Endangered Fish Monitoring and Nonnative Fish Control in the Lower San Juan River 2013

FINAL REPORT

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EXECUTIVE SUMMARY

The twelfth consecutive year of nonnative fish control in the lower San Juan River was conducted in 2013. This project was initiated to remove large-bodied nonnative fish species and to identify factors involved in movement of striped bass (*Morone saxatilis*) into the lower San Juan River from Lake Powell. Since 2003 the nonnative removal project has focused on reducing channel catfish (*Ictalurus punctatus*) and other large-bodied nonnative fishes that occur within the San Juan River.

In 2013, nine nonnative fish removal passes were made, beginning in early-March and continuing through August. Raft mounted electrofishing was conducted from Mexican Hat to Clay Hills, UT between river miles (RM) 52.8-2.9. Mean daily river flow ranged from 447-2,884 cubic feet per second (cfs) during sampling trips in 2013.

Channel catfish made up the majority of large-bodied nonnative fishes collected in 2013. Mean catch per unit effort was 28.3 fish per hour. Considerable variability in catch rates occurred between passes, but overall catfish populations have remained relatively stable since removal efforts began. Common carp catches remained low in 2013 with just 13 individuals being captured and removed.

In 2013 sampling, 421 Colorado pikeminnow and 24 razorback sucker were collected in the lower San Juan River. All pikeminnow captured are likely of hatchery origin stocked within the San Juan River from 2003 through 2012 at upstream locations near Farmington, NM. Population estimates based on capture-recapture data for Colorado pikeminnow indicated that 609 to 1276 fish are utilizing the lower San Juan River.

INTRODUCTION

Native fishes in the Southwestern United States have been negatively impacted by extensive water development, anthropogenic alteration of habitats, and the spread of nonnative fishes (Minckley and Marsh 2009). The establishment of nonnative species occurred via the intentional planting of desired sport fishes and through illegal stockings or bait bucket introductions. The widespread distribution of nonnative species has led to the homogenization of fish communities throughout the Southwest, and elsewhere and potentially effects the survival and persistence of native fish communities (Rahel 2003). Within the Upper Colorado River Basin (i.e. Colorado River, Green River, San Juan River), increases in the abundance of nonnative fishes coupled with habitat changes have led to reductions in abundance and range contractions of many native fishes. Subsequently, four native species including the Colorado pikeminnow, razorback sucker, humpback chub and bonytail chub have been federally listed as endangered and are fully protected under the Endangered Species Act. Competitive and predatory interactions between native and nonnative fishes have been identified by management agencies as potential factors limiting recovery of these species, and managers within the Upper Colorado River Recovery Program and the San Juan River Recovery Implementation Program have established removal projects to control nonnative fish species (Mueller 2005).

The lower San Juan River in southeastern Utah contains remnant populations of Colorado pikeminnow and razorback sucker (Ryden 2000, Davis et al. 2010). These populations are recruitment limited and augmentation activities have been established since 1994 to re-establish populations (Ryden 2003). Since the threat of nonnative fishes exists and there was concern that striped bass and other Lake Powell resident fish may colonize and establish reproducing populations within the Lower San Juan River (Gustaveson et al. 1984), the Utah Division of Wildlife Resources Moab Field Office initiated the mechanical removal of nonnative fish in the lower San Juan River from Mexican Hat, UT to the Clay Hills Crossing beginning in 2002.

The objectives of this study include: 1) mechanical removal of large-bodied nonnative species in the lower portion of the San Juan River from Mexican Hat to Clay Hills; 2) estimate population size and exploitation rate of channel catfish from mark-recapture data; 3) and determine the abundance and distribution of Colorado pikeminnow and razorback suckers in the lower San Juan River. These objectives are identified in the San Juan Recovery Implementation Program Draft Long Range Plan under Element 3 and goal 3.1 (U.S. Fish and Wildlife Service 2013).

METHODS

Study Area

The study area includes the San Juan River from Mexican Hat (RM 52.8) to Clay Hills (RM 2.9), Utah (Figure 1). The river from Mexican Hat to RM 16 is primarily bedrock confined and dominated by riffle and run habitats. The river is canyon bound with an active alluvial bed from RM 16 to Clay Hills (RM 2.9). Habitats within this section exhibit considerable heterogeneity and river geomorphology is significantly influenced by spring freshets, monsoonal floods, and changing reservoir elevations. This section of river has been identified as nursery habitat for native and endangered fishes (Archer et al. 2000).

Sampling

Two raft mounted electrofishing boats were used to sample fish populations in the Lower San Juan during nine five-day sampling trips in 2013. Trips occurred between March and late-August. Each electrofishing boat was outfitted with an ETS electrofishing system to sample fish populations. Amperage for the ETS system was typically set at 8 to 18 depending on specific conductivity measurements and sampling occurred on each side of the river. Individual sampling units consisted of approximately three-mile segments of shoreline fished by each electrofishing raft. Data are collected for approximately 30 sample units per trip.

All nonnative and endangered species were netted. Total length (mm) was measured for all nonnative and endangered fishes and a sub-sample of nonnative fishes were also measured for standard length (mm) and weight (g). Standard length and weight were measured for all endangered fishes. All endangered fishes $\geq$ 150 mm TL were assessed for the presence of a PIT tag and tagged if not previously marked. The location of captured endangered fishes was determined to the nearest tenth of a river mile. All endangered fishes were released at or near the location of capture. From 2003-2006 and 2008-2011, all channel catfish $\geq$ 200 mm TL collected during the first pass (trip) were marked in various ways and released. Channel catfish collected in 2009 to 2013 were uniquely marked with individually numbered T-bar floy tag. Prior to 2009, channel catfish were tagged with colored tags only and were not uniquely marked. Since 2010, channel catfish $\geq$ 200 mm TL were tagged and received an adipose fin clip. Channel catfish and all other large-bodied nonnative fishes collected on subsequent passes were removed. Turbidity, using a Secchi disk, river temperature, conductivity, and salinity were measured each day and if an obvious change in flow or turbidity was observed. River discharge was determined from the USGS gage # 09379500 near Bluff, UT.

Data Analysis

Catch-per-unit-effort (CPUE) was calculated as the number of fish caught per hour of electrofishing effort for a given sampling section. For each sampling trip approximately 30, three-mile sections were sampled. CPUE was calculated for channel catfish, common carp, Colorado pikeminnow, and razorback sucker and summarized by trip and year. All analyses were done in SigmaStat version 3.2. Catch-per-unit-effort data for all species were highly non-normal (failed a Kolmogorov-Smirnov test; $p<0.05$) and the non-parametric Kruskal-Wallis test was used to assess for differences in species-specific CPUE by year and trip. The Dunn's Method was selected for post hoc multiple comparisons because it's ability to test with unequal sample sizes (Dunn 1964).

During trips one and two of 2013, we estimated the abundance of channel catfish greater than 200 mm TL using a Lincoln-Petersen estimator with Chapman's correction (Equation 1).

Equation 1: $$N = \frac{(M+1)(C+1)}{R+1} - 1$$

In Equation 1, M is the number of channel catfish marked during trip 1, C is the total number of channel catfish greater than 200 mm TL captured during trip 2, R is the number of channel catfish marked in trip 1 that were recaptured during trip 2, and N is estimated channel catfish abundance. Lincoln-Petersen population estimates have been used to assess early season channel catfish abundance since 2003 with the exception of 2007.

Tag return data were also used to calculate exploitation rates for tagged catfish and upstream movement rates for channel catfish (Equation 2). Exploitation rates, μ, were estimated as the proportion of recaptured marked fish (R) to the total number marked fish (M) (Deroba et al. 2005),

Equation 2: $$\mu = \frac{R}{M}$$

Tag return studies can be biased by immigration, emigration, tag loss, mortality and changing capture probabilities between trips. However, when they are used with other trend data they are effective in assessing our removal effectiveness.

Population size was estimated for age-2+ Colorado pikeminnow (>150 mm) in the lower San Juan River using closed population models within Program CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991). Capture histories for

Colorado pikeminnow were generated in Microsoft Excel and converted to a file for Program CAPTURE to read. Several combinations of passes were selected for analysis to lessen the likelihood of violating assumptions of the models used. There are two types of models used in Program CAPTURE: the M_o model (null model) was appropriate when capture probabilities (p-hat) remained similar among the passes in the model and the M_t model (time variable model) was used when p-hat was variable among passes. Confidence intervals, the coefficient of variation, and the probability of capture were also calculated within Program CAPTURE.

RESULTS

Nine sampling passes were conducted on the San Juan River between Mexican Hat and Clay Hills, UT in 2013. Sampling dates were: March 4-8, March 19-23, March 30-April 3, April 10-15, July1-5, July 18-21, August 2-6, August 13-17, and August 23-27. Eight large-bodied fish species were encountered including Colorado pikeminnow, razorback sucker, and five nonnative species (Table 1). We also collected one suspected razorback-flannelmouth sucker hybrid. Native bluehead and flannelmouth suckers were present during all passes but not netted during nonnative control efforts because of their large population sizes. Electrofishing effort totaled 227 hours and resulted in the capture of 7,115 fish (Table 1). Similar to past years, channel catfish was the most abundant species captured; no striped bass or walleye were encountered.

Nonnative Species

Channel catfish

In 2013, channel catfish comprised 93% of the total catch during nonnative removal passes in the lower San Juan River. The mean catch rate of all sizes of channel catfish was 28.3 fish per hour; catch rates varied significantly between passes and ranged from 12.5 to 48.9 fish per hour ($p < 0.001$; Figure 2). Catch rates showed an increase from 2012 to 2013. In 2013, catch rates were statistically higher than 2005 and 2011, but statistically similar to all other years (Figure 3). The mean catch rate of adult (>300 mm TL) channel catfish in 2013 was 4.12 fish per hour and significantly lower than in 2002, 2008 and 2009 (Figure 4). As observed in previous years, the juvenile channel catfish catch drives CPUE trends in the lower San Juan River.

The mean total length of channel catfish collected in the lower San Juan River in 2013 was 217 mm. In general, the mean size of channel catfish has declined since removal programs began (Appendix C). Analysis of length-frequency histograms showed that 84% of catfish collected during 2013 were fish under 300 mm (Figure 5). Visual observation of length frequency histograms indicates four distinct modes, which likely represent YOY to Age 3 fish. The percentage of adult (≥300 mm TL) channel catfish in the total catch was similar to previous years except 2008 (Figure 6). The catch of adults significantly increased in 2008 was attributed to

immigration of channel catfish from the Middle San Juan River in response to a period of high flow from Navajo Dam. Large-bodied adult channel catfish greater than 400 mm continue to represent a small proportion of the overall catch. Channel catfish $\geq$ 400mm TL have declined from 9.4% in 2002 to 1.3% in 2013 of the total channel catfish catch.

In 2013, the channel catfish population greater than 200 mm was assessed (Figure 7). For the population estimate, 1,338 channel catfish were tagged during the first sampling trip; 1,129 catfish were captured during second sampling trip with 76 recaptures. In 2013, 19,649 individuals (95% CI =15,562-23,736) were estimated within the lower San Juan River. The 2013 estimate is significantly higher than the 2004 and 2009 estimates, but statistically similar to all other years.

In 2013, the exploitation rate of channel catfish was assessed using tag return data. Exploitation rates increased with size class (Table 2) and ranged from 5.5% for channel catfish between 200-299 mm TL to 8.8% for channel catfish between 300-399 mm TL (Table 2).

Upstream movement of channel catfish from the lower San Juan to the middle San Juan was observed in 2013. Seventy one channel catfish tagged in 2013 within the lower reach were recaptured in 2013 by Fish and Wildlife Service collaborators in the middle river reach. Additionally, 40 channel catfish originally tagged between 2010 and 2012 in the lower river were recaptured in the middle reach in 2013. Twenty-eight fish originally tagged in the middle San Juan were recaptured in the lower river in 2013 and all of those recaptures occurred in early spring.

Common carp

In 2013, 13 common carp were captured and the mean catch rate of all trips was 0.05 fish per hour. Sixty-one percent of the fish collected in 2013 were young of the year/juveniles. Catch rates precipitously declined between 2002 -2004 and have not exceeded 0.2 fish per hour since 2005 (Figure 8).

Endangered Species

Colorado pikeminnow

A total of 421 Colorado pikeminnow were collected in 2013. Catch rates in 2013 were not significantly different than 2011 or 2012 (Figure 9). Catch rates in 2013 were significantly higher than catch rates from 2003 to 2008 ($p<0.05$) and were significantly lower than 2009 and 2010 (Figure 9). Catch rates in 2012 ranged from 1.2 to 4.3 fish per hour and varied between trips (Figure 10).

Trips eight (8/13-17) and nine (8/23-27) had significantly higher catch rates than trips one (3/4-8), three (3/30-4/3), and four (4/10-15) (Figure 10). Catch rates were generally higher in the summer trips compared to the spring trips (Figure 10). Analysis of length frequency histograms indicated three distinct modes of cohorts presumed to represent age-0, age-1 and age-2 fish (Figure 11). The small mode centered around 75 mm are thought to be small fish that were stocked during the fall of 2012 and subsequently captured during early trips in 2013 (Figure 11). These fish are from the 2010 (Age 2) and 2011 (Age 1) fish-stocking program. Colorado pikeminnow captures were widely distributed throughout the study reach in 2013 (Figure 12). Catches of Colorado pikeminnow were lowest for river miles 3 to 15 and generally highest between river miles 53 to 35. Colorado pikeminnow capture locations were consistent with distributional patterns observed in previous years (Figure 12).

Population estimates of Colorado pikeminnow have been generated for the lower San Juan River since 2004 (Table 3). In 2013, the Mt model was used which estimates a trip specific capture probability and a year specific abundance estimate. Only data from trips 5-9 were incorporated , so the assumption of closure was less likely violated because trips 5-9 were summer trips. Also, more Colorado pikeminnow were captured during those trips. The model estimated 862 Colorado pikeminnow in the lower San Juan River with a confidence interval of 609 to 1276 individuals. Capture probabilities were low and ranged from 0.02 to 0.11. Population estimates for Colorado pikeminnow in the lower San Juan River indicate that abundance increased from 2004 to 2009 and stabilized around 1100 individuals from 2009 to 2011. The population experienced a nearly 50% reduction from 2011 to 2012, then increased in 2013. Increases and decreases in Colorado pikeminnow populations in the lower San Juan River are likely affected by changes in stocking numbers, movement, and overwinter mortality rather than variable recruitment.

Captures of adult (>450 mm TL) Colorado pikeminnow have been low since this project began in 2002. No adult Colorado pikeminnow were captured in 2013. One was captured in 2012 (480 mm TL) and from 2002-2011 only eight adult pikeminnow were captured with sizes ranging from 460 mm-590 mm.

Razorback sucker

Twenty four razorback sucker were collected in the lower San Juan River in 2013 (Table 1). Mean catch rate in 2013 was significantly lower than 2007 and 2012 and no difference was observed in the other years (Figure 13). Catch rates varied between trips from 0 to 0.18 fish captured per hour. Catch rates were generally higher during the early season trips compared to the late season trips (Figure 14). The mean size of razorback sucker captured in the lower San Juan River was 387 mm and ranged from 55 to 487 mm total length. Razorback sucker catches were widely distributed throughout the lower Canyon, but the greatest frequency of captures occurred between river mile 42 to 39 and river mile 18 to 20. During the early season many of the razorback captures were aggregated in groups near cobble bars. One suspected razorback-flannelmouth sucker hybrid was collected in 2013 at RM 40.8.

DISCUSSION

Channel catfish catch rates in 2013 were slightly higher than those observed in 2002 and 2011. Overall, CPUE trends from 2002 to 2013 exhibit considerable yearly variation, but overall have remained relatively stable. Many factors may have contributed to the higher catch rates in 2013 such as the time of year, river discharge, water temperature, turbidity, netter and raft operator experience, and pass number. The decreasing trend in CPUE between passes in the spring may be a result of emigration, changing capture probability between passes and behavioral responses to electrofishing gear. The increasing trend in CPUE between passes in the summer is an increase in the number of YOY captured and not larger individuals. The actual temporal trend of adult CPUE follows the decrease that is observed in the spring and hovers just above zero during the summer trips. This decrease in the number of adults captured in the summer is result of emigration and/or turbidity. Seasonal movement behavior was observed 2012 and 2013 where numerous adult channel catfish that were tagged in the lower canyon in the spring and recaptured in the middle San Juan during the summer. Also in 2013 three of our four removal trips experienced extreme increases in turbidity due to monsoonal events (Appendix A). The use of CPUE as an index of population abundance is a popular way to assess fish populations (Fabrizio and Richards 1996; Hubert 1996; Ney 1999). Future analysis of channel catfish CPUE in the lower San Juan River should consider comparing CPUE from similar times of year such as pre-runoff trips and mid-summer trips in order to minimize some of the fluctuations in capture probability that may be obscuring overall population trends and the utility of CPUE as a population index.

Population estimates of channel catfish $\geq$ 200 mm TL have been conducted in the lower San Juan River since 2003. The 2013 population estimate was only significantly higher than the 2004 and 2009 estimates and within the confidence limits of the 2003, 2005, 2006, 2008, 2010, 2011, and 2012 estimates. In general, population sizes have been relatively stable since 2003 but large declines in the channel catfish population greater than 400 mm have also been observed. The increases in adult catfish in 2008 were likely a result of immigration of fish from the middle reaches in response to high spring discharges from Navajo Dam. When considering both CPUE and the abundance estimate, channel catfish populations in the San Juan seem relatively stable.

Exploitation rate for channel catfish was estimated using tag return data from individually marked fish. Exploitation rates varied depending on fish length and increased with increasing total length. Electrofishing gear is biased toward collecting larger individuals. This bias occurs because larger individuals have more surface area for the electrical field to come into contact with (Reynolds 1996). The reduced exploitation rate in 2013 may be the result of numerous factors such as capture probability, fish movement, and wind. Exploitation rates were calculated during the first two sampling trips in the spring. During spring trips wind is often a factor that reduces the number fish captured due to inability to control the raft. In addition, channel catfish tagged in the lower San Juan move outside of the study reach. This movement may indicate a more widespread upstream dispersal of catfish and result in a markedly reduced tagged population within our study reach. Movements in excess of 100 km have been observed in other channel catfish populations (Dames et al. 1989, Hale et al. 1986).

The large number of YOY and juvenile channel catfish in the lower San Juan River could be the result of numerous factors. The lower San Juan may be a rearing habitat for juvenile catfish and as they grow they migrate and reside in the middle and upper reaches of the San Juan River. The removal of large adult channel catfish from the population may be causing a compensatory improvement in juvenile channel catfish survival rates, which would account for the increase in fish from 200-299 mm (Walters and Martell 2004). This pattern of a compensatory increase in juvenile survival rates has been noted in numerous fish populations throughout North America (Rose et al. 2001). The mechanism for improved juvenile survival can be caused by reduction in predator abundances, increases in food availability, improved growth (caused by reduced predation or improved food) or a reduction in cannibalistic behavior (Walters and Martell 2004). Past research within the Powder River drainage in Wyoming indicated that population structure and abundance of channel catfish changed considerably as adult exploitation rates increased (Gerhardt and Hubert 1991). Gerhardt and Hubert (1991) reported that an annual exploitation rate of 22% would result in a 75% reduction in overall abundance of catfish $\geq$ 300 mm TL, and cause a substantial shift towards smaller individuals. Similar shifts in yield and population structure have been observed in sport and commercial fisheries as the rate of exploitation increased (Bennett 1971, McHugh 1984, Pitlo 1997). In the San Juan River, shifts in size structure of channel catfish were observed upstream (Davis 2005) and on a river-wide scale (Ryden 2005) after the initiation of nonnative removal. Continuing population estimates for channel catfish will allow for evaluation of removal effectiveness and exploitation rate of the channel catfish population.

Since 2002, a significant decline in catch rates of common carp has been observed. During the first year of removal, 1052 common carp were removed from the lower San Juan River. In 2013, only 13 common carp were captured in the same river section. It is unclear if this decline is directly related to removal efforts, the presence of the waterfall, limited habitat availability, or the water conditions that have been present over the period of this project. All or some of these factors are likely responsible for the reduction in common carp. Nonnative removal efforts in the upper San Juan River have also documented a significant decline in the CPUE of common carp (Davis 2010, Duran et al 2013). River-wide adult and sub-adult monitoring has also shown a significant decline in CPUE of common carp (Ryden 2010, Schleicher and Ryden 2013.

Population estimates generated for stocked juvenile Colorado pikeminnow indicate that pikeminnow abundance has increased from 2002 to 2011 and declined from 2011 to 2012. The estimated abundance for 2013 was between 609 to 1276 individuals. The strong support for trip- specific estimates illustrates the importance of estimating unique capture probabilities. The preciseness of the estimate is dependent on the estimate of capture probability. Years (2006 in particular) which have a low estimate of capture probability (less than 5%) estimate abundance poorly, whereas years with higher capture probability (greater than 10%) provide relatively precise estimates of abundance. Movement of pikeminnow outside of the study reaches may reduce capture probability within the study reach which would reduce the precision of the estimate causing increased uncertainty in population estimates. A river-wide sampling trip which minimized the length between passes may be a sufficient way to achieve precise estimates of

abundance. The use of robust design population models and passive PIT tag antennas may be useful in understanding pikeminnow movements and mortality patterns in the Lower San Juan.

The catch of adult Colorado pikeminnow has been low and declined slightly over the period of this study (2002-2012). No adult Colorado pikeminnow were captured in our study reach in 2013. The reasons for this decline are unknown but might be explained by several factors: 1) avoidance of the electrofishing field; 2) emigration below the waterfall outside of the study area; 3) emigration upstream of the study reach; 4) or mortality. Past radio telemetry studies of adult Colorado pikeminnow within the San Juan River indicated fish were able to detect electrofishing rafts and actively moved to avoid the electrical field (Ryden 2000). Colorado pikeminnow that avoided the electrofishing boats ranged from 521 to 948 mm TL. Their avoidance of rafts has been documented by other researchers as well (Bestgen et. al 2004). In contrast to channel catfish, capture probabilities for pikeminnow declined with increasing fish size. Thus, adult fish had lower capture probabilities than younger smaller fish. We are uncertain whether adult fish are present and can avoid electrofishing gear or generally absent from the lower San Juan reach. Alternatively, the deep pools used for foraging and resting by are scarce in the lower river and may contribute to the lack of adults in this region.

The total number of razorback suckers captured in the lower San Juan River in 2013 was lower than the previous year. This drop in catch rate from 2012 to 2013 is a result of lower catch probability. Reduced flows during 2012 allowed more razorback sucker to be captured than in 2013. Also the monsoonal events in 2013 increased flow and turbidity, which also significantly lowers catch rates. Only four razorback suckers were captured during the summer trips of 2013 compared to 25 in 2012.

CONCLUSIONS AND RECOMMENDATIONS

• Population estimates of channel catfish in the lower San Juan River have been relatively stable since removal began in 2002. There is considerable variation around yearly estimates. Estimates of channel catfish populations were relatively imprecise (indicated by large confidence intervals) from 2003 to 2006 but have improved in recent years with the notable exception of 2012. The proportion of the channel catfish $\geq$ 400 mm TL in the total catch has continued to decrease. Channel catfish should continue to be marked with numbered tags during the first pass in order to determine population size at the beginning of each removal year. Along with population estimates, mark/recapture using individually numbered tags allows for determination of exploitation rate by size class, and monitoring of channel catfish growth rates and movement throughout the river.

• The CPUE and mean TL of channel catfish in 2013 are similar to most of the previous years. Length-frequency histograms from fish captured in 2009-2011 indicate large numbers of juvenile fish in the catch. It is unknown if the increase in juvenile channel catfish is the result of removal efforts or favorable environmental conditions.

• In 2012 and 2013 adult channel catfish exhibited vast amounts of movement from the lower canyon to the middle reaches during the summer months. This movement causes substantial drops in adult channel catfish catch rates during the summer months. To increase catch rates, some summer effort should be shifted from the lower canyon to the middle reaches (Montezuma Creek to Mexican Hat). This shift in effort will likely remove more adult channel catfish.

• Catch rates of common carp decreased significantly from 2002 to 2013. The cause of the decreasing trend in catch rate for these fish is unknown. Several factors may be acting together including: continued nonnative removal, the presence of the waterfall which prevents upstream colonization of carp from Lake Powell and low water conditions present during the first three years of removal which may have limited recruitment. Common carp should continue to be removed from the lower San Juan River to reduce potential competition with native and endangered fishes.

• Population estimates of juvenile Colorado pikeminnow increased from 2003 through 2011 and have declined from 2011 to 2012. From 2004 to 2013, the majority of captures were age-1 and age-2 fish. Age-0 stocked fish are likely more abundant, but electrofishing sampling effectiveness increases with fish size. Ongoing monitoring and population estimates for Colorado pikeminnow should be continued in future monitoring programs.

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Table 1. Total counts of fish species collected during electrofishing sampling in the lower San Juan River in 2013.

	3/4-3/8	**3/19-3/23**	**3/30-4/3**	**4/10-4/14**	**7/1-7/5**	**7/18-7/22**	**8/2-8/6**	**8/13-8/17**	**8/23-8/27**	**Grand Total**
Black Bullhead	3	8	2		3	6	4	2	6	34
Brown Trout	1									1
Channel Catfish	1362	1128	840	448	362	252	525	1223	476	6616
Common Carp	1	1				2	6		3	13
Colorado Pikeminnow	17	42	28	13	63	35	70	113	40	421
Flannelmouth Sucker						3	1			4
Flannel x Razorback Hybrid									1	1
Largemouth Bass					1					1
Razorback Sucker	5	6	5	3	4		1			24
Grand Total	**1389**	**1185**	**875**	**464**	**433**	**298**	**607**	**1338**	**526**	**7115**

Table 2. Percentage of total catch, number of channel catfish tagged by size class and exploitation rate of channel catfish by size class in 2013 in the lower San Juan River.

Trip	200-299	300-399	400-499	500-599	Total
(1) Number Tagged	896	400	39	4	1339
(2) 3/19-3/22	50	35	1	0	86
Exploitation by size class	5.6%	8.8%	2.6%	0.0%	

Table 3. Population estimates for juvenile Colorado pikeminnow ≥ 150 mm TL in the lower San Juan River from 2004 to 2013. Models used include the null model (Mo) and the time variable model (Mt) from Program Capture. CI represents confidence interval. CV indicates the coefficient of variation, and p-hat represents capture probability.

Year	Passes	Model	Estimate	CI	CV	p-hat
2004	1-2	Lincoln-Peterson	160	17-303	-	-
	1-3	Mo	315	218-545	0.22	0.07
	1-5	Mo	183	99-469	0.38	0.09
	4-6	Mo	195	124-372	0.27	0.13
	5-8	Mt	157	100-297	0.26	0.1
2005	1-3	Mo	536	288-1,283	0.37	0.06
	1-4	Mt	537	321-1,064	0.30	0.06
	1-6	Mt	696	454-1,189	0.24	0.03
	3-6	Mt	582	293-1,556	0.41	0.04
	7-9	Mo	681	241-3,950	0.67	0.03
2006	1-3	Mo	202	112-2,135	0.94	0.03
	4-6	Mo	124	78-237	0.30	0.14
	7-9	Mt	976	237-4,775	0.94	0.02
	7-10	Mt	1267	417-4,296	0.67	0.02
	1-10	Mt	455	340-640	0.16	0.04
2007	1-3	Mt	238	148-436	0.29	0.1
	4-6			No Estimate		
	7-9	Mo	68	36-180	0.31	0.13
	1-9	Mt	296	233-399	0.14	0.06
	1-10	Mt	326	257-433	0.13	0.05
2008	1-5	Mt	470	358-652	0.15	0.09
	6-9	Mt	270	149-636	0.36	0.07
	1-9	Mt	572	450-715	0.12	0.05
2009	1-4	Mo	1078	965-1222	0.06	0.16
	6-9	Mt	1221	678-2335	0.33	0.03
	1-4 and 6-9	Mt	1452	1306-1633	0.06	0.07
2010	1-7	Mo	1100	1022-1193	0.04	0.13
	1-9	Mo	1273	1185-1377	0.04	0.1
2011	1-5	Mt	1010	863-1207	0.09	0.1
	1-9	Mt	1160	1014-1348	0.07	0.06
2012	1-8	Mt	666	480-965	-	0.025-0.07
2013	5-9	Mt	862	609-1276	-	0.02-0.11

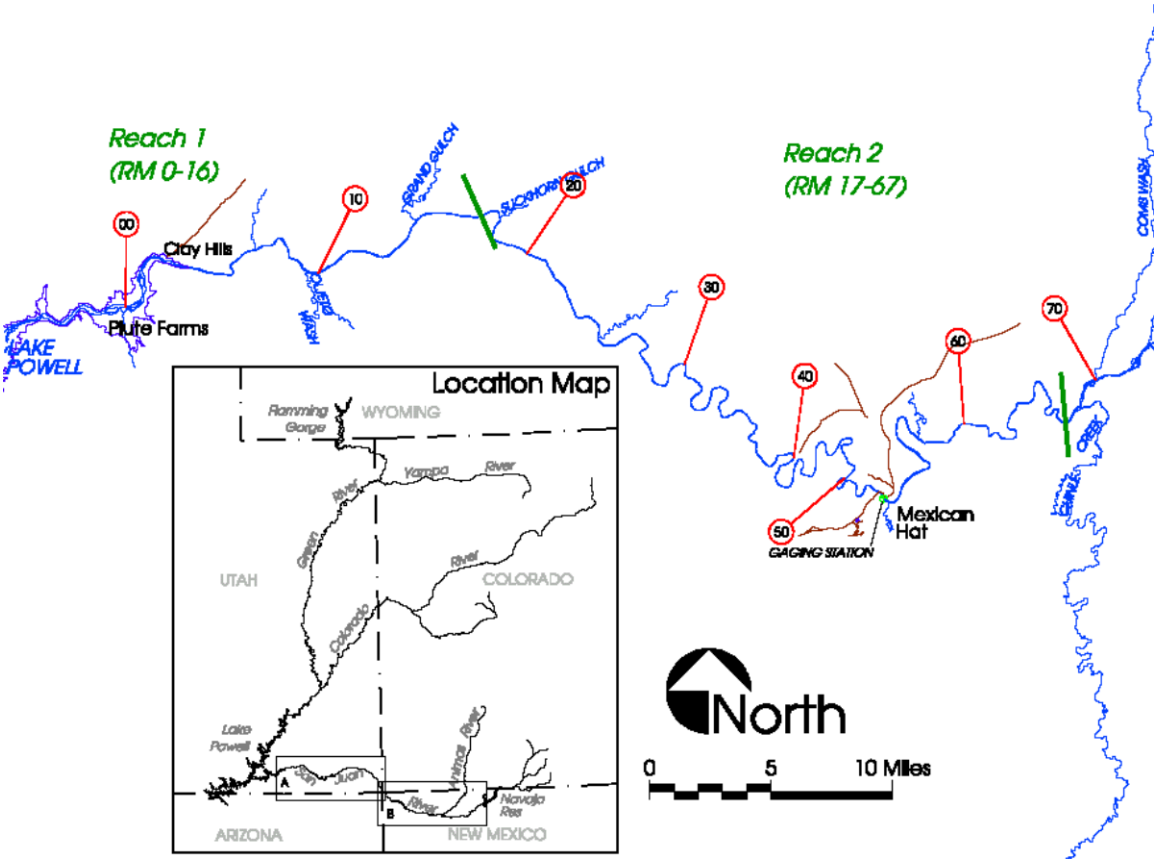


Figure 1. Map of the study area for nonnative fish control in the lower San Juan River. Sampling area extends from Mexican Hat to Clay Hills.

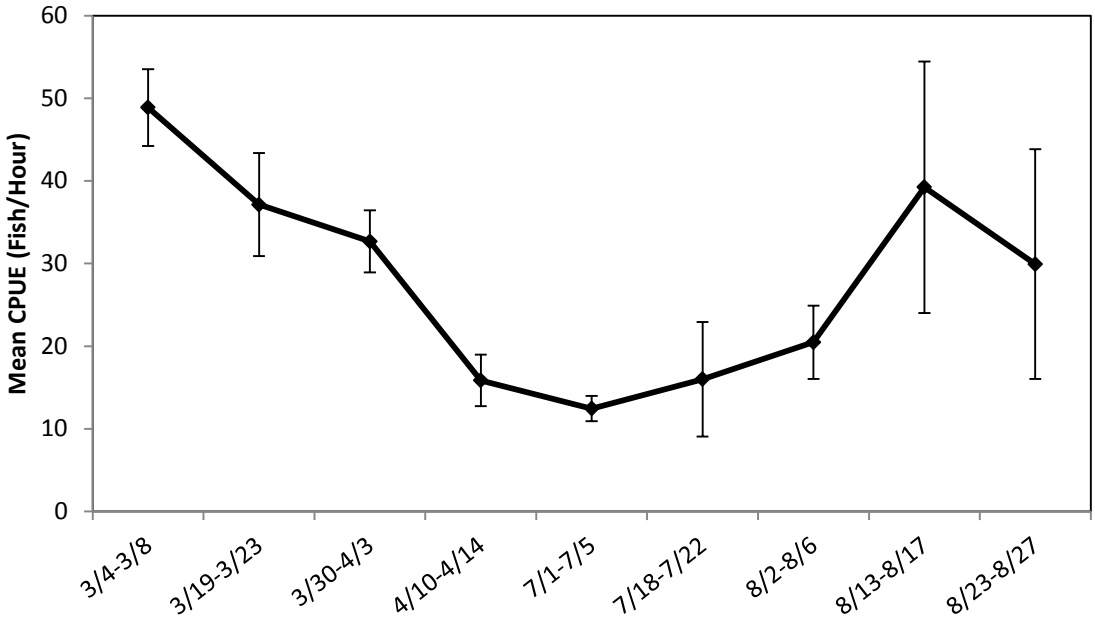


Figure 2. Mean electrofishing catch-per-unit-effort of channel catfish in the lower San Juan River by pass in 2013. Error bars represent ± 1 standard error.

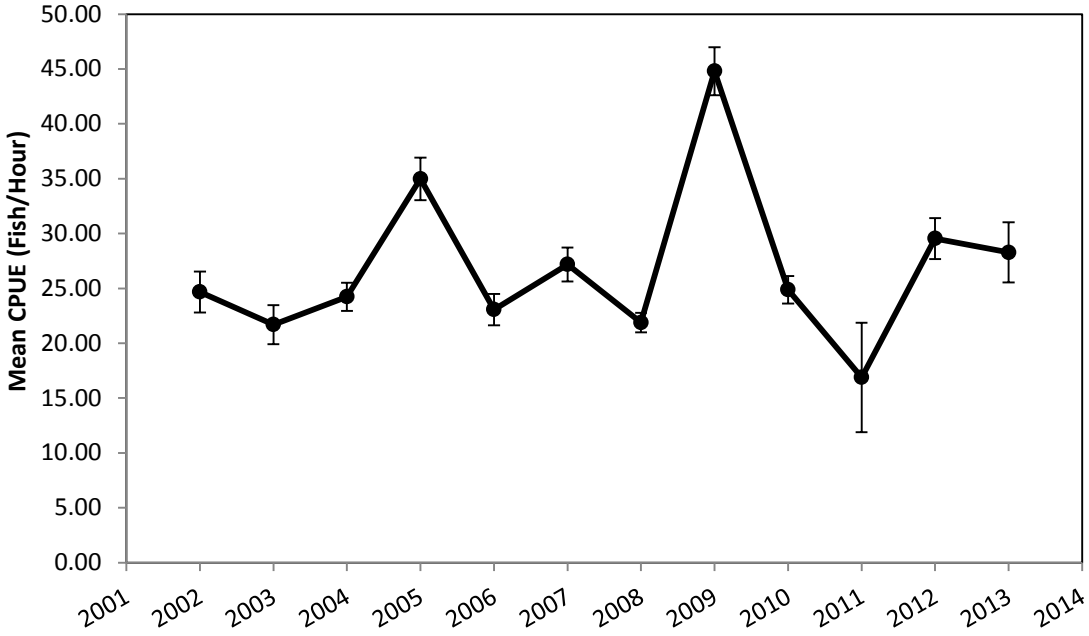


Figure 3. Mean electrofishing catch-per-unit-effort of channel catfish in the lower San Juan River from 2002 to 2013. Error bars represent ± 1 standard error.

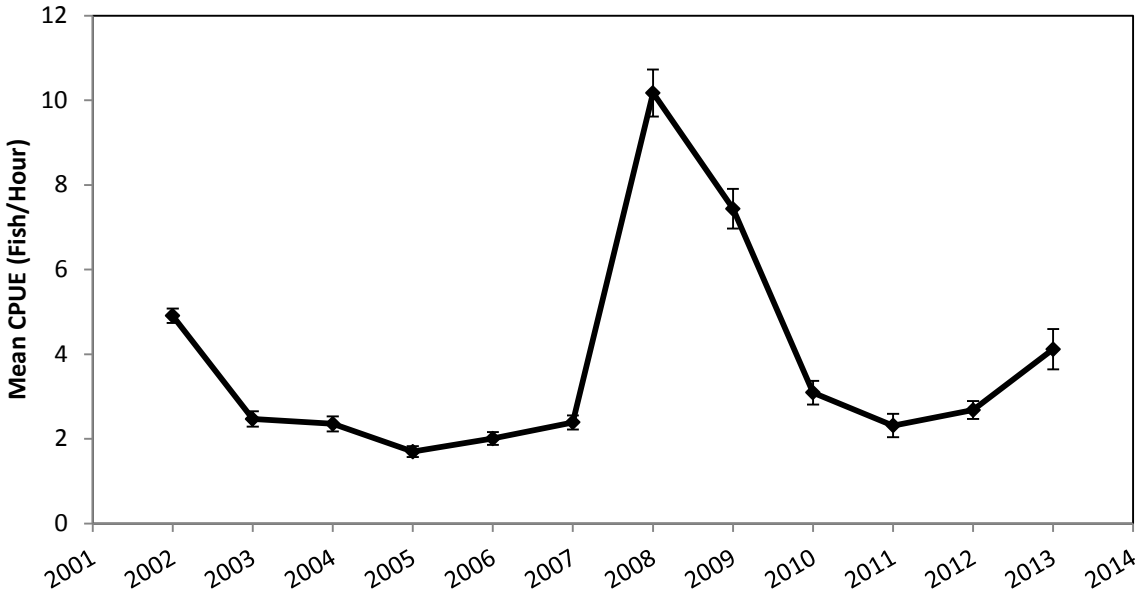


Figure 4. Mean electrofishing catch per unit effort of adult (>300 mm TL) channel catfish in the lower San Juan River from 2002 to 2013. Error bars represent ± 1 standard error.

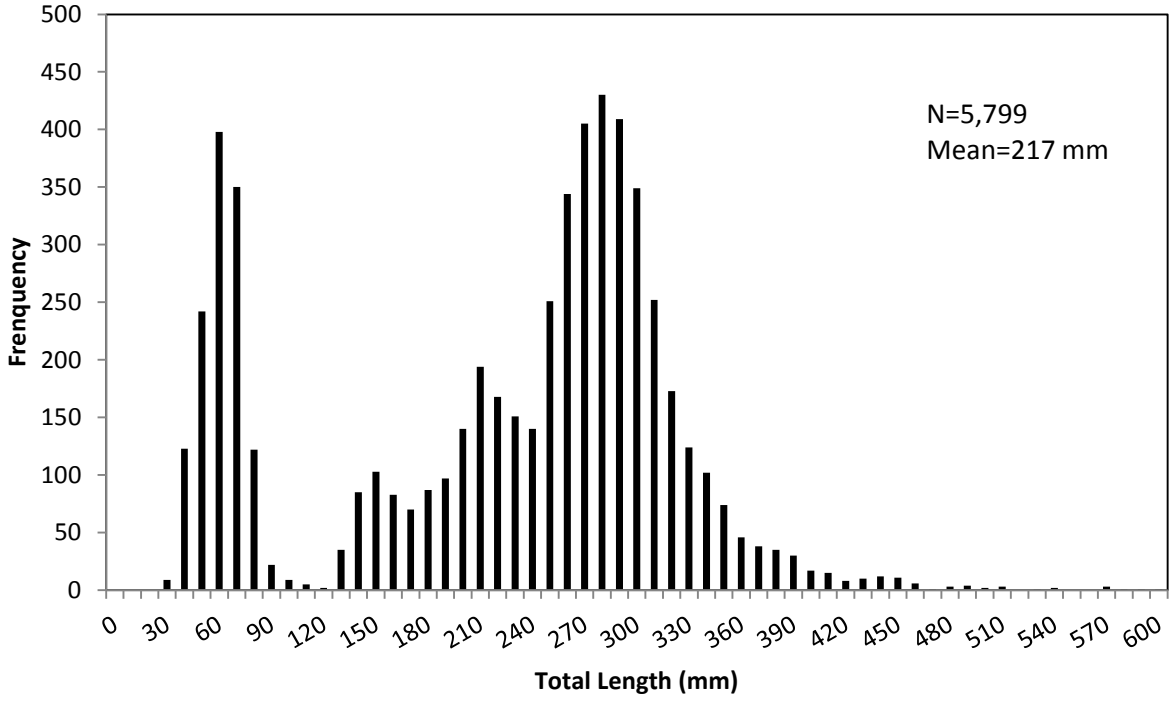


Figure 5. Length-frequency histograms of channel catfish in the lower San Juan River in 2013.

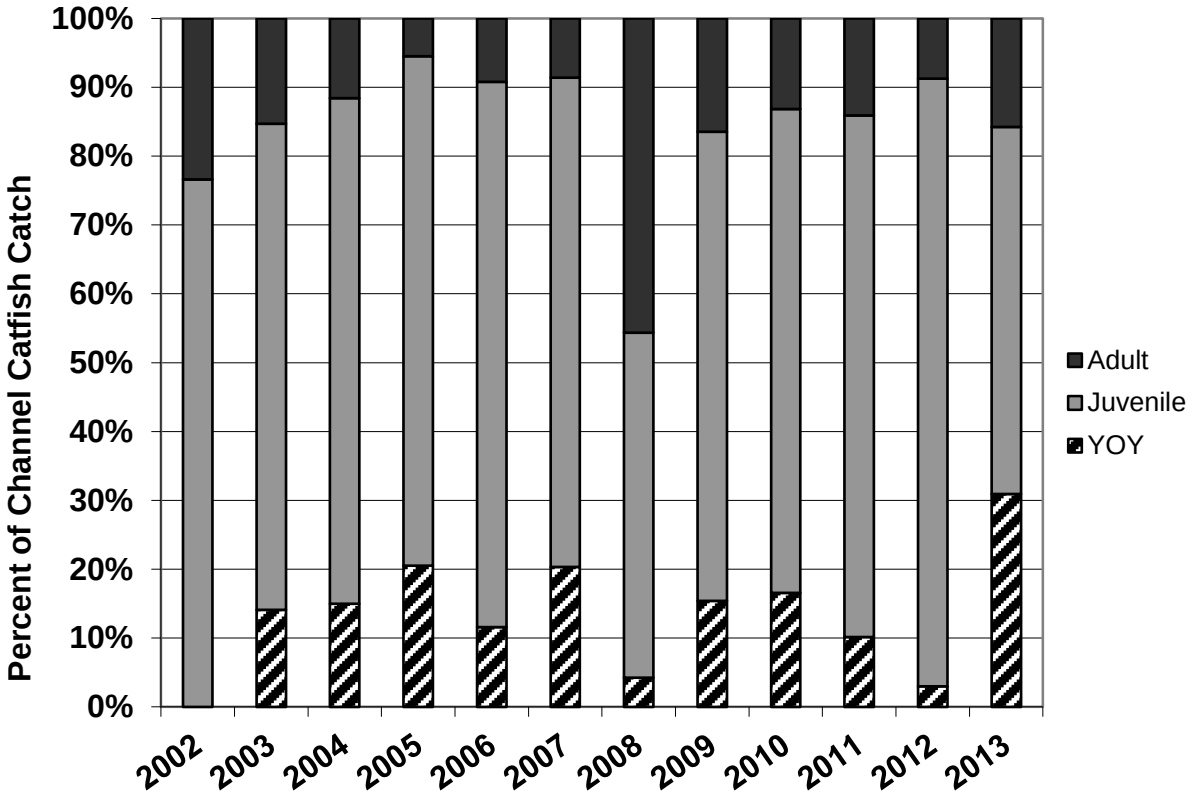


Figure 6. Percent of each life stage of channel catfish in the total channel catfish catch from 2002 to 2013. Note: YOY and juveniles life stages were not differentiated in 2002.

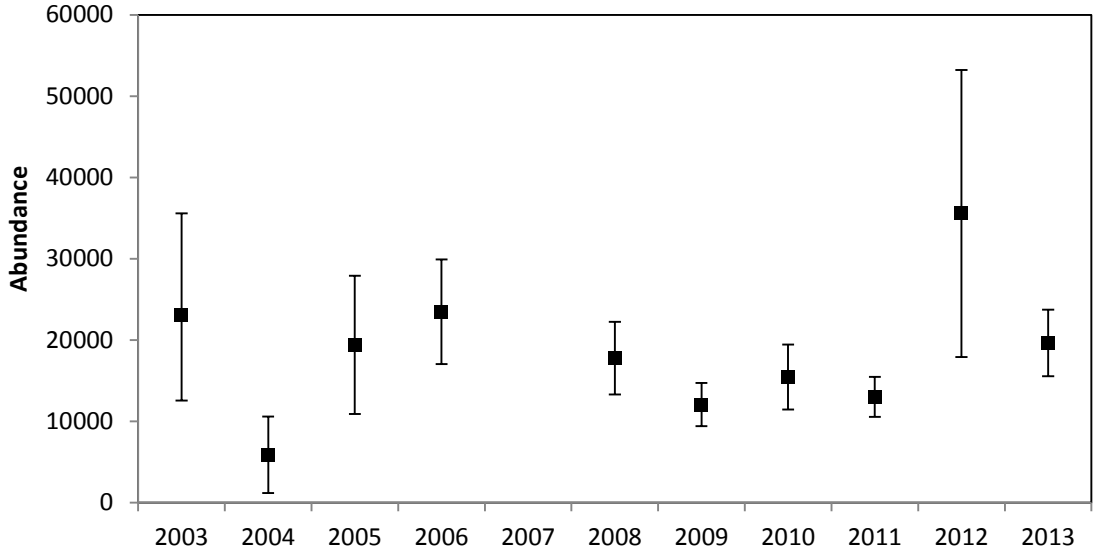


Figure 7. Abundance estimates for channel catfish from 2003 to 2013 in the lower San Juan River. Error bars represent 95% confidence intervals. Abundance estimates were calculated using the Lincoln-Peterson estimator with Chapman's correction.

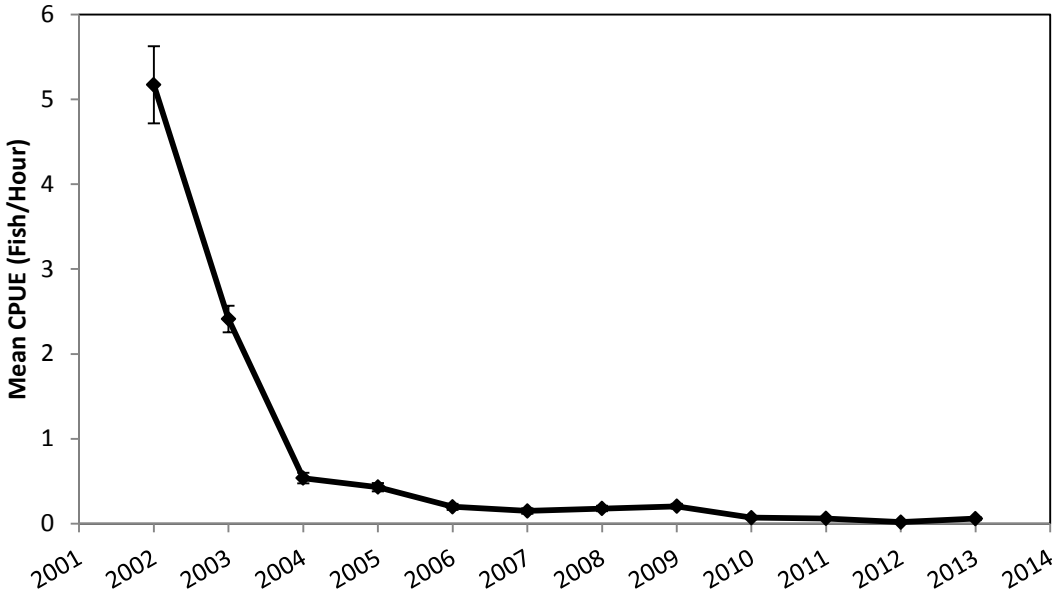


Figure 8. Mean electrofishing catch-per-unit-effort of common carp from 2002 to 2013 in the lower San Juan River. Error bars represent ± 1 standard error.

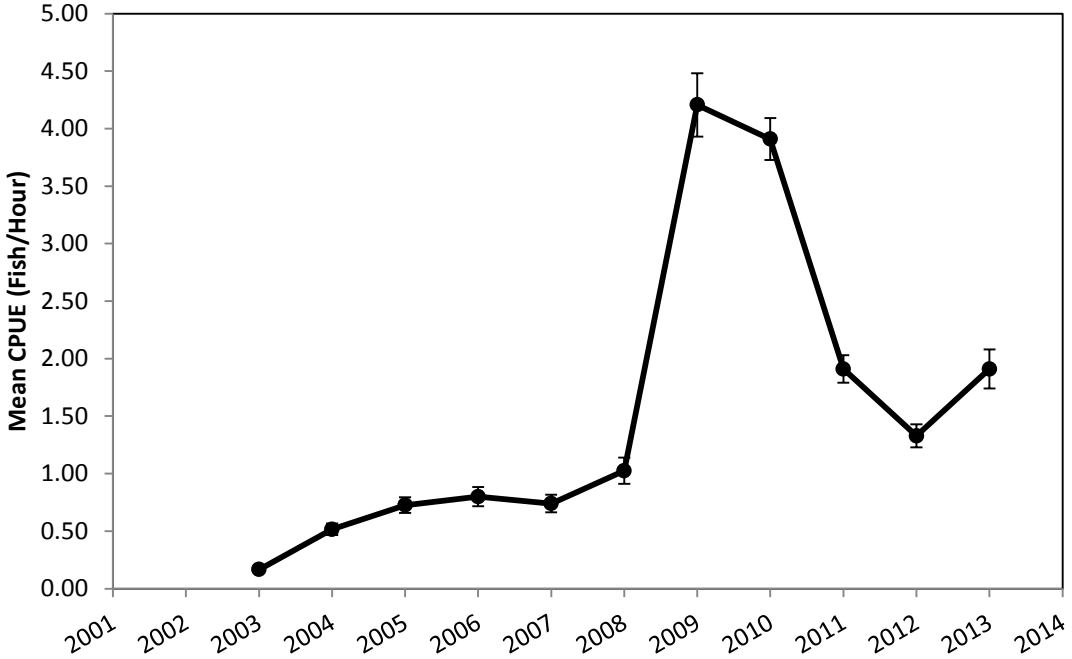


Figure 9. Mean electrofishing catch-per-unit-effort of Colorado pikeminnow in the lower San Juan River from 2003 to 2013. Error bars represent ± 1 standard error.

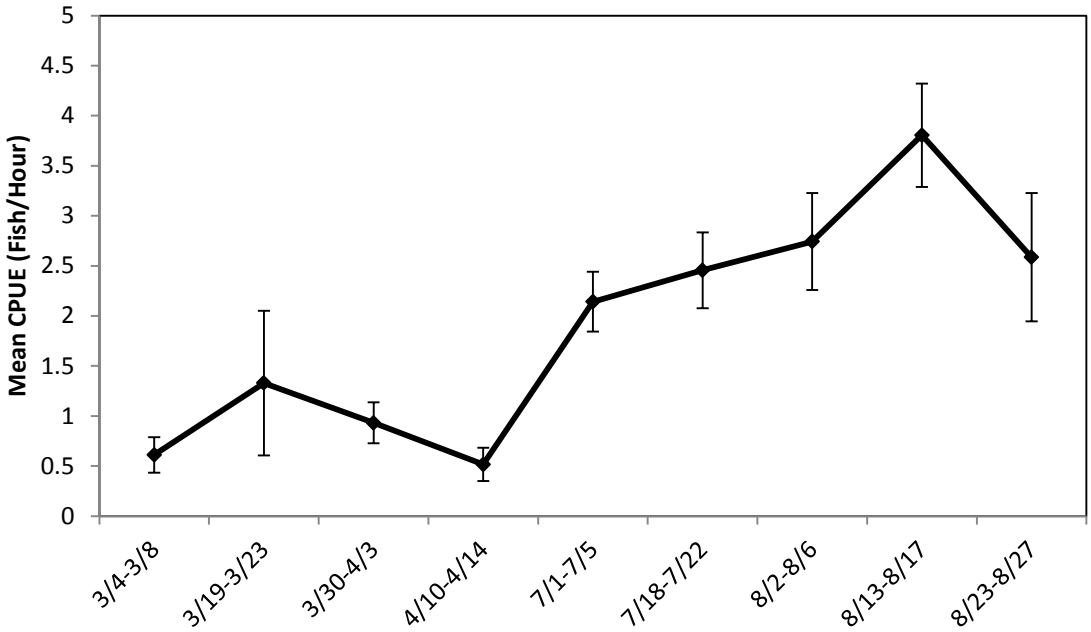


Figure 10. Mean electrofishing catch-per-unit-effort of Colorado pikeminnow by pass in the lower San Juan River during 2013. Error bars represent ± 1 standard error.

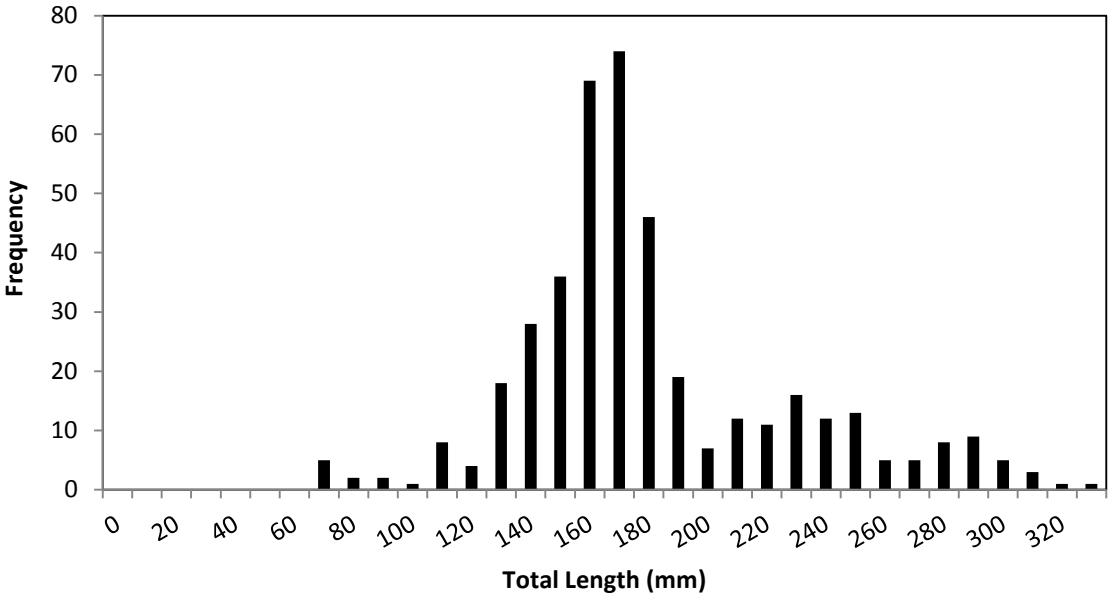


Figure 11. Length-frequency histogram of Colorado pikeminnow in the lower San Juan River during 2013.

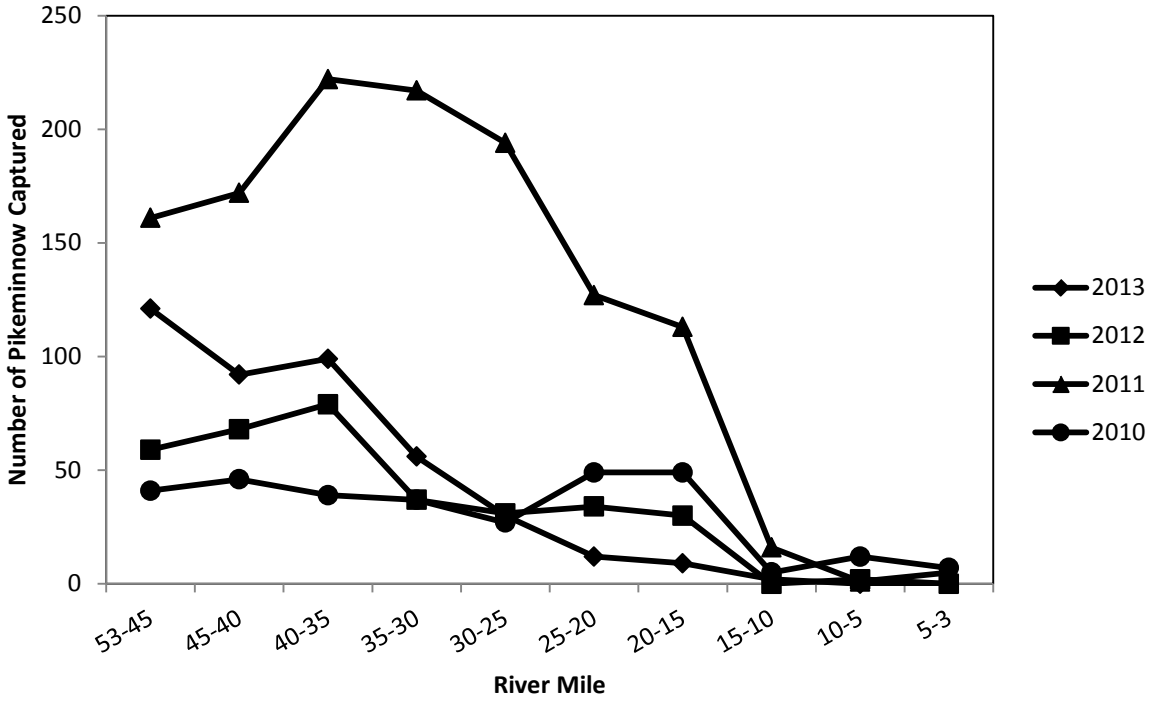


Figure 12. Distribution of Colorado pikeminnow captures by river mile from 2010 to 2013 in the lower San Juan River.

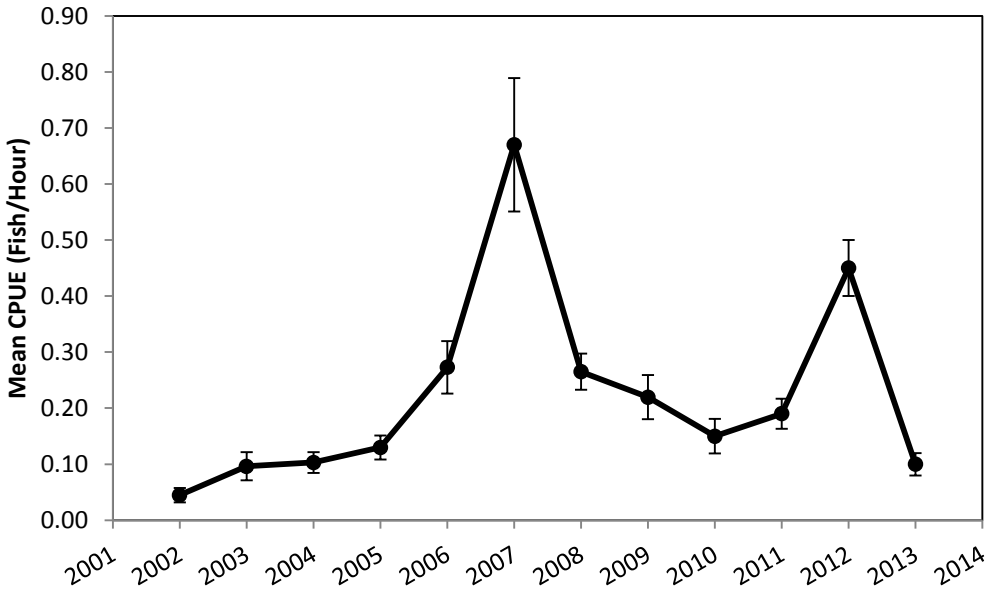


Figure 13. Mean electrofishing catch per unit effort of razorback sucker in the lower San Juan River from 2002 to 2013. Error bars represent ± 1 standard error.

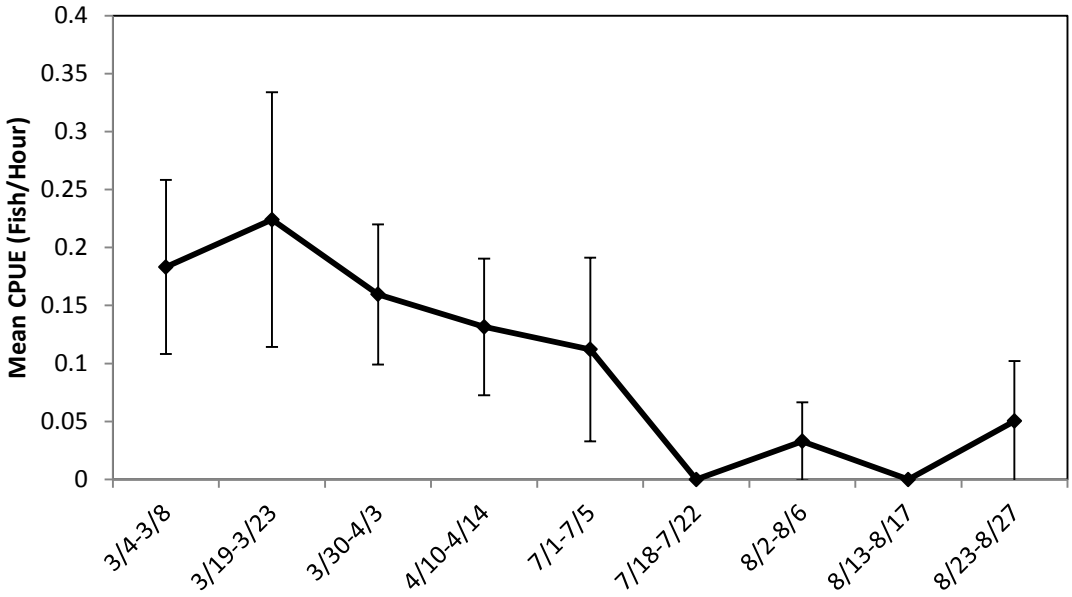
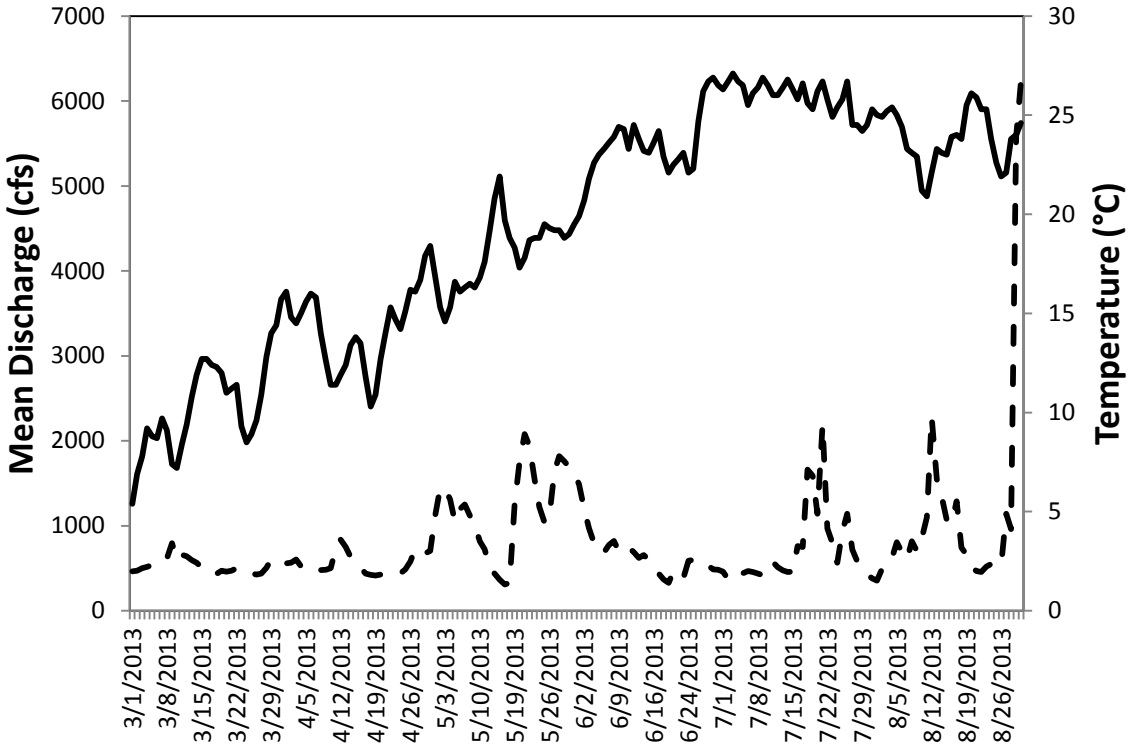
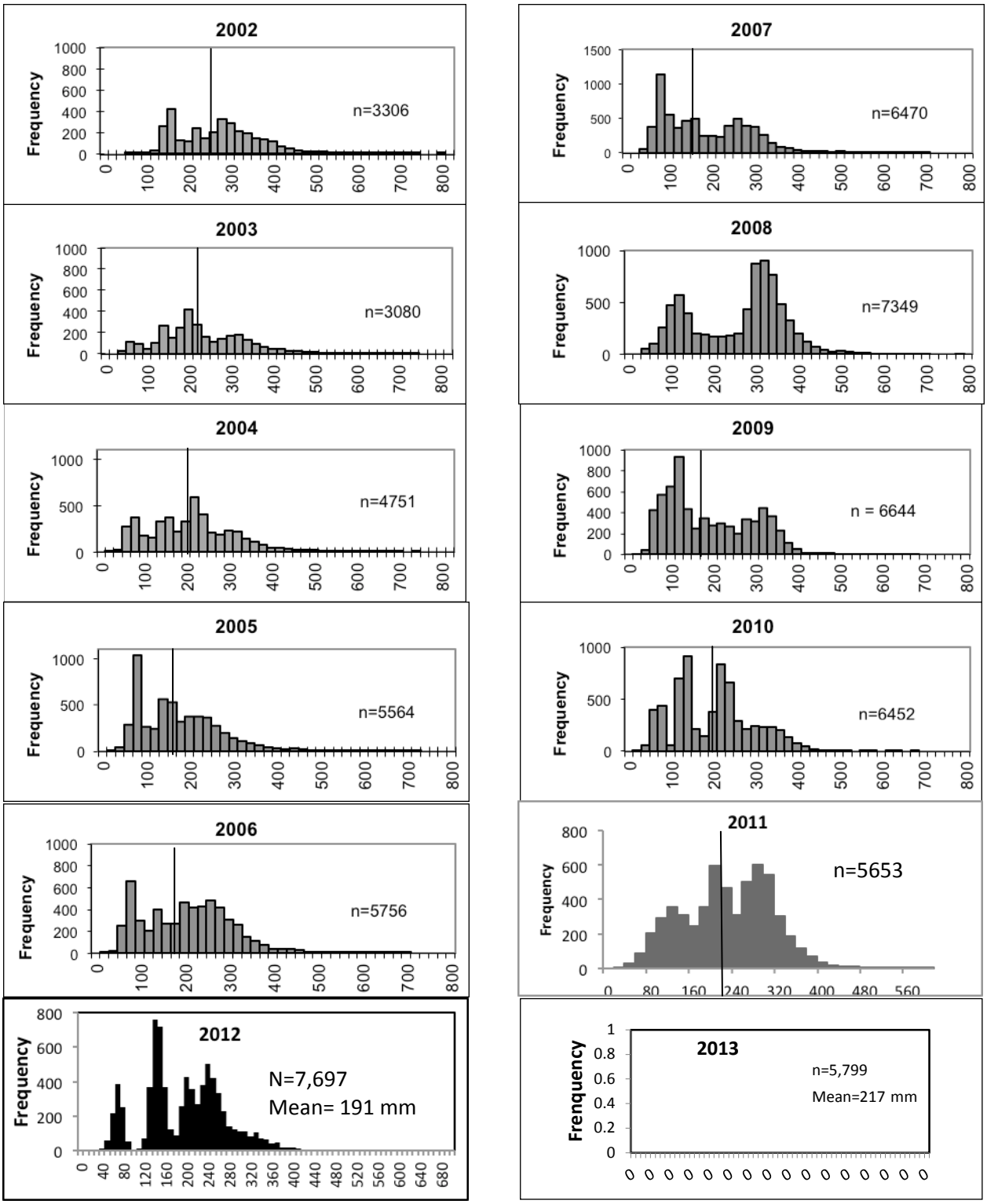


Figure 14. Mean electrofishing catch per unit effort of razorback sucker by pass in the lower San Juan River in 2013.

Appendix A. Average daily flow (USGS gage 09379500 near Mexican Hat, Utah), average water temperature, average specific conductivity, and average turbidity (mm to Secchi disk disappearance) during sampling trips on the lower San Juan River in 2013.

	Temp	Discharge	Spec C	Turbidity (mm)
3/4-3/8	9.1	573.8	842	333
3/19-3/23	10.98	474.4	896	211
3/30-4/3	15.1	585.2	692	219
4/10-4/14	12.1	691.8	763	360
7/1-7/5	26.66	414.2	455	1
7/18-7/22	25.92	1509.4	843	12.5
8/2-8/6	24.98	626.8	622	10.2
8/13-8/17	23.46	1258	655	1
8/23-8/27	23.14	656	911	27.3

Appendix B. Average daily flow (dashed line) and temperature (solid line) (USGS gage 09379500 near Mexican Hat, Utah) during the 2013 field season on the lower San Juan River.



Appendix C. Length-frequency histograms of channel catfish in the lower San Juan River from 2002 to 2013. Vertical lines indicate mean TL by year.