

Nonnative Control in the Lower San Juan River 2007

Interim Progress Report

for the  
San Juan River Recovery  
Implementation Program

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## EXECUTIVE SUMMARY

The sixth consecutive year of nonnative control in the lower San Juan River was conducted in 2007. This project was initiated to remove nonnative fish species, and to identify factors involved in movement of striped bass (*Morone saxatilis*) and other reservoir species out of Lake Powell and into the lower San Juan River. Relationships between these factors and nonnative catch rates were intended to help in the refinement of removal effort timing. Since the formation of the new waterfall at Piute Farms in 2003, channel catfish (*Ictalurus punctatus*) and other resident nonnative fishes have been the focus of removal actions.

In 2007, nine removal passes were made, beginning in late-March and continuing through early 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). Mean daily river flows ranged from 785-7,230 cubic feet per second (cfs) during sampling trips in 2007.

The majority of nonnative specimens collected in 2007 were channel catfish. Eleven thousand five hundred eighty one channel catfish were removed. Catch rates of channel catfish varied between trips. Mean catch rates of channel catfish in 2007 were not significantly different than catch rates in 2002, 2004, or 2006 but were significantly lower than catch rates in 2005. A significant decrease in the size structure of channel catfish occurred between 2002 and 2007.

In 2002 and 2003, common carp (*Cyprinus carpio*) was the second most abundant species collected. From 2004 to 2007, the mean catch rate of common carp was significantly lower than in 2002 and 2003. Size structure of common carp remained similar from 2002 to 2006. In 2007, size of common carp captured was significantly lower than from 2002 to 2006.

Three hundred eighty seven endangered fishes were collected during 2007 sampling in the lower San Juan River. Two hundred thirteen were juvenile or sub-adult (< 450 mm Total Length [TL]) Colorado pikeminnow (*Ptychocheilus lucius*) stocked in 2003 through 2006 near Farmington, NM. Preliminary population estimates of Colorado pikeminnow were quite variable and depended upon the set of passes used in the estimate. One hundred seventy one razorback suckers (*Xyrauchen texanus*) were collected in 2007.

In 2007, sampling was conducted below the waterfall at Piute Farms to determine species present and blocked by the waterfall to upstream movement. Five trips were conducted between April and October. Two adult razorback sucker and eight Colorado pikeminnow were collected below the waterfall in 2007. Walleye (*Stizostedion vitreum*), striped bass, gizzard shad (*Dorosoma cepedianum*), channel catfish, common carp, and juvenile native suckers were collected in this area as well. This was the first year walleye or striped bass were collected during monitoring below the waterfall. All endangered fishes captured below the waterfall were released upstream of the waterfall.

## INTRODUCTION

The lower San Juan River is likely to be essential in the recovery of the Colorado pikeminnow and razorback sucker in the San Juan River Basin. It contains nursery habitats comparable to those existing on the Green and Colorado rivers, where wild young-of-year (YOY) and juvenile Colorado pikeminnow are typically found. In past years, collections of endangered fishes 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 congregated around Slickhorn Rapid (RM 17.7) in the spring of 2002, and around RM 23.5 in the spring of 2006 during this study. These congregations of adult razorback suckers were potentially spawning aggregations. Collections of adult Colorado pikeminnow in the San Juan River have been extremely rare. No wild adults have been collected since 2000 (Ryden 2003). From 2002 to 2004, sampling conducted for this study revealed low numbers of Colorado pikeminnow adults, presumably from the 1996-1997 stocking efforts, using the lower San Juan River in the spring and summer. From 2003-2005, age-0 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. 2006).

This project was originally initiated in an attempt to target striped bass and other nonnative predatory fishes such as walleye that move from Lake Powell into the San Juan River. Striped bass became a particular concern in 2000 when high numbers (approximately 270 individuals) and widespread distribution of these fish were observed in July during electrofishing surveys on the upper 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*), 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). Further evidence of this relationship was found during the October 2000 sampling when higher numbers of flannelmouth sucker, bluehead sucker, and common carp were collected above the PNM weir where striped bass were not present.

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 all 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 these species were presumed to have invaded from the lake.

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°C and 21.1°C (Sigler and Sigler 1996). In the Sacramento-San Joaquin 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. Although it has been speculated 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 or be affected by rising river temperatures. Striped bass in Lake Powell are unique in their ability to reproduce in the reservoir itself (Gustaveson et al. 1984). In 2002, during the first year of this project, striped bass were found inhabiting the lower river in low numbers. 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).

No striped bass or walleye was collected or observed in 2003. 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 of 2003. At that time, a waterfall of approximately 15 meters wide and 1 meter high was discovered. The waterfall was directly responsible for the lack of striped bass and walleye in the sampling. Similarly, 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 a barrier of this size. High flows in the river may eventually cause the river to flow around the waterfall or to wash it out entirely thereby allowing fishes to pass and move upstream again. Since forming of the waterfall, the focus of this project has been to suppress other nonnative fishes in the lower San Juan River, as well as to track the abundance and distribution of endangered fishes.

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

The objectives of this study were to: 1) continue mechanical removal efforts of large bodied nonnative species in the lower portion of the San Juan River from Mexican Hat to Clay Hills and sample just below the waterfall; 2) generate a population estimate of channel catfish by mark-recapture data from Mexican Hat to Clay Hills; 3) characterize abundance of endangered fishes in the San Juan River just below the waterfall; 4) characterize abundance of predators moving out of Lake Powell into the San Juan River upstream to the new waterfall; and 5) relate striped bass movement from Lake Powell into the San Juan River to lake and river conditions (including temperature, flows and turbidity). These objectives are identified in the San Juan Recovery Implementation Program Draft Long Range Plan under Element 4 and goal 4.1.

## METHODS

### *Study Area*

The study area included the San Juan River from Mexican Hat (RM 52.8) to Clay Hills (RM 2.9), Utah (Figure 1). The river from Mexican Hat to RM 16 is primarily bedrock confined and dominated by riffle-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 nursery habitat for native and endangered fishes (Archer et al. 2000).

### *Sampling*

Raft mounted electrofishing gear was used during all trips. A Smith-Root electrofishing unit (5.0 GPP) was used with amperage ranges set from 4-6 depending on water conditions. One boat electrofished each shoreline during sampling passes. When conditions allowed, a chase boat would follow to net fishes not captured by the electrofishing boats. Beginning in 2007, a 6 foot X 30 foot 1-inch mesh seine was also utilized for removing nonnative fishes. The seine was extended out into the river and held in place for several minutes after the electrofishing raft had passed downstream.

All nonnative and endangered species were netted (Appendix B), while non-listed native suckers were not captured. Total and standard lengths to the nearest millimeter (mm) and weight to the nearest gram (g) were recorded for fish collected. When large numbers of channel catfish were collected within a three-mile stretch of river, 20 randomly selected catfish in each life stage (YOY [0-79 mm TL], juvenile [80-299 mm TL], adult [300+ mm TL]) were measured and the rest of the channel catfish in the life stage were enumerated. Endangered fishes > 150 mm TL received a PIT tag (125 kHz) if one was not already present and general condition of the fish was noted. Endangered fish were released at or near the location of capture. A global position system (GPS) reading and river mile where the fish was captured were recorded. From 2003 to 2006, all channel catfish greater than 200 mm total length collected during the first pass (trip) were tagged and released. In 2007, tagging of channel catfish was discontinued after the first day of sampling because catch rates were too low to obtain a population estimate. Channel



catfish collected on subsequent passes (trips) and all other nonnative species were removed from the river. Channel catfish that were large (>400 mm TL) and had extended stomachs, had their stomach contents examined. River temperature, conductivity, and salinity were measured at least two times per trip. Light penetration was measured using a Secchi disk, with depth to disappearance of disk measured in millimeters at least twice per trip. River discharge was determined from the USGS gage # 09379500 near Bluff, UT. Lake Powell elevations and temperatures were taken from the Lake Powell water database website.

Five two-day sampling trips were conducted below the waterfall at RM -0.5 from April through October. Angling, cast netting, seining, and fyke netting were used to collect fishes. Endangered fishes collected were measured and weighed and scanned for a PIT tag as described above. All endangered fishes collected were released upstream of the waterfall. Walleye and striped bass captured below the waterfall were weighed and measured; other nonnative fishes were enumerated but not weighed and measured.

### *Data Analysis*

Catch per unit effort (CPUE) was calculated using the number of fish caught per hour of electrofishing. Fishes that were collected by the chase boat or block seine were not included in the CPUE, but were included in length-frequency analyses. 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. Length frequency distributions and CPUE were compared between years using non-parametric Kruskal-Wallis tests 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 (> 200 mm) captured during the first two passes from 2003 to 2006. The Lincoln-Peterson model was used for channel catfish since fish were marked with non-numerical tags, therefore precluding the ability to determine on which pass fish were originally marked. 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. In 2007, no abundance estimate of channel catfish was calculated.

Population size was estimated 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). Program CAPTURE allows for the use of two or more passes in generating population estimates. 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 a confidence interval around the estimate, the coefficient of variation, and the probability of capture. The  $M_0$  model (null model) was appropriate when capture probabilities ( $\hat{p}$ ) remained similar among the passes in the model. The  $M_t$  model (time variable model) was used when  $\hat{p}$  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 a wider confidence interval. In addition, these intervals are more precise for small samples (Ross Moore, Mathematics Dept., Macquarie University, Sydney Australia *personal communication*).

## RESULTS

Ten sampling passes, including the Fall Monitoring pass, were conducted on the San Juan River between Mexican Hat and Clay Hills, UT (Figure 1). Sampling dates were: March 27-31, April 10-14, April 20-24, May 1-5, June 15-19, June 26-30, July 10-14, July 24-28, August 7-11 and October 7-11. Twelve large-bodied fish species, including Colorado pikeminnow and razorback sucker, were collected in the lower San Juan River during nonnative control. The remaining ten species were nonnative. Native bluehead sucker and flannelmouth sucker were present during all passes, but not netted during nonnative control efforts. Electrofishing effort totaled 309 hours and resulted in 9,443 fishes captured (Table 1). An additional 2,657 channel catfish were captured using chase boats and block seines. No striped bass or walleye was collected in 2007 in the lower San Juan River above the waterfall.

### Nonnative Species

#### *Channel catfish*

In 2007, channel catfish comprised > 90% of the total catch in the lower San Juan River. Mean catch rates of channel catfish varied significantly between some passes and ranged from 14 to 39 fish per hour ( $p < 0.05$ ; Table 2, Figure 2). Mean catch rates of all life stages of channel catfish combined in 2007 were not significantly different from 2002, 2004, or 2006 (Figure 3), but were significantly lower than in 2005 ( $p < 0.05$ , Figure 3) and significantly higher than in 2003 ( $p < 0.05$ , Figure 3). Mean catch rate of adult (>300 mm TL) channel catfish was significantly lower than in 2002 ( $p < 0.05$ ). The mean catch rate of adult channel catfish declined after the first year of removal and has remained at a similar low level from 2003-2007 (Figure 4).

Mean total length of channel catfish decreased from 269 mm (SD = 107) in 2002 to 178 mm (SD = 103) in 2007 ( $p < 0.05$ ; Figure 5 and 6). From 2002 to 2003, the mean total length of channel catfish decreased significantly. In 2007, the mean total length of channel catfish was significantly lower than in 2003, 2004, and 2006. Length-frequency histograms show the majority of catfish collected during the summer months were small juveniles (Figure 7). Additionally, the percentage of adult channel catfish remain similar to years 2003-2006 and lower than 2002, the first year of intensive control in the lower San Juan River (Figure 8).

A Lincoln-Peterson population estimate for channel catfish was calculated for years 2003 to 2006 (Figure 9). In 2007, no abundance estimate of channel catfish was conducted.

During the first nonnative removal trip in 2007, very low numbers of channel catfish large enough to tag were captured. Tagging was discontinued at the end of the first day of sampling during the first nonnative removal trip. A reliable population estimate was not possible with the low number of channel catfish > 200 mm that were captured.

No predation of endangered fishes by channel catfish was observed in 2007. Examination of channel catfish stomach contents revealed unidentifiable suckers and non-endangered native suckers. Nonnative channel catfish were also found infrequently in the stomachs of large channel catfish. In 2004, predation of endangered fishes by channel catfish was observed on two occasions. A recently stocked razorback sucker and Colorado pikeminnow were found in the stomachs of two 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*

In 2007, mean catch rates of common carp continued to decline. Catch rates of common carp were not significantly different between passes in 2007 (Figure 10). From 2002 to 2007, catch rates of common carp decreased significantly ( $p < 0.001$ ; Figure 11). In 2007, the mean catch rate of common carp was significantly lower than from 2002 to 2005 ( $p < 0.05$ ), but was not significantly lower than in 2006. Size structure of common carp remained similar among years from 2002 to 2006, but was significantly lower ( $p < 0.05$ ) in 2007 than in years 2002 to 2006 (Figures 12 and 13). The percentage of adult carp in the total carp catch has also continued to decline since the initiation of control efforts (Figure 14).

#### Endangered Species

##### *Colorado pikeminnow*

A total of 198 Colorado pikeminnow were collected in 2007 during nonnative control efforts in lower San Juan River. An additional 18 Colorado pikeminnow were captured in the lower San Juan during the adult fall monitoring trip. Catch rates of Colorado pikeminnow significantly increased from 2003 to 2006 ( $p < 0.05$ , Figure 15). In 2007, catch rates of Colorado pikeminnow were significantly higher ( $p < 0.05$ ) than in 2003, but were not significantly different from catch rates in 2006. Catch rates of Colorado pikeminnow also varied by pass (Figure 16). In 2007, the majority of juvenile Colorado pikeminnow captured were age-2 (2005 cohort). This pattern is similar to the trend in previous years (Figure 17). Length-frequency histograms by pass further illustrate that the majority of juvenile Colorado pikeminnow collected in 2007 were age-2 fish stocked in the fall of 2005 (Figure 18).

Distribution of Colorado pikeminnow captures in 2007 appears similar to capture locations in 2006. In 2006, RM 25-15 contained a high concentration of juvenile Colorado pikeminnow, but RM 53-40 also contained more Colorado pikeminnow than in previous years (Figure 19). Colorado pikeminnow collected in 2004 through 2005, (age-1-3) were distributed throughout the entire sample reach, yet were still concentrated between RM 25-15. In 2003, age-1 Colorado pikeminnow appeared to concentrate in two sections in the lower river, RM 52-36 and RM 29-14, with the highest concentrations between RM 20 and 17 (Figure 19).

In 2007, 45 recaptures of the 139 Colorado pikeminnow greater than 150 mm TL were recorded during nonnative control and fall monitoring on the lower San Juan River. The 45 recaptures include Colorado pikeminnow that were captured up to 4 times in 2007. Additionally, one Colorado pikeminnow initially captured on the lower San Juan was recaptured approximately 129 miles upstream during nonnative control efforts near Shiprock, New Mexico.

Population estimates of Colorado pikeminnow have been generated for the lower San Juan River since 2004 (Table 3). Several population estimates were calculated using different passes to formulate a rough idea of population size of Colorado pikeminnow greater than 150 mm TL. In 2004, 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. Passes 4-6 had the highest probability of capture (13%) and a coefficient of variation of 27%. In 2005, estimates were approximately double those generated in 2004. Estimates ranged from 536 to 696 individuals depending on the model and number of passes chosen. The coefficient of variation around the highest 2005 population estimate (696) was 24% using passes 1-6 and the time variable model. Passes 1-3 and 1-4 had the highest probabilities of capture (6% for both) and a coefficient of variation of 37% and 30%, respectively (Table 3). In 2006, population estimates ranged from 124 to 1267 Colorado pikeminnow greater than 150 mm TL in the lower San Juan River depending upon which set of sampling passes were included in the model (Table 3). The coefficients of variation for the lowest (124) and highest (1267) population estimates were 30% and 67% respectively. In 2007, Colorado pikeminnow population estimates ranged from 68-326. The coefficients of variation for the lowest (68) and highest (326) population estimates were 31% and 13% respectively. The observed variation in the population estimates within and among years makes identifying trends in the number Colorado pikeminnow difficult.

Captures of adult Colorado pikeminnow have diminished since this project began in 2002. No adult Colorado pikeminnow were collected in 2005, 2006 or 2007 in the lower San Juan River. During the first year (2002), five adult Colorado pikeminnow ranging from 460 to 539 TL were captured. 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*

One hundred forty-five razorback suckers were collected in the lower San Juan River (Table 1) in 2007 during nonnative removal trips. An additional 26 razorback suckers were captured during the adult fall monitoring trip in the lower San Juan River. Mean catch rate of razorback suckers was significantly higher in 2007 than in previous years ( $p < 0.05$ , Figure 20). No suspected razorback-flannelmouth hybrids were collected in 2007 in the lower San Juan River.

### Waterfall

Five sampling trips below the San Juan waterfall(s) were conducted in 2007 on April 4-5, June 20-21, July 11-12, August 13-14 and October 19. Similar to conditions in summer 2006, the waterfall was approximately 7-8 meters high. Fish sampling methods below the waterfall(s) include fyke nets, seines, cast nets and angling.

Fishes collected below the waterfall during 2007 included native, nonnative and endangered species. In 2007, striped bass and walleye were collected for the first time below the waterfall since waterfall sampling began in 2005. Other species collected included: channel catfish, Colorado pikeminnow, common carp, flannelmouth sucker, gizzard shad (*Dorosoma cepedianum*), and razorback sucker. Juvenile channel catfish dominated the catch. Two adult and hundreds of YOY gizzard shad were collected in 2007. Endangered fishes collected were two razorback sucker and eight Colorado pikeminnow. All endangered fishes were PIT tagged and released above the waterfall.

### Other Observations

Over the course of this project, important information has also been obtained on endangered fishes. We have observed the apparent spawning aggregation of razorback sucker in spring 2002 at Slickhorn Rapid, located another possible spawning aggregation near RM 23.5 in 2006, documented the distribution and abundance of Colorado pikeminnow stocked in 2002 –2006, generated preliminary population estimates for juvenile Colorado pikeminnow in 2004, 2005, 2006 and 2007, and documented the first cases of channel catfish predation on stocked juvenile razorback sucker and Colorado pikeminnow in the San Juan River.

The increases in catch rates of juvenile Colorado pikeminnow in the lower San Juan River from 2003 to 2007 are correlated with the stocking of YOY fish each year. From our collections, it is evident that once Colorado pikeminnow approach 150 mm TL, they are more likely to be captured by electrofishing. In 2004, 2005, 2006, and 2007, age-2 fish made up the majority of the catch. It has been observed in the past that the number of Colorado pikeminnow in this size class decreases in collections, as was the case after the 1996-1998 stocking events. USFWS Colorado River Fisheries Program (CRFP) fall

monitoring data (Ryden 2003) show that catch rates of age-3 fish diminished one year after a good catch of age-2 fish.

## DISCUSSION

In 2007, the waterfall near Piute Farms persisted and was a barrier to upstream movement of fishes from Lake Powell. Lake Powell elevations remained far below full pool and below elevations that would inundate the waterfall. At the time of this report, Lake Powell's elevation was 3590 feet above sea level, approximately 110 feet below full pool. Current prediction for Lake Powell indicates a substantial increase in lake level in 2008, but lake levels will not be high enough to inundate the waterfall in 2008.

Eleven thousand five hundred eighty channel catfish were mechanically removed from the lower San Juan River in 2007. Eight thousand nine hundred twenty-three channel catfish were captured by electrofishing equipment including the 381 catfish removed during the adult fall monitoring trip. An additional 2,657 channel catfish were removed by utilizing chase boats and block seines.

In 2007, UDWR-Moab began experimenting with using a seine to capture catfish not collected by the electrofishing raft. The seine was placed perpendicular to shore and held in place for several minutes after the electrofishing raft had passed. Block seining was particularly effective when large concentrations of catfish were located. In one particular block seine setup, 270 channel catfish were captured. Block seining proved effective when river flows were less than about 1500 cfs and channel catfish seemed to be concentrated in shallow run habitats. On the first three nonnative removal trips in 2007, block seining increased the number of channel catfish removed by 35%-45%.

The channel catfish catch rate in 2007 was significantly lower than in 2005, and significantly higher than in 2003. No significant difference was found in 2007 between mean catch rates from 2002, 2004 and 2006. Many factors may have contributed to the high catch rates in 2005. First, removal of the larger channel catfish may be providing more opportunity for smaller channel catfish to persist. Stomach content examinations from the lower river do not show large numbers of small channel catfish in the stomachs of large (>400 mm TL) channel catfish. As large channel catfish stomachs infrequently contain small channel catfish, conspecific predation by large channel catfish is not likely precipitating an increase in juvenile and YOY channel catfish abundance, but increased habitat and food resource availability may be improving survival of small channel catfish. Second, high flows during approximately half of the sampling trips in 2005 may have resulted in netters "blind sweeping" (i.e. dragging net through the water where fish are expected) when larger fish were not apparent. This method tends to result in the capture of more small channel catfish. To further support this hypothesis, on subsequent passes after fish were marked, recaptures of marked channel catfish were low until the July trip. Flows at this time had returned to pre run-off levels, therefore making it easier to capture larger fish. Third, reproductive success of channel catfish may have been greater in 2004 than in previous years increasing the abundance of small channel catfish in 2005.

The mean total length of channel catfish captured and removed in 2007 (178 mm TL) from the lower San Juan River decreased from 2006 (204 mm TL). The mean total length was also significantly lower than from 2002 (269 mm TL), 2003 (227 mm TL), and 2004 (208 mm TL) and was significantly higher than in 2005 (171 mm TL). The same factors that may have caused the increased catch rate in 2005, such as blind sweeping, may have affected the lower mean TL of captured channel catfish in 2005 and in 2007. Overall, nonnative control appears to be maintaining a shift towards smaller mean total lengths of channel catfish in the lower San Juan River. The decrease in adult channel catfish mean CPUE and the decreasing percentage of adults in the total channel catfish catch data also suggest reduced abundance of large channel catfish in the lower San Juan River. Unfortunately, no mark/recapture population estimate was attempted in 2002 when mean CPUE of adult channel catfish was ~250 percent higher than in 2007. The maximum size of channel catfish captured in the lower San Juan has also decreased from 789 mm TL in 2002 to 683 mm TL in 2007.

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 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. Alternately, increasing the probability of a Colorado pikeminnow encountering a channel catfish may be unlikely as the two species are certain to interact as channel catfish are and have been abundant and ubiquitously distributed throughout the lower San Juan River since the nonnative control began in 2002. The expectation is that Colorado pikeminnow will choose flannelmouth sucker and bluehead sucker over channel catfish, especially when these prey are more abundant.

Population estimates generated for channel catfish from 2003 to 2006 are cursory, and may 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 efficiency of capturing channel catfish based on flow, turbidity, netter ability, and unknown factors. Three channel catfish tagged in the section of river near Farmington, NM where NMFRO conducts mechanical removal were collected during sampling on the lower San Juan in 2006. Additionally, NMFRO captured three catfish in 2006 tagged in 2005 in the lower San Juan River greater than 100 miles upstream from the tagging site in 2005. These data indicate catfish moving long distances throughout the San Juan River. Using the first two passes, conducted within one month, reduces the likelihood of immigration and emigration affecting the mark/recapture Lincoln-Peterson population estimate of channel catfish. Dames et al. (1989) documented that a channel catfish traveled 469 km upstream in the Missouri River in just 72 days, while Hale et al. (1986) observed movement of 108 km upstream in 22 days in the St. Johns River in Florida. Channel catfish movement into the lower San Juan River from downstream sources is unlikely because of the waterfall at Piute Farms. With the expansion of nonnative removal upstream, as proposed for 2008, movement of channel catfish from upstream into the lower San Juan should be reduced.

Continuing population estimates for channel catfish will allow for evaluation of removal effectiveness and exploitation rate of the channel catfish population. 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 (Bennett 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.

Since 2002, a significant and continuing decline in catch rates of common carp has been observed. During the first year of removal, 1052 common carp were removed from the lower San Juan River. In 2007, only 41 carp were captured in the same river section. It is unclear if this decline is directly related to removal efforts, the presence of the waterfall, limited habitat availability, or the water conditions that have been present over the period of this project. All or some of these factors are likely responsible for the reduction in common carp. The majority of carp removed from the lower San Juan River are captured in the bottom 14 miles of the reach. This indicates carp are not occupying the majority of the lower San Juan River nonnative control reach.

In 2007, the size structure of common carp removed from the lower San Juan showed a significant decrease from previous years of sampling. From 2002 to 2006, the mean total length of common carp removed from the lower San Juan River ranged from 382 to 459 mm TL compared to 285 mm TL in 2007. The percentage of adult carp in the total carp catch has also declined since nonnative control began. In 2007, YOY and juvenile carp made up almost 40% of the carp catch. While the percentage of YOY and juvenile carp has increased, the number of YOY and juvenile carp captured each year has remained low. The increase in the percentage of juvenile and YOY carp in the total carp catch has resulted from the large reduction in the number of carp captured each year. These data may indicate low levels of carp reproduction in the lower San Juan River.

Population estimates generated for stocked juvenile Colorado pikeminnow, although preliminary at this point, provide a basis for future estimates. In 2005, spring estimates appeared to be the most precise, with the lowest coefficients of variation. In 2006, Colorado pikeminnow estimates were quite variable across all sets of passes making the validity of the estimates questionable other than for exploratory purposes. In 2007, Colorado pikeminnow estimates were again quite variable and were lower than estimates from 2006.



In 2006 and 2007, Colorado pikeminnow were found moving extended distances during the summer. Population estimates may be biased if the closure assumption was violated. In 2006 and 2007, mark/recapture data indicates some Colorado pikeminnow were indeed moving large distances (80-129 river miles) throughout the summer. These data indicate that some unknown percent of fishes captured in the lower San Juan during spring or early summer are indeed moving upstream and out of our sample reach. An estimate with the shortest time between passes, either in the spring or fall is likely to be the most reliable. If riverwide population estimates are attempted in the future, late summer or early fall would be a logical time as age-1 fish begin reaching a size where they are more susceptible to capture by electrofishing. A riverwide estimate would also alleviate concern about a closed population, as the entire river would be sampled above the waterfall.

The catch of adult Colorado pikeminnow has declined over the period of this study (2002-2007). The reasons for this decline 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; 4) mortality may also be the reason for the absence of adult Colorado pikeminnow in the lower San Juan River. 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 total number of razorback suckers captured in the lower San Juan River in 2007 was more than twice the number captured in any previous year. The increasing razorback sucker numbers and razorback sucker catch rate resulted from increased numbers of razorback suckers being stocked upstream. Sixty of the one hundred seventy-one razorback suckers captured in 2007 were stocked in spring and summer of 2007. Even without including razorback suckers that were and captured in 2007, the total number of razorback suckers captured in 2007 was nearly twice as in the previous year. While stocking is producing the increase in captures of razorback sucker, the substantial increase in the last two years is encouraging.

Sampling at the base of the waterfall in 2005 to 2007 showed that both endangered and nonnative fishes are blocked from moving upstream. It is possible that the larger pikeminnow that were collected in 2002-2004 have moved below the waterfall and cannot return upstream. No adult Colorado pikeminnow have been captured below the waterfall, but in 2007 hook and line sampling below the waterfall collected one large (397 mm TL) Colorado pikeminnow. This Colorado pikeminnow is larger than any other captured in the lower San Juan since 2004 with the exception of the large Colorado pikeminnow stocked in the summer of 2006. After being released above the waterfall, this fish was recaptured 12 days later during a nonnative control trip 48 miles upstream from the waterfall. This Colorado pikeminnow was initially tagged in the lower San Juan in 2005. A total of eight Colorado pikeminnow and two razorback suckers were captured below the waterfall in 2007 indicating some loss of stocked endangered fishes over the waterfall. At this time, no estimate of the number of endangered fishes passing over the waterfall is available.

Sampling below the waterfall in 2007 resulted in the first captures of striped bass and walleye below the waterfall since monitoring began in 2005. Striped bass were captured on two sampling occasions and walleye were captured on one sampling occasion. The total numbers of these species captured were low (3 striped bass and 2 walleye). All striped bass and walleye were captured in early to mid-summer indicating when these species are attempting to move upstream into the lower San Juan River. Sampling directly below the waterfall is difficult, and the probability of capture for striped bass and walleye may be low. Continued monitoring will strengthen the dataset for predicting when these species are attempting to move into the lower San Juan River.

## CONCLUSIONS AND RECOMMENDATIONS

- Population estimates of channel catfish remained similar from 2003 to 2006; 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. Expansion of nonnative control, as proposed for 2008, into the upstream reach may aid in alleviating some immigration into the estimate reach. 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.
- Continue use of block seines when river flows are compatible.
- Catch rates of common carp have decreased significantly from 2002 to 2006, while the size structure has remained relatively unchanged. The cause of the decreasing trend in catch rate for these fish is unknown. Several factors may be acting together: the presence of the waterfall which has been reducing or eliminating reinvasion into the removal section from downstream; low water conditions present during the first three years of 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 fishes.

- Catch rates and population estimates of juvenile Colorado pikeminnow increased from 2003 through 2005. In 2007, the catch rates and population estimates were similar to 2006. From 2004 to 2007, the majority of captures were age-2 fish. Age-1 fish are likely more abundant, but electrofishing sampling effectiveness increases with fish size. Population estimates of juvenile Colorado pikeminnow in the lower San Juan River should continue.
- No adult Colorado pikeminnow have been collected in the lower San Juan River from 2004 to 2007; the reasons for this are unknown. Mortality, avoidance of electrofishing rafts or movement from the lower river to upstream sections may be explanations for the disappearance of age-3 Colorado pikeminnow. Life history studies could possibly illuminate food or habitat shifts at age-3, which might be causing a bottleneck.
- Striped bass and walleye were collected for the first time in 2007. Sampling at the base of the waterfall should continue to determine when striped bass and walleye are moving from the lake up to the waterfall. Since it is probable that the waterfall will persist for several years, channel catfish, and common carp 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 fishes, and complement removal efforts being conducted further upstream.

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Table 1. Total count of most abundant fish species collected during sampling in the lower San Juan River in 2007. Species codes are defined in Appendix B.

Trip	Ptyluc	Xyrtex	Ictpun (Electrofishing)	Ictpun (Chase/Seine)	Ictpun Total	Cypcar	Amemel & Amenat
March 27 - 31	50	3	1446	779	2225	3	11
April 10 - 14	21	4	1381	972	2353	5	4
April 20 - 24	19	7	1500	802	2302	6	2
May 1 - 5	15	36	434	74	508	1	2
May 15 - 19	16	22	1028	-	1028	3	1
June 26 - 30	40	43	725	4	729	2	18
July 10 - 14	13	10	905	23	928	5	1
July 24 - 28	10	8	362	3	365	7	3
August 7 - 11	14	12	761	-	761	5	3
October 7 - 11	18	26	381	-	381	4	0
Total	216	171	8923	2657	11580	41	45

Table 2. Mean CPUE (fish/electrofishing hour) of most abundant fish species collected during electrofishing sampling in the lower San Juan River in 2007. Species codes are defined in Appendix B.

Trip	<i>Ptyluc</i>	<i>Xyrtex</i>	<i>Ictpun</i>	<i>Cypcar</i>	<i>Amemel &amp; Amenat</i>
March 27 - 31	1.21	0.07	38.66	0.09	0.22
April 10 - 14	0.56	0.10	36.23	0.12	0.10
April 20 - 24	0.66	0.16	37.10	0.26	0.10
May 1 - 5	0.98	2.40	25.85	0.05	0.09
May 15 - 19	0.49	0.78	37.03	0.13	0.05
June 26 - 30	1.13	1.23	19.95	0.14	0.49
July 10 - 14	0.40	0.31	28.68	0.16	0.03
July 24 - 28	0.37	0.30	14.77	0.26	0.11
August 7 - 11	0.58	0.49	32.48	0.21	0.12
October 7 - 11	0.66	0.96	14.38	0.15	0.00

Table 3. Population estimates for juvenile Colorado pikeminnow greater than 150 mm TL in the lower San Juan River from 2004 to 2007. Models used include the null model (Mo) and time variable model (Mt) from Program CAPTURE. CI represents the profile likelihood interval. CV indicates the coefficient of variation, and p-hat indicates the probability of capture.

Year	Passes	Model	Estimate	CI	CV	p-hat
2004	1-2	Lincoln-Peterson	160	17-303	-	-
	1-3	Mo	315	218-545	0.22	0.07
	1-5	Mo	183	99-469	0.38	0.09
	4-6	Mo	195	124-372	0.27	0.13
	5-8	Mt	157	100-297	0.26	0.1
2005	1-3	Mo	536	288-1,283	0.37	0.06
	1-4	Mt	537	321-1,064	0.30	0.06
	1-6	Mt	696	454-1,189	0.24	0.03
	3-6	Mt	582	293-1,556	0.41	0.04
	7-9	Mo	681	241-3,950	0.67	0.03
2006	1-3	Mo	202	112-2,135	0.94	0.03
	4-6	Mo	124	78-237	0.30	0.14
	7-9	Mt	976	237-4,775	0.94	0.02
	7-10	Mt	1267	417-4,296	0.67	0.02
	1-10	Mt	455	340-640	0.16	0.04
2007	1-3	Mt	238	148-436	0.29	0.1
	4-6			No Estimate		
	7-9	Mo	68	36-180	0.31	0.13
	1-9	Mt	296	233-399	0.14	0.06
	1-10	Mt	326	257-433	0.13	0.05



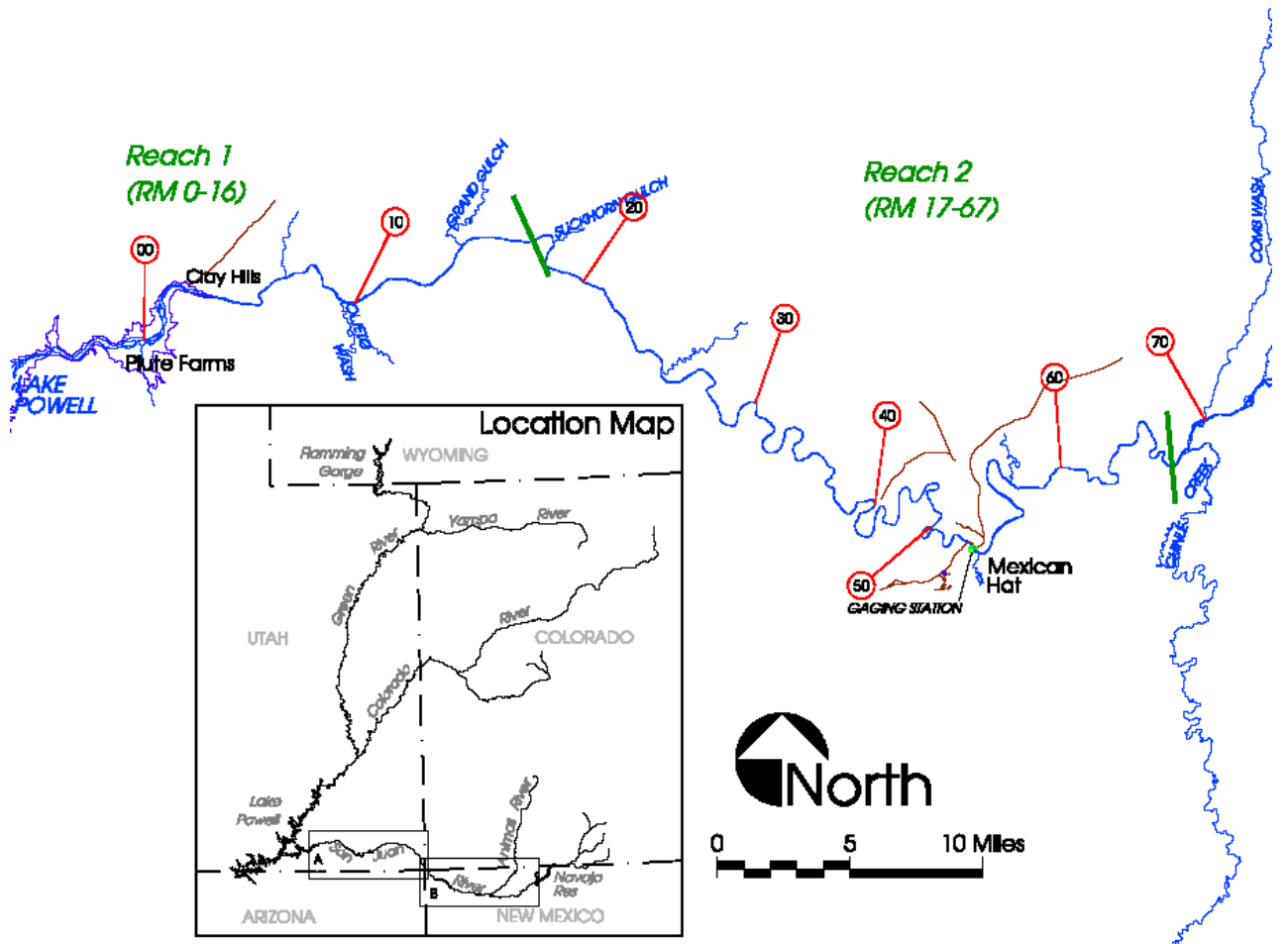


Figure 1. Map of the study area for nonnative control in the lower San Juan River. Sampling extends from Mexican Hat to Clay Hills.

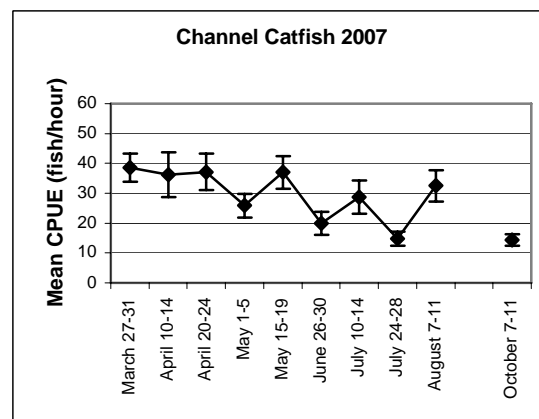
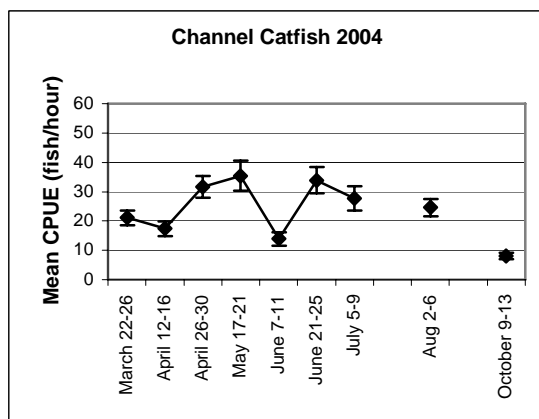
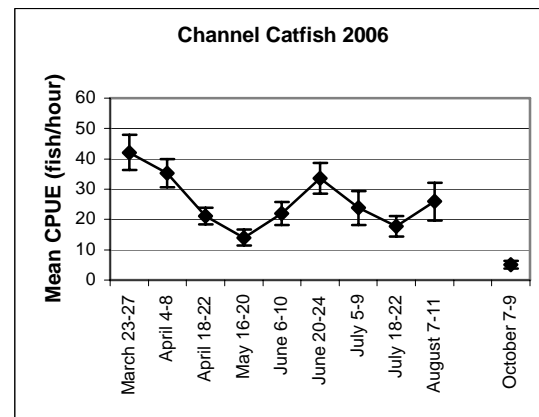
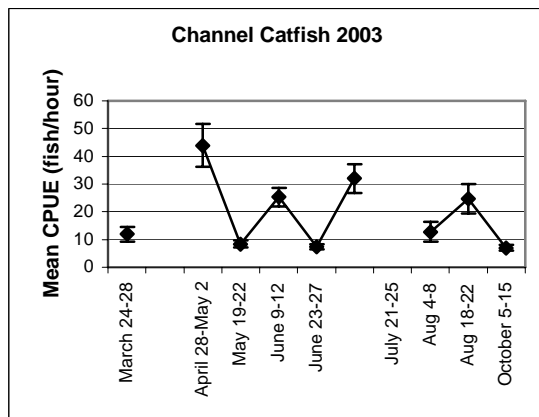
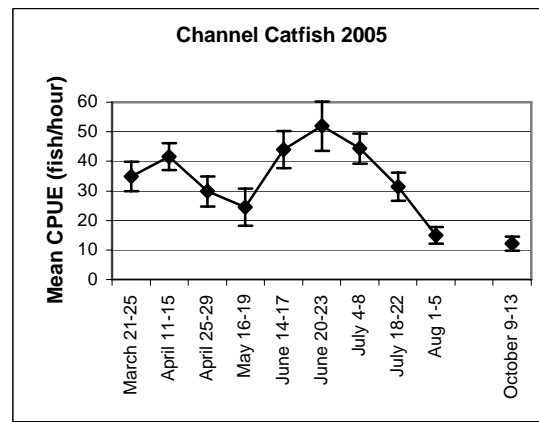
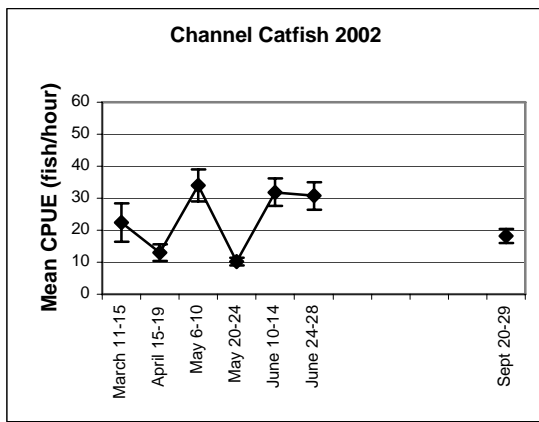


Figure 2. Mean electrofishing catch rates of channel catfish in the lower San Juan River by pass for years 2002 to 2007. Error bars represent  $\pm 1$  standard error.

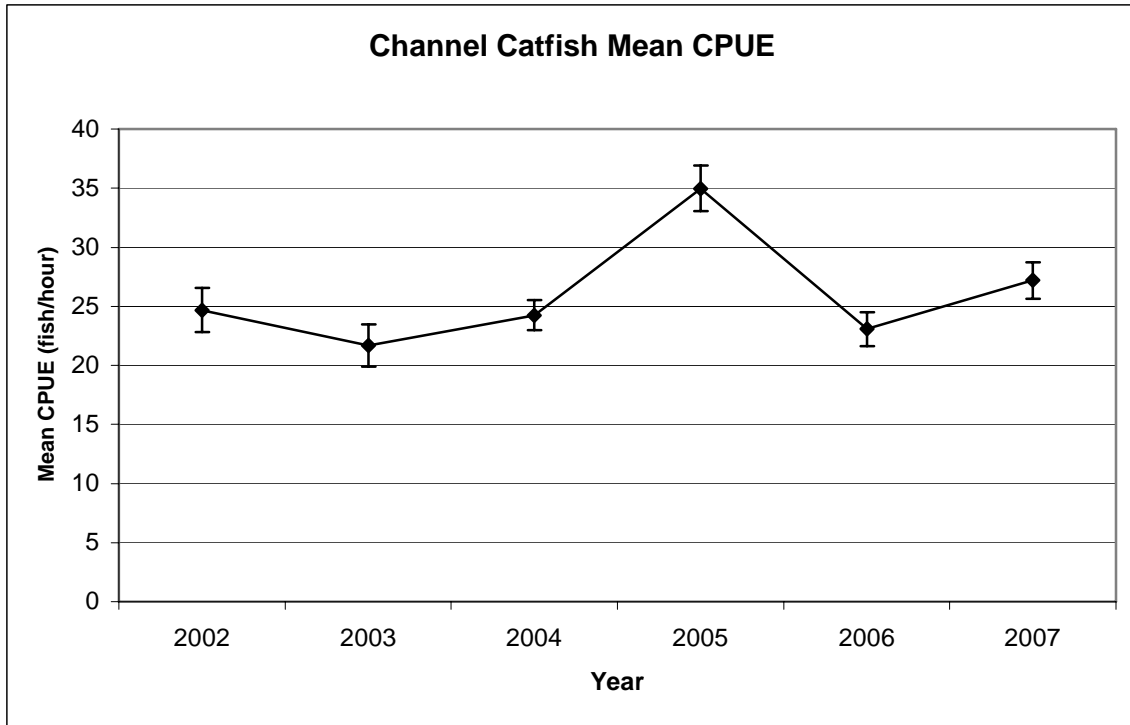


Figure 3. Mean electrofishing catch rate of channel catfish in the lower San Juan River by year. Error bars represent  $\pm 1$  standard error.

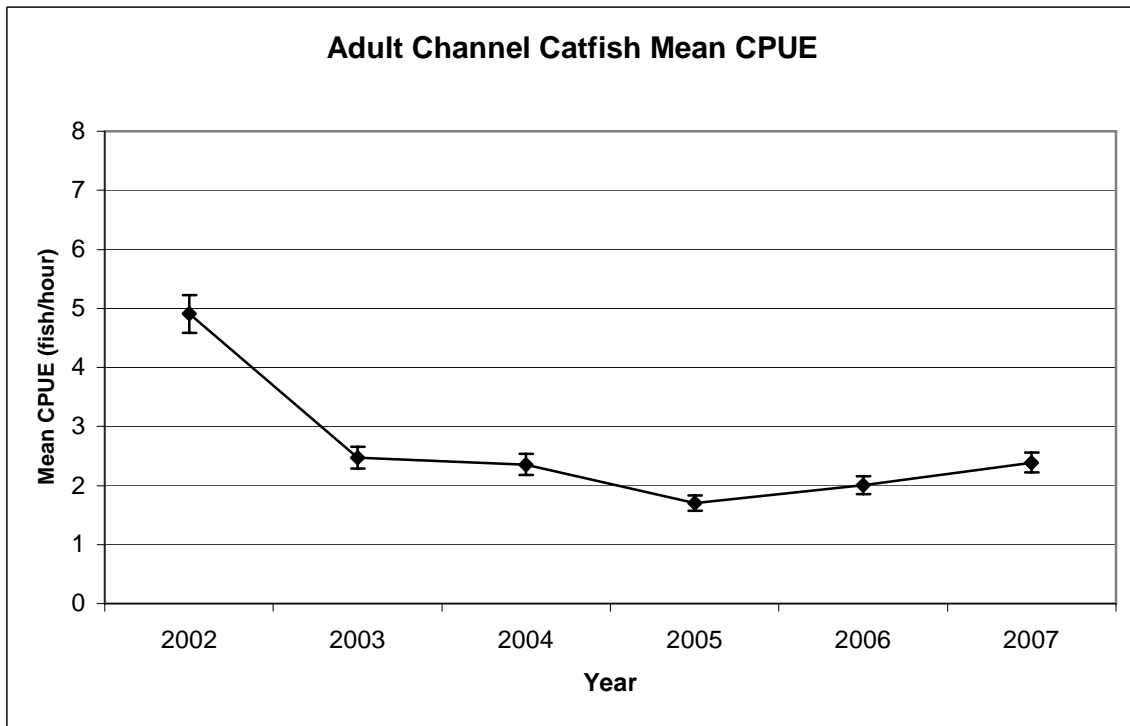


Figure 4. Mean adult (>300 mm) electrofishing catch rate of channel catfish in the lower San Juan River by year. Error bars represent  $\pm 1$  standard error.

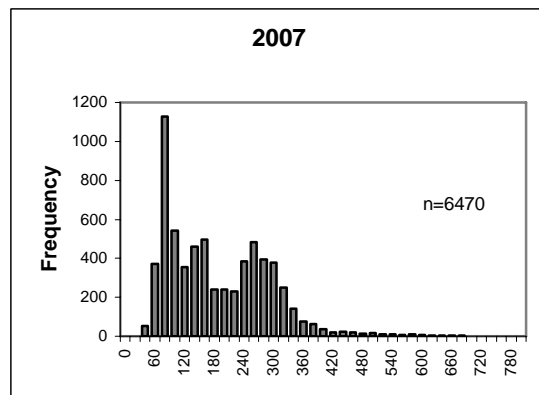
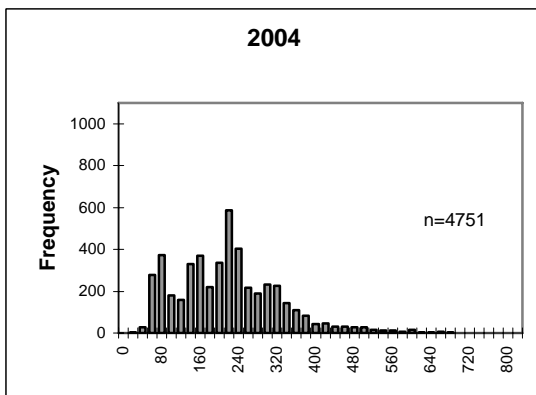
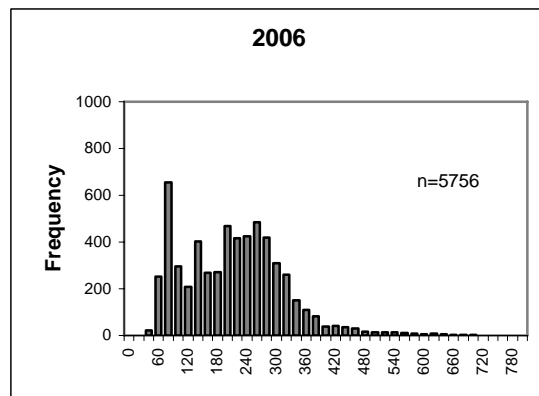
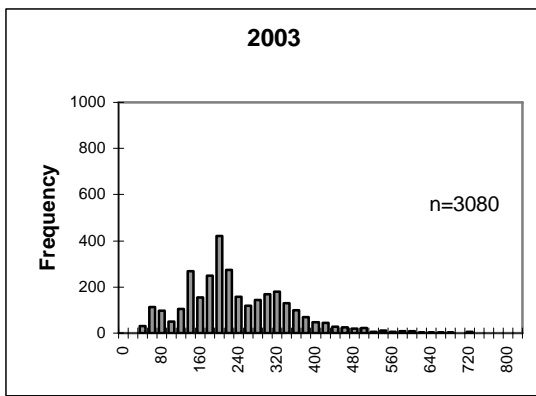
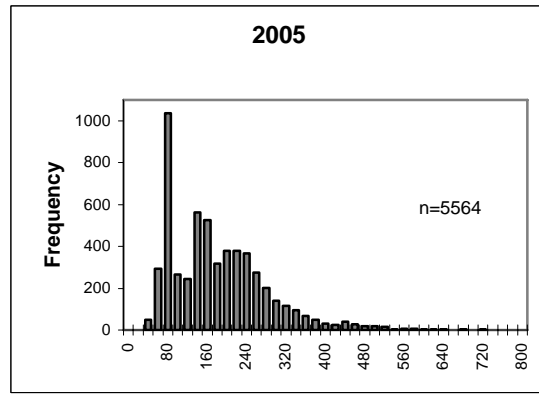
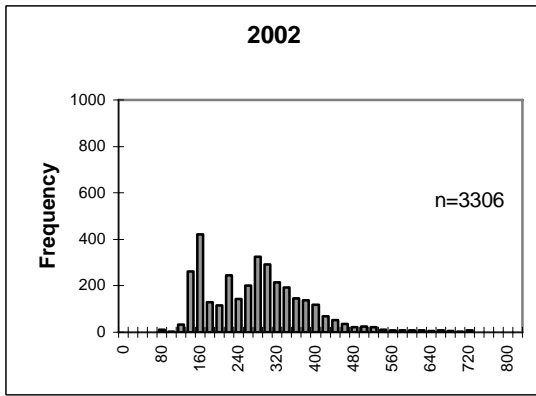


Figure 5. Length-frequency histograms of channel catfish collected by electrofishing in the lower San Juan River from 2002 to 2007.

## Channel Catfish

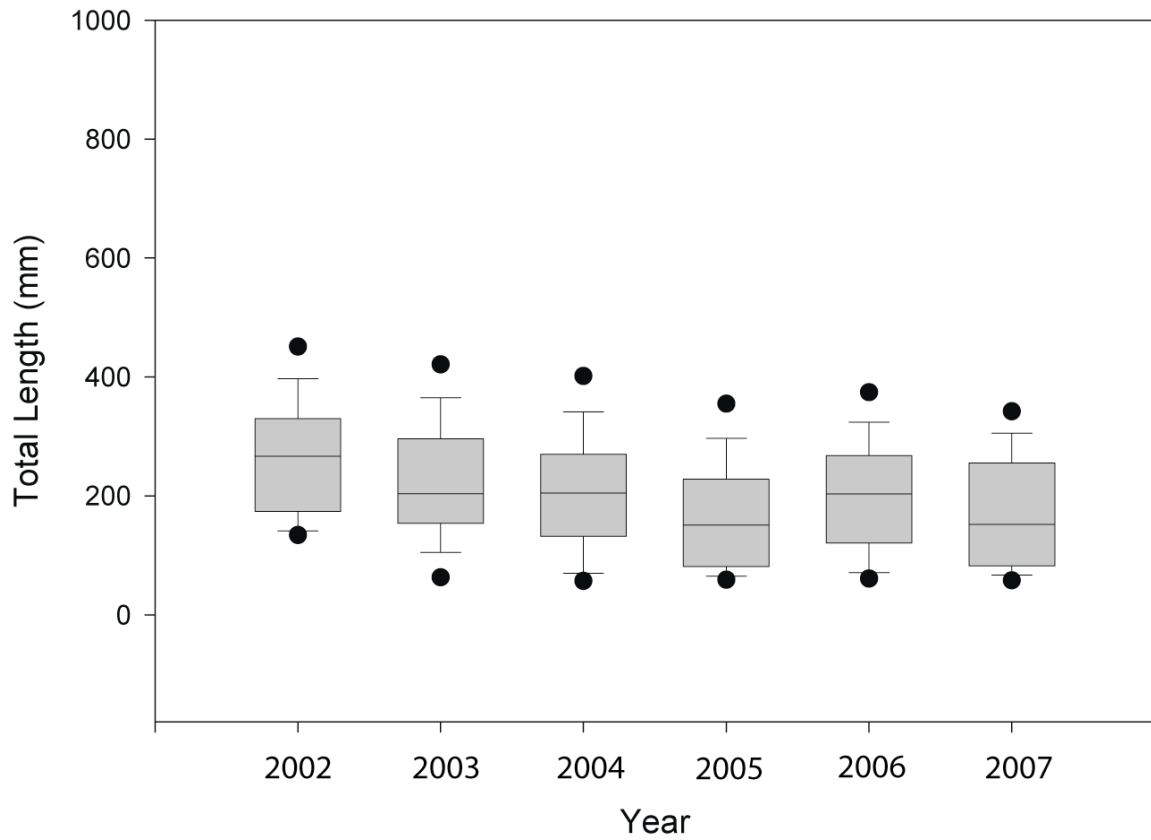


Figure 6. Distribution of total lengths of channel catfish by year from the lower San Juan River. Gray rectangles represent 25<sup>th</sup> and 75<sup>th</sup> percentiles. Horizontal line within the gray rectangles is the median total length. Whiskers represent 10<sup>th</sup> and 90<sup>th</sup> percentiles. Black dots represent 5<sup>th</sup> and 95<sup>th</sup> percentiles.

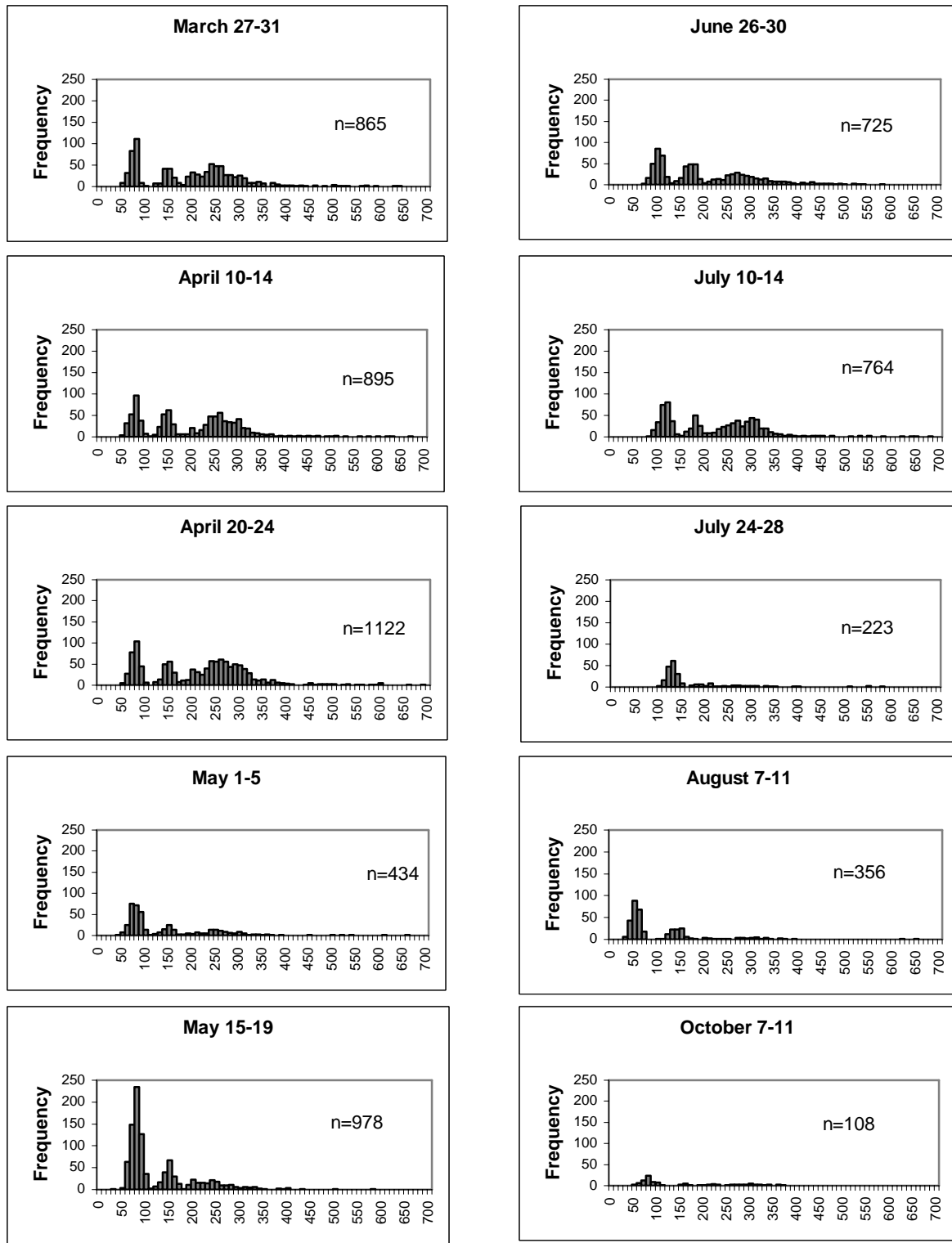


Figure 7. Length-frequency histograms of channel catfish collected by pass in the lower San Juan River in 2007.

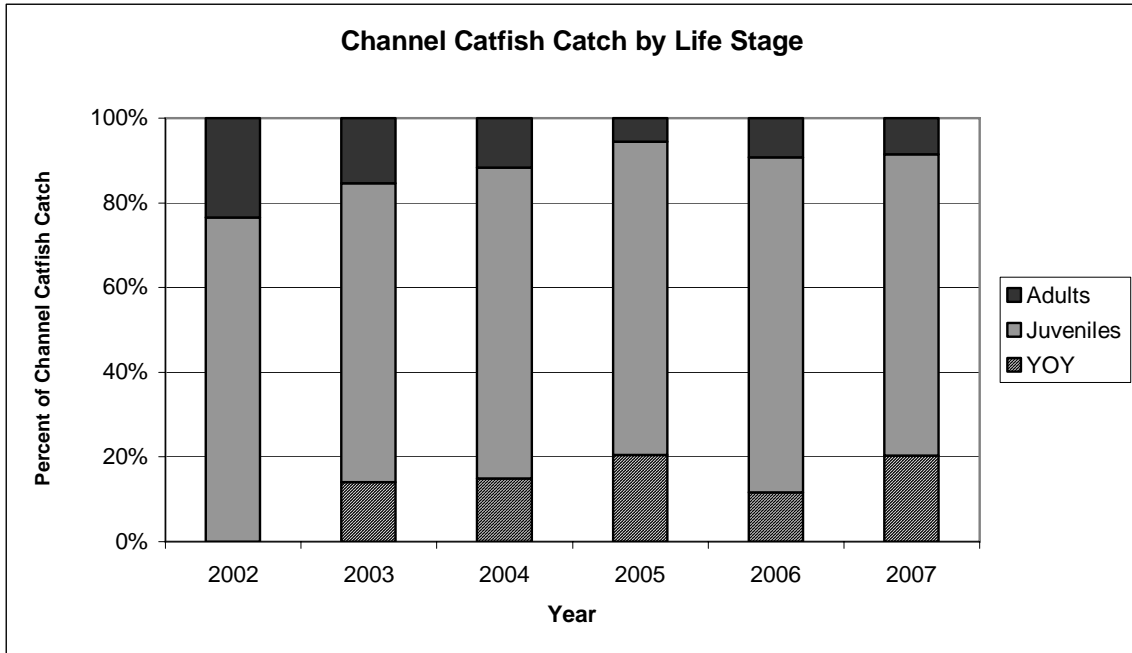


Figure 8. Percent of each life stage of channel catfish in the total channel catfish catch by year. Note: YOY and juveniles life stages were not differentiated in 2002.

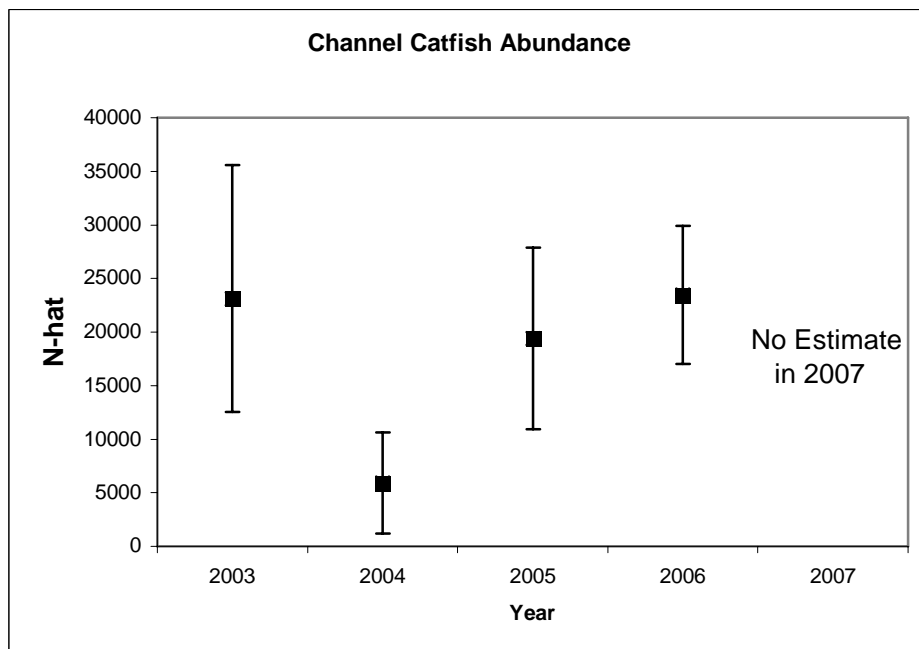


Figure 9. Abundance estimates (N-hat) of channel catfish by year in the lower San Juan River. Error bars represent 95% confidence intervals.

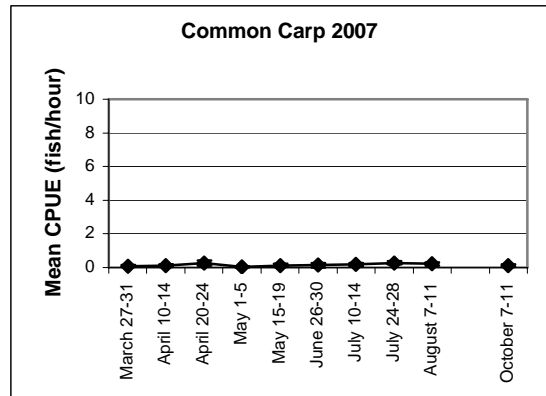
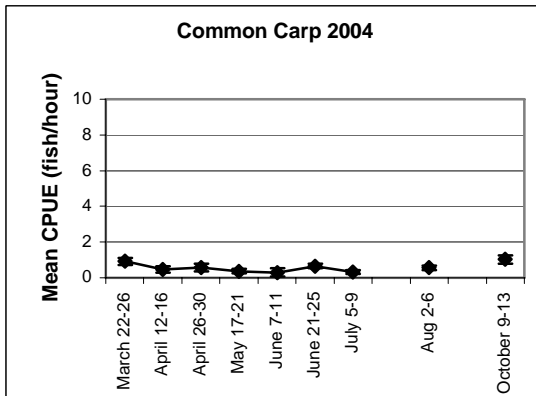
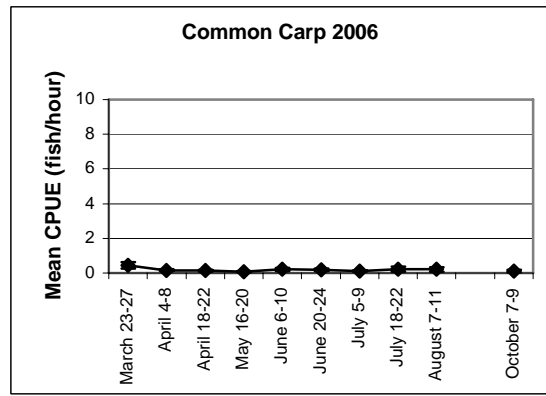
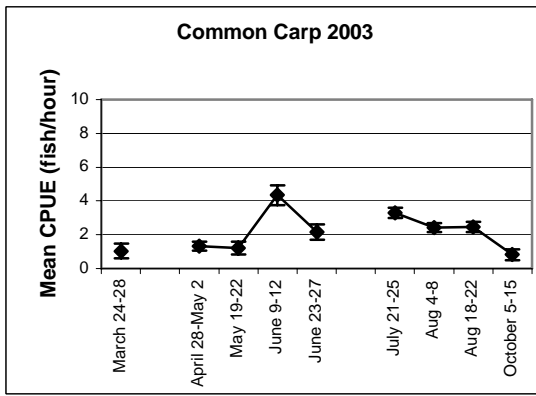
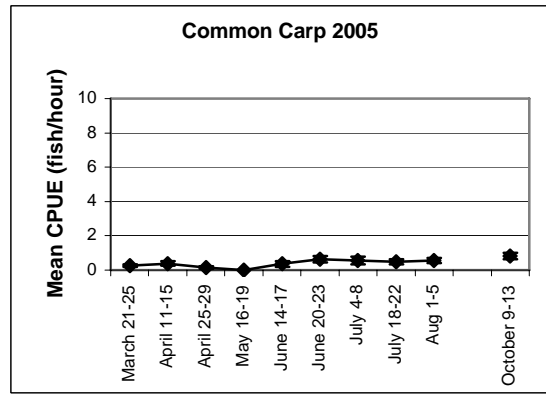
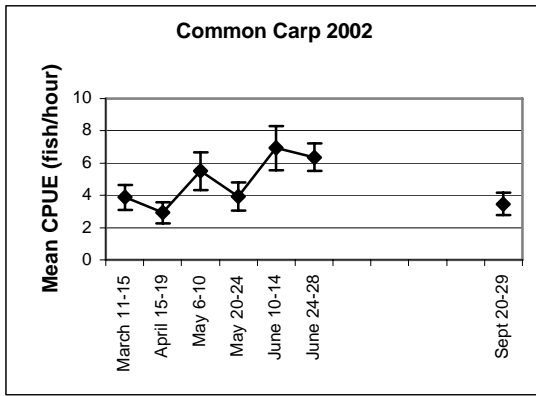


Figure 10. Mean electrofishing catch rate of common carp by pass from 2002 to 2007 in the lower San Juan River. Error bars represent  $\pm 1$  standard error.



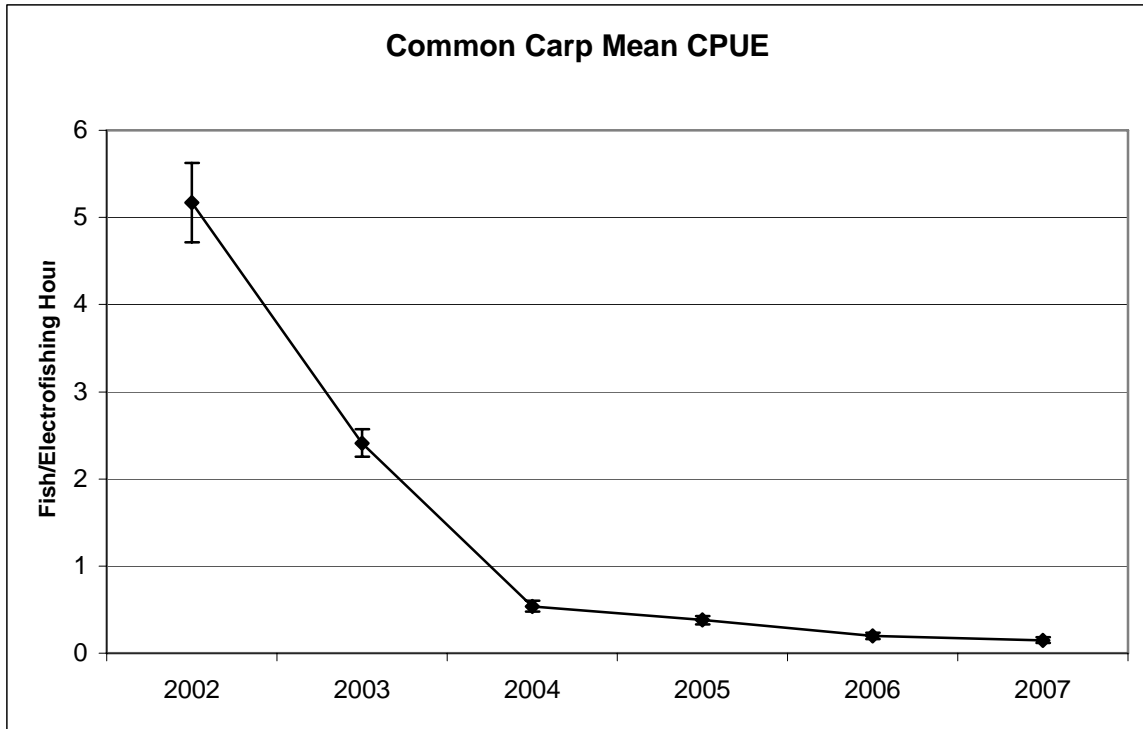


Figure 11. Mean common carp electrofishing catch rate by year from 2002 to 2007 in the lower San Juan River. Error bars represent  $\pm 1$  standard error.

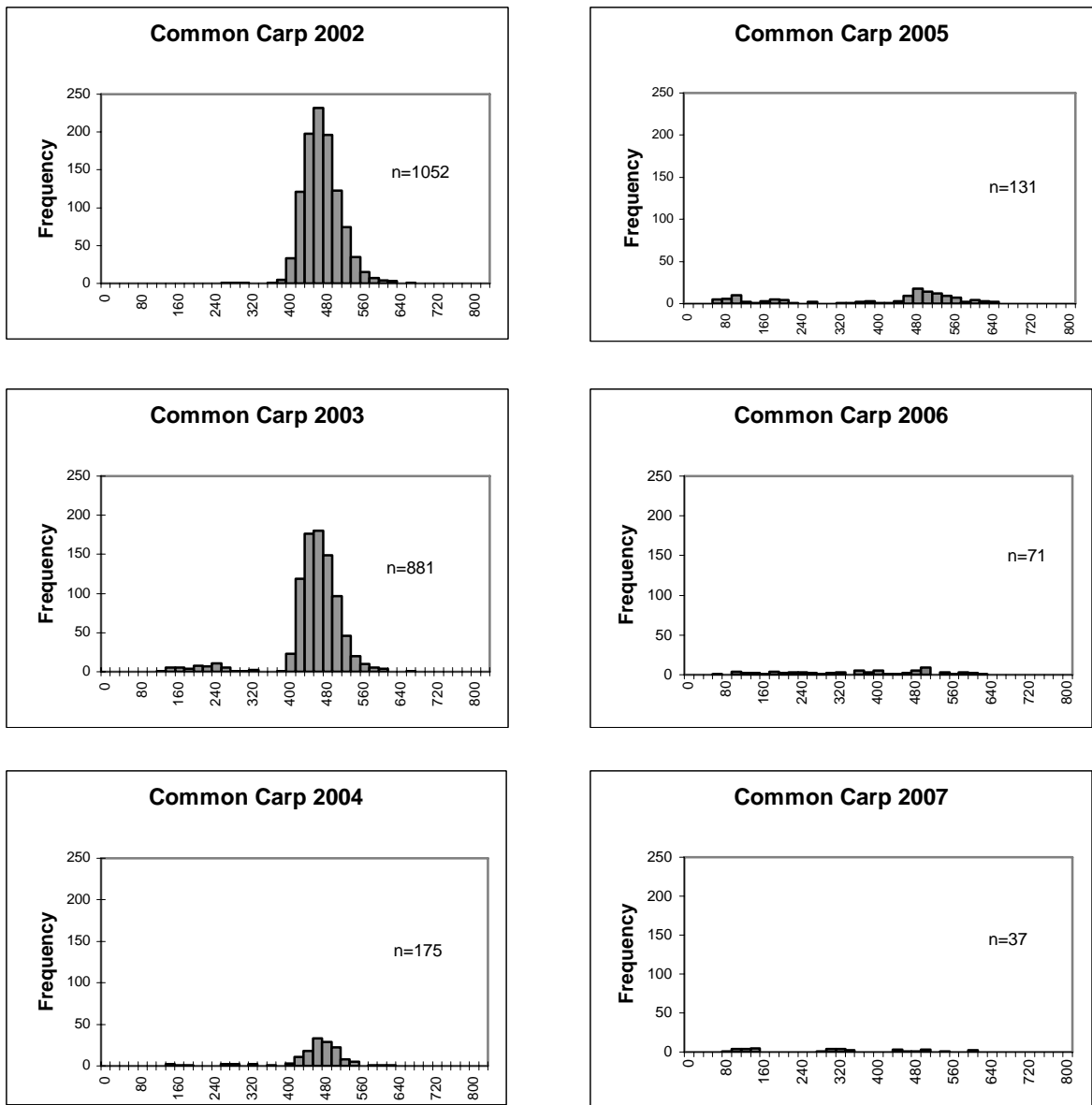


Figure 12. Length-frequency histograms of common carp in the lower San Juan River by year from 2002 to 2007.

## Common Carp

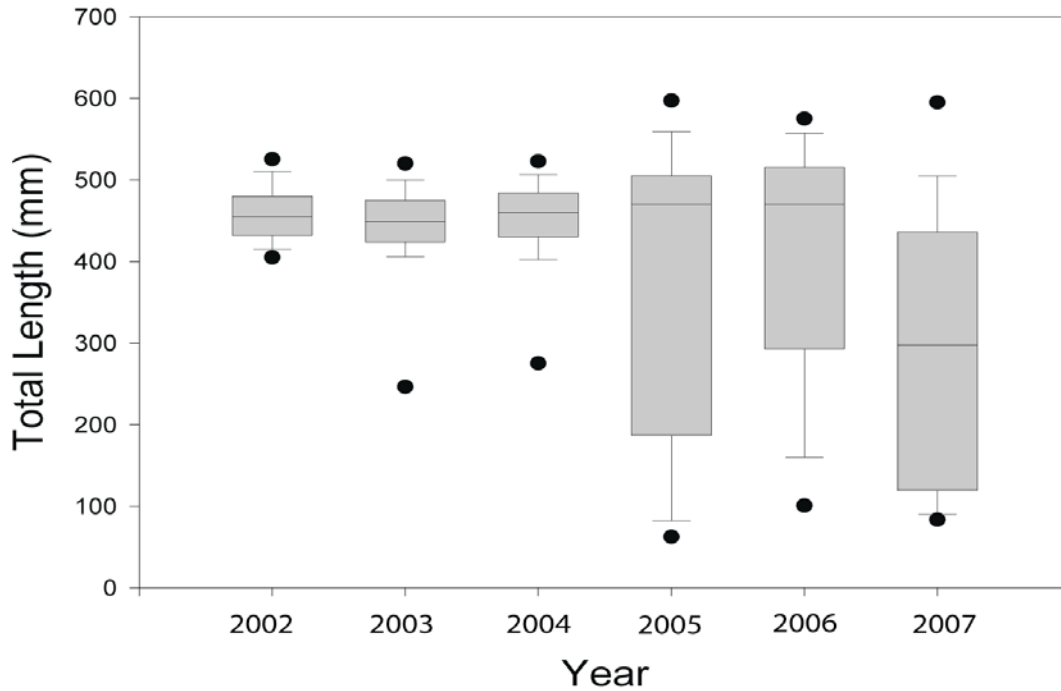


Figure 13. Distribution of total length of common carp by year from the lower San Juan River. Gray rectangles represent 25<sup>th</sup> and 75<sup>th</sup> percentiles. The horizontal line within the gray rectangles is the median total length. Whiskers represent 10<sup>th</sup> and 90<sup>th</sup> percentiles. Black dots represent 5<sup>th</sup> and 95<sup>th</sup> percentiles.

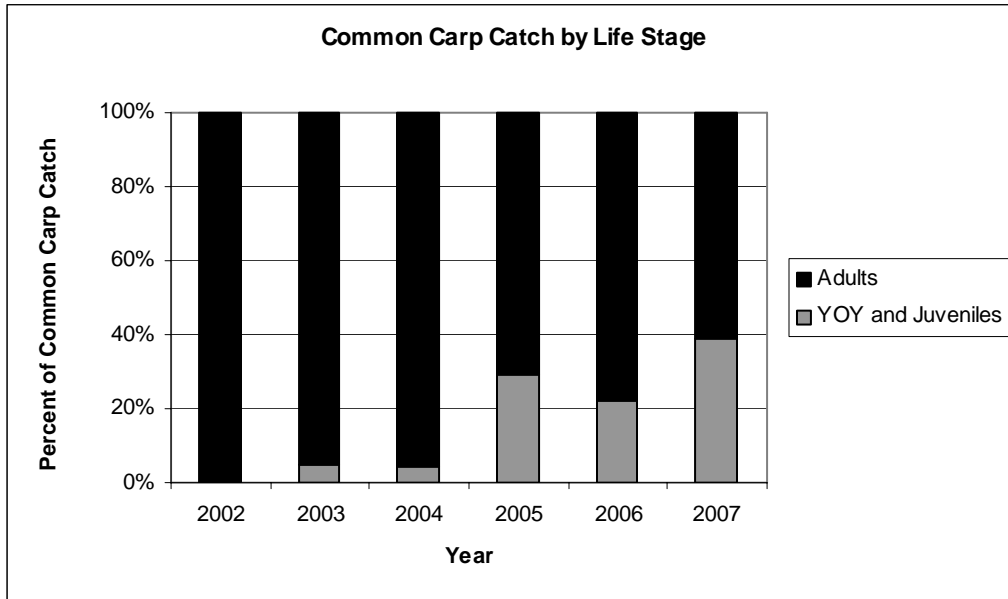


Figure 14. Percent of each life stage of common carp in the total channel catfish catch by year.

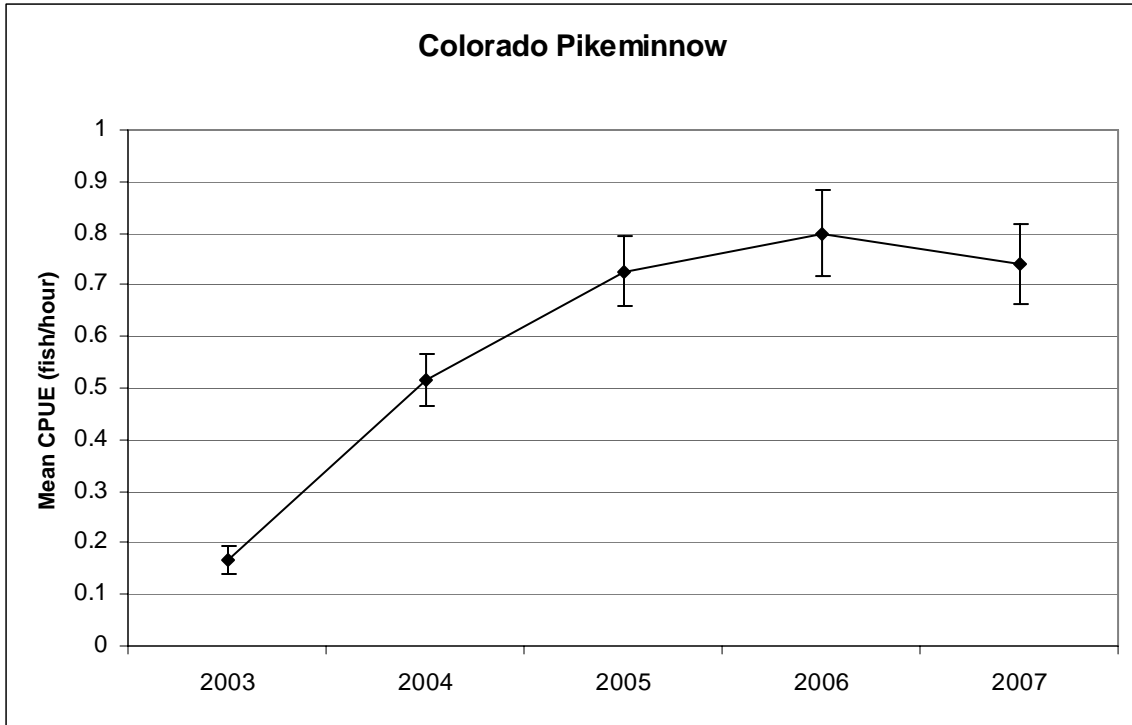


Figure 15. Mean catch rate of Colorado pikeminnow in the lower San Juan River by year from 2003 to 2006. Error bars represent  $\pm 1$  standard error.

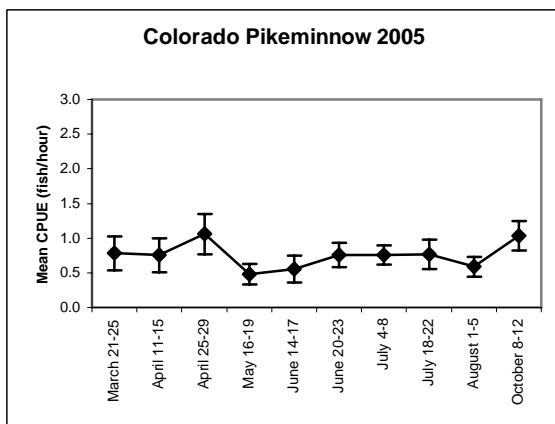
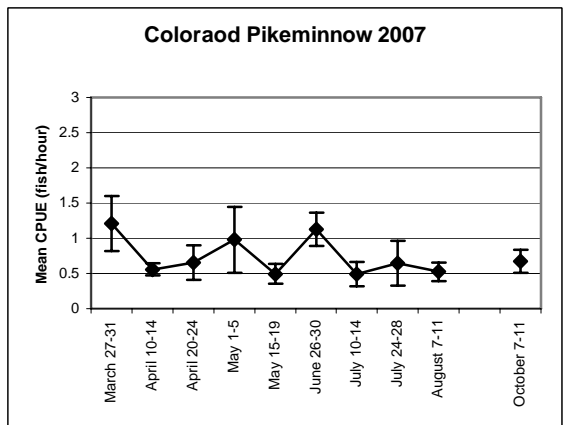
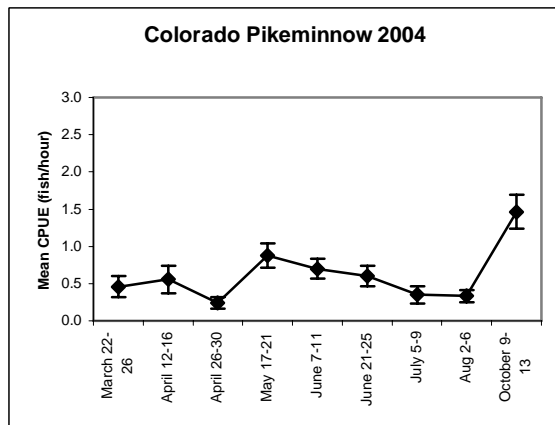
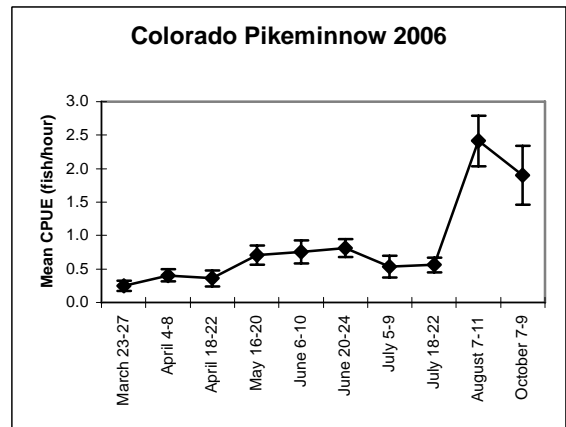
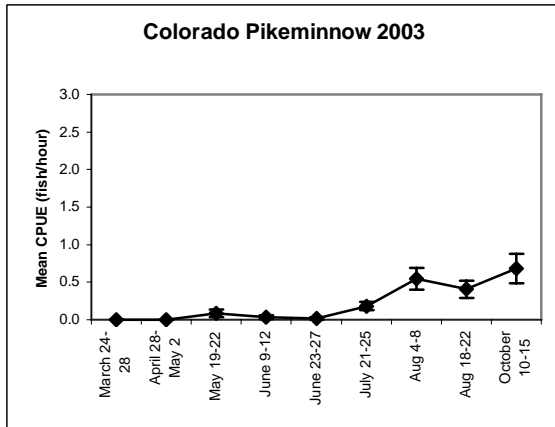


Figure 16. Mean Colorado pikeminnow electrofishing catch rate by pass from 2003 to 2007 in the lower San Juan River. Error bars represent  $\pm 1$  standard error.

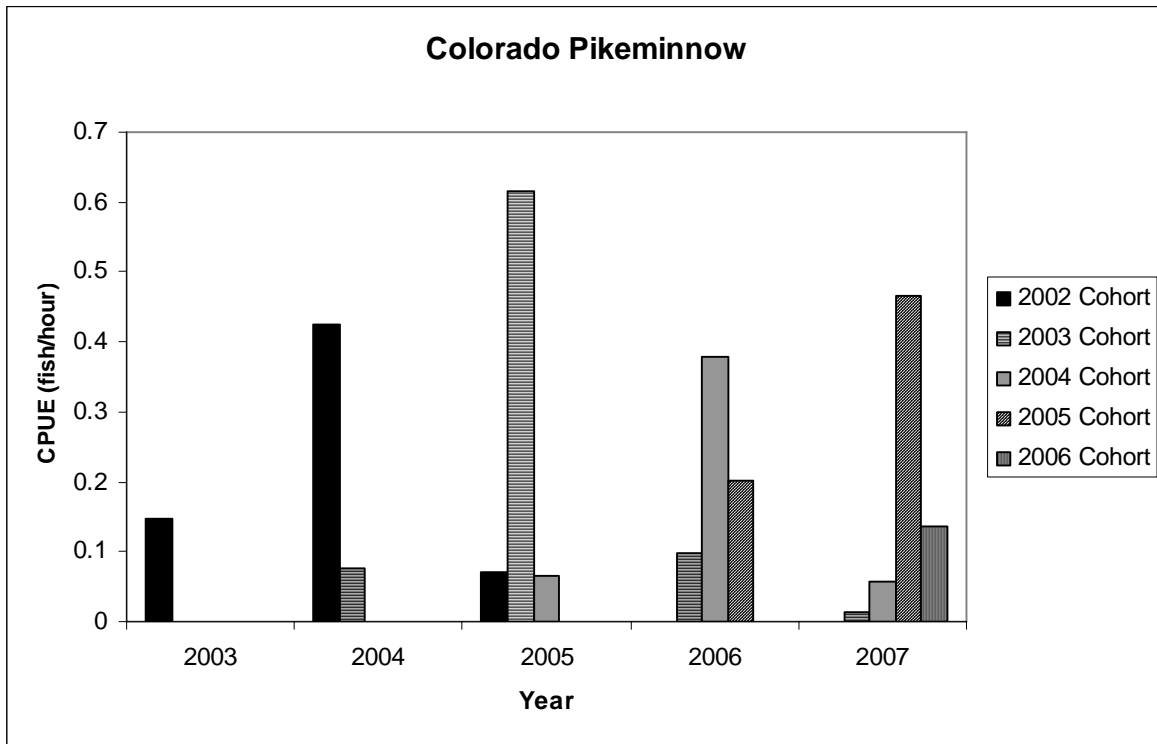


Figure 17. Colorado pikeminnow electrofishing catch rate by cohort across years from 2003 to 2007 in the lower San Juan River.

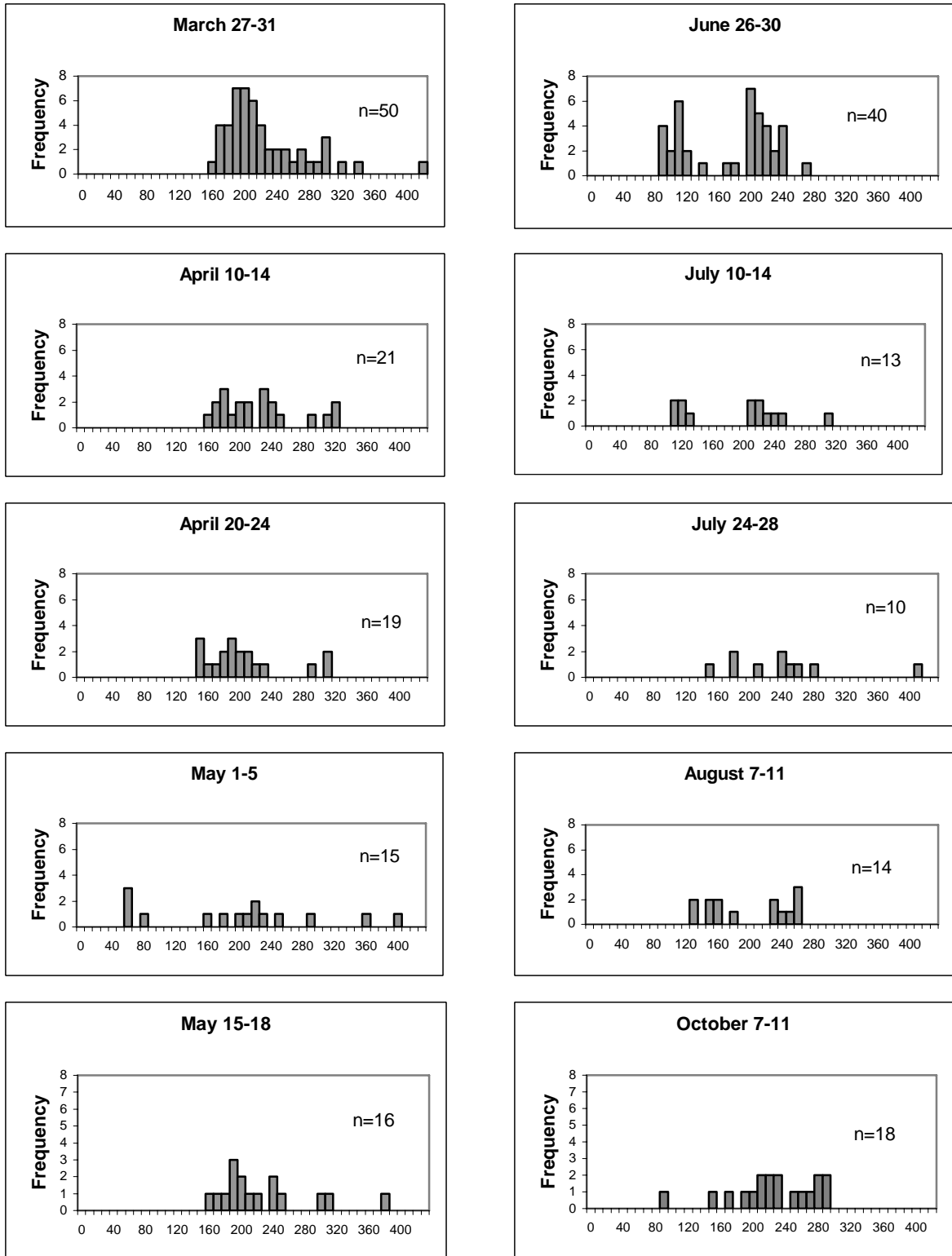


Figure 18. Length-frequency histograms of Colorado pikeminnow collected by pass in the lower San Juan River in 2007.

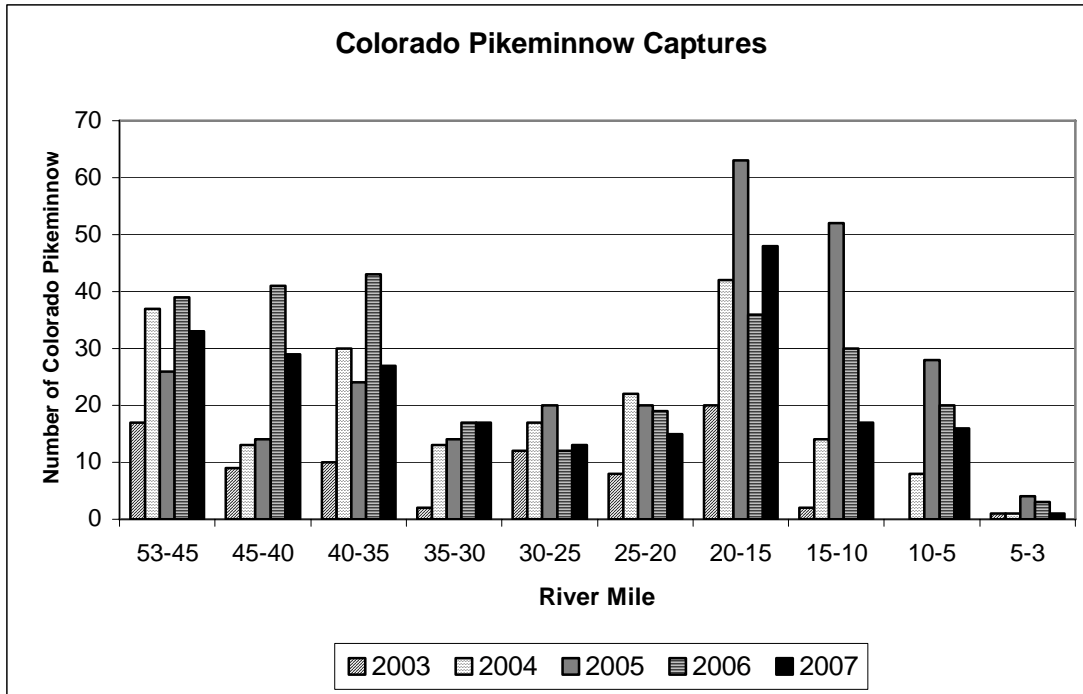


Figure 19. Distribution of Colorado pikeminnow captures by river mile from 2003 to 2007 in the lower San Juan River.

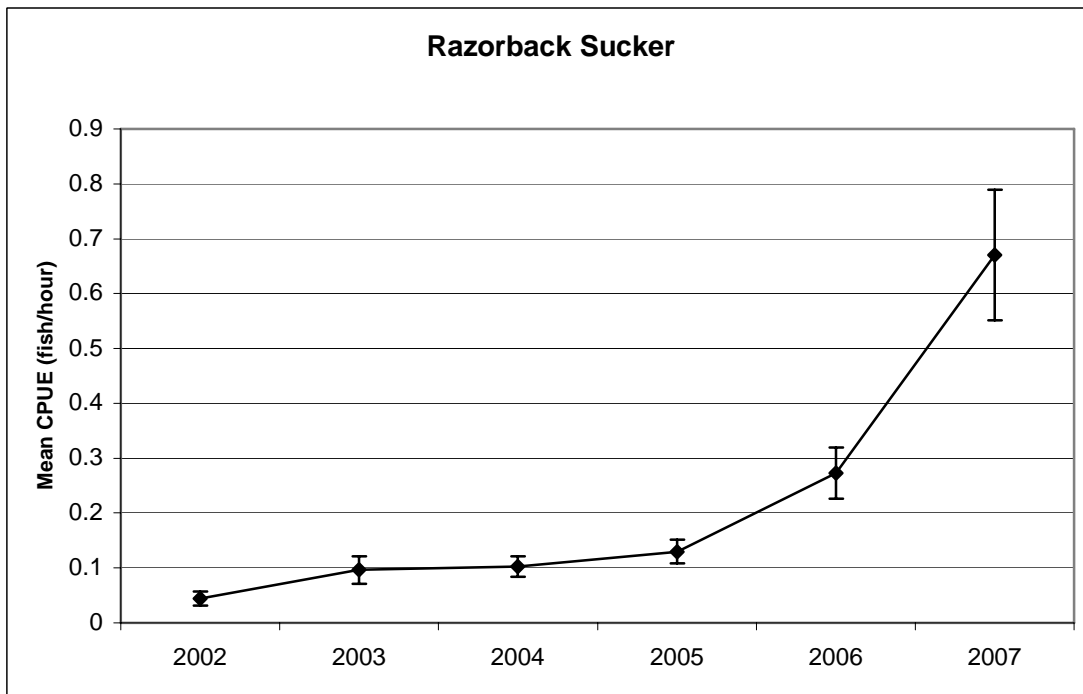


Figure 20. Mean electrofishing catch rate of razorback sucker in the lower San Juan River by year from 2002 to 2007. Error bars represent  $\pm 1$  standard error.



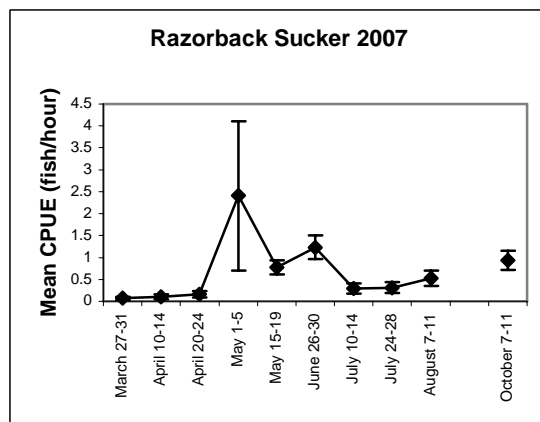
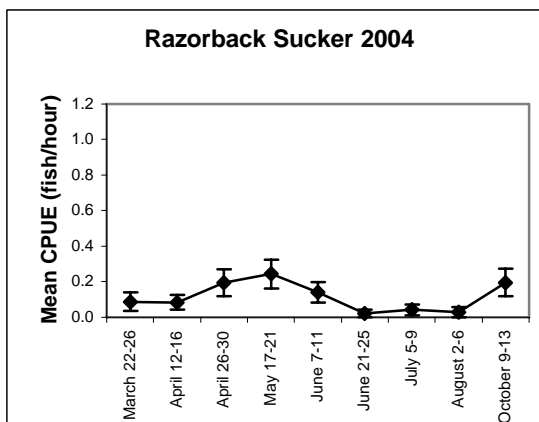
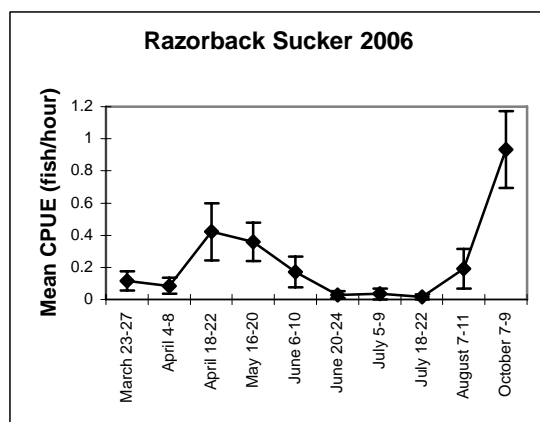
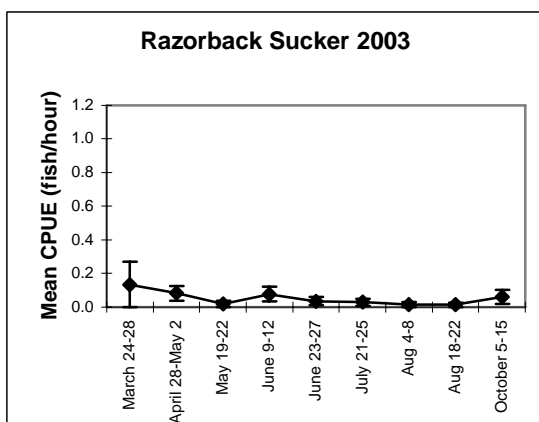
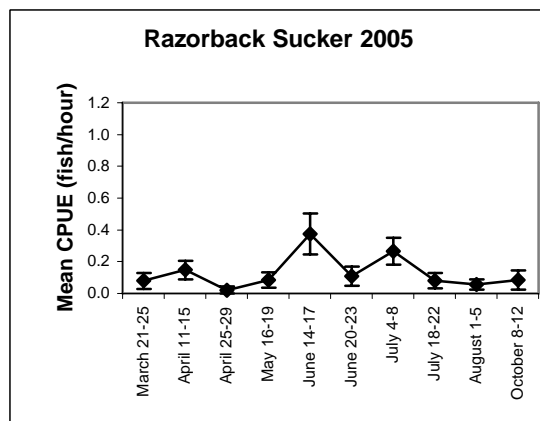
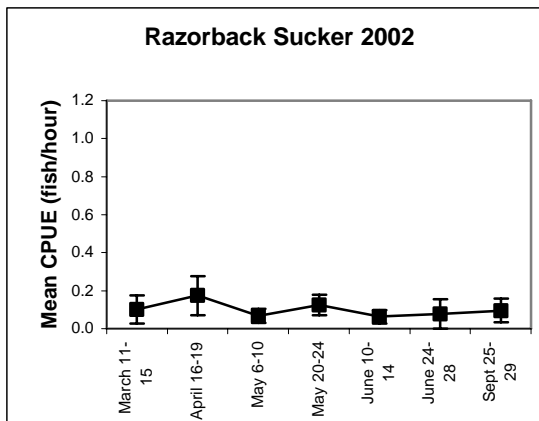


Figure 21. Mean electrofishing catch rate of razorback sucker by trip across years from 2002 to 2007 in the lower San Juan River. Note: Y-axis scale is different in 2007 graph.

Appendix A. Average daily flow, average water temperature and average turbidity (mm to Secchi disk disappearance) during sampling trips on the lower San Juan River in 2007.

Trip Date	Average Flow (ft <sup>3</sup> /s)	Average Water Temp. (C°)	Average Turbidity (mm)
March 27-31	1586	8.9	NA
April 10-14	1560	14	110
April 20-24	1372	14	173
May 1-5	4336	17.6	59
May 15-19	6610	16.3	61
June 26-30	2616	24.8	218
July 10-14	877	27.5	388
July 24-28	1522	27.5	17
August 7-11	3274	24.4	NA
October 7-11	1674	13.5	190

Appendix B. Common name, scientific name and abbreviations for fish in the lower San Juan River.

Common name	Scientific name	Abbreviation
black bullhead	<i>Ameiurus melas</i>	Amemel
bluegill	<i>Lepomis macrochirus</i>	Lepmac
brown trout	<i>Salmo trutta</i>	Saltru
channel catfish	<i>Ictalurus punctatus</i>	Ictpun
Colorado pikeminnow	<i>Ptychocheilus lucius</i>	Ptyluc
common carp	<i>Cyprinus carpio</i>	Cypcar
gizzard shad	<i>Dorosoma cepedianum</i>	Dorcep
green sunfish	<i>Lepomis cyanellus</i>	Lepcya
largemouth bass	<i>Micropterus salmoides</i>	Micsal
rainbow trout	<i>Oncorhynchus mykiss</i>	Oncmyk
razorback sucker	<i>Xyrauchen texanus</i>	Xyrtex
striped bass	<i>Morone saxatilis</i>	Morsax
threadfin shad	<i>Dorosoma petenense</i>	Dorpet
walleye	<i>Stizostedion vitreum</i>	Stivit
yellow bullhead	<i>Ameiurus natalis</i>	Amenat