Illustration and Description of Woundfin Larvae and Early Juveniles — Contribution to a Guide to Larval Fishes of the Virgin River

Final Report

VRRMRP Project Number VIII.10.03

Prepared for

Virgin River Resource Management and Recovery Program
1594 W. North Temple, Suite 3310
Salt lake City, Utah 84116-5610

via

Steven M. Meismer, Local Coordinator
136 North 100 East
St George, Utah 84770

31 March 2011
(Page 1 of species account modified, 29 October 2015)

by

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Larval Fish Laboratory
Contribution
164

Colorado State University

Knowledge to Go Places

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Project Duration:

17 December 2009 through 31 March 2011.

Relationship to Recovery Action Plan:

Objective 6: Determine ecological factors limiting abundance of native species.
Objective 7: Monitor habitat conditions and populations of native species.

Project Background Information:

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.

Of the six fishes native to the Virgin River, half were undescribed as larvae–the woundfin *Plagopterus argentissimus* and Virgin chub *Gila seminuda*, both federally endangered, and the Virgin spinedace *Lepidomeda mollispinis*, a Utah state conservation species. The other native and all non-native species have been, or are being, described and included in guides for other waters.

Description of Virgin River fish larvae and preparation of a guide for their identification was originally proposed by the Larval Fish Laboratory (LFL) to the Bureau of Land Management, a Program partner, in 1993 at that agency's request (via Mike Herder). In recent years, prospects for that work have been discussed informally with the Virgin River Resources Management and Recovery Program Local Coordinator (Steven Meismer), and pre-proposals were submitted to the

Program for illustrating the larvae pending successful culture and assemblage of preserved developmental series of needed species via Dexter National Fish Hatchery and Technology Center (DNFTC). Pre-proposals were also submitted for preparing of the guide itself pending completion of guides to cyprinid larvae of the Upper Colorado River Basin (now delayed until September 2011) and cypriniform larvae of the Middle Rio Grande (to be completed by July 2012). Developmental study series of woundfin were finally reared, preserved, and assembled for LFL in 2006 and 2009, and of Virgin chub in 2007, leaving only a series of Virgin spinedace yet to be reared and preserved. We have proposed preparation needed illustrations as soon as possible in advance of the guide because the longer-term availability of LFL's illustrator, C. Lynn Bjork, could be assured. Based in part on our spring 2009 pre-proposal for illustrating larvae and early juveniles, the Program requested (via the local coordinator) a proposal (SOW) for illustrating woundfin and documenting associated descriptive data for immediate use and eventual inclusion in a guide and computer-interactive key. The proposed work was to be conducted with preserved specimens by the Larval Fish Laboratory at Colorado State University.

Goal and Objective:

The goal of this project was to facilitate researcher identification of collected woundfin larvae by documenting morphological development from recently hatched protolarvae through early juveniles with a set of eight detailed, dorsal-, lateral-, and ventral-view drawings and selected morphometric, meristic, size-relative-to-developmental-state, and pigmentation data . The objective was to begin documenting the early morphological development of Virgin River fish with a descriptive species account of woundfin larvae and juveniles for immediate use and, if funded in the future, eventual inclusion in a guide and key to at least the cypriniform fish larvae and early juveniles of the Virgin River.

Results and End Products:

The results of this project are summarized in the appended species account describing woundfin larvae and early juveniles. The end products of the project are a set of previously submitted high-resolution digital scans of the drawings, a recently submitted Excel spreadsheet of recorded individual specimen and summarized descriptive data, and the appended descriptive species account in LFL's standard 6-page format, supplemented with methodological diagrams, a list of literature cited in the account, and acknowledgments (content that would be included elsewhere in a guide).

Species Account – *Plagopterus argentissimus*, Woundfin

Fig. 1. *Plagopterus argentissimus* adult (© Joseph R. Tomelleri).

Adult description: Up to 9 cm TL, but rarely >7.5 cm. Head wide and dorsally flat, with long snout, large nasal flaps, moderately small eyes, subterminal mouth with barbels at corners, and intermandibular patch of sensory papillae. Fins typically large with pectoral fins extending to origin of pelvics and pelvics to vent. Falcate dorsal fin begins behind origin of pelvics with two long, stout, spinous rays–a modified rudimentary ray with posterior groove that partially encloses a similarly modified first principal ray; remaining rays of dorsal and pelvic fins have distinctively thickened, spine-like bases, also present but much less obvious in anal and pectoral fins. Pelvics adnate to body along much of innermost ray. Scaleless except for rudiments along anterior lateral line and embedded dermal platelets on anterodorsal body. Body silvery with dusky dorsum and bluish tinges laterally; breeding males pink ventrally. See table of meristics below.

Reproduction: Non-guarding, open-substrate lithophil. Batch spawn May-early June at 19-26 °C, possibly April-August, 14-30 °C. Females observed to congregate in pools, then join males in open, flowing water to spawn, preferably over coarse substrate <10 cm deep. Eggs demersal, adhesive, and 1.5-2.0 mm in diameter, usually 1.7-1.8 mm.

Young: Hatch in 4-5 days at 21-22 °C. Prefer slow shallow habitats over sand, gravel, or mud, often near shore or cover; seek quiet, sandy backwaters. Juveniles appear distinctively iridescent blue in sunlight.

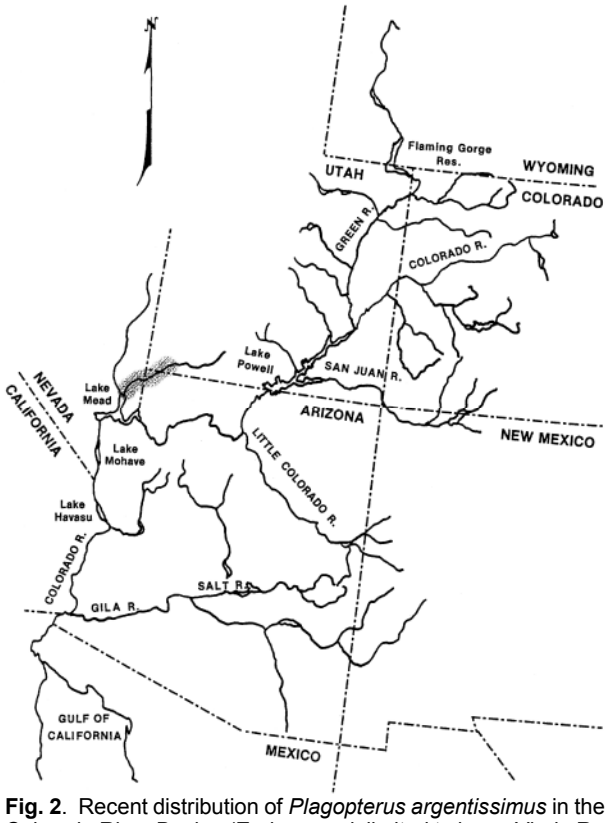

Fig. 2. Recent distribution of *Plagopterus argentissimus* in the Colorado River Basin. (Endangered, limited to lower Virgin R.; historically also present from mouth of Gila R. to lower Salt R.)

Table 1. Selected juvenile and adult meristics for *Plagopterus argentissimus*. (P = principal rays; R = rudimentary rays; D = dorsal; V = ventral. Scales are lateral series or line when complete. Four added to vertebral count for Weberian complex. Pharyngeal teeth given as left outer row, inner row/right inner row, outer row. Mean or modal values underlined if known and noteworthy; rare values in parentheses.)

Character	Observed	Literature	Character	Observed	Literature
Dorsal-fin rays - P	(7)8-9 [a]	8-9(10) [a]	Dorsal-fin rays - R	1(2) [b]	1 [b]
Anal-fin rays - P	9-10(11)	(8)9-10-11	Anal-fin rays - R	2(3)	–
Caudal-fin rays - P	19	19	Caudal-fin rays - RD	10-11-12	–
Pectoral-fin rays	14-15-16	16	Caudal-fin rays - RV	9-10-11(12)	–
Pelvic-fin rays	7	(6)7	Lateral scales	not applicable	–
Vertebrae	–	39-40-41	Pharyngeal teeth	–	1(2),5(4)/4(5),1(2)

[a] Includes second spinous ray which develops from unbranched first principal ray; with rudimentary-based spine, fin formula would be II,7-8.
[b] Includes first spinous ray which develops from unbranched rudimentary ray, sometimes closely preceded by a very tiny first rudimentary ray.

Table 2. Size at onset of selected developmental events for *Plagopterus argentissimus*. (As apparent under low-power magnification. P = principal rays; R = rudimentary/secondary rays. Structures of lateral line are presumed to be rudimentary scales. Rare values in parentheses.)

Event or structure	Onset or formation mm SL	mm TL	Fin rays or scales	First formed mm SL	mm TL	Last formed mm SL	mm TL
Hatched	5(6)	5-6	Dorsal - P	(8)9	9-10	10	11-12(13)
Eyes pigmented	before hatching		Anal - P	(8)9	9-10	10	11-12(13)
Yolk assimilated	(6)7(8)	7-8	Caudal - P	(6)7	7(8)	(7)8(9)	(8)9
Finfold absorbed	(17-)20-22(-26)	(21-)25-27(-33)	Caudal - R	(8)9	9-10	(12)13-14(-16)	(14-)16-18(-20)
Pectoral-fin buds	before hatching		Pectoral	(8)9	9-10	14	17-18
Pelvic-fin buds	(8)9	10	Pelvic	10	(11)12	14	17-18
Maxillary barbels	10	12	Lat. line rudiments	22-23	27-29	(35-37?)	(44-47?)

References: Arizona Game and Fish Department 2001 & 2004, Balon 1975 and 1981, Boschung et al. 1983, Fridell and Wagner (undated brochure), Gilbert and Scofield 1898, Greger and Deacon 1982, Holden (pers. comm.), La Rivers 1962, Miller and Hubbs 1960, Minckley 1973, Moore 1968, Mueller and Marsh 2002, Page and Burr 1991, Scharpf 2006, Sigler and Miller 1963, Sigler and Sigler 1996, Simon 1998, Snyder 1915, US Fish and Wildlife Service 1985, Webb et al. 2010.

SPECIES ACCOUNT prepared by D. E. Snyder, J. A Charles, and C. L. Bjork, Colorado State University Larval Fish Laboratory, Fort Collins, Colorado, for the Virgin River Resource Management and Recovery Program, Salt lake City, Utah (31 March 2011, modified 29 Oct. 2015).

Table 3. Size at developmental interval (left) and gut phase (right) transitions for *Plagopterus argentissimus*. (See Fig. 11 for phases of gut folding. Rare values in parentheses.)

Transition to	mm SL	mm TL	Transition to	mm SL	mm TL
Flexion mesolarva	(6)7	7(8)	2 - 90° bend	(11)12	14
Postflexion mesolarva	(7)8(9)	(8)9	3 - Full loop	20-22	25-27
Metalarva	10(11)	(11)12(13)	4 - Partial crossover	not applicable	
Juvenile	(17-)20-22(-26)	(21-)25-27(-33)	5 - Full	not applicable	

Table 4. Summary of morphometrics and myomere counts by developmental phase for *Plagopterus argentissimus*. (See Figure 12 for abbreviations and methods of measurement and counting. Protolarvae with unpigmented eyes excluded. Standard deviation (SD) of 0 represents a value <0.5.)

	Protolarvae (N=10)			Flexion mesolarvae (N=8)			Postflexion mesolarvae (N=9)			Metalarvae (N=16)			Juveniles (N=15)		
	$\bar{x}$	±SD	Range	$\bar{x}$	±SD	Range	$\bar{x}$	±SD	Range	$\bar{x}$	±SD	Range	$\bar{x}$	±SD	Range
SL, mm	6	1	5 - 7	8	1	6 - 9	9	1	7 - 10	15	5	10 - 26	27	7	17 - 38
TL, mm	6	1	5 - 8	8	1	7 - 9	10	1	8 - 12	19	6	12 - 33	34	8	21 - 48
Lengths %SL															
AS to AE	4	1	3 - 5	5	1	4 - 5	6	0	5 - 6	7	1	6 - 8	7	1	6 - 8
PE	10	1	9 - 12	11	1	10 - 11	12	1	10 - 14	14	1	12 - 15	13	1	12 - 15
OP1	19	2	15 - 21	21	1	20 - 22	24	1	22 - 26	25	1	23 - 27	24	1	22 - 26
OP2							45	1[c]	44 - 46	47	1	44 - 48	45	1	44 - 48
PY	60	4[a]	52 - 64	55	0[b]	55 - 56									
OPAF	38	7	31 - 54	32	1	31 - 34	34	1	32 - 37	44	8	34 - 58			
ODF	44	3	42 - 50	46	1	44 - 47	49	1	48 - 51	48	2[f]	46 - 50			
OD							52	2[a]	49 - 54	49	1	48 - 52	49	1	46 - 52
ID							65	1[d]	64 - 66	66	1	65 - 69	67	1	65 - 69
PV	65	1	63 - 67	64	1	63 - 67	69	1	68 - 71	65	3	60 - 70	63	1	61 - 66
OA							68	1[a]	67 - 70	65	2	61 - 69	65	1	62 - 66
IA							78	1[e]	77 - 79	79	1	77 - 82	80	1	78 - 81
AFC							112	1	110 - 114	115	2	113 - 118	115	1	113 - 118
PC	105	1	104 - 106	107	0	106 - 107	115	2	111 - 117	123	2	119 - 126	126	1	123 - 129
Y	33	20	0 - 53	6	12	0 - 29									
P1	10	4	4 - 15	15	1	13 - 16	15	1	13 - 17	18	2	15 - 22	21	1	20 - 22
P2							3	2	0 - 7	10	3	5 - 14	16	1	13 - 18
D							18	2[b]	16 - 20	23	2	18 - 26	26	2	24 - 29
A							14	2[b]	13 - 16	19	3	13 - 23	21	1	20 - 23
Depths %SL															
at BPE	12	1	11 - 14	11	0	11 - 11	13	0	12 - 14	14	1	12 - 16	14	1	13 - 15
OP1	16	5	12 - 25	13	1	12 - 14	17	1	16 - 18	18	2	16 - 22	18	1	17 - 19
OD	11	1	9 - 13	10	1	9 - 11	12	1	11 - 14	17	3	12 - 22	20	1	17 - 21
BPV	7	1	6 - 8	7	1	6 - 8	9	1	8 - 10	12	2	9 - 16	15	1	12 - 17
AMPM	3	0	3 - 4	3	0	3 - 4	6	1	4 - 7	8	1	7 - 10	10	1	9 - 11
Max. yolk	9	8	0 - 23	1	1	0 - 3									
Widths %SL															
at BPE	12	1	12 - 13	13	1	12 - 15	15	0	15 - 16	15	1	15 - 17	15	1	14 - 17
OP1	12	4	9 - 21	10	1	10 - 11	13	1	10 - 15	16	1	14 - 17	17	1	16 - 20
OD	6	1	5 - 7	6	0	5 - 6	7	1	7 - 8	11	2	7 - 15	14	1	12 - 17
BPV	4	0	4 - 5	4	0	4 - 5	5	1	5 - 6	8	1	6 - 10	10	1	8 - 13
AMPM	2	0	2 - 3	2	0	2 - 3	3	0	3 - 4	4	1	3 - 5	4	1	3 - 5
Max. yolk	10	9	0 - 24	1	3	0 - 7									
Myomeres															
to PY	22	1[a]	19 - 24	22	1[b]	21 - 22									
OPAF	11	3	7 - 17	8	1	7 - 9	8	1	6 - 9	13	4	8 - 20			
OP2							14	1[c]	13 - 14	14	1	12 - 15	13	1[c]	12 - 14
ODF	14	1	13 - 15	16	1	15 - 16	16	1	15 - 16	15	1[f]	14 - 16			
OD							17	1[a]	16 - 18	16	1	13 - 18	15	1[c]	14 - 16
PV	25	1	24 - 27	26	0	25 - 26	26	1	26 - 27	25	2	21 - 27	23	1[c]	22 - 24
Total	39	1	38 - 40	40	1	39 - 41	40	1	39 - 41	39	1	36 - 40	39	1[c]	37 - 40
After PV	14	1	12 - 15	14	1	13 - 15	14	1	13 - 15	14	1	13 - 16	16	1[c]	15 - 16

[a] N = 8. [b] N = 2. [c] N = 6. [d] N = 3. [e] N = 4. [f] N = 5.

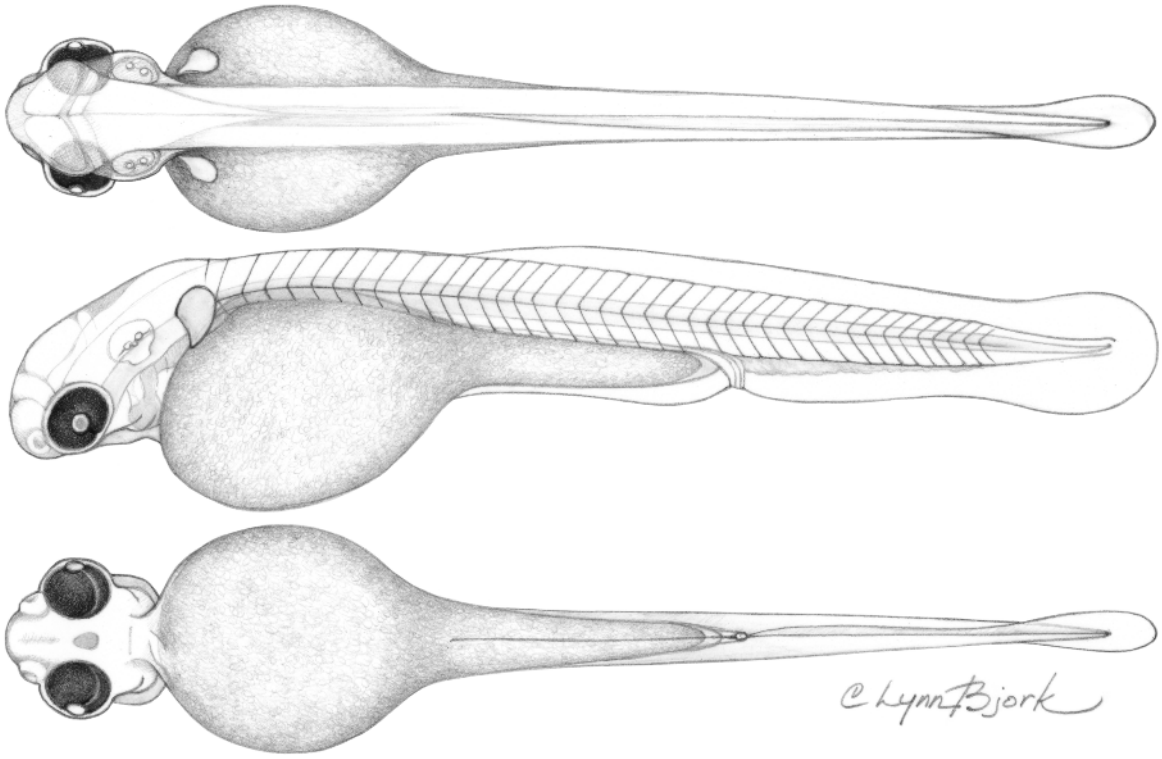

Fig. 3. *Plagopterus argentissimus* protolarva with yolk, recently hatched, 4.8 mm SL, 5.0 mm TL. (Cultured in 2009 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 110881.)

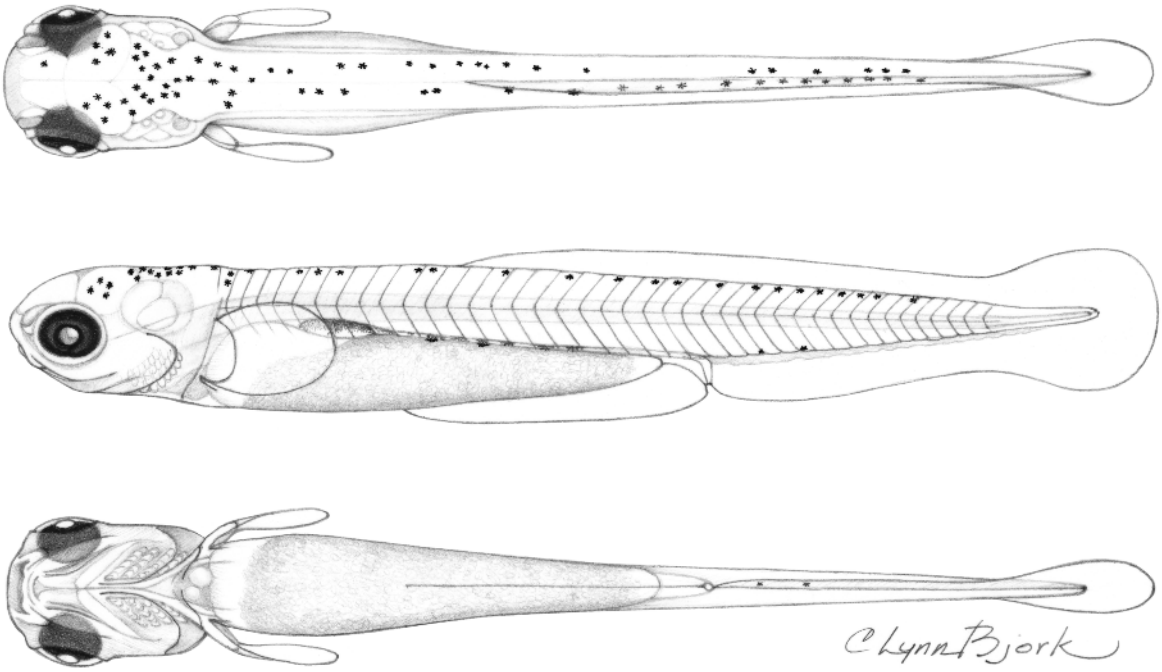

Fig. 4. *Plagopterus argentissimus* protolarva with yolk, 6.0 mm SL, 6.3 mm TL. (Cultured in 2009 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 110885.)

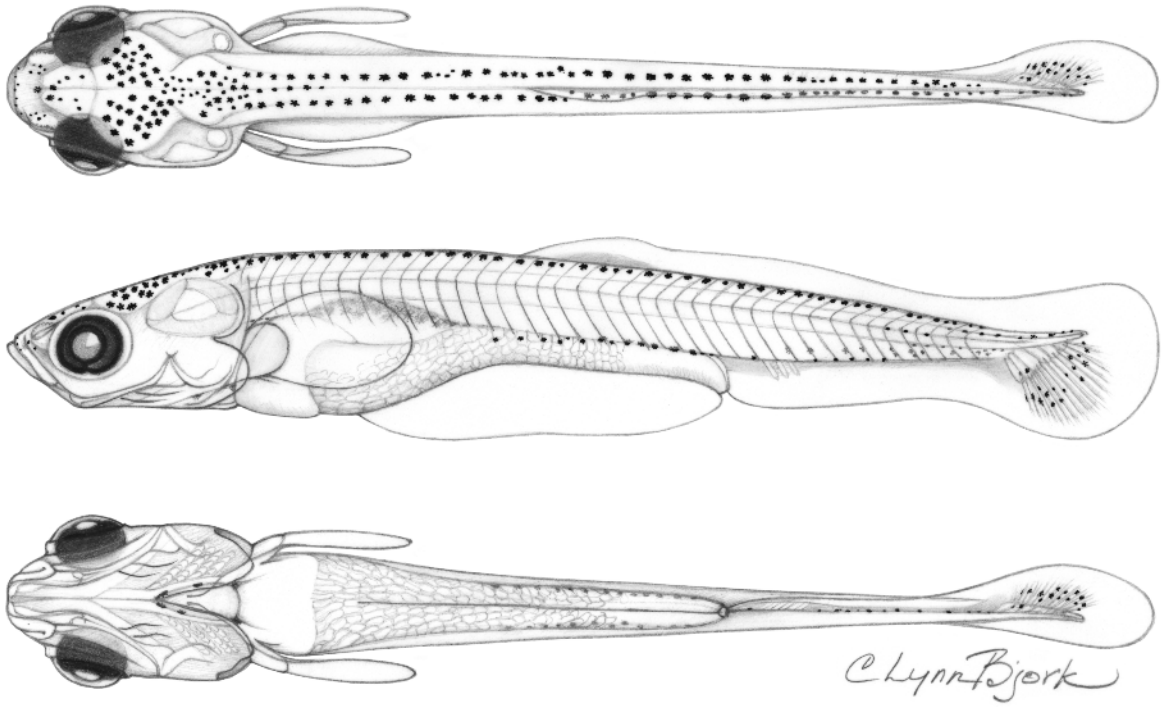

Fig. 5. *Plagopterus argentissimus* flexion mesolarva, 7.5 mm SL, 8.0 mm TL. (Cultured in 2009 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 110893.)

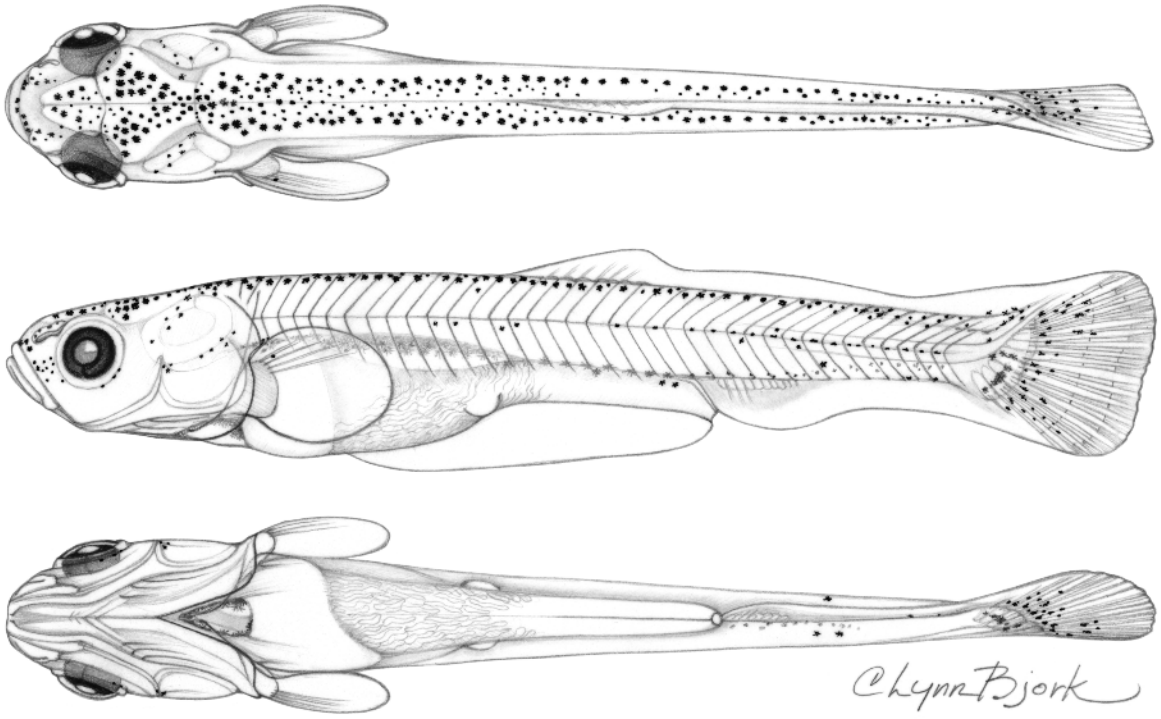

Fig. 6. *Plagopterus argentissimus* postflexion mesolarva, 9.6 mm SL, 10.7 mm TL. (Cultured in 2006 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 103104.)

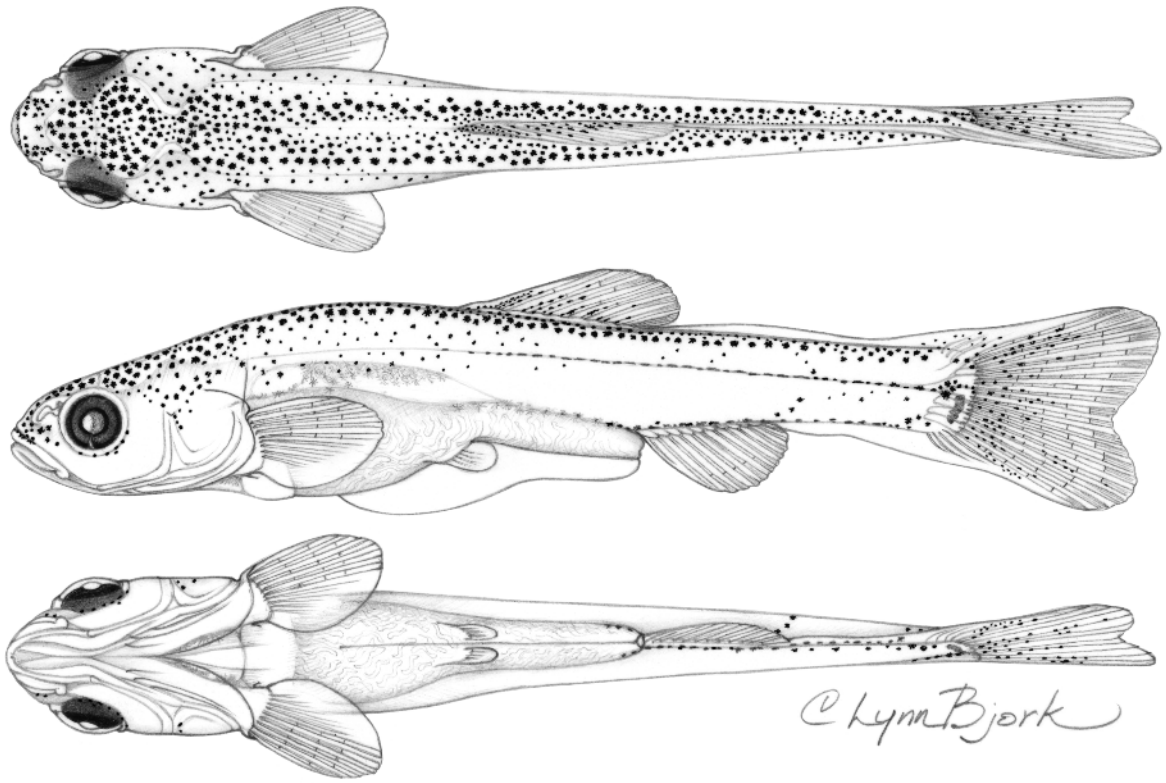

Fig. 7. *Plagopterus argentissimus* metalarva, recently transformed, 11.9 mm SL, 14.1 mm TL. (Cultured in 2006 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 103117.)

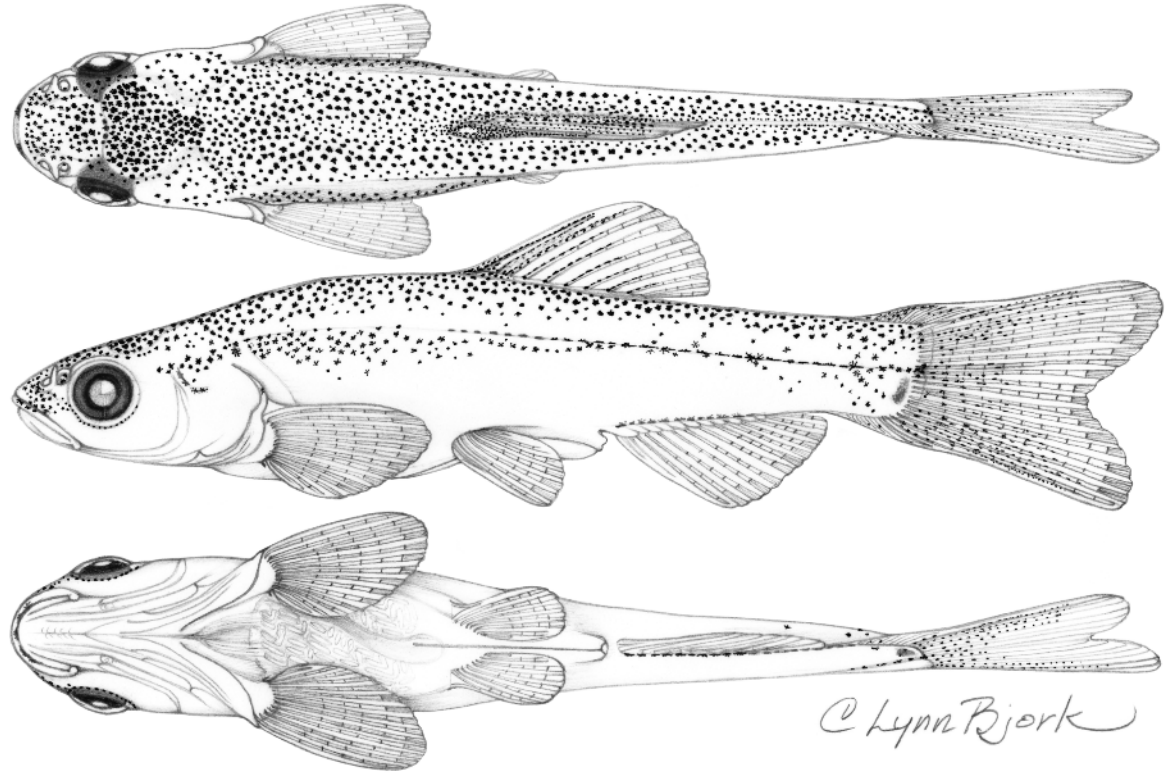

Fig. 8. *Plagopterus argentissimus* metalarva, 15.8 mm SL, 19.7 mm TL. (Cultured in 2006 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 103120.)

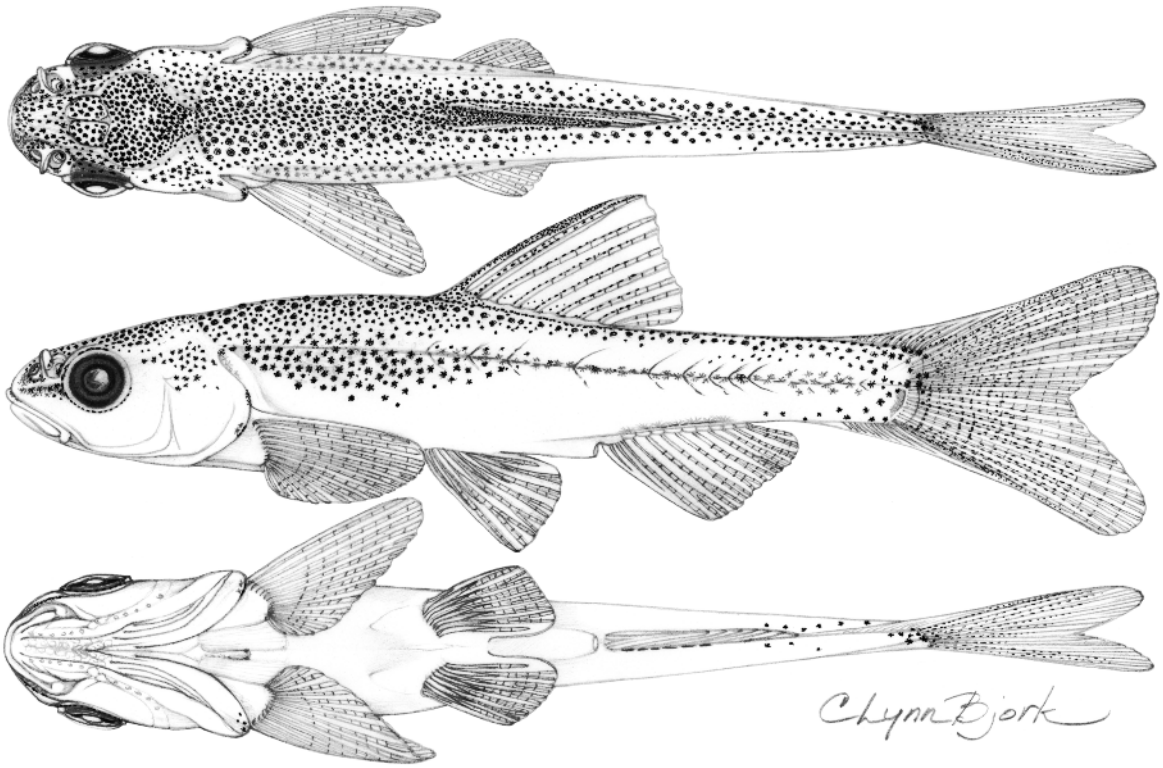

Fig. 9. *Plagopterus argentissimus* juvenile, recently transformed, 20.7 mm SL, 26.0 mm TL. (Cultured in 2009 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 110905.)

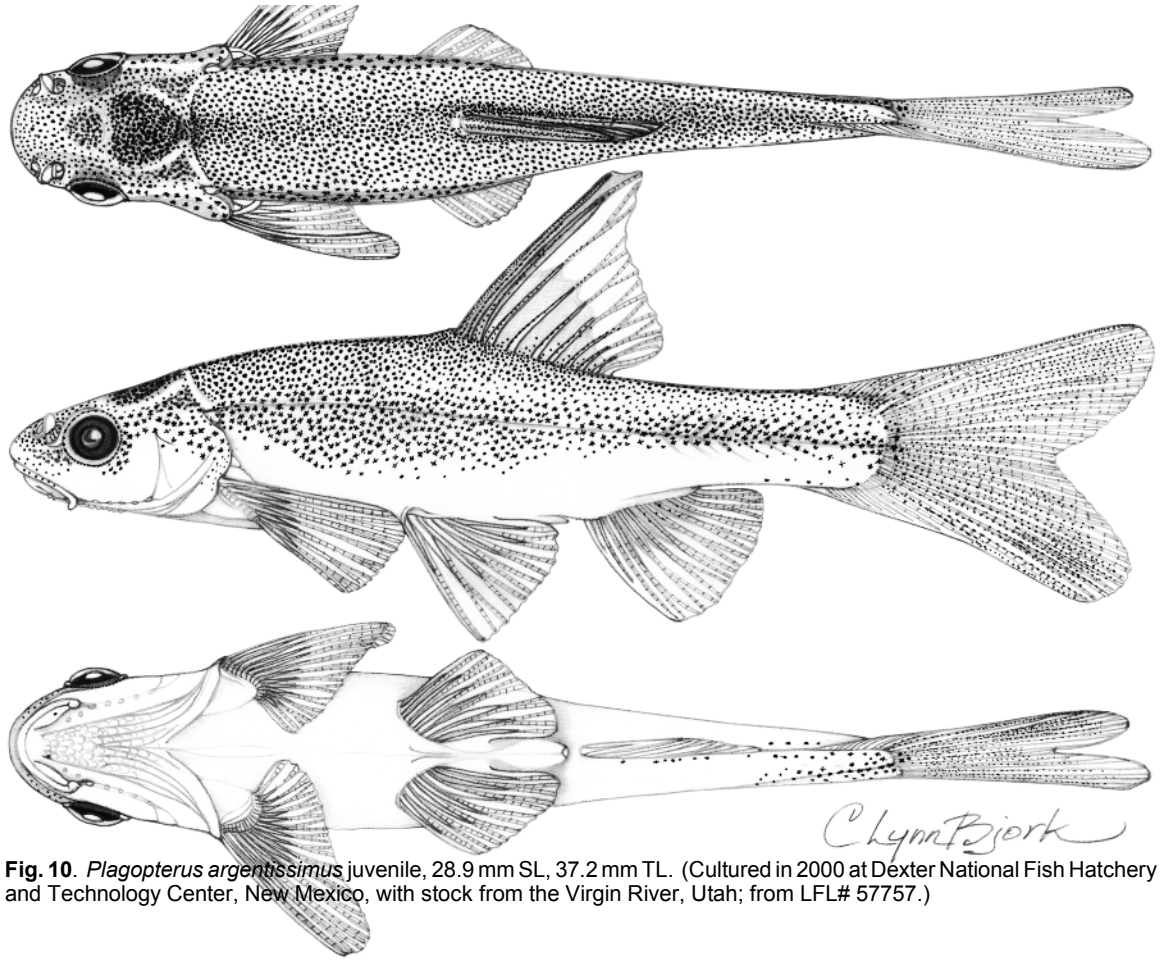

Fig. 10. *Plagopterus argentissimus* juvenile, 28.9 mm SL, 37.2 mm TL. (Cultured in 2000 at Dexter National Fish Hatchery and Technology Center, New Mexico, with stock from the Virgin River, Utah; from LFL# 57757.)

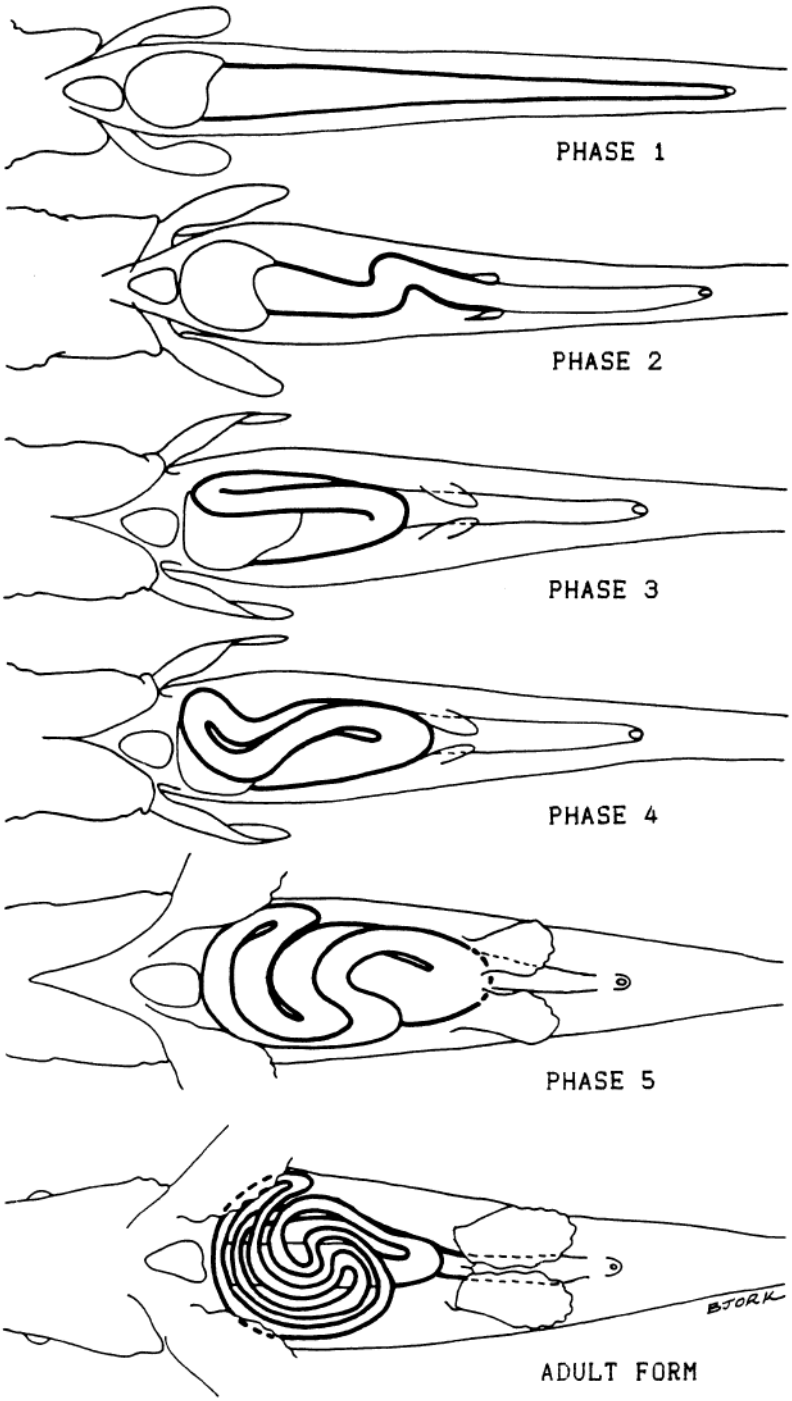

Fig. 11. Phases of gut coil development in catostomid fish larvae and early juveniles with comparison to adult form in *Catostomus commersonii* (latter modified from Stewart 1926). Phase 1 – essentially straight gut. Phase 2 – initial loop formation (usually on left side), begins with 90° bend. Phase 3 – full loop, begins with straight loop extending to near anterior end of visceral cavity. Phase 4 – partial fold and crossover, begins with crossing of first limb over ventral midline. Phase 5 – full fold and crossover, begins with both limbs of loop extending fully to opposite (usually right) side, four segments of gut cross nearly perpendicular to the body axis. Later in Phase 5 and in adult form, outer portions of gut folds or coils extend well up both sides of visceral cavity. (From Snyder and Muth 1988, Fig. 4, as reprinted in Snyder and Muth1990 and 2004, Fig. 5, and Snyder et al. 2005, Fig. 5.)

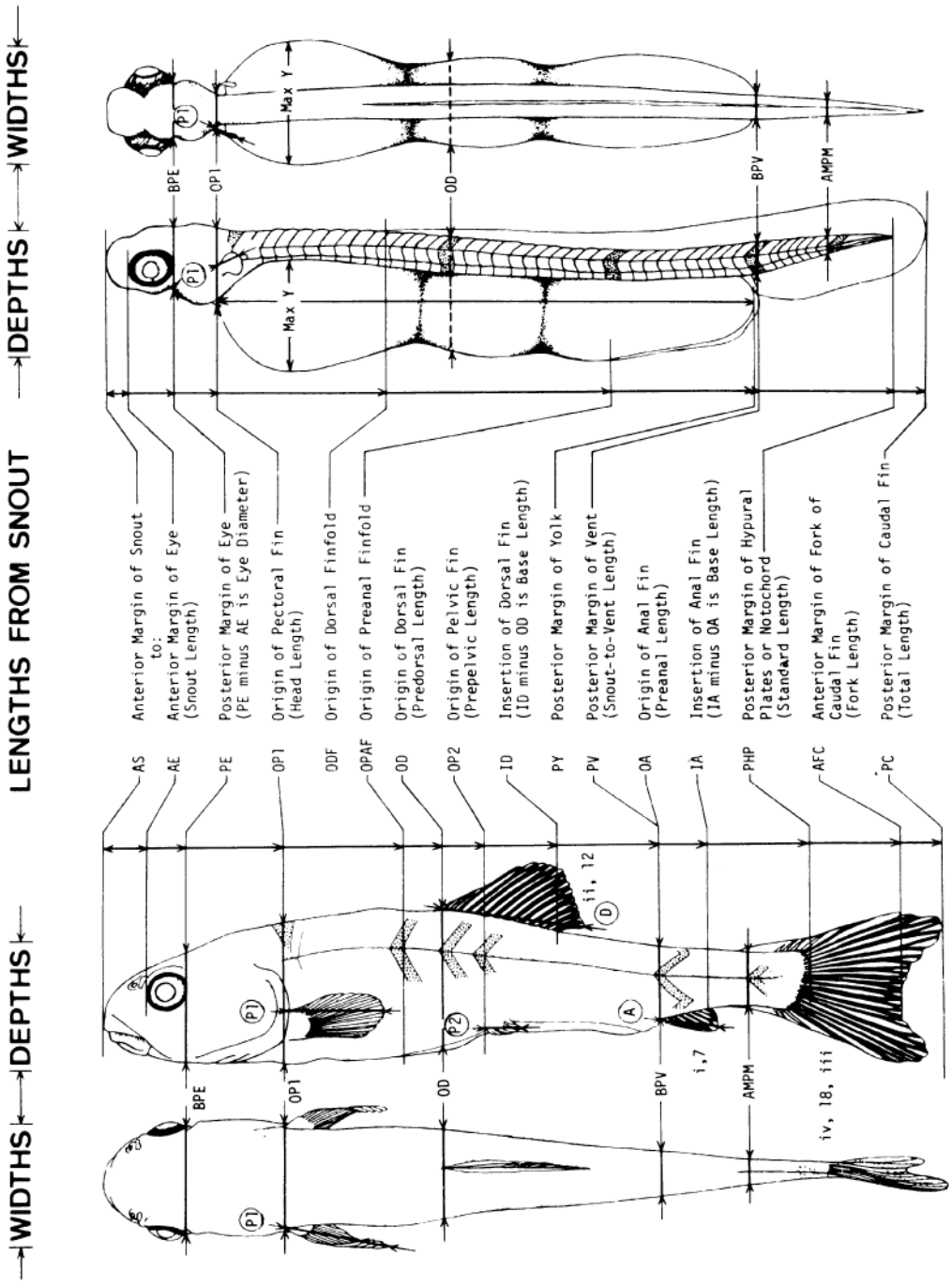

Fig. 12. Measures and counts for larval and early juvenile fishes. Yolk sac and pterygiophores are included in width and depth measures but fins and finfolds are not. "B" in BPE and BPV means immediately behind. AMPM is anterior margin of most posterior myomere. Location of width and depth measures at OD prior to D formation is approximated to that of later larvae. PHP is measured to end of notochord until adult complement of principal caudal-fin rays are observed. Fin lengths (D, A, P1, and P2, encircled) are measured along plane of fin from origin to most distal margin. When reported together, rudimentary median-fin rays (outlined above) are given in lower case Roman numerals, while principal median-fin rays (darkened above) are given in arabic numerals; rudimentary rays are not distinguished in paired fins. Most anterior, most posterior, and last myomeres in counts to specific points of reference are shaded above. (From Snyder 1981, Fig. 4, as reprinted in Snyder and Muth 1988, Fig 3, Snyder and Muth 1990 and 2004, Fig. 4, and Snyder et al. 2005, Fig. 4.)

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Personal Communication

Holden, Paul. Bio-West Inc., 1063 W. 1400 North, Logan, UT 84321 (verbal communication in late January 2010 at a Upper Colorado River Endangered Fishes Recovery Program Researcher's Meeting regarding observations of young woundfin greater than 15-20 mm TL in the wild having a distinctive iridescent blue coloration; communication verified by e-mail, 1 February 2011).

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