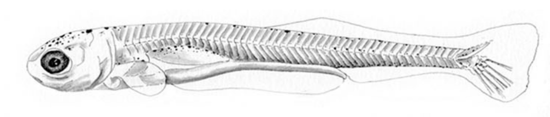
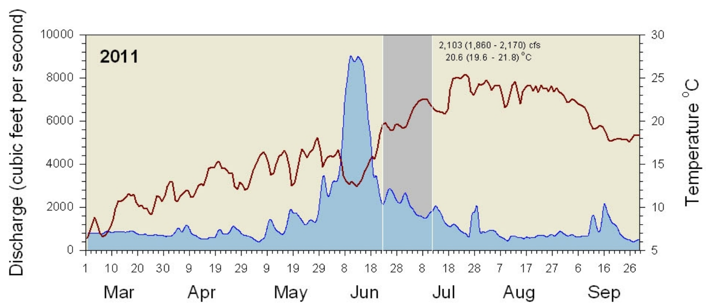
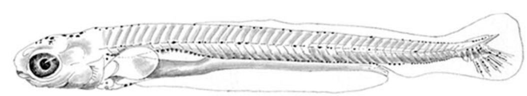
Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2011

FINAL REPORT

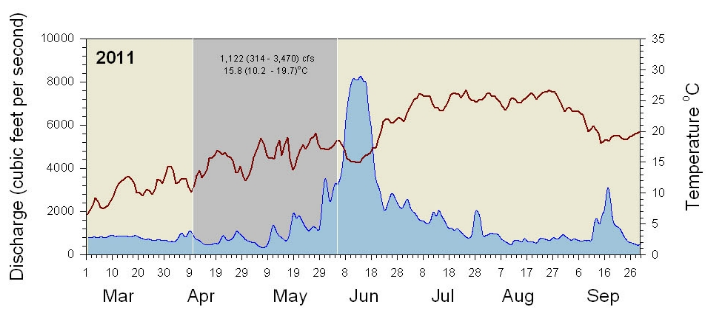


Colorado pikeminnow, *Ptychocheilus lucius*, larva





razorback sucker, *Xyrauchen texanus*, larva



illustrations by W.H. Brandenburg

Cooperative Agreement Number: 07 FG 40 2642

1 October 2010- 30 September 2011

W. Howard Brandenburg, Michael A. Farrington (ASIR),
and
Eliza I. Gilbert (NMDGF)

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

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1 October 2010- 30 September 2011

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submitted to:

San Juan River Basin Biology Committee
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San Juan River Basin Recovery Implementation Program

30 June 2012

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Executive Summary

1. From 18 April to 11 August 2011 five monthly larval survey trips were conducted between river mile 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 2,048 cfs (314 – 8,250 cfs) and 20.0 ºC (12.0 – 26.7 ºC).

3. A total of 260 collections were made encompassing 9,387.9 m^2 of low velocity habitat.

4. The 2011 larval fish collections produced 28,259 fishes representing seven families and 17 species. One suspected age-0 bluehead X flannelmouth sucker hybrid was collected.

5. Age-0 fishes accounted for 92.7% of the total catch (n= 26,208) and had a river-wide mean of 309.3 (SE=55.3) fish per 100 m^2.

6. Flannelmouth sucker was the numerically dominant (n=5,849) and most frequently encountered species during the 2011 larval fish survey.

7. Between 16 May and 19 July 2011(three survey trips), 1,065 wild age-0 razorback sucker were collected in six different habitat types.

8. The back-calculated hatching dates for razorback sucker ranged from 10 April to 5 June 2011. Mean daily discharge and water temperature during that period was 1,122 cfs (314 – 3,470) and 15.8 ºC (10.2 – 19.7 ºC).

9. Age-0 razorback sucker consisted of protolarvae (5.4%), mesolarvae (86.3%), metalarvae (7.2%), and early juvenile (1.0%).

10. Twenty-nine larval Colorado pikeminnow were collected in backwater and isolated pool habitats during the July and August sampling trips in Reaches 3 and 1.

11. The ontogenetic stages of the Colorado pikeminnow larvae were mesolarvae and metalarvae and ranged in size from 10.0 to 21.3 mm total length.

12. The back-calculated spawning dates for the age-0 Colorado pikeminnow were 23 June to 12 July 2011. Mean daily discharge and water temperature during this period was 2,103 cfs (1,490 – 2,840 cfs) and 20.6 ºC (18.9 – 22.6 ºC).

13. A total of 19 age-1+ (66 –174 mm SL) Colorado pikeminnow were collected during the study period in 2011. It is presumed these fish were the result of augmentation efforts.

14. For the first time since 1999, roundtail chub were collected in the larval fish surveys. Two metalarvae and two early juvenile specimens were collected between 19 July and 9 August 2011 in the vicinity of Mancos River.

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 °C and 25 °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). 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 °C (Tyus and Karp, 1990). Razorback sucker larvae have been collected from Lake Mohave at 9.5–15.0 °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 has 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*, preys on cypriniform larvae (Brandenburg and Gido, 1999; Bestgen, 2006). Red shiner comprise up to 80% of the ichthyofaunal community in nursery habitats in the San Juan River (Propst et al., 2003; Brandenburg and Farrington, 2010) 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. Collections of larval Colorado pikeminnow in the San Juan River during the (1993-2010) 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

Table 1. (Con't.) Collections of larval Colorado pikeminnow in the San Juan River during the (1993-2010) and back-calculated dates of spawning.

Field Number	MSB Catalog Number	Number specimens	Total Length mm	Date Collected	Date Spawned	River Mile	Sample Method
MAF10-140	82014	1	12.6	23 Jul 10	27 Jun 10	58.9	larval seine
WHB10-096	82040	1	19.7	20 Jul 10	18 Jun 10	41.5	larval seine
WHB10-096	82040	1	19.9	20 Jul 10	18 Jun 10	41.5	larval seine
WHB10-096	82040	1	21.4	20 Jul 10	15 Jun 10	41.5	larval seine
WHB10-106	82071	1	16.2	22 Jul 10	23 Jun 10	13.0	larval seine
TOTAL		**17**					

Beginning in 2002, the sampling protocol was switched to active collection of larval fishes using larval seines and using a raft to navigate the San Juan River. Using this active approach 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 (2011). The goals and objectives of this specific monitoring project are identified in the aforementioned document and listed below:

- 4.1.2.1 Determine if razorback sucker and Colorado Pikeminnow reproduction occurred in the San Juan River and estimate the extent of annual reproduction.
- 4.1.2.5 Collect catch rate (CPUE) statistics to estimate relative abundance of endangered fish populations.
- 4.2.2.1 Quantify attributes of habitats important to each life-stage of endangered fish.
- 4.2.3.2 Document and track trends in the use of specific mesohabitat types by larval Colorado pikeminnow and razorback sucker
- 4.1.1.1 Document and provide a comparative analysis of the reproductive effort of the entire ichthyofaunal community.
- 4.1.1.2 Analyze and evaluate monitoring data and produce Annual Fish Monitoring Reports to ensure that the best sampling design and strategies are employed.

Table 2. Larval and age-0 razorback sucker collected during the San Juan River larval fish survey 1998-2010 (Xyrtex = *Xyrauchen texanus*, razorback sucker).

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
2010	141.5 - 2.9	19 Apr - 3 Sep	16,761.0	1,251	larval seine
TOTAL				**3,586**	

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 snow-melt 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 snow-melt 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 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 Sand Island, UT) and a “lower” section (Sand Island, UT to Clay Hills, UT). 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 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 sample, 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 (Figure A-1). 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 (SJRBIP) 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 SJRBIP 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.

Beginning in 2011 ASIR researchers defined 20 monitoring stations throughout the study area (Table A-1) in an attempt to assess persistence of backwaters habitats. The monitoring stations were locations that age-0 razorback sucker have been repeatedly captured in past larval fish surveys. All but three stations were geomorphically similar and are characterized as lateral washes or canyons which form backwaters during increased river discharge. The three monitoring sites not located in lateral washes or canyons were excluded from analysis. In addition, two stations designated in Reach 5 were also excluded because one was fed by irrigation return water and the other was inaccessible at most discharge levels. The 15 remaining monitoring stations were visited in each monthly survey. If backwater habitats had formed in them at the time of visitation they were sampled. If they were dry or isolated, photographs were taken and field notes written detailing condition of the habitat. Conditions of monitoring stations were then related back to discharge at time of visitation.

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 (Auer, 1982; 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 cataloged in the Division of Fishes of the Museum of Southwestern Biology (MSB) at the University of New Mexico (UNM).

Results reported in this document pertain primarily to age-0 fishes. Raw numbers of age-1+ and age-0 fishes are presented in Appendix A (Tables A-2 and A-3). Scientific and common names of fishes used in this report follow Nelson (2004) and six letter codes for species are those adopted by the San Juan River Basin Biology Committee (Table 3). Total length (TL) and standard length (SL) were measured on all Colorado pikeminnow and razorback sucker to be consistent with information gathered by the San Juan River Basin and Upper Colorado River Basin programs (Tables A-4 and A-5). 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.

Figure 1. Map of the San Juan River larval fish study area. The study area encompasses the river between Cudei, NM (river mile 141.5) and Clay Hills Crossing, UT (river mile 2.9). Purple bars denote study area.

Table 3. Scientific names, common names, and species codes of fishes collected in the San Juan River. Asterisk (*) indicates a species was collected in prior years surveys but not in the 2011 larval fish survey.

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)
Catostomus latipinnis x discobolus	flannelmouth bluehead hybrid	(CATLATxCATDIS)
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)

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 at Mexican Hat, UT (USGS gauge #9379500) 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 (2003-2011), 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 -2011 using only the months April - June. This was done in an effort to include data from 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 analysis.

Although both ANOVA and Kruskal-Wallis were used to analyze data, data transformations 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 are presented.

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

Habitat occupancy graphs were generated using log transformed mean CPUE in order to measure density of age-0 species within sampled habitats. The larval surveys adopted the standardized habitat 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 in the middle of the summer season (mid August). Daily mean discharge during the study period was acquired from U.S.

Geological Survey Gauges (#09371010) near Four Corners, CO and (#09379500) Mexican Hat, UT. Mexican Hat discharge and temperature were used for all data analysis in this report except for back-calculated spawning dates of Colorado pikeminnow in which Four Corners discharge and temperature were used. Temperature data (mean, max, min) was taken at the state highway 160 bridge crossing in Colorado (river mile 119.2) and Mexican Hat, UT (river mile 52.0).

Results

2011 Summary

The 2011 San Juan River larval fish survey encompassed a five month period from 18 April to 11 August 2011. 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 temperatures were 2,048 cfs (314 – 8,250 cfs) and 20.0 ^{o}C (12.0 – 26.7 ^{o}C). Spring runoff began in mid-May and exceeded 5,000 cfs for a period of 11 days with discharge peaking on 14 June 2011 at 8,250 cfs (Figure 2). The descending limb of spring runoff occurred over a six week period following peak discharge.

A total of 260 fish collections were made in zero and low velocity habitats encompassing 9,387.9 m^2 of habitat. The collections resulted in the capture of 28,259 age-0 and age-1+ fishes representing seven families and 17 species. Age-0 fish accounted for 92.7% of the total catch (n=26,208). Age-0 fish were collected in each of the five months sampled with a river-wide mean of 309.3 fish per 100 m^2 (SE=55.3). Flannelmouth sucker was the numerically dominant and most frequently encountered fish taxa during the 2011 survey. With the exception of 2008 and 2011, red shiner has been the numerically dominant species throughout the tenure of this study. Native species made up 60.3% of the age-0 catch in 2011. Age-0 specimens collected in April consisted solely of flannelmouth sucker. The following month all three native catostomid species as well as fathead minnow, speckled dace, and western mosquitofish, *Gambusia affinis*, were collected (Figure 3). The June survey documented the addition of age-0 red shiner and common carp. By July, every species encountered during the 2011 survey, with the exception of green sunfish, was captured. July was the last month that razorback sucker was collected and the first month that Colorado pikeminnow and roundtail chub were encountered. The August survey was the only month in which non-native species outnumbered native species. Over 90 percent of the August catch consisted of non-native species.

Trip Summary

The first survey trip (18-21 April 2011) was conducted prior to spring runoff at a mean daily discharge of 564 cfs and mean daily water temperature of 16.4 ^{o}C. A total of 48 discrete habitats were sampled throughout the study area for a total effort of 1,579.2 m^2. For the first time since 2007 larval catostomids were collected during the April survey. The April catostomid catch consisted of a single species, flannelmouth sucker, which were initially collected in the lower half of Reach 3 (RM 87.1) and distributed in downstream reaches. The highest catch of larval flannelmouth sucker in April occurred in Reach 2 (23.7 fish per 100 m^2 [SE=10.9]. A total of 1,395 Age-1+ fish were captured during the April survey, of those, 98.7% were red shiner.

The May survey (16-19 May 2011) took place at the initiation of spring runoff with increasing mean discharge (1,174 cfs) and a mean daily temperature of 16.2 ^{o}C. Fifty-three discrete habitats were sampled, one of which was an isolated pool. The 52 remaining habitats

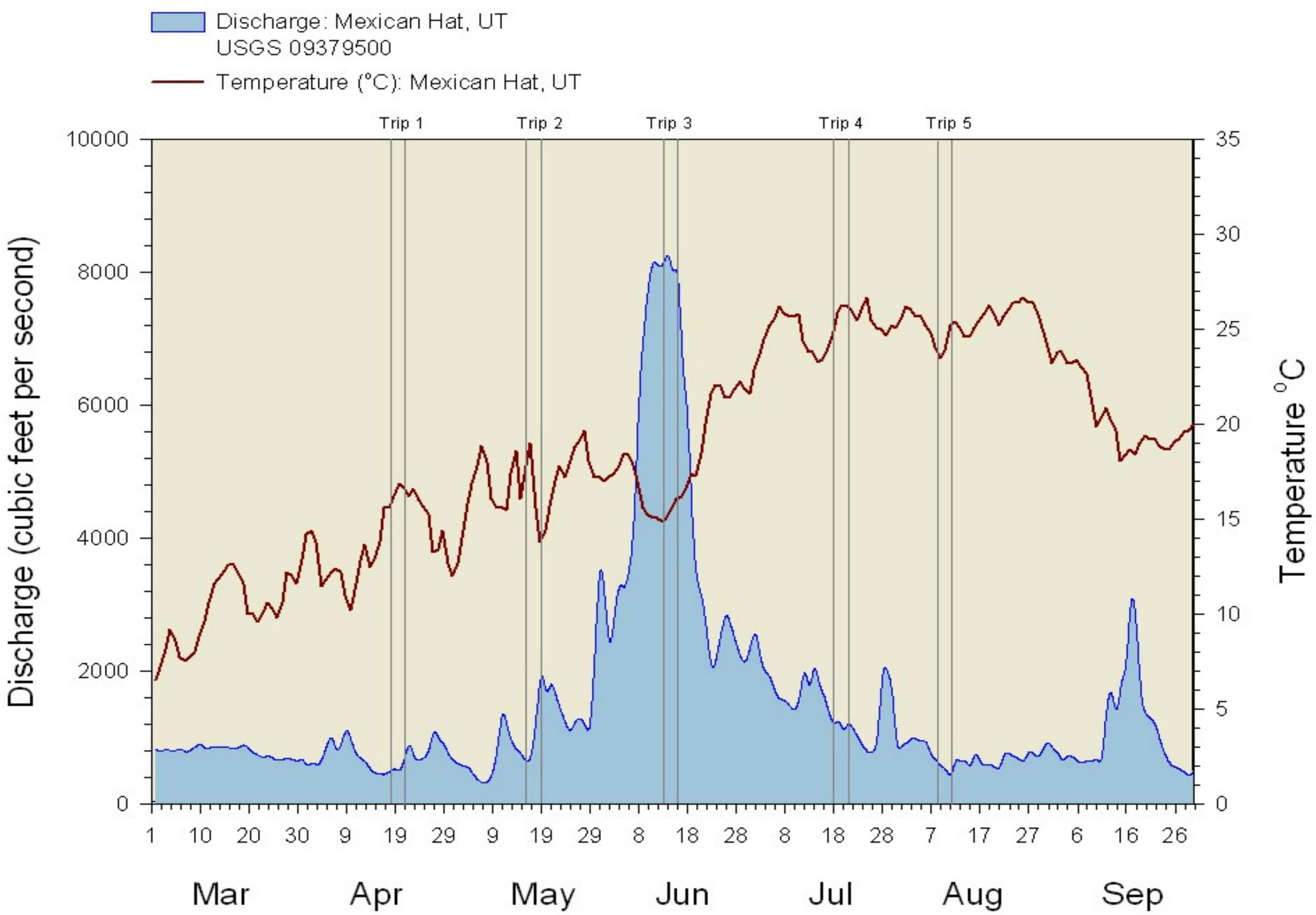

Figure 2. Discharge (cfs) and water temperature (ºC) at Mexican Hat, UT (USGS gauge#09379500) in the San Juan River during the 2011 sampling period. Gray vertical bars denote individual collecting trips.

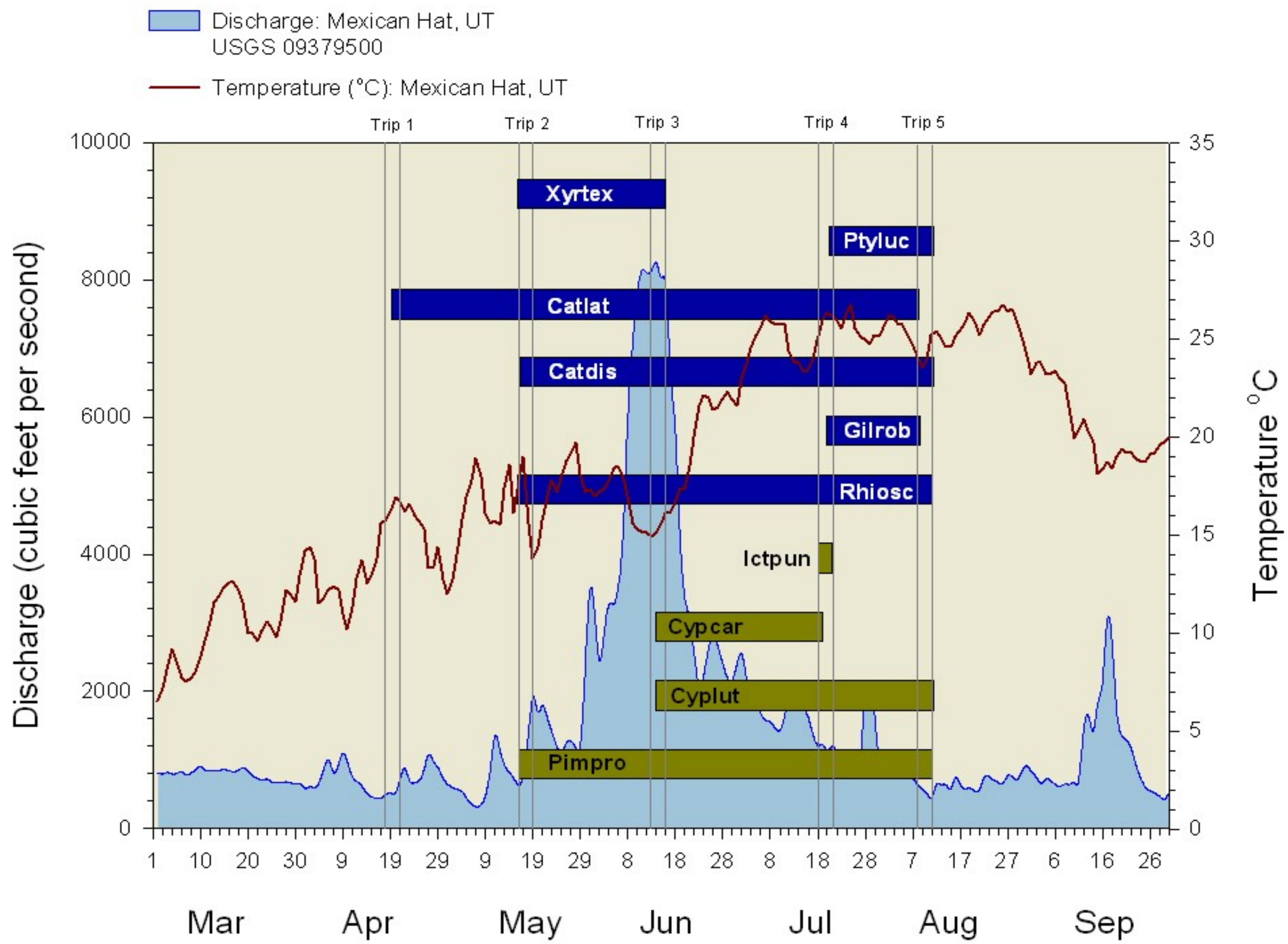

Figure 3. Occurrence of larval fishes in the San Juan River during 2011 plotted against discharge and water temperature (USGS gauge #09379500 Mexican Hat,UT). Bars represent the period between date of first and last collection of larvae for each species. Blue bars denote native species, yellow bars denote non-native species.

encompassed 1,635.6 m^2 of low velocity habitat. The first collections containing razorback sucker were taken on 16 May 2011 by both the upper and lower section sampling crews (RM 137.9 and 70.2 respectively). A total of 901 larval razorback suckers were collected in 36 of the 52 samples (69.2%). Larval razorback sucker were distributed throughout the majority of the study area (river miles 137.9 – 5.6). The May survey had the largest numerical collection of larval razorback sucker consisting of 347 individuals captured in a backwater habitat at river mile 10.0 (Buckhorn Canyon). In addition to the three native catostomids, larval fathead minnow and speckled dace were also documented during the May survey. Fathead minnow were only collected in Reach 5 while speckled dace were collected in low densities in all but Reach 1. Native species comprised 99.6% of the larval fish catch. Flannelmouth sucker was the numerically dominant and most frequently encountered species occurring in 51 of the 52 collections. A total of 336 Age-1+ specimens were captured during the May survey, with 82.7% (n= 278) of those fish being red shiner.

The third survey trip took place between 13 and 16 June 2011 during the peak of spring runoff at mean discharge of 8,080 cfs and mean water temperature of 15.4 °C. The increase in discharge created over-bank flooding and substantially increased the surface area of backwaters that formed in lateral washes. Fifty-one discrete habitats were sampled encompassing 1,878.3 m^2 of nursery habitat. No isolated pools were sampled during the June survey. Native species constituted the majority (98.3%) of the larval fish catch. A total of 162 age-0 razorback sucker were collected in 15 collections between river miles 124.8 and 7.0. The first collections of larval red shiner and common carp were documented during this month. Seventeen age-1+ Colorado pikeminnow were collected in nine discrete habitats between river miles 133.5 and 10.0. These fish were presumably a product of recent stocking activities that took place 17-18 May 2011 in Reach 6. Age-1+ red shiner accounted for 85.6% of the 201 age-1+ fish collected during the month of June.

The July survey took place between the 18th and 21st of the month during the descending limb of spring runoff with mean daily discharge of 1,190 cfs and mean daily water temperature of 25.8 °C. The reduction of discharge between the June and July surveys had deposited large amounts of sediment isolating some of the backwaters formed in lateral washes and canyons. A total of 59 discrete habitats were sampled including one isolated pool. The remaining 58 collections encompassed 2,182.2 m^2 of nursery habitat. This was the last month in which age-0 razorback sucker were collected. A single juvenile specimen was captured in a backwater habitat at river mile 52.4 (Gypsum Wash). The July collections contained nearly every species encountered during the 2011 larval survey including a larval bluehead x flannelmouth sucker hybrid. Larval Colorado pikeminnow were first collected on 20 July 2011 in a backwater habitat at river mile 87.4 (Reach 3). The following day, two more collections made in Reach 1 (river miles 10.8 and 10.0) also contained larval Colorado pikeminnow. Two age-0 roundtail chub were collected during this month at river mile 122.2, just downstream of the Mancos River confluence. Roundtail chub were last collected in the larval fish surveys in 1999, however, the 1999 specimens represented age-1 fish. The 2011 survey marks the first year in which age-0 roundtail chub have been collected. There were nearly even numbers of native and non-native age-0 fish collected during this month (n=6,755 and 6,031 respectively). The increase in non-native age-0 fish are attributed to the increased collection of age-0 red shiner and fathead minnow. A total of 103 age-1+ fish were collected, including two Colorado pikeminnow. July was the last month in which age-1+ Colorado pikeminnow were encountered.

The final survey took place between 8 and 11 August 2011 during summer base flow conditions. Mean discharge and temperature during this period was 545 cfs and 24.2 °C. Forty-nine discrete collections were made including one in an isolated pool. The 48 remaining habitats encompassed 2,032.1 m^2 of low velocity habitat. Of all the species collected in 2011, razorback sucker was the only species not collected during the August survey. Two larval Colorado pikeminnow were collected in two separate backwater habitats at river miles 92.6 and 7.0. A single backwater habitat at river mile 122.6 (Mancos River) contained two age-0 roundtail chub. Non-native fish species dominated the age-0 catch in August. Native species comprised just 9.3% of the total catch. Only 16 age-1+ fishes were collected during this month.

Endangered Species

Razorback sucker. A total of 1,065 age-0 razorback sucker were collected during the 2011 larval survey. Larval razorback sucker were first collected during the May survey with the last collection containing this species occurring during the July survey. The riverwide mean for razorback sucker was 10.7 fish per 100m^2 (SE=3.6). This species occurred in 20.2% of the 2011 samples and was distributed throughout the study area between river miles 137.9 to 5.6 (Figure 4).

A total of 901 razorback sucker larvae were collected in May representing the highest catch and broadest longitudinal distribution over the study period (river mile 137.9 to 5.6). Reach 1 had the highest mean catch of larval razorback sucker,142.7 fish per 100 m^2 (SE=125.3), while Reach 5 and Reach 3 had the lowest (5.3 fish per 100 m^2 [SE=3.3] and 5.5 fish per 100 m^2 [SE=2.0], respectively). While a similar distribution of larval razorback sucker was observed in June (river mile 124.8 to 7.0) the mean catch was significantly lower than the May catch (F=43.04, P<0.0001). During the June survey Reach 1 had the highest mean catch of age-0 razorback sucker followed by Reach 4 (15.1 fish per 100 m^2 [SE=8.3] and 8.3 fish per 100 m^2 [SE=4.9], respectively), while Reach 3 had the lowest mean catch of 1.3 fish per 100 m^2 (SE=0.60). The only age-0 razorback sucker collected during the July survey was a 26.2 mm SL (34.2 mm TL) specimen collected in a backwater at river mile 52.4 (Gypsum Wash). This was the largest age-0 razorback sucker encountered in 2011.

Despite the higher catch rates observed in Reach 1 in individual sampling months, there were no significant differences in catch of age-0 razorback sucker among reaches during the 2011 study period (Figure 5, [F=2.31, P 0.0586]). A similar catch trend was also observed in 2010. In these two years, catch of larval razorback sucker in Reach 1 had not decreased but rather CPUE of this species increased in upstream reaches.

From 1999 to 2011 annual mean catches of age-0 razorback sucker have varied. Catch rates appear more stable beginning in 2006. Catch in 2011 was significantly higher than all other years except 2002 (F=17.24, P<0.0001 [Figure 6]).

The combined monthly catch from 1999 to 2011 established the May survey as having significantly higher catch rates than any other month (F=124.95, P<0.0001[Figure 7]). Catch rate was significantly higher in Reach 1 compared to other reaches during the thirteen years of surveys (F=28.73, P<0.0001 [Figure 8]).

Back-calculated hatching dates for razorback sucker (protolarvae and mesolarvae) ranged from 10 April to 5 June 2011 (Figure 9). The back-calculated hatching duration encompassed pre-runoff and a portion of the ascending limb of spring runoff, terminating prior to the peak in discharge. Mean daily discharge and water temperature during that period was 1,122 cfs (314 –

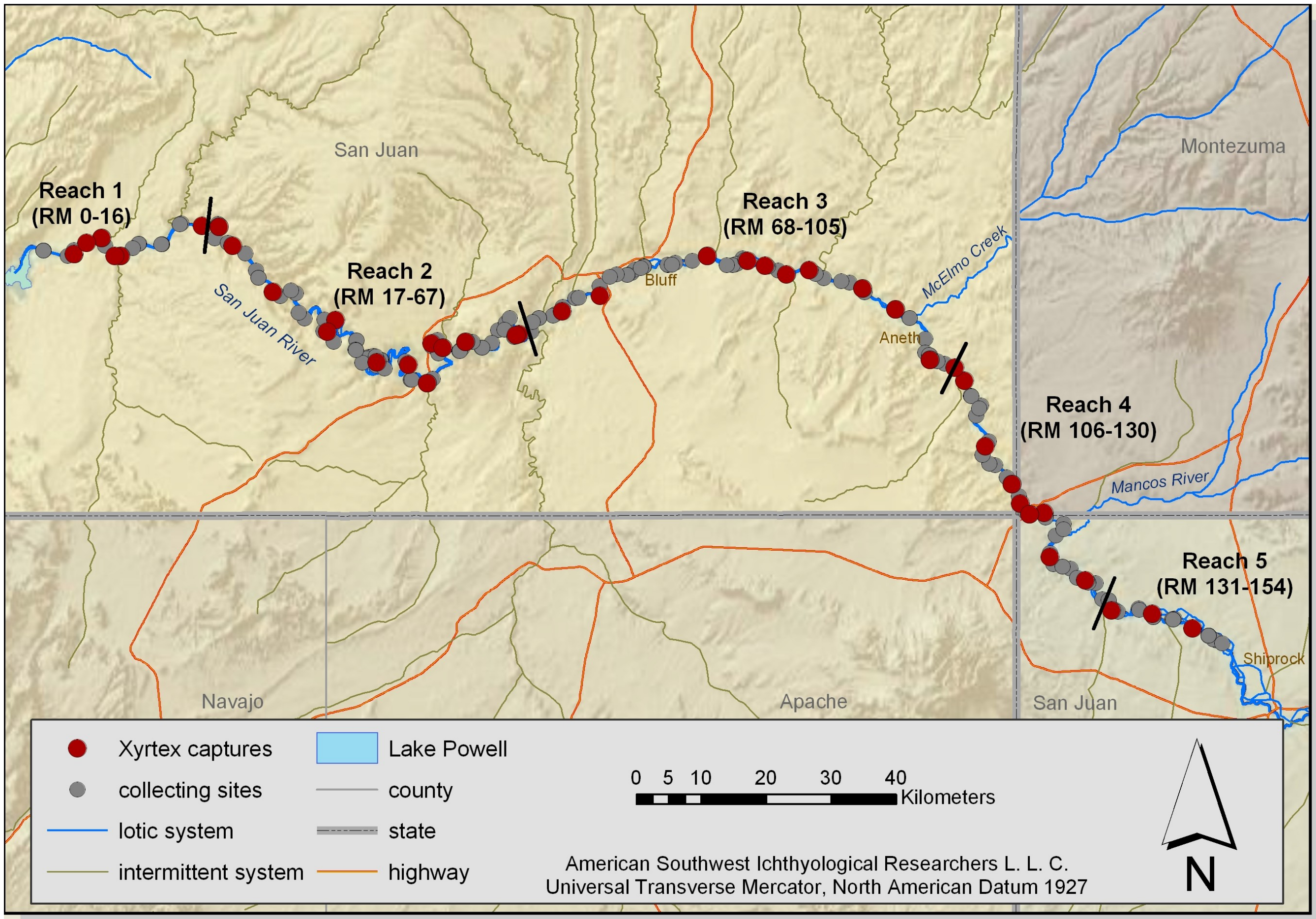

Figure 4. Map of collection sites containing larval razorback sucker (red dots) during the 2011 larval fish survey.

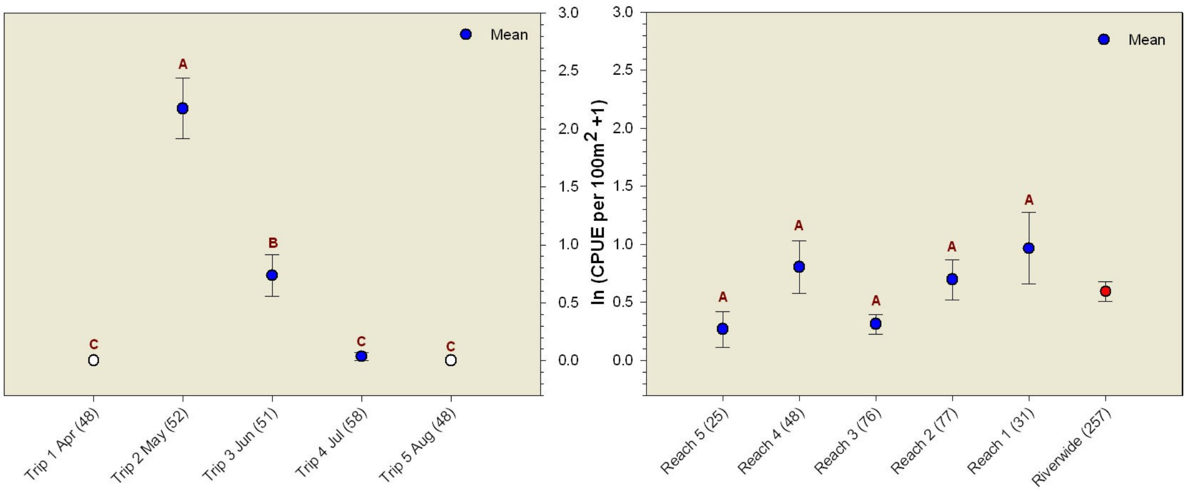

Figure 5. ln(CPUE per 100 m2 +1) [+/-1 SE] for age-0 razorback sucker by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

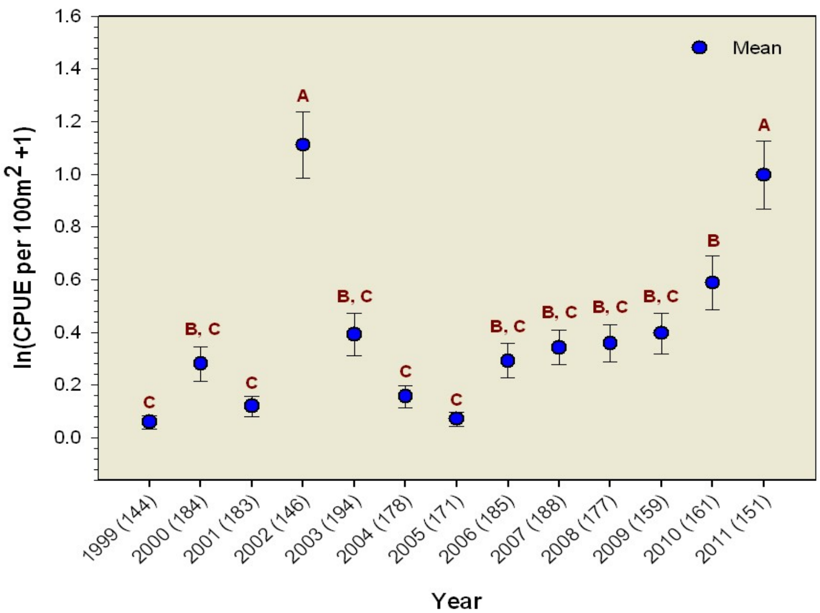

Figure 6. ln(CPUE per 100 m2 +1) [+/-1 SE] for age-0 razorback sucker by year (April-June 1999- 2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

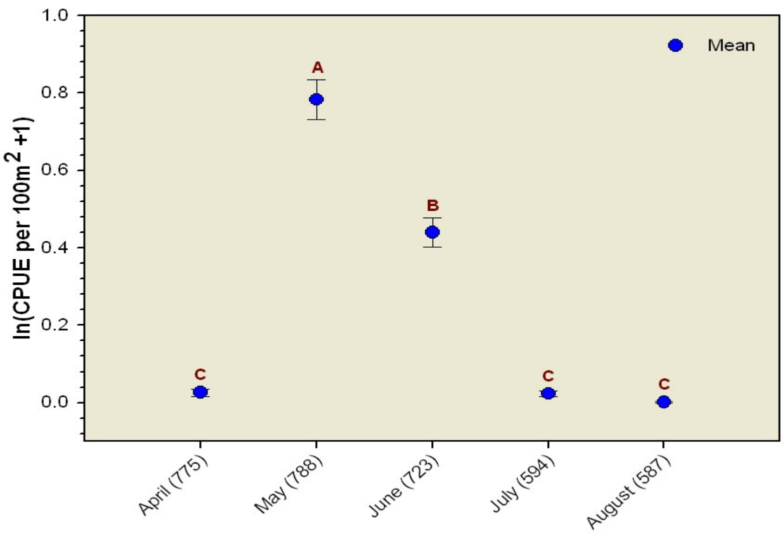

Figure 7. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 razorback sucker by month (April-August 1999-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

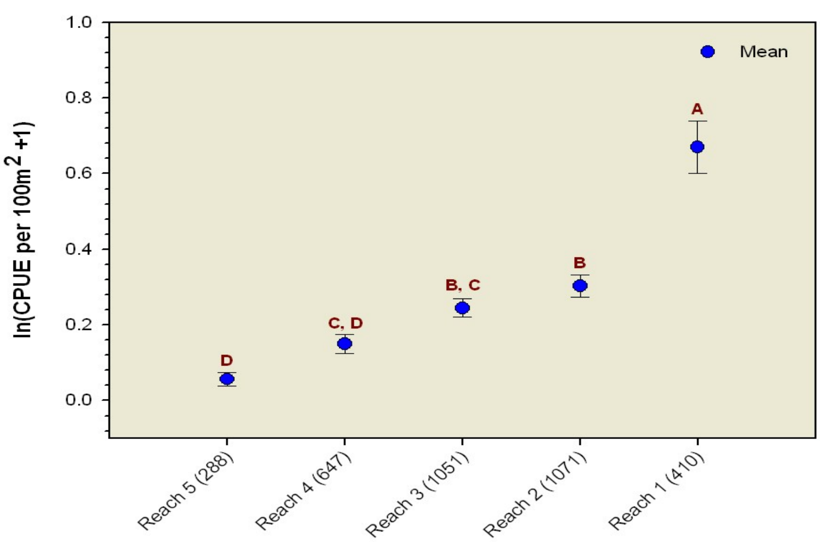

Figure 8. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 razorback sucker by Reach (April-August 1999-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

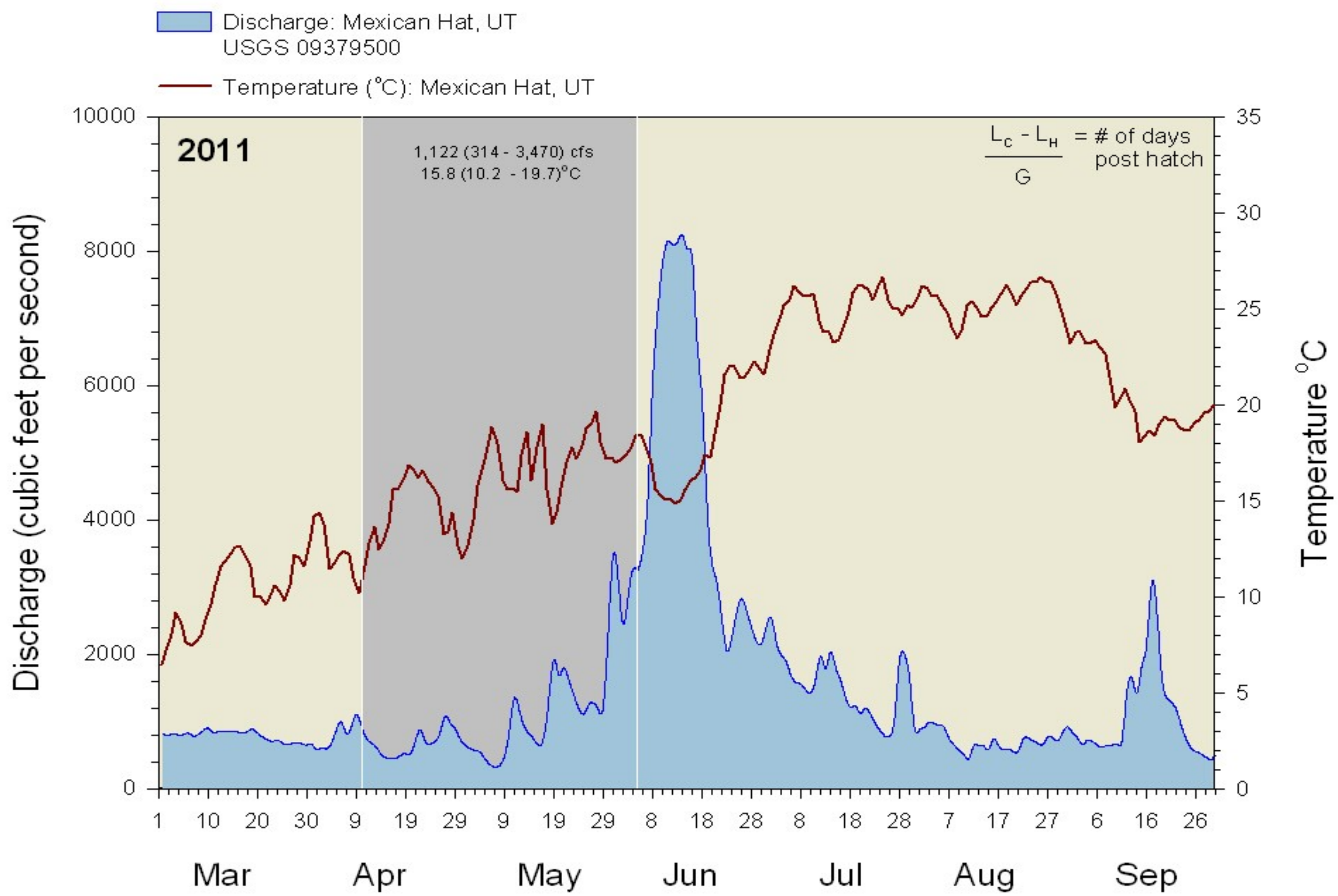

Figure 9. Back-calculated hatching dates for razorback sucker plotted against discharge and water temperature (USGS gauge #09379500 Mexican Hat, UT) during 2011. The gray box delineates hatching period with mean (min max) discharge and water temperature reported.

3,470) and 15.8 ºC (10.2 – 19.7 ºC). Spawning dates for razorback sucker can be derived from the back-calculated hatch dates by subtracting temperature dependent incubation times (Bozek et al. 1990) based on the mean water temperature during the hatching period (15.8 ºC). Incubation times are approximately 11 days prior to hatching placing the date of initial spawning on 31 March 2011.

Age-0 razorback sucker collected in 2011 were almost entirely represented by larval fish (protolarvae to metalarvae) with the exception of eleven juvenile fish that were collected in June and July. Protolarvae composed 5.4% of the age-0 razorback sucker collected during the 2011 survey (n=58) and all protolarvae were collected during the May survey (Figure 10).

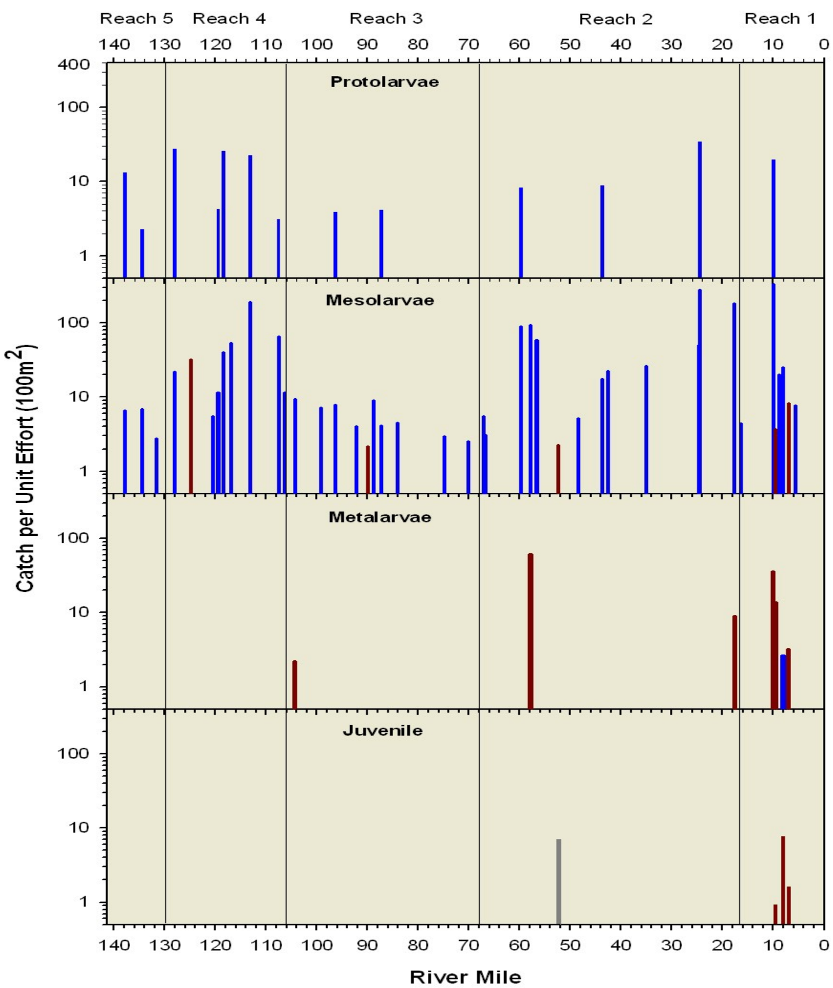

Figure 10. Catch per unit effort /100 m^2 of discrete ontogenetic stages (protolarvae, mesolarvae, metalarvae, and juvenile) of razorback sucker by sample locality during the 2011 survey. Blue bars represent May collections; red bars, June collections; and gray bars, July collections.

There were no clumped distributions of this ontogenetic stage found in any of the river reaches so potential spawning bars within the study area were not elucidated. Protolarvae were distributed fairly uniformly throughout the study area during the May survey. Collection of protolarvae from river mile 137.9 indicate spawning adults upstream of this location. Mesolarvae were collected in May (n=899) and June (n=20) and accounted for 86.3% of age-0 razorback sucker. There were peaks in the catch of mesolarvae in Reaches 4, 2 and 1. The low catch of mesolarvae in June indicates the tail end of razorback sucker hatching. Metalarvae were also collected during the May and June surveys (n=5 and n=72 respectively). This ontogenetic stage was encountered in Reaches 3 -1; however, metalarvae were only present in seven collections. Eleven recently transformed juvenile razorback sucker were collected during the 2011 larval fish survey. Juveniles were captured in four collections between June and July in the lower two reaches of the study area.

Between April and June (1999-2011), the percent frequency of occurrence in which age-0 razorback sucker have been documented in the larval collections has been increasing since 2005. Frequency of occurrence peaked in 2002 (43.8%) which was a drought year without spring run-off (mean daily discharge was 444.3 cfs). In 2005, percent frequency of occurrence dropped to 4.4%, but has increased steadily every year since 2005. Age-0 razorback sucker were present in one-third (34.2%) of the 2011 spring collections (Figure 11).

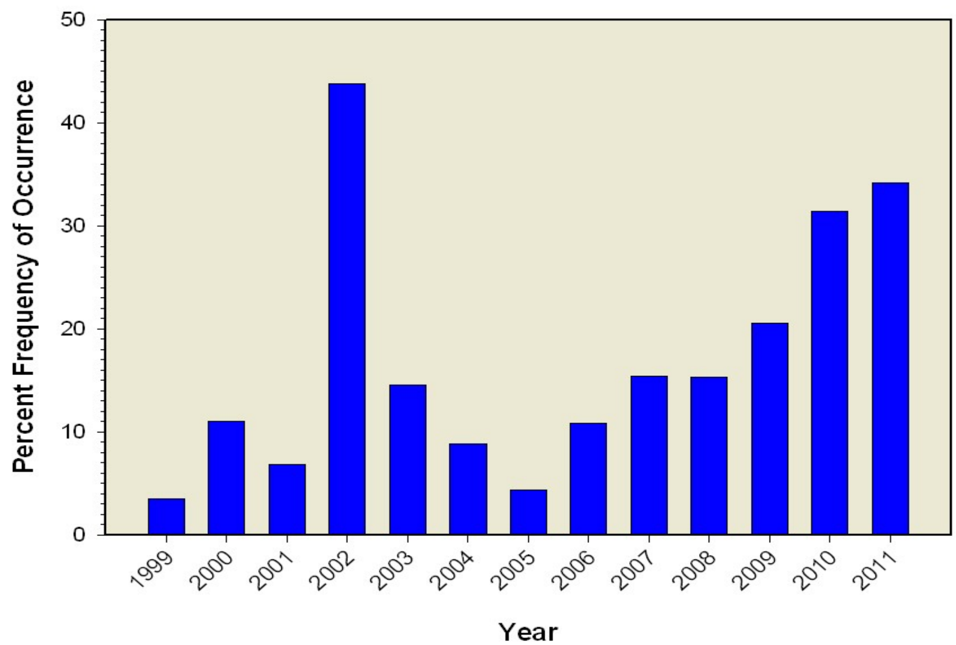

Figure 11. Percent frequency of age-0 razorback sucker occurring in annual collections from 1999- 2011. Percent frequency of occurrence include razorback collected from isolated pools.

Age-0 razorback sucker were collected in six of the nine habitat types sampled in 2011. Backwater habitats contained the largest number of razorback sucker followed by pool habitats (n=784 and n=265 respectively). Together these two habitat types accounted for 98.5% of the age-0 razorback sucker collected in 2011. Between 1999 and 2011, larval razorback sucker have been collected in nine of the ten different habitat types sampled (Figure 12). Backwater habitats have accounted for 66.6% of all age-0 razorback collected over the tenure of this study. Catch rates are significantly higher in isolated pool habitats when compared to every other habitat type (F=18.72, P<0.0001). Isolated pools are closed systems and in the case of desiccating pools fishes are highly concentrated producing unusually high catch rates.

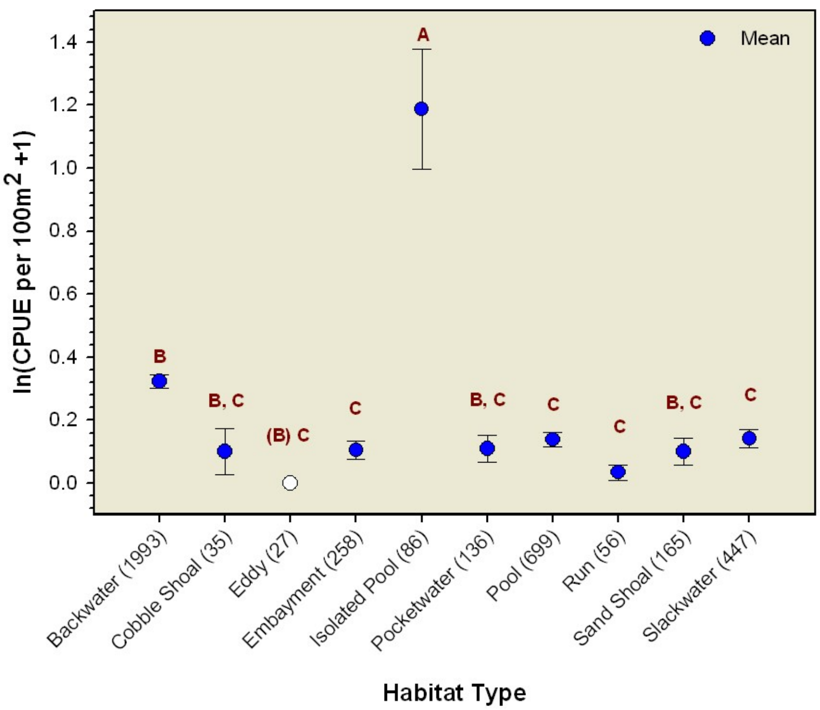

Figure 12. ln(CPUE per 100 m^2 +1) [+/-1 SE] for razorback sucker by habitat type sampled from 1999 to 2011. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicated that no fish were collected.

Colorado pikeminnow. There were 29 larval Colorado pikeminnow collected from five discrete samples in 2011. This number exceeds the total number of larval Colorado pikeminnow collected in previous larval surveys (both drift-net and larval seining efforts) in the twenty year period between 1991 and 2010 (n=22). The first collection of larval Colorado pikeminnow occurred on 20 July 2011 and the last collection to contain this species was taken on 11 August 2011. There were no significant differences in catch among months or river reach. Of the five samples that contained larval Colorado pikeminnow, four were backwater habitat types and one was an isolated pool. The 29 specimens ranged in size from 10.0 to 21.3 mm TL and encompassed two ontogenetic stages (mesolarvae to metalarvae). Mesolarvae composed 89.7% of the larval Colorado pikeminnow collected.

The back-calculated spawning dates ranged from 23 June to 12 July 2011 (Figure 13). This spawning period coincides with the descending limb of the spring hydrograph. Mean daily discharge and water temperature during this period were 2,103 cfs (1,490 – 2,840 cfs) and 20.6 °C (18.9 – 22.6 °C).

Larval Colorado pikeminnow were distributed within Reach 3 and Reach 1 (Figure 14). The spatial disparity between these two reaches and the similarity in ontogenetic life stage suggest two separate spawning locations.

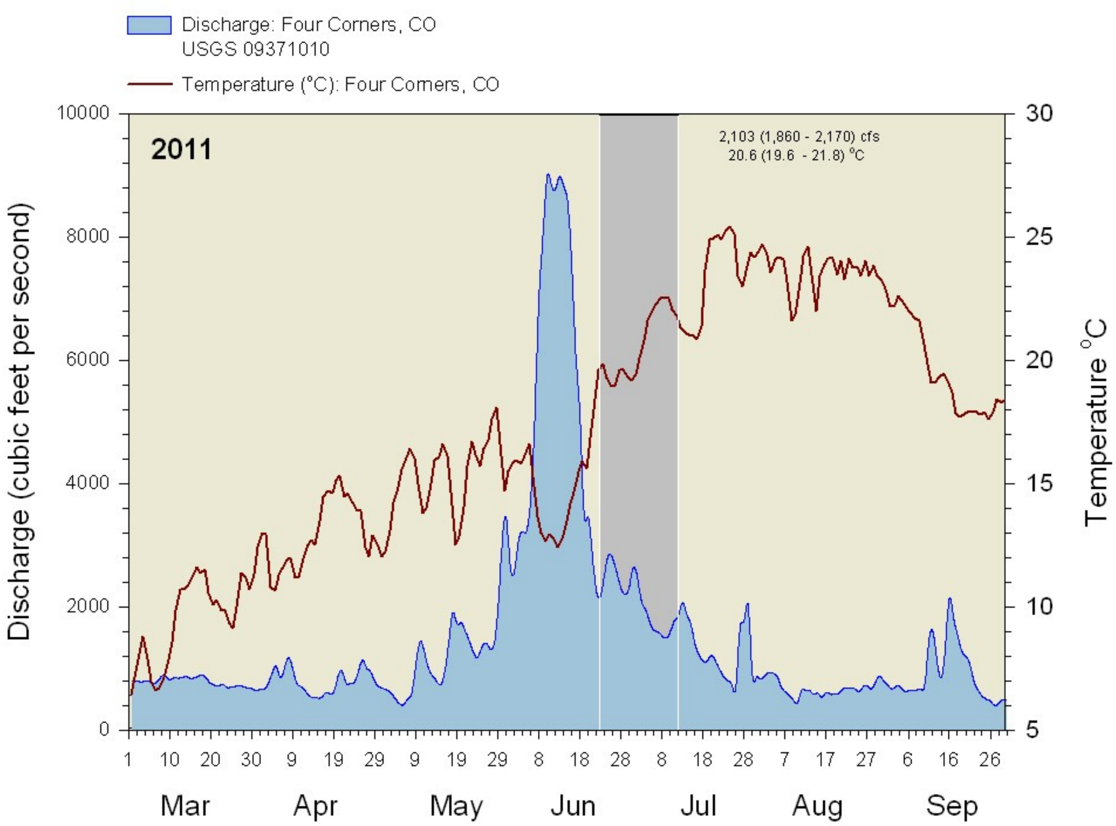

Figure 13. Back-calculated spawning dates for Colorado pikeminnow plotted against discharge (Four Corners, NM, USGS gauge #09371010) and mean water temperature (Four Corners, CO) during 2011. Gray bar represent back-calculated spawning dates.

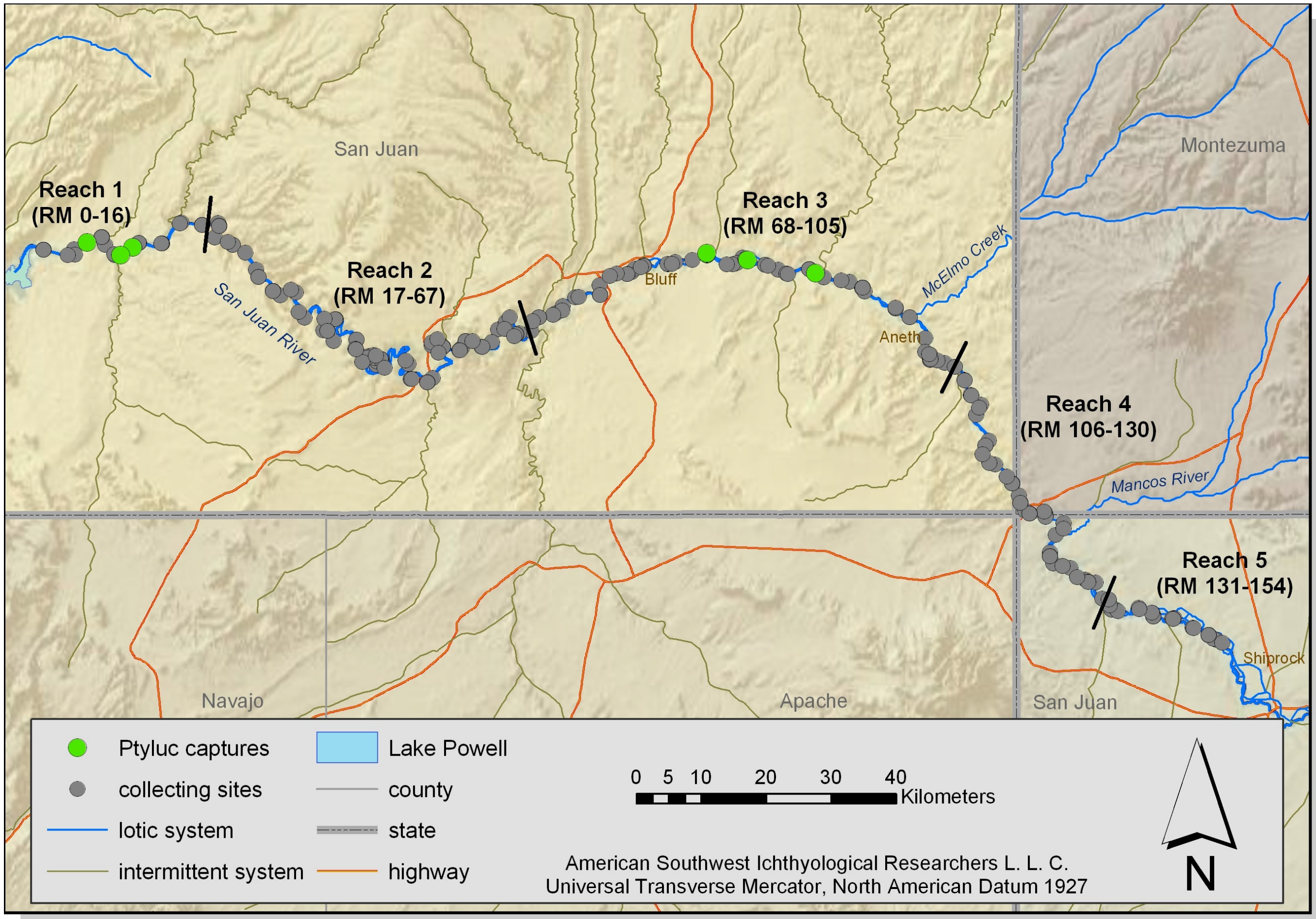

Figure 14. Map of collection sites containing larval Colorado pikeminnow (green dots) during the 2011 larval fish survey.

Nineteen age-1+ Colorado pikeminnow were collected and released during the 2011 larval fish surveys. The specimens ranged in size from about 80 – 230 mm TL (66-174 mm SL). The smallest specimen collected (66 mm SL) escaped before an accurate total length measurement could be taken. The largest specimen (230 mm TL) was collected in Reach 1 and had been previously PIT tagged (3D9.1C2C445A6E). All age-1+ Colorado pikeminnow were collected during the July and August surveys and were distributed between river miles 139.1 and 10.0 (Figure 15).

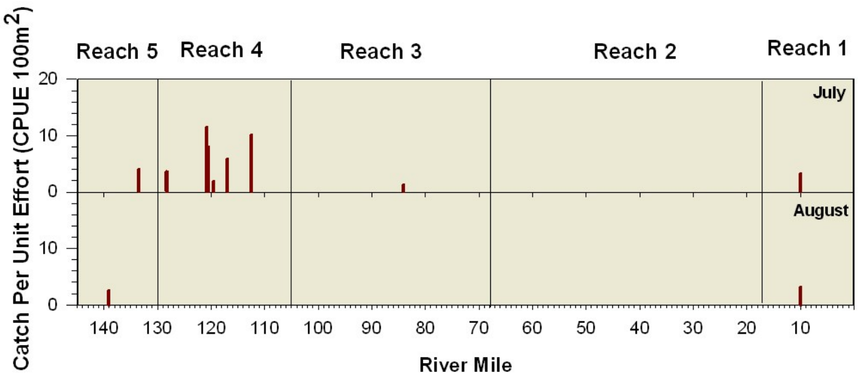

Figure 15. Catch per unit effort /100m^2 of age-1+ Colorado pikeminnow (N= 19) by sampling locality during the 2011 larval fish survey.

Native Species

Roundtail chub. During the 2011 survey age-0 roundtail chub were collected for the first time in 14 years of larval surveys in the San Juan River. A total of four specimens were identified in two discrete backwater habitats during trips four and five (19 July and 9 August 2011). Both collections comprised two ontogenetic stages (metalarvae and early juvenile). Age-0 roundtail chub were 23.4-29.5 mm SL. The July collection was located at river mile 122.2, and the August collection was taken in the Mancos River (RM 122.6). The proximity and association of these collections to the Mancos River in conjunction with records of stocking roundtail chub by Colorado state and tribal agencies suggest these fish originated from the Mancos River.

Speckled dace. Age-0 speckled dace were present in 41.9% (n=109) of the 2011 larval fish collections and accounted for 16.3% of the catch by number. Larval speckled dace were first encountered during the May survey. Speckled dace had the highest catch in July followed by August (F=81.61, P<0.0001 [Figure 16]). During these two months larval speckled dace were distributed throughout the study area and occurred in 83.3% of the collections. There was no significant difference in catch among any of the river reaches. Between 2003 and 2011, catch rates for this species have been relatively stable (Figure 17). Catch rates in 2011 were not significantly different than any other year with the exception of 2003 (F=7.23, P<0.0001).

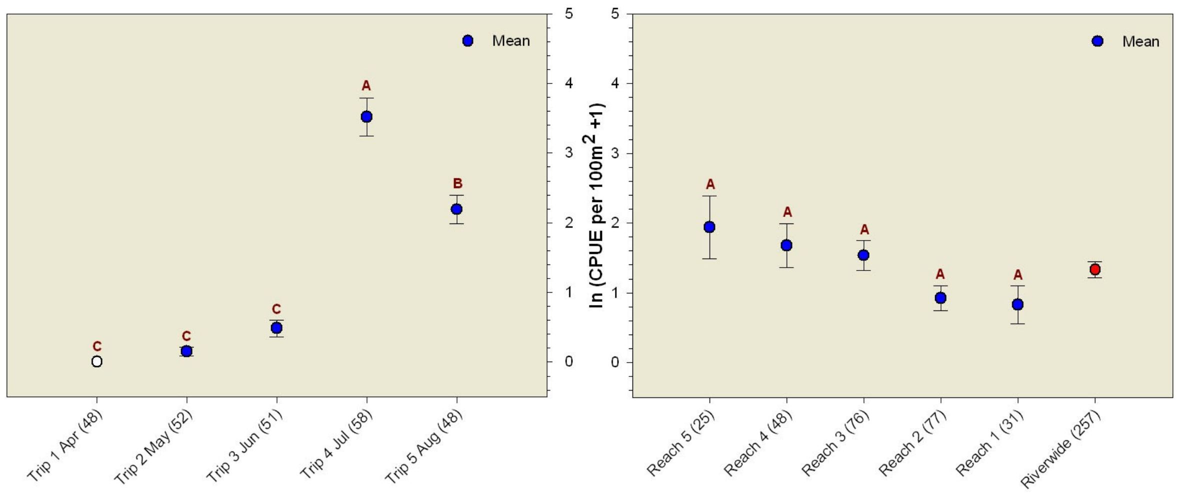

Figure 16. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 speckled dace by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

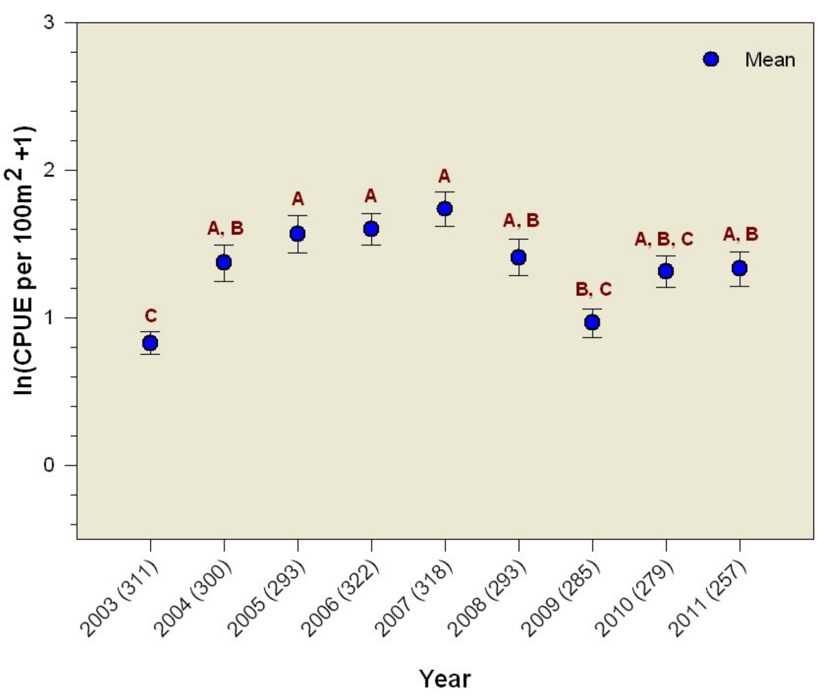

Figure 17. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 speckled dace by year (2003-2011). Sample size reported on x-axis labels. Means not connected by the same letter are significantly different.

Bluehead sucker. Larval bluehead sucker were first collected during the May survey and were present until the end of the study period. This species made up 17.3% of the 2011 catch by number, and was present in 46.3% (n=119) of the collections. Bluehead sucker larvae were distributed through out the study area from May to July. Catch rates for bluehead sucker increased monthly between May and July (Figure 18). Catch rates in July were significantly higher than both May and August (F=34.22, P<0.0001). Age-0 bluehead sucker were found in each of the five reaches, with nearly two-thirds (62.5%) of the specimens collected in Reach 4. Catch rates in Reach 4 were significantly higher than Reaches 2 and 1 (F=4.42, P=0.0018 [Figure 18]). Among years (2003-2011), catch rates for this species have been variable. The 2011 catch rate was not significantly lower than any of the preceding eight years, and was significantly higher than 50% of those years (F=9.31, P<0.001 [Figure 19]).

Flannelmouth sucker. The first collections of larval flannelmouth sucker were documented during the April survey at river mile 87.1 and subsequent collections downstream. Flannelmouth sucker was the only age-0 species collected during this month. The collection of age-0 flannelmouth sucker continued until the end of the study period making it the only age-0 species present in every monthly sampling effort. Flannelmouth sucker was the numerically dominant (n=5,807) and most frequently encountered species (57.2% frequency of occurrence) during the 2011 larval fish survey. Catch rates for this species were highest during the May survey (F=57.49, P<0.0001) followed by the June survey (Figure 20). There were no significant differences among any of the river reaches (Figure 20). The 2011 catch rate was significantly higher than that of 2009 (F=12.18, P <0.0001 [Figure 21].

Non-Native Species

Common carp. There was low abundance of age-0 common carp during the 2011 larval fish survey. A total of 73 age-0 specimens was collected. This species was first collected during the June survey, represented by a single fish taken in a backwater habitat at river mile 8.1 (Reach 1). Catch rates for this species were highest the following month (F=18.83, P<0.0001) and it was also present during the August survey (Figure 22). There were no significant differences among river reaches for this species; however reaches 2 and 1 accounted for nearly two-thirds (63.0%) of the catch by number (Figure 22). The catch of common carp in 2011 was significantly higher than both 2003 and 2006 (F=8.55, P<0.0001 [Figure 23]). Overall catch rates for common carp have remained low for the period between 2003 and 2011.

Channel catfish. The first age-0 channel catfish were collected during the July survey (Figure 24). July was the only month that larval channel catfish were collected indicating a truncated spawning period. A total of 302 specimens were collected during the July and August surveys accounting for 1.2% of the 2011 catch by number. Age-0 channel catfish were not collected in Reach 5. Catch rates increased sequentially in the subsequent four downstream reaches (Figure 24). Catch rates in Reach 1 were significantly higher than Reaches 4 and 3 (F=4.83, P=0.0009). Among years (2003-2011*)*, the 2011 channel catfish catch rate was significantly lower than both 2007 and 2008 (F=14.46, P<0.0001 [Figure 25]).

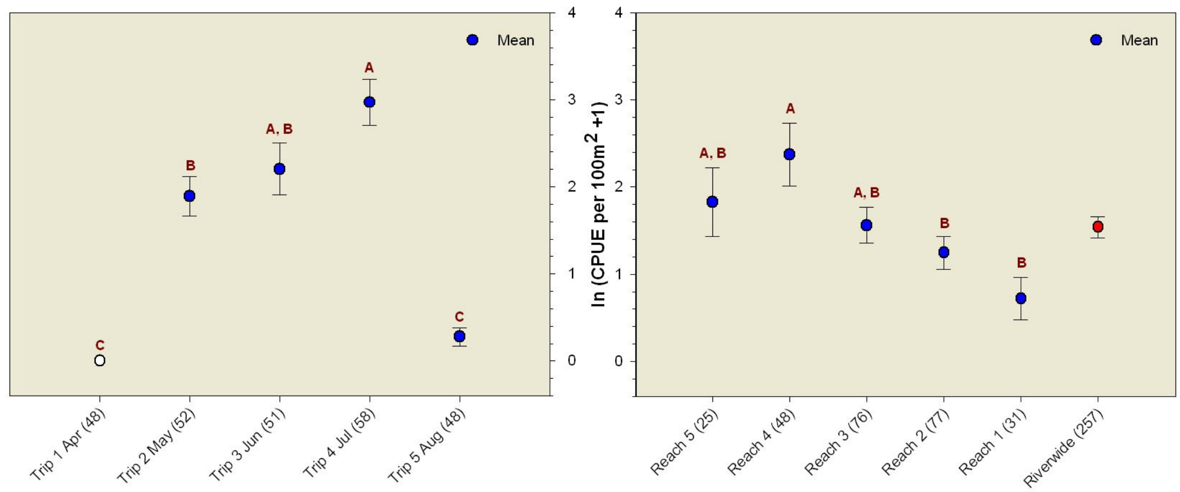

Figure 18. ln(CPUE per 100 m² +1) [+/-1 SE] for age-0 bluehead sucker by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

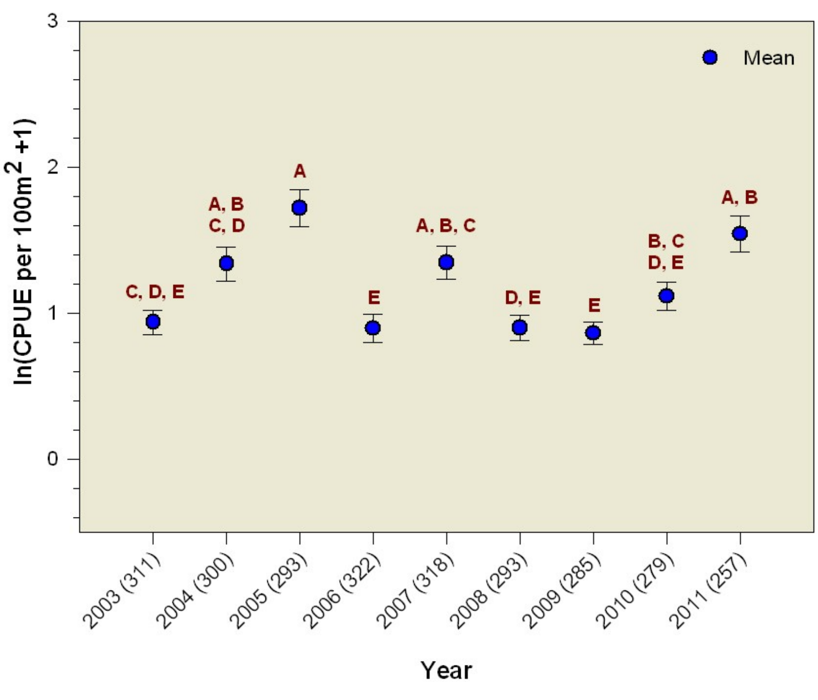

Figure 19. ln(CPUE per 100 m² +1) [+/-1 SE] for age-0 bluehead sucker by year (2003-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

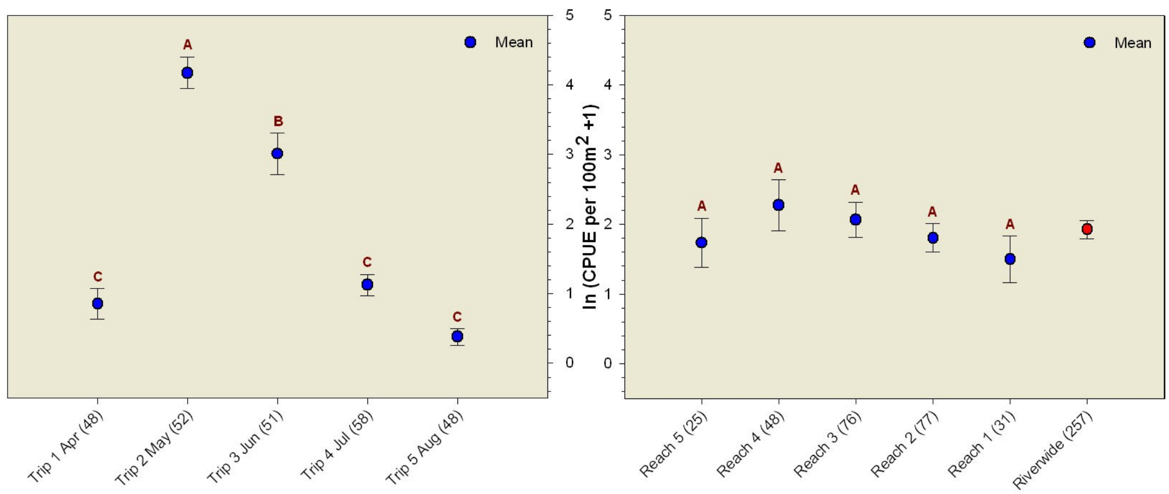

Figure 20. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 flannelmouth sucker by trip (left graph), reach,and riverwide (right graph) for 2011. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different and open circles indicate that no fish were collected.

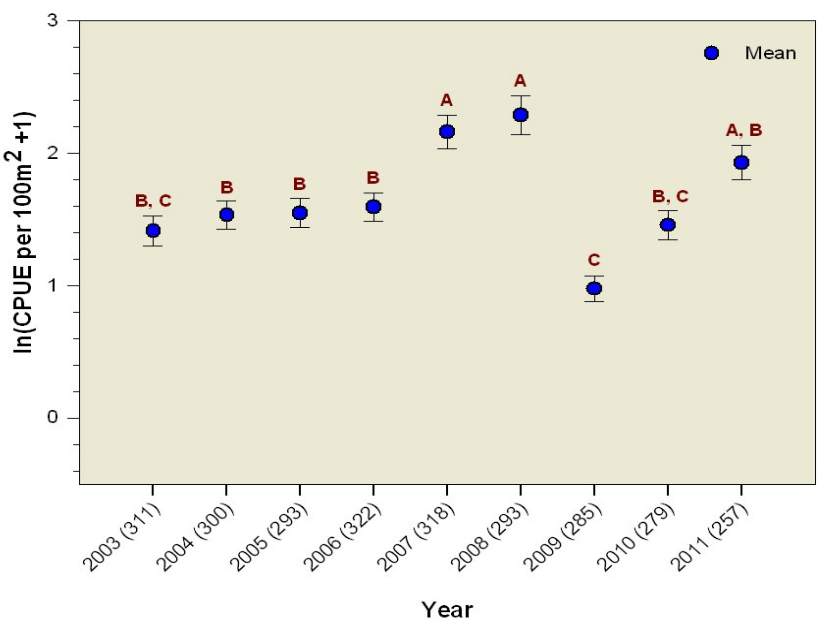

Figure 21. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 flannelmouth sucker by year (2003-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

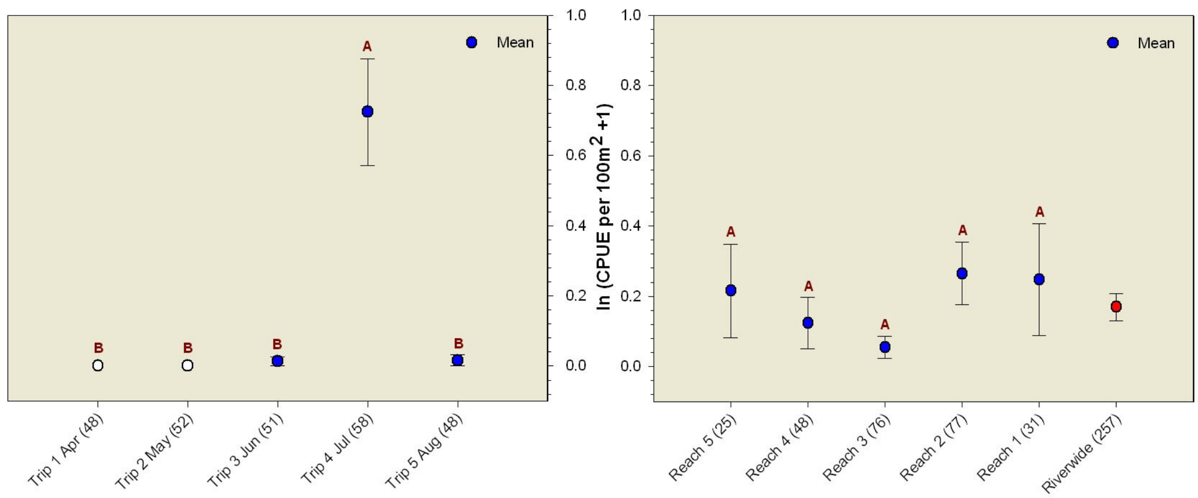

Figure 22. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 common carp by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

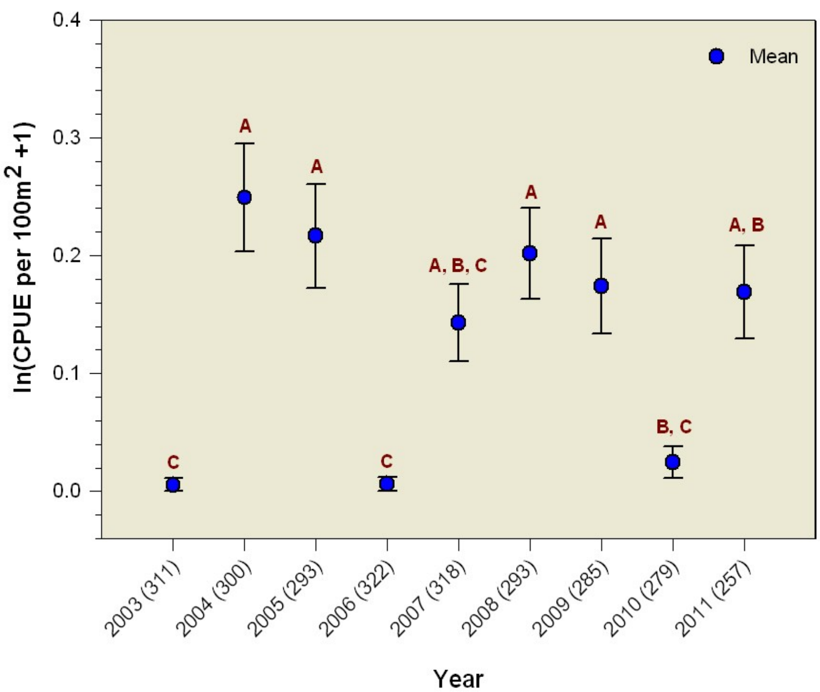

Figure 23. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 common carp by year (2003-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

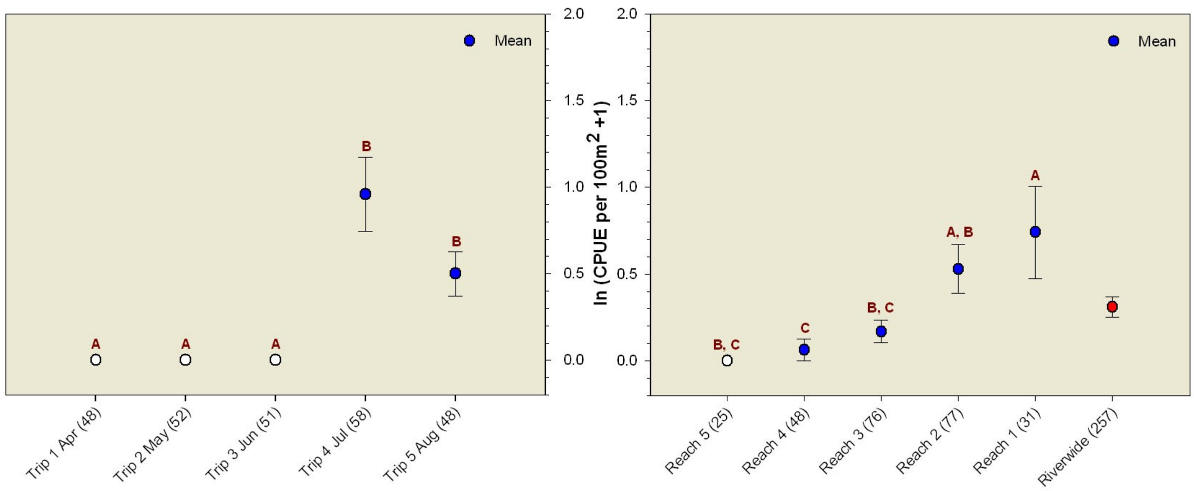

Figure 24. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 channel catfish by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

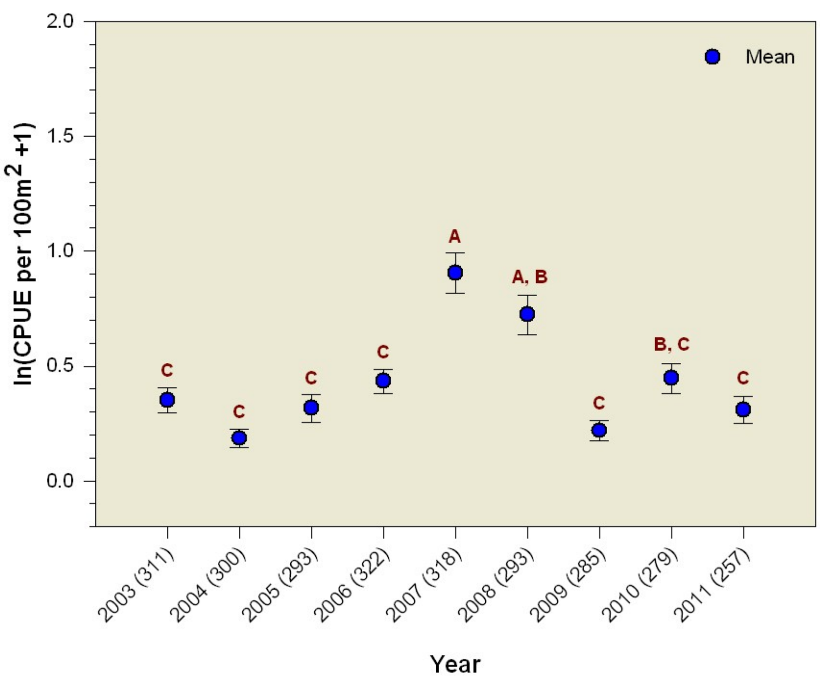

Figure 25. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 channel catfish by year (2003-2011). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

Fathead minnow. A total of 3,042 age-0 fathead minnow were collected in 2011 composing 11.7% of the total catch by number. Fathead minnow and red shiner were the most frequently encountered non-native species. Each of these species were present in 30.7 % of the collections made. The first occurrence of larval fathead minnow was documented during the May survey. During that month, a single collection containing 15 individuals was taken near the top of the study area (river mile 134.5). Catch rates peaked two months later during the July survey (F=32.01, P<0.0001 [Figure 26]). Among reaches there was little statistical difference in catches; however, 82.9% of all age-0 fathead minnow captured were collected in Reach 2. Catch rates for this reach were significantly higher than Reach 3 (F=4.96, P=0.0007 [Figure 26]). Catch rates of fathead minnow during 2011 were significantly higher than those of 2009 (F=32.50, P<0.0001) but lower than 2003, 2004, and 2006 (Figure 27).

Red shiner. Red shiner was the numerically dominant (n=4,789) non-native species during the 2011 larval fish survey, making up 25.0% of the catch by number. This species is often the most frequently encountered and most abundant species found during the larval fish surveys. The last and only other year in which red shiner did not dominate the larval fish catch was 2008. The first age-0 red shiner was collected in a single sample during the June survey. Catch rates dramatically increased the following month and were highest during the August survey (F=63.14, P<0.0001[Figure 28]). Catch rates did not differ significantly among river reaches (Figure 28). Annual catch rates during 2011 were among the lowest documented during the tenure of this study. The years 2003, 2004, 2005, 2009 and 2010 all had catch rates significantly higher (F=11.11, P<0.0001) than 2011 (Figure 29).

Native and Non-native Catch

From 2003 to 2011 the proportions of age-0 native and non-native catch have varied considerably. 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 30). The trends of native verses non-native catch are driven by the spawning efforts of non-native red shiner, and the two most abundant native fish taxa, 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 catch of age-0 red shiner. Catch 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 fishes in 2010 are similar to each other. In 2011, a divergence between the catch of native and non-native fishes is evident. Increased catch of native species and a significant decline in catch of red shiner resulted in the observed result.

Isolated Pools

During the 2011 larval fish survey, three isolated pool habitats were sampled. These collections were removed for the purposes of analyzing trend data among trips, river reaches and years. Isolated pools are closed systems and in the case of desiccating pools, fishes are highly concentrated making for unusually high catch rates. The three isolated pools sampled

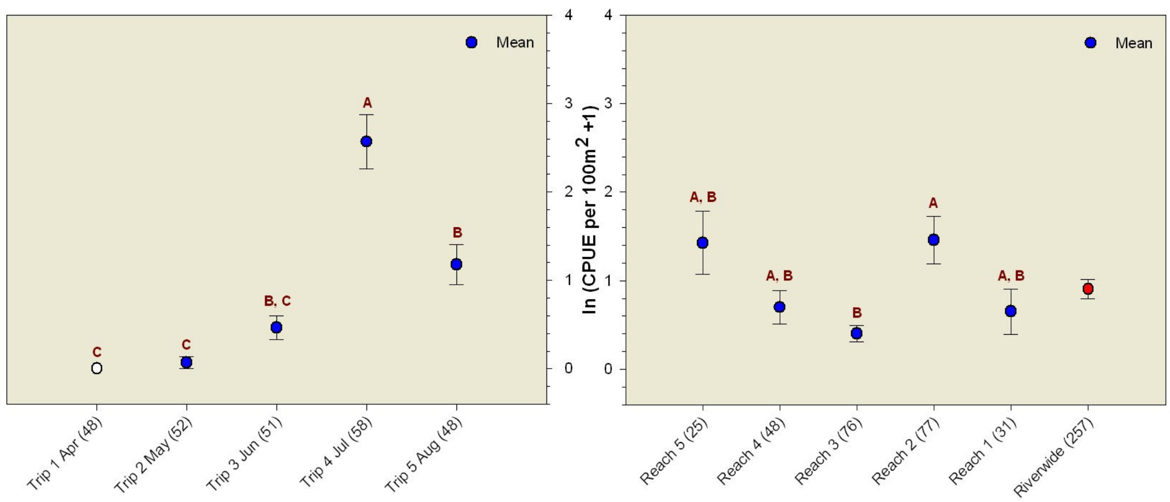

Figure 26. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 fathead minnow by trip (top graph), reach, and riverwide (bottom graph) during the 2010 survey. Sample size is reported on the x-axis label. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

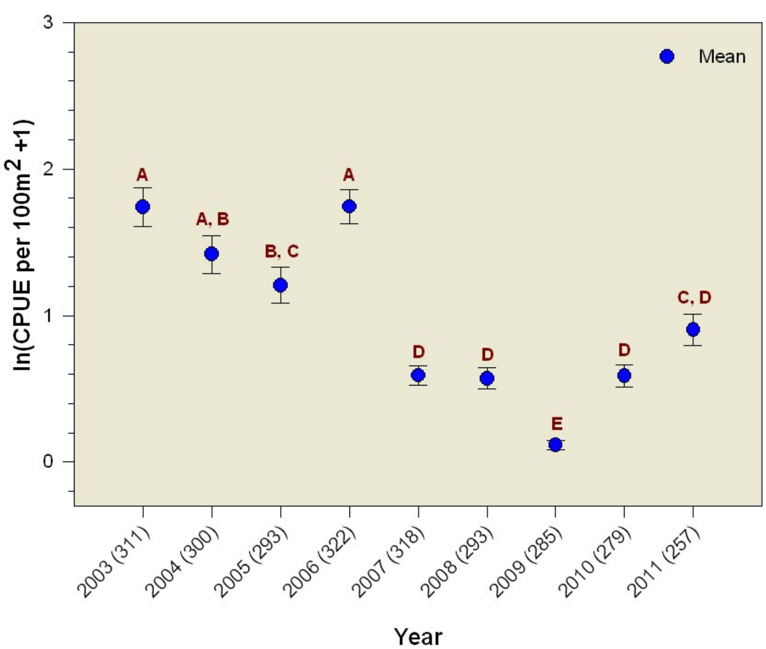

Figure 27. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 fathead minnow by year (2003-2010). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

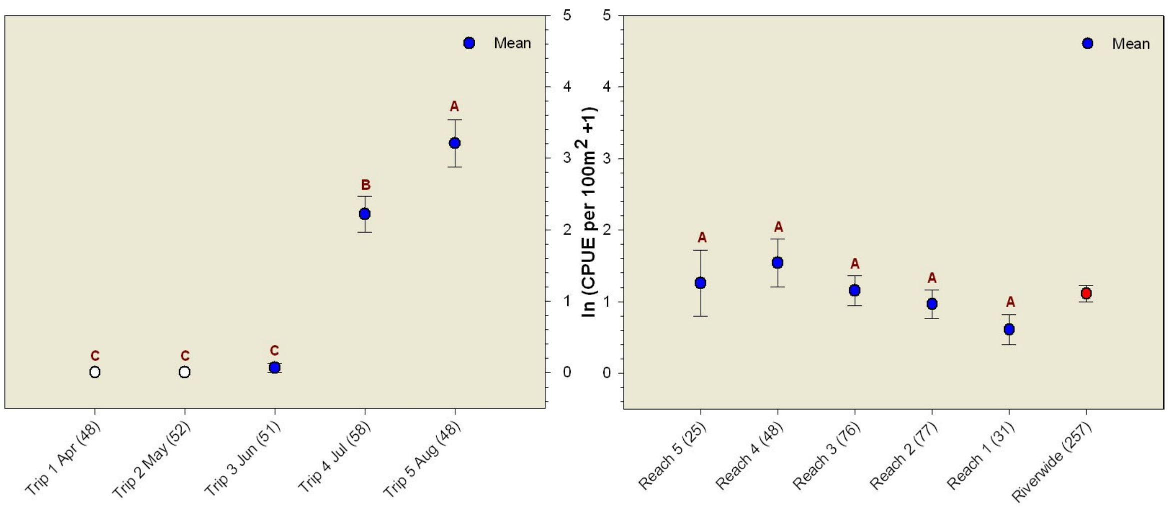

Figure 28. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 red shiner by trip (left graph), reach, and riverwide (right graph) during the 2011 survey. Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different, and open circles indicate that no fish were collected.

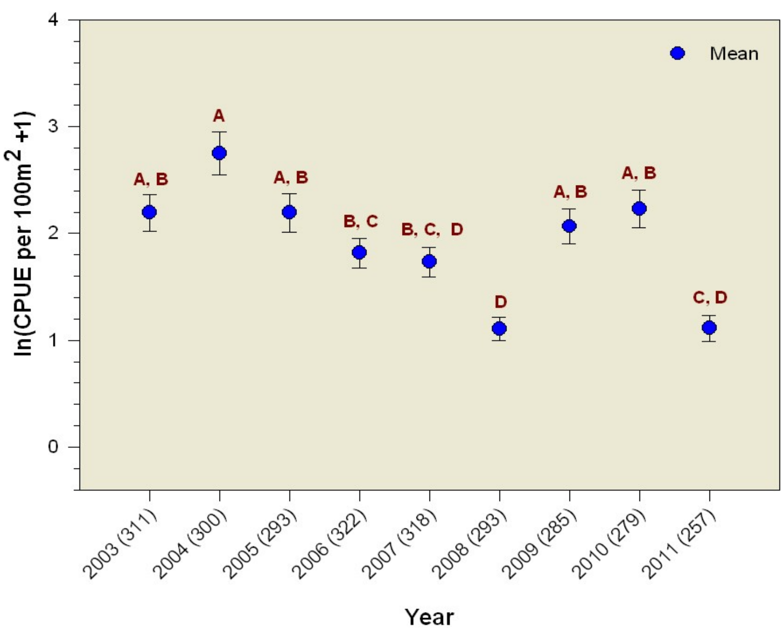

Figure 29. ln(CPUE per 100 m^2 +1) [+/-1 SE] for age-0 red shiner by year (2003-2010). Sample size is reported on x-axis labels. Means not connected by the same letter are significantly different.

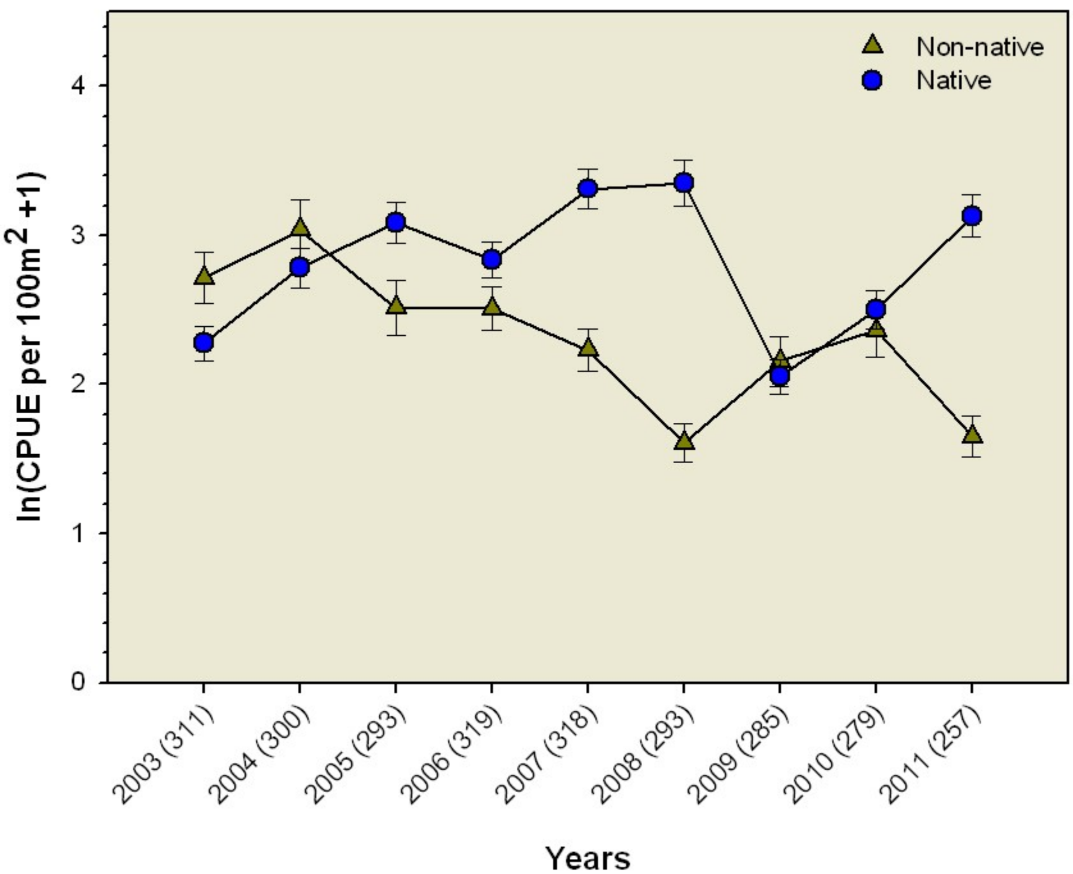

Figure 30. ln(CPUE per 100 m^2 +1) [+/-1 SE] of non-native and native taxa from 2003-2011. Sample size is reported on the x-axis labels.

during the 2011 larval fish survey contained 212 larval fish; of those 154 were red shiner. The most common native species found in isolated pool habitats were flannelmouth sucker (n=42). One larval razorback sucker was collected during the May survey in an isolated pool at river mile 74.9. Three larval Colorado pikeminnow were collected in an isolated pool at river mile 10.0 (Buckhorn Canyon) during the July survey. Following the July survey, a spike in discharge caused by a rain event brought river levels up to approximately 2000 cfs presumably connecting the isolated pool at river mile 10.0 with the main stem San Juan River.

Habitat Persistence

In 2010 an initial effort was made to link backwater area with discharge in an attempt to document persistence of backwater habitats in relation to flow. The 2010 effort had design and equipment flaws that made the pilot study ineffective (Brandenburg and Farrington, 2011). In 2011 a different approach to habitat persistence was developed by designating monitoring stations (n=15) of similar geomorphic backwater habitats (lateral washes or canyons). Each station was visited during the monthly sampling surveys, if the habitat was suitable (low velocity habitat), a larval fish collection was taken. During the April survey all but one station (84.1, Recapture Creek) were dry or isolated from the main channel. Recapture Creek was connected to the main channel due to water releases from Recapture Reservoir, UT. The collection made in Recapture Creek produced eight larval flannelmouth sucker. During the May survey when mean discharge was 1,316 cfs, 86.7% of the monitoring stations were connected to the main channel forming backwater habitats (Figure 31). Larval razorback sucker were captured in 12 of the 13 stations sampled in May. During the June survey, coinciding with peak spring discharge (mean discharge 8,089 cfs), all the monitoring stations were connected to the main channel, in most cases forming large backwater habitats. Larval razorback sucker were collected in 11 of the monitoring stations and larval fish were documented at all 15 monitoring stations. Nine monitoring stations were inundated in July (60%) forming backwater habitats. Mean discharge during the July sampling period was 1,191 cfs. Stations that were connected produced one age-0 razorback sucker. The monitoring station at river mile 10.0 (Buckhorn Canyon) was a large isolated pool in which three larval Colorado pikeminnow were collected; however, because this station was isolated it was not considered connected for purposes of percent backwater habitats. During the August survey all the monitoring stations were either dry or isolated. Mean discharge during the August survey was 511cfs. As expected, the relation of connected habitats track the annual hydrograph. However, there are some discrepancies of individual backwater morphology that influence their connectivity with the river. For example, in May, the monitoring station at 124.8 was dry, but the subsequent stations just downstream (i.e. river mile 119.5, 118.5, and 116.9) were connected at the same mean daily discharge. Similarly, in July, the monitoring station at 124.8 was inundated while the stations at 119.5 and 118.5 were dry under the same mean daily discharge.

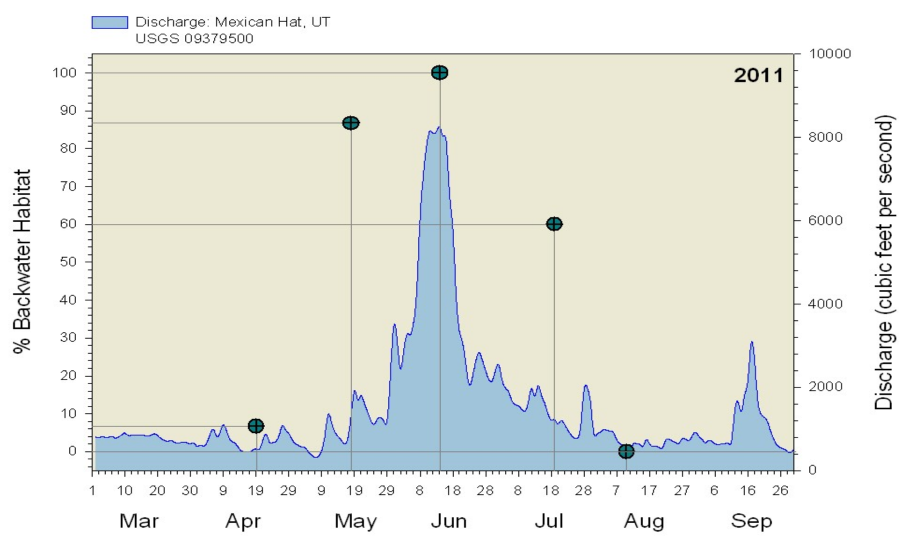

Figure 31. Percent of backwater habitat (green circles) at monitoring sites in relation to discharge.

Discussion

The 2011 larval fish survey produced interesting results. Native fish fauna dominated the catch in most months including one of the highest catch of age-0 razorback sucker, the highest catches of larval Colorado pikeminnow to date, as well as the first collections of age-0 roundtail chub.

Collection of age-0 razorback sucker in 2011 marks the fourteenth consecutive year of documented reproduction by razorback sucker in the San Juan River. Similar to all prior years, the highest catch of razorback sucker occurred in May followed by June. The consistency of peak catch rates during the May survey define a fairly uniform spawning period for razorback sucker among differing annual discharge events. The total catch in Reach 1 between 1999 and 2011 is significantly higher than any other reach; however, there were no significant differences in catch among reaches for the individual years of 2010 and 2011. This coupled with documentation of larval razorback sucker farther upstream in the study area (Brandenburg and Farrington, 2011) suggest that larval razorback sucker are distributed and retaining higher in the study area. Longitudinal differences in collection of early developmental life stages indicate delayed spawning or prolonged duration of spawning in the upper reaches of the study area. Earlier life stages of razorback sucker were collected in the upper reaches of the study area in June while later stages (metalarvae and juvenile) were collected in the lower reaches in that same month. This distribution of developmental stages probably reflects differences in water temperature between the upper and lower reaches. Air and water temperature are typically warmer in the lower reaches and cooler in the upper reaches eliciting spawning sooner in the lower reaches. Although the riverwide CPUE is lower for razorback sucker compared with the other two sucker species, in the last three years the annual catch of catostomids seems to be following the same upward trend (Figure 32).

Eleven juvenile razorback sucker were collected during the 2011 survey. Juveniles ranged in size from 24.2 – 34.2 mm TL. All the juvenile razorback sucker were collected in backwater habitats. A total of 161 early juvenile razorback sucker have been captured in 50% of the years surveyed. Backwater habitats have produced 62.7% of the total juvenile razorback catch. The highest number of juveniles collected, as well as the largest specimen, were captured in 2002 (n=127 and 62.4 mm TL). There was no spring runoff in 2002 and river temperature were on average higher, potentially increasing growth and survival rates. Juveniles represent fish that have progressed past the larval stage and thus may not be as vulnerable to predation by gape limited small-bodied non-native fishes (i.e. red shiner) and are a positive step towards recruitment (Bestgen, 2008).

In addition to the 29 larval Colorado pikeminnow collected during the 2011 larval survey, five additional larval Colorado pikeminnow were collected by ASIR personnel that were providing data for a graduate studies project. The five larvae were collected in a single backwater habitat located at Recapture Creek (RM 84.1) on 15 July 2011. That collection was five days earlier than the first capture of larval Colorado pikeminnow documented during the larval fish survey. The five fish (mesolarvae - metalarvae) were captured within the same larval Colorado pikeminnow distribution boundary defined by the larval fish survey during 2011 (RM 92.6 – 7.0). The back-calculated spawning dates for these fish were 24–27 June 2011. These dates fall within the spawning dates established by the 29 larvae collected during the 2011 larval fish survey.

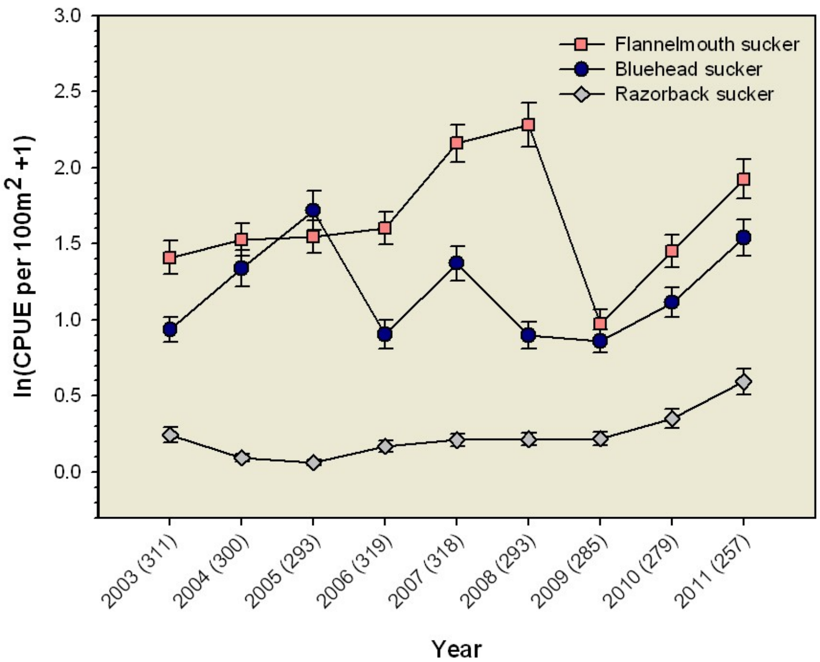

Figure 32. Annual CPUE of native age-0 catostomids collected during the larval fish survey between 2003 and 2011.

In all prior larval fish survey years (2002-2010), the larval ontogenetic stage of Colorado pikeminnow collected during the July survey have consisted of metalarvae. In 2011, the ontogenetic stage for Colorado pikeminnow ranged from mesolarvae to metalarvae. The presence of these earlier life stages indicate collection of larvae closer to their hatching dates which allow for more meaningful back-calculated hatch dates. Larval Colorado pikeminnow were collected in five separate collections spanning two months (July and August). Collections prior to 2011 only produced larval Colorado pikeminnow during the July survey. With the increasing numbers of Colorado pikeminnow stocked into the river and the potential numbers of these fish that are becoming reproductively viable, catch of larval Colorado pikeminnow will hopefully continue to increase as well.

Beginning in 2010 a few metalarvae and early juvenile catostomids were observed with deformities of the opercula. These observations included a range of opercula deformities from shortened opercle to a complete absence of the opercle and subopercle and partial absence of the preopercle and interopercle resulting in partial to full exposure of the gill filaments. While the overall frequency was low in 2010 it stood out as unusual. Through the identification process of catostomids in 2011, a greater number of specimens were observed with partial to full deformities of the opercula resulting in exposed gill filaments. The deformities were not observed in the early life stages of catostomids or in any other family of fish collected in the San Juan River. The opercula deformities affected all three species of catostomids in the San Juan

River and was documented from June to August between river miles 141.8 and 7.0. Potential causes of opercula deformities could be contaminates (PCBs and PBDEs), nutrition, and or increases in water temperatures. (J. Lusk 2010, per. comm.). A post identification effort was made to quantify the frequency of deformities in each of the three catostomid species. Because the deformity is believed to be caused by some environmental factor, primarily metalarvae and juvenile specimens were used for the analysis. The assumption being that the earliest life stages (i.e. protolarvae and mesolarvae) may not have sufficient exposure time to the environmental factor responsible for the deformity.

Both the right and left side opercula were examined in 1,618 flannelmouth sucker, 237 bluehead sucker and 67 razorback sucker. The deformity was present in 15.9% of the flannelmouth sucker examined, 11.4% of bluehead sucker, and 44.8% of razorback sucker. Survival rates of catostomids with damaged opercula are unknown.

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Appendix A

Table A-1. Locality and habitat descriptors of Monitoring Stations designated for habitat persistence.

Station No.	River Mile Locality	Reach	Easting	Northing	Habitat Type	
1	139.1	5	698072	4082062	lateral wash	Gypsum Wash
2	134.8	5	691148	4084169	lateral wash	river left
3*	124.8	4	678281	4091267	lateral wash	river left
4*	119.5	4	675632	4096476	lateral wash	river left
5*	118.5	4	674456	4097745	lateral wash	river left
6*	116.9	4	673442	4100108	lateral wash	Cowboy Wash
7*	104.4	3	663008	4115111	lateral wash	river left
8*	96.4	3	654559	4123661	lateral wash	Allen Canyon
9*	92.2	3	648003	4125824	lateral wash	Montezuma Cr.
10*	84.1	3	635458	4127339	lateral wash	Recapture Cr.
11*	74.9	3	622358	4122284	instream BW	river right
12*	57.9	2	603144	4115670	lateral wash	Lime Creek
13*	52.4	2	601301	4111310	lateral wash	Gypsum Cr.
14	24.7	2	588948	4117463	instream BW	river left
15	24.5	2	582188	4122278	lateral canyon	John's Canyon
16*	17.7	2	575497	4130142	lateral canyon	Slickhorn
17*	16.4	1	573427	4130259	lateral canyon	river right
18*	10.0	1	563449	4126456	lateral canyon	Buckhorn
19*	8.1	1	561124	4128666	lateral canyon	Steer Gulch
20*	3.3	1	553978	4127054	lateral wash	river right

* indicate sites used for habitat persistence analysis

Table A-2. Summary of age-1+ fishes collected in the San Juan River during the 2011 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	1,870	91.4	19.9	87	33.5
common carp	I	-	-	-	-	-
roundtail chub	N	-	-	-	-	-
fathead minnow	I	20	1.0	0.2	12	4.6
Colorado pikeminnow	N	19	0.9	0.2	11	4.2
speckled dace	N	37	1.8	0.4	17	6.5
SUCKERS						
flannelmouth sucker	N	17	0.8	0.2	10	3.8
bluehead sucker	N	-	-	-	-	-
razorback sucker	N	-	-	-	-	-
bluehead X flannelmouth sucker	N	-	-	-	-	-
BULLHEAD CATFISHES						
black bullhead	I	-	-	-	-	-
yellow bullhead	I	-	-	-	-	-
channel catfish	I	8	0.4	0.1	6	2.3
TROUT						
kokanee salmon	I	-	-	-	-	-
KILLIFISHES						
plains killifish	I	3	0.1	*	3	1.2
LIVEBEARERS						
western mosquitofish	I	70	3.4	0.7	16	6.2
SUNFISHES						
green sunfish	I	-	-	-	-	-
bluegill	I	2	0.1	*	2	0.8
largemouth bass	I	-	-	-	-	-
TOTAL		2,046		21.8		

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=260 samples.
*Value is less than 0.05%

Table A-3. Summary of age-0 fishes collected in the San Juan River during the 2011 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	4,943	18.9	52.7	80	30.8
common carp	I	78	0.3	0.8	24	9.2
roundtail chub	N	4	*	*	2	0.8
fathead minnow	I	3,043	11.6	32.4	80	30
Colorado pikeminnow	N	29	0.1	0.3	5	1.9
speckled dace	N	4,272	16.3	45.5	109	41.9
SUCKERS						
flannelmouth sucker	N	5,849	22.3	62.3	149	57.3
bluehead sucker	N	4,503	17.2	48.0	120	46.2
razorback sucker	N	1,065	4.1	11.3	53	20.4
bluehead X flannelmouth sucker	N	1	*	*	1	*
BULLHEAD CATFISHES						
black bullhead	I	1,931	7.4	20.6	14	5.4
yellow bullhead	I	1	*	*	1	*
channel catfish	I	302	1.2	3.2	31	11.9
TROUT						
kokanee salmon	I	-	-	-	-	-
KILLIFISHES						
plains killifish	I	8	*	0.1	5	1.9
LIVEBEARERS						
western mosquitofish	I	160	0.6	1.7	44	16.9
SUNFISHES						
green sunfish	I	4	*	*	3	1.2
bluegill	I	-	-	-	-	-
largemouth bass	I	15	0.1	0.2	13	5.0
TOTAL		26,208		279.2		

1 N = native; I = introduced
2 CPUE = catch per unit effort; value based on catch per 100 m^2 (surface area) sampled
3 Frequency and % frequency of occurrence are based on n=260 samples.
*Value is less than 0.05%

Table A-4. Summary of age-0 razorback sucker collected in the San Juan River during the 2011 larval fish survey.

Field Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
WHB11-036	6	9.9 -11.5	proto - mesolarvae	16-May-11	137.9	larval fish seine
WHB11-038	4	10.9 -11.3	proto - mesolarvae	16-May-11	134.5	larval fish seine
WHB11-040	1	11.6	mesolarva	16-May-11	131.3	larval fish seine
WHB11-042	9	10.5 -11.1	proto - mesolarvae	16-May-11	128.1	larval fish seine
WHB11-046	1	10.9	mesolarva	17-May-11	120.5	larval fish seine
WHB11-047	2	10.4, 10.7	proto - mesolarvae	17-May-11	119.5	larval fish seine
WHB11-048	18	9.8 -12.0	proto - mesolarvae	17-May-11	118.5	larval fish seine
WHB11-049	22	10.0 -11.7	mesolarvae	17-May-11	116.9	larval fish seine
WHB11-050	84	9.5 -12.0	proto - mesolarvae	17-May-11	113.2	larval fish seine
WHB11-051	22	10.0 -11.7	mesolarvae	18-May-11	107.6	larval fish seine
WHB11-052	4	10.1 -11.2	mesolarvae	18-May-11	106.4	larval fish seine
WHB11-054	2	9.1, 10.4	mesolarvae	18-May-11	104.4	larval fish seine
WHB11-056	3	10.1 -11.2	mesolarvae	18-May-11	99.3	larval fish seine
WHB11-057	6	9.6 -12.0	proto - mesolarvae	18-May-11	96.4	larval fish seine
WHB11-058	2	10.7, 10.9	mesolarvae	18-May-11	92.2	larval fish seine
WHB11-059	3	10.4 -13.2	mesolarvae	18-May-11	88.8	larval fish seine
WHB11-060	4	9.1 -13.0	proto - mesolarvae	18-May-11	87.4	larval fish seine
WHB11-062	1	10.0	mesolarva	19-May-11	84.1	larval fish seine
MAF11-035	1	12.0	mesolarva	16-May-11	74.9	larval fish seine
MAF11-037	1	10.1	mesolarva	16-May-11	70.2	larval fish seine
MAF11-038	2	10.0, 11.0	mesolarvae	17-May-11	67.2	larval fish seine
MAF11-040	1	10.7	mesolarva	17-May-11	66.8	larval fish seine
MAF11-042	12	9.0 -13.5	mesolarvae	17-May-11	59.8	larval fish seine
MAF11-043	76	9.4 -14.9	mesolarvae	17-May-11	57.9	larval fish seine
MAF11-044	18	10.2 -11.6	mesolarvae	17-May-11	56.7	larval fish seine
MAF11-046	1	10.9	mesolarva	17-May-11	48.5	larval fish seine
MAF11-047	6	9.2 -11.2	proto - mesolarvae	17-May-11	43.8	larval fish seine
MAF11-048	8	9.8 -12.8	mesolarvae	18-May-11	42.6	larval fish seine
MAF11-050	10	11.2 -15.1	mesolarvae	18-May-11	35.0	larval fish seine
MAF11-051	14	9.9 -14.2	mesolarvae	18-May-11	24.7	larval fish seine
MAF11-052	137	8.2 -13.1	proto -mesolarvae	18-May-11	24.5	larval fish seine
MAF11-054	22	11.5 -17.4	mesolarvae	19-May-11	17.7	larval fish seine
MAF11-055	1	12.2	mesolarva	19-May-11	16.4	larval fish seine
MAF11-056	347	9.4 -16.3	proto - mesolarvae	19-May-11	10.0	larval fish seine
MAF11-057	3	9.6 -10.6	mesolarvae	19-May-11	8.8	larval fish seine
MAF11-058	47	10.0 -17.0	meso -metalarvae	19-May-11	8.1	larval fish seine
MAF11-059	1	12.0	mesolarva	19-May-11	5.6	larval fish seine
Total	**902**					

Table A-4 (con't). Summary of age-0 razorback sucker collected in the San Juan River during the 2011 larval fish survey.

Field Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
WHB11-074	9	11.0 -13.8	mesolarvae	14-June-11	124.8	larval fish seine
WHB11-077	8	11.0 -14.5	mesolarvae	14-June-11	119.5	larval fish seine
WHB11-079	18	12.0 -15.5	mesolarvae	14-June-11	116.9	larval fish seine
WHB11-083	1	17.4	metalarva	15-June-11	104.4	larval fish seine
WHB11-085	2	11.9, 13.4	mesolarvae	15-June-11	99.3	larval fish seine
WHB11-086	1	10.7	mesolarva	15-June-11	96.4	larval fish seine
WHB11-088	1	11.5	mesolarva	15-June-11	90.0	larval fish seine
WHB11-091	5	11.8 -13.7	mesolarvae	15-June-11	84.1	larval fish seine
MAF11-066	36	10.4 -18.4	meso - metalarvae	14-June-11	57.9	larval fish seine
MAF11-068	1	12.3	mesolarva	14-June-11	52.4	larval fish seine
MAF11-079	1	19.7	metalarva	16-June-11	17.7	larval fish seine
MAF11-082	38	10.8 -19.4	meso - metalarvae	16-June-11	10.0	larval fish seine
MAF11-083	20	12.6 -24.1	meso - juvenile	16-June-11	9.6	larval fish seine
MAF11-084	13	14.8 -23.8	meso - juvenile	16-June-11	8.1	larval fish seine
MAF11-085	8	11.5 -23.8	meso - juvenile	16-June-11	7.0	larval fish seine
WHB11-106	1	26.2	juvenile	19-July-11	52.4	larval fish seine

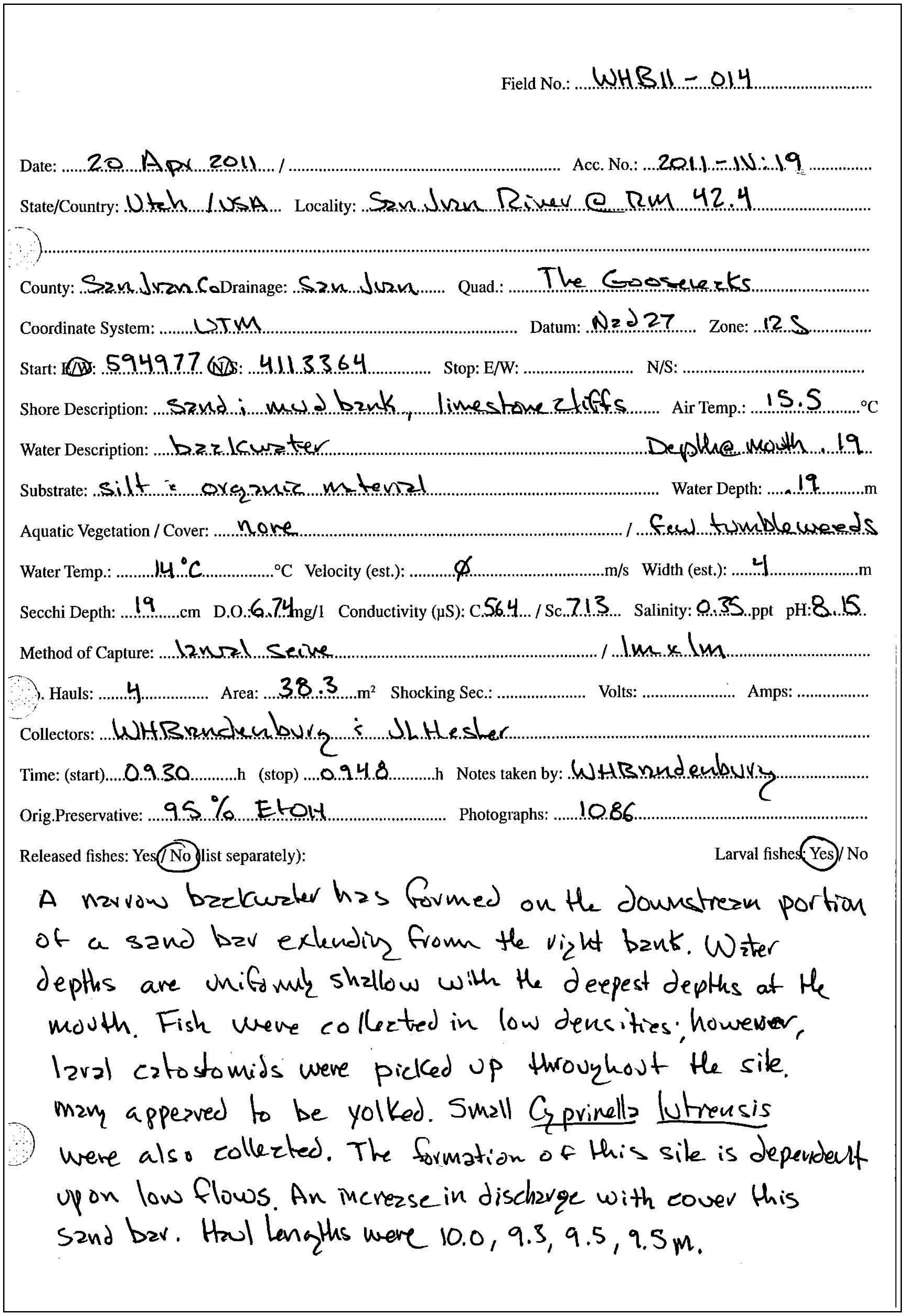
Total 163

2011 Total 1,065

Table A-5. Summary of age-0 Colorado pikeminnow and roundtail chub collected in the San Juan River during the 2011 larval fish survey.

Field Number	Number of Specimens	Total Length	Larval Stage	Date Collected	River Mile	Sampling Method
Colorado pikeminnow						
MAF11-114	3	9.4 -10.2	mesolarvae	20-July-11	87.4	larval fish seine
WHB11-122	21	8.8 -11.1	meso - metalarvae	21-July-11	10.8	larval fish seine
WHB11-124	3	10.1 -12.3	meso - metalarvae	21-July-11	10.0	larval fish seine
WHB11-153	1	16.3	metalarva	10-Aug-11	92.6	larval fish seine
MAF11-149	1	13.6	metalarva	11-Aug-11	7.0	larval fish seine
Total	**29**					
Roundtail chub						
MAF11-098	2	21.7 -22.1	meta - juvenile	19-July-11	122.2	larval fish seine
WHB11-139	2	8.8 -11.1	meta - juvenile	9-Aug-11	122.8	larval fish seine
Total	**4**					

Figure A-1. Example of field data recorded at each sampling locality.


Field No.: WHB11 - 014

Date: 20 Apr 2011 / Acc. No.: 2011 - IV : 19

State/Country: Utah / USA Locality: San Juan River @ RM 42.4

County: San Juan Co. Drainage: San Juan Quad.: The Goosenecks

Coordinate System: UTM Datum: Nad 27 Zone: 12 S

Start: E/W: 594977 N/S: 4113364 Stop: E/W: N/S:

Shore Description: sand & mud bank, limestone cliffs Air Temp.: 15.5 °C

Water Description: backwater Depth @ mouth .19

Substrate: silt & organic material Water Depth: .19 m

Aquatic Vegetation / Cover: none / few tumbleweeds

Water Temp.: 14 °C °C Velocity (est.): ∅ m/s Width (est.): 4 m

Secchi Depth: 19 cm D.O. 6.74 mg/l Conductivity (µS): C 564 / Sc 713 Salinity: 0.35 ppt pH: 8.15

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

No. Hauls: 4 Area: 38.3 m² Shocking Sec.: Volts: Amps:

Collectors: WHBrandenburg & JLHester

Time: (start) 0930 h (stop) 0948 h Notes taken by: WHBrandenburg

Orig. Preservative: 95 % EtOH Photographs: 1086

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

A narrow backwater has formed on the downstream portion of a sand bar extending from the right bank. Water depths are uniformly shallow with the deepest depths at the mouth. Fish were collected in low densities; however, larval catostomids were picked up throughout the site. Many appeared to be yolked. Small *Cyprinella lutrensis* were also collected. The formation of this site is dependent upon low flows. An increase in discharge will cover this sand bar. Haul lengths were 10.0, 9.3, 9.5, 9.5 m.