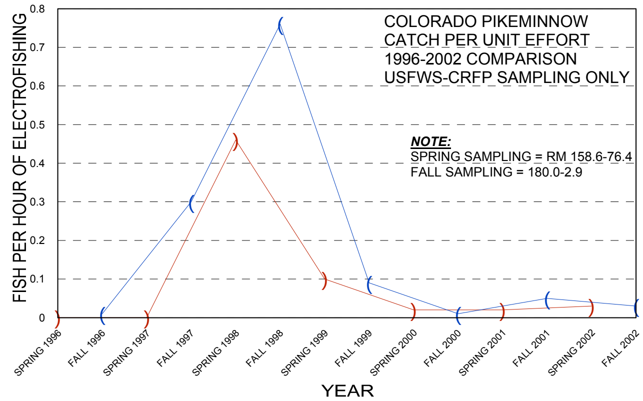
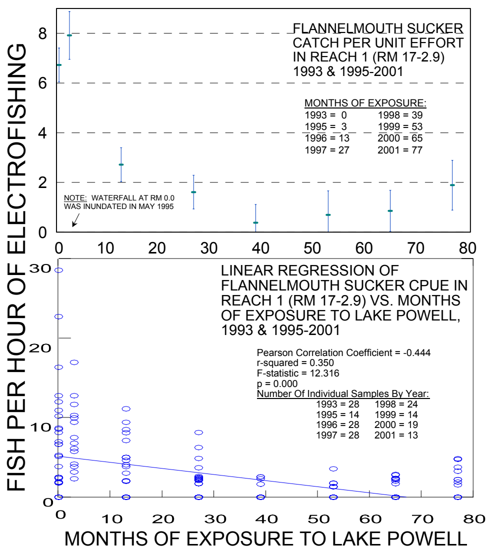
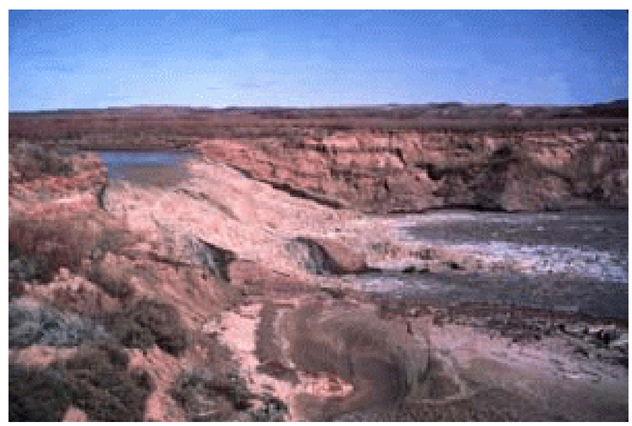
LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 1999-2001 INTEGRATION REPORT







Final Report

15 July 2003

U. S. Fish and Wildlife Service

LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 1999-2001 INTEGRATION REPORT

Final Report

Submitted By:

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15 July 2003

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EXECUTIVE SUMMARY

- Native fishes
    - Colorado pikeminnow
        - Wild Colorado pikeminnow continue to be extremely rare in adult monitoring collections
        - Adult Colorado pikeminnow stocked in 1997 survived extremely poorly
        - Adult Colorado pikeminnow stocked in 2001 survived somewhat better, but seem to be concentrated in the area of the river between PNM Weir and Hogback Diversion
        - Age-0 Colorado pikeminnow stocked in 1996 and 1997 were fairly common in collections until fall 1998, after which time their numbers appear to have decreased dramatically
            - Survival among age-0 Colorado pikeminnow stocked at larger sizes (45-55 mm TL) in the fall was much better than among age-0 Colorado pikeminnow stocked as larvae in the summer
            - The reason for the dramatic drop-off in Colorado pikeminnow collections after fall 1998 is unknown
    - Razorback sucker
        - Stocking larger size-class fish (> 300 mm TL) appears to increase post-stocking survival
        - Relative to numbers stocked, recapture events with razorback sucker are much more common than for stocked Colorado pikeminnow
        - Suspected spawning aggregations of adult razorback sucker were documented at RM 100.2 in May 1997, April 1999, and April 2001
        - Crews from UNM have documented spawning, through the collection of larval razorback sucker, for four straight years (1998-2001)
    - Roundtail chub
        - Very rarely collected during adult monitoring trips
        - Do not appear to have a resident population present in the San Juan River at this time
    - Flannelmouth sucker
        - Continue to numerically dominate adult monitoring collections
        - All life stages occur throughout the study area (RM 180.0-2.9)
        - Flannelmouth sucker population appears to be relatively stable
            - Decline in flannelmouth sucker CPUE in Reaches 5-3 observed in mid- to late-1990's has stopped and numbers have increased significantly in those reaches since that time
            - Flow manipulations from Navajo Dam since 1992 do not appear to be causing dramatic long-term shifts in numbers of flannelmouth sucker present in study area
        - A very large number of age-0 flannelmouth sucker were collected in 2000, mostly upstream of the PNM Weir
        - Numbers in Reach 1 (and 2), adjacent to Lake Powell have shown statistically significant declines since 1995

- Bluehead sucker
    - Population is centered around upstream reaches of the study area, specifically Reach 6
    - Bluehead sucker have never been collected in Reach 1 adjacent to Lake Powell during adult monitoring
    - Bluehead sucker population appears to be relatively stable
        - Flow manipulations from Navajo Dam since 1992 do not appear to be causing dramatic long-term shifts in numbers of bluehead sucker present in study area
    - Like flannelmouth sucker, a very large number of age-0 bluehead sucker were collected in 2000, mostly upstream of the PNM Weir

- Nonnative fishes
    - Channel catfish
        - Occur in large numbers in the study area from downstream of the PNM Weir to Lake Powell (RM 166.6-0.0)
        - Continue to be the most commonly-collected large-bodied nonnative fish species in the San Juan River
        - Channel catfish population appears to be relatively stable
            - Flow manipulations from Navajo Dam since 1992 do not appear to be having dramatic, long-term, negative impacts on numbers of channel catfish present in study area
        - Mechanical removal efforts appear to have had the following effects:
            - Reduced number of large channel catfish (> 525 mm TL) riverwide in adult monitoring collections since 1996
            - Length-frequency distributions have skewed towards smaller fish riverwide since 1996
            - An increase in CPUE for smaller size-class channel catfish
            - Channel catfish from Reach 5 appear to be moving upstream and quickly recolonizing lower Reach 6, essentially filling the void being created by mechanical removal efforts
        - Although large numbers of age-0 channel catfish were not collected during 2000 adult monitoring collections, very large numbers of age-1 channel catfish were collected during 2001 adult monitoring collections
            - It appears that like flannelmouth sucker, bluehead sucker, and common carp, channel catfish also had a very successful spawn in 2000
            - Apparently age-0 channel catfish spawned in summer 2000 were too small to show up in fall 2000 adult monitoring collections
    - Common carp
        - Are ubiquitous, occurring throughout the entire study area from the Animas River confluence to Lake Powell (RM 180.0-0.0)
        - Continue to be the second most commonly-collected large-bodied nonnative fish species in the San Juan River
        - CPUE for common carp upstream of the PNM Weir is usually only about half of that for common carp downstream of the PNM Weir
            - Common carp tend to be longer (mean TL) and heavier (mean WT) upstream of the PNM Weir than those downstream of the PNM Weir

  - Common carp CPUE in lower Reach 6 (RM 166.6-158.6) has declined over the last several years, indicating that mechanical removal efforts may be having an effect on this species in this section of the river
  - A very large number of age-0 common carp were collected in 2000, mostly upstream of the PNM Weir
  - Common carp from Lake Powell may be invading and recolonizing the San Juan River
- Other nonnative fishes (largemouth bass, striped bass, and walleye)
  - Usually rare in collections
  - Have all three been documented to prey on native fishes in the San Juan River
  - Largemouth bass
    - Usually very rare in adult monitoring collections
      - Relatively large number of largemouth bass collected on the fall 2000 adult monitoring trip may have been due to low stable flows and clear-water conditions present in the river throughout summer 2000
    - Most largemouth bass collected in the San Juan River are juveniles
    - Most are collected in upstream reaches of the study area in close proximity to irrigation returns
      - Suggests that off-channel sources may be continually providing access to the river through irrigation canals
  - Striped bass
    - In summer 2000, during an extended period of low flows and clear water, an extremely large number of striped bass invaded the San Juan River, being collected as far upstream as the PNM Weir (RM 166.6)
      - During the summer 2000 razorback sucker monitoring trip, researchers noted an almost complete absence of “small native suckers”
      - Most stripers collected on this trip had fish remains in their stomachs, most of which were native fish
    - Appear to be unable to tolerate high volume or turbid river flows
      - Usually much less common in electrofishing collections after these types of flow events
  - Walleye
    - Have been very rare in adult monitoring collections over the last several years
    - Like Colorado pikeminnow are obligate piscivores (at $\geq$ age-1), thus bringing them into potential competition for food resources with Colorado pikeminnow
      - Any Colorado pikeminnow of appropriate size ($<$ 350 mm TL) that happen to be using the same habitats as walleye in the pursuit of prey are potentially in danger of being eaten
    - Like striped bass, walleye appear to be unable to tolerate high volume or turbid river flows
      - Usually absent from electrofishing collections after these types of flow events

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INTRODUCTION

Research performed between 1991 and 1997 led to the initiation of several major management actions by the San Juan River Recovery Implementation Program (SJRIP) that are intended to have long-term positive impacts on the native fish community. These included the development of flow recommendations for the reoperation of Navajo Reservoir, the initiation of a mechanical removal program for nonnative fishes, modification or removal of several instream water diversion structures, and augmentation efforts for both endangered fish species –- Colorado pikeminnow and razorback sucker. To assess the effects of these management actions over the duration of the SJRIP, a long-term monitoring program (Propst et al. 2000) was initiated. Standardized data collection under long-term monitoring plan guidelines began in 1999 and will continue until the termination of the SJRIP.

One component of the long-term monitoring program, the "sub-adult and adult large-bodied fish monitoring," was the primary responsibility of the U.S. Fish and Wildlife Service's (USFWS) Colorado River Fishery Project (CRFP) office in Grand Junction, CO. Numerous other state and federal agencies supplied manpower, equipment, and logistical support for these sampling efforts.

The objectives of the sub-adult and adult large-bodied fish monitoring (referred to hereafter as "adult monitoring") are as follows:

1) Monitor the San Juan River's main channel fish community, specifically the large-bodied fish species, to identify shifts in fish community structure, species abundance and distribution, and length/weight frequencies that are occurring corresponding to management actions that are being implemented by the San Juan River Recovery Implementation Program. These include:
    a) reoperation of Navajo Reservoir
    b) mechanical removal of nonnative fishes
    c) modification or removal of instream water diversion structures
    d) augmentation efforts for both federally-listed endangered fish species –- Colorado pikeminnow and razorback sucker.

2) Monitor population trends (e.g., distribution and abundance, habitat use, spawning and staging areas, growth rates, recruitment) of the rare San Juan River fish species -- Colorado pikeminnow, razorback sucker, and roundtail chub.

The study area for adult monitoring begins at the Animas River confluence (river mile {RM} 180.0) and continues downstream to Clay Hills boat landing (RM 2.9) just upstream of Lake Powell. This study area encompasses six of the eight major geomorphic reaches identified (by Bliesner and Lamarra 2000) in the San Juan River between Navajo Reservoir and Lake Powell. The six geomorphic reaches in our study area are: Reach 6 (RM 180.0-155.0); Reach 5 (RM 155.0-131.0); Reach 4 (RM 131.0-106.0); Reach 3 (RM 106.0-68.0); Reach 2 (RM 68.0-17.0); and Reach 1 (RM 17.0-0.0). Although the study area ends 2.9 RM short of the end of Reach 1, it is assumed herein that the data collected from RM 17.0-2.9 are representative of the entirety of Reach 1.

SECTION I:

MONITORING REPORT

METHODS

Sampling conducted from 1999-2001 followed the protocols for long-term monitoring set forth in Propst et al. (2000). The entire study area was sampled between mid-September and the end of October. Electrofishing was performed in a continuous 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 electrofishing equipment. Electrofishing was done in one-RM increments, with two of every three RM being sampled. At the end of each sampled RM, all fish were identified and enumerated by life stage and species. At the end of every fourth sampled RM (known as a designated mile, or "DM" for short), all fish were weighed (± 5 grams {g}) and measured (± 1 mm total length {TL} and standard length {SL}). All nonnative fishes were then removed from the river. All common native fishes were returned alive to the river. Rare native fishes (Colorado pikeminnow, razorback sucker, and roundtail chub) were weighed, measured, had distinguishing characteristics noted (e.g., sex, external parasites), and were 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) fished by each raft in each sampled RM.

The descriptions of the analyses that follow apply only to the four most common large-bodied fish species collected during adult monitoring trips. These species are flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), channel catfish (Ictalurus punctatus), and common carp (Cyprinus carpio). These are the only four fish species present in the San Juan River in large enough numbers to yield sufficient sample sizes (via electrofishing) from which statistically valid conclusions can be drawn on an annual basis.

Electrofishing data were pooled for all rafts to obtain total catch numbers for each sampling trip. Numbers of fish (juvenile and adult life stages) collected by all rafts were combined to obtain total catch for each species. Numbers of fish collected for each species were then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain "riverwide" (i.e., Reaches 6-1 {RM 180.0-0.0} combined) catch per unit effort (CPUE) values for juvenile and adult life stages and for all life stages combined (i.e., juvenile + adult; referred to hereafter as "total" CPUE). CPUE values for each of the four most common species collected was then partitioned by whole geomorphic reach and compared to 1991-1998 electrofishing data to evaluate long-term trends.

TL and weight (WT) data obtained from fish measured at DM's were used to examine changes in mean TL, mean biomass (i.e., WT in g), biomass per hour of electrofishing (i.e., mean biomass X total CPUE), and mean condition factor ($\{K\} = [WT\ (in\ g) \times 10^5]/[TL\ (in\ mm)]^3$). These analyses were done for all life stages of a species in a reach, combined. As with CPUE data, mean TL, mean biomass, biomass per hour of electrofishing, and mean condition factor

(K) data were compared to 1991-1998 data to evaluate long-term trends. TL data were also used to develop riverwide length frequency histograms for the for most common species from 1996-2001.

A few notes of explanation about 1991-1998 data sets are warranted here. Adult monitoring studies performed from 1991-1998 followed protocols (detailed in Ryden 2000a) very similar to those in Propst et al. (2000). The only two differences between these two sets of sampling protocols were: 1) from 1991-1998, electrofishing was done every RM (instead of two out of every three RM); and 2) DM's were done every fifth sampled RM (instead of every fourth sampled RM). However, from 1991-1998 adult monitoring studies did not always sample the entirety of the study area (Reaches 6-1) contiguously in a given year. It was only from 1996 on that the entirety of the study area was sampled during similar time-frames (i.e., late-summer through late-October) and flow conditions to allow for valid riverwide comparisons of data sets between years. Data collected prior to 1996 were only included in comparative analyses for this report if data were available for a whole geomorphic reach. Therefore, appropriate comparative data sets were available for Reach 6 from 1996-1998, for Reaches 5-3 from 1991-1998, and for Reaches 2-1 from 1993 and 1995-1998.

Additionally, it was not until 1994 that fish species collected in non-DM samples were characterized by life stage (i.e., juvenile or adult). Before 1994, fishes collected in non-DM samples were enumerated only by the total numbers collected per species. Therefore, juvenile and adult CPUE comparisons can only be made from 1994 on while CPUE comparisons for all life stages combined (i.e., total CPUE) can be made for all years in which data are available for a given geomorphic reach, since total CPUE is based on data from *ALL* fish of a given species, regardless of age, collected in an electrofishing sample. Therefore, in this report, no juvenile or adult CPUE data are presented for Reaches 5-3 from 1991-1993 or for Reaches 2 or 1 in 1993, but total CPUE data are presented for these reaches in these years.

All statistical tests and comparisons were performed using the SYSTAT® computer program (version 7.0, ©1997 SPSS Inc.). Data were first analyzed to see if they were normally distributed. If they were, a one-way analysis of variance (ANOVA) with a post-hoc, Bonferroni-adjusted, pairwise multiple comparison test (hereafter referred to as an ANOVA/Bonferroni) was used to test for significant differences among species characteristics (CPUE, mean TL, mean biomass, mean K) riverwide and within each of the six geomorphic reaches between years. If data were not normally distributed, they were first normalized by doing a rank transformation and then analyzed using ANOVA/Bonferroni. Since values for CPUE, TL, biomass, and K data represented samples of populations collected under field conditions and not specifically known values (i.e., not a population parameter), significance was determined at $p < 0.10$. This high alpha value was used to help avoid making a Type II Error (i.e., failing to statistically detect a difference when one exists).

RESULTS

Mean river flows during 2000 and 2001 adult monitoring trips were considerably lower than in all previous years during which riverwide sampling was conducted, with flows in 2001 being the lowest over that six-year period 1996-2001 (Table 1). In fact mean river flows during the 2001 adult monitoring trip (611 CFS) were only 28.1% of those encountered during the 1999 adult monitoring trip (2,177 CFS; Table 1). The low mean river flows during 2000 and 2001 adult monitoring trips were a function of both these years having extremely low overall discharge.

Table 1. Summary of dates, river miles (RM) sampled, and mean flow during riverwide adult/juvenile large-bodied fish community monitoring (i.e., “adult monitoring”) trips in the San Juan River, New Mexico, Colorado, and Utah, 1996-2001.

Beginning Date Of Sampling	Ending Date Of Sampling	River Miles Sampled	Mean Trip Flow At The Shiprock, New Mexico USGS Gage (#09368000) in CFS and (cubic meters/second)
17 June 1996	25 October 1996	RM 180.0-2.9	1,531 CFS (43.3 m^3/sec)
11 August 1997	9 October 1997	RM 180.0-2.9	1,753 CFS (49.6 m^3/sec)
10 August 1998	7 October 1998	RM 180.0-2.9	767 CFS (21.7 m^3/sec)
20 September 1999	7 October 1999	RM 180.0-2.9	2,177 CFS (61.6 m^3/sec)
18 September 2000	10 October 2000	RM 180.0-2.9	657 CFS (18.6 m^3/sec)
25 September 2001	19 October 2002	RM 180.0-2.9	611 CFS (17.3 m^3/sec)

Over the period 1999-2001 a total of 25 different fish species or associated hybrid forms were collected from the San Juan River (Tables 2 and 3). Among these, were seven native species, two native sucker X native sucker hybrids, 14 nonnative species, and two native sucker X nonnative sucker hybrids (Table 2). Riverwide, the total catch was heavily dominated by fish representing two families: catostomids (suckers and sucker hybrids); and cyprinids (carps and minnows; Table 2).

In 1999, a total of 20 different fish species or hybrids were collected with flannelmouth sucker being the most abundant (n = 5,579), followed in descending order by channel catfish (n = 3,314), bluehead sucker (n = 2,007), and common carp (n = 1,203; Table 3). Native fishes accounted for 7,761 specimens or 63.0% of the total catch in 1999 (n = 236 individual electrofishing collections riverwide). Nonnative fishes accounted for 4,563 specimens or 37.0% of the total catch in 1999 (n = 236 individual electrofishing collections riverwide). The overall native to nonnative fish ratio riverwide was 1.70:1 in 1999 (Figure 1). Endangered fishes collected during 1999 adult monitoring included eight Colorado pikeminnow, five razorback sucker.

In 2000, a total of 21 different fish species or hybrids were collected with flannelmouth sucker being the most abundant (n = 7,904), followed in descending order by channel catfish (n = 3,704), bluehead sucker (n = 2,609), and common carp (n = 1,498; Table 3). Native fishes accounted for 11,049 specimens or 66.7% of the total catch in 2000 (n = 293 individual electrofishing collections riverwide). Nonnative fishes accounted for 5,511 specimens or 33.3% of the total catch in 2000 (n = 293 individual

Table 2. Scientific and common names, status, and six-letter codes for fish species collected during adult monitoring trips in the San Juan River, 1999-2001 (following Robins et al. 1991, Nelson et al. 1998[a], and the California Academy of Sciences Catalog of Fishes website).

SCIENTIFIC NAME	COMMON NAME	STATUS	CODE
Class Actinopterygii			
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
C.latipinnis X X.texanus	hybrid	native	latXtex
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 Moronidae-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 melas	black bullhead	introduced	Amemel
Ameiurus natalis	yellow bullhead	introduced	Amenat
Ictalurus punctatus	channel catfish	introduced	Ictpun

Table 3. Total number of fish collected during fall adult monitoring trips on the San Juan River, 1999-2001.

Species (Common Name)	Total Number Of Specimens			Percent Of Total			Frequency Of Occurrence		
	1999	2000	2001	1999	2000	2001	1999	2000	2001
Native Fishes:									
flannelmouth sucker	5,579	7,904	6,750	45.3	47.7	45.2	227	263	260
bluehead sucker	2,007	2,609	1,941	16.3	15.8	13.0	167	189	243
speckled dace	143	498	309	1.2	3.0	2.1	58	109	129
bluehead sucker X flannelmouth sucker	16	21	26	0.1	0.1	0.2	14	15	21
razorback sucker	5	8	11	---[a]	---	---	5	6	8
Colorado pikeminnow	8	1	5	---	---	---	5	1	5
mottled sculpin	1	8	2	---	---	---	1	6	2
roundtail chub	2	0	0	---	N/A	N/A	2	0	0
razorback sucker X flannelmouth sucker	0	0	1	N/A	N/A	---	0	0	1
Nonnative Fishes:									
channel catfish	3,314	3,704	4,286	26.9	22.4	28.7	218	269	252
common carp	1,203	1,498	1,327	9.8	9.0	8.9	205	246	238
red shiner	13	50	244	0.1	0.3	1.6	9	24	81
brown trout	9	12	11	---[a]	---	---	7	7	10
fathead minnow	2	7	8	---	---	---	1	5	7
walleye	9	7	1	---	---	---	8	6	1
white sucker X flannelmouth sucker	4	1	4	---	---	---	4	1	4
white sucker	2	5	1	---	---	---	2	3	1
black bullhead	1	2	1	---	---	---	1	2	1
largemouth bass	0	111	2	N/A	0.7	---	0	58	2
striped bass	0	109	2	N/A	0.7	---	0	64	2
white sucker X bluehead sucker	4	1	0	---	---	N/A	4	1	0
green sunfish	0	3	0	N/A	---	N/A	0	3	0
rainbow trout	0	1	0	N/A	---	N/A	0	1	0
smallmouth bass	1	0	0	---	N/A	N/A	1	0	0
yellow bullhead	1	0	0	---	N/A	N/A	1	0	0

[a] = less 0.1%
N/A = Not Applicable

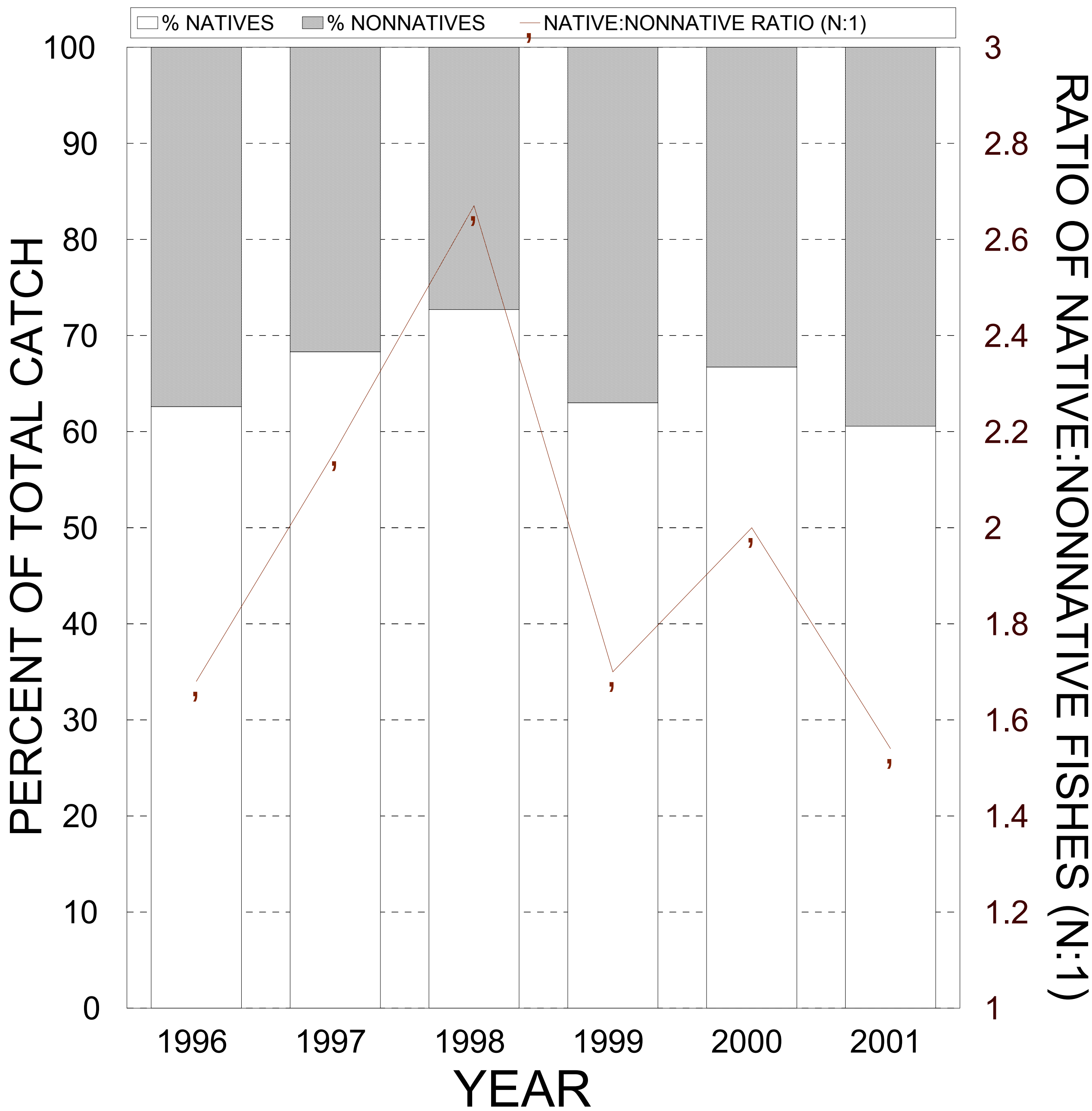

Figure 1. The bars represent the percent of the total catch accounted for by native fishes (white bars) versus nonnative fishes (shaded bars), riverwide (RM 180.0-0.0), on adult monitoring trips, 1996-2001. The line represents the ratio of native to nonnative fishes (*x*:1) collected on those same trips.

electrofishing collections riverwide). The overall native to nonnative fish ratio riverwide was 2.00:1 in 2000 (Figure 1). Endangered fishes collected during 2000 adult monitoring included one Colorado pikeminnow, eight razorback sucker. Also notable among 2000 adult monitoring collections were relatively large numbers of largemouth bass (n = 111) and striped bass (n = 109; Table 3).

In 2001, a total of 19 different fish species or hybrids were collected with flannelmouth sucker being the most abundant (n = 6,750), followed in descending order by channel catfish (n = 4,286), bluehead sucker (n = 1,941), and common carp (n = 1,327; Table 3). Native fishes accounted for 9,045 specimens or 60.6% of the total catch in 2001 (n = 267 individual electrofishing collections riverwide). Nonnative fishes accounted for 5,887 specimens or 39.4% of the total catch in 2001 (n = 267 individual electrofishing collections riverwide). The overall native to nonnative fish ratio riverwide was 1.54:1 in 2001 (Figure 1). This is the lowest riverwide native to nonnative fish ratio observed in the last six years (Figure 1). Endangered fishes collected during 2001 adult monitoring included five Colorado pikeminnow, 11 razorback sucker. Also notable among 2001 adult monitoring collections was the collection of a suspected razorback sucker X flannelmouth sucker hybrid. This fish (TL = 282 mm; WT = 210 g) was collected on 1 October 2001 at RM 20.3 from the river left shoreline just upstream of Government Rapid. It was preserved and sent to the University Of New Mexico's Museum of Southwestern Biology for identification and curation.

Rare Native Fishes

Colorado Pikeminnow

Fish Stocked As Part Of An Augmentation Effort

Between 1996 and 2002, a little over one million Colorado pikeminnow were stocked into the San Juan River (Table 4). These included: 1) 227,449 age-0 juveniles stocked by the Utah Division of Wildlife Resources (UDWR) between 1996 and 1998 (Archer et al. 2000); 2) 605,000 larval Colorado pikeminnow also stocked by UDWR in 1999 and 2000 (Jackson 2001); 3) 197 adult Colorado pikeminnow stocked by the USFWS (49 in 1997 and 148 in 2001; Ryden 2000b, 2003a); and, 210,418 age-0 juveniles stocked by the USFWS in October 2002; Ryden 2003a and Table 4). None of the young Colorado pikeminnow stocked by the UDWR were PIT-tagged before their release into the wild. In contrast, all of the 197 adult Colorado pikeminnow stocked by the USFWS were PIT-tagged before release. Since spring 1997, the vast majority of Colorado pikeminnow collected from the San Juan River during various sampling efforts have been recaptures from these nine stockings of Colorado pikeminnow (Tables 5 and 6).

The 49 adult Colorado pikeminnow stocked in 1997 were 1981 year-class fish that were age-16 at stocking. These fish were the left-overs from a selenium depuration experiment that had been performed at the U.S. Geological Survey's Columbia Environmental Research Center in Yankton, South Dakota. When these fish became available to the SJRIP, they were in very poor health. These fish were small for their age (mean TL = 644 mm; Table 4), an artifact of being held in a hatchery environment their entire lives. In addition, all 49 of these fish had mild to severe "ich" infections from weekly handling during the selenium study and they were very stressed when stocked, with recently radio-implanted fish (n = 17) appearing to be more stressed than their PIT-tagged counterparts (n = 34). Overall, retention and survival of these fish in the river post-stocking was

Table 4. Stockings of Colorado pikeminnow in the San Juan River, 1996-2002.

Date	Number Stocked	River Mile Stocked At	Mean Total Length (mm)	Range Of Total Lengths (mm)	Responsible Agency[a]
11/04/1996	~50,000	148.0	55	25-85	UDWR
11/04/1996	~50,000	52.0	55	25-85	UDWR
08/15/1997	62,578	148.0	45	35-55	UDWR
08/15/1997	54,300	52.0	45	35-55	UDWR
09/23/1997	49	180.2	644	550-753	USFWS
07/02/1998	10,571	148.0	24	18-28	UDWR
07/07/1999	~500,000	158.6	“Larvae”	Not Specified	UDWR
06/11/2000	~105,000	141.9	“Larvae”	Not Specified	UDWR
04/11/2001	148	180.2	540	442-641	USFWS
10/24/2002	~105,200	180.2	51	32-127	USFWS
10/24/2002	~105,200	158.6	51	32-127	USFWS

[a] UDWR = Utah Division of Wildlife Resources - Moab Field Station, Moab, Utah; USFWS = U.S. Fish and Wildlife Service - Colorado River Fishery Project, Grand Junction, Colorado

Table 5. Information on PIT-tagged Colorado pikeminnow adults that have been recaptured since they were stocked on 23 September 1997 at RM 180.2. None of the adult fish from this particular stocking have ever been recaptured more than once.

PIT Tag Number	Date Of Recapture	Number Of Days In River Since Stocking	Total Length	Sex	River Mile (Or Section Occupied)[a]
7F7F1E784D	09/29/1997	6	734 mm	Female	179.0-178.0
7F7F336047	09/29/1997	6	610 mm	Male	179.0-178.0
7F7F32203C	09/29/1997	6	610 mm	Unknown	179.0-178.0
7F7F1F0E25	09/29/1997	6	707 mm	Female	178.0-177.3
7F7F1F1C01	09/29/1997	6	698 mm	Female	178.0-177.3
7F7F323F5C	09/29/1997	6	674 mm	Female	178.0-177.3
7F7F1F0F3A	09/29/1997	6	640 mm	Female	177.0-176.0
7F7F1F1503	09/29/1997	6	624 mm	Female	177.0-176.0
7F7F067F30	09/29/1997	6	624 mm	Male	175.0-174.0
7F7F1E7228	09/30/1997	7	685 mm	Female	156.1
7F7F1F156F	03/31/1998	189	622 mm	Female	177.2
7F7F1F1E1E	03/31/1998	189	671 mm	Female	173.6

[a]: These fish were all collected during adult monitoring trips. The Colorado pikeminnow collected in 1997 were not usually worked up immediately upon capture, but were held in fresh water separate from other fish until that particular electrofishing sample (usually one mile in length) was completed. Fruitland Diversion is located at RM 177.3. Therefore the RM (178.0-177.0) was split into two separate electrofishing samples, RM 178.0-177.3 and RM 177.3-177.0. Fish collected upstream of the diversion were counted and released upstream of the structure, then once the electrofishing boats had run the diversion, the remainder of the RM was completed as separate sample.

Table 6. Information on PIT-tagged Colorado pikeminnow adults that have been recaptured only once since being stocked on 11 April 2001 at RM 180.2.

PIT Tag Number	Date Of Recapture	Number Of Days In River Since Stocking	Total Length	Sex	River Mile (Or Section Occupied)[a]
7F7B130C56	06/21/2001	71	503 mm	Male	155.3
7F7B19570C	08/15/2001	126	513 mm	Male	163.3
7F7B1B6436	09/11/2001	153	496 mm	Unknown	166.6-163.4
7F7B177D17	09/11/2001	153	516 mm	Unknown	163.4-159.0
7F7D4C391B	09/12/2001	154	466 mm	Unknown	163.4-159.0
7F7B195C63	09/12/2001	154	547 mm	Female	161.5
7F7D78355C	09/13/2001	155	509 mm	Unknown	166.6-163.4
7F7D137454	02/06/2002	301	496 mm	Unknown	163.4-159.0
7F7B124128	02/07/2002	302	587 mm	Unknown	166.6-163.4
7F7B1B0B31	02/28/2002	323	515 mm	Unknown	163.4-159.0
7F7D486622	03/12/2002	335	510 mm	Unknown	166.6-163.4
7F7D506D04	04/03/2002	357	480 mm	Unknown	163.4-159.0
7F7D477548	04/03/2002	357	554 mm	Unknown	163.4-159.0
7F7D481D3C	06/12/2002	427	564 mm	Unknown	166.6-163.4
7F7D401014	06/12/2002	427	486 mm	Unknown	166.6-163.4

[a]: In many instances fish were recaptured by channel catfish removal crews. These crews, for the most part, did not report specific RM's of capture for Colorado pikeminnow. Rather they reported the river section that the fish was collected in, either: PNM Weir to APS Diversion (RM 166.6-163.4) or APS Diversion to the take-out on Buck Wheeler's property (RM 163.4-159.0).

probably extremely low. Only 12 of these fish were recaptured after stocking, 10 within the first week after stocking (Table 5). The other two were recaptured six months later (189 days after stocking) in March 1998, but none have been recaptured since then (Table 5). Radio-tagged fish from this stocking displayed erratic behavior and rapid downstream displacements (Figure 2). Three of the 17 radio-tagged fish were only contacted once after stocking and by July 1998, another 11 had been confirmed dead. Only three of these fish were thought to be alive at the time of last contact (Figure 2).

The 148 adult Colorado pikeminnow stocked in 2001 were 1991 year-class fish that were age-10 at stocking. These fish were excess (i.e., less-desirable) fish that were being culled from broodstock lots being held at Dexter National Fish Hatchery (NFH) in Dexter, New Mexico. These fish were also small for their age (mean TL = 540 mm; Table 4). Because of their small size, the weight of the radio tags being implanted into these fish often exceeded the rule-of-thumb percentage (i.e., 2% or less) of body weight. Most of these fish also had "ich" infections, although in most cases it was not as severe as was observed among adult fish from the 1997 stocking. As with the 1997 stocking, recently radio-implanted fish (n = 8) appeared to be more stressed at stocking than their PIT-tagged counterparts (n = 141). Through 2002, the retention and survival of adult fish stocked in 2001 has been somewhat better than that observed among adults stocked in 1997. Twenty-six of these fish have been recaptured since stocking. Fifteen of these fish have been recaptured once each, with recaptures occurring as late as 427 days post-stocking (Table 6). The other 11 fish have been recaptured two or more times, with recaptures occurring as late as 548 days post-stocking (Table 7). The large majority of these fish (n = 24) have remained in the section of river between the PNM Weir and Hogback Diversion (RM 166.6-158.6; Tables 6 and 7). The recapture of so many individual fish over a year after stocking, the large number of multiple recaptures, and the retention of fish so far upriver are all encouraging. Unfortunately, as in 1997, survival among radio-tagged fish from the 2001 stocking was also very poor. As in 1997, radio-tagged fish from the 2001 stocking also displayed erratic behavior and rapid downstream displacement (Figure 3). By March 2003, seven of the eight radio-tagged fish were either confirmed or suspected dead (Figure 3). Only one of these fish was thought to be alive at the time of last contact in April 2003 (Figure 3).

The 210,418 age-0 Colorado pikeminnow stocked on 24 October 2002, were the first lot to be stocked as part of an eight-year augmentation effort, scheduled to last through 2009 (Ryden 2003a). Roughly half of these fish were stocked at RM 158.6, while the remainder were stocked at RM 180.2 (Table 4). The mean TL of age-0 fish stocked in 2000 (51 mm TL) was very close to that of fish stocked by UDWR in the fall of 1996 (mean TL = 55 mm), the stocking from which the large majorities of recaptures in 1997 and 1998 occurred (Ryden 2000a, 2000b).

1999-2001 Collections

1999: Ten stocked juvenile Colorado pikeminnow were recaptured from RM 149.0-5.0 during the 1999 adult monitoring trip (Table 8). 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; Ryden 2000a). The other nine stocked juvenile Colorado pikeminnow collected in 1999 were all first-time recaptures. These nine fish were all PIT-tagged before being released (Table 8). Two of the ten recaptures (i.e., 346 and 367 mm TL) were fish that had been stocked by UDWR in 1996, four (273, 277, 279, and 297 mm TL) had been stocked by UDWR in 1997, and the last four (157, 164, 207, and 215 mm TL) had been stocked by UDWR in 1998 (Table 4).

Table 7. Information on PIT-tagged Colorado pikeminnow adults that have been recaptured two or more times since stocking. All of these fish were stocked on 11 April 2001 at RM 180.2.

PIT Tag Number	Total Number Of Recaptures	Date Of Last Recapture	Number Of Days In River Since stocking	Total Length At Last Capture	Sex	River Mile (Or Section Occupied) At Last Capture[a]	Comments
7F7B105D64	3	02/28/2002	322	565 mm	Unknown	166.6-163.4	
7F7B13071A	2	03/13/2002	336	500 mm	Male	166.6-163.4	
7F7D154613	3	03/13/2002	336	621 mm	Female	163.4-159.0	
7F7D154556	2	03/13/2002	336	558 mm	Male	163.4-159.0	
7F7B12420E	2	04/02/2002	356	515 mm	Unknown	163.4-159.0	
7F7D131841	2	04/30/2002	384	525 mm	Unknown	129.4	First recapture was on 14 August 2001 between RM 163.4 and RM 159.0
7F7B025D78	3	06/11/2002	426	526 mm	Unknown	163.4-159.0	Mortality: 06/11/2002
7F7D15303F	5	06/13/2002	428	605 mm	Unknown	166.6-163.4	
7F7B107B59	4	10/11/2002	548	618 mm	Male	166.5	This fish moved downstream of APS Diversion (RM 163.4) after stocking, then moved back upstream of APS prior to its last recapture
7F7B0E4C63	4	10/11/2002	548	532 mm	Male	163.2	
7F7B122152	3	10/11/2002	548	521 mm	Male	163.2	

[a]: In many instances fish were recaptured by channel catfish removal crews. These crews, for the most part, did not report specific RM's of capture for Colorado pikeminnow. Rather they reported the river section that the fish was collected in, either: PNM Weir to APS Diversion (RM 166.6-163.4) or APS Diversion to the take-out on Buck Wheeler's property (RM 163.4-159.0).

Table 8. Colorado pikeminnow collected from the San Juan River on adult monitoring trips, 1999-2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Fall 1999 Adult Monitoring Trip (n = 10):							
09/21/1999	512440727B	NONE	207	60	I	149.0	Stocked
09/30/1999	51247F0A6A	NONE	164	20	I	103.0	Stocked
09/30/1999	5124671D22	NONE	157	29	I	97.0	Stocked
10/01/1999	1F681D510B®	NONE	367	335	I	86.0	Stocked
10/01/1999	51247F0B49[b]	NONE	346	274	I	86.0	Stocked
10/01/1999	51246F2B26	NONE	215	55	I	83.0	Stocked
10/03/1999	51247C5B3D	NONE	277	155	I	58.0	Stocked
10/03/1999	5124706D35	NONE	279	160	I	58.0	Stocked
10/07/1999	51246D5A66	NONE	297	115	I	5.0	Stocked
10/07/1999	51247B0D6B	NONE	273	85	I	5.0	Stocked
Fall 2000 Adult Monitoring Trip (n = 1):							
09/21/2000	51247D4B57	NONE	402	470	I	149.0	Stocked
Fall 2001 Adult Monitoring Trip (n = 5):							
09/25/2001	7F7F187A5A	NONE	197	48	I	112.8	Stocked
09/27/2001	5326480E0A	NONE	234	105	I	86.0	Stocked
09/28/2001	5326231C12	NONE	244	105	I	61.0	Stocked
10/19/2001	7F7B0E4C63	NONE	520	1100	I	163.3	Stocked
10/19/2001	7F7B107B59	NONE	605	1500	I	163.2	Stocked

[a]: I = Indeterminate; M = Male; F = Female

[b]: This fish had a channel catfish (111 mm TL) lodged in its throat when it was recaptured.

®: This fish was originally recaptured and PIT-tagged on 7 October 1997 at RM 79.6 (215 mm TL).

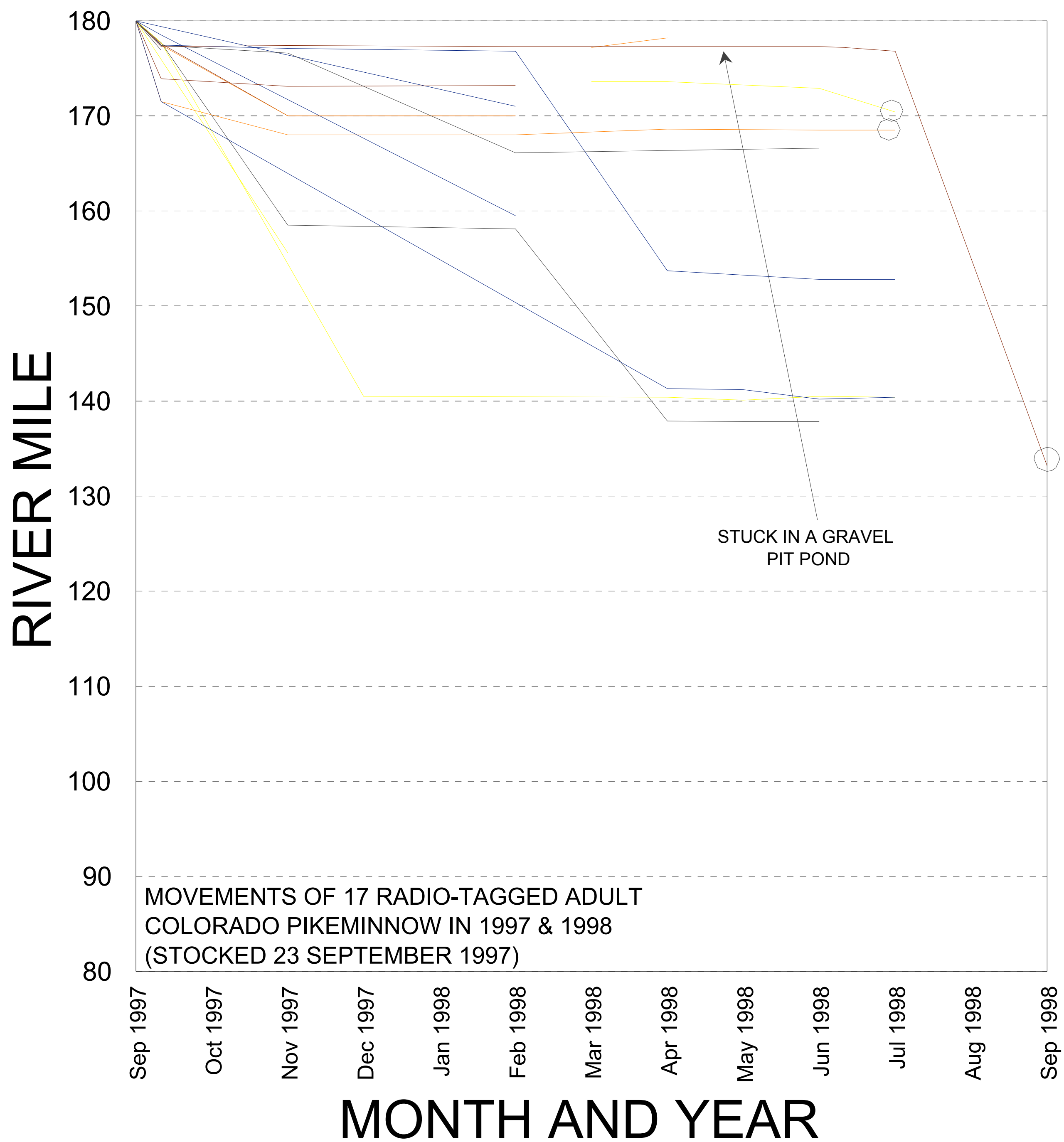

Figure 2. Movements of 17 radio-tagged adult Colorado pikeminnow in 1997 and 1998. All of these fish were stocked on 23 September 1997 at RM 180.2. These fish were age-16 when stocked. The circle indicates a fish that was known to be alive at the time of last contact.

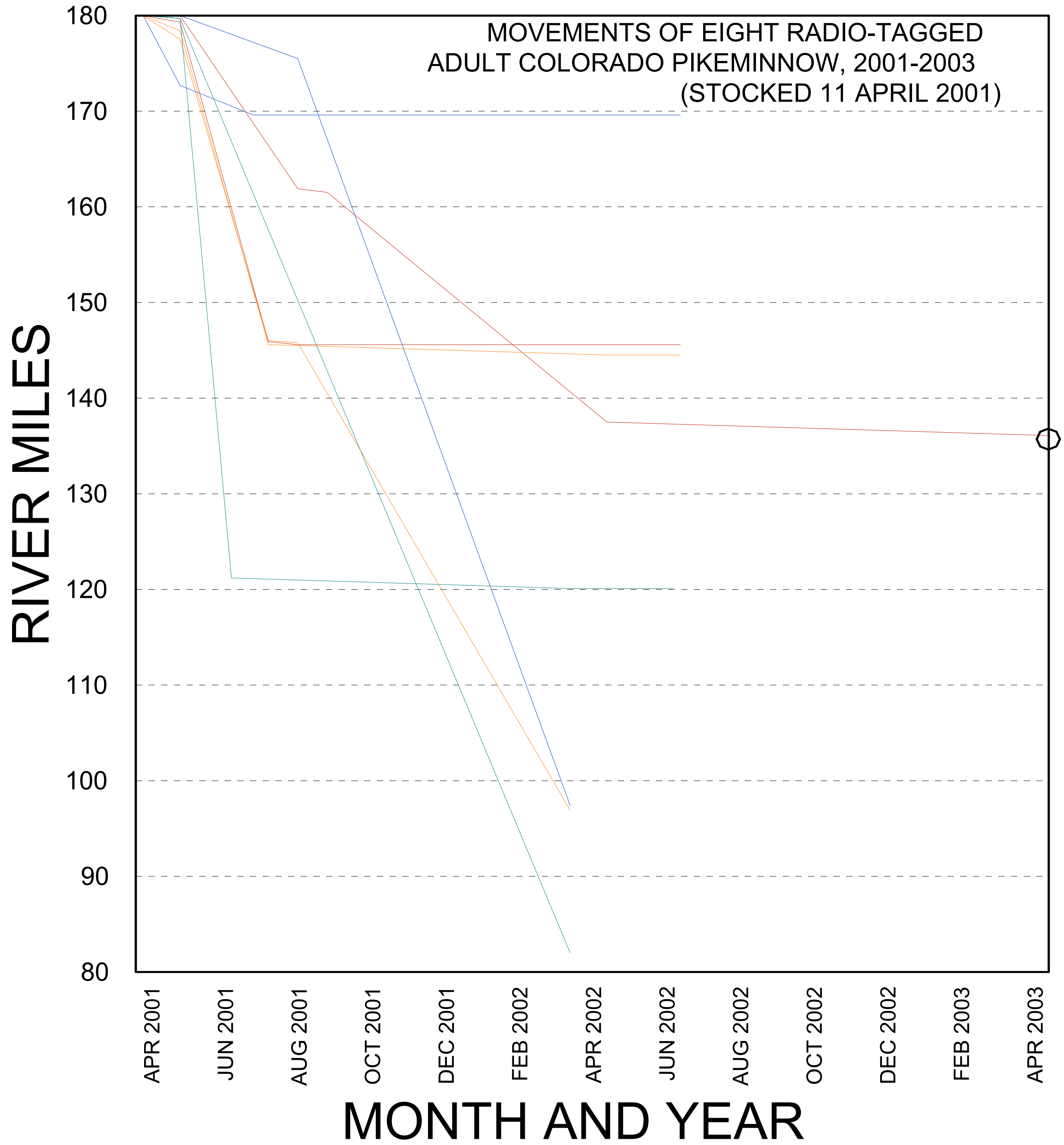

Figure 3. Movements of eight radio-tagged adult Colorado pikeminnow 2001-2003. All of these fish were stocked on 11 April 2001 at RM 180.2. These fish were age-10 when stocked. The circle indicates a fish that was known to be alive at the time of last contact.

Of particular note among Colorado pikeminnow collected on the 1999 adult monitoring trip was the recapture of a 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 (Table 8). For full details on this particular fish see Ryden (2000b) or Ryden and Smith (2002). An additional 16 stocked juvenile Colorado pikeminnow were recaptured during sampling for other studies (Table 9a).

An additional 17 Colorado pikeminnow were collected during sampling for other studies in 1999 from RM 151.05-104.0 (Table 9a). One of these, a wild adult female, was originally captured on 14 April 1993 at RM 128.8 (797 mm TL, 5550 g) and implanted with radio tag #40.980 (Figure 4; Ryden 2000a). It was recaptured on 12 April 1994 at RM 133.2 (820 mm TL, 5810 g), at which time the old radio tag was removed and a new radio tag (#40.848) was implanted (Ryden 2000a). 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 recaptured during a channel catfish mechanical removal trip on 23 March 1999 (Table 9a) and again on a razorback sucker monitoring trip on 25 July 2000 (Table 9b). In all, 34 contacts (i.e., captures, recaptures, and radio telemetry contacts) have been made with this fish over more than six years (Ryden 2000b). The movements of this healthy, wild radio-tagged fish over a several year period (Figure 4) provide a stark contrast to those observed among hatchery-reared adult fish stocked in 1997 and 2001 (Figures 2 and 3; Ryden 2000b).

2000: Only one Colorado pikeminnow was recaptured during the October 2000 adult monitoring trip (Table 8; Ryden 2001a). This 402 mm TL sub-adult was recaptured at RM 149.0 on 21 September 2000. This was a recapture of a fish stocked by the UDWR, probably in August 1998. Eleven more stocked Colorado pikeminnow were collected during sampling for other studies in 2000 from RM 137.3-10.7 (Table 9b). The same wild Colorado pikeminnow female that was captured in 1999 was recaptured again on 25 July 2000 at RM 138.9 (Table 9b).

2001: Five Colorado pikeminnow were recaptured during the October 2001 adult monitoring trip from RM 163.3-61.0 (Table 8). Three of these fish (197, 234, and 244 mm TL) were juveniles that had been stocked as larvae by the UDWR in either 1999 or 2000 (Table 4). The other two (520 and 605 mm TL) were recaptures of adult Colorado pikeminnow stocked by the USFWS in 2001 (Table 4). An additional 20 Colorado pikeminnow collected during sampling for other studies in 2001 (Table 9c). Fifteen of these (all > 450 mm TL), including all the recaptures that occurred upstream of RM 155.0, were recaptures of adult fish that had been stocked at RM 180.2 in April 2001 (Table 4). The other five fish were recaptures of juvenile fish stocked by UDWR (Table 9c).

Population Trends

Captures of wild Colorado pikeminnow continue to be extremely rare in the San Juan River. The last wild Colorado pikeminnow to be collected was the 846 mm TL female that was recaptured on 25 July 2000 at RM 138.9 (Table 9b). This fish had also been captured each of the previous two years - at RM 131.5 on 23 March 1999 and at RM 137.6 on 29 September 1998.

Recaptures of stocked Colorado pikeminnow also continue to be relatively rare, especially when compared to the number of fish that have been stocked (i.e., over one million) since 1996 (Table 4). However, many adult Colorado

Table 9a. Colorado pikeminnow collected from the San Juan River during sampling efforts for other studies in 1999.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Albuquerque in 1999 (n = 13):							
03/23/1999	1F66536147	NONE	117	11	I	134.0	Stocked
03/23/1999	1F66226178	NONE	151	21	I	134.0	Stocked
03/23/1999	520074553F	NONE	153	25	I	132.5	Stocked
03/23/1999	41652A6621	NONE	156	25	I	131.8	Stocked
03/23/1999	NONE	NONE	90	2	I	131.8	Stocked
03/23/1999	416D076613	NONE	137	17	I	131.8	Stocked
03/23/1999	7F7D225E24	970	845	7500	F	131.5	Wild
03/23/1999	420F251833	NONE	166	26	I	131.0	Stocked
03/23/1999	1F606D1103	NONE	148	21	I	127.7	Stocked
03/24/1999	1F65532504	NONE	153	22	I	127.7	Stocked
03/24/1999	1F717D787B	NONE	167	28	I	127.7	Stocked
03/24/1999	1F631E3030	NONE	156	22	I	127.7	Stocked
03/24/1999	416E391251	NONE	149	20	I	127.7	Stocked
Captures by Ecosystems Research Institute and Miller Ecological Consultants (ERI/MEC) in 1999 (n = 3):							
10/13/1999	NONE	NONE	202	59	I	147.0	Stocked
10/13/1999	NONE	NONE	233	92	I	147.0	Stocked
10/20/1999	NONE	NONE	420	482	I	104.0	Stocked
Captures by New Mexico Department of Game and Fish (NMGF)-Santa Fe in 1999 (n = 1):							
09/21/1999	1F41470C4D	NONE	226	70	I	151.05	Stocked

[a]: I = Indeterminate; M = Male; F = Female

Table 9b. Colorado pikeminnow collected from the San Juan River during sampling efforts for other studies in 2000.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 2000 (n = 3):							
05/04/2000	512737211D	NONE	220	90	I	97.0	Stocked
07/25/2000	7F7D225E24®	970	846	6850	F	138.9	Wild
07/25/2000	7F7B113D5C	NONE	404	425	I	137.3	Stocked
Captures by UDWR-Moab in 2000 (n = 6):				*NOTE: SL = Standard Length*			
06/13/2000	NONE	NONE	8.5 SL	----[b]	I	114.9	Stocked
06/13/2000	NONE	NONE	8.5 SL	----	I	78.8	Stocked
06/13/2000	NONE	NONE	8.0 SL	----	I	78.1	Stocked
06/13/2000	NONE	NONE	8.5 SL	----	I	78.1	Stocked
07/09/2000	NONE	NONE	65	----	I	106.7	Stocked
07/11/2000	NONE	NONE	340	----	I	10.7	Stocked
Captures by NMGF-Santa Fe in 2000 (n = 3):							
10/02/2000	NONE	NONE	75	----	I	117.4	Stocked
10/02/2000	NONE	NONE	75	----	I	117.4	Stocked
10/05/2000	NONE	NONE	93	----	I	69.8	Stocked

[a]: I = Indeterminate; M = Male; F = Female

[b]: These fish were not weighed

®: This is the same wild Colorado pikeminnow female that was recaptured in 1999 (see Table 6a).

Table 9c. Colorado pikeminnow collected from the San Juan River during sampling efforts for other studies in 2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 2001 (n = 6):							
05/06/2001	1F63564563	NONE	351	375	I	109.0	Stocked
06/21/2001	7F7B130C56	NONE	503	1100	M	155.3	Stocked
06/25/2001	7F7B113B34	NONE	354	280	I	90.0	Stocked
06/25/2001	7F7B0D621F	NONE	398	505	I	88.2	Stocked
06/25/2001	53246B7241	NONE	143	19	I	86.0	Stocked
06/25/2001	7F7B033C22	NONE	140	18	I	84.0	Stocked
Captures by USFWS-Albuquerque in 2001 (n = 14):							
08/14/2001	7F7D131841	NONE	525	950	I	159.0	Stocked
08/15/2001	7F7D15303F	NONE	598	1400	I	165.0	Stocked
08/15/2001	7F7B19570C	NONE	513	770	M	163.3	Stocked
08/15/2001	7F7D154556	NONE	552	1100	M	163.3	Stocked
08/15/2001	7F7B122152	NONE	505	900	M	160.7	Stocked
08/15/2001	7F7D154613	NONE	614	1800	I	159.0	Stocked
09/11/2001	7F7B122152®	NONE	505	970	M	164.0	Stocked
09/11/2001	7F7B1B6436	NONE	496	855	I	164.0	Stocked
09/11/2001	7F7B177D17	NONE	516	1050	I	159.0	Stocked
09/12/2001	7F7B105D64	NONE	565	1150	I	164.0	Stocked
09/12/2001	7F7B195C63	671	547	1100	F	161.5	Stocked
09/12/2001	7F7D4C391B	NONE	466	650	I	159.0	Stocked
09/13/2001	7F7D78355C	NONE	509	870	I	164.0	Stocked
09/13/2001	7F7B025D78	NONE	523	850	I	159.0	Stocked

[a]: I = Indeterminate; M = Male; F = Female

®: Second recapture of this fish in 2001.

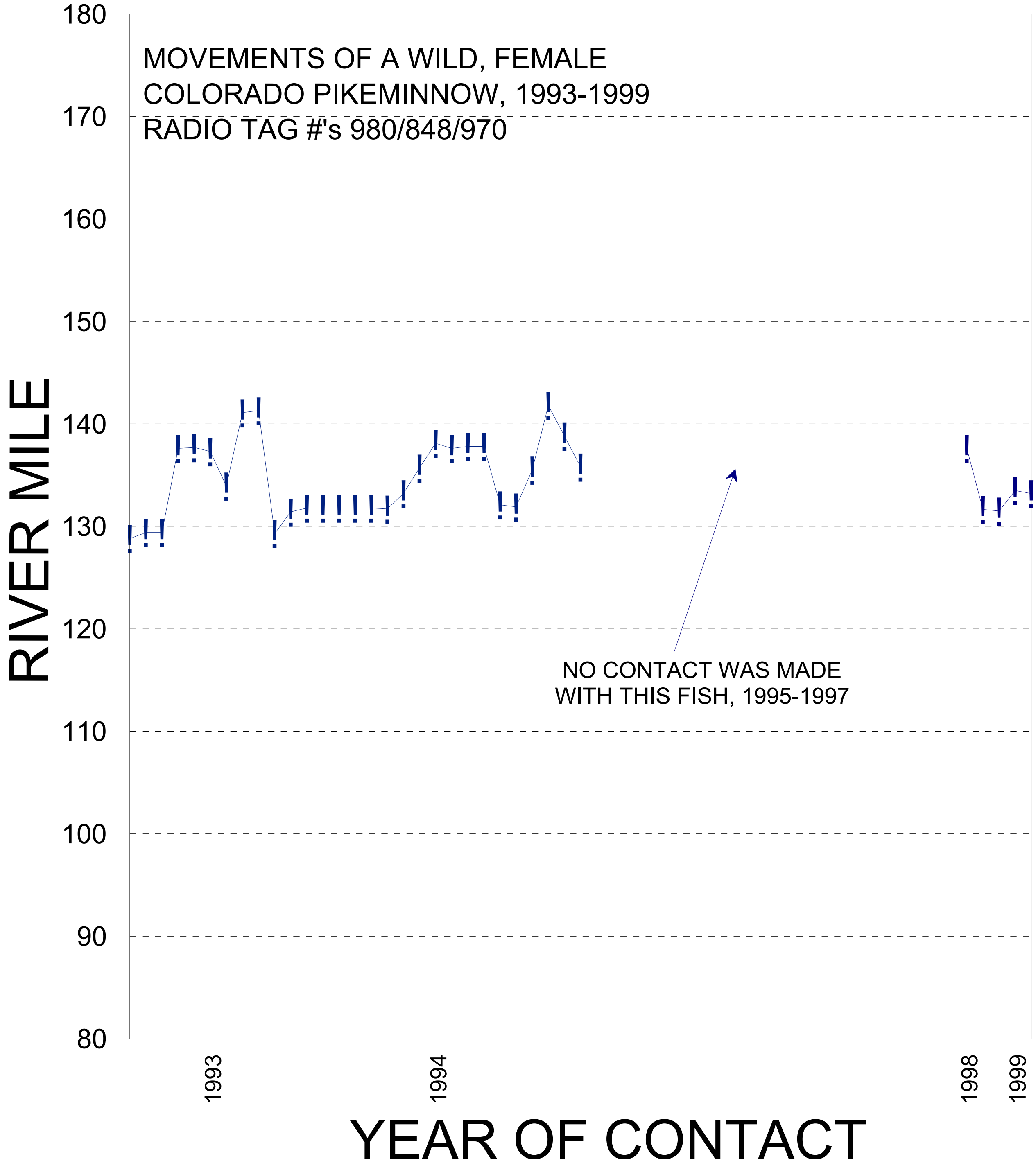

Figure 4. Movements of a wild, adult female Colorado pikeminnow between 1993 and 1999.

pikeminnow stocked at RM 180.2 in April 2001 have been documented using the section of river from PNM Weir to Hogback Diversion (RM 166.6-158.6) up to a year and half after stocking (Tables 6 and 7). Small numbers Colorado pikeminnow stocked as juveniles or larvae between 1996 and 2000 continue to be captured on adult monitoring and other sampling trips (Tables 9a-9c).

In 1997 and 1998 it appeared that Colorado pikeminnow that had been stocked since 1996 were becoming well-established and would successfully recruit into the adult population. CPUE of Colorado pikeminnow had increased steadily between spring 1997 and fall 1998 to the highest level observed for this species since studies began in 1991 (Figure 5). In fact 95 individual Colorado pikeminnow were collected on the fall 1998 adult monitoring trip -- an unprecedented number (Ryden 2000b). Several of the Colorado pikeminnow that had originally been stocked in 1996 at an average size of 55 mm TL (Table 4) had reached sizes as large as 367 mm TL by fall 1998 (Ryden 2000b). Then, after the fall 1998 adult monitoring trip, these fish essentially disappeared from collections (Figure 5; Ryden 2001a). The reason for this sudden, marked drop off is unknown. To date, CPUE for Colorado pikeminnow (both wild and stocked) remains low.

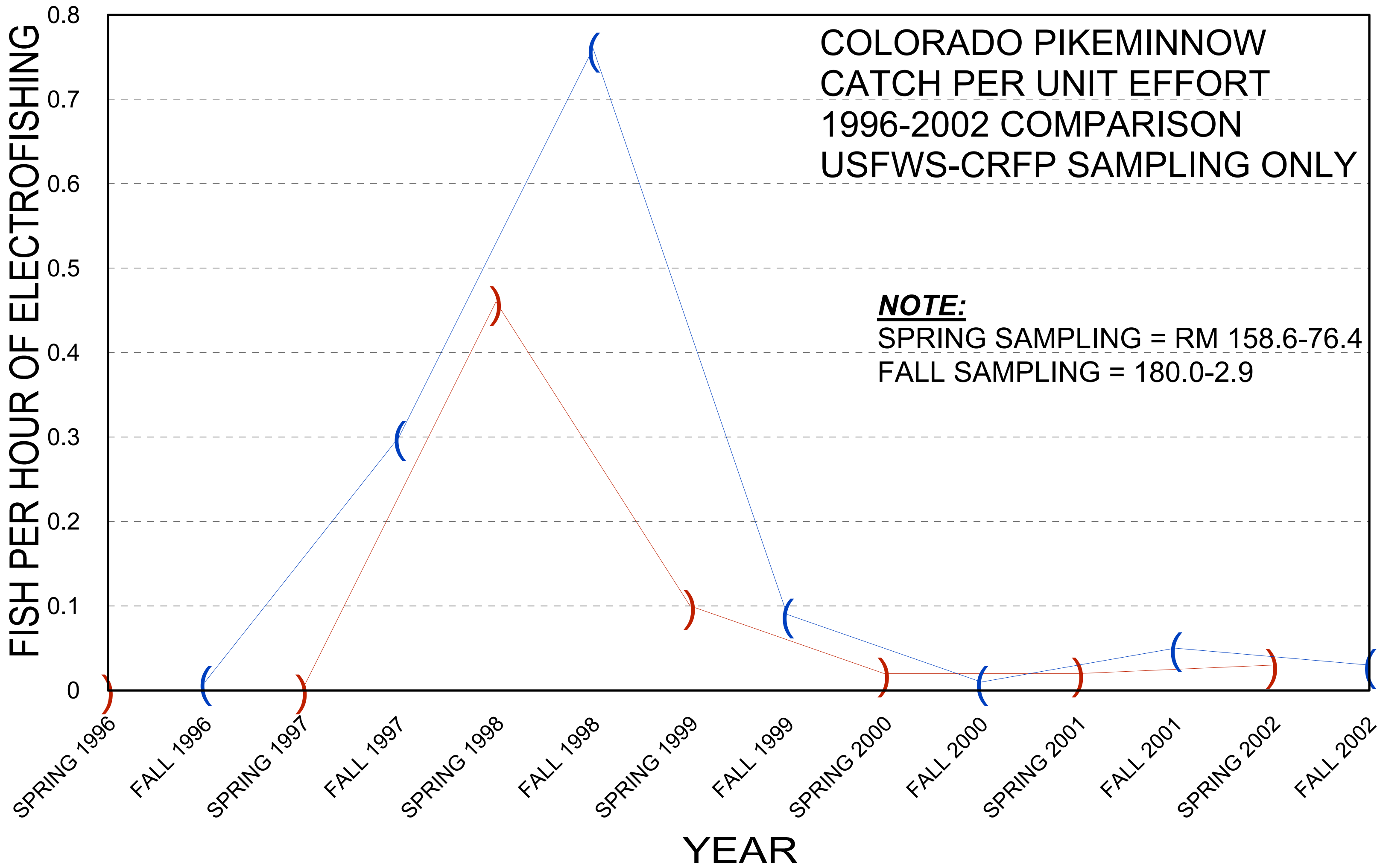

Figure 5. Colorado pikeminnow catch per unit effort (CPUE) on fall adult monitoring trips and spring razorback sucker monitoring trips, 1996-2001. This graph includes all Colorado pikeminnow collected by USFWS-CRFP during these trips, including both captures of wild fish and recaptures of stocked fish (juveniles and adults).

Razorback Sucker

Fish Stocked As Part Of An Augmentation Effort

Between March 1994 and April 2003, 7,166 razorback sucker were stocked into the San Juan River (Table 10). These included: 1) 940 stocked between 1994 and 1996 as part of an experimental stocking study (Ryden and Pfeifer 1994); 2) 5,896 stocked between 1997 and 2001 as part of the original five-year augmentation plan (Ryden 1997); and, 3) 330 stocked in 2002 and so far in 2003 – the interim period between the end of the first five-year augmentation effort (Ryden 1997) and the upcoming eight-year augmentation effort (Ryden 2003b) scheduled to begin in 2004. All 7,166 of these fish were stocked into the San Juan River, either by or under the direction of the USFWS, for the purpose of reestablishing a self-sustaining population of razorback sucker in the San Juan River (Ryden and Pfeifer 1994, Ryden 1997, Ryden 2003b). These 7,166 fish were all individually-implanted with PIT tags before being released into the wild.

In a separate effort, the UDWR stocked 130 razorback sucker into Lake Powell in August 1995 - 65 on 8 August and another 65 on 15 August (Table 10). Three of these fish have since been recaptured upstream in the San Juan River (Tables 10, 11, and 12a). So, although the fish stocked by UDWR in Lake Powell in August 1995 were not part of the "official" stocking effort in the San Juan River, evidence indicates that at least a few of them have moved upstream from Lake Powell and have likely become part of the riverine population. All 130 of these fish were individually-implanted with PIT tags before being released into the wild.

There was also an unintentional stocking of razorback sucker on 3 August 1999 (Table 10). This occurred when unseasonably heavy rains caused the earthen dam on the razorback sucker grow-out pond near Ojo Amarillo, NM to wash out, completely draining the pond, and washing the fish being held there down Ojo Wash (Ryden 2000c, 2001b). An unknown number of these fish subsequently entered the San Juan River at RM 170.8. The exact number or sizes of these fish were unknown. None of these fish had PIT tags. To date, 12 fish thought to be from this unintentional stocking have been collected in the San Juan River. Collections occurred from 21 September 2000 to 7 February 2002 between RM 169.0 and 153.8 (range of TL's = 351-440 mm).

1999-2001 Collections

<u>1999</u>: Five razorback sucker were collected during the 1999 adult monitoring trip from RM 107.7-55.3 (Table 11; Ryden 2000c). All five were from relatively recent stockings, with four having been stocked in 1998 (241, 452, 486, and 489 mm TL), and the other (357 mm TL) in 1997.

An additional twenty razorback sucker were collected during sampling for other studies from RM 151.0-0.7 (Table 12a; Ryden 2000c). Of note among recaptures from other studies were three razorback sucker collected from a suspected spawning aggregation at RM 100.2 on 16 April 1999 (Table 12a), discussed in more detail below. Three of five razorback sucker collected in the Lake Powell inflow area (i.e., downstream of RM 3.0) in 1999 were fish that had been stocked at RM 158.6 in 1998, the fourth (532 mm TL) at RM 0.0 in 1995, and the fifth (489 mm TL) had no detectable PIT tag at the time of capture (Table 12a).

Table 10. Stockings of razorback sucker in the San Juan River, 1994-2003.

Date	Number Stocked	River Miles Stocked At[a]	Mean Total Length (mm)	Range Of Total Lengths (mm)	Responsible Agency[b]
03/30/1994	15	136.6-79.6	277	239-316	USFWS
10/27/1994	16	136.6-79.6	403	384-435	USFWS
11/17/1994	478	158.6-79.6	190	100-374	USFWS
11/18/1994	178	158.6-79.6	400	330-446	USFWS
08/08/1995	65	0.0	405	348-431	UDWR[c]
08/15/1995	65	0.0	409	369-437	UDWR[c]
09/27/1995	16	158.6	424	397-482	USFWS
10/03/1996	237	158.6	335	204-434	USFWS
09/03/1997	1027	158.6	193	Not Specified	USFWS
09/17/1997	227	158.6	229	Not Specified	USFWS
09/19/1997	1631	158.6	185	104-412	USFWS
04/22/1998	57	158.6	420	380-460	UDWR
05/28/1998	67	158.6	417	341-470	UDWR
10/15/1998	1155	158.6	232	185-315	USFWS
08/03/1999	Unknown	170.8	Unknown	Unknown	-----[d]
10/20/2000	1044	158.6	214	111-523	USFWS
11/01/2001	688	158.6	410	288-560	USFWS
04/11/2002	13	178.2	137	110-170	CDOW
04/22/2002	101	158.6	334	240-470	UDWR
11/06/2002	25	158.6	351	295-456	USFWS
04/14/2003	121	158.6	413	341-491	UDWR
04/17/2003	70	158.6	380	255-495	USFWS

[a] In 1994, fish were stocked at one of four stocking sites (RM 158.6, 136.6, 117.5, or 79.6). When groups of fish were stocked at multiple sites, they were stocked in roughly equal numbers at each site (i.e., on 03/30/1994 each of the three stocking sites got five of the 15 fish stocked).

[b] CDOW = Colorado Division of Wildlife - Information and Education Program, Grand Junction, Colorado; UDWR = Utah Division of Wildlife Resources - Wahweap Warmwater Fish Hatchery, Big Water, Utah; USFWS = U.S. Fish and Wildlife Service - Colorado River Fishery Project, Grand Junction, Colorado

[c] These fish were stocked in Lake Powell at Piute Farms (RM 0.0). They are listed here because three of them have been recaptured in the San Juan River (one at RM 58.0 on 05/21/1996; one at RM 1.1 on 10/05/1999; and, one at RM 71.1 on 09/28/2001).

[d] This was an unintentional stocking that occurred when heavy rains caused the earthen dam on a grow-out pond near Ojo Amarillo, NM to wash out. The pond completely drained washing an unknown number of fish down Ojo Wash to its confluence with the San Juan River (RM 170.8). Twelve of these fish were recaptured between 09/21/2000 and 02/07/2002.

Table 11. Razorback sucker collected from the San Juan River on adult monitoring trips, 1999-2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Fall 1999 Adult Monitoring Trip (n = 5):							
09/29/1999	513402471F	NONE	241	110	I	107.7	Stocked
10/01/1999	7F7B107949	741	486	1450	F	88.0	Stocked
10/01/1999	7F7B177D42	771	357	400	F	76.4	Stocked
10/02/1999	7F7B107152	761	452	980	M	59.4	Stocked
10/03/1999	7F7B1A510C	841	489	1275	F	55.3	Stocked
Fall 2000 Adult Monitoring Trip (n = 8):							
09/21/2000	NONE	NONE	410	820	I	169.0	Stocked
09/21/2000	NONE	NONE	380	615	I	169.0	Stocked
09/21/2000	NONE	NONE	351	457	I	169.0	Stocked
10/02/2000	420F365F58	751	474	1120	I	108.7	Stocked
10/03/2000	1F43597253	831	510	1400	M	100.0	Stocked
10/03/2000	42131C4420	811	508	1400	F	100.0	Stocked
10/04/2000	1F743D161A	820	422	1800	M	77.0	Stocked
10/09/2000	7F7B124458	791	483	1005	M	11.0	Stocked
Fall 2001 Adult Monitoring Trip (n = 11):							
09/26/2001	1F413C7C68	032	565	1700	F	103.0	Stocked
09/26/2001	1F4143510C	131	506	1200	I	103.0	Stocked
09/27/2001	1F731B4112	121	446	850	M	79.0	Stocked
09/28/2001	1F462A5918	111	525	1800	I	71.1	Stocked
09/29/2001	7F7B13512F	011	464	720	M	53.4	Stocked
10/15/2001	1F40195E2A	276	478	1075	F	128.3	Stocked
10/15/2001	532463751B	NONE	398	640	I	128.1	Stocked
10/15/2001	416D4F3B55®	NONE	456	940	M	128.0	Stocked
10/15/2001	5327580D15®	NONE	527	1300	F	124.0	Stocked
10/16/2001	53245A7C46	NONE	407	640	I	134.1	Stocked
10/18/2001	5326075E44	NONE	402	750	F	149.2	Stocked

[a]: I = Indeterminate; M = Male; F = Female

®: Second recapture of this fish in 2001.

Table 12a. Razorback sucker collected from the San Juan River during sampling efforts for other studies in 1999.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 1999 (n = 11):							
04/12/1999	1F73326C50	NONE	474	1350	I	151.0	Stocked
04/13/1999	7F7D175C49	NONE	393	660	F	141.0	Stocked
04/13/1999	1F402E452E	NONE	440	900	M	140.0	Stocked
04/16/1999	1F404E666D	NONE	548	1840	F	108.0	Stocked
04/16/1999	1F435D1C25	NONE	509	1300	M	100.2	Stocked
04/16/1999	1F40464E0D	NONE	438	790	M	100.2	Stocked
04/16/1999	1F74362314	NONE	565	1650	F	100.2	Stocked
04/17/1999	1F40496870	NONE	431	815	M	95.0	Stocked
04/17/1999	1F413C7C68	NONE	527	1850	F	91.5	Stocked
04/17/1999	51337B7079	NONE	440	950	M	89.8	Stocked
04/17/1999	1F414E3E14	NONE	472	930	M	86.3	Stocked
Captures by U.S. Geological Survey-Biological Resources Division (USGS-BRD) and UDWR in Lake Powell in 1999 (n = 5):							
07/13/1999	5220551C28	NONE	489	1495	I	2.0	Stocked
08/17/1999	7F7B1B5402	NONE	467	1075	I	1.1	Stocked
10/05/1999	1F75115803	NONE	532	1590	I	1.1	Stocked
10/05/1999	7F7B18014B	NONE	490	1320	M	0.7	Stocked
10/07/1999	7F7B12155F	NONE	459	1048	M	1.1	Stocked
Captures by MEC/ERI in 1999 (n = 4):							
10/20/1999	7F7B127127	NONE	458	1008	I	104.0	Stocked
10/20/1999	-----[b]	NONE	473	990	I	104.0	Stocked
10/20/1999	-----[b]	NONE	478	1021	I	104.0	Stocked
10/20/1999	-----[b]	NONE	542	1686	I	104.0	Stocked

[a]: I = Indeterminate; M = Male; F = Female

[b]: These values were not available due to lack of a PIT tag reader.

2000: Eight stocked razorback sucker were recaptured during the 2000 adult monitoring trip from RM 169.0-11.0 (Table 11; Ryden 2001b). For the first time ever, razorback sucker (n = 3) were collected upstream of the PNM Weir (RM 166.6). These fish did not have PIT tags at the time of recapture. It is likely that these fish came from Ojo Pond which washed out on 3 August 1998 when the dike broke during heavy rains (Ryden 2000c). Among the other five recaptures during adult monitoring, two had been stocked in 1994 (422 and 510 mm TL), two in 1997 (474 and 508 mm TL), and the last in 1998 (483 mm TL).

Ten additional razorback sucker were collected during sampling for other studies in 2000 from RM 141.0 to -4.1 (Table 12b; Ryden 2001b). Of the seven razorback sucker collected in the inflow area (i.e., downstream of RM 3.0) or in Lake Powell itself, four (492, 505, 505, and 522 mm TL) were fish that had been stocked at upstream locations in 1994, one (485 mm TL) in 1998, one (472 mm TL) at RM 0.0 in 1995, and the last (495 mm TL) had no detectable PIT tag at the time of capture (Table 12b).

2001: Eleven stocked razorback sucker were recaptured during the 2001 adult monitoring trip from RM 149.2-53.4 (Table 11). Two of these fish had been captured earlier in 2001 on razorback sucker monitoring trips (Table 12c). Another (radio tag 276), had originally been implanted with a radio tag and stocked on 27 September 1995 at RM 158.6, but had not been contacted between that date and its recapture at RM 128.3 on 15 October 2001. Of the 11 adult monitoring razorback captures, three (446, 506, and 565 mm TL) were stocked in 1994, two in 1995 - one at RM 0.0 (525 mm TL) and the other upstream (478 mm TL), one in 1997 (456 mm TL), one in 1998 (464 mm TL), and four in 2000 (398, 402, 407, and 527 mm TL).

An additional 44 razorback sucker were collected during sampling for other studies in 2001 from RM 167.0-85.4 (Table 12c). For the second year in a row, a razorback sucker was collected upstream of the PNM Weir at RM 167.0 on 15 September 2001 (Table 12c). The crew that captured this fish did not have a PIT tag reader with them, so it is unknown whether or not this fish had been previously PIT-tagged. However, it is very likely that this fish came from Ojo Pond which washed out on 3 August 1999 (Ryden 2000c). In addition to the fish collected at RM 167.0, six razorback sucker (355, 357, 359, 366, 370, and 386 mm TL) recaptured from RM 166.6-158.6 in 2001 had no detectable PIT tags at time of capture (Table 12c). These six fish were likely also fish that had washed out of Ojo Pond in August 1999 (Ryden 2000c). These fish were implanted with PIT tags before being returned to the river. The other two razorback sucker collected by USFWS-Albuquerque had both moved upstream past the Hogback Diversion. One of them (PIT tag number 203F4C3A1B, recaptured at RM 160.7 on 15 August) had been captured earlier in 2001 (on 24 June at RM 109.6) and had moved upstream 51.1 RM in just 52 days (an average of 0.98 RM/day).

The last fish of note among 2001 captures was collected on 19 April 2001 (Table 12c). On this date three radio-tagged fish (two males and a female) were observed, via radiotelemetry, in very close proximity to one another at the suspected spawning site (RM 100.2). When an attempt was made to recapture these radio-tagged fish using a trammel net, a PIT-tagged fish (1F40447964) was collected instead. The presence of this ripe male fish in close proximity to other ripe adults helped strengthen the evidence that this is indeed a spawning area for razorback sucker.

Table 12b. Razorback sucker collected from the San Juan River during sampling efforts for other studies in 2000.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 2000 (n = 3):							
05/01/2000	7F7D175C49	NONE	398	740	F	141.0	Stocked
05/03/2000	507F727F1E	NONE	469	1500	M	115.0	Stocked
05/04/2000	7F7D1B6654	639	449	760	M	88.0	Stocked
Captures by USGS-BRD and UDWR in Lake Powell in 2000 (n = 7):							
06/06/2000	1F41482038	NONE	492	1294	I	0.0	Stocked
06/06/2000	7F7B11352B	NONE	485	982	M	0.0	Stocked
06/06/2000	1F6B2B7356	NONE	472	1202	I	0.0	Stocked
06/07/2000	1F732D724F	NONE	505	1392	M	-4.1[b]	Stocked
06/27/2000	1F412A2D49	NONE	505	1466	I	0.7	Stocked
06/28/2000	1F4E594773	NONE	495	1390	I	1.1	Stocked
07/18/2000	1F43686353	475	522	1540	M	-2.4[b]	Stocked

[a]: I = Indeterminate; M = Male; F = Female

[b]: These recapture were in Lake Powell, 4.1 and 2.4 miles downstream of the San Juan River-Lake Powell confluence.

Table 12c. Razorback sucker collected from the San Juan River during sampling efforts for other studies in 2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 2001 (n = 35):							
04/19/2001	1F40447964	NONE	444	760	M	100.2	Stocked
05/03/2001	5324111728	NONE	389	610	I	153.8	Stocked
05/03/2001	5327681556	NONE	366	380	I	153.8	Stocked
05/03/2001	5324092063	NONE	363	435	I	153.8	Stocked
05/03/2001	223F4E6841	NONE	393	575	I	153.8	Stocked
05/03/2001	53245C6849	NONE	347	400	I	152.0	Stocked
05/03/2001	5324577E3D	NONE	372	550	I	148.1	Stocked
05/03/2001	5324123E3D	NONE	380	580	I	145.3	Stocked
05/04/2001	5326050D33	NONE	366	520	I	140.0	Stocked
05/04/2001	53241E7154	NONE	353	500	I	140.0	Stocked
05/04/2001	53254E7309	NONE	396	650	M	140.0	Stocked
05/04/2001	531A711B76	NONE	404	650	I	138.0	Stocked
05/04/2001	53261B3558	NONE	396	690	I	136.2	Stocked
05/04/2001	416D4F3B55	NONE	451	965	M	130.3	Stocked
05/04/2001	5324784972	NONE	387	560	I	130.1	Stocked
05/05/2001	1F4040075A	NONE	501	1210	F	128.0	Stocked
05/05/2001	531C35164F	NONE	380	580	I	128.0	Stocked
05/05/2001	420F365F58	751	477	1100	F	119.7	Stocked
05/06/2001	5325645E52	NONE	410	625	I	105.0	Stocked
05/06/2001	1F4361437A	NONE	443	820	M	104.2	Stocked
05/06/2001	1F732C5C7E	NONE	482	990	M	100.5	Stocked
05/06/2001	1F435F1728	NONE	498	1120	F	100.3	Stocked
06/21/2001	5328656061	NONE	510	1290	F	149.2	Stocked
06/21/2001	5326004514	NONE	356	565	I	149.2	Stocked

[a]: I = Indeterminate; M = Male; F = Female

Table 12c, continued. Razorback sucker collected from the San Juan River during sampling efforts for other studies in 2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Captures by USFWS-Grand Junction in 2001 (n = 35), continued:							
06/22/2001	531C417968	NONE	382	620	I	141.7	Stocked
06/22/2001	53257F7548	NONE	391	605	I	140.3	Stocked
06/22/2001	5324111728	NONE	389	630	I	136.0	Stocked
06/22/2001	5325504875	NONE	387	640	I	130.0	Stocked
06/23/2001	5325591360	NONE	362	510	I	118.0	Stocked
06/24/2001	203F4C3A1B	NONE	483	1150	F	109.6	Stocked
06/24/2001	53245B1240	NONE	379	590	I	108.0	Stocked
06/24/2001	1F413C3034	NONE	490	1050	F	104.3	Stocked
06/24/2001	5327580D15	NONE	523	1200	F	104.0	Stocked
06/25/2001	512A685219	141	473	900	M	86.0	Stocked
06/25/2001	1F5B747C16	101	497	1040	F	85.4	Stocked
Captures by USFWS-Albuquerque in 2001 (n = 8):							
02/21/2001	1F68210850	NONE	370	600	I	165.0	Stocked
03/14/2001	42401D0A49	NONE	357	500	I	164.4	Stocked
03/14/2001	423D527B19	NONE	366	450	I	163.2	Stocked
03/15/2001	42404D392E	NONE	355	460	I	161.4	Stocked
04/24/2001	7F7B0E2C1C	NONE	386	620	I	164.6	Stocked
04/24/2001	1F72146873	NONE	359	480	I	164.6	Stocked
07/10/2001	53255D3F33	NONE	465	960	M	163.2	Stocked
08/15/2001	203F4C3A1B	NONE	483	1000	F	160.7	Stocked
Captures by MEC/ERI in 2001 (n = 1):							
09/15/2001	-----[b]	NONE	440	970	I	167.0	Stocked

[a]: I = Indeterminate; M = Male; F = Female

[b]: These values were not available due to lack of a PIT tag reader.

Population Trends

Over time, it has become apparent that razorback sucker stocked at > 300 mm TL have a much higher recapture (= survival) rate than fish stocked at smaller sizes (Table 13). Between 1994 and 2002, razorback sucker stocked at > 300 mm TL represented just 22.2% of all razorback sucker stocked through 2002 (n = 6,975). However, fish stocked at > 300 mm TL accounted for 88.7% (150 of 169) of all first-time recaptures through 2002 (Table 13). Even razorback sucker recaptured from lots of stocked fish that had mean TL's < 300 mm at the time of stocking (Table 10) tended to be the few individuals that were larger than their lot's mean TL and usually > 300 mm TL at stocking. For this reason, beginning in 2001, the SJRIP decided to not stock razorback sucker < 300 mm TL.

In contrast to the marked increases in CPUE observed for stocked Colorado pikeminnow in 1997 and 1998 (Figure 5), CPUE for stocked razorback sucker remained fairly low, but steady between 1996 and 2000 (Figure 6). However, in 2001 and then again in 2002, razorback sucker CPUE for both the spring razorback sucker monitoring trip and the fall adult monitoring trip were at the highest values ever observed (Figure 6). Even though this value has remained under 1.0 fish per hour, CPUE for stocked razorback sucker has been consistently higher over time than that for stocked Colorado pikeminnow, especially when compared to overall numbers of fish stocked for each species (razorback sucker = 6,975 stocked individuals through 2002 versus > one million Colorado pikeminnow stocked through 2002; Tables 4 and 10).

Table 13. Numbers, by size-class at time of stocking, of razorback sucker stocked into the San Juan River between 1994 and 2002 and recaptured as of 31 December 2002. Note: This table is for first-time recaptures only.

	Of 6975 Stocked Fish		Of 169 Known-Origin Recaptures	
Total Length In mm	Percent of Total Represented By This Size-Class	Total Number Stocked	Percent of Total Represented By This Size-Class	Total Number Caught
< 51	0.0%	0	0.0%	0
51-100	<0.1%	1	0.0%	0
101-150	6.7%	467	0.0%	0
151-200	40.9%	2849	2.4%	4
201-250	27.3%	1906	5.9%	10
251-300	2.9%	199	3.0%	5
301-350	3.4%	235	6.5%	11
351-400	8.0%	557	33.1%	56
401-450	9.1%	638	39.6%	67
451-500	1.5%	107	6.5%	11
>500	0.2%	16	3.0%	5
Totals	100.0%	6975	100.0%	169

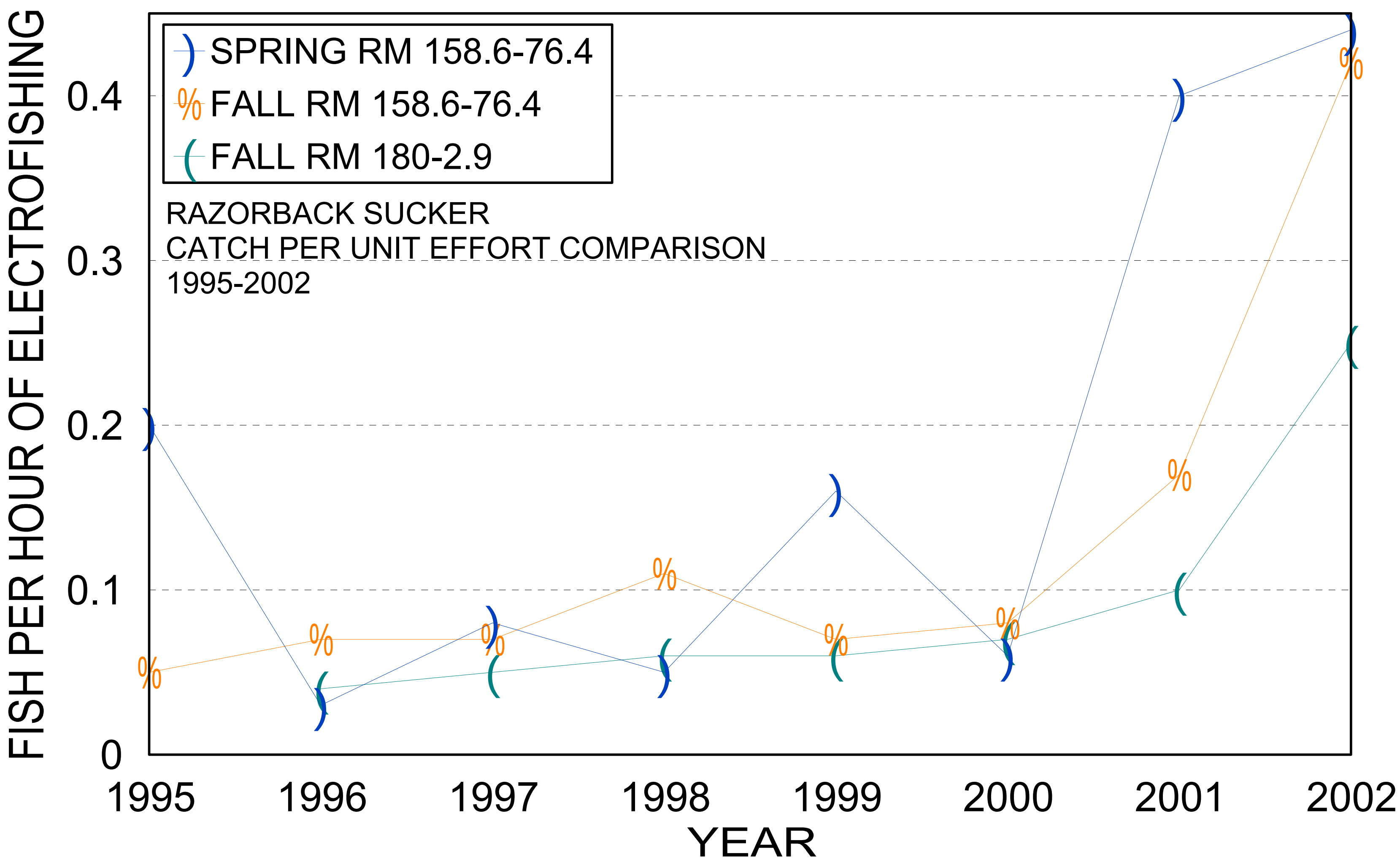

Figure 6. Razorback sucker catch per unit effort (CPUE) on fall adult monitoring trips and spring razorback sucker monitoring trips, 1995-2001.

Spawning Aggregations

1997: A possible spawning aggregation of razorback sucker was encountered just downstream of Aneth, UT on 3 May 1997 (Table 14, Figure 7; Ryden 2000d). One male razorback sucker (397 mm TL, 692 g) was collected within a few yards downstream of the McElmo Creek confluence (RM 100.5), on river right by one of two electrofishing rafts working in tandem. Approximately three-tenths of a mile downstream of this location (RM 100.2), again on river right, three more ripe male razorback sucker (412-456 mm TL, 650-770 g) were captured in a single dip net full of fish over a shoreline cobble shoal/run by the other electrofishing raft. These three male razorback sucker were captured in the midst of an aggregation of ripe, presumably spawning, flannelmouth sucker. Three other razorback sucker were observed but not captured in this same aggregation of fish. Of the four male razorback sucker that were recaptured at RM 100.5 and 100.2, three had originally been stocked at either Hogback Diversion (RM 158.6) or Bluff, UT (RM 79.6), and had converged near Aneth presumably to spawn. A PIT tag number was not determined for the fourth fish, as the PIT tag reader quit working after reading the PIT tag for the third fish. Therefore a stocking location for the last fish could not be determined. The ripe male razorback sucker that was recaptured at RM 100.5 was a radio-tagged fish that had been located at RM 129.9 in February 1997. One of the three males captured at RM 100.2 was also a radio-tagged fish that was last contacted at RM 93.8 on 22 October 1996. Flows were increasing in the river during the time these electrofishing collections were made, indicating that these razorback sucker were spawning on the ascending limb of the hydrograph as is seen in other Upper Colorado River Basin (UCRB) rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998). Flows at the Shiprock, NM USGS gage on 15 April 1997 were 1,390; 1,770 on 3 May; 5,580 on 15 May; and 8,050 on 31 May 1997.

1999: In April 1999, another suspected spawning aggregation of razorback sucker was documented in literally the exact same location as the suspected 1997 spawning aggregation (Table 14, Figure 7; Ryden 2000c). On 16 April 1999, two ripe male razorback sucker (438 and 509 mm TL) and one ripe female (565 mm TL) razorback sucker were collected at RM 100.2 within a few feet of where the three razorback sucker were collected on 3 May 1997. These three razorback sucker were collected in the midst of numerous ripe adult, presumably spawning, flannelmouth sucker, over an embedded cobble substrate (shoreline run habitat), approximately 5-10 feet from the river right bank in about 2-3 feet of water. These three fish, all stocked on 18 November 1994 had come from three different stocking sites (RM 158.6, 177.5, and 79.6). Flows at the Shiprock, NM USGS gage on 1 April 1999 were 1030 CFS; 1010 CFS on 16 April; 1940 on 1 May; and 2590 on 15 May 1999. As in May 1997, the increasing flows in the river during the general time frame in which these electrofishing collections were made, indicates that these razorback sucker were spawning on the ascending limb of the hydrograph as is seen in other Upper Colorado River Basin (UCRB) rivers (Tyus 1987, Tyus and Karp 1989, USFWS 1998).

2001: No razorback sucker were collected via electrofishing during the suspected 2001 spawning season (i.e., April-May). However, during a radio-tracking trip on 19 April 2001, four razorback sucker were contacted in very close proximity to one another from RM 100.2 to 100.0. Two of these fish (radio tag numbers 40.831 {male} and 40.811 {female}) had been captured on 3 October 2000 at RM 100.5 (510 and 508 mm TL, respectively) within a few feet of one another and implanted with radio tags (Ryden 2001b). These two fish had remained between RM 100.0 and 100.2 continuously since that date, often being contacted within a few feet of each other. On 19 April 2001, 40.831 (male) was at RM 100.0 and 40.811 (female) was at RM 100.2. Although these two fish were not together on this occasion, another radio-tagged male razorback sucker (40.820) was within a foot or two of 40.811 (Table 14, Figure 7). This male, 40.820 (implanted 4 October 2000 at RM 77.0, 422 mm TL; Ryden 2001b), had been contacted at RM 77.4

Table 14. Details about individual razorback sucker that have been recaptured (via electrofishing or trammel-netting) or contacted (via radio telemetry) in suspected spawning aggregations in spring 1997, 1999, 2001, and 2002. Information presented below on total length, weight, and sex was determined at time of recapture unless otherwise noted.

RM Recaptured At	PIT Tag Number	Total Length (in mm)	Weight (in g)	Sex[a]	Days Since Stocking	Date Stocked	RM Fish Was Stocked At	Year-Class & (Age At Recapture)
Suspected Spawning Aggregation On 3 May 1997: (NOTE -- 3 other razorbacks were seen, but not collected)								
100.5	7F7D17641A	397	692	Male, tb	212	10/03/1996	158.6	1992 (5)
100.2	1F4031135D	412	650	Male, tb/r	897	11/18/1994	79.6	1992 (5)
100.2	1F5B684A54	452	770	Male, tb/r	603	09/27/1995	158.6	1992 (5)
100.2	unknown[b]	456	750	Male, tb/r	unknown	unknown	unknown	unknown
Suspected Spawning Aggregation On 16 April 1999:								
100.2	1F74362314	565	1650	Female, r	1610	11/18/1994	79.6	1992 (7)
100.2	1F435D1C25	509	1300	Male, tb/r	1610	11/18/1994	117.5	1992 (7)
100.2	1F40464E0D	438	790	Male, tb/r	1610	11/18/1994	158.6	1992 (7)
Suspected Spawning Aggregation On 19 April 2001:								
100.2	1F40447964	444	760	Male, tb/r	2344	11/18/1994	79.6	1992 (9)
100.2	42131C4420	508[c]	1400[c]	Female[c]	1308	09/19/1997	158.6	1996 (5)
100.2	1F743D161A	422[d]	1800[d]	Male[d]	2344	11/18/1994	117.5	1992 (9)
100.0	1F43597253	510[c]	1400[c]	Male[c]	2344	11/18/1994	158.6	1992 (9)

a: tb = tuberculate, r = ripe (i.e., freely expressing milt or eggs)

b: The PIT tag reader quit working before a PIT tag number could be obtained for this fish. Therefore, several pieces of information about this fish could not be determined.

c: These two fish were contacted via radio telemetry on 19 April 2001, but not physically recaptured and examined. Therefore, the information presented here for total length, weight, and sex, was that obtained at the time of radio tag implantation on 3 October 2001 at RM 100.0.

d: Same as “c:” above, except this fish was implanted on 4 October 2001 at RM 77.0.

Table 14, continued. Details about individual razorback sucker that have been recaptured (via electrofishing or trammel-netting) or contacted (via radio telemetry) in suspected spawning aggregations in spring 1997, 1999, 2001, and 2002. Information presented below on total length, weight, and sex was determined at time of recapture unless otherwise noted.

RM Recaptured At	PIT Tag Number	Total Length (in mm)	Weight (in g)	Sex[a]	Days Since Stocking	Date Stocked	RM Fish Was Stocked At	Year-Class & (Age At Recapture)
Suspected Spawning Aggregation On 18 April 2002: (documented by UDWR's nonnative fish removal crews)								
18.0	512A724849	480	1100	Male, tb/r	1282	10/14/1998	158.6	1997 (5)
17.9	1F414E3E14	487	1150	Male, tb/r	2708	11/18/1994	79.6	1992 (10)
17.8	1F750B7869[e]	505	1275	Male, tb/r	unknown	unknown	unknown	unknown
17.8	203E3F3C27	495	1125	Male, tb/r	1421	05/28/1998	158.6	1993 (9)
17.8	42151C0F23	500	1150	unknown	1688	09/03/1997	158.6	1996 (6)
17.5	423F635449	478	1175	Male, tb/r	170	10/30/2001	158.6	1999 (3)

e: No PIT tag could be detected in this fish, so a previous stocking history could not be determined. A new PIT tag was implanted in this fish before it was returned to the river.

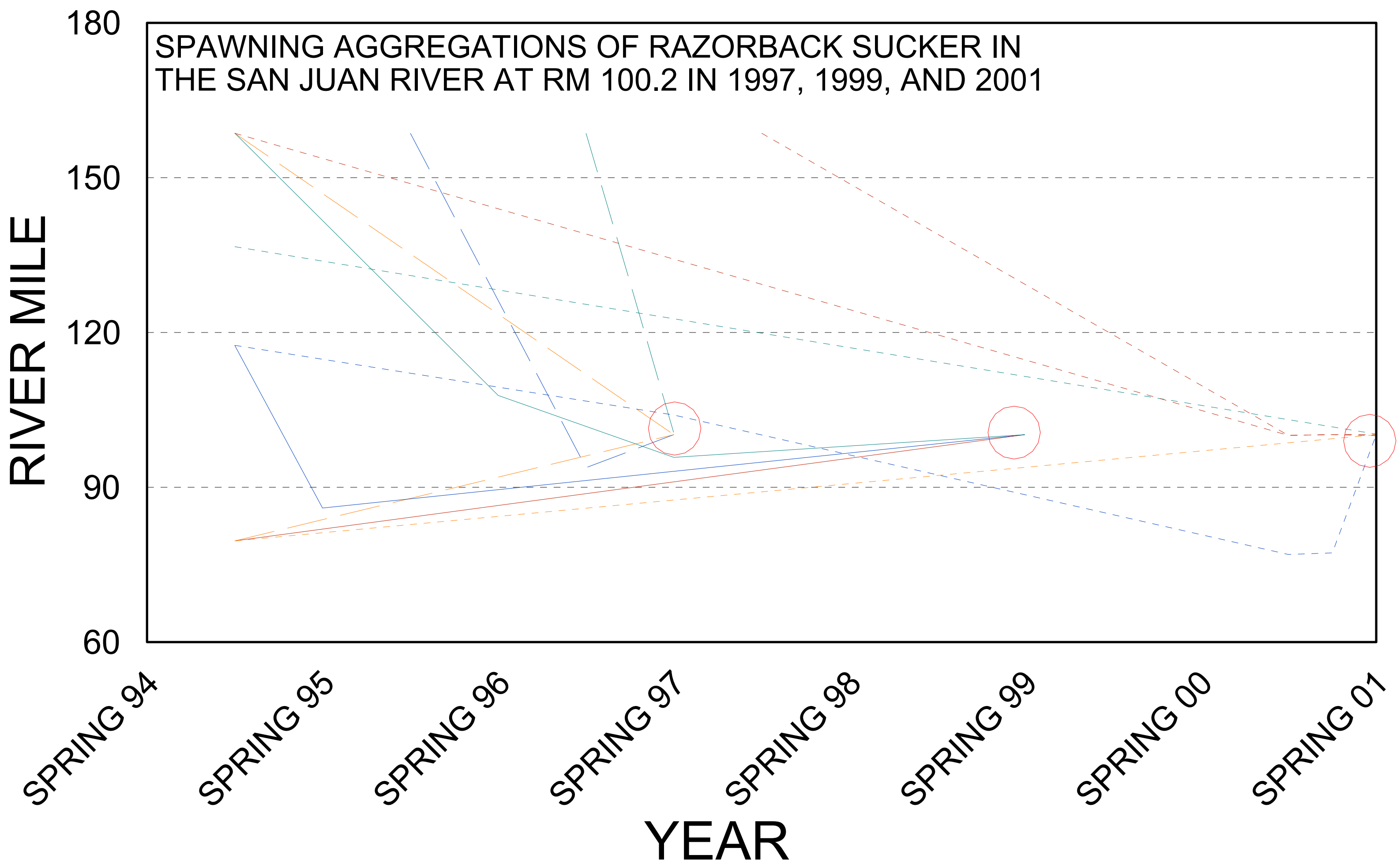

Figure 7. Suspected spawning aggregations of razorback sucker at RM 100.2 in the San Juan River in the spring of 1997, 1999, and 2001.

on 12 March 2001 and would be contacted at RM 77.4 again on 7 May 2001, 18 days after this contact. This pair (40.811 and 40.820) were about six feet from the river left shoreline, in run habitat, over a clean cobble/gravel substrate. Water depth was 1.9 feet, mean water column velocity was 1.3 ft/sec (bottom velocity = 0.7 ft/sec), and water temperature was 16.0°C at 1215. This was the same exact location that groups of ripe, presumably spawning razorback sucker had been collected from in 1997 and 1999. A trammel net was drifted along the shoreline at RM 100.2 to try to recapture the radio-tagged fish (40.811 and 40.820). Although neither of these two fish was recaptured, another ripe male (444 mm TL) razorback sucker (no radio tag) was captured. All four of the razorback sucker had come from different stocking times or locations (Figure 7). Two radio-tagged fish (40.820 and 40.831) and the fish recaptured in the trammel net (i.e., all three male fish) had all been stocked on 18 November 1994, but at three different stocking sites (RM 117.5, 158.6, and 79.6, respectively). The female (40.811) had been stocked on 19 September 1997 at RM 158.6. Flows at the Shiprock gage on 10 April 2001 were 1100 CFS, on 19 April were 1490 CFS, on 30 April were 2730 CFS, and on 15 May were 4680 CFS, indicating that spawning was taking place on the ascending limb of the hydrograph.

So, as in past years (i.e., 1997 and 1999), razorback sucker collected at this site were composed of many different individuals from different stocking sites and times, some of which had until recently occupied different areas of the river and moved to RM 100.2 for a short-term interval, while others occupied this site for many months. Also, as in past years, ripe male razorback sucker collected outnumbered ripe females and these suspected spawning aggregation occurred on the ascending limb of the hydrograph.

2002: In 2002, a suspected spawning aggregation of razorback sucker were collected by the UDWR in the lower San Juan River adjacent to Slickhorn Canyon (Table 14). A total of six razorback sucker were collected from RM 18.0-17.5 on 18 April 2002. An indeterminate number of other razorback sucker were also sited but not collected. Five of these six fish were ripe males, the sex was not determined for the sixth fish. One of the six fish did not have a PIT tag detectable upon capture, but was implanted with one before its release. The razorback sucker collected from this aggregation represented a wide range of age-classes (age-3 to age-10). All but one were first-time recaptures - PIT tag number 1F414E3E14 had been recaptured once before at RM 86.3 on 17 April 1999.

Roundtail Chub

1999-2001 Collections

1999: Two wild roundtail chub juveniles were collected during the 1999 adult monitoring trip, one at RM 118.0 and one at RM 25.0 (Table 15). The individual collected at RM 25.0 (134 mm TL) represents the farthest downstream a roundtail chub has ever been collected during an adult monitoring trip (Table 15; Ryden 2000b).

Four additional wild roundtail chub were collected in 1999 during sampling for other studies, from RM 153.0-116.1 (Table 16). Only one of these four fish (346 mm TL) was an adult (Table 16).

2000: No roundtail chub were collected during 2000, either on adult monitoring trips or on sampling trips for other studies (Ryden 2001a).

2001: No roundtail chub were collected during the 2001 adult monitoring trip. However, four wild roundtail chub were collected during sampling for other studies, from RM 164.0-87.0 (Table 15). Again, only one of these four fish (369 mm TL) was an adult (Table 16).

Population Trends

Roundtail chub, a state-listed endangered species in both New Mexico and Utah, continues to be the most rarely-collected of the three rare fish species that reside in the San Juan River. Based on plots of 187 individual roundtail chub collections between 1987 and 2001, collections of roundtail chub tend to be concentrated mostly in areas downstream of the LaPlata and Mancos river confluences (Figure 8; SJRIP Integrated Database). These two rivers and the Animas River, are the only three of the San Juan's tributaries that are known to have resident populations of roundtail chub (Miller and Rees 2000). The large majority of the 187 roundtail chub collections between 1987 and 2001 consisted of subadult fish (Figure 8).

Since 1991, a total of 25 roundtail chub (TL range = 116-414 mm) have been implanted with PIT tags (SJRIP Integrated Database). Of these 25, only two individuals have been recaptured a second time after their initial capture and release. One individual (PIT tag number 7F7D142D70, TL = 278 mm), of indeterminate sex, was originally collected on 13 May 1992 at RM 147.9 and was recaptured later the same year at RM 137.7 on 8 October 1992 (294 mm TL; Ryden and Pfeifer 1993). The second individual (PIT tag number 1F6D185B01, TL = 414 mm), a female, was originally collected on 15 April 1996 at RM 131.3 and was recaptured again on 5 May 1998 at RM 133.4 (414 mm TL; Ryden 2000a, 2000c).

The dearth of adult roundtail chub in the San Juan River, combined with a lack of recaptures among PIT-tagged fish over time, and the fact that most roundtail chub captures in the mainstem San Juan River occur downstream of major tributaries known to have resident populations of roundtail chub, would seem to argue that the roundtail chub being collected in the mainstem San Juan are transient members of the fish community at best. It seems plausible that roundtail chub collected in the mainstem San Juan River get flushed out of tributaries during high flow events and either perish or move up- or downstream out of the mainstem river fairly quickly after entering it.

Table 15. Roundtail chub collected from the San Juan River on the 1999 adult monitoring trip.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
Fall 1999 Adult Monitoring Trip (n = 2):							
09/29/1999	NONE	NONE	195	100	I	118.0	Wild
10/05/1999	5124744920	NONE	134	28	I	25.0	Wild

[a]: I = Indeterminate; M = Male; F = Female

Table 16. Roundtail chub collected from the San Juan River during sampling efforts for other studies in 1999 and 2001.

Date Of Capture	PIT Tag Number	Radio Freq.	Total Length (mm)	Weight (grams)	Sex[a]	Capture River Mile	Wild Or Stocked Fish
1999:							
Captures by USFWS-Grand Junction in 1999 (n = 2):							
04/12/1999	51365B4108	NONE	346	420	I	153.0	Wild
04/12/1999	223F71510A	NONE	116	13	I	147.0	Wild
Captures by NMGF-Santa Fe in 1999 (n = 2):							
09/29/1999	NONE	NONE	84	5	I	116.4	Wild
09/29/1999	NONE	NONE	147	30	I	116.1	Wild
2001:							
Captures by USFWS-Grand Junction in 2001 (n = 3):							
05/05/2001	NONE	NONE	227	160	I	128.0	Wild
05/07/2001	NONE	NONE	206	75	I	87.0	Wild
06/25/2001	7F7B0D3B00	NONE	174	50	I	98.8	Wild
Captures by USFWS-Albuquerque in 2001 (n = 1):							
09/11/2001	7F7B0D3356	NONE	369	530	I	164.0	Wild

[a]: I = Indeterminate; M = Male; F = Female

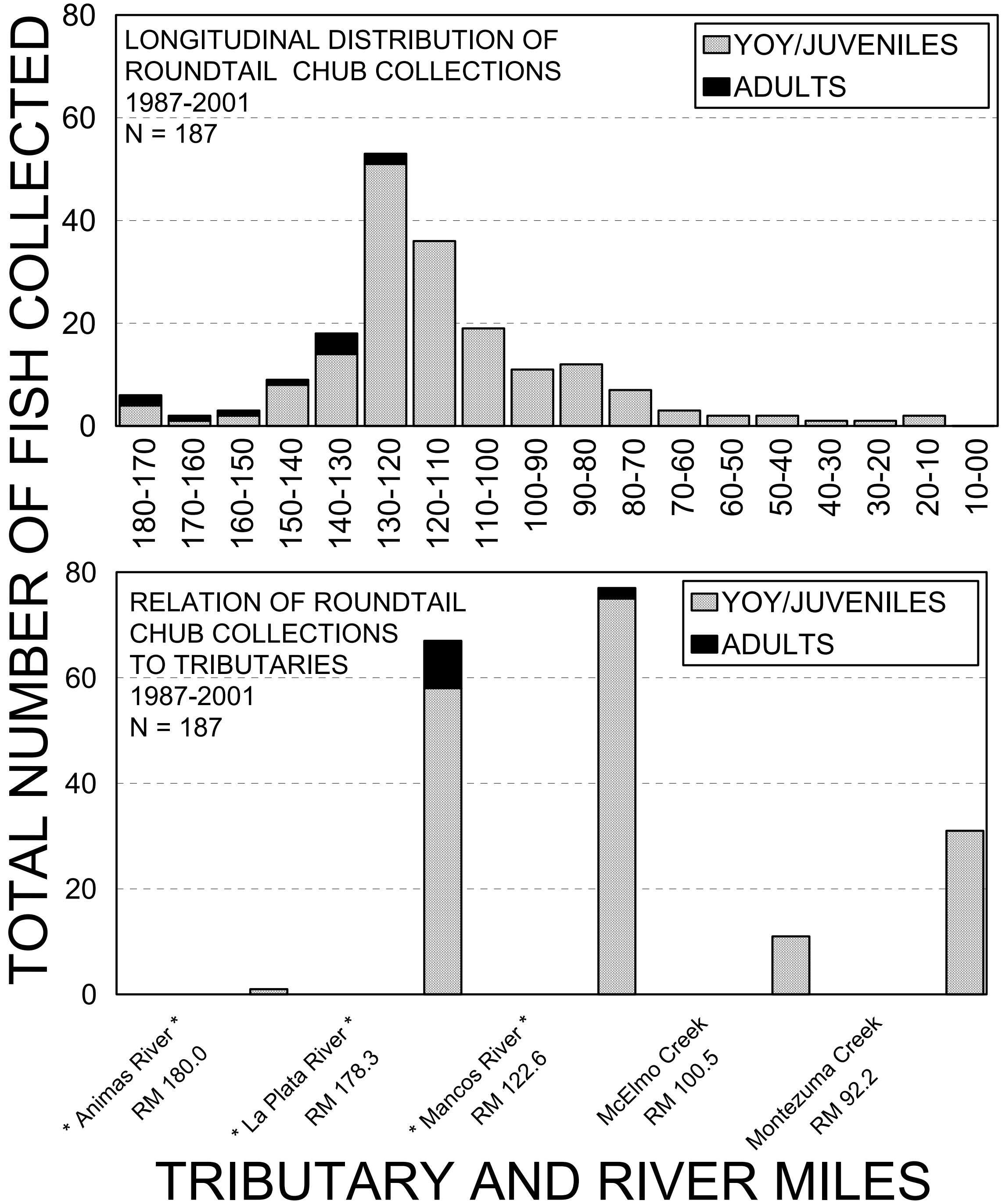

Figure 8. Spatial distribution of all roundtail chub collections from all studies in the San Juan River, 1987-2001 (top). Relation of all roundtail chub collections from all studies to major tributaries of the San Juan River, 1987-2001 (bottom). Tributaries that have asterisks by their names are those known to have resident populations of roundtail chub (Miller and Rees 2000).

Common Native Fishes

Flannelmouth Sucker

Catch Per Unit Effort (CPUE)

Flannelmouth sucker continue to be the most common large-bodied fish collected riverwide during adult monitoring trips (Table 3; Ryden 2000a, 2000b, 2001a). While numbers of this fish have fluctuated both riverwide and in individual geomorphic reaches over the years, flannelmouth sucker have remained numerically dominant in both overall numbers of specimens collected and in frequency of occurrence in electrofishing samples (Table 3, Ryden 2000a, 2000b, 2001a). In four of the last six years (1996 and 1999-2001), flannelmouth sucker CPUE for all life stages combined riverwide has remained relatively stable (i.e., between 63 and 71 fish per hour of electrofishing) -- the two exceptions to this were 1997 (due to lower than usual numbers of adult fish) and 1998 (due to lower than usual numbers of juvenile fish; Figure 9). Statistical matrices comparing between-year CPUE values of flannelmouth sucker, both riverwide and for individual geomorphic reaches, are presented in Appendix A.

Flannelmouth sucker occur throughout Reach 6, both up- and downstream of all the various major and minor water diversion structures, including PNM Weir (RM 166.6; Ryden 2000a, 2000b, 2001a). Between 1996 and 2001, total CPUE for flannelmouth sucker in Reach 6 remained relatively constant, with exceptions of 1999 and 2000 (Figure 10). Total CPUE for flannelmouth sucker in 1999 was significantly higher when compared to previous years and 2001, due to an increase in CPUE among adult fish (Table A2b, Figure 10). Then in 2000, total CPUE for flannelmouth sucker rose again significantly to the highest value ever recorded for this species in any river reach or year since our studies began in 1991 (Table A2c, Figure 10). This was due to the enormous number of juvenile flannelmouth sucker collected in Reach 6 in 2000, the majority of which were collected upstream of the PNM Weir (Ryden 2001a).

The flannelmouth sucker population in Reach 5 has demonstrated the most dramatic shift in total CPUE observed for this species since our studies began in 1991 (Figure 10). The significant decline in total CPUE between 1992 and 1997 led to some concern that the flannelmouth sucker population was in a long-term decline (Tables A3a-A3c, Figure 10; Ryden 2000a). However, between 1997 and 2001, flannelmouth sucker total CPUE increased again significantly, with this increase occurring both in juvenile and adult life stages (Tables A3a-A3c, Figure 10).

Flannelmouth sucker total CPUE in Reach 4 demonstrated a decline between 1992 and 1997 that was very similar to that observed in Reach 5 immediately upstream (Figure 11). However, like Reach 5, total CPUE in Reach 4 increased significantly between 1997 and 1999 and has remained relatively stable since that time (Table A4c, Figure 11).

In Reach 3 (and adjoining Reach 2 downstream), juvenile fish become the numerically dominant life stage in the flannelmouth sucker population (Figure 11). In Reach 3, there was also a decline in total CPUE between 1992 and 1998 in the case of this reach (Figure 11). However, unlike upstream in Reaches 5 and 4, total CPUE has not risen again significantly since its low in 1998 (Table A5c, Figure 11).

Starting in Reach 6 and proceeding downstream to Reach 2, there is a generally declining trend in total CPUE for flannelmouth sucker (Figures 10-12). In addition, Reach 2 is the most downstream reach in which flannelmouth sucker are regularly collected in any kind of appreciable numbers. Like Reach 3 directly upstream, the flannelmouth sucker population in Reach 2 is

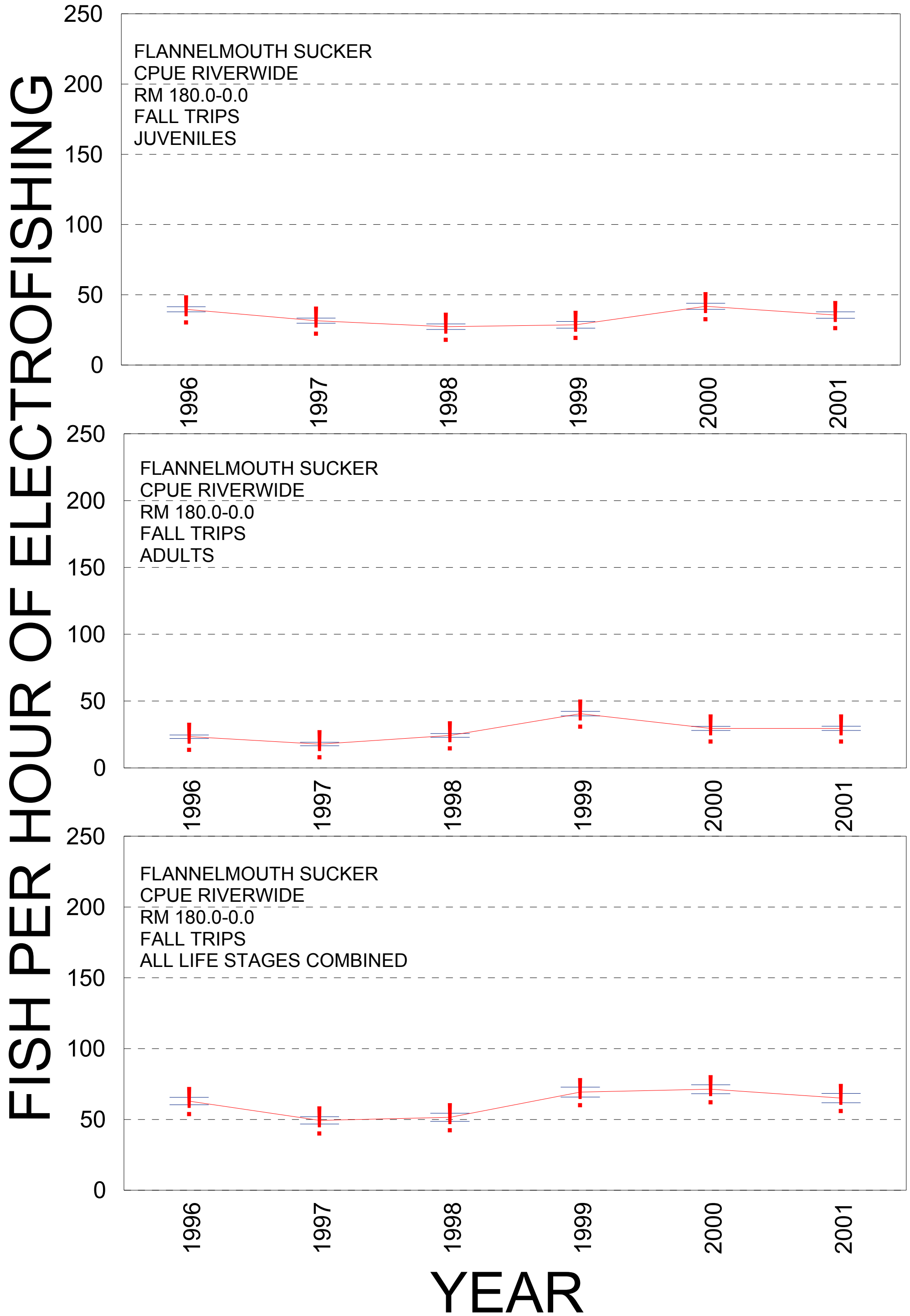

Figure 9. Flannelmouth sucker catch per unit effort (CPUE) riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001 for juvenile fish (< 410 mm TL; top), adult fish (≥ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

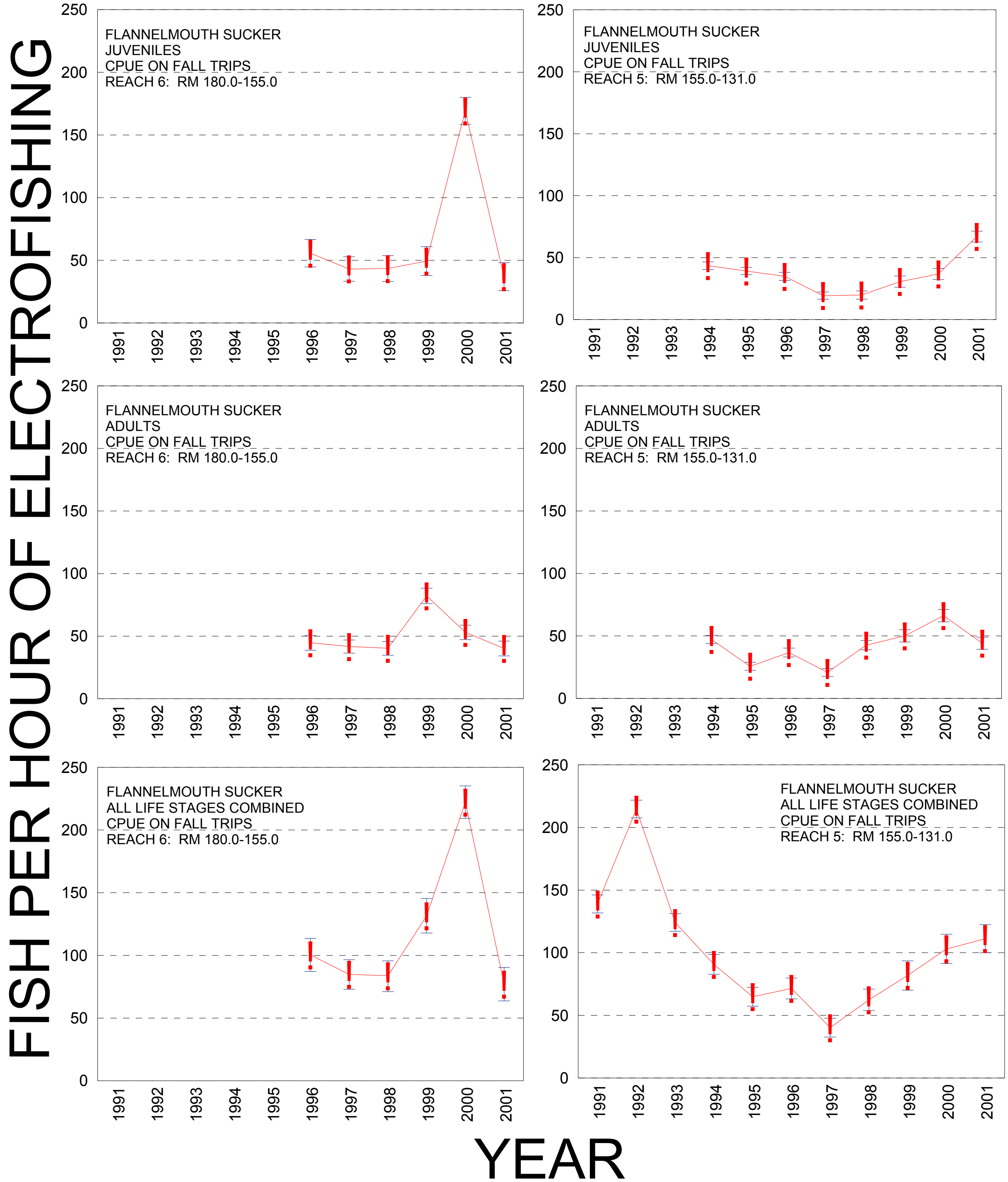

Figure 10. Flannelmouth sucker catch per unit effort (CPUE) in Reach 6 and Reach 5 on fall adult monitoring trips for juvenile fish (< 410 mm TL; top), adult fish ($\geq$ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

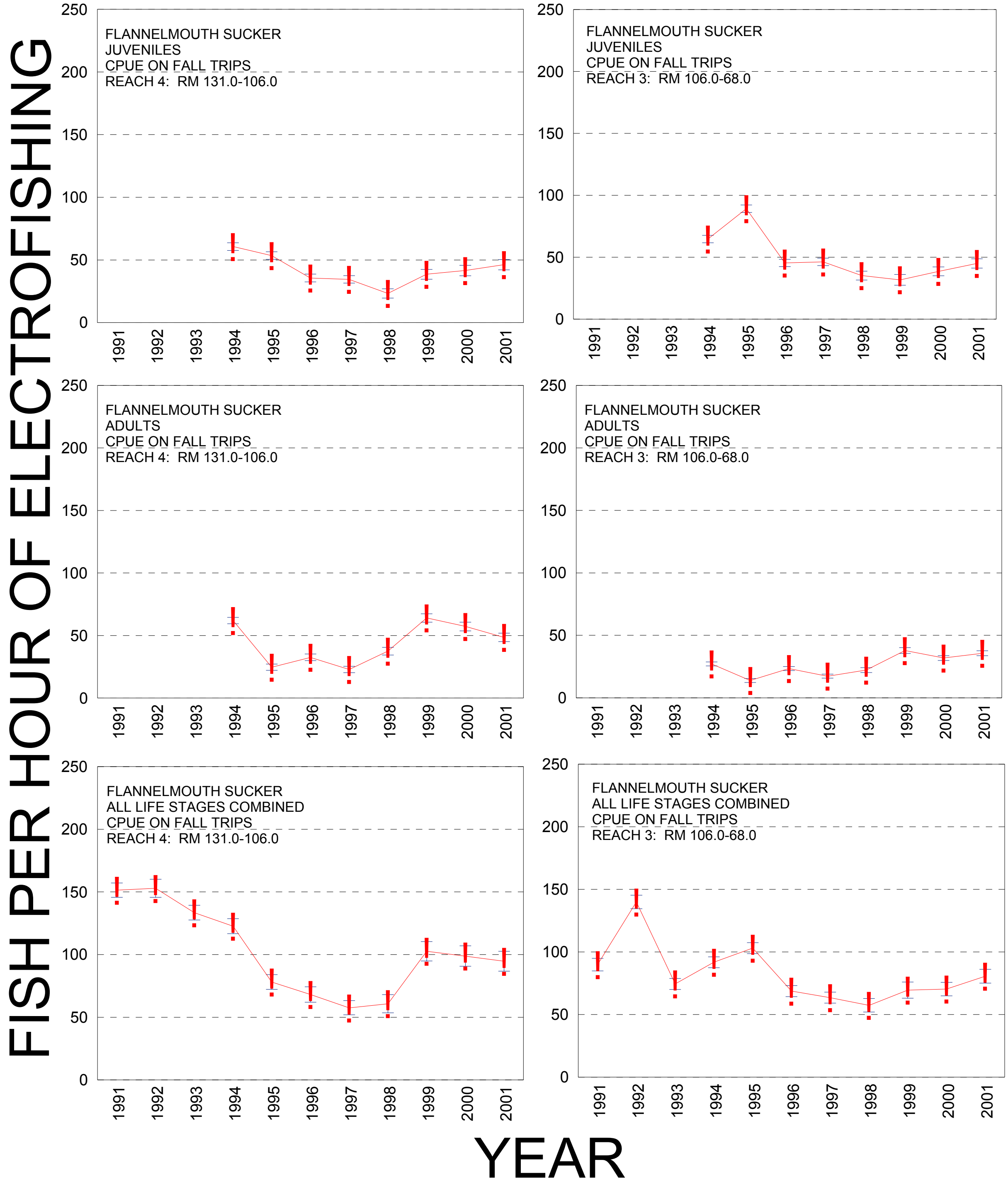

Figure 11. Flannelmouth sucker catch per unit effort (CPUE) in Reach 4 and Reach 3 on fall adult monitoring trips for juvenile fish (< 410 mm TL; top), adult fish (≥ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

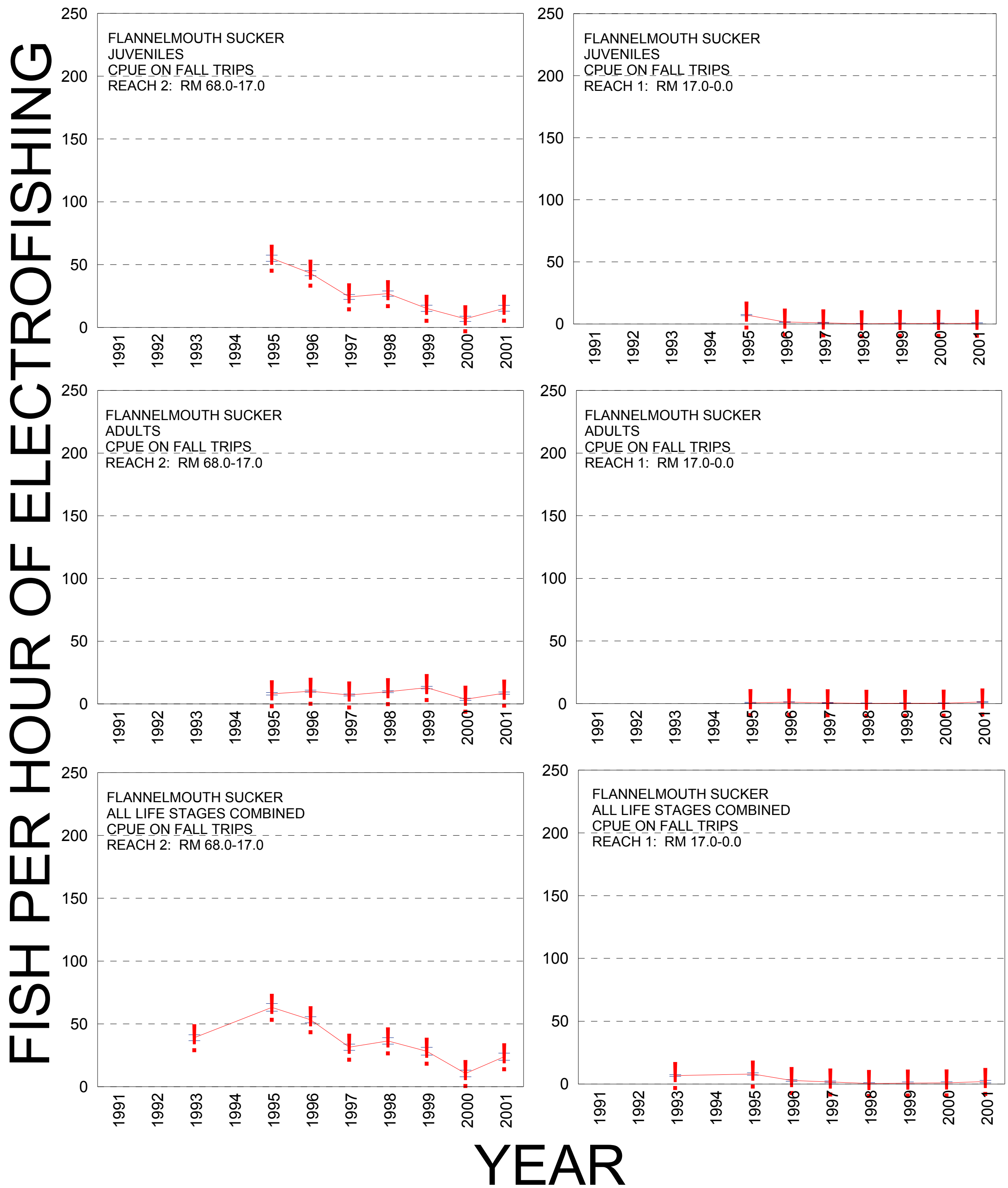

Figure 12. Flannelmouth sucker catch per unit effort (CPUE) in Reach 2 and Reach 1 on fall adult monitoring trips for juvenile fish (< 410 mm TL; top), adult fish ($\geq$ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

numerically dominated by juvenile fish, but to an even greater degree than in Reach 3 (Figure 12). Therefore, total CPUE values in Reach 2 tend to track those of juvenile fish much more closely than those of adult fish. The overall trend for flannelmouth sucker total CPUE in Reach 2 between 1995 and 2001 has been a steady decline (Figure 12).

Flannelmouth sucker are much more rare in electrofishing collections in Reach 1, relative to CPUE values for more upstream reaches (Figures 10-12). It is intriguing that even though flannelmouth sucker have always been less common in Reach 1 than in other upstream reaches, they were markedly more abundant in Reach 1 before the waterfall at RM 0.0 became inundated in spring 1995 (Figure 12). The inundation of this waterfall allowed predatory fishes inhabiting Lake Powell (e.g., striped bass and walleye) unhindered access to the lower San Juan River (Ryden 2000a).

Length Frequency And Mean Total Length

Histograms of flannelmouth sucker length-frequency distributions riverwide between 1996 and 2001 show a trend towards this population becoming increasingly dominated by adult fish (i.e., > 410 mm TL) between 1996 and 1999 with over half of all flannelmouth sucker measured in 1999 being between 376 and 475 mm TL 1999 (Figure 13). During October 2000 sampling, there was a large influx of small (76-100 mm TL, assumed to be age-0) flannelmouth sucker, causing the length-frequency of the flannelmouth sucker population to become strongly bimodal in 2000 and 2001 (Figure 13). It appears as though small flannelmouth sucker (76-100 mm TL) from the October 2000 length-frequency histogram had grown approximately 150 mm by October 2001 (Figure 7). Looking at the rate of growth among young flannelmouth sucker in 2000 and 2001 (Figure 13) and interpolating what their total lengths might be in one to two years (i.e., assuming these fish will have an approximate mean TL of 301-325 mm at age-2 or age-3), one could reasonably argue that the group of flannelmouth sucker centered around the 301-325 mm TL mark in the 1996 length-frequency histogram (Figure 13) were age-2 to age-3 fish that were spawned in 1993 or 1994.

As was evidenced by the length-frequency histograms, flannelmouth sucker mean TL values riverwide (for all life stages combined) increased significantly between 1996 and 1999 (Table A8, Figure 14). Mean TL for flannelmouth sucker then dropped significantly riverwide in 2000 due to the large influx of age-0 juveniles (Table A8, Figure 14). The increase in mean TL of flannelmouth sucker riverwide between 2000 and 2001 (Figure 14), tracks right along with the 2000 year-class attaining larger sizes and beginning to recruit (Figure 13).

From reach to reach, flannelmouth sucker mean TL varied greatly (Figure 15). Notable among trends for mean TL is the significant drop in Reach 6 between 1999 and 2000, caused by the large influx of age-0 fish, mostly upstream of the PNM Weir at RM 166.6 (Table A9, Figure 15; Ryden 2001a). Also notable is the strongly increasing (though not significant) trend of flannelmouth sucker mean TL in Reach 1, adjacent to Lake Powell, between 1993 and 2001 (Table A14, Figure 15). Like the decrease in total CPUE observed for flannelmouth sucker in Reach 1 after 1995 (Figure 12), this rise in mean TL in Reach 1 could very easily be attributable to predatory fishes from Lake Powell entering the lower river and eliminating smaller size-classes of flannelmouth sucker through predation.

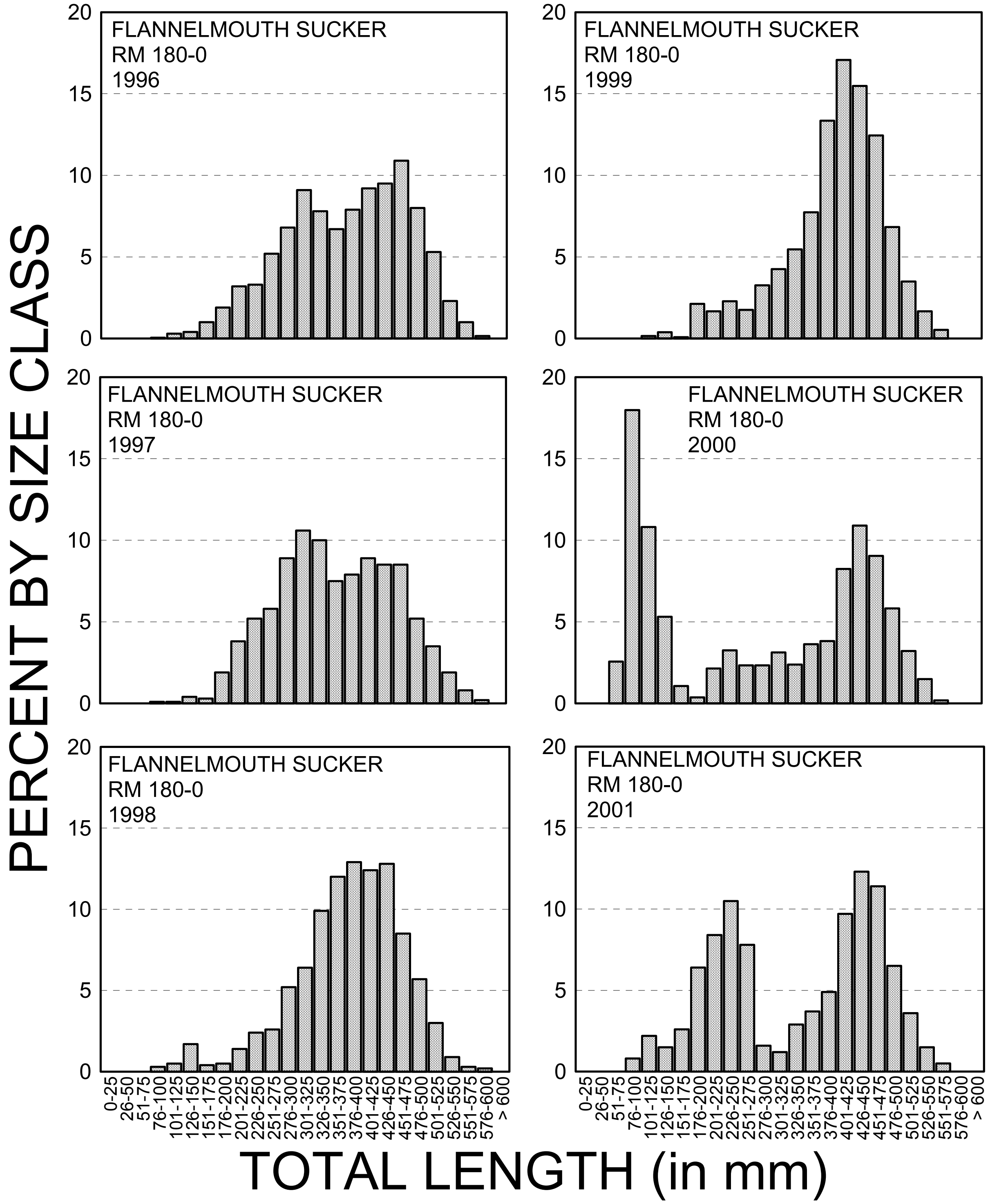

Figure 13. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of flannelmouth sucker on fall adult monitoring trips in the San Juan River, 1996-2001.

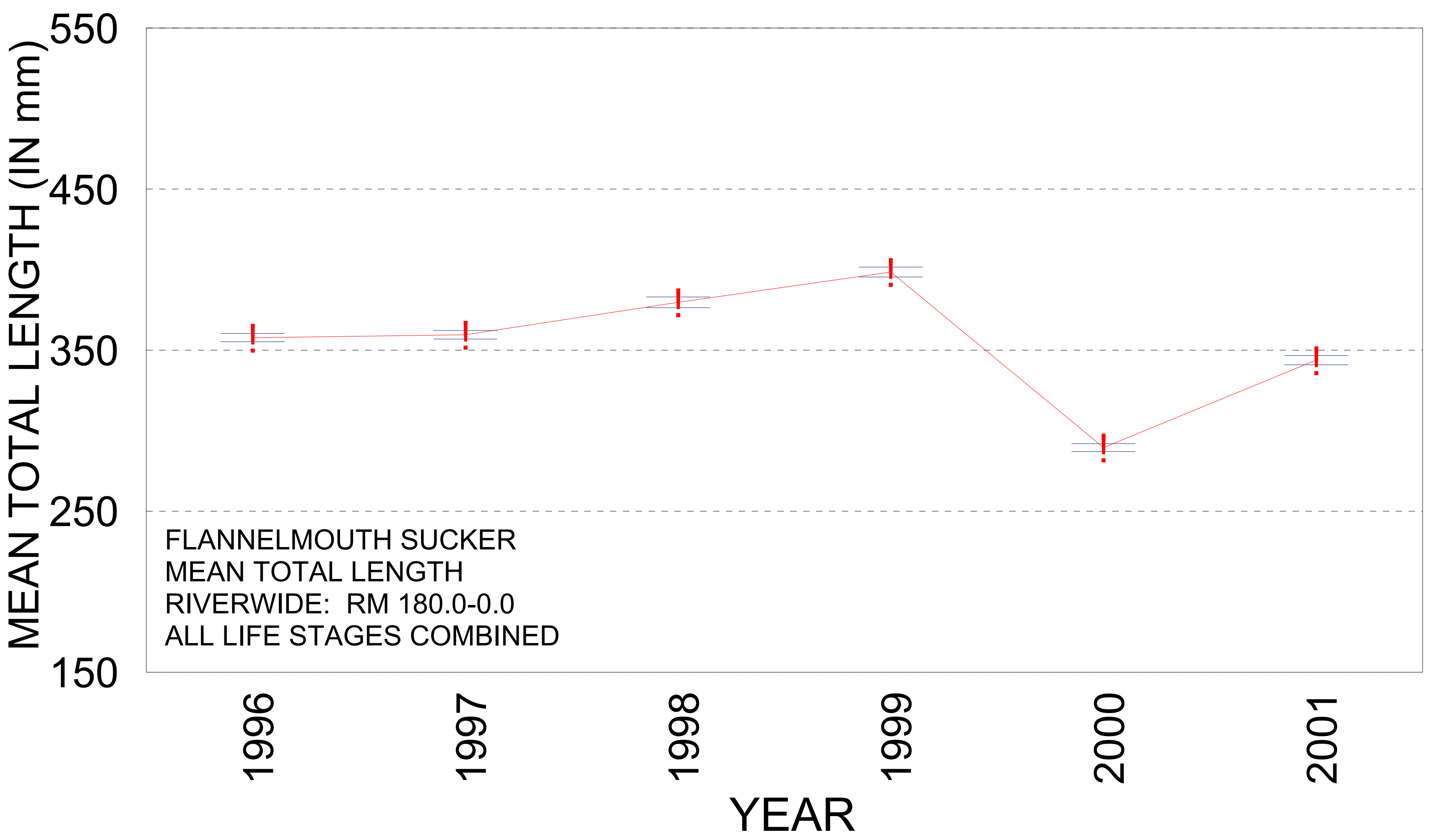

Figure 14. Mean total length (in mm) of flannelmouth sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

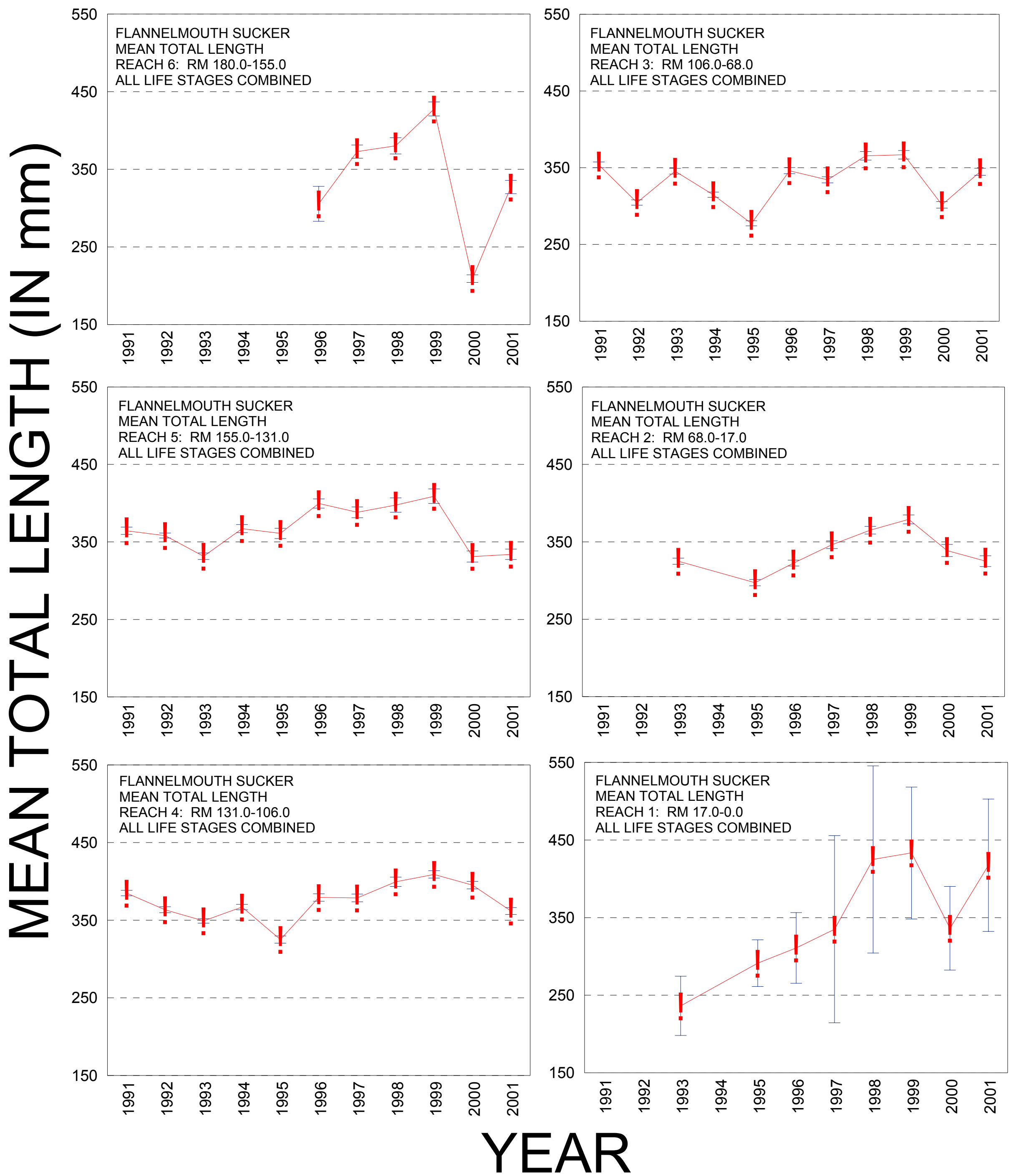

Figure 15. Mean total length (in mm) of flannelmouth sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

Biomass

Riverwide, mean biomass of flannelmouth sucker increased significantly between 1997 and 1999, then dropped significantly to its lowest observed value in 2000, before rising slightly again in 2001 (Table A15, Figure 16). This tracks very well with values for mean TL, which show the same pattern (Figure 14). Flannelmouth sucker mean biomass fluctuated depending upon the reach, but again, generally tracked very well with values for mean TL (Figures 15 and 17). Once again, the significant decline in mean biomass observed in Reach 6 in 2000 can be explained by the influx of numerous age-0 fish in Reach 6 upstream of PNM Weir (Table A16, Figures 10, 15, and 17). Likewise, the significant increase in mean biomass in Reach 1 (Table A21, Figure 17) adjacent to Lake Powell corresponds to fewer (Figure 12) and bigger fish (Figure 15) being collected in this Reach after the inundation of the waterfall at RM 0.0.

Plots of flannelmouth sucker biomass collected per hour of electrofishing indicate that the large majority of flannelmouth sucker biomass in the San Juan River occurs in Reaches 6-4 (Figure 17). It also shows that biomass per hour of electrofishing declines in each successive downstream reach, practically disappearing by Reach 1 (Figure 17).

Condition Factor

With the exception of 1997 (i.e., the year of lowest CPUE among flannelmouth sucker riverwide), flannelmouth sucker condition factor riverwide increased slightly between 1996 and 2001 (Figure 18). This same trend of a gradual increase in condition factor over time was also apparent in Reaches 5-1 (Figure 19). This increase in condition factor over time was somewhat more marked in Reaches 5 and 1 (Figure 19). Reach 6 did not have a clearly discernable trend in condition factor over time (Figure 19).

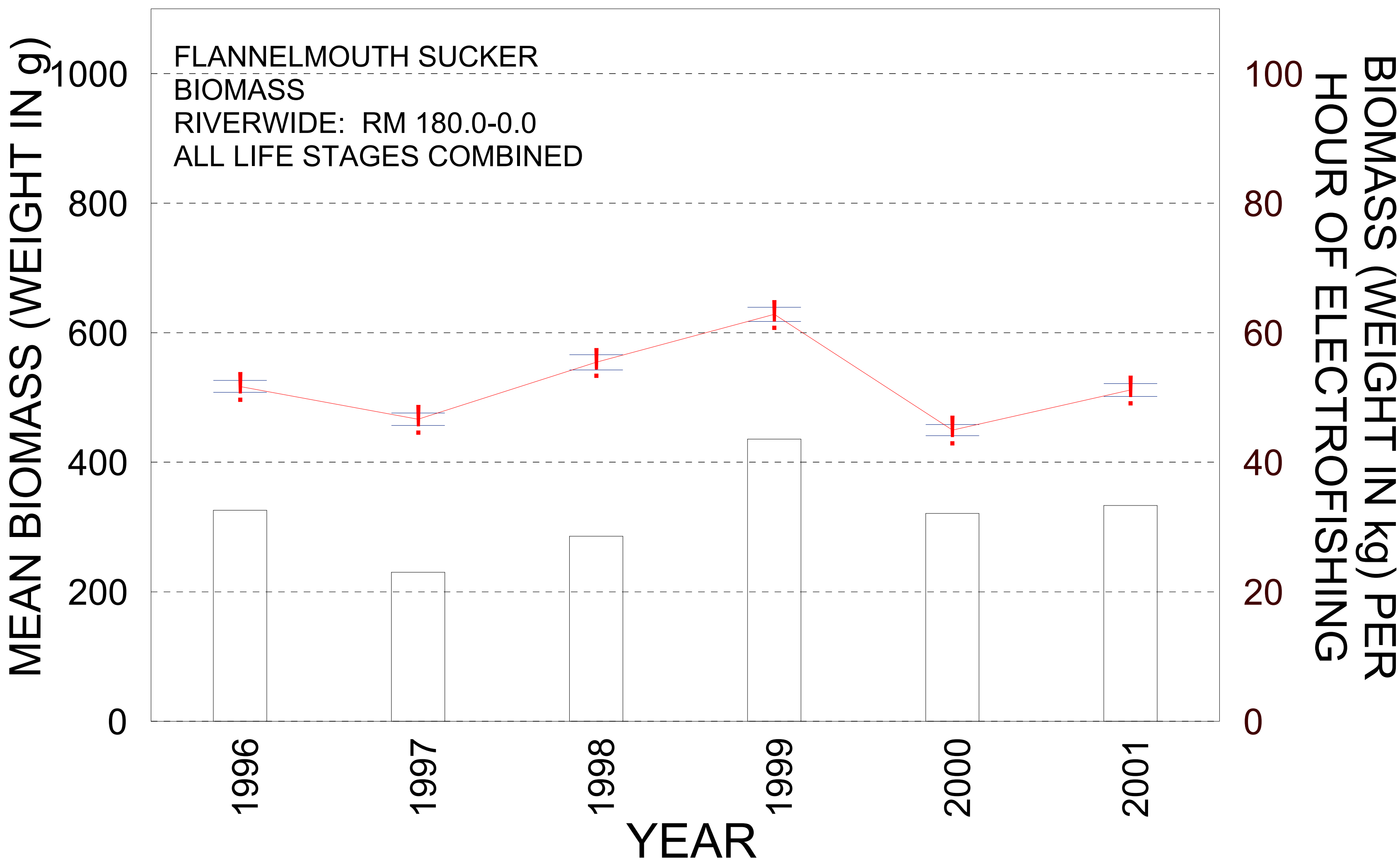

Figure 16. Mean biomass (line = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for flannelmouth sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001. Error bars represent the standard error values.

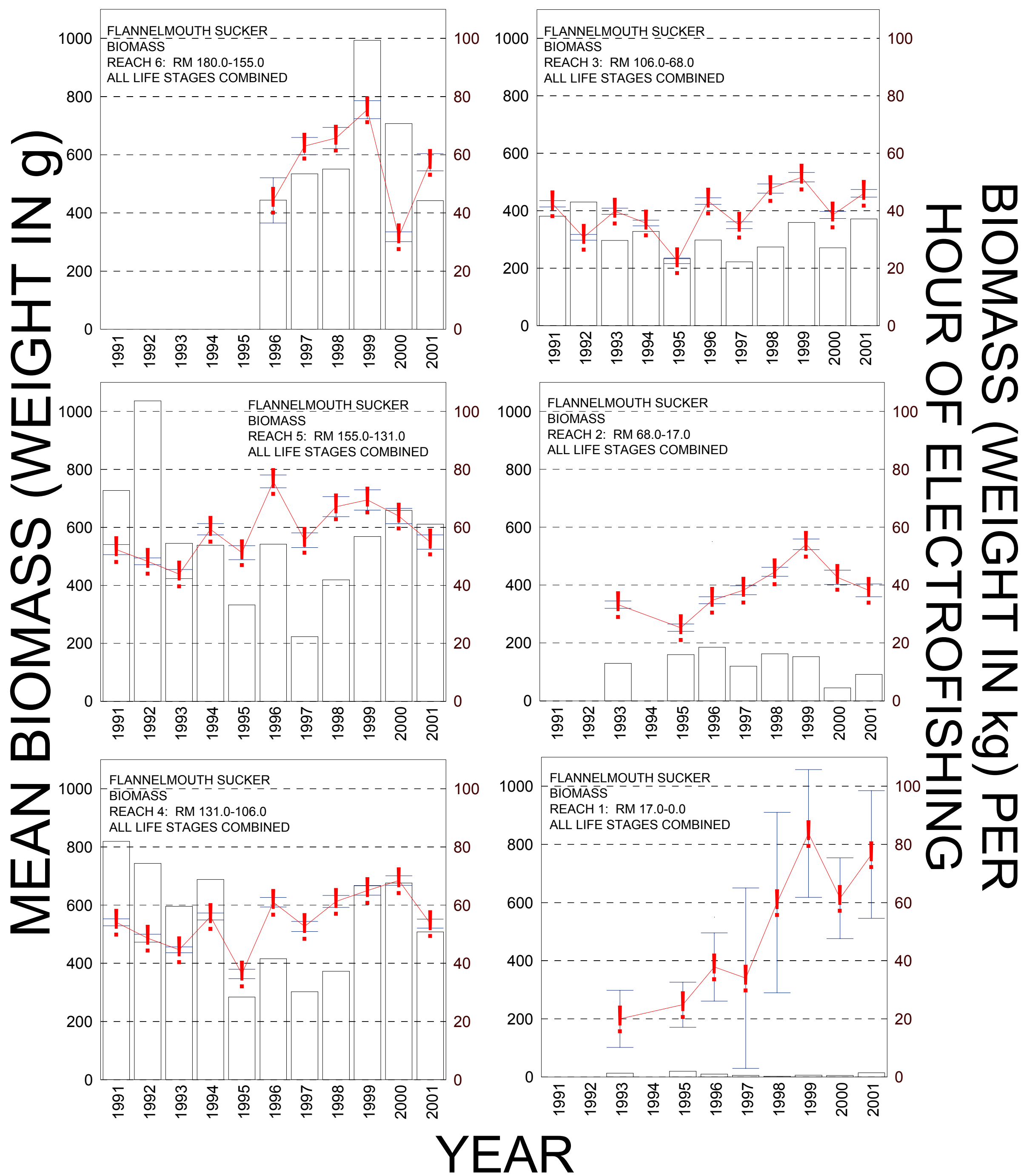

Figure 17. Mean biomass (lines = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for flannelmouth sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

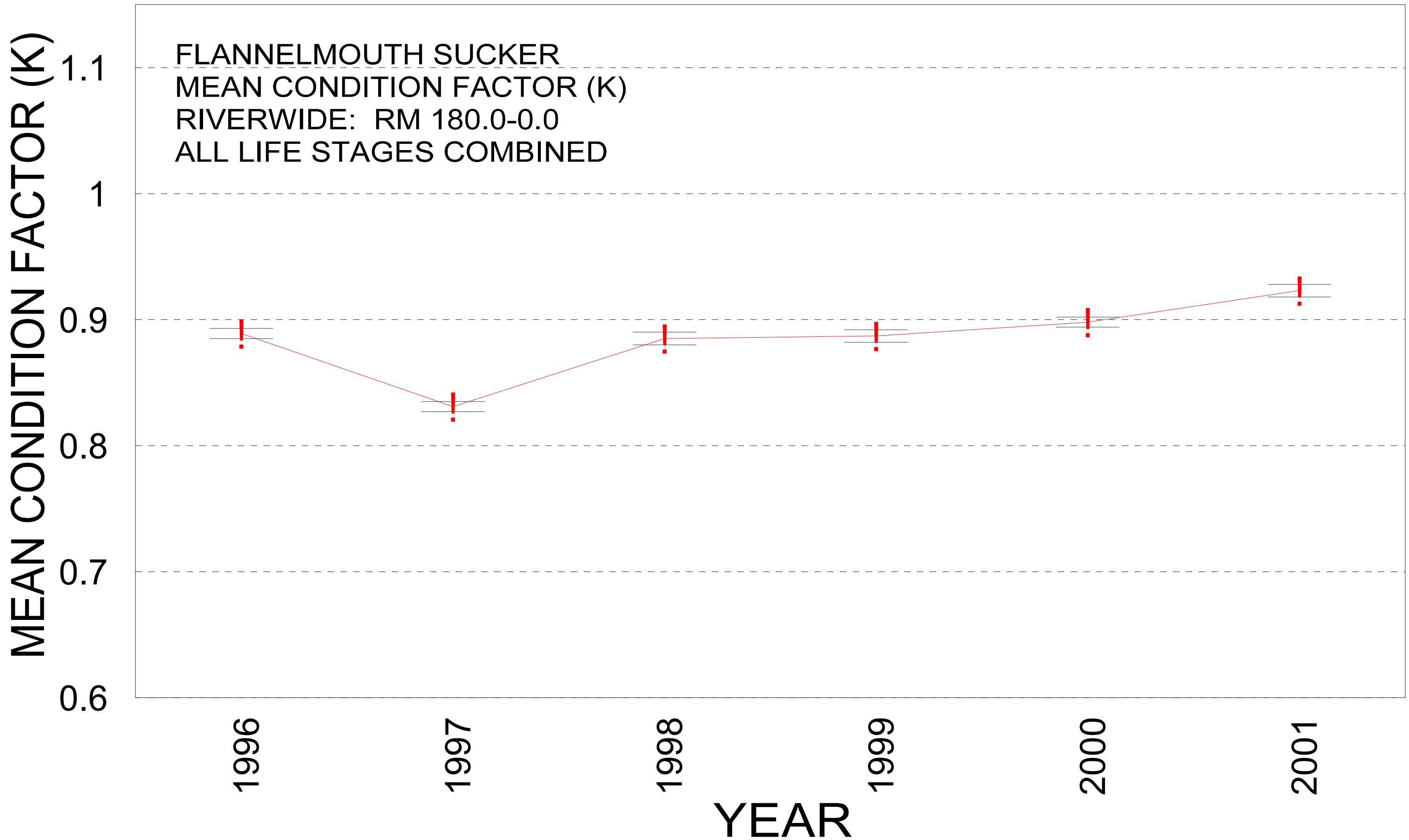

Figure 18. Mean condition factor (K) for flannelmouth sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

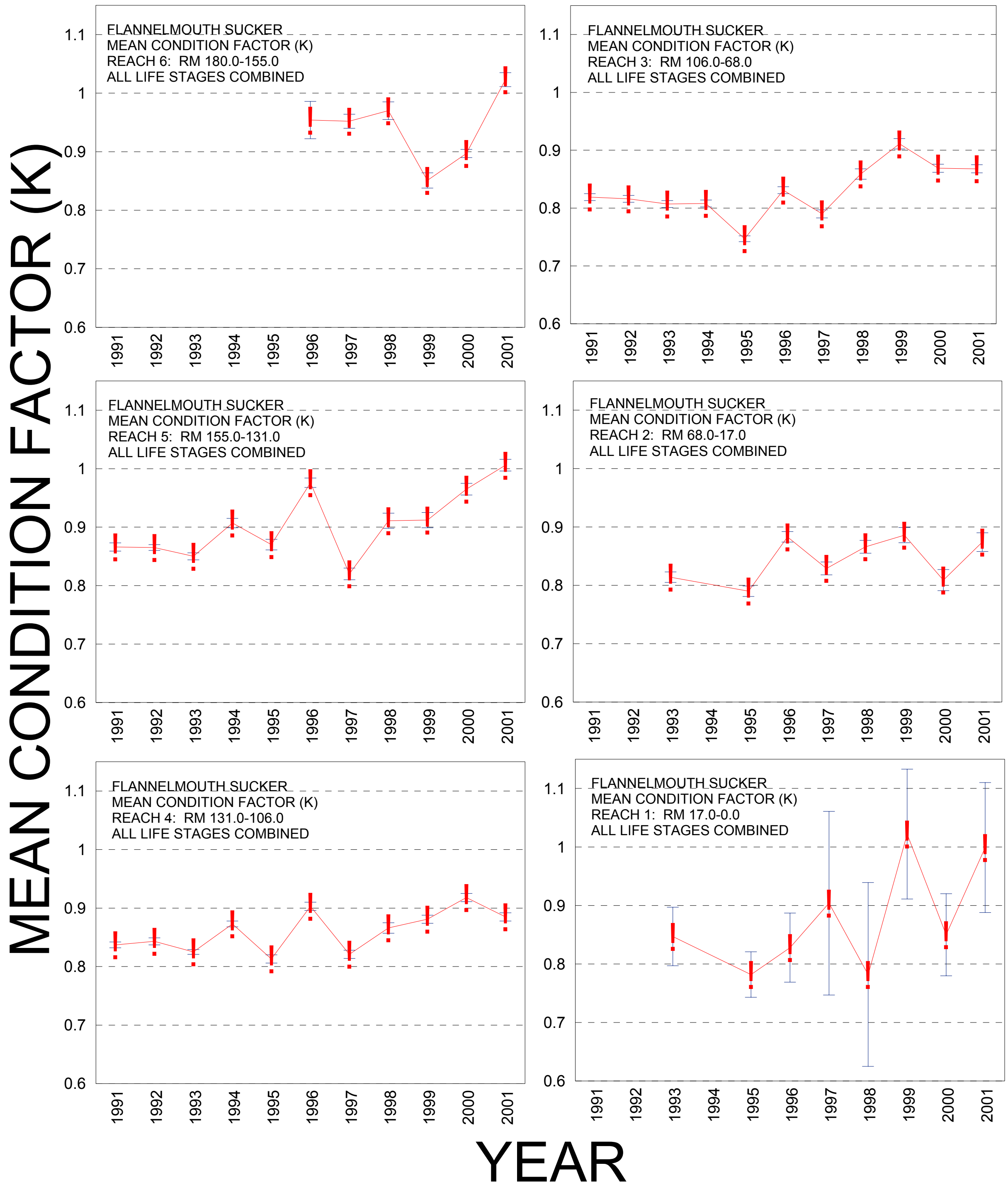

Figure 19. Mean condition factor (K) for flannelmouth sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

Bluehead sucker

Catch Per Unit Effort (CPUE)

Over the last several years, bluehead sucker have been the second most commonly-collected native fish and the third most commonly-collected large-bodied fish overall (following flannelmouth sucker and channel catfish) during the adult monitoring study (Table 3). Riverwide, bluehead sucker total CPUE has remained relatively stable (i.e., between 13 and 24 fish per hour of electrofishing) with one exception, 1999 (Figure 20). Only 1999 total CPUE values were significantly different from any other year and then only because of increased numbers of adult fish collected in Reach 6 during that year (Table A29c, Figures 20 and 21). Statistical matrices comparing between-year CPUE values of bluehead sucker, both riverwide and for individual geomorphic reaches, are presented in Appendix A.

The San Juan River bluehead sucker population, within our study area, is largely centered in Reach 6 and the upstream portion of Reach 5 (Figures 21-23). In fact, in Reach 6, bluehead sucker are often the most common large-bodied fish species collected. In Reach 6 there was a significant increase in the number of juvenile fish collected in both 1999 and 2000 (Table A30a, Figure 21). In 2000 this large influx of young fish occurred almost exclusively upstream of the PNM Weir (RM 166.6; Ryden 2001a). These two years of high juvenile CPUE combined with a high adult CPUE in Reach 6 in 1999, led to Reach 6 having the two highest CPUE totals ever observed for this species in any reach or year. Between 2000 and 2001 there have been significant decreases in both adult and juvenile CPUE in Reach 6 (Table A30a and A30b, Figure 21). However, it appears likely that the juvenile fish observed in Reach 6 in 2000 have moved into downstream river reaches and are responsible for the highest juvenile CPUEs ever recorded in Reaches 4, 3, and 2 in 2001 (Figures 21-23).

Though not as dramatic as the decline in total CPUE observed among flannelmouth sucker, bluehead sucker also had been reported as having a declining total CPUE in Reaches 5, 4, and 3 between 1992 and 1997 (Ryden 2000a). That conclusion was based largely on an observed decline in bluehead sucker total CPUE in Reach 5 (Reach 6 was not included in the previous analysis) between 1992 and 1997 (Figure 21). Without the Reach 6 data included in the previous analysis (Ryden 2000a), the decline that occurred in Reach 5 (and to a lesser extent in Reaches 4 and 3) appeared to be more important to the entire San Juan River population bluehead than it probably was (Figures 21 and 22).

Like flannelmouth sucker, bluehead sucker CPUE declines noticeably in each contiguous downstream reach (Figures 21-23). By Reach 2, bluehead sucker have become relatively rare in samples and before Reach 1, they disappear from fish collections altogether (Figure 23). No bluehead sucker of any life stage were collected in Reach 1 during the period 1991-2001.

Length Frequency And Mean Total Length

Histograms of bluehead sucker length-frequency distributions riverwide between 1996 and 1999 show a fairly stable trend with sampled populations being centered around the 301-325 mm TL size-class from 1996-1998 and shifting upwards slightly to being centered around the 326-350 mm TL size-class in 1999 (Figure 24). Then, much like what was observed in flannelmouth sucker, there was a large influx of small (76-100 mm TL, assumed to be age-0) bluehead sucker in Reach 6 in 2000 (mostly upstream of the PNM Weir at RM

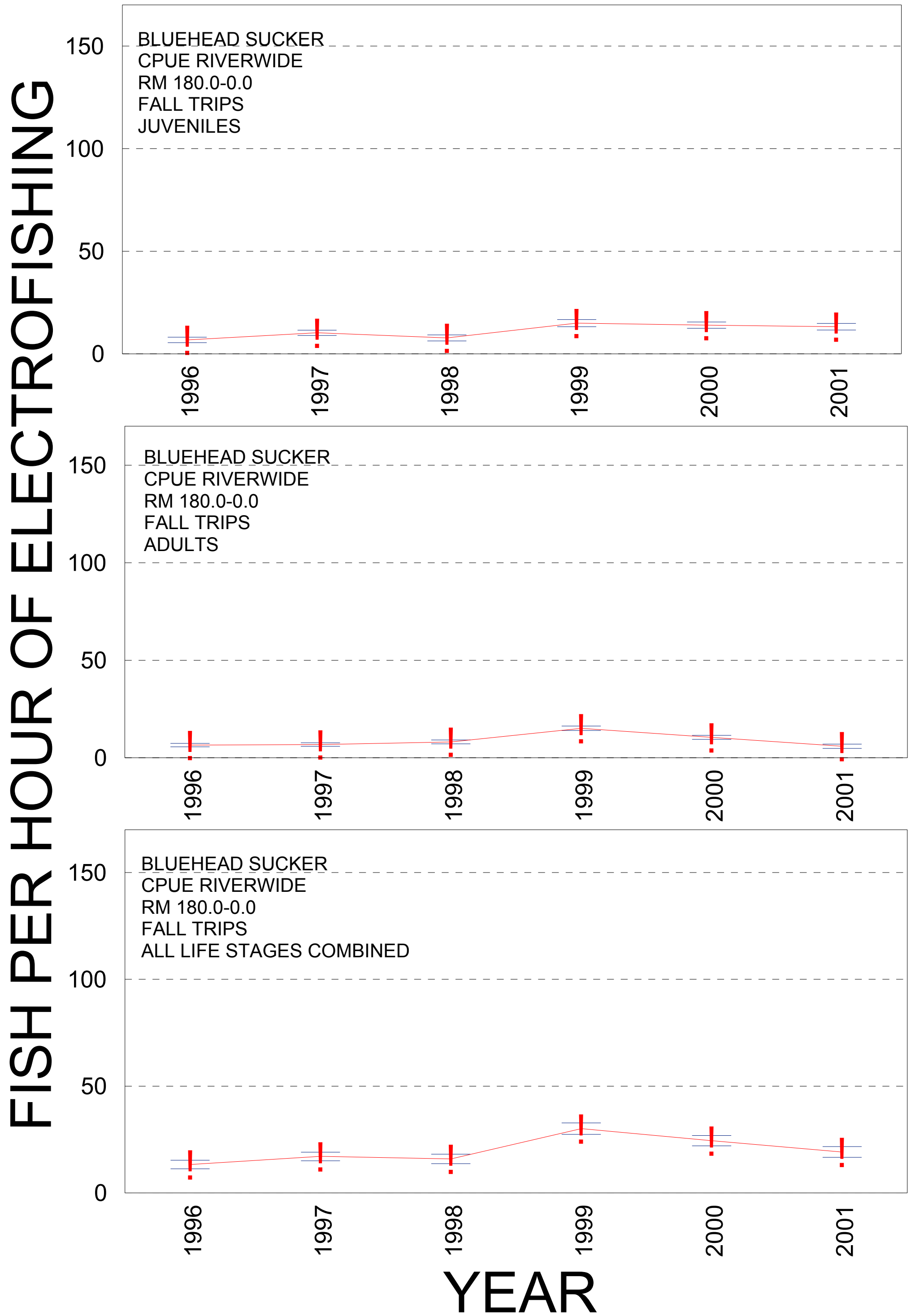

Figure 20. Bluehead sucker catch per unit effort (CPUE) riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001 for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

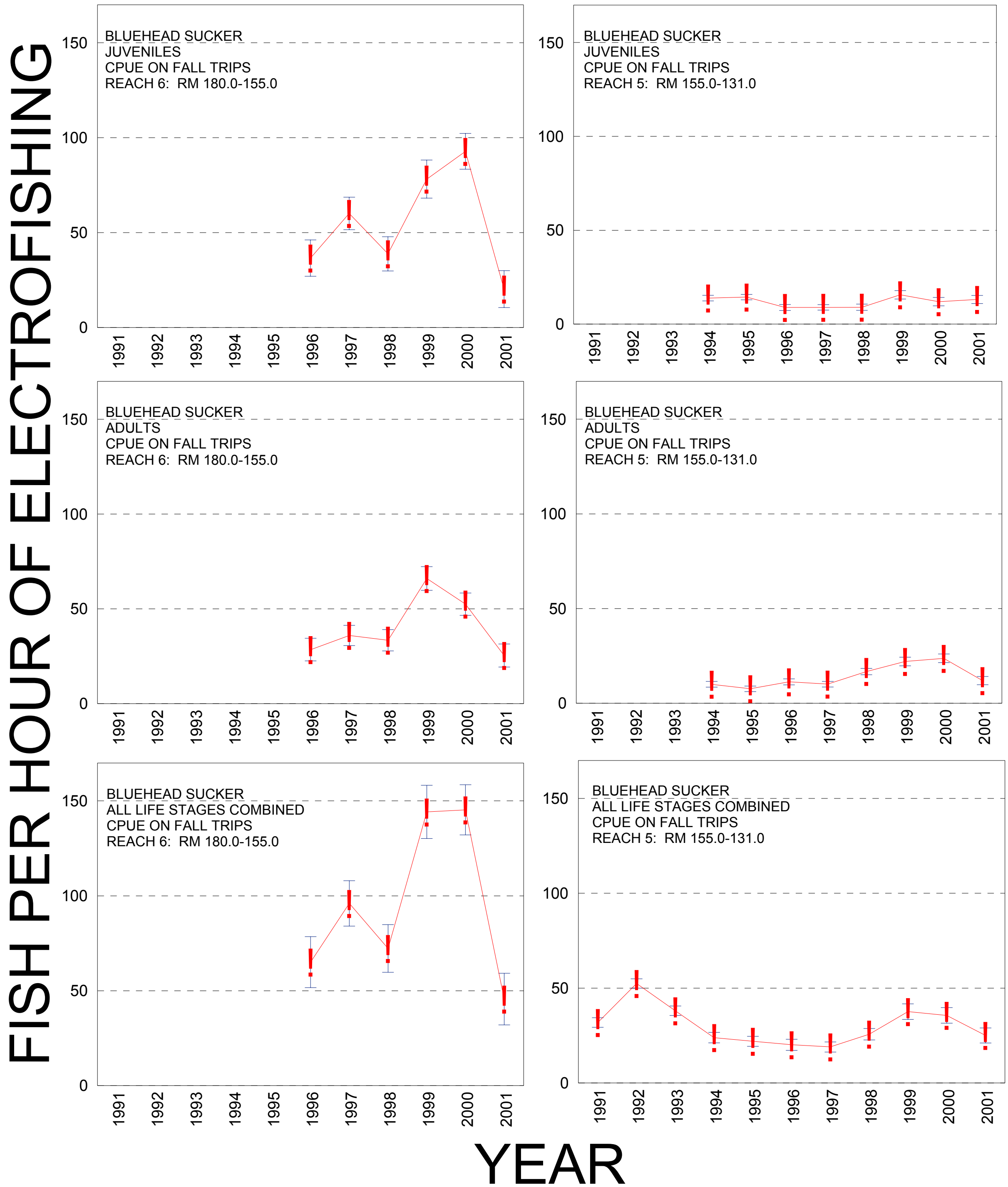

Figure 21. Bluehead sucker catch per unit effort (CPUE) in Reach 6 and Reach 5 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

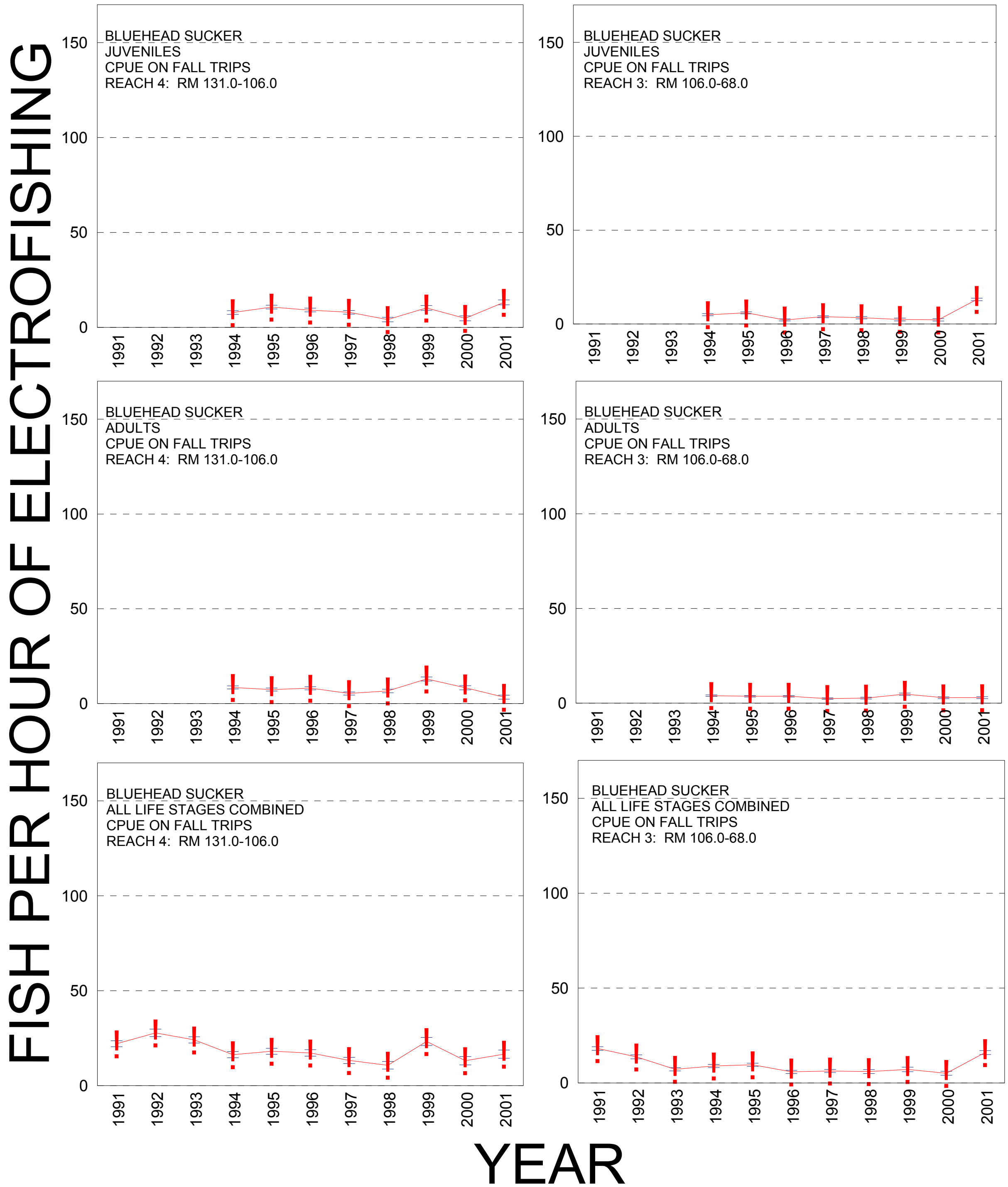

Figure 22. Bluehead sucker catch per unit effort (CPUE) in Reach 4 and Reach 3 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

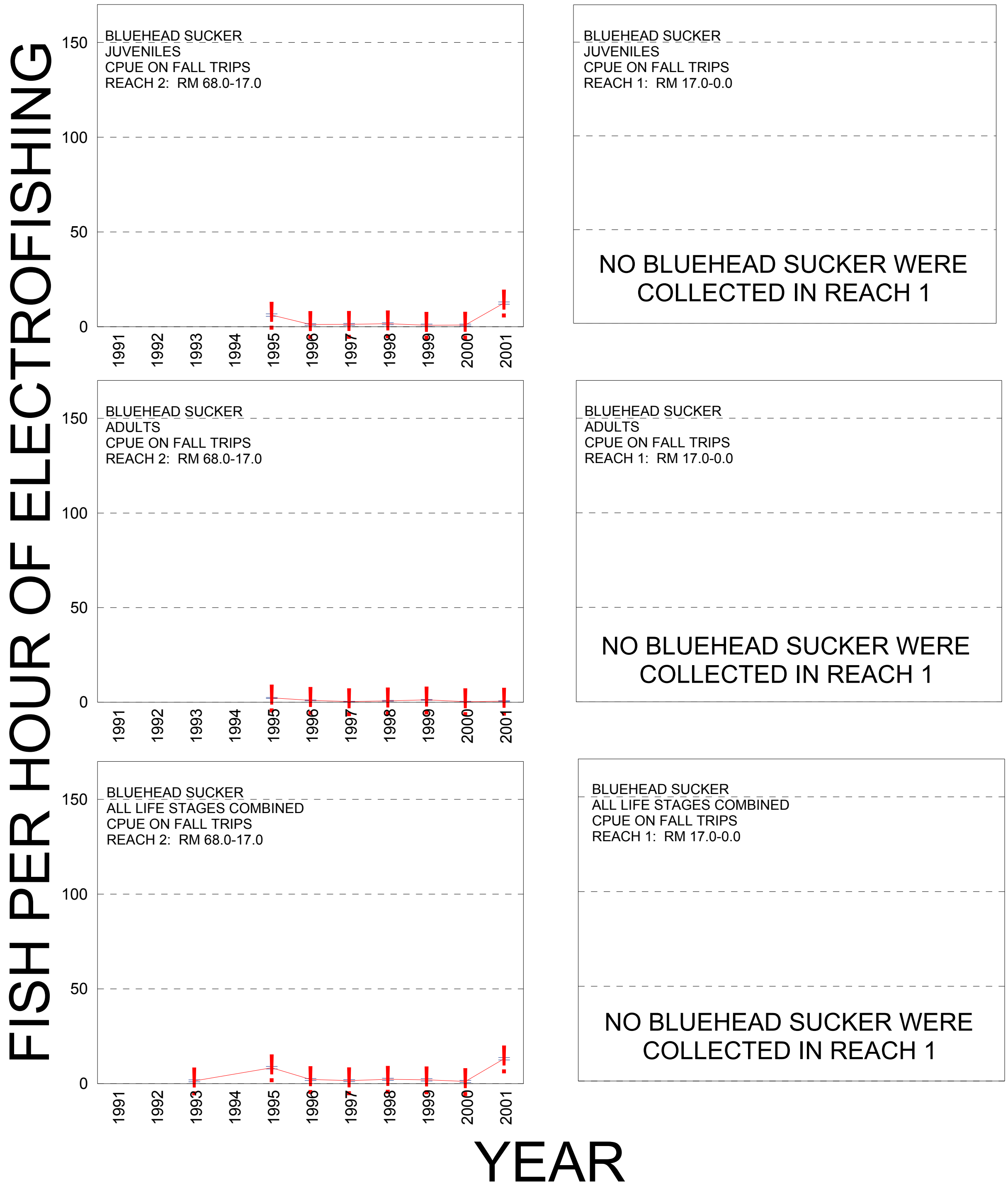

Figure 23. Bluehead sucker catch per unit effort (CPUE) in Reach 2 and Reach 1 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

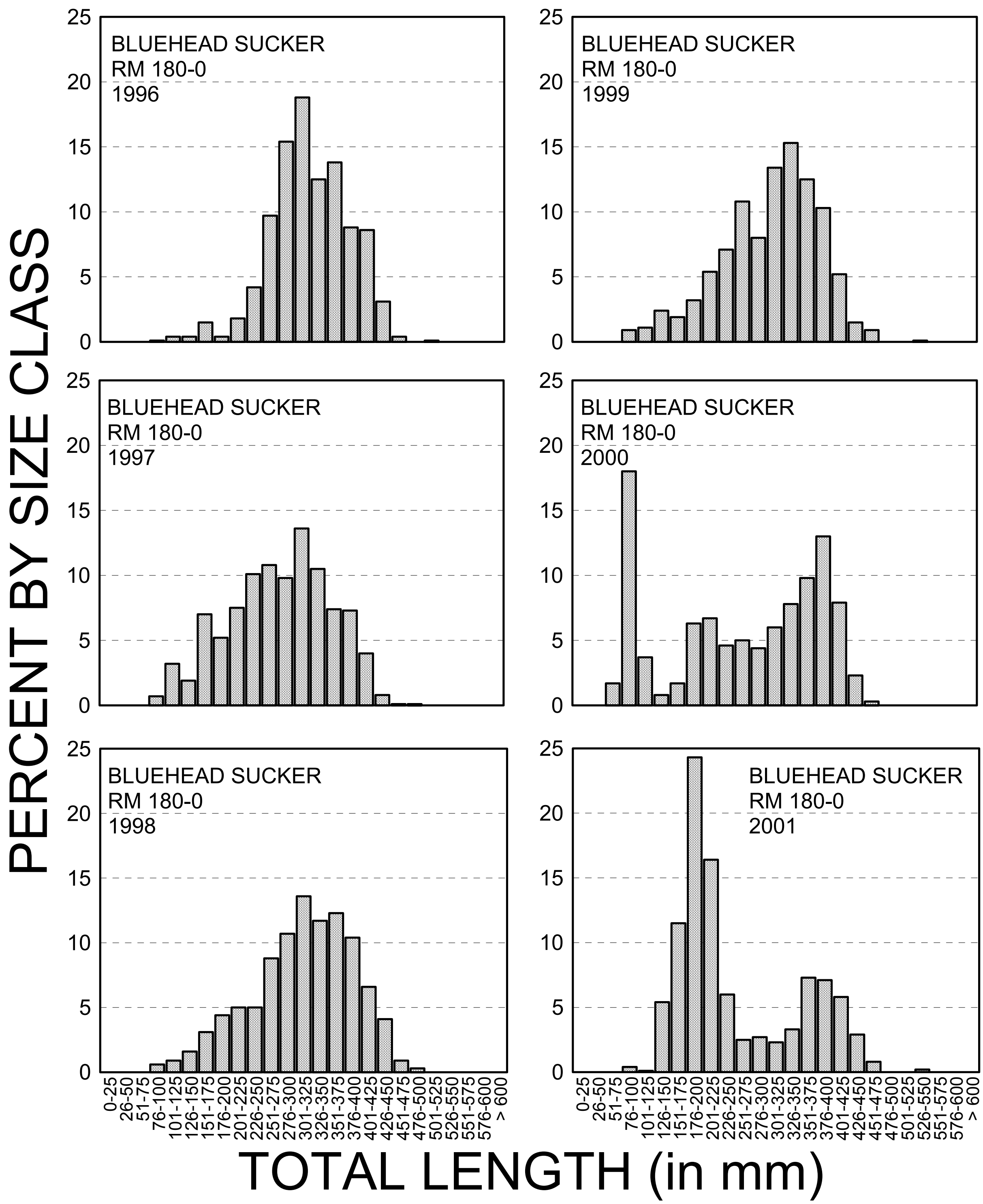

Figure 24. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of bluehead sucker on fall adult monitoring trips in the San Juan River, 1996-2001.

166.6; Ryden 2001a), causing the length-frequency of the bluehead sucker population to become strongly bimodal in 2000 (Figure 24). In 2001, the bluehead sucker population was largely centered around the 176-200 mm TL size-class (Figure 24). It appears as though small bluehead sucker (76-100 mm TL) from the October 2000 length-frequency histogram had grown approximately 100 mm by October 2001 (Figure 24).

With the large influxes of young fish, bluehead sucker mean TL values (for all life stages combined) dropped significantly riverwide between 1999 and 2000 and significantly again between 2000 and 2001 (Table A35, Figure 25). Riverwide, bluehead sucker mean TL values in 2001 were lower than in any of the five preceding years (i.e., 1996-2000; Table A35, Figure 25). In Reaches 4-2, bluehead sucker mean TL dropped significantly between 1999 and 2001 (Tables A38-A40, Figure 26) as young bluehead sucker originating from Reach 6 (Figure 21) dispersed downstream and colonized those river reaches (Figures 22-23).

Biomass

As the bluehead sucker population became dominated by larger adult fish in 1998 and 1999 (Figure 24) and mean TL riverwide rose to its highest observed levels (Figure 25), mean biomass followed suit, reaching its highest observed level in 1998 (Figure 27). Then, like mean TL, mean biomass dropped significantly to the levels observed in 2001 as juvenile fish spread riverwide and became more prominent in electrofishing collections (Table A41, Figure 27). Again, the influx of smaller fish into Reach 6 in 1999 and 2000 and Reaches 4-2 in 2001 caused corresponding drops in mean biomass (Figure 28).

As bluehead sucker CPUE reached its highs in 1999 and 2000 (Figures 20 and 21), bluehead sucker biomass per hour of electrofishing also peaked, as would be expected (Figure 27). Plots of bluehead sucker biomass collected per hour of electrofishing indicate that the vast majority of bluehead sucker biomass in the San Juan River occurs in Reaches 6 and 5, rapidly diminishing in downstream reaches, almost disappearing in Reach 2 and being completely absent in Reach 1 adjacent to Lake Powell (Figure 28).

Condition Factor

Riverwide, bluehead sucker mean condition factor showed a distinct yearly pattern of significant increases followed by significant declines until 2001, when mean condition factor increased for the second year in a row (Table A47, Figure 29). The riverwide pattern of bluehead sucker mean condition factor very closely resembled that for Reach 6, where the majority of bluehead sucker are located (Figures 29 and 30). Among reaches, bluehead sucker mean condition factor showed very few clear-cut trends, but there was a trend of generally decreasing mean condition factor in Reaches 5-3 between 1991 and 1997 (Figure 30). This trend reversed itself and generally increased in these three reaches between 1997 and 2001 (Figure 30).

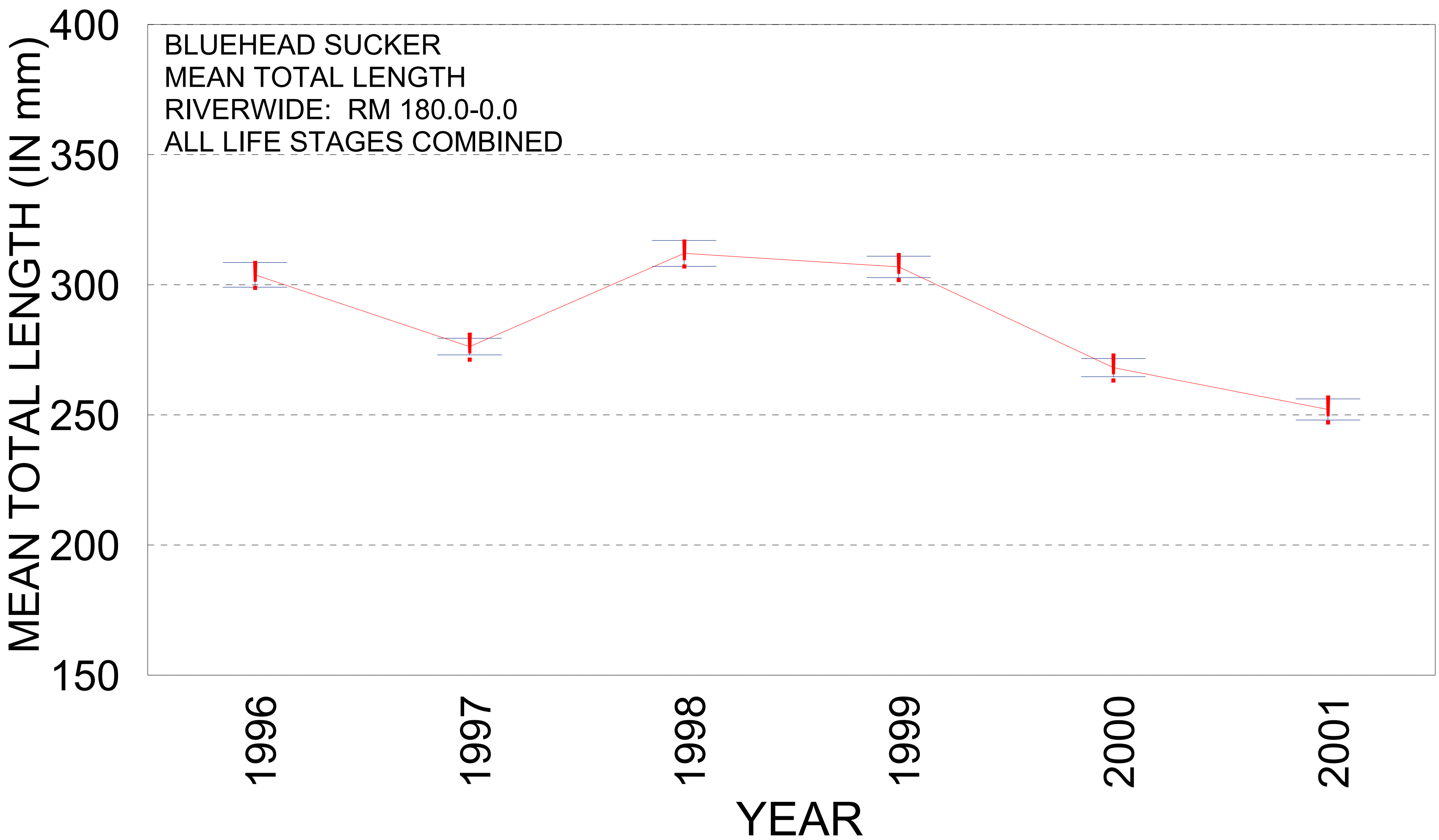

Figure 25. Mean total length (in mm) of bluehead sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

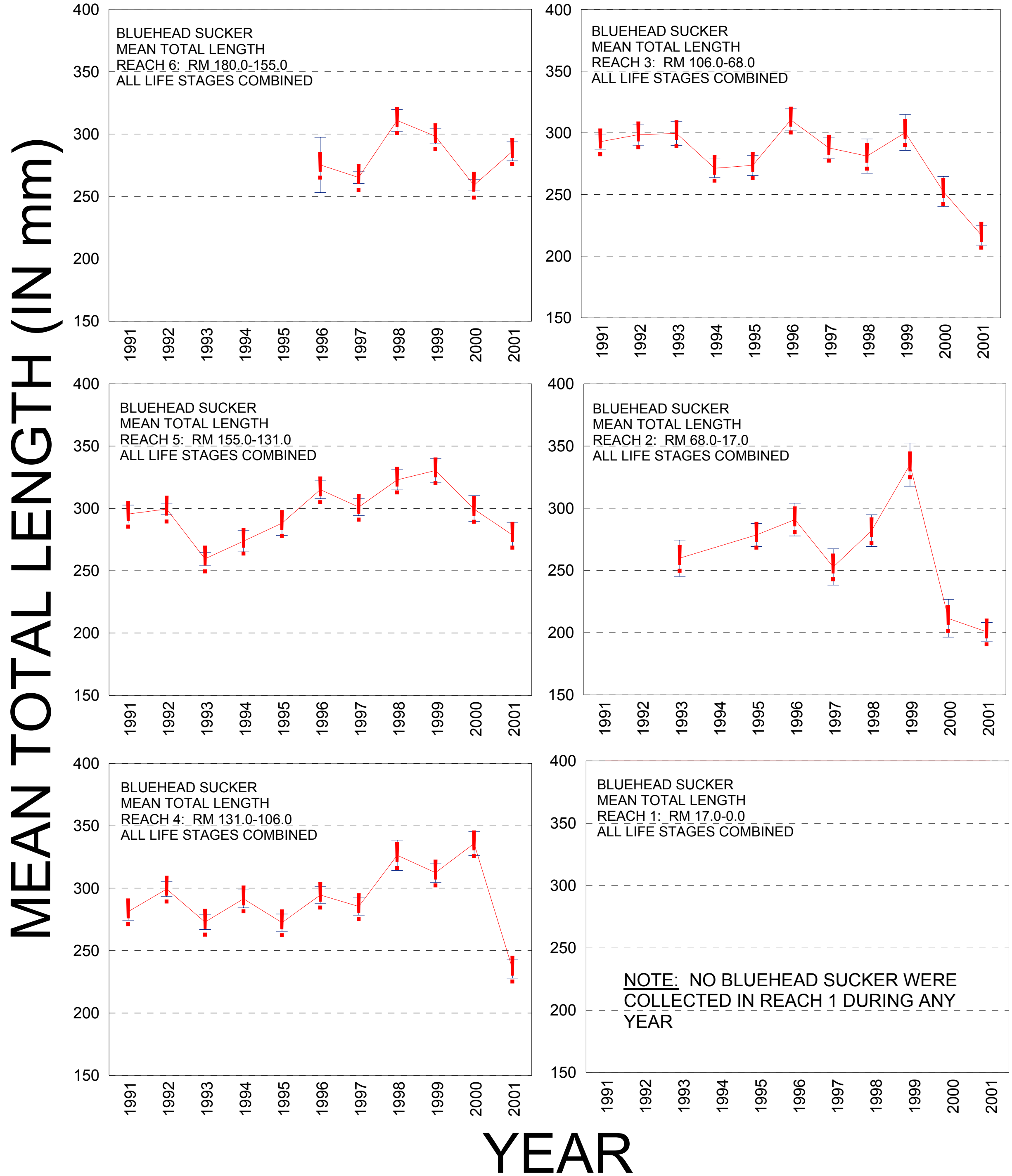

Figure 26. Mean total length (in mm) of bluehead sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

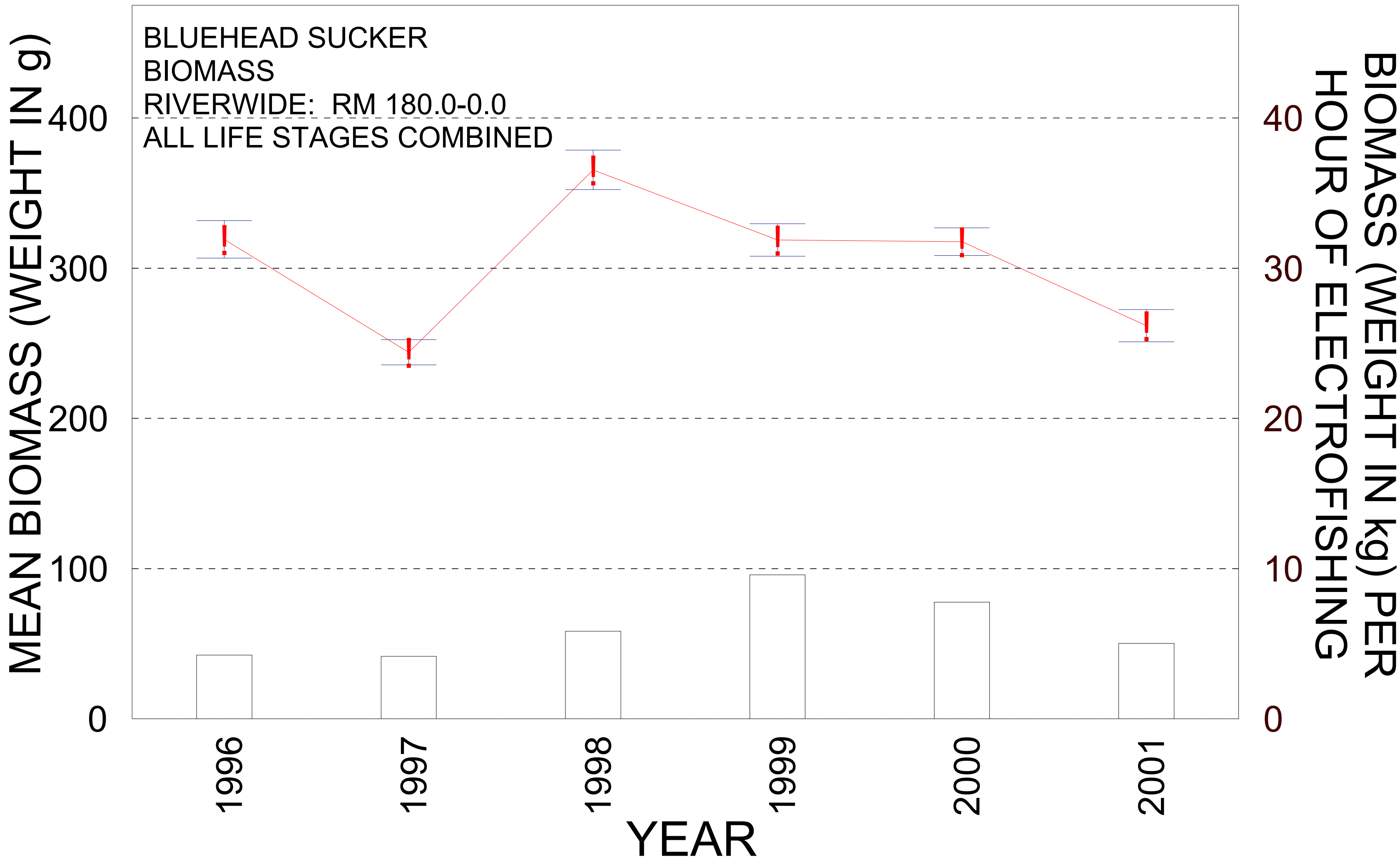

Figure 27. Mean biomass (line = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for bluehead sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001. Error bars represent the standard error values.

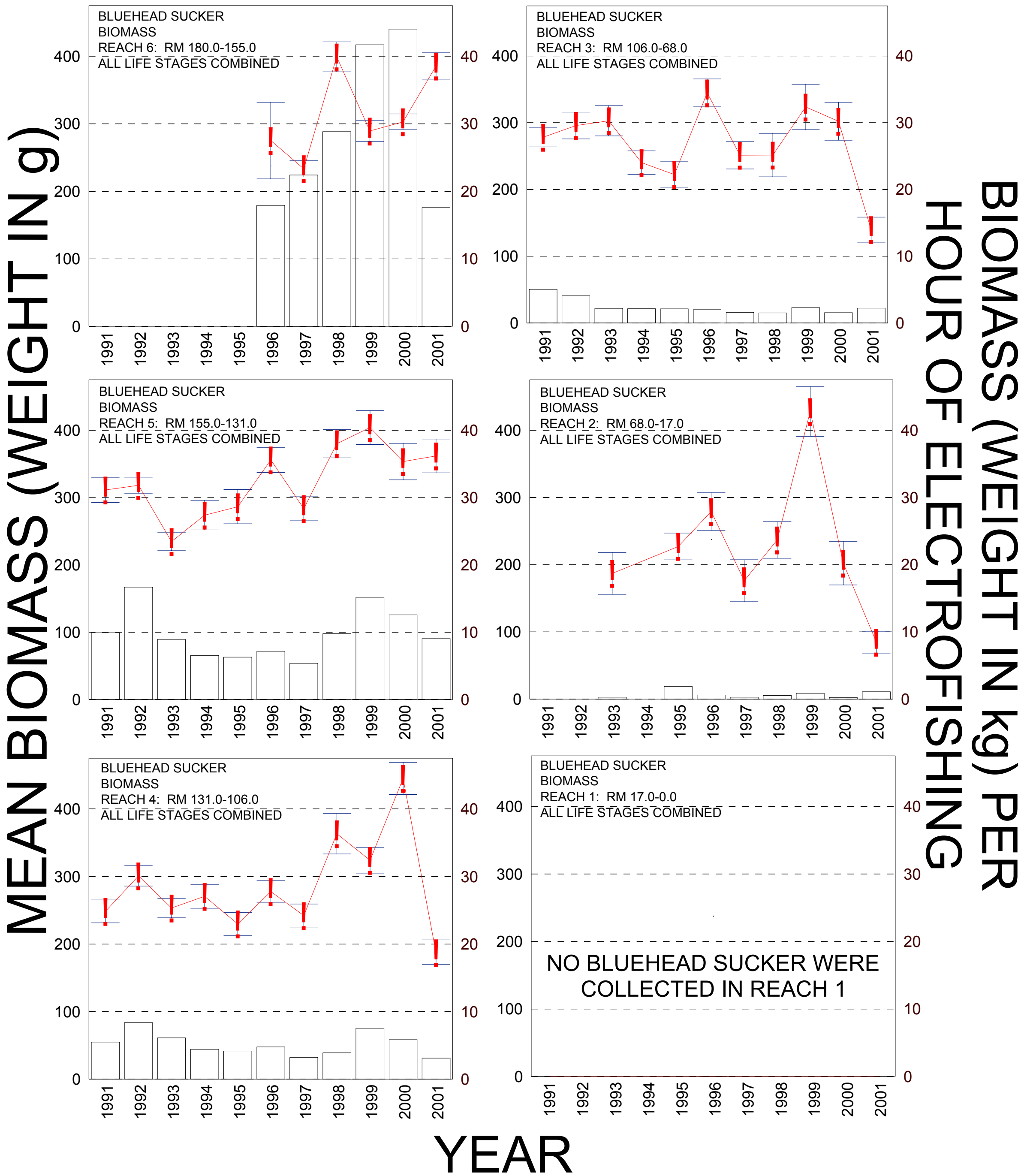

Figure 28. Mean biomass (lines = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for bluehead sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

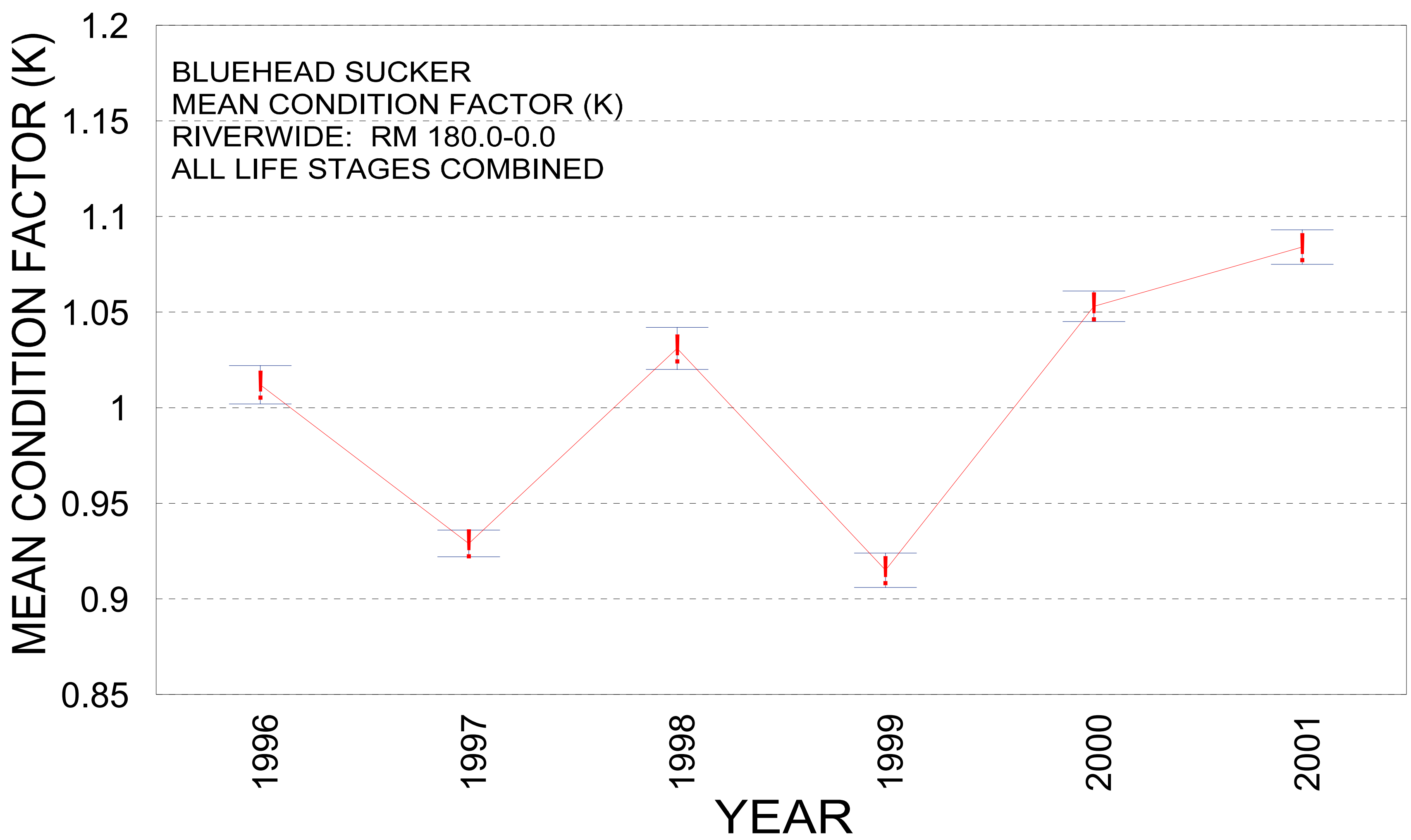

Figure 29. Mean condition factor (K) for bluehead sucker riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

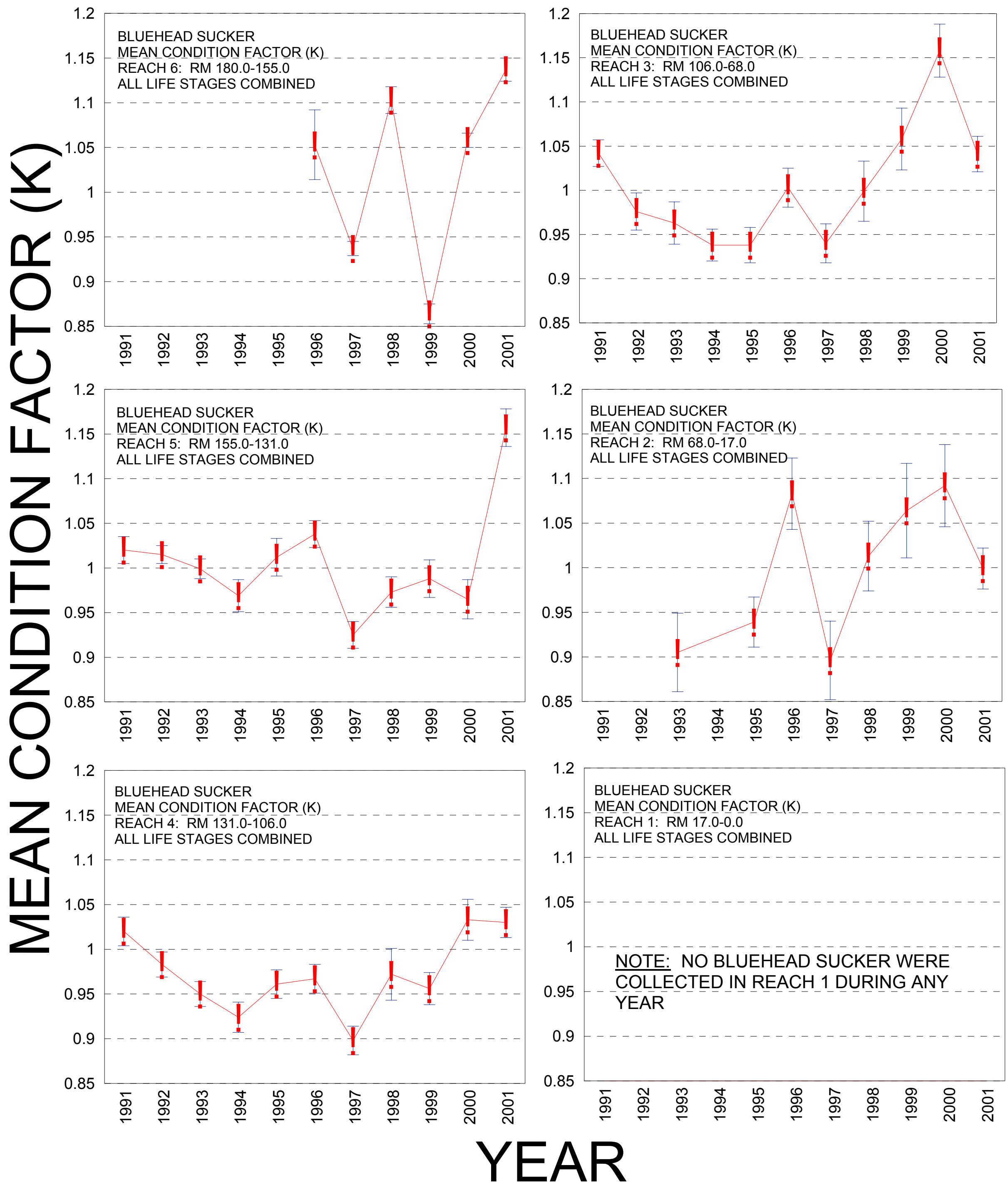

Figure 30. Mean condition factor (K) for bluehead sucker in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

Common Nonnative Fishes

Channel Catfish

Catch Per Unit Effort (CPUE)

Channel catfish are the most common nonnative fish collected on adult monitoring trips (Table 3). Channel catfish are ubiquitous, being collected in a myriad of habitat types (pers. obs.) and occasionally being collected in more individual electrofishing samples than even flannelmouth sucker (Table 3). Riverwide, total CPUE for channel catfish has risen significantly since 1998 (Table A53c, Figure 31). This increase has been predominantly caused by an increase in juvenile fish riverwide, although adult channel catfish CPUE riverwide has also risen slightly every year since 1997 (Figure 31). Among reaches trends in channel CPUE have been hard to discern at best. This has been due to very pronounced fluctuations in CPUE, especially among juvenile channel catfish. However, CPUE for both juvenile and adult channel catfish has been increasing steadily in Reach 5 since 1994 (Figure 32). This is likely complicating nonnative removal efforts in adjacent Reach 6 upstream, since there are more than enough channel catfish in Reach 5 to recolonize lower Reach 6 (i.e., downstream of PNM Weir, RM 166.6-155.0) on a regular basis after its resident channel catfish are mechanically removed. Upstream movement of channel catfish from the upstream end of Reach 5 into Reach 6 has been documented (J. Davis pers. comm.). Although harder to discern, there has been an upward trend in CPUE among juvenile channel catfish in Reaches 4, 3, and 2 and since the mid- to late 1990's depending upon the reach (Figures 33 and 34). Channel catfish are the second most commonly-collected large-bodied fish in Reach 1, adjacent to Lake Powell, after common carp (compare Figures 12, 23, 34, and 45). Statistical matrices comparing between-year CPUE values of channel catfish, both riverwide and for individual geomorphic reaches, are presented in Appendix A.

Length Frequency And Mean Total Length

As was the case with channel catfish CPUE, identifying clear-cut patterns in channel catfish length-frequency histograms is difficult. In 1996, the San Juan River channel catfish population was centered around the 301-325 mm TL size-class (Figure 35). However, channel catfish > 425 mm TL were regularly collected. By 1999, the channel catfish population had shifted to being centered around smaller size-classes and many fewer fish > 425 mm TL were being collected (Figure 35). Unlike native flannelmouth sucker and bluehead sucker and nonnative common carp, large numbers of age-0 channel catfish were not observed in 2000 collections (Figure 35). However, in 2001 the dominant size-class for channel catfish was 126-150 mm TL (Figure 35). These fish were likely spawned late in 2000, but were too small to be collected in the fall 2000 adult monitoring samples via electrofishing, thus it appears that channel catfish had as successful a reproductive year in 2000 as did the other three common, large-bodied fishes. The paucity of channel catfish > 425 mm TL in 1999-2001 collections would seem to indicate that nonnative fish removal is successful in decreasing the numbers of large size-class channel catfish in the San Juan River.

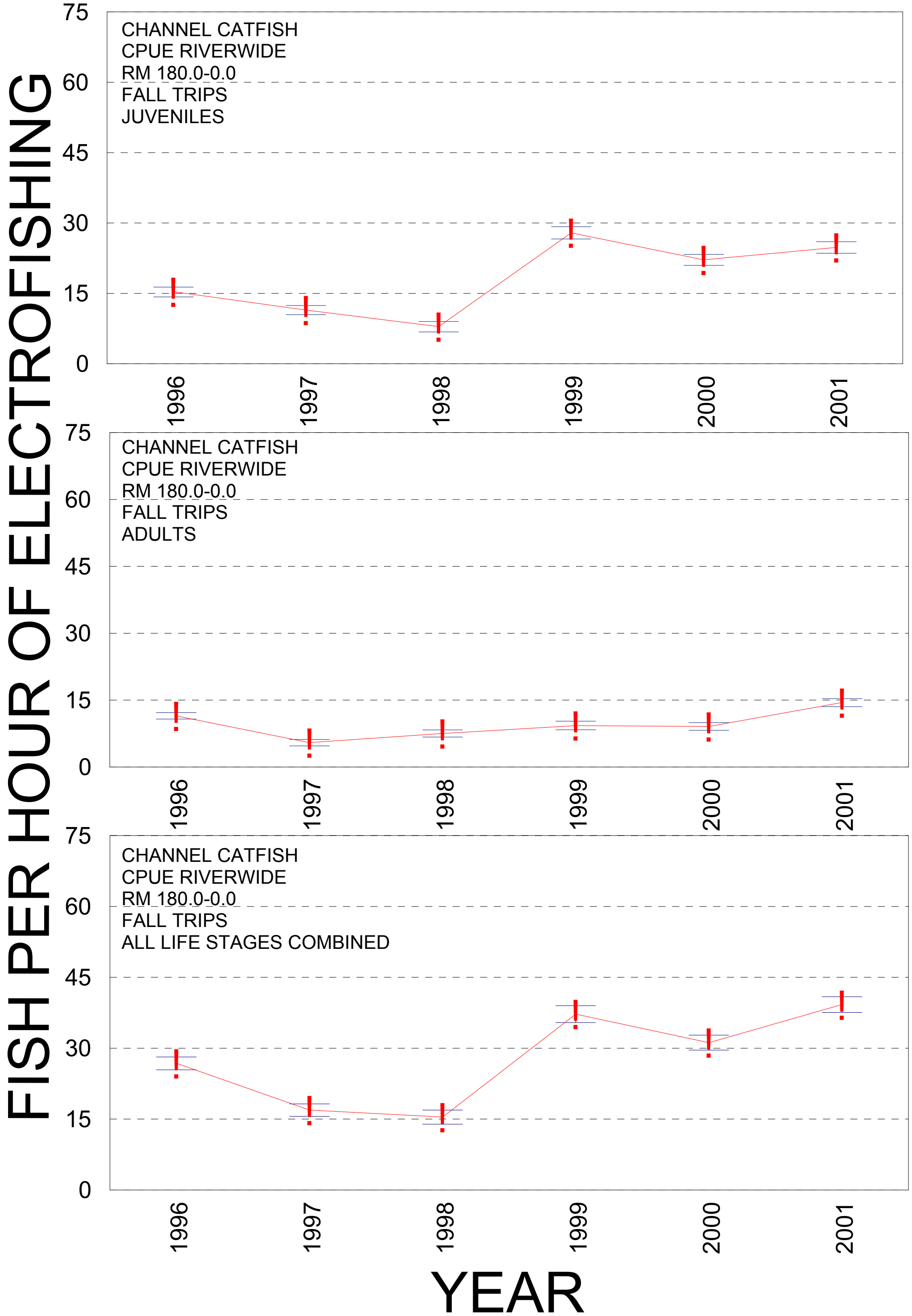

Figure 31. Channel catfish catch per unit effort (CPUE) riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001 for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

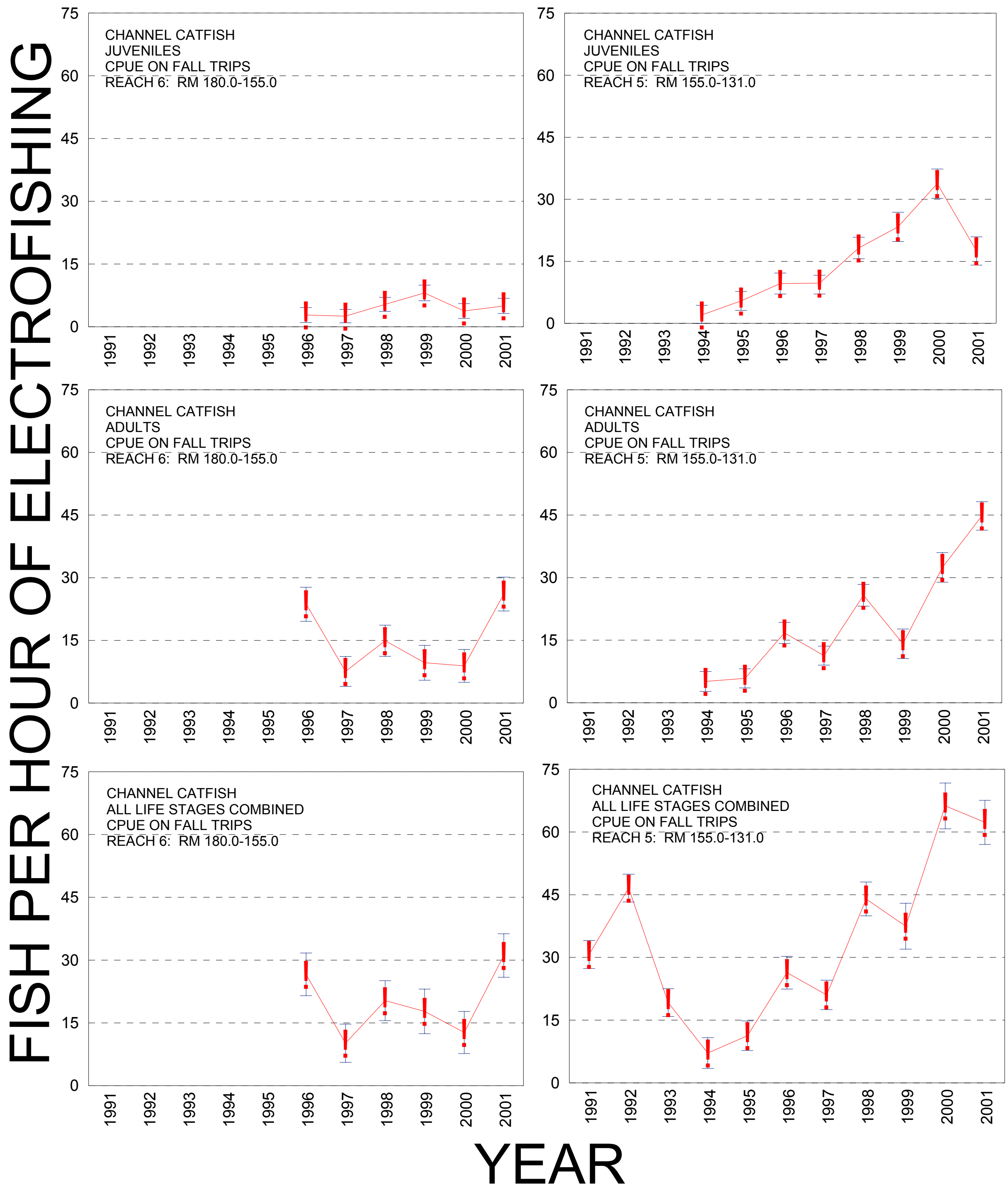

Figure 32. Channel catfish catch per unit effort (CPUE) in Reach 6 and Reach 5 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish ($\geq$ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

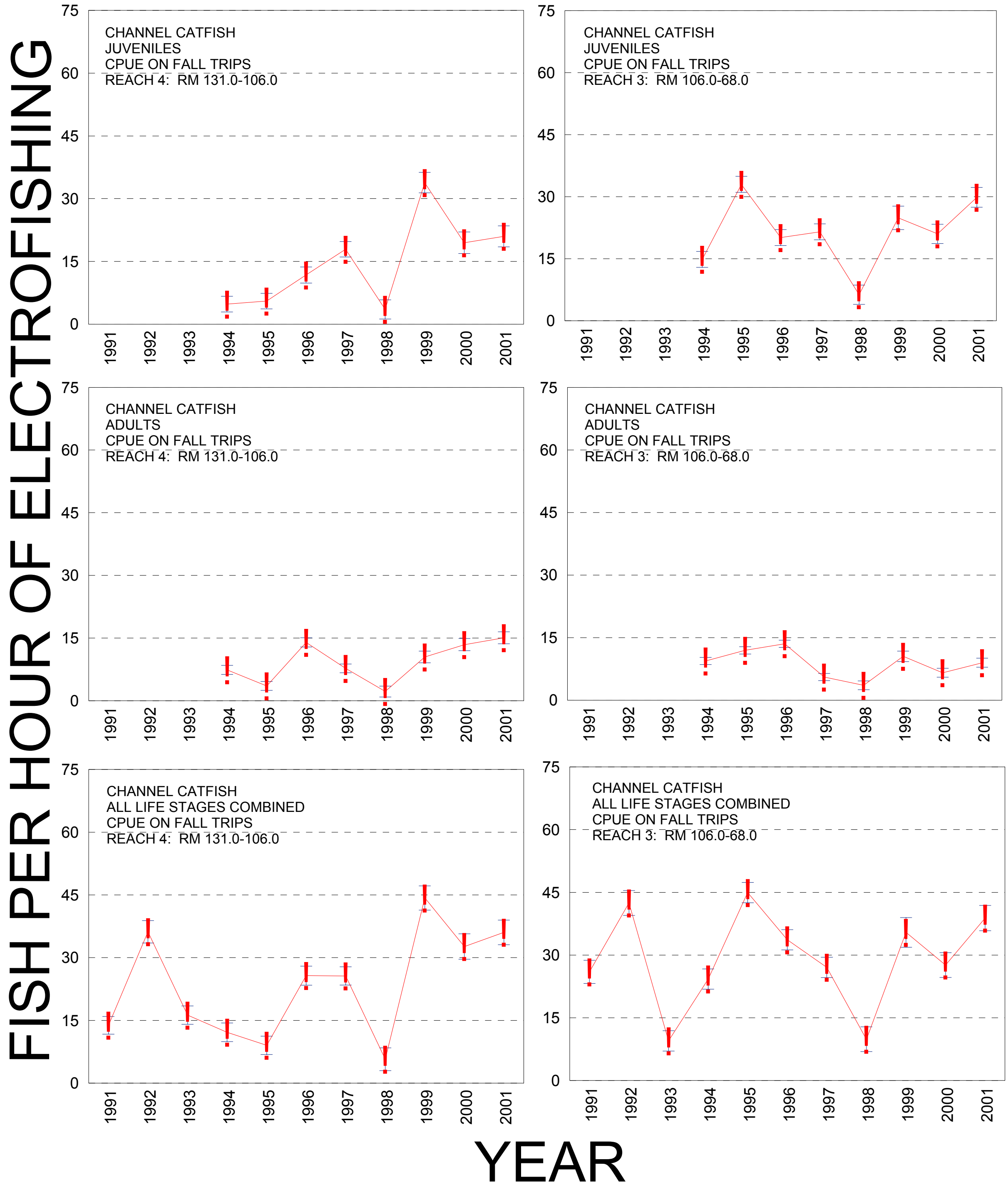

Figure 33. Channel catfish catch per unit effort (CPUE) in Reach 4 and Reach 3 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

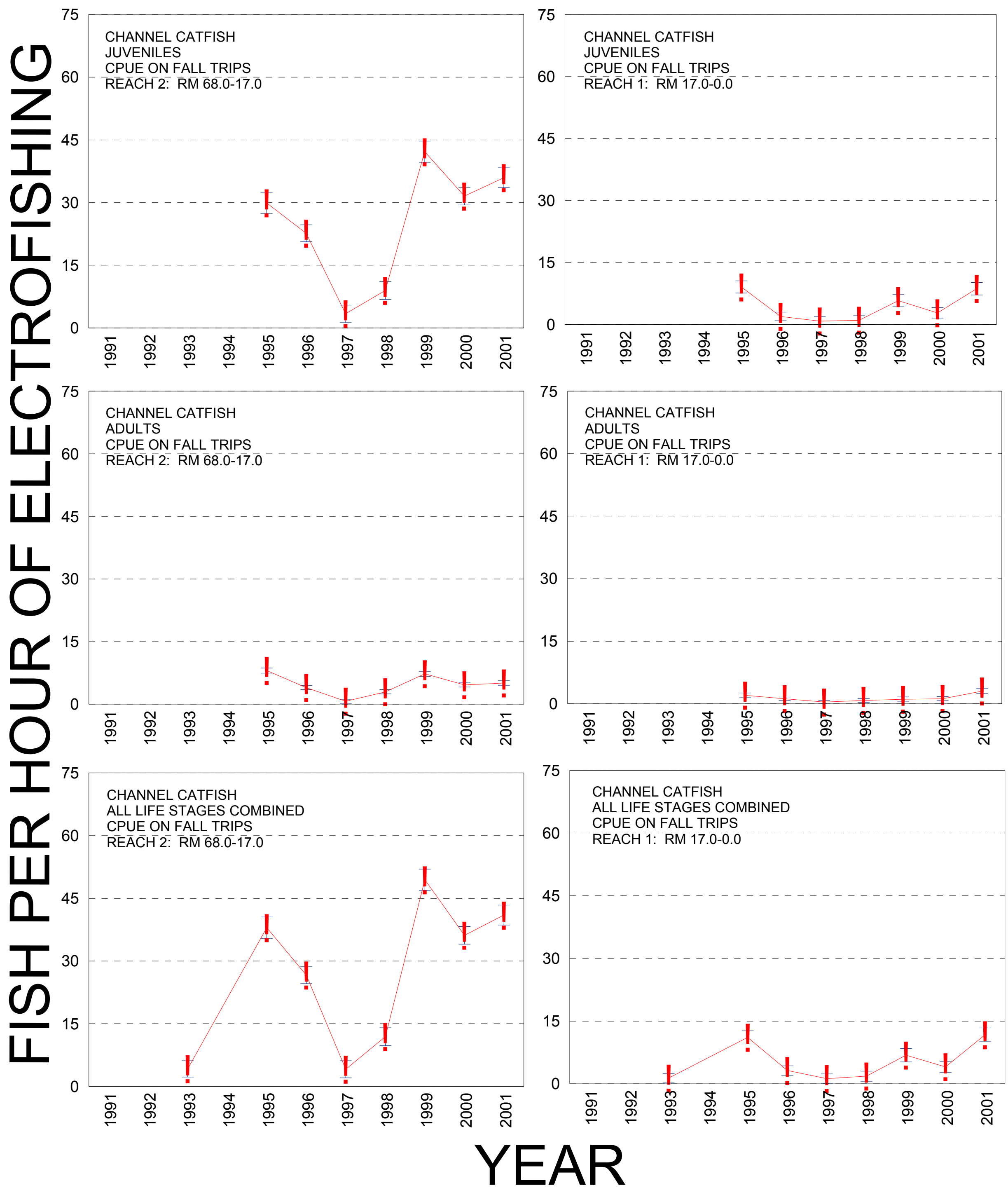

Figure 34. Channel catfish catch per unit effort (CPUE) in Reach 2 and Reach 1 on fall adult monitoring trips for juvenile fish (< 300 mm TL; top), adult fish ($\geq$ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

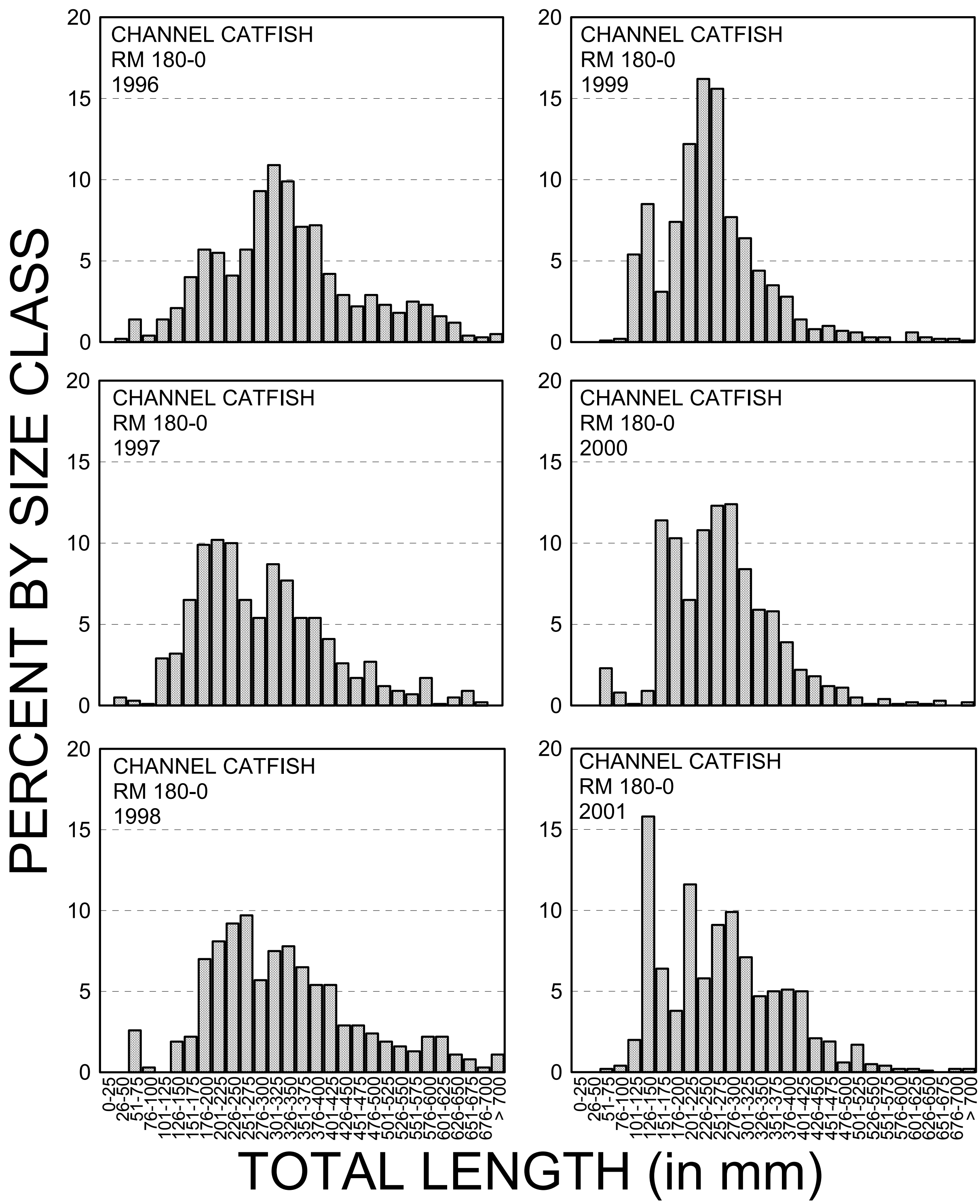

Figure 35. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of channel catfish on fall adult monitoring trips in the San Juan River, 1996-2001.

As was evidenced by the length-frequency histograms, channel catfish mean TL values riverwide (for all life stages combined) from 1999-2001 were significantly lower than they were from 1996-1998 (Table A60, Figure 36). This is due to the higher proportion of smaller fish in the channel catfish population from 1999-2001 (Figure 35). Among reaches, channel catfish mean TL fluctuated greatly depending upon the reach, but Reaches 6 and 3-1 showed a gradual declining trend (more marked in Reach 1) in mean TL over the years (Figure 37). However, the difference in mean TL between the beginning and end sampling years in any given river reach was significantly lower in only two cases (i.e., Reaches 2 and 1; Tables A61-A66, Figure 37).

Biomass

Riverwide, channel catfish mean biomass was significantly lower in the period 1999-2001 than at its highest point in 1998 (Tables A67, Figure 38). This is directly linked to the generalized shift of the San Juan River channel catfish population towards smaller size-class fish over the last several years (Figure 35). In 2001 channel catfish biomass per hour of electrofishing riverwide was at essentially the same level as at its high point in 1996, but not dramatically higher than 1997-2000 (Figure 38). So, while the San Juan River channel catfish population has noticeably shifted from larger to smaller size-class fish over the last several years, the overall biomass of channel catfish in the San Juan River has changed little if at all (Figure 38). Among reaches, channel catfish mean biomass showed general downward trends in all six river reaches from about 1993 on (1994 in the case of Reach 4; Figure 39). This downward trend in mean biomass logically follows the downward trend in mean TL observed among channel catfish. However, in three reaches (Reaches 6, 5, and 1), there has been a marked (though not significant) increase in mean biomass in the last year to three years (Tables A68, A69, and A73, Figure 39). In only two reaches (Reach 3 and 2) were mean biomass values significantly different (i.e., lower) in 2001 than they were in the first year in which that reach was sampled (Tables A71 and A72, Figure 39).

Plots of channel catfish biomass collected per hour of electrofishing indicate that the channel catfish biomass drops steadily in each contiguous downstream river reach, almost disappearing by Reach 1. The increase in channel catfish biomass per hour of electrofishing in Reach 1 in 2001 (Figure 39), along with corresponding increases in CPUE (Figure 34) and mean TL (Figure 37), could be indicative of larger juvenile and/or smaller adult (approximately 250-300 mm TL) channel catfish invading Reach 1 from Lake Powell.

Condition Factor

Riverwide, channel catfish mean condition factor has not changed markedly in the last six years (Figure 40). In fact, channel catfish mean condition factor riverwide in 2001 was significantly different from only one of the preceding five years, 1999, which it was significantly higher than (Table A74, Figure 40). This held true among reaches as well. Despite fluctuations in channel catfish mean condition factor in individual reaches river the years (including significant drops in mean condition factor in Reach 6 in 1999 and Reach 5 in 1998), in only one reach (Reach 2) was the mean condition factor value significantly different (i.e., lower) in 2001 than in the first year in which this reach was sampled (Tables A75-A80, Figure 41).

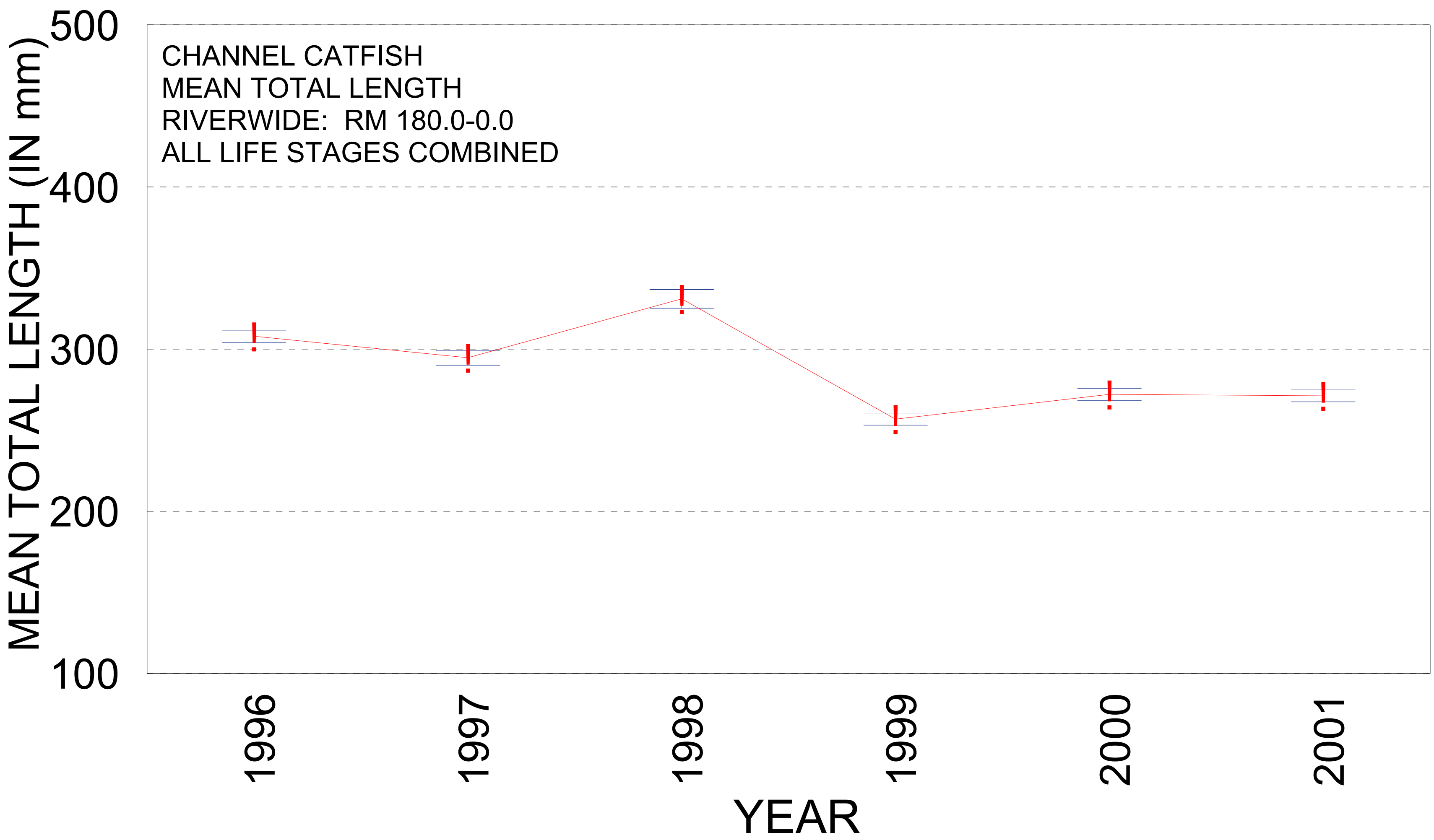

Figure 36. Mean total length (in mm) of channel catfish riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

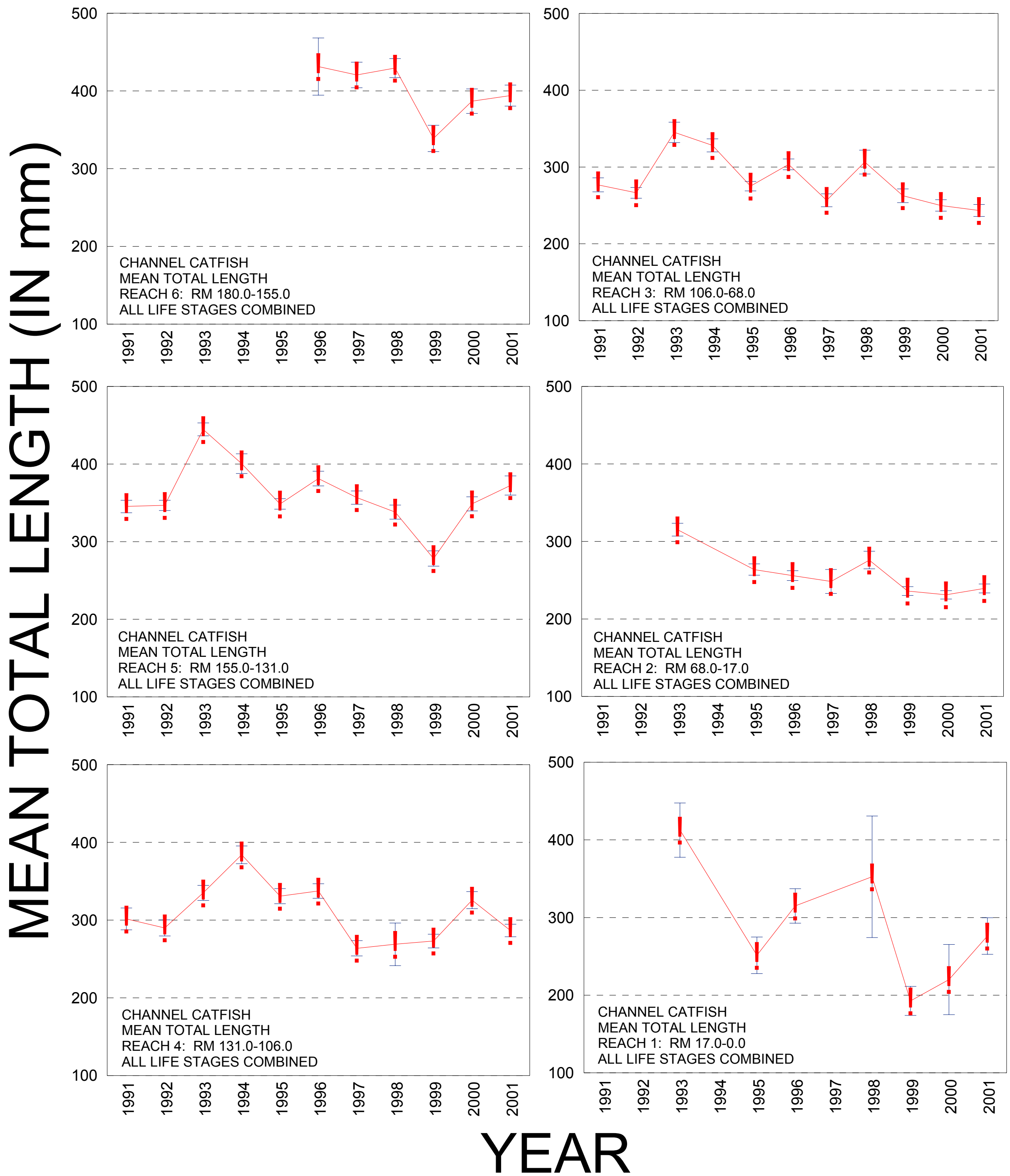

Figure 37. Mean total length (in mm) of channel catfish in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

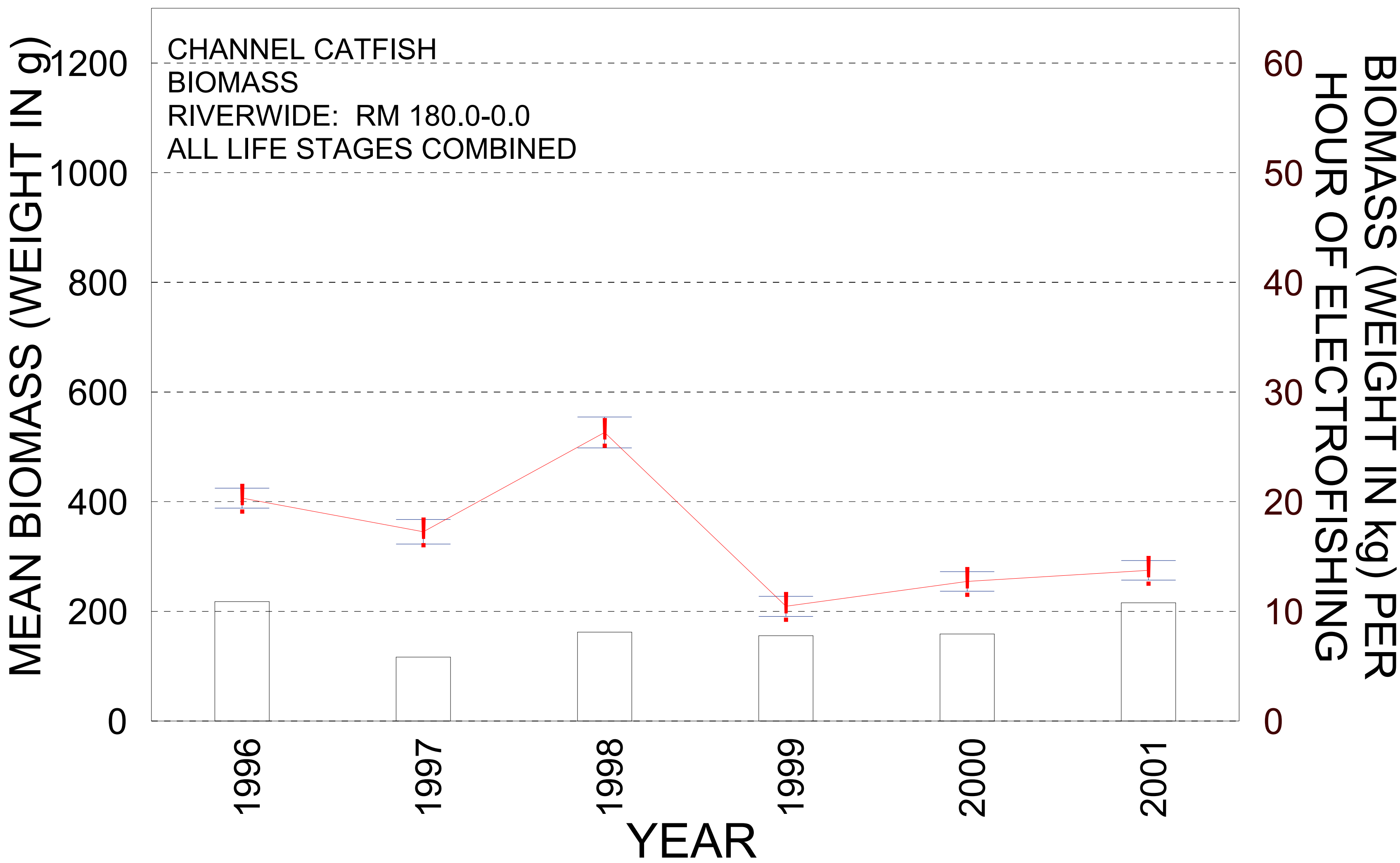

Figure 38. Mean biomass (line = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for channel catfish riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001. Error bars represent the standard error values.

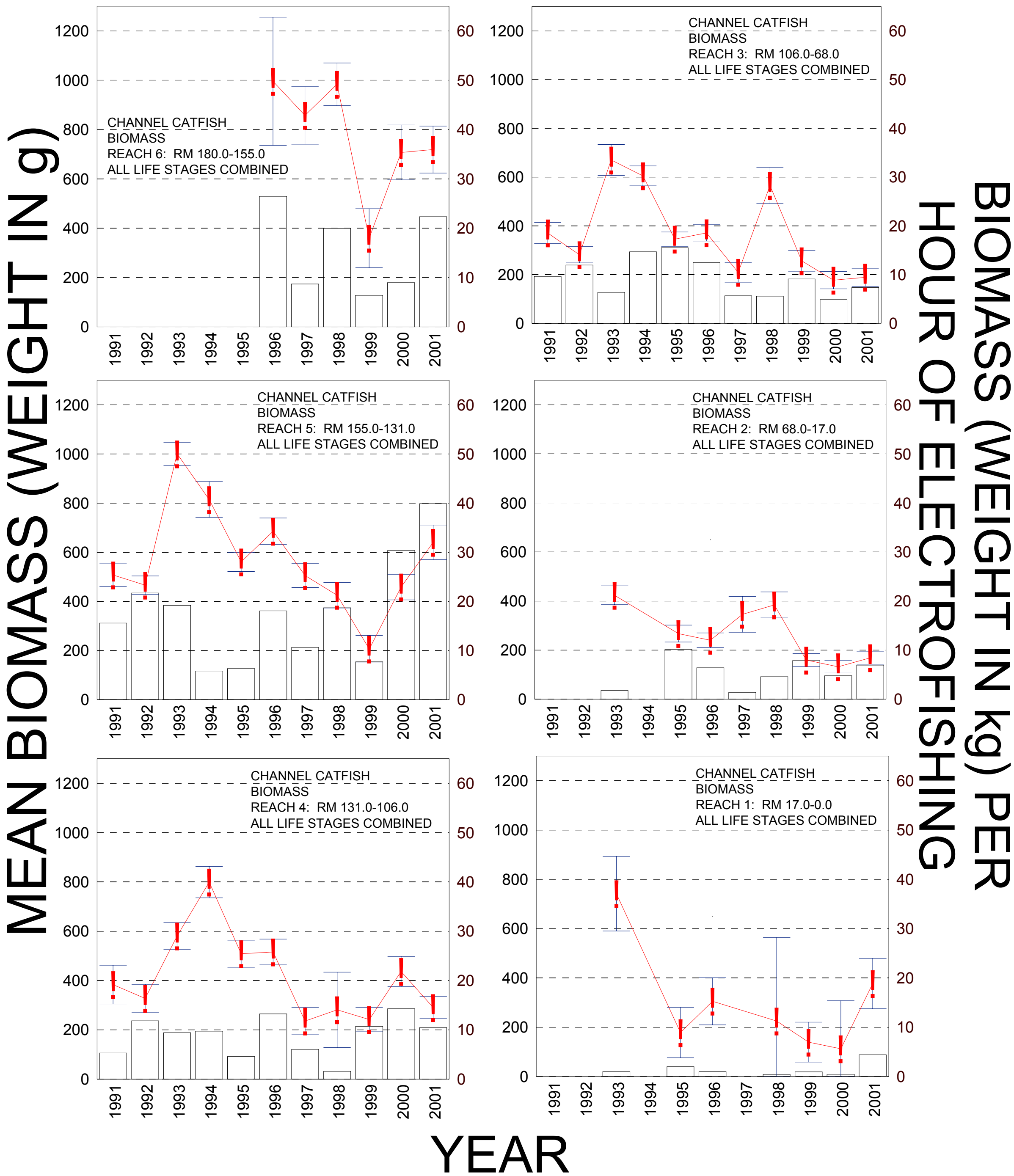

Figure 39. Mean biomass (lines = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for channel catfish in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

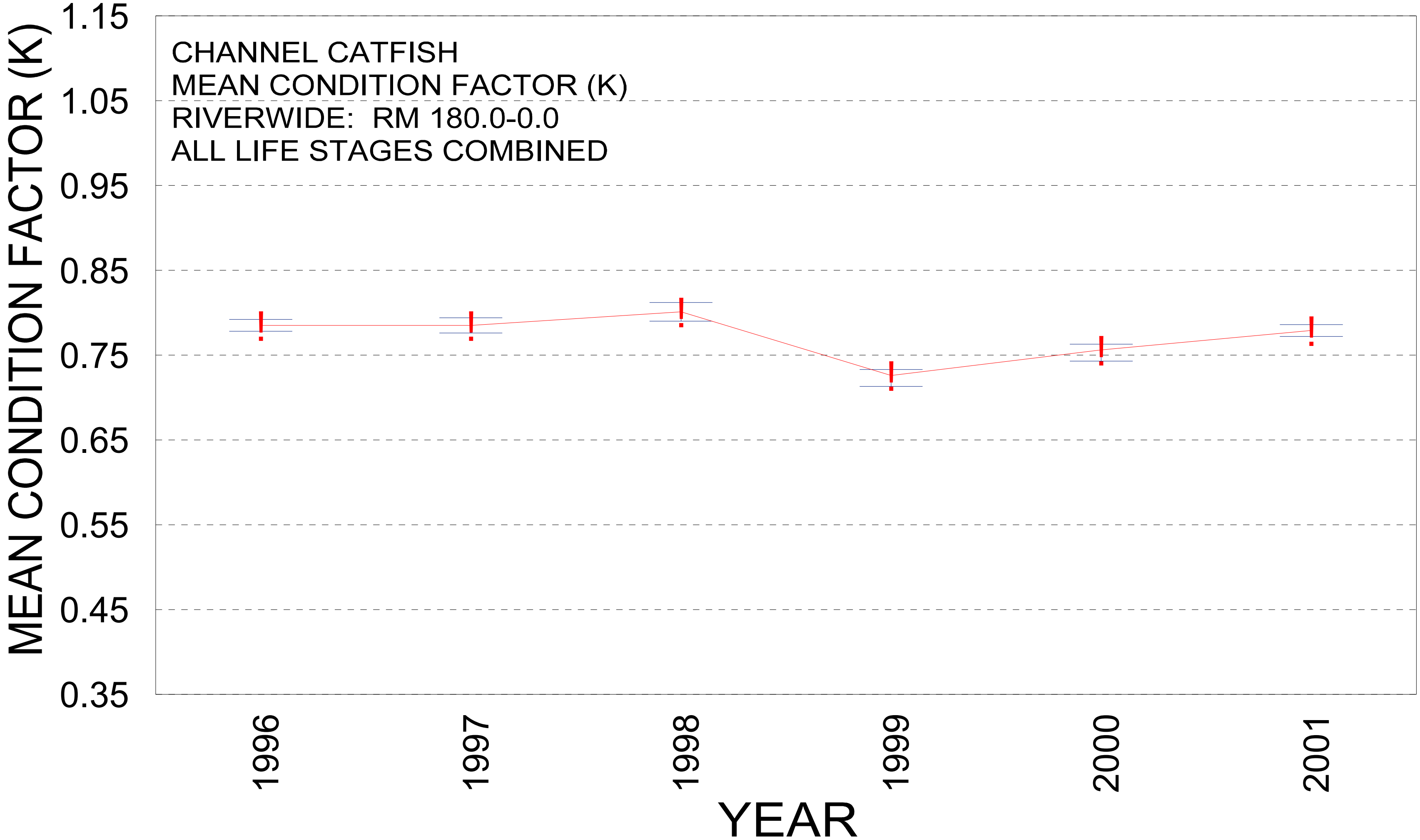

Figure 40. Mean condition factor (K) for channel catfish riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

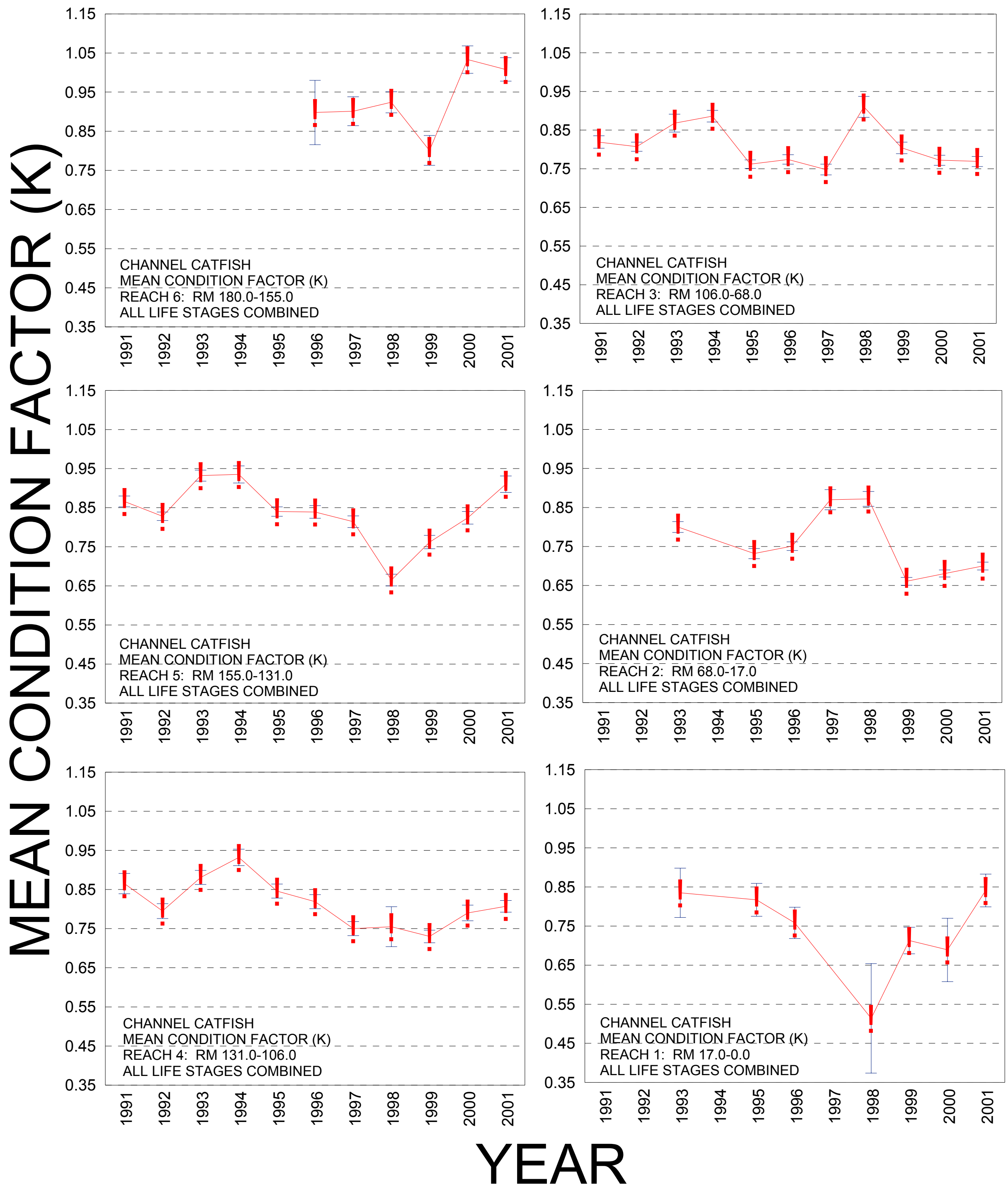

Figure 41. Mean condition factor (K) for channel catfish in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

Common Carp

Catch Per Unit Effort (CPUE)

Riverwide, common carp total CPUE has not changed significantly since 1997, despite ongoing mechanical removal efforts (Table A81c, Figure 42). However, conspicuous among riverwide collections of common carp was the collection of a relatively large number of juvenile fish in 2000 (Figure 42). This particular life stage of common carp is usually very rare or completely absent from electrofishing samples (Figures 43-45). However, in 2000 juvenile common carp were conspicuous in their relative abundance in Reaches 6-4 and 1 (Figures 43 and 44). Numerically, the majority of the juvenile common carp collected in 2000 were collected in Reach 6, upstream of the PNM Weir (RM 166.6), mirroring the phenomenon that was observed among flannelmouth sucker and bluehead sucker in 2000 (Figures 10, 21, and 43; Ryden 2000a). Statistical matrices comparing between-year CPUE values of common carp, both riverwide and for individual geomorphic reaches, are presented in Appendix A.

Trying to discern trends in adult common carp CPUE in individual reaches over the years has been difficult. Numbers of adult common carp in any given reach tend to fluctuate dramatically between years, making overall trends hard to fathom. It seems somewhat odd that riverwide, adult CPUE remains relatively stable between years (Figure 42) while adult CPUE among reaches varies so considerably from year to year (Figures 43-45). It is possible that this could be an indication of fairly large-scale movements of adult common carp between reaches. However, even with the variable adult CPUE's, there are two trends that seem to stand out. In Reach 6, CPUE among adult common carp steadily declined between 1996 (when nonnative removal efforts began) and 2000 (Figure 43). If this trend is linked to the intensive mechanical removal efforts that are ongoing in that reach, it would be the first indication that fisheries managers are able to have a profound effect on the numbers of common carp through mechanical manipulation.

Length Frequency And Mean Total Length

Riverwide length-frequency histograms of common carp show a population whose main channel component is based very heavily (typically 20-30% of collected individuals) around large adult fish, (the 426-450 mm TL size-class in all years except 2000; Figure 46). Even in 2000, when relatively large numbers of age-0 common carp (based around the 76-100 mm TL size-class) were collected, causing a bimodal length-frequency histogram, the larger of the two modes was still based around large, adult fish (i.e., the 451-475 mm TL size-class; Figure 46).

Common carp mean TL for all life stages combined riverwide rose steadily (and significantly) between 1996 and 2001, with the exception of one year, 2000 (Table A88, Figure 47). The significant drop in mean TL observed riverwide among common carp in 2000 (Figure 47) was an artifact of the collection of large numbers of age-0 fish in Reaches 6-4 and 1 (Figures 43 and 44). Among reaches, common carp mean TL was higher in all reaches in 2001 than in the first year any given Reach was sampled (Figure 48). In Reaches 5, 4, 3, and 2 these differences were significant (Tables A90-A93, Figure 48). Notable among mean TL values for individual reaches is the very marked drop in mean TL in Reach 6 and corresponding smaller drops in mean TL

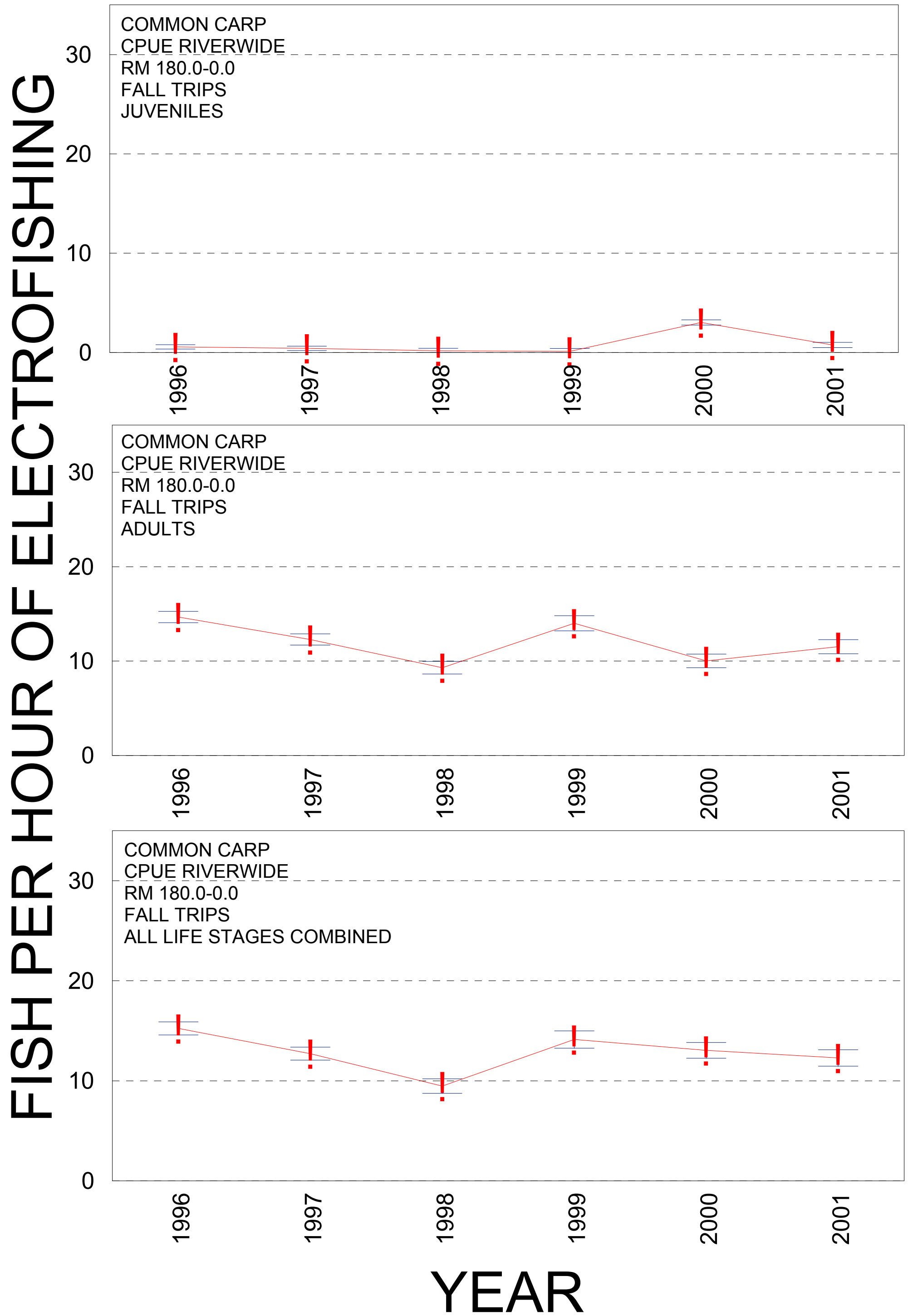

Figure 42. Common carp catch per unit effort (CPUE) riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001 for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

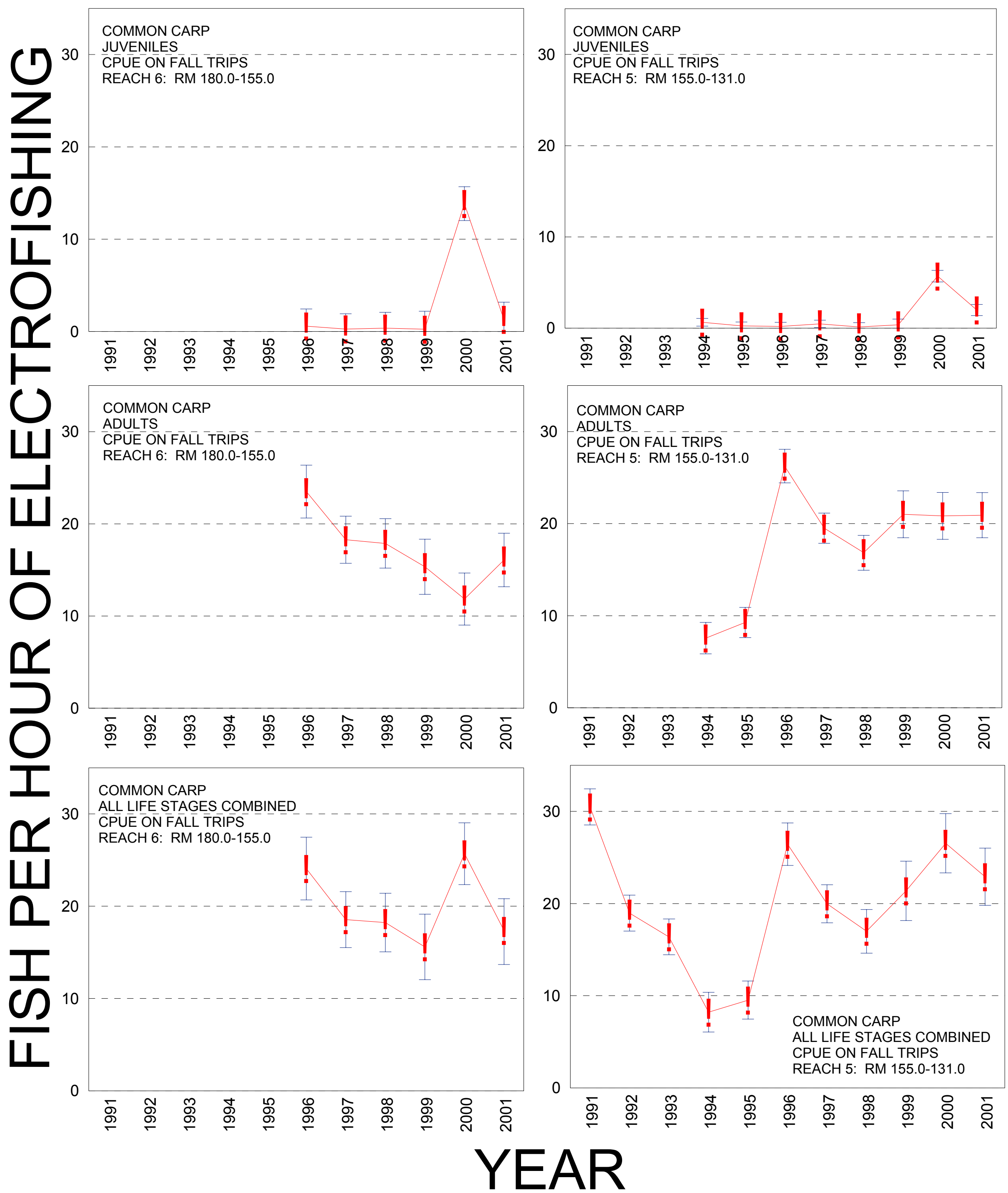

Figure 43. Common carp catch per unit effort (CPUE) in Reach 6 and Reach 5 on fall adult monitoring trips for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

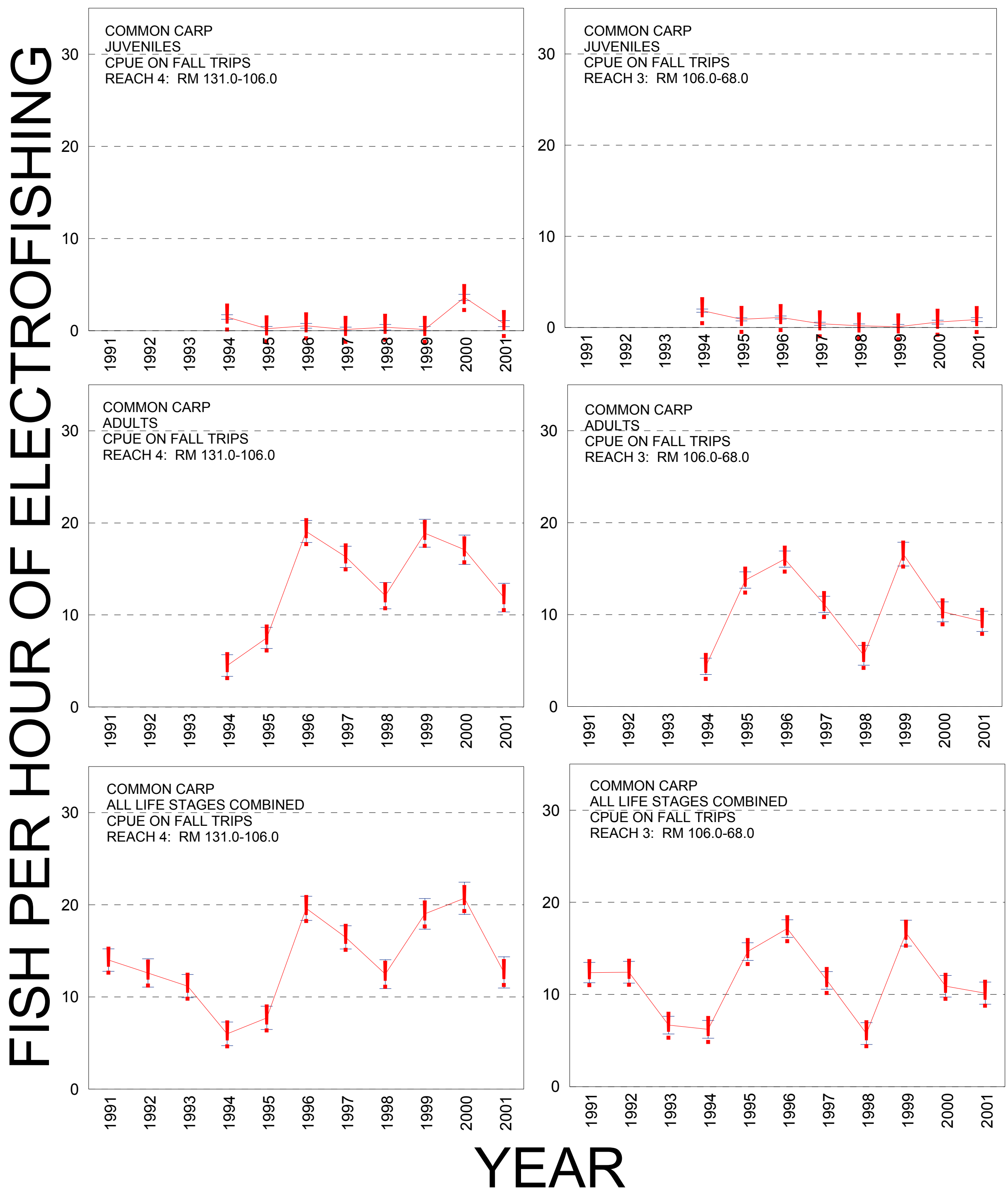

Figure 44. Common carp catch per unit effort (CPUE) in Reach 4 and Reach 3 on fall adult monitoring trips for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

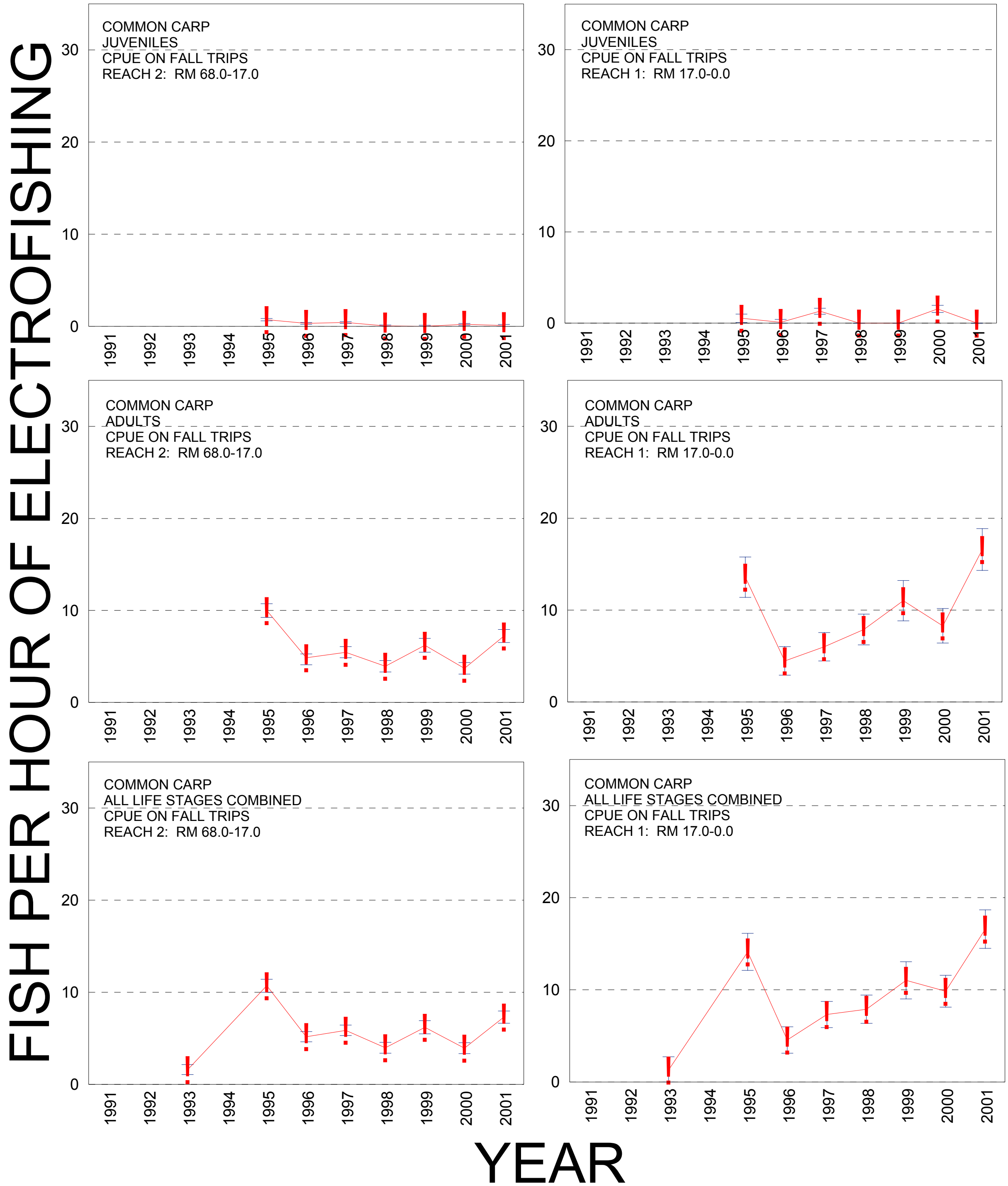

Figure 45. Common carp catch per unit effort (CPUE) in Reach 2 and Reach 1 on fall adult monitoring trips for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars represent the standard error values.

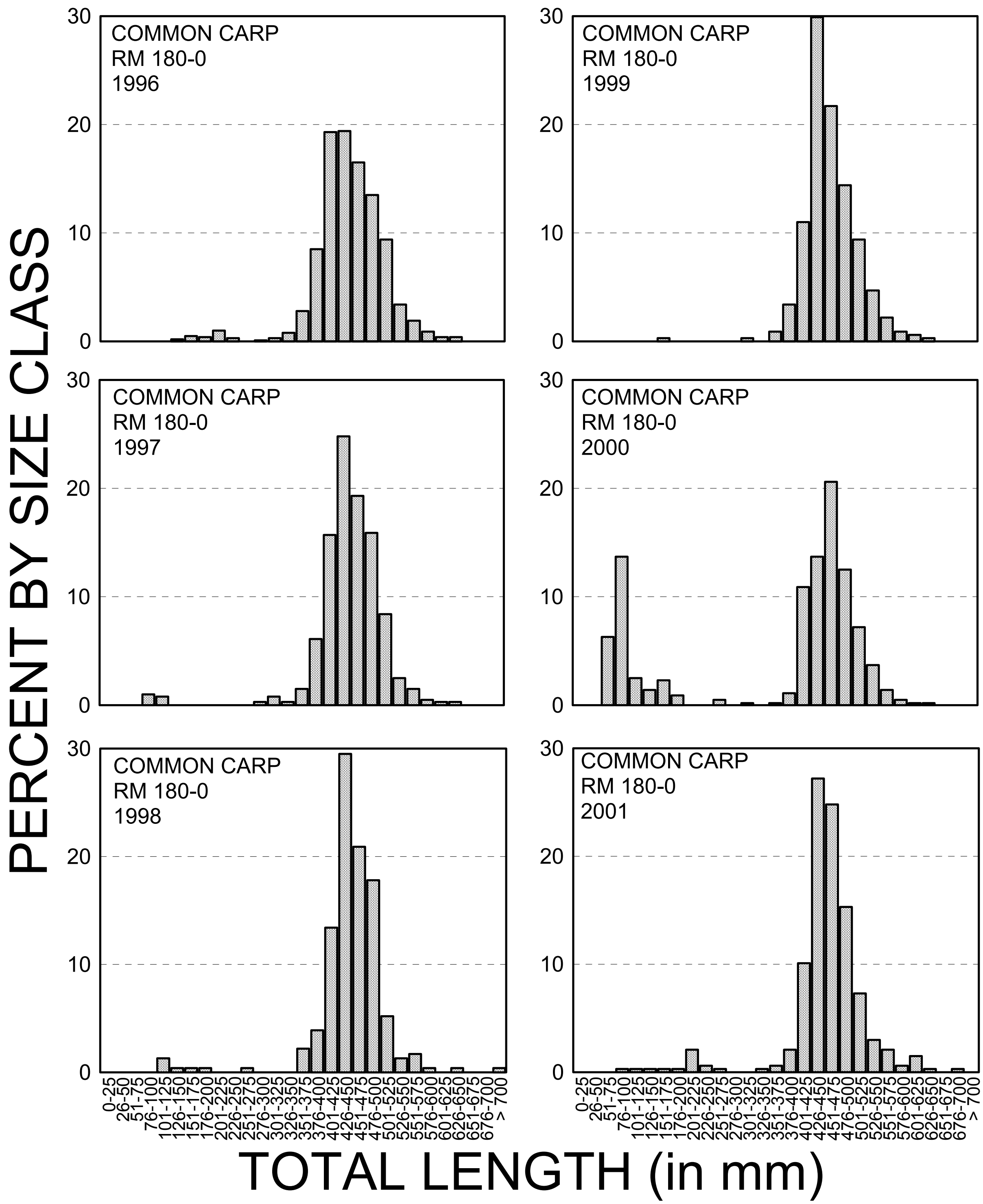

Figure 46. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of common carp on fall adult monitoring trips in the San Juan River, 1996-2001.

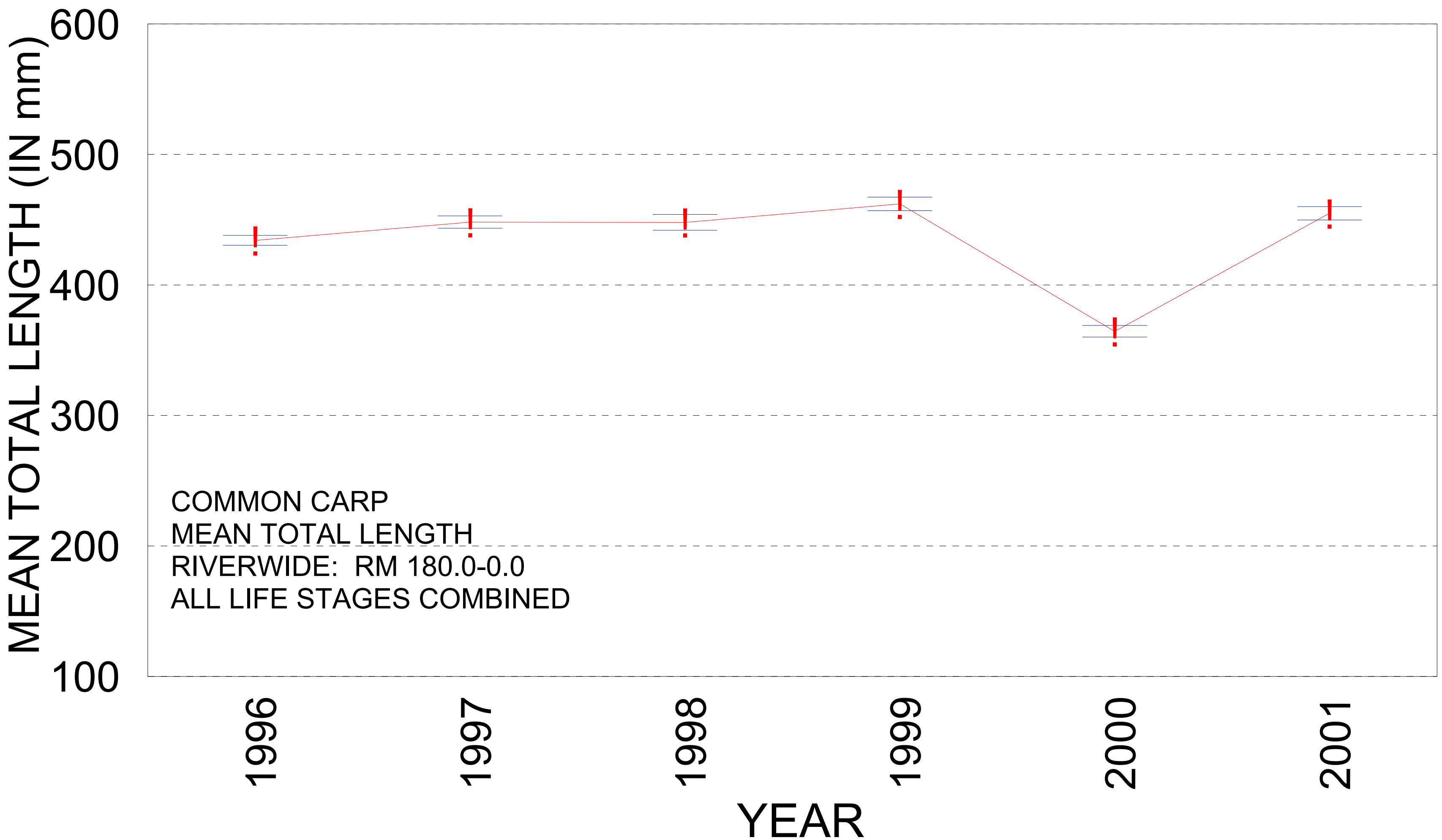

Figure 47. Mean total length (in mm) of common carp riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

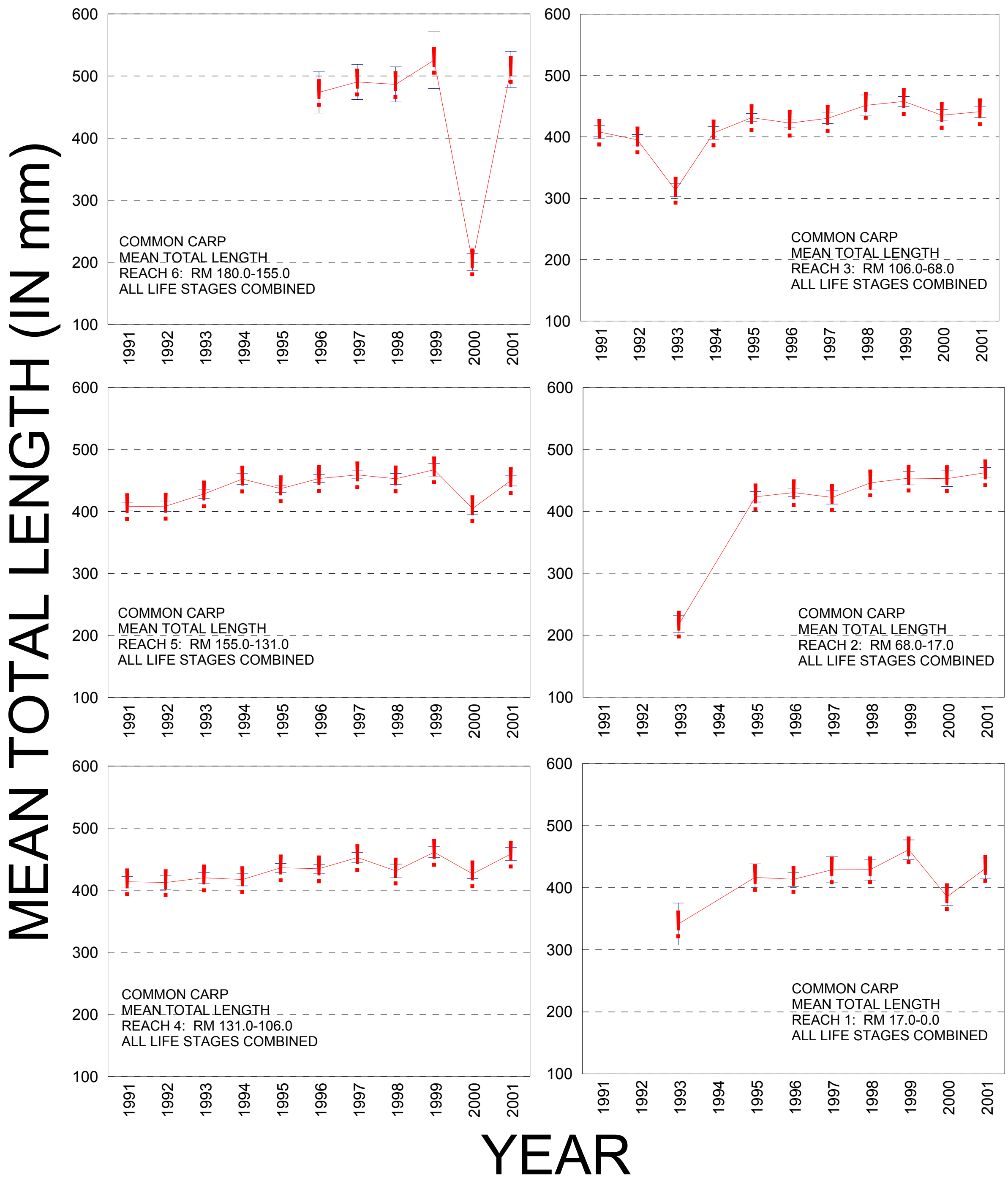

Figure 48. Mean total length (in mm) of common carp in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

in downstream Reaches 5, 4, and 1 (Figure 48). The other notable change in common carp mean TL occurred in Reach 2 and to a lesser degree in Reach 1, between 1993 and 1995, when mean TL values increased greatly, essentially doubling in Reach 2 at the same time the lower San Juan River became reconnected with Lake Powell (Figure 48). This points to a possible invasion of the lower San Juan River by larger common carp from Lake Powell once the waterfall at RM 0.0 was inundated.

Biomass

Riverwide, common carp mean biomass for all life stages combined tracked very logically with riverwide values for mean TL (Figures 47 and 49), increasing significantly between 1996 and 2001, with the exception of 2000 (Table A95). So as common carp in the San Juan River have generally gotten longer over the last six years, they have also gotten heavier. Again, the drop in mean biomass of common carp riverwide in 2000 was an artifact of the collection of the large number of age-0 fish in Reaches 6-4 and 1 that year (Figures 43-45 and 49). Among reaches, this same general upward trend in mean biomass over time was observed in all six river reaches over their relative sampling periods, again with the exception of Reach 6 in 2000 (Figure 50). In Reaches 6-2, common carp mean biomass values in 2001 were significantly higher than in the first year those reaches were sampled (Tables A96-A100, Figure 50).

Plots of common carp biomass collected per hour of electrofishing indicate that the common carp biomass drops steadily between Reaches 6 and 2, then rises again slightly in Reach 1, adjacent to Lake Powell (Figure 50). Interestingly, common carp biomass per hour of electrofishing in both Reaches 2 and 1 were very minimal in 1993 when these reaches were isolated from Lake Powell, but were significantly higher in the period 1995-2001 after the waterfall at RM 0.0 became inundated. This again points to an invasion of the lower river by nonnative fishes from Lake Powell. However, even with these increased biomass per hour of electrofishing values in Reaches 2 and 1, the bulk of common carp biomass in the San Juan River still occurs in Reaches 6-4. The precipitous drop in common carp mean biomass in Reach 6 in 2000 is an artifact of the relatively large number of juvenile fish collected in that reach that year and corresponds with a similar drop in mean TL (Figures 43 and 50).

Condition Factor

Riverwide, common carp mean condition factor for all life stages combined did not change significantly between the 1996 and 2001 (Table A102, Figure 51). Among reaches, common carp mean condition factor showed few clear patterns (Figure 52). In Reach 6, common carp mean condition factor rose steadily and significantly between 1997 and 2001 (Table A103, Figure 52) and in Reach 1 there was a significant increase in common carp mean condition factor between 1995 and 2001 (Table A108, Figure 52), although the overall upward trend in condition factor in Reach 1 over time was much less clear than in Reach 6. In the other reaches, trends in common carp mean condition factor were much more ambiguous. In none of the six reaches were the 2001 values significantly different than in the first year in which a given reach was sampled (Tables A103-A108, Figure 52).

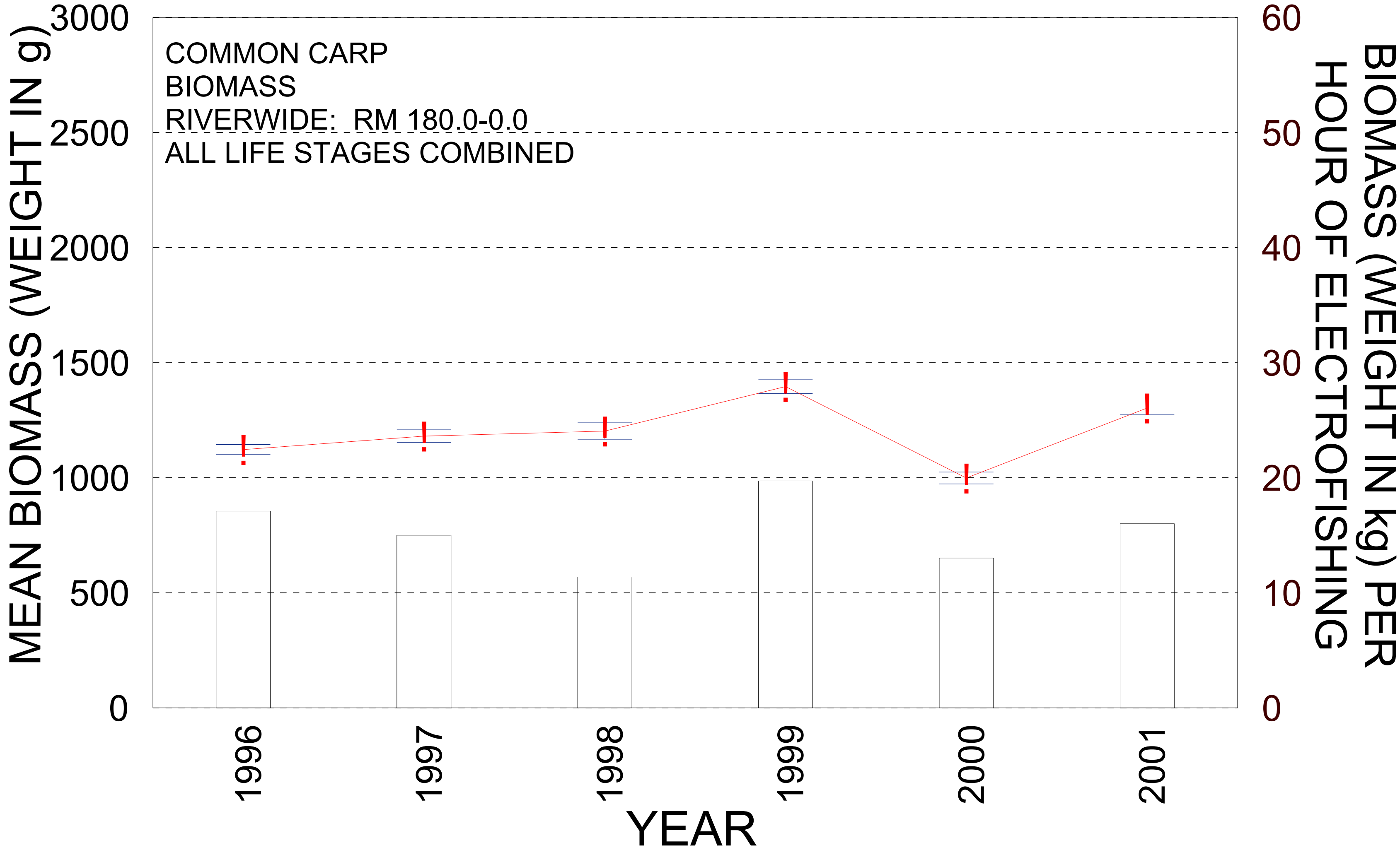

Figure 49. Mean biomass (line = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for common carp riverwide (RM 180.0-0.0) on fall adult monitoring trips, 1996-2001. Error bars represent the standard error values.

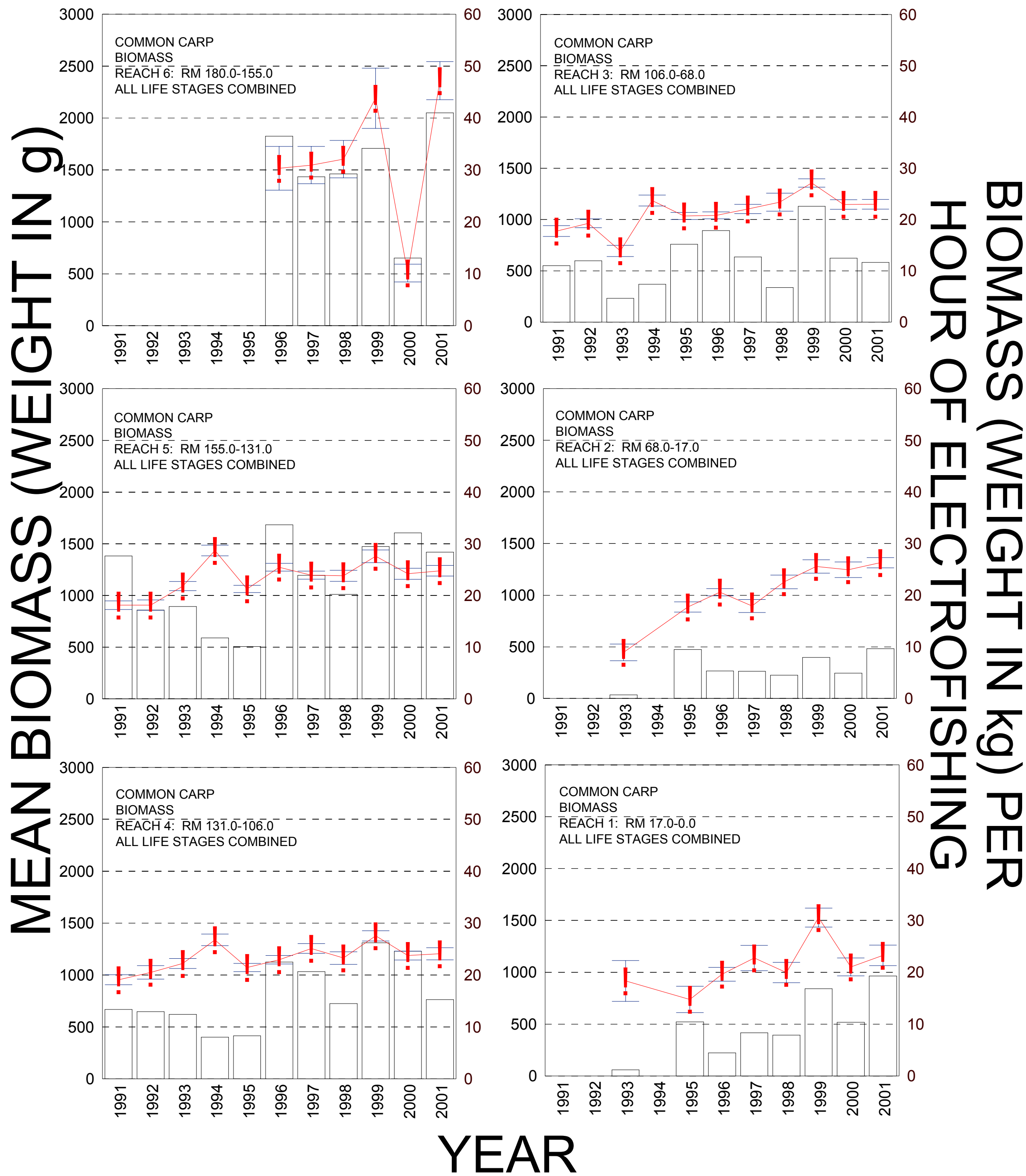

Figure 50. Mean biomass (lines = weight in grams) and biomass per hour of electrofishing (bars = weight in kg) for common carp in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

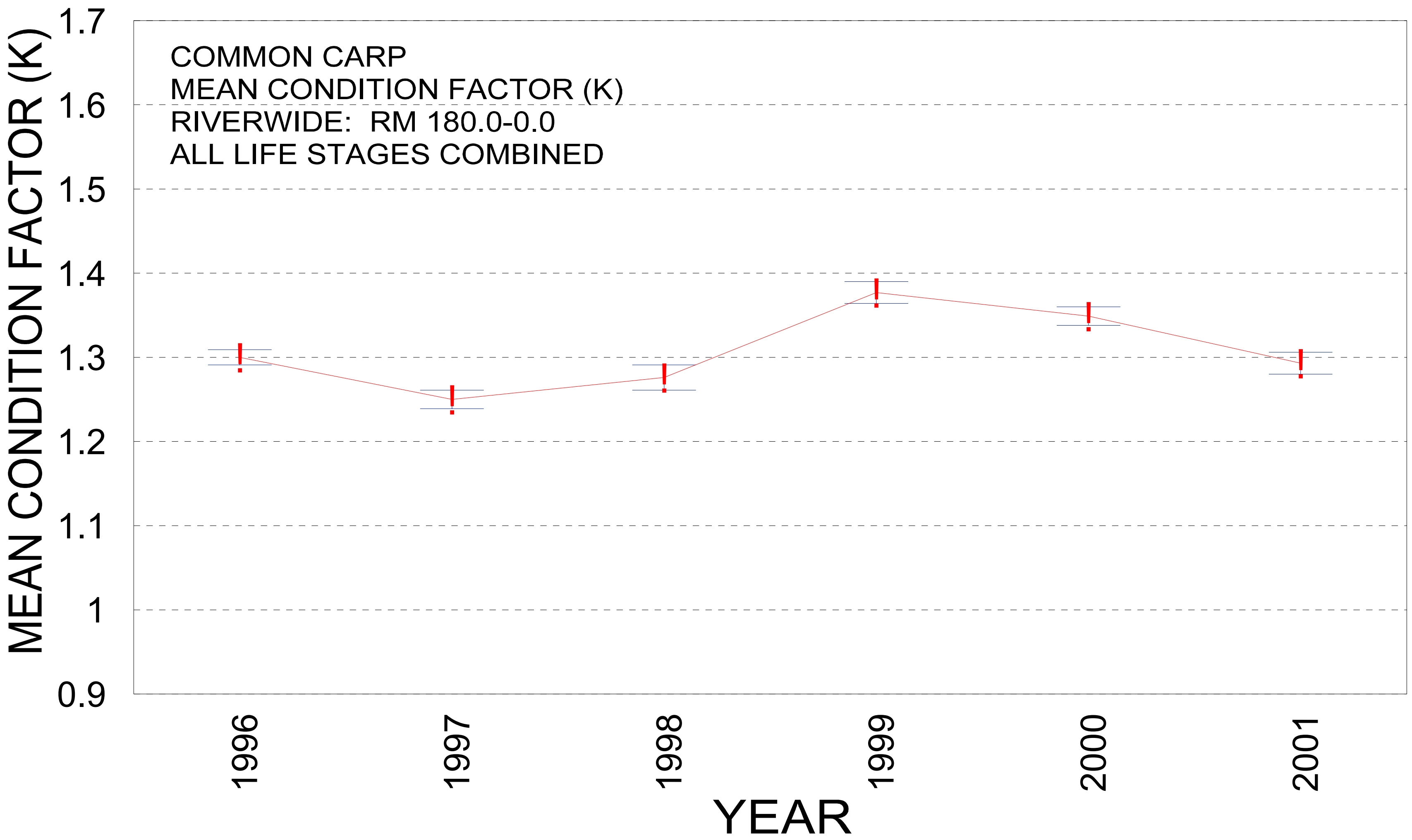

Figure 51. Mean condition factor (K) for common carp riverwide (RM 180.0-0.0) on fall adult monitoring trips in the San Juan River, 1996-2001. Error bars represent the standard error values.

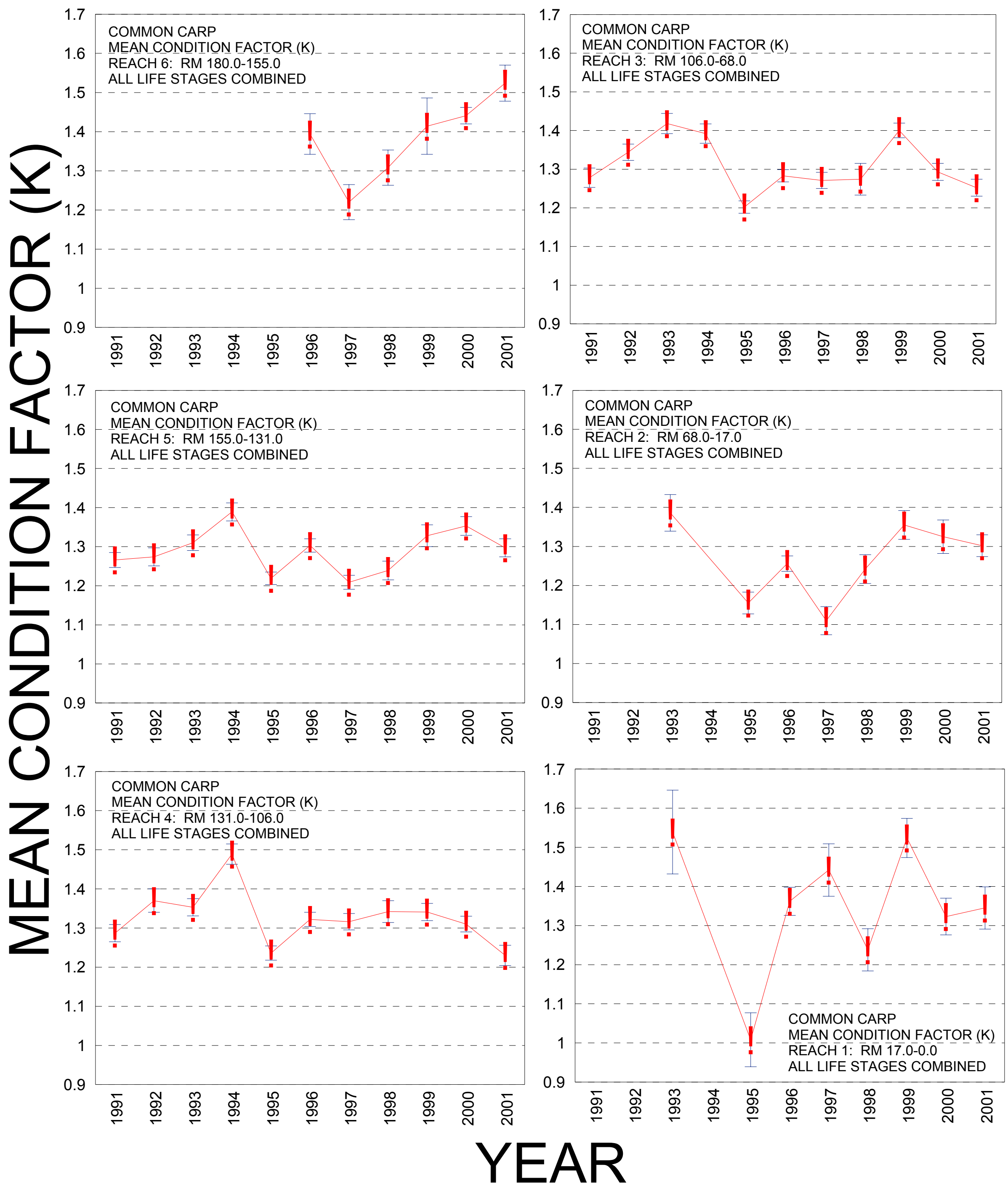

Figure 52. Mean condition factor (K) for common carp in Reaches 6-1 on fall adult monitoring trips in the San Juan River. Error bars represent the standard error values.

Other Nonnative Fishes

Largemouth Bass, Striped Bass, and Walleye

In most years nonnative predatory fishes (excluding channel catfish) tend to be rare in adult monitoring collections (Table 17). In fact in five of the last six years the total CPUE for these three species combined has been < 0.35 fish per hour of electrofishing (Table 17). However, in 2000 there was a dramatic increase in the number of nonnative predatory fishes collected in the San Juan River. The 2000 calendar year (up through mid-August) was characterized by very low, stable river flows, very clear water conditions riverwide, and by Lake Powell being at a high enough level that it still inundated the waterfall which was present at RM 0.0 from 1989 through spring 1995. During 2000 large numbers of adult striped bass invaded the San Juan River (as far upstream as the PNM Weir at RM 166.6) from Lake Powell, while numerous juvenile largemouth bass (mostly collected upstream of RM 100.0) invaded the river, probably from upstream sources (Ryden 2001a).

Based on observational data, nonnative predatory fishes, especially striped bass, tend to invade the lower San Juan River on an annual basis, usually around the runoff period, remaining in the river and continuing to move upstream as long as turbidity remains low (pers. obs.). However, numbers of nonnative predatory fishes (again excluding channel catfish) become greatly reduced when turbidity is high, particularly when summer storm spikes occur. Almost all nonnative predatory fishes collected in turbid water conditions tend to have empty stomachs, while those collected during 2000 (i.e., in clear water conditions) largely had full stomachs (Ryden 2001a). Also, it does not appear that large numbers of nonnative predatory fishes overwinter in the San Juan River as numbers collected on spring razorback sucker sampling trips are always low (Ryden unpublished data).

Table 17. A comparison of numbers of fish collected and catch per unit effort (CPUE), riverwide, for the three nonnative predatory fishes (excluding channel catfish) collected during adult monitoring trips in the San Juan River, 1996-2001.

Year	Number Of Hours Of Electrofishing	Species, Total Numbers Collected, Life Stages and (CPUE)		
		Largemouth Bass	Striped Bass	Walleye
1996	165.41	16 16 juveniles (0.10/hr)	14 14 adults (0.08/hr)	21 21 adults (0.13/hr)
1997	166.01	2 2 adults (0.01/hr)	0 (0.00/hr)	9 5 juveniles 4 adults (0.05/hr)
1998	137.15	5 5 juveniles (0.04/hr)	17 6 juveniles 11 adults (0.12/hr)	6 1 juvenile 5 adults (0.04/hr)
1999	88.36	0 (0.00/hr)	0 (0.00/hr)	9 9 adults (0.10/hr)
2000	116.89	111 109 juveniles 2 adults (0.95/hr)	109 1 juvenile 108 adults (0.93/hr)	7 7 adults (0.06/hr)
2001	109.61	2 2 juveniles (0.02/hr)	2 2 adults (0.02/hr)	1 1 adult (0.01/hr)

SECTION II:

ADDITIONAL DATA ANALYSIS

SECTION II(a): FISH POPULATION TRENDS IN REACH 6 UP- AND DOWNSTREAM OF THE PNM WEIR

METHODS

To examine the impact of intensive nonnative fish removal efforts (specifically aimed at channel catfish and common carp) that are being conducted from the PNM Weir to Hogback Diversion (RM 166.6-158.6) in Reach 6 on the fish community in that reach of river, trends in CPUE were examined for the four most common fish species in “upper” (RM 180.0-166.6) and “lower” (RM 166.6-158.6) Reach 6 from 1996-2001. The use of the terms “upper” and “lower” Reach 6 in this particular analysis are not meant to imply that the combination of these two values will equate to those CPUE and mean TL values presented for the whole of reach 6 in earlier analyses. “Upper” Reach 6 in this particular analysis refers to the area of Reach 6 upstream of the PNM Weir. “Upper” Reach 6 is virtually devoid of channel catfish and numbers of common carp occurring here are much reduced from downstream areas of the San Juan River. “Lower” Reach 6 in this particular analysis refers to the area of reach 6 in which channel catfish and common carp commonly occur but have been subjected to intensive mechanical removal efforts over the last several years (i.e., RM 166.6-158.6). The most downstream portion of Reach 6, from RM 158.6-155.0 (i.e., downstream of the Hogback Diversion), is ***NOT*** included in this analysis.

RESULTS

Flannelmouth Sucker

CPUE for juvenile flannelmouth sucker in Reach 6 upstream of the PNM Weir (RM 180.0-166.6) decreased steadily between 1996 and 1999, then increased markedly in 2000, before dropping back to near levels observed in 1997 (Figure 53). Conversely, CPUE for juvenile flannelmouth sucker in Reach 6 downstream of the PNM Weir (RM 166.6-158.6), increased steadily between 1996 and 2000, before showing a drop to lowest ever observed levels in 2001 (Figure 53). In all juvenile flannelmouth sucker were more abundant downstream of the PNM Weir (RM 166.6-158.6) in three of the last six years (1997-1999), while juvenile flannelmouth sucker were more abundant upstream of PNM Weir in the other three years (1996, 2000, and 2001; Figure 53). The sub-groups of juvenile flannelmouth sucker up- and downstream of the PNM Weir had divergent trends during the period 1997-1999, but tracked each other more closely in 1996, 2000 (both were at highest level ever observed), and 2001 (Figure 53). The steady increase in juvenile flannelmouth sucker CPUE from 1996-1999 (Figure 53) corresponds with nonnative fish removal efforts which began in lower reach 6 in 1996. It is interesting to note that the marked drop in juvenile CPUE in both juvenile flannelmouth sucker and juvenile bluehead sucker in lower Reach 6 (Figure 53) in 2001 corresponded to a marked increase in adult channel catfish CPUE in lower Reach 6 in that same year (Figure 54).

Unlike juvenile CPUE, trends for adult flannelmouth sucker CPUE in Reach 6, both up- and downstream of the PNM Weir (RM 180.0-166.6) tracked each other very closely, with the exception of 1997 (Figure 53). Total CPUE

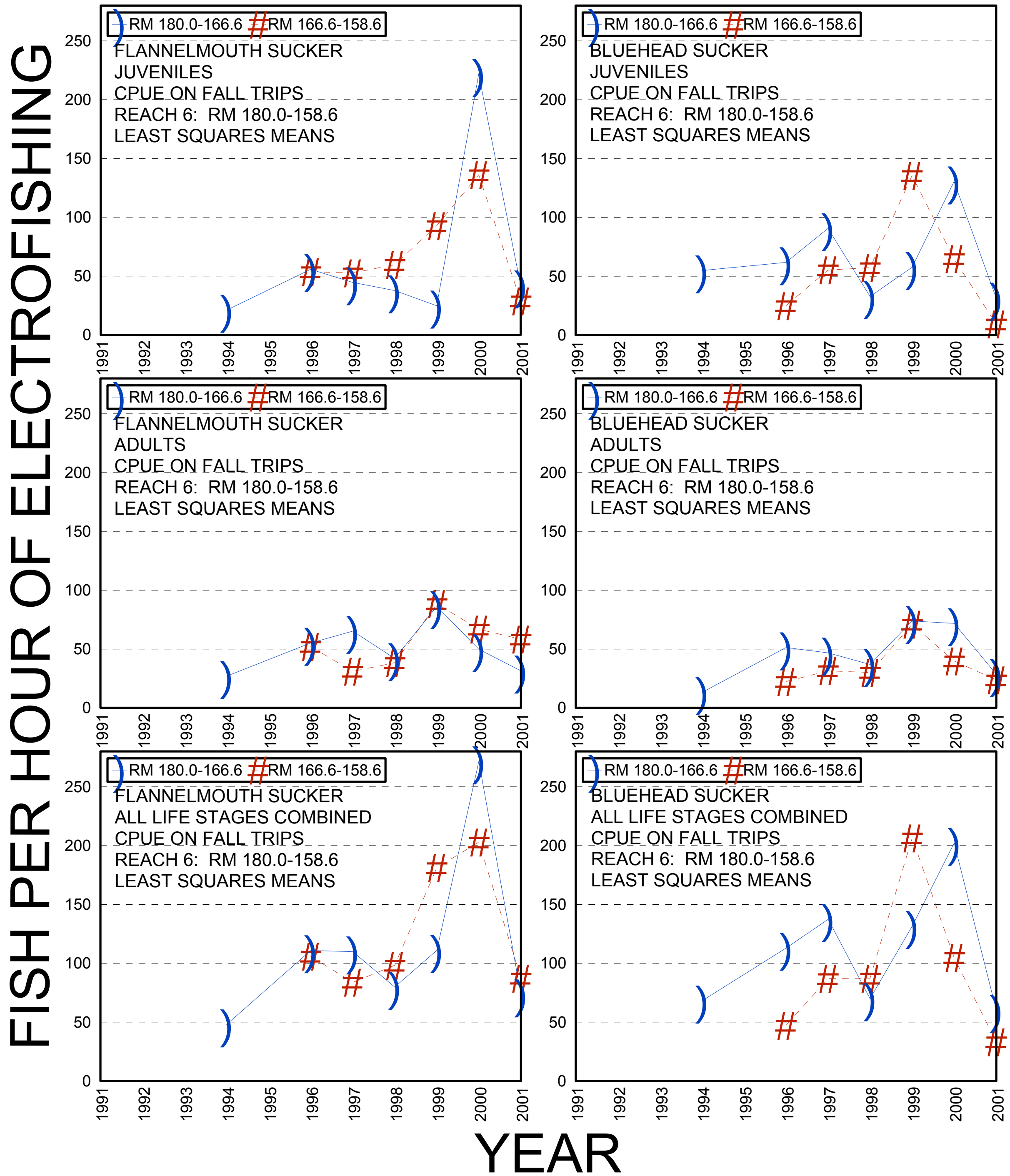

Figure 53. Flannelmouth sucker and bluehead sucker catch per unit effort (CPUE) in “upper” (RM 180.0-166.6) and “lower” (RM 166.6-158.6) Reach 6 on fall adult monitoring trips for juvenile fish (top), adult fish (middle), and for all life stages combined (juveniles + adults; bottom).

trends for all life stages of flannelmouth sucker combined up- and downstream of PNM Weir also tracked each other very close, with steady total CPUE increases between 1998 and 2000 upstream and 1997 and 2000 downstream of the PNM Weir, before marked drops (back to 1998 and 1997 levels, respectively) in both areas in 2001 (Figure 53).

Bluehead Sucker

Unlike flannelmouth sucker, bluehead sucker CPUE values were almost always more abundant upstream of the PNM Weir than below (Figure 53). This is true for juvenile CPUE in four of six years, adult CPUE in all six years, and total CPUE in four of six years. Like flannelmouth sucker, bluehead sucker showed spikes in juvenile CPUE in Reach both up- and downstream of PNM Weir, but unlike flannelmouth sucker, the spikes in bluehead sucker juvenile CPUE did not both occur in 2000. Instead they were offset a year with the first spike in juvenile CPUE in Reach 6 occurring in 1999 downstream of the PNM Weir, followed an almost identical spike upstream of PNM Weir in 2000 (i.e., the same year similar spikes were observed in juvenile CPUE for flannelmouth sucker and common carp both up- and downstream of the PNM Weir; Figures 53 and 54). It should be noted that Reach 6 is the only reach within our study area where numbers of bluehead sucker collected are similar to or even exceed numbers of flannelmouth sucker collected. Reach 6 is also the only Reach in our study area where bluehead sucker are consistently much more common than are nonnative channel catfish. The marked drop in juvenile bluehead sucker CPUE in lower Reach 6 (Figure 53) in 2001 corresponded to a marked increase in adult channel catfish CPUE in lower Reach 6 in that same year (Figure 54).

Channel Catfish

The distribution of channel catfish in Reach 6 is markedly different than that for any of the other common large-bodied fish species. Channel catfish are rarely ever collected upstream of the PNM Weir and then only in low numbers (Figure 54). In addition, juvenile channel catfish have been collected upstream of PNM Weir in only one year, 2000 (Figure 54). Conversely, in Reach 6 downstream of PNM Weir channel catfish are much more abundant than they are upstream, with the population being numerically dominated by adult fish (Figure 54). Marked drops in adult and total CPUE observed in 1997 and again in 2000 were both originally thought to have been caused to mechanical removal efforts (Figure 54). But large increases in adult and total CPUE in 1998 and 2001 have shown that if the drops in adult and total CPUE observed in 1997 and 2000 were indeed caused by mechanical removal efforts, then recolonization of lower Reach 6 (i.e., RM 166.6-158.6) from downstream reaches is apparently able to replenish numbers of channel catfish in this section of the river in short order.

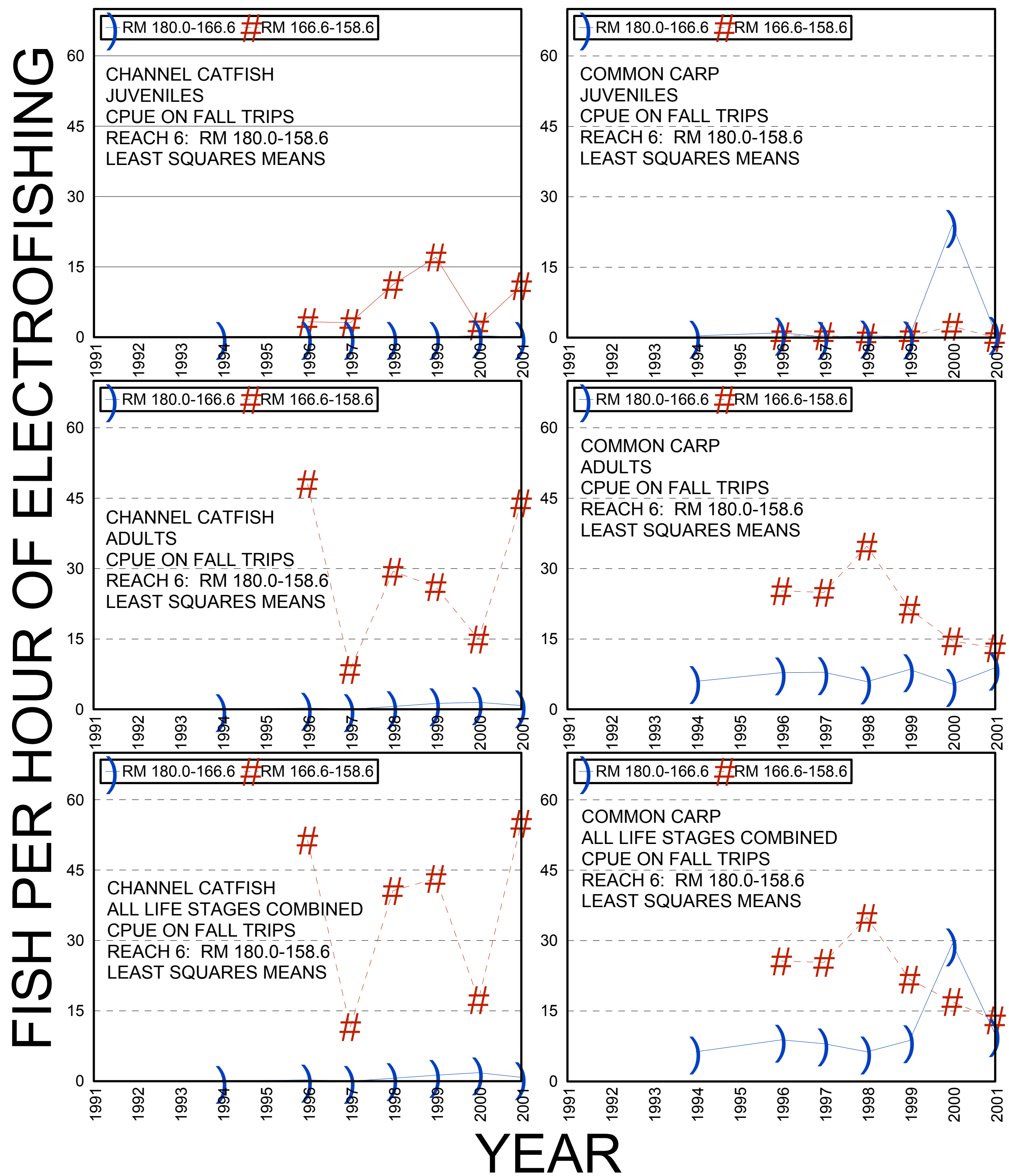

Figure 54. Channel catfish and common carp catch per unit effort (CPUE) in "upper" (RM 180.0-166.6) and "lower" (RM 166.6-158.6) Reach 6 on fall adult monitoring trips for juvenile fish (top), adult fish (middle), and for all life stages combined (juveniles + adults; bottom).

Common Carp

Juvenile common carp are consistently rare in adult monitoring collections throughout the San Juan River (Figures 43-45). This is also the case in Reach 6 both up- and downstream of the PNM Weir. The one exception to this was in 2000 when exceptionally large numbers of juvenile common carp were collected upstream of the PNM Weir (Figure 54). A much smaller increase in juvenile common carp CPUE was also observed in Reach 6 downstream of the PNM Weir in 2000 (Figure 54).

Adult common carp CPUE has always been markedly lower in Reach 6 upstream of the PNM Weir than downstream, with adult common carp CPUE in Reach 6 downstream of PNM Weir ranging from 1.48 to 5.88 times higher, depending upon the year (Figure 54). Adult common carp CPUE upstream of the PNM Weir has also remained very consistent since 1994 (Figure 54). In contrast, adult common carp CPUE in Reach 6 downstream has been noticeably declining (with the exception of 1998) from 1996-2001 (Figure 54).

Total CPUE for all life stages of common carp combined in Reach is 6 very much a reflection of the trends seen among adult fish, with one exception, 2000. This exception was due to the large spike in juvenile common carp CPUE in Reach 6 upstream of the PNM Weir, discussed earlier (Figure 54).

SECTION II(b): FLANNELMOUTH SUCKER POPULATION TRENDS IN REACH 1

From the late 1989 until May 1995, the San Juan River was physically separated from Lake Powell by a large waterfall (up to 10 m high at one time) that had formed at RM 0.0 as lake levels receded. This waterfall prevented any access upstream for fish from Lake Powell to the San Juan River. When the waterfall was inundated by rising lake levels in May 1995, nonnative predatory fishes, specifically striped bass and walleye began to freely invade the lower San Juan River (Ryden 2000a).

METHODS

Field observations indicating a perceived decline in flannelmouth sucker abundance in Reach 1 (RM 17.0-0.0), adjacent to Lake Powell, beginning in 1995 were examined using CPUE and mean TL statistics versus the number of months Reach 1 had been exposed to Lake Powell since May 1995. Linear regression analysis was used to determine if trends in flannelmouth sucker CPUE and mean TL were positively or negatively related with increasing months of exposure.

RESULTS

When Reach 1 was sampled in the summer of 1993, flannelmouth sucker were relatively abundant compared to other fish species (Figures 12, 23, 34, and, 45). At that time the waterfall at RM 0.0 still physically separated the lower San Juan River from Lake Powell. In 1995, Reach 1 was sampled again approximately three months after the inundation of the waterfall and flannelmouth sucker were again found to be relatively abundant compared to other fish species in this reach (Figures 12, 23, 34, and, 45). However, in the years following 1995, various researchers began to make anecdotal observations that flannelmouth sucker were becoming less and less common in Reach 1.

This anecdotal observations were proven true when plots of flannelmouth sucker total CPUE in Reach 1 versus months of exposure (i.e., the number months the waterfall was inundated allowing unimpeded passage of fishes to and from Lake Powell) showed a steady and significant decline between 1995 and 1998 (Figure 55). This trend has reversed itself slightly with flannelmouth sucker total CPUE increasing in Reach 1 from 1998-2001 (Figure 55). However, even with this four-year increase flannelmouth sucker total CPUE in 2001 was still 4.18 times lower than that observed in 1995 (Figure 55).

A linear regression analysis of flannelmouth sucker total CPUE in Reach 1 versus months of exposure to Lake Powell showed a significantly negative correlation (Figure 55). The increases in flannelmouth sucker total CPUE over the last four years have almost certainly helped to flatten out the slope of this negative regression line, but the trend still remains significantly negative (Pearson correlation coefficient = -0.444, r^2 = 0.350, F-statistic = 12.316, p = 0.000).

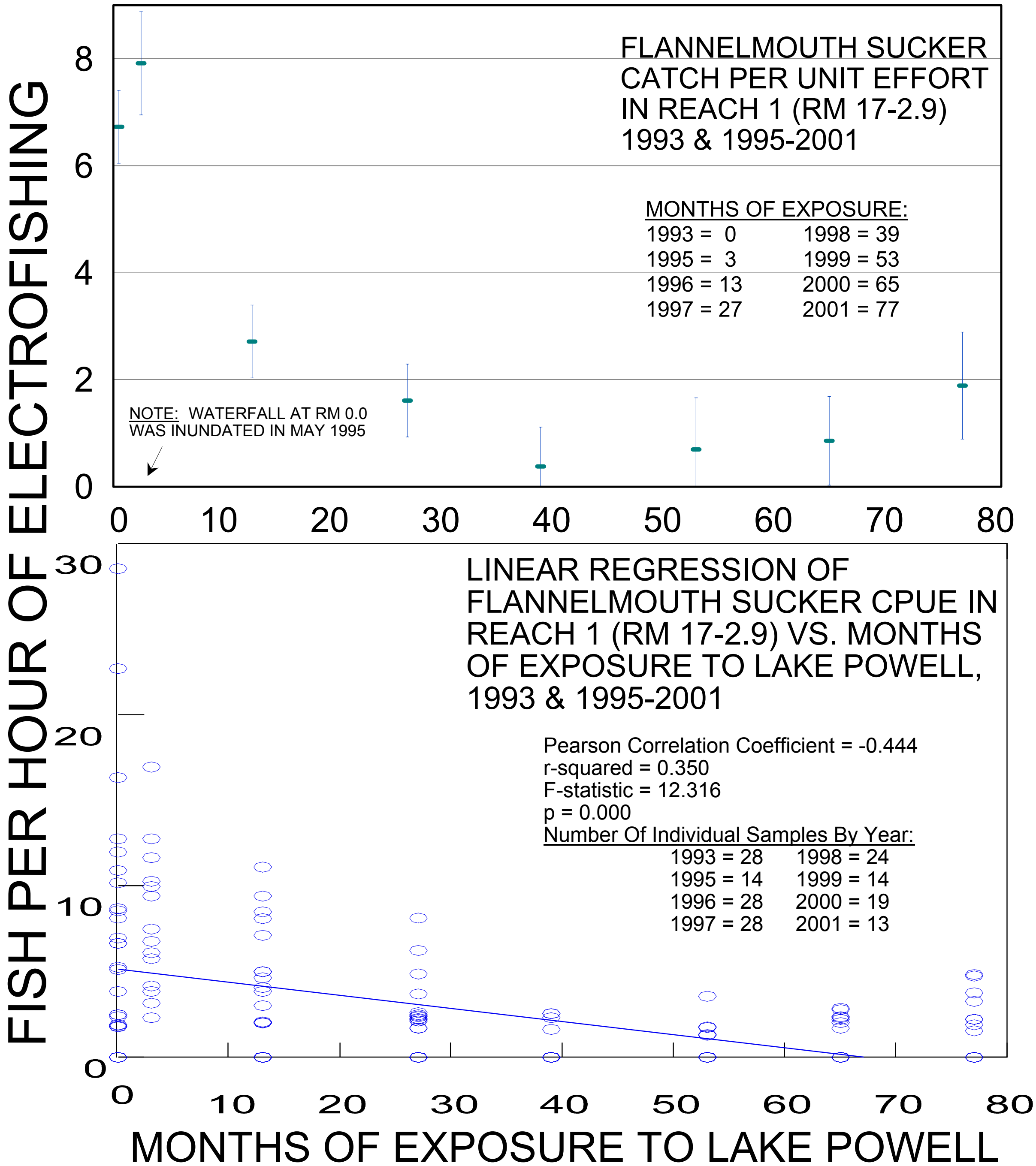

Figure 55. Flannelmouth sucker catch per unit effort (CPUE) versus months of exposure to Lake Powell after the inundation of the waterfall at RM 0.0 in May 1995. The top graph is the CPUE with associated standard error values (error bars) over time, while the bottom graph is a linear regression analysis of the relationship between the two variables.

SECTION II(c): CHARACTERISTICS OF THE SAN JUAN RIVER HYDROGRAPH

METHODS

Aspects of the annual hydrograph for calendar years 1991-2001 were examined to see if links could be identified between various fish population characteristics (e.g., CPUE) and annual flow regimes. The 11 annual flow regimes were first characterized into one of five flow-year classifications (high, moderately high, moderate, moderately low, low), based on how they compared to one another. Three methods were used to preliminarily classify individual flow-years. All flow statistics were obtained from the USGS river gage at Shiprock, NM (09368000).

First, a visual examination was made of various yearly hydrograph characteristics to rank flow-years. Hydrograph characteristics examined included: days < 500 CFS; days > 2,500 CFS; days > 5,000 CFS; days > 8,000 CFS; and days > 10,000 CFS. These hydrograph characteristics were listed, graphed, and after examination were subjectively classified.

Second, monthly discharge totals (in acre-feet {af}) were grouped into four distinct periods, winter baseflow (November-February), runoff (March-July), summer baseflow (August-October), and calendar year totals (January-December). The five-month period from March through July was used for the runoff classification in order to fully bracket both ends (ascending and descending limbs) of the spring hydrograph in all 11 years. Graphs of runoff period af totals were then visually examined to preliminarily classify flow-years.

Lastly, monthly af values were totaled to establish a benchmark flow for the “high” classification during the runoff period. The high flow year benchmark was set subjectively at 1,500,000 CFS from 1 March through 31 July based on the relatively high flow years of 1993 (1,566,060 af) and 1995 (1,544,800 af). Other flow years were then figured as percentages of this high flow benchmark and then classified accordingly. The results of these three methods were then compared to one another and flow-years were given final classifications based upon how they were classified most often (i.e., two out of three or three out of three times) during the three preliminary classification attempts.

In addition to comparing fish population characteristics (e.g., CPUE) to annual flow-year classifications, other factors were examined as well. These included examining the effect of antecedent winter base-flows periods (i.e., were they stable or characterized by storm spike perturbations) and the total volume of antecedent summer and winter baseflow periods to determine if they affected subsequent fish population characteristics (e.g., CPUE).

RESULTS

When hydrograph characteristics were listed and then graphed and examined, three years (1993, 1995, and 1997) were preliminarily classified as high flow years based on number of days the hydrograph was > 8,000 and > 10,000 CFS (Table 18). Likewise low flow years (1991, 1996, and 2000) were preliminarily classified as such based on lack of days with high flow and a greater number of days with flows < 500 CFS (Table 18). Intermediate years were preliminarily classified as follows: moderately high (1992, 1994, 1999); moderate (1998); moderately low (2001).

Table 18. Characteristics of calendar year hydrographs in the San Juan River, 1991-2001. Data are from the Shiprock, NM USGS river gage (09368000).

Year	Number of Days:				
	<500 CFS	>2,500 CFS	>5,000 CFS	>8,000 CFS	>10,000 CFS
1991	28	50	0	0	0
1992	9	87	45	4	0
1993	5	136	101	11	0
1994	23	65	43	7	0
1995	0	140	69	21	10
1996	66	33	0	0	0
1997	0	112	47	26	10
1998	15	60	25	0	0
1999	0	130	58	0	0
2000	49	26	1	0	0
2001	23	51	29	1	0

Winter and summer baseflow periods (with the exception of 1999 summer baseflow period) tended to contribute a fairly small and predictable amount of water to the yearly totals (Table 19, Figure 56). Therefore, classifying flow years on the acre-foot totals seen in runoff periods (i.e., the only part of the flow years that really showed any appreciable variation) appears to be a viable method. A visual examination of runoff period acre-foot totals led to the following preliminary classifications: high (1993, 1995, 1997); moderately high (1992); moderate (1994, 1998, 1999, 2001); moderately low (1991), and; low (1996, 2000; Table 19, Figure 56).

Finally, basing a high flow year on a runoff period benchmark of 1,500,000 acre-feet and figuring the 11 flow-years as percentages of this value led to the following preliminary classifications: high (1993, 1995); moderately high (1997); moderate (1992, 1994, 1998, 1999, 2001); moderately low (1991), and: low (1996, 2000). See Table 20 for specific acre-foot and percentage values.

Preliminary classifications from the above three methods were compared (Table 21) to determine in which classifications flow-years occurred the majority of the time (two out of three or three out of three times). Based on that analysis, the final classifications for flow-years were as follows: high (1993, 1995, 1997); moderately high (1992); moderate (1994, 1998, 1999, 2001); moderately low (1991), and; low (1996, 2000; Table 22).

Examination of flows during winter baseflow periods revealed that between November 1990 and February 1995, four of the five winter baseflow periods were perturbated by at least one major storm spike. Only the flows during the winter baseflow period of 1993-1994 were relatively stable (Figure 57). Conversely, between November 1995 and February 2000, only two (1996-1997 and 1998-1999) of the six winter baseflow periods were perturbated by at

Table 19. Monthly acre-foot values for the San Juan River at the Shiprock USGS gage (09368000), used to determine volumes of water present in the river during winter baseflow, runoff, and summer baseflow periods, as well as to determine calendar year totals, 1991-2001.

Month	Acre-Foot Totals:					
	1990	1991	1992	1993	1994	1995
January		66,050	55,330	74,890	65,790	55,550
February		67,500	73,380	79,400	47,470	58,900
March		63,290	77,380	313,500	54,480	173,200
April		104,100	198,100	355,200	51,670	202,900
May		216,200	393,700	392,700	293,800	365,500
June		145,400	283,000	405,600	390,600	539,200
July		47,340	92,710	99,060	123,500	264,000
August		27,910	56,050	65,100	30,010	90,840
September		79,460	55,650	64,900	56,930	67,510
October		42,020	46,920	59,690	61,830	60,140
November	67,360	85,790	55,090	72,760	59,670	63,120
December	62,650	69,990	55,760	70,330	58,410	62,990
Totals		1,015,050	1,443,070	2,053,130	1,294,160	2,003,850

Month	Acre-Foot Totals:					
	1996	1997	1998	1999	2000	2001
January	43,300	39,580	75,870	56,640	51,300	48,500
February	44,860	36,180	65,460	48,680	46,200	48,150
March	43,020	126,500	70,130	54,240	57,830	63,520
April	31,630	136,500	84,810	69,040	98,280	82,370
May	122,800	350,600	322,800	199,100	142,100	294,000
June	158,400	493,100	236,300	349,600	119,600	283,200
July	36,410	162,800	102,400	191,600	20,040	42,440
August	24,700	148,700	58,940	352,400	37,000	69,620
September	43,520	135,300	38,320	255,800	38,630	32,820
October	75,650	80,510	83,840	64,510	58,850	43,030
November	49,250	65,830	72,750	47,030	56,650	45,570
December	37,200	72,990	59,160	52,080	51,910	47,730
Totals	710,740	1,848,590	1,270,780	1,740,720	778,390	1,100,950

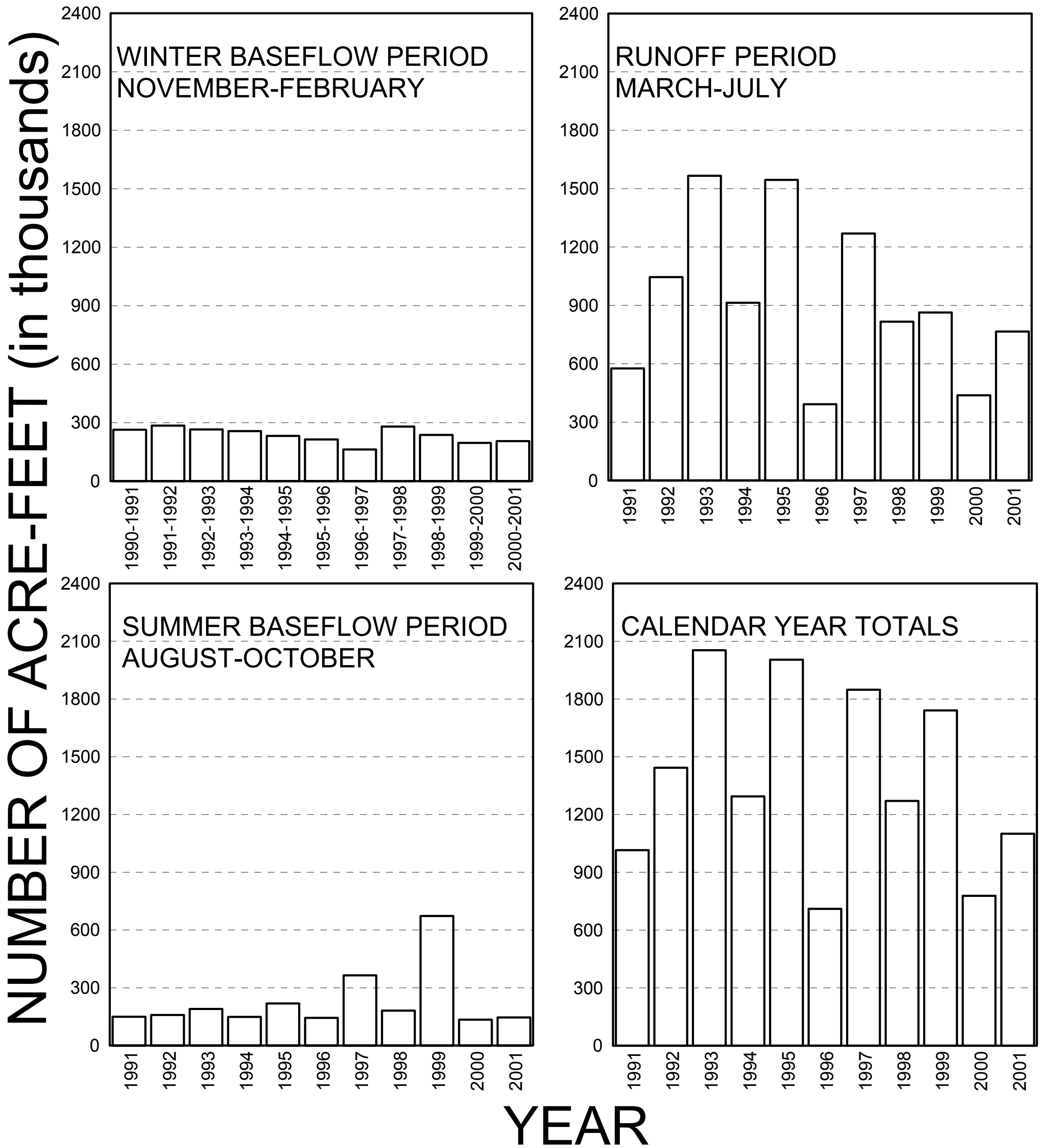

Figure 56. Acre-foot values for various periods of the San Juan River hydrograph, 1990-2001.

Table 20. A summary of San Juan River "runoff period" (i.e., March-July) flows in acre-feet (af), 1991-2001. These flow volumes are used here to attempt to preliminarily classify the flow year (high, moderately high, moderate, moderately low, low) in which they occurred. The preliminary benchmark for a high flow year was set at 1,500,000 acre-feet during the runoff period (based on the high flow years of 1993 and 1995).

Classification	Calendar Year (af During Runoff Period) and Percent of 1,500,000 af "High" Classification Benchmark
High	1993 (1,566,060 af) = 104.40% 1995 (1,544,800 af) = 102.99%
Moderately High	1997 (1,269,500 af) = 84.63%
Moderate	1992 (1,044,890 af) = 69.66% 1994 (914,050 af) = 60.94% 1999 (863,580 af) = 57.57% 1998 (816,440 af) = 54.43% 2001 (765,530 af) = 51.04%
Moderately Low	1991 (576,330 af) = 38.42%
Low	2000 (437,850 af) = 29.19% 1996 (392,260 af) = 26.15%

Table 21. A comparison of the 1991-2001 flow years, using varying sets of criteria to preliminarily classify flow years (i.e., low, moderately low, moderate, moderately high, or high) in order to help determine the possible effects of each classification of flow year on the San Juan River large-bodied fish community.

Preliminary Classification Of Flow Year:	Based On A Visual Examination Of A Series Of Yearly Hydrograph Characteristics	Based On Visual Examination Of A Graph Displaying The Total Number Of Acre-Feet During Runoff Period In Each Flow Year	Based On The Percent Of A High Flow Benchmark Value (i.e., 1,500,000 Acre-Feet) Present During The Runoff Period In Each Flow Year
High	1993, 1995, 1997	1993, 1995, 1997	1993, 1995
Moderately High	1992, 1994, 1999	1992	1997
Moderate	1998	1994, 1998, 1999, 2001	1992, 1994, 1998, 1999, 2001
Moderately Low	2001	1991	1991
Low	1991, 1996, 2000	1996, 2000	1996, 2000

Table 22. Final classification of 1991-2001 flow years (i.e., low, moderately low, moderate, moderately high, or high) adopted for this report. The final classifications were based on which classification flow years were most frequently placed in during various preliminary classification attempts (see previous tables).

Final Classification Of Flow Year:	
High	1993, 1995, 1997
Moderately High	1992
Moderate	1994, 1998, 1999, 2001
Moderately Low	1991
Low	1996, 2000

least one major storm spike, while flows during the other four winter baseflow periods were relatively stable (Figures 57 and 58). Even the 1998-1999 winter baseflow period was stable after two early storm spikes (i.e., both occurring prior to 11 November 1998; Figure 57).

Acre-foot totals for winter baseflow periods ranged from 162,210 af in 1996-1997 to 284,490 af in 1991-1992 (Table 23). Acre-foot totals for summer baseflow periods ranged from 134,480 af in 2000 to 672,710 af in 1999 (Table 23). Winter baseflow af totals were larger than following summer baseflow af totals in 9 of 11 years. The two exceptions to this were the 1997 (364,510 af) and 1999 (672,710 af) summer baseflow periods (Table 23). The summer baseflow period value for 1999 was an extreme anomaly, actually being higher than runoff period flows observed in 1991 (576,330 af), 1996 (392,260 af), and 2000 (437,850 af; Table 23). This was caused by a combination of unseasonably heavy rains in August and September 1999 combined with large-scale releases from Navajo Reservoir to avoid a spill (necessitated by the large reservoir inflows generated by the precipitation during those two months).

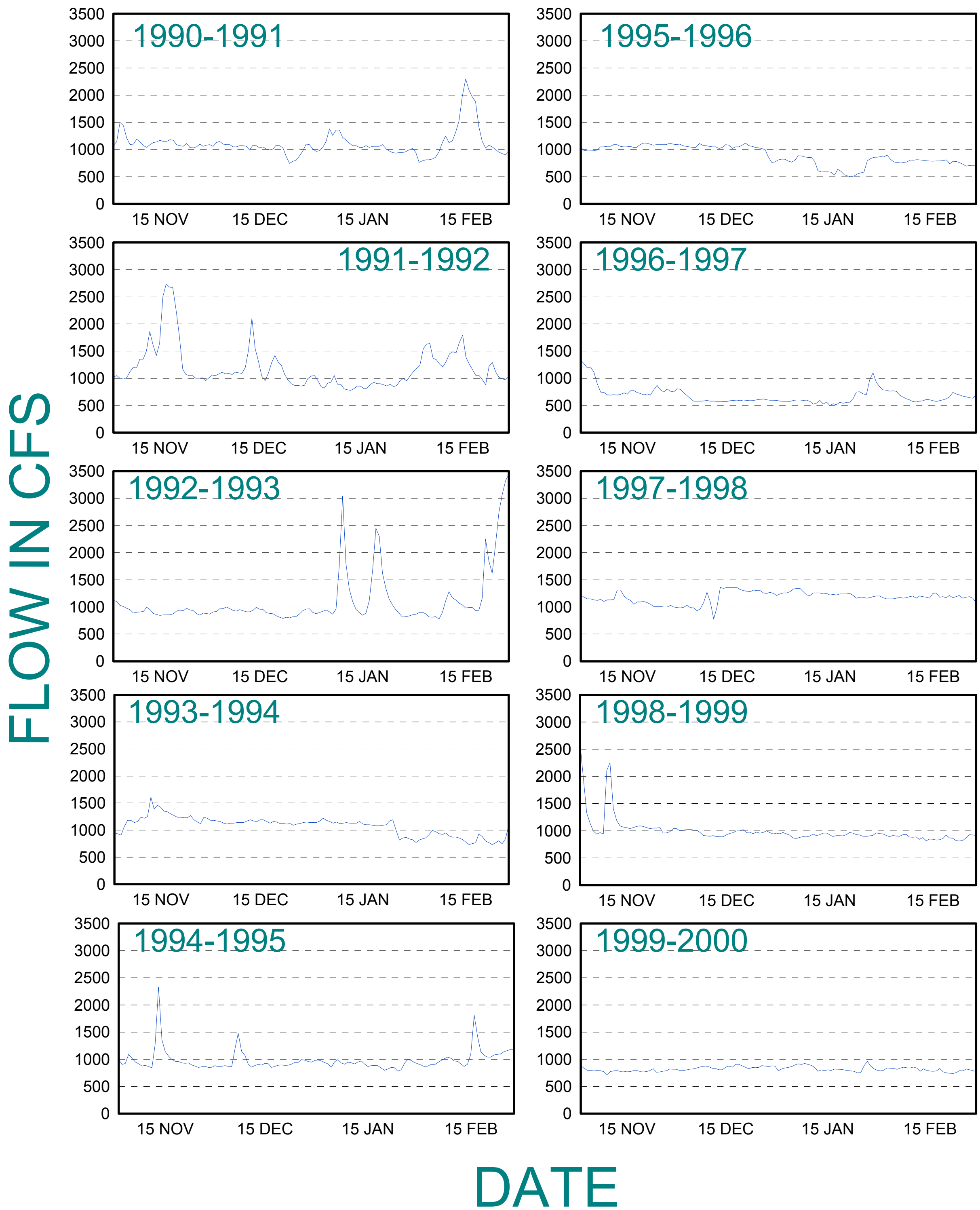

Figure 57. Instream flows (in CFS) during winter baseflow periods (November-February) in the San Juan River, 1990-1991 to 1999-2000. Data are from the Shiprock, NM USGS gage (09368000).

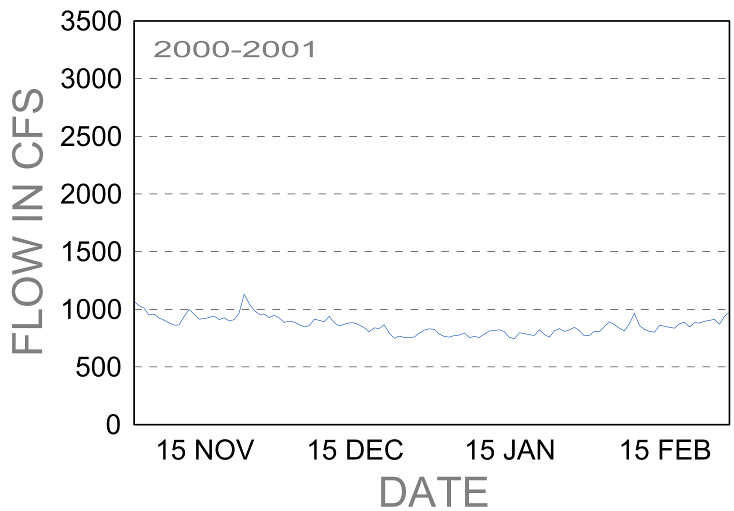

Figure 58. Instream flows (in CFS) during the winter 2000-2001 baseflow period (November-February) in the San Juan River. Data are from the Shiprock, NM USGS gage (09368000).

Table 23. Acre-foot (af) values for flow periods used in this report. Flow data taken from the Shiprock, NM USGS gage (09368000). Flow periods are defined as follows: winter baseflow (November-February), runoff (March-July), summer baseflow (August-October), calender year totals (January-December of a given calendar year).

Winter Baseflow Period:		Other Flow Periods:			
Years Encompassed	Winter Baseflow Period af Totals	Calendar Year	Runoff af Totals	Summer Baseflow af Totals	Calendar Year af Totals
1990-1991	263,560	1991	576,330	149,390	1,015,050
1991-1992	284,490	1992	1,044,890	158,620	1,443,070
1992-1993	265,140	1993	1,566,060	189,690	2,053,130
1993-1994	256,350	1994	914,050	148,770	1,294,160
1994-1995	232,530	1995	1,544,800	218,490	2,003,850
1995-1996	214,270	1996	392,260	143,870	710,740
1996-1997	162,210	1997	1,269,500	364,510	1,848,590
1997-1998	280,150	1998	816,440	181,100	1,270,780
1998-1999	237,230	1999	863,580	672,710	1,740,720
1999-2000	196,610	2000	437,850	134,480	778,390
2000-2001	205,210	2001	765,530	145,470	1,100,950

DISCUSSION

Riverwide, the overall native to nonnative fish ratio was at its lowest ever observed level in 2001 (1.54:1), although not dramatically lower than 1996 or 1999 values. This was a function of an increase in channel catfish collections (up to 28.7% of the total catch in 2001) and a slight decrease in flannelmouth sucker collections (down to 45.2% of the total catch in 2001). These two species, together with bluehead sucker and common carp, continue to be the dominant four species in the San Juan River, accounting for over 90% (95.8% in 2001) of the total catch during adult monitoring annually. Despite all the flow manipulations, rare fish augmentation efforts, nonnative fish removal efforts, fish passage improvements, etc., initiated by the San Juan River Recovery Implementation Program over the last several years, riverwide proportions of these four fish species have remained relatively stable over the last six years.

Two thoughts concerning this fact come to mind. First, these four species are very common and continue to flourish in the San Juan River even though it has been a highly modified and regulated system for approximately forty years. This points to these particular species being very adaptable to the range of conditions (flows, contaminants, predation/competition, range reductions, etc.) that have existed in the San Juan River over the last four decades. In a sense, it appears that these four species may have reached a state of equilibrium. Localized and yearly fluctuations in this equilibrium would be expected as various factors (listed above) affect spawning success, year-class strength, available forage base, recruitment, and the suitability of localized areas of the river to meet life history requirements (e.g., Reach 1 for flannelmouth sucker), but likely these fluctuations are just that. Given the relatively long life-span of these species and their relative abundance, they are likely to be able to absorb the effects of “bad” years (or even a series of years) and recover fairly quickly during years when conditions are more favorable. Thus, it may be that there is little that can be done to passively manipulate overall numbers of these four common fish species on a long-term basis given the limited resources (e.g., restrictions on flows from Navajo Reservoir) available to the San Juan River Recovery Implementation Program. In other words, we may not be able to throw anything at them (e.g., in terms of river flows) that they haven’t already seen and lived through. If this is true, then any long-term, large-scale changes (positive or negative) in population numbers of these four species would indicate a very fundamental change from the wide range of conditions to which they have adapted.

This leads to a second thought. The attempts that have been made to physically alter the fish community in the San Juan River over the last six years, represent our best chance to make such a fundamental change. Mechanical removal of common nonnative fish species, expansion of range for native fishes through modification or removal of instream diversion structures, and reintroduction of missing members of the fish community (Colorado pikeminnow and razorback sucker) through augmentation all have the potential to make dramatic changes in abundance and distribution of the four common, large-bodied fish species. However, these management actions have been in place for such a relatively short time (and so far on such a small scale) and numbers of the four common fish species are so large, that it will likely take many years to assess whether these management actions can be successful in fundamentally changing the makeup of the populations of the four common large-bodied fish species in the river's main channel habitats. To complicate matters, the "natural" fluctuations in population parameters (i.e., deviations from the assumed equilibrium discussed above) will likely mask any changes that are occurring as a result of management-based manipulations until the effects of these manipulations populations to surpass some critical threshold level. This will make assessing management-based manipulations, using populations of the four common large-bodied fish species as a metric, problematic until such time as a critical threshold is surpassed.

Rare Native Fishes

Recent flow manipulations (i.e., 1992-present) in the San Juan River have not appeared to make long-lasting changes in numbers of the four common large-bodied fish species, specifically in larger juvenile and adult life-stages. However, mimicry of a natural hydrograph is still considered to be a critical component in recovering both Colorado pikeminnow and razorback sucker in the San Juan River (Holden 1999). The timing and relative success of spawning for both razorback sucker and Colorado pikeminnow appears to be very closely tied to the annual spring hydrograph. Razorback sucker spawn on the ascending limb of the hydrograph (Tyus 1987, Tyus and Karp 1989, USFWS 1998, Ryden 2001b) and Colorado pikeminnow spawn on the descending limb of the hydrograph (e.g., Vanicek and Kramer 1969, Hamman 1981, Haynes et al. 1984, Tyus 1990, McAda and Kaeding 1991, Holden 1999). The decline of these two species over time (e.g., Miller 1961, Holden and Stalnaker 1975, Moyle 1976, McAda and Wydoski 1980, Minckley 1983, McAda 1987, Tyus 1987, Marsh and Minckley 1989, Tyus 1991, Osmundson and Burnham 1998) and their struggle to carry out basic life history functions in today's highly modified river systems argues for a return to as natural an environment as can be practically achieved, the largest component of which is a natural flow regime (Holden 1999).

Colorado Pikeminnow

Collections of wild adult Colorado pikeminnow have been extremely rare since 1995. Stocked juvenile Colorado pikeminnow continue to be recaptured, but numbers recaptured in 2000 and 2001 were much lower than in previous years (i.e., 1996-1999). It is evident that some small percentage (relative to total numbers stocked) of stocked juvenile Colorado pikeminnow continue to persist and grow in the San Juan River and the likelihood that at least a few of these fish will recruit and become spawning adults seems good. However, the reason for the rather severe drop-off in numbers of stocked fish recaptured in 2000-2001 as compared to previous years is unknown. It seems plausible that some stocked juvenile Colorado pikeminnow were lost to striped bass predation in the summer of 2000. While there is no direct evidence of this, striped bass are known to prey on sympatric native fishes, some as large as 280 mm TL (SJRIP integrated database). Furthermore, Colorado pikeminnow stocked between 1996 and 1998 would have grown to a sufficient size that they would have become obligate piscivores by summer 2000 and very likely would have been occupying the same types of habitats as adult striped bass to pursue their prey. The size ranges (TL in mm) observed for recaptured individuals would place many of them within the size range vulnerable to striped bass predation and any overlap in habitat use between these two species would increase the chances of young Colorado pikeminnow being eaten.

Adult Colorado pikeminnow stocked at RM 180.2 in April 2001 were recaptured fairly frequently Reach 6 between the PNM Weir and Hogback Diversion (RM 166.6-158.6) by nonnative fish removal crews in 2001 (n = 15). However, no stocked adult Colorado pikeminnow were collected between the stocking site (RM 180.2) and the PNM Weir in 2001. Only one stocked adult was collected downstream of Hogback Diversion (RM 158.6), at RM 155.3.

Only time will tell if adult Colorado pikeminnow stocked in 2001 will survive long-term. However, in the short-term, their survival has been much better than the 49 adult fish stocked in 1997. Both groups of stocked adults were small for their age and in less than perfect health when stocked. To date, there has not yet been (what I would consider) a good experiment done with stocking larger size-class Colorado pikeminnow into the San Juan River.

Among early life stage Colorado pikeminnow stocked between 1996 and 2000, fish stocked as large age-0 fish (i.e., mean TL = 55 mm) in the fall seemed to survive at much higher rates than did those stocked as larvae in June and July. However, after these fish reached about 350 mm TL, they essentially disappeared from monitoring collections. It remains to be seen whether these fish have completely disappeared from the fish community or whether they are just particularly hard to sample at that size and will reappear in samples as adult fish at some later date. An augmentation plan for Colorado pikeminnow was finalized in 2003 (Ryden 2003a). Under the direction of this stocking plan, 200,000 to 300,000 age-0 Colorado pikeminnow (mean TL $\geq$ 50 mm) will be stocked annually in late October or early November for eight years beginning in fall 2002 (Ryden 2003a).

Razorback Sucker

Stocked razorback sucker continue to persist throughout the San Juan River. Unfortunately, due to difficulties in obtaining and rearing razorback sucker for stocking, many fewer razorback sucker have been stocked than were originally planned (Ryden 1997, 2000c, 2001b). However, the comparatively few razorback sucker that have been stocked continue to grow and have successfully spawned for four straight years. Larval razorback sucker were collected in 1998, 1999, 2000, and 2001 (S. Platania pers. comm.) and suspected spawning aggregations of razorback sucker were identified near Aneth, UT (at RM 100.2) in May 1997, April 1999, and April 2001 (Ryden 2000c, 2001b). An unknown number of razorback sucker that washed out of Ojo Pond in August 1998, have survived and are now resident in the San Juan River. Several stocked razorback sucker have also been recaptured downstream in Lake Powell, in areas that were known to be frequented by wild razorback sucker (i.e., Piute Farms) in the late 1980's (Platania 1990, Ryden 2000c, 2001b, G. Mueller pers. comm.).

Based on the numbers stocked versus numbers recaptured, stocked razorback sucker have had much higher survival post-stocking than have stocked Colorado pikeminnow in the San Juan River. One reason for this may be their size at time of stocking. Razorback sucker stocked at larger sizes (> 300 mm TL) have survived much better than razorback sucker stocked at smaller sizes (Ryden 2001b). A few large, adult Colorado pikeminnow have been stocked into the San Juan River in recent years (49 in 1997 and 148 in 2001). However, the few adult pikeminnow that were stocked were in fairly poor health (e.g., small for their age, skinny {i.e., low condition factor}, infested with “ich”) when stocked. Thus trying to compare their survival rates to that of large (> 300 mm TL), healthy razorback sucker post-stocking is problematic.

Roundtail Chub

Roundtail chub collections continue to be very rare in San Juan River. No roundtail chub were collected on either 2000 or 2001 adult monitoring trips and only two were collected during 1999 adult monitoring. There appears to be no resident roundtail chub population in the mainstem San Juan River, as might be documented by regular recaptures of previously PIT-tagged fish or by population length-frequencies that would indicate recruitment. Only a very few, scattered adult fish appear to be resident in the mainstem San Juan River. The few juvenile roundtail chub collected in the mainstem river appear to be transients, rarely if ever recruiting into adulthood.

Common Native Fishes

Flannelmouth Sucker

Riverwide, flannelmouth sucker total CPUE was significantly higher from 1999-2001 than during the lowest two years, 1997 and 1998. The decline in flannelmouth sucker total CPUE in Reaches 5-3 (the area of the San Juan River in which the majority of flannelmouth sucker population occurs) observed between 1992 and 1997-1998 has ceased. Total CPUE values for flannelmouth sucker in Reaches 5 and 4 were both significantly higher in 2001 than they were in 1997 and the total CPUE for flannelmouth sucker in Reach 3 in 2001 was also higher (though not significantly) than that observed in 1998.

One explanation for the decline in flannelmouth sucker total CPUE in Reaches 5-3 between 1992 and 1997-1998 may be found in the hydrograph. The five largest discharge runoff periods during our studies all occurred during the six-year period 1992-1997. In addition, the winter baseflow periods of 1991-1992, 1992-1993, and 1994-1995 were three of the four most perturbated (based on number of storm spikes) since our studies began. Since river flows represent a strong selective force, this combination of many successive years of relatively high flows and several winters of perturbated flows may have acted to reduce flannelmouth sucker numbers in Reaches 5-3.

Another possible factor in the observed decline might include biological sampling. Between 1991 and 1997, the “core sampling area” from RM 158.6-53.0 was being sampled very heavily (in some years almost continuously from May to October) by electrofishing, seining, and other methods. This intense sampling pressure may have led to an unknown amount of delayed mortality among sampled flannelmouth sucker. If this is the case, since flannelmouth sucker account for roughly half of all fish collected during adult monitoring, then it seems likely that any declines in total CPUE due to delayed mortality associated with sampling would be greatest (and easiest to detect over time) with this species. However, if this were the case, one might reasonably expect that the declines in flannelmouth sucker total CPUE would have continued beyond the 1997-1998 time period, instead of significantly reversing themselves.

The significant increases in juvenile and total CPUE observed in Reach 6 in 2000 were not evident again in 2001. It appears that many of the large number of age-0 juveniles from Reach 6 in 2000 may have moved into downstream reaches as age-1 fish in 2001, specifically into Reach 5, but also to a lesser degree into Reaches 4, 3, and 2. This is evidenced by the relatively large number of flannelmouth sucker collected in the 176-275 mm TL size-classes in 2001.

The reason for the large increase in age-0 flannelmouth sucker in Reach 6 in 2000 is not entirely clear. However, the explanation may be found by looking at the hydrograph from summer 1999 to fall 2000. The 1999 summer baseflow period had a much higher volume discharge than any seen since our studies began in 1991. This likely kept cobble-based habitats from degrading (i.e., sedimenting in) as happens during normal summer baseflow periods due to summer storm spikes followed by low flows which are unable to flush the newly introduced sediments. This extremely high discharge summer baseflow period was immediately followed by one of the most stable and nonperturbated winter baseflow periods (1999-2000) seen since our studies began in 1991. Low, stable winter baseflows are characterized by low turbidity and high primary productivity. These factors would have provided native flannelmouth sucker good overwinter forage thus boosting their condition factor in preparation for the coming spring 2000 spawning season (unfortunately, no spring 2000 data exist to verify this). A very successful spawning effort in spring 2000 was then followed by a very low discharge runoff period (the second lowest discharge since 1991) which was in turn followed by lowest discharge summer baseflow period since 1991. This low, stable, summer baseflow period remained nonperturbated until mid-September. This likely allowed high survival and little downstream displacement of age-0 flannelmouth sucker followed by a period of high primary productivity in the river which contributed to their rapid growth and relatively high survival into the fall 2000 sampling period.

Unfortunately, the invasion of the San Juan River by large numbers of striped bass (as far as 166.6 RM upstream) in summer 2000 likely led to very large predation losses among young flannelmouth sucker. During the July 2000 razorback sucker monitoring trip 279 striped bass were collected in only 15.8 RM of electrofishing. During the same trip, an almost complete absence of “smaller” flannelmouth sucker in collections was noted (pers. obs.). It is likely that the large number of adult striped bass observed in summer 2000 adversely affected the survival of flannelmouth sucker < 300 mm TL in the river sections where they occurred. Adult striped bass have been documented preying upon flannelmouth sucker as large as 280 mm TL (SJRIP integrated database). The presence of the PNM Weir, which acts as an impediment to upstream fish movements (Ryden 2000a), likely sheltered age-0 flannelmouth sucker occurring upstream of this barrier from striped bass predation in 2000 (Ryden 2001a).

However, there may be alternative explanations for the large number of age-0 flannelmouth sucker collected in Reach 6 above the PNM Weir. One alternative explanation (P. Holden, pers. comm.) assumes that some condition or set of conditions in Reach 6, upstream of the PNM Weir, was especially beneficial to the common large-bodied fish species that are spring spawners (i.e., flannelmouth sucker, bluehead sucker, and common carp). Relatively large numbers of age-0 fish of all three of these species were collected upstream of the PNM Weir in 2000, with average or below average numbers of age-0 fish of these species being collected in downstream reaches. The other common large-bodied fish species, channel catfish (a summer spawner), did not demonstrate the same trend in numbers or distribution of age-0 fish. It is possible that some beneficial condition or set of conditions favored successful spring spawning of these three fishes upstream of the PNM Weir in 2000, but did not benefit channel catfish either because conditions had changed by summer 2000, or because channel catfish do not occur in sufficient numbers upstream of the PNM Weir to have benefitted from this supposed set of beneficial conditions.

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 may be directly related to nonnative predators. This decline first became apparent in our data sets in June 1996, a little over a year after the waterfall separating Lake Powell and the San Juan River was inundated, allowing nonnative predatory fishes unimpeded access into the lower San Juan River for the first time since 1986. There is a significant negative correlation between flannelmouth sucker total CPUE and the amount of time (in months) that Reach 1 has been exposed to Lake Powell.

This same trend may be taking place in Reach 2 as well, as evidenced by the significant declines in total and juvenile CPUE between 1995 and 2001. Striped bass, walleye, and the ubiquitous channel catfish have all been documented to prey on flannelmouth sucker (Brooks et al. 2000, Ryden 2000a) and the majority of walleye and (up until summer 2000) striped bass were collected in Reach 1 and adjacent Reach 2 (Ryden 2000a). All of the above data forms a compelling circumstantial argument to say that nonnative predatory fishes are a detriment to the native fish community, even affecting species as abundant as the flannelmouth sucker.

However, like the situation in Reach 6, alternative explanations may apply to the virtual disappearance of flannelmouth sucker from Reach 1. Over the last several years, The San Juan River in Reach 1 has accumulated an extremely heavy sediment load (R. Bliesner pers. comm.). This accumulation of sediment may have had a drastic enough effect on the productivity of this reach to reduce the forage base to a point where flannelmouth sucker (and other species) could no longer find sufficient forage, causing them to vacate the reach.

Bluehead Sucker

Bluehead sucker in the San Juan River tend to be concentrated in upstream reaches of the river, specifically Reach 6 in our study area. In most years, bluehead sucker total CPUE in Reach 6 is twice as high (sometimes as much as three times as high, e.g., in 1999 and 2000) as in adjacent Reach 5, where they are next most abundant. In 1999, bluehead sucker total CPUE in Reach 6 was the highest that had ever been observed in that reach, to date. In 2000, bluehead sucker total CPUE in Reach 6 increased yet again. Like flannelmouth sucker, the majority of age-0 bluehead sucker collected in Reach 6 during 2000 adult monitoring were collected upstream of RM 166.6 and were probably also sheltered from striped bass predation by the presence of the PNM Weir. As with flannelmouth sucker, “smaller” bluehead sucker were essentially absent from electrofishing collections during the July 2000 razorback sucker monitoring trip (pers. obs.). Although bluehead sucker occur in lesser numbers in Reaches 4-2 than do flannelmouth sucker, they are still common enough that they were probably affected adversely by the presence of large numbers of adult striped bass during summer 2000. While there is no documentation to date of striped bass preying upon bluehead sucker, the fact that striped bass will consume both sympatric flannelmouth sucker and speckled dace would argue that at least some predation on bluehead sucker occurs when striped bass are present. However, as was discussed with flannelmouth sucker, the alternative explanation for the large number of age-0 bluehead sucker in Reach 6 above the PNM Weir (P. Holden, pers. comm.), may also apply here.

In the last two years the bluehead sucker population riverwide has become numerically dominated by smaller size-class fish. Juvenile bluehead sucker CPUE declined significantly in Reach 6 between 2000 and 2001. At the same time, juvenile bluehead sucker CPUE increased significantly in Reaches 4-2. In fact, juvenile (and total) bluehead sucker CPUE in 2001 was the highest ever observed for those reaches. Like flannelmouth sucker, it appears that young bluehead sucker observed in upper Reach 6 in 2000 may have moved into downstream reaches where they were collected in 2001. This is supported by an increase in bluehead sucker mean TL in Reach 6 in 2001 and a corresponding decrease in bluehead sucker mean TL in downstream Reaches 5-2 in 2001. Juvenile bluehead sucker appeared to have grown about 100 mm between October 2000 (age-0 fish) and October 2001 (age-1 fish).

Adult bluehead sucker CPUE also dropped significantly in Reaches 6-4 between 2000 and 2001. However, the reason for this observed decline is not obvious at the moment. Riverwide, bluehead sucker total CPUE was not significantly different in 2001 than it was in five of the six preceding years and the percent of the total catch made up by bluehead sucker has not changed markedly since 1996, staying between 10.7% and 16.6% of the total catch.

Bluehead sucker exhibit population trends independent of those observed among sympatric flannelmouth sucker. This is logical, given the two species often occupy different habitats, with bluehead sucker being more closely associated with cobble-dominated habitats such as riffles, whereas flannelmouth sucker tend to be more of a generalist species, being found in almost all habitat types that occur in the San Juan River. Also, bluehead sucker are more limited in their longitudinal distribution than are flannelmouth sucker. Thus the factors that affect flannelmouth sucker may affect bluehead sucker differently or not at all.

Common Nonnative Fishes

Channel Catfish

Riverwide, channel catfish total CPUE increased significantly from 1996-2001. This is mainly due to increased numbers of juvenile channel catfish over the last three years riverwide. Overall channel catfish CPUE trends in individual reaches are extremely variable and hard to interpret. However, it is apparent that numbers of channel catfish have increased fairly dramatically: in Reach 5 (both juvenile and adults) since 1994; in Reach 4 (juveniles) since 1998; and in Reach 2 (juveniles) since 1997.

Like CPUE, channel catfish mean TL trends are also highly variable. However, there has been a generalized downward trend in mean TL in Reaches 6 and 3-1 over the entire sampling period (i.e., from 1991 on). However, if data sets are cropped to begin at 1996 (i.e., when nonnative fish removal began), the declining trends in mean TL become much less clear or disappear altogether. Thus it is hard to definitely tie declining mean TL trends among channel catfish to nonnative fish removal efforts. Yet, while mean TL graphs for channel catfish remain hard to interpret, riverwide length-frequency histograms do show that channel catfish > 525 mm TL have become much less common in electrofishing collections since 1996. This is probably directly attributable to nonnative fish removal efforts.

In 2001, it was thought that the significant increases seen in juvenile bluehead sucker CPUE in lower Reach 6 (RM 166.6-158.6) in 1999 and in juvenile flannelmouth sucker CPUE in lower Reach 6 in 2000 were directly correlated with the mechanical removal of channel catfish from this section of river. Nonnative fish removal crews were collecting very few channel catfish on late winter/early spring sampling trips and the mean TL of those fish was smaller than it had been in past years (J. Davis, pers. comm.). Then in 2001, channel catfish total CPUE in Reach 6 increased to highest value ever observed. Channel catfish mean TL in Reach 6 also increased. In both 2001 and 2002, channel catfish FLOY-tagged downstream of the newly-completed Hogback Diversion fish passage structure (a non-selective fish passage) were recaptured upstream in lower Reach 6 (J. Davis, pers. comm.). This indicates that lower Reach 6 may be getting recolonized regularly by fish moving upstream from Reach 5. Based on CPUE values, Reach 5 presently harbors the largest numbers of channel catfish present in any reach in the San Juan River. Therefore, until numbers of channel catfish have been greatly reduced in both lower Reach 6 and adjacent Reach 5, it is unlikely that any long-lasting positive effects on the flannelmouth and bluehead sucker populations in lower Reach 6 will be readily apparent.

Unlike the other three common large-bodied fishes in the San Juan River, large numbers of age-0 channel catfish were not collected in Fall 2000 sampling. However, in Fall 2001 collections, a very large cohort of 126-150 mm TL (age-1) channel catfish were observed, accounting for over 15% of all sampled channel catfish riverwide. It appears that like the other three common large-bodied fishes, channel catfish also had a highly successful spawning effort during the low-flow, clear-water conditions present in the summer of 2000. But, since channel catfish are summer spawners (not spring spawners like flannelmouth sucker, bluehead sucker, and common carp) their 2000 year-class progeny were apparently too small to be adequately sampled via electrofishing in Fall 2000.

Common Carp

Common carp total CPUE riverwide has not changed significantly in the last five years. Like channel catfish, common carp CPUE trends are highly variable in individual reaches. However, unlike channel catfish, common carp total CPUE trends tend to almost exactly mirror CPUE trends for adult common carp. This is because adult common carp are by far the most commonly collected life-stage. However, there are two trends observed among common carp that are of interest. First, the decreasing (though not statistically significant) trend in adult common carp CPUE in Reach 6, specifically in lower Reach 6 (RM 166.6-158.6) over the last six years may be directly related to nonnative fish removal efforts. If so, this would be the first evidence ever collected that would indicate that fisheries managers could have an impact on the San Juan River common carp population. Only further monitoring will tell. Second, the significant increase in common carp total CPUE in Reach 1, adjacent to Lake Powell, since 1993 is likely tied to common carp invading the lower San Juan River from Lake Powell. As habitats in the lower river become more and more embedded and marginal for species such as flannelmouth sucker, common carp may be taking advantage of their ability to thrive where other species cannot.

As was the case with native flannelmouth sucker and bluehead sucker, large numbers of age-0 common carp were collected in Reach 6 in 2000, the majority of which were collected upstream of the PNM Weir. At the same time, adult common carp CPUE in Reach 6 was the lowest ever observed in this reach during a fall monitoring trip. It seems probable that the same factors that contributed to the presence of large numbers of age-0 native suckers in 2000 (discussed previously) were likely also responsible for the large number of age-0 common carp observed in fall 2000.

Other Nonnative Fishes

Largemouth Bass

There are usually very few largemouth bass collected in the San Juan River during adult monitoring trips. This was the case again in 2001, when only two largemouth were collected in the San Juan River. However, in 2000, largemouth bass were much more common in adult monitoring collections. Given that most of the largemouth bass collected in 2000 occurred upstream of RM 100.0 and that most of them were juveniles, it would appear that these fish are entering the San Juan River from upstream sources (much like roundtail chub). Largemouth bass (mostly juveniles) have been collected in Reaches 6 and 5 in past years, usually in or near the mouths of irrigation return canals. Off-channel ponds linked to these irrigation return canals may be the source of these fish. Low, clear flows and a stable hydrograph throughout spring and summer 2000 may have contributed to a higher-than-usual survival rate of juvenile largemouth bass once they entered the river.

Despite numbers of largemouth bass collected in 2000 being markedly higher than in previous years, when compared to other fish species in the river, the percent of the fish community composed by this species was still very low. However, while juvenile largemouth bass are not an overwhelming threat to native fishes by themselves, they are just one more stressor in a system already heavily laden with stressors. Juvenile and adult largemouth bass are known to prey on native speckled dace (SJRIP integrated database), and will place predation pressures on sympatric native species when they are present (Lentsch et al. 1996, Tyus and Saunders 1996). Given the stockings of age-0 Colorado pikeminnow scheduled to take place in Reaches 6 and 5 over the next eight years (Ryden 2003a), it is possible that largemouth bass could prey on these stocked endangered fish (Lentsch et al. 1996, Tyus and Saunders 1996).

Striped Bass

Like largemouth bass, only two striped bass were collected in the San Juan River in 2001. However, striped bass are a problem in the San Juan River, albeit on an intermittent basis. The numbers of this particular predator found at any given time in the San Juan River are usually very low. Yet, even one striped bass in the river represents the loss of native fish through predation (SJRIP integrated database, Lentsch et al. 1996, Tyus and Saunders 1996). Striped bass have been documented preying upon common fish species, both native and nonnative, in the San Juan River (SJRIP integrated database). Data collected during the July 2000 razorback sucker monitoring trip (i.e., absence of small native suckers in electrofishing collections combined with common native and nonnative fishes documented in striped bass stomachs; Ryden 2001a) and during the October 2000 adult monitoring trip (i.e., the skewed distribution of age-0 flannelmouth sucker, bluehead sucker, and common carp occurring largely upstream of the PNM Weir, where striped bass did not occur in summer 2000) indicates adult striped bass likely cropped large numbers of juvenile, common fishes during summer 2000. There is no reason to believe that rare native fishes occupying the same habitats as adult striped bass would not be eaten as well. Just because rare fish are less abundant and predation on them is that much harder to document, does not mean it doesn't occur. This becomes an issue of concern to the SJRIP as significant financial and manpower resources are being shifted towards stocking efforts for Colorado pikeminnow and razorback sucker. If influxes of large numbers of striped bass from Lake Powell occur with any regularity (as was observed in summer 2000), whole stockings of endangered fish could be affected.

The quandary that the SJRIP finds itself in is that there are few remedial actions that can be taken to address this problem. Mechanical removal efforts can be intensified when striped bass invasions are identified and angler bag limits on striped bass in the mainstem San Juan River and Lake Powell can be removed, but realistically, there is little else that can be done.

Walleye

Like largemouth bass and striped bass, walleye are usually present in the San Juan River only in low numbers. This was the case again in 2001 when only one walleye was collected . However, like striped bass, walleye possess the ability to consume both early life-stage and larger juvenile native fishes (SJRIP integrated database). Like Colorado pikeminnow, walleye are exclusively and aggressively piscivorous (at $\geq$ age-1; S. Ross pers. comm.), thus bringing them into potential competition with Colorado pikeminnow for food resources. In addition, walleye will consume other predatory fishes (pers. obs.). Walleye stomachs collected from the San Juan River and Lake Powell contained largemouth bass remains (310 mm SL) as well as those of channel catfish (40-85 mm TL; unpublished data).

While the competition and predation pressures placed on Colorado pikeminnow by walleye in the San Juan River may be small due to their low numbers, walleye, like largemouth bass represent another stressor on native fish populations in a highly modified river system already heavily laden with stressors.

POINTS FOR DATA INTEGRATION

- What was it about calendar year 2000 that allowed all four common, large-bodied fishes to have such a successful spawning effort?
    - Did the unusually high flows in August and September 1999 combined with a nonperturbated winter in 1999-2000 prepare extremely favorable spawning conditions for all common fish species?
    - Did the low-flow, clear-water conditions of spring and summer 2000 enhance survival of age-0 fish well beyond what would be expected in a more “normal” year?
- Can the decline in flannelmouth sucker CPUE in Reaches 1 and 2 since 1995 be tied to habitat degradation (i.e., deposition of sediments)?
- What factors can be identified to help explain the dramatic drop-off in Colorado pikeminnow CPUE after fall 1998?
- Is there any way to back-calculate spawning dates for razorback sucker?
    - Could this possibly be tied to Steve Platania’s drift research to help determine where in the river larval razorback sucker were spawned?
- Is the increase in smaller size-class channel catfish observed in adult monitoring over the last several years reflected in small-bodied fish monitoring data?
- Is there an alternate explanation (i.e., other than mechanical removal efforts) for the decreasing CPUE observed for common carp in lower Reach 6 (RM 166.6-158.6)?
- Is there a way to manipulate flows to help keep turbidity at a level that will suppress numbers of largemouth bass, striped bass, and walleye in the San Juan River?

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APPENDIX A

Results of statistical tests performed to determine whether or not significant differences existed between various population metrics (i.e., catch per unit effort, mean total length, mean biomass, and mean condition factor) among years, both riverwide and among individual geomorphic reaches, for the four common large-bodied fishes in the San Juan River, 1991-2001.

Table A1a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.151, r^2 = 0.020, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.025*	1.000				
1998	0.000*	1.000	1.000			
1999	0.004*	1.000	1.000	1.000		
2000	1.000	0.004*	0.000*	0.001*	1.000	
2001	1.000	1.000	0.096*	0.543	0.686	1.000

Table A1b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 25.389, r^2 = 0.061, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.038*	1.000				
1998	1.000	0.012*	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.037*	0.000*	0.217	0.000*	1.000	
2001	0.048*	0.000*	0.251	0.000*	1.000	1.000

Table A1c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.966, r^2 = 0.025, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.003*	1.000				
1998	0.054*	1.000	1.000			
1999	1.000	0.000*	0.001*	1.000		
2000	0.601	0.000*	0.000*	1.000	1.000	
2001	1.000	0.002*	0.028*	1.000	1.000	1.000

Table A2a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 22.212, $r^2 = 0.341$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	0.000*	1.000

Table A2b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.381, $r^2 = 0.147$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	1.000	1.000	1.000	0.010*	1.000	
2001	1.000	1.000	1.000	0.000*	1.000	1.000

Table A2c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 18.402, $r^2 = 0.300$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	0.157	0.154	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	0.074*	0.000*	1.000

Table A3a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 16.400, r^2 = 0.244, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	0.000*	0.000*	0.012*	1.000				
1998	0.000*	0.000*	0.036*	1.000	1.000			
1999	0.531	1.000	1.000	0.993	1.000	1.000		
2000	1.000	1.000	1.000	0.035*	0.073*	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A3b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 13.377, r^2 = 0.209, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	0.873	0.608	1.000					
1997	0.000*	1.000	0.026*	1.000				
1998	1.000	0.015*	1.000	0.000*	1.000			
1999	1.000	0.001*	0.791	0.000*	1.000	1.000		
2000	0.042*	0.000*	0.000*	0.000*	0.004*	0.605	1.000	
2001	1.000	0.039*	1.000	0.002*	1.000	1.000	0.041*	1.000

Table A3c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 42.056, r^2 = 0.427, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.000*	1.000								
1994	0.000*	0.000*	0.090*	1.000							
1995	0.000*	0.000*	0.000*	0.982	1.000						
1996	0.000*	0.000*	0.000*	1.000	1.000	1.000					
1997	0.000*	0.000*	0.000*	0.000*	1.000	0.300	1.000				
1998	0.000*	0.000*	0.000*	0.854	1.000	1.000	1.000	1.000			
1999	0.002*	0.000*	0.116	1.000	1.000	1.000	0.156	1.000	1.000		
2000	0.499	0.000*	1.000	1.000	0.344	1.000	0.000*	0.293	1.000	1.000	
2001	1.000	0.000*	1.000	1.000	0.037*	0.268	0.000*	0.035*	1.000	1.000	1.000

Table A4a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.884, $r^2 = 0.165$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.000*	0.001*	1.000					
1997	0.000*	0.000*	1.000	1.000				
1998	0.000*	0.000*	0.319	0.523	1.000			
1999	0.000*	0.078*	1.000	1.000	0.135	1.000		
2000	0.006*	0.562	1.000	1.000	0.030*	1.000	1.000	
2001	0.123	1.000	1.000	0.562	0.001*	1.000	1.000	1.000

Table A4b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 35.442, $r^2 = 0.353$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	0.000*	0.820	1.000					
1997	0.000*	1.000	0.219	1.000				
1998	0.000*	0.038*	1.000	0.008*	1.000			
1999	1.000	0.000*	0.000*	0.000*	0.000*	1.000		
2000	1.000	0.000*	0.000*	0.000*	0.001*	1.000	1.000	
2001	0.046*	0.000*	0.006*	0.000*	0.492	0.031*	1.000	1.000

Table A4c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 30.527, $r^2 = 0.317$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.029*	0.071*	1.000	1.000							
1995	0.000*	0.000*	0.000*	0.000*	1.000						
1996	0.000*	0.000*	0.000*	0.000*	1.000	1.000					
1997	0.000*	0.000*	0.000*	0.000*	0.696	1.000	1.000				
1998	0.000*	0.000*	0.000*	0.000*	1.000	1.000	1.000	1.000			
1999	0.000*	0.000*	0.087*	1.000	0.639	0.027*	0.000*	0.005*	1.000		
2000	0.000*	0.000*	0.032*	1.000	1.000	0.147	0.002*	0.029*	1.000	1.000	
2001	0.000*	0.000*	0.005*	0.275	1.000	0.448	0.009*	0.092*	1.000	1.000	1.000

Table A5a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 34.945, r^2 = 0.252, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	0.000*	0.000*	1.000					
1997	0.000*	0.000*	1.000	1.000				
1998	0.000*	0.000*	0.849	0.528	1.000			
1999	0.000*	0.000*	0.275	0.170	1.000	1.000		
2000	0.000*	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	0.001*	0.000*	1.000	1.000	1.000	0.577	1.000	1.000

Table A5b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.954, r^2 = 0.168, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	1.000	0.001*	1.000					
1997	0.000*	1.000	0.208	1.000				
1998	1.000	0.029*	1.000	1.000	1.000			
1999	0.005*	0.000*	0.000*	0.000*	0.000*	1.000		
2000	1.000	0.000*	0.024*	0.000*	0.014*	1.000	1.000	
2001	0.024*	0.000*	0.000*	0.000*	0.000*	1.000	1.000	1.000

Table A5c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.472, r^2 = 0.170, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.000*	1.000								
1994	1.000	0.000*	0.302	1.000							
1995	1.000	0.000*	0.000*	1.000	1.000						
1996	0.086*	0.000*	1.000	0.012*	0.000*	1.000					
1997	0.005*	0.000*	1.000	0.000*	0.000*	1.000	1.000				
1998	0.001*	0.000*	0.772	0.000*	0.000*	1.000	1.000	1.000			
1999	0.709	0.000*	1.000	0.244	0.001*	1.000	1.000	1.000	1.000		
2000	0.450	0.000*	1.000	0.117	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	1.000	0.000*	1.000	1.000	0.084*	1.000	0.831	0.140	1.000	1.000	1.000

Table A6a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 55.592, r^2 = 0.351, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.004*	1.000					
1997	0.000*	0.000*	1.000				
1998	0.000*	0.000*	1.000	1.000			
1999	0.000*	0.000*	0.107	0.007*	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.230	1.000	
2001	0.000*	0.000*	0.082*	0.005*	1.000	0.158	1.000

Table A6b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.872, r^2 = 0.096, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	1.000	1.000					
1997	1.000	0.158	1.000				
1998	1.000	1.000	0.519	1.000			
1999	0.008*	0.440	0.000*	0.213	1.000		
2000	0.014*	0.000*	0.052*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	0.023*	0.001*	1.000

Table A6c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 36.608, r^2 = 0.260, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.001*	0.337	1.000					
1997	0.763	0.000*	0.000*	1.000				
1998	1.000	0.000*	0.000*	1.000	1.000			
1999	0.156	0.000*	0.000*	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	
2001	0.001*	0.000*	0.000*	1.000	0.032*	1.000	0.015*	1.000

Table A7a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile flannelmouth sucker CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 30.248, r^2 = 0.577, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.000*	1.000					
1997	0.000*	1.000	1.000				
1998	0.000*	0.079*	1.000	1.000			
1999	0.000*	0.950	1.000	1.000	1.000		
2000	0.000*	0.882	1.000	1.000	1.000	1.000	
2001	0.000*	1.000	1.000	1.000	1.000	1.000	1.000

Table A7b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult flannelmouth sucker CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.749, r^2 = 0.073, p = 0.115

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	1.000	1.000					
1997	1.000	1.000	1.000				
1998	1.000	0.425	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	0.587	1.000	1.000	1.000

Table A7c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) flannelmouth sucker CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.209, r^2 = 0.348, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	0.002*	0.001*	1.000					
1997	0.000*	0.000*	1.000	1.000				
1998	0.000*	0.000*	0.590	1.000	1.000			
1999	0.000*	0.000*	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	0.003*	0.001*	1.000	1.000	1.000	1.000	1.000	1.000

Table A8. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 193.232, r^2 = 0.090, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	0.000*	0.000*	1.000			
1999	0.000*	0.000*	0.001*	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	0.004*	0.001*	0.000*	0.000*	0.000*	1.000

Table A9. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 139.691, $r^2 = 0.280$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.078*	1.000				
1998	0.040*	1.000	1.000			
1999	0.000*	0.000*	0.009*	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	0.003*	0.001*	0.000*	0.000*	1.000

Table A10. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 18.393, $r^2 = 0.039$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.000*	0.000*	1.000								
1994	1.000	1.000	0.000*	1.000							
1995	1.000	1.000	0.009*	1.000	1.000						
1996	0.000*	0.000*	0.000*	0.003*	0.001*	1.000					
1997	0.258	0.005*	0.000*	0.880	0.253	1.000	1.000				
1998	0.077*	0.003*	0.000*	0.235	0.071*	1.000	1.000	1.000			
1999	0.001*	0.000*	0.000*	0.006*	0.002*	1.000	1.000	1.000	1.000		
2000	0.006*	0.032*	1.000	0.003*	0.119	0.000*	0.000*	0.000*	0.000*	1.000	
2001	0.012*	0.063*	1.000	0.005*	0.222	0.000*	0.000*	0.000*	0.000*	1.000	1.000

Table A11. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 29.775, $r^2 = 0.046$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.003*	1.000									
1993	0.000*	0.198	1.000								
1994	0.017*	1.000	0.005*	1.000							
1995	0.000*	0.000*	0.001*	0.000*	1.000						
1996	1.000	0.592	0.000*	1.000	0.000*	1.000					
1997	1.000	0.911	0.000*	1.000	0.000*	1.000	1.000				
1998	1.000	0.000*	0.000*	0.000*	0.000*	0.458	0.432	1.000			
1999	0.002*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	1.000		
2000	1.000	0.000*	0.000*	0.000*	0.000*	1.000	0.943	1.000	1.000	1.000	
2001	0.003*	1.000	0.984	1.000	0.000*	0.432	0.659	0.000*	0.000*	0.000*	1.000

Table A12. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 52.648, $r^2 = 0.072$, p = 0.000*
Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.000*	1.000								
1994	0.000*	1.000	0.000*	1.000							
1995	0.000*	0.000*	0.000*	0.000*	1.000						
1996	1.000	0.000*	1.000	0.000*	0.000*	1.000					
1997	0.024*	0.000*	1.000	0.015*	0.000*	1.000	1.000				
1998	1.000	0.000*	0.164	0.000*	0.000*	0.267	0.000*	1.000			
1999	1.000	0.000*	0.078*	0.000*	0.000*	0.133	0.000*	1.000	1.000		
2000	0.000*	1.000	0.000*	0.905	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	0.000*	1.000	0.000*	0.000*	1.000	1.000	0.248	0.128	0.000*	1.000

Table A13. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 28.795, $r^2 = 0.093$, p = 0.000*
Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	1.000	0.000*	1.000					
1997	0.025*	0.000*	0.005*	1.000				
1998	0.000*	0.000*	0.000*	0.201	1.000			
1999	0.000*	0.000*	0.000*	0.001*	1.000	1.000		
2000	1.000	0.000*	1.000	1.000	0.133	0.001*	1.000	
2001	1.000	0.018*	1.000	0.383	0.000*	0.000*	1.000	1.000

Table A14. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean total length data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.267, $r^2 = 0.198$, p = 0.294
Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A15. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 40.632, $r^2 = 0.020$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.002*	1.000				
1998	0.189	0.000*	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.000*	1.000	0.000*	0.000*	1.000	
2001	1.000	0.015*	0.081*	0.000*	0.000*	1.000

Table A16. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 46.333, r^2 = 0.114, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.376	1.000				
1998	0.191	1.000	1.000			
1999	0.003*	0.052*	0.628	1.000		
2000	1.000	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	0.000*	0.000*	1.000

Table A17. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 22.128, r^2 = 0.046, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.018*	1.000	1.000								
1994	0.413	0.000*	0.000*	1.000							
1995	1.000	1.000	0.608	0.531	1.000						
1996	0.000*	0.000*	0.000*	0.000*	0.000*	1.000					
1997	1.000	0.557	0.006*	1.000	1.000	0.000*	1.000				
1998	0.007*	0.000*	0.000*	1.000	0.009*	1.000	0.379	1.000			
1999	0.001*	0.000*	0.000*	0.630	0.001*	1.000	0.074*	1.000	1.000		
2000	0.015*	0.000*	0.000*	1.000	0.025*	0.028*	1.000	1.000	1.000	1.000	
2001	1.000	0.864	0.009*	1.000	1.000	0.000*	1.000	0.217	0.038*	0.746	1.000

Table A18. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 37.738, r^2 = 0.058, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.150	1.000									
1993	0.000*	1.000	1.000								
1994	1.000	0.002*	0.000*	1.000							
1995	0.000*	0.000*	0.001*	0.000*	1.000						
1996	0.039*	0.000*	0.000*	0.870	0.000*	1.000					
1997	1.000	1.000	0.003*	1.000	0.000*	0.025*	1.000				
1998	0.159	0.000*	0.000*	1.000	0.000*	1.000	0.080*	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	0.000*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.077*	0.000*	0.378	1.000	1.000	
2001	1.000	0.840	0.000*	1.000	0.000*	0.062*	1.000	0.182	0.000*	0.000*	1.000

Table A19. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 50.603, $r^2 = 0.069$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.000*	1.000								
1994	0.000*	0.023*	0.261	1.000							
1995	0.000*	0.000*	0.000*	0.000*	1.000						
1996	1.000	0.000*	1.000	0.000*	0.000*	1.000					
1997	0.000*	0.345	0.113	1.000	0.000*	0.000*	1.000				
1998	0.375	0.000*	0.003*	0.000*	0.000*	1.000	0.000*	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	0.001*	0.000*	1.000	1.000		
2000	1.000	0.000*	1.000	1.000	0.000*	0.223	1.000	0.000*	0.000*	1.000	
2001	1.000	0.000*	0.015*	0.000*	0.000*	1.000	0.000*	1.000	0.405	0.002*	1.000

Table A20. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 30.394, $r^2 = 0.098$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	1.000	0.000*	1.000					
1997	0.376	0.000*	1.000	1.000				
1998	0.000*	0.000*	0.000*	0.108	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.002*	1.000		
2000	0.020*	0.000*	0.117	1.000	1.000	0.006*	1.000	
2001	1.000	0.000*	1.000	1.000	0.490	0.000*	1.000	1.000

Table A21. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean biomass data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.406, $r^2 = 0.319$, p = 0.040*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.332	0.448	1.000	1.000	1.000	1.000		
2000	0.553	0.764	1.000	1.000	1.000	1.000	1.000	
2001	0.683	0.925	1.000	1.000	1.000	1.000	1.000	1.000

Table A22. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 45.235, $r^2 = 0.023$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	1.000	0.000*	1.000			
1999	1.000	0.000*	1.000	1.000		
2000	1.000	0.000*	0.993	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.001*	1.000

Table A23. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 26.099, r^2 = 0.068, p = 0.000*
Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.041*	0.000*	0.000*	1.000		
2000	1.000	0.001*	0.000*	0.022*	1.000	
2001	0.671	0.001*	0.099*	0.000*	0.000*	1.000

Table A24. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 45.786, r^2 = 0.091, p = 0.000*
Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.002*	0.000*	0.000*	1.000							
1995	1.000	1.000	1.000	0.126	1.000						
1996	0.000*	0.000*	0.000*	0.000*	0.000*	1.000					
1997	0.008*	0.002*	0.571	0.000*	0.013*	0.000*	1.000				
1998	0.134	0.056*	0.002*	1.000	0.714	0.002*	0.000*	1.000			
1999	0.115	0.048*	0.001*	1.000	0.614	0.003*	0.000*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	0.000*	0.057*	0.085*	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	0.000*	0.000*	0.000*	0.199	1.000

Table A25. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 29.251, r^2 = 0.045, p = 0.000*
Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.837	1.000								
1994	0.000*	0.005*	0.000*	1.000							
1995	0.399	0.077*	1.000	0.000*	1.000						
1996	0.000*	0.000*	0.000*	0.047*	0.000*	1.000					
1997	1.000	1.000	1.000	0.000*	1.000	0.000*	1.000				
1998	0.308	1.000	0.002*	1.000	0.000*	0.064*	0.007*	1.000			
1999	0.000*	0.001*	0.000*	1.000	0.000*	1.000	0.000*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	0.000*	0.000*	0.014*	1.000	
2001	0.000*	0.000*	0.000*	1.000	0.000*	1.000	0.000*	1.000	1.000	0.047*	1.000

Table A26. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 43.635, $r^2 = 0.060$, $p = 0.000$*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	1.000	1.000	1.000							
1995	0.000*	0.000*	0.000*	0.000*	1.000						
1996	1.000	1.000	0.286	0.379	0.000*	1.000					
1997	0.055*	0.149	1.000	1.000	0.000*	0.000*	1.000				
1998	0.017*	0.003*	0.000*	0.000*	0.000*	0.683	0.000*	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.002*	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.002*	0.000*	1.000	0.013*	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.008*	0.000*	1.000	0.013*	1.000	1.000

Table A27. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.595, $r^2 = 0.043$, $p = 0.000$*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	0.000*	0.000*	1.000					
1997	1.000	0.205	0.004*	1.000				
1998	0.008*	0.000*	1.000	0.591	1.000			
1999	0.000*	0.000*	1.000	0.029*	1.000	1.000		
2000	1.000	1.000	0.005*	1.000	0.195	0.014*	1.000	
2001	0.027*	0.000*	1.000	0.606	1.000	1.000	0.183	1.000

Table A28. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of flannelmouth sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.038, $r^2 = 0.168$, $p = 0.422$

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A29a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 5.201, $r^2 = 0.013$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.853	1.000				
1998	1.000	1.000	1.000			
1999	0.003*	0.447	0.022*	1.000		
2000	0.006*	0.994	0.053*	1.000	1.000	
2001	0.031*	1.000	0.186	1.000	1.000	1.000

Table A29b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.736, $r^2 = 0.024$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.066*	0.119	1.000	0.052*	1.000	
2001	1.000	1.000	1.000	0.000*	0.050*	1.000

Table A29c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.599, $r^2 = 0.017$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.001*	0.001*	1.000		
2000	0.006*	0.273	0.145	1.000	1.000	
2001	1.000	1.000	1.000	0.046*	1.000	1.000

Table A30a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.920, $r^2 = 0.162$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.046*	1.000	0.057*	1.000		
2000	0.001*	0.163	0.001*	1.000	1.000	
2001	1.000	0.035*	1.000	0.001*	0.000*	1.000

Table A30b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.629, $r^2 = 0.134$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.005*	0.002*	1.000		
2000	0.071*	0.586	0.303	1.000	1.000	
2001	1.000	1.000	1.000	0.000*	0.024*	1.000

Table A30c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.641, $r^2 = 0.183$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.001*	0.145	0.003*	1.000		
2000	0.000*	0.093*	0.001*	1.000	1.000	
2001	1.000	0.088*	1.000	0.000*	0.000*	1.000

Table A31a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.632, $r^2 = 0.049$, p = 0.012*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.651	0.313	1.000					
1997	0.515	0.229	1.000	1.000				
1998	0.826	0.413	1.000	1.000	1.000			
1999	1.000	1.000	0.428	0.386	0.517	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A31b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.278, $r^2 = 0.155$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	0.090*	0.001*	0.575	0.085*	1.000			
1999	0.000*	0.000*	0.004*	0.000*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.405	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	0.044*	0.007*	1.000

Table A31c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 14.278, $r^2 = 0.202$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.003*	1.000								
1994	1.000	0.000*	0.008*	1.000							
1995	0.392	0.000*	0.001*	1.000	1.000						
1996	0.144	0.000*	0.000*	1.000	1.000	1.000					
1997	0.026*	0.000*	0.000*	1.000	1.000	1.000	1.000				
1998	1.000	0.000*	0.097*	1.000	1.000	1.000	1.000	1.000			
1999	1.000	0.122	1.000	0.322	0.084*	0.034*	0.009*	1.000	1.000		
2000	1.000	0.029*	1.000	1.000	0.308	0.130	0.041*	1.000	1.000	1.000	
2001	1.000	0.000*	0.315	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A32a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.225, $r^2 = 0.087$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.948	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	0.448	0.000*	0.034*	0.321	1.000			
1999	1.000	1.000	1.000	1.000	0.011*	1.000		
2000	1.000	0.009*	0.249	1.000	1.000	0.080*	1.000	
2001	0.025*	1.000	0.355	0.032*	0.000*	1.000	0.000*	1.000

Table A32b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.862, $r^2 = 0.108$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	0.125	1.000	0.392	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.017*	0.000*	0.006*	0.000*	0.000*	1.000		
2000	1.000	1.000	1.000	0.660	1.000	0.056*	1.000	
2001	0.003*	0.068*	0.012*	1.000	0.638	0.000*	0.030*	1.000

Table A32c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.827, $r^2 = 0.106$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.659	0.001*	0.043*	1.000							
1995	1.000	0.009*	0.479	1.000	1.000						
1996	1.000	0.003*	0.184	1.000	1.000	1.000					
1997	0.006*	0.000*	0.000*	1.000	1.000	1.000	1.000				
1998	0.001*	0.000*	0.000*	1.000	0.249	0.753	1.000	1.000			
1999	1.000	1.000	1.000	0.577	1.000	1.000	0.012*	0.001*	1.000		
2000	0.065*	0.000*	0.004*	1.000	1.000	1.000	1.000	1.000	0.064*	1.000	
2001	1.000	0.009*	0.323	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A33a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 31.753, r^2 = 0.235, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.006*	0.000*	1.000					
1997	1.000	0.173	0.578	1.000				
1998	1.000	0.058*	1.000	1.000	1.000			
1999	0.178	0.004*	1.000	1.000	1.000	1.000		
2000	0.029*	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A33b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.599, r^2 = 0.024, p = 0.012*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	0.171	0.940	0.875	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	0.030*	0.177	1.000		
2000	1.000	1.000	1.000	1.000	1.000	0.398	1.000	
2001	1.000	1.000	1.000	1.000	1.000	0.515	1.000	1.000

Table A33c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 21.353, r^2 = 0.176, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.097*	1.000									
1993	0.000*	0.000*	1.000								
1994	0.000*	0.015*	1.000	1.000							
1995	0.000*	0.089*	1.000	1.000	1.000						
1996	0.000*	0.000*	1.000	0.459	0.082*	1.000					
1997	0.000*	0.000*	1.000	1.000	0.331	1.000	1.000				
1998	0.000*	0.000*	1.000	1.000	0.408	1.000	1.000	1.000			
1999	0.000*	0.002*	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	1.000	0.201	0.039*	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A34a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile bluehead sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 61.641, $r^2 = 0.375$, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.000*	1.000					
1997	0.000*	1.000	1.000				
1998	0.000*	1.000	1.000	1.000			
1999	0.000*	1.000	1.000	1.000	1.000		
2000	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A34b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult bluehead sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.901, $r^2 = 0.071$, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.003*	1.000					
1997	0.000*	0.431	1.000				
1998	0.000*	1.000	1.000	1.000			
1999	0.118	1.000	0.108	1.000	1.000		
2000	0.000*	0.395	1.000	1.000	0.100	1.000	
2001	0.000*	1.000	1.000	1.000	1.000	1.000	1.000

Table A34c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) bluehead sucker CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 50.001, $r^2 = 0.324$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	1.000	0.000*	1.000					
1997	1.000	0.000*	1.000	1.000				
1998	1.000	0.000*	1.000	1.000	1.000			
1999	1.000	0.000*	1.000	1.000	1.000	1.000		
2000	1.000	0.000*	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A35. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 33.495, $r^2 = 0.053$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	1.000	0.000*	1.000			
1999	1.000	0.000*	1.000	1.000		
2000	0.000*	1.000	0.000*	0.000*	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.040*	1.000

Table A36. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.140, r^2 = 0.033, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	0.000*	1.000			
1999	1.000	0.000*	1.000	1.000		
2000	1.000	1.000	0.000*	0.000*	1.000	
2001	1.000	0.300	0.489	1.000	0.036*	1.000

Table A37. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.098, r^2 = 0.060, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.003*	0.000*	1.000								
1994	1.000	0.411	1.000	1.000							
1995	1.000	1.000	0.552	1.000	1.000						
1996	1.000	1.000	0.000*	0.011*	1.000	1.000					
1997	1.000	1.000	0.000*	0.673	1.000	1.000	1.000				
1998	0.621	0.684	0.000*	0.002*	0.347	1.000	1.000	1.000			
1999	0.215	0.235	0.000*	0.001*	0.124	1.000	0.782	1.000	1.000		
2000	1.000	1.000	0.029*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	0.143	1.000	0.027*	0.010*	1.000	1.000

Table A38. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 11.381, r^2 = 0.094, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.092*	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	0.197	1.000	1.000	1.000						
1996	1.000	1.000	0.804	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000	1.000	1.000	1.000				
1998	0.071*	1.000	0.004*	0.753	0.007*	1.000	0.189	1.000			
1999	0.142	1.000	0.002*	1.000	0.007*	1.000	0.492	1.000	1.000		
2000	0.000*	0.079*	0.000*	0.013*	0.000*	0.025*	0.001*	1.000	1.000	1.000	
2001	0.000*	0.000*	0.003*	0.000*	0.014*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A39. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.605, r^2 = 0.121, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	0.968	1.000	1.000							
1995	1.000	1.000	1.000	1.000	1.000						
1996	1.000	1.000	1.000	0.046*	0.132	1.000					
1997	1.000	1.000	1.000	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
2000	0.173	0.114	0.143	1.000	1.000	0.007*	1.000	1.000	0.644	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.004*	0.000*	0.836	1.000

Table A40. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean total length data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 14.182, r^2 = 0.330, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.029*	0.123	1.000	0.010*	0.409	1.000		
2000	0.600	0.005*	0.003*	1.000	0.012*	0.000*	1.000	
2001	0.011*	0.000*	0.000*	0.047*	0.000*	0.000*	1.000	1.000

<u>NOTE:</u> No bluehead sucker were collected in Reach 1, adjacent to Lake Powell, during 1991-2001 sampling.

Table A41. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 17.976, r^2 = 0.029, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	0.160	0.000*	1.000			
1999	1.000	0.000*	0.092*	1.000		
2000	1.000	0.000*	0.044*	1.000	1.000	
2001	0.007*	1.000	0.000*	0.003*	0.001*	1.000

Table A42. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 14.017, $r^2 = 0.045$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	0.625	0.000*	1.000			
1999	1.000	0.064*	0.001*	1.000		
2000	1.000	0.001*	0.002*	1.000	1.000	
2001	0.985	0.000*	1.000	0.002*	0.005*	1.000

Table A43. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.560, $r^2 = 0.050$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.046*	0.000*	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	1.000	1.000	1.000	1.000						
1996	1.000	1.000	0.000*	0.237	1.000	1.000					
1997	1.000	1.000	1.000	1.000	1.000	0.269	1.000				
1998	0.803	0.604	0.000*	0.028*	0.257	1.000	0.027*	1.000			
1999	0.176	0.122	0.000*	0.006*	0.059*	1.000	0.006*	1.000	1.000		
2000	1.000	1.000	0.005*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	0.000*	0.460	1.000	1.000	0.604	1.000	1.000	1.000	1.000

Table A44. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.847, $r^2 = 0.090$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	0.101	1.000	1.000	1.000						
1996	1.000	1.000	1.000	1.000	1.000	1.000					
1997	1.000	0.540	1.000	1.000	1.000	1.000	1.000				
1998	0.048*	1.000	0.052*	0.428	0.006*	0.684	0.025*	1.000			
1999	0.165	1.000	0.162	1.000	0.013*	1.000	0.074*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	0.004*	1.000	
2001	0.824	0.000*	0.260	0.061*	1.000	0.015*	1.000	0.000*	0.000*	0.000*	1.000

Table A45. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.705, r^2 = 0.100, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	0.461	0.380	1.000	1.000						
1996	0.479	1.000	1.000	0.008*	0.001*	1.000					
1997	1.000	1.000	1.000	1.000	1.000	0.080*	1.000				
1998	1.000	1.000	1.000	1.000	1.000	0.875	1.000	1.000			
1999	1.000	1.000	1.000	1.000	0.518	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.006*	0.116	0.000*	0.004*	0.165	0.000*	0.000*	1.000

Table A46. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean biomass data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 14.296, r^2 = 0.331, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	0.818	1.000	1.000					
1997	1.000	1.000	0.422	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.000*	0.000*	0.045*	0.000*	0.001*	1.000		
2000	1.000	1.000	1.000	1.000	1.000	0.000*	1.000	
2001	0.113	0.000*	0.000*	0.277	0.000*	0.000*	0.036*	1.000

<u>NOTE:</u> No bluehead sucker were collected in Reach 1, adjacent to Lake Powell, during 1991-2001 sampling

Table A47. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 70.740, $r^2 = 0.105$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	1.000	0.000*	1.000			
1999	0.000*	1.000	0.000*	1.000		
2000	0.016*	0.000*	1.000	0.000*	1.000	
2001	0.000*	0.000*	0.002*	0.000*	0.104	1.000

Table A48. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 85.543, $r^2 = 0.223$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.051*	1.000				
1998	1.000	0.000*	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	1.000	0.001*	0.150	0.000*	1.000	
2001	0.630	0.001*	1.000	0.000*	0.000*	1.000

Table A49. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.152, $r^2 = 0.066$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	1.000	1.000	1.000	1.000						
1996	1.000	1.000	1.000	0.209	1.000	1.000					
1997	0.000*	0.000*	0.004*	1.000	0.039*	0.000*	1.000				
1998	1.000	1.000	1.000	1.000	1.000	0.280	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000	1.000	0.744	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	0.403	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000

Table A50. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 5.954, $r^2 = 0.052$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.057*	1.000	1.000								
1994	0.003*	0.425	1.000	1.000							
1995	0.577	1.000	1.000	1.000	1.000						
1996	1.000	1.000	1.000	1.000	1.000	1.000					
1997	0.000*	0.005*	0.838	1.000	0.384	0.148	1.000				
1998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
1999	0.479	1.000	1.000	1.000	1.000	1.000	0.977	1.000	1.000		
2000	1.000	1.000	0.106	0.007*	0.580	0.955	0.000*	1.000	0.471	1.000	
2001	1.000	1.000	0.018*	0.001*	0.215	0.396	0.000*	1.000	0.183	1.000	1.000

Table A51. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.500, r^2 = 0.097, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.600	1.000									
1993	0.289	1.000	1.000								
1994	0.001*	1.000	1.000	1.000							
1995	0.002*	1.000	1.000	1.000	1.000						
1996	1.000	1.000	1.000	1.000	1.000	1.000					
1997	0.007*	1.000	1.000	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	0.147	0.178	1.000	0.247	1.000	1.000		
2000	0.028*	0.000*	0.000*	0.000*	0.000*	0.002*	0.000*	0.025*	1.000	1.000	
2001	1.000	1.000	0.641	0.008*	0.015*	1.000	0.033*	1.000	1.000	0.059*	1.000

Table A52. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of bluehead sucker mean condition factor data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 3.486, r^2 = 0.108, p = 0.002*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	0.086*	0.097*	1.000					
1997	1.000	1.000	0.056*	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.597	1.000	1.000	0.437	1.000	1.000		
2000	0.102	0.134	1.000	0.068*	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

<u>NOTE:</u> No bluehead sucker were collected in Reach 1, adjacent to Lake Powell, during 1991-2001 sampling

Table A53a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 46.829, r^2 = 0.107, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.075*	1.000				
1998	0.000*	0.230	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.000*	0.000*	0.000*	0.015*	1.000	
2001	0.000*	0.000*	0.000*	1.000	1.000	1.000

Table A53b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 15.107, r^2 = 0.037, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	0.004*	0.823	1.000			
1999	1.000	0.020*	1.000	1.000		
2000	0.526	0.018*	1.000	1.000	1.000	
2001	0.149	0.000*	0.000*	0.001*	0.000*	1.000

Table A53c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 42.652, r^2 = 0.098, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.000*	1.000				
1998	0.000*	1.000	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.530	0.000*	0.000*	0.167	1.000	
2001	0.000*	0.000*	0.000*	1.000	0.007*	1.000

Table A54a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.302, $r^2 = 0.029$, p = 0.264

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.656	0.390	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000

Table A54b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 4.120, $r^2 = 0.087$, p = 0.001*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.043*	1.000				
1998	1.000	1.000	1.000			
1999	0.234	1.000	1.000	1.000		
2000	0.132	1.000	1.000	1.000	1.000	
2001	1.000	0.011*	0.669	0.079*	0.040*	1.000

Table A54c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.620, $r^2 = 0.057$, p = 0.025*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.257	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	0.814	1.000	1.000	1.000	1.000	
2001	1.000	0.040*	1.000	1.000	0.174	1.000

Table A55a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.044, r^2 = 0.192, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.809	1.000	1.000					
1997	0.546	1.000	1.000	1.000				
1998	0.000*	0.007*	0.515	0.407	1.000			
1999	0.000*	0.001*	0.050*	0.038*	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.013*	1.000	1.000	
2001	0.006*	0.096*	1.000	1.000	1.000	1.000	0.029*	1.000

Table A55b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 21.729, r^2 = 0.300, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.025*	0.043*	1.000					
1997	1.000	1.000	1.000	1.000				
1998	0.000*	0.000*	0.377	0.001*	1.000			
1999	0.984	1.000	1.000	1.000	0.242	1.000		
2000	0.000*	0.000*	0.010*	0.000*	1.000	0.008*	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.350	1.000

Table A55c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.459, r^2 = 0.266, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.044*	1.000									
1993	0.813	0.000*	1.000								
1994	0.000*	0.000*	0.840	1.000							
1995	0.004*	0.000*	1.000	1.000	1.000						
1996	1.000	0.005*	1.000	0.021*	0.241	1.000					
1997	1.000	0.000*	1.000	0.362	1.000	1.000	1.000				
1998	0.643	1.000	0.000*	0.000*	0.000*	0.101	0.001*	1.000			
1999	1.000	1.000	0.250	0.000*	0.004*	1.000	0.660	1.000	1.000		
2000	0.000*	0.127	0.000*	0.000*	0.000*	0.000*	0.000*	0.064*	0.013*	1.000	
2001	0.000*	0.669	0.000*	0.000*	0.000*	0.000*	0.000*	0.335	0.065*	1.000	1.000

Table A56a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 21.224, r^2 = 0.246, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.284	0.559	1.000					
1997	0.000*	0.000*	0.619	1.000				
1998	1.000	1.000	0.174	0.000*	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	1.000		
2000	0.000*	0.000*	0.476	1.000	0.000*	0.002*	1.000	
2001	0.000*	0.000*	0.104	1.000	0.000*	0.008*	1.000	1.000

Table A56b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 15.108, r^2 = 0.189, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.311	1.000						
1996	0.001*	0.000*	1.000					
1997	1.000	0.145	0.001*	1.000				
1998	0.065*	1.000	0.000*	0.030*	1.000			
1999	1.000	0.002*	1.000	1.000	0.001*	1.000		
2000	0.027*	0.000*	1.000	0.048*	0.000*	1.000	1.000	
2001	0.001*	0.000*	1.000	0.001*	0.000*	0.600	1.000	1.000

Table A56c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 23.837, r^2 = 0.266, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.000*	1.000									
1993	1.000	0.000*	1.000								
1994	1.000	0.000*	1.000	1.000							
1995	1.000	0.000*	1.000	1.000	1.000						
1996	0.009*	0.169	0.165	0.001*	0.000*	1.000					
1997	0.007*	0.133	0.145	0.001*	0.000*	1.000	1.000				
1998	1.000	0.000*	0.142	1.000	1.000	0.000*	0.000*	1.000			
1999	0.000*	1.000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000		
2000	0.000*	1.000	0.001*	0.000*	0.000*	1.000	1.000	0.000*	0.322	1.000	
2001	0.000*	1.000	0.000*	0.000*	0.000*	0.326	0.269	0.000*	1.000	1.000	1.000

Table A57a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 14.746, $r^2 = 0.125$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	1.000	0.000*	1.000					
1997	0.406	0.001*	1.000	1.000				
1998	0.140	0.000*	0.000*	0.000*	1.000			
1999	0.094*	0.506	1.000	1.000	0.000*	1.000		
2000	1.000	0.003*	1.000	1.000	0.000*	1.000	1.000	
2001	0.000*	1.000	0.045*	0.190	0.000*	1.000	0.244	1.000

Table A57b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.661, $r^2 = 0.109$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.022*	1.000	1.000					
1997	0.044*	0.000*	0.000*	1.000				
1998	0.001*	0.000*	0.000*	1.000	1.000			
1999	1.000	1.000	1.000	0.033*	0.001*	1.000		
2000	1.000	0.003*	0.000*	1.000	1.000	0.478	1.000	
2001	1.000	0.899	0.030*	0.357	0.010*	1.000	1.000	1.000

Table A57c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 19.269, $r^2 = 0.162$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.003*	1.000									
1993	0.000*	0.000*	1.000								
1994	1.000	0.000*	0.001*	1.000							
1995	0.000*	1.000	0.000*	0.000*	1.000						
1996	1.000	1.000	0.000*	0.348	0.058*	1.000					
1997	1.000	0.003*	0.000*	1.000	0.000*	1.000	1.000				
1998	0.004*	0.000*	1.000	0.010*	0.000*	0.000*	0.000*	1.000			
1999	1.000	1.000	0.000*	0.535	1.000	1.000	1.000	0.000*	1.000		
2000	1.000	0.023*	0.000*	1.000	0.000*	1.000	1.000	0.001*	1.000	1.000	
2001	0.099*	1.000	0.000*	0.010*	1.000	1.000	0.134	0.000*	1.000	0.451	1.000

Table A58a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 41.002, $r^2 = 0.285$, p = 0.000*
Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.525	1.000					
1997	0.000*	0.000*	1.000				
1998	0.000*	0.000*	1.000	1.000			
1999	0.014*	0.000*	0.000*	0.000*	1.000		
2000	1.000	0.051*	0.000*	0.000*	0.029*	1.000	
2001	1.000	0.000*	0.000*	0.000*	1.000	1.000	1.000

Table A58b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.781, $r^2 = 0.168$, p = 0.000*
Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.000*	1.000					
1997	0.000*	0.000*	1.000				
1998	0.000*	1.000	0.032*	1.000			
1999	1.000	0.000*	0.000*	0.000*	1.000		
2000	0.000*	1.000	0.000*	0.455	0.018*	1.000	
2001	0.007*	1.000	0.000*	0.128	0.168	1.000	1.000

Table A58c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 63.369, $r^2 = 0.378$, p = 0.000*
Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.000*	0.014*	1.000					
1997	1.000	0.000*	0.000*	1.000				
1998	0.212	0.000*	0.000*	0.235	1.000			
1999	0.000*	0.043*	0.000*	0.000*	0.000*	1.000		
2000	0.000*	1.000	0.034*	0.000*	0.000*	0.002*	1.000	
2001	0.000*	1.000	0.000*	0.000*	0.000*	0.438	1.000	1.000

Table A59a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile channel catfish CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.068, $r^2 = 0.242$, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.003*	1.000					
1997	0.000*	1.000	1.000				
1998	0.001*	1.000	1.000	1.000			
1999	1.000	0.736	0.139	0.231	1.000		
2000	0.032*	1.000	1.000	1.000	1.000	1.000	
2001	1.000	0.008*	0.001*	0.002*	1.000	0.076*	1.000

Table A59b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult channel catfish CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.771, $r^2 = 0.111$, p = 0.014*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	1.000	1.000					
1997	0.457	1.000	1.000				
1998	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	0.243	0.007*	0.057*	0.357	0.390	1.000

Table A59c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) channel catfish CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.595, $r^2 = 0.273$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	1.000	0.002*	1.000					
1997	1.000	0.000*	1.000	1.000				
1998	1.000	0.000*	1.000	1.000	1.000			
1999	0.152	1.000	1.000	0.128	0.370	1.000		
2000	1.000	0.027*	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	1.000	0.001*	0.000*	0.000*	0.993	0.013*	1.000

Table A60. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 37.350, $r^2 = 0.039$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.393	1.000				
1998	0.013*	0.000*	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.000*	0.002*	0.000*	0.054*	1.000	
2001	0.000*	0.001*	0.000*	0.090*	1.000	1.000

Table A61. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 4.393, $r^2 = 0.090$, p = 0.001*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.348	0.010*	0.000*	1.000		
2000	1.000	1.000	0.518	0.588	1.000	
2001	1.000	1.000	0.807	0.172	1.000	1.000

Table A62. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.781, $r^2 = 0.110$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.000*	0.000*	1.000								
1994	0.014*	0.010*	0.206	1.000							
1995	1.000	1.000	0.000*	0.018*	1.000						
1996	0.202	0.149	0.000*	1.000	0.266	1.000					
1997	1.000	1.000	0.000*	0.243	1.000	1.000	1.000				
1998	1.000	1.000	0.000*	0.004*	1.000	0.052*	1.000	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000		
2000	1.000	1.000	0.000*	0.053*	1.000	0.708	1.000	1.000	0.000*	1.000	
2001	1.000	1.000	0.000*	1.000	1.000	1.000	1.000	1.000	0.000*	1.000	1.000

Table A63. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 11.824, $r^2 = 0.079$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.081*	1.000								
1994	0.000*	0.000*	0.061*	1.000							
1995	1.000	0.228	1.000	0.022*	1.000						
1996	1.000	0.036*	1.000	0.091*	1.000	1.000					
1997	1.000	1.000	0.000*	0.000*	0.000*	0.000*	1.000				
1998	1.000	1.000	1.000	0.006*	1.000	0.983	1.000	1.000			
1999	1.000	1.000	0.000*	0.000*	0.001*	0.000*	1.000	1.000	1.000		
2000	1.000	0.935	1.000	0.012*	1.000	1.000	0.001*	1.000	0.010*	1.000	
2001	1.000	1.000	0.007*	0.000*	0.029*	0.002*	1.000	1.000	1.000	0.217	1.000

Table A64. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.216, $r^2 = 0.048$, $p = 0.000$*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.001*	0.000*	1.000								
1994	0.002*	0.000*	1.000	1.000							
1995	1.000	1.000	0.000*	0.000*	1.000						
1996	1.000	0.011*	0.302	1.000	0.317	1.000					
1997	1.000	1.000	0.000*	0.000*	1.000	0.001*	1.000				
1998	1.000	1.000	1.000	1.000	1.000	1.000	0.268	1.000			
1999	1.000	1.000	0.000*	0.000*	1.000	0.019*	1.000	0.803	1.000		
2000	1.000	1.000	0.000*	0.000*	0.526	0.000*	1.000	0.059*	1.000	1.000	
2001	0.313	1.000	0.000*	0.000*	0.082*	0.000*	1.000	0.017*	1.000	1.000	1.000

Table A65. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 13.331, $r^2 = 0.050$, $p = 0.000$*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.000*	1.000	1.000					
1997	0.004*	1.000	1.000	1.000				
1998	0.149	1.000	1.000	1.000	1.000			
1999	0.000*	0.084*	0.559	1.000	0.047*	1.000		
2000	0.000*	0.011*	0.088*	1.000	0.011*	1.000	1.000	
2001	0.000*	0.246	1.000	1.000	0.109	1.000	1.000	1.000

Table A66. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean total length data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.772, $r^2 = 0.261$, $p = 0.000$*

Bonferroni matrix:

	1993	1995	1996	1998	1999	2000	2001
1993	1.000						
1995	0.005*	1.000					
1996	0.423	1.000	1.000				
1998	1.000	1.000	1.000	1.000			
1999	0.000*	1.000	0.001*	1.000	1.000		
2000	0.022*	1.000	1.000	1.000	1.000	1.000	
2001	0.034*	1.000	1.000	1.000	0.136	1.000	1.000

NOTE: No channel catfish were measured on DM’s in Reach 1 in 1997

Table A67. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 26.629, $r^2 = 0.028$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.503	1.000				
1998	0.006*	0.000*	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.000*	0.024*	0.000*	1.000	1.000	
2001	0.000*	0.210	0.000*	0.147	1.000	1.000

Table A68. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 3.951, r^2 = 0.082, p = 0.002*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.408	0.047*	0.001*	1.000		
2000	1.000	1.000	0.779	0.519	1.000	
2001	1.000	1.000	0.618	0.296	1.000	1.000

Table A69. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 16.483, r^2 = 0.089, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.000*	0.000*	1.000								
1994	0.021*	0.001*	1.000	1.000							
1995	1.000	1.000	0.000*	0.119	1.000						
1996	0.662	0.049*	0.001*	1.000	1.000	1.000					
1997	1.000	1.000	0.000*	0.024*	1.000	0.722	1.000				
1998	1.000	1.000	0.000*	0.001*	1.000	0.027*	1.000	1.000			
1999	0.002*	0.007*	0.000*	0.000*	0.000*	0.000*	0.003*	0.230	1.000		
2000	1.000	1.000	0.000*	0.004*	1.000	0.136	1.000	1.000	0.055*	1.000	
2001	1.000	1.000	0.001*	1.000	1.000	1.000	1.000	0.760	0.000*	1.000	1.000

Table A70. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.643, r^2 = 0.059, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.076*	1.000								
1994	0.002*	0.000*	0.496	1.000							
1995	1.000	1.000	1.000	0.030*	1.000						
1996	1.000	0.847	1.000	0.033*	1.000	1.000					
1997	1.000	1.000	0.001*	0.000*	0.026*	0.013*	1.000				
1998	1.000	1.000	1.000	0.098*	1.000	1.000	1.000	1.000			
1999	1.000	1.000	0.000*	0.000*	0.017*	0.008*	1.000	1.000	1.000		
2000	1.000	1.000	1.000	0.002*	1.000	1.000	0.796	1.000	0.703	1.000	
2001	1.000	1.000	0.002*	0.000*	0.114	0.061*	1.000	1.000	1.000	1.000	1.000

Table A71. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 13.376, $r^2 = 0.053$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.006*	0.000*	1.000								
1994	0.005*	0.000*	1.000	1.000							
1995	1.000	1.000	0.000*	0.000*	1.000						
1996	1.000	1.000	0.002*	0.001*	1.000	1.000					
1997	0.357	1.000	0.000*	0.000*	0.341	0.108	1.000				
1998	1.000	0.027*	1.000	1.000	0.323	0.941	0.001*	1.000			
1999	1.000	1.000	0.000*	0.000*	1.000	1.000	1.000	0.017*	1.000		
2000	0.033*	1.000	0.000*	0.000*	0.015*	0.004*	1.000	0.000*	1.000	1.000	
2001	0.087*	1.000	0.000*	0.000*	0.055*	0.016*	1.000	0.000*	1.000	1.000	1.000

Table A72. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.075, $r^2 = 0.034$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.071*	1.000						
1996	0.005*	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	0.511	1.000	1.000			
1999	0.000*	0.374	1.000	0.450	0.005*	1.000		
2000	0.000*	0.044*	0.165	0.154	0.001*	1.000	1.000	
2001	0.000*	0.667	1.000	0.624	0.008*	1.000	1.000	1.000

Table A73. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean biomass data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.506, $r^2 = 0.116$, p = 0.026*

Bonferroni matrix:

	1993	1995	1996	1998	1999	2000	2001
1993	1.000						
1995	0.053*	1.000					
1996	0.344	1.000	1.000				
1998	1.000	1.000	1.000	1.000			
1999	0.013*	1.000	1.000	1.000	1.000		
2000	0.256	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	1.000

NOTE: No channel catfish were weighed on DM’s in Reach 1 in 1997

Table A74. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 11.634, $r^2 = 0.013$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.064*	0.150	0.009*	0.035*	1.000	
2001	1.000	1.000	1.000	0.000*	0.315	1.000

Table A75. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 5.475, r^2 = 0.110, p = 0.000*
Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	0.862	0.132	1.000		
2000	1.000	0.153	0.228	0.000*	1.000	
2001	1.000	0.385	0.603	0.000*	1.000	1.000

Table A76. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 22.727, r^2 = 0.119, p = 0.000*
Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.048*	0.000*	1.000								
1994	0.423	0.001*	1.000	1.000							
1995	1.000	1.000	0.000*	0.007*	1.000						
1996	1.000	1.000	0.001*	0.021*	1.000	1.000					
1997	0.532	1.000	0.000*	0.000*	1.000	1.000	1.000				
1998	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000			
1999	0.000*	0.061*	0.000*	0.000*	0.007*	0.051*	0.960	0.002*	1.000		
2000	1.000	1.000	0.000*	0.002*	1.000	1.000	1.000	0.000*	0.371	1.000	
2001	1.000	0.034*	1.000	1.000	0.209	0.405	0.011*	0.000*	0.000*	0.056*	1.000

Table A77. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.326, r^2 = 0.063, p = 0.000*
Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.063*	1.000								
1994	1.000	0.000*	1.000	1.000							
1995	1.000	1.000	1.000	0.117	1.000						
1996	1.000	1.000	0.825	0.002*	1.000	1.000					
1997	0.019*	1.000	0.000*	0.000*	0.012*	0.352	1.000				
1998	1.000	1.000	1.000	0.079*	1.000	1.000	1.000	1.000			
1999	0.001*	0.592	0.000*	0.000*	0.000*	0.012*	1.000	1.000	1.000		
2000	1.000	1.000	0.052*	0.000*	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	0.096*	0.000*	1.000	1.000	0.912	1.000	0.033*	1.000	1.000

Table A78. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.145, r^2 = 0.041, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	0.912	1.000								
1994	0.101	0.002*	1.000	1.000							
1995	0.142	0.289	0.001*	0.000*	1.000						
1996	1.000	1.000	0.013*	0.000*	1.000	1.000					
1997	0.052*	0.108	0.000*	0.000*	1.000	1.000	1.000				
1998	0.176	0.022*	1.000	1.000	0.000*	0.000*	0.000*	1.000			
1999	1.000	1.000	1.000	0.006*	1.000	1.000	0.463	0.030*	1.000		
2000	1.000	1.000	0.013*	0.000*	1.000	1.000	1.000	0.000*	1.000	1.000	
2001	0.848	1.000	0.009*	0.000*	1.000	1.000	1.000	0.000*	1.000	1.000	1.000

Table A79. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 27.639, r^2 = 0.098, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.010*	1.000						
1996	0.161	1.000	1.000					
1997	0.551	0.000*	0.001*	1.000				
1998	0.077*	0.000*	0.000*	1.000	1.000			
1999	0.000*	0.000*	0.000*	0.000*	0.000*	1.000		
2000	0.000*	0.027*	0.000*	0.000*	0.000*	1.000	1.000	
2001	0.000*	1.000	0.014*	0.000*	0.000*	0.137	1.000	1.000

Table A80. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of channel catfish mean condition factor data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.063, r^2 = 0.097, p = 0.063*

Bonferroni matrix:

	1993	1995	1996	1998	1999	2000	2001
1993	1.000						
1995	1.000	1.000					
1996	1.000	1.000	1.000				
1998	0.828	0.869	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	0.583	0.413	1.000	1.000

NOTE: No channel catfish were measured or weighed on DM’s in Reach 1 in 1997

Table A81a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 17.874, $r^2 = 0.044$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	0.000*	1.000

Table A81b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.988, $r^2 = 0.025$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.078*	1.000				
1998	0.000*	0.013*	1.000			
1999	1.000	1.000	0.000*	1.000		
2000	0.000*	0.224	1.000	0.003*	1.000	
2001	0.018*	1.000	0.410	0.354	1.000	1.000

Table A81c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.463, $r^2 = 0.019$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.094*	1.000				
1998	0.000*	0.013*	1.000			
1999	1.000	1.000	0.001*	1.000		
2000	0.474	1.000	0.013*	1.000	1.000	
2001	0.074*	1.000	0.154	1.000	1.000	1.000

Table A82a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.932, r^2 = 0.172, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	0.000*	1.000

Table A82b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.845, r^2 = 0.041, p = 0.105

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.756	1.000	1.000	1.000		
2000	0.062*	1.000	1.000	1.000	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000

Table A82c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 1.399, r^2 = 0.032, p = 0.226

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	0.596	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000

Table A83a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.079, $r^2 = 0.166$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	0.531	0.503	1.000	0.463	1.000	0.001*	1.000

Table A83b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.623, $r^2 = 0.199$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.000*	0.000*	1.000					
1997	0.000*	0.000*	0.172	1.000				
1998	0.008*	0.069*	0.010*	1.000	1.000			
1999	0.000*	0.003*	1.000	1.000	1.000	1.000		
2000	0.001*	0.004*	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.003*	1.000	1.000	1.000	1.000	1.000	1.000

Table A83c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 10.102, $r^2 = 0.152$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	0.002*	1.000									
1993	0.000*	1.000	1.000								
1994	0.000*	0.013*	0.280	1.000							
1995	0.000*	0.052*	0.886	1.000	1.000						
1996	1.000	0.743	0.050*	0.000*	0.000*	1.000					
1997	0.014*	1.000	1.000	0.005*	0.021*	1.000	1.000				
1998	0.001*	1.000	1.000	0.348	0.988	0.242	1.000	1.000			
1999	0.881	1.000	1.000	0.040*	0.113	1.000	1.000	1.000	1.000		
2000	1.000	1.000	0.395	0.000*	0.001*	1.000	1.000	0.949	1.000	1.000	
2001	1.000	1.000	1.000	0.006*	0.020*	1.000	1.000	1.000	1.000	1.000	1.000

Table A84a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 13.925, r^2 = 0.176, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.008*	1.000						
1996	0.213	1.000	1.000					
1997	0.003*	1.000	1.000	1.000				
1998	0.127	1.000	1.000	1.000	1.000			
1999	0.027*	1.000	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	1.000	1.000	0.000*	1.000

Table A84b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1994 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 18.753, r^2 = 0.224, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	1.000	1.000						
1996	0.000*	0.000*	1.000					
1997	0.000*	0.000*	1.000	1.000				
1998	0.001*	0.353	0.006*	0.604	1.000			
1999	0.000*	0.000*	1.000	1.000	0.034*	1.000		
2000	0.000*	0.000*	1.000	1.000	0.564	1.000	1.000	
2001	0.005*	0.682	0.008*	0.629	1.000	0.039*	0.563	1.000

Table A84c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 11.538, r^2 = 0.149, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.000*	0.057*	0.224	1.000							
1995	0.020*	0.793	1.000	1.000	1.000						
1996	0.099*	0.031*	0.000*	0.000*	0.000*	1.000					
1997	1.000	1.000	0.165	0.000*	0.000*	1.000	1.000				
1998	1.000	1.000	1.000	0.075*	0.981	0.026*	1.000	1.000			
1999	0.829	0.259	0.010*	0.000*	0.000*	1.000	1.000	0.227	1.000		
2000	0.093*	0.029*	0.001*	0.000*	0.000*	1.000	1.000	0.025*	1.000	1.000	
2001	1.000	1.000	1.000	0.100	1.000	0.069*	1.000	1.000	0.419	0.055*	1.000

Table A85a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.982, $r^2 = 0.080$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.003*	1.000						
1996	0.067*	1.000	1.000					
1997	0.000*	1.000	0.131	1.000				
1998	0.000*	0.248	0.022*	1.000	1.000			
1999	0.000*	0.209	0.024*	1.000	1.000	1.000		
2000	0.000*	1.000	1.000	1.000	1.000	1.000	1.000	
2001	0.011*	1.000	1.000	1.000	0.665	0.498	1.000	1.000

Table A85b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1994 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 20.653, $r^2 = 0.166$, p = 0.000*

Bonferroni matrix:

	1994	1995	1996	1997	1998	1999	2000	2001
1994	1.000							
1995	0.000*	1.000						
1996	0.000*	1.000	1.000					
1997	0.000*	0.983	0.002*	1.000				
1998	1.000	0.000*	0.000*	0.002*	1.000			
1999	0.000*	1.000	1.000	0.015*	0.000*	1.000		
2000	0.001*	0.388	0.001*	1.000	0.058*	0.006*	1.000	
2001	0.016*	0.046*	0.000*	1.000	0.474	0.001*	1.000	1.000

Table A85c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 13.986, $r^2 = 0.123$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.006*	0.009*	1.000								
1994	0.001*	0.003*	1.000	1.000							
1995	1.000	1.000	0.000*	0.000*	1.000						
1996	0.062*	0.104	0.000*	0.000*	1.000	1.000					
1997	1.000	1.000	0.020*	0.006*	1.000	0.002*	1.000				
1998	0.002*	0.004*	1.000	1.000	0.000*	0.000*	0.009*	1.000			
1999	0.920	1.000	0.000*	0.000*	1.000	1.000	0.147	0.000*	1.000		
2000	1.000	1.000	0.304	0.118	0.744	0.002*	1.000	0.114	0.096*	1.000	
2001	1.000	1.000	1.000	0.597	0.189	0.000*	1.000	0.507	0.025*	1.000	1.000

Table A86a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 4.504, $r^2 = 0.042$, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.279	1.000					
1997	1.000	1.000	1.000				
1998	0.001*	1.000	0.226	1.000			
1999	0.001*	0.871	0.189	1.000	1.000		
2000	0.058*	1.000	1.000	1.000	1.000	1.000	
2001	0.006*	1.000	0.717	1.000	1.000	1.000	1.000

Table A86b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 9.708, $r^2 = 0.086$, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.000*	1.000					
1997	0.000*	1.000	1.000				
1998	0.000*	1.000	1.000	1.000			
1999	0.008*	1.000	1.000	0.418	1.000		
2000	0.000*	1.000	0.955	1.000	0.223	1.000	
2001	0.150	0.209	1.000	0.010*	1.000	0.004*	1.000

Table A86c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 18.098, $r^2 = 0.148$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.000*	0.000*	1.000					
1997	0.000*	0.000*	1.000	1.000				
1998	0.088*	0.000*	1.000	0.602	1.000			
1999	0.000*	0.000*	1.000	1.000	0.454	1.000		
2000	0.108	0.000*	1.000	0.530	1.000	0.403	1.000	
2001	0.000*	0.014*	0.398	1.000	0.005*	1.000	0.004*	1.000

Table A87a. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of juvenile common carp CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 3.257, r^2 = 0.128, p = 0.005*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	1.000	1.000					
1997	1.000	0.170	1.000				
1998	1.000	1.000	0.143	1.000			
1999	1.000	1.000	0.441	1.000	1.000		
2000	1.000	0.087*	1.000	0.073*	0.222	1.000	
2001	1.000	1.000	0.510	1.000	1.000	0.259	1.000

Table A87b. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of adult common carp CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1995 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 4.794, r^2 = 0.178, p = 0.000*

Bonferroni matrix:

	1995	1996	1997	1998	1999	2000	2001
1995	1.000						
1996	0.019*	1.000					
1997	0.117	1.000	1.000				
1998	0.861	1.000	1.000	1.000			
1999	1.000	0.336	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	1.000	0.000*	0.004*	0.053*	1.000	0.120	1.000

Table A87c. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of total (juvenile + adult) common carp CPUE data, in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.236, r^2 = 0.265, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	1.000	0.004*	1.000					
1997	0.091*	0.183	1.000	1.000				
1998	0.056*	0.422	1.000	1.000	1.000			
1999	0.003*	1.000	0.266	1.000	1.000	1.000		
2000	0.005*	1.000	0.541	1.000	1.000	1.000	1.000	
2001	0.000*	1.000	0.000*	0.009*	0.028*	1.000	0.390	1.000

Table A88. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 60.793, r^2 = 0.117, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.296	1.000				
1998	0.830	1.000	1.000			
1999	0.000*	0.677	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	0.017*	1.000	1.000	1.000	0.000*	1.000

Table A89. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 45.653, r^2 = 0.516, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	1.000	1.000	1.000	1.000	0.000*	1.000

Table A90. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.768, r^2 = 0.072, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.004*	0.016*	1.000	1.000							
1995	0.094*	0.341	1.000	1.000	1.000						
1996	0.000*	0.001*	0.631	1.000	1.000	1.000					
1997	0.000*	0.000*	0.112	1.000	0.567	1.000	1.000				
1998	0.005*	0.019*	1.000	1.000	1.000	1.000	1.000	1.000			
1999	0.000*	0.001*	0.128	1.000	0.539	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	0.007*	0.159	0.001*	0.000*	0.009*	0.000*	1.000	
2001	0.009*	0.035*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.016*	1.000

Table A91. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 3.554, r^2 = 0.036, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	1.000	1.000	1.000	1.000							
1995	1.000	1.000	1.000	1.000	1.000						
1996	1.000	1.000	1.000	1.000	1.000	1.000					
1997	0.066*	0.289	0.375	0.374	1.000	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
1999	0.007*	0.050*	0.049*	0.057*	1.000	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.168	1.000	
2001	0.053*	0.187	0.256	0.246	1.000	1.000	1.000	1.000	1.000	0.756	1.000

Table A92. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 15.221, $r^2 = 0.129$, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.000*	0.000*	1.000								
1994	1.000	1.000	0.000*	1.000							
1995	1.000	0.046*	0.000*	1.000	1.000						
1996	1.000	0.602	0.000*	1.000	1.000	1.000					
1997	1.000	0.224	0.000*	1.000	1.000	1.000	1.000				
1998	1.000	0.180	0.000*	1.000	1.000	1.000	1.000	1.000			
1999	0.007*	0.000*	0.000*	0.006*	0.645	0.038*	1.000	1.000	1.000		
2000	1.000	0.072*	0.000*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
2001	0.886	0.013*	0.000*	0.716	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A93. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 37.125, $r^2 = 0.405$, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.000*	1.000	1.000					
1997	0.000*	1.000	1.000	1.000				
1998	0.000*	1.000	1.000	1.000	1.000			
1999	0.000*	0.861	1.000	1.000	1.000	1.000		
2000	0.000*	1.000	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.033*	0.055*	0.096*	1.000	1.000	1.000	1.000

Table A94. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean total length data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 2.698, $r^2 = 0.109$, p = 0.012*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	0.829	1.000	1.000	1.000				
1998	0.614	1.000	1.000	1.000	1.000			
1999	0.045*	1.000	0.422	1.000	1.000	1.000		
2000	1.000	1.000	1.000	1.000	1.000	0.017*	1.000	
2001	0.530	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A95. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 24.722, r^2 = 0.051, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	0.841	1.000	1.000			
1999	0.000*	0.000*	0.001*	1.000		
2000	0.004*	0.000*	0.000*	0.000*	1.000	
2001	0.000*	0.039*	0.472	0.438	0.000*	1.000

Table A96. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 25.280, r^2 = 0.371, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	1.000	1.000				
1998	1.000	1.000	1.000			
1999	0.917	0.916	1.000	1.000		
2000	0.000*	0.000*	0.000*	0.000*	1.000	
2001	0.042*	0.027*	0.054*	1.000	0.000*	1.000

Table A97. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.593, r^2 = 0.111, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.155	0.356	1.000								
1994	0.000*	0.000*	0.000*	1.000							
1995	0.234	0.595	1.000	0.000*	1.000						
1996	0.000*	0.000*	0.112	0.628	0.003*	1.000					
1997	0.000*	0.000*	1.000	0.013*	0.612	1.000	1.000				
1998	0.002*	0.006*	1.000	0.055*	1.000	1.000	1.000	1.000			
1999	0.000*	0.000*	0.010*	1.000	0.001*	1.000	0.685	1.000	1.000		
2000	0.001*	0.002*	1.000	0.143	1.000	1.000	1.000	1.000	1.000	1.000	
2001	0.000*	0.000*	1.000	0.393	0.263	1.000	1.000	1.000	1.000	1.000	1.000

Table A98. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.400, r^2 = 0.062, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.000*	0.015*	0.119	1.000							
1995	1.000	1.000	1.000	0.006*	1.000						
1996	0.112	1.000	1.000	0.310	1.000	1.000					
1997	0.000*	0.225	1.000	1.000	0.143	1.000	1.000				
1998	0.383	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
1999	0.000*	0.001*	0.006*	1.000	0.000*	0.016*	1.000	0.345	1.000		
2000	0.016*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.196	1.000	
2001	0.050*	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table A99. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 12.807, r^2 = 0.111, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.605	0.007*	1.000								
1994	0.004*	0.077*	0.000*	1.000							
1995	1.000	1.000	0.000*	1.000	1.000						
1996	0.785	1.000	0.000*	1.000	1.000	1.000					
1997	0.108	1.000	0.000*	1.000	1.000	1.000	1.000				
1998	0.323	1.000	0.000*	1.000	1.000	1.000	1.000	1.000			
1999	0.000*	0.000*	0.000*	0.622	0.000*	0.000*	0.002*	1.000	1.000		
2000	0.013*	0.238	0.000*	1.000	1.000	1.000	1.000	1.000	0.045*	1.000	
2001	0.012*	0.215	0.000*	1.000	1.000	1.000	1.000	1.000	0.047*	1.000	1.000

Table A100. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 17.494, r^2 = 0.243, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.000*	1.000						
1996	0.000*	0.502	1.000					
1997	0.000*	1.000	1.000	1.000				
1998	0.000*	0.088*	1.000	0.290	1.000			
1999	0.000*	0.000*	0.024*	0.001*	1.000	1.000		
2000	0.000*	0.002*	0.250	0.010*	1.000	1.000	1.000	
2001	0.000*	0.000*	0.000*	0.000*	0.655	1.000	1.000	1.000

Table A101. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean biomass data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 5.091, r^2 = 0.187, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	1.000	1.000						
1996	1.000	1.000	1.000					
1997	1.000	0.669	1.000	1.000				
1998	1.000	1.000	1.000	1.000	1.000			
1999	0.155	0.000*	0.000*	0.325	0.003*	1.000		
2000	1.000	1.000	1.000	1.000	1.000	0.006*	1.000	
2001	1.000	0.257	1.000	1.000	1.000	0.208	1.000	1.000

Table A102. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, RM 180.0-0.0, October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 15.205, $r^2 = 0.032$, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.011*	1.000				
1998	1.000	1.000	1.000			
1999	0.000*	0.000*	0.000*	1.000		
2000	0.008*	0.000*	0.001*	1.000	1.000	
2001	1.000	0.157	1.000	0.000*	0.012*	1.000

Table A103. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 6 (RM 180.0-155.0), October 1996 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.288, r^2 = 0.128, p = 0.000*

Bonferroni matrix:

	1996	1997	1998	1999	2000	2001
1996	1.000					
1997	0.179	1.000				
1998	1.000	1.000	1.000			
1999	1.000	0.349	1.000	1.000		
2000	1.000	0.000*	0.120	1.000	1.000	
2001	0.955	0.000*	0.013*	1.000	1.000	1.000

Table A104. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 5 (RM 155.0-131.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.391, r^2 = 0.068, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.002*	0.020*	0.535	1.000							
1995	1.000	1.000	0.024*	0.000*	1.000						
1996	1.000	1.000	1.000	0.158	0.016*	1.000					
1997	1.000	1.000	0.010*	0.000*	1.000	0.007*	1.000				
1998	1.000	1.000	1.000	0.000*	1.000	1.000	1.000	1.000			
1999	1.000	1.000	1.000	1.000	0.035*	1.000	0.016*	0.844	1.000		
2000	0.249	0.918	1.000	1.000	0.000*	1.000	0.000*	0.048*	1.000	1.000	
2001	1.000	1.000	1.000	0.278	0.290	1.000	0.135	1.000	1.000	1.000	1.000

Table A105. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 4 (RM 131.0-106.0), October 1991 to October 2001 ($p < 0.10$ = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 8.670, r^2 = 0.083, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	1.000	1.000	1.000								
1994	0.000*	0.128	0.003*	1.000							
1995	1.000	0.007*	0.002*	0.000*	1.000						
1996	1.000	1.000	1.000	0.000*	0.047*	1.000					
1997	1.000	1.000	1.000	0.000*	0.212	1.000	1.000				
1998	1.000	1.000	1.000	0.006*	0.074*	1.000	1.000	1.000			
1999	1.000	1.000	1.000	0.001*	0.015*	1.000	1.000	1.000	1.000		
2000	1.000	1.000	1.000	0.000*	0.285	1.000	1.000	1.000	1.000	1.000	
2001	1.000	0.024*	0.018*	0.000*	1.000	0.232	0.572	0.183	0.073*	0.773	1.000

Table A106. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 3 (RM 106.0-68.0), October 1991 to October 2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 11.144, r^2 = 0.098, p = 0.000*

Bonferroni matrix:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1991	1.000										
1992	1.000	1.000									
1993	0.005*	1.000	1.000								
1994	0.070*	1.000	1.000	1.000							
1995	0.572	0.000*	0.000*	0.000*	1.000						
1996	1.000	1.000	0.000*	0.015*	0.023*	1.000					
1997	1.000	0.791	0.001*	0.014*	0.539	1.000	1.000				
1998	1.000	1.000	0.160	0.802	1.000	1.000	1.000	1.000			
1999	0.006*	1.000	1.000	1.000	0.000*	0.000*	0.000*	0.314	1.000		
2000	1.000	1.000	0.011*	0.172	0.056*	1.000	1.000	1.000	0.015*	1.000	
2001	1.000	0.126	0.000*	0.002*	1.000	1.000	1.000	1.000	0.000*	1.000	1.000

Table A107. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 2 (RM 68.0-17.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 7.021, r^2 = 0.114, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.001*	1.000						
1996	0.309	0.109	1.000					
1997	0.000*	1.000	0.013*	1.000				
1998	0.471	1.000	1.000	0.323	1.000			
1999	1.000	0.001*	0.570	0.000*	0.938	1.000		
2000	1.000	0.029*	1.000	0.004*	1.000	1.000	1.000	
2001	1.000	0.008*	1.000	0.001*	1.000	1.000	1.000	1.000

Table A108. One-way ANOVA statistics and matrix of Bonferroni-adjusted pairwise comparisons of common carp mean condition factor data (all life stages combined), in the San Juan River, Reach 1 (RM 17.0-0.0), October 1993 and October 1995-2001 (p < 0.10 = * = statistically significant relationship). Values in the matrix are the p-values for between-year comparisons.

One-way ANOVA: F-statistic = 6.595, r^2 = 0.229, p = 0.000*

Bonferroni matrix:

	1993	1995	1996	1997	1998	1999	2000	2001
1993	1.000							
1995	0.002*	1.000						
1996	1.000	0.000*	1.000					
1997	1.000	0.000*	1.000	1.000				
1998	0.369	0.273	1.000	0.506	1.000			
1999	1.000	0.000*	0.270	1.000	0.004*	1.000		
2000	1.000	0.007*	1.000	1.000	1.000	0.112	1.000	
2001	1.000	0.005*	1.000	1.000	1.000	0.448	1.000	1.000

APPENDIX B

Sampling protocol for conducting sub-adult and adult large-bodied fish monitoring (i.e., “adult monitoring”), as detailed in the ***San Juan River Monitoring Plan And Protocols*** (Propst et al. 2000).

Annual monitoring of large-bodied fishes in the San Juan River between the confluence of the Animas and San Juan rivers (RM 180) and Clay Hills Crossing (RM 3) will occur between mid-September and mid-October each year. Monitoring will occur mainly in the primary channel. However, secondary channels with sufficient flow to support an electrofishing raft will also be sampled.

Raft-mounted electrofishing gear will be used to collect fishes. Rafts will not be motorized. Output of electrofishing units will not exceed 400 volts and 6 amps, pulsed DC. Two electrofishing rafts will be deployed along opposite shorelines to collect fishes. Each raft will proceed downstream perpendicular to shore at a fairly constant rate of speed with continuous electrical output. Each electrofishing crew will consist of one raft operator (rower) and one netter; both will be experienced in raft-mounted fish collecting techniques. Effort will be made to net all fishes stunned by the electrofisher. To minimize injury to netted fish, they will be promptly dumped into a live-well located behind the netting deck; netted fish will not be repeatedly swept through the electrical field. Sampling will be conducted in 1-mile increments with two of every three miles being sampled. Sampling effort will be recorded as elapsed time electrofished by each raft per river mile. All fish captured will be identified and enumerated by life stage (juvenile, sub-adult, and adult) and species. Fish will be identified by six-letter codes (first three letters of genus and first three letters of species). All fish captured every fourth sampled mile (DM) will be weighed ($\pm$ 5 g) and measured ($\pm$ 1 mm total and standard length). All nonnative fishes will be removed from the river and all native fishes will be returned to the river alive.

Each rare fish captured will be weighed ($\pm$ 1 g if $<$ 200 mm TL and $\pm$ 5 g if $\geq$ 201 mm TL) and measured ($\pm$ 1 mm SL and TL), have sex determined (if possible), and be scanned for a PIT tag. If a specimen does not have a PIT tag, one will be implanted (if specimen is $>$ 150 mm TL).

Water temperature will be measured at each DM. Each river mile sampled by each raft will be treated as a separate collection, with a unique collection number. All data will be recorded on standard field forms (see following pages). Rare fish information will be recorded on the standard field form for the river mile in which it was captured.

Annual reports summarizing data obtained during large-bodied fish monitoring will be submitted (written and electronic formats) by 31 March of the year following the effort. The annual report will minimally contain a summary of species captured, species density (number of fish per hour of elapsed electrofishing time) by geomorphic reach, size-structure of common species populations (flannelmouth sucker, bluehead sucker, channel catfish, and common carp) by geomorphic reach, and rare fishes captured (including somatic data). Original field notes will be retained by the entity responsible for conducting large-bodied fish monitoring. Photocopies of all field notes will be archived with the USFWS NMFRO Albuquerque field office. Summary reports (the first in three years [2002] and thence every five years) will include an overview of trends in species populations (including size-structure and condition), distribution patterns, and relation of status of species populations to abiotic and biotic conditions. Descriptive statistics (e.g., mean, mode, range, standard deviation, and standard error) of sampling results will be provided. Statistical methods to evaluate changes in fish assemblages will include non-parametric (Kruskal-Wallis and Kolmogorov-Smirnov) and parametric (paired *t*-test, analysis of variance, and analysis of covariance tests), and linear regression. Various population-estimates (manually generated such as Schnabel or Petersen index estimates or computer generated such as CAPTURE or MARK [Cormack-Jolly-Seber]) will also be used to analyze data.

SAMPLE NUMBER: DATE:

TIME: WEATHER:

RIVER: RIVER MILE(S): TO:

COUNTY: STATE:

BOAT: CHANNEL: SHORELINE:

SHOCK TIME: AMPS: VOLTS:

NETTER: AIR TEMP: WATER TEMP:

ROWER: D.O.:

FISH ID: CONDUCTIVITY:

RECORD: SALINITY:

TURBIDITY: BOTTOM 0.5m 0.25m 0.0.m

RARE FISH COLLECTED:

COMMENTS:

SAMPLE NUMBER: PAGE: of

SPECIES	YOY	JUVENILE	ADULT
CATLAT (FM)	(0-60)	(60-410)	(410+)
CATDIS (BH)	(0-60)	(60-300)	(300+)
ICTPUN (CC)	(0-60)	(60-300)	(300+)
CYPCAR (CP)	(0-70)	(70-250)	(250+)
RHIOSC (SD)	(0-20)	(20-32)	(32+)
CYPLUT (RS)	(0-20)	(20-30)	(30+)
PIMPRO (FH)	(0-20)	(20-35)	(35+)
CATLAT X CATDIS (FM X BH)			
	(0-60)	(60-300)	(300+)

LENGTH AND WEIGHT DATA:

SPECIES	TL	SL	WT	TAG/NOTES

J. L. DARLING CORP. TACOMA, WA 98424-1017
www.riteintherain.com

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SAMPLE NUMBER: PAGE: of

SPECIES	TL	SL	WT	SEX	TAG/NOTES