Endangered Fish Monitoring and Nonnative Species Monitoring and Control in the Upper/Middle San Juan River: 2015

Final Report

Prepared for:

San Juan River Basin Recovery Implementation Program

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ENDANGERED FISH MONITORING AND NONNATIVE SPECIES MONITORING AND CONTROL IN THE UPPER/MIDDLE SAN JUAN RIVER: 2015

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SUBMITTED TO:

SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM

BIOLOGY COMMITTEE

JUNE 29, 2016

EXECUTIVE SUMMARY

1. A total of 22,697 Channel Catfish and 76 Common Carp were removed from river miles (RM) 158.7 – 52.9 in 715 hours of electrofishing.

2. Intensive nonnative removal did not take place from PNM Weir to Hogback Diversion. Effort from this section was shifted to removal efforts from Shiprock Bridge to Montezuma Creek, Utah.

3. Channel Catfish CPUE values from Hogback Diversion to Shiprock Bridge have fluctuated over time and have not realized significant declines since the initiation of intensive removal.

4. Exploitation rates for Channel Catfish from Shiprock Bridge to Mexican Hat, Utah ranged from 7.6% for fish 200-299 mm TL to 22.9% for fish 400-499 mm TL.

5. Population estimates for Channel Catfish from Shiprock Bridge to Mexican Hat, Utah were 22,491 for juvenile Channel Catfish and 31,863 for adult Channel Catfish.

6. Channel Catfish CPUE during fall monitoring from Shiprock Bridge to Mexican Hat, Utah, was similar to values observed in recent years.

7. Mean Common Carp CPUE was < 1.0 fish/hour in all removal sections during nonnative removal trips as well as annual fall monitoring sampling

8. A total of 655 (580 unique individuals) Colorado Pikeminnow and 1,590 (1,308 unique individuals) Razorback Sucker were collected during our efforts in 2015.

9. Forty adult Colorado Pikeminnow ($\geq$ 450 mm TL) were collected in 2015

10. Razorback Suckers continue to show long-term persistence in the river. Twenty-six individual fish captured in 2015 had been in the San Juan River 10 or more years.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The San Juan River is home to two federally endangered fishes, Colorado Pikeminnow *Ptychocheilus lucius* and Razorback Sucker *Xyrauchen texanus.* The establishment of Channel Catfish *Ictalurus punctatus* and Common Carp *Cyprinus carpio* has been identified as a detriment to the recovery of Colorado Pikeminnow and Razorback Sucker (USFWS 2002a, b). Reducing the impacts of nonnative fishes has specifically been identified as a management element in the San Juan River Basin Recovery Implementation Program's Long Range Plan (U.S. Fish and Wildlife Service 2014):

Element 3 - Management of Nonnative Aquatic Species

Goal 3.1 Control Problematic Nonnative Fishes.

Action 3.1.1 Develop, implement, and evaluate the most effective strategies for reducing problematic nonnative fish.

Task 3.1.1.1 Mechanically remove nonnative fish to achieve objectives

Removal efforts by the U.S. Fish and Wildlife Service, New Mexico Fish and Wildlife Conservation Office (NMFWCO), began on a limited basis in 1998. Intensified multiple pass electrofishing began in 2001 and was focused from PNM Weir to Hogback Diversion (RM 166.6 - 159.0). As changes in distribution and abundance of Channel Catfish were documented, nonnative fish removal was expanded to include areas of high importance. Effort was expanded in 2003 to include another section of river from Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9) and based on observed increases in Channel Catfish abundance (Ryden 2007, 2008), efforts were expanded in 2008 to include intensive removal from Shiprock Bridge to Mexican Hat, UT (RM 147.9 – 52.9). In 2015, intensive nonnative removal conducted by NMFWCO occurred over 105.8 river miles of the San Juan River.

Study objectives were as follows:

1. Continue data collection and mechanical removal of large bodied nonnative fishes
2. Conduct mark/recapture to determine exploitation rates and population estimates for Channel Catfish
3. Evaluate distribution and abundance of nonnative species to determine effects of mechanical removal
4. Characterize distribution and abundance of endangered fishes in the upper and middle reaches of the San Juan River

STUDY AREA

Intensive nonnative removal efforts in 2015 focused on two individual sections of the San Juan River, New Mexico, Colorado, and Utah, encompassing 105.8 river miles (RM). Sections sampled included Hogback Diversion to Shiprock Bridge (RM 158.8 – 147.9), and Shiprock Bridge to Mexican Hat, Utah (RM 147.9 – 52.9) (Figure 1). Nonnative removal was conducted in portions of Geomorphic reaches 6 through 2 (Bliesner and Lamarra 2000). Hogback Diversion

to Shiprock Bridge encompassed portions of both Geomorphic reaches 6 and 5, and Shiprock Bridge to Mexican Hat was in reaches 5 – 2.

METHODS

Nonnative fishes were collected using raft-mounted electrofishing units (Smith-Root 5.0 GPP). Electrofishing settings were standardized to run pulsed direct current (PDC) on high range. Percent of power was adjusted by raft operators to maintain an output current of 4 amperes. Rafts sampled near each shoreline and netters attempted to collect any nonnative fishes observed. In addition to nonnative species, native rare fishes were netted during all efforts. Electrofishing proceeded downstream and fishes were processed at designated stops.

All nonnative fishes were enumerated by size class. At one random stop each day all nonnative fishes were measured (nearest 1 mm) for total length (TL). Seconds of electrofishing were recorded to determine effort at the end of each sampling unit. Sampling units ranged from 2 to 3 river miles depending on the section. All nonnative fishes collected were removed from the river. Two electrofishing rafts sampled for three consecutive days during each trip from Hogback Diversion to Shiprock Bridge. During sampling from Shiprock Bridge to Mexican Hat, four electrofishing rafts were used. Two rafts began sampling 1 hour prior to the remaining rafts resulting in the completion of two electrofishing passes per trip.

Native rare fishes collected were immediately placed in a live well or 5-gallon bucket separate from that of nonnative fishes. Rare native fishes were measured (nearest 1 mm) for total and standard lengths, weighed (nearest 5 g), and checked for the presence of a Passive Implant Transponder (PIT) tag. If a PIT tag was detected, the number was recorded and it was noted that the fish was a recaptured fish. If the presence of a PIT tag was not detected and the fish was ≥ 150 mm TL, a 134.2 kHz PIT tag was implanted and the capture status was recorded as a new capture (Davis 2010).

A mark-and-recapture study from Shiprock Bridge to Mexican Hat for Channel Catfish was initiated in 2011. The purpose of this effort was to determine exploitation rates and generate population size estimates. All Channel Catfish and Common Carp ≥ 200 mm TL were tagged with individually numbered anchor tags and released back to the river. A population estimate was calculated for adult and juvenile Channel Catfish using a Lincoln-Petersen estimate with Chapman's Correction. The estimate was based on fish recaptured during the first trip conducted after tagging. Fish that moved upstream of Shiprock Bridge were not included in the calculation of exploitation rates or the population estimate. Exploitation rates, *u*, were estimated as the proportion of recaptured marked fish to marked fish (Deroba et al. 2005),

$$u = R/M$$

where, R represents number of recaptured fish and M represents number of marked fish.

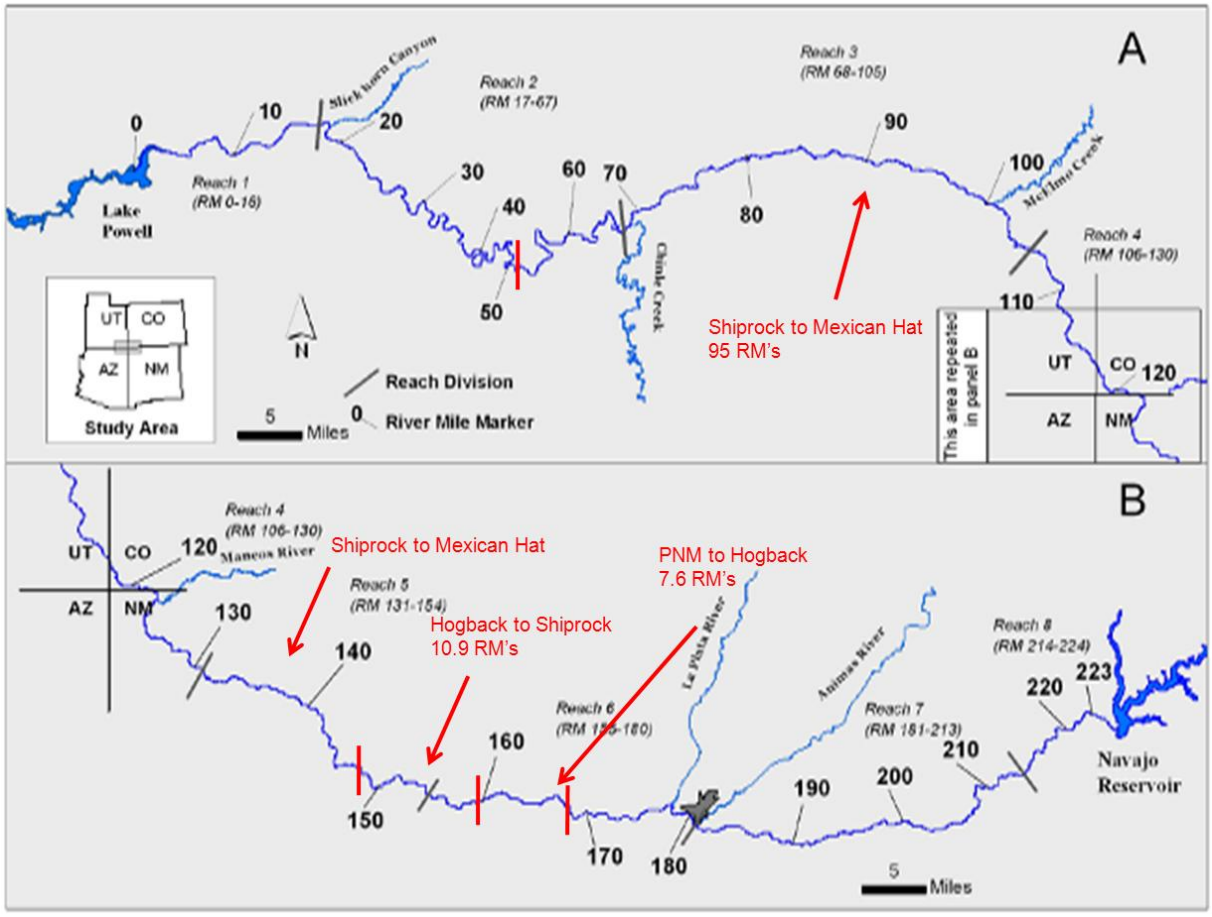

Figure 1. Map of study area – map provided by UNM MSB. Red bars represent boundaries of sampling sections. Black bars represent geomorphic reaches.

Determination of trends in distribution and abundance, mean catch rates (fish per hour of electrofishing; CPUE) and standard error (± 1 SE) were calculated using the software package Systat version 13. Species CPUE was calculated as the total number of fish collected divided by the total sampling effort (hours of electrofishing). If CPUE data met the assumptions of normality and equality of variance, a one-way analysis of variance (ANOVA) was conducted to determine if significant differences existed. Multiple pairwise comparisons using Tukey post-hoc tests were used to determine where significant differences existed. Significance levels were set at $P<0.05$.

Data for each removal section were summarized by trip. Catch rates among individual trips were analyzed to assess temporal changes within the year. Due to differences in the number and timing of removal trips conducted in each section among years, we used data collected during the annual sub-adult and adult fish community monitoring (FWS-Colorado River Project) to assess long term trends in catch rates. These data were collected under standardized monitoring protocols with the primary assumptions that sampling methods employed were appropriate to the species, size, and habitats being sampled, and that sampling efficiency remained relative constant (SJRIP 2012). Catch data pre and post intensive removal were analyzed to assess the effects of removal efforts on nonnative fishes.

RESULTS

HOGBACK DIVERSION TO SHIPROCK BRIDGE (RM 158.8 – 147.9)

A total of 1,463 Channel Catfish and 40 Common Carp were removed during three trips (July, October and November) and 77.2 hours (h) of electrofishing (Appendix A-2). In addition to Channel Catfish and Common Carp, other nonnative fishes collected included Bullhead catfishes *Ameiurus spp.*, Green Sunfish *Lepomis cyanellus,* and Largemouth Bass *Micropterus salmoides*.

CHANNEL CATFISH

Channel Catfish CPUE in 2015 ranged from 6.5 fish/h in November to 26.9 fish/h in October. Mean Channel Catfish CPUE in 2015, all life stages and trips, was 19 fish/h. Channel Catfish in 2015 averaged 363 mm TL (range 145 – 575 mm TL). Juvenile Channel Catfish comprised 30.5% of total catch in 2015, compared to 11.6% in 2014.

Mean CPUE for juvenile Channel Catfish during fall monitoring in 2015 was 0.6 fish/h compared to 5.1 fish/h in 2014. Mean CPUE for adult Channel Catfish during 2015 fall monitoring was 1.1 fish/h compared to 16.1 fish/hour in 2014. Juvenile and adult Channel Catfish CPUE values fluctuated over time and have not realized significant declines pre or post removal (Figure 2).

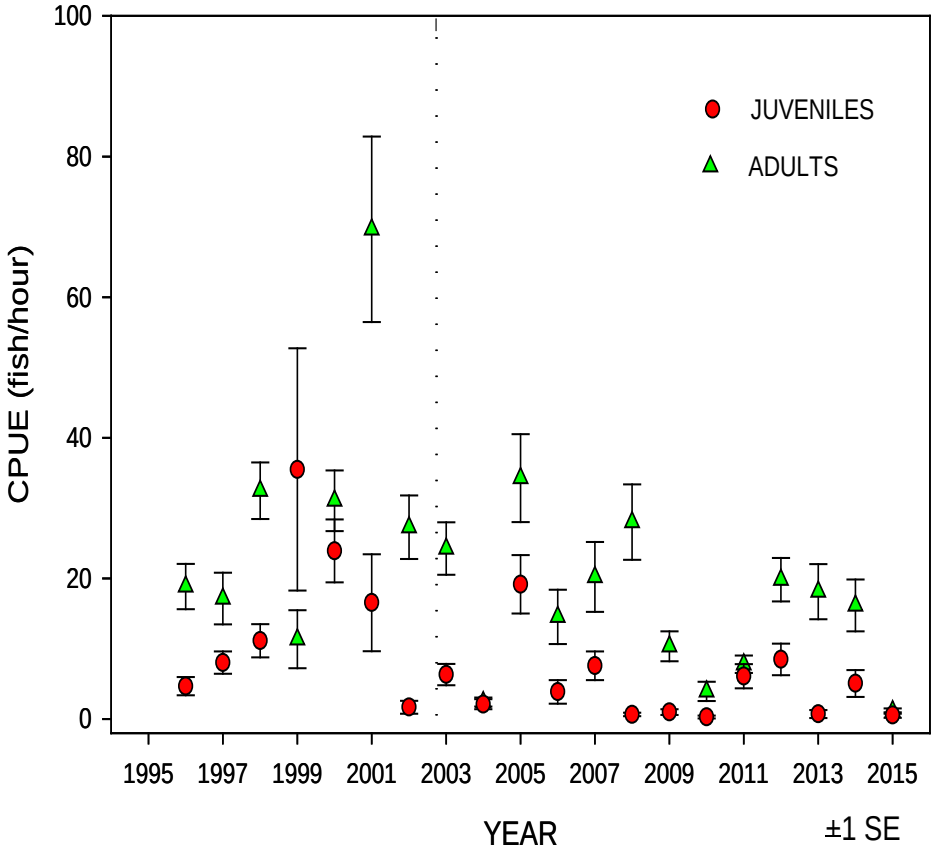

Figure 2. Channel Catfish CPUE (fish/hour) during annual fall monitoring by year, Hogback Diversion to Shiprock Bridge; 1996-2015. Adult CPUE is represented by triangles. Juvenile CPUE is represented by circles. The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

COMMON CARP

Common Carp catch rates by trip were < 1.0 fish/h and varied little among the three trips in 2015. Mean Common Carp CPUE, all life stages and trips combined, was 0.5 fish/h in 2015. This marked the 6th consecutive year that Common Carp CPUE was < 1.0 fish/h.

Three adult fish and no juveniles were collected during 2015 fall monitoring surveys. Common Carp CPUE during annual fall monitoring was 0.7 fish/h. Common Carp CPUE trends generated using fall monitoring data, declined since nonnative removal was initiated in 2003 (Figure 3).

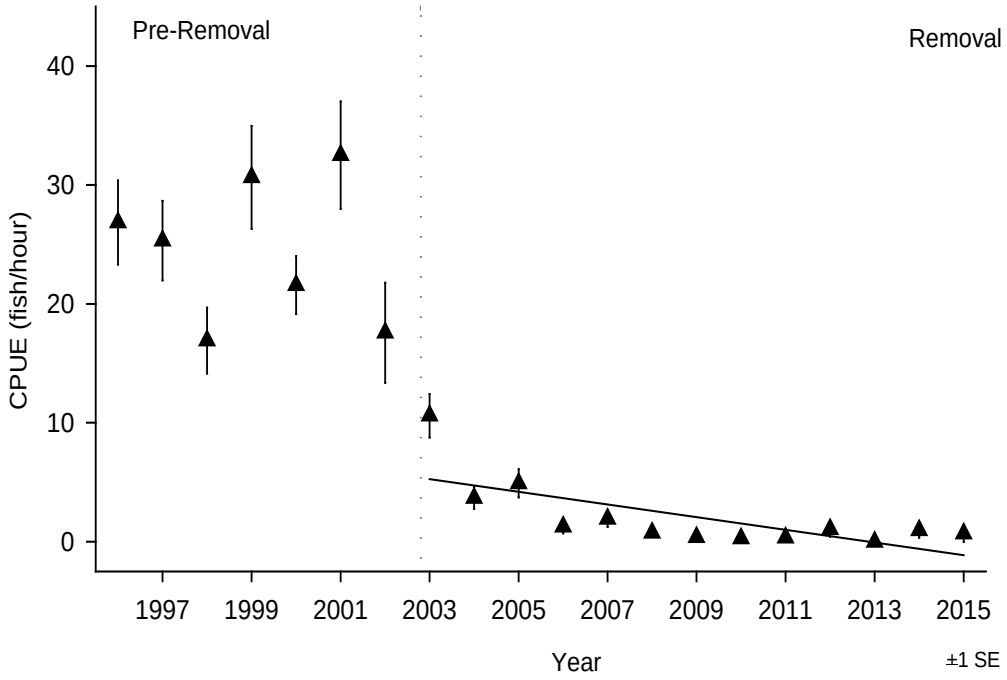

Figure 3. Common Carp CPUE (fish/hour) during annual fall monitoring by year, Hogback Diversion to Shiprock Bridge; 1996-2015. A line was fitted to the data if the trend was significant ($y=5.269- 0.532x$; $r^2= 0.50$; $p= 0.007$). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

SHIPROCK BRIDGE TO MEXICAN HAT (RM 147.9 - 52.9)

One tagging trip and three removal trips (April/May, June, and September) were conducted from Shiprock Bridge to Mexican Hat in 2015. During removal trips only, 11,189 Channel Catfish and 23 Common Carp were removed in 447.4 h of electrofishing. Nonnative fish removal also took place in conjunction with FWS Colorado River Fishery Project's annual fall monitoring in September, resulting in the removal of an additional 9,929 Channel Catfish and 12 Common Carp in 152.7 h of electrofishing. Due to high abundance of Channel Catfish in this section, effort was shifted from other reaches of the San Juan River to include additional removal passes in this section including one pass from Shiprock Bridge to Montezuma Creek completed by NMFWCO and three passes (three trips) from Montezuma Creek to Mexican Hat, Utah completed by Utah Division of Wildlife Resources (UDWR). These trips removed an additional 495 Channel Catfish and 3 Common Carp in 111.6 h of electrofishing. For the year, 21,613 Channel Catfish and 38 Common Carp were removed during 710.7 h of electrofishing from Shiprock Bridge to Mexican Hat, Utah. Other nonnative fishes removed included Brown Trout *Salmo trutta*, Rainbow Trout *Oncorhynchus mykiss*, Bullhead catfishes, Green Sunfish, and Largemouth Bass. No Striped Bass or Walleye were collected or observed.

MARK AND RECAPTURE

To assess exploitation and generate population estimates, Channel Catfish and Common Carp collected in April from Shiprock Bridge to Mexican Hat, UT, were fitted with an alphanumeric anchor tag. During this effort, 3,677 Channel Catfish and 7 Common Carp were tagged. Total length measurements were taken from all fish that were tagged to determine exploitation rates by size classes. Adult Channel Catfish (≥ 300 mm TL) composed 75% of the total number of Channel Catfish tagged (N=2,770), while juvenile Channel Catfish (200 – 299 mm TL) composed 25% (N=907). The majority of adult Channel Catfish tagged were newly recruited adults 300-399 mm TL.

Exploitation rates for each size class of Channel Catfish were generated using recaptures from the first post-tagging trip (Table 1). Exploitation rates ranged from 7.6% for juveniles (200-299 mm TL) to 22.9% for adults 400-499 mm TL during the post-tagging trip. Total exploitation rate for all size classes for the post-tagging trip was 14.7%.

Table 1. Channel Catfish exploitation rates from Shiprock Bridge to Mexican Hat, UT, 2015. Numbers in parentheses in the Mark Pass row represent total number of Channel Catfish tagged in that size class. Numbers in parentheses in the Trip 1 row represent total number of Channel Catfish recaptured for that size class and trip and percentage is the exploitation rate for that size class during that trip.

	Total Length (mm) of Channel Catfish at Time of Tagging					
	200-299 mm TL	300-399 mm TL	400-499 mm TL	500-599 mm TL	600+ mm TL	Total
Mark Pass	25%	50%	22%	3.3%	1.4%	100%
	(907)	(1,833)	(792)	(122)	(23)	(3,677)
Trip 1 April/May	7.6 %	14.5 %	22.9 %	18.9 %	8.7 %	14.7 %
	(69)	(266)	(181)	(23)	(2)	(541)

During the tagging trip, 2,770 adult (≥ 300 mm TL) Channel Catfish were tagged. On the first removal trip in April/May, a total of 5,438 adult fish were captured including 472 anchor-tagged fish. The population estimate for adult Channel Catfish from Shiprock Bridge to Mexican Hat, UT was 31,863 (95% CI = 29,066-34,659; CV=4.39%, SE=1,398).

A total of 907 juvenile fish (200-299mm TL) were tagged in 2015. During the post tagging removal trip, 1,733 juvenile fish were captured including 69 anchor-tagged fish. The population estimate for juvenile Channel Catfish from Shiprock Bridge to Mexican Hat, UT was 22,491 (95% CI = 17,261-27,721; CV=11.63%, SE=2,615).

A population estimate was completed for adult Common Carp in 2015. Seven adult Common Carp were tagged and 12 Common Carp were collected during the first post tagging trip, with two fish being recaptured fish. The adult Carp population estimate from Shiprock Bridge to Mexican Hat, UT was 34 (95% CI = 4-63; CV=43.85%, SE=14.76).

REMOVAL TRIPS

CHANNEL CATFISH

Channel Catfish CPUE, all life stages combined, varied among trips in 2015 (Figure 4). Juvenile Channel Catfish CPUE ranged from 6 to 42.9 fish/h, with the highest catch rates occurring during fall monitoring in September. Adult Channel Catfish CPUE ranged from 1.3 to 26.4 fish/h of electrofishing. Mean CPUE for all life stages and trips combined was 34.3 fish/h.

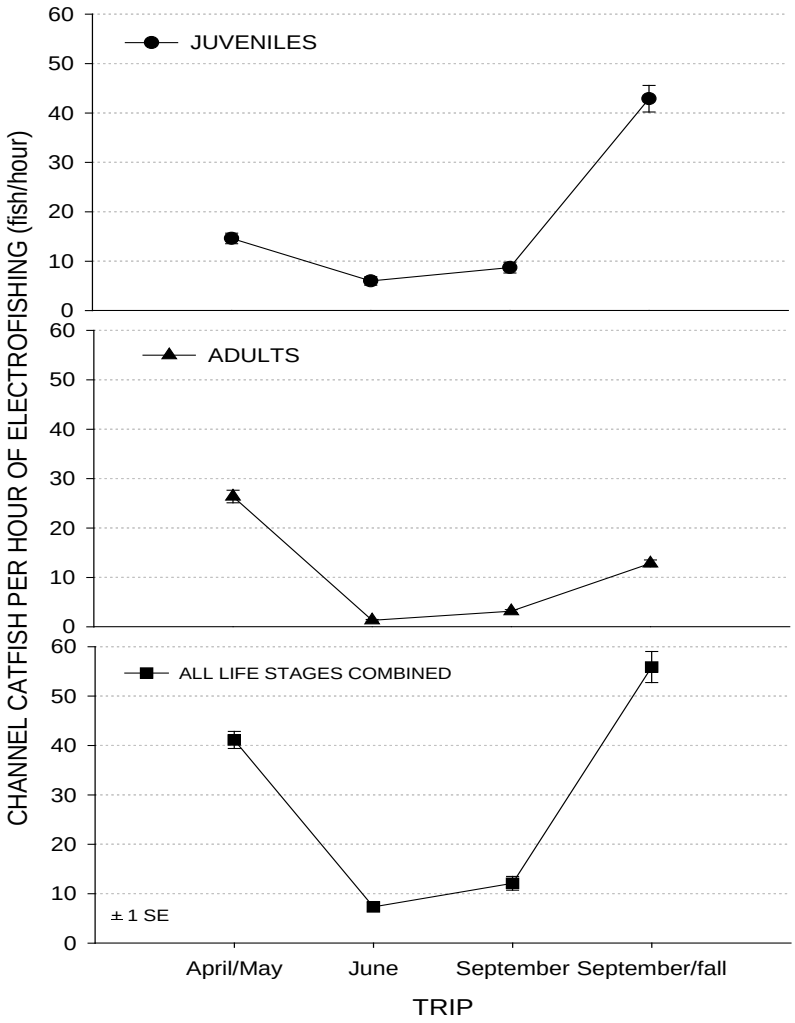

Figure 4. Channel Catfish CPUE (fish/hour) by trip from Shiprock Bridge to Mexican Hat; 2015. Error bars represent ± 1 SE.

Mean CPUE for juvenile Channel Catfish during fall monitoring increased from 15.6 fish/h in 2014 to 42.9 fish/h in 2015 (Figure 5). Mean CPUE for adult Channel Catfish during 2015 fall monitoring was 12.9 fish/h and was similar to values observed in 2014 (12.5 fish/h).

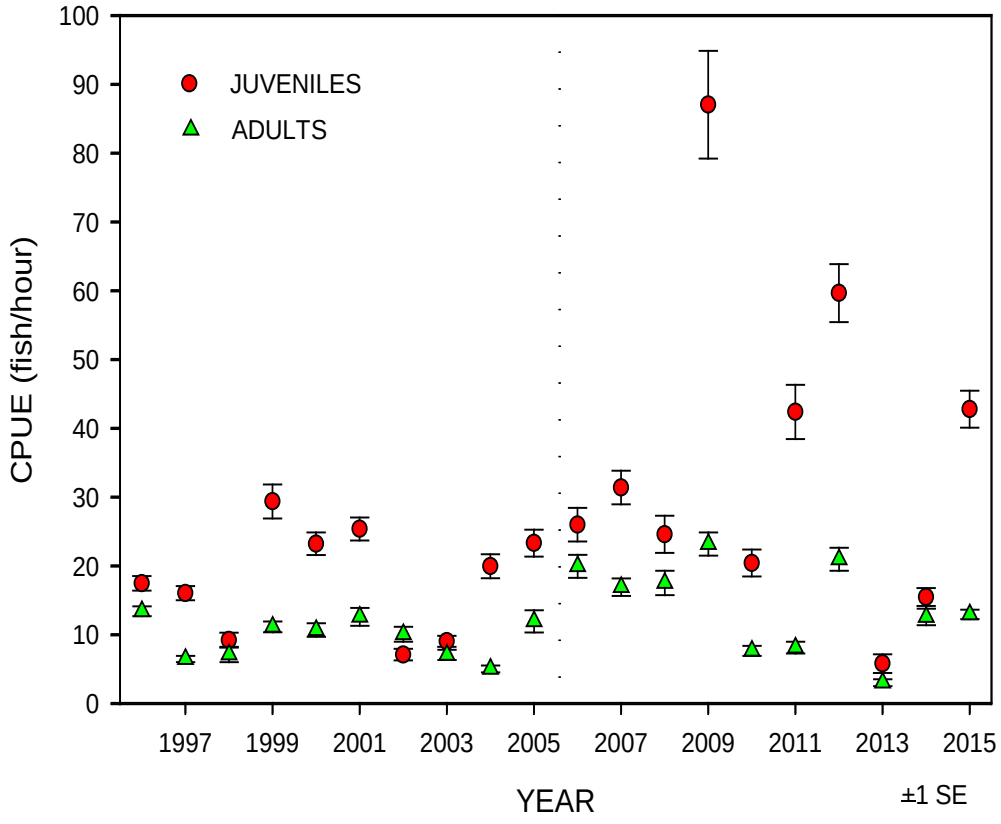

Figure 5. Channel Catfish CPUE (fish/hour) during annual fall monitoring by year, Shiprock Bridge to Mexican Hat; 1996-2015. Adult CPUE is represented by triangles. Juvenile CPUE is represented by circles. The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

Mean total length of Channel Catfish in 2015 was 286 mm (range = 50 – 700 mm). Forty-four percent of measured Channel Catfish were < 300 mm TL, 33 % were between 300 – 400 mm TL, and 22.9 % were > 400 mm TL.

COMMON CARP

Catch rates for Common Carp were < 0.08 fish/h during each of the four removal trips conducted in 2015. Mean Common Carp CPUE in 2015 was 0.08 fish/h.

A comparison of Common Carp catch rates among years of adult fall monitoring shows a decline in CPUE during pre-removal efforts and continuing after intensive removal began in

2006 (Figure 6). Catch rates have remained < 1.0 fish/h for the last seven years. Catch rates in 2015 were significantly lower than observed values pre- removal.

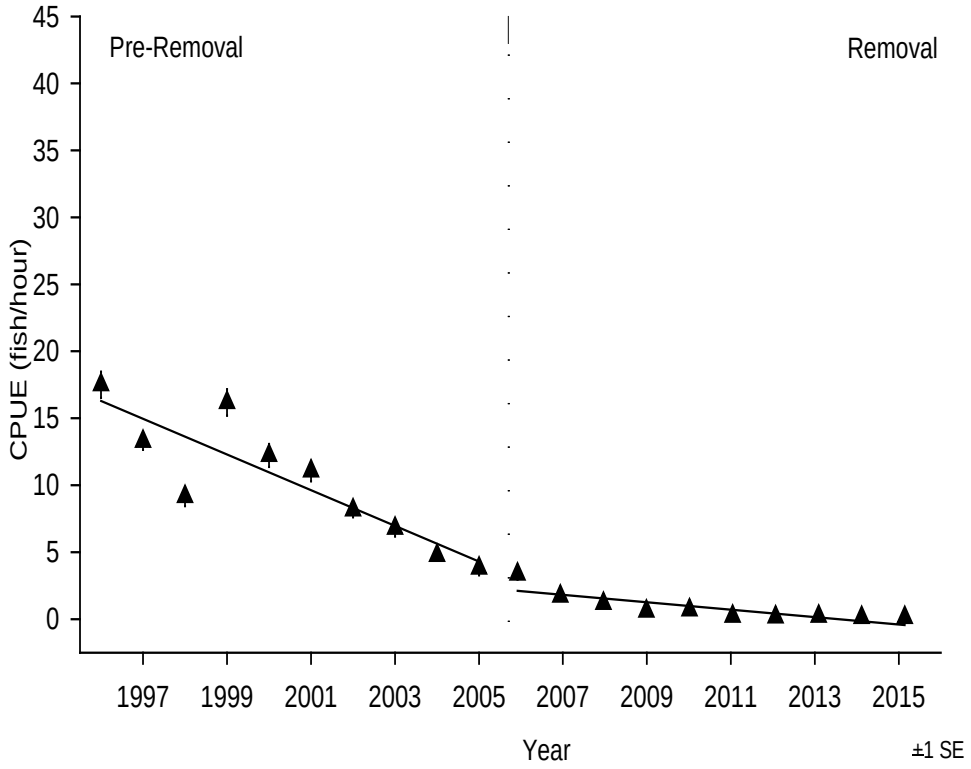

Figure 6. Common Carp CPUE (fish/hour) during annual fall monitoring by year, Shiprock Bridge to Mexican Hat; 1996-2015. A line was fitted to the data if the trend was significant (96-05: y= 16.289 – 1.332x; r^2 = 0.77; p<0.001; 06-15: y= 2.068 – 0.284x; r^2= 0.70; p=0.003). The vertical hash line represents the initiation of intensive nonnative removal in this section. Error bars represent ± 1 SE.

RARE FISH COLLECTIONS

During nonnative removal trips from Hogback Diversion to Mexican Hat, Utah, 655 Colorado Pikeminnow (580 individual fish) and 1,590 Razorback Sucker (1,308 individual fish) were captured (Appendix A-3). Totals of 173 Colorado Pikeminnow and 854 Razorback Sucker were collected from Hogback Diversion to Shiprock Bridge, 68 Colorado Pikeminnow and 119 Razorback Sucker were collected from Shiprock Bridge to Montezuma Creek, and 263 Colorado Pikeminnow and 620 Razorback Sucker were collected from Shiprock Bridge to Mexican Hat. These totals do not include rare fishes collected during the shifted effort done from Montezuma Creek to Mexican Hat conducted by UDWR nor the rare fishes collected during annual sub-adult and adult fish community monitoring conducted by U.S Fish and Wildlife Service- Colorado Fishery Project. They do include the rare fishes collected during the tagging trip in early April

from Shiprock Bridge to Mexican Hat. For analysis purposes, fish that were recaptured multiple times on an individual trip or throughout the year were included, but recaptures of an individual fish on the same day were excluded.

COLORADO PIKEMINNOW

All Colorado Pikeminnow collected in 2015 were considered to be stocked fish. A total of 101 individual fish had PIT tags at time of capture and recaptures ranged from 1 to 4,760 days (d) since first encounter. Fish were classified as first encounters when the fish was stocked in the river or collected and tagged in the river. Days since first encounter could not be calculated for all PIT-tagged Colorado Pikeminnow due to errors when recording PIT tag numbers. The majority of PIT tagged fish (66%, n= 101) were captured < 730 d since first encounter, and 51 fish were recaptured > 730 d since first encounter.

A total of 333 Colorado Pikeminnow were implanted with a PIT tag at the time of capture. These newly implanted fish ranged in size from 137 to 568 mm TL, with a mean TL of 217 mm. Of these newly implanted fish, six were adult fish; 124 fish were not implanted with a PIT tag because they were < 150 mm TL. Mean TL of Colorado Pikeminnow collected during our efforts in 2015 was 230 mm TL (range = 75 – 705 mm TL). Fish < 150 mm TL composed 21.7 % (n = 126) of the total catch while fish > 400 mm TL composed 9 % (n = 52) of the catch. Forty adult Colorado Pikeminnow were collected during our efforts in 2015.

For three consecutive years prior to 2015, a possible spawning aggregation of adult Colorado Pikeminnow was found at RM 118 during the June sampling trip. This aggregation was not evident during the 2015 June sampling trip; however, this may be a direct result of high flows and poor sampling conditions during this trip.

RAZORBACK SUCKER

All Razorback Sucker collected in 2015 were considered to be stocked fish. Forty-eight Razorback Sucker were lacking PIT tags at time of capture. These fish ranged in size from 405 to 562 mm TL, with a mean of 474 mm TL, so we assumed these fish were stocked fish that lost a PIT tag or were stocked from NAPI ponds in earlier years without a PIT tag. The majority of untagged Razorback Sucker had fin rays collected for a study using elemental analysis to determine Razorback Sucker natal origin. All 48 of these fish were implanted with a 134.2 kHz PIT tag prior to release. Razorback Sucker in 2015 averaged 438 mm TL and sizes ranged from 270 to 595 mm TL. Of the 1,308 individual fish measured, 76% (n = 988) were adult fish ($\geq$ 400 mm TL). Of these adult fish, 184 fish were $\geq$ 500 mm TL. Various known age classes of Razorback Sucker were recaptured dating back to 1999 with the majority (56%) of recaptures composed of the 2008-2010 year classes (Table 2).

Table 2. Summary of Razorback Sucker by age class collected during nonnative fish removal; 2015.

Year class	N
1999	6
2000	4
2001	15
2002	3
2003	3
2004	6
2005	1
2006	22
2007	53
2008	212
2009	213
2010	170
2011	162
2012	32
2013	159
2014	1

Days in river since first encounter ranged from 1 – 5,074 d. Of the 1,213 Razorback Sucker that had a known stocking history, 25 % (n = 302) were recaptured < 1 year since first encounter and 14.8 % (n = 179) were recaptured > 5 years since first encounter. Twenty-six individuals were recaptured 10 years since first encounter.

DISCUSSION

Intensive nonnative removal was initiated in 2001 from PNM Weir to Hogback Diversion. Channel Catfish catch rates in recent years leading up to 2014, remained relatively low and stable compared to years prior to intensive removal. Starting in 2014, in an effort to maximize efficiency and target Channel Catfish in areas of higher abundance, funds and personnel for two trips from PNM Weir to Hogback Diversion were shifted in order to complete one 5-day trip from Shiprock Bridge to Montezuma Creek, Utah. This shifted effort continued in 2015. Data from annual fall monitoring in 2014 and 2015 failed to identify a Channel Catfish population rebound in the absence of nonnative fish removal.

In 2003, nonnative removal efforts were expanded to include the Hogback Diversion to Shiprock Bridge section. Due to low spring catch rates in recent years, the March sampling trip was moved to August in 2014. Due to the Gold King Mine spill, the two trips scheduled for August were rescheduled and completed in October and November 2015. Channel Catfish catch rates for juvenile and adult fish during 2015 fall monitoring were lower, although not significantly, compared to recent years. Forty-nine Channel Catfish were recaptured that were

originally tagged downstream of Shiprock Bridge, including four fish that were tagged downstream of Mexican Hat, Utah. These recaptures illustrate long-range upstream movement and the potential to repopulate upstream removal reaches throughout the year. This long-range movement and the absence of any impediments to upstream movement at Shiprock Bridge could be a main factor as to why we have not observed significant declines in catch rates in this section. Although data from each removal section are analyzed and presented independently, it is important to recognize the effect that high Channel Catfish abundance in other areas may have on removal sections through immigration.

Beginning in 2008, the expansion of removal efforts to include two passes per trip from Shiprock Bridge to Mexican Hat, UT, was expected to result in significant declines in Channel Catfish abundance river-wide. Even with the increased effort and two passes per trip in this section, no declining trend has been observed for juvenile or adult Channel Catfish. Catch rates for juvenile Channel Catfish have actually increased since intensive removal began in this section. Similar increases in juvenile Channel Catfish catch rates were observed after the initial years of intensive removal in the uppermost section of our study area only to decline with continued exploitation (Davis and Duran 2009). An increase in smaller size classes of fish and a reliance on single year classes has been documented as a response to exploitation of Channel Catfish in the Mississippi River (Pitlo 1997). Regardless, if increases in juvenile abundance are a response to exploitation, or other unknown factors, it may be critical to maintain or even increase intensive removal efforts to facilitate a declining population trend. Increased, or focused, removal efforts should concentrate on high priority areas that target the highest Channel Catfish abundances and size classes most susceptible to our gear type.

The majority of Channel Catfish captured in 2015 were juvenile, sub-adult, and newly recruited adult fish. Channel Catfish greater than 400 mm TL comprised 17.9% of all Catfish measured in 2015. A reduction in abundance of large Channel Catfish, greater than 400 mm TL, may be important in not only limiting the reproductive potential of Channel Catfish in the San Juan River but may also limit overall predatory impacts on native fishes by Channel Catfish. Brooks et al. (2000) found that San Juan River Channel Catfish < 300 mm TL consumed almost exclusively macroinvertebrates and Russian Olive fruits. Piscivory occurred most frequently in fish > 450 mm TL. Removing smaller sized fish before they reach sexual maturity may reduce overall reproductive potential and recruitment. Helms (1975) found that 1 of 10 Channel Catfish were sexually mature at 330 mm TL, compared to 5 of 10 at 380 mm TL. In addition, he found that Channel Catfish at 330 mm TL produced around 4,500 eggs/fish compared with the production of 41,500 eggs/fish at 380 mm TL. In 2012, in an attempt to disrupt Channel Catfish spawning, the summer trip from Shiprock Bridge to Mexican Hat that was typically completed in July was moved to June. This was in effort to target Channel Catfish either aggregating for spawning or disrupt males guarding egg nests. Although 2015 was the fourth consecutive year of this effort, no clear response can be quantified.

Common Carp were once ubiquitous in the San Juan River and during 1991-1997 SJRIP studies were the fourth most abundant fish in electrofishing collections (Ryden 2000). Corresponding with the initiation of intensive removal in each of the three sections, Common Carp abundance has been greatly reduced to a level of infrequent collection across all studies (Elverud 2010; Ryden 2010). Common Carp catch rates in 2015 were < 1.0 fish/h in all removal sections, and were < 1.0 fish/h during fall monitoring for the 7th consecutive year. Prior to the initiation of nonnative removal in the upper two sections, Common Carp catch rates during annual fall monitoring were relatively high and showed little variance among years. After intensive nonnative removal began in each of the two sections, Common Carp CPUE immediately declined. These declines may be a result of a combination of factors including intensive nonnative removal efforts, a regulated flow regime resulting in a lack of overbank flow and the waterfall at Clay Hills prohibiting upstream movement of fish out of Lake Powell.

Common Carp are one of the world's most damaging and invasive fish (Lowe et al. 2004). Their establishment in a system can lead to declines in vegetation, water quality and native fauna. Nonnative removal combined with other variables has drastically reduced the Common Carp population in the San Juan River from one of the most abundant fish in the 1990's to one that is now infrequently collected river wide. This successful management of a very invasive nonnative species is often overshadowed by the trends of Channel Catfish abundance in the river. While Common Carp are not predatory, they can still negatively impact native fish communities and affect recovery efforts of endangered. Decreased Common Carp abundance may limit competitive interactions with native fishes and negative habitat modifications often associated with Common Carp (i.e. uprooting of aquatic plants causing increased turbidity, possible cause of noxious algae blooms by recycling of nutrients from silt substrates) (Cooper 1987). These decreases in abundance and the subsequent declines in Common Carp biomass may allow for higher utilization of resources by native fishes with limited levels of interspecific competition.

In addition to our goal of removing large-bodied nonnative fishes, intensive nonnative removal trips have contributed to the gathering of information on rare fish distribution and abundance and may be used as a barometer to measure the success of current augmentation programs. The frequency and range of our trips, initially near stocking locations and now river wide, provide the opportunity to collect large amounts of data on stocked fish and may be used to evaluate the success, or failure, of individual stocking events.

In 2015, we captured 40 individual adult Colorado Pikeminnow. This represents the highest number of adult fish collected during one year of sampling. Additionally, the documented spawning aggregation of adult Colorado Pikeminnow found in June 2012-2014 suggests that the numbers of sub-adult and adult fish in the San Juan River are reaching numbers that enable them to 'find' each other for spawning. Numbers of Colorado Pikeminnow that had a PIT tags at time of capture remain low. It is unknown if these fish are still in the river and go

undetected throughout the year or if they have moved out of the system or perished. However with the recent work sampling tributaries of the San Juan River and the installation of remote PIT tag arrays in tributaries and the main stem San Juan, we should get a better idea of how many PIT tagged fish are missed with current sampling methodologies. Razorback Suckers continue to show long term persistence in the San Juan River. Twenty-six individual fish captured in 2015 had been in the river 10 years or more. We continued to collect Razorback Sucker without PIT tags in 2015; however, fin rays were taken from untagged Razorback Sucker for a study using elemental analysis of fin rays to determine natal origin.

Under the framework of adaptive management, the SJRIP will continue to seek ways to improve the efficacy of nonnative fish removal. By using data collected from annual fall monitoring to assess long-term trends, we have moved away from trying to maintain trips consistent in time and section each year to instead focus on areas of known higher Channel Catfish abundance. In 2014, we started this transition by shifting effort from areas of known lower Channel Catfish abundance, such as PNM Weir to Hogback Diversion, to areas of higher abundance. Utah Division of Wildlife Resources also shifted effort from downstream of Mexican Hat, UT to include three trips from Montezuma Creek to Mexican Hat, UT in 2015. We feel this shift in effort is needed to focus on the areas of highest abundance at certain times of the year when we can maximize our capture efficiency. Complete eradication of these species is not expected; however, using multiple pass sampling is expected to continue to reduce abundance to manageable levels. By reducing abundance and biomass of these species, spatial and trophic interactions with Common and rare native fishes should be reduced and may result in improved post-stocking survival of stocked rare fishes. Collecting data on growth, distribution and abundance of rare fishes in conjunction with intensive nonnative fish removal continues to supplement monitoring data of these two species and will assist researchers with future management decisions and assessing progress towards recovery.

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Appendix A-1. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Shiprock Bridge to Montezuma Creek, Utah, 2015. Species listed by the first three letters of the Genera and first three letters of Species (i.e. *Ptychocheilus lucius = Ptyluc).* [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus spp*	*Saltru*
July 6-10	2,414	38.7	68	119	116	1	1	4	1
Totals		**38.7**	**68**	**119**	**116**	**1**	**1**	**4**	**1**

Appendix A-2. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Hogback Diversion to Shiprock Bridge, 2015. [1] Mean discharge from USGS gauge #09368000 near Shiprock, New Mexico.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus* spp	*Saltru*
July 27-29	749	28.1	49	267	618	10	7	28	0
October 13-15	535	25.7	64	310	692	24	0	17	0
November 10-12	704	23.4	60	277	153	6	0	3	0
Totals		**77.2**	**173**	**854**	**1,463**	**40**	**7**	**48**	**0**

Appendix A-3. Mean discharge, effort and total count of major species collected during intensive non-native removal efforts from Shiprock Bridge to Mexican Hat, Utah; 2015. Endangered fishes were not collected by upstream boats (n/a). [1] Mean discharge from USGS gauge #09371010 near Four Corners, Colorado.

Trip	Discharge[1] (ft^3/sec)	Effort (hours)	*Ptyluc*	*Xyrtex*	*Ictpun*	*Cypcar*	*Micsal*	*Ameiurus* spp	*Saltru*
Tagging Trip									
April 9-17	618	**89.8**	**148**	**-**	**4,882**	**13**	**0**	**5**	**2**
Totals for trip									
April 23 – May 1									
Downstream boats		100.4	109	269	3,631	7	0	17	3
Upstream boats	591	102	9	n/a	4,741	5	0	22	2
Totals for trip		**202.5**	**118**	**269**	**8,372**	**12**	**0**	**39**	**5**
June 18 - 22									
Downstream boats		41.4	32	190	332	1	0	1	0
Upstream boats	5,196	33.8	1	n/a	304	0	0	1	3
Totals for trip		**75.2**	**33**	**190**	**636**	**1**	**0**	**2**	**3**
August 27- Sept 4									
Downstream boats		85.9	93	160	989	4	0	6	0
Upstream boats	817	83.8	13	n/a	1,192	6	0	13	0
Totals for trip		**169.7**	**106**	**160**	**2,181**	**10**	**0**	**19**	**0**
****September 17 - 25**									
Downstream boats		63.4	93	215	3,486	5	0	31	1
Upstream boats	845	89.3	6	n/a	6,443	7	1	26	0
Totals for trip		**152.7**	**99**	**215**	**9,929**	**12**	**1**	**57**	**1**
Totals (excluding tagging trip)		**600.1**	**356**	**834**	**21,118**	**35**	**1**	**117**	**9**

** Nonnative removal trip conducted in conjunction with annual sub-adult and adult fish community monitoring. Downstream boats sampled using standardized sampling protocols as defined in *San Juan River Monitoring Plan and Protocols (Propst et al. 2006)*. Downstream boats sampled in one river mile increments, with two of every three river miles sampled. When possible, upstream boats sampled all river miles and did not skip the same miles as the downstream boats.