NON-NATIVE SPECIES MONITORING AND CONTROL IN THE UPPER SAN JUAN RIVER: 2002-2003

and

ASSESEMENT OF FISH MOVEMENT THROUGH THE NON-SELECTIVE FISH LADDER AT HOGBACK DIVERSION, NEW MEXICO 2003

PROGRESS REPORT
FOR THE SAN JUAN RIVER RECOVERY
IMPLEMENTATION PROGRAM

DRAFT REPORT

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EXECUTIVE SUMMARY

Intensive non-native removal efforts from PNM Weir to Hogback Diversion (RM 166.6 – 159.0) continued for the third consecutive year in 2003. These efforts initially began to assess efficacy of mechanical removal as an efficient method of decreasing the distribution and abundance of non-native fishes, with emphasis on channel catfish and common carp. These efforts have been recognized as a Recovery Action by the San Juan River Recovery Implementation Program (SJRIP).

Catch per unit effort (CPUE) for channel catfish have not significantly declined since 2001. However, significant increases in juvenile CPUE and an associated decrease in adult channel catfish CPUE have been observed. Removal efforts have resulted in declines in mean total length of channel catfish from 487 mm in 1999 to 328 mm in 2003. Common carp CPUE in the PNM Weir to Hogback Diversion reach have seen significant declines since 2001 and is primarily a result of decreases in the number of adult fish being collected. Collections of common carp in both 2002 and 2003 were almost exclusively adult fish.

Due to seasonally low CPUE for channel catfish, removal efforts were expanded to the next adjacent downstream reach, Hogback to Shiprock, in 2003. This marked the first year of intensive removal efforts throughout this stretch of river. A total of five trips were conducted with no apparent reduction in abundance of non-native fishes as a result of removal efforts. Overall, CPUE for both common carp and channel catfish were markedly higher below Hogback Diversion than above.

Variability of CPUE in trip by trip comparison since 2001 suggested that channel catfish utilized a non-selective fish ladder at Hogback Diversion at certain times of the year to re-colonize areas that had been vacated through removal efforts. To assess this hypothesis, a mark/recapture study began in 2001. Both channel catfish and common carp were recaptured above Hogback Diversion indicating utilization by both species of the non-selective fish ladder. Factors that trigger movement are unknown at this time but are likely associated with multiple variables including discharge, water temperature and season corresponding to spawning.

Due to the high abundance and overall larger size of channel catfish found in these upper reaches of the San Juan River, removal efforts may play a significant role in decreasing abundance riverwide. For example, removal efforts in the upper portions of the San Juan River are removing large fecund individuals that contribute significantly to channel catfish recruitment throughout the river. These efforts combined with removal in the lower river, where on average smaller fish that will contribute to future recruitment are removed, may impact non-native distribution and abundance more rapidly than if efforts were focused in only one reach.

The upper reaches of the San Juan River are also important because augmentation efforts currently in place for both razorback sucker and Colorado pikeminnow. Augmentation efforts are centered in reaches where non-native removal takes place. Fewer non-native fish present may give these rare fish a competitive edge and reduce predation by non-natives resulting in higher retention further up in the system.

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INTRODUCTION

Non-native species interactions with and impacts on native fish populations have long been a concern to fisheries biologists (Tyus and Saunders 2000; Minckley 1991). The establishment of these populations may negatively impact native fishes through direct competition for habitat and resources or by predation (Sigler 1987). Alteration to riverine habitats by dam operations, water diversion and bank stabilization have all contributed to the establishment and spread of non-native fish, primarily channel catfish *Ictalurus punctatus* and common carp *Cyprinus carpio* in the San Juan River Basin (Brooks et al. 2000).

Both channel catfish and common carp pose potential threats to native fishes in the San Juan River through competition for resources and through direct predation of larval, sub-adult fish and eggs of native fishes. Piscivory by channel catfish within the San Juan River has been documented primarily in individuals > 450 mm total length although some level of piscivory was shown in smaller individuals (Brooks et al. 2000). Although piscivory was at low levels during this study, the widespread distribution and abundance of channel catfish could have significant impacts on the native fish community. Due to low numbers of rare fish found in the system, documented predation on razorback sucker *Xyrauchen texanus* and Colorado pikeminnow *Ptychocheilus lucius* has not been reported but, may become a factor as augmentation continues and recovery goals are met. In addition, due to the omnivorous feeding habits of channel catfish, competition with native fish for similar prey types (macroinvertebrates) is likely to occur (Brooks et al. 2000).

Common carp impacts on the native fish community are unknown but may include competition and habitat modification. Common carp are often considered pest species because of abilities to alter habitats through uprooting of aquatic vegetation causing increased levels of turbidity. In addition, common carp predation on the eggs of other fish species has been documented (Sublette et al. 1990; Cooper 1987). Common carp were the second most commonly collected non-native fish and fourth most abundant large bodied fish collected in mainstream electrofishing efforts in 2002 (Ryden 2003).

Adult fish monitoring and research conducted from 1991-1997 on the San Juan River revealed distinctive patterns in both size class distribution and relative abundance of channel catfish from upstream to downstream reaches. Ryden (2000) found that channel catfish collected in the furthermost upstream reaches, Geomorphic Reaches 6 and 5 (RM

180.0 - 131.0), as described by Bleisner and Lamarra (1999), were almost exclusively adults while downstream populations were predominantly juvenile fish. In addition, catch per unit effort (CPUE) for channel catfish tended to be highest in Reaches 5 and 4 with mean catch rates declining to virtually no channel catfish in Reach 1 (RM 17.0 - 0.00). Common carp are found throughout the entire San Juan River in virtually all habitat types and individuals collected by electrofishing are almost exclusively adult fish.

Intensive mechanical removal efforts, beginning in 1998, were focused from PNM Weir [PNM] to Hogback Diversion [Hogback] (RM 166.6 - 159.0). This reach was thought to be ideal to study the efficacy of mechanical removal of non-native fish due to reported data suggesting that PNM serves as a barrier to upstream emigration. Riverwide surveys conducted from 1991 to 1997 showed that of 1,712 channel catfish collected in Reach 6, only ten (0.6%) were collected upstream of PNM (Ryden 2000). In addition, channel catfish collected in this reach were almost exclusively adult fish (> 300 mm TL). It was also found that common carp CPUE upstream of the diversion were at least half of those downstream. This barrier to upstream movement provided a unique situation to evaluate the efficacy of intensive mechanical removal of large bodied non-native fishes.

Seasonal declines in abundance of channel catfish observed during removal trips conducted in 2001 and 2002 prompted efforts to expand intensive removal to the adjacent downstream reach, Hogback to Shiprock Bridge [Shiprock] (RM 158.6 – 147.9).

Study objectives were as follows:

1.) Continue data collection and mechanical removal of non-native species during main channel adult rare fish monitoring efforts.
2.) Evaluate distribution and abundance patterns of non-native species to determine effects of mechanical removal on abundance and distribution patterns.
3.) Continue transplantation of channel catfish to fishing impoundments isolated from the San Juan River.
4.) Characterize the distribution and abundance of striped bass into the San Juan River upstream of Lake Powell during removal efforts and determine predative impacts via stomach content analysis.

5.) Develop catch per unit effort targets for use in evaluation of mechanical removal in discrete river reaches.

STUDY AREA

Non-native fishes were removed from the San Juan River; Colorado, New Mexico, Utah; including accessible secondary channels from Farmington, New Mexico (Animas River confluence [RM 180.0]) downstream to Clay Hill's Landing (RM 2.9), Utah. Intensive removal efforts were conducted in New Mexico from PNM Weir (RM 166.6) downstream to Hogback Diversion (RM 159) and from Hogback Diversion (RM 158.6) to Shiprock Bridge (RM 147.9).

METHODS

Collections

Sampling during adult monitoring trips in 2003 followed the same protocol as previous years (Ryden 2000). Fish were collected using raft mounted electrofishers. Each raft consisted of one rower and one netter and floated perpendicular to the shoreline netting all fish seen. Sampling was conducted in one RM increments. At the end of each RM, all fish collected were enumerated by species and size class. At the end of every fifth mile, or designated mile, fishes were measured to the nearest millimeter (mm) for total and standard lengths and weighed to the nearest 5 grams (g) for mass. All non-native fishes were removed from the river.

Sampling conducted from PNM to Hogback and Hogback to Shiprock followed a similar protocol. In addition, a support raft was used both to collect any non-native fish that surfaced behind the shocking rafts and to serve as a holding unit for transporting live fish. All non-native fishes or a representative sub-sample were measured (nearest 1 mm) for total and standard lengths and weighed (nearest 5 g) for mass. All non-native fish were removed from the river. When possible, channel catfish were held for transplantation. Channel catfish were kept in live wells treated with salt and stress coat to alleviate stress caused by handling. A battery powered aeration system or compressed oxygen was used for circulation and aeration. Channel catfish were transported from the San Juan River in distribution trucks provided by the New Mexico Department of Game and Fish and the

Navajo Nation Department of Fish and Wildlife to closed impoundments located within the drainage.

Data Analysis

Analysis of all available capture data were divided between project types and were analyzed independently of each other. Catch per unit effort among years from PNM to Hogback, Hogback to Shiprock and Riverwide sampling were compared independently. Dale Ryden of U.S. Fish and Wildlife Service, Grand Junction (FWS-GJ) provided data collected from spring razorback sucker and fall adult/sub-adult monitoring trips. These data were combined and analyzed separately from the intensive removal trips.

Catch per unit effort of each channel catfish and common carp size class was calculated using all available capture data. Data was first checked for normality and a one-way analysis of variance (ANOVA) using Tukey multiple pairwise comparisons measured for significant differences among years. Multiple pairwise comparisons were made for all reaches combined and for individual reaches where sample size were adequate for comparison among years. Data was ranked when normal distributions did not occur and an ANOVA using Tukey multiple pairwise comparisons was used on the ranked data. This methodology was also used when comparing length differences of the two species. All analyses were conducted using SPSS Base 10.0 (SPSS, 1999).

RESULTS

Intensive Removal Efforts

PNM Weir to Hogback Diversion (RM 166.6 – 159.0)

Channel catfish catch per unit effort

Channel catfish CPUE have varied greatly between years and among trips since 2001 (Figure 1). In all years sampled, CPUE were low early in the year with associated peaks or spikes in CPUE occurring during the summer months.

Nine separate, two to three day, intensive repeated removal trips were conducted in 2002. A total of 3,624 channel catfish were removed from the San Juan River in 134.78 hours of electrofishing (Table 1). Channel catfish CPUE varied greatly among trips and ended with a slightly higher mean CPUE of 22.66 fish/hour of electrofishing (fish/hour) than 2001 (Table 1; Figure 1). Six trips yielded CPUE less than 10 fish/hour, four of which yielded less

than two fish/hour. The highest CPUE in 2002 were observed in June, July and September, comprising 93.90% of the total channel catfish catch for the year (Table 1). During these three trips, CPUE were similar to each other and significantly ($p < 0.05$) higher than all other trips.

Similar to 2001, CPUE for channel catfish in 2002 mainly consisted of adult fish, > 300 mm TL, with very few juveniles collected (Figure 2). A total of 185 juveniles were collected over the nine trips for a mean juvenile catch rate of 1.11 fish/hour. All but one individual juvenile catfish was collected in the months of June, July and September.

A total of 2,192 channel catfish were removed in 81.74 hours of electrofishing during five intensive repeated removal trips in 2003. Among trip comparisons, CPUE varied greatly and ranged from 0.51 to 88.59 fish/hour (Table 4). Trips were spread out and conducted throughout the calendar year and under various sampling conditions. The first trip of the year, April 2003, yielded a total of 29 channel catfish in three days of sampling. The next trip, 15-17 July 2003, saw a significant ($p < 0.001$) increase in CPUE from 1.33 to 88.59 fish/hour (Table 4; Figure 1). Subsequent trips saw significant declines in CPUE from the 15-17 July 2003 trip with the final trip conducted in December 2003 yielding only eight channel catfish in three days of sampling. An increase in mean CPUE of all size classes combined was observed from 2001-2003 (Figure 2).

Channel catfish CPUE in 2003 were comprised of primarily adult fish > 300 mm TL. However, during the initial July sampling trip, the highest number of juvenile channel catfish over three years of sampling were collected. A total of 922 juvenile fish were removed representing more than double the number collected in the previous two years of sampling. Juvenile channel catfish CPUE in 2003 was 9.67 fish/hour, compared to less than two juvenile fish/hour collected during removal efforts in 2001 and 2002.

Catch per unit effort for all size classes of channel catfish combined among years has changed very little. However, when CPUE were analyzed by size class, a significant ($p = 0.003$) increase in juvenile CPUE was observed, 2001 to 2003. In 2003, significant increases ($p = 0.001$) in juvenile CPUE and an associated decrease in adult numbers were observed (Figure 2).

Channel catfish size class distribution

Mean TL significantly ($p < 0.001$) decreased in comparisons between 2001 and 2002 continuing the trend observed since 1999 (Table 3; Figure 5). Mean TL of channel catfish in 2002 was 384.90 mm with over 60% of fish collected falling into the 301-400 mm TL length range. In addition, less than 5% of channel catfish collected in 2002 were comprised of fish > 500 mm. Juvenile fish comprised only 5.10% of the total catch and percentages of juvenile fish collected were similar to that observed in 2001 (Figure 5).

Mean TL significantly ($p < 0.001$) decreased in 2003 (327.56 mm), the lowest mean TL from 1999 to 2003. This significant decline in TL is primarily a result of the increased numbers of juvenile fish collected during the 15-17 July 2003 sampling. During this trip a total of 922 juvenile fish were removed and the mean TL of 306.40 mm was the lowest observed in five years of sampling from PNM Weir to Hogback Diversion. Over 40% of the total catch in 2003 were represented by juvenile fish. Fish within the 401-500 mm length range also saw a decrease for the second straight year and less than 5% of the total catch were made up of fish > 500 mm TL (Figure 5). Significant decreases in mean TL have occurred every year since 1999 and fewer large individuals (> 500 mm TL) are comprising the total catch. In 1999, 39.6% of the total catch were fish > 500 mm while 2002 and 2003 saw the percentages decrease to 2.1 and 3.1, respectively. In addition, fish > 600 mm, once common in collections, have virtually become absent from collections. Fish within this size classification comprised 13% of the total catch in 1999 and only 0.1% in both 2002 and 2003.

Common carp catch per unit effort

In 2002, a total of 1,668 common carp were removed during nine intensive repeated removal trips. Common carp CPUE varied among trips however, a general decline in CPUE with each subsequent removal trip was observed. The three highest CPUE in 2002 occurred during the initial sampling trips and decreased to less than two fish/hour by the final trip in November (Table 2; Figure 3).

Catch per unit effort for all size classes combined of common carp significantly ($p = 0.05$) decreased from 2001-2002 (Figure 4). Juvenile common carp comprised a small percentage of all common carp collected during removal efforts and ended with a nine trip mean CPUE of 0.41 fish/hour while adult carp CPUE in 2002 were 12.29 fish/hour.

During removal efforts in 2003, a total of 627 common carp were removed yielding a five trip mean CPUE of 7.28 fish/hour. All but one of the five trips conducted had CPUE for common carp less than ten fish/hour. Catch per unit effort ranged from 3.77 to 10.51 fish/hour and varied little among trips (Table 6).

Again, CPUE for all size classes combined declined in 2003 and a significant ($p < 0.001$) difference from 2001 catch rates were observed. Although CPUE continued to decrease from 2002 a significant difference was not measured. The majority of common carp collected were represented by adult fish, 99.78% of the total catch.

Common carp size class distribution

Size class distribution has remained consistent since 1999 with mean TL's averaging over 450 mm each of the past five years. Mean TL increased slightly from 475.35 mm in 2001 to 478.03 mm in 2002 (Table 5). Mean TL again increased in 2003 to end with a five a five trip mean of 488.81. This increase in TL was significantly different from both 2001 and 2002. Similar to previous years, over 90% of all fish collected in 2003 were considered adult fish with only 14 fish being classified as juveniles. No young-of-year common carp were collected in 2003.

Hogback Diversion to Shiprock Bridge (RM 158.6 – 147.9)

Channel catfish catch per unit effort

Five removal trips were conducted in 2003 and marked the first year of intensive repeated removal efforts throughout this reach. In 70.78 hours of electrofishing, a total of 3,927 channel catfish were removed for a five trip mean CPUE of 58.10 fish/hour (Table 7).

Adult channel catfish CPUE varied little among trips and range from 38.39 to 69.26 fish/hour. Juvenile CPUE varied among trips and ranged from 0.36 to 21.34 fish/hour. The lowest number of juveniles (n = 5) was collected on the first trip, 7-9 May 2003 and the most (n = 328) on the 10-12 June 2003 trip. A total of 729 juvenile fish (97% of all juvenile channel catfish) were collected during three consecutive sampling trips conducted in June, September and November, when CPUE were the highest among five trips (Table 7).

Channel catfish size class distribution

Mean TL among trips ranged from 343.60 to 432.18 mm and the five trip mean TL was 385.02 mm (Table 7). No apparent declining trend in mean TL among trips was measured. In three out of five trips, channel catfish within the range of 401-500 mm comprised over 50% of the total catch. Juvenile fish, < 300 mm, comprised 19% of the total catch and adults comprised 81%. No young of year channel catfish were collected during removal efforts within this reach.

Common carp catch rates

Common carp CPUE ranged from 16.41 to 39.31 fish/hour during the five removal trips, for a mean CPUE of 29.55 fish/hour (Table 8). The highest CPUE occurred on the 9-11 December 2003 trip when 28.69% of all common carp collected during the year were removed on this trip. No declining trend in CPUE, attributable to depletion sampling, was evident.

As observed in surveys riverwide, the majority of common carp collected by mainstream electrofishing consist almost exclusively of adult fish (>250 mm TL). Juvenile CPUE never exceeded one fish/hr in 2003 and only 1.34% (n = 28) of all common carp collected were classified as juveniles.

Reach Comparisons

Prior to 2003, intensive removal efforts were focused in the PNM to Hogback reach. Due to seasonal peaks in CPUE for channel catfish, removal efforts were expanded to include the adjacent downstream reach, Hogback to Shiprock, in 2003.

A total of ten removal trips were conducted in 2003, five in each of the designated reaches. A total of 6,119 channel catfish and 2,722 common carp were removed from both of the reaches combined. Of the channel catfish removed, 64.18% (n = 3,927) were from the Hogback to Shiprock reach. A total of 76.97% (n=2,095) of all common carp were removed from this downstream reach.

A comparison of CPUE among trips and between reaches shows higher CPUE for both channel catfish and common carp below Hogback Diversion than above (Figures 6 and 7). These data should be interpreted carefully because sampling trips within each of these

reaches were not conducted at the same time and variable sampling conditions related to water temperature, turbidity and discharge existed.

However, sampling conducted in both reaches in December 2003 exhibited interesting comparisons among CPUE. Sampling occurred upstream of Hogback on 2-4 December 2003 and downstream on the 9-11 December. Sampling upstream yielded a total of eight channel catfish and 118 common carp to end with three day catch rates of 0.51 and 6.80 fish/hour of electrofishing, respectively. When sampling was conducted downstream of Hogback, five days later, sampling yielded a total of 551 channel catfish and 601 common carp. Catch per unit effort were 40.68 and 39.31 fish/hour, respectively (Figures 6 and 7). These data simply suggest that abundance of both channel catfish and common carp below Hogback Diversion are much higher than above.

In addition, due to augmentation efforts of both Colorado pikeminnow and razorback sucker and the frequency of sampling within these reaches, multiple captures of these rare fish occurred during intensive removal trips. These data are important in aiding researchers in determining retention rates of fish further up in the system post stocking and are summarized in Appendices A to D.

Riverwide sampling

The number of channel catfish removed riverwide in 2002 and 2003 was the lowest since 1998. A total of 2,409 channel catfish (in 243.45 hours of electrofishing) was removed from Reaches 6-1 in 2002 and 1,599 (126.64 hours of electrofishing) in 2003. The number of channel catfish removed in 2003 was much reduced from 2001 when 6,814 were removed (Table 10). During both years, an approximate 50:50 ratio of adult and juvenile fish was removed, with less than 2.0% represented by young-of-year fishes.

Number of common carp removed in 2002 and 2003 from Reaches 6-1 was the lowest since 1998. A total of 1,268 and 812 common carp was removed from Reaches 6-1 during these two years. As noted from previous sampling, the majority of common carp removed riverwide each year consist of mostly adult fish, generally comprising over 90% of the total common carp catch each year (Table 10).

Channel catfish catch per unit effort

Channel catfish CPUE in 2002 and 2003 were the lowest reported in riverwide sampling since 1998 (Table 11). In 2002, CPUE were 18.72 fish/hour and 12.65 fish/hour in 2003. The only other year where CPUE dropped below twenty fish/hour during this time period was in 1998 (Table 14; Figure 8). In 2003, CPUE were significantly lower than that of 1998 to 2001.

Declines in CPUE within Reach 6, where intensive non-native removal occurs, were observed. These declines may be a result of intensive removal efforts but could likely be a result of turbid river conditions present at the time of sampling; Secchi range 0.05-0.12 meters in 2003 (Ryden un-published data). In Reach 6, CPUE between 2001 and 2003 were significantly ($p = 0.03$) different due to fewer adult fish in 2003 (Figure 9).

In Reaches 5 and 4, CPUE exhibited a "general" downward trend since 2000. This downward trend is most notable in Reach 5 and is likely a factor of high juvenile CPUE in 2000 (Figure 9). In 2000, CPUE was significantly ($p < 0.001$) higher among all other years.

A general decrease in CPUE was detected in Reaches 3-1 since 2001 (Figures 10 and 11). A significant ($p < 0.001$) decline in CPUE between 2001 and 2003 occurred in Reach 3 and are a result of fewer number of juvenile fish. For all life stages combined in Reach 1, CPUE remained low in both 2002 and 2003 with less than five fish/hour collected (Figure 11).

Total channel catfish CPUE in both 2002 and 2003 were significantly lower than the previous three years ($p < 0.001$). Although CPUE for adult channel catfish have changed little since 1998, significantly ($p <0.001$) higher juvenile CPUE were detected among comparisons of 2002-2003 and the previous three years. This decline is a result of fewer juvenile fish being collected most notably in Reaches 4-2 (Figures 10 and 11).

Channel catfish size class distribution

Mean TL (mm) of channel catfish sampled riverwide has change little since 1998. In spite of this small change, a "general" upward trend has been noticed since 1999 (Figure 12). An increasing trend in mean TL has occurred in Reaches 6-3 since 2001 (Figure 13). Mean TL in Reach 1 should be interpreted carefully due small sample sizes collected each year as explained by the large error bars.

Reach 6, where intensive removal occurs, saw a general increase in mean TL since 1999. These data are opposite of those reported on in the *Intensive repeated removal* (pp. 4-6) section of this report where significant declines in mean TL of channel catfish have been documented with each subsequent year of removal. Mean TL reported was 327.6 mm (n = 2,192) during five intensive repeated removal trips in 2003 as compared to 423.61 mm (n = 23) during adult monitoring in 2003. The difference in mean TL within this Reach is most likely a result of the overall difference in sample sizes among the two efforts.

Common carp catch rates

Riverwide CPUE in 2002 and 2003 for common carp have seen significantly ($p < 0.05$) declined since 1998 (Figure 14). Common carp CPUE were the lowest observed, 6.58 fish/hour, in sampling from 1998 to 2003 and number of common carp removed in 2003 was less than 1,000 fish (Tables 12 and 13). Declines in CPUE have been observed every year since 1999.

In Reaches 6-4, CPUE have decreased each year since 1998. Within Reach 6, a significant ($p = 0.048$) decline in overall CPUE of common carp was observed from 2000 to 2003. This decline may be a result of intensive repeated removal efforts within this reach or could be a result of the significantly higher CPUE observed in 2000 primarily in juvenile common carp (Figure 15). In Reaches 3 and 2, CPUE have remained consistent from 1998 to 2003 (Figures 16 and 17) while Reach 1 have seen declines since 2001 (Figure 17).

Common carp size class distribution

Common carp size class distribution riverwide is dominated by adult fish. A total of 154 and 52 juvenile common carp were collected in 2002 and 2003 representing 12.15% and 6.40% of the total common carp collection, respectively (Table 13). Mean TL of common carp in 2002 was significantly different than all years, excluding 1998, but still remains above 400 mm. Mean TL in 2003 saw a significant ($p < 0.001$) increase from 2002 and is likely a result of fewer fish being measured (Figure 18).

During 2003, increases in mean TL occurred in all reaches, most notably in Reaches 5 and 4 (Figure 19). Within these reaches, mean TL reached close to 500 mm, the highest observed from 1998-2003.

DISCUSSION

Intensive non-native removal completed its third consecutive year in 2003. Majority of removal efforts have focused on a discrete portion of Reach 6, PNM Weir to Hogback Diversion. Beginning in 2003, intensive removal efforts were expanded from Hogback to Shiprock and now include the upper portions of Reach 5.

Declining trends in CPUE of large size classes and changes in size class distribution of both channel catfish and common carp have been encouraging over the past three years. Comparisons of channel catfish CPUE among years has changed little with no significant differences detected. However, each year of removal has exhibited declining numbers early on only to see elevated CPUE towards the summer months. These elevated numbers are likely a result of fish movement upstream of Hogback Diversion and fish occupying areas that were previously vacated through removal efforts.

Although CPUE for all size classes combined of channel catfish have not declined, a decrease in adult fish removed associated with significant increases in juvenile CPUE was observed in 2003. This shift towards smaller fish may be important in the long term suppression and reduction in channel catfish numbers in the San Juan River and is explained in the following paragraphs.

The increase in CPUE of smaller sized fish is similar to observations of over-exploited stocks of channel catfish in the Mississippi River (Pitlo 1997) and angler exploitation in the Powder River, Wyoming (Gerhardt and Hubert 1991). For example, overharvest in the Mississippi River resulted in (1) declines in yield, (2) increases in the proportion of smaller fish, (3) a narrow range of age groups, (4) high dependence on single year-classes and (5) high mortality rates (Pitlo 1997). These declines were observed during a relatively long time period, 1955 to 1984 and focused on the over exploitation of larger sized channel catfish. In the San Juan River, removal efforts are concentrated on all size classes. Sexually mature channel catfish as well as sexually immature individuals that would contribute to the breeding population in subsequent years are removed. Theoretically, this type of non-size selective removal will impact the population more rapidly than size selective removal (Smith 2000).

Understanding reproductive potential and how it relates to size is an important factor in managing channel catfish for both commercial and recreational fisheries. Various studies have shown that channel catfish fecundity increases with TL, particularly at 380mm (Helms 1975; Jearld and Brown 1971; Raibley and Jahn 1991). Helms (1975) found that 1 of 10 channel catfish were sexually mature at 330 mm TL producing about 4,500 eggs compared to 5 of 10 at 380 mm TL producing about 41,500. Pitlo (1997) estimated that an increase in slot limits from 330 mm to 380 mm would increase channel catfsih reproductive potential 10 fold in the Mississippi River.

A shift to smaller individuals is crucial to removal efforts. An initial response to removal of larger, sexually mature channel catfish can be an increase in the number of smaller size classes, potentially increasing interactions with native fish. However, continued removal (exploitation) will reduce the number of smaller size classes as well (Pitlo 1997). Intensive removal of all size classes and reductions in abundance could affect the reproductive potential of channel catfish within the upper reaches of the San Juan River and limit recruitment in subsequent years.

Common carp CPUE within the intensive removal reach have significantly declined since 2001. It was once thought by researchers that the ability to obtain a measurable decreasing trend in carp numbers would be difficult to attain. Although CPUE continue to decline, the majority of common carp collected are adult fish. The lack of juvenile common carp in collection efforts may be attributed to gear bias associated with raft mounted electrofishing and the lack of ability to effectively sample habitats where juvenile fish may reside. It is also possible that a significant portion of the common carp population in the San Juan River may come from off-channel sources but is unknown at this time.

Although positive native fish responses to mechanical removal has not been specifically identified, one can assume that a reduction in overall numbers and biomass of non-native fish would result in increased distribution and abundance by the native fish community. In addition, non-native removal in the upper reaches may be important to other portions of ongoing recovery activities for rare fish. Augmentation efforts are centered in the upper reaches. Fewer non-native fish may result in greater rare fish retention within the system.

Riverwide removal has resulted in little declines in distribution, abundance or in size class distribution of either species. Although intensive removal is likely to result in quicker responses, it is recommended that removal of non-native species during all sampling efforts on the San Juan River continue. The majority of these trips are essentially one pass sampling efforts but contribute to over 8,000 non-native fish being removed annually.

Non-native removal efforts conducted by Utah Division of Wildlife Resources (UDWR) in the lower portions of the San Juan River may also lead to quicker negative responses in both channel catfish and common carp distribution and abundance. While FWS removal efforts are on average removing larger channel catfish from the upper reaches, UDWR crews are removing smaller size classes. This type of two tiered effort may result in declines of non-native fish in a more rapid time than if removal was only conducted in one reach. One effort are removing large, fecund fish that are potentially producing hundreds of thousands of eggs annually. The other effort are removing smaller sized fish, many of which are not of reproductive age, that would contribute the reproductive effort in future years.

Removal of non-native fishes, especially channel catfish and striped bass, in the San Juan River has met with both controversy and praise from the public. Channel catfish were ranked as medium importance in New Mexico, Arizona and Colorado and as low importance in Utah to anglers (Michaletz and Dillard, 1999). In New Mexico, seven of the designated warm water fisheries have reduced limits on channel catfish with all of them being small impoundments (New Mexico Department of Game and Fish 1999). Increasing demand for channel catfish in "put and take" fisheries has resulted in lack of supply from hatcheries. It was suggested by Smith (2000) that augmentation of hatchery reared channel catfish stocks with wild stocks could alleviate the limited supply of channel catfish in some waters.

Channel catfish transplantation from the San Juan River to closed impoundments within the drainage began in 1997 and is supported by both the Navajo Nation and the New Mexico Department of Game and Fish (NMDGF). Transplant of wild caught channel catfish (up to 15 times larger than typical hatchery-reared fish) transplanted to the Navajo Nation and State of New Mexico managed waters has been met with positive comments from the

community and has helped ease tensions concerning the sacrifice of these species during other sampling efforts (Smith 2000).

To date, over 7,000 channel catfish have been stocked into closed impoundments within the San Juan drainage. The average sizes of channel catfish stocked from the San Juan River are 14 to 16 inches and 0.68 fish/pound. This is in comparison to federal hatchery reared fish that average 8 to 10 inches and 2 to 4 fish/ pound. Many of these fish have been stocked into Navajo Nation lakes and have become an important source of supplement fish for recreational fishing on the Reservation.

During FY 2004, plans for intensive removal in the upper reaches of the San Juan River will continue. A total of ten, separate, three day removal trips will be conducted. Effort will be divided between the PNM to Hogback and Hogback to Shiprock reaches. Timing of trips above Hogback will be determined and rely upon monthly reports of species and catch by the Navajo Nation Fish and Wildlife Department at the selective fish ladder at PNM. The remaining trips will be conducted from Hogback to Shiprock.

In addition, data collected (FWS-GJ) within the intensive removal reaches over several years will be analyzed to detect any native fish response to mechanical removal. Continued data will be collected on various sampling conditions, including water temperature, clarity and discharge. These factors may limit the success of individual removal trips (Appendix F). These data will be incorporated into the decision making of when trips should be conducted to maximize removal effort.

CONCLUSIONS

PNM Weir (RM 166.6) to Hogback Diversion (RM 159.0)

- Intensive repeated removal efforts from have resulted in significant reductions ($p < 0.001$) in CPUE of common carp in comparisons between 2001 and 2003.
- Decreases in mean TL of common carp from 2001-2003 have not been observed.
- Overall CPUE of channel catfish have not decreased since 2001.
- Significant ($p = 0.003$) increases in juvenile channel catfish CPUE and associated declines in adult CPUE were observed from 2001-2003.
- Significant declines ($p < 0.001$) in mean TL of channel catfish have been observed with each subsequent year of removal since 1999.
- Juvenile channel catfish comprised < 1% of the total channel catfish catch in 1999 and over 40% in 2003. Fish > 500 mm comprised 39.6% of the catch in 1999 and 2.1% and 3.1% each of the last two years.
- Data analyses and determination of native fish response within intensive removal reaches will be conducted in FY 2004.
- Due to augmentation efforts and frequency of sampling by non-native removal crews, important recapture data is collected on both the Colorado pikeminnow and razorback sucker.

Hogback Diversion (RM 158.6) to Shiprock Bridge (RM 147.9)

- A total of five removal trips were conducted marking the first year of intensive repeated removal effort below Hogback Diversion.
- CPUE and mean TL were higher below the diversion than above.
- No apparent declines in abundance or mean TL were observed over the five sampling trips.
- Continued sampling within this reach is recommended to further expose a greater portion of the non-native fish community to repeated removal efforts.

Riverwide Removal Efforts (RM 180.0 – RM 0.00)

- Both channel catfish and common carp CPUE decreased in 2002 and 2003 among comparisons from 1998-2003.

- Reductions in CPUE in 2002 and 2003 may be a result of riverwide mechanical removal or from sampling conditions (i.e. limited water clarity) which may have limited the ability to see and net fish.

- Mean TL of both species have not seen significant declines in the past several years

- A slight decrease in mean TL within Reach 6, where intensive repeated removal occurs, was observed.

- Common carp catch are almost exclusively dominated by adult fish > 350 mm TL.

Channel catfish transplantation efforts

- The stocking of channel catfish from the San Juan River to closed impoundments within the drainage continued in 2002 and 2003.

- Approximately 7,000 channel catfish have been removed and stocked since 1998 with the help of both the Navajo Nation Department of Fish and Wildlife Service (NNFWS) and the New Mexico Department of Game and Fish (NMGF)

- Average size of a San Juan River channel catfish stocked is 14-16" and 0.68 fish/lb compared to hatchery reared fish 8-10" and 2-4 fish/lb.

- Continued cooperation with partners (NNFWS, NMGF, and Southwest Tribal Fisheries Commission) will occur in 2004.

Table 1. Date of trip, total number of channel catfish, mean TL and SL (mm), mean mass (grams) and catch rate (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2002.

Trip	Number of Fish	Mean TL (mm)	Mean SL (mm)	Mean WT (g)	CPUE (fish/hour)
5-7 Feb 2002	130	435.68	352.41	842.33	7.76
26-28 Feb 2002	5	407.40	318.60	844.00	1.17
12-14 Mar 2002	16	439.13	361.63	830.00	1.12
2-3 April 2002	14	463.50	380.29	1204.64	1.15
11-13 June 2002	945	386.80	309.75	613.94	44.37
16-18 July 2002	1,323	375.24	300.86	535.32	59.71
27-29 Aug 2002	1,135	385.20	314.36	631.60	62.39
22-24 Oct 2002	53	445.00	368.11	1066.98	3.29
20-22 Nov 2002	3	467.00	387.67	1375.00	0.22
Totals	**3,624**	**384.27**	**308.23**	**590.30**	**22.66**

Table 2. Date of trip, total number of common carp, mean TL and SL (mm), mean mass (grams) and catch rate (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2002.

Trip	Number of Fish	Mean TL (mm)	Mean SL (mm)	Mean WT (g)	CPUE (fish/hour)
5-7 Feb 2002	427	473.75	376.51	1514.22	27.25
26-28 Feb 2002	62	482.48	379.81	1575.92	20.77
12-14 Mar 2002	336	481.85	378.76	1529.39	25.30
2-3 April 2002	95	481.77	382.52	1558.79	8.09
11-13 June 2002	406	483.65	383.60	1734.07	20.27
16-18 July 2002	146	480.65	381.06	1750.32	6.93
27-29 Aug 2002	94	469.63	379.43	1646.55	5.26
22-24 Oct 2002	72	445.40	347.78	1742.05	4.29
20-22 Nov 2002	30	504.03	400.21	1940.17	1.90
Totals	**1,668**	**478.03**	**378.85**	**1629.46**	**12.69**

Table 3. Year, total number of channel catfish, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2001-2003.

Year	No. of Trips	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
2001	10	4,024	396.48	319.91	678.46	22.39
2002	9	3,624	385.58	311.22	611.58	22.66
2003	5	2,192	327.56	264.12	444.62	23.64

Table 4. Date of trip, total number of channel catfish, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2003.

Date	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
8-10 April	29	479.66	396.45	1470.86	1.33
15-17 July	1,799	306.40	245.76	346.90	88.59
29-30 July	17	364.18	293.88	697.06	1.62
28-30 Oct	339	421.36	345.47	851.40	18.80
2-4 Dec	8	483.63	403.88	1040.00	0.51
Totals	**2,192**	**327.56**	**264.12**	**444.62**	**23.64**

Table 5. Year, total number of common carp, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2001-2003.

Year	No. of Trips	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
2001	10	3,247	475.35	378.72	1522.34	18.47
2002	9	1,668	478.03	378.85	1629.46	12.69
2003	5	627	488.81	385.25	1820.33	7.28

Table 6. Date of trip, total number of common carp, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from PNM Weir to Hogback Diversion, 2003.

Date	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
8-10 April	115	498.99	400.18	2026.68	5.38
15-17 July	169	488.02	385.25	1746.45	8.77
29-30 July	36	513.03	415.03	2030.56	3.77
28-30 Oct	189	479.44	386.86	1610.26	10.51
2-4 Dec	118	487.47	393.60	1975.81	6.80
Totals	**627**	**488.81**	**392.06**	**1820.33**	**7.28**

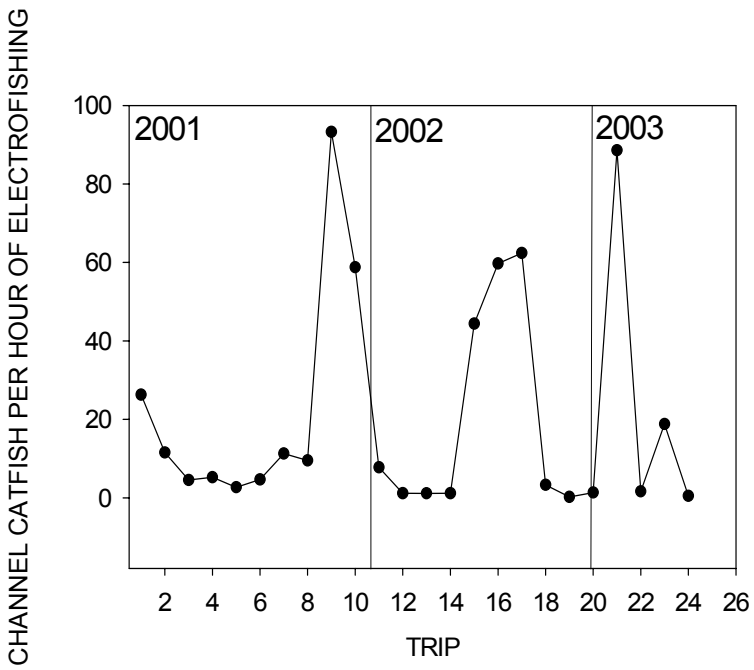

Figure 1. CPUE (fish/hour of electrofishing) of channel catfish by trip in the PNM Weir to Hogback Diversion Reach (RM 166.6 – 159.0), 2001-2003.

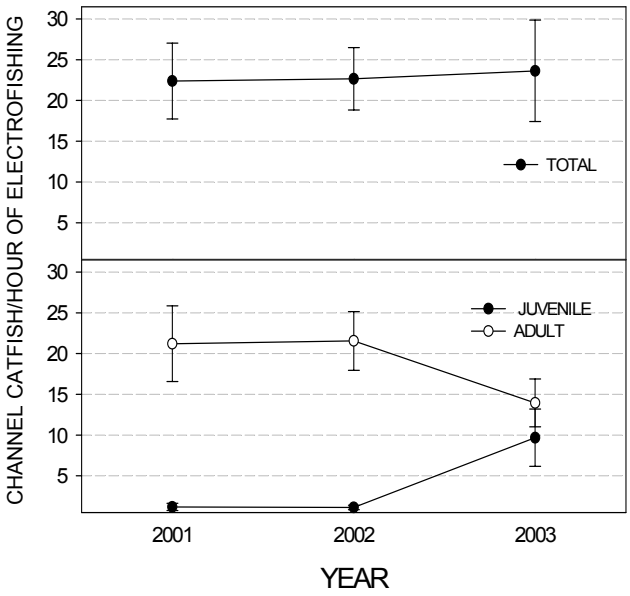

Figure 2. CPUE (fish/hour of electrofishing) of channel catfish by juvenile, adult, and all life stages combined collected in the PNM Weir to Hogback Diversion (RM 166.6 - 159.0) reach during intensive non-native removal trips, 2001-2003. Error bars represent the standard error of the mean.

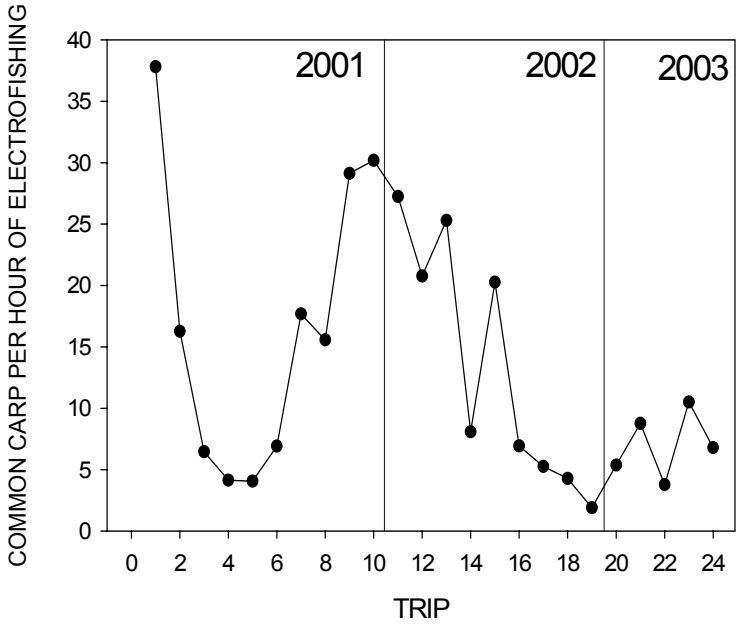

Figure 3. CPUE (fish/hour of electrofishing) of common carp by trip in the PNM Weir to Hogback Diversion Reach (RM 166.6 – 159.0), 2001-2003.

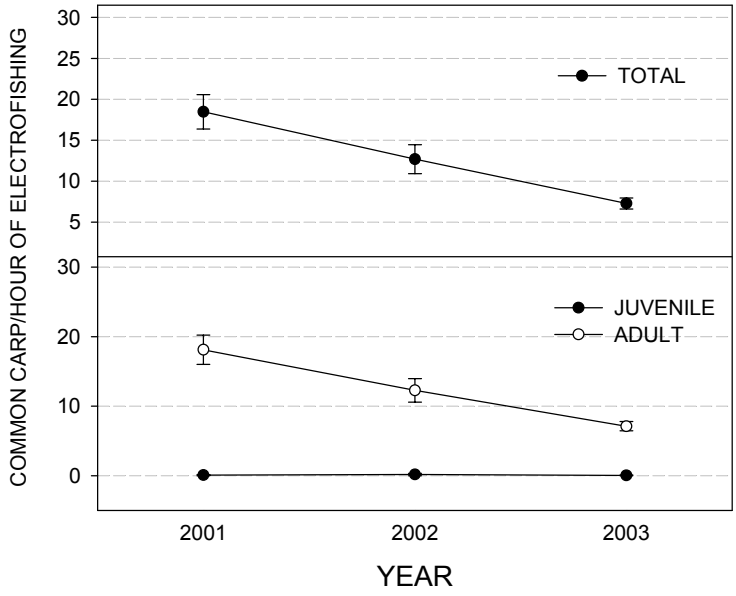

Figure 4. CPUE (fish/hour of electrofishing) of common carp by juvenile, adult, and all life stages combined collected in the PNM Weir to Hogback Diversion (RM 166.6-159.0) reach during intensive non-native removal trips, 2001-2003. Error bars represent the standard error of the mean.

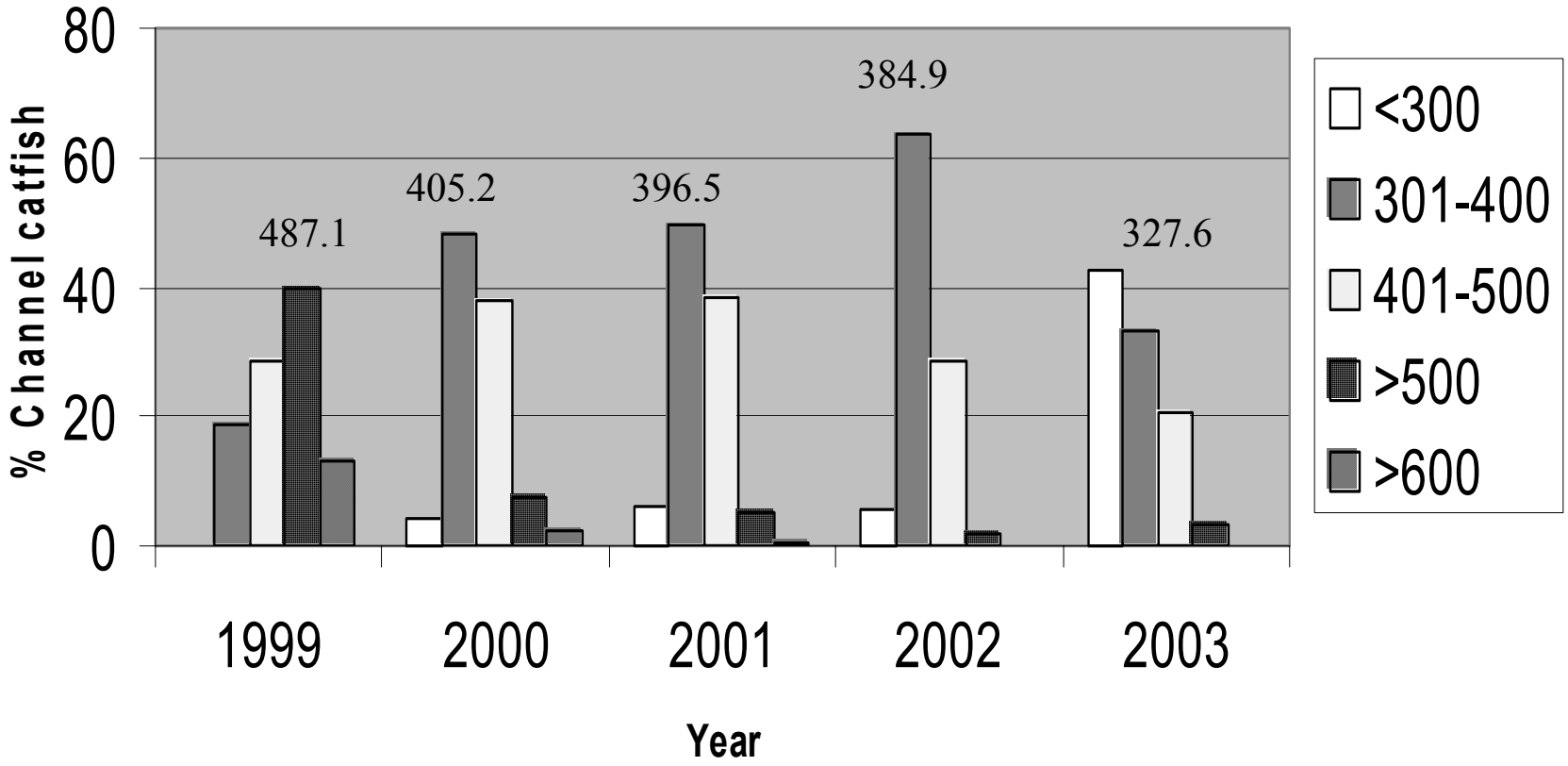

Figure 5. Size class distribution of channel catfish collected from PNM Weir to Hogback Diversion, 1999-2003.

Table 7. Date of trip, total number of channel catfish, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from Hogback Diversion to Shiprock Bridge, 2003.

Date	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
7-9 May 2003	522	426.16	349.31	938.94	43.05
10-12 June 2003	1,010	343.60	278.23	548.86	64.42
3-5 Sept 2003	1,026	365.62	297.59	511.12	63.29
11-12 Nov 2003	818	413.67	336.83	757.71	79.81
9-11 Dec 2003	551	432.18	361.45	779.99	40.68
Totals	**3,927**	**385.02**	**314.61**	**666.30**	**58.10**

Table 8. Date of trip, total number of common carp, mean TL and SL (mm), mean mass (grams) and CPUE (fish/hour of electrofishing) removed during non-native removal trips from Hogback Diversion to Shiprock Bridge, 2003.

Date	No. of Fish Removed	Mean TL (mm)	Mean SL (mm)	Mean Mass (grams)	Catch rate (fish/hour of electrofishing)
7-9 May 2003	431	492.95	398.13	1,792.21	33.75
10-12 June 2003	268	489.75	489.75	1,946.53	16.41
3-5 Sept 2003	431	486.25	387.30	1,558.40	26.94
11-12 Nov 2003	364	485.64	386.70	1,613.32	34.39
9-11 Dec 2003	601	488.90	394.18	1,703.74	39.31
Totals	**2,095**	**488.13**	**391.16**	**1,687.03**	**29.55**

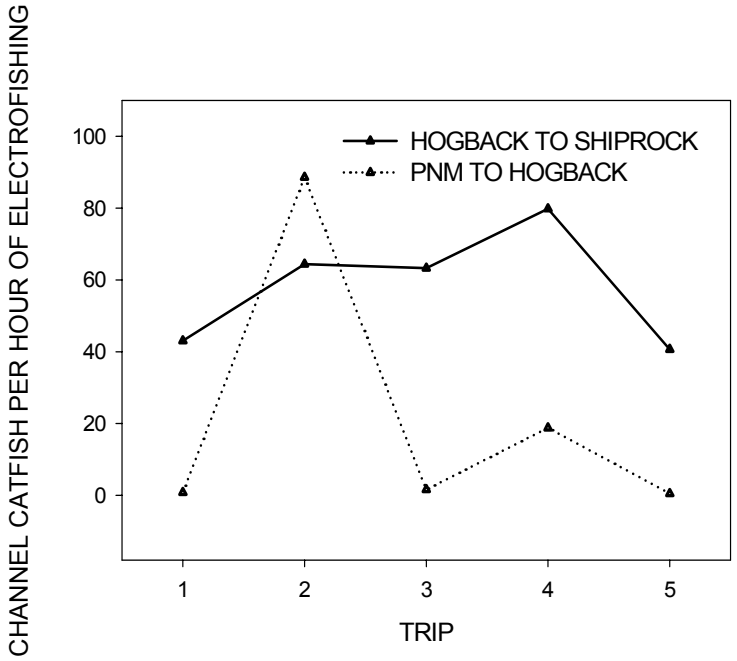

Figure 6. Comparison of CPUE (fish/hour of electrofishing) of channel catfish collected on separate trips with adjacent reaches, PNM Weir to Hogback (RM 166.6 – 159.0) and Hogback to Shiprock (RM 158.6 – 148.0).

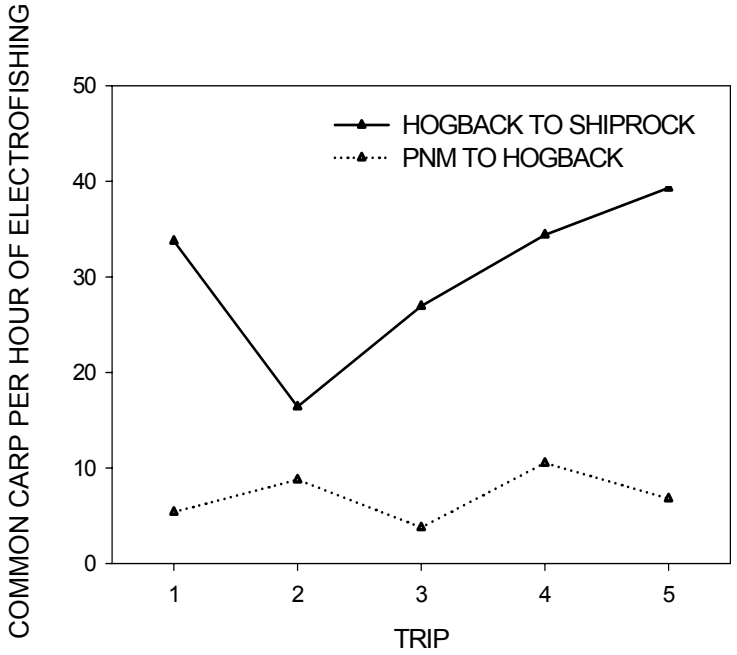

Figure 7. Comparison of CPUE (fish/hour of electrofishing) of common carp collected on separate trips with adjacent reaches, PNM Weir to Hogback (RM 166.6 – 159.0) and Hogback to Shiprock (RM 158.6 – 148.0)..

Table 10. Total number of channel catfish (*Ictalurus punctatus*) and common carp (*Cyprinus carpio*) collected during main channel electrofishing surveys conducted in the spring/fall of each year, 1998-2002

Species	Year	Young of Year	Juvenile	Adult	Total	Total Effort (Hours)
Channel catfish	1998	63	2,738	1,994	4,795	241.78
	1999	114	2,798	2,224	5,136	158.88
	2000	112	4,305	1,907	6,320	178.06
	2001	110	4,435	2,269	6,814	212.05
	2002	40	1,193	1,166	2,409	243.45
	2003	52	774	773	1,599	126.64
	Total	491	16,243	10,333	27,073	1,160.86
	% of total catch	(1.81%)	(60.00%)	(38.17%)	(100.00%)	
Common carp	1998	1	51	3,308	3,360	235.12
	1999	0	13	3,075	3,088	158.88
	2000	99	235	2,430	2,764	178.06
	2001	0	98	3,508	3,606	212.05
	2002	31	154	1,082	1,268	235.90
	2003	3	52	757	812	126.64
	Total	134	603	14,160	14,898	1,160.86
	% of total catch	(0.90%)	(4.05%)	(95.05%)	(100.00%)	

Table 11. CPUE for channel catfish (*Ictalurus punctatus*) and common carp (*Cyprinus carpio*) collected during main channel electrofishing surveys conducted in the spring/fall of each year, 1998-2002.

		Fish per hour of electrofishing		
		Juvenile	Adult	Total
Species	Year			
Channel catfish	1998	11.31	8.06	19.61
	1999	19.62	13.49	33.85
	2000	23.54	10.57	34.70
	2001	21.27	11.96	33.63
	2002	8.97	9.27	18.72
	2003	5.87	6.41	12.65
	Total	15.62	9.92	25.99
Common carp	1998	0.20	13.64	13.84
	1999	0.10	18.41	18.51
	2000	1.44	14.13	16.14
	2001	0.55	15.42	15.97
	2002	1.48	8.51	10.28
	2003	0.41	6.15	6.58
	Total	0.63	13.27	14.04

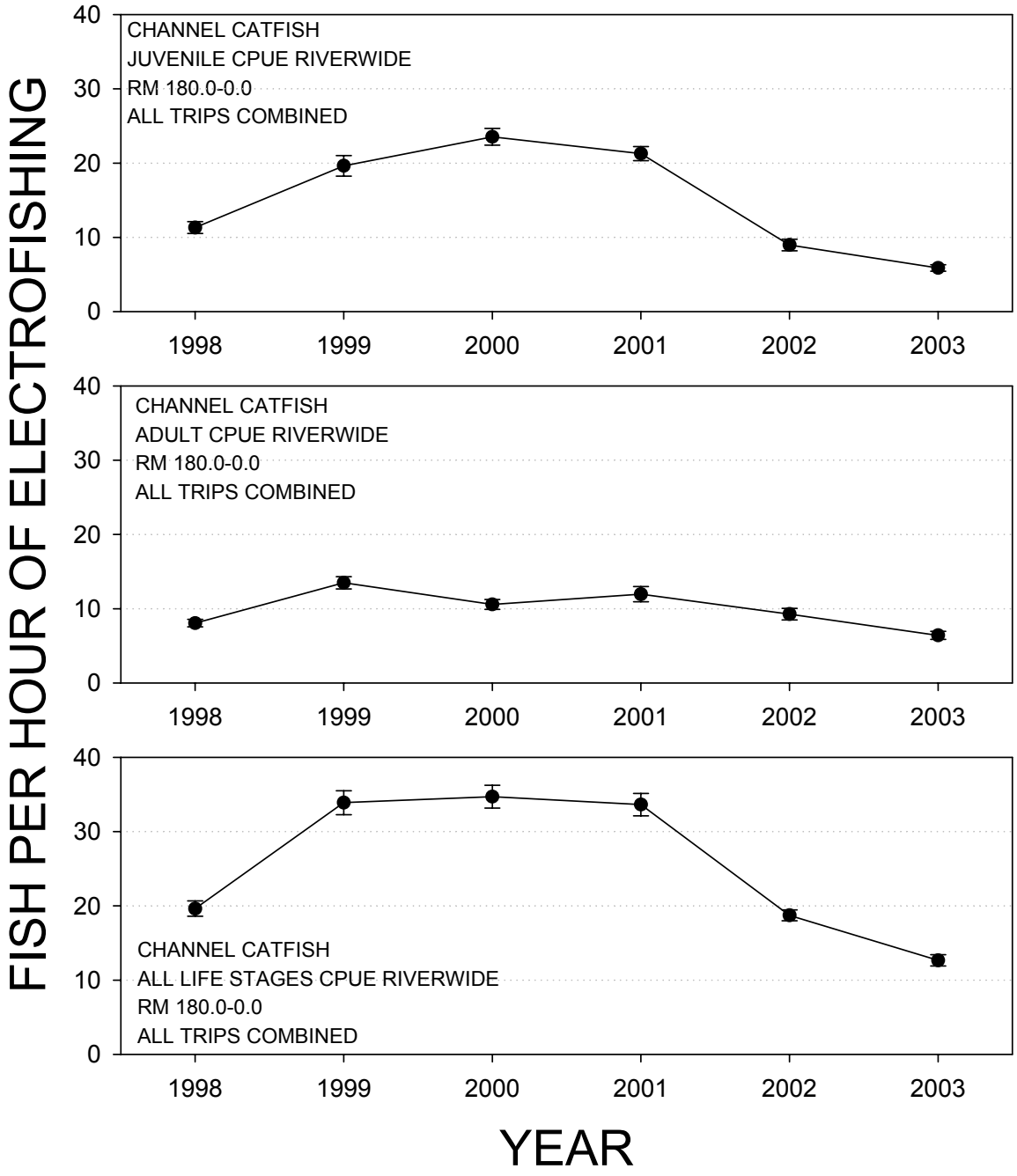

Figure 8. Catch per unit effort (fish/hour of electrofishing) of channel catfish by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

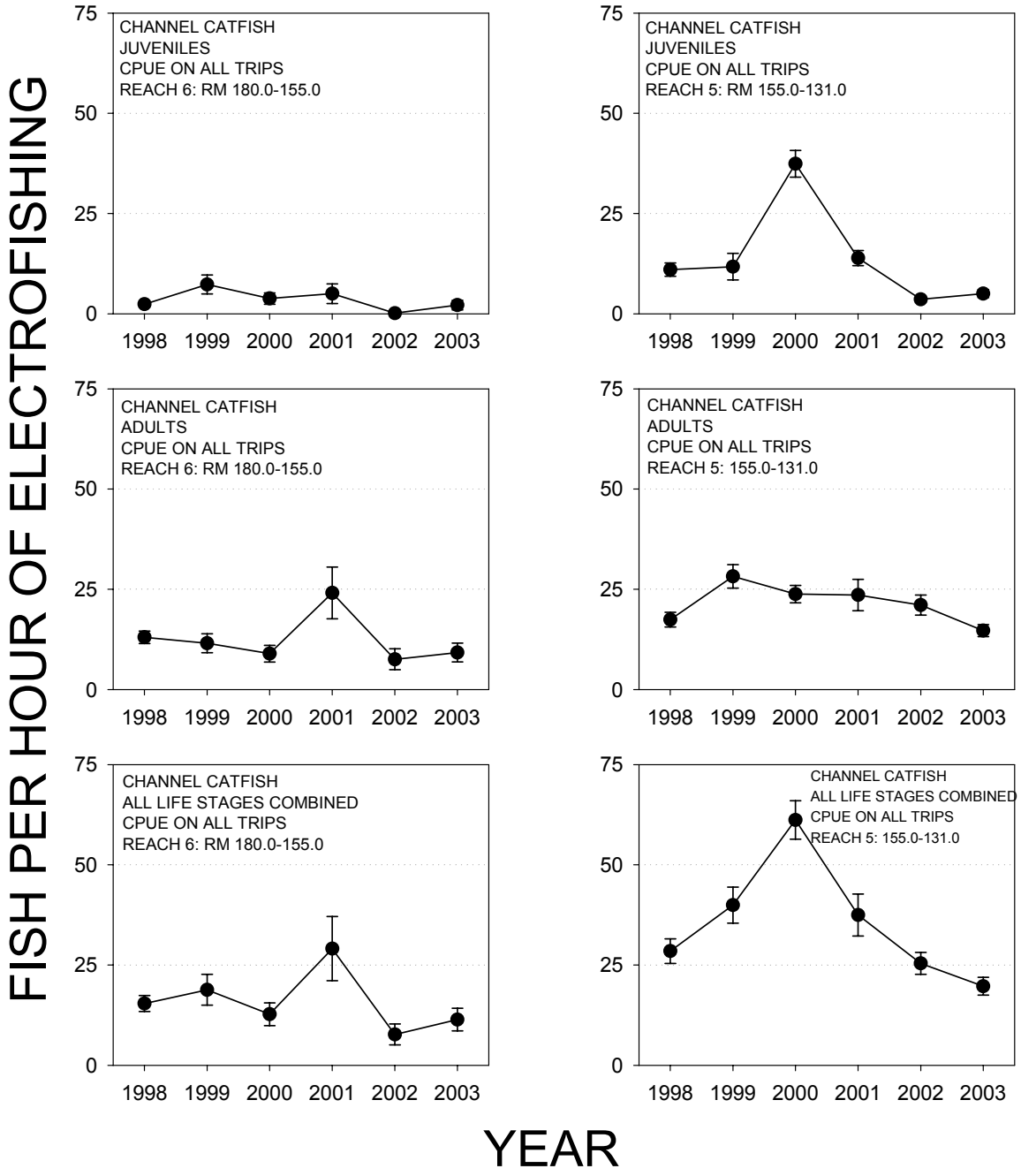

Figure 9. Catch per unit effort (fish/hour of electrofishing) of channel catfish in Reaches 6 and 5 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

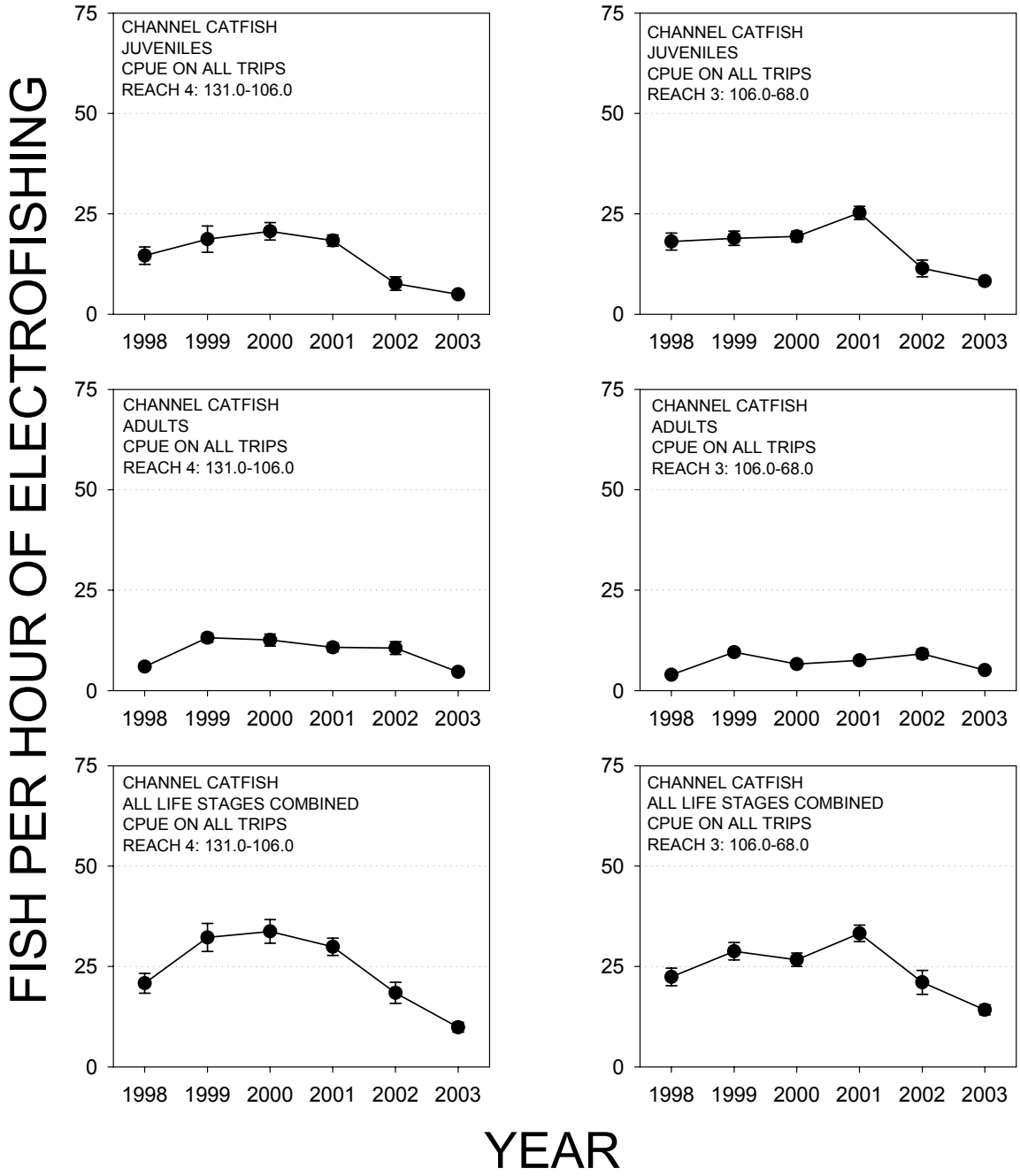

Figure 10. Catch per unit effort (fish/hour of electrofishing) of channel catfish in Reaches 4 and 3 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

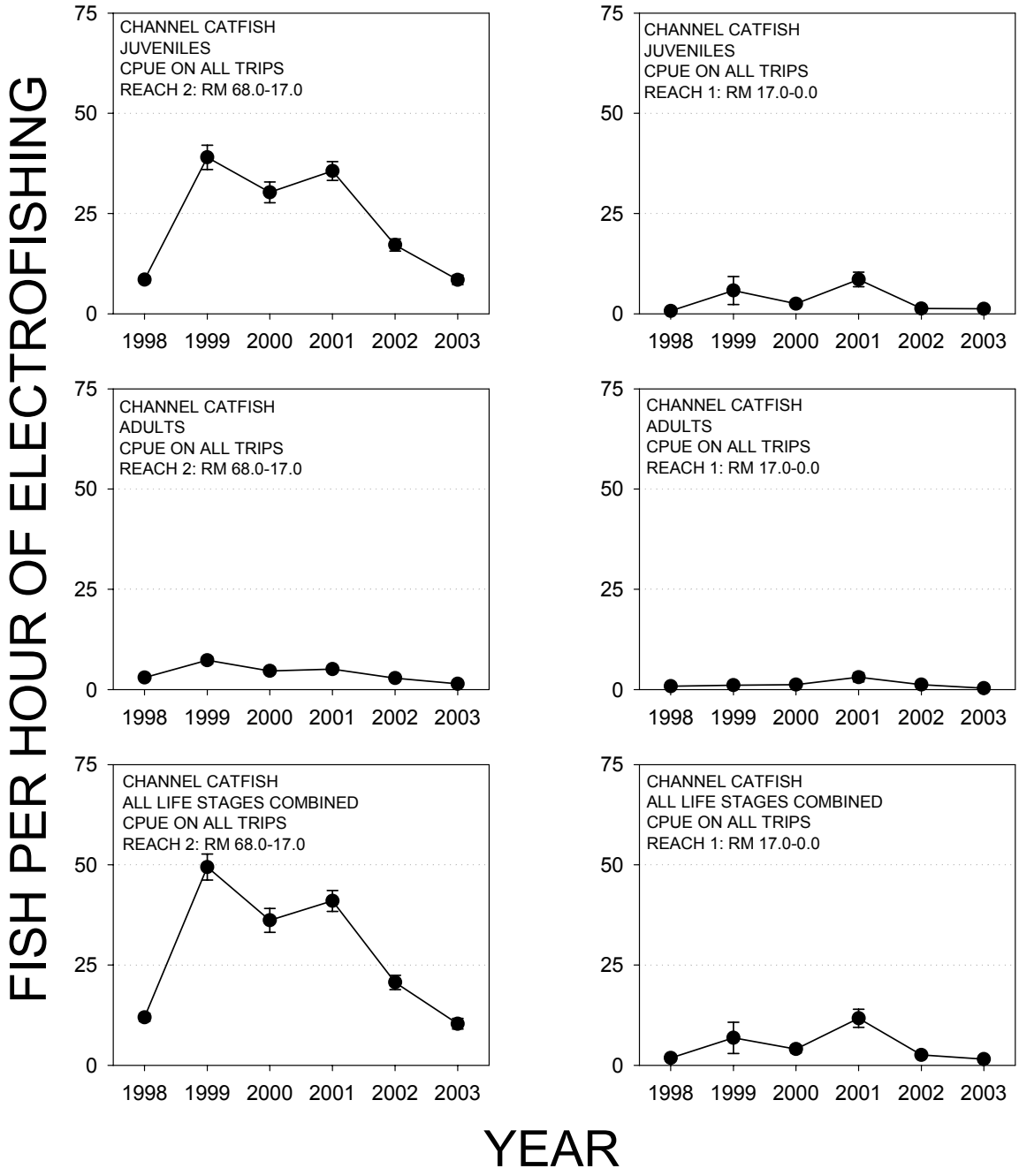

Figure 11. Catch per unit effort (fish/hour of electrofishing) of channel catfish in Reaches 2 and 1 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

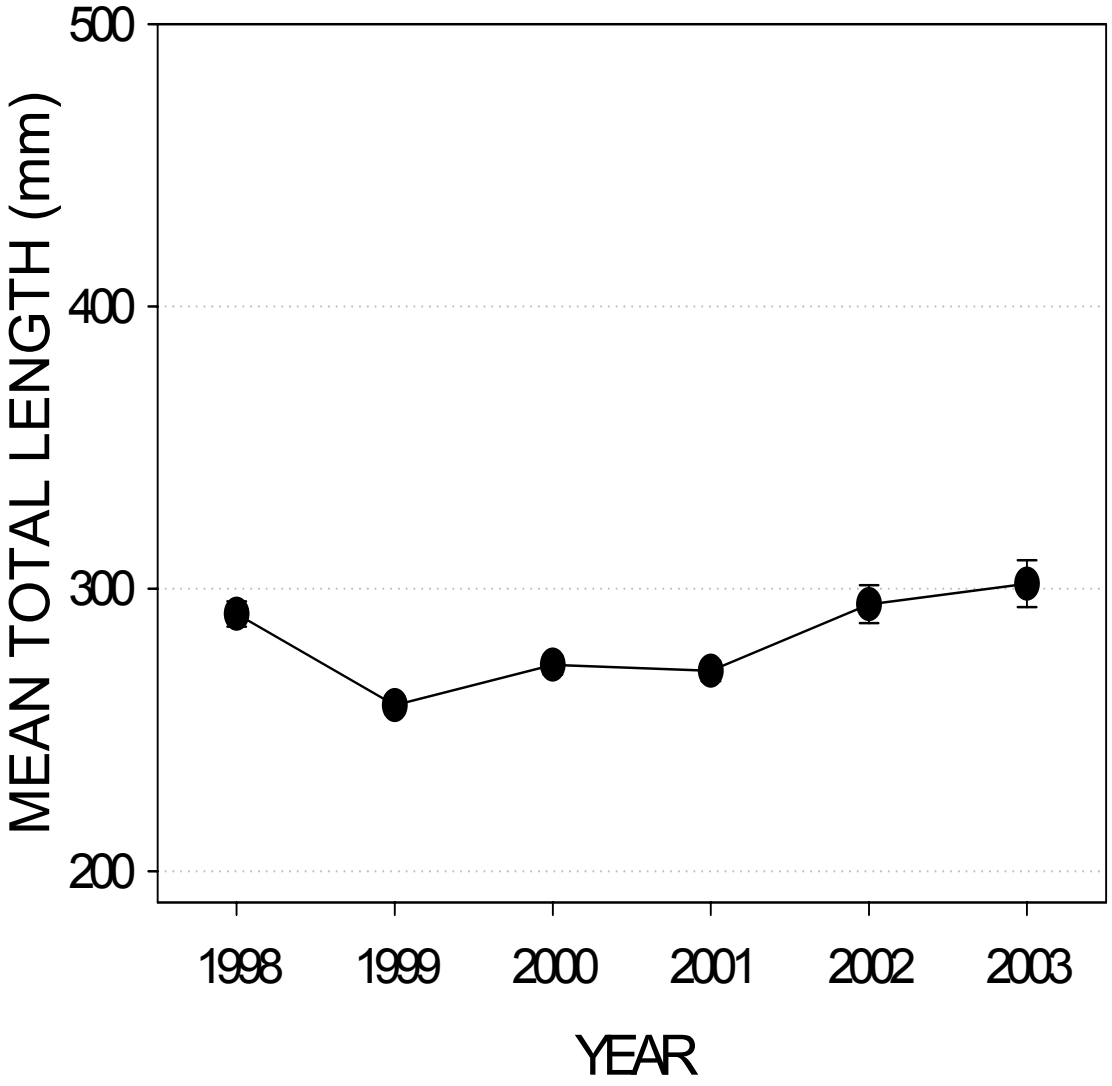

Figure 12. Mean total length (mm) of channel catfish in all Geomorphic Reaches collected during fall monitoring trips of each year, 1998-2003.

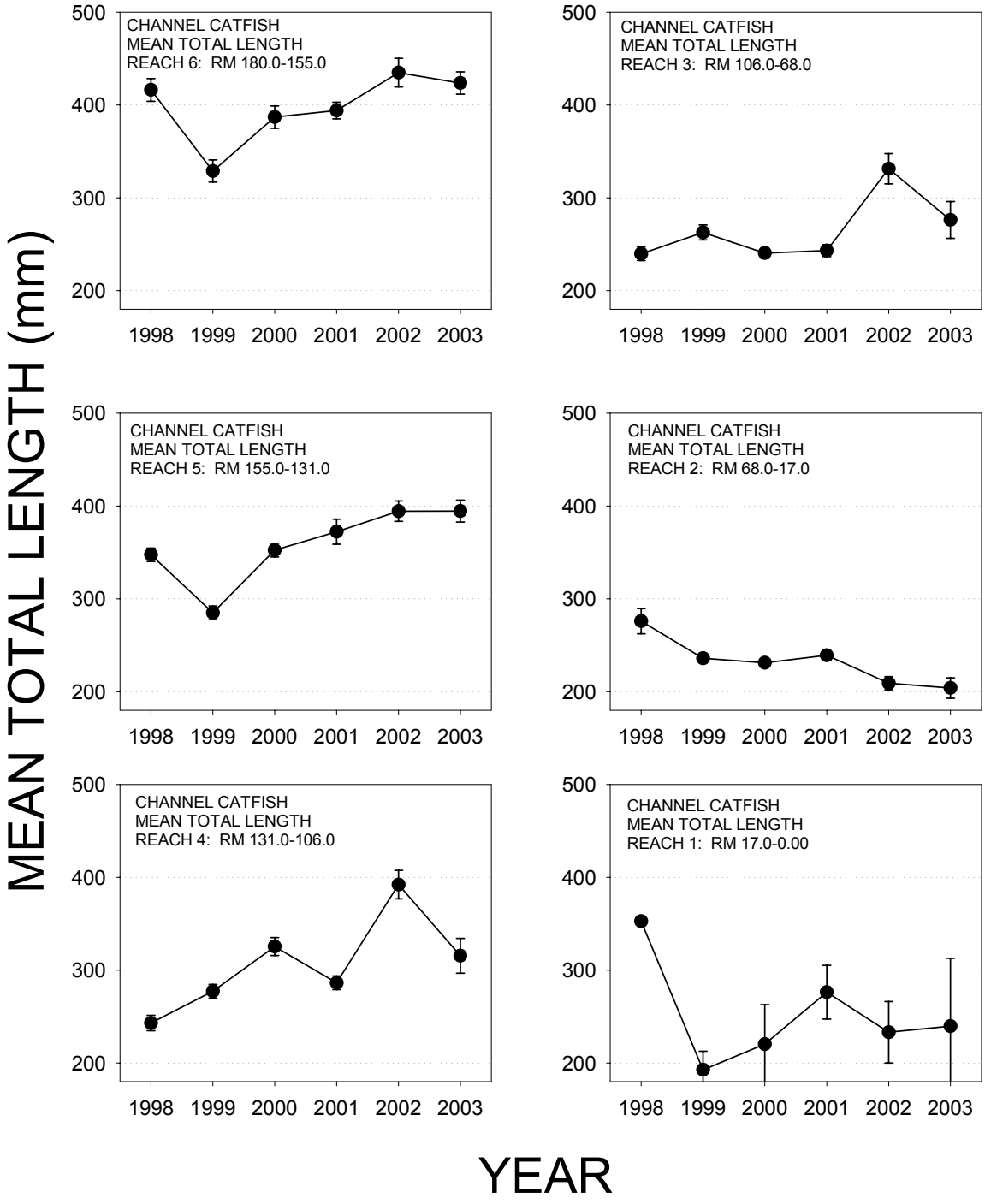

Figure 13. Mean total length (mm) of channel catfish by Geomorphic Reach and by year. Error bars represent the standard error of the mean.

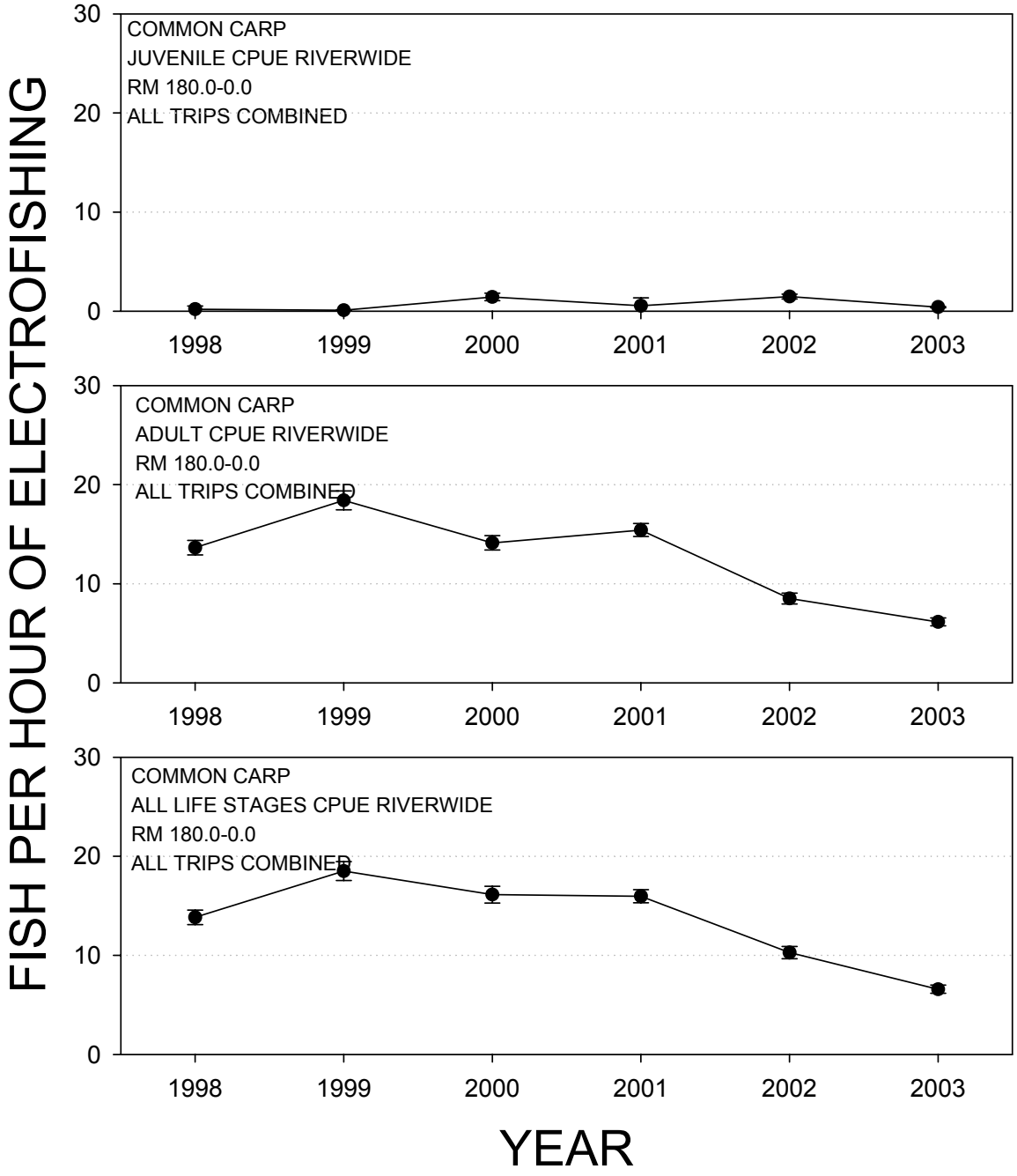

Figure 14. Catch per unit effort (fish/hour of electrofishing) of common carp by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

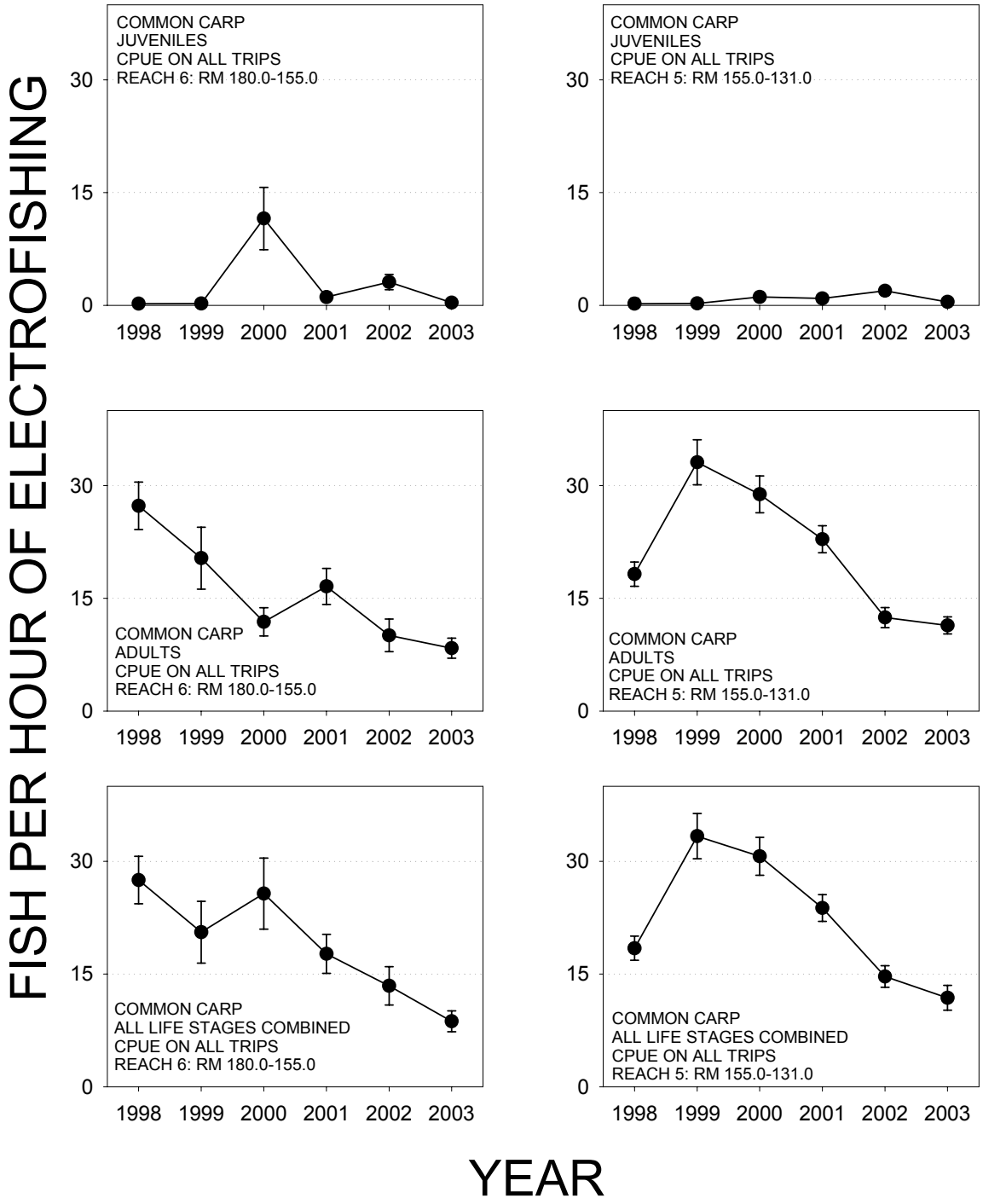

Figure 15. Catch per unit effort (fish/hour of electrofishing) of common carp in Reaches 6 and 5 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

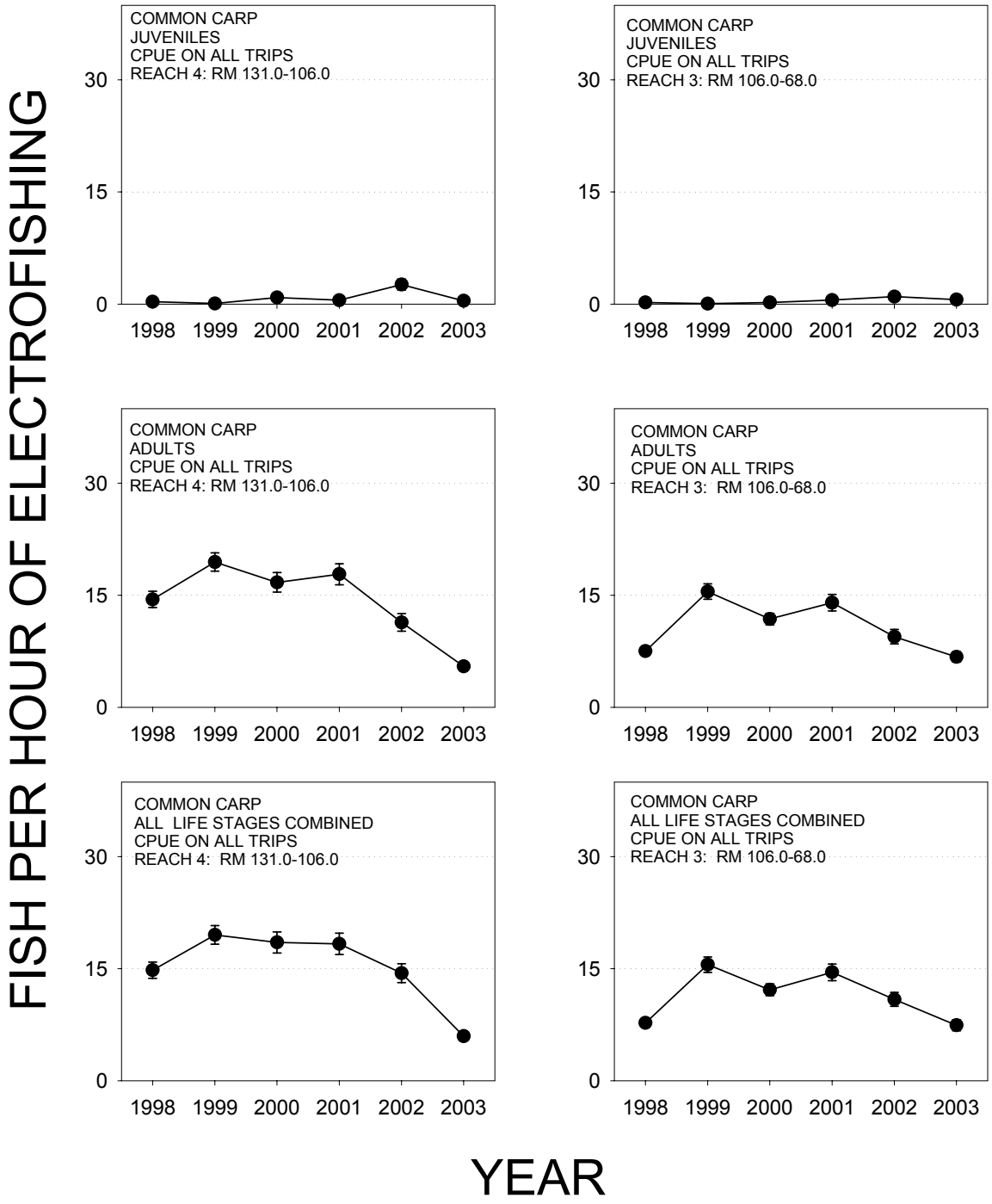

Figure 16. Catch per unit effort (fish/hour of electrofishing) of common carp in Reaches 4 and 3 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

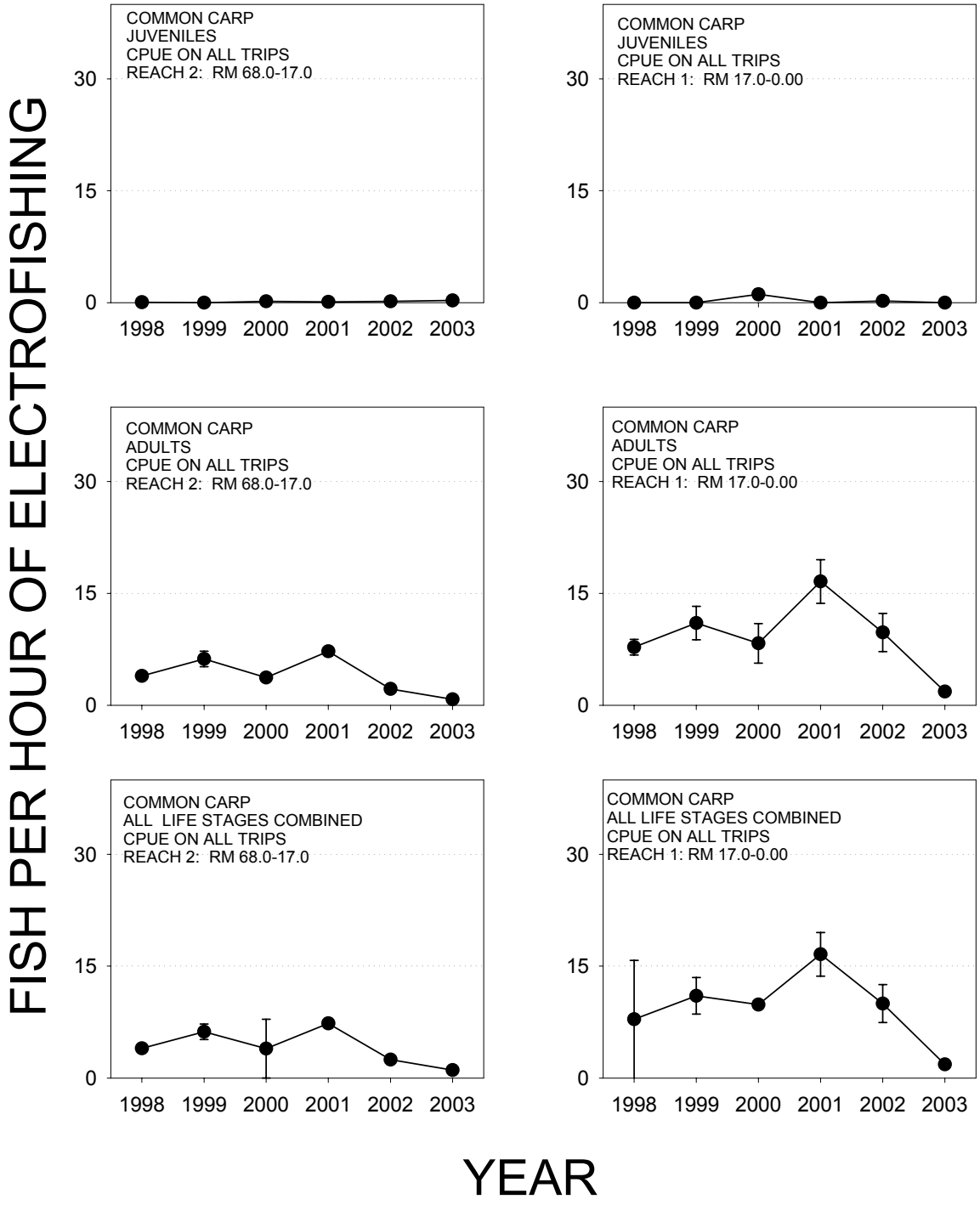

Figure 17. Catch per unit effort (fish/hour of electrofishing) of common carp in Reaches 2 and 1 by size class (juvenile, adult, and all life stages combined) and year, 1998-2003. Fish collected during the spring and fall of each year are included in CPUE calculation. Error bars represent the standard error of the mean.

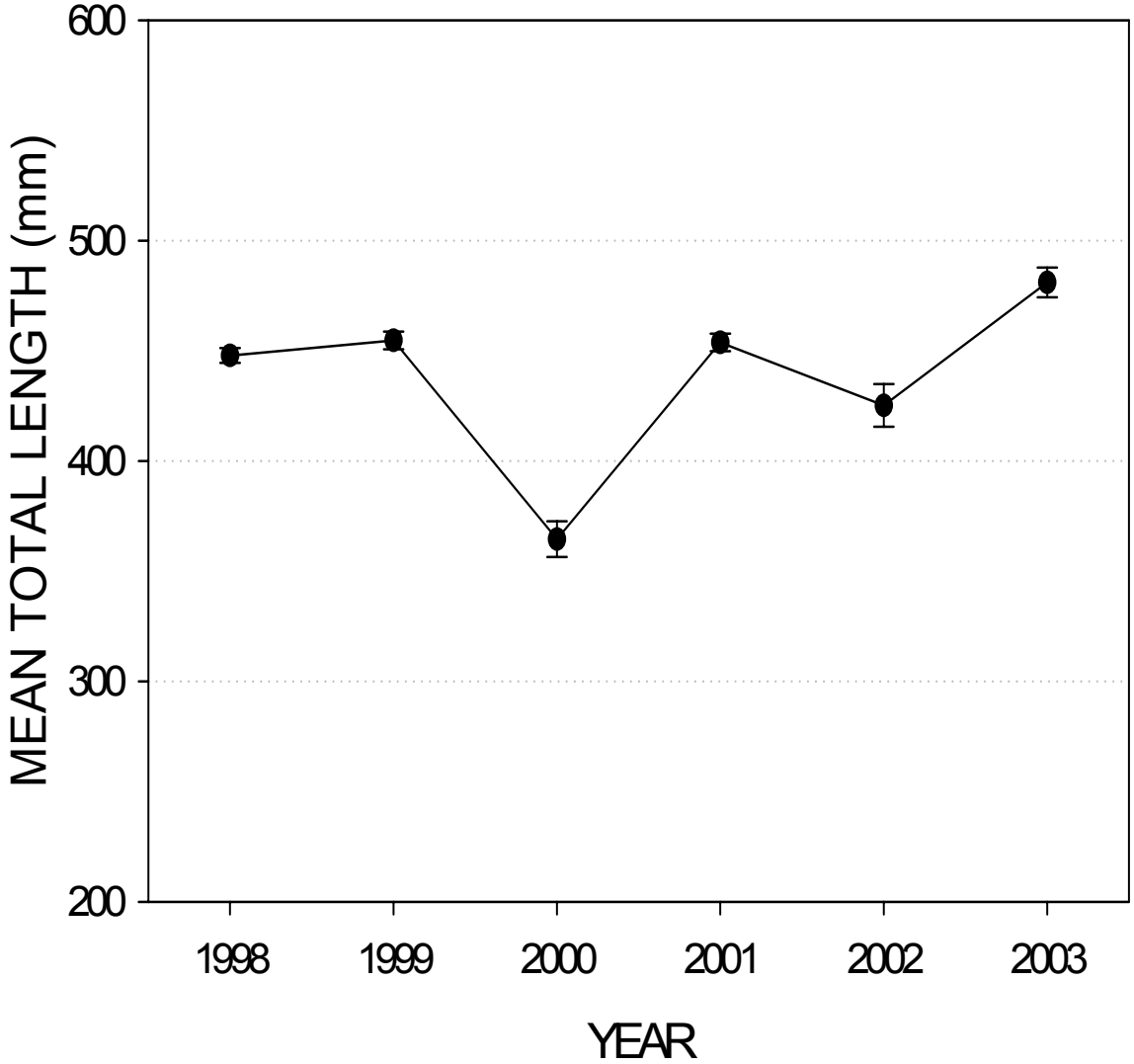

Figure 18. Mean total length (mm) of common carp in all Geomorphic Reaches collected during fall monitoring trips of each year, 1998-2003

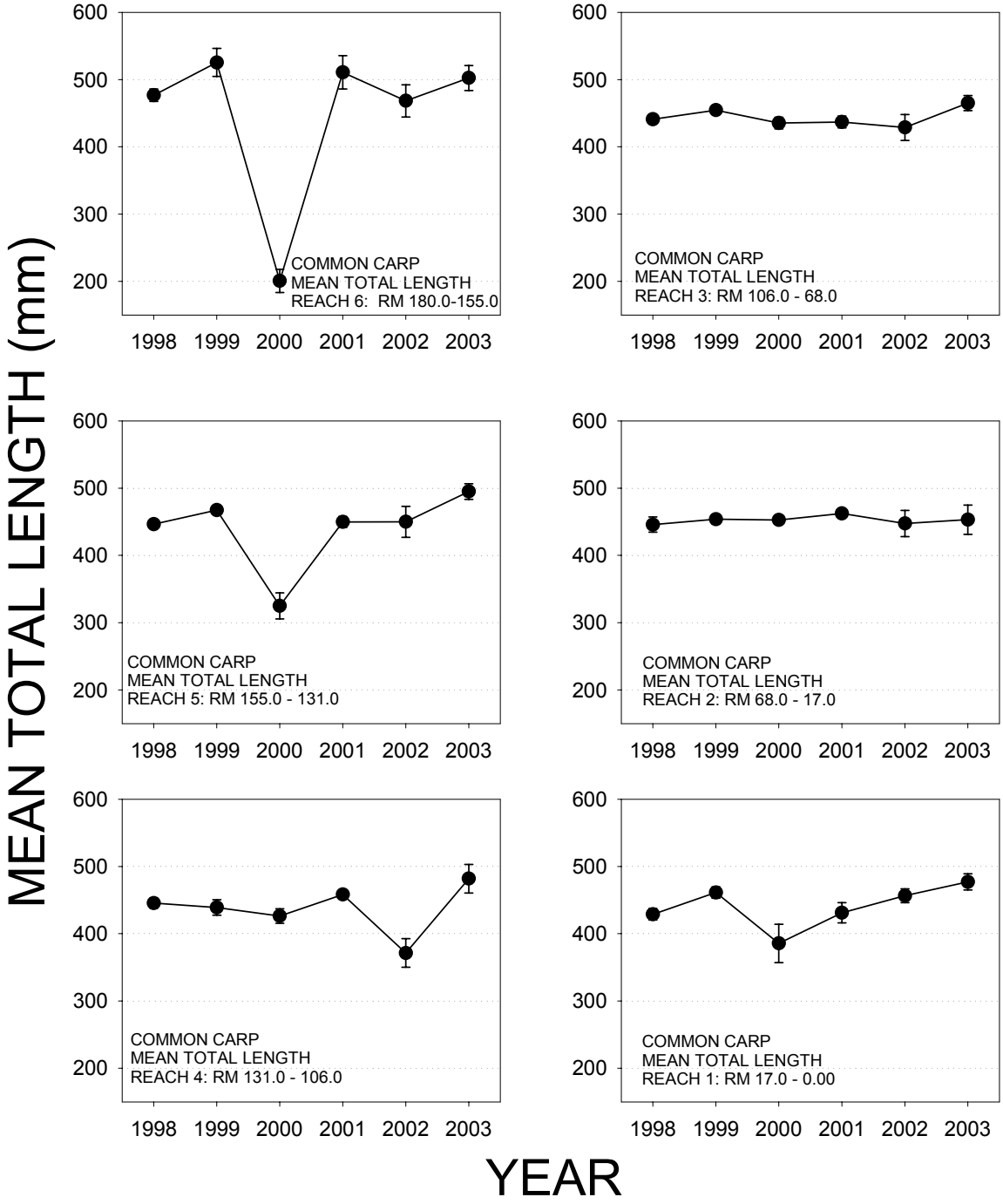

Figure 19. Mean total length (mm) of common carp by Geomorphic Reach and by year. Error bars represent the standard error of the mean.

CHAPTER II: ASSESEMENT OF FISH MOVEMENT THROUGH THE NON-SELECTIVE FISH LADDER AT HOGBACK DIVERSION, NEW MEXICO: 2003

INTRODUCTION

Fish movement through diversion structures on the San Juan River has been a concern to researchers for several years (Holden and Masslich 1996, Ryden 2000). Prior to 2001, five diversion structures were present in Reaches 6 and 5; Fruitland (RM 178.5), PNM (RM 166.6), APS (RM 163.3, Hogback (RM 158.6), and Cudei (RM 142.0). Such structures may affect fish communities by impeding fish movement, through entrainment, and disturbing fish and benthic communities during routine repair and reconstruction. Ryden (2000), during a mark/recapture study, found that native and non-native fishes could move upstream of each of these structures at certain flows. Cudei was removed in 2001 and replaced with a sub-surface siphon that shows no negative effects on fish movement. The removal of this structure allows free movement of fish for the 16.6 RM upstream to Hogback Diversion. It was also shown that Hogback Diversion likely limited upstream fish movement at certain times of the year (Ryden 2000). Construction of a non-selective fish ladder in 2001 at Hogback increases the opportunity for upstream movement for both native and non-native fish.

Mechanical removal efforts targeting channel catfish in a sub-portion of Reach 6, PNM Weir to Hogback Diversion (RM 166.6 to 159.0) has been ongoing since 1998, with intensive removal beginning in February 2001. Declining trends in abundance and distribution of channel catfish were observed in 2001, prior to spring runoff, with a significant increase in the number of channel catfish captured the rest of the year (Davis 2002). Speculation for the apparent increase in channel catfish catch rates post runoff included an increased activity level due to higher water temperature, better sampling conditions created by low, clear flows and upstream movement through the non-selective fish ladder at Hogback. To assess movement through the Hogback fish ladder, actions preliminary to full implementation of a mark-recapture project began in fall 2001. This project officially began as a San Juan River Recovery Implementation Program (SJRIP) action in fiscal year 2003.

Study objectives were as follows:

1.) Determine utilization of the non-selective fish ladder at Hogback Diversion by channel catfish, common carp, and flannelmouth and bluehead suckers.

2.) Determine and evaluate fish movement above APS Weir.

3.) Relate non-selective fish passage results to attainment of non-native removal target objectives.

4.) Relate results towards future recommendations regarding fish ladder design at other diversion structures on the San Juan River.

STUDY AREA

The study area was the San Juan River, New Mexico from PNM Weir (RM 166.6) downstream to Shiprock (RM 147.9) and encompasses portions of geomorphic Reaches 6 and 5. Fish tagging occurred from Hogback Diversion (RM 158.6) downstream to Shiprock. Sampling for monitoring recaptures was conducted from PNM Weir to Hogback Diversion during FWS intensive removal trips. However, recaptures are monitored riverwide during fall monitoring conducted by FWS-GJ and in Reaches 2 and 1 during UDWR non-native removal efforts in the lower San Juan River

METHODS

A total of five tagging trips were conducted from 2001 to 2003, prior to high spring flows, below Hogback Diversion. Trips in 2001 and 2002 focused exclusively on channel catfish. Efforts were expanded in 2003 to include common carp, and flannelmouth *Catostomus latipinnis* and bluehead *Catostomus discobolus* suckers. Fish were collected using a raft-mounted electrofishing unit. All fish collected were measured for total and standard lengths (nearest 1mm), weighed (nearest 5g) and equipped below the dorsal fin with a visual dangler tag. Dangler tags were blue with the initials SJR followed by a unique 5-digit numeric code. Length and weight data and collection effort (hours of electrofishing) were separated by river mile and utilized to calculate CPUE by reach. All rare fish collected were measured for total and standard lengths, weighed, checked for the presence of a PIT or radio tag, PIT tagged if appropriate, and immediately released. River mile of capture (GPS location when possible) and comments on relative condition of the fish were also recorded.

Monitoring movement of tagged fish was done in conjunction with non-native mechanical removal trips performed by U.S. Fish and Wildlife Service, New Mexico Fishery Resources Office and cooperators (FWS-GJ, U.S. Bureau of Indian Affairs, NMDGF and

UDWR). Recaptured fish were measured for total and standard lengths, weighed and tag number recorded. Location of recapture was recorded by beginning river mile of sampling reach (which differed between tagging and non-native removal efforts) along with effort (hours of electrofishing). Initially, all non-native fish recaptured above Hogback Diversion were removed. After further review, recaptured fish were released to determine if further movement upstream of APS or downstream of Hogback occurred. Data from fish recaptured during the fall main channel monitoring trips were incorporated in the dataset.

Data were summarized by species and separately for tagged and recaptured fish. Total number of fish was calculated by trip and year. Catch per unit effort was calculated by dividing the number of fish collected by total effort (hours). Distance moved by recaptured fish was calculated for each individual by subtracting the beginning river mile of when the fish was tagged from the beginning river mile of when the fish was recaptured. Negative distances indicate movement upstream while positive distances indicate movement downstream.

RESULTS

A total of 1,828 fish were captured during tagging efforts conducted from 2001 to 2003. Channel catfish comprised 55% of total catch (n=1,007), common carp 32% (n=587) , and flannelmouth and bluehead suckers comprised 9% and 2% (n=171 and n=37) respectively. Other species represented by less than ten fish captured were black bullhead *Ameiurus melas*, red shiner *Cyprinella lutrensis*, and sucker hybrids (Table 12). Mean CPUE (fish/hour of electrofishing) were 127.91 for a single trip in 2001 and 96.08 for three trips in 2003 (Table 13). Effort was not recorded for the 2002 tagging trip.

Total number of fish tagged from 2001-2003 was 1,758 (Table 3). Channel catfish comprised 57% of overall species tagged (n=979); common carp 33% (n=577); flannelmouth and bluehead suckers 9% (n=164) and 2% (n=36) respectively. Two hybrids, one flannelmouth x white sucker *Catostomus latipinnis* x *Catostomus commersoni* and a flannelmouth x bluehead sucker, were also tagged (Table 14, Figure 20). Mean CPUE for tagged fish were 126.28 in 2001 and 91.20 fish/hour of electrofishing in 2003 (Table 15).

A total of 512 fish (29% of all tagged fish) were recaptured during all sampling efforts in 2002-2003 (Table 16). Common carp and channel catfish comprised 98% of recaptures (50% and 48% respectively). Channel catfish recaptures totaled 247, with 214

recaptured below Hogback Diversion and 33 above Hogback. Of the channel catfish recaptured upstream of Hogback, 28 were between APS Weir and Hogback Diversion (RM 163.6-159.0) and 5 recaptured above APS weir (RM 166.6-163.6). These 33 recaptures represented 31 individual channel catfish (two individuals were recaptured twice) and averaged 435 mm TL, 359 mm SL and 934 g in weight. All channel catfish recaptured during 2002 and 2003 above Hogback Diversion were recaptured during or after June of each year. Twenty five different channel catfish were recaptured between APS Weir and Hogback Diversion and moved an average of 7.1 river miles upstream from their last capture. Five channel catfish were recaptured between PNM and APS and had moved an average of 9.2 river miles upstream from last capture site.

A total of 256 common carp were recaptured during sampling efforts in 2003. Of these fish, 242 were recaptured below Hogback and 14 fish representing 12 individuals were recaptured between APS and Hogback. No tagged common carp were recaptured above APS. The twelve common carp that navigated upstream of Hogback averaged 496 mm TL, 367 mm SL and 1789 g in weight. One individual was recaptured in April while the remaining 11 were captured after June, moving an average of 6.7 river miles upstream. Five bluehead suckers and 4 flannelmouth suckers were recaptured below Hogback Diversion (Table 16).

Recaptured channel catfish moved an average of 0.61 RM upstream and recapture distances ranged from zero to 12 RM (Table 17). A total of 97 channel catfish moved upstream for an average distance of 3.47 RM. One hundred fourteen channel catfish moved downstream an average of 1.65 RM, and 34 channel catfish were recaptured in the same river mile of original capture (Table 18). For fish that did not exhibit either upstream or downstream movement, 5 were recaptured two or more times in the same river mile. Two channel catfish, considered outliers and not included in the calculation of downstream average, moved 109.5 and 119.5 RM downstream after initial tagging (Dale Ryden, personal communication). As mentioned previously, 33 channel catfish moved upstream of Hogback during 2002-2003 including five individuals that continued to move upstream of APS (Figures 21 and 22). One recaptured channel catfish moved both up and downstream of Hogback during winter 2003 (Figure 22).

Recaptured common carp moved an average of 0.13 RM upstream and recapture distances from original capture location ranged from zero to 8.1 RM (Table 17). A total of 104 common carp moved upstream for an average distance of 1.74 RM. Eighty nine common carp moved downstream for an average of 1.6 RM and 55 showed no movement (Table 18). Of the fish that did not exhibit either upstream or downstream movement, 6 were captured more than twice in the same river mile. Fourteen common carp moved upstream of Hogback in 2003 (Figures 23 and 24).

Recaptured flannelmouth sucker moved an average of 0.98 RM upstream with a range of 0.1 to 2 RM, while bluehead sucker moved an average of 1.25 RM downstream with a range of 0.5 to 3 RM (Table 17). One flannelmouth sucker moved upstream 0.1 RM and the other three moved an average of 1.5 RM downstream. All recaptured bluehead sucker movement was downstream (Table 18).

Rare fish collected in 2001-2003 during tagging trips included 16 razorback suckers and one Colorado pikeminnow (Appendix E).

DISCUSSION

A decreasing trend was observed in the number of channel catfish tagged with each subsequent tagging effort. The trend corresponds with a steady decline in channel catfish CPUE. The decrease may be due to an increase in mechanical removal efforts from Hogback to Shiprock in 2003. The opposite trend was noted in native suckers. In 2003, CPUE for flannelmouth and bluehead suckers increased with each subsequent tagging trip. No explanation for the increase can be determined at this time. Continued tagging efforts in FY 2004 will allow for a better assessment and hypotheses as to the occurrence of both trends.

Non-native fish tagged below Hogback and subsequently recaptured above the diversion indicate probable use of the non-selective fish ladder completed in 2001. Actual use of the ladder by tagged fish has not been documented through presence/absence sampling to date but it is assumed that these recaptured fish utilized the ladder. Data indicate that the majority of these fish were recaptured post May of each year. These results are a possible factor that sampling above Hogback initially occurred in April 2003 and not again until June 2003. However, data collected by Albert Lapahie (Navajo Nation Department of Fish and Wildlife) at the PNM fish ladder indicated that movement of

channel catfish and common carp was concentrated in June and July 2003. These data, coupled with that reported on during non-native removal trips from 2001 to 2003, would support the theory that channel catfish movement occurs primarily during the summer months.

Factors which trigger upstream movement of non-native fish in the San Juan River are not fully understood. It has been theorized by researchers that peaks in discharge during spring runoff may be the trigger but undoubtedly this factor is not mutually exclusive. Additional factors including water temperature and season (corresponding with the spawning season of channel catfish) may also play important roles.

Data collected in 2003 also show that APS diversion is not a barrier to fish movement. Both this study and that reported by Masslich and Holden (1996) showed that movement upstream of APS occurs at certain times of the year with passage possible when the sluice gate is open. When the gate is closed, fish would be required to navigate over the weir itself. No conclusive data indicates that movement above APS when the gate closed is completely prevented but one would think that it is limited.

This project will continue in FY 2004 and will be in the second and final year of the study. Current mark/recapture data, although limited, show channel catfish and common carp use the non-selective fish ladder at Hogback and that channel catfish can also bypass APS Weir. More channel catfish have been recaptured above Hogback than common carp, but on average common carp moved above the diversion after initial tagging in shorter time than channel catfish. More channel catfish are marked at present which increases the likelihood of recapture of this species. Efforts will be made in 2004 to increase the number of tagged flannelmouth and bluehead suckers and assess their use of Hogback as compared to non-natives. In addition, attempts to sample within the fish ladder at Hogback will also be conducted in 2004. These efforts will simply be a check of presence/absence of both marked and unmarked fish within the ladder. Data collected during 2004 will help answer questions on movement of the four common large bodied fish through both Hogback and APS diversions. Also, continued data collection and analyses may provide answers on what environmental cues trigger upstream movement of these fishes.

CONCLUSIONS

- Both channel catfish and common carp were recaptured above Hogback in 2002 and 2003. Recapture data also indicate APS Weir does not serve as a complete barrier to upstream movement of non-native fish.

- Majority of recaptures occurred after May of each year.

- Factors that trigger movement of non-native fish are unknown at this time but are likely associated with multiple variables including discharge, water temperature and season corresponding to spawning.

- Recaptured channel catfish moved an average of 0.61 river miles upstream while common carp recaptures moved an average of 0.13 river miles upstream.

- Continued tagging efforts and subsequent sampling trips will contribute to answering questions on the ability of the four common large bodied fish to bypass both Hogback and APS diversions.

Table 12. Total fish captured by species and year during tagging efforts from Hogback Diversion to Shiprock Bridge 2001-2003.

SPECIES	2001	2002	2003	TOTAL
AMEMEL			1	**1**
CATDIS			37	**37**
CATLAT			171	**171**
CATLAT X CATCOM			1	**1**
CATLAT X CATDIS			1	**1**
CYPCAR			587	**587**
ICTPUN	550	175	282	**1007**
PTYLUC			1	**1**
SALTRU			5	**5**
XYRTEX			16	**16**
TOTAL	**550**	**175**	**1103**	**1828**

Table 13. CPUE (fish/hour of electrofishing) calculated by trip and year for all fish collected during tagging efforts from Hogback Diversion to Shiprock Bridge 2001-2003.

	2001	2002	2003		
CPUE By Year	127.91	NA	96.08		
	11/05/2001	**4/04/2002**	**2/19/2003**	**3/04/2003**	**5/14/2003**
CPUE By Trip	127.91	NA	137.14	87.25	81.49

Table 14. Number of fish tagged by species and year from Hogback Diversion to Shiprock Bridge 2001-2003.

Species	Year			
	2001	2002	2003	Total
CATDIS			36	**36**
CATLAT			164	**164**
CATLAT X CATCOM			1	**1**
CATLAT x CATDIS			1	**1**
CYPCAR			577	**577**
ICTPUN	543	168	268	**979**
Total	**543**	**168**	**1047**	**1758**

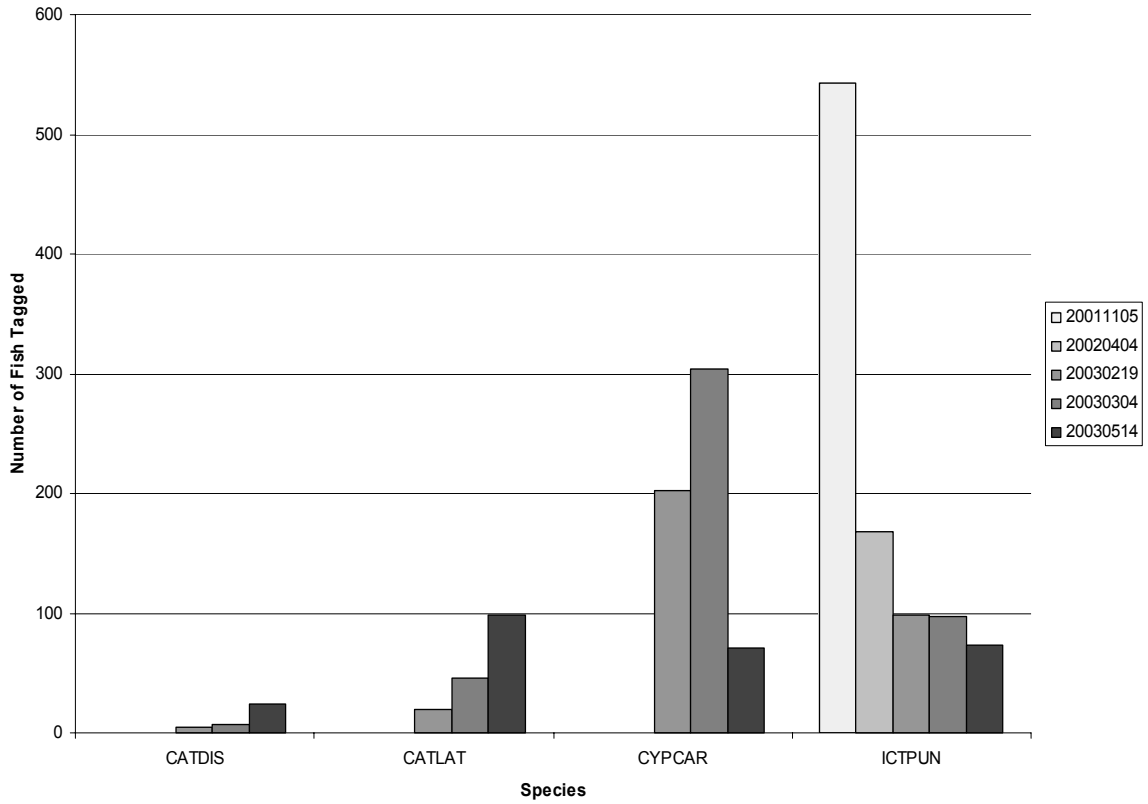

Figure 20. Number of fish tagged by species per tagging trip during 2001-2003 from Hogback Diversion to Shiprock Bridge.

Table 15. CPUE (fish/hour of electrofishing) calculated by year and trip for tagged fish from Hogback Diversion to Shiprock Bridge 2001-2003.

	2001	2002	2003		
CPUE By Year	126.28	NA	91.20		
	11/5/2001	**4/4/2002**	**2/19/2003**	**3/4/2003**	**5/14/2003**
CPUE By Trip	126.28	NA	132.65	84.10	73.76

Table 16. Recaptured fish by species and year 2002-2003, categorized into discrete river reaches separated by diversion structures.

Year	Species	PNM to APS	APS to Hogback	Hogback to Shiprock	Totals
2002	ICTPUN	5	21	7	**33**
2003	ICTPUN		7	207	**214**
	CYPCAR		14	242	**256**
	CATLAT			4	**4**
	CATDIS			5	**5**
	Total	**5**	**42**	**465**	**512**

Table 17. Average distance in river miles moved by species of recaptured fish 2002-2003. Negative values represent upstream movement.

Species	Average Distance	Range (RM)	N=
ICTPUN	-0.61	0 - 12	256
CYPCAR	-0.13	0 - 8.1	247
CATLAT	-0.98	0.1 - 2	4
CATDIS	1.25	0.5 - 3	5
Total	-0.36		512

Table 18. Summary of average upstream and downstream movement by species of recaptured fish 2002-2003.

Species	Upstream		Downstream		No movement
	N=	Average Distance (RM)	N=	Average Distance (RM)	N=
ICTPUN	97	3.47	114	1.65	34
CYPCAR	104	1.74	89	1.60	55
CATLAT	1	0.1	3	1.5	NA
CATDIS	NA	NA	5	1.25	NA

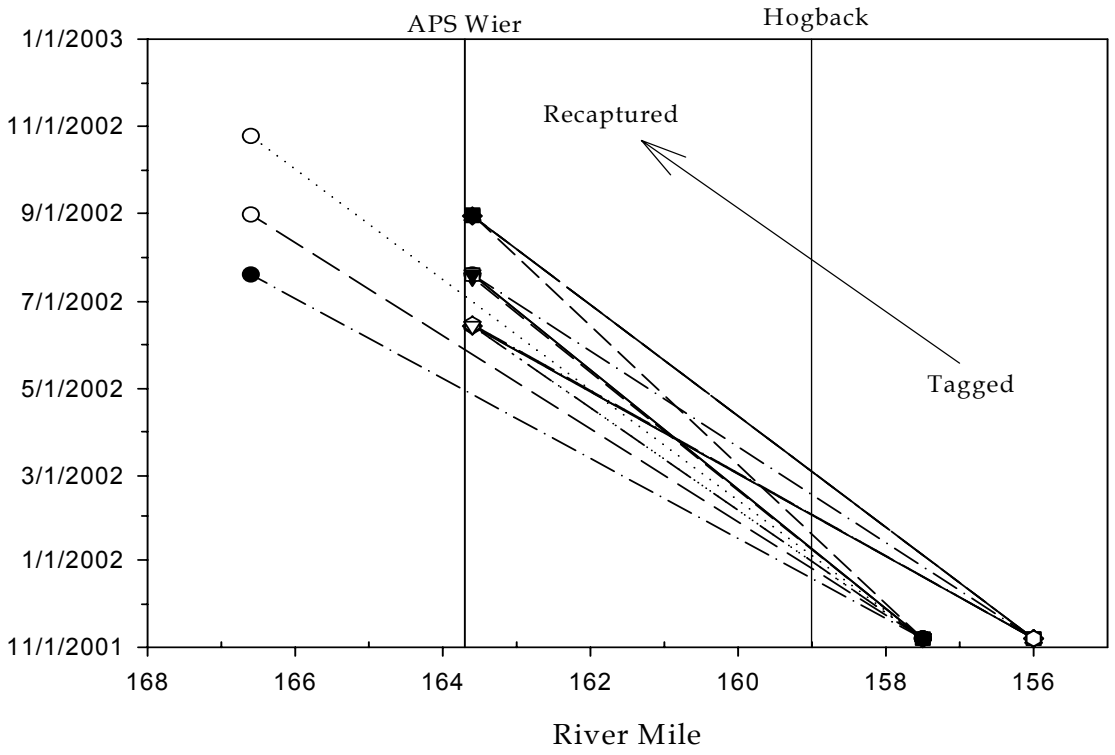

Figure 21. Channel catfish recaptured from November 2001 tagging effort. Each line represents the movement of an individual fish over time from initial capture/tag site to each subsequent recapture date/site. Vertical lines depict location of diversion structures. Arrows depict direction of movement.

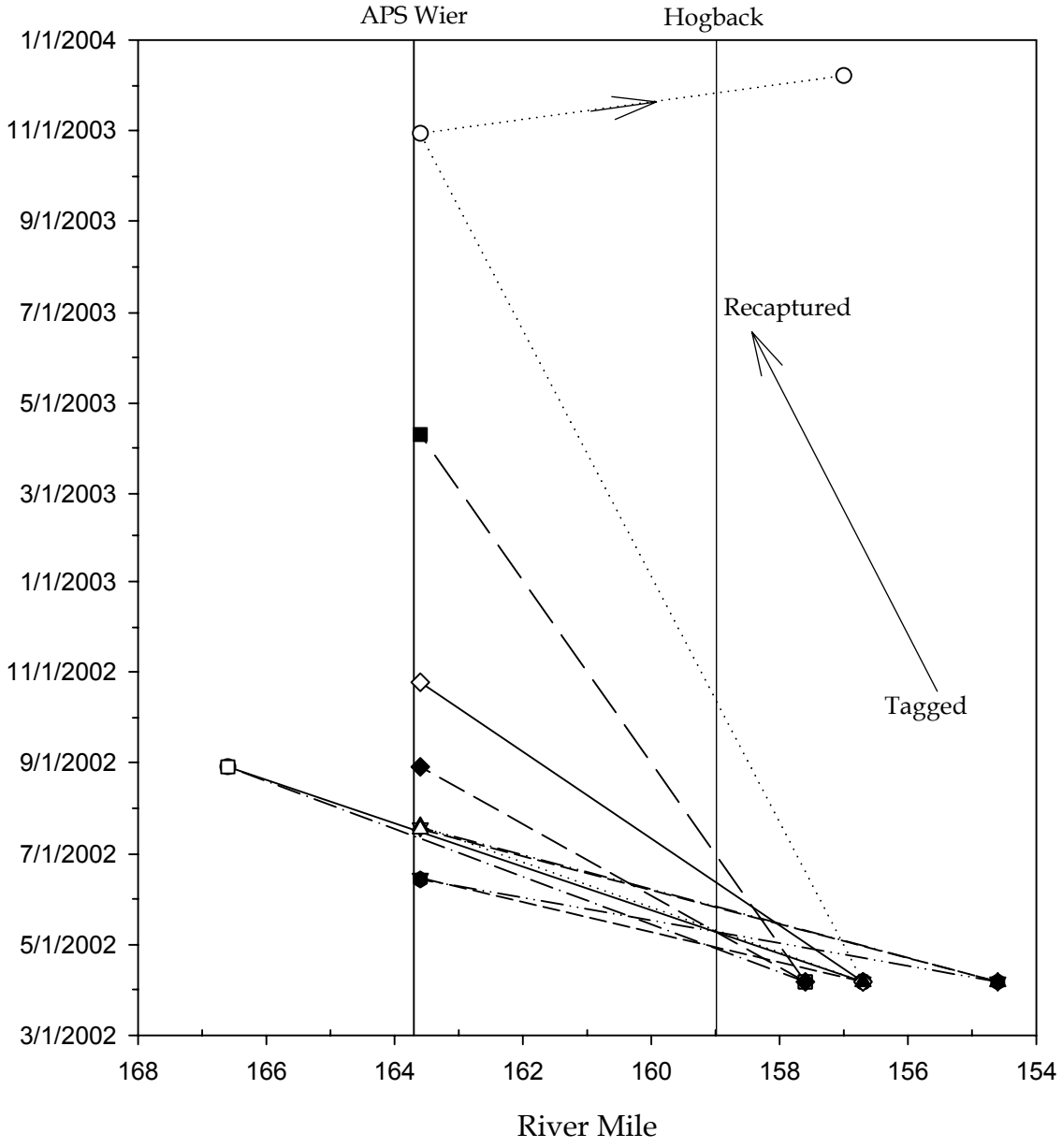

Figure 22. Channel catfish recaptured from April 2002 tagging effort. Each line represents the movement of an individual fish over time from the river mile tagged to each subsequent recapture date/site. Recaptures span a two year period. Vertical lines depict location of diversion structures and arrows depict direction of movement.

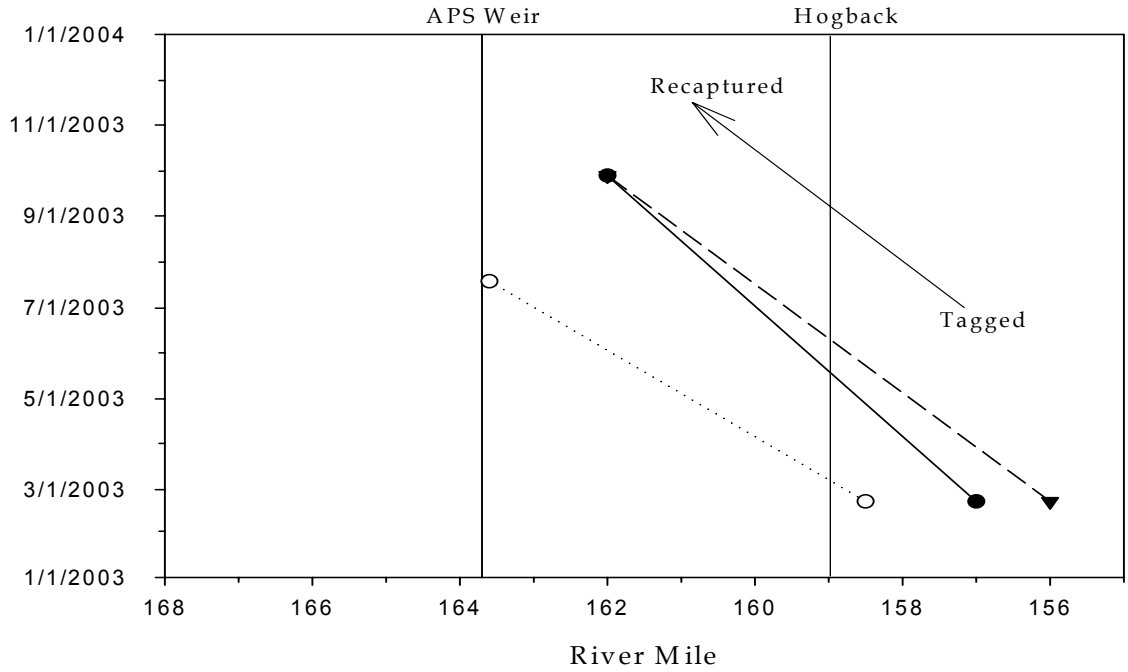

Figure 23. Common carp recaptures from April 2002 tagging effort. Each line represents the movement of an individual fish over time.

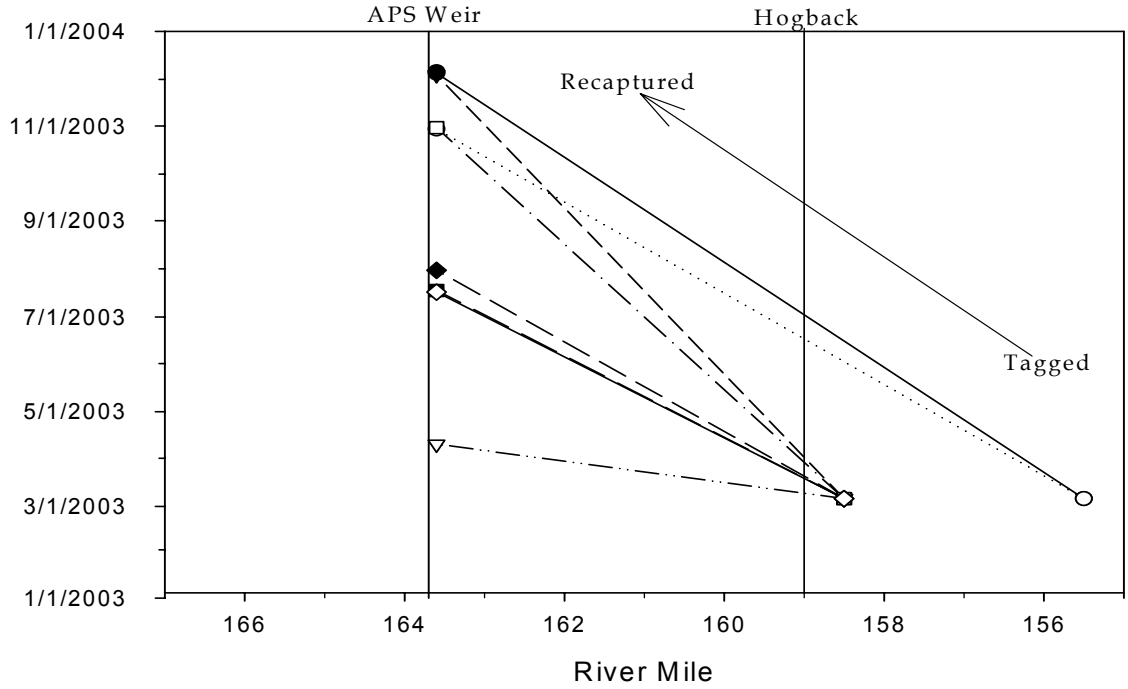

Figure 24. Common carp recaptured from March 2003 tagging effort. Each line represents the movement of an individual fish over time.

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APPENDICES

Appendix A. Colorado pikeminnow collected during intensive removal trips from PNM Weir to Hogback Diversion, 2003.

Date	RM or Section	PIT tag	Recapture	Total Length (mm)	Standard Length (mm)	Weight (grams)	Comments
03/08/2003	163.4-159.0	7F7B1B0B31	Y	524	440	1100	
	163.4-159.0	7F7B12420E	Y	524	430	1100	
07/16/2003	163.4-159.0	NO TAG	N	111	92	10	MORTALITY
07/17/2003	163.4-159.0	NO TAG	N	107	72	--	
07/17/2003	163.4-159.0	NO TAG	N	102	78	--	
07/17/2003	163.4-159.0	NO TAG	N	114	90	--	
10/28/2003	164.2	423D1A4419	N	181	143	35	
	163.4-159.0	7F7B1B0B31	Y	531	445	1250	
10/29/2003	163.4-159.0	423D1A4419	Y	190	155	25	
	163.4-159.0	423C7F3F46	N	168	134	42	
12/02/2003	163.4-159.0	423C68185B	N	168	137	33	
	163.4-159.0	423C695F3B	N	153	122	20	
	166.6-163.4	4415221419	Y	167	138	40	
	163.4	423D083C50	N	155	124	20	
	161.2	423D016C14	N	171	135	40	
12/03/2003	163.4-159.0	423D17104B	N	174	142	39	
	163.4-159.0	44170A027E	Y	183	149	65	

Appendix B. Razorback sucker collected during intensive removal trips from PNM Weir to Hogback Diversion, 2003.

Date	RM or Section	PIT tag	Recapture	Total Length (mm)	Standard Length (mm)	Weight (grams)	Sex (M/F) Tubercles (T)
07/16/2003	166.6-163.4	423F6C1D7D	Y	439	365	900	
	166.6-163.4	5228604717	Y	435	358	850	
10/28/2003	163.4-159.0	425B650B18	Y	445	368	1050	M/T
	163.4-159.0	5239306E3E	Y	385	315	510	

Appendix C. Colorado pikeminnow collected during intensive removal trips from Hogback Diversion to Shiprock Bridge, 2003.

Date	RM or Section	PIT tag	Recapture	Total Length (mm)	Standard Length (mm)	Weight (grams)	Comments
05/07/2003	157.0	7F7D11472D	Y	632	535	2050	
06/10/2003	155.8	NO TAG	N	90	75	--	
09/03/2003	154.2	423C7D771E	N	130	101	13	
	154.2	423D101951	N	152	115	25	
09/04/2003	156.0-155.0	NO TAG	N	137	113	20	
11/11/2003	158.6-157.0	NO TAG	N	69	55	--	
	158.6-157.0	NO TAG	N	60	47	--	
	157.0-156.0	NO TAG	N	49	38	--	
	157.0-156.0	NO TAG	N	59	44	--	
	157.0-156.0	NO TAG	N	47	43	--	
	156.0-155.0	NO TAG	N	69	56	--	
	156.0-155.0	NO TAG	N	72	55	--	
	156.0-155.0	NO TAG	N	62	47	--	
	153.0-152.0	NO TAG	N	55	44	--	
	156-0-155.0	NO TAG	N	145	115	22.5	
11/12/2003	158.6-157.0	NO TAG	N	58	47	--	
	158.6-157.0	NO TAG	N	50	39	--	
	158.6-157.0	NO TAG	N	69	52	--	
	153.0-152.0	NO TAG	N	69	53	--	
	157.0-156.0	NO TAG	N	121	95	16	
	156.0-155.0	NO TAG	N	65	50	--	
	155.0-154.0	NO TAG	N	--	--	--	**
12/09/2003	158.8-157.0	NO TAG	N	61	47	--	
12/10/2003	151.5	NO TAG	N	64	50	--	

Appendix D. Razorback sucker collected during intensive removal trips from Hogback Diversion to Shiprock Bridge, 2003.

Date	RM or Section	PIT tag	Recapture Blank = Y No = N	Total Length (mm)	Standard Length (mm)	Weight (grams)	Sex (M/F) Tubercles (T)
05/07/2003	156.5	426A236D20		365	304	850	
	157.1	423F6E6558		405	330	600	
	158.4	423F171D43		408	342	900	F
	156.5	424A237242		411	354	840	T
	155.6	423E682972		425	352	900	M
	157.1	423E633457		425	340	1050	F
	157.0-156.0	52283B0450		426	345	900	
	155.1	532405032C		428	345	1100	M/T
	158.4	423E446022		428	354	900	F
	156.5	4240181B0C		435	365	840	
	155.1	5228404A7F		436	362	950	M/T (RIPE)
	156.5	423F5D406A		442	368	810	
	155.5	423E5D0D08		443	370	1350	M/T (RIPE)
	156.3	4242324D75		453	359	800	
	156.6	423F0D5520		455	372	1150	
	155.4	42417F735D		460	390	1200	T
	158.3	42421C7E34		465	392	1100	
	156.5	5324507146		481	409	1480	
05/08/2003	158.0	42696B386C		290	240	300	F
	158.5	4269582672		312	259	450	F
	158.4	425C030138		366	310	870	
	157.0-156.0	423E40602E		423	350	1200	
	155.9	423E25020E		432	357	990	
	158.3	423E744C06		432	368	1000	
	155.9	5326034D21		460	386	1220	
05/09/2003	158.5	426926224E		328	270	400	
	155.8	52290D4047		402	330	680	F
	155.9	423F7F6019		431	360	920	
	158.1	4240122A62		434	357	820	F
	157.5	4268707839		435	365	1250	
	156.0	4240010F47		436	362	820	M/T (RIPE)
	155.5	53245A7C46		449	375	1150	F
06/10/2003	158.4	423E5E570E		415	398	1000	
	157.3	423F1A154A		468	380	1350	M/T (RIPE)
06/11/2003	154.0	5228752719		425	332	700	M (RIPE)
“	154.7-152.0	52392E6708		395	318	950	F
06/12/2003	156.5	423F0E4F5F		413	330	770	M/T (RIPE)
	157.1	4242473622		450	375	1075	
09/03/2003	158.0	423E38730A		432	348	920	
	151.4	532405032C		433	366	300	
	158.0	423F7E7469		440	366	1100	
	156.2	423E654D5D		537	400	1500	
09/04/2003	158.0	522A575300		403	329	620	

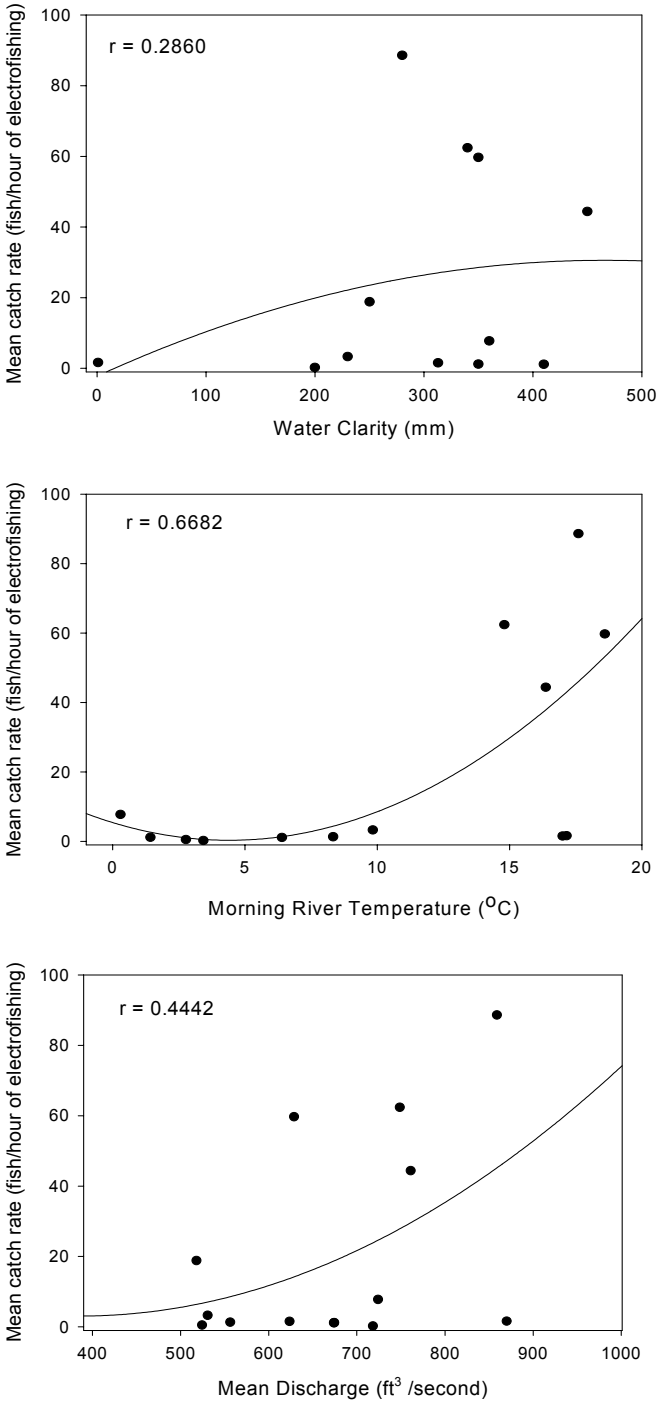
Appendix D (continued). Razorback sucker collected during intensive removal trips from Hogback Diversion to Shiprock Bridge, 2003.

Date	RM or Section	PIT tag	Recapture	Total Length (mm)	Standard Length (mm)	Weight (grams)	Sex (M/F) Tubercles (T)
11/11/2003	158.6-157.0	42694D0D54		271	225	225	
	153.0-152.0	4269025C39		290	233	215	
	158.6-157.0	42693C4E34		303	248	250	
	158.6-157.0	42695B6262		305	--	290	
	158.6-157.0	4269055C39		306	238	250	
	158.6	42695B6262		308	240	240	
	158.6	426956485C		319	249	295	
	158.6	426A261D6B		320	253	321	
	157.0-156.0	4269E7955*		324	260	310	
	155.0-154.0	426B245C32		335	271	360	
	153.0-152.0	42686E2511		336	264	320	
	153.0-152.0	425B744666		358	290	380	
	158.6	425B6A1A6D		380	271	370	
	158.6-157.0	425B733110		393	229	200	
	158.6-157.0	426A40196C		393	231	285	
	156.3	423D073604	N	435	360	1500	
	158.6	423F035D5A		435	355	1600	
	158.6-157.0	42423D5E34		440	360	1300	M/T
	156.3	42686F5C64		440	359	1850	
	158.6	423F5D406A		443	362	860	
	156.0-1553.0	423E6F352F		448	367	930	
	156.6	423F0D5520		455	372	1650	
	158.6-157.0	423F633E41		462	385	1250	
	156.3	423E557862		510	421	1550	
	158.6-157.0	423E725455		518	518	1410	
11/12/2003	152.0-151.0	42685B592A		310	248	280	
	158.6-157.0	42687195611		272	221	165	
	155.0-154.0	426B2B3208		299	236	240	
	156.0-155.0	426A090E3D		306	245	240	
	152.0-151.0	4269044367		312	256	340	
	157.0-156.0	426956485C		313	248	290	
	158.6-157.0	425B68262B		315	248	260	
	153.0-152.0	4268577300		324	255	320	
	152.0-151.0	4269581102		339	248	250	
	152.0-151.0	425B744666		357	290	400	
	158.6-157.0	423F7E0831		467	389	1010	
12/09/2003	158.6-157.0	42694D4C0E		266	217	200	
	158.6-157.0	426A3B7928		279	226	75	
	158.6-157.0	426B3F043B		283	233	200	
	158.6-157.0	425B733110		295	240	225	
	157.0-156.0	42687E4733		295	245	225	
	155.9	426B10597C		305	241	140	
	157.0-156.0	426B10597C		307	250	250	
	158.6-157.0	42694E4215		311	255	275	
	158.6-157.0	42694A6A5C		320	264	300	
	158.6-157.0	--		325	265	230	
	157.0-156.0	522A215F2D		410	347	700	
	158.6-157.0	423E454C69		444	370	800	
	157.0-156.0	522A616543		445	370	990	
	158.8-157.0	4240033016		456	382	1150	
12/10/2003	150.0-149.0	426A295045		307	254	320	
12/11/2003	149.0-148.6	425B687F49		278	231	215	
	151.0-150.0	426B360141		290	241	270	
	151.0-150.0	425B6F7467		324	270	310	

Appendix E. Razorback sucker collected during tagging efforts from Hogback Diversion to Shiprock Bridge 2001-2003

Date	RM or Section	PIT tag	Recapture Blank = Y No = N	Total Length (mm)	Standard Length (mm)	Weight (grams)	Comments
02/19/2003	157.8	4242312966		489	402	1200	
	156.8	53245A7C46		446	365	950	
03/04/2003	157.1	5324111728		423	341	1200	
	156.7	423E78024C		459	380	1180	
	156.3	522A4D342B		360	302	650	
	155.7	423E78141C		418	335	820	
	154.6	424004437A		425	357	900	
05/14/2003	157.6	42301B1B41		569	475	2000	
	156.9	423E7E4D15		432	367	850	
	156.8	423F712672		498	423	1450	
	156.6	423E25020E		422	350	850	
	155.2	425B650B18		440	365	850	
	154.9	423F633E41		462	393	1250	
	154.8	423F031672		487	410	1400	
	154.4	522A47736F		435	370	800	
	154.1	423F5E0F2B		409	329	750	

** An individual Colorado pikeminnow was observed but not netted on 02/19/2003 at RM 157.0



Appendix F. Catch per unit effort of channel catfish (fish/hour of electrofishing) compared to various water quality conditions (water clarity and morning river temperature) and mean discharge for intensive removal trips from PNM Weir to Hogback Diversion, 2002-2003.