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RECOVERY POTENTIAL ASSESSMENT REPORT OF COPPER REDHORSE (*Moxostoma hubbsi*)

Source: Louis Bernatchez. Les poissons d'eau douce du Québec et leur répartition dans l'est du Canada © 2000

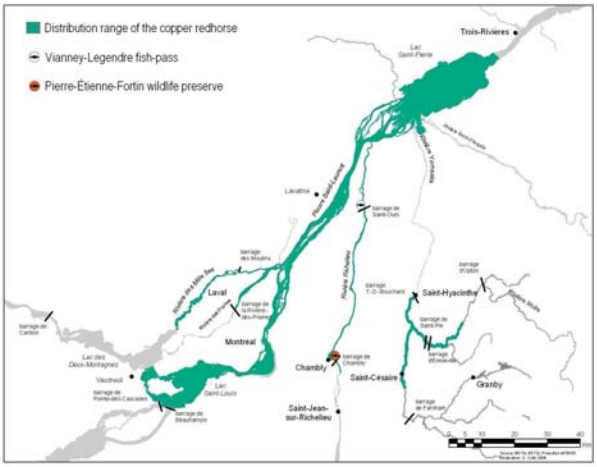

Figure 1: Distribution range of copper redhorse in Quebec. Map produced by the ministère des Ressources naturelles et de la Faune du Québec.

Context

The copper redhorse was designated threatened in 1987 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The COSEWIC revised this status in 2004 and the species was designated as endangered. When a species becomes a candidate for being added to the list under the Species at Risk Act (SARA), the Department of Fisheries and Oceans (DFO) must carry out a number of activities in order to protect it. This document presents the recovery potential assessment (RPA) of copper redhorse. It includes relevant science information to help guide the process of deciding whether to add the species to Schedule 1 of the SARA, to develop a recovery strategy and action plan.

Copper redhorse are only present in Canada in a few rivers in southwest Quebec. The species' designation as endangered is based on the current status of the population and its development over the last 40 years. The species' abundance has considerably diminished and its distribution range has decreased over the years due to a certain number of anthropogenic factors (e.g. urban expansion, agriculture and the construction of dams) which have affected water quality and deteriorated and fragmented the available habitat.

SUMMARY

- The copper redhorse was designated in 1987 by the COSEWIC. The COSEWIC revised this status in 2004 and the species was designated as endangered. In 1999, the copper redhorse was designated threatened under the Quebec *Act respecting threatened or vulnerable species*. It is the first vertebrate species to receive this most critical designation under this Quebec Act.

- Historically, the copper redhorse is only found in Canada and more specifically in the southwest part of Quebec. Its distribution has been declining for at least forty years. Currently, it can only be found in the St. Lawrence River between Lake Saint-Louis and Lake Saint-Pierre as well as in the Richelieu, Mille-Îles and des Prairies rivers. Its occurrence is now uncertain and probably very unlikely in the Yamaska and Noire rivers. Genetic analysis and telemetric monitoring of 20 adults indicate that the species now only forms one single population.

- Copper redhorse population abundance is considered very low and it is decreasing. The population is aging, recruitment is very low and they have difficulty reproducing in natural settings. The very rare nature of the species and the low recapture levels make copper redhorse population modeling impossible.

- Three objectives have been identified that can change the trajectory of the population and improve its situation in the medium term. The two first recovery objectives target recruitment increases of young individuals produced naturally and of the number of spawners. Ratios of 3% are expected for these two targets, compared with the entire redhorse population, all species confounded. Finally, the third objective targets the production of 4,000 copper redhorse spawners in order to maintain genetic diversity.

- The timeframe for reaching these objectives is 20 years due to the species' longevity.

- Since 1995, three 5-year intervention plans (1995, 1999, 2004) were developed and implemented. These plans propose strategies and actions to accelerate copper redhorse recovery. At the same time, these intervention plans increased basic knowledge on the species' biology and its limiting factors, such as the characterization and delineation of its habitats. Significant effort was also extended in order to raise public awareness and implement legal measures to protect the species.

- Although the copper redhorse critical habitat has yet to receive a specific and accepted definition, certain habitats have been defined as being strategic for the species' survival. These habitats include the only two known spawning grounds; the Chambly rapids and the area downstream from the Saint-Ours dam and the only identified rearing ground to this date which includes the Jeanotte and aux Cerfs islands at Saint-Marc-sur-Richelieu. The grass beds along the shore throughout the Richelieu River were identified as important feeding grounds for juveniles and adults during migration.

- Habitat degradation and fragmentation mostly caused by human activities appear to be the main threats on the species. Agricultural activities, urban expansion, the presence of dams and recreational activities (swimming, jet-skiing, kayaking, fishing, etc) that occur in certain

strategic copper redhorse habitats appear to be the principal causes for the species' decline and failure to recover.

INTRODUCTION

Rationale for Assessment

The *Species at Risk Act* (SARA) provides legal protection to species listed in Schedule 1 of this act. If the copper redhorse population was added to this list as an endangered species, it would be protected by the restrictions provided by the SARA. Listing the species could lead to a ban of activities that would harm individuals and their critical habitats. However, section 73 of the SARA authorizes competent ministers, the DFO in this case, to come to an agreement with a person or issue a permit which authorizes an activity affecting a listed wildlife species, any part of its critical habitat, or the residences of its individuals. Finally, listing the copper redhorse will require the development of a recovery plan, which would represent an extension to the three intervention plans mentioned earlier.

Under section 73(2) of the SARA, agreements can be reached and permits issued only if the minister agrees that it is one of the following activities:

a) the activity is scientific research relating to the conservation of the species and conducted by qualified persons;
b) the activity benefits the species or is required to enhance its chance of survival in the wild;
c) affecting the species is incidental to the carrying out of the activity.

Under section 73(3), the competent minister does not finalize an agreement or issue a permit unless he is of the opinion that:

a) all reasonable alternatives to the activity that would reduce the impact on the species have been considered and the best solution has been adopted;
b) all feasible measures will be taken to minimize the impact of the activity on the species or its critical habitat or the residences of its individuals;
c) the activity will not jeopardize the survival or recovery of the species.

Decisions made on permitting of incidental harm and in support of recovery planning need to account for the impact of human activities on the species, alternatives and mitigation measures to these activities, and the potential for recovery. An evaluation framework, consisting of three phases (species status, scope for human–induced harm and mitigation) has been established by DFO to allow determination of whether or not SARA incidental harm permits can be issued. The analysis provided here will also support decisions relating to the addition of the copper redhorse to the List of Species at Risk and its recovery planning. In the context of this report, "harm" refers to all prohibitions as defined in SARA.

Species Biology

The copper redhorse is a large-scaled fish of the genus *Moxostoma*, a group of relatively large fish, with an inferior, protrusible mouth, lips with plicae and a pharyngeal apparatus with teeth arranged in an arch around the opening of the oesophagus. The copper redhorse feeds almost exclusively on molluscs. The crushing of shells is made possible by its pharyngeal apparatus equipped with teeth that resemble molars. The copper redhorse is the only Canadian species with such a highly developed pharyngeal apparatus, which represents an evolutionary summit.

Compared to the other species with which it occurs in sympatry, the copper redhorse has the longest lifespan (over 30 years). It is also the most fecund species and reaches the largest size (more than 700 mm). In addition, the copper redhorse reaches sexual maturity at a later age; 10 years old. Compared to its congeners, the copper redhorse spawns later, from late June to early July when water temperature varies between 18 and 26 ºC.

The copper redhorse is the only fish species whose geographic range only includes Canada, and more specifically Quebec. All specimens have been found in the St. Lawrence plain. Its historical distribution includes the mouth of the Maskinongé River, Mille-Îles River, the segment downstream from the des Prairies and Richelieu rivers, a median reach of the Yamaska and Noire rivers, as well as a reach of the St. Lawrence River, from Lake Saint-Louis to Lake Saint-Pierre (Figure 1). Genetic characterization of the copper redhorse indicate the existence of only one single population, which does not yet show any loss of genetic diversity.

ASSESSMENT

Current Situation of the Species and Trajectory

Although copper redhorse population abundance is difficult to estimate, it is considered very weak and consistently decreasing. During the 1990s, several individuals were tagged in the Richelieu River but even with all the effort, none of them were recaptured, which makes it impossible with this method to estimate the population size in this river. As for the individuals in the Lavaltrie-Contrecoeur river area in the fall of 2000, the adult population totalled between 150 and 563 individuals, based on the method used and target period. The maximum and minimum estimates calculated while accounting for the 95% confidence interval were 46 and 1,647 individuals. This estimate is broad and based on a few recaptures made by a commercial fisherman in the fall of 2000. The species' trajectory is decreasing in terms of its known natural population.

Catch analyses indicate that the population is aging and is experiencing difficulty reproducing in natural settings. Since the species' discovery in 1942, size comparisons of copper redhorse caught in the St. Lawrence and Richelieu rivers over the years clearly show that size distribution has been moving towards higher values. Over the last 30 years, there have been almost no catches made of juveniles over the age of 2. The very low recruitment is likely insufficient to balance natural mortality. In order to compensate for this and rebuild the population's spawning stock, the ministère des Ressources naturelles et de la Faune du Québec (MRNF) began annual fish stocking activities in 2004, based on a reproductive plan aimed at preserving the current genetic diversity. It will likely take at least one generation before the effects are noticed.

The relative historical abundance of copper redhorse compared to other redhorse species was estimated by examining archaeological remains and inventories conducted in the 1960s. The species represented 16.7% of all redhorses at the pre-Columbian site of Mandeville, on the west coast of the Richelieu River and 9.1% of all redhorses at Place Royale in Montreal in the 19th century. More recently, the abundance of copper redhorse was estimated at between 2 and 3% compared to its congeners, in ichtyological inventories conducted in the Montreal area between 1963 and 1985. This proportion dropped to 0.04% during the monitoring of the Vianney-Legendre fish-pass in 2003. The relative abundance of young copper redhorse of the year compared to other redhorses in the Jeannotte and Aux Cerfs islands was below or equal to 0.35% in 1998, 1999 and 2001. In 1997, intense fisheries covering a larger portion of the Richelieu River showed a relative abundance of copper redhorse of the year of 0.63%.

Since 1998, 40 stations have been regularly sampled by the MRNF in the Richelieu in the area of Saint-Marc-sur-Richelieu in order to find young of the year and monitor the redhorse's recruitment level. This sampling was used as a performance index for conservation and support measures for the copper redhorse population. A young copper redhorse born naturally in the wild was found in 1998, 1999 and 2001, but none were found in 2003. Twenty-one copper redhorse were found in 2004 and 62 in 2006. The increase in the number of catches in recent years can be explained in part by the introduction of the juvenile fish-stocking program in 2004. Genetic analyses that were carried out in 2006 are very encouraging as they confirm the capture of young redhorses of the year stemming from artificial spawning, the capture of four young of the year spawned naturally and the capture of a one-year-old copper redhorse that had been seeded in 2005.

The copper redhorse's distribution shows a downward trajectory. The current distribution range includes the St. Lawrence, from Lake Saint-Louis to Lake Saint-Pierre along with the Richelieu, Yamaska, Noire, des Prairies and Mille-Îles rivers. Its occurrence in the Yamaska and Noire rivers, where the species was identified in the 1960s, is now uncertain and probably very unlikely. The last captures occurred in 1992 and 1995 respectively and the aquatic habitats in these rivers, which were already highly fragmented by a number of dams, have significantly decayed. The development of an intense agriculture appears to be the cause. In the 1970s, the copper redhorse was only identified once in the mouth of the Maskinongé River, a tributary of Lake Saint-Pierre.

Recovery Targets and Schedules

Three objectives aimed at changing the species' trajectory and improving the situation in the medium term have been identified:

1. Increase natural recruitment of copper redhorses in the Richelieu River during the fall catches to a ratio of 3+% for all young redhorses, all species combined.

2. Obtain a spawner ratio of at least 3% compared to all redhorses, all species combined.

3. Obtain at least 4,000 spawners for the entire copper redhorse population.

The 3% value for targets 1 and 2 has been defined based on historical scientific catch data from 1963 to 1970. The number of spawners from target 3 represents the minimum value to be reached in order to maintain genetic diversity in the copper redhorse population.

The minimum scheduled delay for these three objectives is 20 years, which is the equivalent of two copper redhorse generations. The species has a very long lifespan, around 30 years, and it spawns for the first time around 10 years of age. The capacity to monitor the species' progress towards reaching the objectives is limited. There has been regular monitoring (annual or biennial) of the abundance of young of the year since 1998 in a pilot reach of the Richelieu River, in the area of Saint-Marc-sur-Richelieu, in order to monitor the progress in terms of recruitment and to attempt to assess the effectiveness of the restoration measures applied or to be applied in the future. The first signs of success in the older segment of the population should be noticeable beginning in 2014, at the Vianney-Legendre fish-pass when the first spawners will be observed. These individuals should be 10 years of age by then and measure around 550 mm. The spawners recently caught were all 20 years and older.

Special Considerations in terms of Recovery Potential

Since 1995, three five-year intervention plans (1995, 1999, 2004) were developed and implement by the MRNF. These plans suggest strategies and actions in order to speed the recovery of copper redhorse. Among the actions that were taken, there was the introduction of the Pierre-Étienne-Fortin wildlife preserve in 2002 for protecting the most significant of the two spawning grounds at Chambly, the construction of the Vianney-Legendre fish-pass on the Richelieu River in 2001 in order to re-introduce access to this spawning ground, as well as the implementation in 2004 of an artificial breeding plan. The breeding plan's objectives are aimed at rebuilding the spawner stock within 10-15 years and maintaining the initial genetic diversity over the next century at a threshold above 90%.

At the same time, these intervention plans provided basic knowledge on the species' biology and limiting factors, such as characterizing and delineating its habitats. Significant effort was also given to raise public awareness and implement legal protection measures for the species.

Description of the Critical Habitat

The critical habitat is the habitat that is essential for a listed wildlife species' survival or recovery, which has been designated as such in a recovery strategy or an action plan developed for the species. For the moment, there is no precise and accepted definition of the copper redhorse critical habitat according to the SARA. However, the research that has been carried out has identified different strategic habitats for the survival of the copper redhorse. The protection and identification of the spawning grounds is a priority for its recovery. Currently, there are only two known copper redhorse spawning grounds, the Chambly rapids and the area downstream from the Saint-Ours dam. The Pierre-Étienne-Fortin preserve was created in order to protect the spawning grounds in the Chambly rapids which were popular for recreational boaters and vacationers during the copper redhorse spawning period. Based on certain more recent observations, the preserve's limits will have to be adjusted to include an area downstream from the preserve used as a resting place for spawners waiting to spawn. The Saint-Ours dam spawning grounds does not benefit from any special protection for the moment. No impending threat to copper redhorse reproduction has been identified in this location. Other potential spawning grounds have been identified, such as the Grand Moulin and Terrebonne rapids in the Mille-Îles River, the Dorion and Sainte-Anne-de-Bellevue channels at the head of Lake Saint-Louis, the Lachine rapids, the lower reach of the Des Prairies hydroelectric station and Hervieux Island near Lavaltrie. However, the occurrence of spawning activities at these sites has never clearly been demonstrated.

Protecting rearing grounds is also a significant element for the species' recovery. The only rearing ground that has been identified for all redhorse species is an area in the Richelieu River (Saint-Marc-sur-Richelieu) which includes the Jeannotte and Aux Cerfs islands. The young redhorses of the year, including copper redhorses that occupy this section of the Richelieu River during their first life season and at least at the beginning of their second year, all come from the Chambly spawning ground. In addition, the grass beds along the shore throughout the Richelieu River have also been identified as areas to be protected because of their significance in terms of feeding juvenile copper redhorse. They represent a significant habitat for migrating juveniles and adults.

Knowledge of adult copper redhorse habitat is important but is still incomplete. Twenty adults were monitored telemetrically during the summer and fall of 2004. This provided a way of identifying certain areas frequented by the adult population and defining the characteristics of the species' summer habitat and identifying the basic outline of its migratory behaviour. This monitoring demonstrated that adults visit the grass beds to feed, and more precisely those located in the part of the river around Longueuil and the Lake Saint-Pierre archipelago. The Mille-Îles and Des Prairies river grass beds are also visited by the copper redhorse and should also be considered as strategic habitats used by this species. These habitats, which are considered strategic in terms of the species' survival, were mapped for the copper redhorse's entire range in the St. Lawrence River, between Lake Saint-Louis and Lake Saint-Pierre for the summer period. These maps, which identifies the known habitats as well as the pressures on these habitats, is presented as an Atlas for copper redhorse habitats produced by the Comité Zone d'intervention prioritaire des Seigneuries in collaboration with the MRNF.

However, our knowledge on spring, fall and winter habitats are incomplete and patchy in certain cases. Some research is being conducted to improve our knowledge on the characteristics and location of these habitats.

Free passage for copper redhorse between the different habitats should be maintained when present and improved in other situations in order to ensure its recovery.

Threats to the Species

The water ways that are used by the copper redhorse are located in the most densely populated areas of Quebec. Several human based activities are endangering the species. The factors responsible for constricting copper redhorse habitats and for lowering their abundance cannot be identified with certainty. The species is without a doubt a victim of a combination of factors (Table 1).

Table 1. Summary table of copper redhorse threats

Threats	Range	Frequency
Silting, turbidity and sedimentation (juveniles and adults)	High	High
Agricultural pollution (Richelieu and Yamaska)	High	High
Agricultural pollution (St. Lawrence)	Moderate	Low
Urban and industrial pollution (St. Lawrence and Richelieu)	High	High
Degradation of riparian environment	High	High
Degradation of grass beds along the shore	High	High
Urban development (loss of habitats, exsiccation, change in moisture balance) (Richelieu)	High	High
Dredging (St. Lawrence)	TBC	Moderate
Existing dams (threat to the recovery but not mortality)	High	High
Building dams (threat to the recovery but not mortality)	High	High
Disturbance at the Pierre-Étienne-Fortin preserve (spawner and incubation)	High	High
Managing water levels (St. Lawrence)	Low	Low
Wave action from boats (St. Lawrence)	High	High
Wave action from boats (Richelieu) (Juveniles, increase in turbidity, erosion, noise disturbance)	Moderate	High
Loss of genetic diversity	Low	High
Exotic or introduced species	Low	High
Bait-fish fishery (Fall)	Low	Low
Bait-fish fishery (Spring and summer)	Unknown	Unknown
Commercial fishery	Low	Moderate
Sport fishing	Low	Low

Range: Based on the known and sampled habitat range
Frequency: Indicates whether the threat has a low occurrence level (sometimes a threat), moderate (often a threat) or high (always a threat)

Silting, increase of turbidity and sedimentation

The acceleration of the erosion process (silting) and the increase of turbidity due to agricultural activities, deforestation and urbanization have a negative impact on copper redhorse. Excessive silting in rivers changes the physical characteristics of the water and has harmful effects on the entire food chain. Spawning and feeding habitats for the copper redhorse are characterized by a coarse-textured substrate and are likely to be modified by an accelerated silting process. In addition, benthic communities, mostly molluscs, which are the main prey for copper redhorse, are sensitive to this type of stress. In the Yamaska and Noire rivers, where the phenomena listed previously are particularly significant, the copper redhorse population has disappeared from these habitats. Silting, the increase of turbidity and sedimentation also has an impact on juveniles by blocking their gills and changing their habitat.

The excessive occurrence of suspended matter from the erosion of cultivated soil deteriorates the quality of copper redhorse habitats by accelerating sedimentation and eutrophication, with phosphorus being absorbed on the particles carried by surface runoff. The massive input of phosphorus in the aquatic system produces major changes in the entire ecosystem.

Agricultural Pollution

Excessive use of pesticides can have harmful impacts on copper redhorse reproduction and on mollusc populations, which they feed on almost exclusively. Some concern has been expressed about the contamination of water by toxic substances in the Richelieu and Yamaska-Noire rivers. The Huron River, a tributary of the Richelieu River which empties near the copper redhorse spawning ground at Chambly, is among the most polluted rivers in Quebec (Ministère de l'Environnement 2002, Giroux 2000). Toxic compounds could act as hormone and olfactory disruptors and consequently slow or interrupt the species' maturation and ovulation. The late spawning of copper redhorse also coincides with a period when water levels are lower and the spreading of pesticides are at their maximum.

River enrichment from the massive use of fertilizers in agricultural settings leads to the deterioration of aquatic environments. Phosphorus, which is a result of these activities, greatly contributes to this observation. Whether the input is from a point or non-point source, the relative significance is estimated at 1 kg P/ha-year with the current agricultural practices. This corresponds to an average concentration of 0.1 mg/l of phosphorus in the aquatic environment, whereas the limit for protecting aquatic life is 0.03 mg/l. One of the consequences of this enrichment is the proliferation of algae and degradation of aquatic grass beds which is beneficial for species that are more tolerant to eutrophication, such as carp (*Cyprinus carpio*), pumpkinseed (*Lepomis gibbosus*) and tench (*Tinca tinca*), a species recently introduced in the Richelieu River. These species likely compete with the copper redhorse in terms of habitat and food resources.

Urban and industrial development and negative impacts on forest and riparian environments as well as on shoreline grass beds

Development, resource exploitation and urbanization are the basis for many sources of pollution. The presence of industrial and urban pollutants in aquatic environments leads to a degradation of water quality and is harmful for several stages of a fish's life cycle. Effluents from cities, textile mills, pulp and paper mills and mines that are dumped into the water can contain several chemical substances such as heavy metals (e.g. lead and mercury), chlorinated hydrocarbons (e.g. DDT and PCB) and polycyclic aromatic hydrocarbons (e.g. benzopyrene). It is known that some of these chemical compounds disrupt the endocrine systems of organisms exposed to these effluents and causes deformities, reproductive and development difficulties for several fish species (e.g. white sucker, copper redhorse, spottail shiner and whitefish). It should be noted, for example, that a portion of the summer habitats occupied by adults are located in the plume created by the effluent from the city of Montreal's water treatment plant. However, real efforts have been made in recent years to clean up several streams that are receiving industrial effluents.

There is also phosphorus from urban and industrial areas. A portion of the phosphorus excreted by humans ends up in streams through the sewage systems. In fact, even with sewage treatment plants, one third of the phosphorus excreted can be found in streams because the effectiveness of the treatment plants varies between 60 and 75%. The relative significance is estimated at 10 kg P/ha-year, a concentration level equal to 1 mg/l.

Even though the impact of urban development on the copper redhorse is not currently as documented as it should be, the negative repercussions on the quality of copper redhorse

habitats merits our concern. These repercussions, which are part of two large categories, are real and visible for the entire copper redhorse distribution range.

Degradation of forest environments

The rapid loss of forest land in the St. Lawrence plain is also becoming significant within the context of copper redhorse conservation. Forests play a significant role in catching phosphorus likely to end up in streams. The relative contribution from forest areas corresponds to approximately 0.1 kg P/ha-year, which represents an input ten times smaller than those from agricultural settings and 100 times less than those from urban areas. Therefore, any new development in a forest area will lead to an increase in fertilizer input towards the aquatic environment.

Degradation of riparian environments

Riparian vegetation forms a buffer area protecting the streams by forming a natural filter for sediment, fertilizers and pollutants and a rampart against soil and shore erosion. The loss of riparian strips and deforestation accelerate erosion and silting in streams. These processes are destroying copper redhorse habitats as well as disrupting the entire food chain.

Excessively stabilizing shorelines and littoral areas and destroying wetlands in order to increase liveable areas for private homes has become a significant source of degradation for aquatic environments. In addition to permanently losing important fish habitats, these activities are contributing towards deteriorating the aquatic environment in the longer term and disrupt wildlife and floristic diversity and productivity. As early as in 1995, the Canadian Wildlife Service estimated that the proportion of artificial shorelines on the St. Lawrence was between 36-60% in the Lanoraie-Verchères corridor and 62-81% in the Montreal archipelago.

Degradation shoreline grass beds

Copper redhorse survival strategically depends on submerged grass beds where it feeds during the first stages of life. Heavily dense grass beds with prized prey for young copper redhorse are rare in the St. Lawrence and Richelieu rivers. Encroachment in aquatic environments from physical works on the shoreline is destroying grass beds and changing the river dynamics by increasing the stemflow speed. The areas that are conducive to grass beds are therefore reduced.

Dredging

Maintaining the St. Lawrence shipping channel requires dredging and dumping sediment into open water. The impact of the dumping on the copper redhorse is not yet known and could be specified when the characterization and delineation of habitats occupied by the copper redhorse have been completed. This work has been completed for summer habitats but field surveys are still being done for fall, winter and spring habitats (Des Seigneuries ZIP Committee and MRNF 2006).

Dams

Several streams occupied by the copper redhorse have been harnessed. Dams disrupt fish displacements. Such is the case with the Saint-Ours dam which had become an insurmountable obstacle since 1969. The Vianney-Legendre multispecies fish-pass, inaugurated in 2001, now allows the species to travel freely up to the spawning grounds at the Chambly archipelago. A dam which was built in 1896 at Chambly and replaced in 1963-64 prevents copper redhorse access to the sector upstream from the Richelieu River. The Yamaska, Noire, Des Prairies and Milles-Îles rivers are also disrupted by several dams. The St. Lawrence River has a free passage of around 350 km, from Beauharnois (Lake Saint-Louis) to the freshwater limits at Ile d'Orléans.

Disturbance at the Pierre-Étienne-Fortin wildlife preserve

The Chambly rapids archipelago is a very busy area for vacationers and recreational boaters who do activities such as swimming, jet-skiing, kayaking, fishing, skin-diving and who organize parties on the islands that are part of the preserve. This area is home to the most significant and best preserved of the two known copper redhorse spawning grounds. Because the copper redhorse spawning period is late (end of June), it corresponds with an increase in aquatic activities at the beginning of the summer holidays and summer festivals. People use one of the known spawning grounds as a swimming area during this period. Human movements are likely to disturb spawners, and in certain areas, eggs are likely to be trampled.

The Pierre-Étienne-Fortin preserve, inaugurated in 2002, was created to protect copper redhorse habitat in this area and limit the disturbance of spawners during their spawning period. Even though access has been prohibited during the copper redhorse spawning period, the preserve continues to be occupied by vacationers and recreational boaters.

Management of water levels in the St. Lawrence River

Water levels in the Great Lakes and St. Lawrence River vary according to long cycles of around 30 years. The alternation of high and low episodes of variability influences the abundance of several commercial species. In the Great Lakes - St. Lawrence Basin, certain scenarios indicate that climate changes could cause a drop in flow rate of around 40% over the next century.

In 2000, the International Joint Commission (IJC) conducted a study to measure the impacts of regulating the flow rate in the St. Lawrence. Significant emphasis was given to the health of the river ecosystem. The modeling of habitats, developed within the framework of the IJC study, was applied to the copper redhorse. Potential summer habitats for adults were calculated for a wide range of flow rates, from very low to very high values, in order to establish the relationship between the available potential habitat and the hydrological regime of the St. Lawrence. It indicated that the flow rate variations, whether climate related or caused by the regulating of the St. Lawrence, have a noticeable effect on the availability of summer habitat for the copper redhorse. Overall, the anticipated decreases in flow rate from climate change scenarios would result in a drop of available habitat area, especially critical between Montreal and Sorel. Regulating, which slightly increases flow rates in summer, already improves available habitat area compared with the natural hydrological regime.

Wave action from passing boats

Bank erosion on the St. Lawrence, resulting from the increase in traffic from commercial vessels and recreational boats, disrupts the aquatic ecosystems. The beating of the waves against the shores of a river, stemming from passing ships, can cause bank erosion and disrupt aquatic grass beds. In the St. Lawrence River, the passing of high tonnage vessels erodes the banks and accelerates silting. In the St. Lawrence freshwater reach, an area where several habitats occupied in summer have been delineated into littoral areas, it is estimated that wave action from passing vessels causes banks to recede up to 3 meters per year. The presence of the shipping channel, where the flow is concentrated in low-water periods, could have a long term harmful impact which, in the case where there is a drop in flow rates during summer in the St. Lawrence due to ongoing climate changes, would lead to the disappearance of the rare grass beds in the river corridor which feed the copper redhorse. In the short term, wave action from vessels also increases the risks of destroying the spawning grounds. The areas that are protected from ship waves have on average 2.4 times more fish than those that are exposed and the sheltered areas support a larger number of species.

The increase in recreational boating activities (e.g. motorized vessels, jet-skis, etc) accelerates the effects of bank erosion by wave action from passing ships and natural shorelines are disappearing rapipidly, especially on the Richelieu River. These activities also disrupt aquatic grass beds, a strategic element for the copper redhorse in terms of feeding area for adults and as a maturing, feeding and shelter area for the young. These activities, which are practised at great frequency in strategic areas for the species, are deteriorating the quality of the water because they are stirring up the sediment. Copper redhorse are likely more sensitive than their congeners towards the increase of turbidity and silting of streams, particularly for eggs and the larvae stage.

Loss of genetic diversity

The impact of losing genetic diversity on the copper redhorse population has not been documented. Although the loss of genetic diversity is not a cause of mortality or direct damage, it can disrupt the species' recovery by making it less capable of adapting to the changes to its environment. Currently, the genetic diversity of the copper redhorse population is still good and sufficient enough to implement a reproduction plan to keep it at an acceptable level.

Exotic or introduced species

The zebra mussel (*Dreissena polymorpha*) could have a significant negative impact on the ecosystem in the Richelieu and St. Lawrence rivers. The zebra mussel takes over areas occupied by certain pelecypods and gastropods on which copper redhorse feeds almost exclusively. In addition, the zebra mussel has a great capacity to concentrate contaminants in its body. A change in diet by incorporating the zebra mussel could lead to increased risks of toxicological effects on copper redhorse growth, reproduction and survival. Ingesting the zebra mussel has previously been observed by juvenile copper redhorse in captivity. The occurrence of highly competitive non-indigenous ubiquitous species such as carp (*Cyprinus carpio*) and tench (*Tinca tinca*) represent an additional threat to the copper redhorse.

Bait-fish commercial fishery

A study on the assessment of the bait-fish commercial fishery on five fish species with a vulnerable status was conducted in the fall of 2005 in southwest Quebec. Copper redhorse were absent from these commercial catches when the sampling was carried out by MNRF biologists. Right now, this risk can not be ignored in summer or spring. A scientific sampling similar to that of 2005 is scheduled for 2007 for these periods. It should be noted that during spring and summer periods, fishermen are mostly in search for white sucker and brook chub as bait. However, the copper redhorse is difficult to differentiate from other redhorse species at the juvenile stage and also easily confused with chubs species.

The available information does not provide any conclusive evidence whether the bait-fish fishery has a harmful impact on the number of individuals caught at the juvenile stage and whether it compromises the recovery of the copper redhorse population. A better targeted identification follow-up for copper redhorse juveniles in bait-fish catches is desirable. It is nevertheless critical, first of all, to identify catch sites that are most at risk for juveniles and protect them.

Commercial fishery

Commercial fishermen are currently uninterested in the copper redhorse. However, in the 19th Century, the species was caught commercially. A recent study highlighted the fact that certain populations may have been seriously diminished by overfishing during that century. At the time, the species was sought after as food and therefore popular on the market. Currently, several measures have been introduced to protect the species. Redhorses have been prohibited as bait-fish for sport fishing since the 1980s. The copper redhorse and river redhorse commercial fishery has been prohibited since 1995. This measure was accompanied by an education program to help identify the species. A reminder was done in 1999. The buy-back of 24 of the 42 fishing permits for Lake Saint-Pierre has reduced the risk of accidental catches of these two redhorse species. There is no commercial fishery practised in the related areas in the Richelieu River downstream from the Chambly dam, Yamaska and Noire Rivers, Milles-Îles and Des Prairies rivers.

Sport fishing

An awareness project for customers who visited the Pierre-Étienne-Fortin wildlife preserve in 2006 (Chambly basin, Richelieu River) revealed that redhorses are often caught during sport fishing, that some fishermen target them and that the copper redhorse is among the acccidental catches observed. Since 1998, catching and keeping redhorses and chubs is prohibited in certain parts of the rivers occupied by the copper redhorse. The MRNF is currently asking that this regulatory feature be applied over a larger area of the copper redhorse distribution range, including part of the St. Lawrence River, the Milles-Îles River and part of the Des Prairies River. It appears that certain ethnic communities value redhorses and chubs as food during sport fishing.

Alternatives for harmful activities

The assessment of alternatives for each of the threats listed above has not yet been done.

Allowable harm

Identification of mortality sources and quantification of each mortality source

Following is a summary of the potential impacts and an estimate of the level of impact.

Impact	Description	Impact
Bait-fish fishery	Fishery conducted by a few individuals in several areas where copper redhorse are found	Fall: little or no impact Spring and summer: to be assessed but could be similar to fall
Directed and accidental fishery	Prohibited directed fishery; Fishing by permit holders for other possible species	Possible by-catches in the St. Lawrence River and riverine lakes; impacts seem low
Sport fishing	Prohibited recreational fishing in certain areas, but possible in others	Low impact
Harmful impacts from authorized activities in the habitat	Forestry, agriculture, linear development, urban development, mine exploitation, plant waste, dredging, wave action from passing boats, existing dams	Generally moderate to high, but difficult to quantify; assessments are limited.
Scientific research	Experimental fishery	Very low impact

Possible mitigation measures

Fisheries

If measures were taken to reduce mortality caused by by-catches during the commercial fishery on other species, the fish-bait fishery and sport fishing, advantages would not amount to much because these catches are not very significant. Nevertheless, monitoring and controlling these fisheries is required in order to reduce the incidence of mortality on the copper redhorse. Furthermore, it would be interesting to have awareness activities among the general public and sport and commercial fishermen concerning the possibility of catching this species at risk and how to return it safely to water and limit mortality when caught accidentally.

Disturbance and destruction of habitat

Knowledge of the copper redhorse critical habitats is essential in order to target the activities that have significant impacts on the species. Therefore, a detailed assessment of its habitats and the impacts of human activities on the habitats are required. It would be interesting to develop actions aimed at ensuring that restrictions are respected in terms of disturbance, disruption or destruction of habitats in the areas likely to have spawning and rearing grounds in order to reduce to a minimum the impacts. However, it is impossible to completely stop the activities that alter the habitats. It would also be interesting to target the areas and periods of the year when tolerance is lowest in terms of anthropogenic activities on mortality and relative harm to species at risk. It is not an issue of prohibiting certain human activities, but of changing

or improving certain ways of operating in order to reduce impacts. The same is true for impacts in terms of urban development, dredging and wave action from passing boats.

Significant efforts have also been made to improve the quality of habitats occupied by the copper redhorse. Some initiatives aimed at changing behaviours and habits that are harmful are an integral part of the copper redhorse recovery actions and will always be considered significant. Among these initiatives, there is increased monitoring of urban development, reforestation projects, the purchase of wetlands and/or their restoration, the promotion of new ways of cultivating agricultural land, the reduction of flood plain cultivation, etc.

SOURCES OF UNCERTAINTY

Even though it is rare, copper redhorse biology is well known, two significant spawning grounds have been identified in the Richelieu River, rearing grounds have been identified, the need to maintain connectivity in the distribution range has been demonstrated and the areas occupied or likely to be occupied have been mapped for the St. Lawrence River as well as for reaches of the Mille-Îles and Des Prairies rivers. Although it is likely that adult copper redhorse visit the Lavaltrie-Contrecoeur area in winter, knowledge of its habitat during this period is still too patchy. The same is true for younger stages (young of the year and one-year-olds) whose habitats are well known, whereas our knowledge is extremely limited in terms of habitats occupied by older juveniles (2+ years old).

The copper redhorse population size is difficult to estimate as it is a rare species. Several specimens were caught and tagged in the Richelieu River during the 1990s, but none of them has been recaptured, which makes it impossible to estimate the abundance of individuals in this river using this method. The only available estimate, the Lavaltrie-Contrecoeur group, was made from a few recaptured individuals in 2002. The number of individuals that occupy this area is estimated at between 150 and 563 individuals. The limits of the 95% confidence interval vary between 46 and 1,647 individuals. We do not have reliable information to effectively evaluate the copper redhorse mortality levels. These levels are probably low, except for younger stages, since the species has a long life span (over 30 years) and that several 20+ year-old individuals have been observed.

The little available quantitative information on copper redhorse is not sufficient to accurately estimate the population's trajectory. Trajectory estimates are based on relative abundance of copper redhorse compared with other redhorse species. They suggest a significant and sharp drop (over about 40 years) of copper redhorse contribution to the catostomidae community in the distribution range and a likely disappearance from the basin of the Yamaska-Noire Rivers.

CONCLUSION AND ADVICE

Several actions have been undertaken in recent years to help copper redhorse recovery. The implementation of the three intervention plans for this species has not only provided widespread sound actions for the species' recovery but has also considerably increased the knowledge level on the population's biology and genetics, as well as raised public awareness in terms of the species' survival. Telemetric monitoring has provided a way to map a significant part of the species' habitat and identify the areas that need protection first. In addition, partnership efforts that were made over these years helped create the Pierre-Étienne-Fortin wildlife preserve, the

creation and operation of the Vianney-Legendre fish-pass at the St-Ours dam and the development of reproduction plan, which should increase the copper redhorse's chances of recovery. The results from the research work have also shown the need to maintain connectivity in the distribution range and to continue the efforts to significantly improve water quality in the Richelieu River and other streams where copper redhorse are still found.

The efforts made so far that are aimed at the species' recovery are very important and the first results are very encouraging for the survival of the copper redhorse. However, these efforts will have to be maintained over the next few years in order to improve population recruitment and habitat conditions so that the species can recover fully.

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