Nonnative control in the Lower San Juan River 2002

Interim Progress Report
Draft

for the
San Juan River Recovery
Implementation Program

Prepared by:

Julie A. Jackson
Utah Division of Wildlife Resources
Moab Field Office
Moab, Utah

March 31, 2003

EXECUTIVE SUMMARY

The first year of nonnative control in the lower San Juan River was conducted in 2002. This project was initiated to remove nonnative fish species and to identify factors involved in striped bass and other lacustrine species movement out of Lake Powell and into the river. Relationships with these factors and nonnative catch rates will provide for refinement in the timing of future removal actions.

Six trips were conducted, beginning in mid-March and continuing to the end of June. Results from the September adult monitoring trip were also incorporated. Electrofishing was conducted from Mexican Hat to Clay Hills, UT (RM 53-2.9). Flows were below 800 cfs throughout sampling (except in September) and three trips in July and August were canceled due to low water conditions.

Striped bass movement out of Lake Powell appeared to peak in June, while catch rates of walleye peaked in May. No striped bass or walleye were collected during the September adult monitoring trip. This may have been the result of a storm spike of 10,000 cfs one week prior to the September trip. No native fish were found in stomachs of striped bass in the lower river but striped bass collected by NMFRO crews in the upper river (near Farmington, NM) contained many native fish. Correlations between striped bass catch rates and river and lake conditions were tested. The strongest correlation was between striped bass catch rate and Lake Powell temperature. This correlation is not surprising since striped bass tend to begin migration in the spring when lake temperatures are warming.

Channel catfish made up the majority of nonnative species collected and over 7,000 were removed. Common carp were the next most abundant nonnative encountered. Catch rates for these two species remained similar between the first and last trips with some variation between trips. A significant decrease was observed in the size structure of channel catfish between the first and last trip but did not exhibit a downward trend across trips. Carp size structure remained the same.

Thirty-four endangered fish were collected during the 2002 sampling. Six Colorado pikeminnow were collected in the lower San Juan River, four were larger than 450 mm TL and two were less than 450 mm TL. One of these fish was a recapture from 1999 and had grown 161 mm. The remaining fish were not tagged and are presumably from the 1996 and 1997 UDWR stocking. Twenty-eight razorback sucker were captured throughout 2002. Five of these were collected around Slickhorn Rapid (RM 17.6) in April with another ten observed in the same area.

The lower San Juan River is an important section of river to endangered species. Continued removal efforts in the lower river will aid in removal efforts being conducted further upstream, and suppress predation and competition impacts to the endangered and native fish community.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In the San Juan River, nonnative lacustrine predators that move from Lake Powell may be having a significant impact on the native fish population. These predators include largemouth bass (*Micropterus salmoides*), walleye (*Stizostedion vitreum*) and striped bass (*Morone saxatilis*). Striped bass from Lake Powell have recently become an issue in the San Juan River. Lake Powell has a large self-sustaining population of striped bass and their life history patterns suggest that they move out of lakes and into lotic waters to spawn in the spring (Lee et al. 1980). Striped bass usually spawn when temperatures are between 10 ºC and 21.1ºC (Sigler and Sigler 1996). Striped bass may move up when river conditions are favorable in the spring (cool temperatures and low turbidity) and remain in the river as long as these conditions persist (i.e. until monsoon storm events). Striped bass introductions into Lake Powell began in 1974 and continued through 1979. Stockings were halted in 1979 when evidence of striped bass reproduction was discovered (Gustaveson 1984). Angler bag limits for striped bass were slowly raised and ultimately removed in Lake Powell to aid in control of the population.

Lacustrine predators began to show up during San Juan River data collection in July 1995 (Ryden 2001). From 1988 to spring/summer 1995 the river flowed over a rock outcropping creating a waterfall that was impassable to lake species. During 1995, Lake Powell levels rose and the waterfall was inundated. This allowed the invasion of lake species into the San Juan River. When lake levels receded in the winter of 1996, the river either cut a new channel or had not scoured the sediment enough to expose the rock and the waterfall did not reappear (Schaugaard and Gustaveson, 1996).

High abundance and widespread distribution of striped bass was first observed in July 2000 during electrofishing surveys on the San Juan River (RM 147.9-129.0; Ryden 2001). U.S. Fish and Wildlife Service New Mexico Fishery Resources Office (NMFRO) crews collected another 33 striped bass between RM 166.6 and 158.6, just below the PNM weir in September and October 2000 sampling (Davis 2002). Adult monitoring in October 2000 revealed approximately one hundred striped bass still in the river. It is speculated that the absence of small native (flannelmouth and bluehead suckers) and nonnative common species (carp) caught in the summer was directly related to the abundance of native and common species found in striped bass stomachs (Ryden 2001). During the October 2000 trip this was further evidenced by the higher distribution of flannelmouth, bluehead, and carp above the PNM weir where striped bass did not occur. Electrofishing surveys in 2001 once again documented the presence of striped bass in the river but at a lower frequency. Striped bass predation upon native fish poses a substantial threat to the recovery of endangered species in the San Juan River.

The objectives of this study were: 1) Determine when striped bass move out of Lake Powell and into the San Juan River; 2) Continue mechanical removal efforts of large-bodied nonnative species from the lower San Juan River; 3) Relate striped bass movement out of Lake Powell into the San Juan River to lake levels and river conditions (including flow and turbidity). 4) Characterize the distribution and abundance of lacustrine predators moving out of Lake Powell and into the San Juan River in spring and summer.

METHODS

The study area included the San Juan River from Mexican Hat (RM 53) to Clay Hills (RM 2.9), Utah. The river from Mexican Hat to RM 16 is primarily bedrock confined and dominated by riffle-type habitat. The river is canyon bound with an active alluvial bed from RM 16 to Clay Hills (RM 2.9). Habitats within this section are heavily influenced by the shifting thalweg, changing river flow, and reservoir elevations. This section of river has been identified as important nursery habitat for native and endangered fish species (Archer et al. 2000).

Raft mounted electrofishing gear was used during all trips. Two boats worked both shorelines on all but the first sampling effort. When conditions allowed, a baggage boat would follow to net fish not captured by the electrofishing boats. All nonnative and endangered species were netted and native suckers were not. Fish collected were measured to the nearest mm and weighed to the nearest gram. In some instances, nonnatives were counted and weighed in mass, or simply counted. Endangered fish received a PIT tag if one was not already present and general condition of the fish was noted. All endangered fish were released at the location of their capture. Stomach contents, sex and reproductive status of lacustrine predators were recorded. All nonnative fish species were removed from the river. River temperature, conductivity, and salinity were measured Turbidity was measured using a Secchi disk, with depth to disappearance of disk measured in millimeters. River discharge was determined from the USGS gage # 09379500 at Bluff, UT. Lake Powell elevations were taken from the Lake Powell water database website.

Catch rates were calculated using number of fish caught per hour of electrofishing. Regression analyses were performed using CurveExpert 1.37 for Windows Microsoft Corp. to distinguish relationships between catch rates and river and lake conditions. Nonparametric Kruskal-Wallis and Mann-Whitney tests were performed on nonnormal data using SigmaStat 2.03 for Windows SPSS Inc. to identify significant changes in catch rates and size distributions.

RESULTS

Seven sampling trips, including fall monitoring, were conducted on the San Juan River between Mexican Hat and Clay Hills, UT. Sampling dates were: March 11-15, April 15-19, May 6-10, May 20-24, June 10-14, June 24-28 and September 20-29. Three scheduled trips were canceled in July and August due to low water conditions, making it difficult to navigate the river. Average river discharge from March through June was below 800 cfs during all trips, with the lowest mean daily flow at 324 cfs during the final June trip. One week before the fall adult monitoring trip in September, storm events produced a 10,000 cfs spike in river flow. Flows had dropped by the time of the fall adult monitoring trip and ranged from 1,070 cfs to 428 cfs.

The elevation of Lake Powell has dropped steadily since the beginning of 2002, and has been below 1988-1995 levels when the waterfall was present (3,670 - 3,623 ft AMSL). Lake elevations averaged 3,654 ft AMSL in January 2002 and dropped to an average of 3,621 ft AMSL in December 2002, however the waterfall has not reappeared. Lake levels are rapidly surpassing the all time record low set in 1993 at 3,612 ft AMSL.

Nine different fish species were collected in the lower San Juan River during nonnative control and adult monitoring trips in 2002 (Table 1). Electrofishing effort totaled 318.8 hours and produced 8,803 fish, 35 of these fish were lacustrine species and 34 were endangered species. Channel catfish dominated the total catch with over 7,000 individuals.

Striped bass

Striped bass were not collected or observed until the third sampling trip at the beginning of May. Catch rates increased from the third trip to the fifth trip when they peaked, and then decreased on the sixth trip at the end of June (Figure 1). During the third trip (May 6-10), striped bass were found only as high as RM 20.3. By the following trip (May 20-24), they were collected as high as RM 52 (Mexican Hat). No striped bass were collected during the fall monitoring trip. NMFRO crews conducting nonnative removal in the upper section of the San Juan River collected twelve striped bass between RM 166.6 and 158.6 in July and August (Jason Davis, pers. comm.).

Sex was determined in nineteen of the twenty-one striped bass collected, 80% of these were female. Four of the females collected in May and June were gravid. Upon examination, striped bass stomachs were either empty or contained a few red shiners. Striped bass had an average total length (TL) of 525 mm and an average weight of 1195 g. Condition factor of striped bass collected in the upper section (RM 166.6-158.6) was significantly higher than of those collected in the lower canyon section (RM 53-2.9).

Regression analysis was performed for striped bass vs. river flow, river temperature, river turbidity, and Lake Powell temperature. The strongest relationship observed was between striped bass catch rates and Lake Powell temperature ($r = 0.71$; Figure 2). A relationship was also observed between striped bass catch rates and river temperatures ($r = 0.62$; Figure 2). Catch rates of striped bass vs. river discharge, and river turbidity were weakly related ($r = 0.31$ and $r = 0.34$, respectively; Figure 3).

Walleye
Fourteen walleye were collected during the first five of seven trips. One other was observed but not captured (Table 1). Average TL and weight of walleye were 492 mm and 1137 g, respectively. Sex was determined in thirteen fish and the ratio of male to female was approximately 1:1. Most of the stomachs examined were empty. Three fish had nonnative species in their stomachs (channel catfish and red shiner) and one had two 140 mm TL flannelmouth suckers.

Channel catfish
Catch rates of channel catfish varied significantly between trips and remained between 10 and 35 fish per hour during each trip (Table 2). Catch rates between the first and last trip did not significantly change ($p = 0.649$; Figure 4). Average TL of all channel catfish collected over the seven trips was 263 mm (SE = 15.4; Figure 4), yet many large channel catfish were collected and TL ranged from 55 mm to 789 mm. A significant reduction in size structure was observed from the first trip to the fall trip ($p<0.001$). However, this reduction was not steady, instead it appeared to increase by trip and then decreased between the sixth trip and the fall trip.

Common carp
Catch rates of common carp were variable throughout the trips. Carp catch rates were highest in June (Figure 5). Patterns of carp and channel catfish catch rates among trips was similar, however, carp catch rates were approximately four times lower than channel catfish catch rates. Carp average TL was 457 mm (SE = 1.45) and remained similar for all trips (Figure 5).

Colorado pikeminnow
Six Colorado pikeminnow were captured during spring and summer sampling (Table 3). Individuals were collected between RM 46 and RM 8. Four were adults (> 450 mm TL) and two were juveniles (< 450 mm TL). One of the adults caught at RM 21.4 on 6/12/02 was a recapture, which was previously tagged on 10/1/99 at RM 86 and later identified as being from the 1996 year class (Ryden 2003). This fish had grown 161 mm in three years. In 2002, it was noted as being male, tuberculated and expressing gametes at the time of capture. Recapture status of one adult Colorado pikeminnow could not be determined because of PIT tag reader malfunction.

Razorback sucker
Twenty-eight razorback sucker were captured during our 2002 sampling in the lower San Juan River (Table 4). In April, catch rates were higher for razorback sucker than for any other trip. Most of these fish were caught around Slickhorn rapid at RM 17.6. Ten other razorback sucker were observed at this time but not netted. Razorbacks were tuberculate from the March trip through the first May trip. Average TL and weight of razorback suckers netted was 464 mm and 1083 g, respectively. One razorback that was captured on March 19 at RM 7.7 was again recaptured on May 23 at RM 17.2

DISCUSSION

From our 2002 data, it appears most striped bass were moving out of Lake Powell at the beginning of June. Since striped bass were found at RM 52 on May 20, it is likely they were also present in the river above. River temperatures in June were warm (23.3 ºC) and lake temperatures averaged 21 ºC. In 2002, there was no spring peak or release from the dam to produce a peak, therefore turbidity remained low during the majority of the summer and was at its lowest during the fourth trip. Striped bass absence during the fall monitoring trip in 2002 might be attributed to extremely high flows (10,000 cfs) caused by monsoonal storms one week prior. These monsoonal storms generally increase turbidity in the river in contrast to dam releases or spring runoff which tend to have lower sediment loads. Another possibility for low striped bass catch rates during the sixth and seventh trips is that Lake Powell elevations dropped and access into the river may have been impeded by the actual inflow area to the lake. Correlations were found between striped bass catch rate and Lake Powell temperatures, and striped bass catch rate and river temperatures. Strong correlations were not found between striped bass catch rate and river flow or river turbidity. Strength and validity of these correlations will be further tested with continuing data collection.

From 1996 to 2001, walleye catch rates were highest in 1996 at 0.13 fish/hour (Ryden 2001), and have remained below 0.10 fish/hour since then. In 2002, mean catch rate for walleye was 0.05 fish/hour during the spring and summer trips, and 0.038 fish/hour for the spring, summer and fall monitoring trips. No walleye were captured during the fall monitoring trip. As shown by our data, walleye appear to move into the river earlier and leave earlier than striped bass. This may be explained by walleye moving into the river to spawn as well (Sigler and Sigler 1996). Walleye were not present in the upper river nonnative removal sampling unlike striped bass.

Low channel catfish catch rates during the second and fourth trips could be attributed to weather and river conditions at the time of sampling. Wind gusts were up to 46 mph during the second and fourth trips, and turbidity measurements were highest during the fourth trip. Windy conditions and high turbidity measurements directly affected our ability to net fish. Catch rates of common carp during these two trips might also have been affected by weather. Comparison of channel catfish and carp catch rates suggest a common factor between these two species.

Our data show that catch rates of lacustrine species were dropping off by the fifth trip and none were found during the September fall monitoring trip. Striped bass collected near Farmington (RM 166.6-158.6) in July and August may represent continuing movement from the lake, or persistence in the river and upstream movement of striped bass that we had encountered in the earlier months. Significantly higher condition factor of striped bass in the upper section versus the lower section can be attributed to the amount of forage present. The upper San Juan River has substantially higher numbers of small native fish which correlates with the larger amount of native fish found in the stomachs of striped bass collected there.

Mechanisms leading to the large abundance and distribution of striped bass in the San Juan River in 2000 remain unexplained. However, there are several factors that could have been involved. Our data from 2002 suggests possible relationships between lake temperature and striped bass movement. This reinforces data from Lake Powell regarding movement of these fish as lake temperatures warm in the spring (Gustaveson 1999). Furthermore, attraction to current (river or turbine) in the spring is a stimulus that triggers striped bass migration in Lake Powell even when fish are not sexually viable. An even stronger stimulus is food availability. Striped bass will spawn without extensive migration as long as food is available. Striped bass feed primarily on threadfin shad in Lake Powell and populations of threadfin shad have remained low since 1996. Striped bass population trends rise and fall over time concurrently with threadfin shad populations. Gill-net and electrofishing surveys in 1996 of young-of-year striped bass in Lake Powell were at or near record numbers that haven't been seen in over 20 years (Gustaveson 1999). Additionally, threadfin shad numbers were high. Male and female striped bass in Lake Powell are mature at age 4, so high numbers in the San Juan River in July 2000 could have been the result of this strong 1996 year class maturing. Since threadfin shad populations in 2000 were not considered high, striped bass would have been more likely to migrate in search of food in addition to the natural urge to migrate for spawning. Discharge of 5,000 cfs on June 5th in the San Juan River would have been a strong stimulus for striped bass to enter the river. Persistence of striped bass in the river could have then been supported by flows less than 1100 cfs through October. Perhaps striped bass invasions in the San Juan River can be predicted when a strong year class is detected in Lake Powell and when forage fish populations are low.

River conditions in 2002 forced the cancellation of three trips that were to occur in July and August. Flows around that time did not reach above 400 cfs for periods long enough to float the lower section of the river. Since drought conditions in the West appear to be holding and low water and low reservoir releases are expected for 2003, other methods of controlling striped bass and walleye invasions may need to be considered.

CONCLUSIONS

- Striped bass catch rate was highest in June.
- Striped bass did not persist in the river through the fall which may have been a result of storm spikes around 10,000 cfs.
- Striped bass catch rate was most strongly correlated with lake water temperature.
- Correlations between striped bass catch rates and river and lake conditions are preliminary and will require subsequent years of data to substantiate relationships.
- Slightly fewer walleye than striped bass were present in the river and were detected earlier.
- Channel catfish and common carp catch rates varied among trips, but there was not a significant change between March and October.
- Colorado pikeminnow adults and subadults are using the lower canyon of the San Juan River in the spring and summer.
- Razorback sucker appear to congregate around Slickhorn Rapid (RM 17.6) in the spring.

RECOMMENDATIONS

- Continue to remove nonnative fish from the lower San Juan River focusing effort in spring and summer when striped bass and other lacustrine species move up from Lake Powell.
- Continue to collect river and lake condition data (i.e. river and lake temperature, turbidity, discharge).
- Consider alternative removal efforts (e.g. hoop netting, trammel netting at Clay Hills) during low water conditions (flows below 375 cfs at the Bluff gage).

LITERATURE CITED

Archer, E.K., T.A. Crowl, and M.A. Trammell. 2000. Abundance of age 0 native fish species and nursery habitat quality and availability in the San Juan River in New Mexico, Colorado, and Utah. Final Report to the San Juan River Recovery Implementation Program: Biology Committee. Utah Division of Wildlife Resources. Salt Lake City, UT.

Davis, J.E. 2002. Non-native species monitoring and control, San Juan River 1999-2001. Progress Report for the San Juan River Recovery Implementation Program. Draft Report. U.S. Fish and Wildlife Service, Albuquerque, NM..

Gustaveson, W., B.L. Bonebrake, S.J. Scott, J.E. Johnson. 1984. Lake Powell fisheries investigations. Completion report Jan. 1980- Dec. 1984, Annual performance report Jan. 1984-Dec.1984. Project F-28-R-13. Publication No. 85-12. Utah Division of Wildlife Resources. Salt Lake City, UT. 73 pp.

Gustaveson, W. 1999. Cyclical population dynamics of self-sustaining striped bass in Lake Powell, Utah-Arizona, 1974-1998. Sport Fish Restoration Act, Project F-46-R. Publication No. 99-09. Utah Division of Wildlife Resources. Salt Lake City, UT. 44 pp.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R.E. Jenkins, D. E. McAllister, J. R. Stauffer, Jr.1980. Atlas of North American Freshwater Fishes. North Carolina State Museum of Natural History.

Ryden, D. W. 2001. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River, 2000. Interim Progress Report. U.S. Fish and Wildlife Service. Grand Junction, CO. 61 pp.

Ryden, D. W. 2003. An augmentation plan for Colorado pikeminnow in the San Juan River. Final Report. U.S. Fish and Wildlife Service. Grand Junction, CO. 53 pp.

Schaugaard, C. and W. Gustaveson. 1997. Nonnative invasion between Lake Powell and the San Juan River, 1996. Completion Report. Utah Division of Wildlife Resources. Salt Lake City, UT. 16 pp.

Sigler, W. F. and J. W. Sigler. 1996. Fishes of Utah. University of Utah Press. Salt Lake City.

Table 1. Total count of nine species of fish collected and electrofishing effort in hours during lower San Juan River nonnative control and adult monitoring trips. Numbers in parentheses represent positive identifications of fish observed but not netted.

Trip	Morsax	Stivit	Ictpun	Cypcar	Saltru	Oncmyk	Amemel	Ptyluc	Xyrtex	Effort
March 11-15[1]	0	1	469	93	1	0	0	0	4	24.1
April 15-19	0	1	585	146	0	0	0	2	7(10)	48.0
May 6-10	4	8(1)	1961	299	1	0	0	0	3	57.3
May 20-24	5(2)	2	494	227	0	1	1	0	5	51.3
June 10-14	9(3)	2	1686	388	1	0	0	2	3	53.9
June 24-28	3	0	1486	334	0	0	0	2	3(1)	47.0
Sept 20-29[2]	0	0	455	23	0	0	0	0	3	37.2
Totals	21(5)	14(1)	7136	1593	3	1	1	6	28(11)	318.8

[1]Only one electrofishing boat used during this trip.

[2]Sampling followed protocol of shock three consecutive miles and skip one mile.

Table 2. Mean catch per unit effort (number of fish / hour of electrofishing) of six species collected during lower San Juan River nonnative control and adult monitoring trips.

Trip	Morsax	Stivit	Ictpun	Cypcar	Ptyluc	Xyrtex
March 11-15[1]	0	0.02	22.41	3.87	0	0.10
April 15-19	0	0.02	12.96	2.93	0.04	0.17
May 6-10	0.08	0.16	34.01	5.50	0	0.07
May 20-24	0.14	0.04	10.20	3.93	0	0.13
June 10-14	0.20	0.03	31.88	6.94	0.03	0.06
June 24-28	0.05	0	30.71	6.36	0.04	0.08
Sept 20-29[2]	0	0	18.25	3.47	0	0.09
Totals	0.07	0.04	23.03	4.70	0.01	0.09

[1]Only one electrofishing boat used during this trip.

[2]Sampling followed protocol of shock three consecutive miles and skip one mile.

Table 3. Colorado pikeminnow collected during 2002 lower San Juan River nonnative control trips.

Date	RM	PIT tag	Recap	TL	SL	WT
4/16/02	45.8	5312122813	N	539	432	1050
4/19/02	8.5	530A454D0E	N	246	203	125
6/12/02	21.4	51247F0B49*	Y	507	430	1200
6/13/02	16	Not scanned or tagged #	NA	415	340	535
6/26/02	23.7	423D133353	N	475	395	800
6/27/02	19.8	5228305F22	N	460	376	790

* This fish caught at RM 86 on 6/12/02 was tagged, and had been previously captured on 10/1/99 at RM 21.4 when it was identified as being from the 1996 year class (stocked at 55 mm TL). This fish had grown 161 mm in three years, was male,tuberculate and expressing gametes.

PIT tag reader malfunctioned and could not scan fish

Table 4. Razorback sucker collected during 2002 lower San Juan River nonnative control trips. All razorbacks were recaptures.

Date	RM	PIT tag	TL	SL	WT	Sex (M/F/I) and/or Tubercles (T)
3/14/02	18.6	507F727F1E	516	439	1500	-
3/14/02	18.5	7F7B123D7C	491	420	1250	T
3/14/02	12.2	4240152E07	461	392	1200	-
3/15/02	7.3	1F41612C13	513	433	1600	T
4/18/02	17.5	423F635449	465	450	1175	T
4/18/02	18	512A724849	480	400	1100	T
4/18/02	17.9	1F414E3E14	487	400	1150	T
4/18/02	17.6	42151C0F23	500	410	1150	T
4/18/02	17.6	203E3F3C27	495	410	1125	T
4/18/02	17.6	1F750B7869	505	420	1275	T, M RIPE
4/19/02	7.75	4240132127	490	412	1350	-
5/07/02	41.9	5324612161	392	321	620	-
5/09/02	18.3	423E77433E	440	363	900	T, M
5/09/02	18.2	423F0F0F32	436	375	1100	T
5/20/02	48.8-45.3	42424E135B	383	309	510	-
5/21/02	38-35	423E793225	515	432	1500	-
5/21/02	24.5	51337C3546	445	372	650	-
5/22/02	17.2	423F057A3F	470	400	1200	-
5/26/02	17.2	4240132127*	480	400	1350	-
6/12/02	14.1	4240072250	440	374	850	-
6/13/02	4.2	53256E784F	452	385	1250	-
6/27/02	17.5	423E440B09	465	393	950	-
6/27/02	16	423E30780C	420	345	700	-
6/27/02	14.9	424010312A	393	320	550	-

*This fish previously captured on 4/19/02 at RM 7.75.

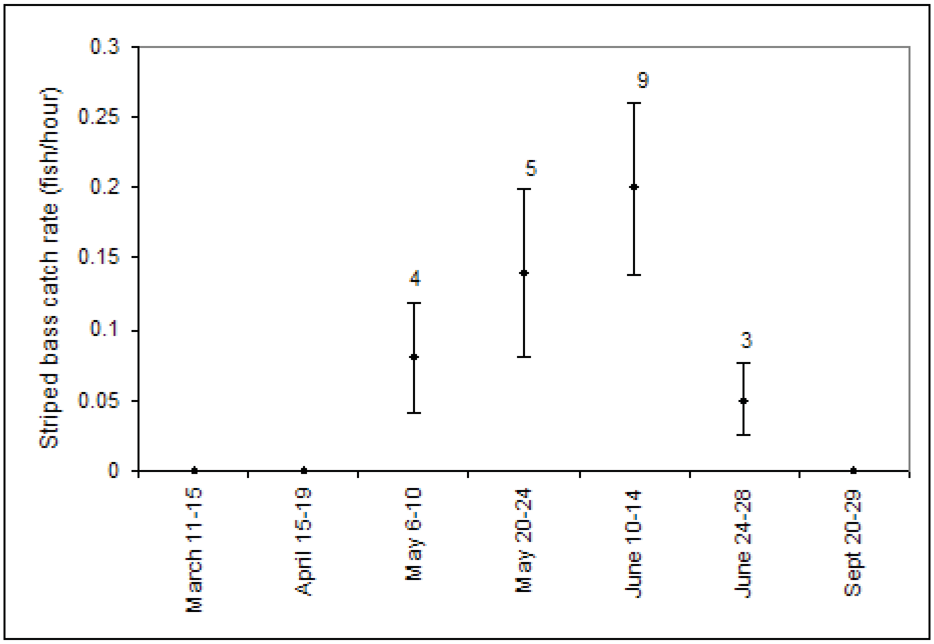

Figure 1. Catch per unit effort (±SE) of striped bass during each lower San Juan River nonnative control trip and fall monitoring trip. Sample size reported above SE bars.

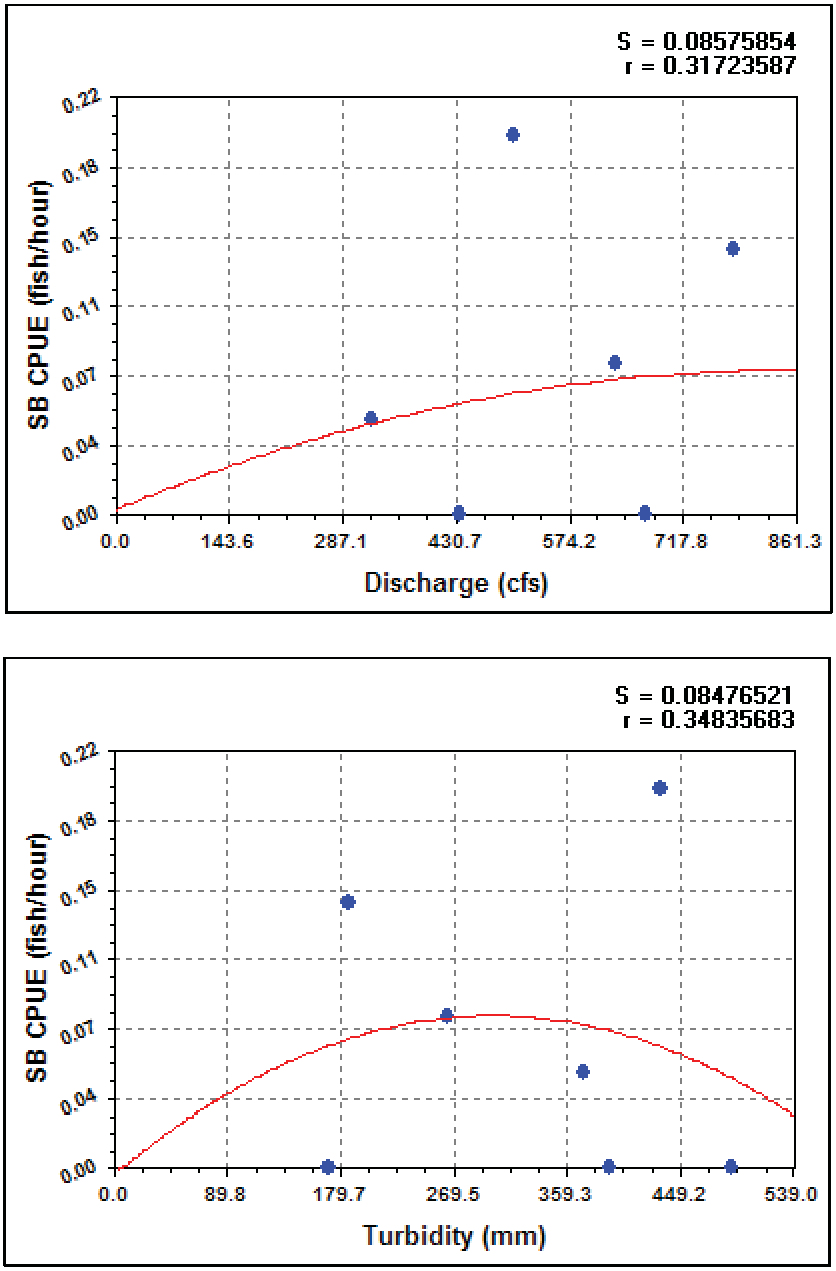

Figure 2. Striped bass catch rates relationships to discharge and turbidity in the San Juan River, 2002. (S = Standard error, r = correlation coefficient).

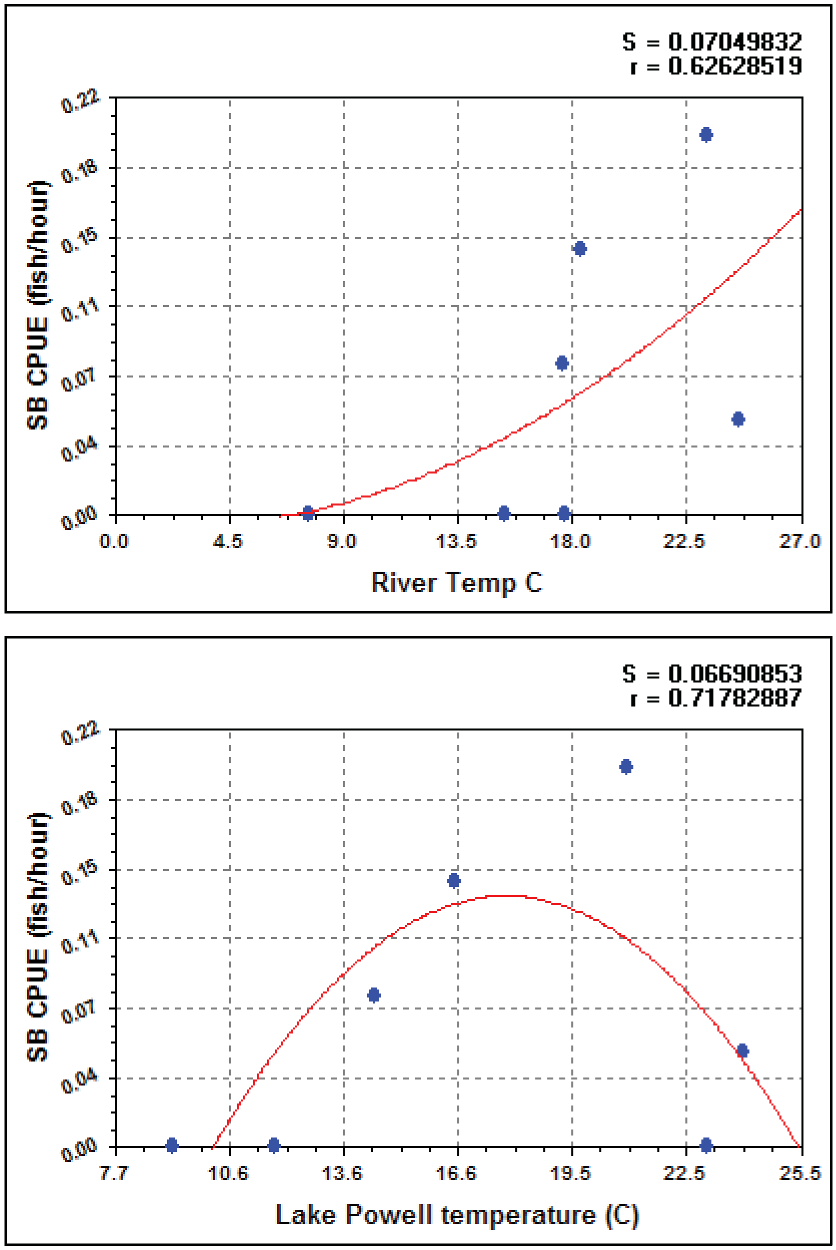

Figure 3. Striped bass catch rate (CPUE) relationships between San Juan River temperature and Lake Powell temperature in 2002. (S = Standard error, r = correlation coefficient).

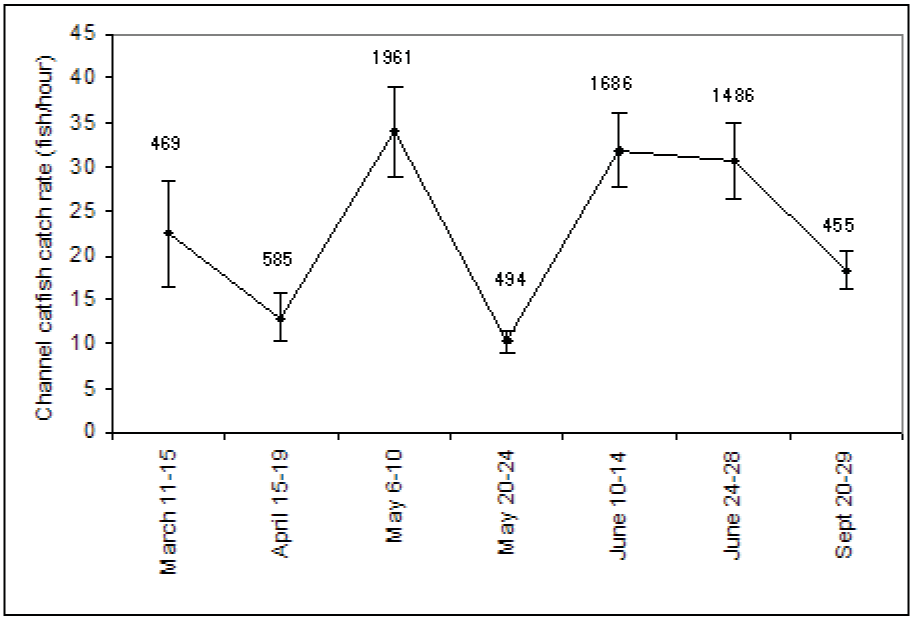

Figure 4. Catch per unit effort (±SE) of channel catfish during each lower San Juan River nonnative control trip and fall monitoring trip. Sample size reported above SE bars.

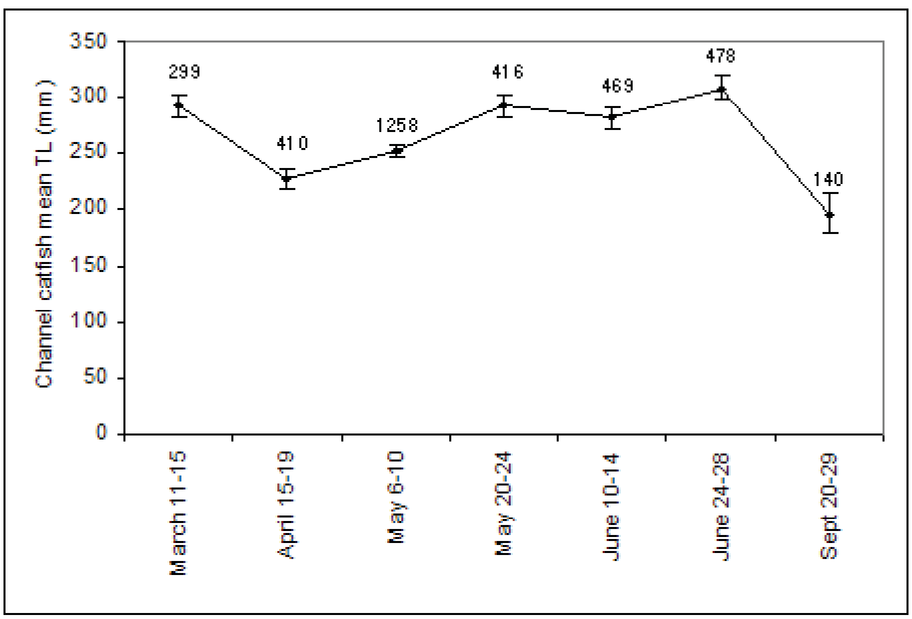

Figure 5. Mean TL (total length) values and 95% confidence intervals (represented by error bars) of channel catfish collected in the lower San Juan River during nonnative control and fall monitoring trips. Sample size (subsample that was measured) is reported above error bars.

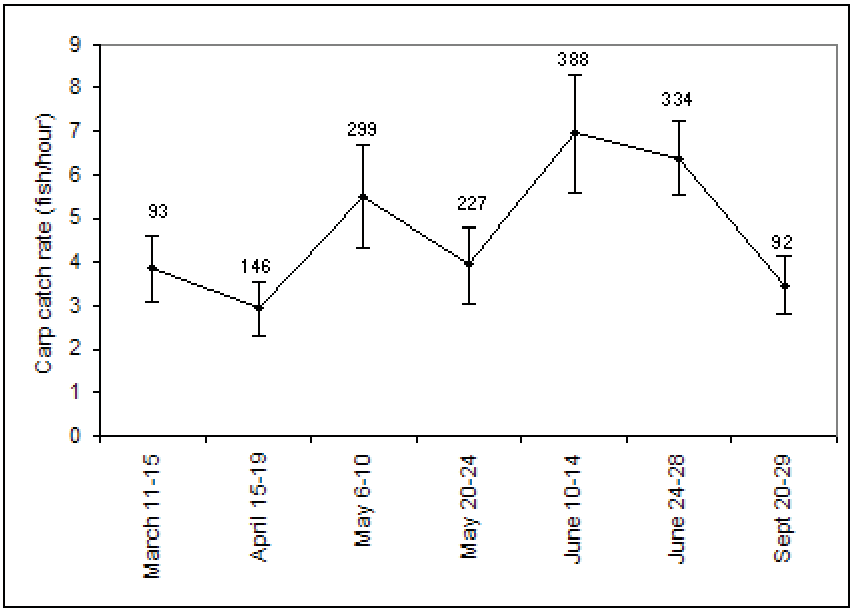

Figure 6. Catch per unit effort (±SE) of common carp during each lower San Juan River nonnative control trip and fall monitoring trip. Sample size reported above SE bars.

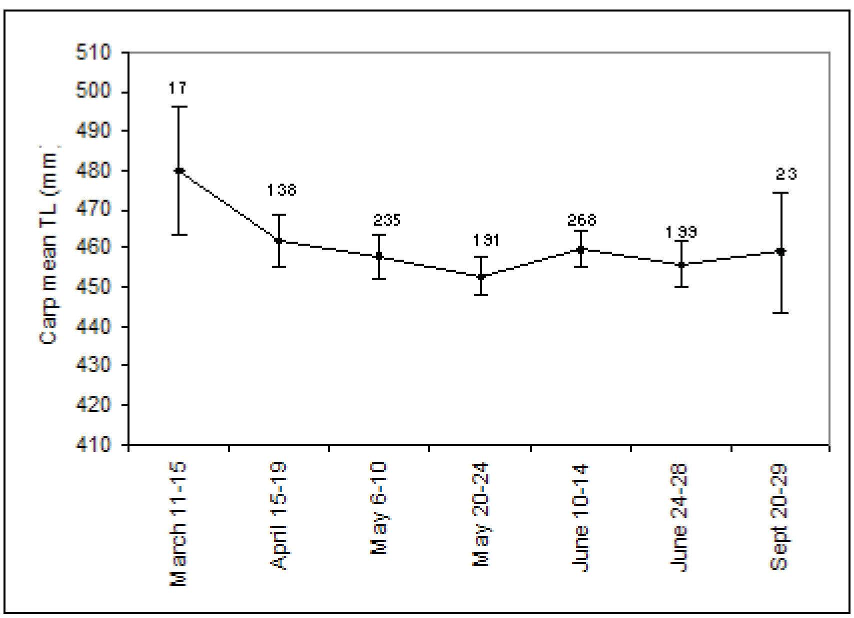

Figure 7. Mean TL (total length) values and 95% confidence intervals (represented by error bars) of common carp collected in the lower San Juan River during nonnative control and fall monitoring trips. Sample size (subsample that was measured) is reported above error bars.

Appendix A. Flow, water temperature (Celcius), and turbidity (mm to Secchi depth disapperance), at the time of sampling on the San Juan River in 2002.

Trip	Average Flow (ft^3/s)	Average H_20 (^oC)	Average Turidity (mm)
March 11-15	671	7.6	490
April 15-19	436	15.3	393
May 6-10	632	17.6	264
May 20-24	783	18.3	186
June 10-14	505	23.3	433
June 24-28	324	24.5	372
Sept 20-29	670	17.7	170

Appendix B. Common name, scientific name and abbreviations of fish collected during 2002 nonnative removal in the lower San Juan River.

Common name	Scientific name	Abbreviation
striped bass	*Morone saxatilis*	Morsax
walleye	*Stizostedion vitreum*	Stivit
channel catfish	*Ictalurus punctatus*	Ictpun
common carp	*Cyprinus carpio*	Cypcar
brown trout	*Salmo trutta*	Saltru
rainbow trout	*Oncorhynchus mykiss*	Oncmyk
black bullhead	*Ameiurus melas*	Amemel
Colorado pikeminnow	*Ptychocheilus lucius*	Ptyluc
razorback sucker	*Xyrauchen texanus*	Xyrtex