Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences

Canadian Science Advisory Secretariat (CSAS)

Research Document 2013/014

Central and Arctic Region

Information in Support of a Recovery Potential Assessment of Carmine Shiner (*Notropis percobromus*)

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June 2013

Canada

FOREWORD

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

PUBLISHED BY:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

ISSN 1919-5044

Correct citation for this publication:

Watkinson, D.A. and Sawatzky, C.D. 2013. Information in support of a recovery potential assessment of Carmine Shiner (*Notropis percobromus*). DFO Can. Sci. Advis. Sec. Res. Doc. 2013/014. iv + 16 p.

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ABSTRACT

The Carmine Shiner (*Notropis percobromus*) was listed under the *Species at Risk Act* (SARA) as Threatened when the Act came into force in 2003. In April 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) re-assessed and confirmed the designation because it occurs in an extremely restricted area of Manitoba and the major threat to the species is the alteration in water flow as a result of stream regulation (COSEWIC 2006). The Science sector in Fisheries and Oceans Canada (DFO) was asked to undertake a Recovery Potential Assessment (RPA); this Research Document supports the RPA. It describes the current state of knowledge of Carmine Shiner in Manitoba in terms of their biology, ecology, abundance, distribution and trends, habitat requirements and threats. A recovery goal, mitigation measures and alternatives to threats and the potential for allowable harm are presented, as is information relevant to critical habitat and residence. The information contained in the RPA and this document may be used to inform the development of recovery documents and to support decision-making with regard to the issue of permits, agreements and related conditions under the SARA.

Information à l'appui de l'évaluation du potentiel de rétablissement de la tête carminée (*Notropis percobromus*)

RÉSUMÉ

La tête carminée (*Notropis percobromus*) a été inscrite à titre d'espèce menacée lors de l'entrée en vigueur de la *Loi sur les espèces en péril* (LEP) en 2003. En avril 2006, le Comité sur la situation des espèces en péril au Canada (COSEPAC) a réévalué et confirmé cette désignation puisque l'espèce ne se trouve que dans une région extrêmement restreinte du Manitoba et que la plus grande menace à son égard est la modification du débit d'eau résultant de la régulation des cours d'eau (COSEPAC 2006). On a demandé au Secteur des sciences de Pêches et Océans Canada (MPO) de réaliser une évaluation du potentiel de rétablissement (EPR) de l'espèce; le présent document de recherche a été préparé à l'appui de cette EPR. Le présent document de recherche fournit une description de l'état actuel des connaissances de la biologie, de l'écologie, de l'abondance, de la répartition et des tendances, des besoins en matière d'habitat et des menaces relatives à la tête carminée au Manitoba. Des mesures d'atténuation des menaces et des solutions de rechanges sont présentées ainsi que l'information relative à l'habitat essentiel et à la résidence. Les renseignements contenus dans l'EPR et dans le présent document peuvent servir de base à l'élaboration de documents en matière de rétablissement et à la prise de décisions en ce qui a trait à la délivrance de permis, aux ententes et aux conditions connexes conformément à la LEP.

SPECIES INFORMATION

Scientific Name – *Notropis percobromus* (Cope, 1871)

Common Name – Carmine Shiner

Range in Canada – Manitoba

Current COSEWIC Status & Year of Designation – Threatened, 2006

COSEWIC Reason for Designation – "This freshwater fish species occurs in an extremely restricted area of Manitoba. The major threat to the species is the alteration in water flow as a result of stream regulation." (COSEWIC 2006)

Canada *Species at Risk Act* – Listed, Schedule 1, Threatened, 2003

Figure 1. Carmine Shiner (Notropis percobromus). Illustration by Joe Tomelleri reproduced with permission.

INTRODUCTION

RATIONALE FOR ASSESSMENT

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Carmine Shiner in April 1994 and designated it Special Concern. In November 2001, COSEWIC re-assessed this species and upgraded it to Threatened. Carmine Shiner was listed on Schedule 1 of the *Species at Risk Act* (SARA) when the Act was proclaimed in June 2003. Its status was re-examined and confirmed by COSEWIC in 2006, based on an update status report (COSEWIC 2006).

When COSEWIC designates an aquatic species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans Canada (DFO) is required by the SARA to undertake a number of actions. Many of these actions require scientific information such as the current status of the designatable unit, the threats to its survival and recovery, and the feasibility of its recovery. In DFO, formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) completed shortly after a COSEWIC assessment of Threatened, Endangered or Extirpated and in advance of a listing decision. This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including recovery planning. If listed, decisions made on permitting of harm and in support of recovery planning need to be informed by the impact of human activities on the species, alternatives and mitigation measures to these activities, and the potential for recovery. As the Carmine Shiner is listed and a Recovery Strategy has been posted on the SARA Registry, the information and scientific advice provided in this document will inform the possible Action Plans, issuance of Section 73 permits, reporting on recovery actions and other related activities.

TAXONOMY

The Carmine Shiner is a small minnow of the genus *Notropis*. It is a member of the Rosyface Shiner species complex, a group of five species (Rosyface Shiner (*N. rubellus*), Highland Shiner (*N. micropteryx*), Rocky Shiner (*N. suttkusi*), Carmine Shiner and a yet to be described species) that had previously been recognized only as “Rosyface Shiners” (Wood et al. 2002). Members of this genus are difficult to distinguish from one another based on morphology and meristics, and phylogenetic relationships among them are largely unresolved (Dowling and Brown 1989).

In agreement with Nelson et al. (2004), Stewart and Watkinson (2004) accepted Carmine Shiner as the identity of the Manitoba population based on the biogeographic information presented in Wood et al. (2002). Ongoing studies have confirmed that the Carmine, Rosyface and Emerald shiners (*N. atherinoides*) are separate taxa based on mitochondrial (ATPase 6 and 8 genes) and nuclear (rRNA ITS-1) DNA sequences (C. Wilson, Ontario Ministry of Natural Resources, pers. comm. 2005). These studies have shown that the fish in Manitoba are Carmine Shiner, like those to the south, and not Rosyface Shiner like those in eastern Canada. The existence of distinct forms within *N. percobromus* supported by morphological characters and phylogenetic analyses of allozyme data may eventually warrant taxonomic recognition (Wood et al. 2002). Since populations in the Whitemouth and Winnipeg rivers (Figure 2) are apparently disjunct from those in the Red River watershed in Minnesota and elsewhere, and were likely isolated there by deglaciation, that may affect future taxonomic revisions.

SPECIES BIOLOGY AND ECOLOGY

The Carmine Shiner is a slender, elongate minnow that can be distinguished from most minnow species in Manitoba by the dorsal fin origin, as it is located behind a line drawn vertically from the insertion of the pelvic fins. It can be distinguished from the Golden Shiner (*Notemigonus crysoleucas*) by an absence of a fleshy keel on the abdomen and the lateral line is only slightly decurved. It can be distinguished from the Emerald Shiner as its snout is narrower, equal in length, or nearly so, to its eye diameter, 5-7 short gill rakers on the lower limb of the first gill arch, the longest being about as long as the width of its base, four slender, hooked, main row pharyngeal teeth (Stewart and Watkinson 2004) and a lack of large chromatophores on the mid-point of the chin (Becker 1983).

Outside of the breeding season the Carmine Shiner is olive green dorsally, silvery with blue/purple hues on the sides and silvery white on the belly. The dorsal scale pockets are outlined by black pigment, and freshly caught adult specimens often retain carmine pigment on the opercula and cheek, which becomes more vivid and extensive during spawning. The fins are transparent. Breeding males develop fine, nuptial tubercles on the head, some predorsal scales and the upper surface of the pectoral fin rays. Spawning fish turn a bright carmine colour around their cheeks and at the base of each fin. In some fish the entire head turns this colour. Breeding females are usually a paler colour on the sides; this pigmentation is usually bordered below by the lateral line. The largest Carmine Shiner in Manitoba was collected in the Whitemouth River and had a fork length of 67 mm.

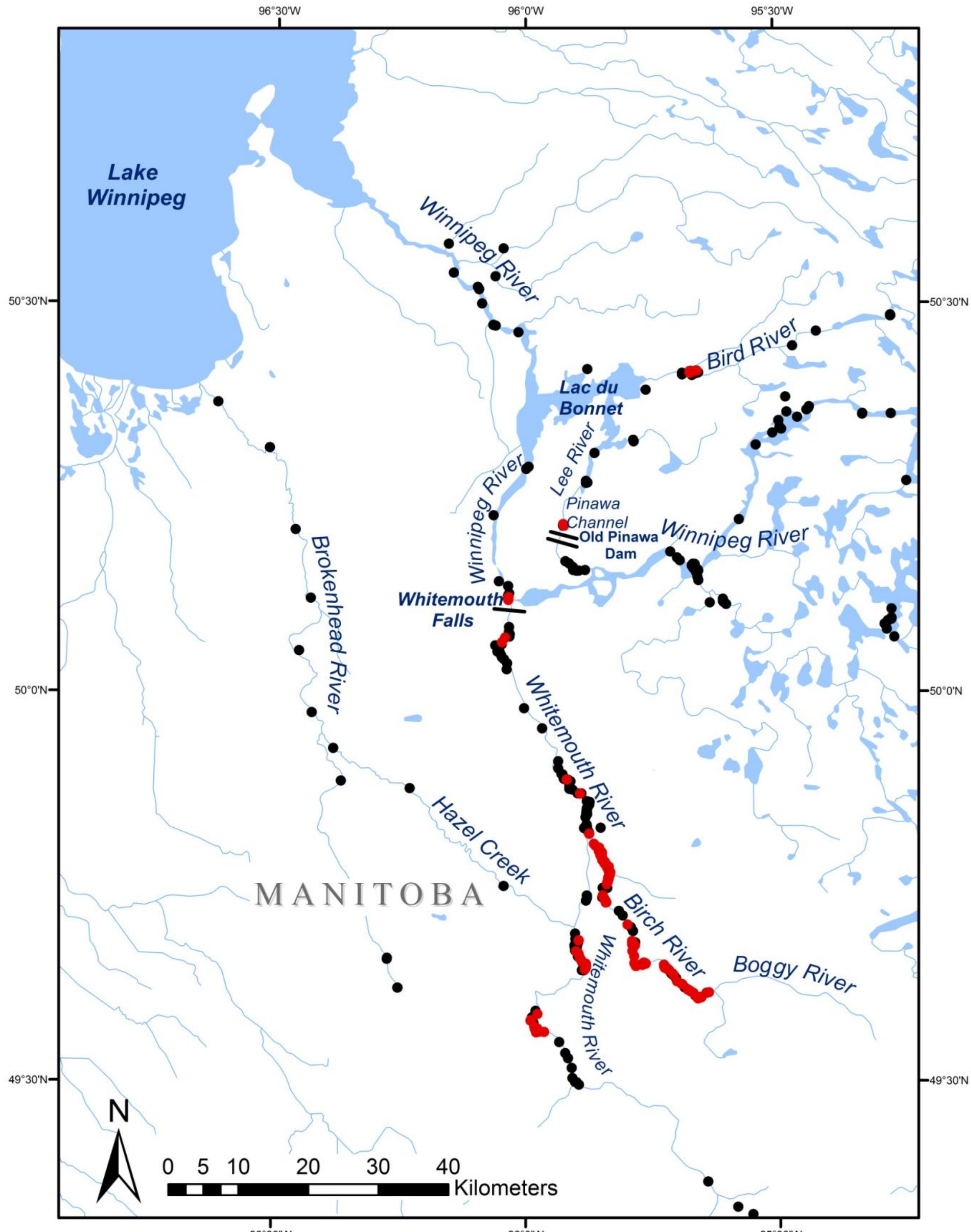

Figure 2. Distribution of the Carmine Shiner in Canada. Red dots identify locations were Carmine Shiner were found, black dots are locations sampled without finding Carmine Shiner.

Information on the Carmine Shiner is limited and somewhat confused as many studies of the Rosyface Shiner species complex were conducted on eastern populations before the western populations were recognised as Carmine Shiner. The COSEWIC review by Houston (1996) included information on both species, as did Becker (1983). To avoid this problem, information from the closely-related Rosyface Shiner is presented only where there is no specific information for the Carmine Shiner.

The Carmine Shiner in Manitoba can live to at least age-3 with spawning individuals (male and female) attaining fork lengths in the range of 55 to 67 mm (DFO unpubl. data).

Little is known of the species' spawning habits in Canada although they are probably similar to those of the Rosyface Shiner. Spawning of Carmine Shiner in the southern part of their range and of Rosyface Shiner in Great Lakes watersheds typically occurs in May and June at water temperatures of 20 to 28.9°C (Starrett 1951; Pfeiffer 1955; Reed 1957a; Miller 1964; Pflieger 1975; Baldwin 1983; Becker 1983). Similarly in Manitoba, female Carmine Shiner collected in the Birch River in 2011 had mature eggs in July when water temperatures were between 20 to 30°C. Carmine Shiner in spawning condition have been caught in the Pinawa Channel, the Whitemouth River and in the Birch River (DFO unpubl. data). Substrates at collection sites included sand, gravel, cobble, boulder and bedrock. There is some evidence from collected specimens of repetitive spawning during the spawning season (DFO unpubl. data). Cold weather has been observed to delay the spawning of Rosyface Shiner (Reed 1957a).

Rosyface Shiner have been observed spawning in groups of 8–20 fish over depressions in the gravel (Pfeiffer 1955; Miller 1964), often, these depressions are nests constructed by other cyprinids, such as the Hornyhead Chub (*Nocomis biguttatus*), Creek Chub (*Semotilus atromaculatus*) (Miller 1964; Vives 1989) and Common Shiner (*Luxilus cornutus*) (Reed 1957a; Miller 1964; Baldwin 1983; Vives 1989).

The total egg count of Carmine Shiner sampled in Manitoba (n=88) ranged from 144 to 984 eggs per female. This is lower than Rosyface Shiner collected in New York (Pfeiffer 1955); however, the development stage of these eggs was not assessed. Both species mature at about age-1, and the number of eggs per female increases with size (Pfeiffer 1955; DFO unpubl. data).

Rosyface Shiner eggs are 1.2 mm in diameter within the female and expand to 1.5 mm on contact with water (Pfeiffer 1955). Fertilized eggs turn bright yellow and become water-hardened and adhesive hatching in 57 to 59 hours at 21.1°C. Newly hatched larvae remain in the interstices of bottom gravel, presumably until egg yolk absorption is complete (Pfeiffer 1955).

Hybridization of the Carmine Shiner with other species has not been described but is possible given that the Rosyface Shiner hybridizes naturally with several species including Common Shiner (Raney 1940; Pfeiffer 1955; Miller 1964), a species that has an overlapping distribution in Manitoba. To date, there have been only six records of hybridization in the minnow family (two for *Percobromus*) for Minnesota and none for Manitoba.

The Carmine Shiner from the Whitemouth River was found to have consumed a variety of invertebrates during the summer, both aquatic and terrestrial insects (DFO unpubl. data). In the Ozarks, Carmine Shiners are omnivorous, lower to mid-level consumers (Hoover 1989). The bulk of the Rosyface Shiner's diet is composed of aquatic insects, particularly caddisfly larvae (Reed 1957b). They also consume algae, diatoms, mayflies, diptera and inorganic material (Reed 1957b). Young-of-the-year (YOY) Rosyface Shiners have a preference for algae and diatoms (Reed 1957b).

Little is known of the predators, parasites and diseases of the Carmine Shiner, in Manitoba they are likely preyed upon by Walleye (*Sander vitreus*) and Northern Pike (*Esox lucius*) and fish-eating birds. Rosyface Shiner eggs are eaten by darters, suckers, Common Carp (*Cyprinus carpio*) and minnows (Baldwin 1983). Hoffman (1999) found two parasitic species of Monogenea infecting Carmine Shiner and 10 parasite species (two Monogenea, seven Trematoda and one Nematoda) infecting Rosyface Shiner. This low number likely reflects limited sampling effort rather than few parasite species, as many more species have been found in Common Shiner (Hoffman 1999).

Little is known of the Carmine Shiner's physiology or ability to adapt to different conditions. The species appears to occupy a relatively narrow ecological niche, which suggests limited adaptive ability. The closely-related Rosyface Shiner also has a narrow range of habitat requirements and responds quickly to changes in habitat and water quality (Cherry et al. 1977; Smith 1979; Trautman 1981; Humphries and Cashner 1994; Houston 1996). For example, the Rosyface Shiner exhibits long-term avoidance of pollutants (Cherry et al. 1977) and avoids water temperatures greater than 27.2°C (Stauffer et al. 1975).

The Carmine Shiner has no direct economic importance as a commercial, recreational or aboriginal fishery and limited importance as a forage species, but is of scientific interest (Scott and Crossman 1973; Houston 1996; Stewart and Watkinson 2004). It has intrinsic value as a contributor to Canada's biodiversity and since the Manitoba population represents the northwestern limit of the distribution of the species, they may be unique and provide evidence of local adaptation to their habitat and genetic differentiation from other populations (Stewart and Watkinson 2004).

ASSESSMENT

HISTORIC AND CURRENT DISTRIBUTION AND TRENDS

The Carmine Shiner was first reported in the Whitemouth River by Smart (1979). They were later found in the Winnipeg River at the confluence with the Whitemouth River (K.W. Stewart, unpubl. data; DFO unpubl. data). Surveys conducted since 2002 have expanded their known distribution to include the Birch River from its confluence with the Boggy River downstream to the Whitemouth River, Bird River near the first set of falls upstream of Lac du Bonnet and the Lee River just downstream of the Old Pinawa Dam (Stewart and Watkinson 2004) (Figure 2). The lack of information on its distribution and abundance are an artefact of limited sampling. Additional sampling may increase the known distribution of the species in Manitoba.

The Whitemouth and Birch rivers are physically isolated from the rest of the watershed by the Whitemouth Falls at the confluence of the Winnipeg and Whitemouth rivers. The falls allow downstream passage and dispersal. As the relationships between individuals in the various waterbodies are unknown, Carmine Shiner was treated as a single population for the purposes of this RPA.

HISTORIC AND CURRENT ABUNDANCE AND TRENDS

Prior to its listing by COSEWIC, the Carmine Shiner had only been reported incidentally in Manitoba (e.g., Smart 1979). This species is common but not abundant in the midcourse reach of the Whitemouth River and lower reach of the Birch River (Smart 1979). Estimates of abundance do not exist other than catch per unit effort for samples collected since 2002 and these collections were rarely made at the same location as most of the survey effort was directed at collecting fish in new locations.

Sampling has not been conducted to detect an upward or downward trend in the population. The status of the population is unknown.

INFORMATION TO SUPPORT IDENTIFICATION OF CRITICAL HABITAT

To date, few studies have examined the biology, life history, or habitat requirements of the Carmine Shiner. As it is understood, on the basis of studies conducted primarily in the Whitemouth River system, adults frequent shallow riffles with clear water and with predominantly sand and gravel substrates, but it is not known whether or which of these habitats are critical to the species (DFO unpubl. data). Carmine Shiner has been collected in a wider range of habitats elsewhere in the Winnipeg River system. Although this species prefers clear water, it has the ability to withstand short-term turbidity, for instance following a rain event. The Carmine Shiner spawns in relatively warm, clear water and frequents shallow, flowing water with clean rocky substrates. In Manitoba, spawning occurs between mid-June and into July. There is some evidence from collected specimens of repetitive spawning during the spawning season (DFO unpubl. data). Little is known about the locations of their nursery, rearing or feeding areas. The habitat requirements of YOY Carmine Shiner are unknown.

Similar to spawning in the southern part of the range and Rosyface Shiner in the Great Lakes watersheds, Carmine Shiner in Manitoba spawn when water temperatures are 20 to 30°C (Starrett 1951; Pfeiffer 1955; Reed 1957a; Miller 1964; Pflieger 1975; Baldwin 1983; Becker 1983; DFO unpubl. data). In more southern portions of their range Carmine Shiner spawn from mid-April to early July, with the peak of activity in May and early June (Pflieger 1975).

Given current distribution patterns, longitudinal and lateral connectivity is assumed to be important. As the diet includes a significant proportion of terrestrial insects, riparian habitat is also likely important for the species.

RESIDENCE

The SARA defines a residence as “a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating”. Residence is interpreted by DFO as being a constructed place (e.g., a spawning redd). The Carmine Shiner does not change its physical environment or invest in a structure during any part of its life cycle, therefore no biological feature of this species meets the SARA definition of residence as interpreted by DFO.

THREATS TO SURVIVAL AND RECOVERY

The Carmine Shiner in the Whitemouth, Bird and Birch rivers and Lee River just below the Old Pinawa Dam may be threatened by a variety of human activities. Impoundments and agricultural drainage that increases sediment loads, streambed gravel removal and stream channelization are examples of activities that have been implicated in the decline or disappearance of the Rosyface Shiner and Rocky Shiner within its distribution (Smith 1979; Trautman 1981; Humphries and Cashner 1994). It is likely that the greatest threats to the survival and persistence of Carmine Shiner in Canada are also related to habitat modification and destruction, especially those that alter the turbidity or flow of water. Increased bank erosion and consequent siltation probably have negative effects on eggs, fry and food supply. Shoreline alterations associated with cottage development and landscape changes might adversely affect this species. Substantial water withdrawals for pipeline hydrostatic testing may also pose a threat. Other threats that may lessen the survival of Carmine Shiner to varying degrees include the introduction of exotic species, pollution, incidental harvest by bait fishing operations and routine scientific sampling.

Three primary categories of threats (habitat loss/degradation, species introductions and pollution) and two other threats (incidental harvest from bait fishing and scientific sampling) have been identified for Carmine Shiner. A description of each threat is summarized below along with an evaluation of its likelihood of occurrence and severity of impact. Threat Likelihood was rated as Known, Likely, Unlikely or Unknown, and the Threat Impact was rated as High, Medium, Low or Unknown (Table 1). The level of Certainty associated with each rating for Threat Impact was identified on the basis of causative studies, correlative studies or expert opinion (Table 1). The Threat Likelihood and Threat Impact ratings were subsequently combined in the Threat Level Matrix (Table 2) resulting in the final Threat Level (Table 3).

Habitat Loss/Degradation

Habitat loss and/or degradation associated with flow regulation, shoreline/riparian development, landscape changes and climate change is likely, and may pose a threat to the species. All these threats, with the possible exception of climate change, can produce turbidity and sediment loading to which Carmine Shiner are relatively intolerant.

Flow alteration

As Carmine Shiner frequent shallow riffles with clear water in summer, flow alterations that affect these conditions may pose a threat to their existence. Hydroelectric development has altered flow in the Winnipeg River. Development began in 1909 at Pointe du Bois, and ended in 1955 with the completion of the station at McArthur Falls. These developments impounded reaches of the river creating forebays, flooding vegetation and eliminating rapids. These hydroelectric stations are in operation and are unlikely to be removed. Manitoba’s first hydroelectric station on the Pinawa Channel was completed in 1906. It was retired in 1951 and flow in the channel was reduced significantly as a diversion dam was built at its origin to divert flow to the Seven Sisters Generating Station. It is uncertain if the hydroelectric development on the Winnipeg River increased turbidity and decreased riffle habitat sufficiently to change the abundance of Carmine Shiner in the system.

Land drainage for farming, highways and peat extraction; the installation of weirs and river crossings; and removal of nearby vegetation for forestry or agriculture affect flow patterns. The effects of these activities on shorelines and runoff may be mitigated to some extent. Water removal for domestic use, lawn or agricultural irrigation and watering livestock has the potential to reduce flow and limit habitat, particularly during dry years. The impacts of these activities can be mitigated by restriction or control of water withdrawals from, or diversions of water into, waterbodies where the Carmine Shiner may occur.

Overall, the likelihood of occurrence of flow alteration is Known while its severity of impact to Carmine Shiner ranges from Low to High depending on the cause of the disturbance and its duration (Table 1). These ratings produced an overall threat level of Low to High (Table 3). The potential for mitigation is likely moderate to high for most activities except for conditions affected by hydroelectric development. There is no control over naturally-occurring changes in flow.

Shoreline/riparian development

Shoreline development in areas adjacent or upstream of Carmine Shiner spawning habitat could have adverse effects by causing physical disturbances or changes in water quality. Clearing of riparian vegetation to the water’s edge for cottage or agricultural development can destabilize banks and increase erosion. Allowing livestock access to the river and adjacent riparian area can disturb habitats by increasing silt and nutrient loading, as can ditching and drainage for local highways. Fortunately, most impacts of these activities on stream habitats can be mitigated using existing technology and best management practices. Mitigation would typically include the establishment of riparian buffers, livestock fencing or otherwise restricting access and the deployment of appropriate erosion control techniques. The likelihood of occurrence of shoreline/riparian development is Known but the severity of impact is Low to Moderate (Table 1), resulting in an overall threat level of Low to Medium (Table 3). Although mitigation measures are available to deal with this threat the potential for mitigation is limited because riparian removal is only covered by provincial recommendation, not legislation.

Table 1. Threat Likelihood (TLH) and Threat Impact (TI) for Carmine Shiner in the Whitemouth, Bird and Birch rivers and Lee River just below the Old Pinawa Dam based on the best available data. The Threat Likelihood was assigned as Known (K), Likely (L), Unlikely (U), or Unknown (UK), and the Threat Impact was assigned as High (H), Medium (M), Low (L), or Unknown (UK). The level of Certainty (C) associated with Threat Impact was based on causative studies (1), correlative studies (2) or expert opinion (3).

THREATS		**TLH**	**TI**	**C**
Habitat Loss/Degradation				
	Flow alteration	K	L-H	3
	Shoreline/riparian development	K	L-M	3
	Landscape changes	K	UK	3
	Climate change	K	UK	3
Species Introductions				
	Predation, competition, food web disruption	L	L-H	3
Pollution				
	Point sources and non-point sources	K	UK	3
Other threats				
	Bait fisheries	U	L	3
	Scientific sampling	K	L	3

Table 2. The Threat Level Matrix combines the Threat Likelihood and Threat Impact rankings to establish the Threat Level.. The resulting Threat Level has been categorized as Low, Medium, High, or Unknown.

		Threat Impact			
		Low (L)	**Medium (M)**	**High (H)**	**Unknown (UK)**
Threat Likelihood	**Known (K)**	Low	Medium	High	Unknown
	Likely (L)	Low	Medium	High	Unknown
	Unlikely (U)	Low	Low	Medium	Unknown
	Unknown (UK)	Unknown	Unknown	Unknown	Unknown

Table 3. Threat Level for Carmine Shiner in the Whitemouth, Bird and Birch rivers and Lee River just below the Old Pinawa Dam, resulting from an analysis of both the Threat Likelihood and Threat Impact.

THREATS	**LEVEL**		
Flow alteration	Low	Medium	High
Species introductions	Low	Medium	High
Shoreline/riparian development	Low	Medium	
Bait fisheries	Low		
Scientific sampling	Low		
Landscape changes	Unknown		
Climate change	Unknown		
Point and non-point sources	Unknown		

Landscape changes

Forestry, agriculture, peat extraction and highway development have the potential to change landscapes in ways that alter the patterns and quality of runoff entering waters that support Carmine Shiner. These changes include the removal of vegetation, grading of overburden, drainage of wetlands, stream channelization and ditching and the construction of physical barriers (e.g., dams, roadways, culverts). Sound project design and management, establishment of appropriate riparian buffers and effective monitoring can mitigate many of the potential impacts of these types of activities on stream habitats. Environmental licensing, as well as the *Fisheries Act*[1] and the SARA, provide the means to mitigate activities that cause negative landscape changes for Carmine Shiner. Although no specific impacts have been identified to date, landscape changes are occurring so the likelihood of occurrence of this threat is Known (Table 1), however the severity of impact is Unknown thus the overall threat level also rates as Unknown (Table 3).

Climate change

Climate change is widespread so its likelihood of occurrence is Known, however the severity of impact on the Carmine Shiner is Unknown (Table 1) thus the overall threat level is also Unknown (Table 3). These effects may be positive or negative depending on the direction, extent and timing of any changes in water temperature and hydrology that affect the species' habitats. Climate change models run by Lyons et al. (2010) predicted Carmine Shiner populations will increase under a warming scenario, however the model used was unable to take drought events into account. The Birch River, where low flow and low oxygen conditions already occur in summer and winter (Clarke 1998; DFO unpubl. data), may be the most vulnerable to any changes. The potential for mitigating threats from climate change is low at the local level.

Species Introductions

Sources of introductions may include interbasin water transfers, possibly associated with hydrostatic pipeline testing, as live bait used by anglers and through the stocking of game fishes. The import of live bait into Canada is illegal and is enforced by Canada Customs. Walleye have been stocked by the Province of Manitoba in Whitemouth Lake since 1960 and Brook Trout (*Salvelinus fontinalis*) were stocked in 1961-62 (D. Leroux, Manitoba Conservation and Water Stewardship, pers. comm. 2005). The Birch River has been stocked with Rainbow Trout (*Oncorhynchus mykiss*), Brook Trout, Brown Trout (*Salmo trutta*) and Walleye (Clarke 1998). Walleye is the only one of these stocked species that remains in the Birch River. Brown Trout have been stocked in the Pinawa Channel and Smallmouth Bass and Rainbow Smelt (*Osmerus mordax*) have been introduced to the Winnipeg River system. The effects of these introduced species on Carmine Shiner populations are unknown, although elsewhere Smallmouth Bass and Carmine Shiner do coexist. The potential for transfer of species from the Lake of the Woods watershed via overland drainage exists and is likely as Rusty Crayfish (*Orconectes rusticus*) were collected in the Birch River in 2011 (DFO unpubl. data). Other non-fish species have also been introduced into the region including Spiny Water Flea (*Bythotrephes longimanus*), Zebra Mussel (*Dreissena polymorpha*), pathogens and viruses.

Potential threats to Carmine Shiner populations through species introductions include predation, competition and food chain disruption. Introduced species might also carry diseases and parasites that Carmine Shiner populations have never been exposed to which could negatively affect them. In addition to exotic species, significant increases in the density of indigenous species or prevalence of naturally-occurring disease can also pose a threat. The frequency of occurrence of this threat is Likely and the severity of impact would range from Low to High depending on the species introduced (Table 1). These ratings produced an overall threat level of Low to High (Table 3).

[1] As of 2013, changes to the *Fisheries Act* may not provide the same level of protection for Carmine Shiner as before.

Pollution

Pollution from point sources (e.g., contaminants and toxic substances) and non-point sources (e.g., nutrient loading) occurs within the range of the Carmine Shiner in Manitoba. Examples of some pollutants that could affect this species include farm fertilizers, herbicides and pesticides. Runoff that carries additional nutrients from barnyards or intensive livestock operations is an ongoing problem that is being addressed by the Province of Manitoba and Prairie Farm Rehabilitation Administration (PFRA). Clarke (1998) found elevated levels of phosphorus (0.2 $mg \cdot L^{-1}$ TDP) and nitrogen (0.99 $mg \cdot L^{-1}$ nitrate/nitrite) in the lower Birch River in April 1996, but not at other times of the year. These levels are likely elevated through mobilization of agricultural chemicals during spring runoff and potentially hydrostatic testing of adjacent pipelines. Other sources of pollution within the region have been identified, including the release of orthophosphate from cottage developments, and tantalum and cobalt from mining operations near the Bird River.

The likelihood of this threat is Known but its impact on Carmine Shiner is Unknown (Table 1), thus the overall threat level is also Unknown (Table 3). That said, if this species responds in a similar fashion as the closely-related Rosyface Shiner, it may exhibit long-term avoidance of pollutants (Cherry et al. 1977). The potential to mitigate, through environmental licensing and public education, or recover from pollution impacts is moderate to high except where long-range transport is the main source of pollutants, since these substances are ubiquitous.

Other Threats

Bait fisheries

Carmine Shiner could potentially be exploited as a bait fish. Bait fisheries include both live and dead (frozen) bait operations. Commercial bait fishing in Manitoba is regulated and requires an annual license from Manitoba Conservation and Water Stewardship. Fishers may harvest fish for use as dead bait from any Crown water within their allocated bait blocks, some of which may encompass areas where Carmine Shiner occurs. Live bait harvest can only occur within specific waters approved by Manitoba Conservation and Water Stewardship. The majority of the commercial bait fish harvest in southeastern Manitoba is aimed at collecting live bait fishes (B. Scaife, Manitoba Conservation and Water Stewardship, pers. comm. 2004), generally non-shiner species. While the use of live traps allows for sorting and release, the Carmine Shiner is difficult to identify and may be easily injured by handling. The Whitemouth, Bird and Winnipeg rivers are not approved for live bait fish harvest, therefore the Carmine Shiner is not likely to be affected by such operations.

Dead (frozen) bait harvesting is of greater potential concern as shiners are generally targeted. The gear used for these harvests (e.g., seines) is more likely to kill or harm the bait fish than that used for live-capture, but these methods are seldom used in the habitats where the Carmine Shiner is most often found (K.W. Stewart, pers. comm. 2004). The harvest from specific waters is currently unknown and commercial bait fishermen with allocations in the Whitemouth and Bird rivers have not indicated any frozen production on their annual production report forms (B. Scaife, pers. comm. 2004). Frozen production, however, is known to occur from some areas in the Winnipeg River system.

The potential for incidental harvest of Carmine Shiner by bait fishing operations does exist, particularly by recreational fishers, but its frequency of occurrence and severity of impact are believed to be Unlikely and Low, respectively (Table 1). These ratings produced an overall threat level of Low (Table 3).

Scientific sampling

Carmine Shiner in the Whitemouth River undergoes routine scientific sampling so the likelihood of occurrence of this activity is Known (Table 1). This activity is carefully regulated through the issuance of scientific collection permits under SARA thus the severity of this threat to Carmine Shiner is likely Low (Table 1) resulting in an overall threat level of Low (Table 3).

MITIGATIONS AND ALTERNATIVES

Habitat Loss/Degradation

Numerous threats affecting Carmine Shiner populations are related to habitat loss or degradation. Habitat-related threats to Carmine Shiner have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM) (Table 2). DFO FHM has developed guidance on generic mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in Central and Arctic region within DFO (Coker et al. 2010). Seventeen of which apply to freshwater systems. This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. The potential for mitigation varies with the type of threat and the affected waterbody. In addition to the guidance offered in the DFO mitigation guide, legislative control/licensing and/or regulatory changes at the provincial and federal levels, public education and watershed planning have the potential to mitigate habitat loss/degradation.

Pollution

The DFO mitigation guide (Coker et al. 2010) also provides guidance on generic mitigation measures for Pathways of Effects related to pollution from point and non-point sources. Table 4 shows the relevant Pathways of Effects for Carmine Shiner. These measures combined with legislative control/licensing at the provincial and federal levels, public education and developing plans to contain and clean up spills and other releases of pollutants have the potential to mitigate this threat. Alternative measures, such as reductions in pesticides (e.g., organic farming), are market driven.

Table 4. Threats to Carmine Shiner populations in Canada and the Pathways of Effect associated with each threat. 1 - Vegetation clearing; 2 – Grading; 3 – Excavation; 4 – Use of explosives; 5 – Use of industrial equipment; 6 – Cleaning or maintenance of bridges or other structures; 7 – Riparian planting; 8 – Streamside livestock grazing; 10 – Placement of material or structures in water; 11 – Dredging; 12 – Water extraction; 13 – Organic debris management; 14 – Wastewater management; 15 – Addition or removal of aquatic vegetation; 16 – Change in timing, duration and frequency of flow; 17 – Fish passage issues; 18 – Structure removal.

Threat	Pathways
Habitat modifications: flow alteration, shoreline/riparian development and landscape changes	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18
Pollution: point and non-point sources	1, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 18

Pathways of Effects were not developed for species introductions, bait fisheries and scientific sampling so the following specific mitigation measures and alternatives are provided for those types of threats.

Species Introductions

Numerous aquatic species have been introduced into the region ranging from microscopic to macroscopic. Some could have negative effects on Carmine Shiner. Introduced species have been successfully removed in some small prescribed lakes but this approach would be difficult, at best, in a river system. Preventing introductions is a more effective strategy for mitigating this threat than removal once invasive species have become established. The potential for mitigating the impacts of species introductions once they occur is likely low.

Mitigation

- Monitor watersheds for exotic species that may negatively affect Carmine Shiner populations directly, or negatively affect Carmine Shiner preferred habitat.
- Develop a plan to address potential risks, impacts and proposed actions if monitoring detects the arrival or establishment of an exotic species.
- Introduce a public awareness campaign and encourage the use of existing exotic species reporting systems.

Alternatives

- For authorized introductions, use only native species.
- Follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

Other Threats

Bait fisheries

The likelihood of incidental catch of Carmine Shiner is low given current provincial legislation and policies regarding the commercial baitfish fishery. The potential for incidental harvest by recreational fishers does exist but none is known to occur in areas where Carmine Shiner are found.

Mitigation

- Provide public education to ensure that commercial fishermen and anglers know where Carmine Shiner may occur, how to identify them and how to reduce the potential for incidental harvest.

Alternatives

- Prohibit baitfishing if it occurs in areas where Carmine Shiner are known to exist.

Scientific sampling

Mitigation

- No known mitigation measures are available.

Alternatives

- Conduct observational studies of Carmine Shiner.
- Sample Carmine Shiner in areas where they are not protected (e.g., Minnesota).

OTHER LIMITING FACTORS FOR POPULATION SURVIVAL OR RECOVERY

Further research on the physiology and ability of Carmine Shiner to adapt to different conditions is needed. The species appears to occupy relatively narrow ecological and bio-geographical niches, suggesting limited adaptive ability. The current lack of knowledge about dispersal in Carmine Shiner limits the ability to predict the impacts of climate change or other disturbances on survival and distribution of this species. It is not known whether Carmine Shiner would move to other habitats in response to climate change and, if so, whether there is potential for hybridization with other minnows.

SOURCES OF UNCERTAINTY

The conservation or recovery of Carmine Shiner in Manitoba is hindered by a lack of knowledge of the species' biology, life history and habitat requirements, preventing an accurate evaluation of potential threats. Knowledge of their distribution, seasonal habitat use of each life stage, spawning requirements and interactions with other species is limited. Their response to potentially limiting environmental factors, including temperature extremes, turbidity and flow is also uncertain.

Survival rates are needed, especially for age-0 fish. Information about population growth rate and population abundance is also needed, as well as the probability of catastrophes (i.e., frequency and magnitude) for Carmine Shiner in Manitoba to improve population modelling. Knowledge is also needed about whether repetitive spawning occurs and how much space an individual fish requires. Another source of uncertainty is the idealized population size for the existing habitat (an estimate of the carrying capacity). The importance of habitat connectivity needs to be investigated.

A better understanding of the similarities and differences in genetics and life history between Carmine Shiner and Rosyface Shiner would also be helpful.

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