ANNUAL REPORT
SMALL-BODIED FISHES MONITORING
SAN JUAN RIVER
September – October 2011

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San Juan River Basin Recovery Implementation Program

ANNUAL REPORT
SMALL-BODIED FISHES MONITORING

SAN JUAN RIVER

to

Bureau of Reclamation

From

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EXECUTIVE SUMMARY

During 2011 small-bodied fishes autumn monitoring, 62 Colorado pikeminnow *Ptychocheilus lucius* were captured in near-shore primary channel habitats, secondary channels, and backwaters. Colorado pikeminnow were about equally common among sampled primary channel mesohabitats. In secondary channels, Colorado pikeminnow were more frequent in run type habitats. Most captures of Colorado pikeminnow occurred in Reaches 5 and 6. The size range of fish was 92-362mm (total length, TL).

Roundtail chub *Gila robusta* was the only other rare species collected during the 2011 small-bodied monitoring. A single age-0 fish was captured at river mile (RM) 98.7, slightly downstream of McElmo Creek. Colorado Division of Parks and Wildlife stocked age-0 roundtail chub in the upper portions of the creek; consequently, it is possible this individual was stocked. This is the first collection of roundtail chub on the San Juan River by small-bodied monitoring since 1998. No razorback sucker *Xyrauchen texanus* were captured in 2011 during small-bodied monitoring.

Although Colorado pikeminnow occur river-wide, there is variation among years and differences among geomorphic reaches and channel types. Analysis of the distribution of Colorado pikeminnow in the San Juan River since 2004 showed that Colorado pikeminnow were most abundant in Reach 5. More Colorado pikeminnow were captured in secondary channels than in the primary channel or backwaters.

In 2011, five native (including rare species) and nine nonnative fish species were collected during small-bodied monitoring. Although more species of nonnative fishes were collected than native species, native fishes were more abundant than nonnative fishes. Densities of common native fishes and channel catfish *Ictalurus punctatus*

remained similar across years whereas densities of red shiner *Cyprinella lutrensis* and fathead minnow *Pimephales promelas* have remained low since in 2005.

The abundance of common native and nonnative fishes differed among river reaches and channel types. Since 2006 native species represented between 50-100% of the fishes in Reaches 5 and 6 with the exception of Reach 5 in 2011. Since 2004, ≤ 30% of the catch in Reaches 1 and 2 consisted of native fishes. Red shiner was the most abundant nonnative species in secondary channels with the exception of 2007 and 2011 when channel catfish took this position in 2011. Densities of speckled dace *Rhinichthys osculus* and red shiner (2003-2011) did not differ among channel types.

Time-lag regression analyses were used to determine if there was a relationship between age-0 channel catfish captured during small-bodied monitoring and subsequent capture of channel catfish by sub-adult/adult monitoring. A significant relationship was observed between the proportions of age-0 and juvenile catfish captured but not between the proportions of age-0 and adult catfish captured.

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INTRODUCTION

The San Juan River Basin Recovery Implementation Program's (SJRIP) Long-Range Plan (Section 4.1) specifies that the fish populations of the San Juan River will be monitored using a standardized monitoring protocol (Goal 4.1.1). Thus, the SJRIP formalized the Monitoring Plan and Protocols (Plan and Protocols) to standardize the monitoring program (SJRIP 2011). The efforts and results communicated in this report accomplish the objective of the Plan and Protocols to document annually the relative density of native and nonnative small-bodied fishes in the San Juan River.

Annual autumn sampling of shallow-water habitats provides information on fishes that occur in these habitats in relation to recovery progress of Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus*. As such, autumn monitoring of small-bodied and age-0 fishes of the San Juan River characterizes survival and/or recruitment of Colorado pikeminnow and razorback sucker. Recruitment of wild-spawned Colorado pikeminnow or razorback sucker has yet to be documented. Therefore, autumn small-bodied monitoring currently provides information on the survival of stocked age-0 and age-1+ Colorado pikeminnow and habitat used by these individuals as well as data on the relative abundance of the greater San Juan native/nonnative fish assemblage.

Small-bodied and age-0 fishes numerically dominate the San Juan River fish assemblage. These fishes are an important component of the diet of piscivorous fishes in the San Juan River (Franssen et al. 2007, 2012). This is especially true for young Colorado pikeminnow whose ontogenic shift to piscivory may affect their recruitment probability as shown for other species of predatory fishes (Garvey and Stein 1998;

Persson and Brönmark 2002). Nonnative small-bodied and age-0 large-bodied, as well as some native fishes, may prey upon or compete with young Colorado pikeminnow (Franssen et al. 2007, 2012; Pilger et al. 2008). Thus, monitoring the status and habitat use by potential Colorado pikeminnow prey and competitors/predators of both age-0 Colorado pikeminnow and razorback sucker is critical to ensuring recovery of Colorado pikeminnow and razorback sucker.

METHODS

In 2011, monitoring occurred from the confluence of the San Juan-Animas , river mile 180 (RM) in Reach 6, to Sand Island (RM 76.4, Reach 3). Previously (since 1998), autumn monitoring occurred from the San Juan-Animas Rivers' confluence downstream to Clay Hills Crossing (RM 3.0, Reach 1). As of 2011, autumn monitoring only occurs downstream from Sand Island (RM 76.4, Reach 3) to Clay Hills Crossing every fifth year; the next effort in this reach will be in 2015.

In 1998, a secondary channel was sampled only if it occurred within the 1-mile reach to be sampled at every 3-mile interval (designated mile). This protocol excluded a large proportion of secondary channels (30 to 50%, depending upon the starting point of the designated mile). Beginning in 2000, attempts were made to sample all secondary channels >200m in length and having surface water. The abundance of secondary channels in certain reaches precludes sampling of all secondary channels.

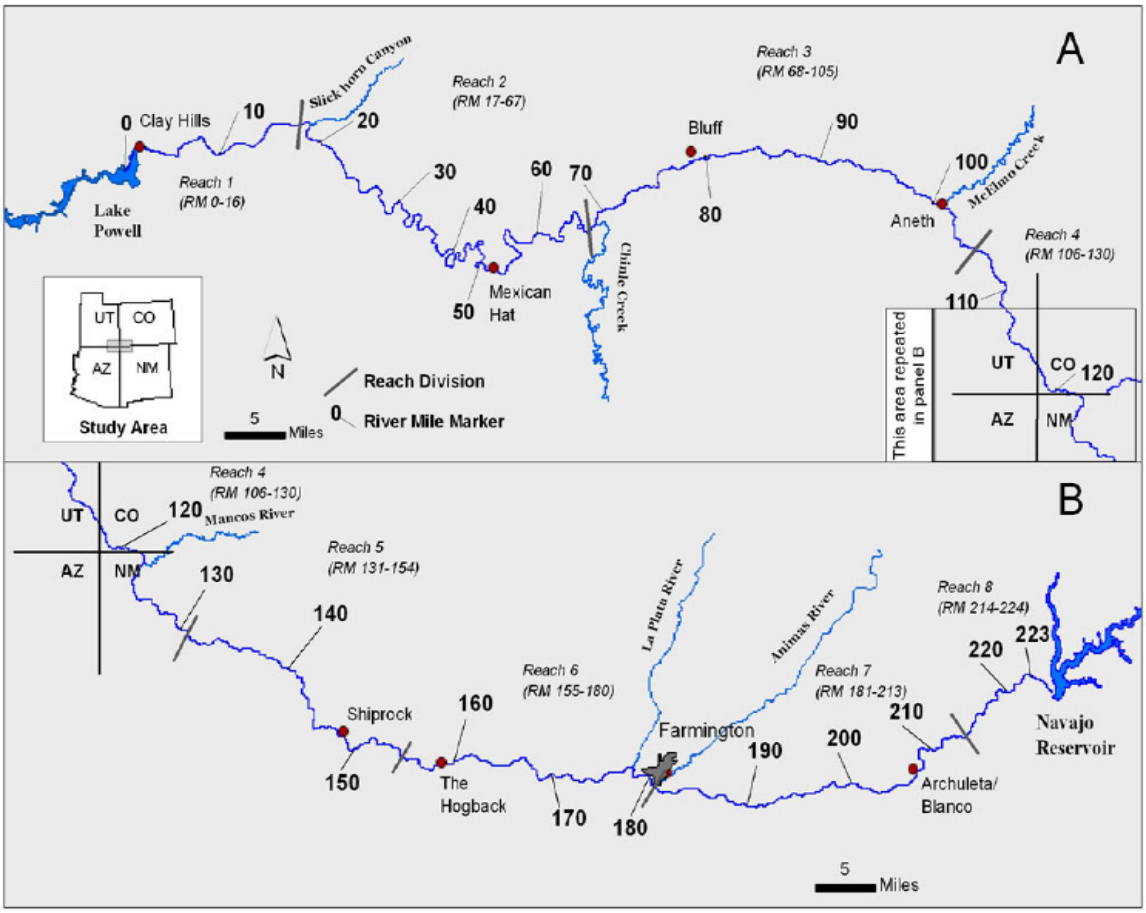

Figure 1. Map of the San Juan River. Study area begins at the confluence of the Animas River near Farmington, NM downstream to Clay Hills Crossing, UT.

In 1998, the primary channel was sampled at each sampled secondary channel or designated mile if no secondary channel was present in a 3-mile reach. Since 2000, fishes were collected from primary channel habitats at each designated mile whether or not a secondary channel was present. Small-bodied monitoring occurs in conjunction with sub-adult/adult monitoring and designated miles were coordinated to occur in miles

that were skipped by the sub-adult/adult monitoring crews. All backwaters (>50m^2), regardless of occurrence within a designated mile, were sampled.

Primary channel sample sites were about 200m long (measured along the shoreline). Lengths of secondary channel sample sites varied depending upon extent of surface water but were normally 100-200m. River mile, GPS readings (UTM NAD83), and water quality information (pH, dissolved oxygen, conductivity, and temperature) were recorded for each site. Within each site (primary and secondary channel), all mesohabitats (see Bliesner and Lamarra 2000 for definitions) present were sampled in rough proportion to their surface area within a site. Beginning in 2003, data (including fishes collected) from each sampled mesohabitat within a site were recorded separately.

Most primary channel mesohabitats sampled were along stream margins, but off-shore riffles and runs (<0.75 m deep) were also sampled. Secondary channel sampling was across the breadth of the wetted channel. All available wadeable mesohabitats within a site were sampled. Uncommon mesohabitats (e.g., debris pools and backwaters) were sampled in greater proportion to their availability than common mesohabitats (e.g., runs).

All mesohabitat types available at a site are sampled. At least five seine hauls (each seine haul samples a distinct mesohabitat) were made at each sample site; however, if habitat was homogeneous, as few as four seine hauls in the primary channel or three seine hauls in secondary channels were made. Where there was high habitat diversity, as many as 14 seine hauls in the primary channel and eight seine hauls in secondary channels were made. Typically, two seine hauls were made in each backwater, one near its mouth and the second in its upper half and parallel to the long axis of the backwater.

In backwaters that were not large enough to make two seine hauls, one seine haul was pulled from the mouth, parallel to the long axis of the backwater to the point where water was no longer present.

Fishes were collected with a drag seine (3.05m x 1.83m, 3.2mm mesh). Each catch was inspected to determine presence of protected species and other native fishes. Total length (TL) of each native fish was measured, recorded, and the fish released. In some years, subsamples of >50 individuals of each fish species, chosen to approximate the proportion of sizes present, were measured for each seine haul; the remainder were counted and released. Nonnative fishes and fishes too small to identify were fixed in 10% formalin and returned to the laboratory.

Following fish collection, the area (length x width) of each sampled mesohabitat was measured and recorded. For each mesohabitat, habitat type, depth in five generalized locations, and dominant substrate at each depth measurement was recorded. Any cover associated with the habitat was also recorded.

Retained specimens were identified, enumerated, and measured (total and standard length) in the laboratory. Personnel of the University of New Mexico Museum of Southwestern Biology (UNM-MSB), Division of Fishes, assisted in verification of fishes identified in the laboratory. All retained specimens were accessioned to the UNM-MSB, Division of Fishes.

In 2007 and 2008, concentrated sampling (hereafter referred to as intense sampling) for Colorado pikeminnow occurred in addition to autumn small-bodied monitoring (Bliesner et al. 2008, 2009). These samples were taken at particular and singular river miles where complex habitat was present (Bliesner and Lamarra 2007). To

make the comparisons among the Colorado pikeminnow mean catch per unit effort (CPUE) determined by intense sampling (2007 and 2008) and small-bodied monitoring (2004-2011), CPUEs were calculated by river mile.

Mean sample catch per unit effort was calculated as the average of individual seine haul (sample unit) CPUEs. In this report, density refers to mean CPUE and is the number of fish captured per m^2. Mean CPUE was plotted to compare the densities of common native and nonnative fishes in the San Juan River among years and channel types.

The Kruskal-Wallis test was used to determine if there were differences in Colorado pikeminnow density among geomorphic reaches (as defined by Bliesner and Lamarra 2000) and among channel types ($p < 0.10$). Non-parametric tests were used due to non-normal data and unequal variance (Shapiro-Wilks test among geomorphic reaches and among channel types $p < 0.000$). The Mann-Whitney U was used for pairwise comparisons with alpha adjusted using a Bonferroni correction.

To determine presence of Colorado pikeminnow within various mesohabitats, mesohabitats were grouped into general categories (shoal, run, riffle, pool, eddy, and backwater). The percentages in which Colorado pikeminnow were captured in each mesohabitat (2004-2011) was then graphed. To investigate the use of mesohabitats by Colorado pikeminnow in 2011, the percentage in which each mesohabitat was sampled was plotted against the percentage of Colorado pikeminnow captured within each mesohabitat and differences calculated.

Time-lag linear regression analyses were used to test for relationships between the proportion of channel catfish *Ictalurus punctatus* captured in small-bodied monitoring

and the proportion of juvenile and adult catfish collected in the sub-adult/adult monitoring. The plots of residuals versus predicted values showed the data met the assumptions of linearity and constant variance. Normal probability plots showed the data met the assumption that errors were normally distributed.

Since the two monitoring programs use different sampling methods, proportions of channel catfish rather than relative density (i.e. CPUE), were used for the regression analysis. Given that small-bodied species dominate small-bodied sampling, captures of the eight most common large-bodied fish species were used when calculating proportions (channel catfish, bluehead sucker *Catostomus discobolus*, flannelmouth sucker *Catostomus latipinnis*, razorback sucker, Colorado pikeminnow, black bullhead *Ameiurus melas*, yellow bullhead *Ameiurus natalis*, and common carp *Cyprinus carpio*). Channel catfish >100mm were excluded from the small-bodied data set for these analyses. Data for juvenile and adult fish was obtained from the sub-adult/adult monitoring project (Ryden 2000-2011).

Shapiro-Wilk and Levene tests were performed using SYSTAT ® software. Kruskal-Wallis and Mann-Whitney U tests were performed using SPSS ® software. Residual and normal probability plots and linear regressions were computed using Microsoft Excel 2010. Due to the natural variability seen with age-0 fish populations, probability values of ≤0.10 were considered significant (Brown and Guy 2007). Data for all years (1998-2011) are available from the U.S. Fish and Wildlife Service Program office, Albuquerque, NM.

RESULTS

RIVER-WIDE SUMMARY

Slightly >50% of the fishes captured during autumn small-bodied monitoring in 2011 were native (Table 1). The total number of fishes captured in 2011 was low compared to the prior 10 years and was about half that of the 10-year mean. The total capture of nonnative fishes in 2011 was 34% less than the prior 10 years (2001-2010). For native fishes, the total captured in 2011 was greater than the 10-year mean. More Colorado pikeminnow were captured in 2011 (N = 62) compared to previous years (2001-2010). Razorback suckers were not collected during the 2011 small-bodied fish monitoring. A single roundtail chub *Gila robusta* (55mm TL) was captured 1.3 river miles downstream of the confluence of McElmo Creek and the San Juan River, Utah (RM 98.7).

Table 1. Summary of fish captures in the San Juan River 2011 small-bodied fish monitoring effort.

	2011	**2001- 2010 Mean**	**2001 – 2010 Range**
Total Fishes	5,428	10,097	3,795 – 29,778
Native Fishes	2,958	2861	704 - 6,844
Non-native Fishes	2,479	7236	787 - 22,934
Colorado Pikeminnow	62	22	0-59
Razorback sucker	0	0	0-1
Roundtail chub	1	0	0

COLORADO PIKEMINNOW

Total Captures by Reach and Length: 2011

In 2011, Colorado pikeminnow capture was greatest in Reach 5 (N = 34) (Table 2) and these fish ranged in size from 96-362mm TL. The size range of fishes captured in Reach 6 was somewhat narrower (106-242mm TL). Captures in Reaches 6, 4, and 3 resulted in a total of 17, 8, and 3 Colorado pikeminnow, respectively. No fish <130mm TL was captured in Reaches 3 or 4 (Table 2). Reaches 1 and 2 were not sampled in 2011.

Table 2. Summary of Colorado pikeminnow captures by small-bodied monitoring in the San Juan River, 2011. Reaches 1 and 2 were not sampled in 2011.

Length Category (total length in mm)	Number of Captures in each Reach				
	6	5	4	3	Grand Total
100	2	1			62
110	4	5			
120	3	10			
130	5	2	2		
140	2	7	1		
150		5	1	1	
160		2	1		
170					
180			2		
190					
200					
210					
220					
230		1			
240	1		1		
250					
260					
270				1	
280					
290					
300				1	
//360		1			

Colorado pikeminnow were captured during small-bodied monitoring in each year, except 2001 to 2003 (Appendix I). Colorado pikeminnow captures were typically greatest in Reach 5, with the exception of 2009 where captures were greatest in Reach 4.

Distribution Longitudinally: 2004-2011

The CPUE of Colorado pikeminnow at river miles where capture of this species occurred (2004 – 2011) was plotted to determine longitudinal distribution through time (Figure 2 andFigure 3). Captures in 2004 occurred primarily in the upper reaches of the river but captures in 2005 only occurred in the lowest three reaches (

Figure 2). Captures in years 2006 – 2010, except for 2008, occurred river-wide. In 2008, no Colorado pikeminnow were captured in Reaches 1 and 2. Colorado pikeminnow were distributed throughout all sampled river reaches in 2011. Within the last seven years, the greatest percentage of Colorado pikeminnow captures occurred in Reach 5 (34%).

Intense sampling in the summer of 2007 resulted in a CPUE in Reach 5 (RM 137) lower than any CPUE at river miles where fish were captured in the fall of 2007 (Figure 3b). The opposite occurred in Reach 3 where the 2007 summer intensive sampling CPUE at RM 82 was higher than any other CPUEs determined from fall 2007 small-bodied fish monitoring. In 2008, CPUE rates among river miles and between sampling efforts did not indicate one sampling season or level of intensity provided the greatest CPUE rates (Figure 3).

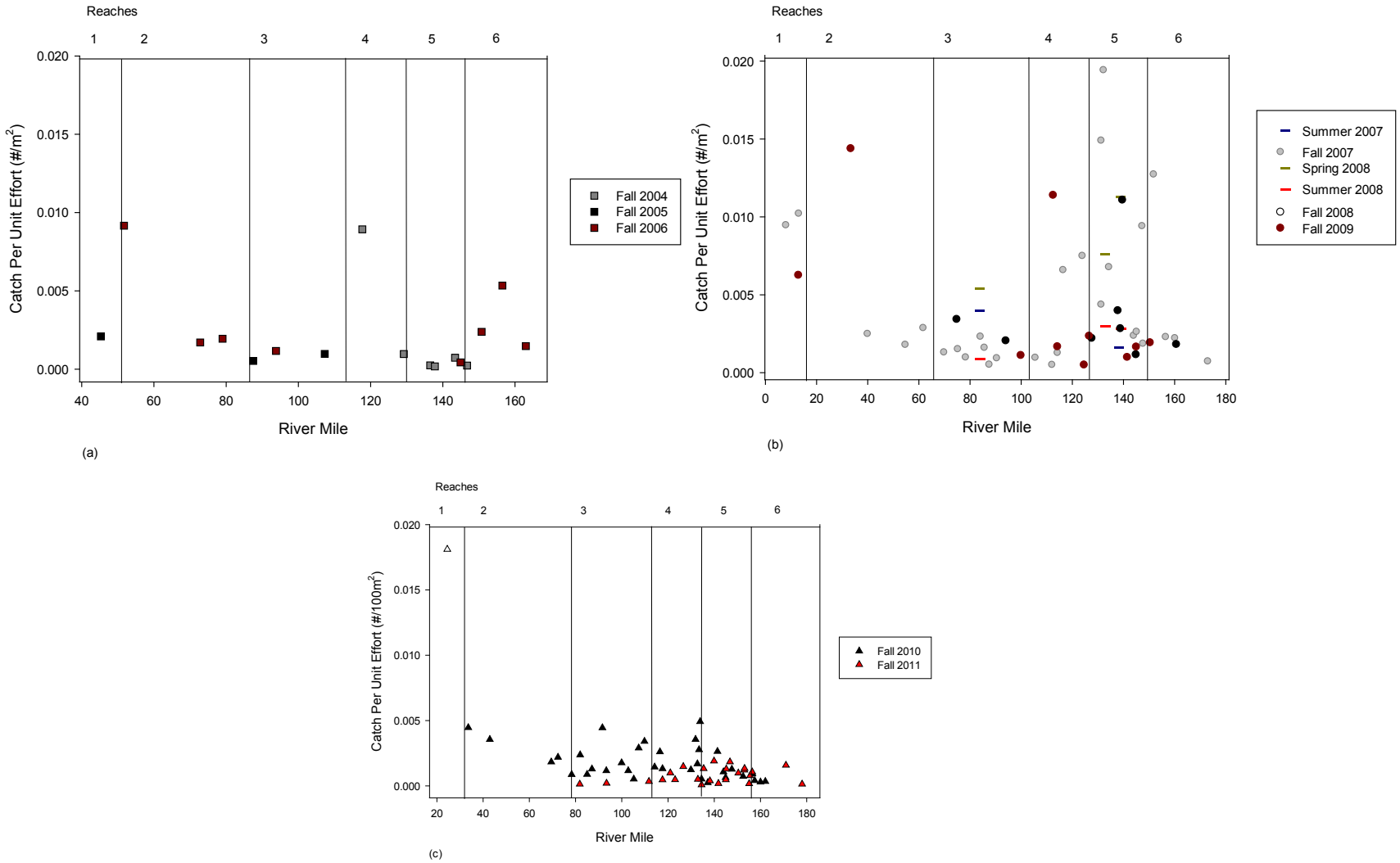

Figure 2. CPUE at river miles in which Colorado pikeminnow were captured during small-bodied monitoring (2004-2011) and intense sampling (2007-2008; denoted by dashes).

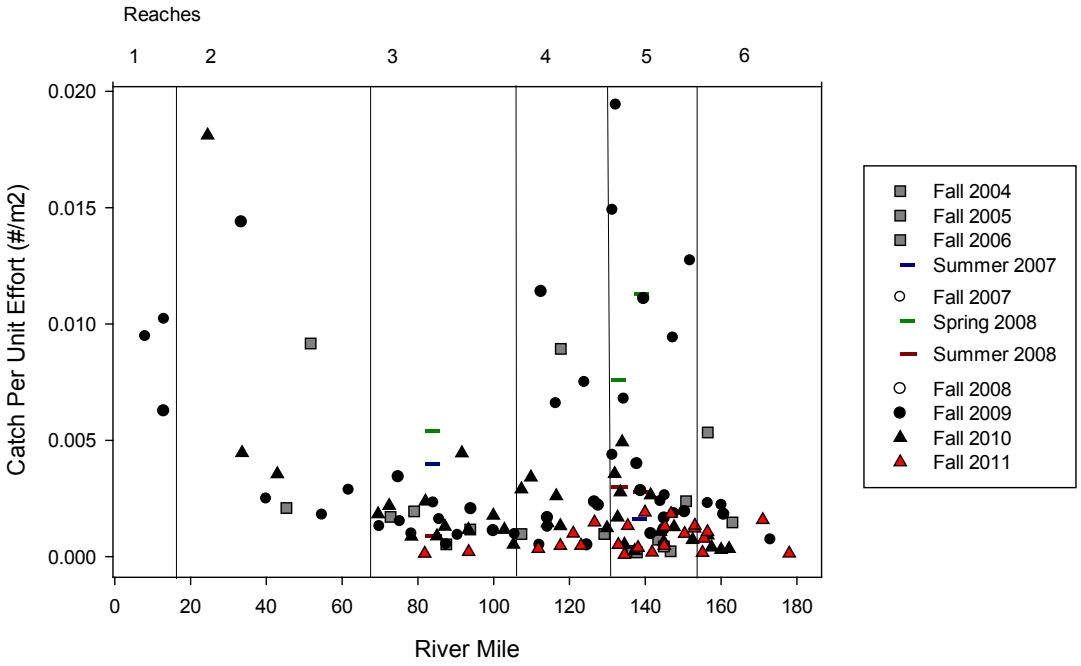

Figure 3. CPUE at river miles in which Colorado pikeminnow were captured during small-bodied monitoring (2004-2011) and intense sampling (2007-2008; denoted by dashes).

Overall, Colorado pikeminnow were captured within all reaches of the San Juan River (**Error! Reference source not found.**). The CPUE for river miles in which fish were captured was generally below 0.005 fish/m^2. The highest single river mile CPUEs were within Reaches 2 and 5.

Distribution among River Reaches: 2004-2011

The density of Colorado pikeminnow captured among reaches was significantly different (Kruskal-Wallis, $p < 0.0001$) (**Error! Reference source not found.**). The CPUE in Reach 5 was significantly greater than all other reaches (Mann-Whitney U, $p < 0.03$). The CPUEs among Reaches 1, 2, 3, 4 and 6 were not different.

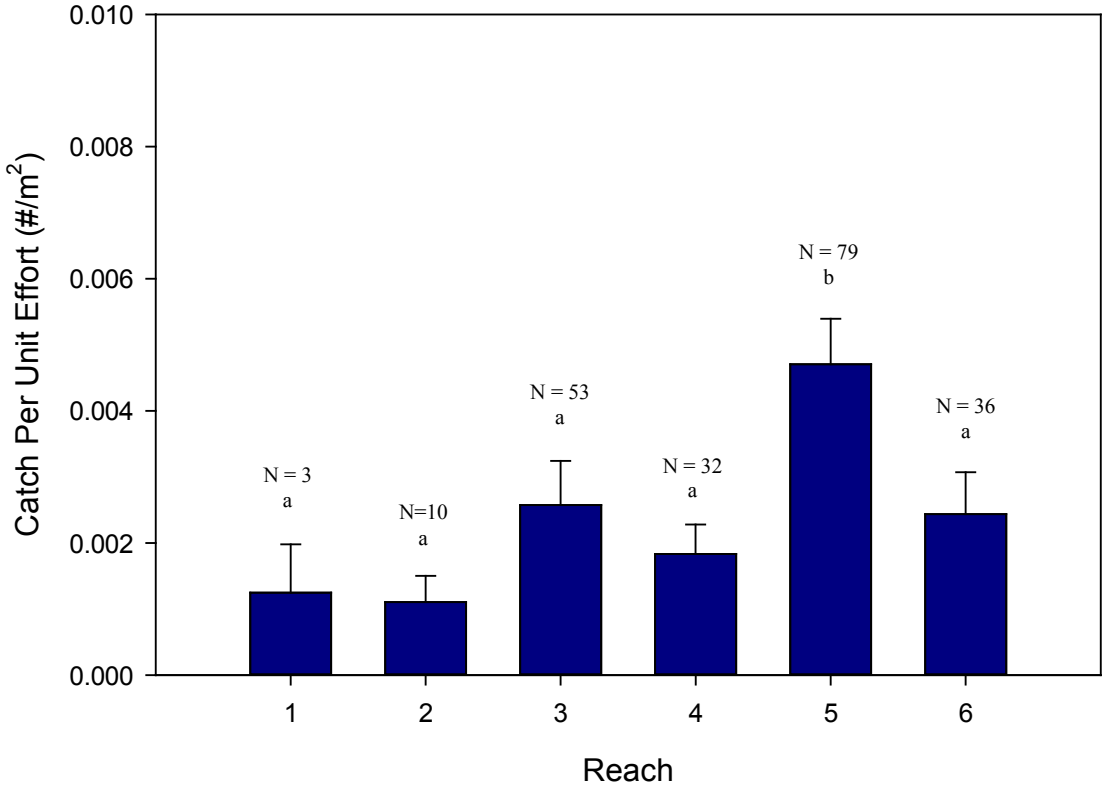

Figure 4. Mean CPUE of Colorado pikeminnow captured among reaches in the San Juan River, 2004-2011 (±1 standard error; N= number of Colorado pikeminnow captured). Reaches sharing the same letter are not significantly different from one another.

Distribution among Channel Types: 2004-2011

The density of Colorado pikeminnow captured among channel types was significantly different (Kruskal-Wallis, p = 0.007) (Figure 5). More Colorado pikeminnow were captured in the primary channel (N = 136) compared with secondary channels (N = 71). Yet, CPUE in the primary channel was significantly lower than secondary channels (Mann-Whitney U, p = 0.003). Significant differences in CPUEs were not observed between the primary channel and backwaters (p = 0.127) or between secondary channels and backwaters (p = 0.965) (Figure 5).

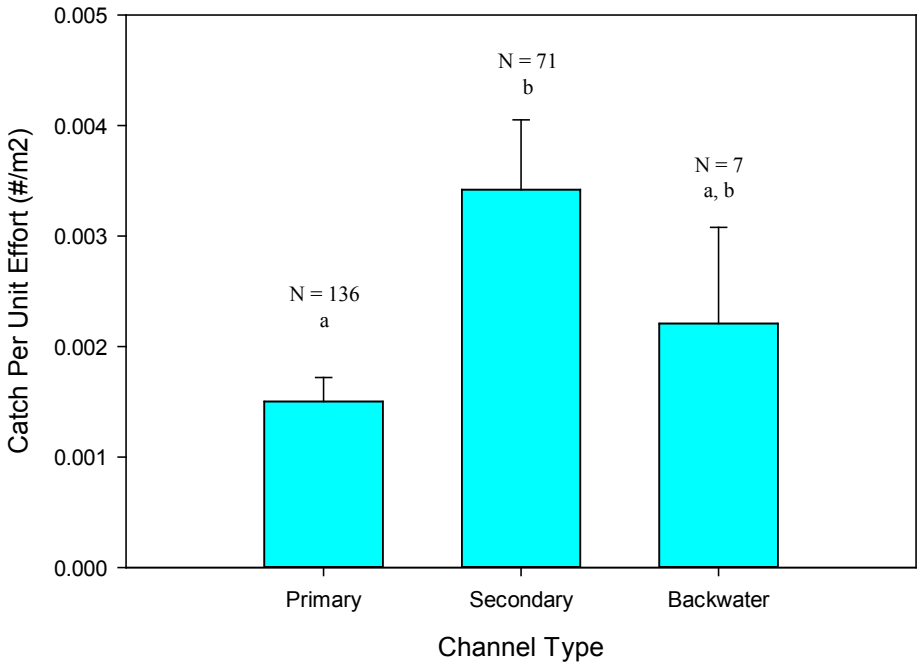

Figure 5. CPUE for Colorado pikemininow among different channel types, San Juan River, 2004-2011 (±1 standard error; N = number of Colorado pikeminnow captured). Channels sharing the same letter are not significantly different from one another.

Distribution among Mesohabitat Types: 2004-2011

Primary Channel

From 2004 to 2011, Colorado pikeminnow were captured in most mesohabitats present within the primary channel (Figure 6). The greatest percentage of fish captured was in shoreline runs. Other than shoreline runs, the percentage of captures were similar across mesohabitat types except for debris, embayments, slackwater, and plunges.

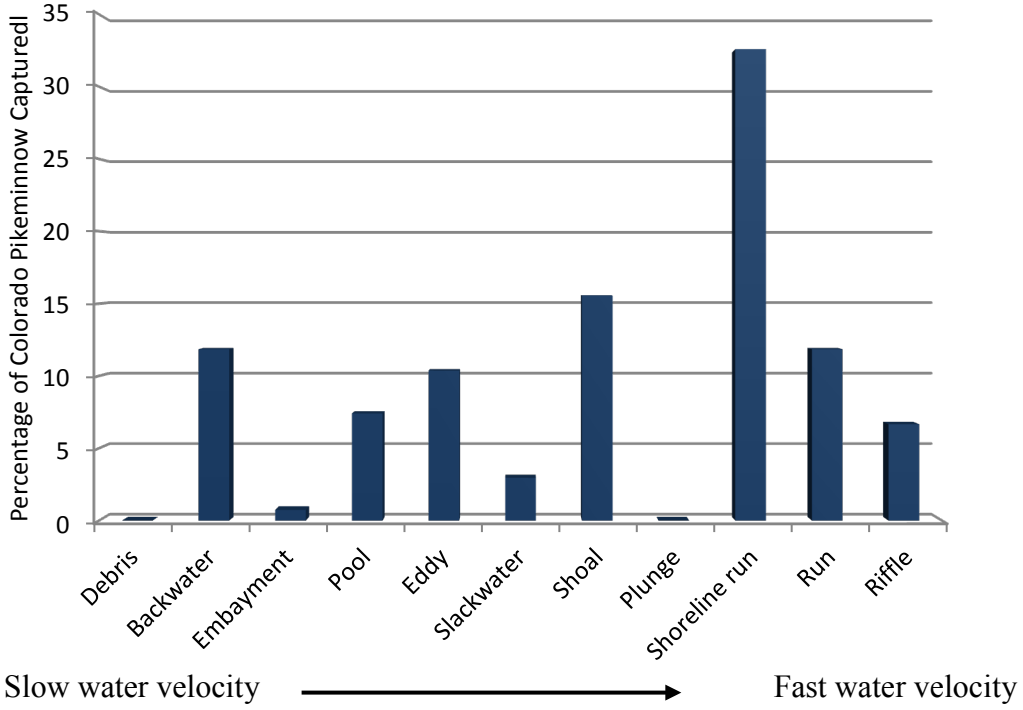

Figure 6. Percentage of Colorado pikeminnow captured by mesohabitat within the primary channel, 2004-2011.

In 2011, the difference between the percentage of Colorado pikeminnow captured in primary channel eddies compared to the percentage in which this habitat was sampled was 10.0% (Figure 7). The difference for riffles was 3.4%. Backwaters were the only other mesohabitat in which the percentage of Colorado pikeminnow captured was greater than the percentage in which this habitat was sampled (difference = 0.2%). Slightly >10% of shoreline runs were sampled compared to Colorado pikeminnow captures in this mesohabitat. Besides shoreline runs, the range of differences between the percentage a given mesohabitat was sampled and the percentage in which Colorado pikeminnow were captured in that same habitat was 0.1-2.6%. In 2011, no apparent relationships were observed between the size (TL) of Colorado pikeminnow captured and mesohabitat sampled (Table 3).

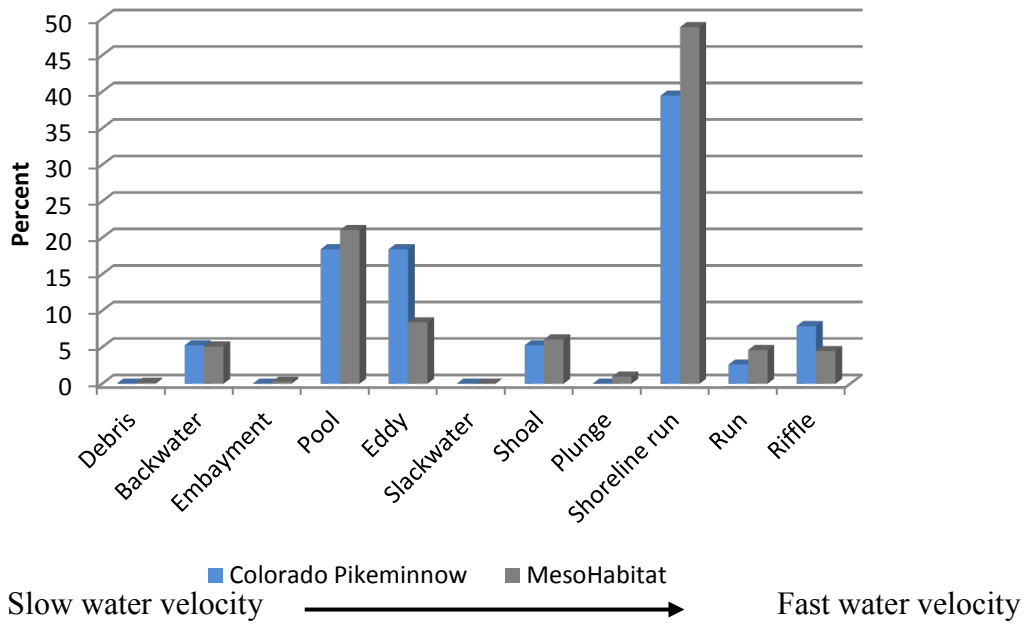

Figure 7. Comparison of percentage of total area of each mesohabitat sampled in the primary channel and percent of Colorado pikeminnow captured within the given mesohabitat, 2011.

Table 3. Total lengths of Colorado pikeminnow captured in the primary channel and mesohabitats in which capture occurred - 2011. Mesohabitats are listed from left to right as slowest to fastest water velocities.

	Mesohabitat						
	Backwater	Pool	Eddy	Shoal	Shoreline run	Run	Riffle
Colorado Pikeminnow Total Length (mm)	150	106	106	109	96	245	158
	300	120	116	185	108		166
		129	131		119		362
		142	139		120		
		145	140		126		
		152	145		129		
		265	154		130		
					132		
					133		
					140		
					147		
					147		
					152		
					165		
					230		
Mean Length (mm)	225	151	131	147	138	245	228
±1 Standard Error (mm)	75	20	6	38	8	----	67

Secondary Channel

In secondary channels from 2004-2011, Colorado pikeminnow were captured in most mesohabitats present (

Figure 8. Percentage of Colorado pikeminnow captured by mesohabitat within secondary channels, 2004-2011.

In 2011, Colorado pikeminnow were captured in a higher percentage within secondary channel shoreline runs and runs than these mesohabitats were sampled (differences of 16.1% and 39.0%, respectively) (Figure 9). Capture of fish in embayments was greater than the percentage of embayments sampled (8.6% difference), but backwaters and pools had lower captures of Colorado pikeminnow relative to sampling effort. No apparent relationships were observed between the size (TL) of Colorado pikeminnow and their presence within a given mesohabitat type (Figure 9).

). The highest percentage of fish captured was in runs, but other than runs, the percentages of captures were similar across mesohabitats. The fewest fish were captured in slackwater and plunges.

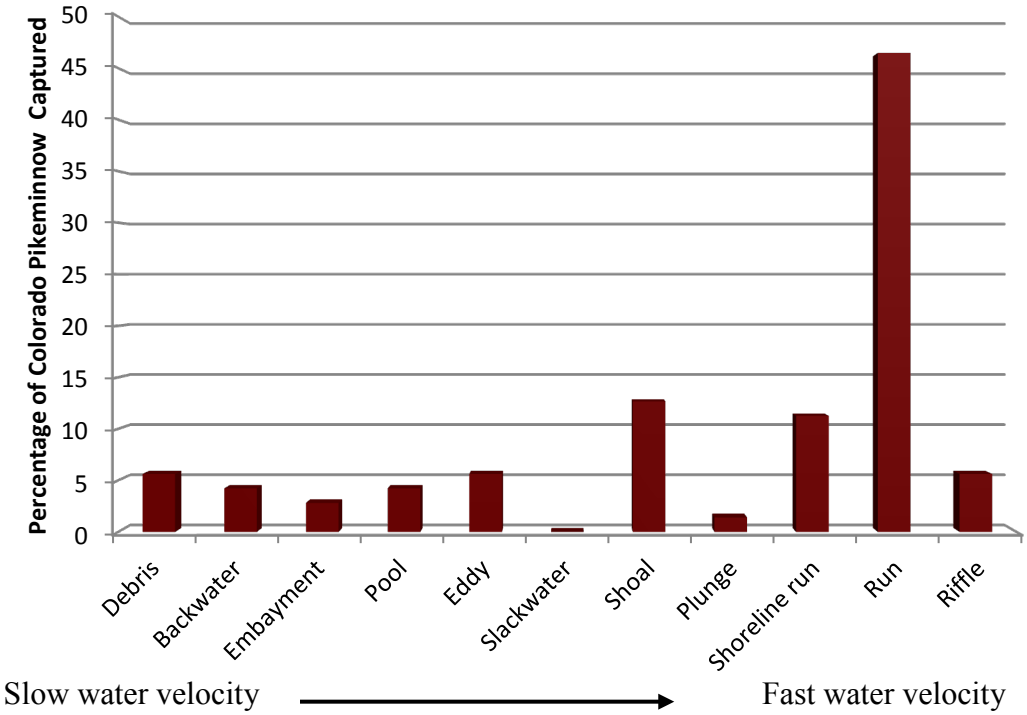

Figure 8. Percentage of Colorado pikeminnow captured by mesohabitat within secondary channels, 2004-2011.

In 2011, Colorado pikeminnow were captured in a higher percentage within secondary channel shoreline runs and runs than these mesohabitats were sampled (differences of 16.1% and 39.0%, respectively) (Figure 9). Capture of fish in embayments was greater than the percentage of embayments sampled (8.6% difference), but backwaters and pools had lower captures of Colorado pikeminnow relative to sampling effort. No apparent relationships were observed between the size (TL) of Colorado pikeminnow and their presence within a given mesohabitat type (Figure 9).

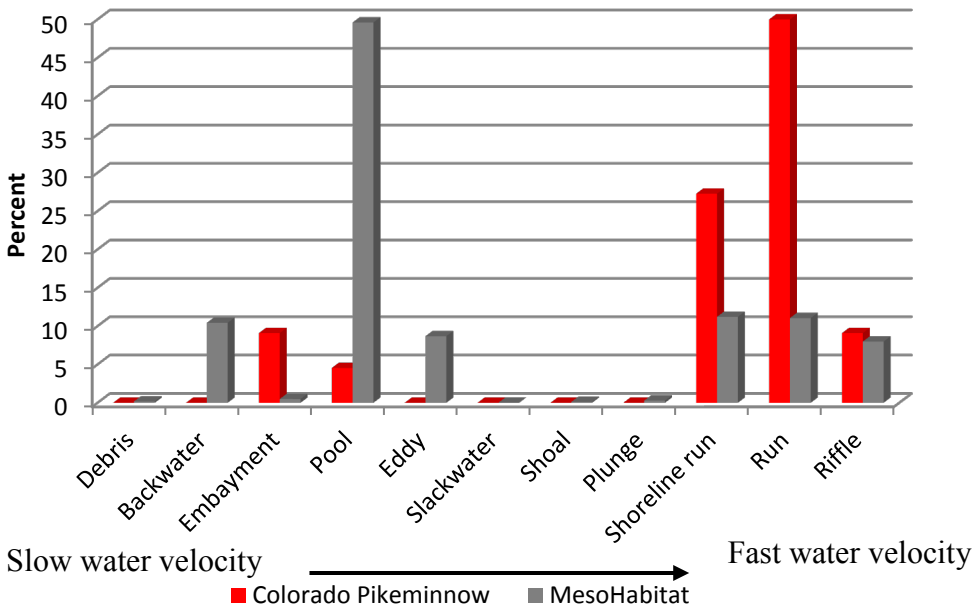

Figure 9. Comparison of percentage of total area of each mesohabitat as sampled in secondary channels and percent of Colorado pikeminnow captured within the given mesohabitat, 2011.

Table 4. Total lengths of Colorado pikeminnow captured in secondary channels and mesohabitats in which capture occurred- 2011. Mesohabitats listed from left to right as slowest to fastest water velocities.

	Mesohabitat				
	Embayment	Pool	Shoreline run	Run	Riffle
Colorado pikeminnow Total Length (mm)	139	129	107	104	140
	146		123	105	155
			125	116	
			125	119	
			126	121	
			131	125	
				136	
				139	
				147	
				165	
				242	
Mean Length (mm)	143	129	123	138	148
± 1 Standard Error (mm)	4	----	3	12	8

PROPORTIONS OF NATIVE AND NON-NATIVE FISHES

Reach and Year: 2004-2011

The most ubiquitous nonnative small-bodied fishes in the San Juan River are channel catfish and red shiner *Cyprinella lutrensis* (Appendices I – III). In all reaches of the river, red shiner dominated the catch in 2004 and 2005 (Figure 10). Since that time, it was the most numerically dominant species in Reach 4 in 2008, Reaches 3 and 4 in 2009, and Reach 5 in 2011. The total number of red shiner varied greatly among reaches and years. Channel catfish was numerically dominant among all species in Reach 3 in 2007 and 2011. With the exception of these two data points, the total capture of channel catfish has remained similar among years and reaches. The total capture of native fishes has varied substantially among reaches and years (Figure 10).

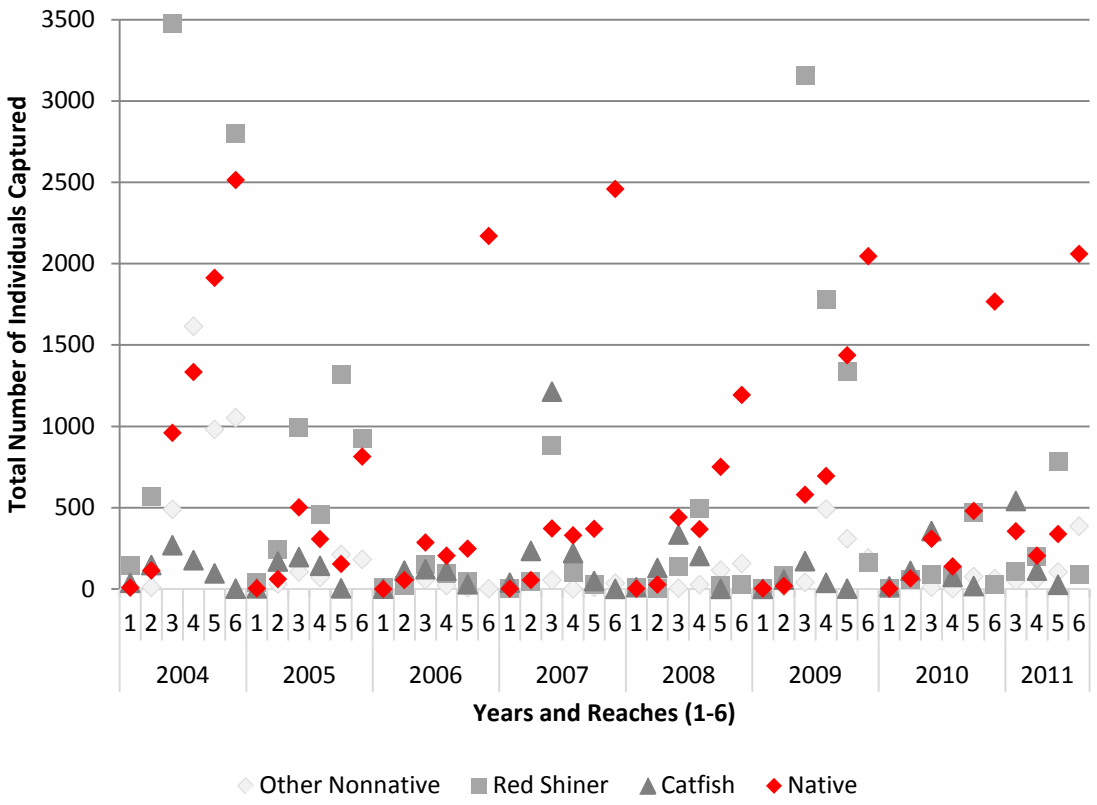

Figure 10. Total number of native fishes, catfish, red shiner, and all other nonnative fish captured by year and reach: 2004-2011. Data points for 2004 for Reaches 4 (N=5968) and 5 (N=5089) are not shown.

Proportionally, the river was dominated by red shiners in 2004 and 2005

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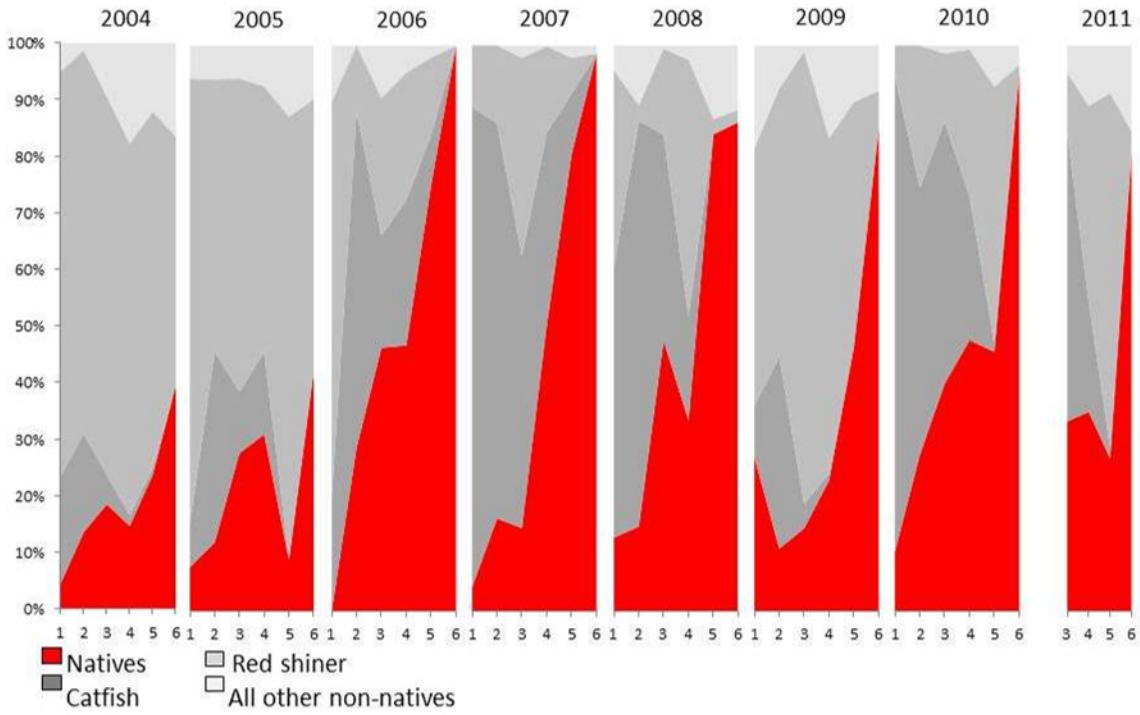

Figure 11 andFigure 12). In all years, nonnative fishes were captured in greater proportion to native fishes in the lower reaches of the San Juan River. In 2006, the fish assemblage in the upper reaches of the river changed. Native fishes either proportionally equaled nonnative fishes or began to surpass nonnative fishes. From 2006 through 2011, with the exception of Reach 5 in 2011, native fishes dominated the fish assemblage in Reaches 5 and 6. This is especially true in Reach 6 (Figure 10). The proportions of native fishes, channel catfish, and red shiner were similar between Reaches 3 and 4 although variability was high.

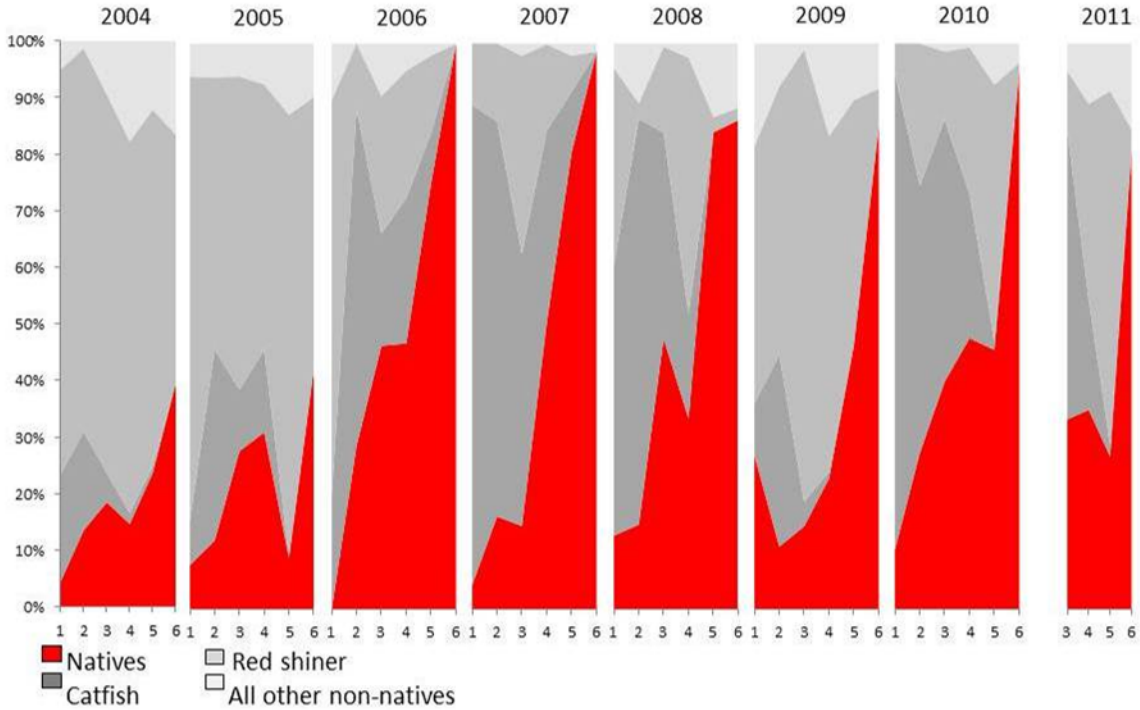

Figure 11. Proportions of native versus nonnative fishes (2004-2011) by years and reach.

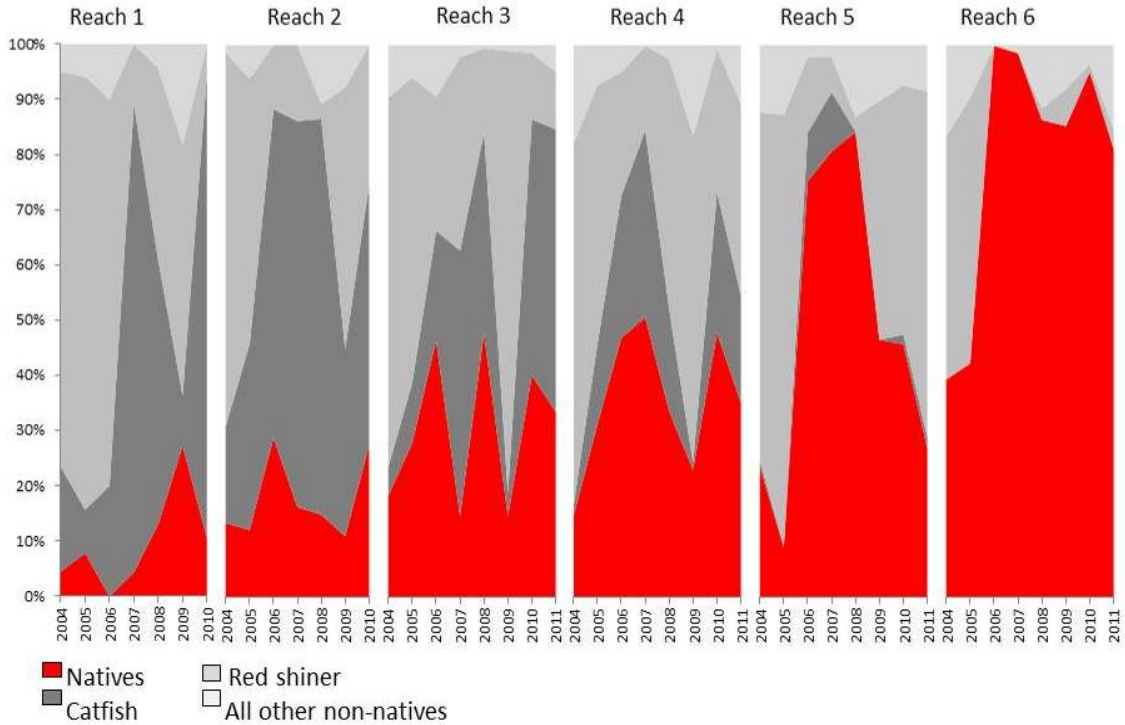

Figure 12. Proportions of native versus nonnative fishes (2004-2011) by reaches and years.

Channel Type: 1998-2011

In 2011, about 50% of fishes collected in the primary channel and 58% in secondary channels were native

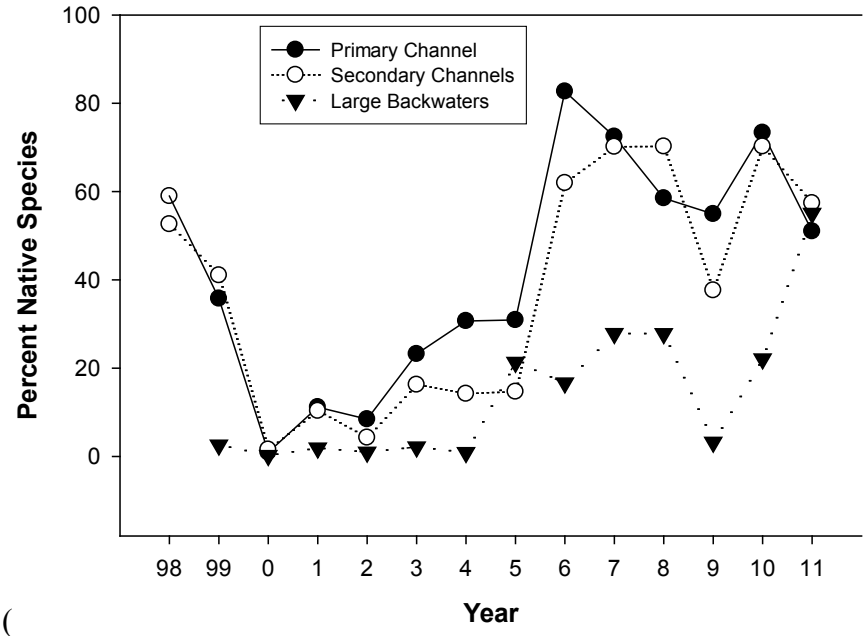

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Figure 13). These proportions decreased over the last year but remain higher than the proportion of native fishes collected in the San Juan River between 2000 and 2005; a time when native fishes were <30% of the catch within each given channel type. Since sampling began in 1998, 2011 was the first year that backwaters were dominated by native species (55%).

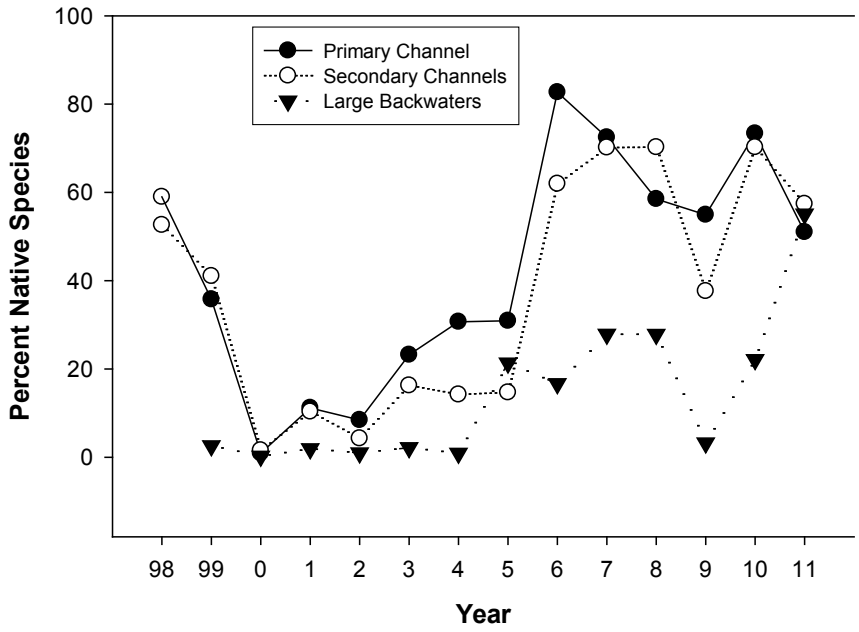


Figure 13. Percent of native fishes collected in the primary channel, secondary channels and large backwaters on the San Juan River 1998-2011.

Channel Catfish: 2000 - 2011

Channel catfish were captured every year in the San Juan River since 1998 (Appendix II-IV). In 2011, 680 catfish were collected (TL = 29-644mm) (Table 5). Most channel catfish captured from 2000 to 2011 during small-bodied monitoring were small (26-100mm TL).

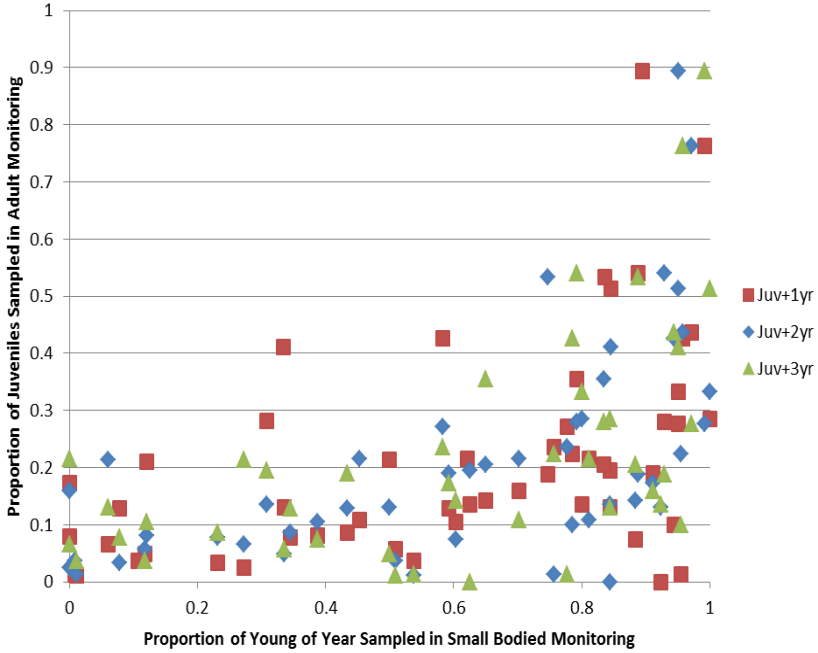
Table 5. River-wide channel catfish CPUE, total fish captured and size ranges 2000 - 2011.

	CPUE	Total Captured	Range (TL - mm)	Number Captured > 100mm (TL)
2000	0.19679	46	35-76	0
2001	-------	37	42-360	8
2002	0.12120	295	19-270	1
2003	0.23684	372	37-393	6
2004	0.23873	729	26-480	19
2005	0.33949	516	32-361	19
2006	0.17686	378	40-336	31
2007	0.51375	1757	35-175	10

2008	0.22098	679	26-425	9
2009	0.25810	270	34-404	13
2010	0.16520	575	25-485	7
2011	0.22363	680	29-664	21

Time-lag regression showed 23% of the sub-adult/adult monitoring capture of juvenile channel catfish could be predicted by small-bodied age-0 captures one year prior ($R^2 = 0.2293$, $F_{(1,53)} = 15.4$, $p = 0.00020$) (Figure 14). Similar values were obtained when using the proportion of juvenile channel catfish captured in the sub-adult/adult monitoring two years and three years later ($R^2 = 0.3241$, $F_{(1,49)} = 24.6$, $p = 0.00001$ and $R^2 = 0.2960$, $F_{(1,48)} = 22.5$, $p = 0.00001$, respectively).

There was not a significant relationship between the proportion of fishes captured in small-bodied monitoring and adults captured two years later ($R^2=0.0001$, $F_{(1,48)} = 0.0058$, $p= 0.93970$) (Figure 15). Similarly, the proportion of adults captured in the sub-adult/adult monitoring three years ($R^2 = 0.0000$, $F_{(1,44)} = 0.1076$, $p= 0.74400$) and six years later were unrelated ($R^2 = 0.0060$, $F_{(1,28)} = 0.1641$, $p=0.68860$).



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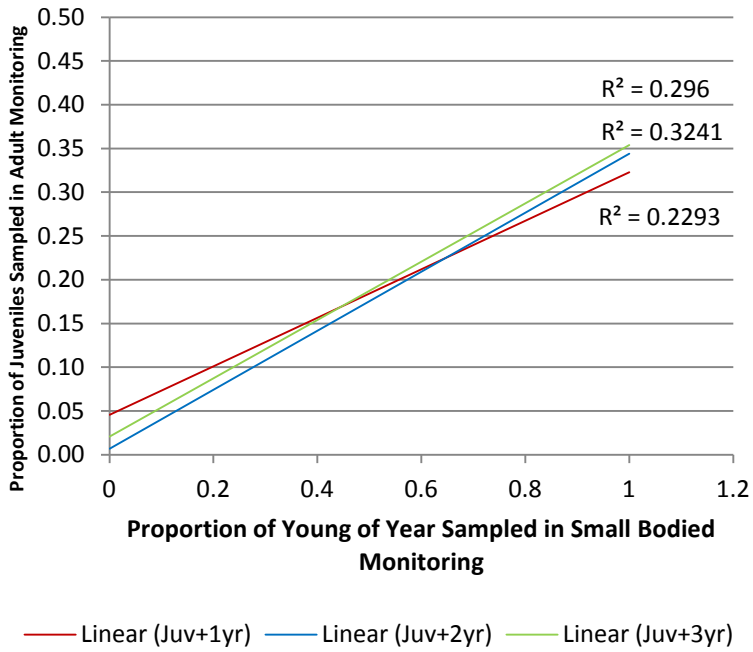


(b)

Figure 14. Proportion of age-0 catfish plotted against proportion of juvenile catfish captured 1 year later, 2 years later and 3 years later – 2000-2011. (a) data points (b) regression lines

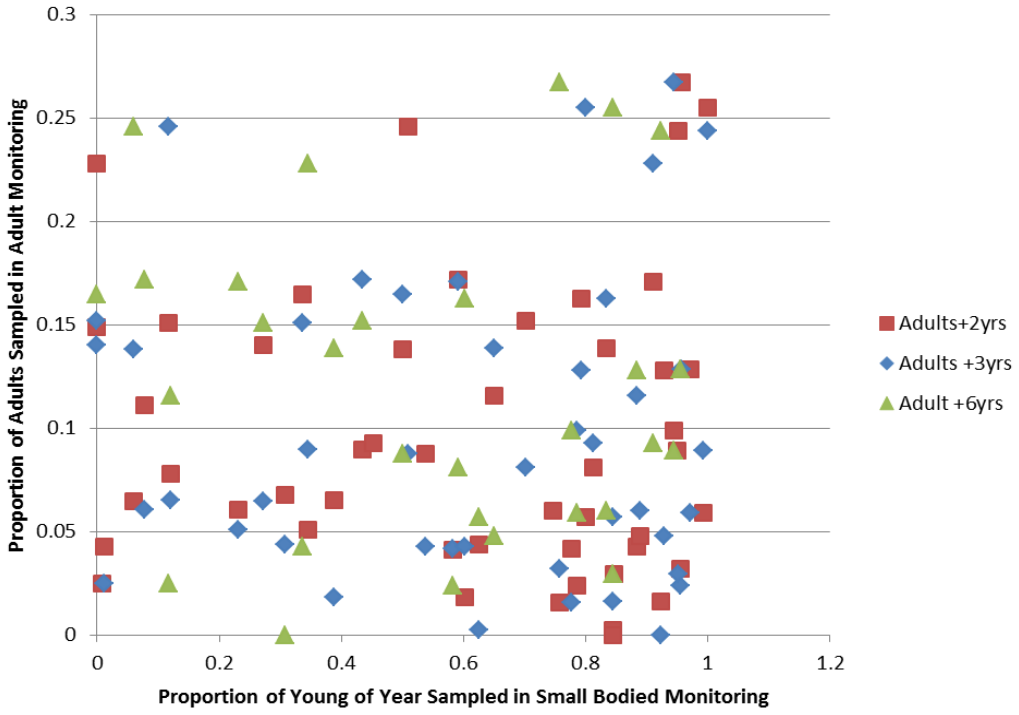


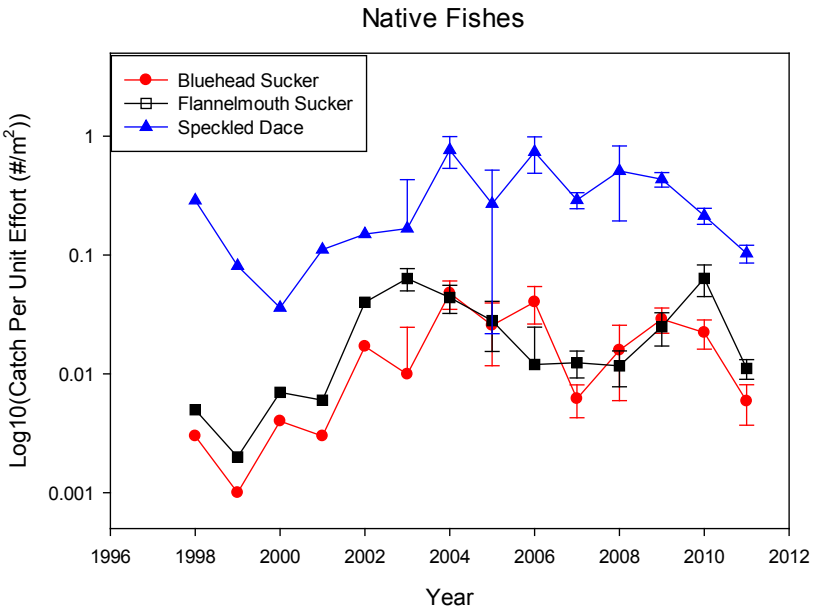
Figure 15. Proportion of age-0 catfish plotted against proportion of adult catfish captured 2 years, 3 years and 6 years later – 2000-2011.

TRENDS OF NATIVE AND NONNATIVE FISHES

Primary Channel: 1998 - 2011

The densities of native fishes in the primary channel varied year to year.

Speckled dace *Rhinichthys osculus* was the most abundant native fish for all years



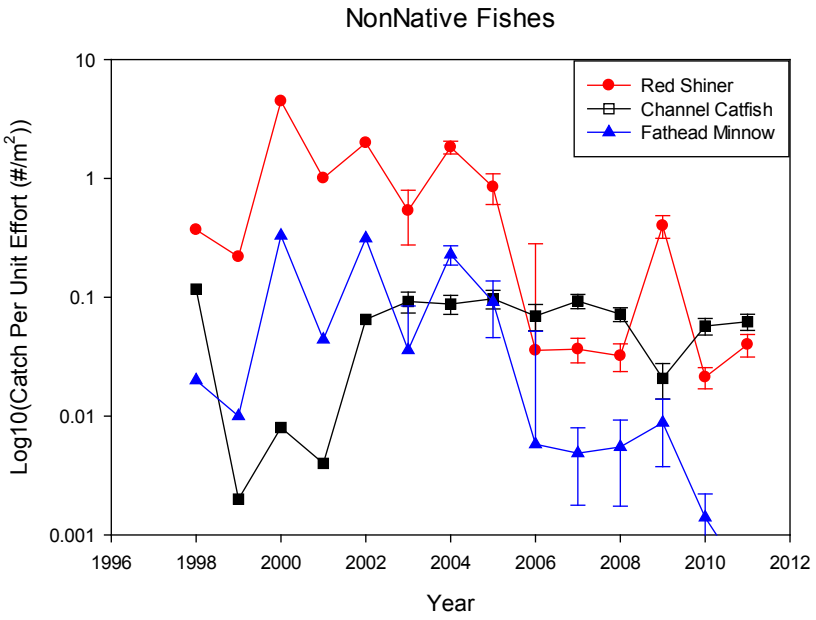


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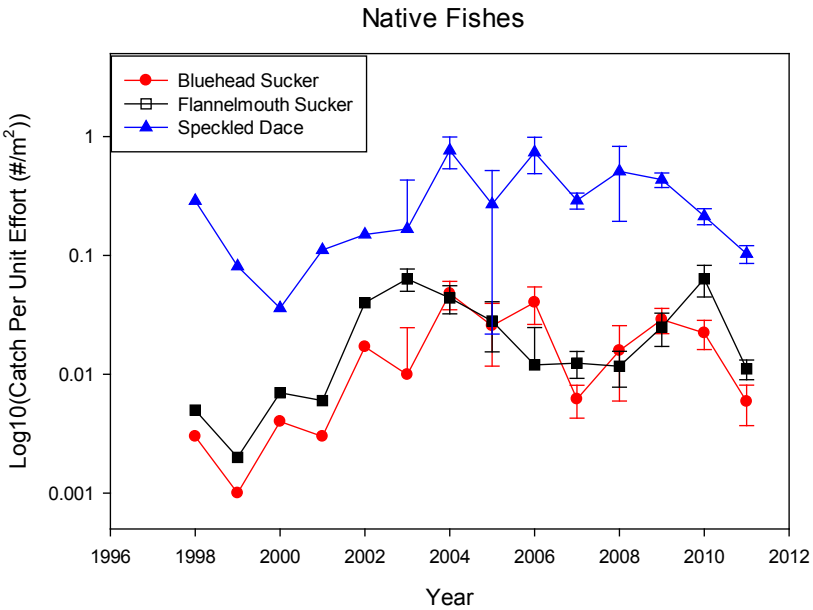
Figure 16 and Appendix II). Within the last 14 years, CPUE for bluehead sucker and flannelmouth sucker varied greatly. Both species were scarce from 1998 to 2002. Since then their densities have remained above the 2001 levels, although densities in 2011 were the lowest since 2002. This pattern was also observed for speckled dace.

With the exception of 2009, densities of red shiner and fathead minnow *Pimephales promelas* have declined since 2005



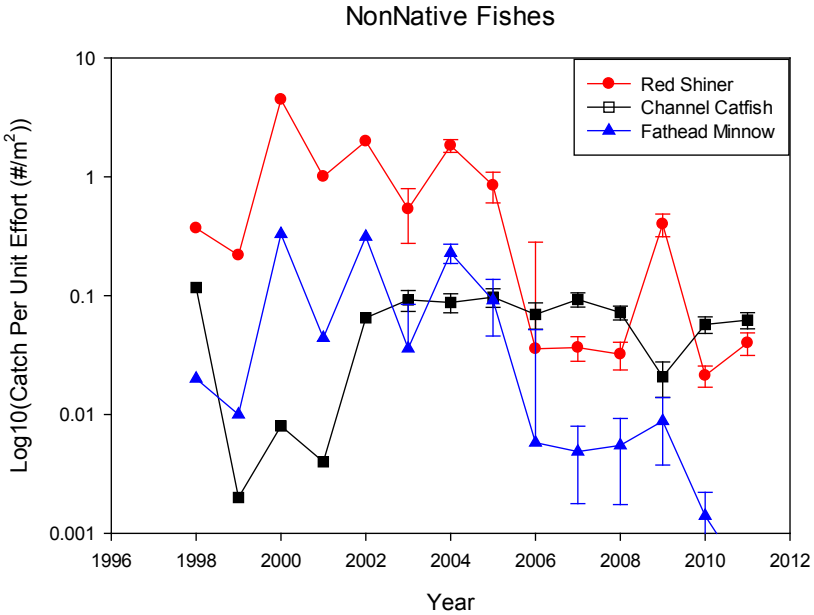


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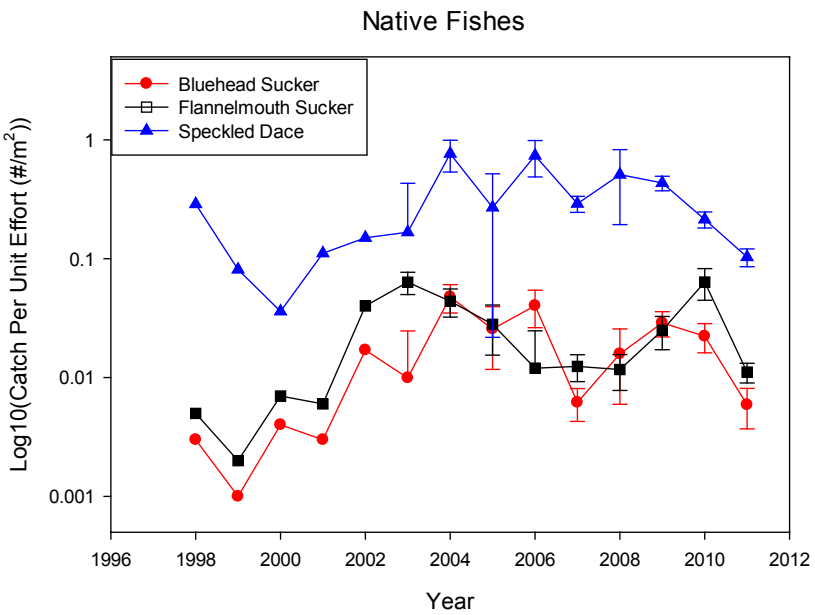
Figure 16). Fathead minnow was not captured in the primary channel in 2011. Since 2002, there has been little change in the density of channel catfish in the primary channel.



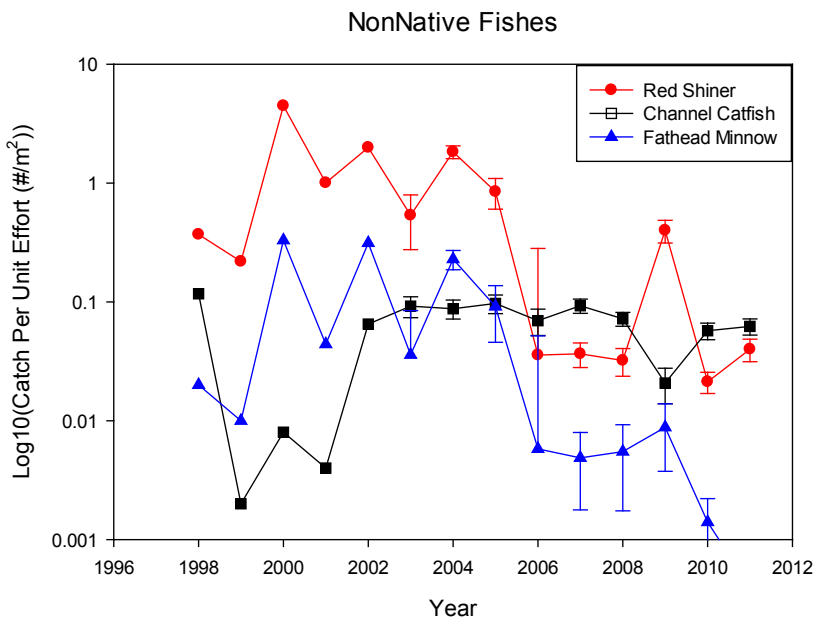


Figure 16. Mean CPUE of all seine hauls (±1 standard error) calculated from 2003-2011 of commonly collected native and nonnative fishes in San Juan River in the primary

channel. River-wide CPUE calculated from 1998-2002 (due to change in methods no standard error presented).

Secondary Channel: 1998-2011

In secondary channels of the San Juan River, CPUE of native fishes varied year to year. Speckled dace had the highest CPUE among native fishes in all years (Figure 17 and Appendix III). The CPUE for flannelmouth sucker was the second highest among all years except for 2011, and bluehead sucker has shown the most variation year to year compared to other native fishes. For the fourth consecutive year, the CPUE for bluehead sucker CPUE was greater than the lowest CPUE recorded in 2007.

Similar to observations in the primary channel, red shiners had the highest CPUE for all nonnative fishes in secondary channels. This was true for all years except for 2007. With the exception of 2009, the CPUE of red shiner has declined since 2005; the density of fathead minnow also declined since 2005. More variation over time has been observed for fathead minnow than red shiner. The CPUE of channel catfish in 2011 was similar to previous years (Figure 17). Channel catfish have shown more variation year to year in secondary channels than in the primary channel.

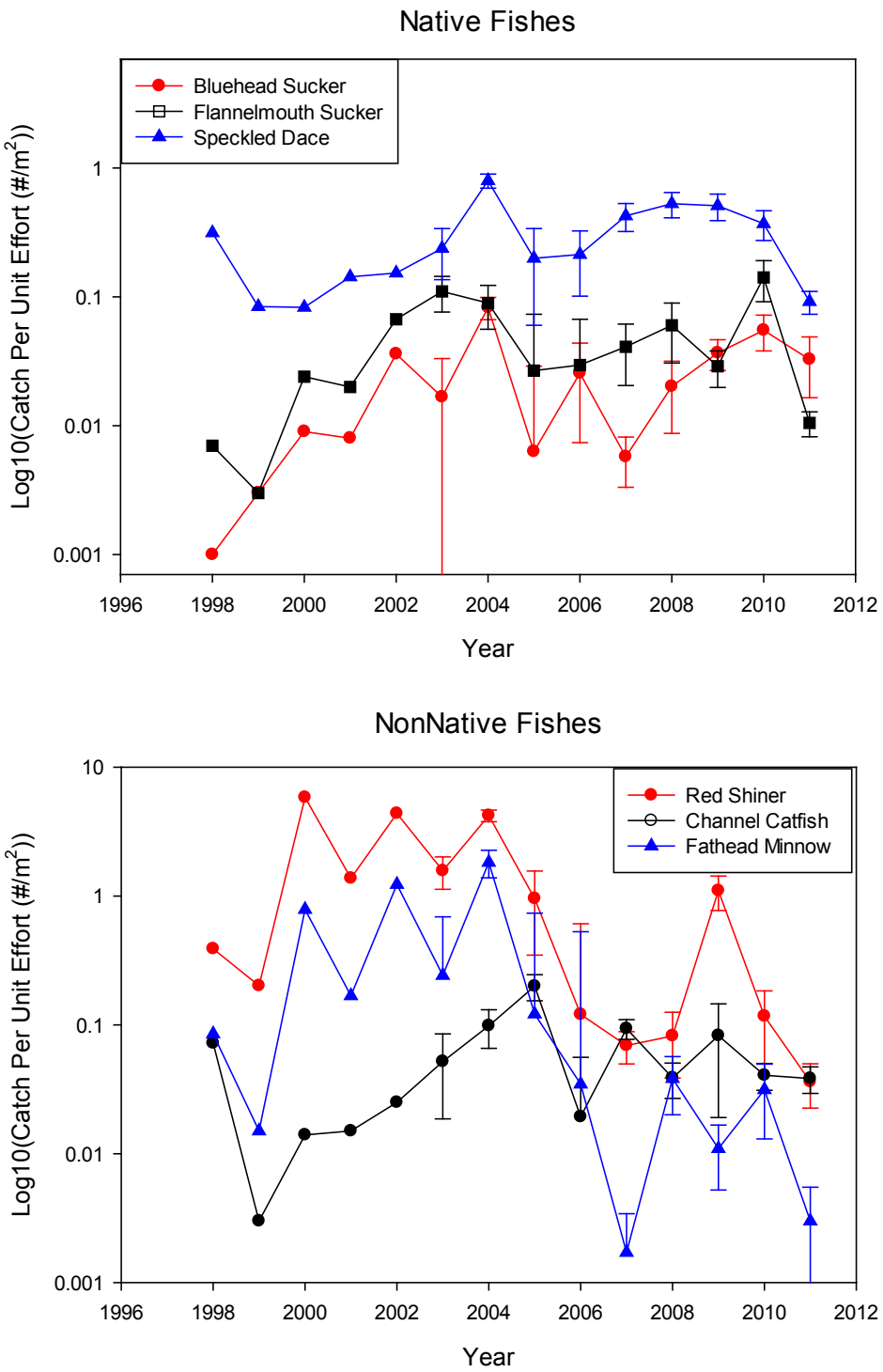
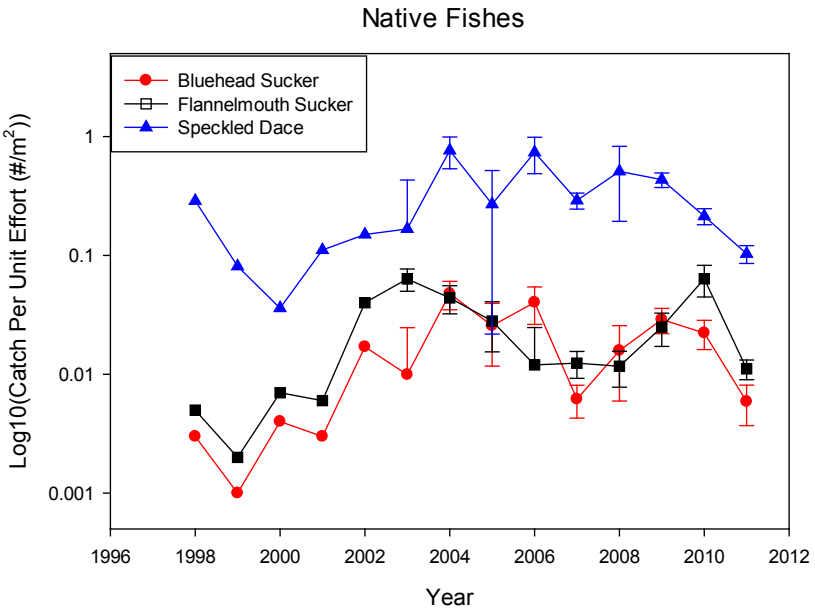
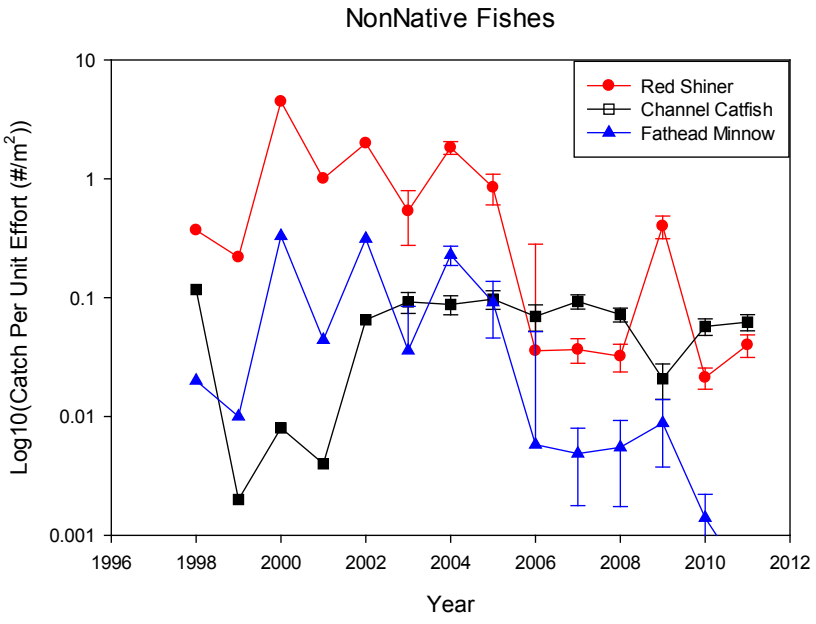


Figure 17. Mean CPUE of all seine hauls (±1 standard error) calculated from 2003-2011 of commonly collected native and nonnative fishes in San Juan River in secondary channels. River-wide CPUE calculated from 1998-2002 (due to change in methods no standard error presented).

Backwaters: 2003-2011

Four native and eight nonnative species were collected in San Juan River large backwaters in 2011, including two Colorado pikeminnow (Appendix IV). Speckled dace were not the most abundant native species in backwaters among all years as they were in both the primary channel and secondary channels





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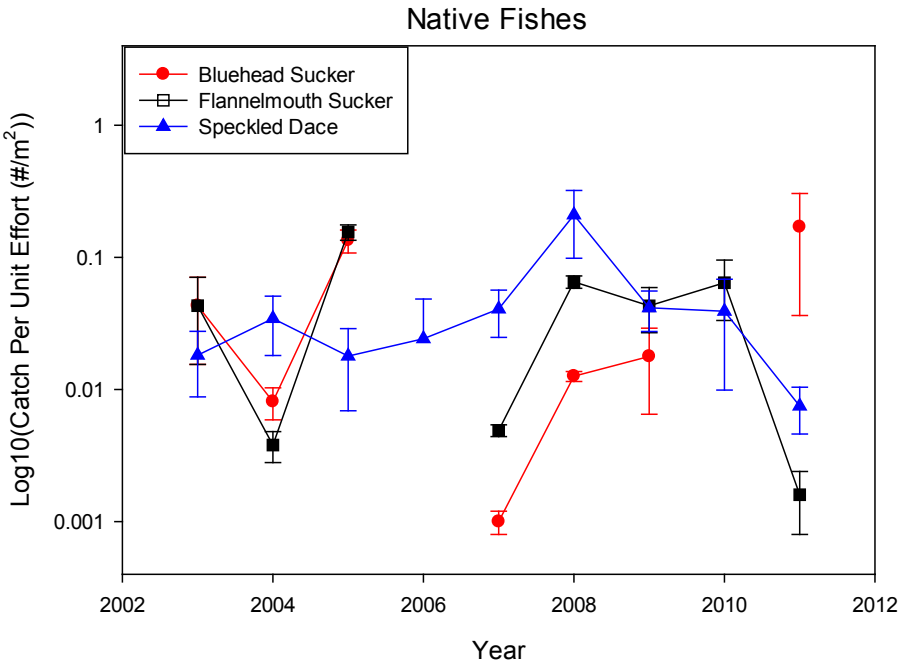


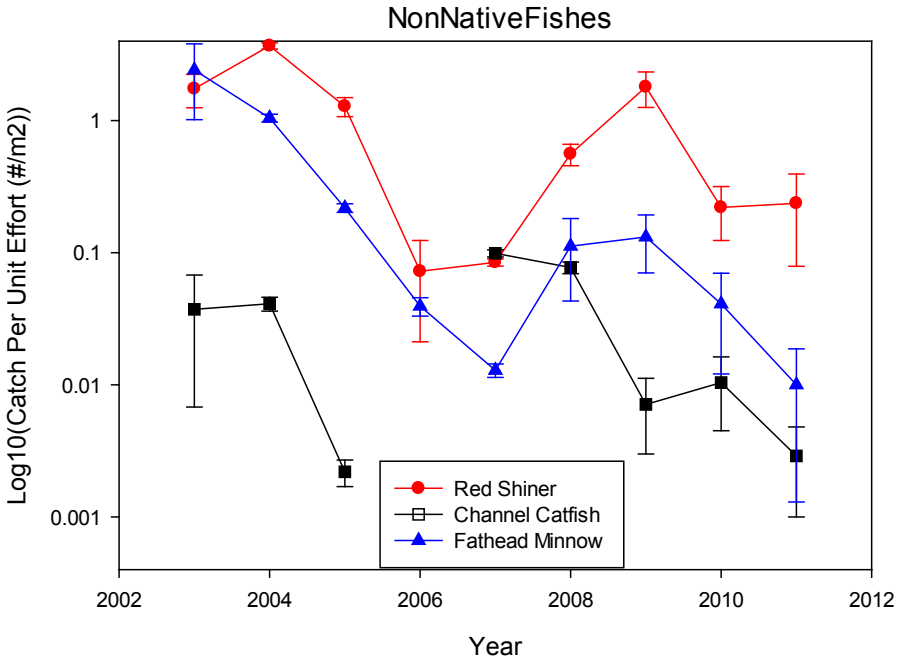
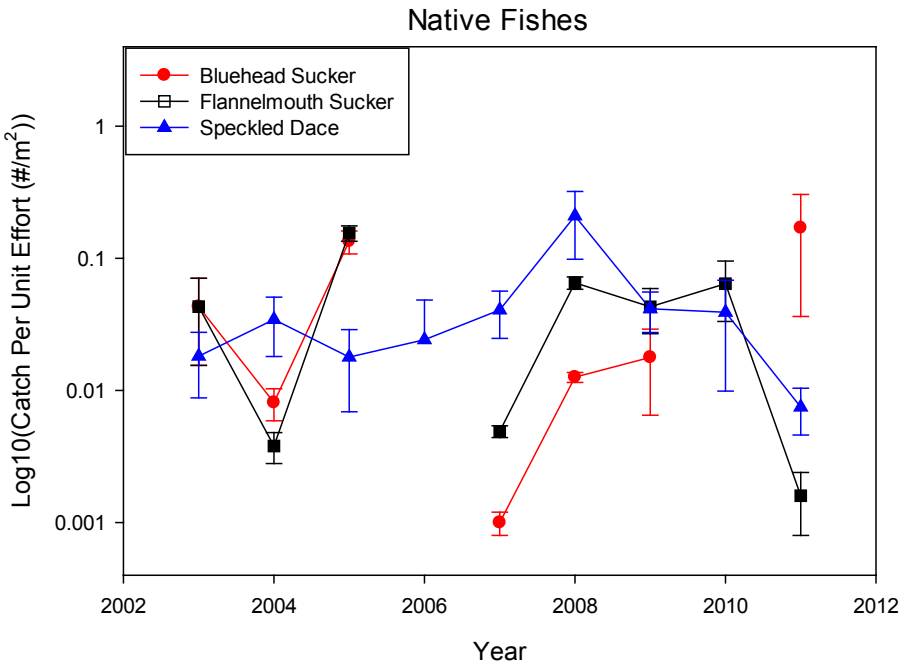
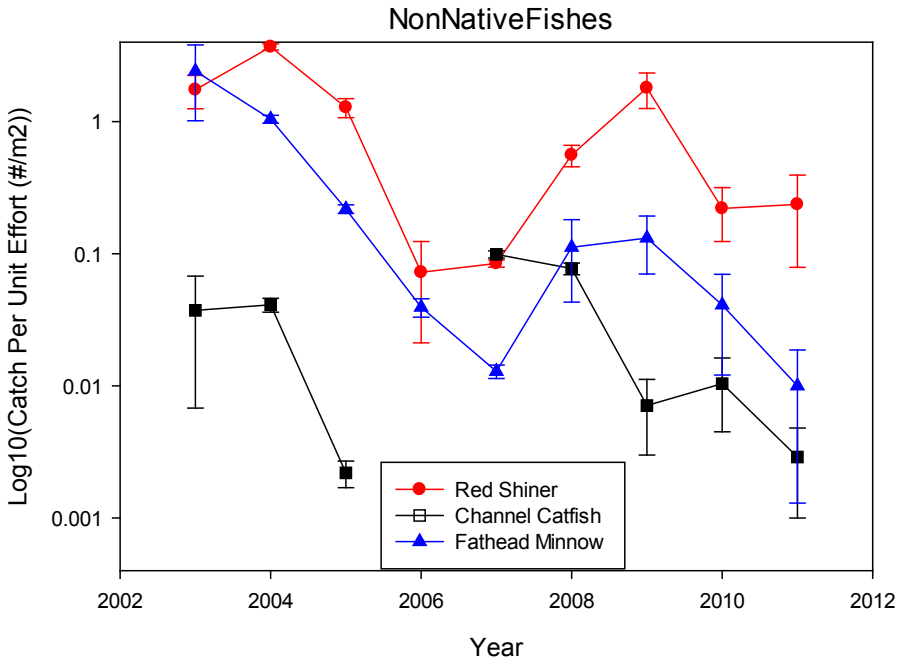


Figure 18). In 2011, the CPUE for bluehead sucker was the highest in backwaters since 2003, although the standard error was larger in 2011 than in most other years. Flannelmouth sucker CPUE was lower in 2011 than in all prior years.

Red shiner was often the most abundant nonnative species in large backwaters, though fathead minnow and channel catfish had higher CPUE rates in 2003 and 2007,





respectively (

Figure 18). Unlike the primary channel and secondary channels, red shiner density increased and remained high in backwaters after its crash in 2005. The CPUE of fathead minnow followed a similar pattern as red shiner in backwaters. Channel catfish CPUE remained below 2007 and 2008 levels for the past three years. Channel catfish density in backwaters has varied among years, not being captured in three of the last nine years (2003-2011).

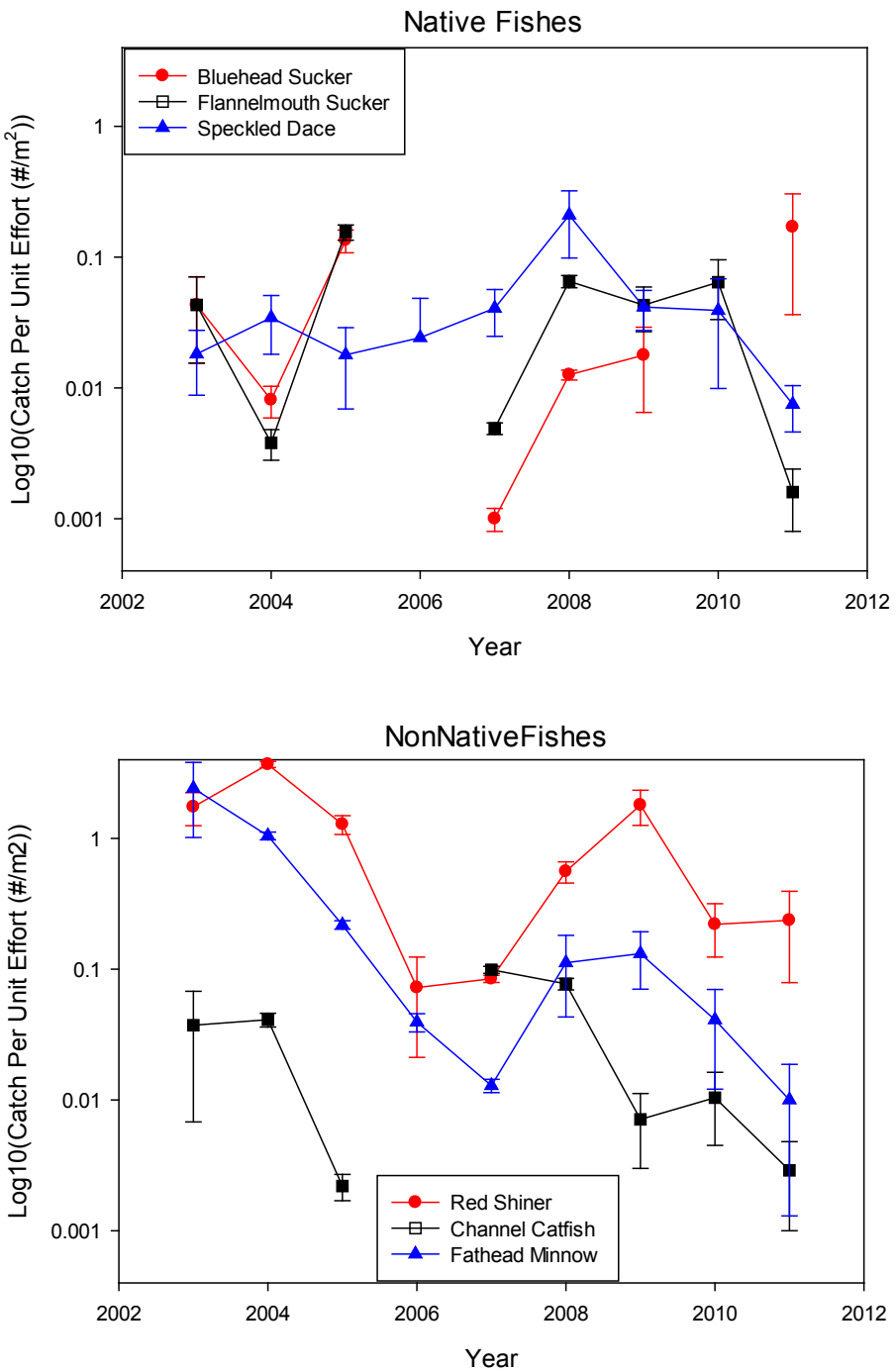


Figure 18. Mean seine-haul CPUE (±1 standard error) of native and nonnative fishes collected from backwaters in the San Juan River 2003-2011.

Comparison among Channel Types

Common native fishes were not distributed evenly among channel types (Figure 19). The CPUE of bluehead sucker was higher in backwaters compared to primary and secondary channels. Flannelmouth sucker CPUE was below 0.1fish/m^2 within all channel types. Speckled dace CPUE ranged from 0.4 fish/m^2 in secondary channels to less than 0.1 fish/m^2 in backwaters.

There were also differences in the density among channel types for some nonnative fish species. Fathead minnow density was greater in secondary channels and backwaters than in the primary channel (Figure 20). Red shiner CPUE was similar among channel types. The density of channel catfish was below 0.1 fish/m^2 in all channel types, with the highest density occurring in secondary channels. The CPUE of mosquito fish *Gambusia affinis* was highest in backwaters.

The most common native species in the San Juan River is speckled dace. Densities of speckled dace were the highest, of all native species captured, in the primary channel 0.37 fish/m^2 and secondary channels 0.4 fish/m^2. Red Shiner is the most common nonnative species in the San Juan River. The highest CPUEs for this species are in backwaters 1.5 fish/m^2 and secondary channels 0.8 fish/m^2.

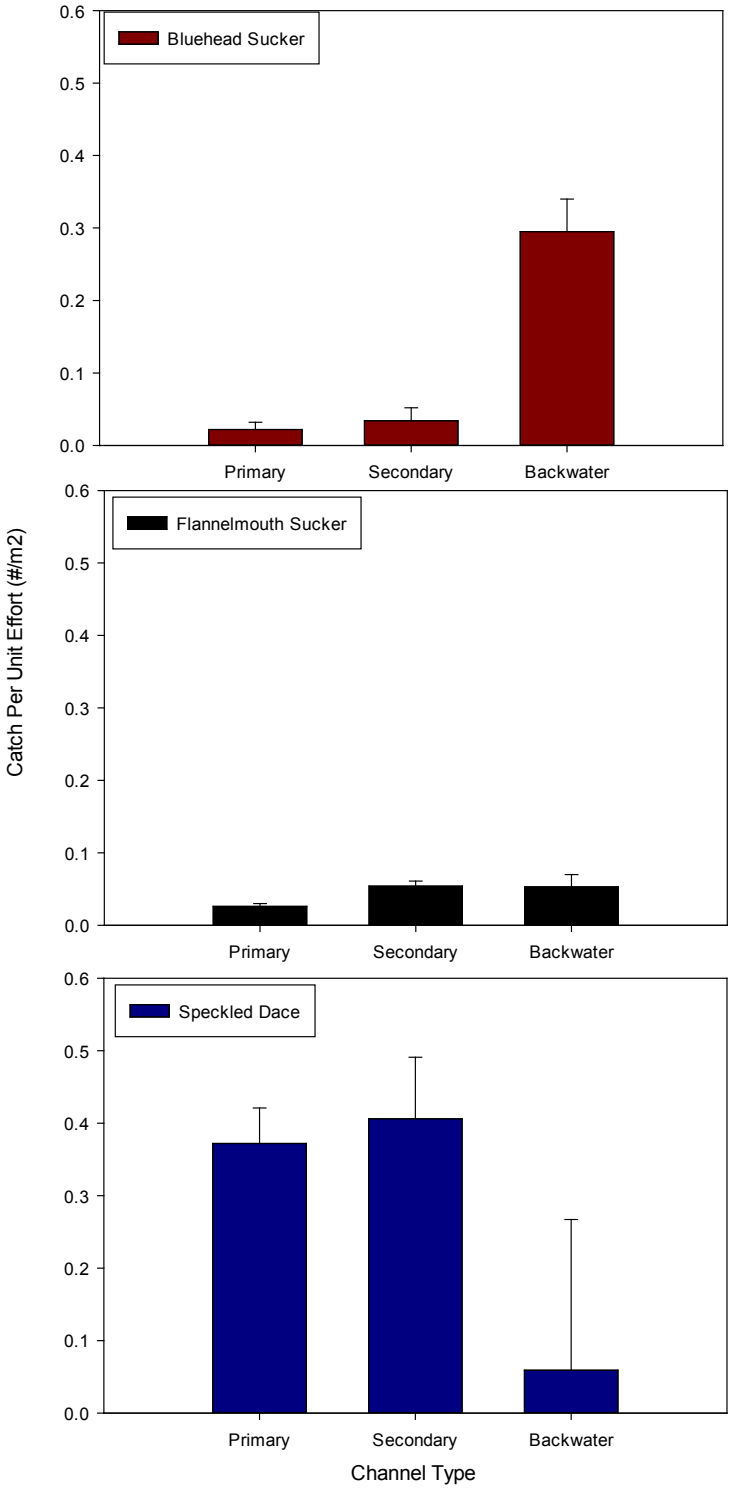


Figure 19. Comparison of mean CPUE (±1 standard error) of native fishes among channel types in the San Juan River 2003-2011.

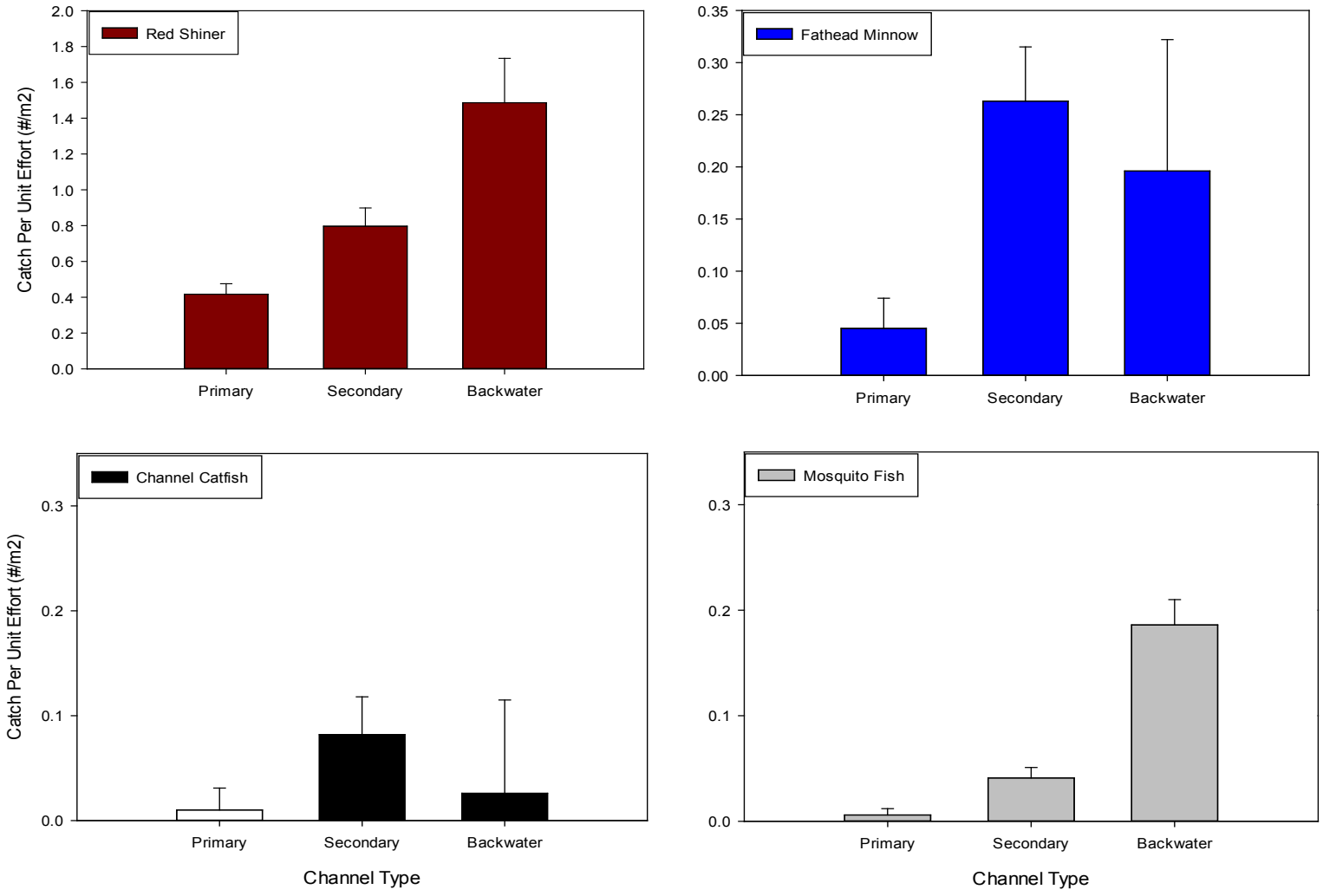


Figure 20. Comparison of mean CPUE (±1 standard error) of nonnative fishes among channel types in the San Juan River 2003-2011. Note difference in scale for red shiner.

DISCUSSION

Small-bodied monitoring provides information on population trends of native and nonnative small-bodied and age-0 fishes to support Colorado pikeminnow and razorback sucker recovery efforts. The 2011 survey resulted in the highest catch of Colorado pikeminnow of any year prior and was the eighth consecutive year in which Colorado pikeminnow were captured in the San Juan River during small-bodied monitoring. In 2011, native fishes consisted of greater than 50% of the fish assemblage among all channel types. Results from 2011 indicate that stocked Colorado pikeminnow survive post-stocking, age-0 razorback suckers have yet to recruit in numbers high enough to be detected by small-bodied monitoring and native fishes were more common than nonnative species.

One hypothesis pertaining to the distribution and abundance of Colorado pikeminnow is that increased channel complexity may provide suitable conditions necessary to retain young Colorado pikeminnow in the San Juan River (Bliesner et al. 2010). Bliesner et al. (2009) quantified island count in the San Juan River as an index for channel complexity. The island count in Reach 5 exceeded all other reaches from 1997 to 2009 followed by Reaches 3 and 6 in most years. Colorado pikeminnow density is consistently higher in Reach 5 followed by Reaches 3 and 6. Colorado pikeminnow density may be associated with reach habitat complexity and may warrant further investigation.

Alternatively, stocking time and/or location may affect Colorado pikeminnow density and distribution. Since the inception of small bodied monitoring in 1998, annual capture was greatest in 2007 and 2011. In these same years, stocking occurred prior to (218,465 fish, May 2011) or during small-bodied monitoring (83,640 fish, September

2007) rather than late fall (November) after completion of small-bodied monitoring (Furr 2011, M. Ulibarri pers. comm.). The majority of Colorado pikeminnow stocking has occurred in Reach 6 (N= 2,128,606, years 2003-2011). The remaining fish were stocked in Reach 5 (N = 98,029, years 2003-2011) (Furr 2010 and 2011; Ulibarri pers. comm.) which has a significantly higher CPUE than any other reach. Thus, locations and timing of Colorado pikeminnow stocking may affect autumn Colorado pikeminnow CPUE and geographic distribution.

Nonnative fishes, especially red shiner and channel catfish, may compete with and prey upon native fishes (Ruppert et al. 1993; Tyus and Saunders, 2000; Bunn and Arthington, 2002; Carpenter and Mueller 2008; Franssen et al. 2012). In laboratory experiments, age-1 Colorado pikeminnow were limited by gape dimensions from feeding upon deep-bodied nonnative prey (Franssen et al. 2007). In addition, Franssen et al. (2007) showed that Colorado pikeminnow preferred small age-0 native prey in predation experiments. Current research in the San Juan River has suggested that the shift to piscivory in Colorado pikeminnow varies by geomorphic reach (Franssen et al. 2012). The timing of ontogenetic diet shifts to piscivory can have a strong impact on recruitment success of predatory fishes (e.g., Garvey and Stein 1998, Persson and Brönmark 2002). Given these facts, tracking the abundance and distribution of small-bodied and age-0 native and nonnative fishes compared to the presence, abundance and distribution of Colorado pikeminnow will benefit this species' recovery.

Colorado pikeminnow, native and nonnative fishes vary in their distribution among river reaches and channel types. In four of the last eight years, the fish assemblage in Reach 5 was dominated by native species and had the highest Colorado pikeminnow CPUE. Channel catfish and red shiner have dominated Reaches 1 and 2

since 2004; these two reaches have the lowest densities of Colorado pikeminnow. Reach 3 has the second highest CPUE of Colorado pikeminnow. The composition of the fish assemblage in this reach has varied considerably and native fish have not been greater than 50% in any one year. Since 2005, native fishes have dominated Reach 6, which has the third highest Colorado pikeminnow CPUE. Although Colorado pikeminnow are most abundant in secondary channels, red shiner are two times as dense as speckled dace. Channel catfish, although not as dense as red shiner, are found in higher densities in secondary channels than the two other channel types. Thus, young Colorado pikeminnow and their prey may have the best chance of survival in the upper reaches of the San Juan River and may be negatively impacted by nonnative fishes in secondary channels.

Stocking, habitat complexity, and non-native fishes all likely affect Colorado pikeminnow recruitment, of lack thereof, to some degree. This report includes some analyses not performed in previous years. The distribution of Colorado pikeminnow among river reaches (most abundant in Reach 5), channel types (most abundant in secondary channels), and mesohabitats (variable results) were assessed. Time-lag regressions were conducted to determine the ability of the small-bodied monitoring dataset to predict captures of channel catfish in the sub-adult/adult monitoring. These analyses relate to the SJRIP Long-Range Plan tasks of collecting catch rate statistics to estimate relative abundance of endangered fish (Task 4.1.2.5), identify principal river reaches and habitats used by various life-stages of endangered fish (Tasks 4.2.3.2, 2.1.1.2 and 4.1.2.2), and conduct review of success of nonnative fish control strategy (Task 3.1.1.4). Additional or more in-depth analyses of this and other datasets may prove useful for attaining Long-Range Plan goals for the SJRIP and contribute to recovery efforts for Colorado pikeminnow and razorback sucker.

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APPENDICES

Appendix I - Colorado pikeminnow captures by reach, year and total length

Year	Length Category	Reach 6	5	4	3	2	1	Grand Total
2003	N/A							0
2004	160		2					8
	170			1				
	180		2					
	200		1					
	210		1					
	230			1				
2005	170				1			3
	180			1				
	290					1		
2006	140	1	1					10
	150	1	1					
	180		1		1			
	190					1		
	200	1						
	210				1			
	280				1			
2007	40*				6	2		59 Total, (*28 Recently Stocked YOY)
	50*				17	2	1	
	120	2						
	130		1					
	140	1	4					
	150	2	6		2			
	160	2		1	1		1	
	170	1	1	3	1			
	180		1		1			
2008	130		1					10
	140	1	1	1				
	150		2	1	1			
	170		1					
	210				1			
2009	130	1					1	12
	170		1	1		1		
	180	1		1				
	190			1				
	200			2				
	210				1			

Year	Length Category	Reach 6	5	4	3	2	1	Grand Total
	330		1					
2010	120		1					
	130	2	1	1				
	140	2	2	1	3			
	150	1	3	4	1			
	160		2		2	1		
	170		3	2	1			
	180		2		1	1		
	190			1	3	1		49
	200		2		1			
	210				1			
	220							
	230				1			
	240							
	250			1				
	260				1			
2011	100	2	1					
	110	4	5					
	120	3	10					
	130	5	2	2				
	140	2	7	1				
	150		5	1	1			
	160		2	1				
	170							
	180			2				
	190							62 (Reaches 1 & 2 not sampled)
	200							
	210							
	220							
	230		1					
	240	1		1				
	250							
	260							
	270				1			
	280							
	290							
	300				1			
	360		1					
Reach Totals		**36**	**79**	**32**	**53**	**10**	**3**	

Appendix II - Species Presence Primary Channel and CPUE Rates

Species collected 1998-2011. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	*SCIENTIFIC*	*CODE*	*STATUS*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X		X		X	X			X	X		
Roundtail chub	*Gila robusta*	GILROB	N	X	X												
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X						X	X	X	X	X	X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth x bluehead	*C. latipinnis x C. discobolus*	LATDIS			X				X								
Razorback sucker	*Xyrauchen texanus*	XYRTEX	N								X						
Black bullhead	*Ameiurus melas*	AMEMEL	I					X		X	X	X		X			X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I									X				X	
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X		X	X	X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X	X	X	X	X			X	X	X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I		X				X	X	X			X	X	X	X
Largemouth bass	*Micropterus salmoides*	MICSAL	I				X			X			X		X		X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X		X	X	X	X	X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X												
Brown trout	*Salmo trutta*	SALTRU	I												X	X	
Native			7	5	5	3	3	3	3	4	5	4	4	4	4	4	4
Introduced			11	5	5	6	6	7	6	9	8	6	4	7	9	8	8

Mean CPUE of age-0 and age 1+ fishes collected in the primary channel during autumn inventories, 2003–2011.

	2003			*2004*			*2005*			*2006*			*2007*			*2008*			*2009*			*2010*			*2011*		
Species	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***	***N***	***CPUE***	***SE***
CYPLUT	1706	0.5243	0.0801	9830	1.8335	0.3551	2521	0.8478	0.2573	164	0.0357	0.0061	204	0.031	0.0072	190	0.0314	0.0084	2568	0.3993	0.0862	218	0.0208	0.0043	250	0.0400	0.0086
CYPCAR				6	0.0012	0.0006	3	0.0005	0.0004							2	0.0006	0.0004	1	0.0001	0.0001						
PIMPRO	90	0.0353	0.0137	1119	0.2416	0.0749	281	0.092	0.0322	44	0.0058	0.0049	32	0.0043	0.0026	24	0.0053	0.0036	62	0.0088	0.0051	12	0.0014	0.0008	3	0.0004	0.0002
PTYLUC				4	0.0005	0.0002	2	0.0003	0.0002	8	0.0013	0.0005	23	0.0031	0.001	3	0.0004	0.0002	10	0.0013	0.0005	28	0.0029	0.0008	38	0.0029	0.0007
RHIOSC	511	0.1655	0.0292	4690	0.7643	0.1026	1234	0.2689	0.0412	2401	0.7378	0.488	2177	0.2653	0.0377	1192	0.2007	0.0244	2964	0.4338	0.0609	2007	0.2105	0.0329	658	0.1033	0.0176
CATDIS	27	0.0068	0.0021	283	0.0463	0.0056	90	0.0267	0.016	154	0.0404	0.0229	53	0.0066	0.0017	58	0.0158	0.0098	245	0.0289	0.0069	201	0.0218	0.0061	33	0.0059	0.0022
CATLAT	140	0.0622	0.0231	255	0.0441	0.0072	111	0.0289	0.0131	62	0.012	0.0028	227	0.0221	0.0073	101	0.0117	0.0039	216	0.0249	0.0078	594	0.0624	0.0189	104	0.0111	0.0021
LATxDIS	1	0.0002	0.0002																								
XYRTEX							1	0.0003	0.0003																		
AMEMEL				2	0.0005	0.0004	1	0.0006	0.0006	3	0.0004	0.0004				1	0.0005	0.0005							4	0.0005	0.0004
ICTPUN	366	0.0912	0.0144	603	0.0887	0.0161	401	0.096	0.0245	336	0.0695	0.009	697	0.0835	0.0109	533	0.0718	0.0096	122	0.0208	0.0069	460	0.0563	0.0091	493	0.0622	0.0097
FUNZEB	21	0.0056	0.0028	30	0.0051	0.0034	1	0.0003	0.0003							2	0.0001	0.0001	13	0.0009	0.0009	3	0.0002	0.0002	2	0.0006	0.0004
LEPCYA	2	0.0004	0.0003	1	0.0004	0.0004	1	0.0003	0.0003							1	0.0001	0.0001	7	0.0009	0.0004	1	0.0001	0.0001	2	0.0003	0.0002
MICSAL				4	0.0009	0.0005							1	0.0004	0.0004				4	0.0007	0.0004				1	0.0010	0.0006
GAMAFF	37	0.0093	0.0059	127	0.0239	0.0075	16	0.0067	0.0035	4	0.0009	0.0007	8	0.0012	0.0009	5	0.0034	0.0028	39	0.0061	0.003	3	0.0004	0.0003	44	0.0093	0.0049
SALTRU																			1	0.0001	0.0001	2	0.0001	0.0001			
AMENAT																						4	0.0008	0.0006			
Total N	2913			17042			4639			3175			2766			2217			6252			3533			1632		
Total Area	3994			7768			5985			5446			9038			7469			8483			11292			10160		
Density	0.73			2.19			0.78			0.58			0.31			0.36			0.74			0.31			0.29		

Appendix III - Species Presence Secondary Channels and CPUE Rates

Species collected 1998-2011. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	*SCIENTIFIC*	*CODE*	*STATUS*	*98*	*99*	*00*	*01*	*02*	*03*	*04*	*05*	*06*	*07*	*08*	*09*	*10*	*11*
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I	X		X	X	X	X	X				X	X		
Roundtail chub	*Gila robusta*	GILROB	N	X	X												X
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X	X				X	X	X	X	X	X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black bullhead	*Ameiurus melas*	AMEMEL	I	X			X	X	X	X	X			X	X		X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I	X			X				X	X		X	X		
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rainbow trout	*Oncorhynchus mykiss*	ONCMYK	I				X										
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X	X	X	X				X		X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I							X					X		X
Largemouth bass	*Micropterus salmoides*	MICSAL	I						X	X				X	X	X	X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X												
Native			6	5	6	4	3	3	3	4	4	4	4	4	4	4	5
Introduced			11	9	5	7	10	8	8	8	6	5	4	9	9	6	9

Mean CPUE of age-0 and age 1+ fishes collected in secondary channels during autumn inventories, 2003–2011.

	2003			*2004*			*2005*			*2006*			*2007*			*2008*			*2009*			*2010*			*2011*		
Species	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*
CYPLUT	1636	1.6186	0.4463	7171	4.2304	0.6358	921	0.9532	0.3283	154	0.1205	0.0368	168	0.0691	0.0194	221	0.082	0.0434	1869	1.0995	0.3286	378	0.1102	0.0668	194	0.0362	0.0136
CYPCAR	2	0.0016	0.0011	10	0.0088	0.004										5	0.0029	0.0015	4	0.0018	0.0009						
PIMPRO	325	0.2417	0.093	2239	1.88	0.7865	106	0.1218	0.0502	27	0.0347	0.0233	4	0.0017	0.0017	117	0.0383	0.0183	18	0.0109	0.0057	50	0.0294	0.0183	22	0.0030	0.0025
PTYLUC				4	0.0046	0.0023	1	0.0005	0.0005	2	0.0011	0.0008	15	0.0083	0.0027	6	0.0013	0.0006	1	0.0004	0.0004	18	0.0065	0.0019	22	0.0020	0.0007
RHIOSC	238	0.2454	0.06121	1364	7976	0.1667	172	0.2013	0.0507	251	0.2131	0.041	821	0.4256	0.1042	1017	0.5288	0.1178	1073	0.5093	0.118	886	0.3724	0.096	553	0.0918	0.0185
CATDIS	24	0.0167	0.0082	123	0.0827	0.0259	7	0.0064	0.0033	62	0.0256	0.0134	13	0.0057	0.0024	87	0.0202	0.0115	100	0.0367	0.0098	173	0.0517	0.017	218	0.0327	0.0162
CATLAT	145	0.1103	0.0531	124	0.0899	0.0293	25	0.0278	0.0099	61	0.0296	0.0131	87	0.041	0.0205	195	0.0602	0.0295	78	0.029	0.0091	281	0.1341	0.0496	66	0.0105	0.0023
AMEMEL	9	0.0057	0.0024	6	0.005	0.0031	3	0.0045	0.0031	4	0.0049	0.003				3	0.0018	0.0013	1	0.0009	0.0009				9	0.0024	0.0017
AMENAT							1	0.001	0.001							3	0.0017	0.0011	5	0.0023	0.0016						
ICTPUN	79	0.0551	0.0139	116	0.0991	0.0278	114	0.2099	0.1086	42	0.0193	0.0053	225	0.0935	0.0163	110	0.0387	0.0119	141	0.0823	0.0632	116	0.0449	0.0096	168	0.0383	0.0089
FUNZEB	11	0.0048	0.0025	32	0.0295	0.0173										4	0.0021	0.0014				1	0.0004	0.0004	16	0.0022	0.0022
LEPCYA				1	0.0007	0.0007													2	0.0006	0.0006				3	0.0004	0.0002
MICSAL	1	0.0016	0.0016	6	0.0037	0.002										10	0.0073	0.0052	6	0.0042	0.0023	2	0.0002	0.0002	6	0.0010	0.0006
GAMAFF	32	0.0258	0.0099	154	0.1584	0.0618	45	0.0463	0.0437	4	0.0058	0.0038	1	0.0004	0.0004	80	0.0236	0.0088	27	0.0148	0.0068	28	0.013	0.0082	221	0.0321	0.0275
GILROB																									1	0.0007	0.0007
Total N	2464			11109			1400			607			1334			1858			3325			1933			1499		
Area	1438			1789			1009			1679			2525			2619			2387			2760			2424		
Density	1.71			6.21			1.38			0.36			0.53			0.71			1.39			0.70			0.76		

Appendix IV - Species Presence Backwaters and CPUE Rates

Species collected 1998-2011. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	***SCIENTIFIC***	***CODE***	***STATUS***	***99***	***00***	***01***	***02***	***03***	***04***	***05***	***06***	***07***	***08***	***09***	***10***	***11***
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	X		X	X		X	X	X	X	
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X							X	X	X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		X	X	X	X	X	X		X	X	X		X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X		X	X	X	X	X
Black bullhead	*Ameiurus melas*	AMEMEL	I		X	X	X	X						X	X	X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I									X		X	X	X
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X		X	X	X	X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I		X	X	X		X	X			X		X	X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I		X	X	X	X	X	X			X	X	X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I			X	X	X					X	X		X
Bluegill	*Lepomis macrochirus*	LEPMAC	I		X											
Largemouth bass	*Micropterus salmoides*	MICSAL	I		X					X			X	X		
Native			4	3	4	3	3	3	3	3	1	4	4	4	3	4
Introduced			10	3	9	9	7	6	6	7	2	5	8	9	8	8

Mean CPUE of age-0 and age 1+ fishes collected in backwaters during autumn inventories, 2003–2011.

	2003			*2004*			*2005*			*2006*			*2007*			*2008*			*2009*			*2010*			*2011*		
Species	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*
CYPLUT	301	1.7454	0.4953	1033	3.6789	0.1984	566	1.2821	0.2102	3	0.0725	0.0513	67	0.0845	0.0054	288	0.5588	0.1032	2081	1.799	0.5392	199	0.2203	0.0965	742	0.2368	0.1578
CYPCAR				3	0.0102	0.002	1	0.0053	0.0012				1	0.0032	0.0005	2	0.0051	0.0008	3	0.0029	0.0017	1	0.0023	0.0023			
PIMPRO	241	2.4151	1.3993	319	1.0457	0.0721	122	0.2182	0.0163	2	0.0394	0.0063	12	0.0129	0.0015	35	0.1122	0.0691	182	0.1317	0.0614	24	0.041	0.0289	88	0.0100	0.0087
PTYLUC													21	0.028	0.0024	1	0.0026	0.0026	1	0.0006	0.0006	3	0.0061	0.0037	2	0.0002	0.0002
RHIOSC	4	0.0182	0.0094	10	0.0345	0.0164	12	0.0179	0.011	1	0.0242	0.0242	30	0.0407	0.0159	116	0.2098	0.1114	39	0.0416	0.0141	19	0.0391	0.0292	96	0.0075	0.0029
CATDIS	3	0.0431	0.0276	2	0.0081	0.0022	69	0.1346	0.0265				1	0.001	0.0002	6	0.0126	0.0011	20	0.0178	0.0113				1152	0.1703	0.1340
CATLAT	6	0.0431	0.0276	1	0.0038	0.001	114	0.1556	0.0207				4	0.0049	0.0005	26	0.0654	0.0071	39	0.043	0.0161	55	0.0644	0.0311	15	0.0016	0.0008
AMEMEL	12	0.0472	0.0445																121	0.0822	0.0811	8	0.012	0.0084	6	0.0018	0.0015
AMENAT													1	0.0036	0.0036				1	0.0011	0.0011	1	0.001	0.001	1		
ICTPUN	10	0.0373	0.0305	10	0.0411	0.005	1	0.0022	0.0005				64	0.0991	0.0061	36	0.0773	0.0078	7	0.0071	0.0041	11	0.0104	0.0059	19	0.0029	0.0019
FUNZEB	1	0.0043	0.0043	24	0.0603	0.0098	3	0.0034	0.0008							1	0.0033	0.0033				3	0.0065	0.0057	11	0.0013	0.0009
LEPCYA	1	0.0108	0.0108													1	0.003	0.003	89	0.0741	0.0737				1	0.0001	0.0001
MICSAL							2	0.0132	0.003							6	0.0154	0.0111	21	0.0188	0.015						
GAMAFF	20	0.1342	0.0812	17	0.0583	0.0059	26	0.0499	0.0077							23	0.0156	0.01	440	0.3973	0.3173	24	0.0205	0.0166	163	0.0352	0.0178
Total N	490			1415			876			6			198			541			3044			348			2296		
Area	245			274			489			53			723			486			1021			728			1235		
Density	2			5.16			1.79			0.11			0.27			1.11			2.98			0.48			0.47		