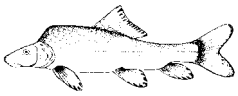
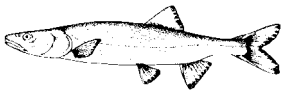
LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER, 1998 AND 1999

INTERIM PROGRESS REPORT
(DRAFT FINAL)





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EXECUTIVE SUMMARY

Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River began in 1999. The long-term monitoring program was based on the main channel adult fish community monitoring study which preceded it the long-term monitoring sampling protocols were designed to allow for data comparisons between the two studies. The previous year, 1998, was a transition year in which the sampling protocols were being designed and implemented.

Flannelmouth sucker total (juvenile) catch per unit effort (CPUE) in the core sampling area (RM 158.6-53.0), which demonstrated statistically significant declines from 1992-1997, ceased to decline in 1998 and actually increased in 1999. Trends in flannelmouth sucker total CPUE for the section of river between RM 180.0 and 53.0 showed this same trend. Total CPUE for flannelmouth sucker in Reach 1, adjacent to Lake Powell continued to decline in both 1998 and 1999. Over the last five years, small size-class flannelmouth sucker (< 400 mm TL) have virtually disappeared from electrofishing collections in Reach 1. This may be associated with the invasion of the lower San Juan River by striped bass and walleye that started in 1995.

Total CPUE of bluehead sucker in the core sampling area also ceased declining in 1998 and 1999. Comparisons of bluehead sucker total CPUE in the area of the river from RM 180.0-53.0 showed significantly more bluehead sucker in 1999 than in any previous year in which this entire area was sampled on the same trip. Plots of bluehead sucker mean TL show very little change over the last several years.

One wild adult Colorado pikeminnow female was recaptured in September 1998. This fish was originally captured in 1993 and recaptured again in 1994. A radio tag was implanted in this fish and it was tracked until June 1999 when contact with it was lost. As in 1993-1994, this fish displayed very little longitudinal movement (i.e., was sedentary) and was not documented using the Mancos River confluence during pre-spawn (i.e., May-June) periods.

In September 1997, 49 adult Colorado pikeminnow were stocked into the San Juan River near Farmington, NM. Fifteen of these fish were radio-tagged. In March 1998, two non-radio-tagged Colorado pikeminnow adults were recaptured and also implanted with radio tags. Based on observations of the fish's health at the time of stocking and recapture, very low recapture rate, somewhat abnormal behavior displayed during radio tracking, and high number of radio tags recovered on land, it appears that the survival rate among these 49 fish was extremely low.

Stocked juvenile Colorado pikeminnow were collected in both 1998 and 1999. However, numbers of fish collected varied greatly from trip to trip. Regardless, it is evident that at least a small number (relative to numbers stocked) of stocked juvenile Colorado pikeminnow continue to persist and grow in the San Juan River. Two of these fish, one each in 1998 and 1999, were recaptured for the second time each since stocking. One recaptured juvenile Colorado pikeminnow (346 mm TL) was found to be choking on a juvenile (111 mm TL) channel catfish. This is the first recorded instance of this phenomenon occurring in the San Juan River.

Stocked razorback sucker continue to be collected from the San Juan River, although in fairly low numbers. These fish are still growing and maturing and have been documented spawning in the San Juan River in both 1998 and 1999.

Roundtail chub collections remain rare in the San Juan River. The two individuals collected in 1999 were both juvenile fish. Roundtail chub, as a population, have demonstrated no documented long-term persistence in the San Juan River since studies began in 1991.

It appears that mechanical removal is beginning to have an effect on the channel catfish population in the San Juan River. While total CPUE of channel catfish has increased over the last several years, the number of large size-class (> 500 mm TL) channel catfish being collected has decreased noticeably. In 1999, CPUE of juvenile channel catfish collected exceeded that of adult channel catfish collected in both Reaches 6 and 5, for the first time since collections began in 1991. In addition, 1999 mean TL values for channel catfish were lower riverwide than those seen in previous years. This shift to smaller size-class channel catfish, but more individuals may be a mixed blessing to native fishes. While reduced numbers of large channel catfish reduces the predation threat, the increase in young channel catfish likely increases competition for food and other resources, as well as increasing the likelihood of juvenile Colorado pikeminnow choking on juvenile channel catfish.

Common carp continue to be ubiquitous throughout the San Juan River, downstream of the Animas River confluence. Despite intensive mechanical removal efforts, no discernible response (i.e., drop in total CPUE) has been observed for this species. Mean TL plots for common carp remain much the same as they were when studies began in 1991. It seems likely that this species, with its potential for extremely fast growth and early maturation, is resilient enough to absorb many if not all of the adverse impacts caused by mechanical removal efforts.

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INTRODUCTION

Research performed on the San Juan River fish community between 1991 and 1997 led to several major management actions being initiated that will have long-term impacts on that community. These management actions included the development of flow recommendations for the reoperation of Navajo Reservoir, mechanical removal of nonnative fish species, modification or removal of several instream water diversion structures, and augmentation efforts for both endangered fishes–the Colorado pikeminnow (Ptychocheilus lucius) and razorback sucker (Xyrauchen texanus). In order to assess the effects of these management actions over the duration of the San Juan River Recovery Implementation Program (SJRIP), a long-term monitoring program was begun in 1999. This monitoring program will continue until the termination of the SJRIP. The previous year, 1998, was a transition year in which the long-term monitoring plan (Propst et al. 2000) was being developed and refined, with 1999 being the first year of standardized data collection under these new sampling guidelines. Data from 1998, while not technically a part of the long-term monitoring program, are reported here to provide continuity between the data sets collected during the seven-year research program and those being collected as part of the long-term monitoring program.

"Sub-adult and adult large-bodied fish monitoring," formerly known as adult fish community monitoring (referred to herein as "adult monitoring" for short), was the primary responsibility of the U.S. Fish and Wildlife Service's Colorado River Fishery Project office in Grand Junction, CO. However, numerous other state and federal agencies supplied manpower, equipment, and logistical support for these sampling efforts. For these contributions, the author would like to greatly thank them.

The objectives of the sub-adult and adult large-bodied fish monitoring are as follows:

1) Determine shifts in fish community structure, abundance and distribution, and length/weight frequencies under the reoperation flow regime.

2) Monitor Colorado pikeminnow population trends (spawning and staging areas, habitat needs).

3) Monitor stocked razorback sucker and Colorado pikeminnow (growth rates, dispersal patterns, and habitat use).

The study area for sub-adult and adult large-bodied fish monitoring began at the Animas River confluence (river mile {RM} 180.0) and continued to Clay Hills boat landing (RM 2.9) just upstream of Lake Powell.

METHODS

Sampling in 1998 was identical to that done during the seven-year research program. Electrofishing was performed in a continuos downstream direction from put-in to take-out. One electrofishing raft sampled each shoreline. Electrofishing crews consisted of one rower and one netter. Rafts shocked perpendicular to the shoreline at a fairly constant rate of speed, with an effort being made to net all fishes stunned by the electrofisher. Electrofishing was done in one-RM increments, with every RM being sampled. At the end of each RM, all fish were identified and enumerated by life stage and species. At the end of every fifth sampled RM (known as a designated mile, or "DM" for short), all fish were weighed ($\pm$ 5 grams {g}) and measured ($\pm$ 1 mm total {TL} and standard {SL} lengths). All common native fishes were then returned alive to the river. All nonnative fishes were removed from the

river. Rare native fishes (i.e., Colorado pikeminnow, razorback sucker, and roundtail chub {Gila robusta}) were weighed, measured, had sex and other distinguishing characteristics noted, and scanned for PIT tags. If no PIT tag was found, one was implanted before the fish was returned to the river. Sampling effort was recorded as elapsed time (in seconds) electrofished by each raft in each RM. There were five sampling trips in 1998 (Table 1). In April, June, and August 1998, RM 180.0 and 158.6 ("Reach 6") were sampled. In August 1998, RM 53.0-2.9 (the "lower river") were sampled. In October 1998, RM 158.6-53.0 (the "core sampling area") were sampled.

Sampling protocols changed somewhat in 1999 from previous years. While electrofishing was still done in one-RM increments, only two of every three RM's were sampled in 1999. Fish were still worked up at the end of each electrofished RM. However, a DM was only done every fourth sampled RM. Thus DM's were done only once in every six sampled RM in 1999 as opposed to once in every five sampled RM in previous years. In addition, instead of sampling the river in discreet segments on different trips throughout the year, the entire study area (RM 180.0-2.9) was sampled on a single trip from late September-early October 1999 (Table 1). Besides these changes, sampling technique remained consistent with that of previous years.

Electrofishing data were pooled for all rafts to obtain total catch numbers for each sampling trip. Total numbers of fish (juvenile + adult life stages), by species, collected by all rafts combined were divided by the number of seconds fished by all rafts combined to obtain total catch per unit effort (CPUE) values. Total CPUE, by species, was then divided into either common sampled areas (1998 data) or whole geomorphic reach (1999 data) and compared to 1991-1997 electrofishing data (Ryden 2000a) to evaluate long-term trends. After total CPUE data were normalized by ranking, a one-way analysis of variance (ANOVA) with a post-hoc, Bonferroni-adjusted, pairwise multiple comparison test was used to test for significant differences between total CPUE values, by species, in selected river reaches between years. Since total CPUE data represented a sample of a population collected under field conditions and not a specifically known value (i.e., population parameter), significance was determined at $p < 0.10$. This high alpha value was used in order to help avoid making a Type II Error (i.e., failing to statistically detect a change in total CPUE values when there was indeed a change).

RESULTS

A total of 21 species and three catostomid hybrid forms representing eight families of fishes were collected from the San Juan River in 1998 and 1999 (Table 2). Of these, seven species and one catostomid hybrid were native fishes (Table 2). Native fishes composed 72.8% (n = 12,674) of all fish collected in 1998 and 63.0% (n = 7,761) of all fish collected in 1999 (Tables 3 and 4). Rare native fishes (i.e., Colorado pikeminnow, razorback sucker, and roundtail chub) contributed only 114 individuals (0.7%) to the total catch in 1998 and 15 individuals (0.1%) to the total catch in 1999 (Table 3). Nonnative fishes composed 27.2% (n = 4,743) of all fish collected in 1998 and 37.0% (n = 4,563) of all fish collected in 1999 (Tables 3 and 4). Four species, two native (i.e., flannelmouth sucker and bluehead sucker) and two nonnative (i.e., channel catfish and common carp), composed 95.7% (n = 16,665) of all fish collected in 1998 and 98.2% (n = 12,103) of all fish collected in 1999 (Tables 3 and 4).

Table 1. Summary of dates, in chronological order, and RM sampled on "adult monitoring" trips in the San Juan River, New Mexico, Colorado, and Utah, 1998 and 1999.

Sampling Dates	River Miles (RM) Sampled	Number of Electrofishing Rafts	Mean trip flow at Shiprock gage (09368000) in CFS and (cubic meters/second)
1998			
03/31/98-04/01/98	180.0-158.6	2	1,300 (36.8)
06/23/98-06/24/98	180.0-158.6	2	2,325 (65.8)
08/10/98-08/14/98	53.0- 2.9	2	464 (13.1)
08/31/98-09/01/98	180.0-158.6	2	586 (16.6)
09/29/98-10/07/98	158.6- 53.0	2	976 (27.6)
1999			
09/20/99-10/07/99	180.0- 2.9	3/2/1[a]	2,173 (61.5)

[a] = Due to difficulties in keeping electrofishing rafts operating continually throughout the entire trip, the number of rafts electrofishing at any one time varied on this trip. From RM 180.0-119.2 two rafts electrofished, from RM 119.2-104.0 there were three rafts, from RM 104.0-10.0 there were again two rafts, and from RM 10.0-3.2 only one raft was operable.

Table 2. Scientific and common names, status, and six-letter codes for fish species collected during "adult monitoring" trips in the San Juan River, 1998 and 1999 (following Robins et al. 1991 and Nelson et al. 1998[a]).

SCIENTIFIC NAME	COMMON NAME	STATUS	CODE
Class Osteichthyes-Bony Fishes			
Order Cypriniformes			
Family Catostomidae-suckers			
Catostomus commersoni	white sucker	introduced	Catcom
Catostomus discobolus	bluehead sucker	native	Catdis
Catostomus latipinnis	flannelmouth sucker	native	Catlat
C.commersoni X C.discobolus	hybrid	introduced	comXdis
C.commersoni X C.latipinnis	hybrid	introduced	comXlat
C.latipinnis X C.discobolus	hybrid	native	latXdis
Xyrauchen texanus	razorback sucker	native	Xyrtex
Family Cyprinidae-carps and minnows			
Cyprinella lutrensis	red shiner	introduced	Cyplut
Cyprinus carpio	common carp	introduced	Cypcar
Gila robusta	roundtail chub	native	Gilrob
Pimephales promelas	fathead minnow	introduced	Pimpro
Ptychocheilus lucius	Colorado pikeminnow[a]	native	Ptyluc
Rhinichthys osculus	speckled dace	native	Rhiosc
Order Perciformes			
Family Centrarchidae-sunfishes			
Lepomis cyanellus	green sunfish	introduced	Lepcya
Micropterus dolomieui	smallmouth bass	introduced	Micdol
Micropterus salmoides	largemouth bass	introduced	Micsal
Family Percichthyidae-temperate basses			
Morone saxatilis	striped bass	introduced	Morsax
Family Percidae-perches			
Stizostedion vitreum	walleye	introduced	Stivit
Order Salmoniformes			
Family Salmonidae-trouts			
Oncorhynchus mykiss	rainbow trout	introduced	Oncmyk
Salmo trutta	brown trout	introduced	Saltru
Order Scorpaeniformes			
Family Cottidae-sculpins			
Cottus bairdi	mottled sculpin	native	Cotbai
Order Siluriformes			
Family Ictaluridae-bullhead catfishes			
Ameiurus natalis	yellow bullhead	introduced	Amenat
Ameiurus melas	black bullhead	introduced	Amemel
Ictalurus punctatus	channel catfish	introduced	Ictpun

Table 3. Total number of fish collected in standardized electrofishing collections, 1998.

Species (Status)[a]	Total number of specimens	Percent of total	Rank	Frequency of occurrence
flannelmouth sucker(N)	8,858	50.9	1	372
bluehead sucker(N)	3,220	18.5	2	307
channel catfish(I)	2,506	14.4	3	299
common carp(I)	2,081	11.9	4	328
speckled dace(N)	437	2.5	5	134
Colorado pikeminnow(N)	106	0.6	6	72
red shiner(I)	57	0.3	7	34
brown trout(I)	51	0.3	8	21
bluehead sucker X flannelmouth sucker(H,N)	31	0.2	9	29
striped bass(I)	17	0.1	10	8
mottled sculpin(N)	14	---[b]	11	11
razorback sucker(N)	8	---	12	6
walleye(I)	6	---	13	6
largemouth bass(I)	5	---	14	5
rainbow trout(I)	4	---	15	4
white sucker X bluehead sucker(H,I)	4	---	15	4
fathead minnow(I)	3	---	16	3
green sunfish(I)	2	---	17	2
black bullhead(I)	2	---	17	2
white sucker(I)	2	---	17	2
white sucker X flannelmouth sucker(H,I)	2	---	17	2
smallmouth bass(I)	1	---	18	1
1998 Native Fishes	12,674 (72.8%)			
1998 Introduced Fishes	4,743 (27.2%)			
Native:Introduced Fishes Ratio = 2.67:1				
GRAND TOTAL	17,417		1998 collections = 393	

[a] = Native species(N); Introduced species(I); Hybrid considered a native species(H,N); Hybrid considered an introduced species(H,I)

[b] = less than 0.1%

Table 4. Total number of fish collected in standardized electrofishing collections,1999.

Species (Status)[a]	Total number of specimens	Percent of total	Rank	Frequency of occurrence
flannelmouth sucker(N)	5,579	45.3	1	227
channel catfish(I)	3,314	26.9	2	218
bluehead sucker(N)	2,007	16.3	3	167
common carp(I)	1,203	9.8	4	205
speckled dace(N)	143	1.2	5	58
bluehead sucker X flannelmouth sucker(H,N)	16	0.1	6	14
red shiner(I)	13	0.1	7	9
brown trout(I)	9	---[b]	8	7
walleye(I)	9	---	8	8
Colorado pikeminnow(N)	8	---	9	5
razorback sucker(N)	5	---	10	5
white sucker X bluehead sucker(H,I)	4	---	11	4
white sucker X flannelmouth sucker(H,I)	4	---	11	4
fathead minnow(I)	2	---	12	1
roundtail chub(N)	2	---	12	2
white sucker(I)	2	---	12	2
black bullhead(I)	1	---	13	1
mottled sculpin(N)	1	---	13	1
smallmouth bass(I)	1	---	13	1
yellow bullhead(I)	1	---	13	1
1999 Native Fishes	7,761 (63.0%)			
1999 Introduced Fishes	4,563 (37.0%)			
Native:Introduced Fishes Ratio = 1.70:1				
GRAND TOTAL	12,324		1999 collections = 236	

[a] = Native species(N); Introduced species(I); Hybrid considered a native species(H,N); Hybrid considered an introduced species(H,I)

[b] = less than 0.1%

Common Native Fishes

Flannelmouth Sucker

Total CPUE for flannelmouth sucker in the core sampling area (RM 158.6-53.0) ceased to decline in 1998 after several years of statistically significant declines in this river section (Figure 1; Ryden 2000a). In the portion of geomorphic Reach 2 (i.e., RM 53.0-17.0) sampled in August 1998, flannelmouth sucker total CPUE increased slightly. However, flannelmouth sucker total CPUE continued to decline in geomorphic Reach 1 (RM 17.0-0.0; Figure 1). Flannelmouth sucker total CPUE in whole geomorphic Reaches 6-4 was higher in 1999 collections than in 1998 and was nearly identical in Reach 3 between the two years (Figure 1).

In Ryden 2000a, it was noted that while the flannelmouth sucker total CPUE in the core sampling area (RM 158.6-53.0) declined significantly between 1992 and 1997, total CPUE for flannelmouth sucker in Reach 6 (RM 180.0-158.6) increased significantly. Comparisons of the flannelmouth sucker total CPUE from RM 180.0-53.0 on all trips in which this area was sampled on the same trip (Figure 2) revealed that between October 1994 and October 1997 there was a statistically significant decline in flannelmouth sucker total CPUE in this river section (Table 5). However, total CPUE for this particular river section between October 1997 and October 1999 increased significantly, so that when comparisons are made between flannelmouth sucker total CPUE in October 1994 and October 1999 there is no significant difference between the two values (Table 5, Figure 2).

Plots of mean total length for flannelmouth sucker from 1991-1999 reveal an alarming trend, the virtual disappearance of small size-class flannelmouth sucker (< 40 mm TL) from Reach 1 (RM 17.0-0.0) immediately adjacent to Lake Powell (Figure 3). This loss of small flannelmouth sucker appears to have begun as early as August 1995 (as is evidenced by the steadily increasing mean TL in Reach 1) and was essentially complete by August 1997, with no flannelmouth sucker less than 300 mm TL being collected in Reach 1 in 1997 or less than 400 mm TL being collected in Reach 1 in either 1998 or 1999 (Figure 3). Flannelmouth sucker of all size-classes continue to be collected in all other river reaches, however (Figure 3).

Bluehead sucker

Total CPUE for bluehead sucker in the core sampling area (RM 158.6-53.0) increased slightly in 1998 and more so again in 1999, especially in Reaches 5 (in both years) and Reach 4 (in 1999), following slight declines in total CPUE in several previous years of sampling (Figure 4; Ryden 2000a). Total CPUE for bluehead sucker remained low in Reaches 3 and 2 and this species continued to be absent from Reach 1 (Figure 4). Bluehead sucker total CPUE in Reach 6 was higher in 1999 than in any previous sampled year (Figure 4).

Comparisons of the bluehead sucker total CPUE between RM 180.0 and 53.0 on all trips in which this area was sampled on the same trip (Figure 5) revealed that between October 1994 and October 1998, there was no statistical difference in bluehead sucker total CPUE. However, in 1999, bluehead sucker total CPUE was significantly higher from RM 180.0-53.0 than in all previous years in which this river section was sampled on the same sampling trip (Table 6).

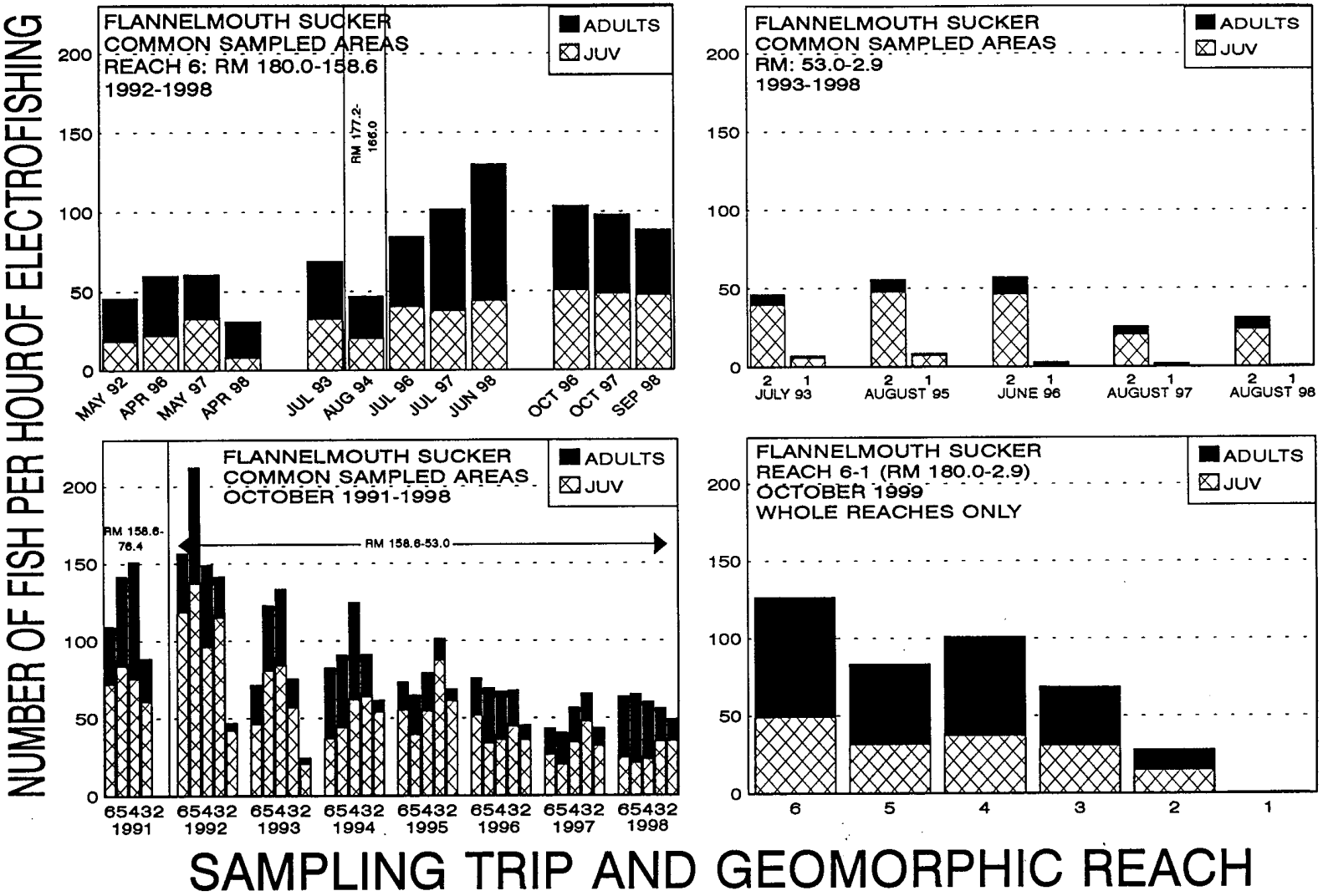

Figure 1. Number of flannelmouth sucker, by life stage, collected per hour of electrofishing in the San Juan River during "adult monitoring" trips, 1991-1999.

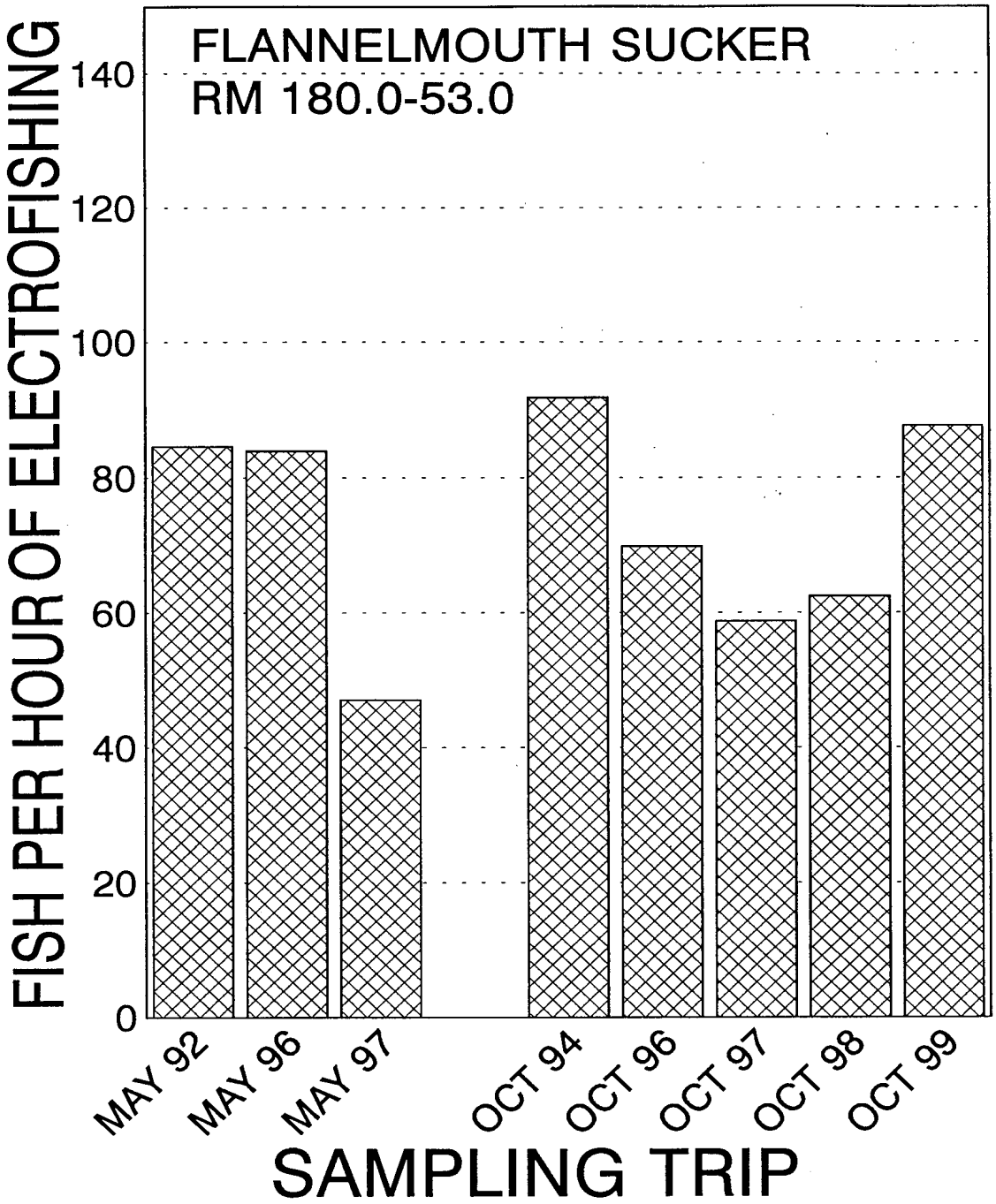

Figure 2. Number of flannelmouth sucker, all life stages combined, collected per hour of electrofishing in the San Juan River, RM 180.0-53.0, during "adult monitoring" trips, 1992-1999. Only those sampling trips on which this entire river section was sampled are presented.

Table 5. One-way ANOVA statistics and matrix of Bonferroni pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, RM 180.0-53.0, October 1994 to October 1999 ($p < 0.10$ = * = statistically significant relationship).

One-way ANOVA: F-statistic = 33.839, $r^2 = 0.091$, $p = 0.000$*

Scheffe matrix:

	1994	1996	1997	1998	1999
1994	1.000				
1996	0.000*	1.000			
1997	0.000*	0.010*	1.000		
1998	0.000*	0.425	1.000	1.000	
1999	1.000	0.000*	0.000*	0.000*	1.000

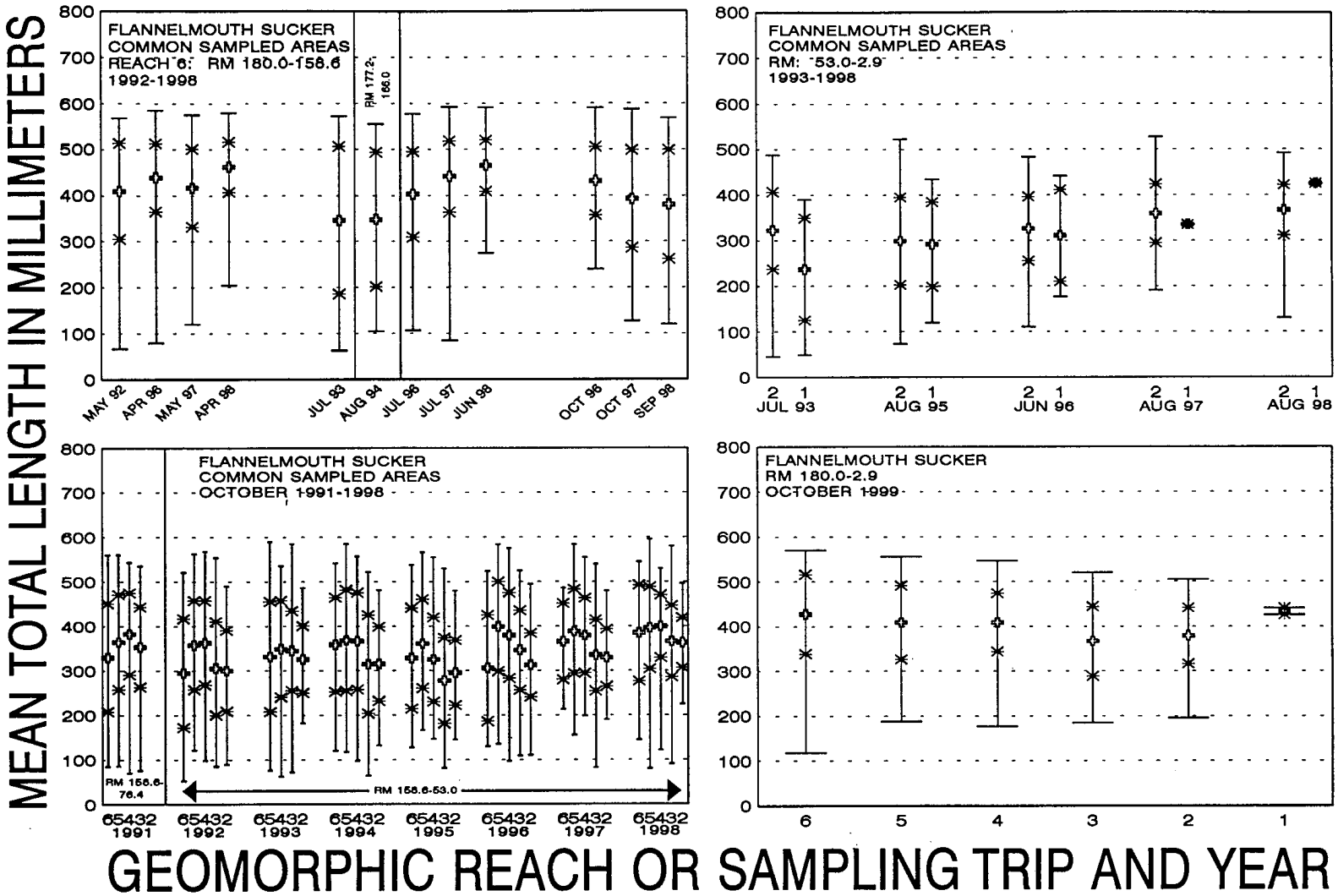

Figure 3. Mean total length (TL) in millimeters for flannelmouth sucker collected on "adult monitoring" trips 1991-1999. Crosses represent the mean values, error bars the range, and asterisks represent the standard deviation.

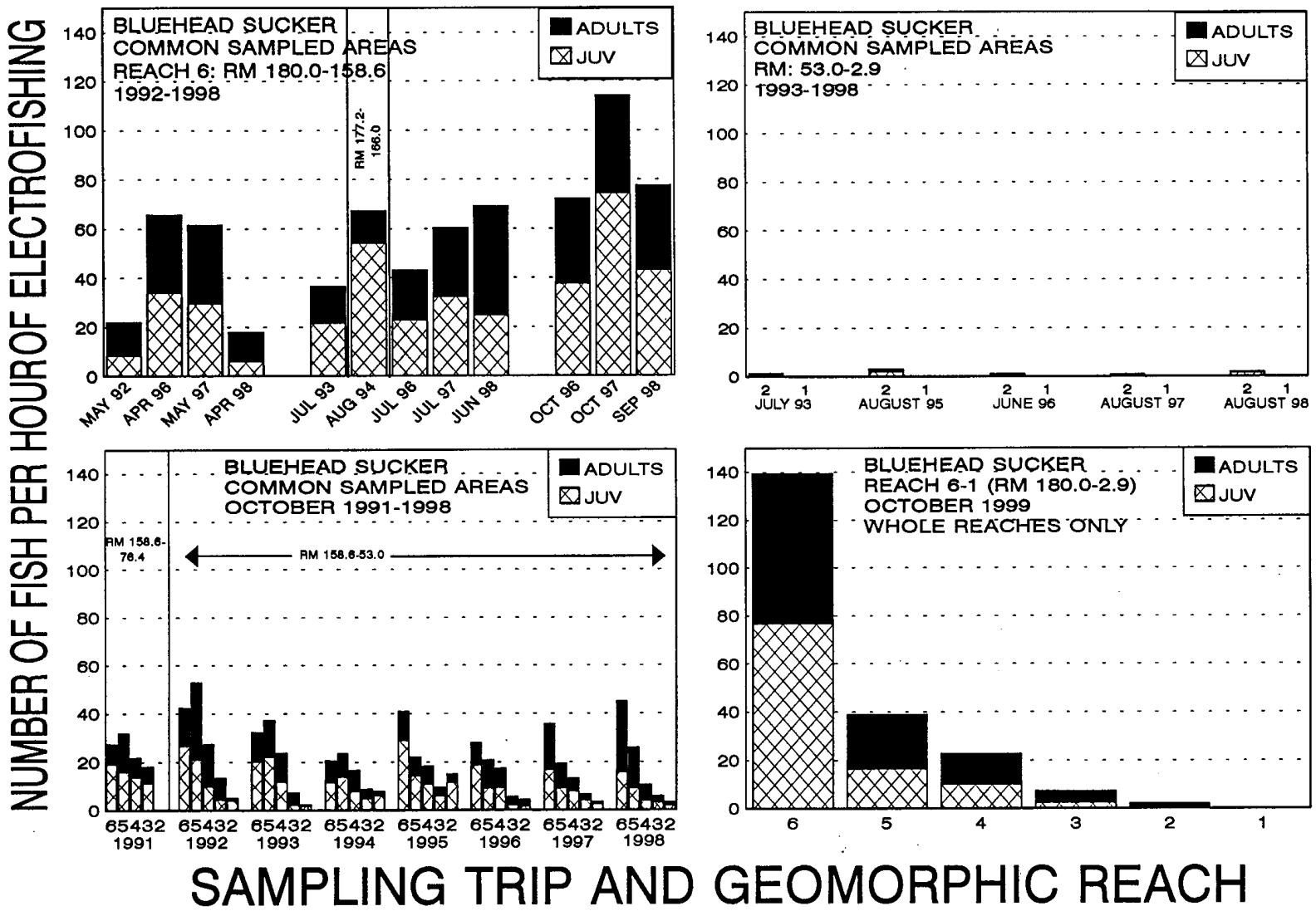

Figure 4. Number of bluehead sucker, by life stage, collected per hour of electrofishing in the San Juan River during "adult monitoring" trips, 1991-1999.

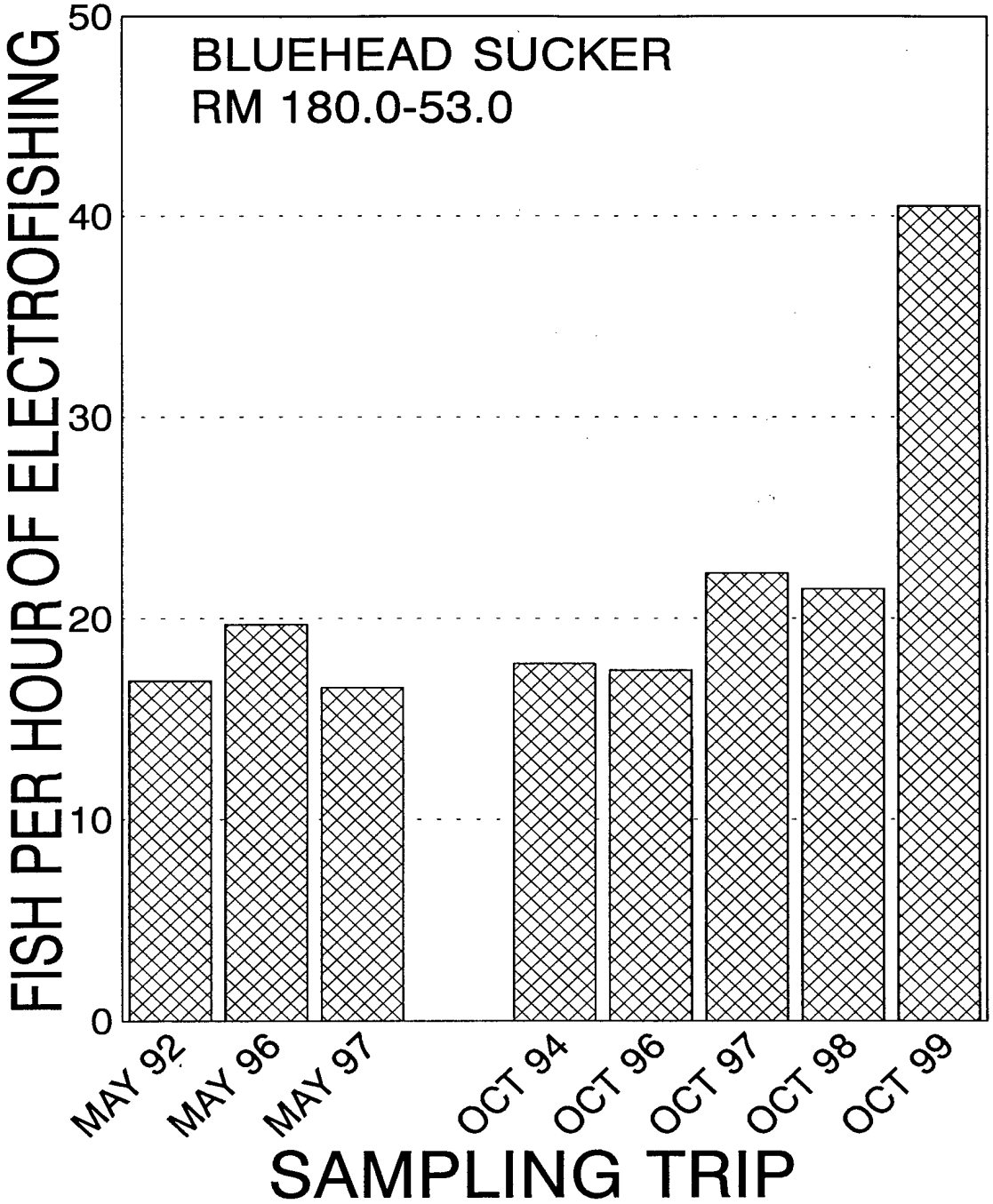

Figure 5. Number of bluehead sucker, all life stages combined, collected per hour of electrofishing in the San Juan River, RM 180.0-53.0, during "adult monitoring" trips, 1992-1999. Only those sampling trips on which this entire river section was sampled are presented.

Table 6. One-way ANOVA statistics and matrix of Bonferroni pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, RM 180.0-53.0, October 1994 to October 1999 ($p < 0.10$ = * = statistically significant relationship).

One-way ANOVA: F-statistic = 10.726, $r^2 = 0.031$, $p = 0.000$*

Scheffe matrix:

	1994	1996	1997	1998	1999
1994	1.000				
1996	1.000	1.000			
1997	1.000	1.000	1.000		
1998	1.000	1.000	1.000	1.000	
1999	0.000*	0.000*	0.000*	0.000*	1.000

Plots of mean total length for bluehead sucker from 1991-1999 reveal that bluehead sucker of all size classes were collected throughout all river reaches, with the exception of Reach 1 where this species is absent (Figures 4 and 6). From 1991-1999 there have been no dramatic changes in bluehead sucker size-class distribution in the San Juan River (Figure 6).

Rare Native Fishes

Colorado Pikeminnow

One wild Colorado pikeminnow adult was recaptured in 1998 at RM 137.6 (Table 7). This large female, originally captured on 14 April 1993 at RM 128.8 (797 mm TL, 5550 g; Ryden 2000a) was implanted with radio tag #40.980. It was recaptured on 12 April 1994 at RM 133.2 (820 mm TL, 5810 g; Ryden 2000a), at which time the old radio tag was removed and a new radio tag (#40.848) was implanted. Radio contact with tag #40.848 was maintained until 4 October 1994. On 29 September 1998, this fish was recaptured again at RM 137.6 (845 mm TL, 6100 g) and was implanted with its third radio tag (#40.970). Contact was maintained with tag #40.870 until 8 June 1999. This fish was also recaptured during a channel catfish mechanical removal trip on 23 March 1999 (Table 8). In all, 34 contacts (i.e., captures, recaptures, and radio telemetry contacts) have been made with this fish over more than six years (Figure 7). This fish was never contacted using the Mancos River confluence area during 1993-1994 contacts (Ryden 2000a) and that held true during 1998 and 1999 radio contacts as well. This fish was classified as displaying sedentary behavior (Ryden 2000a) during previous contacts and maintained that behavior during 1998-1999 contacts as well (Figure 7), moving only 6.25 RM from its most upstream contact location to its most downstream contact location (Maximum Displacement {MD}) and was within 4.40 RM of its point of release at the time of the final radio contact (Final Displacement {FD}) in June 1999.

On 23 September 1997, 49 adult Colorado pikeminnow (mean TL = 644 mm, range = 550-753 mm TL, SD = 56.68; mean WT = 1862 g, range = 1092-3100 g, SD = 507.04) were stocked into the San Juan River at RM 178.8. These fish were 16-year old adults of Green River lineage that had been used throughout their lifetime for various experimental purposes. Thirty of these fish were females, 18 were males, and one was of indeterminate sex. All fish were PIT-tagged before their release into the San Juan River. Due to a large amount of handling prior to stocking, all of these adult Colorado pikeminnow were in relatively poor health at the time of stocking. Most had large amounts of the parasite “ich” over much of their bodies. Of the 49 stocked adults, 15 (14 females and 1 male) were originally implanted with radio tags. Movements of these fish are reported upon by Miller and Ptacek (2000). Two of these stocked adult Colorado pikeminnow (both females) were recaptured on 31 March 1998 during our sampling. Neither of these fish had been implanted with a radio tag prior to this date. However, both fish were implanted with radio tags before being released (Table 7). The general health of these two stocked adults at the time of recapture was still relatively poor.

In 1998, 103 stocked juvenile Colorado pikeminnow were recaptured (Table 7). These recaptures ranged from RM 162.3-9.4 (Table 7). One of these (PIT tag # 1F6B205D79, collected 3 October 1998 at RM 95.0, 276 mm TL) had previously been captured and PIT-tagged on 8 May 1998 at RM 93.0 (205 mm TL).

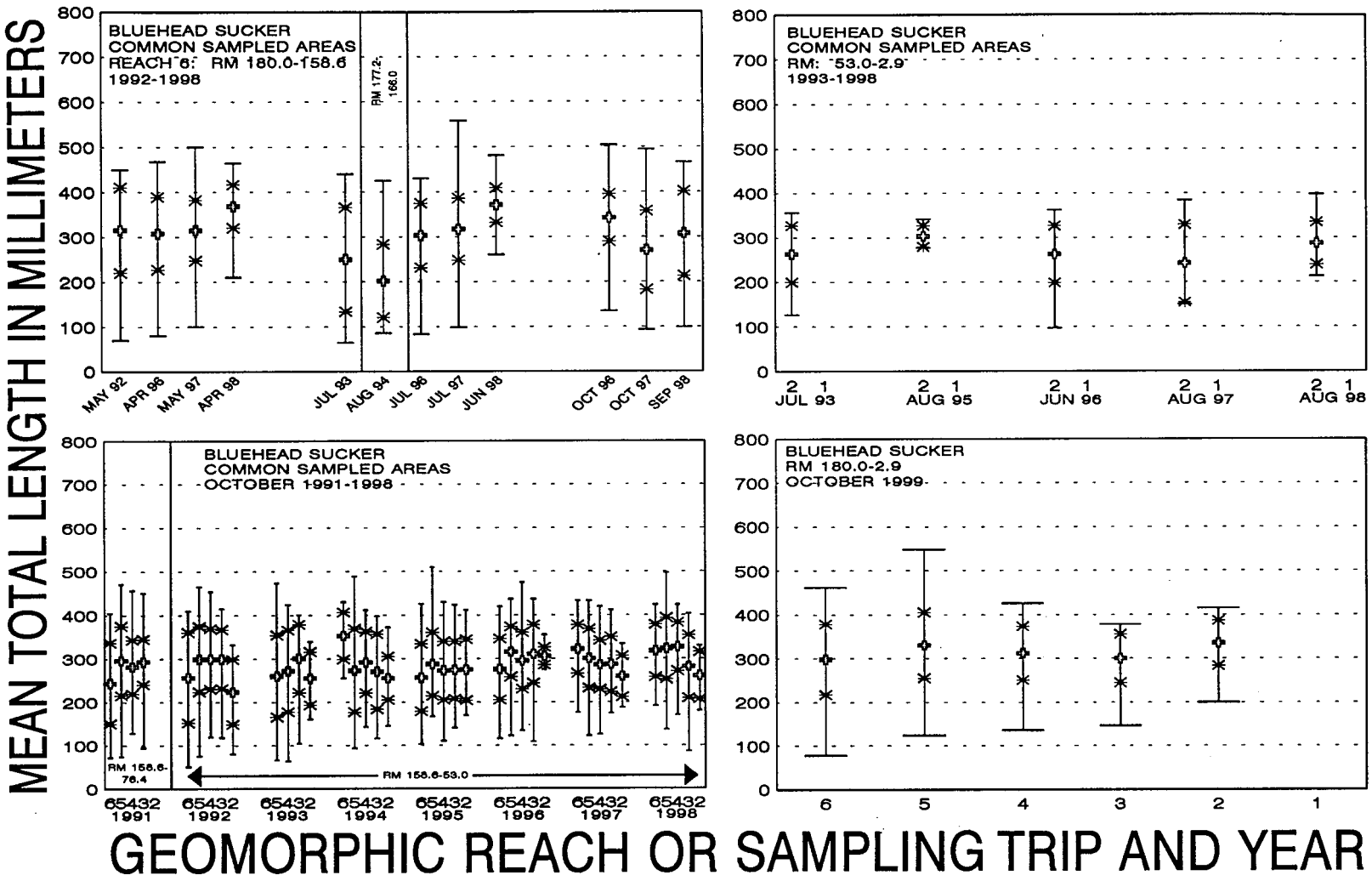

Figure 6. Mean total length (TL) in millimeters for bluehead sucker collected on "adult monitoring" trips 1991-1999. Crosses represent the mean values, error bars the range, and asterisks represent the standard deviation.

Table 7. Adult and juvenile Colorado pikeminnow collected from the San Juan River on "adult monitoring" trips, 1998 and 1999.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Wild Colorado pikeminnow-1998						
09/29/98	7F7D225E24®	970	845	6100	F	137.6
Recaptured, stocked Colorado pikeminnow-1998						
03/31/98	7F7F1F156F®	490	620	1500	F	177.1
03/31/98	7F7F1F1E1E®	780	661	2300	F	173.0
08/12/98	1F75110457	NONE	151	30	I	25.3
08/13/98	1F6D193823	NONE	315	186	I	19.0
08/13/98	1F40177F0B	NONE	307	240	I	18.5
08/13/98	1F41661A20	NONE	274	150	I	19.4
08/13/98	1F6B283717	NONE	300	150	I	18.0
08/13/98	7F7B0D4A00	NONE	262	175	I	17.0
08/14/98	1F5A78147B	NONE	295	210	I	9.4
08/31/98	7F7B135653	NONE	183	42	I	162.3
09/28/98	NONE	NONE	137	10	I	155.0
09/28/98	NONE	NONE	135	14	I	154.2
09/28/98	7F7B1B061A	NONE	153	13	I	153.0
09/28/98	NONE	NONE	150	10	I	153.0
09/28/98	7F7D031D69	NONE	160	43	I	152.0
09/28/98	7F7B114004	NONE	336	260	I	148.0
09/28/98	7F7D441650	NONE	173	34	I	147.0
09/29/98	7F7B134840	NONE	164	30	I	144.0
09/29/98	7F7B136C6C	NONE	172	35	I	144.0
09/29/98	7F7B10752F	NONE	181	40	I	143.0
09/29/98	7F7B11277B	NONE	162	27	I	143.0
09/29/98	7F7B112D6F	NONE	162	25	I	143.0
09/29/98	7F7B135A40	NONE	175	32	I	143.0
09/29/98	7F7D084A62	NONE	155	23	I	143.0
09/29/98	7F7B1B141F	NONE	163	25	I	143.0
09/29/98	7F7D031574	NONE	151	22	I	143.0
09/29/98	7F7D071A67	NONE	242	100	I	143.0
09/29/98	7F7B1B577C	NONE	179	42	I	142.0
09/29/98	7F7B106837	NONE	174	35	I	142.0
09/29/98	7F7B1A7405	NONE	160	37	I	141.0
09/29/98	MORTALITY	NONE	152	23	I	141.0
09/29/98	1F40184C3D	NONE	161	35	I	141.0
09/29/98	7F7D087E14	NONE	182	40	I	140.0
09/29/98	7F7B1A3769	NONE	129	20	I	140.0
09/29/98	7F7B105701	NONE	258	105	I	140.0
09/29/98	1F41721A14	NONE	155	24	I	140.0
09/29/98	1F6B254E03	NONE	188	48	I	140.0
09/29/98	1F6D0E4C1A	NONE	133	30	I	140.0
09/29/98	1F40270971	NONE	187	43	I	138.0
09/29/98	7F7B195215	NONE	162	32	I	138.0
09/29/98	4215192C2F	NONE	166	37	I	138.0
09/29/98	7F7B1B6603	NONE	156	35	I	138.0
09/30/98	7F7B113E28	NONE	290	150	I	136.0
09/30/98	7F7B1A7835	NONE	256	100	I	136.0
09/30/98	7F7B117B35	NONE	160	30	I	136.0
09/30/98	7F7B127A38	NONE	290	150	I	135.0
09/30/98	7F7B137318	NONE	163	30	I	132.0
09/30/98	7F7B135E01	NONE	270	135	I	130.0
09/30/98	7F7B10652C	NONE	180	41	I	130.0
09/30/98	7F7B194838	NONE	270	130	I	129.0
09/30/98	7F7B135F21	NONE	299	205	I	127.0
09/30/98	7F7B134543	NONE	296	180	I	126.0
09/30/98	7F7B126B4E	NONE	258	80	I	123.0
10/01/98	7F7B114870	NONE	271	128	I	120.0
10/01/98	7F7B0A1741	NONE	163	36	I	120.0
10/01/98	7F7B11354A	NONE	169	35	I	117.0

® = This was a recapture of a previously-tagged fish

Table 7, continued.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
10/01/98	4214485624	NONE	192	38	I	117.0
10/01/98	7F7B12485C	NONE	157	39	I	113.0
10/01/98	7F7B176A6A	NONE	180	42	I	113.0
10/01/98	7F7B105926	NONE	268	130	I	111.0
10/01/98	42143C1C39	NONE	270	122	I	111.0
10/01/98	7F7B14226F	NONE	194	53	I	111.0
10/02/98	7F7B127541	NONE	250	125	I	109.0
10/02/98	7F7B1A4130	NONE	245	100	I	109.0
10/02/98	4122384657	NONE	209	65	I	108.0
10/02/98	7F7B13084D	NONE	100	8	I	108.0
10/02/98	7F7B134640	NONE	169	24	I	107.0
10/02/98	420F453E68	NONE	171	38	I	107.0
10/02/98	416E003A2C	NONE	251	110	I	104.0
10/02/98	416F1C6310	NONE	280	225	I	104.0
10/02/98	7F7B1B570A	NONE	185	45	I	104.0
10/02/98	4122445D39	NONE	283	160	I	104.0
10/02/98	4122465336	NONE	305	195	I	103.0
10/02/98	4170591971	NONE	183	40	I	103.0
10/02/98	4170687847	NONE	325	200	I	103.0
10/02/98	420F392732	NONE	172	40	I	103.0
10/02/98	416525042F	NONE	265	110	I	103.0
10/02/98	412222372C	NONE	160	50	I	103.0
10/02/98	4122232572	NONE	280	140	I	103.0
10/02/98	416E153B7B	NONE	280	125	I	103.0
10/02/98	416E0F3830	NONE	242	100	I	102.0
10/02/98	415A025664	NONE	180	30	I	101.0
10/02/98	41650D312B	NONE	210	55	I	99.0
10/02/98	420F33165C	NONE	201	60	I	99.0
10/02/98	41537D7D6A	NONE	170	23	I	98.0
10/03/98	421317322E	NONE	296	175	I	97.0
10/03/98	420F430E7E	NONE	207	52	I	97.0
10/03/98	116E02257E	NONE	179	35	I	96.0
10/03/98	116E032C0F	NONE	323	239	I	95.0
10/03/98	1F6B205D79®	NONE	276	130	I	95.0
10/03/98	416F00195C	NONE	300	199	I	89.0
10/03/98	4213144D12	NONE	173	25	I	89.0
10/03/98	421307454B	NONE	266	115	I	89.0
10/04/98	416F23743D	NONE	106	7	I	85.5
10/04/98	4170496AOE	NONE	285	158	I	83.0
10/05/98	4170747202	NONE	204	45	I	75.0
10/05/98	415A175424	NONE	286	140	I	75.0
10/05/98	7F7B113D5C	NONE	282	156	I	75.0
10/05/98	4122214262	NONE	360	320	I	75.0
10/05/98	7F7B1B1D58	NONE	328	230	I	71.0
10/05/98	416C643C0F	NONE	269	125	I	71.0
10/06/98	7F7B065825	NONE	304	185	I	63.0
10/06/98	415A043A29	NONE	367	343	I	61.0
10/07/98	7F7B18080C	NONE	304	265	I	58.0
10/07/98	4165177603	NONE	280	135	I	55.0
Recaptured, stocked Colorado pikeminnow-1999						
09/21/99	512440727B	NONE	207	60	I	149.0
09/30/99	51247F0A6A	NONE	164	20	I	103.0
09/30/99	5124671D22	NONE	157	29	I	97.0
10/01/99	1F681D510B®	NONE	367	335	I	86.0
10/01/99	51247F0B49	NONE	346	274	I	86.0
10/01/99	51246F2B26	NONE	215	55	I	83.0
10/03/99	51247C5B3D	NONE	277	155	I	58.0
10/03/99	5124706D35	NONE	279	160	I	58.0
10/07/99	51246D5A66	NONE	297	115	I	5.0
10/07/99	51247B0D6B	NONE	273	85	I	5.0

Table 8. Colorado pikeminnow collected from the San Juan River during other sampling efforts[1], 1998 and 1999.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
On channel catfish removal trips–1998:						
Recaptured, stocked Colorado pikeminnow						
04/01/98	NONE	NONE	171	37	I	135.2
04/01/98	NONE	NONE	158	24	I	132.9
04/02/98	NONE	NONE	165	10	I	135.8
04/02/98	NONE	NONE	148	18	I	134.0
On rare fish population goal trips–1998:						
Recaptured, stocked Colorado pikeminnow						
09/18/98	NONE	NONE	295	166	I	75.0
On channel catfish removal trips–1999:						
Wild Colorado pikeminnow						
03/23/99	7F7D225E24	970	845	7500	F	131.5
Recaptured, stocked Colorado pikeminnow						
03/23/99	1F606D1103	NONE	148	21	I	127.7
03/23/99	420F251833	NONE	166	26	I	131.0
03/23/99	416D076613	NONE	137	17	I	131.8
03/23/99	NONE	NONE	90	2	I	131.8
03/23/99	41652A6621	NONE	156	25	I	131.8
03/23/99	520074553F	NONE	153	25	I	132.5
03/23/99	1F66226178	NONE	151	21	I	134.0
03/23/99	1F66536147	NONE	117	11	I	134.0
03/24/99	1F65532504	NONE	153	22	I	127.7
03/24/99	1F717D787B	NONE	167	28	I	127.7
03/24/99	1F631E3030	NONE	156	22	I	127.7
03/24/99	416E391251	NONE	149	20	I	127.7
On rare fish population goal trips–1999:						
Recaptured, stocked Colorado pikeminnow						
10/13/99	NONE	NONE	202	59	I	147.0
10/13/99	NONE	NONE	233	92	I	147.0
10/20/99	NONE	NONE	420	482	I	104.0

[1] Information on Colorado pikeminnow collected during channel catfish removal trips supplied by Jude Smith (U.S. Fish and Wildlife Service-Albuquerque, NM) and rare fish population goal trips supplied by Keith Lawrence (Ecosystems Research Institute-Logan, UT)

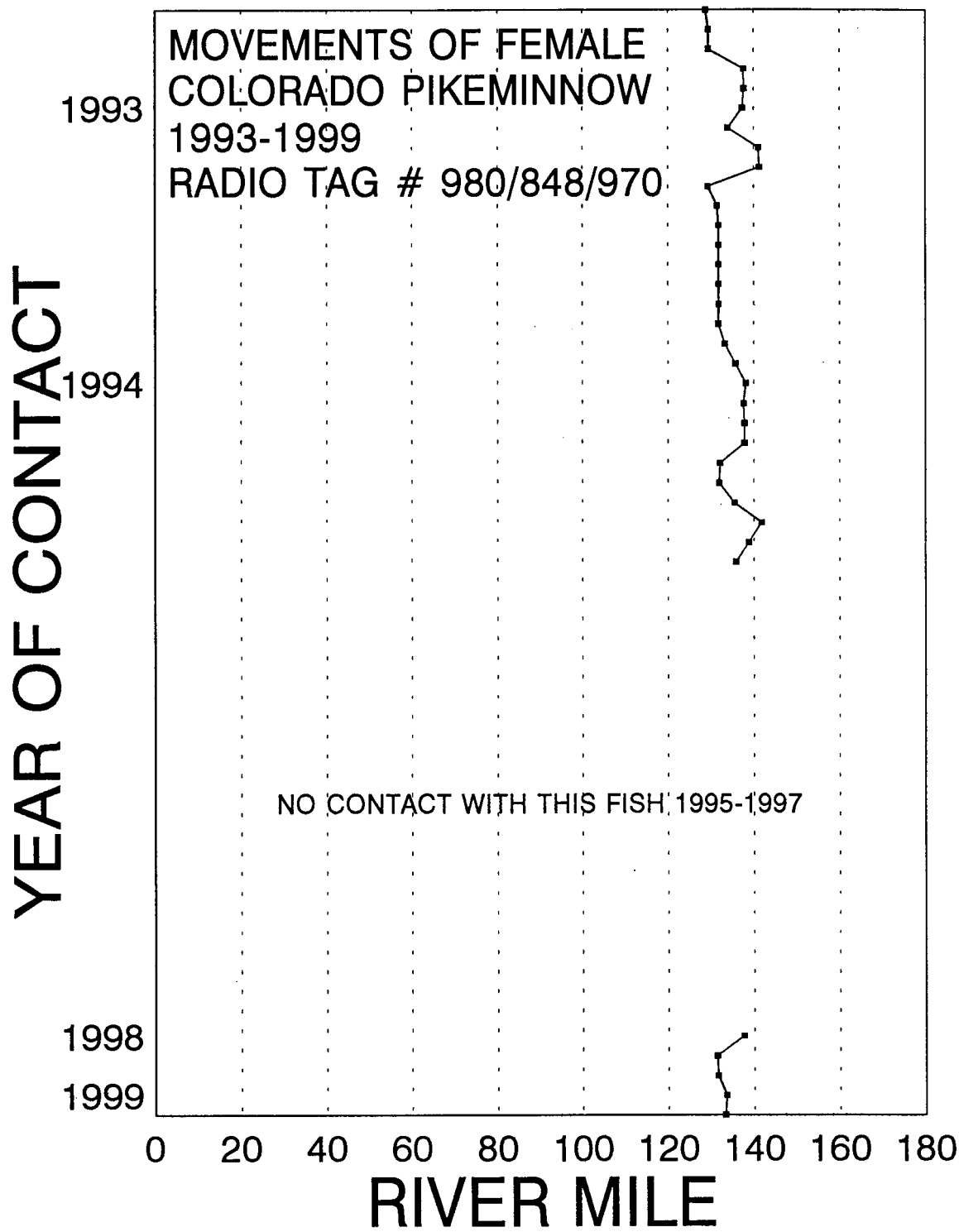

Figure 7. Movements of a wild adult Colorado pikeminnow female in 1993-1994 and 1998-1999. Contacts included captures, recaptures, and radio telemetry contacts (n = 34).

The individual collected at RM 162.3 on 31 August 1998 (PIT tag # 7F7B135653, 183 mm TL) is the first Colorado pikeminnow to be documented moving upstream past Hogback Diversion. All but three of the stocked juvenile Colorado pikeminnow collected in 1998 were PIT-tagged before their release (Table 7).

Another 10 stocked juvenile Colorado pikeminnow were recaptured in 1999 (Table 7). These recaptures ranged from RM 149.0-5.0 (Table 7). One of these (PIT tag # 1F681D510B, collected 1 October 1999 at RM 86.0, 367 mm TL) had previously been captured and PIT-tagged on 7 October 1997 at RM 79.6 (215 mm TL). The other nine stocked juvenile Colorado pikeminnow collected in 1999 were all PIT-tagged before being released (Table 7).

One stocked juvenile Colorado pikeminnow (PIT tag # 51247F0B49, 346 mm TL, 274 g)collected on 1 October 1999 between RM 87.0 and 86.0 in Utah had a channel catfish (111 mm TL, 11 g) lodged firmly in its mouth (see Appendix A; Ryden and Smith In Prep.). This is a predator-prey length ratio of 3.12:1. The ingested channel catfish was lodged head-first in the pikeminnow's mouth anterior to the pikeminnow's gills. At the time of recapture, the channel catfish was still alive and struggling. The catfish's spines were firmly extended and its dorsal spine had penetrated the roof of the pikeminnow's mouth and entered the right eye socket, causing the eye to become distended and swollen due to hemorrhaging. The pectoral spines were also firmly lodged in the sides of the pikeminnow's mouth. The posterior end of the catfish, from just anterior of the adipose fin to the end of the caudal fin, protruded from the pikeminnow's mouth. A strip of flesh about one-half inch wide was worn from the catfish's body near the caudal peduncle where the pikeminnow's mouth would normally close. After photographing the specimen (see Appendix A), the catfish was removed from the pikeminnow's mouth by severing the spines with wire cutters and backing the catfish out of the mouth. One pectoral spine was removed from the pikeminnow's mouth using needle-nosed pliers, but the other two spines were left in place because it was felt that further dissection would have caused irreversible damage to the pikeminnow. Both fish were weighed and measured. The Colorado pikeminnow was implanted with a PIT tag before being released. The channel catfish was removed from the river. Water temperatures were not taken at the collection site, however, the water temperature at RM 88.0 was 11.9ºC at 10:15 AM and at RM 85.0 was 13.3ºC at 12:20 PM.

An additional 20 stocked juvenile Colorado pikeminnow were collected during either channel catfish mechanical removal trips (n = 16) or rare fish population goal sampling trips (n = 4) in 1998 and 1999 (Table 8).

Razorback Sucker

Thirteen razorback suckers were collected during 1998 (n = 8) and 1999 (n = 5) adult monitoring trips (Table 9). These collections ranged from RM 122.0-68.7 in 1998 and from RM 107.7-55.3 in 1999 (Table 9). For more detailed information on these collections, see Ryden 2000b.

Roundtail Chub

No roundtail chub were collected during 1998 adult monitoring trips. Two roundtail chub were collected in 1999 (Table 10). One of these, a 134 mm TL individual, collected at RM 25.0, represents the farthest downstream a roundtail chub has ever been collected during an adult monitoring trip (Table 10).

Table 9. Razorback sucker collected from the San Juan River during “adult monitoring” trips, 1998 and 1999.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Recaptured, stocked razorback sucker–1998						
09/30/98	1F7441614B	NONE	474	1100	F	122.0
10/01/98	7F7B126F4C	670	511	1600	I	121.0
10/01/98	1F43670136	127	493	1525	I	119.2
10/03/98	7F7B121B14	087	468	956	I	89.0
10/03/98	7F7B1A565B	NONE	456	850	I	89.0
10/05/98	1F74343F7A	NONE	444	820	M	77.5
10/05/98	1F41341F4D	NONE	423	700	M	77.3
10/05/98	1F74335B5F	NONE	444	1050	I	68.7
Recaptured, stocked razorback sucker–1999						
09/29/99	513402471F	NONE	241	110	I	107.7
10/01/99	7F7B107949	741	486	1450	F	88.0
10/01/99	7F7B177D42	771	357	440	F	76.4
10/02/99	7F7B107152	761	452	980	M	59.4
10/03/99	7F7B1A510C	841	489	1275	F	55.3

Table 10. Roundtail chub collected from the San Juan River during “adult monitoring,” and other sampling trips in 1998 and 1999.

Date of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex	River Mile
Razorback Sucker Monitoring Trips:						
Wild roundtail chub-1998						
05/05/98	1F6D185B01®	NONE	414	760	F	133.4
05/07/98	NONE	NONE	51	——-	I	114.0
Wild roundtail chub-1999						
04/12/99	51365B4108	NONE	346	420	I	153.0
04/12/99	223F71510A	NONE	116	13	I	147.0
“Adult Monitoring” Trips:						
Wild roundtail chub–1999						
09/29/99	NONE	NONE	195	100	I	118.0
10/05/99	5124744920	NONE	134	28	I	25.0

® This fish was originally captured on 15 April 1996 at RM 131.3 (TL = 414 mm, WT = 840 g)

Four additional roundtail chub were collected during 1998 and 1999 razorback sucker monitoring trips, including only the second individual ever known to be recaptured since studies began 1991 (Table 10).

Common Nonnative Fishes

Channel Catfish

As in past years, channel catfish total CPUE in the core sampling area (RM 158.6-53.0) was highly variable again in 1998 and 1999 (Figure 8). In 1998 channel catfish total CPUE in Reach 5 was the highest it had been since 1992 and the second highest since studies began in 1991 (Figure 8). Conversely, 1998 channel catfish total CPUE in Reaches 4, 3, and 2 was at its lowest in several years, but 1999 channel catfish total CPUE in these same reaches rebounded to be among some of the highest observed since studies began in 1991 (Figure 8). Channel catfish total CPUE was also higher in Reach 1 in 1999 than it had been since 1995 (Figure 8). The most notable change in 1999 collections of channel catfish was the relatively large percentage of juvenile fish compared to adult fish. Juvenile channel catfish accounted for more than half the total catch for this species in all river reaches sampled in 1999 (Figure 8). In previous years, adult channel catfish numerically dominated the total catch for this species in both Reaches 6 and 5 (Figure 8). This was not the case in 1999.

Comparisons of channel catfish total CPUE from RM 180.0-53.0 (Figure 9) show that October 1999 total CPUE was significantly higher than all previous trips in which this river section was sampled on the same trip (Table 11). Until October 1999, October 1996 channel catfish total CPUE had been significantly higher than all other years' total CPUE in this river section. However, October 1999 channel catfish total CPUE greatly exceeded that observed in October 1996 (Table 11, Figure 9).

Examinations of channel catfish mean TL shows that in October 1999 sampling, channel catfish mean TL was lower in Reaches 6, 5, 2, and 1 than in other years in which these reaches were sampled (Figure 10). In contrast, channel catfish mean TL was almost identical in Reach 4 for the three years spanning 1997-1999. In Reach 3 channel catfish mean TL values fluctuated up and down, with 1999 values being almost identical to those seen in 1995 and 1997 (Figure 10). Two other items of note can be observed in 1999 channel catfish mean TL plots. The first was that while large individual channel catfish continued to be collected in Reaches 5-1, the standard deviation values for these all reaches had shifted noticeably downward from previous years values (Figure 10). Second, the largest channel catfish collected in Reach 6 in 1999 was only as large as the mean TL values observed in previous years' sampling in this reach (Figure 10).

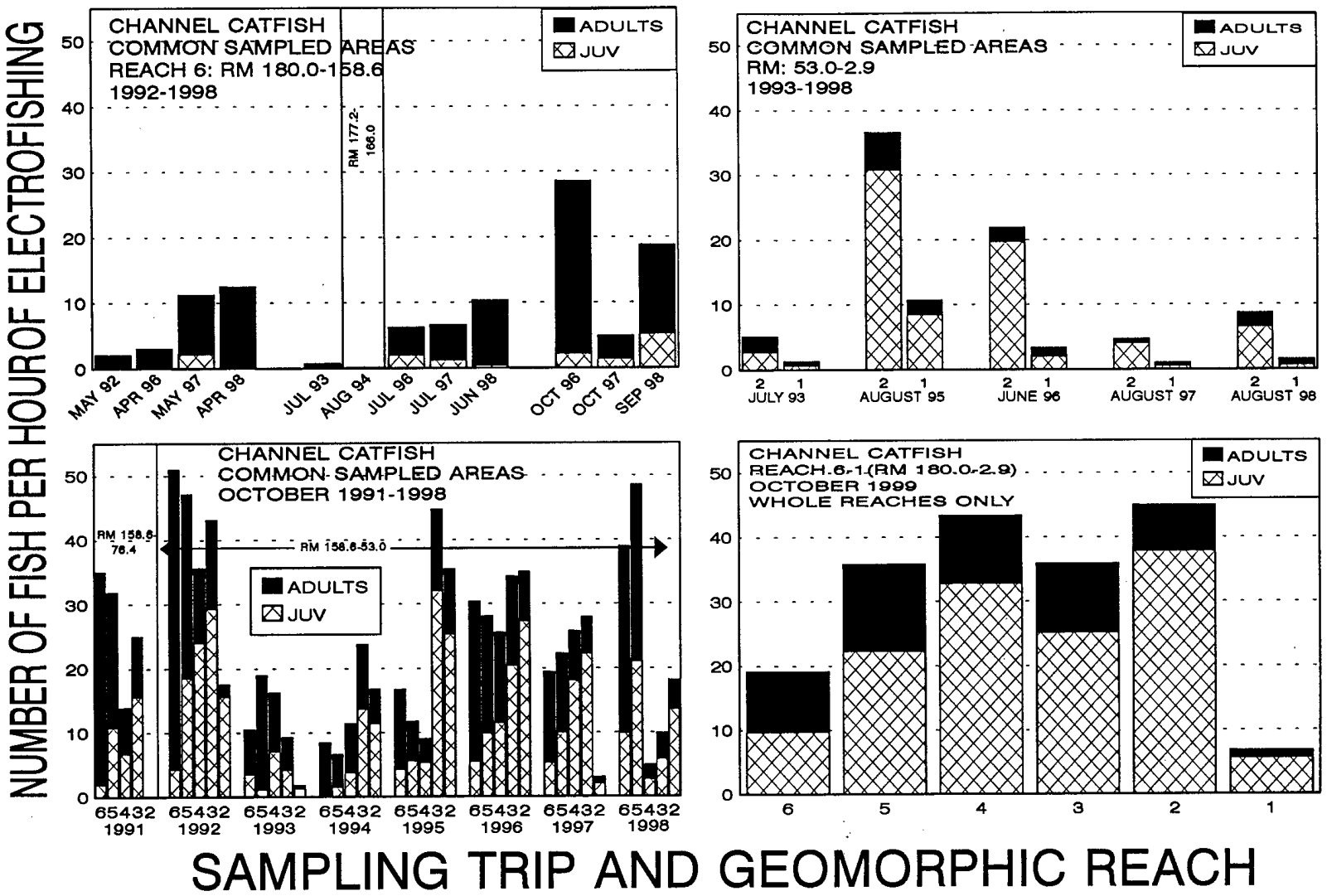

Figure 8. Number of channel catfish, by life stage, collected per hour of electrofishing in the San Juan River during "adult monitoring" trips, 1991-1999.

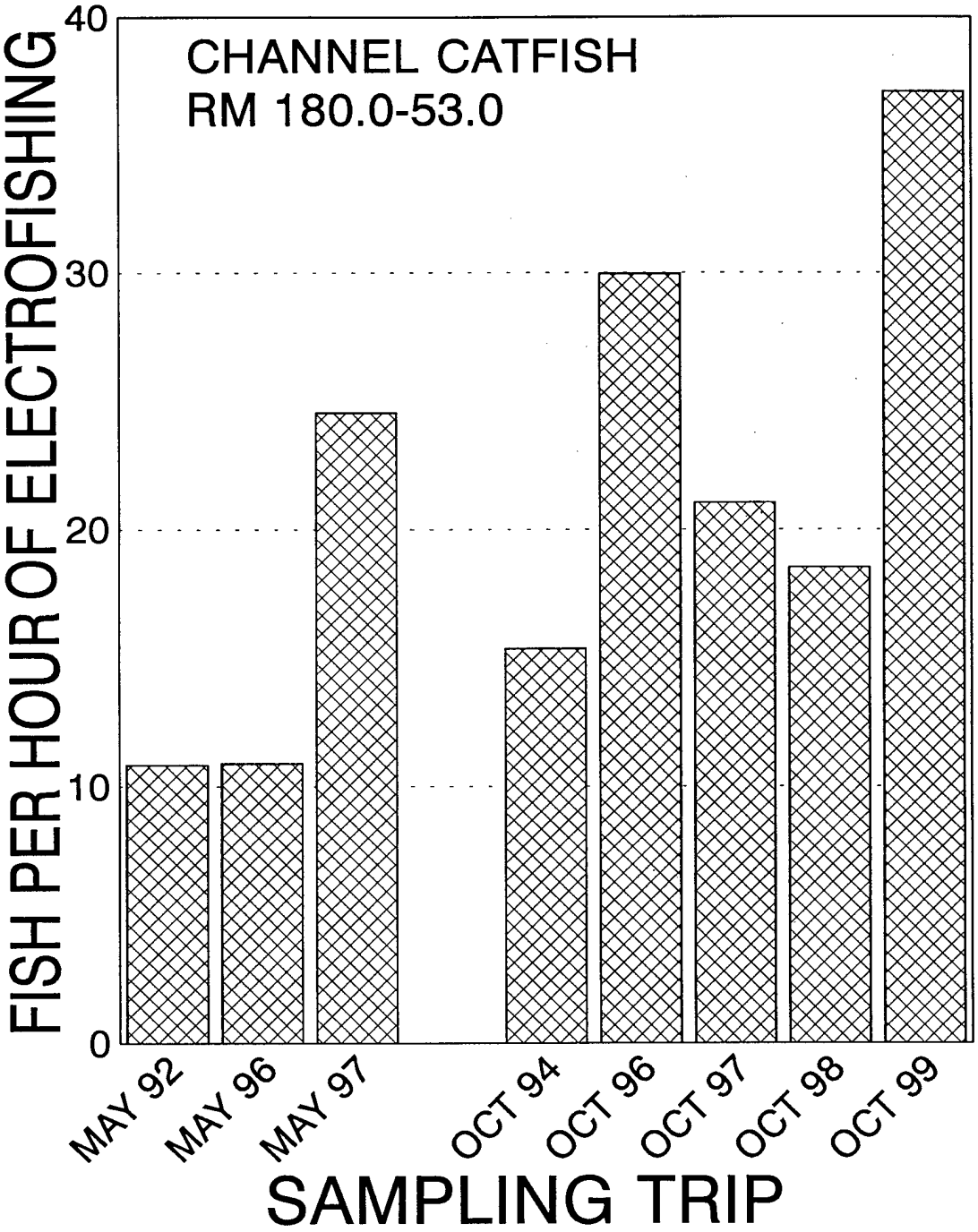

Figure 9. Number of channel catfish, all life stages combined, collected per hour of electrofishing in the San Juan River, RM 180.0-53.0, during "adult monitoring" trips, 1992-1999. Only those sampling trips on which this entire river section was sampled are presented.

Table 11. One-way ANOVA statistics and matrix of Bonferroni pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, RM 180.0-53.0, October 1994 to October 1999 ($p < 0.10$ = * = statistically significant relationship).

One-way ANOVA: F-statistic = 30.594, $r^2 = 0.083$, $p = 0.000$*

Scheffe matrix:

	1994	1996	1997	1998	1999
1994	1.000				
1996	0.000*	1.000			
1997	0.034*	0.000*	1.000		
1998	1.000	0.000*	1.000	1.000	
1999	0.000*	0.022*	0.000*	0.000*	1.000

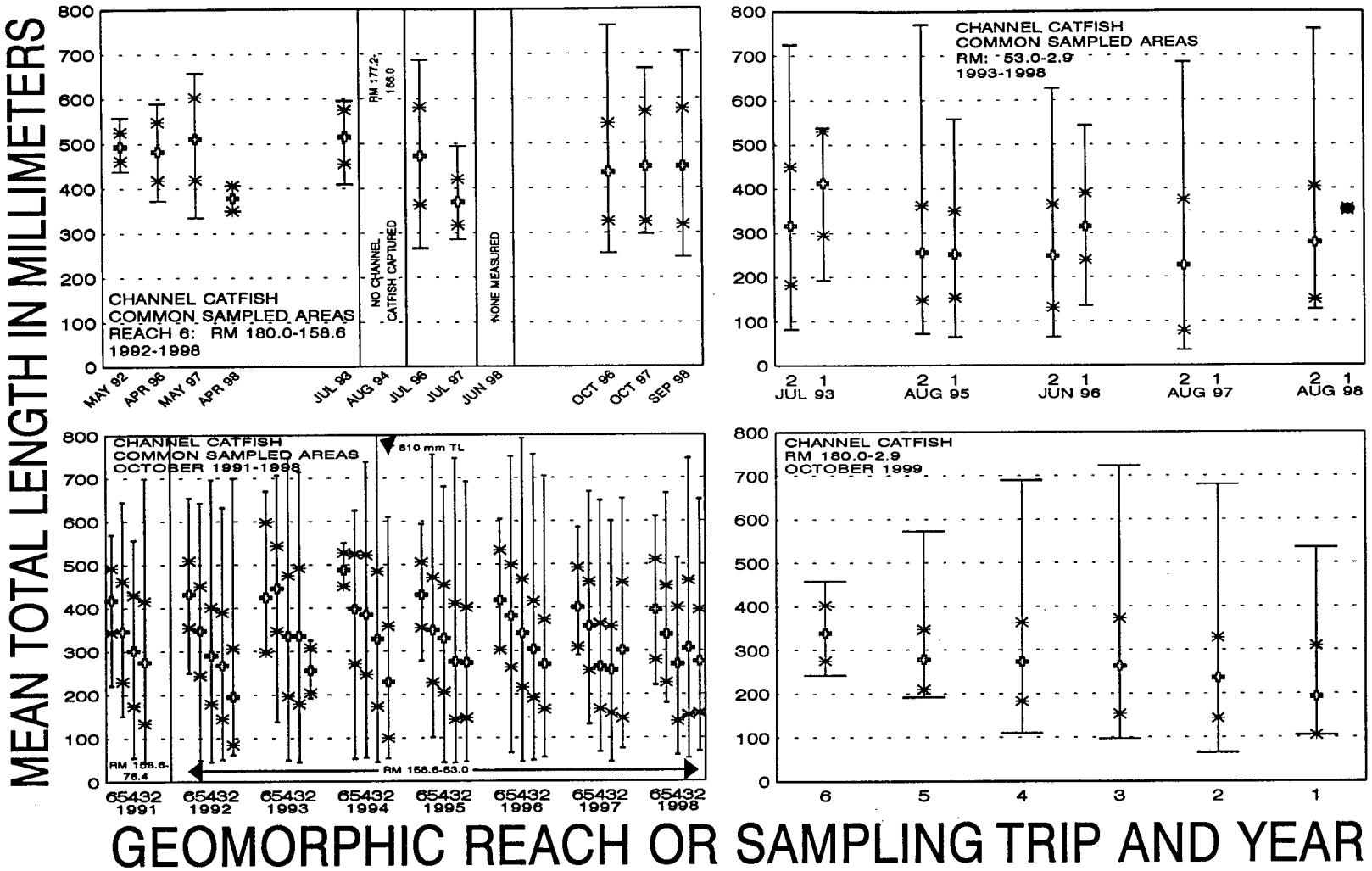

Figure 10. Mean total length (TL) in millimeters for channel catfish collected on "adult monitoring" trips 1991-1999. Crosses represent the mean values, error bars the range, and asterisks represent the standard deviation.

Common Carp

In the core sampling area (RM 158.6-53.0) common carp total CPUE in 1998 and 1999 were not dramatically different from one another and while lower than those seen in 1996-1997 in this area, they were higher than those seen in 1993-1995 (Figure 11). The total catch for common carp, as has been the case since 1991, was numerically dominated by adult fish again in both 1998 and 1999 (Figure 11).

Comparisons of common carp total CPUE from RM 180.0-53.0 (Figure 12) showed that although October 1999 values were slightly higher than those seen in October 1997 and slightly lower than those seen in October 1996, they were not statistically different than those two years (Table 12). Common carp total CPUE in this river reach was also significantly higher from October 1996-October 1999 than in October 1994 (Figure 12) when total CPUE was at its lowest since studies began in 1991 (Figures 11 and 12).

Plots of common carp mean TL showed no discernible changes in 1998 and 1999 from previous years with mean TL remaining between 400 and 550 mm TL for almost all reaches over the last several years (Figure 13).

DISCUSSION

Common Native Fishes

Flannelmouth Sucker

The decline in flannelmouth sucker total CPUE in the core sampling area (RM 158.6-53.0) observed between 1992 and 1997 (Ryden 2000a) has ceased. In addition, the increase in flannelmouth sucker total CPUE in Reach 6 (upstream of RM 158.6) is likely a sign that the San Juan River flannelmouth sucker population in this reach is responding positively to flow manipulations. When these two river sections are combined (i.e., RM 180.0-53.0) and total CPUE examined, it shows that flannelmouth sucker numbers increased in 1999 compared to 1996-1997. The reason for this increase in flannelmouth sucker numbers is presently unknown. It may be an upswing in a naturally fluctuating cycle, a stabilization in the flannelmouth sucker population after a period of readjustment to reoperation flows from Navajo Reservoir (and possibly the reintroduction of razorback sucker as well), a positive reaction to mechanical removal of channel catfish, or a combination of all, or none, of these or other factors.

The declining total CPUE of flannelmouth sucker in Reach 1 (immediately adjacent to Lake Powell) and the almost complete disappearance of small size-class flannelmouth sucker from this river reach is disconcerting. This decline first became apparent in our data sets in 1995, the year the waterfall separating Lake Powell and the San Juan River was inundated, allowing lacustrine predators free access into the lower San Juan River once again. Both striped bass (*Morone saxitilis*) and walleye (*Stizistedion vitreum*), as well as the ubiquitous channel catfish have been documented to prey on flannelmouth sucker in this river reach (Brooks et al. 2000, Ryden 2000a) and the majority of the two lacustrine predators collected in the San Juan River

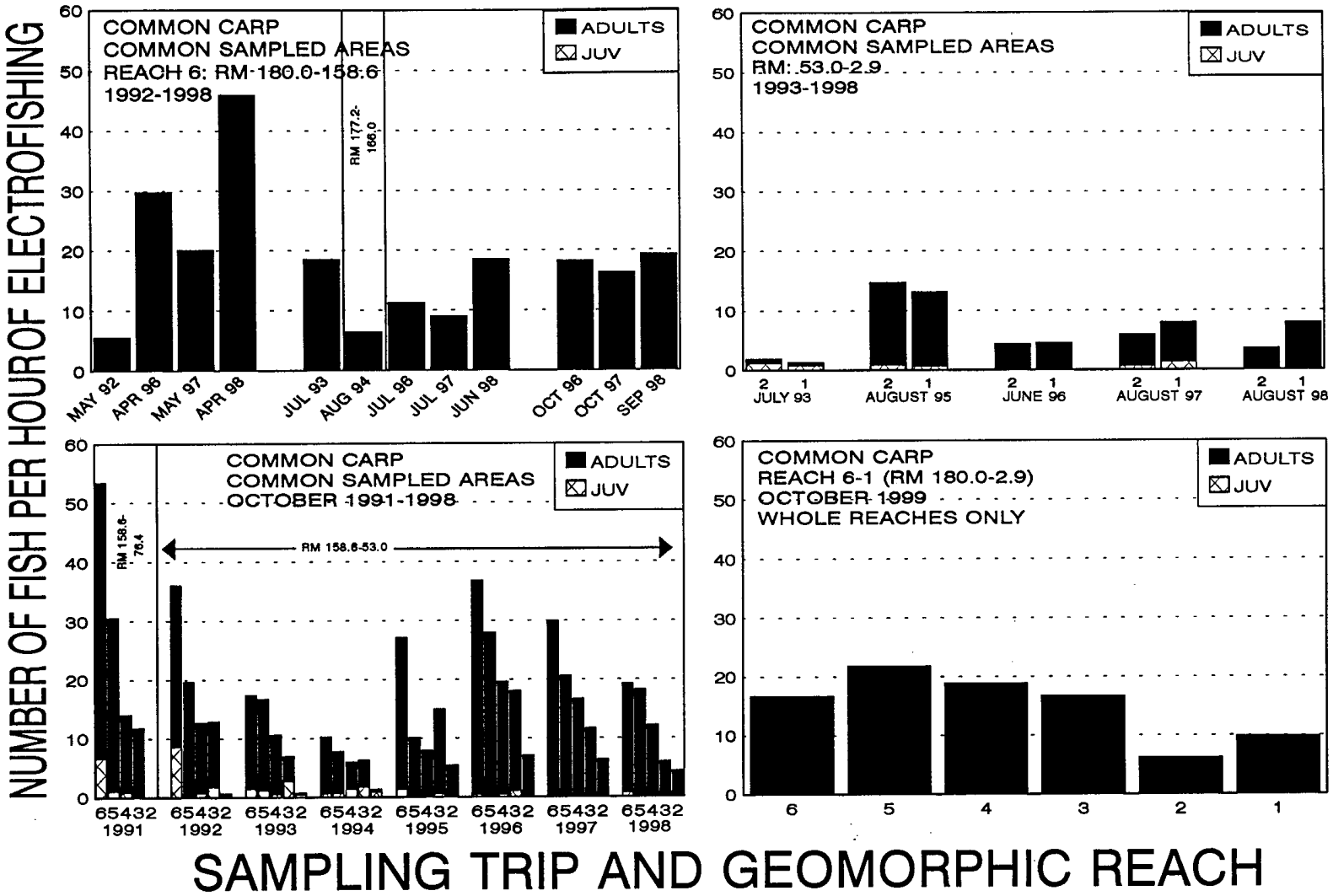

Figure 11. Number of common carp, by life stage, collected per hour of electrofishing in the San Juan River during "adult monitoring" trips, 1991-1999.

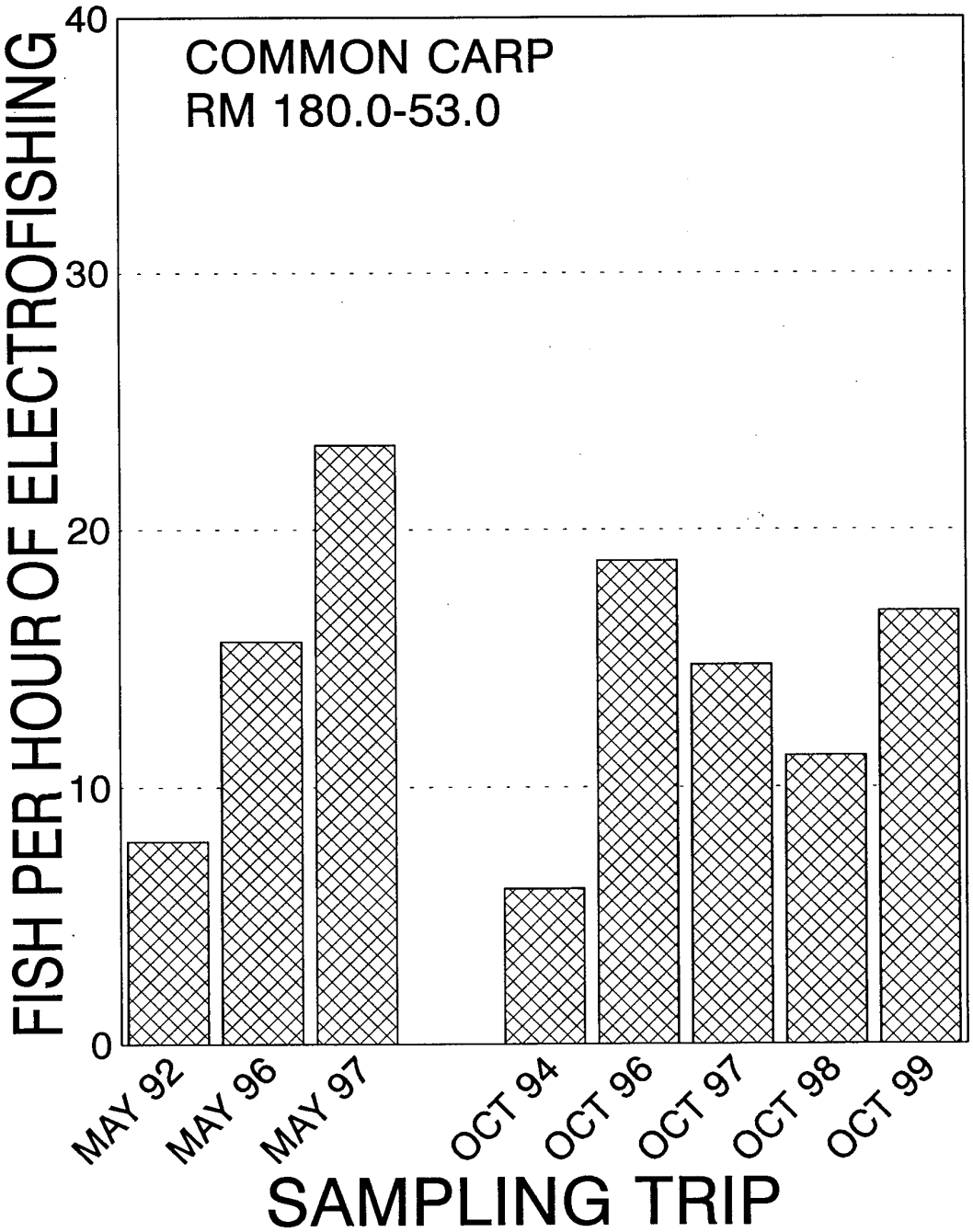

Figure 12. Number of common carp, all life stages combined, collected per hour of electrofishing in the San Juan River, RM 180.0-53.0, during "adult monitoring" trips, 1992-1999. Only those sampling trips on which this entire river section was sampled are presented.

Table 12. One-way ANOVA statistics and matrix of Bonferroni pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, RM 180.0-53.0, October 1994 to October 1999 ($p < 0.10$ = * = statistically significant relationship).

One-way ANOVA: F-statistic = 46.919, $r^2 = 0.122$, $p = 0.000$*

Scheffe matrix:

	1994	1996	1997	1998	1999
1994	1.000				
1996	0.000*	1.000			
1997	0.000*	0.001*	1.000		
1998	0.000*	0.000*	0.009*	1.000	
1999	0.000*	1.000	0.761	0.000*	1.000

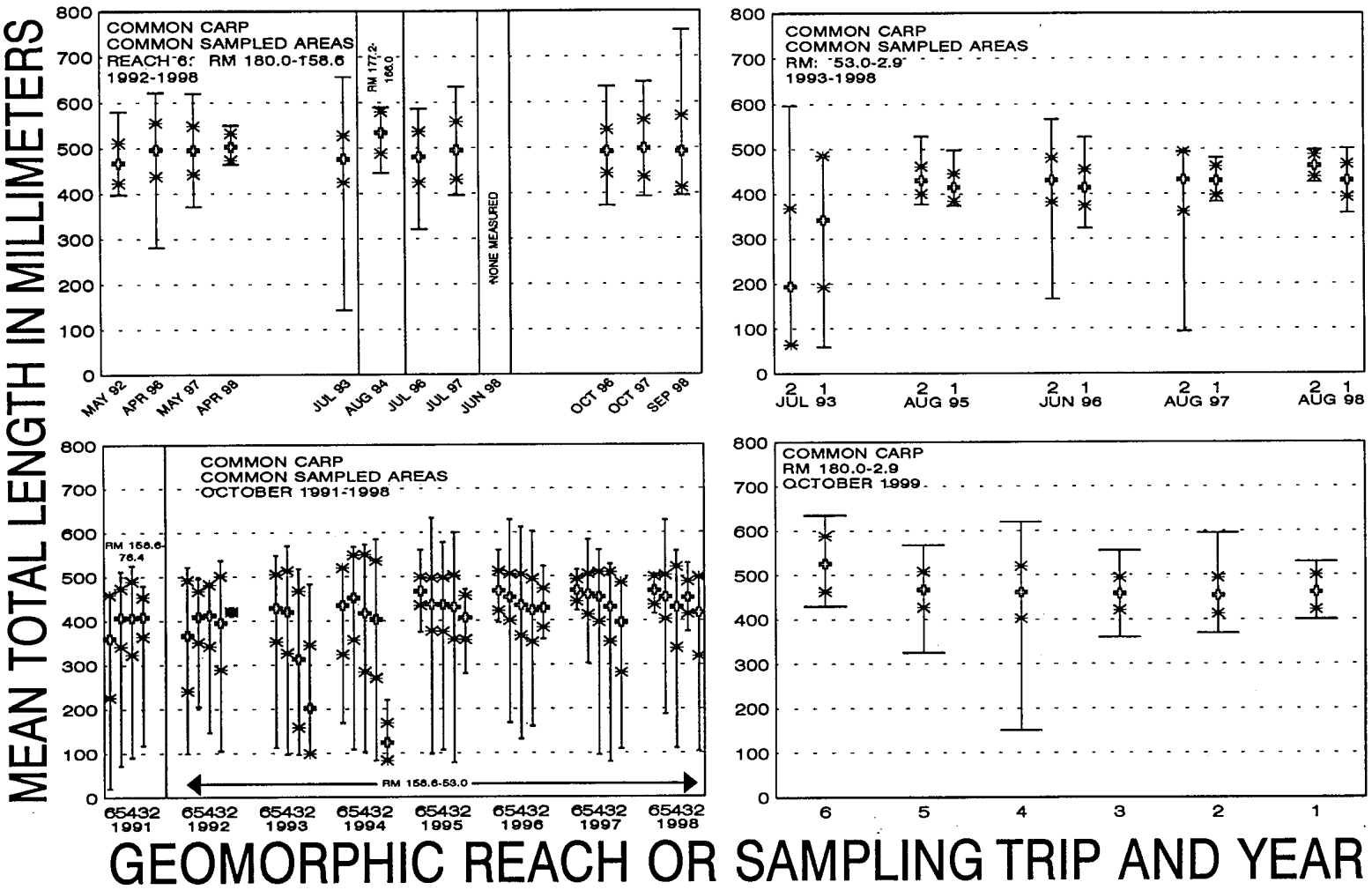

Figure 13. Mean total length (TL) in millimeters for common carp collected on "adult monitoring" trips 1991-1999. Crosses represent the mean values, error bars the range, and asterisks represent the standard deviation.

are collected in Reach 1 and adjacent Reach 2 (Ryden 2000a). This data forms a compelling circumstantial argument to say that lacustrine predatory fish in this river reach are a detriment to the native fish community, even the relatively abundant flannelmouth sucker.

Bluehead Sucker

Trends in bluehead sucker total CPUE are much less dramatic than those observed for flannelmouth sucker and are thus harder to interpret. Flannelmouth sucker total CPUE declined fairly dramatically in the core sampling area (RM 158.6-53.0) from 1992-1997 (Ryden 2000a). Bluehead sucker total CPUE also declined in this core sampling area during that period, but to a much lesser degree (Ryden 2000a). The slight decline in bluehead sucker total CPUE in the core sampling area from 1992-1997 was not evident in 1998 or 1999. In addition, in 1999, bluehead sucker total CPUE in Reach 6 (where over half the bluehead sucker population in the San Juan River resides at any given time), was by far the highest of any time period in which this reach has been sampled. When total CPUE for Reach 6 and the core sampling area are combined (RM 180.0-53.0) bluehead sucker total CPUE is significantly higher in 1999 than in all previous years when this entire area was sampled on the same trip. Thus, it would appear that reoperation of flows from Navajo Reservoir has been a boon to the San Juan River bluehead sucker population.

Rare Native Fishes

Colorado Pikeminnow

Collections of wild adult Colorado pikeminnow continue to be few and far between. Unfortunately, radio contact was lost with the large female being tracked in 1999 before spawning season began. However, the fact that large adult Colorado pikeminnow continue to persist in the San Juan River is, in itself, encouraging.

The 49 adult Colorado pikeminnow stocked in the San Juan River in September 1997 were in poor physical condition when they were stocked. Based on very low recapture rates, abnormal behaviors observed during radio telemetry efforts (pers. obs.), and the high incidence of recovering loose radio tags (usually on land with no associated carcass), it appears likely that the survival rate of these fish was very low.

Stocked juvenile Colorado pikeminnow continue to be recaptured. However, numbers of these fish recaptured on any given sampling trip are highly variable. It is evident that at least small numbers (relative to total numbers stocked) of stocked Colorado pikeminnow continue to persist and grow in the San Juan River. The recapture of two PIT-tagged individuals for the second time since stocking (i.e., demonstrating long-term survival) and several individuals > 300 mm TL (Table 7) is encouraging. As these fish become larger juveniles and small adults, there likely will come a time when they are difficult to collect due to the habitats they utilize. This is the case in other Upper Colorado River Basin rivers where Colorado pikeminnow between 200 and 500 mm TL are not as easily collected as are small juvenile or large adult fish (pers. obs.).

The Colorado pikeminnow that was recaptured with the channel catfish lodged in its throat represents the first time this phenomenon has been

documented in the San Juan River. This incident may have implications for trying to assess stocking success. This phenomenon appears to be rare in the wild, but how many stocked juvenile Colorado pikeminnow ingest young channel catfish and die before they are ever collected? Other research has indicated that large adult Colorado pikeminnow with average predator-prey length ratios of 5.8:1, 4.23:1 (Pimental et al. 1985), and 4.6:1 (McAda 1983) can expel ingested channel catfish with some degree of success. The Colorado pikeminnow collected from the San Juan River in October 1999 had a predator-prey length ratio of only 3.12:1 (346 mm TL vs. 111 mm TL). Given the size of the of the widest part of the channel catfish's pectoral girdle with spines extended compared to the gape size of the Colorado pikeminnow, there was no possible way the pikeminnow could open its mouth wide enough to expel its once-intended prey. This particular Colorado pikeminnow would likely have starved to death or suffocated before the catfish in its mouth died and disintegrated. This suggests that as predator-prey length ratio decreases, it becomes more difficult for Colorado pikeminnow to expel channel catfish from their oral cavities once they attempt to consume them. There appears to be a window of time when young Colorado pikeminnow are particularly susceptible to potentially fatal encounters with young channel catfish. Even if this is a rare phenomenon, in the San Juan River where Colorado pikeminnow are rare and channel catfish ubiquitous, the loss of even a single Colorado pikeminnow to choking diminishes recovery potential for this species.

Razorback Sucker

Stocked razorback sucker continue to persist in the San Juan River. Unfortunately, due to difficulties in obtaining and rearing enough razorback sucker for stocking, many fewer razorback sucker have been stocked than were originally planned (Ryden 1997, 2000b). However, the few razorback sucker that have been stocked continue to grow and have begun to spawn. Larval razorback sucker were collected in both 1998 and 1999 (S. Platania pers. comm.) and suspected spawning aggregations of razorback sucker were identified near Aneth, UT (at RM 100.2) in both May 1997 and April 1999 (Ryden 2000c).

Roundtail Chub

Roundtail chub continue to be very rare in San Juan River fish collections. The individual collected at RM 25.0 was one of only six roundtail chub to be collected downstream of RM 50.0 since 1991 (Ryden 2000a) and by far the largest collected in the lower 50 RM of the San Juan River. One roundtail chub collected on a razorback sucker monitoring trip on 5 May 1998 (Table 9; Ryden 2000a) represents only the second time an individual roundtail chub has been recaptured during 1991-1999 studies. There appears to be no persistent roundtail chub population in the mainstem San Juan River, as might be documented by recaptures of tagged fish or population length-frequencies indicating recruitment. Only a very few, scattered adult fish appear to be resident in the mainstem San Juan River.

Common Nonnative Fishes

Channel Catfish

Total CPUE for channel catfish continues to vary widely from year to year and reach to reach. Analysis done on 1991-1997 channel catfish total CPUE showed no negative correlations associated with reoperation flows from Navajo Reservoir (Buntjer 1999). Yet total CPUE of channel catfish in the last several years, especially 1999, show two clear trends. First, CPUE for large channel catfish (i.e., $\geq$ 500 mm TL) has dropped noticeably, especially in Reach 6. Second, total CPUE of channel catfish has increased. The most logical explanation for these observed shifts in channel catfish populations is mechanical removal efforts. Since electrofishing tends to be somewhat size selective for larger fishes, it would make sense that larger channel catfish would be more dramatically effected by mechanical removal efforts based around electrofishing. The removal of these larger size class fish would make more resources available for smaller channel catfish (i.e., less competition). Survival of smaller size-classes of channel catfish may also increase due to reduced intraspecific predation by larger members of their own species. While the reduction in numbers of large channel catfish bodes well for native fishes by reducing the predation potential, the increase in small channel catfish poses a unique threat to subadult Colorado pikeminnow, as has already been discussed. In addition, higher numbers of small size-class channel catfish may also cause increased competition for food and other resources with certain native species (specifically flannelmouth sucker and roundtail chub).

Common Carp

Common carp total CPUE in 1998 and 1999, while less than that observed from 1996-1997, was still greater than that observed from 1993-1994. It could be that these differences in numbers are part of a naturally fluctuating cycle. Like channel catfish, common carp total CPUE showed no negative correlation related to reoperation flows from Navajo Reservoir between 1991 and 1997 (Buntjer 1999). However, unlike channel catfish, common carp do not appear to be demonstrating any identifiable trends in total CPUE related to mechanical removal efforts. Since common carp grow and mature to adulthood faster than channel catfish, it could be that this species is able to quickly overcome any adverse effects caused by mechanical removal efforts.

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APPENDIX A

Figure A-1. Frontal view of a Colorado pikeminnow with a channel catfish lodged firmly in its mouth.

Figure A-2. Another view of the channel catfish lodged in the Colorado pikeminnow's mouth. Note the extremely distended right eye of the Colorado pikeminnow and the dark band on the caudal peduncle of the channel catfish where the flesh has been worn away by the mouth of the pikeminnow.