LONG TERM MONITORING OF SUB-ADULT AND ADULT LARGE-BODIED FISHES IN THE SAN JUAN RIVER: 2012

Interim Progress Report

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EXECUTIVE SUMMARY

General Information

- A total of 12,634 fishes were collected during 2012 Adult Monitoring
  - Native fishes accounted for 69.1% of the total catch in 2012

Native Species:

- Colorado pikeminnow
  - No wild Colorado pikeminnow were collected in 2012
  - 272 stocked Colorado pikeminnow were collected in 2012
    - Sixth most abundant species collected
    - Scaled CPUE of Colorado pikeminnow in the river for 1+ overwinter periods post-stocking was significantly higher in 2012 than 5 of the previous 9 years
      - Due to the collection of 196 age-1 fish (stocked as age-0 fish in fall 2011)
    - Sizes in 2009 ranged from 98-600 mm TL (age-1 to age-6)
      - 3 adult fish (450-600 mm TL) collected in 2012
      - 1 sub-adult fish (416 mm TL) collected in 2012
      - 18 large juvenile fish (300-399 mm TL) collected in 2012
    - Captures ranged from RM 180.0-77.0
      - 43 in Reach 6, 95 in Reach 5, 69 in Reach 4, and 64 in Reach 3
    - 196 (72.0%) of the 272 were in the river ≤ 365 days post-stocking
      - All 272 Colorado pikeminnow collected were in the river for at least one overwinter period
- Razorback sucker
  - No wild razorback sucker were collected in 2012
  - 321 stocked razorback sucker were collected in 2012
    - Fifth most abundant species collected
    - Most razorback sucker ever collected during an Adult Monitoring trip in the common sampled area (RM 180.0-77.0)
    - Scaled CPUE of razorback sucker that had been in the river for 1+ overwinter periods in 2012 was significantly higher than 7 of the previous 9 years
    - Sizes ranged from 297-576 mm TL (age-1 to age-18)
    - Captures ranged from RM 179.0-79.1
    - 106 were collected in Reach 6, 127 in Reach 5, 69 in Reach 4, and 19 in Reach 3
    - Of 271 razorback sucker collected with PIT tags and known stocking histories in 2012, 170 (62.7%) were in the river ≤ 365 days post-stocking
      - 46 of those fish were in the river < 1 overwinter period when they were collected
      - The others were in the river from 1-18 overwinter periods
  - Razorback sucker that have been in the river ≥ 6 overwinter periods have been collected every year since 2001
- Roundtail chub
  - 13 stocked roundtail chub were collected in 2012
    - Age-1 to age-2 fish
  - This is more roundtail chub than were collected on all previous fall Adult Monitoring trips combined

        - These were assumed to all be fish that were stocked by Colorado Parks and Wildlife
- Flannelmouth sucker
    - Most abundant species in 2012 in the common sampled area (RM 180.0-77.0)
        - Flannelmouth sucker were the numerically dominant species in Adult Monitoring collections in the common sampled area in all of the last 14 years
        - Accounted for only 42.3% of the total catch (n = 5,347 fish)
        - Had the widest distribution of any species, being collected in all 132 electrofishing samples (RM 180.0-77.0)
- Bluehead sucker
    - Among the three most-commonly collected species in each of the last 14 years in the common sampled area (RM 180.0-77.0)
    - Third most common species collected in 2012
        - Accounted for 17% of the total catch (n = 2,153 fish)
        - Collected in all 132 electrofishing samples (RM 180.0-77.0)

Nonnative Species:

- Channel catfish
    - Among the three most commonly-collected species in each of the last 14 years in the common sampled area (RM 180.0-77.0)
    - Second most abundant species collected in 2012
        - Accounted for 30.1% of the total catch (n = 3,801 fish)
        - Collected in 80.3% of electrofishing samples (RM 180.0-77.0)
        - In 2012 the majority of both juvenile and adult channel catfish were collected in the middle nonnative fish removal section
            - Numbers considerably reduced upstream of Shiprock, NM
            - Adult CPUE didn't show any declining trend in the common sampled area (RM 180.0-77.0) in the face of intensive nonnative fish removal efforts
            - Juvenile CPUE actually showed an increasing trend in the common sampled area (RM 180.0-77.0) in the face of intensive nonnative fish removal efforts
- Common carp
    - Percent of total catch accounted for by this species has decreased steadily over the last 14 years (to 0.2% in 2012) in the coomon sampled area (RM 180.0-77.0)
        - Was the fourth most commonly-collected species in 1999
    - The seventh most commonly-collected species in 2012
        - Only 27 common carp collected from RM 180.0-77.0 in 2012
            - 24 (88.9%) were adult fish (i.e., $\geq$ 250 mm TL)
        - Collected in 13.6% of electrofishing samples (RM 180.0-77.0)
        - Less abundant than both endangered Colorado pikeminnow and razorback sucker during 2012 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 twice since 1999 (Propst et al. 2006, SJRIP 2012). 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-2012 workplan) are:

1) Annually, during autumn, document fish community structure, species abundance (presented as catch/effort, CPUE) and distribution, and size structure among populations of both native and nonnative large-bodied fishes in San Juan River. Specific emphasis shall be placed upon monitoring the population parameters among the rare San Juan River fish species -- Colorado Pikeminnow, Razorback Sucker, and Roundtail Chub (both wild and stocked fish).

2) Obtain data that will aid in the evaluation of the responses (e.g., year-to-year survival, reproduction, recruitment, growth, and condition factor) of both native and nonnative large-bodied fishes to management actions.

3) Continue to perform activities that support other studies and recovery actions being implemented by the SJRIP. For example:
    a. Remove nonnative fish species which prey upon and may compete with native fish species in the San Juan River.

    b. Collect GPS waypoints in habitats where endangered Colorado Pikeminnow and Razorback Sucker are collected.

c. Collect tissue samples from various fish species for stable isotope, genetics, and contaminants studies.

d. Document hybridization of endangered fish with native fishes.

e. When appropriate document any observed parasites, lesions, or abnormalities on collected fishes. Make this data available to appropriate studies when they occur.

Relationship to the Recovery Program

Adult Monitoring provides data for, or makes possible (at least in part), the following actions under element numbers 1-4 of the Long Range Plan (SJRIP 2013): 1.1.1.1, 1.1.1.2, 1.2.1.1, 1.2.1.2, 1.2.2.1, 2.4.2.2, 3.1.1.1, 3.1.1.3, 3.1.1.4, 4.1.1.1, 4.1.1.2, 4.1.1.3, 4.1.2.3, 4.1.2.4, 4.1.2.5, 4.1.3.1, 4.1.5.1, 4.1.5.2, 4.3.3.1, 4.3.4.1, and 4.3.4.2. The Comprehensive Monitoring Plan is currently undergoing revision. However, the monitoring protocols discussed in the Methods section of this report reflect those that are currently included in the latest version of the Monitoring Plan and Protocols (SJRIP 2012).

Study Area

In 2012, the study area for Adult Monitoring began just downstream of the Bloomfield boat (RM 195) and continued downstream to the Sand Island boat landing, near Bluff, UT (RM 77.0). This study area encompassed five geomorphic reaches of the San Juan River between Navajo Reservoir and Lake Powell. These included the lower 15 miles of Reach 7, three complete reaches (Reaches 6, 5, and 4) and the majority of Reach 3, as defined by Bliesner and Lamarra (2000). The seven geomorphic reaches in their entireties are: Reach 7 (RM 214.0-180.0); 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).

METHODS

Field Sampling

Sampling conducted in 2012 followed the protocols for long-term monitoring set forth in the latest version of the Monitoring Plan and Protocols (SJRIP 2012). 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.

Common Sampled Area Versus Riverwide Sampling

From 1999-2010, Adult Monitoring sampled the large majority of geomorphic reaches 6-1 (RM 180.0-2.9). Although our study area ended 2.9 RM short of the end of Reach 1 (at Clay Hills boat landing) during those years, it was assumed during data analysis for those years that the data collected from the majority of Reach 1 (RM 17.0-2.9) were representative of the entirety of Reach 1 (RM 17.0-0.0). This approach to data analysis allowed year-to-year comparisons of data for the fish species we were interested in to be made on a "riverwide" basis (i.e., from RM 180.0-0.0).

However, as per modifications made to the long-term monitoring protocols in the latest version of the Monitoring Plan and Protocols (SJRIP 2012), the study area for Adult Monitoring was reduced to sample just RM 180.0-77.0 in four out of five years, with the entirety of the previous study area (reaches 6-1) being sampled only every fifth year. Thus, 2011 was the first year of reduced sampling under the new sampling protocols and 2012 was the second year. The entire study area from RM 180.0-2.9 isn't scheduled to be sampled again until fall 2015.

This change in sampling protocol for 2011 necessitated a cropping of 1999-2010 data sets to a common sampled area (RM 180.0-77.0). Therefore, all data comparisons in this report will be just for this common sampled area and will not include any data from the downstream, mostly canyon-bound areas of the San Juan River (RM 77.0-2.9) reported in 1999-2010 reports.

In 2012 two river sections (totaling 15 RM) upstream of the confluence of the San Juan and Animas Rivers were sampled to see 1) if sampling in these areas of the river was feasible at this time of the year, and 2) to attempt to document range expansion of Colorado Pikeminnow and Razorback Sucker upstream of the Animas river confluence. Low water levels prevented sampling the lower several miles of the Animas River in 2012.

Since we only have a single year of data from the two upstream San Juan River sections, the 2012 data will not be used for comparative purposes in this report. A separate sub-section will be added at the end of the RESULTS section to describe the 2012 findings. If sampling is continued in these upstream river sections, year-to-year comparisons will be presented in future reports.

Data Analysis

Rare Native Fishes

Based on data collected over the last several years, it appears that essentially all of the endangered Colorado Pikeminnow and Razorback Sucker being collected during Adult Monitoring are fishes that have been stocked during augmentation efforts. Large disparities exist in numbers of fish stocked between various calendar years, making year-to-year comparisons of CPUE problematic. To deal with this problem, endangered fishes 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 fishes were then scaled to account for the differences in numbers of fishes stocked between years (Golden and Holden 2005, Robertson and Holden 2007, R. Ryel pers. comm.).

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

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

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

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

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

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

Common Large-Bodied Fishes

The four "common" large-bodied fishes encountered during Adult Monitoring sampling 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 common sampled area basis, i.e., RM 180.0-77.0) across years. Electrofishing data were pooled for all rafts to obtain total catch by species for the entire sampling trip. Total catch for each species was then divided by the number of seconds (converted to hours) fished by all rafts combined to obtain CPUE values (i.e., number of fish per hour of electrofishing) for juvenile and adult life stages and for all life stages combined (i.e., juvenile + adult; referred to hereafter as "total CPUE"). CPUE values for each common large-bodied fish species were then compared to previous years' common sampled area 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 $p < 0.10$ (Ryden 2000a, Brown and Guy 2007). 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 $p < 0.10$ (Ryden 2000a, Brown and Guy 2007). Length data obtained from fish measured at designated miles (DMs) were used to develop common sampled area length frequency histograms for wild populations of the four common large-bodied fish species.

RESULTS

The mean river flow (at the Shiprock USGS gage #09368000) during the 2012 Adult Monitoring trip was 804 CFS (Table 1). Overall, the mean river flow during the entire 14-year period (1999-2012) of Adult Monitoring sampling was 992 CFS. Thus the 2012 mean river flow during sampling fell below the mean value for this 14-year period.

Nineteen fish species and hybrids were collected during the 2012 Adult Monitoring trip (Table 2). This included 6 native species, 2 native sucker X native sucker hybrids, 1 native sucker X nonnative sucker hybrid, and 10 nonnative species (Tables 2 and 3). Six species (Flannelmouth Sucker, Channel Catfish, Bluehead Sucker, Speckled Dace, Razorback Sucker, Colorado Pikeminnow) accounted for 99.0% (12,510 fish) of the total catch. The other 10 species and three hybrids contributed only 1.0% (124 fishes) to the total catch in 2012 (Table 3). Native fishes accounted for the majority (69.1%) of fishes collected in 2012 (Table 3). Native Flannelmouth Sucker were once again the most abundant species collected during Adult Monitoring, accounting for 42.3% of all fish collected in our common sampled area.

In general fish collected during Adult Monitoring appeared to be in good health. Any noticeable instances of abnormalities, parasites, or deformities were noted in the field notes, but the rate of occurrence was low. Currently there are no studies being conducted to explore these phenomenon, but the data is available to the program if a study is initiated.

Table 1. Summary of dates, river miles (RM) sampled, and mean flow during riverwide Adult Monitoring trips in the San Juan River in New Mexico, Colorado, and Utah, 1999-2012.

Beginning Date Of Sampling	Ending Date Of Sampling	River Miles Sampled	Mean Trip Flow At The Shiprock, NM USGS Gage (#09368000) In CFS And (Cubic Meters/Second)
20 September 1999	7 October 1999	RM 180.0-2.9	2,177 CFS (61.6 m^3/sec)
18 September 2000	10 October 2000	RM 180.0-2.9	657 CFS (18.6 m^3/sec)
25 September 2001	19 October 2001	RM 180.0-2.9	611 CFS (17.3 m^3/sec)
20 September 2002	7 October 2002	RM 180.0-2.9	458 CFS (12.9 m^3/sec)
22 September 2003	14 October 2003	RM 180.0-2.9	450 CFS (12.7 m^3/sec)
20 September 2004	13 October 2004	RM 180.0-2.9	1,432 CFS (40.5 m^3/sec)
19 September 2005	12 October 2005	RM 180.0-2.9	1,072 CFS (30.3 m^3/sec)
18 September 2006	9 October 2006	RM 180.0-2.9	2,479 CFS (70.1 m^3/sec)
17 September 2007	11 October 2007	RM 180.0-2.9	1,262 CFS (35.7 m^3/sec)
22 September 2008	15 October 2008	RM 180.0-2.9	638 CFS (18.1 m^3/sec)
21 September 2009	14 October 2009	RM 180.0-2.9	532 CFS (15.0 m^3/sec)
20 September 2010	12 October 2010	RM 180.0-2.9	762 CFS (21.5 m^3/sec)
12 September 2011	29 September 2011	RM 180.0-52.9	615 CFS (17.4 m^3/sec)
10 September 2012	28 September 2012	RM 195.0-52.9	804 CFS (22.7 m3/sec)
14-year statistics: Mean = 992 CFS 28.2 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 2012 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
Catostomus latipinnis	Flannelmouth Sucker	Native	Catlat
Xyrauchen texanus	Razorback Sucker	Native	Xyrtex
X. texanus X *C. latipinnis*	hybrid	Native	texXlat
C. latipinnis X *C. discobolus*	hybrid	Native	latXdis
C. commersoni X *C. latipinnis*	hybrid	Introduced	comXlat
Order Cypriniformes: Family Cyprinidae - carps and minnows			
Cyprinella lutrensis	Red Shiner	Introduced	Cyplut
Cyprinus carpio	Common Carp	Introduced	Cypcar
Ptychocheilus lucius	Colorado Pikeminnow	Native	Ptyluc
Gila robusta	Roundtail Chub	Native	Gilrob
Rhinichthys osculus	Speckled Dace	Native	Rhiosc
Order Perciformes: Family Centrarchidae – sunfishes			
Lepomis cyanellus	Green Sunfish	Introduced	Lepcya
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 natalis	Yellow Bullhead	Introduced	Amenat
Ameiurus melas	Black Bullhead	Introduced	Amemel
Ictalurus punctatus	Channel Catfish	Introduced	Ictpun

Table 3. Total number of fishes collected during the 2012 Adult Monitoring trip in the common sampled area (RM 180.0-77.0).

Species (Status)[a]	Number Collected	Percent Of Total[b]	Number Of Samples Collected In
Flannelmouth Sucker (N)	5347	42.3	132
Channel Catfish (I)	3801	30.1	106
Bluehead Sucker (N)	2153	17	132
Speckled Dace (N)	616	4.9	107
Razorback Sucker (N)	321	2.5	95
Colorado Pikeminnow (N)	272	2.2	98
Common Carp (I)	27	0.2	18
Black Bullhead (I)	25	0.2	18
Largemouth Bass (I)	16	0.1	11
Roundtail Chub (N)	13	0.1	9
Brown Trout (I)	11	0.1	8
Red Shiner (I)	11	0.1	10
Flannelmouth Sucker X Bluehead Sucker (H, N)	6	-----	5
Flannelmouth Sucker X White Sucker (H, I)	5	-----	5
White Sucker (I)	5	-----	5
Rainbow Trout (I)	2	-----	2
Green Sunfish (I)	1	-----	1
Razorback Sucker X Flannelmouth Sucker (H, N)	1	-----	1
Yellow Bullhead (I)	1	-----	1
GRAND TOTAL	12,634		
Total Electrofishing Collections In 2012 = 132 Total Electrofishing Effort In 2012 = 54.51 Hours			
2012 Native Fishes = 8,729 (69.1% Of The Total Catch) 2012 Introduced Fishes = 3,905 (30.9% Of The Total Catch) 2012 Native To Introduced Fishes Ratio = 2.24:1			

a: (N) = Native species; (I) = Introduced species; (H, N) = A hybrid of two native fish species, considered to be a native fish; (H, I) = A hybrid of a native and a nonnative fish 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 2012, but we did capture 272 stocked Colorado Pikeminnow from RM 180-77 (Table 3). This marked the seventh consecutive year that > 100 Colorado Pikeminnow were collected during an Adult Monitoring trip from this common sampled area (2006 = 250; 2007 = 140; 2008 = 197; 2009 = 300; 2010 = 371; 2011 = 386). Colorado Pikeminnow captures ranged from RM 180.0-77.0 (Table 4), with 43 being collected in Reach 6, 95 in Reach 5, 69 in Reach 4, and 65 being collected in the portion of Reach 3 (RM 106-77) that was sampled in 2012. This was the first year that every Colorado Pikeminnow collected during Adult Monitoring had been in the river for one or more overwinter periods.

Fifteen (3.6%) Colorado Pikeminnow were collected upstream of the Hogback Diversion (RM 158.6) in 2012. Five of these collections occurred upstream of PNM Weir (RM 166.6), and 4 of the 15 Colorado Pikeminnow captured upstream of Hogback Diversion had PIT tags. Two of these fish were stocked at age-2 fish (hard-released) at Boyd Park on 18 May 2011. The other two PIT-tagged fish were stocked as an age-0 fish in the fall of 2011 at RM 166.6, just downstream of the PNM Weir, or at Boyd Park (Animas RM 1.0). One of the two PIT-tagged fish was marked as a recapture on 14 September 2012. However there is no previous record of this fish in the data base. The other PIT-tagged fish was captured and tagged during a nonnative fish removal trip on 15 August 2012 (RM 159.4) and recaptured during the 2012 Adult Monitoring trip (14 September at RM 160.0). Like many stocked fish, these fish showed a pattern of initial downstream displacement (Ryden 2000b), followed by upstream movements as they grew and matured (Osmundson et al., 1997a, 1998).

Four Colorado Pikeminnow without PIT tags were also collected upstream of PNM Weir. Of these, three (118-226 mm TL) were age-1 fish, assumed to have been stocked as age-0 fish in November 2011 (Furr 2013a). The other Colorado Pikeminnow captured without a PIT tag could be a large age-1 fish stocked at age-0 in November 2011 or a fish that shed its PIT tag after being stocked as an age-1 fish in May 2011 (Furr 2013a).

Table 4. General information on 269 known-origin stocked Colorado Pikeminnow collected in 2012.

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-1 (196)	98-261	176.0-77.0	313-329 (1)	11/2/2011	Age-0 (2011)	Dexter
Age-2 (62)	241-346	178.0-79.1	482-497 (1)	5/17/2011 5/18/2011	Age-1 (2010)	Dexter
Age-3 (2)	358-360	144.0-83.0	1046-1051 (3)	11/9/2009	Age-0 2009	Dexter
Age-3 (5)	337-416	179.0-113.0	481-493 (1)	5/18/2011	Age-2 (2009)	Dexter
Age-4 (2)	395-450	146.0-82.0	1414-1419 (4)	11/6/2008	Age-0 (2008)	Dexter
Age-6 (1)	600	133.0	2150-2164 (6)	10/19/2006 11/2/2006	Age-0 (2006)	Dexter
Age-6 (1)	460	137.0	1283 (3)	3/17/2009	Age-3 (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 three Colorado Pikeminnow in 2012. These three fish (170-208 mm TL), collected from RM 122-113, were all recorded as being “recaptures” on the data sheets (i.e., having PIT tags in them at the time of their capture). In all three cases, the PIT tag recorded had 14 digits (when it should have had 13). This left 269 Colorado Pikeminnow of known origin (Table 4).

The majority (n = 196; 72.9%) of the 269 known-origin Colorado Pikeminnow collected in 2012 were in the river ≤ 365 days post-stocking, but still had one overwinter period in the river (i.e., they were stocked in November 2011). Only 73 (27.1%) of the 269 known-origin Colorado Pikeminnow collected in 2012 were in the river > 365 days post-stocking and more than one overwinter period. Of those 73 fish, 5 (7%) were stocked as age-0 fish. In fall 2010, a Largemouth Bass Virus (LMBV) quarantine at Dexter National Fish Hatchery and Technology Center (NFH&TC) caused that hatchery to hold back approximately 214,000 age-0 Colorado

Pikeminnow and 3,700 age-1 fish, that were scheduled to be stocked that fall. These fish were instead stocked in May of 2011 as age-1, or age-2, fish after the hatchery cleared quarantine (Furr 2013a). Sixty-eight of the Colorado Pikeminnow collected on the fall 2012 Adult monitoring trip came from these stockings of age-1 and age-2 fish.

Numerous larger Colorado Pikeminnow were collected during 2012 Adult Monitoring. These included 18 fish from 300-399 mm TL (age-2 to age-3 fish), 1 fish from 400-449 mm TL (age-3 fish), and 3 fish ≥ 450 mm TL (age-4 and age-6). Thus, the Colorado Pikeminnow collected in 2012 met the Recovery Goal demographic criteria for Downlisting (USFWS 2002a). However, these larger size-class fish were likely all stocked fish. They were stocked at larger sizes than is normal for wild fish of the same age-class and are reaching the target size-class thresholds for both sub-adult and adult fish faster than would be true for wild fish (Osmundson et al. 1996, 1997b; D. Ryden, unpublished data). The use of the Recovery Goal demographic criteria for Downlisting in this context is simply a convenient way to judge progress of this species towards recovery (i.e., by comparing Adult Monitoring collections against a published target number or size). As a point of clarification:

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

Comparisons of scaled CPUE among groups of Colorado Pikeminnow stocked as age-0 fish showed that at age-1, recapture rates were highly variable (indicating either highly variable survival or highly variable recapture probabilities) between years (Figure 1). However, between 2003 and 2012, there was a general upward trend in scaled CPUE for fish stocked at age-0 and recaptured at age-1. This might indicate that stocking fish higher in the system and implementing more rigorous handling, transport, and stocking protocols is helping to increase short-term retention of Colorado Pikeminnow. Data collected from 2004-2009 indicated that by age-2, differences in scaled CPUE among stocking years tended to essentially disappear, with few significant differences being present (Figure 1). Age-2 fish collected in 2010 and 2011 were an exception to this trend, with scaled CPUE for age-2 fish in both 2010 and 2011 being significantly higher than the previous six years values (Figure 1). Again, this may be indicative of the handling, transport, and stocking protocols implemented in the last couple of years. No age-2 fish stocked as age-0 fish were captured in 2012 due to the quarantine for the LMBV at Dexter NFH&TC in 2012. However, by age-3, few significant differences existed in scaled CPUE among any of the groups of Colorado Pikeminnow stocked as age-0 fish (Figure 1).

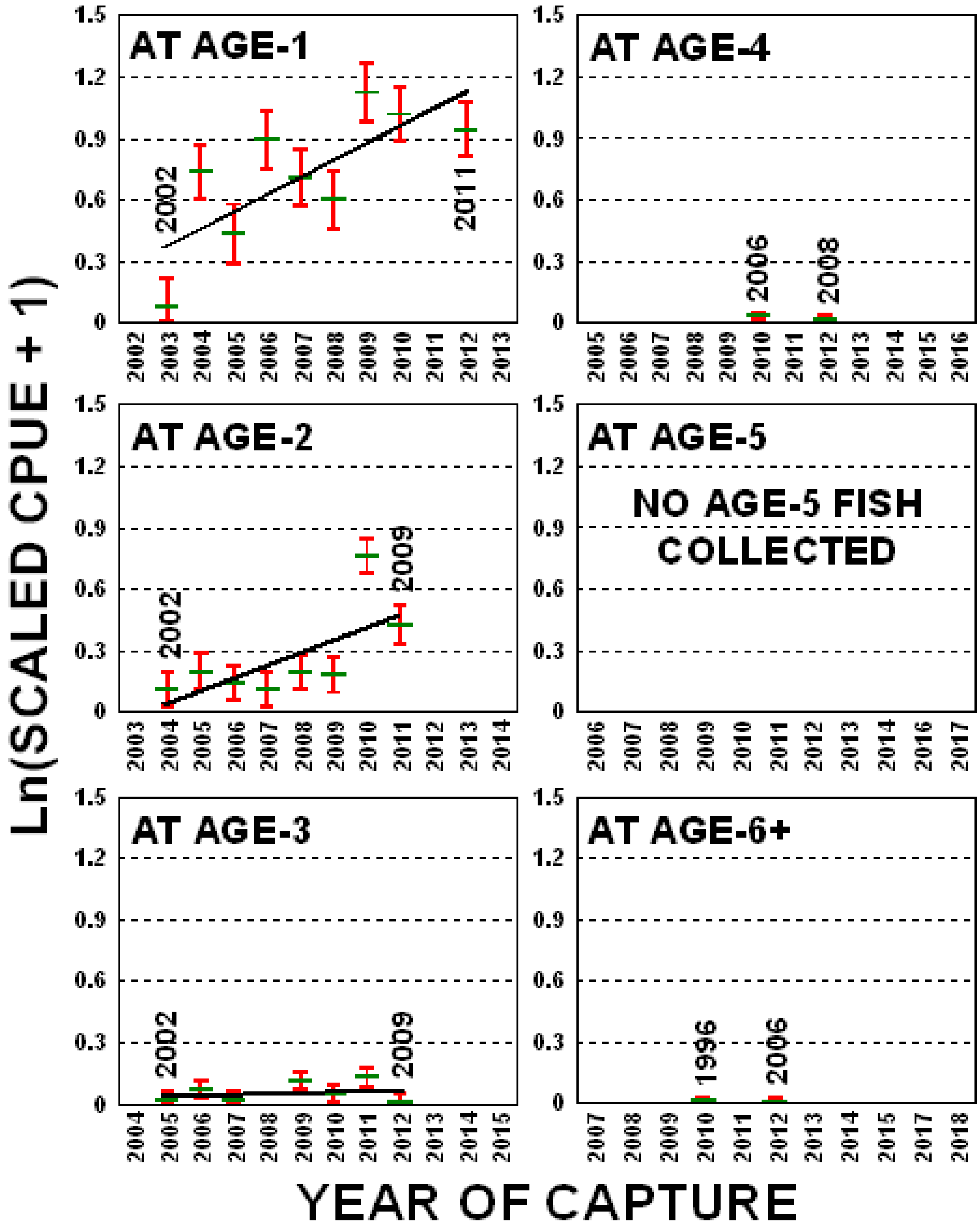

Figure 1. A comparison of scaled CPUE at age among groups of Colorado Pikeminnow stocked as age-0 fish and captured during subsequent Adult Monitoring trips, 2003-2012, in the common sampled area (RM 180.0-77.0). The green line shows the mean scaled CPUE values for each year-class of fish during a given calendar year. Red error bars are +/- 2 SE. The black lines show a linear regression from year to year for each year-class. The first and last year-classes collected are specified on each graph.

There were two years (2006 and 2008) in which an age-4 Colorado Pikeminnow that had been stocked as an age-0 fish was collected from RM 180.0-77.0 (Table 4, Figure 1). No Colorado Pikeminnow stocked as an age-0 fish have ever been collected at age-5 during Adult Monitoring. However, one age-6 Colorado Pikeminnow stocked as an age-0 fish was captured in 2012.

Of the 269 known-origin Colorado Pikeminnow collected in 2012, a relatively high number (n = 68; 25.3%) were fish stocked as age-1+ fish (Table 4). However, of these 68 fish, only one fish stocked at age-1+ was recaptured after 2 overwinter periods post-stocking so that longer-term recaptures are from fish stocked as age-0 (Table 4).

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 (Figure 2). However, in 2009, 2010 and again in 2012, the value for this metric showed significant increases over previous years (Figure 2). In most years (2003-2009), the magnitude of this metric has really been driven by (i.e., reflective of) fish stocked at age-0 that survived into their age-1 year-class (Figure 1). This is because the largest majority of Colorado Pikeminnow that are available for capture in any given year are fish that were stocked as age-0 fish the previous fall. Thus, almost all Colorado Pikeminnow that we encounter during Adult Monitoring (which are usually numerically dominated by age-1 fish stocked the previous fall) have already experienced at least one 1 overwinter period (Table 5) and are thus used in this calculation. In 2010 this changed somewhat (Table 5). Significantly higher numbers of age-2 fish (stocked at age-0 in fall 2008) combined with large numbers of age-1 fish (stocked at age-0 in fall 2009) helped drive the significant increase observed in 2010 (Figure 1). In 2011, scaled CPUE for fish stocked at age-0 that survived into their age-2 year-class was once again high, although not as high as in 2010 (Figure 1). However, there were no age-0 Colorado Pikeminnow stocked in fall 2010 (Furr 2013a), thus there were no age-1 fish available to be recaptured as age-1 fish during the fall 2011 Adult Monitoring trip. Thus, the decrease observed between 2010 and 2011 in scaled CPUE for all Colorado Pikeminnow that were in the river 1+ overwinter periods (Figure 4) was really driven by (i.e., reflective of) this lack of age-1 fish in the system. These 2010 and 2009 year-class fish were present in the 2012 Adult Monitoring catch as both age-2 and age-3 fish (Figure 4). The 2012 scaled CPUE value for Colorado Pikeminnow that had been in the river 1+ overwinter periods also increased significantly from the catch rate in 2011 (Figure 2).

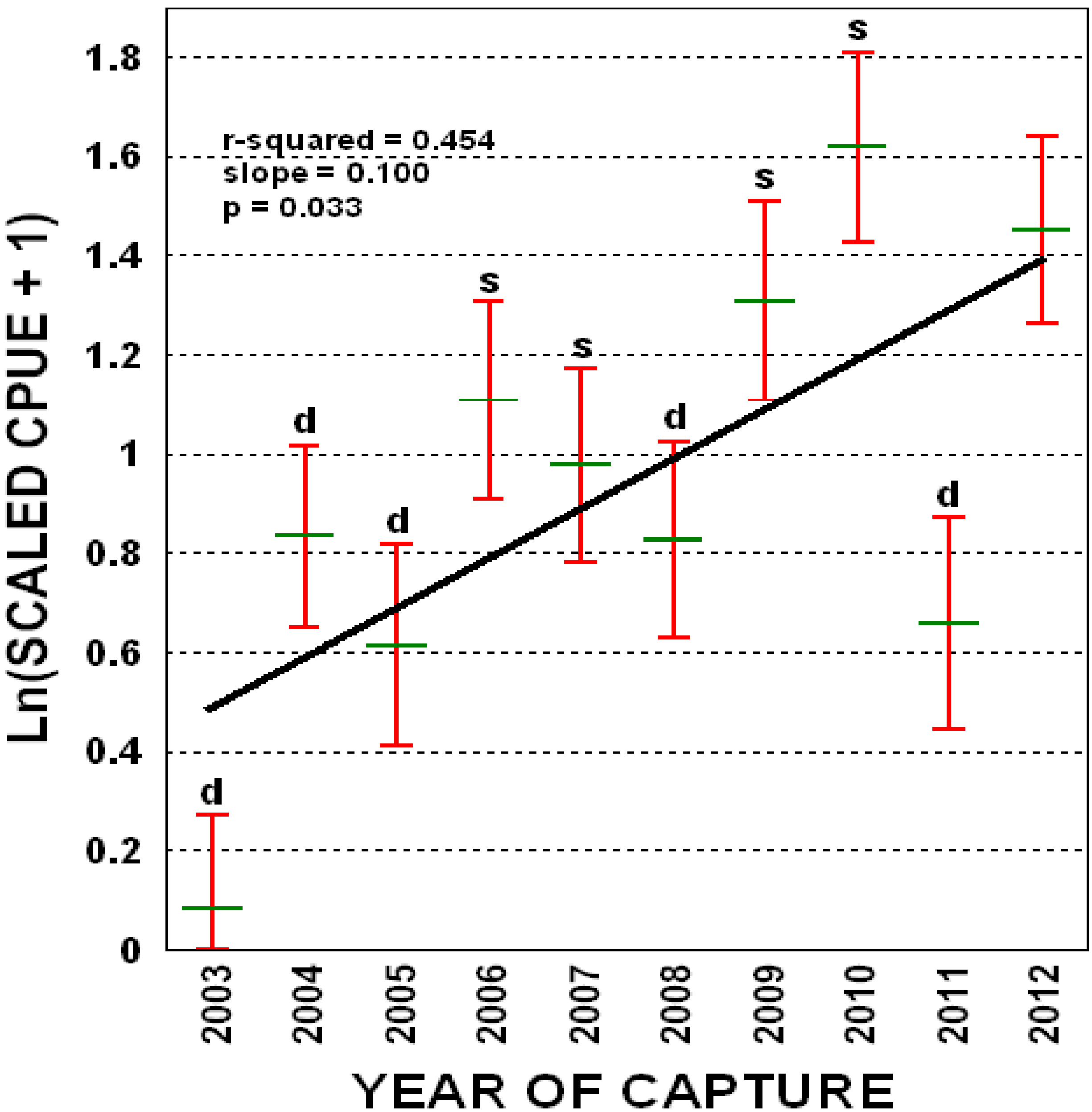

Figure 2. Year-to-year comparison of scaled CPUE for all Colorado Pikeminnow collected on Adult Monitoring trips in the common sampled area (RM 180.0-77.0) that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. The solid black line shows a linear regression between years. 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.

Table 5. Information on stocked Colorado Pikeminnow collected from 2003-2012 that had been in the river for 1+ overwinter periods.

Information For Fish Collected During Adult Monitoring Trips (RM 180-77):			Information For Fish That Were In The River For 1+ Overwinter Periods At Time Of Capture:		
Year	Effort (Total Hours Electrofished)	Total Number Collected	Number Of Fish Collected That Were In River 1+ Overwinter Periods	Oldest Year-Class Captured	Number Of Overwinter Periods
2003	51.98	8	8	2002	1
2004	50.25	102	91	2002	1-2
2005	47.31	84	62	2002	1-3
2006	51.19	250	146	2002	1-4
2007	50.64	140	117	2004	1-3
2008	58.77	197	162	2006	1-2
2009	58.34	300	257	2006	1-3
2010	54.96	371	351	1996	1-14
2011	48.68	386	75	2006	1-5
2012	54.51	272	272	2006	1-6

Razorback Sucker

A total of 321 Razorback Sucker were collected in 2012, all of which were assumed to be stocked fish (Table 6). This marks largest number of this species ever collected during Adult Monitoring and the seventh consecutive year during which > 50 Razorback Sucker were collected during an Adult Monitoring trip from this common sampled area (2006 = 121; 2007 = 171; 2008 = 73; 2009 = 77; 2010 = 149; 2011 = 197). Razorback Sucker captures ranged from RM 179.0-79.1 (Table 6), with 106 being collected in Reach 6, 127 in Reach 5, 69 in Reach 4, and 19 being collected in the portion of Reach 3 (RM 106-77) that was sampled in 2012.

Twenty-nine Razorback Sucker (9.0%) were collected upstream of the PNM Weir and fish passage facility (RM 166.6). In contrast, there were no collections of Razorback Sucker upstream of PNM Weir during our 2010 sampling. However, the large majority (n= 259; 80.1%) of Razorback Sucker collections in 2012 still occurred downstream of Hogback Diversion (RM 158.6).

A total of 48 Razorback Sucker were collected for which either the stocking history or the exact length of the time the fish had been in the river could not be determined (Table 6). Personnel errors (e.g., not recording the correct number of digits for the PIT tag number) led to usable PIT tag numbers not being obtained for two Razorback Sucker. Eleven Razorback Suckers were fish that had been collected without a PIT tag on previous sampling trips; these fish were PIT tagged prior to being released. Twenty-five Razorback Sucker had no detectable PIT tag upon capture during the 2012 Adult monitoring trip, these fish (likely from the 2006-2007 clean-out of the NAPI grow-out ponds) were implanted with a new 134 kHz PIT tag prior to being released. The last 10 Razorback Sucker were recorded in field notes as having a 134 kHz PIT when collected. However, the original stocking/tagging histories for these fish could not be found in the combined PIT tag database.

Of the 271 Razorback Sucker recaptured with PIT tags and known stocking histories in 2012, 170 (62.73%) were in the river ≤ 365 days post-stocking and 46 were in the river < 1 overwinter period when they were collected. The other 101 (37.27%) were in the river > 365 days post-stocking and had been in the river from 1-18 overwinter periods (Table 6).

Table 6. General information on stocked Razorback Suckers collected in 2012.

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 271 Razorback Sucker with known stocking histories:					
4-177 (0)	Age-4 (46)	297-470	197.0-86.0	2012	Age-4 (2008)
321-560 (1)	Age-3 & Age-5 (130)	353-508	178.0-79.1	2011	Age-2 & Age-4 (2007 & 2009)
675-747 (2)	Age-3 &Age-4 (61)	392-499	164.0-100.0	2010	Age-1 & Age-2 (2008 & 2009)
1036-1075 (3)	Age-5 (14)	404-533	169.0-119.0	2009	Age-2 (2007)
1408-1445 (4)	Age-6 (4)	433-506	148.5-101	2008	Age-2 (2006)
1882-1983 (5)	Age-6 & Age-9 (4)	459-560	149.0-128.0	2007	Age-1 & Age-4 (2003 & 2006)
2222-2280 (6)	Age-9 & Age-10 (2)	485-506	130.0-116.0	2006	Age-3 & Age-4 (2002-2003)
2939-3070 (8)	Age-10 – Age-12 (6)	447-561	160.0-110.0	2004	Age-2 – Age-4 (2000-2002)
3968-3978 (11)	Age-12 (3)	480-576	158.0-124.0	2001	Age-1 (2000)
6520 (18)	Age-20 (1)	480	95.0	1994	Age-2 (1992)
Information on the 48 Razorback Sucker captured without known stocking histories:					
Unknown	Unknown (48)	385-527	163.7-80	Unknown	Unknown

Comparisons of capture data for Razorback Suckers with known stocking histories that were in the river for 1+ overwinter periods and collected during Adult Monitoring trips changed little from 2003-2009 (range = 18-36; Table 7). However, in 2010, this number rose to 70 fish, double the value observed in any previous year. In 2011, this number rose again to 118 fish, and in 2012 this number nearly doubled again with 231 Razorback Suckers that had been in the river 1+ overwinter periods being collected (Table 7). Razorback Sucker collected after 1+ overwinter periods also continue to demonstrate a much longer post-stocking persistence (up to 18 overwinter periods or 6,520 days post-stocking) than Colorado Pikeminnow (Table 7). On every Adult Monitoring trip since 2003, Razorback Sucker were collected that had been in river for at least six overwinter periods post-stocking (Table 7). The two 1992 year-class Razorback Suckers collected on the 2007 and 2010 Adult Monitoring trips (both stocked in 1995), and a 1992 year-class fish stocked in 1994 and captured 2012, indicate that older Razorback Suckers continue to persist in the San Juan River, albeit in low numbers. The 2012 scaled CPUE value for Razorback Suckers that were in the river 1+ overwinter periods was not significantly higher than two previous years; however, it was significantly higher than the period from 2003-2009 (Figure 3). This was likely a direct result of the 231 Razorback Suckers mentioned above.

Table 7. Information on stocked Razorback Sucker collected from 2003-2012 that had been in the river for 1+ overwinter periods.

Information For Fish Collected During Adult Monitoring Trips (RM 180-77):			Information For Fish That Were In The River For 1+ Overwinter Periods At Time Of Capture:		
Year	Effort (Total Hours Electrofished)	Total Number Collected	Number Of Fish Collected That Were In River 1+ Overwinter Periods	Oldest Year-Class Captured	Number Of Overwinter Periods
2003	51.98	17	17	1992 (1 wild juvenile collected)	1-9 (wild fish; 249 mm TL = age-1 or age--2)
2004	50.25	108	18	1992	1-10
2005	47.31	46	30	1998	1-6
2006	51.19	121	23	1997	1-8
2007	50.64	171	22	1992	1-12
2008	58.77	73	36	2000	1-7
2009	58.34	77	35	1999	1-9
2010	54.96	149	70	1992	1-15
2011	48.68	197	118	1999	1-11
2012	54.51	321	231	1992	1-18

Source of origin could be determined for 271 Razorback Sucker. Of these, 209 (77.12%) were reared in the Navajo Agricultural Products Industry (NAPI) grow-out ponds, southwest of Farmington, NM. Twenty (7.38%) were reared at the USFWS' Dexter NFH&TC, near Roswell, NM. Forty (14.76%) were reared at the USFWS' Uvalde National Fish Hatchery, in Uvalde, TX. Two (0.74%) were reared in Wahweap Warmwater Hatchery, Big Water, UT. Of the 209 fish reared at the NAPI ponds, 84 were from Hidden Pond, 65 from West Avocet Pond, 58 from East Avocet Pond, and two from the now-defunct 6-Pack Ponds.

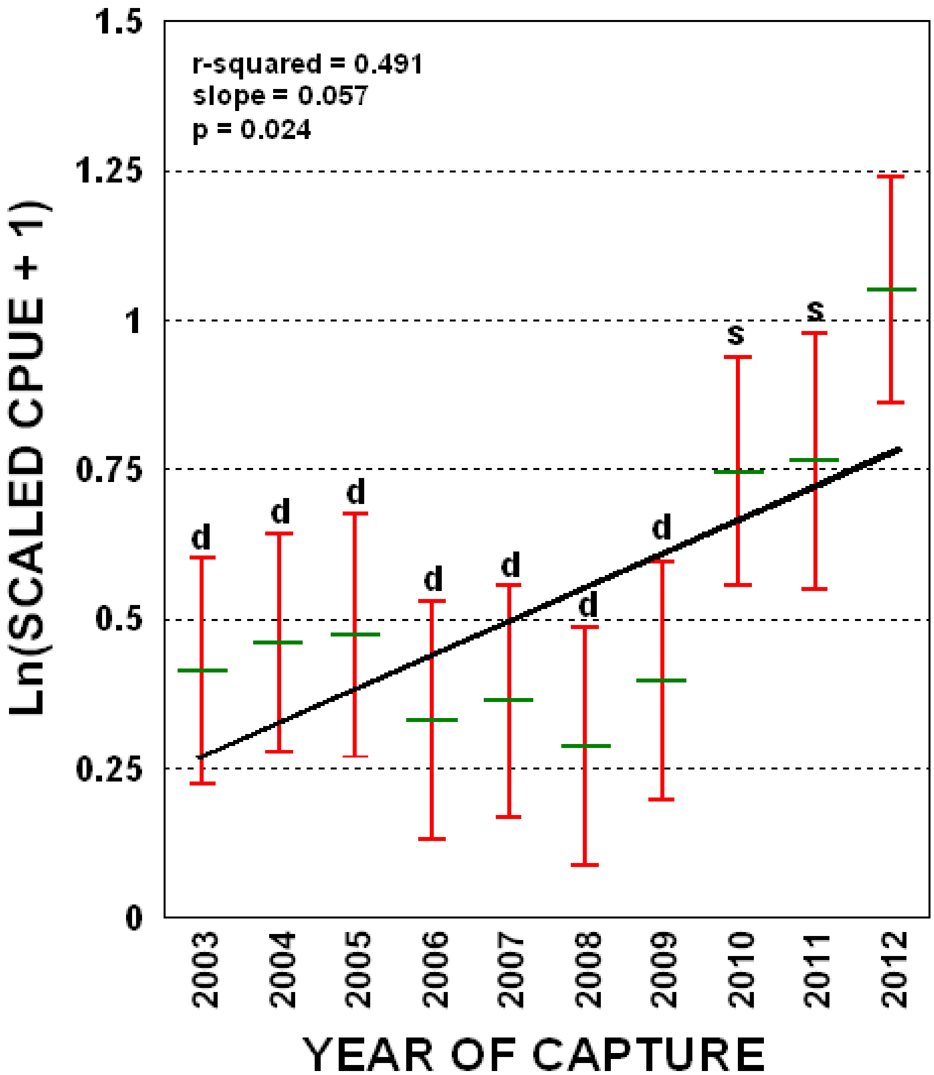

Figure 3. Year-to-year comparison of scaled CPUE for all Razorback Sucker collected on Adult Monitoring trips in the common sampled area (RM 180.0-77.0) that were in the river for one or more overwinter periods following stocking (regardless of age). The green lines show the mean scaled CPUE values for each year. Red error bars are +/- 2 SE. The solid black line shows a linear regression between years of capture.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

Thirteen Roundtail Chub were collected during 2012 Adult Monitoring, from RM 146-119. Twelve of these were captured in Reach 4 and one in Reach 5 (RM 155- 131). This number is considerably larger than numbers of Roundtail Chub collected during past Adult Monitoring trips. One Roundtail Chub was collected during both 2008 and 2009 sampling. The next previous collection occurred during 2002 sampling.

The Roundtail Chub collected during the 2012 Adult Monitoring trip ranged in size from 112-215 mm TL. Of the 13 Roundtail Chub collected, only three were larger than 150 mm TL. Two of those were PIT tagged and the third was released without a PIT tag due stress concerns.

The J.W. Mumma Native Aquatic Species Restoration Facility (Mumma) in Alamosa, CO has been stocking Roundtail Chub into the Colorado portions of several tributaries to the San Juan River for several years now. After reviewing their 2012 stocking tickets, it was determined that the Roundtail Chub we collected in 2012 were considerably larger than the fish Mumma had stocked in 2012. Given the dearth of wild Roundtail Chub in our collections for many years, we are assuming here that the 13 Roundtail Chub we collected represent either age-1 or age-2 fish stocked by Mumma in previous years (T. Smith, pers. comm.).

Common Native Fishes

Flannelmouth Sucker

Catch Information

Flannelmouth Sucker was once again the most common large-bodied fish species collected in the common sampled area during the 2012 Adult Monitoring trip (Table 3, Figure 4), being collected in all 132 electrofishing samples in the common sampled area from RM 180.0-77.0 (Table 3, Figure 4).

In the common sampled area, Flannelmouth Sucker juvenile CPUE has shown far more variation over the last 14 years than has adult CPUE (Figure 5). Although year-to-year juvenile CPUE values showed a comparatively high degree of variation, the long-term trend indicated no significant change. If you compare the 1999, 2000, and 2001 with 2012 adult CPUE values, there is a significant decline between those four data points. However, the 2012 adult CPUE value was not significantly different than 9 of the previous 13 years. Therefore, this particular declining trend is really being driven by the 1999, 2000, and 2001 data points for adult Flannelmouth Sucker. Despite the significant long-term decline in adult Flannelmouth Sucker CPUE, the combined adult and juvenile CPUE showed no significant change over the last 12 years (Figure 5).

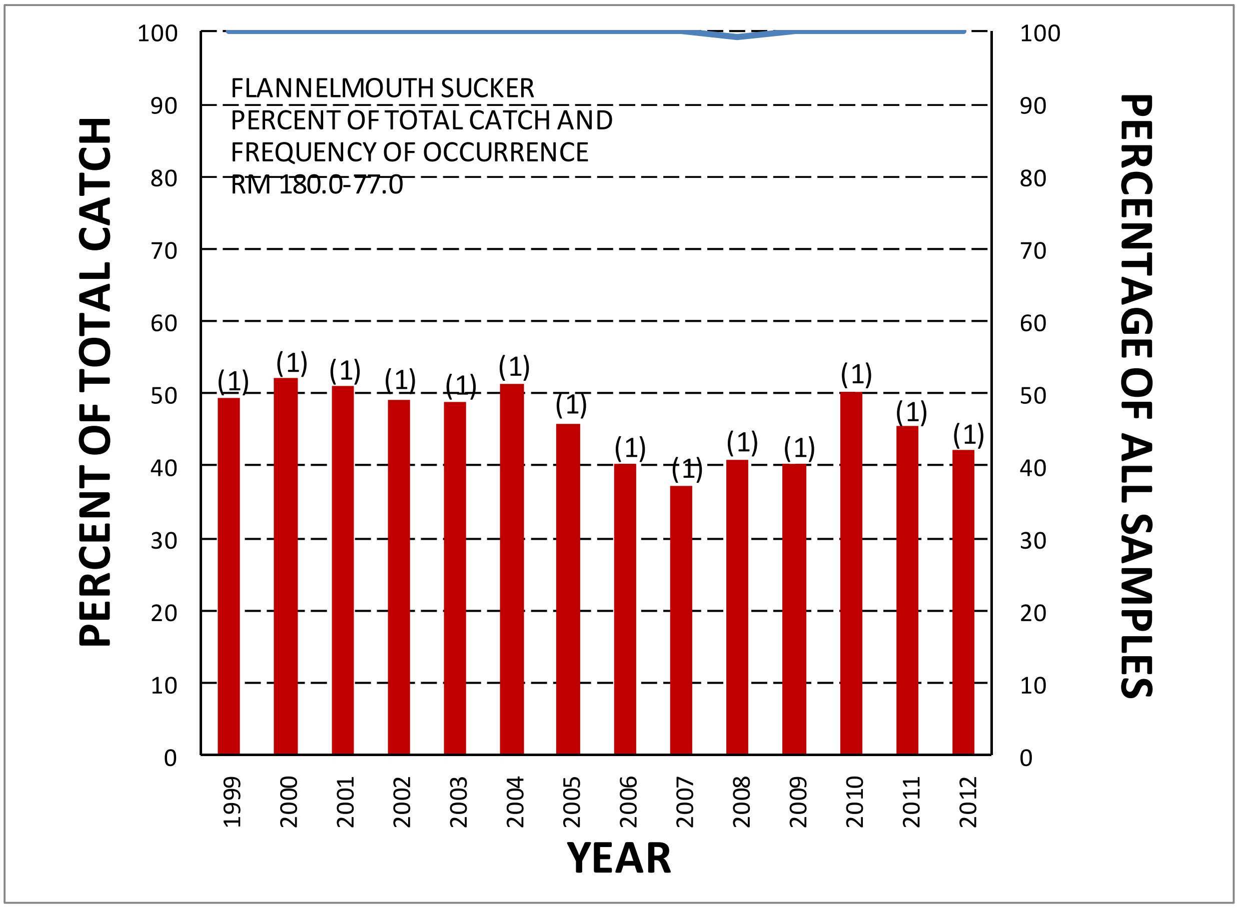

Figure 4. A summary of Flannelmouth Sucker relative abundance in Adult Monitoring collections, 1999-2012. The solid blue line at the top of the graph represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The solid red 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 in the common sampled area (RM 180.0-77.0).

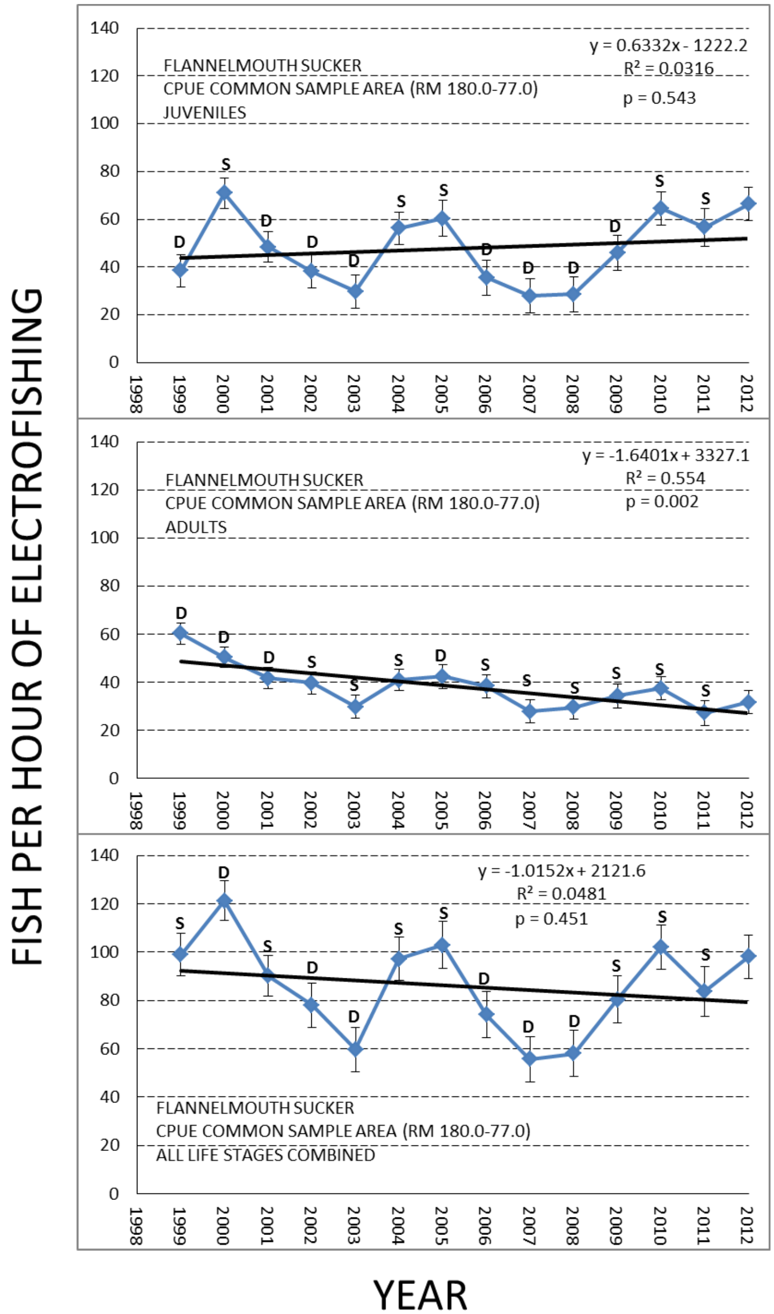

Figure 5. Flannelmouth Sucker CPUE (blue line) in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips, for juvenile fish (< 410 mm TL; top), adult fish (≥ 410 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Bold black letters are between-year comparisons. The letter "**S**" means the value is not significantly different from the 2012 value. The letter "**D**" means the value is significantly different from the 2012 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

Length Information

Flannelmouth Sucker sampled in 2012 ranged in size from 59-570 mm TL (mean TL = 345 mm). The 2012 length-frequency histogram for Flannelmouth Sucker was bimodal, with one peak centered around large juvenile fish (251-300 mm TL) preparing to enter the recruiting sub-adult category, probably in 2013. The second, smaller mode showed a cohort of fish (351-425 mm TL) that were just beginning to recruit into adulthood (Figure 6). The remainder of this cohort of fish may finish entering adulthood in 2013 as well.

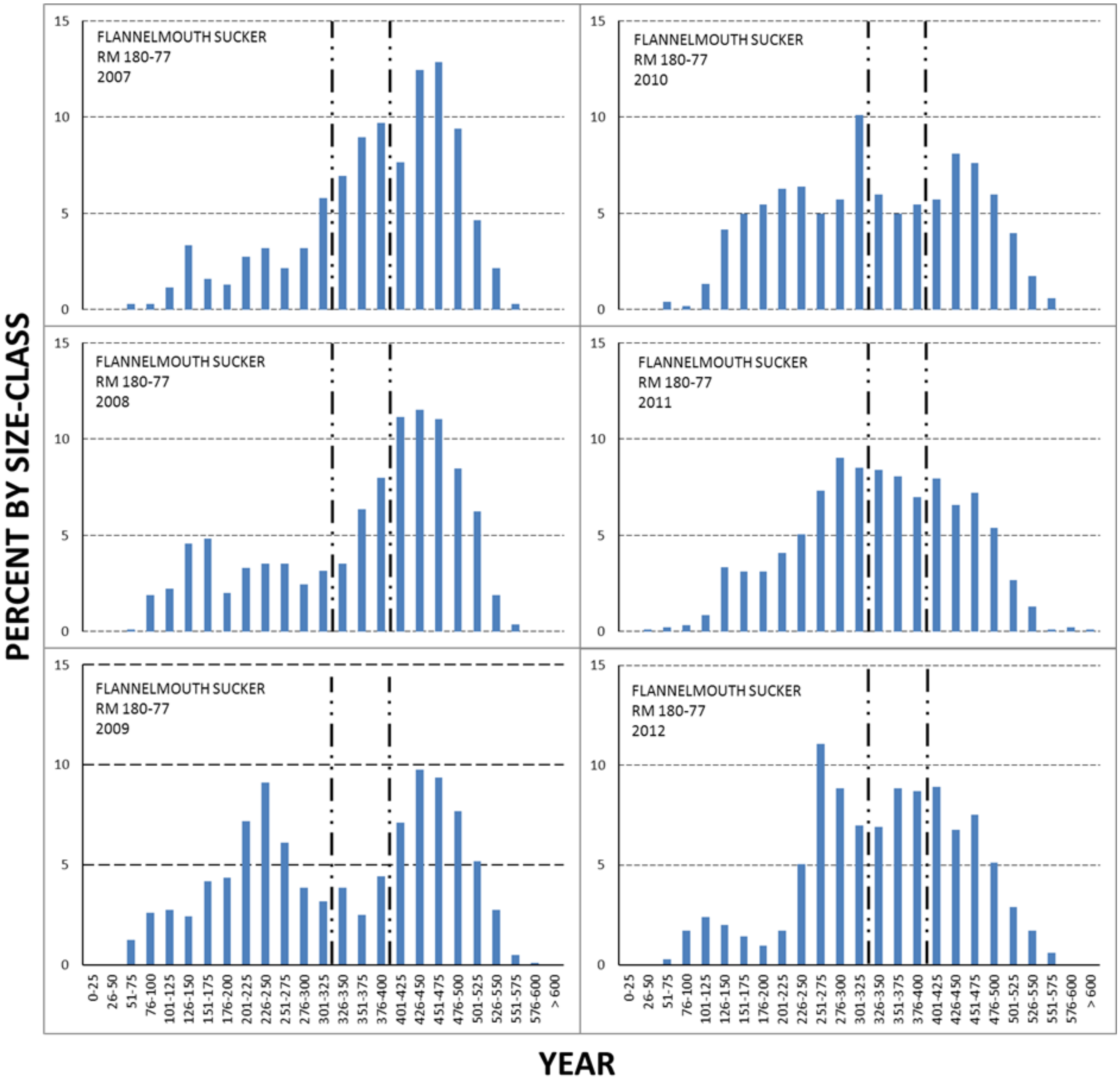

Figure 6. Length-frequency histograms showing the size-class distribution of flannelmouth sucker in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips in the San Juan River, 2007-2012. Solid blue bars to the left of both hashed, vertical lines are juvenile fish. Solid blue bars between the two hashed, vertical lines are recruiting sub-adult fish. Solid blue bars to the right of both hashed, vertical lines are adult fish.

Bluehead Sucker

Catch Information

Bluehead Sucker were the third most commonly-collected large-bodied fish species during 2012 Adult Monitoring (Table 3, Figure 7). The percentage of the total catch composed of Bluehead Sucker in 2012 (17%) was on the lower end of the total catch values observed for this species over the last 14 years, being higher than only 4 of the previous 11 years, but lower than the other nine (Figure 7). Bluehead Sucker were collected in Reaches 6-3 in 2012 (from RM 180.0-77.0). In each of the last two years (2011-2012) Bluehead Sucker have been collected in every electrofishing sample in the common sampled area (Figure 7).

The 2012 Bluehead Sucker adult CPUE value wasn't significantly different than 12 of the previous 13 years (Figure 8). Despite what looks like marked year-to-year fluctuations, the 2012 Bluehead Sucker juvenile CPUE value wasn't significantly different from any of the previous 13 years (Figure 8).). Likewise, the 2012 Bluehead Sucker total CPUE value also wasn't different than 12 of the previous 13 years. Juvenile CPUE among both Bluehead and Flannelmouth Sucker has shown noticeable year-to-year fluctuations that appear to be cyclical events. Despite these year-to-year fluctuations, the long-term trends for Bluehead Sucker juvenile, adult, and total CPUE riverwide has shown no significant change in these abundance indices over the last 14 years (Figure 8).

Length Information

Bluehead Sucker ranging from 76-453 mm TL (mean TL = 289 mm) were collected during 2012 Adult Monitoring. In 2012, the largest mode of the Bluehead Sucker length-frequency histogram was centered around a group of young, adult fish from 301-325 mm TL (Figure 9). These fish have been evident in the yearly length-frequency histograms since 2010. There also appeared to be a number of recruiting sub-adult fish in the 251-300 mm TL range that will likely recruit to adulthood in 2013 (Figure 9).

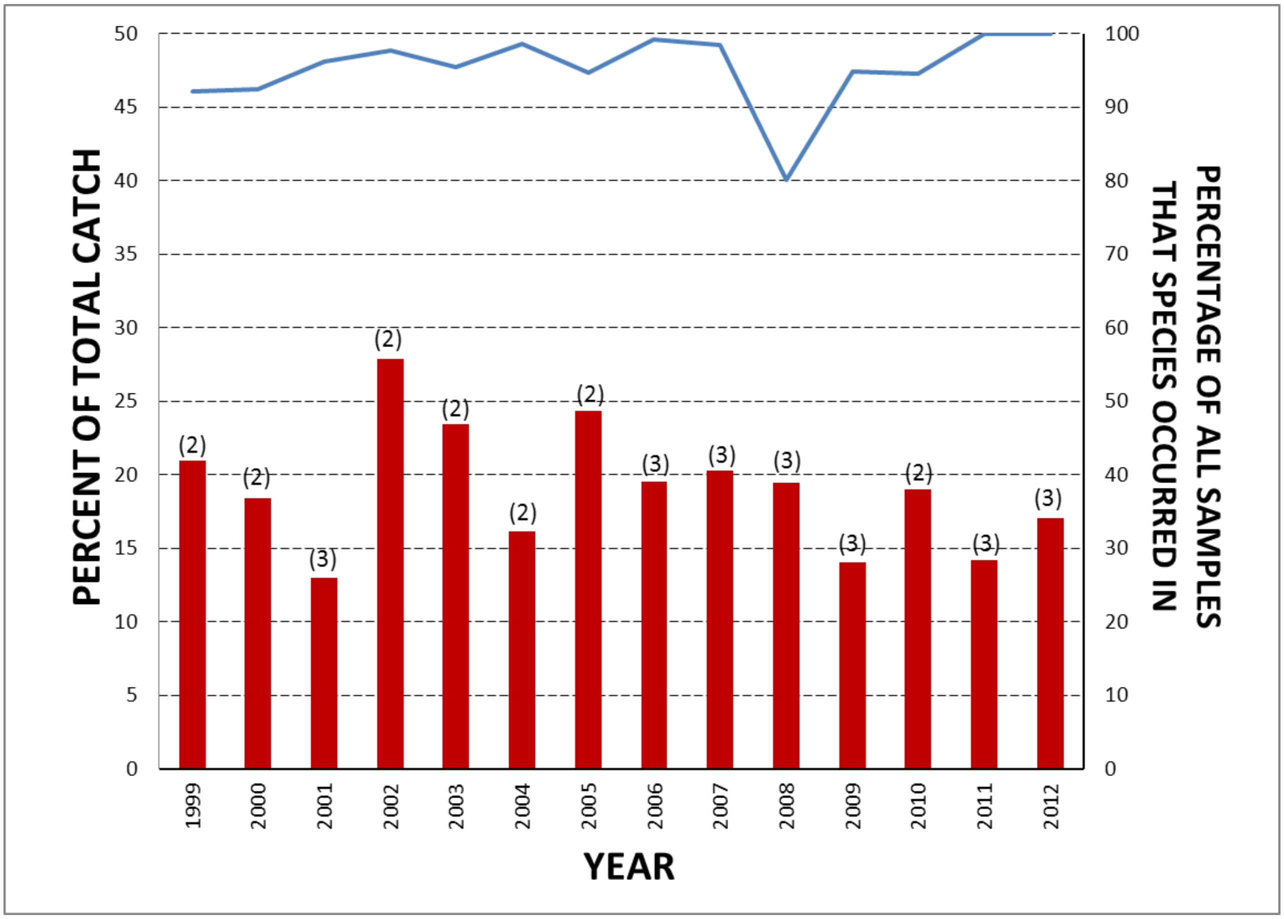

Figure 7. A summary of Bluehead Sucker relative abundance in Adult Monitoring collections, 1999-2012. The solid blue line at the top of the graph represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The solid red 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 in the common sampled area (RM 180.0-77.0).

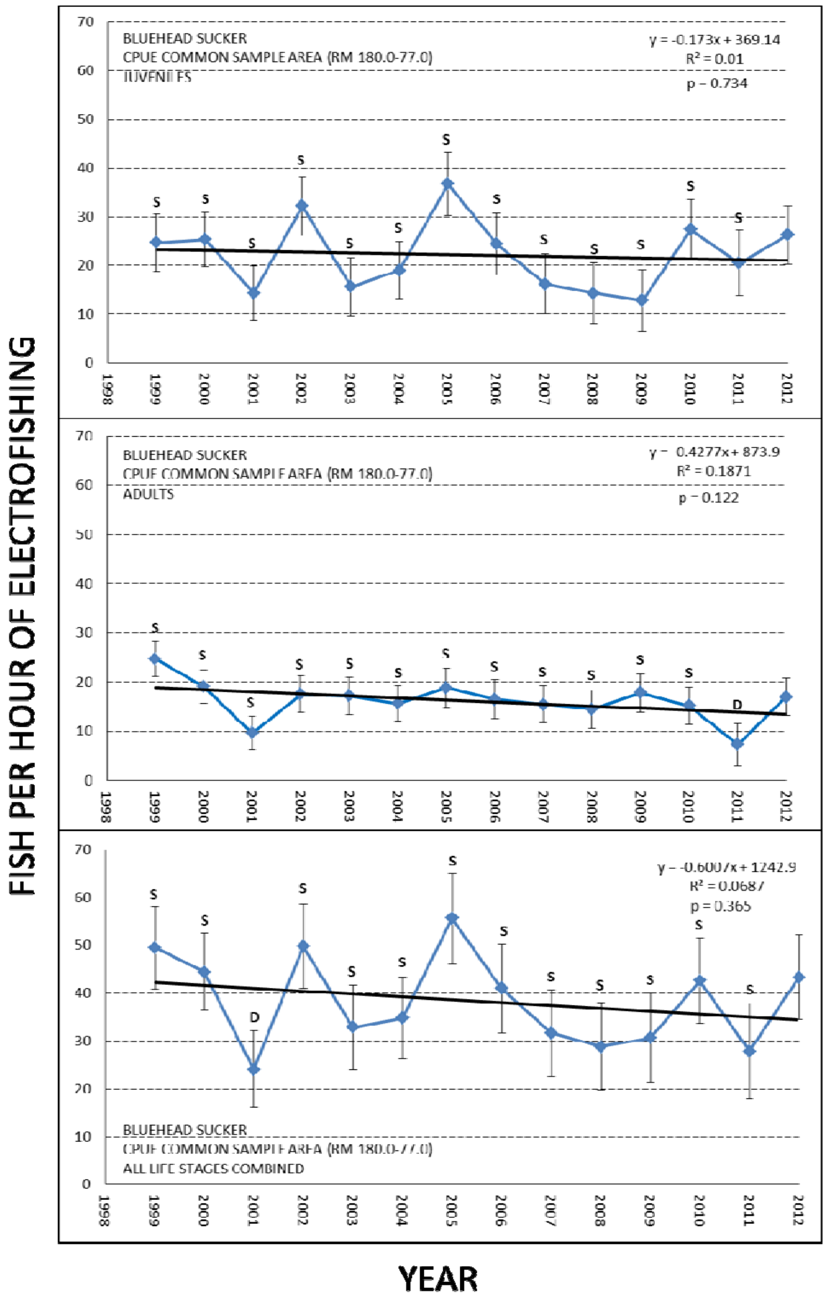

Figure 8. Bluehead Sucker CPUE (blue line) in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish (≥ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Bold black letters are between-year comparisons. The letter "S" means the value is not significantly different from the 2012 value. The letter "D" means the value is significantly different from the 2012 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

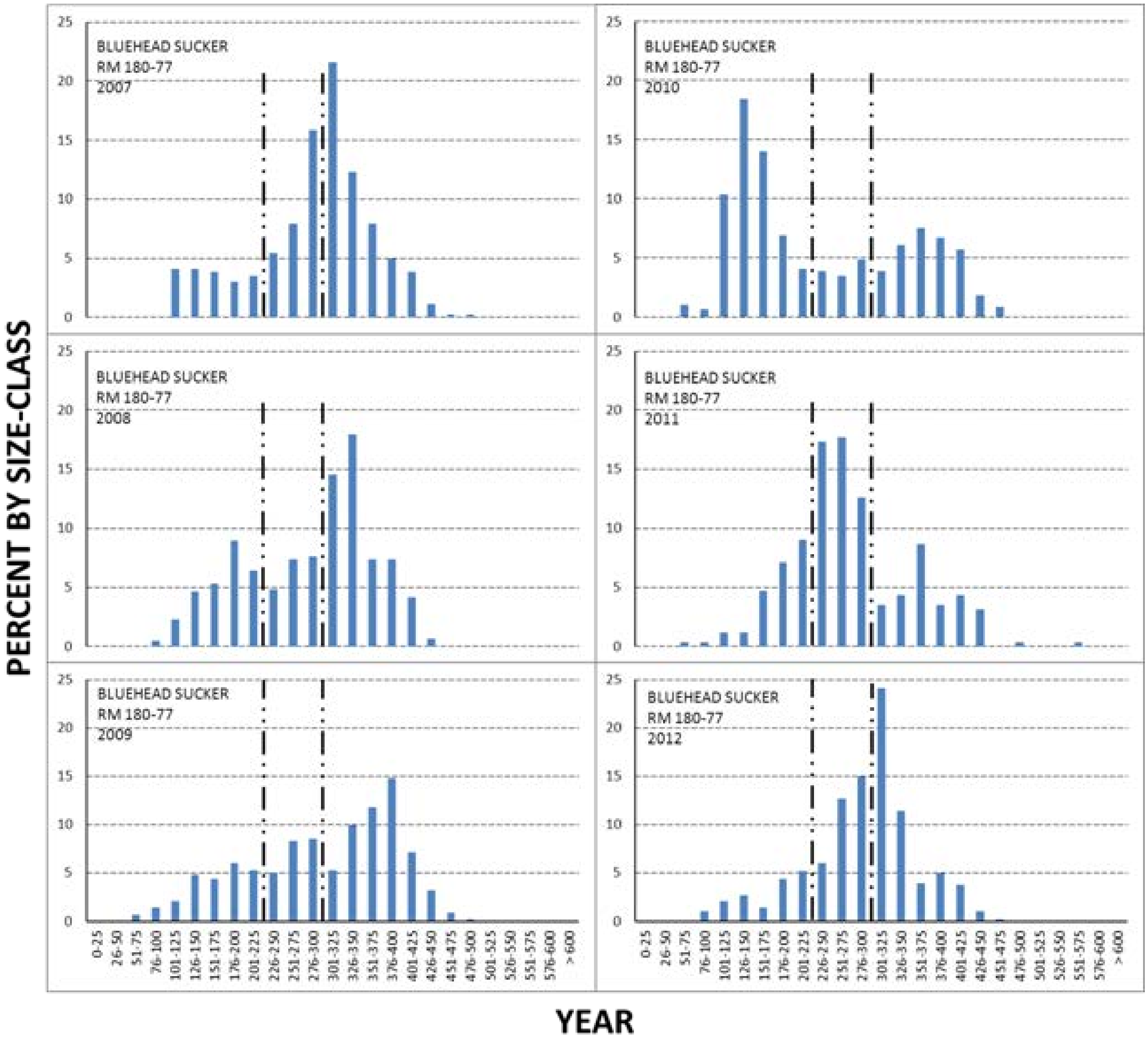

Figure 9. Length-frequency histograms showing the size-class distribution of bluehead sucker in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips in the San Juan River, 2007-2012. Solid blue bars to the left of both hashed, vertical lines are juvenile fish. Solid blue bars between the two hashed, vertical lines are recruiting sub-adult fish. Solid blue bars to the right of both hashed, vertical lines are adult fish.

Common Nonnative Fishes

Channel Catfish

Catch Information

In 2012, Channel Catfish were the second most abundant species, 30.1% of total catch, in electrofishing samples (Table 3, Figure 10), which marked the third highest total catch value in the common sampled area since 1999. Channel Catfish were collected in 82.2% of all electrofishing samples in the common sampled area in 2012 and occurred in all four river reaches (from RM 180.0-77.0; Figure 10).

Prior to 2009, the riverwide CPUE value for juvenile Channel Catfish had not changed significantly for five years (2004-2008). However in three of the last four years (2009, 2011, and 2012) the juvenile CPUE value was significantly higher than that observed in years prior to 2009 (Figure 11). These spikes in the juvenile Channel Catfish CPUE values were not apparent during 2010 Adult Monitoring collections for whatever reason. In fact, the 2010 juvenile CPUE value was not significantly different than 8 of the previous 11 years (Figure 11). However, there has been an increase in the juvenile Channel Catfish CPUE value in the common sampled area (RM 180.0-77.0) from 2002-2012 (Figure 11).

Much like the trend seen among juvenile common native suckers, the CPUE value for adult Channel Catfish has shown a somewhat cyclical pattern over time, as large influxes of new fish enter the adult population, then are cropped off by nonnative fish removal efforts, only to be replaced by another incoming cohort of recruiting fish (Figure 11). The 2012 adult Channel Catfish CPUE value was not significantly different than six previously-observed highest values (2001 and 2005-2009). Thus, the long-term trend data seems to indicate that overall, Channel Catfish CPUE in the San Juan River has not been reduced significantly by nonnative fish removal efforts since 2001.

However, the center of Channel Catfish abundance has shifted to downstream river sections since nonnative fish removal efforts began in 2001 (Ryden 2012). 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 (Ryden 2012). 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 (Ryden 2012).

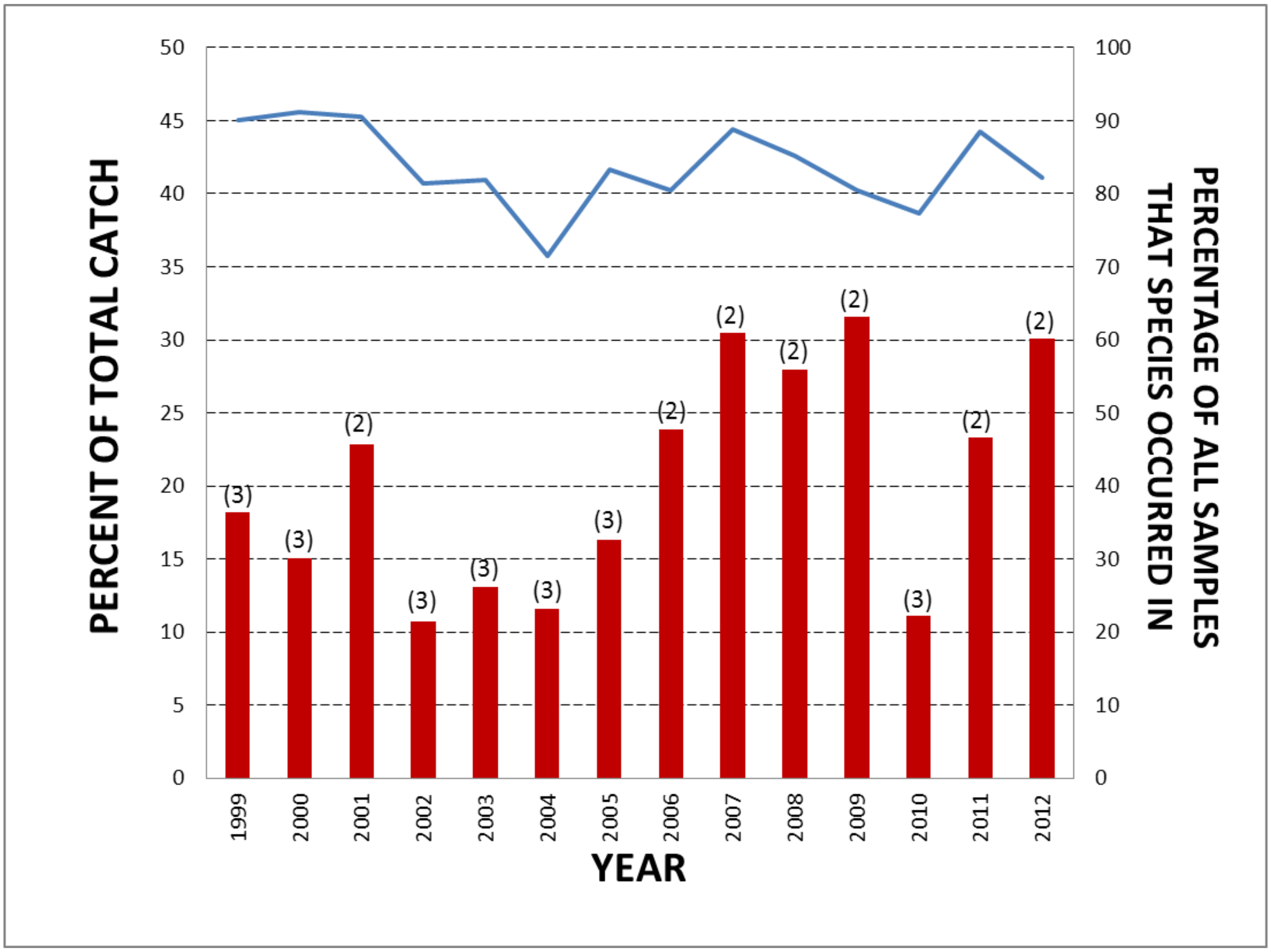

Figure 10. A summary of Channel Catfish relative abundance in Adult Monitoring collections, 1999-2012. The solid blue line at the top of the graph represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The solid red 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 in the common sampled area (RM 180.0-77.0).

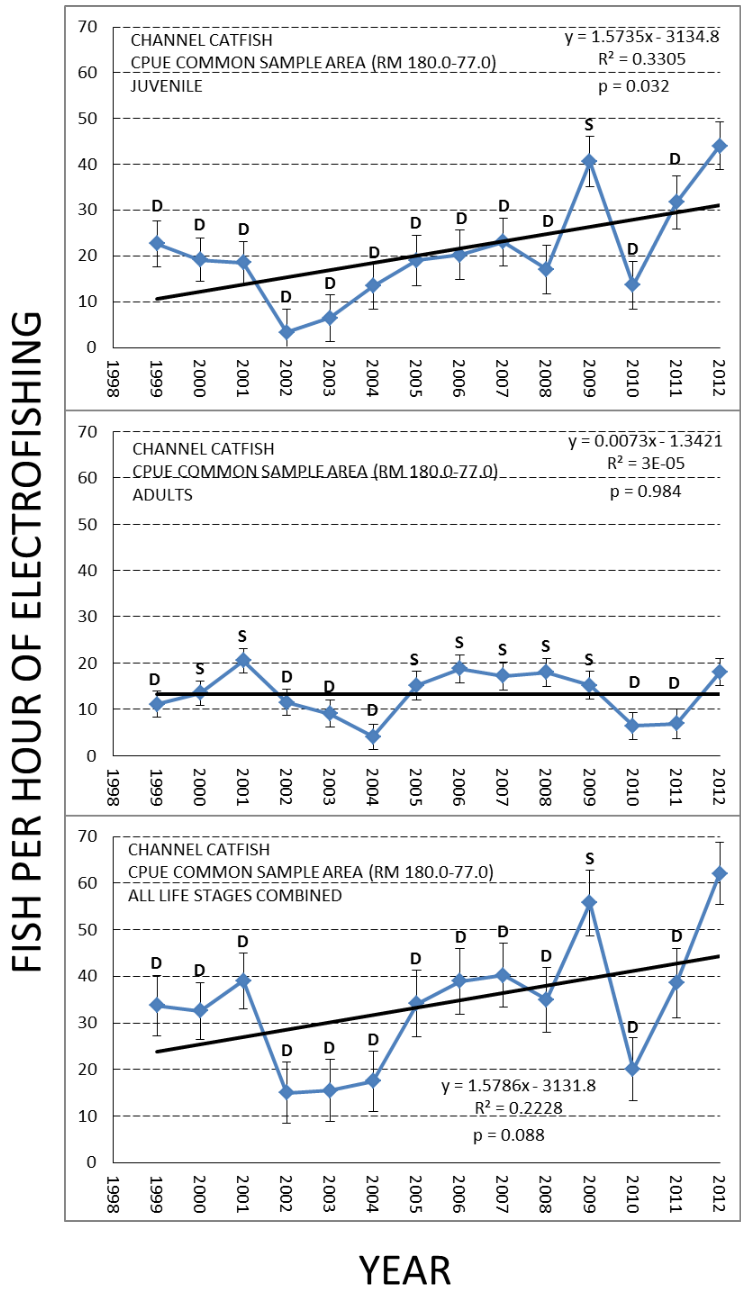

Figure 11. Channel Catfish CPUE (blue line) in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips, for juvenile fish (< 300 mm TL; top), adult fish ($\geq$ 300 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Bold black letters are between-year comparisons. The letter "S" means the value is not significantly different from the 2012 value. The letter "D" means the value is significantly different from the 2012 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

In 2012, numbers of Channel Catfish being collected did not surpass numbers of Bluehead Suckers until downstream of RM 140.0, and numbers of Flannelmouth Suckers until downstream near the Mancos River at RM 122.6 (Figure 12). These locations are approximately 8 and 15 RM downstream of Shiprock, NM, which is one of two most upstream nonnative fish removal sections that have been sampled intensively since the early 2000s. So, it appears that nonnative fish removal efforts have been successful in suppressing numbers of Channel Catfish in the most upstream sections of the river in which they occur. By about 10 RM upstream of Aneth, UT Channel Catfish became the dominant species collected during 2012 Adult Monitoring (Figure 12).

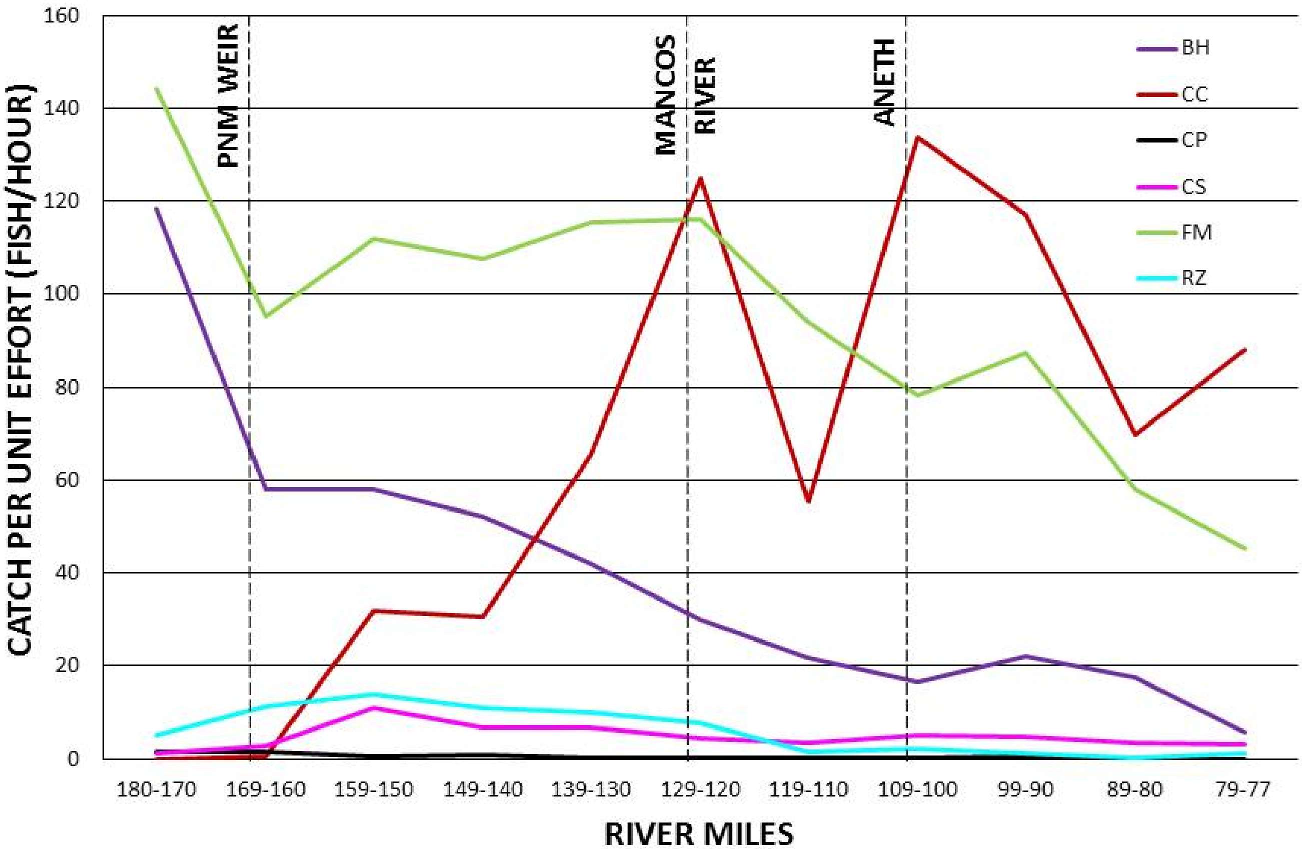

Figure 12. A comparison of the longitudinal distribution by 10-RM section of Channel Catfish (expressed as total CPUE) compared to the other rare and common species collected in the common sampled area (RM 180.0-77.0) in 2012.

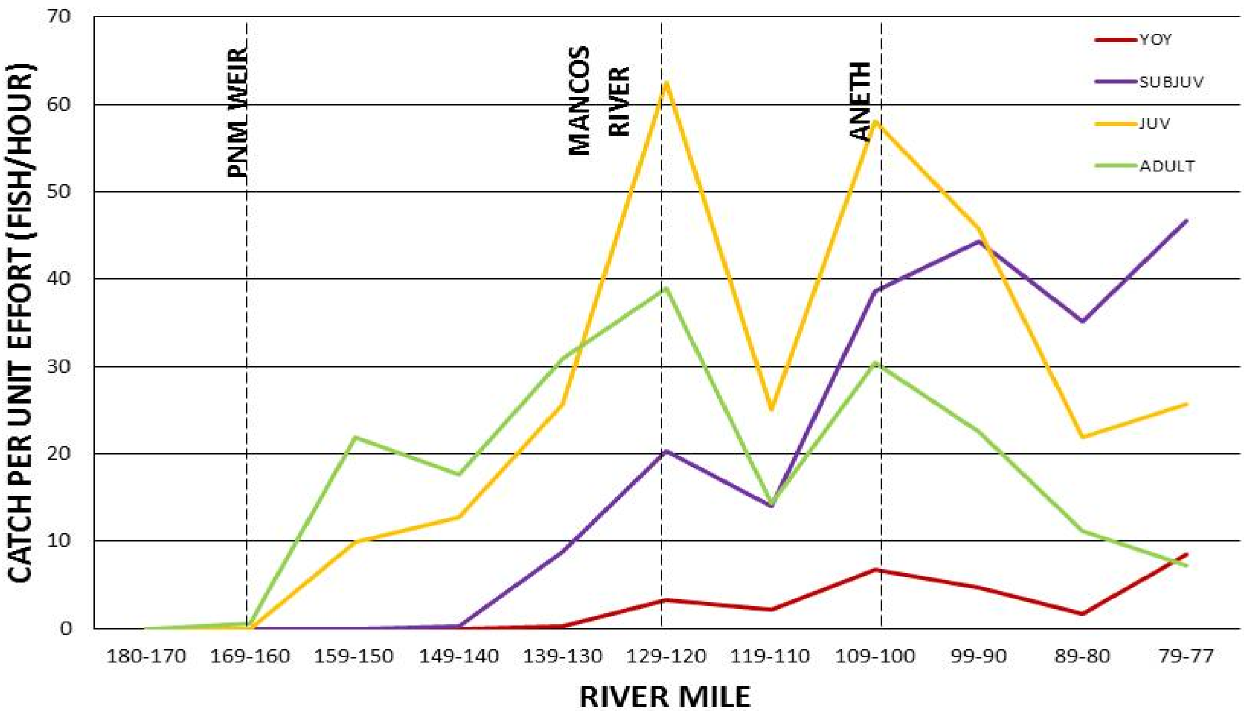

Figure 13. A comparison of the longitudinal distribution by 10-RM section of the various life-stages of Channel Catfish (expressed as total CPUE) compared to one another in the common sampled area (RM 180.0-77.0) in 2012. YOY = young-of-the-year (< 60 mm TL); SUBJUV = sub-juvenile fish (60-200 mm TL); JUV = juvenile fish (200-299 mm TL); ADULT = adult fish ($\geq$ 300 mm TL).

A longitudinal comparison of distribution of various life-stages of Channel Catfish shows that adult Channel Catfish, followed closely by larger juvenile fish (200-299 mm TL), are the dominant life-stages collected from PNM Weir (RM 166.6) downstream to around RM 130 (Figure 13). Downstream of that point, juvenile and sub-juvenile (60-200 mm TL) fish become the dominant life-stages collected. Young-of-the-year Channel Catfish (a size of fish that raft-mounted electrofishing is really not set up to sample effectively) start to appear in our samples about RM 130 and become increasingly common in more downstream areas (Figure 13).

With the discontinuation of Adult Monitoring sampling at RM 77.0 in the last two years, the ability to use the Adult Monitoring data set to measure the effectiveness of nonnative fish removal efforts downstream of this point has ended.

Length Information

Channel Catfish ranging from 51-692 mm TL (mean TL = 279 mm) were collected during 2012 Adult Monitoring. In the 2012 length-frequency histogram, the largest groups of Channel Catfish were fish from 201-225 mm TL (likely age-2) and recruiting sub-adult (likely age-3) fish from 276-300 mm TL (Figure 14). These distinct influxes of young cohorts of Channel Catfish continue to be very pronounced in length-frequency histograms for this species over the years. In 2013 the Channel Catfish population will likely show an increase of both young adult and recruiting sub-adult fish.

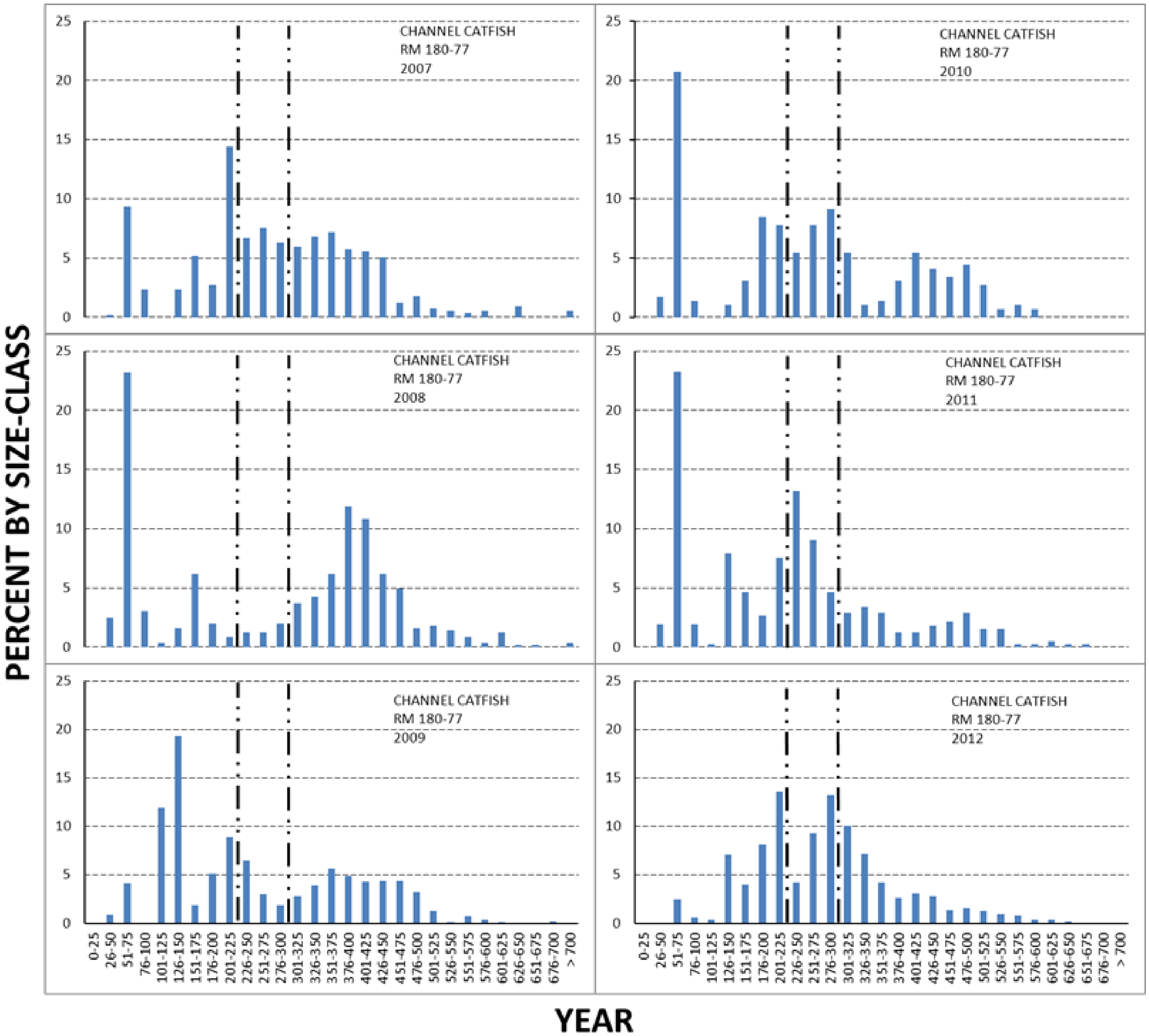

Figure 14. Length-frequency histograms showing the size-class distribution of channel catfish in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips in the San Juan River, 2007-2012. Solid blue bars to the left of both hashed, vertical lines are juvenile fish. Solid blue bars between the two hashed, vertical lines are recruiting sub-adult fish. Solid blue bars to the right of both hashed, vertical lines are adult fish.

Common Carp

Catch Information

Common Carp were the seventh most commonly-collected fish during 2012 Adult Monitoring (Table 3, Figure 15). This marks the eighth consecutive year that Common Carp have not been among the four most commonly-collected fish species (Figure 15). Only 27 total Common Carp were collected river wide in 2012 (Table 3), of which 24 (88.9%) were adults (i.e., ≥ 250 mm TL) and 3 were juveniles. Common Carp were collected from Reaches 6-3 in 2012 (from RM 176.0-91.0), with 13 being collected from Reach 6, 5 from Reach 5, 5 from Reach 4, and 1 from Reach 3.

In 2012, Common Carp accounted for only 0.2% of the total catch and was collected in just 13.6% (n = 18) of electrofishing samples in the common sampled area (Table 3, Figure 15). Of the 18 electrofishing samples that had Common Carp, 11 contained a single fish, 5 had two fish, and 1 sample had six fish. When more than one Common Carp were in a sample they were usually in close proximity, and in the sample with six fish, all were within a few feet of each other.

Common Carp juvenile CPUE was not significantly different than 10 of the previous 13 years and was significantly lower than the pulses of juvenile Common Carp observed in 2000, 2002, and 2004 (Figure 16). These pulses of juvenile fish didn't last more than one year and didn't ultimately increase numbers of adult fish in the river. Common Carp adult CPUE hasn't changed significantly over the last six years and has continued to remain significantly lower than the 1999-2006 period (Figure 16).

Length Information

Common Carp ranging from 114-770 mm TL (mean TL = 544 mm) were collected during 2012 Adult Monitoring. The numerically dominant cohorts of juvenile Common Carp observed in 2008, 2009, and 2011 were not evident in the 2012 length-frequency histogram (Figure 17). With the exception of two fish (114 and 122 mm TL), the 2012 length-frequency histogram was numerically dominated by large, adult fish (430-770 mm TL).

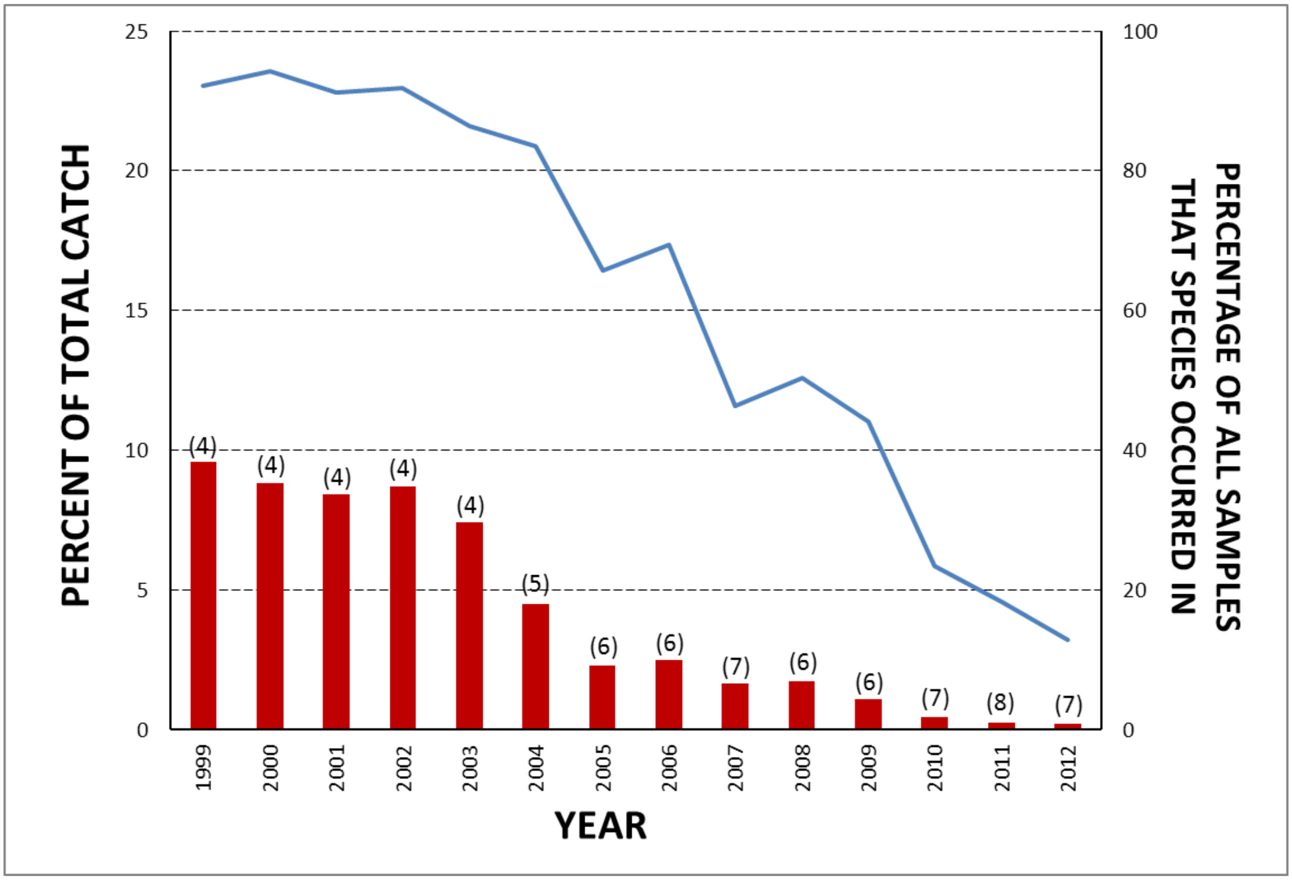

Figure 15. A summary of Common Carp relative abundance in Adult Monitoring collections, 1999-2012. The solid blue line at the top of the graph represents the percentage of all electrofishing samples on a given Adult Monitoring trip in which this species occurred (i.e., percent occurrence). The solid red 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 in the common sampled area (RM 180.0-77.0).

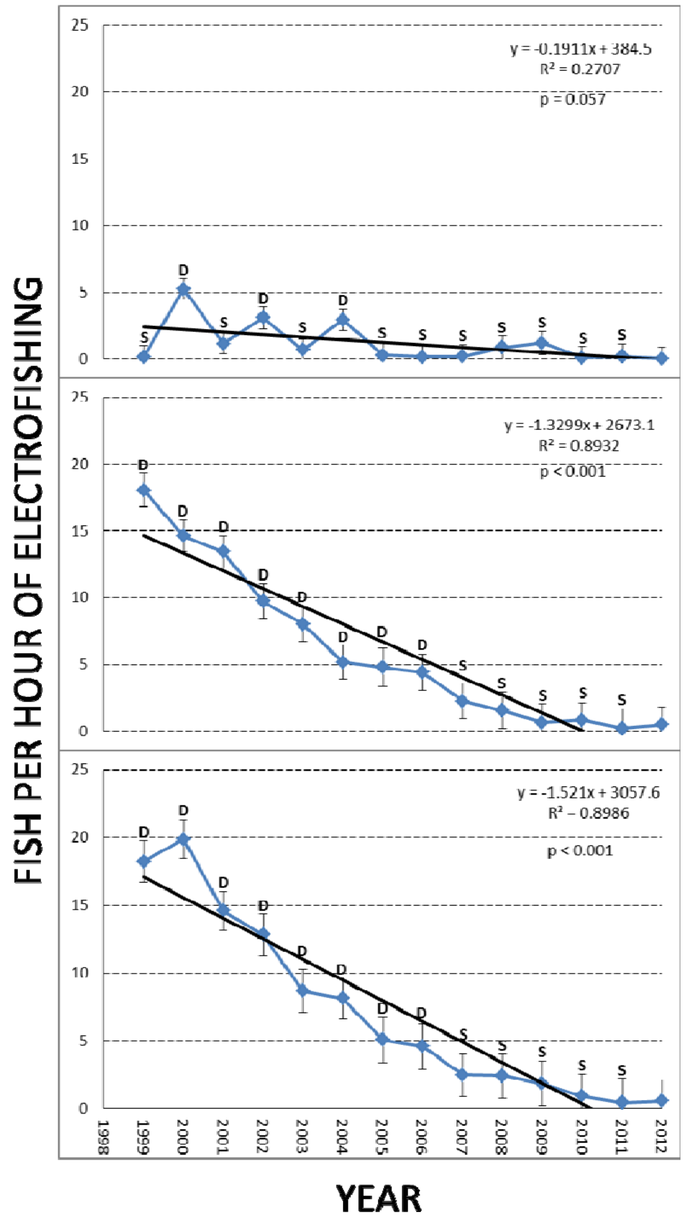

Figure 16. Common Carp CPUE (blue line) in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips, for juvenile fish (< 250 mm TL; top), adult fish (≥ 250 mm TL; middle), and for all life stages combined (juveniles + adults; bottom). Error bars are +/- 2 SE. Bold black letters are between-year comparisons. The letter "S" means the value is not significantly different from the 2012 value. The letter "D" means the value is significantly different from the 2012 value. The solid, black sloping line is a linear regression analysis of the mean CPUE values. The statistics are for these regression lines.

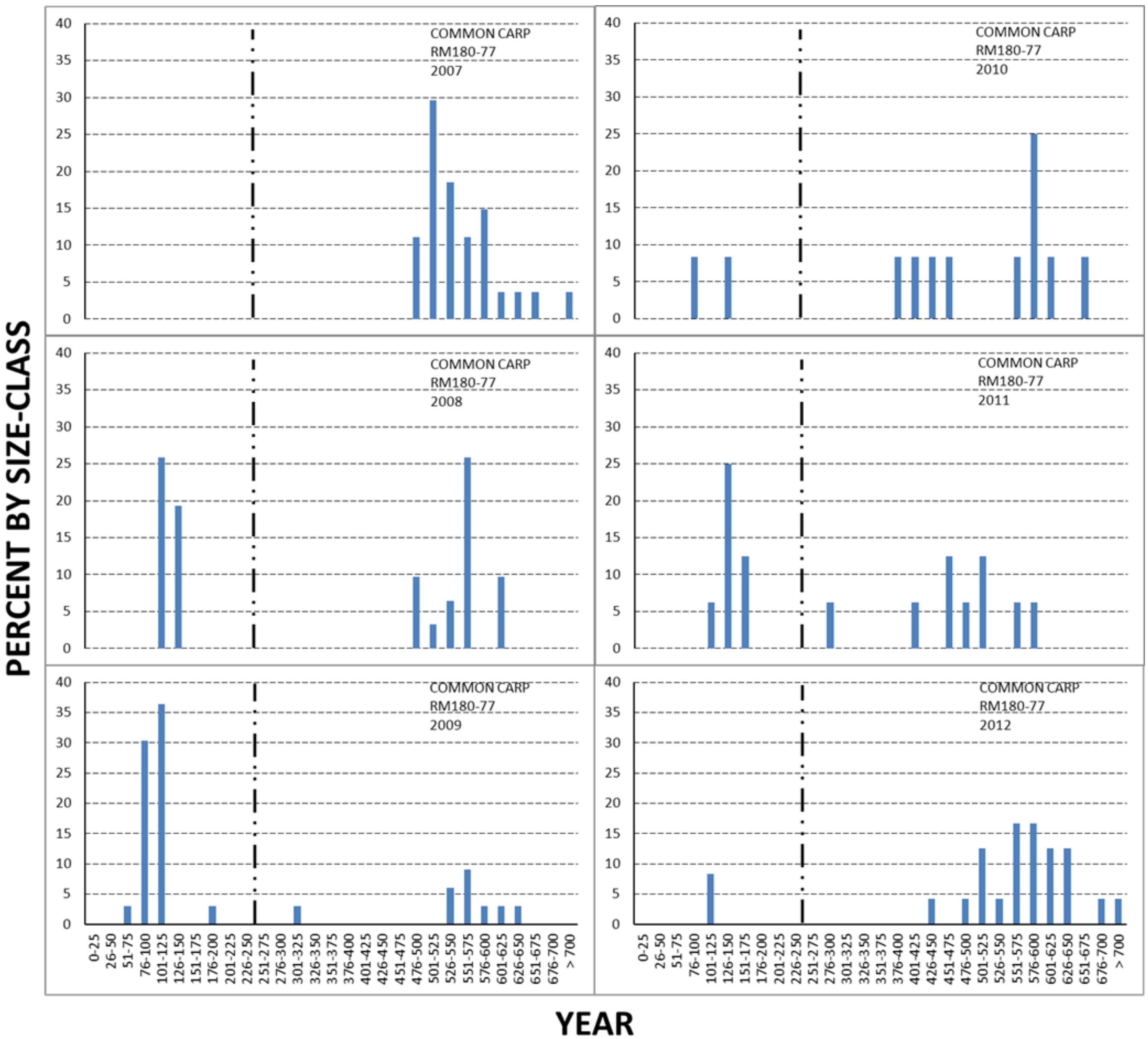

Figure 17. Length-frequency histograms showing the size-class distribution of Common Carp in the common sampled area (RM 180.0-77.0) on fall Adult Monitoring trips in the San Juan River, 2007-2012. Solid blue bars to the left of the hashed, vertical line are juvenile fish. Solid blue bars to the right of the hashed, vertical line are adult fish.

Sampling Upstream of the Animas River Confluence

On 12 and 13 September 2012, a 15-RM section of the San Juan River upstream of the Animas River confluence was sampled. The purpose of this sampling was to expand Adult Monitoring upstream to document possible range expansion by Colorado Pikeminnow and Razorback Sucker into these upstream areas, as well as documenting the overall makeup of the fish community. This effort was preliminary and exploratory (finding boat launches, learning to navigate new sections of river with unknown obstacles, etc.) and was performed without Program funding. On 12 September, sampling conditions were good, as was reflected by the electrofishing data (389 fish collected in 2.82 hrs of electrofishing = 137.9 fish/hr). However, an overnight rain event caused the water to become extremely turbid and sampling conditions were much poorer on 13 September (199 fish collected in 3.03 hrs of electrofishing = 65.7 fish/hr). The lower 7-10 miles of the Animas River were also scheduled to be sampled on this trip. However, very low water levels in the lower Animas River prevented that sampling from occurring.

Seven fish species (588 total fish) were collected during upstream sampling. This included four native and three nonnative species (Table 8). The four native species in descending order of abundance were Flannelmouth Sucker (342 fish), Bluehead Sucker (102 fish), Speckled Dace (24 fish), and Razorback Sucker (2 fish). No Colorado Pikeminnow were collected. The four native species (470 total fish) accounted for 79.9% of the total catch during upstream sampling. The three nonnative species in descending order of abundance were Brown Trout (96 fish), common carp (20 fish), and Rainbow Trout (2 fish).

Table 8. Total number of fishes collected during sampling upstream of the Animas River on the 2012 Adult Monitoring trip.

Species (Status)[a]	Number Collected	Percent Of Total	Number Of Samples Collected In
Flannelmouth Sucker (N)	342	58.3	22
Bluehead Sucker (N)	102	17.3	20
Brown Trout (I)	96	16.3	16
Speckled Dace (N)	24	4.1	13
Common Carp (I)	20	3.4	8
Razorback Sucker (N)	2	0.3	2
Rainbow Trout (I)	2	0.3	2
GRAND TOTAL	588		
Total Electrofishing Collections In 2012 = 22 Total Electrofishing Effort In 2012 = 5.85 Hours			
2012 Native Fishes = 470 (79.9% Of The Total Catch) 2012 Introduced Fishes = 118 (20.1% Of The Total Catch) 2012 Native To Introduced Fishes Ratio = 3.98:1			
a: (N) = Native species; (I) = Introduced species; (H, N) = A hybrid of two native fish species, considered to be a native fish; (H, I) = A hybrid of a native and a nonnative fish species, considered to be an introduced fish			

Native Fishes

Sampling upstream of the Animas River confluence documented the presence of Razorback Sucker as far upstream as RM 191.0 (approximately 10.4 RM upstream of the Animas river confluence). Two individual Razorback Sucker were collected during upstream sampling. The first fish (427 mm TL) was collected from RM 191.7-191.0 on 12 September. It was a 2009 year-class fish passively harvested from Avocet East Pond (NAPI ponds) and stocked on 4 October 2011 at San Juan RM 196.1 (398 mm TL). The second fish (441 mm TL) was collected from RM 183.0-182.0 on 13 September. It was a 2009 year-class fish passively harvested from Hidden Pond (NAPI ponds) and stocked on 14 October 2011 at Animas RM 5.0 (389 mm TL).

Razorback Sucker accounted for considerably less of the total catch upstream of the Animas (0.3%) when compared to the common sampled area downstream (2.5%). In addition, razorback sucker total CPUE was considerably lower upstream of the Animas confluence (0.34 fish/hr) than in the common sampled area downstream (5.89 fish/hr). In fact this same trend in total CPUE held true for all native species collected in this upstream section of river. This may be due to the poorer sampling conditions on 13 September 2012, which greatly hindered netters collecting fish. Sampling of upstream river sections in future years should help clarify this question.

As in the common sampled area (RM 180.0-77.0) downstream, native Flannelmouth Sucker were the most abundant large-bodied fish species collected (Tables 3 and 8), they accounted for 58.3% of the total catch upstream of the Animas, versus the42.3% downstream. However, their total CPUE was almost twice as high in the downstream common sampled area (98.1 fish/hr) as it was upstream (58.5 fish/hr). Unlike downstream collections however, adult Flannelmouth Sucker were numerically more abundant (263 fish; 76.9% of all Flannelmouth Sucker collected) upstream of the Animas River than were juvenile fish (79 fish).

Native Bluehead Sucker were the second most abundant large-bodied species collected in upstream sampling (Tables 3 and 8). They accounted for almost identical percentages of the total catch upstream of the Animas (17.3%) and in the downstream common sampled area (17.0%). However, their total CPUE was over twice as high in the downstream common sampled area (39.5 fish/hr) as it was upstream (17.4 fish/hr). The Bluehead Sucker population upstream of the Animas confluence were more consistent with downstream population, with juvenile fish being numerically more abundant (56 fish; 54.9% of all Bluehead Sucker collected) than adult fish (46 fish).

Speckled Dace made up only a small percent of the total catch in both upstream (4.1%) and downstream (4.9%) samples; however, the downstream CPUE was higher than upstream CPUE (11.3 vs. 4.1 fish/hr).

Nonnative Fishes

Common Carp accounted for 3.4% of the total catch in upstream sampling, versus 0.2% in the common sampled area downstream (Tables 3 and 8). Unlike what was observed among native fishes, Common Carp total CPUE was almost seven times as high in the short upstream section (3.42 fish/hr of electrofishing) versus the downstream common sampled area (0.50 fish/hr).

Brown Trout became much more abundant upstream of the Animas river confluence. A total of 96 fish (16.4 fish/hr) were collected, making them the third most abundant species collected during upstream Sampling (Table 8). In contrast, only 11 Brown Trout (0.20 fish/hr) were collected in the common sampled area from RM 180.0-77.0 (Table 3). This represented an 82-fold increase in total CPUE for this species upstream of the Animas River.

DISCUSSION

Data Integration

Adult Monitoring gives the San Juan River Basin Recovery Implementation Program a once-a-year snapshot of the entire large-bodied fish community as these fish prepare to head into winter. This study has a long-term, statistically-powerful data set associated with it that provides an effective tool to help assess the success or failure of several ongoing management actions, including retention, survival, and growth of stocked endangered fish, attempts to increase occupied range among endangered fish, and the effects of nonnative fish removal on the large-bodied fish community. Adult Monitoring also contributes data to assess the issue of PIT tag retention/loss and how that effects the SJRIP's determination of recruitment and overall population size among endangered fish species. It also provides information on recaptured FLOW-tagged fish movement from other studies as well as fin clips from both common and endangered fishes for stable isotope analysis (diet overlap) work.

Adult Monitoring has been used to help assess progress towards recovery by making comparisons between numbers of endangered fishes actually being collected during fall monitoring and numbers of these same species that would be expected if the SJRIP were at or near the numbers specified in the Recovery Goals. This relative status of the two endangered fish species in the San Juan River can be used to make comparisons to the status of these same species in other sections of the upper Colorado River basin.

Changes In and Importance of the Adult Monitoring Study

From 1996 to 2010, Adult Monitoring was able to provide a "riverwide" (Reaches 6-1) look at population trends and concentrations among not only the endangered fishes, but also wild Roundtail Chub, and the common large-bodied fish species (Flannelmouth Sucker, Bluehead Sucker, Channel Catfish, and Common Carp). The truncating of Adult Monitoring, in 2011, to sampling just RM 180.0-77.0 has eliminated our ability to make "riverwide" statements about the trends among various fish species. Sampling riverwide will occur once every five years to include the lower canyon, starting in 2015. It is obvious that the lower San Juan River still plays a vital role in telling the story of certain fish species populations (particularly Channel Catfish) and their interactions with one another. Unfortunately with the adoption of this restriction in sampling, we no longer have population data for common native fish species in this section of the river (RM 77.0-0.0) or comparative population data for Channel Catfish and Common Carp at the time of year we are using Adult Monitoring to "measure" the success or failure of our management actions.

Despite these changes, Adult Monitoring is still a highly useful tool in understanding and managing the San Juan River fish community. Adult Monitoring data has been used to bolster other data sets and to undertake independent analyses, such as those done for the 1999 Flow recommendations for the San Juan River (Holden 1999), contributing data to the population model, providing data to help determine the effects of nonnative fish removal of native fish populations (N. Franssen 2013 presentation the Biology and Coordination committees and Peer Review Panel), and nonnative fish populations (Duran et al. 2013), to name a few.

Rare Native Fishes

Colorado Pikeminnow

Wild Colorado Pikeminnow continue to be absent from our fall Adult Monitoring collections. However, over the last several years, it has become relatively common to collect several hundred stocked Colorado Pikeminnow of varying size-classes during Adult Monitoring. While the 272 stocked Colorado Pikeminnow collected during 2012 weren't the most Colorado Pikeminnow ever collected during Adult Monitoring, 2012 marked the seventh consecutive year that > 100 Colorado Pikeminnow were collected during our study.

The collection 22 Colorado Pikeminnow ≥ 300 mm TL, suggests that there may be close to 1,000 fish of this size riverwide (see Appendix A for details). The 1,000 number is the Demographic Delist Criteria for Colorado Pikeminnow in the San Juan River (USFWS 2002a). The collection of three adult fish (> 450 mm TL) and one fish in the recruiting sub-adult size-class (400-449 mm TL) proves that recruitment into the adult population from younger stocked fish is indeed taking place. This same ratio of adult Colorado Pikeminnow was seen in the nonnative fish removal study in the upper/middle San Juan River, where a total of 25 adult fish (> 450 mm TL) were collected in a 8-10 times of electrofishing passes (depending upon the particular reach of river in question) as was expended during Adult Monitoring (Duran et al. 2013). In all, more individual adult Colorado Pikeminnow were collected during all 2012 sampling (n = 29 individuals), than were collected in the period from June 1991 to October 1994 (n = 17 individuals) when wild adult Colorado Pikeminnow were still present and being collected via electrofishing in the San Juan River (S. Durst pers. comm., Ryden and Ahlm 1996). The Colorado Pikeminnow we collected during Adult Monitoring at ≥ 300 mm TL (including sub-adult and adult size-class categories as defined in USFWS 2002a) tended to be larger than wild fish would have been at these same ages (Osmundson et al. 1997b).

Once again in 2012, the large majority of the 269 known-origin Colorado Pikeminnow collections (201 of 269 = 74.7%) were fish that had been stocked as age-0 fish. In the past 2-3 years, it appears that better handling, transport, tempering, and acclimation protocols have helped increase scaled CPUE (i.e., post-stocking survival) of young Colorado Pikeminnow through the age-2 year-class. This still hasn't translated into a significant increase of young fish into the age-3 year-class. However, despite this lack of an observable significant increase in scaled CPUE at age-3, numbers of both recruiting sub-adult and adult size Colorado Pikeminnow fish seem to be slowly increasing, not only in Adult Monitoring collections, but also in collections for other studies (e.g., Duran et al. 2013). This begs the question, since Colorado Pikeminnow are a top predator, is this bottleneck at around age-3 a natural phenomenon? In other words, can the San Juan River only support a certain number of fish passing into adulthood in a given period of time, with the others dying off for some unknown reason (e.g., competition, lack of forage at a certain size-class)? Based on the number of adult Speckled Dace and juvenile native suckers encountered during sampling, it would not seem intuitive that this is a bottleneck based on lack of forage at this size-class. However, there may be other factors that are not as evident that are causing such a bottleneck to occur. If such a bottleneck does exist, would stocking more young Colorado Pikeminnow make any difference when it comes to trying to increase the rate of recruitment? Perhaps exploring this issue further with the use of the population model will help provide new insight into this issue.

Colorado Pikeminnow were collected throughout the common sampled area (RM 180.0-77.0) in 2012 with the largest number being collected in Reach 5. During 2012 Adult Monitoring, a small percentage of Colorado Pikeminnow collections (3.6%, n = 15) occurred upstream of Hogback Diversion (RM 158.6). Five of those collections occurred between RM 180.0 and the PNM Weir (RM 166.6). These fish (147-379 mm TL) had all been in the river at least 11 months prior to our sampling, which points to stocked Colorado Pikeminnow are now retaining in the river upstream of that barrier. 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). To date, this range expansion has been accomplished by stocking hatchery-reared fish directly into this river section, as well as providing upstream passage of fish at the PNM Fish Passage. Long-term (multi-year) 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. To offset this, recent stockings have been moved to more upstream locations and have used longer tempering and holding times to help acclimate fish to the river prior to release (e.g., Furr 2013a). Short-term results seem to indicate that this approach has helped stocked Colorado Pikeminnow retain in higher numbers upstream of PNM Weir.

Adult Monitoring data, combined with data from other San Juan studies, indicates that range expansion appears to be occurring in other areas of the San Juan River Basin as well. Eleven Colorado Pikeminnow were collected from Yellowjacket Canyon, a tributary of McElmo Creek from 2007-2010 (Fresques 2007, 2008, 2009, and 2010). McElmo Creek enters the San Juan River at RM 100.5. Only one of these fish (425 mm TL) was documented to have a PIT tag upon capture. This individual had been stocked with a PIT tag at RM 134.9 on 16 April 2008 and recaptured at RM 125.0 on 4 September 2008 (250 mm TL). The other ten fish (ranging from 168-307 mm TL) collected from the Yellowjacket Canyon site were almost certainly fish that were stocked into the San Juan River that had moved up McElmo Creek to Yellowjacket Canyon. In April 2011, a Colorado Division of Wildlife crew sampling McElmo Creek about a mile upstream of the Yellowjacket Canyon confluence recaptured one of the Colorado Pikeminnow (298 mm TL) that had been captured and tagged in Yellowjacket Canyon on 29 September 2010 (296 mm TL: J. White, pers. comm.). In the spring and summer of 2011, 24 individual Colorado Pikeminnow (range = 225-519 mm TL) were collected from the San Juan River arm of Lake Powell, from the waterfall at Piute Farms boat launch to Neskahi Canyon (Francis et al. 2013). One additional individual was collected in the summer 2012 (Francis et al. 2013 In Prep.).

While no larval Colorado Pikeminnow were collected in 2012 (Farrington et al. 2013), 34 larval Colorado Pikeminnow were collected during 2011 larval sampling (Brandenberg and Farrington 2012), 5 in 2010 (Brandenburg and Farrington 2011), and 1 in 2009 (Brandenburg and Farrington 2010). Three more larval Colorado Pikeminnow were collected during 2007 larval sampling (Brandenburg and Farrington 2008). Although these larvae could have been produced by some heretofore uncollected extant wild fish, the chances are equally as good (in fact probably better) that they are progeny of stocked Colorado Pikeminnow that have recruited to adulthood and are now reproducing. While the numbers of larvae collected are small, they document that successful reproduction has occurred in four of the previous six years (2007-2012). Despite low numbers of larval Colorado Pikeminnow being collected in four of the last six years, there has been no detectable recruitment of these young fish to adulthood. However, it may be extremely hard to detect young, wild-produced Colorado Pikeminnow in the presence of hundreds of thousands of stocked fish. The only way we may ever be able to tell for sure if natural reproduction and recruitment is occurring with this species is stop stocking altogether for some period of time. However, we would not advise this course of action until numbers of both adult and wild-produced larval fish have increased greatly over the numbers now being observed.

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

On the down side, we know that Colorado Pikeminnow can be lost from the San Juan system in a number of ways. Stocked Colorado Pikeminnow have been documented becoming entrained in two different canals (Trammell 2000, Renfro et al. 2006). In the case of the Hogback canal, 201 Colorado Pikeminnow were documented as being entrained in 2004 (n = 140) and 2005 (n = 61). Colorado Pikeminnow have moved into and now occupy the San Juan River arm of Lake Powell (Francis et al. 2013). However, a large (approximately 10 meter high) waterfall prevents their moving back upstream and into the San Juan River. Lastly, a number of studies in the San Juan River have documented negative interactions between Colorado Pikeminnow and nonnative Channel Catfish. These include both predation upon stocked Colorado Pikeminnow by Channel Catfish (e.g., Jackson 2005) as well as Colorado Pikeminnow choking on Channel Catfish and Black Bullhead after attempting to ingest them (e.g., Ryden and Smith 2002, A. Lapahie unpublished data).

Despite various sources of loss, a wide spectrum of size-classes of Colorado Pikeminnow were collected in 2012, up to and including sub-adult and adult fish. Documented reproduction of Colorado Pikeminnow in four of the last six years indicates that stocked fish that have recruited into adulthood are now successfully spawning. In addition, Colorado Pikeminnow have been documented using areas of the San Juan River basin where they have never before been seen. Caution must be taken when interpreting these data, because the San Juan River Colorado Pikeminnow population is essentially still a population of stocked fish. However, given that just ten years ago, Colorado Pikeminnow were all but nonexistent in Adult Monitoring collections, their current status (i.e., having thousands of these fish in the river) is encouraging.

Razorback Sucker

Razorback Sucker

We believe that no wild Razorback Sucker were collected in 2012. The 321 stocked Razorback Sucker collected in 2012 marked the seventh consecutive year during which > 50 Razorback Sucker during an Adult Monitoring trip. Like Colorado Pikeminnow, the numbers of Razorback Sucker collected during any given Adult monitoring trip have tended to fluctuate based on the number of fish that were recently stocked into the river (i.e., in that year and the previous year). For example, the previous 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 2012 Adult Monitoring jumped to 321 fish, the highest number of individuals ever collected during our study, with many of the fish being collected having been in the river multiple years post-stocking.

Unlike Colorado Pikeminnow, some Razorback Sucker are retaining in the San Juan River for as long as 15 overwinter periods post-stocking (Ryden 2012). In addition, larval Razorback Sucker were collected for the 15^{th} consecutive year (1998-2012; Farrington et al. 2013). 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 in the San Juan River since that time and there is no evidence at this time that the age-1 and age-2 fish collected in 2003 and 2004 recruited into adulthood.

Razorback Sucker were collected throughout the common sampled area in 2012 (RM 179.0-79.1). However, most of those were collected in Reaches 6 and 5. Like Colorado Pikeminnow, Razorback Sucker appear to be expanding their range upstream beyond PNM Weir, both via stocking and upstream passage through the PNM Fish Passage facility. Sixty-three Razorback Sucker collected in the common sampled area in 2012 (19.6%) were collected upstream of Hogback Diversion. Razorback Sucker from the NAPI grow-out ponds were stocked both immediately downstream, as well as upstream of the PNM Weir in 2012 (Furr 2013b), which explains the presence of most of the collections of this species between the Animas River confluence and Hogback Diversion. The collection of two additional adult Razorback Sucker upstream of the Animas River confluence in fall 2012 was also very encouraging.

Seventy-five Razorback Sucker were collected in the San Juan river arm of Lake Powell in 2011 and another 72 in 2012 (Francis et al. 2012, Francis et al. In Prep.). Five of these fish are known to have moved upstream (from 147-144 RM) when the waterfall at the old Piute Farms Marina almost disappeared due to rising lake levels in late July 2011 (Francis et al. 2013). In addition, database searches have indicated that at least three Razorback Sucker stocked into the San Juan

River in 2004 (n = 1; 360 mm TL) and 2006 (n = 2; 167 and 253 mm TL) moved downstream out of the San Juan River, through Lake Powel and back upstream into the Colorado River, a movement on 477 RM in the most extreme case (T. Francis, pers. comm.). Additionally, Razorback Sucker have been detected over remote PIT tag antennas in upstream locations of both Chaco Wash (RM 153.0) and McElmo Creek (RM 100.5). Thus like Colorado Pikeminnow, Razorback Sucker seem to be moving into and exploiting more habitats peripheral to the mainstem San Juan River. The detection of fish moving between river basins also shows that habitats once thought to be a barrier to this species may indeed be acting more like a highway.

A total of 1,778 larval Razorback Sucker were collected during 2012 larval sampling (Farrington et al. 2013). This marks the 15th consecutive year (1998-2010) that reproduction of Razorback Sucker has been documented in the San Juan River (Brandenburg and Farrington 2008, 2010, 2011, 2012).

Despite the relatively large numbers of larval Razorback Sucker being collected (when compared to Colorado Pikeminnow) that have been documented since 1998, there has been no detectable recruitment of these young fish to adulthood. Captures of age-1 and age-2 fish in the early 2000s were very encouraging, but haven't been seen since that time. As with Colorado Pikeminnow, the only way we may ever be able to tell for sure if natural reproduction and recruitment is occurring with this species is stop stocking altogether for some period of time.

Between 2001 and 2012 there were 23 capture events with Razorback Sucker X Flannelmouth Sucker hybrids during Adult Monitoring trips. These fish were collected from near the APS Weir, downstream to just above Lake Powell (RM 163.0-13.0). Four of these captures were juvenile fish (240-360 mm TL). The other 19 captures were adult fish (410-510 mm TL). One was captured in 2001, 2 in 2003, 1 in 2004, 1 in 2005, 6 in 2006, 1 in 2007, 1 in 2008, 4 in 2009, 3 in 2010, 2 in 2011, and 1 in 2012. In addition, two Razorback Sucker X Flannelmouth Sucker hybrids were collected in the San Juan River arm of Lake Powell in 2011 (Francis et al. 2013). 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?

It has been assumed that it will take the consistent collection of small, unmarked Razorback Sucker by an intensive, seining-based study such as the small-bodied fish monitoring study to prove that recruitment of wild-produced Razorback Sucker is indeed taking place. It has long been known among Colorado River basin endangered fish researchers that it is extremely difficult to collect early life-stage Razorback Sucker in any of the Upper Colorado rivers, not just the San Juan River. In 2012 investigators from UDWR-Moab reported capturing and releasing two YOY Razorback Sucker during fall seine surveys in the lower Colorado River downstream of Moab, UT (J. Howard, pers. comm.). Unfortunately, they didn't take any pictures and some wondered whether they had identified these fish correctly, given the rarity with which young Razorback Sucker are encountered.

However, in spring 2013, a large number (over 20 so far) of age-1 and age-2 Razorback Sucker (range = 106-240 mm TL) have been collected in the Colorado River around and downstream of Moab, UT (T. Francis, pers. comm.). Unlike the fall 2012 captures, these fish were all collected with boat-mounted electrofishing units performing shoreline electrofishing – essentially identical to the sampling we are doing during Adult Monitoring. These young Razorback Sucker were collected across a range of flows (from low to high water), mostly from slackwater habitats along shorelines, although some were collected over low-velocity point sand bars. They also seemed to be associated with instream structure (brush piles, tamarisk root wads, and boulders/rocks). In many cases, these young Razorback Sucker were collected in groups and often those groups were in the same places where young Colorado Pikeminnow were also being collected. In most cases, these young Razorback Sucker were described as being “easy to recognize” as they came into the electrofishing field. The Principal Investigator described it as these fish just reacting “differently" to the electrofishing field than did Flannelmouth Sucker or Bluehead Sucker, swimming vigorously towards the electrofishing boat once they were in the electrofishing field, just like larger Razorback Sucker do and were easy to recognize as being razorbacks because of that fact (T. Francis, pers. comm.). The Principal Investigator who has sampled these areas for years (as well as performing Adult Monitoring in the San Juan River) felt sure that his crews were not doing anything different or special to collect these fish this year. He also stated that he felt Adult Monitoring is sampling in an effective manner to document the presence of these fish in the San Juan River, if and when they are present in large enough numbers to be documented.

Using Program MARK, riverwide population estimates were generated for Razorback Sucker in 2010, using three complete riverwide nonnative fish removal passes (Duran et al. 2011). Two separate models yielded the following population estimates: Model M(t) = 2,928 (CI = 1,952-4,796); Model M(o) = 3,021 (CI = 2,007-4,940). All Razorback Sucker, regardless of age that had been in the river for one over-winter period were used in this estimate. Thus, these estimates give numbers just for fish that have survived through a full set of yearly conditions. However, the number of Razorback Sucker in the river at any given time would actually be higher than these estimates indicate. These population estimates haven’t been repeated since that time.

On the down side, we know that Razorback Sucker, like Colorado Pikeminnow can be lost from the San Juan system in a couple of ways. To date, stocked Razorback Sucker have not been documented being entrained in canals -- although data from two canals in Grand Junction, CO indicates that they do become entrained in canals (D. Ryden, pers. obs.). However, Razorback Sucker have moved into and now occupy the San Juan River arm of Lake Powell. Until summer 2011 it was assumed that the presence of the waterfall prevented any movement of Razorback Sucker back upstream and into the San Juan River. We now know that at least some of these fish will return upstream if the opportunity presents itself. Lastly, a number of studies in the San Juan River have documented predation upon stocked Razorback Sucker by Channel Catfish (e.g., Jackson 2005).

Despite various sources of loss, and the far lesser numbers of fish that have been stocked over the years in comparison to Colorado Pikeminnow (Furr 2013a and 2013b), Razorback Sucker continue to persist and spawn in the San Juan River, producing far greater numbers of larval fish annually than do Colorado Pikeminnow (Farrington et al. 2013). Population estimates indicate that several thousand of the fish now occupy the San Juan River, mostly upstream of the canyon-bound reaches, which begin at RM 68.0. As with Colorado Pikeminnow, caution must be taken when interpreting these data, because the San Juan River Razorback Sucker population is essentially still a population of stocked fish. Like Colorado Pikeminnow, Razorback Sucker were all but nonexistent in Adult Monitoring collections just 15 years ago. Looking at this data through that lens, their current status (i.e., having numbers of adult fish that we know are consistently reproducing) is encouraging.

Common Native Fishes

Flannelmouth Sucker

Flannelmouth Sucker remain the most abundant species collected in the common sampled area, as well as in the 15 RM upstream of the Animas River confluence. Flannelmouth Sucker were the only species to be collected in every single electrofishing sample in 2012. Flannelmouth Sucker 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 great fluctuations, but no significant long-term change over the last 14 years. The long-term trend line for adult Flannelmouth Sucker CPUE riverwide has shown a significant decline in this abundance index over the last 14 years. However, the first three data points on that line (1999-2001) are the three that drive that relationship. In fact, those three data points are the three highest CPUE values for adult Flannelmouth Sucker seen since 1996, when CPUE values for adult Flannelmouth Sucker were about the same as what they were in 2012 (Ryden 2004). If those three data points are excluded, the long-term trend line for adult Flannelmouth Sucker CPUE is flat over the last 11 years. The exact reason for the marked decline in adult Flannelmouth Sucker CPUE from 1999-2001 is unknown. There has been some speculation that the stocking of large numbers of large juvenile and adult Razorback Sucker (a competitor of Flannelmouth Sucker) could be to blame. However, a small number of Razorback Sucker were stocked prior to 1999 (only 5,100 of the 130,402 stocked to date = 3.91%) when the downward trend began, and most of those were relatively small fish, which PIT tag data shows were not recaptured in high numbers (Furr 2013b, Durst 2013). However, this trend does bear close examination in future years. As a whole (juvenile and adult fish combined), the San Juan River Flannelmouth Sucker population has remained relatively stable and widespread in the common sampled area over the last 14 years. This is the case despite: 1) the stocking of over > 3.1 million Colorado Pikeminnow (potential predators) from 2002-2012 and > 114,650 Razorback Sucker (potential competitors) from 1994-2012; and, 2) repeated intensive electrofishing efforts that are ongoing in the San Juan River.

There are populations of Flannelmouth Sucker in the San Juan River upstream of the Adult Monitoring study area, in the Animas River, Chaco Wash, the Mancos River, and in McElmo Creek and its tributaries (including Yellowjacket Canyon). Flannelmouth Sucker have also been documented in the San Juan River arm of Lake Powell in both 2011 and 2012 (Francis et al.

2013, Francis et al. In Prep.). Based on recaptures of Flannelmouth Sucker FLOY-tagged in the mid-1990s (SJRIP database), we know that Flannelmouth Sucker move upstream at least into the Animas River from the San Juan River. This exchange of fish probably also occurs between the mainstem San Juan and the other tributary streams mentioned above. It could be that mainstem San Juan population is just the downstream end of a larger functional unit and that the fluctuating trends in CPUE (especially juvenile CPUE, but possibly also the long-term decline in adult CPUE values) that we've observed over time are reflective of changes within this larger metapopulation.

Bluehead Sucker

Bluehead Sucker were the third most common large-bodied fish species collected in the common sampled area and the second most abundany in the 15 RM upstream of the Animas River confluence in 2012. Bluehead Sucker were collected in every electrofishing sample in the common sampled area and in almost all (20 of 22) samples upstream of the Animas. 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 14 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 14 years. Much like Flannelmouth Sucker, the two highest CPUE data points for adult Bluehead Sucker were in 1999 and 2000. However, unlike Flannelmouth Sucker, the long-term trend line for adult Bluehead Sucker CPUE riverwide has shown no significant change over the last 14 years. In fact, there were no significant differences between the 2012 adult Bluehead Sucker CPUE value and that observed for 12 of the previous 13 years. To date, the San Juan River Bluehead Sucker population has remained relatively stable and widespread in the common sampled area. This is the case despite: 1) the stocking of over > 3.1 million Colorado Pikeminnow (potential predators) from 2002-2012 and > 114,650 Razorback Sucker (potential competitors) from 1994-2012; and, 2) repeated intensive electrofishing efforts that are ongoing in the San Juan River.

Like Flannelmouth Sucker, there are also populations of Bluehead Sucker in the San Juan River upstream of the Adult Monitoring study area, in the Animas River, Chaco Wash, the Mancos River, and in McElmo Creek and its tributaries (including Yellowjacket Canyon). Bluehead Sucker have also been documented in Lake Powell, as far downstream as Neskahi Canyon (Francis et al. In Prep.). Recaptures of Bluehead Sucker FLOY-tagged in the mid-1990s (SJRIP database), showed that at least some of these fish had moved upstream into the Animas River from the San Juan River. An exchange of fish probably also occurs between the mainstem San Juan and the other tributary stream populations of Bluehead Sucker, as mentioned above. It could be that mainstem San Juan population of Bluehead Sucker is just the downstream end of a larger functional unit and that the fluctuating trends in CPUE that we've observed over time are reflective of changes within this larger metapopulation.

Common Nonnative Fishes

Channel Catfish

Channel Catfish have been the second most abundant species collected in 6 of the last 7 years (2006-2012) in the common sampled area. Channel Catfish continue to be collected throughout our study area (RM 180.0-77.0), being present in > 80% of all electrofishing samples. Discouragingly, numbers of adult Channel Catfish have shown no significant long-term decline in the face of intensive nonnative fish removal efforts in the common sampled area. Additionally, numbers of juvenile Channel Catfish have shown a long-term increasing trend from 1999-2012.

In 2001 (the year intensive nonnative fish removal efforts began), the largest numbers of Channel Catfish were collected in the upper nonnative fish removal section, from RM 166.6-147.9 (Ryden 2012). In 2012, the Channel Catfish population was most abundant in the portion of the middle nonnative fish removal section (RM 147.9-77.0) that we sampled. Large numbers of both juvenile and young adult Channel Catfish were common in samples downstream of Shiprock, NM. Sizeable numbers of YOY Channel Catfish also began to be collected from RM 110.0 downstream, indicating the presence of large numbers of these small size-class fish (since raft-mounted electrofishing isn't really set up to collect these fish unless they are present in very large numbers).

Strong year-classes of young Channel Catfish continue to be observed in length-frequency histograms in the common sampled area. This points to the resilience of the Channel Catfish population in the San Juan River. Channel Catfish have demonstrated an impressive capacity for reproduction and recolonization that has, so far, managed to offset many of the impacts made by intensive nonnative fish removal efforts in both the middle and lower nonnative fish removal sections.

While the population trends would seem to indicate that nonnative fish removal efforts are ineffective in reducing numbers of this species in the common sampled area, it should be remembered that in the upper nonnative fish removal sections it took several years of hard work in a much shorter area of river to bring numbers of Channel Catfish down significantly. It is anticipated that with the repetition of multiple-pass, intensive nonnative fish removal efforts being applied in all sections of the San Juan River (i.e., enough pressure over a long enough period of time), will make it possible to effectively reduce the number of Channel Catfish in the section of river from Shiprock, NM downstream to Mexican Hat, UT.

Common Carp

Common Carp were the seventh most commonly-collected species during 2012 Adult Monitoring. A total of only 27 Common Carp were collected in 132 electrofishing samples in the common sampled area in 2012. Over the last 14 years, Common Carp numbers have become much reduced. While the exact causes of the large-scale decline of Common Carp are unknown

(N. Franssen, pers. comm.), nonnative fish removal has been a heavily contributing factor. Common Carp were numerically less abundant in 2012 than both endangered Colorado Pikeminnow and Razorback Sucker. Common Carp accounted for only 0.2% of the total catch and were collected in only 13.6% of all electrofishing samples riverwide in 2012. Only 27 Common Carp were collected during 2012 Adult Monitoring (RM 180.0-77.0), of which all but three were adult fish. In comparison, during 1998 Adult Monitoring, 77 adult Common Carp were collected in just one electrofishing sample (RM 163-162). If there has been a success story associated with the nonnative removal efforts in the San Juan River to date, it would be the marked reduction in numbers of Common Carp riverwide.

Sampling Upstream of the Animas River Confluence

With only two days of electrofishing data in 2012 (and one of those days having had very poor sampling conditions), it is too early to be making statements about the fish community in this upstream river section. However, it was encouraging to see that two most abundant species in our electrofishing collections were the common native suckers and that Razorback Sucker were also present in this river section. The lack of Channel Catfish collections was also encouraging. Unfortunately no Colorado Pikeminnow were collected in this river section, although we know they have been stocked both up- and downstream of here (Furr 2013). Future years' sampling should help to bring clarity to the fish community structure and how it is relating to Reach 6, immediately downstream.

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APPENDIX A

An estimation of how many Colorado Pikeminnow and Razorback Sucker need to be collected during a fall Adult Monitoring trip to indicate that numbers in the river are at or near the downlist and/or delist criteria for these two species as specified in their respective Recovery Goals documents?

INTRODUCTION

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

The question we were 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, 2002c).

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

In 2009 and 2010, endangered fish capture data from several different nonnative fish removal trips that, as a group, sampled the entirety of the San Juan River in fairly close temporal proximity to one another was used to make preliminary riverwide population estimates for the two endangered fish species (Davis et al. 2010, Duran et al. 2011). The results of these preliminary riverwide population estimates indicated that the capture probability for Colorado Pikeminnow on any given electrofishing pass was 5% and for Razorback Sucker it was 4%. Thus, the calculations presented here use these more recent (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 (> 450 mm TL; age-7+) riverwide (i.e., from Animas confluence to Lake Powell = 180 RM) to delist

{FYI: Downlist criteria = 1,000 fish > 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 just upstream of the Sand Island Boat Landing (103.0 total RM) and we only sample two out of every three of those RM

RM 180.0-77.0 = 103.0 total RM
2/3 = 0.667
103.0 RM X 0.667 = 68.7 RM sampled

- Therefore, with our current sampling regime, we would have to collect 15 adult Colorado Pikeminnow during a fall Adult monitoring trip to be reasonably sure that there were about 800 adult Colorado Pikeminnow riverwide

68.7 RM sampled X 0.222 fish per mile = 15.25 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 just upstream of the Sand Island Boat Landing (103.0 total RM) and we only sample two out of every three of those RM

RM 180.0-77.0 = 103.0 total RM
2/3 = 0.667
103.0 RM X 0.667 = 68.7 RM sampled

- Therefore, with our current sampling regime, we would have to collect 2 age-6 (400-449 mm TL) Colorado Pikeminnow during a fall Adult monitoring trip to be reasonably sure that there were about 120 age-6 Colorado Pikeminnow riverwide

68.7 RM sampled X 0.033 fish per mile = 2.26 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 19 Colorado Pikeminnow (> 300 mm TL; age-5+) would indicate that there were close to 1,000 fish > 300 mm TL riverwide.

To Delist (Demographic Criteria only): Collecting 15 adult Colorado Pikeminnow (> 450 mm TL; age-7+) and 2 sub-adult Colorado Pikeminnow (400-449 mm TL; age-6) would indicate that there were close to 800 fish > 450 mm TL, with a 15% recruitment rate.

For Razorback Sucker:

To Downlist (Demographic Criteria only): Collecting 88 adult Razorback Sucker (> 400 mm TL; age-4+) and 26 sub-adult Razorback Sucker (300-399 mm TL; age-3) would indicate that there were close to 5,800 fish > 400 mm TL, with a 30% recruitment rate. This would need to occur over a consecutive 5-year period.

To Delist (Demographic Criteria only): Collecting 88 adult Razorback Sucker (> 400 mm TL; age-4+) and 26 sub-adult Razorback Sucker (300-399 mm TL; age-3) would indicate that there were close to 5,800 fish > 400 mm TL, with a 30% recruitment rate. This would need to occur over a consecutive 3-year period beyond downlisting.

Discussion

Exactly when the SJRIP should begin formal (riverwide, repeated-pass) population estimates for the two endangered fishes is a tough question to answer. In the upper Colorado River basin, specific studies to obtain population estimates (repeated periodically over an extended period of time) are being performed for both Colorado Pikeminnow and Humpback Chub. However, populations of both of these species are made up entirely of wild fish that are known to fulfill all aspects of their life cycle (natural reproduction through recruitment into adulthood) at some level in the wild. Preliminary efforts to generate population estimates for Razorback Sucker (populations that now consist of both wild and stocked fish) in the upper basin are also underway. However, data for that effort is not being collected via a separate study, but rather being collected opportunistically during several other studies.

Switching to a population estimate approach in the San Juan River would help provide the SJRIP more precise numbers of fish by species and size-class. This information could be used in the population model to help make future management decisions. Additionally, at some point, the SJRIP will need to switch to the population estimate approach to provide the kind of data specified in the Recovery Goals documents (USFWS 2002a, 2002c). The population estimate approach may provide a better understanding of the size-structure of endangered fish populations, thus helping inform whether or not the SJRIP needs to stock more or less fish than what our current augmentation program is doing. Lastly, if the same approach is used in the SJRIP as is being used in the upper basin (three years of sampling, followed by two years off -- five years total for a cycle), then the SJRIP could anticipate doing slightly less than two full cycles of population estimates before the Recovery Program is scheduled to end in 2023.

On the down side, population estimate studies (as they are being performed in the upper basin) are really intended to be performed on populations of fish that are completing all aspects of their life cycle. Current research tells us that there are still “holes” in the life cycles of both Colorado Pikeminnow and Razorback Sucker in the San Juan River. For Colorado Pikeminnow, the hole occurs with producing large enough numbers of wild larvae every year that can then recruit into and through the juvenile life stages and back into adulthood. This may be a problem of not enough adult fish, or it may be a problem of survival of enough larvae post-spawning (e.g., egg viability, etc.). Current studies show that if large enough numbers age-0 Colorado Pikeminnow are present in the fall of the year during every year (i.e., as with our current stocking regime), some of them will eventually recruit to adulthood (although maybe not as quickly and in as large of numbers as we would like or anticipate) and natural reproduction can then occur. For Razorback Sucker, the hole occurs between early life stages and adulthood as well. Wild-produced, larval Razorback Sucker have been collected every year since 1998 and the numbers of larvae being collected appear to be increasing over time. We also know that some stocked Razorback Sucker are retaining and surviving in the river for long periods of time post-stocking and are contributing to the production of larval fish. There have even been occasional collections of age-1 and age-2 Razorback Sucker in the San Juan River. However, it doesn’t appear that enough fish are surviving from age-0 through adulthood to fill in behind the larger juvenile and adult fish that are being stocked. So, if these life cycles aren't being completed, population estimate studies are just giving a more precise way of measuring groups of stocked fish.

The second consideration is that population estimate studies are very expensive to do and they are very resource intensive. In order to accommodate population estimate studies like those being done in the upper basin (during which sampling occurs literally every day for three straight months – April through June), the SJRIP would need to do a major reorganization of not only how it spends its funding, but also how its available manpower and equipment are allocated. This could lead to the modification or elimination of numerous current study and management efforts, due to budgetary considerations and overlapping timing of sampling. While we feel that it still may be premature to expect population estimate studies to yield all of the information the SJRIP needs, beginning the process of developing workplans, sampling regimes, and a strategy whereby the SJRIP can fund such a large undertaking could be advantageous to the SJRIP in the long-term.