LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 2010

Interim Progress Report

(Final)
2 February 2012

Funded by the U. S. Bureau of Reclamation
Salt Lake City Projects Office
Agreement # 08-AA-40-2715

Submitted by:

Dale W. Ryden

U. S. Fish and Wildlife Service
Colorado River Fishery Project
764 Horizon Drive, Building B
Grand Junction, Colorado 81506

EXECUTIVE SUMMARY

General Information

- A total of 10,732 fishes were collected during 2010 Adult Monitoring
    - Native fishes accounted for 84.2% of the total catch in 2010

Native Species:

- Colorado pikeminnow
    - No wild Colorado pikeminnow were collected in 2010
    - 433 stocked Colorado pikeminnow were collected in 2010
        - Fifth most abundant species collected
        - Scaled CPUE of Colorado pikeminnow in the river for 1+ overwinter periods post-stocking was significantly higher in 2010 than previous seven years
            - Due to the collection of 262 age-1 fish (stocked as age-0 fish in fall 2009) and 136 age-2 fish (stocked as age-0 fish in fall 2008)
        - Sizes in 2009 ranged from 124-658 mm TL (age-1 to age-14)
            - 4 adult fish (459-658 mm TL) collected in 2010
            - 7 sub-adult fish (400-435 mm TL) collected in 2010
            - 61 larger juvenile fish (300-399 mm TL) collected in 2010
            - Widest range of age- and size-classes ever collected during an Adult Monitoring trip
            - Most adult and sub-adult fish ever collected during an Adult Monitoring
        - Captures ranged from RM 175.0-17.0
            - 43 in Reach 6, 121 in Reach 5, 88 in Reach 4, 145 in Reach 3, 35 in Reach 2, and 1 in Reach 1
        - 274 (63.4%) were in the river ≤ 365 days post-stocking
            - However, all but 11 (2.5%) of these fish were in the river for at least one overwinter period
- Razorback sucker
    - No wild razorback sucker were collected in 2010
    - 153 stocked razorback sucker were collected in 2010
        - Sixth most abundant species collected
        - Scaled CPUE of razorback sucker that had been in the river for 1+ overwinter periods higher in 2010 than the previous three years' values
            - First time this has happened in last 8-year period
        - Sizes ranged from 290-535 mm TL (age-2 to age-18)
        - Captures ranged from RM 166.0-53.0
            - 71 were collected in Reach 6, 54 in Reach 5, 14 in Reach 4, 13 in Reach 3, 1 in Reach 2, and 0 in Reach 1
        - Of 102 razorback sucker collected with PIT tags and known stocking histories in 2010, 74 (72.5%) were in the river ≤ 365 days post-stocking
            - 32 of those 74 fish were in the river < 1 overwinter period when they were collected
            - The other 28 fish were in the river from 1-15 overwinter periods
        - Razorback sucker that have been in the river ≥ 6 overwinter periods have been collected every year since 2001

- Roundtail chub
    - No roundtail chub were collected in 2010
- Flannelmouth sucker
    - Most abundant species in 2010
        - Flannelmouth sucker were the numerically dominant species in Adult Monitoring collections in 19 of the last 20 years
        - Accounted for only 50.0% of the total catch (n = 6,372 fish)
        - Had the widest distribution of any species, being collected in 191 (98.5%) of 194 electrofishing samples (RM 180.0-2.9)
        - Collected in all six river reaches
- Bluehead sucker
    - Among the three most-commonly collected species in each of the last 12 years
    - Second most common species collected in 2010
        - Accounted for 17.5% of the total catch (n = 2,227 fish)
        - Collected in 85.1% of electrofishing samples (RM 180.0-2.9)
        - Collected in Reaches 6-2 in 2010

Nonnative Species:

- Channel catfish
    - Among the three most commonly-collected species in each of the last 12 years
    - Third most abundant species collected in 2010
        - Accounted for 14.8% of the total catch (n = 1,881 fish)
        - Collected in 83.0% of electrofishing samples (RM 180.0-2.9)
        - In 2010 the majority of both juvenile and adult channel catfish were collected in the middle nonnative fish removal section
            - Numbers considerably reduced both up- and downstream of that area
            - Adults = 88.9% (415 of 467 fish) collected from RM 147.9-52.9
            - Juveniles = 81.3% (1,150 of 1,414 fish) collected from RM 147.9-52.9
        - The very large spike observed in juvenile channel catfish CPUE numbers in 2009 was not apparent in 2010 Adult Monitoring collections
- Common carp
    - Percent of total catch accounted for by this species has decreased steadily over the last 12 years (from 9.8% in 1999 to 0.4% in 2010)
        - Was the fourth most commonly-collected species in 1999
    - The seventh most commonly-collected species in 2010
        - Only 54 common carp collected from RM 180.0-2.9 in 2010
            - 48 (88.9%) were adult fish (i.e., $\geq$ 250 mm TL)
        - Collected in 18.6% of electrofishing samples (RM 180.0-2.9)
        - Less abundant than both endangered Colorado pikeminnow and razorback sucker during 2010 Adult Monitoring collections

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

Tables In Appendix A

LIST OF TABLES

Tables In Appendix A

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

INTRODUCTION

Research performed from 1991-1997 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 development of flow recommendations for the reoperation of Navajo Reservoir, instituting the mechanical removal of nonnative fishes, modifying or removing three instream water diversion structures to provide fish passage and minimize entrainment, and augmentation efforts for both federally-listed endangered fish species (Colorado pikeminnow, Ptychocheilus lucius and razorback sucker, Xyrauchen texanus). To assess the effects of management actions on the fish community over the duration of the SJRIP, a long-term monitoring program was initiated in 1999 (Propst et al. 2000). These standardized long-term monitoring protocols have been updated twice since 1999 (Propst et al. 2006, SJRIP 2010). Data collection following these long-term monitoring protocols began in 1999 and is scheduled to continue throughout the life of the SJRIP.

One component of long-term monitoring, ***Sub-Adult And Adult Large-Bodied Fish Community Monitoring*** (referred to hereafter as "Adult Monitoring"), is the primary responsibility of the U. S. Fish and Wildlife Service's (USFWS) Colorado River Fishery Project (CRFP) office in Grand Junction, CO. However, other state and federal agencies supply personnel, equipment, and logistical support.

Objectives

The objectives of Adult Monitoring (as stated in the FY-2010 workplan) are:

1) Monitor the San Juan River's fish community, specifically the large-bodied fish species, to identify shifts in fish community structure, species relative abundance and distribution, and length/weight frequencies that are occurring over time. Determine whether these shifts in fish community parameters correspond to management actions that are being implemented by the SJRIP. These include, but may not be limited to, the following:
    a) Reoperation of water releases from 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) of the rare San Juan River fish species -- Colorado pikeminnow, razorback sucker, and roundtail chub (both wild and stocked fish).

3) Remove nonnative fish species which prey upon and may potentially compete with native fish species in the San Juan River.

Relationship to the Recovery Program

Adult Monitoring provides data for or makes possible (at least in part) the following actions under element numbers 1-5 of the Long Range Plan (SJRIP 2009): 1.1.1.1, 1.1.1.3, 1.1.4.3, 1.2.1.1, 1.2.3.1, 2.2.5.1, 2.2.5.2, 3.2.1.2, 4.1.1.4, 4.1.1.8, 4.1.1.9, 5.1.1.2, 5.1.2.3, 5.1.2.4, 5.1.2.5, and 5.1.4.1. The monitoring protocols discussed in the Methods section of this report reflect those that are currently included in the latest update to the revised Comprehensive Monitoring Plan (SJRIP 2010).

Study Area

The study area for Adult Monitoring begins just downstream of the Animas River confluence (at 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 in the San Juan River between Navajo Reservoir and Lake Powell (Bliesner and Lamarra 2000). 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 our 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.

METHODS

Field Sampling

Sampling conducted in 2010 followed the protocols for long-term monitoring set forth in the latest update to the revised Comprehensive Monitoring Plan (SJRIP 2010). These sampling protocols were first used during the fall 1999 Adult Monitoring trip. Similar data collected prior to the inception of these sampling protocols (i.e., 1991-1998) are not included in comparative analyses for this report.

Data Analysis

Rare Native Fishes

Based on data collected over the last several years, essentially all of the endangered Colorado pikeminnow and razorback sucker being collected during Adult Monitoring were fish that were stocked during augmentation efforts for those two species. Large disparities exist in numbers of fish stocked between various calendar years. This made comparing year-to-year catch per unit effort (CPUE) values for these two species problematic, since large numbers of fish being stocked in any particular year tended to lead to artificially-inflated CPUE values in that year's Adult Monitoring data set. To deal with this problem, endangered fish collected during Adult Monitoring were sorted by year of stocking as well as length of time (expressed in number of overwinter periods) that they had been in the river post-stocking. Additionally, since different age-classes of Colorado pikeminnow were stocked in numerous years, they were further sorted by their age-class at stocking. Ages provided for fish were either determined using PIT tag information for known-age fish or were based on length frequency histograms and observed between-year growth rates. Emphasis in analyzing CPUE values was then placed on groups of fish that had been in the river for one or more overwinter periods post-stocking. Electrofishing data were pooled for all rafts to obtain total catch numbers by species for the entire sampling trip. Total catch numbers for endangered fish were then scaled to account for the differences in numbers of fish stocked between years (Golden and Holden 2005, Robertson and Holden 2007, R. Ryel pers. comm.).

The number of Colorado pikeminnow collected during Adult Monitoring from any given stocking year and age-class at stocking was transformed to a theoretical annual stocking of 300,000 Colorado pikeminnow. The transformation for Colorado pikeminnow followed the formula:

$$SCPM = (300{,}000/N)CPM$$

where SCPM = the scaled number of Colorado pikeminnow, N = the total number of Colorado pikeminnow of a given age-class stocked in a particular calendar year, and CPM = the number of Colorado pikeminnow of that same age-class from that particular stocking year that were collected during Adult Monitoring. The scaled number of Colorado pikeminnow was then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain a scaled CPUE value (i.e., the scaled number of fish per hour of electrofishing). Scaled CPUE values were then log-transformed (i.e., ln{scaled CPUE + 1}) prior to all analyses (Golden and Holden 2005, Robertson and Holden 2007, R. Ryel pers. comm.).

Analysis of razorback sucker data was slightly different. Since all razorback sucker being stocked tended to be older fish (i.e., age-1 to age-3) and since there was only one target stocking size ($\geq$ 300 mm TL) for all razorback sucker, catch data for razorback sucker were pooled only by number of overwinter periods (i.e., regardless of age at stocking). CPUE for razorback sucker was also scaled, to a theoretical annual stocking of 11,400 individuals. The transformation for razorback sucker followed the formula:

$$SCRZ = (11{,}400/N)RZ$$

where SCRZ = the scaled number of razorback sucker, N = the total number of razorback sucker stocked in a particular calendar year, and RZ = the number of razorback sucker from that particular stocking year that were collected during Adult Monitoring. Scaled CPUE for razorback sucker was calculated, transformed, and analyzed (ANOVA, Tukey's HSD, $p < 0.10$) as described for Colorado pikeminnow.

Common Large-Bodied Fishes

The four "common" large-bodied fishes are flannelmouth sucker (Catostomus latipinnis), bluehead sucker (Catostomus discobolus), channel catfish (Ictalurus punctatus), and common carp (Cyprinus carpio). These were the only wild, large-bodied fish species present in the San Juan River in large enough numbers to yield sufficient sample sizes from which statistically valid conclusions could be drawn (on a riverwide basis, i.e., Reaches 6-1 -- RM 180.0-0.0) across years.

Electrofishing data were pooled for all rafts to obtain total catch by species for the entire sampling trip. Total catch for each species was then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain CPUE values (i.e., number of fish per hour of electrofishing) 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 common large-bodied fish species were then compared to previous years' riverwide electrofishing data to evaluate long-term trends. Analysis of variance (ANOVA) using Tukey's Honestly Significant Difference (Tukey's HSD) multiple-comparison post hoc tests, was then used to determine whether significant differences in CPUE values occurred between years. Significance was determined at $p < 0.10$ (following Ryden 2000). Linear regression analysis was used to determine if the long-term CPUE trends among common native species were increasing or decreasing and whether those increases or decreases were significant at $p < 0.10$ (following Ryden 2000). Length data obtained from fish measured at designated miles (DMs) were used to develop riverwide length frequency histograms for wild populations of the four common large-bodied fish species.

RESULTS

The mean river flow (at the Shiprock USGS gage #09368000) during the 2010 Adult Monitoring trip was 762 CFS (Table 1). This was higher than six of the previous 11 years, but lower than the other five years' values. Overall, the mean river flow during the entire 12 year period (1999-2010) of Adult Monitoring sampling was 1044 CFS. Thus the 2010 mean river flow during sampling fell below the mean value for this 12-year period. In general, lower flows (≤ 1,000 CFS) tend to be more conducive to collecting greater numbers of nonnative fishes, in particular channel catfish (Pers. Obs.; Ryden 2000).

Eighteen fish species and hybrids were collected during the 2010 Adult Monitoring trip (Table 2). This included 6 native species, 1 native sucker X native sucker hybrids, 10 nonnative species and 1 native sucker X nonnative sucker hybrid (Tables 2 and 3). Nine species (flannelmouth sucker, bluehead sucker, channel catfish, speckled dace, Colorado pikeminnow, razorback sucker, common carp, black bullhead, and red shiner) accounted for 99.8% (12,723 fish) of the total catch during the 2010 Adult Monitoring trip. The other seven species and two hybrids contributed only 0.2% (26 fishes) to the total catch in 2010 (Table 3). Native fishes accounted for the large majority (84.2%) of fishes collected in 2011 (Table 3). For the 11th time in the last 12 years, flannelmouth sucker were the most abundant species collected during Adult Monitoring. For the seventh consecutive year common carp were not among the four most commonly-collected fish species.

Table 1. Summary of dates, river miles sampled, and mean flow during riverwide Adult Monitoring trips in the San Juan River in New Mexico, Colorado, and Utah, 1999-2010.

Beginning Date Of Sampling	Ending Date Of Sampling	River Miles Sampled	Mean Trip Flow At The Shiprock, NM USGS Gage (#09368000) In CFS And (Cubic Meters/Second)
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 2001	RM 180.0-2.9	611 CFS ($17.3\ m^3/sec$)
20 September 2002	7 October 2002	RM 180.0-2.9	458 CFS ($12.9\ m^3/sec$)
22 September 2003	14 October 2003	RM 180.0-2.9	450 CFS ($12.7\ m^3/sec$)
20 September 2004	13 October 2004	RM 180.0-2.9	1,432 CFS ($40.5\ m^3/sec$)
19 September 2005	12 October 2005	RM 180.0-2.9	1,072 CFS ($30.3\ m^3/sec$)
18 September 2006	9 October 2006	RM 180.0-2.9	2,479 CFS ($70.1\ m^3/sec$)
17 September 2007	11 October 2007	RM 180.0-2.9	1,262 CFS ($35.7\ m^3/sec$)
22 September 2008	15 October 2008	RM 180.0-2.9	638 CFS ($18.1\ m^3/sec$)
21 September 2009	14 October 2009	RM 180.0-2.9	532 CFS ($15.0\ m^3/sec$)
20 September 2010	12 October 2010	RM 180.0-2.9	762 CFS ($21.5\ m^3/sec$)
12-year statistics: Mean = 1,044 CFS ($29.5\ m^3/sec$)			

Table 2. Scientific and common names (following Nelson et al. 2004), status, and database codes for fish species collected from the San Juan River during the 2010 Adult Monitoring trip.

Scientific Name	Common Name	Status	Database Code
Order Cypriniformes: Family Catostomidae – suckers			
Catostomus discobolus	bluehead sucker	Native	Catdis
Catostomus commersoni	white sucker	Introduced	Catcom
C.commersoni X C. latipinnis	hybrid	Introduced	comXlat
Catostomus latipinnis	flannelmouth sucker	Native	Catlat
Xyrauchen texanus	razorback sucker	Native	Xyrtex
X.texanus X C.latipinnis	hybrid	Native	texXlat
Order Cypriniformes: Family Cyprinidae - carps and minnows			
Cyprinella lutrensis	red shiner	Introduced	Cyplut
Cyprinus carpio	common carp	Introduced	Cypcar
Ptychocheilus lucius	Colorado pikeminnow	Native	Ptyluc
Rhinichthys osculus	speckled dace	Native	Rhiosc
Order Perciformes: Family Centrarchidae – sunfishes			
Lepomis cyanellus	green sunfish	Introduced	Lepcya
Micropterus dolomieu	smallmouth bass	Introduced	Micdol
Micropterus salmoides	largemouth bass	Introduced	Micsal
Order Salmoniformes: Family Salmonidae – trouts			
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 fishes collected during the 2010 Adult Monitoring trip.

Species (Status)[a]	Number Collected	Percent Of Total[b]	Number Of Samples Collected In
flannelmouth sucker (N)	6,372	50.0	191
bluehead sucker (N)	2,227	17.5	165
channel catfish (I)	1,881	14.8	161
speckled dace (N)	1,542	12.1	130
Colorado pikeminnow (N)	433	3.4	130
razorback sucker (N)	153	1.2	62
common carp (I)	54	0.4	36
black bullhead (I)	43	0.3	34
red shiner (I)	18	0.1	12
brown trout (I)	6	-----	6
green sunfish (I)	4	-----	4
largemouth bass (I)	3	-----	2
razorback sucker X flannelmouth sucker (H, N)	3	-----	3
white sucker (I)	3	-----	3
white sucker X flannelmouth sucker (H, I)	3	-----	3
yellow bullhead (I)	2	-----	2
smallmouth bass (I)	1	-----	1
mottled sculpin (N)	1	-----	1
GRAND TOTAL	12,749		
Total Electrofishing Collections In 2010 = 194 Total Electrofishing Effort In 2010 = 84.17 Hours			
2010 Native Fishes = 10,731 (84.17% Of The Total Catch) 2010 Introduced Fishes = 2,018 (15.83% Of The Total Catch) 2010 Native To Introduced Fishes Ratio = 5.32:1			

a: (N) = Native species; (I) = Introduced species; (H, N) = A hybrid of two species, considered to be a native fish; (H, I) = A hybrid of two species, considered to be an introduced fish

b: ----- = less than 0.1%

Rare Native Fishes

Colorado Pikeminnow

No wild adult Colorado pikeminnow were collected in 2010. A total of 433 stocked Colorado pikeminnow were collected in 2010 (Table 3). This was the largest number of stocked Colorado pikeminnow ever collected during an Adult Monitoring trip. This also marked the seventh consecutive year that > 100 Colorado pikeminnow were collected during an Adult Monitoring trip (2004 = 159; 2005 = 127; 2006 = 323; 2007 = 167; 2008 = 207; 2009 = 376).

Colorado pikeminnow captures ranged from RM 175.0-16.0 (Table 4). The majority (n = 388; 89.6%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Twenty-three (5.3%) of these collections occurred upstream of the Hogback Diversion (RM 158.6). Only one occurred upstream of PNM Weir (340 mm TL at RM 175.0). Six of the Colorado pikeminnow caught upstream of Hogback Diversion had PIT tags upon collection. Of these six, three were stocked at RM 180.6 on 28 July 2010 and had moved downstream past the APS Diversion and were recaptured at RM 175.0, 164.0, and 160.0. Another had been stocked on 17 March 2009 at RM 133.5 and had moved 27.5 RM upstream past the Hogback Diversion. The other two had been stocked as age-0 fish without PIT tags. One was tagged on 8 August 2007 at RM 39.2 and recaptured at RM 160.0. The other was tagged on 28 April 2009 at RM 70.0 and recaptured at RM 163.0. Forty-three Colorado pikeminnow were collected in Reach 6, 121 in Reach 5, 88 in Reach 4, 145 in Reach 3, 35 in Reach 2, and 1 in Reach 1.

Stocking history (and length of time in the river) could not be determined for one Colorado pikeminnow. The majority (n = 274; 63.4%) of the 432 known-origin Colorado pikeminnow collected in 2010 were in the river ≤ 365 days post-stocking. However, all but 11 (2.5%) of these fish had been in the river for at least one overwinter period (Table 4). Only 158 (36.6%) of the 432 known-origin Colorado pikeminnow collected in 2010 were in the river > 365 days post-stocking. Of those 158 fish, 149 (94.3%) were stocked as age-0 fish.

Numerous larger Colorado pikeminnow were collected during 2010 Adult Monitoring. These included 61 fish from 300-399 mm TL (age-2 to age-4 fish), 7 fish from 400-449 mm TL (age-3 and age-4 fish), and 2 fish ≥ 450 mm TL (for the purposes of this report, assumed to be age-7 and age-14). Thus, Colorado pikeminnow meeting the Recovery Goal size criteria for both sub-adult (400-449 mm TL) and adult (≥ 450 mm TL) Colorado pikeminnow (USFWS 2002a) were collected in 2010. However, because these fish were likely all stocked fish, they had been stocked at larger sizes than wild fish of the same age-class and would likely have reached the size-class thresholds for both sub-adult and adult fish faster than wild fish would have (D. Ryden, unpublished data). While I think it unlikely, it is possible that the two “adult” Colorado pikeminnow collected in 2010 could have been wild-produced fish. The use of the Recovery Goal criteria in this context is simply a convenient way to judge progress of this species towards recovery (i.e., by comparing yearly collections against a known target number). As a point of clarification:

Where stocked fish are involved, a self-sustaining population must consist of young produced in the wild and recruited to the adult population at the required rates; stocked fish are included in the count of adults after their progeny are recruited to adults (USFWS 2002b).

Table 4. General information on stocked Colorado pikeminnow collected in 2010.

Age At Capture & (Number Captured)	Size Range At Capture (TL in mm)	Range of Capture RM's	Days In River Post-Stocking (Number Of Overwinter Periods)	Stocking Dates	Age At Stocking & (Year-Class Of Fish)	Source[a]
Age-2 (11)	295-372	175.0-98.0	55-69 (0)	07/28/2010	Age-2 (2008)	Dexter
Age-1 (262)	124-288	164.0-17.0	315-337 (1)	11/09/2009	Age-0 (2009)	Dexter
Age-3 (1)	305	40.0	349 (1)	10/26/2009	Age-2 (2007)	Dexter
Age-4 (6)	380-435	161.0-53.0	553-571 (1)	3/17/2009	Age-3 (2006)	Dexter
Age-2 (136)	233-374	164.0-19.0	683-705 (2)	11/06/2008	Age-0 (2008)	Dexter
Age-4 (3)	400-459	157.0-137.0	887-889 (2)	04/15/2008	Age-2 (2006)	Dexter
Age-3 (8)	350-435	163.0-68.0	1,041-1,059 (3)	10/03/2007, 11/07/2007 & 11/14/2007	Age-0 (2007)	Dexter
Age-4 (3)	392-484	160.0-110.0	1,420-1,432 (4)	10/19/2006 & 11/02/2006	Age-0 (2006)	Dexter
Age-7 *Assumed* (1)	560	70.0	2,528 (7) *Assumed*	11/06/2003 *Assumed*	Age-0 (2003)	Dexter
Age-14 *Assumed* (1)	658	142.0	5,068 (14) *Assumed*	11/04/1996 *Assumed*	Age-0 (1996)	Dexter

a: Dexter = U. S. Fish & Wildlife Service, Dexter National Fish Hatchery & Technology Center, Dexter NM.

Comparisons of scaled CPUE among groups of Colorado pikeminnow stocked as age-0 fish showed that at age-1, recapture rates were highly variable (indicating either highly variable survival or highly variable recapture probabilities) between years (Figure 1). Data collected from 2004-2009 indicated that by age-2, differences in scaled CPUE among stocking years

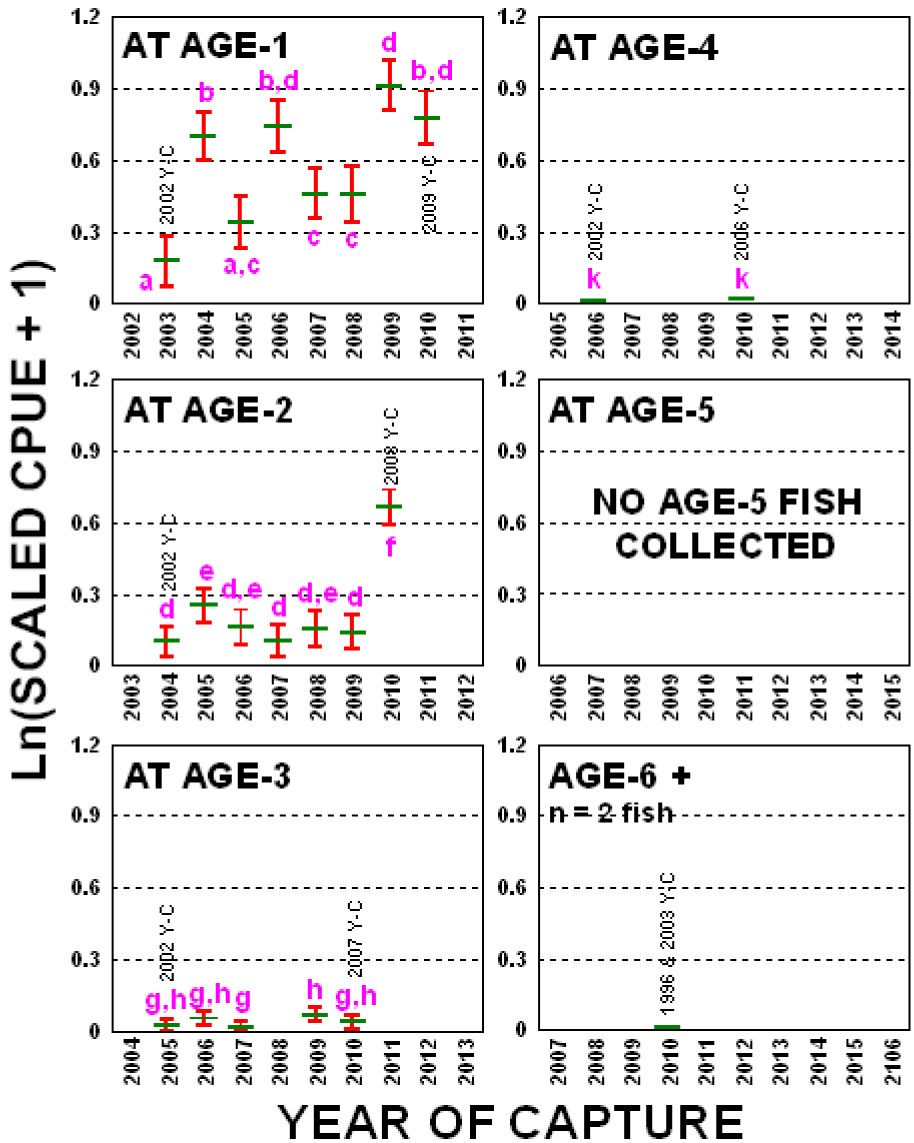

Figure 1. A comparison of scaled CPUE at age among groups of Colorado pikeminnow stocked as age-0 fish and captured during subsequent Adult Monitoring trips, 2003-2010. The green line shows the difference in scaled CPUE values between years. Red error bars are +/- 2 SE. Purple letters are within-age multi-year comparisons. Letters that are the same within a graph are not significantly different from one another. Letters that are different within a graph are significantly different from one another. Y-C = year-class.

tended to greatly diminish, with few significant differences being present (Figure 1). Age-2 fish collected in 2010 were the exception to this trend. The scaled CPUE for age-2 fish in 2010 was significantly higher than the previous six years values (Figure 1). By age-3, few significant differences existed in scaled CPUE among any of the groups of Colorado pikeminnow stocked as age-0 fish.

Prior to 2010, there was only one year (2006) in which an age-4 Colorado pikeminnow stocked as an age-0 fish had been collected during Adult Monitoring. In 2010, three age-4 Colorado pikeminnow stocked as age-0 fish were collected (Table 4, Figure 1). In addition, two larger Colorado pikeminnow were also collected. If these two fish were indeed stocked as age-0 fish, these recaptures would represent an age-7 and an age-14 fish. As stated above, these two fish could have been wild-produced fish. However, given the dearth of wild adult Colorado pikeminnow known to have been in the river during those years, the few larval Colorado pikeminnow collected during those same years, and the fact that large numbers of relatively large-sized, age-0 Colorado pikeminnow were stocked in both years, I'm assuming that these two large adults were the result of those stockings.

As in previous years, few Colorado pikeminnow that were stocked at age-1 or older were collected during Adult Monitoring. Only 21 (4.9%) of the 432 known-origin Colorado pikeminnow collected in 2010 were fish that had been stocked at age-1 or older (Table 4). None of these fish stocked at age-1 or older had been in the river longer than 2 overwinter periods. Stockings of Colorado pikeminnow older than age-0 are scheduled to be discontinued.

Between-year comparisons of scaled CPUE for all Colorado pikeminnow that were in the river 1+ overwinter periods showed that from 2004-2008 scaled CPUE changed very little. However, the 2009 value for this metric was significantly higher than five of the six previous years (Figure 2). The 2010 scaled CPUE value for all Colorado pikeminnow that were in the river 1+ overwinter periods was significantly higher than all previous years, including 2009 (Figure 2). This seems to be a direct result of very high recapture (i.e., survival) rates observed among age-2 fish that had originally been stocked as age-0 fish in 2008 (Figure 1).

Table 5. Information on stocked Colorado pikeminnow collected from 1998-2010 that had been in the river for 1+ overwinter periods.

Information For Fish Collected During The Entire Adult Monitoring Trip:			Information For Fish That Were In The River For 1+ Overwinter Periods At Time Of Capture:			
Year	Effort (Total Hours Electrofished)	Total Number Of Stocked Colorado Pikeminnow Collected	Number Of Fish Collected That Were In River 1+ Overwinter Periods	Year-Classes Of Captured Colorado Pikeminnow	Days In River Post-Stocking (Number Of Overwinter Periods)	Years During Which These Fish Were Stocked
1998	137.14	104	104	1996-1997 & 1 wild adult	362-702 (1-2) (wild fish = 7+)	1996 (45 fish) 1997 (58 fish) wild fish = 1
1999	88.36	10	10	1996-1998	446-1061 (1-3)	1996 (n = 2) 1997 (n = 4) 1998 (n = 4)
2000	116.89	1	1	1996	1417 (4)	1996 (n = 1)
2001	109.61	5	3	1999-2000	471-814 (1-2)	1999 (n = 1) 2000 (n = 2)
2002	92.17	3	3	1991	548 (1)	2001 (n = 3)
2003	94.42	32	32	2002	333-354 (1)	2002 (n = 32)
2004	93.75	159	146	2002-2003	319-719 (1-2)	2002 (n = 16) 2003 (n = 130)
2005	85.95	127	105	2002-2004	326-1082 (1-3)	2002 (n = 3) 2003 (n = 33) 2004 (n = 69)
2006	77.80	323	205	2002-2005	319-1445 (1-4)	2002 (n = 1) 2003 (n = 6) 2004 (n = 26) 2005 (n = 172)
2007	90.95	167	146	2004-2006	319-1073 (1-3)	2004 (n = 2) 2005 (n = 20) 2006 (n = 124)
2008	83.88	207	175	2006-2007	320-708 (1-2)	2006 (n = 29) 2007 (n = 146)
2009	104.73	376	337	2006-2008	319-1088 (1-3)	2006 (n = 14) 2007 (n = 38) 2008 (n = 285)
2010	84.17	432	421	1996-2009	315-5,068 (1-14)	2009 (n = 262) 2008 (n = 136) 2007 (n = 9) 2006 (n = 12) 2003 (n = 1) 1996 (n = 1)

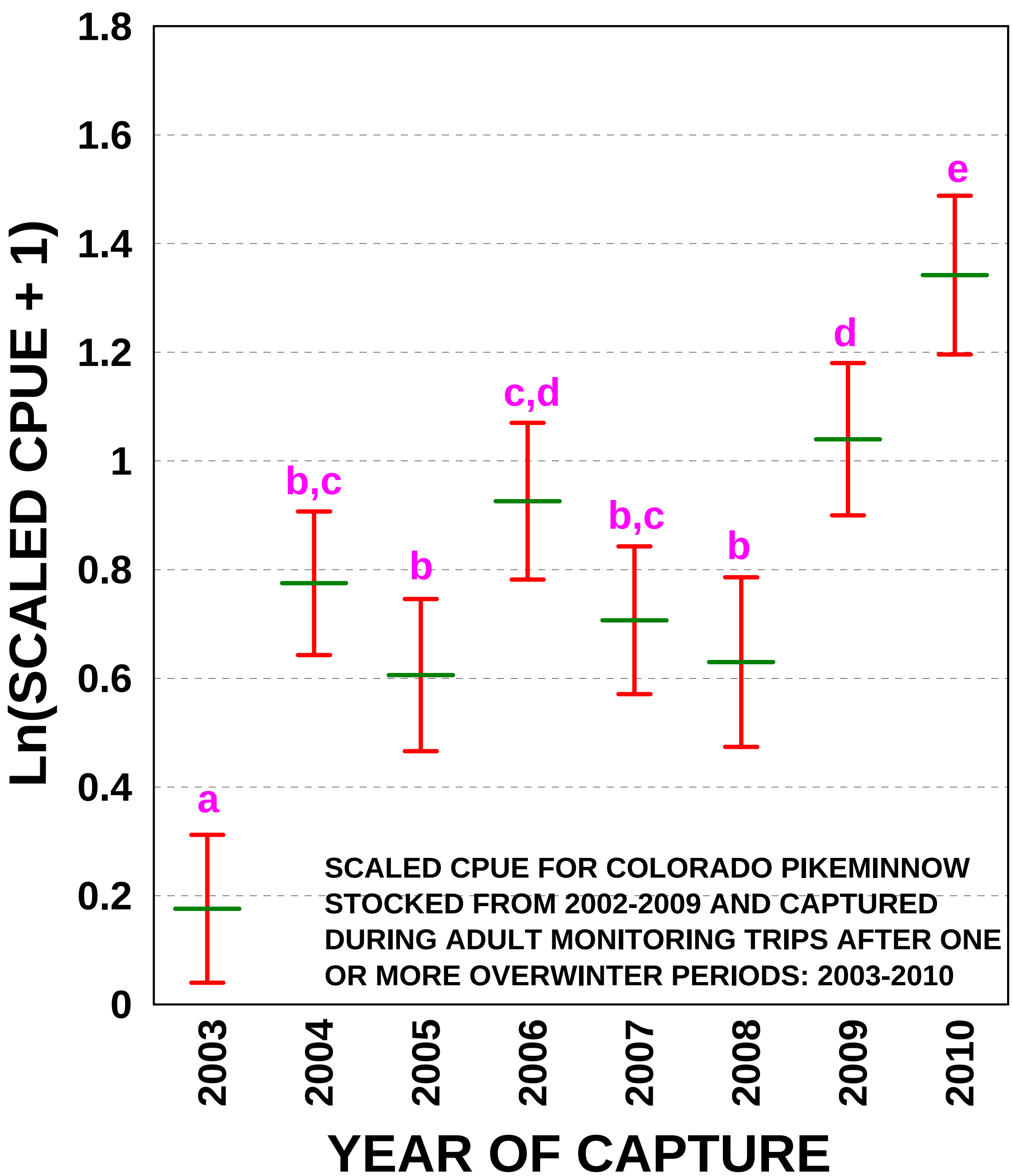

Figure 2. Year-to-year comparison of scaled CPUE for all Colorado pikeminnow collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. Purple letters are between-year comparisons (using Tukey's HSD post-hoc test). Letters that are the same between years are not significantly different from one another. Letters that are different between years are significantly different from one another.

Razorback Sucker

There were no definitive collections of wild razorback sucker in 2010. However, a total of 153 razorback sucker (assumed here to all be stocked fish) were collected in 2010 (Table 6). This marks the seventh consecutive year during which > 50 razorback sucker (2004 = 117; 2005 = 52; 2006 = 144; 2007 = 207; 2008 = 78; 2009 = 84) were collected during an Adult Monitoring trip.

Razorback sucker captures ranged from RM 166.0-53.0 (Table 6). All but one (n = 152; 99.3%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Forty-six razorback sucker (30.1%) were collected upstream of the Hogback Diversion (RM 158.6). The relatively large percentage of razorback sucker collections upstream of Hogback Diversion is almost certainly an artifact of the many fish that have recently been stocked at RM 166.6, just downstream of the PNM Weir and fish passage facility. However, even with razorback sucker being stocked just below the PNM Weir and the fish passage facility, the large majority (n= 107; 69.9%) of razorback sucker collections still occurred downstream of Hogback Diversion, and none occurred upstream of the PNM fish passage facility during 2010 Adult Monitoring. Seventy-one razorback sucker were collected in Reach 6, 54 in Reach 5, 14 in Reach 4, 13 in Reach 3, 1 in Reach 2, and 0 in Reach 1.

Table 6. General information on stocked razorback sucker collected in 2010.

Days In River Post-Stocking (Number Of Overwinter Periods)	Age At Capture & (Number Captured)	Size Range At Capture (TL in mm)	Range of Capture RM's	Stocking Year	Age At Stocking & (Year-Class Of Fish)
Information on the 102 razorback sucker with known stocking histories:					
2-29 (0)	Age-2 (32)	290-395	166.0-82.0	2010	Age-2 (2008)
315-371 (1)	Age-3 (44)	374-463	164.0-107.0	2009	Age-2 (2007)
677-762 (2)	Age-3 To Age-4 (5)	412-470	161.0-53.0	2008	Age-1 To Age-2 (2006-2007)
1155-1266 (3)	Age-4 To Age-7 (9)	405-499	149.0-101.0	2007	Age-1 To Age-4 (2003-2006)
1517-1534 (4)	Age-8 To Age-9 (2)	440-467	133.4-95.0	2006	Age-4 To Age-5 (2001-2002)
1848-1868 (5)	Age-8 (2)	480-505	155.0-134.0	2005	Age-3 (2002)
2221-2264 (6)	Age-9 (4)	489-533	160.0-154.0	2004	Age-3 (2001)
3246-3261 (9)	Age-10 (3)	439-485	143.0-97.0	2001	Age-1 (2000)
5487 (15)	Age-18 (1)	530	100.0	1995	Age-3 (1992)
Information on the 51 razorback sucker captured without known stocking histories:					
≥ 336 (3-4)	Age-5 To Age-8 (46)	320-535	164.0-70.0	2006-2009	Age-2 To Age-4 (2002-2008)
Unknown	(5)	338-510	160.0-134.0	Unknown	Unknown

Personnel errors led to PIT tag numbers not being obtained for five razorback sucker. For various other reasons, the exact length of time that 46 of the razorback sucker captured during 2010 Adult Monitoring had been in the river post-stocking could not be determined (Table 6). Of the 102 razorback sucker recaptured with PIT tags and known stocking histories in 2010, 74 (72.5%) were in the river < 365 days post-stocking and 32 were in the river < 1 overwinter period when they were collected. The other 28 (27.4%) were in the river > 365 days post-stocking and had been in the river from 1-15 overwinter periods (Table 6).

Comparisons of capture data for razorback sucker with known stocking histories that were in the river for 1+ overwinter periods and collected during Adult Monitoring trips changed little from 2003-2009 (range = 19-36; Table 7). However, in 2010, this number rose to 70 fish, double the value observed in any previous year. Razorback sucker collected after 1+ overwinter periods also continue to demonstrate a much longer post-stocking persistence (up to 15 overwinter periods or 5,487 days post-stocking) than Colorado pikeminnow. On every Adult Monitoring trip since 2003, razorback sucker were collected that had been in river for at least 6 overwinter periods post-stocking (Table 7). The two 1992 year-class razorback sucker collected on the 2007 and 2010 Adult Monitoring trips (both stocked in 1995) indicate that older razorback sucker continue to persist in the San Juan River, albeit in low numbers. The 2010 scaled CPUE value for razorback sucker that were in the river 1+ overwinter periods was significantly higher than the previous three-year period from 2007-2009 (Figure 3). This was a direct result of the 70 known-origin razorback sucker mentioned above.

Source of origin could be determined for 129 razorback sucker. Of these 129 fish, 121 (93.8%) were reared in the NAPI grow-out ponds, southwest of Farmington, NM. Another seven (5.4%) were reared at the USFWS' Dexter National Fish Hatchery and Technology Center (NFH&TC), near Roswell, NM. The last individual, stocked in 1995, was reared at the Utah Division of Wildlife Resources' (UDWR) Wahweap Warmwater Fish Hatchery. No razorback sucker from the USFWS' Uvalde NFH were recaptured during 2010 Adult Monitoring collections.

Table 7. Information on stocked razorback sucker collected from 2003-2010 that had been in the river for 1+ overwinter periods and had known stocking histories.

Information For Fish Collected During The Entire Adult Monitoring Trip:			Information For Fish That Were In The River For 1+ Overwinter Periods At Time Of Capture:			
Year	Effort (Total Hours Electrofished)	Total Number Of Razorback Sucker Collected	Number Of Fish Collected That Were In River 1+ Overwinter Periods	Year-Classes Of Captured Razorback Sucker	Days In River Post-Stocking (Number Of Overwinter Periods)	Years During Which These Fish Were Stocked
2003	94.42	19	19	1992, 1999-2001 & 1 wild juvenile	518-3246 (1-9) (wild fish = 1-2)	1994 (2 fish) 2000 (4 fish) 2001 (10 fish) 2002 (2 fish) wild fish = 1
2004	93.75	117	18	1992, 1998-2001	527-3609 (1-10)	1994 (1 fish) 1999 (1 fish) 2000 (3 fish) 2001 (9 fish) 2002 (3 fish) 2003 (1 fish)
2005	85.95	52	30	1998-2002	394-2254 (1-6)	1999 (1 fish) 2000 (3 fish) 2001 (6 fish) 2003 (1 fish) 2004 (19 fish)
2006	77.80	145	23	1997, 2000-2002	382-2914 (1-8)	1998 (1 fish) 2001 (1 fish) 2002 (1 fish) 2004 (16 fish) 2005 (4 fish)
2007	90.95	207	22	1992, 1999-2001, 2004, 2005	375-4389 (1-12)	1995 (1 fish) 2001 (5 fish) 2003 (1 fish) 2004 (3 fish) 2006 (12 fish)
2008	83.88	78	36	2000-2007	421-2519 (1-7)	2001 (1 fish) 2004 (7 fish) 2005 (4 fish) 2006 (5 fish) 2007 (19 fish)
2009	104.73	84	35	1999-2006	312-3263 (1-9)	2000 (1 fish) 2001 (3 fish) 2004 (2 fish) 2005 (3 fish) 2006 (7 fish) 2007 (8 fish) 2008 (11 fish)
2010	84.17	153	70	1992-2007	315-5487 (1-15)	1995 (1 fish) 2001 (3 fish) 2004 (4 fish) 2005 (2 fish) 2006 (2 fish) 2007 (9 fish) 2008 (5 fish) 2009 (44fish)

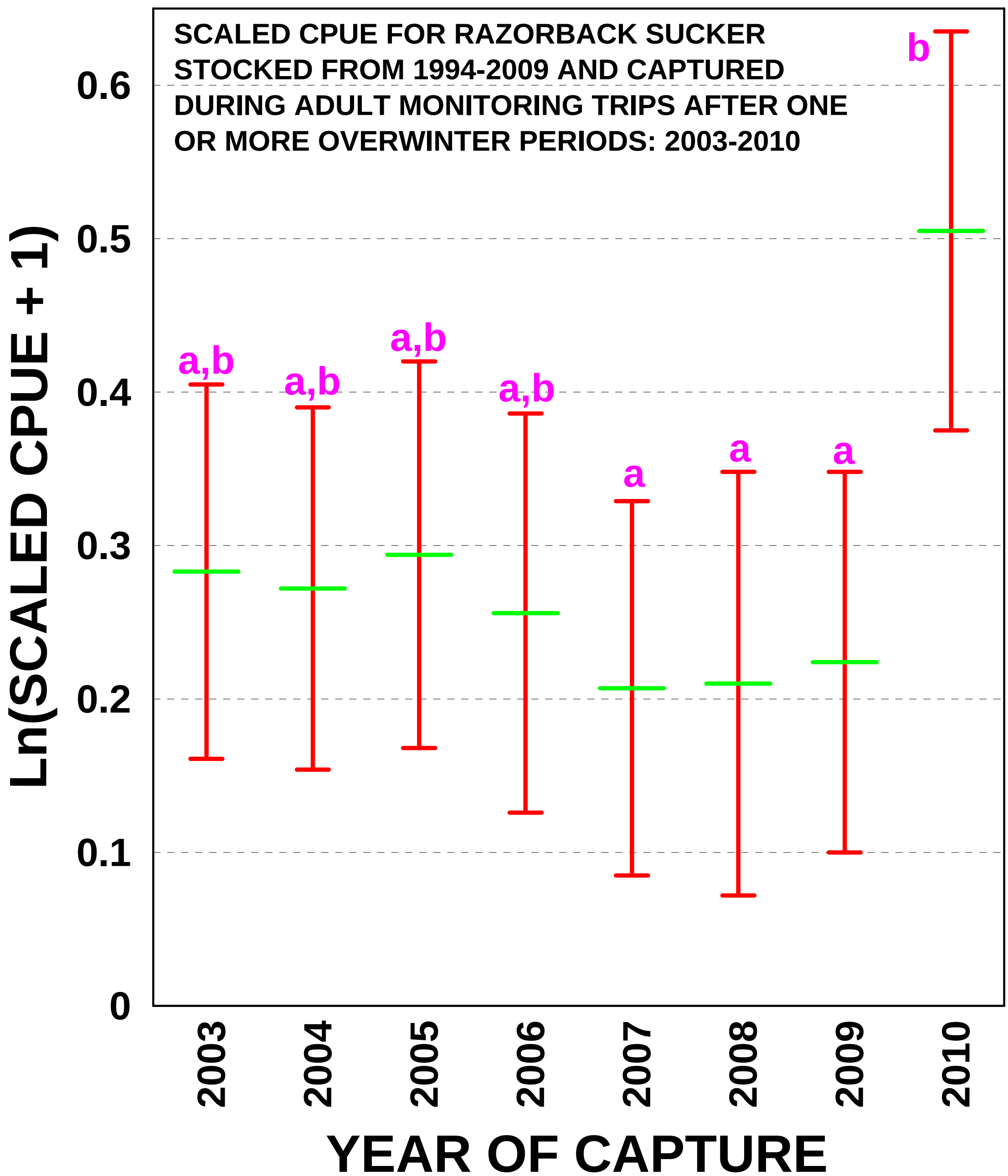

Figure 3. Year-to-year comparison of scaled CPUE for all razorback sucker collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. Purple letters are between-year comparisons (using Tukey's HSD post-hoc test). Letters that are the same between years are not significantly different from one another. Letters that are different between years are significantly different from one another.

Roundtail Chub

There were no wild roundtail chub collected during the 2010 Adult Monitoring trip. One roundtail chub was collected on both the 2008 and 2009 Adult Monitoring trips. Prior to those two collections, the next previous collection occurred on the fall 2002 Adult Monitoring trip.

Common Native Fishes

Flannelmouth Sucker

Catch Information

Flannelmouth sucker was once again the most common large-bodied fish species collected riverwide during the 2010 Adult Monitoring trip (Table 3, Figure 4). Flannelmouth sucker had the widest distribution of any species, being collected in 191 (98.5%) of 194 electrofishing samples riverwide (Table 3, Figure 4). Flannelmouth sucker were collected throughout all six river reaches in 2010 (from RM 179.0-7.0).

Riverwide, flannelmouth sucker juvenile CPUE has shown far more variation over the last 12 years than has adult CPUE (Figure 5). Although year-to-year juvenile CPUE values showed a comparatively high degree of variation, the long-term trend indicated no significant change. If you compare the 1999 and 2010 adult CPUE values, there is a significant decline between those two data points. However, the 2010 adult CPUE value was not significantly different than 9 of the previous 11 years. Therefore, this particular declining trend is really being driven by the 1999 data point for adult flannelmouth sucker. Despite the significant long-term decline in adult flannelmouth sucker CPUE, the combined adult and juvenile CPUE showed no significant change over the last 12 years (Figure 5).

Length Information

Flannelmouth sucker ranging in size from 56-572 mm TL (mean TL = 334 mm) were collected during 2010 Adult Monitoring. The 2010 riverwide length-frequency histogram for flannelmouth sucker was bimodal, with one peak centered around adult fish from 426-450 mm TL and the other centered around juvenile fish from 301-325 mm TL (Figure 6). The large group of juvenile fish centered around 301-325 mm TL will move into the recruiting subadult size-class in 2011.

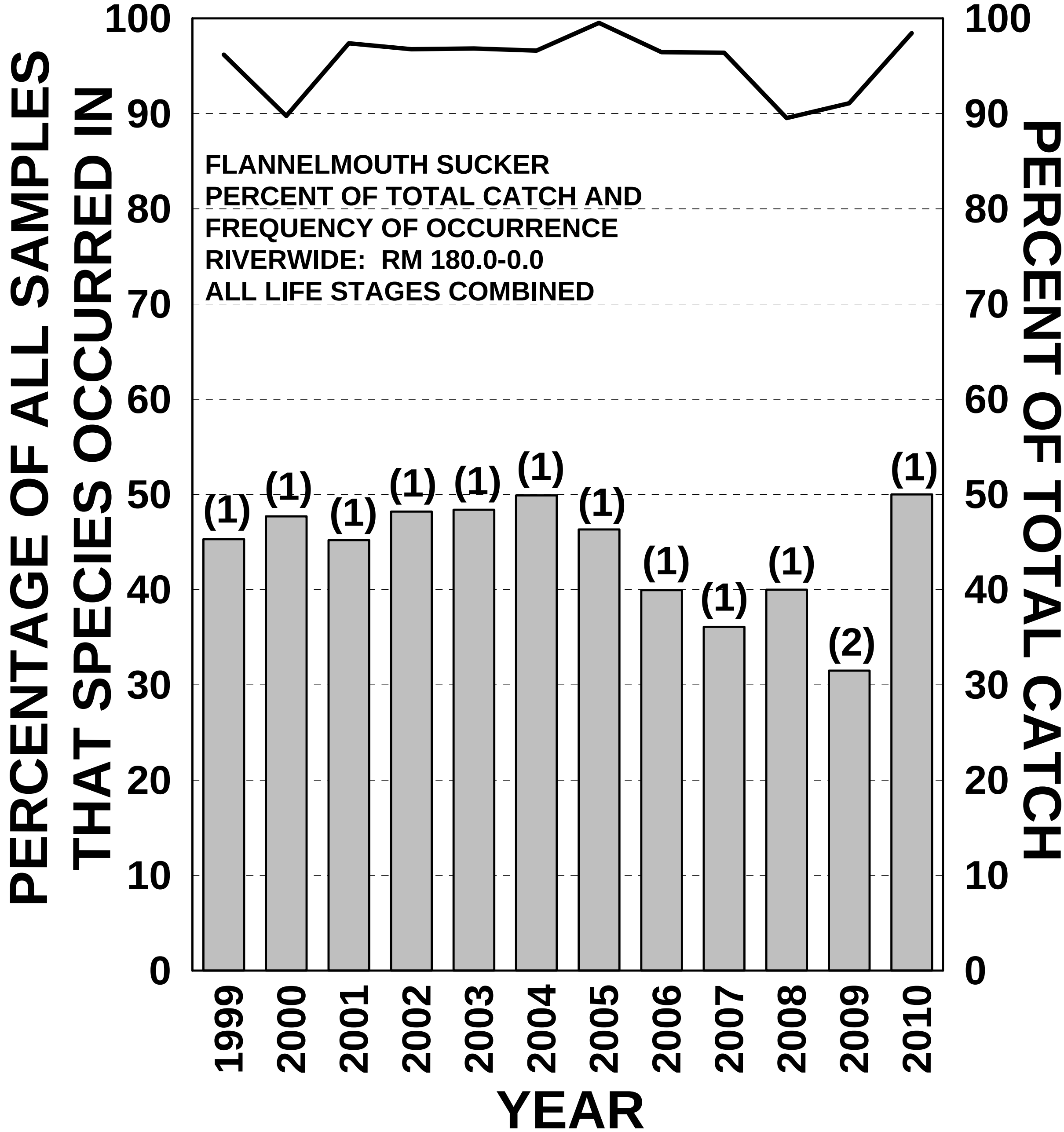

Figure 4. A summary of flannelmouth sucker relative abundance in riverwide Adult Monitoring collections, 1999-2010. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent the percent of the total catch that this species composed in a given year. Numbers in parentheses indicate the numeric rank for this species in a given year relative to all other fish species collected.

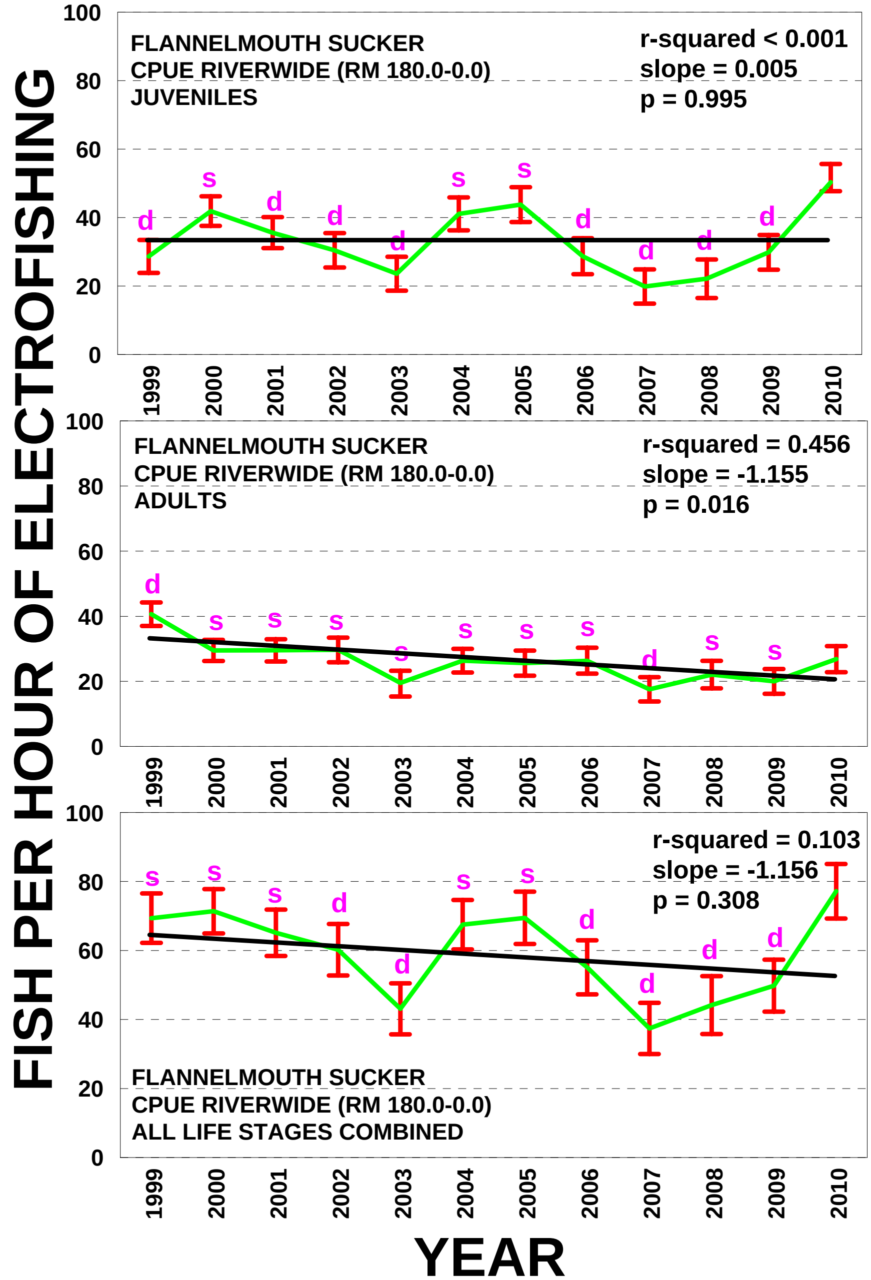

Figure 5. Flannelmouth sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 410 mm TL; top), adult fish (≥ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2010 value. The letter "d" means the value is significantly different from the 2010 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

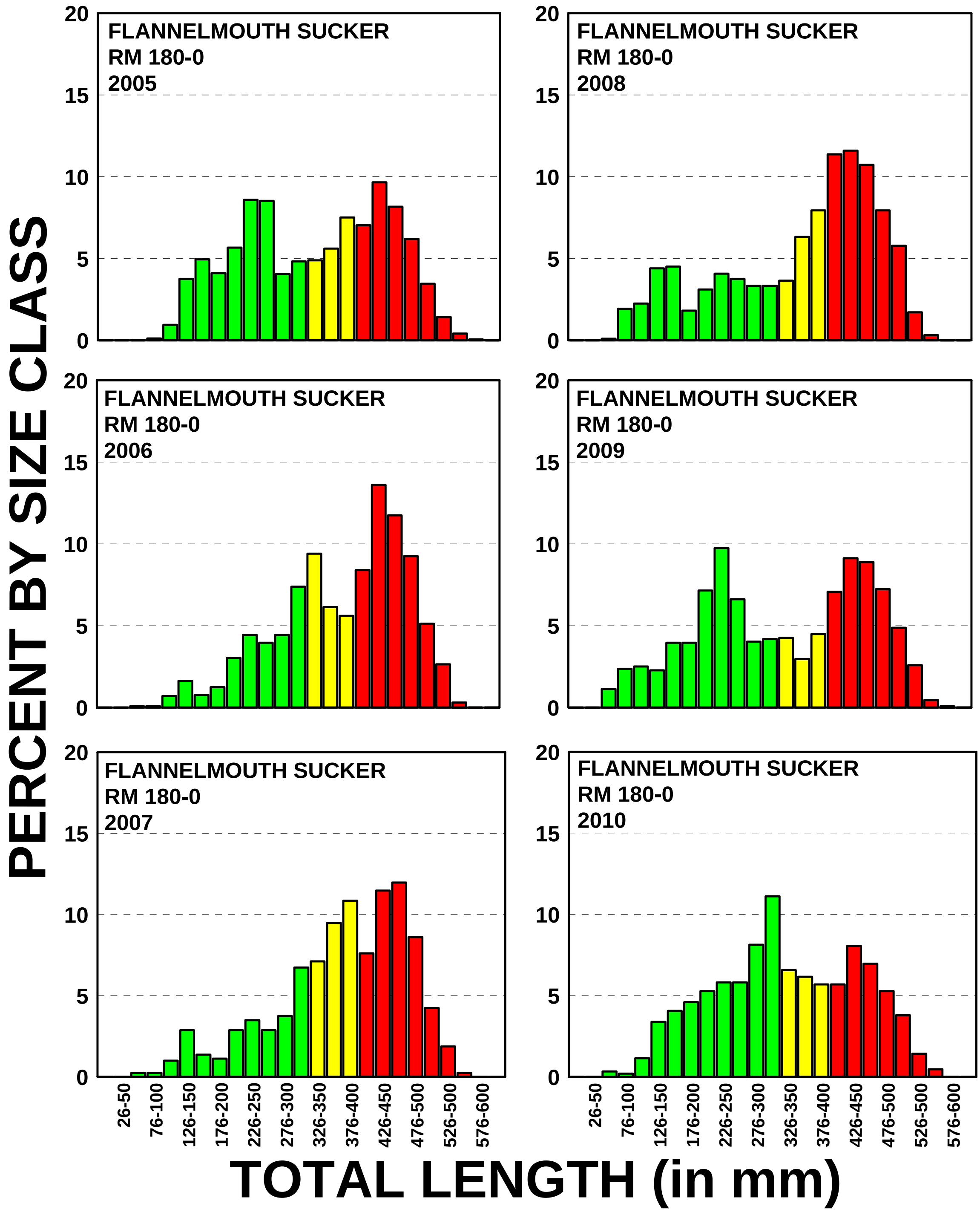

Figure 6. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of flannelmouth sucker on fall Adult Monitoring trips in the San Juan River, 2005-2010. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Bluehead Sucker

Catch Information

Bluehead sucker were the second most commonly-collected large-bodied fish species during 2010 Adult Monitoring (Table 3, Figure 7). The percentage of the total catch composed of bluehead sucker in 2010 (17.5%) was close to being a median value, being higher than 5 of the previous 11 years, but lower than the other six (Figure 7). Bluehead sucker were collected in Reaches 6-2 in 2010 (from RM 179.0-23.0). However, unlike 2003-2007, when bluehead sucker were collected in Reach 1 in four out of five years, no bluehead sucker were collected in Reach 1 in 2008, 2009, or 2010. Prior to 2003 (i.e., 1994-2003), bluehead sucker were never collected in Reach 1, adjacent to Lake Powell, during Adult Monitoring. The more widespread distribution of bluehead sucker observed from 2001-2007 (when bluehead sucker consistently occurred in over 80% of all electrofishing samples riverwide and in > 90% in four of those years) was not evident in either 2008 or 2009. However, in 2010, bluehead sucker were once again collected in 85.1% of all electrofishing samples riverwide (Figure 7).

Bluehead sucker adult CPUE has not changed significantly over the last 12 years (Figure 8). Thus, the changes in the bluehead sucker total CPUE are being driven completely by fluctuations in juvenile catch rates. Bluehead sucker juvenile CPUE in 2010 was not significantly different from 9 of the previous 11 years (Figure 8). Juvenile CPUE among both bluehead and flannelmouth sucker has shown noticeable year-to-year fluctuations that appear to be cyclical events. Despite these year-to-year fluctuations, the long-term trends for bluehead sucker juvenile, adult, and total CPUE riverwide has shown no significant change in these abundance indices over the last 12 years (Figure 8).

Length Information

Bluehead sucker ranging from 63-469 mm TL (mean TL = 236 mm) were collected during 2010 Adult Monitoring. In 2010, the largest mode of the bluehead sucker length-frequency histogram was centered around a group of juvenile fish that were 101-175 mm TL (Figure 9). The presence of the adult fish seen recruiting into the adult population from 2007-2009 was masked in 2010 by the presence of this large cohort of younger fish (Figure 9).

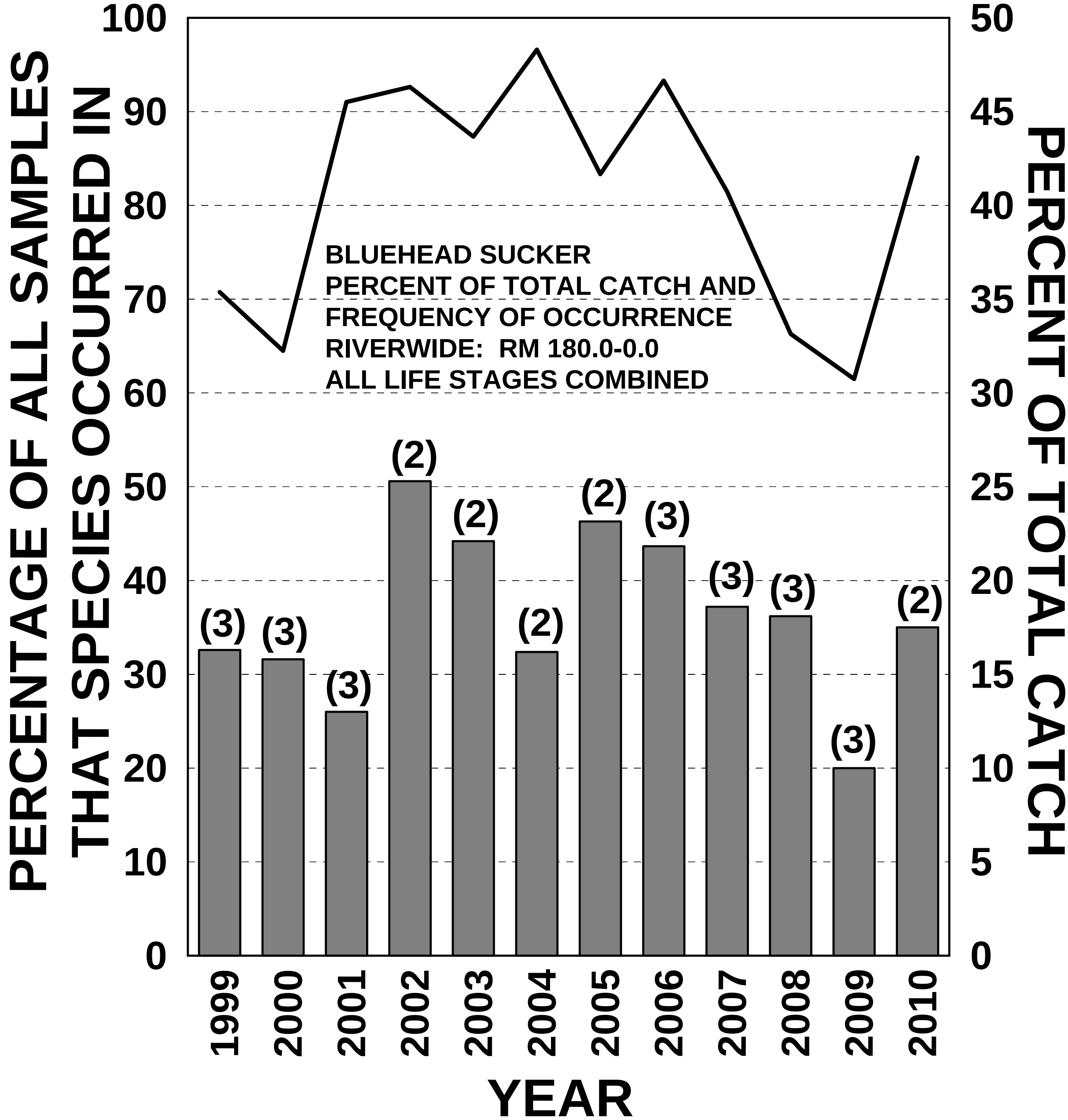

Figure 7. A summary of bluehead sucker relative abundance in riverwide Adult Monitoring collections, 1999-2010. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent the percent of the total catch that this species composed in a given year. Numbers in parentheses indicate the numeric rank for this species in a given year relative to all other fish species collected.

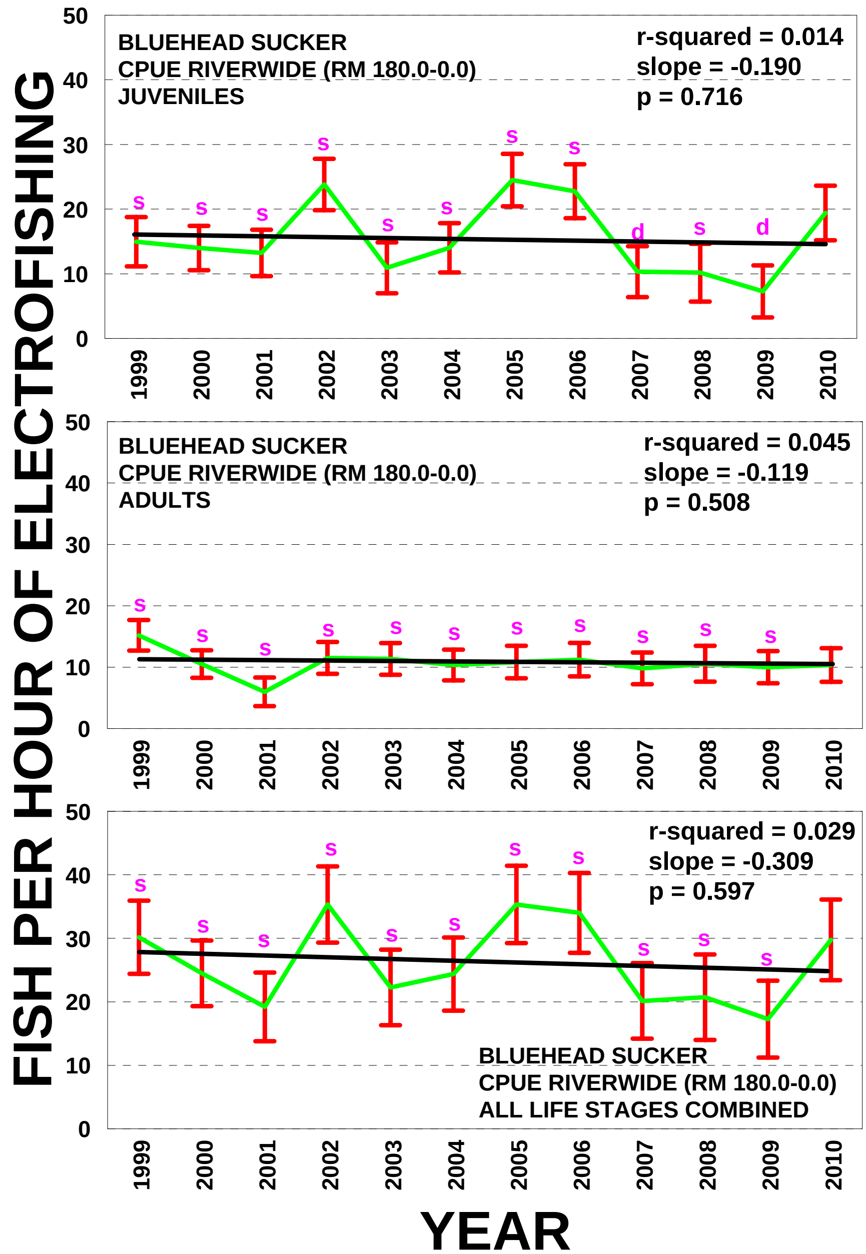

Figure 8. Bluehead sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2010 value. The letter "d" means the value is significantly different from the 2010 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

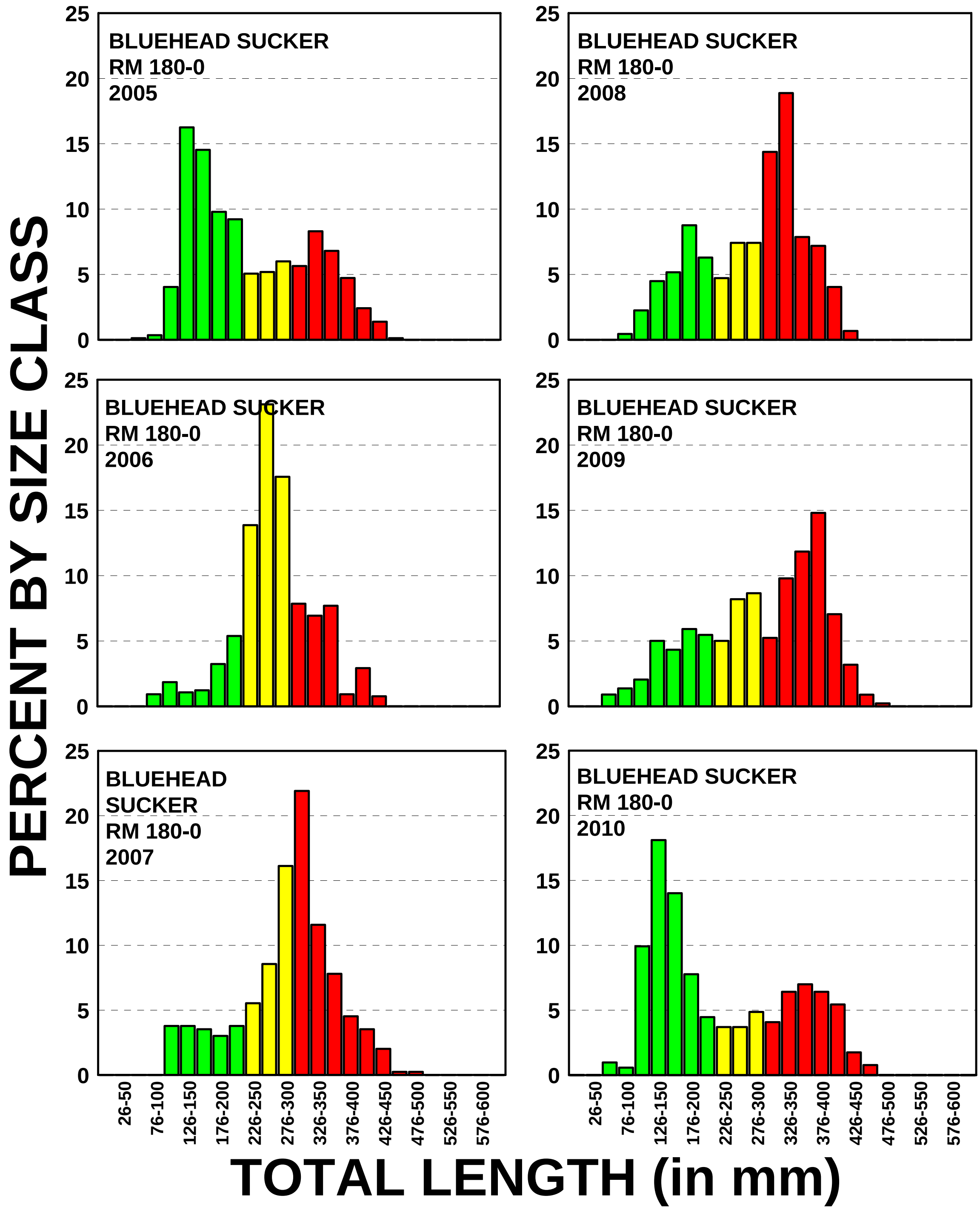

Figure 9. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of bluehead sucker on fall Adult Monitoring trips in the San Juan River, 2005-2010. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Common Nonnative Fishes

Channel Catfish

Catch Information

In 2010, channel catfish were the third most abundant species in electrofishing samples (Table 3, Figure 10). Channel catfish accounted for only 14.8% of the total catch in 2010. This reversed a five-year trend (2005-2009) during which the proportion of the total catch composed by channel catfish rose markedly during Adult Monitoring trips. The proportion of the total catch accounted for by channel catfish was the second lowest value observed in the last 12 years (Figure 10). Despite this relatively low proportional value, channel catfish were collected in 83.0% of all electrofishing samples riverwide in 2010 and occurred in all six river reaches (from RM 160.0-8.0; Figure 10).

Prior to 2009, the riverwide CPUE value for juvenile channel catfish had not changed significantly for five years (2004-2008). However the 2009 juvenile CPUE value was significantly higher than that observed in any previous year (Figure 11). The 2009 channel catfish juvenile CPUE value was 3.44 times higher than the 2008 value and 1.98 times higher than the value for the closest previous year (1999). This anomalous and alarming spike in the juvenile channel catfish CPUE was not apparent during 2010 Adult Monitoring collections. In fact, the 2010 juvenile CPUE value was not significantly different than 8 of the previous 11 years (Figure 11). The riverwide CPUE value for adult channel catfish was significantly lower than that observed for the previous four-year period (2006-2009) and not significantly different than the 2004 adult channel catfish CPUE value, which was the lowest observed value in the last 12 years (Figure 11). Yet, despite the significant drop in both juvenile and adult channel catfish CPUE between 2009 and 2010, the long-term trend lines indicate that overall, channel catfish CPUE in the San Juan River has not been reduced significantly by recent nonnative fish removal efforts.

However, the center of channel catfish abundance has shifted to downstream river sections since nonnative fish removal efforts began in 2001. In 2001, the largest part of this population resided within the upper nonnative fish removal section (RM 166.6-147.9; PNM Weir to Shiprock bridge) with relatively large numbers (36.3-42.0 fish/hr) of channel catfish in adjacent downstream river sections (Figure 12). By 2006, multi-year, intensive removal efforts in both the upper and lower (RM 52.9-2.9; Mexican Hat launch to Clay Hills launch) nonnative fish removal sections had noticeably cropped the peripheries of this population and concentrated the large majority of the remaining channel catfish, as well as the bulk of the remaining channel catfish biomass into the middle section of the San Juan River, from RM 147.9-52.9 (Shiprock bridge to Mexican Hat launch), where only occasional, single-pass removal efforts had occurred up until that time (Figure 12).

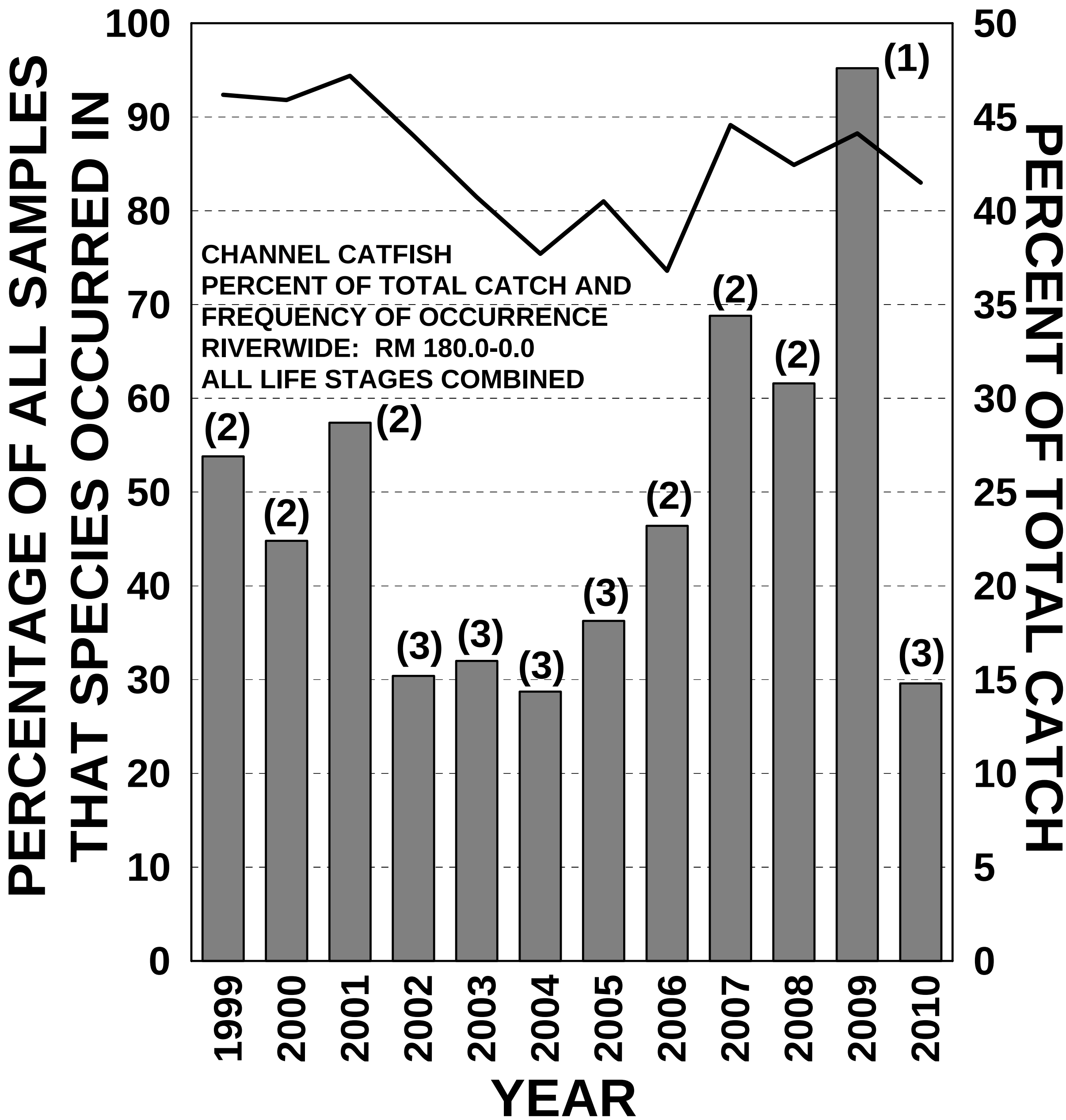

Figure 10. A summary of channel catfish relative abundance in riverwide Adult Monitoring collections, 1999-2010. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent the percent of the total catch that this species composed in a given year. Numbers in parentheses indicate the numeric rank for this species in a given year relative to all other fish species collected.

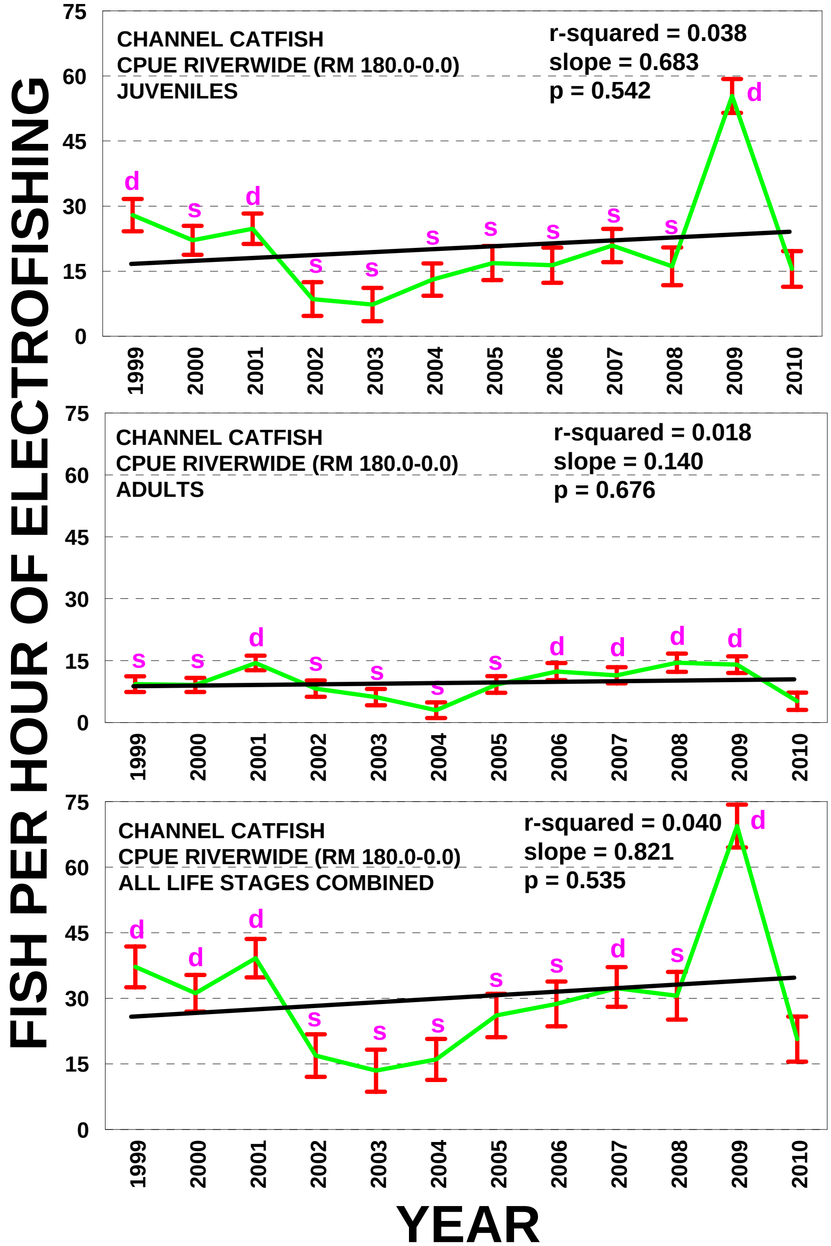

Figure 11. Channel catfish CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2010 value. The letter "d" means the value is significantly different from the 2010 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

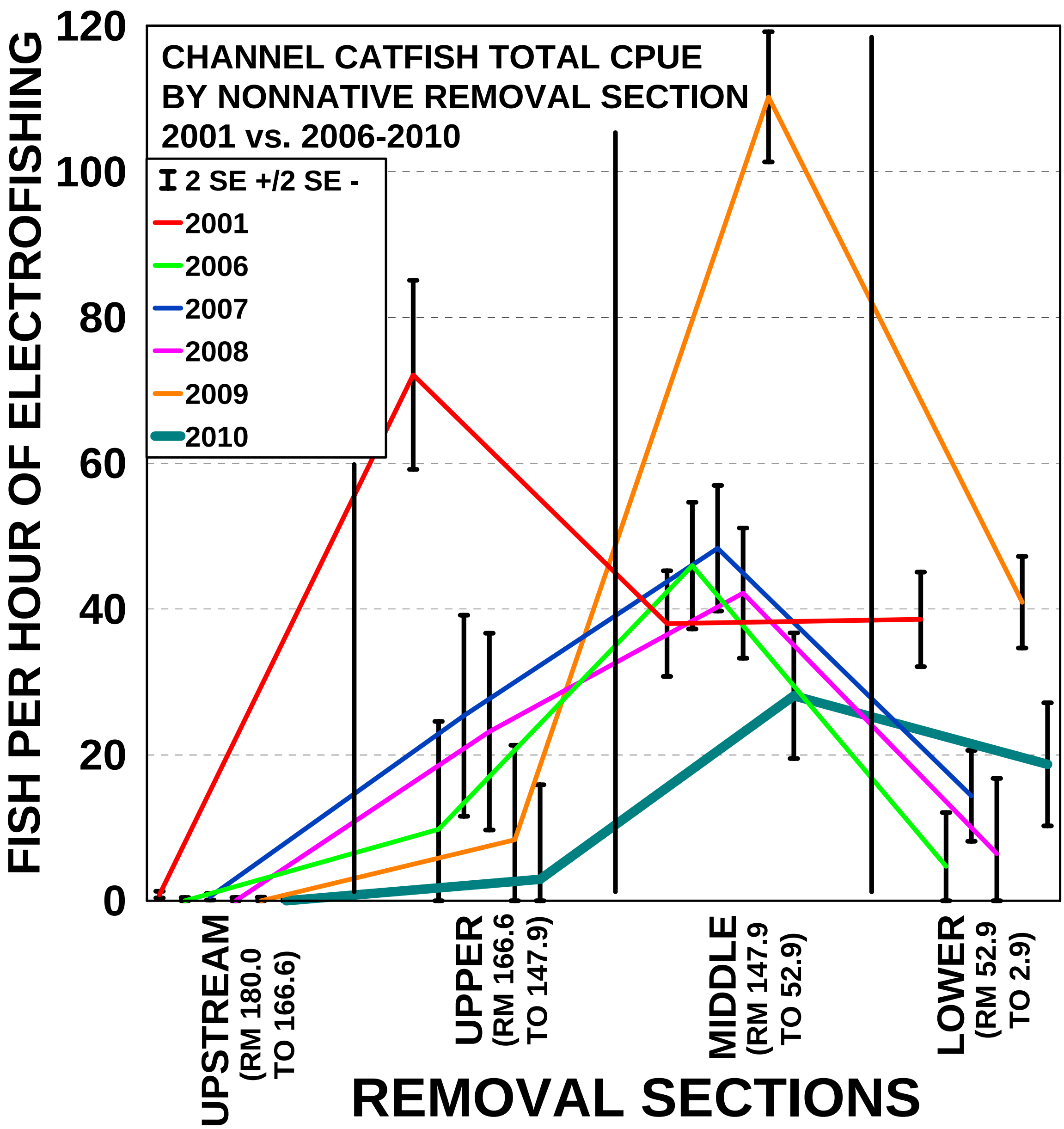

Figure 12. A comparison of channel catfish total CPUE within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2010. Lines represent the mean total CPUE values for each year, by river section. Error bars are +/- 2 SE.

Multiple-pass, intensive removal efforts began in the middle section of the San Juan River in 2007 and intensified greatly in 2008 and 2009. In 2007 and 2008, the large majority of channel catfish encountered during Adult Monitoring continued to be collected from this middle section of the San Juan River (Figure 12).

In both the upper and lower nonnative fish removal sections, the longer-term removal efforts were successful in keeping numbers of channel catfish significantly lower (p-values for both sections were all ≤ 0.001) from 2006-2008 than they were in 2001 (Figure 12). Despite the majority of channel catfish being collected in the middle nonnative fish removal section in 2007 and 2008, the bulk of the channel catfish biomass being collected during these two years was evenly split between the upper nonnative fish removal section (fewer, larger adult fish) and the middle nonnative fish removal section (numerous, smaller juvenile fish). Yet, even with the increase in biomass in the upper nonnative fish removal section in 2007 and 2008, biomass totals for both of those years were significantly lower than they were in 2001, when nonnative fish removal efforts were just beginning in this river section (Figure 13).

In 2009, an unprecedented increase in channel catfish juvenile CPUE was observed in the middle nonnative fish removal section (Figures 12). A corresponding increase in channel catfish juvenile CPUE was also observed in the lower nonnative fish removal section, which brought CPUE values for that section back to levels essentially identical to those observed in 2001 (Figure 12). Corresponding increases in channel catfish biomass in both the middle and lower nonnative fish removal sections were also evident in 2009 versus the previous three year's values (Figure 13). In 2010, channel catfish CPUE declined significantly in the middle and lower nonnative fish removal sections compared to 2009 (Figure 12). In 2010, channel catfish biomass was significantly lower than each of the previous four years' values in both the upper and middle nonnative fish removal sections (Figure 13). Once again, the large spikes seen in juvenile channel catfish CPUE values in 2009 were not evident in 2010.

A total of 467 adult and 1,414 juvenile/YOY (collectively referred to here as "juveniles") channel catfish were collected during 2010 Adult Monitoring. Almost 9 out of every 10 adults (88.8%; n = 415) collected in 2010 came from the middle nonnative fish removal section, from RM 147.9-52.9, with the majority (71.3%; n = 333) being concentrated from RM 147.9-85.0 (Figure 14). Juvenile channel catfish were concentrated slightly farther downstream than adults in 2010, with 88.2% (n = 1,247) of all juvenile channel catfish being collected from RM 120-30 (Figure 14). This distribution encompassed both the middle and lower nonnative fish removal sections. However, juvenile channel catfish collected in the middle nonnative fish removal section alone accounted for 81.3% (n = 1,150) of all juveniles caught in 2010 (Figure 14).

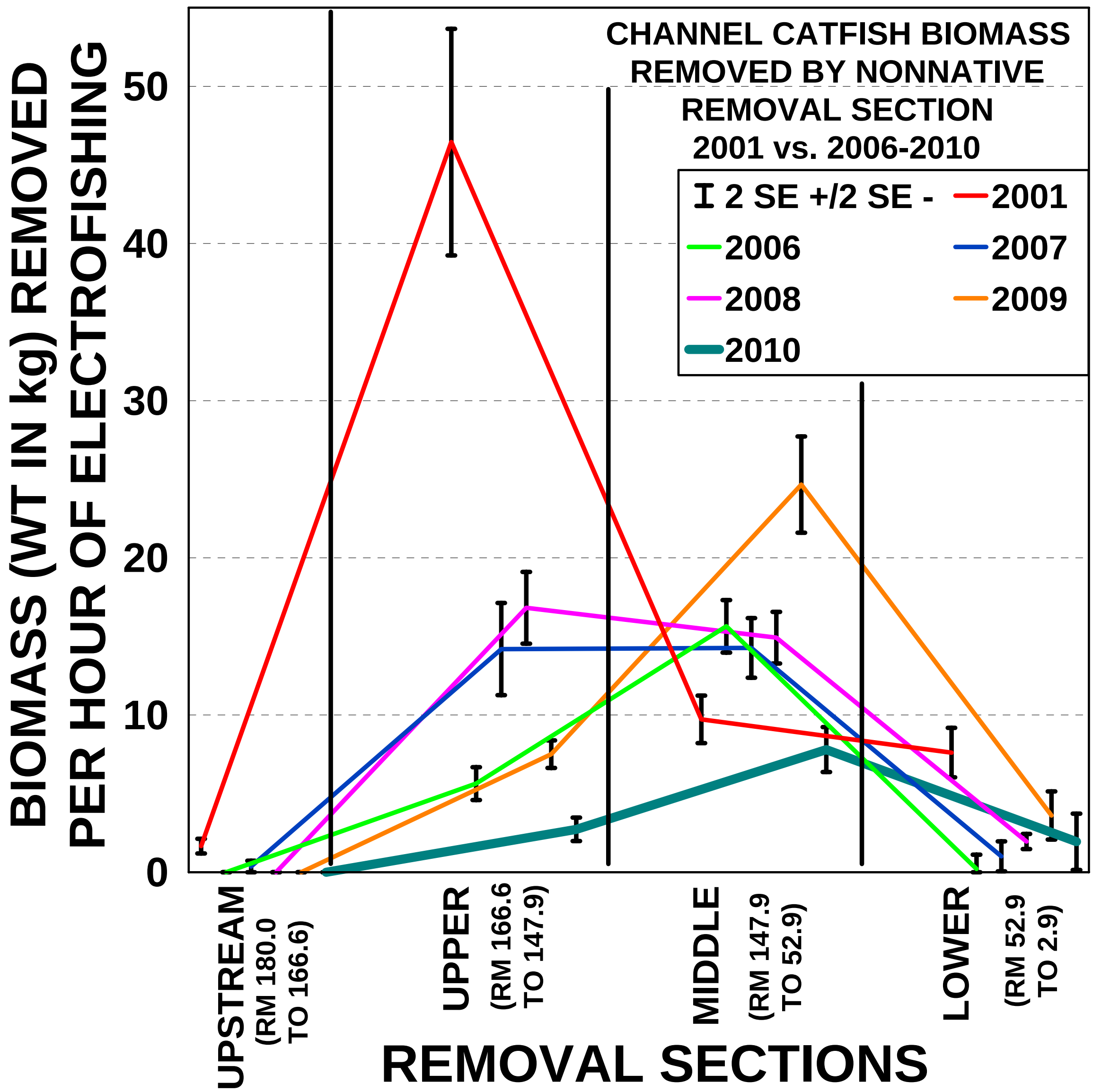

Figure 13. A comparison of the amount channel catfish biomass that was removed from within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2010. Lines represent the total amount of biomass (in kg) removed each year, by river section. Error bars are +/- 2 SE.

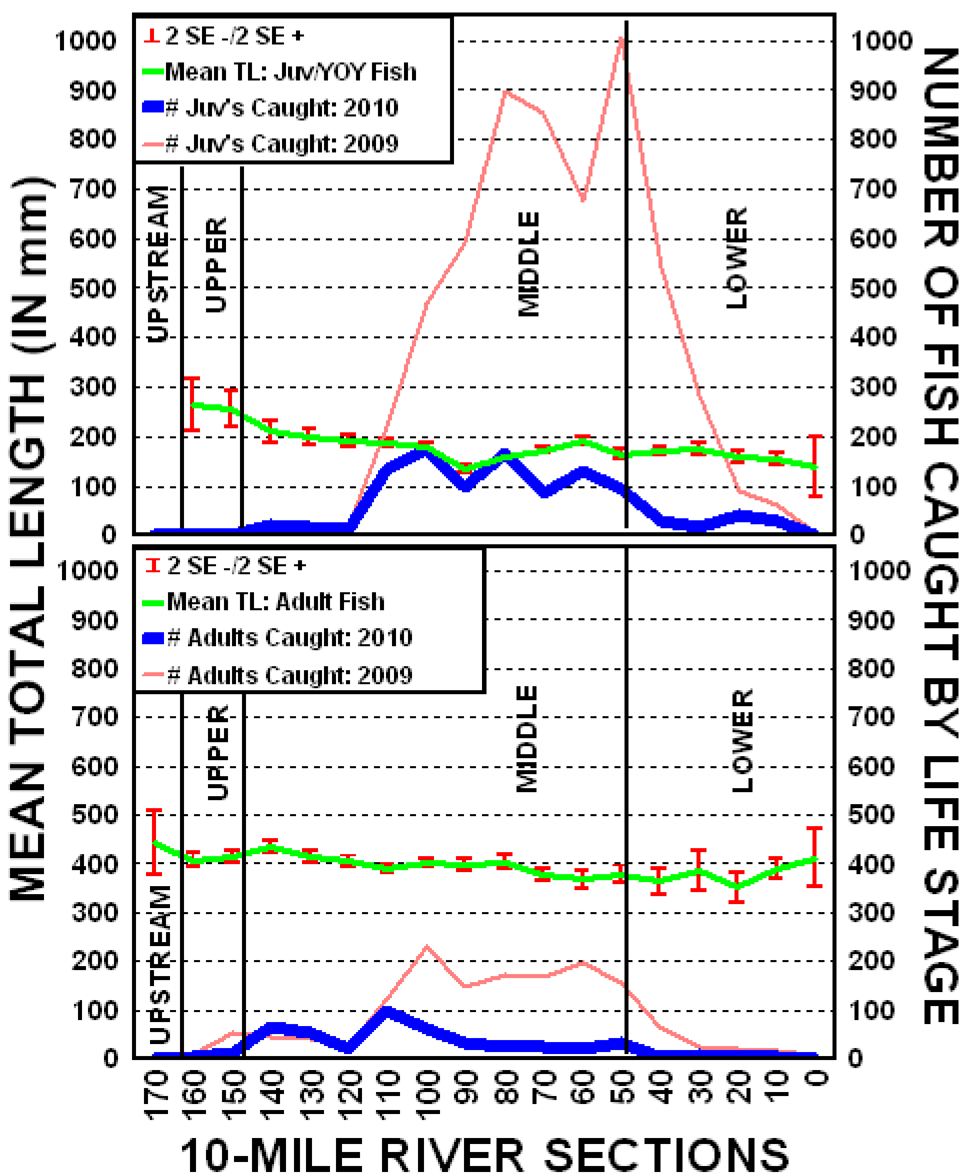

Figure 14. Total number of channel catfish, by life stage, collected within each 10-mile river section of the Adult Monitoring study area in both 2009 (salmon-colored lines) and 2010 (blue lines). Mean total length (green line) is also shown for both adult and sub-adult (YOY and juvenile fish combined) channel catfish collected in each 10-mile river section in 2010. Boundaries of the various nonnative fish removal sections are indicated by vertical labels and solid black vertical lines.

Length Information

Channel catfish ranging from 46-620 mm TL (mean TL = 237 mm) were collected during 2010 Adult Monitoring. In the 2010 length-frequency histogram, the largest groups of channel catfish were age-0 fish from 51-75 mm TL and a group of slightly older, but still very small channel catfish, centered around 176-200 mm TL (Figure 15). These channel catfish centered around 176-200 mm TL appear to be age-2 fish. These distinct influxes of young cohorts of channel catfish continue to be very pronounced in length-frequency histograms for this species over the last four years.

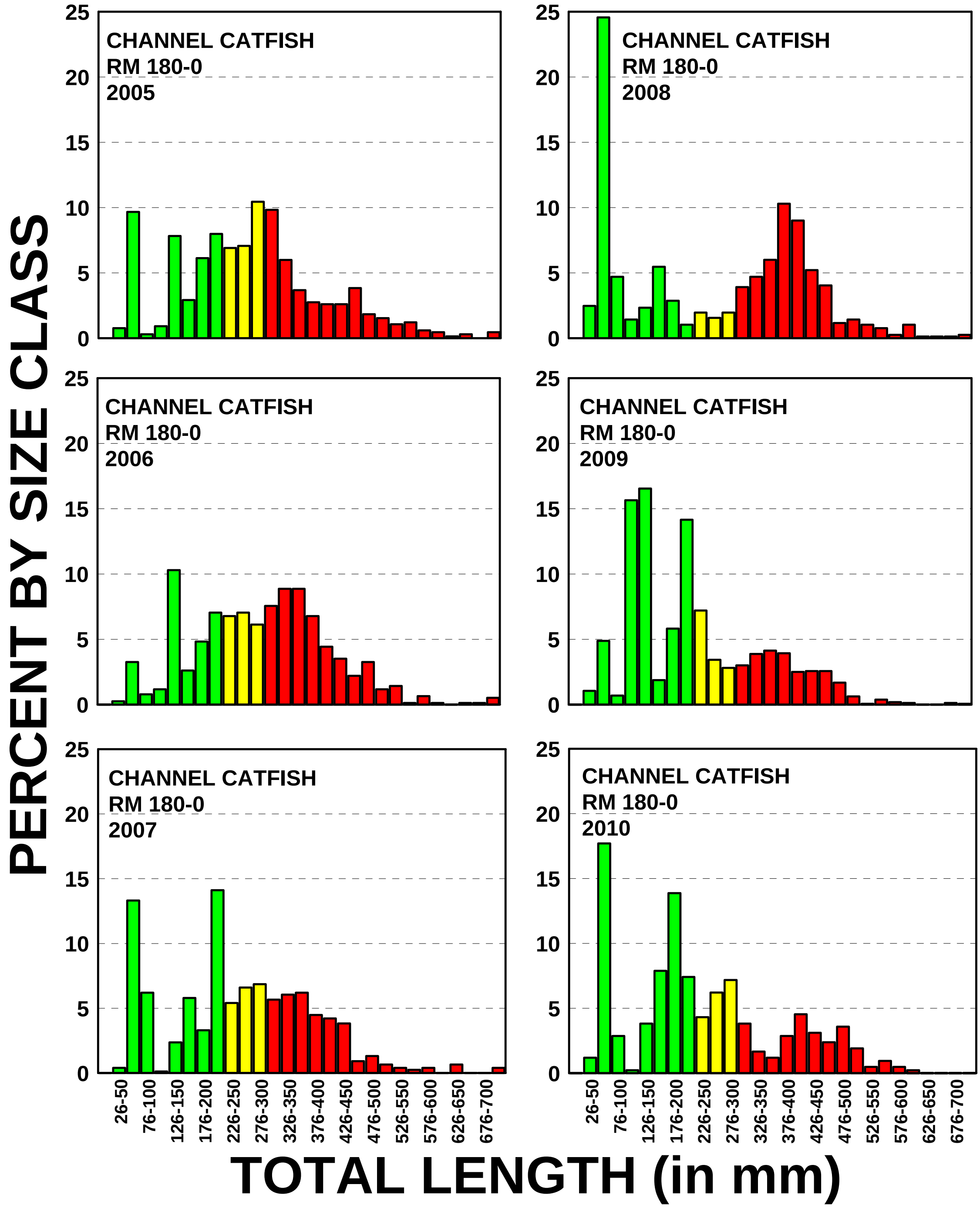

Figure 15. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of channel catfish on fall Adult Monitoring trips in the San Juan River, 2005-2010. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Common Carp

Catch Information

Common carp were the seventh most commonly-collected fish during 2010 Adult Monitoring (Table 3, Figure 16). This marks the seventh consecutive year that common carp have not been among the four most commonly-collected fish species (Figure 16). Only 54 total common carp were collected riverwide in 2010 (Table 3), of which 48 (88.9%) were adults (i.e., $\geq$ 250 mm TL) and 6 were juveniles. Common carp were collected from all six river reaches in 2010 (from RM 179.0-8.0), with 12 being collected from Reach 6, 24 from Reach 5, 6 from Reach 4, 6 from Reach 3, 2 from Reach 2, and 4 from Reach 1.

In 2010, common carp accounted for only 0.4% of the total catch and was collected in just 18.6% (n = 36) of electrofishing samples riverwide (Table 3, Figure 16). Of the 36 electrofishing samples that had common carp in them, 24 contained a single fish, 9 samples had 2 common carp, 2 samples had 3 fish, and 1 sample had six common carp. When more than one common carp were collected in a sample they were almost always collected in very close proximity to one another. In the electrofishing sample that had 6 common carp in it, all 6 fish were collected within a few feet of each other.

Common carp juvenile CPUE was not significantly different than eight of the previous eleven years and was significantly lower than the pulses of juvenile common carp observed in 2000, 2002, and 2004 (Figure 17). These pulses of juvenile fish did not last more than one year and did not ultimately increase numbers of adult fish. Common carp adult CPUE has not changed significantly over the last four years and has continued to remain significantly lower than the 1999-2006 period (Figure 17).

Length Information

Common carp ranging from 84-671 mm TL (mean TL = 432 mm) were collected during 2010 Adult Monitoring. The numerically dominant cohorts of juvenile common carp observed in 2008 and 2009 were not evident in the 2010 length-frequency histogram (Figure 18). The 2010 length-frequency histogram had a relatively wide distribution of varying sized adult fish, with large adults (576-600 mm TL) being numerically dominant.

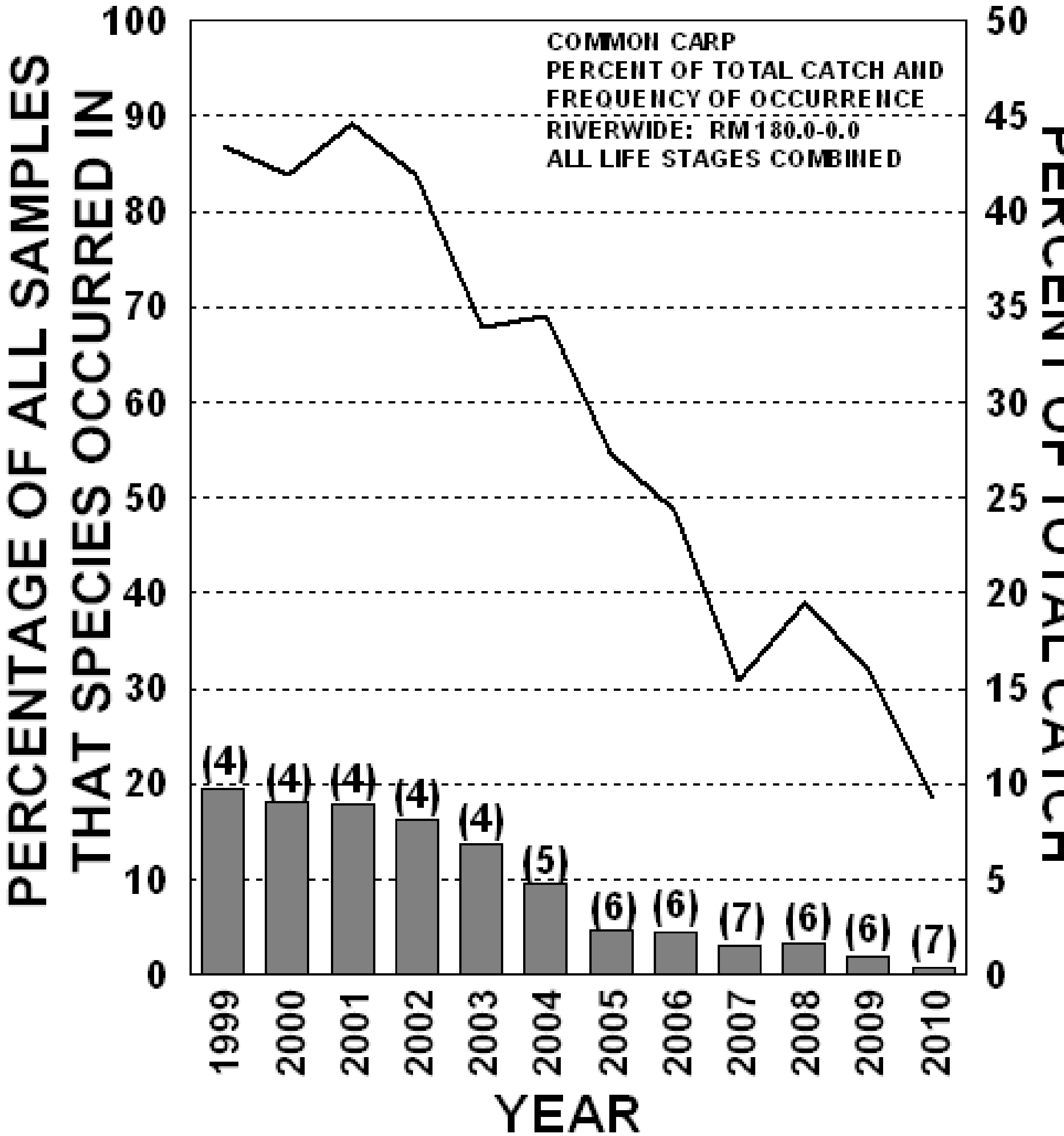

Figure 16. A summary of common carp relative abundance in riverwide Adult Monitoring collections, 1999-2010. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent the percent of the total catch that this species composed in a given year. Numbers in parentheses indicate the numeric rank for this species in a given year relative to all other fish species collected.

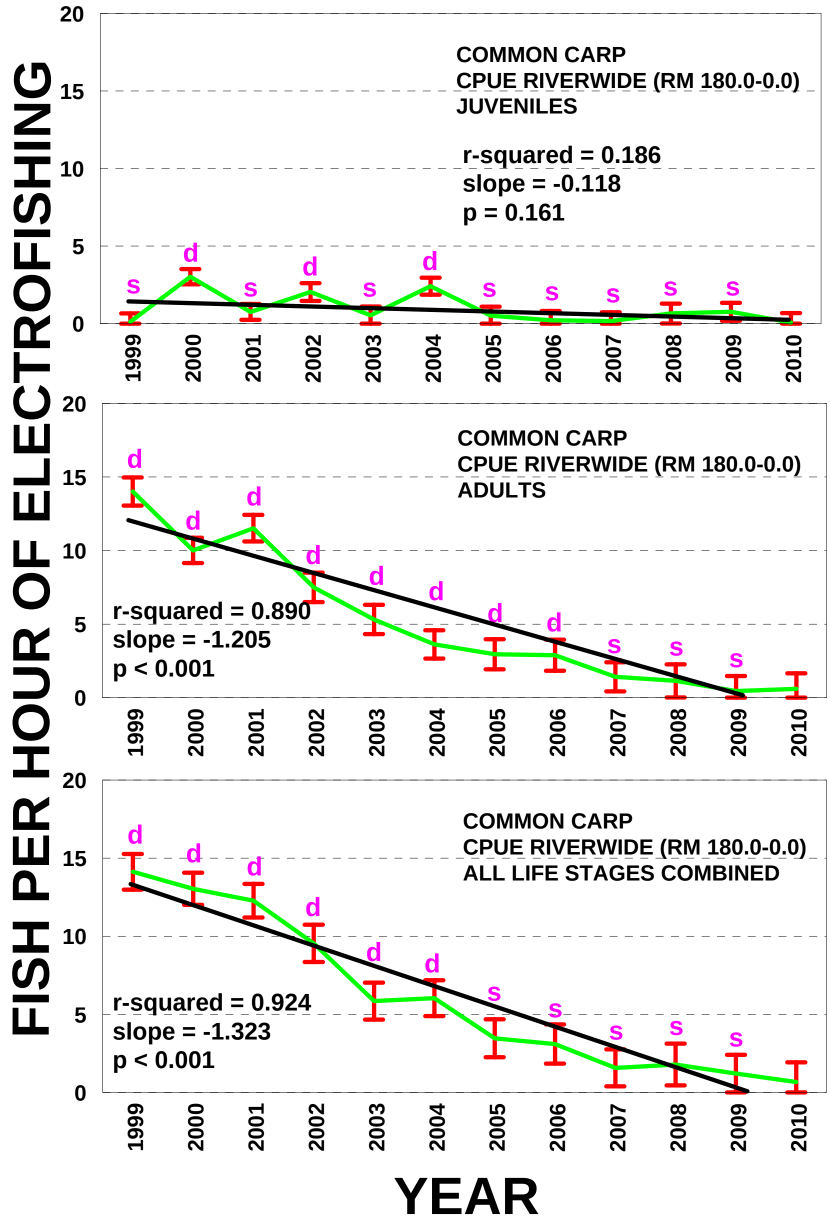

Figure 17. Common carp CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2010 value. The letter "d" means the value is significantly different from the 2010 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

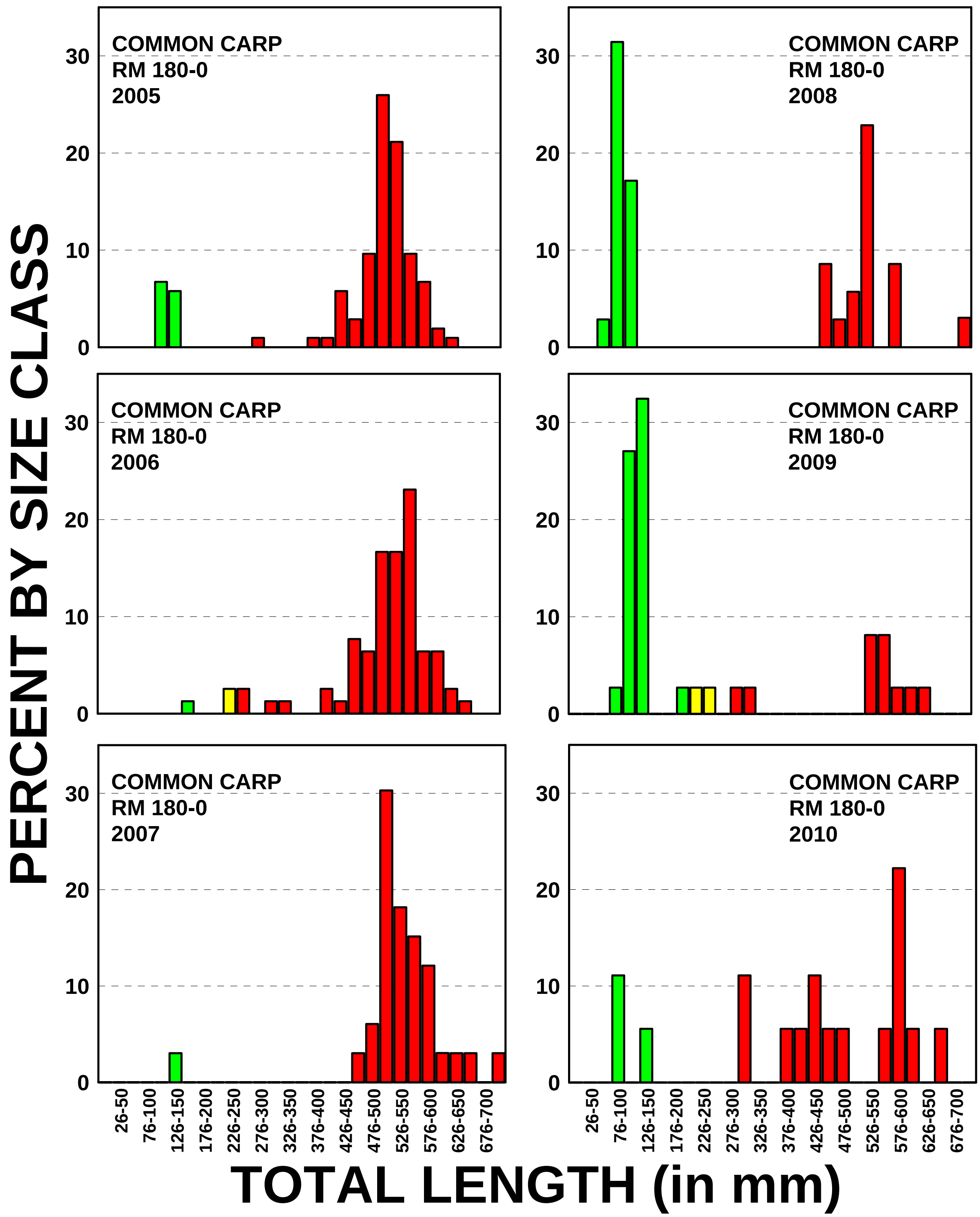

Figure 18. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of common carp on fall Adult Monitoring trips in the San Juan River, 2005-2010. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

DISCUSSION

Rare Native Fishes

Colorado Pikeminnow

The 433 stocked Colorado pikeminnow collected during 2010 were the most Colorado pikeminnow ever collected during Adult Monitoring. Additionally, 2010 marked the seventh consecutive year that > 100 Colorado pikeminnow were collected during our study. It is thought that wild Colorado pikeminnow continue to be absent from our fall fish community monitoring collections.

However, in 2010 two adult Colorado pikeminnow were collected that could either have been from stocking events or could possibly have been wild-produced fish. The first, a 658 mm TL adult of indeterminate sex, captured from RM 143-142 on 20 September 2010 was originally tagged on a nonnative fish removal trip on 28 July 2005 at RM 157.0 (was 603 mm TL at that time). If this were a stocked Colorado pikeminnow, it most likely would have been stocked in November 1996 as an age-0 fish, by UDWR. This would have made it an age-14 fish at the time it was captured in September 2010. The second, a 560 mm TL adult of indeterminate sex, captured from RM 71-70 on 8 October 2010 was originally tagged on a nonnative fish removal trip on 7 September 2008 at RM 93.0 (was 422 mm TL at that time). If this were a stocked Colorado pikeminnow, it most likely would have been stocked in November 2003 as an age-0 fish, by USFWS. This would have made it an age-7 fish at the time it was captured in October 2010.

Although these two fish could have been wild-produced fish, the dearth of wild adult Colorado pikeminnow known to have been in the river during the years in which these individuals would have been spawned, the dearth of Colorado pikeminnow larval collections during those same years, and the fact that large numbers of relatively large-sized, age-0 Colorado pikeminnow were stocked in both years, I’m assuming here that these two large adults were the result of stocking efforts.

Overall, 2010 was a good year for Colorado pikeminnow collections during Adult Monitoring. In addition to the two larger, two smaller adult fish (459 and 484 mm TL) were also collected in 2010. These fish, while of adult size were both only age-4 fish. One (484 mm TL) had been stocked in 2006 as an age-0 fish. The other (459 mm TL) had been stocked in 2008 as an age-2 fish. There were also seven sub-adult (400-449 mm TL) Colorado pikeminnow collected in 2010. These fish (400-435 mm TL) ranged from age-3 to age-4. An additional 61 larger juvenile Colorado pikeminnow were collected in 2010, ranging from age-2 to age-4 (300-398 mm TL). In general, Colorado pikeminnow that were collected in the sub-adult and adult size-class categories (defined in USFWS 2002a) were larger than wild fish would have been at these same ages.

In 2010, more adult and sub-adult sized Colorado pikeminnow were collected than during any Adult Monitoring trip, back to the inception of this study in 1991. This includes the period of the early 1990s when wild adult Colorado pikeminnow were still present in the San Juan River in large enough numbers to be collected frequently. In addition, a wider size-range of Colorado pikeminnow was collected during 2010 Adult Monitoring than ever before.

Of the 434 Colorado pikeminnow collected in 2010, 413 (95.2%) were fish that had been stocked as age-0 fish. In past years, high numbers of Colorado pikeminnow collected in the first year post-stocking diminished significantly by 2+ overwinter periods, before disappearing from Adult Monitoring collections at or before four overwinter periods post-stocking. In 2010, the number of age-2 Colorado pikeminnow being recaptured (i.e., having been stocked as age-0 fish in 2008 and in the river for 2 overwinter periods) was significantly higher than any previous cohort of age-2 fish. This was also the first time during Adult Monitoring that Colorado pikeminnow stocked as age-0 fish were collected at ≥ 5 overwinter periods post-stocking. In 2009, the presence of this same large cohort of fish at age-1 generated discussion as to whether or not there were really more fish of this age in the river, or whether it was an artifact of flow, timing of sampling, or some other factor. The appearance of this large 2008 cohort of fish again in 2010 electrofishing samples seems to verify that for whatever reason, this year-class survived better than their predecessors. Whether or not this will translate into survival to adulthood remains to be seen.

Colorado pikeminnow were collected in Reaches 6-1 in 2010 with the largest numbers being collected in Reaches 3 and 5. During 2010 Adult Monitoring, a small percentage of Colorado pikeminnow collections (5.3%, n = 23) occurred upstream of Hogback Diversion (RM 158.6). Only one of those collections occurred upstream of PNM Weir. This fish (an age-2 fish stocked at RM 180.6, recaptured at RM 175.0) had only been in the river for 57 days post-stocking and had not survived an overwinter period yet. Expanding the range of Colorado pikeminnow to sections of the San Juan River upstream of PNM Weir was identified as being important to recovery for this species (U. S. Bureau of Reclamation 2001). However, to date, this range expansion has only been accomplished by stocking hatchery-reared fish directly into this river section. Long-term retention of stocked Colorado pikeminnow between PNM Weir and the Animas River confluence (RM 180.6) has not been documented yet. However, this is a very short river section – only 14 RM in length. In past years, large downstream displacements have been documented among stocked Colorado pikeminnow of all age-classes, often within the first few days to first two weeks post-stocking. Thus, it may be necessary to stock Colorado pikeminnow higher up in either the San Juan or Animas rivers, upstream of Critical Habitat, to allow them enough time and distance to retain upstream of PNM Weir after undergoing this initial post-stocking displacement.

While Colorado pikeminnow have not expanded their range upstream past PNM Weir, evidence from other studies, when combined with our Adult Monitoring data indicate that several positive things are occurring with Colorado pikeminnow in the San Juan River basin. Eleven Colorado pikeminnow have now been collected over the last four years from Yellowjacket Canyon, a tributary of McElmo Creek (Fresques 2007, 2008, 2009, and 2010). McElmo Creek enters the San Juan River at RM 100.5. Only one of these fish (425 mm TL) was documented to have a PIT tag upon capture. This individual had been stocked with a PIT tag at RM 134.9 on 16 April 2008 and recaptured at RM 125.0 on 4 September 2008 (250 mm TL). The other ten fish (ranging from 168-307 mm TL) collected from the Yellowjacket Canyon site were almost certainly fish that were stocked into the San Juan River that had moved up McElmo Creek to Yellowjacket Canyon. In April 2011, a Colorado Division of Wildlife crew sampling McElmo Creek about a mile upstream of the Yellowjacket Canyon confluence recaptured one of the Colorado pikeminnow (298 mm TL) that had been captured and tagged in Yellowjacket Canyon on 29 September 2010 (296 mm TL: J. White, pers. comm.). In April 2011, a total of six Colorado pikeminnow were collected from the San Juan River arm of Lake Powell near Spencer Canyon (D. Elverud and T. Francis, unpublished data). Two were adults (470 and 484 mm TL) and four were juveniles (276-391 mm TL). Four, including both adults, had PIT tags, the other two juveniles did not. Stocking history could be determined for three of the four PIT-tagged individuals. One was stocked into the San Juan River in 2004 and two were stocked in 2006. The other three fish were almost certainly fish that had come downstream over the waterfall (located at the old Piute Farms Marine site – RM 0.0) and moved into the riverine portion of the San Juan River arm of Lake Powell. Growth could be determined for two of the PIT-tagged fish. One had grown from 189-484 mm TL between 2004 and 2010. The other had grown from 240-391 mm TL between 2006 and 2010.

Also, five larval Colorado pikeminnow were collected during 2010 larval sampling (Brandenburg and Farrington 2011). In addition, one larval Colorado pikeminnow was collected in 2009 (Brandenburg and Farrington 2010) and three others during 2007 (Brandenburg and Farrington 2008). Although these nine larval fish could have been produced by some heretofore uncollected extant wild fish, the chances are equally as good (in fact probably better) that they are progeny of stocked Colorado pikeminnow that have recruited to adulthood and are now reproducing. While the numbers of larvae collected are small, they document that reproduction has occurred among San Juan River Colorado pikeminnow in three of the last four years.

Using Program MARK, riverwide population estimates were generated for Colorado pikeminnow in 2010, using three complete riverwide nonnative fish removal passes (Duran et al. 2011). Two separate models yielded the following population estimates: Model M(t) = 5,418 (CI = 4,049-7,549); Model M(o) = 5,466 (CI = 4,082-7,614). Only age 2+ Colorado pikminnow that had been in the river for one over-winter period were used in this estimate. Thus, these estimates give numbers just for older fish that have survived through a full set of yearly conditions. However, since younger fish are not accounted for in these estimates, the actual number of Colorado pikeminnow in all age groups in the river at any given time would actually be higher than these estimates indicate.

On the down side, we know that Colorado pikeminnow can be lost from the San Juan system in a number of ways. Stocked Colorado pikeminnow have been documented becoming entrained in two different canals (Trammell 2000, Renfro et al. 2006). In the case of the Hogback canal, 201 Colorado pikeminnow were documented as being entrained in 2004 (n = 140) and 2005 (n = 61). As mentioned above, Colorado pikeminnow have moved into and now occupy the San Juan River arm of Lake Powell. However, a large (approximately 10 meter high) waterfall prevents their moving back upstream and into the San Juan River. Lastly, a number of studies in the San Juan River have documented negative interactions between Colorado pikeminnow and nonnative channel catfish. These include both predation upon stocked Colorado pikeminnow by channel catfish (e.g., Jackson 2005) as well as Colorado pikeminnow choking on channel catfish and black bullhead after attempting to ingest them (e.g., Ryden and Smith 2002, A. Lapahie unpublished data).

Despite various sources of loss, a wide spectrum of size-classes of Colorado pikeminnow were collected in 2010, up to and including sub-adult and adult fish. The survival rate of age-2 Colorado pikeminnow in 2010 was unprecedented. Reproduction was documented for the third time in the last four years. And, Colorado pikeminnow have been documented using areas of the San Juan River basin where they have never before been seen. Caution must be taken when interpreting these data, because the San Juan River Colorado pikeminnow population is essentially still a population of stocked fish. However, given that just ten years ago, Colorado pikeminnow were all but nonexistent in Adult Monitoring collections, their current status (i.e., having thousands of these fish in the river) is encouraging.

Razorback Sucker

It is my opinion that no wild razorback sucker were collected in 2010. The 153 stocked razorback sucker collected in 2010 marked the seventh consecutive year during which > 50 razorback sucker during an Adult Monitoring trip. Like Colorado pikeminnow, the numbers of razorback sucker collected during any given Adult monitoring trip tend to fluctuate based on the number of fish that were recently stocked into the river (i.e., in that year and the previous year). The highest numbers of razorback sucker collected during any Adult Monitoring trips occurred in 2006 and 2007 (n = 144 and 207, respectively), when the NAPI grow-out ponds were being drained and large numbers of razorback sucker were being salvaged and stocked prior to Adult monitoring taking place. In contrast, the number of razorback sucker collected during Adult Monitoring jumped from just 84 fish collected in 2009 to 153 fish collected in 2010. However, many more razorback sucker were stocked in 2009 (n = 12,439) than in 2008 (n = 4,444; Furr 2010a).

Unlike Colorado pikeminnow, some razorback sucker are retaining in the San Juan River for as long as 15 overwinter periods post-stocking. In addition, larval razorback sucker were collected for the 13th consecutive year (1998-2010; Brandenburg and Farrington 2008, 2010, 2011). The continued collection of larval razorback sucker, paired with the presence of older fish indicate that stocked razorback sucker are able to retain, find one another, and spawn successfully in the wild. The presence of a few small untagged razorback sucker collected by various studies in 2003 and 2004, when no fish of that size were being stocked indicates that at least some of these larvae had recruited to the age-1 and age-2 year-classes during those particular years (e.g., Jackson 2004, Ryden 2004, Golden and Holden 2005, Jackson 2005). Unfortunately, razorback sucker of these age-classes have not been documented since that time and there is no evidence that the age-1 and age-2 fish collected in 2003 and 2004 recruited into adulthood. In 2010, several smaller razorback sucker (≤ 300 mm TL) were collected by various studies (D. Campbell, pers. comm.). It is not known whether these young, unmarked fish were wild-produced fish or possibly fish that were recently harvested from grow-out ponds in salvage operations and stocked without PIT tags. However, the small size of some of these fish would seem to preclude the idea that they originated from the 2006-2007 NAPI ponds salvage efforts.

Between 2001 and 2010 there have been a total of 20 capture events with razorback sucker X flannelmouth sucker hybrids during Adult Monitoring trips. These fish were collected from RM 163.0-13.0. Three of these captures were juvenile fish (240-282 mm TL). The other 17 captures were adult fish (410-510 mm TL). One capture occurred in 2001, 2 in 2003, 1 each in 2004 and 2005, 6 in 2006, 1 each in 2007 and 2008, 4 in 2009, and 3 in 2010. The presence of these juvenile and adult fish over numerous years points to a low level of successful spawning, survival, retention, and recruitment among this hybrid form. If these razorback sucker X flannelmouth sucker hybrids are surviving, retaining, and recruiting to adulthood in numbers large enough to document via Adult Monitoring, why then aren't pure razorback sucker able to do the same? In my opinion, it will take the consistent collection of small, unmarked razorback sucker by a study such as the small-bodied fish monitoring study to prove that recruitment of wild-produced razorback sucker is indeed taking place.

Razorback sucker were only collected from Reaches 6-2 (RM 166.0-53.0) in 2010. Their numbers were highest in Reach 6 and decreased in all subsequent downstream reaches, with only one individual being collected in canyon-bound Reach 2 (n = 1). Nearly a third of all razorback sucker collected in 2010 (n = 46; 30.1%) were collected upstream of Hogback Diversion in 2010. Razorback sucker from the NAPI grow-out ponds were stocked immediately downstream of PNM Weir (at RM 166.5) in both 2009 and 2010, which explains the presence of most of the collections of this species between PNM Weir and Hogback Diversion. Continued collections of razorback sucker in the PNM fish ladder (A. Lapahie, pers. comm.) attest to the presence of razorback sucker upstream at least as far as RM 166.6 during parts of the year. However, despite the large numbers of razorback sucker being released immediately downstream of the PNM fish ladder, and the documented use of that facility by this species, no razorback sucker were documented using the river section from the PNM Weir upstream to the Animas River confluence during 2010 Adult Monitoring. Indeed, over two-thirds of all razorback sucker collected in 2010 were still collected downstream of Hogback Diversion. Thus, like Colorado pikeminnow, further upstream range expansion of razorback sucker seems to be slow in happening.

Like Colorado pikeminnow, razorback sucker have not expanded their range upstream beyond PNM Weir. However, in April 2011, a total of 11 razorback sucker (430-620 mm TL) were collected from the San Juan River arm of Lake Powell from Spencer Canyon downstream to Piute Canyon. Six of these fish had PIT tags and are known to have come downstream over the waterfall (located at the old Piute Farms Marine site – RM 0.0) and moved into the riverine portion of the San Juan River arm of Lake Powell (D. Elverud and T. Francis, unpublished data). However, five of these fish did not have PIT tags when captured, so their origin can't be determined. One of these (620 mm TL) was a very large, old female that may be a wild fish that's managed to remain undetected for quite some time. Unlike Colorado pikeminnow, razorback sucker have not been documented using tributaries, other than the very terminal end of McElmo Creek (D. Ryden, unpublished data).

A total of 1,251 larval razorback sucker were collected during 2010 larval sampling (Brandenburg and Farrington 2011). This marks the 13th consecutive year (1998-2010) that reproduction of razorback sucker has been documented in the San Juan River (Brandenburg and Farrington 2008, 2010, 2011).

Using Program MARK, riverwide population estimates were generated for razorback sucker in 2010, using three complete riverwide nonnative fish removal passes (Duran et al. 2011). Two separate models yielded the following population estimates: Model M(t) = 2,928 (CI = 1,952-4,796); Model M(o) = 3,021 (CI = 2,007-4,940). All razorback sucker, regardless of age that had been in the river for one over-winter period were used in this estimate. Thus, these estimates give numbers just for fish that have survived through a full set of yearly conditions. However, the number of razorback sucker in the river at any given time would actually be higher than these estimates indicate.

On the down side, we know that razorback sucker, like Colorado pikeminnow can be lost from the San Juan system in a couple of ways. To date, stocked razorback sucker have not been documented being entrained in canals. However, razorback sucker have moved into and now occupy the San Juan River arm of Lake Powell. As mentioned above, the presence of the waterfall prevents their moving back upstream and into the San Juan River. Lastly, a number of studies in the San Juan River have documented predation upon stocked razorback sucker by channel catfish (e.g., Jackson 2005).

Despite various sources of loss, and the far lesser numbers of fish that have been stocked over the years in comparison to Colorado pikeminnow (Furr 2010a and 2010b), razorback sucker continue to persist and spawn in the San Juan River, producing far greater numbers of larval fish annually than do Colorado pikeminnow (Brandenburg and Farrington, 2011). Population estimates indicate that several thousand of the fish now occupy the San Juan River, mostly upstream of the canyon-bound reaches, which begin at RM 68.0. As with Colorado pikeminnow, caution must be taken when interpreting these data, because the San Juan River razorback sucker population is essentially still a population of stocked fish. Like Colorado pikeminnow, razorback sucker were all but nonexistent in Adult Monitoring collections just 15 years ago. Looking at this data through that lens, their current status (i.e., having thousands of consistently reproducing fish in the river) is encouraging.

Common Native Fishes

Flannelmouth Sucker

In 2010, flannelmouth sucker were once again the most abundant species collected during Adult Monitoring. In 2009, channel catfish were the most abundant species collected. This was the first time since 1991 that flannelmouth sucker had not been the most numerous species collected during Adult Monitoring. However, that apparent change in status was not the result of a decline in flannelmouth sucker abundance in 2009, but rather a result of the marked increase in channel catfish abundance during 2009. Flannelmouth sucker also had the widest distribution of any species in 2010, being collected in 191 (98.5%) of 194 electrofishing samples riverwide. Flannelmouth sucker are found throughout all six river reaches in the Adult Monitoring study area and are ubiquitous, occupying a multitude of habitat types. In addition, flannelmouth sucker of all life stages continue to be collected with regularity, showing that reproduction and recruitment are still occurring. The long-term trend line for juvenile flannelmouth sucker CPUE riverwide has shown no significant change in this abundance index over the last 12 years. However, the long-term trend line for adult flannelmouth sucker CPUE riverwide has shown a significant decline in this abundance index over the last 12 years. The exact reason for this long-term decline in adult flannelmouth sucker CPUE is unknown. If the adult CPUE value for 1999 is excised and this analysis is run again, then the trend shows no significant change over time. It might be that this long-term declining trend is just an artifact of a single artificially high data point. To date, the San Juan River flannelmouth sucker population has remained relatively stable and widespread. This is the case despite: 1) the stocking of over > 2½ million Colorado pikeminnow (potential predators) from 2002-2009 and > 71,000 razorback sucker (potential competitors) from 1994-2009; and, 2) repeated intensive electrofishing efforts that are ongoing in the San Juan River.

There are populations of flannelmouth sucker in the San Juan River upstream of the Adult Monitoring study area, in the Animas River, the Mancos River, and in McElmo Creek and its tributaries (including Yellowjacket Canyon). Flannelmouth sucker have also been documented in Lake Powell as far downstream as Spencer canyon in April 2011 (D. Elverud and T. Francis unpublished data). Based on recaptures of flannelmouth sucker FLOY-tagged in the mid-1990s (SJRIP database), we know that flannelmouth sucker move upstream at least into the Animas River from the San Juan River. This exchange of fish probably also occurs between the mainstem San Juan and the other tributary streams mentioned above. It could be that mainstem San Juan population is just the downstream end of a larger functional unit and that the fluctuating trends in CPUE (especially juvenile CPUE, but possibly also the long-term decline in adult CPUE values) that we've observed over time are reflective of changes within this larger metapopulation.

Bluehead Sucker

Bluehead sucker continue to be among the three most common large-bodied fish species collected during Adult Monitoring. In 2010, they were the second most abundant species collected. Bluehead sucker are collected in Reaches 6-2 in all years, with low numbers being collected in Reach 1 adjacent to Lake Powell in some years. The bluehead sucker population is strongly associated with cobble-dominated habitats in upstream reaches of the San Juan River (i.e., upstream of Reach 4). Riverwide, the bluehead sucker population has remained relatively stable over the last 12 years. The long-term trend line for juvenile bluehead sucker CPUE riverwide has shown that despite some relatively large year-to-year fluctuations, there has been no significant change in this abundance index over the last 12 years. Likewise, the long-term trend line for adult bluehead sucker CPUE riverwide has also shown no significant change over the last 12 years. In fact, there were no significant differences between the 2010 adult bluehead sucker CPUE value and that observed for any of the previous 11 years. To date, the San Juan River bluehead sucker population has remained relatively stable and widespread. This is the case despite: 1) the stocking of over > 2.5 million Colorado pikeminnow (potential predators) from 2002-2009 and > 71,000 razorback sucker (potential competitors) from 1994-2009; and, 2) repeated intensive electrofishing efforts that are ongoing in the San Juan River.

Like flannelmouth sucker, there are also populations of bluehead sucker in the San Juan River upstream of the Adult Monitoring study area, in the Animas River, the Mancos River, and in McElmo Creek and its tributaries (including Yellowjacket Canyon). Bluehead sucker have not been documented in Lake Powell. Recaptures of bluehaed sucker FLOY-tagged in the mid-1990s (SJRIP database), showed that at least some of these fish had moved upstream into the Animas River from the San Juan River. An exchange of fish probably also occurs between the mainstem San Juan and the other tributary stream populations of bluehead sucker, as mentioned above. It could be that mainstem San Juan population of bluehead sucker is just the downstream end of a larger functional unit and that the fluctuating trends in CPUE that we've observed over time are reflective of changes within this larger metapopulation.

Common Nonnative Fishes

Channel Catfish

After being the most common fish, native or nonnative, collected during 2009 Adult Monitoring, channel catfish dipped to being the third most abundant species collected in 2010. Channel catfish continue to be collected in all six geomorphic reaches, although their numbers in reaches encompassed by nonnative fish removal efforts were noticeably reduced between 2009 and 2010. The unprecedented increase in channel catfish juvenile CPUE observed in the middle nonnative fish removal section (RM 147.9-52.9) in 2009 was not apparent in 2010 Adult Monitoring collections. While not nearly as abundant as in 2009 Adult Monitoring collections, the majority of both juvenile and adult channel catfish collected in 2010 were still collected in this middle nonnative fish removal section.

Whether the marked increase in juvenile catfish numbers (mostly age-1 and age-2 fish) observed in 2009 was due to more space and resources being available for smaller fish as larger individuals were being removed, a reduction in predation upon smaller channel catfish by larger individuals, or the result of some other factor (such as instream flows) is unknown. There could have been some special set of circumstance that allowed researchers to collect channel catfish in unprecedented numbers during 2009 Adult Monitoing collections. However, this seems unlikely. No other common large-bodied fish species showed a similar trend in CPUE between 2008 and 2010. Turbidity, flow, water temperature, time of year, and sampling effort per mile were all unremarkable when compared to previous years. Sampling crews were composed, for the most part, of experienced individuals who had sampled these same sections of river in years prior to 2009 and again in 2010 and netters were instructed not to do “blind sweeps” to collect young channel catfish when netting. Whether or not the 2009 juvenile channel catfish CPUE value was an erroneous value or not, it was a relief to see that it was not repeated again in 2010.

Strong year-classes of young channel catfish continue to be observed in riverwide length-frequency histograms. This points to the resilience of the channel catfish population in the San Juan River. Channel catfish have demonstrated an impressive capacity for reproduction and recolonization that has, so far, managed to offset many of the impacts made by intensive nonnative fish removal efforts in both the middle and lower nonnative fish removal sections. Hopefully, the repetition of multiple-pass, intensive nonnative fish removal efforts being applied in all sections of the San Juan River, will make it possible to effectively reduce the number of channel catfish riverwide.

Common Carp

Common carp were the seventh most commonly-collected species during 2010 Adult Monitoring. Common carp were collected in all six geomorphic reaches in 2010. However, most were collected in Reach 5. Over the last 12 years, common carp numbers have become much reduced. While the exact causes of the large-scale decline of common carp are unknown, it is my belief that nonnative fish removal has been a heavily contributing factor. Common carp were numerically less abundant in 2010 than both endangered Colorado pikeminnow and razorback sucker. Common carp accounted for only 0.4% of the total catch and were collected in only 18.6% of all electrofishing samples riverwide in 2010. Only 54 common carp were collected during 2010 Adult Monitoring (RM 180.0-2.9), most of which (n = 48; 88.9%) were adult fish. In comparison, during 1998 Adult Monitoring, 77 adult common carp were collected in just one electrofishing sample (RM 163-162). If there has been a real success story associated with the nonnative removal efforts in the San Juan River to date, it would appear to be the marked reduction in numbers of common carp riverwide.

ACKNOWLEDGEMENTS

Numerous individuals participated in the field portions of this study: Travis Francis, Greg Fraser, Mike Gross, Karie Hiam, Jon Jankovitz, Lindsey Lesmeister, and Ben Schelicher (U.S. Fish and Wildlife Service - Region 6); Jason Davis, Andrew Dean, Bobby Duran, Erica Johnson, and Ernest Teller, Sr. (U.S. Fish and Wildlife Service – Region 2); Darek Elverud (Utah Division of Wildlife Resources - Moab); and Kirstie Yeager (volunteer). Invaluable logistical support was provided by: Ernest Teller, Sr. (U.S. Fish and Wildlife Service – Region 2); and J.R. Benallyson, Bruce Hakas, Ray Smith, Paul Thompson, and Willard Yazzie (U.S. Bureau of Indian Affairs - NIIP). Permission to use boat take-outs on private land were graciously granted Mr. Buck Wheeler (Waterflow, NM) and the good folks at Hatch Trading Post (Fruitland, NM). Scott Durst, Steve Ross, and Tom Wesche submitted comments on an earlier draft of this report. The author would like to thank these individuals for their time and efforts in reviewing and helping improve the quality of this report.

This study was approved by the Biology and Coordination committees of the San Juan River Recovery Implementation Program. It was funded under agreement # 08-AA-40-2715, administered by Mark McKinstry of the U.S. Bureau of Reclamation's Salt Lake City Projects Office. Fish collections were authorized under collecting permits issued by the Colorado Division of Wildlife, National Park Service – Glen Canyon National Recreation Area, Navajo Nation Department of Fish and Wildlife, New Mexico Department of Game and Fish, and the Utah Division of Wildlife Resources.

LITERATURE CITED

Bliesner, R., and V. Lamarra. 2000. Hydrology, geomorphology, and habitat studies. Keller-Bliesner Engineering and Ecosystems Research Institute, Logan, UT.

Brandenburg, W. H., and M. A. Farrington. 2008. Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2007. American Southwest Ichthyological Researchers LLC, Albuquerque, NM. 51 pp.

Brandenburg, W. H., and M. A. Farrington. 2010. Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2009. American Southwest Ichthyological Researchers LLC, Albuquerque, NM. 61 pp.

Brandenburg, W. H., and M. A. Farrington. 2011. Colorado pikeminnow and razorback sucker larval fish survey in the San Juan River during 2010. American Southwest Ichthyological Researchers LLC, Albuquerque, NM. 55 pp.

Davis, J. E., B. R. Duran, and E. Teller, Sr. Nonnative species monitoring and control in the upper/middle San Juan River: 2010. U. S. Fish and Wildlife Service, Albuquerque, NM. 46 pp.

Duran, B., J. E. Davis, and E. Teller, Sr. 2011. Nonnative species monitoring and control in the upper/middle San Juan River: 2010. U. S. Fish and Wildlife Service, Albuquerque, NM. 37 pp.

Fresques, T. 2007. Dolores Public Lands Office stream surveys: August 2007. Yellowjacket Canyon – Water Code #38442. U.S. Bureau of Land Management, Glenwood Springs, CO. 8 pp.

Fresques, T. 2008. Dolores Public Lands Office/CANM stream surveys: September 2008. Yellowjacket Canyon – Water Code #38442. U.S. Bureau of Land Management, Glenwood Springs, CO. 7 pp.

Fresques, T. 2009. Dolores Public Lands Office stream surveys: September 2009. Yellowjacket Canyon – Water Code #38442. U.S. Bureau of Land Management, Glenwood Springs, CO. 6 pp.

Fresques, T. 2010. Canyon of the Ancients National Monument/Dolores Public Lands Office stream surveys: September 2010. Yellowjacket Canyon – Water Code #38442. U.S. Bureau of Land Management, Glenwood Springs, CO. 8 pp.

Furr, D. W. 2010a. San Juan River razorback sucker population augmentation: 2009 Annual Report. U. S. Fish and Wildlife Service, Albuquerque, NM. 17 pp.

Furr, D. W. 2010b. Augmentation of Colorado pikeminnow (*Ptychocheilus lucius*) in the San Juan River: Phase II 2010-2020. U. S. Fish and Wildlife Service, Albuquerque, NM. 16 pp.

Golden, M. E., and P. B. Holden. 2005. Retention, growth, and habitat use of stocked Colorado pikeminnow in the San Juan River: 2003-2004 Annual Report. BIO-WEST, Inc., Logan, UT. 77 pp.

Jackson, J. A. 2004. Nonnative control in the lower San Juan River: 2003. Utah Division of Wildlife Resources, Moab. 28 pp.

Jackson, J. A. 2005. Nonnative control in the lower San Juan River: 2003. Utah Division of Wildlife Resources, Moab. 28 pp.

Nelson, J. S., E. J. Crossman, H. Espinoza-Perez, L. T. Findley, C. R. Gilbert, R. N. Lea, and J. D. Williams. 2004. Common and scientific names of fishes from the United States, Canada, and Mexico. American Fisheries Society, Special Publication 29, Bethesda, MD.

Propst, D. L., S. P. Platania, D. W. Ryden, and R. L. Bliesner. 2000. San Juan River Monitoring Plan and Protocols. San Juan River Basin Recovery Implementation Program, U. S. Fish and Wildlife Service, Albuquerque, NM. 20 pp. + appendices.

Propst, D. L., S. P. Platania, D. W. Ryden, and R. L. Bliesner. 2006. San Juan River Monitoring Plan and Protocols (Revised). San Juan River Basin Recovery Implementation Program, U. S. Fish and Wildlife Service, Albquerque, NM. 19 pp.

Renfro, L. E., S. P. Platania, and R. K. Dudley. 2006. An assessment of fish entrainment in the Hogback diversion canal, San Juan River, New Mexico: 2004. American Southwest Ichthyological Researchers LLC, Albuquerque, NM. 61 pp.

Robertson, M. S., and P. B. Holden. 2007. Retention, growth, and habitat use of Colorado pikeminnow stocked as age-0 fish in the San Juan River: 2005-2006 Annual Report. BIO-WEST, Inc., Logan, UT. 57 pp. + appendices

Ryden, D. W. 2000. Adult fish community monitoring on the San Juan River, 1991-1997. Final Report. U. S. Fish and Wildlife Service, Grand Junction, CO. 269 pp.

Ryden, D. W. 2004. Long term monitoring of sub-adult and adult large-bodied fishes in the San Juan River, 2003: Interim Progress Report (Final). U. S. Fish and Wildlife Service, Grand Junction, CO. 67 pp. + appendices.

Ryden, D. W., and J. R. Smith. 2002. Colorado pikeminnow with a channel catfish lodged in its throat in the San Juan River, Utah. The Southwestern Naturalist 47(1):92-94.

San Juan River Basin Recovery Implementation Program. 2009. Long-range plan. San Juan River Basin Recovery Implementation Program, U. S. Fish and Wildlife Service, Albuquerque, NM. 40 pp. + appendices.

San Juan River Basin Recovery Implementation Program. 2010. San Juan River Recovery Implementation Program Comprehensive Monitoring Plan. San Juan River Basin Recovery Implementation Program, U. S. Fish and Wildlife Service, Albuquerque, New Mexico.

Trammell, M. 2000. Evaluation of reintroduction of young of year Colorado pikeminnow in the San Juan River: 1999 Annual Report. Utah Division of Wildlife Resources, Moab, UT. 20 pp.

U. S. Bureau of Reclamation. 2001. Positive Population Response Criteria for Colorado pikeminnow and razorback sucker in the San Juan River, Animas LaPlata Biological Opinion. Memorandum from Carol DeAngelis, Area Manager, U. S. Bureau of Reclamation, Western Colorado Area Office, Grand Junction, CO to LeRoy Carlson, Colorado State Supervisor, Ecological Services, U. S. Fish and Wildlife Service, 755 Parfet Street #361, Lakewood, CO 80215 (Memo dated 6 July 2001). 18 pp. + attachments.

U. S. Fish and Wildlife Service. 2002a. Colorado pikeminnow (*Ptychocheilus lucius*) Recovery Goals: amendment and supplement to the Colorado Squawfish Recovery Plan. U. S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado. 71 pp. + appendices.

U. S. Fish and Wildlife Service. 2002b. Response to public comments on draft Recovery Goals for the Colorado pikeminnow, humpback chub, razorback sucker, and bonytail. U. S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado. 272 pp.

APPENDIX A

A preliminary attempt to predict year-to-year survival among groups of Colorado pikeminnow that are stocked as age-0 fish in the fall of the year.

INTRODUCTION

One of the ongoing difficulties in the augmentation programs for both endangered fish is the difficulty in predicting year-to-year survival among groups of stocked fish. This problem is caused by numerous factors, including: 1) highly variable numbers of fish stocked between years; 2) different age-classes of fish stocked within and among years; and 3) a generalized lack of captures of older stocked fish. This third factor tends to become more problematic with increasing years post-stocking.

The marked decrease in captures of endangered Colorado pikeminnow between age-0 (i.e., stocking) and age-4 have, thus far, precluded doing mark-recapture studies on these fish. Rather, as a first attempt to determine post-stocking survival, I examined the recaptures among Colorado pikeminnow stocked as age-0 fish over an eight-year period (2002-2009). These calculations make possible preliminary predictions on the numbers of Colorado pikeminnow that might be expected to be seen in the river per every 100,000 age-0 fish that are stocked in the fall of the year (i.e., late October to early November).

All of the following discussion applies strictly to Colorado pikeminnow stocked as age-0 fish in the fall of each year, from 2002-2009.

METHODS

Captures of Colorado pikeminnow from Adult Monitoring trips from 2003-2010 were partitioned by age-class at stocking. Age-class at stocking was determined either by the presence the of a PIT tag or by comparing untagged fish against growth curves generated for Colorado pikeminnow stocked as age-0 fish between 2002 and 2005 (unpublished data). Captures of Colorado pikeminnow stocked as age-0 fish and subsequently captured during Adult Monitoring trips as age-1 through age-7 fish were totaled for each year. In this manner, the actual number of Colorado pikeminnow from a particular stocking of age-0 fish could be tracked across years (Table A-1).

Since the actual number of Colorado pikeminnow collected was obtained from our electrofishing samples, this number was then multiplied by 20 to account for the 5% capture probability generated during the 2010 riverwide population estimate for Colorado pikeminnow (Duran et al. 2011). This capture probability indicates that during any single pass through a given river section, sampling crews will collect 5% of all of the Colorado pikeminnow that are actually present in that river section. This gave me the total number of fish expected to be present in all sampled RM within our 180-RM study area (with 2 of every 3 RM being sampled; Table A-2).

After applying the 5% capture probability, I extrapolated the total number of Colorado pikeminnow expected to be within our electrofishing samples to include the unsampled RM in our 180-RM study area. The expected number (from Table A-2) was multiplied by 1.5 to predict what might be expected had all 180 RM been sampled, assuming fish were evenly distributed throughout the entire study area. This gave me the total number of Colorado pikeminnow expected to be present within the entirety of our 180-RM study area (Table A-3).

The total number of fish expected to be present within the entirety of our 180-RM study area was then divided by 180 to obtain the expected number of Colorado pikeminnow per RM present during our sampling efforts (Table A-4).

Dividing the total number of fish expected to be within the our entire 180-RM study area at age-1 (Table A-3) by the actual number of age-0 fish that were stocked allowed me to obtain a mean expected survival rate between age-0 and age-1. Survival rates for yearly cohorts from age-1 to age-2, age-2 to age-3, etc. could be calculated by dividing the predicted number of Colorado pikeminnow occupying the entire study area by the previous years value for that same cohort (e.g., for the 2002 cohort of age-0 fish: 960 expected age-1 fish in 2003 ÷ 210,418 age-0 fish stocked in 2002 = 0.0046 X 100 = a 0.46% survival rate from age-0 to age-1; 480 ÷ 960 = 0.5000 X 100 = a 50.00% survival rate from age-1 to age-2; 90 ÷ 480 = 0.1875 X 100 = a 18.75% survival rate from age-2 to age-3; and 30 ÷ 90 = 0.3333 X 100 = a 33.33% survival rate from age-3 to age-4). By continuing these calculations for all yearly cohorts in Table A-3, I was able to obtain expected age-to-age survival rates for each individual cohort of age-0 fish stocked from 2002-2009. A mean value could then be calculated for all similar age-to-age survival rates (i.e., age-0 to age-1, age-1 to age-2, etc.) across yearly cohorts (Table A-5, top row). Multiplying the mean expected survival rate from age-0 to age-1 by 100,000 allowed me to predict how many Colorado pikeminnow could be expected to survive at age-1 per 100,000 age-0 fish stocked (Table A-5, middle row). This value was then multiplied by the mean expected survival rate from age-1 to age-2 to predict how many of those fish could be expected to survive at age-2, and so on across the middle row. The values thus obtained were then divided by 180 to determine the expected number of fish per RM (Table A-5, bottom row). By dividing that value into 1.0 (RM) I was able to predict how many RM one would theoretically have to sample to collect one Colorado pikeminnow in that age category per every 100,000 fish that had been stocked. Table A-5 uses data from all seven stockings of age-0 Colorado pikeminnow that occurred from 2002-2009, even though age-0 fish stocked in 2002 were not tempered for as long prior to stocking and none of them were acclimated prior to their release into the river.

I was also interested in whether or not there was any difference in expected survival between fish stocked in 2002 and fish stocked from 2003-2009 (i.e., when longer tempering times and pre-release, in-river acclimation were being employed). To examine this, I first excised the data from the 2002 stocking of age-0 fish, then repeated the procedures detailed in the previous paragraph (Table A-6).

RESULTS AND DISCUSSION

My calculations predicted that at age-1, Colorado pikeminnow stocked as age-0 fish the prior year, occurred from 5.33-47.00 fish/RM (Table A-4). In most years (2004-2009), this observed variation dropped off considerably by age-2, with this age fish occurring from 2.67-6.33 fish/RM. However, the large group of age-2 fish that had been stocked at age-0 in 2008 broke this trend, with that cohort of age-2 fish occurring at 22.67 fish/RM. By age-3, there was even less variation, with occurrence being 0.00-2.33 fish/RM. And, at age-4, occurrence ranged from 0.00-0.50 fish/RM. So, despite the wide variation in numbers of age-0 fish being stocked each year, by age-3 there was little difference in the number of fish being collected in our electrofishing samples. By age-4, there was essentially no difference. It appears that the efforts to be more careful during handling, transport, tempering, and acclimation of age-0 fish since 2003 have increased their survival at age-1 and with the value observed 2010, possibly at age-2 as well. However, this apparent benefit has not carried over to older year-classes. The catch of age-3 fish during the 2011 Adult Monitoring trip will provide an interesting test of this possible trend-breaking cohort.

Put in terms of survival per 100,000 fish stocked, at age-1 Colorado pikeminnow are common enough (at 1 fish every 0.12 RM) to be collected on a relatively regular basis (Table A-5). However, the number of fish per RM drops markedly in subsequent years, such that by age-4 there is predicted to be only one Colorado pikeminnow per every 16.67 RM. At 1 fish every 25.00 RM per 100,000 age-0 fish stocked since 2002, my calculations predict that there should have been 108 total age-4 to age-8 fish occupying our 180 RM study area in fall 2010 (i.e., 34 age-4 fish, 28 age-5 fish, 22 age-6 fish, 12 age-7 fish, and 12 age-8 fish; Table A-7). Given a 5% capture probability, we could have been expected to collect 5.40 fish, if we were sampling every RM. However, since we sample only two of every three RM, my calculations predict that Adult Monitoring should have collected 3.62 (or four) age-4+ fish in 2010. In fact, we collected five age-4+ fish in 2010 that had been stocked as age-0 fish. However, one of those five was probably around age-14 when collected and assumed to be a product of the 1996-1999 experimental stockings of age-0 Colorado pikeminnow done by UDWR-Moab. This leaves Colorado pikeminnow collected in 2010 that were age-4+ and a product of the stockings of age-0 since 2002 (Table 4).

This exercise has been enlightening in helping explain why age-4+ Colorado pikeminnow have, so far, been relatively rare in Adult Monitoring collections. Table A-7 predicts that there are still relatively few age-4+ Colorado pikeminnow presently in the San Juan River. This fact, combined with a 5% electrofishing capture probability and a two out of every three RM sampling regime, makes capturing Colorado pikeminnow in these age-classes difficult. Hopefully, this should become less of an issue over the next several years, if numbers of age-4+ Colorado pikeminnow from stockings continue to increase as predicted (Table A-7).

Table A-1. Actual number of Colorado pikeminnow (stocked as age-0 fish) that were captured during subsequent years' Adult Monitoring trips (with 2 of every three RMs being sampled).

Year-Class & (Number Stocked)	Year Of Capture							
	2003	2004	2005	2006	2007	2008	2009	2010
2002 (210,418)	32	16	3	1	0	0	0	0
2003 (175,928)	-----	130	33	6	0	0	0	1
2004 (280,000)	-----	-----	67	26	2	0	0	0
2005 (302,270)	-----	-----	-----	171	20	0	0	0
2006 (313,854)	-----	-----	-----	-----	115	29	14	3
2007 (475,970)	-----	-----	-----	-----	-----	143	38	8
2008 (270,234)	-----	-----	-----	-----	-----	-----	282	136
2009 (468,000)	-----	-----	-----	-----	-----	-----	-----	262

Table A-2. Predicted number of Colorado pikeminnow (stocked as age-0 fish) occupying the study area (180 RMs) during subsequent years' Adult Monitoring trips, based on actual numbers collected and extrapolated using a 5% electrofishing capture probability (with 2 of every three RMs being sampled).

Year-Class & (Number Stocked)	Year Of Capture							
	2003	2004	2005	2006	2007	2008	2009	2010
2002 (210,418)	640	320	60	20	0	0	0	0
2003 (175,928)	-----	2,600	660	120	0	0	0	20
2004 (280,000)	-----	-----	1,340	520	40	0	0	0
2005 (302,270)	-----	-----	-----	3,420	400	0	0	0
2006 (313,854)	-----	-----	-----	-----	2,300	580	280	60
2007 (475,970)	-----	-----	-----	-----	-----	2,860	760	160
2008 (270,234)	-----	-----	-----	-----	-----	-----	5,640	2,720
2009 (468,000)	-----	-----	-----	-----	-----	-----	-----	5,240

Table A-3. Predicted number of Colorado pikeminnow (stocked as age-0 fish) occupying the entire study area (180 RMs) during subsequent years' Adult Monitoring trips, based on predicted numbers generated in Table A-2 extrapolated to what they might be expected to be if all 180 RMs were sampled.

Year-Class & (Number Stocked)	Year Of Capture							
	2003	2004	2005	2006	2007	2008	2009	2010
2002 (210,418)	960	480	90	30	?	?	?	?
2003 (175,928)	-----	3,900	990	180	?	?	?	30
2004 (280,000)	-----	-----	2,010	780	60	?	?	?
2005 (302,270)	-----	-----	-----	5,130	600	?	?	?
2006 (313,854)	-----	-----	-----	-----	3,450	870	420	90
2007 (475,970)	-----	-----	-----	-----	-----	4,290	1,140	240
2008 (270,234)	-----	-----	-----	-----	-----	-----	8,460	4,080
2009 (468,000)	-----	-----	-----	-----	-----	-----	-----	7,860

Table A-4. Predicted average number of Colorado pikeminnow (stocked as age-0 fish) per RM expected to be distributed throughout the entire study area (180 RMs) during subsequent years' Adult Monitoring trips, based on predicted numbers generated in Table A-3 divided by the length of the study area.

Year-Class & (Number Stocked)	Year Of Capture							
	2003	2004	2005	2006	2007	2008	2009	2010
2002 (210,418)	5.33	2.67	0.50	0.17	?	?	?	?
2003 (175,928)	-----	21.67	5.50	1.00	?	?	?	0.17
2004 (280,000)	-----	-----	11.17	4.33	0.33	?	?	?
2005 (302,270)	-----	-----	-----	28.50	3.33	?	?	?
2006 (313,854)	-----	-----	-----	-----	19.17	4.83	2.33	0.50
2007 (475,970)	-----	-----	-----	-----	-----	23.83	6.33	1.33
2008 (270,234)	-----	-----	-----	-----	-----	-----	47.00	22.67
2009 (468,000)	-----	-----	-----	-----	-----	-----	-----	43.67

Table A-5. Predicted survival parameters for Colorado pikeminnow stocked as age-0 fish during subsequent years' Adult Monitoring trips, based on numbers generated in Tables A-1 through A-4.

	Age-0 to Age-1	Age-1 to Age-2	Age-2 to Age-3	Age-3 to Age-4	Age-4 to Age-5	Age-5 to Age-6	Age-6 to Age-7
Predicted Year-To-Year Survival	Mean = 1.49% Range = 0.46-3.13% (8 data points)	Mean = 32.27% Range = 11.70%-50.00% (7 data points)	Mean = 18.99% Range = 0.00%-48.28% (6 data points)	Mean = 10.95% Range = 0.00%-33.33% (5 data points)	Mean = 0.00% Observed Range = 0.00% (4 data points)	Mean = 0.00% Observed Range = 0.00% (3 data points)	Mean = 8.34% Observed Range = 0.00%-16.67% (2 data points)
	At Age-1	At Age-2	At Age-3	At Age-4	At Age-5	At Age-6	At Age-7
Predicted Number Of Fish Occupying The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	1,490	481	91	10	0	0	1
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	8.28 (= 1 Fish Per Every 0.12 RMs)	2.67 (= 1 Fish Per Every 0.37 RMs)	0.51 (= 1 Fish Per Every 1.96 RMs)	0.06 (= 1 Fish Per Every 16.67 RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.01 (= 1 Fish Per Every 100.00 RMs)

Table A-6. Predicted survival parameters for Colorado pikeminnow stocked as age-0 fish during subsequent years' Adult Monitoring trips, based on numbers generated in Tables A-1 through A-4 and excising the data from the 2002 stocking (i.e., just including data collected after longer tempering times and acclimation of stocked fish were implemented).

	Age-0 to Age-1	Age-1 to Age-2	Age-2 to Age-3	Age-3 to Age-4	Age-4 to Age-5	Age-5 to Age-6	Age-6 to Age-7
Predicted Year-To-Year Survival	Mean = 1.64% Range = 0.72%-3.13% (7 data points)	Mean = 29.32% Range = 11.70%-48.23% (6 data points)	Mean = 19.04% Range = 0.00%-48.28% (5 data points)	Mean = 5.36% Observed Range = 0.00%-21.43% (4 data points)	Mean = 0.00% Observed Range = 0.00% (3 data points)	Mean = 0.00% Observed Range = 0.00% (2 data points)	Mean = 16.67% Observed Range = 16.67% (1 data point)
	At Age-1	At Age-2	At Age-3	At Age-4	At Age-5	At Age-6	At Age-7
Predicted Number Of Fish Occupying The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	1,640	481	92	5	0	0	1
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	9.11 (= 1 Fish Per Every 0.11 RMs)	2.67 (= 1 Fish Per Every 0.37 RMs)	0.51 (= 1 Fish Per Every 1.96 RMs)	0.03 (= 1 Fish Per Every 33.33 RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.01 (= 1 Fish Per Every 100.00 RMs)

Table A-7. An estimate of how many age-4+ Colorado pikeminnow might be surviving riverwide (i.e., from RM 180.0-0.0) in the San Juan River from the fall stockings of age-0 fish which occurred from 2002-2010 (based on Tables A-1 to A-5).

Year Stocked	Number Of Age-0 Colorado Pikeminnow Stocked	Multiplier To Get Riverwide Number Of Age-4 Fish[A]	Estimated Number Of Age-4+ Fish Surviving Riverwide (RM 180.0-0.0) In Successive Calendar Years[B]							
			2006	2007	2008	2009	2010	2011	2012	2013
2002	210,418	10.79	22.70	19.30	16.40	13.94	11.85	10.07	8.56	7.28
2003	175,928	10.79		18.98	16.14	13.71	11.66	9.91	8.42	7.16
2004	280,000	10.79			30.21	25.68	21.83	18.55	15.77	13.41
2005	302,270	10.79				32.61	27.72	23.56	20.03	17.03
2006	313,845	10.79					33.86	28.78	24.47	20.80
2007	475,970	10.79						51.36	43.65	37.11
2008	270,234	10.79							29.16	24.78
2009	468,000	10.79								50.50
Total Numbers Of Fish Surviving At:										
Age-4			23	19	30	33	34	51	29	51
Age-5	Age-5+ fish			19	16	26	28	29	44	25
Age-6					16	14	22	24	24	37
Age-7	Age-7+ = adult fish					14	12	19	20	21
Age-8							12	10	16	17
Age-9								10	8	13
Age-10									9	7
Age-11										7

A: It is estimated that there is one surviving age-4 fish every 16.67 RM's (see Table A-5, page 51) per every 100,000 age-0 fish stocked. Extrapolated riverwide: 180 ÷ 16.67 = 10.79 age-4 fish riverwide (i.e., from RM 180.0-0.0) per every 100,000 age-0 fish stocked. So, to obtain numbers of age-4 fish, divide the number of age-0 fish stocked by 100,000, then multiply by 10.8 (e.g., for 2002: 210,418 age-0 fish stocked ÷ 100,000 = 2.10418; then 2.10418 × 10.79 = 22.70 age-4 fish in 2006, from RM 180.0-0.0).

B: From age-4 to age-11, the 85% (0.85) annual survival rate, found in the Colorado pikeminnow Recovery Goals document, was used. Total numbers of fish surviving at age-4 through age-11 in each calendar year are rounded off from the numbers shown in the upper portion of Table A-7.

APPENDIX B

How many Colorado pikeminnow and razorback sucker need to be collected during a fall Adult Monitoring trip to indicate that numbers in the river are at or near the downlist and/or delist criteria for these two species as specified in their respective Recovery Goals documents?

INTRODUCTION

During spring 2009, a series of three workshops were held in Albuquerque, NM to assess the various monitoring studies that the SJRIP currently uses to monitor both fish populations (large-bodied, small-bodied, and larval fishes) and riverine habitats. During these workshops, it was noted that when populations of the two endangered fishes increased to certain levels, it would be appropriate to switch from doing relative abundance oriented studies (such as Adult Monitoring) which use CPUE as their main abundance index, to doing multiple-pass, mark-recapture population estimate studies to obtain precise point estimates. These precise point estimates (and associated confidence intervals) could then be used to tell when the SJRIP had reached the downlist and/or delist criteria specified in the Recovery Goals documents for these two species (USFWS 2002a, 2002b).

The question I was trying to answer was, at what point does the SJRIP make that switch? This topic was the subject of several slides presented during the Adult Monitoring data presentations at those workshops. The focus of those portions of the Adult Monitoring presentations was to identify how many adult and recruiting sub-adult Colorado pikeminnow and razorback sucker would need to be collected on a standardized fall Adult Monitoring trip (sampling from RM 180.0-2.9 and sampling 2 of every 3 RM) to indicate that populations were at or near the downlist or delist criteria for these two species, as specified in their respective Recovery Goals documents (USFWS 2002a, 2002b).

My analysis used the age-class and size-class breakdowns specified in the Recovery Goals documents for the two endangered fishes. The original analysis, done in spring 2009 for the workshops, used a 20% capture probability for both Colorado pikeminnow and razorback sucker. This 20% capture probability came from a rule of thumb (generated by Bill Miller and Vince Lamarra) that stated that during the first electrofishing pass through a given RM, sampling crews will collect an average of 20% of all of the fish (regardless of species) that are actually present in that RM. This rule of thumb had been used for several years, when trying to relate relative abundance data to actual population numbers.

In 2009 and 2010, endangered fish capture data from several different nonnative fish removal trips that, as a group, sampled the entirety of the San Juan River in fairly close temporal proximity to one another was used to make preliminary riverwide population estimates for the two endangered fish species (Davis et al. 2010, Duran et al. 2011). The results of these preliminary riverwide population estimates indicated that the capture probability for Colorado pikeminnow on any given electrofishing pass was 5% and for razorback sucker it was 4%. Thus, the calculations presented here use these newer (and likely more accurate) capture probabilities to answer the question of when do we switch from one study to another.

METHODS

An example, for Colorado pikeminnow, to reach the delist criteria (USFWS 2002a):

To predict if there are 800 naturally-produced adult Colorado pikeminnow in the San Juan River using our current Adult Monitoring sampling protocols, I used the following calculations.

- Recovery Goal = 800 adult Colorado pikeminnow ($\geq$ 450 mm TL; age-7+) riverwide (i.e., from Animas confluence to Lake Powell = 180 RM) to delist

{FYI: Downlist criteria = 1,000 fish $\geq$ 300 mm TL; age -5+}

- Using a 5% capture probability (J. E. Davis, pers. comm.), if 800 adult Colorado pikeminnow are present in 180 RM, then Adult Monitoring sampling (i.e. shoreline, raft-borne electrofishing) should catch 40 of them if we sample every single RM

5% = 0.05
800 fish X 0.05 = 40 fish collected per 180 RM sampled
40 adult fish collected in 180 RM sampled = 0.222 adult fish per RM

- But, right now we only sample from the Animas confluence to Clay Hills (177.1 total RM) and we only sample two out of every three of those RM

RM 180.0-2.9 = 177.1 total RM
2/3 = 0.667
177.1 RM X 0.667 = 118.13 RM sampled

- Therefore, with our current sampling regime, we would have to collect 26 adult Colorado pikeminnow during a fall Adult monitoring trip to be reasonably sure that there were about 800 adult Colorado pikeminnow riverwide

118.13 RM sampled X 0.222 fish per mile = 26.22 adult Colorado pikeminnow

Also, the mean estimated recruitment of age-6 (400–449 mm TL) naturally-produced Colorado would need to equal or exceed the average annual adult mortality (estimated at 15% on page 21 of the Colorado pikeminnow Recovery Goals document; USFWS 2002a).

15% of 800 = 120 naturally-produced age-6 fish (400-449 mm TL) each year in 180 RM.

- 120 age-6 Colorado pikeminnow (400-449 mm TL) riverwide (i.e., from Animas confluence to Lake Powell = 180 RM)

- Using a 5% capture probability (J. E. Davis 2009), if 120 age-6 Colorado pikeminnow are present in 180 RM, then Adult Monitoring sampling (i.e. shoreline, raft-borne electrofishing) should catch 6 of them, if we sample every single RM

5% = 0.05
120 fish X 0.05 = 6 fish collected per 180 RM sampled
6 age-6 fish collected in 180 RM sampled = 0.033 age-6 fish per RM

- But, right now we only sample from the Animas confluence to Clay Hills (177.1 total RM) and we only sample two out of every three of those RM

RM 180.0-2.9 = 177.1 total RM
2/3 = 0.667
177.1 RM X 0.667 = 118.13 RM sampled

- Therefore, with our current sampling regime, we would have to collect 4 age-6 (400-449 mm TL) Colorado pikeminnow during a fall Adult monitoring trip to be reasonably sure that there were about 120 age-6 Colorado pikeminnow riverwide

118.13 RM sampled X 0.033 fish per mile = 3.90 age-6 Colorado pikeminnow

RESULTS

Performing these calculations for Colorado pikeminnow (using a 5% capture probability) and for razorback sucker (using a 4% capture probability), for both the downlist and delist criteria, indicates that the following numbers of fish would need to be collected on a typical October Adult Monitoring trip (i.e., sampling 2 of every 3 river miles from RM 180.0-2.9):

For Colorado pikeminnow:

To Downlist (Demographic Criteria only): Collecting 33 Colorado pikeminnow (≥ 300 mm TL; age-5+) would indicate that there were close to 1,000 fish ≥ 300 mm TL riverwide.

To Delist (Demographic Criteria only): Collecting 26 adult Colorado pikeminnow (≥ 450 mm TL; age-7+) and 4 sub-adult Colorado pikeminnow (400-449 mm TL; age-6) would indicate that there were close to 800 fish ≥ 450 mm TL, with a 15% recruitment rate.

For razorback sucker:

To Downlist (Demographic Criteria only): Collecting 152 adult razorback sucker (≥ 400 mm TL; age-4+) and 46 sub-adult razorback sucker (300-399 mm TL; age-3) would indicate that there were close to 5,800 fish ≥ 400 mm TL, with a 30% recruitment rate. This would need to occur over a consecutive 5-year period.

To Delist (Demographic Criteria only): Collecting 152 adult razorback sucker (≥ 400 mm TL; age-4+) and 46 sub-adult razorback sucker (300-399 mm TL; age-3) would indicate that there were close to 5,800 fish ≥ 400 mm TL, with a 30% recruitment rate. This would need to occur over a consecutive 3-year period beyond downlisting.