# POPULATION STATUS AND CHARACTERISTICS OF MACRHYBOPSIS GELIDA, PLATYGOBIO GRACILIS AND RHINICHTHYS CATARACTAE IN THE MISSOURI RIVER BASIN

BY

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POPULATION STATUS AND CHARACTERISTICS OF
*MACRHYBOPSIS GELIDA*, *PLATYGOBIO GRACILIS* AND
*RHINICHTHYS CATARACTAE* IN THE MISSOURI RIVER BASIN

This thesis is approved as a creditable and independent investigation by a candidate for the degree Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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POPULATION STATUS AND CHARACTERISTICS OF
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## ABSTRACT

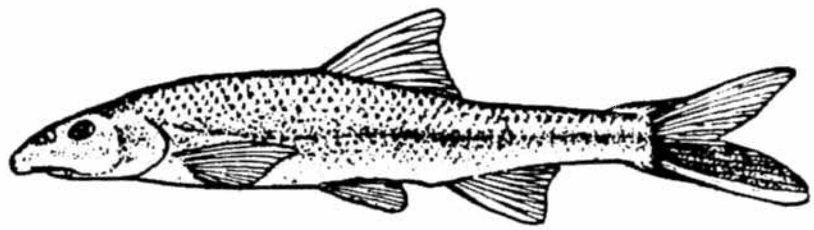
Few sturgeon chub (*Macrhybopsis gelida*: Cyprinidae) have been collected in the last decade, therefore their status, habitat selection and morphology were investigated at 172 previous collection sites. Data on two ecologically similar species, *Platygobio gracilis* and *Rhinichthys cataractae*, were also collected. *Macrhybopsis gelida* were collected at 28 sites on the Powder River (n = 158) in Wyoming and Montana, and at one site on the Yellowstone River (n = 1) in Montana. Age-I, Age-II and Age-III *M. gelida* were collected. Specimens were 37 to 95 mm in total length. *Macrhybopsis gelida* were ripe in mid-June, at water temperatures of 18.3-22.2°C, and produced about 5,000 eggs. Sites where *M. gelida* were collected in the Powder River typically had flows > 0.35 m/sec and substrates with ≥ 40% gravel/rubble. Percent species composition of *M. gelida* at riffle sites on the Powder River declined from 28% in 1979-80 to about 3% in 1989-90. Morphometric characters of *M. gelida* were similar throughout the Powder River, except for head width, snout length and body depth. Counts of *M. gelida* anal, dorsal, pelvic and pectoral fin rays; lateral line scales; and scale rows above and below the lateral line were significantly ($P \leq 0.05$) different among three sections of the Powder River. No *M. gelida* x *M. aestivalis* hybrids were found. *Platygobio gracilis* (n = 8,889) and *R. cataractae* (n = 2,857) were more widely distributed and more abundant than *M. gelida* and distinct habitat associations were not identified. Morphometric characters of *P. gracilis* and *R. cataractae* with significant ($P \leq 0.05$) differences among rivers were: anal and dorsal fin base lengths; pelvic, pectoral and dorsal fin lengths; caudal peduncle depth; eye diameter; head length and width; snout length; and body depth. *Platygobio gracilis* and *R. cataractae* from the Little Missouri River in North and South Dakota had longer anal and dorsal fin bases; longer pelvic, pectoral and dorsal fins; longer heads and snouts; and deeper caudal peduncles than specimens from other streams in the Missouri River Basin. Meristic characters of *P. gracilis* and *R. cataractae* with significant ($P \leq 0.05$) differences among rivers were: anal, dorsal, pelvic and pectoral fin rays; lateral line scales; and scale rows above and below the lateral line. No subspecies of *P. gracilis* or *R. cataractae* were identified, however, *R. cataractae* showed the greatest tendency for subspeciation.

# INTRODUCTION

The sturgeon chub (*Macrhybopsis gelida*: Cyprinidae) is endemic to the Missouri and Lower Mississippi River drainages. First identified from the Milk River in Montana during the Pacific Railroad Surveys of 1853-1855 (Girard, 1856), *M. gelida* has been collected from nearly 200 sites. The majority of collections were made in North Dakota (Reigh and Owen, 1978), Montana (Elser et al., 1980), Wyoming (Stewart, 1981) and Missouri (Pflieger, pers. comm.). As early as 1978, it was recognized that *M. gelida* populations were declining (National Audubon Society, 1978). *Macrhybopsis gelida* (Fig. 1, A) is currently rare throughout much of its range and has been classified as a Category II species by the United States Department of the Interior, Fish and Wildlife Service (USFWS, 1989). This classification indicates that the species is likely threatened or endangered and that further studies of its status are recommended. The extent of subpopulation formation and hybridization in *M. gelida* is unknown and more definitive morphometric and meristic data could improve identification.

Swift currents and high turbidities characterize rivers inhabited by *M. gelida*. The sensory systems of *M. gelida* depict evolutionary responses to turbid conditions (Reno, 1969). Scales on the dorsal and lateral surfaces have unique, longitudinally-arranged epidermal keels, which may improve hydrodynamic efficiency and may also have a sensory

A



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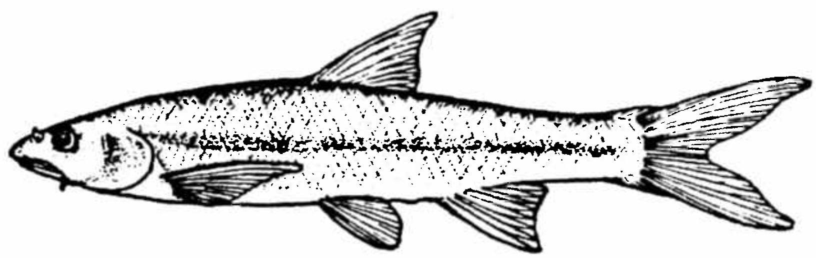

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Fig. 1. A - sturgeon chub (Macrhybopsis gelida), B - flathead chub (Platygobio gracilis), C - longnose dace (Rhinichthys cataractae). (From S. Eddy and J.C. Underhill. How to know the freshwater fishes, 3d ed. Pictured Key Nature Series. Copyright (c) 1978 Wm. C. Brown Communications, Inc., Dubuque, Iowa. All rights reserved. Reprinted by special permission.)

function (Cross, 1967). Exceptionally dense concentrations of sensory papillae are located on the ventral surface, fins and gular region (Branson, 1963, 1966). The head is depressed and a long, fleshy snout overhangs the subterminal mouth. The eyes are small and the optic lobes are reduced (Reno, 1969).

Published data exist on morphometric and meristic characters of M. gelida (Table 1), but few data are available on age-growth relationships, reproductive potential or habitat preferences (Stewart, 1981). In general, M. gelida are like other large-river species in that the number of specimens studied is not commensurate with their actual abundance within the river (Gilbert and Bailey, 1962).

An ecologically similar species, the flathead chub (Platygobio gracilis) (Fig. 1, B), may also be disappearing from portions of its range (Pflieger and Grace, 1987), while the range of the ecologically similar longnose dace (Rhinichthys cataractae) (Fig. 1, C) remains stable (Jordan and Evermann, 1896; Scott and Crossman, 1973). Both species have been collected in habitats occupied by M. gelida, and they were studied to investigate the possible effects of habitat changes on abundance and distribution of species similar to M. gelida. Comparison of morphometric and meristic variation within each species will assist taxonomists in making accurate species identifications,

TABLE 1. MERISTIC CHARACTERS OF *Macrhybopsis gelida* AS REPORTED IN THE LITERATURE.

| Reference | Lateral line scales | Pharyngeal teeth | Dorsal fin rays | Anal fin rays |
|---|---|---|---|---|
| Bailey (1951) | 40-43 | - | - | - |
| Baxter & Simon (1970) | 41-46 | 1,4-4,1 | 8 | 8 |
| Brown (1971) | 37-44 | 1,4-4,1 | - | 8 |
| Cross (1967)[ab] | 39-43 | 1,4-4,1 | 8 | 8 |
| Eddy & Underhill (1978) | 40-43 | 4-4 | - | - |
| Harlan & Speaker (1951) | 40-43 | - | - | - |
| Jordan & Gilbert (1882)[b] | 44 | - | 8 | 8 |
| Jordan & Evermann (1896)[b] | 44 | 4-4 | 8 | 9 |
| Robison & Buchanan (1988) | 39-43 | 1,4-4,1 | 8 | 8 |
| Schrenkeisen (1963) | 44 | 4-4 | 8 | 9 |
| Stewart (1981)[c] | 41-46 | 1,4-4,1 | 8 | 8 |

[a] Also reported pectoral and pelvic fin rays.
[b] Also reported some morphometric data.
[c] Also reported scale rows, pectoral and pelvic fin rays, and vertebrae.

basic to the recovery plans of rare fish. I report here the results of my survey to determine the distribution, abundance, habitat utilization, morphometrics and meristics of these three species in the Missouri River Basin.

## METHODS

Population status of M. gelida was determined by sampling sites where the species was historically collected in the Missouri River Basin (1,354,570 $km^2$) (Fig. 2). Additional sites were sampled to determine if M. gelida was more widespread than previously recorded. Collection sites were selected from capture sites reported in the literature and through personal communications with fishery biologists. Some authors reported exact site locations; others identified collection sites with simply a mark on a map. Consequently, some of my collection sites were approximated. Sites (n = 172) on 21 streams throughout the Missouri River Basin were visited during June and July, 1989, and from May through October, 1990. Each site was sampled once, except for four sites in Montana which were sampled once in 1989 and once in 1990. At each site, about 50 m were sampled using a seine (9.14 x 1.22 m; 6.35 mm bar measure mesh; 1.22 x 1.22 x 0.61 m bag).

Macrhybopsis gelida, P. gracilis and R. cataractae were fixed with a 10% formalin solution, but age and growth data were collected only for M. gelida. Scales were removed

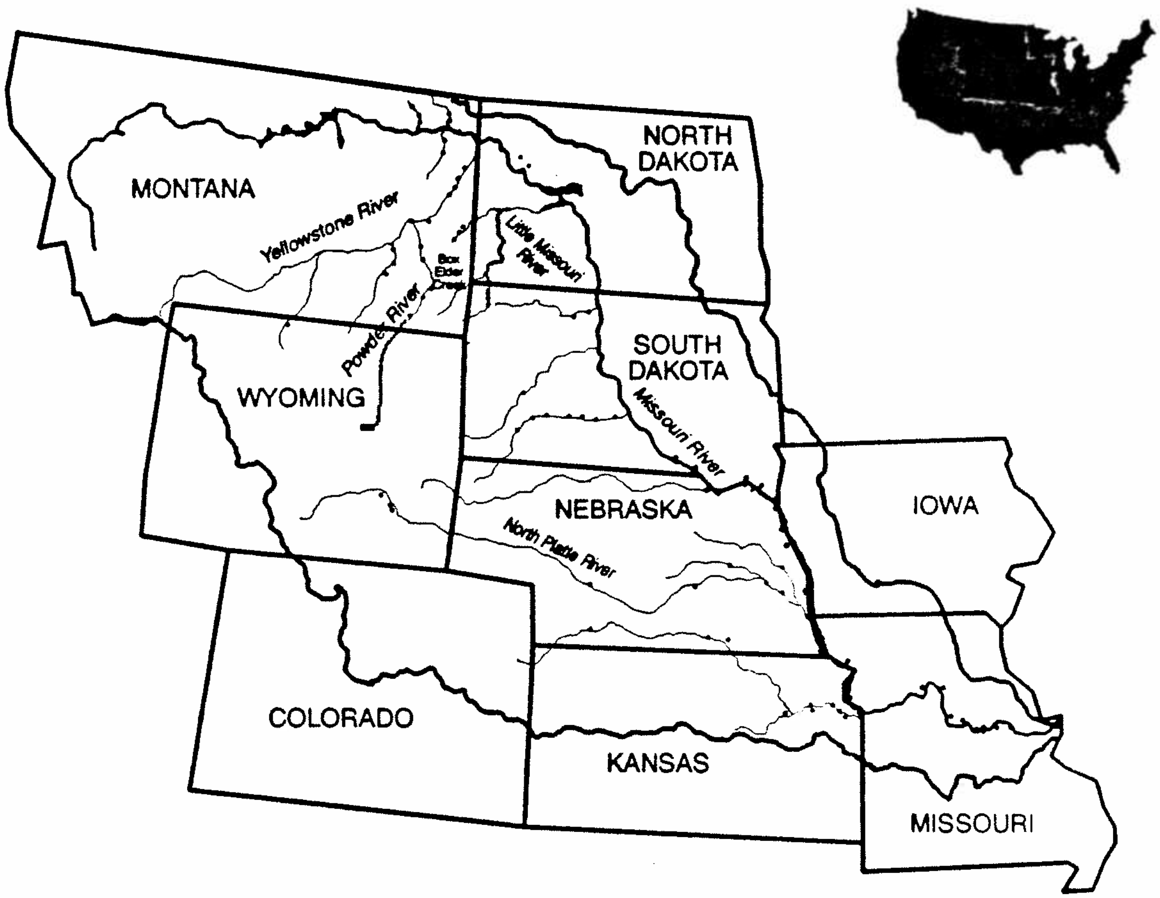



Fig. 2. Location of collection sites in the Missouri River Basin, 1989-1990. The Powder, Little Missouri and North Platte Rivers, and Box Elder Creek were streams where collections of Macrhybopsis gelida, Platygobio gracilis and Rhinichthys cataractae were large enough (> 8) for statistical analyses. (Sites overlapping due to map scale are represented by shaded areas).

from the left side, above the lateral line and anterior to the insertion of the dorsal fin. Scales were read twice and annuli measurements were made using a Ken-A-Vision microprojector (mag. 84x), digitizing pad and microcomputer. The DISBCAL program of Frie (1982) was used to calculate linear body-scale regressions, lengths-at-annuli and associated statistics. Scales of Age-I *M. gelida* often lacked distinct annuli and thus, scale edges were used in back-calculation of lengths-at-annuli.

Live *M. gelida* were considered ripe if light abdominal pressure expelled eggs or milt from the vent. A total egg count from one ripe *M. gelida* was made using a 0.7-3.0x dissecting microscope. Gonadosomatic indices [(gonad mass/body mass) x 100] were determined for three ripe female *M. gelida*. Ovaries and testes from ripe *M. gelida* (one of each sex) were sectioned and stained using standard histological techniques (Hinton, 1990). Sex was not determined for *P. gracilis*, *R. cataractae* and non-ripe *M. gelida*.

Data for 13 morphometric and seven meristic characters (Table 2) were collected from preserved specimens according to the methods of Strauss and Bond (1990). Rudimentary first fin rays were included in ray counts when present. The largest specimens collected at each site were used to reduce human error in meristic counts. Measurements were made to the nearest 0.05 mm using vernier calipers,

TABLE 2. MORPHOMETRIC AND MERISTIC CHARACTERS RECORDED FROM *Macrhybopsis gelida*, *Platygobio gracilis* AND *Rhinichthys cataractae*.[a]

| Morphometrics | Meristics |
|---|---|
| Anal fin base length | Anal fin rays |
| Dorsal fin base length | Dorsal fin rays |
| Pelvic fin length | Pelvic fin rays |
| Pectoral fin length | Pectoral fin rays |
| Dorsal fin length | Lateral line scales |
| Caudal peduncle depth | Scale rows above lateral line |
| Interorbital width | Scale rows below lateral line |
| Eye diameter | |
| Head length | |
| Head width | |
| Snout length | |
| Body depth | |

[a] Specimens are stored in the ichthyology collection at South Dakota State University, Brookings.

except standard length which was measured to the nearest 1 mm with a ruler.

*Macrhybopsis gelida* were found only in the Powder River (with one exception on the Yellowstone River), so possible changes in morphometric and meristic characters were investigated by partitioning the Powder River data into upstream, middle and downstream sections based on three major tributary confluences (Fig. 3). The upstream section extended from the mouth of Salt Creek, near the headwaters of the Powder River in Wyoming, to the mouth of Crazy Woman Creek. The middle section included sites from the mouth of Crazy Woman Creek to that of the Little Powder River. The downstream section reached from the mouth of the Little Powder River to the confluence of the Powder and Yellowstone Rivers in Montana.

Water temperature, velocity and substrate composition were determined at each site. Water temperature was measured with a hand-held mercury thermometer. Mean water velocity was measured at 0.6 of the depth (from the surface) (Hynes, 1970) using a Marsh-McBirney Portable Flowmeter, Model 201. From one to six velocity readings were taken per site, depending on site uniformity. Substrate classifications were based on the Wentworth particle-size scale modified by Cummins (1962).

The wide distribution and relative abundance of *P. gracilis* and *R. cataractae* allowed within species

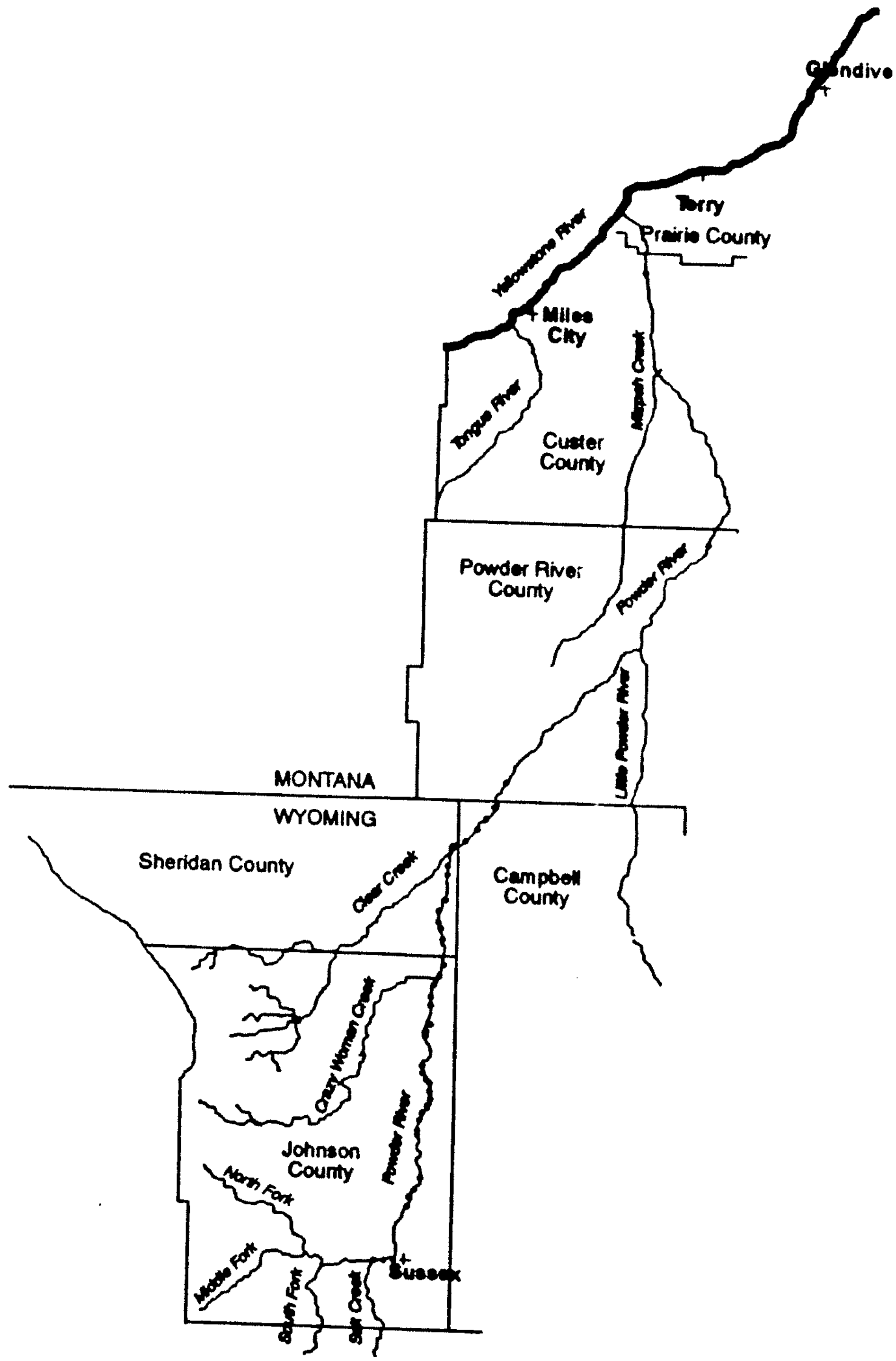



Fig. 3. Location of <u>Macrhybopsis gelida</u> collection sites on the Powder River in Wyoming and Montana, and the Yellowstone River in Montana, 1989-1990.

comparisons of morphometric and meristic characters among rivers. In analysis of each species, I eliminated sites where < 8 specimens were collected to prevent bias resulting from small sample sizes.

All statistical analyses were made using the Statistical Analysis System (SAS, 1985). Univariate (ANOVA) and multivariate (MANOVA) Least Squares General Linear Modeling were used to determine if there were differences in morphometric character means among river sections or among rivers. Standard length was used as the covariate in the analyses to eliminate the effect of specimen size differences (Atchley et al., 1976). Roy's Maximum Root was used to examine whether ANOVA or MANOVA was the best test procedure to determine differences among river sections and among rivers. Morphometric character measurements were also analyzed with stepwise discriminate analysis (STEPDISC) using continuous independent variables. STEPDISC analysis selected variables in the order of importance in discriminating among river sections or among rivers. The F-test ($P \leq 0.05$) was used for statistical significance. Differences in meristic counts among river sections and among rivers were determined with Chi-Square tests using count frequency data (Proc FREQ) and categorical data modeling (Proc CATMOD). Fischer's Protected Least Significant Difference was used to compare mean meristic counts among river sections and among rivers where significant differences occurred.

## RESULTS

Macrhybopsis gelida were collected at 28 sites on the Powder River in Wyoming and Montana, and at one site on the Yellowstone River in Montana. At these 29 sites, M. gelida (n = 159) represented from < 1.0% to 36.4% (mean 6.1%) of the total species composition. Total lengths ranged from 37 to 95 mm; mass ranged from 0.30 to 7.30 g. Total lengths were effective in differentiating most Age-I and Age-II M. gelida, but Age-II and Age-III fish lengths overlapped (Appendix A).

Three year-classes of M. gelida were evident from scale readings; 23.9% were Age-I, 72.3% were Age-II and 3.8% were Age-III (Table 3). Annual growth of Age-I M. gelida averaged 48.2 mm, while growth of Age-II and Age-III fish averaged 21 and 11 mm, respectively.

Ripe male (n = 2) and female (n = 4) M. gelida were collected from two sites on the Powder River in Wyoming in mid-June, 1990. Water temperatures at these sites were 18.3 and 22.2°C. Microscopic examination of histological preparations of the ovaries from a ripe female revealed previtellogenic, vitellogenic and mature oocytes (Crim and Glebe, 1990) (Appendix B-1). One ripe female contained 5,310 immature and mature oocytes and had a gonadosomatic index

TABLE 3. AVERAGE BACK-CALCULATED LENGTHS-AT-ANNULI (mm) OF *Macrhybopsis gelida* COLLECTED IN 1990.

| Year Class | Age | N | Back-calculated lengths-at-annuli 1 | 2 | 3 |
|---|---|---|---|---|---|
| 1989 | 1 | 33 | 41.8 | | |
| 1988 | 2 | 97 | 50.4 | 69.4 | |
| 1987 | 3 | 4 | 46.4 | 62.5 | 80.1 |
| All classes | | | 48.1 | 69.1 | 80.1 |
| | | N | 134 | 101 | 4 |

(GSI) of 15.6. Two other ripe females had GSI's of 15.4 and 20.7. Ripe female M. gelida had total lengths of 76, 80, 81 and 85 mm. The 85 mm specimen was Age-III, all others were Age-II. Histological analysis of testes from one ripe male revealed spermatocytes and spermatids, indicative of maturation (Crim and Glebe, 1990) (Appendix B-2). Ripe males were 78 and 79 mm in total length and were Age-II.

Platygobio gracilis and R. cataractae were more abundant and more widely distributed than M. gelida. Platygobio gracilis were present at 116 sites, including all 29 M. gelida collection sites; R. cataractae were present at 81 sites, including 27 of 29 M. gelida collection sites. Platygobio gracilis (n = 8,889) were collected from the Tongue, Powder, Yellowstone, Little Missouri, Poplar and Redwater Rivers in Montana; the Powder and Big Horn Rivers in Wyoming; the Little Missouri River and Box Elder Creek in North Dakota; the Little Missouri, White and Cheyenne Rivers in South Dakota; and the Niobrara and Platte Rivers in Nebraska. Rhinichthys cataractae (n = 2,857) were collected from the Tongue, Powder, Yellowstone, Little Missouri, Poplar and Redwater Rivers, and Beaver Creek in Montana; the Powder, Big Horn and North Platte Rivers in Wyoming; the Little Missouri and Little Knife Rivers, and Box Elder Creek in North Dakota; and the Little Missouri River in South Dakota. Other species (n = 39) were also collected (Appendix C).

Habitat characteristics were similar at sites where M. gelida, P. gracilis and R. cataractae were each present or absent (Table 4). However, grand mean water velocities were higher at sites where M. gelida and P. gracilis were present. For each species, substrate composition differed between sites where they were present or absent. Macrhybopsis gelida were more abundant at sites with $\geq$ 40% gravel/rubble substrate (Fig. 4) and were not collected at sites with > 10% clay substrate (Appendix D).

Morphometric and meristic character data were taken from 159 M. gelida, 1,080 P. gracilis and 401 R. cataractae. After eliminating sites where < 8 fish were collected, only data from populations in the Little Missouri, Powder and North Platte Rivers, and Box Elder Creek remained (Fig. 2). There was a linear relationship between standard length and each of the 12 morphometric characters measured for M. gelida ($R^2$ = 0.82-0.98), P. gracilis ($R^2$ = 0.83-0.96) and R. cataractae ($R^2$ = 0.75-0.94). Therefore, no data transformation was needed before statistical analysis.

Mean head width, snout length and body depth of M. gelida had significant ($P \leq 0.05$) differences among sections of the Powder River and each was greatest from the middle section (Table 5).

There were significant ($P \leq 0.05$) differences among rivers for all morphometric characters of P. gracilis and R. cataractae except interorbital width (Table 5). However,

TABLE 4. HABITAT CHARACTERISTICS AT SITES WHERE *Macrhybopsis gelida*, *Platygobio gracilis* and *Rhinichthys cataractae* WERE PRESENT OR ABSENT.

| Species: | *M. gelida* | | *P. gracilis* | | *R. cataractae* | |
|---|---|---|---|---|---|---|
| Occurrence: | Present | Absent | Present | Absent | Present | Absent |
| Number of Sites: | 29 | 143 | 116 | 56 | 81 | 91 |
| Water Velocity (m/sec): | | | | | | |
| Mean maximum | 0.85 | 0.90 | 0.90 | 0.82 | 0.82 | 0.90 |
| Mean minimum | 0.42 | 0.25 | 0.32 | 0.23 | 0.31 | 0.27 |
| Grand Mean | 0.52 | 0.37 | 0.44 | 0.34 | 0.42 | 0.39 |
| Water Temp. ($^{o}$C)[a] : | 11.7-25.5 | 9.0-35.0 | 9.0-30.0 | 11.0-35.0 | 11.7-30.0 | 9.0-35.0 |
| Substrate Composition (mean %)[b]: | | | | | | |
| Rubble | 35.9 | 10.7 | 22.8 | 5.4 | 29.0 | 6.0 |
| Gravel | 25.9 | 15.0 | 23.6 | 9.0 | 28.9 | 8.7 |
| Sand | 36.8 | 56.2 | 46.5 | 59.8 | 35.7 | 65.4 |
| Clay | 1.4 | 18.1 | 7.1 | 25.8 | 6.4 | 19.9 |

[a] Wide ranges reflect diel and seasonal temperature changes.
[b] Based on modified Wentworth System of particle-size distribution (Cummins, 1962).

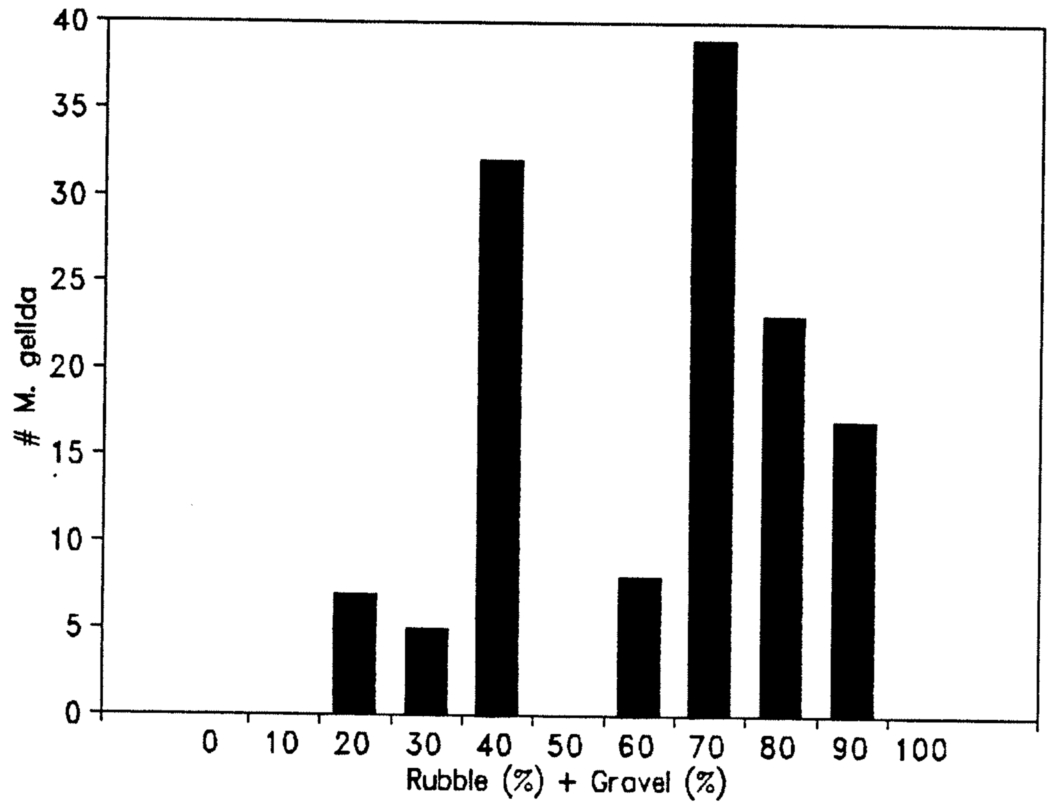



Fig. 4. Number of Macrhybopsis gelida collected based upon combined percent rubble and gravel substrate composition at selected sites on the Powder River in Wyoming and Montana, 1989-90.

TABLE 5. LEAST SQUARES MEANS* (mm) FOR 12 MORPHOMETRIC CHARACTERS OF *Macrhybopsis gelida* (A), *Platygobio gracilis* (B) and *Rhinichthys cataractae* (C).

| | | River/River Section** | | |
|---|---|---|---|---|
| Character | Species*** | 1 | 2 | 3 |
| Anal fin base length | A | 6.21[a] | 6.33[a] | 6.18[a] |
| | B | 5.65[a] | 6.76[b] | 6.60[c] |
| | C | 4.42[a] | 5.24[b] | 4.67[c] |
| Dorsal fin base length | A | 7.38[a] | 7.49[a] | 7.37[a] |
| | B | 7.06[a] | 8.02[b] | 7.86[b] |
| | C | 5.15[a] | 5.96[b] | 5.28[a] |
| Pelvic fin length | A | 8.24[a] | 8.22[a] | 8.24[a] |
| | B | 11.54[a] | 11.58[a] | 10.74[b] |
| | C | 7.08[a] | 7.86[b] | 7.56[c] |
| Pectoral fin length | A | 11.30[a] | 11.18[a] | 11.19[a] |
| | B | 16.90[a] | 16.91[a] | 15.79[b] |
| | C | 9.76[a] | 10.66[b] | 10.23[c] |
| Dorsal fin length | A | 11.66[a] | 11.58[a] | 11.66[a] |
| | B | 16.10[a] | 16.27[a] | 15.34[b] |
| | C | 9.49[a] | 10.81[b] | 10.28[c] |
| Caudal peduncle depth | A | 4.53[a] | 4.58[a] | 4.53[a] |
| | B | 7.10[ab] | 7.19[a] | 6.99[b] |
| | C | 5.25[ab] | 5.36[a] | 5.26[b] |
| Interorbital width | A | 3.92[a] | 3.95[a] | 3.95[a] |
| | B | 5.77[a] | 6.12[a] | 6.08[a] |
| | C | 3.00[a] | 2.98[a] | 2.93[a] |
| Eye diameter | A | 2.22[a] | 2.21[a] | 2.22[a] |
| | B | 3.54[ab] | 3.46[a] | 3.41[b] |
| | C | 2.18[a] | 2.24[b] | 2.22[ab] |
| Head length | A | 15.07[a] | 15.33[a] | 15.13[a] |
| | B | 17.76[a] | 18.62[b] | 17.50[a] |
| | C | 12.38[a] | 13.57[b] | 13.10[c] |

TABLE 5 (con't). LEAST SQUARES MEANS* (mm) FOR 12 MORPHOMETRIC CHARACTERS OF *Macrhybopsis gelida* (A), *Platygobio gracilis* (B) and *Rhinichthys cataractae* (C).

| Character | Species*** | River/River Section** 1 | 2 | 3 |
|---|---|---|---|---|
| Head width | A | $8.54^{a}$ | $8.99^{b}$ | $8.50^{a}$ |
| | B | $11.00^{ab}$ | $11.11^{a}$ | $11.29^{b}$ |
| | C | $7.76^{a}$ | $6.88^{b}$ | $7.23^{c}$ |
| Snout length | A | $6.10^{a}$ | $6.32^{b}$ | $6.16^{ab}$ |
| | B | $5.25^{ab}$ | $5.43^{a}$ | $5.05^{b}$ |
| | C | $4.01^{a}$ | $5.12^{b}$ | $4.83^{c}$ |
| Body depth | A | $10.57^{a}$ | $11.14^{b}$ | $10.70^{ab}$ |
| | B | $14.06^{ab}$ | $14.19^{a}$ | $14.66^{b}$ |
| | C | $9.77^{a}$ | $10.10^{b}$ | $9.88^{a}$ |

* Least squares means with the same superscripts are not significantly ($P \leq 0.05$) different.

** A1 = upstream, A2 = middle, A3 = downstream. B1 = Box Elder Creek, B2 = Little Missouri River, B3 = Powder River. C1 = North Platte River, C2 = Little Missouri River, C3 = Powder River.

*** Sample sizes: A1 = 87, A2 = 48, A3 = 23; B1 = 14-15, B2 = 226, B3 = 867-881; C1 = 28, C2 = 149, C3 = 168.

differences were typically small (< 0.5 mm). Specimens of P. gracilis from the Little Missouri River had greater mean anal and dorsal fin base lengths; pelvic, pectoral and dorsal fin lengths; caudal peduncle depth; interorbital width; head length and width; and snout length than specimens from other streams. Platygobio gracilis populations from the Little Missouri River and Box Elder Creek were morphometrically more similar to each other than to populations in the Powder River. Rhinichthys cataractae from the Little Missouri River had the largest mean anal and dorsal fin base lengths; pelvic, pectoral and dorsal fin lengths; caudal peduncle depth; eye diameter; head length; snout length; and body depth. Of these, anal and dorsal fin bases showed the greatest disparity in size among rivers.

I used stepwise discriminant analysis to select morphometric characters that explained differences among rivers for P. gracilis and R. cataractae (Table 6). No morphometric characters explained a significant ($P > 0.05$) amount of variation among river sections for M. gelida. For example, pelvic fin length, body depth, head length and width, and anal fin base length explained 22.8% of the variation among rivers for P. gracilis (Table 6). However, for R. cataractae, snout length, head width, dorsal and anal fin base lengths, and dorsal fin length explained 62.5% of the morphometric variability among rivers (Table 6).

TABLE 6. MORPHOMETRIC CHARACTERS EXPLAINING A SIGNIFICANT AMOUNT OF VARIATION AMONG *Platygobio gracilis* FROM BOX ELDER CREEK (ND), AND THE LITTLE MISSOURI (ND, SD) AND POWDER RIVERS (WY, MT), AND AMONG *Rhinichthys cataractae* FROM THE LITTLE MISSOURI, NORTH PLATTE (WY) AND POWDER RIVERS.

| Character | Probability[a] | Wilk's Lambda[b] |
|---|---|---|
| *P. gracilis* | | |
| Pelvic fin length | 0.0001 | 0.9576 |
| Body depth | 0.0001 | 0.8401 |
| Head length | 0.0001 | 0.8091 |
| Head width | 0.0001 | 0.7851 |
| Anal fin base length | 0.0001 | 0.7716 |
| *R. cataractae* | | |
| Snout length | 0.0001 | 0.9190 |
| Head width | 0.0001 | 0.6376 |
| Dorsal fin base length | 0.0001 | 0.4174 |
| Anal fin base length | 0.0001 | 0.3915 |
| Dorsal fin length | 0.0008 | 0.3753 |

[a] Probability of a greater F statistic.
[b] Wilk's Lambda shows which variables contribute the most to the discriminatory power of the STEPDISC model and is equal to (1 - partial $R^2$).

Meristic character count ranges of *M. gelida* (Table 7) overlapped among river sections, and count ranges for meristic characters of *P. gracilis* (Table 8) and *R. cataractae* (Table 9) overlapped among rivers. However, there were significant differences among river sections (SEC: $P \leq 0.0000$) for *M. gelida* and among rivers (RIV: $P \leq 0.0000$) for *P. gracilis* and *R. cataractae* in mean counts of anal, dorsal, pelvic and pectoral fin rays; lateral line scales; and scale rows above and below the lateral line. Mean counts of scale rows below the lateral line, lateral line scales and pectoral fin rays had the most variable mean counts for *M. gelida* and *P. gracilis*. In addition to these characters, *R. cataractae* also had highly variable mean counts of scale rows above the lateral line. No river section or river consistently had higher or lower mean counts for any species.

Within each species, meristic count data were pooled by character (i.e., anal fin rays of all *M. gelida*) and significant count differences for each character were detected using Chi-Square tests of count-frequencies. For example, there was a significant (CTS: $P \leq 0.0000$) difference in the number of *M. gelida* in the Powder River with either eight (n = 4), nine (n = 153) or ten (n = 1) anal fin rays (Table 7). In addition, *M. gelida* had significant (CTS: $P \leq 0.0000$) differences among counts for: dorsal, pelvic and pectoral fin rays; lateral line scales;

TABLE 7. MERISTIC CHARACTER COUNT MEANS AND RANGES FOR *Macrhybopsis gelida* COLLECTED FROM THE POWDER RIVER (WY,MT), AND SIGNIFICANCE LEVELS OF DIFFERENCES AMONG SECTIONS OF THE POWDER RIVER (SEC), AMONG COUNTS (CTS) AND RIVER SECTION-COUNT INTERACTIONS (INT).

| Character | River Section[a] | N | $\bar{X}$ | Range | Significance |
|---|---|---|---|---|---|
| Anal fin rays | 1 | 87 | 8.96 | 8-9 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 9.00 | 8-10 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 9.00 | 9 | INT $P = 0.4230$ |
| Dorsal fin rays | 1 | 87 | 9.01 | 9-10 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 8.96 | 8-9 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 9.04 | 9-10 | INT $P = 0.1318$ |
| Pelvic fin rays | 1 | 87 | 7.86 | 7-8 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 7.92 | 7-8 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 7.91 | 7-8 | INT $P = 0.5674$ |
| Pectoral fin rays | 1 | 87 | 10.64 | 8-13 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 10.17 | 9-13 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 11.30 | 10-13 | INT $P = 0.0006$ |
| Lateral line scales | 1 | 87 | 43.04 | 40-46 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 43.31 | 40-46 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 42.13 | 40-44 | INT $P = 0.0605$ |
| Scale rows above lateral line | 1 | 87 | 6.34 | 5-7 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 6.19 | 6-8 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 6.17 | 6-7 | INT $P = 0.7105$ |
| Scale rows below lateral line | 1 | 87 | 6.33 | 5-7 | SEC $P \leq 0.0000$ |
| | 2 | 48 | 4.81 | 5-7 | CTS $P \leq 0.0000$ |
| | 3 | 23 | 5.87 | 5-7 | INT $P = 0.0040$ |

[a] 1 = upstream, 2 = middle, 3 = downstream.

TABLE 8. MERISTIC CHARACTERS COUNT MEANS AND RANGES FOR *Platygobio gracilis* COLLECTED FROM BOX ELDER CREEK (ND) AND THE LITTLE MISSOURI (ND,SD) AND POWDER RIVERS (WY,MT), AND SIGNIFICANCE LEVELS OF DIFFERENCES AMONG RIVERS (RIV), AMONG COUNTS (CTS) AND RIVER-COUNT INTERACTIONS (INT).

| Character | River[a] | N | $\bar{X}$ | Range | Significance |
|---|---|---|---|---|---|
| Anal fin rays | 1 | 14 | 8.86 | 8-9 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 8.47 | 8-10 | CTS $P \leq 0.0000$ |
| | 3 | 881 | 8.64 | 7-10 | INT $P \leq 0.0000$ |
| Dorsal fin rays | 1 | 15 | 8.73 | 8-9 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 8.48 | 7-10 | CTS $P \leq 0.0000$ |
| | 3 | 879 | 8.73 | 7-10 | INT $P \leq 0.0000$ |
| Pelvic fin rays | 1 | 15 | 8.00 | 8 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 8.22 | 8-9 | CTS $P \leq 0.0000$ |
| | 3 | 877 | 7.99 | 7-9 | INT $P \leq 0.0000$ |
| Pectoral fin rays | 1 | 15 | 13.72 | 13-16 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 14.07 | 10-17 | CTS $P \leq 0.0000$ |
| | 3 | 877 | 12.49 | 7-18 | INT $P \leq 0.0000$ |
| Lateral line scales | 1 | 15 | 51.17 | 48-54 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 50.60 | 42-57 | CTS $P \leq 0.0000$ |
| | 3 | 869 | 50.68 | 42-57 | INT $P = 0.0474$ |
| Scale rows above lateral line | 1 | 15 | 6.87 | 6-8 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 7.02 | 5-8 | CTS $P \leq 0.0000$ |
| | 3 | 867 | 6.99 | 5-8 | INT $P = 0.8044$ |
| Scale rows below lateral line | 1 | 15 | 5.60 | 5-6 | RIV $P \leq 0.0000$ |
| | 2 | 226 | 6.03 | 5-7 | CTS $P \leq 0.0000$ |
| | 3 | 870 | 6.84 | 5-10 | INT $P \leq 0.0000$ |

[a] 1 = Box Elder Creek, 2 = Little Missouri River, 3 = Powder River.

TABLE 9. MERISTIC CHARACTER COUNT MEANS AND RANGES FOR *Rhinichthys cataractae* COLLECTED FROM THE LITTLE MISSOURI (ND,SD), NORTH PLATTE (WY) AND POWDER RIVERS (WY,MT), AND SIGNIFICANCE LEVELS OF DIFFERENCES AMONG RIVERS (RIV), AMONG COUNTS (CTS) AND RIVER-COUNT INTERACTIONS (INT).

| Character | River[a] | N | $\bar{X}$ | Range | Significance |
|---|---|---|---|---|---|
| Anal fin rays | 1 | 149 | 7.53 | 7-8 | RIV P ≤ 0.0000 |
| | 2 | 28 | 7.04 | 7-8 | CTS P = 0.0154 |
| | 3 | 166 | 7.32 | 7-8 | INT P ≤ 0.0000 |
| Dorsal fin rays | 1 | 148 | 8.15 | 8-9 | RIV P ≤ 0.0000 |
| | 2 | 28 | 8.11 | 8-9 | CTS P ≤ 0.0000 |
| | 3 | 168 | 8.39 | 8-9 | INT P = 0.0001 |
| Pelvic fin rays | 1 | 149 | 7.72 | 7-8 | RIV P ≤ 0.0000 |
| | 2 | 28 | 7.82 | 7-8 | CTS P ≤ 0.0000 |
| | 3 | 168 | 7.82 | 7-9 | INT P = 0.1443 |
| Pectoral fin rays | 1 | 149 | 11.38 | 8-14 | RIV P ≤ 0.0000 |
| | 2 | 28 | 9.50 | 8-11 | CTS P ≤ 0.0000 |
| | 3 | 167 | 10.15 | 7-15 | INT P ≤ 0.0000 |
| Lateral line scales | 1 | 149 | 61.21 | 54-69 | RIV P ≤ 0.0000 |
| | 2 | 28 | 62.14 | 50-70 | CTS P ≤ 0.0000 |
| | 3 | 164 | 59.77 | 50-71 | INT P = 0.0040 |
| Scale rows above lateral line | 1 | 149 | 10.28 | 10-13 | RIV P ≤ 0.0000 |
| | 2 | 28 | 11.4 | 10-12 | CTS P ≤ 0.0000 |
| | 3 | 160 | 10.60 | 9-13 | INT P ≤ 0.0000 |
| Scale rows below lateral line | 1 | 149 | 11.89 | 10-14 | RIV P ≤ 0.0000 |
| | 2 | 28 | 12.11 | 10-14 | CTS P ≤ 0.0000 |
| | 3 | 159 | 10.22 | 8-15 | INT P ≤ 0.0000 |

[a] 1 = Little Missouri River, 2 = North Platte River, 3 = Powder River.

and scale rows above and below the lateral line. *Platygobio gracilis* (Table 8) and *R. cataractae* (Table 9) had significant (CTS: P ≤ 0.0000) differences among counts for these same seven meristic characters.

Meristic characters with significant interaction between river sections (or rivers) and counts had different count-frequency distributions for the river sections (or rivers). For example, scale rows below the lateral line of *M. gelida* had significant (INT: P = 0.004) interaction between river sections and counts. Scale rows below the lateral line ranged from five to seven in each section, however, there were not equal proportions of *M. gelida* with each row count (5, 6 or 7) within the sections (Table 10). *Macrhybopsis gelida* also had significant (INT: P = 0.0006) interaction between river sections and counts for pectoral fin rays, while *P. gracilis* (INT: P ≤ 0.0000 to P = 0.0474) and *R. cataractae* (INT: P ≤ 0.0000 to P = 0.004) had significant interactions between rivers and counts for all meristic characters, except scale rows above the lateral line for *P. gracilis* and pelvic fin rays for *R. cataractae*.

## DISCUSSION

### *Hybopsis gelida*

#### Distribution, Abundance and Habitat

*Macrhybopsis gelida* appears to have undergone substantial range reduction; I found them only in the Powder

TABLE 10. NUMBERS OF *Macrhybopsis gelida* COLLECTED FROM THE POWDER RIVER, BY RIVER SECTION, AND COUNT OF SCALE ROWS BELOW THE LATERAL LINE.

| Scale row count | River section | N |
|---|---|---|
| 5 | Upstream | 4 |
| | Middle | 4 |
| | Downstream | 4 |
| 6 | Upstream | 69 |
| | Middle | 27 |
| | Downstream | 18 |
| 7 | Upstream | 14 |
| | Middle | 17 |
| | Downstream | 1 |

and Yellowstone Rivers. Other recent M. gelida collection sites include: the Platte River in Nebraska during 1987 (n = 1) (Peters et al., 1989), the Missouri River in Nebraska during 1988 (n = 1) (Hesse, pers. comm.), and two sites on the Missouri River in Missouri during 1990 (n = 40) (Etnier, pers. comm.). Data are limited on numbers collected at historic sites, but do indicate previous localized abundance of M. gelida (Table 11).

Macrhybopsis gelida abundance in the Powder River has declined from levels of a decade ago. Percent species composition of M. gelida was approximately 2% at sites in Wyoming during 1990, a decline from 5% in 1979-80 (Table 12) (Stewart, 1981). Percent species composition for M. gelida in 1979-80 was much higher in riffle habitat (28%) than in mixed riffle/non-riffle habitat (5%) (Stewart, 1981). In 1989-90, M. gelida comprised about 3% of the species composition at sites in Wyoming and Montana that were approximately 90% gravel/rubble riffles (Table 12). Their reduced abundance within riffles indicates that factors in addition to availability of riffle habitat may be limiting the abundance of M. gelida in the Powder River.

The substrate at Stewart's (1981) Powder River sites had changed somewhat between 1979-80 and 1990. In 1990, 73% had gravel/rubble riffles, 24% had sand substrate and 3% had clay substrate. Decreases in the amount of gravel and rubble substrate at historic collection sites caused by

TABLE 11. NUMBER OF *Macrhybopsis gelida* HISTORICALLY COLLECTED AT SELECTED SITES RESAMPLED IN 1990.[a]

| Year | Number Collected | Reference |
|---|---|---|
| 1926 | 4 | Hankinson (1929) |
| 1931 | 3 | Bailey and Allum (1962) |
| 1934 | 10 | Bailey and Allum (1962) |
| 1940 | 54 | Bailey and Allum (1962) |
| 1945 | 1 | Fisher (1962) |
| 1945 | 1 | Fisher (1962) |
| 1950-51 | 13 | Bailey and Allum (1962) |
| 1951-52 | 42 | Cross (1953) |
| 1952 | 12 | Bailey and Allum (1962) |
| 1952 | 24 | Bailey and Allum (1962) |
| 1952 | 15 | Bailey and Allum (1962) |
| 1964 | 3 | Metcalf (1966) |
| 1974-83 | 55 | Pflieger (pers. comm.) |
| 1987 | 1 | Peters et al. (1989) |
| 1988 | 1 | Hesse (pers. comm.) |

[a] No *M. gelida* were collected at these sites in 1990.

TABLE 12. PERCENT SPECIES COMPOSITION OF *Macrhybopsis gelida* IN RIFFLE AND MIXED RIFFLE/NON-RIFFLE HABITAT ON THE POWDER RIVER IN WYOMING AND MONTANA.

| | | Habitat Type | | |
|---|---|---|---|---|
| Year | State | Riffle | Mixed | Reference |
| 1975 | MT | - | 1.7-8.6% | Rehwinkel (1978) |
| 1979-80 | WY | 28% | 5% | Stewart (1981) |
| 1979 | WY | - | 1.3-2.0% | Wichers (1980) |
| 1990 | WY | 3.04%[a] | 1.95%[b] | [c] |
| 1989 | MT | 1.21% | - | [c] |
| 1990[d] | MT | 2.49% | - | [c] |

[a] Data for five sites with ≥ 90% gravel and/or rubble riffle habitat.
[b] 73% of sites had riffles.
[c] Data collected in this study.
[d] Includes data for two 1989 sites resampled in 1990.

sedimentation may be responsible for the reduced relative abundance of *M. gelida* in 1990. Also, gravel/rubble riffle formation in other locations may have shifted some *M. gelida* away from historic sites. My subjective observations were that *M. gelida* preferred water velocity > 0.35 m/sec and a predominant gravel/rubble substrate. Reigh and Elsen (1979) reported that 93% of their *M. gelida* collection sites had rock and gravel substrates. Bailey and Allum (1962) attributed the patchy distribution of *M. gelida* to the predominance of sand substrate in much of its range. Gravel/rubble substrates may be associated with suitable flows, cover, spawning and/or preferred food items.

The Powder River remains in a natural state (except for minor irrigation withdrawals), with turbidity > 500 JTU and total dissolved solids averaging > 1300 mg/l (Smith and Hubert, 1989). If *M. gelida* populations are dependent on gravel/rubble riffles, high flows are necessary to keep riffles sediment-free. Also, reduced turbidity due to low flows would increase visibility and could increase predation on adult and juvenile *M. gelida* (Cerri, 1983; Vandenbyllaardt et al., 1991).

Reproduction, Age and Growth

Reproduction of *M. gelida* in 1990 was likely because ripe fish of both sexes were present. *Macrhybopsis gelida* have reproduced successfully in the Powder River for three consecutive years (1987-89), despite drought in the Great

Plains region. Decreased annual growth rates indicated that M. gelida mature at Age-II (Wooton et al., 1980). The majority (76.1%) of M. gelida collected were Age-II or Age-III, but few were ripe (six of 159). I believe this was related to the time of sampling (late May to mid-June). Ripe and non-ripe M. gelida were most abundant (n = 30) in a narrow (4.6 m-wide) Powder River side-channel. I speculate that they were staging prior to spawning and that the side-channel may have provided more suitable water depth, velocity and/or substrate (20% gravel, 50% rubble, 30% sand) than the main channel (> 90% sand).

In mid-June, ripe M. gelida contained immature and mature eggs, suggesting that the entire egg mass may not be deposited at once. Stewart (1981) collected gravid females as late as July 26, while females collected in November, 1979 had apparently spawned (Wichers, 1980).

Macrhybopsis gelida collected in 1990 were similar in total length (mean 69.3 mm) and mass (mean 2.88 g) to those collected by Stewart (1981) (means 69.0 mm, 2.66 g). The heavier (0.2 g) average mass of my specimens may reflect gonadal development. Stewart (1981) collected during summer and early fall and probably collected post-spawning fish. Wichers (1980) collected M. gelida during November with average masses < 1.0 g. Despite their reduced abundance in 1989-90, M. gelida had attained sizes similar to M. gelida collected in 1979-80.

### Hybridization

Based on morphometric and meristic characters of collected fish, I found no evidence of hybridization in *M. gelida*. Johnson (1942) and Morris et al. (1974) reported hybridization of *M. gelida* with speckled chub, *M. aestivalis* in Nebraska. I collected five *M. aestivalis* at sites in Nebraska and Missouri where *M. gelida* were absent. However, these species were collected together in 1990 in Missouri (Etnier, pers. comm.), and *M. aestivalis* greatly outnumbered *M. gelida* at one location. Hybridization increases when rare species and abundant species live in close proximity (Hubbs et al., 1943). The range of *M. aestivalis* does not include the Powder and Yellowstone Rivers (Pflieger, 1975). Thus, the possibility of *M. gelida* hybridizing with this species is low over much of its present range.

## *Platygobio gracilis*

### Distribution, Abundance and Habitat

Distribution and abundance of *P. gracilis* were both reduced compared to historic records. All *P. gracilis* collected in 1989-90 were from Missouri River tributaries. In 1945, on the Missouri River in Missouri, *P. gracilis* comprised 30% of seine collections (Berner, 1951). Pflieger and Grace (1987) associated the decline in abundance of *P. gracilis* on the Lower Missouri River from 1940 to 1983 with the construction of dikes, revetments, levees and upstream reservoirs. Man-made structures changed the Lower Missouri River from a turbid, meandering stream with a seasonal flow regime, into a uniform, channelized stream with flows controlled for navigation, and reduced turbidity. In contrast, the Little Missouri River is essentially unmodified (except for minor irrigation withdrawals and downstream inundation by Lake Sakakawea) and P. gracilis remain abundant and widespread, as they were in 1950 (Personius and Eddy, 1955) and 1976 (Bich and Scalet, 1977).

Platygobio gracilis utilized habitat similar to that utilized by M. gelida, and I typically collected them in the higher velocity regions of a site. Olund and Cross (1961) reported that P. gracilis have an extreme tolerance to silt and prefer sand substrate in alkaline streams which are subject to extreme changes. Their continued existence in the absence of M. gelida, at some historic collection sites, is likely due in part to the greater historic abundance of P. gracilis. Also, the eyes (and optic lobes) of P. gracilis are larger than those of M. gelida, which make it an effective sight-feeder (Davis and Miller, 1967). Both species have well-developed chemical sensitivity to detect and secure food items without resorting to vision. However, in streams varying from clear to extremely turbid, the ability to utilize both senses gives P. gracilis an edge over M. gelida, which must predominantly rely on a single method (Davis and Miller, 1967).

Rhinichthys cataractae

Distribution, Abundance and Habitat

Rhinichthys cataractae were abundant in Upper Missouri River Basin tributaries and their distribution was similar to historic records (Scott and Crossman, 1973). Although collected often in other habitats, they were most abundant in gravel riffles. Rhinichthys cataractae and M. gelida occupy a similar niche in riffles and may compete for resources (Stewart, 1981). Certain aspects of R. cataractae biology may contribute to their greater abundance and wider distribution compared to M. gelida. Rhinichthys cataractae spawn over sand and/or gravel (Harlan and Speaker, 1951) and thus, may better tolerate loss of gravel and rubble substrate. Also, R. cataractae may live five years (Kuehn, 1949) and thus, survive longer during unsuitable spawning periods. Macrhybopsis gelida may tolerate higher turbidities and higher flows due to their unique anatomical features (i.e., sensory papillae and epidermal keels) and compete successfully with R. cataractae under those conditions.

Morphometric Characters

Macrhybopsis gelida were morphometrically similar throughout the Powder River, except for mean head width, snout length and body depth, which were larger for fish in the middle section. All six ripe M. gelida were collected in the middle section, and gonadal development likely influenced mean body depth. The measured habitat variables were similar throughout the Powder River and thus, cannot account for significant differences in mean head width or snout length. These were likely statistical differences with no apparent biological significance.

The greater mean anal and dorsal fin base lengths; dorsal fin length; caudal peduncle depth; head depth; and snout length of P. gracilis from the Little Missouri River (Table 5) may be adaptations to local environmental conditions, but not representative of a distinct subpopulation. Platygobio gracilis from the Little Missouri River and Box Elder Creek were geographically isolated from the Powder River, but each river had similar turbidity, substrate and flows [except Box Elder Creek which had lower flows ($\leq$ 0.03 mps)] (Reigh and Owen, 1978; Gerhardt and Hubert, 1991). Morphological divergence results from geographic isolation and environmental diversity (Williams and Wilde, 1981) and morphometric characters of P. gracilis explained only 22.8% of the variability among the three rivers.

Rhinichthys cataractae showed the greatest tendency for subpopulation formation of the species examined. Populations were geographically separated, thus the likelihood of genetic mixing was low. Rhinichthys cataractae from the North Platte River had much longer snouts and wider heads than Little Missouri and Powder River fish and these were the most important differentiating characters in the STEPDISC analysis. Rhinichthys cataractae from the North Platte River likely belong to a different subspecies (R. c. dulcis) than those in the Upper Missouri River Basin (R. c. ocella) (Baxter and Simon, 1970).

Dorsal and anal fin base lengths and dorsal fin lengths of R. cataractae from the Little Missouri River were much larger than in the other rivers. Larger fins increase maneuverability (Felley, 1984), and increased fin lengths of wild salmon are associated with higher flows in natal streams (Riddell et al., 1981). Rhinichthys cataractae exhibit sexual dimorphism of fin size (Becker, 1962), which could have biased mean fin lengths if sex ratios were unequal.

Rhinichthys cataractae were collected from the Little Missouri River in August and had a greater (0.22 mm) mean body depth than Powder (May-June) and North Platte (May) River specimens. Rhinichthys cataractae spawn from April to early July (Harlan and Speaker, 1951; Scott and Crossman, 1973) and rapidly accumulate fat around the viscera after spawning (Becker, 1962). Thus, Little Missouri River specimens may reflect post-spawning fat accumulation.

## Meristic Characters

Meristic character count ranges of M. gelida (Table 7) were consistent with published data (Table 1), but mean counts were significantly (CTS: $P \leq 0.0000$) different among sections of the Powder River. Pectoral fin rays, lateral line scales and scale rows below the lateral line were the most variable and illustrate the value of site-specific meristic data for accurate species identifications.

Olund and Cross (1961) recognized two subspecies of P. gracilis based on morphometrics and meristics: P. g. gracilis, found in large northern and eastern rivers of the Missouri River Basin, and P. g. gulonella, typical of smaller streams to the south and west. The subspecies can be separated using lateral line scales, pectoral fin rays, post-Weberian vertebrae and head depth, except in areas of intergradation (Olund and Cross, 1961). I counted lateral line scales and pectoral fin rays, but could not differentiate P. gracilis from Box Elder Creek, and the Little Missouri and Powder Rivers to subspecies. Also, meristic characters showed no trends among the rivers.

Rhinichthys cataractae I collected from the North Platte River exhibited meristic count ranges comparable to those in the other rivers. However, mean counts of scale rows above and below the lateral line, and lateral line scales were largest in the North Platte River specimens. These differences may be associated with subspeciation (Baxter and Simon, 1970).

Meristic characters develop during a series of "sensitive" stages in embryonic development and colder water temperatures of more northern latitudes typically increase numbers of meristic character elements (i.e., vertebrae, scales, pyloric caecae, gill rakers and fin rays) (Fowler, 1970; Garside, 1970; Angus and Schultz, 1983). The number of meristic character elements is not related to size, age or nutrition (Fowler, 1970; Angus and Schultz, 1983), and the advantages or disadvantages of additional meristic character elements are unknown. One may speculate on the survival advantage of morphometric changes (i.e., they are adaptive), but changes in meristics are not related to survival, just temperature.

## SUMMARY AND CONCLUSIONS

The range of *M. gelida* appears reduced from historic records. Specimens were collected only in the Powder and Yellowstone Rivers in 1989-90. Correspondingly, *M. gelida* appear to have declined in abundance over much of their range, and specifically in the Powder River from 1979-80 to 1990. However, the species is surviving in low numbers elsewhere in its range.

Gravel/rubble riffles are the predominant habitat utilized by adult *M. gelida* in the Powder River. Morphological and sensory adaptations of the species indicate that turbidity is also a vital habitat component. Loss of velocity, turbidity and gravel/rubble substrate in the Powder River could have detrimental effects on the *M.*

gelida population. My habitat utilization data should be useful for directing further sampling efforts, delineating critical habitat areas and developing hatchery culture techniques. Reproduction and growth data gathered from Powder River specimens will also aid propagation efforts.

Although no hybrids were found, M. gelida may be threatened by hybridization with M. aestivalis where M. gelida population levels are low. Further research is needed to determine the extent of hybridization. Accurate identification of rare species is essential for management and recovery, and my data on morphometric and meristic variation should be useful in identifying hybrids.

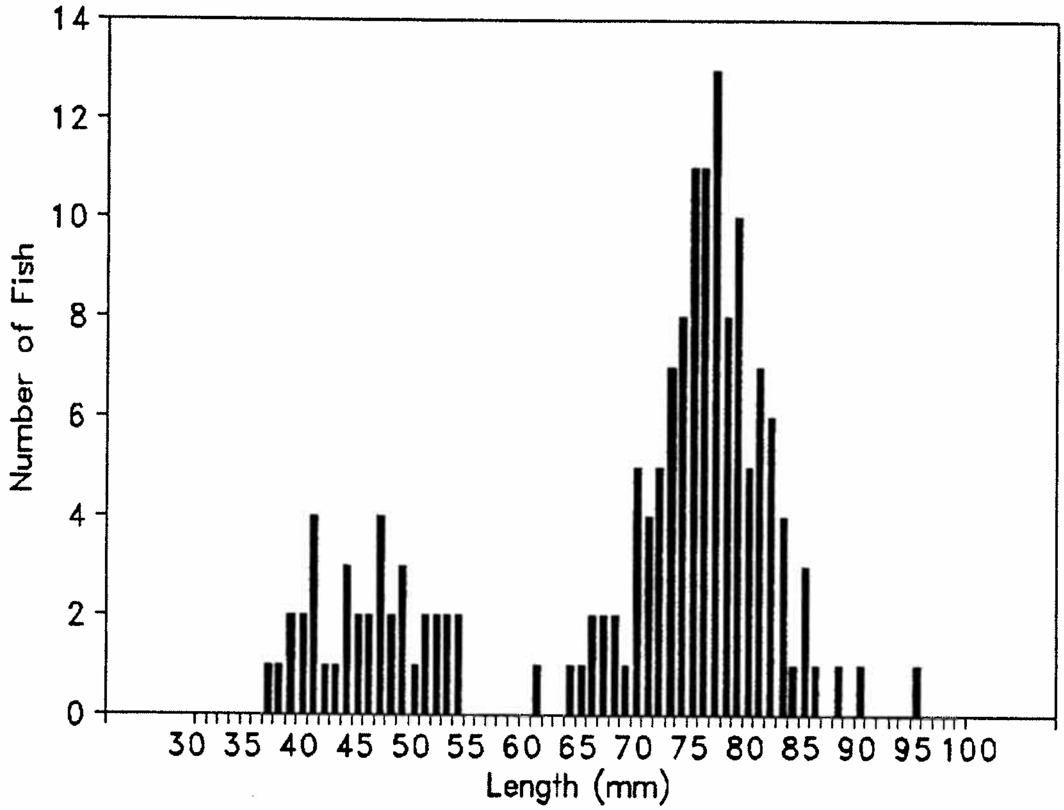
Some morphometric character differences among river sections for M. gelida, and among rivers for P. gracilis and R. cataractae, had biological significance (i.e., body depth and fin lengths); others were perhaps associated with geographic isolation and environmental diversity. Subspeciation was reported for P. gracilis (Olund and Cross, 1961) and R. cataractae (Baxter and Simon, 1970), but was not found for either species. Rhinichthys cataractae was closest to exhibiting subpopulation formation (62.5% explained morphometric variation).

Meristic characters of M. gelida, P. gracilis and R. cataractae showed more significant differences among river sections and among rivers than did morphometric characters, and were likely influenced by temperature during embryonic development. No species exhibited latitudinal meristic clines, perhaps because of little latitudinal change among river sections and among rivers.

*Platygobio gracilis* distribution was reduced from historic records. Abundance decreased in the Lower Missouri River Basin, but remained high in upstream Missouri River tributaries. The population status of this species warrants future observation.

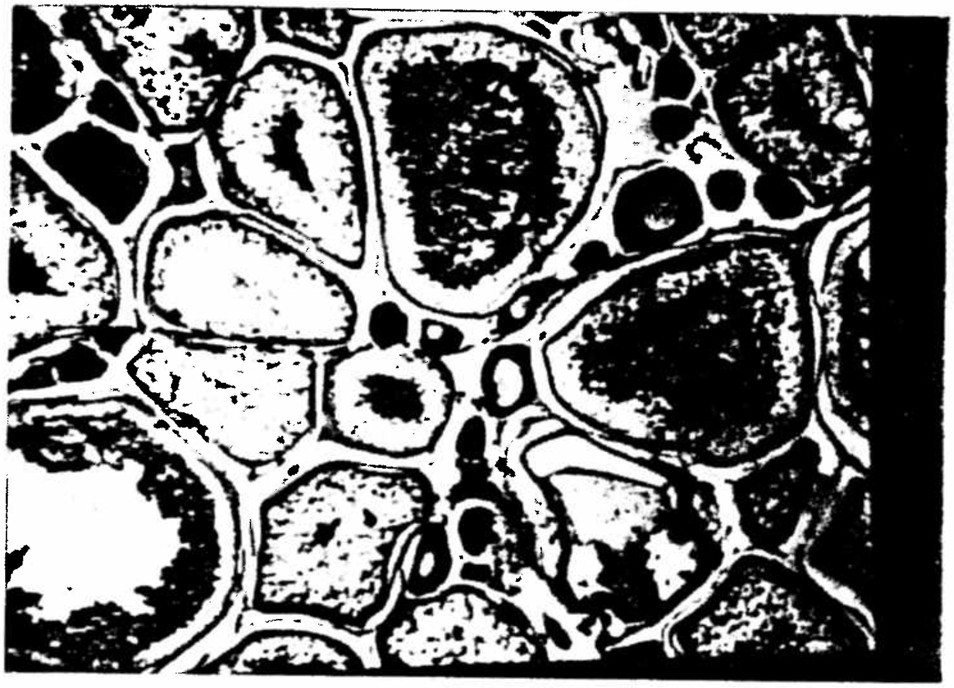
The Powder River supports a viable, reproducing *M. gelida* population. However, distribution and abundance data gathered in 1989-90 indicate that threatened status is likely warranted for *M. gelida* throughout the Missouri River Basin. Further research on *M. gelida* population status is needed in the Lower Missouri and Mississippi Rivers.

# APPENDICES

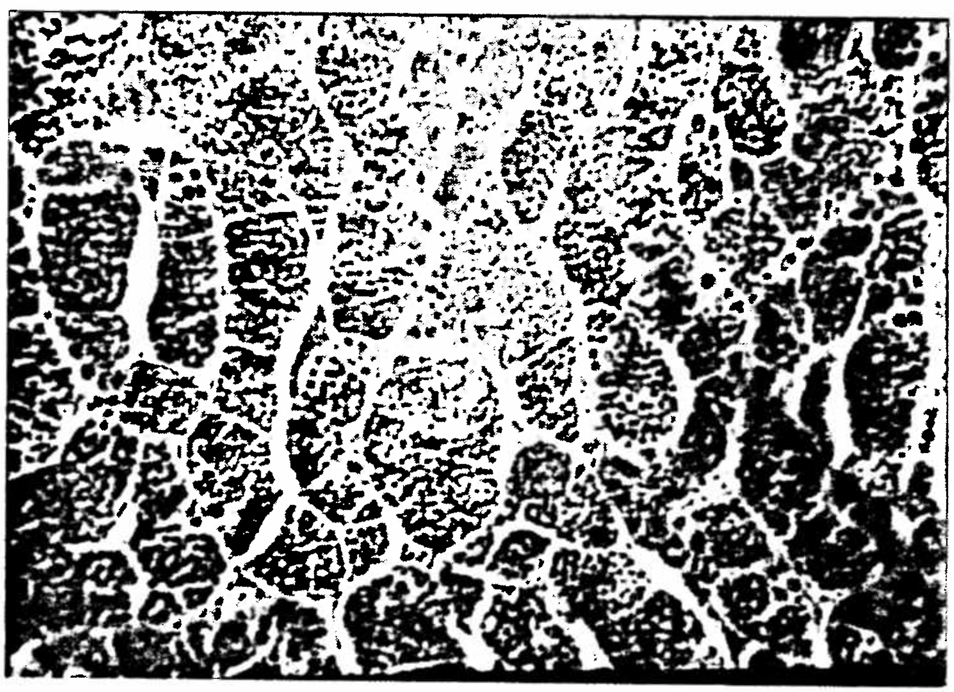



Appendix A. Length frequency diagram of *Macrhybopsis gelida* collected from the Powder River, Wyoming and Montana, and the Yellowstone River, Montana, 1989-1990.

1



2

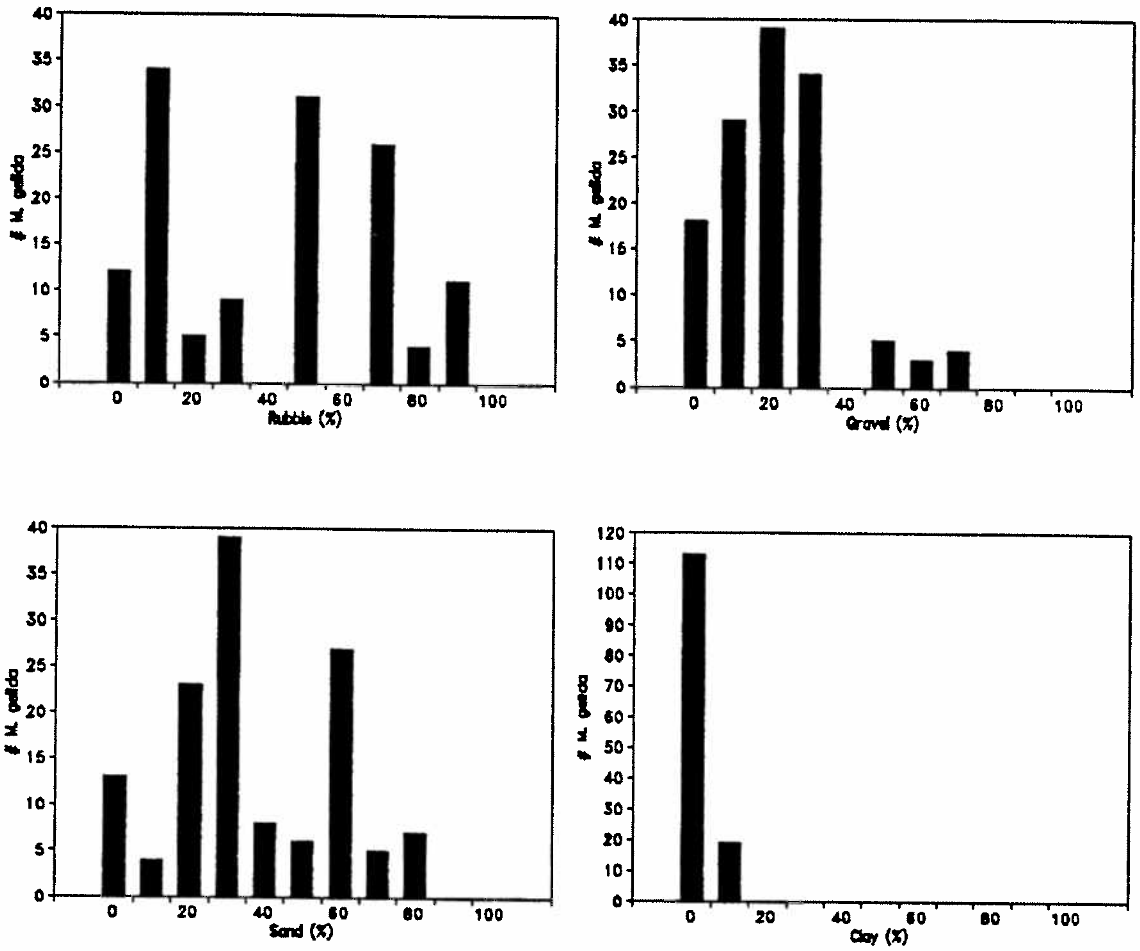


Appendix B. Longitudinally-sectioned Macrhybopsis gelida gonadal tissue. 1 - Previtellogenic, vitellogenic and mature oocytes; 2 - Spermatocytes and spermatids.

Appendix C. List of species collected in 1989-90 and the number of streams where they were found.

| Species | Streams |
|---|---|
| Ameiurus melas | 4 |
| Aplodinotus grunniens | 3 |
| Carpoides carpio | 14 |
| Catostomus commersoni | 11 |
| Culea inconstans | 1 |
| Cyprinella lutrensis | 9 |
| Cyprinus carpio | 14 |
| Dorosoma cepedianum | 1 |
| Esox lucius | 3 |
| Etheostoma exile | 2 |
| Etheostoma nigrum | 3 |
| Fundulus zebrinus | 5 |
| Hiodon alosoides | 6 |
| Hybognathus placitus/Hybognathus nuchalis [a] | 14 |
| Ictalurus punctatus | 10 |
| Ictiobus cyprinellus | 2 |
| Lepisosteus platostomus | 1 |
| Lepomis cyanellus | 5 |
| Lepomis macrochirus | 3 |
| Lota lota | 1 |
| Macrhybopsis aestivalis | 2 |
| Macrhybopsis gelida | 2 |
| Micropterus dolomieu | 1 |
| Micropterus punctulatus | 1 |
| Micropterus salmoides | 2 |
| Morone chrysops | 2 |
| Notropis atherinoides | 11 |
| Notropis blennius | 4 |
| Notropis dorsalis | 1 |
| Notropis hudsonius | 1 |
| Notropis stramineus | 17 |
| Noturus flavus | 5 |
| Osmerus mordax | 1 |
| Phenacobius mirabilis | 2 |
| Pimephales promelas | 16 |
| Platygobio gracilis | 12 |
| Pomoxis annularis | 3 |
| Rhinichthys cataractae | 11 |
| Salmo trutta | 1 |
| Semotilus atromaculatus | 5 |
| Stizostedion canadense | 2 |
| Stizostedion vitreum | 3 |

[a] Hybognathus placitus and Hybognathus nuchalis were not differentiated.




Appendix D. Number of Macrhybopsis gelida collected by percent substrate composition at selected sites on the Powder River in Wyoming and Montana, 1989-90.

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