. Ballast water⁹ has been identified as a probable factor in the introduction of numerous species into shipping channels. Studies have shown that the ballast water, hulls and side tanks of ships coming from abroad and entering the St. Lawrence contain various assemblages of living organisms from all over the world (including non-indigenous taxa, toxic or harmful taxa, and taxa that constitute a potential risk) (Gauthier and Steel, 1996; Bourgeois et al., 2001). The sale and distribution of ornamental plants is also responsible for introducing several non-indigenous plant species into the aquatic ecosystems of Quebec (White et al., 1993; de Lafontaine and Constan, 2002). The Richelieu River, connected to Lake Champlain and the Hudson River, is another known route of entry for several exotic species (de Lafontaine and Constan, 2002). Lack of public awareness and certain legal ambiguities contribute to the introduction of invasive and exotic species in the aquatic environment (Dumont et al., 2002). The establishment of exotic species can modify the species composition of ecosystems and alter the food chain. The

⁸ Biological or biochemical oxygen demand is a measure of the amount of oxygen required to allow micro-organisms to decompose the organic matter present in water, usually over a period of five days. The higher the measurement, the more organic matter there is in the water.

⁹ To ensure ship stability, reservoirs known as ballasts are filled with water at one port and emptied at another.

widespread presence of highly competitive non-indigenous species presents a threat to the Copper Redhorse.

Several aquatic species recently established in the Copper Redhorse distribution range, including the tench (*Tinca tinca*), the round goby (*Neogobius melanostomus*), and the zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*), constitute potential threats to the recovery of the Copper Redhorse. Other species, such as Asian carp species introduced to North America and considered very invasive, also need to be monitored (Vanderploeg et al., 2002; DFO, 2005). Climate change, too, could advance the northern migration of species which could compete with the Copper Redhorse (reviewed in Rahel et al., 2008). Climate change could contribute to the impact that invasive species have on the habitat and on the Copper Redhorse by leading to increases in water temperatures, changes in competition and predation relationships, and an increase in disease severity (Rahel et al., 2008; Rahel and Olden, 2008).

1.5.2.2 Introduction of Pathogens

The introduction of pathogens can also constitute a serious threat to various fish species. For example, Viral Hemorrhagic Septicemia (VHS) is a contagious viral disease which, to varying degrees, affects at least 65 species of fish, including two redhorse species. First identified in the Great Lakes in 2005, this disease can cause massive mortalities in several fish species in that region (Canadian Cooperative Wildlife Health Centre, 2005). A screening program was implemented for the St. Lawrence River and some of its tributaries in 2007 by the MRNF and the Canadian Food Inspection Agency and, as of spring 2010, no cases of VHS have been detected in Quebec. There is no known treatment for this disease. The Canadian Food Inspection Agency has implemented a biennial strategy to monitor the presence of the VHS virus in Canadian wild fish (CFIA, 2009). Given the present precarious status of the Copper Redhorse, massive mortality associated with this disease, or other pathogens and parasites, could significantly impede the survival and recovery of the species.

1.5.4 Dams

Numerous hydroelectric dams and flow regulation structures have been constructed on the St. Lawrence River and its tributaries (Figure 2). These structures present a threat to the recovery of the Copper Redhorse because they impede migration and fragment species habitat when they are impassable. For more than thirty years, the dam at Saint-Ours obstructed the free passage of the Copper Redhorse to the spawning grounds in Chambly. Until the construction of the Vianney-Legendre multispecies fish ladder in 2001, the possibility for a fish to cross the dam was limited to a short period of time of 2 to 3 weeks on average, from early April to mid May. Since 1967, the majority of Copper Redhorse was forced to spawn in the afterbay of the dam, which is not an optimum habitat (La Haye et al., 1992; Boulet et al., 1995; Branchaud et al., 1996; Dumont et al., 1997). Hydroelectric projects, new or existing, (on flow regulation) within the Copper Redhorse distribution range, constitute a threat not only by posing obstacles to the free passage of fish, but also by causing high mortalities due to the turbines. Dams can also destroy spawning habitat by affecting water flow patterns. A mini-hydroelectric facility project on the Chambly rapids was abandoned in 1994 because of the threat it posed to spawning of the Copper Redhorse.

1.5.5 Recreational activities

The popularity of the Chambly archipelago among swimmers and recreational boaters (jet-skis, kayaks, motor boats), especially during the Copper Redhorse spawning period, increases stress on the spawners and can lead to the destruction of eggs (Gendron and Branchaud, 2001; Laporte and Maurice, 2008). Mooring and the use of propeller engines in shallow waters can considerably cause the destruction of the grass beds. The area around the Île Jeannotte and Île aux Cerfs, a productive fry rearing ground, is also popular with boaters in the summer. The St. Lawrence River, particularly around the Boucherville and Lac Saint-Pierre archipelagos, is another regular destination for pleasure boaters. Noise, the crushing of eggs, and damage caused by boat motors (water turbulence, uprooting of vegetation) can prevent the Copper Redhorse from feeding and carrying out other vital activities. Disturbances caused by recreational activities in the strategic habitats of this species such as the aquatic grass beds and the spawning grounds constitute a threat to the recovery of the Copper Redhorse.

1.5.6 Contaminants

The rotation of corn and soybean crops is constantly changing in southern Quebec (Statistics Canada, 2006). These crops have undergone profound changes in the last few years with the beginning of genetically modified seeds resistant to glyphosate herbicide. Although pesticides are used on many crops, the main crops are corn and soybean (MEQ, 2003; Giroux, 2010). More than 30 pesticides, especially herbicides, can be used on corn crops in Quebec. Their widespread use, their application on bare soil in the spring, and the need for two or three applications in the growing season, make it very likely that they are present in the watercourses. The risk increases if herbicide application is followed closely by rain because these products are easily transported by runoff. Because of the Copper Redhorse's late spawning period, the presence of adults in the Richelieu spawning grounds coincides with periods of lowering water levels and peak pesticide application (Gendron and Branchaud, 1997). Significant quantities of pesticides are used throughout the Richelieu River watershed on almost all (96%) of the row crops grown there (Simoneau and Thibault, 2009). Up to 29 pesticides including atrazine, metolachlor, and glyphosate have been found at the mouth of the Rivière des Hurons, a tributary of the Richelieu, . They were found regularly at levels exceeding established limits for the protection of aquatic life (Giroux, 2010).

Industry, waste disposal sites, and municipal effluent are also an important source of contaminants such as heavy metals, dioxins, furans, polycyclic aromatic hydrocarbons (PAH), and residues from domestic products such as detergents and medications. These contaminants have been found in the St. Lawrence River, especially in sediments. The Copper Redhorse occupies habitats located in the plume created by the effluent from the water treatment plants of Montreal, Longueuil and Laval and consequently, is exposed to the various contaminants contained in this wastewater. A decrease in certain contaminant levels (metals, for example) has been observed in the sediments of Lac Saint-Pierre, although those in Lac Saint-Louis reveal little or no decrease in twenty years (State of the St. Lawrence Monitoring Committee, 2008). Though levels of certain contaminants, such as organochlorines¹⁰, tend to decrease in the fluvial

¹⁰ For example, dichloro-diphenyl-trichloroethane (DDT), mirex, polychlorinated biphenyls (PCBs)

ecosystem, new compounds such as organobromides¹¹ are increasing exponentially (De Wit, 2002; State of the St. Lawrence Monitoring Committee, 2008). Concentrations of PAH, PCB, furans and dioxins exceeding water quality guidelines have been detected at the mouth of the Richelieu River and several fish species in this river have been found to contain levels of mercury and PCB exceeding guidelines for the protection of wildlife (MDDEP, 1998; Laliberté and Mercier, 2006). Several contaminants have also been found near the spawning grounds in the Richelieu River (Giroux, 2000). Permits have been granted for the exploration of natural gas along the St. Lawrence valley and in the Richelieu River basin, using a new method, the extraction of shale gas by hydraulic fracturing and horizontal drilling. This method uses great quantities of water and a variety of chemical additives. The environmental impacts of this industry, particularly on the water table, air and soil quality, are still largely unknown.

The effects of herbicides in the environment, can cause a decrease in the abundance of herbivorous zooplankton, a reduction in growth, chlorophyll content and photosynthesis in phytoplankton, and reduced levels of primary productivity and oxygen production in water. The Copper Redhorse is exposed to contaminants through its prey and the water and sediments in its environment. Persistent contaminants have been found in the flesh and viscera of several Copper Redhorse at levels comparable to those identified in other *Catostomidae* in the Richelieu and Yamaska river basins (de Lafontaine et al., 2002).

The Copper Redhorse is exposed to non-persistent contaminants in aquatic environments and this may be responsible for the reproductive difficulties experienced by the species. Some pesticides may act as olfactory disruptors reducing the ability of spawners to sense pheromones, substances involved in behavioral synchronization and in gamete maturation in both sexes (Gendron and Branchaud, 1997). Certain industrial, agricultural, pharmaceutical and personal hygiene products can also act as hormone disruptors in many fish species and disrupt the reproductive system (Donohoe and Curtis, 1996; Aravindakshan et al., 2004). For example, close to a third of male spottail shiners (*Notropis hudsonius*) presented both male and female anatomical and biochemical characteristics downstream of the Montreal wastewater effluent, in the St. Lawrence River. The combination and interaction of these compounds may affect Copper Redhorse health and reproduction in ways not yet identified.

Climate change may also affect the impact of contaminants on the Copper Redhorse. The predicted increase in the frequency and intensity of severe weather events increases the risk of toxic discharges, while a change in rainfall patterns could increase pesticide runoff into watercourses (Schiedek et al., 2007; Bourque and Simonet, 2008). A rise in water temperature could also affect the toxicity of contaminants (reviewed in Schiedek et al., 2007). A decrease in flow in rivers would result in a lower dilution effect and thus greater concentrations of contaminants in the habitat.

1.5.7 Fisheries

1.5.6.1 Commercial Fishery

¹¹ Polybrominated diphenyl ethers (PBDEs)

It is possible that the commercial fishery of the 19th century, which targeted mainly the larger individuals, decreased the Copper Redhorse population. At the time, the species was a valuable food source (and was popular on the market) (Branchaud and Jenkins, 1999). Today, there is no Copper Redhorse commercial fishery anymore. The species can, however, be incidentally caught by fishermen in the bait-fish and other commercial fisheries. There are about 70 and 75 fishermen involved in the bait-fish fishery in zones 7 and 8 along the St. Lawrence River, including Lac Saint-Pierre. In accordance with the fishing permits issued by the MRNF, these fishermen work primarily outside the Copper Redhorse distribution range, in the Upper Richelieu, Lac Saint-François and the smaller streams, but do have access to the St. Lawrence. There are 25 commercial fishermen licensed to fish sturgeon using gillnets, and 6 are also authorized to use fyke nets, which increases the possibility of incidental catches of Copper Redhorse in Lake Saint Pierre. An outreach project aimed at these commercial fishermen was organised by the Committee for the Lac Saint-Pierre Priority Intervention Zone (PIZ) in 2008 and 2009, to assess bycatch of Copper Redhorse. None were captured incidentally by fishermen in Lake St. Pierre during that period. Incidental catches remain low in this lake since this species is rare in the lake, there are few commercial fishermen, and there is limited overlap between habitats of Copper Redhorse and the main fishing areas. The risk for incidental catches is greater in the St. Lawrence River, where fyke net fishing areas overlap with the main Copper Redhorse habitats. To date, the risk has been managed through close collaboration between the one fisherman operating in the Contrecoeur sector and the MRNF personnel (Vachon and Chagnon, 2004). However, the situation could change if, for example, this fisherman were to sell his fishing rights to a less vigilant person. Though constant vigilance is required to assess the impact of commercial fisheries on the species, the buy-back of yellow perch permits in Lac Saint-Pierre and the relatively low number of commercial fishermen operating within the Copper Redhorse distribution range makes this threat of lesser concern.

1.5.6.2. Sport Fishing

During the summer months, the Richelieu River, the islands of Sorel and of Boucherville, and the fluvial lakes are areas of high recreational activity, including sport fishing. In 2004, the region of Montérégie alone accounted for close to 140,000 sport fishermen (MRNF, 2004). The spawning period of the Copper Redhorse coincides with the Quebec and Canadian national holidays, a very busy period on the Richelieu River. Copper Redhorse can be caught with a fish hook, but they are not popular with fishermen who have to release them back into the water according to the *Quebec Fisheries Regulations (1990)* (SOR/90-214). However, certain ethnic communities in the metropolitan area are fond of carp, chub and redhorse and do not release these species when caught (Y. Labonté, MRNF, pers. comm.). These fishermen are often less informed about regulations and the presence of endangered species (Laporte and Maurice, 2008).

1.5.8 Water Levels

The ecology of fish is significantly affected by water flow rates that determine habitat availability throughout the spring freshets and yearly cycles. The quantity and quality of aquatic grass beds necessary to the growth and nutrition of the Copper Redhorse depend in part on the water levels in the St. Lawrence River and the tributaries where the species is found. The St. Lawrence River exhibits high interannual variability in water levels, with cycles of

alternating high and low water flow. The rivers of southern Quebec, especially the Ottawa River which is the main tributary of the St. Lawrence, have a high number of dams (Figure 2). The flow of water issuing from Lake Ontario is also regulated by the Iroquois dam in the international section of the St. Lawrence River. In accordance with the Regulation Plan 1958-D of the International Joint Commission, the regulation of water flow is aimed at optimizing hydroelectric production and commercial navigation, while ensuring flood prevention.

A study was conducted on the potential adult summer habitat in watercourses with a wide range of flow rates, from very low to very high, in order to determine the relationship between the available potential habitat and the hydrological regime of the St. Lawrence (D. Hatin, MRNF, unpub. data). This study demonstrated that variations in flow rates, caused by climate change or the regulation of the St. Lawrence River water levels, have a notable effect on the availability of summer habitat for the Copper Redhorse. The area of available habitat may be reduced by half or doubled depending on whether flow rates are low or high.

Hydrology of the St. Lawrence River is also partly affected by dredging operations in the shipping channel and harbour facilities. Dredging of the shipping channel in the river has increased the flow depth in Lac Saint-Pierre from 4.3 m in 1847 to 11.3 m in 1998 (Morin and Côté, 2003). This activity has modified in quality and in quantity shallow-water shoreline habitats in the river corridor downstream of Montreal, particularly around Lac Saint-Pierre.

Changes in the rainfall caused by climate change will affect water levels in the St. Lawrence River basin. This could result in a modification in water flow. According to Morstch and Quinn (1996), a temperature increase of 4°C could reduce annual water flow by 40%. McBean and Motiee (2008), however, forecast a medium-term increase in precipitation and consequently in water flows in the Great Lakes and St. Lawrence River. Changes in the rainfall and subsequent water levels in the St. Lawrence could also influence the frequency and intensity of dredging operations in the shipping channel and harbour facilities.

2. RECOVERY

2.1 Population and Distribution Objectives

The goal of this recovery strategy is to improve the current situation of the Copper Redhorse in order to halt the process of extinction, increase species abundance and, in the long term, to bring the population to a level sufficient for COSEWIC to reduce its status listing to threatened, of special concern, or not at risk. The population recovery goal, in order to maintain a self-perpetuating Copper Redhorse population while maintaining 90% genetic diversity, was estimated at 4,000 adults (Bernatchez, 2004; Lippé et al., 2006; DFO, 2007). The time frame set out to reach this goal is 20 years. Present assessment methods cannot measure directly attainment of the recovery goal. Therefore, several population and distribution objectives were determined in order to measure progress:

- the ratio of Copper Redhorse spawners to total redhorse population, irrespective of species, should reach 3%;

- autumn catches of Copper Redhorse young-of-the-year should constitute 3% of total juvenile redhorse catches, irrespective of species;
- in the next few years, juveniles introduced through stocking initiatives should contribute significantly to population inventories, while those issuing from natural reproduction gradually increase;
- the present distribution range must be maintained.

In order to reach the population objectives, three broad approaches have been identified:

- 1) **Conservation:** legislative and administrative regulatory and management actions are required to supplement research and outreach strategies;
- 2) **Education and outreach:** improve awareness among stakeholders of the precarious situation of the Copper Redhorse population and of the threats to its recovery;
- 3) **Research and monitoring:** scientific research and monitoring programs to improve knowledge about the Copper Redhorse and the threats to its recovery.

2.2 Actions Already Completed or Underway

The implementation of earlier Copper Redhorse recovery strategies has resulted in previous measures to assist in the recovery of the species (Comité d'intervention, 1995, 1999; Équipe de rétablissement du chevalier cuivré, 2005).

2.2.1 Conservation measures

2.2.1.1 Legal Protection

The Copper Redhorse has been listed in Schedule 1 of SARA since 2007 and existing regulations prohibit the killing, disturbance, harassment and capture of listed wildlife species. The Copper Redhorse was also designated as a threatened species in 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. In order to limit mortalities, under the Quebec Fishery Regulations (SORS/90-214 and SORS/2008-322), a prohibition is in place against sport fishing and possession of chub and redhorse in the distribution area of the Copper Redhorse, with the exception of Lac Saint-Pierre and its archipelago, because these fish resemble the Copper Redhorse and it is difficult for fishermen to distinguish between them.

All commercial fishermen must release any Copper and River Redhorse incidentally captured, and the use of any species of redhorse as bait is prohibited. A ban on bait fishing has been in place since April 1, 2008 in the Richelieu River, downstream from the Chambly basin, in order to protect Copper Redhorse juveniles. Furthermore, the *Fisheries Act* protects Copper Redhorse habitat by prohibiting any activity resulting in the disturbance, deterioration or destruction of the habitat, unless an authorization is granted by the Minister.

The *Act Respecting the Conservation and Development of Wildlife* (R.S.Q. C-61.1, r.46) provides legal protection to the Pierre-Étienne-Fortin Wildlife Preserve in the Chambly rapids 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. The Act also provides for fish habitat protection through the development of wildlife habitat plans that establish the norms and conditions regulating any actions undertaken in the environment (Chapter IV.1).

2.2.1.2 Construction and operation of the Vianney-Legendre fish ladder

Since the late 1960s, the unrestricted passage of Copper Redhorse and other fish species was seriously compromised by improvements made to the Saint-Ours dam, which did not have a fish ladder as before (Dumont et al., 1997). In the spring of 2001, a multi-species fish ladder was put into operation with the logistical and financial participation of several partners.¹² The structure is operated by Parks Canada which oversees the Saint-Ours Canal and Dam historic site. The operating permit for the fish ladder, issued by Fisheries and Oceans Canada, required that a testing period be devoted to committee supervised¹³ experimenting and comparison of various fish pass and dam shutter operational procedures in order to identify the optimal means of providing unrestricted passage to Copper Redhorse and other targeted species, such as lake sturgeon (*Acipenser fulvescens*), American shad (*Alosa sapidissima*), American eel (*Anguilla rostrata*) and river redhorse (*Moxostoma carinatum*). Results have been very encouraging: Copper Redhorse do make use of the fish ladder, though they remain quite rare (Fleury and Desrochers, 2003; Fleury and Desrochers, 2004; Fleury and Desrochers, 2005; Fleury and Desrochers, 2006).

2.2.1.3 Establishment of the Pierre-Étienne-Fortin Wildlife Preserve

The Pierre-Étienne-Fortin Wildlife Refuge, inaugurated in October 2002, was named after the naturalist who first described a Copper Redhorse specimen (in a scientific journal) in 1866. The wildlife preserve in the Chambly rapids aims to preserve the integrity of the more important of the only two known spawning grounds, to ensure that spawners are not disturbed during the period of reproduction and to protect eggs during incubation. The refuge was created with the collaborative efforts of Hydro-Quebec, the MNRF, the municipalities of Richelieu and Chambly, and the Nature Conservancy of Canada (NCC). The NCC has been granted ownership of a 15 km section of the river bed upstream of the refuge and is active in conservation of aquatic habitats and in outreach programs in the preserve.

2.2.1.4 Protection of the Île Jeannotte and Île aux Cerfs

In order to ensure long-term protection of the île Jeannotte and Île aux Cerfs, in the Richelieu River, the NCC was granted ownership of the islands in December 2006 and February 2009. Ownership of the Île aux Cerfs was later transferred to MRNF. This provides protection to sites particularly favorable to the growth of the Copper Redhorse. The banks of the islands are essentially the only ones in this section of the Richelieu River which have not been disturbed by development. In 2010, an outreach project around the islands was organised by NCC and the Comité de concertation et de valorisation du bassin versant de la rivière Richelieu (COVABAR).

¹² Parks Canada, DFO, Department of Transport Canada, Economic Development Agency, MRNF, Ministère de l'agriculture, des pêcheries et de l'alimentation du Québec, Fondation de la faune du Québec and Projet Rescousse.

¹³ The committee consisted of representatives from DFO, MRNF and Parks Canada Agency.

Buoys and two platforms were installed to raise awareness among boaters of the presence of this important habitat for juveniles. Awareness events were carried out during the summer to inform boaters on wildlife habitats and best practices in navigation.

2.2.1.5 Artificial reproduction, breeding and stocking

In 2004, an artificial reproduction plan was implemented to counter the low rate of natural reproduction. From 2004 to 2009, close to three million larvae and 140,000 juveniles were released into the nursery areas of the Richelieu River. Spawners are captured at the Vianney-Legendre fish ladder. The objective of the plan is to rebuild the reproductive stock by preserving at least 90% of the initial genetic diversity of the population over a period of 100 years (Bernatchez, 2004). Nine ponds were created by the MNRF specifically for rearing Copper Redhorse at the Baldwin Provincial Fish Culture Station. Artificial reproduction is carried out by the MRNF at Park Canada facilities, with the support of DFO since 2009.

2.2.1.6 Actions undertaken within the environment

The agro-environmental advisory club *Conseilsol* has been granted funding from the Fondation de la faune du Québec program “Development of biodiversity in watercourses in agricultural areas,” in collaboration with the Union des producteurs agricoles, to undertake restoration and bank stabilization projects on Ruisseau Richer. This tributary has an impact on water quality of the nursery areas in the Richelieu River. This club has joined with the COVABAR to plan and carry out remedial actions in agricultural areas and to work with farmers to implement changes in agricultural practices.

Since 2006, the NCC has helped in the restoration and characterization of the banks of the Richelieu River, upstream of the Pierre-Étienne Fortin Wildlife Refuge and in the vicinity of the Île Jeannotte and Île aux Cerfs. Several bank stabilization and restoration projects were completed in the Rivière des Hurons, Rivière L’Acadie and Rivière Beloeil, which are tributaries of the Richelieu considered in need of priority remedial action, from 2006 to 2010, by COVABAR in collaboration with the Department of Agriculture and Agri-food. The Rivière des Hurons – the most polluted river in Quebec – was targeted because of the proximity of its outflow with the main spawning area for Copper Redhorse and other threatened species. These works were carried out with the assistance of funding from the Interdepartmental Recovery Fund and several other partners. The *Eco-Nature* organization has implemented a bank characterization program along the Rivière des Mille Îles in order to provide a comprehensive description of the state of the river banks and to propose remedial action. Since 2007, approximately 180 properties (private and municipal) have been assessed. Property owners receive a Riverside Package encouraging them to restore the banks through revegetation and the signing of honor-based conservation agreements. This is part of the Habitat Stewardship Program for Species at Risk (HSP).

2.2.2 Outreach and Public Education

2.2.2.1 Educational tools about the Copper Redhorse

Publication of pamphlets on the Copper Redhorse was designed to educate and inform the general public about the precarious status of the species, to propose remedial action, to describe the importance of the Richelieu River, and to publicize the role of the Pierre-Étienne-Fortin Wildlife Preserve. One pamphlet was produced by COVABAR. Another one, with a more detailed description of the wildlife refuge, was published by the NCC in collaboration with the MRNF, the Parks Canada Agency, the HSP and Projet Rescousse. The Lake St. Pierre PIZ committee produced identification and educational guides on several species at risks, including the Copper Redhorse, and targeted various groups (e.g. anglers and commercial fishermen). Eight information panels were placed at strategic sites around the lake (launching ramps). The species was also the subject of numerous articles in newspapers and journals, and was featured in television and radio reports and also some theatrical presentations.

2.2.2.2 The Rescousse Project

Projet Rescousse is a non-profit organization with two objectives: to raise funds for the protection of threatened species, and to improve public awareness of this environmental issue. In December 1998, Projet Rescousse launched a micro-brewery beer on the market, La Rescousse. Some of the profits are paid into the Partenaire pour la biodiversité fund, part of the Fondation de la faune du Québec, in order to support projects on threatened species in Quebec. The Copper Redhorse is presently considered the standard-bearer of threatened species in Quebec and La Rescousse, which serves as an excellent communications vehicle throughout the media, has contributed to promoting the species' image among the public. Projet Rescousse was also one of the financial partners involved with the Vianney-Legendre fish ladder in Saint-Ours.

2.2.2.3 The Rivière des Mille Îles

With the help of the HSP, *Eco-Nature*, a non-profit environmental organization, began a public awareness program specifically targeting land owners along the river bank. The program included interpretive sign postings, lectures and educational material and was primarily aimed at habitat conservation and improving awareness of the status of the Copper Redhorse. Collaborative efforts of several agencies, including *Eco-Nature* and MRNF, led to the creation of the Mille-Îles River Wildlife Preserve. This preserve, protected in 1998, includes ten islands totalling 26.2 hectares of private land, property of the cities of Laval and Rosemère, and of *Eco-Nature*. The latter manages the site.

2.2.2.4 Protection of the Pierre-Étienne-Fortin Wildlife Preserve

The COVABAR, in collaboration with the MRNF and other partners, undertook a warden service project in the Pierre-Étienne-Fortin Wildlife Preserve. The objective of the project was to preserve the most important of the two known Copper Redhorse spawning grounds and of the species' habitat. This extremely rich, natural site is very popular for recreation in the summer months (swimmers, kayakers, jet-ski users, sport fishermen).

The presence of awareness officers patrolling the sector during the summers of 2006, and from 2008 to 2010, especially during the spawning periods of the species in the area, ensured that wildlife preserve and sports fishing regulations were followed, improved awareness among the

public, and permitted the completion of a creel survey. This awareness project was made possible with funding by the HSP, Environment Canada, and the Fondation de la faune du Québec.

2.2.2.5 The “Discover the Journey of the Copper Redhorse” Project

Five interpretive panels describing the Copper Redhorse were designed. This project is the result of close collaboration between the NCC, the COVABAR and the MRNF. Placed at strategic locations along the Richelieu River, these bilingual panels provide descriptions of the Copper Redhorse and its habitat, threats to its survival, recovery initiatives undertaken, and suggestions for further actions to assist in its conservation.

2.2.2.6 Interpretation Program and Activities at the Vianney-Legendre fish ladder

In the summer of 2010, COVABAR began a pilot project offering interpretation activities at the Vianney-Legendre fish ladder in the Saint-Ours Canal National Historic Site. The goal of the project was to increase public awareness by providing information related to the Richelieu River watershed and the various fish species that use the fish ladder, particularly the Copper Redhorse.

This project provided an opportunity to pursue the outreach initiatives targeting riverside landowners and users and to develop a program of organized interpretation activities which may be continued in the coming years.

2.2.3 Research and Monitoring

2.2.3.1 Juvenile Identification Guide

Given the difficulties in identifying juvenile redhorse of the five species present in Quebec, a bilingual dichotomous key for juveniles (35 mm and over) was designed in 2003 (Vachon, 2003a). Work has also been completed on descriptions of smaller specimens, most notably through comparative evaluations of the osteological development of the redhorse's tail (Grünbaum et al., 2003).

2.2.3.2 Genetic Analyses

To date, DNA analysis is the only reliable method of distinguishing larvae (25 mm and under) because identification based on external morphological characteristics has proved inconclusive. Analytical methods have been refined, and genetic analysis of the population, along with an evaluation of genetic heterogeneity, has been carried out (Lippé et al., 2004, 2006). This work has provided the information necessary to design a reproduction strategy. Besides the genetic characterization of all captured specimens and of spawners used for artificial reproduction, a marking study was carried out in 2007 and parental assignment analyses have been conducted on the tissue of captured juveniles in order to determine their natural or artificial origin and add to present knowledge of the survival of juveniles introduced into natural environments. Overall, the ratio of Copper Redhorse born from artificial and natural reproduction is of 9:1 (Vachon, 2010). This monitoring allows measuring the efficiency of protection and recovery activities.

2.2.3.3 Annual Monitoring of Fish Recruitment

A protocol for the monitoring of redhorse young-of-the-year in the Richelieu River was designed and implemented on a yearly basis. The objective of this project is to develop a performance index to evaluate present and future conservation and recovery measures. Using seine nets, fish were captured at 40 stations during the fall in 1998 and 2009. As of 2008, this work was extended to include the Saint-Ours sector in Sorel. Certain preliminary tendencies have been detected in population abundance, young-of-the-year growth and the climatic and hydrological conditions (Vachon, 1999b, 2002, 2007). These efforts, combined with genetic analyses, have also confirmed the short-term survival of juvenile Copper Redhorse introduced into the environment as part of the stocking program and have added to our knowledge about older juveniles.

2.2.3.4 Telemetric Tracking

As a first step, telemetric tracking has proven to be the best tool to locate habitats used by Copper Redhorse in the St. Lawrence River and its tributaries. The next step was to provide a thorough description of habitat characteristics, in order to identify and quantify critical areas within the distribution range which may be used by adults of the species (spawning grounds, feeding grounds, migration corridors). Appropriate conservation measures can then be developed, along with management strategies to maximize protection of Copper Redhorse habitat. Phase I of the telemetric tracking project produced improved methods of tagging fish, while subsequent phases provided information on Copper Redhorse distribution, movements and preferred habitat. Telemetric tracking has revealed that the distribution range of the species is much broader than was initially believed, based on captured specimens. Telemetry was also used to identify the environmental variables involved in habitat selection and to run a multivariate habitat model. This model was used to produce maps indicating the probability of species' presence during the spring, summer and fall periods (Comité ZIP des Seigneuries, 2006; Hatin, MRNF, unpublished data). This information was then used to identify critical habitat for adult Copper Redhorse in the St. Lawrence River (DFO, 2010a).

2.2.3.5 Monitoring Accidental Catches in Commercial Fisheries and angling

In 1998, the collaboration of one commercial fisherman operating in the Lavaltrie-Contrecoeur sector of the St. Lawrence River provided evidence of a significant concentration of adult Copper Redhorse in the area. Since then, the collaboration has been ongoing and the MRNF has overseen an annual monitoring of incidental catches in his fishing gear from April to November.

This monitoring program collates the following information: date, type of fishing gear, site, total length, presence of nuptial tubercles and external anomalies, state of health at point of release, and other pertinent information (stage of sexual maturity, distinctive colorings, etc.). When possible, sex is determined by abdominal pressure, presence of nuptial tubercles, and the angle formed by the pelvic fins. A microchip is implanted in each fish released to permit future identification. The discovery of this group has provided considerable new information on the species.

In 2009, the PIZ committee began a project to evaluate the impacts of commercial and sport fishing in Lac Saint-Pierre. The goal of the project is to improve awareness among fishermen of the precarious state of the Copper Redhorse and to verify the scale of accidental catches. The project uses several approaches including education of fishermen, training of personnel, and establishment of an emergency phone line.

2.3 Recovery Objectives

To reach the target of 4,000 mature individuals and to achieve the population and distribution objectives, five recovery objectives are proposed:

Objective 1. Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse by:

- a. protecting known key habitat zones and creation of supplementary habitat;
- b. improving water quality and habitat, in the Richelieu and St. Lawrence River watersheds, to ensure conditions suitable for normal reproduction and growth;
- c. maintaining connectivity between habitats used for the different stages of the life cycle.

Objective 2. Support the Copper Redhorse population through stocking until natural reproduction can ensure the long-term stability of the population.

Objective 3. Promote further research into the sub-adult component of the population (100–500 mm) to fill the gaps in our current knowledge of this stage of the Copper Redhorse life cycle.

Objective 4. Reduce the impact of anthropogenic pressures on the Copper Redhorse and its habitat.

Objective 5. Implement regular monitoring of the state of the population.

The following table includes measures aimed at providing strategic orientation to recovery actions implemented by DFO and all partners interested in the recovery of the Copper Redhorse

2.4 Recommended Strategies to Meet Recovery Objectives

2.4.1 Recovery planning

Table 2. Recovery Planning: recovery strategies to mitigate the impact of threats are suggested for each recovery objective. These recovery strategies are grouped according to the corresponding approach (conservation, education, research) and are further described in the “measures” column. The recovery strategies are prioritized: beneficial: would aid in the recovery; necessary: of high value for recovery; essential: indispensable for recovery.

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
Objective 1. Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse.				
Objective 1a. Protection of known key habitat zones and creation of supplementary habitat				
Essential	Conservation	Dam	Ensure optimal operation of the Vianney-Legendre fish ladder	Maintain and adapt if needed optimal long-term operational conditions for the Vianney-Legendre fish ladder.
Essential	Conservation	Degradation of habitat, water levels	Maintain physical and hydrological integrity of the known spawning grounds.	Ensure a suitable management of the Saint-Ours dam during the migration, spawning and incubation period of Copper Redhorse.
				Implement specific measures within the protocols governing the evaluation and monitoring of activities conducted in riparian and aquatic environments in order to maintain physical and hydrological integrity of the Chambly spawning grounds.
Essential	Conservation	Degradation of habitat	Acquire or provide legal protection for sites suitable for reproduction, feeding, rearing and growth of the Copper Redhorse.	Review and amend the limits and rules of the Pierre-Étienne-Fortin Wildlife Refuge (periods of access and activities prohibited).
				Provide legal protection for Île Hervieux (Lavaltrie)
				Consolidate protection of Île Jeannotte and Île aux Cerfs through the creation of a wildlife refuge.

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
Necessary	Conservation	Habitat degradation	Protect key habitat, particularly grass beds, from degradation due to dredging and dumping of dredged materials.	Implement specific measures within the protocols governing the evaluation and monitoring in order to prevent the dredging and the dumping of dredging debris in the grass beds of the St. Lawrence River corridor and of the Richelieu River.
Necessary	Conservation	Water levels	Maintain St. Lawrence water levels and flows regulation to comply with habitat requirements of the Copper Redhorse.	Promote including suitable water levels in the grass beds of the St. Lawrence, offering appropriate habitat conditions to the Copper Redhorse, in the water level management criteria, to the International Joint Commission.
Necessary	Conservation	Habitat degradation	Slow the process of the hardening of banks and restore riparian environments.	Promote the uniform implementation of the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains throughout the MRCs located within the Copper Redhorse distribution range.
				Evaluate the regulations in place in the riverside municipalities to regulate bank stabilization and construction of retaining walls and which are derived from the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains.
				Implement specific measures within the protocols governing the evaluation and monitoring of activities conducted in riparian and aquatic environments in order to prevent the hardening of banks.
				Develop a mechanism that provides expert advice on vegetation stabilization.
				Develop a bank restoration plan covering the Copper Redhorse distribution range, with priority accorded to: the Richelieu River, the confluence of the Rivière des Prairies and Rivière des Mille Îles and the Varennes-Boucherville reach of the St. Lawrence River.

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
Necessary	Outreach and education	Habitat degradation	Improve awareness, among riverbank landowners, farmers and municipalities, of the negative impacts of hardening of banks and promote restoration of riparian strips.	Launch awareness programs. Identify target audience and evaluate effectiveness of awareness campaigns in modifying and maintaining behaviors.
				Promote 10 to 15 m wide riparian zone restoration within the distribution range of the species.
Beneficial	Research and monitoring	Habitat degradation	Develop a monitoring approach for aquatic habitats in the Copper Redhorse distribution area.	Implement regular monitoring of the grass beds of the St Lawrence River corridor and improve aquatic vegetation models.
				Quantify and qualify aquatic habitats of the Yamaska and Noire Rivers in order to evaluate the possibility of rehabilitating the Copper Redhorse population in these rivers.
Beneficial	Conservation	Habitat degradation	Create new suitable habitat within the Copper Redhorse distribution area.	Restore aquatic habitats suitable for various life stages of the species.
Objective 1b. Improvement of water quality and habitat, in the Richelieu and St. Lawrence River watersheds, to ensure conditions suitable for normal reproduction and growth				
Essential	Conservation	Habitat degradation, Contaminants	Reduce the input of nutrients and of pesticides from agricultural activities into streams within the Copper Redhorse's distribution area.	Modify agricultural practices in order to reduce the input of nutrients and of pesticides into watercourses.
				Establish riparian strips that can significantly filter nutrients and pesticides coming from agricultural activities.
Essential	Conservation	Habitat degradation, Contaminants	Reduce the input into water courses of organic matter and contaminants from waste waters within the Copper Redhorse's distribution area.	Increase performance of municipal waste water treatments in order to reduce outputs of organic matter and contaminants and to ensure the outflow of treated water at all times and in any circumstances.
				Reduce the outputs of hormones disruptors in municipal effluents, in particular in the Montréal agglomeration effluent.

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
				Apply regulations on autonomous wastewater treatments.
Necessary	Research and monitoring	Habitat degradation, Contaminants	Monitor regularly water quality as well as pesticides and contaminants concentrations in the Copper Redhorse's habitat.	Continue monitoring of water quality, pesticides and contaminants in the Richelieu and St. Lawrence Rivers.
Necessary	Research and monitoring	Contaminants	Monitor the evolution, over time, of the estrogenicity of water and assess exposure to hormonal disruptors.	Diagnose the possible role of hormone disruptors in the difficulties facing Copper Redhorse reproduction (feminization, hermaphrodisism, etc.)
Beneficial	Outreach and education	Habitat degradation, Contaminants	Increase awareness among farmers of the situation of the Copper Redhorse and of the impact of agricultural pollution on the species.	Encourage farmers to reduce erosion in the Richelieu and St. Lawrence River watersheds.
				Encourage farmers to reduce the use of pesticides.
Beneficial	Outreach and education	Habitat degradation, Contaminants	Increase awareness among municipalities, industries and riverside landowners of the impact of wastewater pollution on the Copper Redhorse and its habitat.	Encourage municipalities to treat wastewater so as to efficiently reduce the levels of contaminants, particularly hormone disruptors, and organic matter in wastewater.
Objective 1c. maintain connectivity between habitats used by the different stages of the life cycle				
Essential	Conservation	Dams	Ensure that proposed and authorized development projects will not obstruct Copper Redhorse migration.	Implement specific measures within the protocols governing the evaluation and monitoring of activities conducted in riparian and aquatic environments in order to prevent any obstruction to migration.
Objective 2. Support the Copper Redhorse population through stocking until natural reproduction can ensure the long-term stability of the population.				
Essential	Conservation	All	Implement the reproduction strategy.	Assess the implementation of the 2004-2009 reproduction strategy and its results.
				Assess the plan's success after ten years and put forward recommendations for continuing the reproduction strategy or to amend it.
Essential	Research and	All	Optimize performance of the artificial	Draft and update a report on Copper Redhorse artificial

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
	monitoring		reproduction plan.	reproduction and rearing techniques. Develop an extender specifically designed to preserve Copper Redhorse sperm. Evaluate other potential introduction sites that offer suitable conditions for the Copper Redhorse. Develop an index to assess the contribution of spawners to the artificial reproduction plan since the beginning of operations. Carry out genetic characterizations and parental assignment analyses of all spawners used for artificial reproduction.
Objective 3. Promote further research into the sub-adult component of the population (100–500 mm) to fill the gaps in our current knowledge of this stage of the Copper Redhorse life cycle.				
Necessary	Research and monitoring	All	Assess sub-adult component of the population and its habitat.	Develop and implement a sampling method for sub-adult Copper Redhorse. Research, identify, characterize and protect habitat of sub-adult Copper Redhorse.
Objective 4. Reduce the impact of anthropogenic pressures on the Copper Redhorse and its habitat.				
Essential	Conservation	Recreational activities, fisheries	Reinforce surveillance of key habitats.	Increase surveillance and enforcement actions in the Pierre Étienne Fortin Wildlife Preserve, during spawning and incubation, particularly during peak pleasure boating periods. Improve signposting of boundaries and regulations of the Pierre-Étienne-Fortin Wildlife Preserve.
Beneficial	Outreach and education	Recreational activities and fisheries.	Improve public awareness about the impact of human activities on Copper Redhorse conservation.	Identify target audience. Bring about lasting changes in public attitudes and behavior through efficient awareness campaigns on

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
				disturbance, destruction (trampling) of spawning grounds, incidental catch and pleasure boating.
				Pursue awareness initiative in the Pierre-Étienne-Fortin Wildlife Refuge and the Île Jeannotte and Île aux Cerfs sector.
				Improve public awareness of Richelieu River ecosystem and of the Vianney-Legendre fish ladder at the Saint-Ours Canal national historic site with the building of an interpretation center and laboratories.
Beneficial	Conservation	Fisheries	Lessen the impact of the commercial fishery and ichthyological inventories.	Prioritize the buy-back of commercial gillnet and fyke net fishing licenses in the St. Lawrence River.
				Continue the evaluation of mortalities caused by accidental catches of Copper Redhorse by commercial fisheries.
				Reduce incidence of Copper Redhorse mortalities during inventories and scientific research.
				Provide adequate training for people working within Copper Redhorse habitat (e.g.: wildlife officers, commercial fishermen and environmental consulting personnel) so that they are able to identify Copper Redhorse specimens.
Beneficial	Conservation	Fisheries	Lessen the impact of sport fishing.	Modify sports fishing regulations in order to complete the prohibition to capture and possess redhorse and chub throughout the species’ distribution range, including Lac Saint-Pierre and its archipelago.
				Continue raising awareness of anglers on releasing Copper Redhorse if captured.
Objective 5. Implement regular monitoring of the state of the population				

Priority of measures (Beneficial, Necessary, Essential)	Approach	Threats addressed	Recovery strategies	Measures
Essential	Research and monitoring	All	Monitor Copper Redhorse population in the Richelieu River.	Implement annual monitoring of recruitment of juvenile redhorse in the Richelieu River.
				Carry out genetic characterizations and parental assignment analyses of all Copper Redhorse collected during sampling in the distribution area of the species.
				Assess the success of natural reproduction in the Richelieu River through genetic characterization.
Necessary	Research and monitoring	All	Develop a method to determine number of spawners.	Develop and implement a validated methodology for counting spawners from data collected during implementation of the reproduction plan.
Beneficial	Research and monitoring	All	Identify new spawning grounds.	Verify presence of reproduction in various potential spawning grounds.

2.4.2 Narrative to support Recovery Planning Table

The first recovery objective aims at protecting Copper Redhorse habitat by maintaining existing habitats through conservation measures (legal protection, management policies) and awareness campaigns (protection of river banks), and also by improving water quality, which is vital to the survival of the species. The second and third objectives aim at increasing Copper Redhorse recruitment by maintaining and improving the artificial reproduction plan and adding to the knowledge of the little-known sub-adult component of the population (100–500 mm). This will, in turn, permit the development of appropriate management and protection measures. The fourth objective will implement measures to reduce the impacts from pressures exerted by anthropogenic activities. Approaches proposed to attain this objective include education of fishermen and surveillance to limit disturbances caused by recreational boaters. The final objective, the monitoring of the population, is necessary in order to validate and improve current recovery efforts and to add to the limited knowledge of this species.

2.5 Critical Habitat

2.5.1 Identification of critical habitat for the species

Critical habitat is defined in the *Species at Risk Act* (2002) section 2(1) as:

“...the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species’ critical habitat in a recovery strategy or in an action plan for the species.” [s. 2(1)]

SARA defines habitat for aquatic species at risk as:

“... spawning grounds and nursery, rearing, food supply, migration and any other areas on which aquatic species depend directly or indirectly in order to carry out their life processes, or areas where aquatic species formerly occurred and have the potential to be reintroduced.” [s. 2(1)]

Critical habitat for the Copper Redhorse has been identified to the extent possible, based on the best available information. This critical habitat consists of aquatic grass beds in the St. Lawrence River, the littoral zone of the Richelieu River and the rapids below the Saint-Ours and Chambly dams (Figures 4 to 9). The grass beds provide rearing and feeding habitats while the rapids are used as spawning grounds. Critical habitat identified in the littoral zone of the Richelieu River is used for rearing and by adults to migrate to the spawning grounds. The critical habitat identified in the present recovery strategy is essential for the survival and recovery of the species but it is insufficient to reach the population objectives. The schedule of studies presented in Section 7.2 outlines the research deemed necessary to complete the identification of critical habitat in order to meet population and distribution objectives.

2.5.2 Information and methods used to identify critical habitat

During two workshops held in 2009 and 2010, with the participation of the Ministère des ressources naturelles et de la faune du Québec, Fisheries and Oceans Canada reviewed the information and used the new data to identify habitat use by the Copper Redhorse in the St. Lawrence and Richelieu rivers (DFO, 2010a). In October 2010, the Copper Redhorse Recovery Team recommended, that the habitat used by the Copper Redhorse in the Rivière des Prairies and Rivière des Mille Îles be identified as critical habitat. These two rivers were not discussed during the workshops due to a lack of time. The identification of critical habitat in the recovery strategy is based on the information gathered during these workshops (summarized below) and the Recovery Team recommendation.

Spawning habitat

In order to identify the critical spawning habitat of the Copper Redhorse, experts have studied the needs and behaviour of the species, the use of the rapids below the Chambly and Saint-Ours dams and the size of potential spawning habitat in the Richelieu River (DFO, 2010b). The spawning behaviour of the Copper Redhorse involves two or more males for each female. The Copper Redhorse appears to use the same sites as the other redhorse species, and apparently experiences reduced levels of competition at these sites due to the late onset of spawning. It adapts to environmental conditions and remains relatively faithful to spawning sites. The area required for spawning was estimated to be 1 m² per female (trio) which corresponds to a minimum required area of 2,000 m² for 2,000 females (to meet the objective of 4,000 mature individuals). This value was extrapolated from known data from other redhorse species. The size of the potential spawning sites in the Richelieu River is estimated at 583,064 m² (Chambly: 488,364 m² and Saint-Ours: 94,700 m²). This potential area has been calculated based on the location of the spawning grounds, the drifting of eggs, resting places for spawners and the variability of the substrate and hydraulic conditions. Thus, the critical spawning habitat identified in this recovery strategy appears sufficient to meet the objective of a recovered population of 4,000 Copper Redhorse spawners.

Rearing and migration habitat

The habitats frequented by young-of-the-year and sub-adults may be generally described as shallow littoral zones exposed to weak currents and with aquatic-grass beds. These habitats are relatively evenly distributed all along the Richelieu River and the size of the grass beds available in the Richelieu River remains unknown. This is why a bathymetric approach has been recommended to identify critical juvenile rearing habitat. Given the current hydrological conditions of the Richelieu River, restoration of lost grass beds would be problematic. The littoral zone frequented by juvenile Copper Redhorse is between 0 and 3 m deep. However, the critical habitat which has been identified in the Richelieu River covers the littoral zone which is 0 to 4 m deep in order to include the migration corridor used by spawners.

Adult feeding habitat

Adult feeding habitat was identified using modeling based on the telemetric monitoring of habitat use and on twelve habitat variables (for example: depth, current velocity, vegetation density). Habitat modeling was applied for the St. Lawrence River, Lac Saint-Louis and Lac Saint-Pierre. It was not applied to the Rivière des Prairies and Rivière des Mille Îles, but use of

the lower stretches of these rivers was confirmed with recent telemetry and historic data. In the St. Lawrence River, between Beauharnois and Trois-Rivières, the size of the potential habitat for rearing and feeding does not seem to be a limiting factor in reaching recovery objectives. However, the size of the habitat currently being used, as confirmed by telemetry, and identified as critical habitat, does appear limiting and is restricted to the fluvial reach between Montreal and Sorel. According to the model, habitat potential in the fluvial lakes is very high though use by Copper Redhorse remains marginal. However, habitat available between Montreal and Sorel, which is smaller in size (between 25 and 35 km² depending on flow rates), is highly frequented. Critical adult feeding habitat is consequently identified as habitat in the fluvial reach between Montreal and Sorel presenting the attributes that were used in the model listed in Table 3. This habitat will be insufficient to support a recovered population of 4,000 spawners who will require an estimated 260 km² of adult feeding habitat (DFO, 2010a).

2.5.3 Description of critical habitat

The Copper Redhorse's identified critical habitat includes three features supporting specific vital functions of the life cycle: the grass beds, the littoral zone, and the rapids. Their attributes are listed in Table 3.

Note that permanent anthropogenic features (e.g. wharfs, ports, marinas) that are present within the areas delineated are specifically excluded from critical habitat. The Saint-Ours fish ladder is also excluded from the critical habitat.

Table 3. Summary of the attributes and functions of critical habitat

Functions	Feature	Location	Attributes
Spawning, incubation (May, June, July)	Rapids	Richelieu River, downstream of Saint-Ours and Chambly dams	Depth between 0.75 to 2 m
			Weak to moderate current (0.2 to 0.6 m/s)
			Heterogeneous substrate consisting of fine to coarse gravel, rocks and sometimes blocks embedded in clay.
Rearing and feeding	Littoral zone	Richelieu River, from the Chambly basin to the river mouth	0 to 4 m deep
			Minor slopes (less than 20 degrees)
			Weak to moderate current (less than 0.5 m/s)
			Presence of vegetation
			Relatively fine substrate (mixture of clay-silt-sand)
Migration	Littoral zone	Richelieu River, from the Chambly basin to the river mouth	0 to 4 m deep
Adult feeding	Grass beds	St. Lawrence River, between Montréal and Sorel Rivière des Prairies Rivière des Milles Îles	0 to 4 m deep
			Weak to moderate current (less than 0.5 m/s)
			Relatively fine substrate
			Medium to high vegetation density, composed primarily of <i>Vallisneria americana</i> and <i>Potamogeton</i> sp.
			Abundance of gastropods and dreissenids

Spawning habitat

Spawning critical habitat includes the only two known spawning grounds of the Copper Redhorse, located in the Richelieu River, below the Saint-Ours dam (Figure 4) and in the Chambly rapids (Figure 5). The spawning grounds are used by the Copper Redhorse during the months of May, June and July. The attributes of these spawning grounds are listed in Table 3.

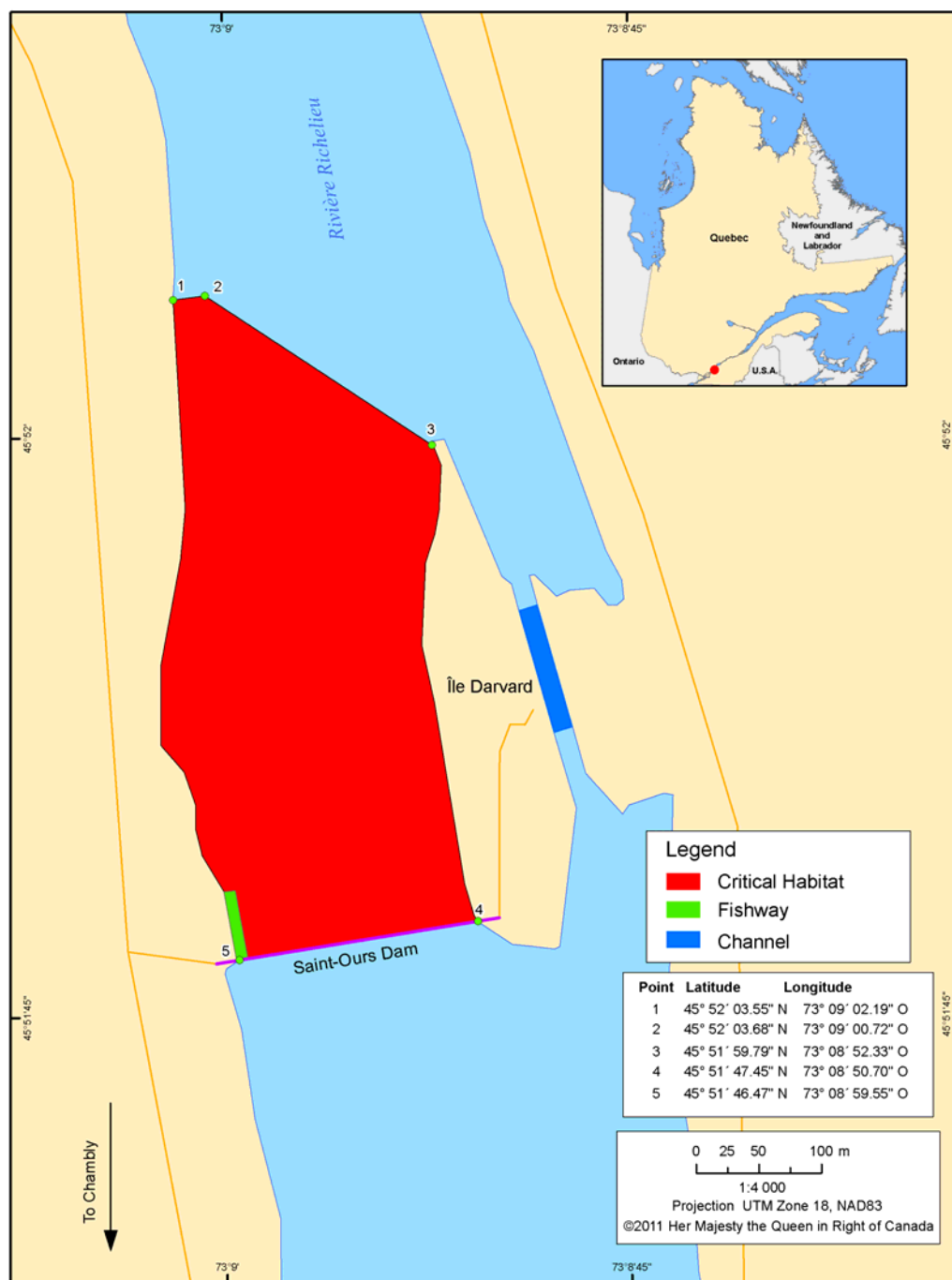


Figure 4. Critical spawning habitat of the Copper Redhorse at the Saint-Ours dam.

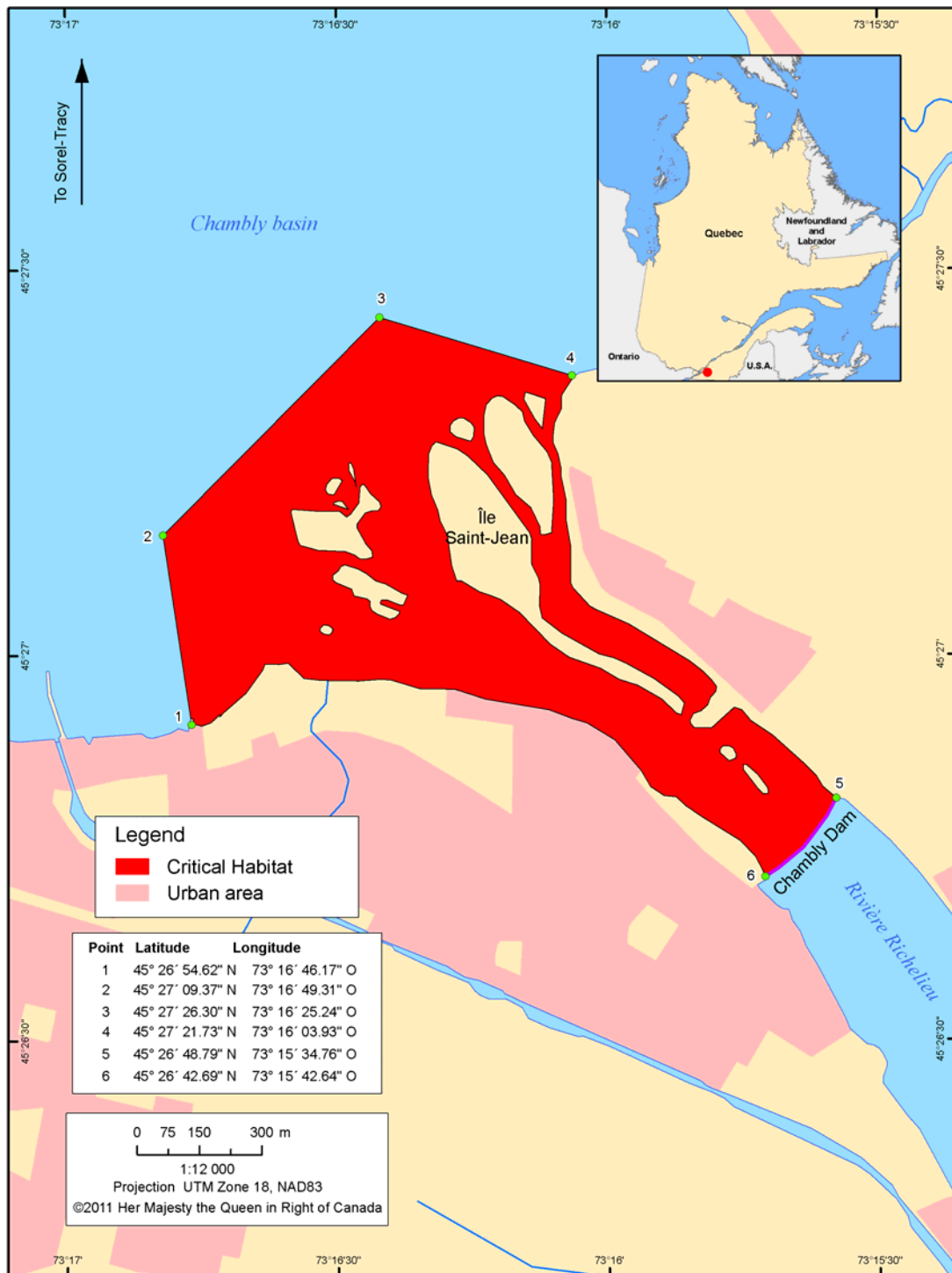


Figure 5. Critical spawning habitat of the Copper Redhorse at the Chamby dam.

Rearing and migration habitat

Critical habitat in the Richelieu River includes the littoral zone of the river, with a depth of 0 to 4 m, from the Chambly basin, to the mouth of the river (Figure 6 and Figure 7). Submerged aquatic vegetation is found in this area (Table 3). The Richelieu River is the only watercourse in which larvae and young Copper Redhorse of the year have been observed. Juvenile redhorse, such as the Copper Redhorse, (less than 100 mm) are confined to the grass beds of the littoral zone. Habitat for the growth of juveniles is in the grass beds in the littoral zone of the Richelieu River, identified as critical habitat. These grass beds, which play a key role during the rearing stage (growth, food and shelter), are not only an important habitat for juveniles, but also for adults who frequent the river or use it as a migration corridor.

Adult feeding habitat

The critical adult feeding habitat which has been identified is located in the St. Lawrence River, between Montreal and Sorel and in the Rivière des Prairies and Rivière des Mille Îles. The critical habitat in the St. Lawrence River, located in a bounding area from the eastern tip of Île Notre-Dame (Figure 8) to the mouth of the Richelieu River (Figure 9), corresponds to gastropod-rich grass beds with the attributes described in Table 3. The potential locations of these grass beds were modeled using telemetry surveys and habitat variables; this model is illustrated in green in Figures 8 and 9. Critical habitat identified in the Rivière des Prairies and Rivière des Mille Îles, also corresponds to gastropod-rich grass beds within a bounding area extending from longitudes 73° 37' 11" W (des Prairies) and 73° 35' 31" W (Milles Îles) to the river mouths. Potential locations of grass beds were not modeled in these rivers.

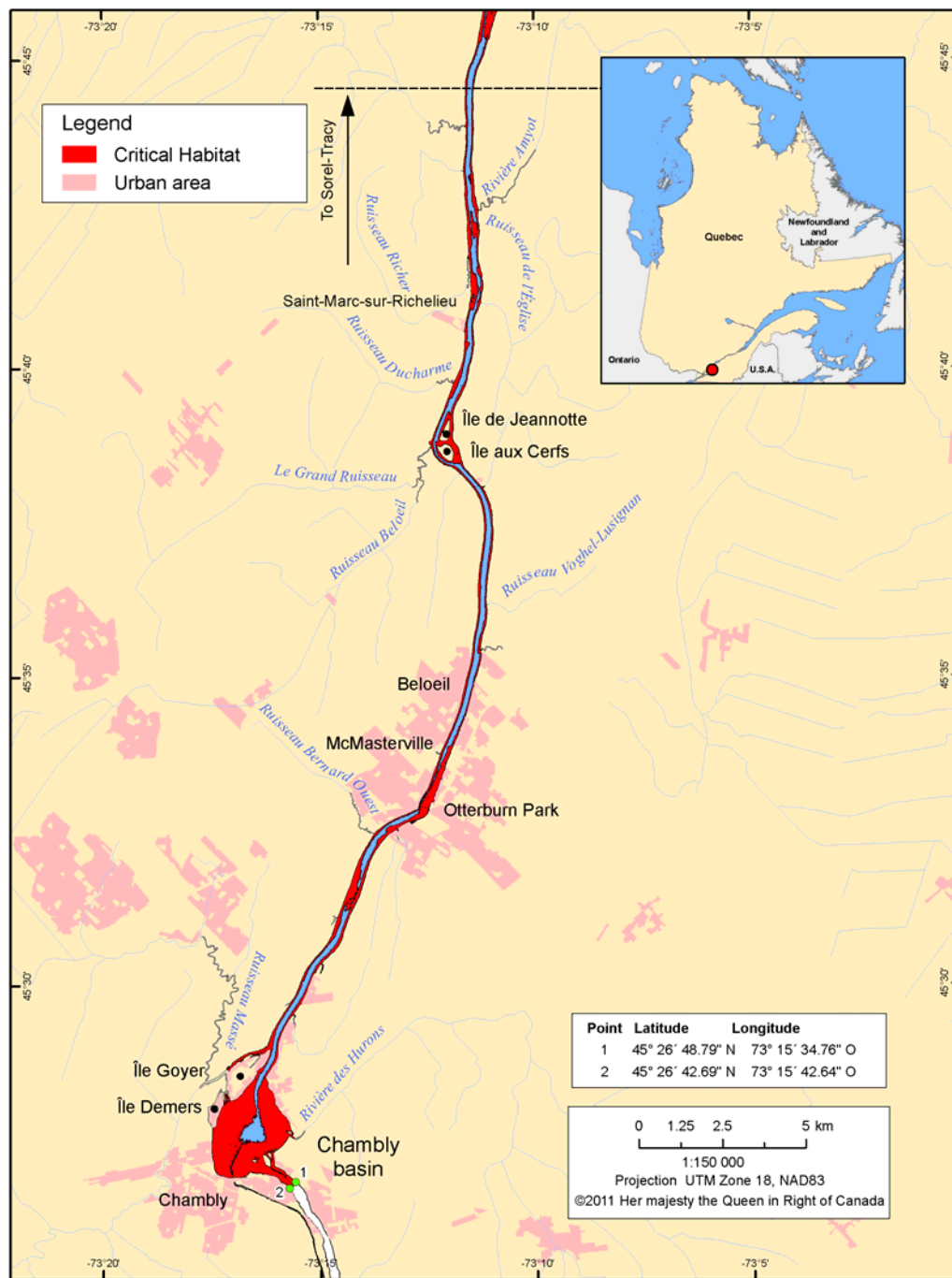


Figure 6. Critical rearing and migration habitat in the upstream reaches of the Richelieu River. Identified critical habitat corresponds to the littoral zone between 0 and 4 m depth (coloured in red), from the Chambly basin (upstream) extending to the river mouth.

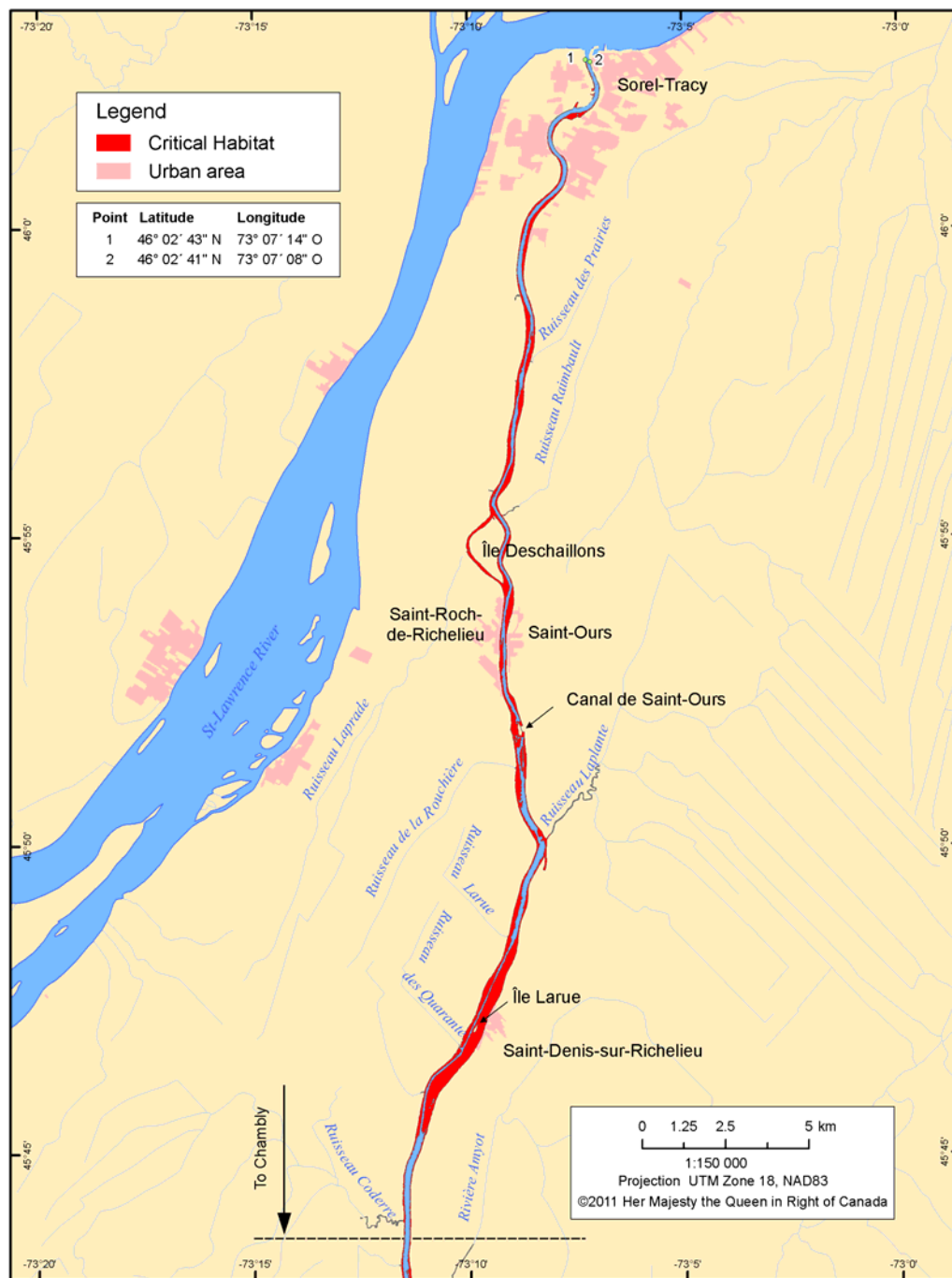


Figure 7. Critical rearing and migration habitat in the downstream reaches of the Richelieu River. Identified critical habitat corresponds to the littoral zone between 0 and 4 m depth (coloured in red), from the Chambly basin (downstream) extending to the river mouth.

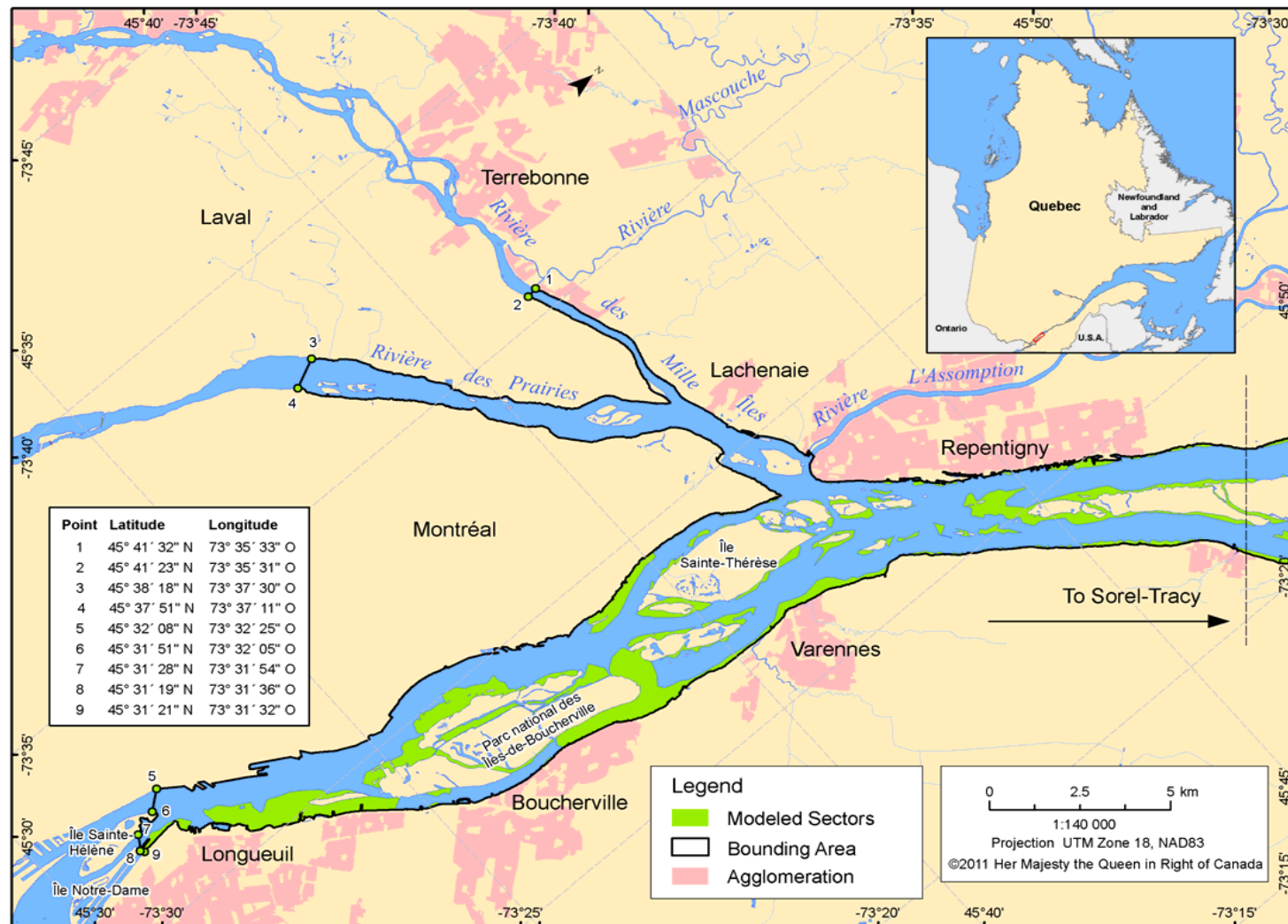


Figure 8. Bounding area (in black) in which critical adult feeding habitat corresponds to grass beds presenting the attributes listed in Table 3. Coloured in green are the areas thought to possess adult feeding critical habitat attributes in the Montréal region of the St. Lawrence River, based on a model. Stretches of the Rivière des Prairies and the Rivière des Mille Îles containing critical habitat begins at longitude 73° 35' 31" W in the Rivière des Mille Îles and at longitude 73° 37' 11" W in the Rivière des Prairies.

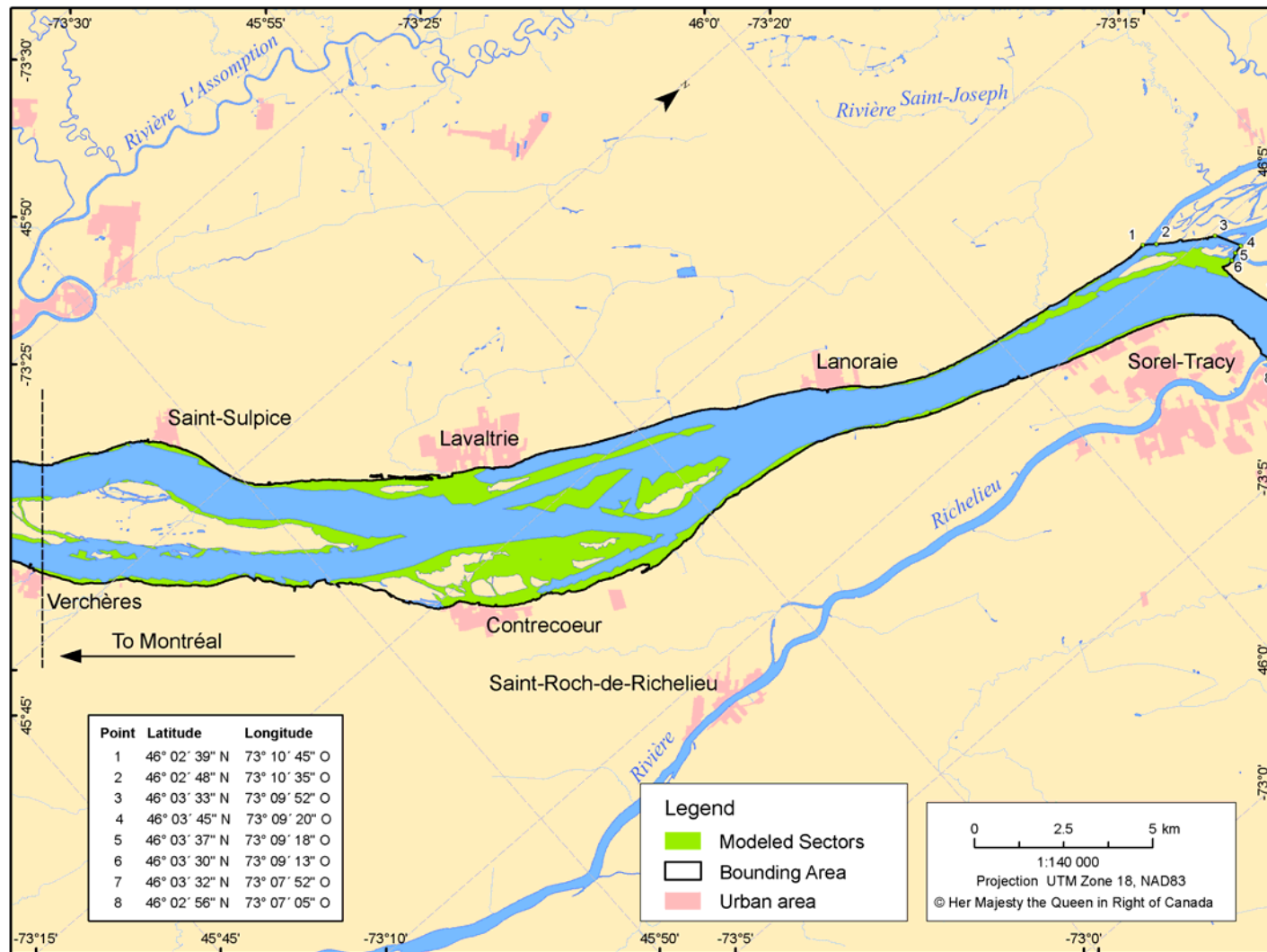


Figure 9. Bounding area (in black) in which critical adult feeding habitat corresponds to grass beds presenting the attributes listed in Table 3. Coloured in green are the areas thought to possess adult feeding critical habitat attributes in the Contrecoeur region of the St. Lawrence River, based on a model.

2.5.4 Schedule of studies to identify critical habitat

The present recovery strategy includes the critical habitat identified to the extent possible, based on the best available information. The quantity and quality of habitat suitable for the growth of adults identified for the purposes of this recovery strategy does not appear sufficient to provide an adequate environment for a population containing 4,000 mature individuals. The fluvial lakes may offer adequate habitat for the Copper Redhorse, but their use by this species is not well documented. Studies need to be conducted to identify the entire critical habitat necessary to attain the population and distribution objectives (Table 4).

Table 4. Schedule of studies

Description of activity	Results/rationale	Timeline
Identify the grass beds in Lac Saint-Pierre, Lac Saint-Louis and in the de la Prairie basin which exhibit the necessary attributes of critical feeding habitat for adult Copper Redhorse.	Identify feeding and growth areas for adults in order to meet population and distribution objectives	2016

2.5.5 Examples of activities likely to result in the destruction of critical habitat

The definition of destruction is interpreted as:

Destruction of critical habitat would result if any part of the critical habitat were degraded, either permanently or temporarily, such that it would not serve its function when needed by the species. Destruction may result from single or multiple activities at one point in time or from cumulative effects of one or more activities over time.

Under SARA, critical habitat must be legally protected from destruction once it is identified. This will be accomplished through a s.58 Order, which will prohibit the destruction of the identified critical habitat unless permitted by the Minister of Fisheries and Oceans Canada pursuant to the conditions of SARA.

The Minister of Fisheries and Oceans invites all interested Canadians to submit comments on the potential use of a s.58 Order to protect the critical habitat of the Copper Redhorse as soon as possible. Please note that, pursuant to s.58, any such Order must be operational within 180 days of the posting of the final version of the Recovery Strategy, or Action Plan, that identifies critical habitat.

Any activity that modifies the attributes presented in Table 3 of the features of identified critical habitat can cause its destruction. As habitat use varies in time, it is important to note that any human activity must be assessed on a case-by-case basis and mitigation measures have to be applied when available and be efficient. The activities described in Table 5 are not exhaustive, and are taken from the General Threats described in section 1.5 of this recovery strategy. The absence of a specific human activity does not preclude, or fetter the department's ability to regulate it pursuant to SARA. Furthermore, the inclusion of an activity does not result in its automatic prohibition because it is destruction of critical habitat that is prohibited and not the activity itself.

Bank stabilization through the use of riprap or the construction of retaining walls leads to shoreline hardening which, in turn, modifies plant composition and water flow in the grass beds. The deforestation of banks prevents containment of runoff and soil erosion and leads to increases in water temperature. In-filling wetlands or grass beds and construction of certain types of docks or other structures within habitat areas lead to the modification or destruction of these habitats. Dredging and the deposition of sediments destroy streambeds, particularly through the disappearance of aquatic grass beds. In addition, many pleasure-boating activities may cause degradation of the substrate by augmenting turbidity, destroying aquatic vegetation and trampling substrates.

Finally, flood control structures and hydroelectric installations which modify water input into the critical habitats of the Copper Redhorse may alter or destroy these habitats. Structures which present obstacles to both upstream and downstream migration may destroy critical habitat.

Table 5. Examples of activities likely to destroy critical habitat

Activities	Pathway of effects	Disrupted function	Disrupted feature	Disrupted attributes
Construction of dams	Modification of hydraulic conditions	Spawning	Rapids	<ul style="list-style-type: none"> ▪ Depth between 0.75 and 2 m ▪ Weak to moderate current (0.2 to 0.6 m/s) ▪ Heterogeneous substrate (fine to coarse gravel, cobble)
		Feeding Rearing	Grass beds Littoral zone	<ul style="list-style-type: none"> ▪ Depth from 0 to 4 m ▪ Weak to moderate current (less than 0.5 m/s) ▪ Minor slope (less than 20 degrees) ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids
	Obstacle to migration	Migration	Littoral zone	<ul style="list-style-type: none"> ▪ Depth from 0 to 4 m
Construction (dock, bridge, marina, etc.)	Destruction of grass beds Sedimentation	Feeding Rearing	Littoral zone Grass beds	<ul style="list-style-type: none"> ▪ Depth from 0 to 4 m ▪ Weak to moderate current (less than 0.5 m/s) ▪ Minor slope (less than 20 degrees) ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids

Activities	Pathway of effects	Disrupted function	Disrupted feature	Disrupted attributes
In-filling	Destruction of grass beds	Feeding Rearing	Littoral zone Grass beds	<ul style="list-style-type: none"> ▪ Depth from 0 to 4 m ▪ Weak to moderate current (less than 0.5 m/s) ▪ Minor slope (less than 20 degrees) ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids
Bank construction (retaining wall, rip-rap, etc.)	Destruction of grass beds Sedimentation	Feeding Rearing	Littoral zone	<ul style="list-style-type: none"> ▪ Depth from 0 to 4 m ▪ Weak to moderate current (less than 0.5 m/s) ▪ Minor slope (less than 20 degrees) ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids
Navigation	Wave action from passing boats causing erosion in the grass beds Destruction of aquatic vegetation	Feeding Rearing	Littoral zone Grass beds	<ul style="list-style-type: none"> ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids
Dredging and deposition of sediments	Destruction of streambed	Feeding Rearing	Grass beds	<ul style="list-style-type: none"> ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids
Pleasure-boating activities	Crushing and destruction of aquatic vegetation	Spawning	Rapids	<ul style="list-style-type: none"> ▪ Heterogeneous substrate (fine to coarse gravel, cobble)
		Feeding Rearing	Littoral zone Grass beds	<ul style="list-style-type: none"> ▪ Relatively fine substrate ▪ Moderate to high vegetation density ▪ Abundance of gastropods and dreissenids

2.6 Knowledge Gaps

Despite the considerable effort made to gather information on such a rare species, knowledge gaps subsist and have been identified. This lack of knowledge must be addressed before the development of a comprehensive and adequate strategy for the recovery of the Copper Redhorse is possible.

2.6.1 Reproduction and Spawning Grounds

There are other potential spawning grounds (Figure 3), though reproductive activity in these sites has never been confirmed. These potential spawning grounds need to be further assessed to ensure that they possess the requisite characteristics.

2.6.2 Immature Fish

Information has been gathered on certain aspects of the growth, nutritional needs, and habitat of larvae and juveniles, which include young-of-the-year and fish that are one year old in the spring (between 25 mm and 60 mm). A fry rearing ground has also been identified in the Richelieu River. However, there is still a lack of knowledge about larvae (under 25 mm) and sub-adults, fish between one and ten years of age with lengths varying between 100 and 500 mm. Knowledge about these groups and their habitats is very fragmentary and is limited to a few captures.

Many questions still remain concerning the distribution range and habitat of immature Copper Redhorse, particularly about the downstream migration and survival of larvae, the presence of sites in the Richelieu River where juveniles congregate, habitat characteristics, and the threats to the habitat and survival of sub-adult fish.

2.6.3 Adults

The adult population is composed primarily of older fish and available knowledge indicates that the level of reproduction is low. The mechanisms of absorption and the physiological effects of contaminants (atrazine, other pesticides, pharmaceutical and personal hygiene products) originating in municipal, industrial, and agricultural waste have not yet been clearly delineated, though they are suspected of acting as hormone and reproduction disruptors. Studies conducted on the spottail shiner (*Notropis hudsonius*), a cyprinid common to the Great Lakes basin and exposed to the wastewater outfall from Montreal, have revealed a high prevalence of feminization in specimens.

It is possible that the methods used to gather information on the total distribution range skewed the results partially to the detriment of Lac Saint-Louis. The information obtained through an analysis of the commercial fishery in Lac Saint-Pierre is based on incidental catches, while research activity itself is concentrated on the portion of the population located in the Richelieu River and St. Lawrence River, downstream of Montréal. Moreover, no sampling program has been carried out in the Rivière Noire and Rivière Yamaska since 1995. Though these environments have been severely degraded and minimum water flow within them greatly reduced, neither the presence nor absence of the species in these rivers can be confirmed. Questions also remain concerning factors (e.g. inadequate grass beds) which could explain why some areas of potential summer habitat in the fluvial lakes are less frequented by Copper Redhorse.

When invasive exotic species such as the tench, round goby, zebra mussel, European water chestnut and common water reed establish themselves in an environment, they bring changes to the physical environment and to the food chain. However, the effects of these introduced species on the Copper Redhorse population have not been sufficiently well documented.

Current knowledge on winter habitat remains fragmentary and is solely based on the telemetric monitoring of 11 fish during the winter of 2008.

Despite these knowledge gaps, the available information on the Copper Redhorse is significant and of high quality considering how rare the species is. Further efforts to collect more information should avoid manipulation of specimens as much as possible as this presents a threat to the survival of the species.

2.7 Existing and Recommended Approaches to Habitat Protection

The *Regulation respecting the Pierre-Étienne-Fortin Wildlife Preserve*, R.Q.c. C-61.1, r.3.01.3.3, provides protection measures for the spawning ground at the Chambly rapids. The land on which the wildlife preserve is located is owned by Hydro-Québec and the municipality of Richelieu. According to sections 3 and 4 of the Regulation, “From 20 June to 20 July, no person may enter, stay in, travel about or engage in any activity in sectors B and C of the wildlife preserve” and “No person may, in the wildlife preserve, engage in an activity that may alter any biological, physical or chemical element of the habitat of the Copper Redhorse, the river redhorse or the channel darter (*Percina copelandi*).” (c. C-61.1, r.46, sections 3 and 4). For critical habitat to be adequately protected, the preserve will need to be extended to include all the spawning grounds.

The Saint-Ours Canal National Historic Site on the Richelieu River, together with the bridge-dam and fish ladder, the adjacent west bank and l'île Darvard fall under the jurisdiction of the Parks Canada Agency. The tailrace of the dam is a known spawning ground, while the fish ladder represents a necessary stage in the migration of Copper Redhorse towards the Chambly spawning ground.

Environment Canada's Canadian Wildlife Service owns several islands in the Contrecoeur archipelago which have been declared national wildlife areas under the *Wildlife Area Regulations* (C.R.C., c. 1609) of the *Canadian Wildlife Act*. The Îles de Contrecoeur National Wildlife Area covers 312 hectares and includes eleven islands in the archipelago.

The Île Jeannotte and Île aux Cerfs, located downstream of the Chambly basin in the Richelieu River were acquired by the NCC. Ownership of Île aux Cerfs has since passed to the MRNF. The shoreline of these islands is thus protected from urban development. This also provides protection for the grass beds around the archipelago. Creation of a wildlife refuge on these islands is in the planning stage.

2.8 Progress towards recovery

The performance indicators presented below provide a way to define and measure progress toward achieving the population and distribution objectives. Specific progress towards implementing the recovery strategy will be measured against indicators outlined in subsequent action plans.

Performance indicators

- Increase in the number of adults inventoried at the Vianney-Legendre fish ladder during the upstream migration;
- Percentage of 3% of redhorse captured during sampling initiatives which are Copper Redhorse;
- Percentage of 3% of juvenile redhorse inventoried in the Richelieu River that are Copper Redhorse;
- Increase in the number and percentage of juveniles sampled in the Richelieu River coming from natural reproduction;
- Maintain at least two spawning grounds used by the species;
- Increase in the number of individuals inventoried in Lac Saint-Louis, Lac Saint-Pierre, the Rivière des Mille Îles and the Rivière des Prairies;
- Maintaining the area, in km², of the Copper Redhorse distribution range.

2.9 Activities Permitted by the Recovery Strategy

The *Species at Risk Act* stipulates that “No person shall kill, harm, harass, capture or take an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species.” (subsection 32 (1)). Under subsection 83(4) of the *Species at Risk Act*, “Subsections 32(1) and (2), section 33 and subsections 36(1), 58(1), 60(1) and 61(1) do not apply to a person who is engaging in activities that are permitted by a recovery strategy, an action plan or a management plan and who is also authorized under an Act of Parliament to engage in that activity, including a regulation made under section 53, 59 or 71.”

Fisheries

Although fishing for Copper Redhorse is prohibited in Quebec, incidental captures occur in the commercial and sport fisheries. The immediate release of this fish is mandatory, according to the *Quebec Fishery Regulations (1990)*, SOR/90-214 of the *Fisheries Act*, R.S.C., 1985, c. F-14. As mentioned in the “Threats” section, the risk of accidental mortalities caused by commercial fisheries is very low. An outreach project aimed at commercial fishermen in Lac Saint-Pierre to assess Copper Redhorse bycatch, determined that no Copper Redhorse was incidentally caught by these fishermen (Comité ZIP du lac Saint-Pierre, 2010). The mortality risk owing to commercial fisheries in the river stretches upstream of the lake is not considered detrimental to the Copper Redhorse because the only permit for fyke nets will be bought back (P. Dumont, MRNF, personal communication) and gill nets used for fishing sturgeon and carp are unlikely to capture Copper Redhorse (Vachon and Chagnon, 2004; Chagnon, 2006c, b, a).

In accordance with subsection 83(4) of SARA, this recovery strategy authorizes fishermen to carry out sport or commercial fishing subject to the following conditions:

- fishing is carried out in accordance with a sport or commercial fishing license issued under the provisions of the *Quebec Fishery Regulations (1990)*, SOR/90-214;
- any person who accidentally captures a Copper Redhorse while fishing shall without delay return the fish to the waters in which it was caught and, if the fish is alive, release it in a manner that causes the least harm to the fish.

Furthermore, in accordance with subsection 83(4) of SARA, this recovery strategy authorizes fishermen to fish under the provisions of an aboriginal communal fishing licence, subject to the following conditions:

- fishing is carried out in accordance with a communal licence issued under the provisions of the *Aboriginal Communal Fishing Licences Regulations*, SOR/93-332;
- any person who accidentally captures a Copper Redhorse while fishing shall without delay return the fish to the waters in which it was caught and, if the fish is alive, release it in a manner that causes the least harm to the fish.

Research

Beginning in 2004, an artificial reproduction plan was implemented to counter the low rate of natural reproduction. The objective of the plan is to rebuild the reproductive stock by preserving at least 90% of the initial genetic diversity of the population over a period of 100 years (Bernatchez, 2004). Artificial reproduction is carried out by the MRNF at Park Canada facilities, with the support of DFO since 2009.

In accordance with subsection 83(4) of SARA, this strategy authorizes employees of the Ministère des ressources naturelles et de la faune du Québec, while performing their duties, to carry out activities related to the Copper Redhorse artificial reproduction programme, with the following conditions:

- These activities are authorized by subsection 3(3) of the *Quebec Fishery Regulations (1990)*, SOR/90-214;
- There has to be a constant monitoring of the net and the fish have to be taken out immediately after capture;
- Spawners are manipulated with caution, in priority and are under constant supervision from qualified personnel;
- Specimens are to be manipulated under anaesthetic and in accordance to the Guidelines for the Use of Fishes in Research (2004) of the American Fisheries Society;
- The location of the artificial reproduction is not accessible to the public in order to reduce disruption. The area is secured and emergency measures are in place in case of an electricity shortage to ensure adequate water supply to the tanks.

A protocol for the monitoring of redhorse young-of-the-year recruitment in the Richelieu River has been designed and implemented on an almost yearly basis. The objective of this project is to develop a performance index with which to evaluate present and future conservation and support measures. Certain preliminary trends have been detected in population abundance, young-of-the-year growth and the climatic and hydrological conditions of the environment (Vachon, 1999b, 2002, 2007). These efforts have also confirmed the short-term survival of juvenile Copper Redhorse introduced into the environment as part of the stocking program and have added to our knowledge of older juveniles.

In accordance with subsection 83(4) of SARA, this strategy authorizes employees of the Ministère des ressources naturelles et de la faune du Québec, while performing their duties, to

carry out activities related to the recruitment monitoring programme, with the following conditions:

- These activities are authorized by subsection 3(3) of the *Quebec Fishery Regulations (1990)*, SOR/90-214;
- There is priority sorting of species at risk such as Copper Redhorse, eastern sand darter and channel darter;
- All one-year or older specimens of Copper Redhorse are measured and released back into the water after a tissue sample;
- Species at risk other than Copper Redhorse will be measured and released back into the water.

There is a lack of knowledge about sub-adults, fish between one and ten years of age with lengths varying between 100 and 500 mm. Knowledge about this group and its habitat is fragmentary and is limited to a few captures. A research effort on this segment of the population (objective 3 of this strategy) will be necessary to better protect it.

In accordance with subsection 83(4) of SARA, this strategy authorizes employees of the Ministère des Ressources naturelles et de la Faune du Québec, while performing their duties, to carry out activities related to the subadult monitoring program, with the following conditions:

- These activities are authorized by subsection 3(3) of the *Quebec Fishery Regulations (1990)*, SOR/90-214;
- Sampling is carried out using safe gear such as fyke nets, seines and trawls;
- There is priority sorting of species at risk such as Copper Redhorse, eastern sand darter and channel darter;
- All specimens of Copper Redhorse are measured and released back into the water after a tissue sample;
- Species at risk other than Copper Redhorse will be measured and released back into the water.

2.10 Statement on Action Plans

One or more action plans will be completed by December 2016.

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4. RECOVERY TEAM

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APPENDIX A: EFFECTS ON THE ENVIRONMENT AND OTHER SPECIES

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

This recovery strategy will clearly benefit the environment by promoting Copper Redhorse recovery. Possible inadvertent negative impacts on other species of this strategy were considered. The SEA concluded that this strategy benefits the environment and would have no significant negative impacts.

Protection of Copper Redhorse habitat and the measures taken to improve that habitat will also benefit several other species which share the same environment. Some of these species appear on the List of Wildlife Species at Risk, such as the river redhorse (*Moxostoma carinatum*), the eastern sand darter (*Ammocrypta pellucida*), the channel darter (*Percina copelandi*) and the bridge shiner (*Notropis bifrenatus*). For example, the monitoring of redhorse recruitment in the Richelieu River, intended to evaluate the efficiency of the measures implemented to support the Copper Redhorse population and the restoration of its habitat, will also contribute to our knowledge of other fish populations (diversity, channel darter, eastern sand darter) and to our understanding of phenomena such as the factors influencing growth in Copper Redhorse young-of-the-year and those suspected of influencing reproductive success. The Vianney-Legendre fish ladder at Saint-Ours was designed to provide passage for the Copper Redhorse and four other species at risk. Work done in monitoring and optimizing operational procedures has confirmed that this structure is being used by more than thirty different species. Water quality improvement projects that aim to reduce the erosion of banks and cultivated fields benefit all species that live in aquatic and riverside habitats such as the northern map turtle (*Graptemys geographica*), the muskrat (*Ondatra zibethicus*) or the least bittern (*Ixobrychus exilis*).