Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2009

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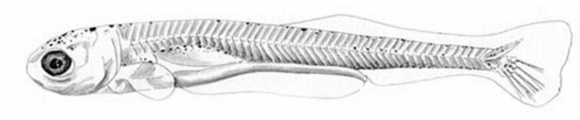
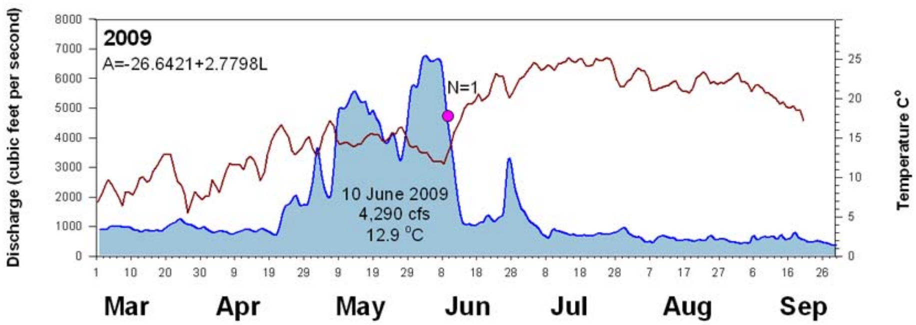
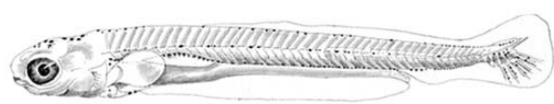
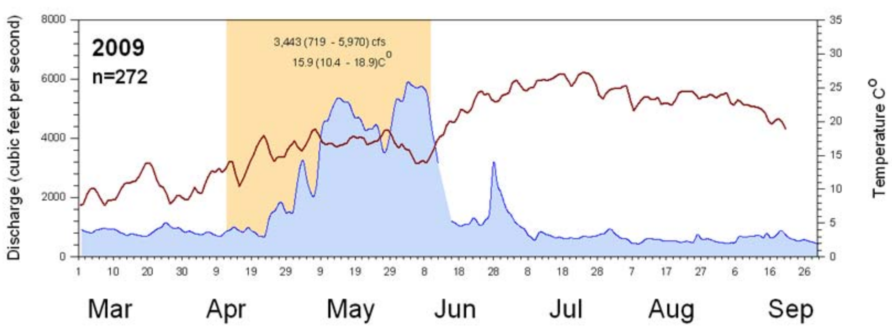


Colorado pikeminnow, *Ptychocheilus lucius*, larva





razorback sucker, *Xyrauchen texanus*, larva



illustrations by W.H. Brandenburg

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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

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submitted to:

San Juan River Basin Biology Committee
under the authority of the
San Juan River Basin Recovery Implementation Program

31 March 2010

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Executive Summary

1. From 13 April to 26 September 2009 six monthly larval fish survey trips were conducted between river miles 141.5 (Cudei, NM) and 2.9 (Clay Hills Crossing, UT) on the San Juan River.

2. During the study period mean daily discharge and water temperature in the San Juan River was 1,765 cfs (431 - 5,850 cfs) and 19.8^{o}C (9.6 - 27.0^{o}C) respectively.

3. A total of 339 collections were made encompassing 15,860.3 m^2 of low velocity habitat sampled.

4. The 2009 larval fish collections produced 72,403 fish representing seven families and 17 species.

5. Age-0 fish accounted for 97.0% of the total catch (n= 70,210) and had a riverwide mean catch rate of 371.1 (SE=44.3) fish per 100 m^2.

6. Red shiner was the numerically dominant (n=57,451) and most frequently encountered species during the 2009 larval fish survey.

7. Between 19 May and 18 June, 272 age-0 razorback sucker were collected in six different habitat types.

8. The back-calculated hatching dates for razorback sucker range from 12 April to 10 June 2009. Mean daily discharge and water temperature during that period was 3,443 cfs and 15.9^{o}C.

9. Age-0 razorback sucker consisted of mostly protolarvae and mesolarvae (n=30 and n=236, respectively). Two separate collections produced five metalarvae and a single juvenile in Reach 1.

9. A single larval Colorado pikeminnow was collected on 29 July 2009 in a backwater habitat at river mile 24.7.

10. The 25.2 mm TL Colorado pikeminnow was staged as late metalarvae (fin fold almost completely absorbed) and is the largest wild spawned Colorado pikeminnow that has been collected during the larval surveys.

11. The back-calculated spawn date for the age-0 Colorado pikeminnow was 10 June 2009 on the descending limb of the spring run-off hydrograph. Mean discharge and water temperature was 4,290 cfs and 12.9^{o}C respectively.

13. A total of 266 age-1+ (34–110 mm SL) Colorado pikeminnow were collected during the study period in 2009. It is presumed these fish were the result of augmentation efforts.

Introduction

Colorado pikeminnow, *Ptychocheilus lucius*, and razorback sucker, *Xyrauchen texanus,* are two endangered populations of cypriniform fishes native to the San Juan River, a large tributary of the Colorado River. The decline of these and other native fishes in the San Juan River has been attributed to flow modifications, the resultant changes to the thermal regime, and instream barriers. In addition, the introduction of non-native fishes may have altered predation dynamics and competition for habitat and resources (Ryden and Pfeifer, 1994; Clarkson and Childs, 2000).

Colorado pikeminnow (family Cyprinidae) was listed as an endangered species by the U.S. Department of the Interior in 1974. It is endemic to the Colorado River Basin where it was once abundant and widespread (Tyus, 1991). Currently this species occupies only about 20% of its historic range (Behnke and Benson, 1983; Tyus, 1990), with the majority of the remaining Upper Basin individuals occurring in the Green River (Holden and Wick, 1982; Bestgen et al., 1998). No Colorado pikeminnow have been reported in the Lower Basin since the 1960's (Minckley and Deacon, 1968; Minckley, 1973; Moyle, P. B. 2002).

Studies in the Upper Colorado River Basin (Yampa and Green Rivers) demonstrated that Colorado pikeminnow spawn on the descending limb of the summer hydrograph at water temperatures between 20 ^{o}C and 25 ^{o}C (Haynes et al., 1984; Nesler et al., 1988; Tyus, 1990). Larval Colorado pikeminnow employ drift as a dispersal mechanism and appear to begin this passive movement approximately five days after hatching. The five-day time frame corresponds with the swim-up period of this fish as reported by Hamman (1981, 1986). Drift of the newly hatched larval fishes counteract upstream migrations of the adults and disperses offspring to favorable nursery habitats downstream.

Razorback sucker (family Catostomidae) was listed as an endangered species in 1991. There are few historic San Juan River records of razorback sucker despite the fact that this is one of three endemic Colorado River Basin Catostomids. There are anecdotal reports from the late 1800's of razorback sucker occurring in the Animas River as far upstream as Durango, Colorado (Jordan, 1891). However, there are no specimens to substantiate this claim. The first verified record of razorback sucker in the San Juan River was in 1976 when two adult specimens were collected at an irrigation pond near Bluff, Utah (VTN Consolidated, Inc., and Museum of Northern Arizona, 1978).

Spawning of razorback sucker has been associated with the ascending limb of the hydrograph, peak spring discharge, and warming river temperatures. Adults congregate in riffles with cobble, gravel, and sand substrates. Spawning has been documented from mid-April to early June in the Green River at mean water temperatures of 14^{o}C (Tyus and Karp, 1990). Razorback sucker larvae have been collected from Lake Mohave at 9.5–15.0^{o}C, indicating successful incubation of eggs at these temperatures (Bozek et al., 1990). Spawning of razorback sucker coincides with spawning of other native Catostomids. Hybridization between flannelmouth sucker and razorback sucker have been documented where these two species co-occur (Douglas and Marsh, 1998; Tyus and Karp, 1990).

Mortality rates are substantial in the early ontogeny of fishes (Harvey ,1991; Jennings and Philipp, 1994). Biotic and abiotic factors often operate simultaneously and affect the survival rates of larval fishes. Starvation, the presence and duration of important environmental conditions, and biotic interactions such as competition and predation all affect the survival of larvae (Bestgen, 1996). Early-life mortality can be especially significant in populations of slow-growing fishes (Kaeding and Osmundson, 1988) such as Colorado pikeminnow and razorback sucker. Abiotic factors, such as water temperature and discharge, act as cues for spawning in adult fishes but also affect growth rates, available food supplies, and mortality rates, of their offspring (Miller et al., 1988).

Food production and competition for food resources, especially in limited nursery habitats, result in high mortality rates of larval fishes (Houde, 1987). These factors are compounded in modified systems with large numbers of non-native fishes. For example, the non-native red shiner, *Cyprinella lutrensis*, has been documented to prey on cypriniform larvae (Brandenburg and Gido, 1999; Bestgen, 2006). Red shiner comprise up to 80% of the ichthyofaunal community in nursery habitats in the San Juan River (Brandenburg and Farrington, 2004; Propst et al, 2003) and may have significant impacts on native fish populations.

To mitigate these negative effects, attempts to mimic natural flow regimes in regulated systems are used to maintain cues for activities such as spawning and migration of native fishes, creation and maintenance of nursery habitat for larval fishes, and suppression of non-native populations. Natural flow regimes also favor the downstream displacement or drifting behavior of larval fishes and exploitation of the most advantageous feeding and rearing areas (Muth and Schmulbach, 1984; Pavlov, 1994). In many western river systems, higher spring and early summer flows increase sediment transport and turbidity and have been shown to reduce predation of larvae (Johnson and Hines 1999). Sediment transport during high spring flows also scours substrates providing critical spawning habitat to native Catostomids (Osmundson et al., 2002).

Investigations into the reproductive success of Colorado pikeminnow began on the San Juan River using larval drift net surveys from 1991 to 2001. During that period of passive sampling only six larval Colorado pikeminnow were collected (Table 1).

Table 1. Summary of larval Colorado pikeminnow collected in the San Juan River (1993-2008) and back-calculated dates of spawning.

Field Number	MSB Catalog Number	Number specimens	Total Length mm	Date Collected	Date Spawned	River Mile	Sample Method
MH72693-2	18098	1	9.2	26 Jul 93	08 Jul 93	53.0	drift netting
MH72793-2	18099	1	9.2	27 Jul 93	09 Jul 93	53.0	drift netting
JPS95-205	26187	1	9.2	02 Aug 95	15 Jul 95	53.0	drift netting
JPS95-207	26191	1	9.0	03 Aug 95	17 Jul 95	53.0	drift netting
WHB96-037	29717	1	8.6	02 Aug 96	18 Jul 96	128.0	drift netting
FC01-054	50194	1	8.5	01 Aug 01	17 Jul 01	128.0	drift netting
MAF04-046	53090	1	14.2	22 Jul 04	24 Jun 04	46.3	larval seine
MAF04-059	53130	1	18.1	26 Jul 04	25 Jun 04	17.0	larval seine
MAF07-139	70144	1	14.9	25 Jul 07	27 Jun 07	107.7	larval seine
MAF07-157	70145	1	17.5	27 Jul 07	27 Jun 07	74.9	larval seine
WHB07-078	64032	1	15.6	25 Jul 07	27 Jun 07	33.7	larval seine
TOTAL		11					

Beginning in 2002, the sampling protocol was switched to active collection of larval fishes using larval seines and utilizing a raft to navigate the San Juan River. Using this active approach a total of five larval Colorado pikeminnow were collected in 2004 and 2008.

Larval surveys using the same active sampling methods as that for the larval Colorado pikeminnow survey began in 1998 on the San Juan River in an attempt to document reproduction of stocked razorback sucker. The 1998 survey produced the first documentation of reproduction by stocked razorback sucker. Larval razorback sucker have been documented every year since (Table 2).

Objectives

This work was conducted as required by the San Juan River Basin Implementation Program Long Range Plan (2009). The goals and objectives of this specific monitoring project are identified in the aforementioned document and listed below:

5.1.1.2 Analyze and evaluate monitoring data and produce annual reports.
5.1.2.1 Conduct larval fish studies to determine if reproduction is occurring, locate spawning and nursery areas, and gauge the extent of annual reproduction of endangered fish populations.
5.1.2.4 Continue to collect catch rate data (CPUE) and statistics to estimate relative abundance of endangered fish populations.
5.1.4.1 Monitor other native and non-native fish populations.
5.2.3.2 Identify principle river reaches and habitats used by various life stages of endangered fish.

Table 2. Summary of larval and YOY razorback sucker collected in the San Juan River (1998-2008).

Year	Study Area	Project Dates	Effort m^2	Xyrtex	Sample Method
1998	127.5 - 53.0	17 Apr - 6 Jun	-	2	larval seine/ light trap
1999	127.5 - 2.9	5 Apr - 10 Jun	2,713.5	7	larval seine/ light trap
2000	127.5 - 2.9	4 Apr - 23 Jun	2,924.6	129	larval seine/ light trap
2001	141.5 - 2.9	10 Apr - 14 Jun	5,733.1	50	larval seine/ light trap
2002	141.5 - 2.9	15 Apr - 12 Sep	9,647.5	815	larval seine/ light trap
2003	141.5 - 2.9	15 Apr - 19 Sep	13,564.6	472	larval seine
2004	141.5 - 2.9	19 Apr - 14 Sep	11,820.3	41	larval seine
2005	141.5 - 2.9	19 Apr - 14 Sep	10,368.6	19	larval seine
2006	141.5 - 2.9	17 Apr - 15 Sep	12,582.6	202	larval seine
2007	141.5 - 2.9	16 Apr - 19 Sep	13,436.0	200	larval seine
2008	141.5 - 2.9	14 Apr - 13 Sep	14,292.3	126	larval seine
TOTAL				2,063	

Study Area

The San Juan River is a major tributary of the Colorado River and drains 38,300 mi^2 in Colorado, New Mexico, Utah, and Arizona (Figure 1). The major perennial tributaries to the San

Juan River are (from upstream to downstream) Navajo, Piedra, Los Pinos, Animas, La Plata, Mancos Rivers, and McElmo Creek. In addition there are numerous ephemeral arroyos and washes that contribute relatively little flow annually but input large sediment loads during rain events.

The San Juan River is currently a 224 mile lotic system bounded by two reservoirs (Navajo Reservoir near its head and Lake Powell at its mouth). From Navajo Dam to Lake Powell, the mean gradient of the San Juan River is 10.1 ft/mi, but can be as high as 21.2 ft/mi. Except in canyon-bound reaches, the river is bordered by non-native salt cedar, *Tamarix chinensis*, Russian olive, *Elaeagnus angustifolia*, native cottonwood, *Populus fremontii*, and willow, *Salix* sp. Non-native woody plants dominate nearly all sites and result in heavily stabilized banks. Cottonwood and willow accounted for less than 15% of the riparian vegetation.

The characteristic annual hydrographic pattern in the San Juan River is typical of rivers in the American Southwest, with large flows during spring snowmelt followed by low summer, autumn, and winter base flows. Summer and early autumn base flows are frequently punctuated by convective storm-induced flow spikes. Prior to operation of Navajo Dam, about 73% of the total annual San Juan River drainage discharge (based on USGS Gauge # 9379500; Bluff, Utah) occurred during spring runoff (1 March through 31 July). Mean daily peak discharge during spring runoff was 10,400 cfs (range = 3,810 to 33,800 cfs). Although flows resulting from summer and autumn storms contributed a comparatively small volume to total annual discharge, the magnitude of storm-induced flows exceeded the peak snowmelt discharge in about 30% of the years, occasionally exceeding 40,000 cfs (mean daily discharge). Both the magnitude and frequency of these storm induced flow spikes are greater than those recorded in the Green or Colorado Rivers.

Operation of Navajo Dam altered the annual discharge pattern of the San Juan River. The natural flow of the Animas River ameliorated some aspects of regulated discharge by augmenting spring discharge. Regulation resulted in reduced magnitude and increased duration of spring runoff in wet years and substantially reduced magnitude and duration of spring flow during dry years. Overall, flow regulation by operation of Navajo Dam has resulted in post-dam peak spring discharge averaging about 54% of pre-dam values. Conversely, post-dam base flow increased markedly over pre-dam base flows. Since 1992 efforts have been made, not always successful, to operate Navajo Dam in an attempt to mimic a “natural” annual flow regime.

Methods

Access to the river and collection localities was gained through the use of 16' inflatable rafts that transported both personnel and collecting gear. There was not a predetermined number of collections per river mile or geomorphic reach for this study. Instead, collections were made in as many suitable larval fish habitats as possible within the river reach being sampled. Previous San Juan River investigations clearly demonstrated that larval fish most frequently occur and are most abundant in low velocity habitats such as pools and backwaters (Lashmett 1993). Sampling of the entire study area is done during a single week in which the study area is divided into an “upper” section (Cudei, NM to Mexican Hat, UT) and a “lower” section (Mexican Hat, UT to Clay Hills, UT [Figure 2]). Sampling trips for both portions of the study area were initiated on the same day.

Collecting efforts for larval fish concentrated on low velocity habitats using small mesh larval fish seines (1 m x 1 m x 0.8 mm). Several seine hauls (between 3 and 12) were made through an individual mesohabitat depending on the size of that habitat. Fishes collected within an individual mesohabitat were preserved together. For each site collection, the length (in

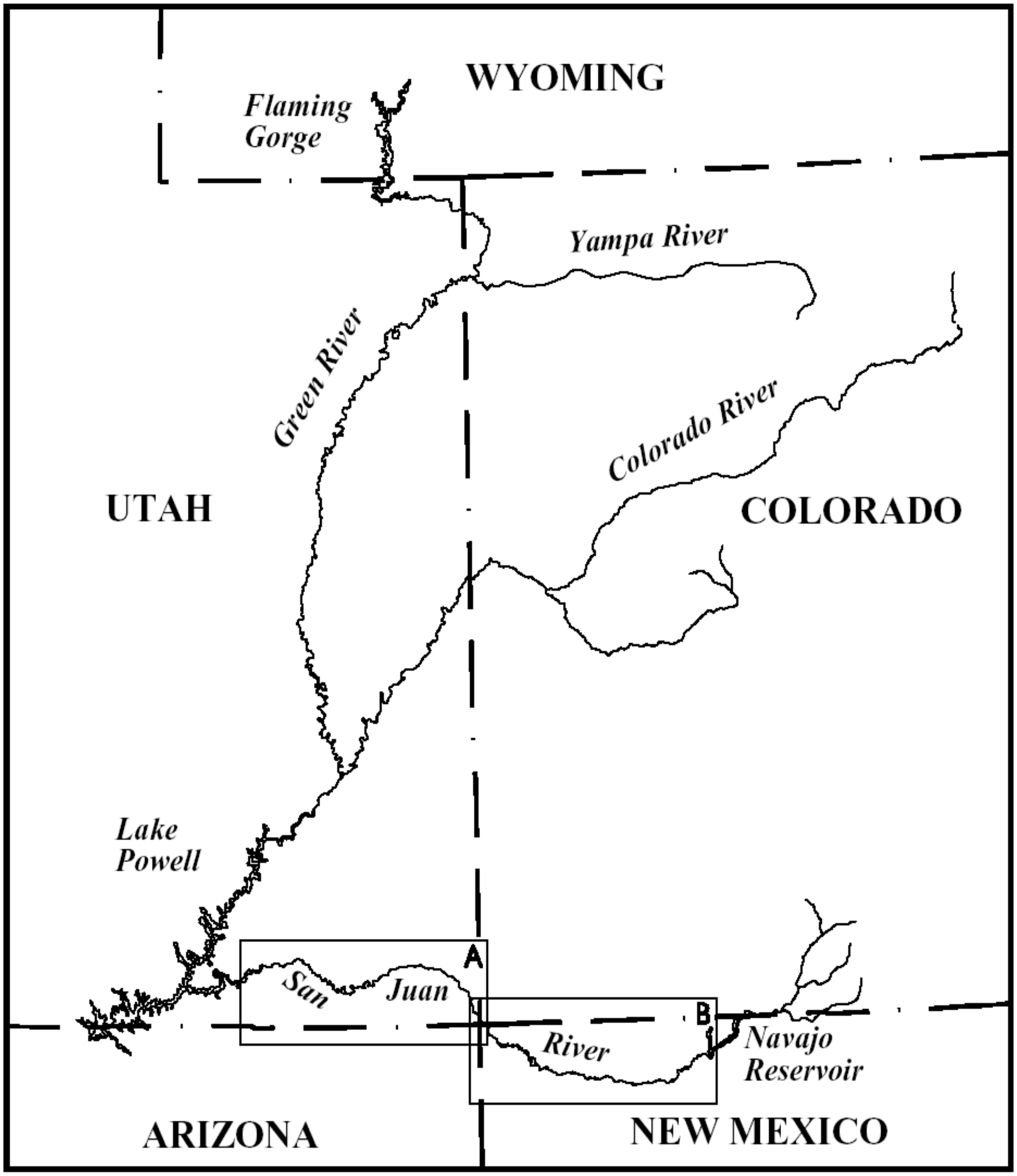

Figure 1. Location of the San Juan River within the Upper Colorado River Basin. The study area is outlined and labelled "A" and "B" with reference to subsequent maps in this report.

meters) of each seine haul was determined in addition to the number of seine hauls per site. Mesohabitat type, length, maximum depth, substrate, and turbidity (using a secchi disk) were recorded in the field data sheet for the particular collecting site (Appendix IV). Water quality measurements (dissolved oxygen, conductivity, salinity, and temperature) were obtained using a multi-parameter YSI-85 water quality meter. Water quality parameters were measured to a minimum of a tenth of a unit. Habitat designations used in this report follow those of Bliesner et al. (2008). A minimum of one digital photograph was recorded at each collection site.

River mile was determined to tenth of a mile using the 2008 standardized aerial maps produced for the San Juan River Basin Recovery Implementation Program and used to designate the location of collecting sites. In addition, geographic coordinates were determined at each site with a Garmin Navigation Geographic Positioning System (GPS) unit and were recorded in Universal Transverse Mercator (UTM) Zone 12 (NAD27). In instances where coordinates could not be obtained due to poor GPS satellite signal, coordinates were determined in the laboratory using a Geographic Information System based on the recorded river mile.

All retained specimens were placed in plastic bags (Whirl-Paks) containing a solution of 100% ethyl alcohol and a tag inscribed with unique alpha-numeric code that was also recorded on the field data sheet. Samples were returned to the laboratory where they were sorted and identified to species. Specimens were identified by personnel with expertise in San Juan River Basin larval fish identification. Underlit stereo-microscopes with polarized light filters were used to aid in identification of larval individuals. Age-0 specimens were separated from age-1+ specimens using published literature to define growth and development rates for individual species (Snyder, 1981, Snyder and Muth, 2004). Both age classes were enumerated, measured (minimum and maximum size [mm standard length] for each species at each site), and catalogued in the Division of Fishes of the Museum of Southwestern Biology (MSB) at the University of New Mexico (UNM).

Results reported in this document pertain to age-0 fishes. Raw numbers of age-0 and age-1+ fishes are presented in Appendices I and II. Scientific and common names of fishes used in this report follow Nelson et al. (2006) while six letter codes for species are those adopted by the San Juan River Basin Biology Committee (Table 3). Total length (TL) and standard length (SL) were measured on all Colorado pikeminnow and razorback sucker to be consistent with information gathered by the San Juan River Basin and Upper Colorado River Basin programs [Appendix III]. Within this report, lengths of these species are given as TL.

The term young-of-year (YOY) can include both larval and juvenile fishes. It refers to any fish, regardless of developmental stage, between hatching or parturition and the date (1 January) that they reach age 1 (i.e., YOY = age-0 fish). Larval fish is a specific developmental (morphogenetic) period between the time of hatching and when larval fish transform to juvenile fish. The larval fish terminology used in this report is defined by Snyder (1981). There are three distinct sequential larval developmental stages: protolarvae, mesolarvae, and metalarvae. Fishes in any of these developmental stages are referred to as larvae or larval fishes. Juvenile fishes are those that have progressed beyond the metalarvae stage and no longer retain traits characteristic of larval fishes. Juveniles were classified as individuals that 1) had completely absorbed their fin folds, 2) had developed the full adult complement of rays and spines, and 3) had developed segmentation in at least a few of the rays.

Only larval specimens (protolarvae, mesolarvae, and metalarvae) were used to generate the larval occurrence graph (Figure 5). The period of larval occurrence was determined by recording the first collection of larval fish within a given year for each species as the initial occurrence. The cessation of larval occurrence was developed using the mean standard length of transformation from metalarvae to juvenile as a cut off (Snyder,1981, 2003). Larval occurrence was then plotted against discharge recorded at Bluff, UT (USGS gauge #9379500) and water temperature recorded

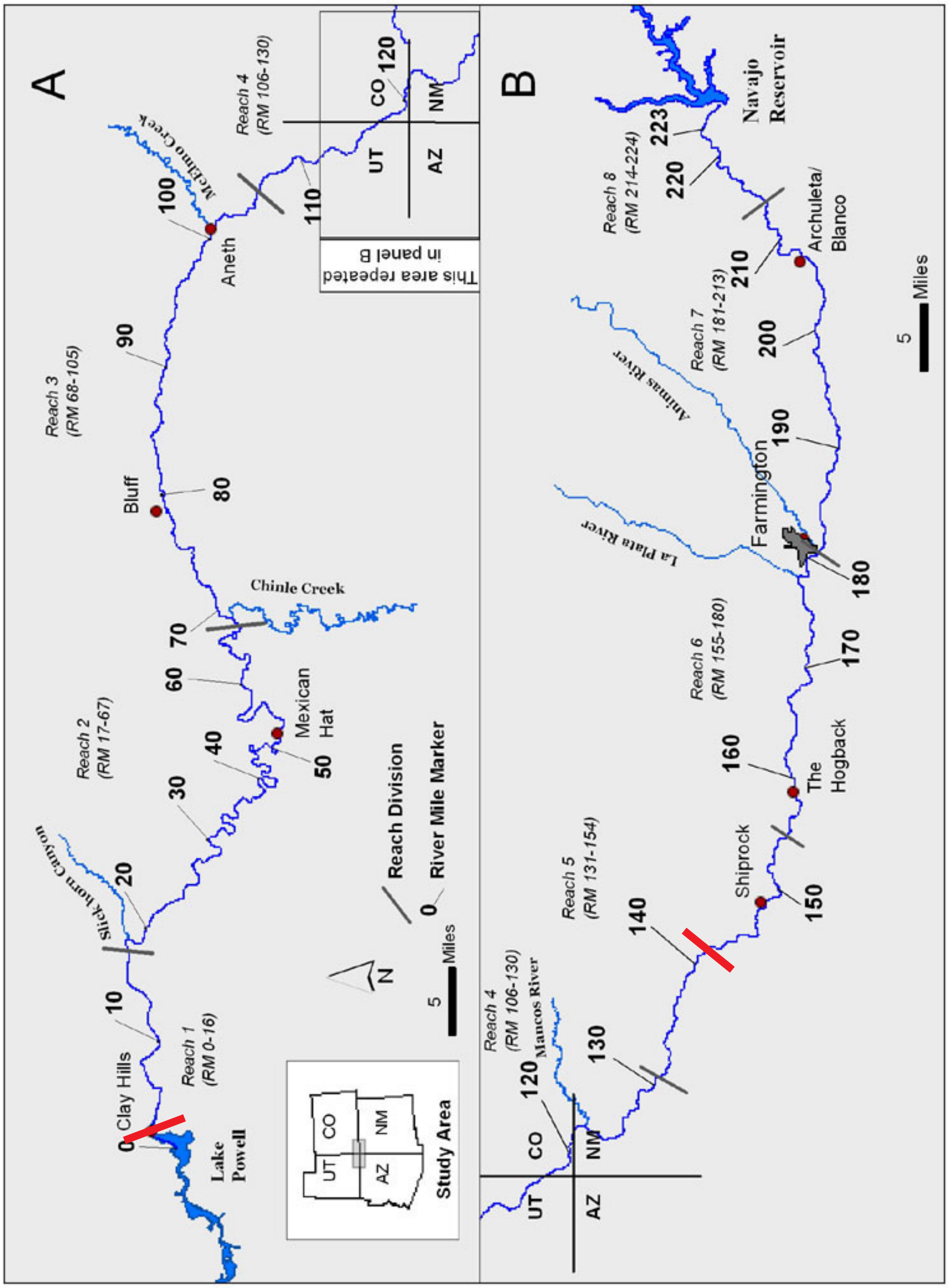

Figure 2. Map of the San Juan River. Study area is delineated by red bars (Cudei, NM river mile 141.5 and Clay Hills Crossing, UT (river mile 2.9).

Table 3. Scientific and common names and species codes of fish collected from the San Juan River. Asterisk (*) indicates species collected in previous years, but absent from 2009 samples.

Scientific Name	Common Name	Code
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Cyprinella lutrensis	red shiner	(CYPLUT)
Cyprinus carpio	common carp	(CYPCAR)
*Gila robusta**	roundtail chub	(GILROB)
Pimephales promelas	fathead minnow	(PIMPRO)
Ptychocheilus lucius	Colorado pikeminnow	(PTYLUC)
Rhinichthys osculus	speckled dace	(RHIOSC)
Family Catostomidae	suckers	
Catostomus (Pantosteus) discobolus	bluehead sucker	(CATDIS)
Catostomus latipinnis	flannelmouth sucker	(CATLAT)
Xyrauchen texanus	razorback sucker	(XYRTEX)
Order Siluriformes		
Family Ictaluridae	catfishes	
Ameiurus melas	black bullhead	(AMEMEL)
*Ameiurus natalis**	yellow bullhead	(AMENAT)
Ictalurus punctatus	channel catfish	(ICTPUN)
Order Salmoniformes		
Family Salmonidae	trouts	
Salmo trutta	brown trout	(SALTRU)
Order Cyprinodontiformes		
Family Fundulidae	killifishes	
Fundulus zebrinus	plains killifish	(FUNZEB)
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(GAMAFF)
Order Perciformes		
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(LEPCYA)
*Lepomis macrochirus**	bluegill	(LEPMAC)
Micropterus salmoides	largemouth bass	(MICSAL)

at Mexican Hat, UT to describe an approximation for the timing and duration of larval occurrence within the San Juan River.

Differences in mean CPUE were determined by species between years, trips and reaches using a one-way Analysis of Variance (ANOVA). A Poisson Distribution provided the best fit to the raw data. A variety of transformations (e.g., logarithmic, reciprocal, square root) were applied on the mean CPUE data for between year comparisons. A natural log transformation yielded the best variance-stabilizing qualities and produced a relatively normal distribution. Pair-wise comparisons between years (2003–2009), trips and reaches were made for each species and significance (i.e., $p<0.05$) was determined using the Tukey-Kramer HSD test. The exception is annual trends in larval razorback sucker where catch rates were analyses from 1999 -2009 using only the months April - June. This was done in an effort to include the larval surveys conducted between 1999 - 2001 when the study period ended in June. Finally, a nonparametric Analysis of Variance (Kruskal–Wallis test) was run for the various data sets to compare results to the parametric analyses.

Although both ANOVA and Kruskal-Wallis were used to analyze data, data transforms enabled use of parametric analysis in all cases. The assumption of homogeneity of variances was assessed using the more conservative variance ratio criterion of <3:1 (Box, 1954), as opposed to <4:1 (Moore, 1995), among years. All species data sets met this more rigorous criterion and in most cases the variance ratio was <2:1 among years. Additionally, the significance values between parametric and nonparametric techniques were nearly identical and so only the parametric analysis will be presented.

Hatching dates were calculated for larval Colorado pikeminnow using the formula: $-76.7105+17.4949(L)-1.0555(L)^2+0.0221(L)^3$ for larvae under 22 mm TL, where L=length (mm TL). For specimens 22-47mm TL the formula $A= -26.6421+2.7798L$ is used. Spawning dates were then calculated by adding five days to the post-hatch ages to account for incubation time at 20 - 22°C (Nesler et al., 1988). Hatch dates of razorback sucker larvae were calculated by subtracting the average length of larvae at hatching (8.0 mm TL) from the total length at capture divided by 0.3 mm (Bestgen et al., 2002), which was the average daily growth rate of wild larvae observed by Muth et al. (1998). The back-calculated hatching formula was only applied to proto- and mesolarvae as growth rates become much more variable at later developmental stages (Bestgen 2008).

Habitat occupancy graphs were generated using log transformed mean CPUE in order to measure density of age-0 species within sampled habitats. The larval surveys adopted the standardized habitat designation beginning in 2005. Data collected prior to 2005 were not used in this analysis.

This study was initiated prior to spring runoff and completed near the end of the summer season (late September). Daily mean discharge during the study period was acquired from U.S. Geological Survey Gauges (#09371010) near Four Corners, Colorado and (#09379500) near Bluff, Utah. Bluff discharge and temperature was used for all data analysis in this report except for back-calculated spawning data of Colorado pikeminnow in which Four Corners discharge and temperature was used. Temperature data (mean, max, min) was supplied by Keller-Bliesner Engineering and taken at the state highway 160 bridge crossing in Colorado (river mile 119.2) and Mexican Hat, Utah (river mile 52.0). Additional temperature loggers were placed by larval survey crews in Reach 4 (RM 127.5), McElmo Creek (RM 100.5) and Clay Hills Crossing (RM 2.9 {Appendix I Table X]).

Results

2009 Summary

The 2009 San Juan River larval fish survey encompassed a six month period from 13 April to 26 September 2009. Monthly trips were conducted from river mile 141.5 (Cudei, New Mexico) to river mile 2.9 (Clay Hills Crossing, Utah). During the study period, the mean daily discharge and water temperature was 1,764 cfs (431 – 5,850 cfs) and 19.8°C (9.6 - 27.0°C) [USGS bluff gauge #9379500]. Spring runoff began on 24 April 2009. Discharge peaked forty-one days later at 5,850 cfs on 3 June 2009 (Figure 3). The descending limb of the spring run-off dropped over a twelve day period following the peak. There was a total of fifteen days that the San Juan River flowed above 5,000 cfs. Increasing spring river temperatures were suppressed during spring runoff for a period of one month (8 May - 8 June 2009). Mean water temperatures during this period was 16.8 C° (13.8 C° – 18.9C°). The release from Navajo Dam did not match the peak in run-off from the Animas River creating two peaks in the hydrograph.

A total of 339 collections were made during the 2009 larval survey. Combined, the total area of zero and low velocity habitat sampled comprised 15,860.3 m^2. A total of 72,403 fish were collected during the 2009 survey representing seven families comprised of 17 species. Age-0, or YOY fish, accounted for 97.0% of the total catch (n= 70,210). Age-0 fish were collected five of the six months sampled (May–September) and had a mean CPUE of 371.1 fish per 100 m^2, SE=44.3 (appendix II, Table 4). Of the native species occurring in the San Juan River speckled dace had the highest mean CPUE (24.2 fish per 100 m^2, SE=5.8). Native catostomids comprised 6.6% of the total catch by number during the 2009 larval survey. Flannelmouth sucker had the highest mean CPUE of the three native suckers (18.2 fish per 100 m^2, SE=4.6).

Documentation of spawning of all native species except Colorado pikeminnow occurred during the May survey and occurred throughout the five reaches of the study area. The June survey was the last occurrence of larval razorback sucker, while collection of the other larval catostomid species continued into July and August (Figure 4). No larval fish were collected during the April survey. In all years prior to 2008 larval catostomids, particularly flannelmouth sucker, were first collected during the April portion of the survey (Brandenburg and Farrington 2008). Larval speckled dace and fathead minnow had the most protracted period of larval occurrence within the study area extending nearly to the end of the study period. Larval red shiner had a truncated period of larval occurrence from late July to the end of the study period. Larval channel catfish were only collected during the July survey. Juvenile channel catfish were subsequently collected in both August and September.

2009 Trip Summary

The first survey trip (13-18 April 2009) was conducted prior to spring runoff. Mean daily discharge and water temperature during this period was 1,120 cfs and 12.0°C respectively. A total of 56 discrete habitats were sampled throughout the study area for a total effort of 2,038 m^2. No larval or age-0 fish were collected during the April survey. The only other year in which larval fishes were not represented during the April survey occurred in 2008.

The second larval survey (18–22 May 2009) took place during the high flows of spring runoff. The mean discharge during the May survey was 4,624 cfs and the mean water temperature was 16.5°C. The elevated discharge filled dry washes and expanded existing backwaters throughout the study area. Larvae of all three native suckers were collected throughout the five reaches (Figure 5). During this trip, flannelmouth sucker had the highest mean catch rate of any species (96.7 fish per 100 m^2, SE=25.9). Reach 4 had the highest

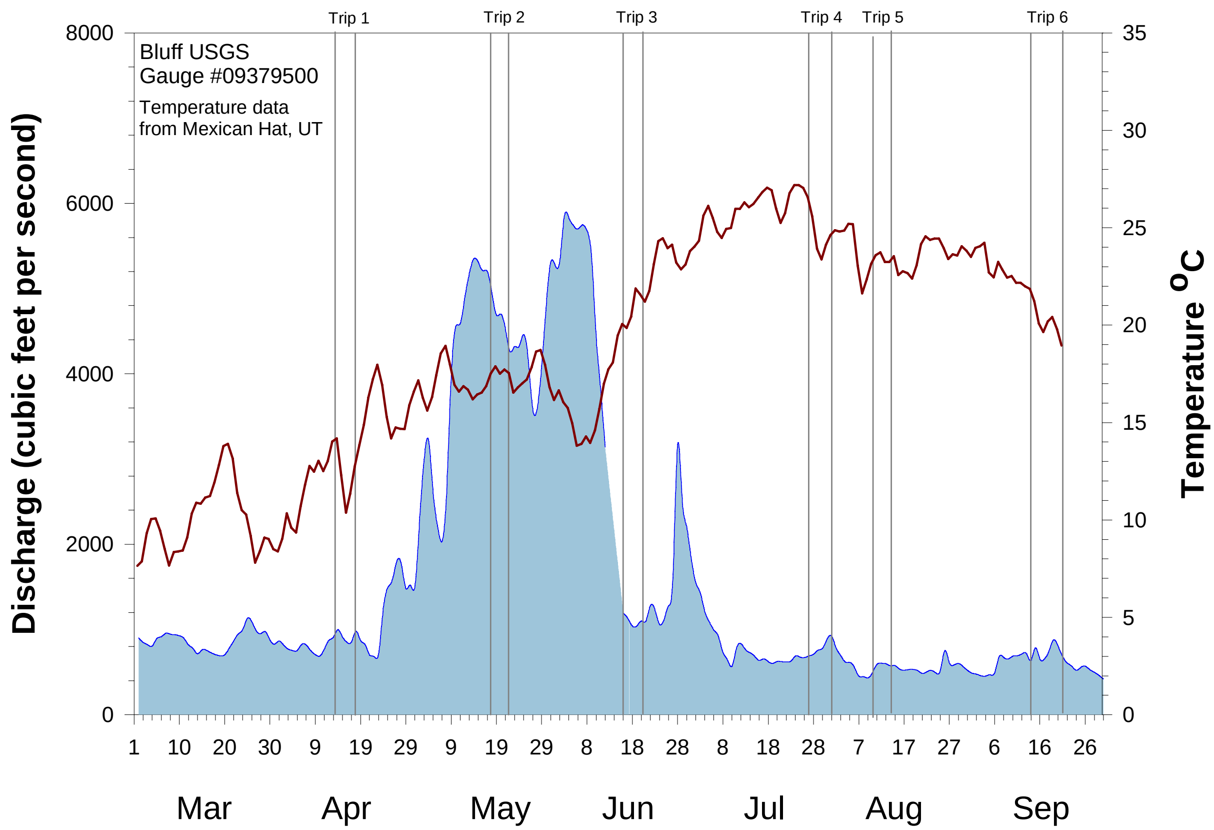

Figure 3. Discharge (cfs) at Bluff, UT (USGS gauge #9379500) and water temperature (°C) at Mexican Hat, UT in the San Juan River during the 2009 sampling period. Grey vertical bars denote individual collecting trips. The blue area represents discharge and the red line represents water temperature.

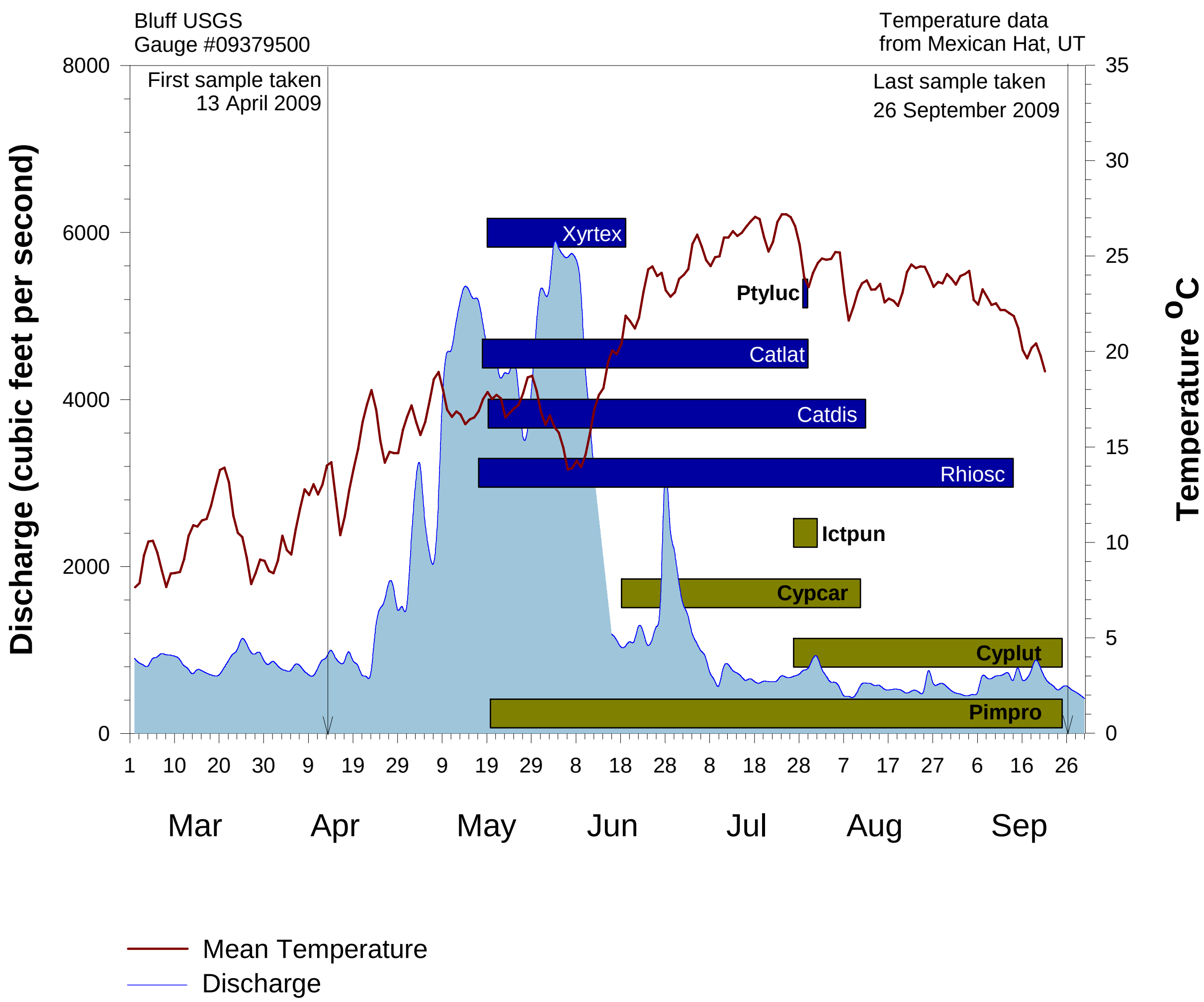

Figure 4. Occurrence of larval fishes in the San Juan River during 2009 plotted against discharge (Bluff, UT USGS gauge #9379500) and water temperature (Mexican Hat, UT). Bars represent the period between date of first and last collection of larvae for each species. Blue bars denote native species, Yellow bars denote numerically dominant non-native species.

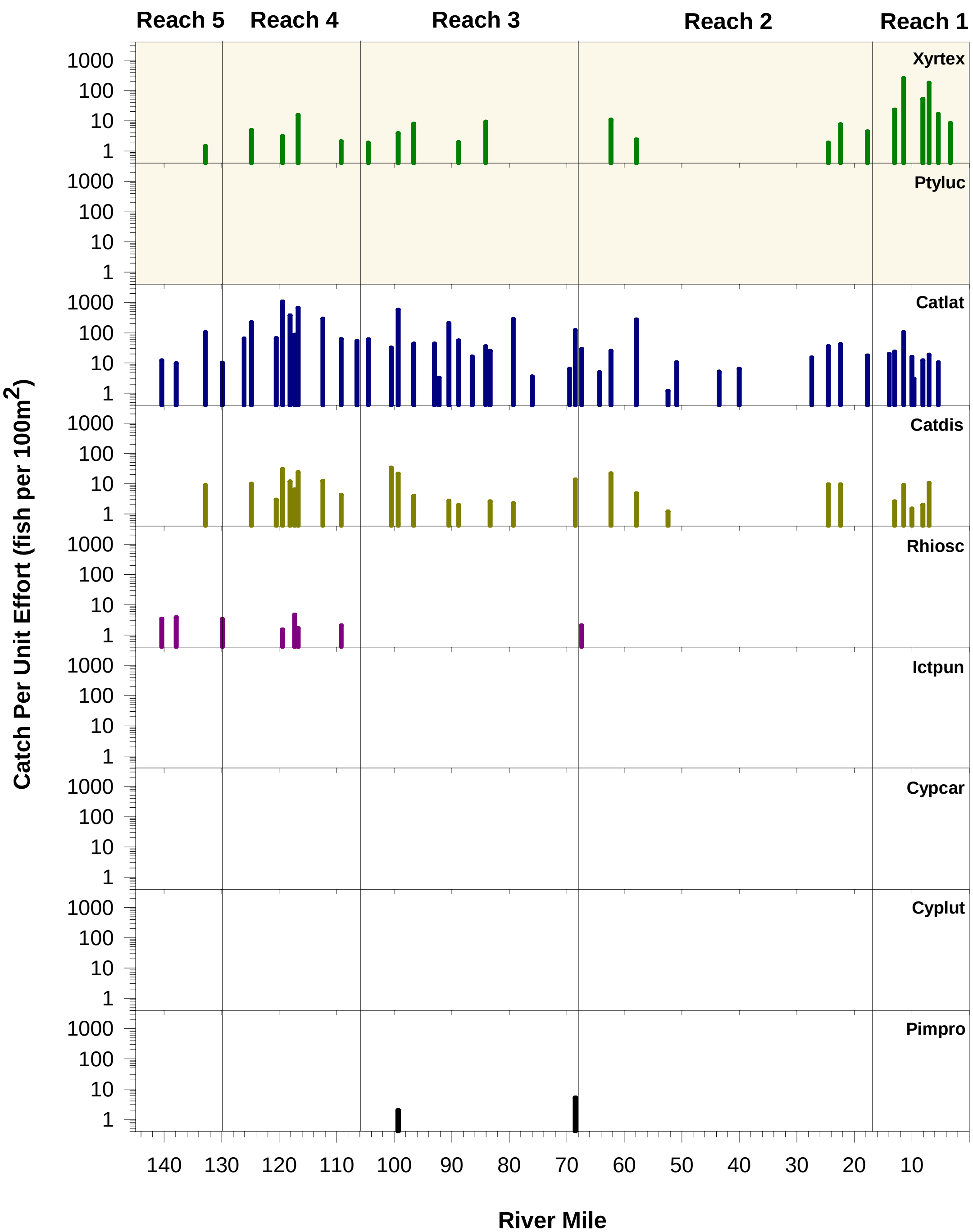

Figure 5. Catch per unit effort /100 m² of age-0 fish by sampling locality, Trip 2 (18 - 22 May 2009).

catch of larval flannelmouth sucker. The highest catch of razorback sucker larvae was in Reach 1 (60.3 fish per 100 m^2, SE=31.5). Razorback sucker was the numerically dominant species in Reach 1 accounting for 69.9% of the catch by number. Speckled dace and fathead minnow were the first documented larval cyprinids collected during the 2009 survey. Speckled dace were collected in Reaches 5, 4 and 2 with two collections in Reach 3 producing larval fathead minnows.

The June survey took place immediately following the descending limb of the spring run-off (16–20 June 2009). The mean water temperature of the main channel during the June survey increased after runoff to 20.1 ^{o}C. The decrease in discharge severed the connection to many of the large backwater sites at the mouths of washes that were sampled during the May survey. The drop in flows most notably affected the large backwaters found in Reach 1. Many of these sites were isolated from the main channel by large sand plugs either forming isolated pools or were altogether dry. In addition to loss of backwater habitat due to the drop in discharge, two huge rock slides buried backwaters located at river mile 13.9 and at Trimble Canyon (RM 13.0). Habitats sampled in Reach 1 were mostly comprised of ephemeral backwaters formed in exposed sandbars. The same species of larval fish that were collected during the May survey were represented in the June collections with the addition of larval common carp in Reach 1. Compared to the May survey, catch rates were lower in June for razorback sucker and flannelmouth sucker while catch rates were higher for bluehead sucker. Reach 1 had the highest catch rates for flannelmouth sucker (31.0 fish per 100 m^2, SE=19.6) and razorback sucker (5.3 fish per 100 m^2, SE=3.8). Conversely, the highest catch rates of bluehead sucker (43.8 fish per 100 m^2, SE=18.6) were found at the top of the study area in Reach 5. Larval razorback sucker were collected in Reaches 3–1 with June being the last month in which age-0 razorback sucker were collected (Figure 6). Speckled dace and fathead minnow had a broader distribution of larvae in June compared to May.

The July survey took place at the end of the month (27 July–1 August 2009). The mean daily discharge was 790 cfs. Mean water temperature during that period was 23.7^{o}C. Catch rates for all larval cyprinids increased during this month. Larval red shiner dominated the catch in July having a mean catch of 456.5 fish per 100 m^2 (SE=109.0). The catch rate for red shiner was more than three times that of all other species combined. Red shiner catch was greatest in Reaches 4 and 3 (850.6 fish per 100 m^2 and 827.2 fish per 100 m^2, SE=332.6 and 265.2 respectively). Reaches 5 and 4 had the highest mean catch rate of speckled dace (343.6 and 287.2 fish per 100 m^2, SE= 204.2 and 92.9 respectively). A single age-0 Colorado pikeminnow was collected in Reach 2 at river mile 24.7 (Figure 7). This single fish was the only evidence of reproduction by Colorado pikeminnow during the 2009 larval fish survey. July was the first month in which age-0 channel catfish were collected. The highest catch of channel catfish in July was in Reach 2 (18.3 fish per 100 m^2, SE=8.0).

The August sampling survey was conducted ten days after the July survey (10–14 August 2009). River conditions remained similar to the July survey however the mean water temperature was slightly lower (22.5^{o}C). Every reach was dominated by larval red shiner (Figure 8). The mean riverwide catch of red shiner during the August survey was 807.4 (SE=145.6) fish per 100 m^2, which was the highest riverwide catch rate of any species of fish during the tenure of the 2009 larval fish survey. Mean densities of red shiner were greatest in Reaches 4 and 3 (1,375.7 and 1,589.3 fish per 100 m^2, SE=286.4 and 401.2 respectively). Speckled dace were collected throughout the study area. Bluehead sucker were collected sporadically in the upper four reaches of the study area. Similar to the July survey, channel catfish had the highest catch rate in Reach 2.

The final collection trip occurred between 14–26 September 2009. Due to staff logistics the two sampling crews were unable to sample the study area simultaneously so upper and

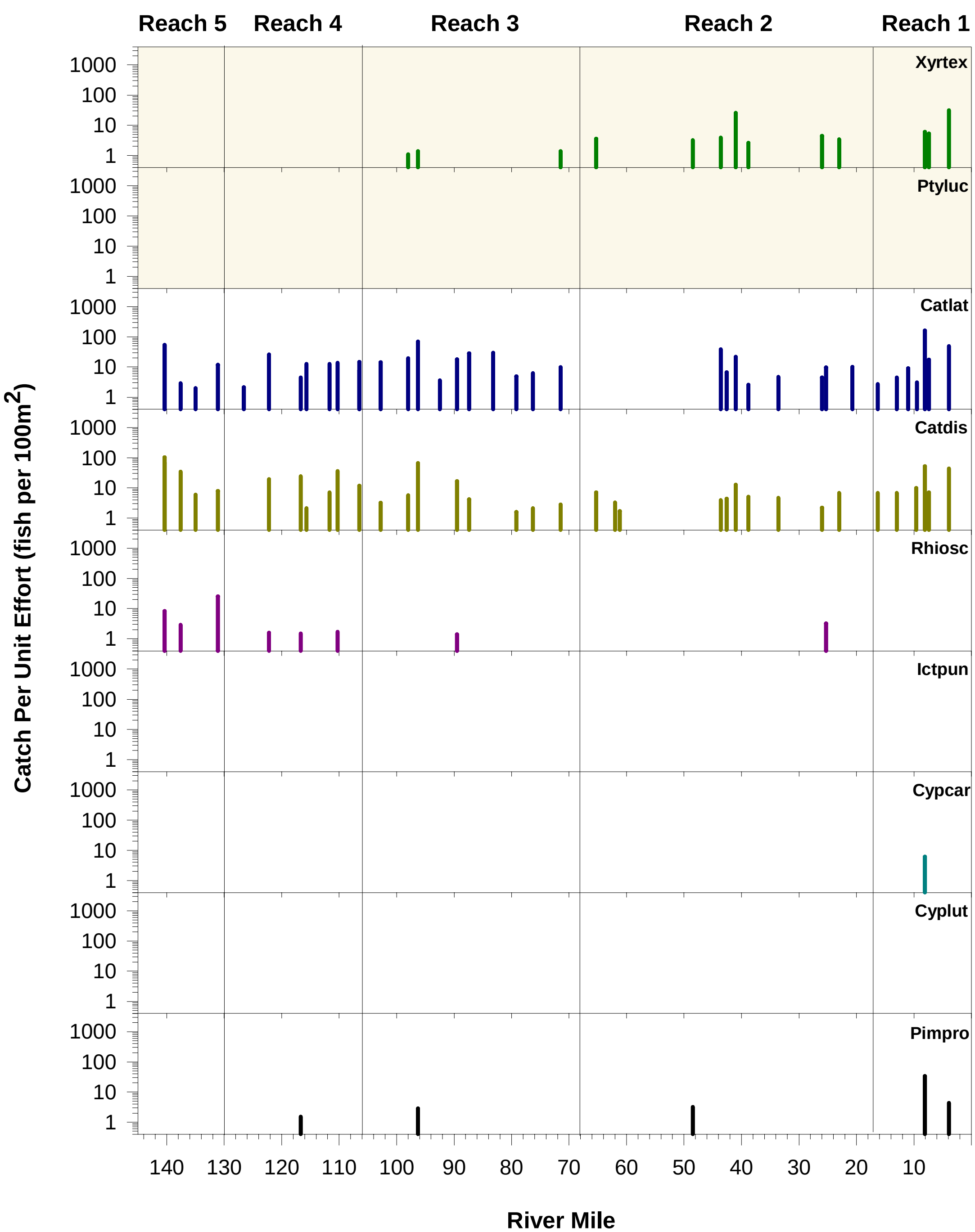

Figure 6. Catch per unit effort /100 m^2 of age-0 fish by sampling locality, Trip 3 (15 - 20 June 2009).

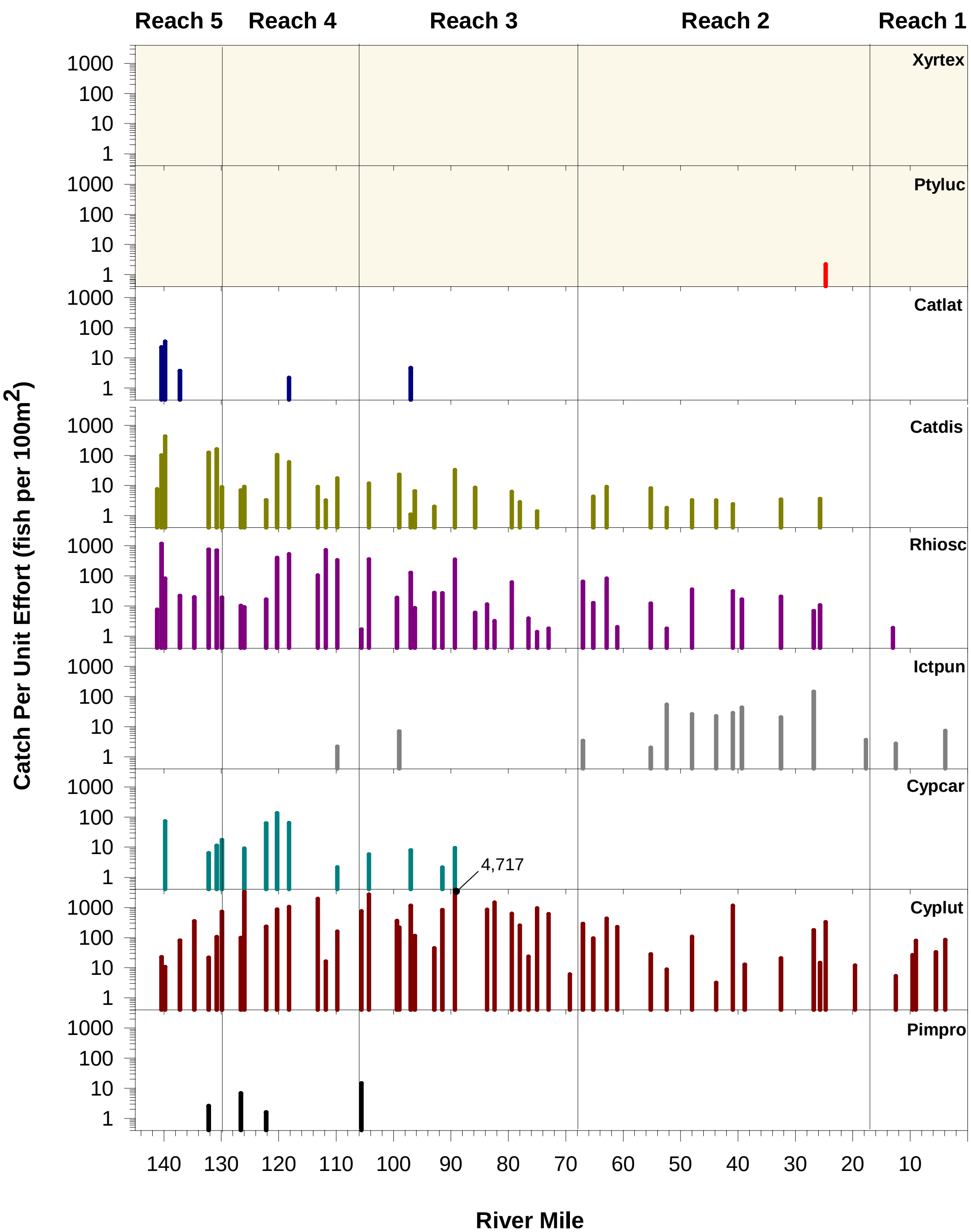

Figure 7. Catch per unit effort /100 m^2 of age-0 fish by sampling locality, Trip 4 (27July - 1 August 2009).

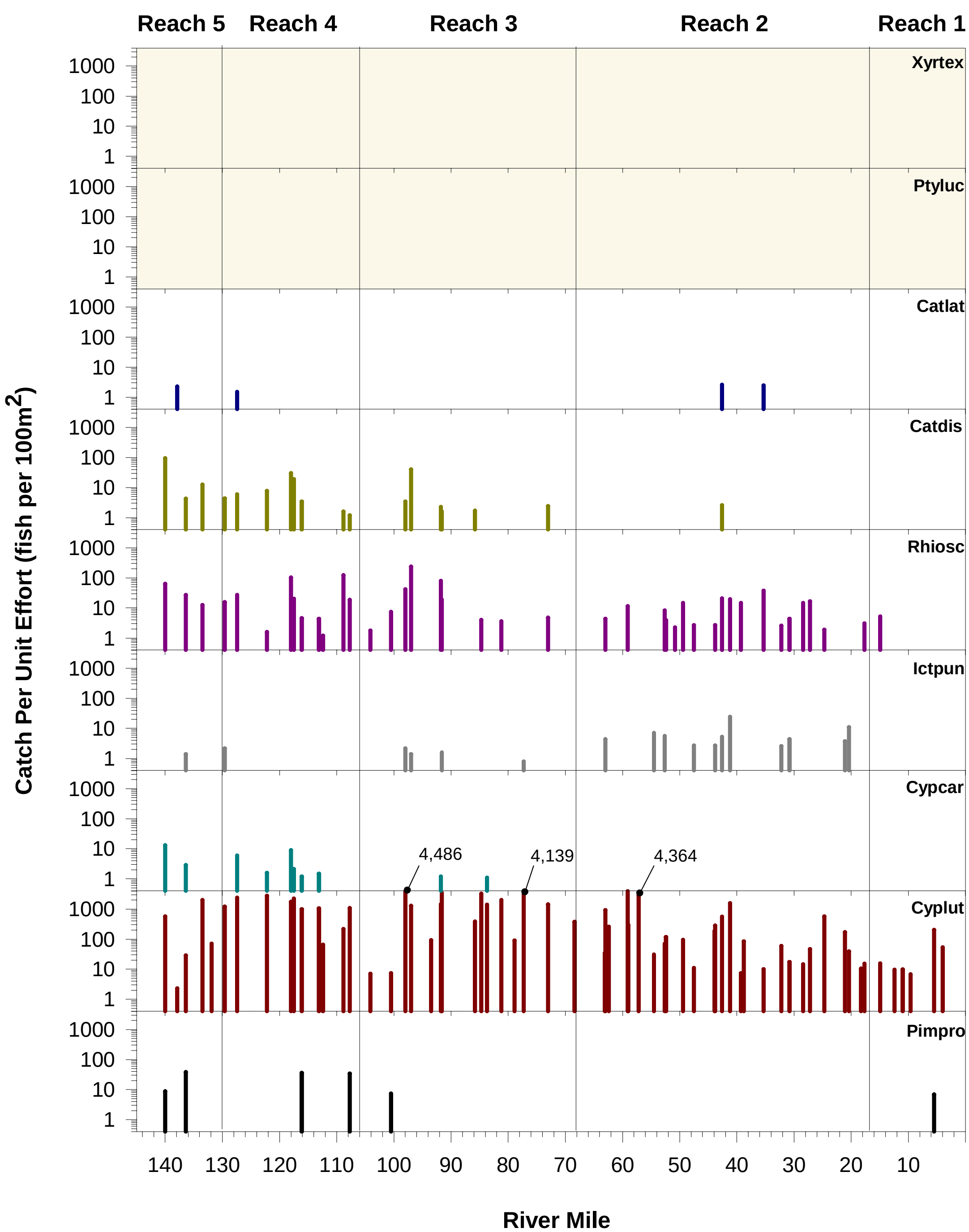

Figure 8. Catch per unit effort /100 m^2 of age-0 fish by sampling locality, Trip 5 (10 - 14 August 2009).

lower ends of the study area were sampled during two consecutive weeks. During this period mean daily discharge and water temperature were 623 cfs and 19.6^{o}C respectively. Similar to July red shiner dominated the catch throughout the study area (402.9 fish per 100 m^2, SE=123.1). Speckled dace were also collected throughout all five reaches with catch rates in Reach 4 (39.9 fish per 100 m^2, SE=13.1) greater than the other four Reaches. Age-0 Bluehead sucker were collected in Reaches 5-3 while flannelmouth sucker were collected in Reaches 3-1 of the study area (Figure 9) . Channel catfish were collected in all but Reach 5 with the highest catch in Reach 2 (9.1 fish per 100 m^2, SE=3.5).

Endangered Species

Razorback sucker. A total of 272 Age-0 razorback sucker were collected during the 2009 larval survey. Age-0 razorback sucker were collected during May and June. May catch rates were significantly higher than those of June (F=17.4797, P<0.0001[Figure 10]). All five reaches in the study area produced larval razorback sucker in May. Larval razorback sucker were collected in Reaches 3, 2, and 1 during the June survey. Of the five reaches, Reach 1 had significantly higher catch rates than any of the other reaches in the study area (F=7.1042, P<0.0001 [Figure 10]). There was no significant difference in catch rates among the other four reaches.

Annual mean catch rate of age-0 razorback sucker between collection years (1999-2009) have varied. Three of the eleven years in which razorback sucker were collected have had significantly higher catch rates than other years (2002, 2003, and 2009). The mean annual catch rate of razorback sucker during the 2009 survey was the third highest catch rate since 1999. It is significantly higher than 1999 and 2005 and significantly lower than 2002 (F=15.8323, P<0.0001[Figure 11]). Combined mean monthly catch rates from 1999 to 2009 show catch of age-0 razorback sucker are significantly higher during May (F=6.5930, P=0.0002 [Figure 12]). Mean catch rates from 1999 to 2009 in Reach 1 are significantly higher than all other reaches in the study area (F=32.1530, P=<.0001 [Figure 13]). The combined catch (1999-2009) of age-0 razorback sucker by month and reach have a similar pattern to the mean catch rates observed in 2009.

Age-0 razorback sucker collected in 2009 were almost entirely represented by larval fish (protolarvae to metalarvae) with the exception of a single recently transformed juvenile that was captured in late June at river mile 3.9. Protolarvae comprised 11.0% of the age-0 razorback sucker collected during the 2009 survey. Protolarvae were collected in both May and June in nearly equal proportions however protolarvae were collected higher in the study area (Reaches 5 and 4) during May. In 2009 protolarvae were collected as high up as river mile 132.8 indicating that there are spawning adults upstream of that river mile. Protolarvae were distributed fairly equally throughout the study area. There was no clumped distribution of larvae that would point to specific spawning areas in 2009. The majority of larvae collected in 2009 were mesolarvae (86.8%). Mesolarvae comprised 92.8% of the razorback sucker catch during the May survey. Mesolarvae were distributed throughout the study area however the highest catch rates were in Reach 1 (Figure 14). Five metalarvae and a single juvenile razorback sucker were collected during the 2009 survey. Both of these ontogenetic stages were found in Reach 1.

The distribution of discrete ontogenetic stages of razorback sucker over time (1999-2009) and by month further defines relationships to potential spawning areas and dispersal of propagules. Protolarvae collected from 1999-2009 were captured in four months of the study period (April-July). Protolarvae had higher catch rates and were distributed throughout the study area during the months of May and June. Collection of protolarvae in the upper portions of Reach 4 over multiple years indicate spawning adults upstream of those fish captures (Figure

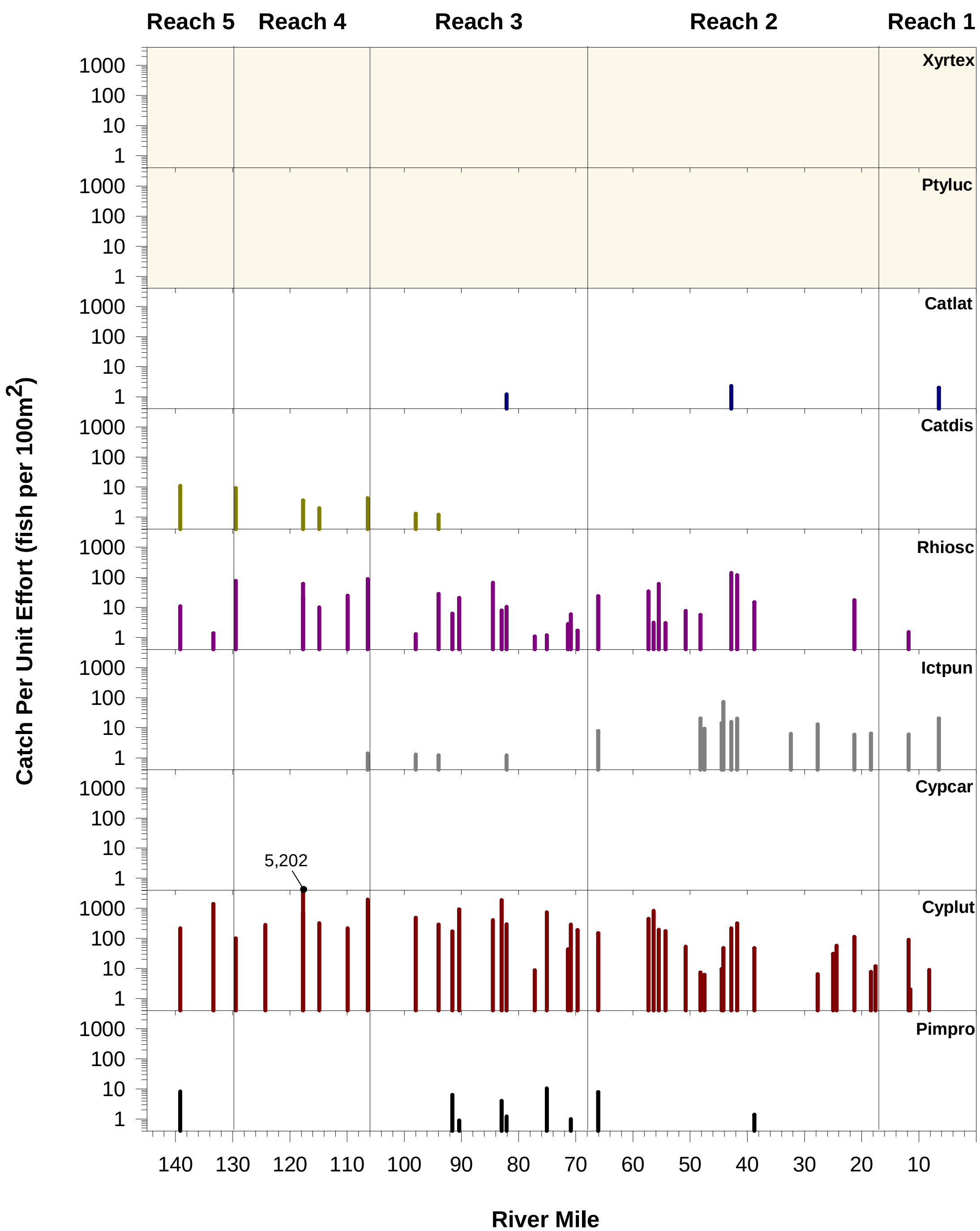

Figure 9. Catch per unit effort /100 m^2 of age-0 fish by sampling locality, Trip 6 (14 - 26 September 2009).

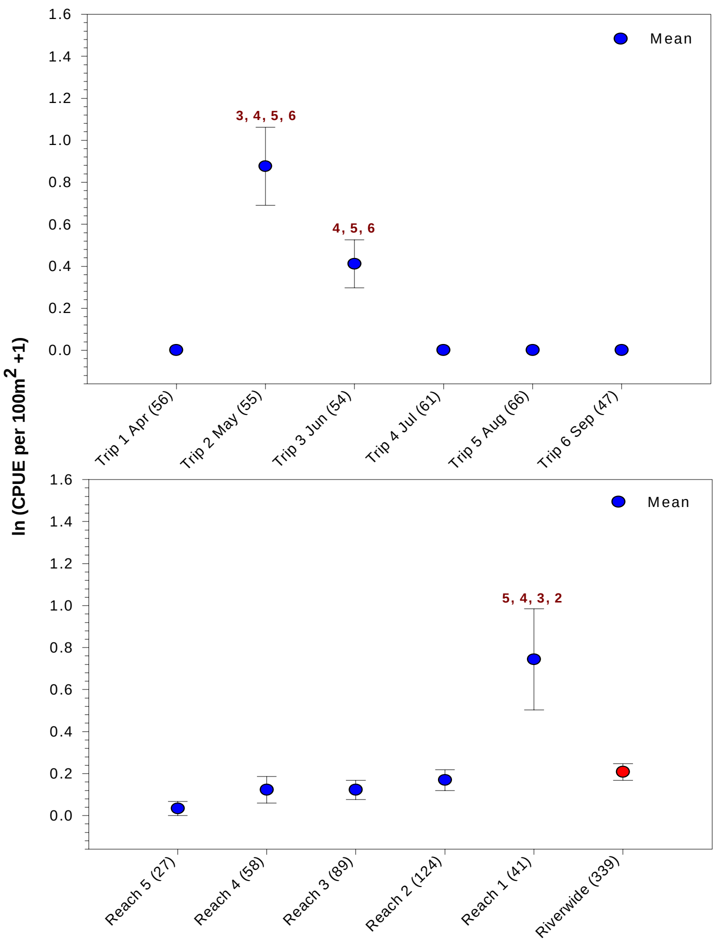

Figure 10. ln(CPUE per 100m² +1) [±1 SE] for age-0 razorback sucker by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

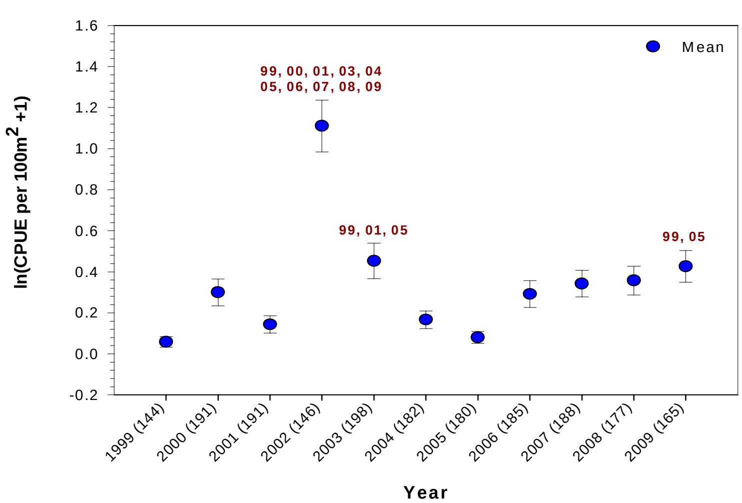

Figure 11. ln(CPUE per 100m² +1) [±1 SE] for age-0 razorback sucker by year (April-June 1999-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

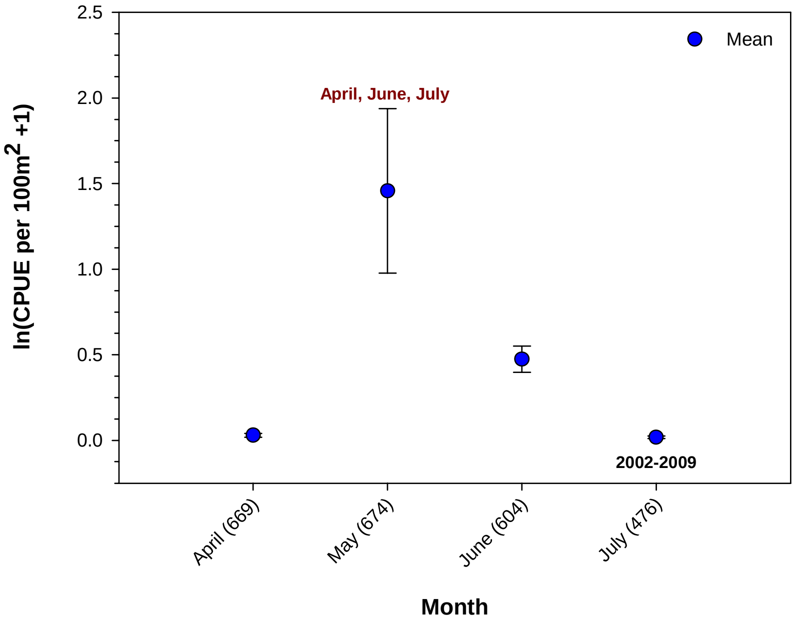

Figure 12. ln(CPUE per 100m^2 +1) [±1 SE] for age-0 razorback sucker by Reach (April-July 1999-2009). Sample size reported on x-axis labels. Red text indicates months that have significantly lower catch rates.

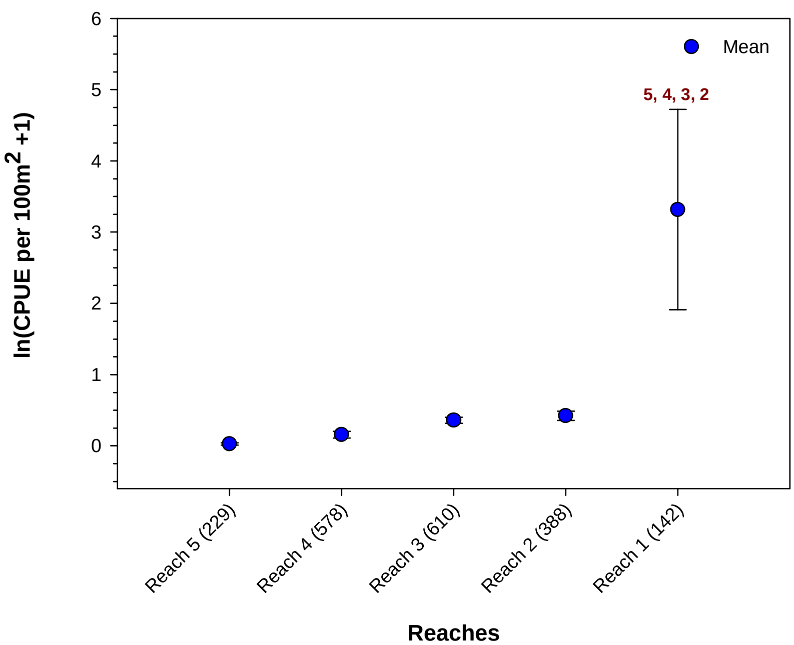

Figure 13. ln(CPUE per 100m^2 +1) [±1 SE] for age-0 razorback sucker by month (April-June 1999-2009). Sample size reported on x-axis labels. Red text indicates reaches that have significantly lower catch rates.

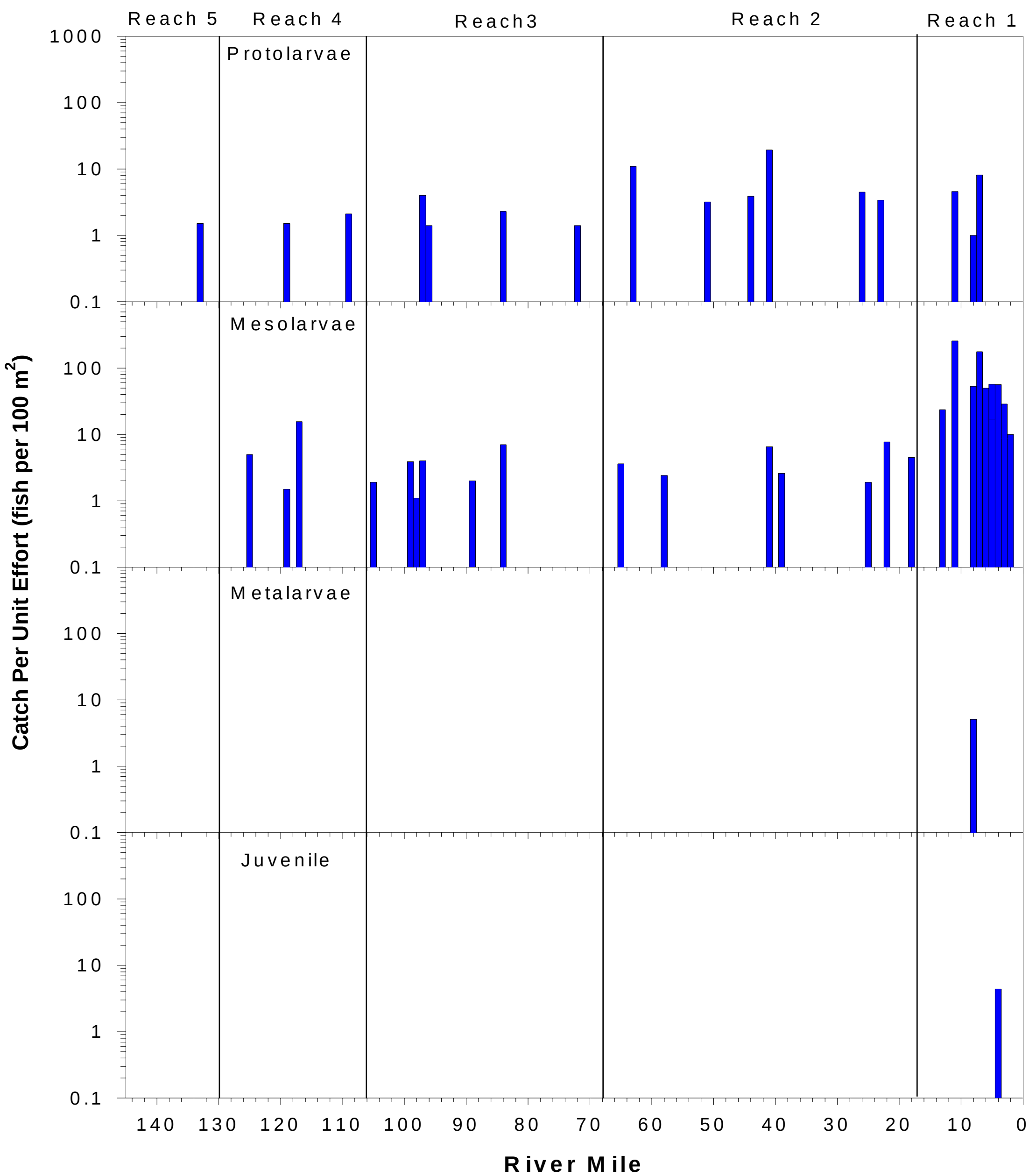

Figure 14. Catch per unit effort /100m^2 of discrete ontogenetic stages (protolarvae, mesolarvae, metalarvae, and juvenile) of razorback sucker by sample locality 2009.

15). Protolarvae were collected throughout the study area making specific spawning areas difficult to determine. Areas that have increased catch of protolarval razorback sucker are located in Reach 3 in the vicinity of McElmo Creek and upstream of river mile 75 (June), in the lower portions of Reach 2, and in Reach 1. Mesolarvae constitute the majority of all larval razorback collected (65%) during the eleven years of larval fish surveys. May collections account for 89.4% of all mesolaraval razorback sucker. Catch rates in May are significantly higher in the lower portions of the study area (Figure 16). The clumped distribution of mesolarvae in the lower reaches suggest that razorback sucker larvae are being displaced downstream during this life stage. Collection of mesolarvae in June have a similar pattern, however, catch rates are much lower during this month. Metalarvae have been collected from June through August (1999-2009). The August collection is represented by one individual collected in 2005. May and June have the highest catch rate of metalarvae. In May this life stage was found in Reaches 3-1 (Figure 17). In June this ontogenetic stage only occurred in Reaches 3 and 1. Metalarvae constitute 16.6% of the total age-0 razorback sucker catch from 1999-2009. Five of eleven years which produced age-0 razorback sucker contained some juvenile fish. These years indicate some fish are developing past the larval stage. Reach 3 had the highest catch of juvenile razorback sucker in June collections (Figure 18). Eighty-seven percent of juvenile razorback sucker collected from 1999-2009 were captured in 2002.

Back-calculated hatch dates of razorback sucker larvae (protolarvae and mesolarvae) collected during the 2009 larval survey place initial hatching of razorback sucker eggs on 12 April 2009 (Figure 19). Mean daily discharge and water temperature at the time of initial hatch was 921 cfs and 12.5 ^{0}C. Hatching of razorback sucker continued to 10 June 2009 and encompassed the peak spring discharge and the initiation of the descending limb of run-off. During the hatching period discharge and water temperature ranged from 719-5,970 cfs and 10.4-18.9^{o}C. Back-calculated hatch dates from previous years show quite a bit of variability especially in regards to discharge. Mean temperature during the hatching periods among all years averages just over 15^{0}C (Brandenburg and Farrington 2008).

Within the seven habitat types sampled in 2009, age-0 razorback sucker were found in all but shoal habitat types (Figure 20). This may be explained by the small sample size (n=3) for that habitat type. Among the six habitats that contained razorback sucker, there was little statistical difference in catch rates. Isolated pools had catch rates significantly higher than pool habitats (F=2.5654, P=0.0192).

The same six habitat types (backwaters, embayments, isolated pools, pocket water, pools, and slackwater) that contained age-0 razorback sucker in 2009 also produce YOY razorback sucker collected between 2005 and 2009. Among these years, backwater habitats had significantly higher catch rates than all other habitat types except isolated pools (F=9.5873, P=<.0001 [Figure 21]). Catch rates among isolated pool collections were highly variable, and comparisons between open and closed habitats are problematic.

Colorado pikeminnow. A single age-0 Colorado pikeminnow was collected during the 2009 larval fish survey. The specimen was collected 29 July 2009 in a backwater in Reach 2 at river mile 24.7 (Figure 22). The 25.2 mm TL fish was late metalarvae (fin fold almost completely absorbed) and is the largest wild spawned Colorado pikeminnow that has been collected during the larval fish surveys. Only two other years have produced larval Colorado pikeminnow using the current larval fish survey protocols (2007 and 2004). There is no significant difference in catch rates between years (F=1.5941, P=0.1447 [Figure 23]).

Spawn date for the 2009 Colorado pikeminnow was back-calculated to 10 June 2009, just seven days after peak runoff and on the upper portion of the descending limb of the spring

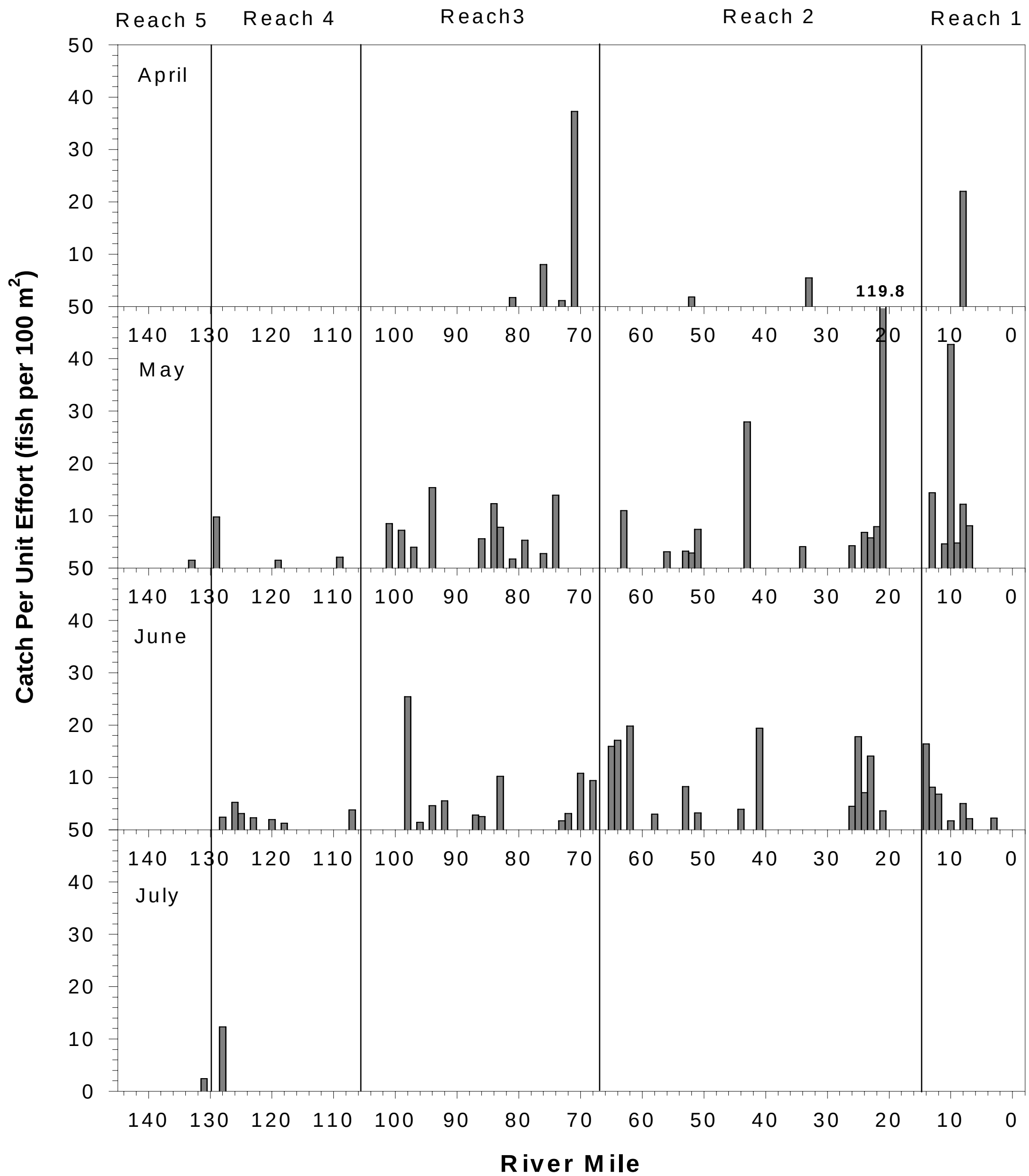

Figure 15. Catch per unit effort of razorback sucker protolarvae by month (April-July) from 1999-2009.

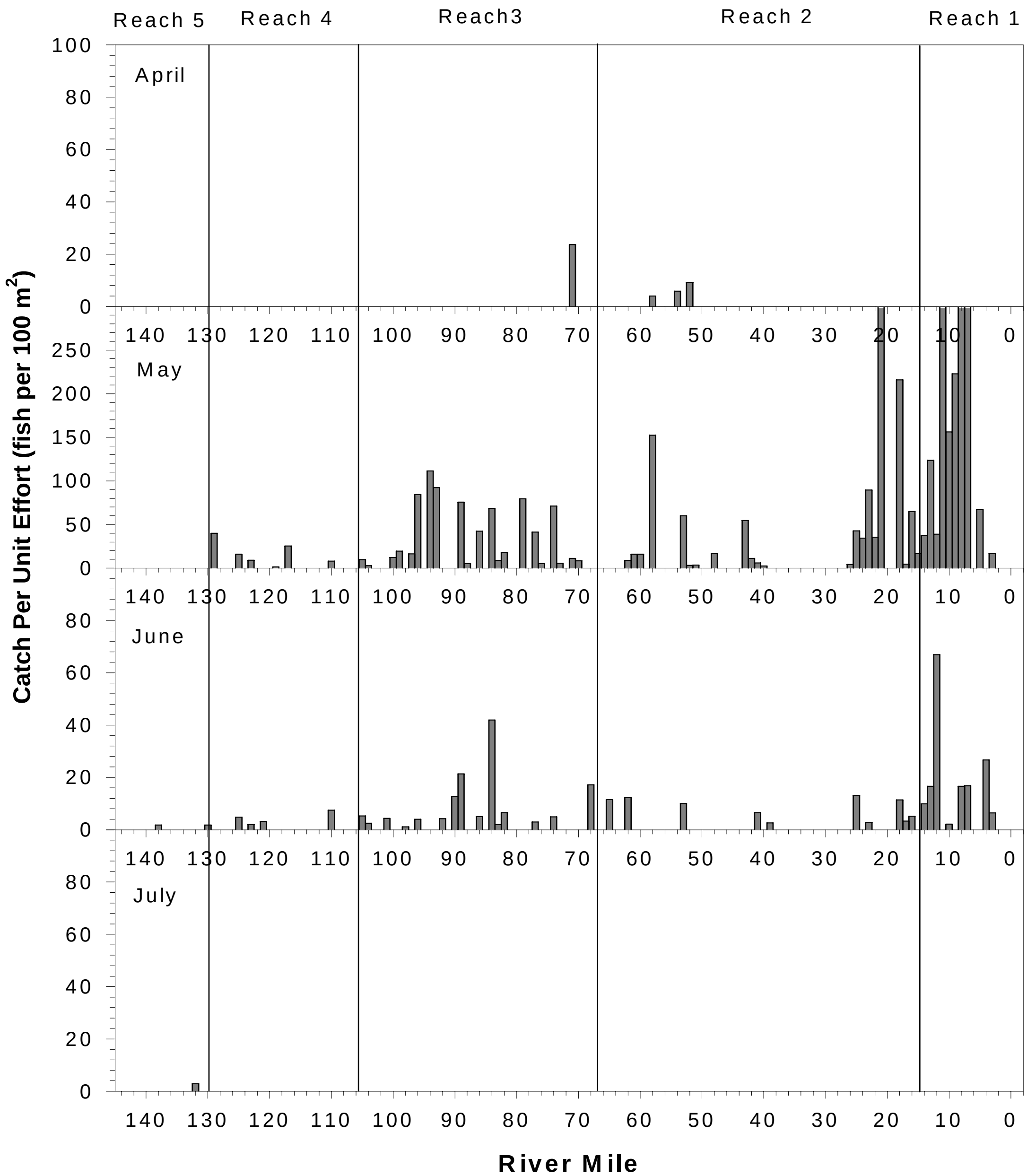

Figure 16. Catch per unit effort of razorback sucker mesolarvae by month (April-July) from 1999-2009.

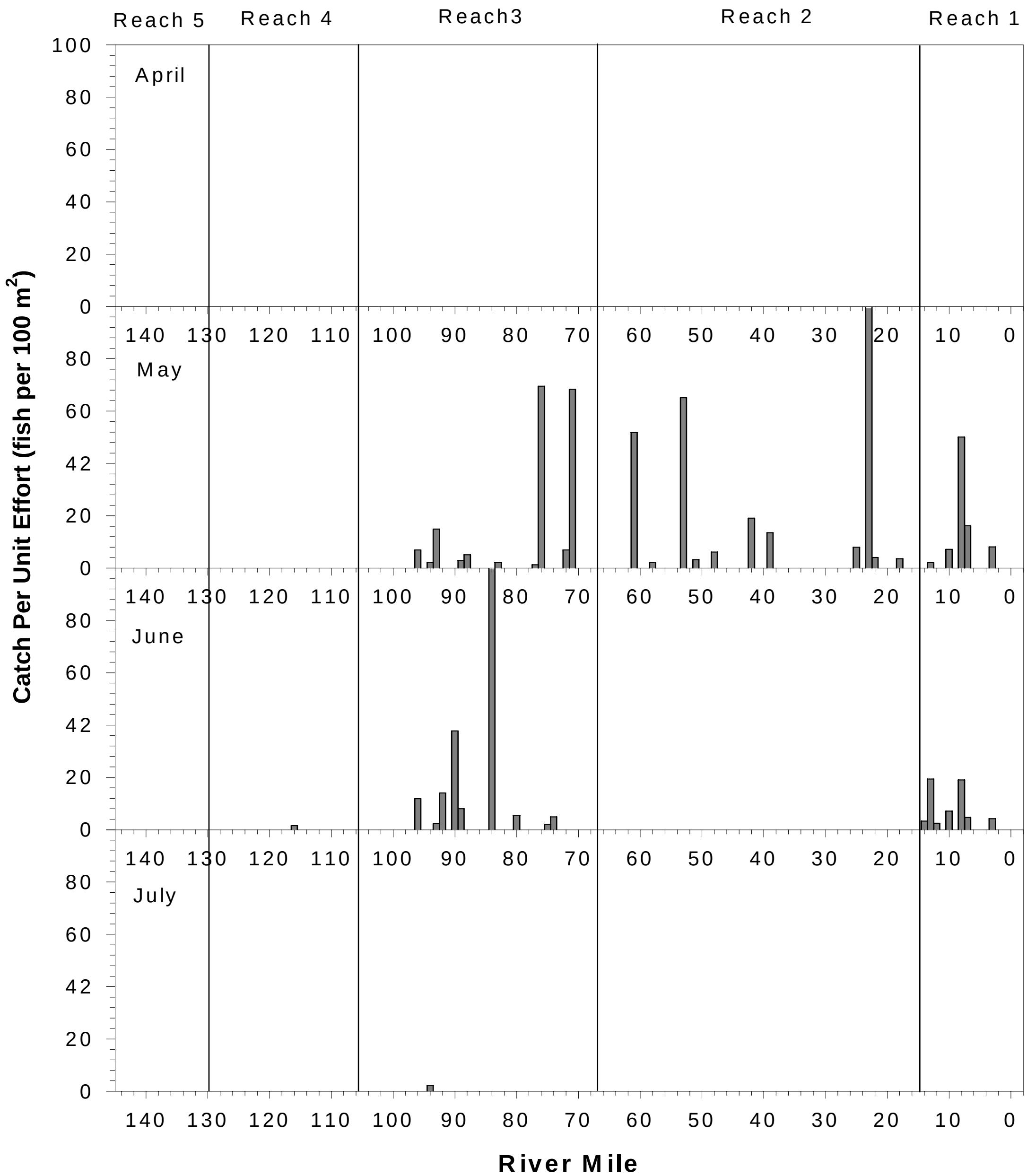

Figure 17. Catch per unit effort of razorback sucker metalarvae by month (April-July) from 1999-2009.

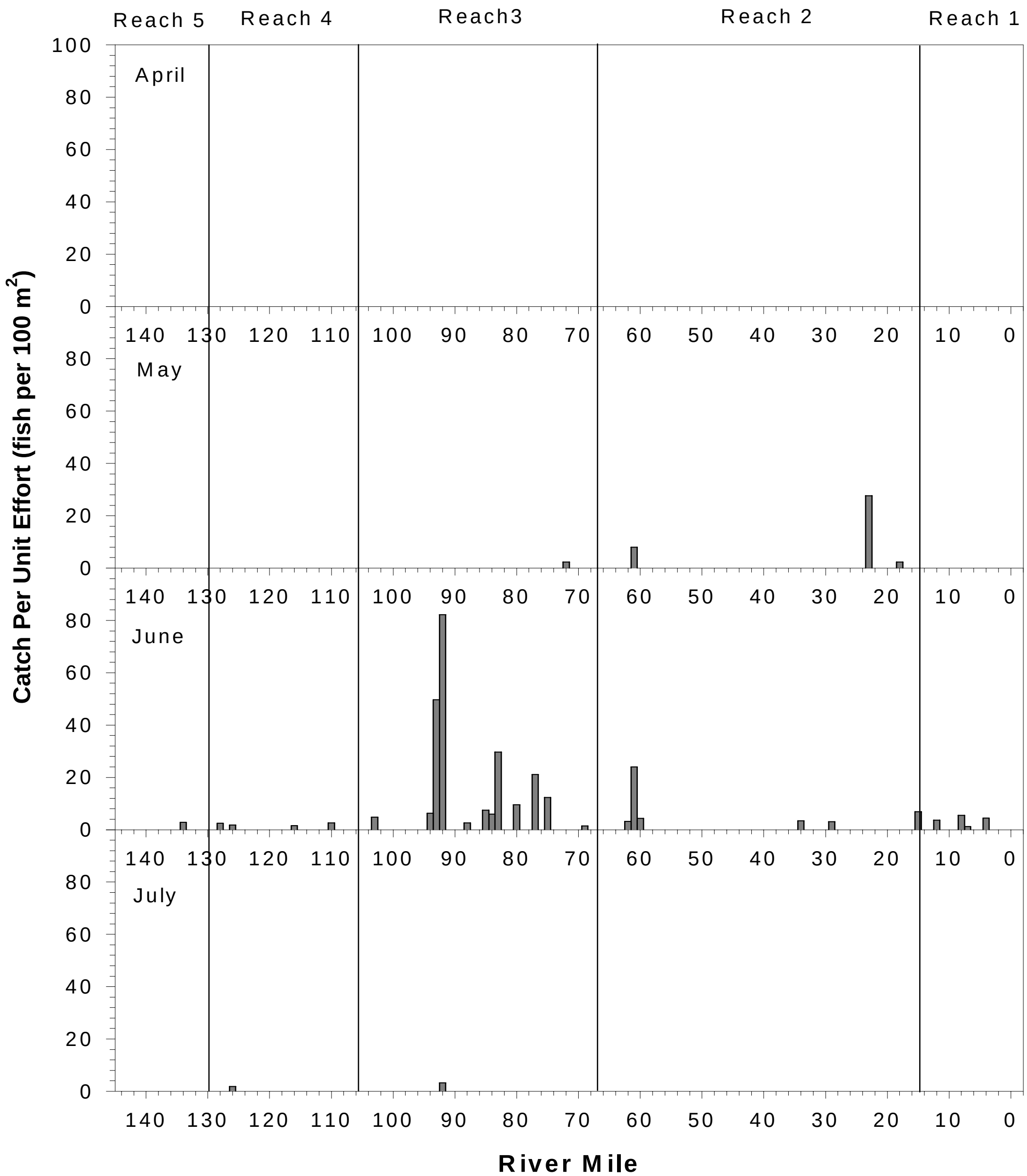

Figure 18. Catch per unit effort of razorback sucker juvenile by month (April-July) from 1999-2009.

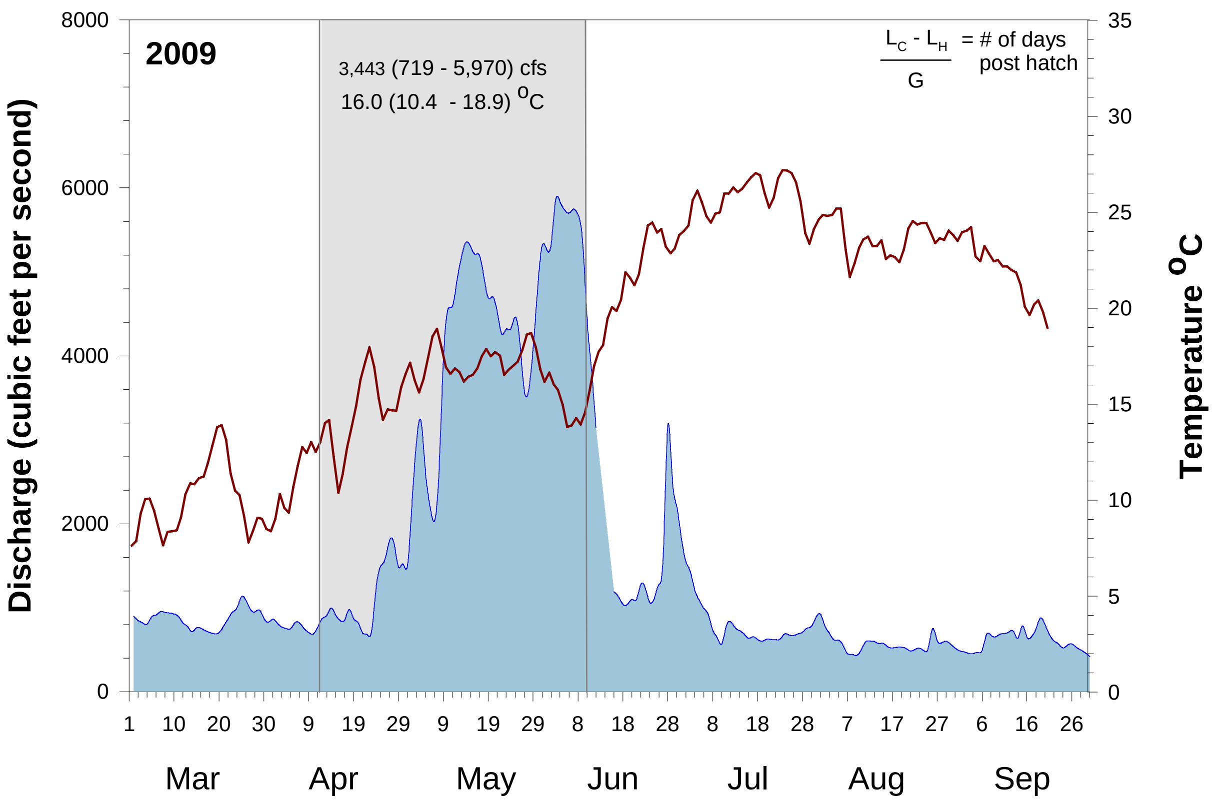

Figure 19. Back-calculated hatching dates for razorback sucker plotted against discharge (Bluff, UT, USGS gauge #9379500) and water temperature (Mexican Hat, UT). Gray box delineates hatching period with mean (min-max) discharge and water temperature reported.

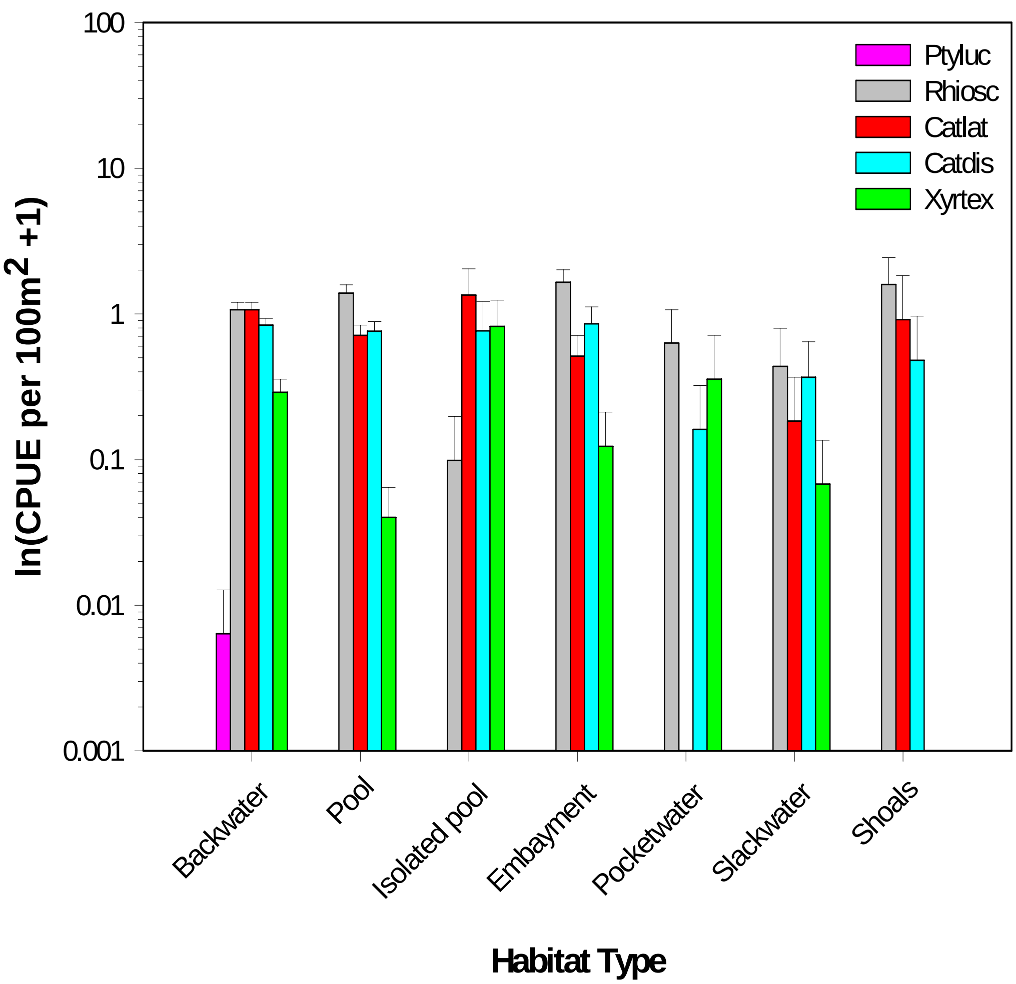

Figure 20. Habitat association by native species during the 2009 larval survey. Colored bars represent mean ln(CPUE per 100m^2 +1) [±1 SE].

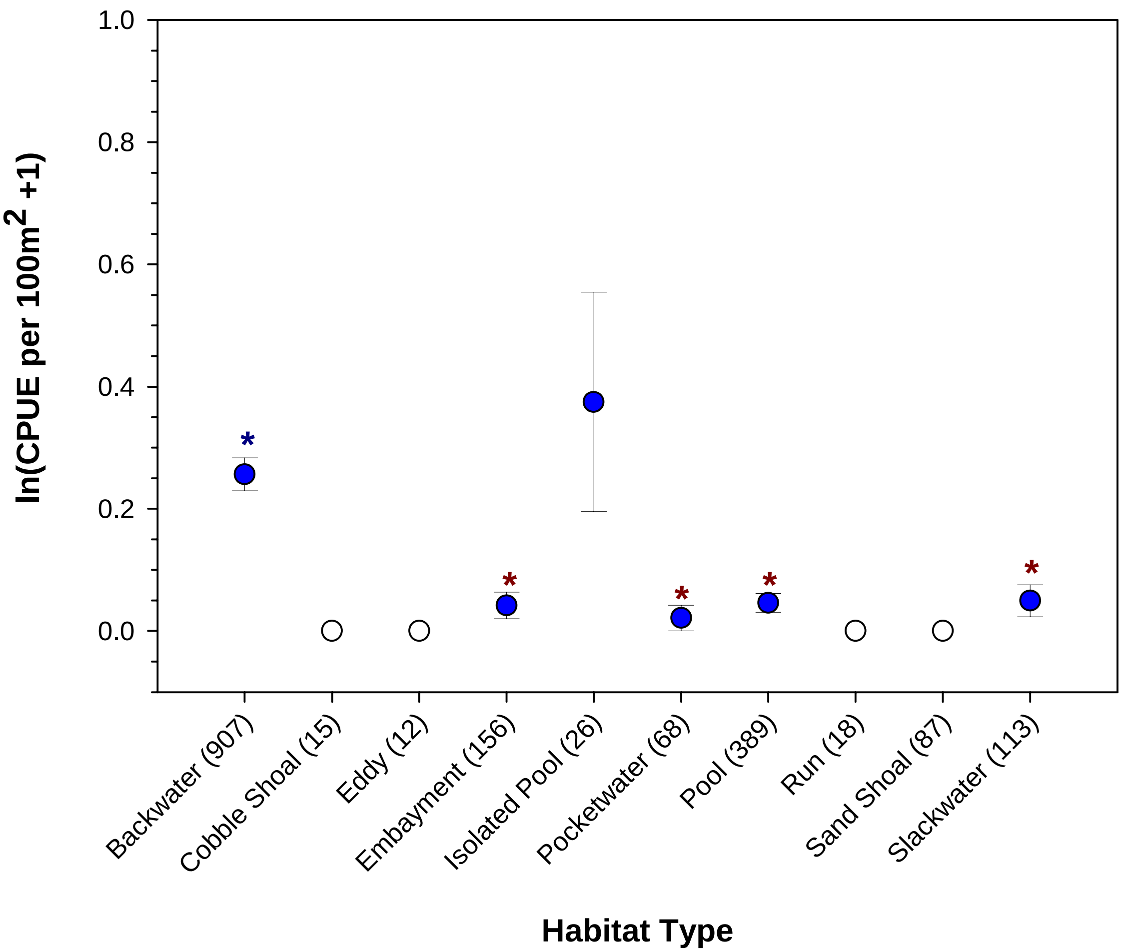

Figure 21. ln(CPUE per 100m^2 +1) [±1 SE] for razorback sucker by low velocity habitat types sampled between 2005 and 2009. Blue asterisk indicated significant

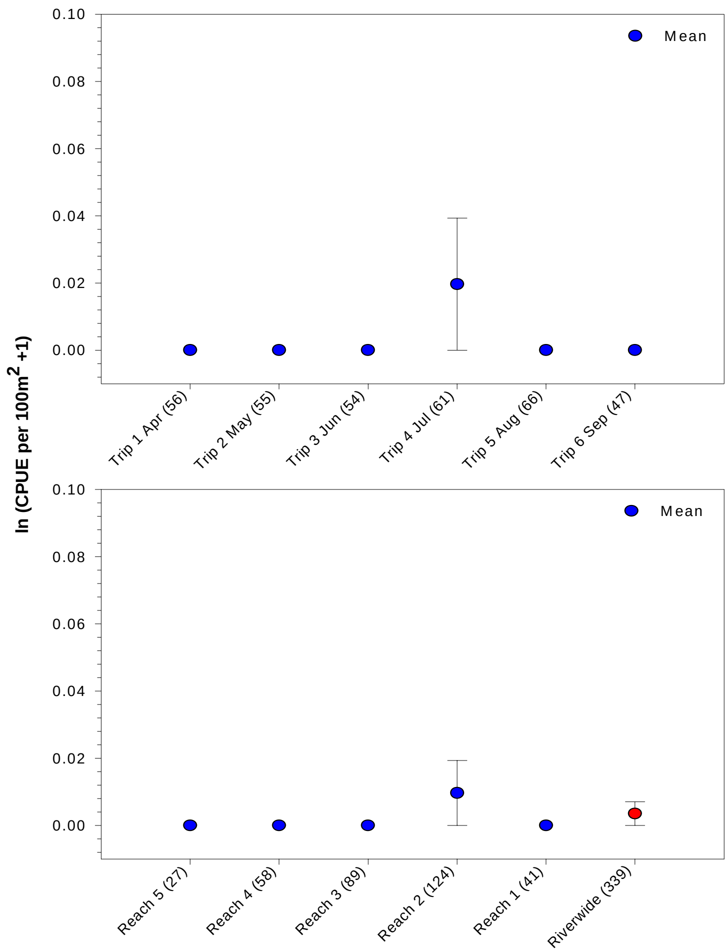

Figure 22. ln(CPUE per 100m² +1) [±1 SE] for age-0 Colorado pikeminnow by trip (top graph), reach and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels.

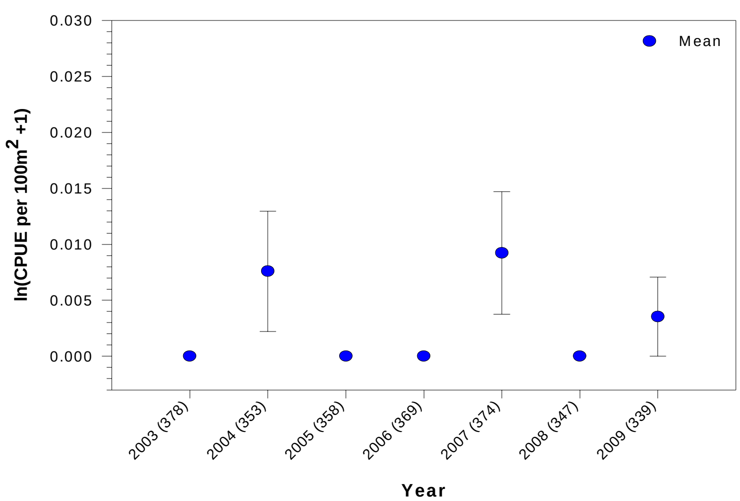

Figure 23. ln(CPUE per 100m² +1) [±1 SE] for age-0 Colorado pikeminnow by year (2003-2009). Sample size reported on x-axis labels.

hydrograph (Figure 24). Mean daily discharge and water temperature during the period of spawning was 4,290 cfs and 12.9°C. The back-calculated spawn date is earlier than what had been calculated for Colorado pikeminnow collected in 2007 and 2004. During those two years, back-calculated spawning dates were in late June (25–27 June) and mean water temperatures during the spawning periods was greater than 20°C.

A total of 266 age-1+ Colorado pikeminnow were collected during the study period in 2009. It is assumed these fish were the result of augmentation efforts. Age 1+ Colorado pikeminnow collected ranged in size from 34–110 mm SL. The April and May trips produced the greatest numbers of age-1+ Colorado pikeminnow (n=101 and 144 respectively). During these two months Colorado pikeminnow were captured throughout the study area. In April nearly half (n=46) of all age-1+ Colorado pikeminnow were captured in Reach 1. During the May survey nearly half (n=68) of all age-1+ Colorado pikeminnow were found in Reach 4 (Appendix II, Figure 44). By the June survey, catch of age 1+ Colorado pikeminnow had diminished within the low velocity habitats that were being targeted during the larval fish survey. Age 1+ Colorado pikeminnow were captured at either ends of the study area in June. By July to the end of the study period captures of age-1+ Colorado pikeminnow became restricted primarily to Reaches 2 and 1.

A single sub-adult Colorado pikeminnow was found dead at river mile 118.0 during the August survey. The fish appeared to have two bite marks along the dorsal surface, just posterior to the dorsal fin. The bite marks appeared to have been made by an Ictalurid . The fish was preserved and retained with the larval collections. A pit tag (# 3D91C2C40A83F) was found.

Native Species

Speckled dace. Speckled dace were the most frequently encountered and numerically dominate native species during the 2009 larval fish survey. Age-0 speckled dace were collected during each of the five months (May–September) that produced age-0 specimens. The catch rate in July was significantly higher than all other months with the exception of September (F=34.2839, P<0.000.1 [Figure 25]). Riverwide, catch rates were highest in the upper reaches of the study area (Reaches 5 and 4), and comprised 70.6% of the total speckled dace catch. Catch rates from these two reaches are significantly higher than Reaches 2 and 1. Reach 4 catch was also higher than Reach 3. (F=9.5317, P<0.0001 [Figure 25]). Catch rates of speckled dace have been fairly stable among years (2003-2009). There were no significant difference in catch between 2004 and 2008. The catch rate during 2009 was significantly lower than 2004-2008 yet was not significantly different from catch rates during 2003. (F=9.4905, P<0.0001[Figure 26]). Age-0 speckled dace were found in every habitat type sampled with no significant difference in catch rate among the seven habitat types (Figure 16).

Flannelmouth sucker. Flannelmouth sucker were the numerically dominant catostomid species collected during the 2009 larval fish survey accounting for 72.3% of the catostomid catch by number. May and June had significantly higher catch rates of age-0 flannelmouth sucker then July through September (F=104.2492, P<0.0001 [Figure 27]). May collections produced 88.7% of the total catch by number of age-0 flannelmouth sucker (n=2,971). There were few differences in catch rates among the five reaches. The catch rate in Reach 2 was significantly lower than the other four reaches (F=3.9517, P<0.0001 [Figure 27]). Flannelmouth sucker is frequently the dominant catostomid species collected during the larval fish surveys, however the catch rate in 2009 was significantly lower than 2003 to 2008 (F=13.2982, P<0.0001 [Figure 28]). Mean catch rate in 2009 was less than half of the 2008 and

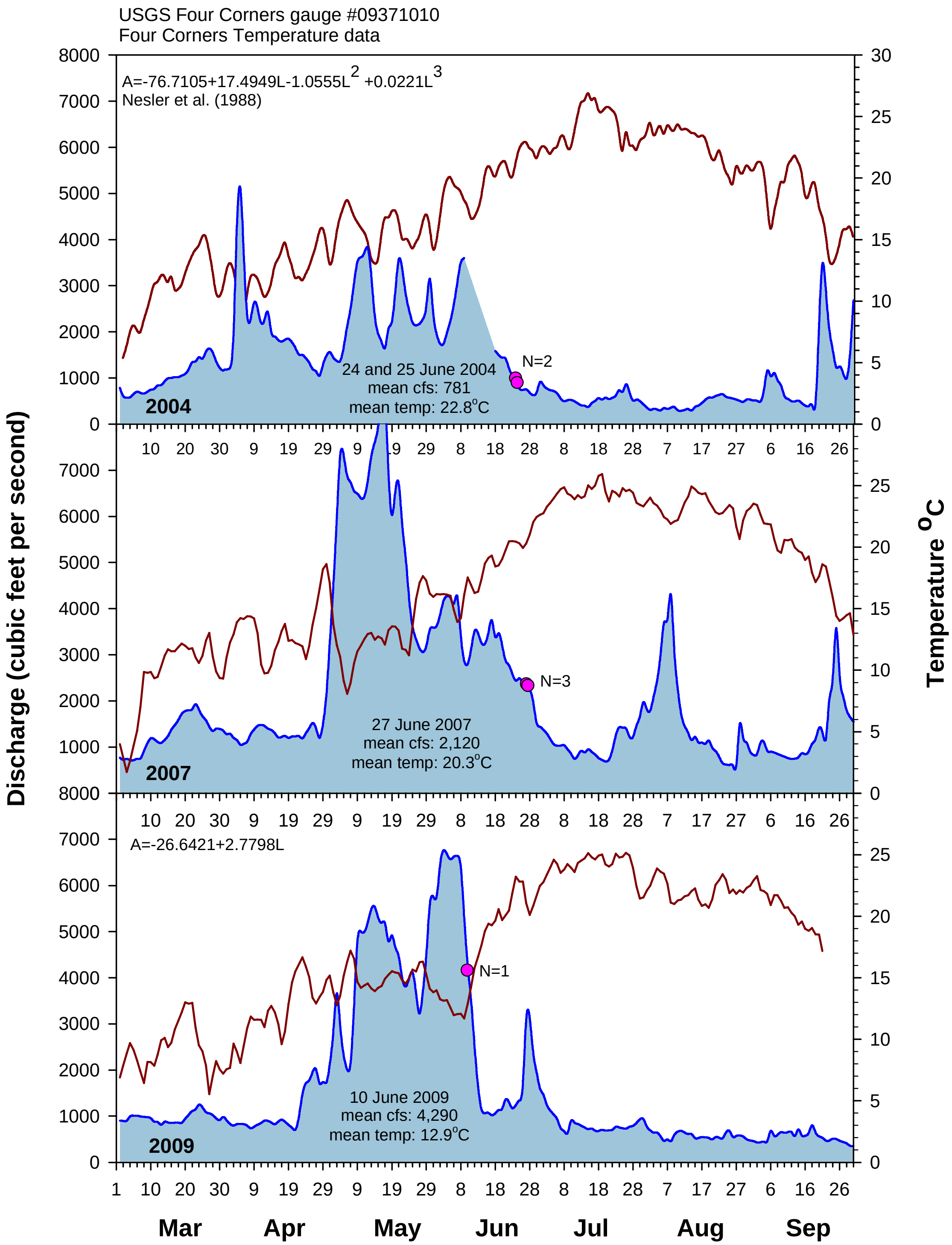

Figure 24. Back-calculated spawning dates for Colorado pikeminnow plotted against discharge (Shiprock, NM, USGS gauge #9371010) and water temperature (Four Corners, CO) during 2004, 2007, and 2009. Pink dot represents spawning date.

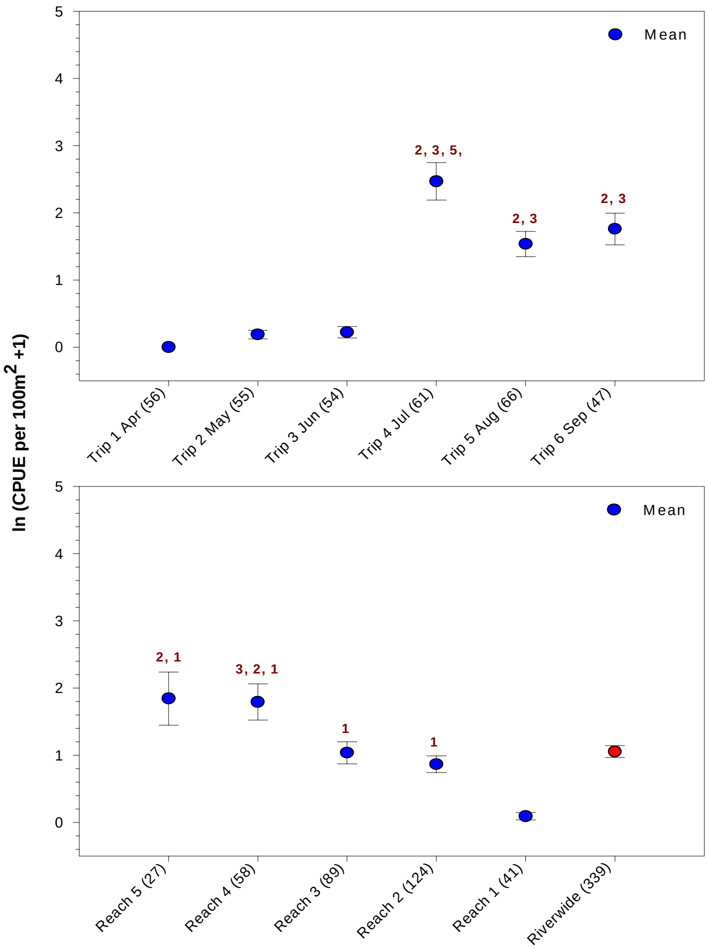

Figure 25. ln(CPUE per 100m^2 +1) [$\pm$1 SE] for age-0 speckled dace by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

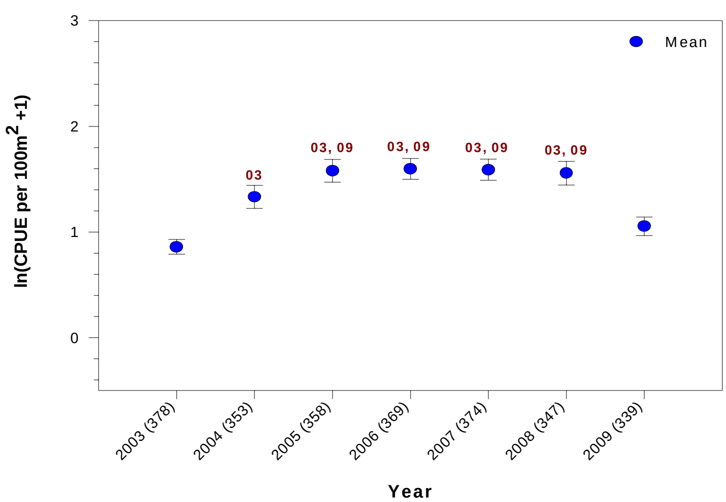

Figure 26. ln(CPUE per 100m^2 +1) [$\pm$1 SE] for age-0 speckled dace by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

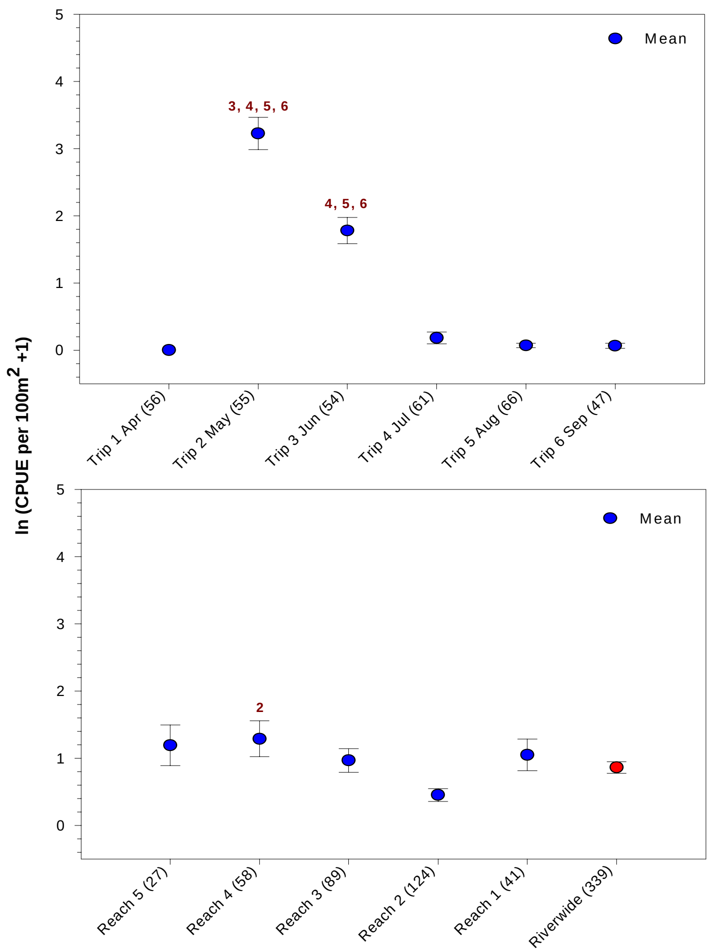

Figure 27. ln(CPUE per 100m^2 +1) [+1 SE] for age-0 flannelmouth sucker by trip (top graph), reach, and river wide (bottom graph) for 2009. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

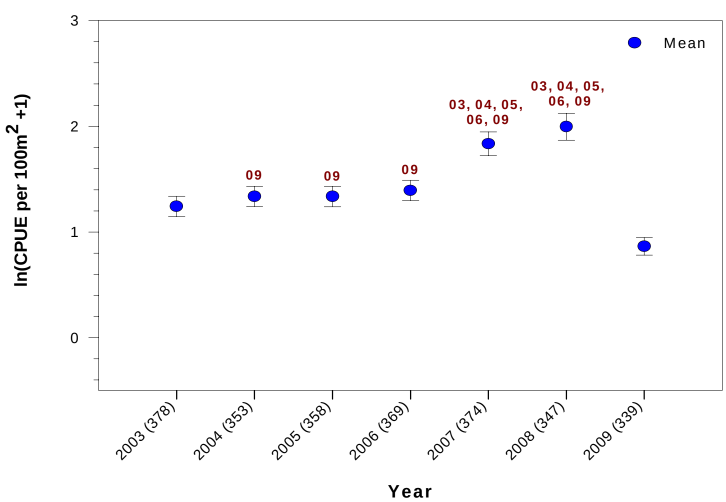

Figure 28. ln(CPUE per 100m^2 +1) [+1 SE] for age-0 flannelmouth sucker by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

2007 catch rates. Age-0 flannelmouth sucker were collected in all of the habitat types sampled with the exception of pocketwater. Catch rates differed little across habitat types for this species.

Bluehead sucker. Age-0 bluehead sucker were collected throughout the study period with the exception of the April survey. Bluehead sucker was the most frequently encountered catostomid species in 2009. June had the highest catch of bluehead sucker, however, the catch rate from this month was not significantly different than either May or July (Figure 29). Catch rates in the two upper reaches of the study area (5 and 4) were significantly higher than Reaches 3 through 1 (F=15.3072, P<0.0001 [Figure 29]). Age-0 bluehead sucker have exhibited varying catch rates from 2003-2009. The 2005 catch rate was higher than all other years except 2004 (F=11.0309, P<0.0001). Catch rates have remained relatively unchanged between 2006 and 2009 (Figure 30). Bluehead sucker was the only catostomid species collected in all habitat types sampled. There was no statistical difference in catch rates among the seven habitat types.

Non-Native Species

Red shiner. The first larval red shiner were collected during the July survey. Prior to 2009, larval red shiner have been collected in June, or in some years, May. Despite what appears to have been a delay in the initiation of spawning, red shiner was the most frequently encountered and numerically dominant species between the months of July and September. Red shiner accounted for 86.8% of the age-0 catch by number. There was no significant difference in catch rates for red shiner during the three months that this species was collected (Figure 31). All reaches produced red shiner and there was little difference in catch rates among the five reaches. The catch rate in Reach 1 was significantly lower than those of Reaches 4 and 3 (F=4.0829 P<0.0001 [Figure 31]). Between 2004 and 2008 there had been a general downward trend in red shiner catch in the San Juan River (Figure 32), however, the catch rate in 2009 was significantly higher than those of 2008 (F=16.8166 P<0.0001). Each of the seven habitat types sampled contained age-0 red shiner, with no significant differences in catch rates (Figure 33)

Common carp. The first collection of age-0 common carp was taken during the June survey. A single collection near the bottom of the study area (river mile 8.1) produced two specimens. During the next two months in which common carp were collected, the species was only encountered in the upper three reaches of the study area. July had the highest catch of age-0 common carp during the 2009 survey (F=8.9552, P<0.0001 [Figure 34]). Reach 4 had significantly higher catch of common carp than Reach 3 and 1 (F=8.6221, P<0.0001[Figure 34]). Between year catch rates (2003-2009) for this species have been variable. Catch rates during 2003 and 2006 were significantly lower than all other years except 2007 (F=8.7036, P<0.0001 [Figure 35]). Pocketwater and shoal habitat types did not produce age-0 common carp in 2009. Within the habitat types than contained this species, catch rates were fairly uniform.

Fathead minnow. There was nearly a tenfold decrease in the number of age-0 fathead minnow collected in 2009 compared to 2008 (n=157 and 1,438 respectively). More age-0 razorback sucker were collected in 2009 than fathead minnow. In prior years, fathead minnow was one of the most common and frequently encountered species. The first age-0 fathead minnow was collected in May with each of the three subsequent months producing some

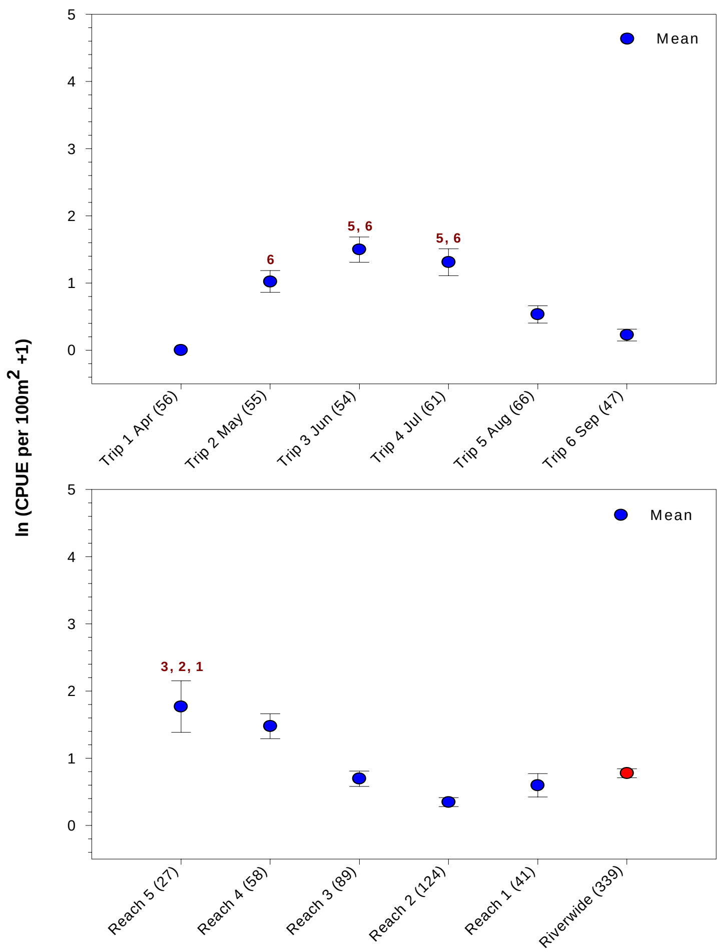

Figure 29. ln(CPUE per 100m^2 +1) [±1 SE] for age-0 bluehead sucker by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

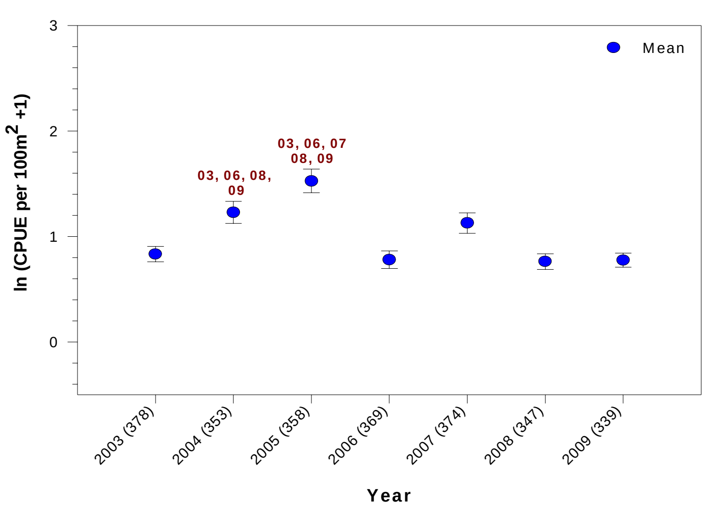

Figure 30. ln(CPUE per 100m^2 +1) [±1 SE] for age-0 bluehead sucker by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

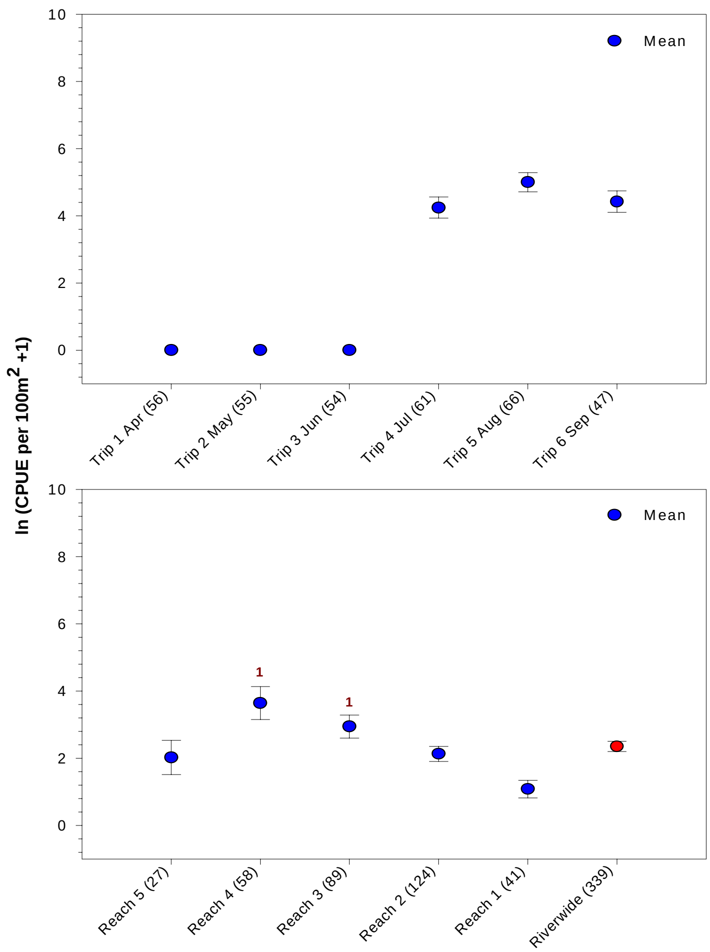

Figure 31. ln(CPUE per 100m^2 +1) [+1 SE] for age-0 red shiner by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

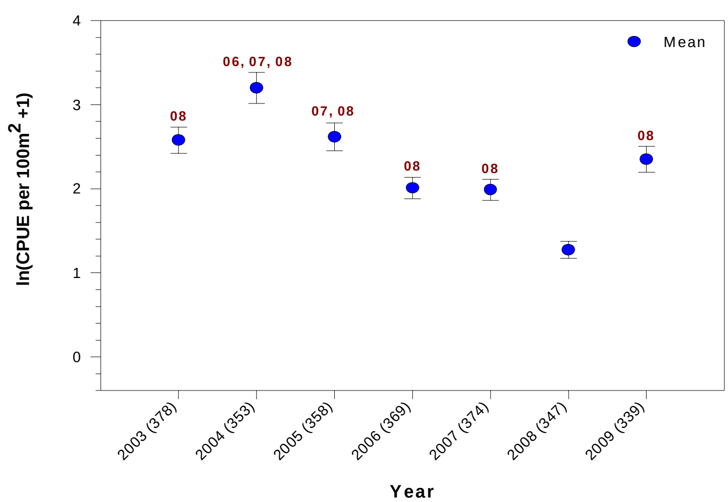

Figure 32. ln(CPUE per 100m^2 +1) [+1 SE] for age-0 red shiner by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

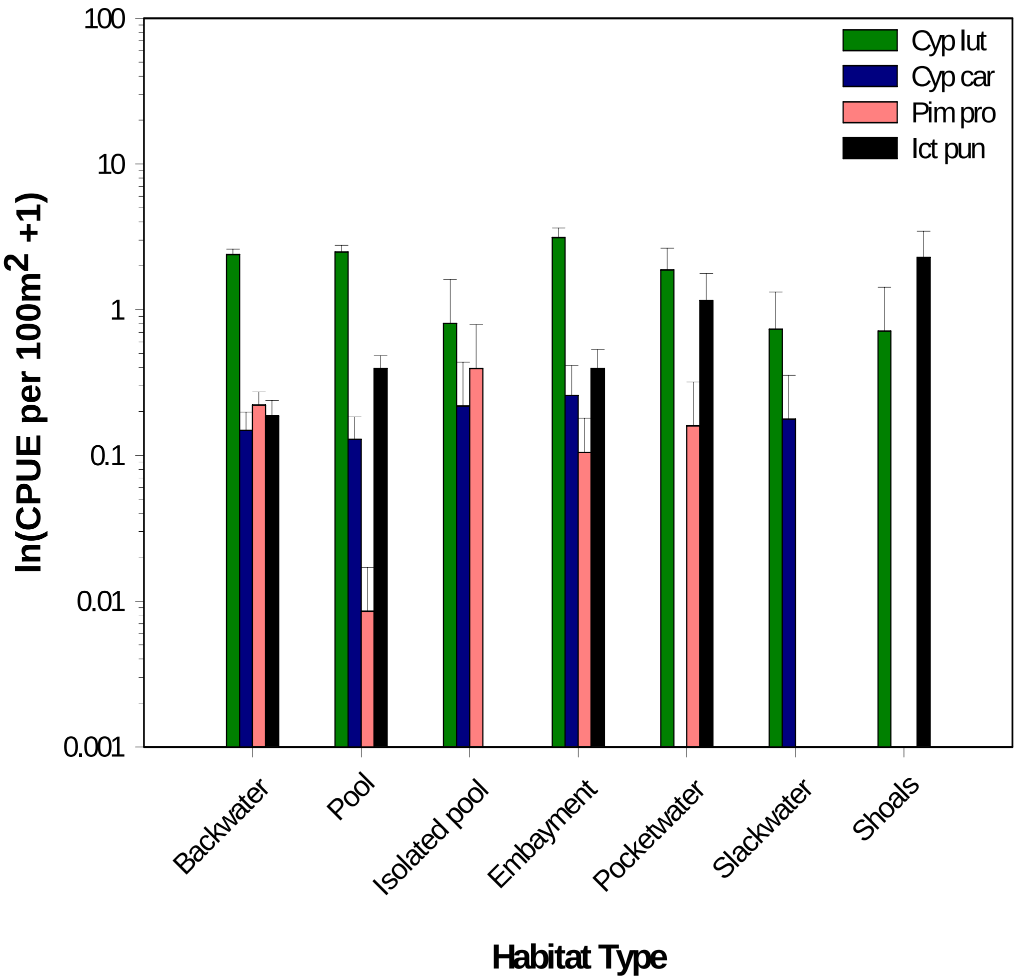

Figure 33. Habitat association by non-native species during the 2009 larval survey. Colored bars represent mean ln(CPUE per 100m^2 +1) [$\pm$1 SE].

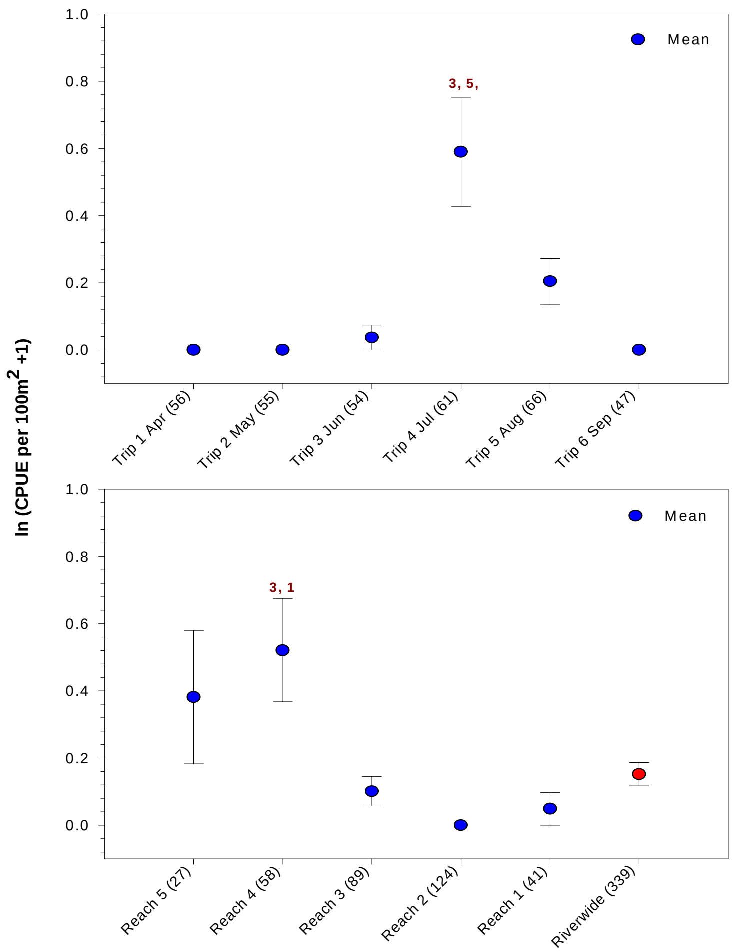

Figure 34. ln(CPUE per 100m² +1) [±1 SE] for age-0 common carp by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

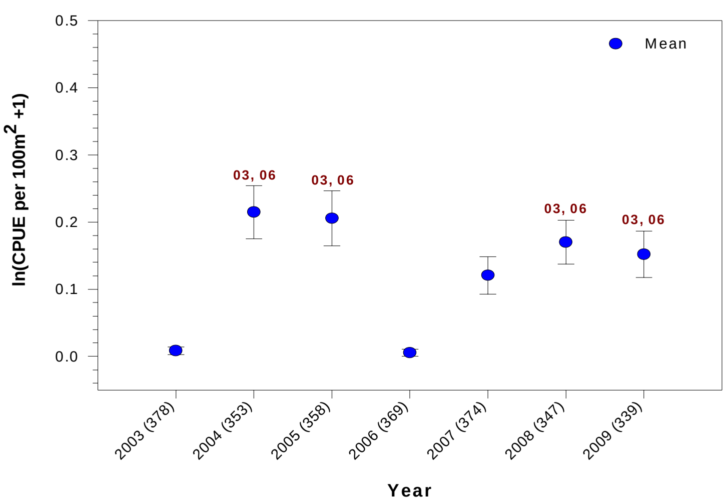

Figure 35. ln(CPUE per 100m² +1) [±1 SE] for age-0 common carp by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

fathead minnow. Fathead minnow were collected in each of the five reaches of the study area in 2009. There was no significant difference between any of the trips (F=2.2376, P=0.0503) or the reaches (F=2.3519, P=0.0539 [Figure 36]). Catch of age-0 fathead minnow have shown a general downward trend between 2003 and 2009. The catch rate in 2009 was significantly lower than the previous six years (F=51.0985, P<0.0001 [Figure 37]). This species was encountered in all but slackwater and shoal habitat types. There was no significant difference in catch rates among habitats for fathead minnow.

Channel catfish. As is typical for this species, the first age-0 channel catfish was collected during the July survey (Figure 38). While each of the five reaches produced channel catfish, the catch rate was significantly higher in Reach 2 (F=9.6437, P<0.0001 [Figure 38]). A similar pattern for channel catfish was observed in 2007. Channel catfish is the only species to have catch rates peak in this mostly canyon bound geomorphic reach. From 2003 to 2009, catch rates for channel catfish have been highly variable, however 2009 was significantly lower than 2007 and 2008 (F=21.3488, P<0.0001 [Figure 39]). Within the habitat types that contained age-0 channel catfish, densities in shoals was significantly higher (F=6.6900, P<0.0001) than those of backwaters (Figure 33).

<u>Native and Non-native Catch</u>

From 2003 to 2009 the proportion of age-0 native and non-native catch rates has varied. Prior to 2005 non-native densities were significantly higher than native. Catch rates of native and non-native species tracked each other during the 2005 and 2006 surveys. Beginning in 2007 there was an increasing trend of native fish catch and a downward trend of non-native catch (Figure 40). These trends appear to be driven by the spawning efforts of non-native red shiner, and the two most abundant native fish taxa encountered in the San Juan River; flannelmouth sucker and speckled dace. In 2009 the red shiner catch exceeded that of flannelmouth sucker and speckled dace driving the catch of native species down and non-native species up. Catch of fathead minnow have declined significantly from earlier years of the larval fish surveys and also play a role in the decline of non-native densities prior to 2009.

Discussion

The long term data set provided by the larval fish surveys provide a temporal occurrence and distribution of age-0 fish taxa in the San Juan River over a range of abiotic variables. The 2009 larval fish survey marks the second consecutive year in which larval catostomids were not collected during the April survey. Prior to 2008 (1999-2007), larval flannelmouth sucker had routinely been collected during the month of April. Water data from 2008 suggested that elevated early-spring discharge (prior to run-off) associated with releases from Navajo Dam suppressed water temperatures enough to delay the spawning of flannelmouth sucker (and possibly razorback sucker) by several weeks. The reasons for an absence of larval flannelmouth sucker (or other larval catostomids) during the April survey in 2009 is unclear. Variations in spawning periods attributed to discharge and temperature may account for the absence of age-0 fish in the April. The 2009 back-calculated hatching dates for razorback sucker suggest that eggs were just beginning to hatch prior to the April survey. The mean water temperature during the April survey was 12.0^{o}C, minimum daily temperatures dropped to 8^{o}C. In the two week period leading up to the April survey, minimum daily temperatures dropped to less than 5^{o}C riverwide (Figure 41). Laboratory studies have shown total razorback sucker egg mortality at temperatures of 8^{o}C and less (Bozek et al., 1990). It is

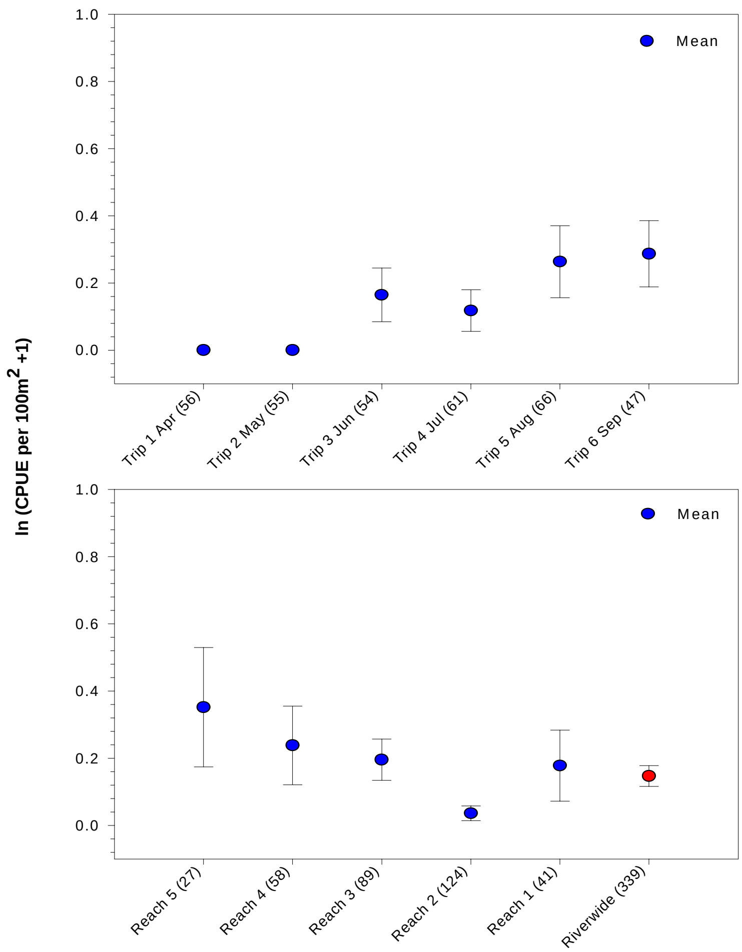

Figure 36. ln(CPUE per 100m^2 +1) [$\pm$1 SE] for age-0 fathead minnow by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels.

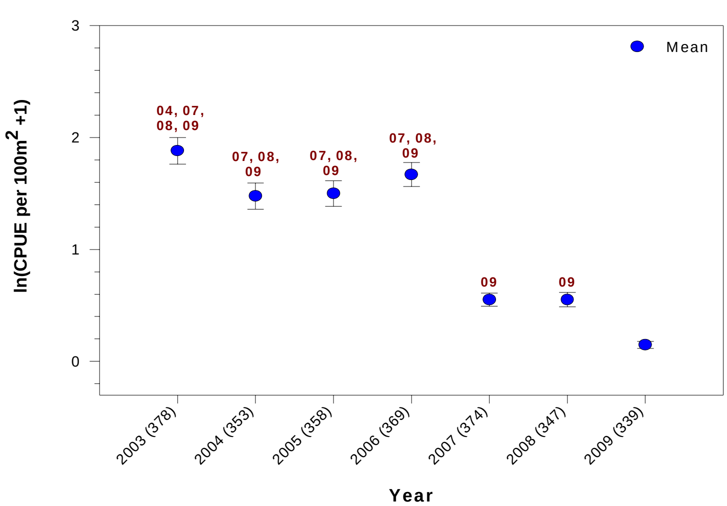

Figure 37. ln(CPUE per 100m^2 +1) [$\pm$1 SE] for age-0 fathead minnow by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

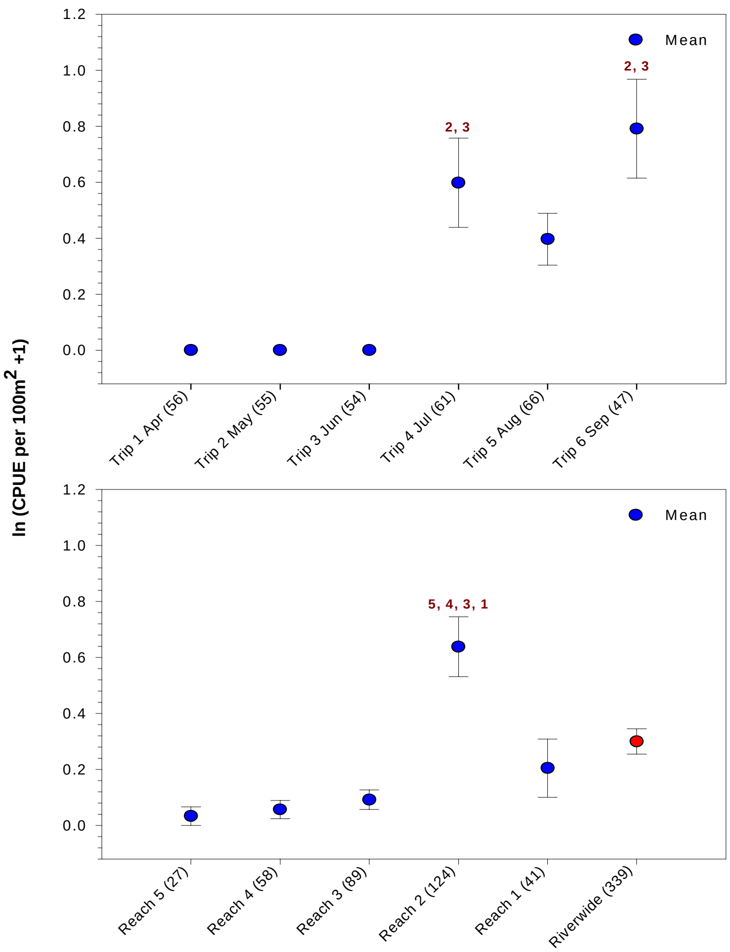

Figure 38. ln(CPUE per 100m² +1) [±1 SE] for age-0 channel catfish by trip (top graph), reach, and river wide (bottom graph) during the 2009 survey. Sample size reported on x-axis labels. Red text indicates trips/reaches that have significantly lower catch rates.

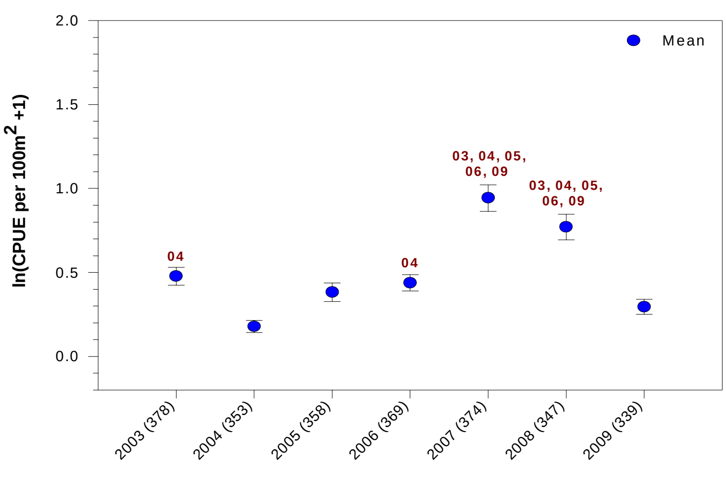

Figure 39. ln(CPUE per 100m² +1) [±1 SE] for age-0 channel catfish by year (2003-2009). Sample size reported on x-axis labels. Red text indicates years that have significantly lower catch rates.

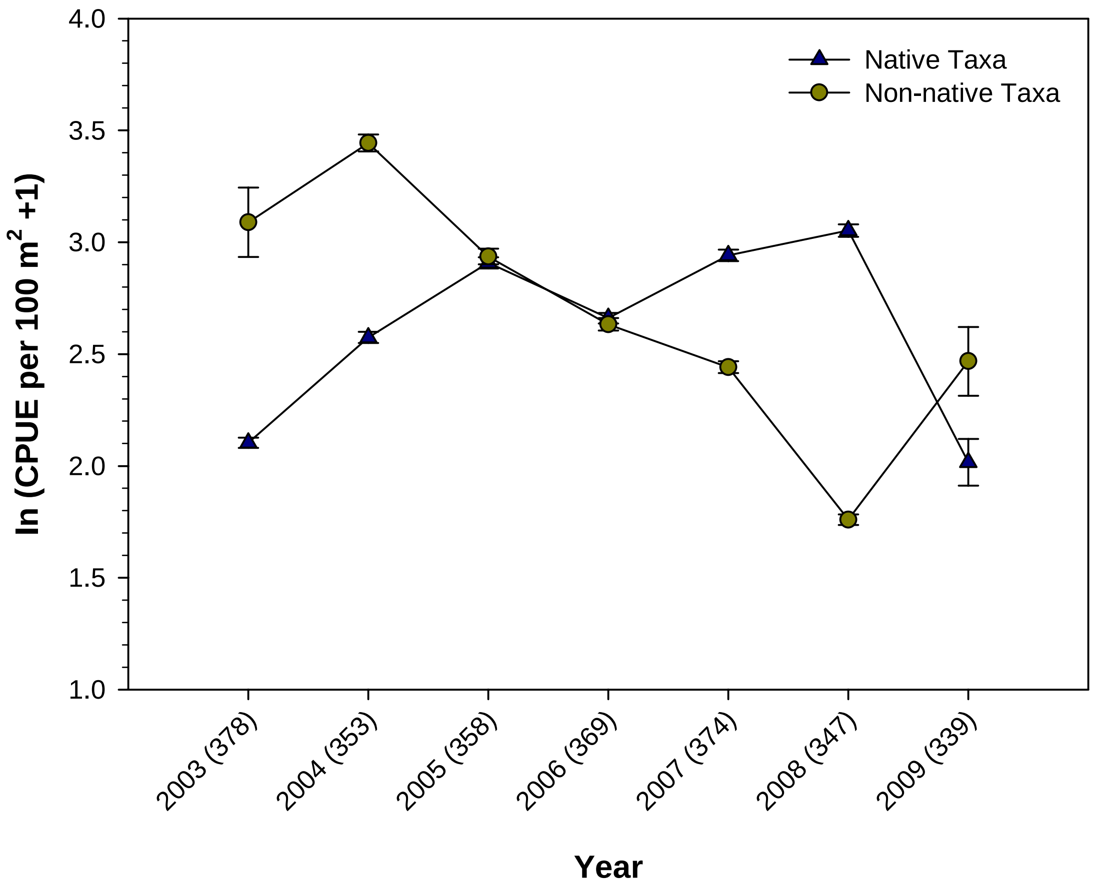

Figure 40. ln(CPUE per 100m^2 +1) [±1 SE] of native taxa [blue triangles] and non-native taxa [yellow circles] from 2003- 2009.

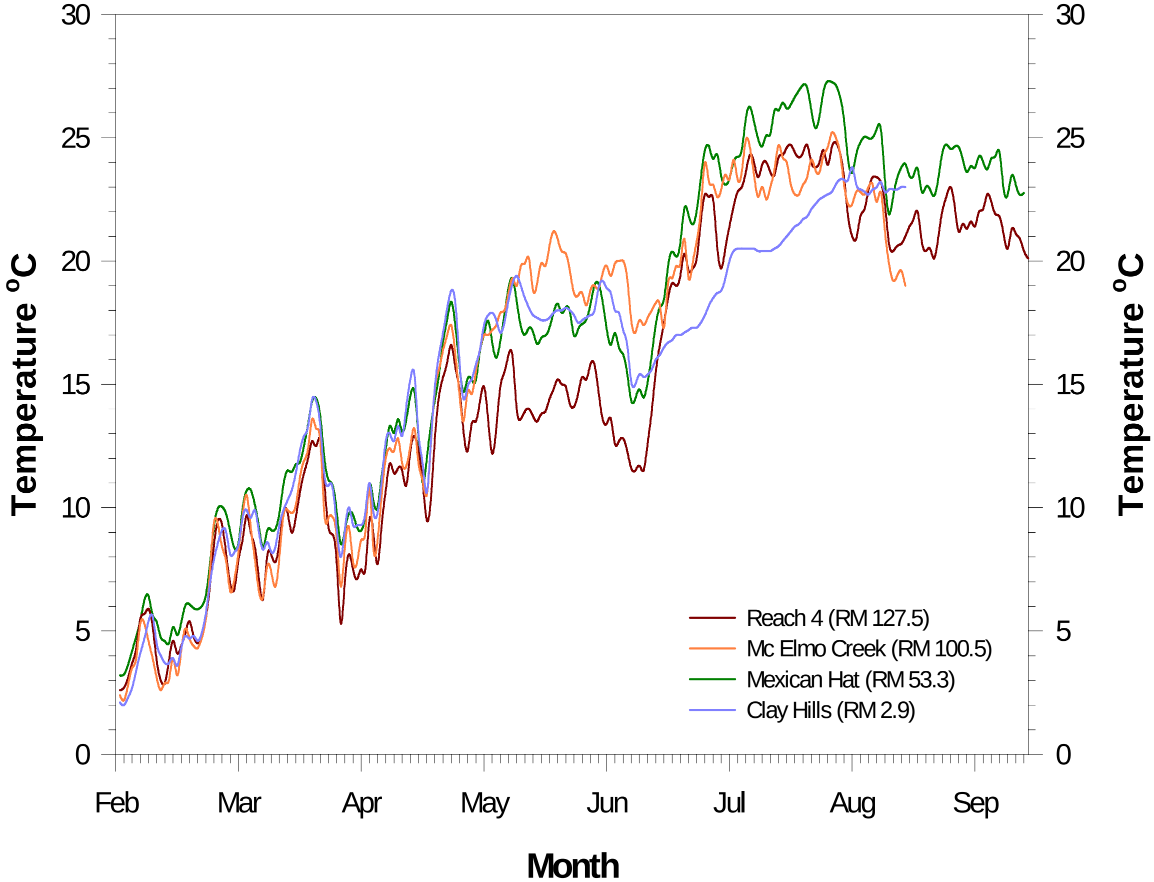

Figure 41. Water temperatures during the 2009 larval survey study period recorded in reach 4 (river mile 128.0), NM, McElmo Creek, UT , and Mexican Hat, UT (Mexican Hat data provided by Keller-Bliesner Engineering), and temperature recorded at Clay Hills Crossing (river mile 2.9) from 1 February to 30 September 2009.

possible that these low minimum daily temperatures resulted in delayed spawning activities or the mortality of some of the catostomid eggs prior to the April survey. Unlike the 2008 larval survey when temperatures were depressed due to water management actions, the 2009 hydrograph suggests that river temperatures were altered by an increase in discharge from the Animas River.

A concern that has been raised by the Biology Committee pertains to the extent of downstream displacement of larval endangered fishes and the ability of the San Juan River to retain the early life stages of these species for recruitment to the following year. Small bodied collections have not produced any juvenile razorback sucker in twelve years of surveys (Propst pers. comm.). The clumped distribution of mesolarvae collected from 1999-2009 in the downstream reaches of the study area, particularly in May, suggests downstream displacement of this life stage is occurring. The broad distribution of protolarvae in the study area also indicates displacement is occurring during the mesolarval stage. A study on transport rates of passively drifting particles (PDP) in the San Juan River (Dudley and Platania 1999) have demonstrated transport of PDP and larval Colorado pikeminnow (released along side the PDP) take between three and four days to pass through the critical habitat (river mile 180.0 -2.9). Persistent and suitable nursery habitats in the San Juan River system and spawning adult populations higher in the system could mitigate the loss of larval razorback sucker to Lake Powell and increase retention of these fish.

The trend of increased catch rate of razorback sucker larvae in downstream reaches is not observed in the other two sucker species. Razorback sucker and flannelmouth sucker have a similar spawning period with the highest catch of both species occurring in May and June, however, the two species differ in distribution by reach (Figure 42). From 1999-2009 flannelmouth sucker have significantly higher catch in Reach 3. Razorback sucker conversely have the highest catch rate in Reach 1. Bluehead sucker have the highest catch rate in Reach 5. It is possible that higher population densities of flannelmouth sucker and bluehead sucker in the upper reaches of the San Juan River, upstream of the larval survey study area including the Animas River, account for higher catch rates in Reaches 5-3. High catch rates of razorback sucker protolarvae at the bottom of Reach 2 may also suggest a spawning area in that reach which could account for some of the increased catch rates observed for this species.

Among the ten different habitat types sampled during the larval surveys (2005-2009), larval razorback sucker have been collected in all but four habitats; runs eddies sand shoals and cobble shoals. These habitat types all have water velocities that generally preclude them from nursery habitat classification. The remainder of habitat sampled during the larval survey have all produced larval razorback sucker. Low to zero water velocity characterize these habitat types. The habitat use of larval fish, including razorback sucker, over the last eleven years suggests that velocity is more of a factor in the presence or absence of larvae rather than specific habitat mesotype. It would also suggest that once any habitat type had suitable low velocity characteristics it could be occupied by larval razorback sucker. The persistence of specific low velocity habitat type and or the quality of them would also determine how long larval fish occupy a specific habitat.

There have been very few larval Colorado pikeminnow collected during the tenure of this study. From 2004-2009 there were documented spawning by this species in half of those years (2004, 2007, and 2009). Given that Colorado pikeminnow is a long lived species, it is seems unlikely that the reproducing adults that spawned in 2007 would not have spawned in 2008. It is possible that the level of reproduction by Colorado pikeminnow is so low that the number of larvae produced was below detection level of the larval fish surveys.

The Colorado pikeminnow that was collected in 2009 was the largest larvae (25.2 mm TL) collected to date. The formula used to generate the spawn date was for fish greater than 22

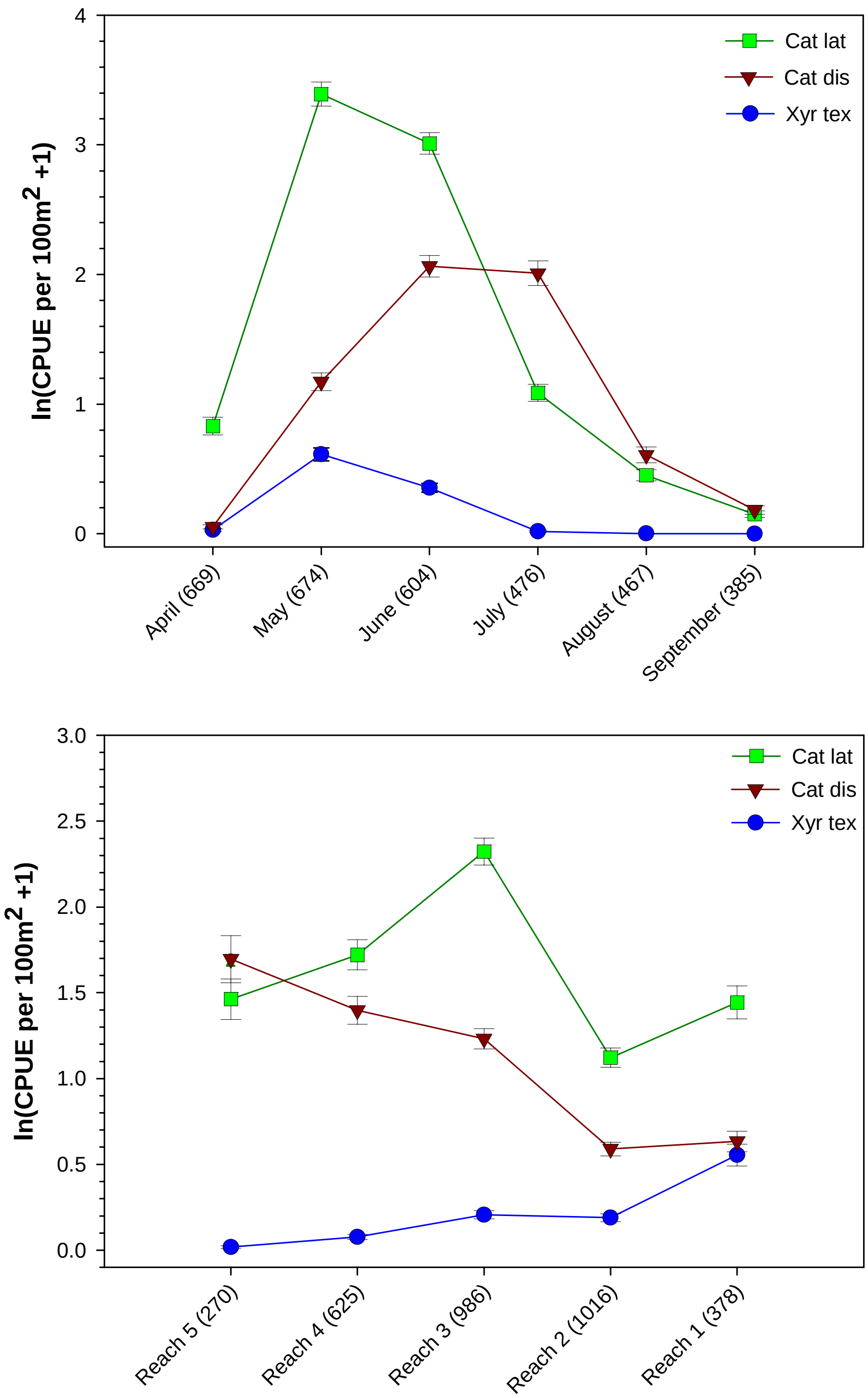

Figure 42. ln(Catch per unit effort per 100m^2+1) of the catostomids species collected from 1999-2009 by trip and reach. Green squares represent flannelmouth sucker, red triangles, bluehead sucker, and blue circles, razorback sucker.

mm TL (Nestler et al. 1988). The back-calculated spawning date that was generated placed the spawn high on the descending limb of the hydrograph. Temperatures during that period (12.9 ^{o}C) were well below the temperatures documented during spawning of Colorado pikeminnow in other systems. Back-calculated spawn and hatch dates become less accurate as a fish develops due to greater variability in growth rates and changes in abiotic conditions. A few days following the reported back-calculated spawn date water temperature rose above 18 ^{o}C. Colorado pikeminnow collected in 2004 and 2007 were younger, recently transformed metalarvae. Spawn dates for all five larvae collected from 2004 and 2007 were calculated in late June at the tail end of the descending limb. Mean water temperatures during that period were greater than 20^{o}C.

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Appendix I. Summary of age-0 fishes collected in the San Juan River during the 2009 larval fish survey.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	MEAN CPUE[2]	FREQUENCY OF OCCURRENCE[3]	% FREQUENCY OF OCCURRENCE[3]
CARPS AND MINNOWS						
red shiner	I	57,451	81.8	295.2	158	46.6
common carp	I	198	0.3	1.3	24	7.1
roundtail chub	N	-	-	-	-	-
fathead minnow	I	157	0.2	0.7	26	7.7
Colorado pikeminnow	N	1	*	*	1	0.3
speckled dace	N	3,722	5.3	24.2	133	39.2
SUCKERS						
flannelmouth sucker	N	3,348	4.8	18.2	99	29.2
bluehead sucker	N	1,012	1.4	6.8	120	35.4
razorback sucker	N	272	0.4	2.1	34	10.0
BULLHEAD CATFISHES						
black bullhead	I	1,964	2.8	11.1	6	1.8
yellow bullhead	I	-	-	-	-	-
channel catfish	I	236	0.3	2.0	48	14.2
TROUT						
brown trout	I	-	-	-	-	-
KILLIFISHES						
plains killifish	I	1	*	*	1	0.3
LIVEBEARERS						
western mosquitofish	I	1,789	2.5	9.4	83	24.5
SUNFISHES						
green sunfish	I	50	0.1	0.2	12	3.5
bluegill	I	-	-	-	-	-
largemouth bass	I	9	*	0.1	4	1.2
TOTAL		70,210		372.2		

[1] N = native; I = introduced
[2] CPUE = catch per unit effort; value based on catch per 100 m^2 (surface area) sampled
[3] Frequency and % frequency of occurrence are based on n=339 samples.
* Value is less than 0.05%

Table I-4. Summary of age-0 fishes collected during the 2009 San Juan River larval Colorado pikeminnow and razorback sucker survey. (13 April - 26 September, 2009). Effort =15,860.3 m^2

Appendix I. Summary of age-0 fishes collected in the San Juan River during the 2009 larval fish survey.

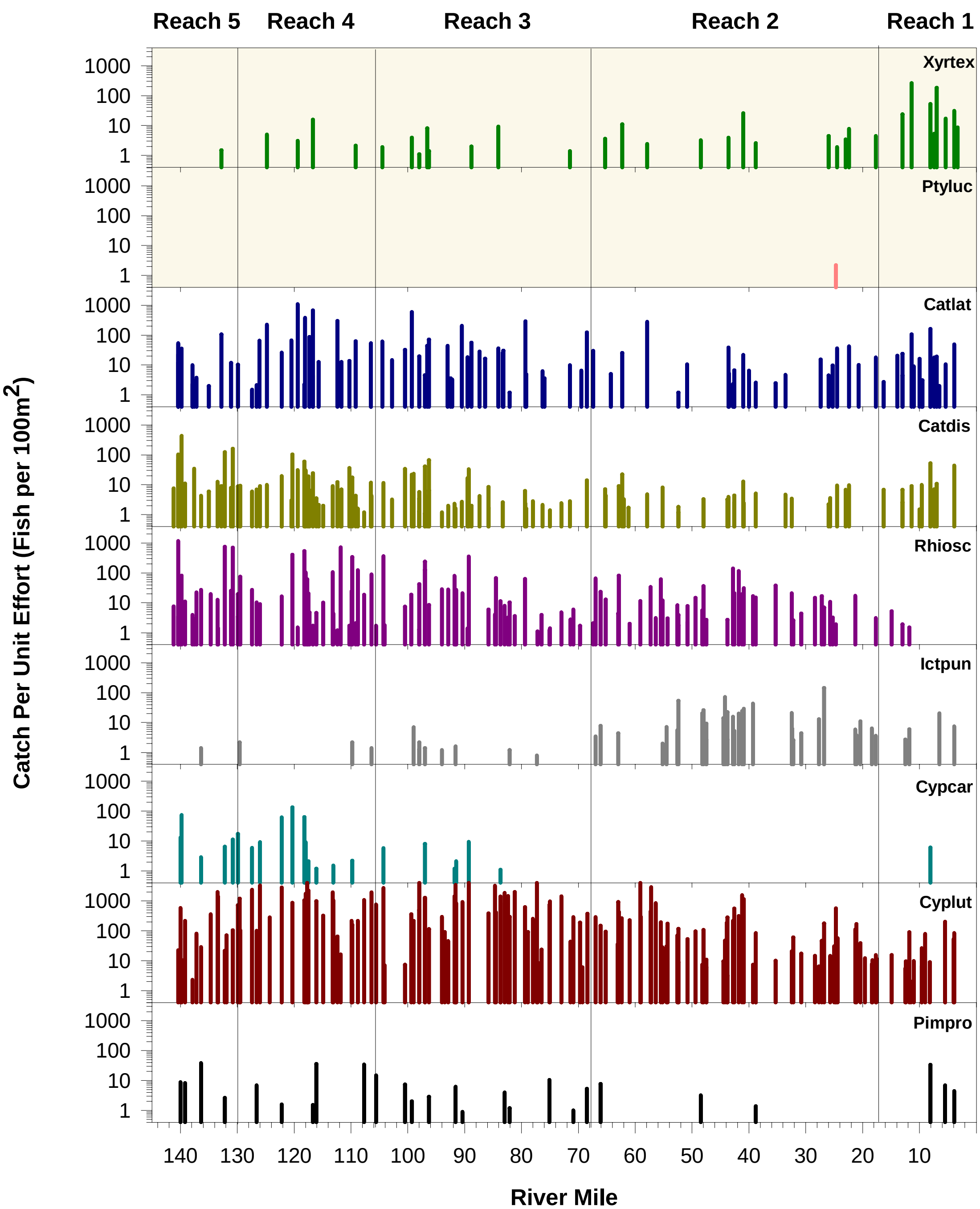


Figure I-43. Catch per unit effort /100m² of age-0 fish by sampling locality, riverwide (13 April - 26 September 2009).

Appendix II. Summary of age-1+ fishes collected in the San Juan River during the 2009 larval fish survey.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	MEAN CPUE[2]	FREQUENCY OF OCCURRENCE[3]	% FREQUENCY OF OCCURRENCE[3]
CARPS AND MINNOWS						
red shiner	I	1,213	55.3	7.5	117	34.5
common carp	I	1	*	*	1	0.3
roundtail chub	N	-	-	-	-	-
fathead minnow	I	161	7.3	1.4	29	8.6
Colorado pikeminnow	N	266	12.1	1.8	61	18.0
speckled dace	N	178	8.1	1.3	63	18.6
SUCKERS						
flannelmouth sucker	N	8	0.4	*	8	2.4
bluehead sucker	N	1	*	*	1	0.3
razorback sucker	N	-	-	-	-	-
BULLHEAD CATFISHES						
black bullhead	I	-	-	-	-	-
yellow bullhead	I	-	-	-	-	-
channel catfish	I	9	0.4	0.1	7	2.1
TROUT						
brown trout	I	1	*	*	1	0.3
KILLIFISHES						
plains killifish	I	3	0.1	*	3	0.9
LIVEBEARERS						
western mosquitofish	I	344	15.7	2.3	57	16.8
SUNFISHES						
green sunfish	I	3	0.1	*	2	0.6
bluegill	I	-	-	-	-	-
largemouth bass	I	5	0.2	*	4	1.2
TOTAL		2,193		14.4		

[1] N = native; I = introduced
[2] CPUE = catch per unit effort; value based on catch per 100 m^2 (surface area) sampled
[3] Frequency and % frequency of occurrence are based on n=339 samples.
* Value is less than 0.05%

Table II-5. Summary of age-1+ fishes collected during the 2009 San Juan River larval Colorado pikeminnow and razorback sucker survey. (13 April - 26 September, 2009). Effort =15,860.3 m^2

Appendix II. Summary of age-1+ fishes collected in the San Juan River during the 2009 larval fish survey.

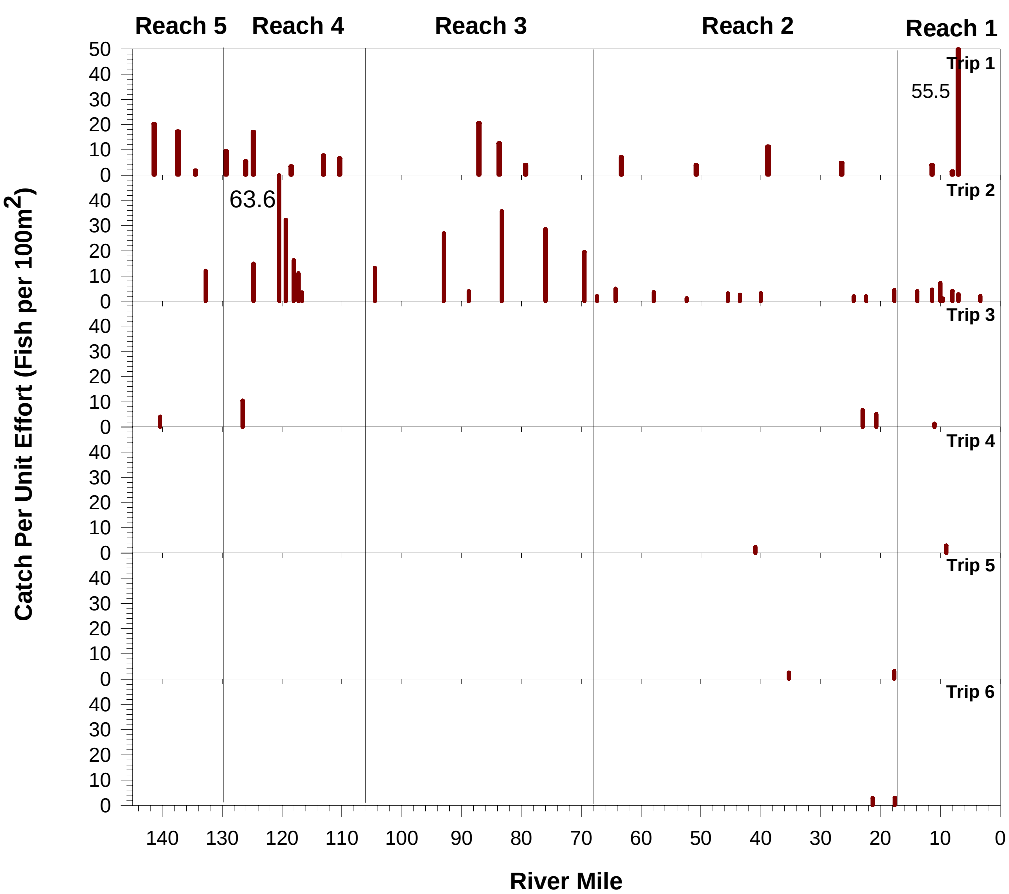


Figure II-44. Catch per unit effort /100m^2 of age-1+ Colorado pikeminnow (N= 266) by sampling locality during the 2009 larval fish survey (13 April - 26 September 2009).

Appendix III. Summary of endangered larval fishes collected in the San Juan River during the 2009 larval fish survey.

Field Number	MSB Catalog Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
WHB09-041		1	10.5	protolarva	19-May-09	132.8	larval fish seine
WHB09-044		3	13.3 -14.4	mesolarvae	19-May-09	124.8	larval fish seine
WHB09-046		2	11.1, 13.6	proto - mesolarvae	19-May-09	119.4	larval fish seine
WHB09-049		9	11.1 -15.9	proto - mesolarvae	20-May-09	116.7	larval fish seine
WHB09-051		1	10.7	protolarva	20-May-09	109.2	larval fish seine
WHB09-053		1	11.6	mesolarva	20-May-09	104.5	larval fish seine
WHB09-055		2	11.9, 13.7	mesolarvae	20-May-09	99.3	larval fish seine
WHB09-056		2	11.1, 12.0	proto - mesolarvae	21-May-09	96.6	larval fish seine
WHB09-060		1	14.4	mesolarva	21-May-09	88.8	larval fish seine
WHB09-062		8	10.1 -15.1	proto - mesolarvae	21-May-09	84.1	larval fish seine
WHB09-070		3	10.9 -11.9	protolarvae	22-May-09	62.5	larval fish seine
WHB09-071		2	12.9, 13.0	mesolarvae	22-May-09	57.9	larval fish seine
MAF09-029		1	11.4	mesolarva	20-May-09	24.5	larval fish seine
MAF09-030		4	12.2 -14.4	protolarva	20-May-09	22.4	larval fish seine
MAF09-031		1	13.0	mesolarva	20-May-09	17.7	larval fish seine
MAF09-033		13	12.4 -17.3	mesolarva	20-May-09	13.0	larval fish seine
MAF09-034		57	11.1 -18.1	proto - mesolarvae	21-May-09	11.4	larval fish seine
MAF09-037		52	11.3 -20.7	proto - metalarvae	21-May-09	8.1	larval fish seine
MAF09-038		67	11.0 -17.4	proto - mesolarvae	21-May-09	7.0	larval fish seine
MAF09-039		8	11.8 -17.9	mesolarvae	21-May-09	5.4	larval fish seine
MAF09-040		4	13.7 -19.2	mesolarvae	21-May-09	3.3	larval fish seine
WHB09-086		1	10.8	mesolarva	18-Jun-09	98.0	larval fish seine
WHB09-087		1	10.7	protolarva	18-Jun-09	96.3	larval fish seine
WHB09-096		1	10.7	protolarva	19-Jun-09	71.5	larval fish seine
WHB09-098		1	12.0	mesolarva	19-Jun-09	65.3	larval fish seine
MAF09-042		1	11.5	protolarva	16-Jun-09	50.8	larval fish seine
MAF09-045		1	11.7	protolarva	16-Jun-09	43.6	larval fish seine
MAF09-047		12	10.9 -11.9	proto - mesolarvae	16-Jun-09	41.0	larval fish seine
MAF09-048		1	12.6	mesolarva	16-Jun-09	38.8	larval fish seine
MAF09-050		2	11.0, 11.2	protolarvae	17-Jun-09	26.0	larval fish seine
MAF09-052		1	11.2	mesolarva	17-Jun-09	23.0	larval fish seine
MAF09-060		2	14.4, 14.6	mesolarvae	18-Jun-09	8.0	larval fish seine
MAF09-061		3	11.3 -11.7	mesolarvae	18-Jun-09	7.4	larval fish seine
MAF09-062		7	10.9 -30.2	meso -juvenile	18-Jun-09	3.9	larval fish seine
Total		**272**					

Table III-6. Summary of the larval razorback sucker collected in the San Juan River during the 2009 larval fish survey.

Appendix III. Summary of endangered larval fishes collected in the San Juan River during the 2009 larval fish survey.

Field Number	MSB Catalog Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
MAF04-046	53090	1	14.2	metalarva	22 July 2004	46.3	larval seine
MAF04-059	53130	1	17.0	metalarva	24 July 2004	17.0	larval seine
2004	**Total**	**2**					
MAF07-139	70144	1	14.9	metalarva	25 July 2007	107.7	larval seine
MAF07-157	70145	1	17.5	metalarva	27 July 2007	74.9	larval seine
WHB07-078	64032	1	15.6	metalarva	25 July 2007	33.7	larval seine
2007	**Total**	**3**					
MAF09-072	not assigned	1	25.2	metalarva	29 July 2009	24.7	larval seine
2009	**Total**	**1**					
Total		**6**					

Table III-7. Summary of larval Colorado pikeminnow collected in the San Juan River during the 2004, 2007, and 2009 larval fish survey.

Appendix IV. Detailed sampling and fish identification protocol.

1. Determination and access to sampling sites

   a. Suitable habitats for larval fish, including areas of low velocity (pools, backwaters, and secondary channels) were identified by field personnel while floating the river.
   b. Access to the habitats was gained via 16' inflatable raft.
   c. River Mile was determined to tenth of a mile using the standardized map set 2003 aerial photos produced for the San Juan River Basin Recovery Implementation Program.
   d. Geographic coordinates were determined at each site with a Garmin Navigation Geographic Positioning System (GPS) Instrument and were recorded in Universal Transverse Mercator (UTM) Zone 12 NAD27 CONUS. In instances where coordinates could not be obtained due to poor GPS satellite signal, coordinates were determined in the lab using a Geographic Information System based on the recorded river mile.

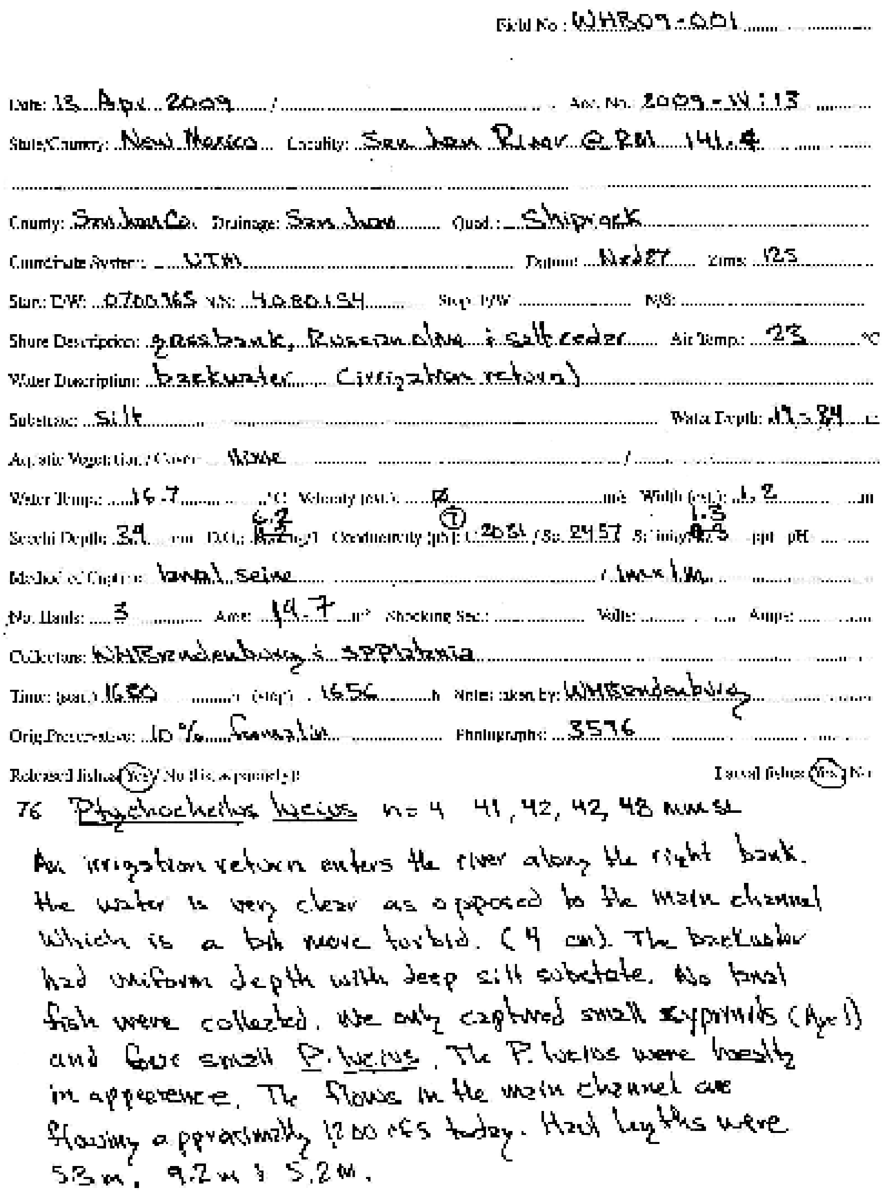
2. Collection of larval fish samples via seine and associated data recorded

   a. Small-mesh seines (1m x 1m x 0.8 mm) were drawn through the sampling site.
   b. The number of seine hauls per site was recorded along with the length of each seine haul. This information was used to calculate effort (area sampled) using the equation:
   c. Ecological data about each site were recorded, including meso-habitat type, length of habitat area, maximum depth, and substrate. A secchi disk was used to determine water clarity. Figure IV-41 illustrates data recorded at seining sites in the field.

4. Retention, identification, and permanent deposition of specimens

   a. Retained specimens at each site were placed in WhirlPak bags containing a solution of 100% ethyl alcohol and a tag inscribed with a unique alpha-numeric code that was also recorded on the field data sheet.
   b. Samples were returned to the Division of Fishes, Museum of Southwestern Biology (MSB), University of New Mexico. The specimens were removed from the field bags, debris and silt was removed and they were transferred to glass museum jars. Specimens from each site were sorted and identified to species, then the species series were enumerated, and measured for minimum and maximum size (mm SL) of that sample.
   c. Specimens were identified to species by MSB personnel with expertise in San Juan River Basin larval fish identification. Identifications were made using a polarized, underlit stereo microscope. Specimens whose species-specific identity was questionable were forwarded to Darrel E. Snyder (Larval Fish Laboratory, Colorado State University) for review.
   d. Specimens identified as razorback sucker were further examined for determination of developmental stage and minimum and maximum size (mm TL).
   e. All collections were catalogued, labeled, and placed on shelves in the in the collection archives of the MSB.

Appendix IV. Detailed sampling and fish identification protocol (continued).


Field No.: WHB09-001

Date: 13 Apr 2009 / Acc. No. 2009-W.113

State/Country: New Mexico Locality: San Juan River @ RM 141.4

County: San Juan Co. Drainage: San Juan Quad.: Shiprock

Coordinate System: UTM Datum: Nad27 Zone: 12S

Start: E/W: 0700365 N/S: 4080154 Stop E/W: N/S:

Shore Description: grassbank, Russian olive & salt cedar Air Temp.: 23 °C

Water Description: backwater (irrigation return)

Substrate: Silt Water Depth: 17-34 cm

Aquatic Vegetation / Cover: None

Water Temp.: 16.7 °C Velocity (est.): Ø m/s Width (est.): 1.2 m

Secchi Depth: 34 cm D.O.: 6.2 mg/l Conductivity (µS): ① 2051 / Sc. 2457 Salinity: 1.3 ppt pH:

Method of Capture: larval seine / 1m x 1m

No. Hauls: 3 Area: 14.7 m² Shocking Sec.: Volts: Amps:

Collectors: WHBrandenburg & SPPlatania

Time: (start) 1650 (stop) 1656 h Notes taken by: WHBrandenburg

Orig. Preservative: 10% formalin Photographs: 3576

Released fishes: (Yes) No (list separately) Larval fishes: (Yes) No

76 Ptychocheilus lucius n=4 41, 42, 42, 48 mm SL

An irrigation return enters the river along the right bank. The water is very clear as opposed to the main channel which is a bit more turbid. (4 cm). The backwater had uniform depth with deep silt substrate. No larval fish were collected. We only captured small cyprinids (Age 1) and four small P. lucius. The P. lucius were healthy in appearance. The flows in the main channel are flowing approximately 1200 cfs today. Haul lengths were 5.3 m, 4.2 m & 5.2 m.

Figure IV-45. Field sheet used to record seine collection data at a sampling site during the Colorado pikeminnow survey in the San Juan River 2009.