SMALL-BODIED FISHES MONITORING, SAN JUAN RIVER

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EXECUTIVE SUMMARY

Monitoring of small-bodied fishes was conducted in the San Juan River from 1998 through 2009. Native fish numbers have remained relatively stable for the duration of the study, but nonnative small-bodied fishes (mainly red shiner and fathead minnow) were declining until this year. In 2009, Red shiner abundance increased considerably in primary and secondary channels and in backwaters but fathead minnow and channel catfish remained largely unchanged.

No age-0 razorback sucker was collected during small-bodied fishes monitoring, although spawning was documented in each of the last 12 years (Brandenburg and Farrington 2010). Bluehead and flannelmouth suckers were collected in sufficient numbers to track cohorts across years (using data from larval and adult monitoring efforts). The 2004 year classes of flannelmouth and bluehead sucker were the last that recruited well into the adult population. Larval densities of these species were not always good predictors of abundance of these species in autumn monitoring or recruitment into the adult population.

Age-0 Colorado pikeminnow were collected in 1998, 2000 and 2007. All were likely stocked individuals. Age-1+ pikeminnow were collected each year beginning in 2004. Abundance of small fishes that are potential prey for Colorado pikeminnow was lower in 2006 through 2009 than previous years (2003 through 2005), although there was some recovery in 2009.

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INTRODUCTION

Small-bodied and young of year (age-0) fishes numerically dominate the San Juan River fish assemblage and likely are essential to recovery of Colorado pikeminnow (*Ptychocheilus lucius*) and influence abundance of razorback sucker (*Xyrauchen texanus*) young. Small-bodied fishes are an important component of the diet of young Colorado pikeminnow, but also may prey upon or compete with larval and age-0 razorback sucker and Colorado pikeminnow (Franssen et al. 2007). Annual autumn sampling of shallow-water habitats is undertaken to obtain information on fishes that occur in these habitats as well to relate this information to recovery progress of Colorado pikeminnow and razorback sucker and conservation of the native fish assemblage of the San Juan River.

As set forth in Section 5.7 of the San Juan River Basin Recovery Implementation Program (SJRIP) Long-Range Plan, a long-term monitoring program "to identify changes in the endangered and other native species populations, status, distributions and habitat conditions," was to be developed by the SJRIP Biology Committee. The ichthyofaunal monitoring portion of the San Juan River Monitoring Plan and Protocols (Propst, et al., 2000) was divided into three primary areas; larval fishes, young-of-year/small-bodied fishes, and sub-adult and adult/large-bodied fishes. The portion of the San Juan River to be monitored extends from the confluence of the Animas and San Juan rivers (Farmington, NM) to Lake Powell (Clay Hills Crossing, UT) (Figure 1).

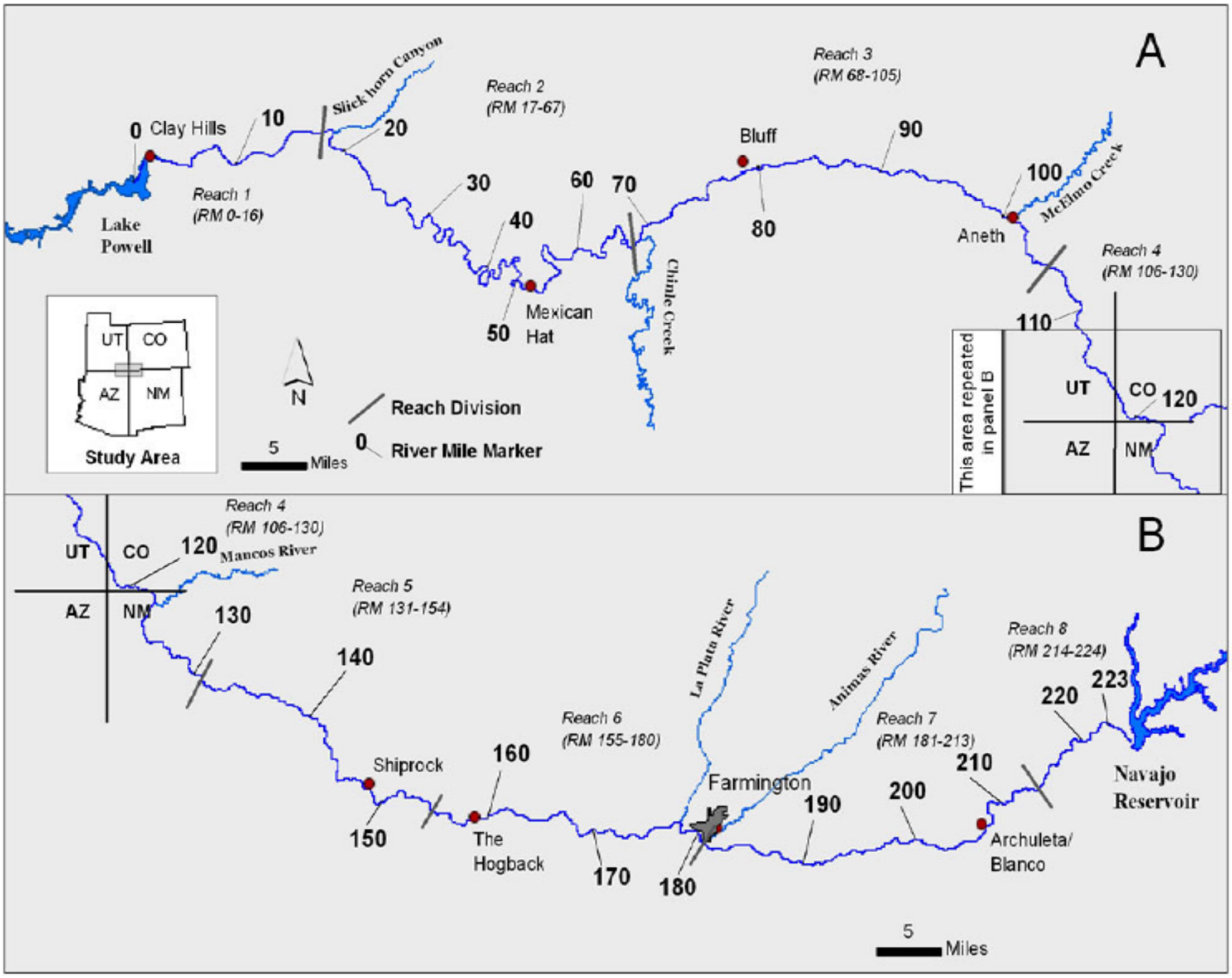


Figure 1. Map of the San Juan River. Study area begins at the confluence of the Animas River near Farmington, NM downstream to Clay Hills Crossing, UT.

Autumn monitoring of small-bodied and age-0 fishes of the San Juan River is designed to characterize survival and recruitment of wild-spawned Colorado pikeminnow and razorback sucker, survival of stocked age-0 Colorado pikeminnow, provide information on habitat use by wild and stocked individuals, monitor status and habitat use by potential Colorado pikeminnow prey and competitors of both Colorado pikeminnow and razorback sucker, and provide data to assess the effects of flow on density of small-bodied and age-0 fishes. Specific objectives of the small-bodied fishes portion of the San Juan River monitoring effort are to:

1. document primary channel shoreline and near-shoreline mesohabitat, secondary channel, and backwater use by age-0 Colorado pikeminnow, razorback sucker, and roundtail chub (*Gila robusta*);

2. obtain data that will aid in the evaluation of the responses (e.g., reproduction, recruitment, and growth) of native and nonnative fishes to different flow regimes and other management actions (e.g., impediment modification);

3. track trends in species populations (e.g., abundance and relative condition), and

4. characterize patterns of mesohabitat use by common native and nonnative small-bodied fishes (including age-0 flannelmouth sucker [*Catostomus latipinnis*], bluehead sucker [*Catostomus latipinnis*], common carp [*Cyprinus carpio*], and channel catfish [*Ictalurus punctatus*]).

Data obtained during small-bodied fishes monitoring efforts will be available to all San Juan River Basin Recovery Implementation Program researchers and may be used in conjunction with data obtained in other studies to evaluate management activities.

To date, this study has documented a decline in the density of small-bodied nonnative fishes (red shiner [*Cyprinella lutrensis*] and fathead minnow [*Pimephales promelas*]) from 2004 through 2008 followed by a rebound in red shiner in 2009. Native fishes densities showed a greater degree of stability from 2004 through 2009. In February 2009, the SJRIP Biology Committee recommended that reports on 2009 monitoring efforts focus on information that pertains to recovery of Colorado pikeminnow and razorback sucker. Summary information on all species is included, but this report is focused on these two species. Analyses in this report mainly concentrate on data collected since 2003. Earlier data (1998-2002) are available and may be obtained from New Mexico Department of Game and Fish.

METHODS

In 1998, autumn monitoring of small-bodied fishes in wadeable habitats of the San Juan River primary and secondary channels and backwaters (including embayments) occurred from Shiprock, New Mexico (RM 147.9, Reach 5) downstream to Chinle Creek, Utah (RM 68.6, Reach 3). In 1999, autumn monitoring was extended upstream to the San Juan-Animas rivers confluence (RM 180, Reach 6) and downstream to Clay Hills Crossing (RM 3, Reach 1). The primary channel was sampled at each sampled secondary channel or at 3-mile intervals (designated miles) if no secondary channel was present in a 3-mile reach. In 1999, a secondary channel was sampled only if it occurred within the 1-mile reach to be sampled in every third mile. This protocol excluded a large proportion of secondary channels (30 to 50%, depending upon the starting point of the 3-mile sampling interval). To adequately sample these habitats, beginning in 2000, all secondary channels longer than 200 m and having surface water during monitoring were sampled. All backwaters (greater than 50 m^2), regardless of occurrence within designated miles, were sampled.

Small-bodied fishes were collected from primary channel habitats at 3-mile intervals. Small-bodied monitoring occurs in conjunction with adult monitoring. Sample intervals are coordinated to occur in miles that are skipped by the adult monitoring crews. All collections were made by pulling a seine through a mesohabitat or kicking into a seine. During several years exploratory sampling methods were added, but there was no significant difference detected between the collections made with these additional methods and traditional methods. Consequently, all data were grouped for analysis within those years.

Primary channel sample sites were about 200-m long (measured along shoreline). Length of secondary channel sample sites varied depending upon extent of surface water, but was normally 100 to 200 m. River mile, GPS readings (UTM NAD83), and water quality information (pH, dissolved oxygen, conductivity, and temperature) were recorded for each site. Within each site (primary and secondary channels), all mesohabitats (see Bliesner and Lamarra 2000 for definitions) present were sampled in rough proportion to their surface area within a site. Beginning in 2003, data (including fishes collected) from each sampled mesohabitat within a site were recorded separately.

Most primary channel mesohabitats sampled were along stream margins, but off-shore riffles and runs (<0.75 m deep) were sampled also. Secondary channel sampling was across the breadth of the wetted channel. All available wadeable mesohabitats within a site were sampled. Uncommon mesohabitats (e.g., debris pools and backwaters) were sampled in greater proportion to their availability than common mesohabitats (e.g., runs). Normally, at least five seine hauls (= five mesohabitats) were made at each sample site; however, if habitat was homogeneous, fewer seine hauls sometimes were made. Where there was comparatively high habitat diversity, more seine hauls frequently were made. The intent was to sample all mesohabitat types available at a site. All large backwaters >50 m^2 associated with the primary channel were sampled. Typically, two seine hauls were made in each backwater; one near its mouth and the second in its upper half and parallel to long axis of the backwater. Additional seine hauls were done as necessary in backwaters with more complexity. Fish collection data from embayments were grouped with backwater data in 2003 through 2009.

Fishes were collected with a drag seine (3.05 x 1.83 m, 3.2 mm mesh) from each mesohabitat. Each catch was inspected to determine presence of protected species and other native fishes. Total length (TL) of each native fish was measured, recorded, and the fish released. Subsamples of at least 50 individuals of speckled dace (*Rhinichthys osculus*) were measured for each reach; the remainder were counted and released. Nonnative fishes were fixed in 10% formalin and returned to the laboratory. Following fish collection, the seined area of each sampled mesohabitat was measured and recorded. Retained specimens were identified and enumerated in the laboratory. Total length was measured for all retained specimens and in 2009, small catostomids were preserved to verify identification. Personnel of the University of New Mexico Museum of Southwestern Biology (UNM-MSB), Division of Fishes, verified identification of retained specimens and retained specimens were accessioned to the UNM-MSB, Division of Fishes. For each seine haul, habitat type, area seined, depth in 5 locations within seined area, dominant substrate, and any cover associated with the habitat were recorded.

Attributes of spring and summer discharge were obtained from USGS Water Resources Data, New Mexico (1998 et seq.). Shiprock gauge (#09368000) data were used for all calculations. Spring was 1 March through 30 June and summer was 1 July through 30 September. Species density data were segregated by Geomorphic Reach (Bliesner and Lamarra 2000).

Mean sample catch per unit effort (CPUE) from 2003-2009 was calculated as the average of individual seine haul CPUEs. Mean sample CPUEs were used in regression analysis of summer discharge relation to autumn abundance of commonly collected secondary and primary channel species from 2003 through 2009. Regression of CPUE and discharge from 2000 through 2009 was computed using mean sample CPUE plotted with time (CPUE prior to 2003 was calculated as number of fish divided by total area sampled).

Mesohabitats were grouped into general categories (shoal, run, riffle, pool, eddy, backwater). Several habitats that did not fall into these general categories (e.g., debris piles and plunge pools) were excluded from habitat graphs because of low number of samples. For each mesohabitat class, the mean sample density of each species was plotted for each year. This representation of mesohabitat association provided an estimate of habitat use by each species. ANOVA was used to determine if there were differences in the densities of each species among the various habitats. Post hoc analyses was used to determine preferences where ANOVA showed use was not homogenous.

Regression, correlation, ANOVA, and post hoc analyses (Tukey HSD) were performed using STATISTICA® software. Due to the natural variability seen with age-0 fish populations, probability values of <0.10 were considered significant (Brown and Guy 2007). Analyses in this report mainly focused on data collected since 2003. Earlier data (1998-2002) are available from New Mexico Department of Game and Fish.

RESULTS

PRIMARY CHANNEL SUMMARY

Four native and nine nonnative species were collected in the primary channel of the San Juan River in 2009 (Table 1). No young-of year razorback sucker has been collected in this study; a single razorback sucker adult was captured in 2005. Colorado pikeminnow were collected from 1998 through 2000, and 2004 through 2009. Young-of-year Colorado pikeminnow specimens were collected during larval fishes monitoring in 1998, 2000, 2007 and 2009, but no age-0 Colorado pikeminnow was collected in these years during autumn small-bodied monitoring. From 2003 through 2005 CPUE of flannelmouth sucker in the primary channel decreased, but its CPUE was fairly stable from 2005 through 2009 (Table 2). Roundtail chub and mottled sculpin (*Cottus bairdi*) have not been collected since 1999.

Native fishes were numerically dominant again in 2009, but due to the increase in red shiner they were a smaller majority than in 2006 through 2008 (Table 2). Speckled dace and red shiner represented almost 90% of fishes captured in the primary channel in 2009. Red shiner displaced channel catfish in 2009 as the second most common species and channel catfish fell to fifth most common. Red shiner was the most common species collected from 1998 through 2005, but in 2006 and 2007 it was third-most common. Bluehead sucker (*Catostomus discobolus*) and flannelmouth sucker (*C. latipinnis*) were third and fourth most common, respectively, in 2009. Fathead minnow were rare in collections from 2006 through 2009. Brown trout (*Salmo trutta*) was collected for the first time in 2009.

The largest Colorado pikeminnow captured in the small-bodied fish monitoring in 2009 had a total length of 328 mm (SL 267 mm). The next largest had a total length of 206 mm (SL 190 mm). Previously, the largest pikeminnow captured was in 2005, and its total length was 289 mm.

Table 1. Species collected during small-bodied fishes autumn monitoring of San Juan River primary channel, 1998-2009. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	SCIENTIFIC	CODE	STATUS	98	99	00	01	02	03	04	05	06	07	08	09
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X		X		X	X			X	X
Roundtail chub	*Gila robusta*	GILROB	N	X	X										
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X						X	X	X	X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth x bluehead	*C. latipinnis x C. discobolus*	LATDIS			X				X						
Razorback sucker	*Xyrauchen texanus*	XYRTEX	N								X				
Black bullhead	*Ameiurus melas*	AMEMEL	I					X		X	X	X		X	
Yellow bullhead	*Ameiurus natalis*	AMENAT	I									X			
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X		X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X	X	X	X	X			X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I		X				X	X	X			X	X
Largemouth bass	*Micropterus salmoides*	MICSAL	I				X			X			X		X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X		X	X	X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X										
Brown trout	*Salmo trutta*	SALTRU	I												X
NATIVE			7	5	5	3	3	3	3	4	5	4	4	4	4
INTRODUCED			11	5	5	6	6	7	6	9	8	6	4	7	9

Table 2. Mean CPUE (number/m2) of fishes collected in San Juan River primary channel during autumn inventories, 2003 – 2009.

	2003			2004			2005			2006			2007			2008			2009		
Species	N	CPUE	SEr	N	CPUE	SE	N	CPUE	SE	N	CPUE	SE	N	CPUE	SE	N	CPUE	SE	N	CPUE	SE
CYPLUT	1706	0.5243	0.0801	9830	1.8335	0.3551	2521	0.8478	0.2573	164	0.0357	0.0061	204	0.0310	0.0072	190	0.0314	0.0084	2568	0.3993	0.0862
CYPCAR				6	0.0012	0.0006	3	0.0005	0.0004							2	0.0006	0.0004	1	0.0001	0.0001
PIMPRO	90	0.0353	0.0137	1119	0.2416	0.0749	281	0.0920	0.0322	44	0.0058	0.0049	32	0.0043	0.0026	24	0.0053	0.0036	62	0.0088	0.0051
PTYLUC				4	0.0005	0.0002	2	0.0003	0.0002	8	0.0013	0.0005	23	0.0031	0.0010	3	0.0004	0.0002	10	0.0013	0.0005
RHIOSC	511	0.1655	0.0292	4690	0.7643	0.1026	1234	0.2689	0.0412	2401	0.7378	0.4880	2177	0.2653	0.0377	1192	0.2007	0.0244	2964	0.4338	0.0609
CATDIS	27	0.0068	0.0021	283	0.0463	0.0056	90	0.0267	0.0160	154	0.0404	0.0229	53	0.0066	0.0017	58	0.0158	0.0098	245	0.0289	0.0069
CATLAT	140	0.0622	0.0231	255	0.0441	0.0072	111	0.0289	0.0131	62	0.0120	0.0028	227	0.0221	0.0073	101	0.0117	0.0039	216	0.0249	0.0078
LATDIS	1	0.0002	0.0002																		
XYRTEX							1														
AMEMEL				2	0.0005	0.0004	1	0.0006	0.0006	3	0.0004	0.0004				1	0.0005	0.0005			
ICTPUN	366	0.0912	0.0144	603	0.0887	0.0161	401	0.0960	0.0245	336	0.0695	0.0090	697	0.0835	0.0109	533	0.0718	0.0096	122	0.0208	0.0069
FUNZEB	21	0.0056	0.0028	30	0.0051	0.0034	1	0.0003	0.0003							2	0.0001	0.0001	13	0.0009	0.0009
LEPCYA	2	0.0004	0.0003	1	0.0004	0.0004	1	0.0003	0.0003							1	0.0001	0.0001	7	0.0009	0.0004
MICSAL				4	0.0009	0.0005							1	0.0004	0.0004				4	0.0007	0.0004
GAMAFF	37	0.0093	0.0059	127	0.0239	0.0075	16	0.0067	0.0035	4	0.0009	0.0007	8	0.0012	0.0009	5	0.0034	0.0028	39	0.0061	0.0030
SALTRU																			1	0.0001	0.0001
Total N	2913			17042			4639			3175			2766			2217			6252		
Total Area	3994			7768			5985			5446			9038			7469			8483		
Density	0.73			2.19			0.78			0.58			0.31			0.36			0.74		

SECONDARY CHANNELS SUMMARY

Most fish species found in the San Juan River primary channel also were found in its secondary channels (Table 3). Colorado pikeminnow was collected in secondary channels in each of the past six years. Roundtail chub and mottled sculpin have not been collected in San Juan River secondary channels since 1999. Razorback sucker has never been collected in a secondary channel during small-bodied fishes monitoring. Four native and nine nonnative species were found in secondary channels in 2009.

Red shiner was the most abundant species in the San Juan River secondary channels from 1998 through 2005 and again in 2009 (Table 4) and speckled dace was the most common species from 2006 through 2008. Red shiner and speckled dace made up almost 90% of fishes collected in secondary channels. Channel catfish, bluehead sucker and flannelmouth sucker were the next most common, respectively.

Table 3. Species collected during small-bodied fishes monitoring in San Juan River secondary channels during autumn, 1998-2009. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	SCIENTIFIC	CODE	STATUS	98	99	00	01	02	03	04	05	06	07	08	09
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I	X		X	X	X	X	X				X	X
Roundtail chub	*Gila robusta*	GILROB	N	X	X										
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X	X				X	X	X	X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X	X	X	X	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X	X	X	X	X	X
Black bullhead	*Ameiurus melas*	AMEMEL	I	X			X	X	X	X	X			X	X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I	X			X				X	X		X	X
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X	X	X	X
Rainbow trout	*Oncorhynchus mykiss*	ONCMYK	I				X								
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X	X	X	X				X	
Green sunfish	*Lepomis cyanellus*	LEPCYA	I							X					X
Largemouth bass	*Micropterus salmoides*	MICSAL	I						X	X				X	X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X	X	X	X	X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X										
NATIVE			6	5	6	4	3	3	3	4	4	4	4	4	4
INTRODUCED			11	9	5	7	10	8	8	8	6	5	4	9	9

Table 4. mean CPUE (number/m^2) of fishes collected in San Juan River secondary channel during autumn inventories, 2003 – 2009

	2003			2004			2005			2006			2007			2008			2009		
Species	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*
CYPLUT	1636	1.6186	0.4463	7171	4.2304	0.6358	921	0.9532	0.3283	154	0.1205	0.0368	168	0.0691	0.0194	221	0.0820	0.0434	1869	1.0995	0.3286
CYPCAR	2	0.0016	0.0011	10	0.0088	0.0040										5	0.0029	0.0015	4	0.0018	0.0009
PIMPRO	325	0.2417	0.0930	2239	1.8800	0.7865	106	0.1218	0.0502	27	0.0347	0.0233	4	0.0017	0.0017	117	0.0383	0.0183	18	0.0109	0.0057
PTYLUC				4	0.0046	0.0023	1	0.0005	0.0005	2	0.0011	0.0008	15	0.0083	0.0027	6	0.0013	0.0006	1	0.0004	0.0004
RHIOSC	238	0.2454	0.06121	1364	07976	0.1667	172	0.2013	0.0507	251	0.2131	0.0410	821	0.4256	0.1042	1017	0.5288	0.1178	1073	0.5093	0.1180
CATDIS	24	0.0167	0.0082	123	0.0827	0.0259	7	0.0064	0.0033	62	0.0256	0.0134	13	0.0057	0.0024	87	0.0202	0.0115	100	0.0367	0.0098
CATLAT	145	0.1103	0.0531	124	0.0899	0.0293	25	0.0278	0.0099	61	0.0296	0.0131	87	0.0410	0.0205	195	0.0602	0.0295	78	0.0290	0.0091
AMEMEL	9	0.0057	0.0024	6	0.0050	0.0031	3	0.0045	0.0031	4	0.0049	0.0030				3	0.0018	0.0013	1	0.0009	0.0009
AMENAT							1	0.0010	0.0010							3	0.0017	0.0011	5	0.0023	0.0016
ICTPUN	79	0.0551	0.0139	116	0.0991	0.0278	114	0.2099	0.1086	42	0.0193	0.0053	225	0.0935	0.0163	110	0.0387	0.0119	141	0.0823	0.0632
FUNZEB	11	0.0048	0.0025	32	0.0295	0.0173										4	0.0021	0.0014			
LEPCYA				1	0.0007	0.0007													2	0.0006	0.0006
MICSAL	1	0.0016	0.0016	6	0.0037	0.0020										10	0.0073	0.0052	6	0.0042	0.0023
GAMAFF	32	0.0258	0.0099	154	0.1584	0.0618	45	0.0463	0.0437	4	0.0058	0.0038	1	0.0004	0.0004	80	0.0236	0.0088	27	0.0148	0.0068
Total N	2464			11109			1400			607			1334			1858			3325		
Area	1438			1789			1009			1679			2525			2619			2387		
Density	1.71			6.21			1.38			0.36			0.53			0.71			1.39		

OVERALL TRENDS IN PRIMARY AND SECONDARY CHANNELS

River-wide, CPUEs of native fishes varied year to year. Speckled dace was the most abundant native fish in samples for all years (Figure 2). Colorado pikeminnow CPUE increased from 2003 (zero) through 2007 due to stocking, but fewer have been collected since 2007.

Small-bodied nonnative fishes CPUE, especially that for red shiner and fathead minnow, significantly declined in the San Juan River from 2003 through 2008, but red shiner rebounded in 2009. Even so, red shiner and fathead minnow showed a declining trend overall (Table 5). From 2000 to 2009 there was a strong negative relationship between summer discharge at the Shiprock Gage (appendix Figure A1 & Table A1) and density of red shiner in primary and secondary channels (r = -0.708, p = 0.02). There was also a negative relationship between summer discharge and fathead minnow density in primary channels (r = -0.675, p = 0.03). The same relationship was true for secondary channels, but was not as strong (r = -0.568, p = 0.09). Mean summer daily discharge between 2000 and 2004 (692 cfs) was lower ($t_{(8)}$ = 2.45, p= 0.04) than 2005 through 2009 (984 cfs). There was no detectable change in the density of channel catfish.

Table 5. Results of regression analysis on mean CPUE of fishes from 2003 through 2009. (Degrees of freedom 1, 2010 for primary and 1, 796 for secondary). Shaded area indicates significant results. Regression slopes were negative for flannelmouth and bluehead suckers in both primary and secondary channels and for speckled dace in the primary channel. Regression slopes for all nonnative species were negative in both primary and secondary channels.

		Primary		Secondary	
	SPECIES	r	p	r	p
Native	CATDIS	0.012	0.550	0.093	0.223
	CATLAT	0.063	0.002	0.067	0.058
	PTYLUC	0.046	0.025	0.003	0.934
	RHIOSC	0.012	0.566	0.023	0.519
Nonnative	CYPLUT	0.109	0.000	0.221	0.000
	ICTPUN	0.079	0.000	0.022	0.526
	PIMPRO	0.083	0.000	0.105	0.003

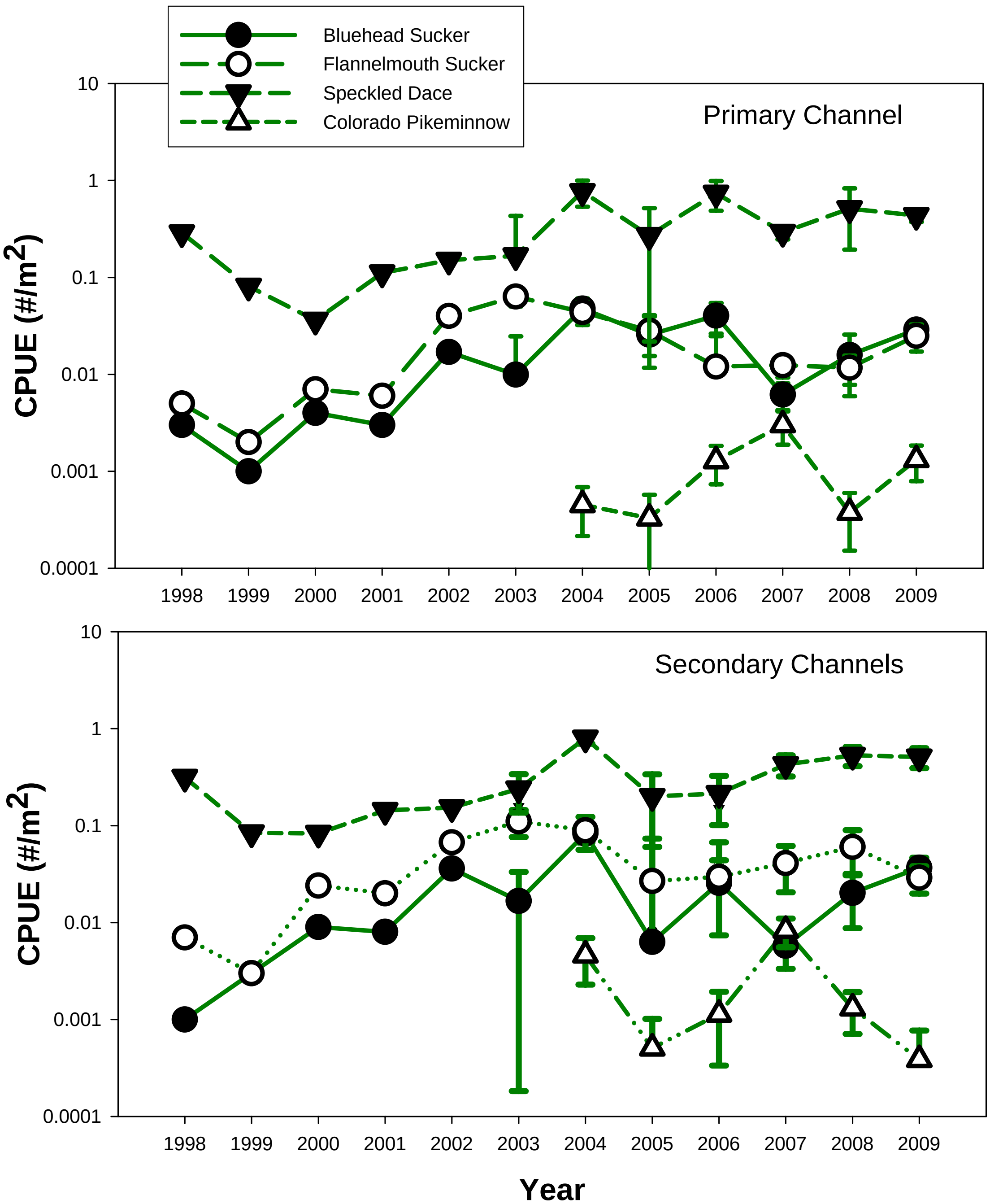


Figure 2. River-wide CPUE (total number/total area sampled, no standard error) calculated from 1998 through 2002 and mean seine-haul CPUE (and associated standard error) from 2003 through 2009 of commonly collected native fishes in autumn sampling of the San Juan River. Note log scale for CPUE. Error bars represent $\pm$ 1 SE.

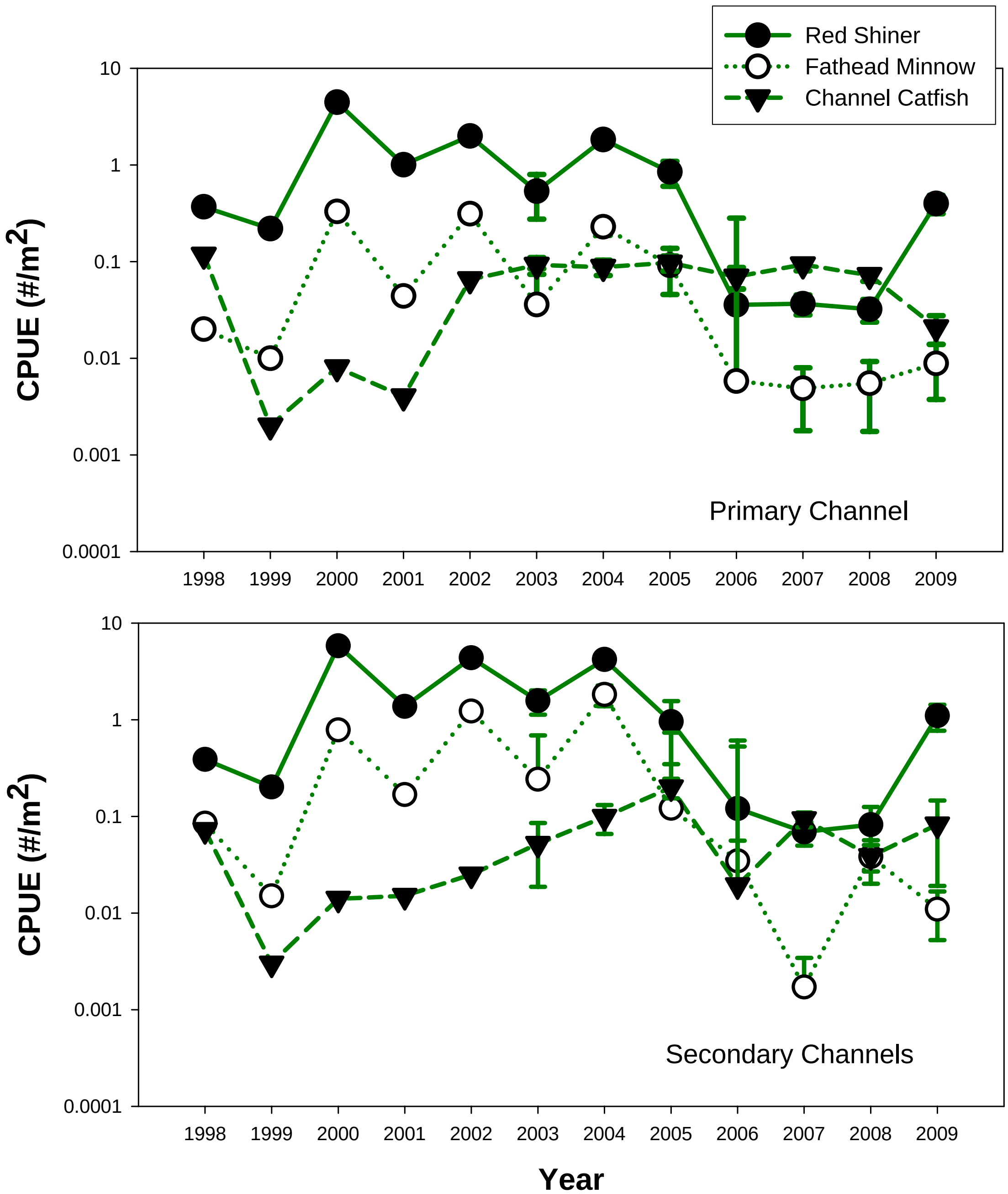


Figure 3. River-wide CPUE (total number/total area sampled, no standard error calculated) from 1998 through 2002 and mean seine-haul CPUE (and associated standard error) from 2003-2009 of commonly collected nonnative fishes in autumn sampling of the San Juan River. Note log scale for CPUE. Error bars represent ± 1 SE.

LARGE BACKWATER SUMMARY

Four native and nine nonnative species were collected in San Juan River large backwaters in 2009, including one Colorado pikeminnow. This is the same number of Colorado pikeminnow collected in 2008, but down from 21 collected in large backwaters in 2007. Eighteen of those collected in 2007 were age-0 and almost certainly recently stocked individuals. Prior to 2007, Colorado pikeminnow had not been collected in a large backwater since 2000 (Table 6). Red shiner was the most abundant species in large backwaters in all years (Table 7).

Table 6. Species collected in San Juan River backwaters during autumn, 1999 – 2009, inventories. N = native and I = nonnative. Six-letter code derived from first three letters of genus and species of each taxon.

COMMON	***SCIENTIFIC***	***CODE***	***STATUS***	***99***	***00***	***01***	***02***	***03***	***04***	***05***	***06***	***07***	***08***	***2009***
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	X		X	X		X	X	X
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X							X	X	X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		X	X	X	X	X	X		X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X		X	X	X
Black bullhead	*Ameiurus melas*	AMEMEL	I		X	X	X	X						X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I									X		X
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X		X	X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I		X	X	X		X	X			X	
Western mosquitofish	*Gambusia affinis*	GAMAFF	I		X	X	X	X	X	X			X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I			X	X	X					X	X
Bluegill	*Lepomis macrochirus*	LEPMAC	I		X									
Largemouth bass	*Micropterus salmoides*	MICSAL	I		X					X			X	X
NATIVE			4	3	4	3	3	3	3	3	1	4	4	4
INTRODUCED			10	3	9	9	7	6	6	7	2	5	8	9

Table 7. Mean CPUE of fishes collected in San Juan River backwaters during autumn inventories, 2003 – 2009.

	2003			*2004*			*2005*			*2006*			*2007*			*2008*			*2009*		
Species	*N*	*CPUE*	*SEr*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*	*N*	*CPUE*	*SE*
CYPLUT	301	1.7454	0.4953	1033	3.6789	0.1984	566	1.2821	0.2102	3	0.0725	0.0513	67	0.0845	0.0054	288	0.5588	0.1032	2081	1.7990	0.5392
CYPCAR				3	0.0102	0.0020	1	0.0053	0.0012				1	0.0032	0.0005	2	0.0051	0.0008	3	0.0029	0.0017
PIMPRO	241	2.4151	1.3993	319	1.0457	0.0721	122	0.2182	0.0163	2	0.0394	0.0063	12	0.0129	0.0015	35	0.1122	0.0691	182	0.1317	0.0614
PTYLUC													21	0.0280	0.0024	1	0.0026	0.0026	1	0.0006	0.0006
RHIOSC	4	0.0182	0.0094	10	0.0345	0.0164	12	0.0179	0.0110	1	0.0242	0.0242	30	0.0407	0.0159	116	0.2098	0.1114	39	0.0416	0.0141
CATDIS	3	0.0431	0.0276	2	0.0081	0.0022	69	0.1346	0.0265				1	0.0010	0.0002	6	0.0126	0.0011	20	0.0178	0.0113
CATLAT	6	0.0431	0.0276	1	0.0038	0.0010	114	0.1556	0.0207				4	0.0049	0.0005	26	0.0654	0.0071	39	0.0430	0.0161
AMEMEL	12	0.0472	0.0445																121	0.0822	0.0811
AMENAT													1	0.0036	0.0036				1	0.0011	0.0011
ICTPUN	10	0.0373	0.0305	10	0.0411	0.0050	1	0.0022	0.0005				64	0.0991	0.0061	36	0.0773	0.0078	7	0.0071	0.0041
FUNZEB	1	0.0043	0.0043	24	0.0603	0.0098	3	0.0034	0.0008							1	0.0033	0.0033			
LEPCYA	1	0.0108	0.0108													1	0.0030	0.0030	89	0.0741	0.0737
MICSAL							2	0.0132	0.0030							6	0.0154	0.0111	21	0.0188	0.0150
GAMAFF	20	0.1342	0.0812	17	0.0583	0.0059	26	0.0499	0.0077							23	0.0156	0.0100	440	0.3973	0.3173
Total N	490			1415			876			6			198			541			3044		
Area	245			274			489			53			723			486			1021		
Density	2.00			5.16			1.79			0.11			0.27			1.11			2.98		

In 2009, nearly 55% of fishes collected in the primary and 38% in secondary channels were native (Figure 4). These lower percentages, as compared to 2008, can be accounted for by the increase in red shiner numbers. The lowest proportion of native fishes in primary and secondary channels occurred in 2000 (<2%), whereas the greatest proportion of native fishes occurred in the primary channel in 2006 (83%). Backwaters were numerically dominated by nonnative species in all years, with natives accounting for just over 3% in 2009. The period of lowest native fishes density coincided with years of low summer discharge (Figure A1).

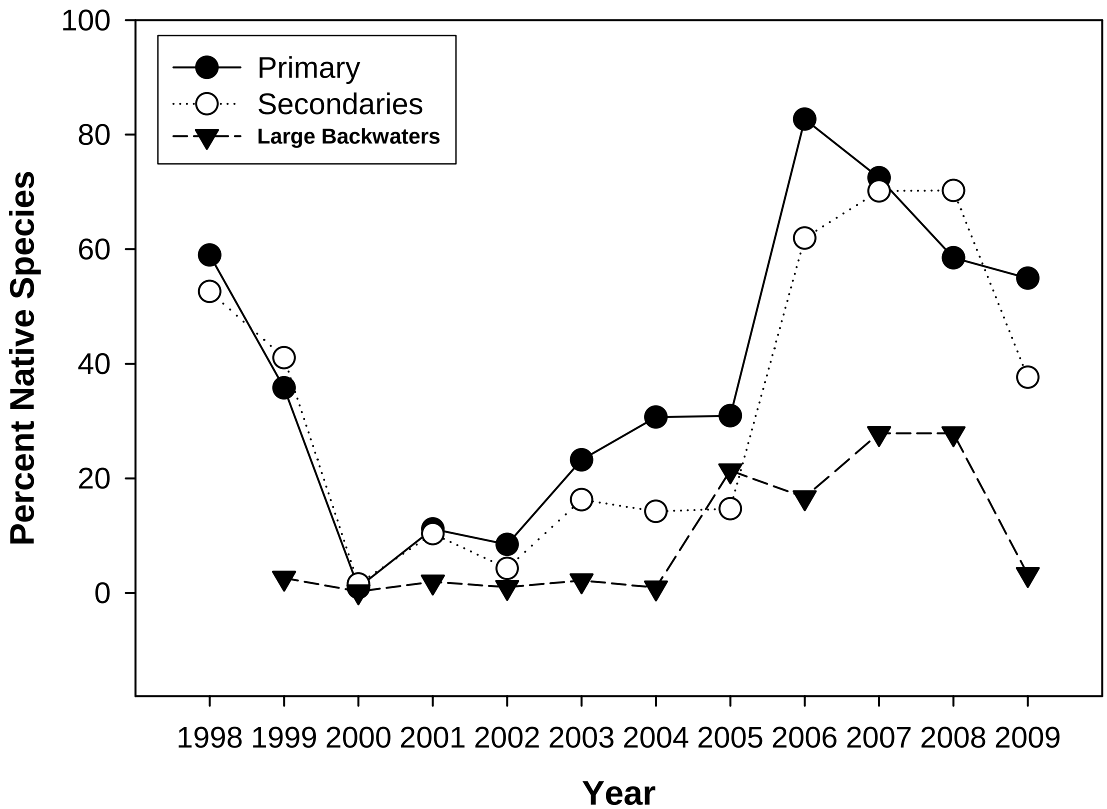
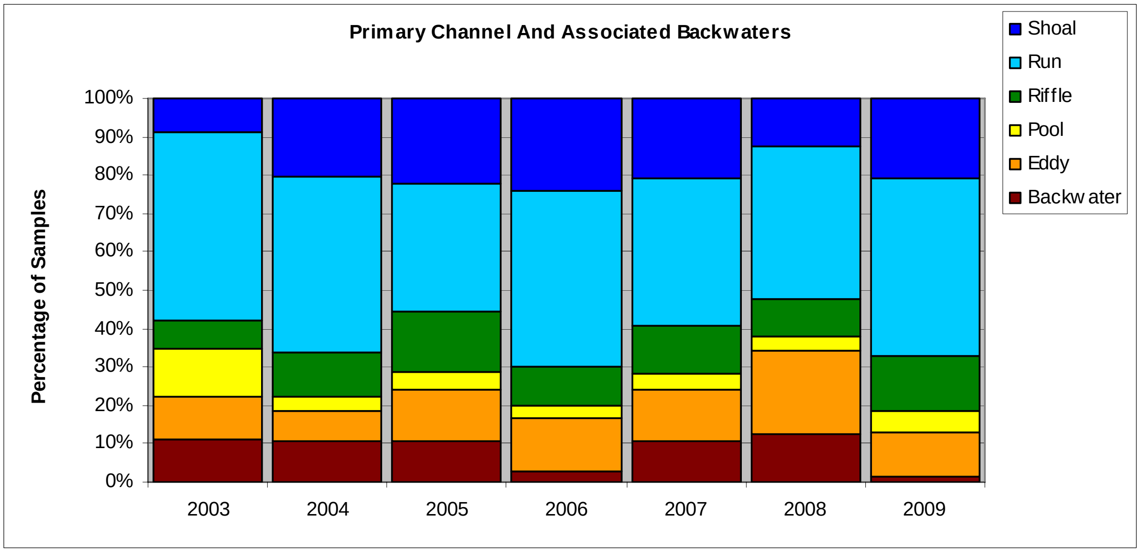


Figure 4. Percent native species collected in autumn sampling on the San Juan River from 1998 through 2009.

HABITAT

The proportion of samples taken in each habitat type was relatively consistent from 2003 through 2009. The greatest number of samples was taken in run habitats in primary and secondary channels (Figure 5); about 80% of the San Juan River is comprised of run habitats (Bliesner and Lamarra 2007). In all years, except 2006 and 2009, approximately 10% of the samples were taken in backwaters associated with the primary channel. Riffle habitats generally comprised 10% of the samples in primary and secondary channels.



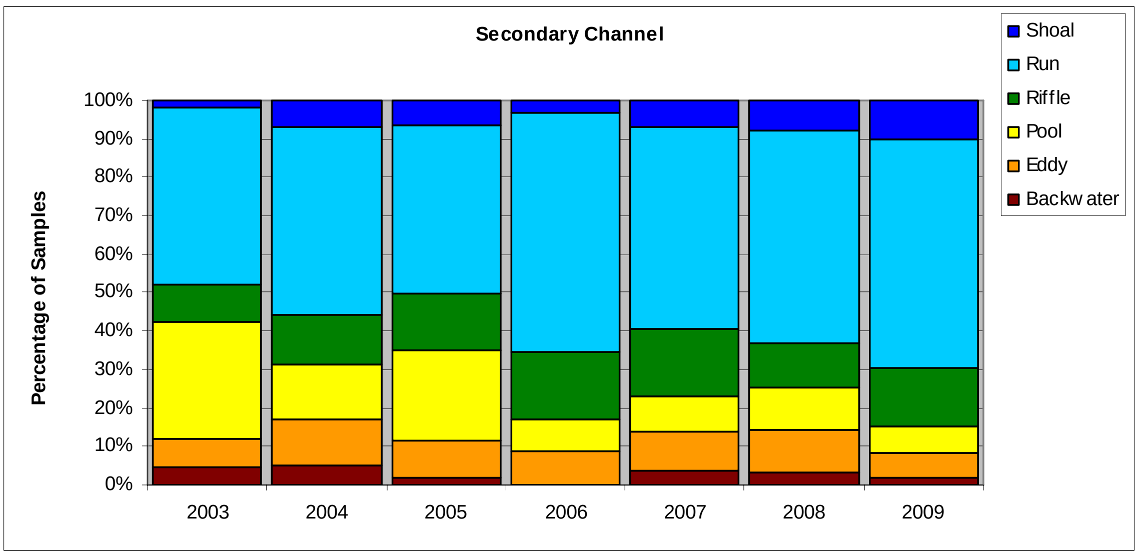


Figure 5. Proportion of samples taken within various habitats in primary and secondary channels of the San Juan River (2003-2009).

RARE FISHES SUMMARY

Razorback Sucker and Other Native Suckers

No young-of-year razorback sucker has been collected during small-bodied monitoring on the San Juan River, although one adult razorback sucker was collected in 2005. Larval razorback sucker were collected during larval fish sampling for the past 12 years (Brandenburg and Farrington 2010). However, no young-of-year razorback sucker has been collected by larval sampling later than July in any year.

Similarly, numbers of commonly collected sucker species generally decrease in larval collections in late summer. Age-0 individuals of these species are likely moving into habitats that are not sampled by larval sampling crews, who concentrate on low-velocity, near-shore habitats. There is little information on habitat use of juvenile razorback sucker in the San Juan River. Larval sampling crews collected single specimens of age-1 razorback sucker in 2004 and 2006. One was collected in an edge pool and the other in a shore run.

Adult razorback sucker in the Green River, a tributary of the Colorado River, were observed mainly in habitats greater than 1 m deep, with sandy substrates (Tyus 1987). In the upper Colorado River basin, studies indicated that floodplain habitats were important habitats for larval razorback sucker, although nonnative predators within the floodplain decreased recruitment success (Christopherson et al. 2004). Floodplain areas were often warmer and had greater abundance of zooplankton than main channel habitats, presumably enabling faster growth by razorback sucker young. Tributary streams may also provide important habitats for spawning and rearing (Minckley 1973). McElmo Creek was noted as a likely spawning location for razorback sucker in the San Juan (Brandenburg and Farrington 2008).

Bluehead Sucker and Flannelmouth Sucker

Although young-of-year razorback sucker have not been collected during San Juan River small-bodied monitoring there is likely relevant information that can be gleaned from collections of common suckers. Bluehead and flannelmouth suckers were collected in various habitat types (Figures 6 & 7). Large aggregations of both sucker species were occasionally found in low-velocity habitats, including backwaters and pools. CPUE of flannelmouth sucker in the primary channel was greatest in pools and backwaters associated with the primary channel ($F_{(5, 2556)} = 7.604$, $p < 0.01$), but not in secondary channels. There were no significant relationships between bluehead sucker density and habitat types in either channel type.

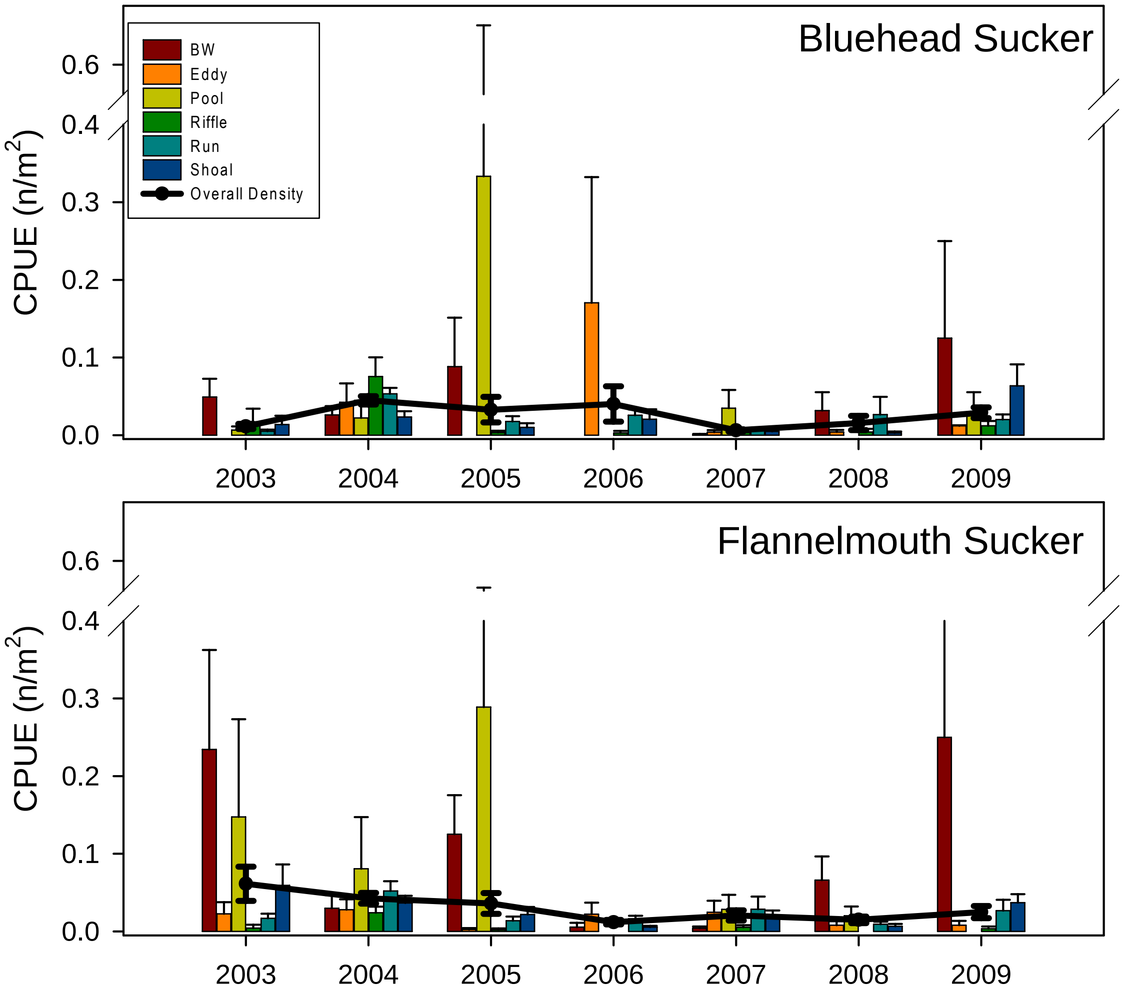


Figure 6. CPUE of bluehead and flannelmouth suckers in habitats associated with the primary channel (including large backwaters) of the San Juan River, 2003-2009. Error bars are ±1 standard error.

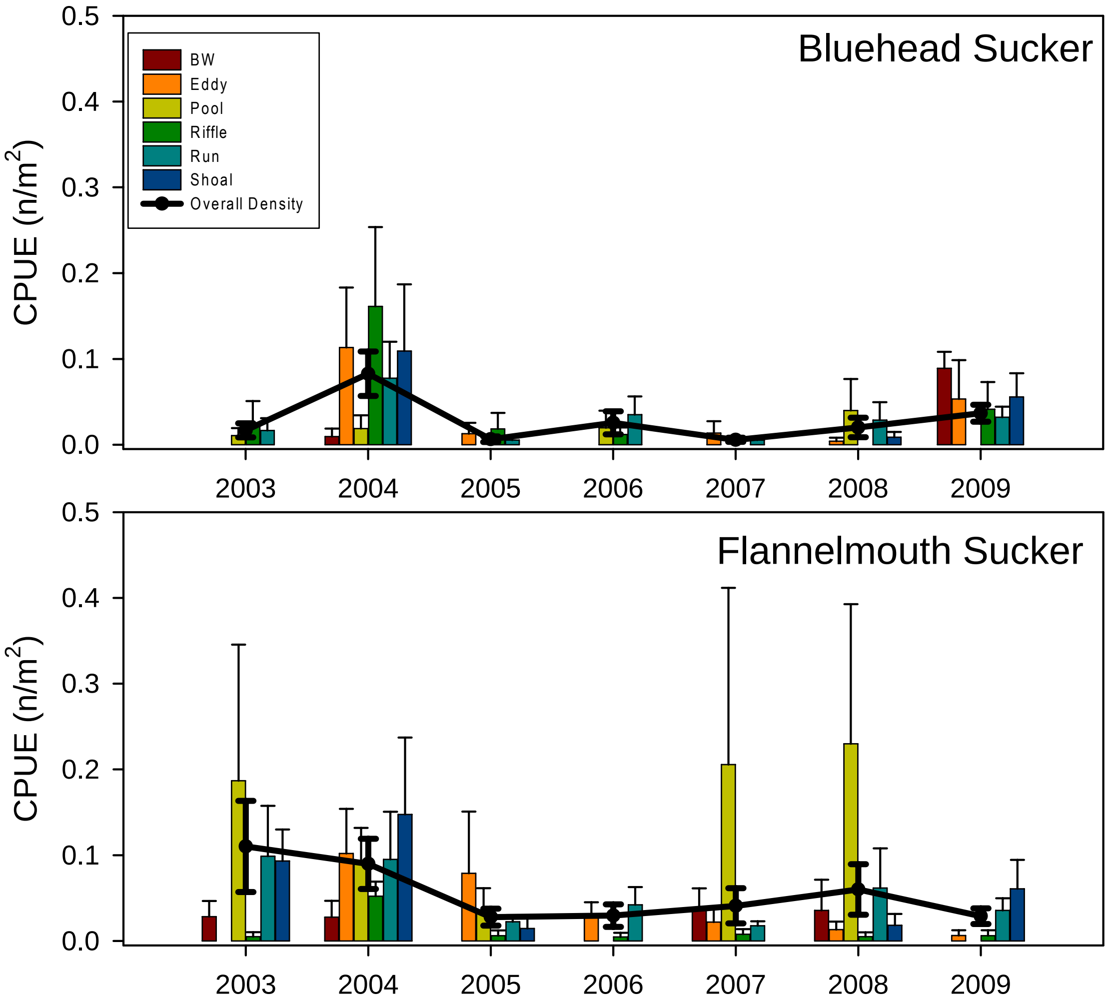


Figure 7. CPUE of bluehead and flannelmouth suckers in habitats associated with secondary channels of the San Juan River, 2003-2009. Error bars are ±1 standard error.

The mean depth of habitats from which small-bodied fishes were collected was 0.31 m (SE = 0.004). The maximum depth that collections are obtained is about 1.5 meters, but seining efficiency in unconfined habitats greater than 0.75 m deep was likely low. The mean depth of samples containing bluehead sucker was 0.28 meters (SE = 0.008), and those containing flannelmouth sucker was 0.29 meters (SE = 0.008). Both sucker species were collected in habitats with various substrate types (Figure 8). Although large samples of flannelmouth sucker were occasionally obtained in slow-water habitats with sand and silt substrates, there was no significant effect of substrate on density of flannelmouth or bluehead sucker ($F_{(4df)}<1.91$, $p>0.10$).

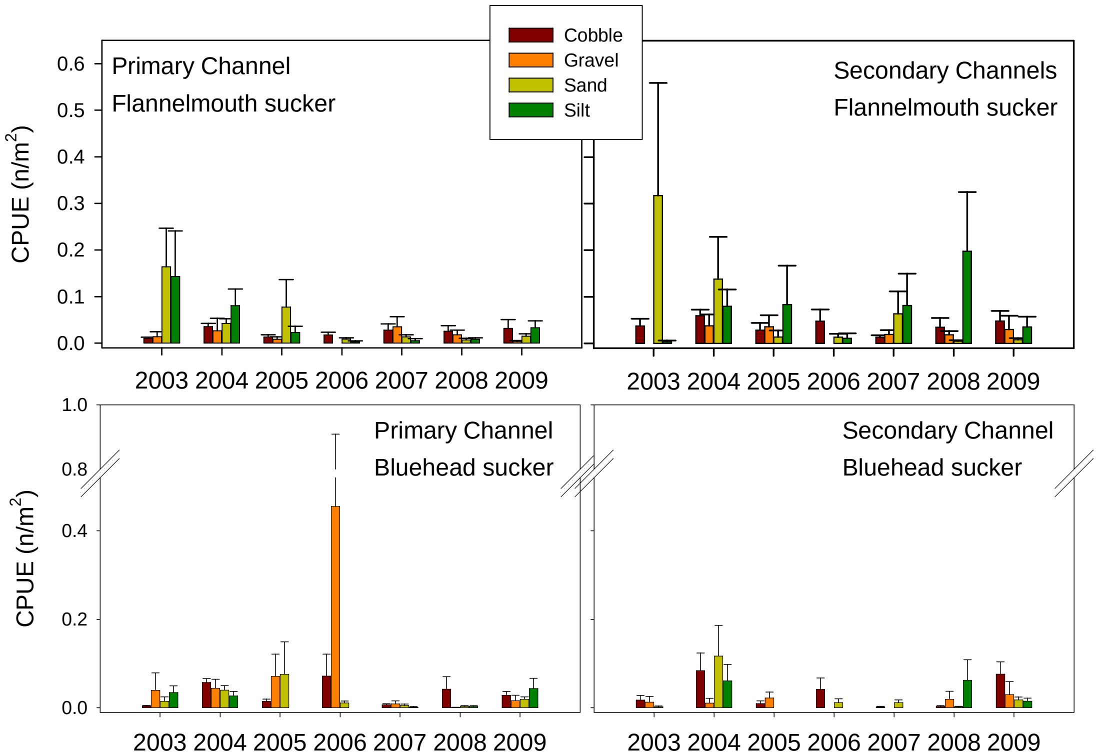


Figure 8. CPUE of flannelmouth and bluehead suckers captured over various substrates in the San Juan River, 2003-2009. Error bars represent ±1 standard error. Note different Y-axis scales.

Recruitment of larval fish into the adult population is an important aspect of recovery that has been problematic for razorback sucker in the San Juan. There was not a clear relationship between the CPUE of commonly-collected suckers captured during larval fish monitoring and CPUE for young-of-year suckers captured during small-bodied monitoring (Figures 9 & 10).

To aid in discerning potential relationships between larval CPUE (and thus, reproductive success) and small-bodied CPUE (and thus early survival and recruitment success, at least to early juvenile), a simple model (Appendix Table A2) was developed to determine how well CPUE of larvae at various times of year predicted the CPUE of young-of year collected during autumn monitoring. For both species, the CPUE of young-of-year collected in August was the best predictor of how many were collected during fall monitoring; expected values were within confidence intervals 6 of 6 years for flannelmouth sucker and 5 of 6 years for bluehead sucker. For example, average CPUE for young-of-year flannelmouth sucker in small-bodied monitoring from 2003 through 2008 was 2.14 (SE 1.82) times the CPUE of August larval surveys. The only year larval razorback suckers were found in August was 2005. If detection/retention of razorback sucker was similar to flannelmouth sucker calculations, 4 ± 8 razorback would have been collected by small-bodied monitoring in 2005.

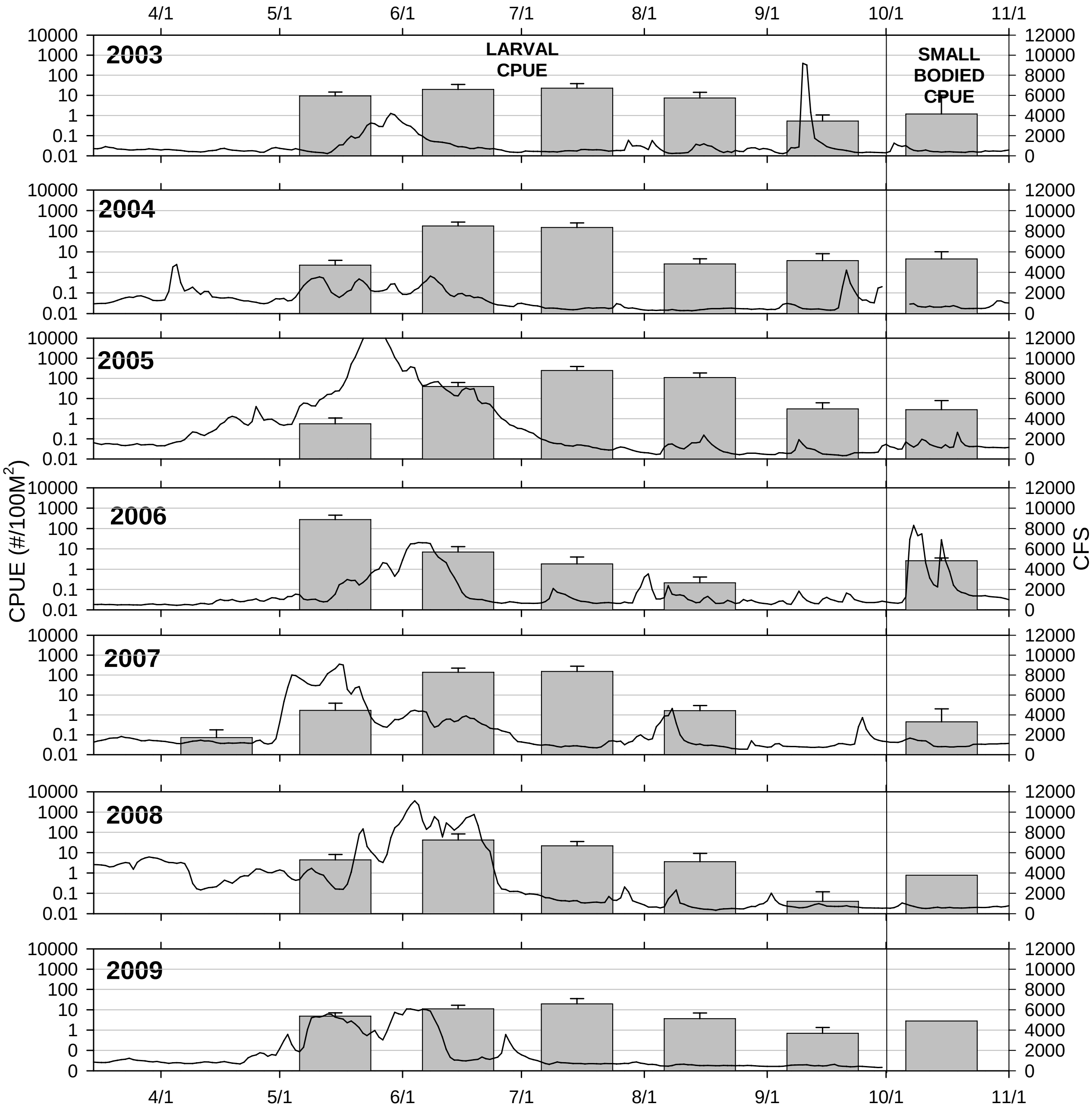


Figure 9. Catch-per-unit-effort (CPUE)for age-0 bluehead sucker during San Juan River larval and small-bodied monitoring, April through October. Error bars represent 2 standard errors. Line represents San Juan River discharge at Shiprock Gage, NM for each year during sampling season.

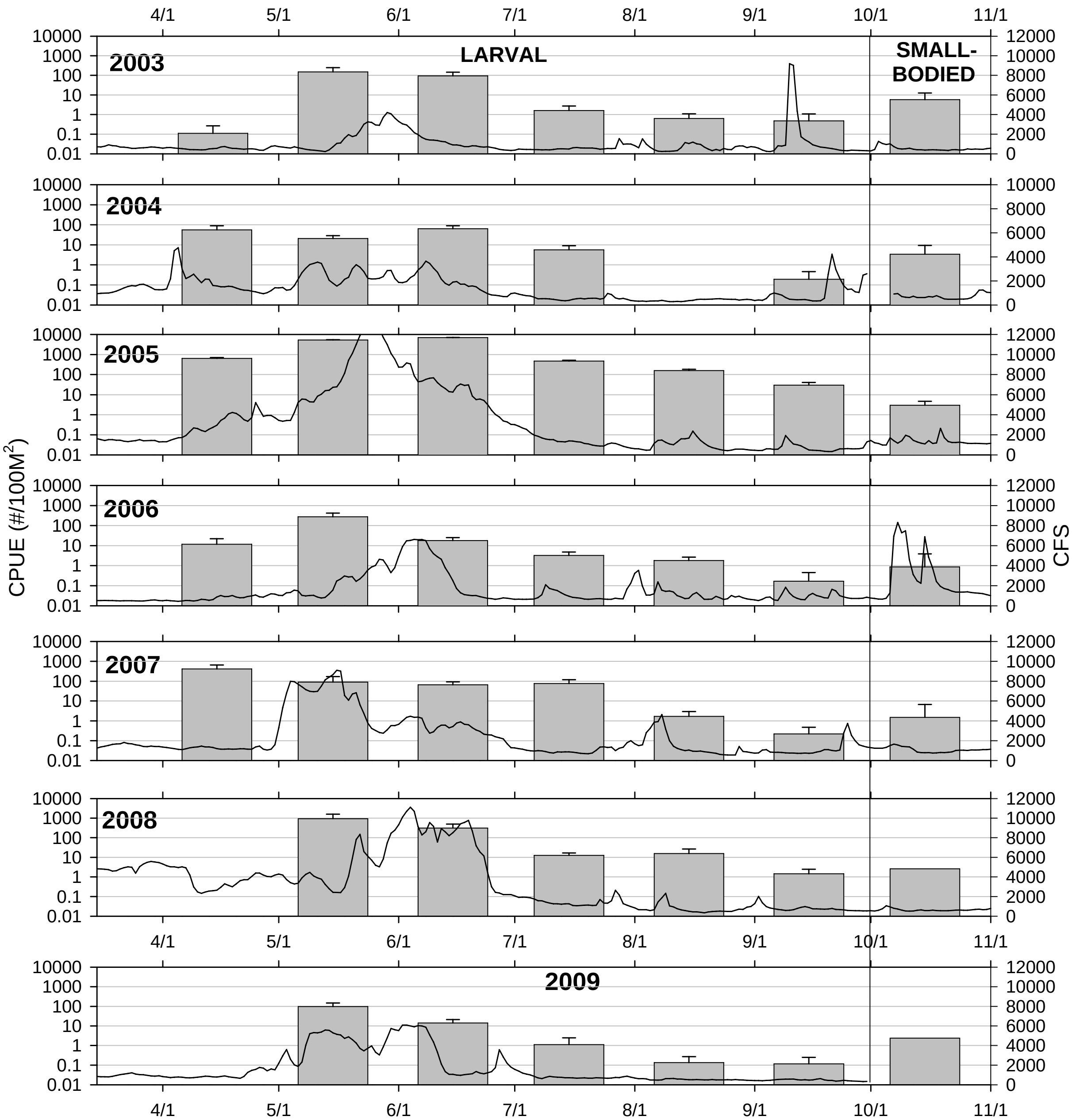


Figure 10. Catch-per-unit-effort (CPUE) for age-0 flannelmouth sucker during San Juan River larval and small-bodied monitoring, April through October. Error bars represent 2 standard error. Line represents San Juan River discharge at Shiprock Gage, NM for each year during the sampling season.

Year classes were tracked through time using length-frequency histograms. There was a strong cohort of bluehead sucker in 2004 that carried through 2009. Bluehead sucker had a strong year class in 2009, with relatively high numbers and comparatively large-sizeage-0 fishes (Figure 11). Flannelmouth sucker had strong year classes both in 2003 and 2004. Age-0 individuals in 2009 were not particularly abundant, but were relatively large (Figure 12). Neither species had strong recruitment in 2005, although age 0 individuals of both species were comparatively abundant in autumn 2005. Recruitment was apparently low for 2006 and 2007, but fairly high for 2008.

Age-0 suckers were generally less than 100 mm TL by autumn. Age-0 individuals of both species were smaller in 2005 and 2008 than other years (Figure 13). Flannelmouth sucker spawned in 2004 were larger than age-o fishes collected in other years. Larger age-0 fishes may have greater survival to the next year than smaller individuals, and thus greater recruitment to the adult population; faster growth rates may reduce the time that larvae are vulnerable to predation by co-occurring small-bodied fish and invertebrate predators in nursery areas (Bestgen 2008, Christopherson et al. 2004). Time of spawning also has an effect on size of age-0 suckers in autumn. Spawning for all sucker species, including razorback sucker, extended over a longer period in 2005 than 2004 (Brandenburg and Farrington 2008).

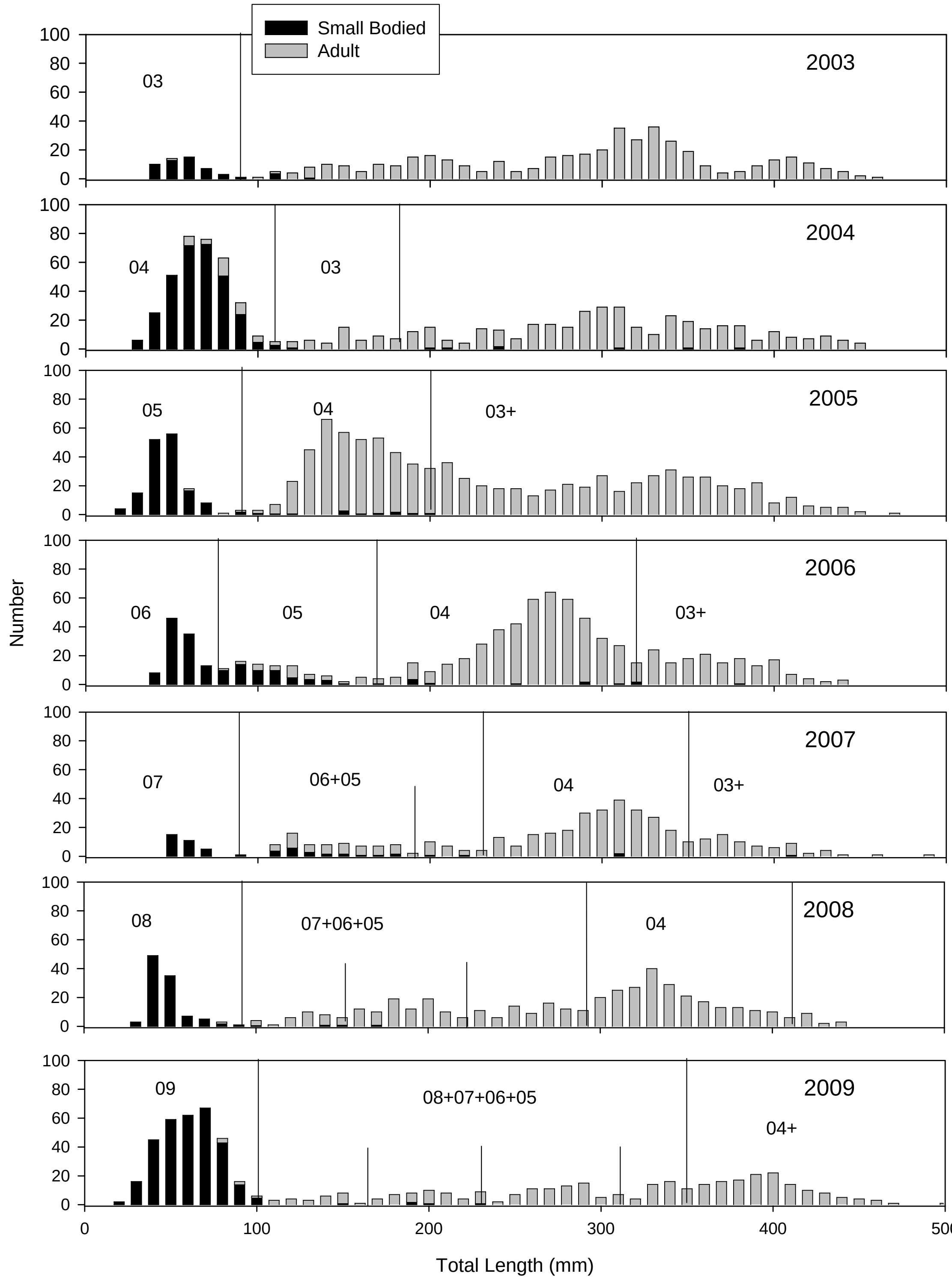


Figure 11. Length frequency and approximate year class of bluehead sucker collected during autumn monitoring by small-bodied and adult monitoring efforts on the San Juan River, 2003-2009. Vertical lines approximate breaks in year-class cohorts.

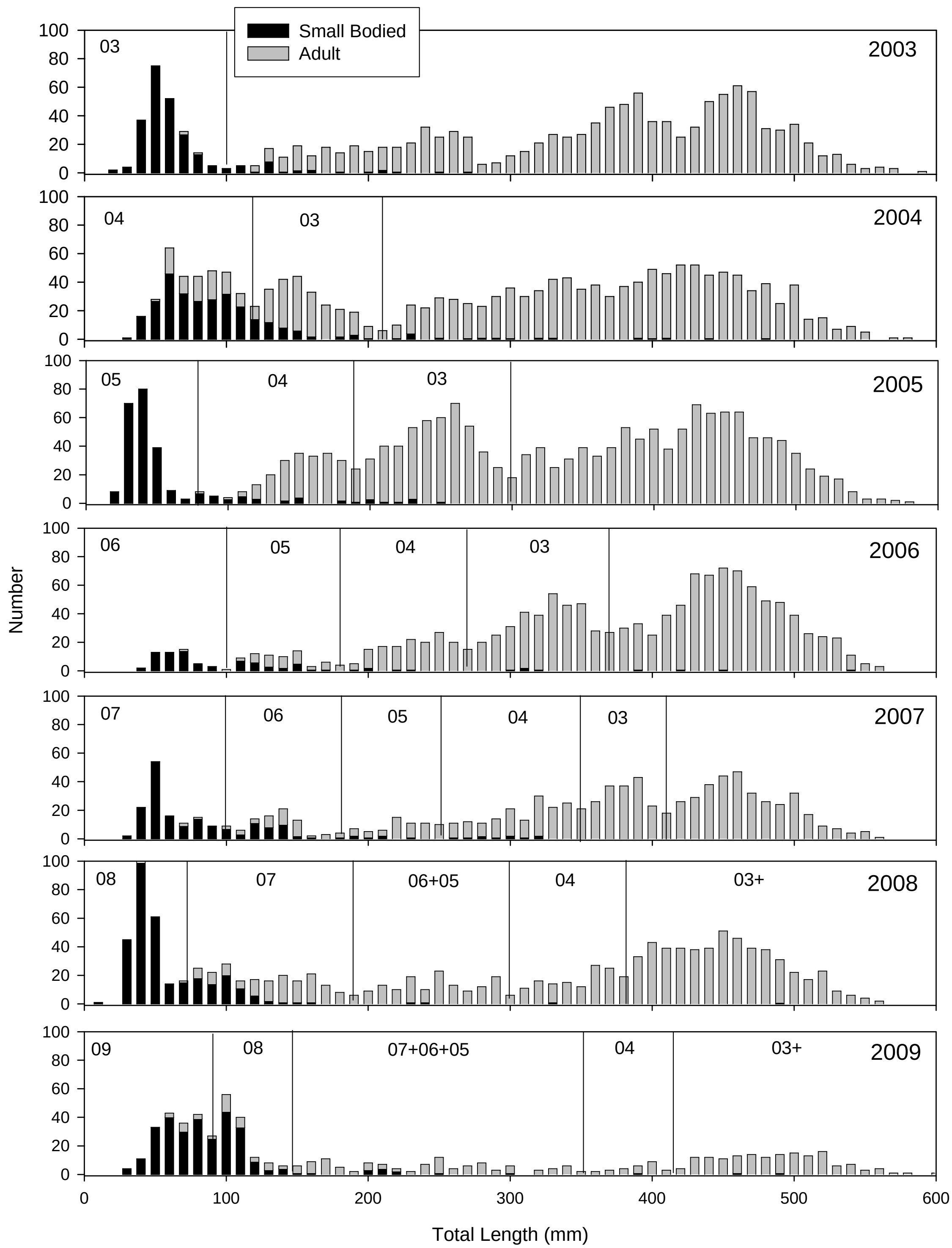


Figure 12. Length frequency and approximate year class of flannelmouth sucker collected during autumn monitoring by small-bodied and adult monitoring efforts on the San Juan River, 2003-2009. Vertical lines approximate breaks in year class cohorts.

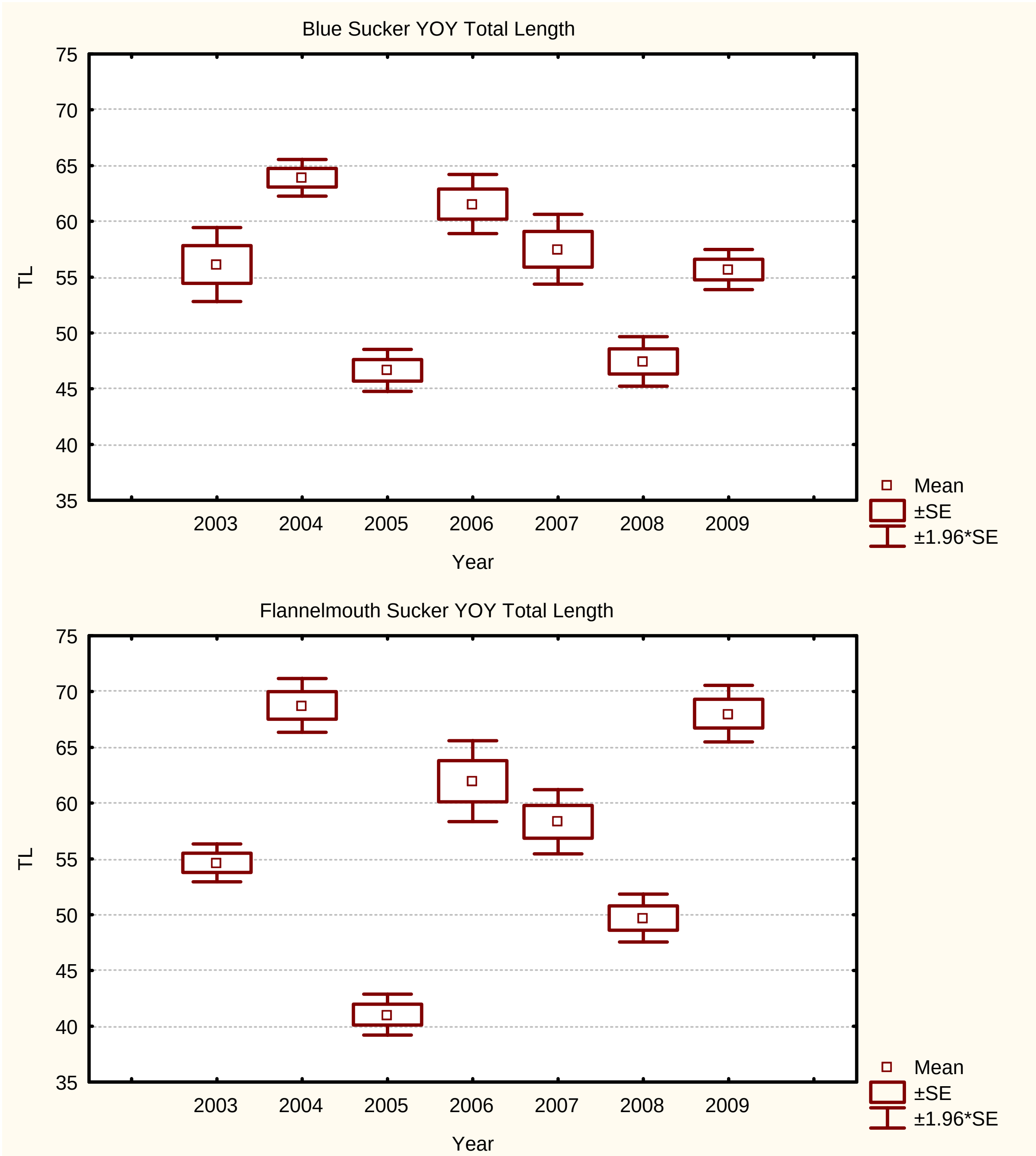


Figure 13. Mean total length (mm) of age-0 bluehead and flannelmouth suckers in the San Juan River 2003-2009.

Colorado Pikeminnow

Larval Colorado pikeminnow were collected by small-bodied monitoring in 1998, 2000, and 2007 (Table 8). Stocking of larval Colorado pikeminnow occurred in each of these years prior to small-bodied monitoring, so it is likely these specimens were captive-bred individuals (Ryden 2006). Total length of these fish averaged 50 mm (SE = 1.74). Twenty-four larval Colorado pikeminnow were captured in September and October from 1987 through 1994, prior to initiation of small-bodied monitoring in 1998 (Table 9) (Platania et al., 2000). These fish were smaller than captures since 1996, averaging 26 mm (SE =1.21) in September and 32 mm (SE = 1.76) in October.

Age-1+ Colorado pikeminnow were collected by small-bodied monitoring in each year, except 2001, 2002, and 2003. Until 2009, most age-1+ Colorado pikeminnow were captured in Reach 5, but in 2009 most age-1+ were captured in Reach 4. Only two age-1+ and one recently stocked age 0 have been collected in Reach 1.

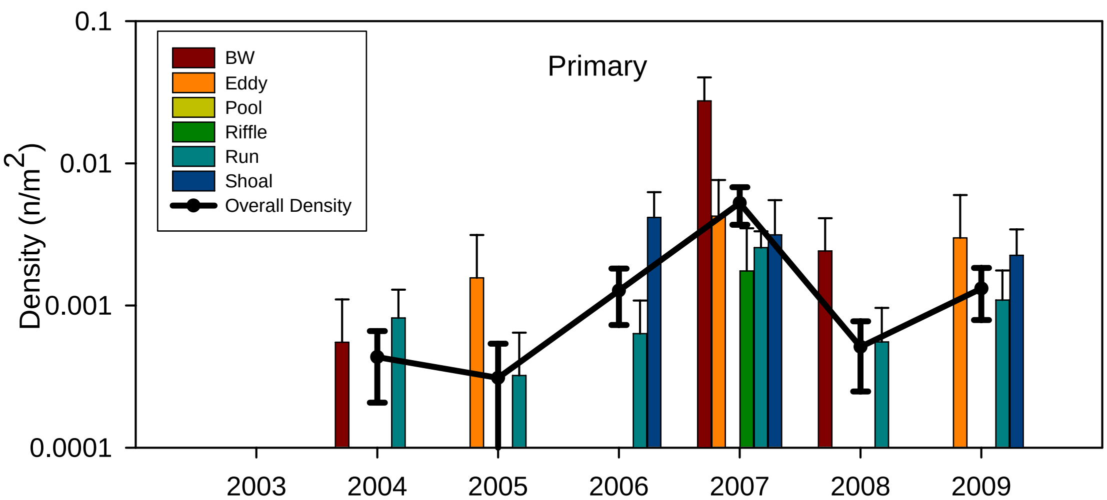
Table 8. Summary of Colorado pikeminnow captures by small-bodied monitoring in the San Juan River, 1998 -2009. Blue highlight indicates recently stocked age-0 individuals.

Year	*Length Category*	*Reach*						*Grand Total*
		6	*5*	*4*	*3*	*2*	*1*	
1998	70			1				5
	80				1			
	130		2	1				
1999	120		1					2
	230		1					
2000	50			1				2
	90				1			
2004	160		2					8
	170			1				
	180		2					
	200		1					
	210		1					
	230			1				
2005	170				1			3
	180			1				
	290					1		
2006	140	1	1					10
	150	1	1					
	180		1		1			
	190					1		
	200	1						
	210				1			
	280				1			
2007	40				6	2		59 Total, (*28 Recently Stocked YOY)
	50				17	2	1	
	120	2						
	130		1					
	140	1	4					
	150	2	6		2			
	160	2		1	1		1	
	170	1	1	3	1			
	180		1		1			
2008	130		1					10
	140	1	1	1				
	150		2	1	1			
	170		1					
	210				1			
2009	130	1					1	12
	170		1	1		1		
	180	1		1				
	190			1				
	200			2				
	210				1			
	330		1					
03-09 Total		14	29	14	35	7	3	102

Table 9. Size of age-0 Colorado pikeminnow collected in September and October in the San Juan River, 1987-1994 (Platania 2000).

	September		October	
Year	*Number*	*Total Length*	*Number*	*Total Length*
1987	16	17-32mm	2	28-38
1990	1	34		
1992	1	23		
1993	5	19-32	4	29-36
1994	1	25		
Total	24		6	
Mean		26.1		32.2
SE		1.21		1.76

The CPUE of Colorado pikeminnow captured in the primary channel was greatest in backwater habitats ($F_{(5, 2556)}$=4.6055, p<0.01), although most of these captures were recently stocked age-0 individuals in 2007 (Figure 14). If these individuals were removed from the analysis, there was no significant difference in the density of age-1+ Colorado pikeminnow across habitat types in the primary channel ($F_{(5, 2140)}$=1.3876, p=0.23). There was no single mesohabitat where Colorado pikeminnow were most commonly found in secondary channels ($F_{(5, 776)}$ = 2.637, p > 0.07).



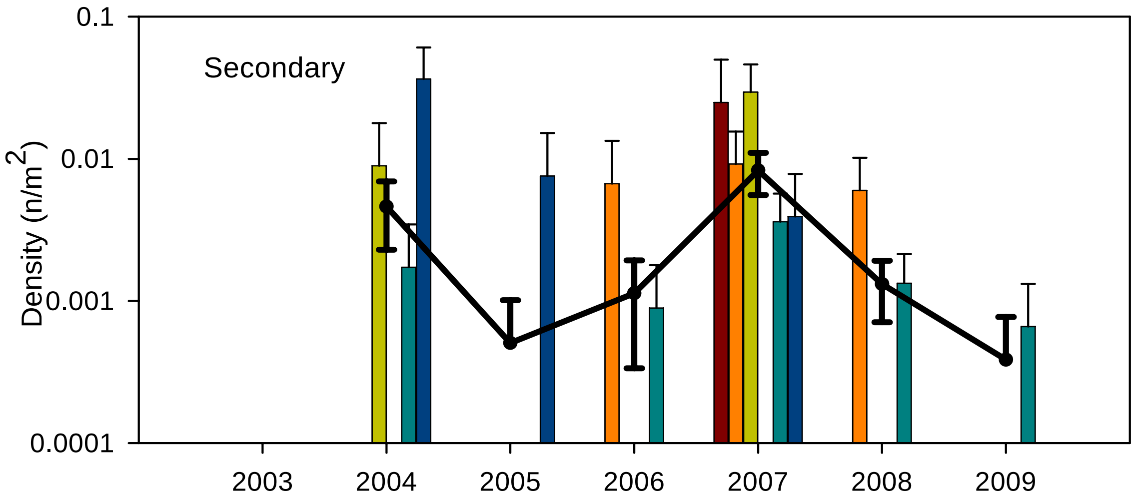


Figure 14. CPUE of Colorado pikeminnow in habitats associated with primary (including large backwaters) and secondary channels of the San Juan River 2003-2009. Error bars are ±1 standard error, note log scale on Y-axis.

There was no significant effect of substrate on density of Colorado pikeminnow collected in the primary channel, but they were captured in significantly higher densities over sand than cobble in secondary channels ($F_{(3, 758)} = 3.224$, $p = 0.02$) (Figure 15). The average depth of habitats that contained Colorado pikeminnow was 0.263 m (SE = 0.02).

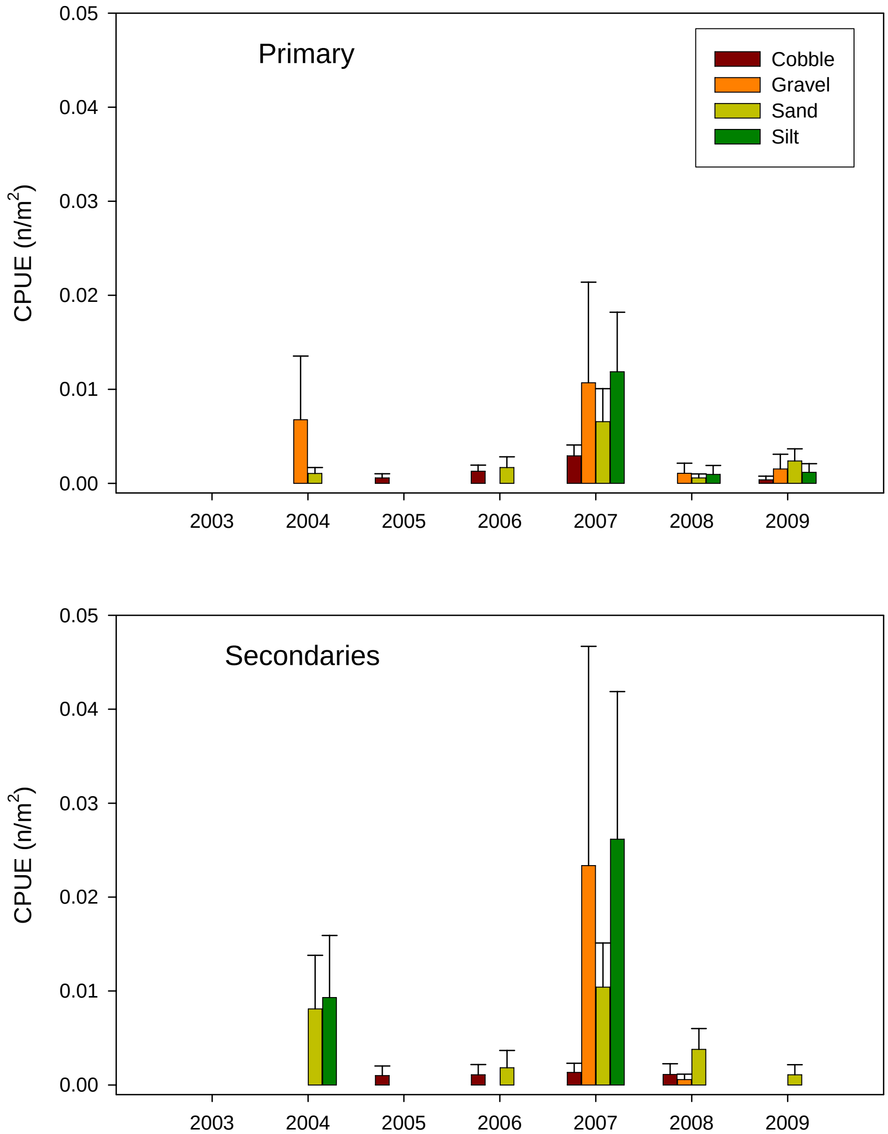


Figure 15. CPUE of Colorado pikeminnow captured over various substrates in the San Juan River, 2003-2009. Error bars represent ±1 standard error.

Young Colorado pikeminnow are thought to switch from insectivory to primarily piscivory between 50-200 mm total length (Franssen et al. 2007, Vanicek and Kramer 1969). Franssen et al. (2007) reported that the maximum prey size for Colorado pikeminnow was dependent on the prey species and gape dimensions of Colorado pikeminnow. Colorado pikeminnow could consume red shiner up to 37% and native suckers up to 43% of their (Colorado pikeminnow) total length.

Figures 16, 17 and 18 demonstrate the proportion of prey with total length less than 40% of Colorado pikeminnow total length up to 200 mm from 2003-2009. These figures also portray CPUE of prey species by reach. From this information it is possible to approximate the abundance of prey available to different-sized Colorado pikeminnow. The information is presented in this manner because not every prey specimen is measured (e.g. in 2009 approximately 55% of fishes captured in small-bodied monitoring were measured; the remaining 45% were counted). All species captured were considered potential prey, except channel catfish and bullhead catfishes. In all years, reaches 6 or 5 had the greatest CPUE of small fishes. The CPUE of small fishes in reaches 2 and 1 was less than 0.1 from 2006 onward. There was an increase in CPUE in reaches 2 and 1 in 2009, but it remained less than prior to 2006. For all years, there was an insufficient prey base of small fishes in autumn for Colorado pikeminnow stocked as age-0; survival of these fish was therefore largely, if not entirely, dependent on consumption of macroinvertebrates. Appropriate-sized prey fishes were not available until the following spring, when larval fish of appropriate size for small Colorado pikeminnow to consume were present. In 2009, less than 10% of prey fishes in most reaches were small enough for 50-mm Colorado pikeminnow to consume (Figure 18). In most years and in most reaches, a Colorado pikeminnow with a total length of 140 mm could eat over 80% of prey fishes. In some years, the upstream reaches, 5 and 6, had a comparatively large proportion of the larger small-bodied fishes captured. This can be seen in 2003, 2006 and

2009 in Figures 16, 17 and 18. This may be due to poor retention of larval fishes in those reaches some years.

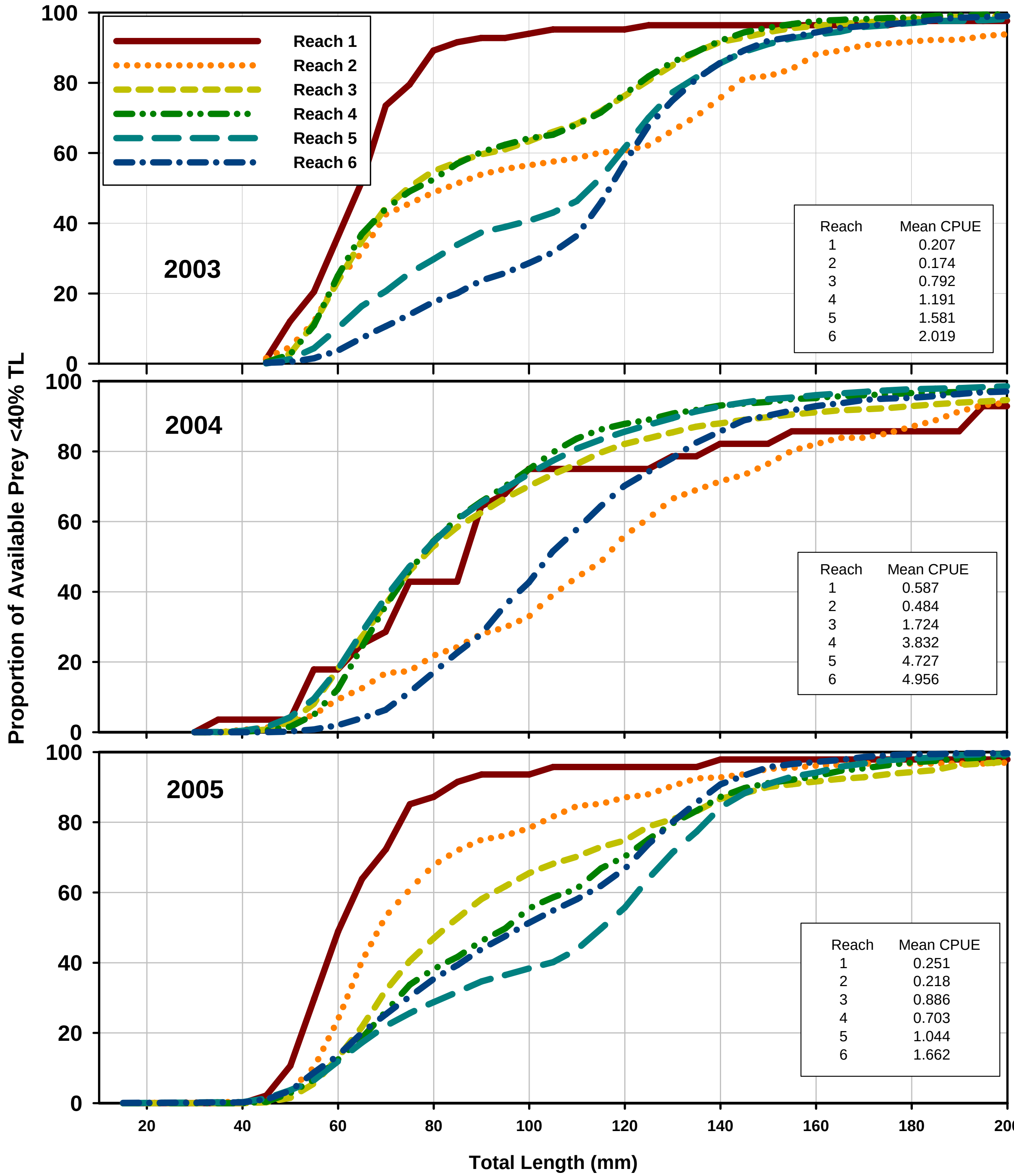


Figure 16. Proportion of prey species <40% TL, excluding catfishes of Colorado pikeminnow TL for each reach in the San Juan River from 2003 through 2005. CPUE is total number of suitable-size prey fishes divided by total sample area (#/m^2).

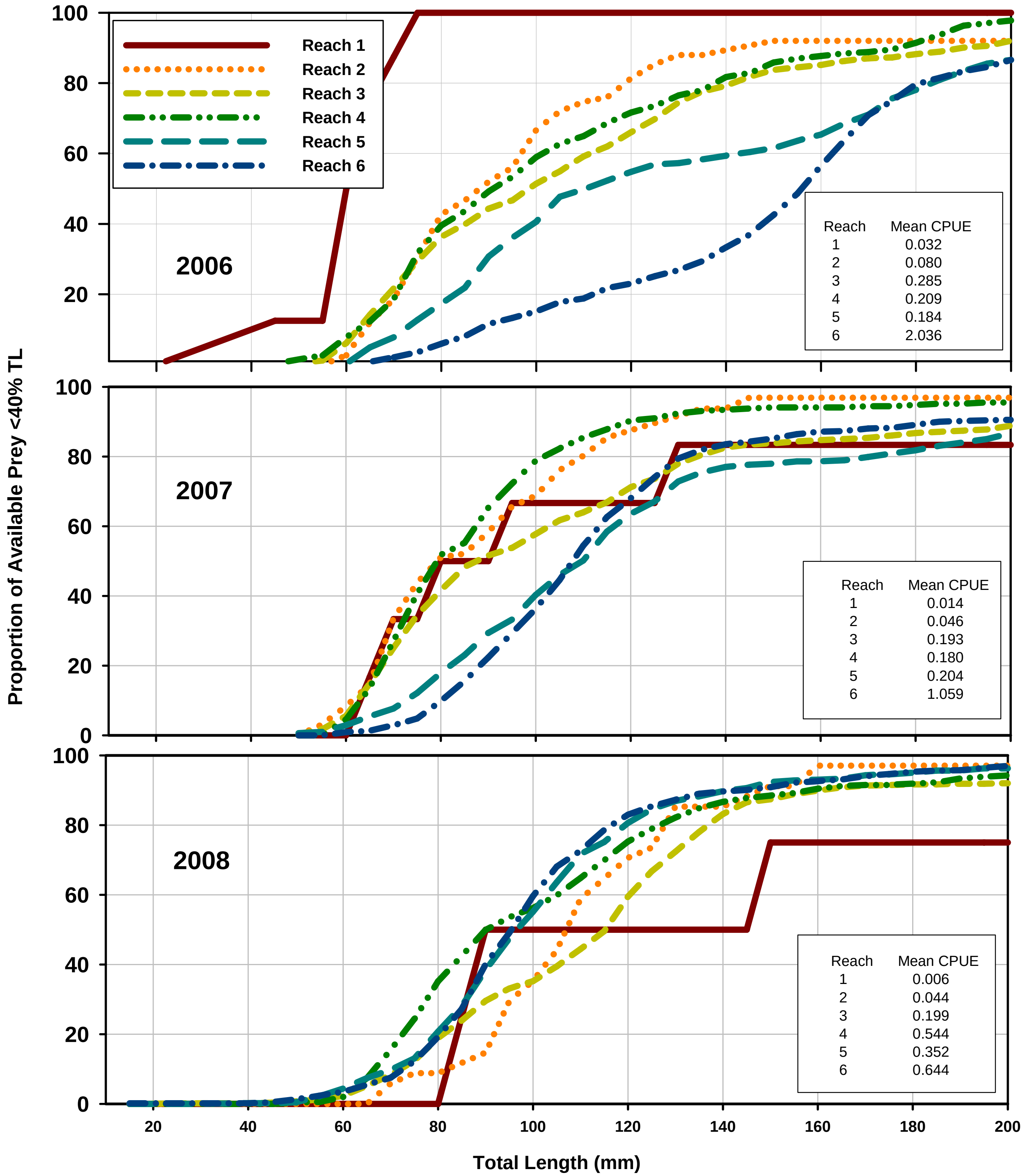


Figure 17. Proportion of prey species <40% TL of Colorado pikeminnow TL, excluding catfishes, for each reach in the San Juan River from 2006 through 2008. CPUE is total number of suitable-size prey species divided by total sample area (#/m^2).

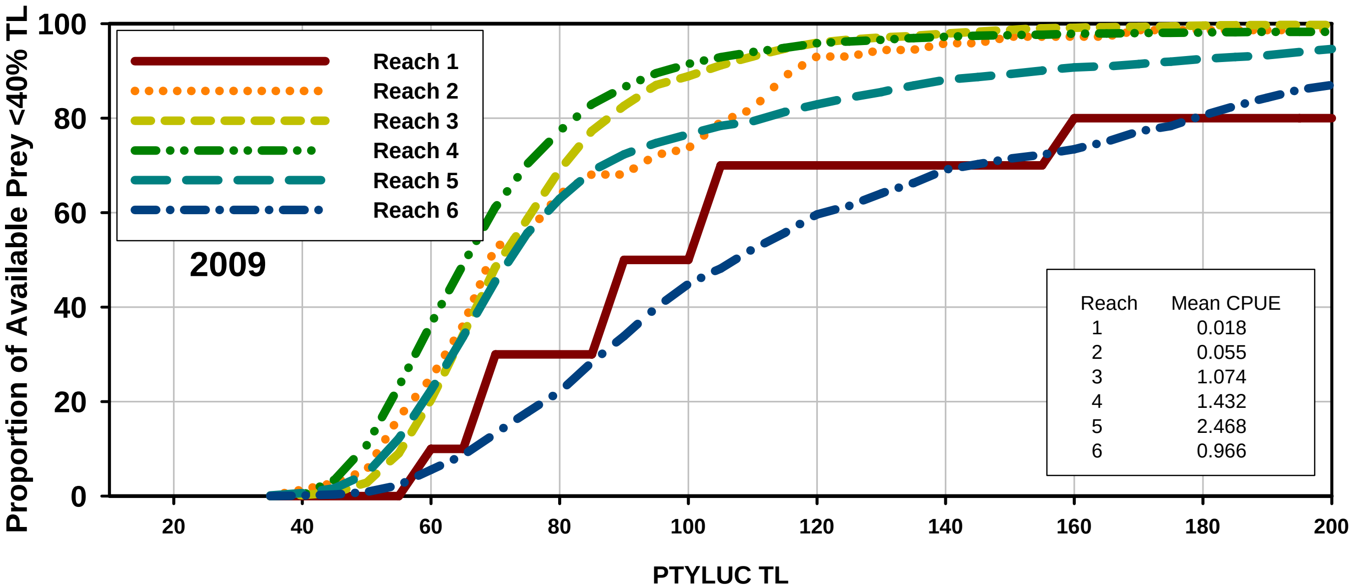


Figure 18. Proportion of prey species <40% TL of Colorado pikeminnow TL, excluding catfishes, for each reach in the San Juan River during 2009. CPUE is total number of suitable-size prey species divided by total sample area (#/m^2).

RECOMMENDATIONS

The data set associated with small-bodied monitoring is useful for filling information gaps between larval fish collections and recruitment into the adult population. Data obtained acquired as part of small-bodied monitoring may be used to characterize survivorship of commonly collected native and nonnative fishes as well as providing insights to survival of stocked age-0 Colorado pikeminnow. These data might also be used to characterize effects of flow regimes on native and nonnative fishes abundance, habitat associations, and relating effects of management activities on cohort strength. Specific questions that might answered, at least in part, from small-bodied fishes monitoring data include effects of suitable-size prey availability on Colorado pikeminnow survival, relationship of Colorado pikeminnow distribution to occurrence of suitable-size prey, and relationship of Colorado pikeminnow prey distribution to habitat attributes.

To detect occurrence of post-larval stages of razorback sucker focused studies to determine the most effective sampling methods are needed. If suckers are habitat generalists or mainly using habitats that are common in the river (i.e. runs) it is unlikely that many will be collected without intense effort. Current sampling methods appear appropriate for detecting presence of age-0 and 1 Colorado pikeminnow that tend to use low- and moderate-velocity habitats. Alternative sampling methods, particularly for age-0 (early juvenile) razorback sucker, should be evaluated. However, any changes in current methods should be designed to minimally compromise the integrity of the existing dataset for river-wide community monitoring.

Paucity of small fish prey in the fall and winter may compromise survival of stocked Colorado pikeminnow, especially if macroinvertebrate densities are low as well. A study to investigate the relationship of food availability for young Colorado pikeminnow and their survival may shed some light on the apparent low recruitment into the adult population. Food abundance for developing razorback sucker also may be limiting because of the rarity of high-productivity inundated floodplain habitats.

Although backwaters are not a large proportion of habitat available to fishes in the San Juan River, they are intensively used by nonnative fishes, particularly red shiner and fathead minnow. Few young native fishes are found in backwaters. The importance of backwaters as nursery habitat for native fishes has been amply demonstrated in the upper Colorado River basin. Assuming, backwaters might also be important nursery habitat for native fishes in the San Juan River, it might be prudent to consider methods and approaches for removing noxious nonnative fishes. One approach might involve periodic and appropriately-timed mechanical removal methods. Another might involve use of piscicides. The initial step would involve a detailed characterization of the problem, identification and evaluation of potential remedies (assuming there is a problem), a cost-benefit analysis, and drafting a proposed course of action.

LITERATURE CITED

Bestgen, K.R. 2008. Effects of water temperature on growth of razorback sucker larvae. Western North American Naturalist 68: 15-20.

Bliesner, R., and V. Lamarra. 2000. Hydrology, geomorphology, and habitat studies; final report. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Bliesner, R., and V. Lamarra. 2007. Hydrology, geomorphology, and habitat studies; 2006 final report. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Brandenburg, W.H., and M.A. Farrington. 2008. Colorado pikeminnow and razorback sucker larval fish surveys in the San Juan River during 2007. San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

Brandenburg, W.H., and M.A. Farrington. 2010. Colorado pikeminnow and razorback sucker larval fish surveys in the San Juan River during 2009. San Juan River Basin Recovery Implementation Program. U.S. Fish and Wildlife Service, Albuquerque, NM.

Brown, M.L., and C.S. Guy. 2007. Science and statistics in fisheries research. Pages 1-30 *in* C.S. Guy and M.L. Brown, editors, Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, MD.

Christopherson, K. D., G. J. Birchell, and T. Modde. 2004. Larval razorback sucker and bonytail survival and growth in the presence of nonnative fish in the stirrup floodplain. Report Submitted to the Upper Colorado River Endangered Fish Recovery Program Project No. C-6-rz/bt Publication Number 05-04, Utah Division of Wildlife Resources.

Franssen, N.R., K.B. Gido, and D.L. Propst. 2007. Flow regime affects availability of native and nonnative prey of an endangered species. Biological Conservation 138:330-340.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Game and Fish Department, Sims Printing Co., Phoenix, Arizona.

Paroz, Y.M., D.L.Propst, and S.M. Carman. 2009. Small-bodied fish monitoring, San Juan River, September-October 2008. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Region 2, Albuquerque, NM.

Platania, S.P., R.K. Dudley, and S.L. Maruca. 2000. Drift of fishes in the San Juan River 1991-1997. University of New Mexico Department of Biology, Final Report to San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Propst, D.L., S.P. Platania, D. Ryden, and R. Bliesner. 2000. San Juan monitoring plan and protocols. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Robertson, M.S., and P.B. Holden. 2007. Retention, growth, and habitat use of Colorado pikeminnow stocked as age-0 fish in the San Juan River 2005-2006 Annual Report San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2006. Long-term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2005 interim progress report. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Ryden, D.W. 2008. Long-term monitoring of sub-adult and adult large-bodied fishes in the San Juan River: 2007 interim progress report. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

Tyus, H. M. 1987. Distribution, reproduction, and habitat use of the razorback sucker in the Green River, Utah, 1979-1986. Transactions of the American Fisheries Society 116: 111-116.

Vanicek, C.D., and R.H. Kramer. 1969. Life history of the Colorado squawfish and the Colorado chub in the Green River in the Dinosaur National Monument 1964-1966. Transactions of the American Fisheries Society 98: 193-208.

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APPENDIX A

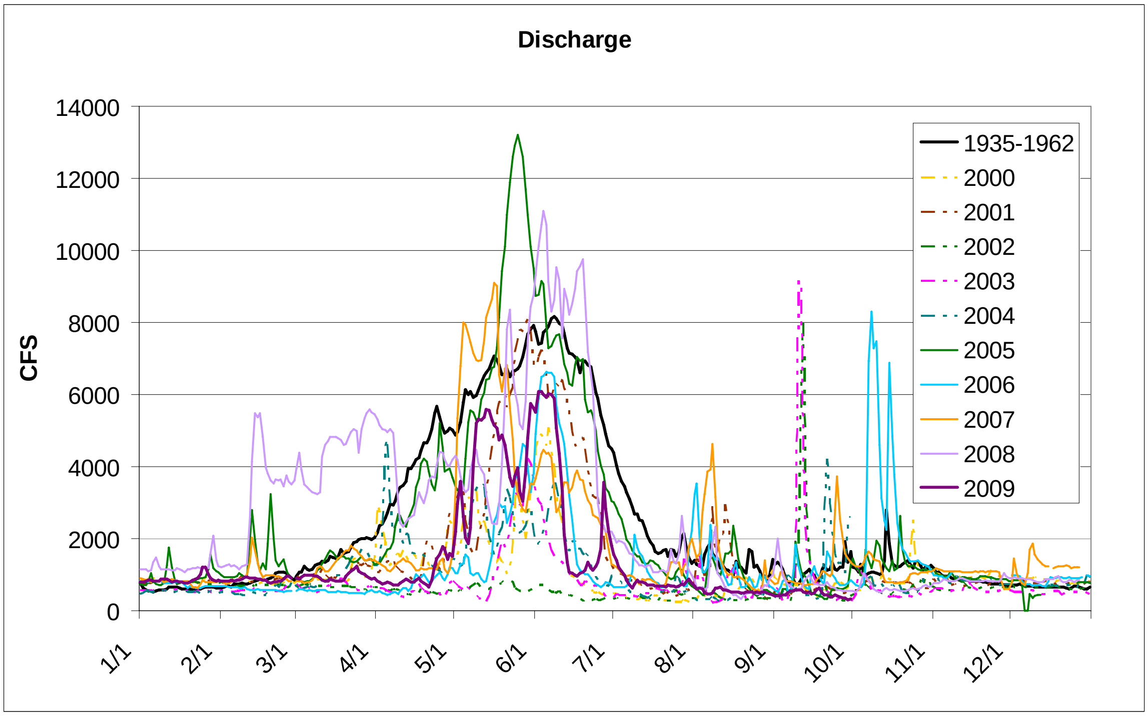

Figure A1. Mean daily discharge (ft^3/s) at Shiprock gage (USGS 936800) for the San Juan River 2003-2008.

Table A1. Mean daily discharge data from Shiprock gage (USGS 936800) for the San Juan River, 1998-2009. The 1935-1962 column represents flows before Navajo Reservoir was constructed.

	MEAN BY YEAR												
Month	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	1935-1962
March	1141	882	941	1033	664	653	1043	1278	537	1276	4483	940	1540
April	1425	1160	1652	1384	533	532	1829	3026	760	1244	3789	987	4017
May	5250	3238	2311	4781	644	1621	2406	7983	2284	6050	4780	4163	6517
June	3970	5876	2011	4760	433	1243	1836	6380	3136	3250	7450	2978	6884
Spring Average	2951	2777	1727	2988	570	1015	1778	4666	1675	2967	5117	2272	4728
July	1665	3116	326	690	358	575	585	1461	967	1054	1463	816	2319
August	959	5731	602	1132	368	642	398	966	1196	1518	740	536	1278
September	644	4298	649	552	1126	1301	1120	684	904	1178	787	464	1109
Summer Average	1094	4383	524	794	612	834	696	1041	1024	1251	999	607	1574
Spring (March - June)													
Days>3000	48	41	18	47	0	9	14	76	23	48	102	37	84
Days>5000	24	26	1	29	0	0	0	50	9	21	47	20	63
Days>8000	0	0	0	1	0	0	0	18	0	5	22	0	3
Days>10000	0	0	0	0	0	0	0	11	0	0	4	0	0
Summer (July - September)													
Days>5000	0	31	0	0	2	2	0	0	0	0	0	0	0
Days>4000	1	42	0	0	2	3	1	0	0	1	0	0	2
Days>3000	1	72	0	0	2	3	1	1	2	6	0	0	7
Days>2000	10	90	0	5	3	3	6	6	5	9	5	0	16
Days>1000	36	92	1	18	7	12	11	41	33	41	37	4	77
Days<1000	55	0	91	74	85	79	80	50	59	51	55	87	14
Days<750	42	0	80	61	80	67	70	40	36	13	41	79	2
Days<500	15	0	45	23	74	43	49	17	0	0	11	29	0

Table A2- Simplistic model for predicting fall CPUE for young-of-year catostomid species in the San Juan River.

	Average Ratio				Predicted Numbers												Ratio of EXPECTED/OBSERVED							
trip	CATLAT	LAT-Se	Count	Year	2003	+/- 2SE	2004	+/- 2SE	2005	+/- 2SE	2006	+/- 2SE	2007	+/- 2SE	2008	+/- 2SE	2003	2004	2005	2006	2007	2008	Average	SE
	smb/larval	YOY	sampled	CATLAT	217		229		222		55		150		286									
04/15	10.60619	4.600957	5		612	531	1047	909	794	689	761	661	1304	1131	1179	1023	2.82	4.57	3.58	13.84	8.69	4.12	6.27	1.73
05/15	0.037861	0.043945	6		2	5	4	9	3	7	3	6	5	11	4	10	0.01	0.02	0.01	0.05	0.03	0.01	0.02	0.01
06/15	0.032447	0.043895	6		2	5	3	9	2	7	2	6	4	11	4	10	0.01	0.01	0.01	0.04	0.03	0.01	0.02	0.01
07/15	0.788638	0.746003	6		46	86	78	147	59	112	57	107	97	183	88	166	0.21	0.34	0.27	1.03	0.65	0.31	0.47	0.13
08/15	2.148453	1.818758	5		124	210	212	359	161	272	154	261	264	447	239	404	0.57	0.93	0.72	2.80	1.76	0.84	1.27	0.35
09/15	7.321775	3.277034	6		422	378	723	647	548	490	526	470	900	806	814	729	1.95	3.16	2.47	9.56	6.00	2.85	4.33	1.19
trip	CATDIS	DIS-SE	Count																					
04/15	6.113354	2.361245	1		353	272	604	466	457	353	439	339	751	580	680	525	7.20	1.73	2.95	3.18	19.27	6.54	6.81	2.64
05/15	1.262266	1.088376	6		73	126	125	215	94	163	91	156	155	268	140	242	1.49	0.36	0.61	0.66	3.98	1.35	1.41	0.55
06/15	0.091984	0.12751	6		5	15	9	25	7	19	7	18	11	31	10	28	0.11	0.03	0.04	0.05	0.29	0.10	0.10	0.04
07/15	0.263733	0.270675	6		15	31	26	53	20	41	19	39	32	67	29	60	0.31	0.07	0.13	0.14	0.83	0.28	0.29	0.11
08/15	2.433718	2.953211	6		140	341	240	583	182	442	175	424	299	726	271	657	2.87	0.69	1.17	1.27	7.67	2.60	2.71	1.05
09/15	5.93842	2.357277	4		343	272	586	465	444	353	426	338	730	579	660	524	6.99	1.68	2.87	3.09	18.71	6.35	6.62	2.57
				Area Sampled	5769.53		9873.3		7482.96		7178.48		12290.29		11117.84									
		YOY	sampled	CATDIS	49		349		155		138		39		104									
		YOY	sampled	CATLAT	217		229		222		55		150		286									

Sum of YOY?	Species	
Year	CATDIS	CATLAT
2003	49	217
2004	349	229
2005	155	222
2006	138	55
2007	39	150
2008	104	286
Grand Total	834	1159

xyrtex cpue larval

					2003		2004		2005		2006		2007		2008	
			conversion	se	average	se	average	se	average	se	average	se	average	se	average	se
04/15		04/15			0	0	0	0	0	0	0.449877	0.369813	0.025253	0.025253	0	0
05/15		05/15	1.41	0.985	16.69424	5.510263	0.841314	0.482344	0.195385	0.112364	7.053048	2.808988	2.038815	1.237067	5.313268	2.14943
06/15		06/15	0.075	0.25	8.044627	6.951236	1.315299	0.56942	0.605436	0.318957	0	0	4.534841	1.344031	2.296102	0.68802
07/15		07/15	0.5	0.5	0	0	0	0	0.292649	0.21257	0	0	0.032603	0.032603	0.106199	0.076031
08/15		08/15	2.14	1.8	0	0	0	0	0.029193	0.029193	0	0	0	0	0	0
09/15		09/15	11	3	0	0	0	0	0	0	0	0	0	0	0	0
					pred	+/- 2SE	pred	+/- 2SE	pred	+/- 2SE	pred	+/- 2SE	pred	+/- 2SE	pred	+/- 2SE
04/15		04/15			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
05/15		05/15			1358.08	626.30	117.12	93.82	20.62	16.56	713.89	397.24	353.31	299.52	832.92	470.77
06/15		06/15			34.81	200.53	9.74	28.11	3.40	11.93	0.00	0.00	41.80	82.59	19.15	38.25
07/15		07/15			0.00	0.00	0.00	0.00	10.95	15.91	0.00	0.00	2.00	4.01	5.90	8.45
08/15		08/15			0.00	0.00	0.00	0.00	4.67	7.86	0.00	0.00	0.00	0.00	0.00	0.00
09/15		09/15			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Average	232.15	137.80	21.14	20.32	6.61	8.71	118.98	66.21	66.19	64.35	142.99	86.25