LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 2009

Interim Progress Report

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EXECUTIVE SUMMARY

General Information

- A total of 15,698 fishes were collected during 2009 Adult Monitoring
  - Native fishes accounted for 50.4% of the total catch in 2009

Native Species:

- Colorado pikeminnow
  - No wild Colorado pikeminnow were collected in 2009
  - 376 stocked Colorado pikeminnow were collected in 2009
    - Fifth most abundant species collected
    - Scaled CPUE of Colorado pikeminnow in the river for 1+ overwinter periods post-stocking was significantly higher in 2009 than five of six previous years
      - Due to the collection of 282 age-1 fish (stocked as age-0 fish in fall 2008)
    - Sizes in 2009 ranged from 139-399 mm TL (age-1 to age-3)
    - Captures ranged from RM 163.0-11.0
      - 31 in Reach 6, 61 in Reach 5, 81 in Reach 4, 152 in Reach 3, 49 in Reach 2, and 2 in Reach 1
    - 320 (85.6%) were in the river ≤ 365 days post-stocking
      - However, all but 37 (9.9%) of these fish were in the river for at least one overwinter period
    - After about four overwinter periods, Colorado pikeminnow stocked as age-0 fish aren't collected during Adult Monitoring
      - After about two overwinter periods, Colorado pikeminnow stocked at age-1 or older aren't collected during Adult Monitoring
- Razorback sucker
  - No wild razorback sucker were collected in 2009
  - 84 stocked razorback sucker were collected in 2009
    - Seventh most abundant species collected
    - Scaled CPUE of razorback sucker that had been in the river for 1+ overwinter periods post-stocking has not changed significantly over the last seven years
    - Sizes ranged from 348-552 mm TL (age-2 to age-10)
    - Captures ranged from RM 166.0-13.0
      - 24 were collected in Reach 6, 34 in Reach 5, 8 in Reach 4, 15 in Reach 3, 2 in Reach 2, and 1 in Reach 1
    - Of 40 razorback sucker collected with PIT tags and known stocking histories in 2009, 16 (40.0%) were in the river ≤ 365 days post-stocking
      - Five of the 16 fish were in the river < 1 overwinter period when they were collected
      - The other 35 fish were in the river from 1-9 overwinter periods
    - Razorback sucker that have been in the river ≥ 6 overwinter periods have been collected every year since 2001
- Roundtail chub
  - One roundtail chub was collected in 2009

- Flannelmouth sucker
    - Second most abundant species in 2009
        - The first time in 19 years that flannelmouth sucker were not numerically dominant in Adult Monitoring collections
            - Due to an increase in channel catfish abundance in 2009, rather than any dramatic decline in flannelmouth sucker abundance
            - Accounted for only 31.5% of the total catch (n = 4,941 fish)
        - Had the widest distribution of any species, being collected in 194 (91.1%) of 213 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 11 years
    - The third most common species collected in 2009
        - Accounted for 10.0% of the total catch (n = 1,572 fish)
        - Collected in 61.5% of electrofishing samples (RM 180.0-2.9)
        - Collected in Reaches 6-2 in 2009

Nonnative Species:

- Channel catfish
    - Among the three most commonly-collected species in each of the last 11 years
    - Most abundant species collected in 2009
        - Accounted for 47.6% of the total catch (n = 7,486 fish)
        - Collected in 88.3% of electrofishing samples (RM 180.0-2.9)
        - In 2009 the majority of both juvenile and adult channel catfish were collected in the middle portion of our study area (i.e., from RM 119.0-40.0) with numbers being considerably reduced both up- and downstream of that area
        - In 2009, 67.9% (n = 5,069) of all the channel catfish collected riverwide were ≤ 250 mm TL (age-0 to age-2 fish)
            - 91.4% of juvenile channel catfish were found from RM 109-40

- Common carp
    - Percent of total catch accounted for by this species has decreased steadily over the last 11 years (from 9.8% in 1999 to 0.9% in 2009)
        - Was the fourth most commonly-collected species in 1999
    - The sixth most commonly-collected species in 2009
        - Only 137 common carp collected from RM 180.0-2.9 in 2009
            - 85 (62.0%) were juveniles (i.e., < 250 mm TL)
            - Common carp were often collected in close proximity to each other
                - 33 of the 68 samples in which common carp occurred had two or more individuals in them
                - Two samples each had 4, 5, 6, or 7 common carp in them
        - Collected in 31.9% of electrofishing samples (RM 180.0-2.9)
        - Less abundant than endangered Colorado pikeminnow during 2009 Adult Monitoring collections

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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 once since 1999 (Propst et al. 2006) and are currently in the process of being updated and revised again (2010 in prep.). 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-2009 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 long-term Monitoring Plan and Protocols are currently undergoing revision. However, the monitoring protocols discussed in the Methods section of this report reflect those that are currently included in the latest draft of the revised long-term Monitoring Plan and Protocols.

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 2009 followed the protocols for long-term monitoring set forth in Propst et al. (1999, 2006). 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 (i.e., age-1 to age-3) fish 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 1999-2008 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, from 1999-2008.

RESULTS

The mean river flow (at the Shiprock USGS gage #09368000) during the 2009 Adult Monitoring trip was 532 CFS (Table 1). This was the lowest average sampling flow in the last six years of Adult Monitoring and the third lowest overall average sampling flow encountered in the last 11 years of long-term monitoring (1999-2009).

Twenty-one fish species and hybrids were collected during the 2009 Adult Monitoring trip (Table 2). This included 6 native species, 2 native sucker X native sucker hybrids, 12 nonnative species and 1 native sucker X nonnative sucker hybrid (Tables 2 and 3). Eight species (channel catfish, flannelmouth sucker, bluehead sucker, speckled dace, Colorado pikeminnow, common carp, razorback sucker, and largemouth bass) accounted for 99.3% (15,580 fish) of the total catch during the 2009 Adult Monitoring trip. The other 10 species and three hybrids contributed only 0.7% (118 fishes) to the total catch in 2009 (Table 3). For the first time in the history of the Adult Monitoring study, nonnative fishes accounted for essentially the same amount of the total catch as did native fishes (49.6% vs. 50.4%; Table 3). For the sixth 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, 1999-2009.

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)
11-year statistics: Mean = 1,070 CFS (30.3 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 2009 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.discobolus	Hybrid	Introduced	comXdis
Catostomus latipinnis	flannelmouth sucker	Native	Catlat
C.latipinnis X C.discobolus	Hybrid	Native	latXdis
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
Pimephales promelas	fathead minnow	Introduced	Pimpro
Gila robusta	roundtail chub	Native	Gilrob
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			
Oncorhynchus mykiss	rainbow trout	Introduced	Oncmyk
Salmo trutta	brown trout	Introduced	Saltru
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 2009 Adult Monitoring trip.

Species (Status)[a]	Number Collected	Percent Of Total[b]	Number Of Samples Collected In
channel catfish (I)	7,468	47.6	188
flannelmouth sucker (N)	4,941	31.5	194
bluehead sucker (N)	1,572	10.0	131
speckled dace (N)	924	5.9	111
Colorado pikeminnow (N)	376	2.4	136
common carp (I)	137	0.9	68
razorback sucker (N)	84	0.5	46
largemouth bass (I)	78	0.5	52
brown trout (I)	51	0.3	25
red shiner (I)	26	0.2	10
yellow bullhead (I)	8	-----	7
green sunfish (I)	8	-----	6
bluehead sucker X flannelmouth sucker (H, N)	7	-----	7
black bullhead (I)	4	-----	4
razorback sucker X flannelmouth sucker (H, N)	4	-----	4
fathead minnow (I)	3	-----	2
white sucker X bluehead sucker (H, I)	3	-----	3
rainbow trout (I)	1	-----	1
roundtail chub (N)	1	-----	1
smallmouth bass (I)	1	-----	1
white sucker (I)	1	-----	1
GRAND TOTAL	15,698		
Total Electrofishing Collections In 2009 = 213 Total Electrofishing Effort In 2009 = 104.73 Hours			
2009 Native Fishes = 7,909 (50.38% Of The Total Catch) 2009 Introduced Fishes = 7,789 (49.62% Of The Total Catch) 2009 Native To Introduced Fishes Ratio = 1.02:1			
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%			

Colorado Pikeminnow

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

Colorado pikeminnow captures ranged from RM 163.0-11.0 (Table 4). The majority (n = 325; 86.4%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Only eight (2.1%) of these collections occurred upstream of the Hogback Diversion (RM 158.6). Only two of the Colorado pikeminnow caught upstream of Hogback Diversion had PIT tags upon collection. One (290 mm TL) was from the fall 2007 stockings of age-0 fish. The other (322 mm TL) was stocked as an age-3 fish on 17 March 2009. Thirty-one Colorado pikeminnow were collected in Reach 6, 61 in Reach 5, 81 in Reach 4, 152 in Reach 3, 49 in Reach 2, and 2 in Reach 1.

Table 4. General information on stocked Colorado pikeminnow collected in 2009.

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-3 (37)	268-362	163.0-94.0	188-204 (0)	03/17/2009	Age-3 (2006)	Dexter
Age-1 (282)	139-238	163.0-11.0	319-341 (1)	11/06/2008	Age-0 (2008)	Dexter
Age-2 (3)	330-354	125.0-103.0	336-538 (1)	04/16/2008 & 10/21/2008	Age-2 (2006)	Dexter
Age-2 (38)	248-314	161.0-50.0	719-738 (2)	10/03/2007, 11/07/2007 & 11/14/2007	Age-0 (2007)	Dexter
Age-3 (14)	321-399	148.0-35.0	1,068-1,088 (3)	10/19/2006 & 11/02/2006	Age-0 (2006)	Dexter

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

Stocking history (and length of time in the river) could not be determined for two Colorado pikeminnow. Most (n = 320; 85.6%) of the 374 known-origin Colorado pikeminnow collected in 2009 were in the river ≤ 365 days post-stocking. However, all but 37 (9.9%) of these fish had been in the river for at least one overwinter period (Table 4). Only 54 (14.4%) of the 374 known-origin Colorado pikeminnow collected in 2009 were in the river > 365 days post-stocking. Of those 54 fish, 52 were stocked as age-0 fish. No Colorado pikeminnow collected in 2008 were in the river > 1,088 days (three years) post-stocking.

Comparisons of scaled CPUE among groups of Colorado pikeminnow stocked as age-0 fish showed that at age-1 there were significant differences between years, with recapture rates among the 2008 year-class fish being significantly higher at age-1 than five of the previous six years (Figure 1). Recapture rates among 2002 year-class fish captured at age-1 in fall 2003 (i.e., fish stocked with shorter tempering times and no acclimation prior to release) were significantly lower than were those for similar groups of fish stocked at age-0 and captured at age-1 in five of the following six years, when longer tempering times and acclimation were being implemented (Figure 1).

By age-2, differences in scaled CPUE among year-classes had greatly diminished, with few significant differences in scaled CPUE values being present (Figure 1). By age-3 even fewer significant differences existed in scaled CPUE among any of the groups of Colorado pikeminnow stocked as age-0 fish. While the 2002-2005 year-classes of Colorado pikeminnow were all theoretically available to be collected as age-4+ fish in 2009, no Colorado pikeminnow older than age-3 were collected during 2009 Adult Monitoring (Figure 1).

Since 1997, stocked Colorado pikeminnow have generally been collected during Adult Monitoring only up to four overwinter periods post-stocking (Table 5). This holds true for age-0 Colorado pikeminnow that were stocked in the fall from 2002-2008 as well (Figure 2). After age-4 these fish have, so far, been absent from Adult Monitoring collections. Likewise, comparisons of scaled CPUE among ten different groups of Colorado pikeminnow stocked as age-1 or older fish since 2003 (Figure 3) showed this same trend. During the calendar year in which they were stocked, these fish were collected in relatively high proportions compared to the low numbers at which they were stocked (Furr 2010 details the numbers and age-classes of Colorado pikeminnow stocked from 2002-2009). However, after their first overwinter period, few if any were collected (Figure 3). After two overwinter periods, no fish from any of these stockings of age-1+ fish were present in Adult Monitoring collections. The reason for the total absence of stocked Colorado pikeminnow in Adult Monitoring collections after four overwinter periods is unknown. These fish may become extirpated from the river, move out of the mainstem river (either into lake Powell or into tributaries), or their numbers may just diminish to the point where single-pass electrofishing efforts, such as Adult Monitoring, are unable to detect their presence (i.e., due to low capture probabilities).

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 4).

Table 5. Information on stocked Colorado pikeminnow collected from 1997-2009 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
1997	166.01	49	38	1996	283-338 (1)	1996 (38 fish)
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 (2 fish) 1997 (4 fish) 1998 (4 fish)
2000	116.89	1	1	1996	1417 (4)	1996 (1 fish)
2001	109.61	5	3	1999-2000	471-814 (1-2)	1999 (1 fish) 2000 (2 fish)
2002	92.17	3	3	1991	548 (1)	2001 (3 fish)
2003	94.42	32	32	2002	333-354 (1)	2002 (32 fish)
2004	93.75	159	146	2002-2003	319-719 (1-2)	2002 (16 fish) 2003 (130 fish)
2005	85.95	127	105	2002-2004	326-1082 (1-3)	2002 (3 fish) 2003 (33 fish) 2004 (69 fish)
2006	77.80	323	205	2002-2005	319-1445 (1-4)	2002 (1 fish) 2003 (6 fish) 2004 (26 fish) 2005 (172 fish)
2007	90.95	167	146	2004-2006	319-1073 (1-3)	2004 (2 fish) 2005 (20 fish) 2006 (124 fish)
2008	83.88	207	175	2006-2007	320-708 (1-2)	2006 (29 fish) 2007 (146 fish)
2009	104.73	376	337	2006-2008	319-1088 (1-3)	2006 (14 fish) 2007 (38 fish) 2008 (285)

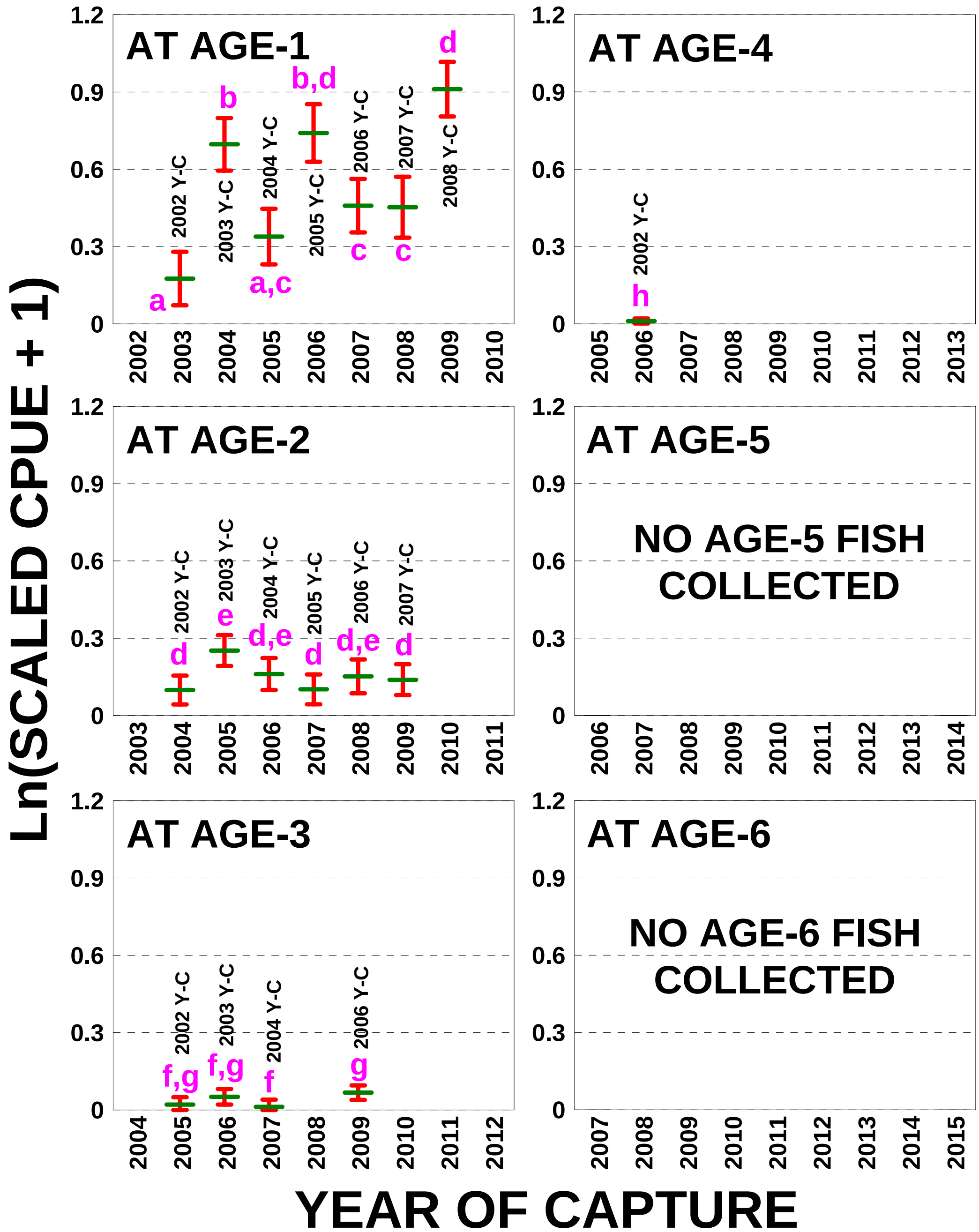

Figure 1. A comparison of scaled CPUE at age among groups of Colorado pikeminnow stocked as age-0 fish and captured during subsequent Adult Monitoring trips, 2003-2009. The green line shows the difference in scaled CPUE values between years. Red error bars are +/- 2 SE. Purple letters are within-age 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.

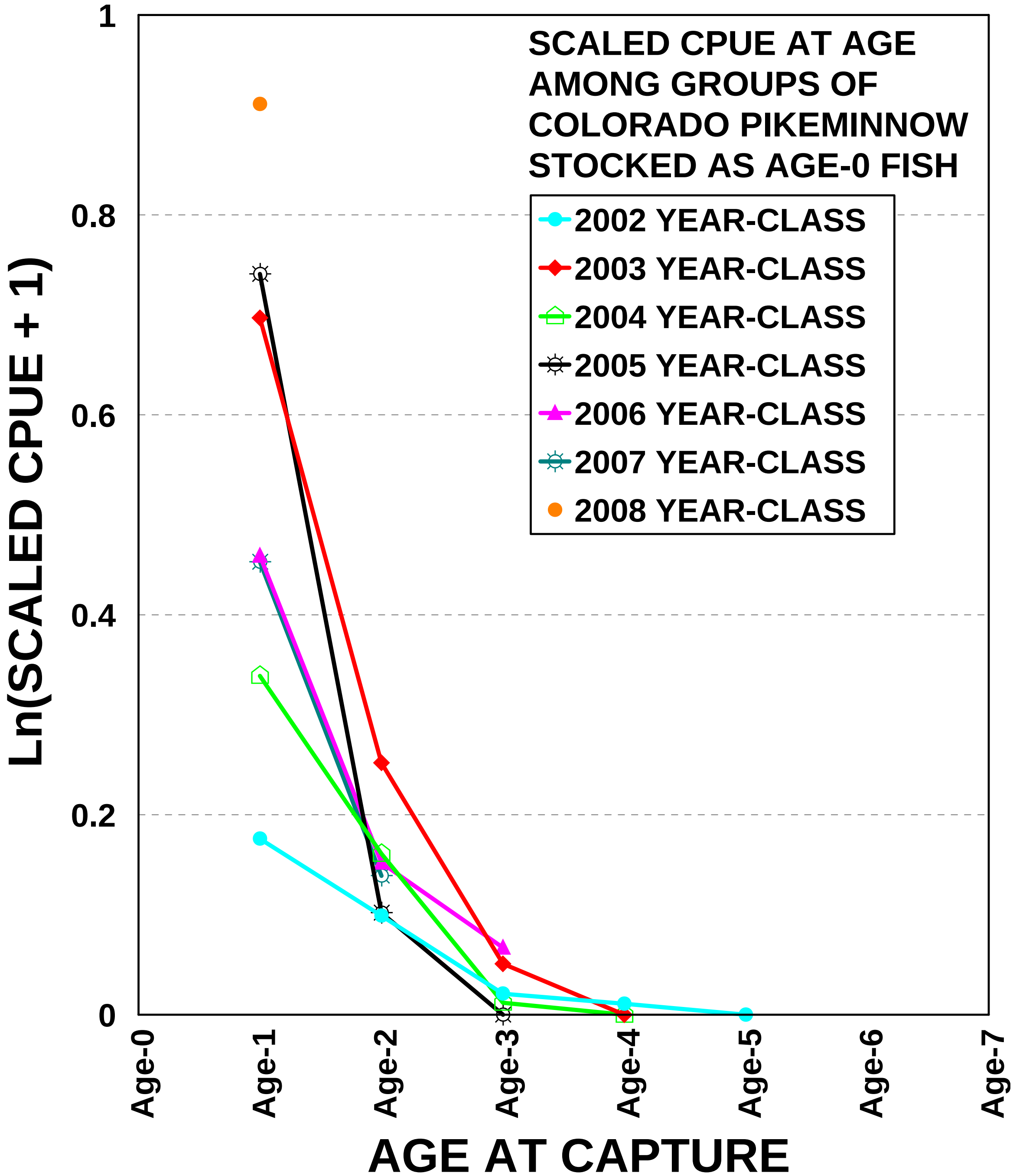

Figure 2. Scaled CPUE at age among groups of Colorado pikeminnow that were stocked as age-0 fish in the fall of the year (2002-2008) and subsequently captured during Adult Monitoring trips from 2003-2009. This graph begins with captures of fish in the calendar year following the year in which they were stocked (i.e., 1 overwinter periods).

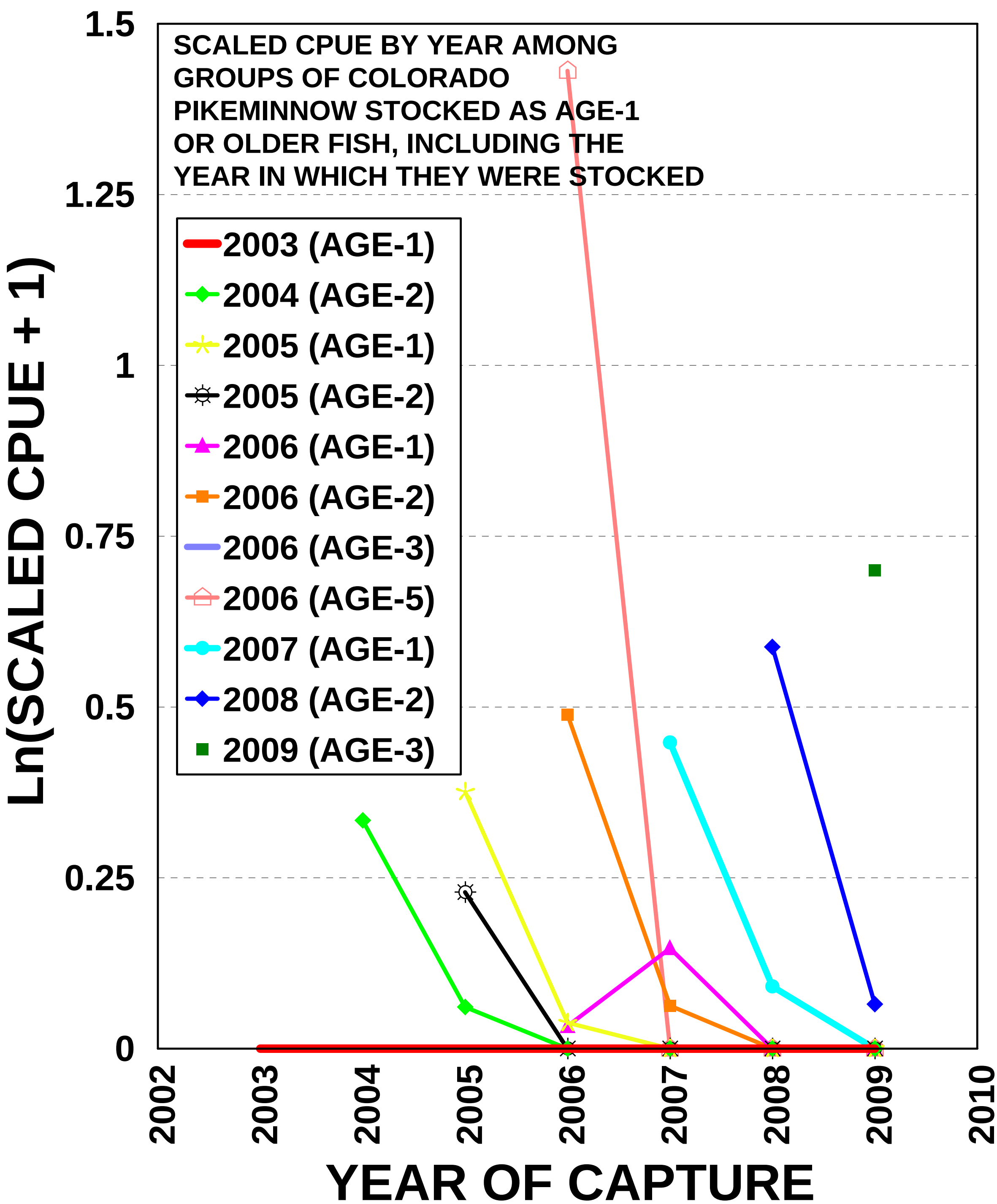

Figure 3. Scaled CPUE by calendar year among groups of Colorado pikeminnow that were stocked as age-1 or older fish and subsequently captured during Adult Monitoring trips from 2003-2009. This graph begins with captures of fish during the same year in which they were stocked (i.e., 0 overwinter periods).

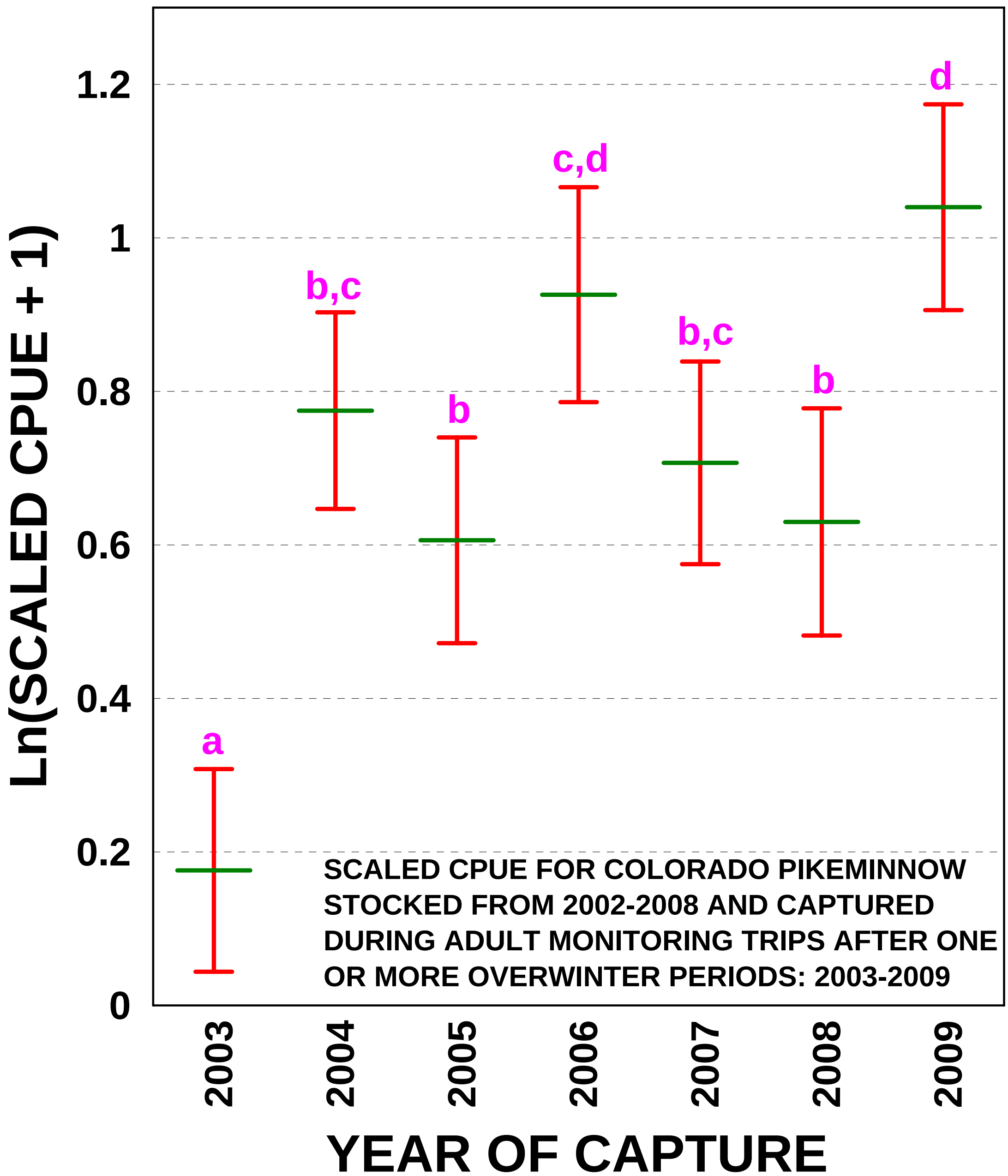

Figure 4. Year-to-year comparison of scaled CPUE for all Colorado pikeminnow collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. 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

No wild razorback sucker were collected in 2009. However, a total of 84 stocked razorback sucker were collected in 2009 (Table 6). This marked the sixth consecutive year during which > 50 razorback sucker (2004 = 117; 2005 = 52; 2006 = 144; 2007 = 207; 2008 = 78) were collected during an Adult Monitoring trip.

Razorback sucker captures ranged from RM 166.0-13.0 (Table 6). The majority (n = 81; 96.4%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Thirteen razorback sucker (15.5%) were collected upstream of the Hogback Diversion (RM 158.6), with six of these 13 being collected upstream of APS Diversion (RM 163.7). No razorback sucker were collected upstream of the PNM Weir and fish ladder (RM 166.6) during 2009 Adult Monitoring. Twenty-four razorback sucker were collected in Reach 6, 34 in Reach 5, 8 in Reach 4, 15 in Reach 3, 2 in Reach 2, and 1 in Reach 1.

Table 6. General information on stocked razorback sucker collected in 2009.

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 40 razorback sucker with known stocking histories:					
7 (0)	Age-2 (5)	348-400	166.0-164.0	2009	Age-2 (2007)
312-363 (1)	Age-3 (11)	384-440	164.0-92.0	2008	Age-2 (2006)
696-889 (2)	Age-3 To Age-4 (8)	395-482	151.0-32.0	2007	Age-1 To Age-2 (2005-2006)
1119-1197 (3)	Age-4 To Age-7 (7)	454-534	158.0-104.0	2006	Age-1 To Age-4 (2002-2005)
1485-1508 (4)	Age-6 To Age-7 (3)	440-521	161.0-113.0	2005	Age-2 To Age-3 (2002-2003)
1856-1897 (5)	Age-8 (2)	486-508	154.0-151.0	2004	Age-3 (2001)
2887-2898 (8)	Age-9 To Age-10 (3)	452-484	160.0-101.0	2001	Age-1 To Age-2 (1999-2000)
3263 (9)	Age-10 (1)	471	155.0	2000	Age-1 (1999)
Information on the 44 razorback sucker captured without known stocking histories:					
≥ 759 (3-4)	Age-4 To Age-7 (42)	403-552	163.0-13.0	2006-2007	Age-1 To Age-4 (2002-2005)
Unknown	(2)	430-505	137.0-158.0	Unknown	Unknown

Equipment failures led to PIT tag numbers not being obtained for two razorback sucker. In addition, because salvage operations at the NAPI ponds in 2006 and 2007 led to several thousand razorback sucker being stocked without PIT tags (Ryden 2008), the exact length of time that 42 of the razorback sucker captured during 2009 Adult Monitoring (without PIT tags) had been in the river post-stocking could not be determined (Table 6). However, since it is known that the only razorback sucker stocked without PIT tags were stocked in either 2006 or 2007, it could be determined that these 42 fish had been in the river ≥ 759 days and a minimum of 3 overwinter periods post-stocking. Of the 40 razorback sucker recaptured with PIT tags and known stocking histories in 2009, 16 (40.0%) were in the river < 365 days post-stocking. Five of these fish were in the river < 1 overwinter period when they were collected. The other 24 (60.0%) were in the river > 365 days post-stocking and had been in the river from 2-9 overwinter periods (Table 6).

Comparisons of capture data for razorback sucker that were in the river for 1+ overwinter periods showed that the number of older fish being collected during Adult Monitoring trips has changed little over the last eight years (range = 16-36; Table 7). However, razorback sucker that were in the river for 1+ overwinter periods did demonstrate a much longer post-stocking persistence (up to 12 overwinter periods or 4,389 days post-stocking) than did Colorado pikeminnow. On every Adult Monitoring trip since 2001, razorback sucker were collected that had been in river for at least 6 overwinter periods post-stocking (Table 7). The razorback sucker collected on the 2007 Adult Monitoring trip that was stocked in 1995 (a 1992 year-class fish) seems to indicate that older razorback sucker are present in the San Juan River in low numbers but are difficult to detect during single-pass electrofishing efforts.

Between-year comparisons for all razorback sucker that were in the river 1+ overwinter periods showed that there was no significant difference in scaled CPUE from 2003-2009 (Figure 5).

Table 7. Information on stocked razorback sucker collected from 2001-2009 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
2001	109.61	16	16	1992, 1993, 1996, 1997, 1999	362-2505 (1-7)	1994 (5 fish) 1995 (2 fish) 1997 (3 fish) 1998 (2 fish) 2000 (4 fish)
2002	92.17	23	20	1992, 1993, 1996, 1997, 1999, 2000	326-2864 (1-8)	1994 (2 fish) 1995 (1 fish) 1997 (1 fish) 1998 (1 fish) 1999 (1 fish) 2000 (3 fish) 2001 (11 fish)
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)

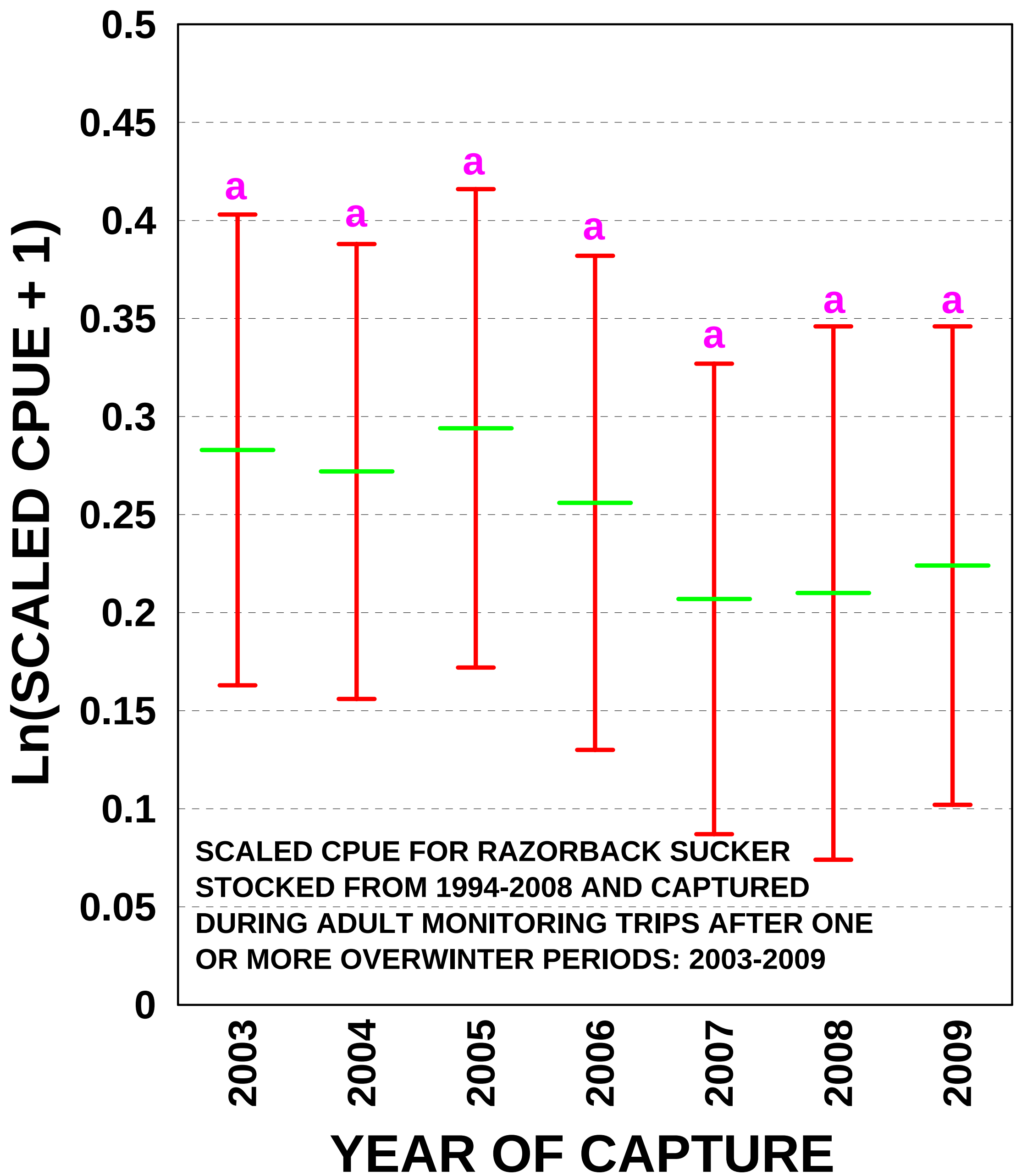

Figure 5. Year-to-year comparison of scaled CPUE for all razorback sucker collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. 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

One wild roundtail chub was collected during the 2009 Adult Monitoring trip. This fish (235 mm TL) was collected in Reach 3 (RM 101-100) on 6 October 2009 and was implanted with a PIT tag prior to being released. This was the second year in a row that a single roundtail chub was collected during an Adult Monitoring trip. However, prior to these two collections, the next previous collection occurred on the fall 2002 Adult Monitoring trip.

Common Native Fishes

Flannelmouth Sucker

Catch Information

Flannelmouth sucker was the second most common large-bodied fish species collected riverwide during the 2009 Adult Monitoring trip (Table 3, Figure 6). This was the first time in 19 years of Adult Monitoring trips (1991-2009) that flannelmouth sucker weren't the most numerous fish in electrofishing samples. However, flannelmouth sucker still had the widest distribution of any species, being collected in 194 (91.1%) of 213 electrofishing samples riverwide (Table 3, Figure 6). Flannelmouth sucker were collected in all six river reaches in 2009 (from RM 179.0-5.0).

Riverwide, flannelmouth sucker juvenile CPUE has shown more variation over the last 11 years than has adult CPUE (Figure 7). Although year-to-year juvenile CPUE values showed a comparatively high degree of variation, the long-term trend indicated no significant change. Conversely, over the last 11 years the long-term trend in adult CPUE has shown a significant decline which also resulted in a significant decline in the combined adult and juvenile CPUE over the last 11 years (Figure 7).

Length Information

Flannelmouth sucker ranging in size from 58-598 mm TL (mean TL = 334 mm) were collected during 2009 Adult Monitoring. The 2009 riverwide length-frequency histogram for flannelmouth sucker was bimodal, with one peak centered around adult fish from 426-475 mm TL and the other centered around juvenile fish from 226-250 mm TL (Figure 8). The large group of juvenile fish centered around 226-250 mm TL will likely become recruiting subadults in 2010.

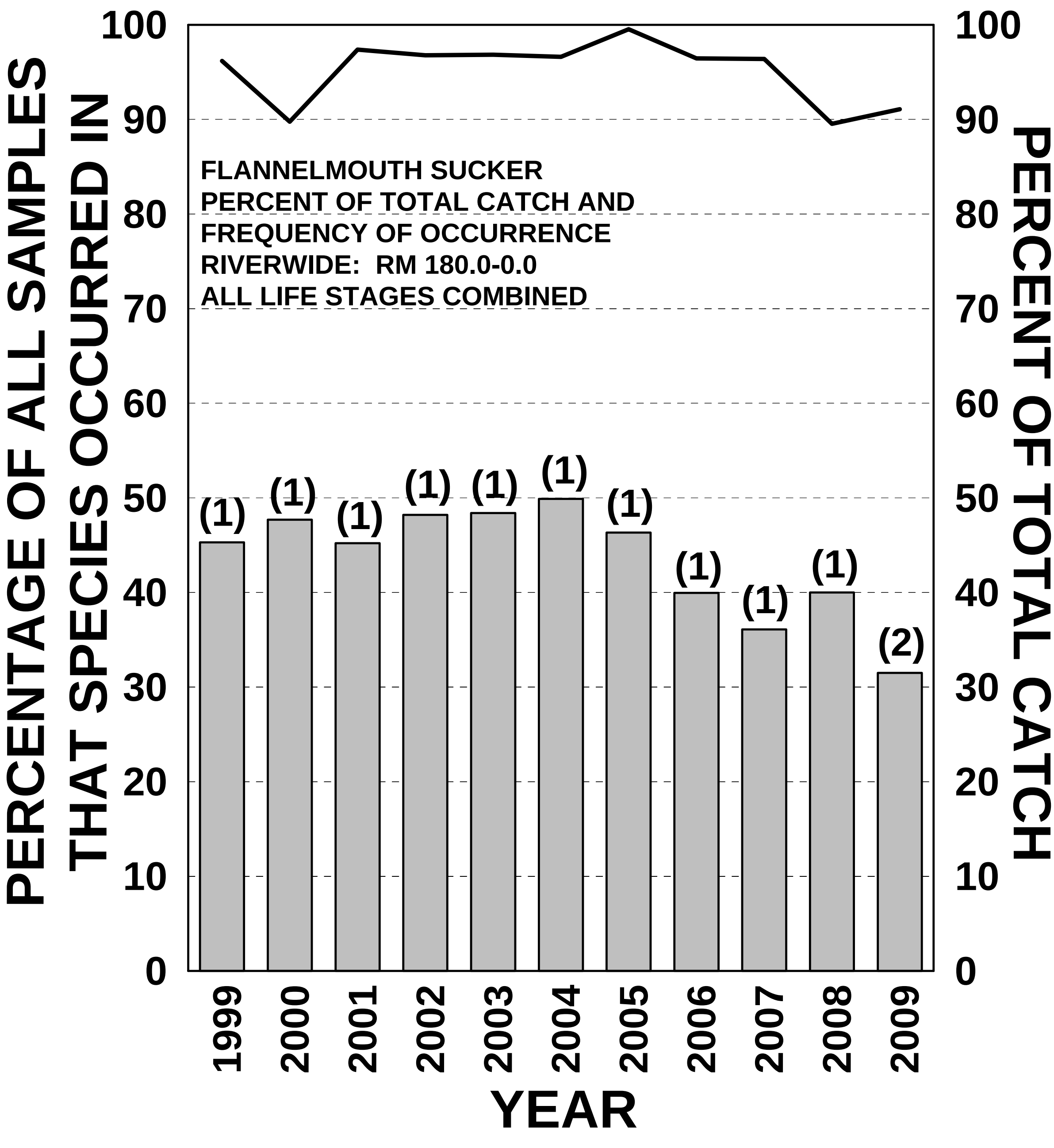

Figure 6. A summary of flannelmouth sucker relative abundance in riverwide Adult Monitoring collections, 1999-2009. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

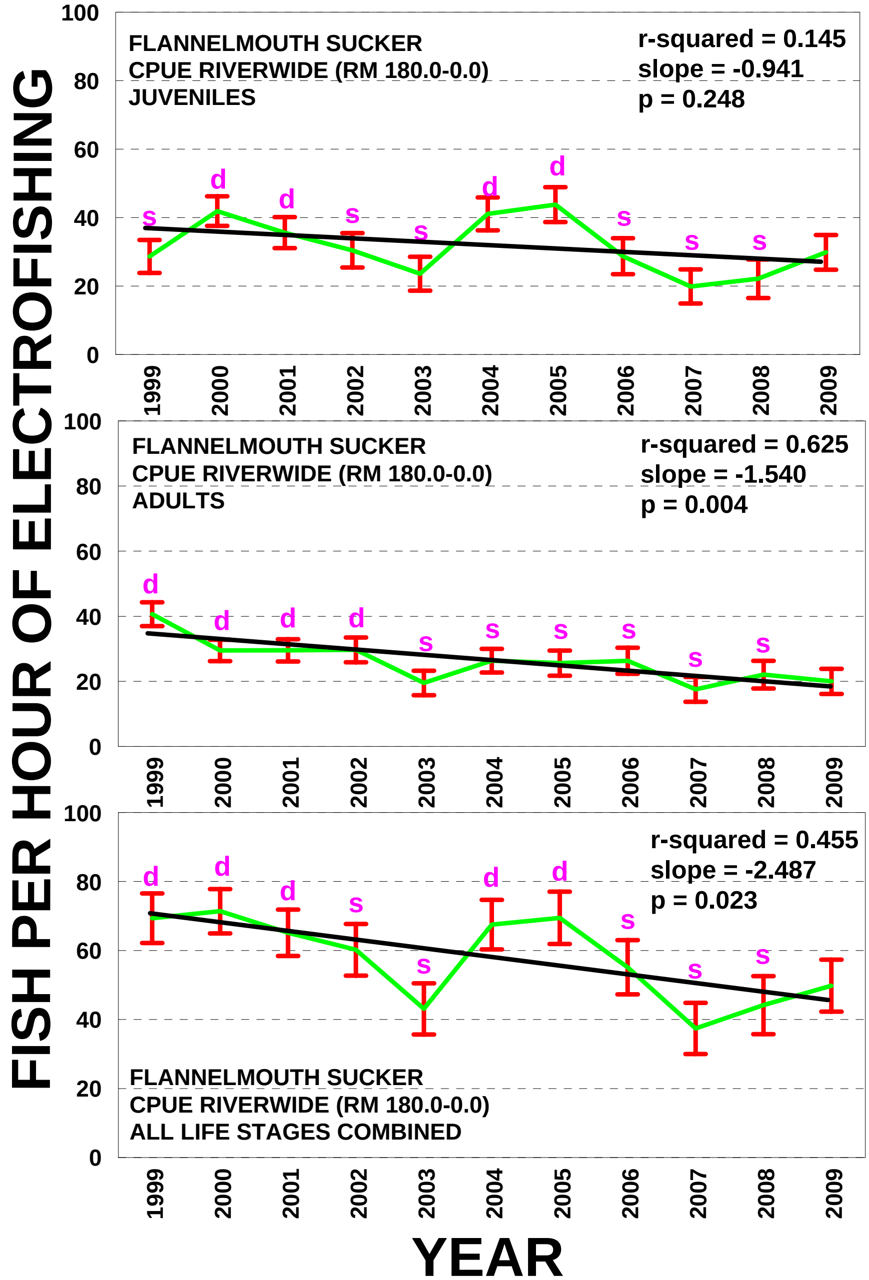

Figure 7. Flannelmouth sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 410 mm TL; top), adult fish ($\geq$ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2009 value. The letter "d" means the value is significantly different from the 2009 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

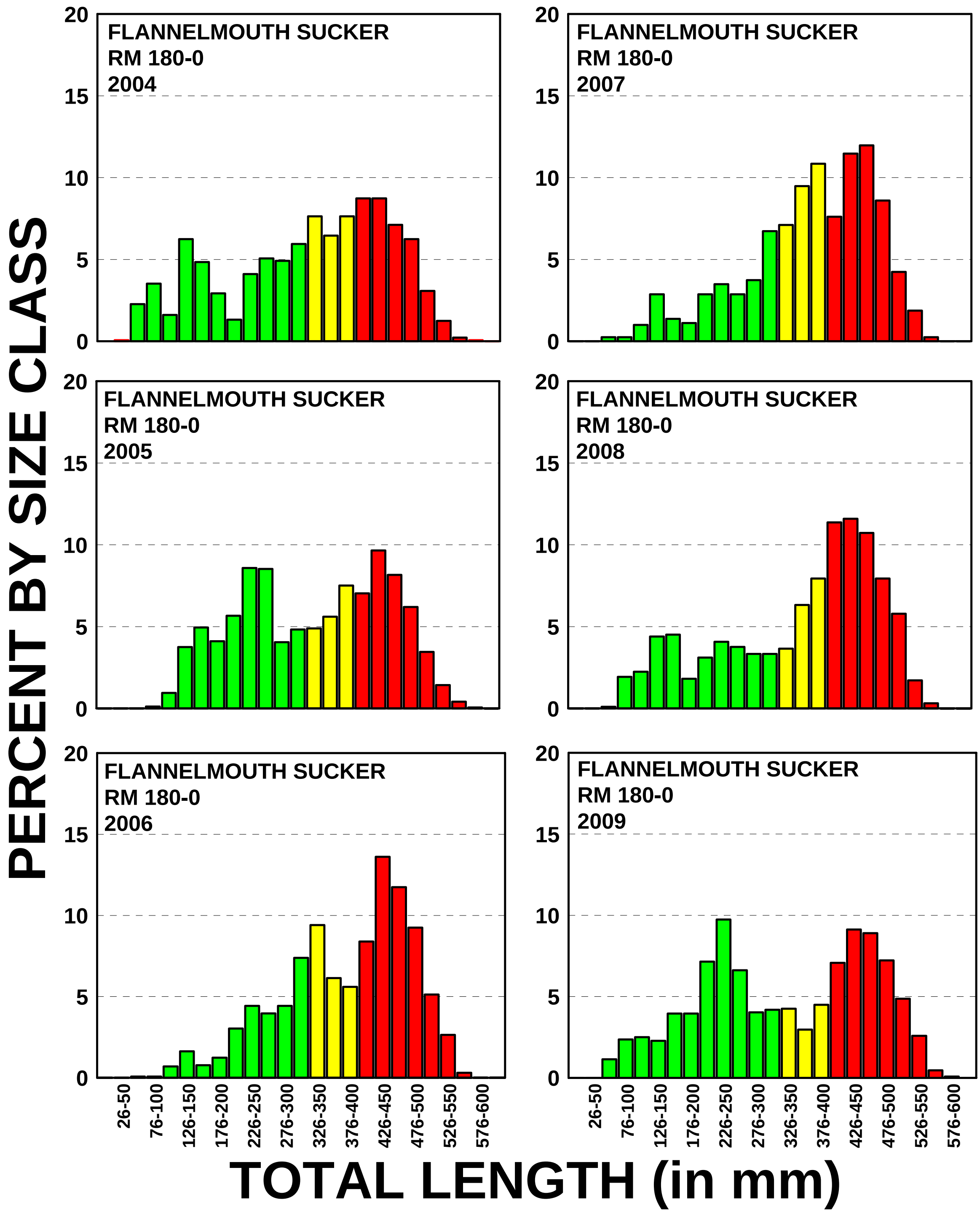

Figure 8. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of flannelmouth sucker on fall Adult Monitoring trips in the San Juan River, 2004-2009. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Bluehead Sucker

Catch Information

Bluehead sucker were the third most commonly-collected large-bodied fish species during 2009 Adult Monitoring (Table 3, Figure 9). The percentage of the total catch composed of bluehead sucker in 2009 (10.0%) was the lowest observed in the last 11 years (Figure 9). However, this was really due to an overall marked increase in channel catfish collections in the total catch (i.e., a proportional measurement metric) as opposed to any significant decrease in bluehead sucker CPUE abundance riverwide in 2009. Bluehead sucker were collected in Reaches 6-2 in 2009 (from RM 179.0-25.0). However, unlike the period from 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 either 2008 or 2009 (prior to 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. Bluehead sucker were collected in only 61.5% of all electrofishing collections during 2009 Adult Monitoring (Figure 9), the lowest observed value for the period 1999-2009.

Bluehead sucker adult CPUE has not changed significantly over the last 11 years (Figure 10). Thus, the changes in the bluehead sucker total CPUE are being driven completely by fluctuations in juvenile catch rates. Bluehead sucker juvenile CPUE in 2009 was not significantly different from seven of the previous ten years (Figure 10). The fluctuations seen in numbers of juvenile bluehead sucker appear to be cyclical events. 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 11 years (Figure 10).

Length Information

Bluehead sucker ranging from 71-493 mm TL (mean TL = 298 mm) were collected during 2009 Adult Monitoring. In 2009, the largest mode of the bluehead sucker length-frequency histogram was centered around a group of adult fish that were 376-400 mm TL, with next two most abundant groups being slightly younger adults (from 326-375 mm TL) that had apparently recruited into the adult population in 2008 (Figure 11). A smaller mode of recruiting subadult bluehead sucker was also apparent (from 251-300 mm TL) in 2009 (Figure 11).

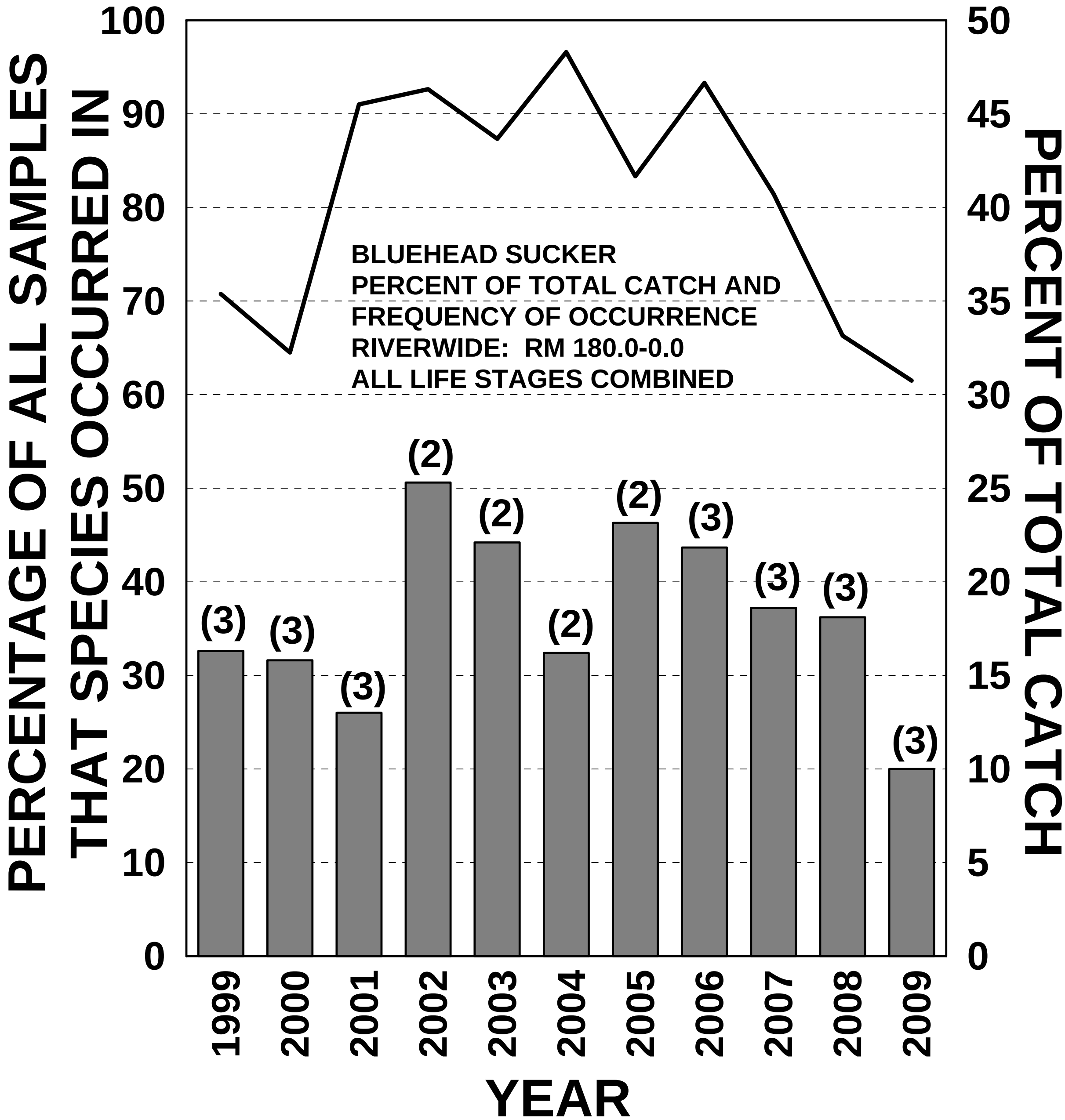

Figure 9. A summary of bluehead sucker relative abundance in riverwide Adult Monitoring collections, 1999-2009. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

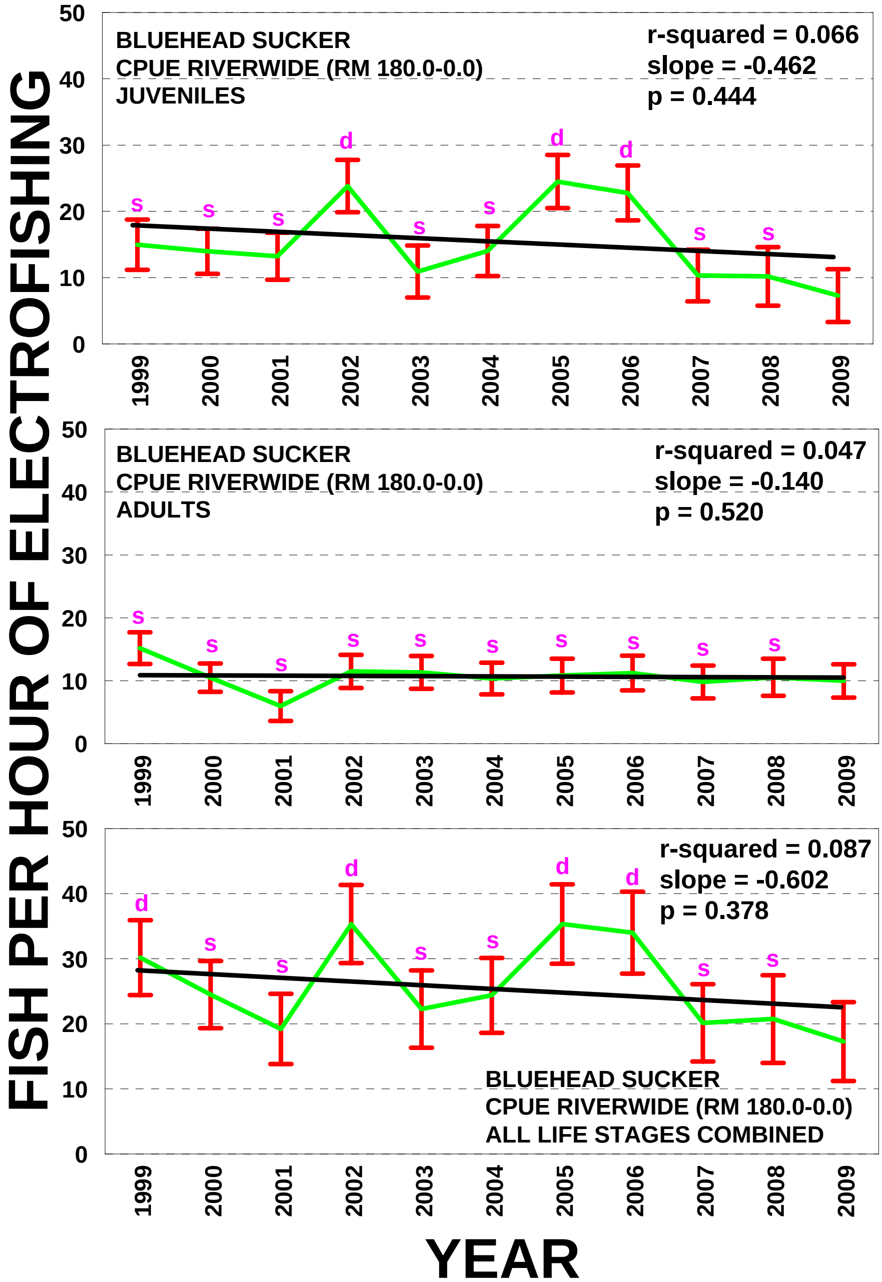

Figure 10. Bluehead sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2009 value. The letter "d" means the value is significantly different from the 2009 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

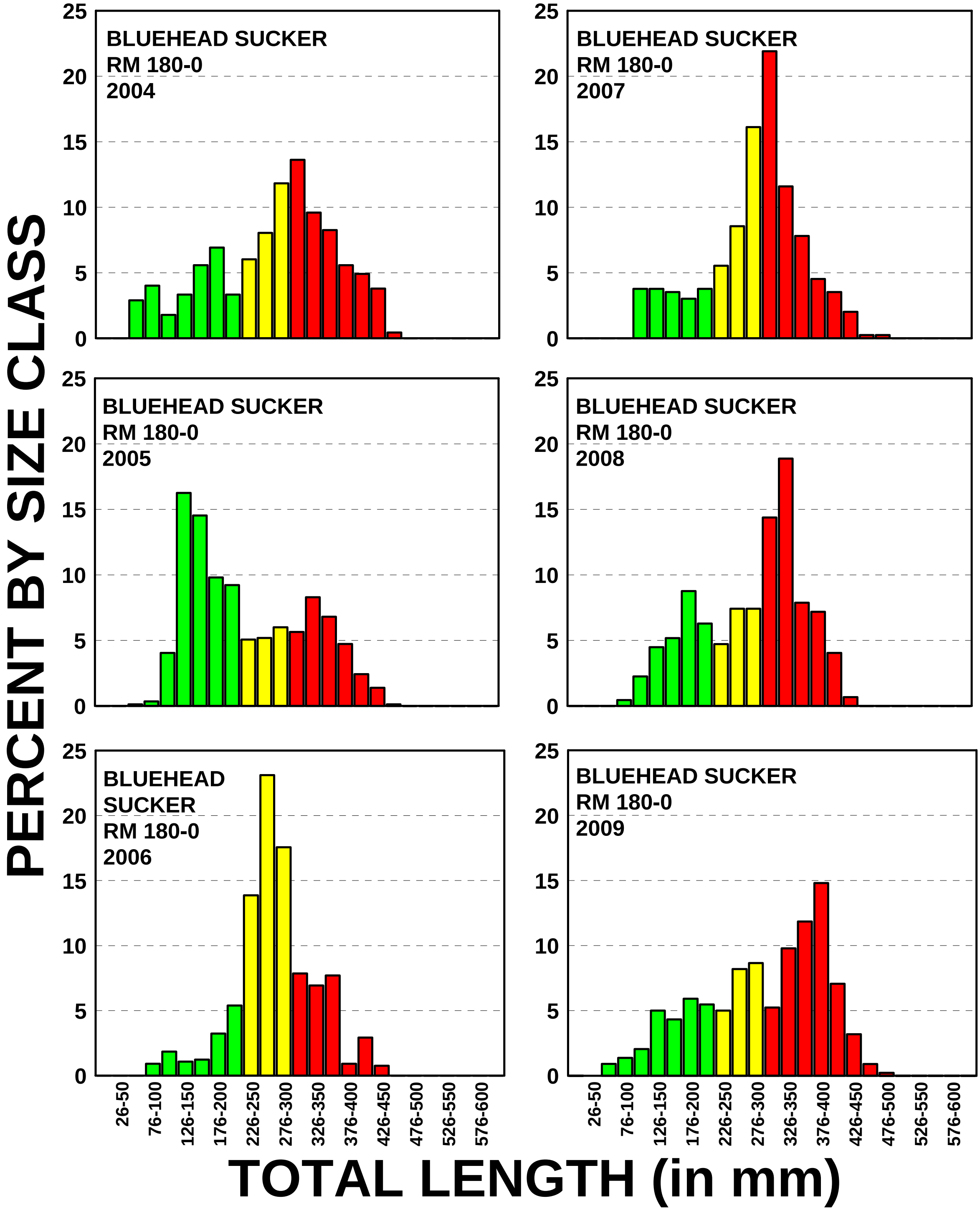

Figure 11. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of bluehead sucker on fall Adult Monitoring trips in the San Juan River, 2004-2009. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Common Nonnative Fishes

Channel Catfish

Catch Information

This was the first time in 19 years of Adult Monitoring trips (1991-2009) that channel catfish was the most numerous species in electrofishing samples (Table 3, Figure 12). Channel catfish accounted for 47.6% of the total catch and were collected in 88.3% of all electrofishing samples riverwide in 2009 (Figure 12). Channel catfish were collected in all six river reaches in 2009 (from RM 163.0-4.0).

Prior to 2009, the riverwide CPUE value for juvenile channel catfish had not changed significantly for the last five years (2004-2008). However the 2009 juvenile CPUE value was significantly higher than that for any previous year (Figure 13). 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). Yet while the 2009 juvenile CPUE value was significantly higher than that of any previous year, linear regression analysis indicated no significant change in the long-term trend for channel catfish juvenile CPUE, for the period 1999-2009 (Figure 13). The riverwide CPUE value for adult channel catfish has not changed significantly for the last four years and remained among the five highest values observed for adult channel catfish since 1999 (Figure 13). 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 14). 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 14).

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 14).

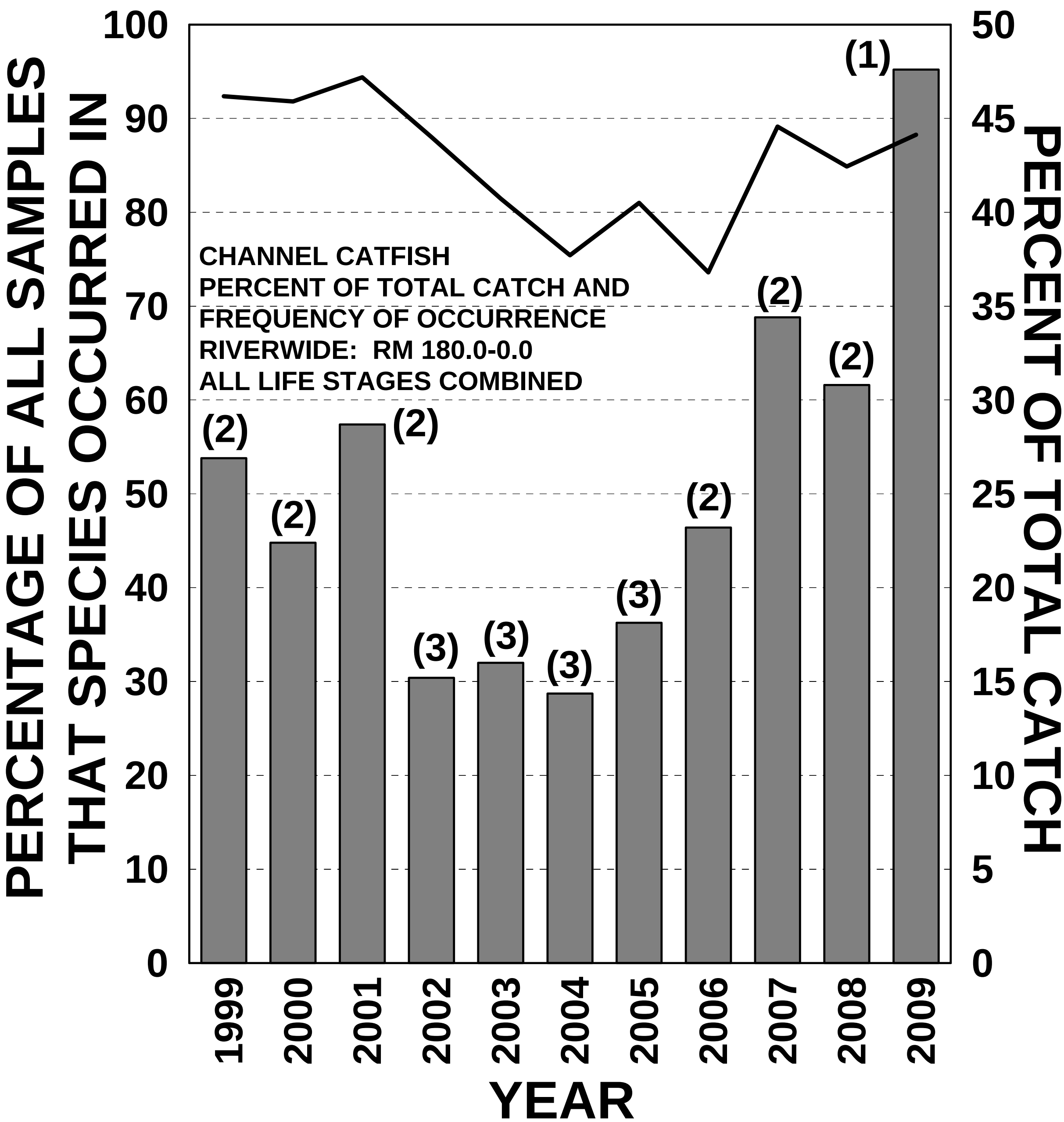

Figure 12. A summary of channel catfish relative abundance in riverwide Adult Monitoring collections, 1999-2009. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

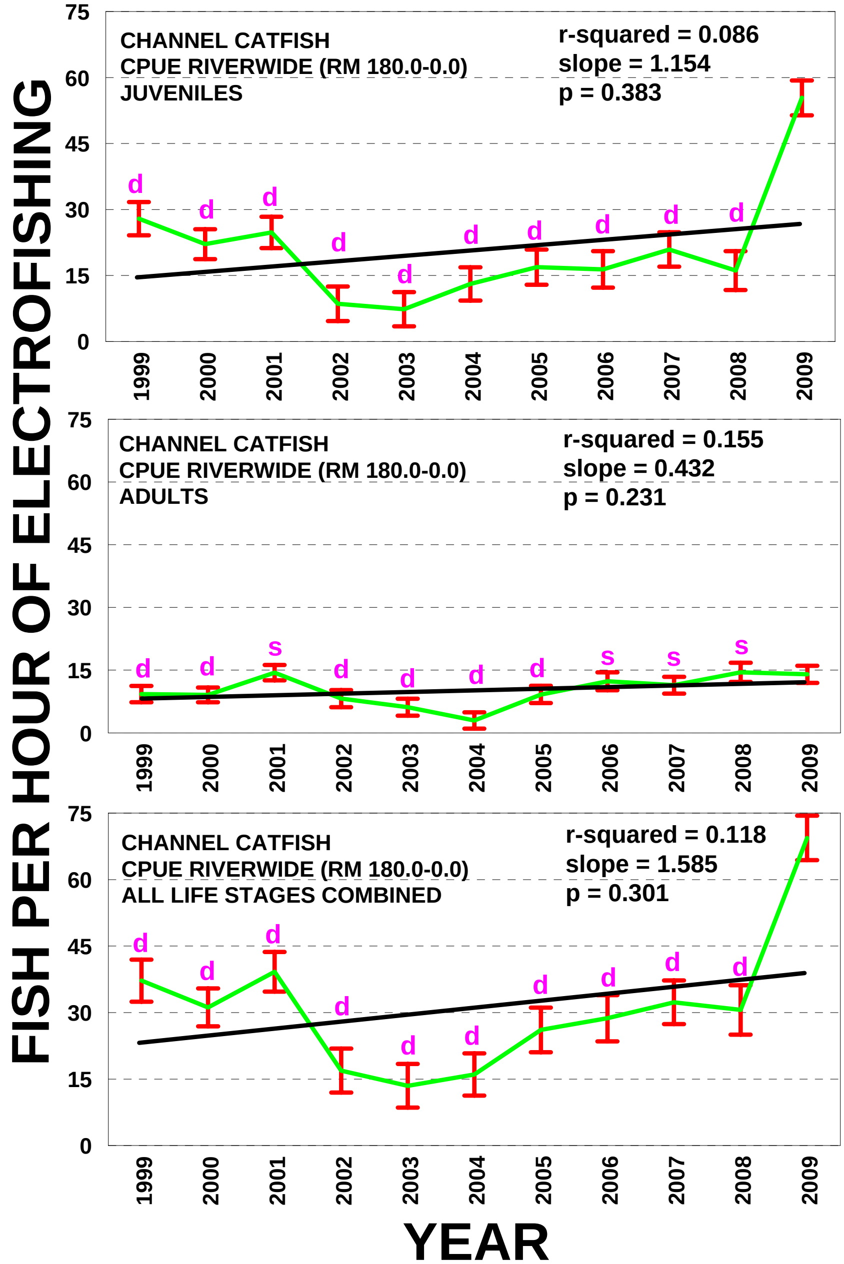

Figure 13. Channel catfish CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish ($\geq$ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2009 value. The letter "d" means the value is significantly different from the 2009 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

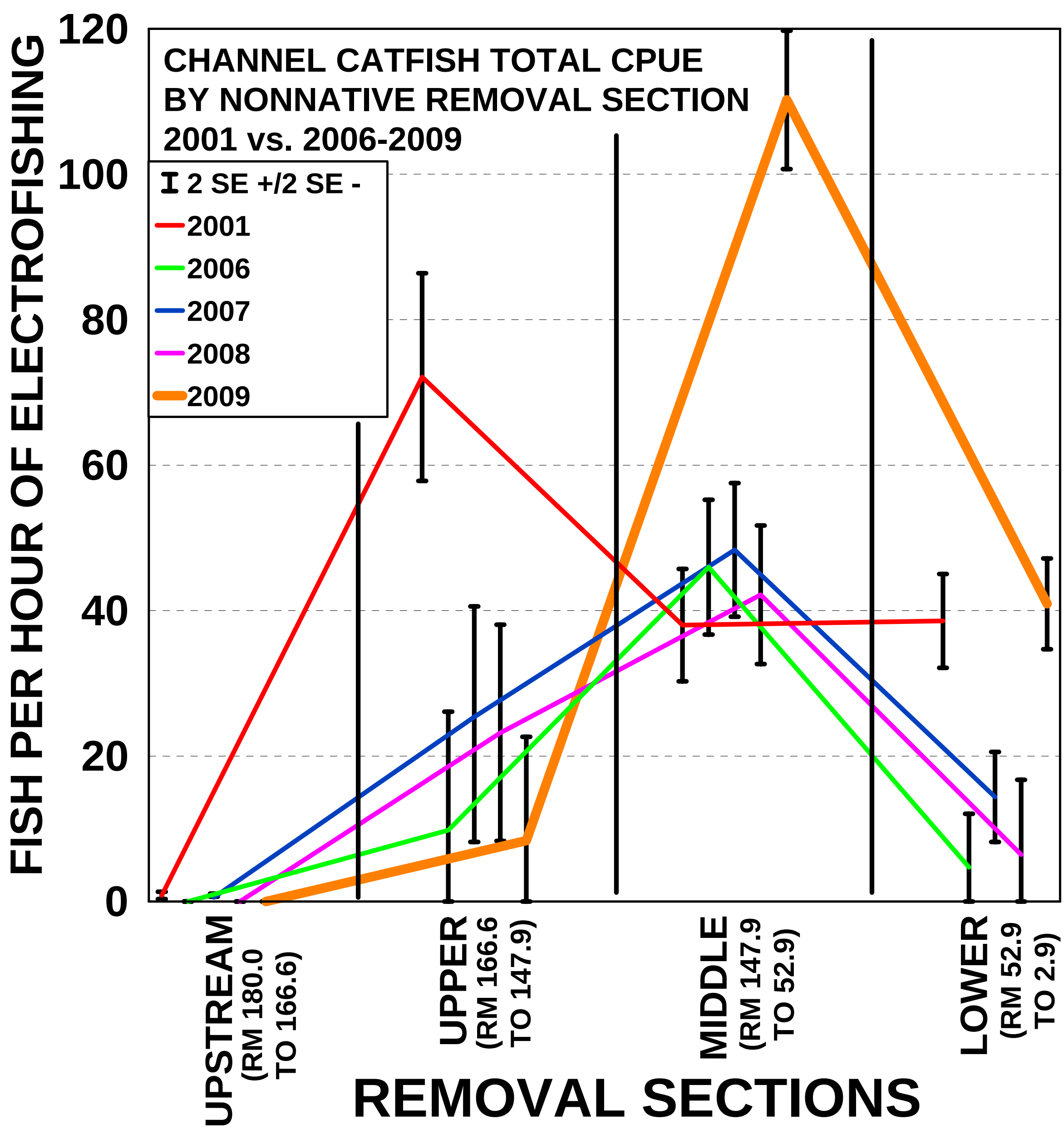

Figure 14. A comparison of channel catfish total CPUE within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2009. Lines represent the mean total CPUE values for each year, by river section. Error bars are +/- 2 SE.

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 $\leq$ 0.001) from 2006-2008 than they were in 2001 (Figure 14). 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 split, essentially evenly, 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 15).

In 2009, an unprecedented increase in channel catfish juvenile CPUE was observed in the middle nonnative fish removal section (Figures 14). 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 14). In 2009, 67.9% (n = 5,069) of all the channel catfish collected riverwide were $\leq$ 250 mm TL (Figure 16). 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 15). The large majority (91.4%) of these juvenile fish were collected from RM 109-40, in the lower 57 miles (i.e., lower 60%) of the middle nonnative fish removal section or the top 10 miles (i.e., top 20%) of the lower nonnative fish removal section (Figure 16).

At the same time, a significant decline in channel catfish biomass was observed in the upper nonnative fish removal section in 2009, when compared to 2007 and 2008 values (Figure 15). Most of the adult channel catfish collected in 2009 were collected in the middle nonnative fish removal section, specifically from RM 119-40 (Figure 16).

Length Information

Channel catfish ranging from 41-726 mm TL (mean TL = 227 mm) were collected during 2009 Adult Monitoring. In the 2009 length-frequency histogram, the largest groups of channel catfish were fish $\leq$ 250 mm TL (Figure 17). These fish consisted of three distinct groups: age-2 fish (centered around 201-225 mm TL); age-1 fish (centered around 101-150 mm TL); and age-0 fish mode centered around 51-75 mm TL). Large influxes of young channel catfish have been evident in length frequency histograms over the last six years (Figure 17).

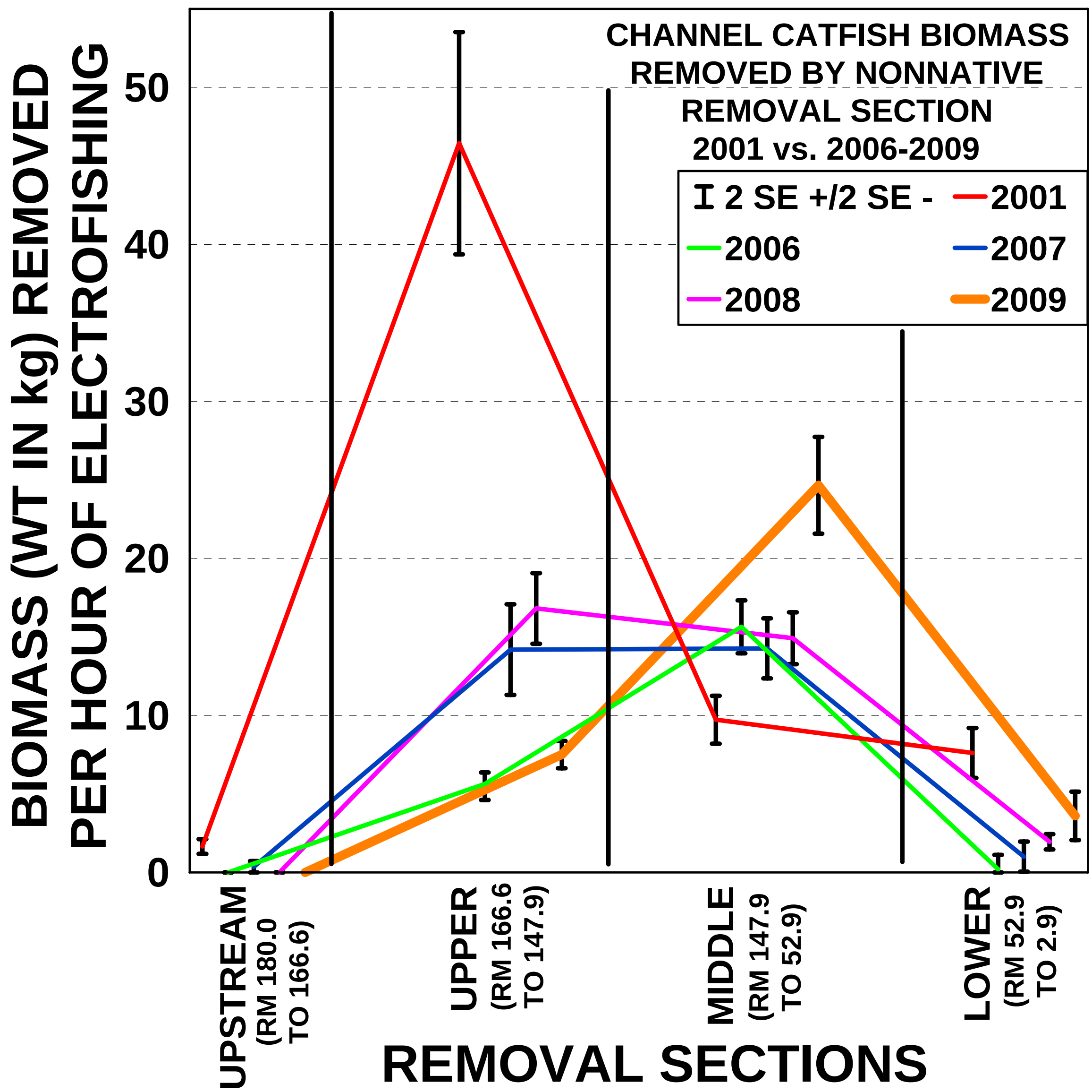

Figure 15. A comparison of the amount channel catfish biomass that was removed from within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2009. Lines represent the total amount of biomass (in kg) removed each year, by river section. Error bars are +/- 2 SE.

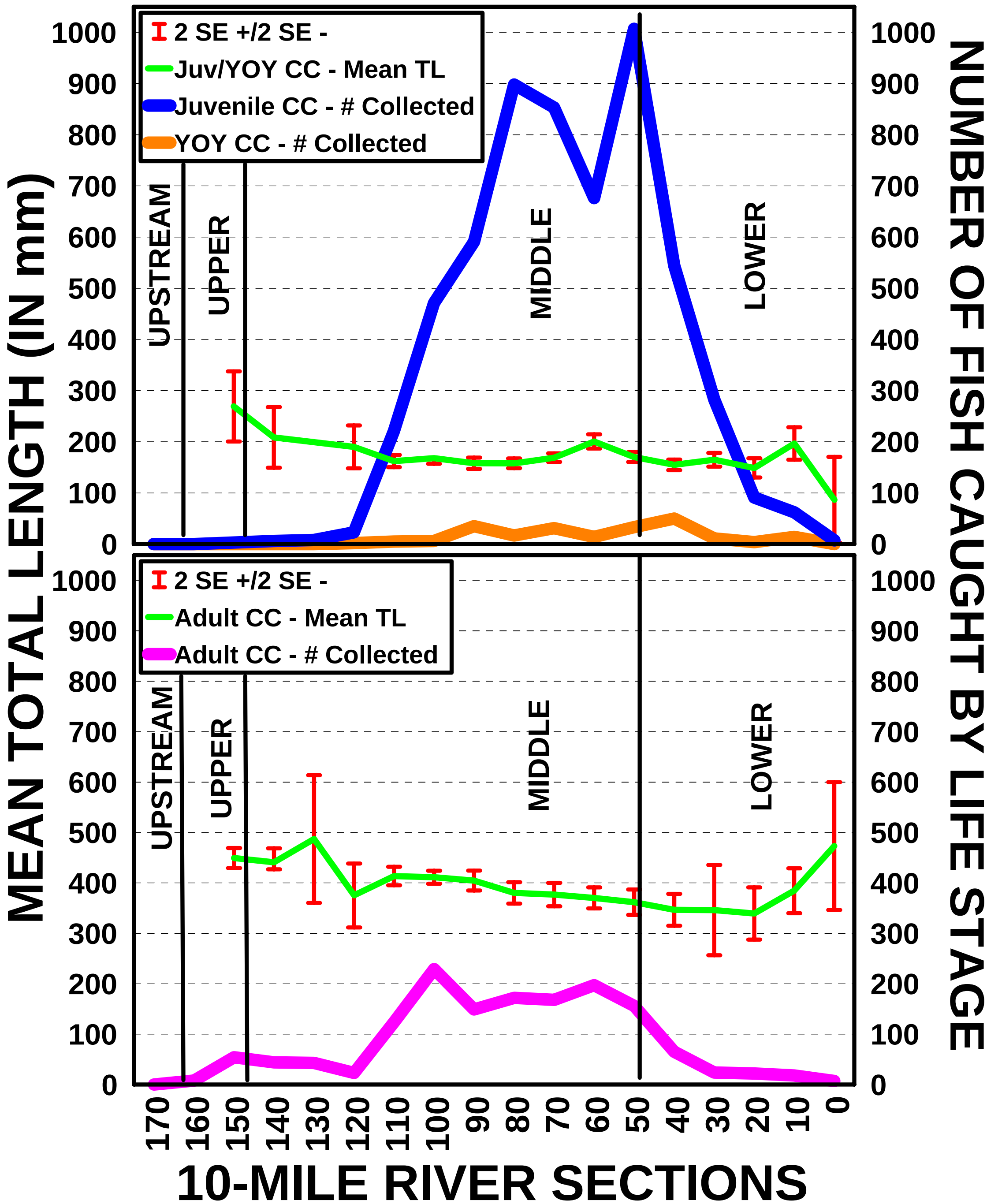

Figure 16. Total number of channel catfish, by life stage, collected within each 10-mile river section of the Adult Monitoring study area in 2009 (orange, blue, and purple lines). Mean total length (green line) is also shown for both adult and sub-adult (YOY and juvenile fish combined) channel catfish for each 10-mile river section. Red error bars are +/- 2 SE. Boundaries of the various nonnative fish removal sections are indicated by vertical labels and solid black vertical lines.

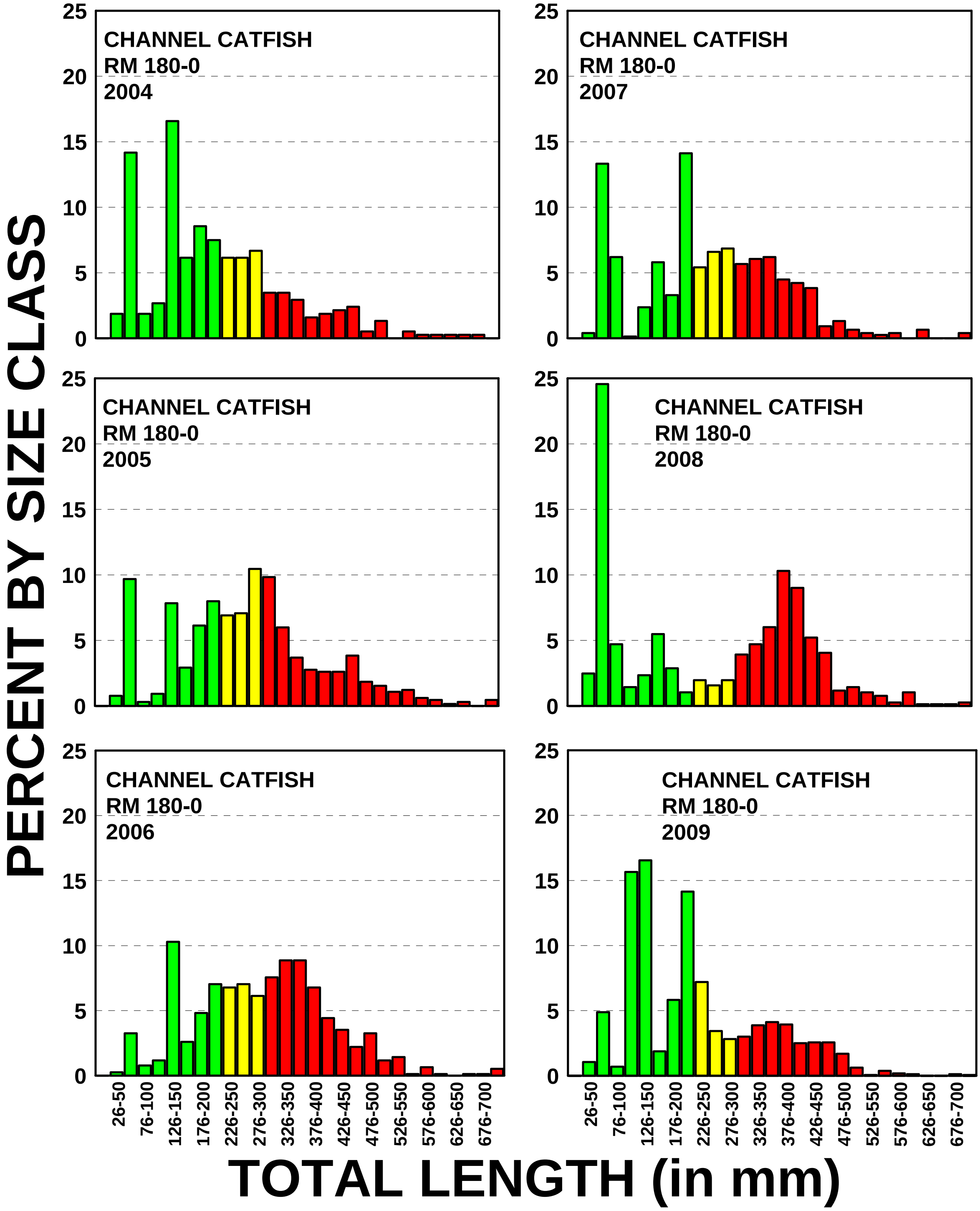

Figure 17. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of channel catfish on fall Adult Monitoring trips in the San Juan River, 2004-2009. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

Common Carp

Catch Information

Common carp were the sixth most commonly-collected fish during 2009 Adult Monitoring (Table 3, Figure 18). This marks the sixth consecutive year that common carp have not been among the four most commonly-collected fish species during Adult Monitoring (Figure 18). Only 137 total common carp were collected riverwide in 2009 (Table 3), of which 85 (62.0%) were juveniles (i.e., < 250 mm TL) and 52 were adults. Common carp were collected from all six river reaches in 2009 (from RM 177.5-7.0). However, most were collected from in Reaches 4 (n = 42; 30.7%) and 3 (n = 55; 40.1%).

In 2009 common carp accounted for only 0.9% of the total catch and was collected in just 31.9% (n = 68) of electrofishing samples riverwide (Table 3, Figure 18). A single common carp was collected in 35 samples. However, 2 carp were collected in 17 samples, 3 carp in 8 samples, and 2 samples each had either 4, 5, 6, or 7 common carp in them. When more than one common carp were collected in a sample they were almost always collected in very close proximity to one another, often within a few feet of each other.

Common carp juvenile CPUE was not significantly different than seven of the previous ten years and was significantly lower than the pulses of juvenile common carp observed in 2000, 2002, and 2004 (Figure 19). 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 three years and has continued to remain significantly lower than the 1999-2006 period (Figure 19).

Length Information

Common carp ranging from 63-632 mm TL (mean TL = 236 mm) were collected during 2009 Adult Monitoring. Juvenile common carp (in particular those centered around 76-125 mm TL) were very prevalent in the 2009 length-frequency histogram, as was the case in 2008 (Figure 20). Over half (62.2%) of all common carp measured and weighed in 2009 were $\leq$ 125 mm TL (Figure 20).

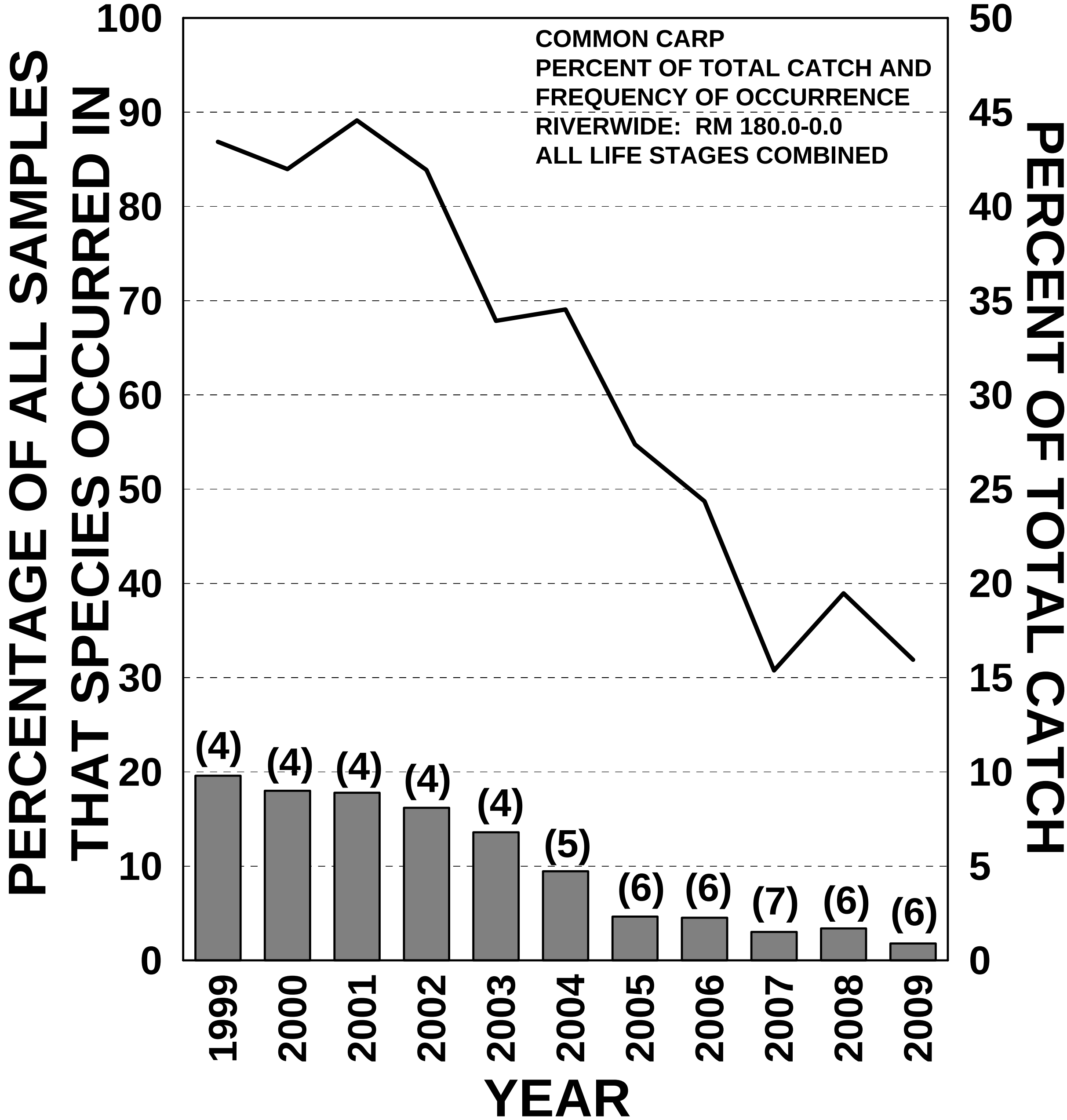

Figure 18. A summary of common carp relative abundance in riverwide Adult Monitoring collections, 1999-2009. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

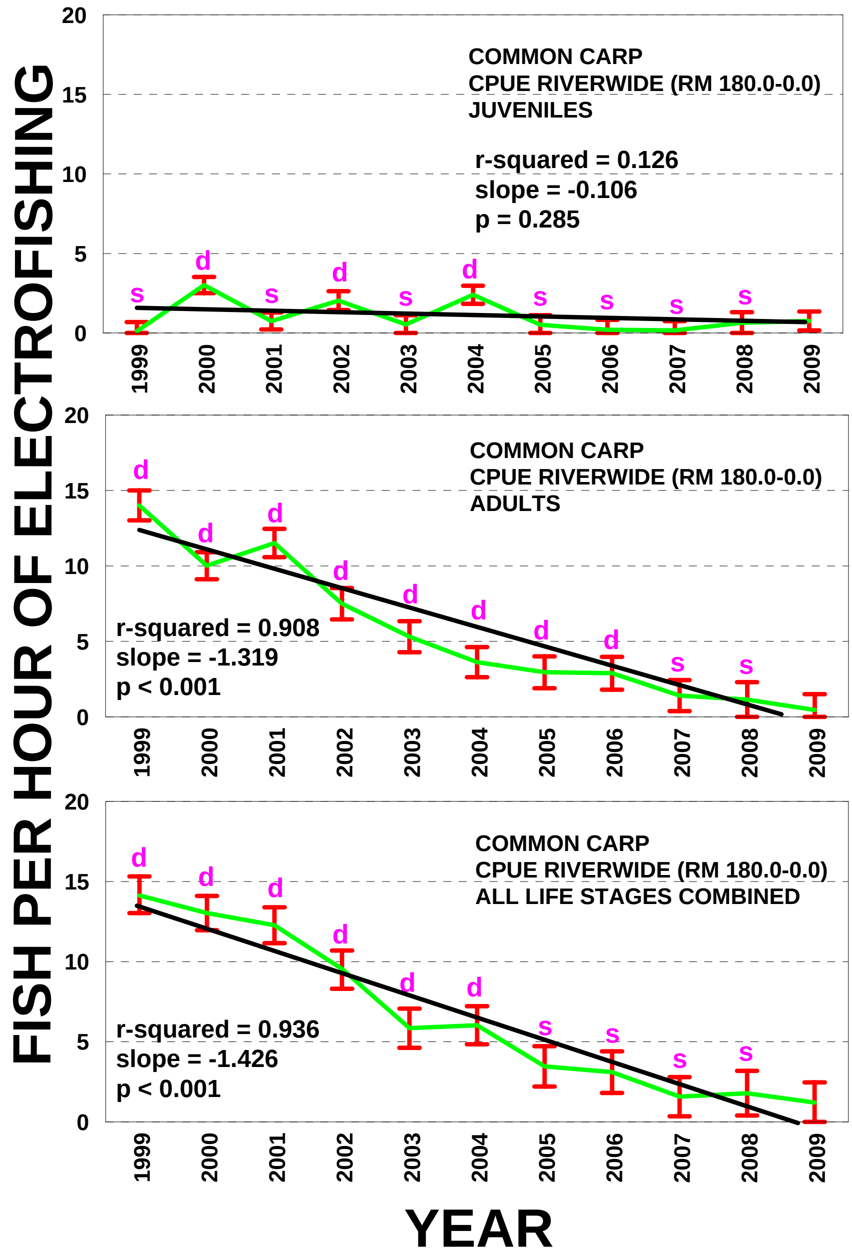

Figure 19. Common carp CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Purple letters are between year comparisons. The letter "s" means the value is not significantly different from the 2009 value. The letter "d" means the value is significantly different from the 2009 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

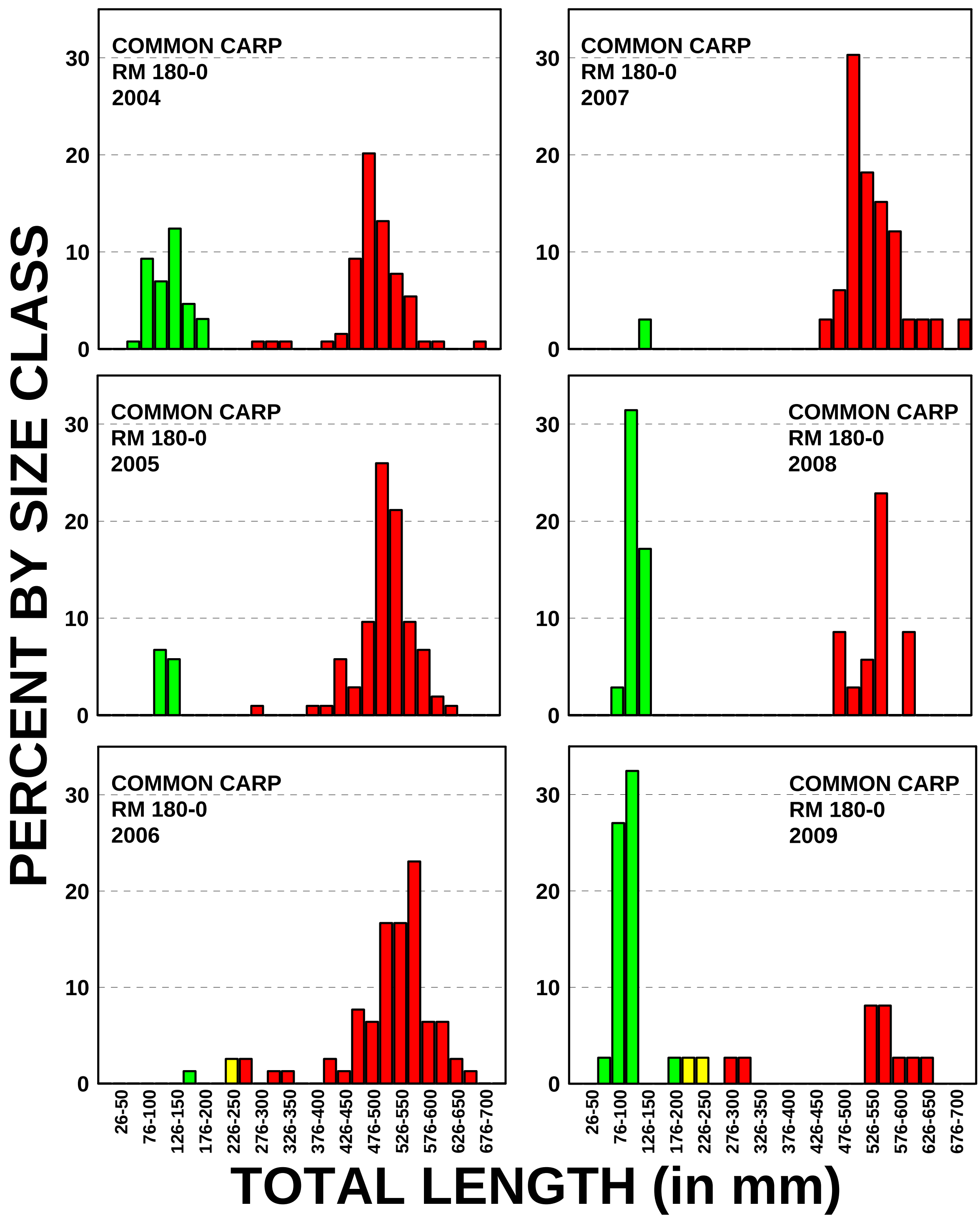

Figure 20. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of common carp on fall Adult Monitoring trips in the San Juan River, 2004-2009. Green bars are juvenile fish. Yellow bars are recruiting sub-adult fish. Red bars are adult fish.

DISCUSSION

Rare Native Fishes

Colorado Pikeminnow

Wild Colorado pikeminnow continue to be absent from Adult Monitoring collections. The 376 stocked Colorado pikeminnow collected during 2009 Adult Monitoring marked the sixth consecutive year that > 100 Colorado pikeminnow were collected during Adult Monitoring. While this is an encouraging trend, care must be taken when interpreting that result. The large numbers of Colorado pikeminnow being collected over the last six years reflect the large numbers of fish being stocked. Survivors from the large groups of Colorado pikeminnow stocked as age-0 fish are evident in Adult Monitoring collections for, at most, four overwinter periods post-stocking. In contrast, survivors from the smaller groups of older Colorado pikeminnow that have been stocked since 2003 are essentially absent from Adult Monitoring collections by their second overwinter period post-stocking.

Because stocked Colorado pikeminnow aren't being collected in Adult Monitoring samples after 3-4 overwinter periods post-stocking doesn't necessarily indicate they are no longer residing in the San Juan River. Survival estimates (Appendix A) predict that small numbers of these fish remain in the river, but that their numbers are low enough and they are widely distributed enough (i.e., one age-4 fish every 25.00 RM's for every 100,000 age-0 fish that are stocked) to avoid detection by electrofishing efforts, such as Adult Monitoring. A recent riverwide population estimate done for Colorado pikeminnow indicated that the capture probability for this species was 5% for any single electrofishing pass (J. E. Davis, pers. comm.; Appendix A). Calculations done in Appendix A indicate that at most, Adult Monitoring should have collected two age-4+ Colorado pikeminnow in 2009. According to these calculations, a maximum of two age-4+ fish should be expected in Adult Monitoring collections again in 2010.

Two pieces of information from other studies point to the continued persistence of small numbers of stocked Colorado pikeminnow into older age-classes. First, six adult Colorado pikeminnow (i.e., ≥ 450 mm TL) were collected during nonnative fish removal trips in 2009 (SJRIP PIT tag database). These six fish ranged from 450-616 mm TL and were all collected from RM 159.0-151.0. These six fish were all stocked Colorado pikeminnow that had subsequently recruited to adulthood. Five of these six fish were collected in either July (n = 2) or August (n = 3), after numerous electrofishing trips (with three passes per trip) had been performed through this river section. The sixth fish was captured on one of the first nonnative fish removal trips in this river section, in April 2009. However, this fish was not collected on the first pass of that particular trip. Second were the recent collections of four larval Colorado pikeminnow, one during 2009 (Brandenburg and Farrington 2010) and three during 2007 (Brandenburg and Farrington 2008). Although these four 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.

Colorado pikeminnow were collected in Reaches 6-1 in 2009 with the majority being collected in Reach 3. During 2009 Adult Monitoring, only eight Colorado pikeminnow (2.1%) were collected between PNM Weir (RM 166.6) and Hogback Diversion (RM 158.6). No Colorado pikeminnow were collected upstream of the PNM Weir in Reach 6 in 2009. Annually, Colorado pikeminnow continue to remain either low in number or absent in Adult Monitoring collections upstream of PNM Weir. When Colorado pikeminnow are collected upstream of the PNM Weir, they are almost always age-1 fish (i.e., fish that retained for only 1 overwinter period in this river section). Few age-2+ fish are ever collected upstream of PNM Weir. 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.

Starting in 2003, the SJRIP implemented stricter protocols for the handling, transport, tempering, stocking and acclimation of Colorado pikeminnow aimed at increasing long-term retention and survival among stocked fish. Scaled CPUE comparisons among Colorado pikeminnow stocked as age-0 fish showed that CPUE varied significantly among age-1 fish, with the scaled CPUE for age-0 fish stocked in fall 2002 (when these procedures were not yet in place) and recaptured as age-1 fish in 2003 being significantly lower than all but one other year. However, by the time Colorado pikeminow stocked as age-0 fish had reached age-2, scaled CPUE values were virtually identical among years. By age-3 and again at age-4 there were no significant differences whatsoever in scaled CPUE between years. Thus it would seem that the protocols implemented in 2003 help stocked Colorado pikeminnow survive in greater numbers through their first overwinter period, but seem to make little difference after that point.

Razorback Sucker

No wild razorback sucker were collected in 2009. The 84 stocked razorback sucker collected in 2009 marked the sixth 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. 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 2009 Adult Monitoring was just 84 fish. However, far fewer razorback sucker were stocked in 2008 and 2009 prior to sampling, so this drop in numbers of fish collected was probably to be expected.

Unlike Colorado pikeminnow however, some razorback sucker are retaining in the San Juan River for as long as 12 overwinter periods post-stocking. In addition, larval razorback sucker were collected for the twelfth consecutive year (1998-2009; Brandenburg and Farrington 2010). 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.

Between 2001 and 2009 a total of 17 razorback sucker X flannelmouth sucker hybrids were collected during Adult Monitoring trips. These fish were collected from RM 118.0-20.2. Three of these fish were juveniles (240-282 mm TL) and 14 were adults (420-510 mm TL). One of these fish was collected in 2001, 2 in 2003, 1 each in 2004 and 2005, 6 in 2006, 1 each in 2007 and 2008, and 4 in 2009. 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?

Razorback sucker were collected from all six geomorphic reaches in 2009, although their numbers were very low in the canyon-bound Reach 2 (n = 2) and Reach 1 (n = 1). Thirteen razorback sucker (15.5%) were collected upstream of Hogback Diversion in 2009, with six of these being collected between APS Diversion (RM 163.7) and PNM Weir (RM 166.6). Razorback sucker from the NAPI grow-out ponds were stocked immediately downstream of PNM Weir (at RM 166.5) in 2009, 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. Despite these razorback sucker being released upstream of the PNM fish ladder, none of them were documented as having retained between the PNM Weir and the Animas River confluence during the October Adult Monitoring trip.

Common Native Fishes

Flannelmouth Sucker

For the first time in 19 years of Adult Monitoring trips, flannelmouth sucker were not the most abundantly-collected large-bodied fish species in the San Juan River. However, this apparent change in status was not the result of a decline in flannelmouth sucker abundance in 2009, but rather an artifact of the marked increase in channel catfish abundance. Flannelmouth sucker CPUE values have not changed significantly among juvenile fish for the last four years and among adult fish for the last seven years. In addition, flannelmouth sucker still had the widest distribution of any species in 2009, being collected in 194 (91.1%) of 213 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 11 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 11 years.

Bluehead Sucker

Bluehead sucker continue to be among the three most common large-bodied fish species collected during Adult Monitoring. 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 eleven 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 11 years. Likewise, the long-term trend line for adult bluehead sucker CPUE riverwide has also shown no significant change over the last 11 years. In fact, there were no significant differences between the 2009 adult bluehead sucker CPUE value and that observed for any of the previous ten years.

Common Nonnative Fishes

Channel Catfish

Channel catfish were the most common fish, native or nonnative, collected during 2009 Adult Monitoring. They continue to be collected in all six geomorphic reaches, although their numbers in reaches encompassed by nonnative fish removal efforts have been noticeably reduced. In 2009, an unprecedented increase in channel catfish juvenile CPUE was observed in the middle nonnative fish removal section (RM 147.9-52.9), specifically from RM 109-40. This portion of the San Juan River was literally choked with very high numbers of juvenile channel catfish (≤ 250 mm TL) in 2009. This large increase in fish ≤ 250 mm TL caused significant increases in both juvenile and total CPUE in 2009, when compared to previous years. Likewise, the majority of adult channel catfish were collected from RM 119-40 in 2009.

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. Whether the marked increase in juvenile catfish numbers observed in 2009 is due to more space and resources being available for smaller fish as larger individuals are 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.

Calendar year 2009 had a fairly small peak (6,090 CFS on 3 June 2009) and short duration (71 days from 23 April to 3 July 2010) runoff period to its hydrograph (at the Shiprock, NM USGS gage: #09368000). Even during the tail end of this runoff period there were nine days during which mean daily streamflows were < 1,200 CFS. During the 251 days between 15 August 2008 and 23 April 2009 (i.e., the period preceding 2009 runoff), there were only 6 days during which mean daily streamflows were ≥ 1,200 CFS. Likewise, during the 273 days between 3 July 2009 and 2 April 2010 (i.e., the period since 2009 runoff), there hasn't been a single day when mean daily streamflows were ≥ 1,200 CFS. Low, stable instream flows during summer and fall 2008, winter 2008-2009, and into spring 2009, combined with a low peak flow, short duration 2009 runoff, and another low, stable period of flows during summer and fall 2009, winter 2009-2010, and into spring 2010 could very well be a contributing factor to the increased survival and retention of young channel catfish. If so, then unless 2010 provides a high peak or long duration runoff event, channel catfish CPUE values could remain very high during 2010 sampling efforts.

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 sixth most commonly-collected species during 2009 Adult Monitoring. Common carp were collected in all six geomorphic reaches in 2009. However, most were collected in Reaches 4 and 3. Over the last ten 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 2009 than were endangered Colorado pikeminnow. Common carp accounted for less than 1.0% of the total catch and were collected in less than a third of all electrofishing samples riverwide in 2009. Only 137 common carp were collected during 2009 Adult Monitoring, with 85 (62.0%) of these being juvenile fish. Only 52 adult common carp were collected in 213 electrofishing samples in 2009. 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.

During the 2008 runoff season, there were 21 days of out-of-bank flows (> 8,000 CFS). These out-of-bank flows should have given the adult common carp in the San Juan River an opportunity for a relatively successful spawning season. These high flows should have given adult common carp access to spawning habitats (e.g., flooded vegetation) that had not been available to them for several years, due to low flows. However, 2008 and 2009 Adult Monitoring collections did not indicate that any successful, large-scale spawning event took place among common carp in 2008. At least not one that translated into increased numbers of common carp being collected during Adult Monitoring. It is possible that numbers of adult common carp are now reduced enough to make large-scale spawning unlikely.

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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 a seven-year period (2002-2008) in an attempt to do some preliminary survival calculations. 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 2002-2008.

METHODS

Captures of Colorado pikeminnow from Adult Monitoring trips from 2003-2009 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 up 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 2009 riverwide population estimate for Colorado pikeminnow (J. E. Davis, pers. comm.). 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 age4). 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 2002-2008. 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 2002-2008, 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 2003-2008 (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). By age-2, this wide variation had dropped to 2.67-6.33 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 0.00-0.17 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. However, this apparent benefit does not appear to carry over into subsequent years. In fact, at age-2 and beyond, Colorado pikeminnow from the fall 2002 stocking of age-0 fish demonstrated survival numbers that were just as good, if not better than those for comparable cohorts of age-0 Colorado pikeminnow stocked from 2003-2008 (Table A-3). In addition, the only age-4 Colorado pikeminnow collected during Adult Monitoring studies since 2003 came from the fall 2002 stocking of age-0 fish.

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 25.00 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 57 total age-4 to age-7 fish occupying our 180 RM study area in fall 2009 (i.e., 22 age-4 fish, 17 age-5 fish, 9 age-6 fish, and 9 age-7 fish; Table A-7). Given a 5% capture probability, we could have been expected to collect 2.85 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 1.90 (or two) age-4+ fish in 2009. In fact, we collected none. The expected and actual collection numbers don't match exactly (i.e., 1.90 age-4+ fish expected versus none collected), but the fact is that they are both very small. If you do this same set of calculations for 2010 Adult Monitoring, it would predict that we should again expect to collect about two age-4+ fish (i.e., 72 age-4+ fish expected {from Table A-7} X .05 capture probability X 2/3 {0.667} of all RM being sampled = 2.40 age-4+ fish expected to be collected).

This exercise has been enlightening in helping explain why age-4+ Colorado pikeminnow have, so far, been extremely rare in Adult Monitoring collections. Table A-7 predicts that there are 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 problematic at this time. However, this should become less of an issue over the next several years as numbers of age-4+ Colorado pikeminnow from stockings are expected to keep increasing steadily (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
2002 (210,418)	32	16	3	1	0	0	0
2003 (175,928)	-----	130	33	6	0	0	0
2004 (280,000)	-----	-----	67	26	2	0	0
2005 (302,270)	-----	-----	-----	171	20	0	0
2006 (313,854)	-----	-----	-----	-----	115	29	14
2007 (475,970)	-----	-----	-----	-----	-----	143	38
2008 (270,234)	-----	-----	-----	-----	-----	-----	282

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
2002 (210,418)	640	320	60	20	0	0	0
2003 (175,928)	-----	2,600	660	120	0	0	0
2004 (280,000)	-----	-----	1,340	520	40	0	0
2005 (302,270)	-----	-----	-----	3,420	400	0	0
2006 (313,854)	-----	-----	-----	-----	2,300	580	280
2007 (475,970)	-----	-----	-----	-----	-----	2,860	760
2008 (270,234)	-----	-----	-----	-----	-----	-----	5,640

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
2002 (210,418)	960	480	90	30	?	?	?
2003 (175,928)	-----	3,900	990	180	?	?	?
2004 (280,000)	-----	-----	2,010	780	60	?	?
2005 (302,270)	-----	-----	-----	5,130	600	?	?
2006 (313,854)	-----	-----	-----	-----	3,450	870	420
2007 (475,970)	-----	-----	-----	-----	-----	4,290	1,140
2008 (270,234)	-----	-----	-----	-----	-----	-----	8,460

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
2002 (210,418)	5.33	2.67	0.50	0.17	?	?	?
2003 (175,928)	-----	21.67	5.50	1.00	?	?	?
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
2007 (475,970)	-----	-----	-----	-----	-----	23.83	6.33
2008 (270,234)	-----	-----	-----	-----	-----	-----	47.00

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 = 1.46% Range = 0.46-3.13% (7 data points)	Mean = 29.61% Range = 11.70%-50.00% (6 data points)	Mean = 18.58% Range = 0.00%-48.28% (5 data points)	Mean = 8.33% Range = 0.00%-33.33% (4 data points)	Mean = 0.00% Observed Range = 0.00% (3 data points)	Mean = 0.00% Observed Range = 0.00% (2 data points)	Mean = 0.00% Observed Range = 0.00% (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)	1,460	432	80	7	0	0	0
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	8.11 (= 1 Fish Per Every 0.12 RMs)	2.40 (= 1 Fish Per Every 0.42 RMs)	0.44 (= 1 Fish Per Every 2.27 RMs)	0.04 (= 1 Fish Per Every 25.00 RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? 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 that was 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 = 1.63% Range = 0.72%-3.13% (6 data points)	Mean = 25.54% Range = 11.70%-38.81% (5 data points)	Mean = 18.54% Range = 0.00%-48.28% (4 data points)	Mean = 0.00% Observed Range = 0.00% (3 data points)	Mean = 0.00% Observed Range = 0.00% (2 data points)	Mean = 0.00% Observed Range = 0.00% (1 data point)	Mean = 0.00% Observed Range = 0.00% (0 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)	1,630	416	77	0	0	0	0
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	9.06 (= 1 Fish Per Every 0.11 RMs)	2.31 (= 1 Fish Per Every 0.43 RMs)	0.43 (= 1 Fish Per Every 2.33 RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? RMs)	0.00 (= 1 Fish Per Every ? 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 2002-2009 (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	7.20	15.15	12.88	10.95	9.30	7.91	6.72	5.71	4.86
2003	175,928	7.20		12.67	10.77	9.15	7.78	6.61	5.62	4.78
2004	280,000	7.20			20.16	17.14	14.57	12.38	10.52	8.95
2005	302,270	7.20				21.76	18.49	15.72	13.37	11.36
2006	313,845	7.20					22.60	19.21	16.33	13.88
2007	475,970	7.20						34.27	29.13	24.76
2008	270,234	7.20							19.46	16.54
2009	468,000	7.20								33.70
Total Numbers Of Fish Surviving At:										
Age-4			15	12	20	22	23	34	19	34
Age-5	Age-5+ fish count towards downlisting			12	11	17	18	19	29	17
Age-6					11	9	15	16	16	25
Age-7	Age-7+ (i.e., adult) fish count towards delisting					9	8	12	13	14
Age-8							8	7	11	11
Age-9								7	6	9
Age-10									6	5
Age-11										5

A: It is estimated that there is one surviving age-4 fish every 25.00 RM's (see Table A-5, page 51) per every 100,000 age-0 fish stocked. Extrapolated riverwide: 180 ÷ 25.00 = 7.2 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 7.2 (e.g., for 2002: 210,418 age-0 fish stocked ÷ 100,000 = 2.10418; then 2.10418 × 7.20 = 15.15 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) to doing multiple-pass, mark-recapture population estimate studies to obtain point estimates with an estimate of precision. These 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 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 (J. E. Davis, pers. comm.). 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, capturing 26 adult Colorado pikeminnow during a fall Adult Monitoring trip could indicate that the adult population is near 800 adults 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, capturing 4 age-6 (400-449 mm TL) Colorado pikeminnow during a fall Adult Monitoring trip could indicate 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+) could 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) could 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) could 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) could 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.