Illustration of Mountain Whitefish Larvae and Early Juveniles

Final Report

Prepared for

Aquatic Wildlife Research Group
Colorado Division of Parks and Wildlife
Fort Collins Research Center
317 West Prospect Street
Fort Collins, Colorado 80526

via

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15 August 2011

by

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Larval Fish Laboratory
Contribution
167

Colorado State University
Knowledge to Go Places

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Project Duration:

29 March 2010 through 30 June 2011.

Background:

Successful research on, and monitoring of, fish reproduction and early life history often depends on accurate identification of their collected larvae and early juveniles. Collections of these early life stages can help define spawning grounds, seasons, and requirements, as well as assess larval and juvenile fish production, survival, transport, migration, habitat use, and susceptibility to entrainment in water diversions and other impacts. Furthermore, knowledge of the morphological ontogeny of fish can be correlated with and is often useful in understanding other aspects of its early life history–physiology, ecology, behavior, and environmental effects.

Fortunately, mountain whitefish (*Prosopium williamsoni*) is the only representative of subfamily Coregoninae among 11 species of Salmonidae present in Colorado and its larvae and early juveniles are sufficiently distinct that their identification in Colorado waters should not be a problem. Of Colorado's salmonids, only the mountain whitefish and cutthroat trout (*Oncorhynchus clarkii*) are native to the state. Within Colorado, mountain whitefish are native to the Yampa, White, and Green River drainages and have been introduced to upper reaches of the Colorado and Cache la Poudre River drainages. Populations have declined in the Yampa River drainage during the past two decades (Brinkman and Crockett 2009, Schisler 2010), prompting the establishment of a Mountain Whitefish Work Group within the Aquatic Wildlife Research Group of the Colorado Division of Wildlife (CDOW; now Parks and Wildlife) and related investigations including the monitoring of populations, improvement of culture

techniques, and assessment of early life stage vulnerability to metals (Brinkman and Vieira 2008), temperature (Brinkman and Crockett 2009), and whirling disease (Schisler 2010).

The embryonic development of mountain whitefish has been moderately well described and illustrated. Brown (1952) briefly chronicled embryology based on a series of egg collections from the Gallatin River, Montana. Rajagopal (1975, 1979) provided a much more detailed description, illustrated with a series of 12 photographs, and concluded that mountain whitefish development is similar to that of other whitefishes. Schisler (2010) also contributed a series of six photographs of embryonic stages and noted that although days to hatch are somewhat similar relative to incubation temperature, mountain whitefish embryos are notably smaller and develop eyes much earlier than rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Water-hardened egg diameters were reported to range from 3.1-4.2 mm (mean of 3.7) by Brown (1952) and 3.1-3.2 mm by Rajagopal (1975, 1979) and average 3.1 mm by Thompson and Davies (1976) who also noted that they were non-adhesive. Incubation periods were reported to range from 210 days at 0°C to 36 days at 11°C by Brown (1952), McAfee (1966), Stalnaker and Gresswell (1974), Rajagopal (1975, 1979), Thompson and Davies (1976), and Brinkman and Crockett (2009). However, Rajagopal (1975, 1979) suggested that 6°C was optimal for embryonic development and he, Brinkman and Crockett (2009), and Schisler (2010) found that mortality and frequency of abnormalities increased dramatically at temperatures greater than of 8°C.

In contrast to the embryos, morphological development of the larvae and early juveniles has been barely described and inadequately illustrated. Brown (1952) reported a mean TL of 11.7 mm and Rajogopal (1975, 1979) a range of 13-14 mm TL upon hatching . Thompson and Davies (1976) documented mean TLs of 12.3 mm upon hatching, 13.3 mm a week later, and 14.3 mm upon yolk sac absorption. Stalnaker and Gresswell (1974) reported that feeding at began at 14-15 mm TL, before the yolk sac was completely absorbed, but also noted that mouth parts were completely formed upon hatching and that larvae would immediately begin feeding if food was available. They and Brinkman and Crockett (2009) found that growth following yolk absorption increased with temperature, at least up to 16°C (the highest temperature tested). Thompson and Davies (1976) reported that scales first became visible along the lateral line at less than 30 mm FL (fork length) and were essentially complete formed by 40-45 mm FL, except in the pectoral girdle region which was not fully scaled until 55-65 mm FL. Brown (1972) reported that scalation commenced at 30-35 mm TL and was complete by 40-50 mm TL. Hagen (1970) reported full scalation by 40-45 3mm. R. L. & L. Environmental Services Ltd. (1995) reported mean myomere counts of 40 preanal and 17 postanal (ranges of 37-46 and 13-23, respectively) and provided somewhat sketchy dorsal- and lateral-view drawings of a 15 mm TL larva and a slightly later stage (erroneously labeled as being 27 mm TL–perhaps 17 mm TL). Rajogopal (1975, 1979) included a few photographs of abnormal recently hatched larvae, but none of a complete normal larva. In his investigation of vulnerability to whirling disease, Schisler (2010) included photographs of normal and deformed larvae a few days after hatching and 5- and 6-month-old juveniles (also electron micrographs of portions of month-old larvae infested with *Myxobolus cerebralis* TAMs, triactinomyxons), but did not note their lengths. Crawford (1925) included a drawing of a parr-marked juvenile (also of unspecified size) in his article on field characters for identifying young salmonid fishes in fresh waters of Washington. Brown (1952) reported that larvae were readily observed and collected in quiet, shallow shoreline and backwater areas but that later young-of-the year juveniles moved into deeper waters.

For future study, possible description, and reference as part of the Colorado State University Larval Fish Laboratory (LFL) Collection, Darrel Snyder, in fall 2008, inquired about the possibility of CDOW preserving a developmental series of mountain whitefish in the course of their investigations. George Schisler and Steve Brinkman agreed to do so and Snyder provided vials, labels, and preservation guidelines. Eggs were obtained from tributaries of the Yampa River in fall 2008 and 2009 and reared by Brinkman at the CDOW Aquatic Toxicology Laboratory in Fort Collins as detailed in Brinkman and Crockett (2009). Three complementary

series were preserved from specimens reared at about 5°C, two in 10% formalin and a smaller series in 100% ethanol. The first formalin series consisted of week-old embryos (3.5-3.8 mm egg diameter) preserved on 28 October 2008 through recently hatched protolarvae (12-13 mm TL (total length)) on 13 January 2009 and recently transformed postflexion mesolarvae (17 mm TL) on 19 February 2009. The second formalin series consisted of recently fertilized eggs (3.4-4.0 mm diameter) preserved on 14 October 2009 through recently hatched protolarvae (12-13 mm TL) on 8 January 2010 and metalarvae (22-25 mm TL) on 17 February 2010. The smaller ethanol series consisted of protolarvae and recently transformed flexion mesolarvae (15-16 mm TL) preserved on 14 January 2010 through metalarvae (23-24 mm TL) on 17 February 2010. Typically six specimens were preserved during each preservation event. These developmental series are complemented in the LFL Collection by many collections of later-stage larvae and early juveniles from the Green River (mostly 18-40 mm TL, but also later juveniles 50-162 mm TL taken in 1994-2008), the Yampa River (22-45 mm TL taken in 1976-78 and a larger juvenile taken in 1979), the White River (couple juveniles slightly > 50 mm TL taken in 1979), and the Colorado River (76 mm TL taken in 1984).

As preservation of the second developmental series by Brinkman and associates was nearing completion early in 2010, Snyder inquired whether CDOW might be interested in funding detailed drawings of mountain whitefish larvae and early juveniles by LFL's illustrator, C. Lynn Bjork. He suggested that it might be appropriate and useful for CDOW to eventually work on or sponsor a relatively complete description of mountain whitefish larvae and early juveniles and that LFL would be happy to advise, assist, or prepare that description for CDOW. In the interim, he suggested that any illustrations done now would contribute to that longer-term goal and be available to help illustrate future CDOW reports and publications on whitefish investigations. CDOW researchers responded in the affirmative and this project is the result.

Objective:

The objective of this project was to prepare a series of detailed drawings illustrating the morphological development of mountain whitefish larvae and early juveniles for use in pertinent CDOW reports and publications on whitefish investigations, identification of field-collected specimens (especially by researchers in parts of the country where other coregonin species might be sympatric with mountain whitefish), and, eventually, a more complete description. The latter could be prepared as a stand-alone descriptive species account (e.g., Snyder et al. 2011 for woundfin) or incorporated in a comparative description (e.g., Martinez 1983, 1984 for brook, brown, rainbow, and cutthroat trout) or guide and key (e.g., Snyder and Muth 2004 for catostomid larvae and juveniles of the Upper Colorado River Basin).

Methods:

Drawings were prepared 8-inch wide on 8.5 x 11 inch white translucent vellum paper using continuous-tone graphite (pencil) and black ink. Black ink was used only to represent surface or near-surface pigmentation and distinguish it from deeper pigmentation, other structures, and shading. Each drawing includes three views portraying the dorsal, lateral, and ventral aspects of the fish–for many species, structure and pigmentation patterns in dorsal and ventral views are useful in the identification of wild-caught specimens. Specimens of typical appearance in good to excellent condition (straight with well-spread fins and little to no damage) were selected as primary, secondary, and often tertiary drawing specimens for each stage to be illustrated. The basic outlines and features of each view were traced from enlarged digital images of the primary drawing specimen to assure proportionally accurate dimensions and placement of body structures. Various structures were checked and detail added while drawing specimens were examined under a microscope. If necessary, drawings were idealized (e.g., closed or frayed fins opened and smoothed and curved bodies straightened), and modified to better represent typical melanophore distribution and structure based on secondary and sometimes tertiary drawing specimens. Preliminary, final base, and completed drawings were

reviewed by Snyder to further assure accurate representation of the illustrated fish. Completed drawings were professionally scanned and processed as high-, medium-, and low-resolution digital files for storage, print reproduction, and electronic display, copy, and transfer. Prints of the drawings are included at the end of this report in a size and format typically used by LFL for its descriptive species accounts. The original drawings are stored and maintained by LFL.

LFL typically illustrates up to eight stages to adequately portray the morphological development of fish larvae and early juveniles–specifically recently transformed and later stages of the protolarval, mesolarval, and metalarval phases of the larval period and also of the early (young-of-the year) portion of the juvenile period. However, because mountain whitefish hatch as relatively large (~12 mm TL) late-stage protolarvae and there is not much difference in the appearance of recently transformed and later metalarvae, it was determined that illustration of six stages would be adequate for this species with only one drawing representing the protolarval and metalarval phase (also, illustration of a later juvenile was considered optional depending on available funds). When available in good condition, we prefer to use or include wild-caught specimens in our descriptive work as more natural appearing representatives of the fish. Accordingly, the drawings of metalarval and juveniles mountain whitefish are based on wild-caught specimens maintained in the LFL Collection.

Results and End Products:

The results of this project are presented in our standard descriptive species account format as Figures 1-6 at the end of this report. A CD (compact disk) with high-, medium-, and low-resolution digital images (cleaned scans) of the six drawings has been prepared and accompanies the originally submitted print version of this report for CDOW archival and use. Additional copies of the CD or specific image files can be provided upon request.

Acknowledgments:

With the guidance and assistance of CDOW Aquatic Wildlife Research Group Leader Mark Jones and Research Scientists Kevin Rogers, Harry Crockett, Ryan Fitzpatrick, and George Schisler, as well as LFL Director Kevin Bestgen, this project was funded by the CDOW through the Colorado Cooperative Fish and Wildlife Research Unit at Colorado State University. The specimens on which the first three drawings are based were reared, preserved, and provided by or under the direction of CDOW Research Scientist Steve Brinkman through arrangements made with George Schisler.

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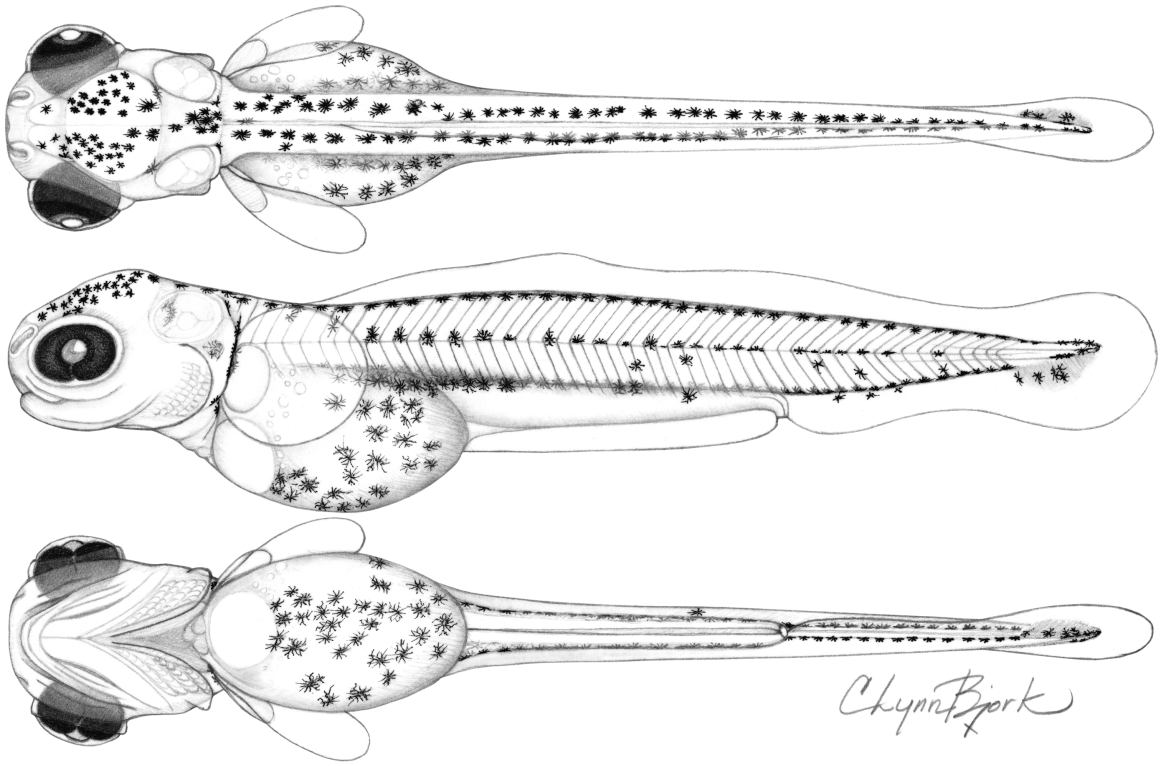

Fig. 1. *Prosopium williamsoni* protolarva, recently hatched, 12.0 mm SL,12.6 mmTL. Cultured in 2009-10 by Steve Brinkman at Colorado Division of Wildlife Fort Collins Research Center with stock from Mad Creek, Routt County, Colorado.

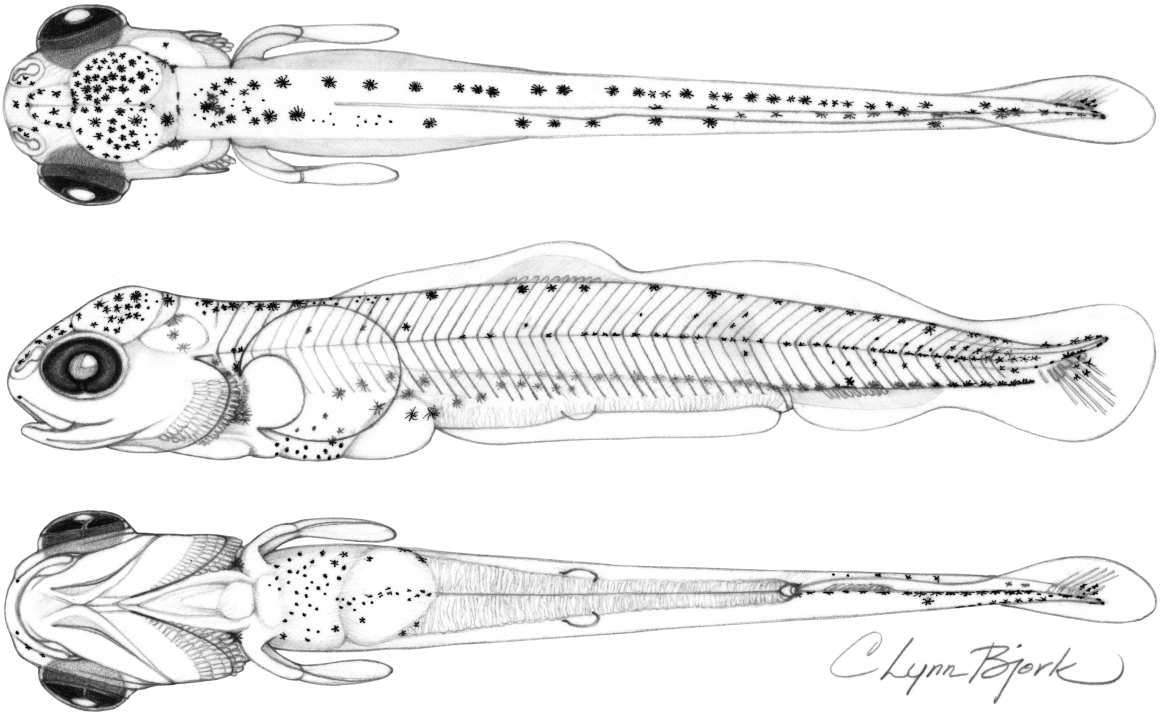

Fig. 2. *Prosopium williamsoni* flexion mesolarva with yolk, 8-10 d posthatch at 5℃, 14.7 mm SL, 15.4 mm TL. Cultured in 2009-10 by Steve Brinkman at Colorado Division of Wildlife Fort Collins Research Center with stock from Mad Creek, Routt County, Colorado.

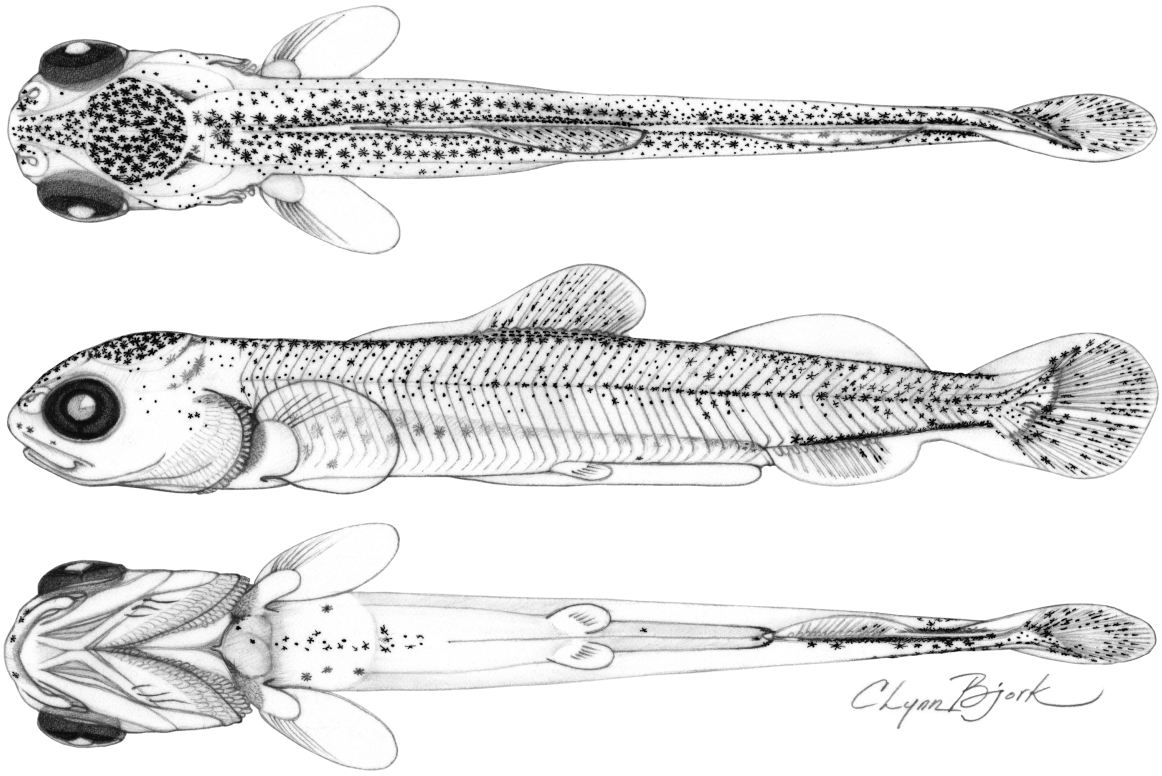

Fig. 3. *Prosopium williamsoni* postflexion mesolarva, 17.7 mm SL, 19.4 mm TL. Cultured in 2009-10 by Steve Brinkman at Colorado Division of Wildlife Fort Collins Research Center with stock from Mad Creek, Routt County, Colorado.

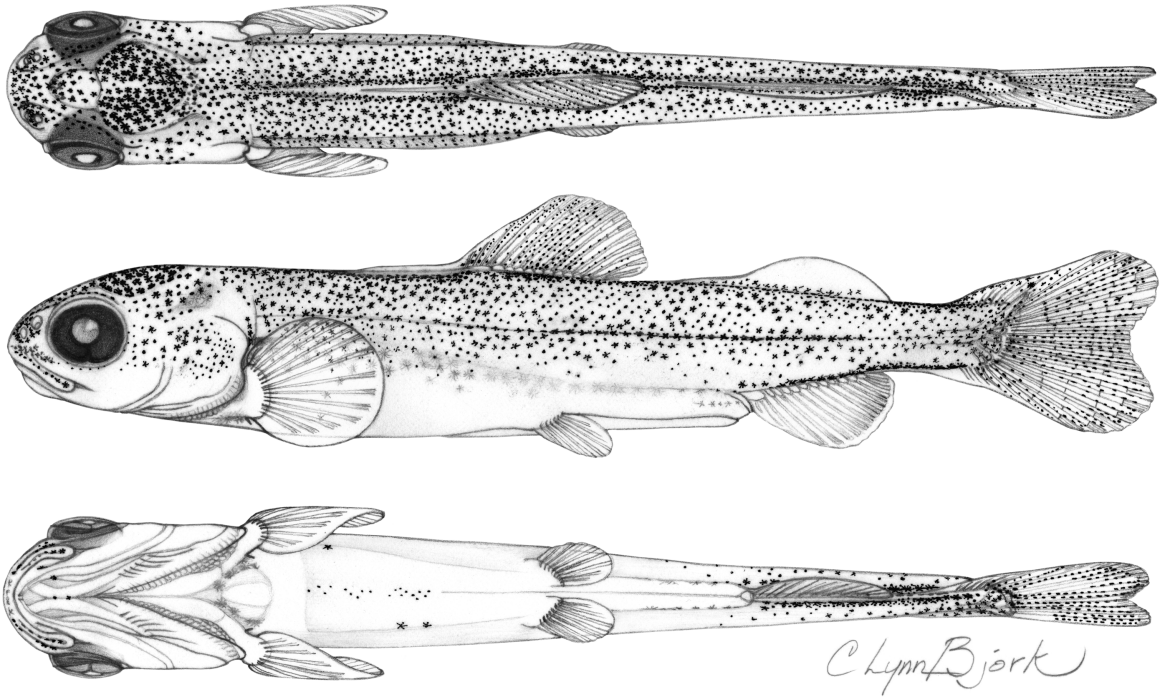

Fig. 4. *Prosopium williamsoni* metalarva, recently transformed, 22.5 mm SL, 25.6 mm TL. Collected in 2004 from Green River in Browns Park National Wildlife Refuge, Moffat County, Colorado (from LFL# 88669).

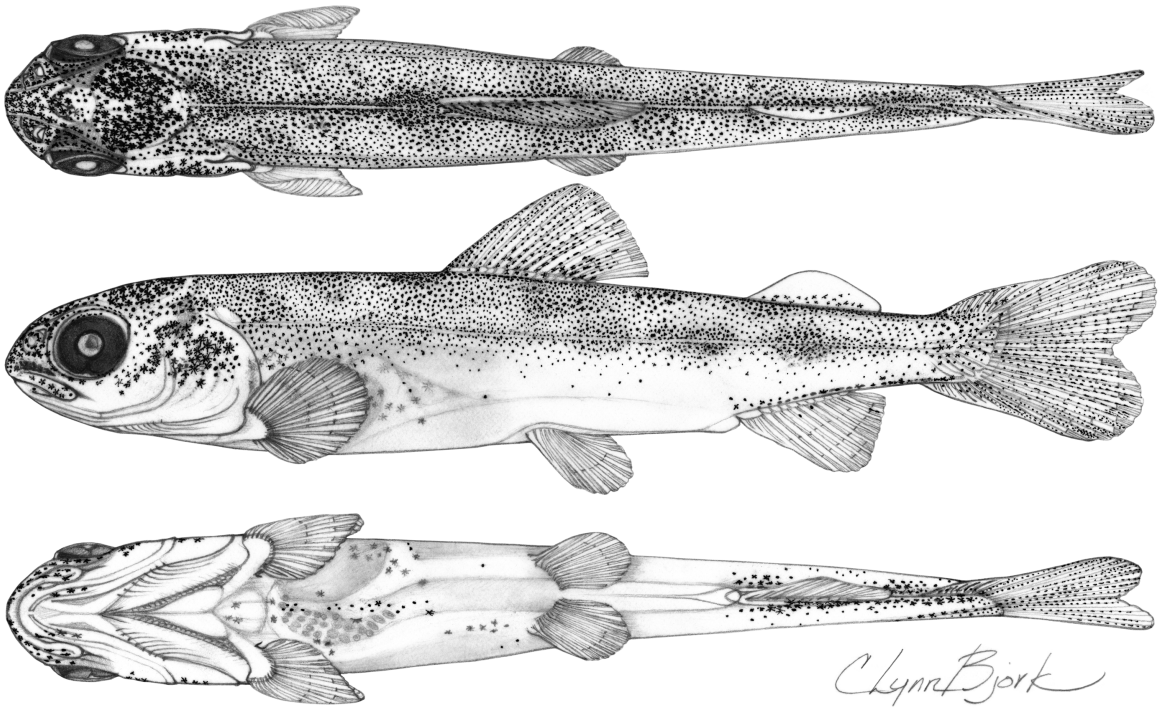

Fig. 5. *Prosopium williamsoni* juvenile, recently transformed, 27.5 mm SL, 31.7 mm TL. Collected in 2003 from Green River in Browns Park National Wildlife Refuge, Moffat County, Colorado (from LFL# 87428).

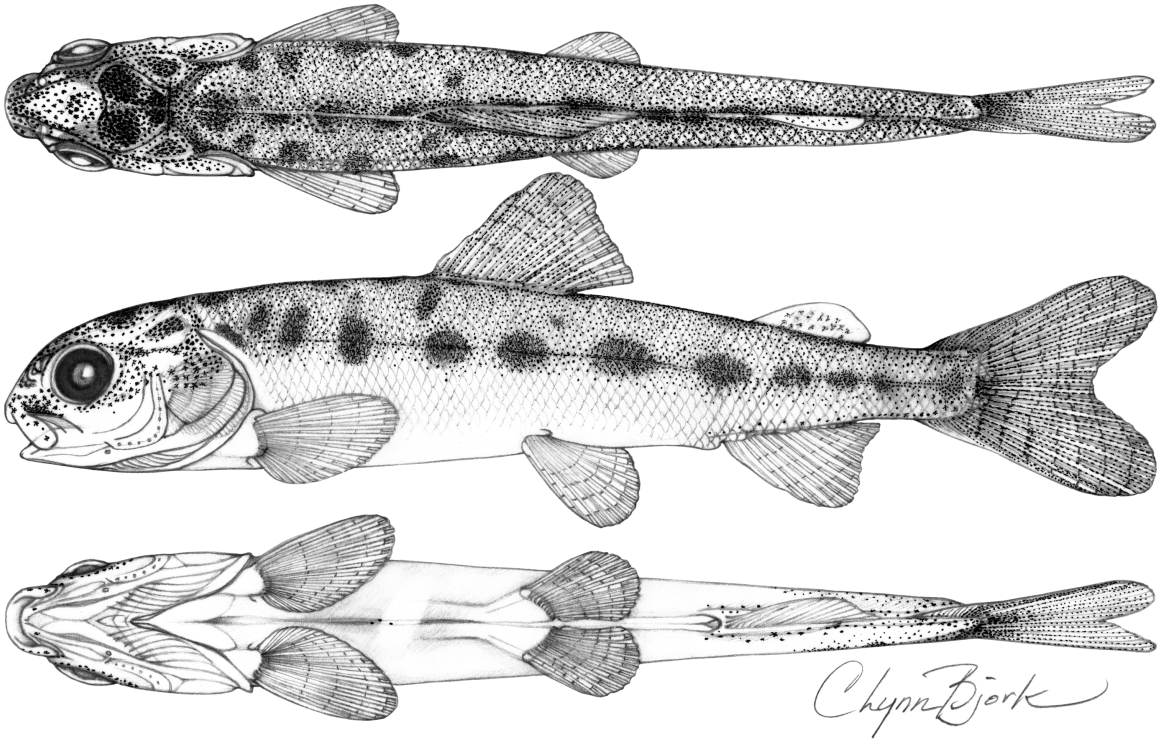

Fig. 6. *Prosopium williamsoni* juvenile, 36.8 mm SL, 43.5 mm TL. Collected in 1976 or 1977 from Yampa River near Hayden, Routt County, or Craig, Moffat County, Colorado (from LFL reference series).