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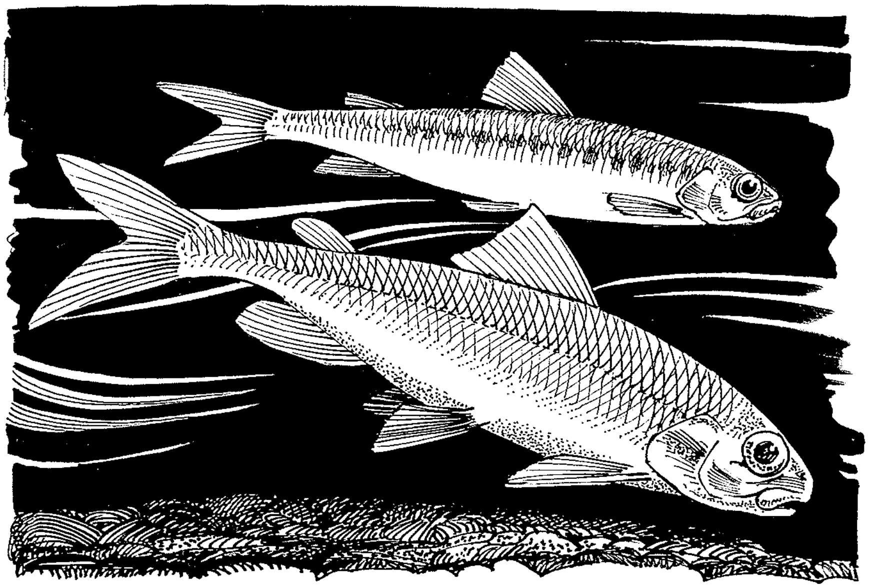
Status of the Pygmy Whitefish (*Prosopium coulterii*) in Alberta:

Update 2011



Alberta Wildlife Status Report No. 27 (Update 2011)

Alberta Conservation Association

Government of Alberta

Status of the Pygmy Whitefish (*Prosopium coulteri*) in Alberta:

Update 2011

Prepared for:
Alberta Sustainable Resource Development (ASRD)
Alberta Conservation Association (ACA)

Update prepared by:
Michael Sullivan

Much of the original work contained in the report was prepared by William C. Mackay in 2000.

This report has been reviewed, revised, and edited prior to publication.
It is an ASRD/ACA working document that will be revised and updated periodically.

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PREFACE

Every five years, the Fish and Wildlife Division of Alberta 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 the Alberta Conservation Association and the Fish and Wildlife Division of Alberta 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 pygmy whitefish (*Prosopium coulterii*) is a glacial relict species that is known from restricted portions of two watersheds in Alberta: Upper Waterton Lake and the Athabasca River between Jasper and Hinton. In 2001, the pygmy whitefish was designated as *Data Deficient* in Alberta. Until 2007, only nine specimens had been collected in Alberta and the species was still considered relatively unknown. Recent surveys conducted by the University of Lethbridge, the Fish and Wildlife Division of Alberta Sustainable Resource Development, and Parks Canada, however, have led to the collection and observation of many specimens in these two watersheds. Extensive and unsuccessful surveying specifically for this species in many other areas of Alberta suggests it has a very restricted distribution in the province. However, within the very small areas of its known habitat, it appears to be relatively common in Upper Waterton Lake and relatively uncommon in the Athabasca River.

Recent environmental impact assessment studies, particularly in the Pacific Northwest, have contributed to considerable advances in our knowledge of this once little-known fish. A resident of very deep, cold boreal and montane lakes, this fish also has local populations resident in shallow, fast rivers. Its small size, rarity, and resemblance to more common whitefish species likely contributed to its Alberta status of *Data Deficient*. More intensive and careful research has resulted in biologists recently recognizing "new" populations that have likely existed for millennia. Populations are known from drainages in the coastal mountains of the Pacific Northwest, from large lakes in the western sub-Arctic, from lakes and rivers in Alaska and Siberia, from one lake and one river in Alberta and from Lake Superior. The unusual geographic distribution of this fascinating little fish suggests it can teach us much about the post-glacial history of North America and Asia. The isolated and small populations in Alberta will undoubtedly be important for taxonomic and geographical studies.

The sustainability of this species in Alberta is of significant concern, based largely on the small sizes of its two known habitats (a lake smaller than 600 ha, and a reach of river only 46 km in length) and the small size of its populations. The Upper Waterton Lake population is relatively protected from local habitat disturbance, but faces threats from invasions of exotic species and potential habitat loss from climate change. The Athabasca River population also faces these threats, but is at further significant risk from accidental spills of deleterious substances (e.g., fuel, chemical, fertilizer, and grain) along the major highway, railway and pipeline corridor that is immediately adjacent to its entire distribution. Mitigation of these threats could include preparation of measures to quickly block, divert, or capture accidental spills of deleterious substances in sensitive areas of this fish's habitat. Surveys of adjacent populations of pygmy whitefish should be conducted to determine if these populations are themselves robust enough and genetically suitable to serve as sources of re-introductions.

ACKNOWLEDGEMENTS

For the original 2000 report prepared by William C. Mackay:
I wish to acknowledge useful information and assistance provided by the following people: Wayne Roberts, curator of the Zoology Museum, Dept. of Biological Sciences, University of Alberta; Dr. Peter McCart, Aquatic Environments Ltd., Spruce View, Alberta; Dave Mayhood, Freshwater Research Ltd., Calgary, Alberta; Bob Shelast, Stantec Consulting, Calgary, Alberta; Derek Tripp, Nanaimo, British Columbia; Dr. Joe Nelson, Department of Biological Science, University of Alberta; and Jane Horb for producing the maps.

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For the 2011 update prepared by Michael Sullivan:
We wish to acknowledge useful information and assistance provided by the following people: George Sterling (fisheries biologist, Edson, Fish and Wildlife Division of Alberta Sustainable Resource Development [ASRD]); Mike Blackburn (fisheries biologist, Edson, Fish and Wildlife Division, ASRD); Ward Hughson (Aquatic Specialist, Jasper National Park); Joe Rasmussen (Department of Biological Sciences, University of Lethbridge); Barb Johnston (Ecosystem Scientist, Waterton Lakes National Park); Wayne Roberts (former curator of the Zoology Museum, Department of Biological Sciences, University of Alberta); Dr. Peter McCart (Aquatic Environments Ltd., Spruce View, Alberta); Dave Mayhood (Freshwater Research Ltd., Calgary, Alberta); Bob Shelast (Stantec Consulting, Calgary, Alberta); Derek Tripp (Nanaimo, British Columbia); Dr. Joe Nelson (Professor Emeritus, Department of Biological Science, University of Alberta); Shelly Humphries (Aquatic Specialist, KYLL Field Unit, Parks Canada); Mark Steinhilber (Royal Alberta Museum, Edmonton, Alberta); Jordan Walker (fisheries biologist, Cold Lake, Fish and Wildlife Division, ASRD); and Cyndi Smith (Conservation Biologist, Waterton Lakes National Park).

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INTRODUCTION

Pygmy whitefish (*Prosopium coulterii*; Eigenmann and Eigenmann 1892) are small, slim whitefish with relatively large scales, a blunt snout and almost cylindrical bodies. Pygmy whitefish have a wide, but unusually disjunct distribution in northern North America (McPhail 2007) and Siberia (Chereshnev and Skopets 1992). They are relatively common in many river and lake systems in Pacific drainages along mountain ranges from Washington, Idaho and Montana, and north through British Columbia to southern Alaska. In drainages east of the Rocky Mountains, however, pygmy whitefish have been found in a few, widely separated large lakes (i.e., Upper Waterton Lake, Lake Athabasca, Great Bear Lake, and Lake Superior). Of note, only one river population (the Upper Athabasca River) is known from east of the Rocky Mountains (McPhail 2007).

Pygmy whitefish in Alberta have been collected in specific habitats from only two locations: Upper Waterton Lake, and a restricted portion of the upper Athabasca River, specifically between the Snaring River (near the townsite of Jasper) and Solomon Creek (near Hinton). Extensive fisheries surveys in surrounding Athabasca River sub-watersheds, with careful attention to correctly identifying pygmy whitefish, have failed to locate other populations (although two assumed-vagrant pygmy whitefish have been collected in one other downstream location). Widespread fisheries surveys in many other Alberta areas have likewise failed to collect pygmy whitefish, except in these two restricted localities.

Pygmy whitefish are designated as *Data Deficient*[1] in Alberta (Alberta Sustainable Resource Development [ASRD] 2010b). 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 high priority candidate for status assessment (COSEWIC 2010b).

This report summarizes current and historical information on pygmy whitefish in order to update its status in Alberta. Concerns regarding the future sustainability of this species are discussed and quantified, with suggestions for mitigating the potential threats.

DISTRIBUTION

1. Alberta

1.1 Lake Populations - There are only a small number of deep, cold lakes in Alberta in which one could expect to find pygmy whitefish: Upper Waterton Lake, in which they have been found (Lindsey and Franzin 1972, Rasmussen et al. 2009; Figure 1), Cold Lake and Lake Athabasca. There is no record of pygmy whitefish from Cold Lake in spite of considerable fishing effort over several years (Leong and Holmes 1981, Roberts 1975, SRD FWMIS records, J. Walker pers. comm.). Records exist from the deep, eastern end of Lake Athabasca in Saskatchewan, including one specimen from 35 m–45 m depth in Black Bay (approximately 65 km NE of the Alberta border [M. Steinhilber pers. comm.; P. McCart and D. Tripp pers. comm.); thus, there is a potential expectation that they may also occur in the Alberta portion of the lake. However, collecting in Upper Waterton Lake found no pygmy whitefish in waters shallower than 30 m, whereas the maximum depth of the portion of Lake Athabasca that is in Alberta is only 17 m (with most of the Alberta portion of the lake being less than 6 m). It is therefore unlikely that pygmy whitefish reside in the shallow, Alberta portion of this lake. However, little or no recent effort has been devoted to collecting them there. Early researchers (Rawson 1947) did extensive collecting in Lake Athabasca, but failed to note pygmy whitefish, either as direct captures or as stomach contents in samples from larger fish.

[1] See Appendix 1 for definitions of selected status designations.

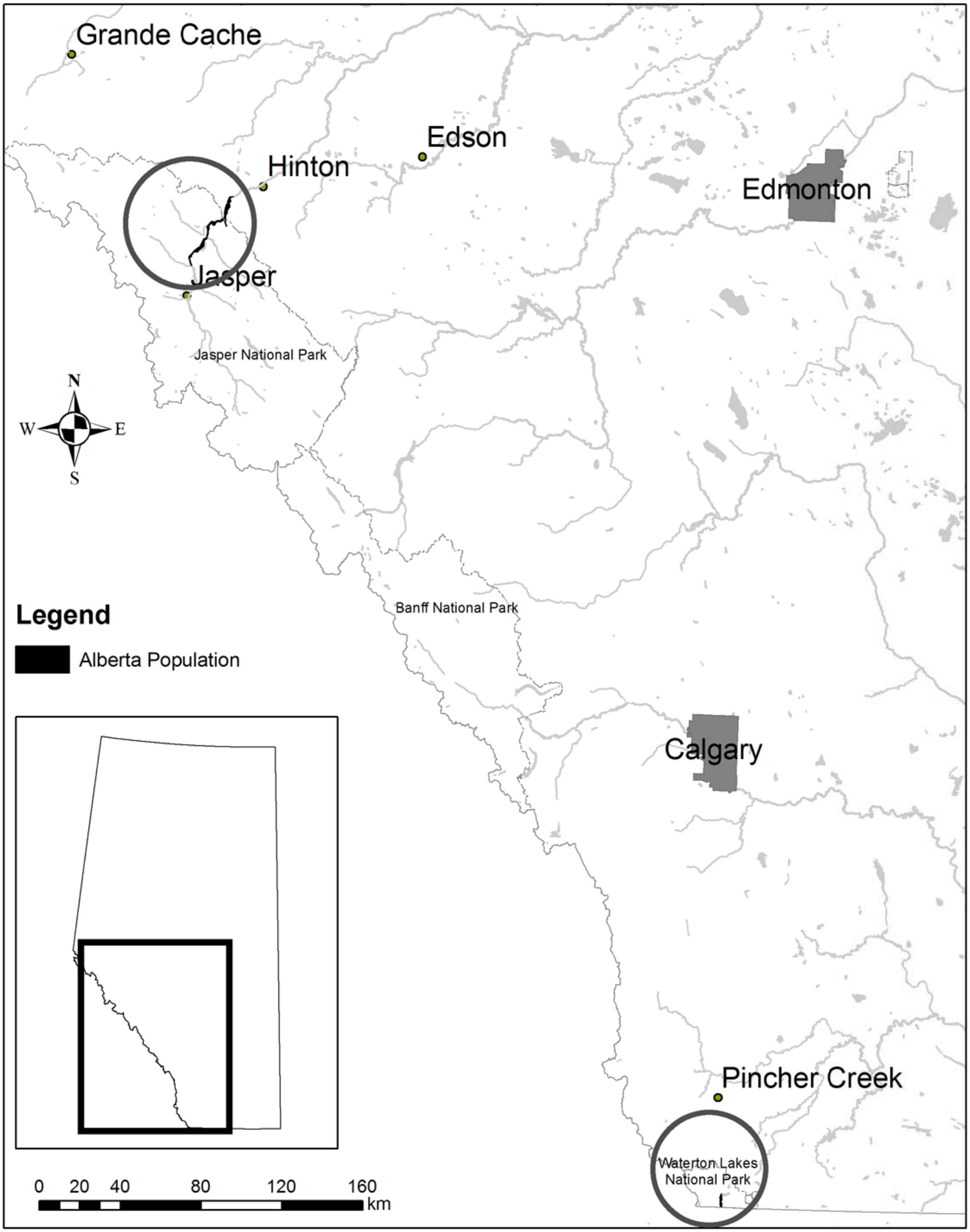

Figure 1. Distribution of the two known populations of pygmy whitefish in Alberta.

The known extent of occurrence of lake-dwelling pygmy whitefish in Alberta is restricted to Upper Waterton Lake (Figure 1). The Alberta (i.e., non-United States) portion of this lake has a maximum polygon area, based on a polygon drawn without concave angles, of 738 ha (7.38 km^2). The surface area of the Alberta portion of Upper Waterton Lake is, however, 585 ha (5.85 km^2). Of this total surface area, pygmy whitefish would only occupy a portion of the lake that was suitable habitat, resulting in a smaller actual extent of occurrence. The area of occupancy in Upper Waterton Lake, based on the sum of occupied 2-km x 2-km grid cells, is 1 grid cell, or 4 km^2. It is possible that there are other areas of pygmy whitefish habitat in Upper Waterton Lake that have not been surveyed sufficiently, but the area of occupancy can not logically exceed the surface area of the lake, which is 585 ha (5.85 km^2). Therefore, the area of occupancy is between 4 km^2 and approximately 6 km^2.

1.2 River Populations - In the upper Athabasca River drainage pygmy whitefish have been found in the mainstem Athabasca River from the Snaring River confluence, and downstream to the confluence with Solomon Creek (Mayhood 1980, 1992, R. L. & L. Environmental Services 1995, G. Sterling pers. comm.; Figure 1). Within this reach of the Athabasca River, a few specimens have been collected in tributaries of the Athabasca River (i.e., Snaring and Snake Indian rivers), but only within a few hundred metres of the confluence with the mainstem Athabasca River. Two pygmy whitefish were found in the Athabasca River beyond this portion, near Whitecourt (Nelson and Shelast 1998). However, intensive surveying during 2009 and 2010 at this site have failed to find any additional specimens, suggesting that these two specimens were vagrant individuals and do not represent a population.

This is corroborated by the extensive records of fisheries survey work on the mainstem Athabasca River. During the period from 1965 to 2010, the Alberta fisheries database (FWMIS) shows records of 19 489 fish (composed of 19 species) sampled in the reach of river from Hinton to Whitecourt. Of these records, only two fish are pygmy whitefish (i.e., the two assumed vagrant fish recorded by Nelson and Shelast 1998). In the entire Athabasca River below Hinton (including Whitecourt and downstream reaches), records show a total sample of 99 457 fish (composed of 28 species) with no additional records of pygmy whitefish other than the two assumed vagrant fish.

Currently, the single collection of the two fish from three km upstream of Whitecourt is believed to represent vagrant fish and should not be considered part of the distribution of the species (G. Sterling pers. comm.).

Widespread and intensive fisheries surveys throughout the tributary streams and rivers of the upper Athabasca River drainage, with specific attention to carefully identifying small whitefish, have not collected any specimens, other than in or near the mainstem Athabasca River between the Snaring River and Solomon Creek.

The known extent of occurrence of river-dwelling pygmy whitefish in Alberta is therefore restricted to a single reach of the upper Athabasca River, between the Snaring River and Solomon Creek (Figure 1). The maximum polygon area, without concave angles, of this reach is 19 980 ha (199.8 km^2).

The area of occupancy, based on occupancy of a 2-km by 2-km grid for the distance of the Snaring River-Solomon Creek reach, is 40 km^2. Alternatively, the actual area of occupied habitat can be roughly estimated using an approximate thalweg (i.e., theoretical center-line of river) distance of the Snaring River-Solomon Creek reach (45.6 km distance) and assuming that all habitat along the river is viable pygmy whitefish habitat. The Athabasca

River is seldom wider than 200 m in the reach known to contain pygmy whitefish, which suggests that the area of habitat would be a maximum of approximately 9 km^2.

1.3 Combined Lake and River Populations - Based on the sum of the areas occupied by the two known pygmy whitefish populations in Alberta, and excluding the unoccupied habitat between the two areas of the province in which the species is found, the maximum polygon area (extent of occurrence) is 207 km^2. The area of occupancy estimated using a 2-km x 2-km grid is 44 km^2; using the maximum surface area of Upper Waterton Lake and the thalweg distance and maximum width of the occupied reach of the Athabasca River, the actual area of habitat occupied would be estimated as a maximum of approximately 15 km^2.

2. Other areas - Pygmy whitefish have been reported from localities very close to Alberta. The species has been reported from the Peace River in British Columbia downstream of the present location of the Bennett Dam (McCart 1965), but has not been reported from the Peace River in Alberta. Pygmy whitefish are also found in Moose and Yellowhead lakes in eastern British Columbia just west of Jasper National Park (McCart 1970). The type locality of pygmy whitefish is located only 15 km west of the Alberta border on the Kickinghorse River, at Field, British Columbia (Eigenmann and Eigenmann 1892). Additional specimens were collected at this location during September and October 2008 (S. Humphries pers. comm.).

Downstream of the Alberta Athabasca River population, pygmy whitefish have been reported in two widely separated lakes and in no rivers. In the Mackenzie River basin, pygmy whitefish have been reported from Great Bear Lake, and the eastern and northern arm of Lake Athabasca in Saskatchewan (Scott and Crossman 1973, P. McCart, cited in Nelson and Shelast 1998 as a pers. comm.; M. Steinhilber pers. comm. citing a RAM specimen from Black Bay, SW of Uranium City, Lake Athabasca).

Pygmy whitefish have a wide but disjunct distribution in northern North America, extending from the Columbia basin in the northwestern United States through western and northwestern Canada and Alaska and in Lake Superior (Figure 2). In Canada, pygmy whitefish are widespread in British Columbia and have been reported from the Yukon Territory, Great Bear Lake in the Northwest Territories (Nelson and Paetz 1992), Lake Superior, and the eastern portion of Lake Athabasca in Saskatchewan. Pygmy whitefish have also been reported from the Chukchi Peninsula in Russia (Chereshnev and Skopets 1992). The species likely had a continuous distribution during the late Pleistocene but became disjunct after the retreat of the Wisconsin glaciation (Eschmeyer and Bailey 1955).

HABITAT

Pygmy whitefish are typically found in the deep parts of deep, cold lakes and in fast, cold montane rivers. Their distribution and preference for cold water suggests that pygmy whitefish are likely a glacial relict species. In the bottom waters of deep cold lakes, pygmy whitefish are spatially separated from lake whitefish (*Coregonus clupeaformis* Mitchill) and cisco (*Coregonus artedi* Lesueur), which appear to occupy a similar niche in shallower water (McCart 1963). In cold, fast-moving rivers, pygmy whitefish appear to coexist with, but are usually less abundant than, their closest relative, the mountain whitefish (*Prosopium williamsoni* Girard).

1. Lakes - In lakes, pygmy whitefish are usually found at depths of greater than 30 m, except during the autumn spawning period when they migrate to shallow, shoreline areas. Fish collected in Upper Waterton Lake were originally caught on the bottom at a depth of about 50 m (Lindsey and Franzin 1972)

Figure 2. Distribution of pygmy whitefish in North America. Compiled from Chereshnev and Skopets (1992), McPhail and Zemlak (2001), and McPhail (2007).

and were considered rare. However, recent collecting with more effective gear (i.e., gill-nets of 6 mm–12 mm square mesh sizes) found them to be relatively common in depths of 30 m–85 m, both near the lake bottom and in deep, mid-water zones (Rasmussen et al. 2009). Similarly, pygmy whitefish collected in the eastern portion of Lake Athabasca (in Saskatchewan) were also from deep water (D. Tripp pers. comm.). One pygmy whitefish specimen in the Royal Alberta Museum is labeled as collected from Black Bay, Lake Athabasca (Saskatchewan) from 35 m–45 m depth (M. Steinhilber pers. comm.).

In southwestern Alaska, pygmy whitefish were found at all depths from shallow areas near shore to 168 m (Heard and Hartman 1965). At these northern latitudes the species was most common in shallow water. In Lake Superior, pygmy whitefish were most common at depths of 55 m–71 m, with the shallowest captures at 18 m (Dryer 1966; depths originally reported as 30–39 fathoms[2] and 10 fathoms, respectively). This corroborated the initial work describing pygmy whitefish in Lake Superior by Eschmeyer and Bailey (1955), who found the shallowest specimens at 18 m (also originally reported as 10 fathoms).

2. Rivers - Pygmy whitefish also occur in moderate to fast-moving montane rivers and streams that can be either clear or silted (Mayhood 1992, McPhail 2007, McPhail and Lindsey 1970). In the Athabasca River, most recent specimens have been collected in moderately deep (0.5 m–1 m) nearshore eddies along the edges of faster mainstem flows. This large river habitat is generally too deep or swift for backpack electrofishing and seining, yet is too shallow to be commonly sampled by large boat electrofishing. This may be the reason few pygmy whitefish have been collected prior to specific sampling in this habitat (G. Sterling pers. comm.). Both adult and juvenile pygmy whitefish have been captured in these habitats. Large numbers of juvenile mountain whitefish are also typically captured with pygmy whitefish in these habitats. Mayhood (1992) reported the two pygmy whitefish collected in the Snake Indian River were captured in very shallow water (10 cm deep). However, this is also the habitat where he was able to conduct seine hauls (i.e., using a small-mesh, hand-towed net to capture small-bodied, shallow water fishes), and only caught two pygmy whitefish in over 90 seine hauls in this area (Mayhood 1992).

CONSERVATION BIOLOGY

Until recently, little was known about the life history of pygmy whitefish in Alberta. One potential reason for this lack of knowledge is that pygmy whitefish can be easily confused with the young of their close relatives, the mountain whitefish, in river populations, and the round whitefish (*Prosopium cylindraceum* Pallas), in northern lakes (Mackay 2000). The few pygmy whitefish specimens collected from Alberta (only nine specimens had been positively identified as recently as of 2007; Appendix 2) were believed to be from a much larger population that had been typically misidentified as other mountain whitefish. However, recent collecting has involved biologists specifically trained to identify this species. Specialized, intensive surveys have been designed and conducted to sample the expected and known habitats of pygmy whitefish. Extensive surveying in broader areas with trained biologists has failed to locate other pygmy whitefish concentrations. From this, biologists have determined that the species is relatively common within its very restricted range and habitat in Alberta. Basic life history information (age, length, maturity, abundance) is now available and is being regularly updated.

In total, 71 pygmy whitefish have currently (as of January 2011) been captured and sampled by biologists in Alberta: 9 specimens province-

[2] fathoms are units of length equal to 1.83 metres.

wide prior to 2007 (i.e., 7 from the Athabasca River, and 2 from Upper Waterton Lake), 42 specimens during the 2007 survey in Upper Waterton Lake (Rasmussen et al. 2009), and 20 specimens during the 2008 surveys along the Athabasca River (G. Sterling pers. comm.) (Appendix 2). No additional specimens were captured in extensive, targeted surveys for pygmy whitefish along the Athabasca River downstream of Hinton during 2009 and 2010 (M. Blackburn pers. comm.).

1. Physical Description and Identification - Pygmy whitefish are typically small (maximum size 65 mm–260 mm) and slim with relatively large scales, a blunt snout and almost cylindrical bodies (Figure 3). In cross section, the depth of the body is less than twice its width (Scott and Crossman 1973). The head is longer than the body depth and the diameter of the eye is larger than the snout length (Scott and Crossman 1973). Pygmy whitefish have 50–70 scales along the lateral line that contain sensory pores and 13–33 pyloric caeca (finger-like projections at the junction of the stomach and small intestine; McPhail and Lindsey 1970).

The maximum length reported is 26.2 cm fork length (FL, measured from the tip of the snout to the fork in the tail) measured in British Columbia (McCart 1963), but in most waters pygmy whitefish reach only 10 cm to 14 cm total length. The large pygmy whitefish reported in McCart (1963) are recognized as being from an unusual population of "giant" pygmy whitefish (Rankin 1999). The Montana State angling record in 2010 was a 9.84 inch (24.99 cm), 5.76 ounce (163 g) specimen.

The largest specimen captured in Alberta was a 13.6 cm, 25 g (round weight) specimen on 10 September 2000 in the Athabasca River (Jasper National Park), approximately 2.4 km downstream of the mouth of the Snake Indian River. This specimen was boat-electrofished and subsequently released alive by J. Campbell, J. Earle, and M. Braener of RL&L Environmental Services Ltd.

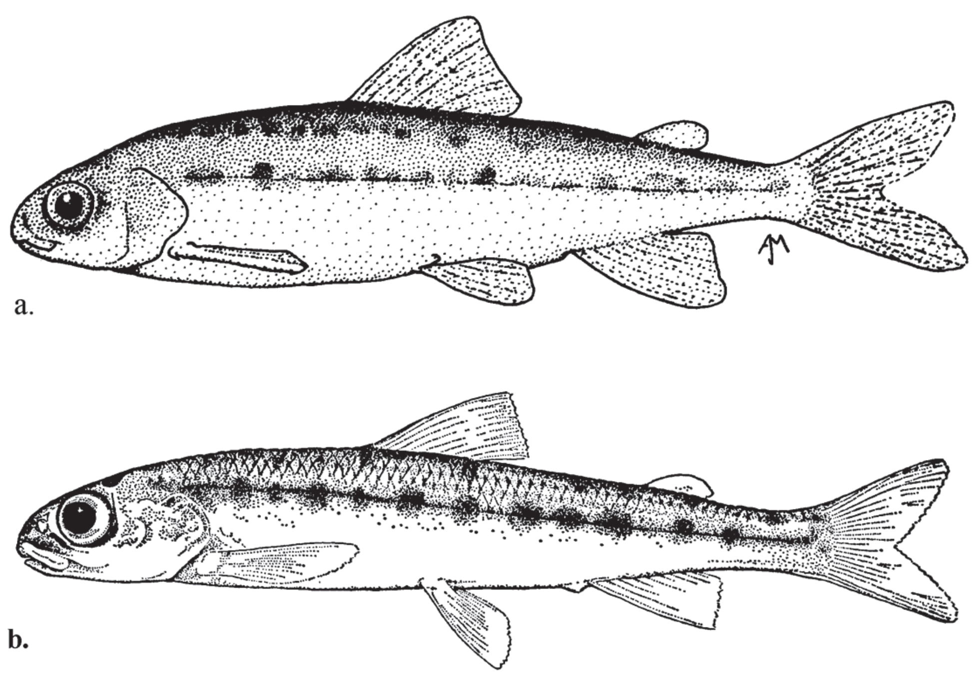

Figure 3. Drawings of pygmy whitefish from a) Nelson & Paetz (1992), and b) Scott & Crossman (1973).

Individuals that are less than 10 cm–2 cm total length have 7–14 distinct dark round to oval markings on the sides along the lateral line, as well as 12–14 similar spots along the middle back. The oval markings along the sides are similar to the dark markings, called "parr marks," which are found along the sides of many juvenile salmonids. These markings, together with the species' small size as adults, can lead to misidentification of pygmy whitefish as juveniles of other whitefish species. During the spawning season, both sexes develop nuptial tubercles (hard, calcified bumps) on the head, back, sides and pectoral fins (Weisel and Dillon 1954). At the same time, the ventral fins of both sexes become orange (Heard and Hartman 1965).

One feature that distinguishes *Prosopium* species from ciscoes is the position of the mouth, which is posterior to the tip of the snout. *Prosopium* species can be distinguished from all *Coregonus* species by the single flap between the nostrils (Figure 4a) and the ventral notch in the adipose eyelid (Figure 4b).

Pygmy whitefish are most likely to be confused with the mountain whitefish in western Alberta and with the round whitefish in the Lake Athabasca region of northeastern Alberta (Appendix 3). A simple and quantitative field identification technique to quickly distinguish pygmy whitefish from mountain whitefish is the count of scales above the lateral line, anterior to the dorsal fin. Pygmy whitefish have 6 rows of scales above the lateral line, whereas mountain whitefish have 11 rows (Plate 1). Chereshnev and Skopets (1992) report that pygmy whitefish in the Amguem River in northeast Siberia may have either five or six rows of scales above the lateral line. All Alberta specimens examined by the author (only 12 specimens from the Athabasca River in 2008), however, have had six rows of scales. The illustration in Eigenmann (1894) of the type specimen of *P. coulterii* also appears to have six rows of scales above the lateral line.

The generalized external features that distinguish pygmy whitefish from other *Prosopium* species are its rather elongate head, relatively large eye (Figure 4c), relatively blunt snout (Figure 4c), and relatively small adipose fin (Figure 5). Along with the dark markings on the sides and back, these identification features are most useful in the field to distinguish pygmy whitefish from mountain whitefish.

Two morphological forms of pygmy whitefish are known: the high-raker and low-raker forms (McCart 1970). These forms are distinguished both by external morphology, and by the quantitative ratio of gill raker count / caudal peduncle scale count : dorsal fin ray count (Figure 6). These forms appear to reflect descent from populations isolated in different glacial refugia, with Cascadian refugium fish being of the low-raker form and Beringia refugium fish being of the high-raker form (Chereshnev and Skopets 1992, Mayhood 1992, Nelson and Shelast 1998, Wiedmer et al. 2010). The two Athabasca River specimens examined for this characteristic (one from the Snaring River area, and one from the Whitecourt area) both are of the low-raker form (Nelson and Shelast 1998). A single specimen from Upper Waterton Lakes examined for this characteristic (Lindsey and Franzin 1972) suggests this population is very different from the Athabasca River population and likely represents descent from a different refugium (Mayhood 1992). Further collections of specimens should include analysis of these characteristics.

The body size of pygmy whitefish in Upper Waterton Lake population appears to be considerably smaller than the fish of the Athabasca River population (Figure 7). This is likely influenced by the differences in capture techniques and size selectivity (i.e., gill-netting in Upper Waterton Lake and electrofishing in the Athabasca River); nonetheless, the lack of large fish in Upper Waterton Lake in spite of a variety of mesh-sizes being employed as capture gear is interesting.

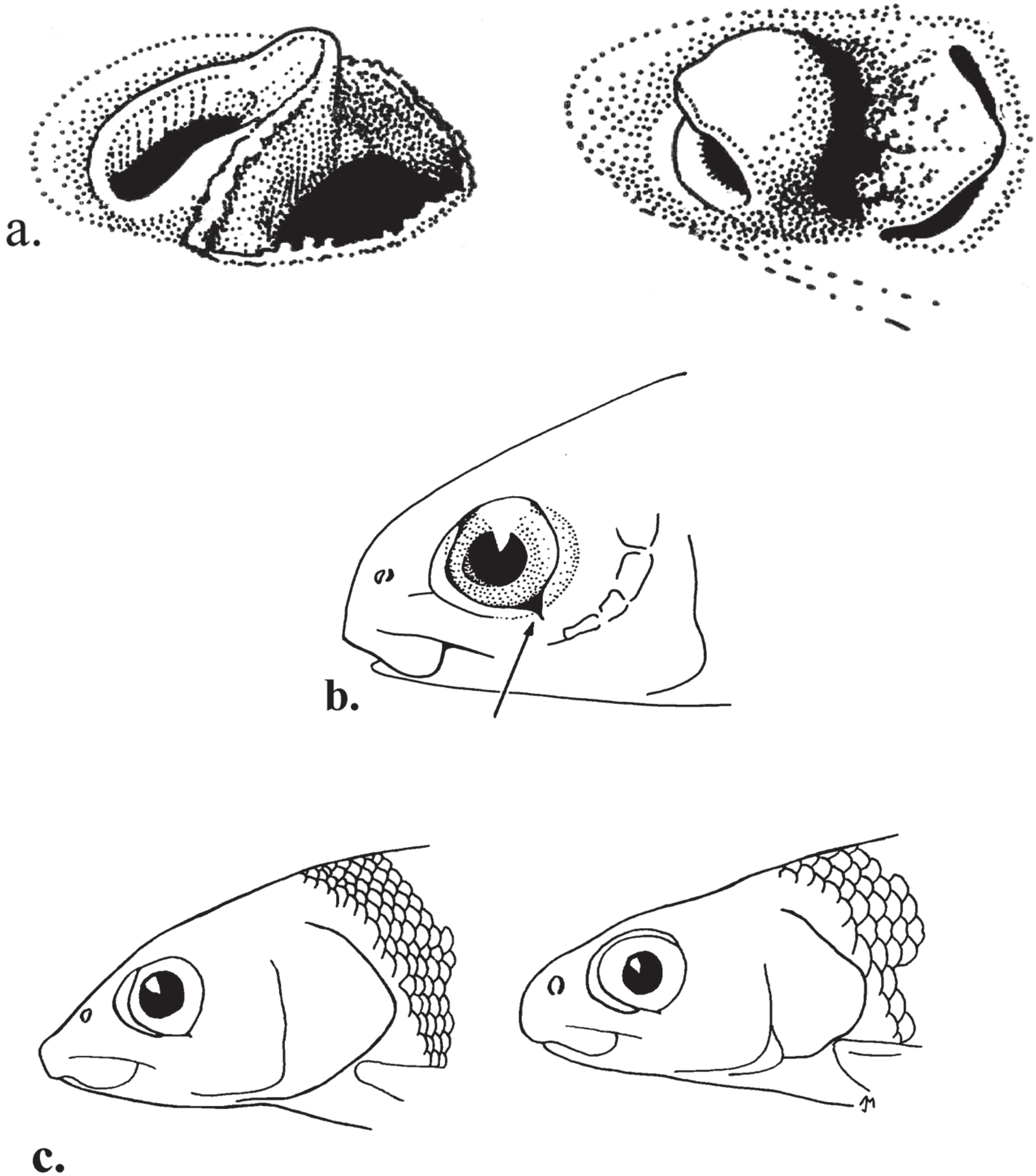

Figure 4. External anatomical features that help distinguish pygmy whitefish from other coregonids: (a) single nasal flap between nostrils of Prosopium species (left) and two nasal flaps found in other coregonids (from McPhail and Lindsey 1970); (b) ventral notch in adipose eyelid of Prosopium species (from McPhail and Lindsey 1970); (c) profile of head of a mountain whitefish (left) and pygmy whitefish (right) (from Nelson and Paetz 1992).

Plate 1. Photograph of adult pygmy whitefish (top) and juvenile mountain whitefish (bottom). A useful field identification meristic characteristic is evident in the different scale counts above the lateral line, with pygmy whitefish having 6 rows of scales and mountain whitefish having 11 rows of scales. Specimens captured in Athabasca River (near Jasper Lake) in Jasper National Park, 24 September 2008. Photo by Ward Hughson, Aquatic Specialist, Jasper National Park, Parks Canada.

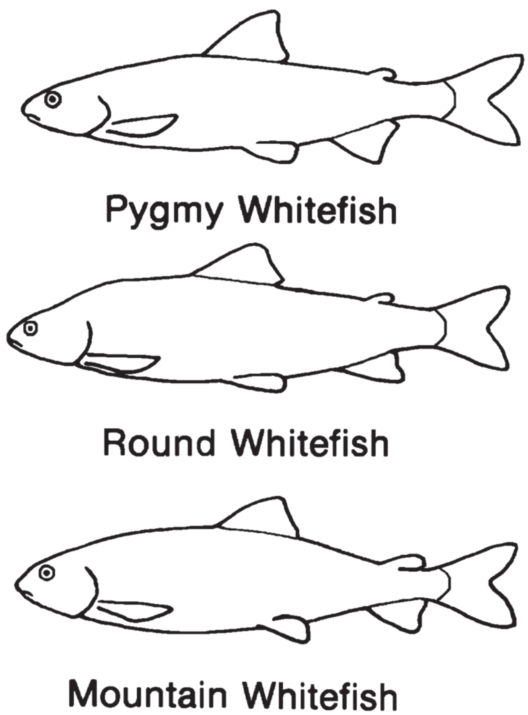

Figure 5. Profiles of pygmy whitefish and other *Prosopium* species (from Nelson and Paetz 1992). Note large adipose fin on mountain whitefish and relatively slimmer body of pygmy whitefish.

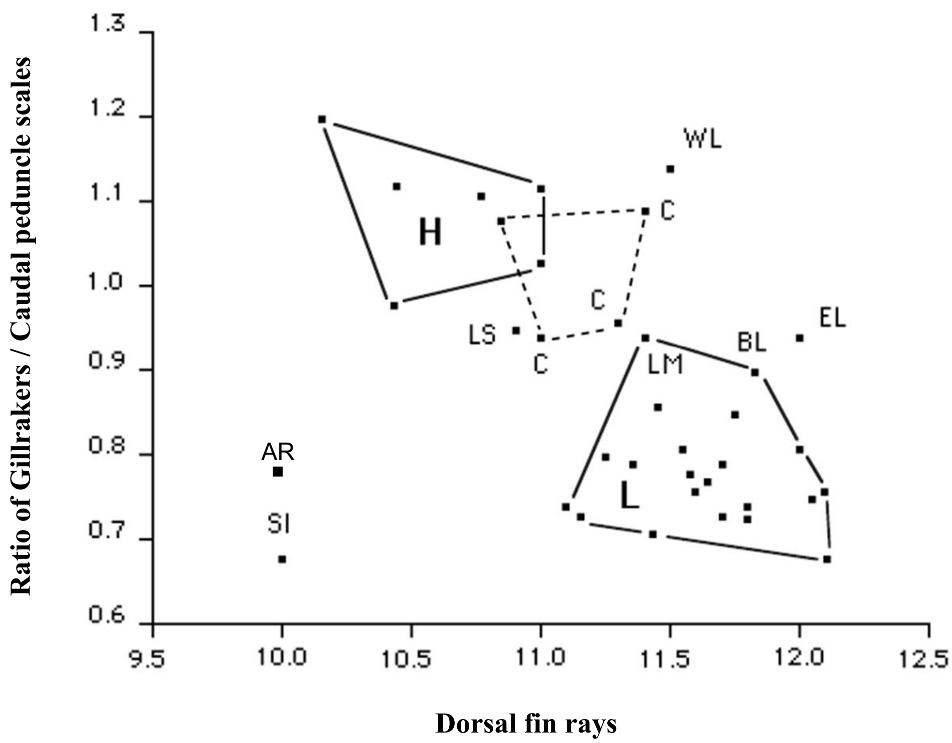

Figure 6. Reproduction of Mayhood (1992) analysis plot of high and low raker forms of pygmy whitefish. Specimen AR is from the Athabasca River near Whitecourt, as reported by Nelson and Shelast (1998). H = high-raked form, L = low-raked form. C = Copper River, AK; WL = Waterton Lake, AB; EL = Elliot Lake, YT; LS = Lake Superior, MI; BL = Bull Lake, MT; LM = Lake McDonald, MT; SI = Snake Indian River, AB.

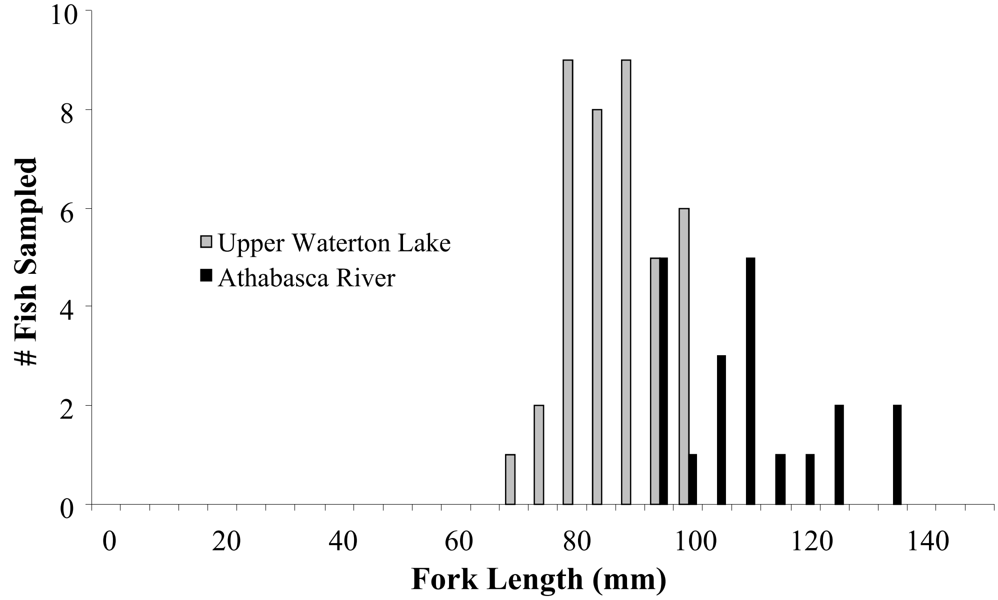

Figure 7. Fork length frequency distributions of pygmy whitefish captured in Upper Waterton Lake during October 2007 and the Athabasca River during September/October 2008. Waterton data from Rasmussen et al. (2009) and Athabasca data from ASRD.

Genetic information can also be very useful to understand the evolutionary relationships and history of stocks of pygmy whitefish. Although specific genetic techniques for pygmy whitefish have been developed (Rogers et al. 2004), a distribution-wide study and analysis is lacking and warranted (Schluter 1996).

2. Reproduction - Pygmy whitefish are potamodromous (i.e., have spawning migrations entirely within freshwater), but have exhibited a wide variety of spawning migrations within this life history. Populations may be entirely non-migratory, may migrate within river systems, may migrate between rivers and lakes, or may migrate entirely within lakes (Northcote 1997).

Like other members of their genus, pygmy whitefish are fall spawners and are assumed to spawn annually when mature (McPhail 2007). Spawning has been reported in November or December for populations in Glacier National Park in Montana (Schultz 1941, Weisel and Dillon 1954), Lake Superior (Eschmeyer and Bailey 1955), British Columbia (McCart 1965) and in southwestern Alaska (Heard and Hartman 1965). Spawning as early as late September has been reported for certain populations in British Columbia (McPhail 2007). In Alaska, pygmy whitefish from Brooks Lake moved into the Brooks River and spawned there at night beginning in early November (Heard and Hartman 1965). Similar spawning behaviour was observed in Montana where pygmy whitefish moved into inlet streams of Bull Lake from mid-December to January and Flathead Lake in late November and December (Weisel et al. 1973).

2.1 Athabasca River Population - In Alberta, one of two pygmy whitefish collected on 4 October 1980 in the lower Snake Indian River was a male in spawning condition, running milt (Mayhood 1992). A large female (134 mm FL) collected on 14 October 2008 in the lower Snaring River near the Athabasca River confluence was carrying eggs and showed obvious nuptial tubercles, but the eggs were not freely running from the oviduct. These sparse records (i.e., one male ready to spawn, one female not ready) suggest that spawning in the Athabasca River population likely occurs in October.

2.2 Upper Waterton Lake Population
In Upper Waterton Lake, gillnet sampling occurred from 15 to 20 October 2007. Mature pygmy whitefish were caught and identified to the state of sexual maturity (19 females, 12 males). All fish were caught in deep water. No pygmy whitefish were caught in shallow, overnight gillnet sets. This suggests that these fish had not yet spawned and were not travelling to the shallow spawning areas. Spawning in Upper Waterton Lake, therefore, likely occurs sometime after mid-October.

3. Growth - Growth data for pygmy whitefish are available for only a few lake populations. These data suggest that females generally have a slightly larger length-at-age than males, and live longer (McPhail and Zemlak 2001). The "giant" pygmy whitefish in MacLure (= Tyhee) Lake in British Columbia (Carl et al. 1959, Rankin 1999) are clearly distinct in length-at-age from the other lake populations. The growth characteristics of these giant pygmy whitefish are unusual enough for this population to be considered for special conservation measures. These giant pygmy whitefish are currently listed as a *Threatened* species in British Columbia (Cannings and Ptolemy 1998).

3.1 Athabasca River Population - Only four specimens were killed and examined for age (determined by examining sectioned otoliths) from the Athabasca River. Of these, three fish were determined to be age four and one fish was age seven. Back-calculated lengths were also determined for each prepared fish, based on a linear relationship of fork length to otolith length (M. Blackburn pers. comm.). These very limited data suggest that the Athabasca River fish may be slightly slower-growing than other pygmy whitefish populations (Figure 8).

3.2 Upper Waterton Lake Population - Ageing structures were taken from many of the 42 pygmy whitefish collected during the October 2007 study. At the time of writing (February 2011), however, the age determination had not been completed for these specimens (J. Rasmussen pers. comm.).

4. Maturity - In general, pygmy whitefish mature at an early age and at a small size. In Dina Lake #1 (a small lake in northern British Columbia), males reached first maturity after three summers of growth (i.e., at age 3), and females after four summers of growth (Zemlak and McPhail 2003). In Brooks Lake in Alaska, both males and females matured at age one or two, and males matured as small as 58 mm and females as small as 61 mm (Heard and Hartman 1965). However, in southern populations males are mature by age two and at 81 mm–130 mm (Eschmeyer and Bailey 1955, Weisel and Dillon 1954, Weisel et al. 1973), and females mature from age two to three and at 97 mm–228 mm (Eschmeyer and Bailey 1955, Weisel and Dillon 1954, Weisel et al. 1973).

Maximum ages recorded for pygmy whitefish are listed in Table 1. In Alberta, the oldest pygmy whitefish was age seven (but only four have been aged). This fish, however, was one of the largest specimens collected. It is reasonable to assume that age seven is near the maximum age for these Athabasca River pygmy whitefish. The generation length for pygmy whitefish in Alberta is estimated at 5.5 years, calculated as the average age between age-at-maturity (age 4) and the maximum age (age 7). Therefore, three generations would be approximately 17 years.

4.1 Athabasca River Population - Only four pygmy whitefish specimens were killed and examined for maturity in the Athabasca River during the 2008 study, but of these, only one was a mature female (134 mm FL). The other three fish (all near 100 mm in length) were immature (Figure 9). The single

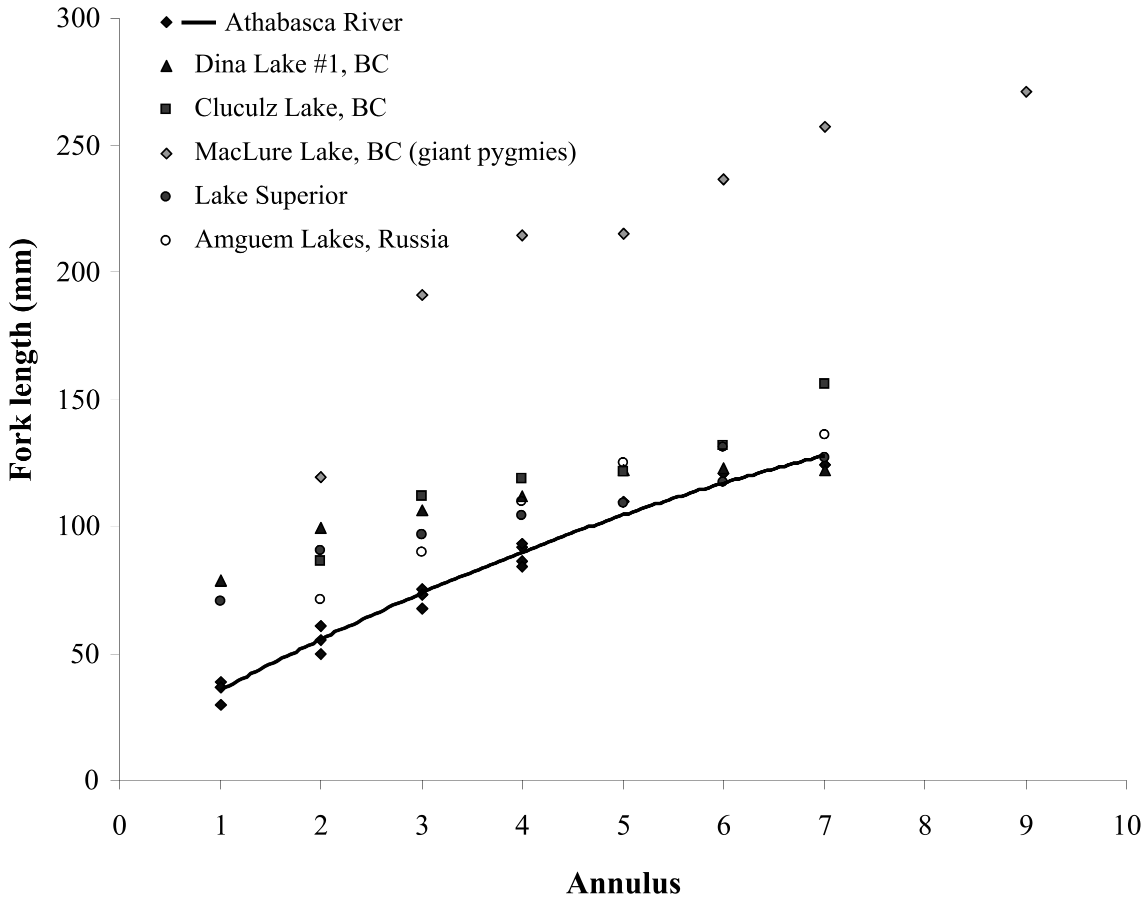

Figure 8. Age - fork length relationship determined from pygmy whitefish populations. Athabasca River data are from back-calculated lengths at each annulus (ASRD). Dina Lake # 1 data from McPhail and Zemlak (2001). Lake Superior and Cluculz Lake data from Scott and Crossman (1973). MacLure (= Tyhee) Lake data from Rankin (1999). Amgeum Basin lakes data from Chreshnev and Skopets (1992). Where data were reported as Total Length (TL) the conversion of TL to FL for mountain whitefish was used; TL = 0.252 + 1.080FL (Rogers et al. 1996).

Table 1. Maximum ages recorded for pygmy whitefish at locations throughout their range.

Lake/River	**Author**	**Maximum Age**
Athabasca River, AB	M. Blackburn (pers. comm.)	7
Lake Superior, MI	Eschmeyer and Bailey (1955)	7
Nanek River, AK	Heard and Hartmann (1965)	3
Lake Aleknagik, AK	McCart (1970)	4
Dina Lake #1, BC	McPhail and Zemlak (2001)	7
Owen Lake (Skeena drainage), BC	Rankin (1999)	10
Chester Morse Lake, WA	Hallock and Mongillo (1998)	4

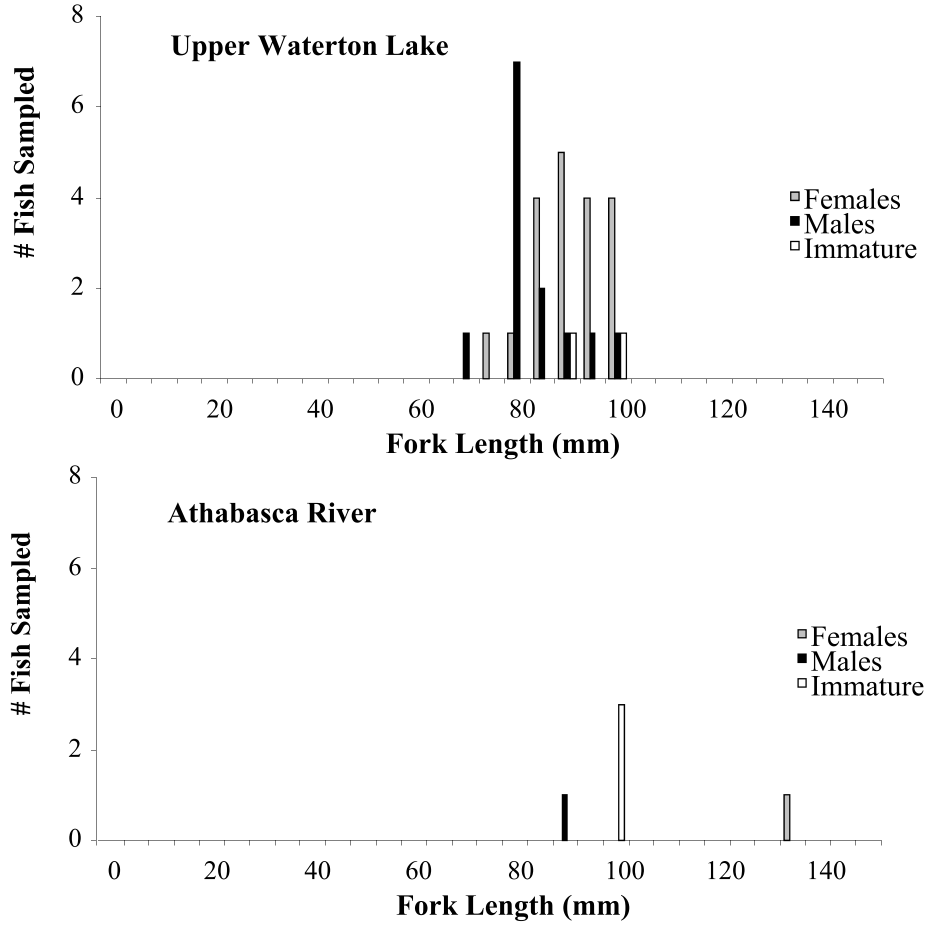

Figure 9. Fork length frequency distributions and state of maturity of pygmy whitefish captured in Upper Waterton Lake during October 2007 and the Athabasca River during September and October 2008. Waterton data from Rasmussen et al. (2009) and Athabasca data from ASRD except data on single male from Mayhood (1992).

sexually mature male killed and collected in the Athabasca River was 86 mm FL (Mayhood 1992). These very limited data allow only the broad generalization that Athabasca River pygmy whitefish may mature at lengths above 86 mm, or approximately age four.

4.2 Upper Waterton Lake Population - In the 2007 Upper Waterton Lake study, the smallest mature female was 74 mm FL and the largest was 100 mm FL. The smallest mature male was 76 mm FL and the largest was 96 mm FL (Rasmussen et al. 2009). From these limited data, it appears that both sexes may be mature at approximately 80 mm FL (Figure 9).

5. Fecundity - Fecundity records range from as low as 97 eggs to over 1000 eggs (Eschmeyer and Bailey 1955, Weisel et al. 1973), with fecundity positively related to size (i.e., 200 eggs for a 90-mm FL female to 1000 eggs for a 150-mm FL female; Heard and Hartman 1965). McPhail and Zemlak (2001) provide a body weight - fecundity relationship for Dina Lake #1 of: Egg Number = 47.606 x Body Weight (g) – 108.669.

The single mature female collected from the Athabasca River was 134 mm FL, with weight of 13.6 g and a measured fecundity of 698 eggs (G. Sterling pers. comm.). This is within the weight–fecundity range observed by McPhail and Zemlak (2001).

Egg size in salmonids is positively correlated with the survival of fry (Hutchings 1991, Miller et al. 1988). Pygmy whitefish eggs are unusually small for salmonids. The diameter of mature eggs has been measured as 2 mm in Lake Superior (Eschmeyer and Bailey 1955) and 2.4 mm in Alaska (Heard and Hartman 1965). McPhail and Zemlak (2001) show a positive trend between fork length and egg diameter. The eggs in their study (Dina Lake #1) were smaller than those previously reported (i.e., 1.40 mm to 1.85 mm).

6. Feeding Habits - Pygmy whitefish appear to be quite flexible in their diet. The diet of lacustrine pygmy whitefish is best known. These populations feed on planktonic and benthic invertebrates. In four British Columbia lakes, the most important food items were small cladocerans, the larvae and pupae of midges and *Chaoborus* larvae (McCart 1965). In Dina Lake #1, pygmy whitefish fed primarily on cladocerans and copepods (McPhail and Zemlak 2001). In Alaska, the major food organisms were crustacean zooplankton and insects. The crustaceans included several cladocerans (*Daphnia, Bosmina* and *Holopedium*) and copepods (*Cyclops* and *Diaptomus*; Heard and Hartman 1965). The major insects eaten were dipterans (mainly Chironomidae) and plecopteran nymphs (Heard and Hartman 1965). In western Montana, pygmy whitefish fed on Cladocera as well as chironomid larvae and pupae (Weisel et al. 1973). The major food organisms in Lake Superior were *Pontoporeia*, a benthic crustacean, but ostracods were also consumed (Eschmeyer and Bailey 1955). Pygmy whitefish are reported to be predators on the eggs of coregonids (either lake whitefish or lake herring; Anderson and Smith 1971). Of the four fish killed and examined from the 2008 Athabasca river sampling, two had empty stomachs, one had the remains of an unidentified winged insect and one contained several Ephemeroptera nymphs, a single Hymenoptera and an unidentified winged insect (G. Sterling pers. comm.).

Parasites of pygmy whitefish are described from populations in Yoho National Park (Mudry and Anderson 1977). These included the monogenean *Tetraonchus variabilis*, and the nematodes *Rhabdochona milleri* and *Cystidicola stigmatura.* Populations of pygmy whitefish in western Montana harboured cysts of the myxobolid parasite (*Henneguya zschokkei* Gurley) in their muscles (Mitchell 1989). Pygmy whitefish in Dina Lake #1 were infected with an unidentified species of digentic trematode (McPhail and Zemlak 2001).

7. Predators - Pygmy whitefish appear to be prey items to most predatory fish in their habitat. Fraley and Shepard (1989) show them to be a minor food item in the diet of bull trout in Flathead Lake, representing only 2.4% (by number) of the food items in bull trout stomachs. Dryer et al. (1965) reported, however, that pygmy whitefish were not found in the stomachs of nearly 1500 lake trout examined from Lake Superior.

POPULATION SIZE AND TRENDS

1. Alberta - Populations of pygmy whitefish are found in only two small areas of habitat in Alberta. Within these two areas, however, the species is relatively common in Upper Waterton Lake (i.e., third most common species captured) and relatively uncommon in the Athabasca River (equally uncommon as the three least-common species) (see Table 2).

Deriving population estimates from catch-per-unit-effort data (e.g. fish caught per net, fish caught per km of electrofishing) is a standard fisheries assessment technique (Hubert and Fabrizio 2007, Hilborn and Walters 1992, Haddon 2001). This technique relies on the estimation of the efficiency (termed catchability) of the fishing technique. These data are typically derived through mark-recapture field studies, where a number of animals are marked, and the proportion recaptured (with a known amount of fishing effort) is the efficiency

Table 2. Fish community composition (i.e., relative abundance of fish species) captured during two specific sampling projects in Alberta's two pygmy whitefish locations.

Upper Waterton Lake[a]	**# caught**	**% caught**
Lake whitefish	113	38
Lake trout	106	36
Pygmy whitefish	42	14
Burbot	23	8
Longnose sucker	7	2
Deepwater sculpin	5	2
Troutperch	1	1
Athabasca River[b]		
Mountain whitefish	23	48
Bull trout	20	42
White sucker	2	4
Pygmy whitefish	1	2
Rainbow trout	1	2
Spoonhead sculpin	1	2

[a] Data from Rasmussen et al. (2009), based on gillnet sampling during Oct. 2007

[b] Data from Parks Canada (Jasper) files, based on backpack electrofishing sampling conducted during Oct. 2008 in the Athabasca River near the mouth of the Snaring River

or catchability coefficient. In Alberta, this technique for estimating population size is used for management of most sport and commercial fisheries.

1.1 Athabasca River Population - The electrofishing data from the Athabasca River study were used to derive an estimate of the abundance of this population of pygmy whitefish. During this study, electrofishing was conducted on five separate reaches of the Athabasca River within the section known to contain pygmy whitefish (i.e., between the Snaring River and Solomon Creek). The electrofishing effort and pygmy whitefish catch rates are shown in Table 3. The overall catch rate was 19 pygmy whitefish/11 240 m or 0.17 fish/100 m. Too few pygmy whitefish were captured to estimate a catchability coefficient; however, mountain whitefish were also marked during this study and their catchability coefficient was derived. In total, 907 mountain whitefish were marked, and 15 marked fish were recaptured in 4.96 km of electrofishing (G. Sterling pers. comm.). Assuming equal catchability of mountain and pygmy whitefish, the density of catchable-sized pygmy whitefish in the study reach (45.6 km; thalweg distance of Athabasca River from Snaring River to Solomon Creek) was therefore approximately 1000 individuals.

The abundance of adult-sized pygmy whitefish is, of course, much lower. Sexual maturity in pygmy whitefish fish is size-based, as is the sampling technique (i.e., electrofishing does not collect very small fish, even though those fish must be present to sustain the population). The proportion of mature fish in a population is therefore simply a function of the capture technique and definition of "population". In the Athabasca River study, the sizes of pygmy

Table 3. Pygmy whitefish survey data from boat electrofishing a total of approximately 80 km on Athabasca River during 2008. Data provided by George Sterling (ASRD June 2010). Data do not include reaches below Solomon Creek and above Snaring River where no pygmy whitefish were caught. #PGWH = number of pygmy whitefish caught.

Date	UTM (Start)	UTM (Finish)	Effort (s)	# PGWH	Distance (m)
23 Sept.	433975 5888092	434463 5889005	1641	1	1590
24 Sept.	434349 5889567	434651 5893123	3743	6	3275
25 Sept.	433975 5888092	434651 5893123	3044	3	3275
14 Oct.	427002 5877000	427111 5879104	n/a	4	2660
22 Oct.	444216 5909477	444624 5909834	672	5	440

whitefish captured were between 92 mm and 134 mm FL. Of the four fish examined for maturity (with sizes of 96 mm, 98 mm, 100 mm, and 134 mm FL), only the 134 mm FL fish was mature.

This very limited sampling data only allows broad interpretations to be made. Of the estimated population of 1000 catchable-sized fish, as few as 25% could be mature, resulting in an estimate of approximately 250 mature pygmy whitefish in the upper Athabasca River. Variance around this estimate was derived by bootstrapping the 5 separate catch rates in each of the 5 study reaches (maximum likelihood estimate of 267 adult pygmy whitefish, 95% confidence limits of 50 to 450 adults; Figure 10). This suggests that the population of mature-sized fish may be very small, and the estimate could be described as likely in the hundreds of fish, rather than in thousands of fish. This approximate estimate should be considered as the best available data and interpretation.

1.2 Upper Waterton Lake Population - Rasmussen et al. (2009) suggest that pygmy whitefish may be more common in Upper Waterton Lake than previously thought. It was the third most common species captured in their study.

The authors also present a quantitative discussion of their catches of lake trout and, using catchability coefficients, estimate that Upper Waterton Lake may have a lake trout abundance of 5/ha. This estimate of lake trout abundance, combined with their reported catch data on pygmy whitefish, allows an approximate estimate to be made of the potential abundance of pygmy whitefish in Upper Waterton Lake.

Rasmussen et al. (2009) present calculations (based on standard multi-mesh gill-net catchability values) that show their catch rate of 8.8 lake trout/net-night (i.e., 106 lake trout in 12 net-nights using catches for Upper Waterton Lake only) correlates to a density of 5 lake trout/ha. Using the assumption that lake trout and pygmy whitefish have similar vulnerability to multi-mesh gill-nets, similar calculations may be made for pygmy whitefish. In the study of Rasmussen et al. (2009), lake trout were caught (and therefore vulnerable) in all 11 sizes of gill-net panels. Pygmy whitefish, however, were only caught (and therefore vulnerable) in the smallest 4 of the 11 panels. Correcting for this effectively reduced netting effort (i.e., pygmy whitefish were only vulnerable to 36% of the gill-net), their effective catch rate was 9.6 pygmy whitefish/net-night (i.e., 42 pygmy whitefish/12 net-nights x 4/11). This catch rate correlates to a density of 5.5 pygmy

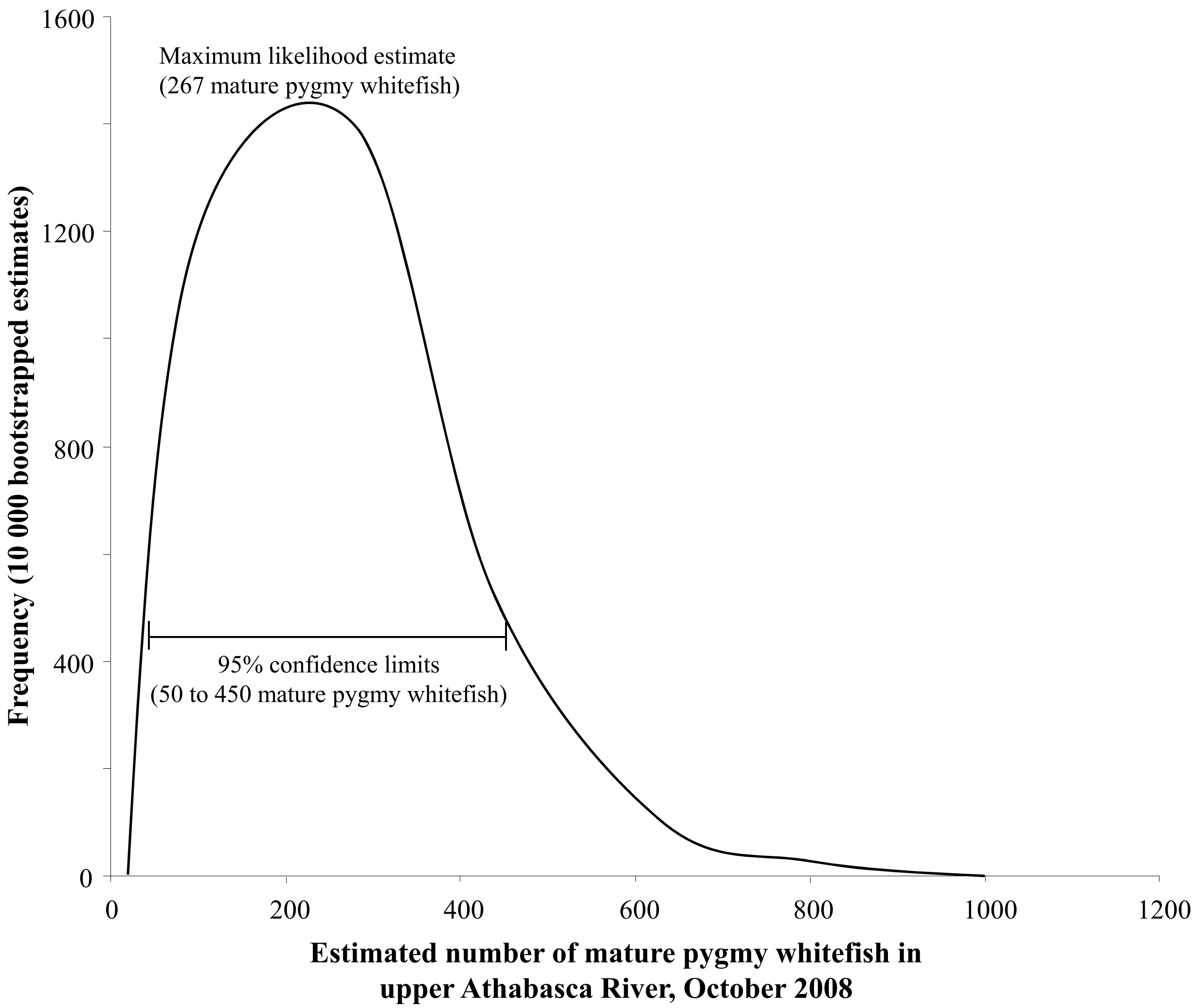

Figure 10. Likelihood frequency distribution of 10 000 bootstrapped estimates of number of mature pygmy whitefish in upper Athabasca River, October 2008. Estimates based on electrofishing data from ASRD.

whitefish/ha. Based on a habitat area of 343 ha, the population of catchable-sized pygmy whitefish could therefore be approximately 1900 fish. The maturity ratio from the gill-net sample in Rasmussen et al. (2009) was 94% mature, implying a population estimate of approximately 1800 mature-sized pygmy whitefish. As explained previously with the Athabasca river population, the estimate of the proportion of mature fish is a function of the capture technique and definition of the population. As the definition of the Upper Waterton Lake population refers only to those fish captured by gill-nets, the proportion of mature fish in the population must also refer only to those fish captured by gill-nets. Because of the combination of size-dependent maturity and size-selective bias inherent in any fish sampling gear, the proportion of mature fish in different samples can not be compared between fish collections taken using different gear-types.

A measure of variance on this estimate may also be derived. The observed pygmy whitefish catch rate (i.e., 42 fish in 12 net-nights, mean of 3.5 pygmy whitefish / net) was composed of data from 12 individual net catches. A bootstrap analysis of the 12 actual net catches was used to derive 10 000 possible mean catch rates and therefore the corresponding abundance estimate of mature pygmy whitefish. The resulting likelihood distribution of possible abundance estimates is shown in Figure 11 (maximum likelihood estimate of approximately 1800 adult fish, with 95% confidence intervals of 750 and 3300 fish).

This is an approximate estimate, and relies on untested assumptions (e.g., equal catchability of lake trout and pygmy whitefish, and static sex ratio). It does, however, provide a line of evidence to assist conservation biologists in assessing the status of this population of fish. An interpretation of these data, in relation to conservation thresholds, is that the population of mature pygmy whitefish in Upper Waterton Lake is likely between 1000 and 2500 individuals, with a lower likelihood of being below 1000 or over 2500 fish. Further, it is very unlikely that the population is composed of fewer than 250 or more than 10 000 fish (Figure 11).

The study of Rasmussen et al. (2009) was the first and only study to gather quantitative data on this population; therefore, no estimate of trends can be made. Local biologists, however, believe that no major changes to the lake ecosystem or community have occurred that may result in a decline or increase in this population (B. Johnston pers. comm.).

1.3 Province-wide Population Estimate - The results from each pygmy whitefish population estimate (i.e., Athabasca River and Upper Waterton Lake) may be combined for an estimate of approximately 2000 (with 95% confidence intervals of 700 to 3000; Figure 12) mature-sized fish as the total Alberta population size. Given the approximate nature of these estimates, it would be reasonable to conclude that the Athabasca river population is likely less than a few hundred and the Upper Waterton Lake population is likely less than a few thousand mature-sized pygmy whitefish.

2. Other Areas - Even in habitats where they are known to occur, pygmy whitefish are believed to be uncommon. Most of the documented range of pygmy whitefish occurs in British Columbia and extends to the northwest through southwestern Yukon and Alaska. They are generally found in areas and habitats that have experienced little human impact. Populations in these areas are likely stable, although most of the data available are from individual populations that been studied only once. The populations for which data are available are from Lake Superior (Eschmeyer and Bailey 1955), central British Columbia (McCart 1963), southeastern Alaska (Heard and Hartman 1965) and the Flathead Lake area of Montana (Weisel et al. 1973). There are no recent data for any of these populations; however, indications are that throughout their range pygmy whitefish are rarely common. In Lake Superior, Eschmeyer and Bailey (1955) caught an average maximum of 37 fish per 10 minutes of trawling. In two British Columbia lakes, the maximum catch rate was 0.929 pygmy whitefish per net hour (McCart 1963). In Flathead Lake in Montana, pygmy whitefish were considered abundant when they made up 4.8% of the total fish catch (Weisel et al. 1973). Pygmy whitefish appear to be more abundant in the Naknek River system in Alaska than anywhere else they have been studied (Heard and Hartman 1965). Using a beach seine, which ranged from 33 m to 43 m long, Heard and Harman (1965) caught up to 964 pygmy whitefish in a single haul, and using a 2.6 m wide, 0.6 m deep otter trawl (a type of deep-water, boat-towed net), towed for less than 1000 m, they caught 1567 pygmy whitefish.

LIMITING FACTORS

1. Threats to Habitat

1.1 Athabasca River Population - Much of the watershed of the upper Athabasca River pygmy whitefish population is located in Jasper National Park. Of the 46 km of river known to support pygmy whitefish, the upper

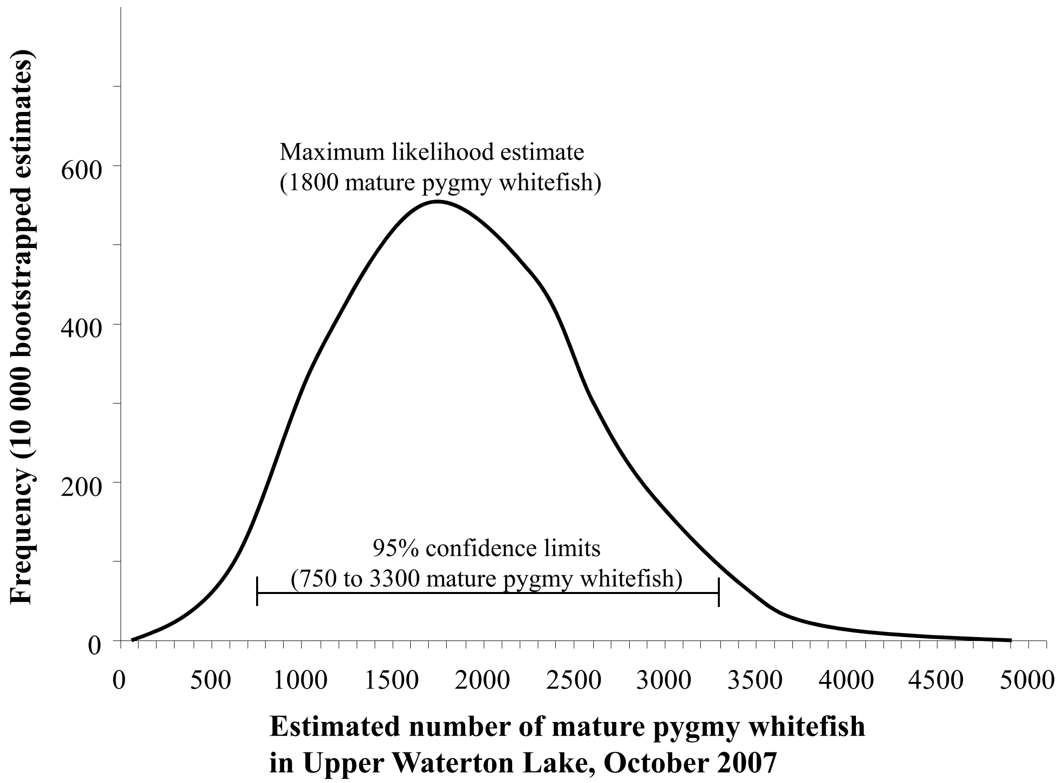

Figure 11. Likelihood frequency distribution of 10 000 bootstrapped estimates of number of mature pygmy whitefish in Upper Waterton Lake. Estimates based on netting data from Rasmussen et al. (2009).

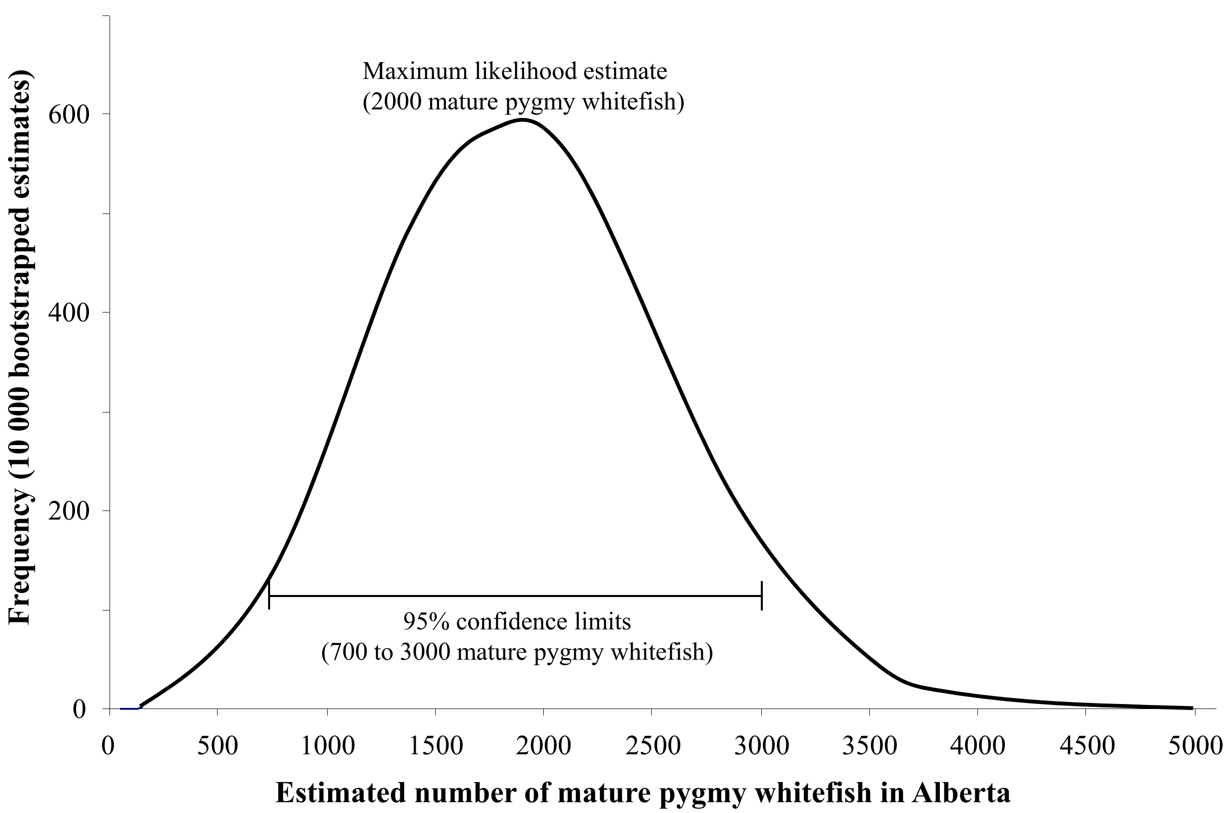

Figure 12. Likelihood frequency distribution of estimated of number of mature pygmy whitefish in Alberta (Upper Waterton Lake and upper Athabasca River estimates combined).

32 km (70%) are within Jasper National Park. The watershed of Solomon Creek (the lower limit of the pygmy whitefish population) is within provincially managed lands. The upper portion of this watershed is protected within the Rock Lake–Solomon Creek Provincial Wildland Park, whereas the lower portion has both private lands and managed timber leases.

In spite of the protected status of much of the surrounding watershed, the river habitat is under considerable threat from accidental spills. The entire length of the known pygmy whitefish habitat is closely paralleled by a heavily-used highway, and a major pipeline and railway corridor. These transportation corridors follow both the Athabasca River and its major tributary in Jasper, the Miette River. Any accidental spill along this corridor could result in deleterious substances damaging the entire known habitat of the pygmy whitefish in the Athabasca River. The length of the combined Athabasca-Miette corridor is approximately 85 km.

The vehicle traffic on Highway 16 adjacent to the Athabasca River has increased from under 1.2 million vehicles/year to over 1.4 million vehicles/year from 1997 to 2008 (Figure 13). The highway is seldom further than a few hundred metres from the river along the entire reach, and any vehicle accident involving liquid spills could pose a direct threat to polluting the river. The vehicle accident rate in Alberta in 2006 was 581 injury or fatality accidents per billion vehicle-kilometres (Alberta Transportation 2007). Assuming the 85 km length is travelled by each vehicle using the highway, the annual use is estimated at 0.12 billion vehicle-kilometres. Using the average accidents rates for Alberta (likely an overestimation for highway travel only) suggests that approximately 70 fatality or injury accidents might be expected annually on this reach. Based on the severity of this class of accident (i.e., fatality or casualty), it is probable that this frequency of accident may also represent potential spills of fuel or deleterious substances.

The pipeline corridor also travels for 85 km along this route. Assuming this is a twinned pipeline, the combined length is 170 km. Spill frequency on pipelines in Alberta, as reported to the Energy Utilities Board, is 0.0017 spills/year/km of pipeline (EUB 2007). This frequency suggests the probability of a pipeline spill along the Athabasca river-Miette corridor is 0.29 spills/year or approximately 1 spill every 3 years.

The railway running alongside this corridor is heavily travelled, with twin tracks on one of the major mountain passes in Alberta. This rail corridor is primarily used for freight by Canadian National railways, who operate approximately 35 trains/day or 12 775 trains/year (Bertwistle 1999). With a distance of 85 km, this is a volume of 1.09 million train-km/year. The rail accident frequency in Canada involving dangerous goods was 1.4/million train-km (5-yr average 2002-2006, TSB 2008). This suggests a train accident frequency involving dangerous goods in the Jasper corridor of 1.5 accidents/year.

The accident frequency suggested by these statistics is based on broad province or nation-wide reporting. They may not accurately reflect the actual accident frequency in the Athabasca-Miette corridor. However, they do strongly imply that accidents involving spills of deleterious substances are a significant risk to the pygmy whitefish habitat adjacent to such a heavily-used transportation route. Deleterious substances can include chemicals such as fuels (Vignier et al. 1992), fertilizers (Meade 2004), agrichemicals (Quinn et al. 2010), coal liquids (Dauble et al. 1983) or industrial substances (Mole et al. 1981), but may also include commonly shipped substances such as grain.

A major spill of grain into the Athabasca River system near Jasper could result in

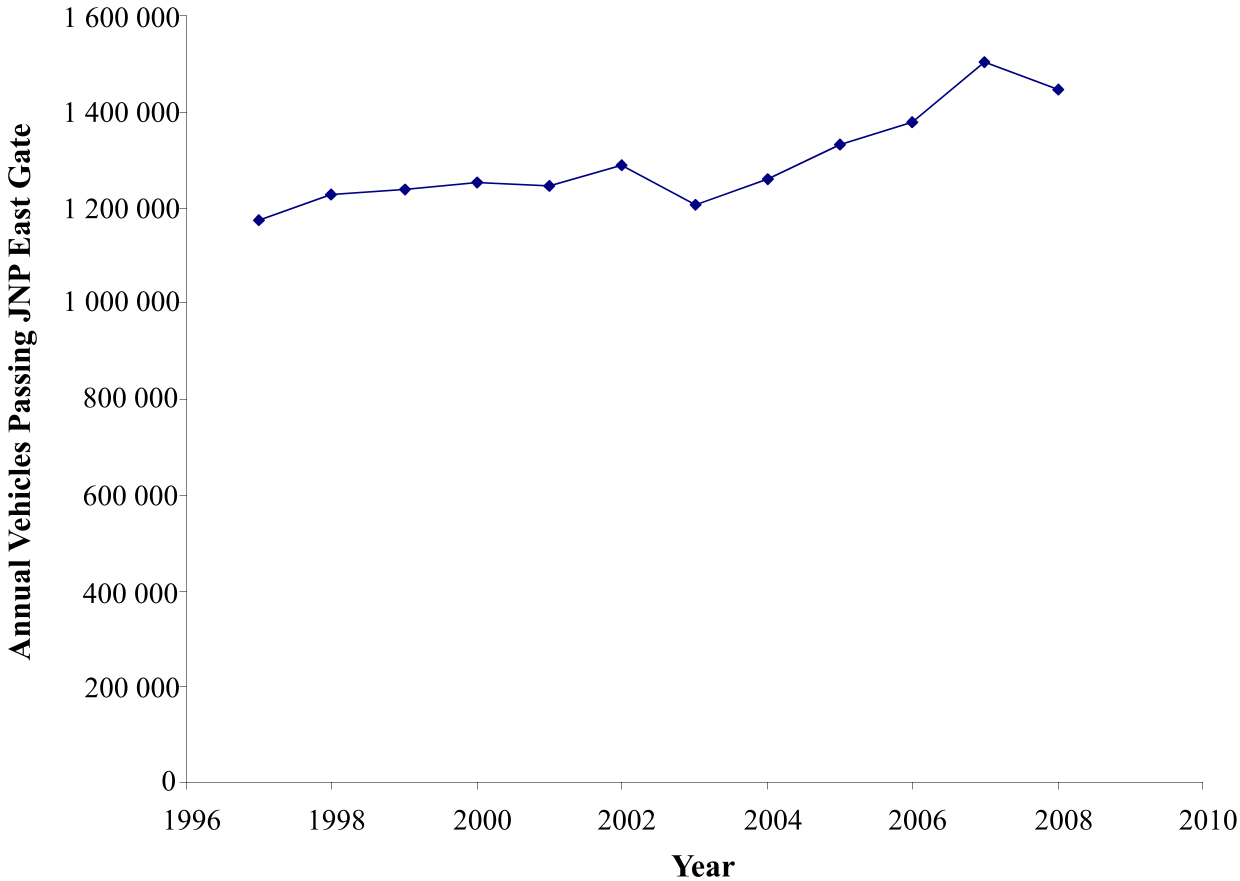

Figure 13. Annual count of vehicles on Highway 16 passing through East Gate in Jasper National Park, 1997–2008. Data from automatic highway counters measuring two-way traffic.

nutrient enrichment, excessive algae growth, and subsequent depression of oxygen levels, plausibly resulting in a fish kill. Although most mountain rivers are naturally unproductive, the Athabasca River in Jasper is unusually high in phosphorus compared to nearby Rocky Mountain rivers (i.e., phosphate levels 7 times higher than near Field, B.C. and Lake Louise, Alberta, and 2 times higher than near Banff, Alberta; Bowman et al. 2005) and are at approximately 60% of the phosphorus threshold for chronic exposure for protection of aquatic life (Alberta Environment 1999, Bowman et al. 2005). These high levels are likely a result of high erosion and sediment loads in the upper Athabasca watershed. At the Jasper townsite, additional phosphorus (in the form of treated sewage water) is discharged into this nutrient-replete river and has caused a 100-fold increase in algae biomass at reference sites 3 km below the sewage outfall (Bowman et al. 2005). A spill into the river from 16 wheat hopper cars (at 91 tonnes of wheat per car, and a wheat phosphorus content of 0.4%; Turmel et al. 2009) would be the equivalent phosphate loading from an entire year of effluent discharge from the Jasper sewage treatment plant, and would very likely result in a further large increase in algae biomass. Train derailments and major spills of grain (e.g., 5 hopper cars) have occurred as recently as 29 June 2008 in Jasper (Plate 2), although fortunately this spill was not directly into the river. The pygmy whitefish habitat in the Athabasca River below Jasper has two large slow-moving, ice-covered sections (Jasper Lake and Brule Lake). The risk of a grain-spill-induced winterkill in this habitat seems plausible.

Plate 2. Photograph of a train derailment and grain spill in the Jasper townsite. "A CN Rail train lost a wheel and derailed near the town's Petro Canada station June 29. A witness said the train was pulling out of the Jasper station when its wheel flew off, causing five cars to derail and grain to spill over the tracks, a pedestrian crossing and into the surrounding forest. Kolby Kongsrud submitted photo." From Petersen (2008).

Mitigating the threats posed by this major transportation corridor should include programs to increase the awareness of officials (i.e., Parks Canada, Canadian National Railways, Alberta Highways, Alberta Energy Utilities Board) of the sensitivity of this stretch of river. A spill in this area would imperil more species than just pygmy whitefish. However, the entire local population of this species is found only in the highest risk area, immediately adjacent to the transportation corridor. Further mitigation measures might be considered to quickly reduce the harm caused by a spill. Berms could be built near crossings on tributary creeks that could be used to block or divert spills. Drainage ditches could be re-routed to enter wetlands instead of directly flowing to the mainstem river. Oil spill and grain spill recovery equipment should be located near the townsite of Jasper to speed reaction to a spill in the sensitive headwaters area. Spill experts should be commissioned to study the sensitivity of this corridor and plan effective mitigation measures.

1.2 Upper Waterton Lake Population - The lake habitat, as well as the surrounding watershed, of this population is entirely encompassed in protected national parks: Waterton Lakes National Park in Canada, and Glacier National Park in the United States. No significant development occurs presently, nor is any immediately planned for the upper portion of the watershed of the Upper Waterton Lake (Parks Canada 2010, U.S. Dept of Interior

1999). Local habitat threats in the upper watershed are therefore likely very low.

However, the hamlet of Waterton Park is located on the shore of Upper Waterton Lake, near the channel dividing the upper lake from the lower lake. This small hamlet had a permanent population of only 160 (Statistics Canada 2006 census), but experiences approximately 380 000 annual visitors (Parks Canada 2010). Tertiary treatment of the town's sewage has been occurring since 1975, with no dumping of sewage into Upper Waterton Lake since that date. The threat of run-off of road pollutants (Hassel et al. 1980) or of accidental discharges of deleterious substances (e.g., fuel, fertilizers, fire retardants) from the town should be recognized. Similarly, accidental discharges from boats (private and commercial operations) using the upper lake should be considered in any threat risk assessment. Prevention and mitigation plans should be in place to prevent and minimize any negative effects to the water quality of the lake.

2. Exotic Species - Stocking with non-native predatory fish may negatively affect pygmy whitefish. Hansen et al. (2008) described concerns regarding an introduced and rapidly expanding lake trout population in Lake Pend Oreille, Idaho to seriously harm the native fish community, including pygmy whitefish. However, Zemlak and McPhail (2006) describe the persistence of a pygmy whitefish population in a small (158 ha) lake experiencing at least 20 years of stocking with exotic rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*). Both Alberta populations of pygmy whitefish have been exposed to intentional stocking of exotic species in the past, but this practice is now officially discouraged (ASRD 2006, Environment Canada 2004). Stocking fish was discontinued in Waterton Lakes National Park in 1988. Direct stocking of the watershed of the Athabasca River in Jasper National Park or in the provincially-managed mainstem portion in Alberta is not currently conducted. Exotic fish species continue to be stocked in the ponds and tributaries of the Athabasca watershed in Alberta (ASRD 2010c).

Unintentional stocking of exotic species can be a continuing problem (Johnson et al. 2009). Illegal stocking of fish such as walleye, pike, and perch is a serious problem to stocks of salmonids in ecosystems of the Pacific Northwest (BC Environment 2007, McMahon and Bennett 1996). The threat is expected to increase as climate change allows warm-water, exotic species to thrive in previously unsuitable habitat. In addition to illegal stocking of fish, illegal or unintentional stocking of other organisms used as bait, such as earthworms and leeches, can pose potentially serious problems (Cameron et al. 2008). Introduced leeches have recently been found to be carriers of serious viral infectious diseases threatening Great Lakes fishes (Faisal and Schulz 2009). Although both populations of pygmy whitefish in Alberta are in areas with bait restrictions on the sport fisheries, illegal bait use is still expected.

3. Sport Fishing - Newspaper and electronic media accounts of the rapidly changing status of the Montana state angling record for pygmy whitefish (i.e., 8 state records set or broken since 1982) have contributed to anglers' awareness of pygmy whitefish, and have given it a somewhat whimsical, but avid following as a sport fish in Montana (Flathead Beacon 2010). To our knowledge, no angler has yet officially reported catching a pygmy whitefish in Alberta, in provincial waters or in the two national parks (i.e., Waterton and Jasper).

Under current (2011) Alberta Fish and Wildlife fisheries management practices, pygmy whitefish are not considered a sport fish, nor are they listed in the possession limit section of the Sport Fishing Regulation synopsis. This means they are considered non-game fish and therefore anglers have no restrictions on the numbers of pygmy whitefish they may keep. However, in the two Alberta national parks with pygmy whitefish (Waterton and Jasper), pygmy whitefish catches by anglers would be restricted to a bag limit of zero. In the 2010 Sport Fishing regulations for all mountain national parks, pygmy whitefish are not specifically listed in the catch and possession limits and therefore fall into the category of "other species," which (in opposite form to provincially managed waters) have a bag limit of zero.

4. Climate Change - Pygmy whitefish generally occur in two distinct habitat types: deep water of cold lakes and fast, cold rivers. Their use of deep water locations may help pygmy whitefish remain relatively isolated from direct human disturbance. However, these populations, as well as those in mountain rivers, may be affected by the warming that has occurred because of global-scale human effects. Pygmy whitefish inhabit montane and northern areas that are experiencing some of the most severe changes in climate (Parmesan 2006), with Arctic and northern fishes facing some of the greatest and uncertain changes (Reist et al. 2006). Using ice cover records from 1846 to 1995 across the northern hemisphere, Magnuson et al. (2000) found that the period of ice cover has been reduced, with freeze-up averaging 5.8 days later per 100 years, and break-up averaging 6.5 days earlier per 100 years. The consequences of such major changes in habitat will increase extinction risk, particularly in species with limited dispersal abilities (Thomas et al. 2004). Other ecological changes associated with climate change, such as the earlier spawning runs observed in alewives (Ellis and Vokoun 2009), could have unforeseen negative consequences.

The broad effects of warmer water temperatures on pygmy whitefish have not been studied. Zemlak and McPhail (2006) found that pygmy whitefish inhabiting an unusually shallow lake were tolerant of both warm water temperatures and low oxygen levels. This population was, however, not typical of pygmy whitefish in their larger study area (Peace -Williston drainage). Even without direct temperature effects on pygmy whitefish, warmer water may force pygmy whitefish to compete with other species in habitats previously unused by sympatric species such as mountain whitefish.

4.1 Modelling Climate Change in the Alberta Pygmy Whitefish Areas - Two sources of data were used to examine the potential changes in local climate resulting from global climate changes. Barrow and Yu (2005) present fine-scale interpretations of a median climate change scenario for all of Alberta. We used their maps of changes in growing degree days (>5˚C) to estimate changes in the two local areas for pygmy whitefish.

A computer model developed by Wang et al. (2006) to investigate temperature and precipitation changes near both Alberta pygmy whitefish populations was used. Although meteorological stations have operated at various spatial and temporal scales in the pygmy whitefish population areas, long-term, consistent records are not available from any single individual station in study areas. To resolve this problem, data from local meteorological stations were interpolated over study landscape types using the Parameter-Elevation Regressions on Independent Slopes Model (PRISM), with the specific modifications for Alberta developed by Wang et al. (2006) in their model ClimateWNA_v4.33 (updated to 2008). This allows a fine-scale grid of meteorological data to be superimposed on the broader study area, and interpolated data for a single site may be derived. Derived climate variables were mean annual temperature and precipitation for the period 1901 to 2002. Three climate change scenarios were also simulated. The Hadley Climate Centre model HADC_M3 (scenario A2) was chosen to represent a median climate change scenario. The United States military/government model PCM (scenario A1Fl) was chosen to simulate a minor change scenario, and the Environment Canada model CGM (scenario M2 A2) was selected to represent a major change scenario. These results were interpolated onto the two study area locations using ClimateWNA_v4.33, for the time periods 2020, 2050, and 2080.

4.1.1 Athabasca River Population - The province-wide compilation of climate change simulations conducted by Barrow and Yu (2005) suggest that the valley of the Athabasca River in Jasper may experience a major increase in annual growing degree days (>5˚C), from approximately 1100 to 2000 by the year 2050.

The past century of mean annual temperatures near the Athabasca River at Jasper Lake, as derived from the model of Wang et al. (2006) is shown in Figure 14. The predicted trends for the next 70 years are also shown. These large changes (i.e., from just over 2˚C to approximately 6˚C) will undoubtedly alter the thermal regime in this reach of the river. Pygmy whitefish may be able to disperse further upstream to cooler reaches (provided they are not limited by barriers). However, other aspects of their habitat such as flow and sediment levels may have caused pygmy whitefish to currently select this small reach. Large-scale temperature changes may result in an unsuitable balance of habitat and temperature.

The past century of mean annual precipitation near the Athabasca River at Jasper Lake, as derived from the model of Wang et al. (2006) is shown in Figure 15. The predicted trends for the next 70 years are also shown. The predicted changes appear to be within the range of currently observed variation in precipitation.

4.1.2 Upper Waterton Lake Population - Barrow and Yu (2005) compile data from a median climate change scenario for all of Alberta and suggest that the area around Upper Waterton Lake may experience a massive increase in annual growing degree days (>5˚C), from approximately 700 to 2000 by the year 2050.

The past century of mean annual temperatures near Upper Waterton Lake, as derived from the model of Wang et al. (2006) is shown in Figure 14. The predicted trends for the next 70 years are also shown. The predicted strong increase in temperature (i.e., from a current mean annual temperature of approximately 3.5˚C to between 6˚C and 8.5˚C) is of particular concern for Upper Waterton Lake. The oligotrophic status of this lake appears to depend on low temperature, rather than nutrient availability (Anderson and Dokulil 1977). A strong increase in temperature could alter the lake's trophic status and significantly alter the habitat for pygmy whitefish.

The past century of mean annual precipitation near Upper Waterton Lake, as derived from the model of Wang et al. (2006) is shown in Figure 15. The predicted trends for the next 70 years are also shown. The expected changes in precipitation appear minor.

5. Rescue Effect - There appears to be little or no potential for adjacent populations to recolonize Alberta's pygmy whitefish habitats should these populations be lost or degraded. Neither the Waterton Lake nor the Athabasca River populations have connection to any known Alberta pygmy whitefish populations. Surveys should be conducted on the deep water portions of Lake Athabasca to ascertain if a) a healthy population exists in this lake, and b) if this population shares enough similar genetic characteristics to the upper Athabasca River population to be a potential re-stocking source.

Surveys should also be conducted in the Pacific drainages to the west of the two known Alberta populations. West of Jasper, in Mount Robson Provincial Park (British Columbia), two lakes in the Fraser River drainage are reported to contain pygmy whitefish (Moose Lake and Yellowhead Lake). It is not known if a riverine

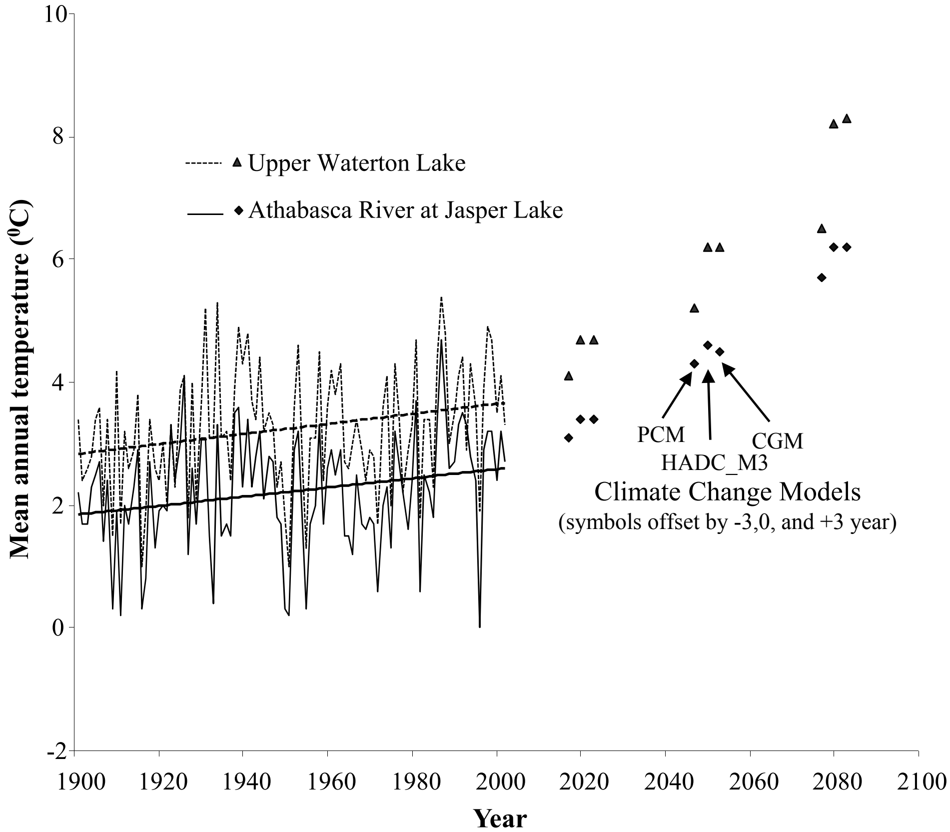

Figure 14. Mean annual temperature data for the two sites with populations of pygmy whitefish in Alberta. Data interpolated from meteorological stations and climate models using model ClimateWNA_v4.33 (Wang et al. 2006, updated to 2008).

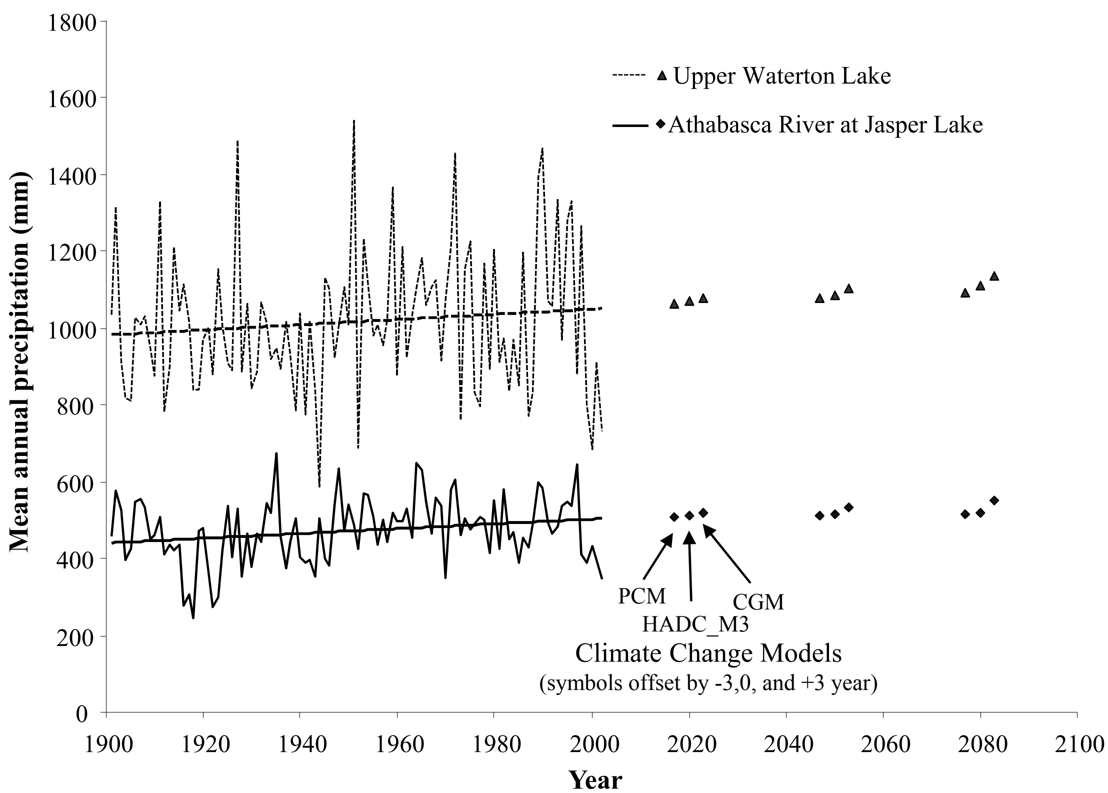

Figure 15. Mean annual precipitation data for the two sites with populations of pygmy whitefish in Alberta. Data interpolated from meteorological stations and climate models using model ClimateWNA_v4.33 (Wang et al. 2006, updated to 2008).

population exists in this area (McPhail 2007). The closest pygmy whitefish population to Waterton Lake is likely in McDonald Lake, Montana (in the Flathead drainage of the Columbia River system; Weisel and Dillon 1954). Other populations are found in the Columbia River drainage in British Columbia (McPhail 2007). The purpose of these surveys would be the same as the survey in Lake Athabasca; i.e., to determine if these populations have appropriate characteristics to be sources for re-introductions of pygmy whitefish should the Alberta populations be lost.

It should be noted, however, that the recovery of these populations by means of artificial re-establishment (i.e., hatchery-based or human transfer) from adjacent populations would render further genetic investigation pointless. The unusually disjunct distribution of pygmy whitefish suggests that detailed genetic studies can teach us much about post-glacial recolonization of North America. If the Alberta populations are harmed, and fish from other areas are artificially used for restoration, this crucial information would be lost. A collection of samples, suitable for meristic and genetic analysis, from these Alberta and nearby populations should be made in the near future and archived for future study

STATUS DESIGNATIONS[3]

1. Alberta - The pygmy whitefish is designated as *Data Deficient* in Alberta, but is not listed under the provincial *Wildlife Act*. Its provincial general status is *May Be At Risk* (ASRD 2001, 2007, 2010a). The Alberta Conservation Information Management System ranks the pygmy whitefish as S1 based on the few known localities in the province (Alberta Conservation Information Management System 2010). Pygmy whitefish are considered to be "rare" in Jasper National Park (Mayhood 1992).

2. Other Areas - Pygmy whitefish do not have any special protection in Canada, other than the general habitat protection provided to all Canadian fishes under the federal *Fisheries Act*. In British Columbia, the status of pygmy whitefish is S4S5, and it is listed as "Yellow" (BC Conservation Data Centre 2004). The species has not been assessed in Saskatchewan (Saskatchewan Conservation Data Centre 2011). In Ontario, the pygmy whitefish is listed as SU (Undetermined) (NHIC OMNR 2010), and it is considered N5 in Canada (NatureServe 2010).

In the United States, pygmy whitefish are listed as S1S2 in Washington (Washington Natural Heritage Program 2009), S2 in Wisconsin (Wisconsin Department of Natural Resources 2009), S4 in Alaska (ADFG 2005), and S3 in Montana (Montana Field Guide 2010). According to the NatureServe Explorer (NatureServe 2010), the pygmy whitefish is globally ranked as G5 meaning the species is secure when considered at the global scale.

RECENT MANAGEMENT AND RESEARCH IN ALBERTA

No specific management for pygmy whitefish had occurred in Alberta until 1998. The apparent low numbers and restricted distribution of pygmy whitefish in Alberta prompted the Fisheries and Wildlife Management Division of Alberta Environment to commission a study of its status and to make a recommendation with regard to its protection. The detailed status report written in 2000 highlighted the susceptibility of the pygmy whitefish population to ecological perturbations and habitat degradation in Alberta (Mackay 2000). The subsequent status evaluation led to the designation of the pygmy whitefish as *Data Deficient* in Alberta. This prompted more research on the species.

In 2007, a detailed study of techniques needed to monitor the fish community in Waterton

[3] See Appendix 1 for definitions of selected status designations.

Lakes was conducted by the University of Lethbridge and Parks Canada (Rasmussen et al. 2009). This study provided much information on this population of pygmy whitefish in Upper Waterton Lake. In 2008, a field sampling program specifically designed to locate pygmy whitefish was conducted by the Fish and Wildlife Division of ASRD and Parks Canada (G. Sterling pers. comm.). This program continued through 2009 and 2010 and determined that the pygmy whitefish was very likely restricted to the small reach of the Athabasca River between Solomon Creek and the Snaring River.

SYNTHESIS

The pygmy whitefish is a glacial relict species that is known to sustain populations from restricted portions of two watersheds in Alberta: Upper Waterton Lake and the Athabasca River between Jasper and Hinton. Two records from the Whitecourt area are now believed to represent vagrant individuals from the upper Athabasca River populations. Until 2007, only nine specimens had been collected in Alberta and the species was considered relatively unknown. Recent surveys conducted by the University of Lethbridge, the Fish and Wildlife Division of ASRD, and Parks Canada, however, have led to the collection and observation of many specimens in these two localities. Extensive and unsuccessful surveying specifically for this species in many other areas of Alberta suggests it has a very restricted distribution in the province, but is relatively common within the very small areas of its known habitat.

Recent environmental impact assessment studies, particularly in the Pacific Northwest, have contributed to considerable advances in our knowledge of this once little-known fish. A resident of very deep, cold boreal and montane lakes, this fish also has local populations resident in shallow, fast rivers. Its small size, rarity, and resemblance to more common whitefish species has resulted in biologists recently recognizing "new" populations that have likely existed for millennia. Populations are known from drainages in the coastal mountains of the Pacific Northwest, from large lakes in the western sub-Arctic, lakes and rivers in Alaska and Siberia, one lake and one river in Alberta and Lake Superior. The unusual geographic distribution of this fascinating little fish suggests it can teach us much about the post-glacial history of North America and Asia. Protection of the isolated and small populations in Alberta will undoubtedly be important for taxonomic and geographical studies. By this same criterion, the preservation of the genetic integrity of these small populations is of crucial importance.

The sustainability of this species in Alberta is of significant concern, based largely on the small size of its habitat and the small size of its populations in only two locations. The Upper Waterton Lake population is relatively protected from local habitat disturbance, but faces threats from invasions of exotic species and potential habitat loss from climate change. The Athabasca River population also faces these threats, but is at further significant risk from accidental spills of deleterious substances (e.g., fuel, chemical, fertilizer, and grain) along the major highway, railway and pipeline corridor that is immediately adjacent to its entire distribution. Mitigation of these threats could include preparation of measures to quickly block, divert, or capture accidental spills of deleterious substances in sensitive areas of this fish's habitat. Surveys of adjacent populations of pygmy whitefish should be conducted to determine if these populations are themselves robust enough and genetically suitable to serve as sources of re-introductions.

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Appendix 1. Definitions of status ranks and legal designations.

A. The General Status of Alberta Wild Species 2010 (after Alberta Sustainable Resource Development 2010a)

2010/2005 Rank	**1996 Rank**	**Definitions**
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	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	Green	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species that has not been examined during this exercise.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	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	n/a	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 2010a)

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.

Appendix 1 continued:

D. Heritage Status Ranks: Global (G), National (N), Subnational (S) (after Alberta Conservation Information Management System [formerly Alberta Natural Heritage Information Centre] 2007, NatureServe 2010)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences; may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated; historical records only.
GH/NH/SH	Historically known; may be relocated in the future.
G?/N?/S?	Not yet ranked, or rank tentatively assigned.

E. United States Endangered Species Act (after National Research Council 1995)

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 2. Biological data for pygmy whitefish in Alberta, 1966 to 2008. Data are from Parks Canada and the Fisheries and Wildlife Management Information System (FWMIS) of ASRD (as indicated with footnote). FL = fork length, Wt = weight.

Athabasca River Population:

Data Source	FL (mm)	Wt (g)	Maturity/ gender
UAMZ # 5277 (Solomon Creek, 1966)	121		
UAMZ # 7962 (Snake Indian R, 1980)	86		Mat. male
UAMZ # 7962 (Snake Indian R, 1980)	55		
UAMZ # 7617 (Athab. R., near Jasper Lake, 1994) [1]	132	29	
UAMZ #7945 (Athab. R, near Whitecourt, 1995) [1]	75		
UAMZ #7945 (Athab. R, near Whitecourt, 1995) [1]	82		
RL&L (Athab. R. 2.4 km ds of Snake Indian R., 2000)	136	25	
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	100	7.3	Imm. male
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	92		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	121		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	92		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	93	6.1	Imm. fem.
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	92		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	92		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	124		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	115		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	118		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	103	7.4	Imm. male
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	107		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	110		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	134	13.6	Mat. fem.
AB F&W (Athab. R, ds Snaring R to Hinton, 2008)	131		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008) [1]	105		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008) [1]	107		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008) [1]	110		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008) [1]	107		
AB F&W (Athab. R, ds Snaring R to Hinton, 2008) [1]	103		

[1] indicates record in FWMIS as of October 2010

Appendix 2 continued:

Upper Waterton Lake Population:

Data Source	FL (mm)	Wt (g)	Maturity[2]/ gender
Lindsey and Franzin (1972)[1]	98		
Lindsey and Franzin (1972) [1]	88		
Rasmussen et al. (2009), sampled in 2007	81	3.88	F
Rasmussen et al. (2009)	87	4.75	F
Rasmussen et al. (2009)	98	5.9	F
Rasmussen et al. (2009)	78	2.4	F
Rasmussen et al. (2009)	85	3.4	F
Rasmussen et al. (2009)	86	3.2	F
Rasmussen et al. (2009)	74	2.4	F
Rasmussen et al. (2009)	100	6.2	F
Rasmussen et al. (2009)	86	4.4	F
Rasmussen et al. (2009)	87	3.9	F
Rasmussen et al. (2009)	93	5.2	F
Rasmussen et al. (2009)	84	n/a	F mat
Rasmussen et al. (2009)	92	4.8	F mat
Rasmussen et al. (2009)	85	3.6	F
Rasmussen et al. (2009)	100	6.99	F;mature
Rasmussen et al. (2009)	92	5.65	F;mature
Rasmussen et al. (2009)	97	5.99	F;mature
Rasmussen et al. (2009)	88	4.55	F
Rasmussen et al. (2009)	91	4.44	F
Rasmussen et al. (2009)	98	8.2	Imm?
Rasmussen et al. (2009)	88	4.7	Imm?
Rasmussen et al. (2009)	79	2.81	M
Rasmussen et al. (2009)	76	2.24	M
Rasmussen et al. (2009)	80	3.24	M
Rasmussen et al. (2009)	81	3.69	M
Rasmussen et al. (2009)	89	4.41	M
Rasmussen et al. (2009)	81	2.4	M
Rasmussen et al. (2009)	78	2.9	M
Rasmussen et al. (2009)	79	2.9	M
Rasmussen et al. (2009)	96	4.5	M
Rasmussen et al. (2009)	76	2.33	M
Rasmussen et al. (2009)	66	1.85	M
Rasmussen et al. (2009)	78	3.29	M
Rasmussen et al. (2009)	92	4.88	M
Rasmussen et al. (2009)		1.8?	
Rasmussen et al. (2009)		7.75	
Rasmussen et al. (2009)	89	4.7	sex unk
Rasmussen et al. (2009)	89	3.86	
Rasmussen et al. (2009)	79	2.76	
Rasmussen et al. (2009)	82	3.25	
Rasmussen et al. (2009)	71	2.12	
Rasmussen et al. (2009)	85	2.69	

[1] indicates record in FWMIS as of October 2010
[2] maturity codes as provided with data from Barb Johnston, Parks Canada

Appendix 3. Meristic characteristics of three *Prosopium* species found in Alberta.

Character	**pygmy whitefish *Prosopium coulterii***	**mountain whitefish *Prosopium williamsoni***	**round whitefish *Prosopium cylindraceum***
Total no. of rakers on gill arch	11-21	19-26	14-21
No. of rakers on lower arm of gill arch	8-13	8-10	9-13
No. of rakers on upper arm of gill arch	3-7	11-15	5-8
Teeth on gill rakers	none	present	present at base
No. of branchiostegal rays	6-9 + 6-9	7-10 + 7-10	6-9 + 7-9
No. of dorsal fin rays	10-12	11-15	11-15
No. pectoral fin rays	13-18	14-18	14-17
No. anal fin rays	10-14	10-13	10-13
No. lateral line scales	50-70	74-90	74-106
No. pyloric caecae	13-33	50-146	50-130
No. of vertebrae	50-55	53-61	62-64
Nuptial tubercles	Both males and females have them on the head, back, sides and paired fins	Only males have them on the sides, not on the head	On sides of males and females; more on the males
Nostril flap	single	single	single

Appendix 4. 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 a glossary of terms used in this technical summary, go to http://srd.alberta.ca/FishWildlife/SpeciesAtRisk/ and click on Detailed Status.

Genus species: *Prosopium coulterii*
Common name: pygmy whitefish
Range of occurrence in Alberta: Two locations (upper Athabasca River, Waterton Lake)

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) 2011 Status Report: Conservation Biology, Section 4, p.13	5.5 yrs
Is there an inferred continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within 2 generations	No inferred decline
Inferred percent in total number of mature individuals over the last 3 generations.	No inferred decline
Suspected percent reduction in total number of mature individuals over the next 3 generations.	No suspected decline
Inferred percent reduction in total number of mature individuals over any 3 generations period, over a time period including both the past and the future.	No inferred decline
Are the causes of the decline clearly reversible and understood and ceased?	N/a
Are there extreme fluctuations in number of mature individuals?	Unknown

Appendix 4 continued:

Extent and Occupancy Information

Estimated extent of occurrence 2011 Status Report: Distribution, Section 1, p. 4	207 km²
Area of occupancy (AO) (Always report 2km x 2km grid value; other values may also be listed if they are clearly indicated [e.g., 1x1 grid for plants]). 2011 Status Report: Distribution, Section 1, p. 4	44 km² (2x2 km grid) 15 km^2 (combined surface area of Upper Waterton Lake and reach of Athabasca River habitat)
Is the total population severely fragmented? 2011 Status Report: Distribution, Section 1, pp. 1-4	Yes
Number of locations 2011 Status Report: Distribution, Section 1, pp. 1-3	2
Is there an inferred continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy?	No
Is there an inferred continuing decline in number of populations?	No
Is there an inferred continuing decline in number of locations?	No
Is there an inferred continuing decline in area of habitat?	No
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Appendix 4 continued:

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Athabasca River	50 to 450
Waterton Lake	750 to 3300
Total	700 to 3000
2011 Status Report: Population Size and Trends, Section 1, p. 16-20, Figs.10-12	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	unknown

Threats (actual or imminent, to populations or habitats)

Athabasca population habitat threat is considerable, based on immediate proximity to increasingly high-use transportation corridor and potential spills of deleterious substances. Waterton population is at much lower habitat threat because of inclusion in protected area (National Park) 2011 Status Report: Limiting Factors, p. 20-29

Rescue Effect (immigration from outside Alberta)

Status of outside population(s)? Populations present, but unknown status and expected distant degree of genetic relatedness 2011 Status Report: Limiting Factors, Section 5, p. 27	
Is immigration known or possible? 2011 Status Report: Limiting Factors, Section 5, p. 27	Unlikely
Would immigrants be adapted to survive in Alberta? 2011 Status Report: Limiting Factors, Section 5, p. 27	Unlikely
Is there sufficient habitat for immigrants in Alberta? 2011 Status Report: Limiting Factors, Section 5, p. 27	Yes
Is rescue from outside populations likely? 2011 Status Report: Limiting Factors, Section 5, p. 27	**No**

Appendix 4 continued:

Current Status

Provincial: Data Deficient; May be at Risk; S1 National: N5 Elsewhere: S4S5, Yellow (B.C.); SU (Ontario); S1S2 (Washington); S2 (Wisconsin); S4 (Alaska); S3 (Montana) 2011 Status Report: Status Designations, p. 29

Author of Technical Summary: Michael Sullivan (Fish and Wildlife Division, ASRD)

Additional Sources of Information:

List of Titles in This Series
(as of June 2011)

No. 1 Status of the Piping Plover (*Charadrius melodus*) in Alberta, by David R. C. Prescott. 19 pp. (1997)

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