LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 2008

Interim Progress Report

(Final Report)

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22 May 2009

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EXECUTIVE SUMMARY

General Information

- A total of 8,729 fishes were collected during 2008 Adult Monitoring
    - Native fishes accounted for 67.2% of the total catch in 2008

Native Species:

- Colorado pikeminnow
    - No wild Colorado pikeminnow were collected in 2008
    - 207 stocked Colorado pikeminnow were collected in 2008
        - Fifth most abundant species collected
        - Scaled CPUE of Colorado pikeminnow that had been in the river for 1+ overwinter periods post-stocking has not changed significantly in four of the last five years
        - Sizes collected in 2008 ranged from 114-342 mm TL (age-1 to age-2)
        - Captures ranged from RM 176.0-11.0
            - 29 were collected in Reach 6, 76 in Reach 5, 63 in Reach 4, 35 in Reach 3, 3 in Reach 2, and 1 in Reach 1
        - 177 (85.5%) of these had been in the river $\leq$ 365 days post-stocking
            - All but 32 (15.5%) of these fish had been in the river for at least one overwinter period
        - After about four overwinter periods, Colorado pikeminnow stocked as age-0 fish are no longer being collected during Adult Monitoring
            - After about two overwinter periods, Colorado pikeminnow stocked at age-1 or older are no longer being collected during Adult Monitoring
- Razorback sucker
    - No wild razorback sucker were collected in 2008
    - 78 stocked razorback sucker were collected in 2008
        - 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 six years
        - Sizes ranged from 273-525 mm TL (age-1 through age-1 and age-8)
        - Captures ranged from RM 161.0-8.0
            - 19 were collected in Reach 6, 39 in Reach 5, 7 in Reach 4, 8 in Reach 3, 3 in Reach 2, and 2 in Reach 1
        - Of 45 razorback sucker captured with PIT tags in 2008, only 9 (20.0%) were in the river $\leq$ 365 days post-stocking
            - All 9 of these fish were in the river < 1 overwinter period when they were collected
        - Razorback sucker that have been in the river for 6 or more overwinter periods have been collected every year since 2001
- Roundtail chub
    - One roundtail chub was collected in 2008

- Flannelmouth sucker
    - The most abundant species collected in each of the last ten years
        - Accounted for 40.0% of the total catch (n = 3,491 fish)
        - Collected in 89.5% of all electrofishing samples from RM 180.0-2.9
        - Was collected in all six river reaches
- Bluehead sucker
    - Among the three most-commonly collected species in each of the last ten years
    - The third most common species collected in 2008
        - Accounted for 18.1% of the total catch (n = 1,580 fish)
        - Collected in 66.3% of all electrofishing samples from RM 180.0-2.9
        - Was collected in Reaches 6-2 in 2008

Nonnative Species:

- Channel catfish
    - Among the three most commonly-collected species in each of the last ten years
    - The second most abundant species collected in 2008
        - Accounted for 30.8% of the total catch (n = 2,686 fish)
        - Collected in 84.9% of all electrofishing samples from RM 180.0-2.9
        - In 2008 the majority of channel catfish were collected in the middle portion of our study area (i.e., from RM 147.9-52.9) with numbers being considerably reduced both up- and downstream of that area
            - Due to the presence of adult fish, the largest percentage of channel catfish biomass was found upstream, from RM 166.6-147.9
- Common carp
    - Percent of total catch accounted for by this species has decreased steadily over the last ten years (from 9.8% in 1999 to 1.7% in 2008)
        - Was the fourth most commonly-collected species in 1999
    - The sixth most commonly-collected species in 2008
        - Only 145 common carp were collected from RM 180.0-2.9 in 2008
        - Collected in 39.0% of all electrofishing samples from RM 180.0-2.9
        - Common carp were less abundant than were endangered Colorado pikeminnow during 2008 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, modification or removal of 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 over the duration of the SJRIP, a long-term monitoring program (Propst et al. 2000) was initiated. Standardized data collection following long-term monitoring protocols began in 1999 and is scheduled to continue throughout 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.

The objectives of Adult Monitoring (as stated in the FY-2008 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.

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 2008 followed the protocols for long-term monitoring set forth in Propst et al. (2000). 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) will not be 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 also 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 were then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain scaled CPUE values (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 were 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. The scaled number of razorback sucker were then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain scaled CPUE values (i.e., the scaled number of fish per hour of electrofishing). Scaled CPUE were then log-transformed (i.e., ln{scaled CPUE + 1}) prior to all analysis (Golden and Holden 2005, Robertson and Holden 2007, R. Ryel pers. comm.).

Using log-transformed, scaled CPUE values made data directly comparable between age-classes and stocking years despite the differences in numbers of fish stocked between years. Analysis of variance (ANOVA) using Tukey's Honestly Significant Difference (Tukey's HSD) multiple-comparison post hoc tests, was then used to determine if significant differences in CPUE values occurred between years. Significance was determined at $p < 0.10$ (following Ryden 2000).

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 {i.e., Reaches 6-1 -- RM 180.0-0.0} basis) 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 of the six large-bodied fish species were then compared to 1999-2007 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).

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 2008 Adult Monitoring trip was 638 CFS (Table 1). This was the lowest average sampling flow in the last five years of Adult Monitoring, but it was close to the average sampling flows encountered during Adult Monitoring trips from 2000-2003.

Nineteen fish species and hybrids were collected during the 2008 Adult Monitoring trip (Table 2). This included six native species and two native sucker X native sucker hybrids, as well as nine nonnative species and two native sucker X nonnative sucker hybrids (Tables 2 and 3). Seven species (flannelmouth sucker, channel catfish, bluehead sucker, speckled dace, Colorado pikeminnow, common carp, and razorback sucker) accounted for 99.3% (8,671 fishes) of the total catch during the 2008 Adult Monitoring trip. The other eight species and four hybrids contributed only 0.7% (58 fishes) to the total catch in 2008 (Table 3). Native fishes dominated the total catch in 2008 (Table 3). For the fifth 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, 1999-2008.

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)
10-year statistics: Mean = 1,124 CFS (31.7 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 2008 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
C.commersoni X C.latipinnis	Hybrid	Introduced	comXlat
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			
Micropterus salmoides	largemouth bass	Introduced	Micsal
Order Salmoniformes: Family Salmonidae – trouts			
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 2008 Adult Monitoring trip.

Species (Status)[a]	Number Collected	Percent Of Total[b]	Number Of Samples Collected In
flannelmouth sucker (N)	3,491	40.0	154
channel catfish (I)	2,686	30.8	146
bluehead sucker (N)	1,580	18.1	114
speckled dace (N)	484	5.5	80
Colorado pikeminnow (N)	207	2.4	79
common carp (I)	145	1.7	67
razorback sucker (N)	78	0.9	41
bluehead sucker X flannelmouth sucker (H, N)	21	0.2	19
black bullhead (I)	10	0.1	10
largemouth bass (I)	6	-----	6
red shiner (I)	4	-----	4
white sucker X bluehead sucker (H, I)	4	-----	4
fathead minnow (I)	3	-----	3
white sucker (I)	3	-----	3
brown trout (I)	2	-----	2
yellow bullhead (I)	2	-----	2
roundtail chub (N)	1	-----	1
razorback sucker X flannelmouth sucker (H, N)	1	-----	1
white sucker X flannelmouth sucker (H, I)	1	-----	1
GRAND TOTAL	8,729		
Total Electrofishing Collections In 2008 = 172 Total Electrofishing Effort In 2008 = 83.88 Hours			
2008 Native Fishes = 5,863 (67.17% Of The Total Catch) 2008 Introduced Fishes = 2,866 (32.83% Of The Total Catch) 2008 Native To Introduced Fishes Ratio = 2.04:1			
a: (N) = Native species; (I) = Introduced species; (H, N) = A hybrid of two species, considered to be a native fish; (H, I) = A hybrid of two species, considered to be an introduced fish b: ----- = less than 0.1%			

Rare Native Fishes

Colorado Pikeminnow

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

Colorado pikeminnow captures ranged from RM 176.0-11.0 (Table 4). The majority (n = 203; 98.1%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Fourteen (6.8%) of these collections occurred upstream of the Hogback Diversion (RM 158.6). None of the Colorado pikeminnow caught upstream of Hogback Diversion had PIT tags upon collection. Thirteen of them (119-179 mm TL) were from the fall 2007 stockings of age-0 fish, but one (270 mm TL) was from the fall 2006 stockings of age-0 fish. Twenty-nine Colorado pikeminnow were collected in Reach 6, 76 in Reach 5, 63 in Reach 4, 35 in Reach 3, 3 in Reach 2, and 1 in Reach 1.

Table 4. General information on stocked Colorado pikeminnow collected in 2008.

Age At Capture & (Number Captured)	Size Range At Capture (TL in mm)	Range of Capture RM's	Days In River Post-Stocking (Number Of Overwinter Periods)	Stocking Dates	Age At Stocking & (Year-Class Of Fish)	Source[a]
Age-2 (32)	216-305	151.0-110.0	159-173 (0)	04/16/2008 & 10/21/2008	Age-2 (2006)	Dexter
Age-1 (143)	114-243	176.0-11.0	320-342 (1)	10/03/2007, 11/07/2007 & 11/14/2007	Age-0 (2007)	Dexter
Age-2 (3)	220-319	131.0-98.0	356-370 (1)	04/19/2007 & 10/03/2007	Age-1 (2006)	Dexter
Age-2 (29)	244-342	161.0-61.0	690-708 (2)	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.

Most (n = 177; 85.5%) of the Colorado pikeminnow collected in 2008 were in the river ≤ 365 days post-stocking. However, all but 32 (15.5%) of these fish had been in the river for at least one overwinter period (Table 4). Only 30 (14.5%) were in the river > 365 days post-stocking. Of those 30 fish, 29 were stocked as age-0 fish. No Colorado pikeminnow collected in 2008 were in the river > 730 days (two 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 2003 and 2005 year-class fish being significantly higher at age-1 than other 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 four of the following five 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 (and again at age-4), there were no significant differences in scaled CPUE among any of the groups of Colorado pikeminnow stocked as age-0 fish. The 2002 year-class of Colorado pikeminnow was the only group stocked as age-0 fish that were available to be collected as age-6 fish in 2008. However, no Colorado pikeminnow older than age-2 were collected during 2008 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 2001-2007 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 (Ryden 2008a details the numbers and age-classes of Colorado pikeminnow stocked from 2002-2007). 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. The 2008 value was not significantly different from three of the previous four years (Figure 4).

Table 5. Information on stocked Colorado pikeminnow collected from 1997-2008 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)

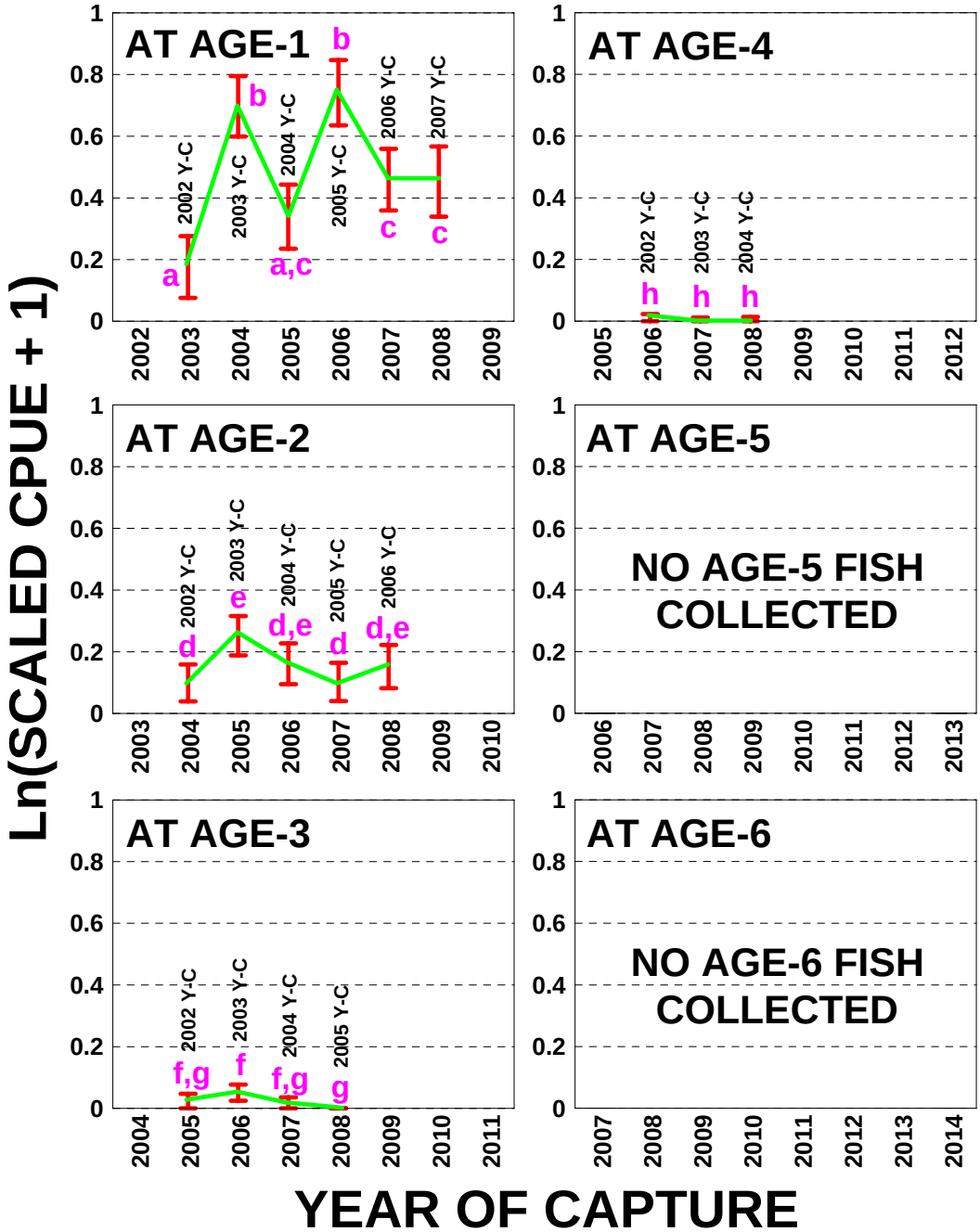

Figure 1. A comparison of scaled CPUE at age among groups of Colorado pikeminnow stocked as age-0 fish and captured during subsequent Adult Monitoring trips, 2003-2008. The green line shows the difference in scaled CPUE values between years. Red error bars are two standard errors. Purple letters are 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.

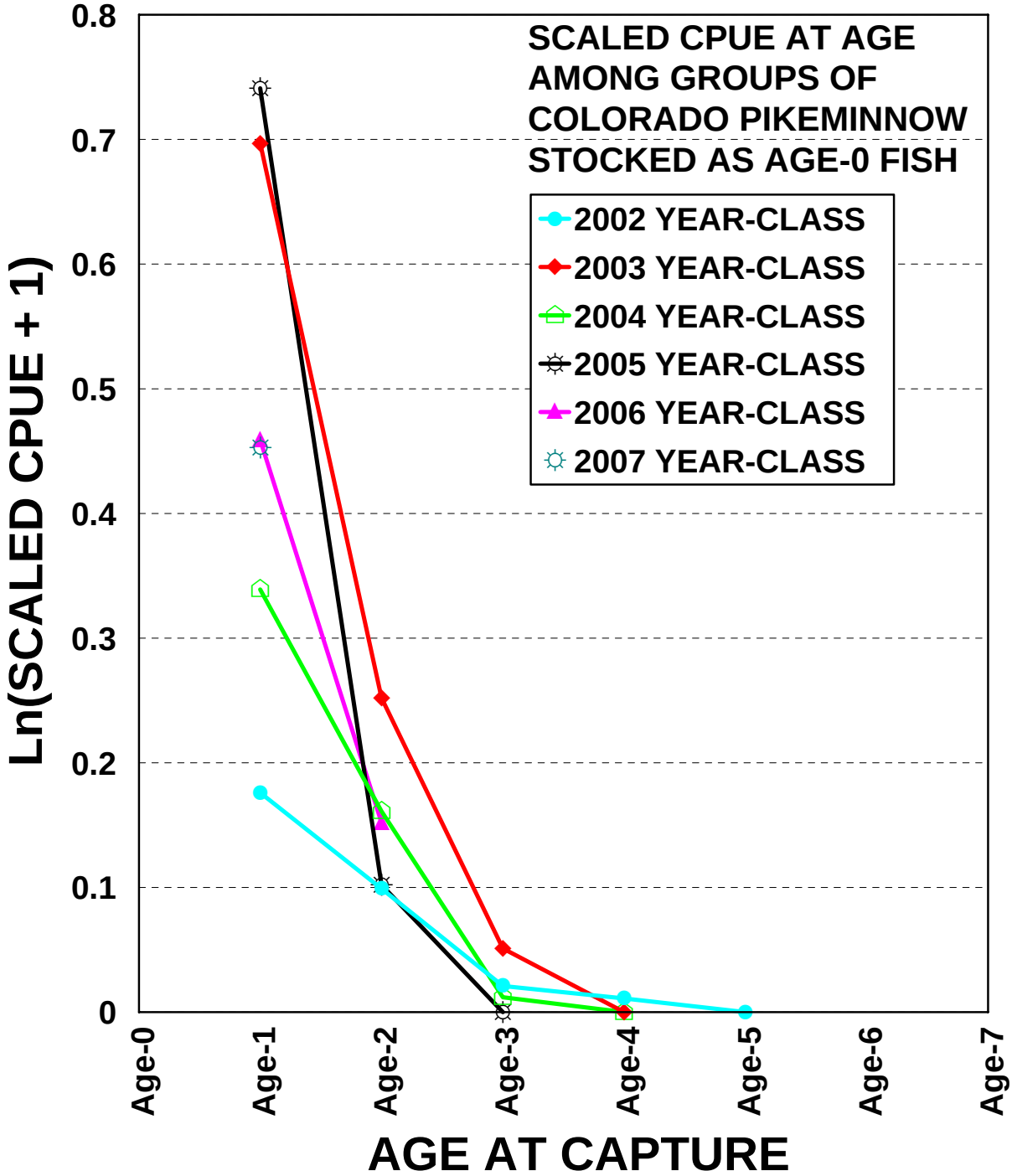

Figure 2. Scaled CPUE at age among groups of Colorado pikeminnow that were stocked as age-0 fish in the fall of the year (2002-2007) and subsequently captured during Adult Monitoring trips from 2003-2008. This graph begins with captures of fish in the calendar year following the year in which they were stocked (i.e., 1 overwinter periods).

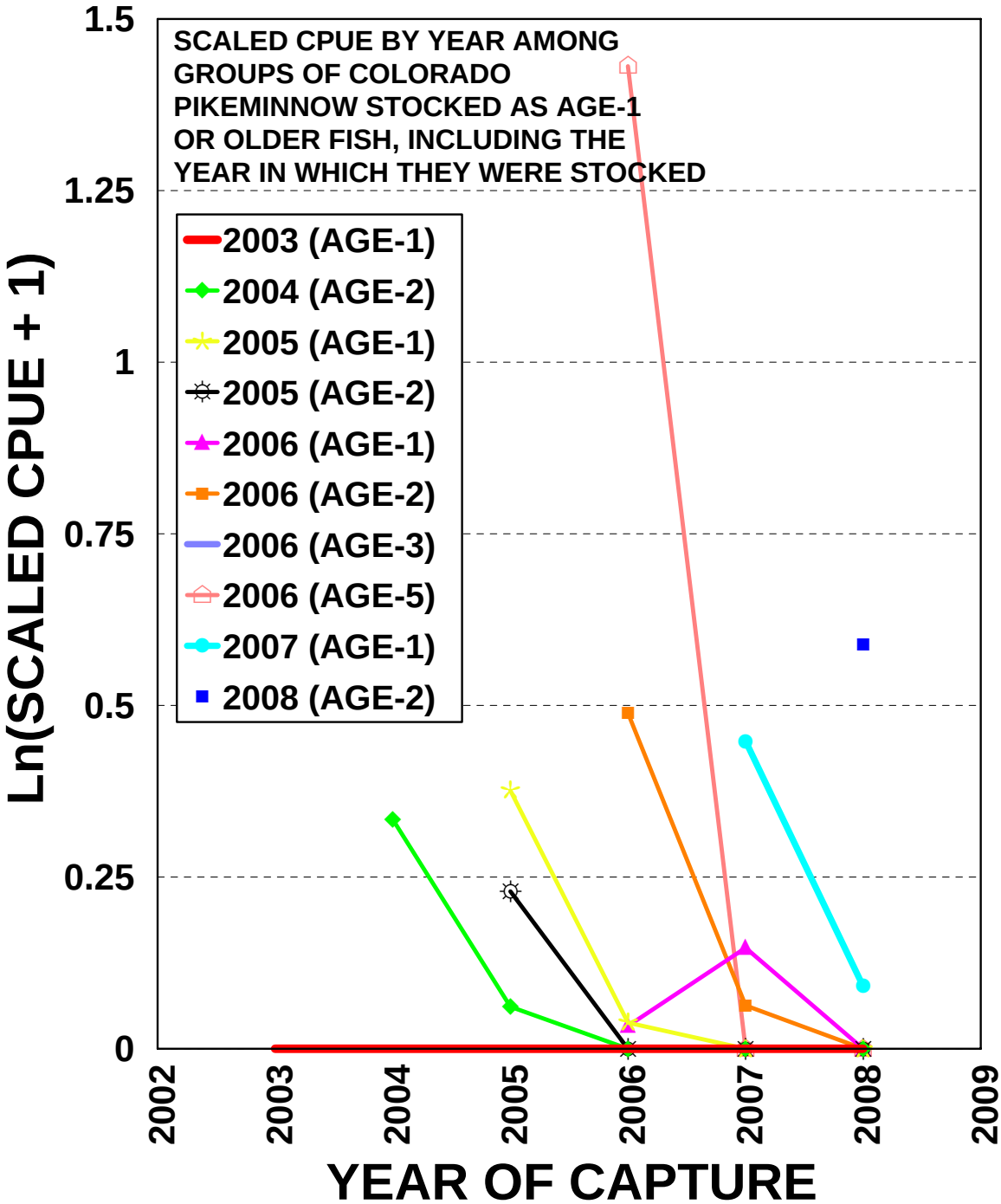

Figure 3. Scaled CPUE by calendar year among groups of Colorado pikeminnow that were stocked as age-1 or older fish and subsequently captured during Adult Monitoring trips from 2004-2008. This graph begins with captures of fish during the same year in which they were stocked (i.e., 0 overwinter periods).

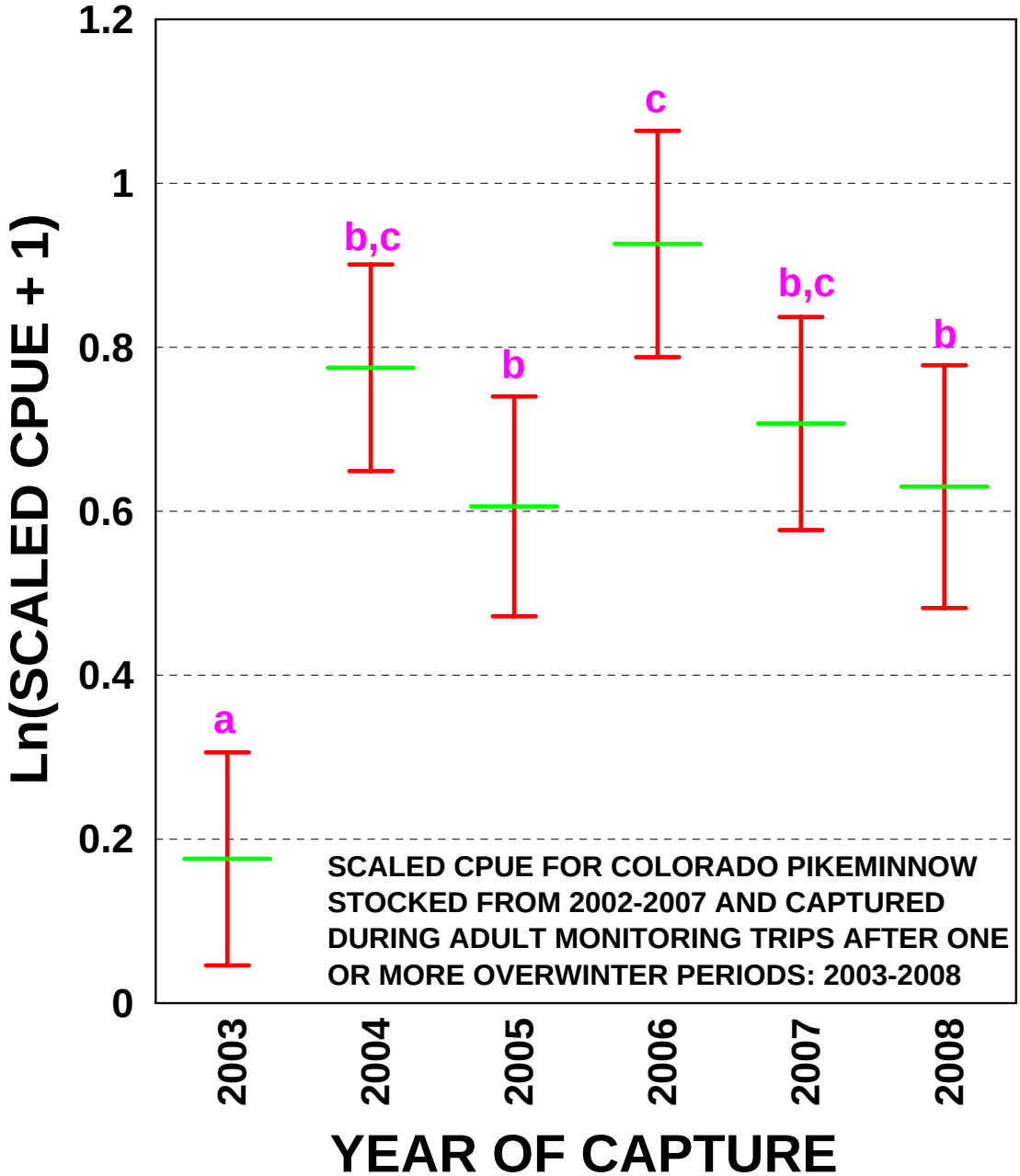

Figure 4. Year-to-year comparison of scaled CPUE for all Colorado pikeminnow collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are two standard errors. 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 2008. A total of 78 stocked razorback sucker were collected in 2008 (Table 6). This marked the fifth consecutive year during which > 50 razorback sucker (2004 = 117; 2005 = 52; 2006 = 144; 2007 = 207) were collected during an Adult Monitoring trip.

Razorback sucker captures ranged from RM 161.0-8.0 (Table 6). The majority (n = 73; 93.6%) occurred upstream of the canyon-bound reaches (RM 68.0-0.0) of the river. Five razorback sucker (6.4%) were collected upstream of the Hogback Diversion (RM 158.6). However, no razorback sucker were collected upstream of either APS Diversion (RM 163.7) or the PNM Weir and fish ladder (RM 166.6) during Adult Monitoring in 2008. Nineteen razorback sucker were collected in Reach 6, 39 in Reach 5, 7 in Reach 4, 8 in Reach 3, 3 in Reach 2, and 2 in Reach 1.

Table 6. General information on stocked razorback sucker collected in 2008.

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 45 razorback sucker captured with PIT tags in 2008:					
34-36 (0)	Age-1 (9)	273-348	158.0-142.0	2008	Age-1 (2007)
421-550 (1)	Age-2 To Age-7 (19)	383-525	158.0-8.0	2007	Age-1 To Age-6 (2001-2006)
757-820 (2)	Age-3 To Age-8 (5)	404-486	154.0-11.0	2006	Age-1 To Age-6 (2000-2005)
1119-1144 (3)	Age-6 To Age-7 (4)	438-513	161.0-155.0	2005	Age-3 To Age-4 (2001-2002)
1489-1634 (4)	Age-6 To Age-8 (7)	455-516	158.0-110.0	2004	Age-2 To Age-4 (2000-2002)
2519 (7)	Age-8 (1)	479	151.0	2001	Age-1 (2000)
Information on the 33 razorback sucker captured without PIT tags in 2008:					
≥ 34 (0-3)	Age-1 To Age-7 (33)	304-509	161.0-19.0	2005-2008	Age-1 To Age-5 (2001-2007)

Because salvage operations at the NAPI ponds in 2006 and 2007 led to several thousand razorback sucker being stocked without PIT tags (Ryden 2008b), the exact length of time that 33 of the razorback sucker captured during 2008 Adult Monitoring (without PIT tags) had been in the river post-stocking could not be determined (Table 6). Of the 45 razorback sucker recaptured with PIT tags in 2008, only 9 (20.0%) were in the river < 365 days post-stocking. All 9 of these fish were in the river < 1 overwinter period when they were collected. The other 36 (80.0%) were in the river > 365 days post-stocking and had been in the river from 1-7 overwinter periods (Table 5).

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). As with older Colorado pikeminnow (Appendix A), 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 2003-2008 (Figure 5).

Table 7. Information on stocked razorback sucker collected from 2001-2008 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 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)

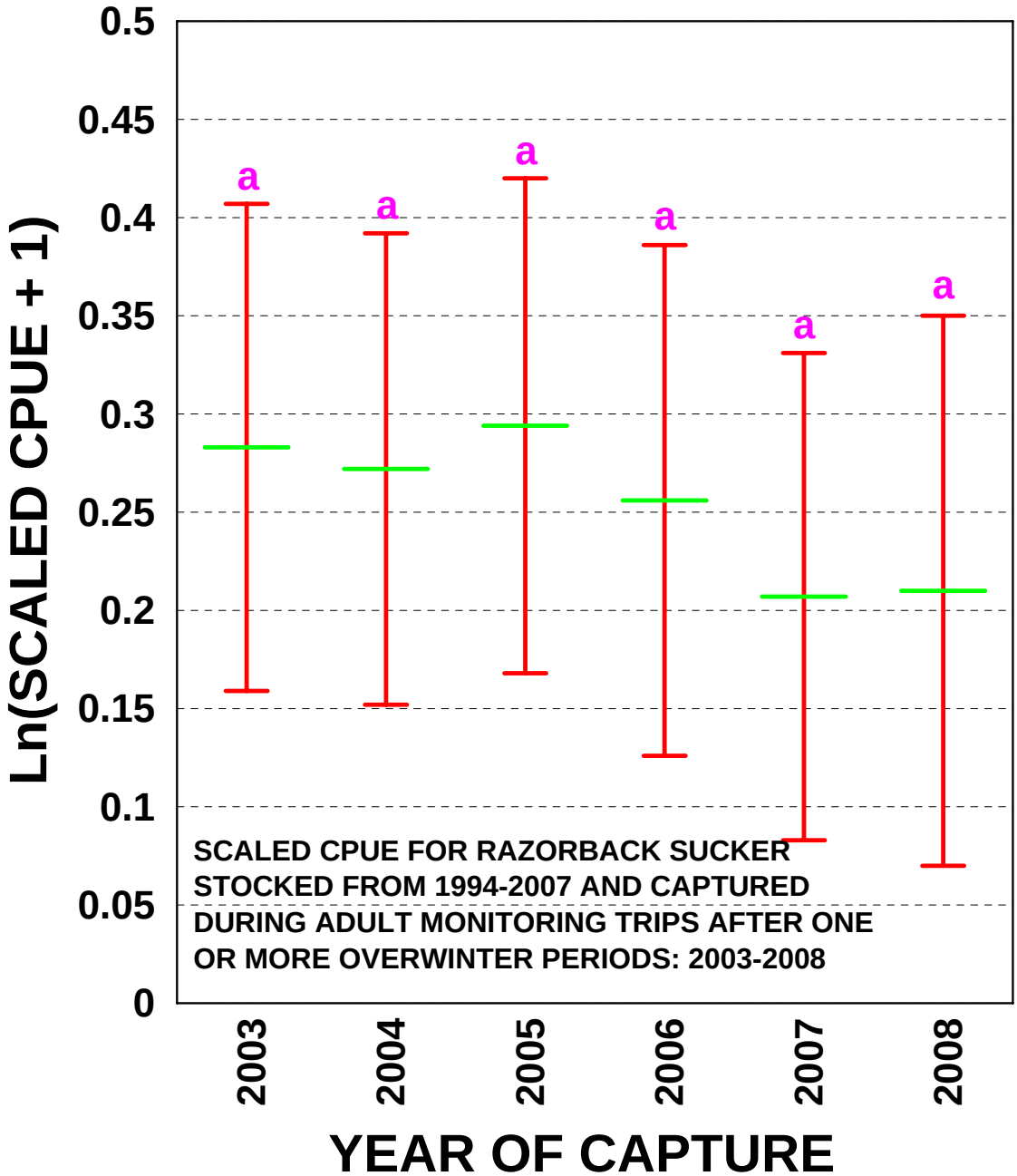

Figure 5. Year-to-year comparison of scaled CPUE for all razorback sucker collected on Adult Monitoring trips that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are two standard errors. 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 2008 Adult Monitoring trip. This fish (227 mm TL) was collected in Reach 3 (RM 99-98) on 7 October 2008 and was implanted with a PIT tag prior to being released. This was the first roundtail chub collected during an Adult Monitoring trip since fall 2002.

Common Native Fishes

Flannelmouth Sucker

Catch Information

Flannelmouth sucker continue to be the most common large-bodied fish collected riverwide during Adult Monitoring trips (Table 3, Figure 6; Ryden 2000, 2001, 2003, 2004, 2005, 2006, 2007, 2008c). Flannelmouth sucker have remained numerically dominant in both overall numbers of specimens collected and in frequency of occurrence in electrofishing samples. Flannelmouth sucker were collected in all six river reaches in 2008 (from RM 179.0-8.0).

Riverwide flannelmouth sucker juvenile CPUE has shown more variation than has CPUE for adult flannelmouth sucker over the last ten years (Figure 7). The result is that the graph for total CPUE among flannelmouth sucker riverwide is heavily affected by swings in juvenile fish. Flannelmouth sucker adult CPUE in 2008 was not significantly different than eight of the previous nine years. In contrast, juvenile CPUE was significantly lower than four of the previous nine years, but not significantly different from the other five, including the 2007 value (Figure 7). In general, the long-term trend for flannelmouth sucker CPUE riverwide over the last ten years continues to remain relatively flat (Figure 7).

Length Information

Flannelmouth sucker ranging in size from 72-564 mm TL (mean TL = 361 mm) were collected during 2008 Adult Monitoring. The 2008 riverwide length-frequency histogram for flannelmouth sucker was strongly centered around large subadult and adult fish from 401-475 mm TL (Figure 8). Younger subadult fish were relatively evenly distributed in the 126-350 mm TL size-classes, with a noticeable group of age-1 fish (spawned in 2007) in the 126-175 mm TL range (Figure 8). More age-1 and age-0 flannelmouth sucker were collected during the 2008 Adult Monitoring trip than during the previous two years Adult Monitoring trips (Figure 8).

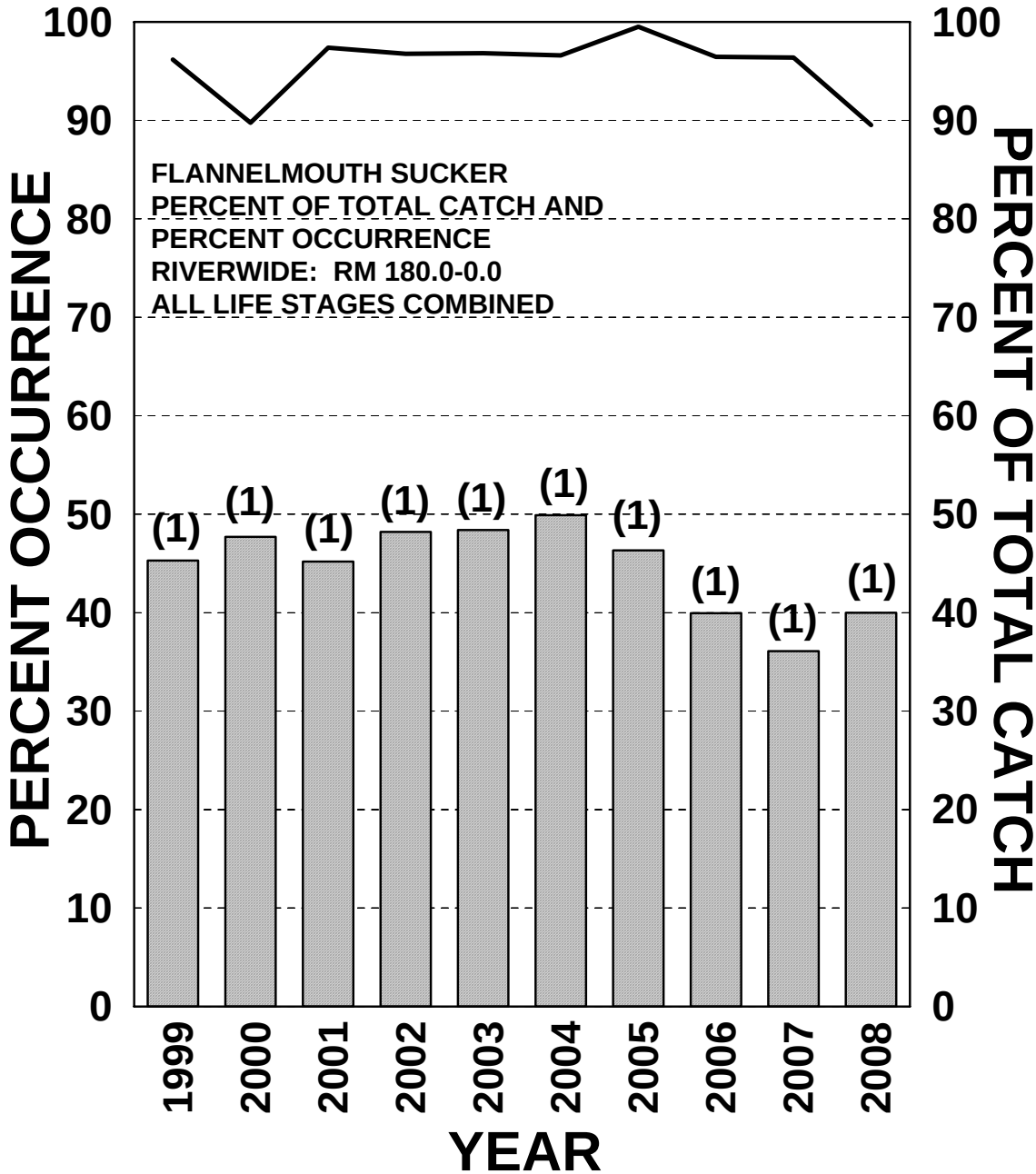

Figure 6. A summary of flannelmouth sucker relative abundance in riverwide Adult Monitoring collections, 1999-2008. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

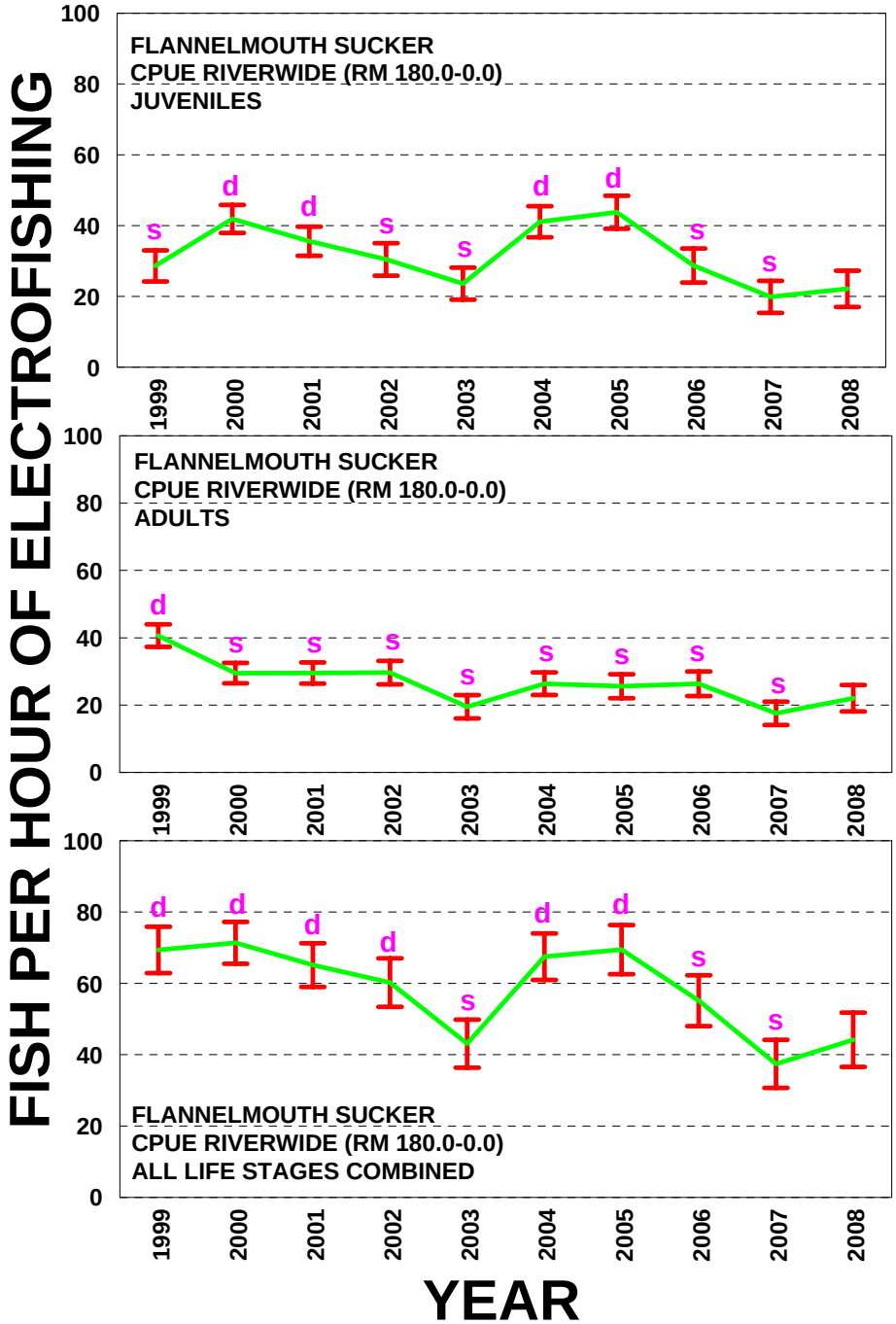

Figure 7. Flannelmouth sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 410 mm TL; top), adult fish (≥ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars equal two standard errors. Purple letters are multi-year comparisons. The letter "s" means the value is not significantly different from the 2008 value. The letter "d" means the value is significantly different from the 2008 value.

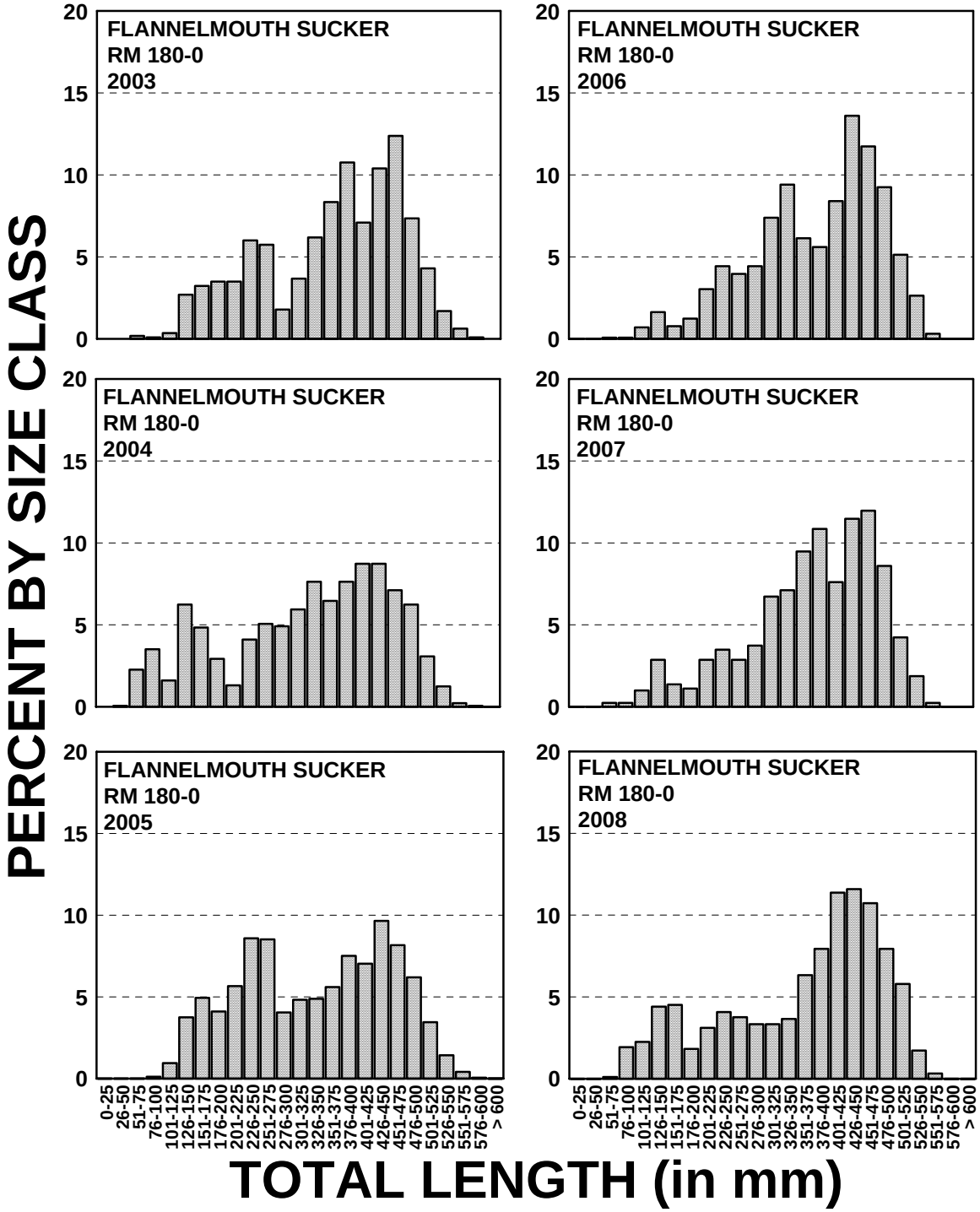

Figure 8. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of flannelmouth sucker on fall Adult Monitoring trips in the San Juan River, 2003-2008.

Bluehead Sucker

Catch Information

Bluehead sucker were the third most commonly-collected large-bodied fish species during 2008 Adult Monitoring (Table 3, Figure 9). The percentage of the total catch composed of bluehead sucker in 2008 (18.1%) was an intermediate value, being higher than four of the previous nine years and lower than the other five but almost identical to the 2007 median value of 18.6% (Figure 9). Bluehead sucker were collected in Reaches 6-2 in 2008 (from RM 179.0-52.0). 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 2008 (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 2008, with bluehead sucker occurring in only 66.3% of all electrofishing collections during 2008 Adult Monitoring (Figure 9).

Bluehead sucker adult CPUE has not changed significantly over the last ten 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 2008 was not significantly different from six of the previous nine years (Figure 10). The fluctuations in numbers of juvenile bluehead sucker appear to be 3-5 year cyclical events. In general, the long-term trend for bluehead sucker total CPUE riverwide over the last nine years is essentially flat (Figure 10).

Length Information

Bluehead sucker ranging from 77-442 mm TL (mean TL = 284 mm) were collected during 2008 Adult Monitoring. In 2008, the bluehead sucker collected were strongly centered around a group of adult fish that were 326-350 mm TL, with second biggest group being slightly younger adults (301-325 mm TL) that had just recruited into the adult population (Figure 11). A smaller mode of juvenile bluehead sucker, centered around 176-200 mm TL (likely age-2 fish) was also observed in 2008 (Figure 11).

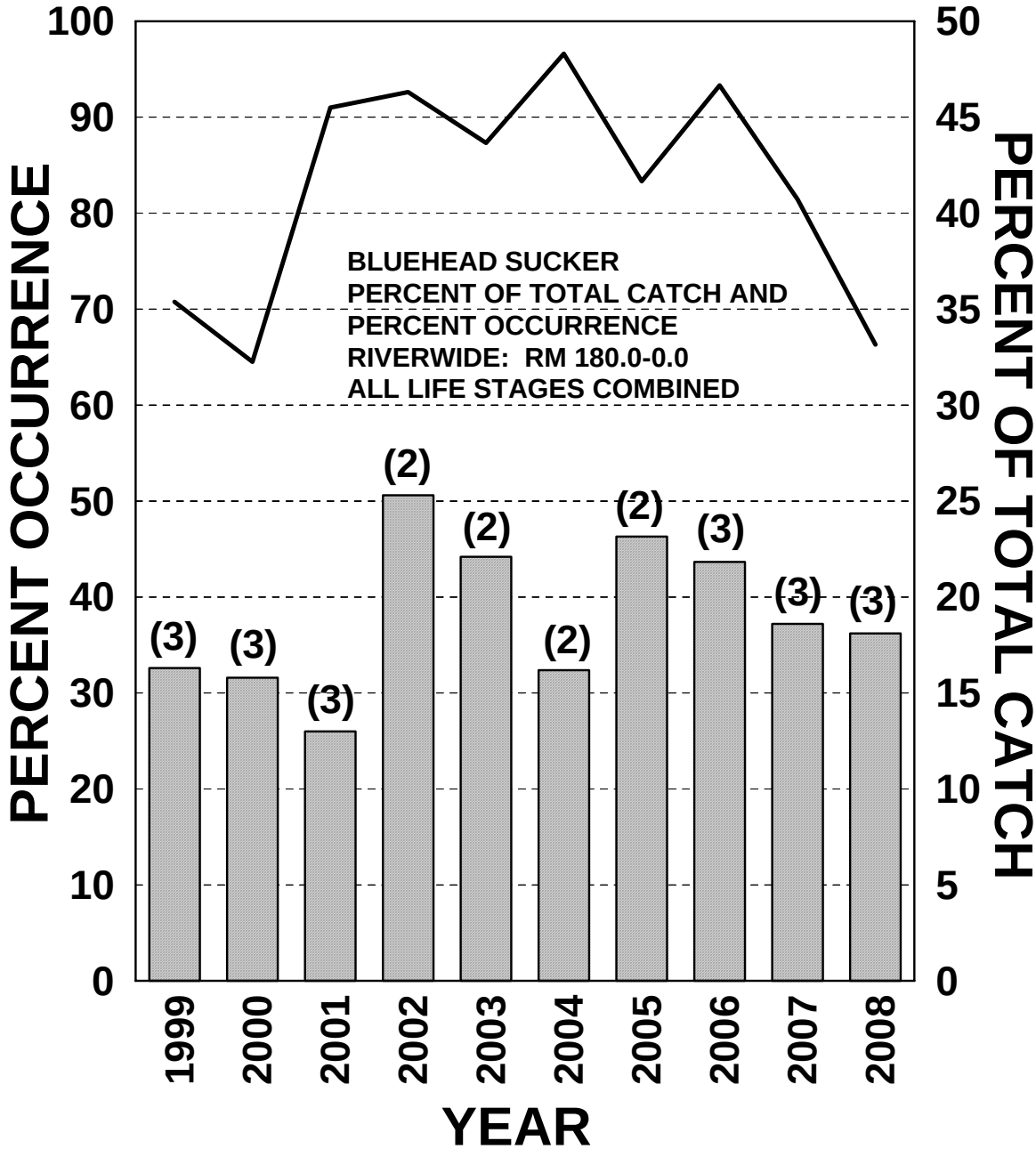

Figure 9. A summary of bluehead sucker relative abundance in riverwide Adult Monitoring collections, 1999-2008. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

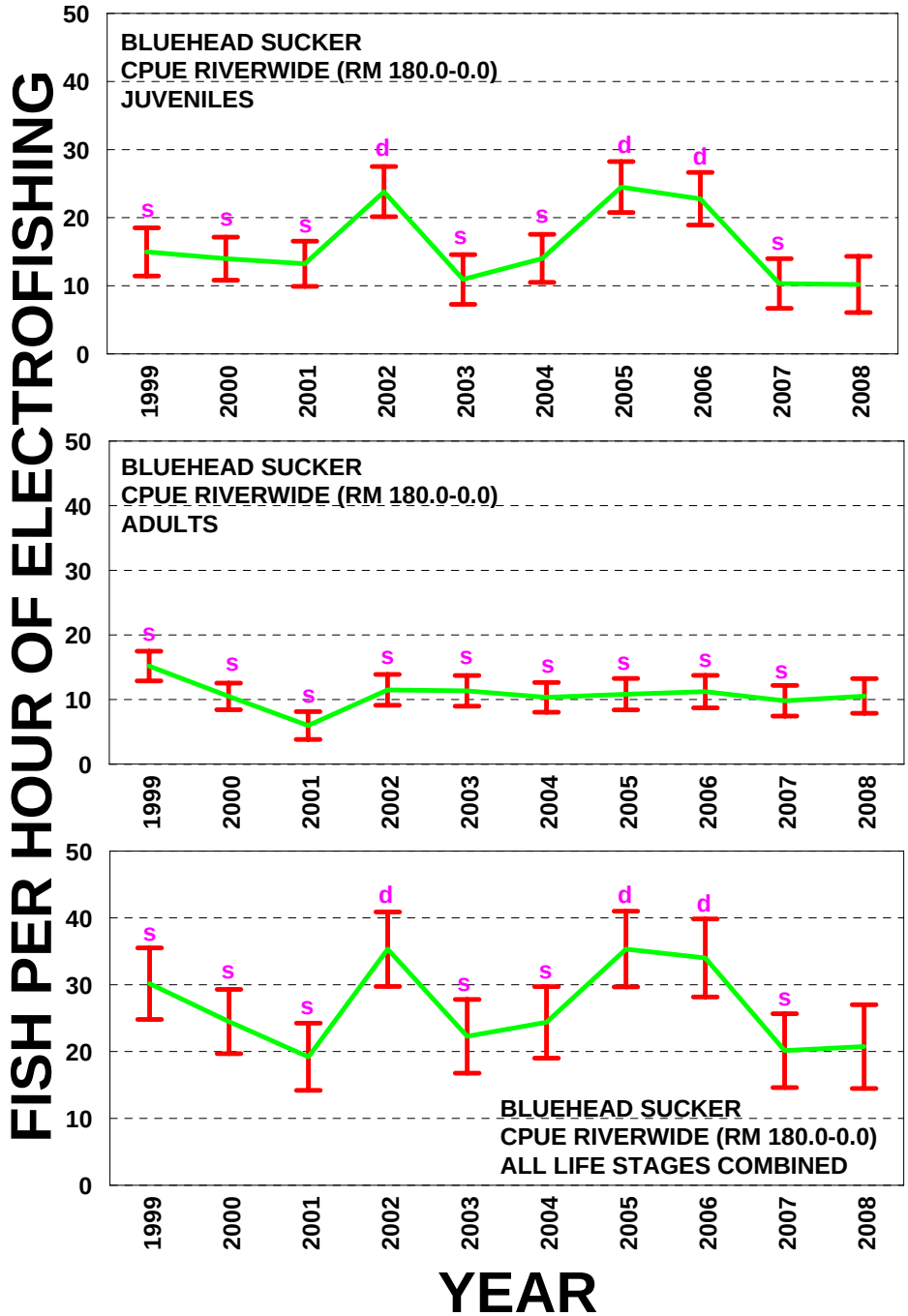

Figure 10. Bluehead sucker CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars equal two standard errors. Purple letters are multi-year comparisons. The letter "s" means the value is not significantly different from the 2008 value. The letter "d" means the value is significantly different from the 2008 value.

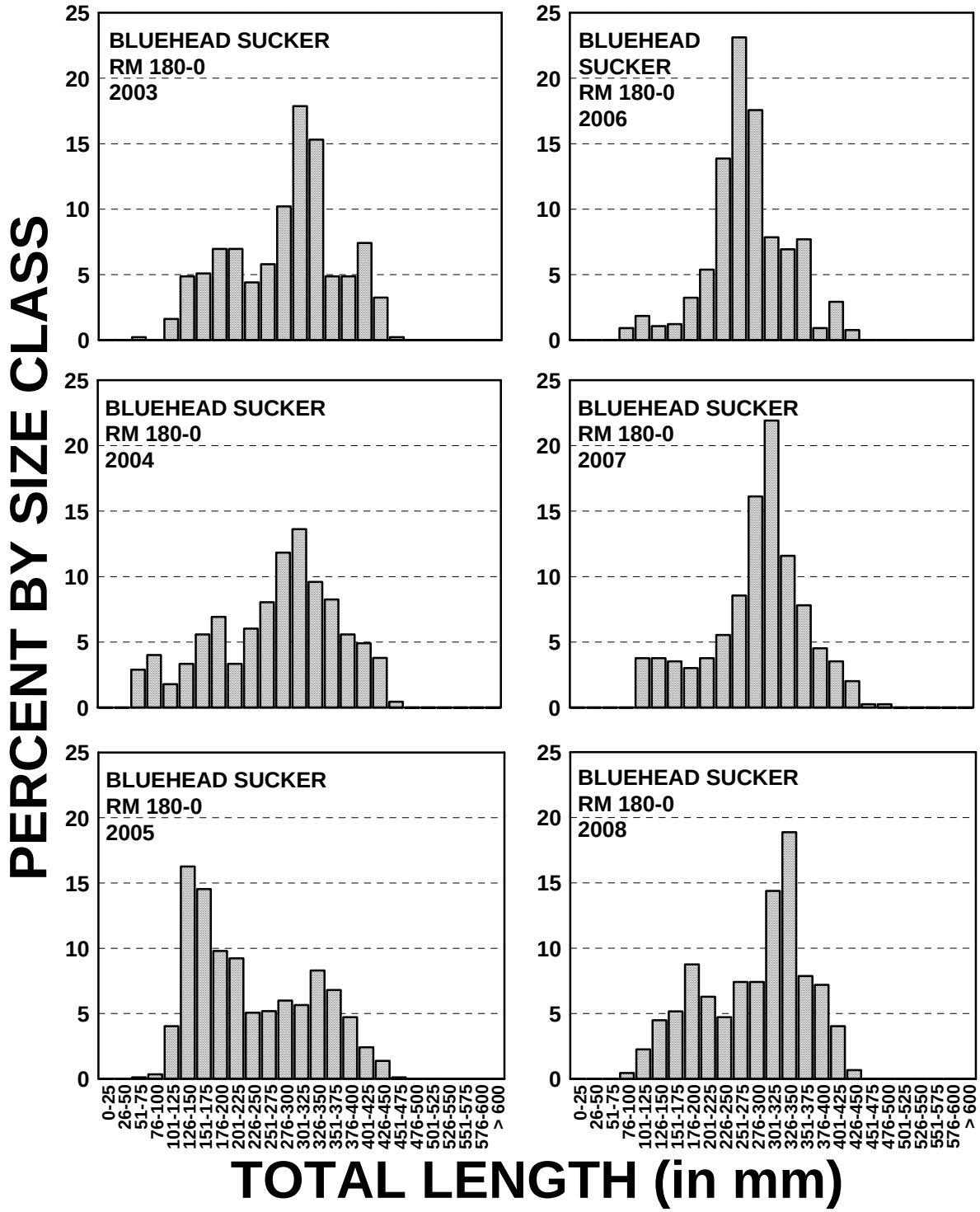

Figure 11. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of bluehead sucker on fall Adult Monitoring trips in the San Juan River, 2003-2008.

Common Nonnative Fishes

Channel Catfish

Catch Information

Channel catfish are the most common nonnative fish collected during Adult Monitoring (Table 3) and have remained among the three most commonly-collected fish species in each of the last ten years (Figure 12). In 2008, channel catfish were the second most commonly-collected fish species, accounting for 30.8% of the total catch, down from the high of 34.4% in 2007, but still the second highest percentage of the total catch observed in the last ten years (Table 3). Channel catfish were collected in 84.9% of all electrofishing samples riverwide in 2008 (Figure 12). Channel catfish were collected in all six river reaches in 2008 (from RM 166.0-5.0).

The riverwide CPUE value for juvenile channel catfish has not changed significantly for the last five years, but it did remain significantly lower than the high values observed from 1999-2001 (Figure 13). The riverwide CPUE value for adult channel catfish has not changed significantly for the last three years and remained among the four highest values observed for adult channel catfish since 1999 (Figure 13). Overall numbers of channel catfish in the San Juan River have not been reduced significantly by recent nonnative fish removal efforts. However, data reflect that the center of channel catfish abundance has shifted downstream since nonnative removal efforts began in 2001. In 2001, the largest part of this population resided within the upper nonnative fish removal section, from RM 166.6-147.9 (PNM Weir to Shiprock bridge) with relatively large numbers (36.3-42.0 fish/hr) of channel catfish in the 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 majority of the biomass represented by this species, 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 (Figures 14 and 15). Multiple-pass, intensive removal efforts began in the middle section of the San Juan River in 2007 and intensified greatly in 2008. However, the large majority of channel catfish encountered during both the 2007 and 2008 Adult Monitoring trips continued to be collected from this middle section of the San Juan River (Figure 14).

In both the upper and lower nonnative fish removal sections, the longer-term removal efforts have been successful in keeping numbers of channel catfish significantly lower (p-values for both sections were all ≤ 0.001) over the last three years than they were in 2001 (Figure 14). However, the collection of large numbers of adult channel catfish in the upper nonnative fish removal section in 2007 and 2008, accounted for the majority of channel catfish biomass

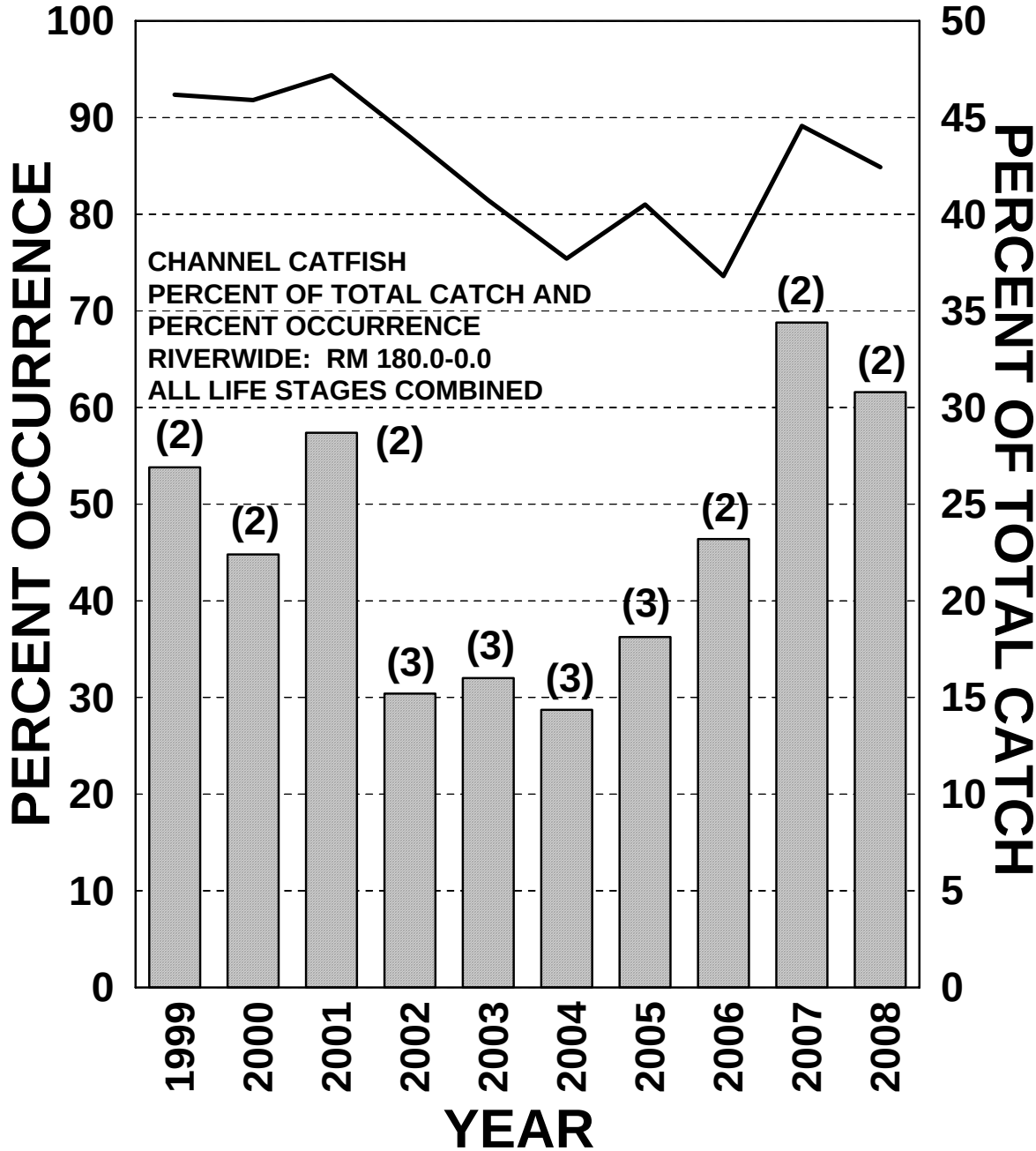

Figure 12. A summary of channel catfish relative abundance in riverwide Adult Monitoring collections, 1999-2008. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

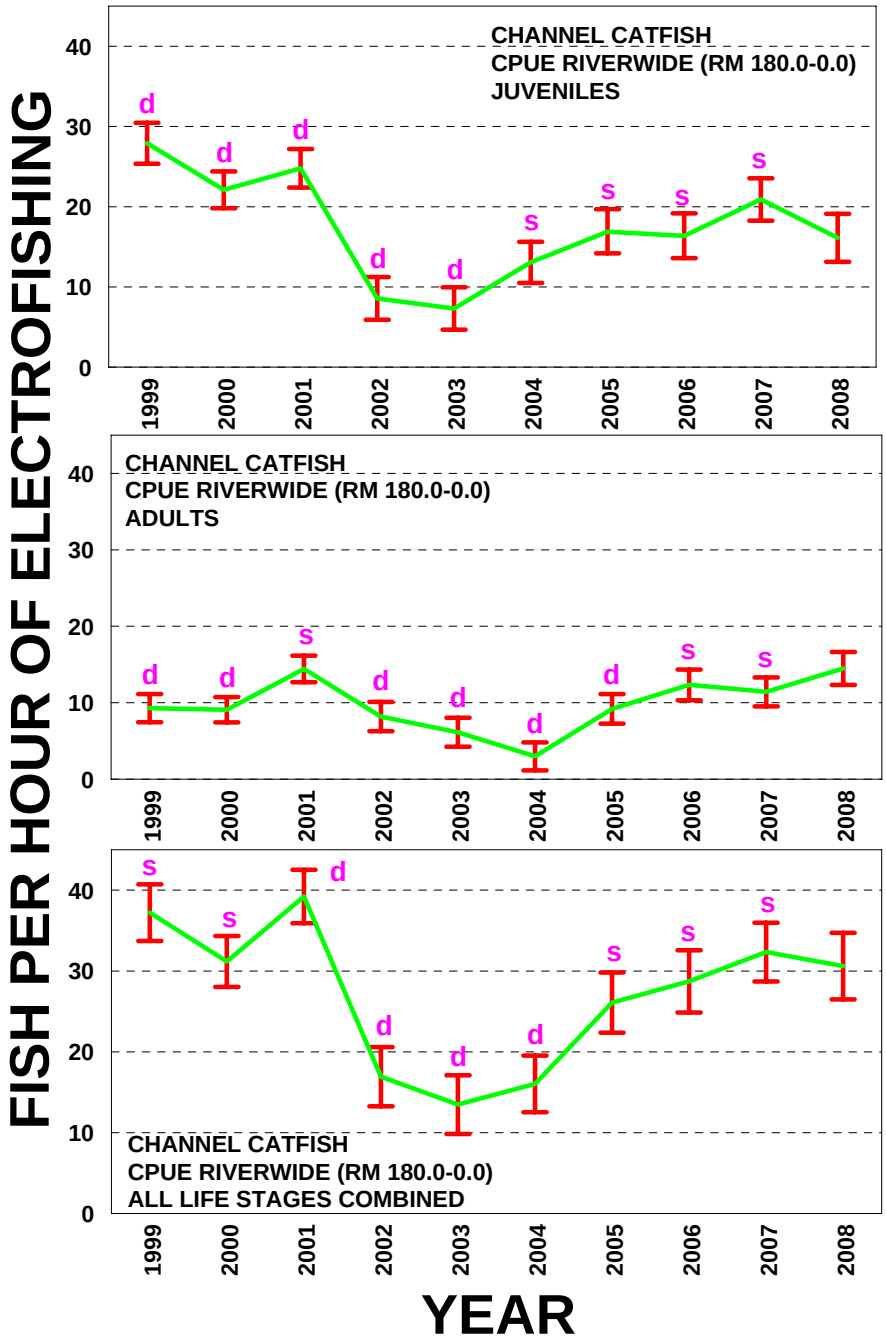

Figure 13. Channel catfish CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars equal two standard errors. Purple letters are multi-year comparisons. The letter "s" means the value is not significantly different from the 2008 value. The letter "d" means the value is significantly different from the 2008 value.

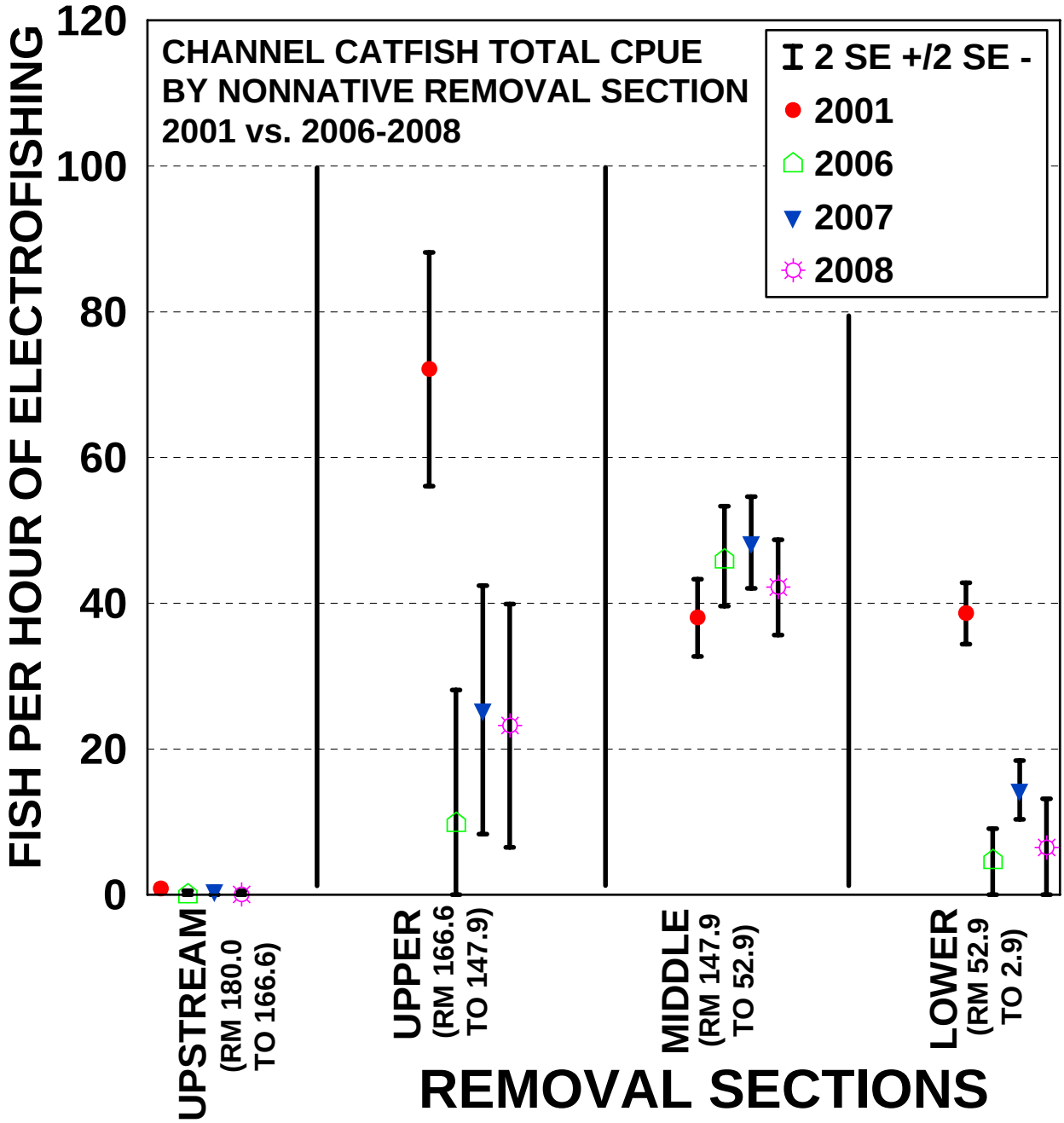

Figure 14. A comparison of channel catfish total CPUE within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2008. Symbols represent the total CPUE values for each year, within a given river section. Error bars are two standard errors.

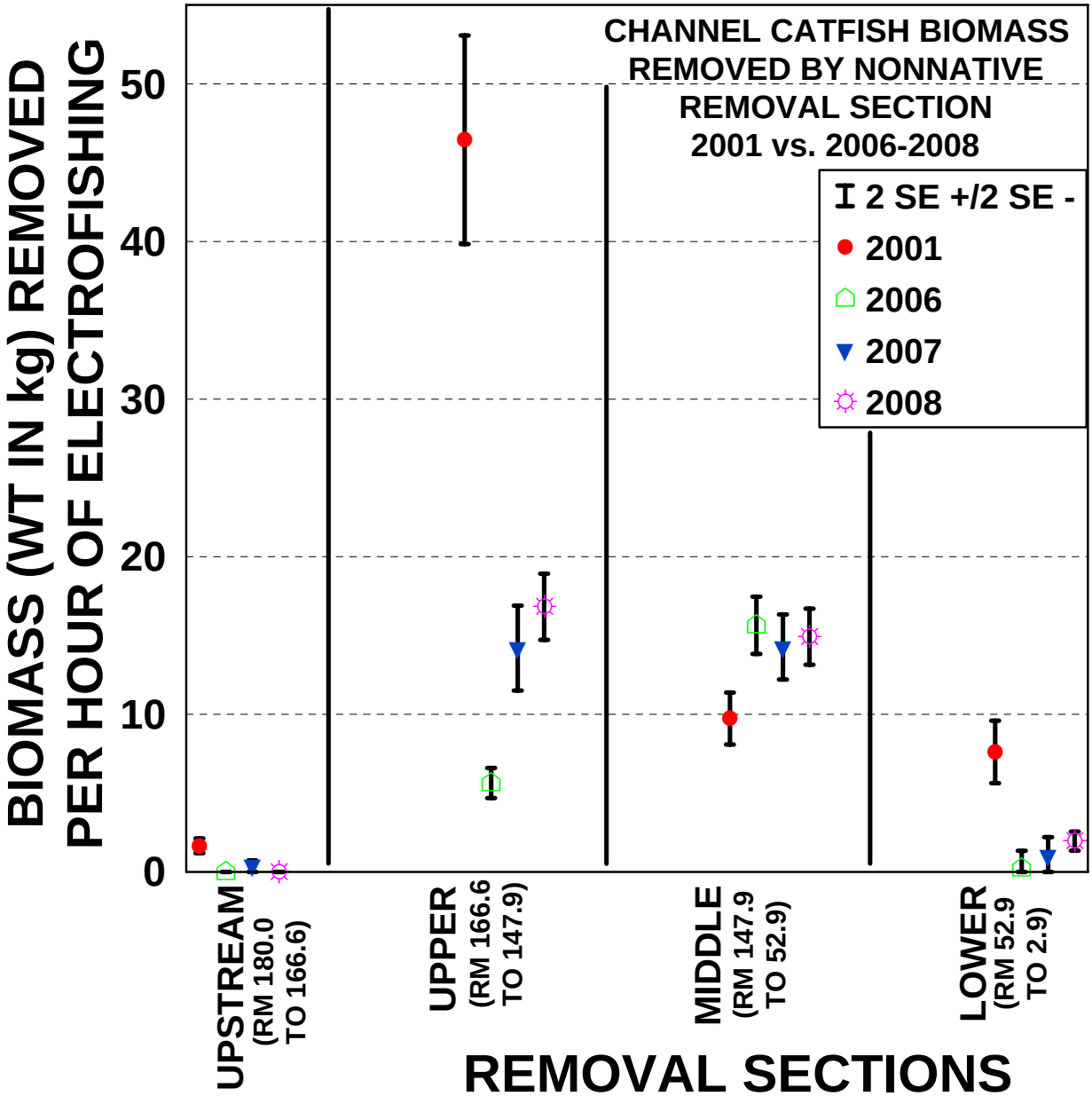

Figure 15. A comparison of the amount channel catfish biomass that was removed from within the various nonnative fish removal sections of the San Juan River in 2001 versus 2006-2008. Symbols represent the total amount of biomass (in kg) removed each year, within a given river section. Error bars are two standard errors.

collected during those two years (Figure 15), despite the noticeably larger numbers of channel catfish that were collected from the adjacent downstream middle removal section (Figure 14). Yet, even with the upswing in biomass in the upper nonnative fish removal section in 2007 and 2008, biomass totals for both of those years were noticeably lower than they were in 2001, when nonnative fish removal efforts were just beginning in this river section (Figure 15).

Length Information

Channel catfish ranging from 32-781 mm TL (mean TL = 261 mm) were collected during 2008 Adult Monitoring. In the 2008 length-frequency histogram, the largest group of channel catfish, by far, were age-0 fish, from 51-75 mm TL (Figure 16). The next two most common size-classes were adult fish from 376-400 mm TL and 401-425 mm TL (Figure 16). In addition, a group of age-1 channel catfish centered around 151-175 mm TL was also evident (Figure 16). Large influxes of young age-0 and age-1 channel catfish have been evident in length frequency histograms over the last six years.

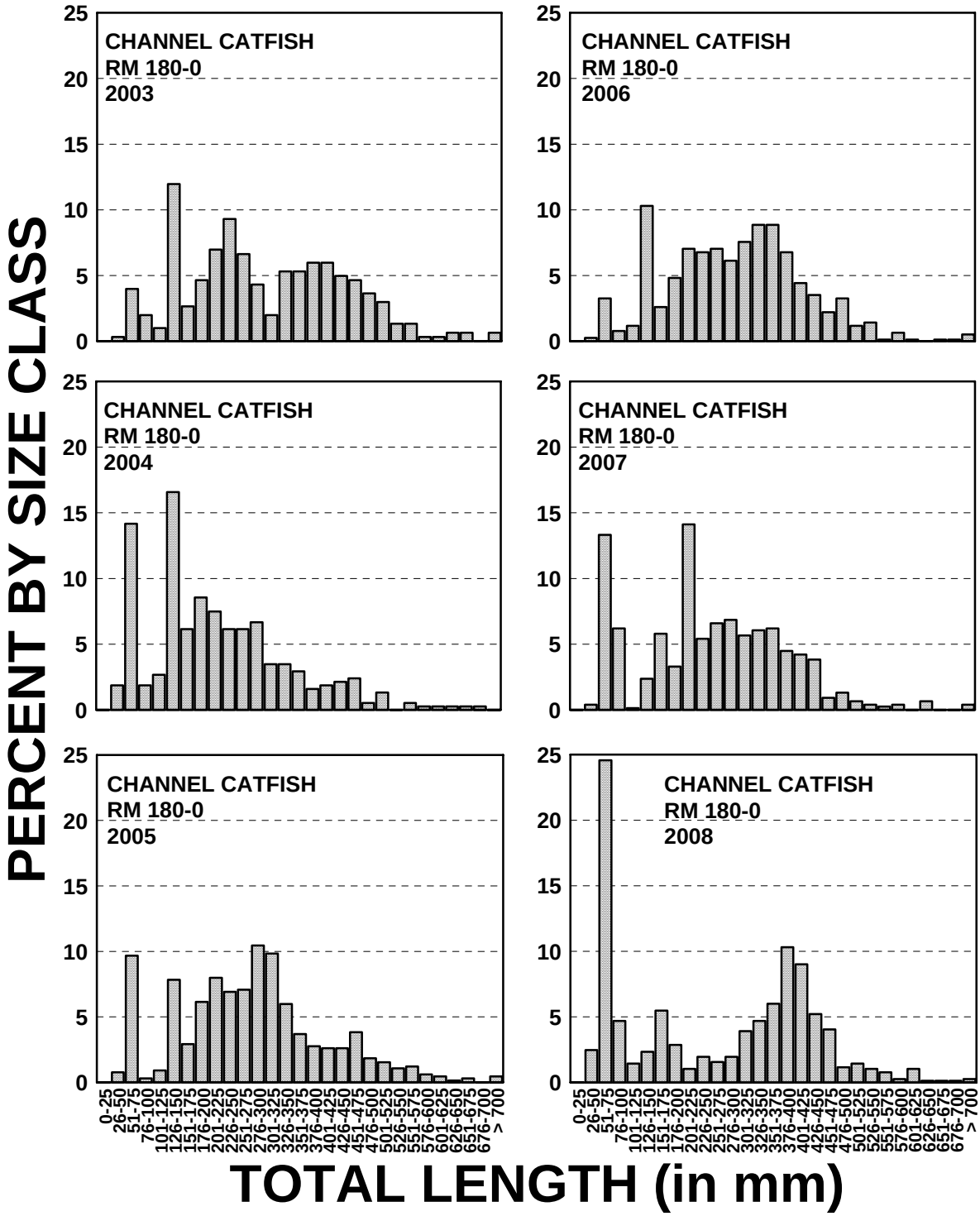

Figure 16. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of channel catfish on fall Adult Monitoring trips in the San Juan River, 2003-2008.

Common Carp

Catch Information

Common carp were the sixth most commonly-collected fish during 2008 Adult Monitoring (Table 3, Figure 17). This marks the fifth consecutive year that common carp have not been among the four most commonly-collected fish species during Adult Monitoring (Figure 17). Only 145 total common carp were collected riverwide in 2008 (Table 3). Of those, 51 (35.2%) were juveniles (i.e., < 250 mm TL). Though their numbers were low, especially in Reaches 2 (n = 2) and 1 (n = 4), common carp were collected from all six river reaches in 2008 (from RM 179.0-11.0).

Between 1999 and 2007, the percent of the total catch composed of common carp had dropped in each consecutive year (from 9.8% in 1999 to 1.5% in 2007). In 2008, the percent of the total catch composed of common carp rose slightly, to 1.7% (Table 3; Figure 17). Common carp were collected in 38.95% of all electrofishing collections riverwide in 2008 (Figure 17). Again, this was a slight increase from the 2007 value (30.77%), but still well below the widespread distributions observed between 1999 and 2002, when common carp were collected in 83.87%-89.14% of all electrofishing collections riverwide (Figure 17).

Common carp juvenile CPUE was not significantly different than six of the previous nine years and was significantly lower than the pulses of juvenile common carp observed in 2000, 2002, and 2004 (Figure 18). 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 five years and has continued to remain significantly lower than the 1999-2003 period (Figure 18).

Length Information

Common carp ranging from 85-623 mm TL (mean TL = 332 mm) were collected during 2008 Adult Monitoring. Juvenile common carp (in particular those centered around 101-125 mm TL) were very prevalent in the 2008 length-frequency histogram (Figure 19). Over half (51.4%) of all common carp measured and weighed in 2008 were ≤ 150 mm TL (Figure 19).

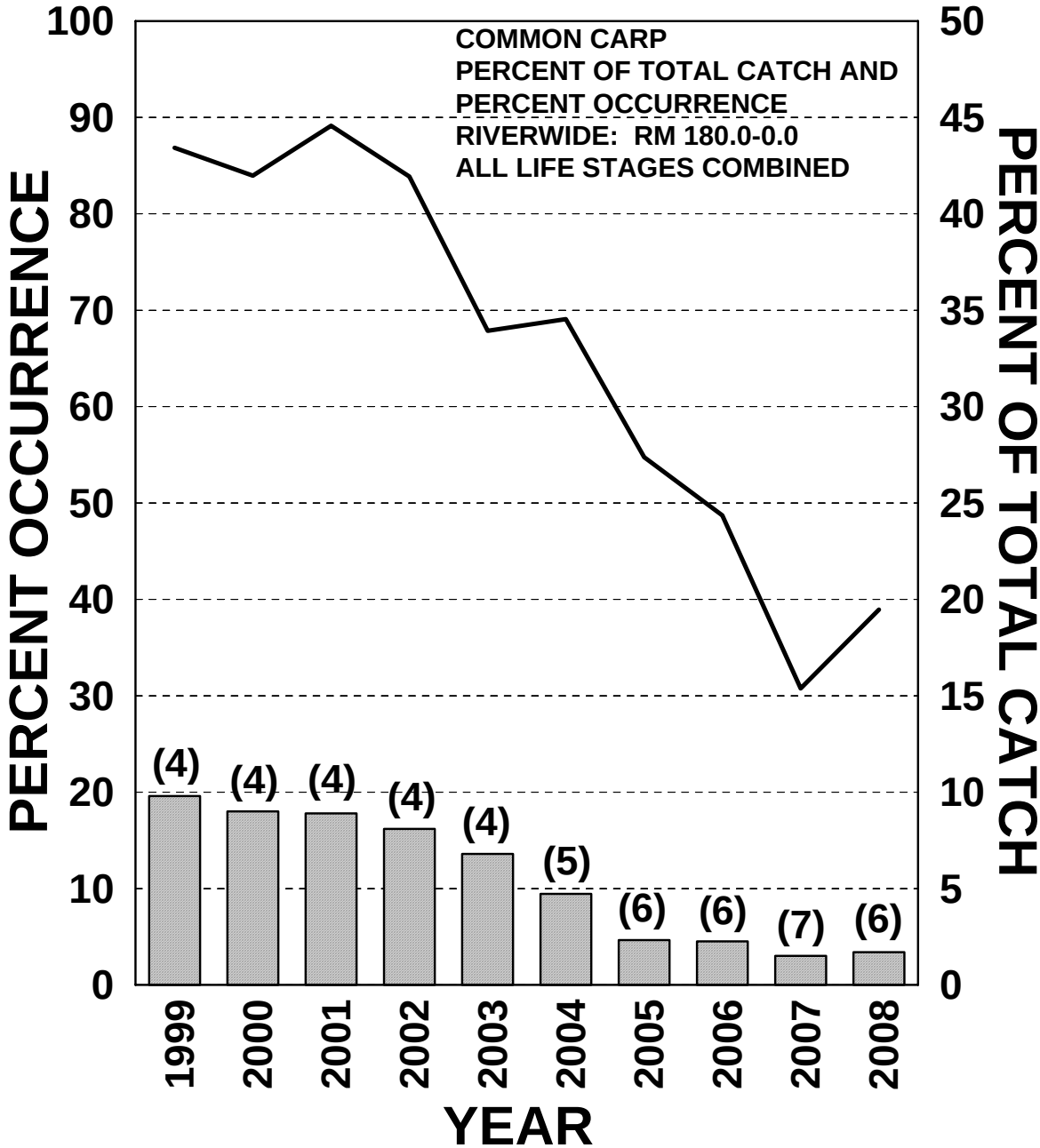

Figure 17. A summary of common carp relative abundance in riverwide Adult Monitoring collections, 1999-2008. The solid black line represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The gray bars represent 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.

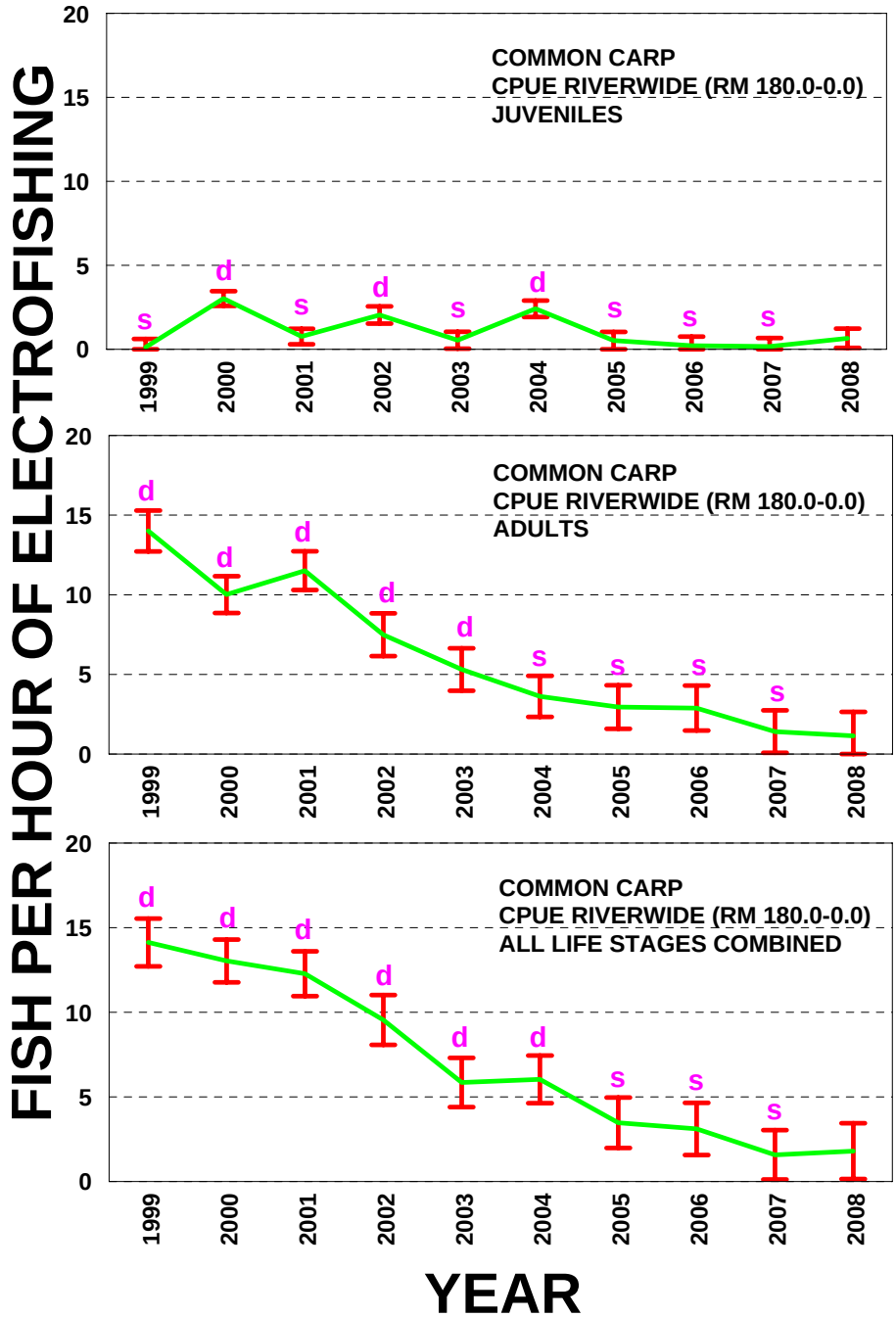

Figure 18. Common carp CPUE (green line) riverwide (RM 180.0-0.0) on fall Adult Monitoring trips, for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars equal two standard errors. Purple letters are multi-year comparisons. The letter "s" means the value is not significantly different from the 2008 value. The letter "d" means the value is significantly different from the 2008 value.

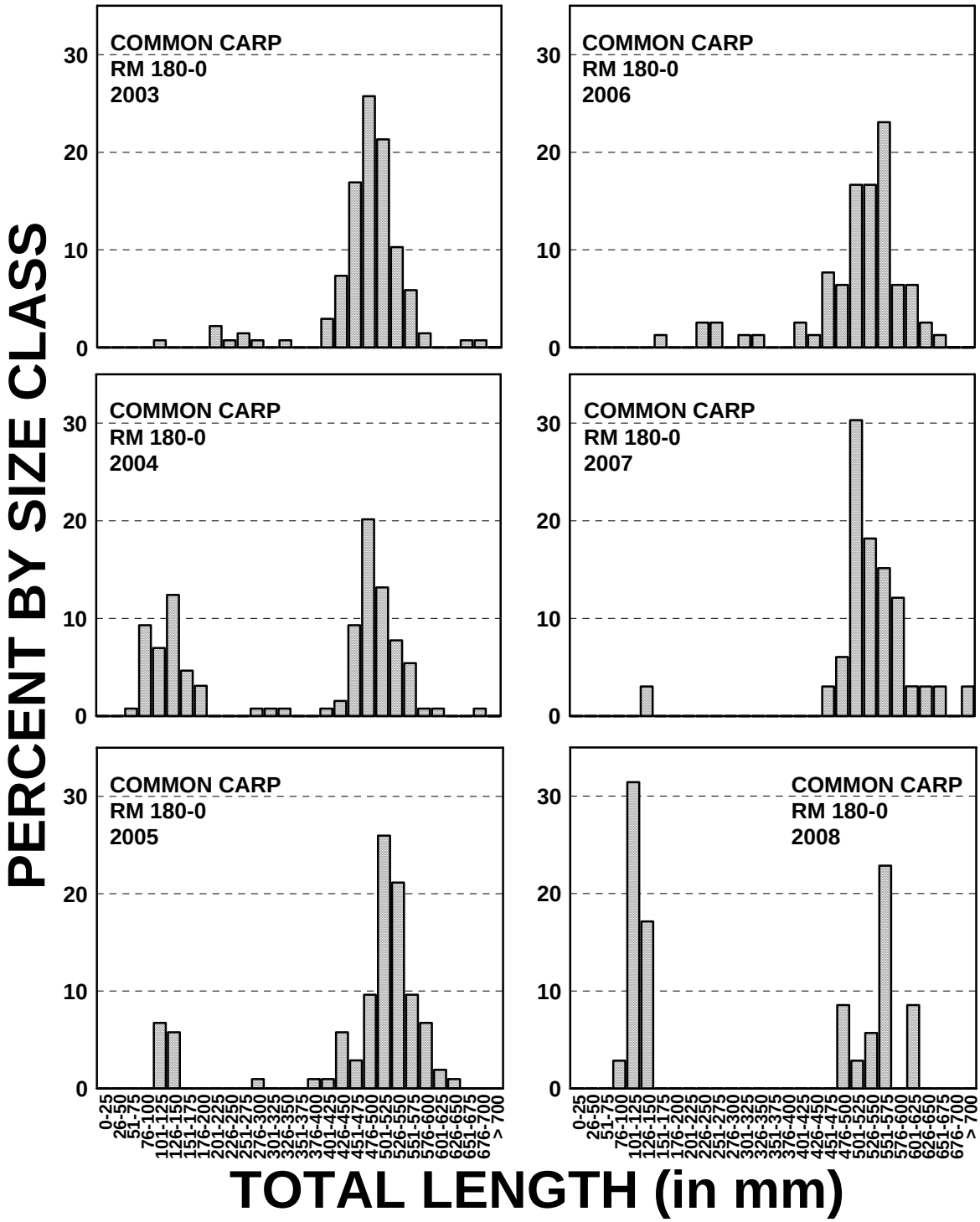

Figure 19. Length-frequency histograms showing the riverwide (RM 180.0-0.0) size-class distribution of common carp on fall Adult Monitoring trips in the San Juan River, 2003-2008.

DISCUSSION

Rare Native Fishes

Colorado Pikeminnow

Wild Colorado pikeminnow continue to be absent from Adult Monitoring collections. The 207 stocked Colorado pikeminnow collected during 2008 Adult Monitoring marked the fifth 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 five 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 are no longer collected in Adult Monitoring collections after a number of years does not necessarily indicate they are not 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 166.7 RM's for every 100,000 age-0 fish that are stocked) to avoid detection by single-pass electrofishing efforts, such as Adult Monitoring. Indeed, two pieces of evidence from other studies also point to the continued persistence of small numbers of stocked Colorado pikeminnow into later years. First are the collections of eight adult Colorado pikeminnow (i.e., < 450 mm TL) between April 2002 and June 2007 that were all either recruits from age-0 fish stocked from 1996-1997 by the Utah Division of Wildlife Resources or were wild-spawned fish (Appendix B). These eight fish were collected over a period of six years during multiple-pass sampling trips for nonnative fish removal efforts. Eight of the ten capture events with these fish occurred in the lower canyon (RM 53.0-2.9) where ten passes per year are done by nonnative removal crews, as opposed to a single pass done by Adult monitoring crews (Appendix B). Second was the collection of three larval Colorado pikeminnow during 2007 (Brandenburg and Farrington 2008). Although these three larval fish could have been produced by extant wild fish, the chances are equally as good 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 2008 with the majority being collected in Reach 5. During 2008 Adult Monitoring, 14 Colorado pikeminnow were collected upstream of the Hogback Diversion (RM 158.6); however, only four Colorado pikeminnow (range = 119-179 mm TL) were collected upstream of the PNM Weir (RM 166.6) in Reach 6. Based on the size of these fish and the fact that none of them had PIT tags when captured, they represent age-1

fish that were stocked as age-0 fish in fall 2007. These four age-1 fish had managed to remain upstream of PNM Weir, despite having to endure several months of extended cold, high-flow releases from Navajo Reservoir in the spring of 2008. While this is encouraging, the numbers of Colorado pikeminnow collected upstream of PNM Weir annually remain low and these fish are almost always age-1 fish. 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. In 2008, no Colorado were stocked upstream of PNM Weir, so 2009 monitoring should provide a chance to analyze whether or not stocked Colorado pikeminnow will survive and remain resident in the river upstream of PNM after more than one overwinter period.

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 through their first overwinter period, but seem to make little difference after that point.

Razorback Sucker

No wild razorback sucker were collected in 2008. The 78 stocked razorback sucker collected in 2008 marked the fifth 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 2008 Adult Monitoring dropped to just 78 fish. However, far fewer razorback sucker were stocked in 2008 prior to sampling, so this drop in numbers of fish collected was 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, in prep.). 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 are recruiting to the age-1 and age-2 year-classes (e.g., Jackson 2004, Ryden 2004, Golden and Holden 2005, Jackson 2005).

Razorback sucker were collected from all six geomorphic reaches in 2008. During 2008 Adult Monitoring, five razorback sucker were collected upstream of the Hogback fish ladder in 2008, but none were collected upstream either the APS or PNM weirs. However, continued collections of razorback sucker in the PNM fish ladder (A. Lapahie, pers. comm.) attest to their presence upstream at least as far as RM 166.6 during parts of the year.

Common Native Fishes

Flannelmouth Sucker

Flannelmouth sucker are still the most abundantly-collected large-bodied fish species in the San Juan River. This species is consistently collected in > 89% of all electrofishing riverwide each year. 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. Long-term trend lines show that despite observed year-to-year fluctuations in riverwide CPUE, the flannelmouth sucker population has remained relatively stable over the last ten years.

Bluehead Sucker

Bluehead sucker continue to be among the three most commonly 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). Like flannelmouth sucker, long-term trend lines show that despite observed year-to-year fluctuations in riverwide CPUE, the bluehead sucker population has remained relatively stable over the last ten years.

Common Nonnative Fishes

Channel Catfish

Channel catfish are the most common nonnative fish collected during 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. However, because of large numbers of channel catfish in the middle section of the San Juan River (RM 147.9-52.9), the riverwide CPUE values for channel catfish are essentially the same as they were in 2001 (when intensive nonnative fish removal efforts began), even though the longitudinal distribution of this species has changed.

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. This species' amazing capacity for reproduction and recolonization has managed to offset many of the impacts made by intensive nonnative removal efforts both the up- and downstream sections of the river. Hopefully with more intensive nonnative removal efforts being applied in the middle section of the San Juan River, it will be possible to effectively reduce the number of channel catfish riverwide.

Common Carp

Common carp were the sixth most commonly-collected species during 2008 Adult Monitoring. Common carp were collected in all six geomorphic reaches in 2008, although they were rare in the two most downstream river reaches (i.e. Reach 2 and 1). 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 2008 than were endangered Colorado pikeminnow. Common carp accounted for barely 1.7% of the total catch and were collected in less than a third of all electrofishing samples riverwide in 2007. Only 145 common carp were collected during 2008 Adult Monitoring, with 51 (35.2%) of these being juvenile fish. In comparison, during 1998 Adult Monitoring, 77 adult common carp were collected in just one electrofishing sample (RM 163-162). During 2008 Adult Monitoring, less than twice that number were collected in 172 electrofishing samples. 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.

The out-of-bank flows, which occurred during the 2008 runoff season, 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, Adult Monitoring collections did not indicate that a large-scale spawning event took place among common carp in 2008. It is possible that numbers of adult common carp are now reduced enough to make large-scale spawning unlikely.

ACKNOWLEDGEMENTS

Written comments on an earlier draft of this report were provided by Dr. Stephen Ross and Dr. Melvin Warren. The author wishes to thank these individuals for their time and efforts in helping to improve this document

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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 six-year period (2002-2007) 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 2002-2007.

METHODS

Captures of Colorado pikeminnow from Adult Monitoring trips from 2003-2008 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-6 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 five to account for the 20% rule of thumb generated by Bill Miller and Vince Lamarra. This rule of thumb states that during the first electrofishing pass through a given RM, sampling crews will collect an average of 20% of all of the fish that are actually present in that RM. This gave me the total number of fish expected to be present in all sampled RMs within our 180-RM study area (with 2 of every 3 RMs being sampled; Table A-2).

After applying the 20% rule of thumb, I extrapolated the total number of Colorado pikeminnow expected to be within our electrofishing samples to include the unsampled RMs 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 RMs 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. By continuing this calculation across a given row in Table A-3, I was able to obtain expected year-to-year survival rates for each individual group of age-0 fish stocked through 2007 (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). Table A-5 uses data from all six stockings of age-0 Colorado pikeminnow that occurred from 2002-2007, 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 2003-2007 (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 1.33-7.13 fish/RM (Table A-4). By age-2, this wide variation had dropped to 0.67-1.38 fish/RM. By age-3, there was even less variation, with occurrence being 0.08-0.25 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. 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 actually have slightly better survival numbers than those stocked from 2003-2007 (Tables A-5 and A-6).

Put in terms of survival per 100,000 fish stocked, at age-1 Colorado pikeminnow are common enough (at a little more than 1 fish every half RM) to be collected on a relatively regular basis. However, the number of fish per RM drops markedly in subsequent years, such that by age-3 there is predicted to be only one Colorado pikeminnow per every 50 RMs. This would explain why age-3+ Colorado pikeminnow are extremely rare in electrofishing collections, especially given the 20% rule discussed earlier.

Therefore, the lack of age-4 and age-5 Colorado pikeminnow during the 2008 Adult Monitoring trip is almost certainly a result of having a very low capture probability for these age-classes of fish. The fact that there are presently predicted to be very few of them in the river, combined with the fact that electrofishing samples don't collect all the fish that are present, makes capturing fish in these age-classes problematic.

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
2002 (210,418)	32	16	3	1	0	0
2003 (175,928)	-----	130	33	6	0	0
2004 (280,000)	-----	-----	67	26	2	0
2005 (302,270)	-----	-----	-----	171	20	0
2006 (313,854)	-----	-----	-----	-----	115	29
2007 (475,970)	-----	-----	-----	-----	-----	143

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 the 20% first-pass electrofishing capture rule (with 2 of every three RMs being sampled).

Year-Class & (Number Stocked)	Year Of Capture					
	2003	2004	2005	2006	2007	2008
2002 (210,418)	160	80	15	5	0	0
2003 (175,928)	-----	650	165	30	0	0
2004 (280,000)	-----	-----	335	130	10	0
2005 (302,270)	-----	-----	-----	855	100	0
2006 (313,854)	-----	-----	-----	-----	575	145
2007 (475,970)	-----	-----	-----	-----	-----	715

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
2002 (210,418)	240	120	23	8	?	?
2003 (175,928)	-----	975	248	45	?	?
2004 (280,000)	-----	-----	503	195	15	?
2005 (302,270)	-----	-----	-----	1,283	150	?
2006 (313,854)	-----	-----	-----	-----	863	218
2007 (475,970)	-----	-----	-----	-----	-----	1,073

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
2002 (210,418)	1.33	0.67	0.13	0.04	?	?
2003 (175,928)	-----	5.42	1.38	0.25	?	?
2004 (280,000)	-----	-----	2.79	1.08	0.08	?
2005 (302,270)	-----	-----	-----	7.13	0.83	?
2006 (313,854)	-----	-----	-----	-----	4.79	1.21
2007 (475,970)	-----	-----	-----	-----	-----	5.96

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
Predicted Year-To-Year Survival	Mean = 0.29% Range = 0.11-0.55% (6 data points)	Mean = 30.23% Range = 11.69%-50.00% (5 data points)	Mean = 11.25% Range = 0.00%-19.17% (4 data points)	Mean = 11.59% Range = 0.00%-34.78% (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
Predicted Number Of Fish Occupying The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	290	88	10	1	?	?
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish Stocked)	1.61 (= 1 Fish Per Every 0.62 RMs)	0.48 (= 1 Fish Per Every 2.08 RMs)	0.05 (= 1 Fish Per Every 20.00 RMs)	0.006 (= 1 Fish Per Every 166.7 RMs)	? (= 1 Fish Per Every ? RMs)	? (= 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
Predicted Year-To-Year Survival	Mean = 0.33% Range = 0.18%-0.55% (5 data points)	Mean = 25.29% Range = 11.69%-38.77% (4 data points)	Mean = 8.61% Range = 7.69%-18.15% (3 data points)	Mean = 0.00% Observed Range = 0.00% (2 data points)	? (1 data point)	? (0 data points)
	At Age-1	At Age-2	At Age-3	At Age-4	At Age-5	At Age-6
Predicted Number Of Fish Occupying The Entire 180-RM Study Area (Per 100,000 Fish stocked)	330	83	7	0	?	?
Predicted Number Of Fish Per RM Throughout The Entire 180-RM Study Area (Per 100,000 Fish stocked)	1.83 (= 1 Fish Per Every 0.55 RMs)	0.46 (= 1 Fish Per Every 2.17 RMs)	0.04 (= 1 Fish Per Every 25.00 RMs)	0.00 (= 1 Fish Per Every ? RMs)	? (= 1 Fish Per Every ? RMs)	? (= 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 2002-2008 (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	1.07978	2.27205	1.93124	1.64156	1.39532	1.18602	1.00812	0.85690	0.72837
2003	175,928	1.07978		1.89963	1.61468	1.37248	1.16661	0.99162	0.84288	0.71644
2004	280,000	1.07978			3.02338	2.56987	2.18439	1.85673	1.57822	1.34149
2005	302,270	1.07978				3.26385	2.77427	2.35813	2.00441	1.70375
2006	313,845	1.07978					3.38883	2.88051	2.44843	2.08117
2007	475,970	1.07978						5.13943	4.36852	3.71324
2008	270,234	1.07978							2.91793	2.48024
2009	???	1.07978								???
Total Numbers Of Fish Surviving At:										
Age-4			2	2	3	3	3	5	3	???
Age-5	Age-5+ fish count towards downlisting			2	2	3	3	3	4	2
Age-6					2	1	2	2	2	4
Age-7	Age-7+ (i.e., adult) fish count towards delisting					1	1	2	2	2
Age-8							1	1	2	2
Age-9								1	1	1
Age-10									1	1
Age-11										1

A: It is estimated that there is one surviving age-4 fish every 166.7 RM's (see Table A-5, page 51) per every 100,000 age-0 fish stocked. Extrapolated riverwide: 180 ÷ 166.7 = 1.07978 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 1.07978 (e.g., for 2002: 210,418 age-0 fish stocked ÷ 100,000 = 2.10418; then 2.10418 × 1.07978 = 2.27205 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

Data on eight adult Colorado pikeminnow captured as adult fish from 2002-2007 that were likely stocked as age-0 fish from 1996-1997.

Table B-1. Eight adult Colorado pikeminnow collected from 2002-2007 that were likely recruits from the 1996-1997 stockings of age-0 Colorado pikeminnow by the Utah Division of Wildlife Resources (detailed in Archer et al. 2000).

Capture information:						Likely Stocking Year:
Capture Date	Capture RM	TL At Capture	Possible Age At Capture	PIT Tag Number	Source Report	
4/16/2002	45.8	539 mm	6	5312122813	Jackson 2003	1996
6/12/2002	21.4	507 mm	6	51247F0B49	Jackson 2003	1996
6/26/2002	23.7	475 mm	5	423D133353	Jackson 2003	1997
6/27/2002	19.8	460 mm	5	5228305F22	Jackson 2003	1997
3/27/2003	16.0	530 mm	7	53180D4E7E 3D9257C69CA71	Jackson 2004	1996
4/29/2003	34.0	535 mm	7	522A213C40	Jackson 2004	1996
4/30/2003	21.4	590 mm	7	4269392329	Jackson 2004	1996
3/25/2004	16.4	547 mm	7	423D133353 ®	SJRIP database	1997
7/28/2005	157.6	603 mm	9	3D91BF18D723B	Davis 2006	1996
6/20/2007	119.0	709 mm	11	53180D4E7E ® 3D9257C69CA71	Davis and Furr 2008	1996

® = Recapture