SMALL-BODIED FISH MONITORING, SAN JUAN RIVER

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Yvette M. Paroz, David L. Propst,
Stephanie M. Carman, and Nikolas D. Zymonas
Conservation Services Division
New Mexico Department of Game and Fish
Santa Fe, New Mexico

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EXECUTIVE SUMMARY

During small-bodied fishes monitoring in the San Juan River during 2007, four native and five nonnative species were collected. Collections in 2007 yielded the fewest number of species since 1998. Several nonnative species that were formerly more common were rare or absent in collections made in the past few years; green sunfish and plains killifish were absent and only a few specimens of common carp, yellow and black bullheads, and largemouth bass were captured. Native roundtail chub and mottled sculpin have not been collected since 1999. One adult razorback sucker was collected in 2005.

From 1998 through 2007 densities of commonly collected native species remained fairly stable. There was a positive trend in the density of bluehead sucker and speckled dace in the primary channel in the past ten years but a declining trend in flannelmouth sucker density from 2003 through 2007. Speckled dace was the most commonly collected species in 2007, but was not found in Reach 1 in 2006 or 2007. Sampling, in addition to routine monitoring effort, was made to capture Colorado pikeminnow in 2007. Fifty two Colorado pikeminnow were captured in regular sampling efforts (i.e., sampling by monitoring protocol), 28 age 0 (likely recently stocked) and 24 age 1+. Seven Colorado pikeminnow were captured by targeted efforts. Recently stocked, age-0 Colorado pikeminnow were collected mainly in backwater habitats.

There was not a significant trend in densities of red shiner and fathead minnow from 1998 through 2007, however numbers of both in 2006 and 2007 were less than 20% of the numbers collected in 2005. The density of channel catfish was highest in 2004 and lowest in 2006.

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INTRODUCTION

Small-bodied and age-0 fishes numerically dominate the San Juan River fish assemblage and likely are essential to recovery of Colorado pikeminnow and influence abundance of razorback sucker young. Small-bodied fishes are an important component of the diet of Colorado pikeminnow, but also may prey on or compete with larval and age-0 razorback sucker and Colorado pikeminnow. Annual autumn sampling of shallow-water habitats is undertaken to obtain information on fishes that occur in these habitats as well as relating this information towards the progress of recovery of Colorado pikeminnow and razorback sucker and the 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 subadult 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) to Lake Powell (Clay Hills Crossing).

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/young-of-year 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;

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, bluehead sucker, common carp, and channel catfish).

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.

Analyses in this report mainly focus 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. The starting point of the 3-mile interval count cycled among years such that sampling would begin at RM 180 one year, RM 179 the next year, and RM 178 the third, and back to RM 180 the following year to repeat the cycle. All collections were made by pulling a seine through a mesohabitat or kicking into a seine. In 2004 and 2005, additional collections were made by electrofishing into a bag seine in riffle, run, and shoal habitats. Primary channel electrofishing collections were made every sixth mile. In 2007, focused Colorado pikeminnow sampling was conducted using a combination of bag-block seining, similar to methods used by Robertson and Holden (2006), and straight seining in an effort to capture more age-1+ Colorado pikeminnow than might be captured during standardized monitoring. This additional effort was conducted in areas that researchers identified as potential Colorado pikeminnow habitat. Unless specifically noted, these samples were not included in the analysis.

Primary channel sample sites were about 200 m long (measured along shoreline). The length of secondary channel sample sites varied depending upon extent of surface water, but was normally 100 to 200 m. 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 also sampled. 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 riffle eddies) 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 were frequently made. The intent was to sample each mesohabitat type available at a site. All large backwaters >50 m^2 associated with the primary channel were sampled and treated as separate sample units. Typically, two seine hauls were made in each backwater; one near its mouth and the second in its upper half. Fish collection data from embayments were grouped with backwater data in 2003 through 2006. Smaller backwaters were included within primary or secondary channel data sets, as backwater mesohabitats.

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 specimen released. Subsamples of at least 50 individuals of speckled dace collected were measured for each reach; the remainder were counted and released. Nonnative fishes were fixed in 10% formalin and returned to the laboratory. Following specimen 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, except collections having more than 250 specimens of a species. For these collections, lengths were obtained for a sub-sample (a haphazard selection of at least 200 specimens). Personnel of UNM-MSB, Division of Fishes, verified identification of retained protected species. All retained specimens were accessioned to the University of New Mexico Museum of Southwestern Biology—Division of Fishes.

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 from 1 July through 30 September. Species density data were segregated by Geomorphic Reach (Bliesner and Lamarra 2000). Mean species densities (number of fish per m^2) were determined by dividing total number of specimens collected by total area sampled. Individual sample densities were determined by the number of fish caught in each seine haul. Mean sample density was calculated as the mean of these individual sample densities. Mean sample densities were used in regression analysis to compare spring and summer discharge attributes to autumn density of commonly collected secondary and primary channel species from 2000 through 2007. Trend regression from 1998 through 2007 was computed using mean sample density plotted with time (8 degrees of freedom). Similar regressions were calculated for the 2003 through 2007 period (3 degrees of freedom) as well as regressions of each individual sample density with time which accounts for variation in sample density (>1500 df primary, >500 df secondary).

Mesohabitats were grouped into categories. High-velocity mesohabitats included riffle, riffle-plunge, and riffle-run; moderate-velocity included run, mid-channel run, shore run, shoal, and pool-run; slow-velocity included riffle eddy, eddy, and pool; and embayments and isolated pools were grouped with backwaters. There were several specialized pockets of habitat that did not fall into these general categories (side channels, debris piles, plunge pools etc.). These were excluded from habitat graphs because of low number of samples from these mesohabitats. For each mesohabitat class, the percent of each species in it was plotted with percent that mesohabitat type contributed to the total sampled area. This representation of mesohabitat association provides a crude estimate of habitat use by each species. ANOVA analysis was run to determine if there were differences in the densities of each species found among the various habitats.

Prior to 2003, fish data were not segregated by mesohabitat; rather data for each site were pooled (e.g., density was all fishes captured in all seine hauls at a site divided by total area seined). Since 2003, mean density of each commonly collected species was calculated by averaging densities of each species from all samples (individual mesohabitats) within a reach. Standard error of the density estimate for each species from each reach was calculated as the standard deviation of mean reach density divided by the square root of the number of mesohabitats sampled within respective reach. ANOVA analysis was performed to determine differences in densities among years. For reach based graphs, error bars prior to 2003 were calculated based upon the number of sampling sites (all mesohabitats pooled for each site) within a given reach. Regression, correlation, and ANOVA analyses 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 four nonnative species were collected in the primary channel of the San Juan River in 2007 (Table 1). No wild-spawned age-0 Colorado pikeminnow or razorback sucker have been collected during small-bodied monitoring since 1998. Stocked individuals of Colorado pikeminnow were collected each year from 2004 through 2007; a single razorback sucker adult was captured in 2005. Roundtail chub and mottled sculpin have not been collected since 1999.

Native fishes numerically dominated collections in 2006 and 2007 (Table 2), comprising nearly 70% of the total catch in 2007. Speckled dace was three times more common in 2007 than the next most abundant species, channel catfish. Red shiner was the most common species collected from 1998 through 2005, but in 2006 and 2007 it was third-most common. Fathead minnow was rare in collections in 2006 and 2007.

Age-0 Colorado pikeminnow were stocked just prior to the 2007 lower river (Sand Island to Clay Hills Crossing) sampling trip. Of the 16 Colorado pikeminnow captured in primary channels, eight were likely from this stocking. All were captured in Reaches 3 and 2.

Most of the habitats sampled from 2003 through 2007 had moderate- to fast-velocity water. Shore run and shoal were the most commonly sampled mesohabitats in the primary channel in 2007, comprising over 60% of the total area sampled (Table 3). Nearly 6750 m^2 of habitat was sampled in the primary channel in 2007, >1000 m^2 more than sampled in 2006.

Table 1. Species collected during small-bodied fishes autumn monitoring of San Juan River primary channel, 1998-2007. I = introduced and N = native. Six-letter code derived from first three letters of genus and second three from species.

COMMON	SCIENTIFIC	CODE	STATUS	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		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
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
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	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
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	
Yellow bullhead	*Ameiurus natalis*	AMENAT	I									X	
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X	
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X	X	X	X	X		
Green sunfish	*Lepomis cyanellus*	LEPCYA	I		X				X	X	X		
Largemouth bass	*Micropterus salmoides*	MICSAL	I				X			X			X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X		X	X	X	X	X	X	X	X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X								
NATIVE			7	5	5	3	3	3	3	4	5	4	4
NONNATIVE			9	5	5	6	6	7	6	9	8	6	4

Table 2. Fishes and mean sample densities (number/m^2) collected in San Juan River primary channel during autumn inventories, 2003 – 2007

2003				*2004*				*2005*				*2006*				*2007*			
Species	*N*	*Density*	*StdError*	*Species*	*N*	*Density*	*StdError*	*Species*	*N*	*Density*	*StdError*	*Species*	*N*	*Density*	*StdError*	*Species*	*N*	*Density*	*StdError*
CYPLUT	1715	0.0600	0.0050	CYPLUT	9929	0.4716	0.1006	CYPLUT	2497	0.0384	0.0040	RHIOSC	2401	0.4225	0.3030	RHIOSC	1800	0.1715	0.0336
RHIOSC	511	0.0462	0.0045	RHIOSC	4690	0.5385	0.1009	RHIOSC	1234	0.0516	0.0058	ICTPUN	336	0.0320	0.0029	ICTPUN	616	0.0315	0.0033
ICTPUN	366	0.0339	0.0032	PIMPRO	1119	0.0842	0.0333	ICTPUN	401	0.0255	0.0030	CYPLUT	164	0.0192	0.0037	CYPLUT	197	0.0139	0.0042
CATLAT	142	0.0178	0.0032	ICTPUN	597	0.0365	0.0074	PIMPRO	281	0.0131	0.0030	CATDIS	153	0.0107	0.0030	CATLAT	68	0.0096	0.0019
PIMPRO	90	0.0128	0.0031	CATDIS	284	0.0281	0.0036	CATLAT	111	0.0114	0.0026	CATLAT	62	0.0103	0.0021	CATDIS	32	0.0056	0.0019
GAMAFF	37	0.0022	0.0008	CATLAT	254	0.0266	0.0036	CATDIS	90	0.0060	0.0020	PIMPRO	44	0.0010	0.0004	PIMPRO	28	0.0042	0.0020
CATDIS	28	0.0068	0.0021	GAMAFF	129	0.0140	0.0051	GAMAFF	16	0.0043	0.0021	PTYLUC	8	0.0015	0.0006	PTYLUC	16	0.0027	0.0010
FUNZEB	21	0.0038	0.0014	FUNZEB	29	0.0030	0.0018	CYPCAR	3	0.0004	0.0003	GAMAFF	4	0.0005	0.0004	GAMAFF	8	0.0007	0.0004
LEPCYA	2	0.0005	0.0004	CYPCAR	6	0.0011	0.0005	PTYLUC	2	0.0004	0.0003	AMENAT	3	0.0002	0.0002	MICSAL	1	0.0006	0.0006
LATDIS	1	0.0002	0.0002	MICSAL	4	0.0010	0.0005	AMEMEL	1	0.0007	0.0007								
				PTYLUC	4	0.0005	0.0003	FUNZEB	1	0.0001	0.0001								
				AMEMEL	2	0.0006	0.0004	LEPCYA	1	0.0003	0.0003								
				LEPCYA	1	0.0004	0.0004	XYRTEX	1	No Area									
Total N	2913				17042				4639				3175				2766		
Total Area	3994				7768				5985				5446				6984		
Density	0.74				2.19				0.78				0.58				0.40		

Table 3. Area (m^2) sampled in each mesohabitat in San Juan River primary and secondary channels during autumn monitoring, 2003-2007. Mesohabitats are arranged from rapid (left) to slow (right) water velocity.

Channel	Year	Riffle	Riffle Run	Run	Mid Channel Run	Shore Run	Shoal	Pool Run	Riffle Eddy	Eddy	Pool	Embayment	Small Backwater	Isolated Pool	Grand Total
Primary	2003	179	263	240	791	1144	388	175	259	91	202	175	39	14	3959
	2004	1081	772	799	342	1903	1785	103	300	145	35	381	112	0	7758
	2005	767	337	533	213	1181	1634	25	292	533	122	89	184	66	5976
	2006	399	238	495	239	1818	1443	0	254	328	88	0	100	44	5446
	2007	748	300	657	326	1788	1692	107	324	513	90	0	165	38	6749
Primary Total		3174	1910	2724	1911	7834	6942	410	1429	1610	537	645	600	162	23139
Percent of Habitat Sampled		14%	8%	12%	8%	34%	30%	2%	6%	7%	2%	3%	3%	1%	
Secondary	2003	87	129	121	327	205	33	233	50	17	204	52	15	41	1512
	2004	194	127	94	376	493	118	81	68	116	73	9	55	0	1802
	2005	104	86	196	177	61	139	27	87	22	143	0	0	0	1042
	2006	160	114	289	432	406	62	26	46	83	61	0	0	0	1679
	2007	242	338	572	315	358	226	134	128	103	27	0	71	0	2513
Secondary Total		787	794	1272	1627	1523	578	501	379	341	508	61	141	41	6036
Percent of Habitat Sampled		13%	13%	21%	27%	25%	10%	8%	6%	6%	8%	1%	2%	1%	

Supplemental Colorado pikeminnow Sampling in Primary Channel

Sixty-six seine hauls were made in nine mesohabitats believed likely to have Colorado pikeminnow in 2007 (Table 4). Collections were obtained using both bag-block methods and straight seines, depending on the habitat and available personnel. Bag-block sampling was only conducted in run and shoal habitats. For similar habitats, 'hunts' did not yield more Colorado pikeminnow than captured during routine sampling ($t_{(228)}$=0.871, p=0.385). No age-0 fish was captured in these efforts.

Table 4. Summary of supplemental sampling conducted in 2007 targeting Age-1 Colorado pikeminnow habitats. Success was calculated as Colorado pikeminnow captured in a mesohabitat, regardless of number of specimens in a mesohabitat.

Sample Type	***Pikeminnow Hunts***		***Regular Sampling***
Gear	Bag Block	Straight Seine	Straight Seine
Area Sampled (square meters)	1289	665	6749
# CPM/ # Seine Hauls	4 of 39	3 of 27	52 of 488
	0.103	0.111	0.107
% Success	10.20%	11.10%	6.56%

While focused sampling did not capture more Colorado pikeminnow than routine sampling, native suckers were captured at a higher frequency in focused than routine sampling. Mean density of bluehead sucker was nearly four times greater in targeted habitats than in similar habitats sampled during routine collections ($t_{(227)}$=2.57; p=0.01) and flannelmouth sucker density was over ten times greater ($t_{(228)}$=2.77; p=0.006). Colorado pikeminnow hunts using bag-block seining was not more successful at capturing native sucker species ($t_{(54)}$=1.05; p=0.30) than straight seining. Straight seining during Colorado pikeminnow hunting yielded greater densities of flannelmouth sucker ($t_{(193)}$=2.96; p=0.003) than the routine straight seining efforts in similar habitats.

SECONDARY CHANNELS SUMMARY

Most fish species found in the San Juan River primary channel also were found in its secondary channels (Table 5). Colorado pikeminnow was collected in secondary channels in each of the past 4 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 four nonnative species were found in secondary channels in 2007, the fewest species collected to date in San Juan River secondary channels.

Speckled dace was the most abundant species in San Juan River secondary channels in 2006 and 2007 (Table 6). Red shiner was the most common species from 1998 through 2005, and was second-most common in 2006; channel catfish was the second-most commonly collected species in 2007. Of the 15 Colorado pikeminnow captured in secondary channels in 2007, two were age 0.

Moderate- to rapid-velocity mesohabitats were the most frequently sampled secondary channel habitats (Table 3). Run, mid-channel run and shore run habitats comprised nearly 50% of the sampled area in 2007.

Table 5. Species collected during small-bodied monitoring in San Juan River secondary channels during autumn, 1998-2007. I = introduced and N = native. Six-letter code derived from first three letters of genus and second three from species.

COMMON	*SCIENTIFIC*	*CODE*	*STATUS*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I	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
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
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	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
Black bullhead	*Ameiurus melas*	AMEMEL	I	X			X	X	X	X	X		
Yellow bullhead	*Ameiurus natalis*	AMENAT	I	X			X				X	X	
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	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			
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	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
NONNATIVE			11	9	5	7	10	8	8	9	6	5	4

Table 6. Mean density (number/m^2) of fishes collected in San Juan River secondary channel during autumn inventories, 2003 – 2007

2003				2004				2005				2006				2007			
Species	N	Density	StdError	Species	N	Density	StdError	Species	N	Density	StdError	Species	N	Density	StdError	Species	N	Density	StdError
CYPLUT	1627	0.0775	0.0111	CYPLUT	7080	1.2321	0.2714	CYPLUT	926	0.0694	0.0201	RHIOSC	251	0.0604	0.0141	RHIOSC	821	0.2797	0.0912
PIMPRO	310	0.0316	0.0059	PIMPRO	2127	0.7063	0.4150	RHIOSC	171	0.0440	0.0094	CYPLUT	154	0.0494	0.0248	ICTPUN	225	0.0322	0.0039
RHIOSC	232	0.0523	0.0065	RHIOSC	1351	0.3450	0.0867	ICTPUN	114	0.0473	0.0198	CATDIS	62	0.0131	0.0083	CYPLUT	168	0.0178	0.0034
CATLAT	153	0.0697	0.0533	GAMAFF	133	0.0629	0.0297	PIMPRO	108	0.0240	0.0075	CATLAT	61	0.0225	0.0126	CATLAT	87	0.0121	0.0028
ICTPUN	65	0.0290	0.0054	CATDIS	122	0.0274	0.0054	GAMAFF	45	0.0040	0.0020	ICTPUN	42	0.0097	0.0022	PTYLUC	15	0.0080	0.0028
GAMAFF	32	0.0132	0.0041	CATLAT	122	0.0485	0.0115	CATLAT	24	0.0201	0.0072	PIMPRO	27	0.0087	0.0040	CATDIS	13	0.0036	0.0014
CATDIS	24	0.0052	0.0020	ICTPUN	115	0.0376	0.0076	CATDIS	7	0.0050	0.0022	GAMAFF	4	0.0053	0.0038	PIMPRO	4	0.0005	0.0005
FUNZEB	11	0.0034	0.0016	FUNZEB	32	0.0182	0.0088	AMEMEL	3	0.0038	0.0029	AMENAT	4	0.0041	0.0024	GAMAFF	1	0.0004	0.0004
AMEMEL	7	0.0055	0.0021	CYPCAR	10	0.0066	0.0033	AMENAT	1	0.0012	0.0012	PTYLUC	2	0.0013	0.0009				
CYPCAR	2	0.0018	0.0013	AMEMEL	6	0.0037	0.0024	PTYLUC	1	0.0006	0.0006								
MICSAL	1	0.0018	0.0018	MICSAL	6	0.0027	0.0015												
				PTYLUC	4	0.0049	0.0025												
				LEPCYA	1	0.0007	0.0007												
Total N	2464				11109				1400				607				1334		
Area	1481				1813				1009				1679				2529		
Density	1.664				6.127				1.388				0.583				0.527		

OVERALL TRENDS IN PRIMARY AND SECONDARY CHANNELS

River-wide primary channel mean densities of each commonly collected native species varied from year to year (Figures 1 and 2). Most commonly collected species showed no trend from 1998 through 2007 (Table 7). Primary channel densities of bluehead sucker and speckled dace, however, trended positively ($P<0.10$) over this period. From 2003 through 2007, plots of mean sample density versus time indicated a decrease in flannelmouth sucker density in primary and secondary channels and an increase in density of Colorado pikeminnow in the primary channel. In contrast, density of no native species changed from 1998 through 2002. Regression analyses performed on individual seine haul densities versus time (2003 through 2007), indicated trends for several species (Table 8). In the primary channel, flannelmouth sucker, bluehead sucker, red shiner, and fathead minnow densities decreased, while Colorado pikeminnow density increased. In secondary channels, flannelmouth sucker and red shiner sample density decreased, but Colorado pikeminnow density increased.

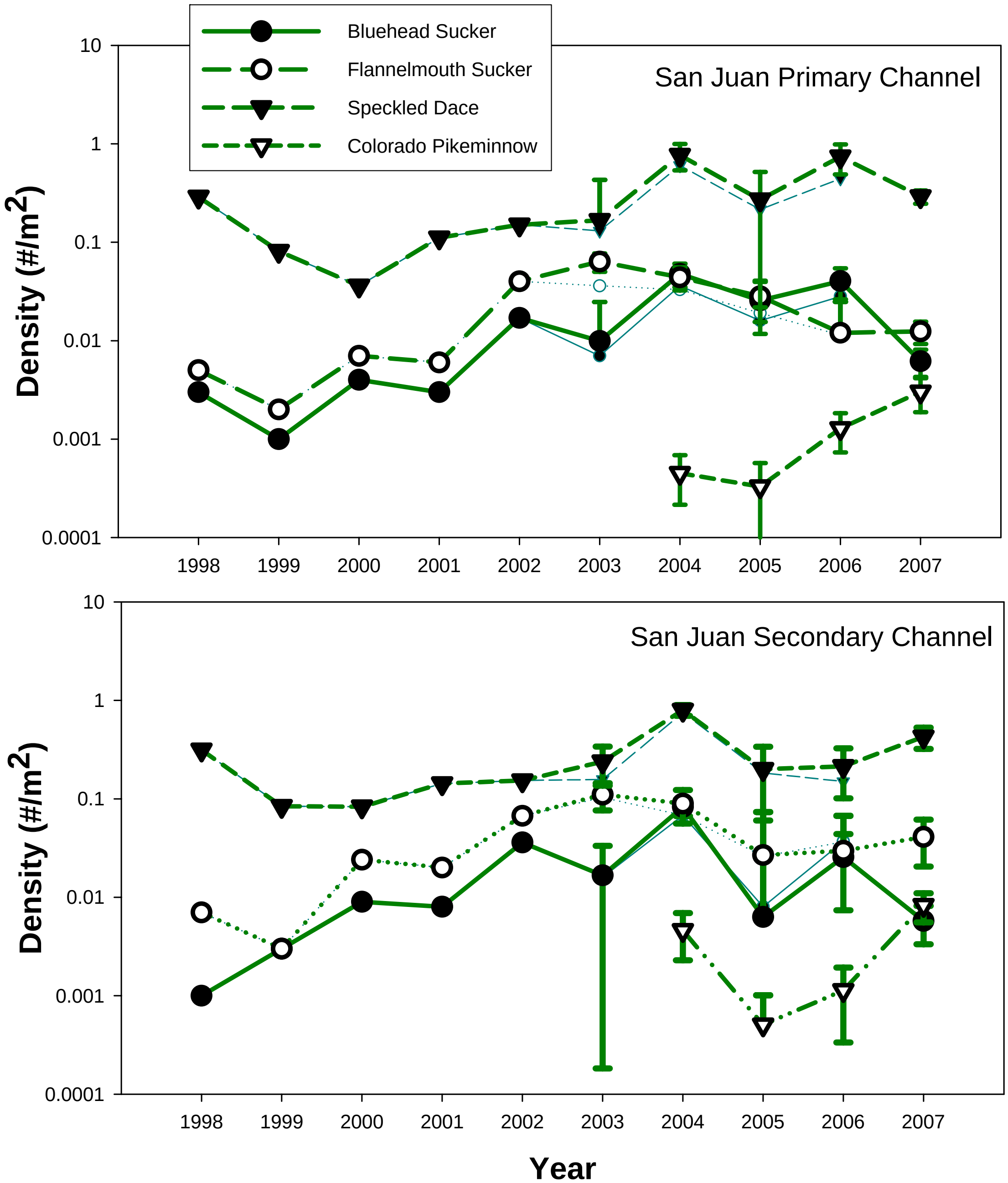

Figure 1. River-wide density (total number/total area sampled) from 1998 through 2002 and mean seine-haul density (and associated standard error) from 2003 through 2007 of commonly collected native fishes in autumn sampling of the San Juan River. Note log scale for density. Error bars represent + 1 SE.

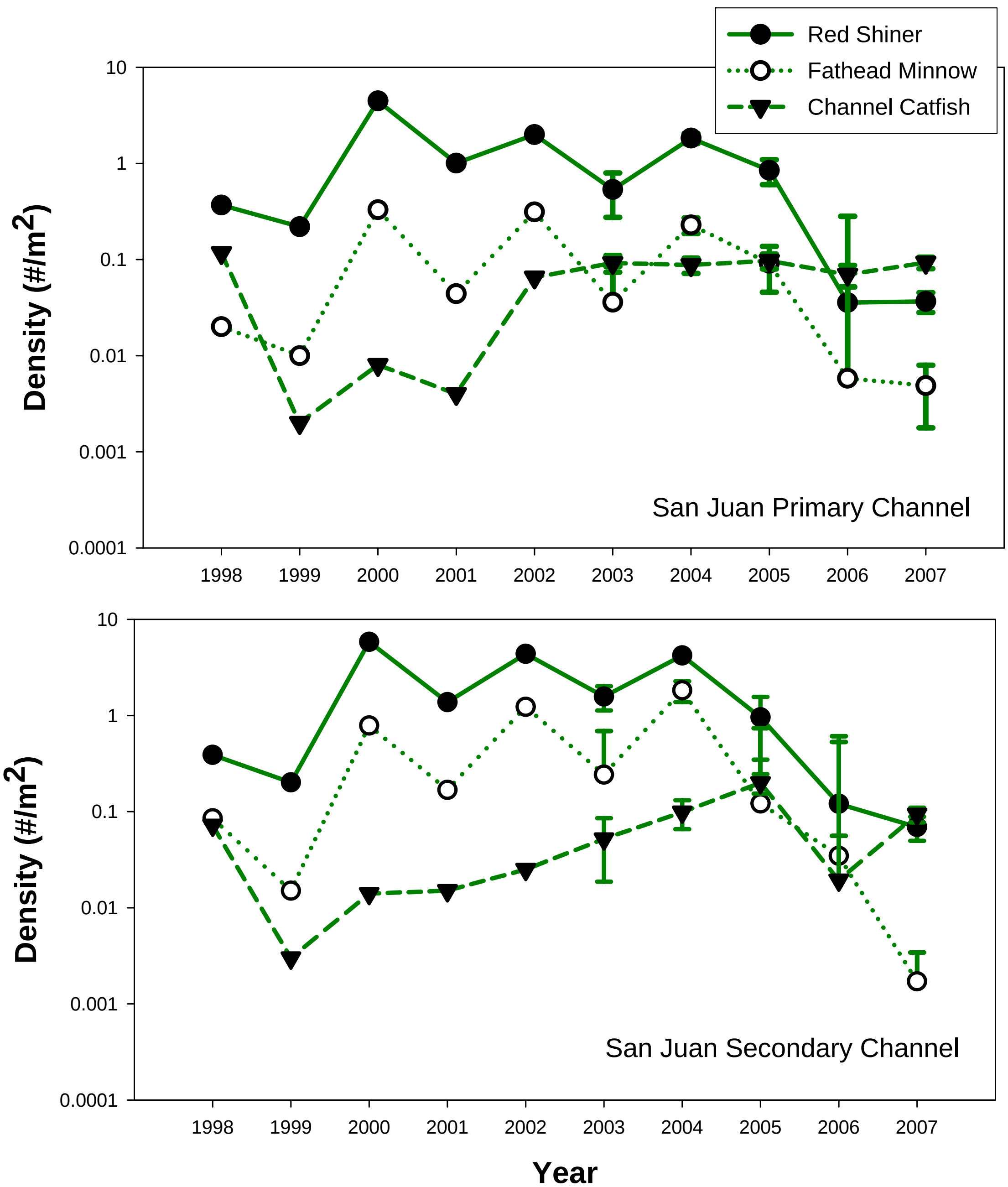

Figure 2. River-wide density (total number/total area sampled) from 1998 through 2002 and mean seine-haul density (and associated standard error) from 2003-2007 of commonly collected nonnative fishes in autumn sampling of the San Juan River. Note log scale for density. Error bars represent ± 1 SE.

Table 7. Results of regression analyses of commonly collected species river-wide annual mean density versus time in San Juan River primary and secondary channels, 1998 through 2007 (8 degrees of freedom). Significant relationships (*P* <0.10) are high-lighted in yellow.

Species	*Primary*		*Secondaries*	
	r	*p*	r	*p*
Speckled dace	0.551	0.099	0.389	0.266
Flannelmouth sucker	0.334	0.346	0.389	0.266
Bluehead sucker	0.590	0.073	0.290	0.416
Red shiner	-0.288	0.419	-0.192	0.594
Fathead minnow	-0.152	0.675	0.001	0.997
Channel catfish	0.416	0.231	0.462	0.179

Table 8. Results of regression analyses of commonly collected species river-wide mean annual density (3 degrees of freedom) and seine-haul density (>1500 df primary, >500 df secondary) versus time in San Juan River primary and secondary channels, 2003 through 2007. Significant relationships (*P* <0.10) are high-lighted in yellow.

	Primary				***Secondaries***			
	River-wide Mean		***River-wide Seine Haul***		***River-wide Mean***		***River-wide Seine Haul***	
Species	**r**	***P***	**r**	***P***	**r**	***P***	**R**	***P***
Speckled dace	0.122	0.845	-0.004	0.866	-0.130	0.835	0.039	0.377
Colorado Pikeminnow	0.894	0.041	0.086	0.001	0.590	0.294	0.093	0.035
Flannelmouth sucker	-0.964	0.008	-0.101	<0.001	-0.825	0.085	-0.078	0.079
Bluehead sucker	-0.131	0.836	-0.078	0.002	-0.390	0.515	-0.067	0.128
Red shiner	-0.595	0.289	-0.093	<0.001	-0.660	0.225	-0.132	0.002
Fathead minnow	-0.481	0.412	-0.051	0.040	-0.462	0.433	-0.054	0.226
Channel catfish	-0.244	0.692	-0.026	0.300	0.010	0.988	-0.034	0.438

In 2007, over 70% of fishes collected in primary and secondary channels were native (Figure 3). Lowest proportion of native fishes in primary and secondary channels occurred in 2000 while greatest proportion of native fishes for study period occurred in the primary channel in 2006. Primary and secondary channels had similar native/nonnative composition from 1998 through 2001, but from 2002 through 2006 the primary channel had a substantially greater proportion native fishes than secondary channels. In 2007, proportion of native fishes in each was almost the same.

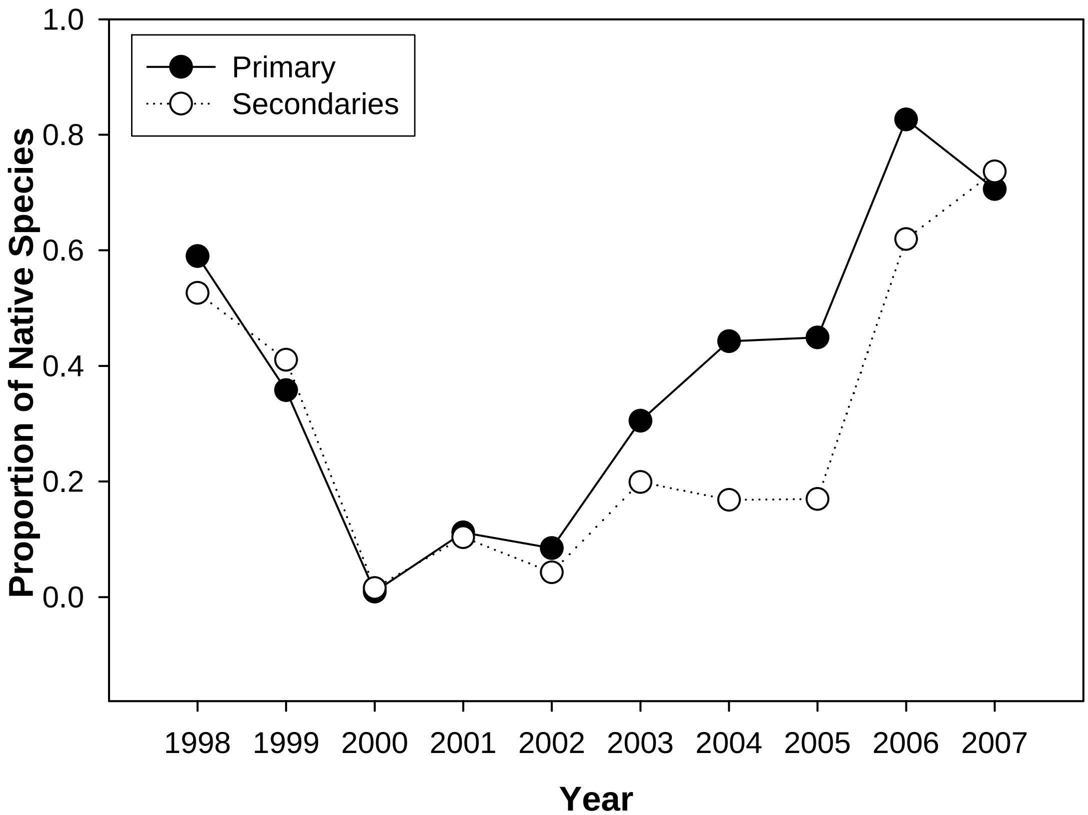

Figure 3. Proportion of native species collected in autumn sampling on the San Juan River from 1998 through 2007.

LARGE BACKWATER SUMMARY

Four native and five nonnative species were collected in San Juan River large backwaters in 2007. The only common carp collected in 2007 small-bodied monitoring was found in a large backwater. Twenty-one Colorado pikeminnow were collected in large backwaters in 2007, 18 of these were age 0 (almost certainly recently stocked individuals). Prior to 2007 Colorado pikeminnow had not been collected in a large backwater since 2000 (Table 9). Red shiner was the most abundant species in large backwaters in the San Juan River in 2007 and channel catfish was the second most abundant species.

Table 9. Species collected in San Juan River backwaters during autumn, 1999 – 2006, 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	X		X	X		X
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X							X
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		X	X	X	X	X	X		X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X		X
Black bullhead	*Ameiurus melas*	AMEMEL	I		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
Plains killifish	*Fundulus zebrinus*	FUNZEB	I		X	X	X		X	X		
Western mosquitofish	*Gambusia affinis*	GAMAFF	I		X	X	X	X	X	X		
Green sunfish	*Lepomis cyanellus*	LEPCYA	I			X	X	X				
Bluegill	*Lepomis macrochirus*	LEPMAC	I		X							
Largemouth bass	*Micropterus salmoides*	MICSAL	I		X					X		
NATIVE			4	3	4	3	3	3	3	3	1	4
NONNATIVE			10	3	9	9	7	6	6	7	2	5

Table 10. Fishes collected in San Juan River backwaters during autumn inventories, 2003 – 2007.

2003				2004				2005				2006				2007			
Species	N	Den	Std. Error	Species	N	Den	Std. Error	Species	N	Den	Std. Error	Species	N	Den	Std. Error	Species	N	Den	Std. Error
CYPLUT	309	0.0913	0.0245	CYPLUT	1031	1.1168	0.3553	CYPLUT	536	0.0361	0.0072	CYPLUT	3	0.0725	0.0725	CYPLUT	67	0.0234	0.0049
PIMPRO	129	0.1162	0.0455	PIMPRO	319	0.2746	0.1072	PIMPRO	122	0.0296	0.0082	PIMPRO	2	0.0394	0.0089	ICTPUN	64	0.0398	0.0077
GAMAFF	17	0.0414	0.0262	FUNZEB	24	0.0202	0.0146	CATLAT	114	0.0166	0.0063	RHIOSC	1	0.0242	0.0242	RHIOSC	28	0.0250	0.0119
AMEMEL	12	0.0067	0.0046	GAMAFF	15	0.0266	0.0095	CATDIS	69	0.0042	0.0032					PTYLUC	21	0.0166	0.0050
ICTPUN	10	0.0073	0.0050	ICTPUN	10	0.0241	0.0092	GAMAFF	16	0.0102	0.0048					PIMPRO	12	0.0069	0.0029
CATLAT	6	0.0334	0.0264	RHIOSC	10	0.0272	0.0138	RHIOSC	12	0.0075	0.0043					CATLAT	3	0.0026	0.0018
CATDIS	3	0.0431	0.0276	CYPCAR	3	0.0066	0.0045	FUNZEB	3	0.0014	0.0014					AMENAT	1	0.0036	0.0036
RHIOSC	3	0.0182	0.0094	CATDIS	2	0.0041	0.0041	MICSAL	2	0.0083	0.0083					CATDIS	1	0.0012	0.0012
LEPCYA	1	0.0108	0.0108	CATLAT	1	0.0038	0.0038	CYPCAR	1	0.0067	0.0067					CYPCAR	1	0.0041	0.0041
FUNZEB	1	0.0043	0.0043					ICTPUN	1	0.0028	0.0028								
Total N	490				1415				876				6				198		
Area	231				272				489				53				708		
Density	2.12				5.20				1.79				0.113				0.282		

BLUEHEAD SUCKER

The greatest densities of bluehead sucker in 2007 were in Reach 6 ($F_{(5, 2167)}$=35.8, p<0.0001) (Figure 4), where it was also most dense in 2004 and 2006 ($F_{(4, 320)}$=2.59, p<0.0367). Densities of bluehead sucker in 2007 were lower than 2006 (primary t=1.75, p<0.08: secondary t=1.71, p<0.09). From 2003 through 2007, there was no difference between overall densities of bluehead sucker in primary and secondary channels ($F_{(1, 2100)}$=0.002, p=0.963).

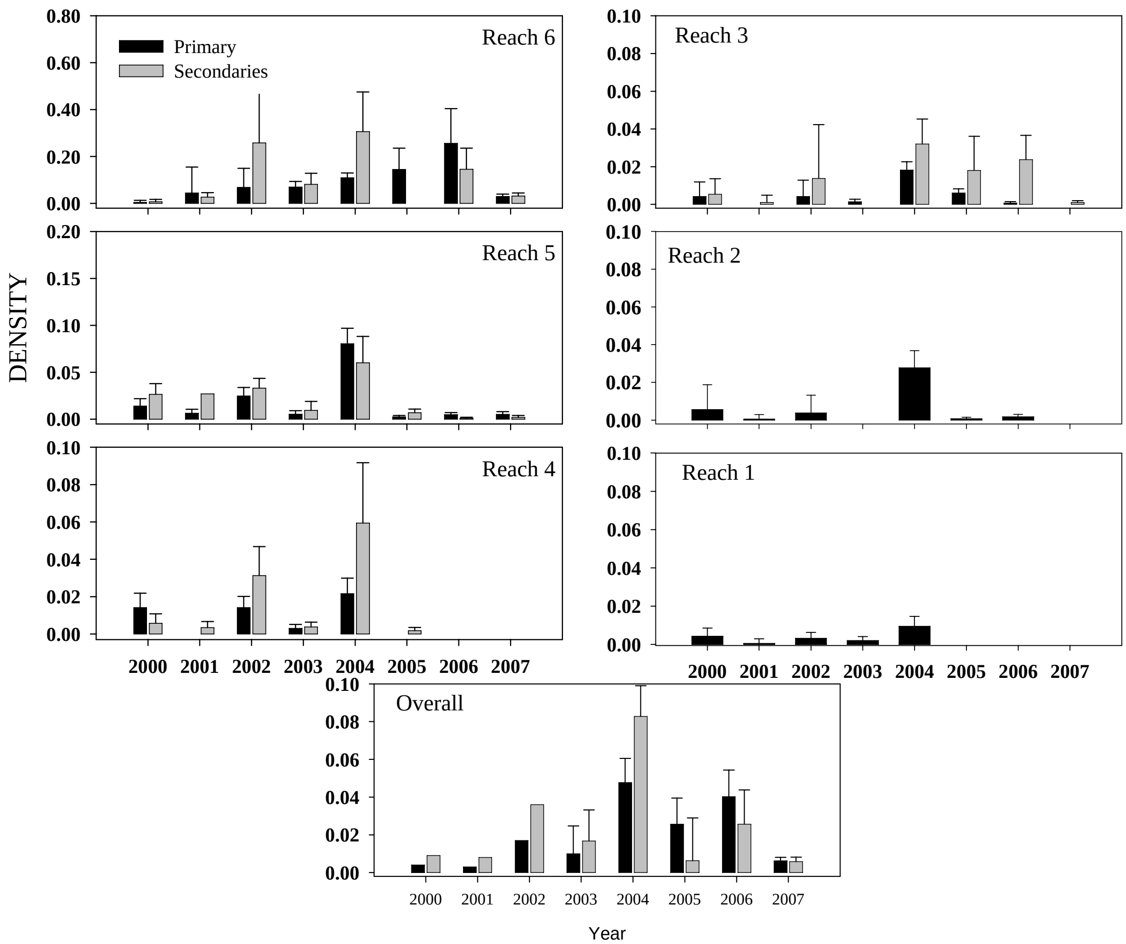

Figure 4. Average autumn densities of bluehead sucker in primary and secondary channels of the San Juan River, 2003-2007. Error bars represent one standard error. Note change in scale of y-axis.

Mean total length of bluehead sucker captured from 2003 through 2006 was 73 mm (SE 1.88). The largest mean total length (94 mm, SE 11.4) was in 2007. These averages, however, are of all bluehead suckers captured, and almost certainly include two or more year-classes in most years (Figure 5). A large proportion of the bluehead suckers collected in 2007 were obtained during Colorado pikeminnow hunts. Bluehead suckers captured during Colorado pikeminnow hunts were larger (136mm, SE=16.5) than those captured during routine sampling (94mm, SE=11.2).

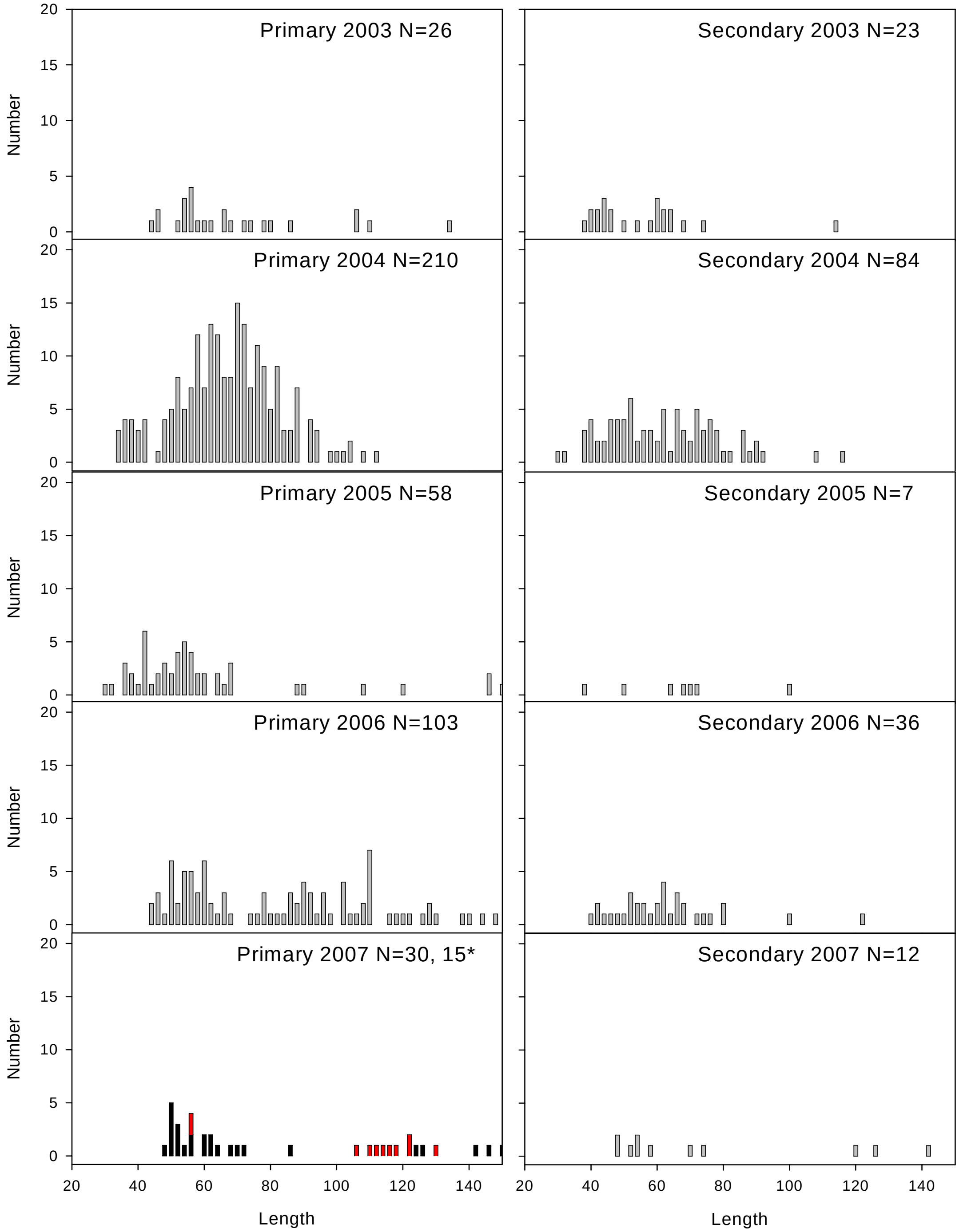

Figure 5. Length-frequency of bluehead suckers from the San Juan River primary and secondary channels, 2003-2007. For primary 2007 panel, N* and red bars indicate individuals captured during Colorado pikeminnow hunts.

From 2003 through 2007, bluehead sucker was collected in all habitats in the primary channel, except isolated pools (Figure 6). Embayments and debris pools were the only habitat in secondary channels where it was not collected. ANOVA analysis of bluehead sucker density indicated that bluehead sucker did not differentially occupy specific mesohabitats in primary channels, including large backwaters ($F_{(15, 1714)}$ =1.19, *p*<0.222). However differentially high densities of bluehead sucker were found in shoal-run habitats in secondary channels ($F_{(14,496)}$ =1.56, *p*<0.053).

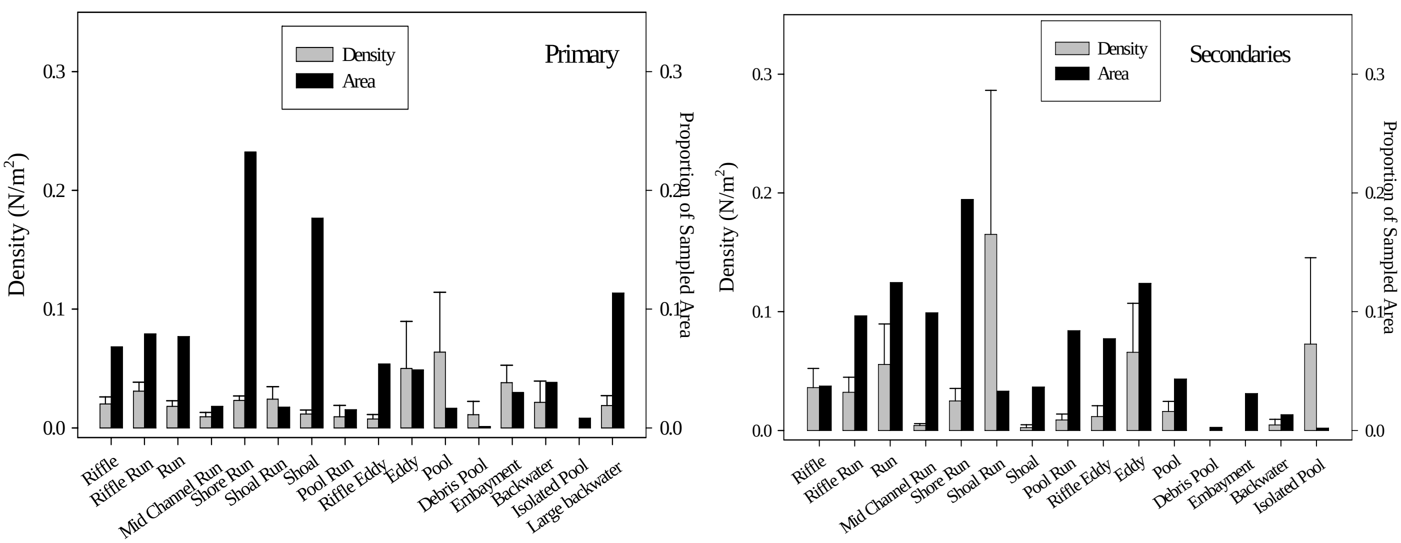

Figure 6. Density of bluehead sucker and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.

FLANNELMOUTH SUCKER

From 2003 through 2007, overall densities of flannelmouth sucker were higher in secondary channels than the primary channel ($F_{(1,2101)}$=7.389, p=0.007) (Figure 7). The greatest densities of flannelmouth sucker consistently occurred in Reach 6 ($F_{(5, 2168)}$=4.89, p<0.002). The greatest densities of flannelmouth sucker in Reach 6 were in 2003 and 2004 ($F_{(4,334)}$=3.67, p=0.006).

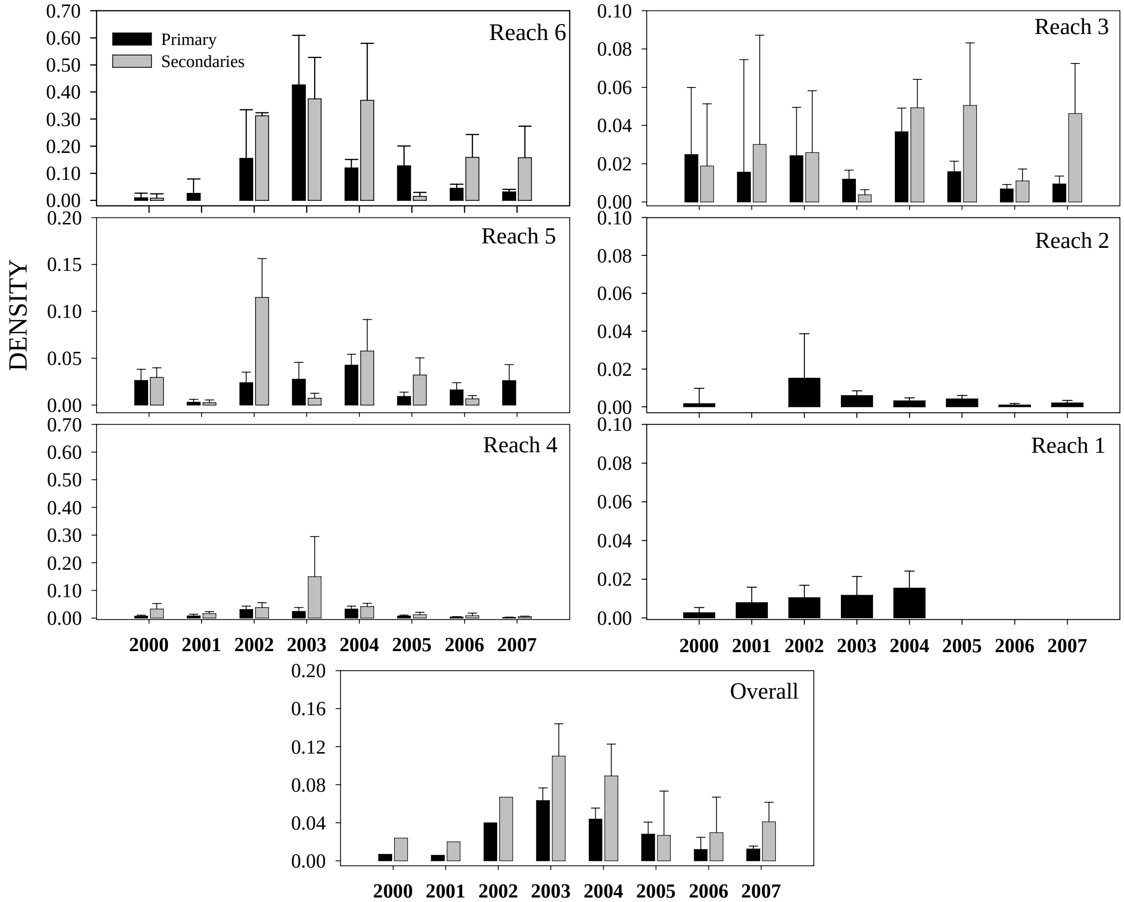

Figure 7. Average autumn densities of flannelmouth sucker in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

Mean total length of flannelmouth sucker captured from 2003 through 2006 was 91 mm (SE 2.29). Similar to bluehead sucker, there were at least two age-classes represented in most years (Figure 8). Flannelmouth suckers collected in the primary channel (TL 96 mm, SE 3.11) were larger than those collected in secondary channels (TL 81mm, SE 3.44). Similar to bluehead sucker, a large proportion of flannelmouth suckers collected in 2007 were captured during Colorado pikeminnow hunts. However, mean total length of flannelmouth sucker collected during Colorado pikeminnow hunts

(TL=104, SE=9.1) was not different than average size of those collected in routine primary channel sampling (TL=115, SE=11.5).

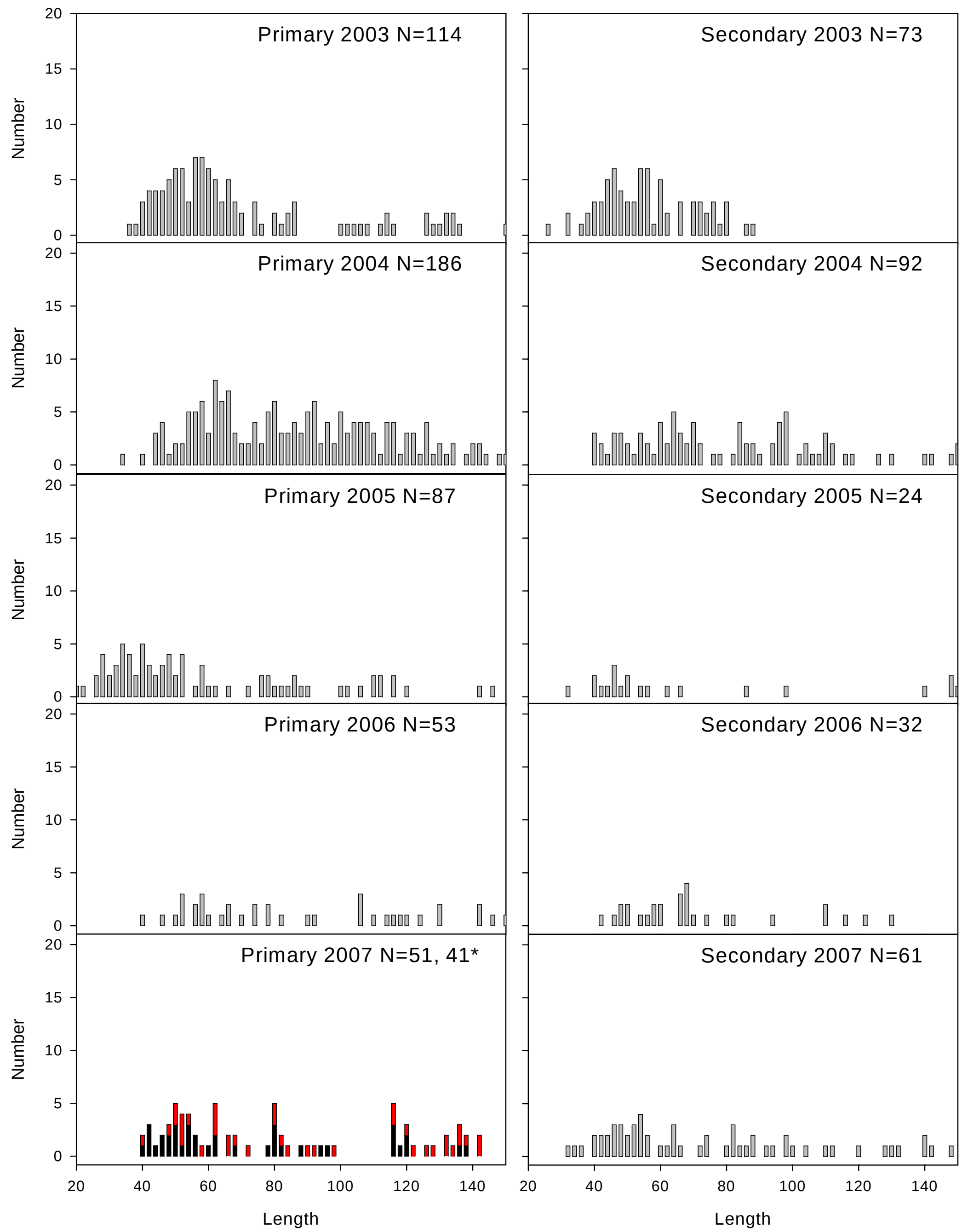

Figure 8. Length-frequency of flannelmouth sucker from the San Juan River primary and secondary channels, 2003-2007. For primary 2007 panel, N* and red bars indicate individuals captured during Colorado pikeminnow hunts.

From 2003 through 2007, flannelmouth sucker was collected in all habitat types sampled in primary channels (Figure 9). In the primary channel, flannelmouth sucker was most common in low-velocity habitats, including large backwaters ($F_{(15, 1700)} = 1.91$, $p<0.008$), but no selection was evident in secondary channels ($F_{(14, 496)} = 0.70$, $p<0.832$).

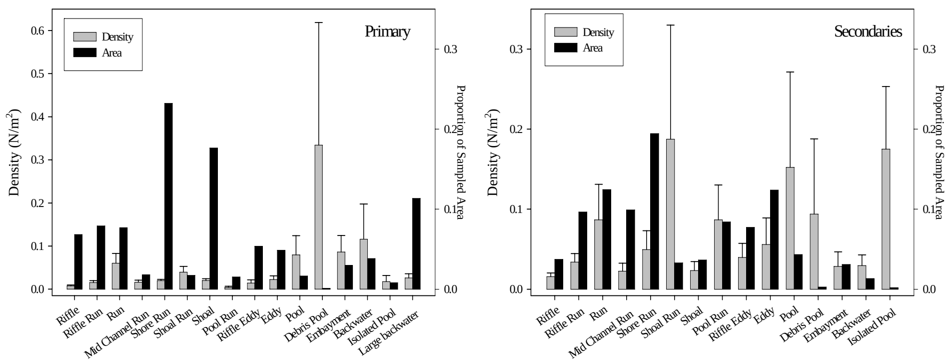

Figure 9. Density of flannelmouth sucker and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.
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SPECKLED DACE

From 2003 to 2007 the greatest densities of speckled dace were in Reach 6 ($F_{(5, 2165)}=9.611$, $p<0.0001$) (Figure 10). There were no significant differences in density of speckled dace collected in Reach 6 in various years ($F_{(4,333)}=1.84$, $p=0.121$). Riverwide densities of speckled dace were greatest in 2004 ($F_{(4,2165)}=2.78$, $p=0.026$). Speckled dace has not been collected in Reach 1 for 2 years.

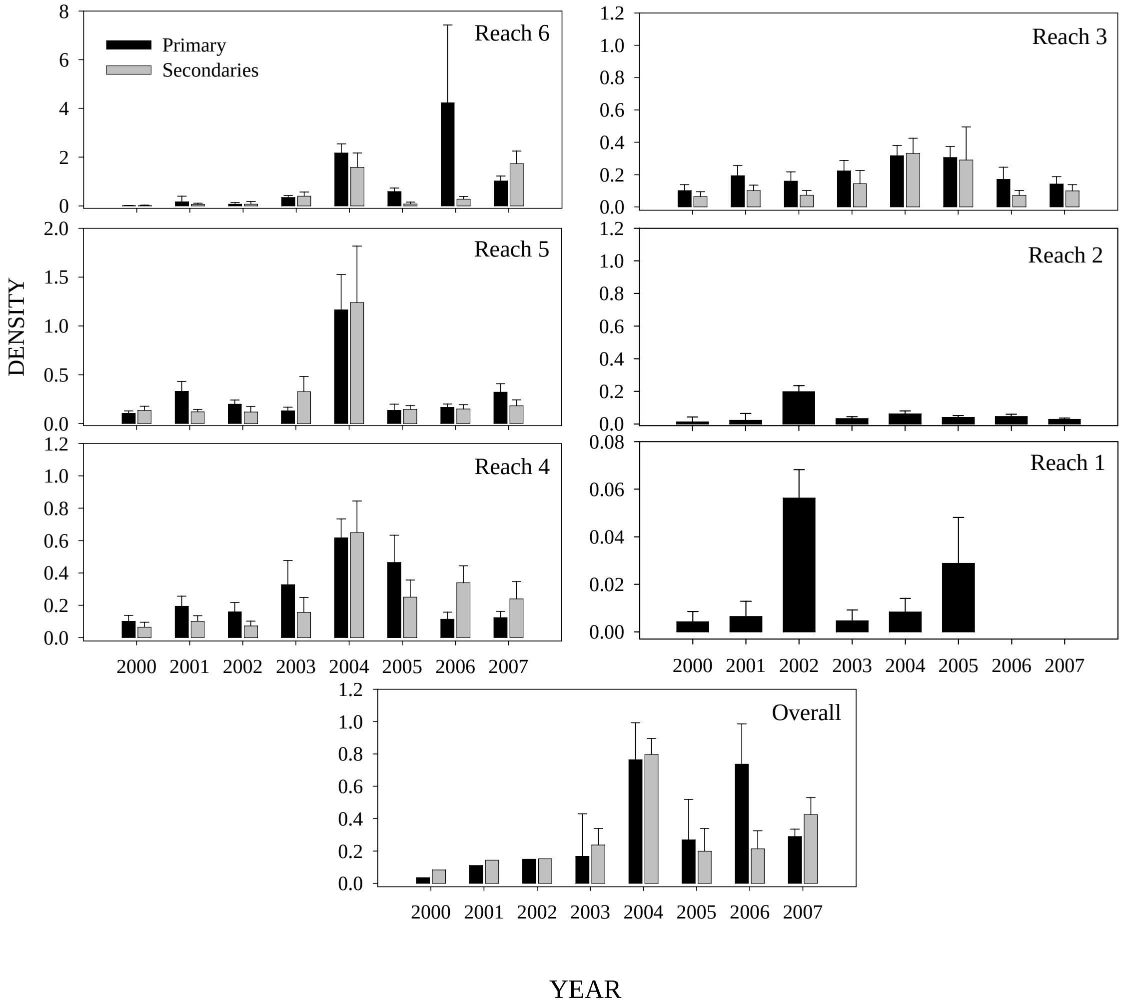

Figure 10. Average autumn densities of speckled dace in primary and secondary channels of the San Juan River, 2000-2007. Error bars represent one standard error. Note change in scale of y-axis.

Average total length of speckled dace captured from 2003 through 2007 was 47 mm (SE=0.23). For most years, two cohorts were distinguishable in the length-frequency histograms (Figure 11). Speckled dace collected in the primary channel (47mm, SE=0.267) were not larger than those found in secondary channels (46mm, SE=0.44).

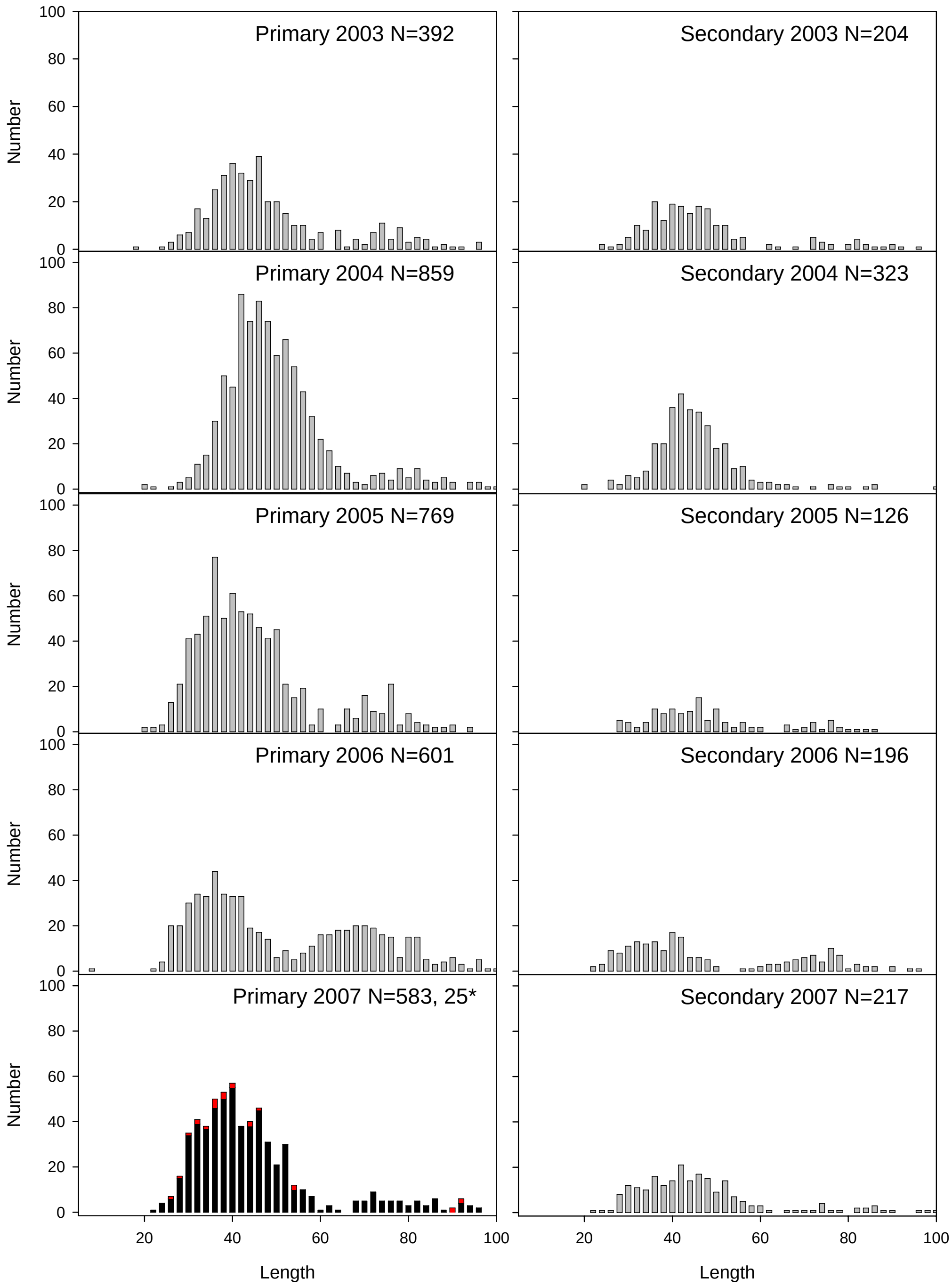

Figure 11. Length frequency of speckled dace from San Juan River primary and secondary channels, 2003-2007. For primary channel 2007 panel, N* and red bars indicate individuals captured during Colorado pikeminnow hunts.

From 2003 through 2007, speckled dace was collected in all habitat types sampled in primary and secondary channels (Figure 12). Speckled dace was not more abundant in one habitat type than any other in the primary channel, ($F_{(15, 1712)}$ =0.531, p<0.981), but it was more common in pool-run and riffle eddy habitats than others in secondary channels ($F_{(14, 493)}$ =1.55, p<0.055).

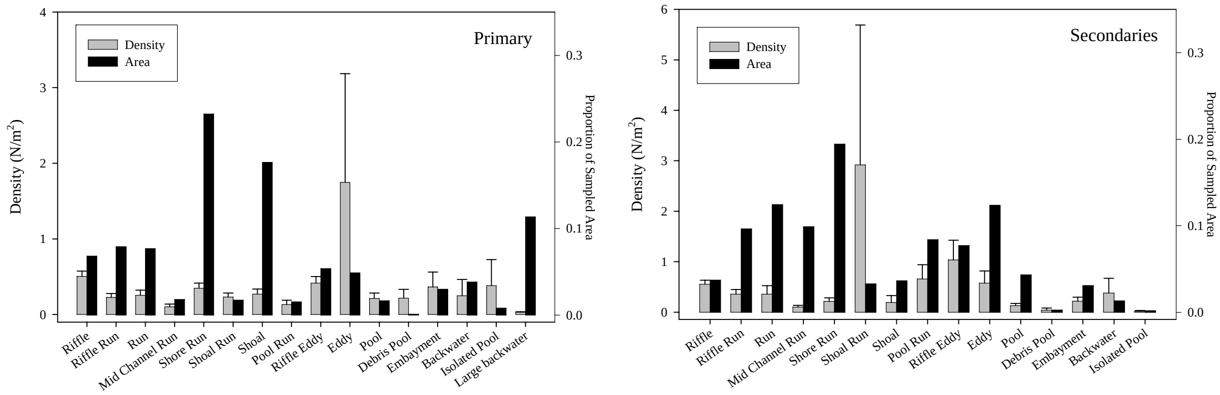

Figure 12. Density of speckled dace and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.

RED SHINER

From 2003 through 2007, greatest densities of red shiner were in Reach 4 ($F_{(5, 2162)}$=2.70, p<0.020) (Figure 13). No red shiner was collected in Reach 6 in 2006 or 2007. Riverwide densities of red shiner were greatest in 2004 ($F_{(4,2162)}$=21.72, p<0.0001). Secondary channels had greater densities of red shiner ($F_{(1,2095)}$=9.129, p<0.0025) than the primary channel.

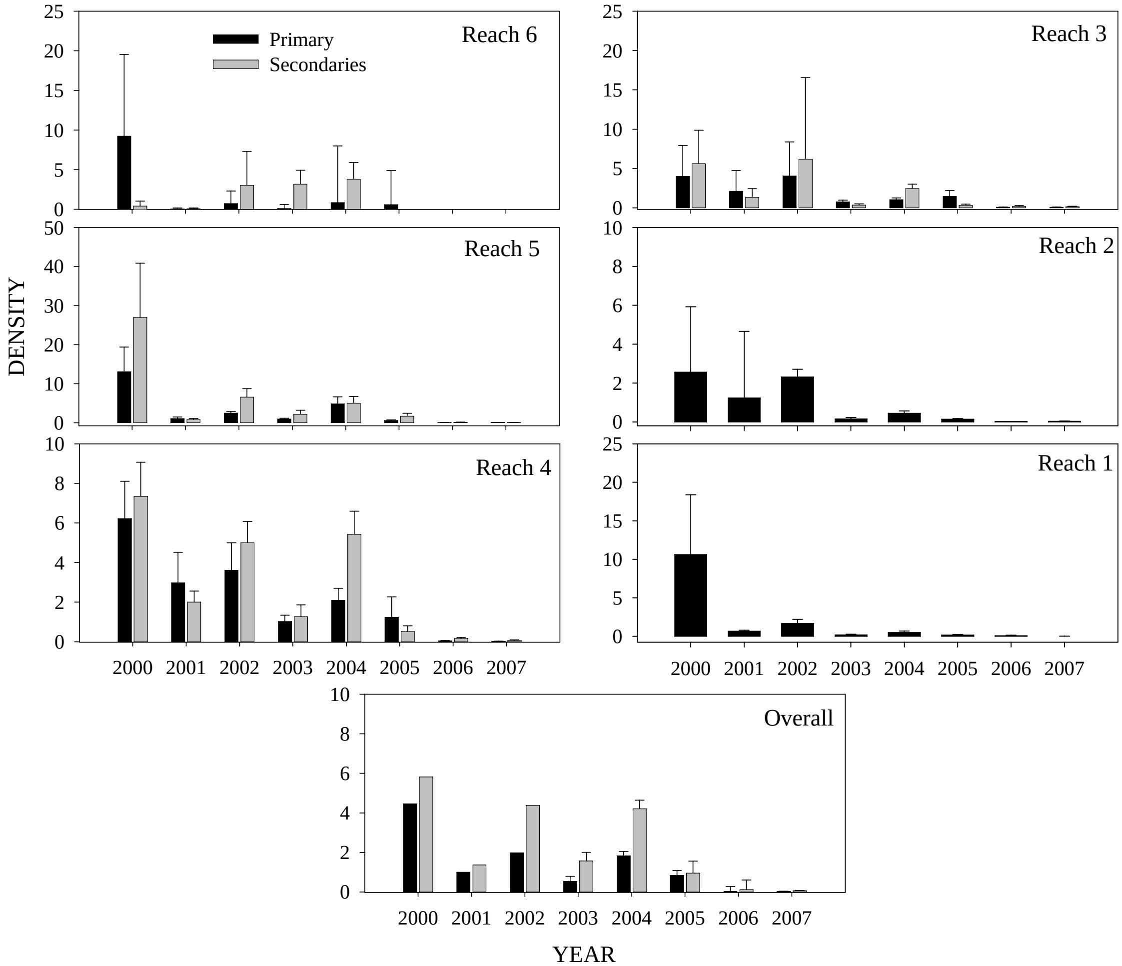

Figure 13. Average autumn densities of red shiner in primary and secondary channels of the San Juan River, 2000-2007. Error bars represent one standard error. Note change in scale of y-axis.

Mean total length of red shiner captured from 2003 through 2007 was 35 mm (SE= 0.122). For most years, two cohorts were distinguishable in length-frequency histograms, though large red shiners were rare in 2007 (Figure 14). Red shiners collected in the primary channel (mean TL=34mm, SE=0.162) were about the same size as those collected in secondary channels (mean TL=35mm, SE=0.185).

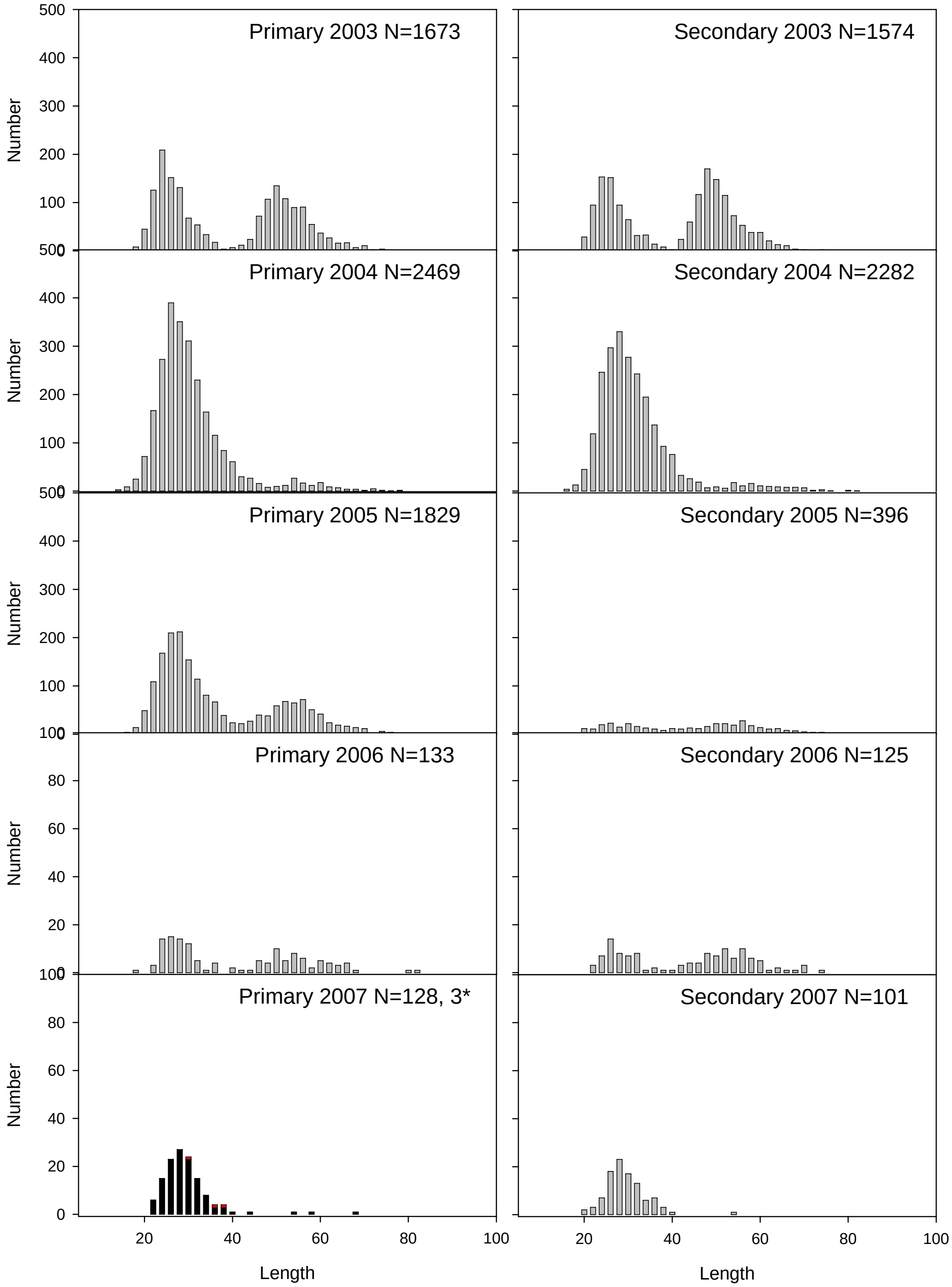

Figure 14. Total length frequency of red shiner from San Juan River primary and secondary channels, 2003-2007. Note axis change for 2006 and 2007. For primary channel 2007 panel, N* and red bars indicate individuals captured during pikeminnow hunts.

From 2003 through 2007, red shiner was collected in all habitat types in primary and secondary channels (Figure 15). Red shiner was most commonly found in low-velocity habitats, especially backwaters in secondary channels ($F_{(14, 491)} = 2.34$, $p < 0.0007$).

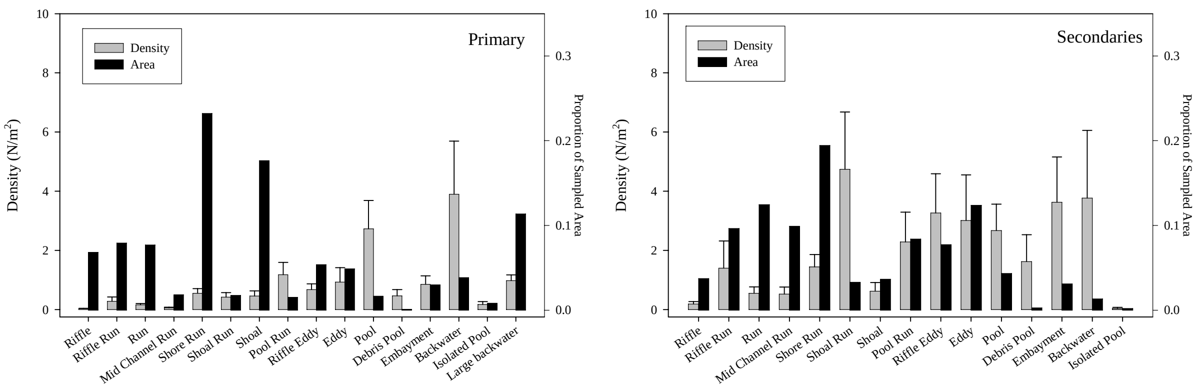

Figure 15. Density of red shiner and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.
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CHANNEL CATFISH

From 2003 through 2007, density of channel catfish was greatest in 2004 and least in 2006 ($F_{(4, 2162)} = 3.113$, $p < 0.014$) (Figure 16). Mean density of channel catfish was greatest in the lower river (Reaches 4 through 1) and channel catfish were rare in Reach 6 ($F_{(5,2162)} = 18.65$, $p < 0.0001$). There was no difference in density of channel catfish in primary and secondary channels ($F_{(1, 2096)} = 0.066$, $p = 0.797$).

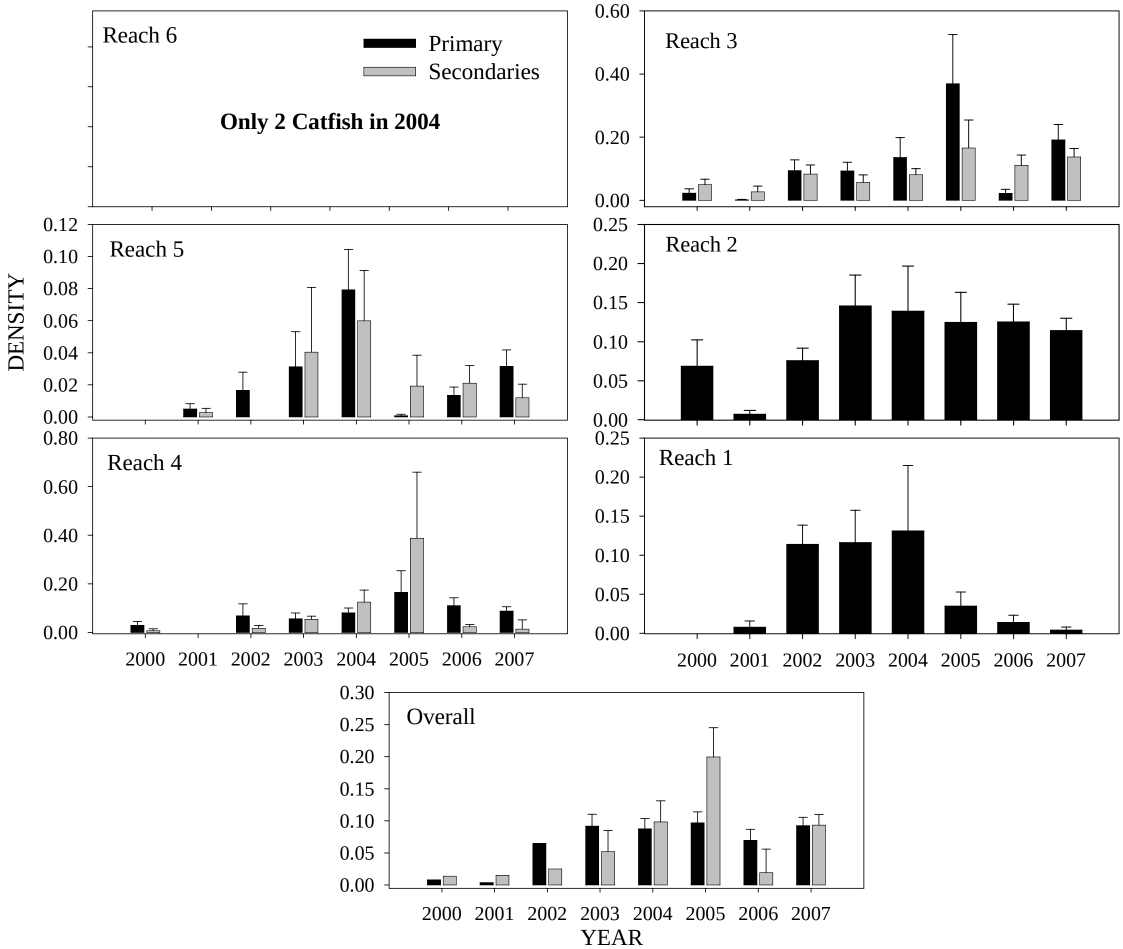

Figure 16. Average autumn densities of channel catfish in primary and secondary channels of the San Juan River, 2000-2007. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of channel catfish captured from 2003 through 2007 was 65 mm (SE 0.649). Mean total length of channel catfish from the primary channel (64mm, SE=0.692) was not different from that of individuals from secondary channels (65mm, SE=1.49). Very few Age 1+ catfish were collected in small-bodied sampling in 2007 (Figure 17).

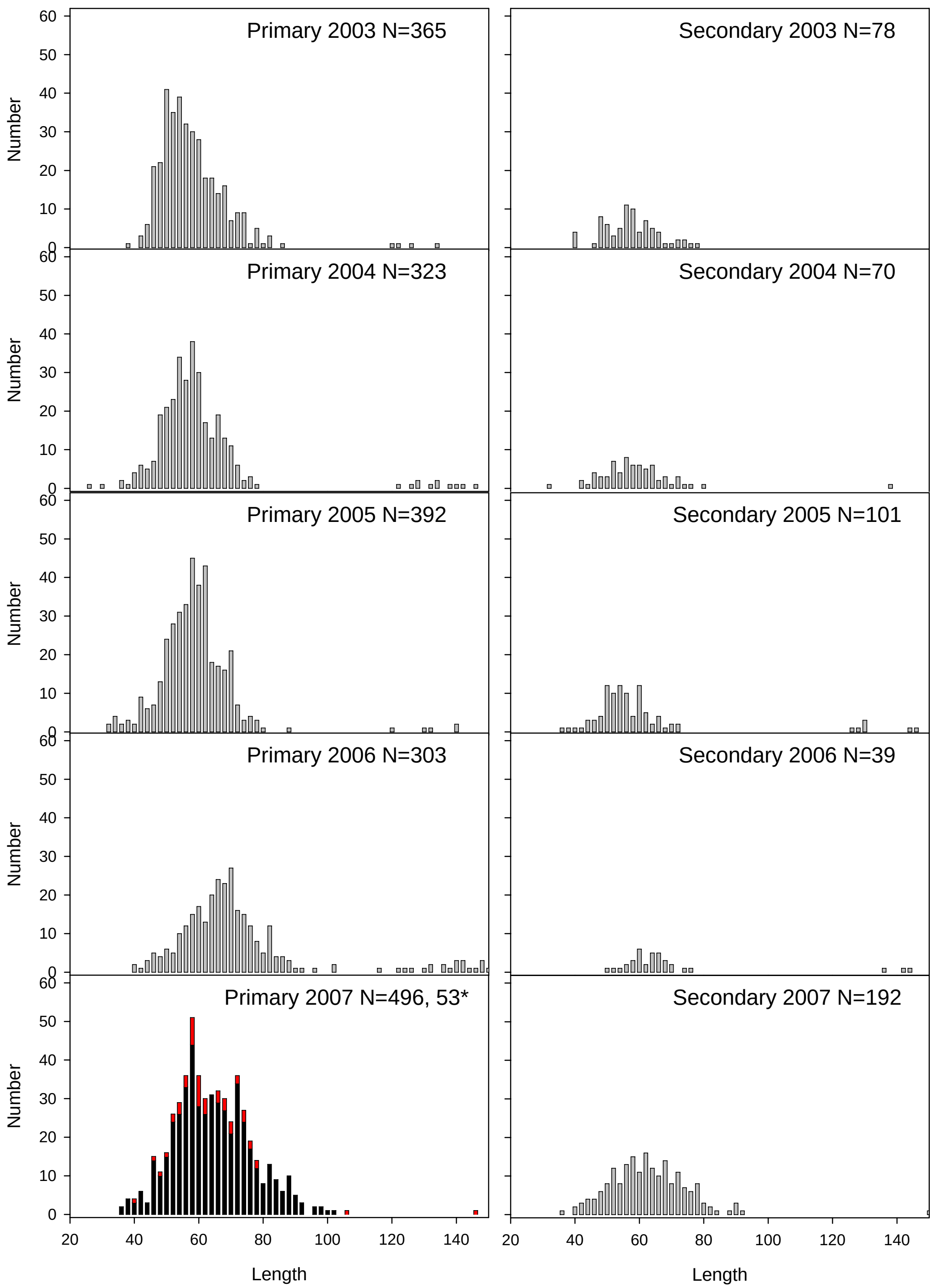

Figure 17. Total length-frequency of channel catfish from the San Juan River primary and secondary channels, 2003-2007. For primary channel 2007 panel, N* and red bars indicate individuals captured during Colorado pikeminnow hunts.

From 2003 through 2007, channel catfish was collected in all habitat types in primary and secondary channels, except isolated pools (Figure 18). In the primary channel, channel catfish was most commonly collected in low-velocity habitats ($F_{(14,\ 1714)}$ =1.76, p<0.007), but no selection was evident in secondary channels ($F_{(13,\ 492)}$ =1.20, p<0.242).

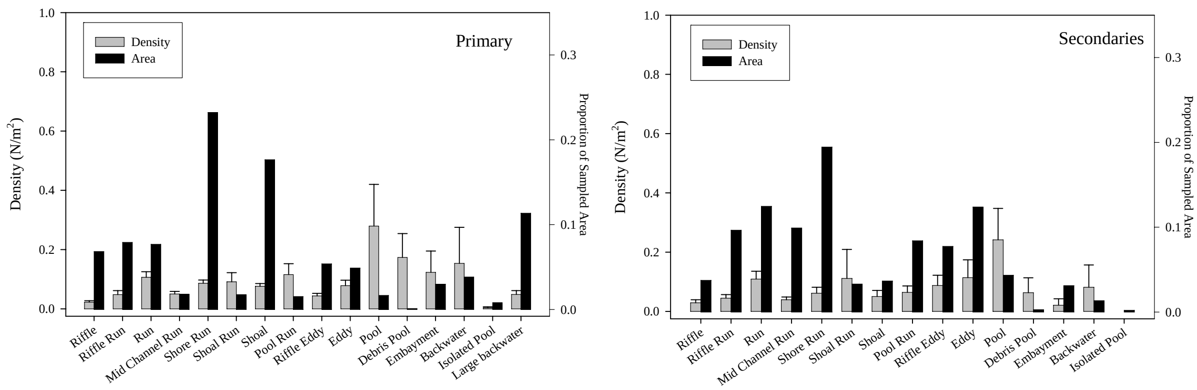

Figure 18. Density of channel catfish and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.

FATHEAD MINNOW

Fathead minnow was rare in samples from 2006 and 2007. From 2003 through 2007, 2004 had the greatest density (0.523 fish/m^2, SE=0.108) of fathead minnow ($F_{(4,\ 2167)}$ =2.73, p<0.028) (Figure 19). There was no difference in fathead minnow density among reaches ($F_{(5,2167)}$=1.42, p<0.212). Fathead minnow density was greater in secondary channels than primary channels ($F_{(1,\ 2100)}$ =5.29, p<0.022).

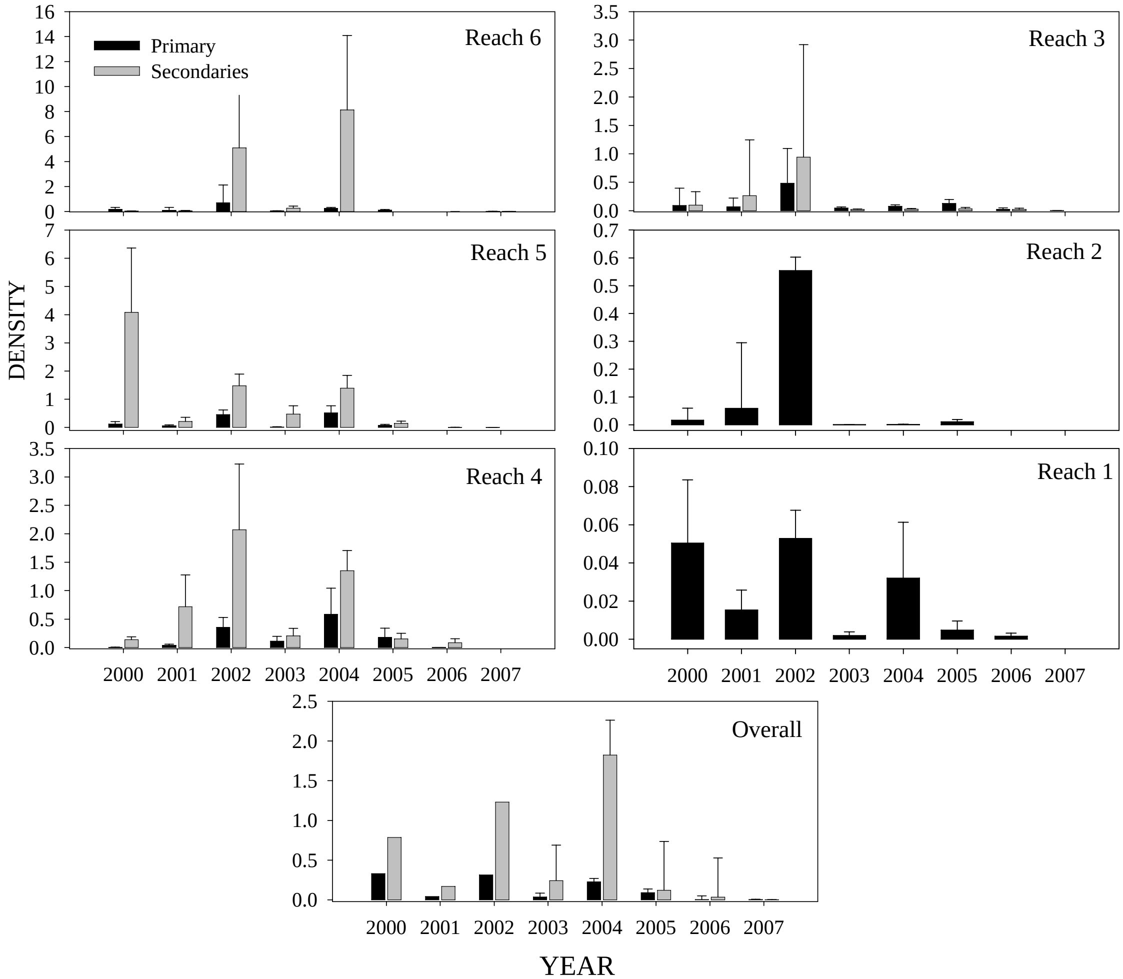

Figure 19. Average autumn densities of fathead minnow in primary and secondary channels of the San Juan River, 2000-2007. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of fathead minnow captured from 2003 through 2007 was 35 mm (SE=0.198). Fathead minnow collected from the primary channel (36mm, SE=0.347) were larger ($t=4.19$, $p<0.001$) than those found in secondary channels (34 mm, SE=0.235). Few large fathead minnow have been captured, but the majority were found in 2005 (Figure 20).

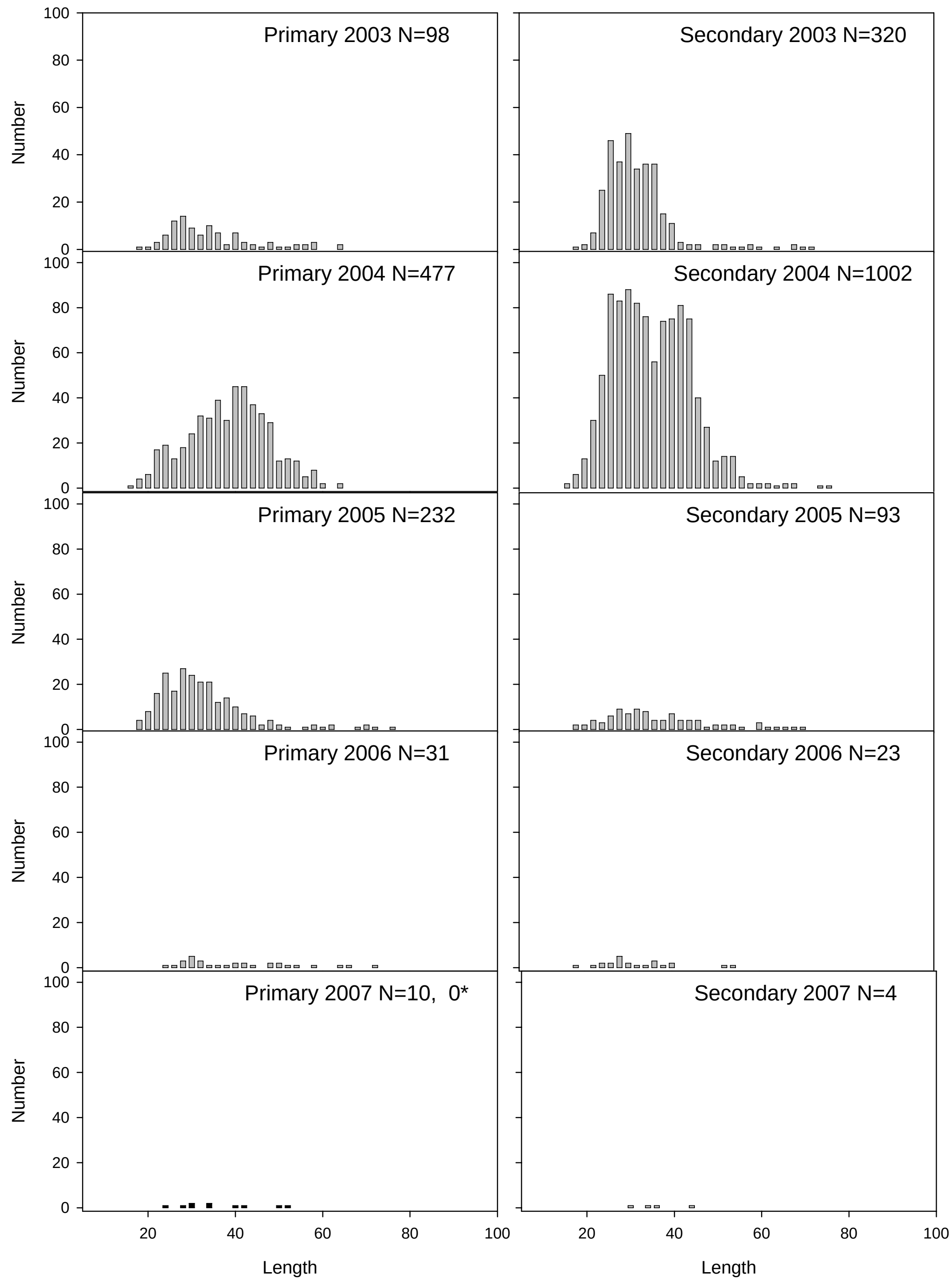

Figure 20. Length frequency of fathead minnow from San Juan River primary and secondary channels, 2003-2007. For primary channel 2007 panel, N* and red bars indicate individuals captured during pikeminnow hunting efforts.

From 2003 through 2007, fathead minnow was collected in all habitat types sampled in primary and secondary channels (Figure 21). Fathead minnow density was greatest in primary and secondary channel backwaters and other low-velocity habitats ($F_{(14, 1704)} = 2.88$, $p<0.001$ and $F_{(13, 379)} = 4.11$, $p<0.001$).

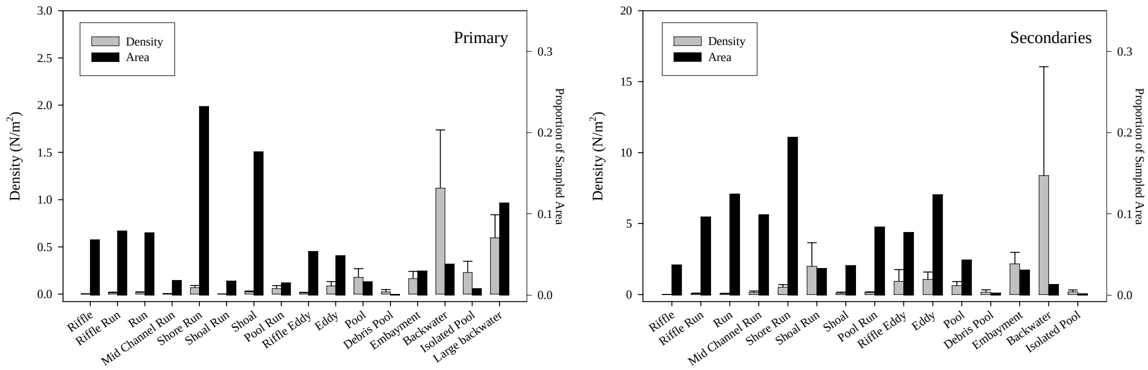

Figure 21. Density of fathead minnow and proportion of area sampled in various habitats from 2003 through 2007. Error bars represent 1 standard error.

COLORADO PIKEMINNOW

Colorado pikeminnow were collected each year from 2004 through 2007; 37 were found in the primary channel, 22 in secondary channels, and 21 in backwaters (Table 11). Age-0 Colorado pikeminnow were stocked just prior to the 2007 lower reaches sampling trip. Of the 16 Colorado pikeminnow captured in lower reach (Reaches 1-3) primary channel in 2007, eight were likely from this age-0 stocking. Of the 15 Colorado pikeminnow captured in secondary channels in 2007, two were age-0 individuals captured in Reach 3. Twenty-one Colorado pikeminnow were collected in large backwaters in 2007, 18 of these were age-0.

Table 11. Colorado pikeminnow captures by reach in autumn sampling of the San Juan River from 2004 through 2007, N* indicate individuals captured during Colorado pikeminnow hunts.

Channel	*Reach*	*2004*	*2005*	*2006*	*2007*	*Total*
Primary	6			2	5 + 1*	7+1*
	5	3		3	0 + 5*	6+5*
	4	1			1	2
	3		1	2	7 +1*	10+1*
	2		1	1	3	5
	1					0
Secondary	6			1	2	3
	5	3			7	10
	4	1	1		3	5
	3			1	3	4
Backwater	6					0
	5				1	1
	4					0
	3				17	17
	2				1	1
	1				2	2
Total		8	3	10	52 + 7*	73 + 7*

Colorado pikeminnow were captured in a variety of habitats in primary and secondary channels. Backwater and debris pool habitats were used most often by age-0 Colorado pikeminnow in 2007 ($F_{(14, 534)}$ =3.380, p<0.001) (Figure 22). Overall, age-1+ Colorado pikeminnow were not captured more frequently in any specific habitat type ($F_{(14, 1635)}$ =0.804, p<0.699). In secondary channels, shoal-run habitats had the greatest density of Colorado pikeminnow ($F_{(13, 499)}$ =3.96, p<0.0001).

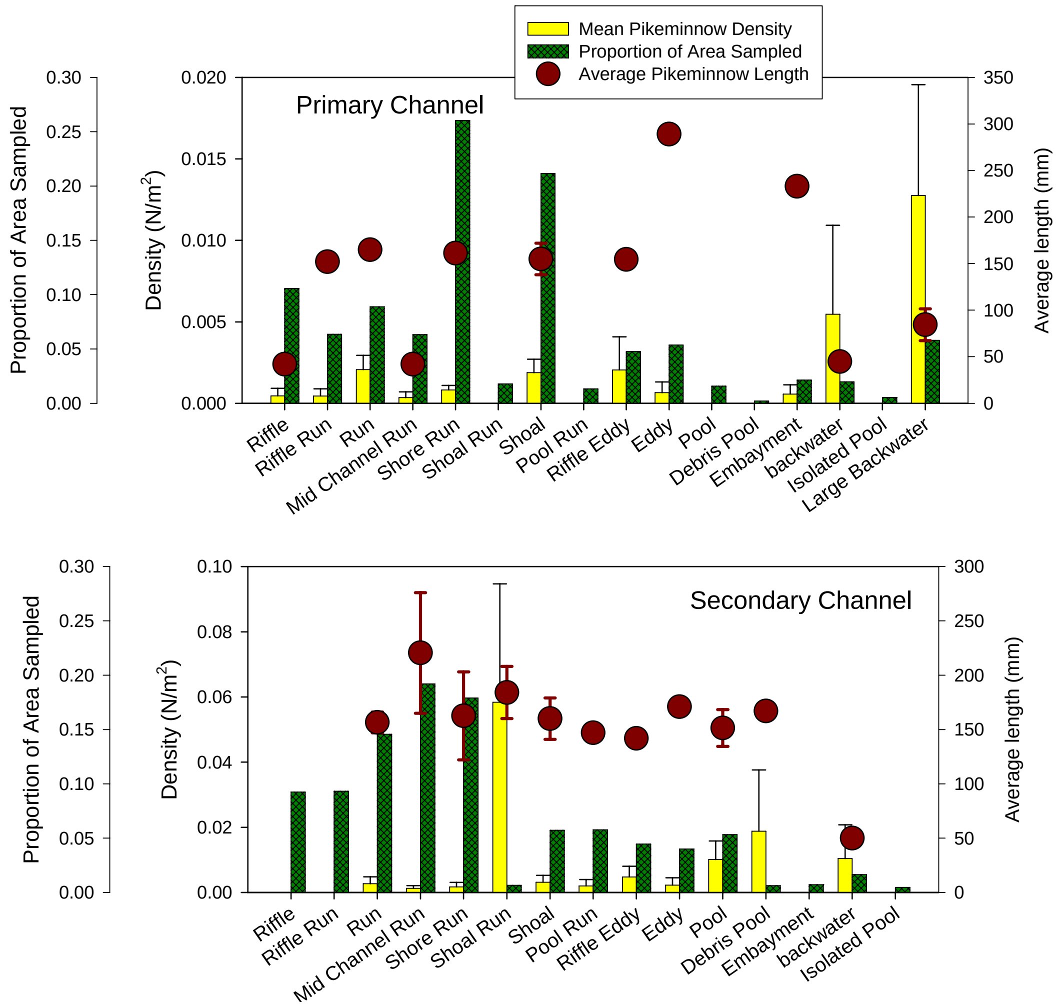

Figure 22. Proportion of area sampled, Colorado pikeminnow density, and mean total length of Colorado pikeminnow collected in San Juan River habitats from 2004 through 2007. Error bars represent 1 standard error.

The average total length of Colorado pikeminnow captured from 2004 through 2007 was 122 mm (SE 7.63) (Figure 22). Recently stocked age-0 Colorado pikeminnow were captured in 2007, most other individuals were likely age-1. Two individuals, likely age-2+, were captured in 2005 and 2006.

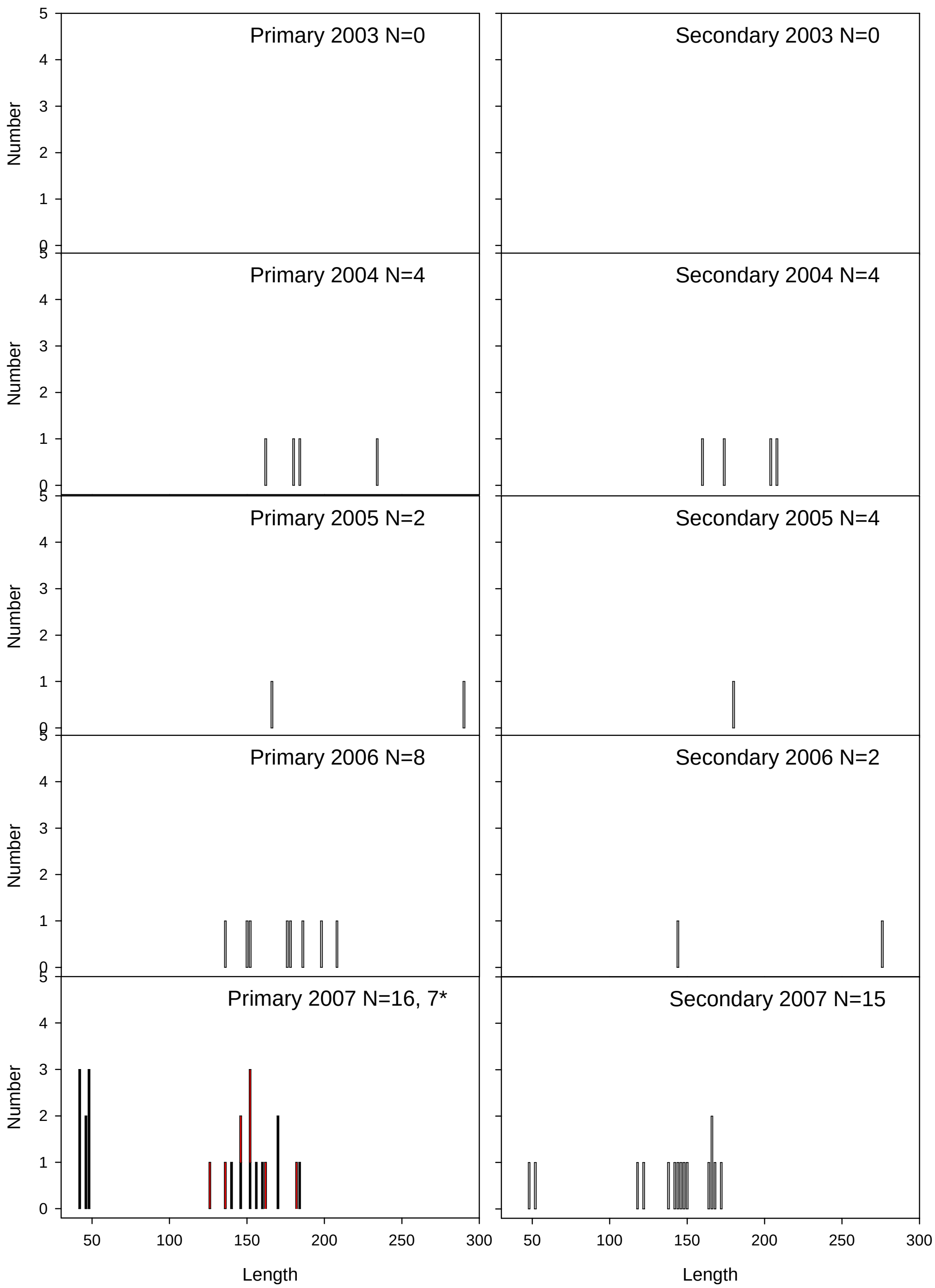

Figure 23. Length frequency of Colorado pikeminnow from San Juan River primary and secondary channels, 2003-2007. For primary 2007 panel, N* and red bars indicate individuals captured during Colorado pikeminnow hunts.

OTHER NATIVE FISHES

For the eighth consecutive year roundtail chub and mottled sculpin were not collected in small-bodied sampling of the San Juan River. Only one razorback sucker (403 mm TL) was collected in a shoal habitat in the primary channel in 2005.

REACH SUMMARY

In primary and secondary channels, from 2003 through 2007, densities of all common native species decreased in downstream reaches (primary: $r_{(2,1657)} > 0.110$, $p < 0.001$, secondary: ($r_{(2,512)} > 0.120$, $p < 0.006$). Colorado pikeminnow density did not change from 2004 through 2007 (primary: $r_{(2,1657)} > 0.013$, $p = 0.590$, secondary: ($r_{(2,1657)} > 0.026$, $p = 0.551$) (Figure 24). Numbers of individuals of each species captured in each reach are presented in Appendix I.

Nonnative fishes (Figure 25) were generally evenly distributed in the river, excluding Reach 6 where few nonnative fish were captured in 2006 and 2007. In the primary channel, red shiner densities decreased in downstream reaches ($r_{(2,1657)} = 0.078$, $p < 0.001$), but showed no pattern in secondary channels ($r_{(2,512)} = 0.055$, $p = 0.195$). Fathead minnow decreased in both channel types (primary: $r_{(2,1657)} = 0.067$, $p = 0.006$, secondaries: $r_{(2,512)} = 0.108$, $p = 0.014$). Channel catfish densities increased downstream in both channel types (primary: $r_{(2,1657)} = -0.150$, $p < 0.001$, secondaries: $r_{(2,512)} = -0.170$, $p < 0.001$), but were generally greatest in the middle reaches.

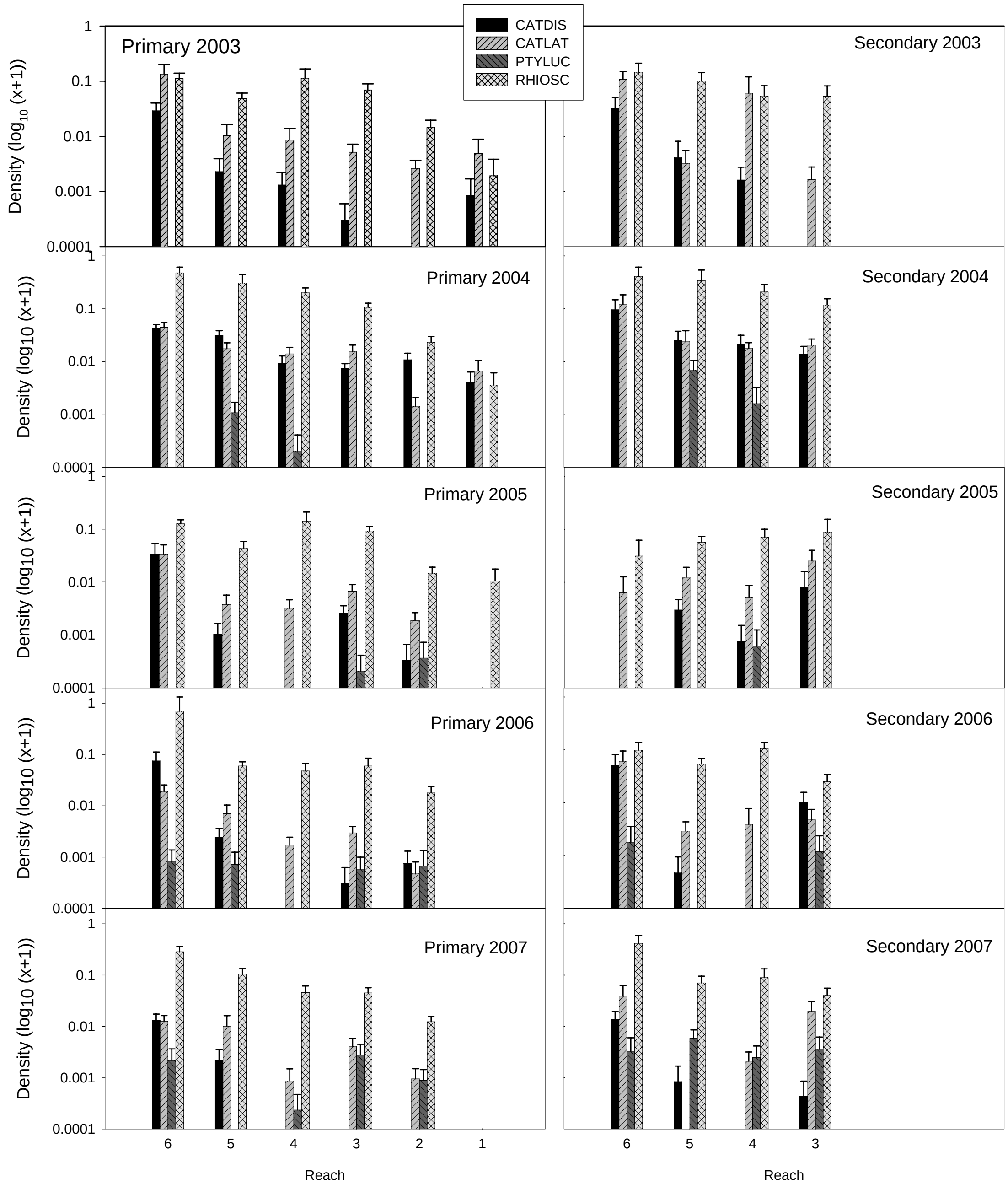

Figure 24. $Log_{10}(x+1)$ density of commonly collected native species and Colorado pikeminnow in the San Juan River, by reach, from 2003 through 2007.

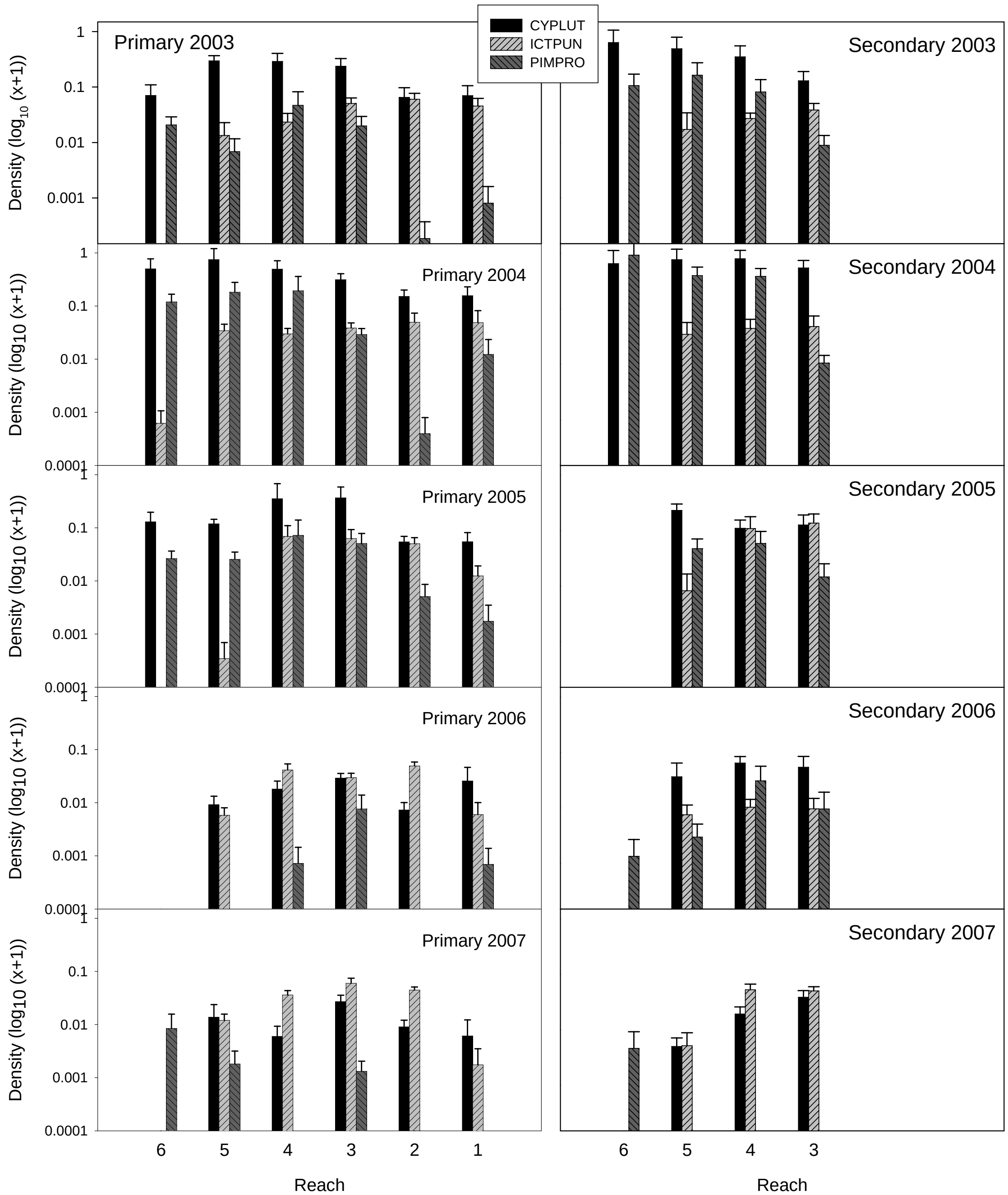

Figure 25. $Log_{10}(x+1)$ density of commonly collected nonnative species in the San Juan River, by reach, from 2003 through 2007.

DISCHARGE

Spring discharge at the Shiprock gage in 2007 exceeded 5000 cfs for 21 days (Table 14). Peak spring discharge in 2007 was greater than the historical (1935-2005) peak daily mean discharge during spring runoff, reaching over 9000 cfs. Duration of spring runoff in 2007, however, was briefer than historically (Figure 26). In 2007, discharge in late summer and autumn was characterized by large flow spikes.

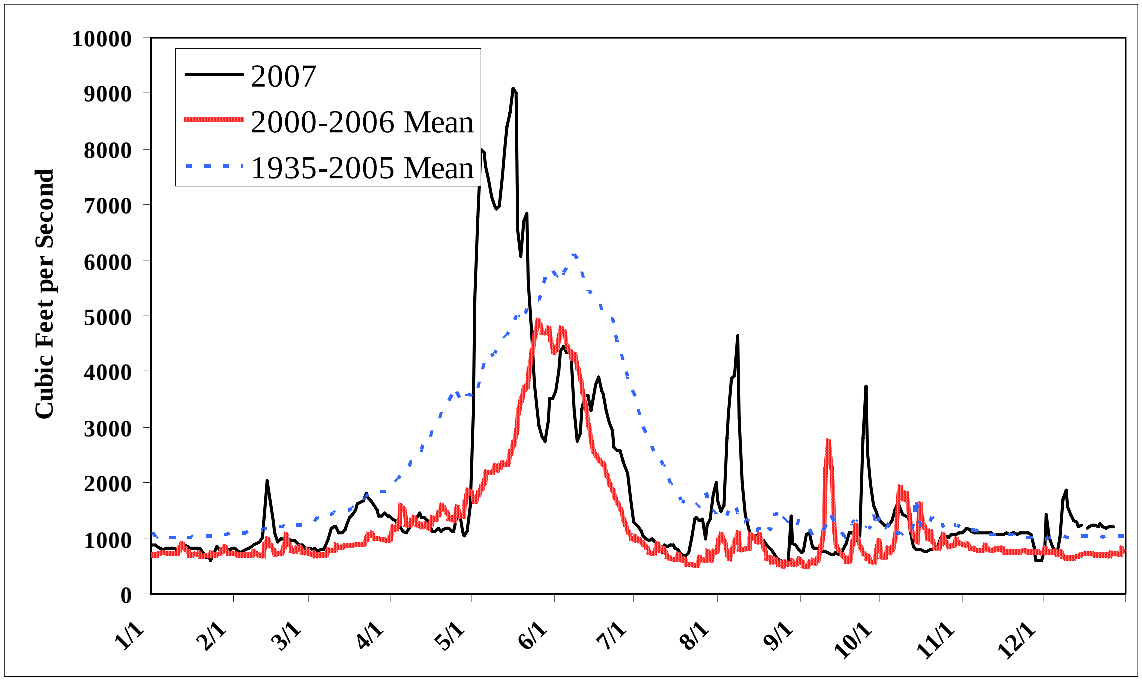

Figure 26. Mean daily discharge (cubic feet/second; cfs) of San Juan River for 2007, 2000-2006 mean, and 1935-2005 mean. Data from USGS Shiprock gage (#09368000).

Timing of spring runoff was similar over the past five years. In 2005, high discharge continued through late July while in 2003, 2004, and 2006 spring discharge was over in June (Figure 27). Discharge in 2007 was greatest in May. Magnitude of spring discharge and mean spring discharge were greatest in 2005 and 2007 (Table 12).

Summer discharge did not drop below 500 cfs in 2007, only the second year since 1999 this has not occurred (Table 13). The period from 2000 through 2004 had the greatest number of days below 500 cfs during the summer. Accordingly, average summer discharge was greater in 2005 through 2007 than the previous five years.

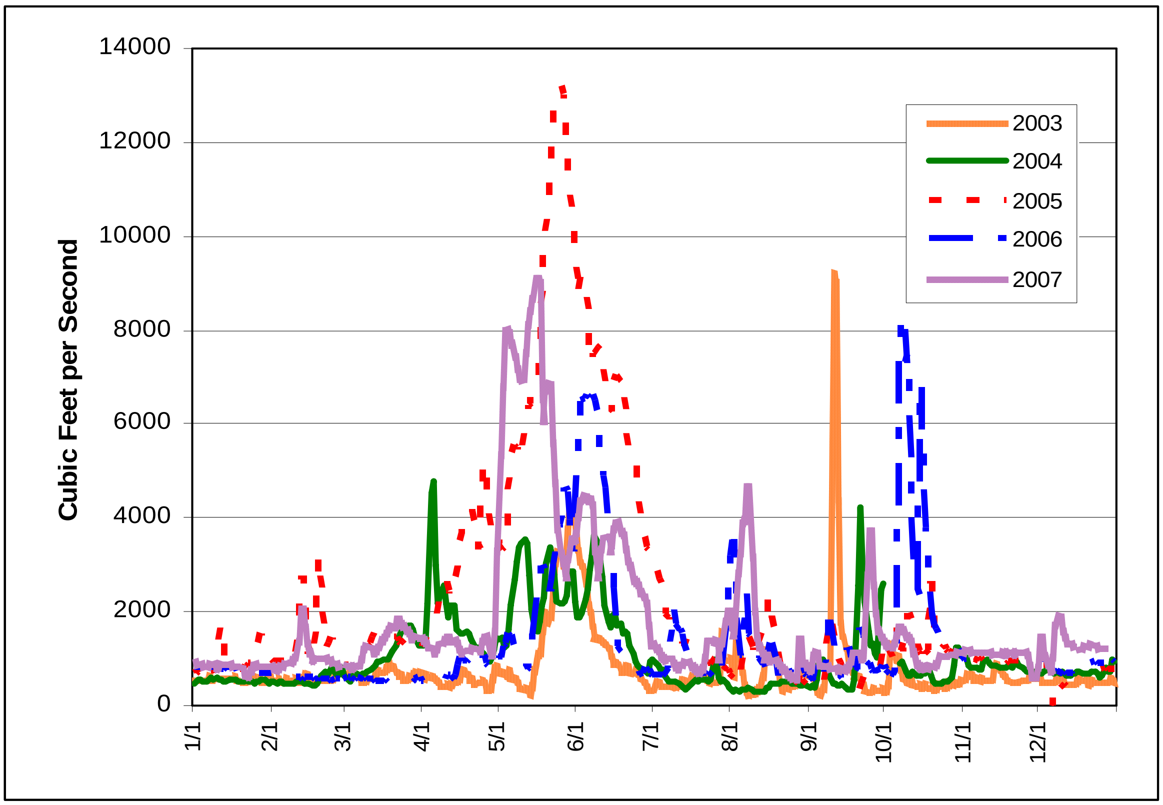

Figure 27. Mean daily discharge (cubic feet/second; cfs) of San Juan River for 2003-2007. Data from USGS Shiprock gage (#09368000).

Table 12. Mean daily discharge (cubic feet/second; cfs) of San Juan River during spring runoff and attributes of spring discharge, 1998 - 2007. Data from USGS Shiprock gage (#09368000).

					YEAR							
MONTH	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2000-2006 MEAN***	***1935-2005 MEAN***
March	1136	878	923	1029	664	654	1036	1277	538	1271	875	1568
April	1425	1160	1652	1384	533	532	1829	3026	760	1244	1388	2884
May	5250	3238	2311	4781	644	1621	2406	7983	2284	6050	3147	4772
June	3970	5876	2011	4760	433	1243	1836	6380	3136	3250	2828	5174
Mean (cfs) - Mar-June	2951	2777	1727	2988	570	1015	1778	4666	1675	2967	2060	3595
Days Q>3,000	48	41	18	47	0	9	14	76	23	48	-	-
Days Q>5,000	24	26	1	29	0	0	0	50	9	21	-	-
Days Q>8,000	0	0	0	1	0	0	0	18	0	5	-	-
Days Q>10,000	0	0	0	0	0	0	0	11	0	0	-	-

Table 13. Mean daily discharge (cubic feet/second; cfs) of San Juan River during summer and attributes of summer discharge, 1998 – 2007. Data from USGS Shiprock gage (#09368000).

					YEAR							
MONTH	***1998***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***	***2007***	***2000-2006 MEAN***	***1935-2005 MEAN***
July	1665	3116	326	690	358	575	585	1461	967	1054	709	2115
August	959	5731	602	1132	368	642	398	966	1196	1518	758	1321
September	644	4298	649	552	1126	1301	1120	684	904	1178	905	1214
Mean (cfs)- July-Sept	1094	4383	524	794	612	834	696	1041	1024	1251	789	1553
Days Q>5,000	0	31	0	0	2	2	0	0	0	0	-	-
Days Q>4,000	1	42	0	0	2	3	1	0	0	1	-	-
Days Q>3,000	1	72	0	0	2	3	1	1	2	6	-	-
Days Q>2,000	10	90	0	5	3	3	6	6	5	9	-	-
Days Q>1,000	36	92	1	18	7	12	11	41	33	41	-	-
Days Q<1,000	55	0	91	74	85	79	80	50	59	51	-	-
Days Q<750	42	0	80	61	80	67	70	40	36	13	-	-
Days Q<500	15	0	45	23	74	43	49	17	0	0	-	-

Mean daily discharge varied each year during annual monitoring (Table 14). During sampling in the upper reaches, discharge was highest in 2004, while in lower reaches highest discharge at time of sampling occurred in 2006. Discharge levels in 2007 were moderate, increasing during sampling of lower reaches. In 2006 discharge levels peaked to over 8000 cfs; 2002 and 2003 had low discharge during monitoring.

Table 14. Mean daily discharge at Shiprock USGS Gage (936800) at the time of small-bodied fish sampling for various reaches from 2000-2007.

			Mean Daily Discharge		
Year	*Sampling Dates*	*Reaches Sampled*	*Mean*	*Min*	*Max*
2000	October 2-10	4, 3, 2, 1	736	580	940
	October 16-20	6, 5, 4	806	745	872
2001	September 25 - October 3	4, 3, 2, 1	524	488	566
	October 10-11	5, 4	753	732	774
	October 23-25	6, 5	684	609	768
2002	September 20 - 29	4, 3, 2, 1	408	277	779
	October 7 - 11	6, 5, 4	557	523	639
2003	September 22 - 26	6, 5, 4	360	309	446
	October 6 - 14	4, 3, 2, 1	576	409	1020
2004	September 20 - 24	6, 5, 4	2710	1600	4220
	October 4 - 12	4, 3, 2, 1	815	619	987
2005	September 19-23	6, 5, 4	419	322	605
	October 3 - 12	4, 3, 2, 1	1165	912	1750
2006	September 18-22	6, 5, 4	1127	778	1650
	October 2-9	4, 3, 2, 1	3323	674	8310
2007	September 17-21	6, 5, 4	995	854	1090
	October 1-10	4, 3, 2, 1	1386	1230	1650

Autumn species densities from 2000 through 2007 were compared with several discharge attributes (Table 15). Densities of native species showed no relationship with spring or summer mean daily discharge or number of low-flow (<500 cfs) days during summer. There were, however, several density -- discharge correlations for nonnative species. Densities of red shiner and fathead minnow were negatively associated with elevated summer flows in primary and secondary channels (Figure 28). Densities of both species in secondary channels were positively correlated with the number of low-flow days; fathead minnow primary channel density was correlated positively with low-flow days.

Table 15. Regression analysis results for density of commonly collected fish species in the San Juan River primary and secondary channels versus average mean daily spring discharge, average mean daily summer discharge, and days mean daily summer discharge less than 500 cfs from 2000 through 2007. Shaded areas indicate significant relationship (p<0.10).

	Primary Channel					
	SPRING Q		***SUMMER Q***		***<500 CFS***	
	r	***p***	***r***	***p***	***r***	***p***
NATIVES						
CATDIS	0.108	0.838	0.114	0.830	-0.040	0.925
CATLAT	-0.413	0.308	-0.191	0.650	0.560	0.149
RHIOSC	-0.049	0.908	0.270	0.518	-0.212	0.483
NONNATIVES						
CYPLUT	-0.681	0.908	-0.828	0.011	0.607	0.111
ICTPUN	0.100	0.813	0.558	0.151	-0.145	0.732
PIMPRO	-0.410	0.313	-0.838	-0.009	0.808	0.015
	Secondary Channels					
	SPRING Q		SUMMER Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES						
CATDIS	-0.366	0.475	-0.345	0.503	0.455	0.257
CATLAT	-0.579	0.133	-0.215	0.610	0.540	0.167
RHIOSC	-0.013	0.976	0.138	0.744	0.007	0.986
NONNATIVES						
CYPLUT	-0.480	0.228	-0.913	0.002	0.824	0.012
ICTPUN	0.726	0.041	0.484	0.224	-0.252	0.546
PIMPRO	-0.473	0.237	-0.700	0.053	0.769	0.025

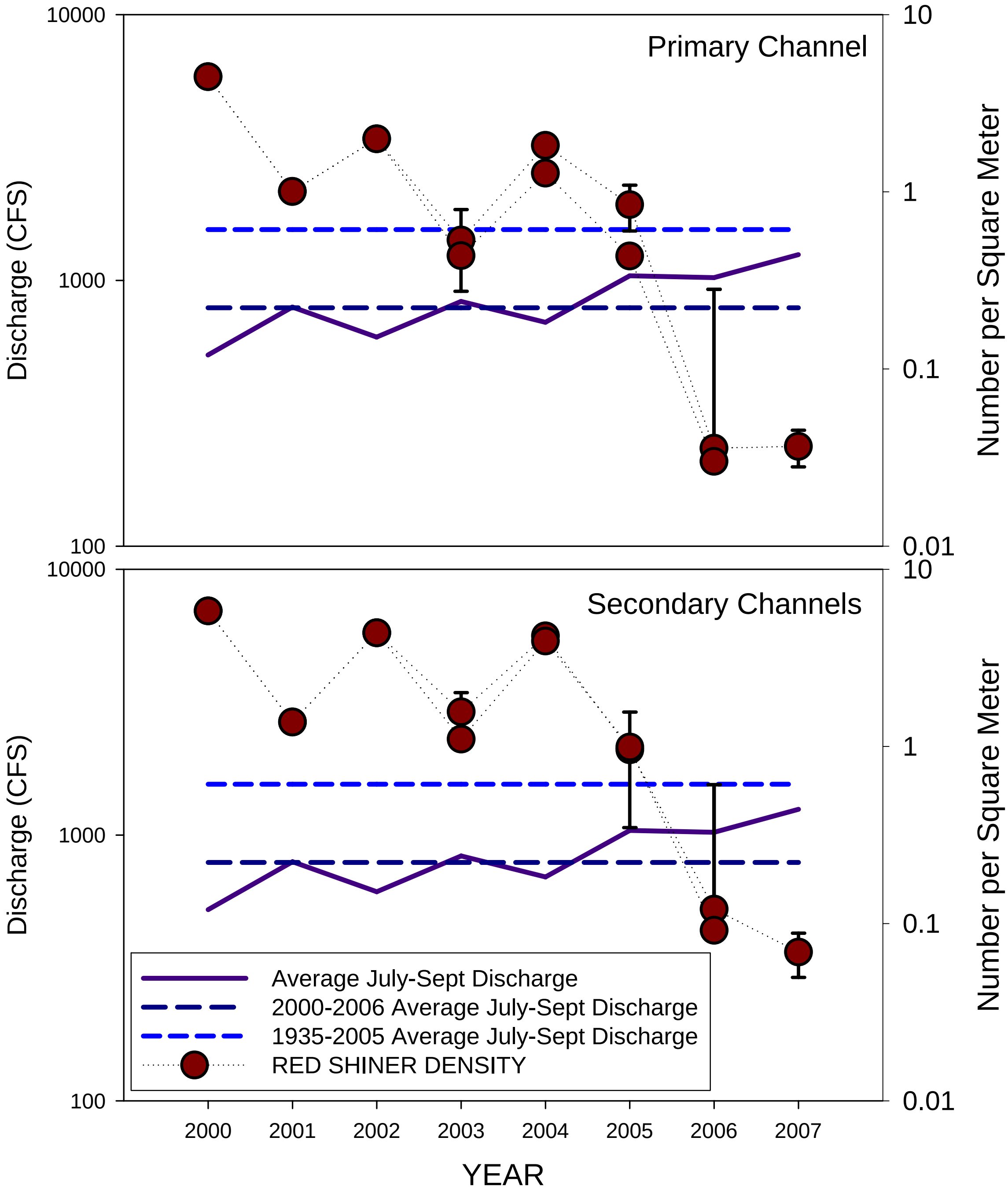

Figure 28. Relationship of density of red shiner collected during autumn sampling and summer average daily discharge measured at Shiprock Gage (#09368000), San Juan River. Note Y axes are log scale.

There was no correlation between mean daily discharge during sampling and density fishes collected in small-bodied sampling ($r<\pm0.27$, $p>0.17$). When analyzed by reach, however, there was a negative correlation between fish density in backwaters and discharge in Reach 3 ($r= -0.761$, $p=0.048$). Although not significant, r values were positive for discharge and fish density comparisons in both channel types in Reaches 6 and 5 and negative for Reaches 4 through 1. It was not possible to discern from our data if this was a consequence of sampling efficiency or the types of habitats available under various flow conditions (Figure 29).

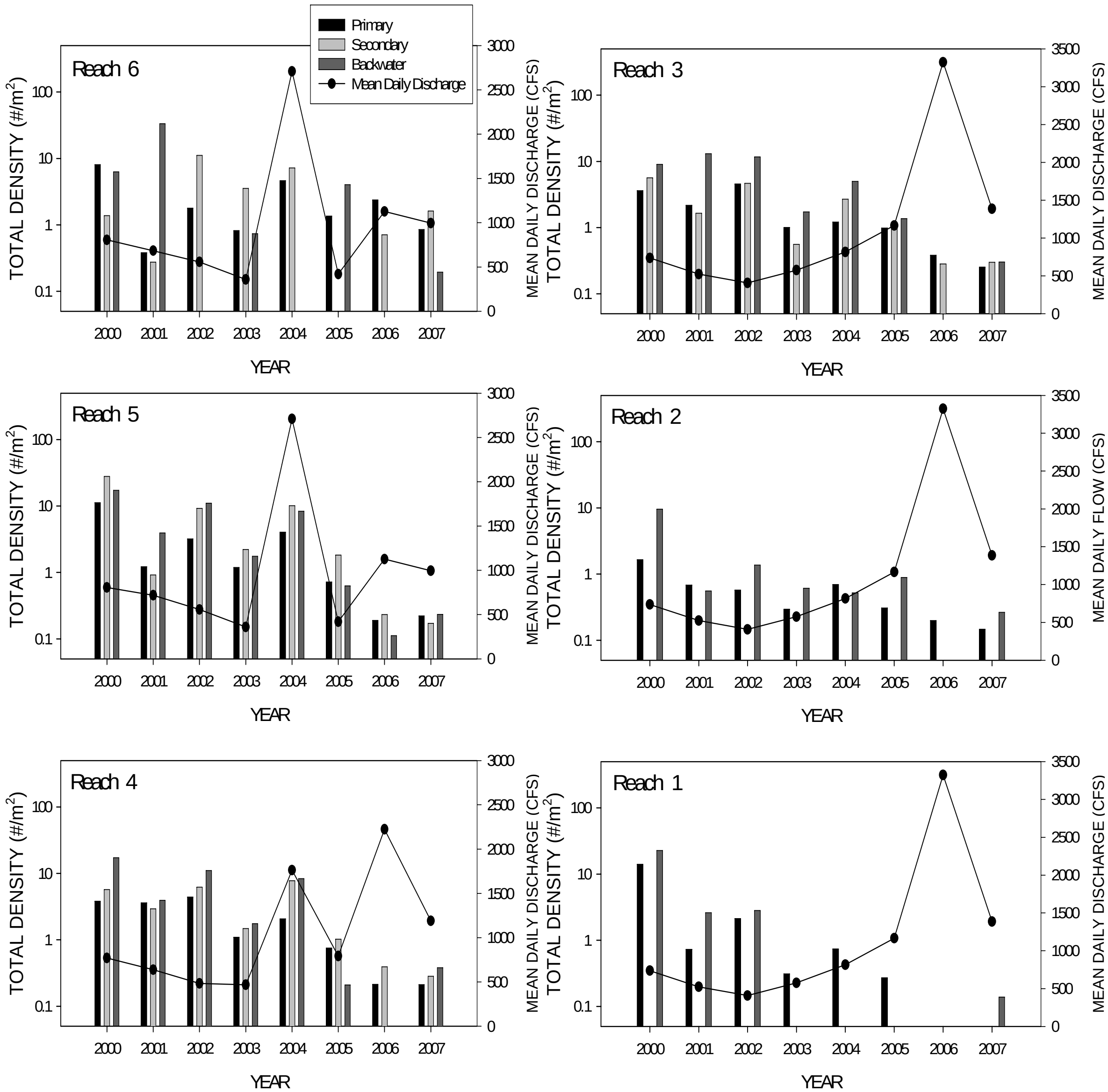

Figure 29. Mean daily discharge at Shiprock Gage (#09368000) during annual autumn sampling and total fish density in Reaches 6 through 1, San Juan River. Note log scale for density axis.

SUMMARY

FISHES

Collections in 2007 yielded the fewest species since autumn monitoring of San Juan River small-bodied fishes began in 1998. Few specimens of native roundtail chub and mottled sculpin have been collected since 1998. One adult razorback sucker was collected in 2005, likely one stunned by an electrofishing crew. In 2007, Colorado pikeminnow were captured for the fourth consecutive year. All were likely stocked individuals, including age-0 specimens collected in 2007. Collection of age-0 individuals indicated that sampling methods used in small-bodied fishes monitoring are sufficient to detect naturally spawned age-0 Colorado pikeminnow. More large backwater habitat was sampled in 2007 than in previous years. Although these habitats are numerically dominated by nonnative fishes, they also were used by recently stocked age-0 Colorado pikeminnow. Several nonnative species, moderately common during early years of this effort, were rare or absent in collections made in the past few years. Green sunfish and plains killifish were not collected and only a few (10 total, all species) common carp, yellow and black bullheads, and largemouth bass have been captured recently.

NATIVE FISHES TREND/RESPONSE TO FLOW REGIME

From 1998 through 2007, no native species or channel catfish density changed over time. For the term of this study (1998 through 2007) densities have remained comparatively constant, although flannelmouth sucker has declined over the past five years (2003-2007). Adult monitoring showed a similar decline in 2007, indicating that there is potentially a decrease in recruitment to the adult population (Ryden 08). Speckled dace densities generally have been stable in most reaches; Reach 6 consistently had the highest densities. Speckled dace was not collected in Reach 1 in 2006 or 2007, likely a consequence of the lack of riffle habitat and gravel substrate.

There was no relationship between native fish densities and spring mean daily discharge. Between 1998 and 2007, there was no relationship between individual native species density and spring mean daily discharge (except bluehead sucker in the primary channel); unlike Propst and Gido (2004) who found positive relationships with autumn native fish density and spring discharge from 1993 through 2001. Their work was accomplished during a comparatively wet period while data reported herein were from a comparatively dry period. Autumn density of native fishes was not related to summer discharge or number of low flow days.

NONNATIVE FISHES TREND/RESPONSE TO FLOW REGIME

Densities of red shiner and fathead minnow from 1998 through 2007 did not change appreciably. However, numbers of red shiner and fathead minnow in 2006 and 2007 were substantially lower than number found in 2005. Densities of both cyprinids were negatively related to summer discharge and positively related to the number of low-flow days (<500 CFS); 2006 and 2007 had comparatively high summer discharge levels characterized by large flow spikes and no low-flow days.

Channel catfish have been actively removed from the San Juan for seven years. However, age-0 channel catfish density has been stable, particularly in the primary channel. Channel catfish density in secondary channels was more variable.

MESOHABITAT USE

Most species did not segregate by mesohabitats, or at least not by our definitions of mesohabitats. More general (i.e., fewer) categories may yield more identifiable use patterns (Gido and Propst 1999). It was possible, perhaps likely, that location within the river channel and dynamics of habitat formation and deformation is as important to fish use and occurrence as the habitats themselves. Our efforts, not reported herein, to better characterize habitats based on depth and substrate have not yielded satisfactory or clarifying results to date. Although it is difficult to distinguish how mesohabitat use is affected by myriad confounding factors, such as flow, water clarity, diurnal use, and interspecific effects (Jackson et al. 2001), we will continue to collect depth and substrate data from sampled mesohabitats and continue efforts to develop a meaningful metric.

PIKEMINNOW HUNTS

Over the past few years, some have opined that small-bodied sampling was not collecting sufficient numbers of age-1 Colorado pikeminnow to be informative and that small-bodied sampling had failed to capture age-0 individuals (despite no evidence of Colorado pikeminnow spawning in all years since 1998, but one). It was suggested that other methods would yield greater numbers of Colorado pikeminnow. Electrofishing into a seine was attempted in 2004 and 2005 with little success (Paroz et al. 2006). The addition of bag/block methods and opportunistic Colorado pikeminnow hunts in 2007 did not significantly increase number of Colorado pikeminnow collected. Excluding sampling in addition to that identified in the monitoring protocol (Propst et al. 2001), over twice as many (24) age-1+ Colorado pikeminnow were captured in 2007 as in any preceding year. A particular reason for increased numbers of age-1+ Colorado pikeminnow in 2007 is not apparent, but it may be a consequence of enhanced survival of age-0 individuals stocked in 2006.

RECOMMENDATIONS

San Juan River small-bodied fishes monitoring has been conducted annually for 10 years. In 2002, fish collection methods were modified (sampling and recording data by mesohabitat) to enable more robust statistical analyses of data. Sufficient data are just now being accumulated to begin to obtain improved and broader insights into community dynamics, responses of fishes to management activities, and identifying population trends. It is also important that data be obtained over the range of environmental conditions individual fish species are likely to encounter over two or more generations (Stoddard et al. 2006). For example, the effects of extended low-flows during summer on nonnative fishes were not considered when flow recommendations were being developed. Based on small-bodied fishes monitoring data, it appears that red shiner and fathead minnow respond positively to diminished summer flows whereas common native fishes (e.g., speckled dace, flannelmouth sucker, and bluehead sucker) are not affected. The effects of extended low flows during summer on Colorado pikeminnow, however, remain uncertain.

Small-bodied and age-0 individuals of large-bodied species are an important component of the diet of Age-1+ Colorado pikeminnow (e.g., Franssen et al. 2007). In addition, there was evidence that relative availability of suitable-sized prey was a factor potentially influencing Colorado pikeminnow survival and recruitment. Data obtained on small-bodied fishes abundance and distribution provide a direct measure of food availability and thus an indirect estimate of survival potential of stocked age-0 and wild-spawned Colorado pikeminnow. However, an intensive investigation of possible linkages among availability of suitable prey and recruitment of stocked Colorado pikeminnow into the adult population has not been accomplished.

In addition to tracking population trends across an array of environmental conditions, long-term data sets are essential for assessing relative importance of species density changes in a single year or a brief series of years and placing such changes in appropriate context. Thus, changes in monitoring protocols and implications of changes should be carefully considered before being made. We recommend that small-bodied monitoring be continued as originally designed to maintain integrity of the dataset. Additional sampling to provide data for specific questions can be added, if necessary. Suggestions from peer-reviewers and biology committee on alternative analytical approaches or graphical presentation of data would be helpful to improve, refine, and condense future reports.

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Appendix I. Number of fish collected by reach in San Juan River primary and secondary channels, 2003-2007.

Channel	Reach	Species	2003	2004	2005	2006	2007	Grand Total
1	6	CATDIS	20	88	45	121	44	318
		CATLAT	76	106	49	32	82	345
		CYPCAR		1				1
		CYPLUT	55	2518	186			2759
		FUNZEB		2	1			3
		GAMAFF	19	36	2		1	58
		ICTPUN		2			1	3
		LEPCYA		1				1
		MICSAL		3				3
		PIMPRO	12	302	54		26	394
		PTYLUC				2	6	8
		RHIOSC	101	1714	268	1660	1452	5195
		Total	283	4773	605	1815	1612	9088
		Area Sampled	414.18	1087.38	911	869.5	1894.77	
	5	CATDIS	2	92	3	6	8	111
		CATLAT	12	36	6	12	18	84
		CYPCAR		3				3
		CYPLUT	362	3029	291	16	21	3719
		FUNZEB		3				3
		GAMAFF	15	40	8		6	69
		ICTPUN	14	84	1	17	38	154
		MICSAL		1				1
		PIMPRO	7	299	49		2	357
		PTYLUC		3		3	5	11
		RHIOSC	43	1250	63	138	224	1718
		XYRTEX			1			1
		Total	455	4840	422	192	322	6231
		Area Sampled	436.64	1375.39	954	1097.06	1454.82	
	4	AMEMEL		1				1
		CATDIS	2	19				21
		CATLAT	5	34	6	5	83	133
		CYPLUT	364	1980	232	28	17	2621
		FUNZEB	4	17				21
		GAMAFF		26				26
		ICTPUN	36	109	80	85	92	402
		LAT DIS	1					1
		LEPCYA	1					1
		PIMPRO	32	405	23	2		462
		PTYLUC		1			1	2
		RHIOSC	116	605	169	83	108	1081
		Total	561	3197	510	203	301	4772

	Area Sampled	569.54	1562.56	823	982.26	1427.12	
3	AMEMEL			1	3		4
	CATDIS	1	36	9	1	1	48
	CATLAT	12	53	20	11	36	132
	CYPCAR		2				2
	CYPLUT	689	1462	889	74	80	3194
	FUNZEB	12	3				15
	GAMAFF	2	7	2	4		15
	ICTPUN	117	186	145	101	252	801
	MICSAL					1	1
	PIMPRO	45	114	91	28	4	282
	PTYLUC			1	2	8	11
	RHIOSC	141	570	337	193	132	1373
	Total	1019	2433	1495	417	514	5878
	Area Sampled	1090.88	2066.71	1639.8	1289.4	2027.12	
2	AMEMEL		1				1
	CATDIS		31	1	2		34
	CATLAT	8	5	6	2	3	24
	CYPCAR			2			2
	CYPLUT	132	510	207	20	31	900
	FUNZEB	4					4
	GAMAFF	1	5	1			7
	ICTPUN	162	127	167	109	203	768
	LEPCYA	1		1			2
	PIMPRO	1	1	13			15
	PTYLUC			1	1	3	5
	RHIOSC	30	65	46	45	43	229
	Total	339	745	446	179	283	1992
	Area Sampled	1081.41	1400.27	1470.16	960.58	1932.85	
1	CATDIS	1	3				4
	CATLAT	2	4				6
	CYPCAR			1			1
	CYPLUT	76	130	40	6	3	255
	FUNZEB	1					1
	ICTPUN	36	35	4	2	1	78
	PIMPRO	1	9	2	1		13
	RHIOSC	2	2	4			8
	Total	119	183	51	9	4	366
	Area Sampled	400.94	275.88	187	247.1	202.4	
6	AMEMEL				1		1
	CATDIS	18	46		42	11	117
	CATLAT	66	48	1	47	34	196
	CYPCAR	2	1				3
	CYPLUT	540	265				805
	FUNZEB		4				4
	GAMAFF	21	36			1	58
	MICSAL	1	3				4
	PIMPRO	60	634		1	4	699

		PTYLUC				1	2	3
		RHIOSC	63	295	3	49	569	979
		Total	771	1332	4	141	621	2869
		Area Sampled	204.1	198.88	60	218.58	384.21	
	5	AMEMEL	2	2	1	2		7
		CATDIS	3	19	3	1	1	27
		CATLAT	3	15	15	4		37
		CYPCAR		7				7
		CYPLUT	425	1692	247	25	5	2394
		FUNZEB	3	5				8
		GAMAFF	4	60	18			82
		ICTPUN	16	9	2	10	5	42
		LEPCYA		1				1
		MICSAL		1				1
		PIMPRO	149	484	45	3		681
		PTYLUC		3			7	10
		RHIOSC	64	298	48	54	63	527
		Total	669	2596	379	99	81	3824
		Area Sampled	313.21	277.01	444	466.21	474	
	4	AMEMEL	4	3	2	1		10
		AMENAT			1			1
		CATDIS	2	29	1			32
		CATLAT	48	26	3	3	4	84
		CYPCAR		2				2
		CYPLUT	449	3893	98	65	37	4542
		FUNZEB	7	17				24
		GAMAFF	4	39	2	3		48
		ICTPUN	29	53	54	18	94	248
		MICSAL		1				1
		PIMPRO	100	1055	40	13		1208
		PTYLUC		1	1		3	5
		RHIOSC	40	557	45	92	94	828
		Total	683	5676	247	195	232	7033
		Area Sampled	496.71	763.31	348	565.55	823.56	
	3	AMEMEL	3					3
		CATDIS		17	3	10	1	31
		CATLAT	2	29	5	4	25	65
		CYPLUT	162	1166	54	44	67	1493
		FUNZEB	1					1
		GAMAFF	3	4		1		8
		ICTPUN	34	38	48	12	100	232
		PIMPRO	11	18	8	8		45
		PTYLUC				1	3	4
		RHIOSC	37	164	43	20	58	322
		Total	253	1436	161	100	254	2204
		Area Sampled	467.16	574.21	157	428.78	847.6	
BKW	6	CATDIS			27			27
		CATLAT	2		43		1	46

	CYPLUT	18		40			58
	FUNZEB	1					1
	GAMAFF	5		16			21
	PIMPRO	108		39			147
	RHIOSC			9		2	11
	Total	134		174		3	311
	Area Sampled	30	0	192	0	15.4	
5	CATDIS	2	2				4
	CATLAT	4		1			5
	CYPCAR		2			1	3
	CYPLUT	81	257	46	3	3	390
	FUNZEB			3			3
	GAMAFF	4	3	4			11
	ICTPUN		1	1		1	3
	PIMPRO	111	36	18	2		167
	PTYLUC					1	1
	RHIOSC	1	6	2	1	12	22
	Total	203	307	75	6	18	609
	Area Sampled	59.5	37.4	218	53.46	77	
4	AMEMEL	11					11
	AMENAT					1	1
	CATDIS	1				1	2
	CATLAT					1	1
	CYPLUT	121		3		16	140
	ICTPUN					17	17
	PIMPRO	16		1			17
	RHIOSC	2				12	14
	Total	151		4		48	203
	Area Sampled	61.16	0	19	0	126.5	
3	AMEMEL	1					1
	CATLAT		1			2	3
	CYPCAR		1	1			2
	CYPLUT	63	752	10		33	858
	FUNZEB		22				22
	GAMAFF	11	8				19
	ICTPUN	2	8			3	13
	PIMPRO	3	273	2		11	289
	PTYLUC					17	17
	RHIOSC	1	4			4	9
	Total	81	1069	13		70	1233
	Area Sampled	47.5	218.9	10	0	231.66	
2	CYPLUT	15	5	31		5	56
	ICTPUN	8				7	15
	LEPCYA	1					1
	MICSAL			2			2
	PIMPRO	1	2	11			14
	PTYLUC					1	1
	Total	25	7	44		13	89

	Area Sampled	33.02	15.4	50	0	49.06	
1	CYPLUT					1	1
	ICTPUN					28	28
	PTYLUC					2	2
	Total	0	0	0	0	31	31
	Area Sampled	0	0	0	0	223.3	