RECOVERY POTENTIAL ASSESSMENT OF CARMINE SHINER (*Notropis percobromus*) IN CANADA

Carmine Shiner Notropis percobromus
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Figure 1. Distribution of Carmine Shiner in Canada.

Context:

*The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Carmine Shiner (*Notropis percobromus*) 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.*

A species Recovery Potential Assessment (RPA) was conducted by DFO Science to provide the information and scientific advice required to meet various requirements of the SARA and assess the recovery potential of Carmine Shiner in Canada. This Science Advisory Report is from the March 15-16, 2011, Recovery Potential Assessment of Carmine Shiner. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The known distribution of the Carmine Shiner is limited to the Winnipeg River, at the base of Whitemouth Falls, and its tributaries (Whitemouth, Birch, Bird, and Lee rivers).
- This species is common, but not abundant, in the midcourse reach of the Whitemouth River and lower reach of the Birch River. Current estimates of population abundance and trajectory are not available.

- In the Whitemouth River system, adult Carmine Shiner frequent shallow riffles with clear water with predominantly sand and gravel substrates. Little is known about nursery, rearing or feeding areas. Longitudinal and lateral connectivity and riparian habitat are likely important. Spawning occurs in relatively warm, clear water from mid-June into July.
- Persistence (i.e., maintaining healthy, viable populations in all locations where they currently exist) rather than recovery reflects a more appropriate long-term goal for this species.
- A population with persistence probability of about 97% over 100 years and quasi-extinction threshold of two adults (one female and one male), experiencing a 10% chance of catastrophe (a one-time decline in abundance of 50% or more) per generation, would require at least 8,884,000 (range: 6,137,000-14,480,000) adult Carmine Shiner (aged 1+) and 3,335 ha of suitable habitat.
- In the absence of additional harm, recovery efforts or habitat limitations, a population at 10% of Minimum Viable Population has a 95% chance of recovering within 12 years (if the probability of catastrophe is 10% per generation). Increasing either the fecundity rate or the annual survival rate of immature Carmine Shiner would have the largest proportional effect on recovery time.
- The greatest threat to the survival and persistence of Carmine Shiner is habitat degradation and loss, especially as a result of flow alteration.
- Carmine Shiner is particularly sensitive to perturbations that affect fecundity and survival in the first year of life.
- Activities that negatively affect key components of the life cycle and damage or destroy functional components of the habitat pose a very high risk to the survival and persistence of Carmine Shiner.
- There remain numerous sources of uncertainty related to Carmine Shiner: life history characteristics, including survival rates, population growth rate and abundance; habitat requirements, including the distribution and extent of suitable habitat, seasonal habitat use and spawning requirements; and an understanding of the environmental factors that limit their existence.

BACKGROUND

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). This Recovery Potential Assessment (RPA) focuses on the Carmine Shiner in Canada, and is a summary of the peer-review meeting that occurred on March 15-16, 2011, in Winnipeg, Manitoba. Two research documents, that provide technical details and the full list of cited material, were reviewed during the meeting. One of the research documents provides background information on the species biology of Carmine Shiner, habitat preferences, current status, threats and mitigations and alternatives (Watkinson and Sawatzky 2013), and the other on allowable harm, population-based recovery targets, and habitat targets (Young and Koops 2013). The proceedings report summarizes the key discussions of the meeting (DFO 2013). This Science Advisory Report summarizes the main conclusions and advice from the science peer review.

Taxonomy

The Carmine Shiner is a small minnow of the genus *Notropis*. It is a member of the Rosyface Shiner species complex which includes Rosyface Shiner (*N. rubellus*), Highland Shiner (*N. micropteryx*), Rocky Shiner (*N. suttkusi*), Carmine Shiner, and a yet to be described species. Members of this genus are difficult to distinguish from one another based on morphology and meristics, and phylogenetic relationships among them are largely unresolved (Watkinson and Sawatzky 2013). The Manitoba population has been identified as Carmine Shiner based on the biogeographic information (Stewart and Watkinson 2004).

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 (Watkinson and Sawatzky 2013). This species is olive green dorsally, silvery with blue/purple hues on the sides and silvery white on the belly. 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, sometimes the entire head, and at the base of each fin. Breeding females are usually a paler colour on the sides.

This species matures at about age-1 and can live to at least age-3. Spawning individuals (male and female) attain fork lengths in the range of 55 to 67 mm in Manitoba (Watkinson and Sawatzky 2013) and the number of eggs per female increases with size. Little is known of the species' spawning habits. Carmine Shiner in spawning condition have been caught in the Pinawa Channel, the Whitemouth River, and in the Birch River in areas with sand, gravel, cobble, boulder and bedrock substrates (DFO unpubl. data). Females collected in the Birch River in 2011 had mature eggs in July when water temperatures were between 20 to 30°C. 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).

It is likely the Carmine Shiner hybridizes with other species given that the Rosyface Shiner, a close relative, hybridizes naturally with several species including Common Shiner (*Luxilus cornutus*) whose distribution overlaps with Carmine Shiner in Manitoba (Watkinson and Sawatzky 2013).

Carmine Shiner taken from the Whitemouth River were found to have consumed a variety of invertebrates during the summer, mostly aquatic and terrestrial insects (DFO unpubl. data). There is little information available on the predators, parasites, and diseases of the Carmine Shiner. In Manitoba, Walleye (*Sander vitreus*), Northern Pike (*Esox lucius*), and fish-eating birds likely prey on Carmine Shiner.

The Carmine Shiner appears to occupy a relatively narrow ecological niche, which suggests limited adaptive ability (Watkinson and Sawatzky 2013). The closely-related Rosyface Shiner also has a narrow range of habitat requirements and responds quickly to changes in habitat and water quality. For example, Rosyface Shiner exhibits long-term avoidance of pollutants and avoid water temperatures greater than 27.2°C (Watkinson and Sawatzky 2013).

Although Carmine Shiner has no direct economic importance as a commercial, recreational or aboriginal fishery and limited importance as a forage species, it is of scientific interest (Watkinson and Sawatzky 2013). It has intrinsic value as a contributor to Canada's biodiversity. Since Carmine Shiner in Manitoba represents the northwestern limit of the distribution of this species, these fish may be unique and provide evidence of local adaptations 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. They were later found in the Winnipeg River at the base of Whitemouth Falls (DFO unpubl. data). Surveys conducted since 2002 have expanded their known distribution to include the Whitemouth, Birch, and Bird rivers, and Lee River just downstream of the Old Pinawa Dam (Stewart and Watkinson 2004). 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. Figure 2 shows the sampling locations for Carmine Shiner.

Historic and Current Abundance and Trends

Prior to its listing by COSEWIC, the Carmine Shiner had only been reported incidentally in Manitoba. This species is common but not abundant in the midcourse reach of the Whitemouth River and lower reach of the Birch River. Since 2002, catch per unit effort data have been collected. However, as most of the survey effort was directed at collecting fish in new locations there are no estimates of abundance or population trajectory so the current 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 in Manitoba. Based on 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 (Watkinson and Sawatzky 2013). 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. In Manitoba, Carmine Shiner spawns in relatively warm (i.e., 20°C to 30°C), clear water and frequents shallow, flowing water with clean rocky substrates. Little is known about the locations of their nursery, rearing or feeding areas. The habitat requirements of young-of-the-year (YOY) Carmine Shiner are unknown. 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 this species.

Residence

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.

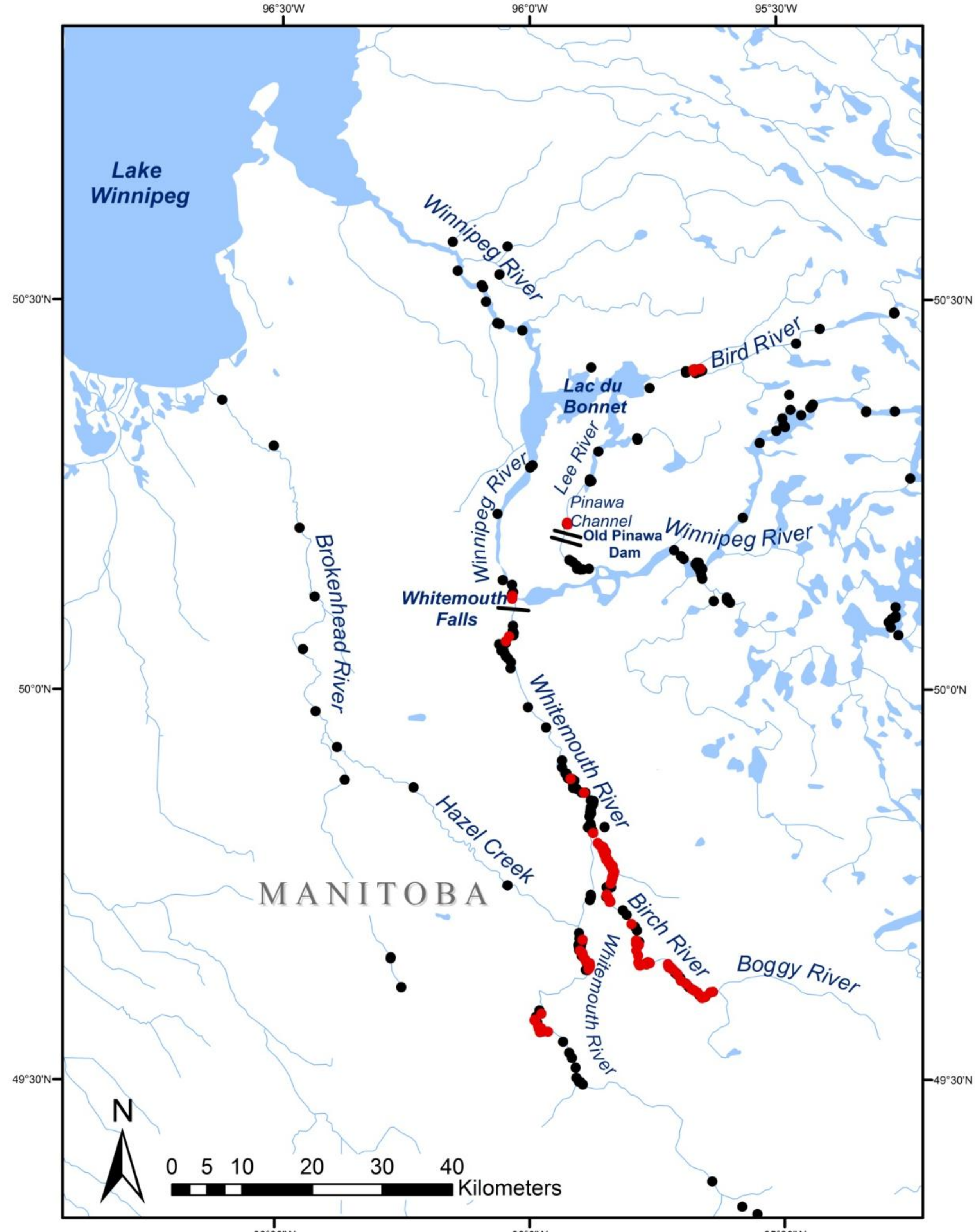

Figure 2. Distribution of Carmine Shiner in Canada. Red dots identify locations where Carmine Shiner were found, black dots are locations sampled without finding Carmine Shiner.

Allowable Harm

Allowable harm was assessed in a demographic framework with the assessment involving perturbation analyses of population projection matrices and including a stochastic element. Outputs of the analyses included calculation of a population growth rate and its sensitivity to changes in vital rates. See Young and Koops (2013) for complete details of the model and results. Based on the mean vital rates, the population growth rate of Carmine Shiner was estimated to be λ = 2.3. Modelling indicated that population growth of this species is very sensitive to perturbations of both fecundity (*f*) and survival in the first year (s_1). Carmine Shiner is relatively insensitive to changes in adult survival ($s_{2)}$ (Figure 3). Uncertainty in sensitivity is driven primarily by uncertainty in the estimate of juvenile survival. Maximum allowable harm should be limited to 59% in either survival of age-0 individuals or fecundity. If human activities are such that harms exceed 27% per vital rate for all aspects of the Carmine Shiner life cycle simultaneously, the future survival of the population is likely to be compromised.

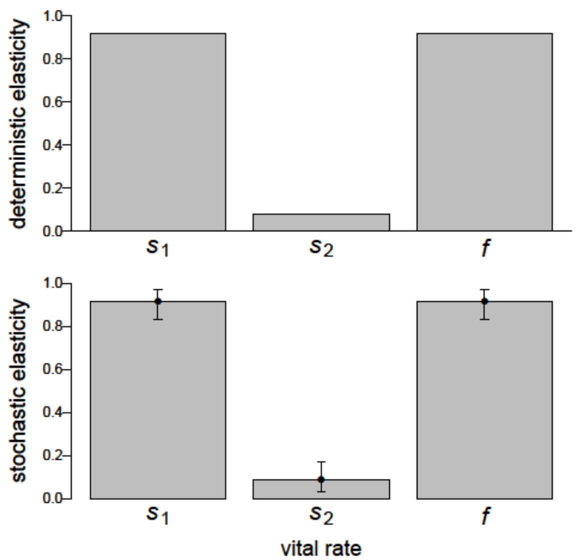

Figure 3. Results of the deterministic and stochastic perturbation analysis showing elasticities (ε_v) of the vital rates: annual survival probability of age j-1 to age j (s_i) and fertility (f). Stochastic results include associated bootstrapped 95% confidence interval.

Recovery Targets

Recovery Targets and Times

Demographic sustainability was used as a criterion to set recovery targets for Carmine Shiner (Young and Koops 2013). Demographic sustainability is related to the concept of a MVP and was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (approximately 77 generations). MVP targets were chosen to optimize the benefit of reduced extinction risk and the cost of increased recovery effort, and resulted in a persistence probability of approximately 97% over 100 years. Assuming that the chance of catastrophic decline was 5% or 10% per generation, simulations indicated that MVPs for a Canadian population of Carmine Shiner are about 516,000 (range: 346,000–817,000) or 8,884,000 (range: 6,137,000–14,480,000) adults (ages 1 and 2), respectively. In both scenarios, the probability of extinction for the respective MVPs were approximately 0.03 over 100 years (Figure 4). Populations were considered extinct at less than 2 adults (one male and one female). MVP is very sensitive to uncertainty in YOY survival. If the true variance of this parameter is smaller than the variance estimated in this modelling, MVP will also be smaller (Young and Koops 2013).

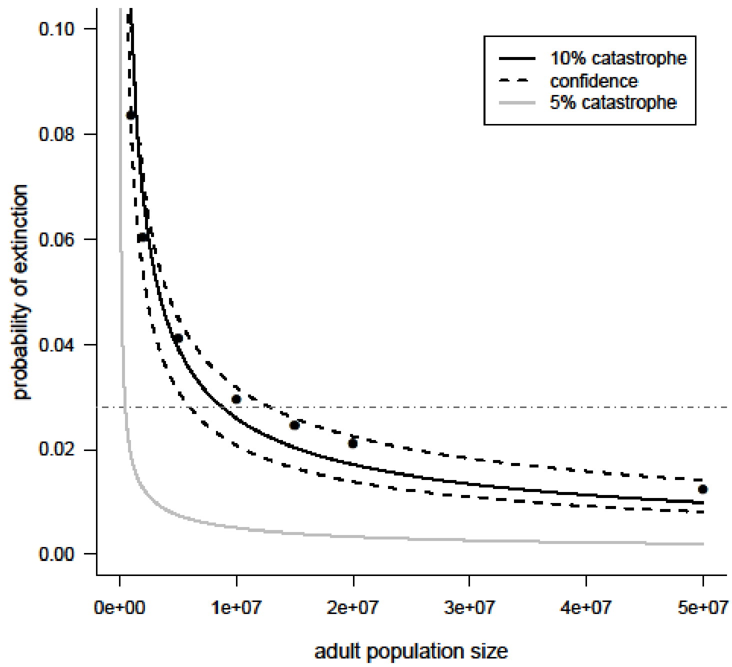

Figure 4. Probability of extinction within 100 years of 10 simulated Carmine Shiner populations at equilibrium, as a function of population size. Bold curves assume a 10% probability of catastrophic decline per generation (solid = mean, dotted = max and min of 10 runs). Solid grey line represents 5% probability of catastrophe. Dashed horizontal reference line is at 0.028 and intersects curves at the associated MVPs.

Assuming a population growth rate of 2.3 and in the absence of recovery efforts additional harm, or habitat restrictions, a Carmine Shiner population was predicted to increase from 20,000 adults to the MVP target of 8.9 million adults in approximately 12 years (assuming a 10% per generation probability of catastrophe). Simulated recovery strategies decreased recovery times as much as 3 years (Young and Koops 2013). The most effective simulated strategy was an improvement to survival of immature individuals ($s_{1,2}$). Conversely, the time to recovery increased exponentially as harm was added to vital rates (Figure 5).

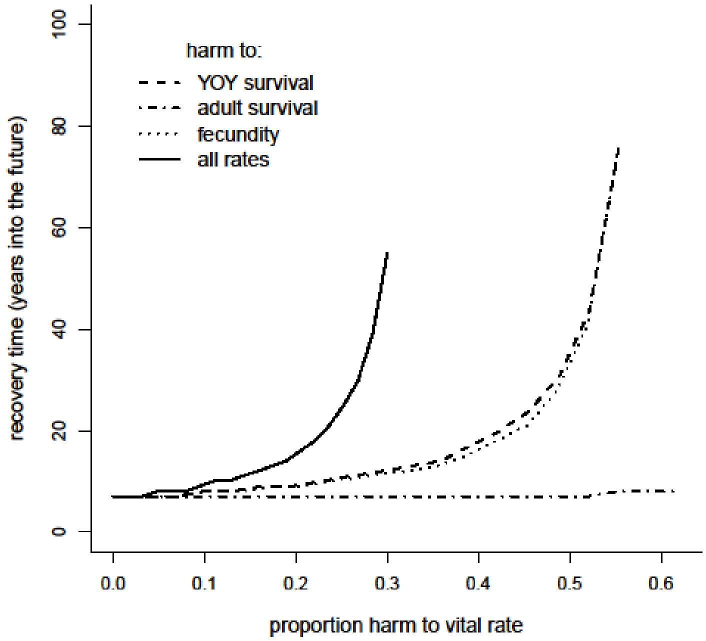

Figure 5. Predicted change in the time to 95% chance of recovery of a Carmine Shiner population that is experiencing increased harm to young of the year survival (s_1), adult survival (s_2), fecundity (f) or all vital rates simultaneously. Recovery times are shown as a function of the proportion reduction to each vital rate(s). 10% per generation probability of catastrophe assumed.

Minimum Area for Population Viability

Minimum area for population viability (MAPV) is a quantification of the amount of habitat required to support a viable population. Variables included in the MAPV assessment include MVP values and area required per individual (API values). API values were estimated from an allometry for river environments from freshwater fishes. A MAPV was estimated for each life stage and then an MAPV for the entire population was estimated by summing across all life stages. The stable stage distribution for Carmine Shiner is 99.84% YOY, 0.13% age-1, and 0.03% age-2 individuals. With a target MVP of 8.9 million adults, under a 10% probability of catastrophe per generation, MAPV was 3,335 ha. A population at the target size with this amount of suitable habitat had a 95.6% probability of persistence over 100 years (Figure 6). This is only slightly lower than the 97% probability of persistence observed in simulations that did not include habitat restrictions or density dependence. However if habitat was reduced below the MAPV level, the extinction risk increased exponentially. The estimated available Carmine Shiner habitat in the Birch and Whitemouth rivers is 402 ha, which would support only 12% of a recovered population. Note the MAPV estimates assume the required habitat per individual, not taking into account any overlapping of individual habitats (sharing) that may occur.

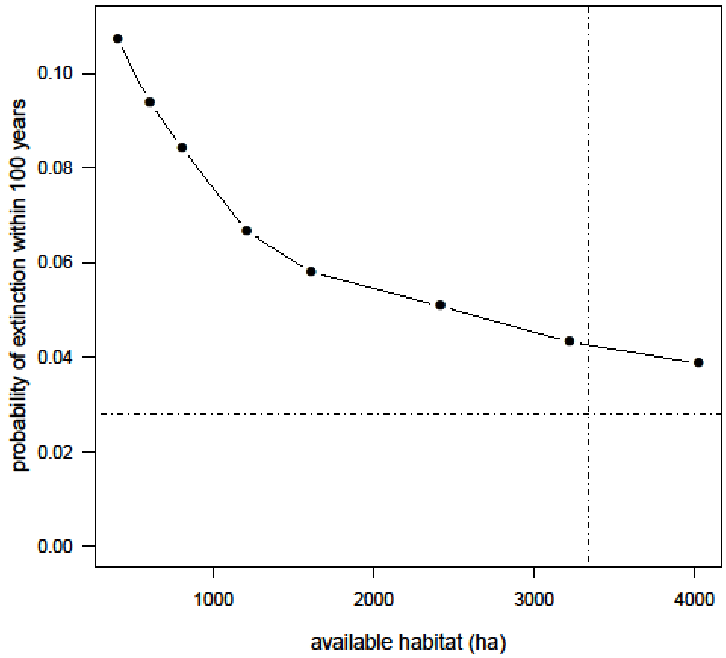

Figure 6. Probability of extinction within 100 years of 10 simulated Carmine Shiner populations at minimum viable population (MVP) size of 8.9 million adults, and experiencing habitat based density dependence, as a function of available habitat area. Simulations assume a 10% chance of catastrophe. Left endpoint represents estimated available habitat. Dashed reference lines show Minimum Area for Population Viability (MAPV, vertical) and the probability of extinction in the absence of habitat restrictions (0.028, horizontal).

Threats to Survival and Recovery

Carmine Shiner may be negatively impacted by a variety of human activities, however, available information on threat-specific cause and effect for this species in Canadian waters is limited. 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 their distributions (Watkinson and Sawatzky 2013). 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 (e.g., forestry, agriculture, peat extraction, and highway development) might also adversely affect Carmine Shiner. Other threats that may lessen the survival of these minnows include the introduction of exotic species, which can result in predation, competition, food web disruption or exposure to diseases and parasites, and pollution from point sources (e.g., contaminants and toxic substances) and non-point sources (e.g., nutrient loading). The incidental harvest of Carmine Shiner by bait fishing operations and routine scientific sampling have also been identified as potential threats to this species.

To assess the Threat Status of Carmine Shiner in the Whitemouth, Bird and Birch rivers and Lee River just below the Old Pinawa Dam, each threat was ranked in terms of its Threat Likelihood and Threat Impact. It is important to note that threats may not always act independently. One threat may directly affect another or the interaction between two threats may introduce an interaction effect. As it is quite difficult to quantify these interactions, each threat is evaluated independently (see Watkinson and Sawatzky 2013 for a description of each threat and its potential impacts on Carmine Shiner).

The Threat Likelihood and Threat Impact ratings were subsequently combined in the Threat Status Matrix resulting in the final Threat Status (Table 1).

Table 1. 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 of pollution	Unknown		

Mitigations and Alternatives

Habitat Loss/Degradation

Many of the threats affecting Carmine Shiner are related to habitat loss or degradation. Habitat-related threats have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (Coker et al. 2010), 17 of which apply to freshwater systems. This guidance should be referred to when considering mitigation and alternative strategies for habitat-related threats. They were developed to mitigate or limit threats, however since they were not developed to specifically consider species at risk they may need to be modified for this purpose. Additionally, site-specific mitigations may be warranted and should be discussed with local conservation managers. Table 2 identifies the relevant Pathways of Effects for Carmine Shiner.

Pollution

The DFO mitigation guide also provides guidance on generic mitigation measures for Pathways of Effects related to pollution from point and non-point sources. Table 2 identifies 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.

Table 2. Threats to Carmine Shiner in Canada and the Pathways of Effects 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; 9 – Marine seismic surveys; 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; 19 – Placement of marine finfish aquaculture site.

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 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. Preventing introductions is a more effective strategy for mitigating this threat than removal once they 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 directly or negatively affect their 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).

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 is not known to occur in areas where Carmine Shiner are found (Watkinson and Sawatzky 2013).

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 the harvest of baitfish if it occurs in areas where Carmine Shiner are known to exist.

Scientific sampling

Mitigation

- Non-lethal sampling or observational studies of Carmine Shiner.
- Sampling under a SARA permit

Alternatives

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

Sources of Uncertainty

Lack of knowledge of the species' biology, life history, habitat requirements, and ability to adapt to different conditions hinders the conservation or recovery of the Carmine Shiner and also prevents 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. Carmine Shiner appears to occupy relatively narrow ecological and bio-geographical niches, suggesting limited adaptive ability. Uncertainty about dispersal 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 (Watkinson and Sawatzky 2013).

Survival rates are needed, especially for age-0 fish, as well as information about population growth rate, and population abundance and also the probability of catastrophes (i.e., frequency and magnitude) for Carmine Shiner in Manitoba to improve population modelling. More knowledge is needed on the spawning period of Carmine Shiner (duration and space requirements). Another source of uncertainty is the idealized population size for the existing habitat (an estimate of the carrying capacity). The importance of habitat connectivity also 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.

SOURCES OF INFORMATION

This Science Advisory Report is from the March15-16, 2011 Recovery Potential Assessment of Carmine Shiner. Additional publications from this meeting will be posted on the [Fisheries and Oceans Canada (DFO) Science Advisory Schedule] as they become available.

Coker, G.A., Ming, D.L., and Mandrak, N.E. 2010. Mitigation guide for the protection of fishes and fish habitat to accompany the species at risk recovery potential assessments conducted by Fisheries and Oceans Canada (DFO) in Central and Arctic Region. Version 1.0. Can. Manuscr. Rep. Fish. Aquat. Sci. 2904. vi + 40 p.

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Stewart, K.W. and Watkinson, D.A. 2004. The freshwater fishes of Manitoba. University of Manitoba Press, Winnipeg, MB. 276 p.

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.

Young, J.A.M. and Koops, M.A. 2013. Recovery potential modelling of Carmine Shiner (*Notropis percobromus*) in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/013. iv + 20 p.

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Centre for Science Advice (CSA)
Central and Arctic Region
Fisheries and Oceans Canada
501 University Crescent
Winnipeg, MB
R3T 2N6

Telephone: (204) 983-5131
E-Mail: xcna-csa-cas@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

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