Species at Risk Act
Recovery Strategy Report Series

Report on the Progress of Recovery Strategy Implementation for the Copper Redhorse (*Moxostoma hubbsi*) in Canada for the Period 2012 to 2018

Copper Redhorse

2022

Canada

Recommended citation:

Fisheries and Oceans Canada. 2022. Report on the Progress of Recovery strategy Implementation for the Copper Redhorse (*Moxostoma hubbsi*) in Canada for the Period 2012 to 2018. *Species at Risk Act* Recovery strategy Report Series. Fisheries and Oceans Canada, Ottawa. ii + 47 pp.

For copies of the progress report, or for additional information on species at risk, including Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports, recovery strategies, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.

Cover illustration: Nathalie Vachon, ministère des Forêts, de la Faune et des Parcs du Québec.

Également disponible en français sous le titre
« Rapport sur les progrès de la mise en œuvre du programme de rétablissement du chevalier cuivré (*Moxostoma hubbsi*) au Canada pour la période 2012 à 2018 »

ISBN 978-0-660-40992-4
Catalogue no. En3-4/141-1-2022E-PDF

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996) agreed to establish complementary legislation and programs that provide for the protection of species at risk throughout Canada. Under section 46 of the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the competent ministers are responsible for reporting on the implementation of the recovery strategy for a species at risk, and on the progress towards meeting its objectives within five years of the date when the recovery strategy was placed on the Species at Risk Public Registry and in every subsequent five-year period, until its objectives have been achieved or the species' recovery is no longer feasible.

Reporting on the progress of recovery strategy implementation requires reporting on the collective efforts of the competent minister(s), provincial and territorial governments and all other parties involved in conducting activities that contribute to the species' recovery. Recovery strategies identify broad strategies and approaches that will provide the best chance of recovering species at risk. Some of the identified strategies and approaches are sequential to the progress or completion of others and not all may be undertaken or show significant progress during the timeframe of a report on the progress of recovery strategy implementation (progress report).

The Minister of Fisheries, Oceans and the Canadian Coast Guard is the competent minister under SARA for the Copper Redhorse. Because this species uses the Vianney-Legendre fishway, the Minister responsible for the Parks Canada Agency is the competent minister for individuals in the fishway. Fisheries and Oceans Canada, Quebec Region, led the preparation of this progress report in collaboration with the Copper Redhorse Recovery Team.

As stated in the preamble to SARA, success in the recovery of species at risk depends on the commitment and cooperation of many different constituencies that will be involved in implementing the guidelines set out in the recovery strategy and will not be achieved by Fisheries and Oceans Canada (DFO) and the Parks Canada Agency, or any other jurisdiction alone. The cost of conserving species at risk is shared amongst different constituencies. All Canadians are invited to join in supporting and implementing the recovery strategy for the Copper Redhorse for the benefit of the species and Canadian society as a whole.

Acknowledgments

This progress report was prepared by Émilie Lapalme and Vincent Coutu of Comité de concertation et de valorisation du bassin de la rivière Richelieu (COVABAR) and Hugues Bouchard, Virginie Christopherson, Arianne Savoie and Marie-Pierre Veilleux of DFO.

The report was prepared with input from the Ministère des Forêts, de la Faune et des Parcs du Québec and other members of the Copper Redhorse Recovery Team : the Ministère de l'Environnement et de la Lutte contre les Changements climatiques du Québec (MELCC), the Ministère de l'Alimentation, des Pêcheries et de l'Agriculture du Québec (MAPAQ), Environment and Climate Change Canada (ECCC), Agriculture and Agri-Food Canada (AAFC), Jacques-Cartier Area of Prime Concern (Zone d'intervention prioritaire) (ZIP) Committee, Des Seigneuries ZIP Committee, Nature Conservancy of Canada, Lac Saint-Pierre ZIP Committee, Fondation de la Faune du Québec (FFQ), Parc de la Rivière-des-Mille-Îles, Réseau Environnement, the Montreal Biodôme, Union des producteurs agricoles (UPA), the city of Montreal, and the Montreal Metropolitan Community (MMC). Fisheries and Oceans Canada

would like to thank all individuals and organizations that have contributed to the recovery of the Copper Redhorse.

Executive summary

The Copper Redhorse (*Moxostoma hubbsi*), which is endemic to Quebec, was designated endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in November 2004. In December 2007, it was listed as endangered in Schedule 1 of the *Species at Risk Act* (SARA) and this status was reconfirmed in 2014. In addition, in 1999, it was designated threatened under Quebec's *Act Respecting Threatened or Vulnerable Species*. The "Recovery strategy for the Copper Redhorse (*Moxostoma hubbsi*) in Canada*"* was finalized and published on the Species at Risk Public Registry in 2012.

The main threats to the Copper Redhorse include habitat degradation, water contamination, the introduction of organisms such as invasive aquatic species and pathogens, dam construction, certain recreational activities, sport and commercial fishing, and water level fluctuations.

Population and distribution objectives for the species are as follows: the ratio of Copper Redhorse spawners to the 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 naturally spawned juveniles should gradually increase; and the species' current range must be maintained.

The "Report on the Progress of Recovery strategy Implementation for the Copper Redhorse (*Moxostoma hubbsi*) in Canada for the Period 2012 to 2018*"* describes the progress made by DFO and its partners in implementing the recovery strategy and in achieving the associated objectives.

During this period, progress was made in the following areas:

Significant advances have been made in artificial spawning techniques, including the establishment of a cryopreserved milt bank, which can be used to increase the number of families created. Between 2012 and 2018, roughly 760,000 larvae, 99,000 autumn fry (young-of-the-year) and 111 fish age one and older fish were stocked in the Richelieu River. Research has led to a better understanding of the species' range and of the threats it faces. Shoreline renaturalization projects have been undertaken in a number of sub-watersheds. Various provincial acts and regulations have been enacted that could have a favourable impact on water quality. Outreach efforts continue; target audiences are usually quite receptive and show a better awareness of issues involving the Copper Redhorse.

The longevity and late sexual maturity of the Copper Redhorse make its recovery somewhat slow, and monitoring the status of the population remains a challenge. Nevertheless, the species' recovery is considered feasible. The species remains susceptible to habitat degradation, and continuing conservation, research and outreach efforts are essential to prevent or mitigate the main threats to its survival and recovery.

Table of contents

1. Introduction

The “Report on the Progress of Recovery strategy Implementation for the Copper Redhorse (*Moxostoma hubbsi*) in Canada for the Period 2012 to 2018” (hereinafter referred to as the progress report) outlines the progress made towards meeting the objectives identified in the recovery strategy for the Copper Redhorse during the period covered in the report. The progress report is part of a series of documents that are linked and should be taken into consideration together, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) status reports (COSEWIC 2014), the recovery potential assessment (DFO 2007) and the recovery strategy (DFO 2012).

Section 2 of the progress report reproduces or summarizes key information on the threats to the species, population and distribution objectives for achieving its recovery, approaches to meeting the objectives, and performance indicators to measure the progress of recovery. For more details, refer to the Recovery strategy for the Copper Redhorse (*Moxostoma hubbsi*) in Canada. Section 3 reports the progress of activities identified in the recovery strategy to support achieving the population and distribution objectives. Section 4 provides a concluding statement about the progress toward achieving the objectives.

2. Background

2.1 COSEWIC assessment summary

The listing of the Copper Redhorse in 2007, which led to the development and publication of the “Recovery strategy for the Copper Redhorse (*Moxostoma hubbsi*) in Canada in 2012” (DFO 2012), was based on the information provided in the COSEWIC Status Report (COSEWIC 2004). This information was included in section 1.1 of the recovery strategy.

Assessment date: November 2004

Common name (population): Copper Redhorse

Scientific name: *Moxostoma hubbsi*

COSEWIC 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 (for example, 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 in Canada: 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.

In 2014, COSEWIC re-examined the status of the Copper Redhorse and confirmed it as endangered in its Assessment and Status Report (COSEWIC 2014).

2.2 Threats

This section summarizes the information found in the recovery strategy on threats to survival and recovery of the Copper Redhorse and threats to its critical habitat.

2.2.1 Threats to the Copper Redhorse

Table 1 summarizes the population-level and species-level threats to the Copper Redhorse. Please refer to section 1.5 of the recovery strategy for more information on these threats.

Table 1. Summary of the threats identified for the Copper Redhorse, based on the recovery strategy.

Threat	Species-level threat risk	Description
Erosion	High	Soil and bank erosion cause the silting of streambeds and riverbeds and increased turbidity, which results in habitat degradation and the disruption of the food chain
Shoreline hardening	High	Alters hydrological regimes, promotes runoff and contributes to the deterioration in water quality and degradation of aquatic grass beds
Eutrophication	High	Leads to a decrease in dissolved oxygen and favours species tolerant of lower dissolved oxygen levels
Invasive aquatic species	Moderate	Modifications to the food chain and introduction of competitors
Pathogen introduction	High	Northward expansion of pathogens due to climate change. Likely to result in significant mortality
Contaminants	High	Reduced levels of primary production and dissolved oxygen. Can be detrimental to reproduction and act as endocrine disruptors
Dams	High	Constitute physical barriers to migration, and cause fragmentation and destruction of certain habitats
Recreational activities	Moderate	Noise, trampling and damage caused by motorized vehicles can be detrimental to feeding, spawning and survival.
Sport fishing	Moderate	Target catch or bycatch of Copper Redhorse
Commercial fishery	Low	Copper Redhorse bycatch in the commercial fishery
Water levels	Low	Fluctuations in flows affect the availability of the Copper Redhorse's summer habitats

2.2.2 Threats to critical habitat

Critical habitat for the Copper Redhorse has been identified, to the extent possible, in section 2.5 of the recovery strategy. Table 2 provides examples of activities that are likely to result in destruction of critical habitat (that is, threats to critical habitat). The list of activities provided in

this table is neither exhaustive nor exclusive, and their inclusion has been guided by the relevant threats to habitat described in the recovery strategy. For more details on the activities likely to result in the destruction of critical habitat, consult the recovery strategy.

Table 2. Threats to critical habitat of the Copper Redhorse, extracted from the recovery strategy.

Threat	Activities	Effect pathway
Dams and water levels	Dam construction	Alteration of hydrological conditions Barriers to migration
Shoreline hardening	• Construction (wharves, bridges, marinas) • Shoreline infilling • Shoreline construction (retaining walls, riprap, etc.)	Destruction of aquatic grass beds Sedimentation
Recreational activities	Pleasure boating	Wave action generated by boats reducing the size of grass beds Trampling and destruction of aquatic vegetation
Erosion and water levels	Dredging and sediment deposition	Destruction of streambed or riverbed

2.3 Recovery

This section summarizes the information found in the recovery strategy (DFO 2012) on the population and distribution objectives that are necessary for the recovery of the Copper Redhorse and on performance indicators that are used to define and measure progress toward achieving the population and distribution objectives.

2.3.1 Recovery objectives

Section 2.3 of the recovery strategy identified the following objectives necessary for the recovery of the species:

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 habitats and creating supplementary habitats
    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 by the different stages of the life cycle

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

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

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

5. Implement regular monitoring of the status of the population

2.3.2 Performance indicators

Section 2.8 of the recovery strategy includes the following performance indicators to define and measure progress toward achieving the population and distribution objectives:

1. Increase in the number of adults enumerated in the Vianney-Legendre fishway during upstream migration
2. Copper Redhorse represent 3% of all redhorse captured during sampling operations
3. Juvenile Copper Redhorse represent 3% of all juvenile redhorse enumerated in the Richelieu River
4. Increase in the number and percentage of naturally spawned juveniles enumerated in the Richelieu River
5. At least two spawning grounds are used by the species
6. Increase in the number of individuals enumerated in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies
7. Area (in km^2) of the Copper Redhorse's range maintained

Some indicators may not be measurable within the timeframe covered in this progress report. In such cases, the implementation of the recovery approaches and critical habitat studies will help report on the progress towards achievement of the performance indicators. Outreach to target audiences is crucial to limit the impacts of anthropogenic activities on Copper Redhorse critical habitat. The addition of protected areas such as the potential expansion of the Pierre-Étienne-Fortin Wildlife Preserve, as well as the conservation of the species' critical habitat, are essential for its recovery. Lastly, research and monitoring activities must be continued to better target the actions to be taken and increase knowledge of the species and the threats it faces. For example, research should be conducted on the effects of toxic substances found in the water and should be continued in other areas in order to identify adults' feeding areas throughout the St. Lawrence River.

Table 3. Recovery objectives and corresponding performance indicators for the Copper Redhorse, extracted from the recovery strategy.

Recovery objectives and sub-objectives	Performance indicators
Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse; protect known habitats and create supplementary habitats	• Maintain at least two spawning grounds used by the species • Increase in the number of individuals inventoried in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies • Area (in km^2) of the Copper Redhorse's range maintained

Recovery objectives and sub-objectives	Performance indicators
Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse; improve water quality and habitat in the Richelieu and St. Lawrence River watersheds to ensure conditions suitable for normal reproduction and growth	• Increase in the number of adults inventoried at the Vianney-Legendre fishway during upstream migration • Juvenile Copper Redhorse represent 3% of all juvenile redhorse in the Richelieu River • Increase in the number of individuals inventoried in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies
Improve habitat conditions necessary for all stages of the life cycle and for the survival and recovery of the Copper Redhorse; maintain connectivity between habitats used by the different stages of the life cycle	• Increase in the number of adults inventoried at the Vianney-Legendre fishway during upstream migration • Copper Redhorse represent 3% of all redhorse captured during sampling operations • Maintain at least two spawning grounds used by the species • Area (in km^2) of the Copper Redhorse's range maintained
Support the Copper Redhorse population through stocking until natural spawning can ensure the long-term stability of the population	• Increase in the number of adults inventoried at the Vianney-Legendre fishway during upstream migration • Copper Redhorse represent 3% of all redhorse captured during sampling operations • Juvenile Copper Redhorse represent 3% of all juvenile redhorse in the Richelieu River
Encourage further research on the sub-adult component of the population (100–500 mm) to fill in the gaps in our current knowledge of this stage of the Copper Redhorse's life cycle	• Increase in the number of individuals inventoried in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies
Reduce the impact of anthropogenic pressures on the Copper Redhorse and its habitat	• Increase in the number of adults inventoried at the Vianney-Legendre fishway during upstream migration • Increase in the number of individuals inventoried in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies
Implement regular monitoring of the state of the population	• All performance indicators

3. Progress towards recovery

The recovery strategy for the Copper Redhorse (DFO 2012) divides the recovery effort into five objectives, as outlined in section 2.3. of this document. Each of these objectives is supported by

several recovery strategies and measures, which are detailed in the recovery strategy and referenced in table 4 of this document. Progress in meeting these overall objectives through the implementation of activities identified in the recovery strategy is reported in Section 3.1. Section 3.2 reports on the activities identified in the schedule of studies to identify critical habitat. Section 3.3 reports on the progress relative to the performance indicators and other commitments (for example, action plan and Critical Habitat Order) identified in the recovery strategy and information obtained through implementing the recovery strategy.

3.1 Activities supporting recovery

Table 4 provides information on the implementation of activities undertaken to address the recovery objectives, strategies, and approaches identified in the recovery planning table of the recovery strategy.

Table 4. Details of activities supporting the recovery of the Copper Redhorse from 2012 to 2018.

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Maintain, and adapt if needed, optimal long-term operating conditions for the Vianney-Legendre fishway	**Ensure optimal operation of the Vianney-Legendre fish ladder.** Approach: Conservation	A number of studies have been conducted to assess the effectiveness and improve the performance of the Vianney-Legendre fishway, some of which focus on redhorse species (Hatry et al. 2016, Thiem et al. 2013). According to these studies, not all species are equally successful in passing through the fishway. Not only do certain species deal with this device better, but differences are also observed between individuals of the same species. In addition, it has been hypothesized that the fish ladder's attraction is likely reduced by accumulated sediments and debris, which probably modify the attraction flow (Vachon, pers. comm., 2019).	**Ministère des Forêts, de la Faune et des Parcs (MFFP), Parks Canada Agency**
Ensure proper management of Saint-Ours dam during Copper Redhorse migration, spawning and incubation periods	**Maintain the physical and hydrological integrity of the known spawning grounds.** Approach: Conservation	Fournier and Desrochers (2009) recommend operating conditions for the dam and fishway and preventive maintenance measures for the fishway, in order to maximize the latter's attraction to fish. Certain deficiencies in the operation of these facilities have been observed in recent years. Continued efforts are needed to optimize the passage of fish through the fishway and spawning conditions in the area. MFFP is on site during the critical period in spring, which ensures the monitoring of spawning conditions for the Copper Redhorse. Annual operator training and outreach must be carried out and is critical to proper site management.	**MFFP, Parks Canada Agency**
Implement appropriate measures in processes for the analysis and monitoring of activities	**Maintain the physical and hydrological integrity of the**	Activities carried out in fish habitat are governed by federal, provincial and municipal legislation. Certain specific mitigation measures or conditions of authorization, as well as offsetting measures, may be required. DFO analyzes each application to	**MFFP, DFO,** Ministère de l'Environnemen

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
in riparian and aquatic environments in order to maintain the physical and hydrological integrity of the Chambly spawning ground	**known spawning grounds.** Approach: Conservation	conduct activities affecting critical Copper Redhorse habitat on a case-by-case basis according to the applicable acts and regulations in place. No authorizations were issued in the Chambly spawning ground sector during the period covered in this report.	t et de la Lutte contre les changements climatiques (MELCC), Municipalities
Review and amend the restrictions and regulations for the Pierre-Étienne-Fortin Wildlife Preserve (access periods and prohibited activities)	**Acquire, or provide legal protection for, sites suitable for the spawning, feeding and growth of, and as nursery areas for, the Copper Redhorse.** Approach: Conservation	The project to amend the *Regulation Respecting the Pierre-Étienne-Fortin Wildlife Preserve* is underway. This will be followed by consultation, approval and publication procedures as specified in the rules on establishing and modifying a wildlife preserve.	**MFFP,** Nature Conservancy Canada (NCC), Comité de concertation et de valorisation du bassin de la rivière Richelieu (COVABAR)
Provide legal protection for Hervieux Island (Lavaltrie)	**Acquire or provide legal protection for sites suitable for reproduction, feeding, rearing and growth of the Copper Redhorse.** Approach: Conservation	Des Seigneuries Zone d'intervention prioritaire ("area prime concern"; ZIP) Committee has initiated discussions with the island's current owner and NCC to obtain protected status for the island. NCC is continuing its efforts to acquire Hervieux Island and turn it into a conservation area.	**NCC,** Des Seigneuries ZIP Committee, Environment and Climate Change Canada (ECCC)
Strengthen the protection of Jeannotte	**Acquire or provide legal**	The project to amend the *Regulation Respecting the Pierre-Étienne-Fortin Wildlife Preserve* and modify the boundaries of	**MFFP,**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Island and Île aux Cerfs through the creation of a wildlife preserve	**protection for sites suitable for reproduction, feeding, rearing and growth of the Copper Redhorse.** Approach: Conservation	the preserve is underway. Following discussions with MFFP, it was agreed to take advantage of this opportunity to add two additional areas to the preserve: (1) Jeannotte Island and Île aux Cerfs (nursery area) and (2) the spawning ground downstream of the Saint-Ours dam. The technical specifications for the project are in a very advanced stage. This will be followed by the consultation, approval and publication processes as specified in the procedures for establishing and modifying a wildlife preserve.	**NCC,** COVABAR
Implement appropriate measures in processes for the analysis and monitoring of activities in order to prevent dredging and disposal of materials in aquatic grass beds in the Richelieu River and the fluvial section of the St. Lawrence River	**Protect key habitat, particularly grass beds, from degradation due to dredging and dumping of dredged materials.** Approach: Conservation	Activities carried out in fish habitat are governed by federal, provincial and municipal legislation. Certain specific mitigation measures or conditions of authorization, as well as offsetting measures, may be required. Biologists working for the Fish and Fish Habitat Protection Program (FFHPP) in DFO evaluate development projects taking place in and around fish habitat. To protect fish and their habitats, including aquatic species at risk and their critical habitat(s) and residence(s), efforts are made to avoid, mitigate or offset impacts. Authorizations, permits and letters of advice issued under the *Fisheries Act* and *Species at Risk Act* (SARA) include conditions to minimize the impact of work.	**MFFP,** **DFO,** **MELCC,** **Municipalities**
Lobby the International Joint Commission to include water levels in aquatic grass beds in the St. Lawrence River in its water level management criteria, in order to ensure suitable habitat conditions for the Cooper Redhorse	**Maintain St. Lawrence water levels and flows regulation to comply with habitat requirements of the Copper Redhorse.** Approach: Conservation	The MFFP participated in consultations leading to the adoption of the *Lake Ontario - St. Lawrence River Plan 2014,* which includes the maintenance of adequate water levels in grass beds in the St. Lawrence River to provide suitable habitat conditions for the Copper Redhorse (IJC 2014).	**MFFP,** International Joint Commission (IJC), NCC

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Implement Quebec's *Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains* (PPLRLZF) in all the Regional County Municipalities (RCMs) with territories in the Copper Redhorse's range	**Slow the process of the hardening of banks and restore riparian environments.** Approach: Conservation	The PPLRLZF is still not being consistently implemented by RCMs with territories in the Copper Redhorse's range. MELCC offers training on this topic to municipal inspectors and citizens, but it is not provided on a regular basis and attendance is voluntary (Piché, pers. comm., 2017). Although MELCC can take action to follow up on a complaint, it does not systematically monitor the enforcement of this policy (Piché, pers. comm., 2017). Éco-Nature provides assistance to municipalities and riparian owners undertaking shoreline restoration and development projects in order to ensure that they follow PPLRLZF guidelines. Efforts to restore riparian habitats and aquatic grass beds occur every year; for example, in 2018, 60 tonnes of concrete were removed from the shoreline of Berge des Goélands park in Laval, and soil bioengineering techniques were used to restore the shoreline.	**Municipalities,** NCC, COVABAR, Éco-Nature, MELCC
Evaluate bylaws enacted by shoreline municipalities arising from the PPLRLZF concerning bank stabilization structures and retaining walls	**Slow the process of the hardening of banks and restore riparian environments.** Approach: Conservation	Municipal bylaws have been reviewed by RCMs to ensure that they are aligned with their land use and development plans (LUDP); cases of non-compliance are referred to MELCC. Once the LUDP has been approved, municipalities have six months to make the required modifications.	**MELCC, (RCMs),** Municipalities
Implement appropriate measures in processes for the analysis and monitoring of activities in riparian and aquatic environments to prevent shoreline hardening	**Slow the process of the hardening of banks and restore riparian environments.** Approach: Conservation	Bank stabilization projects carried out in fish habitat are governed by federal, provincial and municipal legislation. Certain specific mitigation measures or conditions of authorization, as well as offsetting measures, may be required. Proposed stabilization projects are analyzed by the various government authorities in order to prescribe the most appropriate methods in a given situation to help preserve the integrity of the natural environment.	**MELCC, MFFP, Municipalities, DFO**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Develop a mechanism for providing expert advice on vegetative stabilization techniques	**Slow the process of the hardening of banks and restore riparian environments.** Approach: Conservation	Although similar services have been developed by organizations in their respective territories, a more universal mechanism for providing expert advice has not been created. For example, COVABAR has developed expertise in using vegetative stabilization techniques in a number of projects in tributaries of the Richelieu River and is advising other organizations that it is collaborating with on these methods. Éco-Nature has partnered with soil bioengineering professionals to develop this expertise and apply it in its territory. It offers shoreline restoration and development workshops for riparian owners on Rivière des Milles Îles and Rivière des Prairies; participants are given a personalized kit with specific recommendations on managing their shorelines, which have been characterized beforehand. Éco-Nature has also joined forces with nine shoreline municipalities to restore municipal shorelines using innovative soil bioengineering techniques. These projects will serve as examples and as a way to publicize and promote promising, environmentally friendly shoreline management techniques to riparian owners on Rivière des Milles Îles.	Ambioterra, COVABAR, Éco-Nature
Implement a shoreline restoration plan in areas in the Copper Redhorse's range, prioritizing the Richelieu River, the confluence of Rivière des Prairies and Rivière des Mille Îles and the stretch of the St. Lawrence between Varennes and Boucherville	**Slow the process of the hardening of banks and restore riparian environments.** Approach: Conservation	An integrated shoreline restoration plan has not yet been introduced. However, many non-governmental organizations have invested considerable efforts in promoting and implementing shoreline restoration in certain high-priority portions of the species' range.	**Agri-environmental advisory clubs (AEACs,)** **NCC,** **Des Seigneuries ZIP Committee,**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
			Lac Saint-Pierre ZIP Committee, COVABAR, Éco-Nature, Union des producteurs agricoles (UPA) Montérégie
Conduct awareness campaigns. Identify target audiences and evaluate the effectiveness of awareness campaigns in modifying and maintaining behaviours	**Improve awareness, among riverbank landowners, farmers and municipalities, of the negative impacts of hardening of banks and promote restoration of riparian strips.** Approach: Outreach and education	Outreach to riparian owners, farmers and municipal authorities continues. Reports evaluating each activity have been produced in order to adapt approaches and more precisely target audiences, where necessary. One of the findings of workshops held on riparian buffers organized by COVABAR and NCC in 2018 was that outreach to elected officials is essential and is lacking. Outreach to farmers is often more effective if it is part of a project by a watershed committee.	**AEACs, NCC, Des Seigneuries ZIP Committee, Lac Saint-Pierre ZIP Committee, COVABAR, Éco-Nature, UPA Montérégie,** Agriculture and Agri-Food Canada (AAFC), Conseil régional de l'environnement

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
			du Centre-du-Québec (CRECQ), ECCC, Evergreen Foundation TD Canada Trust, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), Municipalities, MELCC, MFFP
Promote the restoration of 10- to 15-m wide riparian buffers in the species' range	**Improve awareness, among riverbank landowners, farmers and municipalities, of the negative impacts of hardening of banks and promote restoration of riparian strips.**	Outreach promoting best practices in shoreline projects in the Copper Redhorse's range is ongoing. Workshops are offered to riparian owners. However, the various characterization reports consulted (COVABAR, 2013, 2016) show a very small percentage of riparian buffers meet the standards. The Des Seigneuries ZIP Committee, in partnership with the city of Repentigny, has organized workshops for residents on establishing riparian buffers and using vegetative stabilization techniques. A shoreline protection guide describing the current situation and providing plans for creating and restoring riparian buffers was also produced (available in French only).	**Conseil des bassins versants des Mille-Îles (COBAMIL), NCC, COVABAR, Éco-Nature, UPA Des Seigneuries**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	Approach: Outreach and education		**ZIP Committee,** **Lac Saint-Pierre ZIP Committee,** AAFC, ECCC, Hydro-Québec, MAPAQ, MELCC , Watershed organizations, Ville de Repentigny, St. Lawrence Action Plan
Implement regular monitoring of the aquatic grass beds in the fluvial section of the St. Lawrence River and improve aquatic vegetation models	**Develop a monitoring approach for aquatic habitats in the Copper Redhorse's distribution area.** Approach: Research and Monitoring	This measure is not addressed by a specific project, but instead is carried out as part of various projects in the fluvial section, particularly the MFFP's fish monitoring network (Réseau de suivi ichtyologique, or RSI). In the past, Éco-Nature has carried out surveys in aquatic grass beds in the Rivière des Milles Îles, including those in Copper Redhorse habitat.	**MFFP,** **Des Seigneuries ZIP Committee,** Éco-Nature
Quantify and qualify aquatic habitats in the Yamaska and Noire	**Develop a monitoring approach for**	No progress has been made on this measure. For the time being, this measure has not been actioned to concentrate	

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
rivers in order to assess the possibility of restoring the Copper Redhorse population in these rivers	**aquatic habitats in the Copper Redhorse's distribution area.** Approach: Research and Monitoring	recovery efforts for the species where it is still present, such as the St. Lawrence and Richelieu Rivers.	
Restore aquatic habitats suitable for the species' various life stages	**Create new suitable habitats in the Copper Redhorse's distribution area.** Approach: Conservation	Quebec's Ministère des Transports (MTQ) is constructing fish enhancements to offset habitat losses caused by the department's work along highways 133 and 223. This includes habitat restoration work at the Saint-Marc-sur-Richelieu wharf in 2017; the department is expected to undertake similar work in the Richelieu River watershed in the future.	**MTQ,** MELCC, DFO,
Modify agricultural practices in order to reduce the input of nutrients and pesticides in watercourses	**Reduce the input of nutrients and of pesticides from agricultural activities into streams within the Copper Redhorse's distribution area.** Approach: Conservation	Various efforts have been made in the last five years to modify agricultural practices. Watershed projects, coordinated by AEACs and the Montérégie branch of the UPA, have been undertaken and some of their measures target farming practices. A project led by ALUS (Alternative Land Use Services) provides financial incentives for expanded riparian buffers, the Prime-Vert project aims to restore riparian buffers and the UPA is working to change farming practices in the Rivière des Hurons watershed. The goals of the Quebec Pesticide Strategy 2015 to 2018 include increasing restrictions on pesticide use, modernizing the *Pesticides Act* (bill tabled in the winter of 2016) and amending the Pesticides Management Code (proposed regulatory amendment in the fall of 2016). The AcadieLab project, implemented in L'Acadie River watershed, is a joint effort between farmers, scientists and professionals to develop agri-environmental solutions.	**AEACs,** **UPA Montérégie,** AAFC, MAPAQ, MELCC, DFO, Regroupement des organismes de bassins-versants du Québec (ROBVQ)

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		The FFHPP has funded numerous projects in the Rivière des Hurons watershed led by the Montérégie branch of the UPA. Outcomes include over a dozen evaluations of integrated crop pest and pesticide management programs, over 30 hydro-agricultural structures and the integration of cover crops in farming systems in the Rivière des Hurons watershed. The Montérégie branch of the UPA will continue this work.	
Establish riparian filter strips, which significantly reduce nutrient and pesticide inputs from agricultural sources	**Reduce the input of nutrients and of pesticides from agricultural activities into streams within the Copper Redhorse's distribution area.** Approach: Conservation	Since 2012, work has been done to establish riparian strips along at least 41 km of shorelines in 21 sub-watersheds in or adjacent to the Copper Redhorse's range, largely funded under the FFHPP. However, according to pesticide monitoring activities by MELCC in the Rivière des Hurons, pesticide concentrations in the river have not been reduced, despite the fact that 24 km of riparian filter strips have been established there in the last 13 years. Lastly, over 15 municipalities and RCMs located in the Copper Redhorse's range have staked the banks of their watercourses to help make the riparian buffers more visible, but this practice is not applied everywhere.	**AEACs,** **Des Seigneuries ZIP Committee,** **Lac Saint-Pierre ZIP Committee,** **COVABAR,** **UPA Montérégie,** AAFC, ECCC, Fondation de la faune du Québec (FFQ), Hydro-Québec, MAPAQ, MELCC, DFO, Municipalities, RCMs,

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
			Watershed organizations, UPA Montérégie
Improve the performance of municipal wastewater treatment systems in order to reduce inputs of organic matter and contaminants in watercourses and to ensure the outflow of treated water at all times and in all circumstances	**Reduce the input into water courses of organic matter and contaminants from waste waters within the Copper Redhorse's distribution area.** Approach: Conservation	The *Regulation Respecting Municipal Wastewater Treatment Works* came into effect in January 2014 and is being phased in. The Regulation governs effluent standards at the discharge point, and standards respecting overflows of untreated wastewater, the monitoring of discharges and overflows and the mandatory certification of treatment plant operators. In addition, MELCC will issue a certificate, called a depollution attestation, to operators of municipal wastewater treatment plants, renewable every five years. These certificates are a legal tool for improving compliance with discharge standards and requirements stipulated in the Regulations (MELCC 2014). Expected results include the protection of aquatic ecosystems, and the reduction of pollutants and overflow events. Éco-Nature is working with MFFP, MELCC and the city of Rosemère on a pilot project to reduce and mitigate the impact of wastewater overflows on wildlife. This project is part of the effort to restore Miller Pond, which will continue in the coming years.	**MELCC,** **Municipalities and intermunicipal management boards,** Éco-Nature, MFFP
Reduce the endocrine disrupting chemical loads in municipal wastewater, particularly those from the Montreal urban agglomeration	**Reduce the input into water courses of organic matter and contaminants from waste waters within the Copper Redhorse's distribution area.**	A project is underway at the city of Montreal's wastewater treatment plant to install an ozone disinfection unit, which should be commissioned in the next few years; however, the reduction of endocrine disrupting chemicals will only occur after a certain break-in period (Fleury, pers. comm., 2017). No other ozone disinfection projects are planned in the Copper Redhorse's range. However, other wastewater treatment facilities may have to adapt when they receive their depollution	**MELCC,** **Municipalities and intermunicipal management boards,** Éco-Nature,

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	Approach: Conservation	attestation from MELCC under the *Regulation Respecting Municipal Wastewater Treatment Works* (Le Floch, pers. comm., 2017).	MFFP
Enforce the regulations on stand-alone domestic wastewater treatment systems	**Reduce the input into water courses of organic matter and contaminants from waste waters within the Copper Redhorse's distribution area.** Approach: Conservation	Pursuant to the *Regulation Respecting Waste Water Disposal Systems for Isolated Dwellings* (CQLR c Q-2, r 22 of the *Environment Quality Act*), municipalities are required to inventory non-compliant sanitary facilities and correct the situation. MELCC will take action against a municipality that fails to comply with the regulations only in response to a complaint. No inspections are carried out to ensure that municipalities exercise their authority in this area. To date, not all municipalities have inventoried non-compliant septic systems present within their territory.	**Municipalities, MELCC**
Continue to monitor water quality, pesticides and contaminants in the Richelieu and St. Lawrence rivers	**Monitor regularly water quality as well as pesticides and contaminants concentrations in the Copper Redhorse's habitat.** Approach: Research and Monitoring	MELCC carries out water quality monitoring on an ongoing basis through its network of sampling stations in the St. Lawrence River, the Richelieu River and its two main tributaries (Rivière des Hurons and L'Acadie River). Bacteriological and physicochemical water quality monitoring in the St. Lawrence River, the Richelieu River and its two main tributaries is performed on an ongoing basis by Réseau-Rivières and Réseau-Fleuve. Since the early 2000s, Éco-Nature has carried out water quality monitoring at 51 sampling stations along Rivière des Mille Îles and Rivière des Prairies. COBAMIL also conducts bacteriological and physicochemical water quality monitoring in the Rivière des Mille Îles tributaries and MELCC also collects data at several stations in this territory. According to the data, water quality index values at the Richelieu River stations have improved since 2012, but the same has not been observed at the Rivière des Hurons stations (MELCC 2017). In addition, pesticides are monitored regularly in Rivière des Hurons and on a more sporadic basis in L'Acadie River (2013)	**MELCC,** COBAMIL, Éco-Nature

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		and the Richelieu River (2016). The results obtained in Rivière des Hurons suggest an increase in pesticide concentrations during the 2011 to 2014 period, as well as an increase in the frequency of exceedance of the criteria for the protection of aquatic life (Giroux 2015).	
Determine the possible role of endocrine disruptors in reproductive problems affecting the Copper Redhorse (feminization, hermaphroditism, etc.)	**Monitor the evolution, over time, of the estrogenicity of water and assess exposure to hormonal disruptors.** Approach: Research and Monitoring	A project (DFO Science, Maurice Lamontagne Institute) has demonstrated the presence of vitellogenin (VTG), a protein involved in oocyte production, in the mucus of male Copper Redhorse. The project also showed that VTG could be detected in the plasma of certain male Silver Redhorse (*Moxostoma anisurum*, a related species) but not in their mucus. However, the cause of the prevalence of polyovular follicles in females of the genus *Moxostoma* remains to be determined (Maltais, pers. comm. 2017). A study was conducted in 2018 by researchers at McGill University in collaboration with MFFP on the effects of contaminants in young life stages of Copper and River Redhorse. According to preliminary observations, contaminant-exposed eggs of both species hatch faster than those in the control group. However, although Copper Redhorse exposed to river water had a lower survival rate, River Redhorse (*Moxostoma carinatum*) did not. According to RNA analyses, close to 140 genes are expressed differently in Copper Redhorse exposed to river water relative to the control group. A number of these genes are linked to growth and development, which suggests that river water exposure could influence these genes and at least in part explain the early hatching of exposed eggs. When River Redhorse were exposed in the laboratory to the pesticides atrazine, clothianidin, glyphosate and metolachlor in similar doses to those found in the environment, no differences in malformation, hatching or survival rates were observed.	**DFO, McGill University, MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		However, additional experiments will be required before any conclusions can be drawn for Copper Redhorse. According to analyses of water from the Richelieu River, a multitude of pesticides are routinely detected, but at concentrations below the chronic toxicity thresholds for the protection of aquatic life. An exploratory preliminary analysis using a comparative toxicogenomics database to examine differently expressed genes suggests that the deregulation of gene expression could be partially due to exposure to pharmaceuticals and personal care products present in wastewater. The effects of the combination of pesticides and wastewater also need to be explored in the near future (H. Marchand, pers. comm., 2019)	
Encourage farmers to reduce erosion in the Richelieu and St. Lawrence river watersheds	**Increase awareness among farmers of the status of the Copper Redhorse and the impact of agricultural pollution on the species.** Approach: Outreach and education	A number of farmers were educated about bank erosion problems. Bank stabilization and shoreline revegetation work was carried out along a number of kilometers of shoreline of watercourses. Efforts to promote sustainable farming practices were stepped up, through sub-watershed-based projects coordinated by AEACs and the Montérégie branch of the UPA and funded in part by DFO's FFHPP. Under these projects, outreach was provided to over 200 farming enterprises, resulting in 500 ha of agricultural land being planted with cover crops every year. These efforts have been strengthened by the launching of the AcadieLab project in 2015, which provides technology exploration workshops. However, significant erosion problems still remain in the region according to the reports from watershed partners characterizing the watercourses in the Richelieu River watershed.	**AEACs, UPA Montérégie,** AAFC, MAPAQ, DFO, Watershed organizations
Encourage farmers to reduce pesticide use	**Increase awareness among farmers of the**	Various participants offered workshops or information sessions on the subject. Quebec's crop health strategy (Stratégie phytosanitaire québécoise en agriculture, or SPQA), which was	**AEACs,**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	status of the Copper Redhorse and the impact of agricultural pollution on the species. Approach: Outreach and education	devised in 2011, emphasizes cooperation and mobilization and targets a 25% reduction in risks associated with pesticide use by 2021. However, the monitoring of pesticides in the river overseen by MELCC is still finding worrisome concentrations of pesticides in surface water and frequent cases in which the criteria for the protection of aquatic life are exceeded (Giroux 2015). Considerable outreach remains to be done.	**UPA Montérégie,** AAFC, MAPAQ
Encourage municipalities to treat wastewater to effectively reduce contaminant levels, particularly endocrine disruptors and organic matter	**Increase awareness among municipalities, industry and riparian owners of the impact of wastewater pollution on the Copper Redhorse and its habitat.** Approach: Outreach and education	The Jacques-Cartier ZIP Committee is working to raise awareness among the municipalities in its territory (Montreal, Laval, Longueuil, Île Bizard) on wastewater treatment issues, including reducing the contaminant load in municipal effluents and monitoring the results of continuous improvement programs at wastewater treatment facilities. This ZIP committee also coordinates the standing committee for wastewater monitoring in Montreal. The committee has undertaken various initiatives, including producing a pamphlet and a wastewater atlas, raising awareness among City administrators about overflow problems and holding a round of information meetings. The ZIP committee finds municipalities to be very receptive, but would like them to make changes more quickly (Bibeau, pers. comm., 2017). The Réseau Environnement has established a wastewater excellence program which aims, among other things, to improve the quality of municipal wastewater released to the environment. This program is recognition-based and provides technical assistance and knowledge sharing through a community of practice. In 2018, four municipalities in the Copper Redhorse's range participated in the Réseau Environnement's PEX-StaRRE (Programme d'excellence en eaux usées – Station de	**Jacques-Cartier ZIP Committee,** **Réseau Environnement**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		récupération des ressources de l'eau) program, including Châteauguay, Terrebonne, Rosemère and Laval.	
Implement specific measures in processes for analysis and monitoring of activities in riparian and aquatic environments to prevent any barrier to migration	**Ensure that future proposed and authorized development projects will not obstruct Copper Redhorse migration.** Approach: Conservation	Activities carried out in fish habitat are governed by federal, provincial and municipal legislation. Project impacts are always analyzed, taking account of requirements in terms of Copper Redhorse migration, larval drift, and the need to ensure the free movement of the species between the different habitats it uses during its life cycle.	**MFFP, DFO, Municipalities, Éco-Nature**
Assess the implementation of the 2004 to 2009 breeding plan and the results obtained	**Implement the reproduction strategy.** Approach: Conservation	According to the report about the breeding strategy (Vachon 2018), despite the species' precarious status and the amount of work required to apply the reproduction strategy, artificial spawning has been successful. The species still spawns naturally, but in low numbers. The report also makes a few recommendations, particularly that milt cryopreservation techniques be developed, that additional efforts be made to capture spawners in the downstream reach of the Saint-Ours dam, and that artificial spawning activities and population and recruitment monitoring efforts be continued.	**MFFP,** DFO
Assess the success of the breeding plan after 10 years and make recommendations to continue the plan as is or to amend it	**Implement the reproduction strategy.** Approach: Conservation	The 2004 to 2014 recovery assessment report for the Copper Redhorse is currently being drafted by the Copper Redhorse Recovery Team (see Appendix 2 for Recovery Team members). After the report has been published, recommendations will be made. Although the results of the most recent parental assignment analyses are not available, there are a number of very encouraging concrete signs, such as the capture of greater numbers of sub-adults since 2016, the capture of a Copper Redhorse less than 300 mm in length in a location other than	**MFFP, DFO**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		the Richelieu River (the St. Lawrence River in 2015 during RSI surveys) for the first time the participation of very young males in artificial spawning since 2017, and the probable beginning (to be validated) of a shift in the size classes of spawners to smaller size classes. These are likely signs that the recovery of the population is underway (Vachon, pers. comm., 2019).	
Draft and update a report on artificial spawning and rearing techniques for the Copper Redhorse	**Optimize performance of the artificial reproduction plan.** Approach: Research and Monitoring	During the reporting period, MFFP drafted a report, to be published soon, examining artificial spawning and rearing techniques (Vachon, in prep. a). Through numerous improvements to techniques over the years (captive rearing of spawners, cryopreservation, development of milt extenders, modifications to stocking techniques, milt cryopreservation techniques), it has been possible to optimize artificial spawning operations (Vachon, pers. comm. 2019). In addition, certain proven techniques used for Copper Redhorse were discussed in two reports on salmonid reproduction (Grondin 2016a and 2016b).	**MFFP, DFO**
Develop an extender specifically designed to preserve Copper Redhorse sperm	**Optimize performance of the artificial reproduction plan.** Approach: Research and Monitoring	A number of effective extenders have been developed specifically for the Copper Redhorse in recent years. In addition, milt cryopreservation techniques have been perfected, and young produced using cryopreserved milt were reared at the fish hatchery and stocked. A sperm bank is available for coming years (Vachon, pers. Comm, 2019).	**MFFP,** FFQ
Evaluate other potential introduction sites that provide suitable conditions for the Copper Redhorse	**Optimize performance of the artificial reproduction plan.**	The Copper Redhorse Recovery Team is questioning the usefulness of this measure. The Richelieu River contains the two known spawning grounds and the only known nursery areas for the species. Evaluating other sites would be premature given the current state of knowledge and the habitat degradation that has occurred in the portion of the species' range that is now considered historical	**MFFP,** DFO

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	Approach: Research and Monitoring	(Yamaska and Noire rivers). Therefore, artificial spawning has been emphasized.	
Develop an index to assess the contribution of spawners to the breeding plan since the beginning of operations	**Optimize performance of the artificial reproduction plan.** Approach: Research and Monitoring	The contribution of each spawner, as well as experience with behaviour in captivity and gamete quality, are documented in MFFP field and laboratory notes, allowing artificial spawning efforts to be improved.	**MFFP**
Carry out genetic characterization analyses of spawners used in the breeding program and parental assignment analyses on all juveniles captured	**Optimize performance of the artificial reproduction plan.** Approach: Research and Monitoring	The genetic characterization of spawners, YOY (young-of-the-year), sub-adults and all the individuals captured during the various fieldwork campaigns conducted by MFFP is up to date and ongoing genetic analyses are being conducted on new specimens captured. In 2016 and 2017, 1,055 samples were analyzed from tissue samples obtained between 2004 and 2014 (Vachon, in prep. a) and other samples have been added since. The laboratory analyses have been completed on samples collected up to 2018. Some analyses will have to be rerun to ensure data quality and for matrix calibration purposes. The data will undergo statistical analyses for parental assignment purposes shortly, to include 2004 spawners (Vachon and Tessier, pers. comm., 2019).	**MFFP**
Develop and implement a sampling method for sub-adult Copper Redhorse	**Assess the status of the sub-adult component of the population and its habitat.**	In 2010 and 2011, attempts to capture sub-adults using different techniques were unsuccessful. In 2015, a Mini-Missouri type trawl was tested, again without success (Vachon and Garceau, in prep.). Efforts continued in 2016 with a purse seine and gillnets (Vachon, in prep. b); this work enabled sub-adults to be caught. Immature Copper Redhorse were also caught in the fishway in recent years during artificial spawning operations (Vachon, pers. comm., 2017).	**MFFP,** DFO

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	Approach: Research and Monitoring		
Identify, delineate, characterize and protect the habitat of sub-adult Copper Redhorse	**Assess the status of the sub-adult component of the population and its habitat.** Approach: Research and Monitoring	In the summer of 2015, efforts were made to locate sub-adults using a trawl in the Richelieu, Saint-François and Yamaska rivers and in a number of stretches of the St. Lawrence River between Sorel and the Lake of Two Mountains. No sub-adults were caught but the habitat was characterized (Vachon and Garceau, in prep.). In 2016, additional efforts were undertaken, using other types of gear, to target sub-adults and to characterize habitat in the St. Lawrence, Saint-François and Richelieu rivers; a few sub-adults were caught in the Richelieu River only (Vachon, pers. comm. 2017). In addition, the first Copper Redhorse less than 300 mm in length was caught in the St. Lawrence River RSI and a few other individuals were captured during MFFP surveys in the St. Lawrence River to monitor Asian carp (Vachon, pers. comm., 2017). A new project by MFFP involves obtaining specimens of age one and older for stocking, tagging and telemetry tracking, which will allow sub-adults to be tracked in the species' range.	**MFFP,** DFO
Increase surveillance, monitoring and enforcement activities in the Pierre-Étienne-Fortin Wildlife Preserve during spawning and incubation periods, particularly during peak pleasure boating periods	**Reinforce surveillance of key habitats.** Approach: Conservation	During patrols in the Chambly Basin, MFFP wildlife officers systematically check catches, bait and fishing licences. Officers also intervene when anglers and pleasure boaters are found in the wildlife preserve during a closed period. Tickets were issued and charges were laid if warranted. Since 2012, over 4,000 hours have been spent on surveillance in the preserve (Lemay, pers. comm., 2017). Measures were also taken throughout the Copper Redhorse's range to enforce the prohibition on catching or possessing suckers and redhorse by sport fishers.	**MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Improve boundary marking and the signposting of regulations for the Pierre-Étienne-Fortin Wildlife Preserve	**Reinforce surveillance of key habitats.** Approach: Conservation	MFFP installs and removes boundary marker buoys annually in the wildlife preserve (Chambly Basin). Boundary marking and the signposting of regulations will be modified and improved when the process to modify the boundaries in Chambly Basin, add two sectors and adopt new regulations specific to each sector has been completed.	**MFFP, COVABAR**
Identify target audiences	**Improve public awareness about the impact of human activities on Copper Redhorse conservation.** Approach: Outreach and education	The target audiences identified include the municipal and agricultural sectors, riparian owners, fishers, pleasure boaters and primary and secondary school students.	**Des Seigneuries ZIP Committee, Lac Saint-Pierre ZIP Committee, NCC, COVABAR, Éco-Nature**
Bring about lasting changes in behaviours through effective awareness campaigns on disturbance, trampling of spawning grounds, bycatch and pleasure boating	**Improve public awareness about the impact of human activities on Copper Redhorse conservation.** Approach: Outreach and education	Outreach is done during various events such as fishing festivals and children's programs (for example, Fête de la pêche and Pêche en herbe), fishing tournaments and hunting and fishing exhibitions, as well as under COVABAR's warden program. Pleasure boaters are given information and written materials. In the summer of 2018, Des Seigneuries ZIP Committee also had representatives present at public boat launches in the fluvial section of the St. Lawrence River to encourage users to adopt best practices for preserving aquatic grass beds. MFFP and NCC install buoys annually around Jeannotte Island and Île aux Cerfs to make pleasure boaters aware of the presence of aquatic grass beds that are critical as nursery areas.	**Des Seigneuries ZIP Committee, Lac Saint-Pierre ZIP Committee, NCC, COVABAR, Éco-Nature** AMQ, ECCC,

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		Des Seigneuries ZIP Committee also produced a guide for pleasure boaters on best navigation practices (Guide des bonnes pratiques à l'intention des plaisanciers), in collaboration with COVABAR, MFFP and Éco-Nature. Interpretation panels were designed and installed at public boat launches (Lavaltrie, Contrecœur, Rivière des Mille-Îles). The Association Maritime du Québec (AMQ) incorporated this best practices guide in its 2017 *Nautiguide.* In 2016, a study measuring boat wake erosion was conducted in the Richelieu River (JFSA 2017). The results could be used to inform pleasure boaters on measures to be taken to minimize the impact of their craft on aquatic habitats and shorelines. However, much outreach remains to be done in order to build and sustain behaviours that will facilitate Copper Redhorse conservation.	DFO, MFFP, PACC
Continue outreach in the Pierre-Étienne-Fortin Wildlife Preserve and the Jeannotte Island and Île aux Cerfs sector	**Improve public awareness about the impact of human activities on Copper Redhorse conservation.** Approach: Outreach and education	Outreach is conducted in the Pierre-Étienne-Fortin Wildlife Preserve and the Jeannotte Island and Île aux Cerfs sector every summer from mid-June to late August as part of COVABAR's warden program. These activities include information booths, distribution of an angler's logbook and brochures, and speaking with anglers and pleasure boaters on the shore and on the water. Information is provided on overall water quality, the introduction of invasive aquatic species, acts and regulations on species at risk (particularly the Copper Redhorse), distinguishing between redhorse/sucker species and carp species, as well as advice on the safe release of fish. In addition, MFFP and NCC install buoys around Jeannotte Island and Île aux Cerfs to encourage pleasure boaters to reduce their speed and to inform them of the presence of key aquatic grass beds and the presence of Copper Redhorse.	**COVABAR,** NCC, ECCC, Éco-Nature Emploi Québec, Canada Summer Jobs, MFFP, Des Seigneuries ZIP Committee

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
Improve public awareness of, and showcase, the Richelieu River ecosystem and the Vianney-Legendre fishway at the Saint-Ours Canal National Historic Site by building an interpretation centre and laboratories	**Improve public awareness about the impact of human activities on Copper Redhorse conservation.** Approach: Outreach and education	Parks Canada will not construct an interpretation centre or laboratories. Parks Canada has raised awareness and enhanced the ecosystem of the Richelieu River and the Vianney-Legendre fishway at Canal-de-Saint-Ours National Historic Site by: 1) redevelopment of the site to make it more visible and welcoming to visitors, and 2) holding awareness workshops. Also, the MFFP personnel who are present during artificial spawning in June provide information and distribute brochures to fishway visitors, whenever possible.	**MFFP,** **Parks Canada Agency,** DFO
Prioritize the buy-back of commercial gillnet and fyke net fishing licences in the fluvial section of the St. Lawrence River	**Lessen the impact of the commercial fishery and ichthyological inventories.** Approach: Conservation	In 2012, MFFP bought back all commercial fishing licences posing a risk of Copper Redhorse bycatch. The buy-back of commercial fyke net fishing licences in the Contrecœur area (frequented extensively by Copper Redhorse) and the relocation of the gillnets authorized in the commercial fishery in this area to another area in 2012 put an end to Copper Redhorse bycatch by the commercial fishery in this area. Since the 2013 to 2014 fishing plan was adopted, the Greater Redhorse has been taken off the list of authorized species in the commercial fishery in the following areas: Maskinongé and Nicolet rivers, St. Lawrence River, Lake Saint-Louis and Lake Saint-Pierre. This was done to better protect the Copper Redhorse, which can be easily mistaken for the Greater Redhorse.	**MFFP**
Continue the evaluation of the mortality of Copper Redhorse bycatch in commercial fisheries	**Lessen the impact of the commercial fishery and ichthyological inventories.**	Given the measures described above, evaluating Copper Redhorse mortalities resulting from the commercial fishery bycatch is no longer required.	**MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
	Approach: Conservation		
Reduce Copper Redhorse mortality during scientific research and surveys	**Lessen the impact of the commercial fishery and ichthyological inventories.** Approach: Conservation	When MFFP analyzes and approves applications for permits for scientific, educational or management purposes, prohibitions and restrictions are imposed when an applicant's activities take place in the Copper Redhorse's range. MFFP implements special measures during its own research and survey activities, such as limiting fishing time and prohibiting certain types of fishing gear in certain areas or during specific periods (Vachon, pers. comm., 2019). Similar mitigation measures are also included in SARA and SARA-compliant *Fisheries Act* authorizations issued by DFO.	**MFFP,** **DFO**
Provide adequate training for individuals working in Copper Redhorse habitat (for example, wildlife officers, commercial fishers and the employees of environmental consulting firms) so that they are able to correctly identify Copper Redhorse specimens	**Lessen the impact of the commercial fishery and ichthyological inventories.** Approach: Conservation	During the period covered in the report, MFFP offered nearly 20 training sessions for different stakeholders working in Copper Redhorse habitat, including wildlife officers and non-profit organizations (Massé, pers. comm., 2017).	**MFFP**
Modify sport fishing regulations in order to extend the prohibition on landing and	**Lessen the impact of sport fishing.** Approach: Conservation	The regulatory change was implemented and came into force in 2018.	**MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
possessing redhorse and suckers to the species' entire range, including Lake Saint-Pierre and its islands			
Continue to educate anglers on the need to release Copper Redhorse if caught	**Lessen the impact of sport fishing.** Approach: Conservation	Outreach is conducted as part of the warden program in the Pierre-Étienne-Fortin Wildlife Preserve, Jeannotte Island and Île aux Cerfs, during events such as fishing tournaments (including ice fishing tournaments) and through the distribution of pamphlets, the publication of articles on relevant fishing spots and the installation of signage on the shoreline of the Richelieu and St. Lawrence rivers and the Rivière des Mille-Îles.	**Des Seigneuries ZIP Committee, Lac Saint-Pierre ZIP Committee, COVABAR, Éco-Nature,** ECCC, Fédération québécoise des chasseurs et pêcheurs, MFFP
Carry out annual monitoring of recruitment of YOY redhorse in the Richelieu River	**Monitor the Copper Redhorse population in the Richelieu River.** Approach: Research and Monitoring	Recruitment monitoring was carried out regularly between 2012 and 2018, except in 2014 (due to budget cuts) and in 2015, when fishing was done later in the season and only at the most productive stations. However, the work in 2015 allowed natural spawning by the species to be confirmed. The percentage of Copper Redhorse less than 100 mm in length (young-of-the-year), which shows strong interannual variations, was found to range between 0% and 31%, depending on the year. During the same period (excluding 2015), YOY Copper Redhorse made up 11.9% (as an absolute value) of other YOY redhorse (Vachon,	**MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
		pers. comm., 2019). A series of reports on these activities are being prepared or reviewed (Vachon 2018; Vachon and Garceau, in prep.; Vachon, in prep., b, c, d, e).	
Carry out genetic characterization analyses of spawners and parental assignment analyses of all juvenile Copper Redhorse collected during sampling operations in the species' range	**Monitor the Copper Redhorse population in the Richelieu River.** Approach: Research and Monitoring	The genetic characterization of spawners, young-of-the-year, sub-adults and all individuals captured during MFFP's various fieldwork programs is up to date and genetic analyses are being carried out on an ongoing basis on new specimens obtained. In 2016 and 2017, 1,055 tissue samples were analyzed, taken from samples obtained between 2004 and 2014 (Vachon, in prep. a) and additional samples have been added since. Laboratory analyses of these samples for parental assignment purposes have been completed for the samples obtained up to 2018. Some analyses will have to be rerun to ensure data quality and for matrix calibration purposes. Statistical analyses on these data will be carried out shortly for parental assignment purposes (N. Vachon and N. Tessier, pers. comm., 2019). The results of parental assignment analyses will then be used to determine whether these fish are the result of artificial or natural reproduction.	**MFFP,** DFO
Assess the success of natural spawning in the Richelieu River through genetic characterization	**Monitor the Copper Redhorse population in the Richelieu River.** Approach: Research and Monitoring	A great deal of information has been compiled by MFFP on this subject (see above). This evaluation will be based on the results of upcoming statistical parental assignment analyses.	**MFFP**
Develop and implement a validated methodology for establishing the number of spawners based on the data	**Develop a method to determine number of spawners.** Approach:	The capture of spawners during the artificial spawning program and the examination of their history when they are recaptured has allowed the MFFP to deduce that the pool of spawners is relatively small. However, catches of young recruits are encouraging.	**MFFP**

Activity	Recovery strategy and approach	Description and outcomes	Participants[a]
collected during the implementation of the breeding plan	Research and Monitoring		
Verify presence of spawning indicators in various potential spawning grounds	**Identify and validate new spawning grounds.** Approach: Research and Monitoring	In 2015, a project was conducted to ascertain the presence of Copper Redhorse spawners in the Sainte-Anne and Vaudreuil rapids in the Ottawa River, during the likely spawning period for the species, between mid-June and mid-July. Even though the study sites had characteristics of the species' known spawning grounds, no individuals of the species were captured there (MPO 2016).	**DFO, MFFP**

[a] Lead participant(s) is/are listed on top and in bold; other participants are listed alphabetically. Not all activities have specific participants identified.

3.2 Activities supporting the identification of critical habitat

Table 5 provides information on the implementation of the studies outlined in the schedule of studies to identify critical habitat of the recovery strategy. Each study has been assigned one of four statuses:

1) completed: the study has been carried out and concluded
2) in progress: the planned study is underway and has not concluded
3) not started: the study has been planned but has yet to start
4) cancelled: the planned study will not be started or completed

Table 5 Status and details of the implementation of the schedule of studies outlined in the recovery strategy.

Study	Timeline	Status	Descriptions and Results	Participants
Identify the aquatic grass beds in Lake Saint-Pierre, Lake Saint-Louis and La Prairie Basin that have the characteristics of critical feeding habitat for adult Copper Redhorse	2016	Not started	No specific studies have dealt with the aquatic grass beds in Lake Saint-Pierre, Lake Saint-Louis and La Prairie Basin. However, MFFP's fish monitoring network (Réseau de suivi ichtyologique, or RSI) data could be used for this purpose.	N/A

3.3 Summary of progress towards recovery

3.3.1 Status of performance indicators

Table 6 provides a summary of the progress made toward meeting the performance indicators outlined in table 3. Each indicator has been assigned one of four statuses:

1) not met: the performance indicator has not been met, and little to no progress has been made
2) partially met, underway: moderate to significant progress has been made toward meeting one or more elements of the performance indicator, and further work is ongoing or planned
3) met: the performance indicator has been met and no further action is required
4) met, ongoing: the performance indicator has been met, but efforts will continue until the population is considered to be recovered (that is, the indicator will be reported against in the next five-year progress report)

Table 6 Description and details of the progress made toward meeting the performance indicators outlined in the recovery strategy.

Performance indicator	Status	Details
Increase in the number of adults inventoried at the Vianney-Legendre fishway during upstream migration	Not met	Owing to the species' longevity, the progress made towards increasing the number of adults in the fishway cannot be fully evaluated during the period covered by this report. The five-year period for meeting this indicator is insufficient because, despite the effectiveness of artificial spawning, individuals take approximately 10 years to reach sexual maturity. The operation of the fishway and Saint-Ours dam should be improved to better comply with the recommendations by Fournier and Desroches (2009). Major maintenance work was carried out on the fishway in 2019 (Vachon, pers. comm., 2019). In addition, in recent years, adverse hydrological conditions have occurred more frequently in both the Richelieu and St. Lawrence rivers, which has made it more difficult to capture spawners and has probably even affected their behaviour during upstream migration (Vachon, pers. comm., 2019).
Copper Redhorse represent 3% of all redhorse captured during sampling operations	Not met	Copper Redhorse do not represent 3% of all redhorse captured during sampling operations. Sampling operations do not specifically target the Copper Redhorse and the timing of these operations may be unfavourable to the capture of the species. These results can also be explained in part by the species' longevity and late sexual maturity, since a longer period is required to measure and evaluate the extent of the species' recovery.

Performance indicator	Status	Details
Juvenile Copper Redhorse represent 3% of all juvenile redhorse in the Richelieu River	Met, ongoing	The proportion of young-of-the-year (YOY) Copper Redhorse found in the Richelieu River relative to the YOY of the four other redhorse species has been highly variable in the last five years. This percentage is influenced by the success of artificial spawning activities each year, rearing success and stocking. Values were 4.9% in 2012, 31.3% in 2013, 0% in 2016, 22.3% in 2017 and 0% in 2018, with an overall average (absolute value) of 11.9%. However, naturally and artificially produced individuals cannot yet be distinguished (parental assignment analyses are forthcoming), except in the years when artificial spawning operations are not performed. In recent years, larger numbers of sub-adults have been found in the Richelieu River. This indicator as written cannot be measured using recruitment monitoring until artificial spawning activities have been completed, since the latter, which involve intercepting spawners at Saint-Ours, influences the results in relation to natural spawning.
Increase in the number and percentage of naturally spawned juveniles enumerated in the Richelieu River	Not met	In recent years, a higher number of sub-adults have been found in the Richelieu River. However, this indicator can only be evaluated when artificial spawning activities have been completed. In addition, upcoming parental assignment analyses, which will include 2004 spawners as well as tissue samples from sub-adults caught during this period, will provide a more complete picture, which will take account of a greater number of individuals from several cohorts at different stages of their life cycle (Vachon, pers. comm., 2019).
Maintain at least two spawning grounds used by the species	Met, ongoing	The species' two known spawning grounds, the Chambly Rapids archipelago and the downstream reach of Saint-Ours dam, are still being used by fish. Since two active spawning grounds is a minimum threshold, this indicator should also be included in the next progress report.
Increase in the number of individuals inventoried in Lake Saint-Louis, Lake Saint-Pierre, Rivière des Mille Îles and Rivière des Prairies	Not met	The number of individuals has not increased. However, the capture in 2015 of a juvenile Copper Redhorse less than 300 mm in total length was a first for the St. Lawrence River (Lake Saint-Pierre archipelago). There are reports of adults and a few sub-adults being caught elsewhere in the St. Lawrence River (for example, Contrecœur area) during sampling that does not specifically target the species (Vachon, pers. comm., 2019).

Performance indicator	Status	Details
Area (in km^2) of the Copper Redhorse's range maintained	Not met	The Noire River and Yamaska River were included as part of the species' range in the 2012 recovery strategy. However, the 2014 COSEWIC status report reassessed these areas as part of the species' historical extent of occurrence, and not part of their current range (COSEWIC 2014), resulting in a decline in the area of the official range of the species.

3.3.2 Completion of action plan

A multispecies action plan to improve water quality in the Richelieu River watershed in Canada, which seeks to respond, in part, to the recovery strategy for the Copper Redhorse, is currently in preparation. The objective of the plan is to improve water quality in the Richelieu River watershed to help in the recovery of the Copper Redhorse, as well as that of the Eastern Sand Darter (*Ammocrypta pellucida*) and the Hickorynut (*Obovaria olivaria*), a freshwater mussel. The actions proposed in the plan fall under the following four broad strategies to optimize the chances of these species' recovery:

1. Reduce water quality degradation associated with agricultural activities
2. Reduce water quality degradation associated with stormwater and wastewater management
3. Reduce shoreline and water quality degradation associated with domestic and recreational use
4. Acquire knowledge (for example, pilot projects to reduce nutrients and pesticides from agricultural activities, projects on the effects of contaminants and boat wake) and follow up on implementation and the results obtained

3.3.3 Critical habitat identification and protection

The identification of critical habitat is an iterative process that requires ongoing monitoring of populations and habitat, in order to make the appropriate updates in response to the species' recovery over time. The critical habitat has been partially identified in the recovery strategy. A study was conducted to verify the presence of the Copper Redhorse at other potential spawning grounds, but no individuals were captured. However, this does not preclude the possibility that, with an increase in the population, spawning grounds other than those in the Richelieu River will be used. Additional studies are required to refine the location of adult feeding areas in aquatic grass beds in Lake Saint-Pierre, Lake Saint-Louis and La Prairie Basin.

3.3.4 Recovery feasibility

The recovery of the Copper Redhorse is considered feasible because it meets the four criteria for technical and biological feasibility. The four criteria are:

1. Individuals in the natural environment are capable of reproduction.
Though natural reproduction in the species is limited, a number of mature individuals are regularly observed on the species' spawning grounds in the Richelieu River (particularly the Saint-Ours site). Furthermore, the remnant 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 a number of aquatic grass beds have been degraded, the protection of available habitats, together with shoreline restoration and other measures to improve water quality, will increase the area of available habitats for the Copper Redhorse and consequently improve its chances of recovery.

3. Threats to the species and its habitat can be avoided or mitigated.
A number of conservation and outreach measures have already been implemented, and many other projects can be undertaken to mitigate the threats facing this species. Agricultural

practices can be modified to reduce fertilizer and pesticide inputs, soil erosion and sedimentation. Wastewater treatment can be improved to reduce the release of contaminants into the natural environment. Critical Copper Redhorse habitats can be protected from disturbance caused by pleasure boaters and fishers.

4. The techniques necessary for the recovery of the species are available.
An artificial spawning plan was developed and has been in place since 2004. The Baldwin-Coaticook hatchery is responsible for the incubation of eggs and pond rearing of Copper Redhorse. Stocking of larvae and autumn fry was carried out in the Richelieu River between 2012 and 2014 inclusively, as well as in 2017 and 2018, in order to increase annual recruitment rates and to try to rebuild the aging spawner stock. During this period, roughly 760,000 larvae, 99,000 fry and 111 age one and older Copper Redhorse (found in the ponds the following season) were released into the Richelieu River. In addition, since 2012, research has been carried out on milt cryopreservation techniques, allowing frozen sperm to be used in spawning; roughly 5,000 young Copper Redhorse produced using this technique have been stocked. This work has also resulted in the creation of a sperm bank, maximizing the number of families produced (Vachon et al. 2013; Vachon 2018; Vachon et al., in prep.; Vachon and Sirois, in prep.; Vachon in prep. a and c). Other techniques, such as the annual monitoring of juvenile abundance and the genetic characterization of spawners and fry, enable the population to be systematically monitored and the achievement of population objectives to be evaluated.

4. Concluding statement

During the period 2012 to 2018, progress was made towards the species' recovery.

Artificial spawning has been successful, allowing roughly 760,000 larvae and 99,000 autumn fry (young-of-the-year) of the species to be stocked in the Richelieu River between 2012 and 2018. The development of milt cryopreservation techniques has already maximized the number of families produced, compensating for a limited number of males in certain years and providing a sperm bank for the coming years.

Considerable efforts have also been invested in outreach to various target audiences. Topics addressed have included the importance of vegetated shorelines in reducing the contaminant load in watercourses, precautions to be taken to avoid spreading invasive species, behaviours to be adopted in pleasure boating and fishing, water quality in general and actions that can be taken to modify farming practices to reduce various contaminants at the source.

Although the bacteriological and physicochemical water quality index seems to have improved at several stations, data on the presence of pesticides in two tributaries of the Richelieu River don't show the same trend. To date, with the exception of nonylphenols and ethoxylated nonylphenols, endocrine disruptors are not subject to any regulations. The modernization of the *Pesticides Act*, the coming into force of the *Regulation Respecting Municipal Wastewater Treatment Works,* and the issuing of depollution attestations could prove to be beneficial. The combined effects of pesticides and wastewater discharges are unknown and exposure to pharmaceuticals and personal care products could also be harmful.

The 2014 COSEWIC assessment and status report indicated a decline in the Copper Redhorse population, although the extent of the decline could not be estimated, and described the population as aging. However, implementation of measures in the recovery strategy is producing encouraging results regarding the Copper Redhorse population status.

Although it is a long process, efforts are underway to expand the Pierre-Étienne-Fortin Wildlife Preserve, and new areas could be added in the next few years. Lastly, research and monitoring activities continue to advance our knowledge of the species and the factors that might slow or hinder its recovery.

DFO remains committed to continuing the efforts towards the recovery of the Copper Redhorse. The progress made to date would not have been possible without the contribution of our partners. DFO is looking forward continuing this successful collaboration and welcomes the participation of additional partners.

5. References

Bibeau, S. pers. comm. Telephone conversation with E. Lapalme. September 2017. Executive Director, Jacques-Cartier ZIP Committee. Montreal, Quebec.

International Joint Commission. 2014. Lake Ontario St. Lawrence River Plan 2014: Protecting against extreme water levels, restoring wetlands and preparing for climate change [Proposed]. A Report to the Governments of Canada and the United States by the International Joint Commission. X + 86 p.

COSEWIC. 2004. COSEWIC assessment and update status report on the copper redhorse *Moxostoma hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, vii + 38 p.

COSEWIC. 2014. 2014. COSEWIC assessment and status report on the Copper Redhorse *Moxostoma hubbsi* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiii + 80 pp.

COVABAR. 2011. Caractérisation du bassin versant des Hurons Nord. 72 p. + 2 appendices.

COVABAR. 2013. Rapport de caractérisation du bassin versant de la rivière L'Acadie : secteur Massé. 61 p.

COVABAR. 2016. Rapport de caractérisation du bassin versant de la rivière L'Acadie : secteur Acadie-Centre. 52 p. + 3 appendices.

DFO, 2007. Recovery Potential Assessment of Copper Redhorse (*Moxostoma hubbsi*). Canadian Science Advisory Secretariat, Science Advisory Report 2007/043

DFO. 2012. Recovery strategy for the Copper Redhorse (*Moxostoma hubbsi*) in Canada, *Species at Risk Act* Recovery strategy Series. Fisheries and Oceans Canada, Ottawa, xi + 60 pp.

DFO. 2016. Inventaire du chevalier cuivré dans le lac Saint-Louis. Fisheries and Oceans Canada, Englobe. vi + 25 p. + 6 appendices.

Drouin, É. pers. comm. 2017. Email message to E. Lapalme. September 2017. Biologist, Ministère des Forêts, de la Faune et des Parcs, Government of Quebec, Longueuil, Quebec.

Fleury, C. pers. comm. Telephone conversation with E. Lapalme. August 2017. Scientific advisor, Ville de Montréal, Montreal, Quebec.

Fournier, A. et D. Desrochers. 2009. Manuel d'opération et d'entretien des passes à poissons au lieu historique national du Canal-de-Saint-Ours, final report prepared for Parks Canada Agency by Milieu inc., 116 p.

Giroux, I. 2015. Présence de pesticides dans l'eau au Québec : Portrait et tendances dans les zones de maïs et de soya – 2011 à 2014, Québec, Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, Direction du suivi de l'état de l'environnement, ISBN .978-2-550-73603-5, 47 p. + 5 appendices. [online] http://www.MELCC.gouv.qc.ca/eau/flrivlac/pesticides.htm.

Grondin, P. 2016a. La reproduction artificielle des salmonidés indigènes, Québec, Ministère des Forêts, de la Faune et des Parcs, Direction générale de l'expertise sur la faune et ses habitats, Direction de la faune aquatique. Technical report. 56 p.

Grondin, P. 2016 b. L'insémination différée et les dilueurs pour salmonidés. Ministère des Forêts, de la Faune et des Parcs, Direction générale de l'expertise sur la faune et ses habitats, Direction de la faune aquatique. Technical report. 26 p.

Hatry, C., J. D. Thiem, D. Hatin, P. Dumont, K. E. Smokorowski and S. J. Cooke. 2016. Fishway approach behaviour and passage of three redhorse species (*Moxostoma anisurum, M. Carinatum, and M. Macrolepidotum*) in the Richelieu River, Quebec. Environmental Biology of Fishes 99(2):249–263.

JFSA. 2017. Impact du batillage sur la mise en suspension des sédiments. Rivière Richelieu, Qc. Prepared for: Division de la gestion des espèces en péril. Division régionale de la gestion des écosystèmes. 40 p. + appendices.

Le Floch, A. pers. comm. 2017. Telephone conversation with E. Lapalme. August 2017. Scientific advisor, Ville de Montréal, Montreal, Quebec.

Lemay, Lt. C. pers. comm. 2017. Telephone conversation with E. Lapalme. September 2017. Chef de service à la direction de la protection de la faune. Ministère des Forêts, de la Faune et des Parcs, Gouvernement du Québec, Saint-Jean-sur-Richelieu, Quebec.

Maltais, D. pers. comm. 2017. Email messages to E. Lapalme. August 2017. Aquatic Science Biologist, Fisheries and Oceans Canada, Government of Canada, Mont-Joli, Quebec.

Marchand, H. pers. comm. 2019. Email messages to N. Vachon. October 2019. Doctoral student at McGill University, Montreal, Quebec.

Massé, H. pers. comm. 2017. Email messages to V. Coutu. September 2017. Wildlife technician, Ministère des Forêts, de la Faune et des Parcs, Government of Quebec, Longueuil, Quebec.

MDDELCC. 2014. Attestation d'assainissement municipales — Orientations pour la délivrance de la première attestation d'assainissement, Québec, Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, Direction générale des politiques de l'eau. iii + 20 p.

MDDELCC, 2017. Banque de données sur la qualité aquatique (BQMA), Quebec City, Direction générales du suivi de l'état de l'environnement.

MFFP. 2015. Lignes directrices pour la conservation des habitats fauniques. Ministère des forêts, de la faune et des parcs. Direction générale de la valorisation du patrimoine naturel. 4th edition. iii + 41 p.

Piché, I. pers. comm. 2017. Telephone conversations with E. Lapalme. September 2017. Biologist, Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques, Government of Quebec, Longueuil, Quebec.

Tessier, N. pers. comm. 2019. Discussions with N. Vachon. October 2019. Biologist, Ministère des Forêts, de la Faune et des Parcs, Government of Quebec, Longueuil, Quebec.

Thiem, J. D., T. R. Binder, P. Dumont, D. Hatin, C. Hatry, C. Katopodis, K. M. Stamplecoskie and S. J. Cooke. 2013. Multispecies Fish Passage Behaviour in a Vertical Slot Fishway on the Richelieu River, Quebec, Canada. River Research and Applications 29:582–592.

Vachon, N. 2010. Reproduction artificielle, ensemencements et suivi du recrutement du chevalier cuivré en 2009, Ministère des Ressources naturelles et de la Faune, Unité de gestion des ressources naturelles et de la faune de Montréal-Montérégie, Longueuil, Technical report 16-44, vii + 28 p. + 5 appendices.

Vachon, N., S. Velásquez, P. Grondin and H. Massé. 2013. Premiers essais de cryopréservation de la laitance du chevalier cuivré *(Moxostoma hubbsi)*. Talk given at Atelier sur la faune aquatique [aquatic wildlife workshop], Quebec City, February 19–21, 2013.

Vachon, N. 2018. Reproduction artificielle, suivi du recrutement et premiers essais de cryopréservation de la laitance du chevalier cuivré (*Moxostoma hubbsi*) en 2012. Technical report 16-52, 33 p.

Vachon, N. and C. Sirois. in prep. Reproduction artificielle, ensemencements et suivi de la population de chevalier cuivré (*Moxostoma hubbsi*) en 2014. Ministère des Forêts, de la Faune et des Parcs. Direction de la gestion de la faune de l'Estrie, de Montréal, de la Montérégie et de Laval. Technical report 16-54.

Vachon, N. in prep. a. Le rétablissement du chevalier cuivré (*Moxostoma hubbsi*) par le soutien à la population par la reproduction artificielle de 2004 à 2014 : méthodes, suivis, bilan et perspectives.

Vachon, N. in prep. b. Recherche de sub-adultes et suivi du recrutement du chevalier cuivré en 2016.

Vachon, N. in prep. c. Reproduction artificielle, ensemencements et suivi de la population du chevalier cuivré (*Moxostoma hubbsi*) en 2013.

Vachon, N. in prep. d. Reproduction artificielle, ensemencements et suivi de la population du chevalier cuivré (*Moxostoma hubbsi*) en 2017.

Vachon, N. in prep. e. Reproduction artificielle, ensemencements et suivi de la population du chevalier cuivré (*Moxostoma hubbsi*) en 2018.

Vachon, N. and S. Garceau. in prep. Recherche de sub-adultes de chevalier cuivré en 2015.

Vachon, N., S. Velásquez-Medina and P. Grondin. in prep. Motilité des spermatozoïdes du chevalier cuivré dans les différents traitements de cryopréservation en 2013.

Vachon, N. pers. comm. 2017. Telephone conversations with E. Lapalme. August and September 2017. Biologist, Ministère des Forêts, de la Faune et des Parcs, Government of Quebec, Longueuil, Quebec.

Appendix 1 — List of abbreviations

AAFC	Agriculture and Agri-Food Canada
AMQ	Association Maritime du Québec
BQMA	Banque de données sur la qualité du milieu aquatique [databank on quality of the aquatic environment]
CARA	Corporation d'aménagement de la rivière l'Assomption
AEAC	Agri-environmental advisory club
IJC	International Joint Commission
MMC	Montreal Metropolitan Community
NCC	Nature Conservancy of Canada
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COVABAR	Comité de concertation et de valorisation du bassin de la rivière Richelieu
CRECQ	Conseil régional de l'environnement du Centre-du-Québec
ECCC	Environment and Climate Change Canada
NWCF	National Wetland Conservation Fund
FédéCP	Fédération québécoise des chasseurs et pêcheurs
FFQ	Fondation de la faune du Québec
IRF	Interdepartmental Recovery Fund
MLI	Maurice Lamontagne Institute
IQBP	Indice de qualité bactériologique et physico-chimique de l'eau [index of bacteriological and physicochemical water quality]
ARCDW	Act Respecting the Conservation and Development of Wildlife
EQA	Environment Quality Act
MAPAQ	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec
MELCC	Ministère de l'Environnement et de la Lutte contre les changements climatiques
MFFP	Ministère des Forêts, de la Faune et des Parcs
DFO	Fisheries and Oceans Canada
MRNF	Ministère des Ressources naturelles et de la Faune
MTQ	Ministère des Transports du Québec
WO	Watershed organization
OMAE	Ouvrage municipal d'assainissement des eaux [municipal wastewater treatment plant]
FFHPP	Fish and Fish Habitat Protection Program
PPLRLZF	Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains
ROBVQ	Regroupement des organismes de bassins versants du Québec [Quebec association of watershed organizations]
RSI	Réseau de suivi ichtyologique [fish monitoring network]
LUDP	Land use and development plan
SEG permit	Permit for capturing wild animals for scientific, educational or management purposes

SPQA	Stratégie phytosanitaire québécoise en agriculture [Quebec's crop health strategy]
UPA	Union des producteurs agricoles

Appendix 2 — Copper Redhorse Recovery Team

Members of the Copper Redhorse Recovery Team:

Stéfanos Bitzakidis	Ministère de l'Environnement et de la Lutte contre les Changements climatiques
Marie-Pierre Veilleux	Fisheries and Oceans Canada
Anaïs Boutin	Parc de la Rivière-des-Mille-Iles
Marcel Comiré	Comité de concertation et de valorisation du bassin de la rivière Richelieu
Louise Corriveau	Lake Saint-Pierre ZIP Committee
Chantal Côté	Ministère des Forêts, de la Faune et des Parcs
Marc-Antoine Couillard	Ministère des Forêts, de la Faune et des Parcs
Chantale Girard	Lake Saint-Pierre ZIP Committee
Caroline Riopel-Leduc	Ministère des Forêts, de la Faune et des Parcs
François Laprise	Protection de la faune
Cesar Largaespada	Union des producteurs agricoles
Sophie Lemire	Des Seigneuries ZIP Committee
Carl Patenaude-Levasseur	Ministère des Forêts, de la Faune et des Parcs
Julien Poisson	Nature Conservancy of Canada
Nathalie Le François	Montreal Biodôme
Nathalie Vachon	Ministère des Forêts, de la Faune et des Parcs