SMALL-BODIED FISHES MONITORING, SAN JUAN RIVER

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EXECUTIVE SUMMARY

Autumn monitoring of shallow water habitats targeting small-bodied fishes was conducted on the San Juan River for the ninth year in 2006. The primary objectives of this ongoing monitoring are to characterize and track changes in assemblages of small-bodied fishes and young-of-year of large-bodied fishes, including razorback sucker and Colorado pikeminnow. A total of 3,788 fishes were collected in 2006. For the first time since 1998, over 50% of the fishes collected were native. Reach 6 near the Animas River confluence had the highest densities of native fishes and lowest densities of nonnatives. Densities of commonly collected native species, including bluehead sucker, flannelmouth sucker, and speckled dace, are on an increasing trend from 2000 through 2006. Nonnative red shiner and fathead minnow densities decreased during this same period while channel catfish densities remained generally stable. Colorado pikeminnow was the only other native species collected in 2006; ten age 1+ were collected, the most in the tenure of small-bodied sampling. No young of year Colorado pikeminnow, razorback sucker, or roundtail chub was collected by small- bodied fish monitoring from 2000 through 2006, though these species are occasionally found in larval fish surveys. Recommendations include an adjustment in sampling methodology that could be made to target sampling more age 1+ Colorado pikeminnow-occupied mesohabitats in future years without compromising the integrity of the long-term data set.

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INTRODUCTION

Monitoring of small-bodied fishes in the San Juan River was initiated following completion of the San Juan River Seven Year Research Program in 1997. This effort was a consequence of the San Juan River Basin Recovery Implementation Program Biology Committee recognizing the need to monitor San Juan River fish assemblages to document responses of fishes to various management activities intended to improve the status of federally- and state-protected Colorado Pikeminnow *Ptychocheilus lucius* and razorback sucker *Xyrauchen texanus* and minimally maintain other native fishes populations. Accordingly, autumn sampling of San Juan River small- and large-bodied fishes began in 1998, following procedures used during the Seven Year Research Program. In 1999, autumn sampling of fish assemblages followed procedures detailed in the draft San Juan River Monitoring Plan and Protocols. Beginning in 2000, autumn fish assemblage monitoring followed the protocols detailed in the San Juan Monitoring Plan and Protocols (Propst et al. 2000). Starting in 2003, sampling occurred by mesohabitat (e.g., riffle, riffle eddy, run, and pool) at each study site and data were recorded by mesohabitat. Seining was the primary collection method, but electrofishing was added in 2004 and 2005 to evaluate efficacy of this method as part of overall monitoring of small-bodied fishes.

In 1998, primary and secondary channels sampling was limited to Reaches 5 through 2. In 1999, autumn monitoring of the primary channel was extended upstream to Reach 6, the confluence of San Juan and Animas rivers near Farmington, and downstream to Clay Hills Crossing. Also beginning in 1999, large backwaters, as a distinct habitat, were sampled from Farmington to Clay Hills.

Autumn sampling of small-bodied fishes in San Juan River primary and secondary channels, as well as backwaters and embayments, was conducted to aid in characterization and quantification of responses of native and nonnative fishes to flow regimes designed to mimic a natural flow regime. Specific objectives of this monitoring effort include:

- documenting occurrence of protected species (i.e., roundtail chub, Colorado pikeminnow, and razorback sucker), particularly age-0 individuals,
- characterizing mesohabitats occupied by protected species and other small-bodied fishes,
- determining effects of different flow regimes on autumn densities of commonly collected native and nonnative species,
- comparing densities of commonly-collected species among primary and secondary channels.

Data collected are used to characterize long-term trends in status (abundance, population size-structure, and recruitment) of individual species.

METHODS

In 1998, autumn monitoring of shallow water habitats targeting small-bodied fishes in 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 compensate, beginning in 2000, all secondary channels longer than 200 m having surface water were sampled. All backwaters (greater than 50 m^2), regardless of occurrence within designated miles, were sampled.

Beginning in 2000, 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 six miles.

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 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 if depths were conducive to seining. Secondary channel sampling was across the breadth of the wetted channel. All mesohabitats within each site were sampled and sampled area of each was roughly proportional to its total area within a site. Because of their comparatively small surface area, some mesohabitats (e.g., debris pools and riffle eddys) were sampled in greater proportion than their availability. Normally, at least five seine hauls were made at each sample site; however, if habitat was homogeneous, fewer seine hauls were made. All 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. Haphazardly selected individuals ($\geq$ 50) of speckled dace 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, 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 stored in the NMGF Collection of Fishes and transferred to UNM-MSB, 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 designated as 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). Total reach densities (number of fish per m^2) were determined by dividing total number of specimens by total area sampled within a reach. These 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 2006.

Mesohabitats were grouped into thirteen 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. For each mesohabitat class the percent composition of each species was plotted alongside the percent contribution of total sampled area to provide a crude estimate of habitat use patterns of each species.

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 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 density estimate of 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. Adult Monitoring catch-per-unit-effort summary data were provided by Dale Ryden (Ryden 2006). These data were plotted with small-bodied fishes mean densities and correlated with 0 to 3 years time lag, depending on the species. Length frequency histograms were used to determine mean lengths for various age cohorts of commonly collected species. Regression, correlation, and ANOVA analyses were performed using STATISTICA® software. Probability values of <0.10 were considered significant.

RESULTS

DISCHARGE

Spring discharge at the Shiprock gage in 2006 exceeded 5000 cfs for 9 days (Table 1). Peak spring discharge in 2006 was slightly greater than the historical (1935-2005) peak daily mean discharge during spring runoff, but duration of runoff was briefer than the historical pattern (Figure 1). In 2006, discharge in late summer and fall was characterized by large flow spikes; the largest occurred during the fall monitoring trip.

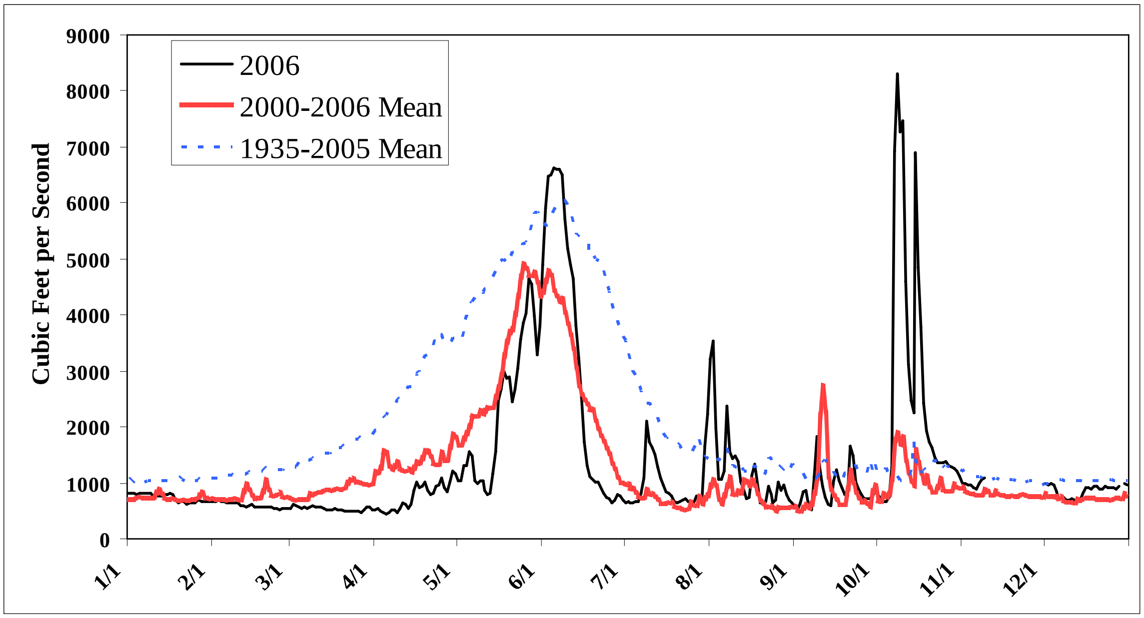


Figure 1. Mean daily discharge (cubic feet/second; cfs) of San Juan River for 2006, 2000-2006 mean, and 1935-2005 mean. Data from USGS Shiprock gage (#09368000).

Timing of spring runoff for the past four years has been similar. In 2005 high discharge levels continued through late July while in 2003, 2004, and 2006 spring discharge was over in June (Figure 2). Magnitude of peak spring discharge was greatest in 2005 and 2006, although average daily spring discharge was highest in 2004 and 2005 (Table 1).

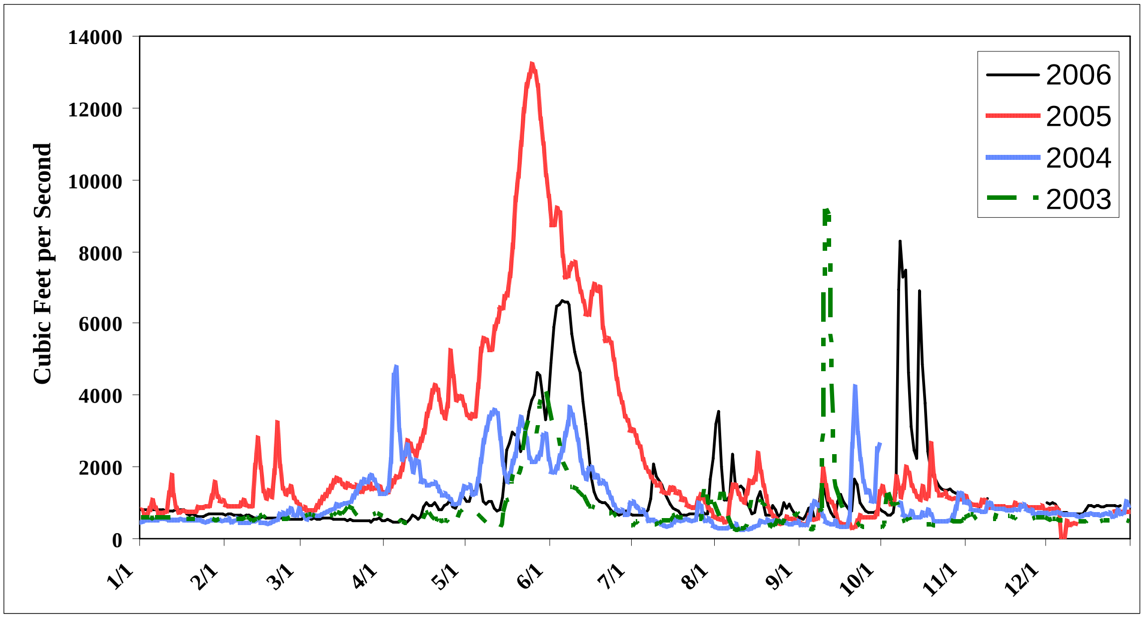


Figure 2. Mean daily discharge (cubic feet/second; cfs) of San Juan River for 2003-2006. Data from USGS Shiprock gage (#09368000).

Summer discharge did not drop below 500 cfs in 2006, the first year since 1999 this has not occurred (Table 2). 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 and 2006 than the previous five years.

Table 1. Mean daily discharge (cubic feet/second; cfs) of San Juan River during spring runoff and attributes of spring discharge, 1998 - 2006. Data from USGS Shiprock gage (#09368000).

	YEAR										
MONTH	1998	1999	2000	2001	2002	2003	2004	2005	2006	2000-2006	1935-2005
March	1136	878	923	1029	664	654	1036	1277	538	875	1568
April	1425	1160	1652	1384	533	532	1829	3026	760	1388	2884
May	5250	3238	2311	4781	644	1621	2406	7983	2284	3147	4772
June	3970	5876	2011	4760	433	1243	1836	6380	3136	2828	5174
Mean (cfs) – Mar-June	2951	2777	1727	2988	570	1015	1778	4666	1675	2060	3595
Days Q>3,000	48	41	18	47	0	9	14	76	23	27	74
Days Q>5,000	24	26	1	29	0	0	0	50	9	0	30
Days Q>8,000	0	0	0	1	0	0	0	18	0	0	0
Days Q>10,000	0	0	0	0	0	0	0	11	0	0	0

Table 2. Mean daily discharge (cubic feet/second; cfs) of San Juan River during summer and attributes of summer discharge, 1998 – 2006. Data from USGS Shiprock gage (#09368000).

	YEAR										
MONTH	1998	1999	2000	2001	2002	2003	2004	2005	2006	2000-2006	1935-2005
July	1665	3116	326	690	358	575	585	1461	967	709	2115
August	959	5731	602	1132	368	642	398	966	1196	758	1321
September	644	4298	649	552	1126	1301	1120	684	904	905	1214
Mean (cfs)-July-Sept	1094	4383	524	794	612	834	696	1041	1024	789	1553
Days Q>5,000	0	31	0	0	2	2	0	0	0	0	0
Days Q>4,000	1	42	0	0	2	3	1	0	0	0	0
Days Q>3,000	1	72	0	0	2	3	1	1	2	0	3
Days Q>2,000	10	90	0	5	3	3	6	6	5	3	13
Days Q>1,000	36	92	1	18	7	12	11	41	33	12	92
Days Q<1,000	55	0	91	74	85	79	80	50	59	80	0
Days Q<750	42	0	80	61	80	67	70	40	36	52	0
Days Q<500	15	0	45	23	74	43	49	17	0		
Number of Q Spikes	4	1	1	1	1	4	1	4	3		
Spike Duration	37	92	7	18	13	12	4	22	19		
Spike Mean (CFS)	1802	4333	850	1596	2130	2645	2988	1389	1806		

Mean daily discharge varied each year during annual autumn monitoring (Table 3). The highest discharge occurred during sampling of lower reaches in 2006; discharge spiked to over 8000 cfs during several days. Discharge was also comparatively high during upper reach sampling in 2004.

Table 3. Mean daily discharge at Shiprock USGS Gage (936800) at the time of small bodied fish sampling for various reaches from 2000-2005.

			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

PRIMARY CHANNEL SUMMARY

Four native and six nonnative species were collected in the primary channel of the San Juan River in 2006 (Table 4). No young-of-year Colorado pikeminnow or razorback sucker have been collected during small-bodied monitoring since 1998. Stocked Colorado pikeminnow were collected in 2004, 2005, and 2006 and a single razorback sucker adult was captured in 2005. Roundtail chub and mottled sculpin have not been collected since 1999.

Table 4. Species collected during small-bodied monitoring in San Juan River primary channel during autumn, 1998-2005. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	SCIENTIFIC	CODE	STATUS	1998	1999	2000	2001	2002	2003	2004	2005	2006
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	
Roundtail chub	*Gila robusta*	GILROB	N	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	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	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	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		
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	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
NONNATIVE			9	5	5	6	6	7	6	9	8	6

For the first time since 1998, native fishes numerically dominated collections in 2006 (Table 5). Speckled dace was over seven times as common as the next most abundant species, channel catfish. Red shiner was the most common species collected from 1998 through 2005, while in 2006 it was third-most common. In 2006, total fish density was second lowest during the study, with 1999 being the lowest.

Table 5. Fishes collected in San Juan River primary channel during autumn inventories, 1998 – 2006. Geomorphic Reaches 6 and 1 not sampled in 1998.

1998		1999		2000		2001		2002		2003		2004		2005		2006	
Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	590	CYPLUT	1071	CYPLUT	20114	CYPLUT	3102	CYPLUT	7124	CYPLUT	1715	CYPLUT	9924	CYPLUT	2497	RHIOSC	2401
RHIOSC	461	RHIOSC	395	GAMAFF	1025	RHIOSC	342	PIMPRO	1116	RHIOSC	511	RHIOSC	4690	RHIOSC	1234	ICTPUN	336
ICTPUN	187	PIMPRO	48	PIMPRO	1490	PIMPRO	136	RHIOSC	533	ICTPUN	366	PIMPRO	1119	ICTPUN	401	CYPLUT	164
PIMPRO	32	CATLAT	8	RHIOSC	161	GAMAFF	59	ICTPUN	231	CATLAT	142	ICTPUN	597	PIMPRO	281	CATDIS	153
CATLAT	8	ICTPUN	8	CATLAT	33	CATLAT	20	GAMAFF	165	PIMPRO	90	CATDIS	284	CATLAT	111	CATLAT	62
PTYLUC	4	GAMAFF	6	ICTPUN	35	CATDIS	8	CATLAT	141	GAMAFF	37	CATLAT	254	CATDIS	90	PIMPRO	44
CATDIS	5	CATDIS	3	CATDIS	18	ICTPUN	13	CATDIS	61	CATDIS	28	GAMAFF	129	GAMAFF	16	PTYLUC	8
GAMAFF	2	CYPCAR	1	CYPCAR	8	FUNZEB	3	CYPCAR	23	FUNZEB	21	FUNZEB	29	CYPCAR	3	GAMAFF	4
GILROB	1	GILROB	1	FUNZEB	3	CYPCAR	1	FUNZEB	15	LEPCYA	2	CYPCAR	6	PTYLUC	2	AMENAT	3
FUNZEB	1	LATDIS	1			MICSAL	1	AMEMEL	4	LATDIS	1	MICSAL	4	AMEMEL	1	AMEMEL	3
		LEPCYA	1									PTYLUC	4	FUNZEB	1		
		COTBAI	1									AMEMEL	2	LEPCYA	1		
												LEPCYA	1	XYRTEX	1		
TOT N	1291		1544		22887		3685		9413		2913		17042		4639		3175
AREA	1601		4883		4510		3091		3564		3935		7787		5975		5446
DENSITY	0.81		0.32		5.07		1.19		2.64		0.74		2.19		0.78		0.58

Area sampled in the primary channel was divided among 13 mesohabitats (Table 6). From 2003 through 2006, shore run and shoal mesohabitats were the most commonly sampled, comprising nearly 50% of the sampled area. Slow-velocity (pool, embayments, backwaters) habitats were not common in fall sampling from 2003 through 2006, comprising less than 10% of area sampled. Commonly collected fish species were distributed among mesohabitats in proportions similar to the amount of habitat sampled.

Generally, fathead minnow was collected more often in slow water habitats and speckled dace in habitats with higher velocities, other species were not collected disproportionally in specific habitats.

Table 6. Area sampled per mesohabitat (m^2) in San Juan River primary and secondary channels during autumn monitoring, 2006. 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	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
Primary Total		2426	1610	2067	1585	6046	5249	303	1105	1096	447	645	436	124	23139
Percent of Habitat Sampled		10%	7%	9%	7%	26%	23%	1%	5%	5%	2%	3%	2%	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
Secondary Total		545	456	700	1311	1165	352	367	251	238	481	61	70	41	6036
Percent of Habitat Sampled		9%	8%	12%	22%	19%	6%	6%	4%	4%	8%	1%	1%	1%	

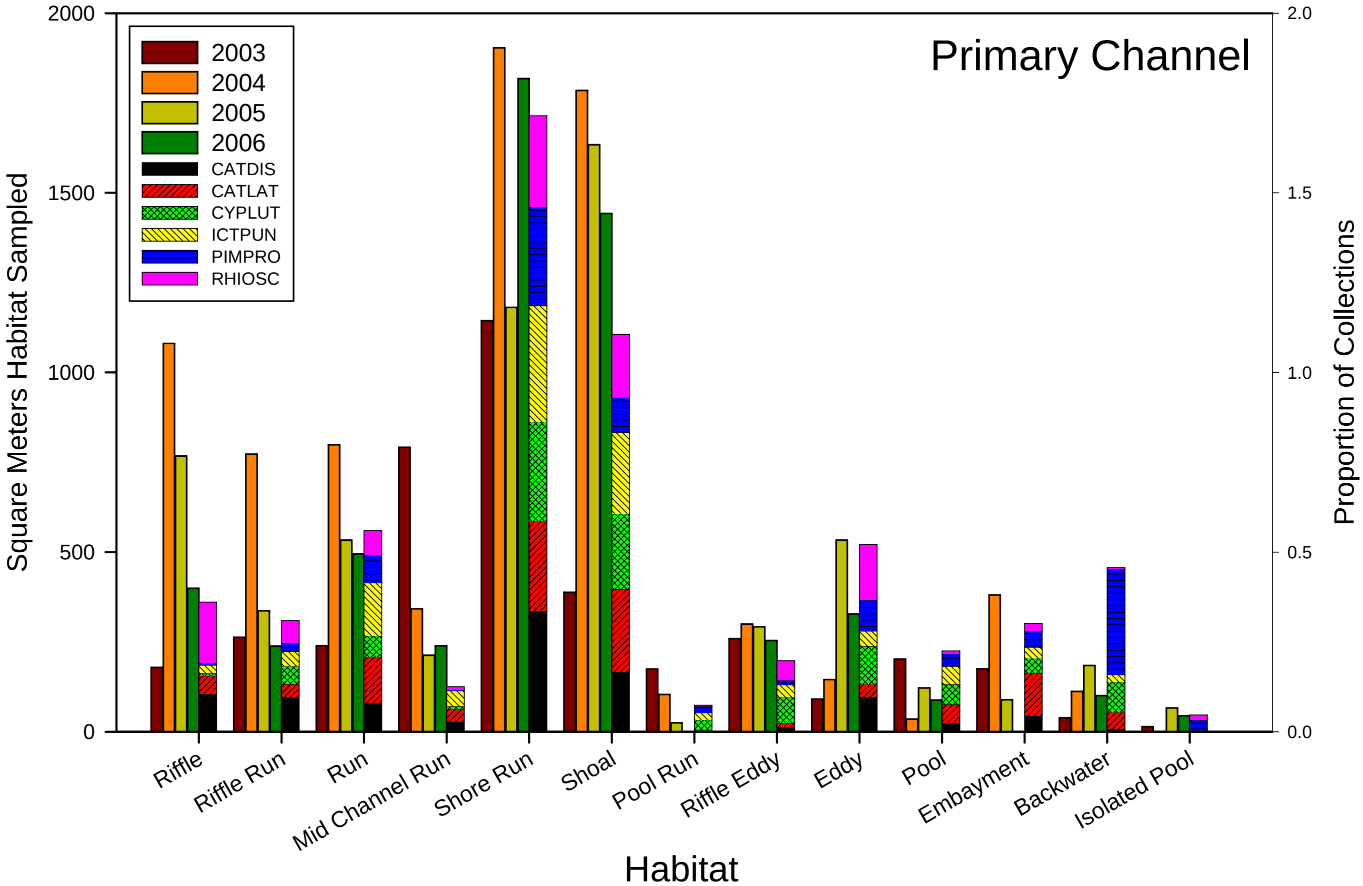


Figure 3. Distribution of sampled area and fish occurrence in the primary channel of the San Juan River in autumn 2006 among mesohabitats. Years correspond with left y-axis, species correspond with right y-axis.

SECONDARY CHANNELS SUMMARY

Most fish species found in the San Juan River primary channel were also found in its secondary channels (Table 7). The only rare species collected in 2006 was Colorado pikeminnow, which has been collected in secondary channels for each of the past three 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 five nonnative species were found in secondary channels in 2006, the fewest number of total species collected to date from secondary channels.

Table 7. Species collected during small-bodied monitoring in San Juan River secondary channel during autumn, 1998-2006. I = introduced and N = native. Six-letter code derived from first three letters of genus and species.

COMMON	SCIENTIFIC	CODE	STATUS	1998	1999	2000	2001	2002	2003	2004	2005	2006
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		
Roundtail chub	*Gila robusta*	GILROB	N	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				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	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	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
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
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X							
NATIVE			6	5	6	4	3	3	3	4	4	4
NONNATIVE			11	9	5	7	10	8	8	9	6	5

Speckled dace was the most abundant species in San Juan River secondary channels in 2006 (Table 8). Red shiner was the most common species from 1998 through 2005, and was second-most common in 2006. Three of the four most common species in 2006 were native. Total fish density in 2006 was lower than it has been since 1999.

Table 8. Fishes collected in San Juan River secondary channel during autumn inventories, 1998 – 2006. Geomorphic Reaches 6 and 1 not sampled in 1998.

1998		1999		2000		2001		2002		2003		2004		2005		2006	
Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	741	CYPLUT	272	CYPLUT	11135	CYPLUT	1847	CYPLUT	6424	CYPLUT	1627	CYPLUT	7080	CYPLUT	926	RHIOSC	251
RHIOSC	597	RHIOSC	114	PIMPRO	1503	PIMPRO	226	PIMPRO	1781	PIMPRO	310	PIMPRO	2127	RHIOSC	171	CYPLUT	154
PIMPRO	162	PIMPRO	20	GAMAFF	1314	RHIOSC	193	GAMAFF	470	RHIOSC	232	RHIOSC	1351	ICTPUN	114	CATDIS	62
ICTPUN	138	CATDIS	4	CYPCAR	309	GAMAFF	113	RHIOSC	224	CATLAT	153	GAMAFF	133	PIMPRO	108	CATLAT	61
GAMAFF	113	CATLAT	4	RHIOSC	158	CATLAT	27	CATLAT	99	ICTPUN	65	CATDIS	122	GAMAFF	45	ICTPUN	42
CATLAT	13	ICTPUN	4	CATLAT	45	ICTPUN	20	FUNZEB	60	GAMAFF	32	CATLAT	122	CATLAT	24	PIMPRO	27
FUNZEB	4	GAMAFF	3	ICTPUN	27	FUNZEB	19	CATDIS	53	CATDIS	24	ICTPUN	115	CATDIS	7	GAMAFF	4
CYPCAR	2	COTBAI	2	CATDIS	17	CATDIS	11	ICTPUN	37	FUNZEB	11	FUNZEB	32	AMEMEL	3	AMENAT	4
GILROB	2	GILROB	1	MICSAL	9	AMEMEL	3	CYPCAR	27	AMEMEL	7	CYPCAR	10	AMENAT	1	PTYLUC	2
CATDIS	2	PTYLUC	1	FUNZEB	5	CYPCAR	2	AMEMEL	8	CYPCAR	2	AMEMEL	6	PTYLUC	1		
AMENAT	2	LEPCYA	1	PTYLUC	3	AMENAT	1			MICSAL	1	MICSAL	6				
PTYLUC	1					ONCMYK	1					PTYLUC	4				
LEPCYA	1					MICSAL	1					LEPCYA	1				
TOT N	1178		426		14508		2464		9183		2464		11109		1400		607
AREA	1904		1356		1914		1346		1468		1480		1802		1040		1679
DENSITY	0.934		0.315		7.58		1.831		6.255		1.665		6.165		1.346		0.583

From 2003 through 2006, over 50% of secondary channel habitat sampled was run, mid-channel run, and shore run habitat (Table 6). Very few embayment, backwater, or isolated pool habitats were sampled in secondary channels, though pool habitats were more common than in the primary channel. Fishes were generally more common in riffle eddy, eddy, and pool habitats than higher-velocity habitats, such as riffles and runs. Collections in high-velocity secondary channel riffle habitats were mainly composed of speckled dace and bluehead sucker.

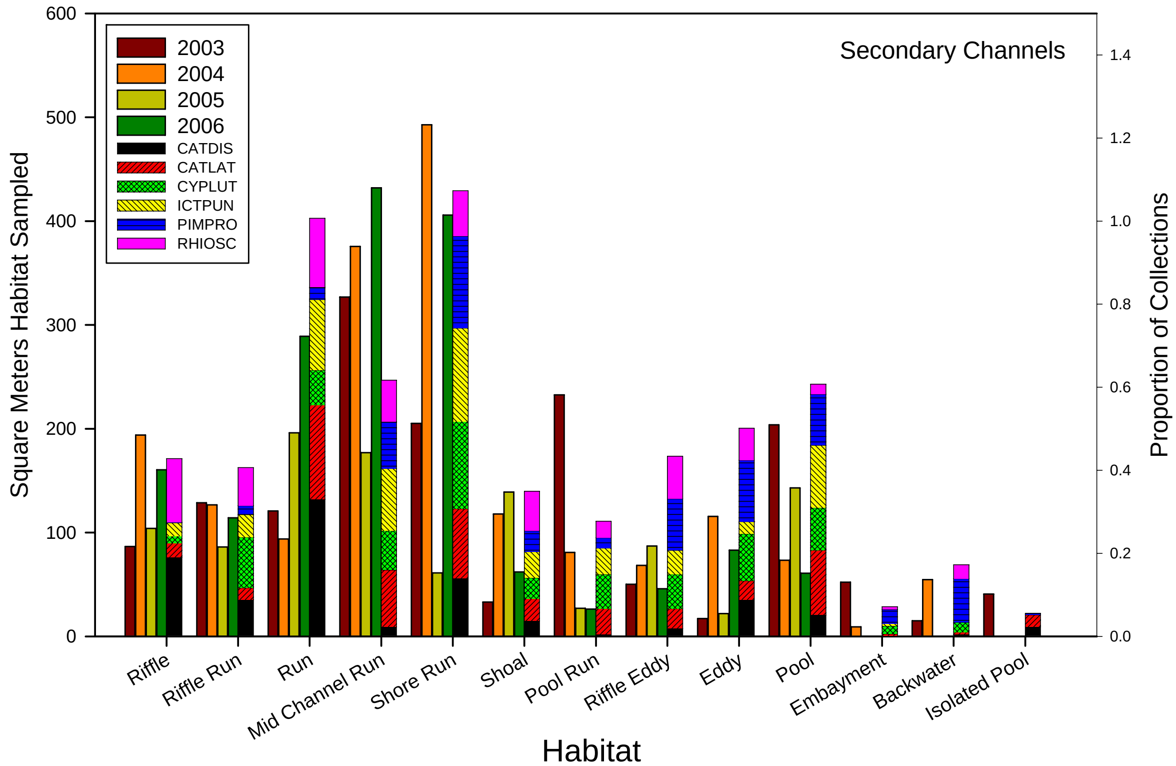


Figure 4. Distribution of sampled area and fishes from secondary channels of the San Juan in autumn 2003-2006 among various mesohabitat categories. Years correspond with left axis, species correspond with right axis.

OVERALL TRENDS IN PRIMARY AND SECONDARY CHANNELS

River-wide primary channel mean densities of each commonly collected native species varied from year to year (Figure 5). Bluehead sucker density increased (r = 0.771 *p* = 0.01) from 1998 through 2006, but that of speckled dace (r = 0.531 *p* = 0.141) and flannelmouth sucker (r = 0.488 *p* = 0.182) did not show any change. In secondary channels river wide, densities of speckled dace (r= 0.199 *p* = 0.060) and bluehead sucker (r = 0.582 *p* = 0.100) increased (Table 9). Similar to commonly collected native fish species, river-wide mean densities of commonly collected nonnative species, varied from year to year in primary and secondary channels (Figure 6), Changes from one year to next for a species in the primary channel were generally mirrored in secondary channels. There was no change in density of any commonly collected nonnative species in the primary or secondary channels over the course of the study.

Though the time period is too short to be very informative, linear regression analysis of river wide (primary and secondary channels) individual sample densities from 2003-2006 indicates a slight but significant decrease in flannelmouth sucker density (r =-0.08, $F_{(1,1272)}$=11.362, p<0.001), and no trend in speckled dace (r=0.021, $F_{(1,1272)}$=0.733, p=0.389) or bluehead sucker (r=0.019, $F_{(1,1272)}$=0.617, p=0.442). Red shiner (r= -0.102, $F_{(1,1272)}$=18.02, p<0.001) and fathead minnow (r= -0.048, $F_{(1,1272)}$=0.042, p=0.047) declined, but that of channel catfish (r=0.019, $F_{(1,1272)}$=0.417, p=0.523) did not.

Table 9. Results of regression analyses of commonly collected species river-wide density versus time in San Juan River primary and secondary channels, 1998 through 2006.

	Primary		Secondaries	
Species	R	*p*	R	*p*
Speckled dace	0.531	0.141	0.199	0.060
Flannelmouth sucker	0.488	0.182	0.484	0.180
Bluehead sucker	0.771	0.010	0.582	0.100
Red shiner	-0.241	.0530	-0.025	0.949
Fathead minnow	-0.107	0.780	-0.060	0.870
Channel catfish	0.237	0.530	0.342	0.368
Western mosquitofish	-0.266	0.490	-0.281	0.464

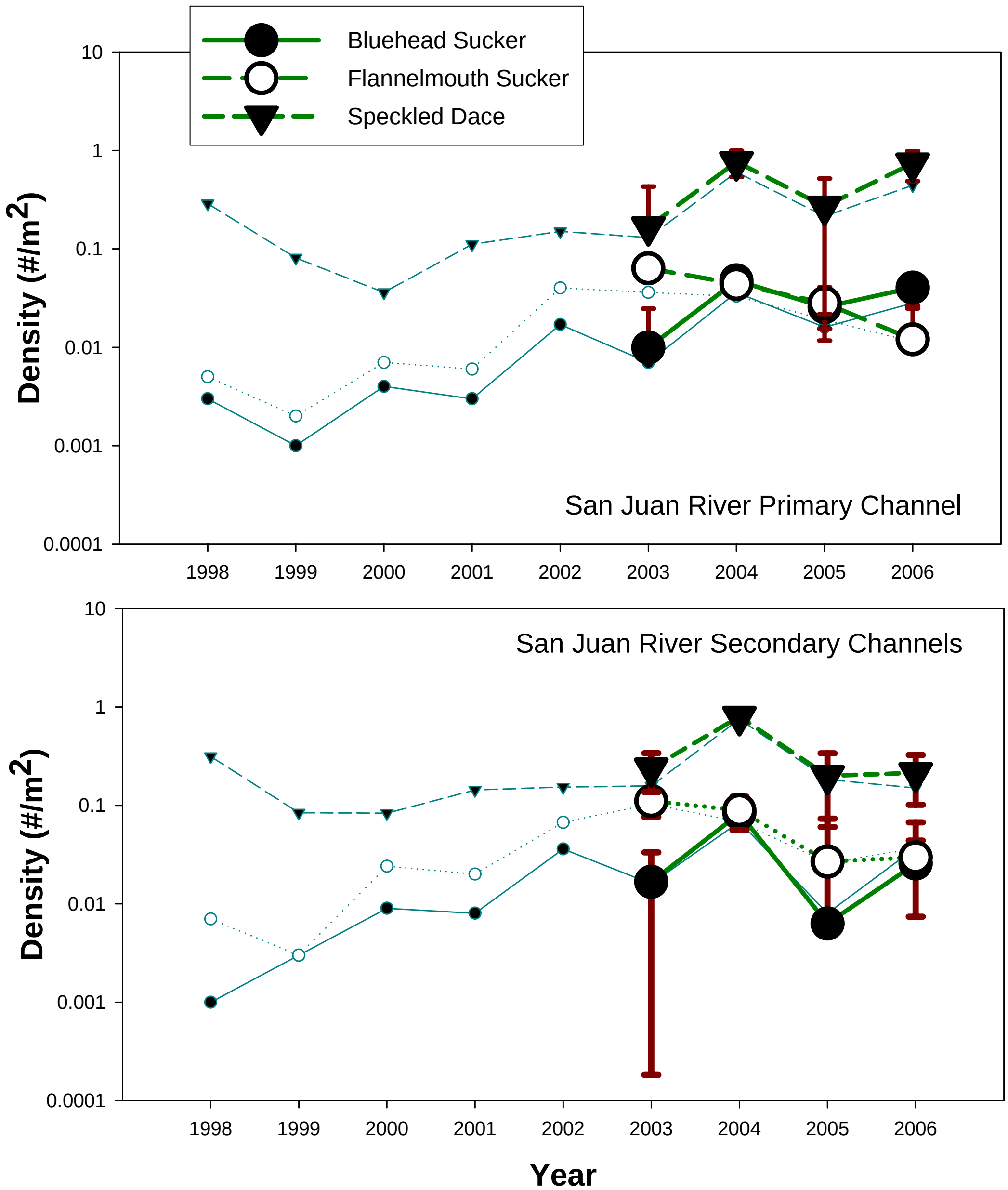


Figure 5. River-wide density (total number/total area sampled) from 1998-2006 and mean sample density (and associated standard error) from 2003-2006 of commonly collected native fishes in autumn sampling of the San Juan River. Note log scale for density.

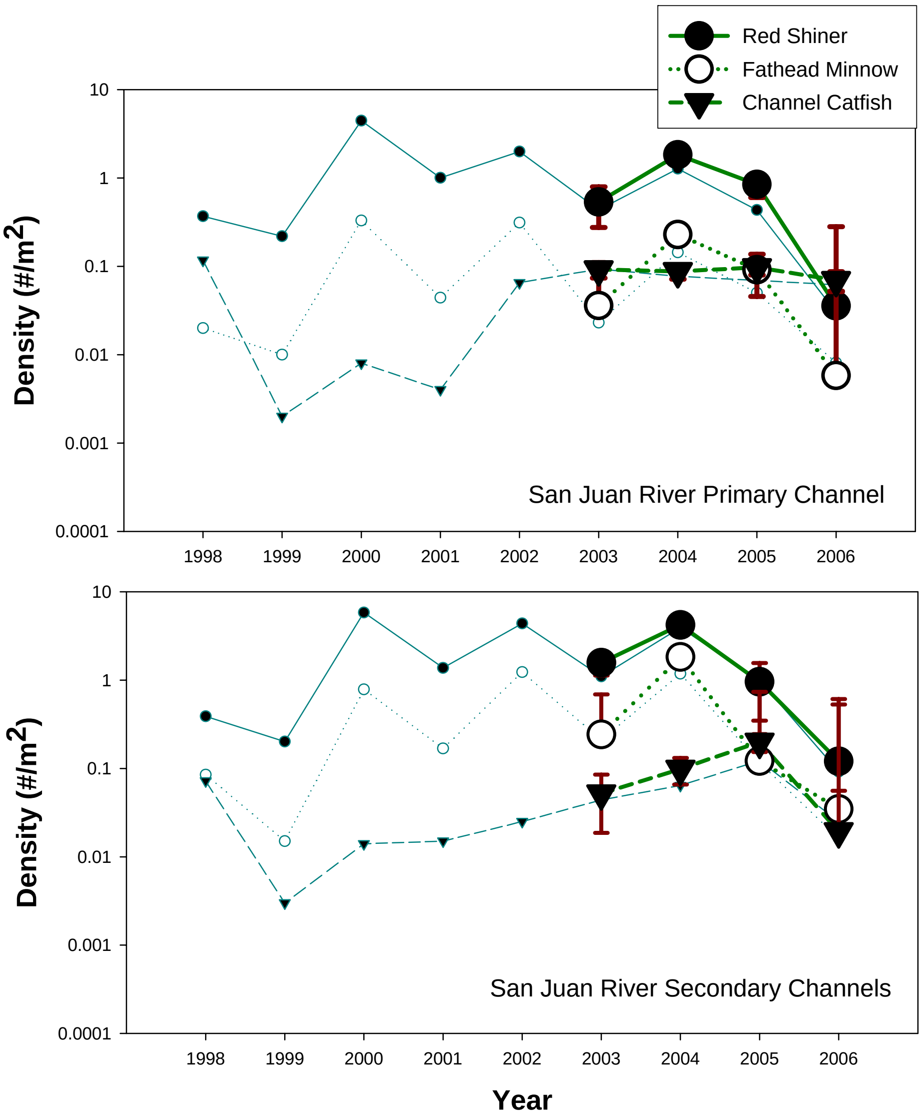


Figure 6. River-wide density (total number/total area sampled) from 1998-2006 and mean sample density (and associated standard error) of commonly collected nonnative fishes in autumn sampling of the San Juan River. Note log scale for density.

In 2006, over 80% of the fishes collected in primary channels and 60% of those in secondary channels were native, the highest proportion of native fishes during this study. Samples in 2000 had the lowest proportion of natives (Figure 7). Primary and secondary channels had similar native/nonnative composition from 1998 through 2001 but beginning in 2002 there was an increasing separation with a greater proportion of natives in primary channel samples versus secondary samples, though proportion of natives have increased in both.

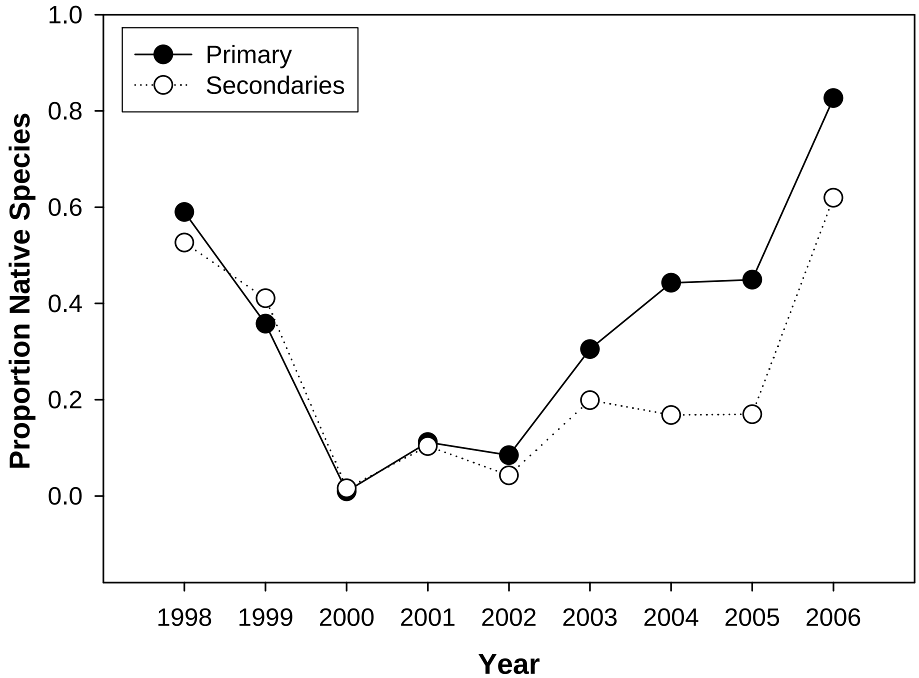


Figure 7. Proportion of native species collected in autumn sampling on the San Juan River from 1998-2006.

LARGE BACKWATER SUMMARY

Only one large backwater (>50 m^2) was sampled in autumn sampling of 2006. In this backwater, located in Reach 5, red shiner, fathead minnow, and specked dace were collected. Colorado pikeminnow has not been collected in a backwater since 2000 (Table 10). Red shiner and fathead minnow have consistently been the most abundant species collected in large backwaters in the San Juan River (Table 11).

Table 10. 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
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	X		X	X	
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X						
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		X	X	X	X	X	X	
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X	X	
Black bullhead	*Ameiurus melas*	AMEMEL	I		X	X	X	X			
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	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
NONNATIVE			10	3	9	9	7	6	6	7	2

Table 11. Fishes collected in San Juan River backwaters during autumn inventories, 1999 – 2006.

1999		2000		2001		2002		2003		2004		2005		2006	
Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	438	CYPLUT	23898	CYPLUT	4408	CYPLUT	4453	CYPLUT	309	CYPLUT	1031	CYPLUT	536	CYPLUT	3
PIMPRO	10	PIMPRO	878	PIMPRO	401	PIMPRO	1634	PIMPRO	129	PIMPRO	319	PIMPRO	122	PIMPRO	2
RHIOSC	8	GAMAFF	659	CATDIS	71	GAMAFF	132	GAMAFF	17	FUNZEB	24	CATLAT	114	RHIOSC	1
CATLAT	3	AMEMEL	106	GAMAFF	39	CYPCAR	35	AMEMEL	12	GAMAFF	15	CATDIS	69		
ICTPUN	2	ICTPUN	44	RHIOSC	19	RHIOSC	37	ICTPUN	10	ICTPUN	10	GAMAFF	16		
PTYLUC	1	CYPCAR	46	CATLAT	6	ICTPUN	40	CATLAT	6	RHIOSC	10	RHIOSC	12		
		CATLAT	33	CYPCAR	4	AMEMEL	14	CATDIS	3	CYPCAR	3	FUNZEB	3		
		CATDIS	27	ICTPUN	4	CATLAT	22	RHIOSC	3	CATDIS	2	MICSAL	2		
		MICSAL	24	FUNZEB	3	CATDIS	5	LEPCYA	1	CATLAT	1	CYPCAR	1		
		RHIOSC	5	AMEMEL	3	FUNZEB	9					ICTPUN	1		
		FUNZEB	3	LEPCYA	1	LEPCYA	3								
		LEPMAC	2												
		PTYLUC	1												
TOT N	459		25727		4957		6385		490		1415		876		6
AREA	242		1576		607		559		313		271		464		53
DENSITY	1.9		16.32		4.86		11.42		1.57		5.21		1.89		0.011

BLUEHEAD SUCKER

From 2003 through 2006 the overall (primary and secondary channel) density of bluehead sucker was highest in 2004 ($F_{(3,1644)}$ =2.98, p<0.030, Tukey HSD p<0.025) . From 2003 through 2006 the highest densities of bluehead sucker were in Reach 6 ($F_{(5,1644)}$ =16.901, p<0.001, Tukey HSD p<0.001). However, none was collected in Reach 6 secondary channels in 2005, where relatively high densities were found in previous years. Bluehead sucker has not been collected in Reach 1 for the past two years (Figure 8). There was no difference in density of bluehead sucker collected in primary versus secondary channels ($F_{(1, 1644)}$=0. 266, p<0.606) in 2006.

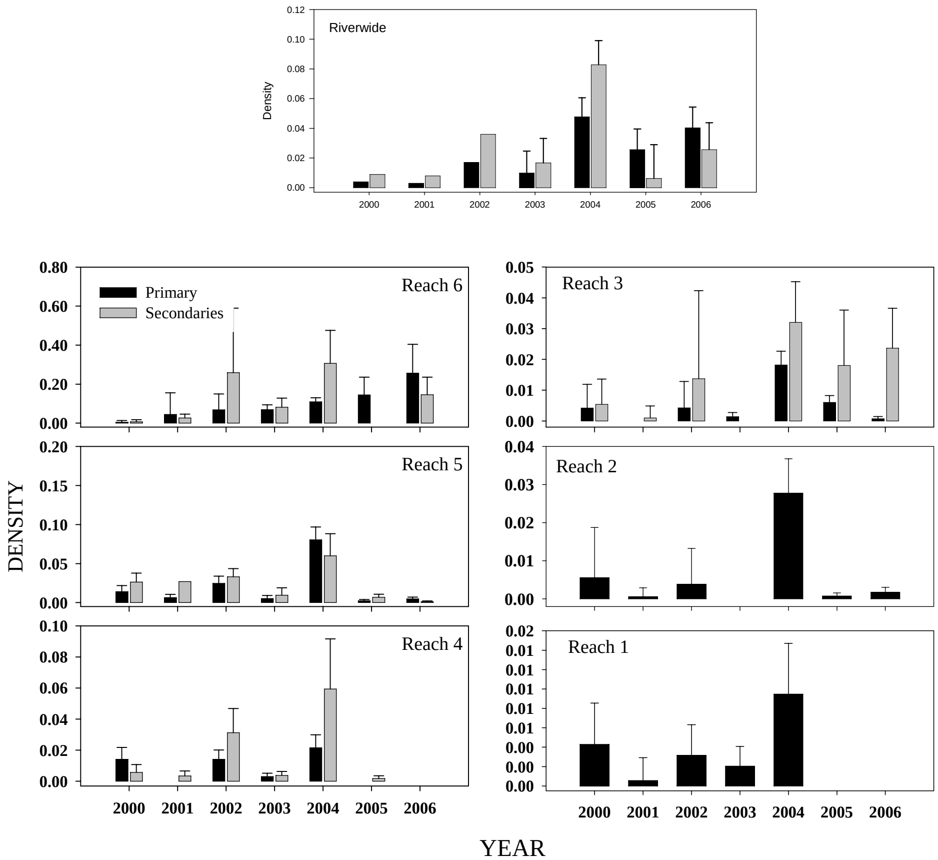


Figure 8. Average autumn densities of bluehead sucker in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

The mean total length of bluehead sucker captured from 2003 through 2006 was 72 mm (SE 1.70). The largest mean total length (85mm, SE 4.38) was in 2006 (Figure 9). These averages, however, are of all bluehead suckers captured, and almost certainly include two or more cohorts in most years. The average total length in the smallest cohort in 2006 was 54 mm (SE 0.75). In 2005, mean TL of smallest cohort was 46 mm (SE 0.82), and in 2004 it was 64mm (SE 0.89). There was no difference in length of bluehead suckers captured in the primary channel (TL 73mm, SE 2.43) versus those in secondary channels (TL 63mm, SE 4.76 $F_{(1,657)}=3.342$, $p<0.068$).

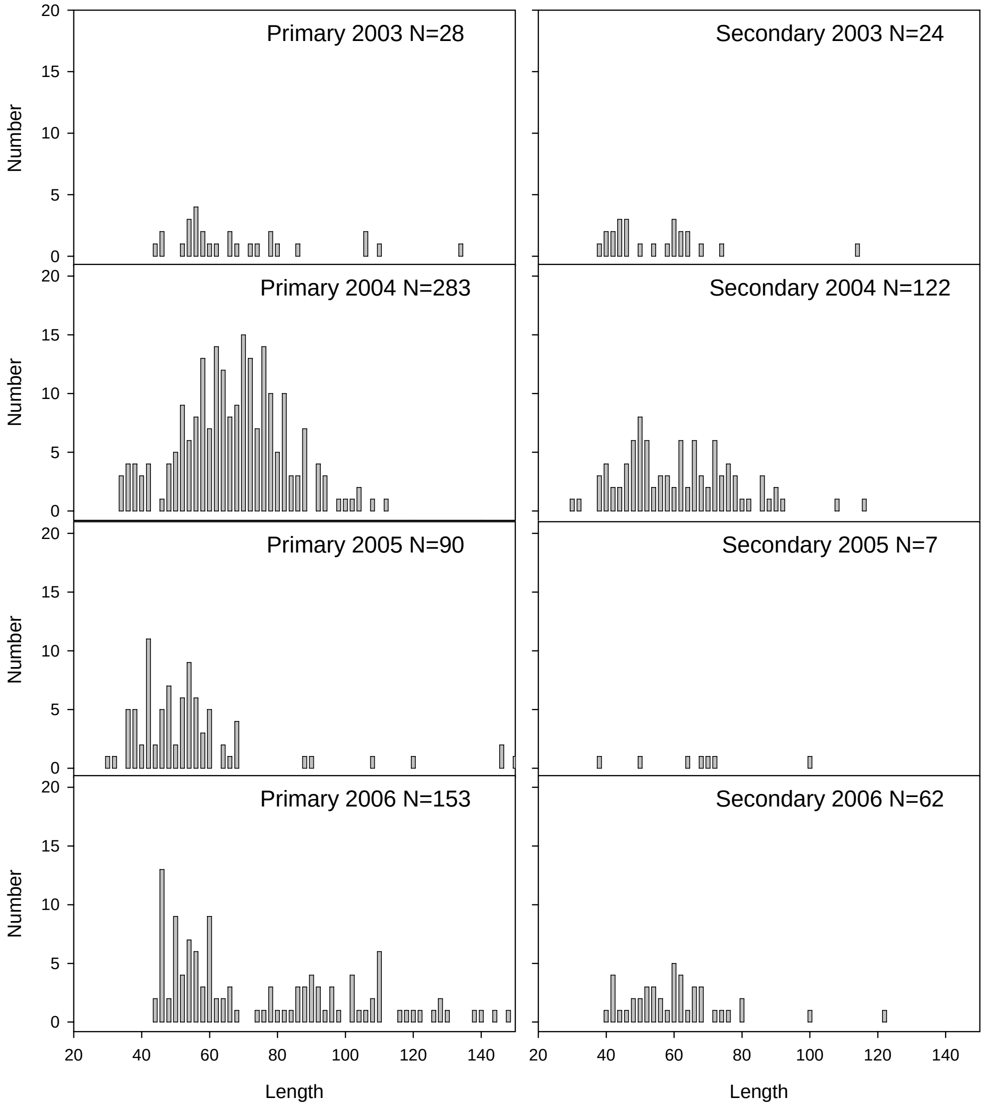


Figure 9. Length-frequency of bluehead suckers from San Juan River primary and secondary channels, 2003-2006.

From 2003 through 2006, bluehead sucker was collected in all habitats in the primary channel, except pool-run and isolated pool habitats (Figure 10). Embayments were the only habitat in secondary channels where it was not collected. Bluehead sucker did not differentially occupy specific mesohabitats in primary ($F_{(12, 1269)}$ =1.18, p<0.295) or secondary channels ($F_{(12,379)}$ =1.20, p<0.283).

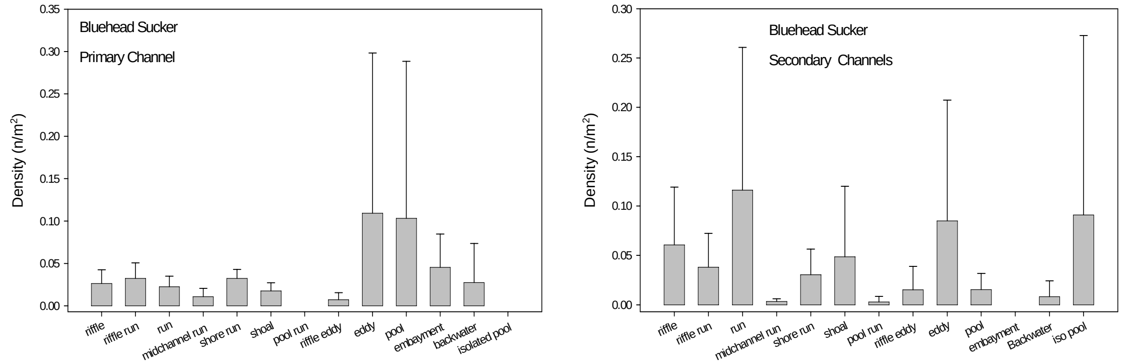


Figure 10. Density of bluehead sucker sampled in various habitats from 2003 through 2006. Error bars represent 2 standard errors.

Bluehead sucker raft mounted electrofishing CPUE and small-bodied fishes seining density comparisons revealed no relationship (Figure 11). The strongest correlation was for juvenile bluehead sucker electrofishing CPUE and a one year time lag with riverwide small-bodied bluehead sucker density (R = 0.673 p=0.067) (Table 12).

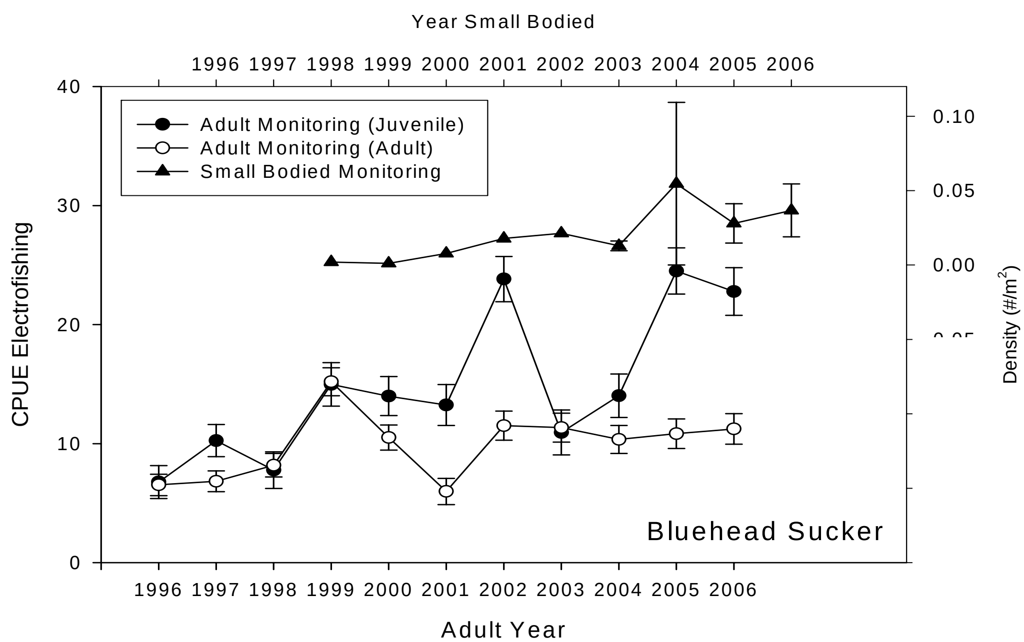


Figure 11. Large-bodied monitoring electrofishing CPUE for adult (>300mm) and juvenile (60-299) bluehead sucker (lower x-axis) and density of bluehead sucker in small bodied sampling (upper x-axis). Error bars represent 1 standard error. Note 1 year difference in sampling year axis.

Table 12. Correlation Coefficients for CPUE large bodied fish collected during raft electrofishing (adults and juveniles) versus riverwide density captured in small-bodied fish monitoring.

Bluehead Sucker		Juvenile		Adult	
		R	*p*	R	*p*
Time Lag	0 years	0.425	0.254	-0.09	0.812
	1 year	0.673	0.067	-0.021	0.962
	2 years	0.331	0.468	0.417	0.352
	3 years	0.226	0.666	0.352	0.493
Flannelmouth Sucker		**Juvenile**		**Adult**	
		R	*p*	R	*p*
Time Lag	0 years	-0.051	0.891	-0.525	0.098
	1 year	0.232	0.584	-0.649	0.081
	2 years	0.328	0.472	-0.209	0.657
	3 years	0.006	0.991	-0.17	0.755
Channel Catfish		**Juvenile**		**Adult**	
		R	*p*	R	*p*
Time Lag	0 years	-0.767	0.012	-0.55	0.125
	1 year	0.021	0.962	-0.183	0.668
	2 years	0.386	0.391	0.027	0.954
	3 years	0.896	0.015	0.907	0.012

FLANNELMOUTH SUCKER

Density of flannelmouth sucker decreased riverwide from 2003 through 2006 (R= -0.08, $F_{(3, 1644)}$ =4.375, p<0.005) (Figure 12). Flannelmouth sucker density was highest in Reach 6 ($F_{(5, 1644)}$ =17.461, p<0.001, Tukey HSD p<0.0002). No flannelmouth sucker has been collected in Reach 1 for two years. Flannelmouth sucker density in the primary channel was higher than secondary channel density ($F_{(1, 1644)}$ =3.611, p<0.06).

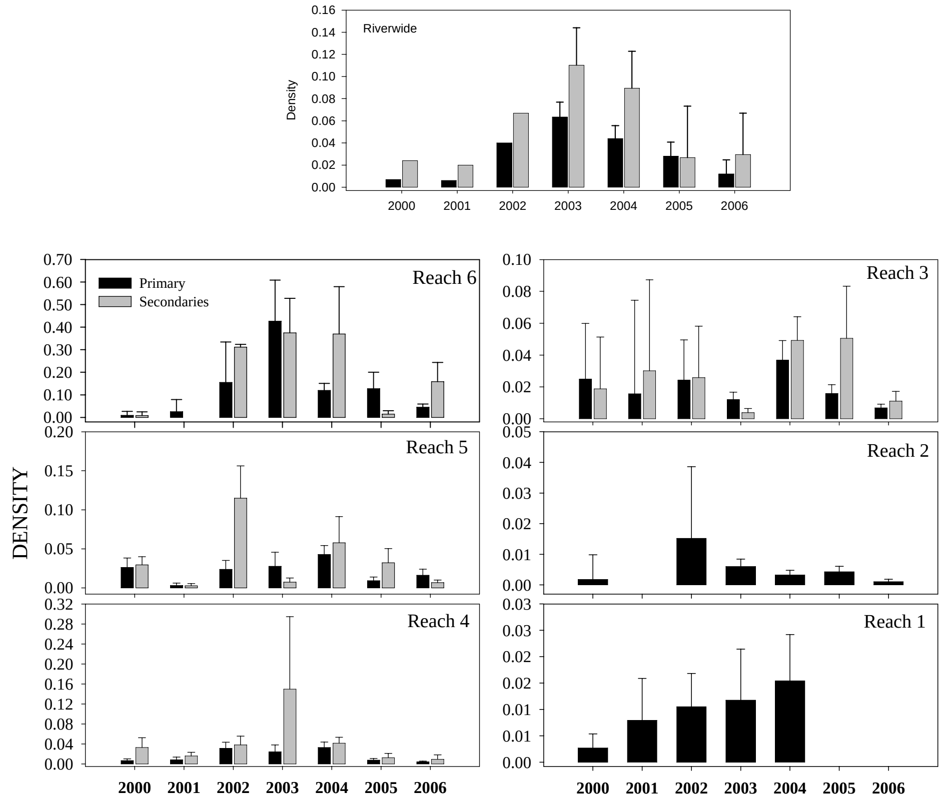


Figure 12. Average autumn densities of flannelmouth sucker in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

Mean total length of flannelmouth sucker captured from 2003 through 2006 was 79 mm (SE 2.05) (Figure 13). Similar to bluehead sucker, the largest average total length of the smallest cohort was in 2004 (61mm, SE=1.02) and 2006 (60mm, SE=1.60) while 2005 had the smallest total length for the smallest cohort (40mm, SE=0.789). Flannelmouth suckers collected in the primary channel (TL 93mm, SE 2.908) were larger than those collected in secondary channels (TL 81mm, SE 4.340, $F_{(1,756)}$=4.763, p<0.029).

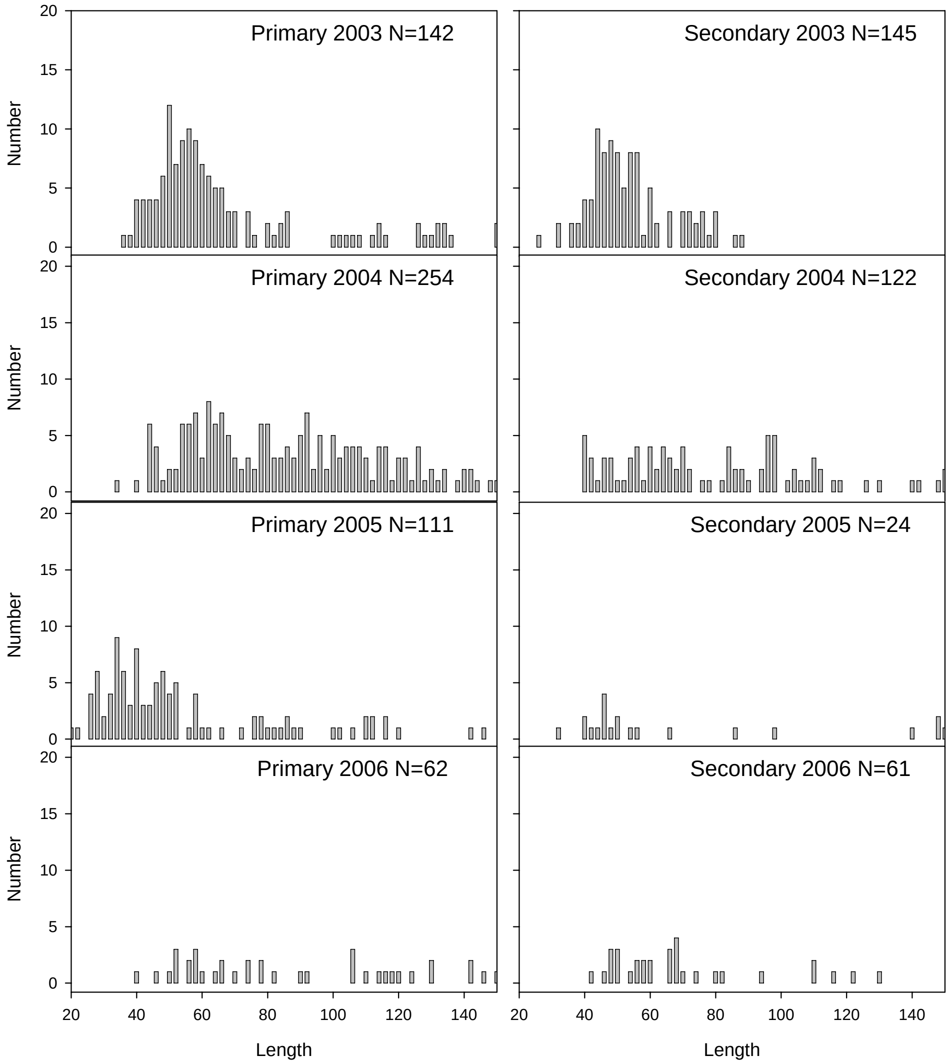


Figure 13. Length-frequency of flannelmouth sucker from San Juan River primary and secondary channels, 2003-2006.

From 2003 through 2006, flannelmouth sucker was collected in all habitat types sampled in primary and secondary channels (Figure 14). In the primary channel, flannelmouth sucker was most common in low-velocity habitats ($F_{(12, 1269)} = 4.41$, $p < 0.001$), but no selection was evident in secondary channels ($F_{(12,379)} = 0.52$, $p < 0.902$).

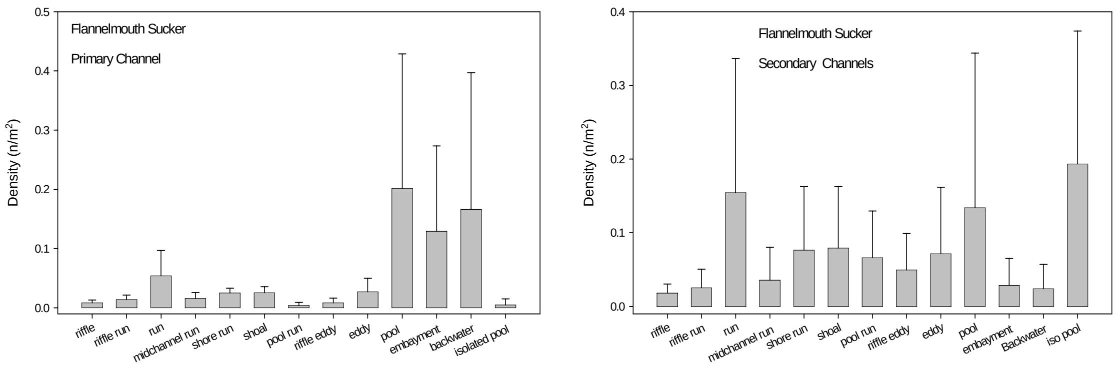


Figure 14. Density of flannelmouth sucker sampled in various habitats from 2003 through 2006. Error bars represent 2 standard errors.

There was no positive correlation between density of flannelmouth sucker in small-bodied sampling and its CPUE in adult sampling (Table 12). There were, however, negative associations between small-bodied sampling and adult densities with zero (R=-0.525, p=0.098) and one year (R=-0.649, p=0.081) time lags. Figure 15 illustrates a two-year lag comparison.

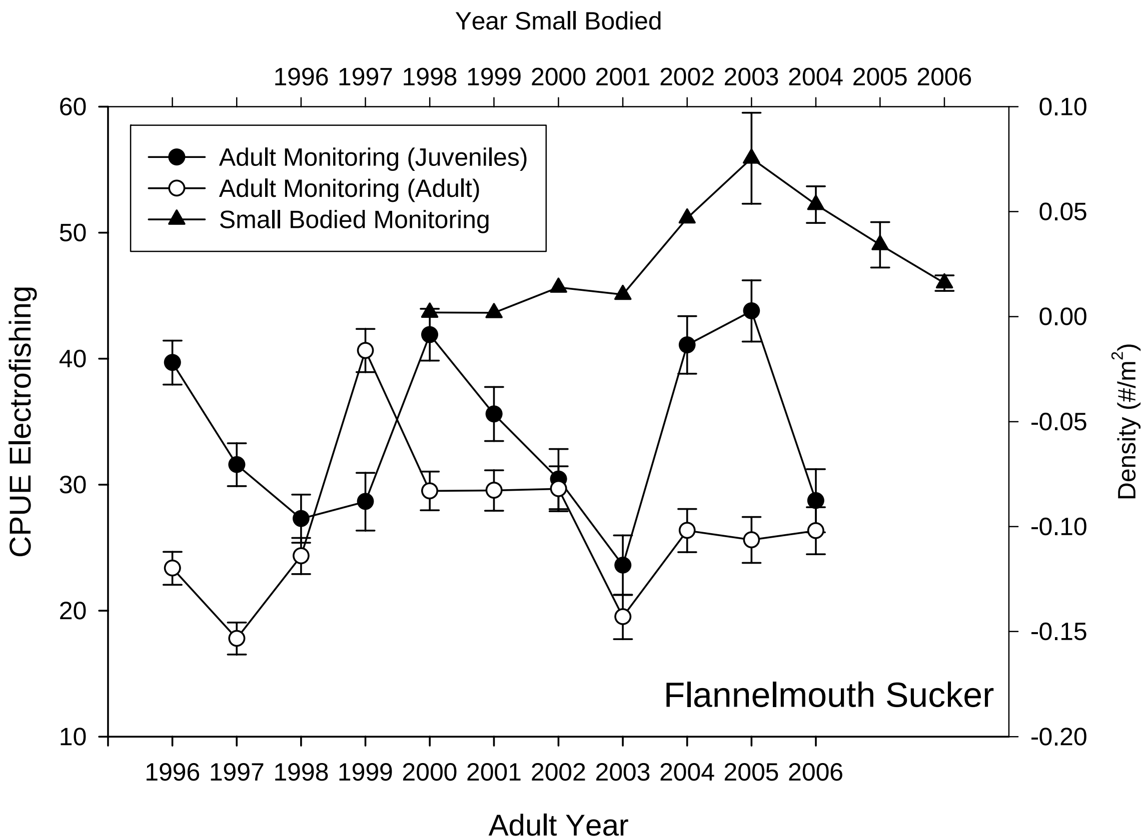


Figure 15. Large-bodied monitoring CPUE for adult (>300mm) and juvenile (60-299) flannelmouth sucker (lower x-axis) and density of flannelmouth sucker in small bodied samples (upper x-axis). Error bars represent 1 standard error. Note 2 year difference in sampling year axis.

SPECKLED DACE

From 2003 through 2006, riverwide density of speckled dace was higher in 2004 and 2006 than 2003 and 2005 ($F_{(3, 1700)}$ =2.30, p<0.076) (Figure 16). Similar to native sucker species, the highest density of speckled dace during 2003 through 2006 was in Reach 6 ($F_{(5, 1679)}$ =21.44, p<0.001, Tukey HSD p<0.007). There was no difference between density of speckled dace in the primary channel and secondary channels ($F_{(1, 1652)}$ =0.28, p<0.63).

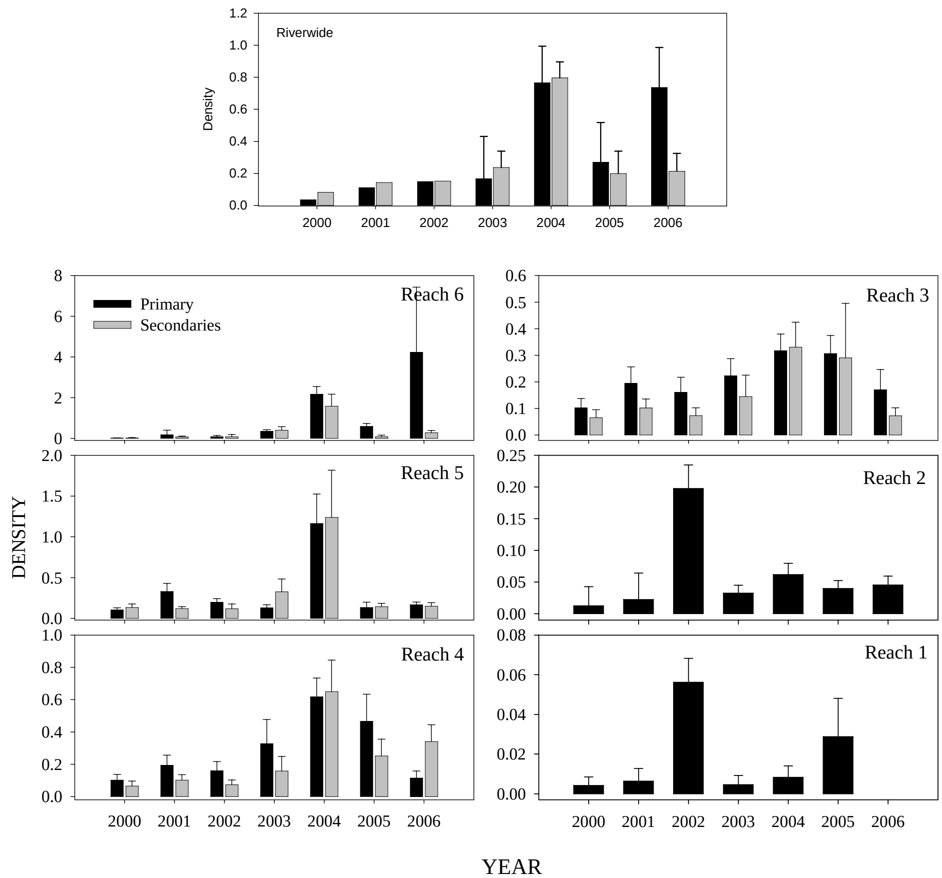


Figure 16. Average autumn densities of speckled dace in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of speckled dace captured from 2003 through 2006 was 47 mm (SE=0.206). For most years, two cohorts were distinguishable in the length-frequency histograms (Figure 17). Similar to other native species, greatest mean total length of the smallest cohort of speckled dace was in 2004 (46mm, SE=0.186), while 2006 had the smallest total length for the smallest cohort (35mm, SE=0.260). Speckled dace collected in the primary channel (47mm, SE=0.242) were not larger than those sampled in secondary channels (46mm, SE=0.459, $F_{(1, 4750)}$ =5.9362, p<0.0149).

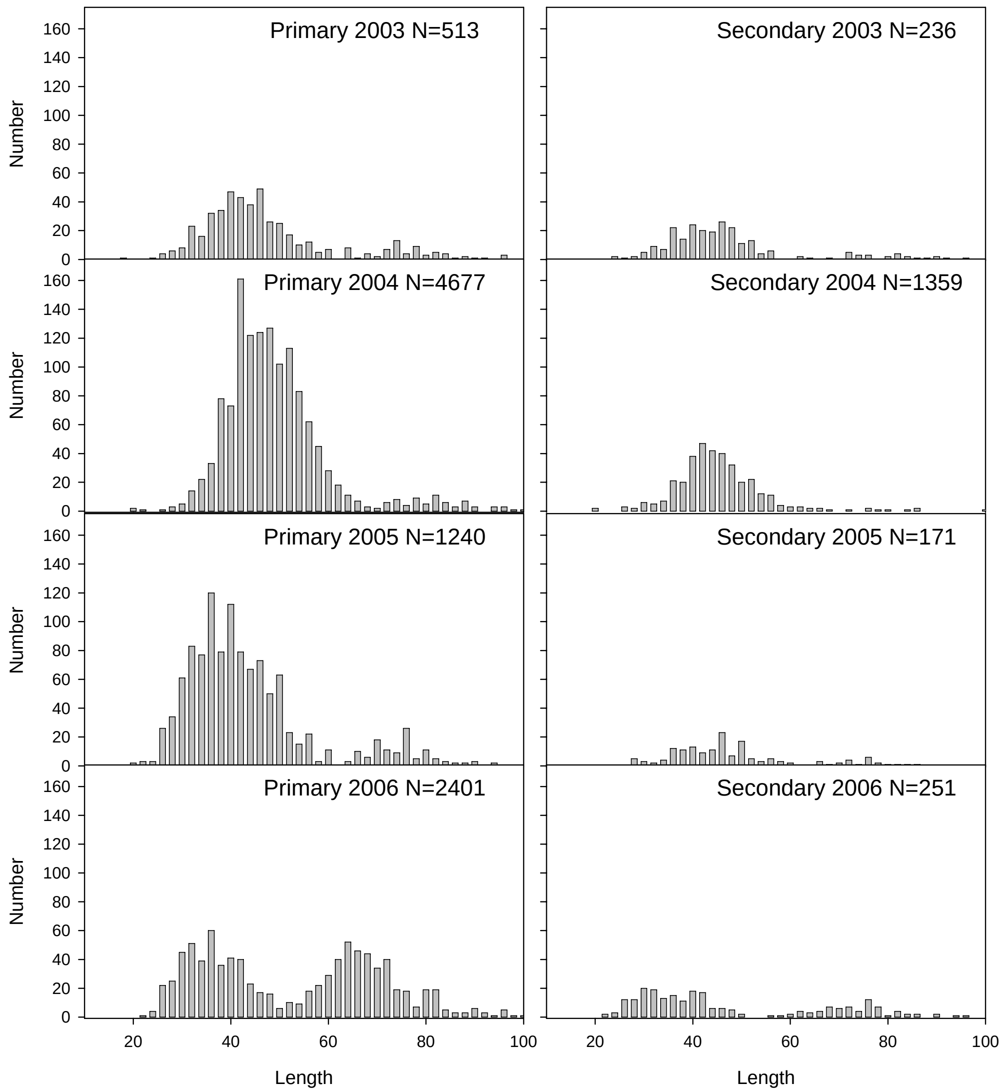


Figure 17. Length frequency of speckled dace from San Juan River primary and secondary channels, 2003-2006.

From 2003 through 2006, speckled dace was collected in all habitat types sampled in primary and secondary channels (Figure 18). Speckled dace was not more abundant in one habitat type than any other in the primary channel, ($F_{(12, 1269)}$ =1.41, p<0.152), but it was more common in shoal and riffle eddy habitats than others in secondary channels ($F_{(12,379)}$ =2.08, p<0.017). In secondary channels, it was least common in midchannel run and pool habitats.

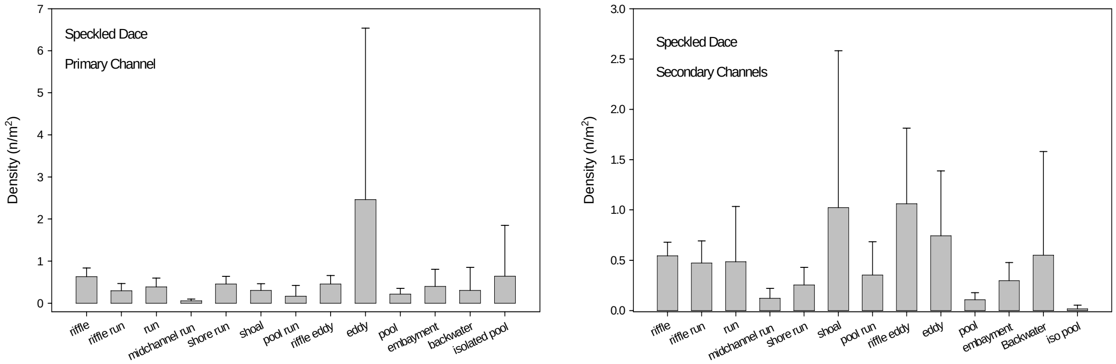


Figure 18. Density of speckled dace sampled in various habitat types from 2003 through 2006. Error bars represent 2 standard errors.

RED SHINER

From 2003 through 2006, density of red shiner was higher in 2004 ($F_{(3, 1700)}$ =23.38, p<0.0001, Tukey HSD p<0.047) than any other year (Figure 19). Density of red shiner was low in all reaches in 2006. Mean density of red shiner was highest in Reach 5 and generally decreased in downstream reaches ($F_{(5, 1697)}$ =6.0552, p<0.001). The average density of red shiner in secondary channels was higher than in primary channels ($F_{(1, 1652)}$ =16.262, p<0.0001).

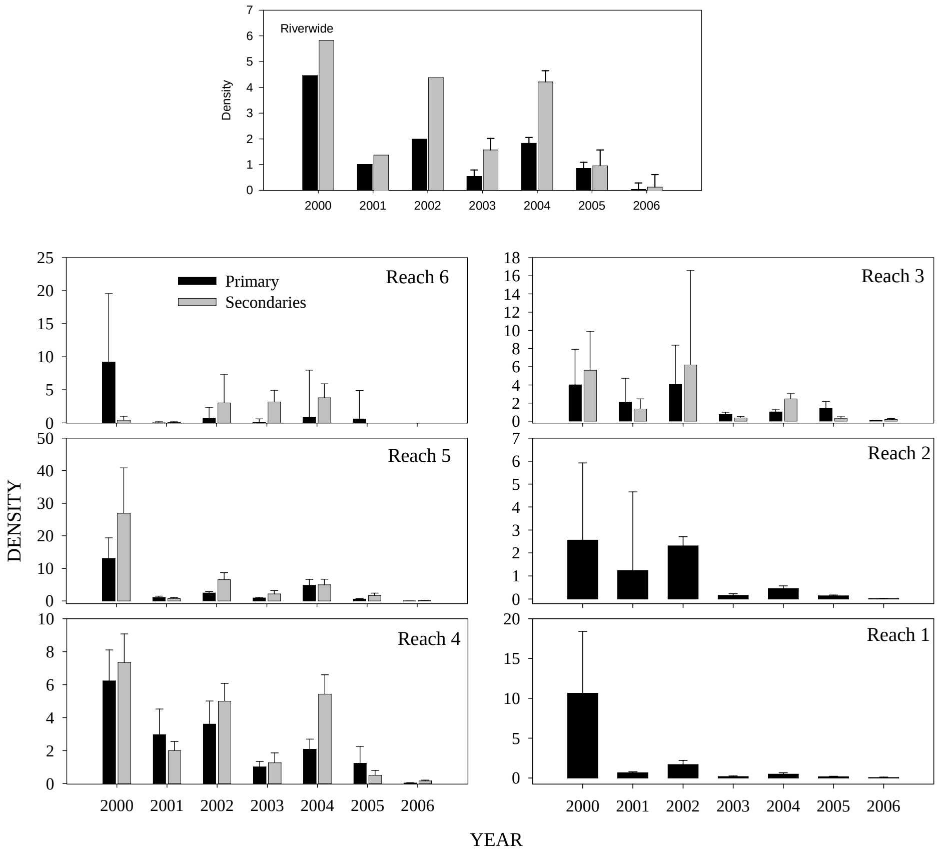


Figure 19. Average autumn densities of red shiner in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of red shiner captured from 2003 through 2006 was 35 mm (SE= 0.114). For most years, two cohorts were distinguishable on the length frequency histograms (Figure 20). Similar to native species, the largest average total length in the smallest cohort of red shiner was in 2004 (29mm, SE=0.086), while 2003 had the smallest total length for the smallest cohort (25mm, SE=0.096). Red shiners sampled in the primary channel (36mm, SE=0.268) were larger than those collected in secondary channels (40mm, SE=0.286, $F_{(1, 12095)}$ =100.03, p<0.0001).

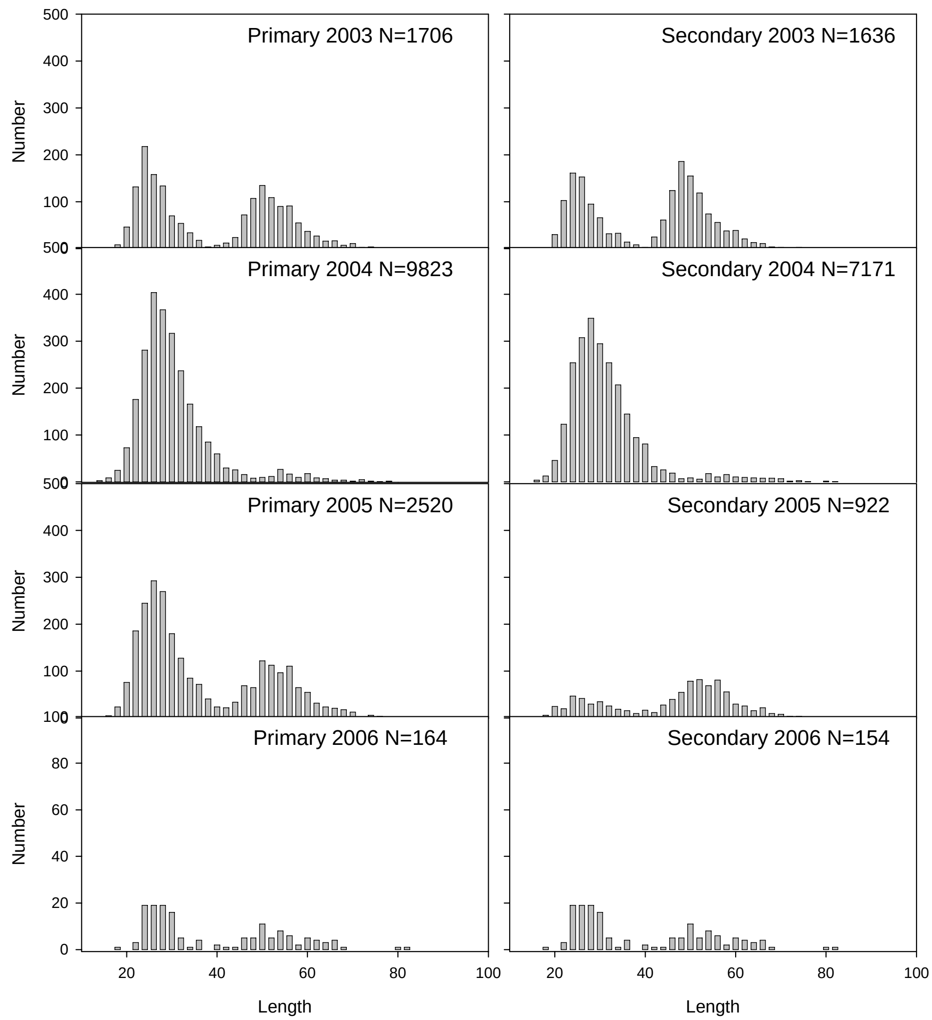
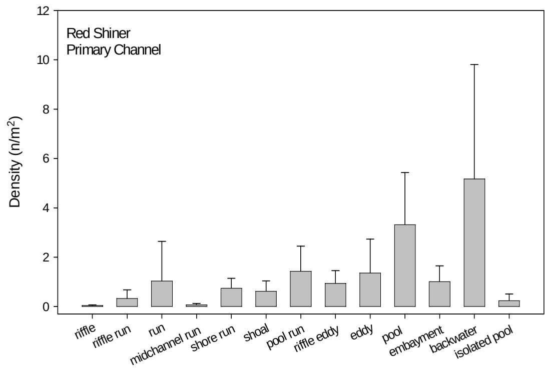


Figure 20. Frequency of total length of red shiner from San Juan River small-bodied sampling. Note y-axis change for 2006.

From 2003 through 2006, red shiner was collected in all habitats in primary and secondary channels (Figure 21). Red shiner was most commonly found in low-velocity habitats in both primary ($F_{(12, 1269)} = 4.81$, $p<0.001$) and secondary ($F_{(12,379)} = 2.51$, $p<0.004$) channels.



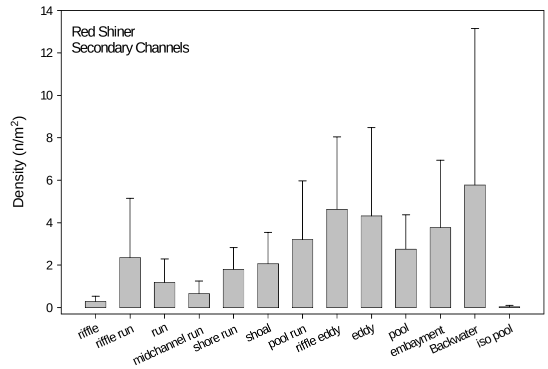


Figure 21. Density of red shiner sampled in various habitat types from 2003-2006. Error bars represent 2 standard errors.

CHANNEL CATFISH

From 2003 through 2006, density of channel catfish was relatively stable ($F_{(3, 1700)}$ =1.8312, p<0.139). Density was highest in 2005 (0.109 fish/m^2, SE=0.016) and lowest in 2006 (0.058 fish/m^2, SE=0.016) (Figure 22). Mean density of channel catfish was highest in Reaches 4, 3, and 2 and lowest in Reaches 5 and 6 ($F_{(5,1679)}$=8.643, p<0.001). There was no difference in the density of channel catfish in primary and secondary channels ($F_{(1, 1646)}$ =0.922, p<0.761).

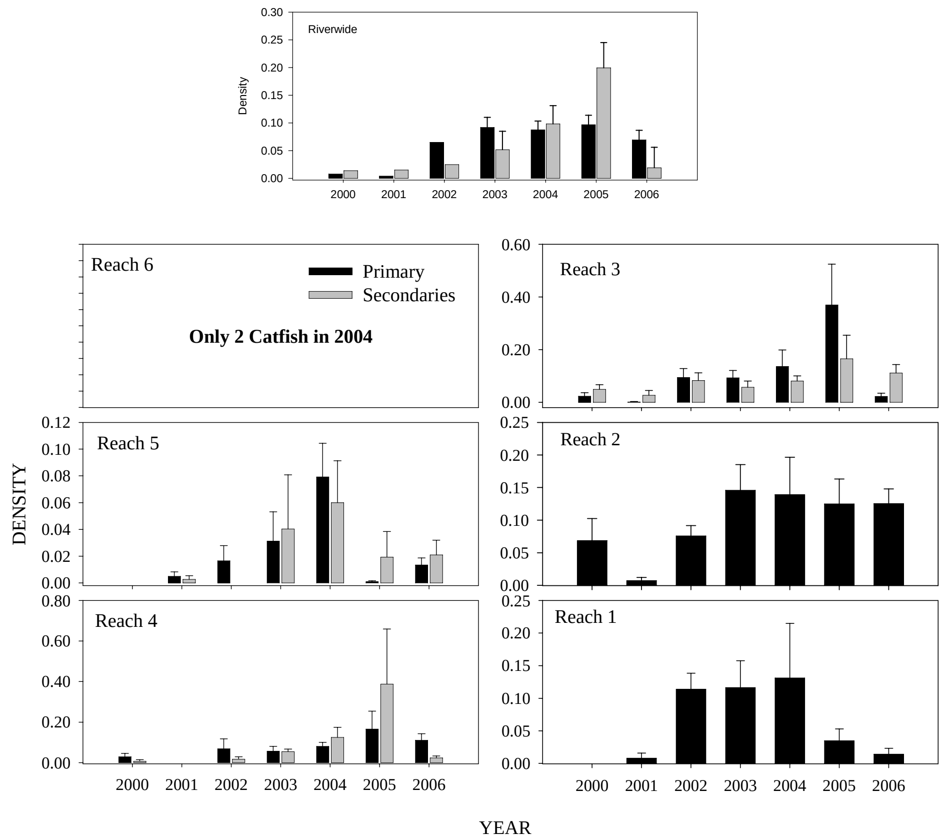


Figure 22. Average autumn densities of channel catfish in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of channel catfish captured from 2003 through 2006 was 65 mm (SE 0.854). The largest mean total length in the smallest cohort of channel catfish was in 2006 (60mm, SE=1.72), while 2005 had the lowest mean total length for the smallest cohort (52mm, SE=1.478) (Figure 23). Mean total length of channel catfish from the primary channel (64mm, SE=0.932) was not different than that of individuals from secondary channels (68mm, SE=2.106, $F_{(1, 1561)}$ =3.312, p<0.069).

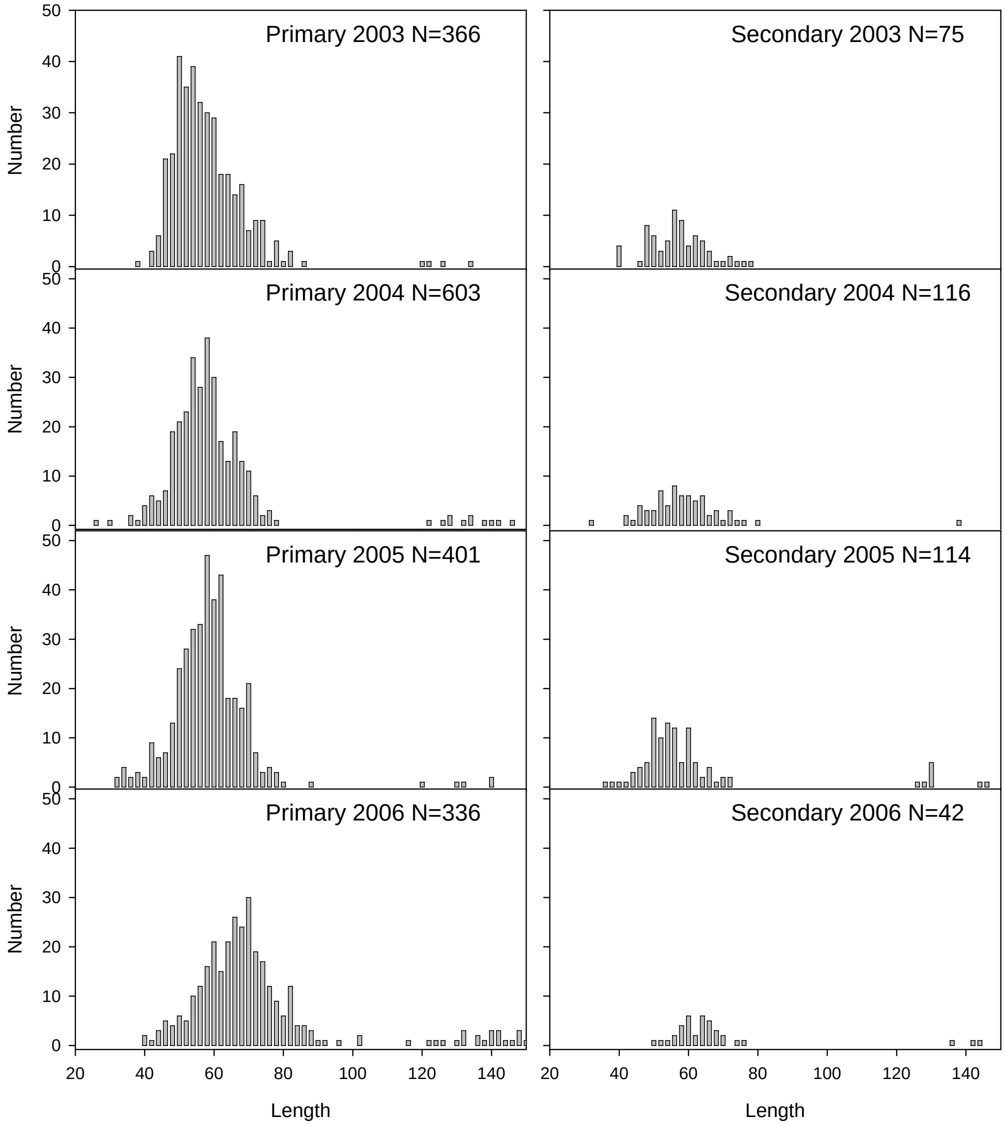


Figure 23. Length of channel catfish from San Juan River primary and secondary channels, 2003-2006.

From 2003 through 2006, channel catfish was collected in all habitat types in primary and secondary channels (Figure 24). In the primary channel, channel catfish was most commonly collected in low-velocity habitats ($F_{(12, 1269)}$ =3.37, p<0.001), but no selection was evident in secondary channels ($F_{(12,379)}$ =1.23, p<0.262). It was least common in midchannel runs and riffle habitats in both primary and secondary channels.

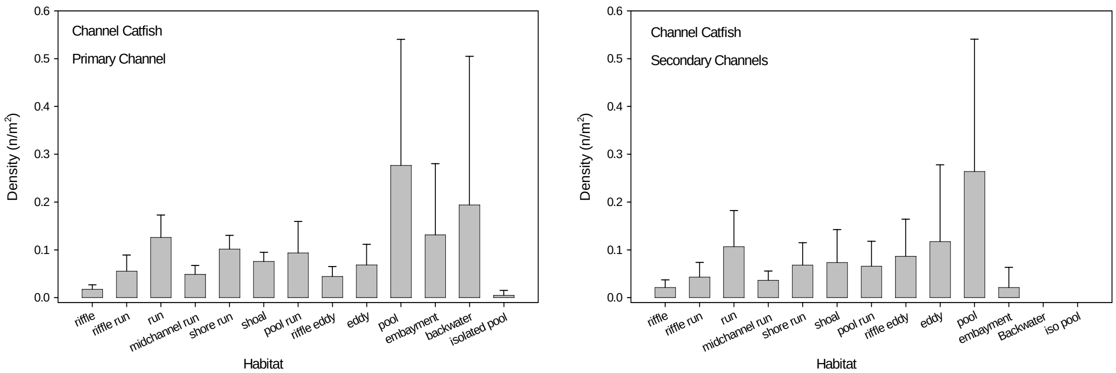


Figure 24. Density of channel catfish sampled in various habitat types from 2003 through 2006. Error bars represent 2 standard errors.

Strong correlations between small-bodied channel catfish density and adult (R=0.907, p=0.012) and juvenile (R=0.896, p=0.015) channel catfish CPUE were noted for a three-year time lag comparison (Figure 25). There was also a negative association between small-bodied channel catfish density and juvenile CPUE with a zero-year time lag (R=-0.767, p=0.012) (Table 12).

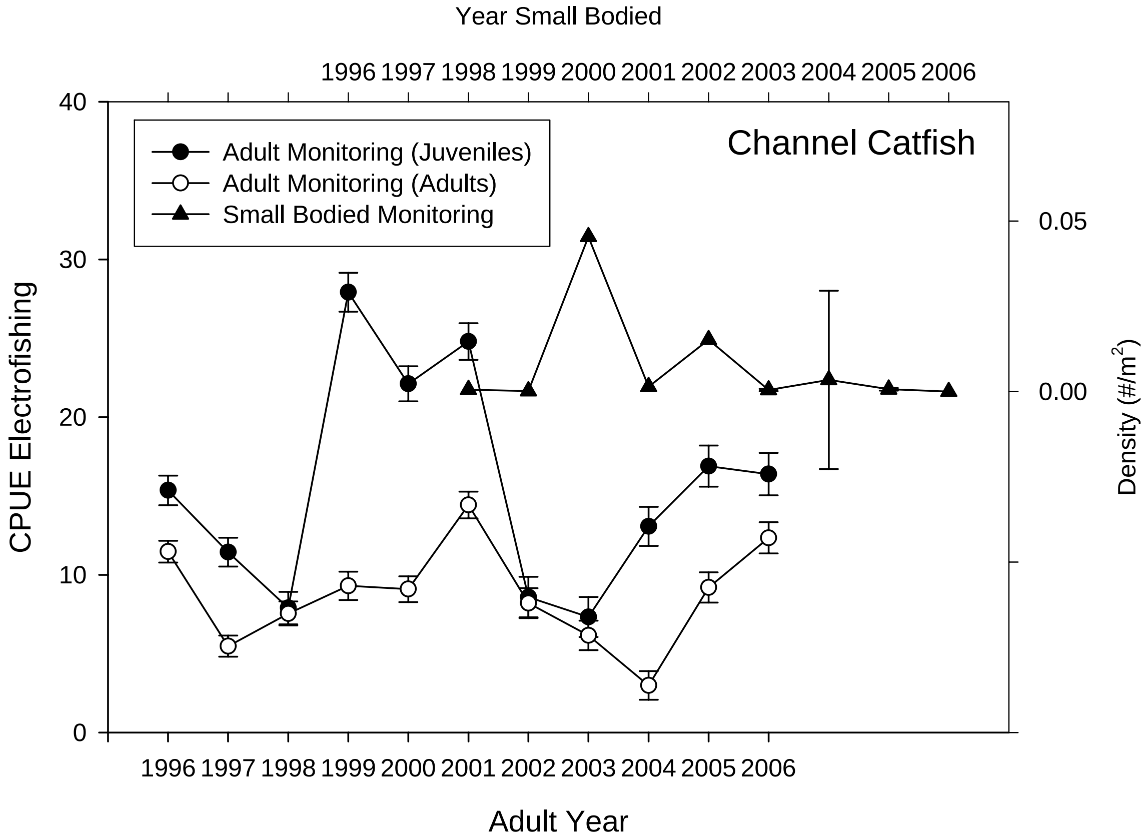


Figure 25. CPUE for adult (>300mm) and juvenile (60-299) channel catfish versus sampling year (lower x-axis) and density of channel catfish in small bodied samples versus sampling year (upper x-axis). Error bars represent 1 standard error – small bodied data only has error presented from 2003-2006. Note 3 year difference in sampling year axis.

FATHEAD MINNOW

From 2003 through 2006, 2004 had the highest density (0.523 fish/m^2, SE=0.108) of fathead minnow and low densities occurred in 2005 (0.102 fish/m^2, SE=0.123) and 2006 (0.013 fish/m^2, SE=0.121, $F_{(3, 1700)}$ =5.808, p<0.0006) (Figure 26). There was a general decrease in fathead minnow density as sampling progressed downstream ($F_{(5,1679)}$=1.9207, p<0.088). Fathead minnow density was higher in secondary channels than primary channels ($F_{(1, 1646)}$ =10.495, p<0.001).

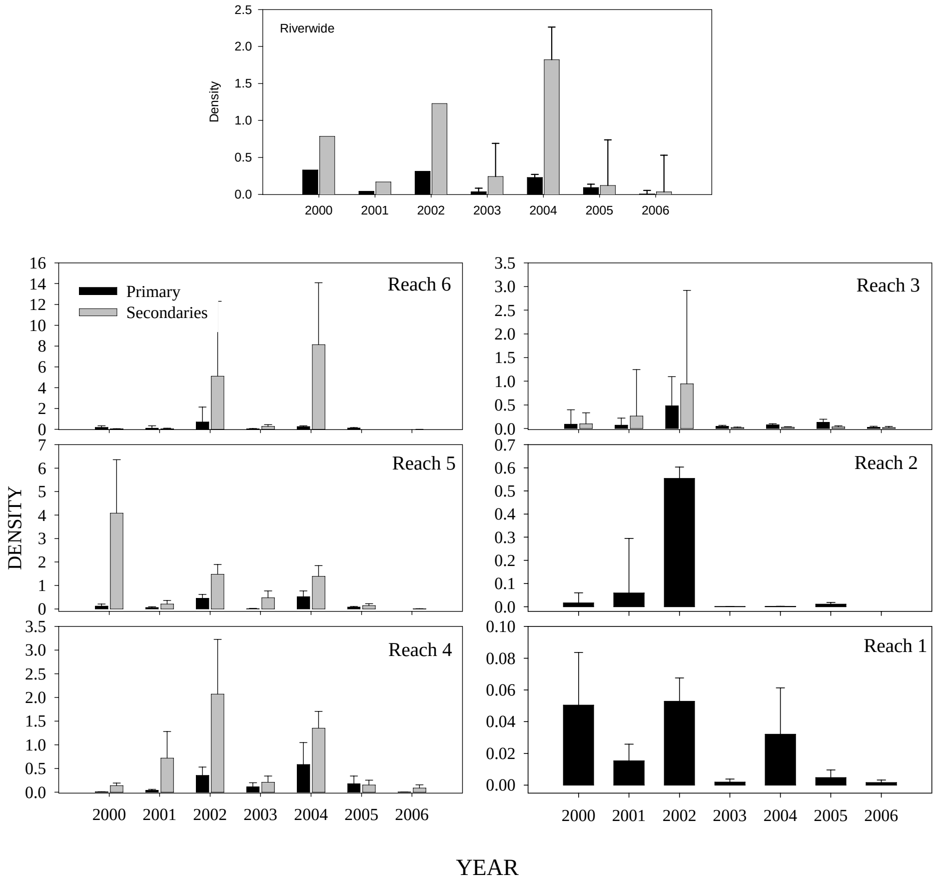


Figure 26. Average autumn densities of fathead minnow in primary and secondary channels of the San Juan River, 2000-2006. Error bars represent one standard error. Note change in scale of y-axis.

The average total length of fathead minnow captured from 2003 through 2006 was 34 mm (SE=0.192). The greatest mean total length in the smallest cohort of fathead minnow was in 2004 (35mm, SE=0.225) and 2006 (34mm, SE=1.056), while 2005 and 2003 had similar and smaller mean total lengths for the smallest cohort (31 and 32mm, SE=0.472) (Figure 27). Fathead minnow collected from the primary channel (36mm, SE=0.455) were larger than those found in secondary channels (33mm, SE=0.542, $F_{(1, 2410)}$ =18.874, p<0.0001).

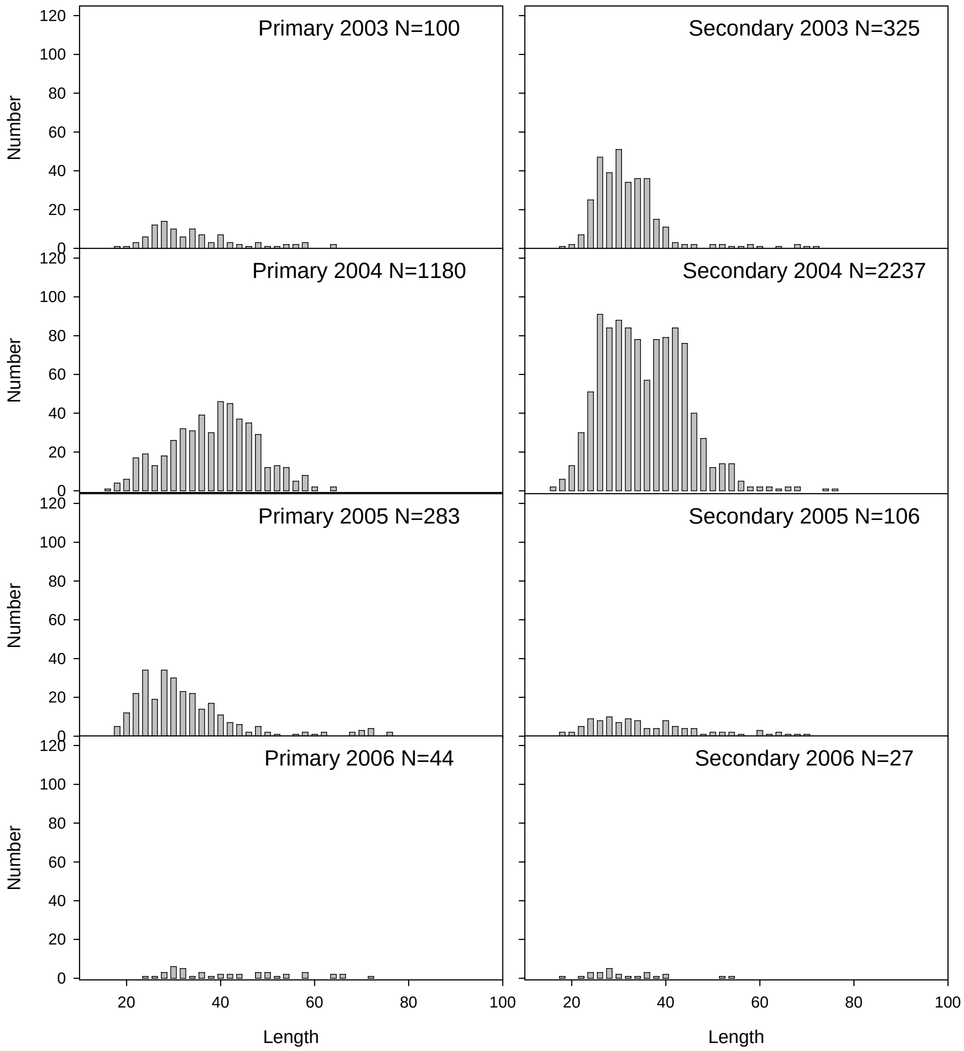


Figure 27. Length frequency of fathead minnow from San Juan River primary and secondary channels, 2003-2006.

From 2003 through 2006, fathead minnow was collected in all habitat types sampled in primary and secondary channels (Figure 28). Fathead minnow density was higher in primary and secondary channel backwater habitats than other sampled habitats ($F_{(12, 1269)}$ =7.83, p<0.001 and $F_{(12,379)}$ =4.86, p<0.001).

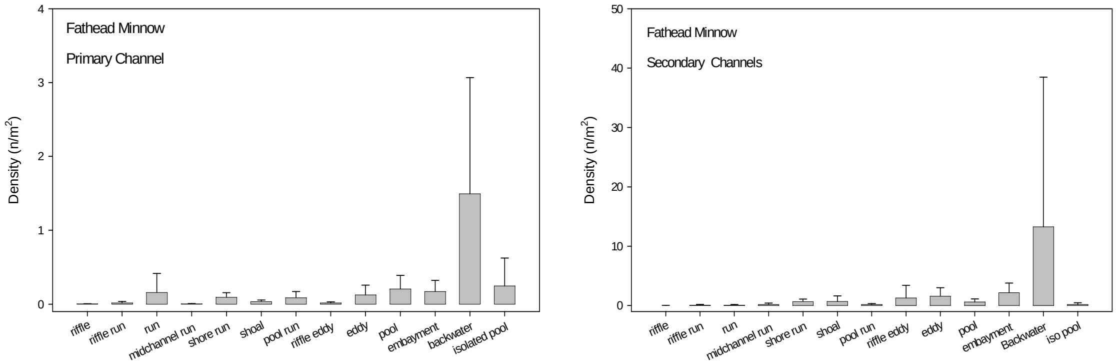


Figure 28. Density of fathead minnow in various San Juan River habitat types from 2003 through 2006. Error bars represent 2 standard errors.

OTHER NATIVE FISHES

For the seventh 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. Colorado pikeminnow was collected each year from 2004 through 2006, 14 in the primary channel and seven in secondary channels (Table 13).

Table 13. Colorado pikeminnow captures by mesohabitat in autumn small-bodied sampling of the San Juan River from 2004 through 2006.

Channel	Habitat	2004	2005	2006	Total
Primary	Eddy		1		1
	Embayment	1			1
	Run	3			3
	Shoal			6	6
	Shore Run		1	2	3
Secondary	Mid Channel Run			1	1
	Pool	1			1
	Riffle Eddy			1	1
	Shoal	2	1		3
	Shore Run	1			1
Total		8	3	10	21

From 2003 through 2006, Colorado pikeminnow was collected mainly in moderate-velocity habitats in primary and secondary channels (Figure 29). There was no difference in habitats occupied by primary channel Colorado pikeminnow ($F_{(12, 1269)}$ =0.90, p<0.0.543), but there was among secondary channel occupants ($F_{(12,379)}$ =2.18, p<0.012). In secondary channels, the highest density of Colorado pikeminnow was in shoal habitat. Small sample size, however, limits interpretation.

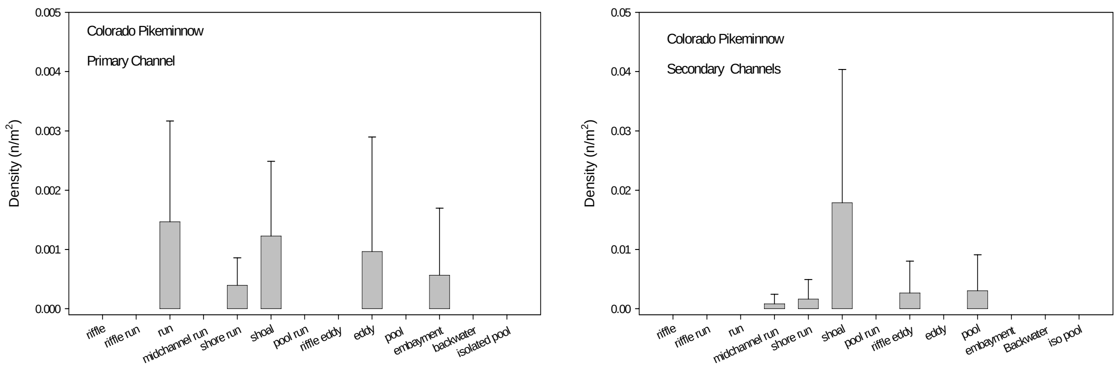


Figure 29. Density of Colorado pikeminnow collected in various San Juan River habitat types from 2003 through 2006. Error bars represent 2 standard errors.

The average total length of Colorado pikeminnow captured from 2004 through 2006 was 187 mm (SE 8.64). Most (n = 19) Colorado pikeminnow captured were likely from the previous years stocking; only two individuals were likely age 2 (Figure 30).

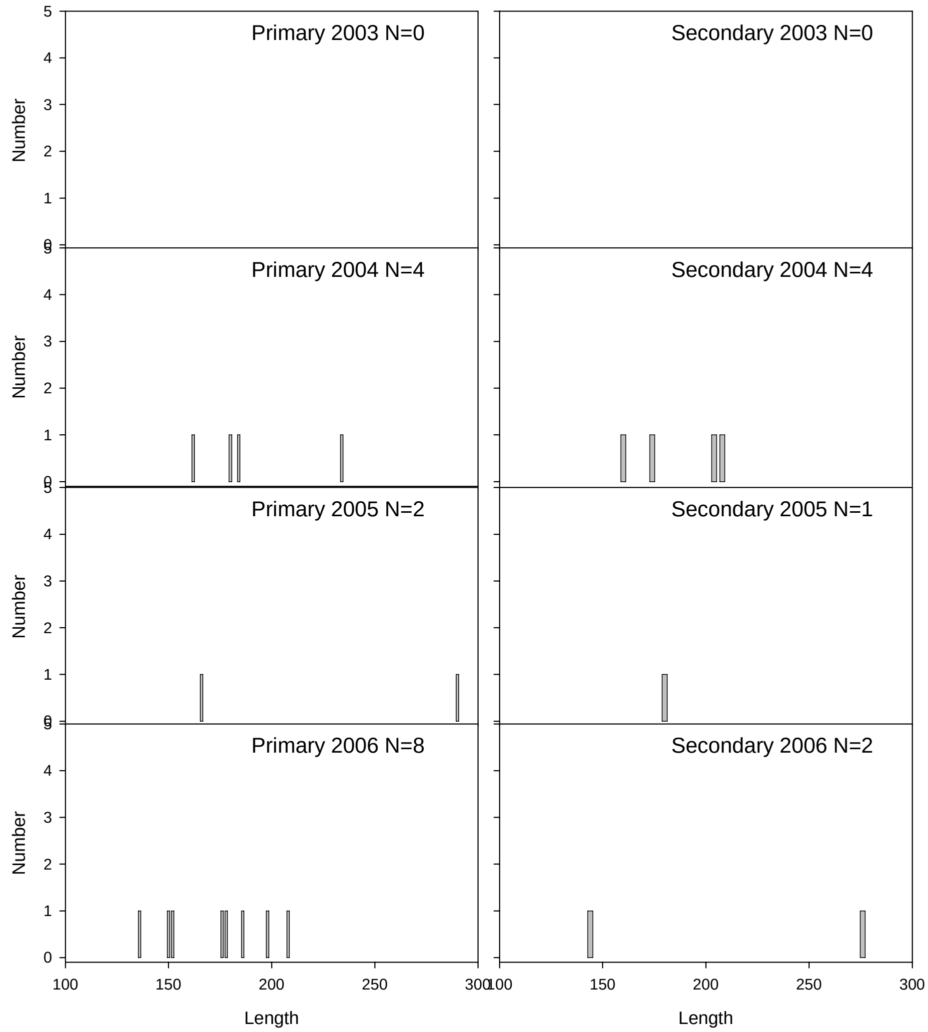


Figure 30. Length frequency of Colorado Pikeminnow from San Juan River primary and secondary channels, 2003-2006.

REACH 6 SUMMARY

Only four species, all native, were collected in the primary channel in Reach 6 in 2006 (Table 14). For the first year, no red shiner was collected in Reach 6. Speckled dace was the most common species collected, with bluehead sucker second-most common. Those two species comprised nearly 98% of the fishes collected in 2006 in Reach 6. Two Colorado pikeminnow were found in the Reach 6 primary channel in 2006. Indeed, no nonnative species was collected in the Reach 6 primary channel in 2006. In contrast, nearly all fishes collected in 2000 in Reach 6 primary channel were nonnatives. Total primary channel fish density was highly variable among years; density in 2006 was slightly less than mean density from 2000 through 2005.

Three secondary channels were sampled in Reach 6 in 2006; slightly more than the average area sampled from 2000 through 2005 (Table 15). One Colorado pikeminnow was captured in a secondary channel in 2006. A single yellow bullhead was found in secondary channels, the only nonnative collected in Reach 6. The third-lowest density of fishes in seven years for Reach 6 secondary channels was in 2006.

The proportion of native species in Reach 6 collections has increased since 2000, when nonnative fish numerically dominated collections (Figures 31 and 32). The greatest number of nonnative species was in 2004, with 11 being collected. Four native species were collected in both primary and secondary channels.

Table 14. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 6 during autumn, 2000–2006.

	2000			2001			2002			2003			2004			2005			2006	
SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY
CYPLUT	2058	7.221	PIMPRO	51	0.108	CYPLUT	316	0.704	RHIOSC	123	0.289	CYPLUT	2529	2.327	CYPLUT	525	0.576	RHIOSC	1881	21.646
GAMAFF	202	0.712	RHIOSC	48	0.102	PIMPRO	229	0.51	CATLAT	101	0.237	RHIOSC	1901	1.749	RHIOSC	468	0.514	CATDIS	145	1.669
PIMPRO	38	0.133	CYPLUT	35	0.074	CATLAT	74	0.164	CYPLUT	55	0.129	PIMPRO	314	0.289	PIMPRO	90	0.099	CATLAT	32	0.368
RHIOSC	2	0.007	GAMAFF	26	0.055	GAMAFF	40	0.089	CATDIS	21	0.049	CATLAT	117	0.108	CATDIS	77	0.085	PTYLUC	2	0.023
CATLAT	2	0.007	CATLAT	12	0.026	CATDIS	35	0.078	GAMAFF	19	0.045	CATDIS	93	0.086	CATLAT	73	0.080			
CATDIS	1	0.004	CATDIS	5	0.011	RHIOSC	33	0.073	PIMPRO	14	0.033	GAMAFF	43	0.040	GAMAFF	4	0.004			
FUNZEB	1	0.004	CYPCAR	1	0.002	FUNZEB	5	0.011				MICSAL	3	0.003	FUNZEB	1	0.001			
			FUNZEB	1	0.002							FUNZEB	2	0.002						
												ICTPUN	2	0.002						
												CYPCAR	1	0.001						
												LEPCYA	1	0.001						
TOTAL N	2304			179			732			333			5006			1238			2060	
AREA	285			471			449			426			1087			911			86.9	
DENSITY	8.08			0.38			1.79			0.78			4.61			1.36			2.37	

Table 15. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 6 during autumn, 2000– 2006.

	2000			2001			2002			2003			2004			2005			2006	
SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY
GAMAFF	87	0.713	GAMAFF	25	0.073	PIMPRO	415	4.428	CYPLUT	571	2.426	PIMPRO	638	3.430	RHIOSC	3	0.05	RHIOSC	52	0.238
CYPLUT	58	0.475	RHIOSC	20	0.058	GAMAFF	269	2.892	CATLAT	92	0.391	RHIOSC	296	1.591	CATLAT	1	0.0167	CATDIS	51	0.233
CYPCAR	9	0.074	CYPLUT	19	0.056	CYPLUT	246	2.631	RHIOSC	67	0.285	CYPLUT	269	1.446				CATLAT	50	0.229
PIMPRO	5	0.041	PIMPRO	18	0.053	FUNZEB	36	0.387	PIMPRO	60	0.255	CATDIS	52	0.280				AMEMEL	1	0.005
MICSAL	4	0.033	CATDIS	9	0.026	CATLAT	29	0.312	CATDIS	19	0.081	GAMAFF	42	0.226				PTYLUC	1	0.005
RHIOSC	2	0.016	FUNZEB	2	0.006	CATDIS	27	0.289	CYPCAR	2	0.008	FUNZEB	4	0.022						
CATLAT	1	0.008	MICSAL	1	0.003	RHIOSC	8	0.086	MICSAL	1	0.004	MICSAL	4	0.022						
CATDIS	1	0.008	ONCMYK	1	0.003	CYPCAR	5	0.053				CYPCAR	1	0.005						
TOTAL N	168			94			1035			833			1357			4			156	
AREA	122			342			93			235.4			186			60			218.5	
DENSITY	1.377			0.275			11.129			3.53			7.30			0.07			0.71	

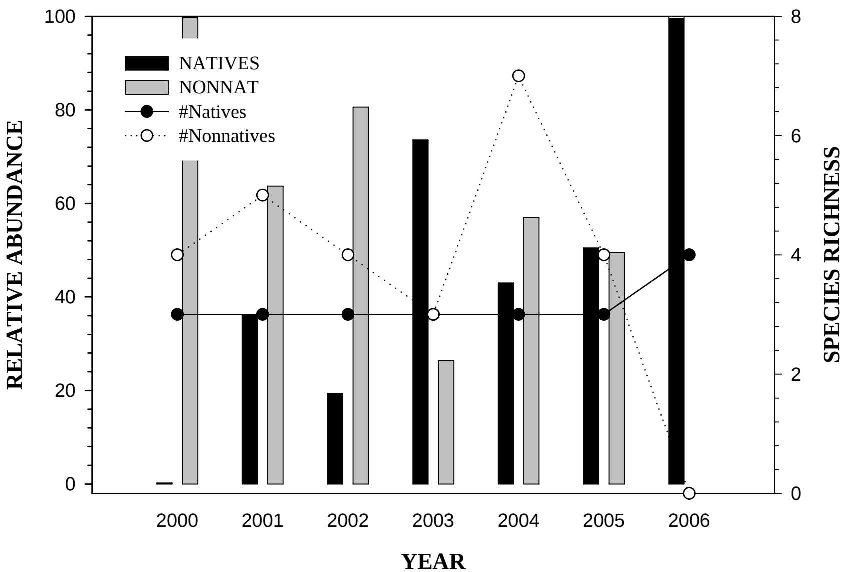


Figure 31. Relative abundance of native and nonnative fishes and species richness in Reach 6 primary channels.

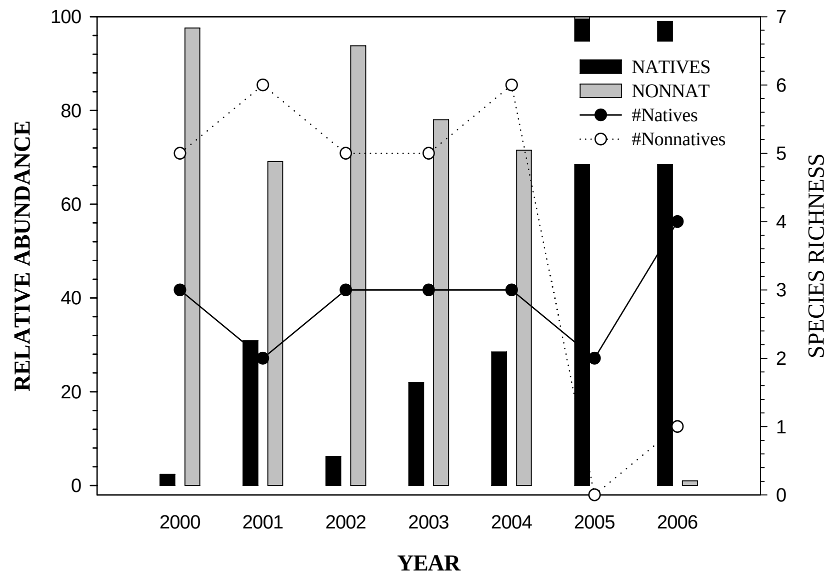


Figure 32. Relative abundance of native and nonnative fishes and species richness in Reach 6 secondary channels.

No backwater was sampled in Reach 6 in 2006 (Table 16). Red shiner was the most common species each year that backwaters were present and sampled. Flannelmouth sucker was not abundant in backwaters from 1998 through 2004, but in 2005, 113 individuals were collected in Reach 6 backwaters. Sixty-nine bluehead suckers were also collected in 2005.

Table 16. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 6 during autumn, 2000 – 2006.

2000			2001			2002	2003			2004	2005			2006
SPECIES	N	DEN	SPECIES	N	DEN		SPECIES	N	DEN		SPECIES	N	DEN	
CYPLUT	481	4.076	CYPLUT	708	23.6	NO BACKWATERS	PIMPRO	110	3.667	NO BACKWATERS	CYPLUT	399	2.078	NO BACKWATERS
PIMPRO	162	1.373	PIMPRO	191	6.367		CYPLUT	18	0.600		CATLAT	113	0.589	
GAMAFF	66	0.56	CATDIS	70	2.333		GAMAFF	5	0.167		PIMPRO	75	0.391	
MICSAL	16	0.136	GAMAFF	25	0.833		CATLAT	2	0.067		CATDIS	69	0.359	
CATDIS	6	0.051	FUNZEB	2	0.067						GAMAFF	12	0.063	
CYPCAR	5	0.042	CYPCAR	1	0.033						RHIOSC	10	0.052	
RHIOSC	2	0.017	RHIOSC	1	0.033									
CATLAT	2	0.017	CATLAT	1	0.033									
FUNZEB	2	0.017	AMEMEL	1	0.033									
N FISH	741			1001				136				678		
AREA	118			30				30				192		
DENSITY	6.28			33.367				4.533				3.536		

REACH 5 SUMMARY

Density of fishes in 2006 in Reach 5 primary channel was the lowest in seven years (Table 17), about 5% of average density from 2000 through 2005. Red shiner was the most abundant fish from 2000 through 2005, but third most abundant in 2006. Speckled dace, second-most abundant for previous 3 years, was the most abundant fish in 2006. Channel catfish was the second-most common species in 2006. A single razorback sucker was collected in 2005. Colorado pikeminnow was collected in both primary and secondary channels of Reach 5 in 2004 and in the primary channel in 2006; none was collected in Reach 5 in 2005. No common carp, plains killifish, or largemouth bass was collected in Reach 5 primary channel in 2006. Nonnative fishes numerically dominated collections (>70%) in Reach 5 for six years, but native fishes gained numerical dominance in both primary and secondary channels in 2006 (Figure 33 and 34). Similarly, 2006 had the fewest number of nonnative species in both primary and secondary channels.

Density of fishes in Reach 5 secondary channels was also lower in 2006 than in previous years, less than 3% of average density from 2000 through 2005 (Table 18). In 2006, speckled dace was the most common species whereas red shiner or fathead minnow was the most common species in the previous six years. No common carp, plains killifish, or largemouth bass was collected in 2005 or 2006.

Only six individuals were collected in Reach 5 backwaters in 2006 (Table 19). Fish density was the lowest in seven years, with the second-lowest backwater area sampled. Backwater area sampled was greatest in 2000. Red shiner and fathead minnow were the most common species from 2000 through 2006.

Table 17. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 5 during autumn, 2000– 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY
CYPLUT	5219	10.522	CYPLUT	376	0.855	CYPLUT	1033	2.311	CYPLUT	363	0.864	CYPLUT	3065	2.245	CYPLUT	539	0.565	RHIOSC	159	0.145
GAMAFF	250	0.504	RHIOSC	122	0.277	PIMPRO	206	0.461	RHIOSC	49	0.117	RHIOSC	1421	1.041	RHIOSC	72	0.075	ICTPUN	17	0.015
RHIOSC	44	0.088	PIMPRO	19	0.043	GAMAFF	80	0.179	GAMAFF	15	0.036	PIMPRO	306	0.224	PIMPRO	63	0.066	CYPLUT	16	0.015
PIMPRO	42	0.085	GAMAFF	14	0.032	RHIOSC	76	0.17	CATLAT	14	0.033	CATDIS	95	0.070	GAMAFF	9	0.009	CATLAT	12	0.011
CATLAT	10	0.02	CATDIS	2	0.005	CATDIS	10	0.022	ICTPUN	14	0.033	ICTPUN	84	0.062	CATLAT	6	0.006	CATDIS	5	0.005
CATDIS	6	0.012	ICTPUN	2	0.005	CATLAT	8	0.018	PIMPRO	7	0.017	GAMAFF	42	0.031	CATDIS	3	0.003	PTYLUC	3	0.003
FUNZEB	1	0.002	CATLAT	1	0.002	ICTPUN	7	0.016	CATDIS	2	0.005	CATLAT	39	0.029	ICTPUN	1	0.001			
			MICSAL	1	0.002	CYPCAR	2	0.005				FUNZEB	6	0.004	XYRTEX	1	0.001			
												CYPCAR	3	0.002						
												PTYLUC	3	0.002						
												ICTPUNS	1	0.001						
												MICSAL	1	0.001						
TOTAL N	5572			537			1428			464			5066			694			212	
AREA	496			440			447			420			1365			954			1097	
DENSITY	11.23			1.22			3.20			1.11			3.71			0.73			0.19	

Table 18. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 5 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	8984	22.074	CYPLUT	219	0.619	CYPLUT	2790	6.906	CYPLUT	435	1.390	CYPLUT	1760	6.331	CYPLUT	689	1.444	RHIOSC	60	0.129
PIMPRO	1352	3.322	PIMPRO	38	0.107	PIMPRO	592	1.465	PIMPRO	154	0.492	PIMPRO	502	1.806	PIMPRO	57	0.119	CYPLUT	26	0.056
GAMAFF	812	1.995	RHIOSC	35	0.099	GAMAFF	195	0.483	RHIOSC	81	0.259	RHIOSC	310	1.115	RHIOSC	50	0.105	ICTPUN	12	0.026
CYPCAR	160	0.393	GAMAFF	29	0.082	CATLAT	51	0.126	ICTPUN	16	0.051	GAMAFF	60	0.216	GAMAFF	43	0.090	CATLAT	4	0.009
RHIOSC	48	0.118	FUNZEB	2	0.006	RHIOSC	49	0.121	GAMAFF	4	0.013	CATDIS	19	0.068	CATLAT	16	0.034	PIMPRO	3	0.006
CATLAT	10	0.025	CATLAT	1	0.003	FUNZEB	16	0.04	CATDIS	3	0.010	CATLAT	15	0.054	CATDIS	3	0.006	AMEMEL	2	0.004
CATDIS	8	0.02	ICTPUN	1	0.003	CATDIS	14	0.035	CATLAT	3	0.010	ICTPUN	10	0.036	ICTPUN	2	0.004	CATDIS	1	0.002
MICSAL	3	0.007				CYPCAR	11	0.027	FUNZEB	3	0.010	CYPCAR	7	0.025	AMEMEL	1	0.002			
						AMEMEL	1	0.002	AMEMEL	2	0.006	FUNZEB	7	0.025						
												PTYLUC	3	0.011						
												AMEMEL	2	0.007						
												LEPCYA	1	0.004						
												MICSAL	1	0.004						
N	11377			325			3719			701			2697			861			108	
AREA	407			354			404			313			278			477			466	
DENSITY	27.953			0.918			9.205			2.252			9.701			1.807			0.232	

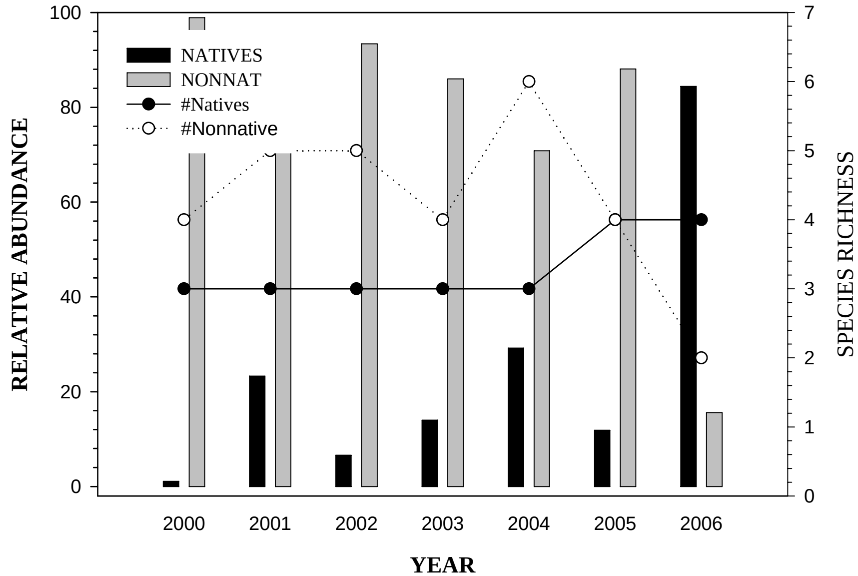


Figure 33. Relative abundance of native and nonnative fishes and species richness in Reach 5 primary channel.

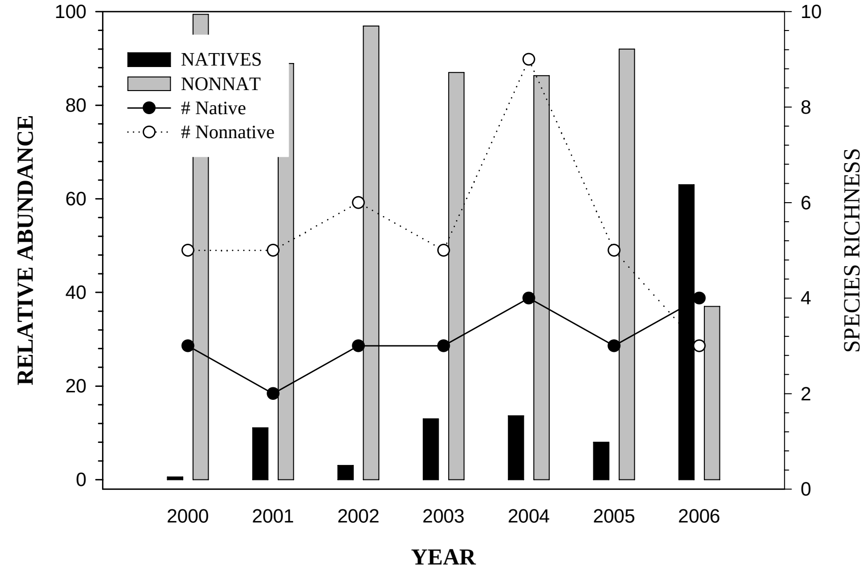


Figure 34. Relative abundance of native and nonnative fishes and species richness in Reach 5 secondary channels.

Table 19. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 5 during autumn 2000-2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	4965	15.965	CYPLUT	909	5.476	CYPLUT	875	8.413	PIMPRO	112	1.047	CYPLUT	264	7.059	CYPLUT	93	0.427	CYPLUT	3	0.056
PIMPRO	274	0.881	PIMPRO	65	0.392	PIMPRO	250	2.404	CYPLUT	97	0.907	PIMPRO	36	0.963	PIMPRO	33	0.151	PIMPRO	2	0.037
GAMAFF	118	0.379	RHIOSC	3	0.018	GAMAFF	12	0.115	CATLAT	4	0.037	RHIOSC	6	0.160	GAMAFF	4	0.018	RHIOSC	1	0.019
CATDIS	8	0.026	CATDIS	1	0.006	CATLAT	7	0.01	GAMAFF	4	0.037	GAMAFF	5	0.134	FUNZEB	3	0.014			
CYPCAR	4	0.013	CATLAT	1	0.006	CATDIS	1	0.01	CATDIS	2	0.019	CATDIS	2	0.053	RHIOSC	2	0.009			
CATLAT	3	0.01	GAMAFF	1	0.006	CYPCAR	1	0.01	RHIOSC	1	0.009	CYPCAR	2	0.053	CATLAT	1	0.005			
RHIOSC	1	0.003	LEPCYA	1	0.006	FUNZEB	1	0.01				ICTPUN	1	0.027	ICTPUN	1	0.005			
ICTPUN	1	0.003																		
MICSAL	1	0.003																		
N	5375			983			1147			205			316			137			6	
AREA	311			166			104			107			37.4			218			53.5	
DENSITY	17.289			3.944			11.058			1.916			8.449			0.633			0.112	

REACH 4 SUMMARY

The same five species were collected in Reach 4 primary channel in 2005 and 2006; however, channel catfish was the most abundant species for the first time since this study began (Table 20). Red shiner was the most abundant species for the previous six years; speckled dace was second-most abundant in all years. Colorado pikeminnow has not been collected in Reach 4 primary channel since 2004. No bluehead sucker was captured in the primary channel of Reach 4 in 2005 or 2006. Fish density in 2006 was lower than in previous years. The proportion of native species increased each of the past seven years in both primary and secondary channels (Figure 35 and 36).

Seven species were collected in Reach 4 secondary channels in 2006 (Table 21). Colorado pikeminnow was collected in Reach 4 secondary channels in 2004 and 2005, but not in 2006. Red shiner was the most common species in all years, except 2006 when it ranked second and speckled dace was the most common. Fathead minnow was the second-most species common from 2001 through 2004; however, channel catfish ranked second in 2005. Fish density in 2006 was less than 10% of the average density of the preceding 6 years.

No backwater was sampled in Reach 4 in 2006 and only one backwater was sampled in Reach 4 in 2005 (Table 22). The highest fish density in Reach 4 backwaters was in 2000, when nine backwaters were sampled. Fathead minnow and red shiner were the most common species in all years.

Table 20. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 4 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	3616	3.649	CYPLUT	1007	3.334	CYPLUT	1704	3.221	CYPLUT	367	0.660	CYPLUT	2025	1.296	CYPLUT	278	0.338	ICTPUN	94	0.096
RHIOSC	50	0.051	RHIOSC	62	0.205	PIMPRO	151	0.327	RHIOSC	127	0.228	RHIOSC	641	0.410	RHIOSC	234	0.284	RHIOSC	81	0.082
GAMAFF	11	0.011	PIMPRO	12	0.04	RHIOSC	92	0.2	ICTPUN	37	0.067	PIMPRO	419	0.268	ICTPUN	80	0.097	CYPLUT	28	0.029
CYPCAR	4	0.004	GAMAFF	5	0.017	ICTPUN	34	0.074	PIMPRO	32	0.058	ICTPUN	119	0.076	PIMPRO	24	0.029	CATLAT	5	0.005
CATLAT	4	0.004	CATLAT	2	0.007	GAMAFF	17	0.037	CATLAT	5	0.009	CATLAT	34	0.022	CATLAT	6	0.007	PIMPRO	2	0.002
ICTPUN	4	0.004	FUNZEB	2	0.007	CATLAT	17	0.037	FUNZEB	4	0.007	GAMAFF	27	0.017						
PIMPRO	3	0.003				CATDIS	7	0.015	CATDIS	2	0.004	CATDIS	19	0.012						
CATDIS	1	0.001				CYPCAR	4	0.009	LAT DIS	1	0.002	FUNZEB	18	0.012						
FUNZEB	1	0.001				FUNZEB	2	0.004	LEPCYA	1	0.002	AMEMEL	1	0.001						
												PTYLUC	1	0.001						
N	3794			1090			2029			576			3304			622			210	
AREA	991			302			461			556			1562			823			982	
DENSITY	3.828			3.609			4.401			1.036			2.115			0.761			0.214	

Table 21. Number and density (number/m^2) of fishes in San Juan River secondary channel in Geomorphic Reach 4 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	2792	5.132	CYPLUT	708	2.192	CYPLUT	1502	4.457	CYPLUT	466	0.979	CYPLUT	3943	5.357	CYPLUT	179	0.514	RHIOSC	112	0.198
CYPCAR	118	0.217	PIMPRO	131	0.406	PIMPRO	509	1.51	PIMPRO	100	0.210	PIMPRO	1076	1.462	ICTPUN	63	0.181	CYPLUT	70	0.124
GAMAFF	77	0.141	RHIOSC	43	0.133	RHIOSC	24	0.071	CATLAT	48	0.101	RHIOSC	578	0.785	RHIOSC	62	0.178	ICTPUN	18	0.032
PIMPRO	74	0.136	GAMAFF	38	0.118	CATLAT	10	0.03	RHIOSC	45	0.095	ICTPUN	52	0.071	PIMPRO	41	0.118	PIMPRO	15	0.027
RHIOSC	31	0.057	FUNZEB	16	0.05	CYPCAR	8	0.024	ICTPUN	25	0.053	GAMAFF	46	0.063	CATLAT	3	0.009	CATLAT	3	0.005
MICSAL	11	0.02	CATLAT	4	0.012	CATDIS	8	0.024	FUNZEB	7	0.015	CATDIS	34	0.046	AMEMEL	2	0.006	GAMAFF	3	0.005
CATLAT	9	0.016	ICTPUN	3	0.009	ICTPUN	6	0.018	AMEMEL	4	0.008	CATLAT	26	0.035	GAMAFF	2	0.006	AMEMEL	1	0.002
PTYLUC	3	0.005	CATDIS	1	0.003	AMEMEL	3	0.009	GAMAFF	4	0.008	FUNZEB	21	0.029	AMENAT	1	0.003			
CATDIS	2	0.004	AMENAT	1	0.003	GAMAFF	3	0.009	CATDIS	2	0.004	ICTPUNS	6	0.008	CATDIS	1	0.003			
ICTPUN	2	0.004	CYPCAR	1	0.003	FUNZEB	2	0.006				AMEMEL	4	0.005	PTYLUC	1	0.003			
FUNZEB	1	0.002										CYPCAR	2	0.003						
												MICSAL	1	0.001						
												PTYLUC	1	0.001						
N	3111			946			2075			701			5790			355			222	
AREA	544			323			337			476			736			348			566	
DENSITY	5.719			2.929			6.22			1.477			7.867			1.02			0.392	

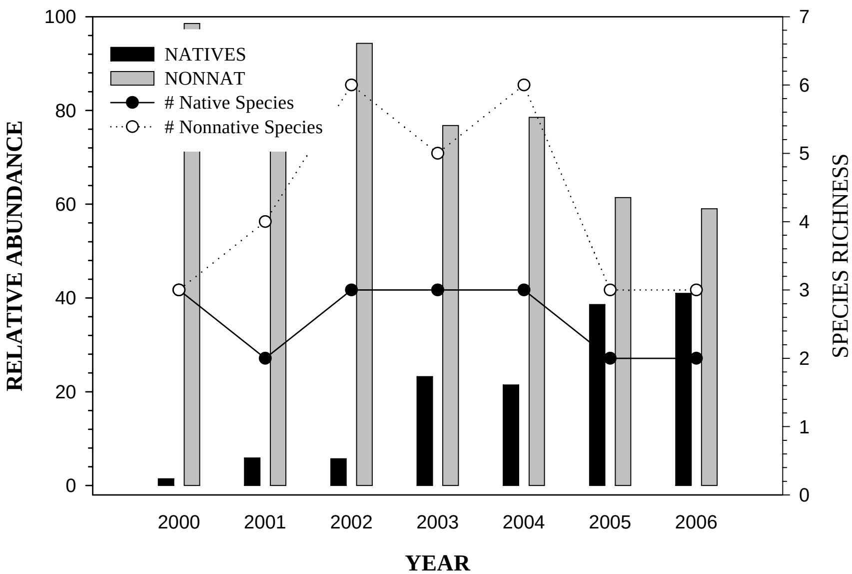


Figure 35. Relative abundance of native and nonnative fishes and species richness in Reach 4 primary channel.

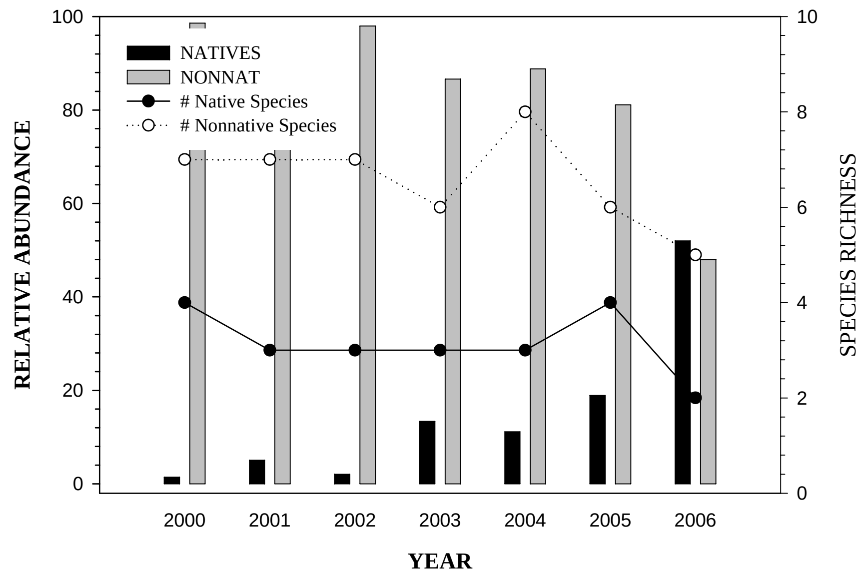


Figure 36. Relative abundance of native and nonnative fishes and species richness in Reach 4 secondary channels.

Table 22. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 4 during autumn 2000 - 2006.

2000			2001			2002			2003			2004	2005			2006
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN		SPECIES	N	DEN	
CYPLUT	4965	15.965	CYPLUT	909	5.476	CYPLUT	875	8.413	CYPLUT	122	1.627	NO BACKWATERS	CYPLUT	3	0.157	NO BACKWATERS
PIMPRO	274	0.881	PIMPRO	65	0.392	PIMPRO	250	2.404	PIMPRO	16	0.213		PIMPRO	1	0.052	
GAMAFF	118	0.379	RHIOSC	3	0.018	GAMAFF	12	0.115	AMEMEL	11	0.147					
CATDIS	8	0.026	CATDIS	1	0.006	CATLAT	7	0.01	RHIOSC	2	0.027					
CYPCAR	4	0.013	CATLAT	1	0.006	CATDIS	1	0.01	CATDIS	1	0.013					
CATLAT	3	0.01	GAMAFF	1	0.006	CYPCAR	1	0.01								
RHIOSC	1	0.003	LEPCYA	1	0.006	FUNZEB	1	0.01								
ICTPUN	1	0.003														
MICSAL	1	0.003														
N	5375			983			1147			152				4		
AREA	311			166			104			120				19.1		
DENSITY	17.289			3.944			11.058			1.26				0.209		

REACH 3 SUMMARY

Nine species were collected in Reach 3 primary channel in 2006, including two Colorado pikeminnow (Table 23). In 2006, speckled dace was the most common species and channel catfish was second-most common. Red shiner and speckled dace were the most common species four of the previous six years. Fish density in Reach 3 primary channel was lower in 2006 than in previous years; highest fish densities were in 2002. The area sampled in 2006 was the third-greatest in six years of sampling; greatest was in 2004. In 2006, there were roughly equal proportions of native and nonnative species in Reach 3 primary channels (Figure 37).

Though speckled dace was the most common species in Reach 3 secondary channels in 2005, red shiner regained the top spot in 2006 (Table 24). A single Colorado pikeminnow was captured in 2006, the first capture in Reach 4 secondary channels. Although area sampled in 2006 in Reach 3 secondary channels was only slightly less than study average, fish density was the lowest in seven monitoring years. The proportion of native to nonnative species was similar in 2005 and 2006 despite the number of native and nonnative species each increasing by one (Figure 38).

Only one backwater was sampled in Reach 3 in 2005 and none was sampled in 2006 (Table 25). Red shiner was the most common species in all years since 2000. Fathead minnow was second-most common 4 of 6 years.

Table 23. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 3 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	3247	3.286	CYPLUT	1298	1.94	CYPLUT	3162	3.639	CYPLUT	713	0.653	CYPLUT	1515	0.733	CYPLUT	928	0.569	RHIOSC	230	0.178
GAMAFF	182	0.184	RHIOSC	93	0.139	PIMPRO	413	0.475	RHIOSC	182	0.167	RHIOSC	639	0.309	RHIOSC	409	0.251	ICTPUN	110	0.085
PIMPRO	69	0.07	PIMPRO	43	0.064	RHIOSC	269	0.31	ICTPUN	117	0.107	ICTPUN	212	0.103	ICTPUN	147	0.090	CYPLUT	91	0.071
RHIOSC	48	0.049	GAMAFF	11	0.016	ICTPUN	55	0.061	PIMPRO	45	0.041	PIMPRO	130	0.063	PIMPRO	91	0.056	PIMPRO	41	0.032
CATLAT	14	0.014	CATLAT	3	0.005	GAMAFF	25	0.028	CATLAT	12	0.011	CATLAT	55	0.027	CATLAT	20	0.012	CATLAT	11	0.009
ICTPUN	7	0.007	ICTPUN	2	0.003	CATLAT	21	0.024	FUNZEB	12	0.011	CATDIS	39	0.019	CATDIS	9	0.006	GAMAFF	4	0.003
CATDIS	3	0.003				CYPCAR	13	0.014	CATDIS	2	0.002	GAMAFF	9	0.004	GAMAFF	2	0.001	AMEMEL	3	0.002
CYPCAR	3	0.003				FUNZEB	8	0.009	GAMAFF	2	0.002	FUNZEB	4	0.002	AMEMEL	1	0.001	PTYLUC	2	0.002
						CATDIS	4	0.004				CYPCAR	2	0.001	PTYLUC	1	0.001	CATDIS	1	0.001
						AMEMEL	2	0.002												
N	3573			1450			3972			1086			2605			1608			493	
AREA	988			669			869			1092			2067			1631			1289	
DENSITY	3.616			2.167			4.571			0.995			1.260			0.986			0.382	

Table 24. Number and density (number/m^2) of fishes in San Juan River secondary channel in Geomorphic Reach 3 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	4885	5.073	CYPLUT	901	1.347	CYPLUT	1886	3.742	CYPLUT	164	0.351	CYPLUT	1199	2.089	RHIOSC	56	0.357	CYPLUT	58	0.135
GAMAFF	338	0.351	RHIOSC	95	0.142	PIMPRO	265	0.526	RHIOSC	43	0.092	RHIOSC	175	0.305	CYPLUT	54	0.344	RHIOSC	27	0.063
RHIOSC	77	0.08	PIMPRO	39	0.058	RHIOSC	143	0.283	ICTPUN	34	0.073	ICTPUN	48	0.084	ICTPUN	49	0.312	ICTPUN	12	0.028
PIMPRO	72	0.75	CATLAT	22	0.033	ICTPUN	31	0.061	PIMPRO	11	0.024	CATLAT	30	0.052	PIMPRO	8	0.051	CATDIS	10	0.023
CATLAT	25	0.026	GAMAFF	21	0.031	CATLAT	9	0.018	AMEMEL	3	0.006	PIMPRO	21	0.037	CATLAT	4	0.025	PIMPRO	8	0.019
ICTPUN	25	0.027	ICTPUN	16	0.024	FUNZEB	6	0.012	GAMAFF	3	0.006	CATDIS	17	0.030	CATDIS	3	0.019	CATLAT	4	0.009
CYPCAR	22	0.023	AMEMEL	2	0.003	CATDIS	4	0.008	CATLAT	2	0.004	GAMAFF	6	0.010				GAMAFF	1	0.002
CATDIS	6	0.006	CYPCAR	1	0.001	AMEMEL	4	0.008	FUNZEB	1	0.002							PTYLUC	1	0.002
FUNZEB	3	0.003	CATDIS	1	0.001	CYPCAR	3	0.006												
						GAMAFF	3	0.006												
N	5456			1099			2354			261			1496			174			121	
AREA	963			669			504			467			574			157			429	
DENSITY	5.666			1.643			4.671			0.559			2.606			1.115			0.282	

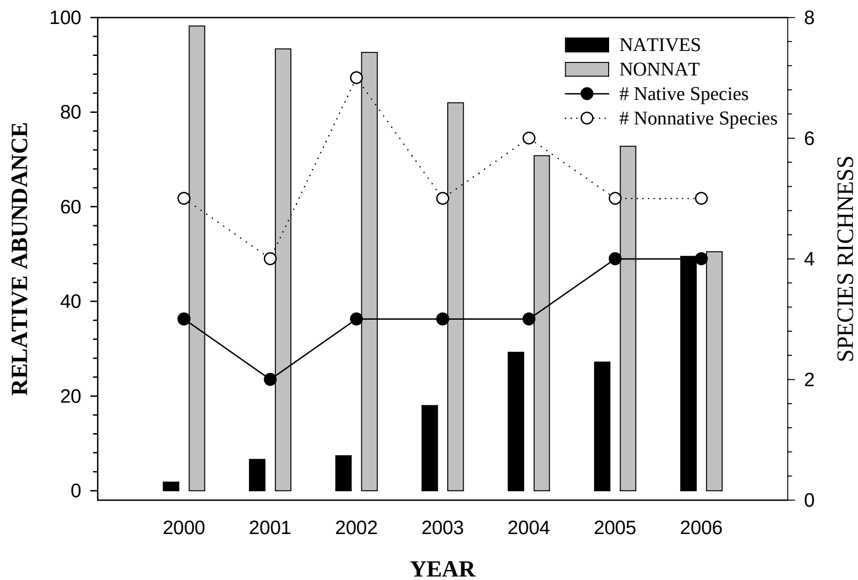


Figure 37. Relative abundance of native and nonnative fishes and species richness in Reach 3 primary channel.

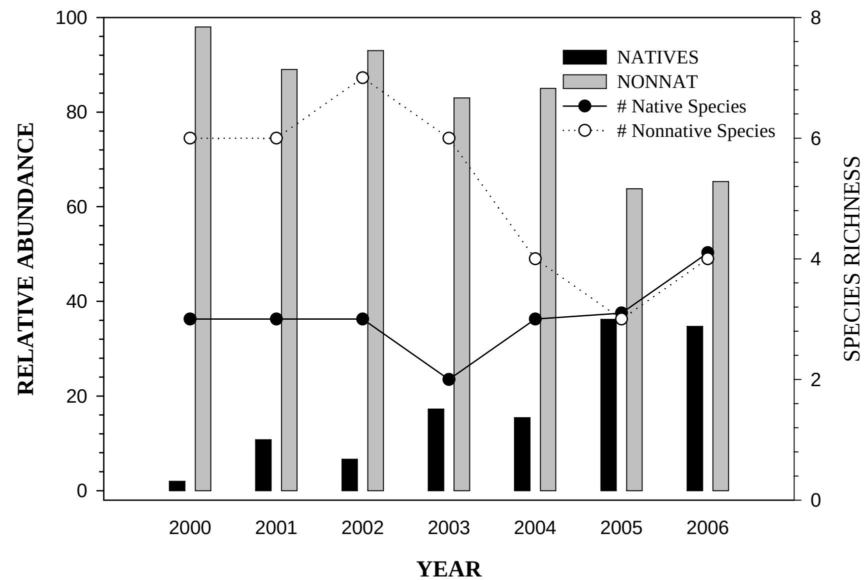


Figure 38. Relative abundance of native and nonnative fishes and species richness in Reach 3 secondary channels.

Table 25. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 3 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	
																		N
CYPLUT	2606	7.642	CYPLUT	2053	12.293	CYPLUT	1881	8.214	CYPLUT	63	1.340	CYPLUT	763	3.484	CYPLUT	10	1.053	O
GAMAFF	267	0.783	PIMPRO	104	0.623	PIMPRO	674	2.943	GAMAFF	11	0.234	PIMPRO	281	1.283	PIMPRO	2	0.211	
PIMPRO	83	0.243	GAMAFF	12	0.072	GAMAFF	45	0.196	PIMPRO	3	0.064	FUNZEB	24	0.110	CYPCAR	1	0.105	B
AMEMEL	106	0.311	RHIOSC	3	0.018	RHIOSC	28	0.122	ICTPUN	2	0.043	GAMAFF	12	0.055				A
CATLAT	5	0.015	CYPCAR	1	0.006	ICTPUN	22	0.096	AMEMEL	1	0.021	ICTPUN	9	0.041				C
CYPCAR	4	0.012	ICTPUN	1	0.006	CYPCAR	17	0.074	RHIOSC	1	0.021	RHIOSC	4	0.018				K
ICTPUN	2	0.006	FUNZEB	1	0.006	AMEMEL	6	0.026				CATLAT	1	0.005				W
PTYLUC	1	0.003				CATLAT	6	0.026				CYPCAR	1	0.005				A
FUNZEB	1	0.003				FUNZEB	5	0.022										T
						LEPCYA	2	0.009										E
						CATDIS	1	0.004										R
																		S
N	3072			2175			2687			81			1095			13		
AREA	341			167			229			47			219			9.5		
DENSITY	9.009			13.024			11.734			1.723			5.000			1.368		

REACH 2 SUMMARY

Six species were collected in Reach 2 primary channel, including one Colorado pikeminnow. This was the second year a Colorado pikeminnow was collected by small-bodied sampling in Reach 2 (Table 26). In 2006, channel catfish and speckled dace were the most common species; red shiner and channel catfish were the most common species for the previous 4 years. In 2006, area sampled and fish density were the lowest of this study. The proportion of natives was low in Reach 2, but 2006 had the highest proportion (approximately 20%) since small-bodied fishes monitoring began (Figure 39). Four native species were collected in 2005 and 2006.

No backwater was sampled in Reach 2 in 2006 (Table 27). Red shiner and fathead minnow were the most common species in Reach 2 backwaters in five of the six years of this study. In 2005, backwater fish density was slightly higher than in the previous two years.

Table 26. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 2 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	2310	1.577	CYPLUT	638	0.637	CYPLUT	407	0.38	ICTPUN	162	0.150	CYPLUT	546	0.390	CYPLUT	210	0.143	ICTPUN	113	0.118
GAMAFF	44	0.03	RHIOSC	18	0.018	ICTPUN	105	0.098	CYPLUT	132	0.122	ICTPUN	147	0.105	ICTPUN	169	0.115	RHIOSC	50	0.052
ICTPUN	20	0.014	PIMPRO	16	0.016	RHIOSC	43	0.04	RHIOSC	30	0.028	RHIOSC	73	0.052	RHIOSC	53	0.036	CYPLUT	22	0.023
PIMPRO	19	0.013	ICTPUN	7	0.007	PIMPRO	32	0.03	CATLAT	8	0.007	CATDIS	34	0.024	PIMPRO	13	0.009	CATDIS	2	0.002
RHIOSC	16	0.011	GAMAFF	3	0.003	CATLAT	17	0.016	FUNZEB	4	0.004	GAMAFF	6	0.004	CATLAT	6	0.004	CATLAT	2	0.002
CATDIS	6	0.004	CATDIS	1	0.001	CATDIS	4	0.004	GAMAFF	1	0.001	CATLAT	5	0.004	CYPCAR	2	0.001	PTYLUC	1	0.001
CATLAT	2	0.001				GAMAFF	3	0.003	LEPCYA	1	0.001	AMEMEL	1	0.001	CATDIS	1	0.001			
						CYPCAR	3	0.003	PIMPRO	1	0.001	PIMPRO	1	0.001	GAMAFF	1	0.001			
						AMEMEL	1	0.001							LEPCYA	1	0.001			
															PTYLUC	1	0.001			
N	2417			683			615			339			813			457			190	
AREA	1465			1002			1072			1080			1400			1470			961	
DENSITY	1.65			0.682			0.574			0.314			0.581			0.310			0.198	

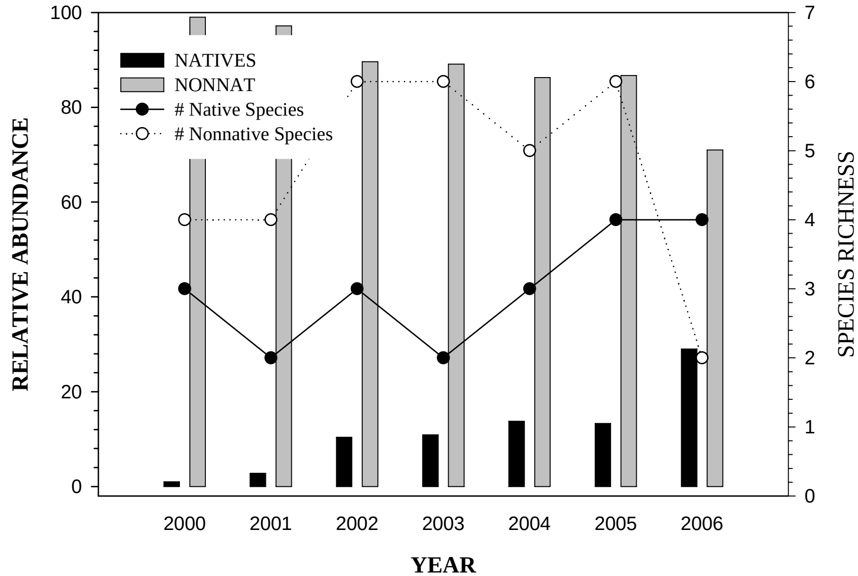


Figure 39. Relative abundance of native and nonnative fishes and species richness in San Juan River Reach 2 primary channel.

Table 27. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 2 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	
CYPLUT	2750	8.567	CYPLUT	30	0.417	CYPLUT	49	0.754	CYPLUT	15	0.366	CYPLUT	23	1.494	CYPLUT	31	0.626	NO BACKWATERS
PIMPRO	144	0.449	PIMPRO	9	0.125	PIMPRO	36	0.554	ICTPUN	8	0.195	RHIOSC	2	0.130	PIMPRO	11	0.222	
GAMAFF	114	0.355	CATLAT	1	0.014	CYPCAR	2	0.031	LEPCYA	1	0.024	PIMPRO	2	0.130	MICSAL	2	0.040	
ICTPUN	37	0.115				CATLAT	1	0.015	PIMPRO	1	0.024	GAMAFF	1	0.065				
CATLAT	9	0.028				ICTPUN	1	0.015										
CYPCAR	5	0.016																
CATDIS	3	0.009																
RHIOSC	2	0.006																
MICSAL	1	0.003																
N	3065			40			89			25			28			44		
AREA	321			72			65			41			15.4			49.5		
DENSITY	9.548			0.556			1.369			0.610			1.818			0.889		

REACH 1 SUMMARY

Although the area sampled was only slightly less than average, only 10 fish were collected in Reach 1 in 2006 (Table 28). Similar to other years, red shiner was the most common fish collected. No native species was collected in 2006 and speckled dace was the only native species collected in 2005. From 2000 through 2004, flannelmouth sucker was collected each year and bluehead sucker four of five years. Native species never comprised more than 10% of collections in Reach 1 primary channels from 2000 through 2006 (Figure 40).

No backwater was sampled in Reach 1 from 2003 through 2006 (Table 29). From 2000 to 2002, red shiner was the most common species in Reach 1 backwaters, comprising over 95% of the fish collected. In 2000, fish density was nearly ten times higher than in 2001 and 2002.

Table 28. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 1 during autumn 2000 - 2006.

2000			2001			2002			2003			2004			2005			2006		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	3664	12.856	CYPLUT	142	0.686	CYPLUT	502	2.154	CYPLUT	76	0.198	CYPLUT	143	0.518	CYPLUT	40	0.214	CYPLUT	7	0.028
GAMAFF	336	1.179	PIMPRO	3	0.014	ICTPUN	30	0.113	ICTPUN	36	0.094	ICTPUN	38	0.138	ICTPUN	4	0.021	ICTPUN	2	0.008
PIMPRO	17	0.06	CATLAT	2	0.01	PIMPRO	15	0.056	CATLAT	2	0.005	PIMPRO	10	0.036	RHIOSC	4	0.021	PIMPRO	1	0.004
CATLAT	2	0.007	ICTPUN	2	0.01	RHIOSC	15	0.056	RHIOSC	2	0.005	CATLAT	4	0.014	PIMPRO	2	0.011			
RHIOSC	1	0.004	RHIOSC	1	0.005	CATLAT	3	0.011	CATDIS	1	0.003	CATDIS	3	0.011	CYPCAR	1	0.005			
CATDIS	1	0.004	FUNZEB	1	0.005	CATDIS	1	0.004	FUNZEB	1	0.003	RHIOSC	2	0.007						
FUNZEB	1	0.004				CYPCAR	1	0.004	PIMPRO	1	0.003									
N	4025			151			567			119			200			51			10	
AREA	285			207			266			383			276			187			247	
DENSITY	14.123			0.729			2.132			0.311			0.725			0.272			0.040	

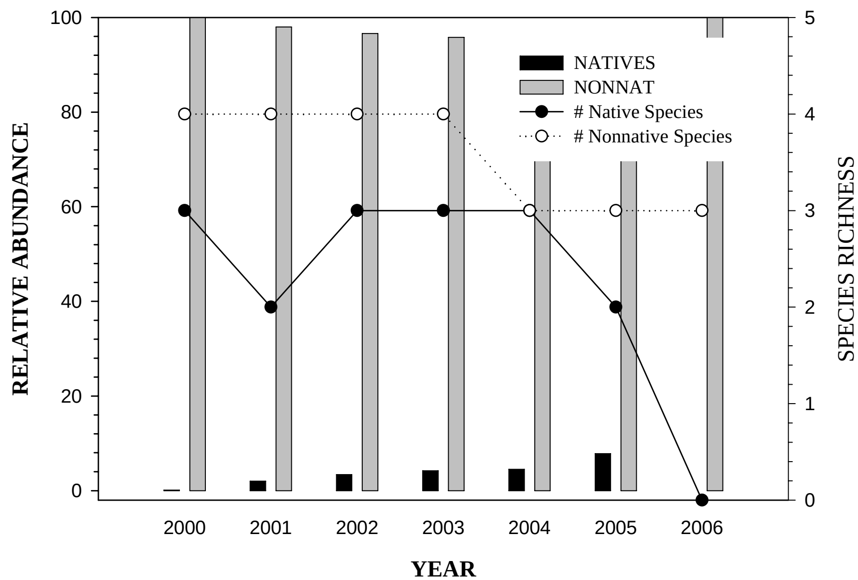


Figure 40. Relative abundance of native and nonnative fishes and species richness in San Juan River Reach 1 primary channel.

Table 29. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 1 (RM 17 – RM 0) during autumn, 2000 – 2005.

2000			2001			2002			2003	2004	2005
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN			
CYPLUT	4769	31.977	CYPLUT	97	2.425	CYPLUT	99	2.25	**NO BACKWATERS**	**NO BACKWATERS**	**NO BACKWATERS**
GAMAFF	91	0.419	PIMPRO	1	0.025	PIMPRO	14	0.318			
PIMPRO	57	0.263	RHIOSC	1	0.025	ICTPUN	8	0.182			
CATLAT	9	0.042	ICTPUN	1	0.025	CYPCAR	1	0.023			
CATDIS	9	0.042	GAMAFF	1	0.025	AMEMEL	1	0.023			
ICTPUN	4	0.018	CATLAT	1	0.025	GAMAFF	1	0.023			
CYPCAR	3	0.014									
LEPMAC	2	0.009									
BKWS N	7			4			2				
N	4944			104			124				
AREA	217			40			44				
DENSITY	22.783			2.6			2.818				
H	0.157			0.325			0.501				

DENSITY VERSUS DISCHARGE

Autumn species densities from 2000 through 2006 were compared with several discharge attributes (Table 30). Flannelmouth sucker was the only native species that showed any relationship with spring or summer mean daily discharge or number of low flow (<500 cfs) summer days. There were, however, several density and 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 41). Both species secondary channel densities were positively correlated with the number of low flow days and fathead minnow primary channel density was correlated with low-flow days.

Table 30. Regression analysis results for density of commonly collected fish species in 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 2006. Shaded areas indicate significant relationship (p<0.10).

Primary Channel						
	SPRING Q		SUMMER Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES						
CATDIS	-0.101	0.829	0.237	0.609	-0.074	0.874
CATLAT	-0.490	0.264	-0.173	0.711	0.682	0.091
RHIOSC	-0.030	0.950	0.297	0.518	-0.213	0.646
NONNATIVES						
CYPLUT	-0.259	0.575	-0.853	0.014	0.519	0.233
ICTPUN	-0.207	0.656	0.376	0.405	0.132	0.778
PIMPRO	-0.417	0.352	-0.868	-0.011	0.755	0.050

Secondary Channels						
	SPRING Q		SUMMER Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES						
CATDIS	-0.425	0.342	-0.140	0.765	0.270	0.558
CATLAT	-0.636	0.125	-0.132	0.779	0.519	0.232
RHIOSC	-0.042	0.929	-0.111	0.813	0.205	0.659
NONNATIVES						
CYPLUT	-0.388	0.390	-0.930	0.002	0.761	0.047
ICTPUN	0.680	0.092	0.540	0.211	-0.205	0.660
PIMPRO	-0.508	0.244	-0.800	0.031	0.863	0.012

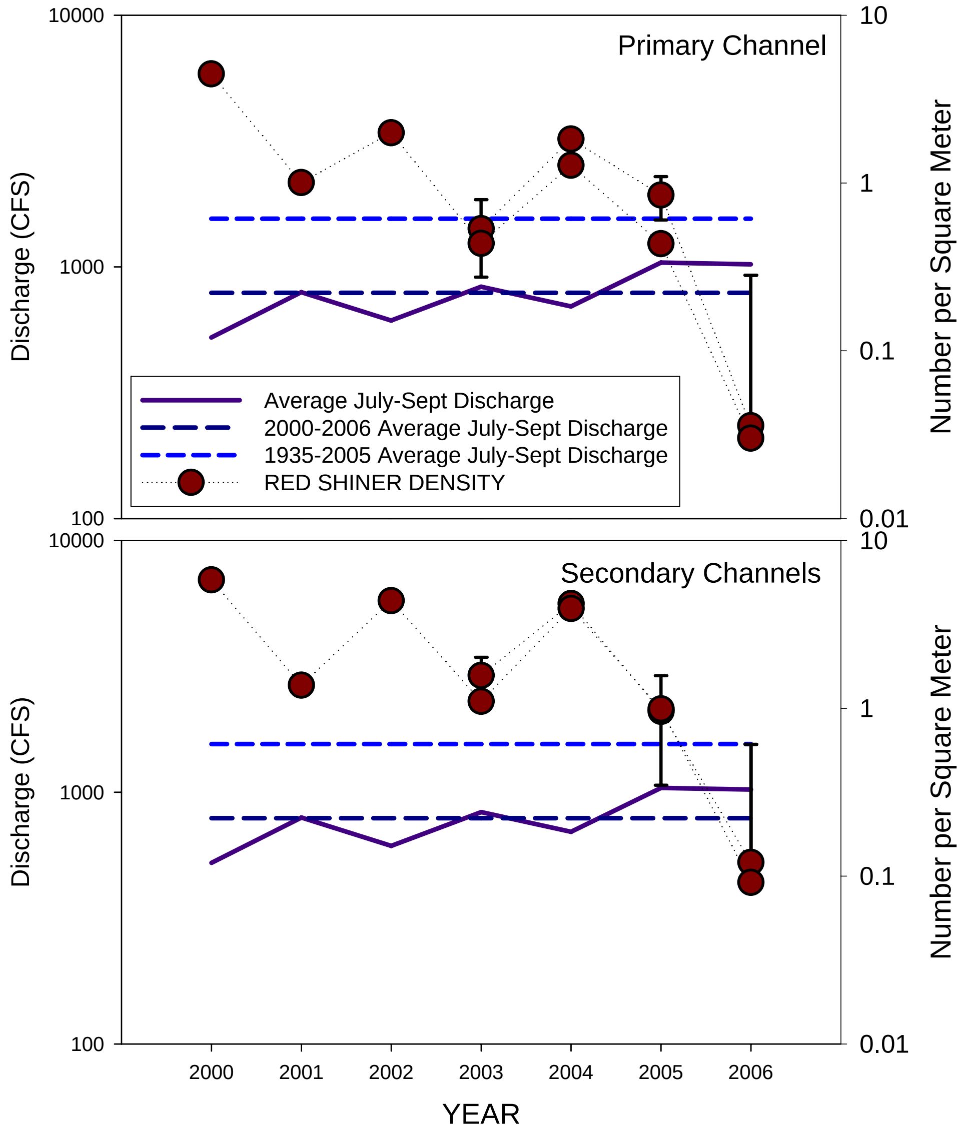


Figure 41. Relationship of density of red shiner collected during autumn sampling and summer average daily discharge measured at Shiprock Gage (#09368000), San Juan River. Note Y-axes are log scale.

Mean daily discharge during sampling varied among years (Figure 42). During sampling in the upper reaches, discharge was highest in 2004, while in the lower reaches highest discharge at time of sampling occurred in 2006. There was no correlation with mean, minimum, or maximum daily discharge and density of fishes collected in small-bodied sampling ($R<|0.27|$, $p>0.17$), indicating that discharge did not directly affect sampling efficiency. Intuitively, however, one would suspect that efficiency would be diminished if discharge was over an unknown threshold. Changes in discharge (particularly flow spikes) may affect the lateral distribution of fishes at a specific location as a consequence of rapidly changing habitat availability. For example, over 1,000 speckled dace were collected in a single seine haul (area seined $<10\ m^2$) through an eddy during a flow spike in autumn 2006 (just downstream of mouth of LaPlata River). At the same site, speckled dace were almost absent in riffles, a habitat in which they are normally common.

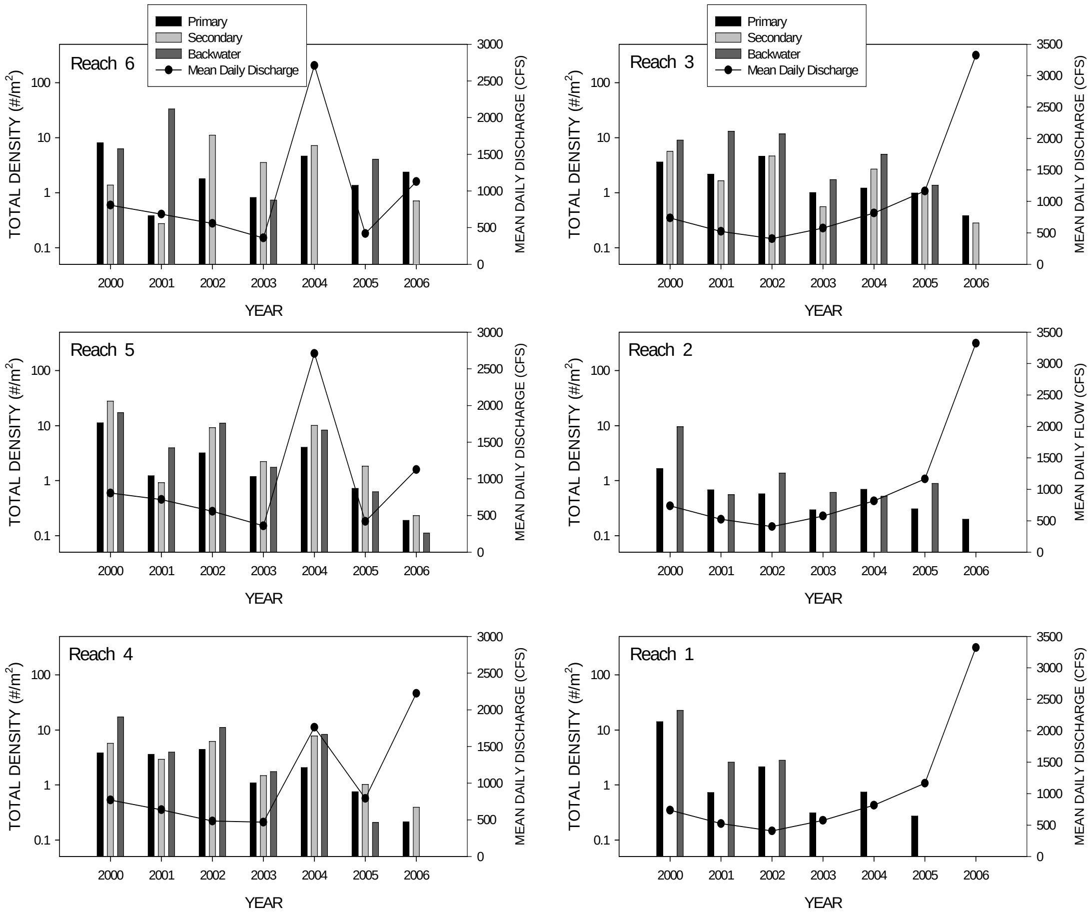


Figure 42. Mean daily discharge at Shiprock Gage (#09368000) during annual autumn sampling and total fish density in Reaches 6 through 1, San Juan River. Note log scale for density axis.

SPECIES LONGITUDINAL DISTRIBUTIONS – 2006

Overall, density of fishes varied among reaches. Due to large collections of speckled dace, Reach 6 had by far the highest fish density (4.5 fish/m^2, SE=1.35) in the primary channel in 2006. Total fish densities in other reaches were less than 0.4 fish/m^2 (SE<0.11). Secondary channels had more similar total fish densities; Reach 5 had the lowest fish (0.29 fish/m^2, SE=0.05) and Reach 4 had the highest density (0.65 fish/m^2, SE=0.17).

The highest densities of commonly collected native species in the primary channel were in Reach 6 (Figure 43). Native fish density showed no longitudinal pattern by Reach in secondary channels. Speckled dace was the most common native species in all reaches in both primary and secondary channels.

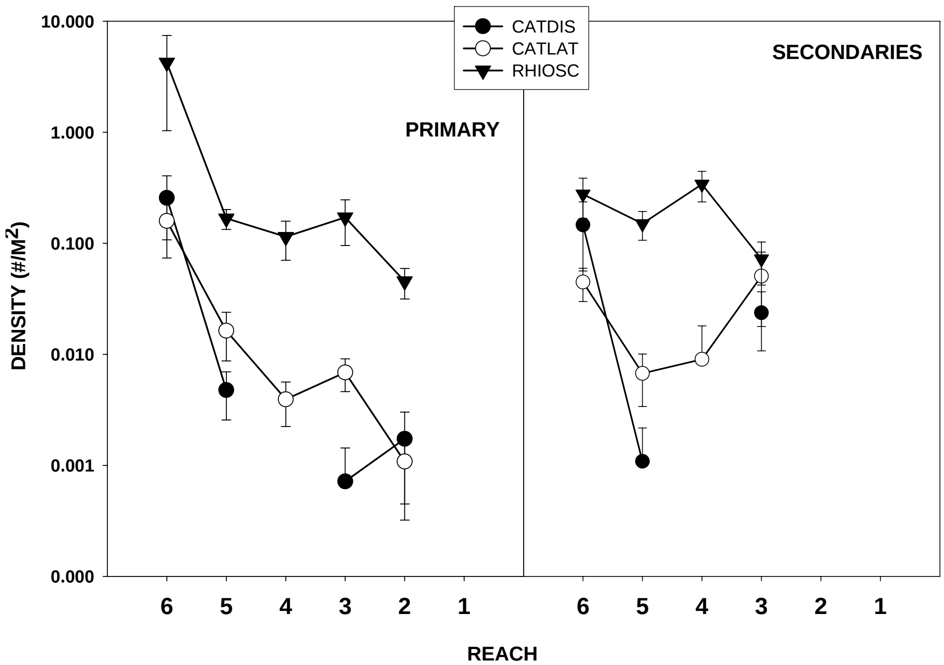


Figure 43. Longitudinal density of commonly collected native fish species in primary and secondary channels, San Juan River, 2006. Error bars represent 1 standard error of sample densities. Note that y-axis is $\log_{10}$ scale.

Collectively, nonnative fishes did not follow a pattern similar to native fishes (Figure 44). Channel catfish increased slightly in density in secondary channels in a downstream direction.

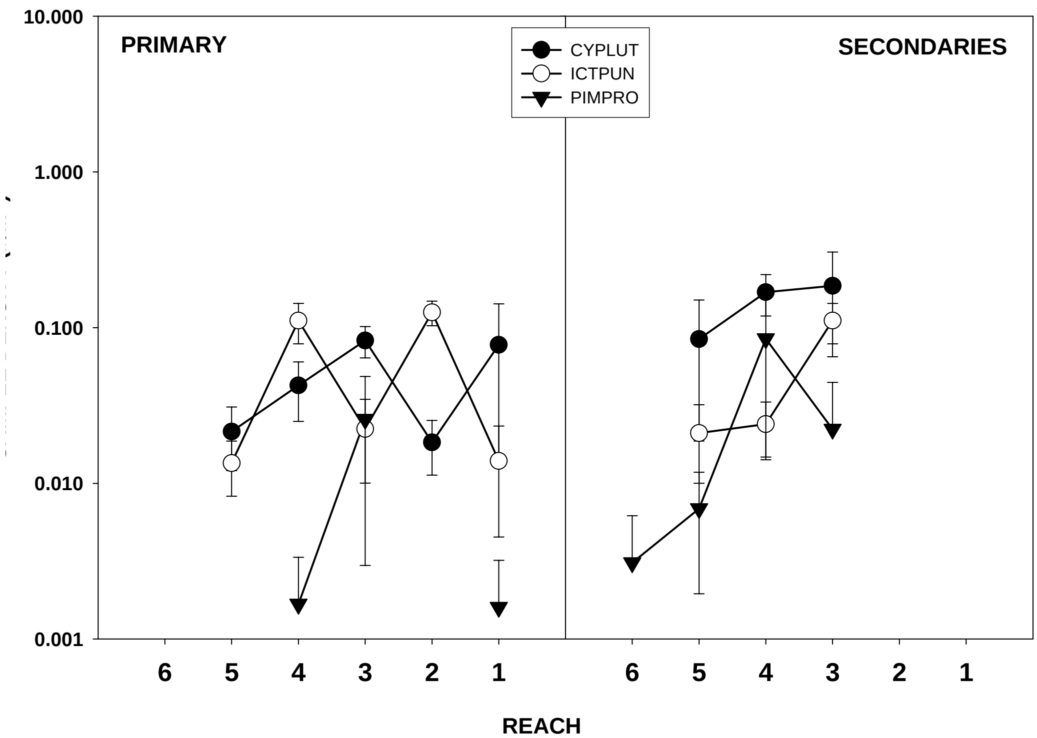


Figure 44. Longitudinal density patterns of commonly collected nonnative fish species in primary and secondary channels, San Juan River, 2006. Error bars represent 1 standard error of sample densities. Note that y-axis is $\log_{10}$ scale.

DISCUSSION

Sampling during 2006 provided additional, and interesting, perspectives on densities and distributions of native and nonnative fishes. It followed the first year of extended high spring discharge in the period of study (2005) and was the second consecutive year with comparatively high summer discharge. During 2006 sampling, discharge ranged from 674 to 8310 cfs. It was difficult to characterize how these flows affected our sampling efficiency or the actual distribution of fishes. It was likely that the only available habitat for sampling in the lower river (Reach 1) had been inundated less than 24 hours, so fish had little time to colonize these areas. With that said, fish densities were low, compared to previous years, in all reaches, except Reach 6. Flows, however, during sampling of Reaches 5 through 1 were not as high as in 2004 when fish densities were among the highest of the study period. The large decrease in abundance of red shiner in 2006, which in previous years was by far the most common species collected, was largely responsible for the marked changes in fish density in 2006. Like red shiner, fathead minnow decreased in abundance.

Both small-bodied and adult monitoring (Dale Ryden, USFWS, pers. comm.) efforts are finding increasing densities of bluehead sucker. In 2004, small-bodied monitoring detected a large cohort of age 0 bluehead sucker. Subsequently, that large cohort appeared as the juvenile cohort captured by adult monitoring in 2005. Speckled dace density has generally increased also. Age-0 flannelmouth sucker density apparently declined slightly in the last few years. Several factors might be contributing to this perceived decline: changes in availability of particular habitats, response to changes in flow regime (e.g., elevated summer flows), negative response to changes in density(ies) of other species, or density change from some other combination of factors. If razorback sucker density increases there may be competition for resources with ecologically similar species, such as flannelmouth sucker, and shifts in density may result (. Similarly, increases in predator populations, such as channel catfish or Colorado pikeminnow, might cause decreases in prey species, such as flannelmouth sucker, density.

Effects of variable flow regimes are manifested in numerous ways on native and nonnative fishes. Diversity and availability of habitats are dependent upon variable flows to move and shape channels and substrates. Timing of spring runoff and water temperature attaining particular levels affect time of spawning of many native and nonnative species. Water temperature also affects growth rate. Between 2003 and 2006, mean TL of age 0 individuals of all commonly collected species (native and nonnative) in autumn was greatest in 2004, a year when spring discharge was low and low-flow conditions prevailed for the entire summer. In contrast elevated summer flows negatively affected red shiner and fathead minnow densities, but had no apparent affect on native fishes.

Native fishes numerically dominated Reach 6 in 2006. The only nonnative species captured was a single yellow bullhead. Densities of bluehead sucker, flannelmouth sucker, and speckled dace were significantly higher in Reach 6 than other reaches. The higher densities of these species in Reach 6 might be due to physical habitat features or lack of nonnative species (predators and competitors). Elsewhere in the San Juan River, small-bodied monitoring generally yielded higher densities of native fishes in 2006 than in previous years.

RECOMMENDATIONS

Small-bodied fish monitoring in the San Juan has been conducted annually for nearly ten years. The main emphasis of the SJRIP has been the recovery of Colorado pikeminnow and razorback sucker; small-bodied monitoring at this time does not add much direct knowledge about the status of these species except that YOY individuals are too rare in the system to be detected by our current methods. Small-bodied monitoring does, however, give insight into status of the prey base for Colorado pikeminnow. Additionally, long term monitoring sets are valuable for tracking changes in the community over time as well and determining the status or trends of various populations at a point in time. These monitoring data sets also provide the opportunity to learn more about how various fishes co-exist in their environment and respond to changes in the environment, including changes in the populations of sympatric fishes. This report is, in part, an effort to demonstrate the depth and breadth of knowledge that might be gained by thoughtful examination and rigorous analyses of the data that has been accumulated over the past 10 years. Further integration of the various data sets in the coming years will provide researchers the opportunity to investigate many questions and help inform decision making in the future.

The initial effort of combination of large-bodied monitoring CPUE data and small-bodied monitoring density data in this report provided some visual insight into how the data sets might be merged and analyzed. Using length-frequency data, for example, would provide a more informed discussion of health of individual species populations and their inter-relationships in future integration reports. Larval fish data could be integrated (providing data enable distinction of larvae from older fish) into such an analysis. A single reporting effort for these three monitoring efforts might aid in developing a better understanding of the dynamics of San Juan River fish assemblages.

Though age 1+ Colorado pikeminnow are collected occasionally, the current protocol for small-bodied fishes monitoring is not designed to intensively, or exclusively, sample those mesohabitats age 1+ Colorado pikeminnow frequently occupy. Consequently, comparatively few Colorado pikeminnow are collected thus limiting analyses of their distribution or abundance patterns. To remedy this, we propose to modify the primary channel small-bodied fishes monitoring protocol to increase the probability of collection of greater numbers of Colorado pikeminnow. This modification would not diminish intensity or thoroughness of current small-bodied fishes monitoring protocol. Block seining, in a manner similar to that used by Robertson and Holden (2006), would be added to effort at each site and analyzed as a separate data set. With this added effort, it would be necessary to adjust the frequency of small-bodied fishes sampling from every 3 to every 5 miles. Currently, at least five seine hauls are made at each site. With this adjustment in frequency of sampling, at least eight seine hauls would be made at each site for small-bodied monitoring and an additional two or more block seine hauls would be made expressly to capture Colorado pikeminnow. The total number of primary channel small-bodied fishes monitoring seine hauls would remain about the same as are made under current protocol. Secondary channel sampling frequency would not change nor would number of seine hauls in each secondary channel. Where appropriate, block seining effort would be added to secondary channel sampling. In canyon-bound reaches, it is often difficult to find sites with five or more seineable mesohabitats. Rather than attempting to sample every 3 miles, sampling would to be more opportunistic. Under this modification, total number of seine hauls would not decrease, but frequency of sites would.

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