Nonnative control in the Lower San Juan River 2004

Interim Progress Report
Draft

for the
San Juan River Recovery
Implementation Program

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## EXECUTIVE SUMMARY

The third year of nonnative control in the lower San Juan River was conducted in 2004. This project was initiated to remove nonnative fish species, and to identify factors involved in the movement of striped bass (*Morone saxatilis*) and other lacustrine species out of Lake Powell and into the river. Relationships between these factors and nonnative catch rates were intended to help in the refinement of removal effort timing.

In 2004, eight passes were conducted, beginning in mid-March and continuing until mid-August. Results from the October adult monitoring pass, conducted by USFWS-Grand Junction (CRFP), were also incorporated in the analysis. Electrofishing was conducted from Mexican Hat to Clay Hills, UT (river mile (RM) 52.8-2.9). Average river flows were 1,455 cubic feet per second (cfs) throughout sampling. Low flows at the beginning of July forced the cancellation of one pass, and the lowest flow of the year (256 cfs) occurred during the August pass.

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 -0.5) in July 2003. Since no striped bass or walleye (*Sander vitreum*) had been collected or observed that year we concluded that low lake elevations, the waterfall, or a combination of both was inhibiting movement of these species up into the San Juan River. The waterfall at Piute Farms was present throughout sampling in 2004, and again no striped bass or walleye were collected. Furthermore, the waterfall had increased to approximately 10 ft high by July 2004. By November, the river had started to erode one side, yet it is likely the waterfall continues to act as a barrier for fish moving upstream from Lake Powell.

The majority of nonnative species collected in 2004 were channel catfish (*Ictalurus punctatus*). More than 8,000 of these fish were removed. Catch rates of channel catfish decreased between the first trip and the fall trip in 2004; however, catch rates of channel catfish remained similar from 2002 to 2004. A significant decrease was observed in the size structure of channel catfish between 2002 and 2004. In 2004, upon examination of two separate channel catfish stomachs, a recently stocked razorback sucker (*Xyrauchen texanus*) and Colorado pikeminnow (*Ptychocheilus lucius*) were found. These endangered fish were roughly half the length of the channel catfish that consumed them.

In previous years, 2002 and 2003, common carp (*Cyprinus carpio*) were the second most abundant species collected. In 2004, their numbers had dropped significantly. Size structure of common carp has remained similar among years, yet in 2004 more juveniles were collected than in 2002 and 2003. The mechanism that caused the drop in catch rates of common carp is unknown. A number of factors may be responsible, including the presence of the waterfall, low river flows, and mechanical removal of these fish. It is likely that all of these factors are responsible to some extent.

Two hundred sixty-seven endangered fish were collected during 2004 sampling in the lower San Juan River. Two hundred twenty-five were Colorado pikeminnow, of which only one was an adult (547 mm total length). The remaining were age-1 and 2 fish that had been stocked in November 2002 and 2003 near Farmington, NM. A few of these individuals were age-2 fish stocked from the Mumma Fish Hatchery. Of the 164 tagged juvenile Colorado pikeminnow greater than 150 mm total length (TL) collected, 24 were recaptures. Several of these fish exhibited upstream movement through the year of 10 to 31 miles, while no considerable downstream movement was observed (beyond one mile). Preliminary population estimates suggest that the number of juvenile Colorado pikeminnow occupying the lower San Juan River is approximately 200 fish with a range of 100-500, depending on the time frame the estimate was conducted. Thirty-eight razorback sucker were collected in 2004, four of these fish were recaptured during the year. Four razorback sucker collected were less than 300 mm TL (120-280 mm TL), did not have PIT tags, and appear to be wild spawned fish. As in 2002, the majority of razorback sucker were collected around Slickhorn Rapid (RM 17.7), yet no spawning aggregations were observed. Ten suspected razorback- flannelmouth hybrids were collected in 2004, compared to two collected in 2003.

The lower San Juan River has proven to contain valuable habitat for endangered fish species and is essential to their success. Due to the increased effort of stocking of endangered fish, evidence of natural reproduction of razorback sucker and Colorado pikeminnow, and the presence of the waterfall at Piute Farms, it is extremely important to continue suppression of nonnative species by mechanical removal. Continued removal of nonnative fish in the lower San Juan River will aid in removal efforts being conducted further upstream, and reduce predation and competition impacts on the endangered and native fish community.

# INTRODUCTION

The lower San Juan River has proven to be essential in the recovery of the Colorado pikeminnow and razorback sucker. It contains nursery habitats comparable to those existing on the Green and Colorado rivers, where wild young-of-year and juvenile Colorado pikeminnow are typically found. Within the past five years, collections of endangered fish have been increasing in the lower San Juan River. The largest collection of razorback sucker larvae in 2002 was from Reach 2 (RM 21.2; Brandenburg et al. 2003) and the largest single collection of razorback sucker larvae in 2003 came from a backwater in Reach 1 at RM 8.1 (Brandenburg et al. 2004). The most recent finding from 2004 was the collection of two wild spawned Colorado pikeminnow larvae at RM 46.3 and 18.1 (Brandenburg et al. 2005). Additionally, adult razorback sucker were found congregating around Slickhorn Rapid (RM 17.7) in the spring of 2002, during this study, and were apparently using this area for spawning. 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 and 2003, sampling during this study resulted in low numbers of Colorado pikeminnow subadults and adults (246-590 mm TL), presumably from the 1996-1997 stocking efforts, using the lower canyon (Reaches 2 and 1) of the San Juan River in the spring and summer. In 2003 and 2004, young-of-year Colorado pikeminnow stocked in the fall of the previous year near Farmington, NM, were also found using the lower portions of the San Juan River (Golden et al. 2005, this study).

This project was originally initiated in an attempt to target striped bass and other nonnative predatory fish species such as largemouth bass (*Micropterus salmoides*) and walleye that move from Lake Powell into the San Juan River. 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). United States 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 during September and October 2000 sampling (Davis 2002). Adult monitoring in October 2000 revealed approximately 100 striped bass still in the river. It was later speculated that the absence of small native flannelmouth sucker (*Catostomus latipinnis*) and native bluehead sucker (*Catostomus discobolus*), and nonnative common carp 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 were not found.

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 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 $10^{o}$C and $21.1^{o}$C (Sigler and Sigler 1996). In the Sacramento-San Juaquin Delta, striped bass movement up river was positively related to high flows and turbidity (Feyrera and Healey, 2003) Similar movements have been observed in the San Juan River in the spring. However, it has been the belief that turbid flows in the fall may preclude striped bass from persisting in the river through the year. Based on the biology of striped bass, turbidity may not be a factor. Instead these fish may simply move back downstream after spawning. Striped bass in Lake Powell are unique in their ability to reproduce in the reservoir itself (Gustaveson, 1984). 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 (Jackson 2003).

In 2003, no striped bass or walleye were collected or observed. As a result of 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 (Quentin Bradwisch, personal communication), 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. Beasley and Hightower (2000) found that a one-meter high (3.28 ft) low head 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 eventually cause the river to flow around the waterfall or to wash it out entirely thereby allowing fish to pass and move upstream again. Since discovery of the waterfall, the focus of this project has been to suppress other nonnative fish in the lower San Juan River, as well as to track the abundance and distribution of endangered fish.

The presence of the waterfall at Piute Farms may provide a rare opportunity to concentrate on removal of nonnative fish while influx from the lake is eliminated. Continuing removal in the lower river will aid in removal efforts being conducted further upstream, and suppress predation and competition impacts on the endangered and native fish community by nonnative fish.

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

*Study Area*

The study area included the San Juan River from Mexican Hat (RM 52.8) to Clay Hills (RM 2.9), Utah (Fig.1). 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).

*Sampling*

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 electrofished each shoreline during sampling passes. 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, nonnative fish 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. A global position system (GPS) reading and river mile where the fish was captured was recorded. Stomach contents, sex and reproductive status of lacustrine predators were recorded. All nonnative fish species were removed from the river. Channel catfish collected during the first pass received an anchor tag and were returned to the river. Channel catfish collected on subsequent passes were removed from the river. Channel catfish that were large (>400 mm TL) or had distended stomachs, had their stomach contents examined. 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.

*Data Analysis*

Catch per unit effort (CPUE) was calculated using the number of fish caught per hour of electrofishing. Approximately thirty samples were taken during each pass comprising the CPUE for every 2 to 3 miles sampled. These samples were then used to calculate the mean and associated variation. CPUE and length-frequency distributions were compared between years using non-parametric Kruskal-Wallis ANOVA on Ranks along with pair-wise multiple comparisons (Dunn's Method ) to examine the equality of samples. All statistical tests were performed using SigmaStat 3.0, (SPSS Inc).

A Lincoln-Peterson population estimate was generated for channel catfish ($\geq$ 200 mm) captured during the first two passes. Captures of channel catfish during subsequent passes allows for monitoring ratios of marked to unmarked fish to aid in determining if assumptions of a closed population are being met.

Population estimates were determined for juvenile Colorado pikeminnow (>150 mm) in the lower San Juan River using closed population models within program CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad and Burnham 1991). Several combinations of passes were selected for analysis in order to lessen the likelihood of violating assumptions of the models used. Program CAPTURE was used to determine confidence intervals around the estimate, the coefficient of variation, and the probability of capture. In most cases the $M_o$ model (null model) was used, since all capture probabilities (p-hat) remained similar among the passes. The $M_t$ model (time variable model) was used when p-hat was variable among passes. The Lincoln-Peterson method was used to determine population estimates between two passes. For the models run through program CAPTURE, profile likelihood intervals were provided in lieu of 95% confidence intervals. The profile likelihood interval helps to account for model selection uncertainty by providing wider confidence intervals. In addition, these intervals tend to give more correct confidence intervals for small samples (Ross Moore, Mathematics Dept., Macquarie University, Sydney Australia *personal communication*).

## RESULTS

Nine sampling passes, including Adult Monitoring conducted by CRFP, were conducted on the San Juan River between Mexican Hat and Clay Hills, UT. Sampling dates were: March 22-26, April 12-16, April 26-30, May 17-21, June 7-11, June 21-25, July 5-9, August 2-6, and October 9-13. Average river discharge from March through August was 1,475 cfs. The lowest mean daily flow was 256 cfs, which occurred during the August pass; the highest mean daily flow was 3,680 cfs during the early June passp. Mean daily flow during the fall monitoring pass was 905 cfs. Lake Powell elevations remained low in 2004, and the waterfall that had emerged at Piute Farms in 2003, has increased to approximately 10 ft high.

### <u>Nonnative Species</u>

*Channel catfish*

Eight different nonnative fish species were collected in the lower San Juan River during nonnative control and adult monitoring trips in 2004 (Table 1). Electrofishing effort totaled 398 hours and produced 8,818 fish; 267 were endangered species. No striped bass or walleye were collected during the 2004 sampling effort. Channel catfish dominated the total catch with over 8,200 individuals.

In 2004, catch rates of channel catfish varied significantly between passes and ranged from 8 to 35 fish per hour during each pass ($p < 0.001$; Table 2, Fig. 2). Mean catch rates of channel catfish among years were significantly lower in 2003 than 2002 and 2004. Mean total length of channel catfish in 2002 was 268.4 mm (SD = 107), 226.9 mm (SD = 109) in 2003, and 207.8 mm (SD = 108; Fig. 4) in 2004, a significant decrease ($p < 0.001$; Fig. 5).

The Lincoln-Peterson population estimate generated for channel catfish ($\geq$ 200 mm) in 2003, from the first to the second pass was 19,966 individuals (95 % confidence intervals = 9,184-30,748). In 2004, the population estimate for channel catfish ($\geq$ 200 mm) was 8,342 individuals (95% confidence intervals = 1,094 – 15,590). Recapture rates after the second pass varied between zero and three recaptures per pass.

In the spring and summer of 2004, a recently stocked razorback sucker and Colorado pikeminnow were found in the stomachs of two different channel catfish. The channel catfish that had eaten the razorback sucker was 690 mm TL, while the razorback sucker measured 325 mm TL. Within the same channel catfish was a native sucker, presumably a flannelmouth, which was approximately 280 mm TL. The channel catfish that had eaten the Colorado pikeminnow, was collected on June 21 and measured 416 mm TL, while the Colorado pikeminnow measured 212 mm TL at the time of stocking on June 9, 2004.

*Common carp*

Catch rates of common carp were variable across passes within years from 2002 to 2004 (Fig. 6). In 2002 and 2003, common carp catch rates were highest in June and ranged from one to four fish per hour across all passes. From 2002 to 2004, catch rates of common carp dropped significantly ($p < 0.001$; Fig. 7). Size structure of common carp has remained similar among years, yet in 2003 more juveniles were collected than in 2002 and 2004 (Fig. 8 and 9).

## Endangered Species

*Colorado pikeminnow*

A total of 225 Colorado pikeminnow were collected in 2004, 166 more than were collected in 2003 (Tables 1 & 3). In 2003, catch rates of the age-1 fish increased considerably during the July through October passes. In 2004, even though catch rates of Colorado pikeminnow overall were higher, catch rates of age-1 fish were lower than those for age-1 fish the previous year. Catch rates of all juvenile Colorado pikeminnow were highest during the Adult Monitoring trip in 2003 and 2004 (Table 3; Fig 10).

Mean TL of juvenile Colorado pikeminnow increased from 2003 to 2004, representing considerable growth of the 2002-stocked fish and capture of individuals stocked in late 2003 and summer 2004 from the Mumma Fish Hatchery (average TL at stocking equal to 179 and 217 mm, respectively; Fig. 11). Length-frequency histograms by pass show that the majority of juvenile Colorado pikeminnow collected in 2004 were age-2 fish stocked in November 2002 (Fig. 12). In 2003, the 2002-stocked Colorado pikeminnow were not collected by electrofishing until the May pass. Conversely, age-1 Colorado pikeminnow from the 2003 November stocking event were collected during the first pass in March 2004. Considering August captures in each year, age-1 fish in 2003 average total length was 173 mm (n=20), and age-1 fish in 2004 average total length was 140 mm (n=9), illustrating that the 2002 stocked fish grew faster through their first summer than did the 2003 stocked fish (Table 3).

In 2003, 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.13). Colorado pikeminnow collected in 2004, (age-1 and 2) were distributed throughout the entire sample reach, yet still appeared to be concentrated between RM 15-25. In 2003, 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.

Growth rates of age-1 Colorado pikeminnow ranged from 11 to 22 mm per month in 2003. In 2004, 24 of 164 individuals greater than 150 mm TL were recaptures marked in either 2003 or 2004. Ten of these 24 had moved 10-31 miles upstream, while there was not considerable downstream movement (beyond one mile). Colorado pikeminnow that were moving these extended distances upstream were between 220 and 240 mm TL.

Preliminary population estimates could be generated for Colorado pikeminnow since many were recaptured in 2004. Several population estimates were calculated using different passes to formulate a rough idea of population size of Colorado pikeminnow greater than 150 mm TL occupying the lower San Juan River. Estimates ranged from 160 to 315 individuals depending on the model and the number of passes chosen. The coefficient of variation around the highest estimate (315) was 22 % using passes 1-5 and the null model. While passes 4-6 had the highest probability of capture (0.13) and a coefficient of variation of 27% (Table 4).

Captures of adult Colorado pikeminnow have diminished since this project began in 2002. During the first year, six Colorado pikeminnow were collected. One of these was a juvenile at 246 mm TL, the other five were adults ranging from 460 mm to 539 mm TL. Three Colorado pikeminnow adults were captured in 2003, their sizes ranged from 530 mm to 590 mm TL. In 2004, one adult Colorado pikeminnow was collected (547 mm TL) at RM 16.4 on March 25. This fish was originally captured and marked in 2002 at RM 19.8 and measured 460 mm TL. All of these Colorado pikeminnow are believed to have come from the stocking events from 1996 and 1997.

*Razorback sucker*

Forty-two razorback sucker were collected in 2004 throughout the lower San Juan River (Table 1). The majority of razorback sucker were recaptures from previous stockings. Catch rates for razorback sucker tended to be highest in the spring and fall (Fig. 14). As in 2002 and 2003, most razorback sucker collected in 2004 were within a few miles of Slickhorn Rapid (RM 17.7), but high concentrations, observed in April 2002, were not observed in 2003 or 2004. Razorback sucker were collected throughout the lower reach. In 2003 and 2004, six juvenile razorback suckers were collected (including one collected during 2003 adult monitoring). It is presumed that the stocked adult razorback suckers spawned these juveniles. These fish ranged from 120 mm TL to 280 mm TL. Additionally, in 2003, two razorback-flannelmouth hybrids were collected (one during fall monitoring). In 2004, ten hybrids were collected (one during fall monitoring); one of these fish was later recaptured. The lengths of the hybrids ranged from 271-306 mm TL. Fin clips were taken on a portion of these fish for genetic analysis.

## DISCUSSION

In 2004, many of the objectives of this project could not be met, given that no striped bass or walleye were collected. However, it is likely that the absence of these species is directly related to the waterfall at Piute Farms, approximately 3 river miles downstream of Clay Hills. The objective to remove other nonnative fish species occupying the lower San Juan River was successful. Over 8,000 channel catfish and approximately 250 common carp were mechanically removed. The decrease in the mean TL of channel catfish is encouraging; it does appear that our efforts are generating a shift in the population size structure to smaller individuals. The significant decline in catch rates of common carp is equally encouraging. However, it is unclear if this decline is directly related to removal efforts, the presence of the waterfall, or the low water conditions that have been present over the period of this project. It is probable that a combination of these factors is causative to some extent. The continuation of removal efforts for both these species will aid in the illumination of contributory factors and the evaluation of the success of this project and similar nonnative control efforts.

Population estimates generated for channel catfish in the last two years are cursory, and probably do not reflect the actual population size in the lower San Juan River. The ratios of captures and recaptures of channel catfish on subsequent passes illustrates the large variability in the efficacy of capturing channel catfish based on flow, turbidity, netter ability, and possibly other unknown factors. These ratios also suggest that large numbers of fish are moving into the removal section from upstream reaches, and therefore violating the closure assumption. Using the first two passes, which are typically conducted within one month, reduces the likelihood of this. Channel catfish that are tagged in the section of river near Farmington, NM where NMFRO conducts mechanical removal are often collected during our sampling, exemplifying the long distances these fish move. Channel catfish movement into the lower San Juan River from downstream sources is unlikely because of the waterfall at Piute Farms. Even though these factors exist, mark-recapture population estimates will continue for channel catfish at the beginning of each year. Gerhardt and Hubert (1991) reported that in the Powder River drainage, the Ricker and Thompson-Bell model indicated that population structure and abundance of channel catfish would change considerably as exploitation rates (harvest) increased. They reported that an annual exploitation rate of 22% would result in a 75% reduction in overall abundance of fish greater than 300 mm TL, and cause a substantial shift towards smaller individuals. Similar shifts in yield and population structure have been observed in sport and commercial fisheries as the rate of exploitation increased (Bennet 1971; McHugh 1984, Pitlo 1997). In the San Juan River, shifts in size structure of channel catfish are being observed further upstream (Davis 2005) and on a river-wide scale (Ryden 2005), as well as in the lower section. Continued removal of all size classes of channel catfish in the San Juan River should facilitate the reduction of the overall impact that these fish have on the native and endangered fish community. It is anticipated that once a reliable population estimate is obtained, we can estimate the exploitation rate of our removal on the channel catfish population.

Over the course of this project, important information has been obtained on the progress of the endangered fish community as well. We have observed the apparent spawning aggregation of razorback sucker in spring 2002 at Slickhorn Rapid; documented the distribution and abundance of Colorado pikeminnow stocked in 2002 and 2003; generated preliminary population estimates for juvenile Colorado pikeminnow; and documented the first cases of channel catfish predation on stocked juvenile razorback sucker and Colorado pikeminnow in the San Juan River.

The increase in catch rates of juvenile Colorado pikeminnow in the lower San Juan River from 2003 to 2004 is a result of having two consecutive years of stocking young-of-year fish, and therefore two year classes available for capture. From our collections, it is evident that once the fish approach 150 mm TL, they are more likely to be captured by electrofishing. Comparisons of the August 2003 to August 2004 data might suggest that the 2002 stocked fish did not fair as well as the 2003 stocked fish. Differences in sampling conditions between the two years were likely a confounding factor in electrofishing efficiency during the summer. During the August 2004 pass, flows were the lowest of any of our passes, at an average of 276 cfs. Sampling efficiency during these flows may have been compromised by reduced time spent working shoreline areas where Colorado pikeminnow are usually found. Another possibility is that Colorado pikeminnow were occupying deeper portions of the river that are not effectively electrofished. An increase in the catch rate between the August and October pass (conducted by CRFP) for both age-1 and age-2 Colorado pikeminnow bolsters these hypotheses.

The decline in the capture of adult Colorado pikeminnow is disappointing. The reasons for this decrease is unknown but might be explained by several factors: 1) Colorado pikeminnow adults may become accustomed to electrofishing boats and learn to avoid the electrofishing field; 2) they may have moved below the waterfall and are unable to move back upstream; 3) they may have moved upstream out of the lower reach into river sections that are not as heavily sampled and thus are less likely to be captured. Radio telemetry of adult Colorado pikeminnow on the San Juan River in the 1990’s indicated that three radio tagged fish were detected (either visually or sonically) moving ahead (downstream) of electrofishing boats and in some cases crossing from one shoreline to the other (Ryden, 2000). The eventual capture of these fish was achieved when the fish were forced to swim back upstream to avoid crossing shallow riffle-sandbar complexes. The fish avoiding the electrofishing boats ranged from 521 to 948 mm TL. Additionally, researchers documented Colorado pikeminnow avoidance of rafts without electrofishing setups. Bestgen et al. (2004) examined Colorado pikeminnow avoidance to electrofishing boats indirectly by analyzing relationships of capture to fish size during population estimates conducted in the Green River. Capture probabilities described by TL of individuals, indicated that fish < 580 mm TL were progressively easier to capture, while the relationship was found to decline for larger fish. They speculated that fish larger than 580 mm TL may be powerful enough to evade the electrofishing field, or they may be occupying deeper water. The largest Colorado pikeminnow collected in recent years in the San Juan River was 590 mm TL; therefore it is likely that Colorado pikeminnow in the lower San Juan River are escaping capture to some extent.

Sampling at the base of the waterfall will be conducted in 2005 to evaluate the fish community, whether Colorado pikeminnow are present, and if the waterfall is blocking upstream movement of Colorado pikeminnow. We will not be able to address if fish are moving upstream of the lower reach until they are collected during adult monitoring conducted in the fall by (CRFP), during nonnative control near Farmington by (NMFRO), or when intensive river wide population estimates for Colorado pikeminnow are initiated sometime in the future.

Population estimates generated for stocked juvenile Colorado pikeminnow, although preliminary at this point, provide a foundation for future estimates. Since juvenile Colorado pikeminnow were found moving extended distances during the summer months, the population estimates constructed at that time (passes 4-6 and 5-8) may be biased if the closure assumption was violated. An estimate with the shortest time between passes, either in the spring or fall is likely to be the most reliable estimate. However, when comparing the pass 1-3 estimate to the pass 4-6 estimate the difference is only twelve fish. During 2005, we plan to increase the effort of marking juvenile Colorado pikeminnow during co-occurring trips with Bio-West in order to attain a more robust population estimate.

While the shift in size structure of channel catfish is encouraging, and may eventually lead to decreased average fecundity and a reduction of the overall population, the risk to Colorado pikeminnow is unknown. The possibility exists that the shift in size structure of the channel catfish population is creating a less palatable food base for Colorado pikeminnow by increasing the chance of mortality of Colorado pikeminnow attempting to consume channel catfish. The expectation is that Colorado pikeminnow will choose flannelmouth sucker and bluehead sucker over channel catfish, especially when these prey are more abundant. In a field setting we are only able to assess this by directly observing channel catfish lodged in Colorado pikeminnow throats, which in most cases, is too late.

## CONCLUSIONS AND RECOMMENDATIONS

- No striped bass or walleye were collected in 2004. This finding is directly related to the presence of the waterfall at Piute Farms. Sampling at the base of the waterfall should be conducted in 2005 to determine if striped bass and walleye are moving from the lake up to the waterfall. From this information we will be able to continue to assess the conditions present in the lake and river that affect upstream movements. Furthermore, it is likely that this barrier is preventing other nonnative fish species (such as channel catfish, common carp, and largemouth bass) from moving up into the river. Since it is probable that the waterfall will persist for several years, channel catfish, common carp and largemouth bass already existing 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 applied by these species on native and endangered fish, and compliment removal efforts being conducted further upstream.

- Channel catfish catch rates from 2002 to 2004 have remained unchanged, while the size structure has shifted to smaller individuals. Population estimates of channel catfish decreased from 2003 to 2004; however, large confidence intervals indicate poor precision of these estimates. Channel catfish movement from Lake Powell and the river below the waterfall has been eliminated, while movement from upstream reaches continues. Channel catfish should continue to be marked during the first pass in order to determine relative population size at the beginning of each removal year. From these population estimates, estimates of exploitation rates may eventually be attained.

- Catch rates of common carp have decreased significantly from 2002 to 2004, while the size structure has remained relatively unchanged. However, some smaller individuals were collected in the last two years. The cause of the decreasing trend in catch rate for these fish is unknown. Several factors may be acting synergistically: the presence of the waterfall which has been reducing or eliminating reinvasion into the removal section from downstream; low water conditions present in the years during removal; and finally, removal actions that may be contributing to the decline. Common carp should continue to be removed from the lower San Juan River to reduce competition with native and endangered fish.

- Catch rates of juvenile Colorado pikeminnow increased from 2003 to 2004. This is most likely the result of having two year-classes of juveniles, after two consecutive years of stocking, available for capture in the lower river. Mean total length of juvenile Colorado pikeminnow similarly has increased. In 2004, the majority of captures were fish that had been stocked in 2002. Preliminary population estimates of juvenile Colorado pikeminnow (>150 mm TL) in the lower San Juan River were approximately 200 with a range of 100 to 500. Population estimates of juvenile Colorado pikeminnow in the lower San Juan River should continue to the extent possible.

- The occurrence of adult Colorado pikeminnow in the lower San Juan River has dropped from 2002 to 2004; the reasons for this are unknown. Electrofishing in the lower San Juan River should continue to attempt to capture these fish. In addition, sampling should be conducted at the base of the waterfall at Piute Farms in order to determine if Colorado pikeminnow are below the waterfall and unable to move upstream.

- Captures of juvenile razorback sucker were first documented in 2003 and continued in 2004; catch of hybrid razorback sucker have increased as well. Fin clips of potential hybrids should be taken whenever possible.

- This project has provided valuable information on the success of endangered fish 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.

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Table 1. Total count of all fish species collected during Nonnative Control and Adult Monitoring in the lower San Juan River in 2004.

| Trip | Ptyluc | Xyrtex | Ictpun | Cypcar | Micsal | Lepcya | Amemel | Amenat |
|---|---|---|---|---|---|---|---|---|
| March 22-26 | 24 | 4 | 193 | 55 | 0 | 1 | 6 | 0 |
| April 12-16 | 27 | 4 | 689 | 23 | 0 | 1 | 15 | 0 |
| April 26-30 | 14 | 9 | 1254 | 31 | 0 | 0 | 4 | 0 |
| May 17-21 | 35 | 10 | 1469 | 17 | 0 | 0 | 6 | 1 |
| June 7-11 | 26 | 5 | 478 | 18 | 0 | 1 | 10 | 1 |
| June 21-25 | 29 | 1 | 1542 | 27 | 0 | 2 | 12 | 0 |
| July 5-9 | 15 | 2 | 1222 | 17 | 1 | 1 | 7 | 0 |
| August 2-6 | 14 | 1 | 1127 | 31 | 5 | 0 | 2 | 1 |
| October 9-13 | 41 | 6 | 249 | 39 | 2 | 1 | 1 | 0 |
| Totals | 225 | 42 | 8223 | 248 | 8 | 7 | 63 | 3 |

Table 2. Mean CPUE of all fish species collected during Nonnative Control and Adult Monitoring in the lower San Juan River in 2004.

| Trip | Ptyluc | Xyrtex | Ictpun | Cypcar | Micsal | Lepcya | Amemel | Amenat |
|---|---|---|---|---|---|---|---|---|
| March 22-26 | 0.45 | 0.08 | 21.10 | 0.91 | 0 | 0.02 | 0.12 | 0 |
| April 12-16 | 0.55 | 0.08 | 17.40 | 0.47 | 0 | 0.02 | 0.35 | 0 |
| April 26-30 | 0.24 | 0.19 | 31.67 | 0.56 | 0 | 0 | 0.08 | 0 |
| May 17-21 | 0.87 | 0.24 | 35.45 | 0.36 | 0 | 0 | 0.14 | 0.02 |
| June 7-11 | 0.70 | 0.14 | 13.86 | 0.30 | 0 | 0.02 | 0.23 | 0.02 |
| June 21-25 | 0.60 | 0.02 | 33.91 | 0.66 | 0 | 0.04 | 0.24 | 0 |
| July 5-9 | 0.34 | 0.04 | 27.64 | 0.32 | 0.03 | 0.02 | 0.15 | 0 |
| August 2-6 | 0.33 | 0.02 | 24.59 | 0.56 | 0.10 | 0 | 0.04 | 0.02 |
| October 9-13 | 1.46 | 0.19 | 8.04 | 1.02 | 0.02 | 0.03 | 0.03 | 0 |

Table 3. Comparison of average total lengths (TL), range and number (n) of juvenile Colorado pikeminnow collected during each trip for nonnative control in the lower San Juan River in 2003 and 2004.

| | 2003 Average TL | 2004 Average TL | |
|---|---|---|---|
| Trip | Age-1 CPM | Age-1 CPM | Age-2 CPM |
| End March | - | 73 (65-80, n=3) | 203.3 (170-236, n=20) |
| Beg April | No trip | 70 (68-72, n=3) | 206 (136-238, n=24) |
| End April | - | 66 (n=1) | 220 (185-296, n=13) |
| May | 67 (61-74, n=3) | 83 (82-85, n=3) | 206 (155-248, n=32) |
| Beg June | 114 (105 & 123, n=2) | 117 (115 & 120, n=2) | 218 (187-255, n=24) |
| End June | 106 (n=1) | 97.6 (93-103, n=3) | 215 (164-257, n=25) |
| Beg July | No trip | 112 (100-129, n=4) | 241 (207-276, n=11) |
| End July | 152 (127-177, n=9) | No trip | No trip |
| Beg August | 161 (135-190, n=24) | 142 (115-153, n=9) | 252 (235-270, n=5) |
| End August | 173 (133-212, n=20) | No trip | No trip |

Table 4. Population estimates for juvenile Colorado pikeminnow greater than 150 mm TL in the lower San Juan River during 2004. Models used include the null model (Mo) and time variable model (Mt) from Program CAPTURE, and the Lincoln-Peterson model with correction for small samples. CI represents either the 95% confidence interval (Lincoln-Peterson) or the profile likelihood interval (Mo and Mt). CV indicates the coefficient of variation, and p-hat indicates the probability of capture.

| Trips | Model | Estimate | CI | CV | p-hat |
|---|---|---|---|---|---|
| 1-2 | Lincoln-Peterson | 160 | 17-303 | - | - |
| 1-5 | Mo | 315 | 218-545 | 0.22 | 0.07 |
| 1-3 | Mo | 183 | 99-469 | 0.38 | 0.09 |
| 4-6 | Mo | 195 | 124-372 | 0.27 | 0.13 |
| 5-8 | Mt | 157 | 100-297 | 0.26 | 0.10 |

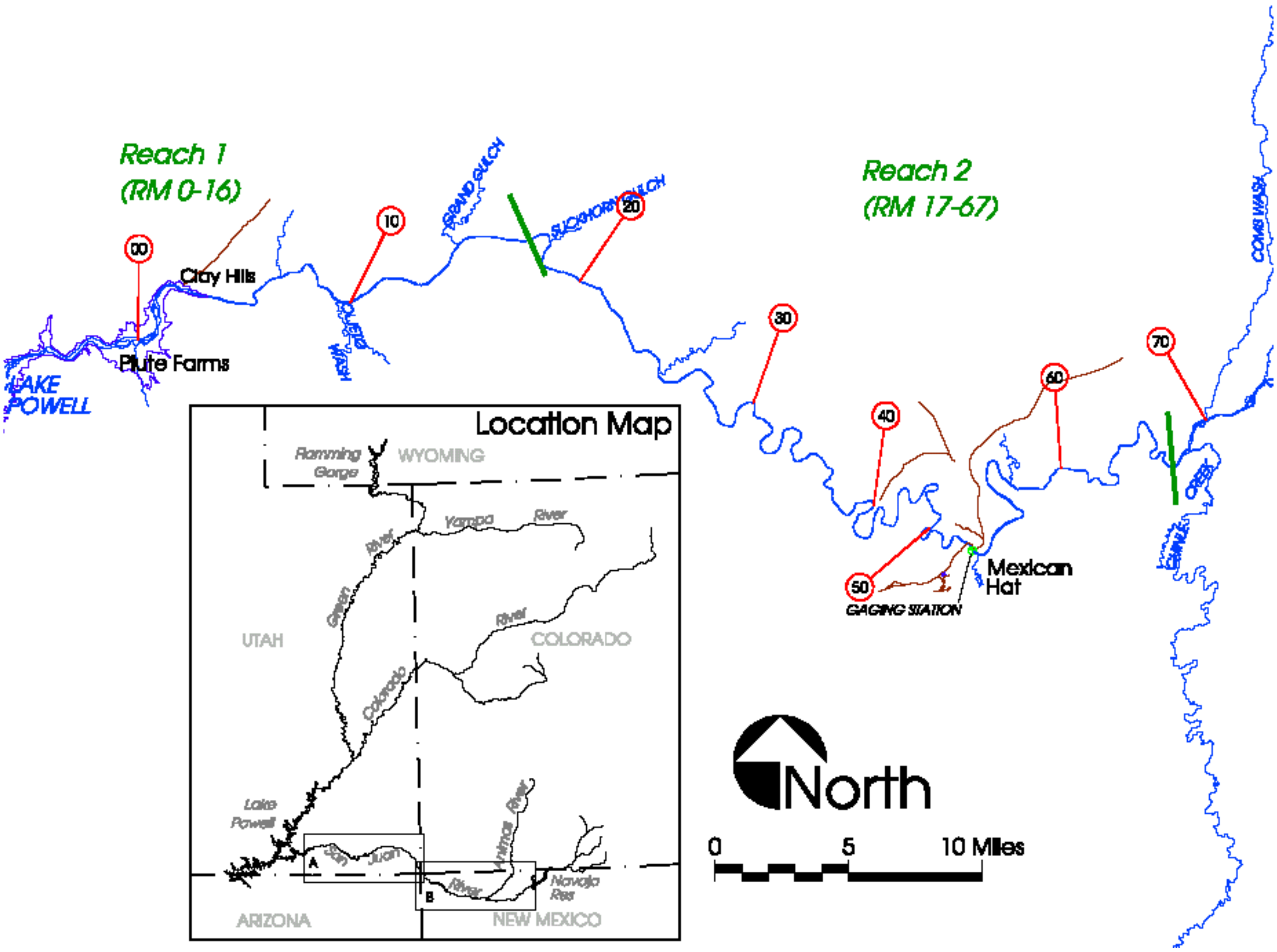


Figure 1. Map of the study area for Nonnative Control in the lower San Juan River. Sampling begins at Mexican Hat and ends at Clay Hills.

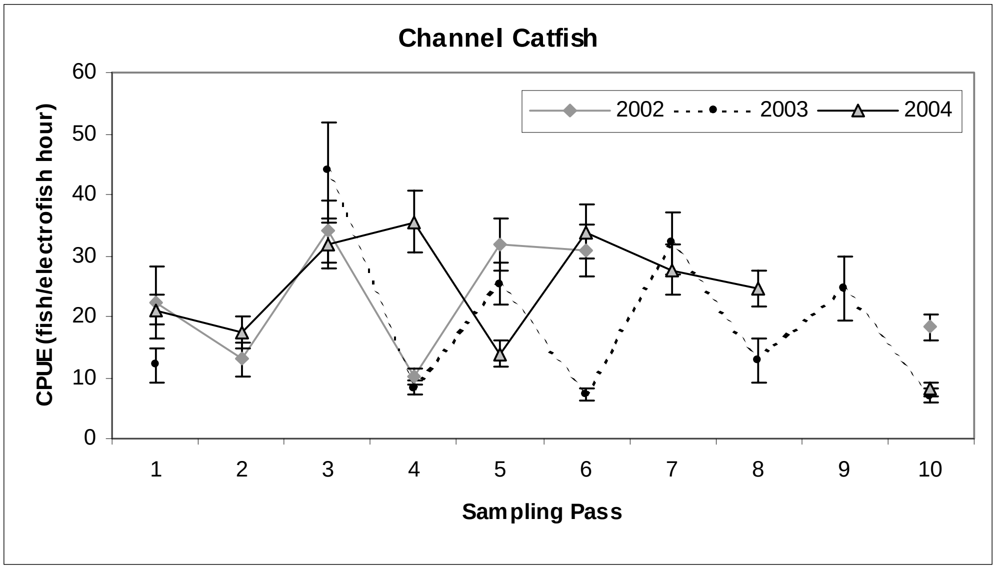


Figure 2. Channel catfish catch rates across passes from 2002 to 2004 Nonnative Control in the lower San Juan River. Error bars represent standard error of the mean. Note: Numbers on x-axis represent similar times of the year that sampling was conducted from 2002 to 2004 (1: March 11-28, 2: April 15-19, 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, August 18-22, September 20- October 15).

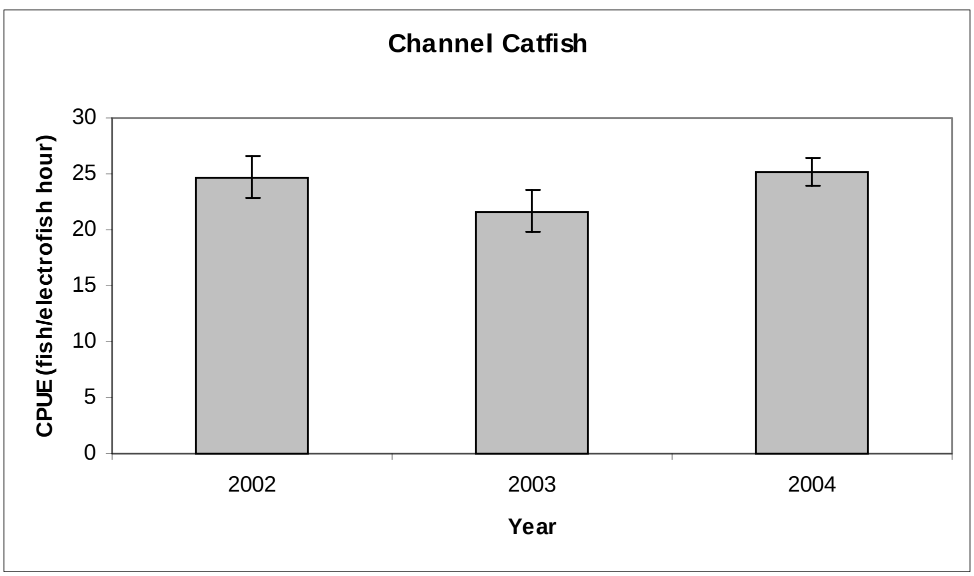


Figure 3. Mean catch rate of channel catfish from 2002 to 2004 during Nonnative Control in the lower San Juan River. Error bars represent standard error of the mean. Sample sizes for 2002-2004 were 7,136, 8,249, and 8,223, respectively.

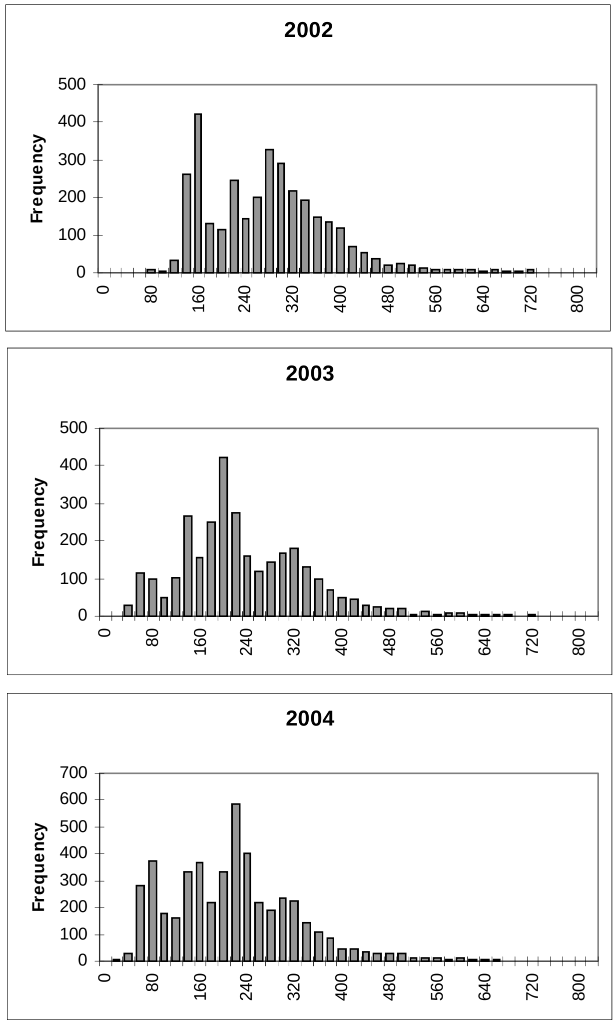


Figure 4. Length-frequency histograms of channel catfish from 2002 to 2004 during Nonnative Control in the lower San Juan River.

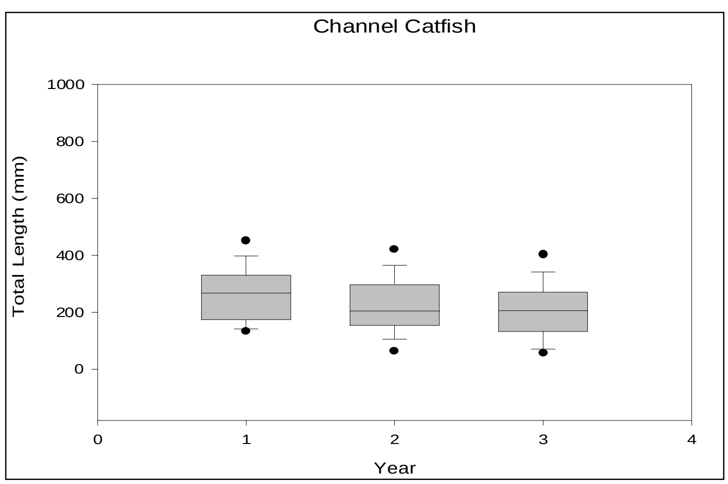


Figure 5. Mean total length of channel catfish during each year of the Nonnative Control in the San Juan River (Year 1: 2002, Year 2: 2003, Year 3: 2004). Bars represent 5th and 95th percentiles, dots represent outliers.

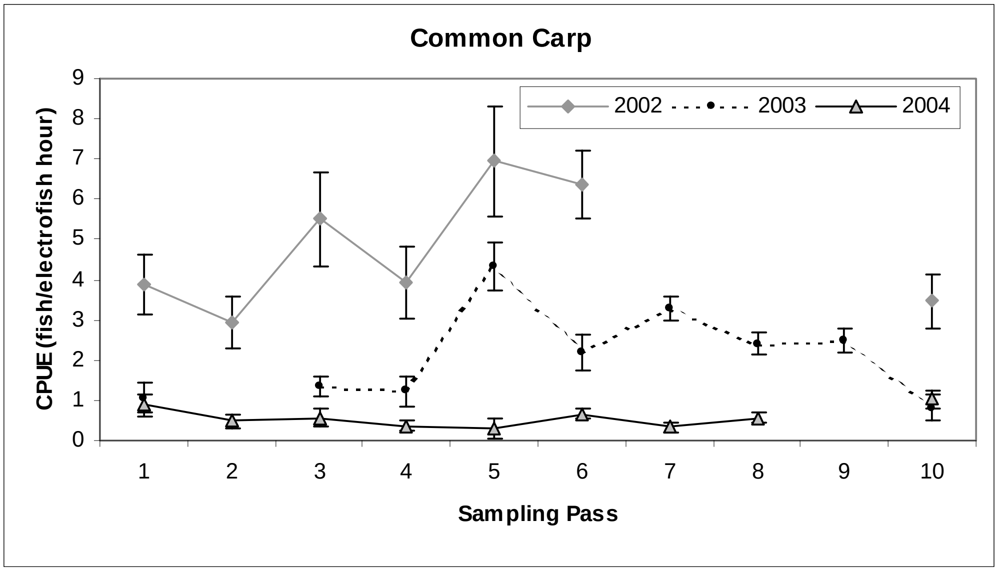


Figure 6. Common carp catch rates across passes during 2002 and 2003 Nonnative Control in the lower San Juan River. Error bars represent standard error of the mean. Note: Numbers on x-axis represent similar times of the year that sampling was conducted in 2002 and 2003 (1: March 11-28, 2: April 15-19, 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, August 18-22, September 20- October 15).

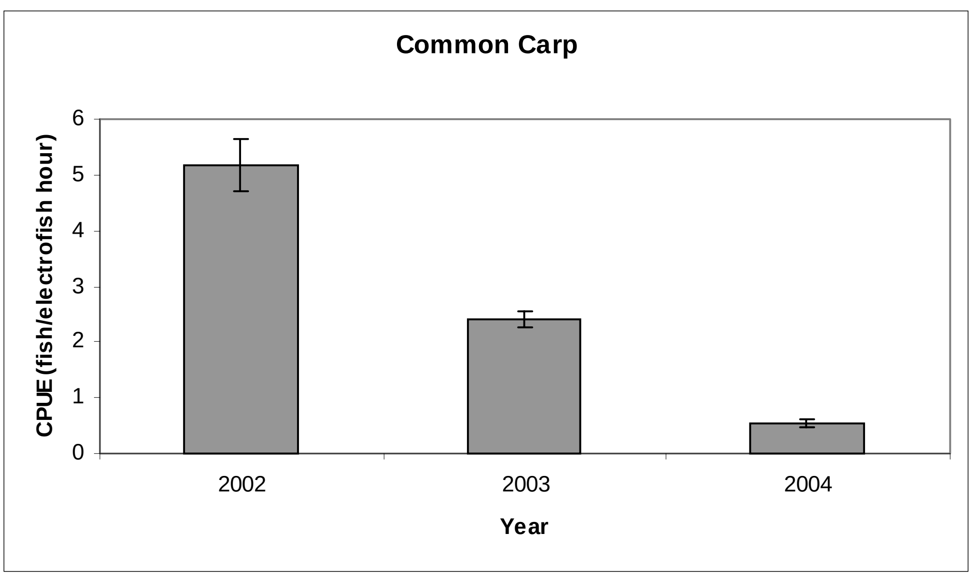


Figure 7. Mean catch rate of common carp from 2002 to 2004 during Nonnative Control in the lower San Juan River. Error bars represent standard error of the mean. Sample sizes for 2002-2004 were 1,593, 909, and 248, respectively.

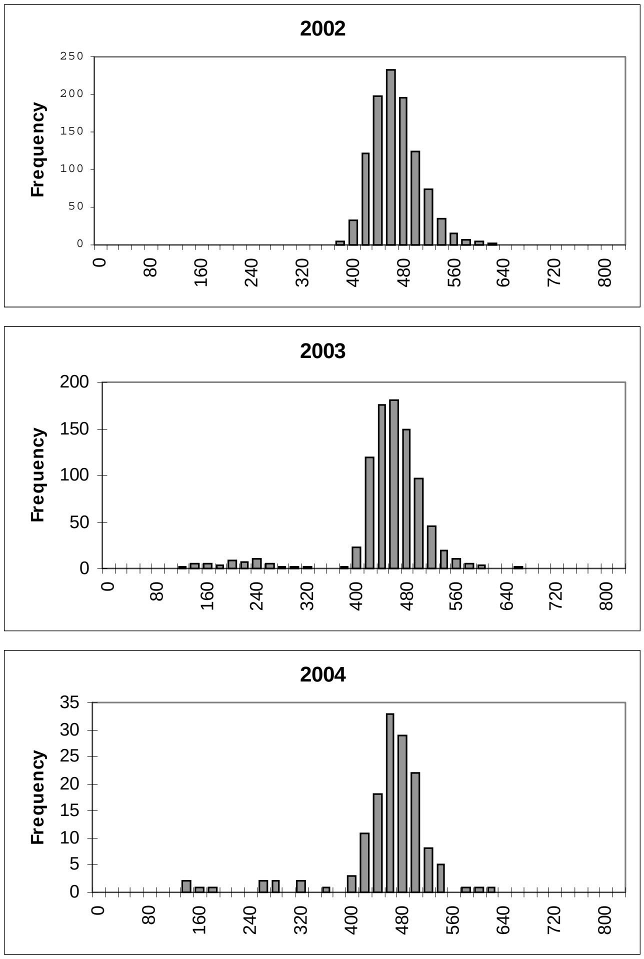


Figure 8.  Length-frequency histograms of common carp from 2002 to 2004 during Nonnative Control in the lower San Juan River.

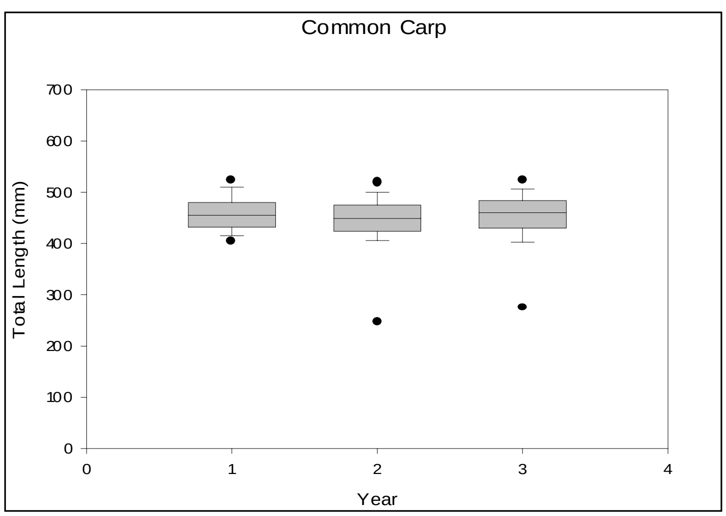


Figure 9. Mean total length of common carp during each year of the Nonnative Control in the San Juan River (Year 1: 2002, Year 2: 2003, Year 3: 2004). Bars represent 5$^{th}$ and 95$^{th}$ percentiles, dots represent outliers.

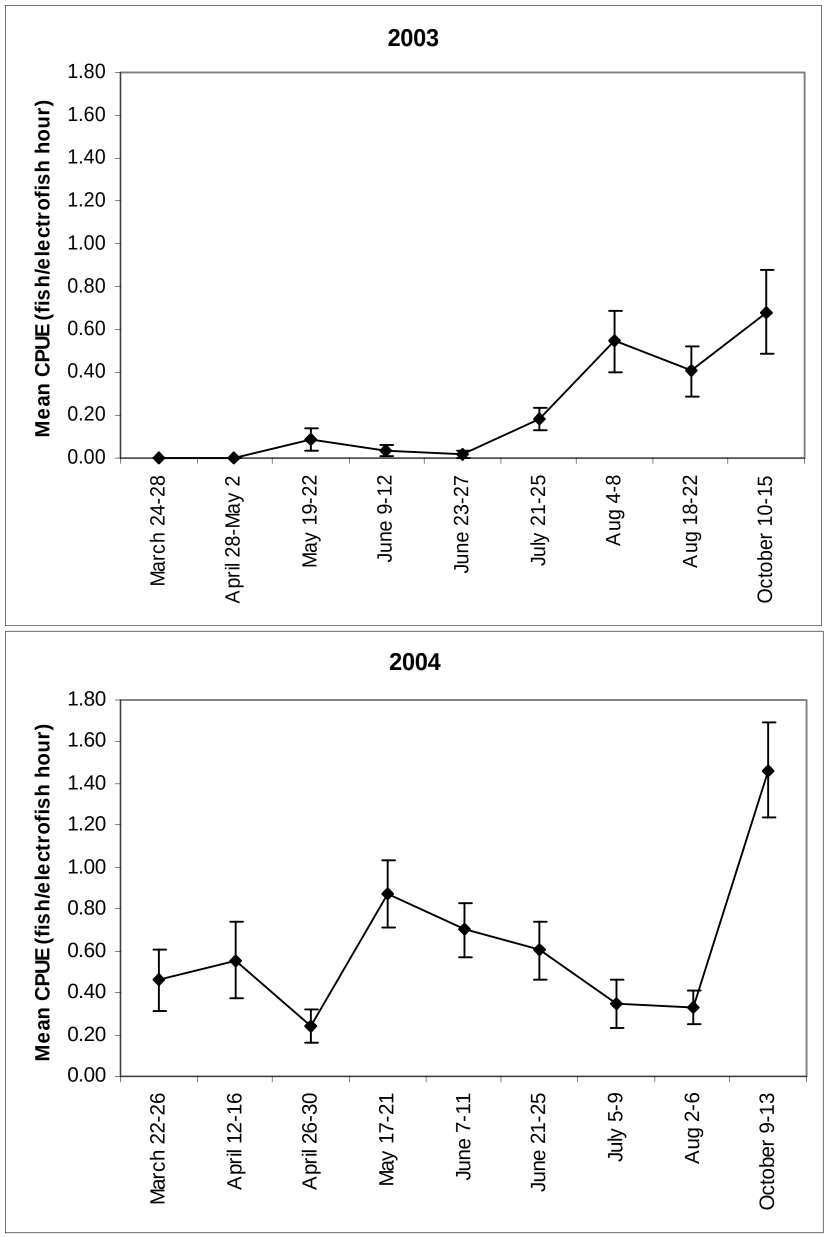


Figure 10. Mean catch rates for all Colorado pikeminnow collected in 2003 and 2004 during Nonnative Control and Adult Monitoring in the lower San Juan River. Error bars represent standard error of the mean. Sample sizes for 2003 and 2004 were 59 and 225, respectively.

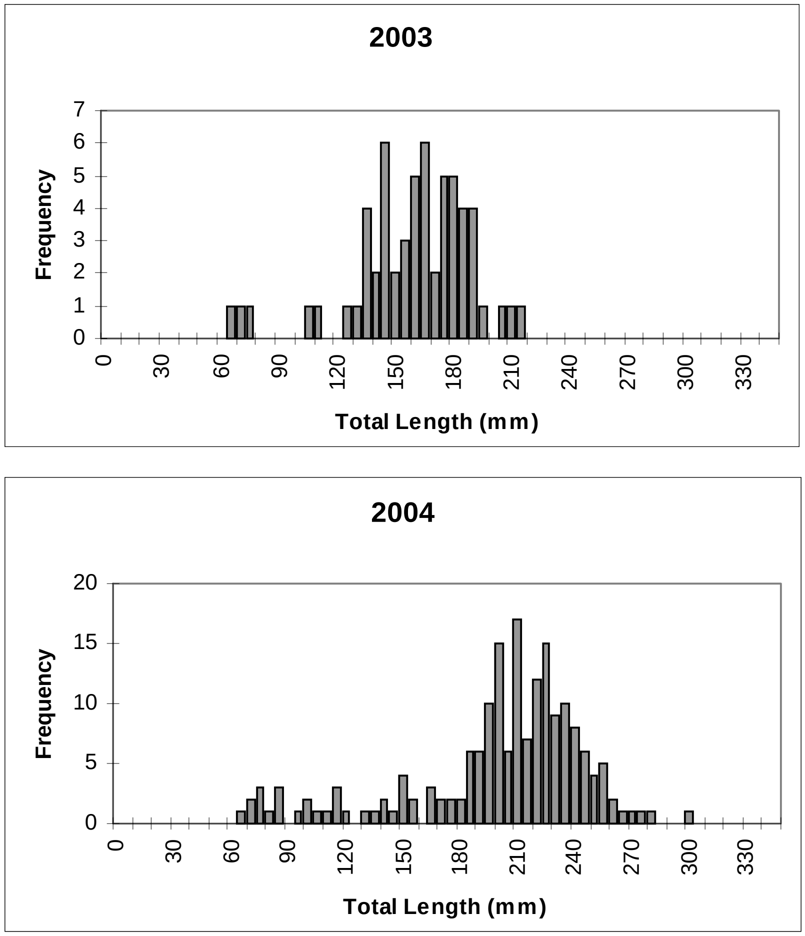


Figure 11. Length-frequency histograms of Colorado pikeminnow collected by electrofishing in 2003 and 2004 during Nonnative Control in the lower San Juan River.

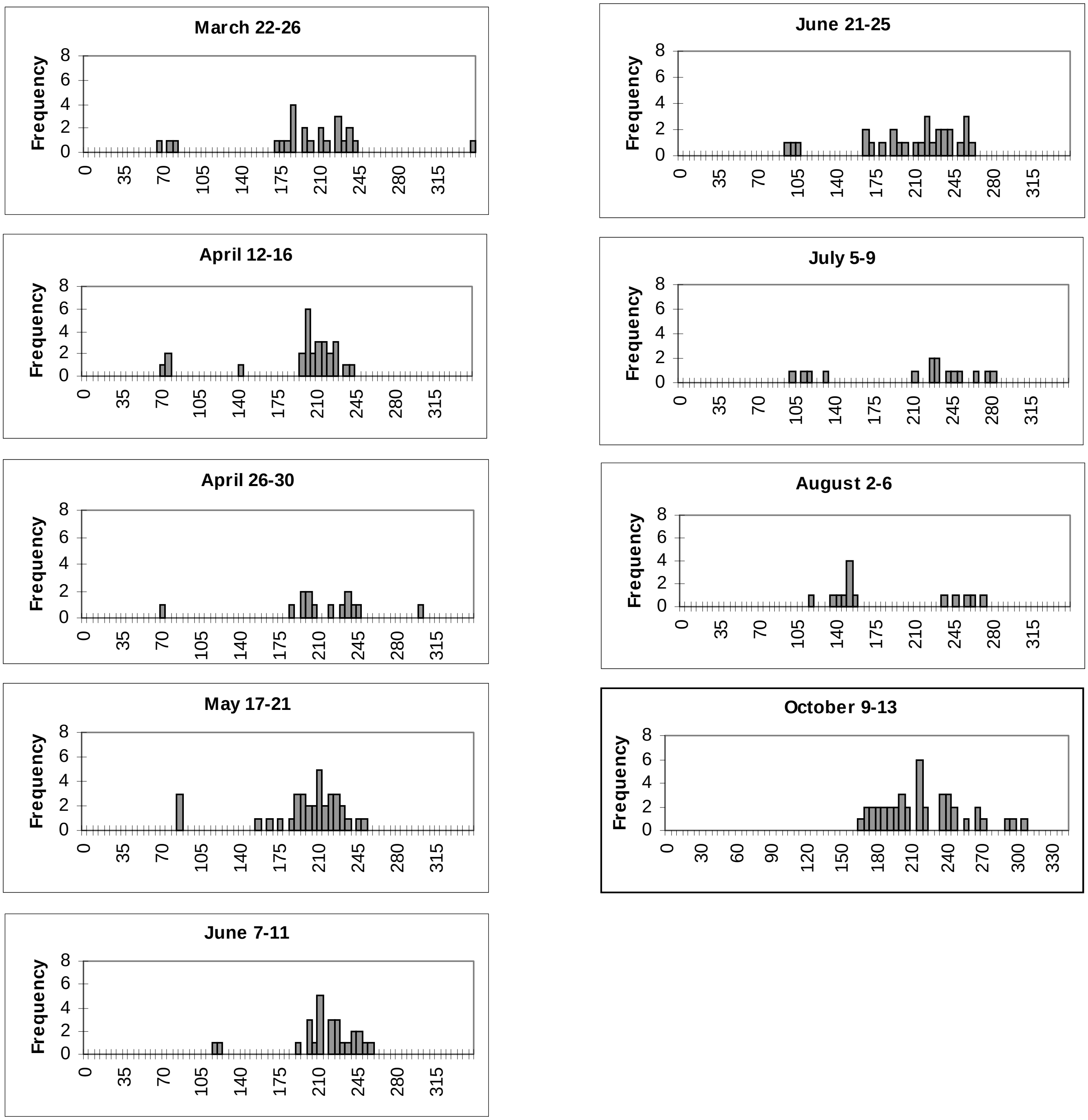


Figure 12. Length-frequency histograms of Colorado pikeminnow collected by month during Nonnative Control and Adult Monitoring in the lower San Juan River in 2004.

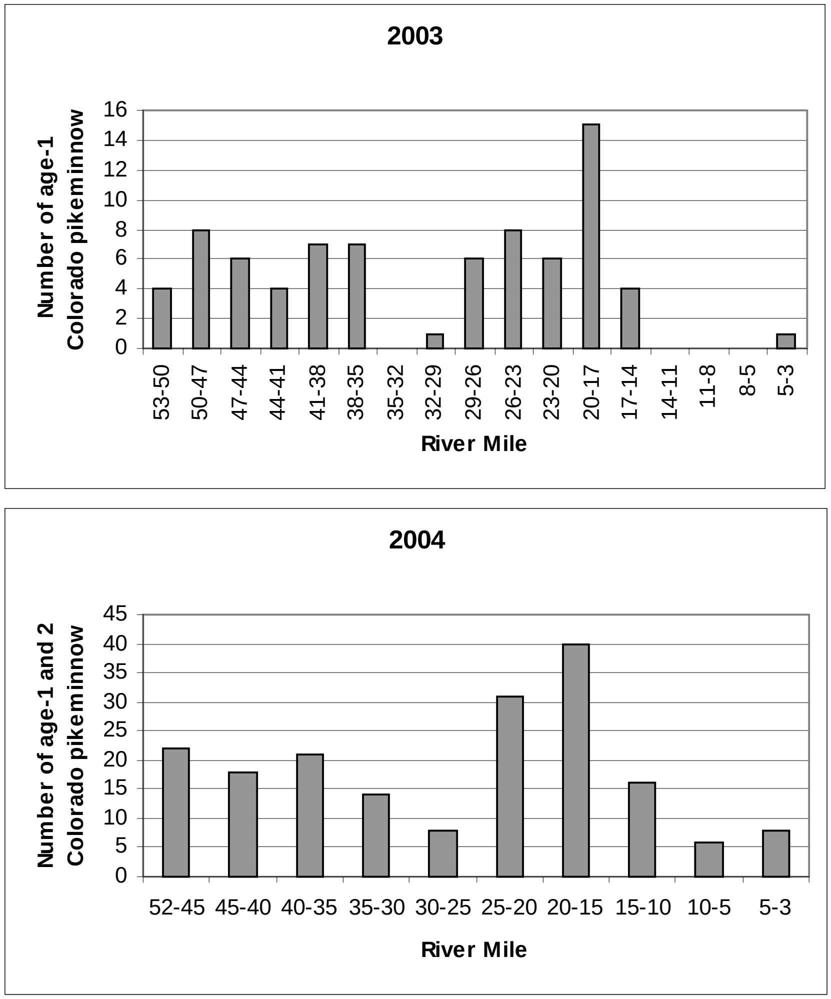


Figure 13. River distributions of Colorado pikeminnow in 2003 and 2004 during Nonnative Control on the lower San Juan River.

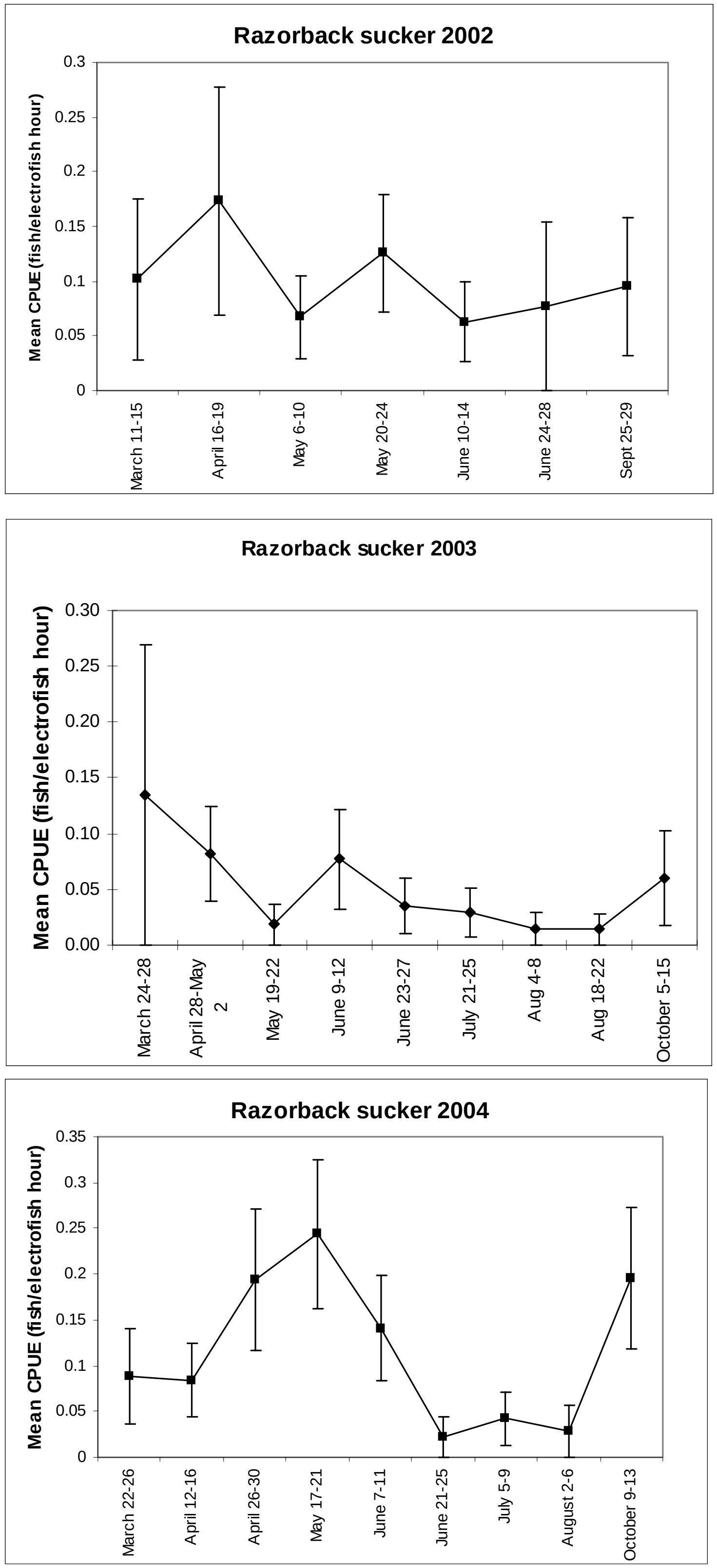


Figure 14. Catch rates of razorback sucker collected during Nonnative Control and Adult Monitoring in the lower San Juan River in 2002-2004. Note: In 2002 during the April pass, 10 razorbacks were not netted and in 2003, 2 razorbacks during the April pass were not netted. Error bars represent standard error.

Appendix A. Flow, water temperature (Celsius), and turbidity (mm to Secchi depth disappearance), at the time of sampling on the San Juan River in 2004.

| | **Average Flow ($ft^3/s$)** | **Average $H_20$ ($^oC$)** | **Average Turbidity (mm)** |
|---|---|---|---|
| March 22-26 | 1412 | 16.9 | 50 |
| April 12-16 | 2350 | 14.2 | 25 |
| April 26-30 | 1000 | 17.2 | 90 |
| May 17-21 | 2024 | 19.3 | 113 |
| June 7-11 | 3283 | 20.7 | 76 |
| June 21-25 | 1046 | 24.4 | 268 |
| July 5-9 | 461 | 24.3 | 401 |
| August 2-6 | 276 | 23.2 | 134 |
| October 9-13 | 905 | 15.2 | 205 |

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 | *Stizostedion vitreum* | Stivit |
| channel catfish | *Ictalurus punctatus* | Ictpun |
| largemouth bass | *Micropterus salmoides* | Micsal |
| green sunfish | *Lepomis cyanellus* | Lepcya |
| bluegill | *Lepomis macrochirus* | Lepmac |
| common carp | *Cyprinus carpio* | Cypcar |
| brown trout | *Salmo trutta* | Saltru |
| rainbow trout | *Oncorhynchus mykiss* | Oncmyk |
| 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 2004.

| Pass | # Marked | # Captured | # Recaptured |
|---|---|---|---|
| March 22-26 | 193 | 193 | |
| April 12-16 | | 689 | 3 |
| April 26-30 | | 1254 | 1 |
| May 17-21 | | 1469 | 2 |
| June 7-11 | | 478 | 0 |
| June 21-25 | | 1542 | 3 |
| July 5-9 | | 1222 | 1 |
| August 2-6 | | 1127 | 1 |