Fisheries and Oceans Canada Pêches et Océans Canada
Science Sciences
Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2013/042

RECOVERY POTENTIAL ASSESSMENT OF PLAINS MINNOW (*Hybognathus placitus*) IN CANADA

Plains Minnow (Hybognathus placitus). Illustration by Joe Tomelleri, reproduced with permission.

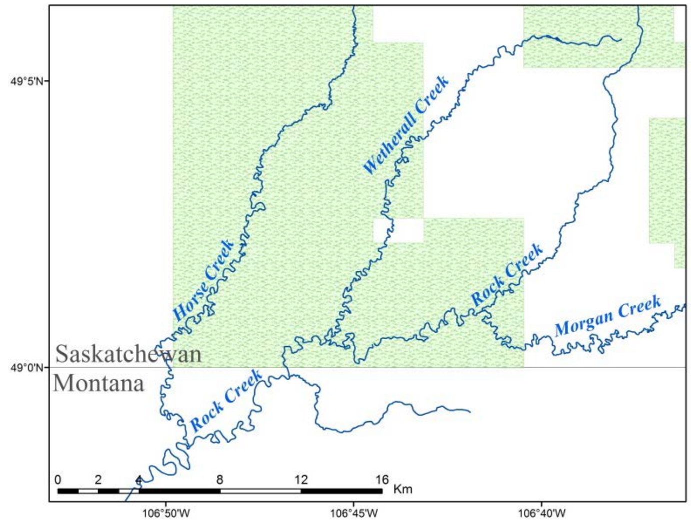

Figure 1. General range where Plains Minnow occurs in Canada. Green shading indicates Grasslands National Park.

Context:

In May 2012, a meeting of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Plains Minnow (Hybognathus placitus) *be designated as Threatened. The Plains Minnow is now being considered for listing under the* Species at Risk Act *(SARA).*

A species Recovery Potential Assessment (RPA) process has been developed by Fisheries and Oceans Canada (DFO) Science to provide the information and scientific advice required to meet the various requirements of the SARA, , to support decision making with regard to SARA agreements and permits as well as to support development of recovery strategies. The scientific information also serves as advice to the Minister of DFO regarding the listing of the species under the SARA and is used when analyzing the socio-economic impacts of adding the species to the list as well as during subsequent consultations, where applicable. This assessment considers the scientific data available with which to assess the recovery potential of Plains Minnow in Canada.

*This Science Advisory Report is from the December 12, 2012, Recovery Potential Assessment of Plains Minnow (*Hybognathus placitus*). Additional publications from this meeting will be posted on the* Fisheries and Oceans Canada (DFO) Science Advisory Schedule *as they become available.*

SUMMARY

- The Canadian distribution of Plains Minnow is currently limited to Rock and Morgan creeks in Saskatchewan.
- Adults are habitat generalists and typically inhabit turbid, sandy, silty waters with a preference for backwaters and embayments. Little is known about young-of-the-year and juvenile habitat.
- Plains Minnow move upstream to spawn during periods of moderate to high flows which are required for successful reproduction. It has been estimated that more than 100 km of flowing river habitat is required for the development of larvae.
- Current population abundance in Canada is estimated at approximately 41,800 adults (80% confidence intervals 2,400–55,400) which is considered High but population trajectory is Unknown, resulting in an overall population status of Fair.
- Based on this abundance, if the population is stable then the risk of extirpation within 100 years is 2% (1–69%).
- To achieve a 99% probability of persistence, given a 15% per generation chance of catastrophic (50%) decline, requires approximately 60,600 adult Plains Minnow.
- 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.
- Population growth of Plains Minnow is most sensitive to changes in the survival of immature individuals. It may also be sensitive to fecundity of first time spawners if post spawning mortality is high, or to survival in the second year if the population is stable or in decline.
- At least 12 ha of suitable habitat, including 115 km of barrier-free river, is needed to support the current estimate of abundance. Available habitat in Canada is estimated at 12 ha including 26.5 km of barrier-free river, therefore maintaining connectivity with Rock Creek in the U.S. is essential. The quality of this habitat is unknown.
- The greatest threats to Plains Minnow in Canada are habitat removal and fragmentation, alteration of natural flow regimes, exotic piscivores, and climate change.
- To avoid a decrease in population growth rate larger than 1%, transient harm (one-time removal of individuals) should not exceed a 12.5% reduction in adult abundance, or a 17% reduction in young-of-the-year abundance, or a 7.5% reduction in total abundance within a seven-year period.
- There are several sources of uncertainty regarding Plains Minnow biology, ecology, life history, habitat requirements, estimated population abundance, and Canadian distribution. A thorough understanding of the severity and impacts of threats facing Plains Minnow in Canada is also lacking.

BACKGROUND

The Plains Minnow (*Hybognathus placitus*) is a small freshwater fish that in Canadian waters occurs within a very limited area of southern Saskatchewan (Figure 1). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) recommended that Plains Minnow be designated as Threatened in May 2012. The reason given for this designation was that Plains Minnow “has a very limited distribution in Canada at only one or two locations, both of which are small streams subject to drought. The species requires long stretches of flowing water to complete its life cycle. Further threats to water supply from additional irrigation dams and excessive drought would increase risks to this species.” Plains Minnow has not yet been listed under the *Species at Risk Act* (SARA). When COSEWIC designates a species as Threatened or Endangered and the Governor in Council decides to list it, the Minister of Fisheries and Oceans (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 population, the threats to its survival and recovery, and the feasibility of its recovery. This scientific advice is developed through a Recovery Potential Assessment (RPA). This allows for the consideration of peer-reviewed scientific analyses in subsequent SARA processes, including recovery planning and issuance of SARA permits.

An RPA of Plains Minnow in Canada was conducted during a Canadian Science Advisory Secretariat peer-review meeting on December 12, 2012, 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, habitat preferences, current status, threats and mitigations and alternatives (Sawatzky and Watkinson 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.

Species Description and Identification

Plains Minnow is a large, silvery minnow with a slightly compressed body, small triangular head with a subterminal mouth, relatively small eyes located immediately above the midline of the head and a complete lateral line with 34–42 scales. Males have longer first dorsal rays and larger heads and caudal peduncles, while females have deeper and longer bodies. Breeding males develop small nuptial tubercles on the head, back and pectoral fin. Plains Minnow is morphologically similar to Mississippi Silvery Minnow (*H. nuchalis*) and Western Silvery Minnow (*H. argyritis*) and may be distinguished by its simple basioccipital process, smaller eye and slightly smaller scales. Average total length (TL) is 50–90 mm, with a maximum reported size of 125–130 mm TL. It is unknown if Plains Minnow reach maturity at age 1 in Canada. Post-spawning mortality is high, with few living beyond age 2. Plains Minnow are thought to be herbivorous or detrivorous, with a diet consisting mainly of benthic algae, diatoms and other microflora.

ASSESSMENT

Current Species Status

In Canada, Plains Minnow is restricted to approximately 26.5 river km in southern Saskatchewan where they have been found at only a few locations in Rock and Morgan creeks (Figure 2). The first Canadian record is of seven Plains Minnow collected from one site on Morgan Creek in 2003. Subsequent targeted sampling by DFO confirmed their presence and refined knowledge of the species' range. The Canadian portion of their global distribution comprises less than 1% of the total and represents the northernmost extent of their range.

Targeted sampling by DFO in the Missouri River watershed in Canada between 2003 and 2007 captured 202 Plains Minnow in 13 collections from Rock and Morgan creeks; all were aged ≥ 1 year. Information on population fluctuation and trends for Plains Minnow in the Canadian portion of their range is not available as historical data is lacking. Natural fluctuations in distribution and numbers are likely given the species' short generation time and the varying hydrographs of the creeks.

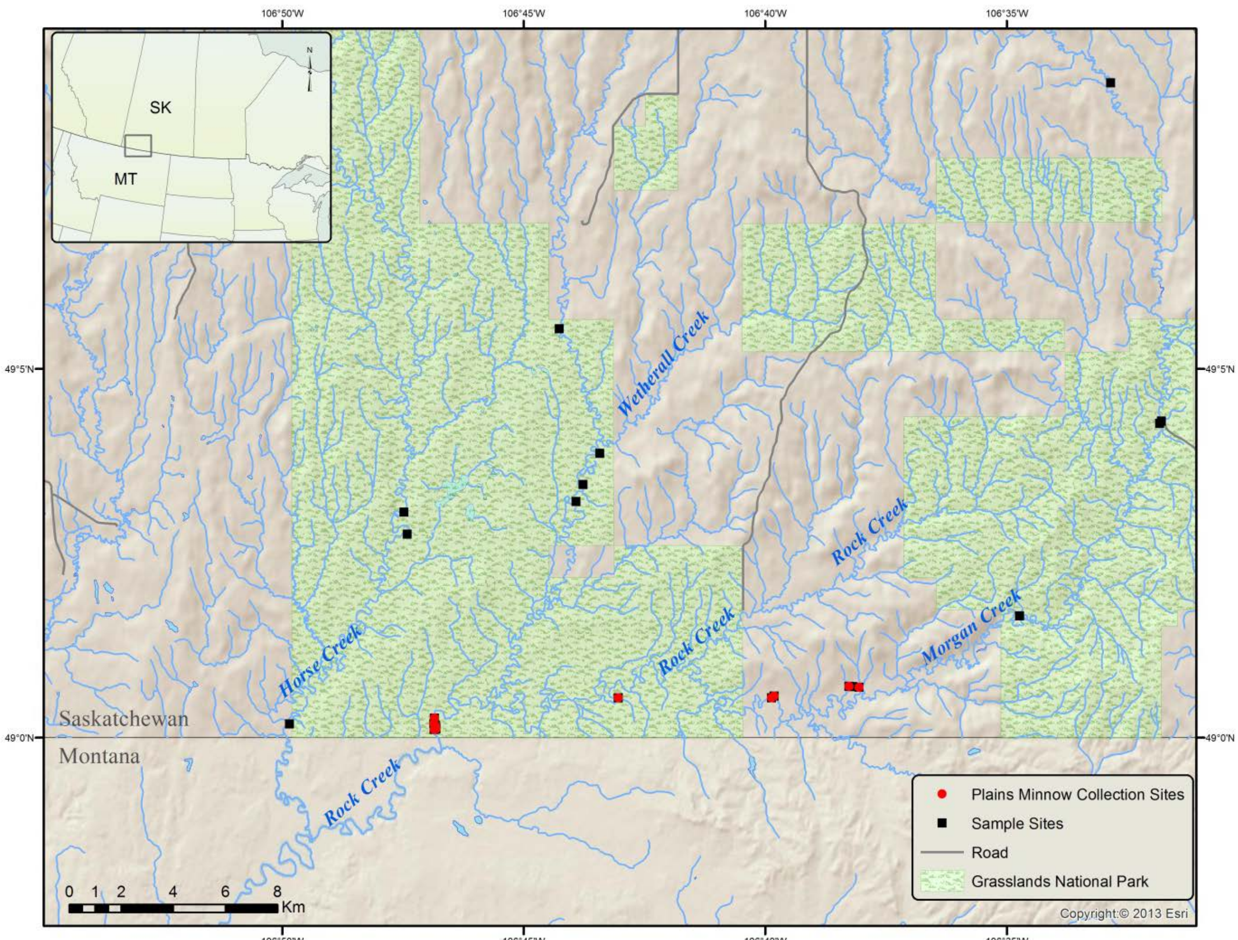

Figure 2. Canadian point distribution of Plains Minnow in Rock and Morgan creeks (in Saskatchewan), and location of sample sites where Plains Minnow were not found (modified from COSEWIC 2012). Note that about 15.5 river km upstream of the Montana/Saskatchewan border, Rock Creek branches into Morgan Creek and Rock Creek. According to the Canadian Gazetteer, Morgan Creek is the name of the upper portion of the mainstem branch as shown in this map. The upper portion of Rock Creek is the tributary that feeds into the mainstem.

Population Status

To assess the Population Status of Plains Minnow in Canada, the population was ranked in terms of its abundance (Relative Abundance Index) and trajectory (Population Trajectory). The Relative Abundance Index is a relative parameter in that the values assigned to each population are relative to the most abundant population. However, in the case of Plains Minnow there is only one population in Canada and only one crude abundance estimate available. This was compared to an abundance estimate calculated for Plains Minnow in the U.S. portion of the Rock Creek drainage. On the basis of current estimates of abundance, the Relative Abundance Index of Plains Minnow in the Canadian portion of the Rock Creek drainage is rated High relative to the U.S. portion of the drainage (Table 1). As no historical data are available for comparison, Population Trajectory of Plains Minnow in Canada is rated Unknown (Table 1). The Relative Abundance Index and Population Trajectory values were combined in the Population Status Matrix to determine the Population Status. The resulting Population Status of Plains Minnow for the Rock Creek and Morgan Creek is Fair with certainty based on expert opinion (Table 1). (Refer to Sawatzky and Watkinson (2013) for the complete Population Status assessment method.)

Table 1. Relative Abundance Index, Population Trajectory and Population Status of Plains Minnow in Canada. The level of Certainty associated with the Relative Abundance Index and Population Trajectory rankings is based on quantitative analysis (1), CPUE or standardized sampling (2) or expert advice (3). Population Status results from an analysis of both the Relative Abundance Index and Population Trajectory. Certainty assigned to each Population Status is reflective of the lowest level of certainty associated with either initial parameter (Relative Abundance Index, or Population Trajectory).

Population	Relative Abundance Index	Certainty	Population Trajectory	Certainty	Population Status	Certainty
Rock and Morgan creeks	High	2	Unknown	3	Fair	3

ASSESSING THE HABITAT USE OF PLAINS MINNOW

Habitat requirements

Knowledge of Plains Minnow habitat in Canada is limited; much of the information presented below is from areas outside of its Canadian range.

Spawning

Little information on Plains Minnow spawning habitat is available in the literature, due in part to their preference for turbid waters, making observation in the wild difficult. Plains Minnows are fractional spawners, spawning at different times in spring through summer during periods of high flow. They belong to a guild of pelagic broadcast spawners. Adults move upstream to spawn during periods of moderate to high flows which are required for successful reproduction. Groups of Plains Minnow have been observed in spawning season during receding high flows in the Cimarron River, Oklahoma, in quiet water along sandbars and in backwaters and schools have been observed preparing to spawn in shallow backwaters. Drifting eggs have also been collected under similar conditions.

Larvae and Juveniles

Little information is available on larval and juvenile habitat, although it is likely similar to that of adults (but not in the same geographical location as adults migrate upstream during spawning season and fertilized eggs drift downstream during development). Eggs hatch in 24–48 hours, depending on temperature. Continuous entrainment of eggs in the water column until hatching appears to be necessary for successful egg development, which has been calculated to occur over 72–144 km of unimpeded river assuming a conservative flow estimate of 3 $km \cdot h^{-1}$. Developing proto-larvae may be carried an additional 216 km during the swim-up stage. The estimated minimum threshold in fragment length for Plains Minnow was calculated to be 115 river km.

Age-0 Plains Minnow have been captured over a hard silt-sand substrate overlaid by loose sand in a narrow, deeply incised channel of the Pecos River, New Mexico. In the same study, age-0 fish were also captured over sand substrate in the wide, braided main channel of the river. Backwater areas may be particularly important as nursery areas due to the increased availability of food.

Adults

The habitat information presented below for Plains Minnow collected in the Rock Creek drainage by DFO are from fish that were ≥ 1 year of age.

Stream characteristics

Adults typically inhabit, often turbid, sandy, silty rivers and have been classified as habitat generalists with a preference for both backwaters and embayments, while avoiding higher velocity mid-channel habitats. They are typically most abundant where sediments accumulate in shallow backwater areas, calm eddies and along edges of shifting dunes in sand-bed rivers with current. Within the Canadian portion of their range, they have been captured in June in run and pool habitat with a mean wetted width of 2.26–3.24 m and at depths less than approximately 1.2 m. DFO collected Plains Minnow in September in Rock and Morgan creeks at an average depth of 0.58 m (range: 0.34–1.2 m) and a mean velocity of 0.02 $m \cdot s^{-1}$ (range: 0–0.11 $m \cdot s^{-1}$).

The Plains Minnow has a high Critical Thermal Maxima (39.7 ± 0.7°C) and a low minimum dissolved oxygen tolerance (2.08 ± 0.14 $mg \cdot l^{-1}$). In the Little Missouri River, North Dakota, Plains Minnow was captured at water temperatures ranging from 15–22°C at dissolved oxygen concentrations > 5 $mg \cdot l^{-1}$.

Rivers occupied by Plains Minnow may be clear to highly turbid with high dissolved solids. They often dry to intermittent pools during times of low flow, but are also subject to flash floods of turbid water during heavy rains. This species is capable of tolerating such conditions and the low water quality that may result. In the Little Missouri River, North Dakota, Plains Minnow was captured at specific conductance ranging from 330–700 $\mu S \cdot cm^{-1}$, Secchi depths ranging from 0.05–0.2 m and pH 7–7.5. In the Rock Creek drainage they have been captured in September in water with a mean Secchi depth of 0.20 m (range: 0.12–0.32 m) and specific conductance of 1,516 $\mu S \cdot cm^{-1}$ (range: 1,082–2,370 $\mu S \cdot cm^{-1}$). Preferred ranges of total dissolved solids and pH could not be found in the literature. Maximum salinity tolerance was determined in the laboratory to be 16 ± 1.94‰.

Little information is available on vegetation presence or absence in habitats utilised by this species. Plains Minnows were commonly caught in vegetated areas in the Little Missouri River, North Dakota. In intermittent prairie streams submerged macrophytes are generally absent, but emergent aquatic vegetation is common and abundant; during the dry season, stream beds often support terrestrial vegetation. Riparian vegetation at the site in Morgan Creek where Plains Minnow was captured consisted of a mixture of grasses, sedges and shrubs.

Plains Minnow is most often found over sand substrate and only rarely occur over rock or mud bottoms. In the Rock Creek drainage the species was captured at sites with silt, sand and gravel substrates, including two areas with 100% silt substrate, one area with 100% sand, three areas of 50% sand and 50% silt, and two areas that were 60% silt and 40% gravel.

Functions, Features and Attributes

A description of the functions, features and attributes associated with Plains Minnow habitat can be found in Table 2. (Refer to Sawatzky and Watkinson (2013) for definitions of functions, features and attributes.) Habitat attributes from the literature, largely from more southerly areas of their distribution, are presented alongside current records within Canada (from 2006 and 2007) to show the maximum range in habitat attributes within which the Plains Minnow may be found. This information is provided to guide any future identification of critical habitat for this species. It should be noted that habitat attributes associated with current records may differ from optimal habitat as Plains Minnows may be occupying sub-optimal habitat where optimal habitat is not available.

Residence

Residence is defined by the SARA 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 constructed by the organism. In the context of the above description of habitat requirements during larval, juvenile and adult life stages, Plains Minnow does not construct residences during its life cycle.

Recovery Targets

Population modelling was used to determine population-based recovery targets and conduct long-term projections of population recovery under a variety of feasible recovery strategies. It is based on a demographic approach (Young and Koops 2013). Demographic sustainability was used as a criterion to set recovery targets for Plains Minnow. Demographic sustainability is related to the concept of a minimum viable population (MVP) and was defined as the minimum adult population size that results in a desired probability of persistence over 100 years (approximately 42 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 99% over 100 years. Recommended targets were estimated at 60,600 adults (ages 1+), assuming the probability of a catastrophic (50%) decline was 0.15 per generation and an extinction threshold of two adults.

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. MAPV for the recommended recovered population (60,600 adults) was 12 ha of suitable Plains Minnow habitat with at least 115 km of barrier-free river. Current available habitat is estimated at 12.1 ha in Canada including 26.5 km of barrier-free river. The quality of this habitat is unknown.

Table 2. Summary of the essential functions, features and attributes for each life stage of Plains Minnow. Habitat attributes derived from the literature (typically outside of the Canadian range) and habitat attributes recorded during collections within Canada (2006 and 2007) have been combined to derive habitat attributes required for the delineation of critical habitat (see text for a detailed description of categories).

Life Stage	Function	Feature(s)	Literature Records United States	Literature Records Canada	Sampling Records	For Identification of Critical Habitat
Spawning	Reproduction (fractional spawners spring to summer)	• Flowing water of rivers or streams	• Require moderate to high flows[1,2,3,4] • Move to upstream areas to spawn[5] • Have been observed preparing to spawn in shallow backwaters (Kansas)[6]	No published information (requirements would be similar to the US)	None	• Can tolerate variable hydrology; periods of moderate to high flow in spring through summer required for successful reproduction • Unimpeded access to spawning areas
Egg to exogenous feeding	Nursery Cover	• Flowing water of rivers or streams, backwaters	• Moderate to high flows[1,2,4,5] • At a conservative flow rate of 3 km·h^{-1}, eggs (hatch in 24–48 hours depending on temperature[7]) are transported over 72–144 km of unimpeded river; developing protolarvae may be carried an additional 216 km[5] • Estimated minimum threshold in fragment length associated with population persistence: 115 river km[22] • Backwaters may be important as nursery habitat[7]	No published information (attributes would be similar to the US)	None	• Moderate to high flows • Minimum unimpeded length of 115 river km to allow developing eggs and protolarvae to be transported to suitable nursery areas • Specific, optimal habitat characteristics of nursery habitat are unknown
Juvenile	Feeding Cover	• Flowing water of rivers or streams, backwaters, intermittent pools	• Backwaters may be important feeding areas[3] • Captured over sand substrate[8] • Likely similar to adults (see below)	No published information (attributes would be similar to the US and likely similar to adults)	None	• Likely similar to adults (see below)

Life Stage	Function	Feature(s)	Literature Records United States	Literature Records Canada	Sampling Records	For Identification of Critical Habitat
Adult	Feeding Cover	• Backwater and embayment areas of rivers • Most abundant where sediment accumulates in shallow backwaters, calm eddies and along edges of shifting dunes in sand-bed rivers with current[6,17,18] • Non-impounded river reaches	**Captured at:** • **Depth:** 0.04– > 2 m[10,11,12] • **Main Channel Width:** 25–55 m[11] • **Mean Wetted Width:** 5.7 m (Montana)[23] • **Velocity:** 0–1.25 $m \cdot s^{-1}$ [10,12] • **Discharge:** 0.40–0.87 $m^3 \cdot s^{-1}$ at 0.5 m depth[11] • **Temperature:** 15–22°C at dissolved oxygen > 5 $mg \cdot l^{-1}$ (North Dakota)[11]; 7.5–37°C at dissolved oxygen 3.3–19.0 ppm (Oklahoma)[12] • **Specific Conductance:** 330–700 $\mu S \cdot cm^{-1}$ [11] • **pH:** 7.0–9.6[11,12] • **Secchi Depth:** 0.05–0.2 m[11] • **Total Dissolved Solids:** 470–1160 ppm[12] • **Salinity:** 2.0–8.0 psu[13] • **Turbidity:** 4–375 JTU[12]	**Captured at[19]:** • **Velocity:** < 0.5 $m \cdot s^{-1}$ • Substrate described as generally small (< 2.0 mm) • Run and pool habitat • Turbid water • Riparian vegetation: mixture of grasses, sedges and shrubs	• Sampled in September 2006 and 2007[20] **Captured at:** • **Depth:** 0.34–1.2 m (Avg: 0.58 m) • **Velocity:** 0–0.11 $m \cdot s^{-1}$ (Mean: 0.02 $m \cdot s^{-1}$) • **Temperature:** 11.3–16.6°C (Mean: 13.8°C) • **Specific Conductance:** 1082–2370 $\mu S \cdot cm^{-1}$ (Mean: 1516 $\mu S \cdot cm^{-1}$) • **Secchi Depth:** 0.12–0.32 m • **Substrate:** silt, sand, gravel	• Low to mid-velocity flows • Shallow backwaters, eddies • Substrate dominated by sand • Non-impounded turbid river reach with low relative abundance of exotic piscivores

References (full citations provided in Sawatzky and Watkinson 2013)

1 – Durham and Wilde 2008; 2 – Durham and Wilde 2009a,b; 3 – Lehtinen and Layzer 1988; 4 – Sliger 1967; 5 – Plantania and Altenbach 1998; 6 – Cross and Collins 1995; 7 – Moore 1944; 8 – Widmer et al. 2010; 9 – COSEWIC 2012; 10 – Peters et al. 1989; 11 – Kelsch 1994; 12 – Matthews and Hill 1980; 13 – Anderson et al. 1983; 14 – Ostrand and Wilde 2001; 15 – Cross and Moss 1987; 16 – Taylor and Miller 1990; 17 – Robison and Buchanan 1988; 18 – Pflieger 1997; 19 – Sylvester et al. 2005; 20 – DFO unpubl. data; 21 – Quist et al. 2004; 22 – Perkin and Gido 2011; 23 – Bramblett et al. 2005

Threats to Survival and Recovery

The greatest threats to Plains Minnow in Canada are habitat removal and fragmentation, alteration of natural flow regimes particularly from large impoundments, exotic piscivores, contaminants and toxic substances resulting from pipeline fractures and climate change. Additional threats which may impact this species include scientific sampling (targeted removal of Plains Minnow), turbidity and sediment loading, nutrient loading, contaminants and toxic substances resulting from sources other than pipeline fractures, alteration of natural flow regimes from small impoundments and dugouts, and barriers to movement.

It has been estimated that more than 100 km of flowing river habitat is required for the successful development of larvae and thus for the survival of Plains Minnow populations. Activities that threaten the persistence of flowing water in the Rock Creek drainage may severely limit Plains Minnow habitat and populations. Land in the watershed outside of Grasslands National Park is primarily used for cattle ranching. Given that the grazing lands are low quality and cattle density is therefore low, the direct impact is probably localized and limited to cattle drinking, stream bank trampling and non-point source nitrification. There have not been any new licensed water allocation projects in Rock Creek drainage since 2000. All existing licensed water allocation projects are located in the headwaters and none are located on the main stem; the majority are private projects for stock-watering purposes. There are a total of 12 reservoirs on Rock Creek with a cumulative capacity of 308.9 m^3 which represents a small proportion (1.84%) of the total annual natural flow volume. Future dam building in the Rock Creek watershed could potentially alter the natural flow regime in Plains Minnow habitat. DFO is not aware of any planned dam construction at this time.

In other areas of their range, declines in Plains Minnow abundance have been associated with exotic piscivores (e.g., Kansas River, Rio Grande River, among others). Game fish introduction would require new dams and reservoirs to provide habitat. Neither native nor exotic piscivores have been captured in Rock and Morgan creeks, however Northern Pike (*Esox lucius*) are present in the Milk River watershed and could access Rock Creek. An invasive species, Common Carp (*Cyprinus carpio*) has been found in the Rock Creek watershed, indicating that invasions by other aquatic species are possible. The impacts of Common Carp on Plains Minnow are unknown, but may include habitat disruption (from foraging on aquatic plants) or predation on eggs and young of Plains Minnow or directly compete with Plains Minnow for food.

The effects of climate change on Plains Minnow are highly speculative. Some of the predicted effects of climate change on the Canadian environment include increases in water and air temperatures, changes in water levels, shortening of the duration of ice cover, increases in the frequency of extreme weather events, emergence of diseases, drought and shifts in predator-prey dynamics, all of which have the potential to impact native fishes. Annual flow volume in Rock Creek has declined since the 1970s. This has been correlated with a decrease in the frequency and duration of flood events. As the total capacity of reservoirs accounts for a small proportion of the annual flow volume, the decrease in annual flow may be due to the effects of climate change. As the effects of climate change are difficult to quantify, this threat was not included in the following analysis.

Threat Level

To assess the Threat Level of Plains Minnow populations in Canada, each threat was ranked in terms of Threat Likelihood and Threat Impact (see Sawatzky and Watkinson 2013 for detailed information). The Threat Likelihood and Threat Impact were combined in the Threat Level Matrix resulting in the final Threat Level (Table 3).

Allowable Harm

For the purpose of the recovery potential assessment modelling, the following definitions are used:

- **Allowable harm** is defined as harm to the population that will not jeopardize population recovery or survival.
- **Chronic harm** refers to a negative alteration to a vital rate that reduces a population growth rate over the long term.
- **Transient harm** refers to a one-time removal of individuals that reduces the mean population growth rate temporarily over a specific time-frame.

Using the current estimated population growth rate, allowable chronic harm is determined such that said harm to the vital rate(s) of Plains Minnow does not cause population decline. Allowable transient harm is defined as an acceptable temporary change in growth rate resulting from one-time removals of individuals over 10 years or three generations, whichever is shorter (seven years for Plains Minnow). The allowable removal rate is determined by simulating removal of individuals (stochastically) and measuring the resulting change in population growth rate.

Current population trajectory of Plains Minnow is unknown. Therefore, allowable chronic harm is not provided for the Plains Minnow. Figure 3 shows the effect of transient harm on the population growth of Plains Minnow. One time removals of individuals in the amount of 12.5% of adult abundance, or 17% of YOY abundance, or 7.5% of total abundance within a 7 year period result in a 1% change in mean population growth rate. To avoid this change, allowable transient harm should not exceed these rates. (See Table 4 in Young and Koops (2013) for examples of removal rates resulting in 3% or 5% changes in growth rate, and for removal numbers based on current population abundance estimates.)

Table 3. Threat Level for Plains Minnow in Canada, resulting from an analysis of both the Threat Likelihood and Threat Impact. The number in parentheses refers to the level of certainty associated with the Threat Impact assignment and has been classified as: 1 = causative studies; 2 = correlative studies; and 3 = expert opinion. Certainty associated with the Threat Level is reflective of the lowest level of certainty associated with either Threat Likelihood or Threat Impact.

Threat	Threat Level
Turbidity and sediment loading (at very high levels over a long period of time)	Low (3)
Habitat removal and alteration	Medium (2)
Alteration of natural flow regimes from small impoundments and dugouts	Low (3)
Alteration of natural flow regimes from large impoundments	Medium (2)
Introduced species and diseases except exotic piscivores	Low (3)
Exotic piscivores	Medium (2)
Scientific sampling	Low (3)
Nutrient loading	Low (3)
Contaminants and toxic substances except from pipeline fractures	Low (3)
Contaminants and toxic substances from pipeline fractures	Medium (3)
Barriers to movement	Unknown (2)

Science Advice on Allowable Harm

Each element of allowable harm advice is independent and assumes no additional sources of harm. If there is harm from multiple sources, allowable harm should be reduced.

Allowable Chronic Harm

- When population trajectory is declining there is no scope for allowable chronic harm (at the population level).
- When population trajectory is stable and exceeds the recovery target (MVP) then chronic harm may be considered that does not result in a decline of the population growth rate.
- When population trajectory is unknown the scope for allowable chronic harm can only be assessed once population data are collected.
- Scientific research to advance the knowledge of population data should be allowed.

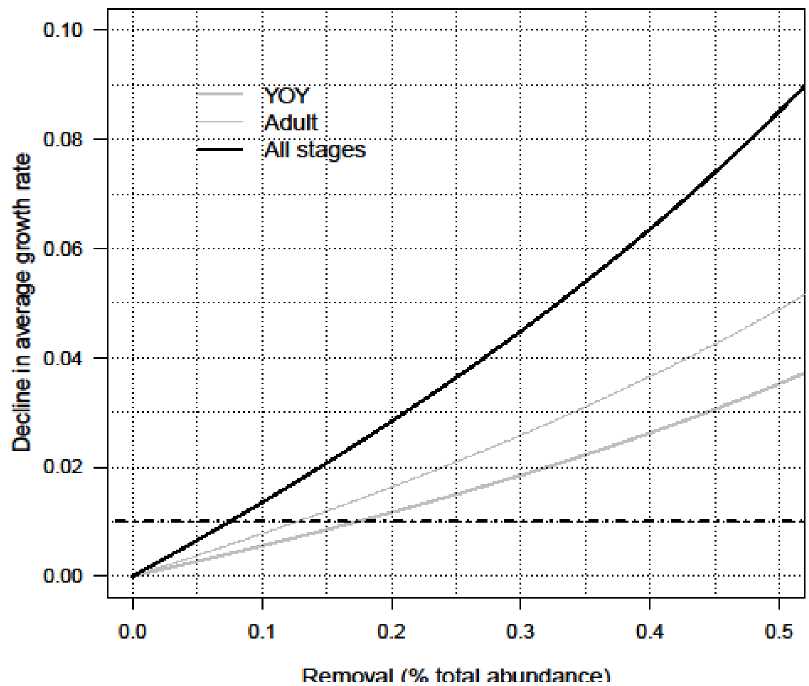

Figure 3. Decline in average population growth rate of a stable population over 7 years, as a function of the percent of individuals removed from the population in one of seven years. Results for removal of YOY only, adults only, or all stages are compared. Values shown are the lower confidence bounds from Figure 4 of Young and Koops (2013). Allowable transient harm can be determined from these curves based on the acceptable decline in average population growth rate. Recommended rates indicated with dashed reference line.

Allowable Transient Harm

- When population trajectory is declining or unknown, even low levels of transient harm may compromise recovery or shorten the time to extirpation.
- When population trajectory is stable, to prevent the population growth rate from decreasing more than 1%, transient harm (one-time removal of individuals) should not exceed a 12.5% reduction in adult abundance, or a 17% reduction in YOY abundance, or a 7.5% reduction in total abundance within a seven-year period. Exact numbers should be based on current abundance estimates.

- When population trajectory is increasing there may be scope for additional allowable transient harm.

Population Sensitivity

The assessment of population sensitivity involves perturbation analyses of population projection matrices, and includes a stochastic element. Outputs of the analyses include calculation of a population growth rate and its sensitivity to changes in vital rates (survival and fecundity). (See Young and Koops (2013) for complete details of the model and results.) Sensitivity of the Plains Minnow model depends on assumptions made regarding life history. Three models were compared: (i) a null hypothesis model that assumes a mortality schedule based on growth patterns, and a population at maximum growth (base model: max growth); (ii) a null hypothesis model assuming growth-based mortality and a stable population (base model: stable); (iii) an alternative hypothesis model that assumes mortality depends on flow such that in high flow years YOY survival, fecundity, and post-spawning mortality are high (high flow trade-off). In low flow years, adults delay spawning until their second year and YOY survival, fecundity, and mortality after the first year are low (low-flow trade-off). Population growth of Plains Minnow is very sensitive to perturbations of YOY survival and fecundity (Figure 4). Population growth of Plains Minnow is most sensitive to changes in the survival of immature individuals. It may also be sensitive to fecundity of first time spawners if post spawning mortality is high, or to survival in the second year if the population is stable or in decline.

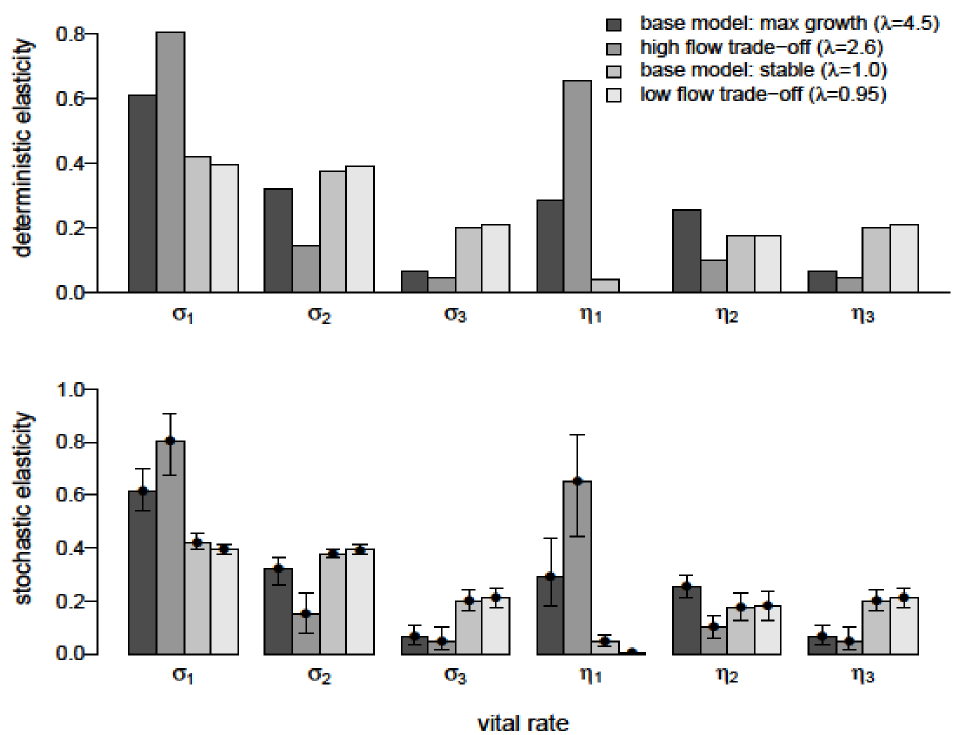

Figure 4. Results of the deterministic (upper panel) and stochastic (lower panel) perturbation analysis showing elasticities (ε_v) of vital rates for Plains Minnow: annual survival probability from age j-1 to age j (σ_j) and fertility at age j (η_j). Four models of Plains Minnow are compared. The base model represents the null hypothesis life history with parameters estimated from sample data, and YOY survival adjusted to reflect either maximum population growth, or stability. The alternative flow-based life history trade-off model is also shown for both low and high flow years. Stochastic results include associated bootstrapped 95% confidence interval. (Exact values listed in Table 3 of Young and Koops 2013.)

Mitigations and Alternatives

Research was conducted to summarize the types of works, activities or projects that have been undertaken in habitat known to be occupied by Plains Minnow (Table 4). The DFO Program Activity Tracking for Habitat (PATH) database was reviewed to estimate the number of projects that have occurred between September 2002 and October 2010.

Habitat-related threats to Plains Minnow have been linked to the Pathways of Effects developed by DFO Fish Habitat Management (FHM)[1]. DFO FHM has developed guidance on generic mitigation measures for 19 Pathways of Effects for the protection of aquatic species at risk in the Central and Arctic Region (Coker et al. 2010). This guidance should be referred to when considering mitigation and alternative strategies.

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

Exotic Piscivores

As discussed in the Threats section, introduction and establishment of exotic piscivores could have significant negative effects on Plains Minnow.

Mitigation

- Physically remove non-native species from areas known to be inhabited by Plains Minnow.
- Monitor the Canadian portion of the watershed for exotic species that may negatively affect Plains Minnow directly, or affect Plains Minnow preferred habitat.
- Coordinate with Montana/U.S. agencies to evaluate all introductions of exotic species in the Rock Creek basin.
- 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

- No alternatives for unauthorized introductions.
- For authorized introductions, use only native species.
- For authorized introductions, follow the National Code on Introductions and Transfers of Aquatic Organisms for all aquatic organism introductions (DFO 2003).

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[1] As of 2013, DFO FHM is now referred to as the DFO Fisheries Protection Program.

Table 4. Summary of works, projects and activities that have occurred in areas known to be occupied by Plains Minnow through a DFO project review during the period of September 2002 to October 2010 (blue shading). Activities identified as threats by RPA participants (DFO 2013) are identified by yellow shading. Threats known to be associated with these types of works, projects, and activities have been indicated by a checkmark. The number of works, projects, and activities associated with each Plains Minnow population, as determined from the project assessment analysis, has been provided. Applicable Pathways of Effects have been indicated for each threat associated with a work, project or activity (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).(Plains Minnow may occur in Wetherall Creek although this has not yet been confirmed.)

Work/Project/Activity	**Threats** (associated with work/project/activity)								**Watercourse/Waterbody** (number of works/projects/activities between Sep. 2002 and Oct. 2010)	
	Habitat removal and alteration	**Alteration of natural flow regimes**	**Contaminants and toxic substances**	**Turbidity and sediment loading**	**Nutrient loading**	**Barriers to movement**	**Species introductions (predation, competition)**	**Targeted removals**	**Wetherall Creek**	**Rock/ Morgan creeks**
Applicable pathways of effects for threat mitigation and project alternatives	1,2,3,5,8, 10,11,12, 16,18	5,10,11, 12,16, 17,18	1,5,8,10, 11,12, 16, 18	1,2,3,5, 8,10,11, 12,16,18	1,8,11, 12,16	10,11, 16,17				
Water Crossings (e.g., bridges, culverts, open cut or ford crossings)	✓	✓	✓	✓		✓			1	3
Trenchless Crossing & Pipeline Remediation (e.g., punch and bore or high pressure directional drill or pipeline remediation and/or maintenance)			✓	✓		✓				2
Well Site Remediation (i.e., oil well repair/remedial work)				✓		✓				1

Work/Project/Activity	Threats (associated with work/project/activity)								Watercourse/Waterbody (number of works/projects/activities between Sep. 2002 and Oct. 2010)	
	Habitat removal and alteration	Alteration of natural flow regimes	Contaminants and toxic substances	Turbidity and sediment loading	Nutrient loading	Barriers to movement	Species introductions (predation, competition)	Targeted removals	Wetherall Creek	Rock/ Morgan creeks
Applicable pathways of effects for threat mitigation and project alternatives	1,2,3,5,8, 10,11,12, 16,18	5,10,11, 12,16, 17,18	1,5,8,10, 11,12, 16, 18	1,2,3,5, 8,10,11, 12,16,18	1,8,11, 12,16	10,11, 16,17				
Aquaculture		✓	✓				✓			1
Grazing Research Project			✓	✓		✓			1	
Ranching[†] (i.e., cattle grazing, forage crops)	✓			✓	✓					
Water Withdrawal[†] (stock watering)		✓	✓		✓					
Small Impoundments and Dugouts[†]	✓	✓				✓				
Large Impoundments[†]	✓	✓				✓				
Species Introductions[†] (accidental and intentional)							✓			
Scientific Sampling[†]								✓		

[†] Activities identified as threats by participants during the Plains Minnow RPA (DFO 2013).

Scientific Sampling

As discussed in the Threats section, scientific sampling of Plains Minnow was recognized as a potentially low risk threat.

Mitigation

- Collection/sampling licenses are issued by DFO pursuant to Part VII of the General Fisheries Regulations, Section 51.
- In Saskatchewan, under the authority of *The Wildlife Act, 1998*, the Ministry of Environment issues provincial Scientific Research Permits to study and work with wildlife.
- Sampling in national parks requires a Research and Collection Permit issued by Parks Canada Agency.

Alternatives

- Prohibit lethal scientific sampling of Plains Minnow.

If Plains Minnow is listed under the SARA, it is possible that alternatives in addition to mitigation may be required.

Sources of Uncertainty

A number of key sources of uncertainty exist for Plains Minnow in Canada. A robust estimate of population size, current trajectory and trends over time are lacking. Thus, continued quantitative sampling of Plains Minnow in areas where it is known to occur is required. The current distribution and extent of suitable Plains Minnow habitat in Canada is also uncertain and should be investigated and mapped. To that end, areas in and around its current known distribution should be the focus of future targeted sampling efforts for the species. There is also a need to identify habitat requirements for each life stage. Larval surveys are required to determine whether spawning and/or nursery grounds exist in Canada. Given that only 26.5 km of the minimum required river length (115 km) is available in Canada, maintaining connectivity with the U.S. portion of Rock Creek is very important. Knowledge of the current distribution and extent of suitable habitat in the U.S. portion of the watershed would also be useful.

Certain life history characteristics required to inform Plains Minnow population modelling efforts are currently unknown, such as fecundity, and the relationship between flow rates, spawning, and survival at all stages. Other uncertainties include growth rate, age at maturity, longevity and the frequency of catastrophic decline of Plains Minnow in Canada. Further studies should focus on acquiring information on fecundity, population growth rate and survival of YOY. It is uncertain whether Plains Minnow can recruit in years/areas of poor flow.

Numerous threats have been identified for Plains Minnow in Canada, although the severity of these threats is currently unknown. There is a need for causative studies to evaluate the impact of each threat on Plains Minnow with greater certainty as well as an estimation of the cumulative effects of interactive threats. There is a need to determine threshold levels for additional water quality parameters (e.g., nutrients) and to determine additional physiological parameter limits including pH and pollution tolerance. Quantification of the impact from threats is required to calculate allowable harm and identify threshold values for specific threats.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 12, 2012, Recovery Potential Assessment of Plains Minnow (*Hybognathus placitus*). 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.

COSEWIC. 2012. COSEWIC assessment and status report on the Plains Minnow, *Hybognathus placitus*, in Canada. Committee on the Status of Endangered Wildlife in Canada, Ottawa. ix + 41 p.

DFO. 2003. National code on introductions and transfers of aquatic organisms. Ottawa, ON. 53 p.

DFO. 2013. Proceedings of the regional peer review meeting for the recovery potential assessment of Plains Minnow (*Hybognathus placitus*); 12 December 2012. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2013/019.

Sawatzky, C.D., and Watkinson, D.A. 2013. Information in support of a recovery potential assessment of Plains Minnow (*Hybognathus placitus*) in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2013/044. v + 35 p.

Young, J.A.M., and Koops, M.A. 2013. Recovery potential modelling of Plains Minnow (*Hybognathus placitus*) in Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/045. iv + 20 p.

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ISSN 1919-5087

Correct Citation for this Publication:

DFO. 2013. Recovery potential assessment of Plains Minnow (*Hybognathus placitus*) in Canada. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/042.

Aussi disponible en français :

*MPO. 2013. Évaluation du potentiel de rétablissement de le méné des plaines (*Hybognathus placitus*) au Canada. Secr. can. de consult. sci. du MPO, Avis sci. 2013/042.*