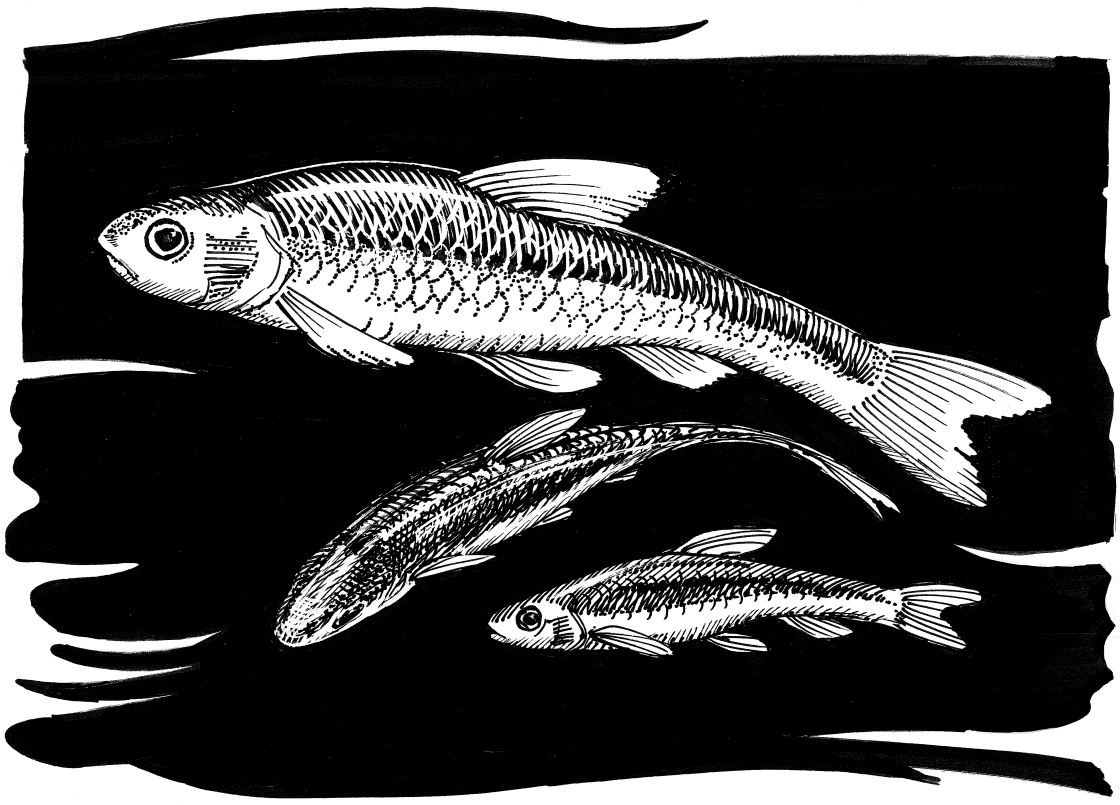
alberta's species at risk program

Status of the Brassy Minnow (*Hybognathus hankinsoni*) in Alberta



Alberta Wildlife Status Report No. 68

Alberta Conservation Association

Alberta Government

Status of the Brassy Minnow (*Hybognathus hankinsoni*) in Alberta

Prepared for:
Alberta Environment and Sustainable Resource Development (ESRD)
Alberta Conservation Association (ACA)

Prepared by:
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This report has been reviewed, revised, and edited prior to publication.
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DEDICATION

This status report is dedicated to Dr. Joseph S. Nelson (1937–2011) who started working at the University of Alberta in 1968 as an Assistant Professor of Zoology, and retired as a Professor Emeritus of Biological Sciences in 2002. He served as Associate Chair and Acting Chair for the Department of Zoology, and as Associate Dean, student services, Faculty of Science, 1995–2000. Dr. Nelson had many different fisheries research interests including non-game species, sticklebacks in particular. In addition to publishing more than 100 research papers on fishes, he co-authored *The Fishes of Alberta* (two editions) with Dr. M. J. Paetz, and authored *Fishes of the World* (four editions). He received many awards for his research during a long and distinguished career, the last being the William E. Ricker Resource Conservation Award from the American Fisheries Society in 2011. He has the honour of being the only Canadian to receive The Robert H. Gibbs Jr. Memorial Award for an outstanding body of published work in systematic ichthyology, handed out by the American Society of Ichthyologists and Herpetologists. Dr. Nelson was widely regarded as the dean of ichthyology in Alberta and was highly respected in the scientific community throughout the world. He kept busy with various hobbies—genealogy, astronomy and karate—and as a devoted family man, married to Claudine.

His passion for fishes and strong sense of ethical environmentalism is lovingly illustrated by his wise yet humorous response interjected into a heated government/industry discussion about stream fragmentation and culverts, “Anyone who prevents sticklebacks from spawning should be made to suffer the same fate”. Thanks for your wisdom, Joe.

PREFACE

Every five years, Alberta Environment and Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000 (*The General Status of Alberta Wild Species 2000*), 2005 (*The General Status of Alberta Wild Species 2005*), and 2010 (*The General Status of Alberta Wild Species 2010*), assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by Alberta Conservation Association and Alberta Environment and Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The brassy minnow (*Hybognathus hankinsoni*) is known from three disjunct subpopulations in Alberta: the Milk River drainage in southeastern Alberta; Musreau Lake in the Peace River basin in northwestern Alberta; and in the Athabasca River near Ft. McMurray in northeastern Alberta. Since 2000, the *General Status of Alberta Wild Species* has ranked it as *Undetermined*. Recent work and estimates of abundance suggest that although the total Alberta habitat area of brassy minnows is very small (less than 8 km^2), the total abundance of this fish likely numbers in the hundreds of thousands. The bulk of these numbers are in the Musreau Lake subpopulation, with much smaller numbers in the Milk River subpopulation, and an uncertain but likely very low number in the Lower Athabasca subpopulation. Less than 15 percent of its Canadian range and less than 5 percent of its North American range occurs in Alberta. The brassy minnow occurs in southern Canada from Quebec through British Columbia and south to Arkansas.

Ecologically, the brassy minnow appears adaptable throughout its range. Very little is known about its habitat requirements in Alberta, but it does appear to be highly adaptable to a range of pH levels, turbidity, water temperatures and dissolved oxygen levels based on the literature. It is, however, only abundant in the absence of predators. The brassy minnow is a forage fish of piscivorous species where their ranges overlap.

There are several threats to the brassy minnow subpopulations in Alberta: potential introduction of exotic species (Musreau Lake subpopulation); water use (including stream channelization for irrigation); extreme climatic fluctuations leading to drought; cold temperatures freezing overwintering pools solid; highly variable water levels (Milk River subpopulation); and oil and gas development (Musreau Lake and Lower Athabasca subpopulations). Additionally, their small and fragmented distribution makes individual subpopulations vulnerable to extreme climatic events (floods, droughts) and other chance events (industrial accidents such as oil spills).

ACKNOWLEDGEMENTS

We wish to acknowledge useful information and assistance provided by the following people: Terry Clayton (Senior Fisheries Biologist, Alberta Environment and Sustainable Resource Development [ESRD], Lethbridge and Medicine Hat Area); Robin Gutsell (Wildlife Status Biologist, Non-game and Wildlife Disease, ESRD, Edmonton); Tina James (University of Alberta librarian), Craig Johnson (Area Fisheries Biologist, ESRD, Grande Prairie); Lauren Makowecki (Resource Data Biologist, ESRD, Edmonton), Sean McFadden (Royal Alberta Museum), Alicia Morin (Fisheries Technician, ESRD, Lac la Biche); Stuart M. Nadeau (Fish and Wildlife Data Management Specialist, ESRD, Edmonton); the late Dr. Joe Nelson (Professor Emeritus, Department of Biological Science, University of Alberta); Sue Peters (Biologist, Alberta Conservation Association, Edmonton); Dr. Mark Poesch (Assistant Professor, Department of Renewable Resources, University of Alberta); Adrienne Radford (technical assistance); Mark Steinhilber (Royal Alberta Museum, Head of Life Sciences and former Curator of Ichthyology); Suzanne Brown (Fisheries Biologist, ESRD, Calgary); and Shevenell Webb (Wildlife Biologist, Alberta Conservation Association, Edmonton).

Preparation of this report was funded by Alberta Conservation Association and Alberta Environment and Sustainable Resource Development.

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INTRODUCTION

The brassy minnow (*Hybognathus hankinsoni)* is a member of the Minnow (Cyprinidae) Family. C. L. Hubbs first described the brassy minnow in 1929 (Nelson and Paetz 1992), whose name comes from *Hybognathus*, meaning protuberant jaw, and *hankinsoni*, after Dr. T.L. Hankinson, a Michigan ichthyologist. According to Alberta Environment and Sustainable Resource Development (ESRD 2013), the Alberta General Status for brassy minnow is *Undetermined**. The ranking is based on work by Mackay (2000), but was examined and updated in 2005 and in 2010 (R. Gutsell pers. comm.). There is no designation for the species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to date, but it is considered a mid-priority candidate for future status assessment (COSEWIC 2014).

Brassy minnows are found in clear, turbid and stained (i.e., acidic muskeg) waters over a range of pH conditions. Brassy minnows are tolerant of extremely high summer water temperatures up to 35.5°C and low dissolved oxygen levels as low as 0.03 mg/L (Scheurer et al. 2003). Limiting factors for brassy minnows include extreme water level fluctuation and low flows, overwinter freezing of some pools, possible vulnerability to predation, and susceptibility to catastrophic conditions such as droughts (Scheurer et al. 2003). Movements of brassy minnows and effects of fish introduction on this species have not been determined.

This report summarizes current and historical information on the brassy minnow in order to assess its status in Alberta.

* See Appendix 1 for definitions of selected status designations.

DISTRIBUTION

1. Alberta - In Alberta, the brassy minnow occurs in three disjunct locations: the Milk River drainage and its tributaries (e.g., Lost River, Lodge Creek, Bare Creek, Kennedy Creek, Red Creek); Musreau Lake (south of Grande Prairie in the Smoky River drainage); and the Athabasca River near Fort McMurray (Figure 1 and Appendix 2). Extensive sampling for small-bodied fishes using seine hauls, electrofishing, and minnow traps has occurred at 66,845 locations in Alberta, as recorded in the provincial fish database (Fisheries and Wildlife Management Information System [FWMIS], March 2014) (ESRD 2014). This has included intensive sampling at 288 waterbodies in northern Alberta specifically targeting rare small-bodied fishes such as brassy minnows (Steinhilber 2009). The three subpopulations, however, include the only confirmed locations (Figure 2). In this report, these three geographical groups will be referred to as "subpopulations," but this does not imply current evidence of genetic and demographic distinctions or relationships.

It is important to note that immature fathead minnows (*Pimephales promelas*) and lake chub (*Couesius plumbeus*) might be identified incorrectly as brassy minnows (Figure 3). It is also possible that immature western silvery minnows (*Hybognathus argyritis*) could be confused with brassy minnows. For this reason, only data collected by experienced fisheries personnel and/or that are accompanied by some form of verification (e.g., voucher specimens) have been considered reliable for use in this report.

1.1 Milk River Subpopulation - Brassy minnows are found in most of the tributaries to the Milk that flow north, and most of the tributaries that flow into Battle Creek (T. Clayton pers. comm.). The distribution of the brassy minnow in the mainstem of the Milk River appears to be limited to the mid-section

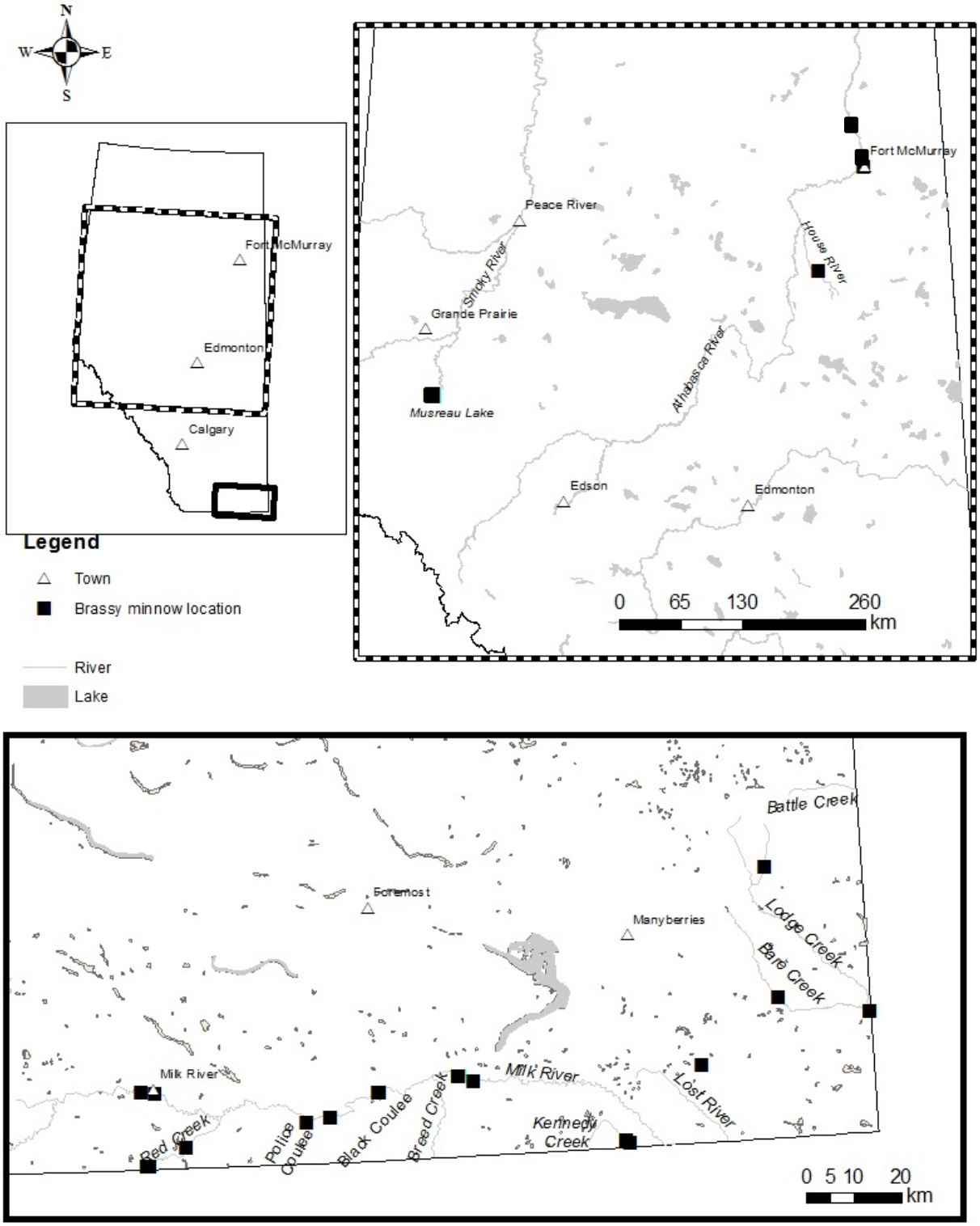


Figure 1. Distribution of brassy minnow in Alberta, based on data from the Fisheries and Wildlife Management Information System ([FWMIS]; updated in 2012) of ESRD, and Nelson and Paetz (1992). Additional records are known from Breed (Halfbreed) Creek (Nelson and Paetz 1992), and Breed, Black and Police coulees (Willock 1969); precise locations were not provided so they are therefore not mapped.

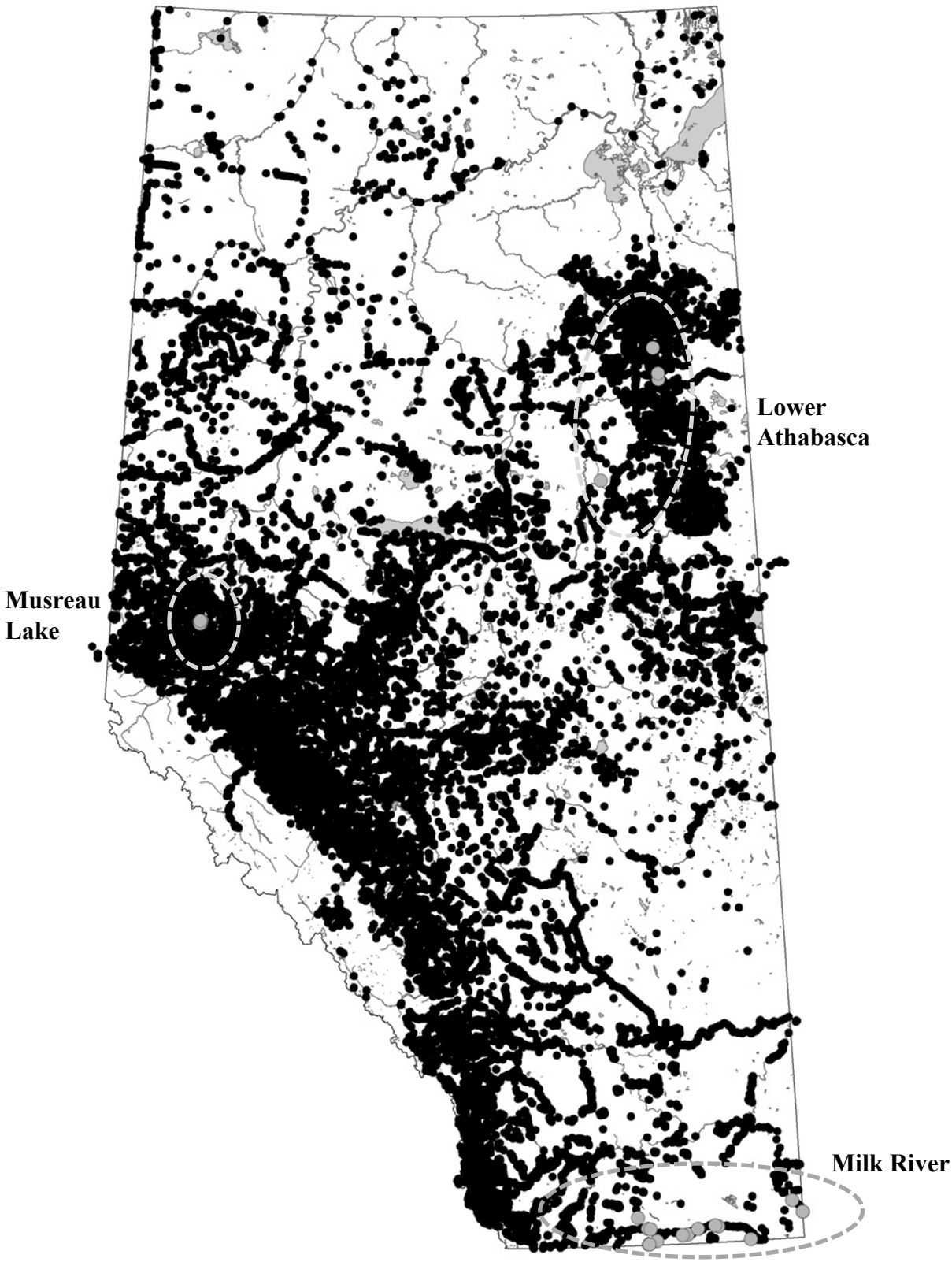
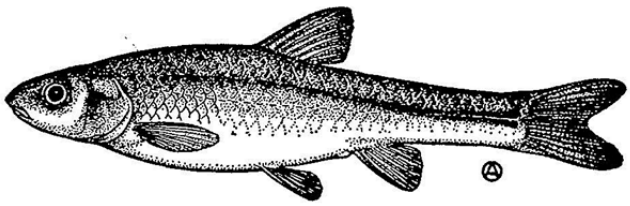
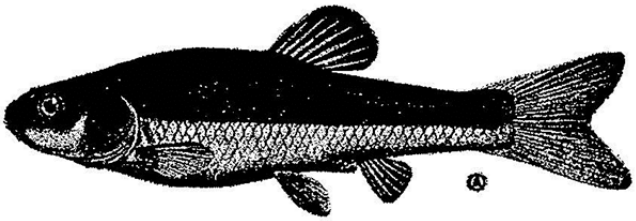


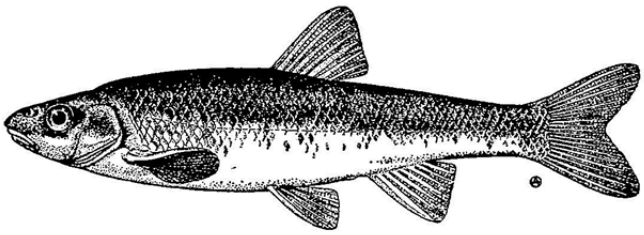
Figure 2. Fish sampling locations documented in Alberta's provincial data base (Fisheries and Wildlife Management Information System; FWMIS) using techniques expected to capture brassy minnows (i.e., seine netting, electrofishing, trap nets). Black circles are locations with no brassy minnows recorded, grey circles are locations with confirmed brassy minnow catches. Three subpopulations are labelled. Data were taken from FWMIS in March 2014. Total number of sample locations = 66,845.



a) brassy minnow



b) fathead minnow



c) lake chub

Figure 3. Comparison of a) brassy minnow, b) fathead minnow and c) lake chub appearance. Drawings taken with permission from Scott and Crossman (1998).

of the Milk River, from the town of Milk River downstream to the Aden Bridge, according to R.L. & L. Environmental Services Ltd. (2002). However, Nelson and Paetz (1992) recorded this species in the lower Milk River near the international border. Willock (1969) captured brassy minnows in a number of tributaries draining from the Sweetgrass Hills and Cypress Hills (including Breed, Black and Police coulees), but did not find any in Deer and Van Cleeve coulees. During the R.L. & L. study in 2000 and 2001, most tributaries were dry because of extreme drought conditions in the area. Brown (2014) conducted surveys specifically targeting brassy minnows in six tributaries of the Milk River during 2013. She reported capturing brassy minnows in two of the six creeks, and at a total of 4 of 33 sites surveyed.

The Milk River subpopulation of brassy minnows can be characterized as having a patchy, uncommon distribution, with occasional abundant catches. Their distribution and abundance can fluctuate with the vagaries of ephemeral prairie streams and variable mainstem river flows.

1.2 Musreau Lake Subpopulation - An isolated subpopulation of brassy minnows

is found in this small (5.49 km^2) lake south of Grande Prairie in the Smoky River watershed. Extensive sampling throughout this watershed has failed to identify any additional locations for brassy minnows (Figure 2). In Musreau Lake, brassy minnows are common and abundant along the shallow shoreline (M. Steinhilber pers. comm.). In annual sampling at six standardized sites for seine hauls during 2006 to 2010, the Royal Alberta Museum (RAM) fisheries crews captured brassy minnows at all sites in each of the five survey years (i.e., 30 sampling events with fish at every event). On average, 222 brassy minnows were captured during each sampling event (ranges = 1 to 991 fish). The Musreau Lake subpopulation of brassy minnows can be described as locally common and abundant.

1.3 Lower Athabasca River Subpopulation - In spite of extremely intensive fisheries sampling for small-bodied fishes in the Ft. McMurray area over the past several decades, brassy minnows have only been captured and confirmed from four locations, with only 20 specimens captured. One fish was captured in the upper House River in 1973, 14 fish were captured in the Athabasca River at the mouth of the Horse River in 1976, 4 fish were captured at island sites in the Athabasca river near Fort McMurray, and 1 fish was captured at an Athabasca river site 28 km downstream of Fort McMurray (Berry 1977). It seems unlikely that a local subpopulation of brassy minnows is abundant or common in this area, given the amount of surveying devoted to fisheries monitoring, particularly small-bodied fishes. Unconfirmed reports of brassy minnows in this region have been received by RAM and ESRD Fisheries Management Branch. Extensive small-fish surveys from 2005 to 2012 at many locations in the Athabasca drainages near Ft. McMurray to verify these reports, however, have not found this species (M. Steinhilber pers comm.; FWMIS data, May 2014). Based on the RAM surveys in this area, M. Steinhilber suspects that most, if not all, unverified reports of brassy minnows are a light-colored variant of fathead minnows that is common in these drainages, or misidentified lake chub. More rigorous attention to confirmation of fish identification is required by fisheries workers in this area. The Lower Athabasca River subpopulation is therefore tentatively described as very uncommon. It is possible that isolated, local subpopulations exist but have not been confirmed. Also, it is possible that the few confirmed reports are vagrants from an unknown subpopulation located up or downstream from the intensively surveyed Ft. McMurray area. An alternate possibility is that the species was once found in the Ft. McMurray area, but is no longer present. Continued sampling by RAM staff is planned, and more rigorous species identification protocols are being implemented for all fisheries workers in Alberta.

1.4 Province-wide Quantitative Distribution - The disjunct occurrences of the three subpopulations of brassy minnows in Alberta (i.e., Milk River, Musreau Lake, Lower Athabasca subpopulations) poses problems for quantifying the extent of occurrence (EO) of this species. Using a simple minimum convex polygon encompassing all three subpopulations results in an extent of occurrence of 261,860 km^2; however, this area includes massive areas of unoccupied watersheds (e.g., South Saskatchewan, Red Deer, and North Saskatchewan river basins). Within this Alberta-wide EO, the index of area of occupancy (AO) in streams with recorded occurrences of brassy minnows is approximately 100 km^2, calculated by summing occupied 2-km x 2-km squares; this interpretation of AO is reduced to 31 km^2 using 1-km x 1-km squares.

More biologically relevant measurements of the AO of brassy minnow habitats in Alberta for the three known disjunct subpopulations are shown in Figure 4. In total, the area of occupancy in Alberta is 7.3 km^2. Of this total AO, 82% is in the Milk River subpopulation, 5% in the Musreau Lake subpopulation, and

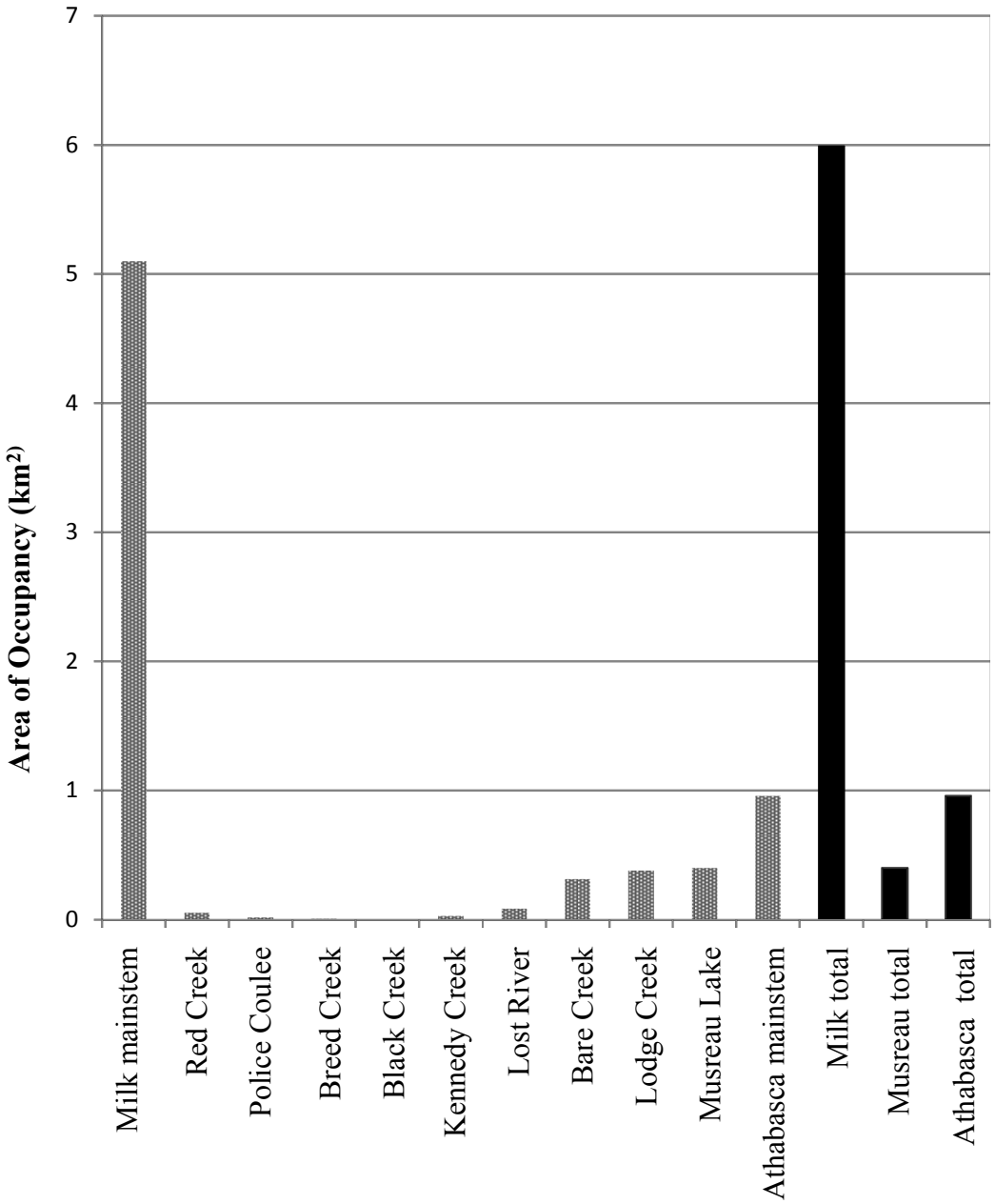


Figure 4. Area of occupancy of subpopulations within three disjunct populations of brassy minnows in Alberta. Total area of occupancy is 7.3 km^2.

13% in the Lower Athabasca subpopulation (Figure 4). These estimates do not account for unoccupied patches of habitat within each AO, nor do they account for the ephemeral nature of the streams, especially in the Milk River subpopulation. The provincial total is therefore likely an overestimate of the actual area of occupied habitat, but it does provide a meaningful scale to understand the limited distribution of this fish in Alberta.

2. Other areas - The brassy minnow occurs from the upper St. Lawrence River and Lake Champlain region of New York, west through southern Ontario, Manitoba, Saskatchewan and Michigan, through the Arkansas and Missouri rivers to Colorado, Wyoming and Montana, north to Alberta. In British Columbia, brassy minnows occur in the Fraser River and the headwaters of the Peace River (Scott and Crossman 1998) (Figure 5). More recent

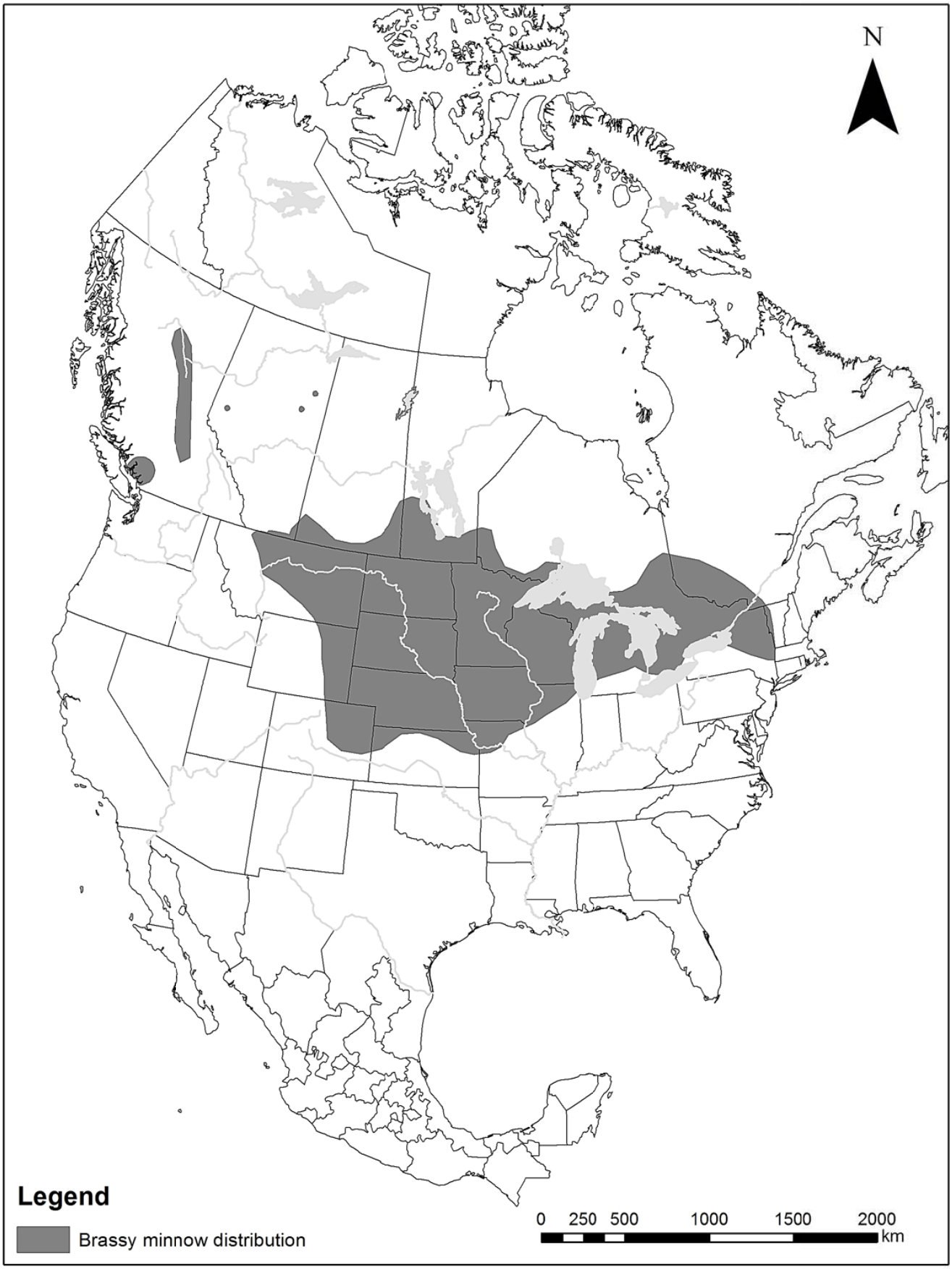


Figure 5. Distribution of the brassy minnow in North America, adapted from Montana Field Guide (2010).

literature documents a distribution more widespread than previously established in northern British Columbia (McPhail 2007).

The disjunctive distribution of brassy minnows in British Columbia and in Alberta may indicate that at one time they were found in locations between these various collection sites (British Columbia Ministry of Fisheries 2011). McPhail and Lindsey (1970) hypothesized that a post-glacial southeast drainage route existed in North America, which allowed the dispersal of fish from a Mississippian refugium or possibly a Missouri drainage system refugium into more northern waters. They predicted that brassy minnow may be discovered in some additional waters in Alberta and Saskatchewan that lie along the hypothetical dispersal route. Bishop (1975) reported that the discovery of brassy minnows in Musreau Lake in the Peace River drainage lends support to the hypothesis that a post-glacial southeast drainage route did exist between the northern British Columbia and southern Alberta subpopulations.

HABITAT

The ecology of brassy minnow has not been well documented. It is commonly referred to only as a forage fish or bait fish in the popular literature and online. Brassy minnows typically reside in small, weedy creeks or streams with sand, gravel or mud bottoms. They can also occur in boggy lakes, sloughs or overflow ponds near rivers.

In Alberta, brassy minnows in the Milk River drainage occur in slow currents, including alkali tributary streams (Nelson and Paetz 1992). The species occurs in scattered groups in several of the small tributaries of the Milk River and the greatest concentration appears to be located in tributaries that flow southeastward from the foothills of the Cypress Hills plateau (Willock 1969). Berry (1977) collected brassy minnows in a region characterized as wide, slow-moving and highly turbid in the Athabasca River, whereas the tributary collections featured low-gradient brown-water streams.

In British Columbia, brassy minnows seem to prefer slow streams and weedy backwaters (Carl et al. 1967), but they typically occur in small lakes, small slow-moving streams, beaver ponds and drainage ditches in that province (McPhail 2007). According to McPhail (2007), adults are often associated with lakes having soft, mud bottoms and dense vegetation; in summer, they are rarely observed in water more than 1.5 m deep. In streams, adult brassy minnows remain close to vegetation and appear to avoid waters with surface velocities greater than 50 cm/s. In the Crooked River system in the Upper Peace River drainage they usually occur in stained waters, but in the lower Fraser Valley they are found in both clear and turbid water. There is no obvious habitat difference between young-of-the-year and adults, except that fry tend to be found in shallower and quieter water than adults (The Peace/Williston Fish and Wildlife Compensation Program 2011).

In Ontario, the species shows a preference for ponds and streams with boggy, acidic waters (Scott 1967). Brassy minnows are reported to be tolerant of a wide range of water temperatures and are found in locations with summer temperatures of between 17°C and 20°C in May and June in these types of habitats (Eakins 2011).

The Canadian distribution in both acidic and alkaline waters throughout their range suggests that brassy minnows can tolerate a range of pH conditions, and have at least a degree of tolerance to turbid water. During the winter, they tend to use pools and deep runs under cover or woody debris. Adults occur in cool pools of sluggish, clear creeks and small rivers, usually over sand or gravel; they are apparently more abundant in cool, acidic waters of silt-covered bog ponds throughout their range, which would

usually be associated with muskeg drainages (Scott and Crossman 1998 and other sources).

Schlosser (1988) reported a contrast in habitat types selected by brassy minnows in the presence and absence of predators. Brassy minnows selected unstructured pools in the absence of predators; however, in the presence of a small predator (e.g., creek chub: *Semotilus atromachulatus*) they selected structurally complex pools. When larger predators were present, such as smallmouth bass (*Micropterus dolemieui*), brassy minnow habitat selection was confined to faster flowing water such as raceways or riffle refugia.

CONSERVATION BIOLOGY

Relatively little is known about the brassy minnow throughout its Canadian range, although it is a bit better understood in the United States. Nowosad (2011) provides an excellent summary of its biology and conservation issues in Canada, and draws attention to the need for research that would support a predictive habitat model. Although brassy minnows apparently prefer cooler water than do some of their minnow cousins and are found in large numbers only when predators (both fish and birds) are absent, they are tolerant of very high water temperatures in excess of 35°C. M. Steinhilber (pers. comm.) noted that brassy minnows may be found in the same places as fathead minnows (i.e., in slow-moving warm water with high salinity).

Scheurer et al. (2003) found that brassy minnow persistence through August was not related to maximum summer water temperature, minimum dissolved oxygen, or any other variable measured at the pool scale. Fish persisted in pools with maximum bottom water temperatures during the afternoon as high as 35.5°C, indicating that high temperature was unlikely to limit survival. Likewise, early morning dissolved oxygen minima were low in all pools with brassy minnows, and the fish persisted in pools with concentrations as low as 0.03 mg/L. Given the high tolerance of brassy minnow to harsh physicochemical conditions, the authors thought it likely that pool drying was a main mechanism of extirpation at the pool scale.

1. Species Identification - Alternative common names for the brassy minnow are grass minnow and Hankinson's minnow.

Brassy minnows have a maximum length of less than 10 cm and an average length of 6.4 cm; they are olive-green to brown in colour dorsally, brassy-yellow to dull silver laterally, and creamy white below. The typical range in weight for adults is 0.7 g – 4.0 g, with a maximum weight of 10 g. Females tend to be larger than males. Brassy minnows are elongate in body form and slightly compressed laterally. They have a small, sub-terminal mouth without maxillary barbels. No typical breeding colours are known; however, golden-coloured males have been noted during the spawning period in Colorado (Scheurer et al. 2003). The flanks of males are a bright brassy colour, whereas those of females are silver in stained waters of the upper Fraser and upper Peace river drainages (McPhail 2007). This latter striking colour difference is absent in fish from the less stained waters of the lower Fraser River system, where both sexes remain silver during the breeding season. Distinguishing characteristics are the large scales, the absence of maxillary barbels, and the origin of the dorsal fin slightly in front of the origin of the pelvic fins (McPhail and Lindsey 1970) (see Figure 3a). They have a dark lateral band that extends from the gill cover to tail, and their peritoneum is uniformly black.

In British Columbia, most erroneous records of the brassy minnow are misidentified lake chub, according to McPhail (2007) who reports that the resemblance is superficial and the two species are easily distinguished by peritoneum colour (black in brassy minnow and silver in

lake chub), mouth position (the snout overhangs slightly in the brassy minnow but is terminal in lake chub), and the absence of maxillary barbells in the brassy minnow.

2. Meristics - Berry (1977) reported on the measurements of 19 specimens collected in beach seines at three locations in the Athabasca River: total length of 49 mm to 72 mm; fork length of 44 mm to 66 mm; 37 to 41 (mode 39) lateral line scales; 6 scales above the lateral line; 8 anal and dorsal fins rays; and 13 to 19 scale radii.

Nelson and Paetz (1992) reported meristic counts in 15 specimens obtained from the Milk River drainage as follows: 35 to 39 scales along the lateral line; 6 or 7 (most at 6) scales above the lateral line; and 16 around the caudal peduncle. They reported the maximum length observed for Alberta being 81 mm fork length from Breed (Halfbreed) Creek near Aden in southern Alberta.

S. McFadden (pers. comm.) kindly provided meristic counts from a sample of 50 specimens from Musreau Lake: total length of 58 mm to 76 mm; fork length of 53 mm to 70 mm; 36 to 41 (mode 39) lateral line scales; 5 to 7 (mode 6) scales above the lateral line; 8 to 9 (mode 9) anal and dorsal fins rays. This compares with meristic measurements reported by Bishop (1975) from a representative sample of 10 specimens collected from Musreau Lake in 1974: total length of 47 mm to 81 mm; fork length of 42 mm to 71 mm; 37 to 40 lateral line scales; 6 to 7 scales above the lateral line; and 8 dorsal fin rays.

3. Life History - Brassy minnows reach sexual maturity at the age of one or two years. In the lower Fraser River valley of British Columbia, both males and females reach sexual maturity after one winter (except for young produced during fall spawning); by the time they reach sexual maturity, females usually are slightly larger than males (McPhail 2007). Populations exist in ponds in the Prince George area of British Columbia that have no inlet or outlet; consequently, reproduction must be possible in the absence of running water (McPhail and Lindsey 1970).

Spawning typically occurs in June and females usually lay their eggs in late spring among vegetation in shallow areas of lakes or streams. Throughout their range in Canada, spawning takes place from May to July when water temperatures range from 16°C to 17°C. Females with ripe eggs have been found in July in the Milk River drainage (Nelson and Paetz 1992). Eggs are shed at 10°C or higher. Eggs are scattered on vegetation or bottom substrate and take between 7 and 10 days to hatch. Female fecundity ranges from 100 to 2500 eggs, depending on their size, a huge range in fecundity for a fish that has a size range at maturity of 4 cm to 10 cm.

Spawning occurs in, or near, vegetation, and the eggs either sink to the bottom or are caught up in the vegetation. According to The Peace/ Williston Compensation Program (2011), not all the eggs are released in a single spawning and females probably spawn several batches of eggs over a period of about a week. Once fertilized, eggs go through rapid embryo development (hatching occurs within 70 hours at 18°C). The newly hatched larvae are small (about 4 mm in length), transparent and lack eye pigment. By day eight they are about 6 mm long and begin to feed. In the lower Fraser Valley, in some years, there is a second spawning in the autumn that produces fish about 15 mm long by mid-November. Growth in the first months of life is rapid and in Huble Lake, young-of-the-year averaged 27.9 mm (fork length) by early August. In the lower Fraser Valley, populations that disappeared in the summer tend to reappear in the fall (early October). At this time, the young-of-the-year average about 42 mm in fork length. Both males and females reach sexual maturity after one winter.

In a Wyoming study (see literature reviewed in Coad 2010), males and females aggregated in schools numbering in the thousands. Up to 15 males each approached a female at the edge of a school and she would respond in one of two ways: the female might spiral up and leap out of the water, discouraging the males; or she might swim to vegetation, which would stimulate one or more males to press against her, quiver and cause release of eggs and sperm. The vibrations apparently were such that they stirred up sediment.

In an eastern Colorado stream (Scheurer et al. 2003), brassy minnow appear to spawn during spring and hatch in early summer. Spawning, as determined by the presence of gravid females or golden-coloured males, was observed during a single period from mid-April through mid-May in two study years, unlike many Great Plains fishes that spawn repeatedly. In 2001, hatching occurred between mid-May and mid-June when spawning and rearing habitats averaged between 15.7°C and 23.5°C. Unlike this Colorado study, no similar data are known for Alberta brassy minnows.

Few brassy minnows live more than three to five years. The maximum age recorded in British Columbia is four years and all individuals of this age were females (McPhail 2007). According to Ripley (2001), the presence of predators (both fish and avian) has a negative impact on their abundance. Apparently, brassy minnows are found in large numbers only when predators are absent.

There are no studies known to have been conducted on the life history of brassy minnow in Alberta (M. Steinhilber pers. comm.). Generation length (defined as the average age of parents of the current cohort) is likely two to three years, based on breeding initiation at one to two years of age and maximum longevity at four years.

4. Diet - Brassy minnows are classified in the planktivore-detritivore trophic class. They feed on phytoplankton and other algae, zooplankton and aquatic insects. Up to 94 percent of their diet is algae, such as diatoms and desmids. Feeding occurs in schools with a peak between 1:00 p.m. and 3:00 p.m. (Coad 2010).

The long intestine and black peritoneum suggest that plant material is an important part of the brassy minnow's diet (The Peace/Williston Fish and Wildlife Compensation Program 2011). Characteristically, such features are associated with species that are largely vegetarian in diet (Carl et al. 1967). In the lower Fraser Valley, brassy minnow intestines were usually filled with what appeared to be organic detritus, algae and occasional chironomids. A similar diet (organic debris, algae, and small insects) was observed in brassy minnows in Huble Lake, British Columbia (McPhail 2007).

Brassy minnows are benthic first-level consumers, and as such, they are important in transferring nutrients to higher trophic levels in their communities (Stewart and Watkinson 2004).

5. Movement - In Musreau Lake, M. Steinhilber (pers. comm.) reported that brassy minnows were abundant in June but not in September, indicating that they may have moved into deep water or possibly Musreau Creek during the summer.

In British Columbia, at some sites they are seasonally abundant every year, whereas at other adjacent (and often connected) sites, they appear only sporadically in large numbers and then disappear for several years. This sporadic appearance of brassy minnows at different sites, and their regular seasonal appearance and disappearance at other sites, suggests that they school and that migrations may be a common feature of their life history in streams and rivers (McPhail 2007).

The brassy minnow is a *Threatened* species in Colorado. They live in harsh, fluctuating stream environments subject to summer drying and winter freezing in the western Great Plains portion of this state, and yet may be capable of rapid dispersal and reproduction during the wet season (Scheurer at al. 2003). Despite poor adult survival in the drier segments in the Arikaree River basin study area, larval brassy minnows were widely distributed in all segments in early summer of both study years, indicating substantial movement for recolonization.

POPULATION SIZE AND TRENDS

1. Alberta

1.1 Milk River Subpopulation - The most comprehensive data for developing population trends for brassy minnow varied by location. For the Milk River mainstem, population estimates were based on seine net surveys (R.L. & L. Environmental Services, 2000–2001, unpublished data). The most complete data for estimating population size of brassy minnow in Lodge and Bare creeks was based on electrofishing data in the FWMIS database (ESRD 2014). To help facilitate comparison with conservation thresholds, several assumptions in the data were needed, including:

- The area of suitable habitat was determined for three primary subpopulations:
  1) Milk River mainstem: a river length of 170 km, with 15 m suitable habitat along each bank, for a total area of 510 ha (5.1 million m^2).
  2) Bare Creek: a stream length of 77 km, with an average width of 4.1 m, for a total area of 32 ha (384,780 m^2).
  3) Lodge Creek: a stream length of 106 km, with an average width of 3.6 m, for a total area of 38 ha (318,267 m^2).
  The other tributary streams where brassy minnows have been captured (e.g., Red Creek, Police Coulee, Lost River, etc.) are much smaller than these three habitats, and only occasional catches have been reported.
- All sampled brassy minnows were older than young-of-year and were mature adults.
- Electrofishing sampling conducted by Brown (2014) comprised a 300 m reach of each stream, with a capture efficiency of 0.5 (i.e., 50% of the brassy minnows in the sampled reach were captured).
- Seine hauls conducted in 2000 and 2001 by R.L. & L. Environmental Services Ltd. (2002) in the Milk River mainstem were 50 m x 3 m (sample area of 150 m^2), with a capture efficiency of 100%.
- Population thresholds were developed using IUCN Red List/COSEWIC criteria (see IUCN 2012, COSEWIC 2011a; i.e., $n < 250$ individuals, $n < 2500$ animals, and $n < 10{,}000$ animals). These benchmarks are provided for comparative purposes only.

For estimating the abundance of brassy minnows in the Milk River mainstem, a binomial distribution was used to assess the R.L. & L. Environmental Services (2000–2001) capture data of three brassy minnows in 25 seine hauls. This distribution was used to extrapolate potential capture rates to the entire available habitat using the above-described assumptions. Based on this extrapolation, the population size of brassy minnow in the Milk River mainstem was estimated as 6800 individuals, with lower and upper 95% confidence intervals of 4080 and 8160 individuals. There are two caveats in estimating population sizes in this way: if the capture efficiency of the seine hauls was less than 100%, these estimates would be correspondingly increased; in addition, the sample sizes are very low for such a large extrapolation. Therefore, these estimates should be considered precautionary and likely lower than the actual value. It is reasonable to conclude that the observed seine haul capture rates in the Milk River are consistent with a subpopulation of brassy minnows numbering in the thousands of fish, but not hundreds nor tens of thousands of fish.

For estimating population size of brassy minnow in Lodge and Bare creeks using the electrofishing data in the FWMIS database (ESRD 2014), population estimates were developed by bootstrapping the data to derive probability distributions of capture rates. These rates were extrapolated to the entire habitat area using the above-described assumptions. For Bare Creek, the abundance estimate was 14,145 (low and high 95% CI of 7073 and 24,400). For Lodge Creek, the abundance estimate was 513 (low and high 95% CI of 2 and 1026). Caveats for these estimates include: 1) in these creeks, occasional deep pools were found that limited the effectiveness of backpack electrofishing; T. Clayton (pers. comm.) suspects that these pools may harbour significant numbers of brassy minnows, but are very difficult to sample; 2) with the low sample sizes, rough estimates of electrofishing efficiency, and lack of sampling coverage, the estimates of abundance of brassy minnows in these creeks should be considered very approximate, and likely low. The data suggest the abundance of brassy minnows in these small tributaries is in the thousands of fish, but not likely hundreds, nor hundreds of thousands.

The overall estimates of abundance of brassy minnows in the three primary Milk River drainages are shown in Figure 6. Some perspective on the size of this subpopulation can be gained by comparing abundance estimates derived from electrofishing data to the abundances corresponding to meaningful thresholds; this exercise drew on population thresholds used in the IUCN Red List/COSEWIC criteria (IUCN 2012, COSEWIC 2011a). The IUCN/COSEWIC thresholds were chosen as benchmarks simply to provide perspective for this single subpopulation of fish. The use of these thresholds was not intended to stand in for,

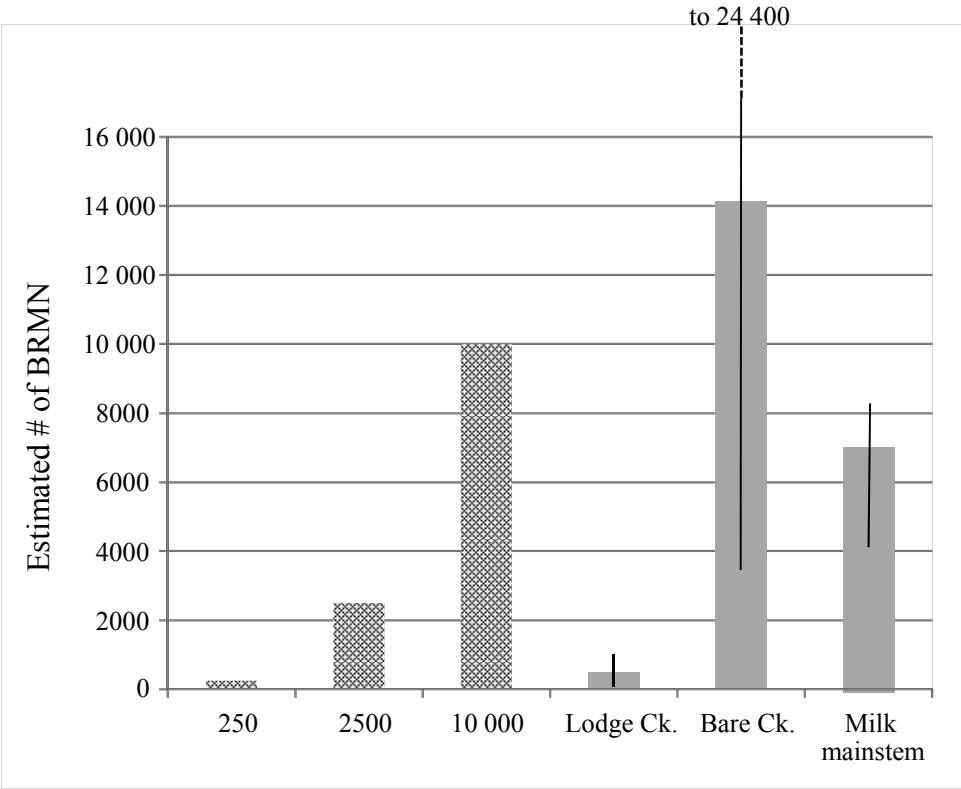


Figure 6. Estimated abundance and 95% confidence intervals of brassy minnows (BRMN) caught in seine hauls and electrofishing in the Milk River drainages compared to IUCN/COSEWIC abundance categories. Total estimated abundance of brassy minnow in three main Milk River subpopulations is approximately 20,000 fish.

or replace, their use during a formal assessment of the status of the entire Alberta population. It is reasonable to suggest that a precautionary estimate of the abundance of brassy minnows in the Milk River drainages is approximately 20,000 fish.

1.2 Musreau Lake Subpopulation - The most comprehensive data for developing trends in population sizes in Musreau Lake was based off seine net hauls conducted by the Royal Alberta Museum (RAM, M. Steinhilber, unpub. data). The abundance estimates for brassy minnows in Musreau Lake were based on the following assumptions:

- Suitable habitat area for the brassy minnow is approximately 40 ha (400,000 m^2), corresponding to the entire shoreline length and a width of 30 m from shore.
- All sampled brassy minnows were older than young-of-year and were mature adults.
- Seine hauls conducted by RAM staff (M. Steinhilber unpubl. data) during 2006 to 2010 were each comprised of a 60 m^2 sampling area (i.e., seine net of 3 m effective length and 20 m sweep area), with five areas sampled each year.
- Capture efficiency within the sampled area was 100% (i.e., all brassy minnows in the sample area were caught)
- Population thresholds were developed using IUCN Red List/COSEWIC criteria (IUCN 2012, COSEWIC 2011a; see section 1.1); these benchmarks are provided for comparative purposes only.

Seine haul catch rates were available for brassy minnows in Musreau Lake for the period 2006–2013 (Figure 7). As for the Milk River subpopulation, some perspective on the size of this subpopulation can be gained by comparing seine haul catch rates to the densities corresponding to meaningful thresholds. For this exercise, the IUCN/COSEWIC thresholds (IUCN 2012 and COSEWIC 2011a) were chosen as benchmarks simply to provide perspective for this single subpopulation of fish (see thresholds and additional rationale in section 1.1). The expected density of fish in Musreau Lake corresponding to each threshold could therefore be compared to the density as estimated from the seine haul catch rates. For example, if the subpopulation of brassy minnows was under 250 animals, the average density of fish in the suitable habitat at Musreau Lake would be less than 0.000625 fish/m^2 and the catch rates in the seine hauls would tend to be less than that value.

The RAM data from each seine haul for each year (2006 to 2013) are shown in Figure 7; data from 2006 to 2010 were analyzed for this purpose. As expected, there is large variance in the catch rates (note: the y-axis is scaled to log10); however, abundance appears to be at least an order of magnitude higher than the threshold of 10,000 adult brassy minnows. Specifically, the average catch rate was 1.2 fish/m^2, suggesting an abundance of approximately 495,000 fish. The short-term subpopulation trend (5 years) was of no obvious or consistent change.

The two key assumptions that may alter this interpretation are capture efficiency and maturity ratio. If capture efficiency was lower than 100%, the true abundance would be higher than estimated (e.g., if efficiency was 50%, abundance would be 990,000 fish). There are no measures of seine net capture efficiency for fishes in Musreau Lake, but discussion with M. Steinhilber (pers. comm.) suggests that efficiency was high, but unlikely as high as 100%. The maturity ratio in the seine captures was assumed to be 100%. Sexual maturity for brassy minnows is described in McPhail (2007) as "Both males and females reach sexual maturity after one winter". The size frequency distribution of brassy minnows sampled by RAM (i.e., caught in the seine nets) in Musreau Lake is shown in Figure 8. Young-of-the-year brassy minnows are described in McPhail (2007) as 27.9 mm fork length (FL, measured from the tip of the snout to the fork in

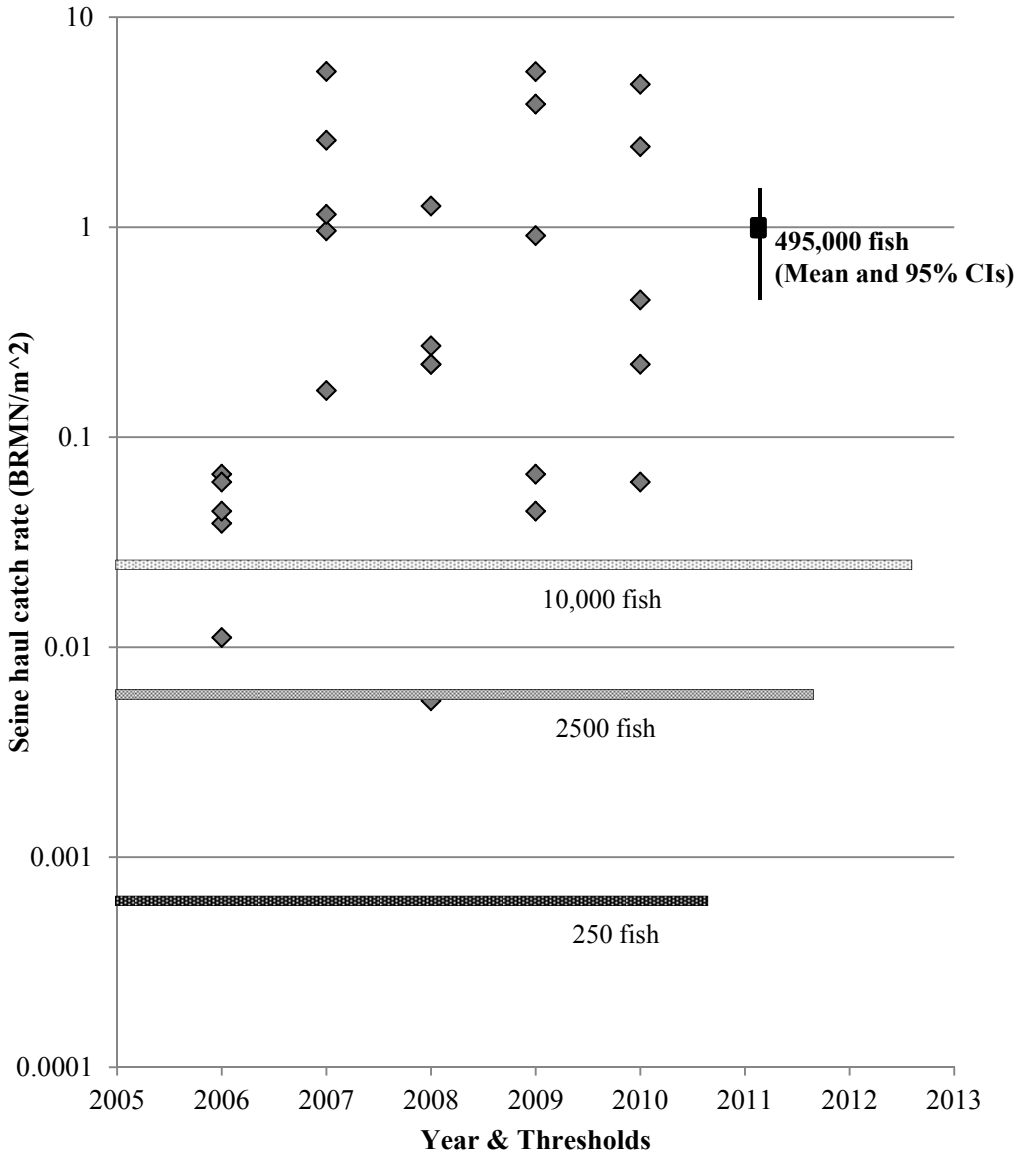


Figure 7. Estimated abundance of brassy minnows (BRMN) at Musreau Lake, 2006 to 2010. Estimates based on seine-haul catch rates of fish/m^2, and habitat area of 40 ha. Estimates can be compared to IUCN/COSEWIC thresholds converted to fish/m^2. Data are from the Royal Alberta Museum (M. Steinhilber, unpublished data). Note that the y-axis is scaled to log10.

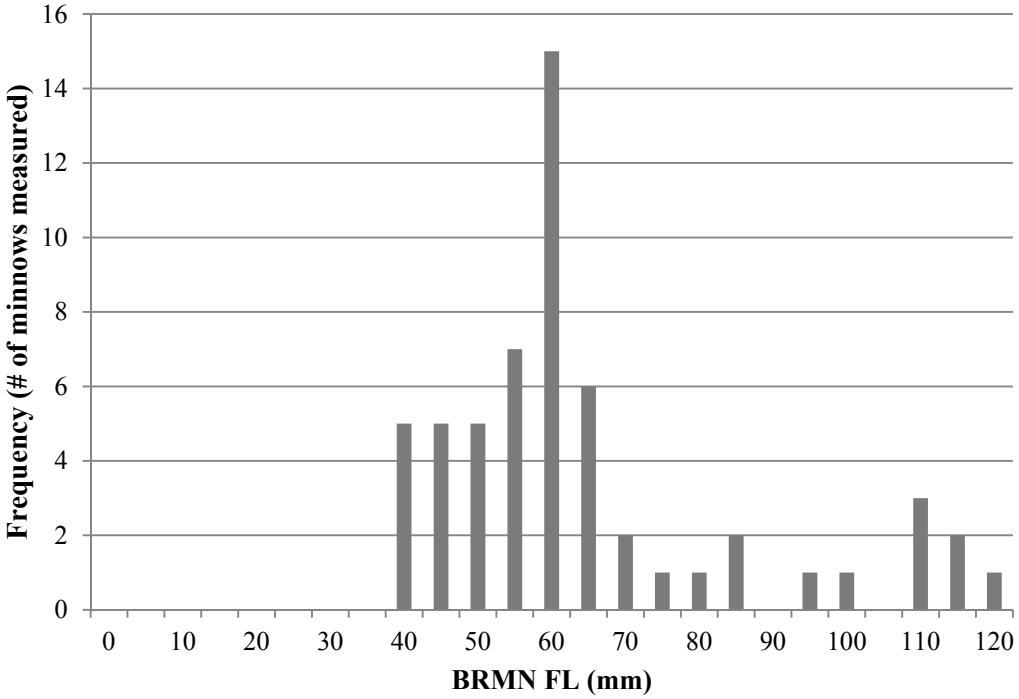


Figure 8. Length frequency distribution of brassy minnows (BRMN) caught in seine hauls at Musreau Lake, 25 June 1998. Data are taken from the Fisheries and Wildlife Management Information System (January 2014). FL = fork length.

the tail) in early August. The data in Figure 8 suggests that all fish sampled in the RAM seine nets were larger than young-of-the-year (and therefore older than one winter) and therefore sexually mature. If the Musreau Lake fish are unusual and mature later than one year of age, the abundance estimate may be much lower. Only 20% of the fish sampled appeared older than age one, suggesting that the subpopulation abundance of age two and older brassy minnows may be approximately 99,000 fish.

Based on this evidence, it is likely that the subpopulation of brassy minnows in Musreau Lake is reasonably described as composed of hundreds of thousands of mature fish, with no obvious short-term (5 years) trends of decline or increase during 2006–2010.

1.3 Lower Athabasca River Subpopulation - There is not enough information to derive approximate abundance estimates for brassy minnows of the Lower Athabasca River subpopulation. The lack of confirmed specimens during recent decades of sampling leaves us with a range of possibilities to describe this subpopulation, extending from loss of this subpopulation, to occasional vagrants, to abundant with failure to confirm identification. No conclusion can be drawn, other than to emphasize that taxonomic rigour is required.

1.4 Provincial Population Size - The population of brassy minnows in Alberta appears to number in the hundreds of thousands of fish. If the Athabasca River subpopulation is found to be existing and abundant, this estimate would be considerably increased. There is a lack of long-term data to analyze trends in the sizes of the subpopulations.

2. Other areas - Brassy minnow subpopulations in the Prince George area of British Columbia have disappeared, likely as a result of competition or predation by introduced brook trout (*Salvelinus fontinalis*, McPhail 2007). Some subpopulations in central British Columbia have disappeared altogether, and others live in water bodies susceptible to

urban pollution and habitat problems (British Columbia Ministry of Fisheries 2011). It is listed as rare or uncommon in British Columbia (McPhail 2007).

In Saskatchewan, single individuals (only) were collected at four sites in 1993: Battle Creek (two locations), Frenchman River and Morgan Creek (McCulloch et al. unpubl. report, undated) in the extreme south of the province.

The brassy minnow has a scattered distribution in Manitoba. It is found mostly in tributaries of the Red and Assiniboine rivers above the Manitoba escarpment and the headwaters of the Roseau River. The pattern of its distribution parallels the southwestern shoreline of Glacial Lake Agassiz (Stewart and Watkinson 2004).

3. Rescue Potential - Rescue potential is the potential for immigration of gametes/ individuals from neighbouring jurisdictions to reproduce successfully in Alberta, such that extirpation or decline of the population could be mitigated. Brassy minnows likely have the ability to disperse and recolonize new or empty habitats, as shown by Scheurer et al. (2003). However, this may be only partially relevant to re-colonization within Alberta. Re-colonization within the Milk River system may follow a similar pattern to that observed by Scheurer et al. (2003), which makes immigration from a small area of Montana into the Alberta portion of the Milk River drainage hypothetically possible. However, the disjunctive nature of the subpopulations outside of the Milk River suggests that other factors limit colonization in those areas.

LIMITING FACTORS

1. Milk River - The Milk River is subject to drastic water level fluctuations, from being bankfull in the spring and summer when water is being diverted from the St. Mary River, to almost dry in the fall and winter after diversion stops. Montana diverts its apportionment of flows from the Milk River and St. Mary drainages into the Milk River near the international border during the summer irrigation season, after which time flows are minimal during autumn and winter. It is quite possible that many pools that would be used by brassy minnow to overwinter could freeze to the bottom, such that extremely low flows during autumn and winter represent a major limiting factor to the subpopulation of the brassy minnow. These fluctuations in water level are unnatural and upset the functioning of the ecosystem. Human-caused changes to natural flows that alter conditions to which fish have adapted over millenia can have unforeseen consequences.

Expected changes to climate in southern Alberta may have a severe effect on flows in the Milk River and its tributaries, and consequently on brassy minnow survival. During the past century, mean warmest month temperature has increased 1°C in Milk River area, with no increase in precipitation. Projections from down-scaled Intergovernmental Panel on Climate Change climate models suggest this trend will be exaggerated, with mean warmest month temperature rising from approximately 21°C today to over 25°C by 2080 (Wang et al. 2011; Sullivan et al. 2013). Increases in drought and increased need for irrigation will alter natural flows in the Milk River basin and consequently change and potentially threaten habitats for brassy minnows. Irrigation and water control practices in the past have resulted in stream channelization to improve flow efficiency. This practice has been very extensive in recent (summer 2014) water control work in the Bow and South Saskatchewan systems. Continued alteration of stream channels could lead to changes in stream flow and fish habitat, as well as increase potential fragmentation and migration of small fishes.

2. Musreau Lake - This subpopulation of brassy minnows has been threatened in recent decades with stocking of exotic rainbow trout in order to expand sport-fishing opportunities in the area. Approximately 200,000 rainbow

trout were stocked semi-annually from 1972 to 1999; however, a viable sport fishery failed to develop and stocking was discontinued, both as a function of repeated failures and with increasing awareness of threats to native biodiversity (C. Johnson, pers. comm.). Musreau Lake, however, has developed into a popular destination for people from Grande Prairie, primarily using the lake for motorized water sports (e.g., water skiing, jet skiing, etc.). A large boat launch, campground, and day-use area have been developed by Alberta Parks. A few anglers still fish at Musreau, mainly for burbot (*Lota lota*) or the rare catch of a bull trout (*Salvelinus confluentus*). Public pressure is ongoing to restore stocking at Musreau Lake, in spite of decades of failures. Stocking would appear to constitute a threat to the brassy minnow subpopulation at Musreau Lake, based on the experiences of loss of subpopulations in British Columbia from stocking. The late Dr. Joe Nelson (pers. comm.) noted when collecting brassy minnows in Alberta and in British Columbia (in the Prince George area) during his Ph.D. thesis that this species seemed to be limited to small lakes lacking predator fishes. However, decades of stocking at Musreau have both failed to create a viable stocked fishery, nor harm the brassy minnow subpopulation. Nonetheless, stocking of exotic fish should be avoided at this small lake.

The watershed surrounding Musreau Lake is heavily affected by forestry, and oil and gas development (Figure 9). Threats from this type of development include excessive nutrient inputs (and corresponding algae blooms and summer/winterkills) and oil spills. Future shale gas development in this area is proposed and will increase the threats from linear development and potential spills.

3. Lower Athabasca River - The current status of this subpopulation is unknown, even to the extent of its distribution. The region is being massively developed for oil sands mining, with both surface mining and well-site development affecting most of the watersheds. Potential threats include nutrient input (from sediment runoff) into waterways resulting from the soil disturbance associated with linear developments, fragmentation of streams by culverts, loss of forest cover, and especially chemical spills. For example, in June 1992, a Suncor pipeline break on the upper House River released 7600 barrels of naptha and kerosene into the river (Mok 1994). Fisheries surveys in the following months indicated that all fish in the river downstream of the spill were killed, with fish being found on the banks suggesting they had leapt out of the river to avoid the chemicals (G. Sterling pers. comm.). No brassy minnows were observed in this fisheries survey, nor on the banks of the House River (post-toxic spill), although they had been previously reported from the House River. Fish leaping out of the water to avoid toxins is a long-reported, common observation (e.g., Belding 1927, Young and Nicholson 1951, Pathan et al. 2009).

In Saskatchewan, data from McCulloch et al. (unpubl. report, undated) suggest that possible threats to rare non-game fish species include habitat alteration, either from natural (e.g., beaver dams) or human sources, as well as species introductions.

In Colorado, a prolonged drought or global climate warming, combined with an increased demand for irrigation water that would further reduce stream flows, could extirpate the brassy minnow from Great Plains basins unless segments with sets of connected deep refuge pools supplied with groundwater (like the upstream segment of the Arikaree River study area) are maintained and protected (Scheurer et al. 2003).

STATUS DESIGNATIONS*

1. Alberta - According to *The General Status of Alberta Wild Species 2010*, the brassy minnow is considered *Undetermined* (Alberta

* See Appendix 1 for definitions of selected status designations.

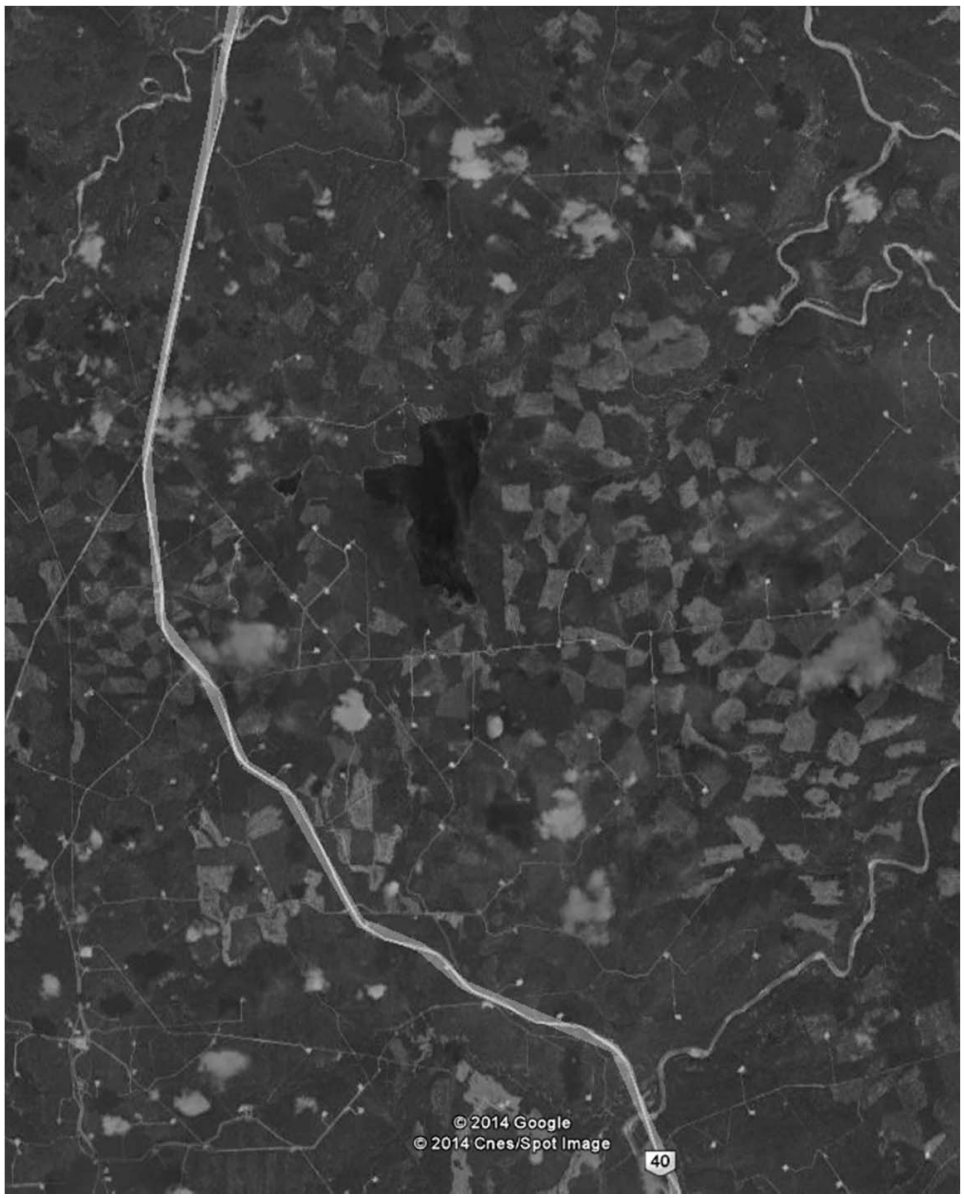


Figure 9. Satellite photo illustrating density of land uses near Musreau Lake, Alberta. Forestry cutblocks, and oil/gas wellsites and roads comprise the majority of land use in this watershed.

Environment and Sustainable Resource Development 2013). According to Alberta's List of Tracked and Watched Elements (Alberta Conservation Information Management System [ACIMS] 2014), the brassy minnow is ranked SU with the reason for tracking stated as "to verify distribution and status in Alberta." The ACIMS compiles detailed information on known locations of selected elements that have been placed on the tracking list, including the brassy minnow. The Provincial Ranks (S Ranks) have been assigned with the assistance of experts and the use of published/non-published data.

2. Other areas - The brassy minnow is ranked G5 globally. A G5 global rating means the species is secure when considered at the global scale.

It is ranked N5 in Canada (NatureServe 2013a), and has been identified on the COSEWIC Fish Species Specialist Subcommittee candidate list (COSEWIC 2014) as an intermediate priority for assessment in Canada. The brassy minnow does not have any special protection in Canada, other than the general protection provided to many Canadian fishes under the federal *Fisheries Act.*

In 2012 and 2013, amendments were made to Canada's *Fisheries Act* such that it no longer protects the habitat of all fish, but only protects the productivity of recreational, commercial and Aboriginal fisheries. This affects many non-game species.

In British Columbia, the brassy minnow has a S4 rating (NatureServe 2013a, B.C. Conservation Data Centre 2014). In Saskatchewan, the rating is S3S4 (NatureServe 2013a). In Manitoba, the brassy minnow is considered S4 (Stewart and Watkinson 2004; NatureServe 2013a). In Ontario, the brassy minnow is considered S5, and in Quebec it is S3S4 (NatureServe 2013a).

In Montana, the brassy minnow has a State Rank of S4. It is a "Potential Species of Concern" in Montana, a term that is used to identify native taxa for which current, often limited, information suggests potential vulnerability (Montana Field Guide 2010). Brassy minnow has a *Threatened* status in Colorado (Colorado Parks and Wildlife 2014).

RECENT MANAGEMENT AND RESEARCH IN ALBERTA

Brown (2014) has conducted recent work on the tributaries of the Milk River, specifically including brassy minnows in the sampling protocols. Her work was instrumental in estimating abundances in this watershed. M. Steinhilber (pers. comm.) is continuing the periodic monitoring of brassy minnows in Musreau Lake, as well as investigating unconfirmed reports of brassy minnows in the Lower Athabasca area. Biologists and consultants in the Fort McMurray area have been alerted to the problem of brassy minnow misidentification, and the lack of confirmation and voucher specimens. New records of brassy minnows in the provincial fisheries database (FWMIS) have been restricted to confirmed specimens. Particularly in the Lower Athabasca area, the confused status of this fish is receiving much more attention, and we expect an increase in confirmation of specimens and new information on abundance and distribution. Advancements and ease of genetic analysis is expected to provide additional information on the relationships of Alberta's three disjunct subpopulations of brassy minnows. No specific plans for this type of analysis are formed, but the recent designation of a provincial environmental monitoring agency (Alberta Environmental Monitoring, Evaluation and Reporting Agency [AEMERA]), includes monitoring genetic diversity in its mandate, and discussions on this specific topic are ongoing.

SYNTHESIS

The brassy minnow is a remarkable, enigmatic little fish that has been poorly researched throughout its range in North America. Life history studies are lacking in Alberta, as are studies on the biology and ecology of brassy minnow in this province and elsewhere. These fish tend to be abundant in habitats with few predators, as they seem to be very vulnerable to fish predation. They appear to be tolerant of a wide range of acidic and alkaline waters, extremely low dissolved oxygen levels and very high water temperatures. Interestingly, select meristic count data are similar for geographically separated subpopulations in the Athabasca River and Milk River drainages and Musreau Lake. Genetic information will be very interesting as it relates to such a disjunct distribution of this fish.

This species is subject to immediate threats of potential introductions of exotic species (Musreau Lake), water use (Milk River) and extensive oil development (Lower Athabasca). In addition, the species is vulnerable to extreme climatic fluctuations, cold temperatures freezing over-wintering pools solid, highly variable water levels, and stream channel relocation. These factors, as influenced by climate change and the associated variance in weather, pose a significant threat to this species in Alberta. In particular, the very limited distribution of this fish in three disjunct patches gives it a heightened level of vulnerability to these cumulative threats.

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Appendix 1. Definitions of status ranks and legal designations.

A. General Status of Alberta Wild Species Categories (used in 2000, 2005 and 2010 General Status exercises) (Alberta Environment and Sustainable Resource Development 2011)

Rank	Definitions
At Risk	Any species known to be *At Risk* after formal detailed status assessment and legal designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	Any species that has not been examined during this exercise.
Exotic/Alien	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/Vagrant	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations
Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2011b)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

D. United States Endangered Species Act (U.S. Fish & Wildlife Service 2005)

Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Appendix 1 continued:

E. Heritage Status Ranks:

Subnational (S) ranks in Alberta (after Alberta Conservation Information Management System 2013)

S1	Known from five or fewer occurrences or especially vulnerable to extirpation because of other factors.
S2	Known from 20 or fewer occurrences or vulnerable to extirpation because of other factors.
S3	Known from 100 or fewer occurrences, or somewhat vulnerable due to other factors, such as restricted range, relatively small population sizes, or other factors.
S4	Apparently secure. Taxon is uncommon but not rare. Potentially some cause for long-term concern because of declines or other factors.
S5	Secure. Taxon is common, widespread, and abundant.
SX	Taxon is believed to be extirpated from the province. Not located despite intensive searches of historical sites and other appropriate habitat. Virtually no likelihood that it will be rediscovered.
SH	Known from only historical records but still some hope of rediscovery. Evidence that the taxon may no longer be present but not enough to state this with certainty.
S?	Not yet ranked, or rank tentatively assigned.
S#S#	A numeric range rank is used to indicate any range of uncertainty about the status of the taxon. Example: S2S3 or S1S3. Ranges cannot skip more than two ranks.
SU	Taxon is currently unrankable because of a lack of information or substantially conflicting information. Example: native versus non-native status not resolved.
SNR	Not ranked. Conservation status not yet assessed.
SNA	Not applicable. A conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities. Example: introduced species.
S#?	Inexact numeric rank. Applied when a specific rank is most likely appropriate but for which some conflicting information or unresolved questions remain.

Global (G), National (N) and other Subnational (S) ranks (after NatureServe 2013b)

G1/N1/S1	Critically Imperiled. At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2/N2/S2	Imperiled. At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3/N3/S3	Vulnerable. At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4/N4/S4	Apparently Secure. At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5/N5/S5	Secure. At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GX/NX/SX	Presumed Extinct/Extirpated. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood of rediscovery.
GH/NH/SH	Possibly Extinct/Extirpated. Known from only historical occurrences but some hope of rediscovery.
G?/N?/S?	Inexact Numeric Rank. Denotes inexact numeric rank.
G#G#/ N#N#/S#S#	A numeric range rank (e.g., G2G3, G1G3) is used to indicate the range of uncertainty about the exact status of a taxon or ecosystem type. Ranges cannot skip more than two ranks.
GU/NU/SU	Unrankable. Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
GNR/NNR/ SNR	Unranked. Conservation status not yet assessed.
GNA/NNA/ SNA	Not Applicable. A conservation status rank is not applicable because the species is not a suitable target for conservation activities

Appendix 2. Summary of brassy minnow counts for each location they have been captured in Alberta, as retrieved from FWMIS in February 2012. Data for the Athabasca River are from Berry (1977), and 2013 data from the Milk River tributaries are from Brown (2014).

WATERBODY	DATE	SURVEY TYPE	COUNT
House River	1973	Seine	1
Athabasca River	1976, 1977	Seine	19
Kennedy Creek	11 July 2002	Electrofishing	87
Lodge Creek	25 September 2002; 2013	Electrofishing	465
Bare Creek	2013	Electrofishing	20
Milk River	01 July & 27 August 1986; 22 October, 2000; 07-21 July 2005;	Seine, Trawl, Electrofishing	1227
Musreau Lake	23 August 1984; 03 & 16 June 1993; 04 & 17 June 1993; 25 June 1998; 10 May & 25 June 1998; 18 June 2002; 03 June 2003;18-19 June 2005; 20 June 2006; 24 June, 2009;	Trap Nets, Minnow Traps, Dip Nets, Seine, Trawl, Electrofishing	1610
Red Creek	08 October 2002; 12 October 2006	Electrofishing	2365

Appendix 3. Technical Summary

A summary of information contained within this report, and used by the Scientific Subcommittee of Alberta's Endangered Species Conservation Committee for the purpose of status assessment based on International Union for the Conservation of Nature criteria. For definitions of terms used in this technical summary, go to: http://www.iucnredlist.org/technical-documents/categories-and-criteria, and http://www.cosepac.gc.ca/eng/sct2/sct2_6_e.cfm

Genus species: *Hybognathus hankinsoni*
Common name: Brassy Minnow
Range of occurrence in Alberta: Milk River drainage in southeastern Alberta, the Peace River basin in northwestern Alberta and the Athabasca River basin in northeastern Alberta, with the occurrences being widely scattered.

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time as indicated in the most recent IUCN guidelines is being used). Based on breeding initiation at 1–2 years and maximum longevity observed at 4 years. See Conservation Biology (3. Life History), pp 10-11.	2–3 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? There are only a few data to analyze trend, from Musreau Lake, which do not suggest any short-term trends over the five years of data that are available. See Population Size and Trends (1. Alberta), pp 12-16.	Unknown
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]?	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10-year, or 3-generation] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	Unknown

Appendix 3 continued:

Are there extreme fluctuations in number of mature individuals? The Milk River subpopulation fluctuates with changing habitat conditions, but the magnitude of the fluctuation is not known. There is variance in catch rates in the Musreau Lake subpopulation, but does not likely indicate extreme fluctuation in that subpopulation. See Distribution (1. Alberta; 1.1 Milk River Subpopulation), pp. 1-4, and Population Size and Trends (1. Alberta; 1.2. Musreau Lake Subpopulation), pp. 14-16.	Possible, but unknown

Extent and Occupancy Information

Estimated extent of occurrence See Distribution (1.4 Province-wide Quantitative Distribution), p. 5.	261,860 km²
Area of occupancy (AO) (Always report 2-km x 2-km grid value. An additional estimate of AO using a measure that is more biologically relevant to the species may be included) See Distribution (1.4 Province-wide Quantitative Distribution), pp. 5-6.	100 km² (2-km x 2-km grid); 31 km^2 (1-km x 1-km grid); 7 km^2 (combined surface area of occupied sites).
Is the total population severely fragmented? The provincial distribution is severely fragmented, with three disjunct areas where the species is found. Within those three areas, however, the subpopulations are not severely fragmented. See Distribution (1. Alberta) and Figure 1, pp.1–2, and Conservation Biology (5. Movement), pp. 11–12	Yes
Number of locations Drought may be the main limiting factor in the Milk River drainage, so the Milk River subpopulation is a single location. Also, the Musreau Lake subpopulation is likely to be affected by a single threat at one time and is therefore considered one location. The Lower Athabasca River subpopulation, if it exists, is considered the third location. See Distribution (1. Alberta) and Figure 1, pp.1–5 and Limiting Factors, pp. 17-18.	Three locations
Is there a continuing decline in extent of occurrence? See Distribution (1. Alberta), pp. 1–6	Unknown, but unlikely

Appendix 3 continued:

Is there a continuing decline in index of area of occupancy? See Distribution (1. Alberta), pp. 1–6	Unknown, but unlikely
Is there a continuing decline in number of subpopulations? See Distribution (1. Alberta), pp. 1–6	Unknown, but unlikely
Is there a continuing decline in number of locations? See Distribution (1. Alberta), pp. 1–6	Unknown, but unlikely
Is there a continuing decline in area, extent and/or quality of habitat? See Habitat, pp. 8–9, and Limiting Factors, p. 17-18	Unknown, but unlikely
Are there extreme fluctuations in number of subpopulations? See Population Size and Trends (1. Alberta), pp. 12–16, and Distribution (1. Alberta), pp. 1–6	No
Are there extreme fluctuations in number of locations? See Population Size and Trends (1. Alberta), pp. 12–16, and Distribution (1. Alberta), pp. 1–6	No
Are there extreme fluctuations in extent of occurrence? See Distribution (1. Alberta), pp. 1–6	No
Are there extreme fluctuations in index of area of occupancy? See Distribution (1. Alberta), pp. 1–6	No

Number of Mature Individuals (in each population)

Population (see Population Size and Trends, 1. Alberta) pp. 12-16	**N Mature Individuals**
Milk River drainages: Musreau Lake: Lower Athabasca River:	~20,000 Hundreds of thousands Unknown, but likely small (0 – 1000)
Total Total provincial population likely in the hundreds of thousands of fish, with the vast majority from Musreau Lake. Estimates for Milk River drainages and Musreau Lake based on abundance estimates derived from electrofishing data and seine haul catch rates. Additional sampling is required to determine accurate population estimates. See Population Size and Trends (1.4 Provincial Population Size), p. 16.	Likely hundreds of thousands of mature individuals

Appendix 3 continued:

Quantitative Analysis

Probability of extinction in the wild is at least 10% within 100 years.	This analysis has not been done.

Threats (actual or imminent, to populations or habitats)

Extreme climatic fluctuations leading to drought, cold temperatures that freeze over-wintering pools solid, highly variable water levels in the Milk River and its tributaries, stream channel relocation causing fish habitat alteration and disruption, oil and gas development, and potential introduction of exotic species.
See Limiting Factors, p. 17-18.

Rescue Effect (immigration from outside Alberta)

Status of outside population(s)? B.C.: S4; SK: S3S4; Mo: S4/"Potential Species of Concern"; CO: Threatened.
See Status Designations (2. Other Areas), p. 19-20

Is immigration known or possible? Immigration is not known; however, it is hypothetically possible in the Milk River drainage from Montana. The rescue effect would be limited by the small area from which the fish could enter Alberta. See Figure 5, p. 7, and Population Size and Trends (3. Rescue Potential), p.17.	Possible
Would immigrants be adapted to survive in Alberta? See Population Size and Trends (3. Rescue Potential), p.17.	Yes
Is there sufficient habitat for immigrants in Alberta? Unoccupied habitat would likely be in areas where subpopulations were lost or displaced in the Milk River drainage as a result of periodic drought and/or freezing to the bottom of overwintering pools; this habitat might not be secure in the long term. See Habitat, pp. 8–9, and Population Size and Trends (3. Rescue Potential), p.17.	Limited
Is rescue from outside populations likely? With limited immigration and little secure habitat available, rescue is unlikely. See Population Size and Trends (3. Rescue Potential), p.17.	No

Current Status

Provincial: SU
National: N5
Elsewhere: G5

Authors of Technical Summary: Duane Radford and Robin Gutsell

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