COLORADO RIVER RECOVERY PROGRAM Project Number: 149
FY 2008-2009 SCOPE OF WORK for:
Guide to Cyprinid Larvae

Lead agency: Larval Fish Laboratory, Colorado State University
Submitted by: Kevin R. Bestgen, Project Manager
Darrel E. Snyder, Principal Investigator
Larval Fish Laboratory
Department of Fishery and Wildlife Biology
Room 33 Wagar Building
Colorado State University
Fort Collins, Colorado 80523-1474
Phone: (970) 491-5295
Fax: (970) 491-5091
E-mail: DESnyder@WarnerCNR.ColoState.edu

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Category:
X Ongoing project
__ Ongoing-revised project
__ Requested new project
__ Unsolicited proposal

Expected Funding Source:
X Annual funds
__ Capital funds
X Other (Co-sponsors)

I. Title of Proposal:

Guide to Cyprinid Larvae and Early Juveniles of the Upper Colorado River Basin with Computer-Interactive Key.

II. Relationship to RIPRAP:

General Recovery Program Support Action Plan items V.B (conduct research to acquire needed life history information) and V.C (develop and enhance scientific techniques required to complete recovery actions).

III. Study Background/Rationale and Hypotheses:

This scope of work (SOW) is for co-sponsorship of the final 2 years of a 4-year project initially funded (FY 06-07) by the Upper Colorado River Endangered Fish Recovery Program (UCRP) to prepare a guide and key to the cyprinid larvae of the Upper Colorado River Basin. The project will be co-sponsored for the remainder of FY 07 and FY 08 by the National Park Service Glen Canyon National Recreation Area via an award from the Colorado Plateau Cooperative Ecosystems Study Unit (CP-CESU). (An amount of current UCRP FY 07 funds equivalent to CP-CESU FY 07 funds will be carried over to FY 09). The project is also expected to be co-sponsored in FY 08 by the San Juan River Basin Recovery Implementation Program (SJRP).

Collections of the early life stages of fish are essential for research on and monitoring of Colorado pikeminnow, humpback chub, bonytail, and other native and non-native fish spawning sites and seasons, larval production, transport, distribution, nursery habitat, and survival, as well as other aspects of early life history. Such research cannot proceed effectively without accurate identification of at least the target species among collected specimens.

Morphological identification requires knowledge of the appearance of not only the target species but all similar species in the waters sampled and the diagnostic criteria for segregating them. For the early life stages of many species, including the catostomids (suckers) and cyprinids (minnows) of the Upper Colorado River Basin (UCRB), morphological criteria for identification change dramatically as the fish grow and develop, making diagnosis especially difficult and complicated. This is well exemplified by the 60-page key by Snyder and Muth (1990) which covers the larvae and early juveniles of just six of the seven species of catostomids in the UCRB.

Descriptive information and diagnostic criteria for larval fish identification must be well founded, sufficiently detailed, and documented in such a way that they are retrievable, usable, and verifiable by any interested researcher, now or in the distant future. Any such knowledge retained only in the minds of one or a few

specialists cannot be effectively used, verified, or further developed by others. Taxonomic expertise must be shared and transferred to avoid risk of sudden loss and need for rediscovery and redevelopment.

About 25 years ago the Larval Fish Laboratory published *Contributions to a Guide to the Cypriniform Fish Larvae of the Upper Colorado River System in Colorado* through the U.S. Bureau of Land Management (Snyder 1981). That document, which was based on descriptive information and illustrations from the literature and several developmental studies funded in part by the Colorado Division of Wildlife, was intended to serve as the foundation for a comprehensive guide. With publication of the guide to catostomid larvae by Snyder and Muth (1990) and the recent expansion and update thereof with a computer-interactive key (Snyder and Muth 2004), Part 1 of the cypriniform guide is now complete and only the cyprinid portion of the 1981 publication, Part 2, remains to be similarly completed.

In 1990, Dr. Robert Muth completed a doctoral dissertation documenting the early morphological development of roundtail chub (*Gila robusta*), the endangered humpback chub (*G. cypha*), and the endangered, nearly extirpated, bonytail (*G. elegans*). His detailed and well-illustrated species accounts purposely followed the format employed by Snyder and Muth (1990) for catostomid larvae and required little modification for inclusion of roundtail chub and bonytail in a similarly formatted final-report guide to *Native Cypriniform Fish Larvae of the Gila River Basin* (Snyder et al. 2005). However, use of Muth's criteria to identify *Gila* recently collected from Dinosaur National Monument suggests that some of those criteria may need to be refined and supplemented (Snyder et al. 2006). Species accounts for Colorado pikeminnow (*Ptychocheilus lucius*), speckled dace (*Rhinichthys osculus*), carp (*Cyprinus carpio*), red shiner (*Cyprinella lutrensis*), and fathead minnow (*Pimephales promelas*) were similarly adapted and minimally updated from Snyder (1981) for the Gila River Basin guide. But data in most of these accounts still remain incomplete and new three-view illustrations will be needed for most accounts.

Developmental series, mensural and meristic data, and (or) illustrations are needed to complete early life stage descriptive accounts for 13 of the 15 species to be covered by this guide, 9 of which are found in the San Juan River Sub-basin. Complete sets of 8 three-view drawings are available only for humpback chub, roundtail chub, and Colorado pikeminnow (however, two of the drawings for the latter account should be replaced with more complete or representative illustrations). Much of the specimen material for needed developmental studies is available in the Larval Fish Laboratory Collection. However, full series of specimens for four species and just the eggs and recently hatched larvae (protolarvae) for at least four additional species will need to be reared, collected, or borrowed from elsewhere.

Computer-interactive keys for catostomid larvae of the UCRB (Snyder and Muth 2004) and for the larvae of native catostomids, selected cyprinids, and families of fishes in the Gila River Basin (Snyder et al. 2005) have proven that such taxonomic tools can be effectively applied to the early life stages of fish. For complex data sets, such keys are much more user friendly and flexible than printed dichotomous or polychotomus keys. They are also much easier to prepare, correct, and update. Portions of the cyprinid key prepared for Snyder et al. (2005) will be adapted and used as a foundation for the UCRB key.

Building on information, species accounts, and keys already assembled by Snyder (1981), Muth (1990), and Snyder et al. (2005) and other information and illustrations from the literature, this four-year project will result in a comprehensive guide to the cyprinid larvae and early juveniles of the UCRB. Combined with the recent update and expansion of the catostomid guide (Snyder and Muth 2004), this project will finally complete work on cypriniform fish larvae as a whole, except for formal publication. Publication will be pursued separately as the manuscript nears completion, preferably as a companion to the catostomid guide recently published by the Colorado Division of Wildlife.

IV. Study Goals, Objectives, End Product(s):

Goal—

- To improve the ability of recovery program researchers and others to accurately identify cyprinid larvae and early juveniles collected in the UCRB.

Objectives—

- To fully document the early morphological development of UCRB cyprinids and publish selected descriptions in technical journals.
- To verify existing, and uncover new, diagnostic criteria for identification of cyprinid larvae and early juveniles.
- To prepare a computer-interactive key for cyprinid larvae and early juveniles that will complement the key previously prepared for UCRB catostomids (Snyder and Muth 2004).

- To prepare as manuscript guide to the cyprinid larvae and early juveniles of the UCRB with a proposal for its publication (both print and electronic).

End Products—
- Annual project reports.
- Preserved developmental series of the early life stages of needed cyprinids for study and reference to supplement existing specimens in the LFL Collection.
- Publication of selected descriptions in technical journals.
- Online (web) access to the key.
- Proposal for publication of the manuscript guide.
- Final report in the form of a manuscript guide for publication.

V. Study Area:

Entire UCRB.

VI. Study Methods/Approach:

Task 1: Acquisition of specimens needed for developmental study (Table 1)—
- Assemble available specimens in the LFL Collection.
- Borrow needed specimens available in other museums and collections.
- Arrange for cooperative preservation of needed developmental series by fish hatcheries or other facilities rearing those species.
- Rear remaining needed developmental series from collected eggs and larvae or from artificially fertilized eggs from captured brood stock.
- Supplement above, as needed, with targeted or opportunistic collections of larvae and early juveniles.

Task 2: Description and illustration of eggs, larvae, and early juveniles of UCRB cyprinids (Table 1)—
- As needed, determine or verify unique size or shape characters of eggs and conduct or complete detailed study of the morphological ontogeny of the larvae and early juveniles of each species, including meristics, morphometrics, size relative to state of development, gut morphology, and pigmentation as in prior descriptions (Snyder 1981, Muth 1990, Snyder and Muth 1990 and 2004, Snyder et al. 2005).
- Prepare or complete standard sets of eight three-view drawings of larvae and juveniles.
- Prepare or complete descriptive species accounts comparable to those in Snyder and Muth (1990, 2004) and Snyder et al. (2005).
- Compare above data and observations for diagnostically useful characters and summarize criteria for identification.

Task 3. Preparation of computer-interactive key to the larvae and early juveniles of UCRB cyprinids—
- Prepare or refine descriptive data assembled for above species accounts in DELTA format for use by INTKEY (Dallwitz 1993; Dallwitz et al. 1993 et seq., 1995 et seq., and 1999 et seq.) in a manner comparable to that previously prepared for UCRB catostomids and Gila River Basin catostomids and cyprinids; prepare, test, and refine a draft version of the computer-interactive key for UCRB cyprinids.
- Modify introduction and instructions previously prepared for the computer-interactive key to UCRB catostomids for use with the key for UCRB cyprinids.
- Submit draft key and instructions for use of the computer-interactive key to critical review and testing by LFL staff and external volunteers (e.g., USFWS, CDOW, or UDWR researchers, and Dr. Dallwitz), and refine and finalize the key and instructions accordingly.

Task 4. Synthesis, publication, presentation, and reporting of results—
- Prepare and submit annual project (progress) reports.
- Present papers on development and identification of UCRB cyprinids with hands-on demonstration of draft and final computer-interactive key at annual Larval Fish Conferences (American Fisheries Society Early Life History Section) and annual meetings of UCRB researchers (use feedback on draft versions of the key to further refine the key). Presentations may be opportunistically offered at annual meetings of the American

Fisheries Society (AFS), AFS Western Division, AFS Colorado/Wyoming Chapter, American Society of Ichthyologists and Herpetologists, and Desert Fishes Council.

- Prepare and submit descriptions of selected species for publication in technical journals.
- Prepare and submit the project final report to the Recovery Program and other co-sponsors of the project. The report will consist of the manuscript guide to cyprinid larvae of the UCRB with the computer-interactive key on a companion CD-ROM disk; like the catostomid guide and key, both will be made available for viewing or download over the Internet.
- Prepare and submit proposal(s) for print publication of the cyprinid guide.

VII. Task Description and Schedule:

Task 1: Acquisition of specimens needed for developmental study—FY 2006-2007
Task 2: Description and illustration of eggs, larvae, and early juveniles—FY 2006-2008.
Task 3: Preparation of computer-interactive key—FY 2006-2009.
Task 4: Synthesis, publication, presentation, and reporting of results—FY 2006-2009.

Due to delays in FY 2006 and 2007 funding, some tasks for FY 2006 and 2007 is behind schedule (see UCRP annual report for Project 149) and might need to be carried over, with the associated funds, into FY 2008; a cascade effect might similarly push some FY 2008 work into FY 2009, but logistical allowances were originally made for such possibilities and all should still be completed by the end of FY 2009.

VIII. Deliverables, Due Dates, and Budget by Fiscal Year:

FY 2006 and 2007: Fully funded at $185,197 in spring 2006 by the UCRP (Project 149), but without assurances of future support and with the expectation that co-sponsors will be found to help fund the final two years of the project.

FY 2008:
Deliverables and Due Dates:

- Presentations of selected descriptions and draft computer-interactive key—UCRP Researchers' Meeting, January 2008 (draft key might be deferred to next year), and Larval Fish Conference, Spring or Summer 2008.
- Annual report—November 2008.

Budget: [a]

Task 1 (Acquisition of specimens)	LFL
Completed	
Task 2 (Description and illustration)	
Labor	
Principal Investigator ($6,527/mo.[b]; 3.43 mo.)	$22,367
Research Associate(s) ($3,144/mo.[b]; 2.77 mo.)	8,713
Illustrator ($4,538/mo.[b]; 2.69 mo.)	12,201
Supplies [c]	155
Services [d]	450
Task 2 Subtotal (Direct Costs)	43,886
Task 3 (Preparation of computer-interactive key)	
Labor	
Principal Investigator ($6,527/mo.[b]; 1.10 mo.)	$7,190
Research Associate(s) ($3,144/mo.[b]; 0.56 mo.)	1,770
Supplies [e]	100
Task 3 Subtotal (Direct Costs)	9,060

Task 4 (Synthesis and communication of results)	
Labor	
Principal Investigator ($6,527/mo.[b]; 1.63 mo.)	$10,669
Research Associate(s) ($3,144/mo.[b]; 0.13 mo.)	419
Travel [f]	
Larval Fish Conference (1 person)	
Airfare and ground transport	541
Per diem (5 d) and lodging (4 nights)	438
Registration	108
Supplies [g]	50
Services	
Primary publication page charges	2,000
Task 4 Subtotal (Direct Costs)	14,226
FY 2008 TOTALS	
Total Direct Costs (all tasks)	$67,172
Indirect Costs (17.5% on $12,766, 15% on $54,406) [h]	10,395
Grand Total	77,567
Co-sponsor shares (direct and indirect cost):	
GLCA/CP-CESU (confirmed for FY 2007, to be carried over for FY 2008)	$15,000
SJRP (expected, as per UCRP FY 2008-2009 Program Guidance)	50,000
UCRP (remainder)	$12,567
(Adjusted for difference if SJRP share is less than expected, $62,567 if SJRP share is not realized)	

[a] Annual estimated increases in fringe benefit rates (generally + 0.5%) and salary and other expenses (x 4%) are specified by the University Office of the Vice President for Research and Information Technology in it's current Proposal Budget Spreadsheet.
[b] Salary plus fringe benefits, update of figures in SOW for FY 2006-2007.
[c] Project-specific computer, lab, drawing, photographic, and specimen preservation and storage supplies.
[d] Photographic services (high-resolution scans of drawings).
[e] Project-specific computer and lab supplies.
[f] Travel costs for participation in UCRP Researchers' Meeting are expected to be covered by another project.
[g] Drawing, photographic, and presentation supplies.
[h] Assumes continuance of current memoranda of understanding (MOUs) through which Colorado State University and the Bureau of Reclamation (for UCRP and SJRP) and CP-CESU (for GLCA) agree to reduced indirect costs of 15% and 17.5%, respectively, with the university waiving the remainder of its standard 46% indirect cost rate as its contribution to the project ($20,504).

FY-2009:

Deliverables and Due Dates:

- Presentations of selected descriptions and final computer-interactive key—UCRP Researchers' Meeting, January 2009 (key might be draft rather than final) and Larval Fish Conference, Spring or Summer 2009.
- Proposal for print publication of the guide to larvae and early juveniles of UCRB cyprinids with computer-interactive keys on diskette or CD, and as web documents—Spring 2009.
- Final report consisting of manuscript for the guide to UCRB cyprinid larvae and the computer-interactive key—September 2009.

Budget: [a]

Tasks 1 and 2 (Acquisition of specimens, description)	
To be completed	
Task 3 (Preparation of computer-interactive key)	
Labor	
Principal Investigator ($6,832/mo.[b]; 0.18 mo.)	$1,214
Task 3 Subtotal (Direct Costs)	1,214

Task 4 (Synthesis and communication of results)	
Labor	
Principal Investigator ($6,832/mo.[b]; 2.84 mo.)	$19,424
Research Associate(s) ($3,291/mo.[b]; 0.47 mo.)	1,561
Travel [c]	
Larval Fish Conference (1 person)	
Airfare and ground transport	563
Per diem (5 d) and lodging (4 nights)	456
Registration	112
Supplies [d]	150
Services	
Primary publication page charges	2,000
Copying and binding final report	1,000
Task 4 Subtotal (Direct Costs)	25,266
FY 2009 TOTALS	
Total Direct Costs (all tasks)	$26,480
Indirect Costs (17.5% on $12,766, 15% on $13,714) [e]	4,291
Grand Total	30,771
Co-sponsor shares (direct and indirect cost):	
GLCA/CP-CESU (confirmed for FY 2008, to be carried over for FY 2009)	$15,000
SJRP (expected, as per UCRP FY 2008-2009 Program Guidance)	0
UCRP (remainder)	$15,771
(Adjusted for difference if SJRP contributes in FY 2009 as well as FY 2008, or splits between years)	

[a] Annual estimated increases in fringe benefit rates (generally + 0.5%) and salary and other expenses (x 4%) are specified by the University Office of the Vice President for Research and Information Technology in it's current Proposal Budget Spreadsheet.

[b] Salary plus fringe benefits, update of figures in SOW for FY 2006-2007.

[c] Travel costs for participation in UCRP Researchers' Meeting are expected to be covered by another project.

[d] Project-specific computer, lab, drawing, photographic, and presentation supplies.

[e] Assumes continuance of current MOUs through which Colorado State University and the Bureau of Reclamation (for UCRP and SJRP) and CP-CESU (for GLCA) agree to reduced indirect costs of 15% and 17.5%, respectively, with the university waiving the remainder of its standard 46% indirect cost rate as its contribution to the project ($7,890).

IX. Budget Summary

Co-sponsors	UCRP	SJRP	GLCA CP-CESU	Total
FY 2008	$12,567	$50,000	$15,000	$77,567
FY 2009	15,771	0	15,000	30,771
Total	$28,338	$50,000	$30,000	$108,338

X. Reviewers: (Not applicable–ongoing project)

XI. References:

Dallwitz, M. J. 1993. DELTA and INTKEY. Pages 287-296 *in* R. Fortuner, editor. Advances in computer methods for systematic biology: artificial intelligence, databases, computer vision. The Johns Hopkins University Press, Baltimore, Maryland.

Dallwitz, M. J., T. A. Paine, and E. J. Zurcher. 1993 et seq. User's guide to the DELTA System: a general system for processing taxonomic descriptions, 4th edition. Commonwealth Scientific and Industrial Research Organization Department of Entomology. Available: http://delta-intkey.com/www/programs.htm, included in program distribution file "all programs" (January 2005).

Dallwitz, M. J., T. A. Paine, and E. J. Zurcher. 1995 et seq. User's guide to Intkey: a program for interactive identification and information retrieval, 1st edition. Commonwealth Scientific and Industrial Research Organization Department of Entomology. Available: http://delta-intkey.com/www/programs.htm, included in program distribution files "Intkey" and "all programs" (January 2005).

Dallwitz, M. J., T. A. Paine, and E. J. Zurcher. 1999 et seq. User's guide to the DELTA Editor. Commonwealth Scientific and Industrial Research Organization Department of Entomology. Available: http://delta-intkey.com/www/ programs.htm, included in program distribution file "all programs" (January 2005).

Muth, R. T. 1990. Ontogeny and taxonomy of humpback chub, bonytail, and roundtail chub larvae and early juveniles. Doctoral dissertation. Colorado State University, Fort Collins.

Snyder, D. E. 1981. Contributions to a guide to the cypriniform fish larvae of the Upper Colorado River System in Colorado. United States Bureau of Land Management, Colorado Office, Biological Sciences Series 3, Denver.

Snyder, D. E., and R. T. Muth. 1990. Descriptions and identification of razorback, flannelmouth, white, bluehead, mountain, and Utah sucker larvae and early juveniles. Colorado Division of Wildlife Technical Publication 38.

Snyder, D. E., and R. T. Muth. 2004. Catostomid fish larvae and early juveniles of the Upper Colorado River Basin–morphological descriptions, comparisons, and computer-interactive key. Colorado Division of Wildlife Technical Publication 42. Available: ftp://ftp.cnr.colostate.edu/pub/lfl/pdf-doc/, select distribution file "Snyder and Muth 2004.pdf" (April 2005).

Snyder, D. E., K. R. Bestgen, and S. C. Seal. 2005. Native cypriniform fish larvae of the Gila River Basin–morphological descriptions, comparisons, and computer-interactive keys. Final report of Colorado State University Larval Fish Laboratory to U.S. Department of the Interior Bureau of Reclamation, Phoenix, Arizona. Available: ftp://ftp.cnr.colostate.edu/pub/lfl/pdf-doc/, select distribution file "Snyder et al 2005-Gila Guide Final Report-r.pdf" (April 2005).

Snyder, D. E., K. R. Bestgen, and D. L. Davis. 2006. Taxonomic analysis of selected YOY juvenile and yearling chub collected from the Yampa River in Dinosaur National Monument, October 2004. Final report of Colorado State University Larval Fish Laboratory to U.S. Department of the Interior Fish and Wildlife Service Colorado River Fish Program, Vernal, Utah.

TABLE 1. Specimens, illustrations, and data needed for an illustrated manual and computer-interactive key for larval and early juvenile cyprinids of the Upper Colorado River Basin. F = full set needed, P = partial set needed, P/F = partial set needed but full set preferred (available published illustrations may not of desired quality), H = only embryos and recently hatched specimens needed. Existing mensural and count data for most species will need to be verified. All species will need to be examined for qualitative and quantitative documentation of pigmentation patterns and structural features.

	Study Specimens Needed	Mensural & Count Data Needed	3-View Illustrations (Drawings) Needed
Cyprinella lutrensis red shiner	H	H	P/F
Cyprinus carpio common carp	–	–	P/F
Gila atraria Utah chub	F	P	P/F
Gila cypha humpback chub	–	–	–
Gila elegans bonytail	–	–	P
Gila robusta roundtail chub	–	–	–
Hybognathus hankinsoni brassy minnow	F	F	F
Notropis stramineus sand shiner	H	H	F
Pimephales promelas fathead minnow	–	P	P
Ptychocheilus lucius Colorado pikeminnow	–	–	P
Rhinichthys cataractae longnose dace	F	F	P/F
Rhinichthys osculus speckled dace	H	H	H
Richardsonius balteatus redside shiner	H	H	H
Semotilus atromaculatus creek chub	F	F	P
Notemigonus crysoleucas [a] golden shiner	–	P	P

[a] Non-native species rarely reported in the basin.