Nonnative Species Control in the Lower San Juan River 2003

Annual Progress Report

for the
San Juan River Recovery
Implementation Program

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EXECUTIVE SUMMARY

The second year of nonnative control in the lower San Juan River was conducted in 2003. This project was initiated to remove nonnative fish species and to identify factors involved in the movement of striped bass and other lacustrine species out of Lake Powell and into the river. Relationships between these factors and nonnative catch rates will provide for refinement in the timing of future control activities.

Eight trips were conducted, beginning in mid-March and continuing to the end of August. Results from the October Adult Monitoring trip were also incorporated. Electrofishing was conducted from Mexican Hat to Clay Hills, UT (RM 52.8-2.9). Average river flows were 870 cfs throughout sampling (except in October). Low flows at the beginning of July forced the cancellation of one trip.

Lake Powell elevations have dropped steadily since the beginning of 2002, and have been below 1988-1995 levels (3,670 - 3,623 ft above sea level) when a waterfall was present at RM 0.5. Lake elevations averaged 3,619 ft above sea level in January 2003, and by July, lake elevations were 3,616 ft above sea level, 84 ft below full pool. A waterfall approximately 50 ft wide and 4 ft high was observed near Piute Farms (RM -0.50). Since no striped bass or walleye had been collected or observed we concluded that either low lake elevations, the waterfall, or a combination of both was inhibiting movement of these species up into the San Juan River.

The majority of nonnative species collected were channel catfish. More than 8,000 of these fish were removed. Common carp were the next most abundant nonnative encountered. Catch rates for these two species remained similar between the first and last trips with some variation between trips. A significant decrease was observed in the size structure of channel catfish between the first and last trip but it did not exhibit a downward trend across trips. Carp size structure remained constant.

One hundred two endangered fish were collected during 2003 sampling. Of the 81, Colorado pikeminnow collected in the lower San Juan River, three were adults (>530 mm TL). The remaining seventy-nine were age-1 fish that had been stocked in November 2002 near Farmington, NM. Three Colorado pikeminnow were recaptured in October that had originally been tagged approximately two months earlier. Nineteen razorback sucker were collected in 2003. As in 2002, the majority were collected around Slickhorn Rapid (RM 17.7). Two of these fish were not previously tagged and measured 249 and 274 mm total length.

The lower San Juan River is an important section of river to endangered species. With the presence of the waterfall at Piute Farms this may be an important and unique time to concentrate on removal of nonnative fish while influx from the lake is eliminated. Continued removal in the lower river will aid in removal efforts being conducted further upstream, and suppress predation and competition impacts to the endangered and native fish community by nonnative fish.

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INTRODUCTION

Nonnative predatory fish species that move from Lake Powell into the San Juan River include largemouth bass (*Micropterus salmoides*), walleye (*Sander vitreum*) and striped bass (*Morone saxatilis*). Striped bass became of particular concern in 2000 when high numbers (approximately 270 individuals) and widespread distribution were observed in July during electrofishing surveys on the San Juan River (RM 147.9-129.0; Ryden 2001). U.S. Fish and Wildlife Service New Mexico Fishery Resources Office (NMFRO) crews collected another 33 striped bass between RM 166.6 and 158.6, just below the PNM weir in September and October 2000 sampling (Davis 2002). Adult monitoring in October 2000 revealed approximately one hundred striped bass still in the river. It was later speculated that the absence of small native flannelmouth sucker (*Catostomus latipinnis*) and bluehead sucker (*Catostomus discobolus*), and nonnative common carp (*Cyprinus carpio*) caught in summer 2000, was directly related to the abundance of these species found in striped bass stomachs (Ryden 2001). During the October 2000 trip, this was further evidenced by higher distributions of flannelmouth sucker, bluehead sucker, and common carp above the PNM weir near Farmington, NM where striped bass did not occur. Due to the threat that striped bass and other lake predatory species pose to endangered and native fish throughout the river, Utah Division of Wildlife Resources (UDWR), with the approval and support of the San Juan River Recovery Implementation Program (SJRIP), began nonnative control in the lower San Juan River in 2002.

Striped bass were first stocked into Lake Powell in 1974, and since 1979 a large self-sustaining population has persisted (Gustaveson 1984). Angler bag limits for striped bass were slowly raised and ultimately removed in Lake Powell to aid in control of the growing population. From 1988 to the summer of 1995, a waterfall at approximately RM 0 acted as a barrier between the river and the lake. Lake levels rose to full pool (3700 ft above sea level) during 1995 and inundated the waterfall allowing for the upstream movement of many nonnative species from Lake Powell. When lake levels receded in the winter of 1996, the river either cut a new channel or had not scoured the sediment enough to expose the rock and the waterfall did not reappear (Schaugaard and Gustaveson, 1996). Striped bass, walleye and threadfin shad (*Dorosoma petenense*), not previously documented in the San Juan River before waterfall inundation, were collected during large bodied fish sampling in 1995 (Ryden, 2001). Additionally, channel catfish (*Ictalurus punctatus*) and common carp catch rates had increased in the lower river and were presumed to have invaded from the lake as well.

The life history of striped bass suggests that they move out of lakes and into lotic waters to spawn in the spring (Lee et al. 1980). Striped bass usually spawn when temperatures are between 10 ºC and 21.1ºC (Sigler and Sigler 1996). They may move upstream when river conditions are favorable in the spring (cool temperatures and low turbidity) and remain in the river as long as these conditions persist (i.e., until monsoon storm events). In 2002, during the first year of this project, striped bass were found inhabiting the lower river in low numbers. In addition, other researchers collected striped bass as far upstream as Farmington, NM (RM 166-158; Davis 2002). Striped bass movement into the San Juan River was positively correlated with Lake Powell water temperatures and catch rates were highest in June when they were first observed in the river.

The lower San Juan River is particularly important in the recovery of the Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*) since it contains typical nursery habitat similar to what is present in the Green and Colorado rivers. Furthermore, the largest collection of razorback sucker larvae in 2002 was from Reach 2 (RM 21.2; Brandenburg et al. 2003). The presence of nonnative fish in this portion of the river can turn nursery habitats into lethal traps for larval and juvenile fish (Mueller et al. 1998). Collections of adult Colorado pikeminnow in the San Juan River have been extremely rare. No wild adults have been collected since 2000 (Ryden 2003). In 2002, Colorado pikeminnow adults and subadults, presumably from the 1996/1997 stocking efforts, were found using the lower canyon of the San Juan River in the spring and summer. Additionally, razorback sucker were found congregating around Slickhorn Rapid (RM 17.7) in the spring and apparently using this area for spawning. Removal of channel catfish and common carp, in addition to lake predatory species, assists in similar efforts conducted further upstream by NMFRO, and aids in the suppression of negative impacts caused by nonnative fish to the endangered and native fish community.

The objectives of this study were to: 1) determine when striped bass move out of Lake Powell and into the San Juan River; 2) continue mechanical removal efforts of large-bodied nonnative species from the lower San Juan River; 3) relate striped bass movement out of Lake Powell into the San Juan River to lake levels and river conditions (including flow and turbidity) and 4) characterize the distribution and abundance of lacustrine predators moving out of Lake Powell and into the San Juan River in spring and summer.

METHODS

The study area included the San Juan River from Mexican Hat (RM 52.8) to Clay Hills (RM 2.9), Utah. The river from Mexican Hat to RM 16 is primarily bedrock confined and dominated by riffle-type habitat. The river is canyon bound with an active alluvial bed from RM 16 to Clay Hills (RM 2.9). Habitats within this section are heavily influenced by the shifting thalweg, changing river flow, and reservoir elevations. This section of river has been identified as important nursery habitat for native and endangered fish species (Archer et al. 2000).

Raft mounted electrofishing gear was used during all trips. A Smith-Root electrofishing unit was utilized with amperage ranges set from 4-6 depending on water conditions. One boat sampled each shoreline on all but the first sampling effort. When conditions allowed, a baggage boat would follow to net fish not captured by the electrofishing boats. All nonnative and endangered species were netted, while native suckers were not. Collected fish were measured to the nearest millimeter (mm) and weighed to the nearest gram (g). In some instances, nonnatives were counted and weighed in mass, or simply counted. Endangered fish received a PIT tag if one was not already present and general condition of the fish was noted. In most cases, endangered fish were released at the location of their capture and a GPS reading was recorded. Stomach contents, sex and reproductive status of lacustrine predators were recorded. All nonnative fish species were removed from the river. River temperature, conductivity, and salinity were measured.

Turbidity was measured using a Secchi disk, with depth to disappearance of disk measured in millimeters. River discharge was determined from the USGS gage # 09379500 at Bluff, UT. Lake Powell elevations and temperatures were taken from the Lake Powell water database website.

Channel catfish collected during the first trip received a floy tag and were returned to the river. Channel catfish collected on subsequent trips were removed from the river. A Lincoln-Peterson population estimate was generated for channel catfish captured during the first two passes. Captures of channel catfish during subsequent trips allows for monitoring ratios of marked to unmarked fish and these ratios were used to calculate a rough population estimate thereafter. Ratios of marked fish to unmarked fish additionally help determine if assumptions of a closed population are being met.

Catch rates were calculated using number of fish caught per hour of electrofishing. Nonparametric Kruskal-Wallis and Mann-Whitney tests were performed on nonnormal data using SigmaStat 2.03 for Windows SPSS Inc. to identify significant changes in catch rates and size distributions.

RESULTS

Nine sampling trips, including Adult Fall Monitoring, were conducted on the San Juan River between Mexican Hat and Clay Hills, UT. Sampling dates were: March 24-28, April 28-May 2, May 19-23, June 9-13, June 23-27, July 21-25, August 4-8, August 18-22 and October 5-15. Average river discharge from March through August was 870 cfs. The lowest mean daily flow was 353 cfs which occurred on the first day of the April trip, and the highest mean daily flow was 1,750 cfs during the mid-May trip. In mid September, storm events produced a 20,000 cfs spike in river flow. Flows had dropped by the time of the Adult Fall Monitoring trip and ranged from 2,760 cfs to 583 cfs.

Lake Powell elevations have dropped steadily since the beginning of 2002, and are below 1988-1995 levels when the waterfall was present (3,670 - 3,623 ft above sea level). Lake elevations averaged 3,654 ft above sea level in January 2002 and at the time of this report were at 3,582.86 ft above sea level (117.14 ft below full pool). In July, in response to rumors that low river depth between Clay Hills and the lake may be impeding striped bass and other lake predators from moving up the San Juan River, a day trip was made to Piute Farms (approximately RM 0). A waterfall of approximately four feet high and fifty feet wide was observed at RM -0.6 (coordinates: 12S 549790E 4122882N, DATUM NAD27).

Nonnative Species

Eight different nonnative fish species were collected in the lower San Juan River during nonnative control and adult monitoring trips in 2003 (Table 1). Electrofishing effort totaled 396 hours and produced 8,968 fish, 87 were endangered species. No striped bass or walleye were collected during the 2003 sampling effort. Channel catfish dominated the total catch with over 7,900 individuals.

Catch rates of channel catfish varied significantly between passes and ranged from 7 to 45 fish per hour during each pass (Table 2). Mean catch rates of channel catfish dropped from 23.7 fish/hour in 2002 to 20.7 fish/hour in 2003. Catch rates between 2002 and 2003 of channel catfish graphically appears to have little variation, and no significant differences were detected (Fig.1). Channel catfish catch rates in 2003 ocellated between passes and were found to be positively correlated to water clarity measured in millimeters to Secchi disk disappearance (r-square = 0.74; Fig.2). Mean total length (TL) of channel catfish collected in 2003 (220 mm, SE = 9.9) was significantly ($p = 0.029$) smaller than those collected in 2002 (263 mm, SE = 15.4; Fig.3). Ranges of channel catfish length were similar between years. The Lincoln-Peterson population estimate performed on channel catfish from the first to the second pass derived 54,983 individuals (95 % confidence intervals = 25,267- 84,699). Recapture rates after the second pass decreased dramatically with zero to one recapture per pass.

Catch rates of common carp were variable across passes. Common carp catch rates were highest in June and ranged from one to four fish per hour across all passes (Fig.4). Positive correlations were not detected between carp catch rates and water clarity in 2003 (r-square=0.002; Fig.5). Catch rates of carp were similarly highest in June of 2002. In 2002, the pattern of common carp and channel catfish catch rates among passes was similar, however, common carp catch rates were approximately four times lower than those of channel catfish. In 2003, this pattern was not as noticeable and no significant correlations were identified. Common carp average TL was 440 mm (SE = 2.33, range 106-648 mm) and appeared to remain relatively constant for all passes (Fig.6). Common carp total length was significantly smaller in 2003 than 2002 ($p<0.001$).

Endangered Species

A total of 81 Colorado pikeminnow were collected in 2003, 78 of these were age-1 fish stocked in November 2002, and three were adults (range of TL 530-590 mm) presumably from the 1996/1997 stocking. The three adult Colorado pikeminnow were collected during the first two sampling trips in March and April between RM's 34-16, after that no adults were collected or observed. Age-1 pikeminnow were first collected during the mid-May trip, and continued to be collected through to the Adult Fall Monitoring trip in October. Catch rates of the age-1 fish increased considerably during the July through October trips (Table 2; Fig.7). Age-1 Colorado pikeminnow appeared to concentrate in two sections of river, RM 52-36 and RM 29-14, with the highest concentrations between RM 20 and 17 (Fig.8). Four age-1 Colorado pikeminnow were recaptures from previous 2003 trips, two were found within one mile of their original capture location, while the other two had moved 5 and 20 miles downstream (Table 3). Growth rates of age-1 Colorado pikeminnow ranged from 11 to 22 mm per month.

Twenty-three razorback sucker were collected in 2003 throughout the lower river, two others were observed and not collected. As in 2002, most razorback sucker collected in 2003 were near Slickhorn Rapid (RM 17.7). High concentrations in April around Slickhorn were not observed in 2003 as in the previous year, and catch rates across all trips were lower in 2003 but not significantly ($p=0.07$) (Table 2, Fig.9). The majority of razorback sucker were recaptures from previous stockings. Two razorbacks collected at RM's 36 and 5, did not have PIT tags and were less than 280 mm TL (Table 4).

DISCUSSION

In 2003, the second year of this study, no striped bass or walleye were collected or observed. Due to this observation in the first few months of sampling, combined with anecdotal reports that these fish may not have access to the San Juan River because of low flows between Clay Hills and Lake Powell, a trip was made by vehicle to Piute Farms in July. At that time a waterfall of approximately 50 ft wide and 4 ft high was discovered. It is believed that this is the direct reason none of the target species were observed in the river. It is not likely that other factors such as turbidity, river discharge or water temperature were the cause of the absence of striped bass and walleye in the river in 2003. These physical factors were similar to those observed the previous year when striped bass and walleye were collected. Beasley and Hightower (2000) found that a one meter high lowhead dam on the Neuse River in North Carolina was a barrier to spawning migrations of striped bass. It is unknown if walleye are able to pass this barrier. High flows in the river may cause the river to flow around the waterfall or to wash it out entirely therefore again allowing fish to pass and move upstream. The river below the waterfall down to Copper Canyon did not appear too shallow for movement of species from the lake. However, direct access to the river was not possible to determine depth of the channel. It is possible that at the river/lake confluence a channel may not be present for passage out of the lake by striped bass and walleye.

Channel catfish catch rates were lower and total lengths smaller than the previous year, in 2003, which may or may not be due to two consecutive years of removal efforts. Subsequent years of data collection will allow for valid correlation of statistical data changes to removal actions. During 2003, a strong positive correlation was observed between catch rates of channel catfish and water clarity, illustrating that channel catfish are more readily caught during times of decreased turbidity. Population estimates using the Lincoln-Peterson method provide some information on the current abundance of channel catfish. Population estimates conducted in subsequent years will provide information on relative abundance of this species. Additionally, it may allow a cursory evaluation of nonnative control in the lower San Juan River.

Movement of channel catfish has been documented in many reports (Brooks 2000, Dames 1989). The longest movements appear to occur in the summer when channel catfish spawn, however shorter movements have been documented during the spring and fall as well. Therefore, channel catfish are undoubtedly moving downstream into the removal area, as well as out of the removal area, upstream of Mexican Hat. This is evidenced by the recapture of fish in the canyon section of the river that were marked near Farmington, NM (RM 166.8- 158.6) by NMFRO personnel. Low recaptures in subsequent trips further support that channel catfish are moving in and out of the removal area between Mexican Hat and Clay Hills.

Ryden (2000) reported that channel catfish catch rates increased significantly from 1993 to1995 in the lower river following inundation of the waterfall in the spring. Nonnative infiltration from Lake Powell was probably eliminated during 2003 by the presence of the waterfall. The presence of this barrier may provide the opportunity to significantly reduce nonnative fish species in the lower San Juan River.

Catch rates of endangered species in 2003 were high and similar to those in 2002. Many age-1 Colorado pikeminnow were collected in the lower river as a result of their stocking in November 2002 near Farmington, NM. Age-1 Colorado pikeminnow exhibited excellent growth rates between May and October. These are likely attributed to warm river temperatures caused by lower than normal flows. The capture of three age-1 Colorado pikeminnow in October that were originally marked in summer is encouraging since a 20,000 cfs spike event occurred in late September. The persistence of these fish at high flows illustrate that once Colorado pikeminnow reach a certain age/length, they may have a better ability to maintain themselves in the river. Furthermore, at the time of their recaptures, two had stayed within approximately one mile of their original capture location. The apparent concentration of these fish between RM's 50-35 and 29-14 is interesting and noteworthy. These portions of the river during low water years may provide important habitat to age-1 Colorado pikeminnow. The decrease in the average number of adult/subadult Colorado pikeminnow in 2003 was disappointing. In 2002, one to two pikeminnow were collected per trip. In 2003, even though more trips were conducted, fewer large Colorado pikeminnow were collected. The reason for this decline in the adult/subadult Colorado pikeminnow is unknown. However, continued monitoring will help determine what factors may be influencing these fish in the lower San Juan River.

CONCLUSIONS AND RECOMMENDATIONS

- No striped bass or walleye were collected in the lower San Juan River. This is likely due to the presence of the waterfall. However, it is unclear whether these fish will be able to pass this barrier during times of high flow. This barrier may be preventing other nonnatives such as channel catfish, common carp and largemouth bass from moving up into the river. Since it is likely that the waterfall will persist for several years, channel catfish, common carp and largemouth bass already present in the river should be considered the primary target species for removal actions. Continued removal of these species in the lower San Juan River will aid in relieving the pressure induced by these species on native and endangered fish, and compliment removal efforts being conducted further upstream.

- General population estimates of channel catfish inhabiting the lower San Juan River are being conducted in order to evaluate the effectiveness of removal. Channel catfish should continue to be marked on the first pass to utilize the Lincoln-Peterson method in estimating population size at the beginning of each year.

- In recent years, this project has been the only one to successfully document adult Colorado pikeminnow in the lower San Juan River. Endangered species abundance, growth and movement in the lower San Juan River should continue to be documented in conjunction with nonnative removal.

LITERATURE CITED

Archer, E.K., T.A. Crowl, and M.A. Trammell. 2000. Abundance of age 0 native fish species and nursery habitat quality and availability in the San Juan River in New Mexico, Colorado, and Utah. Final Report to the San Juan River Recovery Implementation Program: Biology Committee. Utah Division of Wildlife Resources. Salt Lake City, UT.

Beasley, C. A., and J. E. Hightower. 2000. Effects of a low-head dam on the distribution and characteristics of spawning habitat used by striped bass and American shad. Transactions of the American Fisheries Society 129:1372-1386.

Brandenburg, H.W., M.A. Farrington, S.J. Gottlieb. 2003. Razorback sucker larval fish survey in the San Juan River during 2002. Draft report to the San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque NM.

Brooks, J.E., M.J. Buntjer, J.R. Smith 2000. Non-native species interactions: Management implications to aid in recovery of the Colorado pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus* in the San Juan River. Final Report to the San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque NM.

Davis, J.E. 2002. Non-native species monitoring and control, San Juan River 1999-2001. Progress Report for the San Juan River Recovery Implementation Program. Draft Report. U.S. Fish and Wildlife Service, Albuquerque, NM.

Dames, H.R., T.G. Coon, J.W. Robinson 1989. Movements of Channel and Flathead Catfish between the Missouri River and a Tributary, Perche Creek. Transactions of the American Fisheries Society: Vol. 118, No. 6, pp. 670—679.

Gustaveson, W., B.L. Bonebrake, S.J. Scott, J.E. Johnson. 1984. Lake Powell fisheries investigations. Completion report Jan. 1980- Dec. 1984, Annual performance report Jan. 1984-Dec.1984. Project F-28-R-13. Publication No. 85-12. Utah Division of Wildlife Resources. Salt Lake City, UT. 73 pp.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R.E. Jenkins, D. E. McAllister, J. R. Stauffer, Jr. 1980. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History.

Mueller, G., P. Marsh, and G.W. Knowles. 1998. Distribution, migratory behavior and habitat use of razorback sucker (Xyrauchen texanus) in Lake Mohave, Arizona-Nevada. Open file report 98-252. U.S. Geological Survey. Denver, CO. 88 pp.

Ryden, D. W. 2000. Adult fish community monitoring on the San Juan River, 1991-1997. Final Report. U.S. Fish and Wildlife Service, Grand Junction CO. 269 pp.

Ryden, D. W. 2001. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River, 2000. Interim Progress Report. U.S. Fish and Wildlife Service. Grand Junction, CO. 61 pp.

Ryden, D. W. 2003. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 1999-2001 Integration Report. U.S. Fish and Wildlife Service. Grand Junction, CO. 68 pp.

Schaugaard, C. and W. Gustaveson. 1997. Nonnative invasion between Lake Powell and the San Juan River, 1996. Completion Report. Utah Division of Wildlife Resources. Salt Lake City, UT. 16 pp.

Sigler, W. F. and J. W. Sigler. 1996. Fishes of Utah. University of Utah Press. Salt Lake City.

Table 1. Total count of all fish species collected during lower San Juan River nonnative control and adult monitoring trips. Numbers in parentheses represent positive identifications of fish observed but not netted.

Trip	Ptyluc	Xyrtex	Ictpun	Cypcar	Micsal	Lepmac	Lepcya	Amemel
March 24-28	1	3	337	27	0	0	1	0
April 28- May 2	2	5(2)	2527	77	0	0	0	0
May 19-23	3	1	346	74	1	0	0	1
June 9-13	2	4	1114	199	0	0	1	1
June 23-27	1	2	389	131	0	0	1	0
July 21-25	9	2	1592	182	2	0	0	1
August 4-8	24	1	663	122	10	0	1	2
August 18-22	20	1	1281	124	4	1	1	4
October 5-15	19	2	62	14	0	0	0	0
Totals	81	21(2)	8249	909	17	1	5	9

Table 2. Mean catch per unit effort (number of fish / hour of electrofishing) of five species collected during lower San Juan River nonnative control and adult monitoring trips in 2003.

Pass	Ptyluc	Xyrtex	Ictpun	Cypcar	Micsal
March 24-28	0.03	0.13	11.89	1.03	0
April 28- May 2	0.03	0.08	43.9	1.34	0
May 19-23	0.06	0.01	8.33	1.22	0.02
June 9-13	0.04	0.07	25.33	4.34	0
June 23-27	0.01	0.03	7.29	2.17	0
July 21-25	0.17	0.02	31.98	3.30	0.03
August 4-8	0.48	0.01	12.76	2.41	0.20
August 18-22	0.39	0.01	24.64	2.47	0.07
October 5-15	0.69	0.06	7.0	0.82	0
All Trips	0.21	0.05	19.23	2.12	0.03

Table 3. Colorado pikeminnow large enough to receive a PIT tag collected by electrofishing during 2003 lower San Juan River nonnative control and adult monitoring trips.

Date	RM	PIT tag	Recap	TL	SL	WT
3/27/03	16	53180D4E7E	N	530	435	1250
4/29/03	34	522A213C40	N	535	417	1350
4/30/03	21.4	4269392329	N	590	490	1600
7/22/03	40.6	425B64443E	N	141	112	16
7/22/03	44	42695F072D	N	160	129	25
7/22/03	37.8	5309125474	N	165	133	32
7/24/03	19.4	5309170245	N	157	130	22
8/04/03	21.2	5309577719	N	188	156	48
8/04/03	48	53095E310D	N	160	132	25
8/04/03	51.5	53120C2D7A	N	181	148	42
8/04/03	47	53120E0E09	N	155	126	25
8/04/03	49.4	5312215677	N	174	140	35
8/05/03	38.8	5309532526	N	156	127	22
8/05/03	40.2	530966653C	N	189	156	38
8/05/03	43.8	5309685749	N	176	146	36
8/06/03	18.5	52290C2B78	N	154	122	27
8/06/03	18.5	522A206F44	N	178	144	39
8/06/03	-	522A49574A	N	184	146	38
8/06/03	25.5	522A61383B	N	176	140	36
8/06/03	17	5309566C22	N	155	120	22.5
8/07/03	15.2	522A237C5E	N	190	156	46
8/07/03	17.6	5309696720	N	164	133	19
8/18/03	51.8	53095B5741	N	162	125	26
8/19/03	37	423C662E34	N	173	147	40
8/19/03	36	423D0B5231	N	202	163	60
8/19/03	47	42417C4167	N	164	130	20

Table 3 (continued). Colorado pikeminnow large enough to receive a PIT tag collected by electrofishing during 2003 lower San Juan River nonnative control and adult monitoring trips.

Date	RM	PIT tag	Recap	TL	SL	WT
8/19/03	40.6	4242033B30	N	206	170	75
8/19/03	39.8	530916313B	N	186	148	46
8/19/03	37.3	530B3B5457	N	171	134	37
8/19/03	46.1	530B432E6C	N	158	125	26
8/19/03	45.2	530B511D0D	N	161	130	29
8/19/03	45.2	53120C2D7A	Y	191	151	54
8/19/03	45.1	531227416F	N	170	134	34
8/20/03	19.8	423C655431	N	212	179	53
8/20/03	26.9	423D031F60	N	178	146	38
8/20/03	25.8	423D08384A	N	169	138	31
8/20/03	23.5	53091A703A	N	182	146	38
8/20/03	19.5	530B3C1D34	N	184	143	35
8/21/03	17.5	423D1D1461	N	162	128	35
8/21/03	13.8	5309604F26	N	174	141	34
10/12/03	52.8-52	426931163A	N	232	192	85
10/12/03	45-44	4241566A12	N	200	160	50
10/12/03	42-41	420F2F0615	N	211	172	55
10/12/03	42-41	423D0A6642	N	181	147	50
10/12/03	41-40	423D024038	N	192	154	40
10/12/03	38-37	423C662E34	Y	207	166	75
10/12/03	38-37	423D19512D	N	200	160	65
10/12/03	36-35	426853647F	N	197	159	50
10/12/03	32-31	4268715C34	N	208	174	55
10/13/03	29-28	42417C4167	Y	186	149	45
10/13/03	29-28	522A43574A	Y	226	180	82
10/13/03	27-26	423D185B4B	N	235	188	75

Table 3 (continued). Colorado pikeminnow large enough to receive a PIT tag collected by electrofishing during 2003 lower San Juan River nonnative control and adult monitoring trips.

Date	RM	PIT tag	Recap	TL	SL	WT
10/13/03	26-25	423C697364	N	218	177	70
10/13/03	26-25	4241793E30	N	178	139	40
10/13/03	26-25	4241692F01	N	173	139	40
10/13/03	21-20.2	423E280D0A	N	224	178	70
10/13/03	20.1-19	423D077B0C	N	235	190	75
10/13/03	20.1-19	42416D6F74	N	230	186	80
10/13/03	20.1-19	423C695836	N	172	135	40

Table 4. Razorback sucker collected during 2003 lower San Juan River nonnative control and adult monitoring trips. All but two razorbacks (#425B63072F and #4121492F55) were recaptures.

Date	RM	PIT tag	TL	SL	WT	Sex (M/F/I)
3/27/03	18.8	5324566328	438	370	980	M
3/27/03	18.8	7F7B10402D	551	465	1500	F
3/27/03	18.8	7F7B106C67	476	399	1100	ripe M
4/28/03	50.7	42424F2863	497	475	1000	F
5/1/03	18.4	4240072250	440	360	960	-
5/1/03	19	423E673807	460	380	980	M
5/1/03	12.9	423F5C3654	394	327	770	-
5/1/03	17.6	51247B6557	485	410	1150	M
5/21/03	15.2	4240072250	442	378	1960	-
6/9/03	47.6	5228381D5F	449	380	870	-
6/10/03	45	52290E016E	405	336	620	-
6/12/03	18	423F7E5A02	462	395	1000	-
6/12/03	18.7	52285E1A28	405	342	700	-

Table 4 (continued). Razorback sucker collected during 2003 lower San Juan River nonnative control and adult monitoring trips. All but two razorbacks (#425B63072F and #4121492F55) were recaptures.

Date	RM	PIT tag	TL	SL	WT	Sex (M/F/I)
6/26/03	17.8	423F7E5A02	471	387	1010	-
6/26/03	20.2	5128465837	475	390	1000	-
7/24/03	18.5	423F167345	410	342	755	-
7/25/03	4.8	425B63072F	274	202	200	-
8/7/03	11.5	507E667172	441	369	890	-
8/19/03	42.5	423E696E12	472	402	1230	-
10/12/03	35.7	4121492F55	249	189	125	I
10/14/03	8-7	522A4C4A53	410	343	670	I

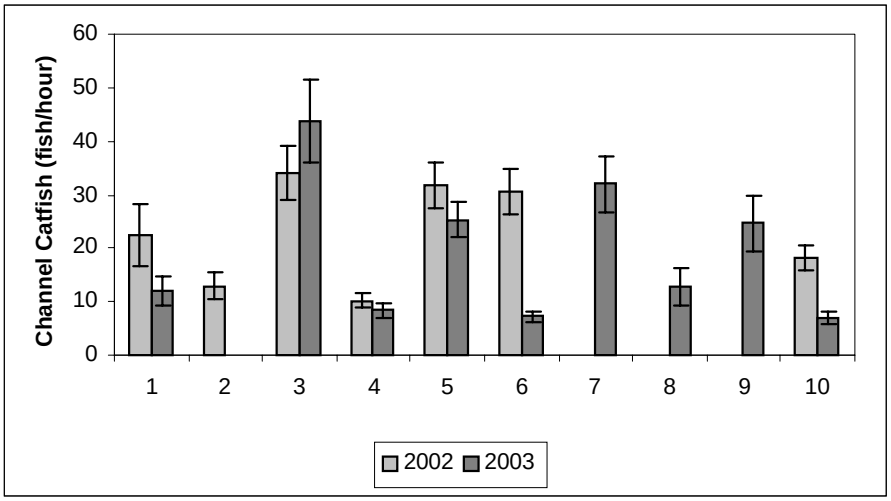

Figure 1. Channel catfish catch rates across passes during 2002 and 2003 nonnative control and adult monitoring trips in the lower San Juan River. Error bars represent standard error. Note: Numbers on x-axis represent similar times of the year that sampling was conducted in 2002 and 2003 (1: March 11-28, 2: April 15-19, 3: April 28- May 10, 4: May 19-24, 5: June 9-14, 6: June 23-28, 7: July 21-28, 8: August 4-8, 9: August 18-22, 10: September 20- October 15).

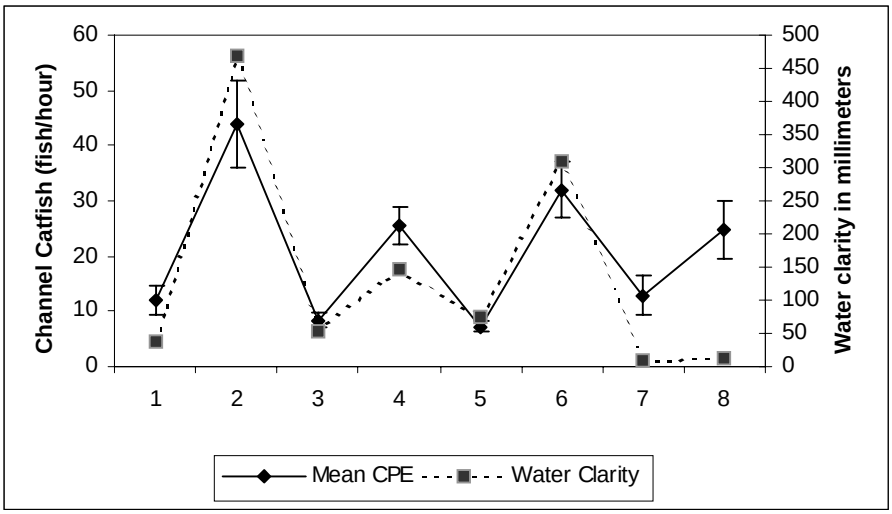

Figure 2. Channel catfish catch rates vs. water clarity across passes during 2003 nonnative control in the lower San Juan River (r-square = 0.74). Error bars represent standard error. Note: Numbers on the x-axis represent each pass performed in 2003.

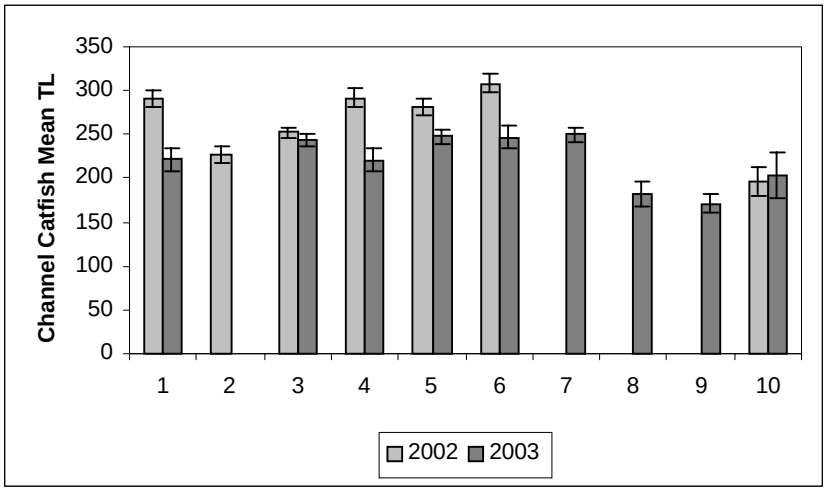

Figure 3. Mean TL (total length) values and 95% confidence intervals (represented by error bars) of channel catfish collected in the lower San Juan River during nonnative control and adult monitoring trips in 2002 and 2003. Note: Numbers on x-axis represent similar times of the year that sampling was conducted in 2002 and 2003 (1: March 11-28, 2: April 15-19, 3: April 28- May 10, 4: May 19-24, 5: June 9-14, 6: June 23-28, 7: July 21-28, 8: August 4-8, 9: August 18-22, 10: September 20- October 15).

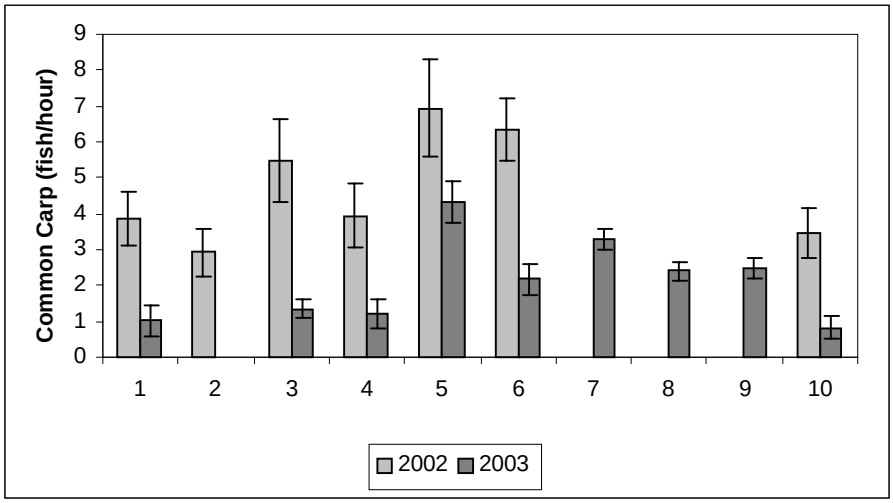

Figure 4. Common carp catch rates across passes during 2002 and 2003 nonnative control and adult monitoring trips in the lower San Juan River. Error bars represent standard error. Note: Numbers on x-axis represent similar times of the year that sampling was conducted in 2002 and 2003 (1: March 11-28, 2: April 15-19, 3: April 28- May 10, 4: May 19-24, 5: June 9-14, 6: June 23-28, 7: July 21-28, 8: August 4-8, 9: August 18-22, 10: September 20- October 15).

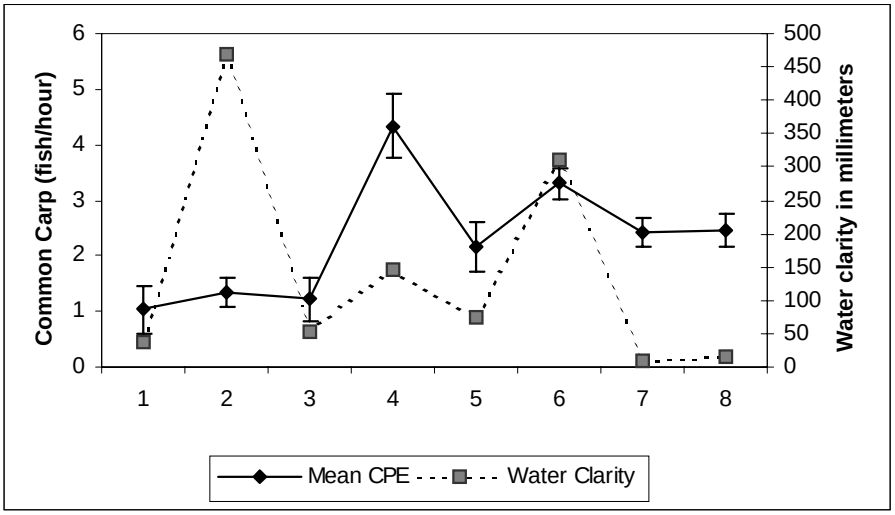

Figure 5. Common carp catch rates vs. water clarity across passes during 2003 nonnative control in the lower San Juan River (r-square = 0.002). Error bars represent standard error. Note: Numbers on the x-axis represent each pass performed in 2003.

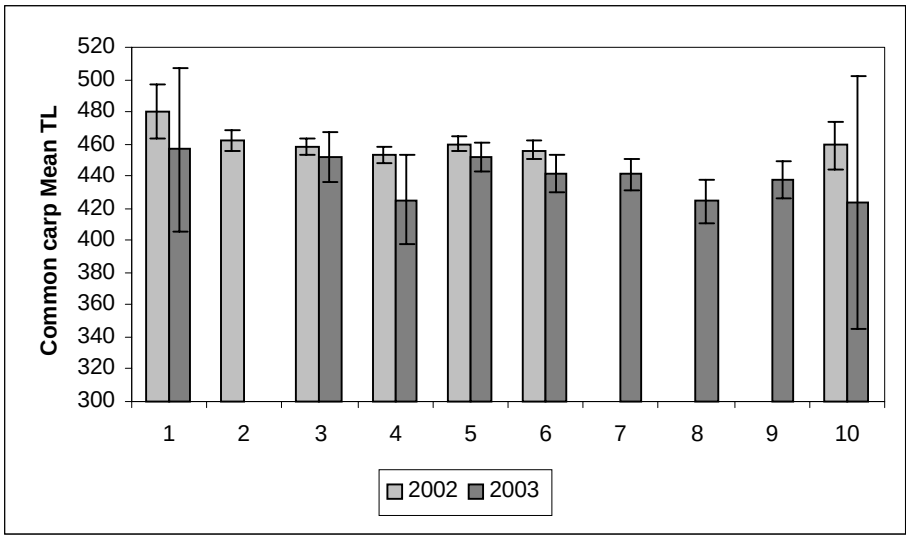

Figure 6. Mean TL (total length) values and 95% confidence intervals (represented by error bars) of common carp collected in the lower San Juan River during nonnative control and adult monitoring trips. Note: Numbers on x-axis represent similar times of the year that sampling was conducted in 2002 and 2003 (1: March 11-28, 2: April 15-19, 3: April 28- May 10, 4: May 19-24, 5: June 9-14, 6: June 23-28, 7: July 21-28, 8: August 4-8, 9: August 18-22, 10: September 20- October 15).

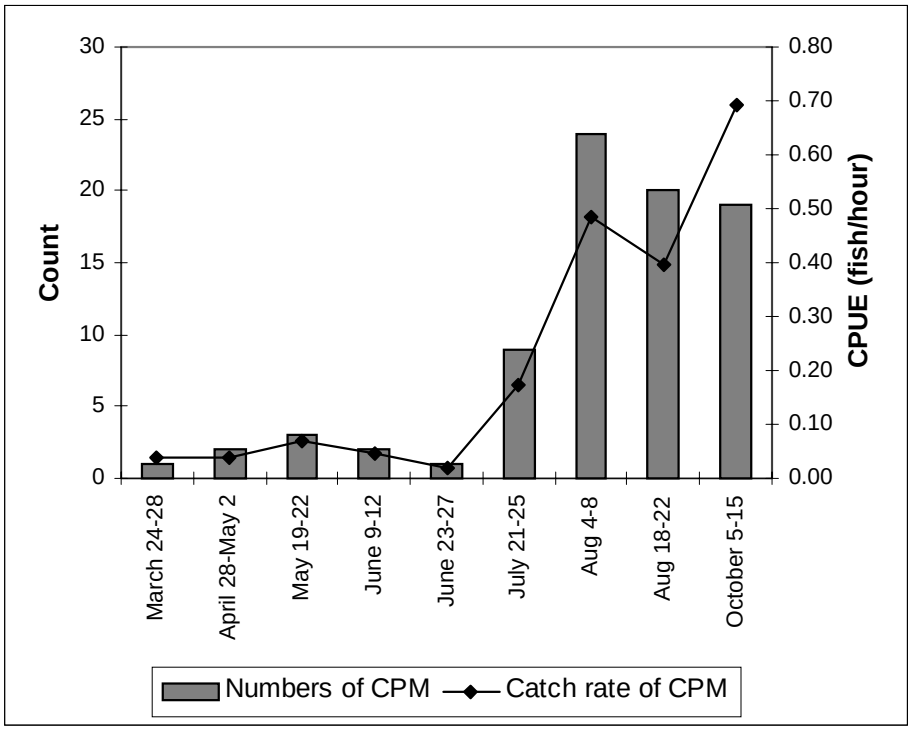

Figure 7. Catch rates of adult and age-1 Colorado pikeminnow collected during nonnative control and adult monitoring trips in the lower San Juan River in 2003.

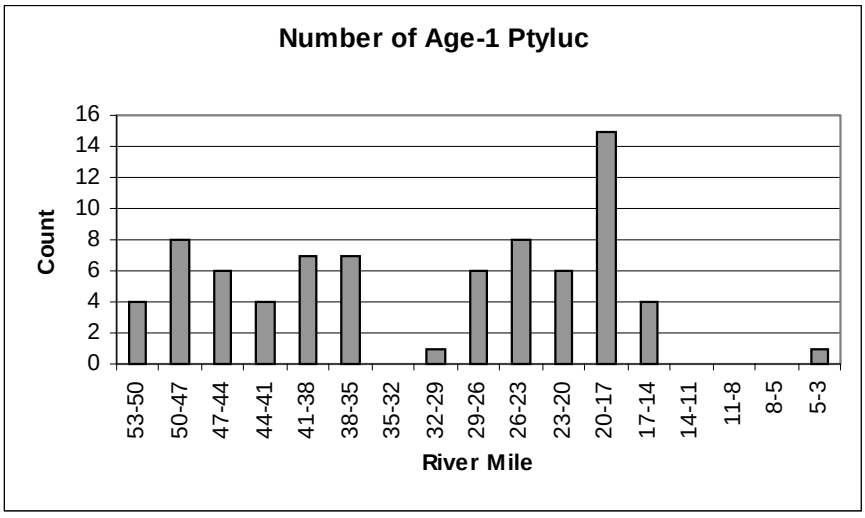

Figure 8. River distribution of age-1 Colorado pikeminnow collected during nonnative control and adult monitoring trips in the lower San Juan River in 2003.

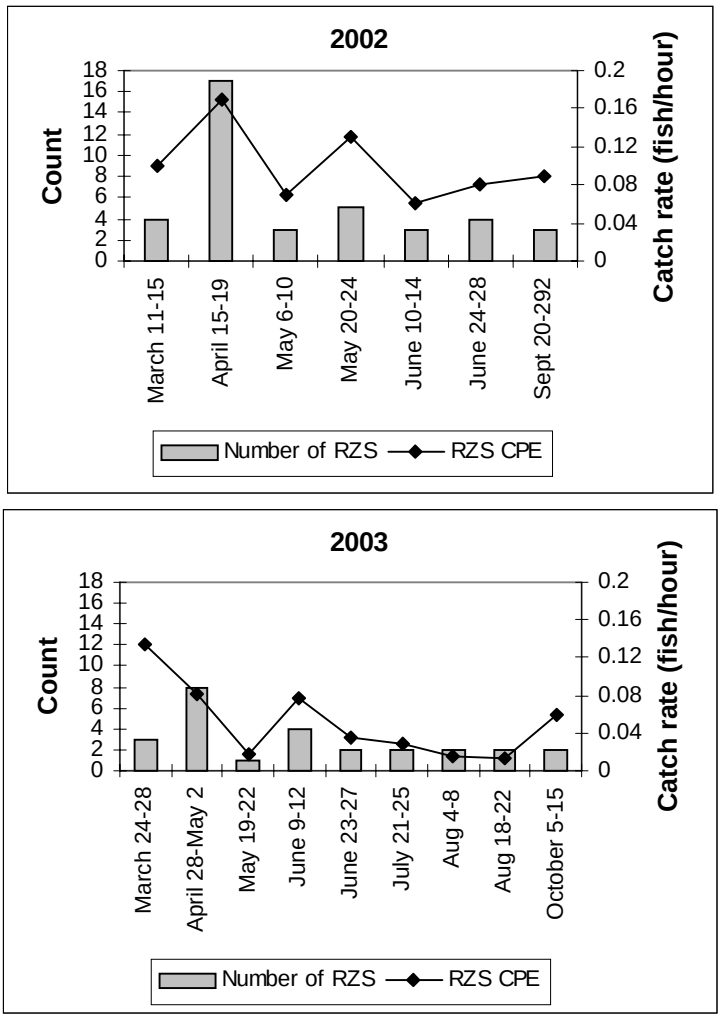

Figure 9. Catch rates of razorback sucker collected during nonnative control and adult monitoring trips in the lower San Juan River in 2002 and 2003. Note: In 2002, during the April trip, ten razorback were not netted and in 2003, two razorbacks during the April trip were not netted.

Appendix A. Flow, water temperature (Celsius), and turbidity (mm to Secchi depth disappearance), at the time of sampling on the San Juan River in 2003.

Trip	Average Flow (ft^3/s)	Average H_20 (^oC)	Average Turbidity (mm)
March 24-28	637	10.9	36
April 28- May 2	653	16.5	470
May 19-22	1535	20.6	52
June 9-12	1386	22.5	146
June 23-27	748	23	76
July 21-25	499	29	310
August 4-8	837	25.2	9
August 18-22	762	24.7	14
October 5-15	1117	15	60

Appendix B. Common name, scientific name and abbreviations of fish collected during 2003 nonnative control in the lower San Juan River.

Common name	Scientific name	Abbreviation
striped bass	*Morone saxatilis*	Morsax
walleye	*Sander vitreum*	Sanvit
channel catfish	*Ictalurus punctatus*	Ictpun
largemouth bass	*Micropterus salmoides*	Micsal
green sunfish	*Lepomis cyanellus*	Lepcya
bluegill	*Lepomis macrochirus*	Lepmac
common carp	*Cyprinus carpio*	Cypcar
black bullhead	*Ameiurus melas*	Amemel
Colorado pikeminnow	*Ptychocheilus lucius*	Ptyluc
razorback sucker	*Xyrauchen texanus*	Xyrtex

Appendix C. Number of channel catfish marked, captured and recaptured during nonnative control in the lower San Juan River in 2003.

Pass	# Marked	# Captured	# Recaptured
March 24-28	260	337	0
April 28- May 2	0	2527	11
May 19-23	0	346	0
June 9-13	0	1114	1
June 23-27	0	389	1
July 21-25	0	1592	1
August 4-8	0	663	0
August 18-22	0	1281	1