COSEWIC
Assessment and Status Report

on the

Brassy Minnow
Hybognathus hankinsoni

Pacific population
Western Arctic population
Missouri population

in Canada

SPECIAL CONCERN
2022

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail:

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Méné laiton (*Hybognathus hankinsoni*), population du Pacifique, population de l'ouest de l'Arctique et population de la rivière Missouri au Canada.

Cover illustration/photo:
Brassy Minnow — Photograph by Doug Watkinson.

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COSEWIC
Assessment Summary

Assessment Summary – May 2022

Common name
Brassy Minnow - Pacific population

Scientific name
Hybognathus hankinsoni

Status
Special Concern

Reason for designation
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. It has a disjunct distribution within Canada in two discrete regions of southwestern and central British Columbia, within the Pacific watershed. Its abundance and population trends are unknown. This population may become Threatened if factors suspected of negatively influencing its persistence are not reversed or effectively managed, especially in the southern portion of its range. There it faces numerous cumulative threats, including predation by invasive species, habitat modifications due to agriculture/ranching, roads and logging, and pollution.

Occurrence
British Columbia

Status history
Designated Special Concern in May 2022.

Assessment Summary – May 2022

Common name
Brassy Minnow - Western Arctic population

Scientific name
Hybognathus hankinsoni

Status
Special Concern

Reason for designation
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. This population is endemic to Canada, occurring only in central British Columbia and central Alberta within watersheds that flow north to the western Arctic Ocean. Although this fish is still abundant at Musreau Lake, Alberta, its population trends are unknown, and its overall distribution may be shrinking. Substantial cumulative threats to its persistence include predation by invasive species, habitat deterioration due to industrial development, and droughts caused by climate change. This population may become Threatened if these factors are not reversed or effectively managed.

Occurrence
British Columbia, Alberta

Status history
Designated Special Concern in May 2022.

Assessment Summary – May 2022

Common name
Brassy Minnow - Missouri population

Scientific name
Hybognathus hankinsoni

Status
Special Concern

Reason for designation
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. This population occurs in Canada only in extreme southeastern Alberta and southwestern Saskatchewan, in the Missouri Watershed. Its overall abundance and population trends are unknown. Substantial cumulative threats to its persistence include loss of available habitat resulting from the interaction between water management practices and climate change-related droughts, as well as predation by invasive species. This population may become Threatened if these factors are not reversed or effectively managed.

Occurrence
Alberta, Saskatchewan

Status history
Designated Special Concern in May 2022.

COSEWIC
Executive Summary

Brassy Minnow
Hybognathus hankinsoni

Pacific population
Western Arctic population
Missouri population

Wildlife Species Description and Significance

Brassy Minnow is moderately deep-bodied and compressed, olive-green dorsally and brassy-yellow to dull silver laterally. The head is broad, and the snout overhangs a small mouth that does not extend back as far as the front margin of the eye. It has large cycloid scales, no barbels, a complete lateral line, and a black peritoneum and long, complexly coiled gut. The largest specimen reported in western Canada (from Musreau Lake, Alberta) measured 120 mm fork length.

Brassy Minnow is often locally abundant where it occurs, although its abundance appears to be negatively impacted by the presence of predatory fishes. Because it typically occurs in waterbodies with low fish species diversity, it is likely an ecologically significant fish in these systems. As a low-level consumer of phytoplankton and other algae, its transfer of energy and nutrients up the food chain is important.

Distribution

Brassy Minnow is distributed in a disjunct fashion across southern Canada from Quebec west to British Columbia: in the St. Lawrence and Lake Champlain drainage, the Great Lakes, the southern portion of the Saskatchewan-Nelson, the upper Mississippi, and the entire Missouri drainage as far south as Kansas. It also occurs as widely separated subpopulations within the Athabasca, Peace, and Fraser drainages. Brassy Minnow in western Canada comprises three designatable units (DUs): the Pacific population (DU1), Western Arctic population (DU2), and Missouri population (DU3). Because there is likely insufficient information to determine the current status of DU4 (Saskatchewan-Nelson), and because hundreds of subpopulations are known in DU5 (Great Lakes-Upper St. Lawrence) with no indication of decline, DU4 and DU5 are not included in this report.

Habitat

Brassy Minnow inhabits small headwater lakes, quiet pools, small slow-moving streams, beaver ponds, and drainage ditches with submerged aquatic vegetation. Brassy Minnow appears tolerant of a range of water quality conditions, but occupancy and abundance are highest in large, deep, backwater habitats that likely improve survival during droughts and over winter, and where there are few or no predatory fishes. Spawning habitat has low water velocity and aquatic plants, and seasonal drying of habitats can negatively impact recruitment success.

Biology

Brassy Minnow is a low-level consumer with adaptations for herbivory of mostly benthic phytoplankton and other algae, although it may consume some aquatic insect larvae and crustaceans.

Brassy Minnow spawns in late spring or early summer. Eggs are broadcast in the shallows over vegetation along the margins of the waterway. The eggs are adhesive and denser than water so they sink and settle onto the vegetation or substrate. Spawning is temperature dependent, occurring when the water is >14°C. Spawning occurs over a 7–10-day period, with not all eggs being released in a single event. In the Lower Fraser Valley, a second spawning period has been observed in the fall. The number of eggs is determined by body size, with females typically producing 100 to 1,000 eggs.

Brassy Minnow grow quickly in their first year. Lake populations are typically ~28 mm fork length (FL) by early August and ~42 mm FL by early October. Sexual maturity is reached by both sexes at age 1, and the females are typically slightly larger than males. Generation time averages 2 years, and the maximum observed age is 4 years; these older fish were females.

Population Sizes and Trends

Given its preference for headwater lakes and streams where predatory fishes are absent, Brassy Minnow is generally not in areas targeted by fisheries managers for sampling. Therefore, population size and trend information in Canada is limited mainly to presence and absence or catch per unit effort data. The only estimate available to examine temporal trends (in Musreau Lake, Alberta) shows no change in population size.

Threats and Limiting Factors

Within the Pacific population (DU1) and the Western Arctic population (DU2), the introduction of predatory fishes is the threat that is most likely to influence Brassy Minnow abundance and distribution. Within the Missouri population (DU3), drought is considered the most serious threat. There are other multifaceted threats that are likely cumulative, and involve the degradation of habitat or habitat quality over the medium-long term in one or more DU.

The influence of these anthropogenic factors will likely be affected by natural fragmentation in the species' distribution. Brassy Minnow likely have a limited ability to move downstream and colonize other headwater tributaries. Given the species' short generation time, events or habitat changes that lead to recruitment failure or high mortality of a year class will have a significant negative impact on abundance.

Protection, Status and Ranks

Brassy Minnow is currently not listed under the *Species at Risk Act*, and it is afforded no legal protection or status other than through the *Fisheries Act*.

The NatureServe (2019) global conservation status as of 2015 is secure (G5). The national status in both the US and Canada is secure (N5).

In Canada, Brassy Minnow is ranked as vulnerable to apparently secure (S3S4) in Saskatchewan and Quebec, imperilled to vulnerable (S2S3) to apparently secure (S4) in British Columbia, secure (S5) in Manitoba and Ontario, and unrankable (SU) in Alberta. In the United States, subnational rankings in the bordering states where Brassy Minnow occurs are: imperilled (S2; New York); imperilled to vulnerable (S2S3; Michigan and Vermont); apparently secure (S4; Montana); and secure (S5; Wisconsin). The species is unranked (SNR) in Minnesota and North Dakota.

TECHNICAL SUMMARY – Pacific population (DU1)

Hybognathus hankinsoni

Brassy Minnow – Pacific population

Méné laiton – Population du Pacifique

Range: British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	2 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years]	Unknown, insufficient sampling
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Suspected reduction, inferred though sampling in the Lower Fraser Valley
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	If the decline is a result of species introductions into the Lower Fraser Valley. a. Unlikely b. Partially c. No
Are there extreme fluctuations in number of mature individuals?	Unknown, insufficient sampling

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	114,768 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	480 km² (Continuous)

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Yes, at the subpopulation level, dispersal would be expected to be extremely limited
Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	>25 locations based on the threat of non-native/alien species/diseases
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in quality of habitat
Are there extreme fluctuations in number of subpopulations?	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

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Lower Fraser Valley	Unknown
Prince George/Vanderhoof area	Unknown
Horsefly drainage	Unknown
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Analysis not conducted

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species?
Yes, the overall assigned threat impact was High-Medium, and the key factors (by IUCN threat category) were identified as:

(8) Invasive & other problematic species & genes (High-Medium: 8.1 Invasive non-native/alien species/diseases; 8.2 Problematic native species/diseases)
(7) Natural system modifications (Medium-Low: 7.1 Fire & fire suppression; 7.2 Dams & water management/use; 7.3 Other ecosystem modifications)
(9) Pollution (Medium-Low: 9.1 Domestic & urban waste water; 9.3 Agricultural & forestry effluents)
(11) Climate change & severe weather (Medium-Low)

Additional threats that may pose a Low impact are:

(2) Agriculture & aquaculture (2.1 Annual & perennial non-timber crops; 2.3 Livestock farming & ranching)
(4) Transportation & service corridors (4.1 Roads & railroads; 4.2 Utility & service lines)
(5) Biological resource use (5.3 Logging & wood harvesting)
(6) Human intrusions & disturbance (6.1 Recreational activities)

What additional limiting factors are relevant? Limited dispersal, short lifespan which puts subpopulations at increased risk of catastrophic events or habitat changes

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	NA. Rescue is not possible because the species is not known in the U.S. portion of this drainage
Is immigration known or possible?	NA
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA
Are conditions deteriorating in Canada?[+]	NA
Are conditions for the source (i.e., outside) population deteriorating?[+]	NA
Is the Canadian population considered to be a sink?[+]	NA
Is rescue from outside populations likely?	NA

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Special Concern in May 2022.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Special Concern	Not applicable

Reasons for designation:
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. It has a disjunct distribution within Canada in two discrete regions of southwestern and central British Columbia, within the Pacific watershed. Its abundance and population trends are unknown. This population may become Threatened if factors suspected of negatively influencing its persistence are not reversed or effectively managed, especially in the southern portion of its range. There it faces numerous cumulative threats, including predation by invasive species, habitat modifications due to agriculture/ranching, roads and logging, and pollution.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No information available on population trends.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. IAO of 480 km^2 is below the threshold for Endangered and there is an inferred decline in habitat quality, but the number of locations is higher than thresholds, and the population is not severely fragmented.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on population size or trend.
Criterion D (Very Small or Restricted Population): Not applicable. No information on population size.
Criterion E (Quantitative Analysis): Not applicable. Data not available. Analysis not conducted.

TECHNICAL SUMMARY – Western Arctic population (DU2)

Hybognathus hankinsoni

Brassy Minnow – Western Arctic population

Méné laiton – Population de l'ouest de l'Arctique

Range: British Columbia, Alberta

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	2 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown, insufficient sampling for nearly all subpopulations, although apparently stable in Musreau Lake (2006–2010)
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling for nearly all subpopulations, although apparently stable in Musreau Lake (2006–2010)
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling for nearly all subpopulations, although apparently stable in Musreau Lake (2006–2010)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling for nearly all subpopulations, although apparently stable in Musreau Lake (2006–2010)
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Unknown, insufficient sampling for nearly all subpopulations, although apparently stable in Musreau Lake (2006–2010)
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Unknown b. Unknown c. Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown, insufficient sampling

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	108,991 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	468 km² (Continuous)
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Yes, dispersal would be expected to be extremely limited

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	13 locations based on the threats of invasive non-native/alien species/diseases and oil & gas drilling
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in quality of habitat
Are there extreme fluctuations in number of subpopulations?	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

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Crooked River drainage	Unknown
Smoky River drainage (Musreau Lake)	~450,000
Athabasca drainage (including the House River drainage) near Fort McMurray	Unknown
Total	>450,000

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Analysis not conducted

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species?
Yes, the overall assigned threat impact was High-Medium, and the key factors (by IUCN threat category) were identified as:

(3) Energy production & mining (High: 3.1 Oil & gas drilling)
(8) Invasive & other problematic species & genes (High: 8.1 Invasive non-native/alien species/diseases)
(11) Climate change & severe weather (Medium-Low)

Additional threats that may pose a Low impact are:

(4) Transportation & service corridors (4.2 Utility & service lines)
(5) Biological resource use (5.3 Logging & wood harvesting)
(7) Natural system modifications (7.1 Fire & fire suppression)

What additional limiting factors are relevant? Limited dispersal, short lifespan which puts subpopulations at increased risk of catastrophic events or habitat changes

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	NA. Rescue is not possible from outside populations because watershed is wholly within Canada
Is immigration known or possible?	NA
Would immigrants be adapted to survive in Canada?	NA
Is there sufficient habitat for immigrants in Canada?	NA
Are conditions deteriorating in Canada?[+]	NA
Are conditions for the source (i.e., outside) population deteriorating?[+]	NA
Is the Canadian population considered to be a sink?[+]	NA
Is rescue from outside populations likely?	NA
Is this a data sensitive species?	No

Current Status

COSEWIC Status History: Designated Special Concern in May 2022.

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Special Concern	Not applicable

Reasons for designation:
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. This population is endemic to Canada, occurring only in central British Columbia and central Alberta within watersheds that flow north to the western Arctic Ocean. Although this fish is still abundant at Musreau Lake, Alberta, its population trends are unknown, and its overall distribution may be shrinking. Substantial cumulative threats to its persistence include predation by invasive species, habitat deterioration due to industrial development, and droughts caused by climate change. This population may become Threatened if these factors are not reversed or effectively managed.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No evidence of decline.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. IAO of 468 km^2 is below the threshold for Endangered and there is an inferred decline in habitat quality, but the number of locations is higher than thresholds, and the population is not severely fragmented.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. No information on population size or trend.
Criterion D (Very Small or Restricted Population): Not applicable. No information on population size.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

TECHNICAL SUMMARY – Missouri population (DU3)

Hybognathus hankinsoni

Brassy Minnow – Missouri population

Méné laiton – Population de la rivière Missouri

Range: Alberta, Saskatchewan

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	2 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown, insufficient sampling
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Unknown, insufficient sampling
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Unknown, insufficient sampling
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Unknown b. Unknown c. Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown, insufficient sampling

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	19,205 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	1,684 km² (Continuous)
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. Yes, at the subpopulation level, dispersal would be expected to be extremely limited

Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	18 locations based on the threats of drought, dams & water management/use, and invasive non-native/alien species/diseases
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	No
Is there an [observed, inferred, or projected] decline in number of subpopulations?	No
Is there an [observed, inferred, or projected] decline in number of “locations”*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in quality of habitat
Are there extreme fluctuations in number of subpopulations?	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

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Milk River drainage	~20,000
Frenchman River/Rock Creek drainage	~20,000
Total	~40,000

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Analysis not conducted

* See Definitions and Abbreviations on COSEWIC website and IUCN for more information on this term.

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species?
Yes, the overall assigned threat impact was High-Medium, and the key factors (by IUCN threat category) were identified as:

(11) Climate change & severe weather (High-Medium: 11.2 Droughts)
(7) Natural system modifications (Medium-Low: 7.2 Dams & water management/use)
(8) Invasive & other problematic species & genes (Medium-Low: 8.1 Invasive non-native/alien species/diseases)

Additional threats that may pose an Unknown impact are:

(3) Energy production & mining (3.1 Oil & gas drilling)

What additional limiting factors are relevant? Limited dispersal, short lifespan which puts subpopulations at increased risk of catastrophic events or habitat changes

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Apparently secure (S4) in Montana
Is immigration known or possible?	Not known, although movement is possible in both directions wherever tributaries cross the international border
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source (i.e., outside) population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No, given that habitat is deteriorating in Canada

Data Sensitive Species

Is this a data sensitive species?	No

Status History:

COSEWIC Status History: Designated Special Concern in May 2022.

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect).

Status and Reasons for Designation:

Status:	**Alpha-numeric codes:**
Special Concern	Not applicable

Reasons for designation:
This small, primarily herbivorous minnow inhabits headwater lakes and slow-moving streams with low fish diversity. This population occurs in Canada only in extreme southeastern Alberta and southwestern Saskatchewan, in the Missouri Watershed. Its overall abundance and population trends are unknown. Substantial cumulative threats to its persistence include loss of available habitat resulting from the interaction between water management practices and climate change-related droughts, as well as predation by invasive species. This population may become Threatened if these factors are not reversed or effectively managed.

Applicability of Criteria:

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. No information available on population trends.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of 19,205 km^2 and IAO of 1,684 km^2 are below the thresholds for Threatened, and there is an inferred decline in habitat quality, but the number of locations is higher than thresholds, and the population is not severely fragmented.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals above threshold.
Criterion D (Very Small or Restricted Population): Not applicable. Number of mature individuals and IAO above thresholds.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2022)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment and Climate Change Canada
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Canada

The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Brassy Minnow
Hybognathus hankinsoni

Pacific population
Western Arctic population
Missouri population

in Canada

2022

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Kingdom: Animalia
Phylum: Chordata
Class: Actinopterygii
Order: Cypriniformes
Family: Leuciscidae

Scientific names: *Hybognathus hankinsoni* Hubbs, 1929

Common names: English: Brassy Minnow
French: Méné laiton

Morphological Description

The following account is largely based on descriptive material provided by Scott and Crossman (1979), Nelson and Paetz (1992), Stewart and Watkinson (2004), McPhail (2007), Holm *et al.* (2009), and Page and Burr (2011). Brassy Minnow is moderately deep bodied and compressed, olive-green dorsally with brassy-yellow to dull silver laterally (Figure 1). The head is broad and the snout overhangs a small mouth that does not extend back as far as the front margin of the eye. There are no barbels. At the end of the upper jaw, there is a deep groove that slopes diagonally forward. The lateral line is complete and slightly decurved with 35–40 scales. It has a black peritoneum and a long, complexly coiled gut with two loops coiled into a spiral overlying the stomach. The dorsal, pectoral, and pelvic fin rays are outlined by melanophores, and breeding males develop nuptial tubercles on the pectoral fins.

Figure 1. Brassy Minnow, *Hybognathus hankinsoni*. Photo used by permission from D. Watkinson (Fisheries and Oceans Canada, Winnipeg).

Brassy Minnow has large cycloid scales with about 20 radii. The dorsal fin is rounded at the first rays. There are usually 8 dorsal (range 7–8), 8 anal (range 6–8), and 13–15 pectoral fin rays. The caudal fin is forked. The pharyngeal tooth formula is 0,4-4,0 (i.e., there are 0 teeth in the outer and 4 teeth in the inner row of the left arch, and 4 teeth in the inner and 0 teeth in the outer row of the right arch); the teeth are not hooked, and they have oblique grinding surfaces.

The dorsal fin profile and position, number and shape of scale radii, eye diameter, and position on the snout may aid in field separation of live Brassy Minnow from co-occurring Western Silvery Minnow (*Hybognathus argyritis*) (Pflieger 1971). The basioccipital process is straight or barely concave on the posterior end (Page and Burr 2011).

Adult body size is ~50–90 mm total length (Scheurer *et al.* 2003). The largest specimen reported for populations in western Canada is an individual with 120 mm fork length (FL) from Musreau Lake, Alberta (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014).

Population Spatial Structure and Variability

The phylogenetic relationships of Brassy Minnow in Canada were studied using two mitochondrial genes (cyt b and ND4), sequenced at up to 32 localities (Nowosad 2011). Brassy Minnow did not form distinct monophyletic 'east-west' clades as seen in other species of Canadian freshwater fishes (e.g., Bernatchez and Dodson 1991; LaFontaine and Dodson 1997; McPhail and Taylor 1999; Turgeon and Bernatchez 2001). There was an approximate 'east-west' geographic split, with Brassy Minnow from Saskatchewan, Alberta, and British Columbia grouped together but still paraphyletic with a few 'eastern' copies within the 'western' group (Nowosad 2011). Fossilized Brassy Minnow were found in the historical extent of the Mississippi-Missouri drainages and Glacial Lake Agassiz (Rempel and Smith 1998). It is likely that Brassy Minnow used the Mississippi-Missouri refugium during the last glaciation and were able to disperse northward and westward.

Designatable Units

Designatable units within Brassy Minnow were considered in light of COSEWIC's "discreteness" and "significance" criteria (COSEWIC 2020), where discrete means that there is currently very little transmission of heritable (cultural or genetic) information from other such units, and evolutionarily significant means that the unit harbours heritable adaptive traits or an evolutionary history not found elsewhere in Canada.

Discreteness

Brassy Minnow is distributed in a disjunct fashion across southern Canada from Quebec west to British Columbia (Figure 2). The species comprises five DUs in terms of discreteness as it is distributed across five National Freshwater Biogeographic Zones (NFBZs): 1) the Pacific (British Columbia in river systems that flow west to the Pacific Ocean); 2) Western Arctic (British Columbia, Alberta, and Saskatchewan in river systems

that flow north to the western Arctic Ocean); 3) Missouri (Alberta and Saskatchewan in river systems that flow south to the Gulf of Mexico); 4) Saskatchewan-Nelson (Alberta, Saskatchewan, and Manitoba in river systems that flow northeast into Hudson Bay); and 5) Great Lakes-Upper St. Lawrence (Ontario and Quebec in systems that flow east to the Atlantic Ocean).

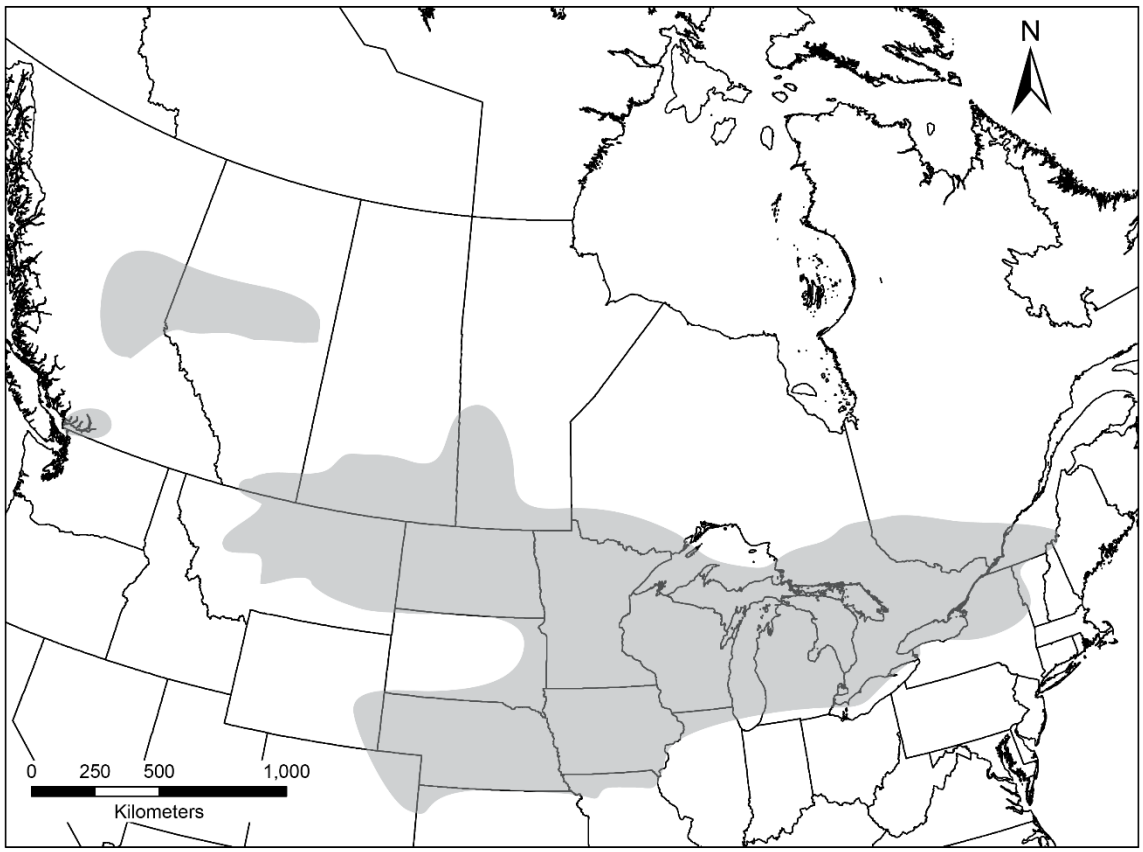

Figure 2. The global distribution of Brassy Minnow (modified from Stewart and Watkinson 2004; Nelson and Paetz 1992; McPhail 2007; Holm *et al.* 2009; Page and Burr 2011).

During the “New Wildlife Species for Priority Assessment” process in 2017, based on expert opinion, the Freshwater Fishes Species Specialist Subcommittee (SSC) concluded that there are hundreds of known subpopulations of Brassy Minnow and no evidence of decline in the Great Lakes-Upper St. Lawrence NFBZ (DU5), while there was insufficient information to determine the current status of the species in the Nelson-Saskatchewan NFBZ (DU4) (N. Mandrak pers. comm. 2022). Therefore, only Brassy Minnow in the three western NFBZs are considered in this status report.

Occupancy within different NFBZs represents natural disjunctions, with little or no possibility of natural dispersal between these “range portions” following the retreat of the Pleistocene ice sheets ~10,000 years ago (McPhail and Lindsey 1970). Following criterion

D2, it can be inferred that sufficient time has passed (~5,000 generations) that either natural selection or genetic drift are likely to have produced discrete units. In terms of overland distances, the Pacific population (DU1) and Western Arctic population (DU2) occur in close proximity north of Prince George, British Columbia (Figure 3), but they are separated by the Continental Divide. Although Brassy Minnow probably crossed the divide from the Peace to the Fraser drainage during initial de-glaciation, there is little likelihood of contemporary movement between the NFBZs. Given the close proximity of subpopulations at the DU1–DU2 boundary at the upper Fraser and southern Williston headwaters, there is a remote possibility of headwater transfer under extreme flooding, but even under these conditions, intervening wetland habitat would likely represent a barrier to Brassy Minnow movement (D. Watkinson pers. comm. 2022).

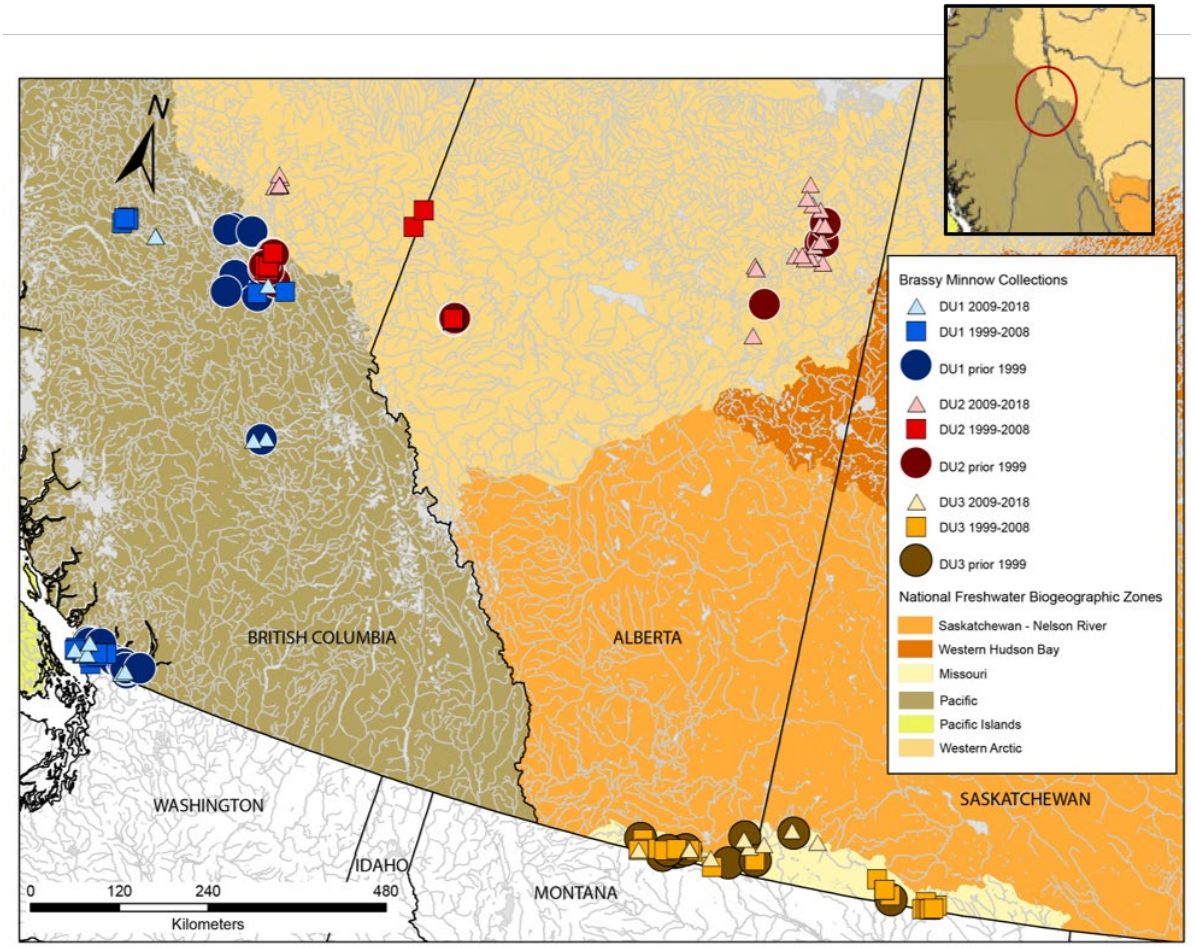

Figure 3. The distribution of Brassy Minnow in Canada across the Pacific (DU1), Western Arctic (DU2), and Missouri (DU3) prior to 1999, 1999–2008, and 2009–2018. DU1 and DU2 occur in close proximity north of Prince George, British Columbia, on either side of the continental divide between the Pacific (e.g., Fraser River) and Arctic (e.g., Peace River) drainages (see inset). DU4 (Saskatchewan-Nelson River population) and DU5 (Great Lakes-Upper St. Lawrence population, not shown here) are not assessed in this report. Map prepared by D. Watkinson.

There is no evidence of heritable traits or markers that clearly distinguish the putative DUs (criterion D1), but available mitochondrial DNA (mtDNA) sequence data distinguishes DUs 1–3 from DU4 and 5 and suggest lack of gene flow between DU1 and the other DUs. Using short fragments of two mitochondrial genes (556–557 bp of cyt *b* and 284–332 bp of ND4), Nowosad (2011) showed an approximate east-west geographic split, with the western populations likely being post-glacial colonists from the Mississippi-Missouri refugium. These markers are not expected to show finer-scale population structure, especially because the two gene trees showed some incongruencies and some Brassy Minnow possessed Common Shiner (*Luxilus cornutus*) (cyt *b*) or Mississippi Silvery Minnow (*Hybognathus nuchalis*) (ND4) haplotypes, suggesting complex evolutionary histories that cannot be reconstructed based on mtDNA sequence alone. However, despite these caveats, haplotype frequencies support lack of gene flow between DU1 and DU2 or DU3. Nowosad (2011) showed that several cyt *b* haplotypes were found only in DU1 (from the upper, mid-, and lower Fraser River sites). These DU1 haplotypes were not monophyletic, but none of them were found in the other DUs. This supports lack of gene flow across the Continental Divide.

Significance

Significance is supported by the isolation of Brassy Minnow in these different NFBZs, which have different post-glacial histories, environments, and fish community assemblages, resulting in the inference of local adaptation within each of the NFBZs (criterion S2).

Although the portions of DU1 and DU2 that are in close proximity (i.e., Nechako/Upper Fraser in DU1 and Upper Peace in DU2) face similar environmental conditions, conditions become more different moving from the headwaters on either side of the Continental Divide into the Lower Fraser and Athabasca rivers, respectively (D. Watkinson pers. comm. 2022), and the majority of the Brassy Minnow known in DU2 occur in Musreau Lake, not the headwaters.

Brassy Minnow in the Missouri population (DU3) experience warmer water, higher turbidity and temperatures, and different seasonal hydrology than in DUs 1 and 2 (D. Watkinson pers. comm. 2022), and the fish fauna in DU3 is more depauperate, with only about half the species found in DUs 1 and 2 (Scott and Crossman 1979). Brassy Minnow in the Missouri NFBZ are part of a fauna found in the only Canadian drainage system that eventually flows to the Gulf of Mexico (via its connections with the Mississippi River).

Given the range disjunction and different ecological conditions in the Lower Fraser versus Upper Fraser rivers), one might suggest that Brassy Minnow from each region form a distinct DU within the Pacific NFBZ. However, although Brassy Minnow on either side of the Continental Divide have been isolated since glacial retreat, the Lower Fraser was likely colonized from migrants from the Upper Fraser River (Rempel and Smith, 1998; McPhail, 2007). Nowosad (2011) found DU1-specific mtDNA haplotypes at upper, middle, and lower Fraser River sites, likewise suggesting that the Lower Mainland subpopulations were the result of downstream colonists from the Upper Fraser River at multiple times in the past.

Thus, there is currently no evidence for markers that clearly distinguish Brassy Minnow in the Lower Fraser versus Upper Fraser rivers (criterion D1) or disjunction between these "range portions" for an extended time (criterion D2), even if one argues for significance.

Genetic data on Brassy Minnow are limited at present, and mtDNA results do not allow for inferences to be made about local adaptation. It would be beneficial to have a more robust population genetic analysis of the species across its range for future assessment reports. However, based on the best available information, the three western populations of Brassy Minnow are assessed here as three DUs named after the NFBZ in which they are found: Pacific (DU1), Western Arctic (DU2), and Missouri (DU3) populations.

Special Significance

Brassy Minnow can be locally abundant where it occurs. Because it typically occurs in waterbodies with low fish species diversity, it is likely an ecologically significant fish in these systems. As a low-level consumer of phytoplankton and other algae (Starrett 1950; Ableson 1973; Scott and Crossman 1979; Nelson and Paetz 1992; McPhail 2007), its transfer of energy and nutrients up the food chain to higher-level consumers is important. There is no information available regarding Indigenous Traditional Knowledge for Brassy Minnow.

DISTRIBUTION

Global Range

Brassy Minnow is distributed from the upper St. Lawrence and Lake Champlain drainages in Vermont and New York, west across the Great Lakes drainage into the southern portion of the Saskatchewan-Nelson drainage, the upper Mississippi, and almost the entire Missouri drainage as far south as Kansas, as well as a disjunct distribution in the Athabasca, Peace, and Fraser drainages in the west (Scott and Crossman 1979; Page and Burr 2011) (Figure 2).

Canadian Range

Brassy Minnow is distributed in Canada in the upper St. Lawrence drainage in Quebec and Ontario, including the Ottawa River drainage, and throughout the Great Lakes drainage of southern Ontario (Scott and Crossman 1979: Holm *et al.* 2009). It has a disjunct distribution within Lake Superior, found only in the drainages at the east and west extremes of the lake (Holm *et al.* 2009). It is found in upper portions of the Winnipeg River (Rainy River) drainage in Ontario (Holm *et al.* 2009), and upper Red River and Lake Manitoba/Winnipegosis drainage in Manitoba (Stewart and Watkinson 2004). In Alberta, it is found in the Missouri River drainage and the Athabasca River drainage (near Fort McMurray) and Musreau Lake (Smoky River drainage, within the Peace River drainage) (Nelson and Paetz 1992) (Figure 3, Appendix 2). In Saskatchewan, it is found in the Missouri River drainage (Figure 3, Appendix 3), as well as the adjacent internal basins of Crane and Old Wives lakes (Atton and Merkowsky 1983), upper portions of the Assiniboine

River drainage, and recently the Saskatchewan River drainage. In British Columbia, it has a disjunct distribution, found in the Fraser River drainage near Prince George/Vanderhoof and the Lower Fraser Valley downstream of Chilliwack, as well as a single record in the Horsefly drainage (McPhail 2007) (Figure 3, Appendix 1). It is also found in the Upper Peace River drainage in the Crooked River drainage (McPhail 2007).

Given its disjunct distribution and that most of the species' distribution is east of the Continental Divide, the species was originally believed to have been introduced when it was first discovered in British Columbia in 1952 (Carl and Clemens 1953; Bailey 1954; Keenleyside 1954). Subsequent collections in the Prince George area raised doubt regarding its non-native status (Lindsey 1956), and the widely scattered distribution within the Alberta portion of the Peace River drainage now supports the native status of this species in British Columbia. Some researchers speculated that the Fraser River drainage (Nelson and Paetz 1992) and Peace/Athabasca drainage were likely colonized from a Mississippi refugium (Rempel and Smith 1998), and that the Milk River system was likely colonized from a Missouri refugium (Nelson and Paetz 1992). Recent genetics research found there is some evidence for east-west differences in Brassy Minnow across North America, but differences were not strong enough to suggest more than one refugium, as fish from both the Mississippi and Missouri systems were not differentiated from one another (Nowosad 2011). The genetic results were also inconsistent with Brassy Minnow in British Columbia originating as the result of recent (human-mediated) introduction; introduced populations are often identical or genetically very similar to the source population, but Brassy Minnow in British Columbia possessed numerous haplotypes not seen in other regions (see **Designatable Units**). Thus, it appears Brassy Minnow re-colonized Canada from glacial lakes and crossed the Continental Divide from the Peace River drainage into the Fraser system during deglaciation, with downstream migrants colonizing the Lower Fraser River. Brassy Minnow are one of the few eastern fish species that occur west of the Continental Divide.

Given their preference for headwater habitats, where predatory fishes are often absent, the possibility exists that Brassy Minnow are distributed more widely within western Canada as these habitats are not typically sampled. Targeted sampling for small-bodied fishes in some regions has increased in recent years, although identification to species can be challenging for inexperienced observers (see **Search Effort**).

Extent of Occurrence and Area of Occupancy

Estimated extent of occurrence (EOO) was calculated for each DU using the minimum convex polygon method (Appendices 1, 2, 3). EOO was mapped for all occurrences and for two 10-year sampling periods (1999–2008 and 2009–2018) but, given the lack of consistent sampling over time, differences between time periods would likely be the result of differences in sampling effort and not indicative of changes in EOO. Therefore, because there is not strong evidence that occurrences have been extirpated, EOO is calculated using all validated occurrences.

The index of area of occupancy (IAO) was calculated using a 2 x 2 km grid. For riverine organisms, IAO may be based on a continuous stretch of river between the observation records (Continuous IAO), or it may include only grids where an observation was found (Discrete IAO). Because suitable Brassy Minnow habitat is patchy (see **Habitat**), Continuous IAO will overestimate area of occupancy, particularly in the Alberta portion of DU2 where there are large stretches of unsuitable habitat (D. Watkinson pers. comm. 2022). In DU3, Brassy Minnow distribution is less patchy in Saskatchewan, but the Milk River mainstem appears not to have Brassy Minnow upstream of about river km 160 from the eastern crossing back into the United States (D. Watkinson pers. comm. 2022). However, Discrete IAO will underestimate area of occupancy where sampling is insufficient, as appears to be the case for Brassy Minnow. Therefore, Continuous IAO is used here to provide a plausible upper limit, although both Discrete and Continuous IAO are shown in Appendices 1, 2, and 3.

Pacific Population (DU1)

The overall calculated EOO was 114,768 km^2, and overall Continuous IAO was 480 km^2 (Appendix 1).

Western Arctic Population (DU2)

The overall EOO (including all records except for 23 questionable specimens from the eastern portion of DU2 collected in 2011–2014) was 108,991 km^2, and overall Continuous IAO was 468 km^2 (Appendix 2). No vouchered specimens were kept from these excluded collections, and they may have been other species that were misidentified as Brassy Minnow (see **Search Effort**). One vouchered specimen collected in 2014 near Fort McMurray was re-examined by the report writers and confirmed to be a Brassy Minnow, and it was included in these calculations.

Missouri Population (DU3)

The EOO, including sampling in 2020 which noted a range extension of Brassy Minnow in the Poplar River drainage at the east end of DU3 (see **Search Effort**), was 19,205 km^2, and overall Continuous IAO was 1,684 km^2 (Appendix 3).

Search Effort

Fish sampling has been extensive in the last 20 years in Alberta across the known range of Brassy Minnow (Figures 3, 4), including extensive sampling for small-bodied fishes. Alberta Environment and Sustainable Resource Development and Alberta Conservation Association (2014) reported that the provincial fish database (Fisheries and Wildlife Management Information System, FWMIS) showed sampling for small-bodied fishes at 66,846 locations as of March 2014, including intensive sampling at 288 waterbodies in northern Alberta. Recent sampling in British Columbia has been more limited and did not always specifically target small-bodied, non-game fish species, but it still covers the known range of Brassy Minnow in the province (Figures 3, 4).

Pacific population (DU1)

The first collection of Brassy Minnow in DU1 was made in 1952, in the Stave River (RBCM 00408). Other than Nowosad (2011), no sampling effort has been directed at Brassy Minnow for the northern locales of DU1 (S. Pollard pers. comm. 2020). Ray Pillipow (Fish and Wildlife Section Head for Forests, Lands and Natural Resource Operations and Rural Development) stated that the species is likely more widespread than previously thought, and that, when found in northern areas of DU1, it tends to be locally very abundant (S. Pollard pers. comm. 2020). A total of 58 collection records are documented for the species in this DU (795 fish). During the most recent (2009–2018) time period, 13 new collection records (208 fish) have confirmed that Brassy Minnow persists throughout the three disjunct regions within its range in DU1, and EOO and IAO appear to have remained relatively stable.

Western Arctic population (DU2)

The first collection of Brassy Minnow in DU2 was made in 1956, in the Crooked River, British Columbia. A total of 153 collection records are documented for the species in this DU (11,391 fish). A total of 72 new collection records (4,122 fish) have occurred in the last 10 years (2009–2018). The majority of the collections in DU2 were made in Musreau Lake, a small (5.49 km^2) lake south of Grande Prairie, Alberta.

Extremely intensive fisheries sampling for small-bodied fishes has occurred in the Fort McMurray area over the past several decades (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014), but the identity of only 20 Brassy Minnow collected from four sites in this area has been confirmed (Berry 1977). Immature Fathead Minnow (*Pimephales promelas*), Lake Chub (*Couesius plumbeus*), and Western Silvery Minnow might be misidentified by inexperienced observers as Brassy Minnow, so the validity of records of 23 Brassy Minnow in the Fort McMurray area, collected during sampling efforts for monitoring of industry in the Athabasca watershed in 2011–2014 without any voucher specimens, has been questioned (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014).

Recent targeted sampling and examination of museum records shows scant evidence of this species in Alberta outside of Musreau Lake. The Royal Alberta Museum extensively sampled historical sites of Brassy Minnow near Fort McMurray from 2005 to 2012 and found no occurrences of the species (S. McFadden pers. comm. 2020). Examination of museum records by the status report writers confirmed a single voucher specimen from this area collected in 2014, located near Fort McKay (museum specimen 6496, Zoology Museum, University of Alberta). Other specimens were missing, including the initial specimens from Berry (1977), or determined by the report writers to have been misidentified (e.g., museum specimen F8391, Zoology Museum, University of Alberta). The historical and 2014 specimens that were confirmed as Brassy Minnow were included in the EOO and IAO calculations; however, given the scarcity of vouchered specimens in the eastern portion of DU2, there is cause for uncertainty about the distribution of Brassy

Minnow in the Lower Athabasca River.

It is possible that isolated subpopulations currently exist in the Lower Athabasca River, but they have not been confirmed. Alternative possibilities are that the species was once found in the Fort MacMurray area (Berry 1977), but is no longer present, or that these older (and occasional recent) specimens were vagrants from healthy subpopulations located upstream of the Fort McMurray area. A small number of individuals may have moved downstream and failed to establish a subpopulation in the Lower Athabasca River or a subpopulation may have established for only a short time. The sampling in that area of Alberta is high, so the probability of sampling vagrant fish is high (D. Watkinson pers. comm. 2022).

Missouri population (DU3)

The first collection of Brassy Minnow in DU3 was made in 1961, on a tributary of Lodge Creek, Alberta (FWMIS 2019). A total of 62 collection records are documented for the species in this DU (749 fish), and 15 new collection records (45 fish) are available for the period 2009–2018. The majority of these collections were made with seine nets. Although the limited sampling in the eastern portion of the DU (Grasslands National Park and the Frenchman River) in the last decade makes EOO and IAO comparisons between time periods uninformative, this sampling has confirmed that Brassy Minnow persists throughout the DU.

In 2020, Fisheries and Oceans Canada (DFO) conducted targeted sampling for Plains Minnow (*Hybognathus placitus*) following a standardized sampling protocol (Macnaughton *et al.* 2019) in the Saskatchewan portion of DU3. They collected Brassy Minnow in the Lodge Creek and Rock Creek drainages, and noted a range extension in the Poplar River drainage at the east end of DU3.

HABITAT

Habitat Requirements

Brassy Minnow inhabits small headwater lakes, quiet pools, small slow-moving streams, beaver ponds, and drainage ditches (Propst and Carlson 1986; Meneks *et al.* 2003; Stewart and Watkinson 2004; McPhail 2009). Low slope areas (Brunger Lipsey *et al.* 2005) with submerged aquatic vegetation are typical habitat features (Quist *et al.* 2005). Brassy Minnow are likely tolerant of a range of water quality given their distribution. Brassy Minnow are found in the somewhat cooler and acidic waters of the Canadian Shield (Scott and Crossman 1979) and the prairies in alkali (Nelson and Paetz 1992) and warmer waters. The water can be stained, clear, or turbid (McPhail 2007). Low predatory fish abundance appears to be a requirement for abundant populations (Schlosser 1988; He and Kitchell 1990; Nowosad and Taylor 2013). This is supported by fish collection data throughout these DUs.

Occupancy and abundance were highest in large, deep, backwater habitats in Colorado (Falke *et al.* 2010a). These deep pools are important for both surviving droughts, overwinter survival, and recruitment success (Falke *et al.* 2010b). The bottom substrate where Brassy Minnow was sampled is typically silt, sand, and gravel (Stewart and Watkinson 2004; McPhail 2007; Holm *et al.* 2009). Brassy Minnow in Colorado were found to be tolerant of water temperatures as high as 35.5°C, with low dissolved oxygen minima (1.52 ± 0.15 mg/L), and they even persisted in pools with oxygen concentrations as low as 0.03 mg/L (Scheurer *et al.* 2003). This suggests that Brassy Minnow are very tolerant to harsh physicochemical conditions (Scheurer *et al.* 2003). These adaptions are not unexpected of a fish that lives in headwater lakes and streams where habitat extremes often occur.

Spawning habitat has low water velocity and aquatic plants (Abelson 1973; Becker 1983; McPhail 2007). Large, deep, backwater habitats were important for spawning success in a Colorado population where habitat typically dries out (Falke *et al.* 2010a).

A study by Nowosad and Taylor (2013) suggests that high water conductivity is a good predictor of Brassy Minnow presence. Conductivity usually correlates positively with primary productivity (Morgan and Good 1988), which increases prey availability of the phytoplankton and diatoms that Brassy Minnow feed on (Hlohowskyj *et al.* 1989; McPhail 2007). Brassy Minnow abundance is typically described as high in habitats with high productivity and abundant submerged vegetation (Quist *et al.* 2005), lakes rich in humic acid (Nürnberg and Shaw 1999; McPhail 2007), areas with high nutrient input from agriculture (Bunnell and Zampella 2008), and waterfowl (Nowosad 2011).

It is possible that the disjunct distribution of Brassy Minnow in British Columbia may, in part, be a result of suboptimal productivity in middle reaches of the Fraser River (Nowosad and Taylor 2013). Nowosad and Taylor (2013) also found that some minimum level of turbidity may be an important determinant of Brassy Minnow presence, possibly by offering some protection from visually based predators (Abrahams and Kattenfeld 1997; Reid *et al.* 1999). Productivity would also be expected to increase in warmer water; Nowosad and Taylor (2013) found higher mean water temperature was positively associated with the presence of Brassy Minnow. In British Columbia, the water is seldom >1.5 m deep where Brassy Minnow are sampled and, in streams, adult fish remain close to vegetation and avoid faster water velocities (>50 cm/s) (McPhail 2007).

Habitat Trends

Changes in habitat for Brassy Minnow have been incremental and cumulative throughout much of the species' range, subject to the broad range of changes related to species introductions, forestry, agriculture, urbanization, road building, and oil and gas exploration and extraction. Because the species' distribution within watersheds is typically restricted to the headwater lakes and streams or smaller tributaries, flow modification and dams have typically had little impact on the habitat.

Pacific population (DU1)

The habitat in DU1 is modified by introduced species, roads, forestry, forest fires, a growing human population, and limited agriculture.

Residential and agricultural development is mostly restricted to the Lower Fraser Valley and has resulted in a limited riparian habitat where Brassy Minnow occurs. Agriculture may have affected flows via extensive use of agriculture ditches, dykes, and other small-scale modifications (S. Pollard pers. comm. 2020). In the Upper Fraser drainage, around Prince George, Robson Valley and especially Vanderhoof, land clearing and conversion for agriculture is continuing (S. Pollard pers. comm. 2020). Forestry has historically occurred throughout the range of the species, and continues in the northern portion of DU1 (S. Pollard pers. comm. 2020). Urbanization, industrialization, and forestry have altered riparian habitat and hydrology in some drainages (S. Pollard pers. comm. 2020).

Western Arctic population (DU2)

Habitat in DU2 where Brassy Minnow occurs has been altered by roads, forestry, and oil and gas exploration and extraction. In particular, the effect of chemical spills has been correlated with the absence of Brassy Minnow. For example, a pipeline break released 7,600 barrels of naptha and kerosene into the House River in June 1992. Subsequent sampling indicated all fish downstream of the spill were killed (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014).

Missouri population (DU3)

Habitat in DU3 has been impacted by agriculture and water management structures. Water management structures likely represent contradictory impacts/benefits throughout the DU. Unlike other species reviewed by COSEWIC in the Missouri drainage that are abundant in the mainstem of the North Milk and Milk rivers, Brassy Minnow is most abundant in the smaller tributaries and likely less influenced by habitat changes related to dams and reservoirs, water diversions, and water removal for irrigation. However, since 1917, when the St. Mary Canal was constructed in Montana to divert water from the St. Mary River to the North Milk River for irrigation purposes, habitat has been significantly altered. The diversion is typically operational from April to September, increasing the water volume in the North Milk River and the Milk River proper (see gauges 11AA029, 11AA028, 11AA037, 11AA038 in Environment and Climate Change Canada 2019). Before construction of the diversion, the Milk River was a small prairie stream with lower turbidity and intermittent flows (Willock 1969a). The diversion has likely increased the abundance and distribution of predatory fishes such as Sauger (*Sander canadensis*) and the introduced Northern Pike (*Esox lucius*), and in turn reduced the suitability of this habitat for Brassy Minnow. Conversely, the diversion likely reduces the likelihood of drought, which has historically left portions of the river dry.

In Saskatchewan, dams include: the Cypress Lake East Dam (in 1939), Eastend Dam (in 1936), West Val Marie Dam (in 1939), and Val Marie Dam (in 1936) (Water Security Agency 2021). On Lodge Creek, drainage irrigation dams include the Middle Creek Dam (in 1937) and Altawan Dam (in 1960) (Water Security Agency 2021). Within the Frenchman River drainage, dams have likely decreased available flows on the mainstem of the Frenchman River, as upstream portions of the watershed can be flowing and downstream portions reduced to series of isolated pools. The Rock Creek drainage has not been modified by large dams.

The majority of the land in DU3 is used as rangeland. There is also a substantial amount of row crop agriculture. Grasslands National Park was established in 1981, and it has likely reduced impacts to the drainage within the park boundaries. In 1989, the Cypress Hills Interprovincial Park was created, although it is still heavily used as rangeland. These areas have low human populations and have ongoing restoration activities to reduce livestock in the river.

BIOLOGY

Although limited published information is available regarding the biology of Brassy Minnow in Canada, several studies describe their biology in the U.S. portion of their range (e.g., Starrett 1950; Scheurer *et al.* 2003; Falke *et al.* 2010a,b).

Brassy Minnow is a low-level consumer with adaptations associated with herbivory (Hlohowsky *et al*. 1989). It feeds mostly on benthic phytoplankton and other algae (Starrett 1950; Ableson 1973; Scott and Crossman 1979; Nelson and Paetz 1992; McPhail 2007), although it also has been noted to consume some aquatic insect larvae and crustaceans (Holm *et al.* 2009).

Life Cycle and Reproduction

Brassy Minnow spawn in late spring or early summer in the western Canadian populations (Nelson and Paetz 1992; McPhail 2007). Eggs are broadcast in the shallows over vegetation along the margins of the waterway (Copes 1975; Becker 1983). In Ontario, large schools have been observed in which one or more males will approach a female; if she is ready to spawn, the group vibrates and eggs and sperm are released over the vegetation, and the eggs are left unguarded (Holm *et al.* 2009). Observations of fish in spawning condition collected in DU1 and held in aquariums confirmed a single female is pursued by multiple males and only a few eggs are released, typically over vegetation (McPhail 2007). The eggs are adhesive and denser than water, so they sink and settle onto the vegetation or substrate below (McPhail 2007). Non-spawning adults occupying the school were observed eating the sinking eggs (McPhail 2007).

Spawning is temperature-dependent (Falke *et al.* 2010b); in DU1, spawning occurs when water temperature is >14°C, typically in mid-May to June in the Lower Fraser Valley (McPhail 2007). In the Prince George region, spawning starts later, in early June, and continues into early August (Abelson 1973). In DU3, mature individuals have been collected in July (Nelson and Paetz 1992). The spawning period is extended over 7–10 days as not all eggs are released in a single event (McPhail 2007). In the Lower Fraser Valley, a second spawning period has been observed in the fall, with fish from the fall spawn growing to 15 mm total length (TL) by mid-November.

The number of eggs is determined by body size, with females typically producing 100 to 1,000 eggs (McPhail 2007). The ripe eggs are about 1 mm in diameter, and they double in diameter once released and fertilized (McPhail 2007). Embryos develop rapidly, hatching within 70 hours at 18°C, and larvae are about 5 mm TL, transparent, and lack eye pigment (McPhail 2007). Development continues rapidly, with melanophores developing at day 4, swim bladder filling on day 6, and by day 8, they are typically ~6 mm long and beginning to feed (McPhail 2007).

Brassy Minnow grow quickly in their first year. Lacustrine populations are typically ~28 mm FL by early August (Ableson 1973) and, in the Lower Fraser Valley, they are ~42 mm FL by early October (McPhail 2007). Sexual maturity is reached by both sexes at age 1, and the females are typically slightly larger than males (McPhail 2007). The maximum observed age in DU1 is 3+ years, and these older fish were all females (McPhail 2007). Average generation time is likely 2 years.

Physiology and Adaptability

Brassy Minnow appear to be tolerant of a wide range of water quality parameters and temperatures (Nelson and Paetz 1992; Stewart and Watkinson 2004; McPhail 2007). Brassy Minnow have been shown to tolerate pH as low as 5.5 (Tremblay-Richard 1993). In addition, they are likely tolerant of a range of water turbidity and water quality given the variety of habitats they are found in (Nelson and Paetz 1992; Stewart and Watkinson 2004; McPhail 2007). In Colorado creeks, Brassy Minnow survived water temperatures as warm as 35.5°C and dissolved oxygen as low as 0.03 mg/L (Scheurer *et al.* 2003).

The adaptability of Brassy Minnow is context-dependent. Despite being tolerant of a wide range of water quality parameters, Brassy Minnow appear to be poorly adapted to interspecific competition with some fish species. Several studies have shown that Brassy Minnow are absent across their North American range in areas with predatory fish species (Whittier *et al.* 1997; He and Kitchell 1990; Nowosad and Taylor 2013).

Dispersal and Migration

Limited information exists for this species on dispersal and migration. However, the disjunct distribution of Brassy Minnow suggests that it likely has limited ability to successfully disperse to similar habitat within a drainage if it requires movement through larger streams, rivers, or lakes. Nevertheless, Brassy Minnow have been documented to quickly colonize previously dry habitats within their range (Scheurer *et al.* 2003). In DU1, Brassy Minnow that inhabit streams overwinter at the spawning sites (McPhail 2007). They may undergo a migration in the summer, as in the Lower Fraser Valley where they are typically not present in these same habitats until the fall (McPhail 2007). Brassy Minnow swimming speed capability of 0.64 m/s (Ficke *et al.* 2011) likely aids them in recolonizing habitat that had previously become unsuitable, despite their preference for calm water.

Interspecific Interactions

Given that the distribution of the species is restricted to headwater lakes and streams, Brassy Minnow is generally found in communities with low species richness, often those limited to smaller-bodied fishes. Their distribution and abundance in other systems may be limited by the presence of healthy predatory fish populations (Schlosser 1988; He and Kitchell 1990; Whittier *et al.* 1997; Nowosad and Taylor 2013).

The only parasites listed for Brassy Minnow are the trematodes *Octobothrium* sp.*,* larval *Neascus* sp.*, Posthodiplostomum minimum,* and *Uvulifer ambloplitis* (Bangham 1941; Hoffman 1967). Similar to other understudied fish species, there are likely a number of other parasites that infect the species.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Population size and trend information is limited mainly to presence and absence or catch per unit effort (CPUE) data, and there have been no quantitative estimates to examine population trends through time for this species (Nowosad and Taylor 2013; Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014). Sampling is usually conducted on foot with seine nets and/or backpack electrofishers, as well as minnow traps. It is possible that incomplete sampling and identification problems could contribute to the perception of a disjunct distribution of Brassy Minnow, although sampling for small-bodied fishes has been extensive in the last 20 years in several regions (Figure 4; see **Search Effort**).

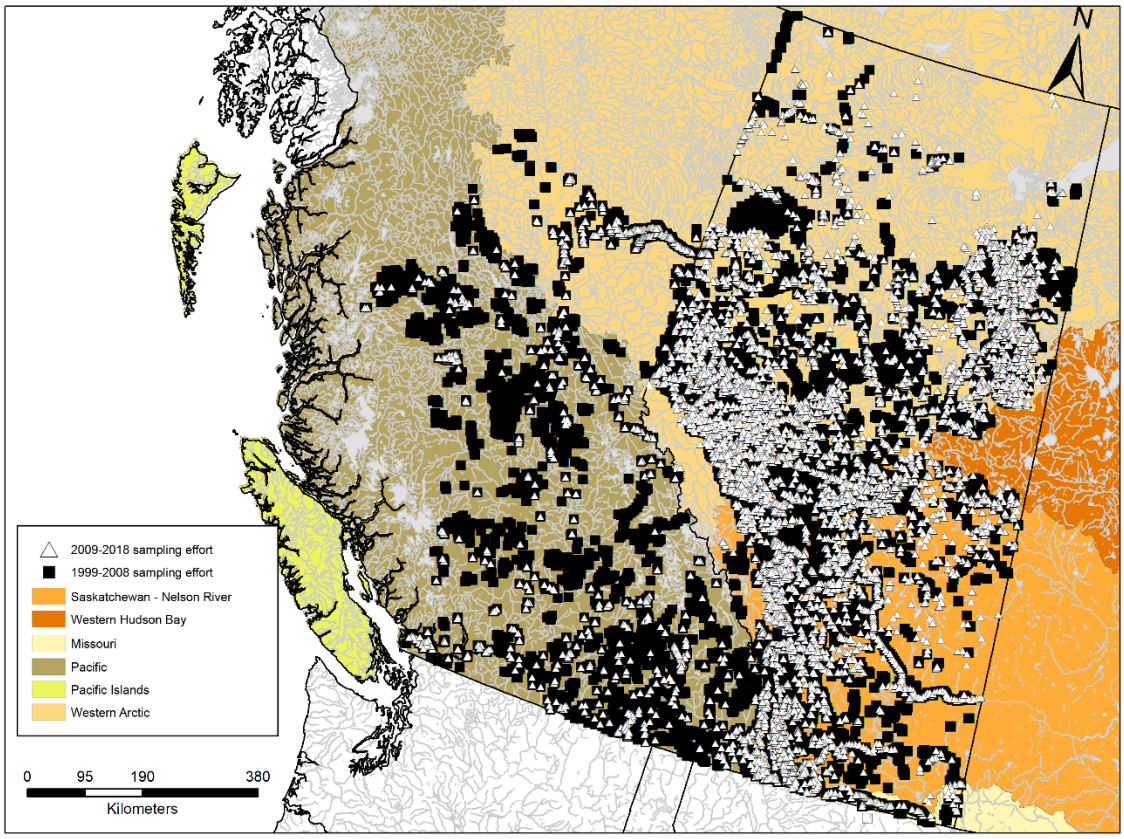

Figure 4. The distribution of sampling effort (electrofishing, seining, minnow trap, dip netting) in British Columbia and Alberta by decade (1999–2008, 2009–2018). Map prepared by D. Watkinson.

Abundance

Collections of Brassy Minnow in DU1, DU2, and DU3 have been sporadic through time. Standardized temporal surveys of the abundance of Brassy Minnow across its range in Canada have not been completed. However, where it occurs, it can be locally abundant (Stewart and Watkinson 2004; McPhail 2007).

In DU1, Nowosad and Taylor (2013) found that Brassy Minnow distribution in the Lower Fraser Valley has declined since the 1950s, with Brassy Minnow occurring in only two of the eight historical sites sampled. In general, cypriniforms (including Brassy Minnow) have decreased in abundance from 1956–1959 to 2008–2009. Abundance of Brassy Minnow specifically did not significantly change, although lack of significance was likely due to low sample size (Nowosad and Taylor 2013).

Population estimates have been calculated for some populations of Brassy Minnow in Alberta. These estimates were developed by extrapolating sampling data using seine netting (Alberta Environment and Sustainable Resource Development and Alberta

Conservation Association 2014). In DU2, the subpopulation estimate for Musreau Lake was ~450,000 fish. This estimate was based on 5 years (from 2006 to 2010) of sampling data with no apparent change in CPUE. In DU3, subpopulation estimates in the Alberta portion of the Milk River system was ~20,000 fish (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014). All sampled Brassy Minnow were mature adults.

Fluctuations and Trends

Abundance data are too limited to provide an estimation of the fluctuations and trends for Brassy Minnow populations in Canada. Canadian studies of fish distributions that report Brassy Minnow in samples are not sufficient to provide more than continued presence (or occasionally relative abundance) at most sites sampled.

Recent sampling (2009–2018) has confirmed the continued presence of Brassy Minnow in DU1, DU2, and DU3. However, Alberta Environment and Sustainable Resource Development and Alberta Conservation Association (2014) is concerned about the validity of recent collections in the eastern portion of DU2. Only one vouchered specimen has been collected in the Athabasca drainage in the past 20 years (see **Search Effort**).

Rescue Effect

Brassy Minnow typically occurs in headwaters of drainages, in pockets isolated from other subpopulations by unsuitable habitat (large main stem rivers and lakes), or in different watersheds without direct connections.

Pacific population (DU1)

Rescue is not possible from the United States. Although small portions of the Pacific drainage extend into Washington State, there are no records of Brassy Minnow in Washington State, and the species is not in the Pacific drainage portion of Montana.

Western Arctic population (DU2)

Rescue is not possible given that the DU does not connect to the United States.

Missouri population (DU3)

The Canadian population of Brassy Minnow could be rescued from the U.S. portion of the Missouri drainage given the distribution of Brassy Minnow in Montana (Holton and Johnson 2003). Fresno Reservoir is only ~60 river km downstream of the international border, and Fresno Dam is a barrier to upstream fish movement. Movement likely occurs in both directions wherever tributaries cross the international border. The Rock Creek drainage is open to migration from the U.S. downstream to the Rock Creek Diversion Dam, which is ~150 river km downstream of the international border. The species is apparently secure (S4) in Montana.

THREATS AND LIMITING FACTORS

Threats

Ongoing and potential threats to Brassy Minnow are presented below in the approximate order of most to least significant threats. Specifics or differences among DUs are discussed, where relevant.

Within DU1 and DU2, the introduction of predatory fishes is the threat that is most likely to influence population abundance and distribution. Within DU3, drought is considered the most severe threat.

In addition, there are other multifaceted threats that are likely cumulative, and they involve the degradation of habitat or habitat quality over the medium-long term in one or more of the DUs (dams & water management/use, oil & gas drilling, logging & wood harvesting, roads & railroads, utility & service lines, fire & fire suppression, other ecosystem modifications, agricultural & forestry effluents, climate change & severe weather, and work & other activities; Appendix 4). The influence of these factors will likely be affected by the natural fragmentation in the species' distribution.

(8) Invasive & other problematic species & genes

(8.1) Invasive non-native/alien species/diseases

The introduction of invasive species can have profound negative impacts on native fish communities (Whittier *et al.* 1997; Gido and Brown 1999; Dextrase and Mandrak 2006; Bunnell and Zampella 2008). Frequently, these invasive species are predators of, or competitors with, small fishes that can cause significant population declines in *Hybognathus* species that may result in local extirpation (Alò and Turner 2005; McPhail 2007). Nowosad and Taylor (2013) conducted Brassy Minnow growth experiments, and the results strongly suggested that Brassy Minnow is a poor competitor with Redside Shiner (*Richardsonius balteatus*) and young-of-the-year Brown Bullhead (*Ameiurus nebulosus*), which are invasive in these drainages. In addition, Brassy Minnow, in the presence of large Brown Bullhead, shifted their habitat use, presumably as the result of predator avoidance (Nowosad and Taylor 2013).

In New York State, where it was reported that Brassy Minnow was widespread in lakes and ponds in the 1920–1930s, the species became rare or was presumed extirpated following the introduction of stocked fishes (Whittier *et al.* 1997). In the presence of a predator (Smallmouth Bass (*Micropterus dolomieu*)), adult Brassy Minnow have been shown to change their habitat selection to riffles and races, habitat they typically are not found in (Schlosser 1988). The selection of less-than-ideal habitat in the presence of predators would likely lead to subpopulation-level impacts. In a natural system experiment where Northern Pike was introduced into a small lake in Wisconsin, Brassy Minnow showed

a strong decrease in abundance after just one open-water season as a result of both predation and emigration (He and Kitchell 1990).

The introduction of non-native fish species (e.g., Common Carp (*Cyprinus carpio*), Brown Bullhead, Yellow Bullhead (*Ameiurus natalis*), Largemouth Bass (*Micropterus salmoides*), and Black Crappie (*Pomoxis nigromaculatus*)) is extensive in habitat occupied by Brassy Minnow in the Lower Fraser River drainage (DU1) (McPhail 2007). In the Prince George/Vanderhoof area, lakes were stocked with Brook Trout (*Salvelinus fontinalis*), and Brassy Minnow disappeared (McPhail 2007). In addition to deliberate stocking of non-native fish species, invasive species can be introduced into natural waters when an aquarium is emptied into a lake or stream (Government of Canada 2021). Some subpopulations in DU1 and DU2 are remote, but it is waterbodies closest to roads and communities where concerns associated with aquarium releases or illegal movement of sport species are greatest (S. Pollard pers. comm. 2020).

In Musreau Lake (DU2), Rainbow Trout *(Oncorhynchus mykiss)* were stocked from 1972 to 1999 (~200,000 fish every few years), but a sport fishery did not establish and the stocking has ceased (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014). However, there is continued public interest in establishing a sport fishery in the lake, as it is a popular destination for recreational boats (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014), and this would represent a substantial threat to this now-abundant Brassy Minnow subpopulation.

Non-native fishes that have established self-sustaining populations in DU3 in Canadian reaches of the Milk River drainages include Walleye (*Sander vitreus*), Northern Pike, and Yellow Perch (*Perca flavescens*). All these fishes are piscivorous and likely impact Brassy Minnow abundance via predation. Northern Pike, Common Carp, and Black Bullhead (*Ameiurus melas*) have been introduced into the Frenchman River drainage. Black Bullhead and Common Carp are also found in Canadian portions of the Rock Creek drainage.

(11) Climate change & severe weather

Climate change can potentially impact water availability, temperature, and a broad range of other ecosystem processes (Schindler 2001), likely affecting the availability and quality of Brassy Minnow habitat. For example, streams in south-central British Columbia (DU1) are trending toward an earlier spring freshet and lower flows in late summer, and they are experiencing a gradual warming trend (Morrison *et al.* 2002; Ferrari *et al.* 2007). However, temperature would not reach the thermal maximum that has been determined for the species elsewhere in its range (>35.5°C, Scheurer *et al.* 2003).

(11.2) Droughts

Canada has abundant fresh water (Gleick 2002); however, there is regional variability in supply. Low-flow conditions that result from droughts can result in elevated water temperatures, reduction in habitat connectivity, reduced dilution potential and degraded water quality (waste discharge), reduced dissolved oxygen levels, and increased vulnerability to terrestrial and aquatic predators. Because Brassy Minnow occupy headwater systems, dramatic changes in water availability are to be expected more frequently. In Colorado, stream drying was suspected as the main cause of local extirpation of Brassy Minnow (Scheurer *et al.* 2003). In the winter, Brassy Minnow may be particularity vulnerable as it occupies small headwater lakes and streams, and low-flow conditions can increase the risk of freezing and low dissolved oxygen levels (COSEWIC 2006).

Streams in DU3 can have zones of alternating flowing water, and stream corridors many kilometres long may be reduced to dry stream beds only a few metres wide for much of the summer and fall (e.g., Rock Creek drainage, Frenchman River drainage, and tributaries of the Milk River). In winter, these conditions may be exacerbated by ice freezing to the bottom and anoxia. Increased frequency and severity of droughts are likely to negatively affect the extent and quality of aquatic habitat of Brassy Minnow within DU3. However, these same conditions also act to limit the distribution and abundance of predatory fishes across all DUs.

(7) Natural system modifications

(7.1) Fire & fire suppression

Increasing frequency and severity of forest fires is a threat that may alter Brassy Minnow habitat. The increase in atmospheric temperature due to climate change may be causing more frequent and severe forest fires in North America (Flannigan *et al.* 2000). These fires have the potential to drastically alter aquatic habitats through bankside erosion and carbon/silt inputs (Gresswell 1999), as well as increased temperature as canopy cover is removed, increasing solar radiation (Isaak *et al.* 2010). It is unknown if fire is detrimental to Brassy Minnow subpopulations, but it would likely depend on fire severity, duration, and size. The potential impacts are more significant in the northern portion of DU1 and all of DU2 given that forests dominate the land cover.

(7.2) Dams & water management/use

Water management structures likely represent contradictory impacts/benefits throughout the range of Brassy Minnow. Generally, impoundments can alter flow, water temperatures, and sediment load, and thereby fish habitat (Quist *et al.* 2004). However, because Brassy Minnow is typically only distributed in or most abundant in headwater lakes and streams (upstream of most structures), dams and water management is typically not an issue in DU1 and DU2.

In DU3, the St. Mary Diversion in the United States has greatly modified the natural hydrography of the North Milk and Milk rivers downstream of the confluence of the two rivers (Environment and Climate Change Canada 2019). The St. Mary Canal was completed in Montana (in 1917) to divert water from the St. Mary River to the North Milk River for irrigation purposes (COSEWIC 2008; International Joint Commission 2022). In most years, the canal diverts water from March to October, increasing the water volume in the North Milk and the Milk rivers. The water in the Milk River (and St. Mary River) is shared by Canada and the United States via the Boundary Waters Treaty. During the augmentation period in the Milk River in Canada (March to October), Canada must leave the majority of that water for the United States, so it is not available as irrigation water for agriculture in Canada. According to the agreement, the United States is able to use the Milk River in Canada for conveyance of water (COSEWIC 2008; International Joint Commission 2022).

Before the construction of the St. Mary diversion, the Milk River was probably a typical small prairie stream, possibly intermittent in times of drought, and generally less turbid (Willock 1969b). The significant increase in water volume since the canal went into use is believed to have extensively altered the ecological regime of the Milk River (with the exception of the Milk River upstream of its confluence with the North Milk River), resulting in a more turbid, higher-flow system in the North Milk and Milk rivers and associated increased erosion and subsequent sedimentation in Alberta (Willock 1969b). While these changes may have a negative impact on Brassy Minnow, the diversion also prevents droughts that have been shown to negatively impact Brassy Minnow (see **Habitat Trends**).

Within the Saskatchewan portion of DU3, dams constructed for irrigation have likely impacted the available habitat. On the Frenchman River, this includes the Cypress Lake East Dam (in 1939), Eastend Dam (in 1936), West Val Marie Dam (in 1939), and Val Marie Dam (in 1936) (Water Security Agency 2021). On Lodge Creek, drainage irrigation dams include the Middle Creek Dam (in 1937) and Altawan Dam (in 1960) (Water Security Agency 2021). It is not uncommon for the Frenchman River to be flowing above the three lower irrigation reservoirs and for the lower river to be a series of isolated pools. The flows in the Frenchman River at the International border are often at or near zero in the late summer and most of the winter (Environment and Climate Change Canada 2019). These reservoirs are drawn down through winter to provide storage for spring runoff, and they are thus prone to winter kill. In the Frenchman River, water released from West Val Marie Dam and Val Marie Dam are diverted for irrigation. Fish are entrained by these diversions into the canals and die (J. Sereda pers. comm. 2020). The Rock Creek drainage has not been modified by large dams, and it is a typical intermittent prairie stream with a highly variable hydrograph, where 37 monthly mean flows of 0 m^3/s occurred between 1979 and 2009 (COSEWIC 2012). A number of small dams, intended for livestock watering, have been built on ephemeral streams in DU3. The overall impact of dams and water management on Brassy Minnow subpopulations is unknown.

(7.3) Other ecosystem modifications

Brassy Minnow may be negatively affected by the loss of riparian habitat, which causes soil erosion and increased sedimentation in lakes and streams (see **4.1** and **5.3**). The riparian zone also provides shade that reduces stream temperature, filters and stabilizes riverbanks, and protects rivers against the effects of fertilizers and pesticides (Broadmeadow and Nisbet 2004). Brassy Minnow is likely tolerant of increases in stream temperature and siltation (see **Habitat**), but given their requirement to spawn on aquatic vegetation (Abelson 1973; Becker 1983; McPhail 2007) and feed on phytoplankton and algae (Hlohowskyj *et al.* 1989; McPhail 2007), water turbidity needs to be low enough to allow for the growth of aquatic plants.

(3) Energy production & mining

(3.1) Oil & gas drilling

Brassy Minnow distribution overlaps with large surface and *in situ* oil and gas exploration in the Alberta portion of DU2. Chemical spills have been linked to the loss of Brassy Minnow in the House River in DU2 (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2014; see **Habitat Trends**).

(9) Pollution

(9.3) Agricultural & forestry effluents

Agricultural runoff can carry pollutants (farm fertilizers, animal waste, herbicides, and pesticides), sediment (see also **5.3**), and nutrient inputs that could negatively affect Brassy Minnow and its habitat. Agriculture is present to some degree in DU1 watersheds in the Lower Fraser Valley and near Prince George/Vanderhoof. DU3 has a mix of predominantly rangeland and some row crop throughout nearly the entire range. Effluent could increase productivity in the habitat occupied by Brassy Minnow, potentially benefiting subpopulations as long as oxygen levels remain sufficient, although herbicides could impair algal growth, limiting food availability.

There is considerable forestry in the northern area of DU1, and forestry near the BC/Alberta border in DU2. The direct impact of forestry effluents on Brassy Minnow populations is unknown.

(4) Transportation & service corridors

(4.1) Roads & railroads, (4.2) Utility & service lines

Road crossings can be barriers to the movement of fishes, fragmenting habitat, reducing population resilience to environmental disturbance, and increasing risk of local extinction (Diebel *et al.* 2015). Additionally, roads and railroads can result in the destruction of habitat from various construction or maintenance projects, including road maintenance

(e.g., road crossings and culvert insertion) and grade-control of stream banks (Maitland *et al.* 2016). In DU1, there has been extensive road-building in most watersheds where Brassy Minnow is found. These roads are related to agriculture and urbanization in the southern portion of DU1. At least 15% of the streams in the Lower Fraser Valley have been paved over or now flow through culverts (Fisheries and Oceans Canada 1998). In the Prince George/Vanderhoof area of DU1, there are road networks built to facilitate logging and agriculture. In DU3, road development has been more limited as the watershed is dominated by rangeland. DU2 has roads built to facilitate logging and oil and gas extraction, but their effect on Brassy Minnow is not known; utility and service lines that cross waterways in DU2 (e.g., extensive development in Grande Prairie in 2019) are thought to be a greater threat.

(5) Biological resource use

(5.3) Logging & wood harvesting

The loss of riparian vegetation typically results in increased siltation levels, although Brassy Minnow appear to be tolerant of a variety of turbidity levels (McPhail 2007). Logging and wood harvesting is often in headwater areas where Brassy Minnow occurs in DU1 and DU2. It is expected to impact Brassy Minnow habitat, although direct effects have not been investigated for this species. No logging occurs within DU3.

(2) Agriculture & aquaculture

(2.1) Annual & perennial non-timber crops, (2.3) Livestock farming & ranching

In DU1, agricultural development in the Lower Fraser Valley has resulted in limited riparian habitat where Brassy Minnow occurs. In the Upper Fraser drainage, around Prince George, Robson Valley and especially Vanderhoof, land clearing and conversion for agriculture is continuing (S. Pollard pers. comm. 2020; see **Habitat Trends**).

(6) Human intrusions & disturbance

(6.1) Recreational activities

In DU1, off-road and all-terrain vehicle (ATV) use likely occurs throughout the Prince George/Vanderhoof area, although the effect on Brassy Minnow is not clear.

Limiting Factors

Brassy Minnow prefers habitat with limited flow in the headwaters of watersheds, and it likely does not occur in great abundance in larger lakes and rivers. This likely limits its ability to move downstream and then colonize similar habitat in other headwater tributaries. Brassy Minnow abundance is also limited by the presence of predatory fishes, and decreases when they are introduced (Schlosser 1988; He and Kitchell 1990; Whittier *et al.* 1997; Nowosad and Taylor 2013).

Given the short life expectancy of Brassy Minnow (<4 years; McPhail 2007), the species is expected to be at increased risk of catastrophic events or habitat changes that lead to increased mortality and reduced or eliminated recruitment within this relatively short generation time.

Number of Locations

The distribution of abundant Brassy Minnow subpopulations is restricted to the headwater of drainage systems where threats identified can potentially have severe impacts. However, these headwaters typically have limited connectivity between one another, and threats would be expected to act independently on each subpopulation. Because subpopulations in general exist in isolation, the number of locations should be considered at the drainage level where connectivity is possible between subpopulations.

Pacific population (DU1)

Based on the most serious and plausible threat of invasive non-native/alien species/diseases (8.1), there are >25 locations for Brassy Minnow in DU1 as it is distributed in numerous creeks, sloughs, marshes, and small lakes within the disjunct range for the species.

Western Arctic population (DU2)

Based on the most serious and plausible threats of invasive non-native/alien species/diseases (8.1) and oil & gas drilling (3.1), there are approximately 13 locations for Brassy Minnow in DU2. Counting subpopulations with voucher specimens, the report writers' best estimate includes the following waterbodies as locations: Summit Lake, Bear Lake, Rocky Marsh, Mugaha Marsh, Peavine Creek, Pouce Coupe River, Smoky River (Musreau Lake), Athabasca River, House River, Horse River, Conn Creek, plus two unnamed tributaries.

Missouri population (DU3)

Based on the threats of drought (11.2), invasive non-native/alien species/diseases (8.1), and dams & water management/use (7.2), there are 18 locations for Brassy Minnow in DU3. These include Milk River, Red Creek, Half Breed Coulee, Police Coulee, Black Coulee, Miners Coulee, Kennedy Creek, Lost River Coulee, Lodge Creek, Middle Creek, Lonepine Creek, Boiler Creek, Conglomerate Creek, Frenchman River, Denniel Creek, Wetherall Creek, Morgan Creek, and Rock Creek.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Brassy Minnow is currently not listed on the *Species at Risk Act* and is afforded no legal protection or status.

Non-Legal Status and Ranks

The NatureServe (2019) global conservation status of the species as a whole, as of 2015, is secure (G5). The national status rank in both the US and Canada is secure (N5).

At the subnational level in Canada, Brassy Minnow is ranked on NatureServe as vulnerable to apparently secure (S3S4) in Saskatchewan and Quebec, apparently secure (S4) in British Columbia, secure (S5) in Manitoba and Ontario, and unrankable (SU) in Alberta. The B.C. Conservation Data Centre has assessed the Pacific Group of Brassy Minnow as imperilled to vulnerable (S2S3; 2019) and the Western Arctic Group as apparently secure (S3S4; 2012) (B.C. Conservation Data Centre 2021).

In the United States, Brassy Minnow is ranked critically imperilled (S1) in Illinois and Kansas, imperilled (S2) in New York, imperilled to vulnerable (S2S3) in Michigan and Vermont, vulnerable (S3) in Colorado and Missouri, apparently secure (S4) in Montana and Nebraska, secure (S5) in Iowa, South Dakota, Wyoming, and Wisconsin, and unranked (SNR) in Minnesota and North Dakota, and not applicable (SNA) in Pennsylvania and Utah.

Habitat Protection and Ownership

The 2019 *Fisheries Act* provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties, and functions for the conservation and protection of fish and fish habitat. The *Fisheries Act* contains provisions that can be applied to regulate flow needs for fish, fish passage, killing of fish by means other than fishing, the pollution of fish-bearing waters, and harm to fish habitat. Environment and Climate Change Canada has been delegated administrative responsibilities for the provisions dealing with regulating the pollution of fish-bearing waters while the other provisions are administered by DFO.

In British Columbia, the Riparian Areas Protection Regulation (RAPR) aims to protect riparian areas, while facilitating urban development that embraces high standards of environmental stewardship.

Within DU3, Brassy Minnow shares some habitat in the Milk River drainage with SARA-listed species. Western Silvery Minnow, Plains Sucker (*Pantosteus jordani*) (formerly known as Mountain Sucker), and Plains Minnow are listed as Threatened, and Rocky Mountain Sculpin (*Cottus* sp.) is listed as Special Concern. Recovery strategies have been published for Western Silvery Minnow and Rocky Mountain Sculpin (Fisheries and Oceans Canada 2012, 2017), as has an action plan for the Milk and St. Mary rivers (Fisheries and Oceans Canada 2018). Brassy Minnow subpopulations and habitat in Grasslands National

Park are protected under the *Canada National Parks Act*, and a Multi-species Action Plan for Grasslands National Park could also benefit Brassy Minnow (Parks Canada Agency 2016). These documents contain descriptions of recovery actions that should also benefit Brassy Minnow where its distribution overlaps with these species in the Milk River system.

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AUTHORITIES CONTACTED

Name of jurisdiction	Name of contact(s) and date(s)
Department of Fisheries and Oceans (aquatic species only)	Ashley Kling, Oct 2, 2019
Canadian Museum of Nature	Robert Anderson, Oct 2, 2019
Royal BC Museum	Gavin Hanke, Oct 2, 2019
Museum of Zoology, University of Alberta	Alison Murray, Oct 17, 2019
UBC	Eric Taylor, Oct 2, 2019
Parks Canada	Pippa Shepherd and Shelley Pruss, Oct 2, 2019
Provincial / territorial representative(s) corresponding to the range of the wildlife species	Gregory A. Wilson (BC), Dr. Gordon Court (AB), Dr. Philip McLoughlin (SK), Oct 2, 2019
Conservation Data Centre(s) or Natural Heritage Information Centre(s) corresponding to the range of the wildlife species	Gordon Oliphant (BC, CDC), Feb 2, 2019 Shevelle Stephens (AB) January 11, 2019 Jeff Keith (SK, CDC) Oct 2, 2019
COSEWIC Secretariat for information and instruction on: sources of Aboriginal Traditional Knowledge; the preparation of distribution maps; and the calculation of extent of occurrence, area of occupancy, and index of area of occupancy	Sonia Schnobb, Oct 2, 2019

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Doug Watkinson is a Research Biologist with Fisheries and Oceans Canada in Winnipeg. He has sampled fish in many of the major river systems of the Saskatchewan-Nelson and Missouri River drainages where *Hybognathus hankinsoni* are found. His current research focuses on species at risk, habitat impacts, and aquatic invasive species. He has co-written eight COSEWIC species status reports and the field guide, The Freshwater Fishes of Manitoba.

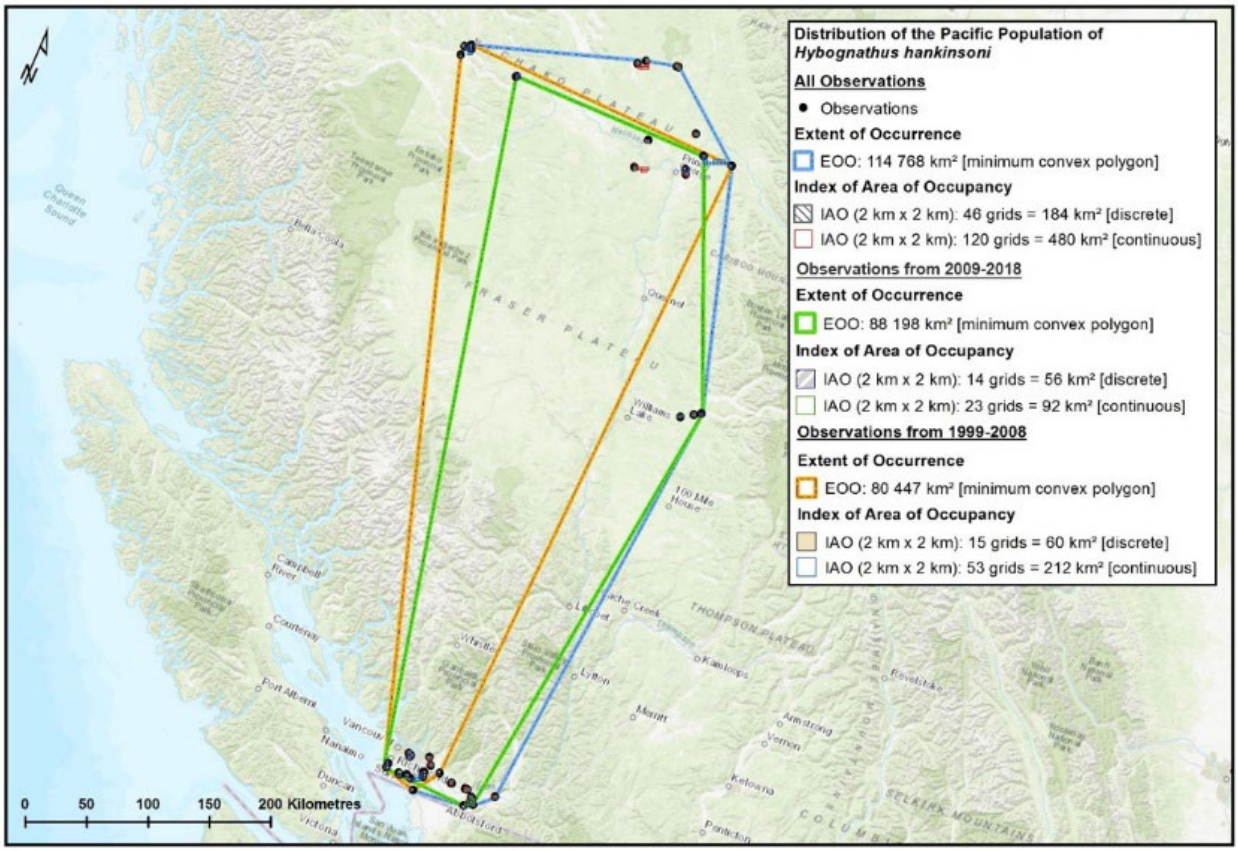
Dr. Mark Poesch is an Associate Professor at the University of Alberta in the Department of Renewable Resources. Dr. Poesch sits on both the federal and provincial listing bodies for species at risk in Canada, and numerous other inter-governmental committees and non-governmental groups, including as the outgoing president of the Canadian Aquatic Resources Section of the American Fisheries Society, the largest professional group focusing on fishes in Canada. Dr. Poesch has conducted research on freshwater species at risk throughout Canada, including on effects of habitat loss and fragmentation, metal contamination and invasive species.

COLLECTIONS EXAMINED

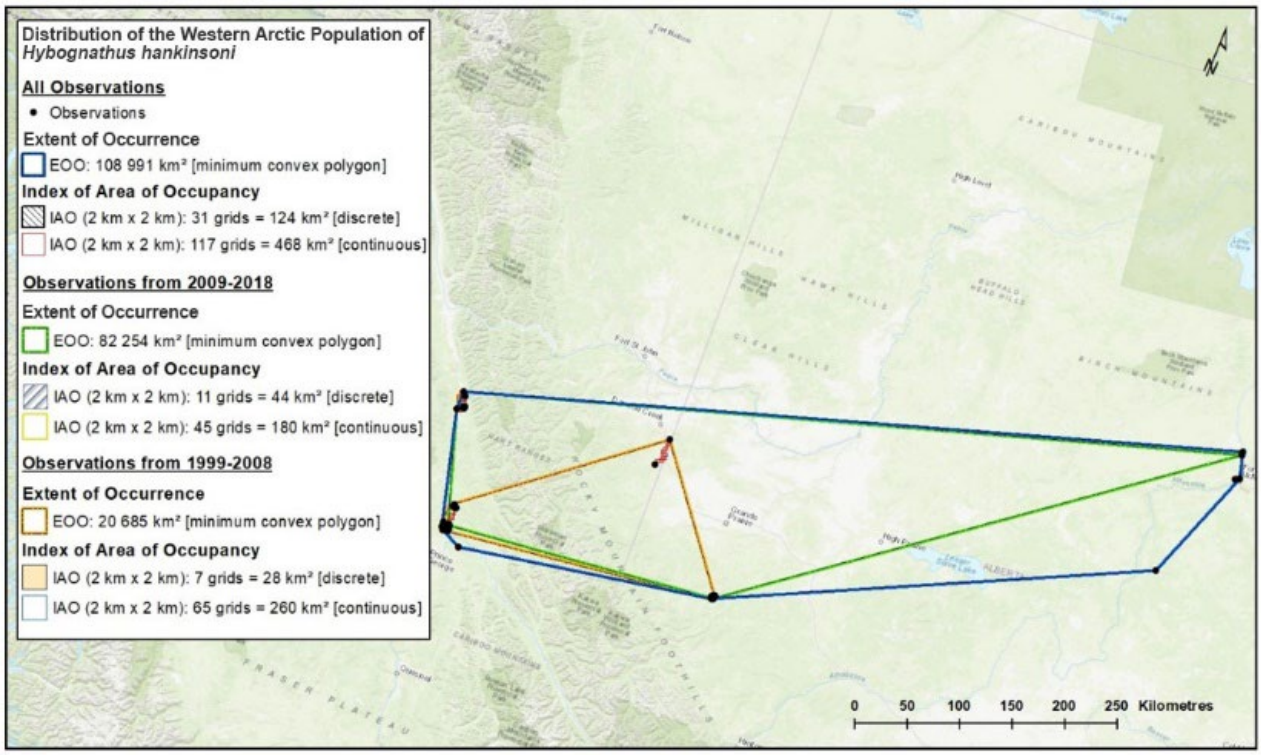
Museum specimen 6496, Zoology Museum, University of Alberta

Museum specimen F8391, Zoology Museum, University of Alberta

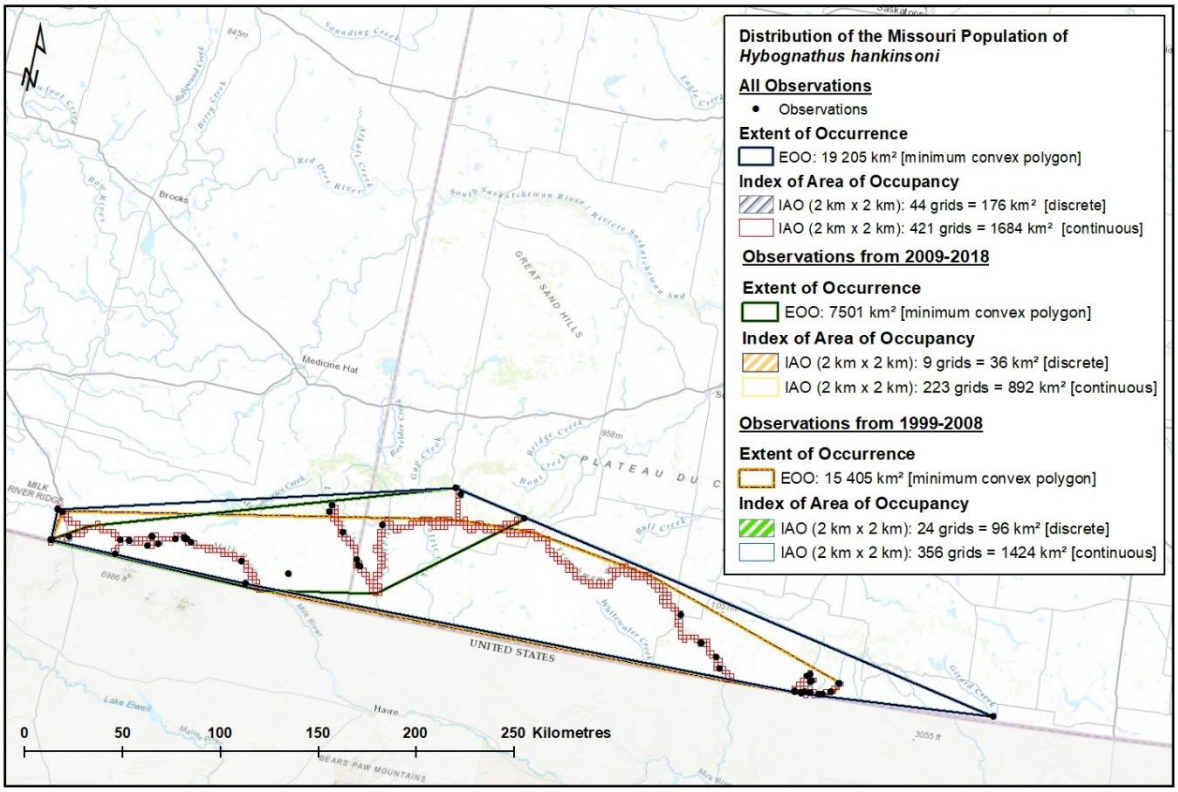
Appendix 1. Estimated Extent of Occurrence (EOO) and Index of Area of Occupancy (IAO) for Brassy Minnow in DU1. Prepared by Sydney Allen (COSEWIC Secretariat).



Appendix 2. Estimated Extent of Occurrence (EOO) and Index of Area of Occupancy (IAO) for Brassy Minnow in DU2. Twenty-three records from the eastern portion of DU2 (collected in 2011–2014) were excluded because of uncertainty regarding identification (see Search Effort); one vouchered specimen collected in 2014 near Fort McMurray was included. Prepared by Amit Saini (COSEWIC Secretariat).



Appendix 3. Estimated Extent of Occurrence (EOO) and Index of Area of Occupancy (IAO) for Brassy Minnow in DU3. "All Observations" includes 18 Brassy Minnow collected by DFO during a 2020 survey for Plains Minnow (see Search Effort). Prepared by Amit Saini (COSEWIC Secretariat).



Appendix 4. Threats Assessment Worksheets.

Species or Ecosystem Scientific Name	Brassy Minnow *Hybognathus hankinsoni* Pacific population (DU1)		
Element ID		**Elcode**	
Date:	2020-05-29		
Assessor(s):	Jennifer Heron (facilitator), John Post (Co-chair), Doug Watkinson (report writer), Margaret Docker, Alan Dextrase, Mark Poesch, Mark Ridgway, Sue Pollard, Julien April, Michael Sullivan, Shane Petry, Jeff Sereda, Eva Enders, Cavan Harpur, Greg Wilson, Jennifer Shaw, Karine Robert, Nickolaus Gantner, Marlena McCabe		
References:			

Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	1	0
C	Medium	3	1
D	Low	4	7
Calculated Overall Threat Impact:		Very High	High

Assigned Overall Threat Impact:	**BC = High – Medium**
Impact Adjustment Reasons:	This DU occurs within two distinct geographic regions of BC, with differing threats within each region. Aquatic habitat in the southern portion of the species' range in the Fraser Valley has numerous cumulative threats (e.g., sedimentation, runoff, infilling, invasive predatory fish) that are substantially higher than subpopulations in the northern (e.g., Nechako) areas. Furthermore, there was a general consensus in the straw ballots prior to the May 2022 Species Assessment Meeting that a few of the Low impact threats (e.g., 2.1, 2.3) may be overstated.
Overall Threat Comments	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						Not directly applicable. Development in the Lower Fraser Valley is an area of intense and increasing residential and urban development, but most development is historical, and riparian set-backs and/or best management practices are in place to prevent development right up to the edge of fish-bearing streams (see also 9.1 re: urban effluent).
1.2	Commercial & industrial areas						Not directly applicable; proximate threats as a result of this development are scored in 9.2.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas						Not directly applicable; there are unlikely to be large-scale infrastructure tourism developments, and proximate threats resulting from tourism & recreation are scored in 6.1.
2	Agriculture & aquaculture	D	Low	Large - Restricted (11-70%)	Slight (1-10%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Large - Restricted (11-70%)	Slight (1-10%)	High (Continuing)	Cropland in the Lower Fraser R Valley & hayland near the Prince George/Vanderhoof area has resulted in some loss of riparian habitat where Brassy Minnow occurs, although some effects may also be accounted for under 7.2, 7.3, and 9.3.
2.2	Wood & pulp plantations						NA
2.3	Livestock farming & ranching	D	Low	Large - Restricted (11-70%)	Slight (1-10%)	High (Continuing)	Some ranching in the Prince George/Vanderhoof area. Impacts are likely low if ranching; may be higher if feed lots. Hobby farms contribute to habitat (Little Campbell R, and other watersheds). Low calculated threat may be overstated if some of the effects are also accounted for under 9.3.
2.4	Marine & freshwater aquaculture						NA. Aquaculture activities in the watershed are outside the species' range.
3	Energy production & mining		Negligible	Small (1-10%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
3.1	Oil & gas drilling						NA. No known oil and gas drilling activities in the species' range.
3.2	Mining & quarrying		Negligible	Small (1-10%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Mining or quarrying activities in the watershed. No identified impacts, but could expect impacts if the specific habitat or large portions of the watershed is modified or destroyed. Local and possible; Lower Mainland gravel mining near water control structures; direct impact from gravel removal small area and not often (e.g., Pepin Creek in 1997, 1999, 2008), but expected in next 10 years. Sediment likely discharged downstream of the distribution of the species (see 9.2).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy						Biomass electrical generation exists. Small, run of the river hydro. No known impacts. Independent Power Producers, but they are usually high up and beyond the Brassy Minnow habitats; accounted for under 7.2.
4	Transportation & service corridors	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	There has been extensive road-building in most watersheds. At least 15% of the streams in the Lower Fraser Valley have been paved over or now flow through culverts. Lots of forestry roads being built, much more applicable in the north.
4.2	Utility & service lines	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Present, more so in Lower Fraser Valley. Pipelines in the Lower Mainland, including natural gas pipelines serving residential areas. Nechako Plateau has gas lines being built, pipelines in the Upper Fraser coming up the Fraser Valley and several new gas lines proposed and twinning of existing pipelines in the north. Threat is direct loss of habitat rather than the pollution (9.2). Works may happen in the winter.
4.3	Shipping lanes						NA. Shipping lanes or dredging activity in the Lower Fraser Valley, but outside the known distribution of the species.
4.4	Flight paths						NA. No impact on aquatic species.
5	Biological resource use	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						NA
5.2	Gathering terrestrial plants						NA

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Considerable historical and, in some portions of the watersheds, contemporary logging activities. Logging and wood harvesting is often in headwater areas that Brassy Minnow occurs. Although direct impacts have not been investigated for this species, it is expected to impact Brassy Minnow habitat.
5.4	Fishing & harvesting aquatic resources		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Recreational fishing is present but likely very limited considering Brassy Minnow are typically in headwaters with poor sport fish populations. The species is not targeted. Scientific research directed at other SARA-listed species, university research, and consultants working for proponents occurs, but this sampling is typically not targeted for Brassy Minnow, and is limited in spatial and temporal scope.
6	Human intrusions & disturbance	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Off-road and ATV use likely present throughout the Prince George/Vanderhoof area. Sedimentation and habitat alteration due to this activity is a minor concern. Hunters will occasionally cross streams, but impact is expected to be minimal.
6.2	War, civil unrest & military exercises						NA
6.3	Work & other activities						NA
7	Natural system modifications	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	Fire may occur in the Prince George/Vanderhoof area. It is unknown if fire is detrimental to Brassy Minnow subpopulations, but would likely depend on fire severity, duration, and size.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/ use	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Because Brassy Minnow is typically only distributed in or most abundant in headwater lakes and streams, the impacts of this threat are likely limited as these habitats are upstream of sites typically chosen for dams. Agriculture in the Lower Fraser Valley may have affected flows via extensive use of agriculture ditches, dykes, and other small-scale modifications.
7.3	Other ecosystem modifications	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Brassy Minnow are likely tolerant of increases in stream temperature and siltation, but given their requirement to spawn on aquatic vegetation and feed on phytoplankton and algae, water turbidity needs to be low enough to allow for the growth of aquatic plants.
8	Invasive & other problematic species & genes	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Throughout their range, Brassy Minnow are not abundant where they co-exist with predatory fish. Introduced fish species (Bullhead, Northern Pike, and Smallmouth Bass) have all been shown to alter habitat use and population size of Brassy Minnow.
8.2	Problematic native species/diseases	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Throughout their range Brassy Minnow are not abundant where they co-exist with predatory fish. Any stocking of native predatory fish would be expected to have a negative consequence on subpopulations, but the extent to which this is occurring is not clear.
8.3	Introduced genetic material						NA. No stocking of Brassy Minnow occurs
8.4	Problematic species/diseases of unknown origin						NA. No known problematic species/diseases affecting Brassy Minnow in this watershed.
8.5	Viral/prion-induced diseases						NA. No known viral/prion-induced diseases affecting Brassy Minnow known.
8.6	Diseases of unknown cause						NA. No known diseases of unknown cause affecting Brassy Minnow known.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9	Pollution	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
9.1	Domestic & urban waste water	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	There are significant urban areas in the Lower Fraser Valley. Because Brassy Minnow occupy headwaters, it is not known if this would impact these habitats. Therefore, impact should perhaps be Unknown.
9.2	Industrial & military effluents						There are industrial activities in the watershed, but effluents would be expected to be discharged downstream of the distribution of the species.
9.3	Agricultural & forestry effluents	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Considerable amounts of forestry in the Prince George/Vanderhoof area. Some agriculture is present within species' range in the Lower Fraser Valley and near Prince George/Vanderhoof. Effluent could increase productivity, potentially benefiting Brassy Minnow, if oxygen levels remain sufficient, but herbicides could impair algal growth, limiting food availability.
9.4	Garbage & solid waste						NA. Occurs within the watershed, but proximity to the species and impact not known.
9.5	Air-borne pollutants						Urban pollutants occur in the Lower Fraser Valley. Wild fires have occurred with significant impacts on air quality in the last decade, but the impact on Brassy Minnow is unknown.
9.6	Excess energy						NA. Noise and light pollution is present, mostly in the Lower Fraser Valley, but it is unlikely to impact Brassy Minnow.
10	Geological events						
10.1	Volcanoes						Volcanoes can occur nearby. Impact unknown.
10.2	Earthquakes/ tsunamis						Earthquakes and tsunamis can occur in the area. Impact unknown.
10.3	Avalanches/landslides						The potential for avalanches exists in the Prince George/Vanderhoof area, but there are no overall predicted impacts on Brassy Minnow.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Drought could be a serious impact, but 11 was scored as a whole, because all of the factors listed are likely contributing to the decline of the fish, although they may or may not be within the 10-year time frame.
11.1	Habitat shifting & alteration						NA. Alterations in seasonal flow rates may have an impact on spawning and overall reproductive success due to timing, but generally impacts are unknown.
11.2	Droughts						Drought may become more prevalent across the Brassy Minnow's range. Because they occupy headwater systems, dramatic changes in water availability are expected more frequently. In the winter, Brassy Minnow may be particularity vulnerable, as they occupy small headwater lakes and streams, and low-flow conditions can increase the risk of freezing and low dissolved oxygen levels.
11.3	Temperature extremes						Streams in south-central British Columbia are tending to have an earlier spring freshet and lower flows in late summer and early as well as a gradual warming trend. However, temperature is not likely reaching the thermal maximum established for other populations of the species (>35.5°C).
11.4	Storms & flooding						Storms and flooding are common throughout the range, but impacts are likely limited in headwaters.
11.5	Other impacts						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).

Species or Ecosystem Scientific Name		Brassy Minnow *Hybognathus hankinsoni* Western Arctic population (DU2)	
Element ID		**Elcode**	
Date:		2020-05-29	
Assessor(s):		Jennifer Heron (facilitator), John Post (Co-chair), Doug Watkinson (report writer), Margaret Docker, Alan Dextrase, Mark Poesch, Mark Ridgway, Sue Pollard, Julien April, Michael Sullivan, Shane Petry, Jeff Sereda, Eva Enders, Cavan Harpur, Greg Wilson, Jennifer Shaw, Karine Robert, Nickolaus Gantner, Marlena McCabe	
References:			
Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
Threat Impact		**high range**	**low range**
A	Very High	0	0
B	High	2	2
C	Medium	1	0
D	Low	3	4
Calculated Overall Threat Impact:		Very High	Very High
Assigned Overall Threat Impact:		**B = High**	
Impact Adjustment Reasons:		There is some uncertainty with respect to the timing of oil spills and non-native fish introductions; the scope and severity are pervasive and serious, respectively, but there is uncertainty whether they would happen within the next 3 generations.	
Overall Threat Comments			

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
1.1	Housing & urban areas						Development is limited because the areas of DU2 inhabited by Brassy Minnow aren't within highly sought-after for housing/urban development; most development is historical, and riparian set-backs and/or best management practices are in place to prevent development right up to the edge of fish-bearing streams. Threats as a result of urban development that might modify water quality are scored under 9.1.
1.2	Commercial & industrial areas						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	There is tourism in the watershed; this would include, hiking, biking, camping, boating as well as tourism in the urban centres. Impacts are likely low, but scored as negligible rather than NA to acknowledge possible expansion of the Musreau Lake Recreation Area and that this may impact some of the aquatic shoreline habitat, but proximate threats (as a result of this development) are scored elsewhere.
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
2.1	Annual & perennial non-timber crops		Negligible	Restricted (11-30%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Cropland exists near the BC/Alberta border. Can be row crop and hayland. It is possible agricultural practices will fill in some waterways, especially during times when there is drought and there isn't water in these areas. This is currently limited, because most landowners are good stewards, but future practices and impacts are unknown.
2.2	Wood & pulp plantations						NA
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Some ranching likely exists near the BC/Alberta border. Impacts are likely low if ranching; may be higher if feed lots. Most ranchers follow best practises and keep cattle out of aquatic habitats that have SAR. Most cattle operations are not large-scale. Effects of agriculture to aquatic systems is accounted for under 9.3.
2.4	Marine & freshwater aquaculture						NA. Aquaculture activities in the watershed are outside the species range.
3	Energy production & mining	B	High	Large (31-70%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
3.1	Oil & gas drilling	B	High	Large (31-70%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Brassy Minnow distribution corresponds to large surface and *in situ* oil and gas exploration in DU2. Chemical spills have been linked to the loss of Brassy Minnow in the House R in DU2. There may be some ghost well clean-up in surrounding areas.
3.2	Mining & quarrying						Mining or quarrying activities in the watershed. No identified impacts, but could expect impacts if the specific habitat or large portions of the watershed is modified or destroyed.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy						NA. None known.
4	Transportation & service corridors	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads						Limited road-building in most watersheds where Brassy Minnow occurs in DU2. Roads are related to agriculture, forestry, and oil and gas.
4.2	Utility & service lines	D	Low	Restricted (11-30%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Present in the DU and crossing waterways (e.g., extensive development in Grand Prairie in 2019, ~5 km away); at least 10 pipeline crossings of creeks, so spill is possible (see 9.2).
4.3	Shipping lanes						NA. None known.
4.4	Flight paths						NA. No impact on aquatic species.
5	Biological resource use	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						NA.
5.2	Gathering terrestrial plants						NA
5.3	Logging & wood harvesting	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Considerable historical and, in some portions of the watersheds, contemporary logging activities. Logging and wood harvesting is often in headwater areas that Brassy Minnow occurs. Direct effects have not been investigated for this species, but they are expected to impact habitat.
5.4	Fishing & harvesting aquatic resources		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Recreational fishing is present, but likely very limited considering Brassy Minnow are typically in headwaters with poor sport fish populations, and the species is not targeted. Scientific research directed at other SARA-listed species, university research, and consultants working for proponents occurs, but this sampling is typically not targeted for Brassy Minnow, and is limited in spatial and temporal scope.
6	Human intrusions & disturbance		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Off-road and ATV use likely present throughout the DU. Sedimentation and habitat alteration due to this activity is a minor concern (see 9.3). Hunters will occasionally cross streams, but impact is likely minimal.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.2	War, civil unrest & military exercises						NA
6.3	Work & other activities						NA
7	Natural system modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fire may occur in this DU. It is unknown if fire is detrimental to Brassy Minnow subpopulations, but would likely depend on fire severity, duration, and size.
7.2	Dams & water management/use		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Because Brassy Minnow is typically only distributed in or most abundant in headwater lakes and streams, the impacts of this threat are likely limited, as these habitats are upstream of sites typically chosen for dams in DU2.
7.3	Other ecosystem modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Brassy Minnow are likely tolerant of increases in stream temperature and siltation, but given their requirement to spawn on aquatic vegetation and feed on phytoplankton and algae, water turbidity needs to be low enough to allow for the growth of aquatic plants.
8	Invasive & other problematic species & genes	B	High	Pervasive (71-100%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
8.1	Invasive non-native/alien species/diseases	B	High	Pervasive (71-100%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Throughout their range, Brassy Minnow are not abundant where they co-exist with predatory fishes. Rainbow Trout stocking in Musreau Lake (~200,000 every few years) stopped in 1999, but there is continued interest in establishing a sport fishery, and this would represent a substantial threat to the only abundant Brassy Minnow subpopulation in DU2.
8.2	Problematic native species/diseases						Throughout their range, Brassy Minnow are not abundant where they co-exist with predatory fishes. Stocking of native predatory fishes would be expected to have a negative consequence on subpopulations.
8.3	Introduced genetic material						NA. No stocking of Brassy Minnow occurs.
8.4	Problematic species/diseases of unknown origin						NA. No known problematic species/diseases affecting Brassy Minnow in this watershed.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.5	Viral/prion-induced diseases						NA. No known viral/prion-induced diseases affecting Brassy Minnow known.
8.6	Diseases of unknown cause						NA. No known diseases of unknown cause affecting Brassy Minnow known.
9	Pollution		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
9.1	Domestic & urban waste water						There is limited activity in the species' distribution. Because Brassy Minnow occupy headwaters, it is not known if this would impact these habitats.
9.2	Industrial & military effluents						There are limited industrial activities in the watershed, but effluents would be expected to be discharged downstream of the distribution of the species. Threats due to spills during oil & gas mining were accounted for under 3.1, due to pipelines under 4.2
9.3	Agricultural & forestry effluents		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Forestry near the BC/Alberta border, and agriculture is present to some degree in DU2 watersheds near the BC/Alberta border. Effluent could increase productivity, potentially benefiting Brassy Minnow, so long as oxygen levels remain sufficient. The direct impact of agriculture and forestry effluents on Brassy Minnow has not been studied, but herbicides could impair algal growth, limiting food availability.
9.4	Garbage & solid waste						NA. Occurs within the watershed, but proximity to the species and impact not known.
9.5	Air-borne pollutants						Wild fires have occurred with significant impacts on air quality in the last decade, but the impact on Brassy Minnow is unknown.
9.6	Excess energy						NA. Noise and light pollution is present, although limited, but it is unlikely to impact Brassy Minnow.
10	Geological events						
10.1	Volcanoes						NA. No Volcanoes occur nearby.
10.2	Earthquakes/tsunamis						NA. Not in this DU.
10.3	Avalanches/landslides						NA. Limited in scale in this DU.
11	Climate change & severe weather	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	11 was scored as a whole because all of the factors listed are likely contributing to the decline of the fish.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration						NA. Alterations in seasonal flow rates may have an impact on spawning and overall reproductive success due to timing, but generally impacts are unknown.
11.2	Droughts						Drought may become more prevalent across the Brassy Minnow's range. Because they occupy headwater systems, dramatic changes in water availability are expected more frequently. In the winter, Brassy Minnow may be particularity vulnerable, as it occupies small headwater lakes and streams, and low-flow conditions can increase the risk of freezing and low dissolved oxygen levels.
11.3	Temperature extremes						Because temperature is not likely reaching the thermal maximum established for other populations of the species (>35.5°C), the impact is likely limited.
11.4	Storms & flooding						Storms and flooding are common throughout the range, but because the distribution of the species tends to be in headwaters, impacts are likely limited.
11.5	Other impacts						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).							

Species or Ecosystem Scientific Name	Brassy Minnow *Hybognathus hankinsoni* Missouri population (DU3)			
Element ID		**Elcode**		
Date:	2020-05-29			
Assessor(s):	Jennifer Heron (facilitator), John Post (Co-chair), Doug Watkinson (report writer), Margaret Docker, Alan Dextrase, Mark Poesch, Mark Ridgway, Sue Pollard, Julien April, Michael Sullivan, Shane Petry, Jeff Sereda, Eva Enders, Cavan Harpur, Greg Wilson, Jennifer Shaw, Karine Robert, Nickolaus Gantner, Marlena McCabe			
References:				
Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	1	0
	C	Medium	2	1
	D	Low	0	2
Calculated Overall Threat Impact:			Very High	Medium
Assigned Overall Threat Impact:			**BC = High - Medium**	
Impact Adjustment Reasons:			There is general consensus that an overall impact of Very High is overstated. For this reason, the overall threat impact for this Designatable Unit was adjusted to High - Medium.	
Overall Threat Comments				

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development						
1.1	Housing & urban areas						Development is very limited in DU3, so impacts are not expected. Most development is historical, and riparian set-backs and/or best management practices are in place to prevent development right up to the edge of fish-bearing stream; urban effluent is scored under 9.1.
1.2	Commercial & industrial areas						Not directly applicable; proximate threats as a result of this development are scored in 9.2.
1.3	Tourism & recreation areas						There is limited tourism in the watershed (e.g., hiking, biking, camping), and impacts of large-scale infrastructure tourism developments are likely low. Proximate threats resulting from tourism & recreation are scored in 6.1.
2	Agriculture & aquaculture		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops						Cropland (row crop and hayland) exists throughout the DU, perhaps as high as 50%. Direct impact of agricultural development is probably not significant (e.g., this DU includes SK portion of the Frenchman R, but most of the development isn't up to the edge; in the Milk R, there is some irrigation, but this is primarily dry land and some grass; it's grazed and probably not turned over annually). In Huff and Newton lakes, and upper part by Cypress Hills, there is flood irrigation, and fields are flooded and water is returned into the river, so there is some impact from this (scored under 7.2).
2.2	Wood & pulp plantations						NA. Limited potential in this DU; if forestry occurs, it is where forests existed.
2.3	Livestock farming & ranching		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Exists throughout this DU (perhaps as high as 50%). Impacts are likely low if ranching; may be higher if feed lots. Effects of agriculture to aquatic systems is accounted for under 9.3.
2.4	Marine & freshwater aquaculture						NA. Aquaculture activities in the watershed are outside the species' range.
3	Energy production & mining		Unknown	Large (31-70%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling		Unknown	Large (31-70%)	Unknown	High (Continuing)	Limited gas and even more limited oil extraction in this DU. No expected impacts. However, potential impacts with natural gas well clean-up, because they have to access all these wells and get there with equipment. If AB wants to clean these up (e.g., through the "Orphan Wells" funding program), this could become a problem.
3.2	Mining & quarrying						Mining or quarrying activities in the watershed. No identified impacts, but could expect impacts if the specific habitat or large portions of the watershed is modified or destroyed by instream work.
3.3	Renewable energy						NA. No known impacts. Large renewable solar project around Medicine Hat, but not likely to impact Brassy Minnow. Large energy projects on public land not yet permitted.
4	Transportation & service corridors						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads						Limited road-building in most DU3 watersheds Brassy Minnow occurs in. Roads are related to agriculture, although may be agricultural farm trails, and every well head has a trail to it. However, roads aren't really maintained, and gas well impacts captured under 3.1.
4.2	Utility & service lines						Present in the DU, although limited. They do cross waterways, so spill is possible, but not considered a threat under normal operation. There are some gas pipelines, but not many new pipelines. Lots of pipeline crossings, but they are old, with no oil sitting in them. Oil pipelines don't go down through Milk R area anymore. Keystone doesn't follow the Milk R Valley area; this was drilled under the South Saskatchewan R. The original Keystone Pipeline reused/reconstituted different lines and goes into SK through Medicine Hat.
4.3	Shipping lanes						NA. None known.
4.4	Flight paths						NA. No impact on aquatic species.
5	Biological resource use		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						NA.
5.2	Gathering terrestrial plants						NA.
5.3	Logging & wood harvesting						NA. No activity in this DU.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Recreational fishing is present, but impacts are likely very limited considering Brassy Minnow is typically in headwaters with poor sport fish populations, and the private land sites aren't accessible for recreational purposes. The species is generally not targeted, although, in AB, it's permitted to use Brassy Minnow as bait fish. Scientific research directed at other SARA-listed species, university research, and consultants working for proponents occurs, but this sampling is typically not targeted for Brassy Minnow. This sampling is not likely to impact subpopulations significantly, as it is limited in spatial and temporal scope. There is some research that is ongoing, and there are permits required.
6	Human intrusions & disturbance		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Off-road and ATV use likely present through the DU, although private ranchers don't allow ATV use on their properties. Scored because it is possibility, but only applicable to crown lands in AB. Sedimentation and habitat alteration due to this activity is a minor concern. Hunters and farmers will occasionally cross streams, but impact is expected to be minimal.
6.2	War, civil unrest & military exercises						NA
6.3	Work & other activities						NA
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression						Fire may occur in this DU, typically grass fires. It is unknown if fire is detrimental to Brassy Minnow subpopulations, but would likely depend on fire severity, duration, and size. However, grass fires have been ongoing for 7000 years, so impact is likely negligible. Fire breaks won't be in creeks. Fire suppression may be a threat, as tanker trucks may draw water and impact subpopulations in low water/drought years (see 7.2).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.2	Dams & water management/use	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	The St. Mary Diversion in the US has greatly modified the natural hydrography of the North Milk and Milk rivers. The significant increase in water volume since the canal went into use is believed to have extensively altered the ecological regime of the Milk R. This may benefit predatory fishes, which would be expect to negatively impact Brassy Minnow. Within the Saskatchewan portion of DU3, dams built on the Frenchman R to release flows for irrigation have likely negatively impacted the available habitat. There is some irrigation near the town of Milk R and other settlements, but not overall. This is governed by international treaty, temporary diversion licences, groundwater extraction, and likely negatively impacts Brassy Minnow. Tanker trucks taking water out of pools could have greater impacts, but it depends on the year; research shows that this is detrimental. The augmentation and the long-term impacts are potentially huge. There are other impacts in SK, not just AB. The Milk R is getting better over time, and much of the oil and gas wells and development is historical. Much of the irrigation areas haven't been sampled; some of the biggest impacts are water management, and a lot of reservoirs are drawn down shallow through winter to provide storage for spring run-off, so they are prone to winter kill. In the Frenchman R and Huff and Newton lakes, waters are flooded/diverted for irrigation; a lot of fish go down these canals and die. Because these reservoirs are drawn down for spring runoff, the general practice is to try and capture as much spring run-off as possible; thus, they do not get the spring runoff because most is impounded. Temporary diversion licences, ground water withdrawal, and other water management actions need to be considered, and there are some drainage systems that don't allow the spring run-off to get to the Milk R.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.3	Other ecosystem modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Brassy Minnow are likely tolerant of increases in stream temperature and siltation, but given their requirement to spawn on aquatic vegetation and feed on phytoplankton and algae, water turbidity needs to be low enough to allow for the growth of aquatic plants. There are no studies that present evidence of an impact, and there may be some benefits of increased productivity.
8	Invasive & other problematic species & genes	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Throughout their range, Brassy Minnow is not abundant where it co-exists with predatory fishes. Introduced species (Bullhead, Northern Pike, and Smallmouth Bass) have been shown to alter habitat use and decrease abundance of Brassy Minnow. Bullhead and Northern Pike are the most pervasive and highest impact threats. Northern Pike are considered non-native, but there are many other species (e.g., crappies, bass) that could conceivably move into the Milk River because there are no barriers for fish. Montana is having an issue with illegal stocking of Walleye, and this could be a threat. For the Frenchman R, the Saskatchewan government stocked Eastman R with Walleye and Yellow Perch, and they are making their way down, both Huff and Newton lakes are full of Yellow Perch and Walleye now. Both these non-native species are prevalent throughout the Frenchman R, and Northern Pike in the Frenchman could be quite prevalent. Rainbow Trout and Brook Trout are expected to have less of an impact in these areas, because Brassy Minnow would generally occur in warmer areas than these species.
8.2	Problematic native species/diseases						Throughout their range, Brassy Minnow are not abundant where they co-exist with predatory fishes. Any stocking of native predatory fishes could be expected to have a negative consequence on subpopulations. Native Sauger could be a threat, although there appear to be no human-mediated changes that would expand its range in this DU.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material						NA. No stocking of Brassy Minnow occurs.
8.4	Problematic species/diseases of unknown origin						NA. No known problematic species/diseases affecting Brassy Minnow in this watershed.
8.5	Viral/prion-induced diseases						NA. No known viral/prion-induced diseases affecting Brassy Minnow known.
8.6	Diseases of unknown cause						NA. No known diseases of unknown cause affecting Brassy Minnow known.
9	Pollution		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
9.1	Domestic & urban waste water						There is limited activity in the species' distribution. Because Brassy Minnow occupy headwaters, it is not known if this would impact these habitats. Sewage lagoons are not considered a big impact, and Brassy Minnow is slightly eutrophic and may not mind this.
9.2	Industrial & military effluents						There is limited industrial activity in the watershed, but effluents would be expected to be typically discharged downstream of the distribution of the species. Point-source pollutions and pipeline failures were included elsewhere (3.1).
9.3	Agricultural & forestry effluents		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Agriculture is present throughout DU3, predominantly rangeland. Increased productivity of the habitat that Brassy Minnow occupy may benefit subpopulations if oxygen levels remain sufficient. Herbicides could impair algal growth, limiting food availability, but most of the lands are pasturelands, and pesticides are not widely applied.
9.4	Garbage & solid waste						Occurs within the watershed, but likely has a limited impact.
9.5	Air-borne pollutants						Wild fires have occurred nearby in the Rocky Mountains with significant impacts on air quality in the last decade, although the impact on Brassy Minnow is unknown.
9.6	Excess energy						NA. Noise and light pollution is present, although limited and unlikely to impact Brassy Minnow.
10	Geological events						
10.1	Volcanoes						NA. No Volcanoes occur nearby.
10.2	Earthquakes/ tsunamis						NA. Not in this DU.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.3	Avalanches/ landslides						Limited in this DU to small streamside landslides.
11	Climate change & severe weather	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Drought could be a serious impact because the US diverts a lot of water, and it can impact the Milk R system to the point that surface flow becomes less detectable. There is interaction between water management and climate change. If they didn't augment flows in the Milk R and only used what came out of the hills, fairly severe changes would be seen.
11.1	Habitat shifting & alteration						NA. Alterations in seasonal flow rates may have an impact on spawning and overall reproductive success due to timing, but the impacts are unknown.
11.2	Droughts						Drought may become more prevalent across the Brassy Minnow's range. Because Brassy Minnow occupy headwater systems, dramatic changes in water availability are to be expected more frequently. In the winter, Brassy Minnow may be particularly vulnerable as they occupy small headwater lakes and streams, and low-flow conditions can increase the risk of freezing and low dissolved oxygen levels.
11.3	Temperature extremes						Because temperature is not likely reaching the thermal maximum for the species (>35.5°C), the impact is likely limited.
11.4	Storms & flooding						Storms and flooding are common throughout the range, but because the distribution of the species tends to be in headwaters, impacts are likely limited.
11.5	Other impacts						

Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).