NON-NATIVE SPECIES MONITORING AND CONTROL, SAN JUAN RIVER 1998 - 1999

PROGRESS REPORT FOR THE SAN JUAN RIVER RECOVERY IMPLEMENTATION PROGRAM

Prepared By:

Jude R. Smith and James E. Brooks
U.S. Fish and Wildlife Service
New Mexico Fishery Resources Office
2105 Osuna NE
Albuquerque, New Mexico 87113

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EXECUTIVE SUMMARY

The mechanical removal of non-native fishes in the San Juan River initially began in October 1995, but was not formally instituted as an ongoing management tool until 1998. This interim report summarizes and presents the results of monitoring and removal efforts for 1998 and 1999. The primary objectives of this portion field activities for the San Juan River Recovery Implementation Program (SJRIP) are to evaluate the efficacy of passive (netting) and active (electrofishing) mechanical methods for removal of large-bodied non-native fishes, to characterize changes in the abundance and distribution patterns of channel catfish as a response to mechanical removal efforts, and to assess the feasibility of a transplantation program to remove channel catfish from the San Juan River and relocate them to isolated impoundments currently used for recreational fisheries.

Mechanical removal efforts includef removal of all non-native fishes collected during routine adult monitoring sampling by electrofishing downstream of the diversion at the Hogback Diversion, New Mexico. In April 1998, one discrete reach between RM 137.2 and 127.6 was intensively sampled to remove channel catfish and common carp. Starting in March 1999, one more discrete reach was added to intensive removal efforts, between the PNM weir and the Hogback diversion. Starting in March 1998, all channel catfish collected within the discrete reaches where retained for distribution to small impoundments. The Navajo Department of Fish and Wildlife and New Mexico Department of Game and Fish were responsible for the distribution of channel catfish to the impoundments.

During 1998 and 1999, a total of 5820 channel catfish were removed from Reaches 1-6. CPUE for all size classes combined increased between 1998 and 1999, from 0.3588 to 0.5503 fish per minute electrofishing. From 1998 to 1999, mean TL decreased from 291.11 ±128 mm to 257 ± 99.7 mm. The number of common carp removed decreased between 1998 and 1999, from 2,081 to 1,203, respectively and catch rates between reaches and years revealed that CPUE increased statistically in reaches 5, 4, and 3 and remained similar in reaches 6, 2, and 1. The mean total length for common carp increased significantly ($p<.01$) between 1998 and 1999.

A total of 296 channel catfish were stocked in the spring of 1998 into Cow Springs, Ganado, and Many Farms lakes, all of which are small, closed impoundments on the Navajo Nation. An additional 189 channel catfish were stocked in the fall of 1998 in conjunction with the adult monitoring trip A total of 429 channel catfish were transplanted from the San Juan River into Farmington and Jackson Lakes, 16-18 March 1999. During April 1999, a total of 688 channel catfish were stocked into closed impoundments on the Navajo Nation.

The occurrence of gizzard shad in Morgan Lake, presumably from a hatchery largemouth bass stocking, poses additional non-native threats to native species. In addition to direct effects of reducing non-native species numbers in the San Juan River, transplantation of channel catfish from the San Juan River minimizes reliance on hatchery-produces fish to maintain recreational

fisheries. It is proposed that hatchery funds be redirected to transplantation efforts to both promote and expand removal of non-natives and to reduce the threat of additional introductions of new non-native fish species.

The primary conclusions of 1998-1999 results were:

1. Electrofishing removal of channel catfish has resulted in a decrease in the mean total length and weight of captured fish and is proposed to continue.

2. Electrofishing removal of common carp has not resulted in changes in the size of captured fish and is proposed to be reassessed.

3. Additional information is needed on the age and growth and reproductive biology of channel catfish and common carp to refine and/or assess removal efforts.

4. Transplantation of channel catfish from the San Juan River to isolated impoundments is supported by local anglers and has provided larger fish than currently supported by hatchery program.

5. The unintentional introduction of non-target organisms during hatchery stockings of sportfish poses additional risks for the introduction of new non-native species in the San Juan Basin.

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INTRODUCTION

The control of non-native species to accomplish reduction in distribution and abundance is a primary concern to be addressed as part of recovery programs for rare native fishes. In the San Juan River, the widely distributed and abundant channel catfish poses a major obstacle to recovery of the Colorado pikeminnow and razorback sucker. While other large-bodied non-native species occur within the San Juan River, the channel catfish occupies essentially all available habitat types on a year-round basis, larger individuals prey upon native fishes, and overlap with resident native fishes in other resource uses is high. Recreational angling in the San Juan River downstream of Farmington, New Mexico appears low based upon personal observations of the authors, other San Juan River researchers, and regional New Mexico Department of Game and Fish. However, no data were available to quantify use and exploitation of the San Juan River channel catfish population by anglers.

The apparent absence of substantial angler exploitation of the channel catfish population, combined with the prevalence of common carp and periodic invasion of warmwater lacustrine species upstream from Lake Powell were the focus of efforts in this study segment to evaluate suppression of non-native fishes by mechanical removal. All non-native fishes were the target of removal efforts, however, channel catfish were emphasized due to the species' magnitude of potential negative impacts to native fishes and due to the potential use of removed channel catfish in recreational angling programs isolated from the San Juan River. We report upon the results of mechanical removal efforts. The relationship of removal to changes in population dynamics of channel catfish is presented and discussed.

The study objectives were to:

1. Evaluate the efficacy of passive (netting) and active (electrofishing) mechanical methods for removal of large-bodied non-native fishes.

2. Characterize changes in the abundance and distribution patterns of channel catfish as a response to mechanical removal efforts.

3. Assess the feasibility of a transplantation program to remove channel catfish from the San Juan River and relocate them to isolated impoundments currently used for recreational fisheries.

STUDY AREA

The entire San Juan River, including accessible secondary channels, from Farmington, New Mexico downstream to Clay Hill's Crossing, Utah was sampled for this study segment. Removal efforts were concentrated from the PNM powerplant weir near Fruitland, New Mexico downstream Mexican Hat, Utah and were integrated into the adult monitoring trips. These trip usually took place in April-May and October in 1998 and 1999. In addition to the adult monitoring trips one discrete reach was added to removal efforts in 1998 and one more was added in 1999. These reaches were from the PNM weir to Hogback diversion and from RM 137 to RM 127. These reaches were sampled independently from the adult monitoring trips.

METHODS

In April 1996, mechanical removal efforts were expanded to include removal of all non-native fishes collected during routine adult monitoring sampling by electrofishing downstream of the diversion at the Hogback Diversion, New Mexico and further expanded river-wide in 1997. In April 1998, one discrete reach between RM 137.2 and 127.6 was added to channel catfish and common carp removal efforts. Starting in March of 1999, one more discrete reach was added between the PNM weir and the Hogback diversion. These reaches were sampled for three consecutive days each. All channel catfish and common carp or at least a large sub sample were measured for total length and standard length to the nearest millimeter, and weighed to the nearest grams. All channel catfish and common carp collected were enumerated regardless.

In addition to the electrofishing effort, hoop netting was applied to a discrete 0.5 km reach located at RM 127. Baited hoop nets were set parallel to the shoreline for up to 120 hour periods. Approximately 6 hoop nets were set within 0.5 km study reach . Netting on the hoop nets were 3 in, 2 in, and ½ in stretch, and the hoops were 2 ½ ft to 4 ft in diameter. Two types of baits were used soured corn /sorghum and aged waste cheese mixed with beef blood . Hoop nets were set in deep low velocity waters and in most cases downstream of a debris pile. Mechanical removal using hoop nets within the 0.5 km test reach was discontinued after the summer of 1998. CPUE for hoop netting efforts was calculated as the number of fish captured per net day (one net set per 24 hour sampling period).

Starting in March 1998, all channel catfish collected within the discrete reaches where retained for distribution to small impoundments. The fish were taken from the electrofishing rafts and held in live wells treated with salt at 189 grams/10 gallons of water and 10 milliliters/10 gallons of water of stress coat. A battery powered aeration system was rigged to circulate and provide adequate oxygen levels during transport in the live wells. Channel catfish were removed from the live well and placed directly to a distribution truck, but in some cases channel catfish were held over night in holding pens until the next day for distribution. All channel catfish were distributed into tribal or state impoundments dependent on the location they were captured. The lakes were small and provided no access of channel catfish back to the San Juan River. The Navajo Department of Fish and Wildlife and New Mexico Department of Game and Fish were responsible for the distribution of channel catfish to the impoundments.

Data are presented for numbers and total weight of channel catfish for all removal methods employed. Additional data analyses were conducted to assess the response of the channel catfish population to removal efforts. Electrofishing data were not normally distributed, owing to variable field conditions caused by the differences in flows, type of electrofishing raft (three different boats used), personnel (experience, competency), and habitat differences between geomorphic reaches that affected fish distribution patterns. Ryden (2000) discussed these sampling aspects in more detail.

We used data for all river miles sampled, including those from non-designated river miles where channel catfish were enumerated and classified according to life stage: young-of-year, <60 mm TL; sub-adult, 60-300 mm TL; adult, >300 mm TL. For 1998-1999, data were analyzed by geomorphic reach, by year, and by size class to detect statistically significant changes in CPUE as a response to mechanical removal efforts.

We analyzed total length data for geomorphic reaches for 1998-1999 to determine changes in mean standard length as a response to mechanical removal of channel catfish. Length frequency distribution and relative skewness of data were determined for each year for the combined sample of all channel catfish measured. Mean total length frequency was determined for each reach by year except for Reach 1, due to low sample sizes. Significance of annual changes in mean total length for each reach were analyzed using the non-parametric Mann-Whitney U test and was characterized as one of three responses: decrease, similar, increase. The biomass (kg) of channel catfish collected during all electrofishing efforts was estimated for each reach from the average weight of all individuals weighed at designated river miles and multiplied by the total number of channel catfish collected within each reach. This weight was then converted from grams to kilograms, which was used for all analysis.

RESULTS

Catch Rates of Channel Catfish

During 1998 and 1999, a total of 5820 channel catfish were removed from Reaches 1-6. The total number of channel catfish increased between 1998 and 1999, from 2,506 to 3,314 catfish, respectively. CPUE for all size classes combined increased between 1998 and 1999, from 0.3588 to 0.5503, while total effort declined from 222 hours to 155 hours, respectively. The increase in CPUE for the total number of channel catfish collected with all reaches combined was statistically significant ($p<.01$) between 1998 and 1999. A comparison of CPUE for each size class for all reaches combined between 1998 and 1999, revealed a significant increase in each size class with the exception of the Young-of-Year size class (Table 1). The decrease in total effort between years was also statistically significant using the same non-parametric test.

Comparisons of CPUE between years and reaches with all size classes combined showed an increase from 1998 to 1999 (Figure 1). Most reaches had a significant increase in two or more size classes with the exception of Reach 6 (Table 1). This reach only had a significant increase in the juvenile size class (60-300mm). Young-of-Year catch rates remained statistically similar in all reaches with the exception of Reach 2 where CPUE for all size classes increased significantly. Reach 1 was not analyzed since sampling was infrequent with catch rates remaining constant.

Table 1. Differences in catch rates of channel catfish between 1998-1999 between size class and geographic reach using the Mann-Whitney U-test.

Geomorphic Reach	<60 mm	class response	60-300 mm	class response	>300mm	class response	total catch	class response
All reaches combined	p=0.161	similar	p>0.1	increase	p>0.1	increase	p>0.1	increase
Reach 6	p=0.99	similar	p>0.1	increase	p=0.141	similar	p=0.793	similar
Reach 5	p=0.247	similar	p=0.89	similar	p>0.1	increase	p>0.1	increase
Reach 4	p=0.457	similar	p>0.1	increase	p>0.1	increase	p>0.1	increase
Reach 3	p=0.991	similar	p>0.1	increase	p>0.1	increase	p>0.1	increase
Reach 2	p<0.1	increase	p>0.1	increase	p>0.1	increase	p>0.1	increase

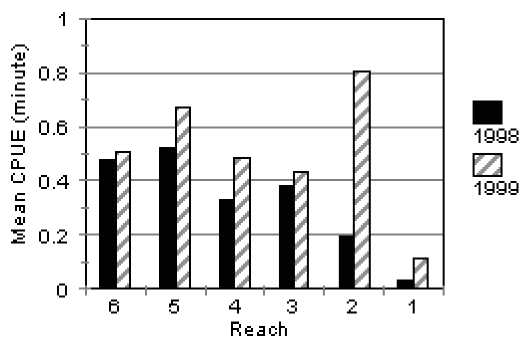

Figure 1. Mean total CPUE for channel catfish within each of six reaches of the San Juan River, New Mexico, 1998 and 1999.

Size Structure of Channel Catfish

From 1998 to 1999, mean TL decreased from 291.11 ±128 mm to 257 ± 99.7 mm, a 11.3% decrease and statistically significant (Figure 2). The coefficient of variation (C.V.) was 43% in 1998 and 38.6% in 1999. There was a significant (p>0.05) decrease in total length in all reaches for channel catfish (Table 2).

The following observations of size structure change between years were made (Reach 6 and 1 were not compared because small or unequal sample sizes):

Reach 5: Fewer large fish (440-705 mm) were caught in 1999 than in 1998. More 180-200 mm fish were caught, and less >300 mm fish were caught .

Reach 4: Larger fish (>620 mm) were caught in 1999 than in 1998. Less 80 mm fish were caught, and more 220-280 mm fish.

Reach 3: Less 180 mm fish were caught in 1999 than in 1998.

Reach 2: More >300 mm fish were caught in 1999 than in 1998.

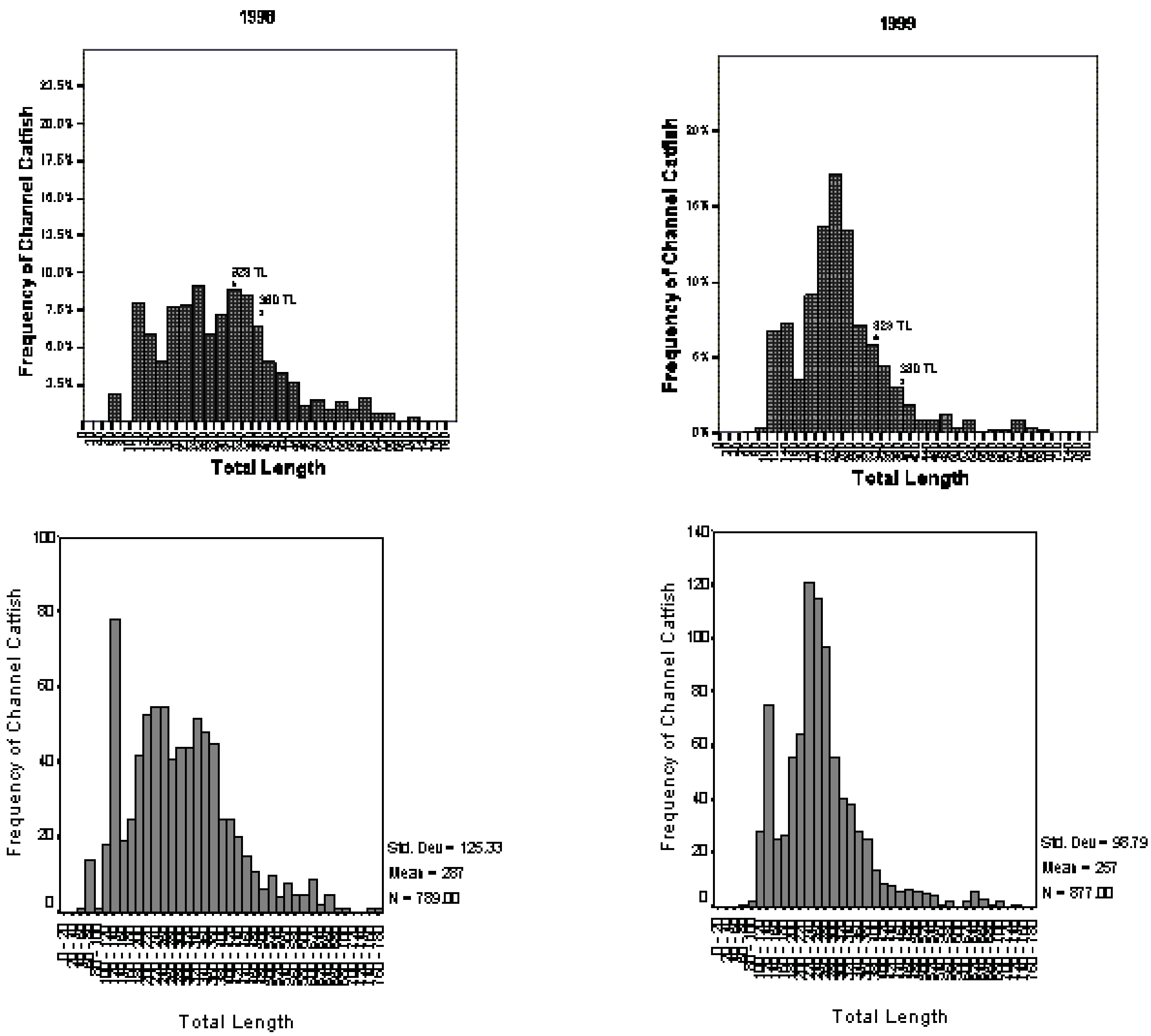

Figure 2. Length frequency distribution for channel catfish collected during 1998 and 1999 mechanical removal efforts.

Table 2. Changes in standard lengths and total lengths from 1998 to 1999.

Reach	p-value	Change from 1998 to 1999
6	p>0.01	decrease
5	p>0.01	decrease
4	p>0.01	decrease
3	p>0.01	decrease
2	p>0.01	decrease

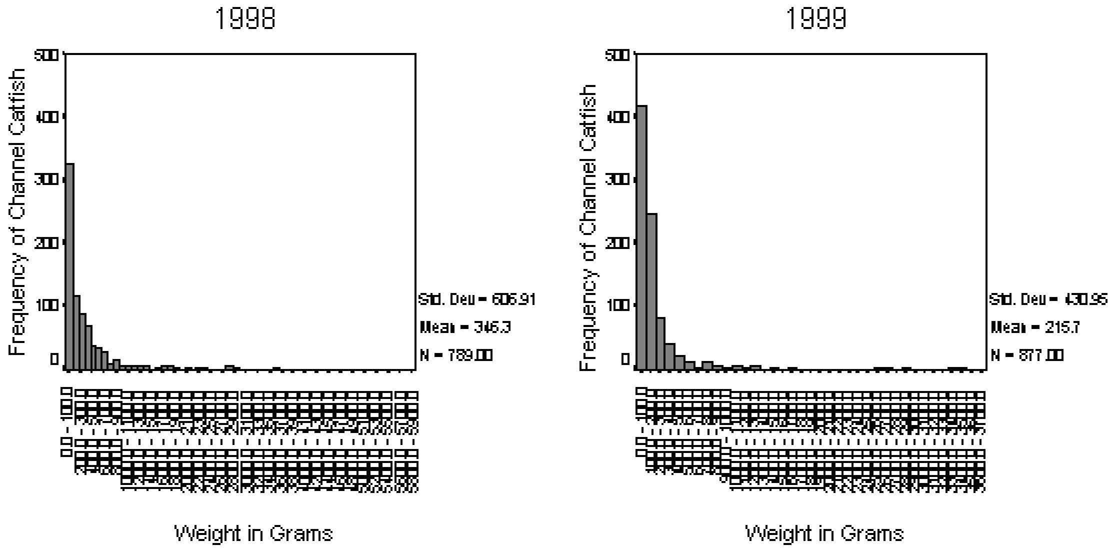

Figure 3. Distribution of channel catfish weights for the adult monitoring trips on the San Juan River, 1998 -1999..

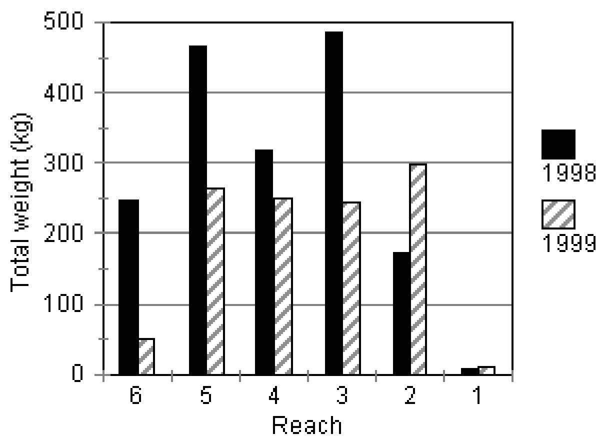

Figure 4. Estimated total weight in kilograms of channel catfish removed from the San Juan River, New Mexico, in each of the six reaches, 1998-1999.

Fitness as measured by the Fulton-type condition factor (K) for larger fish (540-667 mm SL) decreased from the 1998 to the 1999 sample. Although this size class of fish was not common (1.4% and 1.2% of the total sample in 1998 and 1999 respectively), its decrease in fitness from one year to the next was disproportionate, when compared to smaller size classes. The mean of

K for all sampled 1998 catfish was 0.1536, and was 0.1447 for 1999, a decrease of 6%. The mean K of 1998 catfish in the 540-667 mm range, however, was 0.1945, and for 1999 was 0.1643, a decrease of 16%. The mean weight in 1998 for catfish in the 540-667 mm range was 3,912.5 g, and in 1999 was 3,115 g, a decrease of 20% (Figure 5).

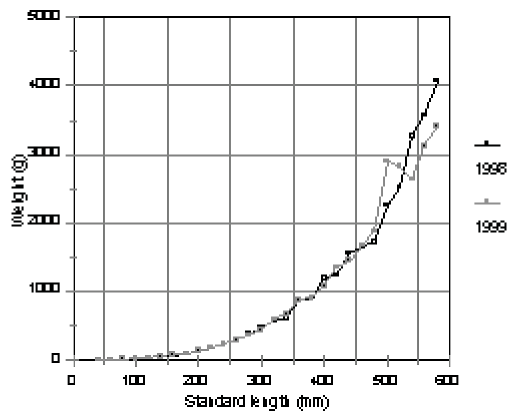

Figure 5. Correlation of individual channel catfish weight and total length illustrating the decrease in weight per length for larger fish taken from the San Juan River, New Mexico from 1998 to 1999.

Catch Rates for Common Carp

During 1998 and 1999, a total of 3,284 common carp were removed. The number of common carp removed decreased between 1998 and 1999, from 2,081 to 1,203, respectively. Comparisons of catch rates between reaches and years revealed that CPUE increased significantly in reaches 5, 4, and 3 and remained similar in reaches 6, 2, and 1 (Figure 6).

Size Structure of Common Carp

The mean total length for common carp increased significantly ($p<.01$) between 1998 and 1999, from 455 mm to 449 mm, respectively. Though total lengths increased significantly the range of these lengths shifted to smaller individuals between 1998 and 1999 from 103-758mm to 42-635mm, respectively. Standard deviations were small for 1998 and 1999 (3% and 2.2%, respectively) and represented the occurrence of a few individuals at the outer limits of the frequency distributions (Figure 7). A reach by reach comparison between years determined that

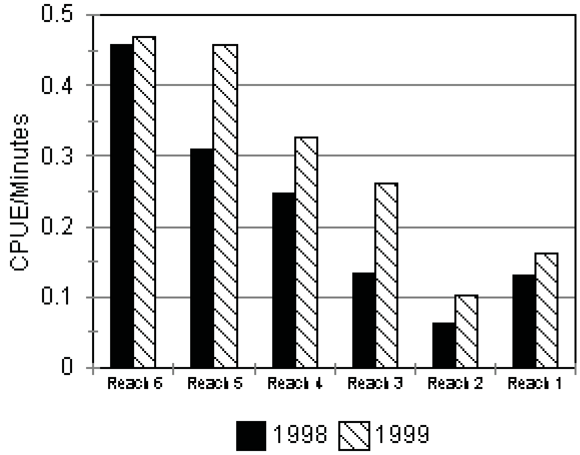

Figure 6. CPUE for common carp by reach in the San Juan River collected during the adult monitoring trips, 1998-1999.

1998 1999

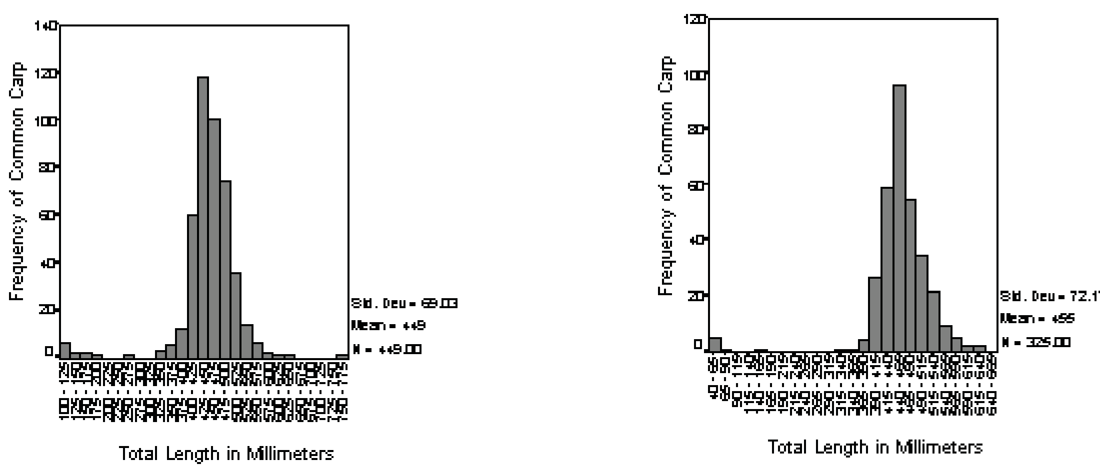

Figure 7. Length frequency distribution for common carp collected by reach in the San Juan River collected during the adult monitoring trips, 1998-1999.

common carp standard lengths increased significantly in reaches 5, 3, and 1. The total lengths were similar between reaches 4 and 2, with reach 6 having to few samples for statistical analyses.

Mechanical Removal from PNM Weir to Hogback, New Mexico 1999

A total of 452 channel catfish were collected in three days of effort. The CPUE declined with each day of sampling. The catch rates were lowest on the second day of sampling, with a slight increase on the third day (Figure 8).

The average total length of channel catfish collected was 487mm and the average weight was 1.3 kg. The range of total length was 321-742mm (CV 18%), with the smaller juvenile and Young-of-Year fish absent (Figure 9). Variation of the metrics (total length, standard length, and weight) was minimal between the three days of sampling (Figure 10).

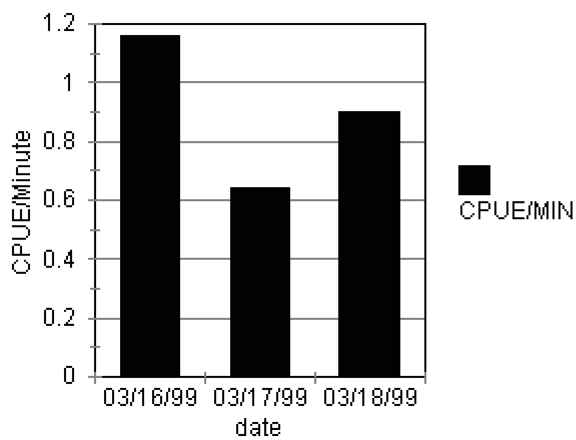

Figure 8. CPUE for channel catfish removed during three consecutive days of sampling between PNM Weir and Hogback, NM, San Juan River, 1999.

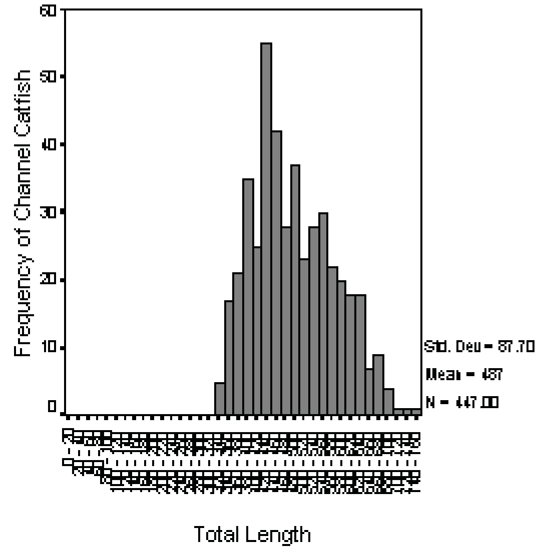

Figure 9. Length frequency distribution for channel catfish removed from the San Juan River between PNM Weir and Hogback, NM during 1999.

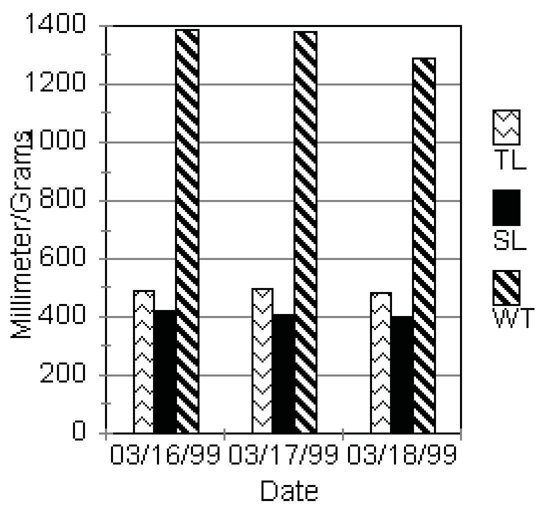

Figure 10. Mean size statistics for channel catfish during each day of mechanical removal on the San Juan River between PNM Weir and Hogback, NM, 1999.

Stocking of Channel Catfish - A total weight of 589.2 kg of channel catfish were stocked into closed impoundments between 16-18 March 1999. A total of 308 and 121 channel catfish were delivered to Farmington and Jackson Lakes, respectively. The number stocked channel catfish varied from total number collected due to handling mortality incurred on the first day. The mean size of channel catfish stocked was 487 mm total length and 1.3 kg. Channel catfish appeared in good condition (active) at time of transport, with less than 1% mortality reported at time of distribution.

Catch Rates and Size Structure of Common Carp - Common carp catch rates increased each subsequent day of sampling (Figure 11). The catch rate of common carp on the last day had increased by 59% as compared to the first day of sampling. There was little to no variation in size of common carp collect each day of sampling (Figure 12). A total of 1524 common carp equaling nearly 1995.4 KG were removed from this reach of the San Juan river during sampling. The third day of sampling produced the greatest amount of biomass at 906 KG of carp (Figure 13).

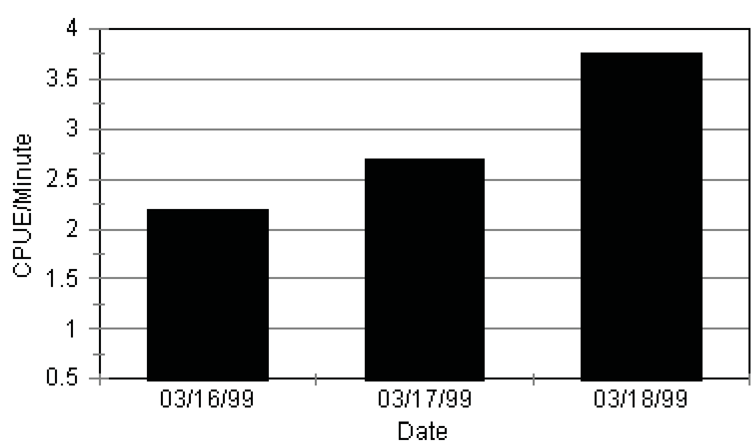

Figure 11. CPUE for common carp removed during three consecutive days mechanical removal on the San Juan River between PNM weir and Hogback, NM, 1999.

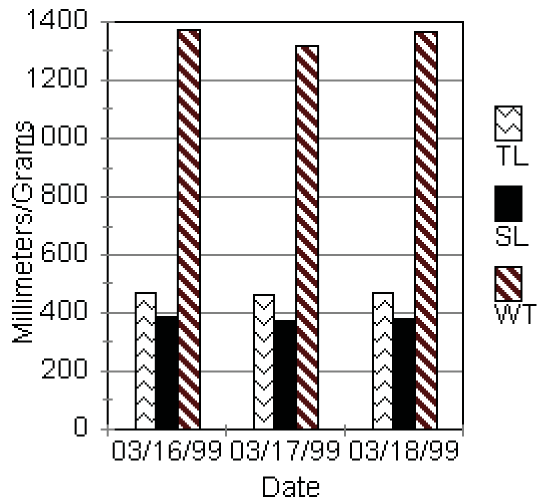

Figure 12. Mean size statistics for common carp removed during each consecutive day on the San Juan River between PNM weir and Hogback, NM, 1999.

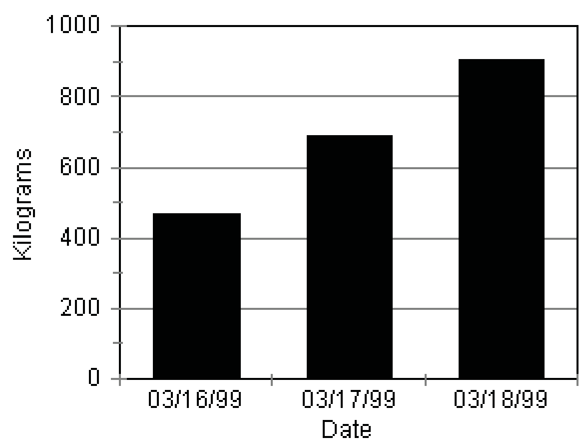

Figure 13. Estimated weight of common carp removed during three consecutive days of mechanical removal on the San Juan River between PNM weir and Hogback, NM, 1999.

Removal Efforts between River Miles 137.2 to 127.8 below Shiprock, NM

Catch Rates and Size Structure of Channel Catfish - A total of 557 and 688 channel catfish were collected in 1998 and 1999, respectively. The CPUE for channel catfish increased each day of sampling in 1998 and 1999, with the exception of day 3 in 1999 (Figure 14). There was a 24 % to 27% increase in CPUE each consecutive day in 1998. In 1999, there was a 40% increase between the first and second day of sampling, but on the third day catch rates had dropped 3 times that of the second and 2 times compared to the first day of sampling.

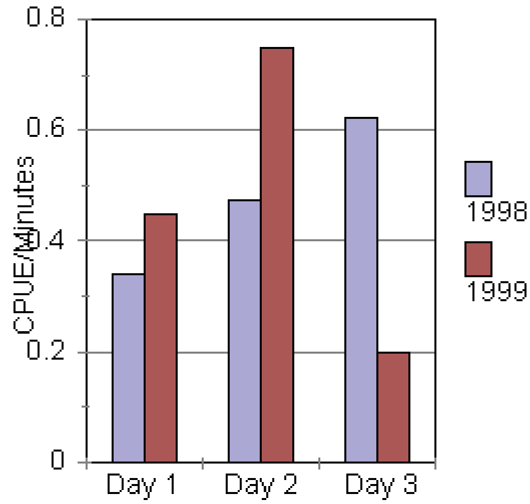

Figure 14. CPUE for channel catfish removed during three consecutive days of mechanical removal on the San Juan River between river miles 137 and 127, NM, 1998.

There was a significant increase in the total length of channel catfish removed from 1998 to 1999. The mean total length increased from 376 mm in 1998 to 403 mm in 1999. The variation in size distribution decreased between 1998 and 1999 from 21.4 C.V. to 15.1 C.V., respectively. Channel catfish in the size range 103 mm to 215 mm were absent from the 1999 sample, but these fish only accounted for 1.8 % of the total catch in the 1998 sample. The shift in size distributions can be seen clearly in the ranges which was 103-695 mm in 1998 and 263-700 mm in 1999 (Figure 15).

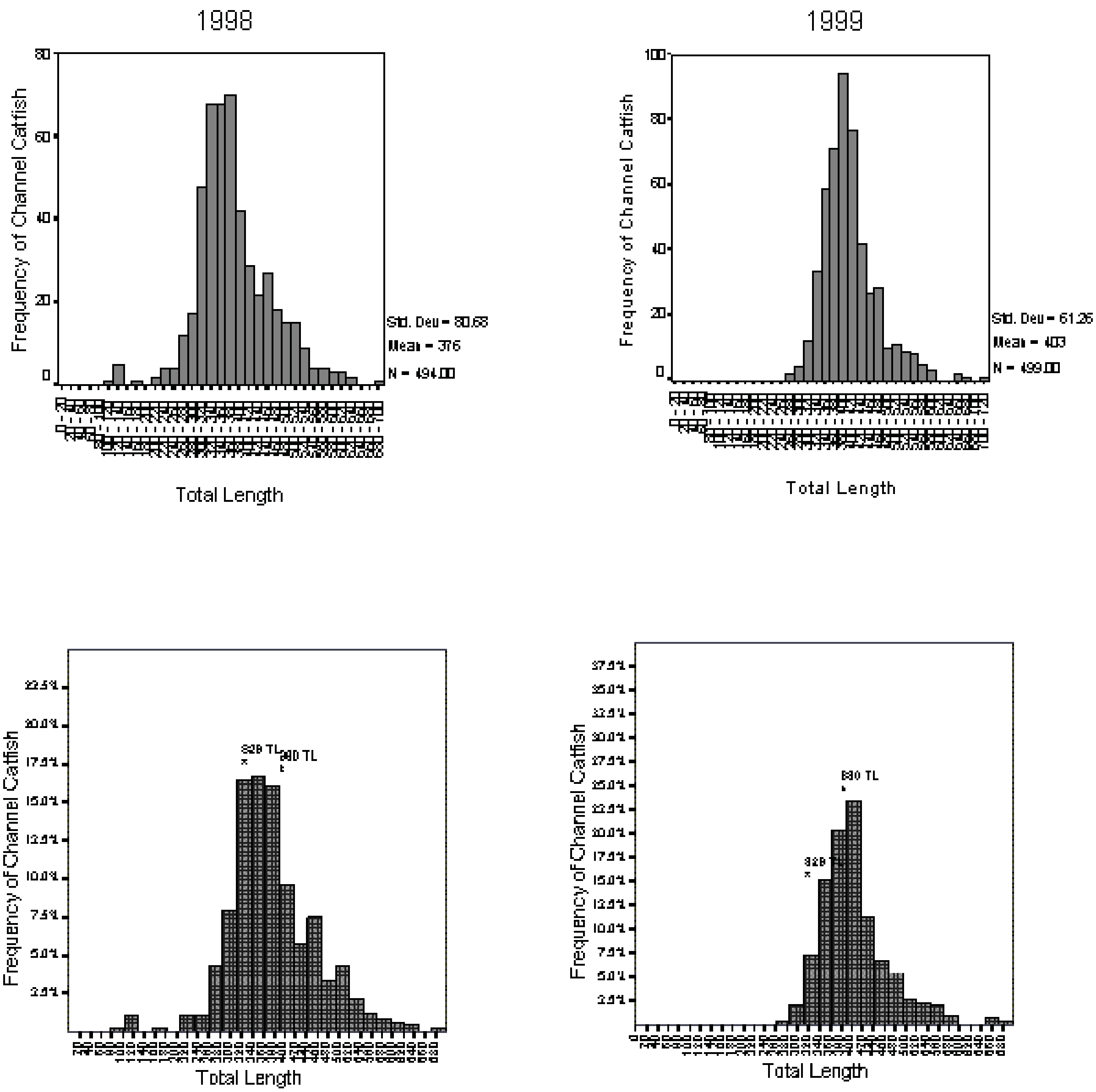

Figure 15. Length frequency distribution for channel catfish removed during three consecutive days of mechanical removal on the San Juan, 1998.

Hoopnetting

A total 177 channel catfish were collected during a effort of 99 net days in 1998. The mean catch rate for three weeks of sampling was 1.74 channel catfish per net day. There was little fluctuation between catch rates during the three week study (Figure 16). Mean total length of channel catfish 239.5 mm (C.V. 31 %) and ranged 125-575 mm (Figure 17). The mean individual weight of channel catfish was 0.14 kg (7-1800 grams), but with a wide variation in weight (C.V. 132.9 %) during the hoop netting study. The variation in weight during the hoop netting study was higher than any other specific removal efforts in 1998 and 1999 and may be attributed to a larger proportion of smaller individuals in the hoop net samples than collected by electrofishing efforts.

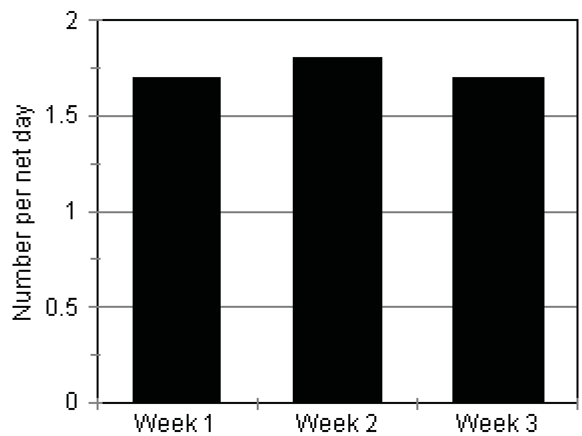

Figure 16. CPUE (number of fish captured per 24 hour set per net) for channel catfish collected by hoop netting, San Juan River, 1998.

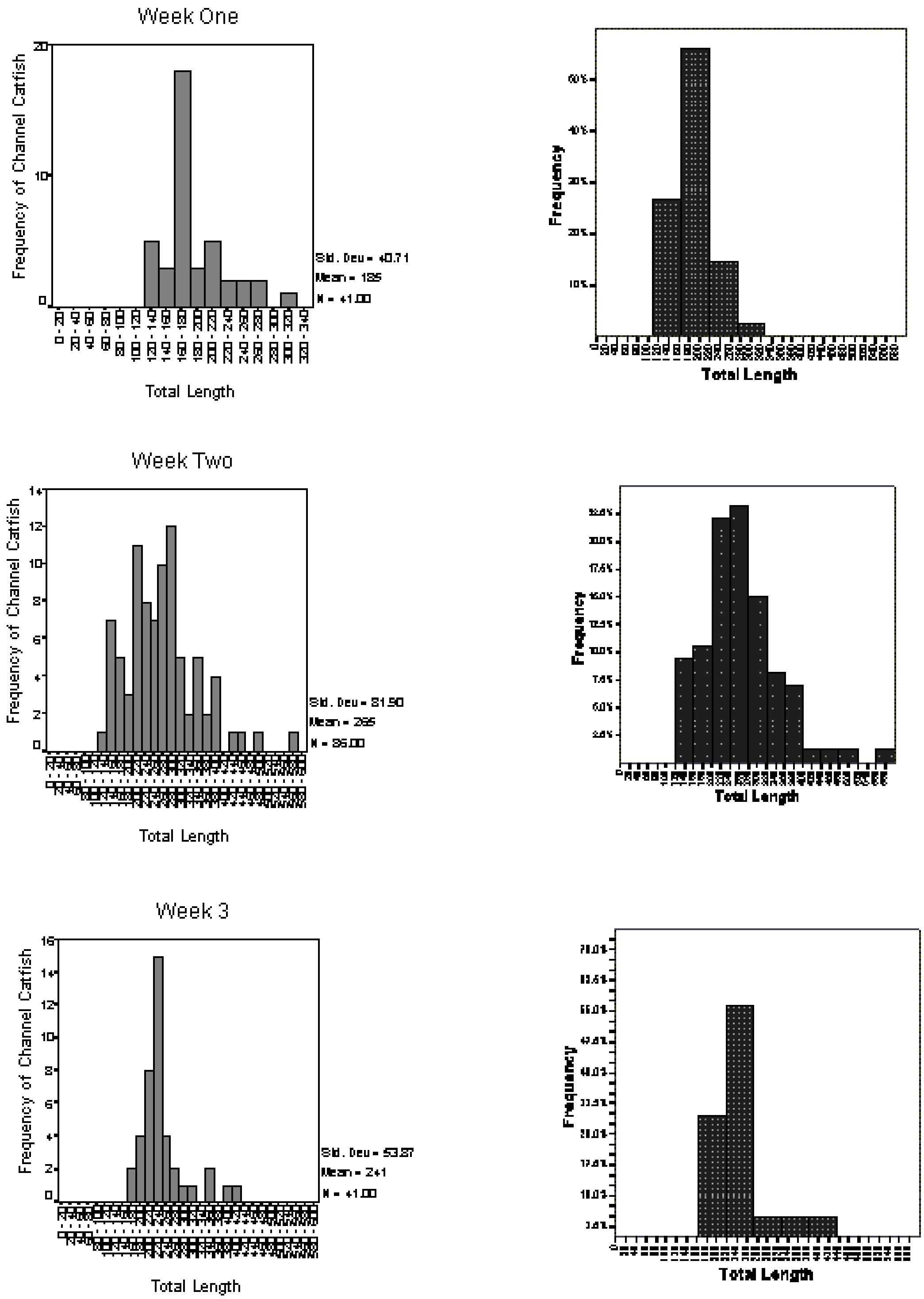

Figure 17. Length frequency distribution for channel catfish sampled by hoop nets on the San Juan River, 1998.

Stocking of Channel Catfish - A total 296 channel catfish were stocked in the spring of 1998 into Cow Springs, Ganado, and Many Farms lakes, all of which are small, closed impoundments on the Navajo Nation. The mean total length and individual weight of channel catfish stocked during the spring of 1998 was 368.3 mm and 0.52 kg, respectively. An additional 189 channel catfish were stocked in the fall of 1998 in conjunction with the adult monitoring trip and size statistics were not separated from adult main channel monitoring analyses. Distribution of the 189 channel catfish was to the following locations: Chuska Lake ,59; Gando Lake, 111; and Red Lake, 19. During spring 1999, a total of 688 channel catfish were stocked into closed impoundments on the Navajo Nation (Table 3). The mean total length and individual weight of channel catfish stocked were larger (398.7 mm and 0.58 kg) than 1998 transplanted fish.

Table 3. Distribution of channel catfish into from the San Juan River into closed impoundments on the Navajo Nation during the spring 1999.

Date	Impoundment	Number of channel catfish	Average Length in Millimeters (Inches)	Average Weight in Kilograms (Pounds)	Total Stocked in Kilograms (Pounds)
03/23/99	Chuska Lake	113	398.7 (15.7)	0.63 (1.4)	72.3 (159.6)
03/24/99	Gando Lake	130	406 (16)	0.63 (1.4)	83.8 (184.9)
03/24/99	Roundrock Lake	135	406 (16)	0.63 (1.4)	87.07 (192)
03/25/99	Morgan Lake	221	393.4 (15.5)	0.54 (1.2)	121.6 (268.3)
03/26/99	Red Lake	89	398.7 (15.7)	0.54 (1.2)	48.9 (108)
Totals and Average Metrics		688	398.7 (15.7)	0.58 (1.3)	414.1 (913.1)

DISCUSSION

During 1998 and 1999, data for channel catfish size class structure showed a shift toward smaller fish. This trend began in 1995, the first year of selective removal of non-natives. In 1996, river-wide removal of non-native fish was established and this was the only year that the length frequency distribution of channel catfish collected was normally distributed (Brooks et al. 2000). Since 1996, the length frequency distribution of channel catfish has continued to shift toward smaller individuals. The increase in catch rates of smaller fish is similar to observations of over-exploited stocks of channel catfish in the Mississippi River (Pitlo 1997). This shift to smaller individuals was also observed in the Powder River, Wyoming after angler exploitation increased (Gerhardt and Hubert 1991). To protect smaller channel catfish harvested by commercial fishing in the Mississippi River, minimum total length allowed for harvest was increased from 330 to 380 mm TL . After the minimum length increase, a corresponding increase in the length frequency distribution of harvested channel catfish was observed (Pitlo 1997). In the San Juan River, SJRIP removal (harvest) efforts are for all size classes. The larger, more fecund channel catfish are removed as well as the smaller, sexually immature individuals that would be recruiting into the breeding population in subsequent years. Theoretically, this type of removal should impact the population faster since all fish are removed, and no age class is spared.

Channel catfish have been found to be most fecund at > 380 mm TL (Helms 1975, Jearld and Brown1971, Raibley and Jahn 1991). In fact, Helms (1975) found that only 1 of 10 channel catfish were sexually mature at 330 mm TL compared to 5 of 10 at 380 mm TL. Pitlo (1997), estimated that the increase in slot limits from 330 mm to 380 mm would increase the reproductive potential 10 fold for the Mississippi River. Raibley and Jahn (1991), found channel catfish over 581 mm TL were the most fecund in the Mississippi River, though the sample size was small. Hubert (1999) reported on growth rates that indicated channel catfish reached >380 mm by their fourth year and observed that there was not a significant difference in channel catfish length in respect to where it was grown after the age of three. In Oklahoma, 380 mm TL individuals were found to be four years old (Hall and Jenkins 1952). Preliminary age and growth data for the San Juan River indicated that a 380 mm TL (215 - 620, S.D.= 65) channel catfish may be 7 years old (n=73, New Mexico Fishery Resources Office files). Since, the majority of channel catfish collected in 1998 and 1999 were well below 380 mm TL and continue to decrease from 1991-1997 data , it is probable that removal efforts are having an impact on the population. This would fit with removal efforts begun in October 1995 and expanded in 1996 now impacting the abundance of cohorts produced before1996. Based upon our preliminary age and growth data and that of Hubert (1999), the average sized channel catfish collected in 1998 was of the 1995 cohort and in 1999 the average sized channel catfish was of the 1997 cohort.

The increase in catch rates of channel catfish in 60-300 mm and >300 mm size class may be an artifact of a too general classification of channel catfish. Channel catfish in the size range > 300 mm could be 2 + years old using the standards set forth by Hubert (1999). This classification makes it difficult to determine an approximate age of channel catfish collected during non-designated river mile collections.

The shift to smaller individuals is key to removal efforts for channel catfish in the San Juan River. First, smaller channel catfish are less likely to be sexually mature and are less fecund if mature (Hubert 1999). However, as was illustrated in the increase in the number and rate of channel catfish capture from 1998 to 1999, an immediate response to removal efforts may increase smaller size classes, thereby increasing interactions with native fishes. Secondly, a reduction in the reproductive effort of channel catfish due to continued removal and suppression of sexually mature individuals in upstream reaches should eventually reduce the abundance of smaller individuals. Pitlo (1997) concluded that the continued removal (overharvest) of sexually mature channel catfish would lead to: 1) a decline in yield of larger fish, 2) an increase in the proportion of smaller fish, 3) a narrow range of age groups, 4) a high dependence upon single year classes, and 5) increased mortality within the population. Our data indicate that at least the first three factors are occurring throughout the study area, with the greatest amount of change in Reach 6, for channel catfish. Additional information on the age at sexual maturity for channel catfish would allow for the development of specific CPUE and length targets in sub-reaches for removal efforts. Such targets could be used to determine the continuation of intensive efforts in a specific reach or initiation of repetitive removal efforts in alternate (downstream) reaches. A step-wise system could be developed using targets on CPUE and size and implemented to rotate intensive removal efforts to maintain reduced population levels for channel catfish in an up- to downstream manner.

Common carp, on the other hand, have not responded similarly to removal efforts. The removal of common carp has been experimented with since the 1870's, shortly after introductions into North America (Shields 1957). Mechanical removal of adults has been termed as a cropping of surplus stock and minimally successful in controlling common carp populations (Shields 1957). It was believed the best method for control of common carp was by the dewatering of habitats supporting eggs and larvae (in this case, reservoir drawdowns). However, the effectiveness of dewatering such habitats may be more difficult in lotic environments. Common carp in the San Juan River are widespread and are collected primarily from low velocity habitats over silt/sand bottoms. Common carp respond to electrofishing (galvanonarcosis) with near complete tetanus and are easily netted. Electrofishing efforts during low flow conditions are very effective in removing large numbers of adult common carp, yet our efforts on subsequent days do not result in decreases in either abundance or size, as has been shown for channel catfish.

In pond situations, juvenile common carp have been found to exceed the standing crop of adults within a single year class by as much as two times (Marz and Cooper 1957a). When common carp were raised with predators (centrarchids), young rarely exceeded 50 % of the adult stock biomass (Marz and Cooper 1957b). In the Salt River, Missouri, the population of common carp contained adults that attained a large size quickly, grew very little or not at all thereafter, and contained few individuals older than 5 years (Purkett 1957). Age five was the age common carp were found to be the most fecund in Canada, but the size of these fish was larger than the mean for the San Juan River (Swee and McCrimmon 1966). It is possible that our inability to demonstrate a removal-caused decrease in the size or number of common carp collected in the San Juan River may be due to fast growth rates and a large number of juveniles present in non-electrofished habitats (backwaters and small secondary channels; Propst and Hobbes 2000) available to replace removed adults.

The mechanical removal of common carp thus appears to be limited in applicability to reduce the abundance and distribution of this species. However, too little is known of common carp biology in the San Juan River to adequately assess the effectiveness or design specific efforts for removal. We cannot confirm growth rates or age class structure noted in other systems. Nor can we identify specific times and locations for concentration of removal efforts to minimize reproductive success. Until additional information is available to allow for determination of the efficacy of removal efforts targeted specifically for common carp, general removal does not appear to negatively impact the species.

<u>Recreational Fisheries</u>

The removal of channel catfish from the San Juan River has been controversial to the angling public and others. 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 a survey conducted in 1997-1998, most agencies did not intensively manage channel catfish populations, with the exception of “put-grow-take” and “put-take” fisheries in small impoundments (Michaletz and Dillard 1999). In New Mexico, only seven of the designated warm water fisheries have reduced limits on channel catfish (2 per day from 15 per day) with all of them being small impoundments (New Mexico Department of Game and Fish 1999). These were the only waters that received special management by restrictive limits for channel catfish in 1999. Increasing interests in channel catfish angling have resulted in a supply and demand problem for hatcheries, e.g. most resource agency hatcheries cannot support existing demands. Therefore, augmentation of hatchery reared channel catfish stocks with wild stocks may provide for an acceptable substitute.

The stocking efforts for wild channel catfish into "put-take" fisheries in 1998 and 1999 provided an enhanced channel catfish fishery in the Four Corners Area of New Mexico and Arizona through the provision of larger fish than typically supplied by hatchery programs (Michaletz and Dillard 1999). Reports from anglers were favorable (Marc Wethington, New Mexico Department of Game and Fish, personal communication) and this stocking program has assisted in the abatement of complaints regarding non-native species control measures (removal without transplantation to impoundments) employed during other electrofishing efforts. Increasing demands upon sport fish hatcheries, combined with continually diminishing budgets are resulting in annual shortages of fish available to requestors and transplantation of wild fish serves to minimize the shortage (Brooks et al. 2000).

Aside from the more direct benefit to native species management by removing non-natives, minimization of reliance on hatcheries may also prove beneficial by avoidance of the introduction of non-target organisms. Courtenay (1995) reviewed the aspects of intentional and accidental introductions of fishes and potential negative consequences, particularly in regard to conservation of native species. Morgan Lake, located in the Chaco Wash drainage, is a powerplant reservoir that is also managed as a warmwater recreational fishery by the Navajo Nation (Arizona Public Service 1999). Largemouth bass *Micropterus salmoides* is the target sportfish species in Morgan Lake and the fishable population is maintained by U.S. Fish and Wildlife Service hatchery-produced stockings of age 0+ fish. During 1999 sampling of Morgan Lake by New Mexico Fishery Resources Office and Navajo Fish and Wildlife biologists, 108 gizzard shad *Dorosoma cepedianum* with a mean TL of 212 mm (85 - 335) were discovered. Previous sampling to this discovery occurred in 1994 and no gizzard shad were collected. Correspondence from the Navajo Nation Fish and Wildlife to U.S. Fish and Wildlife Service, dated 8 January 1997, referred to a recent (presumably late 1996) fish survey employing seines, 15.3 m long and 6.4 mm mesh, and did not identify gizzard shad in collections. Thus, it appears that gizzard shad were introduced into Morgan Lake during 1997 - 1998. We believe that the gizzard shad were introduced into Morgan Lake in May 1998 with a shipment of largemouth bass from Inks Dam National Fish Hatchery, located in south-central Texas in the Rio Colorado drainage where gizzard shad are abundant and occur in the source water for the surface diversion water supply for the hatchery. On 6 June 2000, the first occurrence (outside of Morgan Lake) of gizzard shad in the Colorado River mainstream was documented by the collection of a 350 mm TL gizzard shad from the San Juan arm of Lake Powell (Gordon Mueller, USGS, personal communication). The likely source of this fish was from Morgan Lake discharge into Chaco Wash which enters the San Juan River near Shiprock, New Mexico.

Previous verbal reports to the authors by Southwest Region, U.S. Fish and Wildlife Service personnel indicated that the unintentional introduction of non-target organisms has historically occurred in such shipments to essentially all receiving waters in the Southwest. Inspections of a largemouth bass shipment from Inks Dam National Fish Hatchery in May 1999 intended for a New Mexico reservoir in the Rio Grande Basin and several lakes in the Gila River Basin in Arizona revealed the inclusion of the following non-target organisms : Guadalupe bass *Micropterus treculi*, logperch *Percina caprodes*, gizzard shad, white bass *Morone chrysops*, bluegill *Lepomis macrochirus*, dollar sunfish *Lepomis marginatus*, unknown tadpoles, unknown macroinvertebrates, and unknown pelecypods (Stewart Jacks, USFWS, personal communication). This discovery occurred after a concerted attempt (initiated by the Morgan Lake issue) during spring 1999 by the USFWS Fisheries Program to develop hatchery procedures to avoid such occurrences. Subsequently, gizzard shad were reported from a largemouth bass shipment from Inks Dam National Fish Hatchery during May 2000 (Sean Denny, New Mexico Department of Game and Fish, personal communication).

Thus, in spite of ours and other USFWS efforts to curtail the shipment of non-target organisms, the problem has continued. Other USFWS hatcheries have also been suspected of introductions of other organisms in the Southwest, particularly amphibians. Platz et al. (1990) discussed the introduction and establishment of the Rio Grande leopard frog *Rana berlandieri* and believed the purported source of the introduction to be a warmwater sportfish shipment from Uvalde National Fish Hatchery, Texas. Given the risk of introduction of non-target organisms by hatcheries, the use of wild-produced fish in recreational angling programs that also addresses removal of non-native species from recovery streams may at least partially negate the need for such hatchery programs. A redirection of hatchery funding for the use of riverine "hatcheries" would increase removal efforts, thereby accelerating efforts to provide predator and competitor free environments for recovery of native species and minimizing the chance for additional introductions of new non-native species.

<u>Conclusions</u>

1. Electrofishing removal of channel catfish has resulted in a decrease in the mean total length and weight of captured fish and is proposed to continue.

2. Electrofishing removal of common carp has not resulted in changes in the size of captured fish and is proposed to be reassessed.

3. Additional information is needed on the age and growth and reproductive biology of channel catfish and common carp to refine and/or assess removal efforts.

4. Transplantation of channel catfish from the San Juan River to isolated impoundments is supported by local anglers and has provided larger fish than currently supported by hatchery program.

5. The unintentional introduction of non-target organisms during hatchery stockings of sportfish poses additional risks for the introduction of new non-native species in the San Juan Basin.

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