# Nonnative Control in the Lower San Juan River 2008

Interim Progress Report

for the
San Juan River Recovery
Implementation Program

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# EXECUTIVE SUMMARY

The seventh consecutive year of nonnative control in the lower San Juan River was conducted in 2008. This project was initiated to remove nonnative fish species, and to identify factors involved in movement of striped bass (*Morone saxatilis*) and other reservoir fish 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 2008, nine removal passes were made, beginning in early-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 708-4,863 cubic feet per second (cfs) during sampling trips in 2008.

The majority of nonnative specimens collected in 2008 were channel catfish (9,050 individuals). Nine thousand fifty channel catfish were collected. Catch rates of channel catfish varied between trips. Mean catch rates of channel catfish in 2008 were not significantly different than catch rates in 2002, 2003, 2004, 2006, or 2007 but were significantly lower than catch rates in 2005. In 2008, mean total length of channel catfish collected during sampling in the lower San Juan River was significantly greater than from the years 2002 to 2007.

In 2002 and 2003, common carp (*Cyprinus carpio*) was the second most abundant nonnative species collected. From 2004 to 2008, 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 2008, size of common carp captured was significantly lower than from 2002 to 2007.

In 2008 sampling, 454 endangered fishes were collected in the lower San Juan River. Of these, 353 were juvenile or sub-adult (< 450 mm Total Length [TL]) Colorado pikeminnow (*Ptychocheilus lucius*) stocked in 2003 through 2007 near Farmington, NM. Preliminary population estimates of Colorado pikeminnow were quite variable and depended upon the set of passes used in the estimate. In 2008, 101 razorback suckers (*Xyrauchen texanus*) were collected.

In 2008, sampling was conducted below the waterfall at Piute Farms to determine species present, but blocked by the waterfall to upstream movement. Two sampling trips were conducted directly below the waterfall. Additionally, boat-mounted electrofishing was completed from the waterfall downstream to Lake Powell. Ten adult razorback sucker and one Colorado pikeminnow were collected below the waterfall in 2008. Walleye (*Sander vitreus*), striped bass, gizzard shad (*Dorosoma cepedianum*), channel catfish, common carp, and juvenile native suckers also were collected in this area.

# 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 collections of razorback sucker larvae in 2003, 2006, and 2007 came from a backwater in Reach 1 at RM 8.1 (Brandenburg et al. 2004, Brandenburg and Farrington, 2007, 2008). 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 Utah Division of Wildlife Resources (UDWR) studies. 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 by UDWR 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). In 2004, wild-spawned Colorado pikeminnow larvae were collected at RM 46.3 and RM 18.1 (Brandenburg et al. 2005), the only Colorado pikeminnow larvae collected from 2002 to 2006. In 2007, three wild-spawned Colorado pikeminnow larvae were collected in the San Juan River with one of these larvae being collected at RM 33.7 (Brandenburg and Farrington, 2008)

The UDWR studies were 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 were 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; and 4) characterize abundance of predators moving out of Lake Powell into the San Juan River upstream to the new waterfall. 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. A single sampling pass consists of one 5-day trip from Mexican Hat to Clay Hills. Sampling units consist of approximately 3-mile segments of river with about 30 samples per trip. 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 used 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. High water during the spring of 2008 prevented extensive use of the seine as an effective technique for capturing channel catfish.

All nonnative and endangered species were netted (Appendix B), but non-listed native suckers were not captured. Total and standard lengths (nearest millimeter, mm) and weight (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 and in 2008, all channel catfish ≥ 200 mm TL collected during the first pass (trip) were tagged and released. In 2008, channel catfish ≥ 200 mm TL were tagged and also received a hole punch in the caudal fin. The purpose of the hole punch was to determine if tag loss was a concern for the population estimate. Channel catfish collected on subsequent passes (trips) and all other nonnative species were removed from the river. Stomach contents were examined of channel catfish that were large (>400 mm TL) and had extended stomachs. 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.

Two sampling trips were conducted directly below the waterfall at RM -0.5 in 2008. One additional electrofishing sampling trip was completed from the waterfall downstream to Lake Powell. Angling, cast netting, seining, and fyke netting were used to collect fishes directly below the waterfall. Any endangered fishes collected were measured, weighed and scanned for a PIT tag as described above. All endangered fishes collected directly below the waterfall were released upstream of the barrier. Walleye and striped bass captured below the waterfall were weighed and measured; other nonnative fishes were enumerated but not weighed and measured. During the electrofishing sampling from the waterfall downstream to Lake Powell, only native species were collected.

*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. About 30 samples were taken during each pass comprising the CPUE for every 2 to 3 miles sampled. These samples were then used to calculate means and variances. Mean TL and CPUE were compared between years and passes using non-parametric Kruskal-Wallis tests along with post hoc pair-wise multiple comparisons (Dunn's Method). The non-parametric Kruskal-Wallis test was used, as the CPUE and TL data did not meet the normality and variance assumptions for parametric tests. 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 and in 2008. 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 $M_o$ model (null model) was appropriate when capture probabilities (p-hat) remained similar among the passes in the model. 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 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 3-7, March 12-16, March 21-25, March 30-April 3, April 8-12, June 23-26, July 7-11, July 21-25, August 4-8 and October 11-15. Eleven large-bodied fish species, including Colorado pikeminnow and razorback sucker, were collected in the lower San Juan River during nonnative control. The remaining nine species were nonnative. Native bluehead sucker and flannelmouth sucker were present during all passes but not netted during nonnative control efforts. Electrofishing effort totaled 359 hours and resulted in 8,924 fishes captured (Table 1). An additional 685 channel catfish were captured using chase boats and block seines. No striped bass or walleye were collected in 2008 in the lower San Juan River above the waterfall.

### Nonnative Species

*Channel catfish*

In 2008, 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 7 to 36 fish per hour ($p < 0.05$; Table 2, Figure 2). Mean catch rates of all life stages of channel catfish combined in 2008 were not significantly different from 2002, 2003, 2004, 2006, or 2007 (Figure 3), but were significantly lower than in 2005 ($p<0.05$). The mean catch rate of adult (>300 mm TL) channel catfish was significantly higher in 2008 compared to 2002 to 2007 ($p<0.05$, Figure 4).

The 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 2008, the mean total length of channel catfish (288 mm) was significantly higher than in 2003 through 2007. Length-frequency histograms show the majority of catfish collected during the summer months were small juveniles (Figure 7), but the majority of channel catfish collected during the spring were adults. Additionally, the percentage of adult channel catfish was much higher in 2008 than in previous years (Figure 8).

A Lincoln-Peterson population estimate for channel catfish was calculated in 2008 (Figure 9). In 2007, no abundance estimate of channel catfish was conducted. In 2008, the Lincoln-Peterson population estimate for channel catfish was 17,792. This estimate is within the confidence limits of similar estimates calculated in the 2003, 2005, and 2006 and is higher than the estimate calculated in 2004. Tag loss rates determined from caudal fin hole punches ranged from 1% to 2% on subsequent removal trips.

Predation of endangered fishes by channel catfish was observed in 2008. On 9 July, a 233 mm TL Colorado pikeminnow was found extending out of a channel catfish 353 mm TL. Examination of other 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 9 June, 2004.

*Common carp*

In 2008, mean catch rates of common carp remained low. Catch rates of common carp were not significantly different between passes in 2008 (Figure 10). From 2002 to 2008, catch rates of common carp decreased significantly ($p < 0.001$; Figure 11). In 2008, 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 or 2007. Mean size of common carp remained similar among years from 2002 to 2006, but was significantly lower ($p<0.05$) in 2008 than in years 2002 to 2006 (Figures 12 and 13). No significant difference of common carp total length occurred between 2007 and 2008. 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 351 Colorado pikeminnow was collected in 2008 during nonnative control efforts in lower San Juan River. Two additional 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 2008, catch rates of Colorado pikeminnow were significantly higher ($p<0.05$) than in 2002 to 2004, but were not significantly different from catch rates in 2005 or 2006. Catch rates of Colorado pikeminnow also varied by pass (Figure 16). In 2008, the majority of juvenile Colorado pikeminnow captured were age-2 (2006 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 2008 were age-2 fish (Figure 18). These age-2 Colorado pikeminnow include both fish stocked as YOY in 2006 and fish stocked at age-1 in the spring and fall of 2007.

Distribution of Colorado pikeminnow captures in 2008 appears similar to capture locations in 2006 and 2007. The main difference is the large increase in the number of captures from river mile 10 to river mile 5. 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).

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 $\geq$ 150 mm TL. In 2008, population estimates of Colorado pikeminnow in the lower San Juan River ranged from 270-572. The coefficient of variation for the lowest estimate (270) and highest (572) estimate were 36% and 12%. 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, 2007 or 2008 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 stockings in 1996 and 1997.

*Razorback sucker*

Ninety-eight razorback suckers were collected in the lower San Juan River (Table 1) in 2008 during nonnative removal trips. An additional three 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 2008 than in 2002 ($p<0.05$, Figure 20), but no significant difference was found between catch rates of razorback suckers between 2008 and the years from 2003 to 2007. No suspected razorback-flannelmouth hybrids were collected in 2008 in the lower San Juan River.

Waterfall

Two sampling trips below the San Juan waterfall(s) were conducted in 2008. An additional electrofishing sampling trip was completed from the waterfall downstream to Lake Powell from June 9th-11th. Similar to conditions in summer 2006, the waterfall was about 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 2008 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. In 2008, three razorback suckers were captured directly below the waterfall in July. All endangered fishes were PIT tagged and released above the waterfall.

During the electrofishing trip from the waterfall downstream to Lake Powell, 7 razorback suckers and one Colorado pikeminnow were collected. Only endangered fishes were collected on the electrofishing pass from the waterfall to Lake Powell. While nonnative species were not netted, observations indicated that gizzard shad, striped bass and walleye were abundant in the San Juan River below 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 –2007, generated preliminary population estimates for juvenile Colorado pikeminnow in 2004, 2005, 2006, 2007and 2008, 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 2008 are correlated with the stocking of YOY fish each year. From our sampling, it is evident that as Colorado pikeminnow increase in TL they are more likely to be captured by electrofishing. In 2004, 2005, 2006, 2007, and 2008 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. Additionally, age-1 Colorado pikeminnow (stocked as YOY in the fall of 2007) began showing up in collections in July of 2008 at around 100 mm TL. In 2008, the number of age-1 Colorado pikeminnow decreased in late July and August, but this may have been because of less favorable sampling conditions (increased turbidity).

## DISCUSSION

In 2008, the waterfall near Piute Farms persisted and was a barrier to upstream movement of fishes from Lake Powell. Lake Powell rose approximately 50 feet from the spring of 2008 to mid-July 2008, but water levels remained below full pool and below elevations that would inundate the waterfall. At the time of this report, Lake Powell's elevation was 3629 feet above sea level, approximately 71 feet below full pool and about 18 feet higher than at this time in 2008.

In 2008, 9,050 channel catfish were captured in the lower San Juan River, with 8365 channel catfish being captured by electrofishing equipment. These data include 86 catfish removed during the adult fall monitoring trip. An additional 685 channel catfish were removed by utilizing chase boats and block seines. On the first three nonnative removal trips in 2007, block seining increased the number of channel catfish removed by 35%-45%. High flows during the spring of 2008 prevented the effective use of the block seine in the lower San Juan River.

The channel catfish catch rate in 2008 was significantly lower than in 2005, but no significant difference was found in 2008 between mean catch rates from 2002, 2003, 2004, 2006 and 2007. 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.

In 2008, the catch rate of channel catfish was lowest during the fall monitoring trip. This pattern is consistent with results in previous years. Several potential reasons exist for the lower CPUE of channel catfish during the fall monitoring trip. Throughout the spring and summer of 2008, nonnative removal efforts removed 9,050 channel catfish from the lower San Juan decreasing the abundance of channel catfish. Another potential reason for the decreased in channel catfish CPUE during the fall monitoring sampling is slight differences in sampling methodology. Both UDWR and fall monitoring sampling use similar equipment, raft-mounted electrofishing with 5.0 GPPs, but slight differences exist in methodology. Nonnative removal trips specifically target channel catfish, as they are the most abundant nonnative species. Targeting channel catfish often involves progressing downstream at a slow rate as channel catfish often come to the surface upstream of the raft. During fall monitoring efforts, rafts progress downstream with the speed of the current as their goal is collected all species present (Ryden, per. comm.). Decreasing water temperatures throughout the fall may also decrease the activity level of channel catfish.

The mean total length of channel catfish captured and removed in 2008 (288 mm TL) from the lower San Juan River increased significantly from all previous years of nonnative removal. In 2008, flows in the lower San Juan were uncharacteristically high for early March. The higher than normal flows were the result of releases from Navajo Dam. In early 2008, inflow predictions were approximately 150 of normal for Navajo reservoir, resulting in the high releases. From 2002 to 2007, nonnative control appears to have been maintaining a shift towards smaller mean total lengths of channel catfish in the lower San Juan River. The high flows in early 2008 may have induced movement of large numbers of large channel catfish into the lower San Juan River. Sampling in the spring of 2009 will help substantiate whether the increased abundance of adult channel catfish observed in 2008 was the result of the high spring flows. The percentage of adult channel catfish in the total channel catfish catch and the CPUE of adult channel catfish also increased in 2008, likely from the same reason as increase in the mean TL. While the mean TL, percentage of adult channel catfish in the total channel catfish catch and the CPUE of adult channel catfish increased in 2008, the population estimate for channel catfish $\geq$ 200 mm TL did not increase from previous years.

The shift in size structure of channel catfish from 2002 to 2007 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 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. Nineteen channel catfish tagged in the lower San Juan River were recaptured by mechanical removal efforts upstream in the middle and upper San Juan in 2008. Additionally, NMFWCO captured one channel catfish in August 2008 at RM 150 tagged in March 2008 in the lower San Juan River. These data indicate the channel catfish moved a minimum of 100 miles upstream from the tagging site. Using the first two passes, conducted within two weeks, 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 $\geq$ 300 mm TL, and cause a substantial shift towards smaller individuals. Similar shifts in yield and population structure have been observed in sport and commercial fisheries as the rate of exploitation increased (Bennett 1971; McHugh 1984, Pitlo 1997). In the San Juan River, shifts in size structure of channel catfish 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 2008, only 69 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 2008, the size structure of common carp removed form 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 254 mm TL in 2008. The percentage of adult carp in the total carp catch has also declined since nonnative control began. In 2008, YOY and juvenile carp made up $\geq$ 60% 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 2008, Colorado pikeminnow estimates were again quite variable and were similar to estimates from previous years.

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 (2002-2008). 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 2008 was lower than the number captured in any previous year, except 2007. The increasing razorback sucker numbers and razorback sucker catch rate resulted from increased numbers of razorback suckers being stocked upstream. While stocking is producing the increase in captures of razorback sucker, the increasing trend in the last two years is encouraging.

Sampling at the base of the waterfall in 2005 to 2008 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. Electrofishing sampling form the waterfall to Lake Powell did not result in the capture of any adult pikeminnow.

A total of one Colorado pikeminnow and 10 razorback suckers were captured below the waterfall in 2008 indicating some loss of stocked endangered fishes over the waterfall. The one pikeminnow and seven razorbacks were captured on the electrofishing trip from the waterfall to Lake Powell. At this time, no estimate of the number of endangered fishes passing over the waterfall is available. Sampling directly below the waterfall is difficult, and the probability of capture for may be low. Continued monitoring will strengthen the dataset for predicting when these species are attempting to mover into the lower San Juan River.

## CONCLUSIONS AND RECOMMENDATIONS

• Population estimates of channel catfish remained similar from 2003 to 2008; however, large confidence intervals indicate poor precision of these estimates. 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.

• The CPUE of channel catfish has remained similar across years in the lower San Juan. 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 occurred in 2008, into the middle San Juan reach may aid in alleviating immigration into the lower San Juan and decrease the number of spawning channel catfish upstream of the lower San Juan removal reach.

• Continue use of block seines when river flows are compatible.

• Catch rates of common carp have decreased significantly from 2002 to 2008, 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 2008. From 2004 to 2008, 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 2008; 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.

• 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 counts of the most abundant fish species collected during sampling in the lower San Juan River in 2008. Species codes are defined in Appendix B.

| Trip | Ptyluc | Xyrtex | Ictpun (Electrofishing) | Ictpun (Chase/Seine) | Ictpun Total | Cypcar | Amemel & Amenat |
|---|---|---|---|---|---|---|---|
| March 3-7 | 58 | 15 | 898 | 420 | 1318 | 15 | 1 |
| March 12-16 | 44 | 12 | 833 | 57 | 890 | 4 | 2 |
| March 21-25 | 23 | 9 | 951 | - | 951 | 5 | 0 |
| March 30-April 3 | 46 | 22 | 1484 | - | 1484 | 4 | 2 |
| April 8-12 | 47 | 13 | 1005 | - | 1005 | 1 | 5 |
| June 23-26 | 20 | 7 | 596 | - | 596 | 0 | 1 |
| July 7-11 | 65 | 15 | 1218 | 208 | 1426 | 0 | 5 |
| July 21-25 | 13 | 1 | 553 | - | 553 | 5 | 1 |
| August 4-8 | 35 | 4 | 741 | - | 741 | 29 | 6 |
| October 11-15 | 2 | 3 | 86 | | 86 | 4 | 3 |
| Total | 353 | 101 | 8365 | 685 | 9050 | 67 | 26 |

Table 2. Mean CPUE (fish/electrofishing hour) of most abundant fish species collected during electrofishing sampling in the lower San Juan River in 2008. The standard error (SE) is in parenthesis below each mean CPUE. Species codes are defined in Appendix B.

| Trip | *Ptyluc* | *Xyrtex* | *Ictpun* | *Cypcar* | *Amemel & Amenat* |
|---|---|---|---|---|---|
| March 3-7 | 1.51 | 0.38 | 23.24 | 0.40 | 0.04 |
| | (0.25) | (0.10) | (2.81) | (0.09) | (0.04) |
| March 12-16 | 1.13 | 0.34 | 21.28 | 0.12 | 0.03 |
| | (0.28) | (0.11) | (2.35) | (0.06) | (0.02) |
| March 21-25 | 0.55 | 0.21 | 24.16 | 0.15 | 0.00 |
| | (0.16) | (0.10) | (2.02) | (0.06) | (0.00) |
| March 30-April 3 | 1.12 | 0.47 | 36.31 | 0.10 | 0.04 |
| | (0.26) | (0.13) | (3.18) | (0.05) | (0.03) |
| April 8-12 | 1.01 | 0.20 | 21.66 | 0.02 | 0.10 |
| | (0.18) | (0.08) | (2.14) | (0.02) | (0.04) |
| June 23-26 | 0.82 | 0.30 | 23.57 | 0.00 | 0.04 |
| | (0.17) | (0.12) | (1.81) | (0.00) | (0.04) |
| July 7-11 | 1.47 | 0.33 | 27.34 | 0.00 | 0.10 |
| | (0.40) | (0.10) | (2.88) | (0.00) | (0.05) |
| July 21-25 | 1.47 | 0.03 | 16.24 | 0.14 | 0.03 |
| | (1.08) | (0.03) | (2.46) | (0.09) | (0.03) |
| August 4-8 | 0.73 | 0.07 | 13.04 | 0.56 | 0.15 |
| | (0.16) | (0.04) | (1.72) | (0.19) | (0.07) |
| October 11-15 | 0.13 | 0.25 | 6.46 | 0.24 | 0.23 |
| | (0.09) | (0.14) | (1.75) | (0.19) | (0.13) |

Table 3. Population estimates for juvenile Colorado pikeminnow ≥ 150 mm TL in the lower San Juan River from 2004 to 2008. Models used include the null model (Mo) and the 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 |
| 2008 | 1-5 | Mt | 470 | 358-652 | 0.15 | 0.09 |
| | 6-9 | Mt | 270 | 149-636 | 0.36 | 0.07 |
| | 1-9 | Mt | 572 | 450-715 | 0.12 | 0.05 |

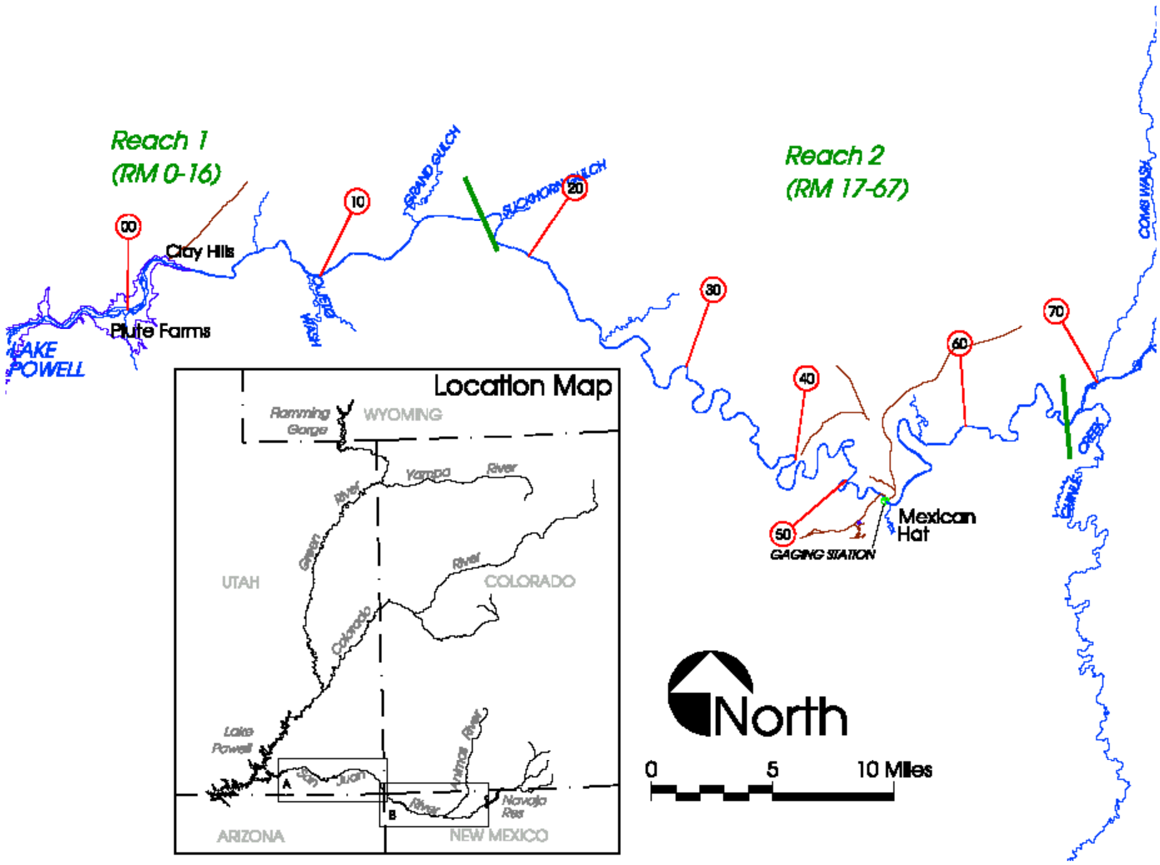


Figure 1. Map of the study area for Nonnative Control in the lower San Juan River. Sampling begins at Mexican Hat and ends at Clay Hills.

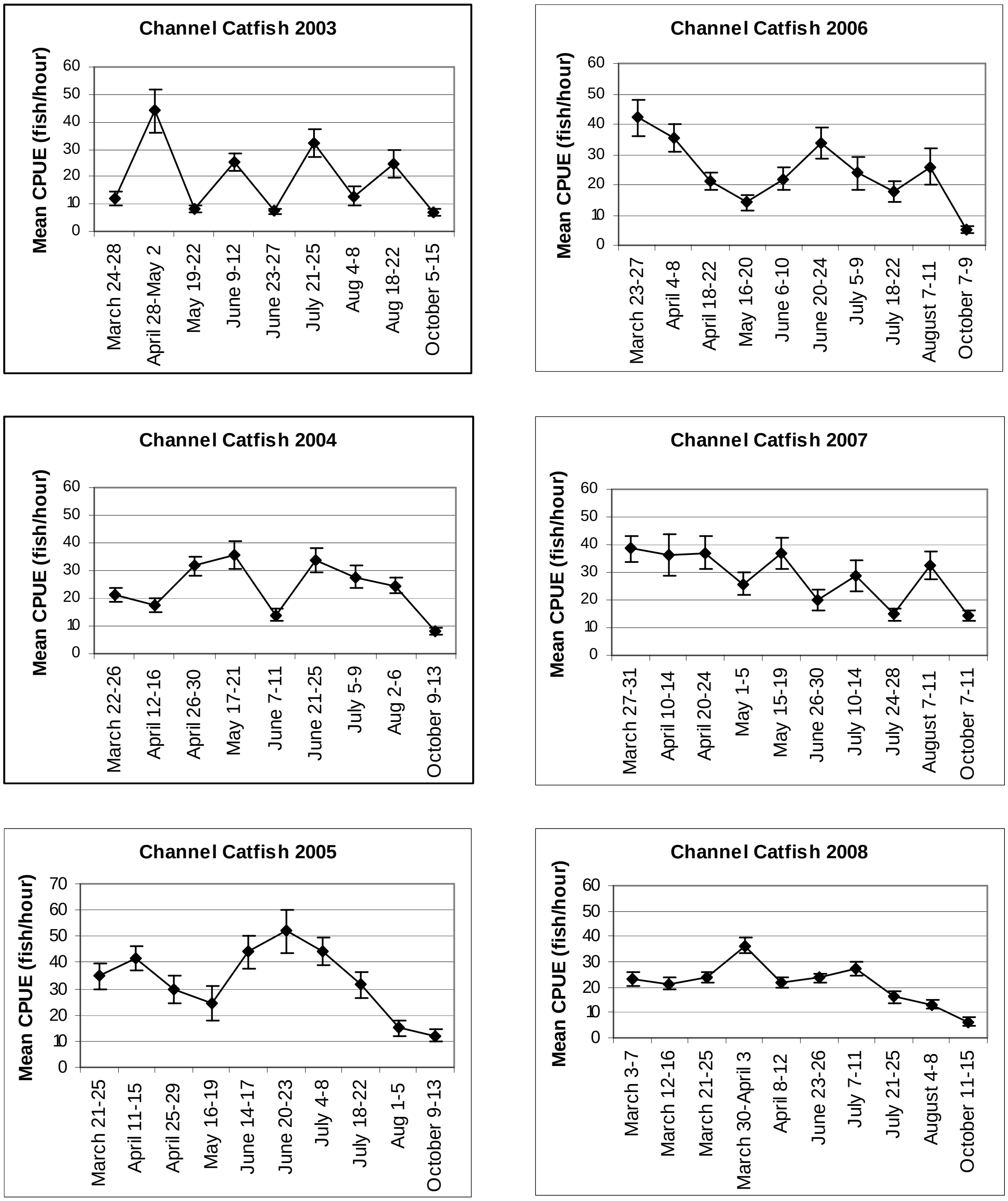


Figure 2. Mean electrofishing catch rates of channel catfish in the lower San Juan River by pass for years 2003 to 2008. Error bars represent ± 1 standard error.

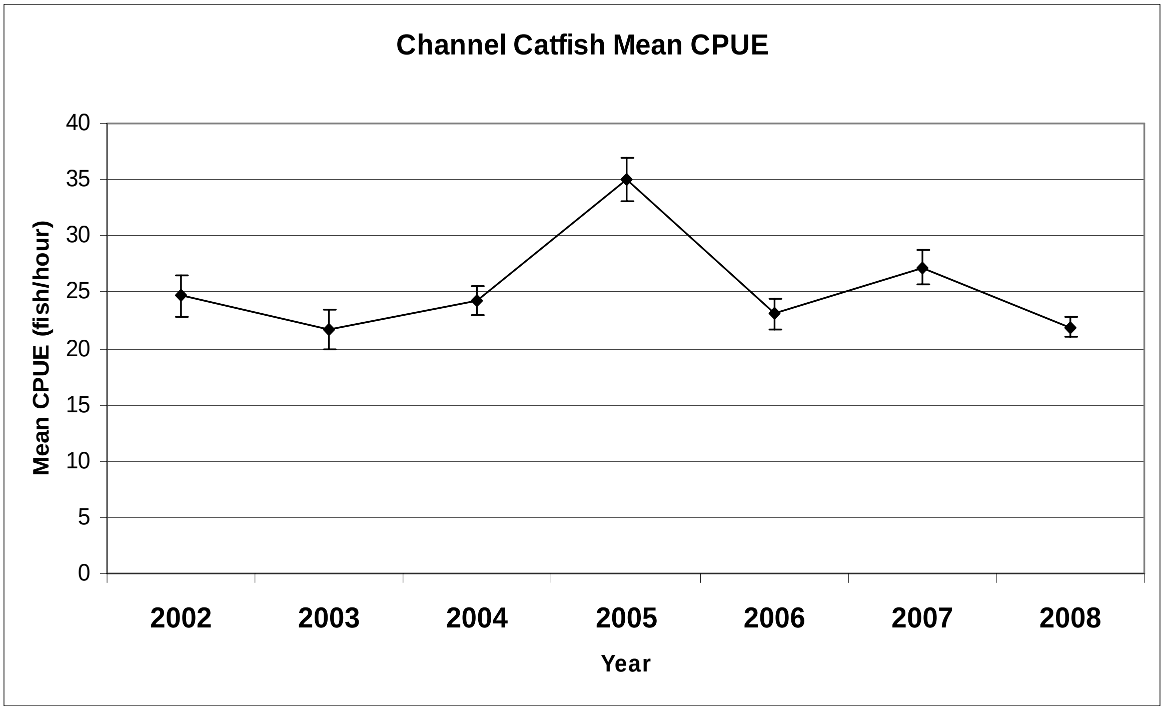


Figure 3. Mean electrofishing catch rates of channel catfish in the lower San Juan River by year. Error bars represent ± 1 standard error.

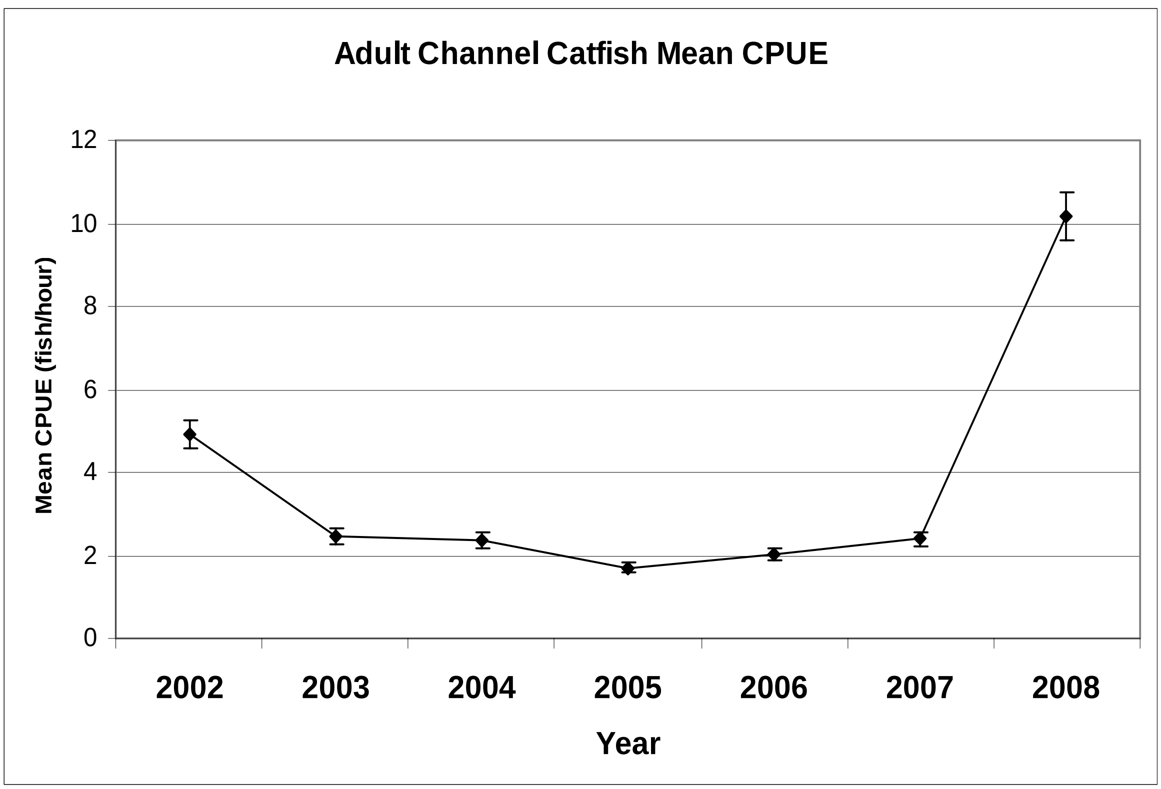


Figure 4. Mean adult (>300 mm) electrofishing catch rates of channel catfish in the lower San Juan River by year. Error bars represent ± 1 standard error.

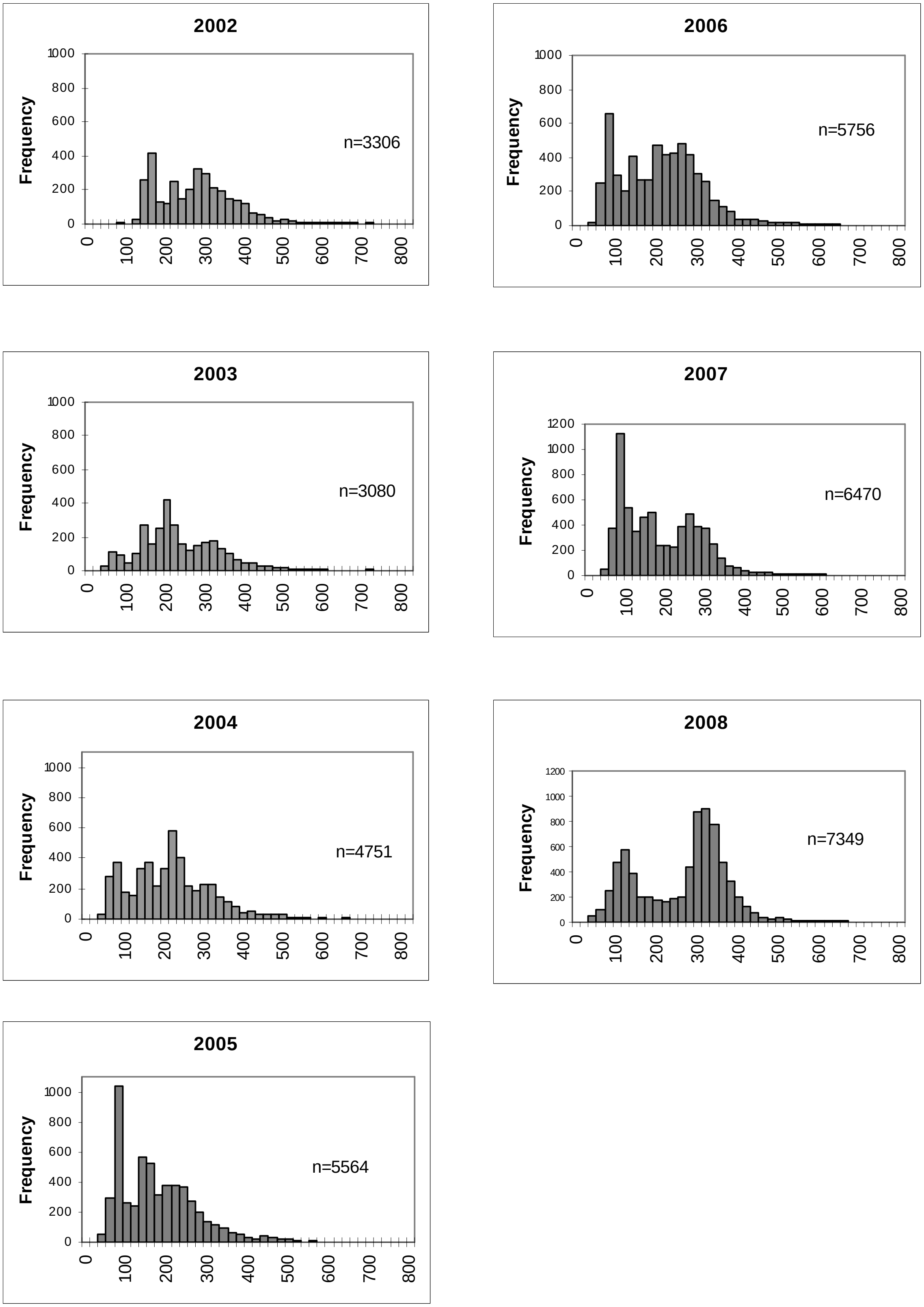


Figure 5. Length-frequency histograms of channel catfish collected by electrofishing in the lower San Juan River from 2003 to 2008.

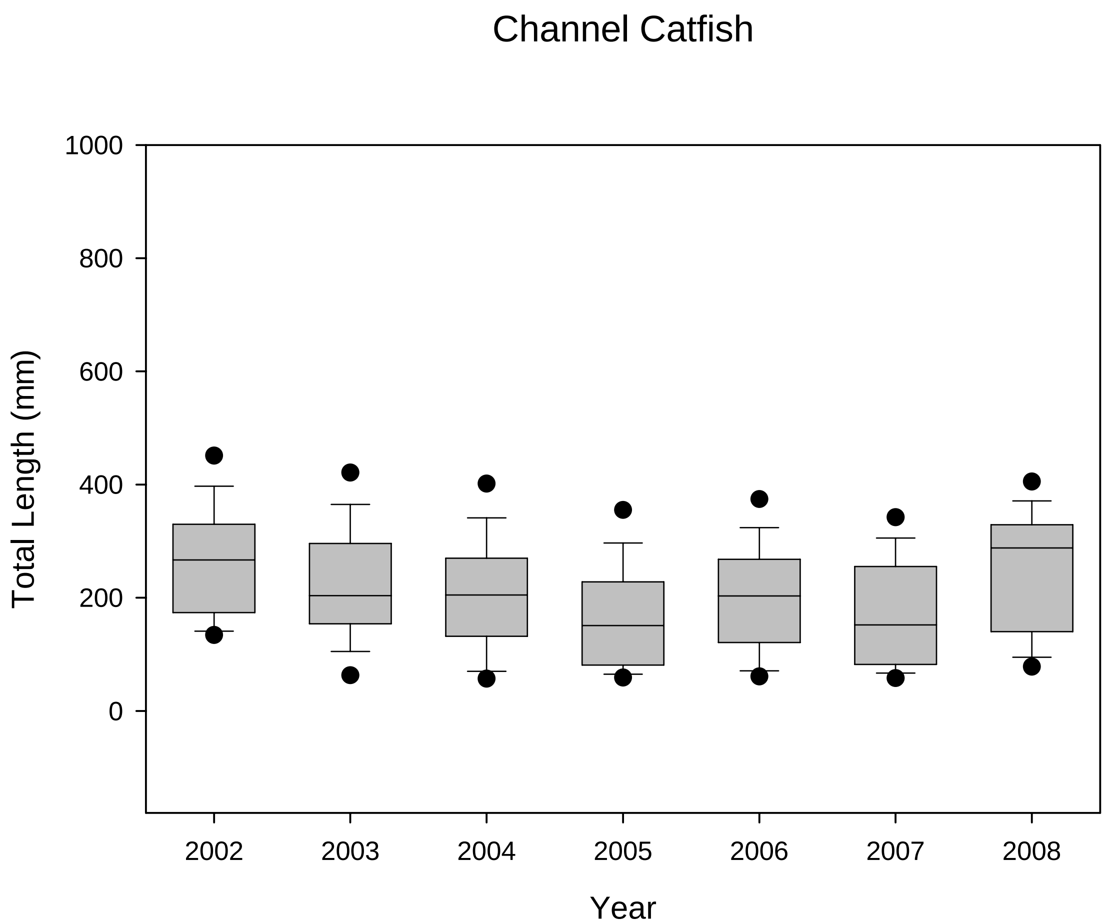


Figure 6. Distribution of total lengths of channel catfish by year from the lower San Juan River. Gray rectangles represent 25th and 75th percentiles. Horizontal line within the gray rectangles is the median total length. Whiskers represent 10th and 90th percentiles. Black dots represent 5th and 95th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

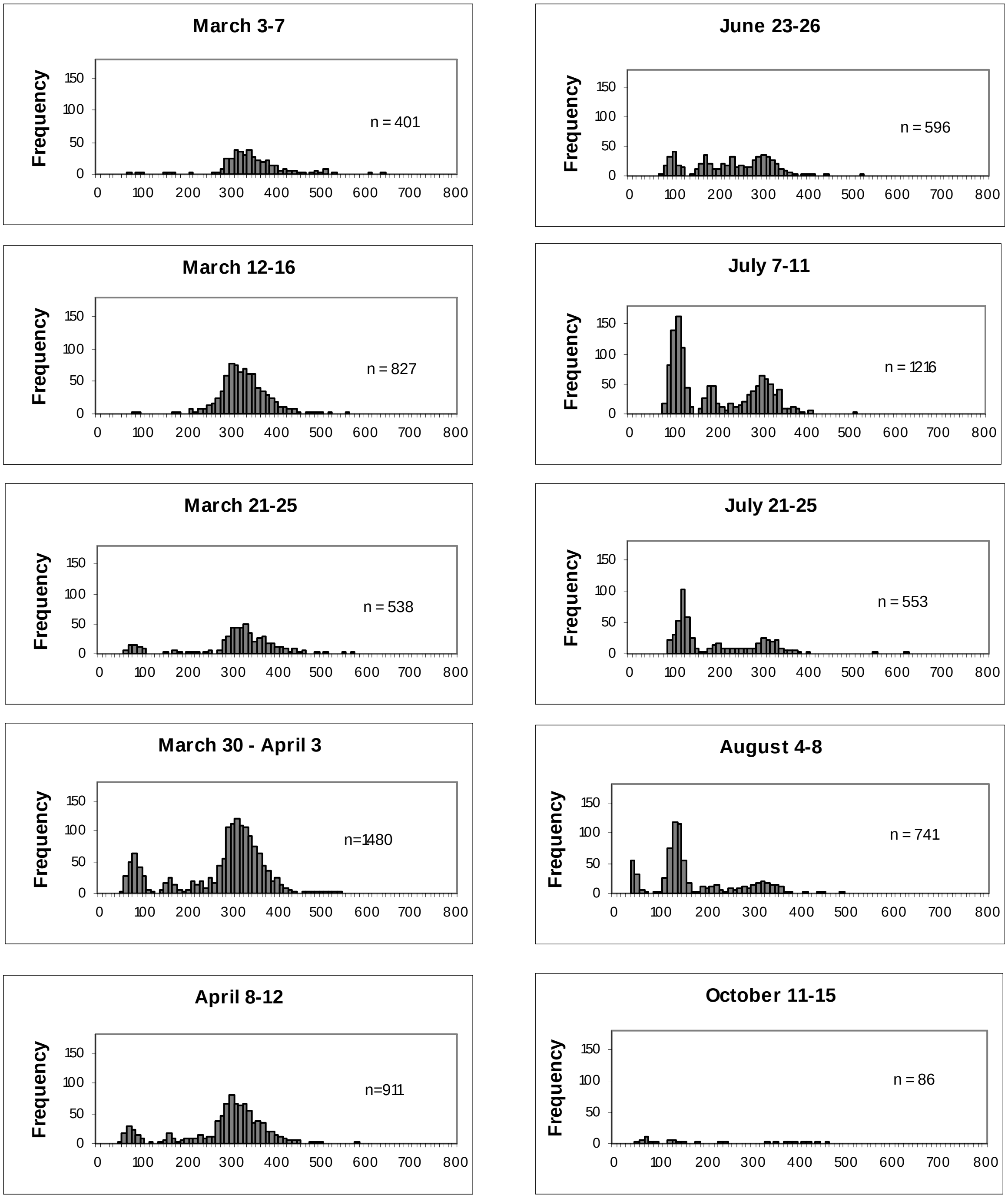


Figure 7. Length-frequency histograms of channel catfish collected by pass in the lower San Juan River in 2008.

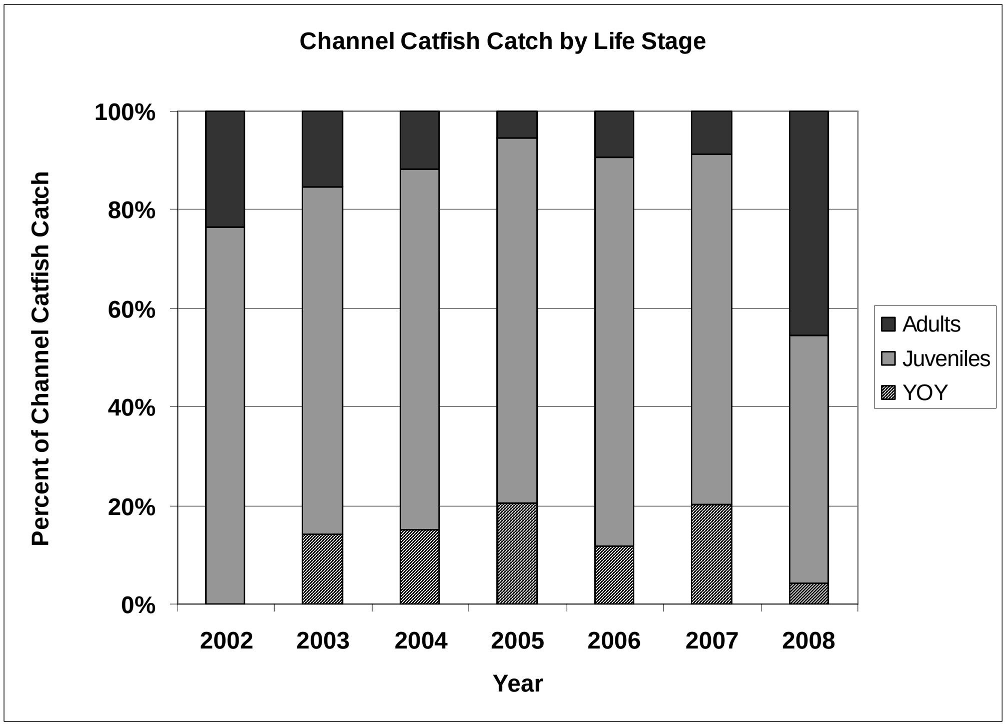


Figure 8. Percent of each life stage of channel catfish in the total channel catfish catch by year. Note: YOY and juveniles life stages were not differentiated in 2002.

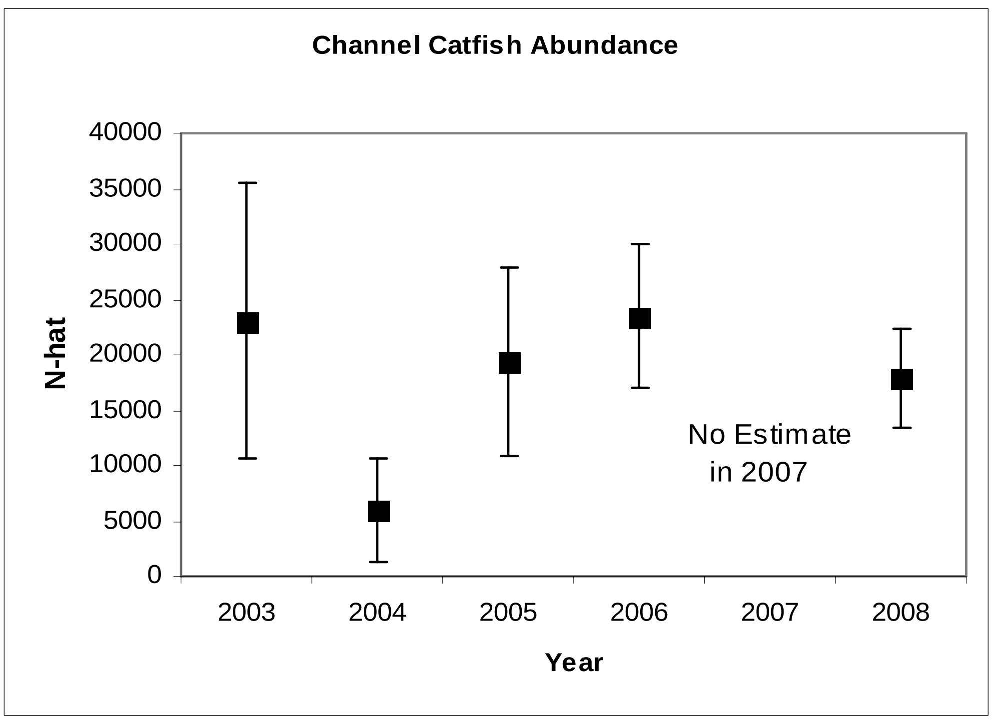


Figure 9. Abundance estimates (N-hat) of channel catfish by year in the lower San Juan River. Error bars represent 95% confidence intervals.

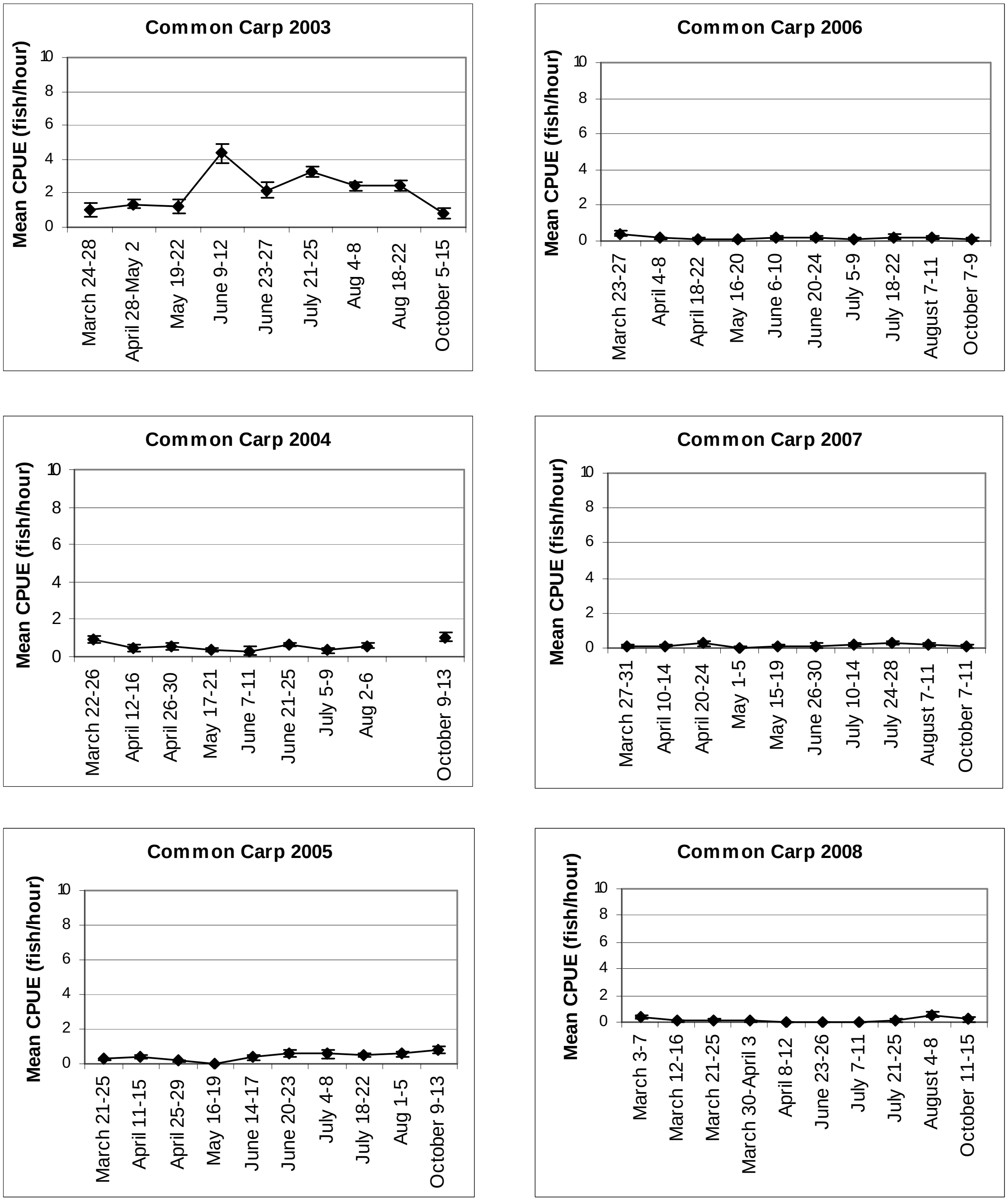


Figure 10. Mean electrofishing catch rate of common carp by pass from 2003 to 2008 in the lower San Juan River. Error bars represent ± 1 standard error.

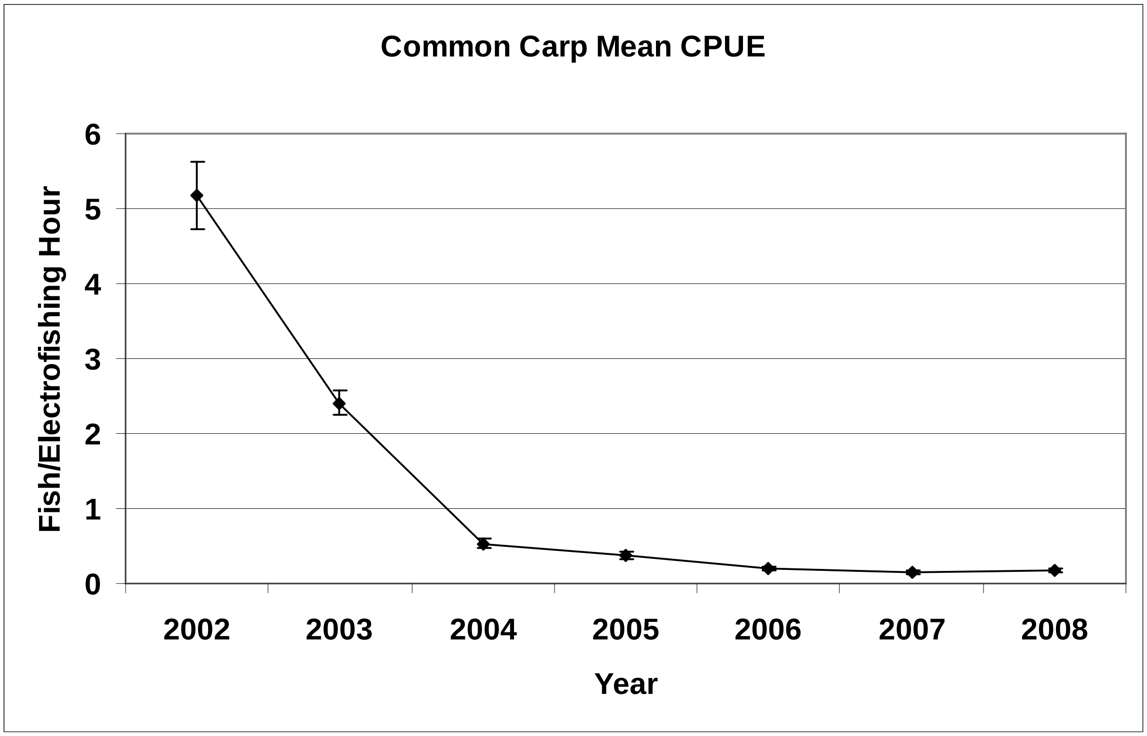


Figure 11. Mean common carp electrofishing catch rate by year from 2002 to 2008 in the lower San Juan River. Error bars represent ± 1 standard error.

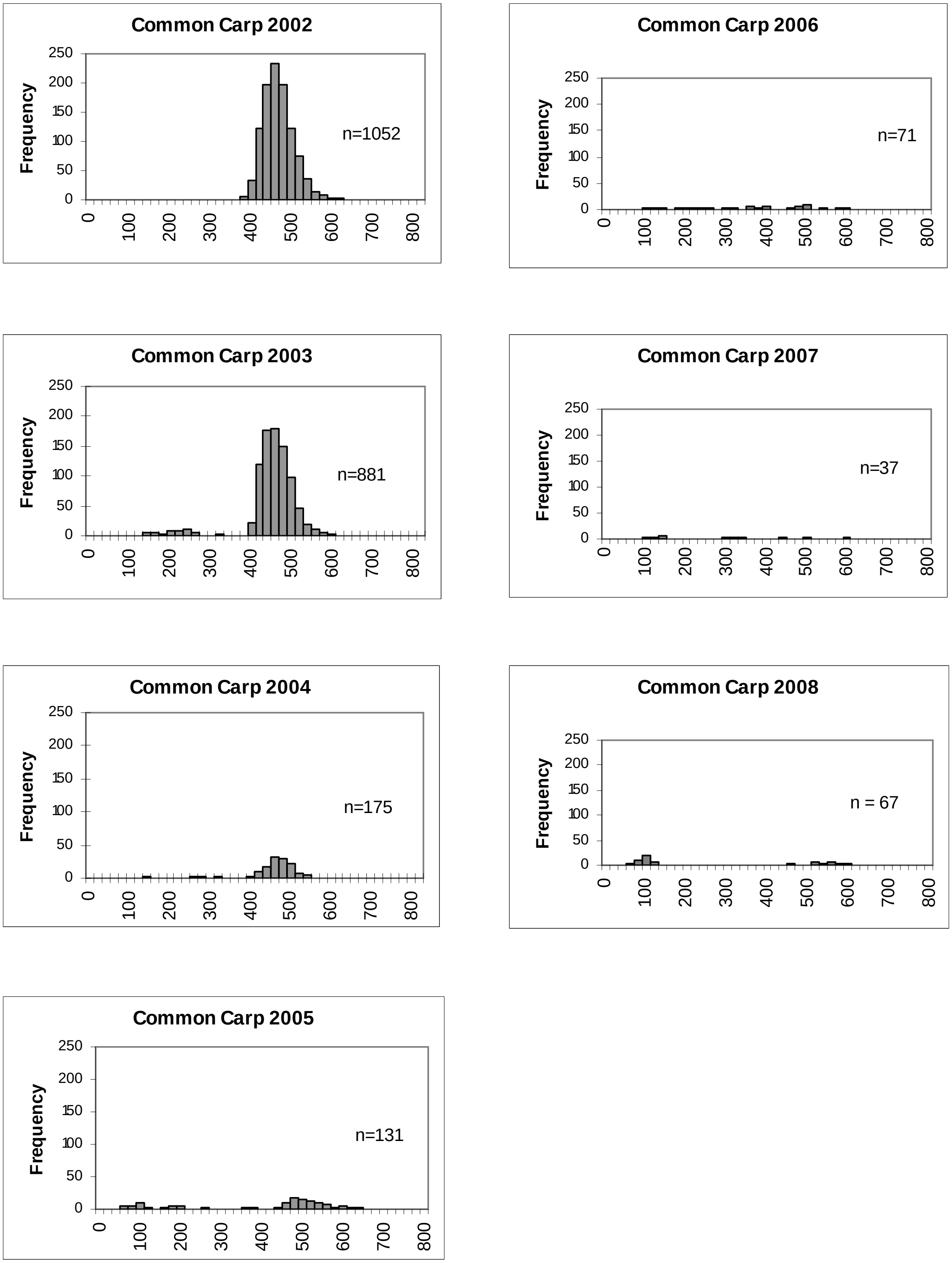


Figure 12. Length-frequency histograms of common carp in the lower San Juan River by year from 2003 to 2008.

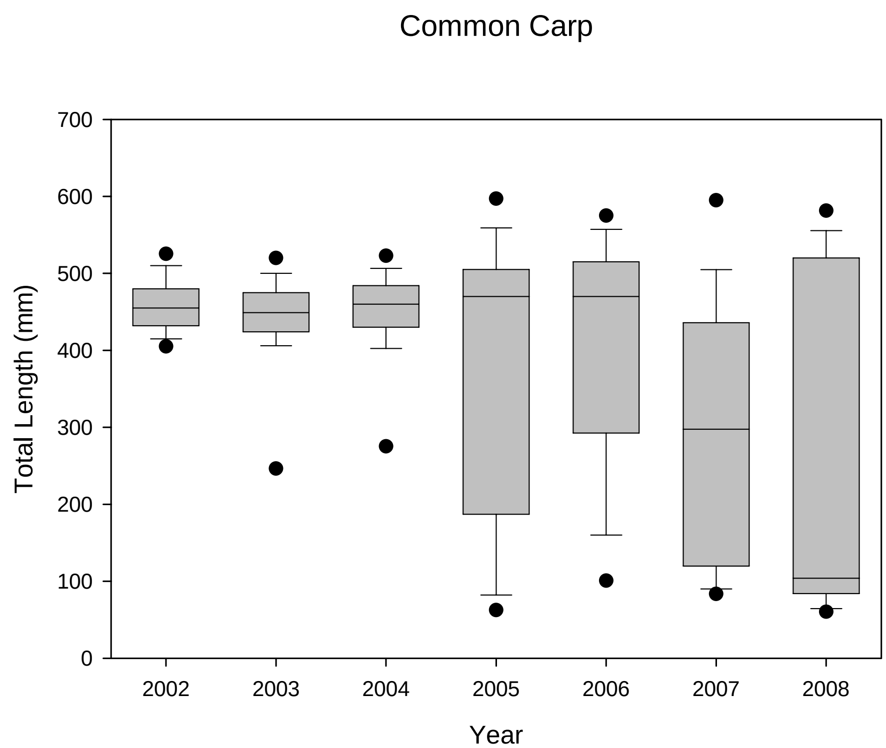


Figure 13. Distribution of total length of common carp by year from the lower San Juan River. Gray rectangles represent 25th and 75th percentiles. The horizontal line within the gray rectangles is the median total length. Whiskers represent 10th and 90th percentiles. Black dots represent 5th and 95th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

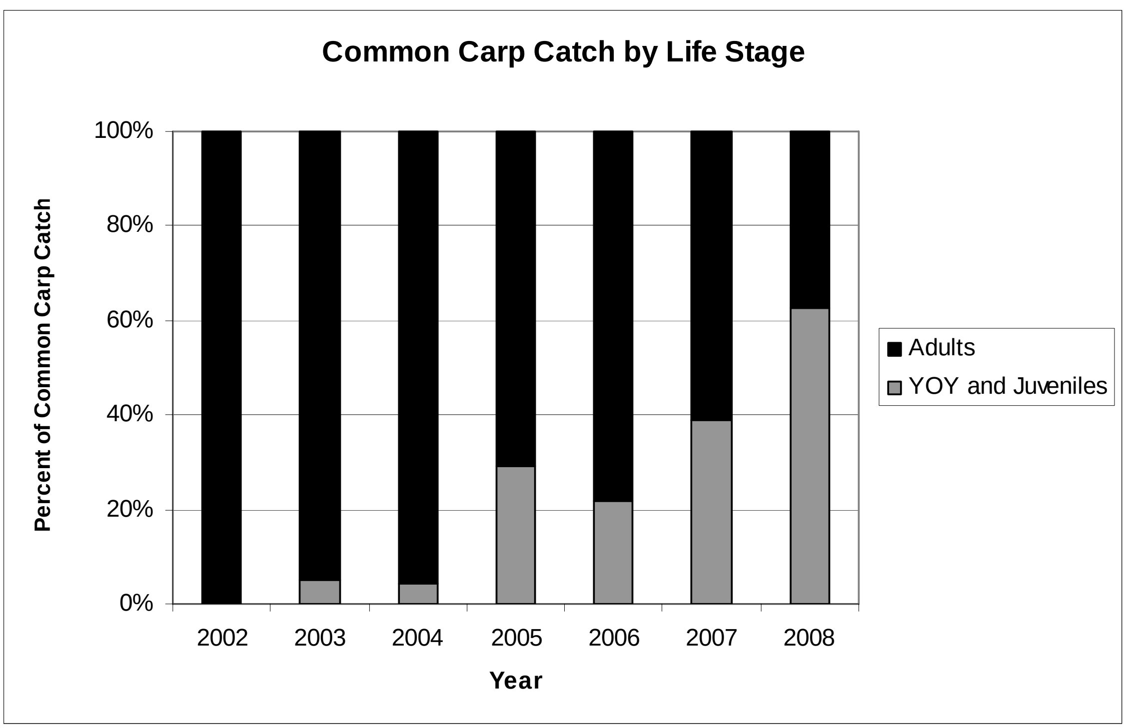


Figure 14. Percent of each life stage of common carp in the total common carp catch by year.

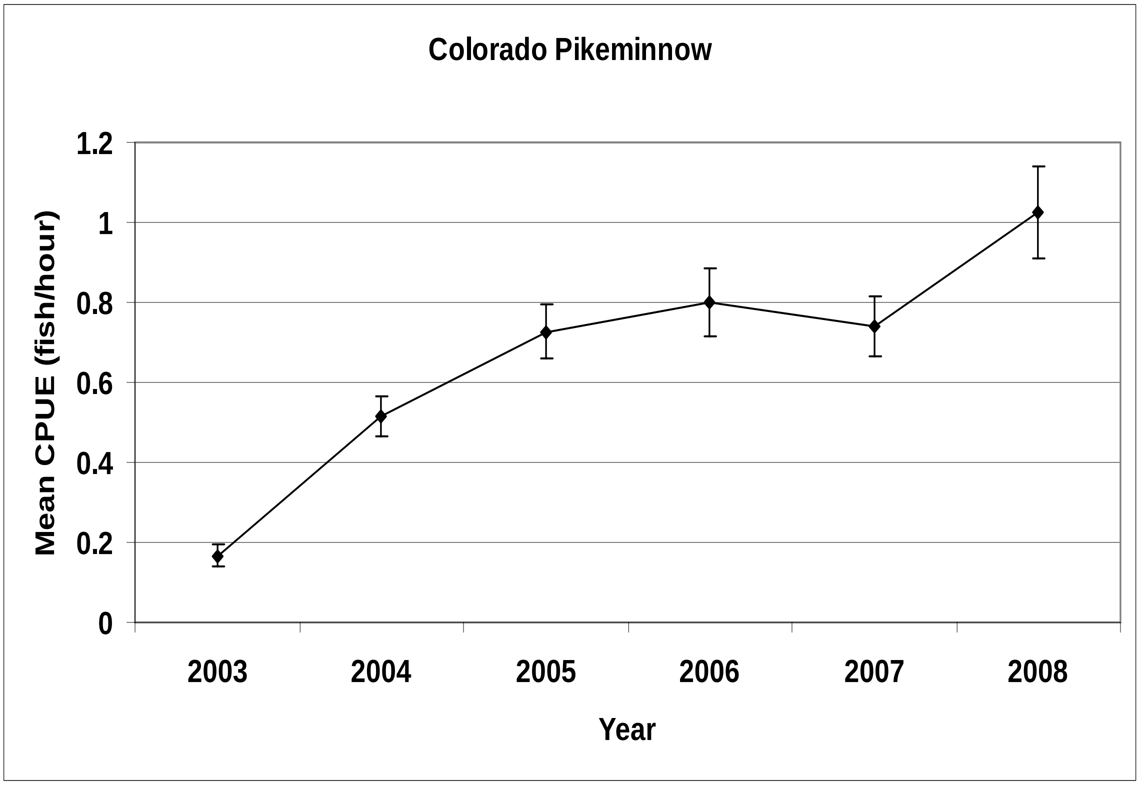


Figure 15. Mean catch rate of Colorado pikeminnow in the lower San Juan River by year from 2003 to 2008. Error bars represent ± 1 standard error.

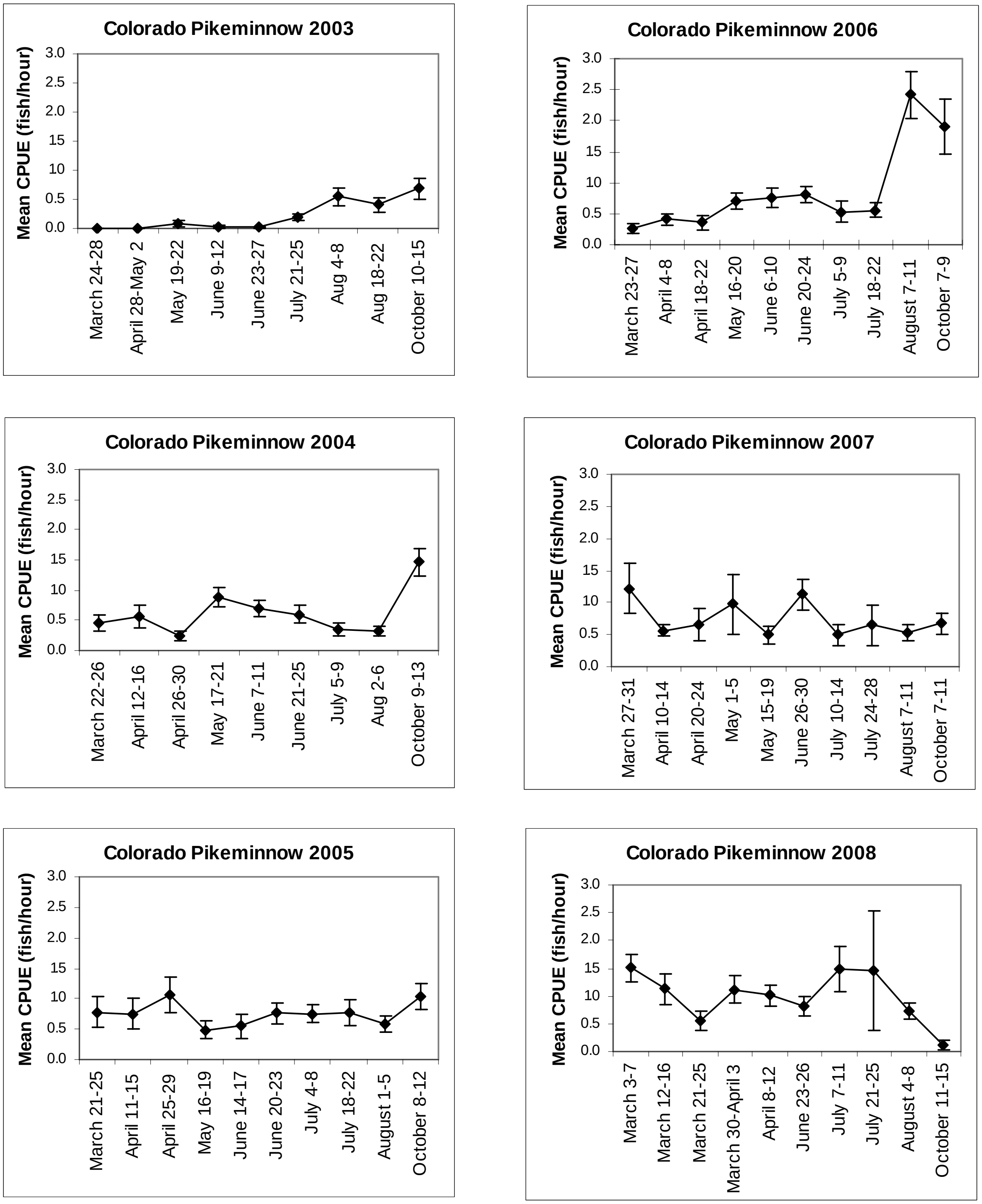


Figure 16. Mean Colorado pikeminnow electrofishing catch rate by pass from 2003 to 2008 in the lower San Juan River. Error bars represent ± 1 standard error.

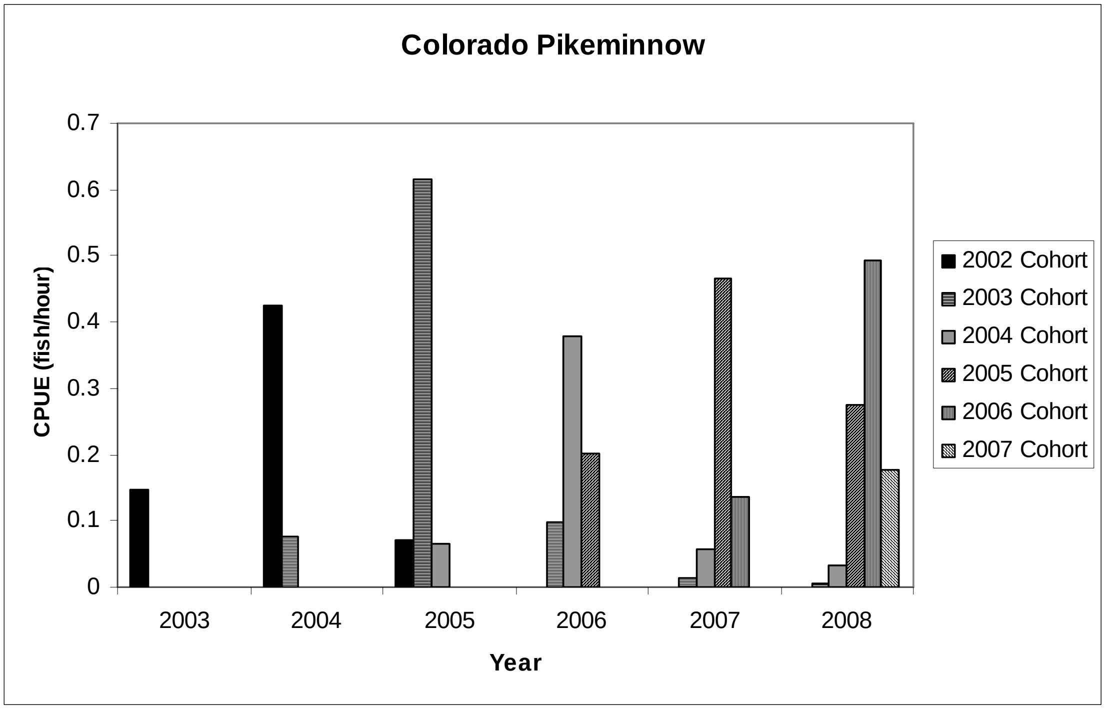


Figure 17. Colorado pikeminnow electrofishing catch rate by cohort across years from 2003 to 2008 in the lower San Juan River.

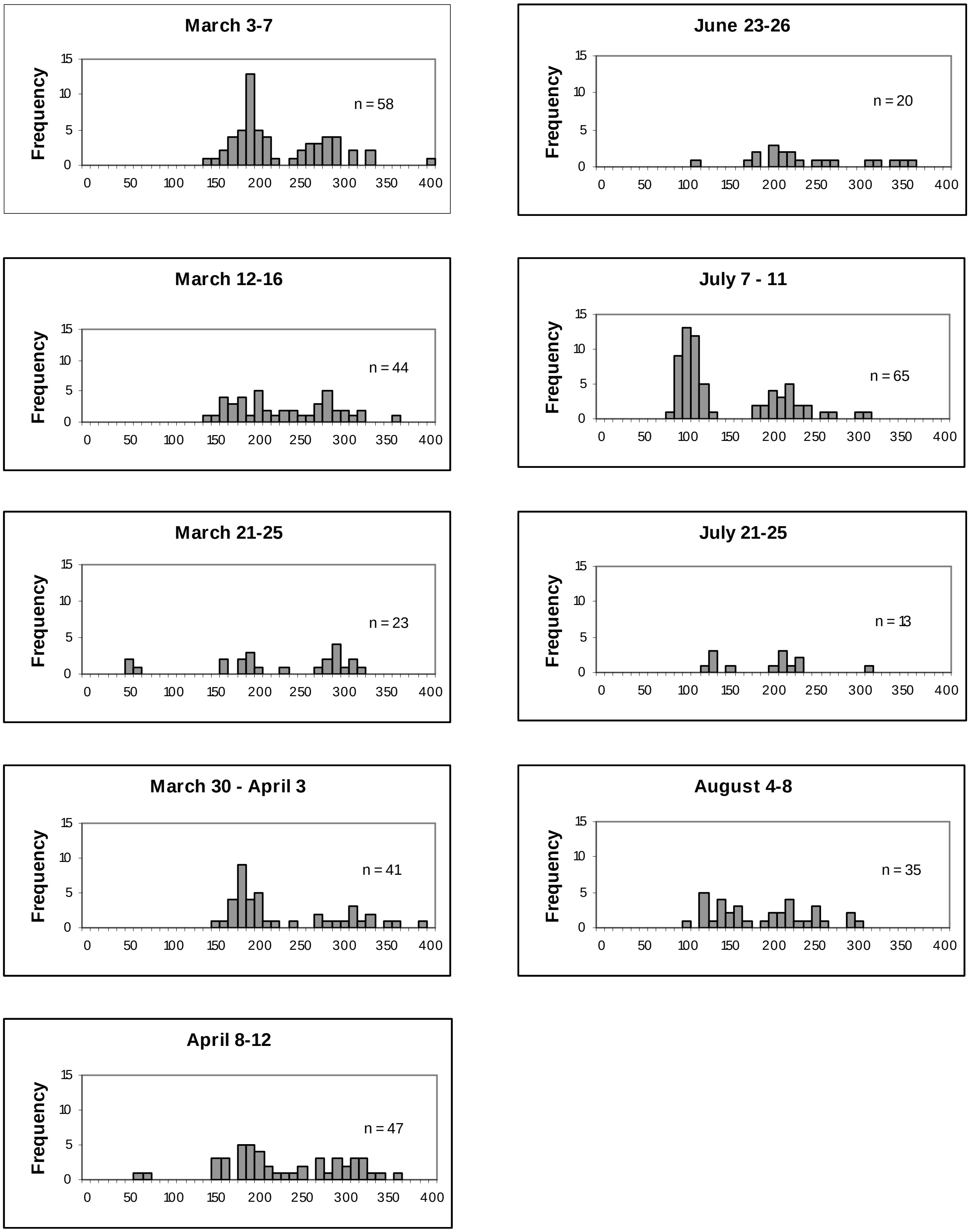


Figure 18. Length-frequency histograms of Colorado pikeminnow collected by pass in the lower San Juan River in 2008.

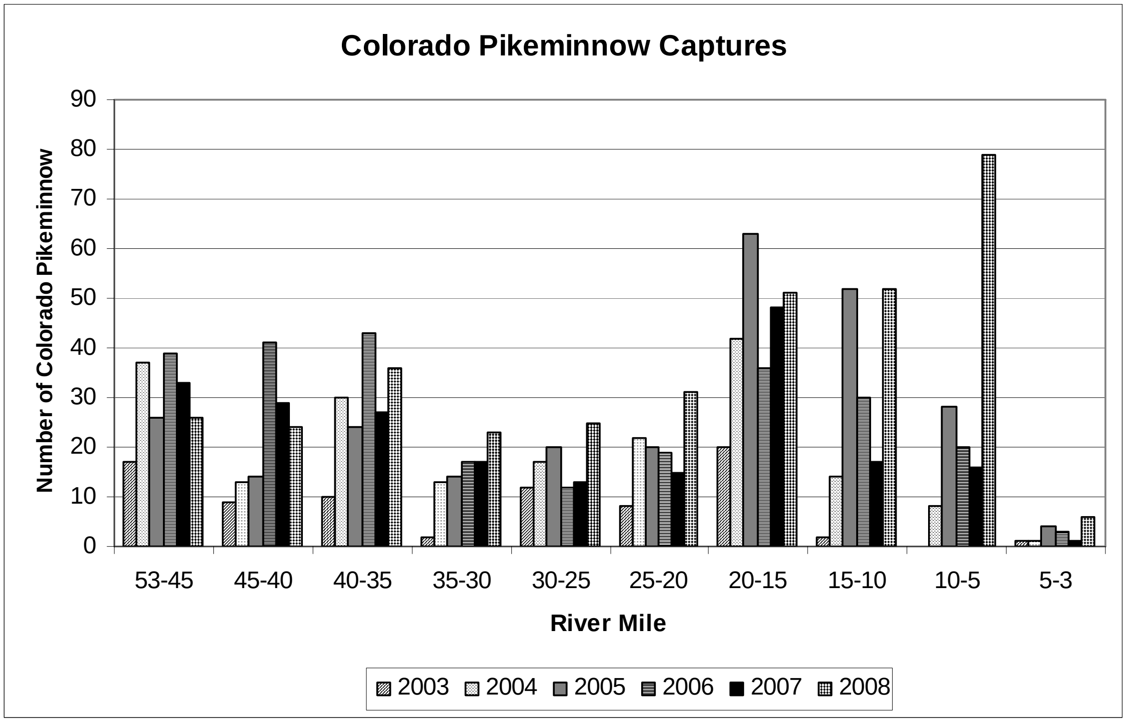


Figure 19. Distribution of Colorado pikeminnow captures by river mile from 2003 to 2008 in the lower San Juan River.

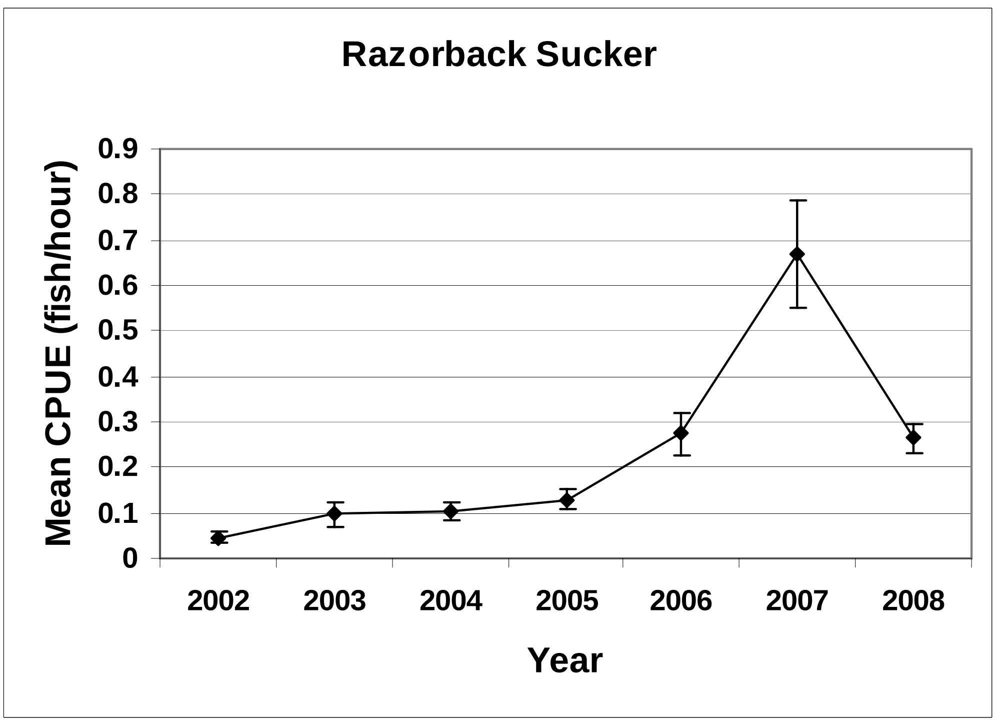


Figure 20. Mean electrofishing catch rate of razorback sucker in the lower San Juan River by year from 2002 to 2008. Error bars represent ± 1 standard error.

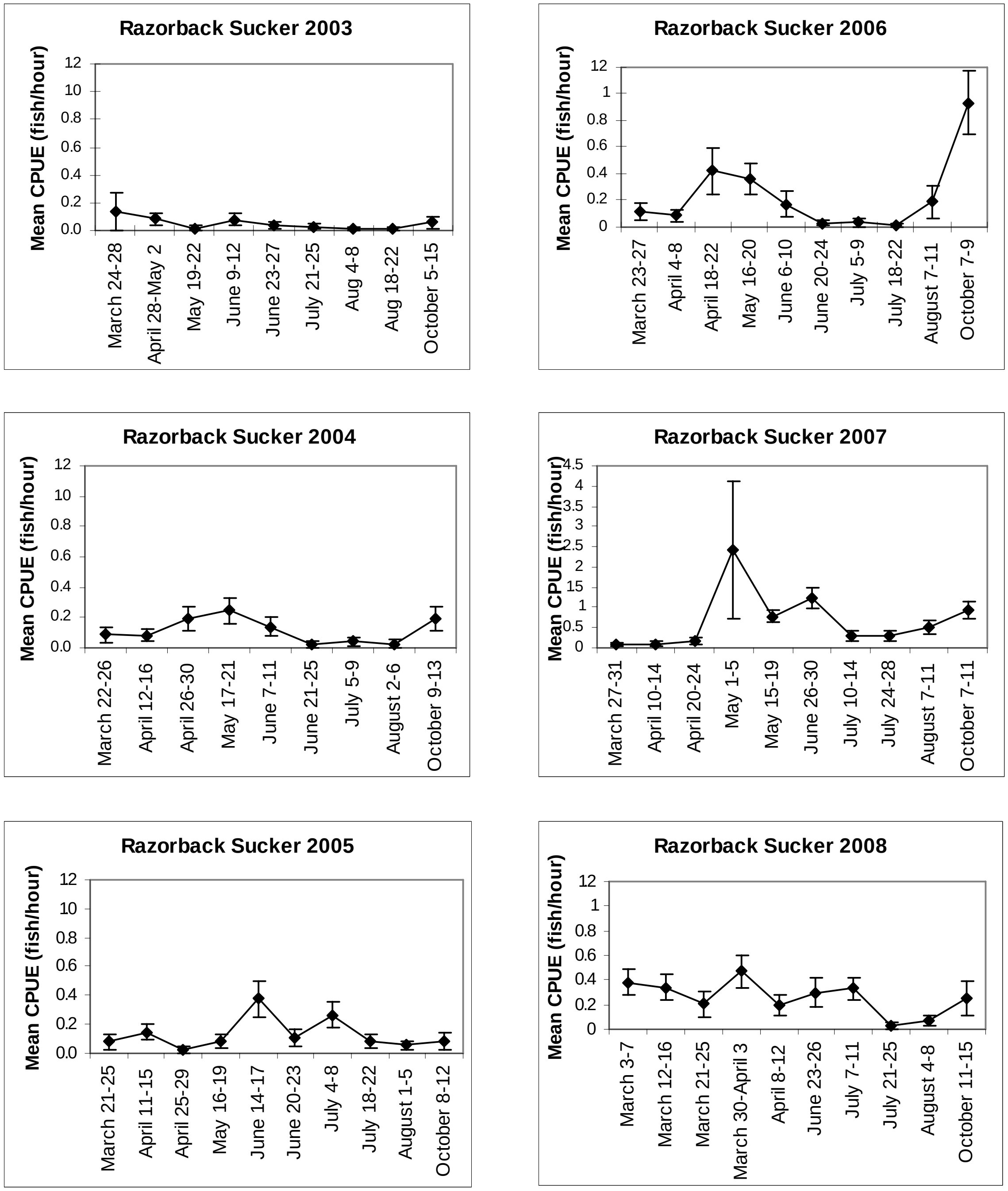


Figure 21. Mean electrofishing catch rate of razorback sucker by trip across years from 2002 to 2008 in the lower San Juan River. Note: Y-axis scale is different in 2007 graph.

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 2008.

| Trip | Trip Date | Average Flow ($ft^3/s$) | Average Water Temp. (C°) | Average Turbidity (mm) |
|---|---|---|---|---|
| 1 | March 3-7 | 3,783 | 5.9 | 183 |
| 2 | March 12-16 | 4,863 | 8.7 | 313 |
| 3 | March 21-25 | 4,663 | 9.2 | 577 |
| 4 | March 30-April 3 | 4,850 | 10.5 | 740 |
| 5 | April 8-12 | 3,433 | 10.8 | 753 |
| 6 | June 23-26 | 4,127 | 21.1 | 173 |
| 7 | July 7-11 | 1,640 | 27.0 | 346 |
| 8 | July 21-25 | 1,500 | 28.2 | - |
| 9 | August 4-8 | 708 | 28.0 | 63 |
| 10 | October 11-15 | 729 | 11.7 | 330 |

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

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