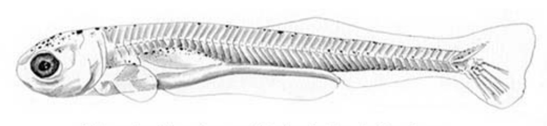
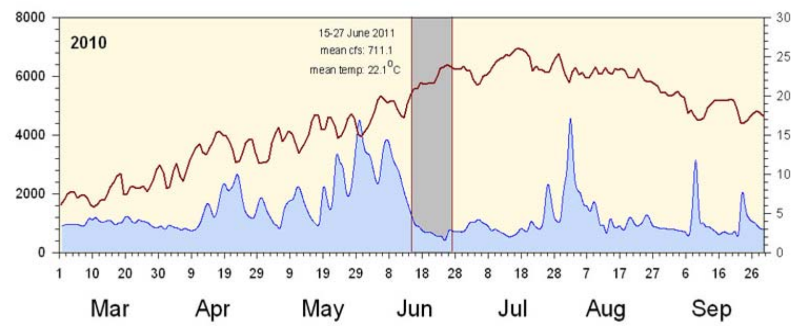
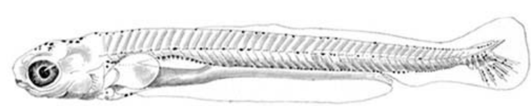
Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2010

FINAL REPORT

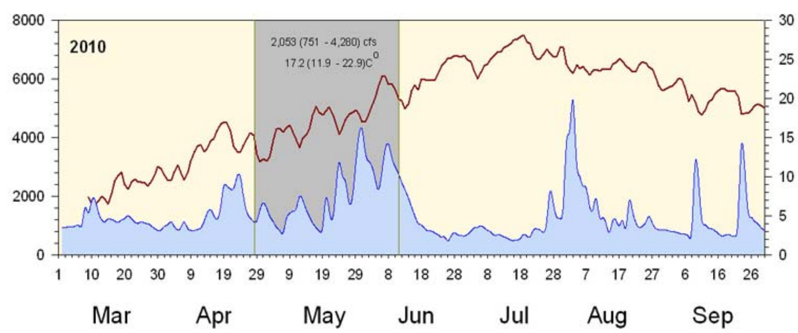


Colorado pikeminnow, *Ptychocheilus lucius*, larva





razorback sucker, *Xyrauchen texanus*, larva



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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2010

FINAL REPORT

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submitted to:

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

30 June 2011

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Executive Summary

1. From 19 April to 3 September 2010 six monthly larval 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 1,552 cfs (488 - 5,280 cfs) and 21.3 ^{o}C (11.9 - 28.1 ^{o}C).

3. A total of 365 collections were made encompassing 16,761 m^{2} of low velocity habitat.

4. The 2010 larval fish collections produced 70,606 fishes representing seven families and 15 species. One possible age-0 razorback X flannelmouth sucker hybrid was collected.

5. Age-0 fishes accounted for 79.1% of the total catch (n= 55,838) and had a river wide mean of 434.1 (SE=88.7) fish per 100 m^{2}.

6. Red shiner was the numerically dominant (n=41,061) and most frequently encountered species during the 2010 larval fish survey.

7. Between 17 May and 20 July 2010, 1,251 wild age-0 razorback sucker were collected in six different habitat types.

8. The back-calculated hatching dates for razorback sucker ranged from 28 April to 11 June 2010. Mean daily discharge and water temperature during that period was 2,054 cfs and 17.2 ^{o}C.

9. Age-0 razorback sucker consisted primarily of protolarvae and mesolarvae (n=332 and n=856, respectively).

10. Five larval Colorado pikeminnow were collected in backwater habitats during the July sampling trip between river miles 58.9 and 13.0.

11. The five Colorado pikeminnow were all metalarvae and ranged in size from 12.6 to 21.4 mm total length.

12. The back-calculated spawning dates for the age-0 Colorado pikeminnow were 15-27 June 2010. Mean daily discharge and water temperature during this period was 711 cfs and 22.1 ^{o}C.

13. A total of 221 age-1+ (28-149 mm SL, 37-182mm TL) Colorado pikeminnow were collected during the study period in 2010. 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, instream barriers, changes to the thermal regime and channel simplification. In addition, the introduction of non-native fishes may have altered predation dynamics and competition for habitat and resources (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, 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). Larval Colorado pikeminnow drift down river 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 fish 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 in 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 spring 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 (Tyus and Karp, 1990; Douglas and Marsh, 1998).

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 of adult fishes but also affect growth rates, available food supplies, and mortality rates, for their offspring (Miller et al., 1988).

Food production, competition for food resources, and predation, 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, non-native red shiner, *Cyprinella lutrensis*, has been documented to prey on cypriniform larvae (Brandenburg and Gido, 1999; Bestgen, 2006). Red shiner compose up to 80% of the ichthyofaunal community in nursery habitats in the San Juan River (Propst et al., 2003; Brandenburg and Farrington, 2004) 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, create and maintain nursery habitat for larval fishes, and suppress non-native fish populations (Poff et al., 1998). 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 (1993-2009) 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
MAF09-072	74264	1	25.2	29 Jul 09	10 Jun 09	24.7	larval seine
TOTAL		**12**					

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 six larval Colorado pikeminnow were collected between 2004 and 2009.

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 (Xyrtex) collected in the San Juan River (1998-2009).

Year	Study Area	Project Dates	Total 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
2009	141.5 - 2.9	13 Apr - 26 Sep	15,860.3	272	larval seine
TOTAL				**2,335**	

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, and 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 compose a small portion 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 successfully, to operate Navajo Dam 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 was accomplished during a one week period 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 of each month.

Collecting efforts for larval fishes were concentrated in low velocity habitats using small

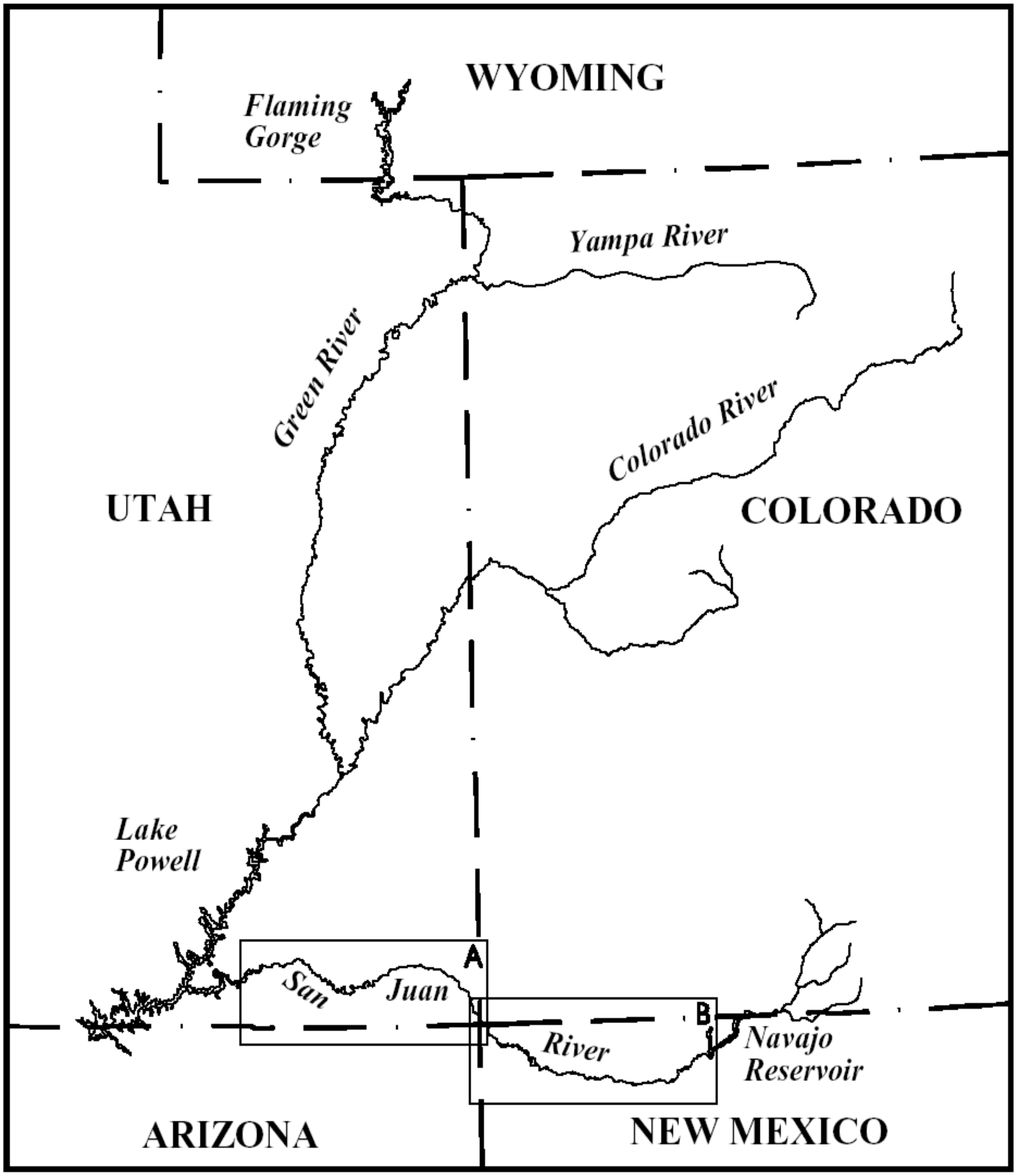

Figure 1. Location of the San Juan River within the Upper Colorado River Basin. The study area is outlined and labelled “A” and “B” with reference to subsequent maps in this report.

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 as a single sample. For each site sampled, the length (in meters) of each seine haul was determined in addition to the number of seine hauls per site. Mesohabitat type, length, maximum and minimum 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, specific conductance, PH, salinity, and temperature) were also obtained using a multi-parameter water quality meter. Habitat designations used in this report were developed for the San Juan River Basin Recovery Implementation Program's (SJRBRIP) monitoring projects (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 2009 standardized aerial maps produced for the SJRBRIP and used to designate the location of collecting sites. In addition, geographic coordinates were determined at each site with a Garmin 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 95% 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. Stereo-microscopes with transmitted light bases and 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).

In 2010 a pilot study was designed to address the persistence and availability of backwater habitats in the San Juan River during the months of May and June (peak periods of age-0 razorback sucker catch). Using catch data from the larval fish surveys (1998-2009), backwater localities were identified that were routinely available during May and June and produced catostomid larvae. These backwater habitats were designated as potential habitat mapping sites for the pilot study. During the May survey, available backwater sites were mapped using a hand held Trimble Ranger Pro-XH or XT Global Positioning System (GPS) and an accompanying staff mounted receiving unit. The GPS unit was enabled with a wide area augmentation system (WAAS). Site maps detailed the area of the backwater and the size of the mouth (connection with the main channel). In addition the maximum depth of water at the mouth was recorded along with data that are normally recorded at all sampling locations. During the subsequent June survey the sites that were mapped in May were re-mapped if the site was available. Data from the Trimble Ranger GPS units were downloaded using Real-time correction with Pathfinder Office 4.1.

Results reported in this document pertain primarily 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 (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

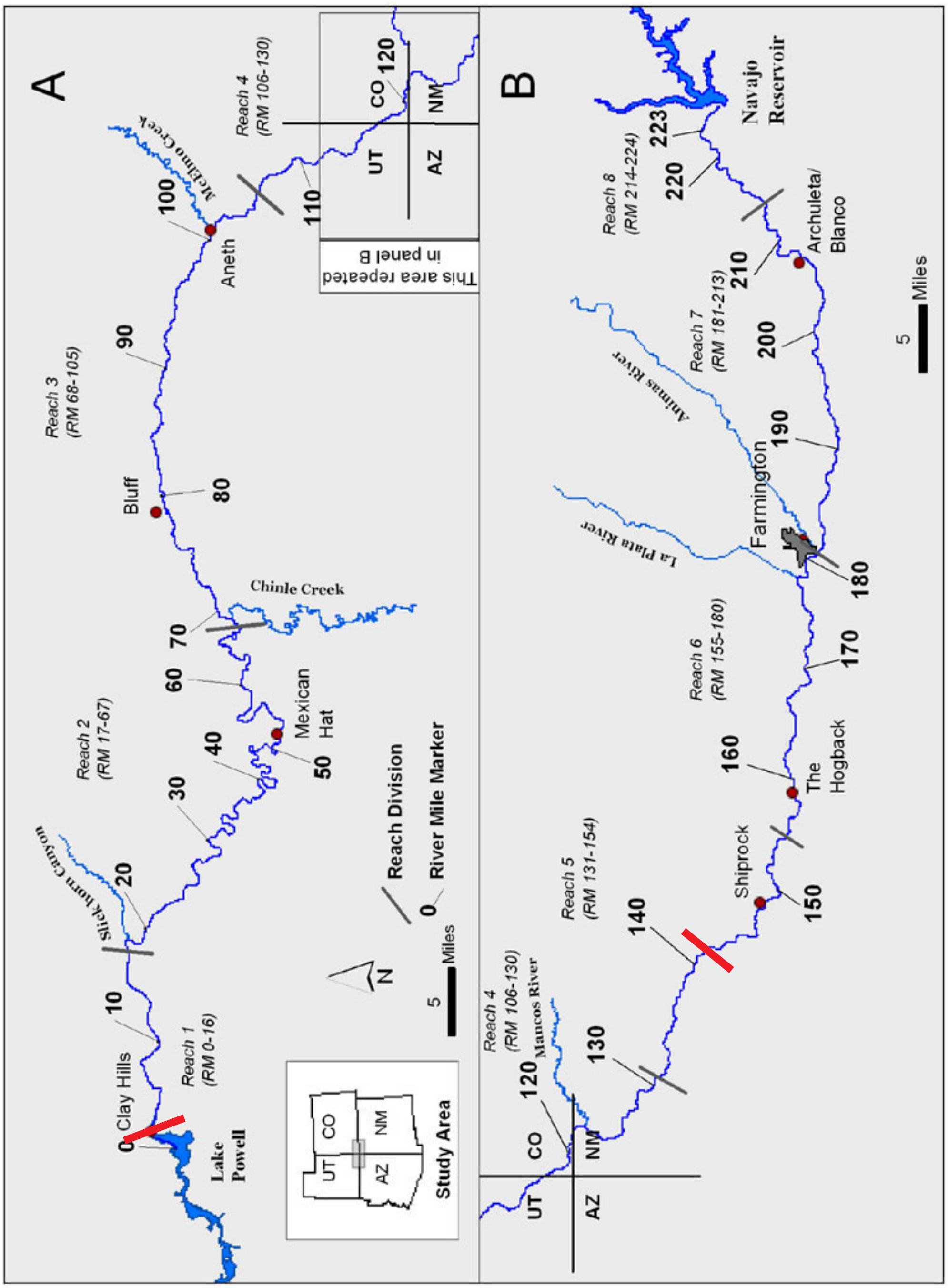

Figure 2. Map of the San Juan River. Study area is delineated by red bars (Cudei, NM river mile 141.5 and Clay Hills Crossing, UT river mile 2.9).

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 2010 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	
Oncorhynchus nerka	kokanee salmon	(ONCNER)
Order Cyprinodontiformes		
Family Fundulidae	topminnows	
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)

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 stage. The larval fish terminology used in this report is defined by Snyder (1981). There are three distinct sequential larval developmental stages: protolarva, mesolarva, and metalarva. Fishes in any of these developmental stages are referred to as larvae or larval fishes. Juvenile fishes are those that have progressed beyond the metalarva 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 (protolarva, mesolarva, and metalarva) were used to generate the larval occurrence graph. 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 metalarva to juvenile as a cut off (Snyder, 1981; Snyder and Muth, 2004). Larval occurrence was then plotted against discharge recorded near Bluff, UT (USGS gauge #09379500) and water temperature recorded 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 among years, trips, and reaches using a one-way Analysis of Variance (ANOVA). Samples collected in isolated pools are not included in yearly or between-year trend analysis. 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 (2003-2010), 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 trend data in larval razorback sucker where catch rates were analyzed from 1999 -2010 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^{o}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 designations beginning in 2005. Data collected prior to 2005 were sorted by primary habitat type sampled and in some cases, primary and secondary habitat types were combined (i.e. pool + edge pool = pool) to reflect the current habitat designations being used by the SJRBRIP.

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 dates 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).

Results

2010 Summary

The 2010 San Juan River larval fish survey encompassed a six month period from 19 April to 3 September 2010. 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, mean daily discharge and water temperature was 1,552 cfs (488 – 5,280 cfs) and 21.3 ^{o}C (11.9 - 28.1 ^{o}C). Spring runoff began on 9 April 2010. Discharge peaked 53 days later on 31 May 2010 at 4,280 cfs (Figure 3). The descending limb of spring runoff dropped over a 26 day period following the peak. There was no spring release from Navajo Dam during 2010. During the study period, discharge on the San Juan river exceeded 5,000 cfs for one day (5,280 cfs) on 3 August 2010. This flow spike was the result of summer rain events.

During the 2010 larval fish survey 365 collections were made in zero and low velocity habitats encompassing an area of 16,761 m^2. Collections resulted in the capture of 70,606 age-0 and age-1+ fishes representing seven families and 15 species. Age-0, or YOY fish, accounted for 79.1% of the total catch (n= 55,838). Age-0 fish were collected five of the six months sampled (May–September) with a mean of 434.1 fish per 100 m^2 (SE=88.7). Of the native species occurring in the San Juan River, flannelmouth sucker had the highest mean of 25.8 fish per 100 m^2 (SE=4.9). Native species made up 17.9% of the total catch by number during the 2010 larval survey. A potential YOY razorback X flannelmouth sucker hybrid (55 mm SL, 71 mm TL) was also collected. For verification, fin clips were taken from this fish for future genetic analysis.

For the third consecutive year, there were no age-0 specimens collected during the April survey. In all years prior to 2008, larval catostomids, particularly flannelmouth sucker, were first collected during the April survey (Brandenburg and Farrington, 2008). Collection of all three native catostomid species occurred during the May 2010 survey during the ascending limb of spring run-off. The June survey was the last occurrence of larval razorback sucker. Larval captures of the other catostomid species continued into the July survey (Figure 4). Two juvenile razorback sucker were collected during the July survey. Juvenile flannelmouth sucker and bluehead sucker were collected until the end of the study period. Larval speckled dace, common carp, red shiner and fathead minnow were first collected during the June survey, in low densities, coinciding with the descending limb of spring run-off. It was not until the July survey that larval cyprinids were collected ubiquitously in the study area. Larval Colorado pikeminnow

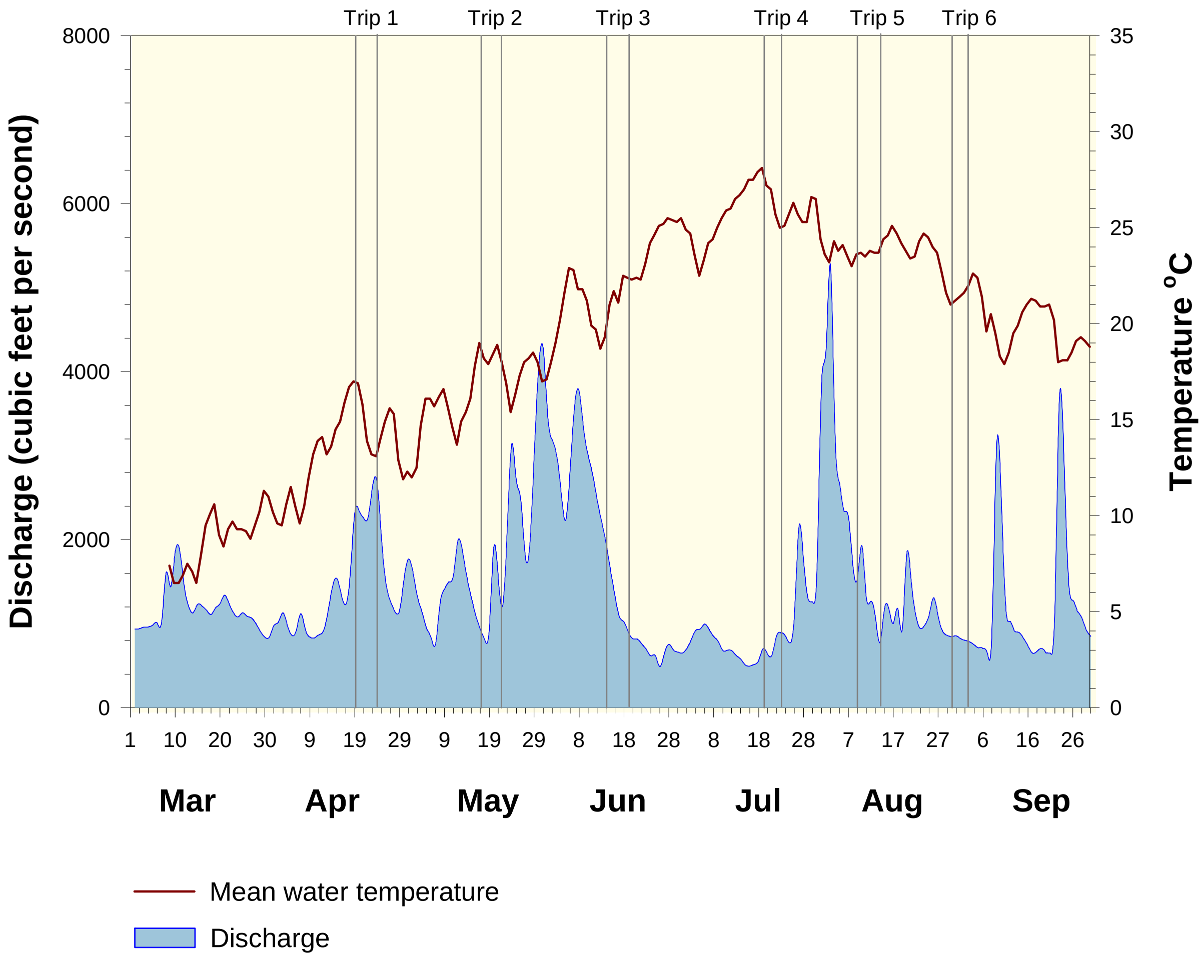

Figure 3. Discharge (cfs) and water temperature (°C) near Bluff, UT (USGS gauge #09379500) in the San Juan River during the 2010 sampling period. Grey vertical bars denote individual collecting trips.

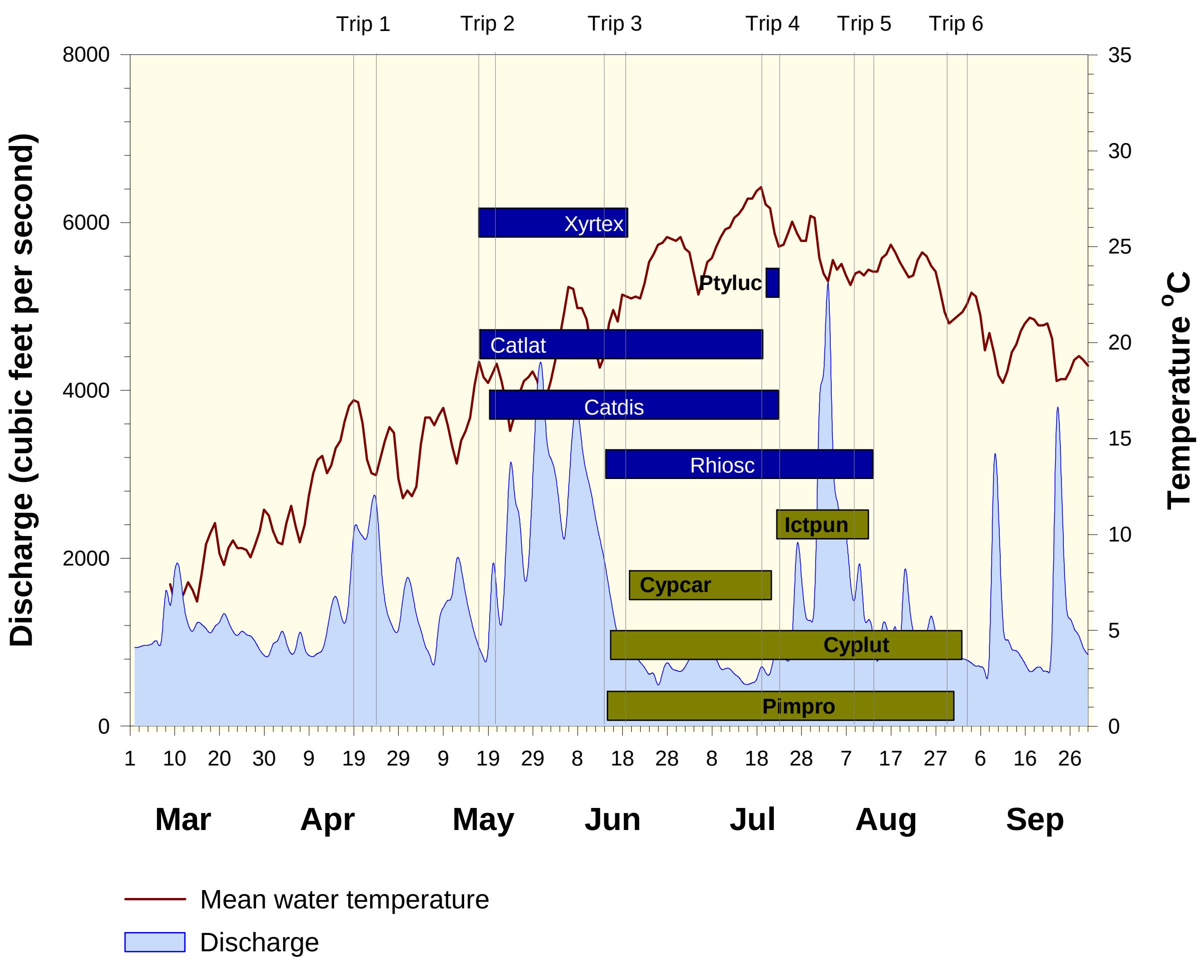

Figure 4. Occurrence of larval fishes in the San Juan River during 2010 plotted against discharge and water temperature (USGS gauge #09379500 near Bluff, UT). Bars represent the period between date of first and last collection of larvae for each species. Blue bars denote native species, yellow bars denote non-native species.

and channel catfish were first collected during the July survey. July was the only trip in which age-0 Colorado pikeminnow were collected.

2010 Trip Summary

The first survey trip (19-24 April 2010) was conducted during spring runoff. Mean daily discharge and water temperature during this period was 2,418 cfs and 15.0 °C. A total of 59 discrete habitats were sampled throughout the study area for a total effort of 2,693.9 m^2. No larval or age-0 fishes were collected during the April survey. Age-1+ red shiner made up 91.1% of the catch in April. Age-1+ Colorado pikeminnow and speckled dace, were the next most abundant species comprising 2.0% and 2.3% respectively.

The second larval survey (17-21 May 2010) took place during a lull in spring runoff. The mean discharge during the May survey was 1,223 cfs and the mean water temperature was 18.5 °C. A total of 63 collections were made encompassing 3,090.0 m^2 of habitat. Due to lower discharge, there was an abundance of isolated pools during the May survey, especially in the lower two reaches of the study area. These conditions were atypical for this period of time. Sixteen isolated pools were sampled during the May survey. The results of those collections, as well as all other isolated pools sampled in 2010 will be discussed later in this report. Larvae of all three native suckers were collected during the May survey. Flannelmouth sucker had the highest mean catch rate of the three catostomid species (94.6 fish per 100 m^2 SE=23.2) and was found in all five reaches of the study area. Bluehead sucker and razorback sucker were collected in Reaches 4 through 1 with a mean of 16.6 (SE=6.1) and 40.9 (SE=15.2) fish per 100 m^2 ,respectively. The largest single collection of larval razorback sucker (n=266) was during the May survey from a pool habitat at river mile 6.0. Catostomids were the only larval fish collected during the May survey.

The June survey (14-19 June 2010) took place during the descending limb of the spring hydrograph at a mean discharge of 1,586 cfs and mean water temperature of 25.6 °C. Of the 69 habitats sampled, 14 were isolated pools and the total area sampled was 3,414.0 m^2. In addition to the three native catostomid species collected during the May survey, age-0 red shiner, common carp, fathead minnow, speckled dace, western mosquitofish and green sunfish were also collected during the June survey. The common carp was collected in an isolated pool. Catch rates were lower in June for flannelmouth sucker (57.5 fish per 100 m^2 SE=18.6) and razorback sucker (2.2 fish per 100 m^2 SE=0.9) while means were higher for bluehead sucker (55.0 fish per 100 m^2 SE=19.0). Only the three catostomid species were distributed in each of the five reaches of the study area.

The fourth survey trip was conducted 19-23 July 2010. The mean daily discharge was the lowest of any of the survey trips (744 cfs) and mean water temperature was the highest at 26.6 °C. A total of 61 collections were made with 2,646.5 m^2 of habitat sampled. There were no isolated pools sampled in July. Catch rates for all small-bodied larval cyprinids increased during this month. Larval red shiner was distributed throughout the study area and dominated the catch with a mean of 1,543.2 fish per 100 m^2 (SE=415.2). The catch rate of red shiner was an order of magnitude higher than that of all other species combined. Additional age-0 species collected for the first time during this month were Colorado pikeminnow, black bullhead, channel catfish, largemouth bass, and a single razorback X flannelmouth sucker hybrid. Five age-0 Colorado pikeminnow were collected between river miles 58.9 and 13.0. July was the only month in which age-0 Colorado pikeminnow were collected and the last month to produce age-0 razorback sucker.

The August sampling survey was conducted from 9–14 August 2010. Of the 59 collections made, two were taken in isolated pools in Reach 1. Total area sampled was 2,205.2

m^2. The August survey was conducted on the tail end of a summer rain storm event which increased discharge to over 5,000 cfs. Mean discharge during the August collection was 1,317 cfs and mean water temperature was 23.7 °C. Similar to the July survey, red shiner had the highest catch rate of any species (210.6 fish per 100 m^2, SE=62.6). The only new age-0 species encountered during this trip was plains killifish. Non-natives species accounted for 95.7% of the total catch which was the highest percentage of non-natives collected for any of the six sampling trips.

The final collection trip occurred between 30 August and 3 September 2010. During this period mean daily discharge and water temperature were 822 cfs and 21.4 °C. A total of 54 collections were taken encompassing 2,711.4 m^2 of habitat. Two isolated pool collections were among the 54 samples taken. Red shiner continued to be the most abundant and frequently encountered species. Bluehead sucker were absent from nearly all collections with six specimens collected in five discrete samples. All of the bluehead sucker and flannelmouth sucker collected had progressed into the juvenile life stage and the majority (70.4%) were collected in habitat types other than backwaters. This shift from backwaters to other habitat types by older age-0 catostomids is similar to what has been observed in previous years.

Isolated Pools

More isolated pools were sampled in 2010 than all prior years combined. Sixteen isolated pools were sampled in May and 14 in June. The May larval fish survey was conducted during a period of low discharge during the spring hydrograph. The majority of the isolated pools sampled in May occurred in the lower portions of Reach 2 and throughout Reach 1. It was unusual to have such a high proportion of isolated pools during the May survey as this period is usually associated with higher spring flows. Immediately following the May survey, discharge in the San Juan River increased markedly presumably reconnecting isolated pools with the main channel. The June survey was conducted on the descending limb of spring run-off. Mean discharge during the June survey was 1,586 cfs. Discharge continued to drop after the survey and remained low for approximately 37 days (mean 803 cfs) until a summer rain storm event increased discharge in the later portions of July. Presumably most isolated pools that were sampled in June dried before main channel discharge spiked 37 days later.

A total of 2,755 larval fish were collected in isolated pools. Seventy-two percent of the catch was composed of larval catostomids. The high catch of catostomids is related to the higher proportions of isolated pools sampled in May and June when catches of cyprinids were low. A total of 322 larval razorback sucker were collected in isolated pools during the 2010 larval fish survey. May accounted for 32.3% (n=105) of the total catch of razorback sucker in isolated pools and June 67.4% (n=217). Catch data from isolated pools were not included in yearly or between year trend analysis because capture efficiencies are highly skewed in these habitats. Isolated pools are closed systems and in the case of desiccating pools fishes are highly concentrated making for unusually high catch rates.

Endangered Species

Razorback sucker. A total of 1,251 Age-0 razorback sucker were collected during the 2010 larval survey. Twenty-five percent of these fish were collected in isolated pool habitats (n=322). The first collections of larval razorback sucker occurred 19 May 2010 at river mile 107.6. The site consisted of two low velocity habitats (slackwater and backwater) formed on the downstream portion of two secondary channels on river right. Both habitats contained larval razorback sucker. Age-0 razorback sucker continued to be collected until 20 July 2010. The last age-0 razorback sucker collected was a 51mm SL juvenile found in a pool habitat at river mile 43.8. The river wide mean for razorback sucker was 6.1 fish per 100 m^2 (SE=2.3). In 2010, 39 collections contained razorback sucker, resulting in a percent frequency of occurrence of 11.8%. Among trips, catch rates were significantly higher in May than any other month (F=25.17, P<0.0001, [Figure 5]). There were no significant differences among reaches. Reaches 2 and 1 accounted for 67.9% of the total age-0 razorback sucker catch in 2010 (n=449 and n=401 respectively). Age-0 razorback sucker made up 10.4% of the total catch in Reach 1, second only to red shiner.

From 1999 to 2010 annual mean catches of age-0 razorback sucker have varied. Catch rates in 2010 were significantly higher than 1999, 2001, 2004, and 2005 (F=14.84, P<0.0001), but significantly lower than 2002 (Figure 6). The combined monthly catch from 1999 to 2010 show May having significantly higher catch rates than any other of the five months in the study period (F=98.27, P<0.0001 [Figure 7]). Catch rates were significantly higher in Reach 1 compared to other reaches during the twelve years of surveys (F=30.80, P<0.0001 [Figure 8]).

Age-0 razorback sucker collected in 2010 were almost entirely represented by larval fish (protolarvae to metalarvae) with the exception of five juvenile fish that were collected in June and July. Protolarvae composed 26.5% of the age-0 razorback sucker collected during the 2010 survey and nearly all protolarvae were collected in the month of May (Figure 9). Similar to previous years, the majority of protolarvae were collected in the lower portion of Reach 2 and throughout Reach 1. A single protolarva was collected at river mile 139.7 indicating spawning adults upstream of that river mile. This specimen marks the highest upstream distribution of age-0 razorback sucker seen during the tenure of this study. The clumped distribution of protolarvae occurs in the lower portions of Reach 2 beginning around John’s Canyon (river mile 24.5). The elevated catch of protolarvae in this area has been documented in prior years. The majority (68.4%) of all razorback larvae collected in 2010 were mesolarvae. Mesolarvae made up 67.0% of the razorback sucker catch during the May survey and 74.7% during the June survey. Similar to protolarvae, the highest catch rates of mesolarvae were documented in the last ten miles of Reach 2 and in Reach 1. Fifty-six metalarvae and five juvenile razorback sucker were collected during the 2010 survey. Both of these ontogenetic stages were found in reaches 2 and 1. The five juvenile fish ranged in size from 20-51 mm SL and were collected during the months of June and July. The largest specimen (51 mm SL) was collected during the July survey, identified, and released.

The distribution of discrete ontogenetic stages of razorback sucker over time (1999-2010) and by month further defines relationships to potential spawning areas and dispersal of propagules. Protolarvae collected from 1999-2010 were captured in four months of the study period (April-July), but had higher catch rates and were distributed throughout the study area in May and June. Collections of protolarvae in the upper Reaches of the study area over multiple years (2004-2010) indicate spawning adults upstream of those fish captures (Figure 10). Locations within the study area that have higher catches of protolarval razorback sucker are in Reach 3 in the vicinity of McElmo Creek, upstream of river mile 75.0 (June), in the lower portions of Reach 2, and in Reach 1. Mesolarvae constitute the majority of all larval razorback sucker collected (67.2%) during the twelve years of larval fish surveys. May accounts for 85.1% of all mesolarvae collected with catch rates being significantly higher (F=69.65, P<0.0001) in the lower portions (River mile 27.0-2.9) of the study area (Figure 11). The May and June distribution of mesolarve were similar; however, densities are lower in May. Metalarvae constitute 12.4% of the total age-0 razorback sucker catch from 1999-2010. Metalarvae have been collected from May through August (1999-2010), with the August collection consisting of one individual collected in 2005 in Reach 3. May and June have the highest catch rates of metalarvae. In May metalarvae occured in Reaches 3-1 (Figure 12), and in June they occurred

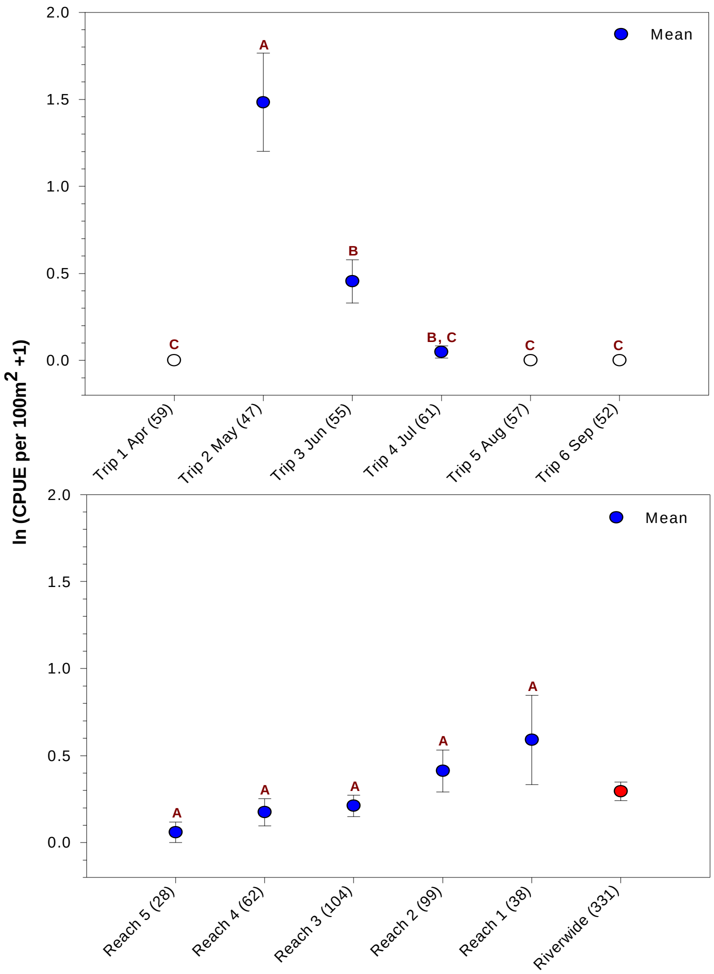

Figure 5. ln(CPUE per 100 m² +1) [±1 SE] for age-0 razorback sucker by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

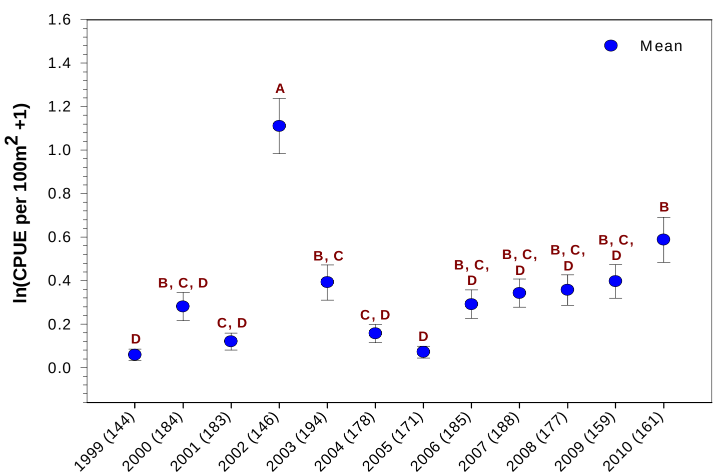

Figure 6. ln(CPUE per 100 m² +1) [±1 SE] for age-0 razorback sucker by year (April-June 1999-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

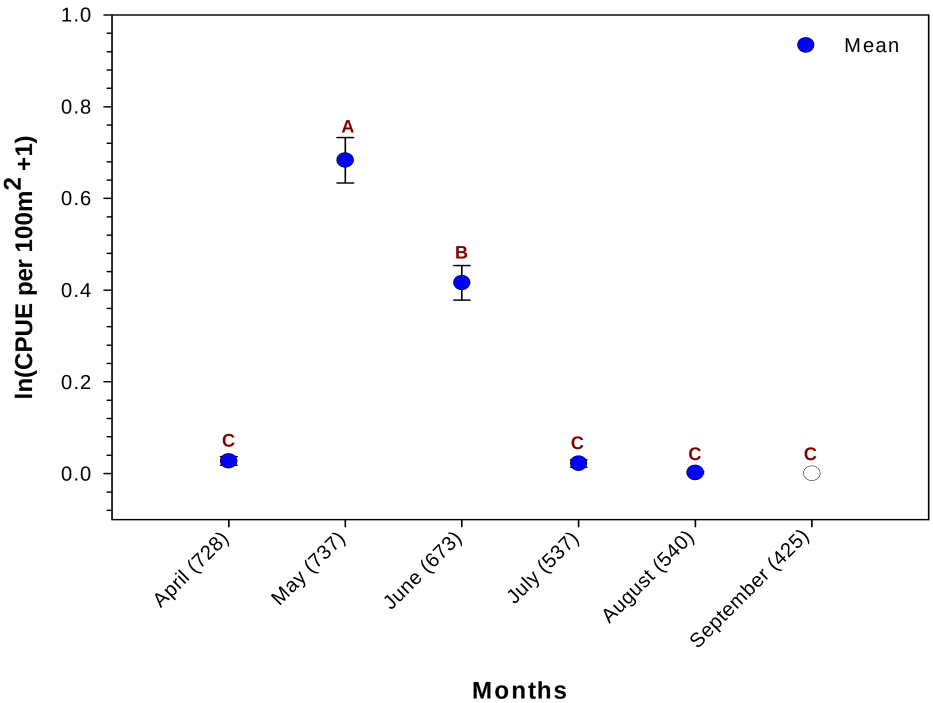

Figure 7. ln(CPUE per 100 m^2 +1) [±1 SE] for age-0 razorback sucker by month (April-June 1999-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected

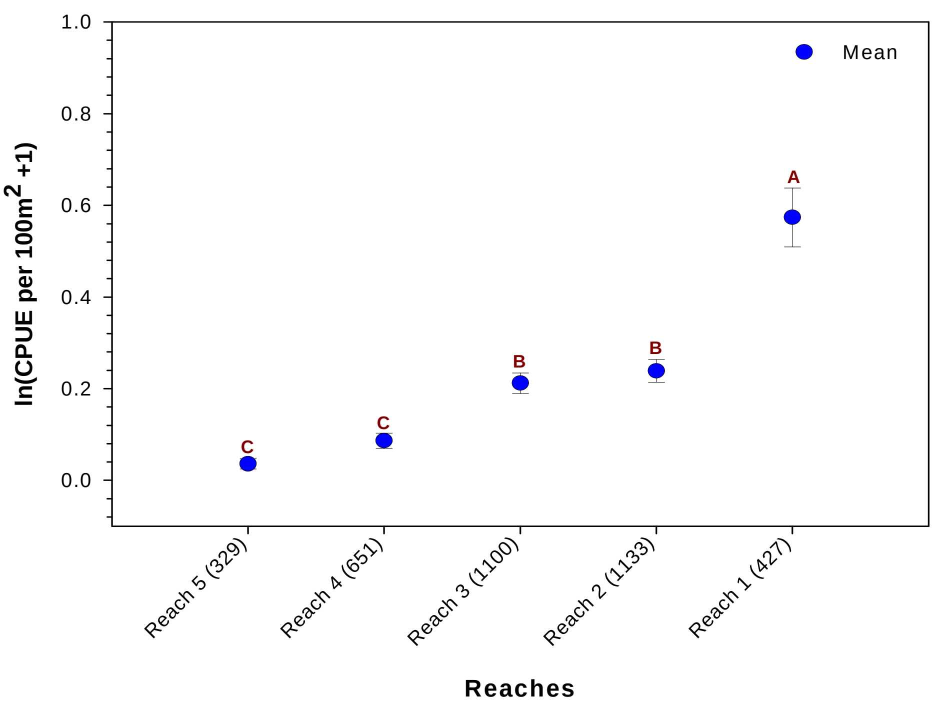

Figure 8. ln(CPUE per 100 m^2 +1) [±1 SE] for age-0 razorback sucker by Reach (April-June 1999-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

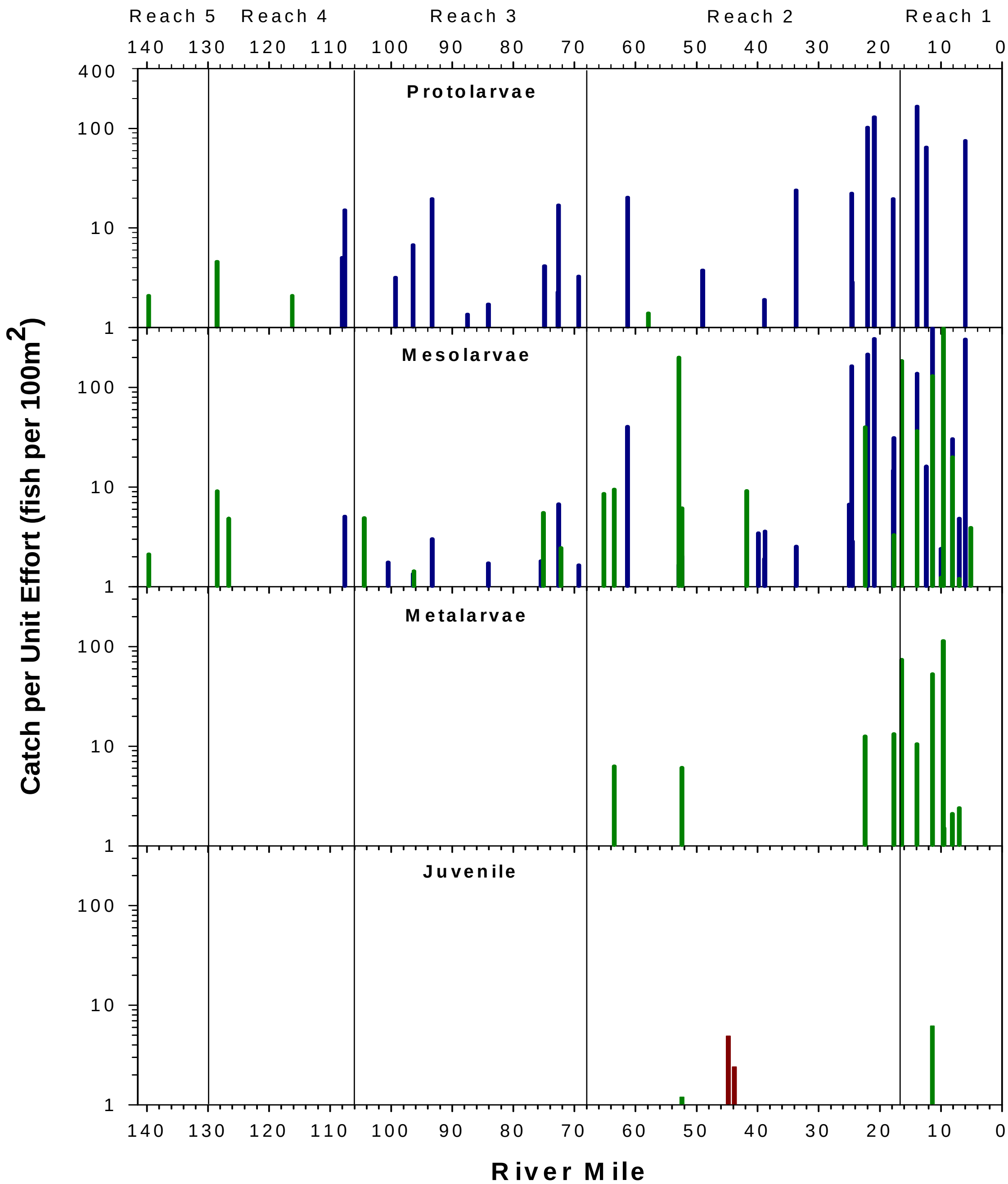

Figure 9. Catch per unit effort /100 m^2 of discrete ontogenetic stages (protolarvae, mesolarvae, metalarvae, and juvenile) of razorback sucker by sample locality during the 2010 survey. Blue bars represent May collections, green bars June collections and red bars July collections.

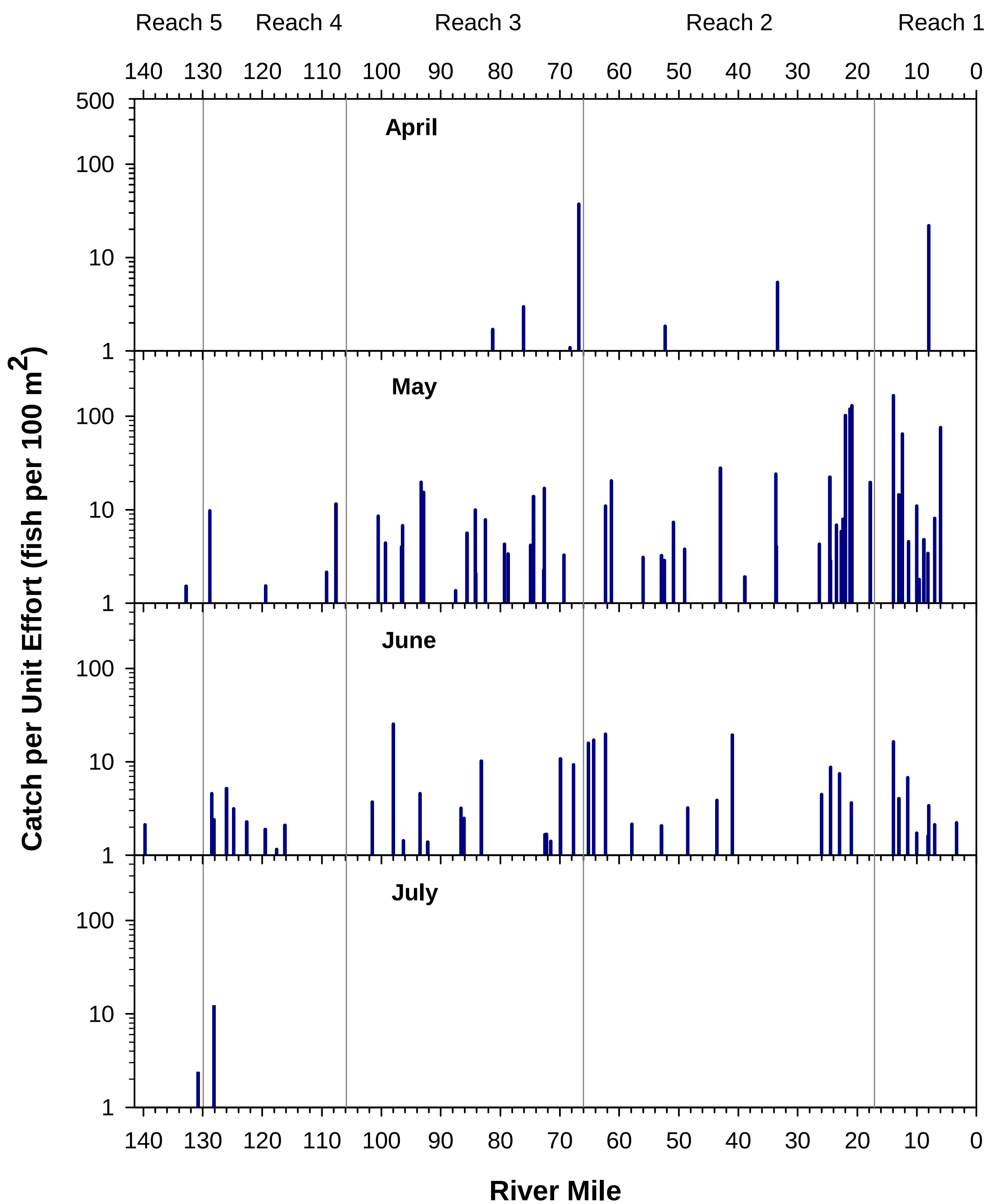

Figure 10. Catch per unit effort of razorback sucker protolarvae by month (April-July) from 1999-2010.

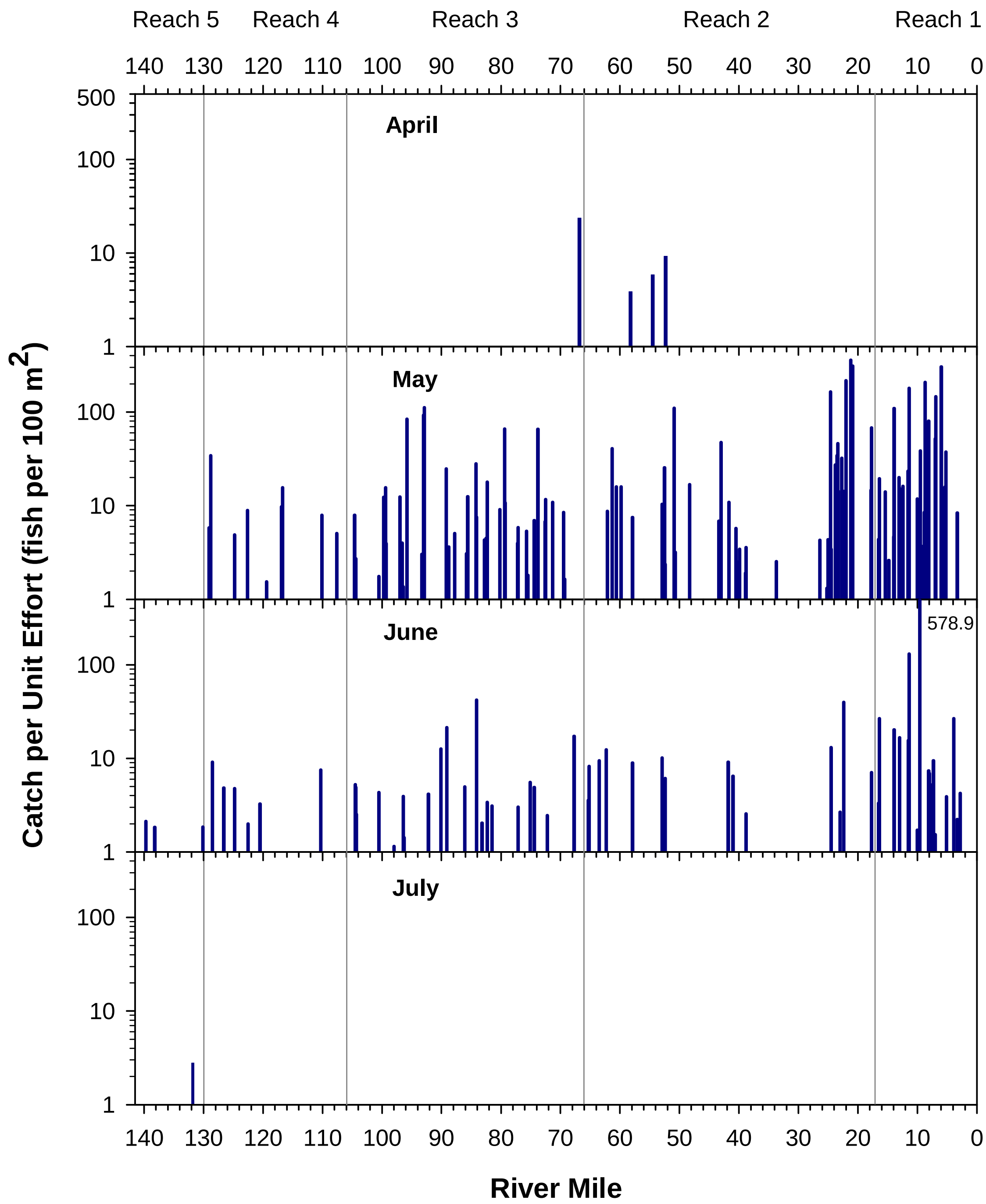

Figure 11. Catch per unit effort of razorback sucker mesolarvae by month (April-July) from 1999-2010.

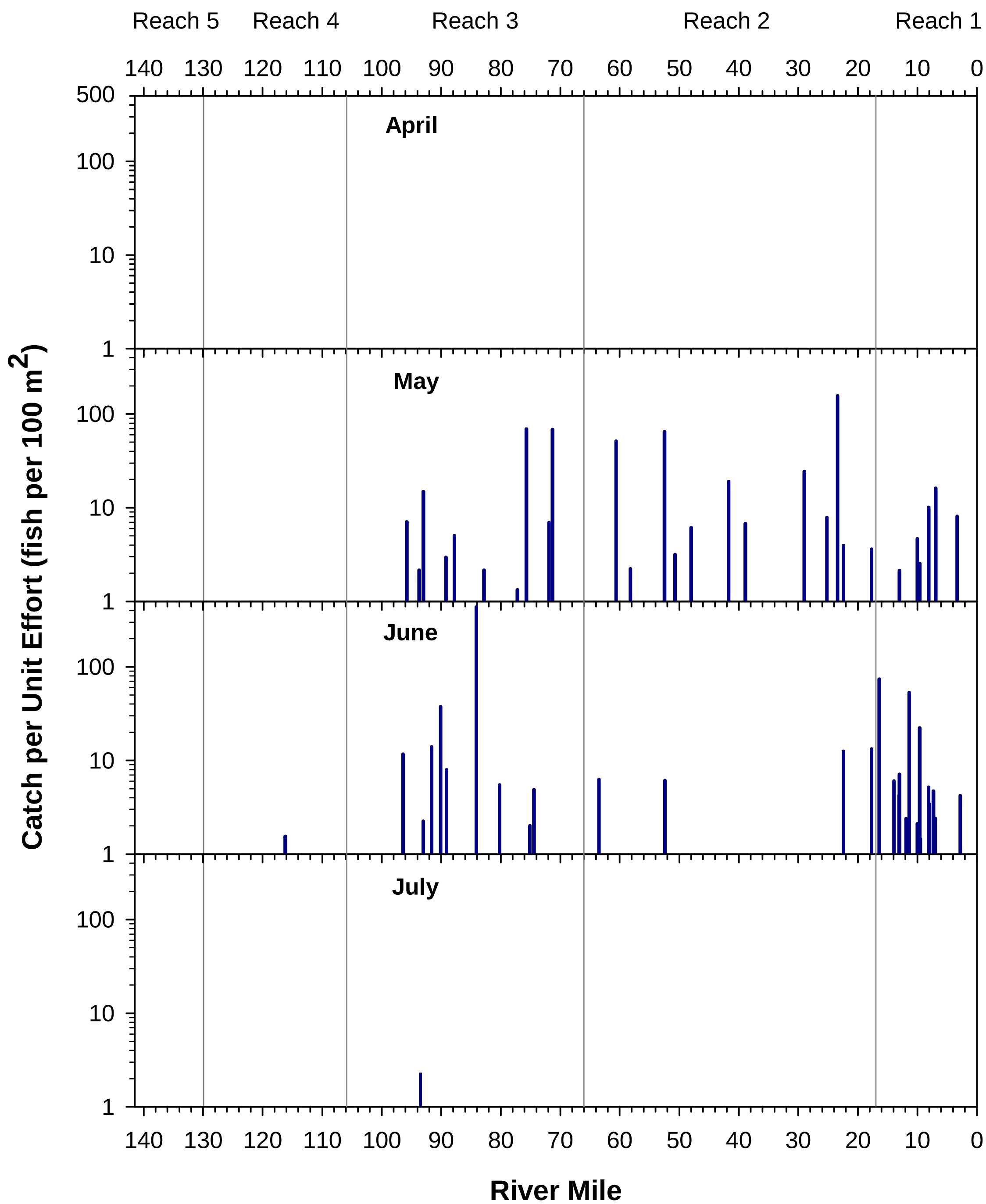

Figure 12. Catch per unit effort of razorback sucker metalarvae by month (April-July) from 1999-2010.

in Reaches 4 through 1. Six of the twelve years (2001, 2002, 2003, 2007, 2009, 2010) that produced age-0 razorback sucker contained juvenile fish (4.2% of total age-0 captures). The highest catch rates of juvenile specimens among all years occured during the month of June in Reach 3 (Figure 13). These years demonstrate larval razorback sucker are developing beyond larval ontogeny and facing decreasing mortality rates (Marsh and Langhorst 1988). Eighty-five percent of the 150 juvenile razorback sucker collected from 1999-2010 were captured in 2002. Juveniles collected during this year ranged in size from 21-57 mm SL and were present in the San Juan River from May through July. Additionally, five sub-adult razorback sucker were collected in 2004, 2006, and 2007. The sub-adult razorback sucker collected in 2004 and 2006 were 101 mm SL and 134 mm SL, respectively. Both fish were captured during the September survey and document survival through at least one over winter period.. The three sub-adult razorback sucker collected in 2007 were larger fish and were in poor condition. They were captured in June, August and September. It was assumed these fish were stocked from the grow-out ponds without PIT tags (Ryden 2007).

Back-calculated hatching dates for razorback sucker larvae (protolarvae and mesolarvae) collected during the 2010 larval survey place initial hatching on 28 April 2010 (Figure 14). Mean daily discharge and water temperature at the time of initial hatch was 1,140 cfs and 15.3 ^{0}C. Hatching of razorback sucker continued to 11 June 2010 and encompassed peak spring discharge and the initiation of the descending limb of runoff. During the hatching period, discharge and water temperature ranged from 751-4,280 cfs and 11.9-22.9 ^{o}C. Plots of back-calculated hatch date from previous years (1999-2009) show quite a bit of abiotic variability, especially in regard to discharge. Annual back-calculated hatch dates encompass periods prior to spring run-off and often include a portion of the ascending limb. In four of the twelve years surveyed, the back-calculated hatch dates encompass a portion of the descending limb of spring run-off (2005, 2007, 2009, and 2010). Larval hatching over all years occured at an average temperature of 16.1 ^{o}C (SE=0.10) and first started at an average temperature of 14.1 ^{o}C (SE=0.49).

Within the habitat types sampled in 2010 that contained age-0 razorback sucker, isolated pools had catch rates significantly higher than any other habitat type [($F=27.82$, $P<0.0001$) Figure 15]. Among all collection years (1999-2010) isolated pools have significantly higher catch rates than any habitat type sampled [($F=20.16$, $P<.0001$) Figure 16]. Catch rates among isolated pool collections were highly variable, and comparisons between open and closed habitats are problematic. Among all years, backwater habitats have significantly higher catch rates than embayments, pools, and slackwater.

Colorado pikeminnow. Five age-0 Colorado pikeminnow were collected from 20-23 July 2010 at three distinct sites. Larval specimens were captured in backwater habitats within a 50 mile stretch of river within Reaches 2 and 1 (Figure 17). The fish ranged in size from 12.6 to 21.4 mm TL and all were metalarvae. Age-0 Colorado pikeminnow were also collected in 2009, 2007 and 2004 using the current larval fish survey protocols. Catch rates of larval Colorado pikeminnow are too low to have any meaningful statistical comparisons among years (Figure 18).

Back calculated spawning dates for Colorado pikeminnow collected in 2010 were 15, 18, 23, and 27 June, and span a range of thirteen days which suggests more than a single spawning event during 2010. Back-calculated spawn dates of Colorado pikeminnow for 2009, 2007, and 2004 suggest that the spawning period was brief (Figure 19). Similar to prior years, the back-calculated spawn dates of 2010 corresponded to the descending limb of the spring hydrograph. Mean daily discharge and water temperature during the 2010 period of spawning

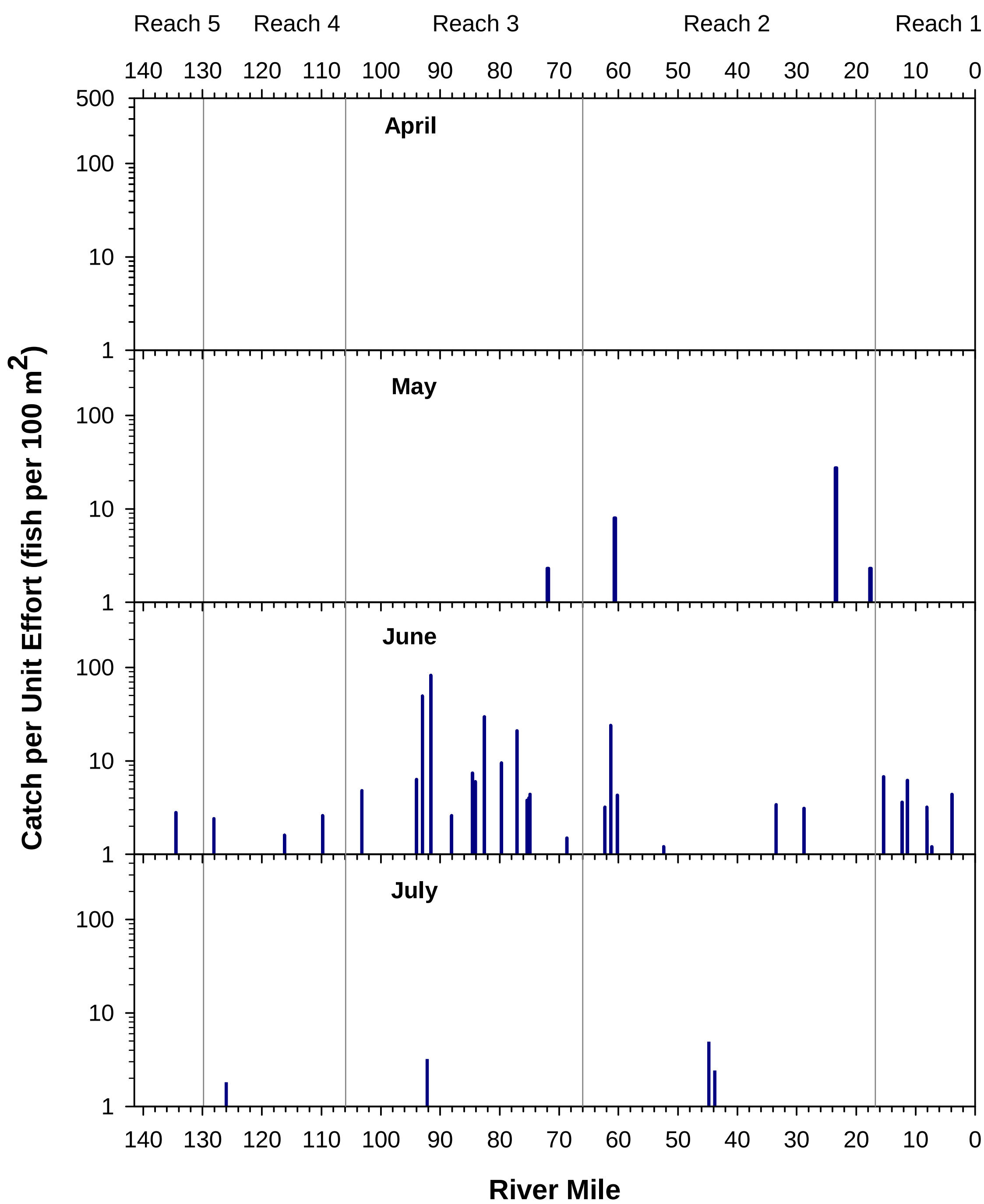

Figure 13. Catch per unit effort of razorback sucker juveniles by month (April-July) from 1999-2010.

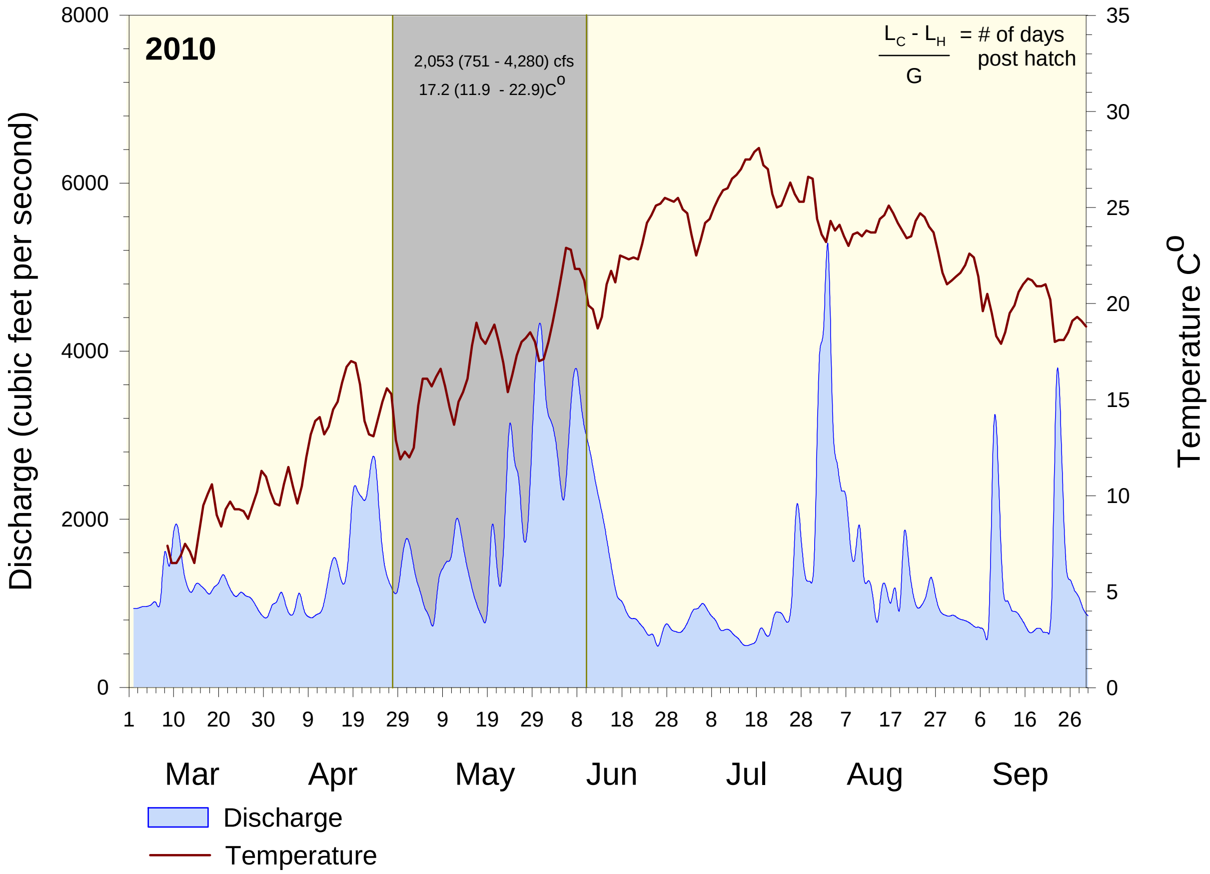

Figure 14. Back-calculated hatching dates for razorback sucker plotted against discharge and water temperature (USGS gauge #09379500 Bluff, UT). Grey box delineates hatching period with mean (min max) discharge and water temperature reported.

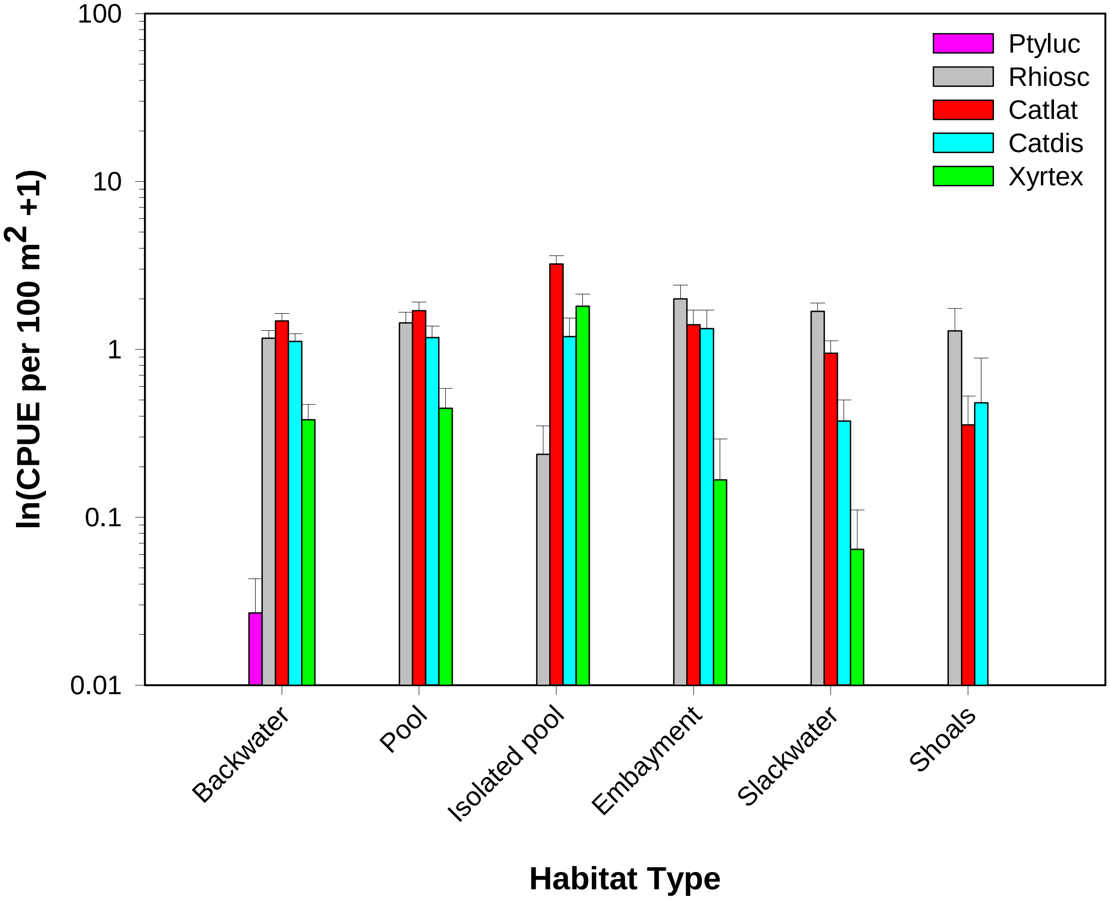

Figure 15. Habitat association by native species during the 2010 larval survey. Colored bars represent mean ln(CPUE per 100 m^2 +1) [±1 SE].

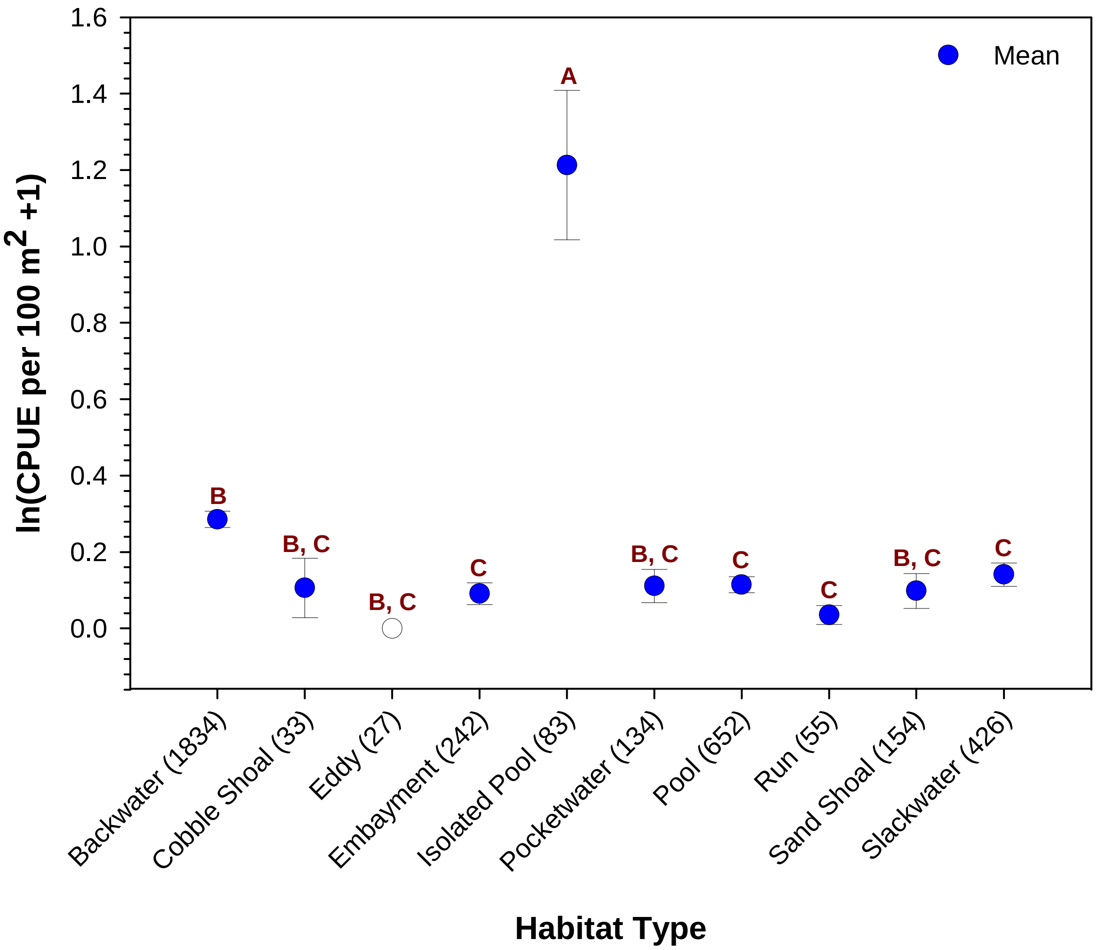

Figure 16. ln(CPUE per 100 m^2 +1) [±1 SE] for razorback sucker by habitat type sampled from 1999 to 2010. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open cirlces indicated that no fish were collected.

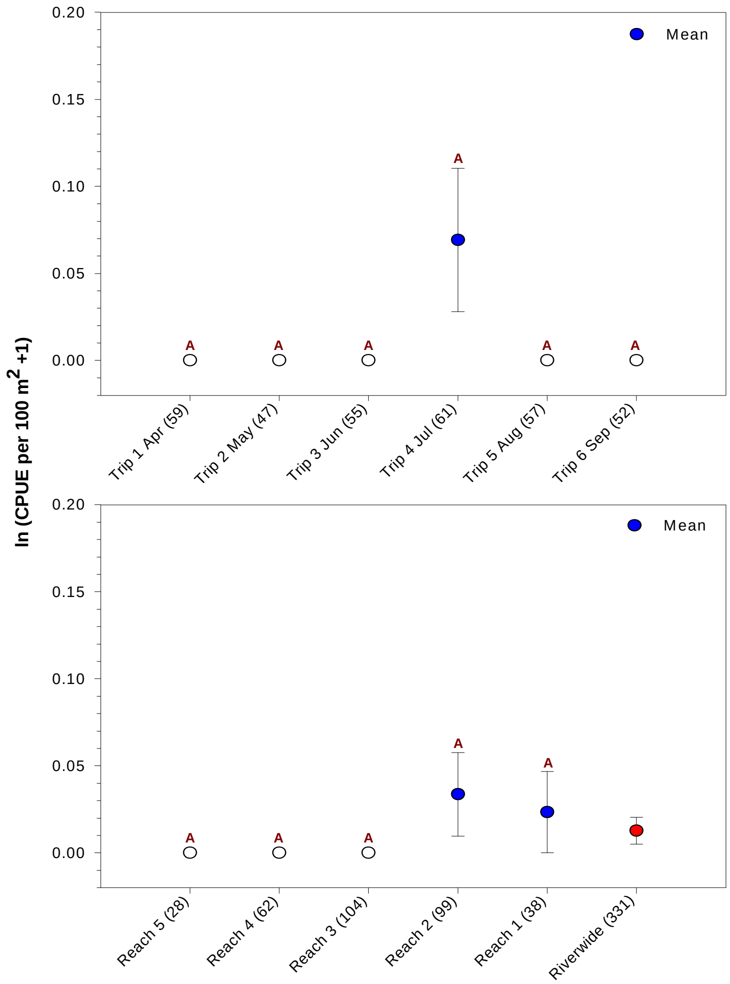

Figure 17. ln(CPUE per 100 m^2 +1) [+1 SE] for age-0 Colorado pikeminnow by trip (top graph), reach and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

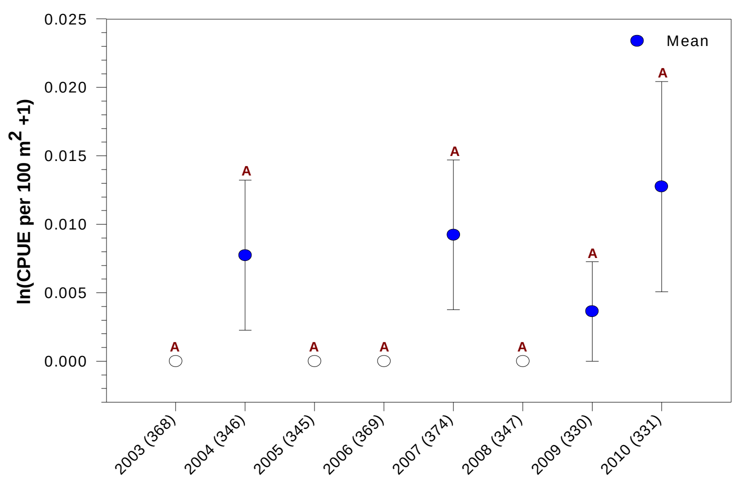

Figure 18. ln(CPUE per 100 m^2 +1) [+1 SE] for age-0 Colorado pikeminnow by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

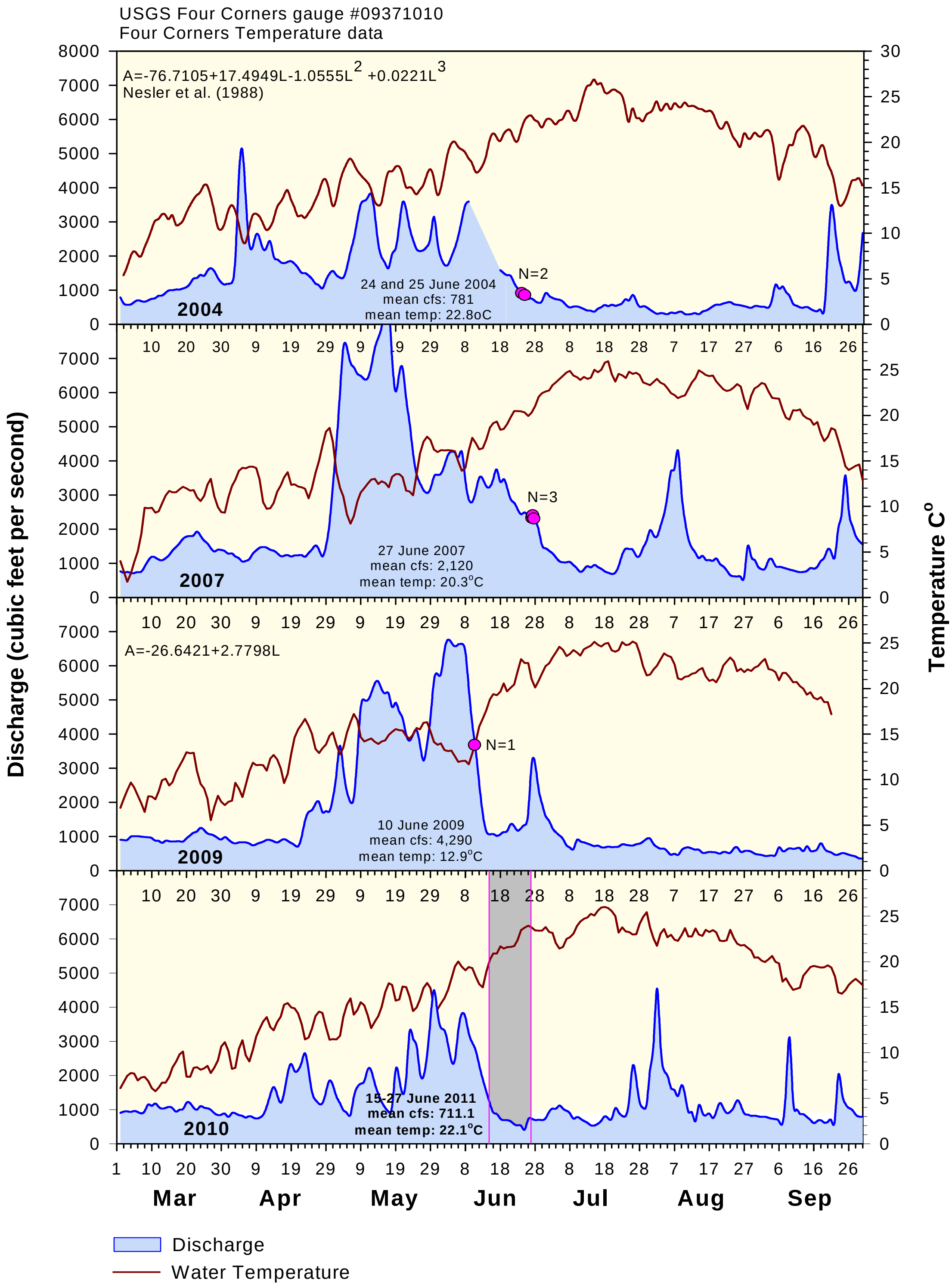

Figure 19. Back-calculated spawning dates for Colorado pikeminnow plotted against discharge (Four Corners, NM, USGS gauge #09371010) and mean water temperature (Four Corners, CO) during 2004, 2007, 2009 and 2010. Pink dots or lines represent spawning dates.

was 711.1 cfs and 22.1 °C. With the exception of 2009, water temperatures during the back-calculated period of spawning was greater than 20 °C.

A total of 221 age-1+ Colorado pikeminnow were collected during in 2010; all presumably the result of augmentation efforts. Age-1+ Colorado pikeminnow collected ranged in size from 37-182mm TL (28-149 mm SL). The April survey produced the greatest numbers of age-1+ Colorado pikeminnow (n=170) and had the highest catch rates of the six months surveyed. May and June surveys had similar catches of age-1+ Colorado pikeminnow (n=23 and n=24 respectively). Although the capture of age-1+ Colorado pikeminnow decreased after the April survey, age-1+ Colorado pikeminnow were distributed throughout the study area during these three months (Figure 20). By the July survey, catch of age-1+ Colorado pikeminnow had diminished within the low velocity habitats that were being targeted during the larval fish survey. Catch rates of age-1+ Colorado pikeminnow among all years (2003-2010) were highest in April followed by May then June. There is no difference in catch rates during July-September (F= 77.89, P<.0001). Within reaches (2003-2010) Reaches 5, 4, and 1 have significantly higher catch rates than Reaches 3 and 2 (F=10.01, P<0.0001).

Native Species

Speckled dace. Age-0 speckled dace were first collected during the June survey with little difference in catch rates among reaches. Catch rates were significantly lower in Reach 1 (F=4.31, P=0.0021) compared to the four upstream reaches. Following the June survey, age-0 speckled dace were captured throughout the study area until the end of the 2010 survey. Speckled dace had the highest catch in July and August (F=72.83, P<0.0001 [Figure 21]). Annual trends in speckled dace catch have been fairly stable among years (2003-2010). The period from 2005 to 2008 had catch rates that were significantly higher than 2003 and 2009. Catch rates in 2010 were similar to all other years except 2003 (F=8.26, P<0.0001 [Figure 22]).

Flannelmouth sucker. Flannelmouth sucker were the numerically dominant catostomid species collected during the 2010 larval fish survey accounting for 59.7% of the catostomid catch by number. Flannelmouth sucker were also the most frequently encountered fish species during the 2010 larval fish surveys occurring in 51.8% of collections. No larval flannelmouth sucker were collected in April. Catches of age-0 flannelmouth sucker were highest in May and June (F=50.30, P<0.0001 [Figure 23]). There were few differences in catch rates among the five reaches in 2010 although CPUE in Reach 3 was significantly greater than Reaches 2 and 1(F=5.4894, P=0.0003 [Figure 23]). CPUE of flannelmouth sucker have been fairly stable over time with the 2010 cpue similar to cathes in 2003-2006. Catch rates were significantly higher in 2007 and 2008 (F=11.99, P<0.0001 [Figure 24]). These trends suggest that 2010 was an average reproductive year for flannelmouth sucker.

Bluehead sucker. Age-0 bluehead sucker were collected throughout the study period with the exception of the April survey. The first captures of larval bluehead sucker occurred in the lower portions of Reach 4 during the May survey. By the following months, captures of larval bluehead sucker were distributed throughout the study area with higher catch rates in the upper reaches. The highest catch of bluehead sucker occurred during the June survey (F=28.41, P<0.0001 [Figure 25]). Reaches 5-3 had similar catch rates and were significantly higher than reaches downstream (F=7.05, P<0.0001 [Figure 25]). Annual catch rates have a higher degree of variability compared to flannelmouth sucker, but the overall trend appears stable. The highest catch rate for bluehead sucker occurred in 2005 which was significantly higher than any year except 2004 (F=9.69, P<0.0001 [Figure 26]).

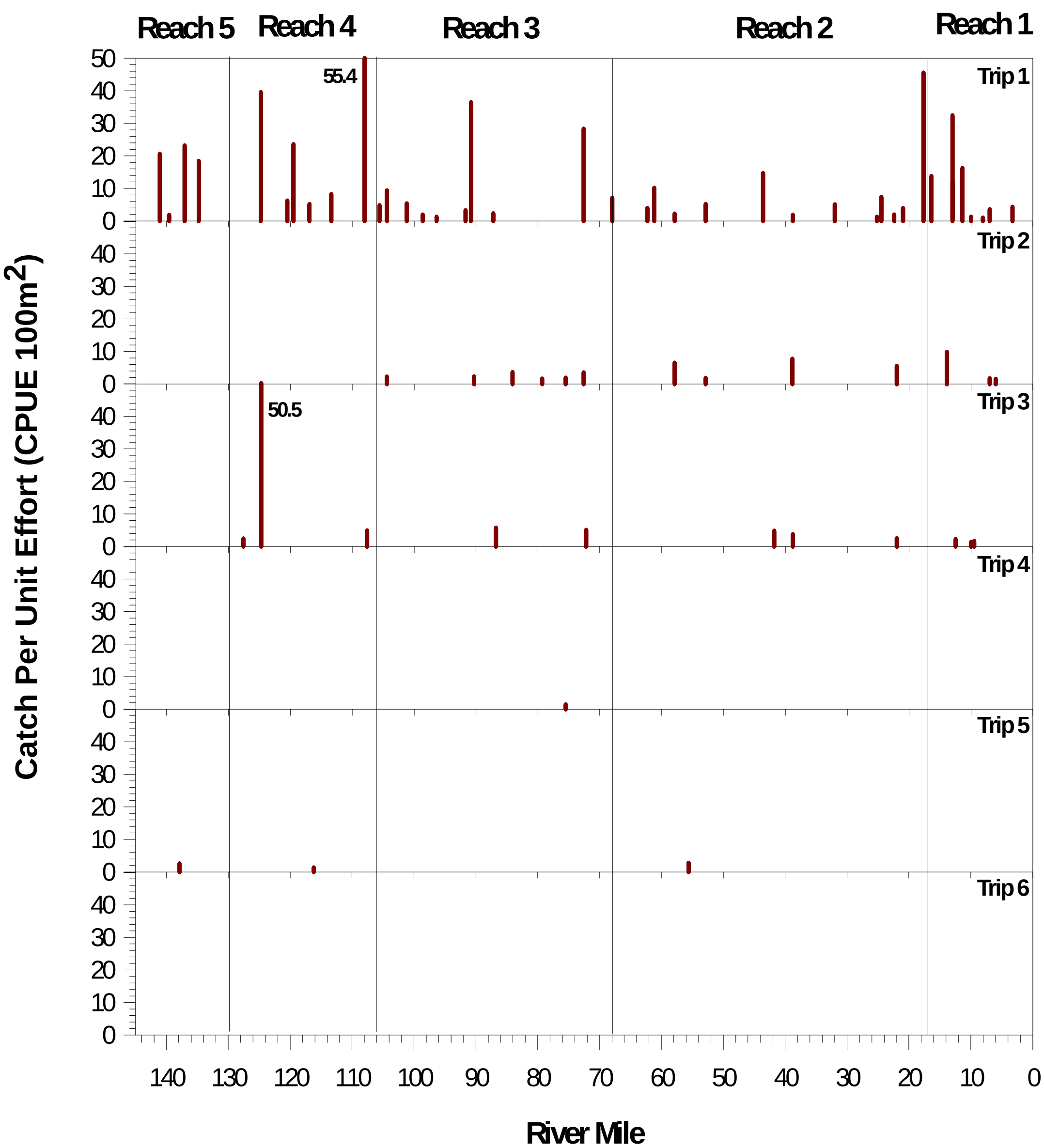

Figure 20. Catch per unit effort /100m^2 of age-1+ Colorado pikeminnow (N= 221) by sampling locality during the 2010 larval fish survey.

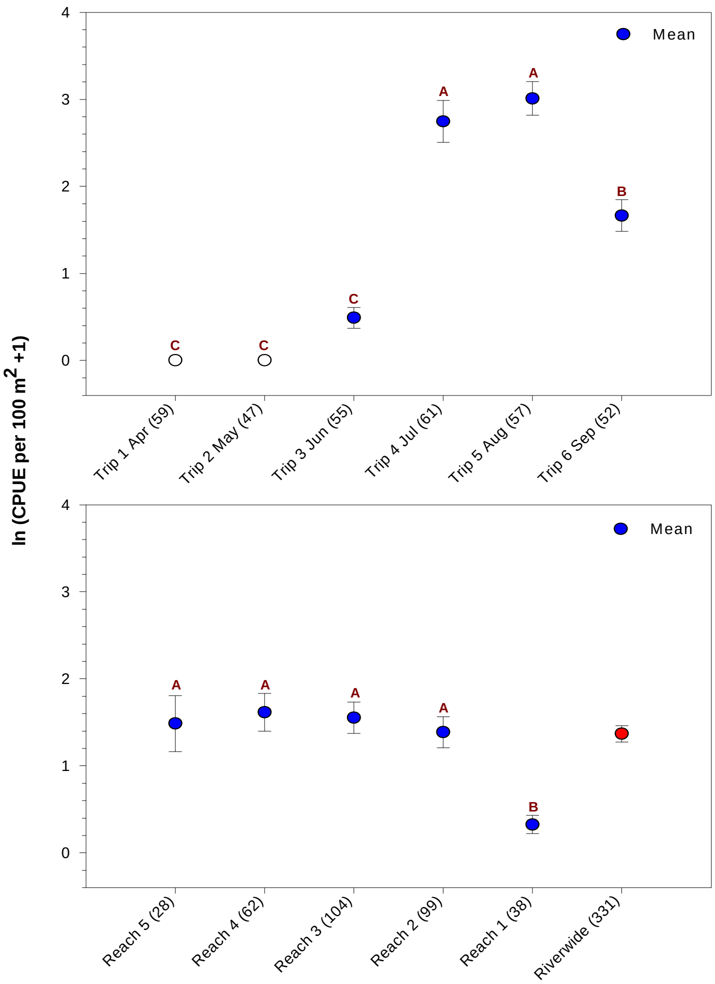

Figure 21. ln(CPUE per 100 m^2 +1) [±1 SE] for age-0 speckled dace by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

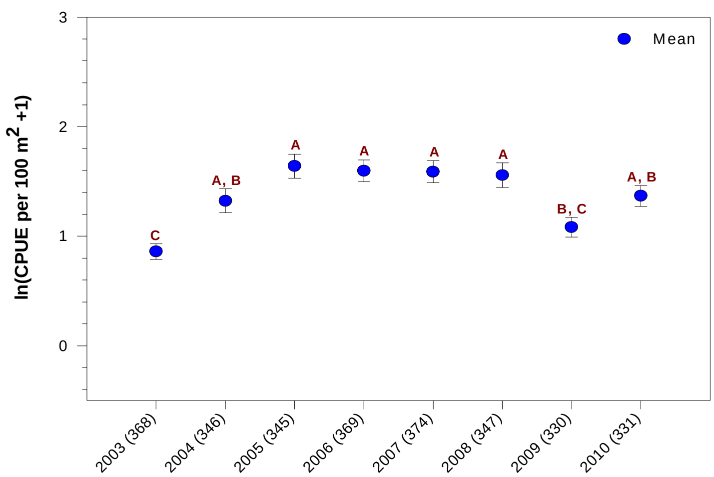

Figure 22. ln(CPUE per 100 m^2 +1) [±1 SE] for age-0 speckled dace by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

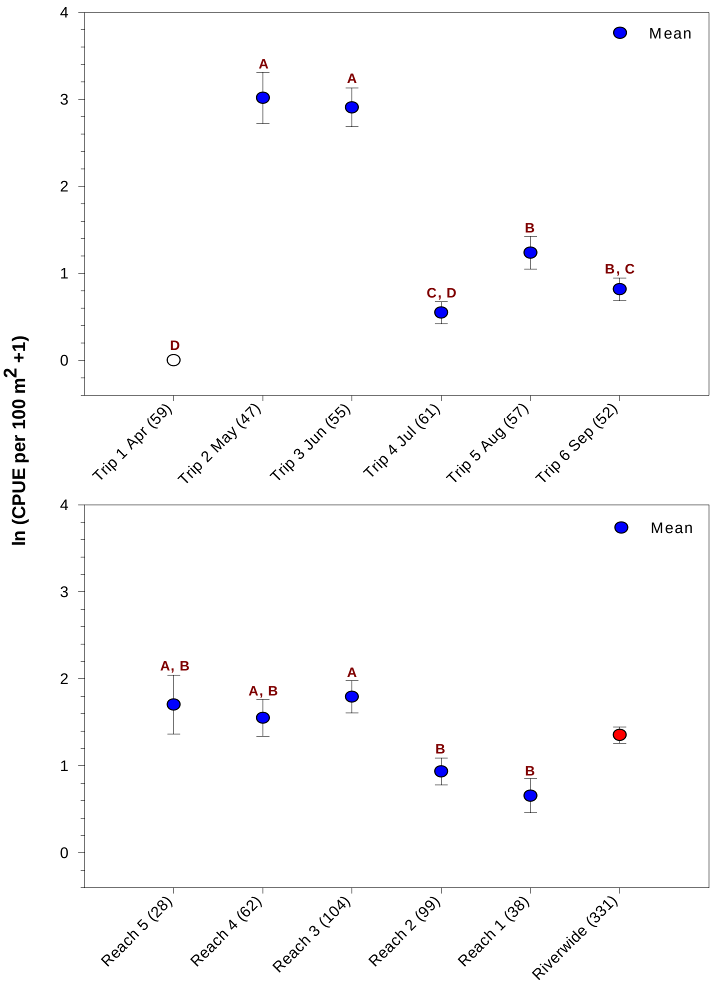

Figure 23. ln(CPUE per 100 m² +1) [+1 SE] for age-0 flannelmouth sucker by trip (top graph), reach, and river wide (bottom graph) for 2010. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

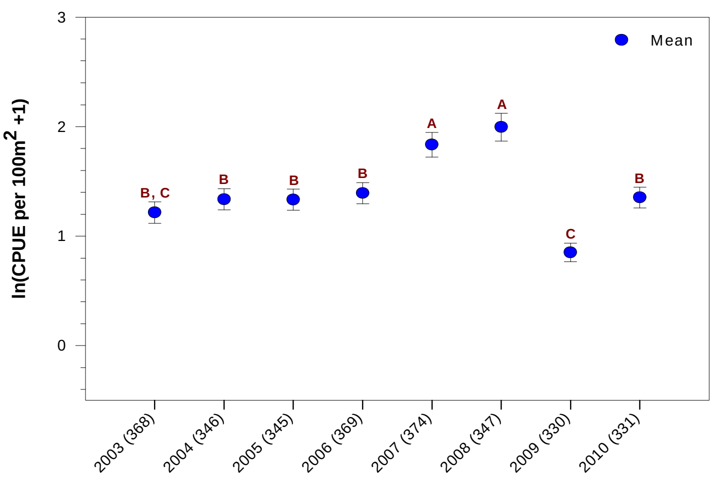

Figure 24. ln(CPUE per 100 m² +1) [+1 SE] for age-0 flannelmouth sucker by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

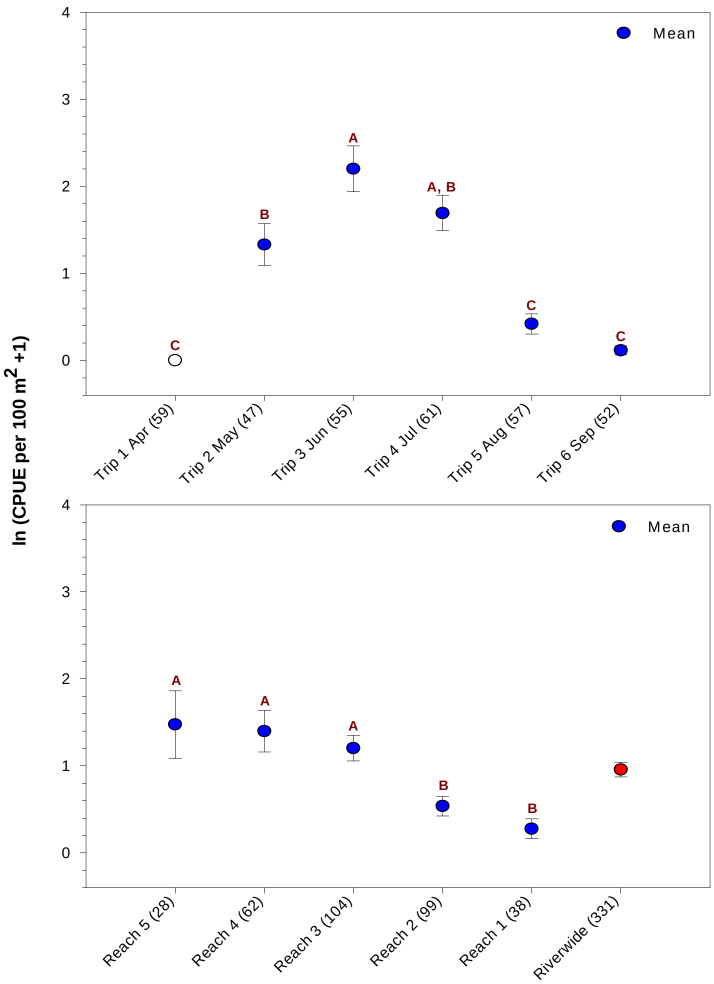

Figure 25. ln(CPUE per 100 m^2 +1) [$\pm$1 SE] for age-0 bluehead sucker by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

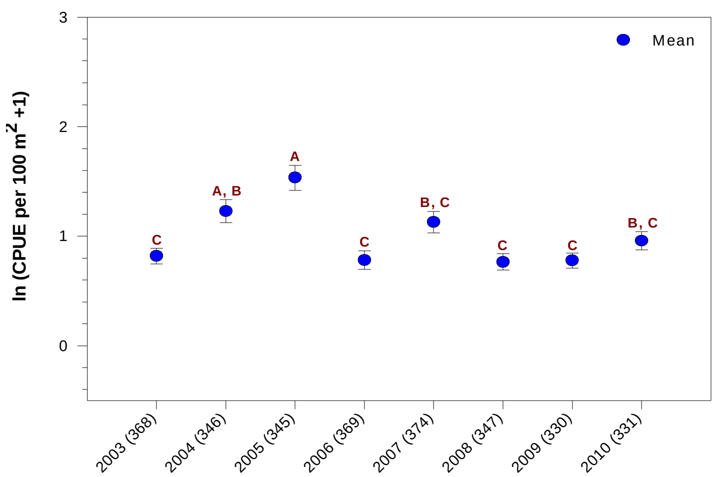

Figure 26. ln(CPUE per 100 m^2 +1) [$\pm$1 SE] for age-0 bluehead sucker by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

Non-Native Species

Red shiner. Over 41,000 larval red shiner were collected during the 2010 survey accounting for nearly 74% of the age-0 catch. Only one collection contained larval red shiner in June, however, by the following month all but one collection contained red shiner. Catches of red shiner were highest in July (F=229.88, P<0.0001) followed by August and September (Figure 27). Red shiner densities were high in all five reaches of the study area during each of these three months with no significant difference between reaches (Figure 27). The period between 2004 and 2008 saw a significant decline in red shiner catch rates (F=14.57, P<0.0001). Catch rates rose in 2009 and 2010 with both of these years significantly higher than 2008 (Figure 28).

Common carp. This species was encountered in low numbers during the June and July surveys. In June a single common carp was collected from an isolated pool in Reach 2; isolated pools were not used in the trend data. Four collecting sites within Reaches 3, 2 and 1 produced a total of seven age-0 common carp during the July survey. Like Colorado pikeminnow, the low numbers of common carp make meaningful statistical analysis difficult. There were no significant differences among reaches (F=9.87, P<0.0001 [Figure 29]). Annual catch rates in 2010 were significantly lower than the prior two years and most similar to 2006 and 2003 (F= 9.87, P<0.0001 [Figure 30]).

Fathead minnow. Larval fathead minnow were first encountered during the June survey. Larvae were collected in all five reaches of the study area during that month. Fathead minnow had the highest catch during the August survey (F=21.97, P<0.0001 [Figure 31]). While fathead minnow were distributed river wide, catches were significantly higher in Reach 5 compared to Reaches 3-1 (F=5.49, P=0.0003). Annual catch rate trends of fathead minnow have been declining since 2003 with the lowest catch of age-0 fathead minnows occurring in 2009 (Figure 32). The catch rates in 2010 increased to the same levels as 2007 and 2008, yet are still significantly lower than years prior to 2007 (F=49.37,P<0.0001).

Channel catfish. This species was first collected during the July survey. Interestingly age-0 channel catfish were only collected in a 18 mile stretch of river in July (river mile 78.0 to 59.8). During the following two months, age-0 channel catfish were collected throughout the study area with the exception of Reach 5. Catches did not differ among reaches (F=3.14, P=0.0148 [Figure 33]). Channel catfish had the highest catch in August (F=34.49, P<0.0001). The channel catfish catch in 2010 was similar to four of the last seven years with the highest catch occurring in 2007 and 2008 (F=17.69, P<0.0001 [Figure 34]).

Native and Non-native Catch

From 2003 to 2010 the proportions of age-0 native and non-native catch have varied. Prior to 2005, non-native densities were significantly higher than native (F=40.27, P<0.0001) . 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 35). 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. By 2008 native catch rates were significantly higher than those of non-natives (F=53.43, P<0.0001). The following year catches of non-natives were again higher than those of natives due to an increase in red shiner.

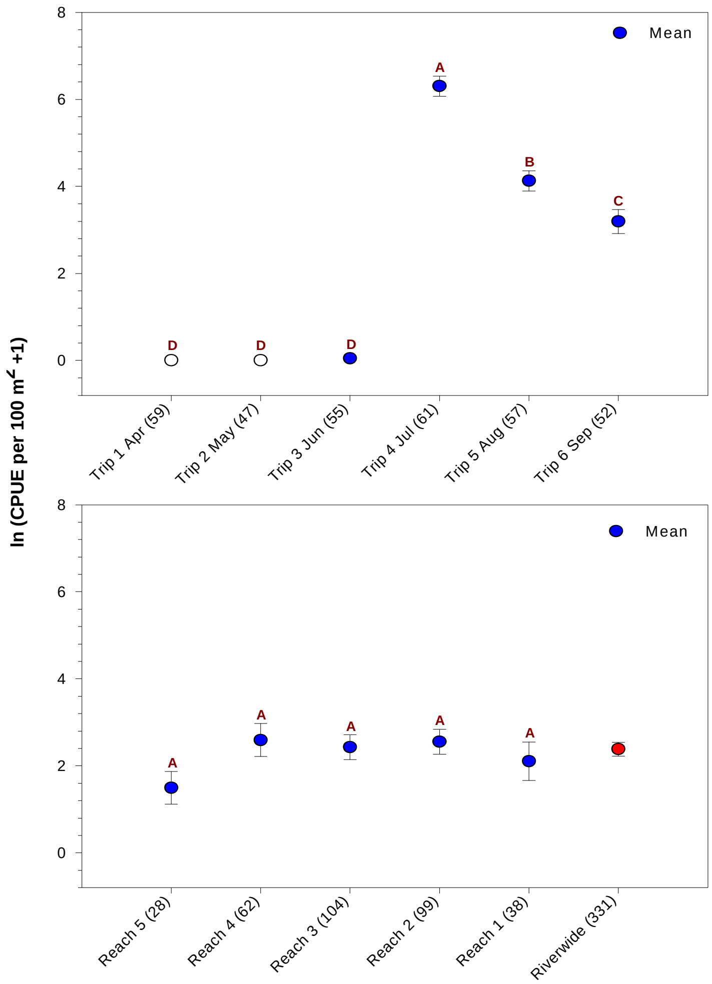

Figure 27. ln(CPUE per 100 m² +1) [±1 SE] for age-0 red shiner by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

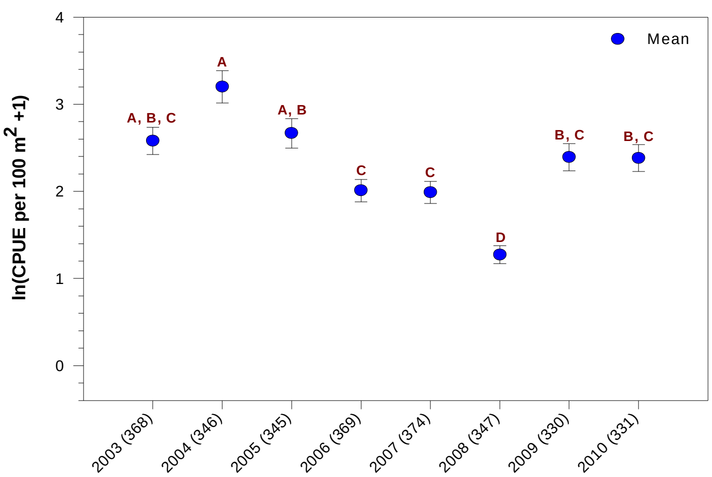

Figure 28. ln(CPUE per 100 m² +1) [±1 SE] for age-0 red shiner by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

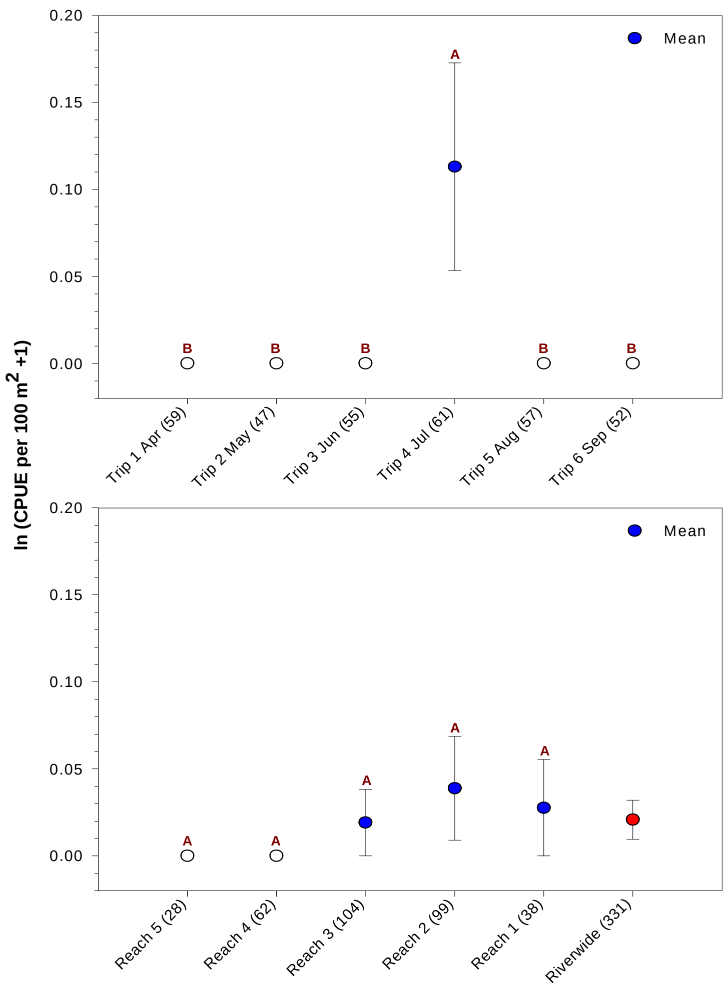

Figure 29. ln(CPUE per 100 m^2 +1) [+1 SE] for age-0 common carp by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

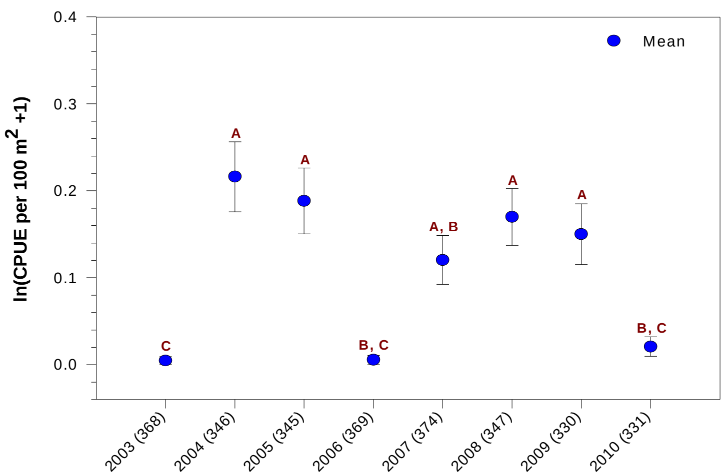

Figure 30. ln(CPUE per 100 m^2 +1) [+1 SE] for age-0 common carp by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

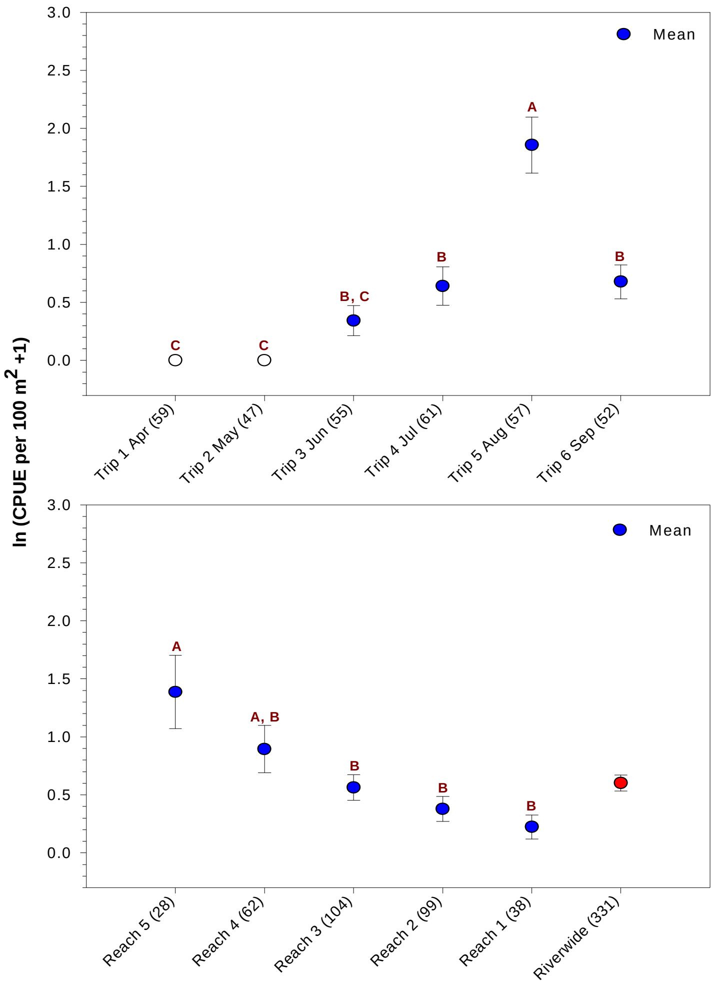

Figure 31. ln(CPUE per 100 m^2+1) [$\pm$1 SE] for age-0 fathead minnow by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

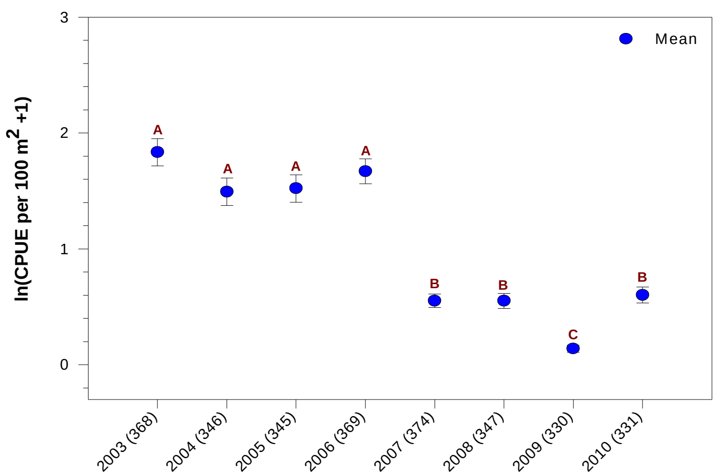

Figure 32. ln(CPUE per 100 m^2+1) [$\pm$1 SE] for age-0 fathead minnow by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

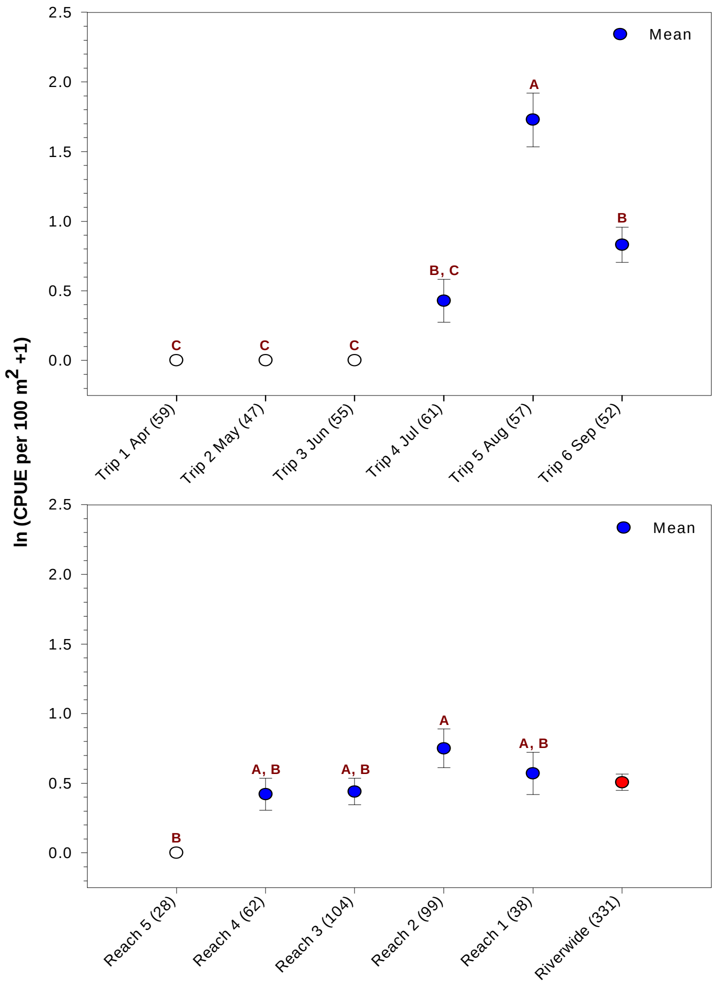

Figure 33. ln(CPUE per 100 m² +1) [±1 SE] for age-0 channel catfish by trip (top graph), reach, and river wide (bottom graph) during the 2010 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

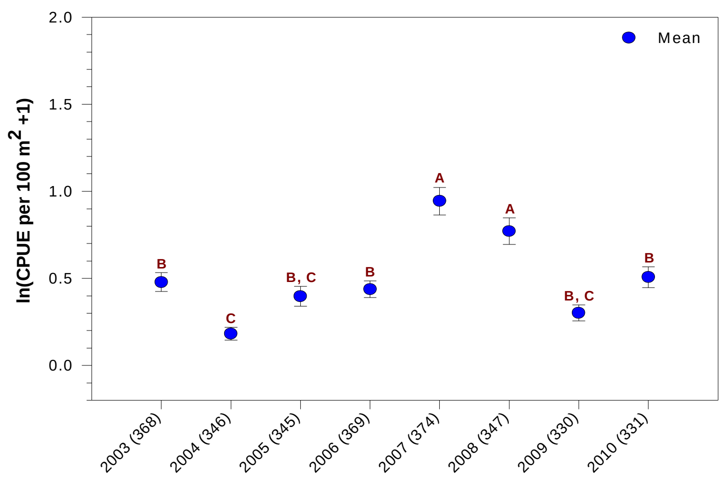

Figure 34. ln(CPUE per 100 m² +1) [±1 SE] for age-0 channel catfish by year (2003-2010). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

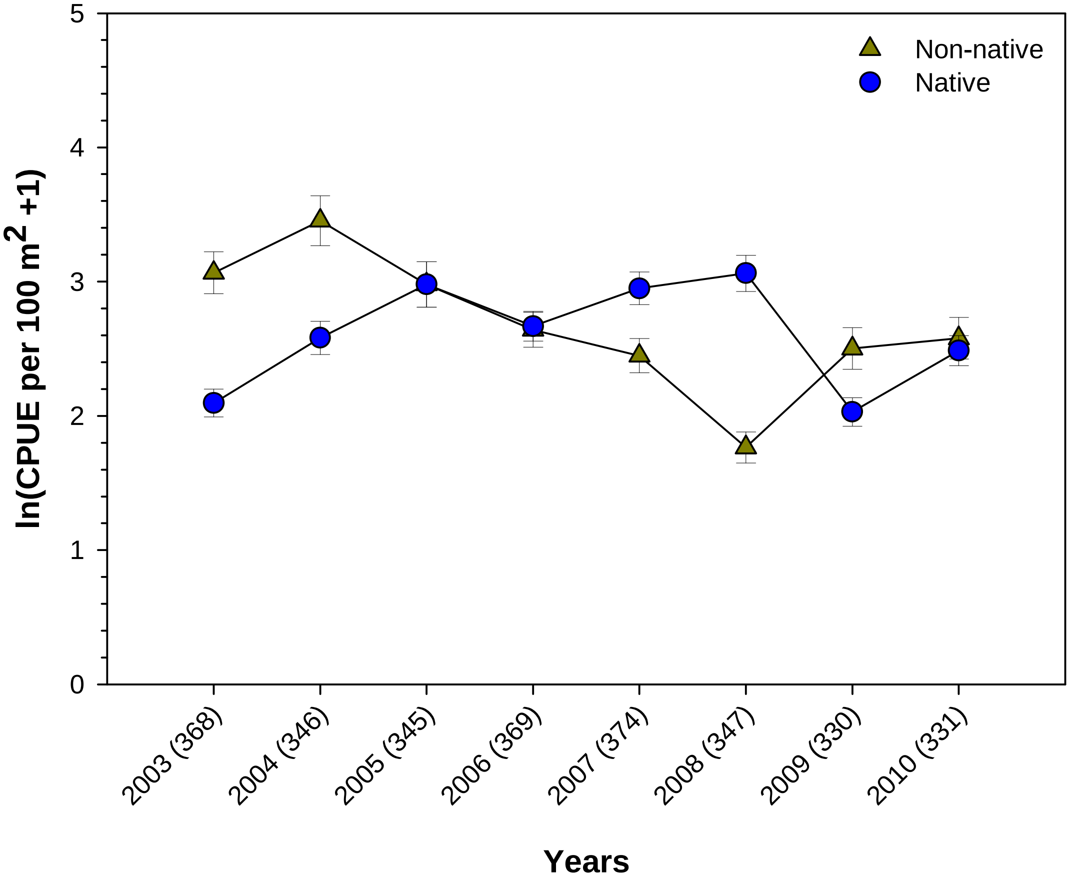

Figure 35. ln(CPUE per 100 m^2 +1) [±1 SE] of non-native taxa and native taxa from 2003-2010. Sample size reported on the x-axis labels.

Catches of fathead minnow have declined significantly from 2006 and play a role in the decline of non-native densities prior to 2009. Catch rates of native and non-native fish in 2010 were similar to each other.

Discussion

The 2010 larval fish survey had the highest catch of larval razorback sucker of any year prior, excluding and including isolated pools (n=929 and n=1,251 respectively). The 2010 survey documents the thirteenth consecutive year of reproduction of adult razorback sucker in the San Juan River. Larval razorback sucker were collected primarily in Reaches 3-1 in May and throughout the study area June. The larvae collected in the upstream portion of the study area in June were protolarvae and mesolarvae. It appears as though spawning of razorback sucker occurs later in the year in the cooler upstream portions of the San Juan River. The temporal and spatial timing of spawning translates to a prolonged back-calculated duration of hatching. Captures of larvae in the upstream reaches of the study area have expanded over time. In 2001 the study area was lengthened upstream to include approximately half of Reach 5 (current study area). The expansion was a result of collections made in 2000 of larval razorback sucker in close proximity to the upstream boundary of the study area (river mile 127.5). From 2001 to 2010 captures of razorback sucker larvae continue to be documented farther upstream (Figure 36). The upstream-most collection of razorback sucker larvae to date was documented in 2010 at river mile 139.7, approximately two miles from the upstream boundary of the study area. Stocking efforts have attempted to establish adult razorback sucker as high up in the system, within critical habitat, as possible. Results from non-native removal activities show a concentration of adults remaining in the area of stocking (Davis, 2009). If populations become established and there are suitable spawning habitat in the upper reaches of the critical habitat it might warrant a further upstream expansion of the larval fish survey study area.

Reach 1 (1999-2010) has a significantly higher catch of age-0 razorback sucker than all other reaches. A few hypotheses could explain the increase in catch in the lower reaches of the study area over time. The high catch rates might be the result of spawning aggregations just upstream. Clumped distribution of larvae, particularly protolarvae (the earliest larval stage), suggest nearby spawning areas (Robinson et al., 1998). In the 13 years of surveys, clumped distribution of protolarvae have been identified in Reach 3, in Reach 2 downstream of river mile 24.5 (John's Canyon), and Reach 1 (Brandenburg and Farrington 2009). This distribution of larvae is observed across years and in different larval life stages which suggests nearby spawning bars. Elevated and clumped catch in the same areas over time (1999-2010) may also suggest spawning site fidelity of adult razorback sucker. Increased catch may also be a result of drifting propagules settling out in these low velocity downstream locations. Drifting behavior has been demonstrated in early life stages of many catostomid species (Robinson et al., 1998, Ellsworth et al., 2010) as a means of dispersal to favorable rearing habitats. Drifting behavior may be passive in the earliest developmental stage but becomes active as larvae develop (Tyus et al., 2000). Dispersal and transport rates as measured by passively drifting particles has shown travel rates between three and four days to pass through the critical habitat (river mile 180.0 -0.0 [Dudley and Platania, 2000]). If drifting behavior in razorback sucker is similar to the other native catostomids in the San Juan River then catch rates of the other native catostomids should also be higher; however, catch rates of the other native suckers is highest upstream of Reach 2. Temporally, razorback sucker and flannelmouth sucker catch rates peak in May and June, however, the two species differ in distribution by reach (Figure 37). Higher population densities of flannelmouth sucker and bluehead sucker in the upper reaches of the San Juan River (upstream of current stocking locations), possibly account for higher catch rates in Reaches 5-3 of these species and potentially increased retention in the San Juan River.

Few larval Colorado pikeminnow have been collected during the tenure of this study. From 2002-2010 documented spawning by this species occurred in 2004, 2007, 2009, and 2010. Given that Colorado pikeminnow is a long lived species, it seems unlikely that some of the reproducing adults that spawned in 2007 would not have spawned in 2008. The level of reproduction by Colorado pikeminnow is possibly so low that the number of larvae produced is below detection levels in some years.

The most interesting results of the 2010 larval Colorado pikeminnow captures were the back-calculated spawning dates which encompassed a thirteen day period indicating more than a single spawning event. Back-calculated dates from prior years suggest a single spawning event. In all years that larval Colorado pikeminnow were collected, individuals were metalarvae. The size of larvae ranged from 12.9 to 25.2 mm TL which indicated rapid growth within the earlier life stages and probably a longer period of time spent as a metalarvae. Catch of Colorado pikeminnow is still very low and the focus of the larval fish survey for this species remains presence-absence. If catch of larval Colorado pikeminnow increases in the future it might warrant altering the July collecting dates to attempt to document the earlier life stages of this species.

The larval fish surveys documented a decline in the catch of larval red shiner from 2004 to 2008 yet saw a significant increase in 2009 and 2010. While the decline in catch between 2004 and 2008 was statistically significant, it is unclear if this decline represents a true population decline or a low point in a cyclic pattern of reproductive effort by this species. Large numbers of age-1 red shiner were collected in 2010. These fish were likely a result of the high numbers of larval red shiner observed in 2009 and suggests high recruitment of the 2009 age class . The 2010 small-bodied collections (October 2010) recorded a low catch of red shiner (Monie pers comm.) whereas the larval catch of red shiner was high. The low summer base flows in 2010 were punctuated by several storm events the most significant one occurring between the July and August larval fish surveys. The catch of red shiner declined following the rain event. The abrupt increase in flow may have pushed non-native larval red shiner out of the system resulting in the lower catches observed by small-bodied monitoring .

Isolated pools were sampled in higher proportion during the 2010 larval fish survey. Low discharge in the river at the time of the collection trips (May and June) made these habitat types prominent features particularly in the lower reaches where the catch of razorback sucker is usually highest. Isolated pools on the San Juan River are highly variable both temporally and spatially. They can be large pond-like areas that hold water for an extended period of time. These types of isolated pools can be found in lateral canyons in Reach 1. Typically, isolated pools consist of desiccating water bodies where fishes become concentrated in the last remnants of water and capture efficiencies increase markedly. Although not used in the trend data, the data provided by isolated pools are important in that they provide a representation of numbers of fish potentially lost to the system by these types of entrapments. Isolated pools that were thought to be in imminent danger of complete desiccation were sampled at river miles 52.9 and 11.4 in May and 119.4, 88.8, 52.9, 16.4, 11.4 and 9.6 in June 2010 and all but one of these sites produced catostomid larvae (n=698). Five of these sites contained larval razorback sucker (n=179). These data collected on isolated pools in 2010 are an important insight into the ephemeral nature of backwaters in the San Juan River and the connection of these habitat types to discharge, particularly during the period of time when they are utilized by larval fishes as nursery habitat.

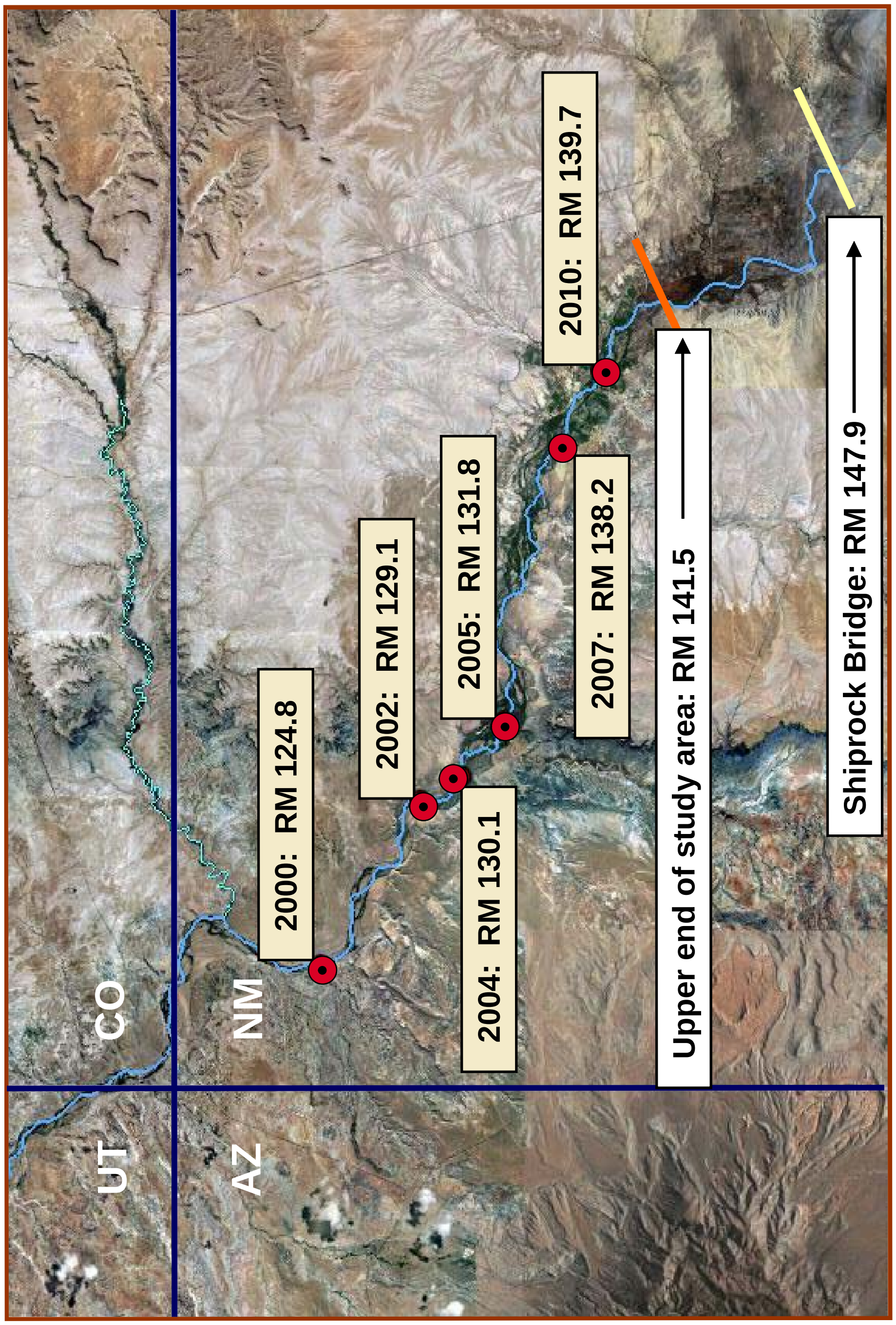

Figure 36. Upstream-most distribution of larval razorback sucker in the San Juan River between 2000-2010.

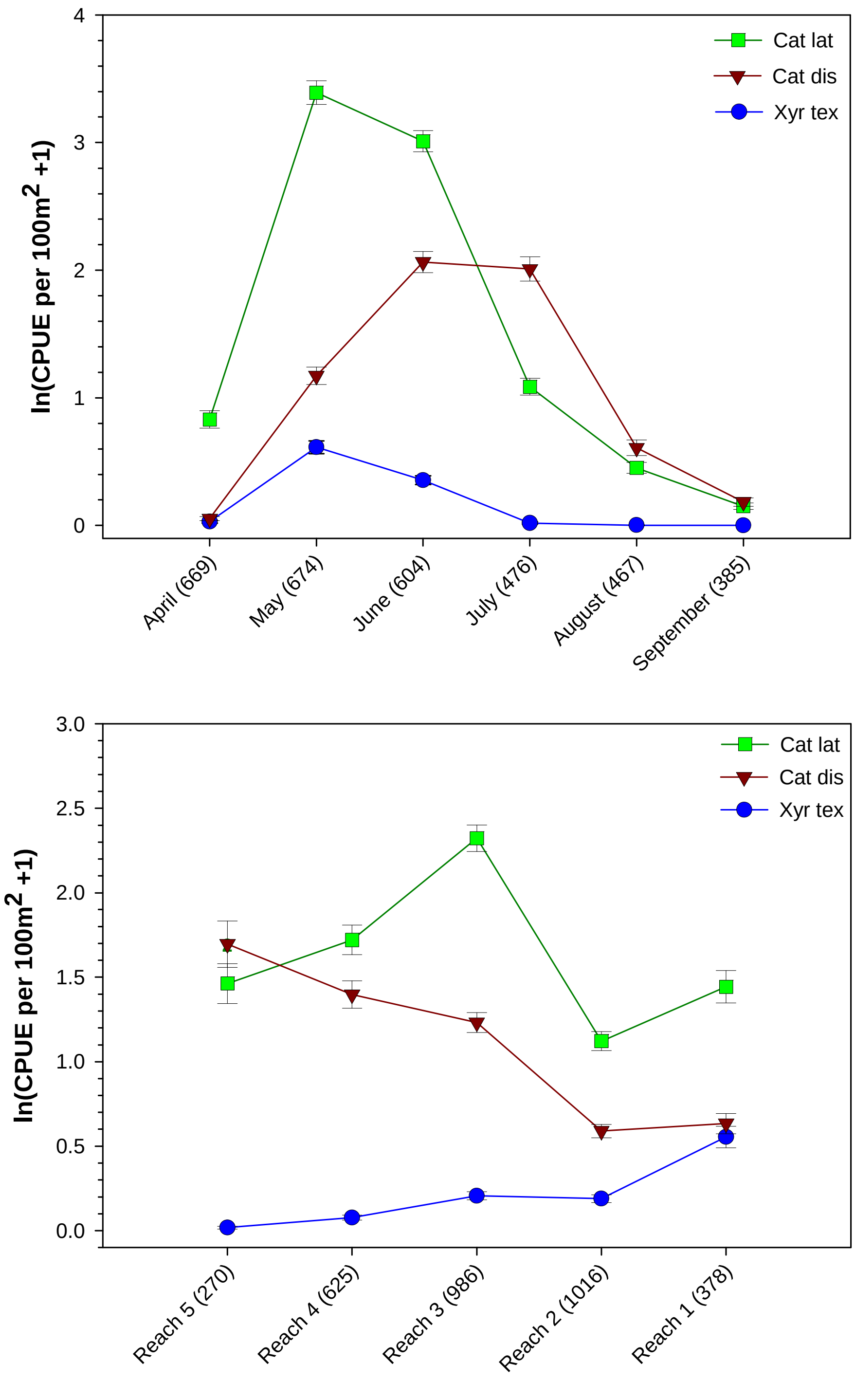

Figure 37. ln (CPUE per 100 m^2+1) of the catostomids species collected from 1999-2010 by trip (top graph) and reach (bottom graph). Green squares represent flannelmouth sucker, red triangles, bluehead sucker, and blue circles, razorback sucker.

Habitat Persistence

The need to understand the temporal dynamics and persistence of backwater habitats within the San Juan River became apparent as a result of the monitoring workshops held in 2009. Habitat monitoring results showed backwater area had decreased 67% from the 1993-1995 average and that backwater habitats are limited (Bliesner et al., 2008). The 2009 larval fish monitoring data set was used as a preliminary analysis of backwater persistence. Results from the 2009 larval fish data set showed that of the backwaters sampled, few persisted more than a month and none persisted three months (Bliesner et al., 2009). To further investigate backwater persistence, a pilot study was designed an implemented in conjunction with the 2010 larval fish survey.

Backwater habitats were mapped during the May 2010 survey. During the following month, an attempt was made to re-map those same habitats to be able to compare the sites between sampling trips. Several problems arose that made this pilot study ineffective. The first problem encountered was the lack of satellite coverage in the lower reaches of the study area (Reaches 2 and 1). Even with the use of a geodesic zephyr antenna to boost receiver capability, satellite coverage was in most cases poor to zero resulting in incomplete maps. Reach 1 has the highest consistent catch rates of larval razorback sucker and also accounted for many of the designated habitat mapping sites. Another issue which seriously curtailed the effectiveness of this pilot study was the variability in discharge between monitoring trips. Flows on the San Juan River are especially variable during spring run-off. The 2010 flow year was very different to a “typical” flow year on the San Juan River. There was no release from Navajo Dam in the spring to match run-off from the Animas River resulting in lower than average spring discharge. In addition, the May larval fish survey was conducted during a depression in the spring hydrograph (mean discharge 1,223 cfs). The result of the reduced discharge translated to a reduction or isolation of backwaters habitats that were identified as potential mapping sites. Without having a constant presence at these sites there was no way to determine when backwater habitats would be reconnected by increasing spring flows. Flows did increase between the May and June surveys. Discharge between trips ranged from 1,230 to 4,280 cfs (mean discharge 2800 cfs). We assume that the increase in flow connected isolated pools to the main channel; however, during the subsequent June surveys many of the backwaters that were isolated in May were again isolated. Mean discharge during the June survey was 1,321 cfs.

During the initial site survey (May) a total of 22 sites were mapped from river mile 133.3 to river mile 7.0. The sites in the canyon-bound section of the river were mostly incomplete maps due to poor satellite coverage. Thirteen of the sites mapped in May were backwaters and 9 were isolated pools. All of the isolated pools mapped were located in reaches 2 and 1. Isolated pools that were mapped in May were sites that had been designated prior to field work as backwater habitat mapping sites. The following month only six of the habitats mapped in May were available (wetted) to map/sample (Table 4). An additional 10 sites were mapped in June that were not mapped in May. Of the sites that were mapped both months, two localities remained the same habitat type. One was a backwater at river mile 13.9 and the other was an isolated pool at river mile 10.0. Neither site was able to be completely mapped due to poor GPS coverage. The remaining sites had changed habitat types due to alteration in flow or were no longer wetted.

Table 4. Backwater habitats that were mapped in May and available for re-mapping in June during the 2010 larval fish survey.

May Backwater Habitats				June Backwater Habitats			
Station	**Date**	**RM**	**Habitat**	**Station**	**Date**	**RM**	**Habitat**
MAF10-030	18-May-10	116.2	backwater	MAF10-071	16-Jun-10	116.2	pool
MAF10-036	19-May-10	104.4	backwater	MAF10-077	16-Jun-10	104.4	isolated pool
WHB10-050	18-May-10	38.8	isolated pool	WHB10-073	15-Jun-10	38.8	pool
WHB10-056	19-May-10	22	backwater	WHB10-077	16-Jun-10	22	embayment
WHB10-060	19-May-10	13.9	backwater	WHB10-080	16-Jun-10	13.9	backwater
WHB10-063	19-May-10	10	isolated pool	WHB10-083	16-Jun-10	10	isolated pool

Acknowledgments

Numerous individuals assisted with the efforts necessary to accomplish this project. Adam L. Barkalow, Mary A. Brandenburg Jennifer L. Hester, Steven P. Platania, Lee E. Renfro, and Kevin R. Schaus (ASIR), Tracy A. Diver (UNM, MSB), Scott L. Durst (USFWS), and Mark McKinstry (U.S. Bureau of Reclamation) participated in field portions of this study. This project benefited from the invaluable logistical assistance of Ernie Teller (USFWS). Assistance with all aspects of collection, database management and curation was provided by Alexandra M. Snyder (UNM, MSB). Collections were prepared for identification and curation by Stephanie L. Clark, Kaitlin M. Hulsbos, Kaylie R. Naegele, Kristyn McDonald (UNM, MSB personnel) and Jennifer L Hester. Adam L. Barkalow assisted in the identification of specimens. Dr. Robert K. Dudley, and Steven P. Platania provided analytical and technical support. Stephen T. Ross, Paul B. Holden, and Scott L. Durst reviewed and commented on earlier drafts. Temperature data were supplied by Keller-Bliesner Engineering. This study was approved by the San Juan River Basin Biology Committee through the San Juan River Basin Recovery Implementation Program and funded under a U. S. Bureau of Reclamation, Salt Lake City Project Office Award # 01-FG-40-5750 administered by Mark McKinstry (U.S. Bureau of Reclamation). The collecting of fish was authorized under scientific collecting permits provided by the Utah Division of Wildlife Resources, New Mexico Department of Game and Fish, U.S. Fish and Wildlife Service, and Navajo Nation.

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Appendix I. Summary of age-0 fishes collected in the San Juan River during the 2010 larval fish survey.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	CPUE[2]	FREQUENCY OF OCCURRENCE[3]	% FREQUENCY OF OCCURRENCE[3]
CARPS AND MINNOWS						
red shiner	I	41,061	73.5	245.0	163	44.7
common carp	I	7	*	*	5	1.4
roundtail chub	N	-	-	-	-	-
fathead minnow	I	1,719	3.1	10.3	88	24.1
Colorado pikeminnow	N	5	*	*	3	0.8
speckled dace	N	2,369	4.2	14.1	161	44.1
SUCKERS						
flannelmouth sucker	N	5,459	9.8	32.6	189	51.8
bluehead sucker	N	2,426	4.3	14.5	131	35.9
razorback sucker	N	1,251	2.2	7.5	62	16.9
razorback X flannelmouth sucker	N	1	*	*	1	*
BULLHEAD CATFISHES						
black bullhead	I	106	0.2	0.6	21	5.8
yellow bullhead	I	-	-	-	-	-
channel catfish	I	388	0.7	2.3	73	17.0
TROUT						
kokanee salmon	I	-	-	-	-	-
KILLIFISHES						
plains killifish	I	22	*	0.1	15	4.1
LIVEBEARERS						
western mosquitofish	I	1,008	1.8	6.0	65	17.8
SUNFISHES						
green sunfish	I	7	*	*	1	0.3
bluegill	I	-	-	-	-	-
largemouth bass	I	9	*	0.1	8	2.2
TOTAL		55,838		333.1		

[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=365 samples.
* Value is less than 0.05%

Table I-5. Summary of age-0 fishes collected during the 2010 San Juan River larval Colorado pikeminnow and razorback sucker survey (19 April - 3 September, 2010). Effort =16,761 m^2

Appendix II. Summary of age-1+ fishes collected in the San Juan River during the 2010 larval fish survey.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	PERCENT OF TOTAL	CPUE[2]	FREQUENCY OF OCCURRENCE[3]	% FREQUENCY OF OCCURRENCE[3]
CARPS AND MINNOWS						
red shiner	I	13,590	92.0	81.1	204	55.9
common carp	I	1	*	*	1	0.3
roundtail chub	N	-	-	-	-	-
fathead minnow	I	126	0.9	0.8	35	9.6
Colorado pikeminnow	N	221	1.5	1.3	68	18.6
speckled dace	N	287	1.9	1.7	77	21.1
SUCKERS						
flannelmouth sucker	N	26	0.2	0.2	13	3.6
bluehead sucker	N	10	0.1	0.1	9	2.5
razorback sucker	N	-	-	-	-	-
razorback X flannelmouth sucker	N	-	-	-	-	-
BULLHEAD CATFISHES						
black bullhead	I	34	0.2	0.2	7	1.9
yellow bullhead	I	-	-	-	-	-
channel catfish	I	16	0.1	0.1	8	2.2
TROUT						
kokanee salmon	I	1	*	*	1	0.3
KILLIFISHES						
plains killifish	I	13	0.1	0.1	12	3.3
LIVEBEARERS						
western mosquitofish	I	433	2.9	2.6	48	13.2
SUNFISHES						
green sunfish	I	9	0.1	0.1	6	1.6
bluegill	I	-	-	-	-	-
largemouth bass	I	1	*	*	1	0.3
TOTAL		14,768		88.1		

[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=365 samples.
* Value is less than 0.05%

Table II-6. Summary of age-1+ fishes collected during the 2010 San Juan River larval Colorado pikeminnow and razorback sucker survey (19 April - 3 September, 2010). Effort =16,761 m^2

Appendix III. Summary of endangered larval fishes collected in the San Juan River during the 2010 larval fish survey.

Field Number	MSB Catalog Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
MAF10-033		17	9.4 -11.1	protolarvae	19-May-10	107.6	larval fish seine
MAF10-034		6	11.1 -12.4	proto - mesolarvae	19-May-10	107.6	larval fish seine
MAF10-037		1	10.9	mesolarva	19-May-10	100.5	larval fish seine
MAF10-038		2	10.2 -10.3	mesolarvae	19-May-10	99.3	larval fish seine
MAF10-039		6	9.5 -11.8	proto - mesolarvae	20-May-10	96.4	larval fish seine
MAF10-040		15	10.1 -12.7	proto - mesolarvae	20-May-10	93.3	larval fish seine
MAF10-043		1	11.2	protolarva	20-May-10	87.5	larval fish seine
MAF10-044		2	10.9, 11.9	proto - mesolarvae	20-May-10	84.1	larval fish seine
MAF10-047		1	10.4	mesolarva	20-May-10	75.5	larval fish seine
MAF10-048		3	10.2 -10.9	protolarvae	20-May-10	74.9	larval fish seine
MAF10-050		1	11.2	protolarva	20-May-10	72.7	larval fish seine
MAF10-051		7	10.6 -12.2	proto - mesolarvae	20-May-10	72.6	larval fish seine
MAF10-052		3	10.6 -11.3	proto - mesolarvae	20-May-10	69.3	larval fish seine
MAF10-054		18	9.6 -13.2	proto - mesolarvae	20-May-10	61.3	larval fish seine
WHB10-041		1	11.4	mesolarva	17-May-10	52.4	larval fish seine
WHB10-042		1	10.5	proto larva	17-May-10	49.0	larval fish seine
WHB10-048		1	11.2	mesolarva	18-May-10	39.9	larval fish seine
WHB10-049		2	11.2, 11.6	proto - mesolarvae	18-May-10	38.9	larval fish seine
WHB10-050		2	11.1, 11.9	mesolarvae	18-May-10	38.8	larval fish seine
WHB10-051		22	9.6 -12.0	proto - mesolarvae	18-May-10	33.7	larval fish seine
WHB10-053		3	10.6 -11.5	mesolarvae	19-May-10	25.0	larval fish seine
WHB10-054		142	9.9 -12.1	proto - mesolarvae	19-May-10	24.6	larval fish seine
WHB10-055		2	9.5, 11.4	proto - mesolarvae	19-May-10	24.5	larval fish seine
WHB10-056		59	9.7 -12.3	proto - mesolarvae	19-May-10	22.0	larval fish seine
WHB10-057		152	9.5 -12.2	proto - mesolarvae	19-May-10	20.9	larval fish seine
WHB10-058		14	10.5 -11.5	proto - mesolarvae	19-May-10	17.8	larval fish seine
WHB10-059		4	11.4 -11.6	mesolarvae	19-May-10	17.7	larval fish seine
WHB10-060		126	9.8 -12.7	proto - mesolarvae	19-May-10	13.9	larval fish seine
WHB10-061		45	10.1 -12.4	proto - mesolarvae	19-May-10	12.4	larval fish seine
WHB10-062		30	11.5 -14.3	mesolarvae	19-May-10	11.4	larval fish seine
WHB10-063		1	12.8	mesolarva	19-May-10	10.0	larval fish seine
WHB10-064		36	11.1 -13.9	mesolarvae	20-May-10	8.1	larval fish seine
WHB10-065		3	10.6 -12.4	mesolarvae	20-May-10	7.0	larval fish seine
WHB10-066		266	9.4 -14.6	proto - mesolarvae	20-May-10	6.0	larval fish seine
Total		**996**					

Table III-7. Summary of the larval razorback sucker collected in May in the San Juan River during the 2010 larval fish survey.

Appendix III. Summary of endangered larval fishes collected in the San Juan River during the 2010 larval fish survey.

Field Number	MSB Catalog Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
MAF10-059		2	10.4, 11.5	proto - mesolarvae	14-June-10	139.7	larval fish seine
MAF10-064		3	12.0 -18.1	proto - mesolarvae	15-June-10	128.5	larval fish seine
MAF10-067		3	15.7 -18.1	mesolarvae	15-June-10	126.6	larval fish seine
MAF10-071		2	9.8, 11.1	proto larvae	16-June-10	116.2	larval fish seine
MAF10-077		1	11.8	mesolarva	16-June-10	104.4	larval fish seine
MAF10-081		1	12.8	mesolarva	17-June-10	96.3	larval fish seine
MAF10-093		3	12.4 -12.6	mesolarvae	18-June-10	75.1	larval fish seine
MAF10-094		1	12.2	mesolarva	18-June-10	72.2	larval fish seine
MAF10-098		2	10.1, 10.5	mesolarvae	18-June-10	65.2	larval fish seine
MAF10-099		5	11.0 -20.7	meso - metalarvae	18-June-10	63.5	larval fish seine
MAF10-100		1	10.4	protolarva	18-June-10	57.9	larval fish seine
MAF10-102		2	13.3, 14.6	mesolarvae	19-June-10	52.9	larval fish seine
WHB10-067		11	11.0 -26.7	meso - juvenile	14-June-10	52.4	larval fish seine
WHB10-070		2	11.3, 17.0	mesolarvae	15-June-10	41.8	larval fish seine
WHB10-076		25	11.8 -22.4	meso - metalarvae	16-June-10	22.4	larval fish seine
WHB10-078		5	12.6 -26.5	meso - metalarvae	16-June-10	17.7	larval fish seine
WHB10-079		7	13.8 -22.3	meso - metalarvae	16-June-10	16.4	larval fish seine
WHB10-080		9	10.6 -21.2	meso - metalarvae	16-June-10	13.9	larval fish seine
WHB10-082		61	11.0 -26.3	meso - juvenile	16-June-10	11.4	larval fish seine
WHB10-083		1	18.2	mesolarva	16-June-10	10.0	larval fish seine
WHB10-084		79	11.1 - 21.3	meso - metalarvae	17-June-10	9.6	larval fish seine
WHB10-085		1	17.1	metalarva	17-June-10	9.5	larval fish seine
WHB10-086		21	12.0 -20.3	meso - metalarvae	17-June-10	8.1	larval fish seine
WHB10-087		3	11.5 -21.1	meso - metalarvae	17-June-10	7.0	larval fish seine
WHB10-088		2	10.6, 11.3	mesolarvae	17-June-10	5.1	larval fish seine
WHB10-093		1	30.0	juvenile	20-July-10	44.8	larval fish seine
WHB10-094		1	51(SL)	juvenile	20-July-10	43.8	larval fish seine

Total	**255**
2010 Total	**1,251**

Table III-7. Summary of the larval razorback sucker collected in June/July in the San Juan River during the 2010 larval fish survey.

Appendix III. Summary of endangered larval fishes collected in the San Juan River during the 2010 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	74264	1	25.2	metalarva	29 July 2009	24.7	larval seine
2009	**Total**	**1**					
MAF10-140	N/A	1	12.6	metalarva	23 July 2010	58.9	larval seine
WHB10-096	N/A	3	19.7-21.4	metalarvae	20 July 2010	41.5	larval seine
WHB10-106	N/A	1	16.2	metalarva	22 July 2010	13.0	larval seine
2010	**Total**	**5**					
Total		**11**					

Table III-8. Summary of larval Colorado pikeminnow collected in the San Juan River during the 2004, 2007, 2009 and 2010 larval fish survey.