SMALL-BODIED FISH MONITORING

SAN JUAN RIVER

1998 – 2001

David L. Propst, Amber L. Hobbes, and Robert D. Larson

Conservation Services Division

New Mexico Department of Game and Fish

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SAN JUAN RIVER BASIN RECOVERY IMPLEMENTATION PROGRAM
U.S. FISH AND WILDLIFE SERVICE
ALBUQUERQUE, NEW MEXICO

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INTRODUCTION

Following completion of the San Juan River Seven Year Research Program in 1997, the need to monitor San Juan River fish assemblages was recognized by the San Juan River Recovery Implementation Program Biology Committee. Autumn sampling of large- and small-bodied fishes was conducted 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 River Monitoring Plan and Protocols (Propst et al. 2000).

Data reported herein were collected from primary channel shoreline habitats since 1998 and secondary channels since 1993. In 1998, primary channel sampling was limited to Reaches 5 through 2. Since 1999, autumn monitoring of primary channels has been conducted in Reaches 6 through 1. Almost all secondary channels occur in Reaches 5 through 3; a few are present in Reach 6 and none is in Reach 2 or 1.

Annual sampling of small-bodied fishes in San Juan River primary and secondary channels was conducted to aid the determination and quantification of responses of native and nonnative fishes to flow regimes designed to mimic a natural hydrograph.

METHODS

Autumn sampling of small-bodied fishes in San Juan River primary and secondary channels and backwaters in 1998 was conducted from Shiprock, New Mexico (RM 149; Reach 5) downstream to Chinle Creek, Utah (RM 68; Reach 3). All secondary channels having surface water were sampled. The primary channel was sampled near each sampled secondary channel, or at 3-mile intervals if no secondary channel was present in a 3-mile reach. In autumn 1999, sampling occurred at the frequency detailed in draft San Juan River Monitoring Plan and Protocols. Under this protocol, sampling began at the Animas-San Juan rivers confluence in Farmington, New Mexico (RM 180; Reach 6) and continued to Clay Hills Crossing, Utah (RM 3; Reach 1). From about Chinle Creek downstream, there are no secondary channels. Primary and secondary channel sampling occurred in 3-mile increments. If a secondary was not within the designated sample-mile, there was no secondary channel data collected for that 3-mile segment. All backwaters, regardless of occurrence within designated mile, were sampled. In 2000, sampling was conducted following the methods detailed in the San Juan River Monitoring Plan and Protocols (Propst et al. 2000). Because secondary channels were sampled only within every third designated-mile in 1999 (as set forth in the San Juan River Monitoring Plan and Protocols), a substantial portion of secondary channels present were not sampled. For this reason, all secondary channels having surface water were sampled in 2000 and 2001. Otherwise, sampling frequency was as detailed in Propst el al. (2000) and occurred from RM 180 through RM 3.

Small-bodied fish sampling methods were those detailed in the monitoring protocol. Fish were collected with a seine (3.05 x 1.83 m, 3.2 mm mesh) from all mesohabitats (see Bliesner and Lamarra 2000 for definitions) within a site. Mesohabitats were sampled in rough proportion to their availability within a site. Primary channel mesohabitats sampled were those along stream margins, but all mesohabitats in secondary channels were sampled. Prior to preservation in 10% formalin, the catch was inspected to determine presence of protected species (roundtail chub, Colorado squawfish, and razorback sucker) and other native fishes >75 mm total length (TL). Length of each native fish found (protected and >75 mm TL) was determined and recorded, and specimen released. Length and width of proportion of each sampled mesohabitat was delimited by surveyor flags. Following specimen collection, seined area of each sampled mesohabitat was measured and recorded. A minimum of 5 seine hauls normally was made at each sample site. Number of primary channel mesohabitats within a site varied, but all present within about 200 m (measured along shoreline) were sampled. All mesohabitats within a secondary channel were sampled. If a secondary channel had surface water inflow, five or more mesohabitats were typically sampled. If there was not surface inflow, pools were usually the only mesohabitat present. Regardless of inflow or not, a minimum of five seine hauls were made in each secondary channel. All data and observations were recorded on standard field forms.

Retained specimens were identified and enumerated in the laboratory. If a sample contained more than 250 specimens of a species, lengths were obtained from a subsample (at least 200 specimens per species). Identification of retained protected species was

verified by personnel of UNM-MSB, Division of Fishes. All retained specimens were accessioned to NMGF Collection of Fishes.

Attributes of spring and summer discharge were derived from USGS Water Resources Data, New Mexico (1993 et seq.). Shiprock gage (#09368000) data were used for all calculations. Spring was 1 March through 30 June and summer was from 1 July through 30 September. Species density data were segregated by Geomorphic Reach (Bliesner and Lamarra 2000). Shannon-Weiner Diversity Index (H; proportional values transformed to natural log) values were calculated for each Geomorphic Reach each year. Density of each species was calculated as number of fish per m^2. Pearson product-moment correlation was used to compare spring and summer discharge attributes to density of commonly collected secondary channel species from 1993 through 200. To reduce the effect of disproportionately large values, fish densities were $\log_{10} (x + 1)$ transformed. Discharge at time of sampling ranged from 550 to 1730 cubic feet/second (cfs) and might have influenced sampling efficiency. However, stepwise multiple regression analysis showed that discharge at time of sampling had little effect on the relationship between fish densities and spring and summer discharge. The only exception was red shiner in Reach 4, which was negatively related ($r = -0.810$, $P = 0.008$) to discharge at time of sampling. Because primary channel data were only collected for 4 years, no analyses of relationship between primary channel fish density and spring and summer discharge attributes were performed. Analysis of variance (ANOVA) was used to compare secondary and primary channel species densities from 1998 through 2001.

RESULTS

DISCHARGE

Since 1993, mean daily spring discharge exceeded 5,000 cfs only in 1993 and 1995 and was less than 2,000 cfs in 1996 and 2000 (Table 1). Mean daily spring discharge exceeded 10,000 cfs 10 days in each 1995 and 1997, and exceeded 5000 cfs at least 20 days in all years except 1996 and 2000. Highest mean daily discharge occurred in June of all years, except 1998, 2000, and 2001 when highest mean daily discharge was in May. Since 1999 (year monitoring program initiated), mean daily discharge during spring runoff has not exceeded 3000 cfs, and in 2000 did not exceed 2000 cfs. From 1993 through 1998, mean daily discharge during summer was less than 1000 cfs only in

Table 1. Attributes of spring discharge (cubic feet/second; cfs), San Juan River, Water Years (WY) 1993 – 2001. Data from USGS Shiprock gage (#09368000).

	WATER YEAR								
MONTH	93	94	95	96	97	98	99	00	01
March	5099	8863	2777	700	2057	1141	869	941	1033
April	5970	868	3472	532	2295	1425	1087	1652	1384
May	6387	4779	6108	1997	5703	5250	3175	2311	4781
June	6816	6563	9351	2661	8286	3970	5716	2011	4760
Mean (cfs)	6068	3274	5308	1473	4585	2947	2712	1729	2989
Days Q >3000 cfs	122	55	97	16	67	48	41	18	47
Days Q >5000 cfs	105	43	55	0	44	24	26	1	29
Days Q >8000 cfs	11	7	21	0	26	0	0	0	1
Days Q >10000 cfs	0	0	10	0	10	0	0	0	0

1996 (Table 2). In 1999, mean daily summer discharge averaged 4333 cfs or 60 % greater than mean daily discharge the preceding spring. Mean daily summer discharge during 2000 and 2001 was less than 1000 cfs.

Table 2. Attributes of summer discharge (cubic feet/second; cfs), Water Years (WY) 1993 – 2001. Data from USGS Shiprock gage (#09368000).

	WATER YEAR								
MONTH	93	94	95	96	97	98	99	00	01
July	922	1020	3282	563	2164	1665	3116	324	690
August	1346	534	1561	491	2306	959	5725	602	1132
September	1432	1078	1193	891	2361	644	4157	649	552
Mean Discharge	1518	1271	2660	697	2524	1089	4333	525	791
Days Q >5000 cfs	0	0	0	0	4	0	31	0	0
Days Q >4000 cfs	3	0	0	0	7	1	42	0	0
Days Q >3000 cfs	4	0	0	0	18	1	71	0	0
Days Q >2000 cfs	10	2	13	0	30	11	89	0	5
Days Q >1000 cfs	35	15	53	22	66	37	92	1	18
Days Q <1000 cfs	37	54	13	55	7	55	0	91	74
Days Q <750 cfs	35	42	0	69	3	42	0	80	59
Days Q <500 cfs	0	20	0	39	0	15	0	45	23
Number Q spikes	4	3	3	5	3	4	1	1	1
Spike duration (days)	35	15	29	22	66	37	92	7	18
Spike mean (cfs)	1878	1437	1589	1253	2479	1802	4333	850	1596

PRIMARY CHANNEL FISHES

Six native and eight nonnative fish species were captured in San Juan River primary channel habitats during small-bodied fish sampling from 1998 through 2001 (Table 3). Speckled dace, flannelmouth sucker, and bluehead sucker were captured in all years, roundtail chub in 1998 and 1999, Colorado pikeminnow in 1998, and mottled sculpin in 1999. Native razorback sucker was not captured during autumn small-bodied fish sampling. Among nonnative fish species collected, red shiner, fathead minnow, and channel catfish were the only species collected in all years. Plains killifish and western mosquitofish were not collected in 1999 and common carp was not collected in 1998 or 2001.

Table 3. Occurrence of fishes in San Juan River primary channel during autumn, 1998 – 2001 inventories. N = native and I = nonnative. Six letter species code derived from first three letters of genus and species names.

COMMON	SCIENTIFIC	CODE	STATUS	98	99	00	01
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	
Roundtail chub	*Gila robusta*	GILROB	N	X	X		
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X			
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X
Flannelmouth x bluehead sucker	*C. latipinnis* x *C.discobolus*	LATDIS			X		
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X		X	X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X		X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I		X		
Largemouth bass	*Micropterus salmoides*	MICSAL	I				X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X		
TOTAL NATIVE			6	5	5	4	3
TOTAL NONNATIVE			8	5	5	6	6

Nonnative red shiner was the most common species in all years and speckled dace was second-most common in all years, except 2000 when western mosquitofish was second-most common (Table 4). Fathead minnow was third-most common in all years, except 1998 when channel catfish ranked third. Native flannelmouth and bluehead suckers were never more than fourth-most common.

Table 4. Fishes collected in San Juan River primary channel during autumn inventories, 1998 2001. Geomorphic Reaches 6 and 1 not sampled in 1998.

1998		1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	592	CYPLUT	1071	CYPLUT	18570	CYPLUT	2765
RHIOSC	464	RHIOSC	335	GAMAFF	904	RHIOSC	387
ICTPUN	189	PIMPRO	48	PIMPRO	209	PIMPRO	148
PIMPRO	32	CATLAT	8	RHIOSC	163	GAMAFF	63
CATLAT	7	ICTPUN	7	CATLAT	38	CATLAT	41
PTYLUC	4	CATDIS	3	ICTPUN	23	CATDIS	13
CATDIS	3	CYPCAR	1	CATDIS	23	ICTPUN	10
GAMAFF	2	GILROB	1	CYPCAR	7	FUNZEB	3
GILROB	1	LAT x DIS	1	FUNZEB	4	MICSAL	1
FUNZEB	1						
LEPCYA	1						
COTBAI	1						
TOTAL N	1295		1511		19953		3431
TOTAL AREA	1601		4883		4510		3091
DENSITY	0.8089		0.3094		4.4242		1.1100
H	1.1902		0.7670		0.3261		0.7286

No nonnative fish species had a clear or consistent longitudinal (upstream to downstream) pattern or trend across years (Figures 1 and 2). Nor was density of any nonnative species consistently higher, or lower, in a specific reach. For example, red shiner density was greatest in Reach 4 in 1998, Reach 1 in 1999, Reach 5 in 2000, and Reach 3 in 2001. Among common native species, speckled dace generally decreased in abundance, in a downstream direction, in 1999 and 2000 (Figure 3). In 1998, speckled

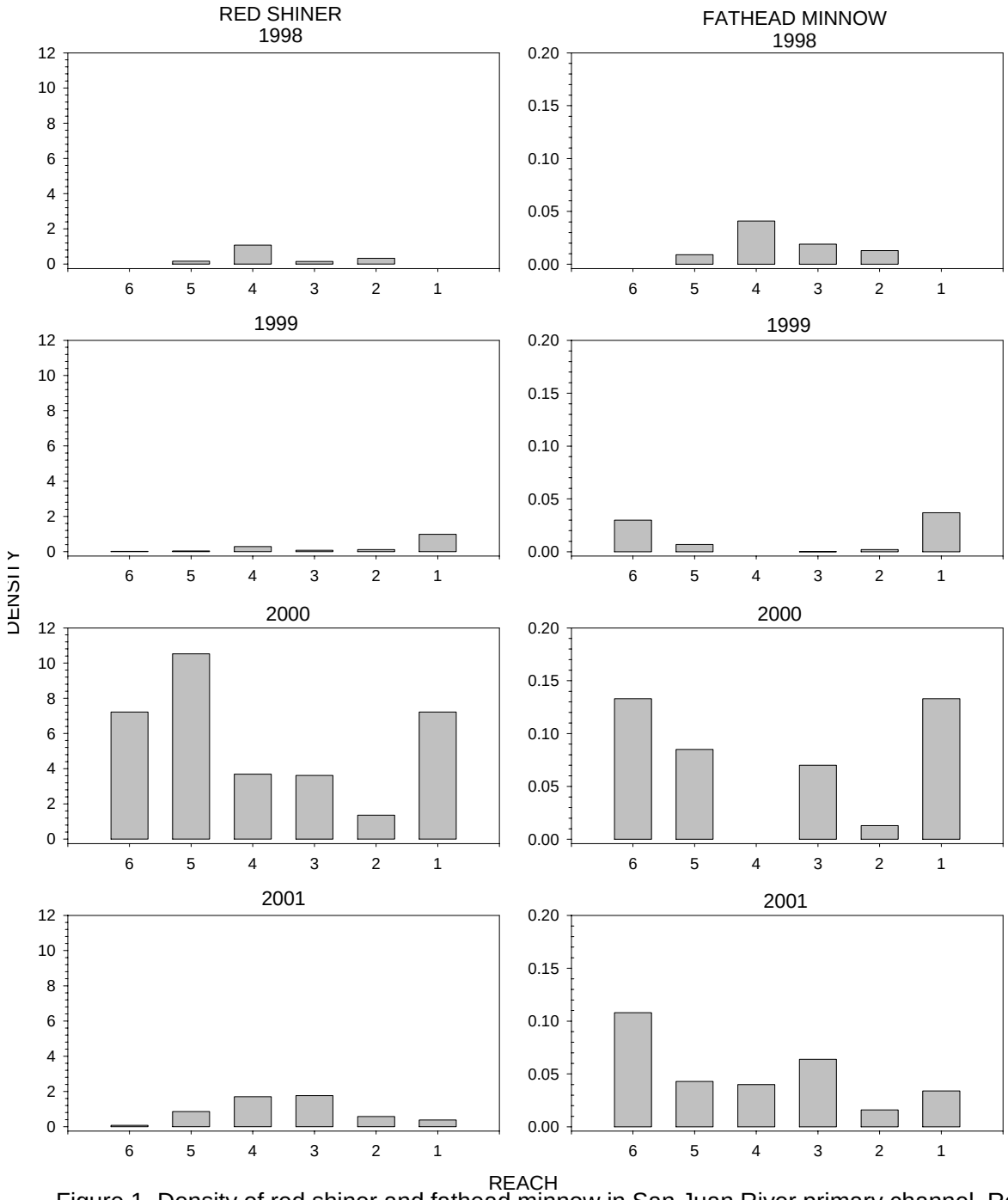

Figure 1. Density of red shiner and fathead minnow in San Juan River primary channel, Reac
1998 -- 2001. Reaches 6 and 1 were not sampled in 1998.

dace density was similar among reaches sampled (5 through 2). In 2001, its density increased from Reach 6 to 5, declined through Reach 2, and increased in Reach 1.

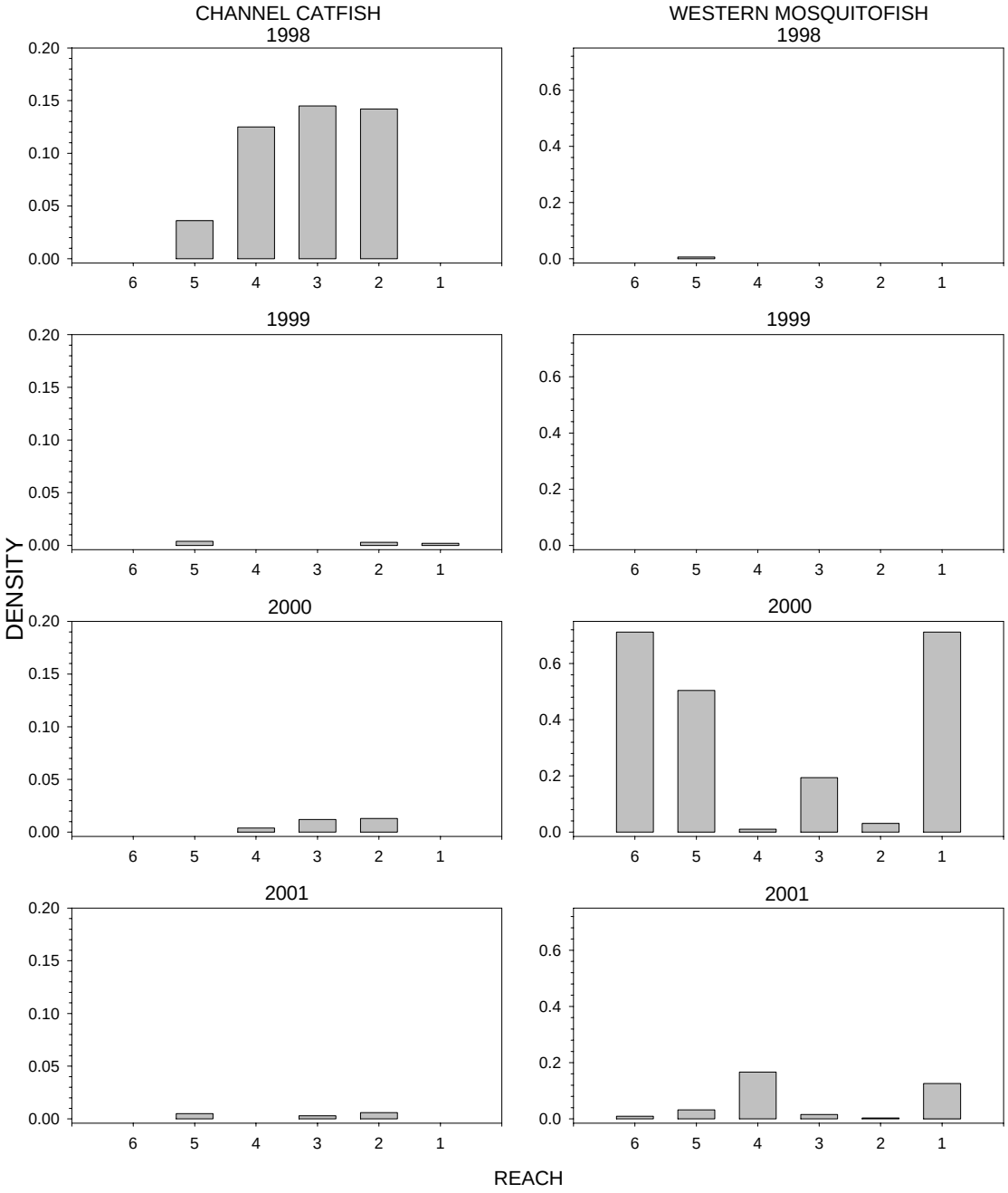

Figure 2. Density of channel catfish and western mosquitofish in San Juan River primary channel, Reaches 6 through 1, 1998 -- 2001. Reaches 6 and 1 were not sampled in 1998.

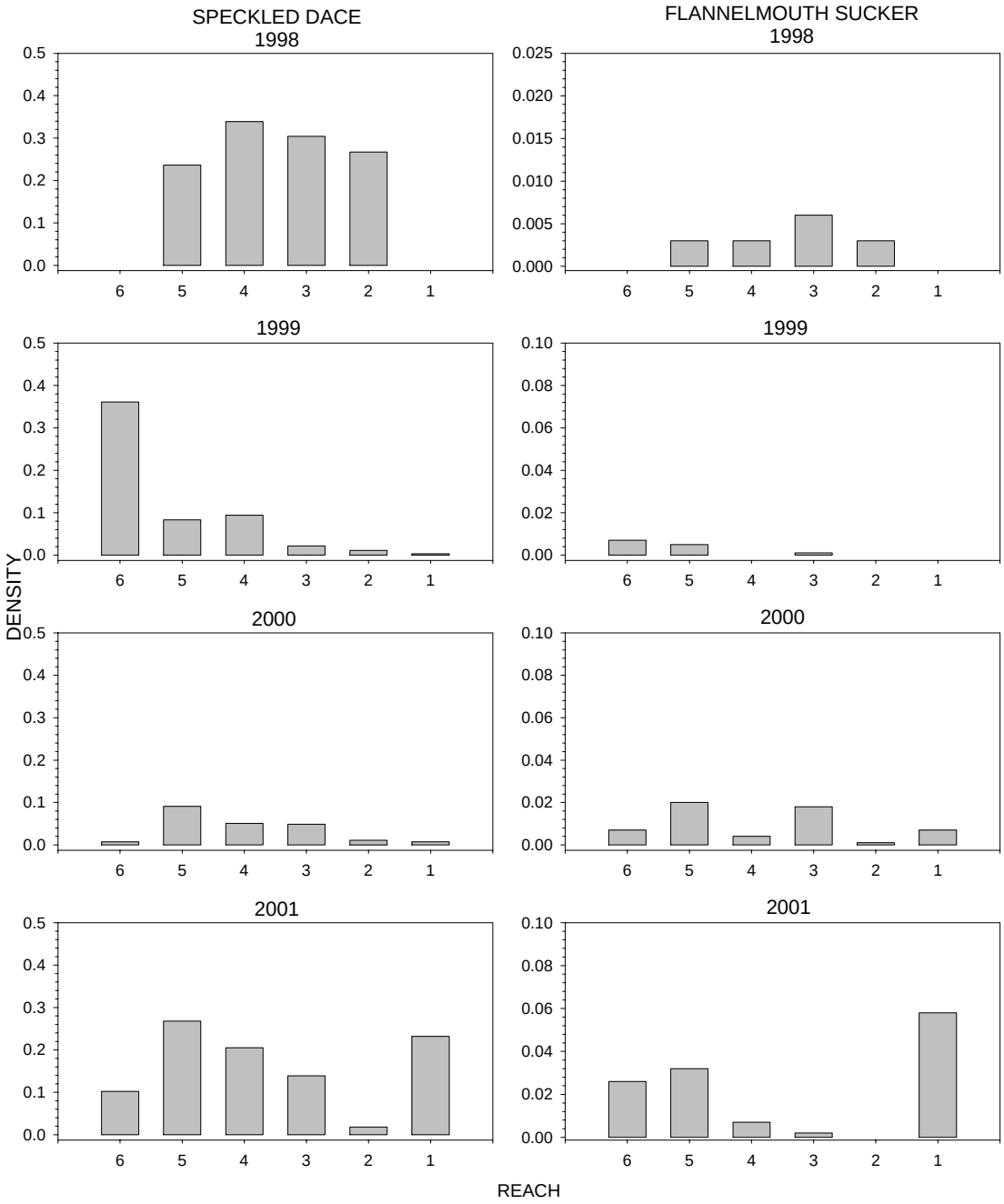

Figure 3. Density of speckled dace and flannelmouth sucker in San Juan River primary channel, Reaches 6 through 1, 1998 -- 2001. Reaches 6 and 1 not sampled in 1998.

Bluehead sucker density was least in Reach 4 in all years and, except for 2001, was highest in Reach 5 (Figure 4).

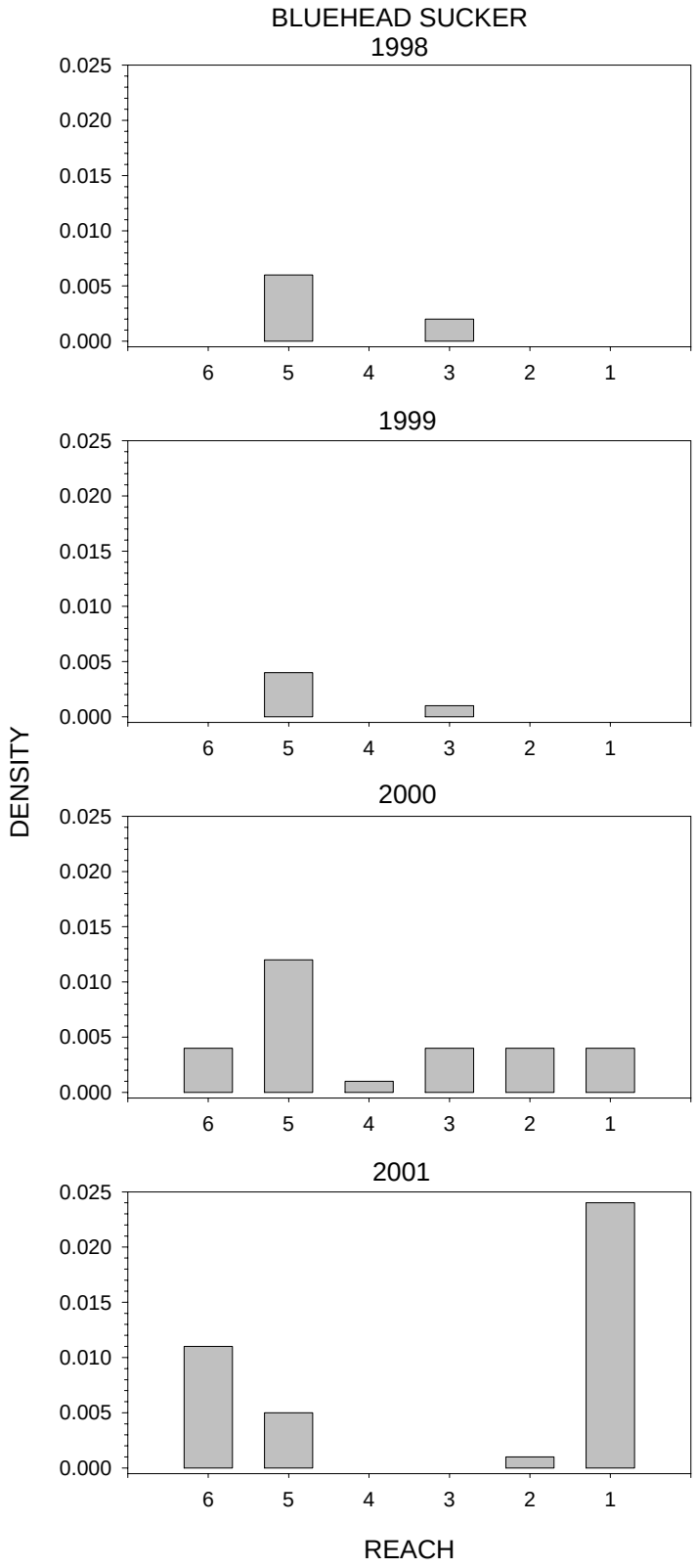

Figure 4. Density of bluehead sucker in San Juan River primary channel, Reaches 6 through 1, 1998 -- 2001. Reaches 6 and 1 not sampled in 1998.

Fish assemblage diversity (H) was highest (>1.00) in most reaches in 1998 and least (<0.50) in 2000 (Figure 5). Although assemblage diversity varied among years within a reach, assemblage diversity was not different among reaches ($F_{3,12} = 0.7577$, $p = 0.539$; data for Reaches 6 and 1 were not included in analysis because neither reach was sampled in 1998).

Among year native fish density (fish/m^2) was variable in each reach, but generally declined in a downstream direction. Differences in density among reaches were not significant ($F_{3,12} = 0.6832$, $p = 0.579$; data for Reaches 6 and 1 were not included in the analysis because neither reach was sampled in 1998). Relative abundance likewise varied considerably within a reach across years and declined in a downstream direction. Excluding 2000, native fish relative abundance was >20.0 % in all years in Reaches 6 and 5. In 2000, a year of low summer discharge (mean daily = 525 cfs), native fish relative abundance was <2.0 % in all reaches. Differences among reaches in native fish relative abundance, however, were not significant ($F_{3,12} = 1.065$, $p = 0.400$; data for Reaches 6 and 1were not included in the analysis because neither reach was sampled in 1998).

Primary channel nonnative fish density was less than 2.0 fish/m^2 in all reaches in all years, except 2000 (Figure 6). In 2000, density was about 4.0 fish/ m^2, or greater, in all reaches except 6 and 2. Averaged across years, nonnative fish density did not evidence a longitudinal pattern or trend. Differences in nonnative fish density among reaches were not significant ($F_{3,12} = 0.4680$, $p = 0.710$). Relative abundance of nonnative fishes, however, generally increased in a downstream direction in all years,

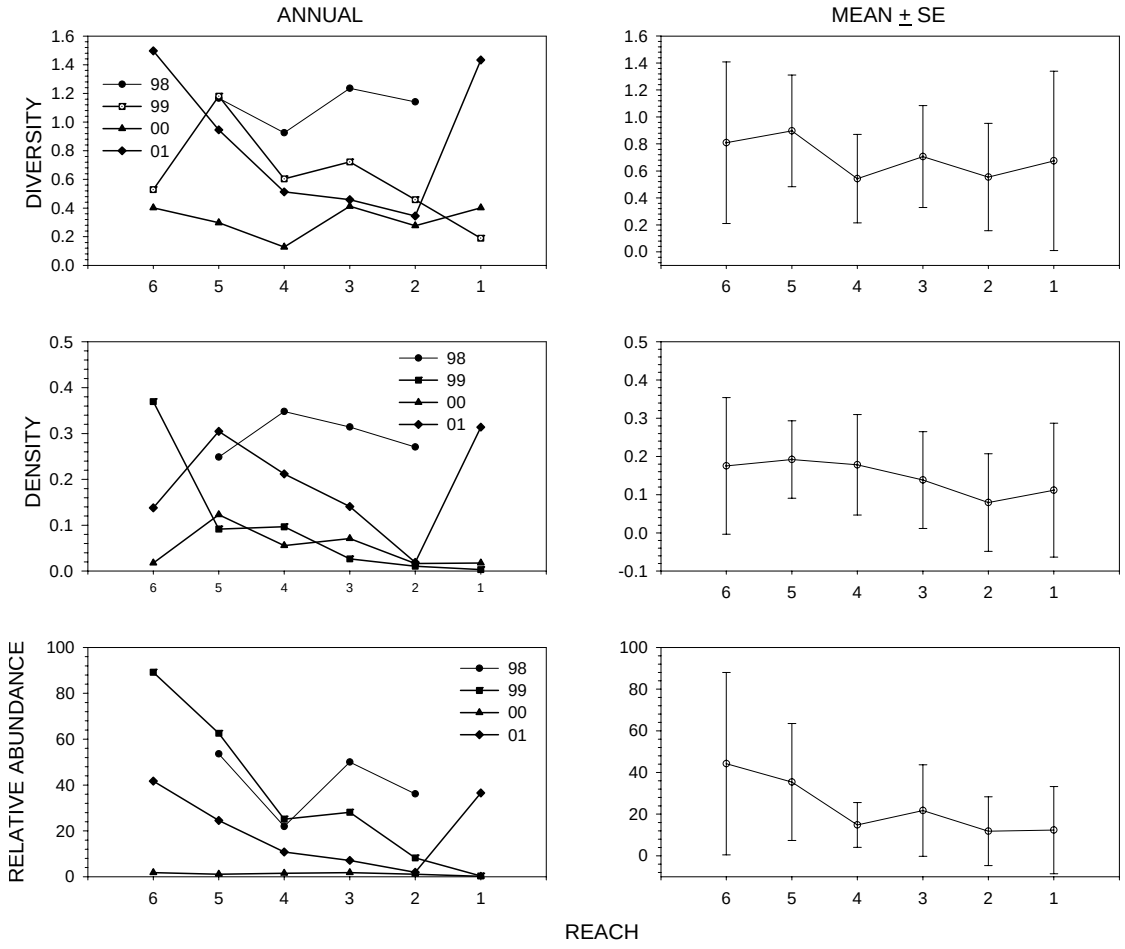

Figure 5. Fish assemblage diversity, native fish density, and native fish relative abundance, San Juan River primary channel, Reaches 6 through 1, 1998 -- 2001.

except 2000 when their relative abundance was >98% in all reaches. In 2001, nonnative fishes represented about 60% of collections in Reach 1.

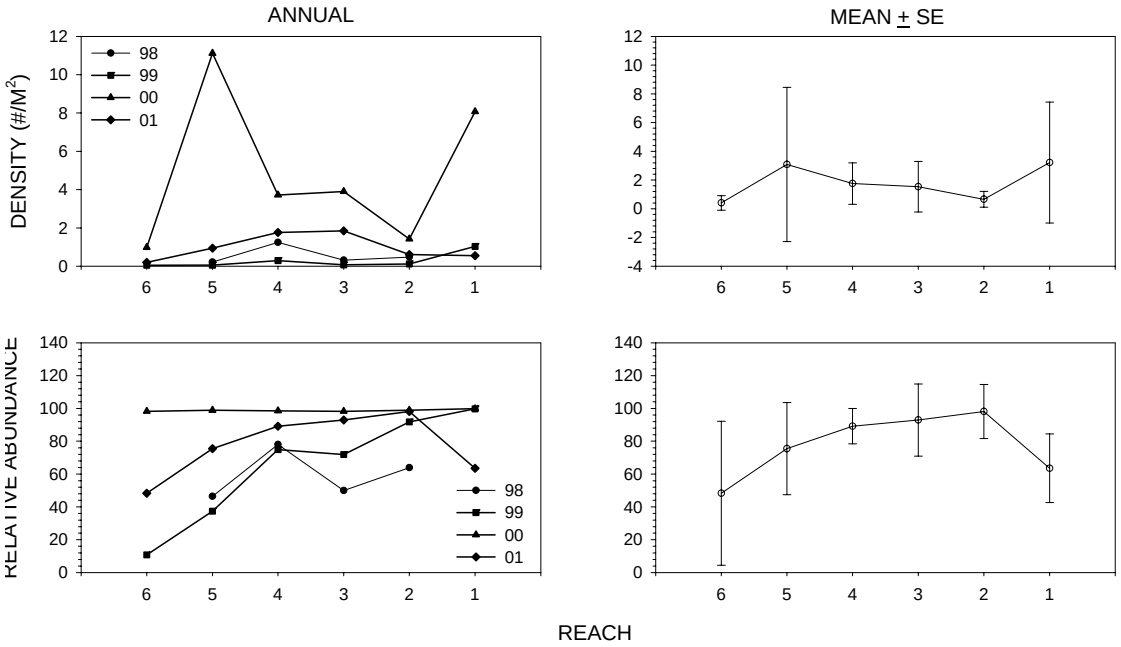

Figure 6. Nonnative fish density and relative abundance in San Juan River primary channel, Reaches 6 through 1, 1998 -- 2001.

Primary Channel, Reach 6

Monitoring of primary channel habitats in Reach 6 for small-bodied fishes began in 1999. From 1999 through 2001, 4 native and 5 nonnative fish species were collected. Speckled dace was the most common species collected in 1999, red shiner in 2000, and fathead minnow in 2001 (Table 5). If not most common, these species were the second- or third most common species, except that western mosquitofish was second-most common and speckled dace was fourth in 2000. Native flannelmouth and bluehead suckers were never more than fourth-most common. We did not collect roundtail chub, Colorado pikeminnow, or razorback sucker during Reach 6 small-bodied fish sampling. Channel catfish was not collected.

Total fish density was greatest in 2000, and nonnative fishes comprised the large majority of specimens collected (Figure 7). Assemblage diversity was highest in 2001.

Table 5. Number and abundance (number/m^2) of fishes in San Juan primary channel, Geomorphic Reach 6, during autumn inventories, 1999 – 2001.

1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	202	0.361	CYPLUT	2058	7.221	PIMPRO	51	0.108
PIMPRO	17	0.030	GAMAFF	203	0.712	RHIOSC	48	0.102
CYPLUT	7	0.013	PIMPRO	38	0.133	CYPLUT	35	0.074
CATLAT	4	0.007	RHIOSC	2	0.007	CATLAT	12	0.026
COTBAI	1	0.002	CATLAT	2	0.007	CATDIS	5	0.011
LEPCYA	1	0.002	CATDIS	1	0.004	GAMAFF	4	0.009
			FUNZEB	1	0.004	FUNZEB	1	0.002
TOTAL N	232			2305			156	
AREA	560			285			471	
DENSITY	0.4143			8.0877			0.3312	
H	0.528			0.402			1.497	

Although density of all common nonnative fishes was highest in 2000, red shiner density was substantially greater than that of other nonnative species (Figure 8). Speckled dace density, greatest of all native fishes in all years, was highest in 1999 (Figure 9). Densities of flannelmouth and bluehead sucker were greatest in 2001.

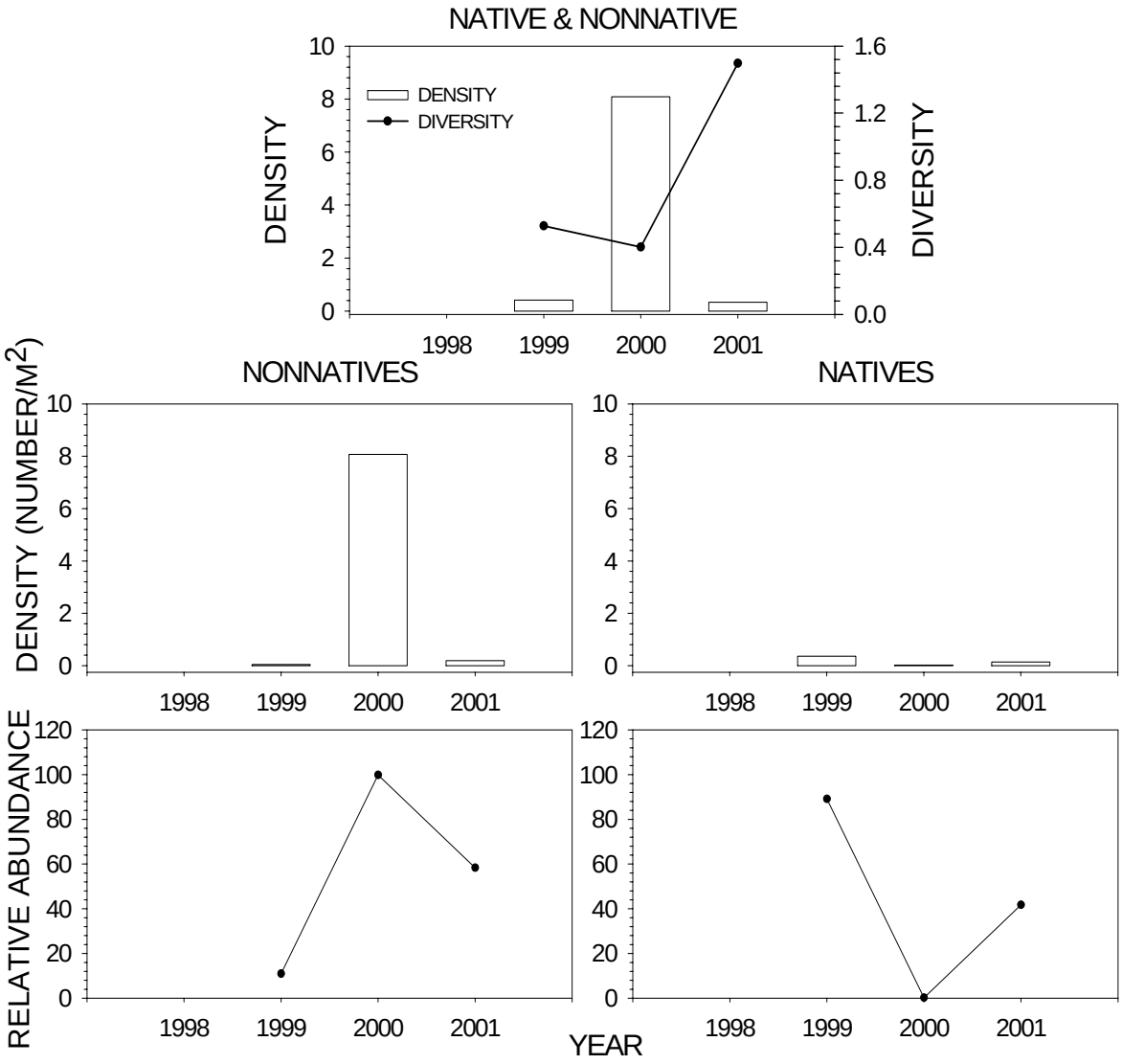

Figure 7. Total density, native and nonnative fishes density, and native and nonnative fishes relative abundance, San Juan River primary channel, Reach 6, 1999 - 2001.

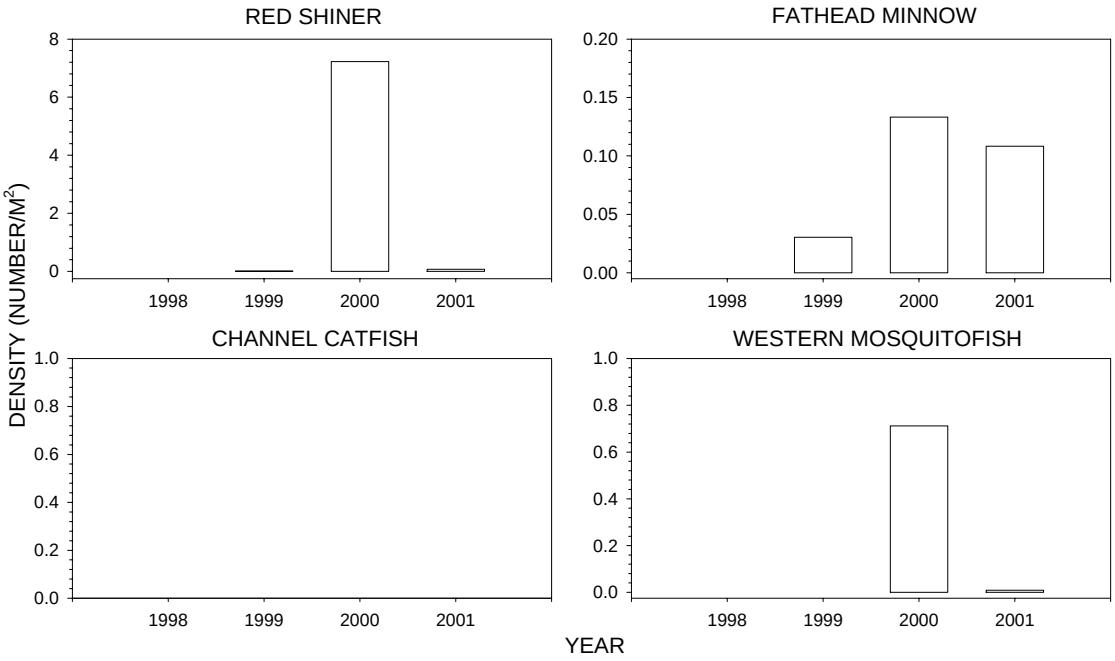

Figure 8. Density of nonnative fishes in San Juan River primary channel, Reach 6, 1999 -- 2001.

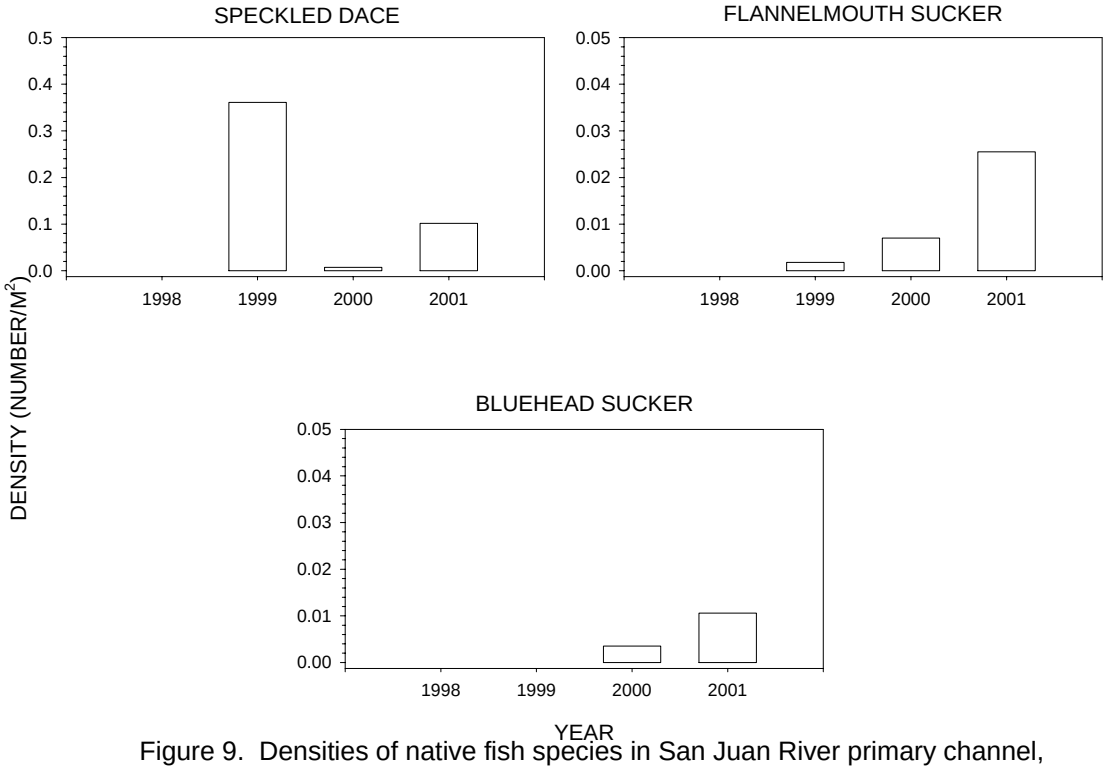

Figure 9. Densities of native fish species in San Juan River primary channel, Reach 6, 1999 -- 2001.

Primary Channel, Reach 5

Primary channel small-bodied fish sampling began in 1998 in Reach 5. Since then, 4 native and 7 nonnative species have been collected in this reach (Table 6). Speckled dace and red shiner were the two-most common species in all years, except 2000 when western mosquitofish was second- and speckled dace was third-most common. One specimen of Colorado pikeminnow was collected in 1998. Flannelmouth and bluehead suckers were found in all years, but neither was common in any year.

Table 6. Number and density (number/m^2) of fishes in San Juan River primary channel, Geomorphic Reach 5, during autumn inventories, 1998 – 2001.

1998			1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	78	0.236	RHIOSC	47	0.083	CYPLUT	5220	10.524	CYPLUT	376	0.855
CYPLUT	54	0.164	CYLUT	24	0.042	GAMAFF	250	0.504	RHIOSC	118	0.268
ICTPUN	12	0.036	PIMPRO	4	0.007	RHIOSC	45	0.091	PIMPRO	19	0.043
PIMPRO	3	0.009	CATLAT	3	0.005	PIMPRO	42	0.085	CATLAT	14	0.032
CATDIS	2	0.006	CATDIS	2	0.004	CATLAT	10	0.020	GAMAFF	14	0.032
GAMAFF	2	0.006	ICTPUN	2	0.004	CATDIS	6	0.012	CATDIS	2	0.005
PTYLUC	1	0.003	CYPCAR	1	0.002	FUNZEB	1	0.002	ICTPUN	2	0.005
CATLAT	1	0.003							MICSAL	1	0.002
TOT N	153			83			5574			546	
AREA	330			568			496			440	
DENSITY	0.464			0.146			11.238			1.241	
H	1.167			1.180			0.297			0.945	

Total density of fishes was greatest and assemblage diversity lowest in 2000 (Figure 10). In 1998 and 1999, native fish density and relative abundance exceeded that of nonnatives. Although less than nonnatives in 2001, native fish density and relative abundance increased substantially over that found in 2000. Among nonnative species,

red shiner density was greater in all years, often by a substantial margin, than that of other nonnative species (Figure 11). Density of all common nonnative species, except

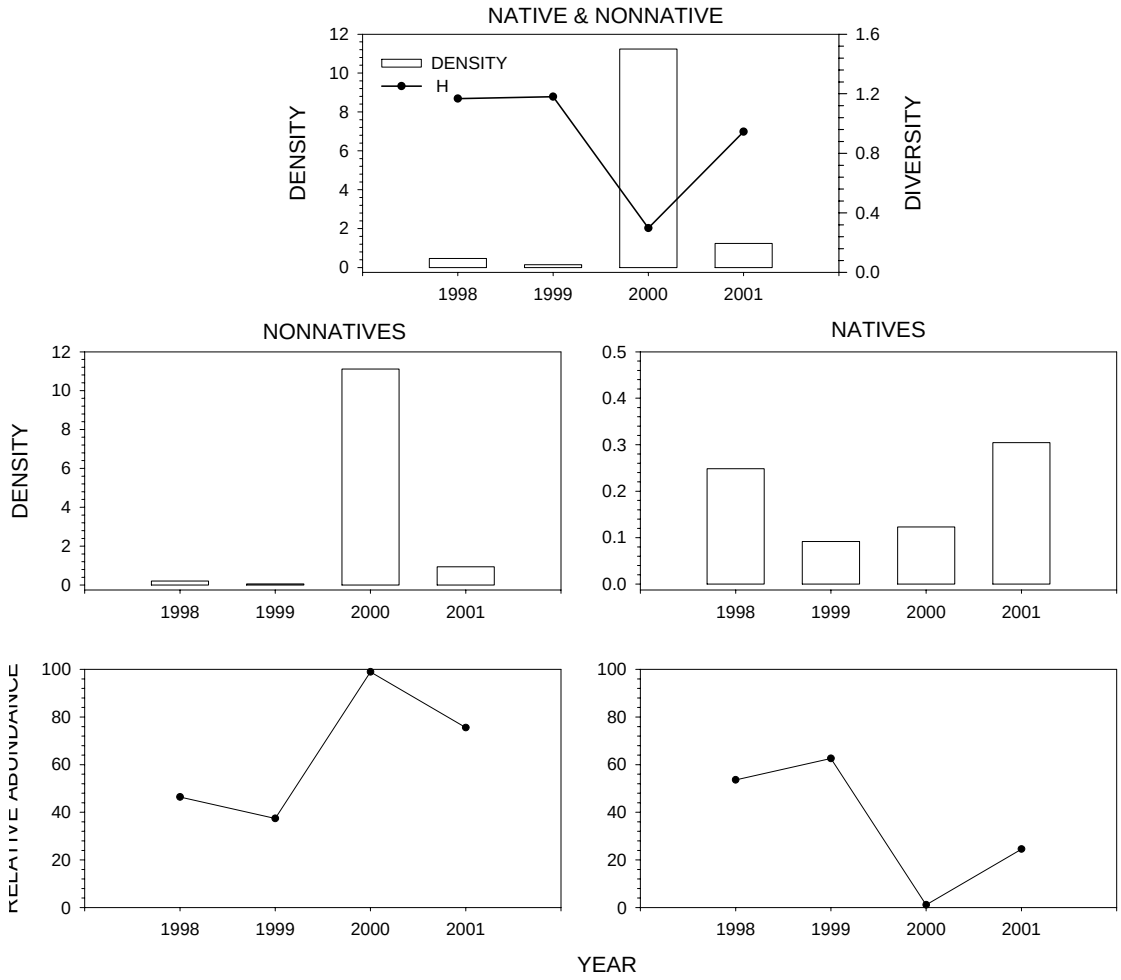

Figure 10. Total density and native and nonnative fishes density and relative abundance in Reach 5, San Juan River, 1998 - 2001.

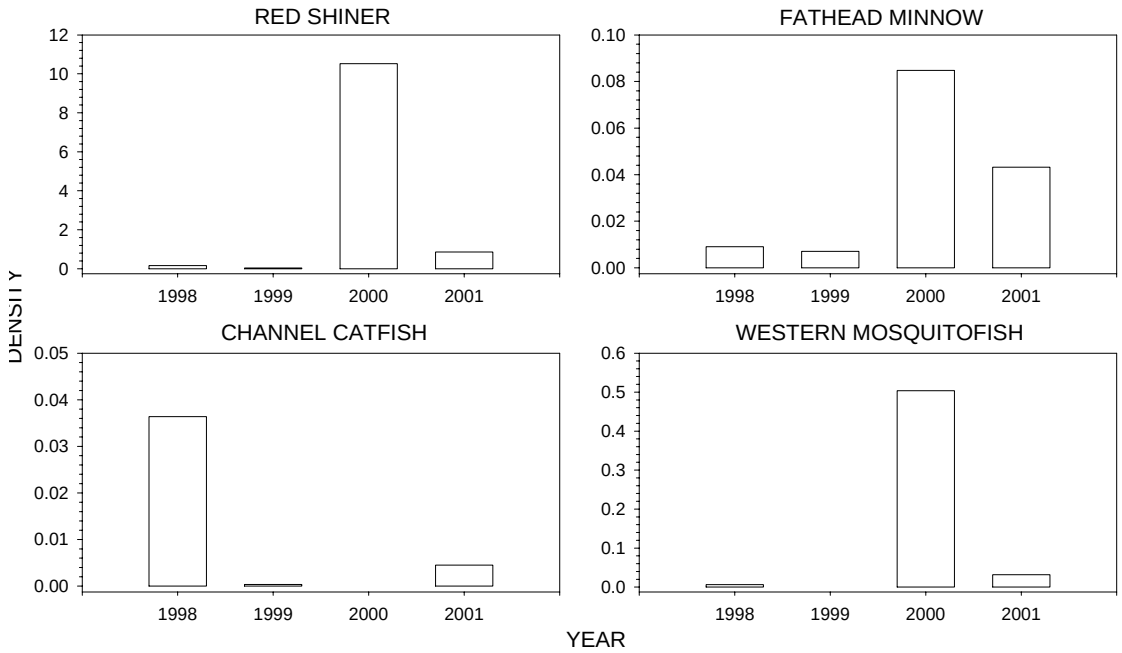

Figure 11. Density of nonnative fishes in San Juan River primary channel, Reach 5, 1998 - 2001.

channel catfish, was greatest in 2000. Speckled dace density was greater than any other native species in Reach 5 in all years (Figure 12). Flannelmouth sucker density increased each year from 1998 through 2001.

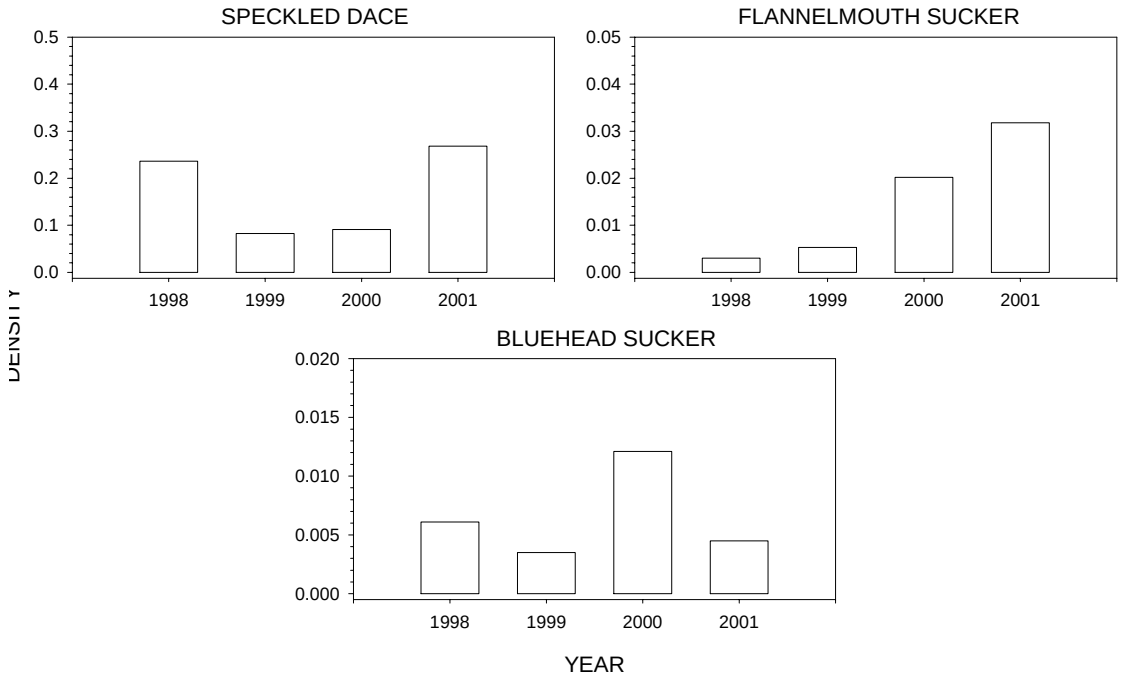

Figure 12. Density of native fishes in San Juan River primary channel, Reach 5, 1998 - 2001.

Primary Channel, Reach 4

Between 1998 and 2001, 5 native and 6 nonnative fish species were collected in Reach 4 (Table 7). Red shiner was the most common and speckled dace was second-most common species in all years. No flannelmouth or bluehead sucker (excluding one flannelmouth x bluehead sucker specimen) was collected in 1999; neither was common any year it was found. Colorado squawfish was collected in 1998 and roundtail chub was found in 1998 and 1999.

Total fish density was greatest in 2000, and was comparatively high in 1998 and 2001 (Figure 13). Assemblage diversity declined from 1998 through 2000, and increased in 2001 to level near that of 1999. Nonnative density was greater than that of natives in all years; lowest nonnative density was least in 1999. Native fish density declined from

Table 7. Number and density (number/m^2) of fishes in San Juan River primary channel, Geomorphic Reach 4, during autumn inventories, 1998 – 2001.

1998			1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	343	1.075	CYPLUT	194	0.288	CYPLUT	3658	3.6914	CYPLUT	512	1.695
RHIOSC	108	0.339	RHIOSC	63	0.094	RHIOSC	50	0.051	RHIOSC	62	0.205
ICTPUN	40	0.125	GILROB	1	0.002	GAMAFF	11	0.011	PIMPRO	12	0.040
PIMPRO	13	0.041	LAT x DIS	1	0.002	CYPCAR	4	0.004	GAMAFF	5	0.167
CATLAT	1	0.003				CATLAT	4	0.004	CATLAT	2	0.007
PTYLUC	1	0.003				ICTPUN	4	0.004	FUNZEB	1	0.003
GILROB	1	0.003				CATDIS	1	0.001			
						FUNZEB	1	0.001			
TOT N	507			259			3736			594	
AREA	319			674			991			302	
DENSITY	1.589			0.384			3.770			1.967	
H	0.925			0.603			0.128			0.513	

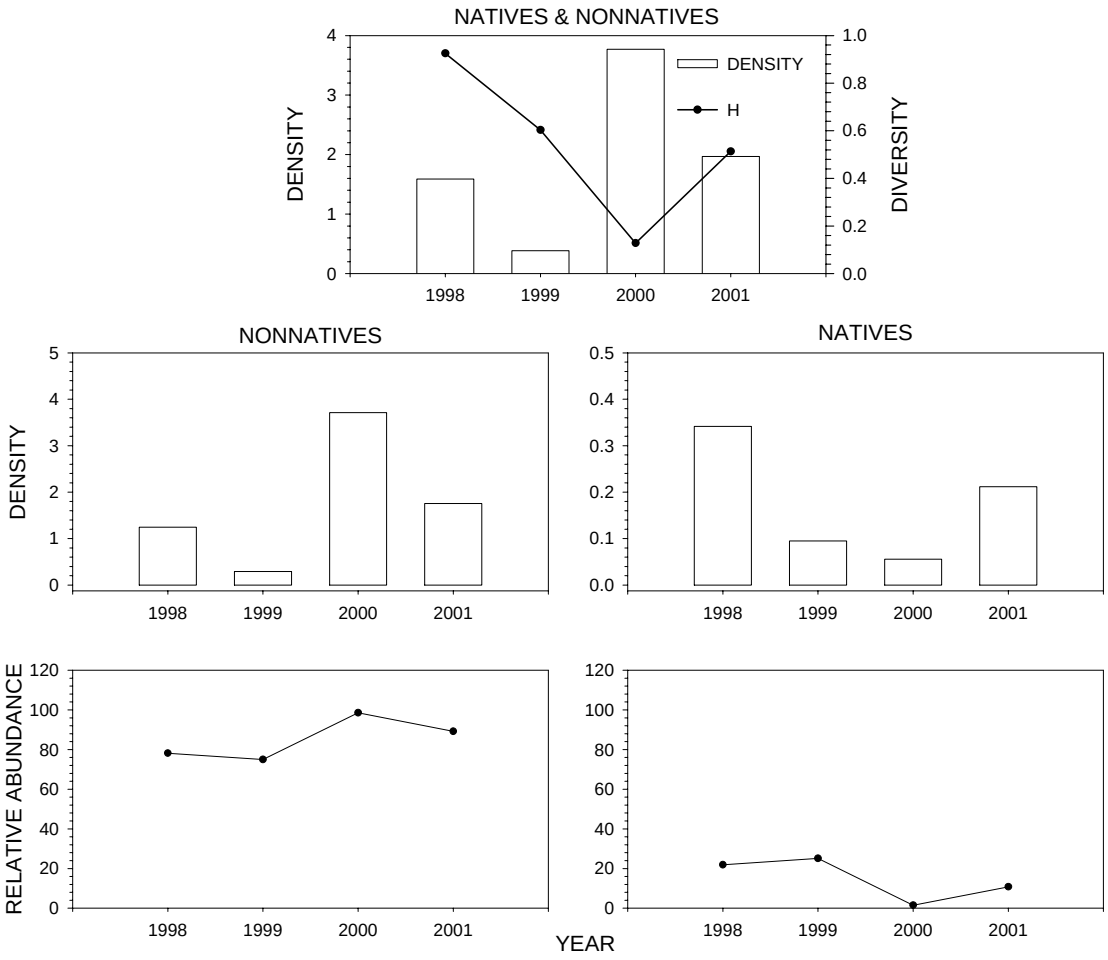

Figure 13. Total density, nonnative and native density and relative abundance in San Juan River primary channel, Reach 4, 1998 - 2001.

1998 through 2000, and increased to its second-highest level in 2001. Relative abundance of native fishes was least (1.5 %) in 2000 and highest (25.1 %) in 1999.

Density of red shiner was considerably higher than any other nonnative species in all years, and in 1999 (its year of lowest density) was the only nonnative species collected (Figure 14). Fathead minnow density was highest in 1998 and 2001 while that of western mosquitofish was greatest in 2000 and 2001. Speckled dace density was greatest in 2000 and lowest in 1999 (Figure 15). Flannelmouth sucker density generally increased

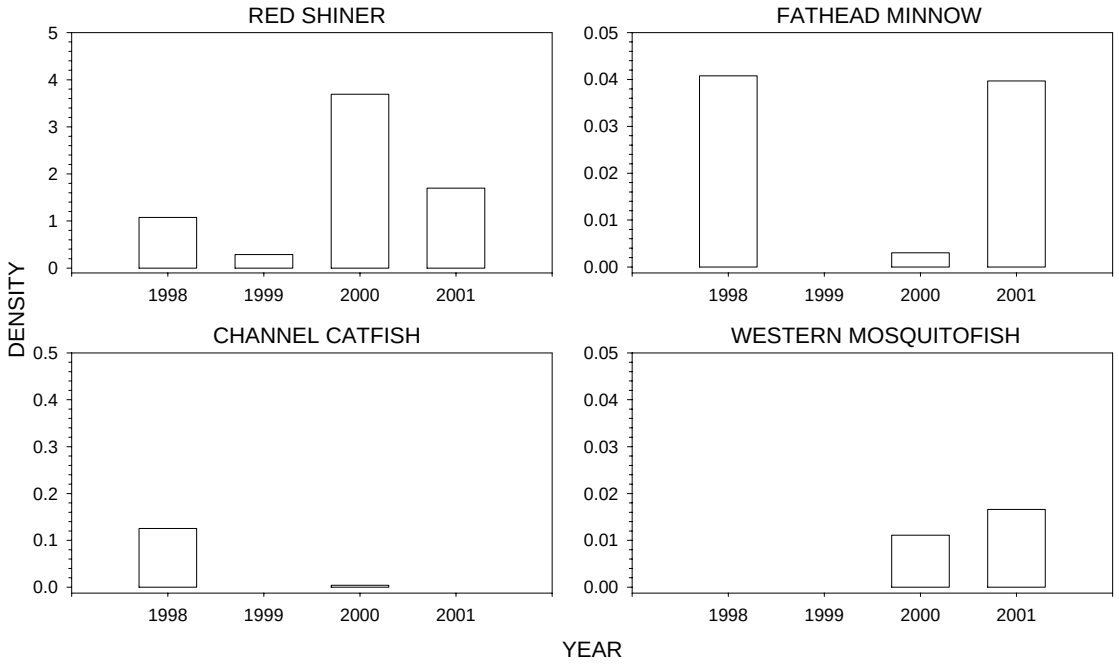

Figure 14. Density of nonnative fishes in San Juan River primary channel, Reach 4, 1998 - 2001

Figure 15. Density of native fishes in San Juan River primary channel, Reach 4, 1998 - 2001.

from 1998 through 2001, despite its absence in collections in 1999. Bluehead sucker was found only in 1999 and 2000.

Primary Channel, Reach 3

Five native and six nonnative fish species were collected in Reach 3 from 1998 through 2001 (Table 8). Red shiner was the most common species in all years, except 1998 when speckled dace was the most- and red shiner was second-most common. Between 1999 and 2001, speckled dace was the second-most common species in two years and western mosquitofish was in one. Both flannelmouth and bluehead suckers were found in all years, except 2001 when bluehead sucker was not collected. Two specimens of Colorado pikeminow were collected in 1998.

Table 8. Number and density (number/m^2) of fishes in San Juan River primary channel, Geomorphic Reach 3, during autumn inventories, 1998 – 2001.

1998			1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	197	0.304	CYPLUT	65	0.069	CYPLUT	3574	3.617	CYPLUT	1180	1.764
CYPLUT	97	0.150	RHIOSC	21	0.022	GAMAFF	192	0.1943	RHIOSC	93	0.139
ICTPUN	94	0.145	PIMPRO	1	0.001	PIMPRO	69	0.070	PIMPRO	43	0.064
PIMPRO	12	0.019	CATLAT	1	0.001	RHIOSC	48	0.049	GAMAFF	11	0.016
CATLAT	4	0.006	CATDIS	1	0.001	CATLAT	18	0.018	ICTPUN	2	0.003
PTYLUC	2	0.003				ICTPUN	12	0.012	CATLAT	1	0.002
CATDIS	1	0.002				CATDIS	4	0.004			
FUNZEB	1	0.002				CYPCAR	3	0.003			
TOT N	408			89			3920			1330	
AREA	649			939			988			669	
DENSITY	0.629			0.095			3.968			1.988	
H	1.236			0.722			0.412			0.458	

Total fish density was >1.0 fish/m^2 in all years, except 1999 when it was <0.1 fish/m^2 (Figure 16). Greatest total density was in 2000. Assemblage diversity declined from 1998 through 2000, and was only slightly greater in 2001 than 2000. Nonnative

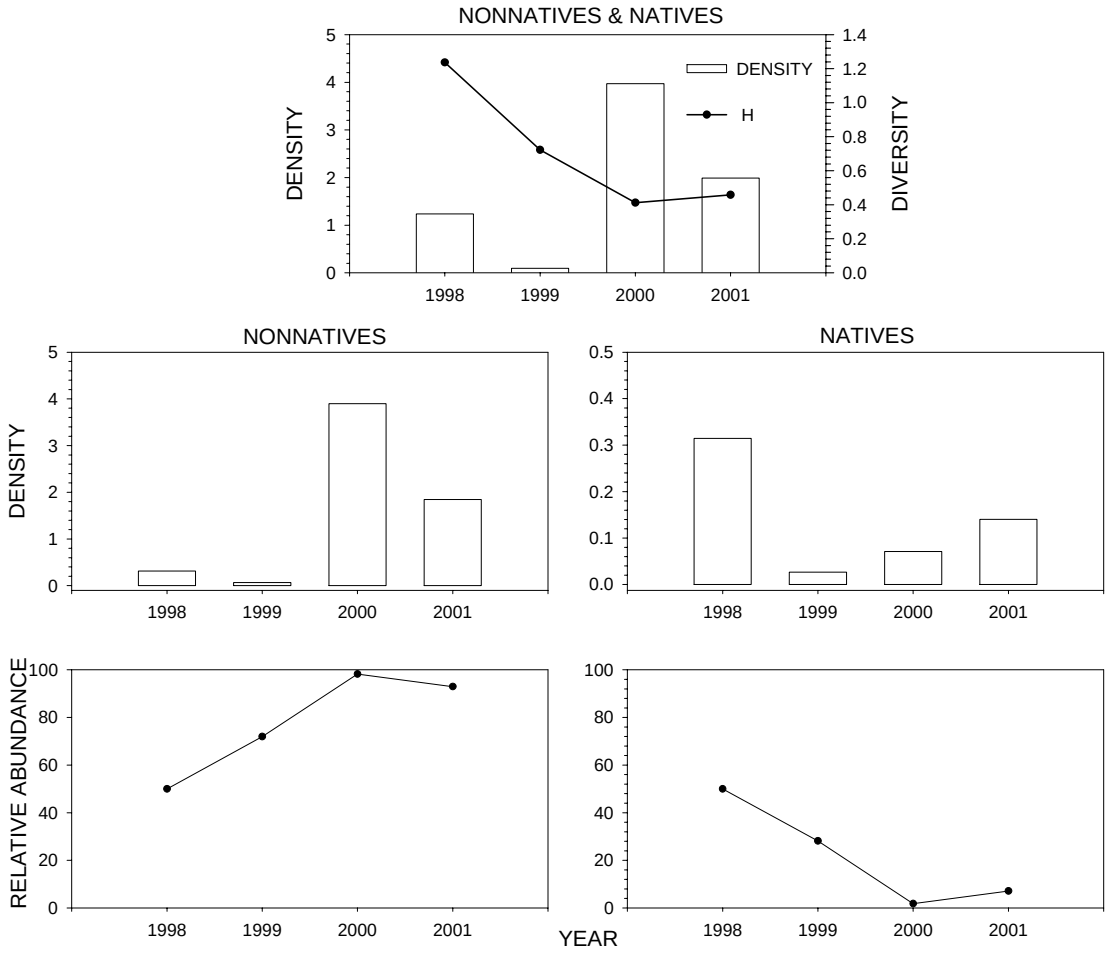

Figure 16. Total density, nonnative and native density and relative abundance in San Juan River primary channel, Reach 3, 1998 - 2001.

fish density was almost 4.0 fish/m^2 in 2000, but was substantially less in other years. Native fish density was highest in 1998, declined to <0.03 fish/m^2 in 1999, and gradually increased thereafter. Nonnative fish relative abundance increased from 50 % of collection to almost 100% in 2000 and declined to 93% in 2001.

Densities of red shiner, fathead minnow, and western mosquitofish in 1998 and 1999 were substantially lower than in 2000 and 2001 (Figure 17). Channel catfish, in

contrast, was most common in 1998 and was rare or absent in subsequent years. Density of speckled dace was greatest in 1998 and densitiest of flannelmouth and bluehead sucker were greatest in 2000 (Figure 18).

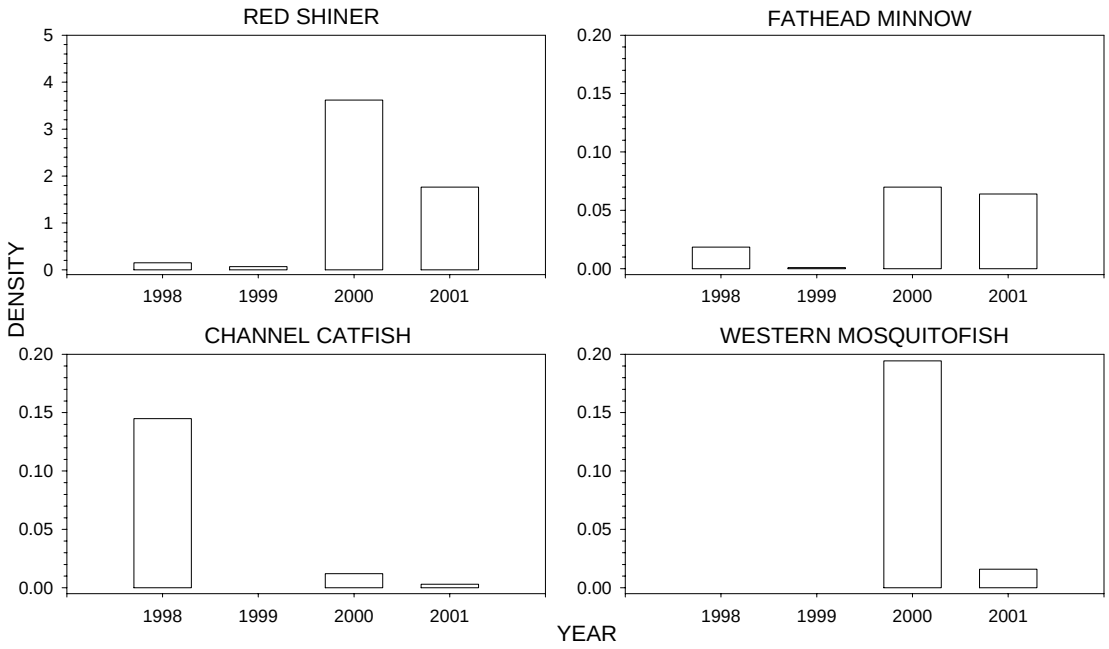

Figure 17. Density of nonnative fishes in San Juan River primary channel, Reach 3, 1998 - 2001.

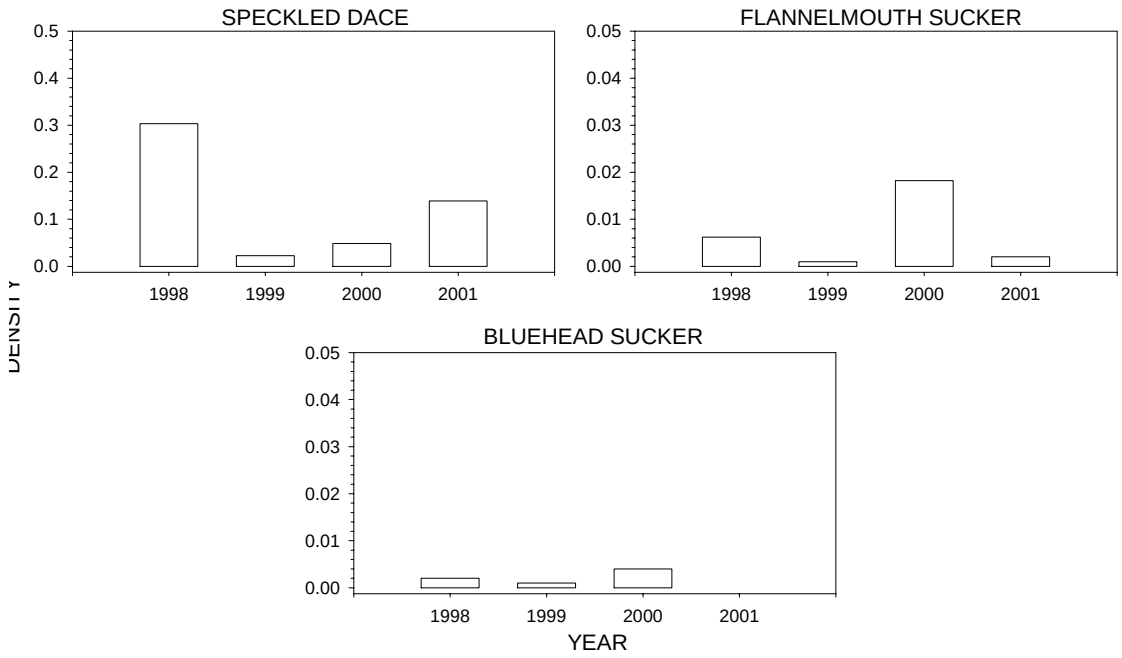

Figure 18. Density of native fishes in San Juan River primary channel, Reach 3, 1998 - 2001.

Primary Channel, Reach 2

Seven fish species (3 native and 4 nonnative) were collected in Reach 2 between 1998 and 2001 (Table 9). Red shiner was the most common species in all years and speckled dace was second-most common in all years, except 2000 when western mosquitofish was second-most common. Neither native sucker species was found in all years, flannelmouth sucker was absent in 1999 and 2001, and bluehead sucker was not found in 1998 and 1999.

Table 9. Number and density (number/m^2) of fishes in San Juan River primary channel, Geomorphic Reach 2, during autumn inventories, 1998 – 2001.

1998			1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	98	0.323	CYPLUT	173	0.113	CYPLUT	2002	1.367	CYPLUT	583	0.582
RHIOSC	81	0.267	RHIOSC	16	0.011	GAMAFF	45	0.0307	RHIOSC	18	0.018
ICTPUN	43	0.142	ICTPUN	4	0.003	PIMPRO	19	0.013	PIMPRO	16	0.016
PIMPRO	4	0.013	PIMPRO	3	0.002	ICTPUN	19	0.013	ICTPUN	6	0.006
CATLAT	1	0.003				RHIOSC	16	0.011	GAMAFF	3	0.003
						CATDIS	6	0.004	CATDIS	1	0.001
						CATLAT	2	0.001			
TOT N	227			196			2109			627	
AREA	303			1525			1465			1002	
DENSITY	0.749			0.129			1.440			0.626	
H	1.141			0.458			0.277			0.344	

Total fish density was greatest in 2000, but never exceed 2.0 fish/m^2 (Figure 19). Assemblage diversity was highest in 1998, declined to four-year low in 2000, and was only slightly greater in 2001 than 2000. Nonnative fish density was greatest in 2000 and least in 1998. Native fish density was considerably higher in 1998 than in subsequent

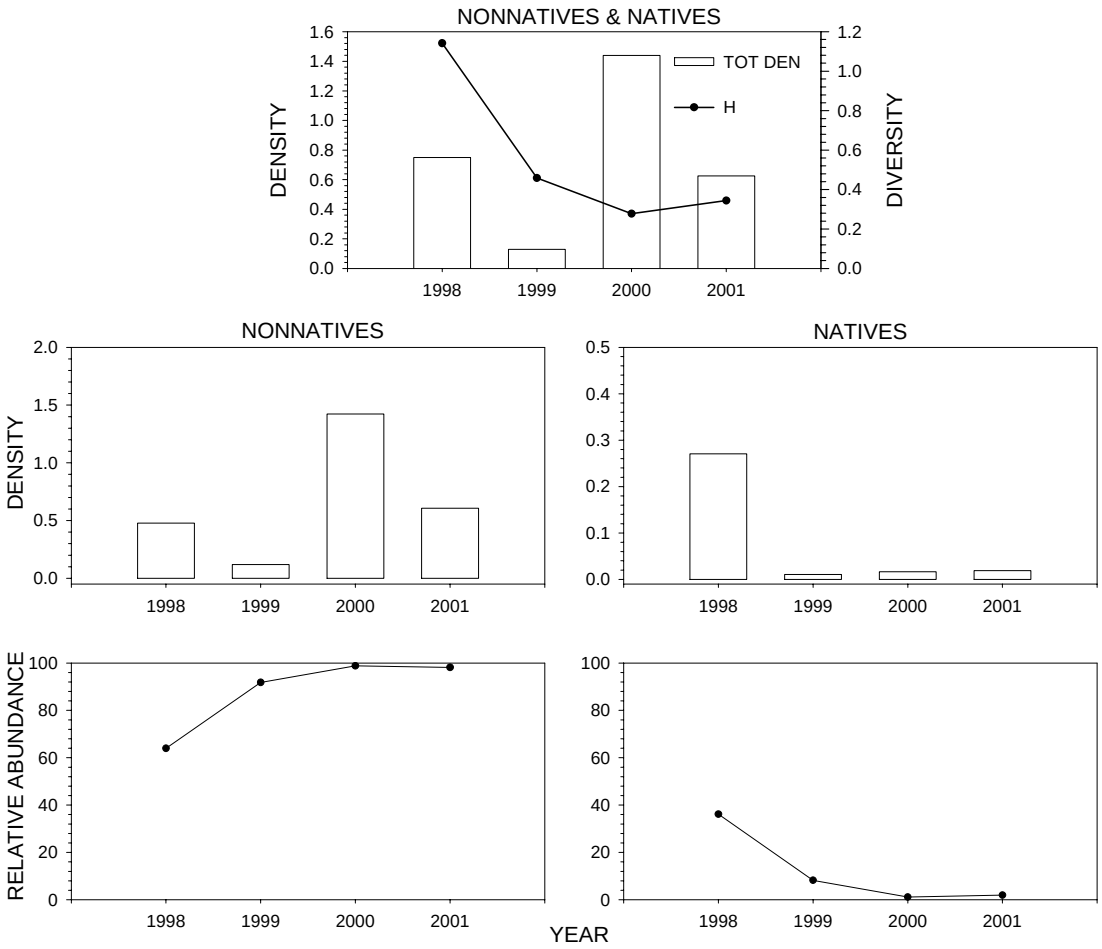

Figure 19. Total density, nonnative and native density and relative abundance in San Juan River primary channel, Reach 2, 1998 - 2001.

years. In 1998, relative abundance of native fishes was comparatively high, but was less than 10 % of collection in 1999 through 2001.

Among nonnative fishes, red shiner density was at least twice that of any other nonnative fish species in all years (Figure 20). Only channel catfish in 1998 and 2000 and western mosquitofish in 2000 was ever represented by more than 10 individuals. Speckled dace density was comparative high in 1998, but was substantially lower in following years. Neither bluehead nor flannelmouth sucker density exceeded 0.005/m^2 in any year (Figure 21).

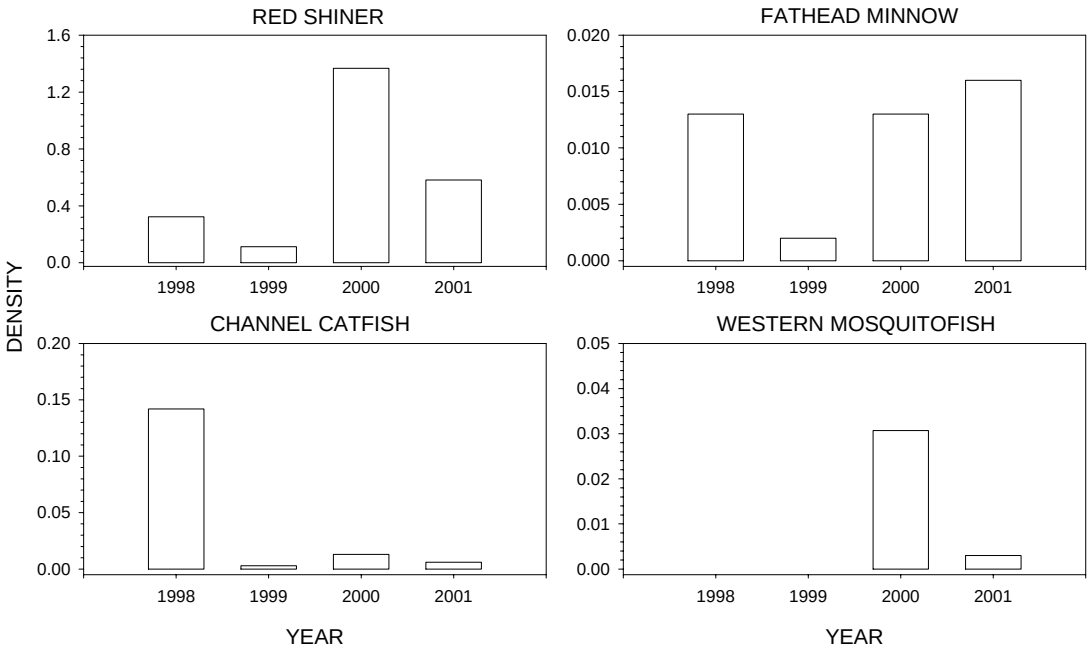

Figure 20. Density of nonnative fishes in San Juan River primary channel, Reac2, 1998-2001.

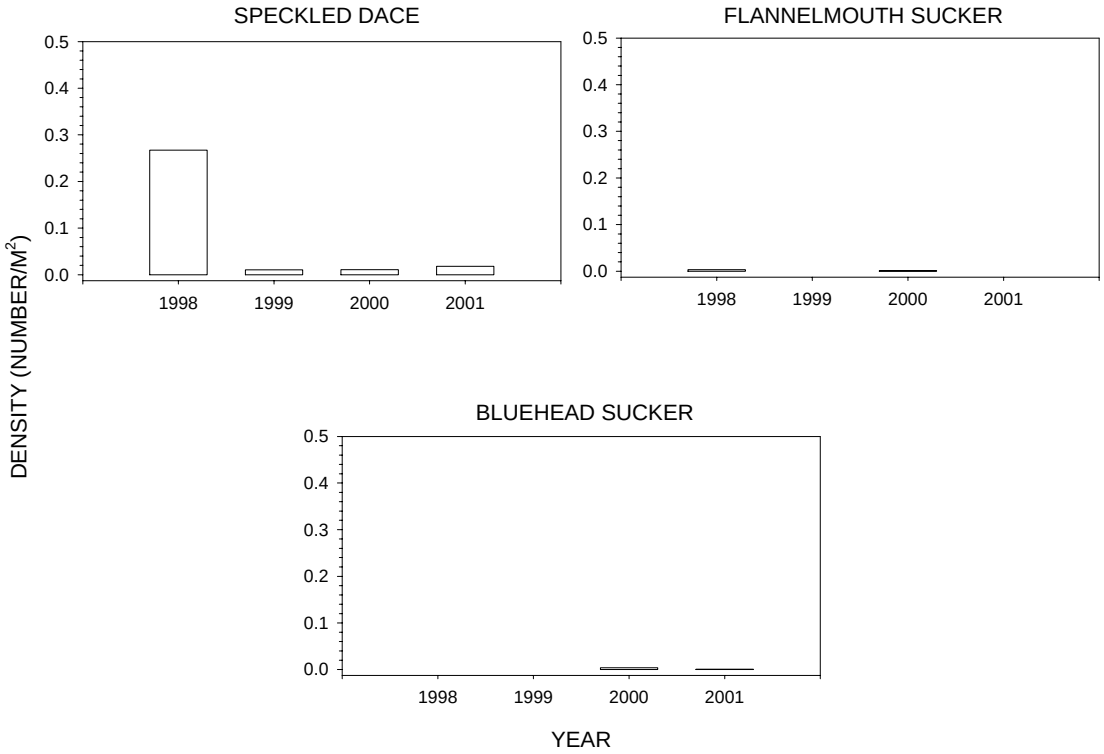

Figure 21. Density of native fishes in San Juan River primary channel, Reach 2, 1998 - 2001.

Primary Channel, Reach 1

Three native and five nonnative fish species were collected in Reach 1 between 1999 and 2001 (Table 10). Red shiner was the most common species in all years. Fathead minnow and western mosquitofish were the second-most common species in 1999 and 2000, respectively. Speckled dace was rare in 1999 and 2000, but comparatively common, and second-most, in 2001. Neither flannelmouth nor bluehead sucker was collected in 1999, but both were found in 2000 and 2001, albeit in low numbers.

Table 10. Number and density (number/m^2) of fishes in San Juan River primary channel, Reach 1, during autumn inventories, 1999 – 2001.

1999			2000			2001		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	608	0.982	CYPLUT	2058	7.221	CYPLUT	79	0.382
PIMPRO	23	0.037	GAMAFF	203	0.712	RHIOSC	48	0.232
RHIOSC	2	0.003	PIMPRO	38	0.133	GAMAFF	26	0.126
ICTPUN	1	0.002	RHIOSC	2	0.007	CATLAT	12	0.058
			CATLAT	2	0.007	PIMPRO	7	0.034
			CATDIS	1	0.004	CATDIS	5	0.024
			FUNZEB	1	0.004	FUNZEB	1	0.005
TOT N	634			2305			178	
AREA	617			285			207	
DENSITY	1.028			8.088			0.860	
H	0.189			0.402			1.433	

Total fish density was greatest in 2000, exceeding 8.0 fish/m^2, but was about 1.0 fish/m^2 in 1999 and 2001 (Figure 22). Assemblage diversity increased from a low of 0.19 in 1999 to a high of 1.43 in 2001. Nonnative density was highest in 2000 while that

of natives was greatest in 2001. In 1999 and 2000, native fishes represented <0.5% of collections, but in 2001 were 36.5% of collection.

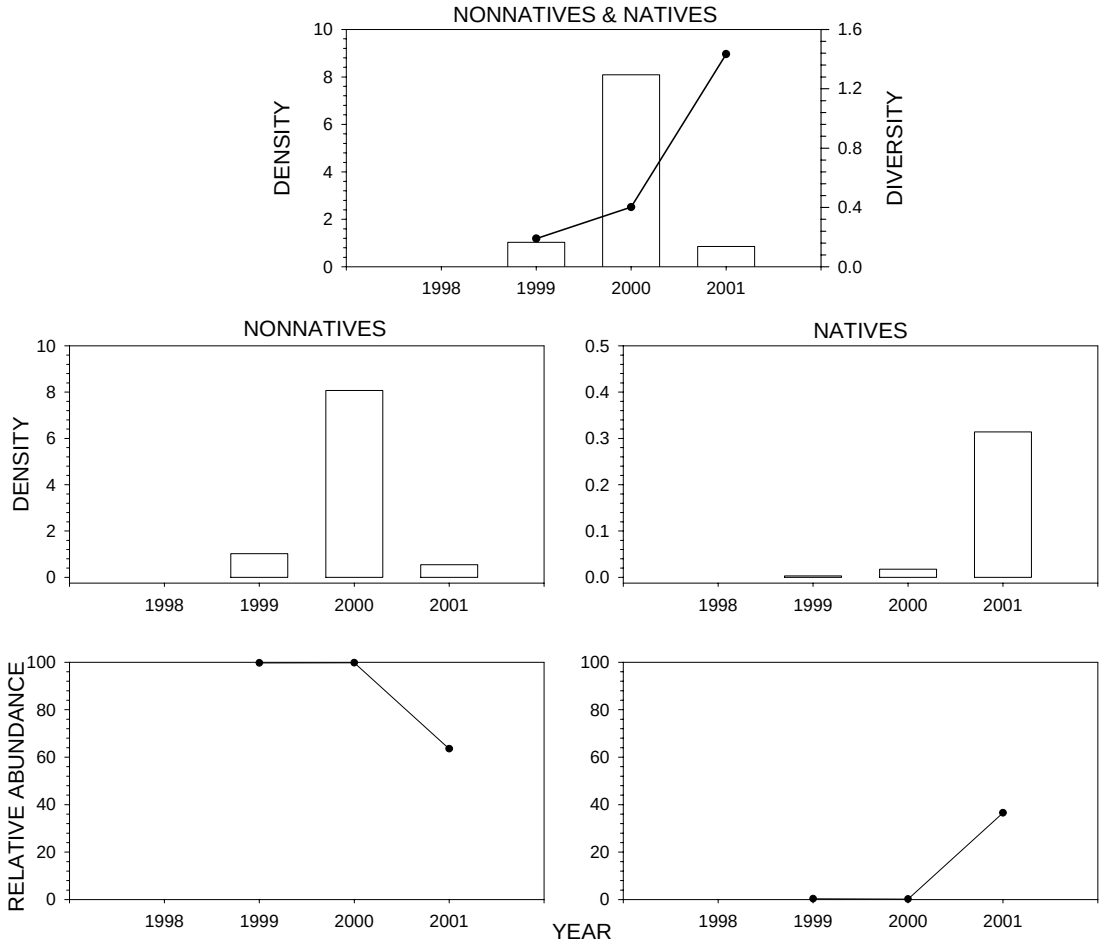

Figure 22. Total density, nonnative and native density and relative abundance in San Juan River primary channel, Reach 1, 1999 - 2001.

Density of each common nonnative fish species, except channel catfish, was greatest in 2000 (Figure 23). In that year, red shiner density was 7.2 fish/m^2, but that of other nonnatives was $\leq$0.75 fish/m^2. Channel catfish was collected only in 1999 in Reach 1, and was represented by 1 specimen in that collection. Speckled dace density was low in 1999 and 2000, but was comparatively high in 2001 (Figure 24). Neither flannelmouth nor bluehead sucker was present in 1999, but both were found in 2000 and 2001.

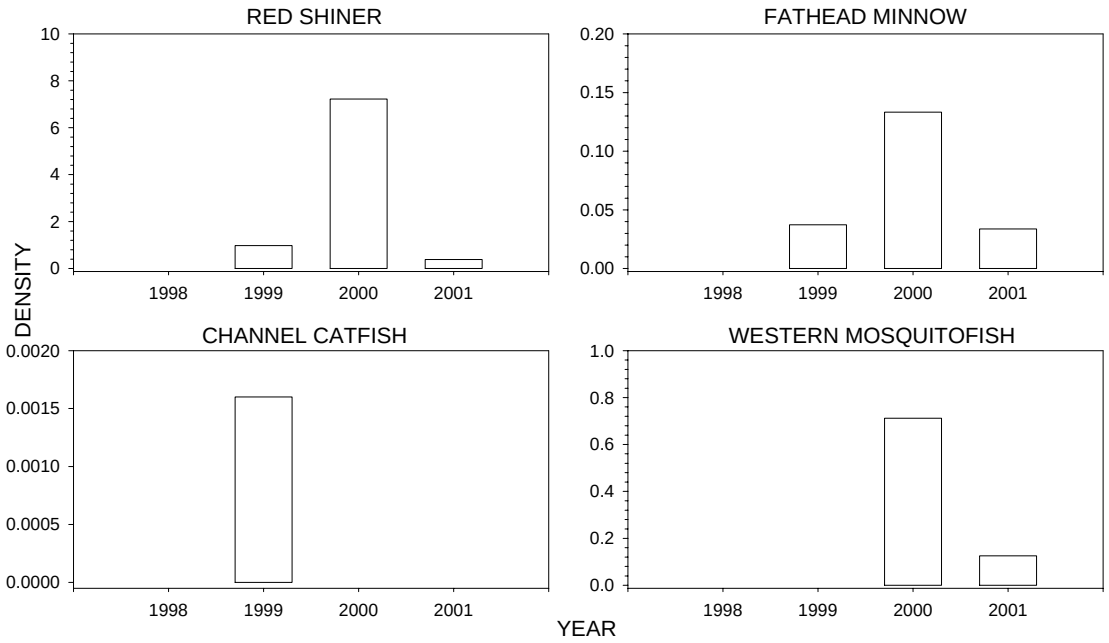

Figure 23. Density of nonnative fishes in San Juan River primary channel, Reach 1, 1999 - 2001.

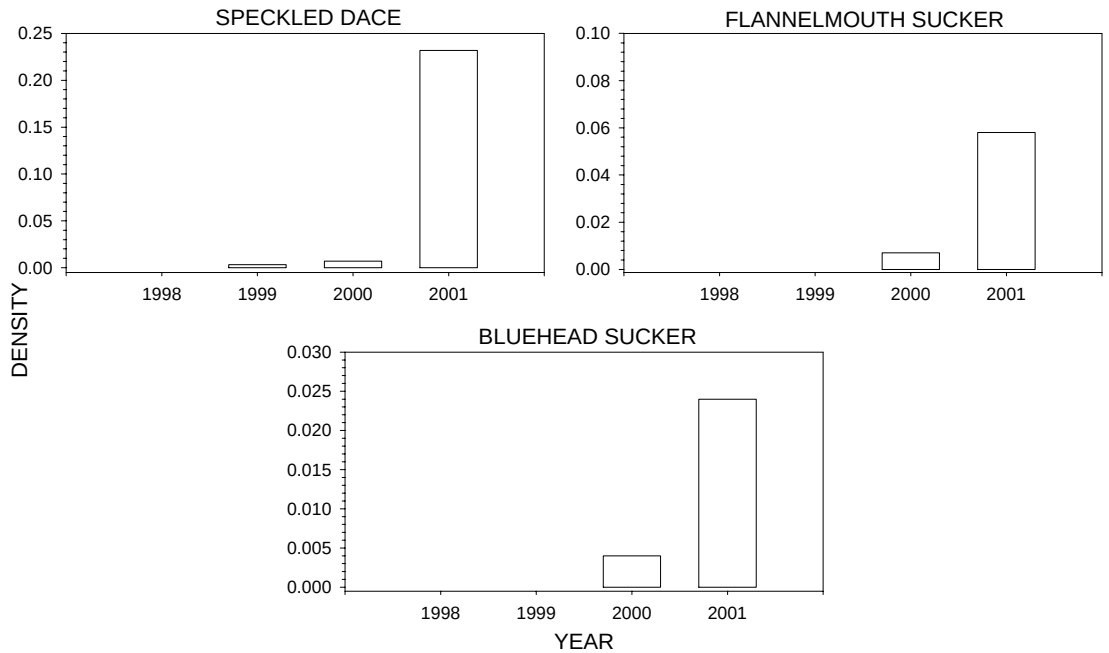

Figure 24. Density of native fishes in San Juan River primary channel, Reach 1, 1999 - 2001.

SECONDARY CHANNELS FISHES

Since 1993, six native and 11 nonnative species have been collected in San Juan River secondary channels (Table 11). Speckled dace, flannelmouth sucker, and bluehead sucker were found in all years. Roundtail chub was collected in 1997, 1998, and 1999. Colorado pikeminnow was found from 1997 through 2000 and mottled sculpin was collected in 1999. Razorback sucker was the only native species not collected in secondary channel habitats since 1993. Red shiner, fathead minnow, channel catfish, and western mosquitofish were collected in all years. Plains killifish was not found in 1999, common carp was not collected in 1999 and 2001, and green sunfish was absent in 2000 and 2001.

Red shiner was the most-common species in all years and fathead minnow or speckled dace were second-most common (Table 12). Number of red shiner collected each year was often twice that of the next-most common species. Channel catfish was never more than fifth-most common, except in 1998 when it was fourth most common. Other ictularids were rare. Centrarchids were likewise uncommon and typically represented by 10 or fewer specimens. Flannelmouth and bluehead suckers were never more than fourth-most common, and typically sixth or less common. In 1997, Colorado pikeminnow was third-most common species in secondary channels. Total fish density was highest in 2000 (year of lowest mean daily summer discharge) and lowest in 1999. Assemblage diversity was >1.0000 from 1993 through 1999, but declined to 0.2824 in 2000 and increased slightly in 2001 to 0.3639.

Table 11. Occurrence of fishes in San Juan River secondary channels during autumn, 1993 – 2001, 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	93	94	95	96	97	98	99	00	01
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		X	
Roundtail chub	*Gila robusta*	GILROB	N					X	X	X		
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X	X	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N					X	X	X	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
Rainbow trout	*Oncorhynchus mykiss*	ONCMYK	I									X
Black bullhead	*Ameiurus melas*	AMEMEL	I		X	X						X
Yellow bullhead	*Ameiurus natalis*	AMENAT	I						X			X
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	X	X	X	X	X	X	X	X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I	X	X	X	X	X	X		X	X
Western mosquitofish	*Gambusia affinis*	GAMAFF	I	X	X	X	X	X	X	X	X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I	X	X	X	X	X	X	X		
Largemouth bass	*Micropterus salmoides*	MICSAL	I		X	X	X	X	X		X	
Mottled sculpin	*Cottus bairdi*	COTBAI	N							X		
TOTAL NATIVE			6	3	3	3	3	5	5	6	4	3
TOTAL NONNATIVE			11	7	9	9	8	8	9	5	7	8

Table 12. Number and density of fishes and assemblage diversity in San Juan River secondary channels during autumn inventories, 1993 – 2001.

1993		1994		1995		1996		1997		1998		1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	2427	CYPLUT	5397	CYPLUT	4125	CYPLUT	3632	CYPLUT	1023	CYPLUT	741	CYPLUT	272	CYPLUT	16371	CYPLUT	1828
RHIOSC	1090	PIMPRO	2196	PIMPRO	2417	PIMPRO	2201	RHIOSC	564	RHIOSC	597	RHIOSC	115	PIMPRO	1467	PIMPRO	208
PIMPRO	699	RHIOSC	967	RHIOSC	987	GAMAFF	716	PTYLUC	241	PIMPRO	162	PIMPRO	20	GAMAFF	1191	RHIOSC	173
CATLAT	189	GAMAFF	643	GAMAFF	135	RHIOSC	127	PIMPRO	175	ICTPUN	138	CATDIS	4	CYPCAR	314	GAMAFF	81
CATDIS	164	ICTPUN	204	ICTPUN	62	ICTPUN	57	CATLAT	75	GAMAFF	113	CATLAT	4	RHIOSC	127	ICTPUN	18
ICTPUN	97	CATLAT	192	CATLAT	57	CATLAT	31	ICTPUN	68	CATLAT	13	ICTPUN	4	CATLAT	44	FUNZEB	18
FUNZEB	65	FUNZEB	43	CATDIS	42	CATDIS	29	CATDIS	45	FUNZEB	4	GAMAFF	3	ICTPUN	27	CATLAT	112
GAMAFF	45	CATDIS	20	FUNZEB	18	FUNZEB	17	CYPCAR	18	CYPCAR	2	COTBAI	1	CATDIS	18	CATDIS	2
CYPCAR	7	MICSAL	10	CYPCAR	9	CYPCAR	1	GAMAFF	15	GILROB	2	GILROB	1	MICSAL	13	AMEMEL	2
		CYPCAR	8	LEPCYA	2	LEPCYA	1	GILROB	11	CATDIS	2	PTYLUC	1	FUNZEB	4	AMENAT	1
		AMEMEL	3	MICSAL	1	MICSAL	1	FUNZEB	3	AMENAT	2	LEPCYA	1	PTYLUC	3	ONCMYK	1
		LEPCYA	1	AMEMEL	1			LEPCYA	1	PTYLUC	1						
								MICSAL	1	LEPCYA	1						
TOT N	4783		9684		7856		6813		2119		1778		427		19579		2344
AREA	1058		2456		1758		2715		2681		1904		1356		1914		1346
DENSITY	4.521		3.943		4.469		2.509		0.790		0.934		0.315		10.229		1.741
H	1.397		1.285		1.159		1.118		1.587		1.412		1.018		0.282		0.364

Among year variation in assemblage diversity, native and nonnative density, and relative abundance of natives and nonnatives varied considerably within each secondary channel. When averaged over years, there was a decline in assemblage diversity from Reach 5 downstream through Reach 3 (Figure 25). Assemblage diversity was significantly different among reaches ($F_{2,24} = 4.63$, $p = 0.020$), post hoc test indicated that mean assemblage diversity of Reach 5 was different from that of Reach 3 ($P = 0.016$). Native fish among-year density differences were not significant ($F_{2,24} = 1.12$, $p = 0.343$). Reach differences in nonnative fish density were not significant ($F_{2,24} = 0.646$, $p = 0.533$). Mean relative abundance of native fishes declined in a downstream direction; however, differences among sites were not significant ($F_{2,24} = 0.985$, $p = 0.388$).

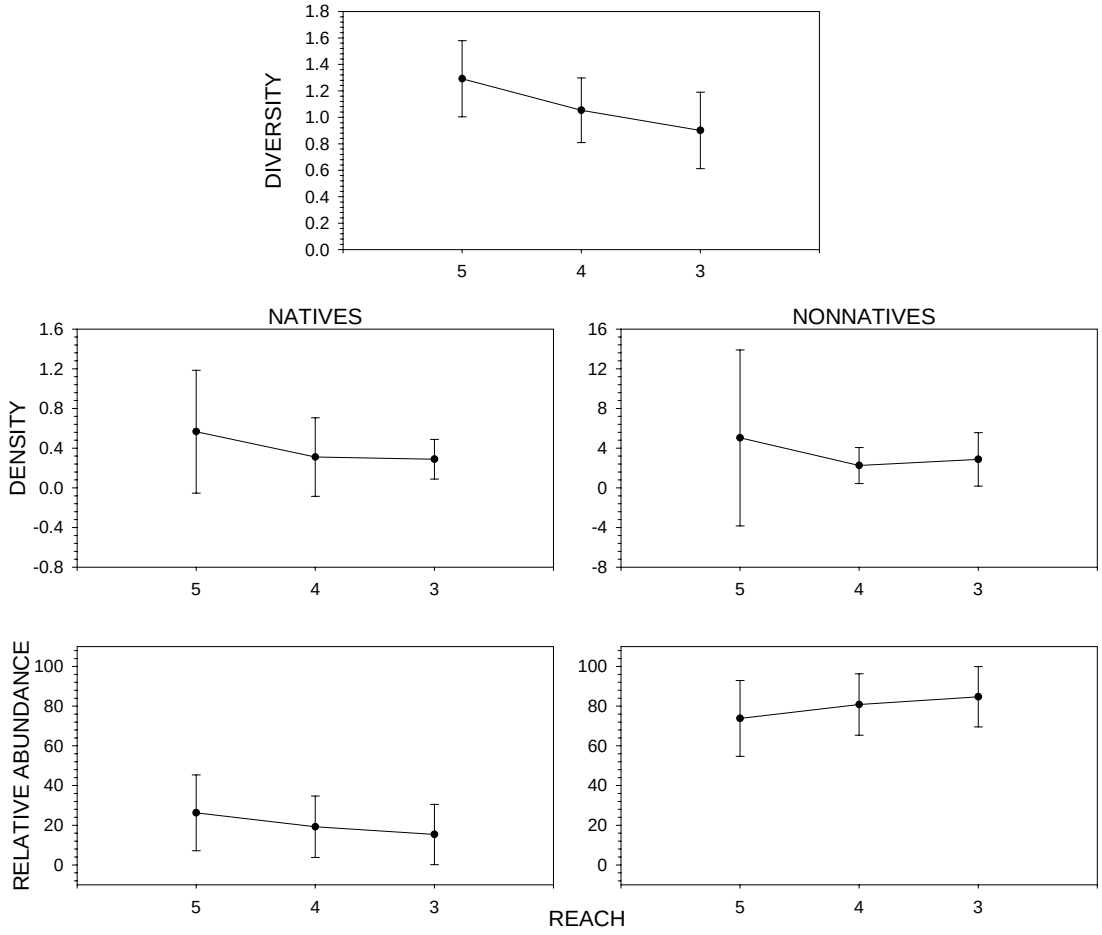

Figure 25. Mean assemblage diversity (± SE), mean diversity (± SE), and mean relative abundance (± SE) of native and nonnative fishes in San Juan River secondary channels, 1993 - 2001.

Secondary Channels, Reach 5

Since 1993, five native and 10 nonnative fish species have been collected in Reach 5 secondary channels (Table 13). Red shiner was the most common species in all years, except 1999 when speckled dace was most common. Fathead minnow and speckled dace were usually the second- or third-most common species. Western mosquitofish was third-most common in 1998 and 2000 and Colorado pikeminnow was

Table 13. Number and density of fishes and assemblage diversity in San Juan River secondary channels, Geomorphic Reach 5, during autumn inventories, 1993 – 2001.

1993		1994		1995		1996		1997		1998		1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	1028	CYPLUT	1066	CYPLUT	341	CYPLUT	1626	CYPLUT	292	CYPLUT	267	RHIOSC	37	CYPLUT	8984	CYPLUT	219
PIMPRO	627	PIMPRO	695	RHIOSC	305	PIMPRO	1559	RHIOSC	292	RHIOSC	106	CYPLUT	32	PIMPRO	1352	PIMPRO	38
RHIOSC	545	RHIOSC	541	PIMPRO	156	GAMAFF	501	PTYLUC	192	GAMAFF	87	PIMPRO	14	GAMAFF	812	RHIOSC	35
CATDIS	110	GAMAFF	268	GAMAFF	49	RHIOSC	63	PIMPRO	114	PIMPRO	46	CATDIS	2	CYPCAR	160	GAMAFF	29
CATLAT	90	ICTPUN	74	CATLAT	35	ICTPUN	13	CATLAT	20	CATLAT	7	CATLAT	2	RHIOSC	43	FUNZEB	2
GAMAFF	44	CATLAT	50	CATDIS	26	FUNZEB	9	CYPCAR	16	ICTPUN	4	PTYLUC	1	CATDIS	9	ONCMYK	1
FUNZEB	11	FUNZEB	26	CYPCAR	4	CATLAT	6	ICTPUN	16	CATDIS	2	ICTPUN	1	CATLAT	9		
ICTPUN	6	CATDIS	10	ICTPUN	2	CATDIS	4	GAMAFF	13	CYPCAR	1	LEPCYA	1	MICSAL	2		
CYPCAR	3	MICSAL	9	LEPCYA	1	CYPCAR	1	CATDIS	12	PTYLUC	1						
		CYPCAR	2	MICSAL	1			GILROB	2	AMENAT	1						
								FUNZEB	2	FUNZEB	1						
								LEPCYA	1	LEPCYA	1						
								MICSAL	1								
TOT N	2464		2741		920		3782		971		384		90		11371		324
AREA	392		920		320		544		738		559		419		407		354
DENSITY	6.286		2.979		2.875		6.952		1.316		0.687		0.215		27.939		0.915
H	1.425		1.522		1.468		1.118		1.650		1.354		1.342		0.722		1.022

third-most common in 1997. In 1996, the three most-common species were nonnative and in 2000 the four most-common species were nonnative.

From 1993 through 1999, total fish density exceeded 5.0 fish/m^2 only in 1993 and 1996 (Figure 26). In 2000, total fish density exceeded 27.0 fish/m^2, but was less than 1.0 fish/m^2 in 2001. Assemblage diversity was similar (between 1.2 and 1.6) among years from 1993 through 1999, but dropped to 0.7 in 2000. Nonnative fish density was highest in 1996 and 2000, years of lowest summer mean daily discharge (697 and 525 cfs) since 1993. Native fish density was highest in 1993 and 1995, years of highest spring mean daily discharge (6068 and 5308 cfs).

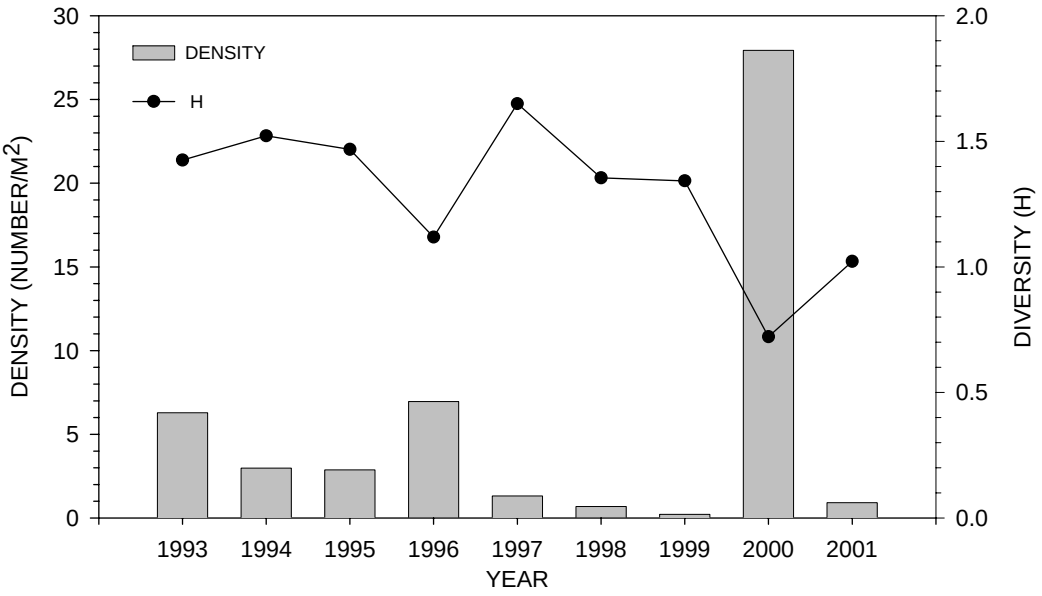

Figure 26. Fish density and assemblage diversity in San Juan River Reach 5 secondary channels, 1993 - 2001.

Autumn density of each commonly collected native species was highest in 1993 and speckled dace and flannelmouth sucker density generally declined from then through 2001 (Figure 27). Lowest speckled dace density occurred in 1999 and the lowest

densities for flannelmouth sucker and bluehead sucker were in 2001. Highest autumn densities of red shiner, fathead minnow, and western mosquitofish were in 2000, but

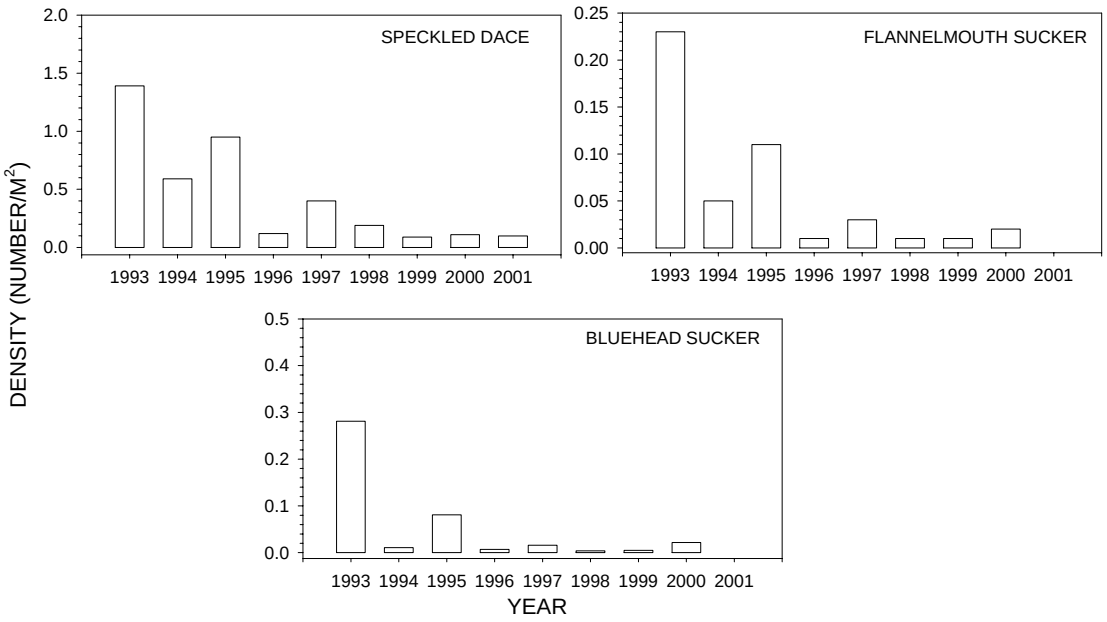

Figure 27. Densities of native fishes in San Juan River secondary channels, Reach 5, 1993 - 2001.

channel catfish density was highest in 1994 (Figure 28). The lowest densities of red shiner, fathead minnow, and western mosquitofish were in 1999; channel catfish was not collected in 2000 and 2001. Autumn density of native fishes was positively related to mean daily spring discharge ($r = 0.92$, $P < 0.01$), but that of nonnatives was not (Figure 29). Density of each native species was related to spring mean daily discharge (Figure 30), but autumn density of nonnative species was not related to spring discharge (Figure 31). There was no relationship between mean daily summer discharge and autumn density of natives or nonnatives (Figure 32). Nor was there a relationship between summer discharge and density of individual species (Figures 33 and 34). The number of days summer mean daily discharge <14 m^3/sec versus native fish density was not related,

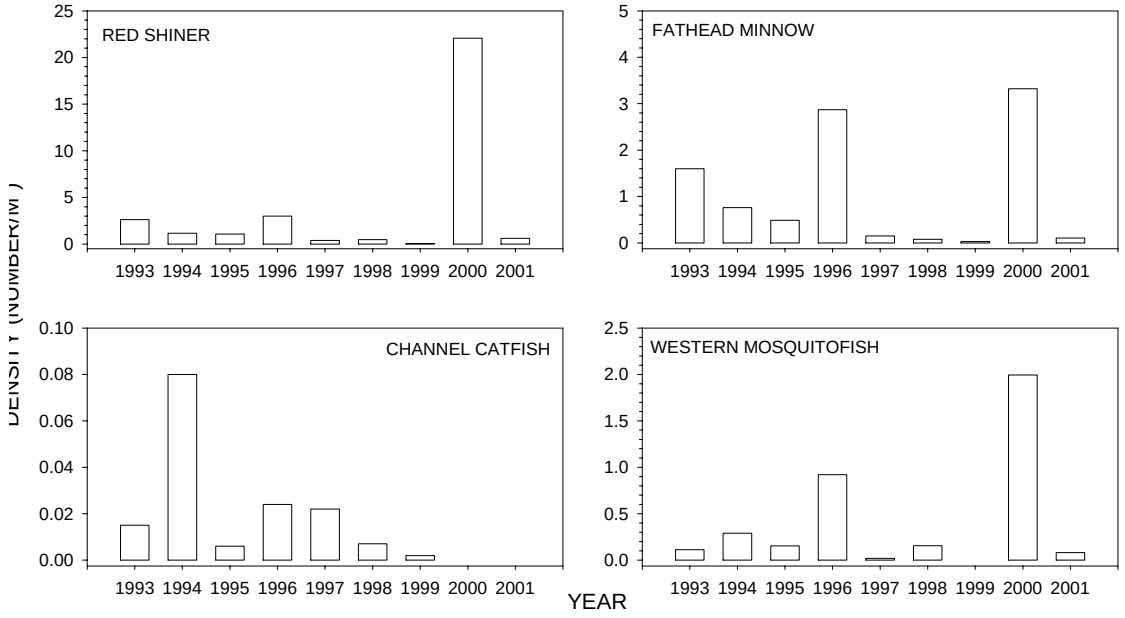

Figure 28. Density of nonnative fishes in San Juan River Reach 5 secondary channels, 1993 - 2001.

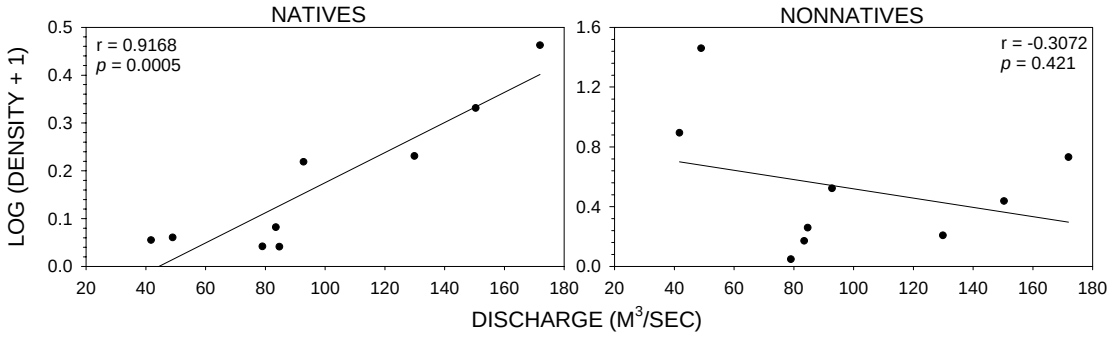

Figure 29. Spring discharge versus native and nonnative fishes density in San Juan River Reach 5 secondary channels, 1993 - 2001.

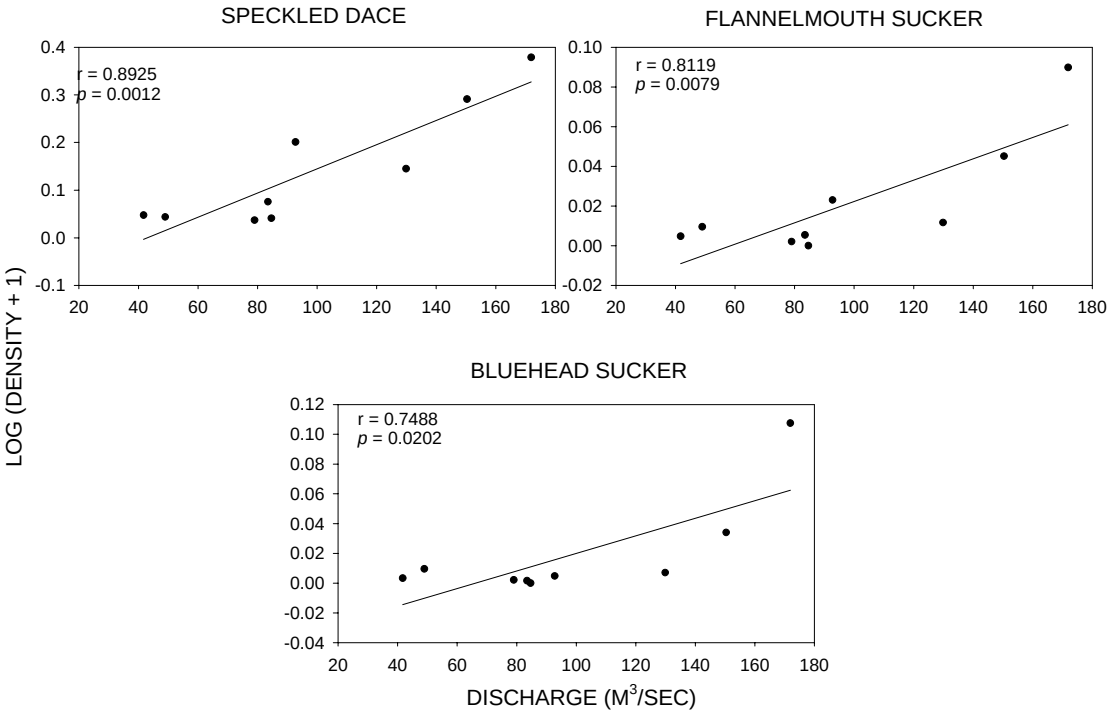

Figure 30. Mean daily spring discharge versus autumn density of native fishes in San Juan River Reach 5 secondary channels, 1993 - 2001.

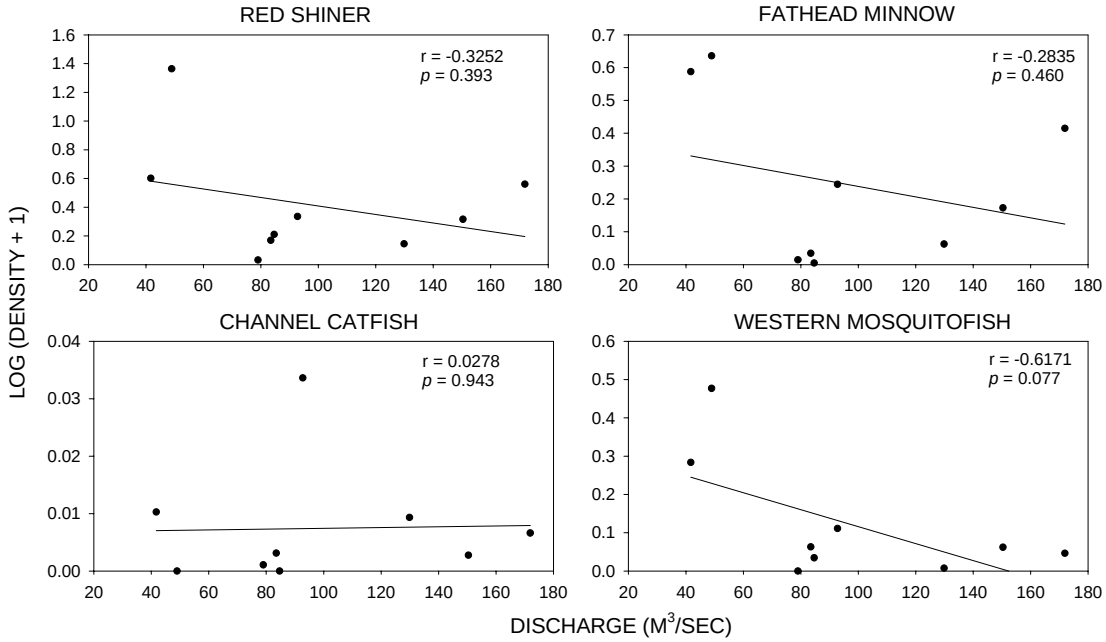

Figure 31. Mean daily spring discharge versus nonnative fish species densities in San Juan River Reach 5 secondary channels, 1993 - 2001.

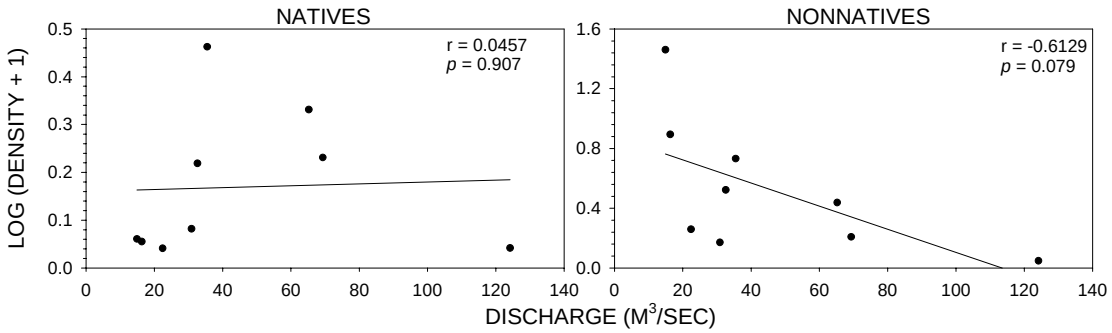

Figure 32. Mean summer daily discharge versus native and nonnative fish species densities in San Juan River Reach 5 secondary channels, 1993 - 2001.

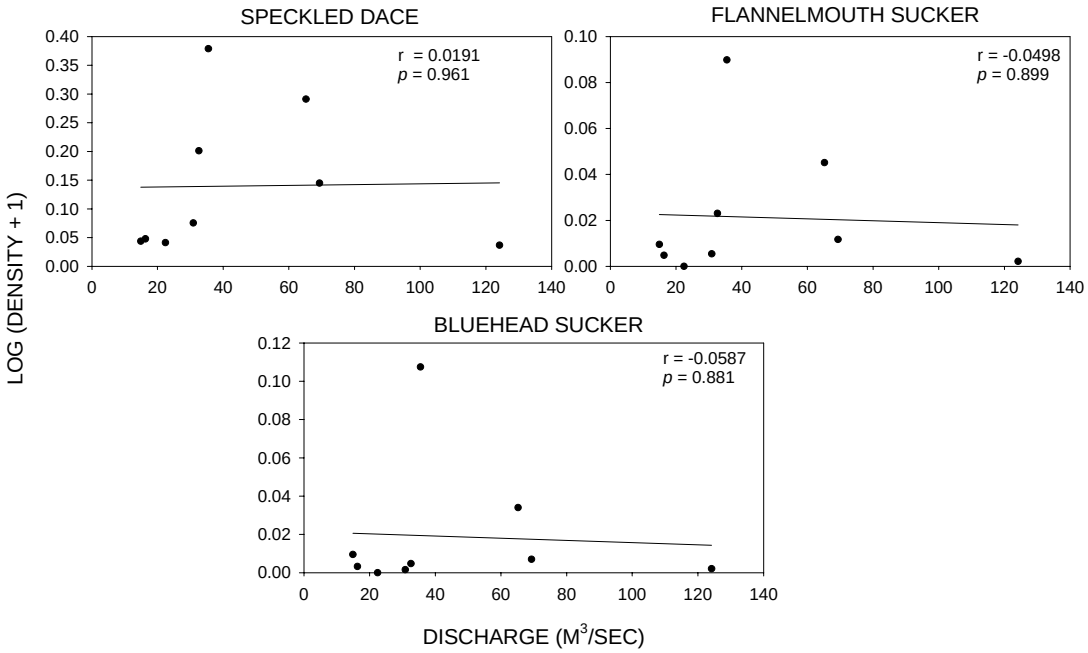

Figure 33. Mean daily summer discharge versus native fish species densities in San Juan River Reach 5 secondary channels, 1993 - 2001.

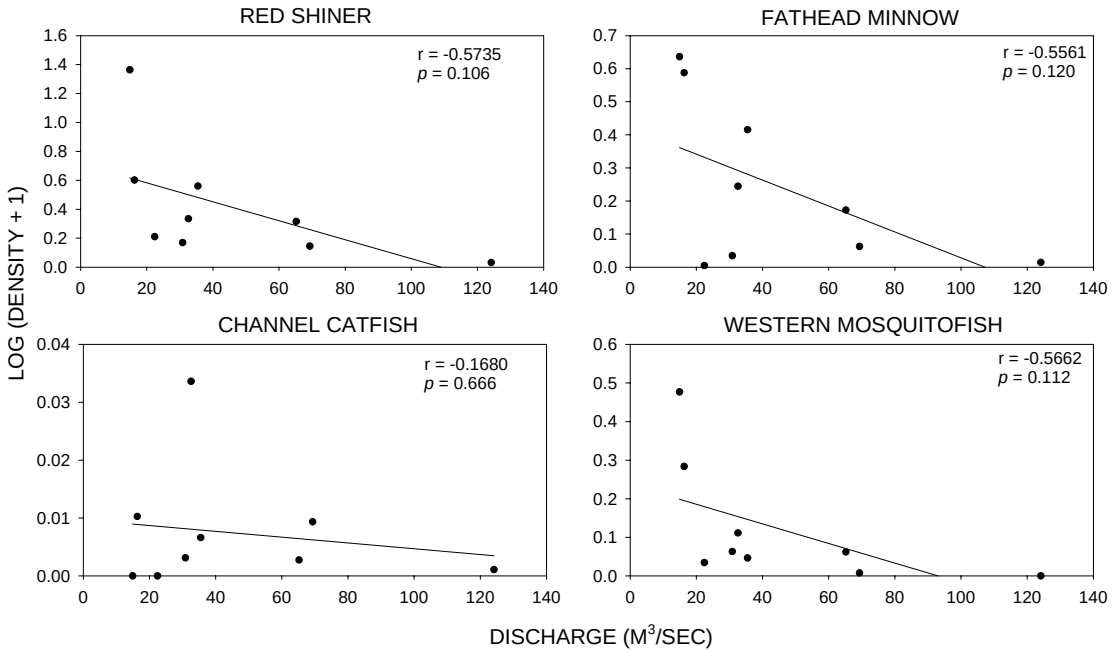

Figure 34. Mean daily summer discharge versus nonnative fish species autumn density in San Juan River Reach 5 secondary channels, 1993 - 2001.

but that of nonnatives showed a positive relationship (r = 0.73, P <0.05; Figure 35). There was no relationship between individual native species and days discharge <14 m^3/sec (Figure 36), but there was positive relationship with nonnative red shiner, fathead minnow, and western mosquitofish (Figure 37).

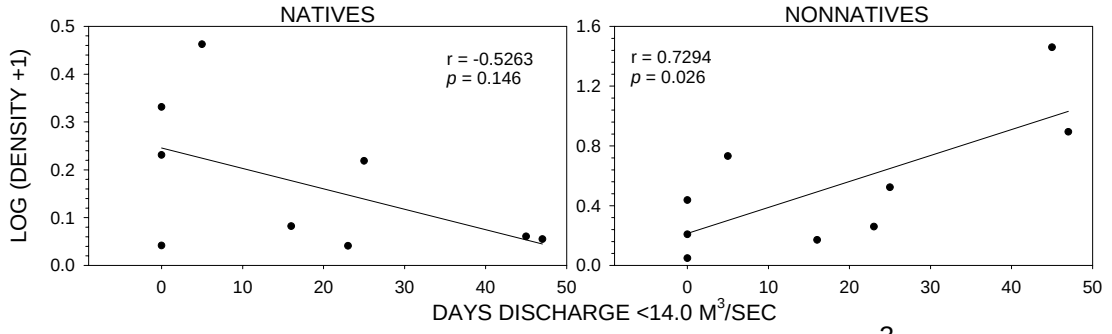

Figure 35. Number of days mean daily summer discharge <14.0 m^3/sec versus native and nonnative fishes densities in San Juan River Reach 5 secondary channels, 1993 - 2001.

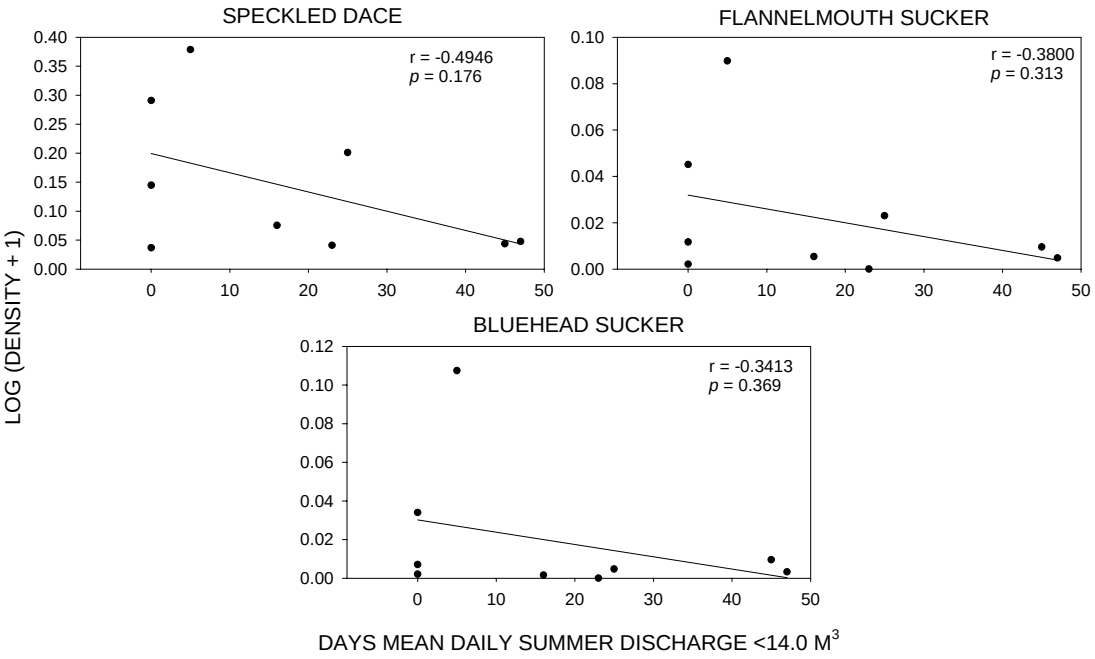

Figure 36. Number days mean daily summer discharge <14.0 m^3/sec versus autumn density of native fishes in San Juan River Reach 5 secondary channels, 1993 - 2001.

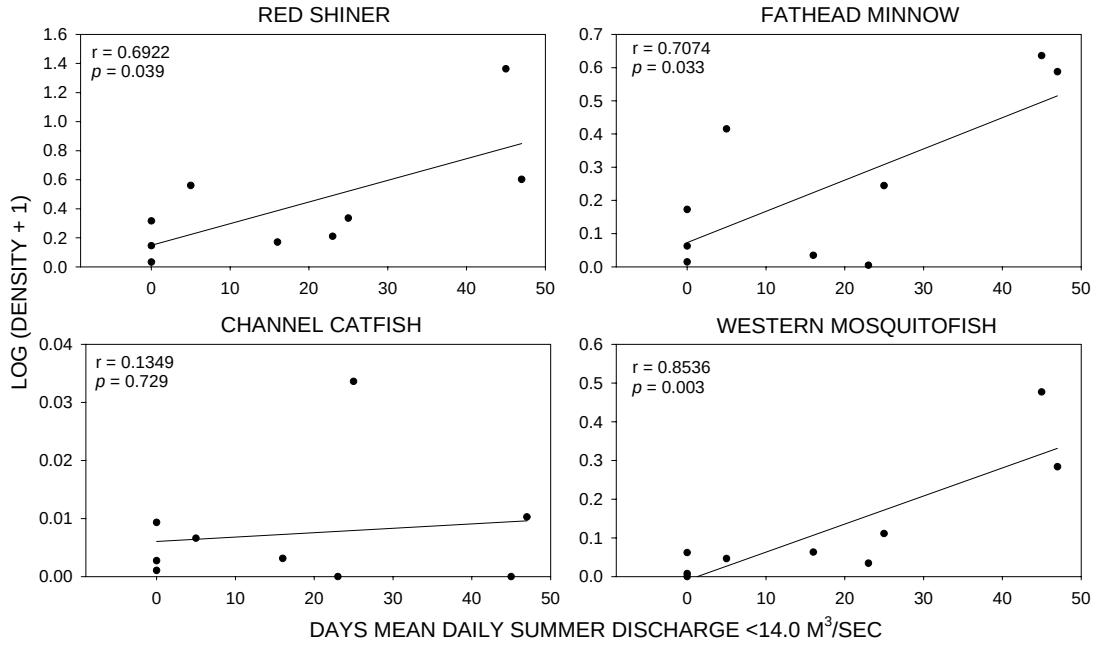

Figure 37. Number days summer mean daily discharge <14.0 m^3/sec versus nonnative fish species density in San Juan River Reach 5 secondary channels, 1993 - 2001.

Secondary Channels, Reach 4

Ten nonnative and five native fish species were collected in Reach 4 between 1993 and 2001 (Table 14). Red shiner was the most common species in all years. Speckled dace or fathead minnow were the second-most common species in all years, except 2000 when common carp was second-most common. The third-most common species varied; flannelmouth sucker held this rank in 1993, speckled dace in 1994 and 2001, fathead minnow in 1995, western mosquitofish in 1996 and 2000, and channel catfish in 1997, 1998, and 1999. Except for 1993, flannelmouth sucker and bluehead sucker were never more than sixth-most common. Colorado pikeminnow was found in 1997 and 2000 and roundtail chub was collected in 1997, 1998, and 1999. With the exception of 2000, common carp was uncommon or absent in Reach 4 secondary channels. Other nonnative species (e.g., plains killifish, green sunfish, largemouth bass, and black bullhead) were rare, if present, and often not collected. In the low spring runoff years of 1996 and 2000, nonnative species were the three and four, respectively, most common species.

From 1993 through 1996, total fish density varied between 2.4 and 3.4 fishes/m^2, but in 1997 dropped to 0.4 fish/m^2 and remained low through 1999 (Figure 38). Total density increased in 2000 to its highest level, but declined to a level similar to that of 1993 through 1996 in 2001. Assemblage diversity was >1.0000 from 1993 through 1999, but only 0.5000 in 2000. Diversity increased in 2001, but was less than during 1993 through 1999. Nonnative fish density exceeded 2.00 fish/m^2 in all years, except 1995,

Table 14. Number and density of fishes and assemblage diversity in San Juan River secondary channels, Geomorphic Reach 4, during autumn inventories, 1993 – 2001.

1993		1994		1995		1996		1997		1998		1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	1084	CYPLUT	1459	CYPLUT	1340	CYPLUT	1046	CYPLUT	203	CYPLUT	250	CYPLUT	35	CYPLUT	2887	CYPLUT	708
RHIOSC	472	PIMPRO	657	RHIOSC	479	PIMPRO	473	RHIOSC	114	RHIOSC	119	RHIOSC	24	CYPCAR	135	PIMPRO	131
CATLAT	68	RHIOSC	164	PIMPRO	220	GAMAFF	188	ICTPUN	20	ICTPUN	71	ICTPUN	3	GAMAFF	78	RHIOSC	43
CATDIS	54	GAMAFF	145	GAMAFF	66	RHIOSC	37	PIMPRO	14	PIMPRO	65	PIMPRO	2	PIMPRO	75	GAMAFF	38
PIMPRO	45	ICTPUN	50	ICTPUN	34	ICTPUN	25	PTYLUC	9	GAMAFF	7	GILROB	1	RHIOSC	31	FUNZEB	16
ICTPUN	24	CATLAT	20	CATLAT	15	CATLAT	4	CATLAT	7	GILROB	2	CATDIS	1	MICSAL	11	ICTPUN	3
FUNZEB	7	FUNZEB	9	CATDIS	6	FUNZEB	3	CATDIS	6	CYPCAR	1			CATLAT	9	CATLAT	2
GAMAFF	1	CATDIS	4	CYPCAR	1	LEPCYA	1	GILROB	5	CATLAT	1			PTYLUC	3	CATDIS	1
		CYPCAR	4	FUNZEB	1	MICSAL	1	CYPCAR	1	FUNZEB	1			CATDIS	2	AMENAT	1
		AMEMEL	1					GAMAFF	1					ICTPUN	2		
		LEPCYA	1											FUNZEB	1		
		MICSAL	1														
TOT N	1755		2515		2162		1778		380		517		66		3234		943
AREA	464		744		888		560		960		664		418		544		323
DENSITY	3.782		3.380		2.435		3.175		0.396		0.778		0.156		5.945		2.920
H	1.062		1.176		1.093		1.075		1.272		1.339		1.078		0.509		0.875

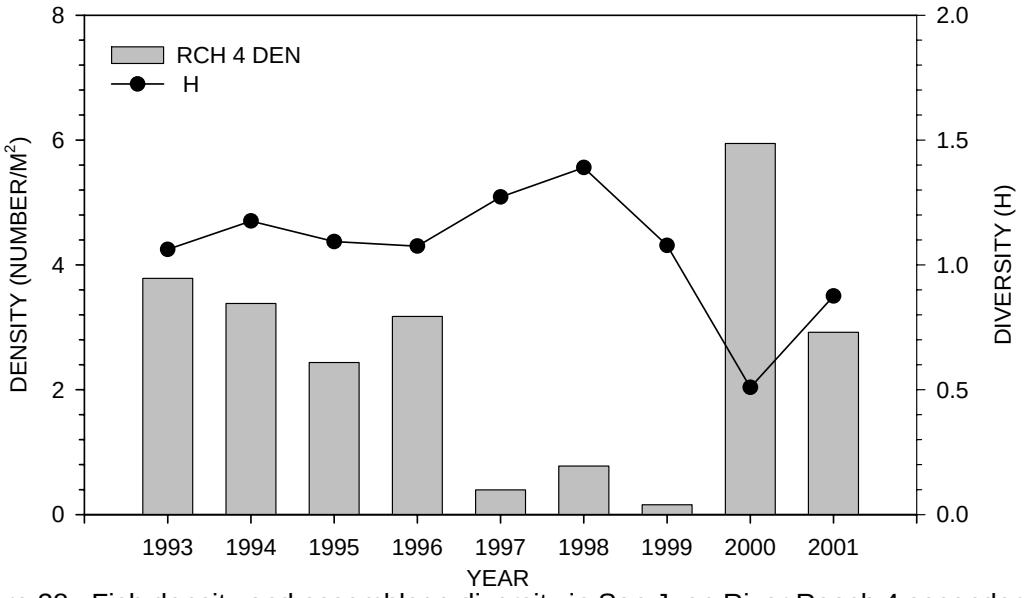

Figure 38. Fish density and assemblage diversity in San Juan River Reach 4 secondary channels, 1993 - 2001.

1997, and 1999. Native fish density was greatest in 1993 and 1995, years of high spring mean daily discharge. Speckled dace density was comparatively high in 1993 and 1995 (>0.80 fish/m^2), but was <0.20 fish/m^2 in all other years (Figure 39). Flannelmouth sucker density declined from its high in 1993 through 1999, when it was not collected in Reach 4 secondary channels. It was collected in 2000 and 2001 at densities comparable to those of 1995 through 1997. Bluehead sucker density was greatest (0.11 fish/m^2) in 1993, and it was rare (<0.01 fish/m^2) or absent in all other years. Red shiner density was similar (1.8 to 2.2 fish/m^2) from 1993 through 1996, declined to <0.4 fish/m^2 from 1997 through 1999, and increased to >6.0 fish/m^2 in 2000 (Figure 40). Its 2001 density was similar to that found in 1993 through 1996. Fathead minnow density peaked in 1994 and 1996, and was lowest in 1999. From 1993 through 1998, channel catfish density varied from about 0.025 to 0.10 fish/m^2, but was <0.01 fish/m^2 thereafter. Western

mosquitofish density was quite variable, ranging from 0.0 fish/m^2 in 1999 to about 0.32 fish/m^2 in 1996.

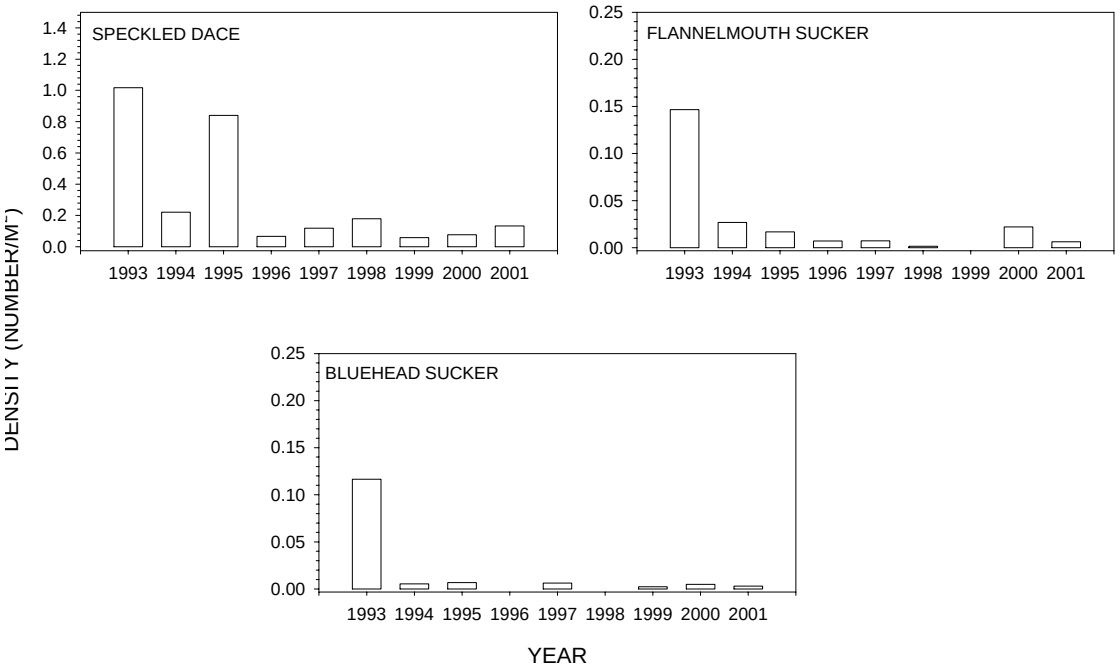

Figure 39. Density of native fish species in San Juan River Reach 4 secondary channels, 1993 - 2001.

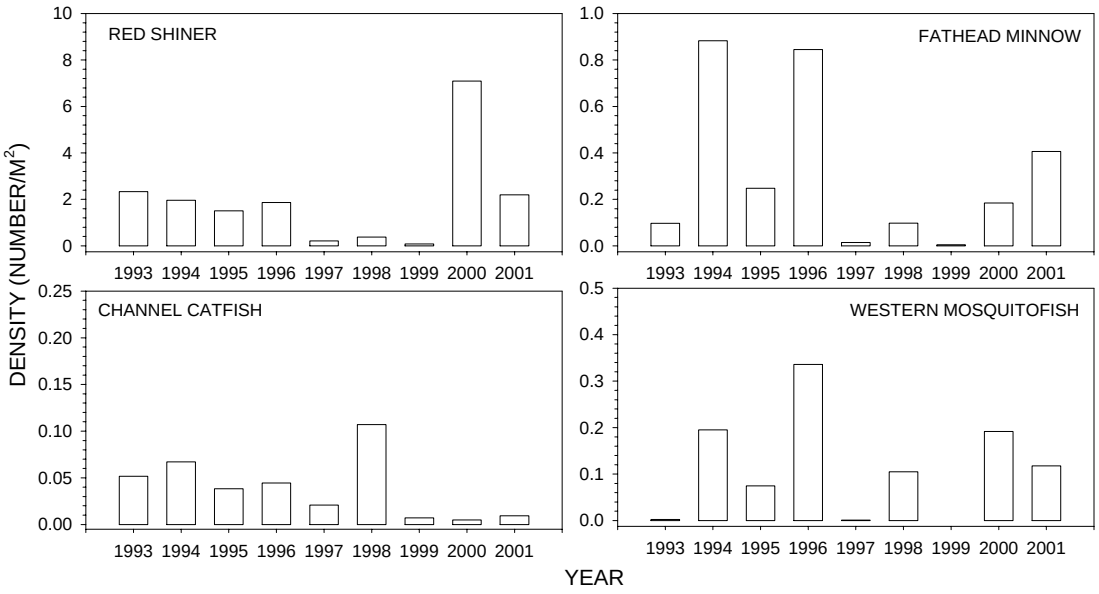

Figure 40. Density of nonnative fish species in San Juan River Reach 4 secondary channels, 1993 - 2001.

Density of native fishes was positively related to spring mean daily discharge in Reach 4, but that of nonnatives was not (Figure 41). Individually, only speckled dace density was related to spring discharge (Figure 42). There was no relationship between spring discharge and any commonly collected nonnative species (Figure 43). Mean daily summer discharge was not related to autumn density of native fishes, but that of nonnatives was negatively related (Figure 44). There was no relationship between summer discharge and autumn density of any native species (Figure 45), but that of nonnative red shiner was negatively related (Figure 46). Native fish density in Reach 4 was not related to number days summer mean daily discharge <14 m^3/sec, but that of nonnatives was (Figure 47). No individual native species autumn density was related to days discharge <14 m^3/sec (Figure 48), but that of nonnative red shiner and western mosquitofish was (Figure 49).

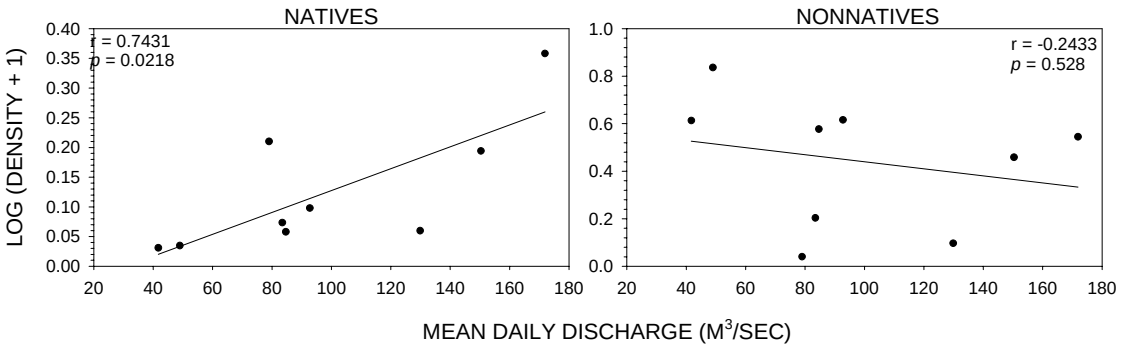

Figure 41. Mean daily spring discharge versus autumn density of native and nonnative fish species in San Juan River Reach 4 secondary channels, 1993 - 2001.

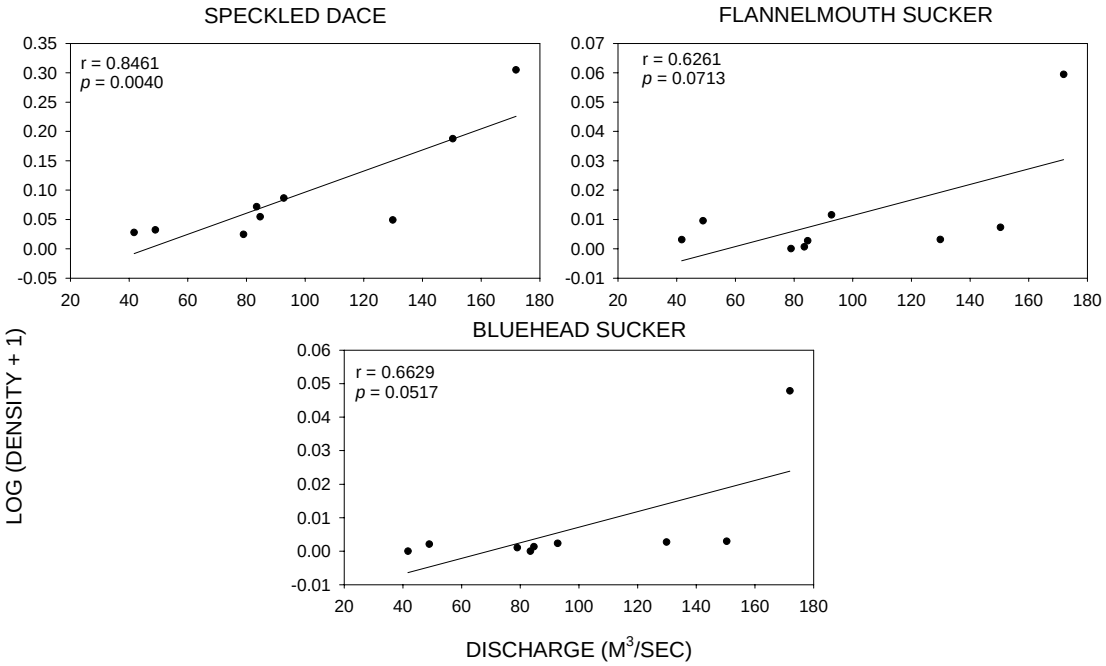

Figure 42. Mean daily spring discharge versus autumn density of native fish species in San Juan River Reach 4 secondary channels, 1993 - 2001.

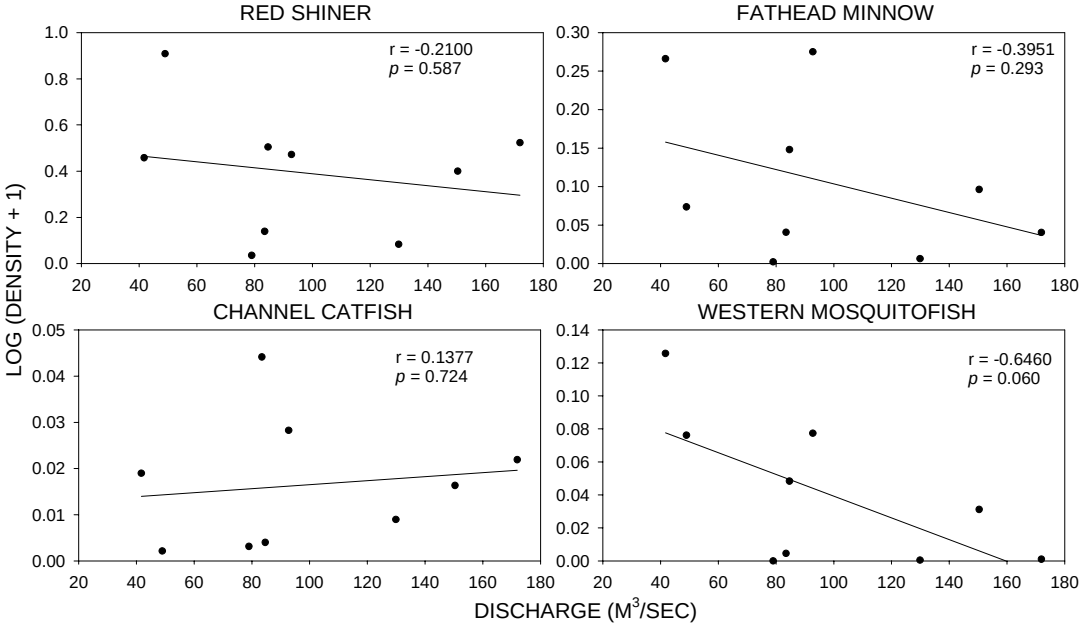

Figure 43. Mean daily spring discharge versus autumn density of nonnative fish species in San Juan River Reach 4 secondary channels, 1993 - 2001.

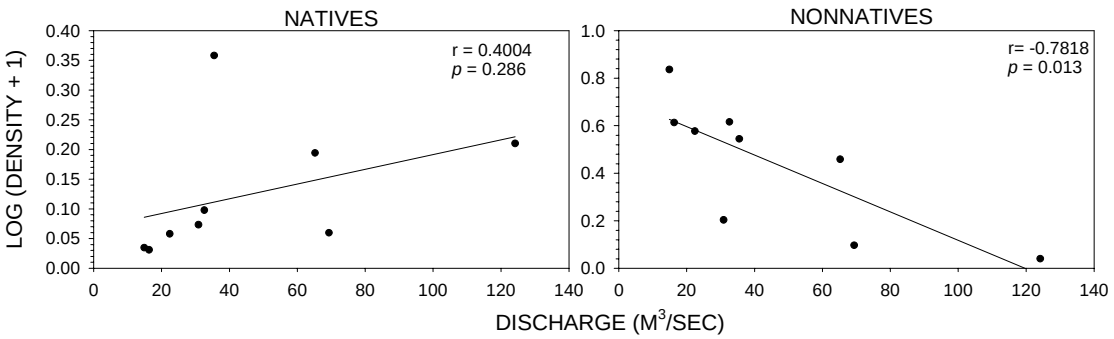

Figure 44. Mean daily summer discharge versus native and nonnative fish densities in San Juan River Reach 4 secondary channels, 1993 - 2001.

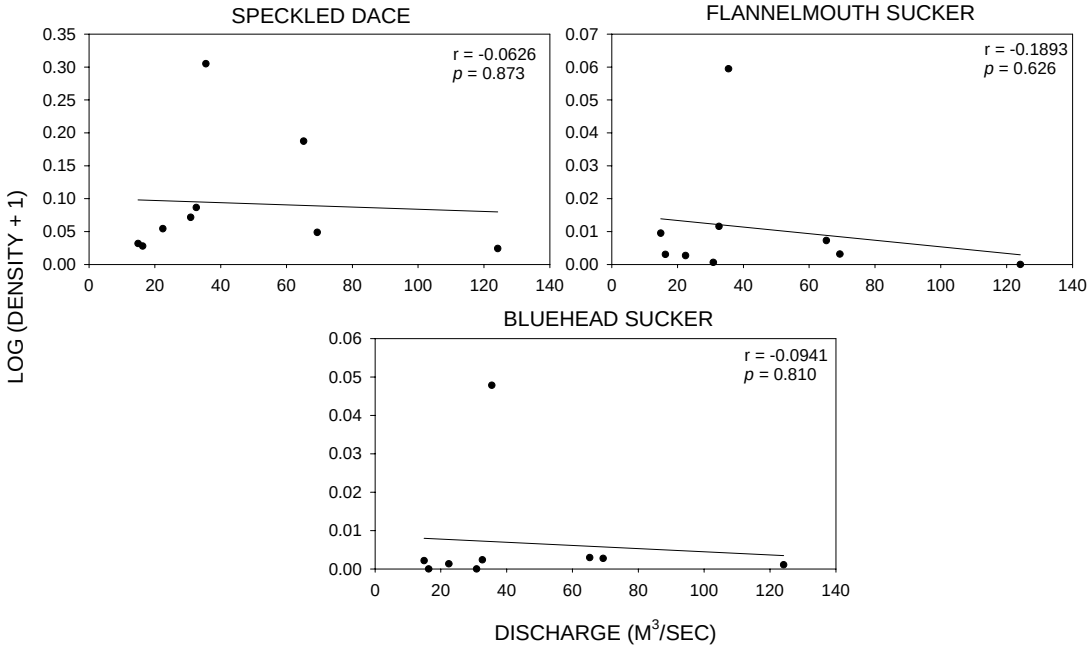

Figure 45. Mean daily summer discharge versus native fish species densities in San Juan River Reach 4 secondary channels, 1993 - 2001.

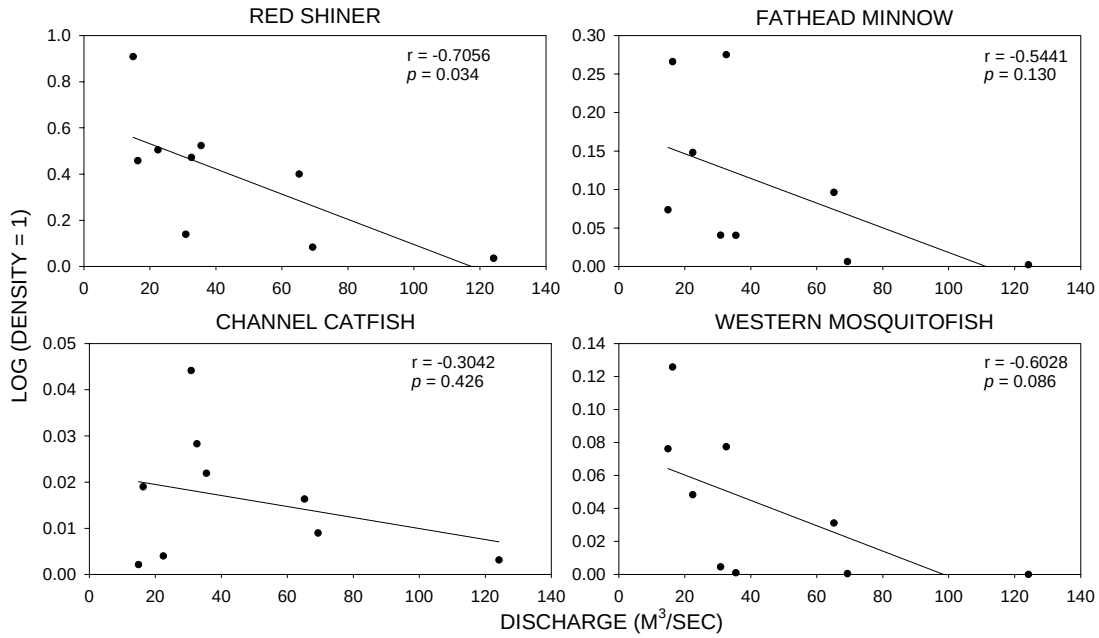

Figure 46. Mean daily summer discharge versus nonnative fish species autumn density in San Juan River Reach 4 secondary channels, 1993 - 2001.

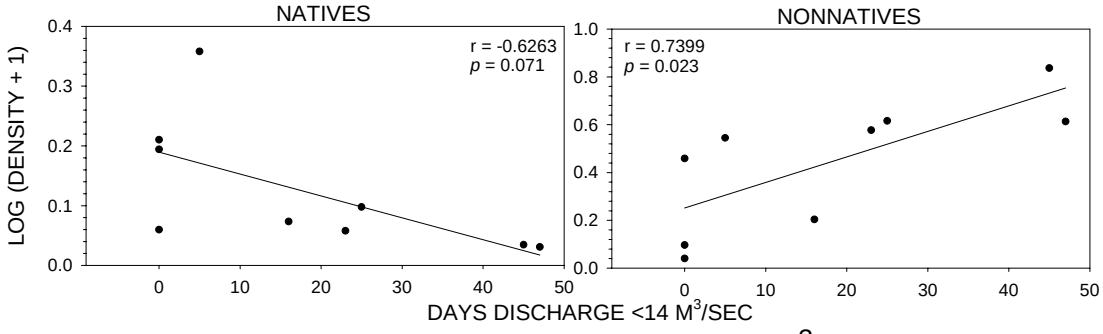

Figure 47. Number days mean daily summer discharge <14.0 m^3/sec versus autumn density of native and nonnative fishes in San Juan River Reach 4 secondary channels, 1993 - 2001.

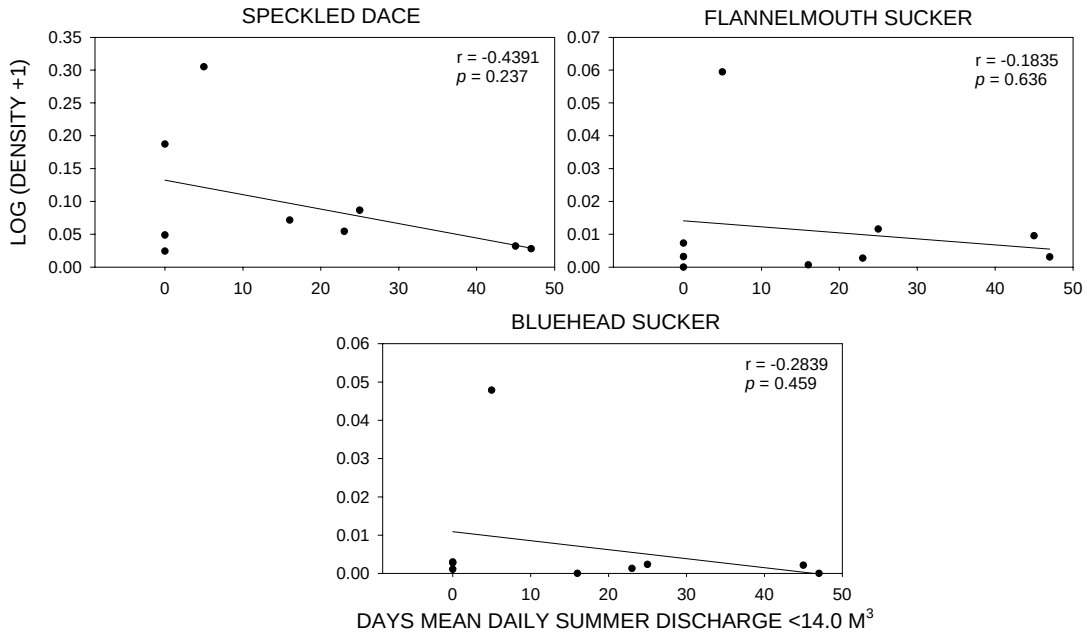

Figure 48. Number days mean daily summer discharge <14.0 m^3/sec versus native fish densities in San Juan River Reach 4 secondary channels, 1993 - 2001.

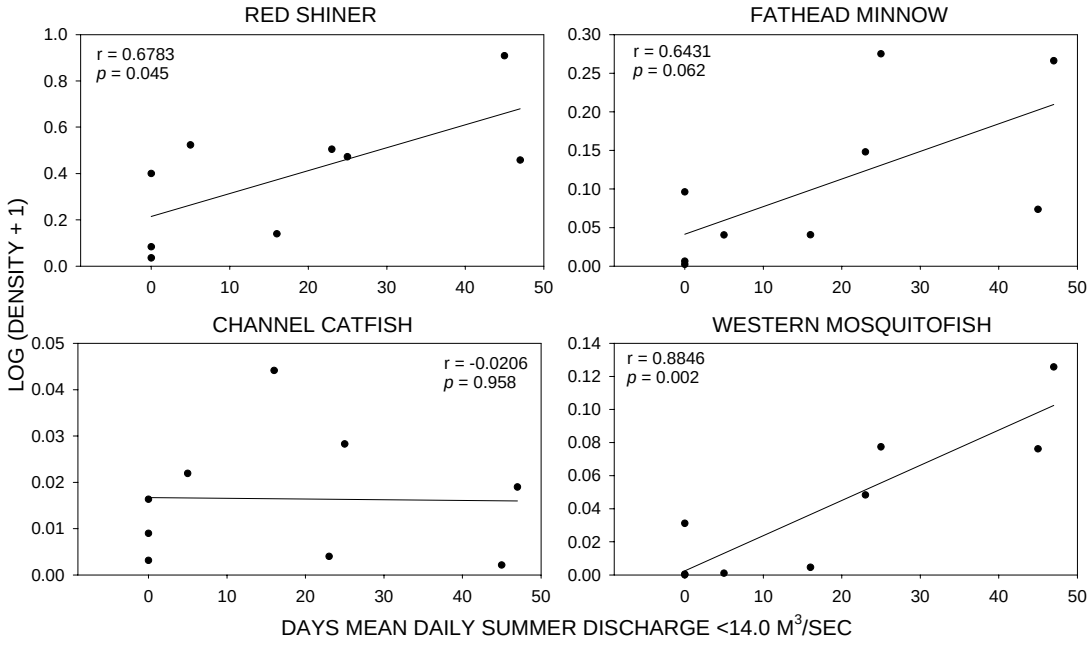

Figure 49. Number days mean daily summer discharge <14.0 m^3/sec versus nonnative fish species density in San Juan River Reach 4 secondary channels, 1993 - 2001.

Secondary Channels, Reach 3

Nine nonnative and five native fish species were collected in Reach 3 secondary channels from 1993 through 2001 (Table 15). Red shiner was the most abundant in all years, except 1998 when speckled dace was most common. Speckled dace and fathead minnow were usually the second- or third-most common species. Native sucker species were typically represented by $\leq$25 individuals, but 122 specimens of flannelmouth sucker were collected in 1994. Colorado pikeminnow and roundtail chub were collected in 1997. Most nonnative species (e.g., common carp, plains killifish, and black bullhead) were represented by $\leq$10 specimens, if present.

Density of fishes (8.7 fish/m^2) was highest in 1995, followed by 1994 (5.6 fish/m^2) and 2000 (5.2 fish/m^2) (Figure 50). Lowest densities were in 1997 (0.8 fish/m^2) and 1999 (0.7 fish/m^2). Native fish density was $\geq$0.40 fish/m^2 from 1993 through 1995 and in 1998, but was never $\geq$0.20 fish/m^2 in other years. Nonnative fish density was highest (8.28 fish/m^2) in 1995, followed by 1994 (5.10 fish/m^2) and 2000 (5.08 fish/m^2). Except for increases in 1997 and 1998, assemblage diversity generally declined from 1993 through 2001. Speckled dace density was $\geq$0.35 fish/m^2 in 1993 through 1995 and in 1998, flannelmouth sucker density was greatest (about 0.15 fish/m^2) in 1993 and 1994, and that of bluehead sucker was highest (0.012 to 0.018 fish/m^2) in 1995 and 1996 (Figure 51). Bluehead sucker was the only commonly collected native species not found in Reach 3 secondary channels in all years. Red shiner density was comparatively high (>3.00 fish/m^2) in 1994, 1995, and 2000 (Figure 52). Fathead minnow density exceeded 3.00 fish/m^2 only in 1995. Peak channel catfish density (0.33 fish/m^2) was in 1993.

Table 15. Number and density of fishes collected and assemblage diversity in San Juan River secondary channels, Geomorphic Reach 3, during autumn inventories, 1993 – 2001.

1993		1994		1995		1996		1997		1998		1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	315	CYPLUT	2872	CYPLUT	2444	CYPLUT	960	CYPLUT	527	RHIOSC	372	CYPLUT	205	CYPLUT	4500	CYPLUT	901
RHIOSC	73	PIMPRO	844	PIMPRO	2041	PIMPRO	169	RHIOSC	151	CYPLUT	224	RHIOSC	32	GAMAFF	301	RHIOSC	95
ICTPUN	67	RHIOSC	262	RHIOSC	203	RHIOSC	27	PIMPRO	47	ICTPUN	63	PIMPRO	4	RHIOSC	53	PIMPRO	39
CATLAT	31	GAMAFF	230	ICTPUN	26	GAMAFF	27	ICTPUN	23	PIMPRO	51	GAMAFF	3	PIMPRO	40	ICTPUN	15
PIMPRO	27	CATLAT	122	GAMAFF	20	CATLAT	21	PTYLUC	13	GAMAFF	19	CATLAT	2	CATLAT	26	GAMAFF	14
CYPCAR	4	ICTPUN	80	FUNZEB	17	ICTPUN	19	CATLAT	10	CATLAT	5	CATDIS	1	ICTPUN	25	CATLAT	10
FUNZEB	2	FUNZEB	8	CATDIS	10	CATDIS	7	GILROB	4	FUNZEB	2			CYPCAR	19	AMEMEL	2
		CATDIS	6	CATLAT	7	FUNZEB	5	CATDIS	2	AMENAT	1			CATDIS	7	CATDIS	1
		CYPCAR	2	CYPCAR	4			CYPCAR	1					FUNZEB	3		
		AMEMEL	2	AMEMEL	1			FUNZEB	1								
				LEPCYA	1			GAMAFF	1								
TOT N	519		4428		4774		1235		780		737		247		4974		1077
AREA	200		792		550		568		983		681		373		963		669
DENSITY	2.595		5.591		8.680		2.174		0.794		1.082		0.662		5.165		1.610
H	1.224		1.117		0.943		0.820		1.048		1.255		0.601		0.437		0.661

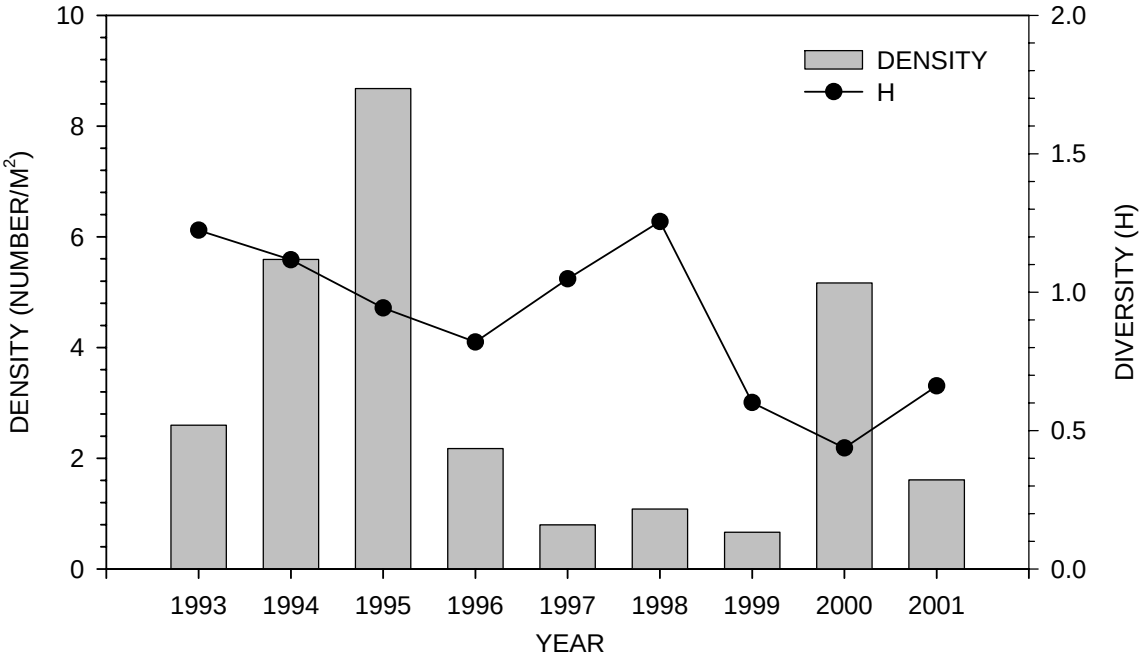

Figure 50. Fish density and assemblage diversity in San Juan River Reach 3 secondary channels, 1993 - 2001.

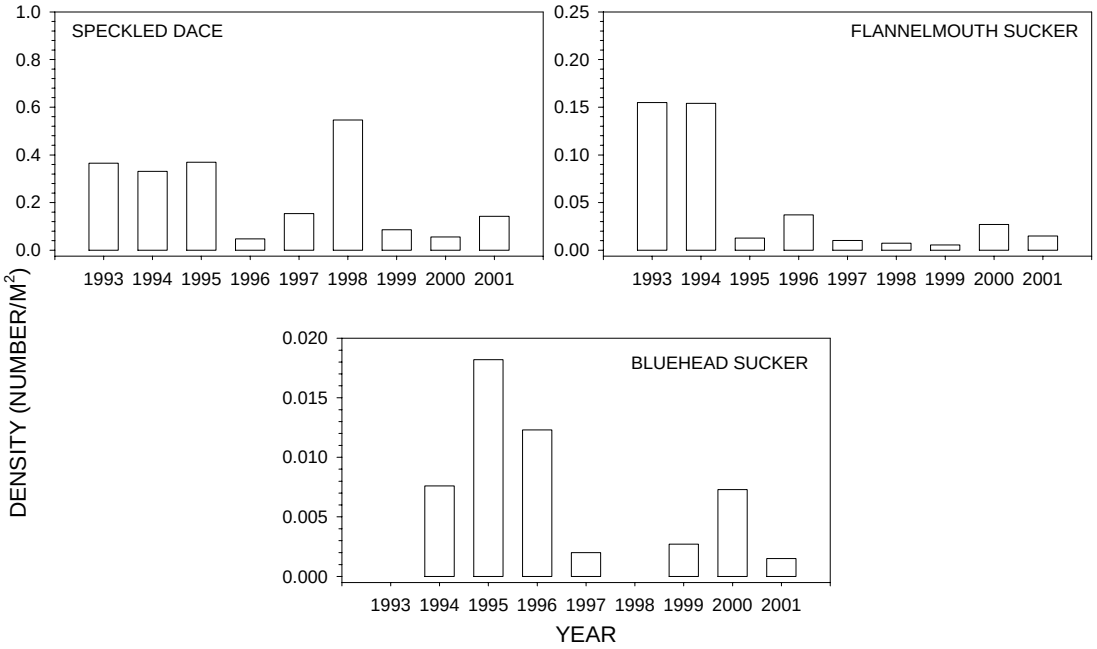

Figure 51. Native fish species density in San Juan River Reach 3 secondary channels, 1993 - 2001.

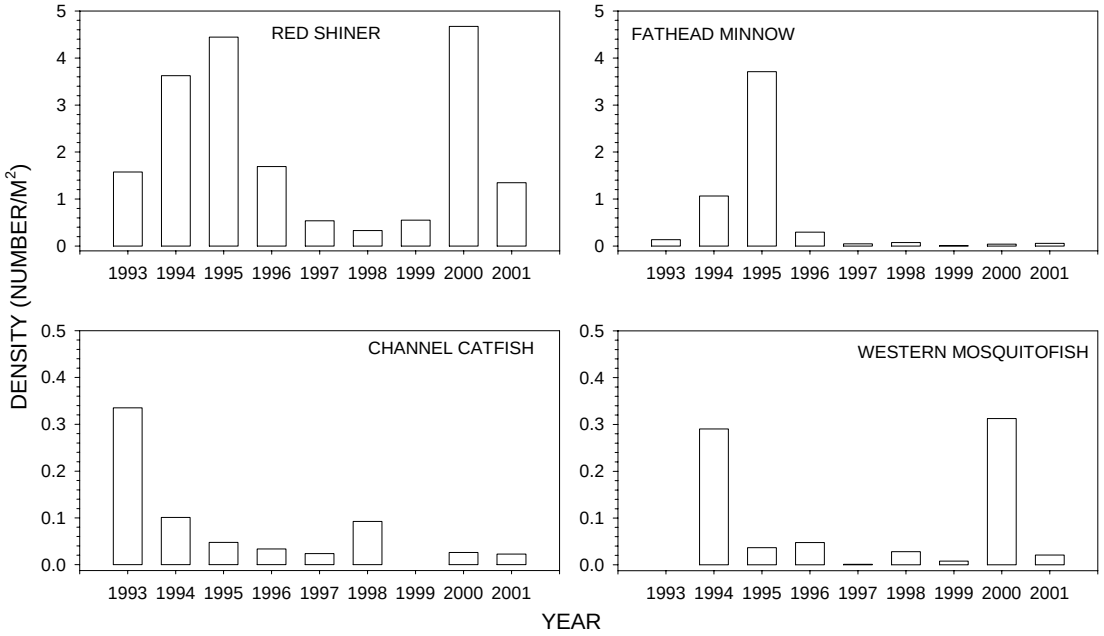

Figure 52. Nonnative fish species density in San Juan River Reach 3 secondary channels, 1993 - 2001.

Western mosquitofish density was comparatively high in 1994 (0.28 fish/m^2) and 2000 (0.30 fish/m^2). Red shiner and fathead minnow were collected in all years, but channel catfish was not in 1999 and western mosquitofish was absent in 1993.

There was no relationship between spring mean daily discharge and native or nonnative autumn density (Figure 53). Nor was there a relationship between individual native (Figure 54) or nonnative (Figure 55) species densities and spring discharge. As with spring discharge, there was no relationship between summer mean daily discharge and native or nonnative fishes autumn densities (Figure 56) and none with individual species (Figures 57 and 58). Neither native nor nonnative fish densities were related to days summer mean daily discharge <14 m^3/sec (Figure 59). Nor was density of

individual native (Figure 60) and nonnative (Figure 61) species related to days discharge <14 m^3/sec.

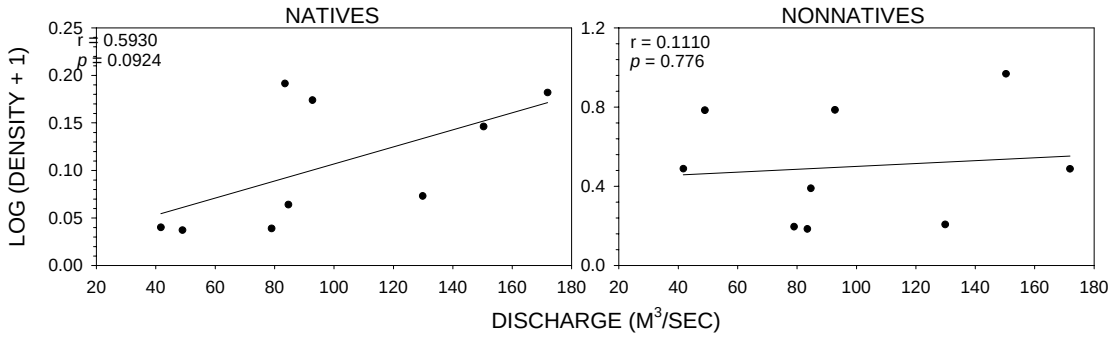

Figure 53. Mean daily spring discharge versus native and nonnative fishes density in San Juan River Reach 3 secondary channels, 1993 - 2001.

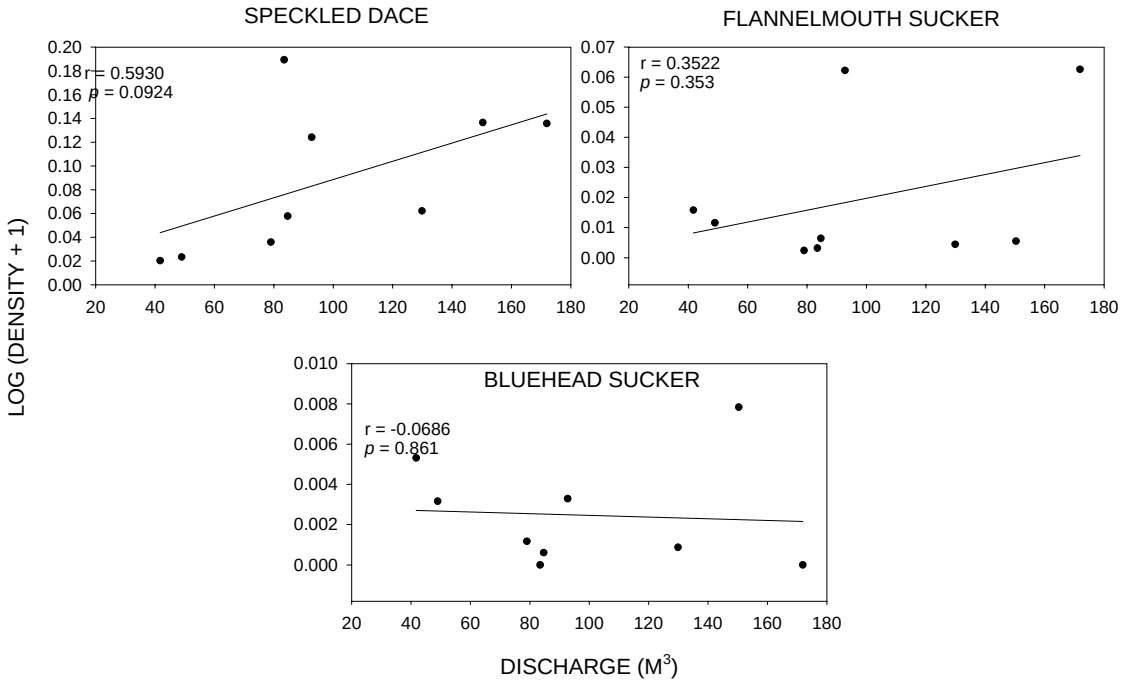

Figure 54. Mean daily spring discharge versus autumn density of native fish species in San Juan River Reach 3 secondary channels, 1993 - 2001.

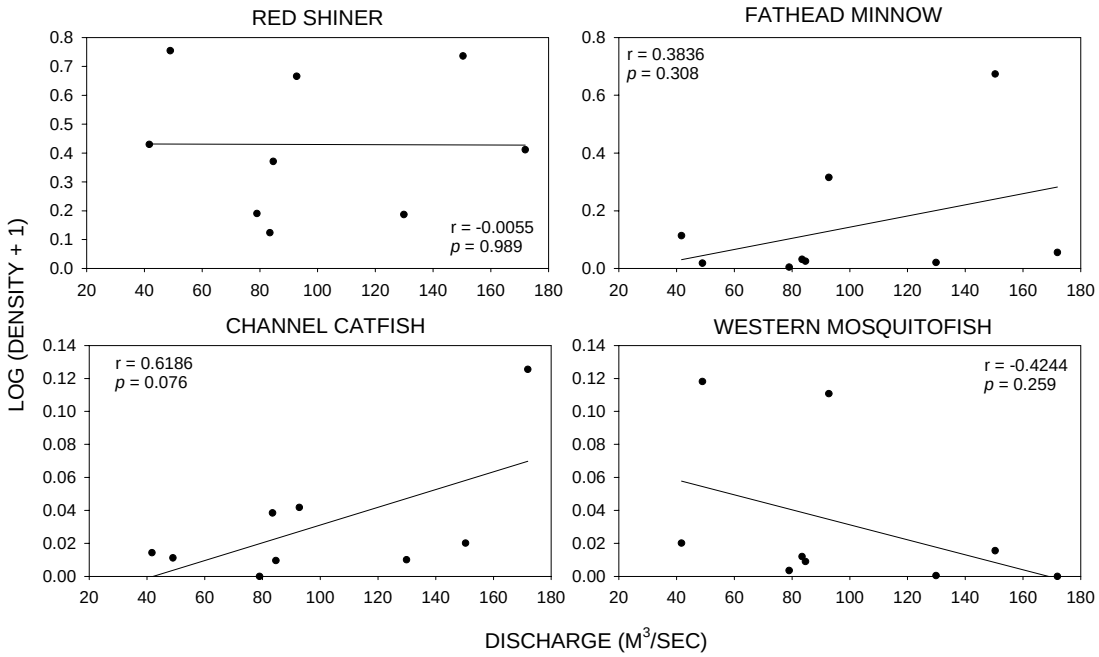

Figure 55. Mean daily spring discharge versus nonnative fish species autumn density in San Juan River Reach 3 secondary channels, 1993 - 2001.

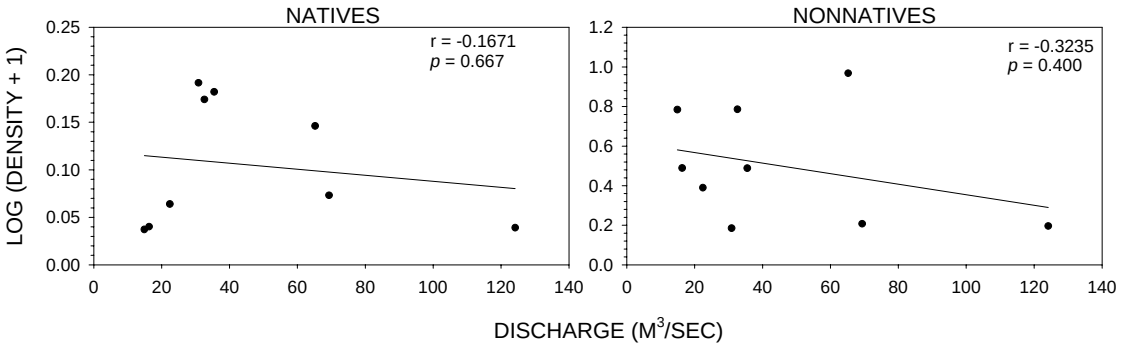

Figure 56. Mean daily summer discharge versus native and nonnative fish densities in San Juan River Reach 3 secondary channels, 1993 - 2001.

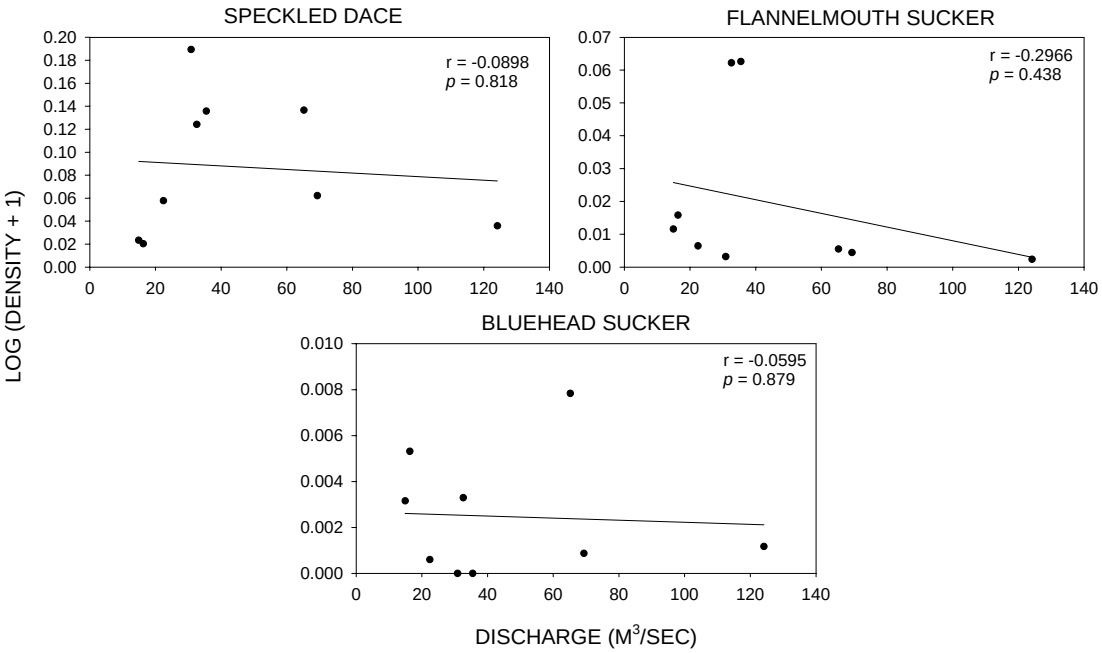

Figure 57. Mean daily summer discharge versus native fish species density in San Juan River Reach 3 secondary channels, 1993 - 2001.

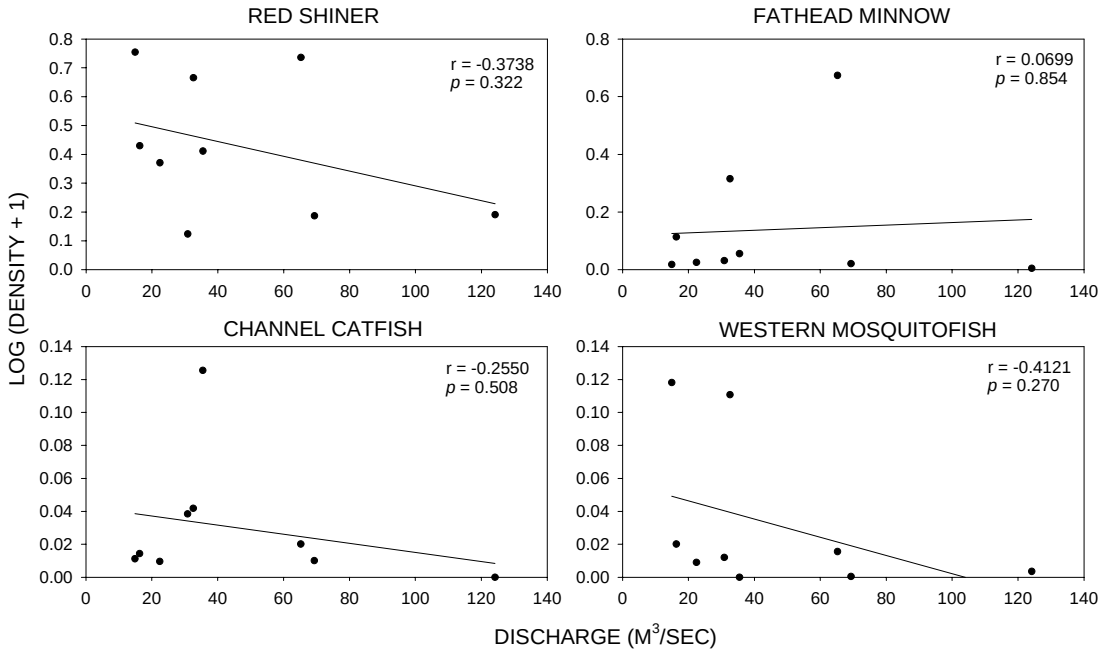

Figure 58. Mean daily summer discharge versus nonnative fish species autumn density in San Juan River Reach 3 secondary channels, 1993 - 2001.

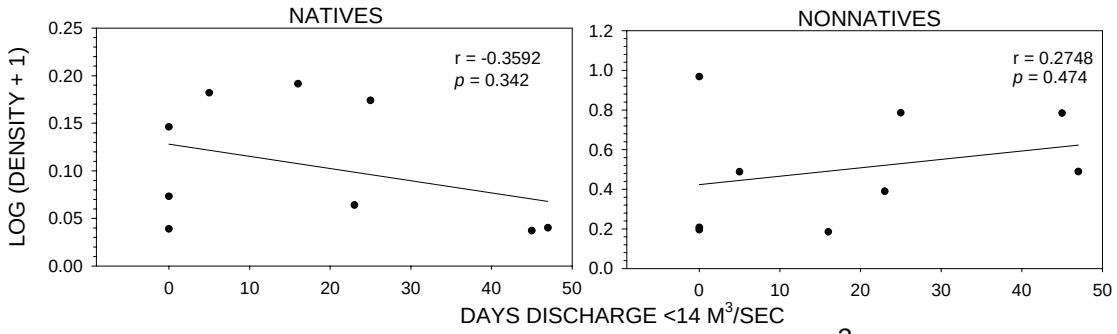

Figure 59. Number days mean daily summer discharge <14.0 m^3/sec versus autumn density of native and nonnative fishes in San Juan River Reach 3 secondary channels, 1993 - 2001.

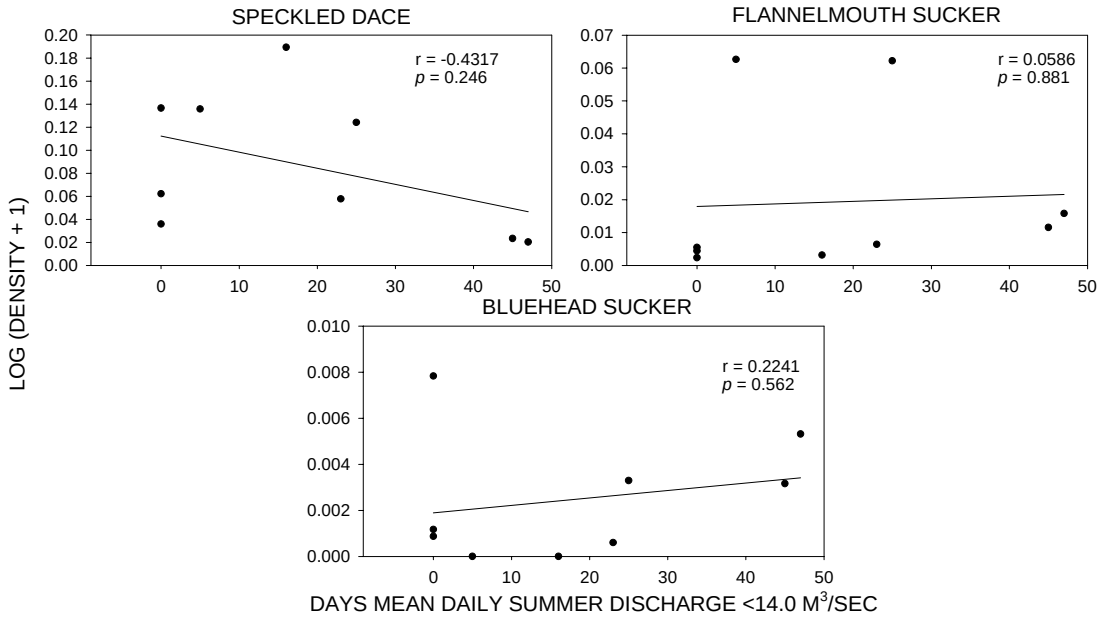

Figure 60. Number days mean daily summer discharge <14.0 m^3/sec versus autumn density of native fish species density in San Juan River Reach 3 secondary channels, 1993 - 2001.

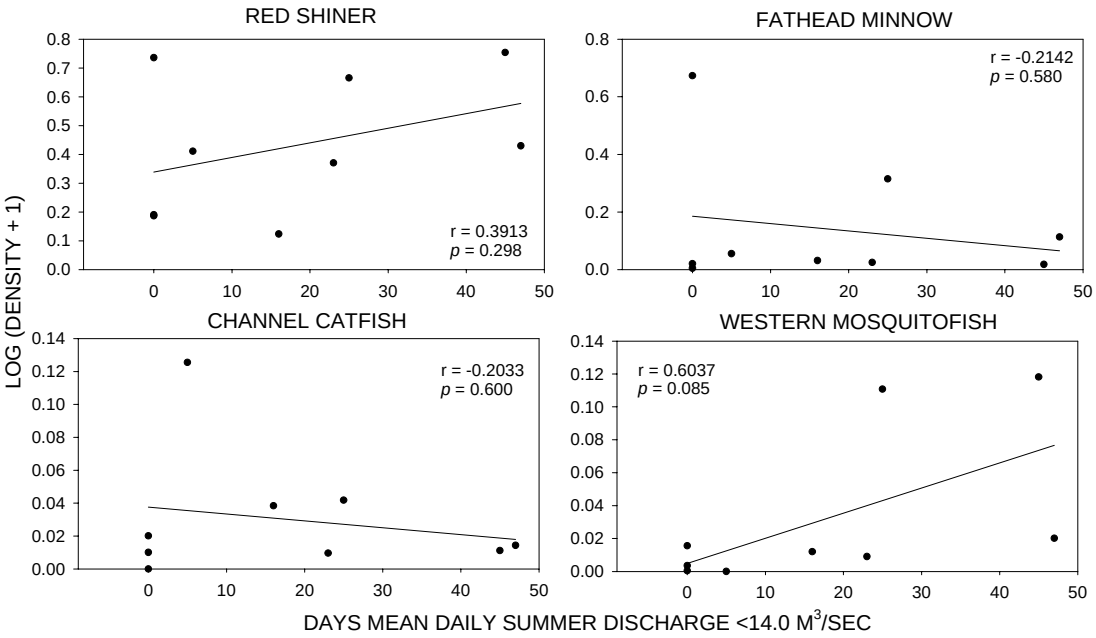

Figure 61. Number days mean daily summer discharge <14.0 m^3/sec versus autumn nonnative fish species density in San Juan River Reach 3 secondary channels, 1993 - 2001.

PRIMARY AND SECONDARY CHANNEL COMPARISONS

There were no differences in primary and secondary channel densities of any nonnative or native species in Reaches 5, 4, and 3 between 1998 and 2001 (Figures 62 through 67). Generally, if density of a species in a reach in a particular year was low (or high) in the primary channel, its density was also low (or high) in secondary channels within the same reach.

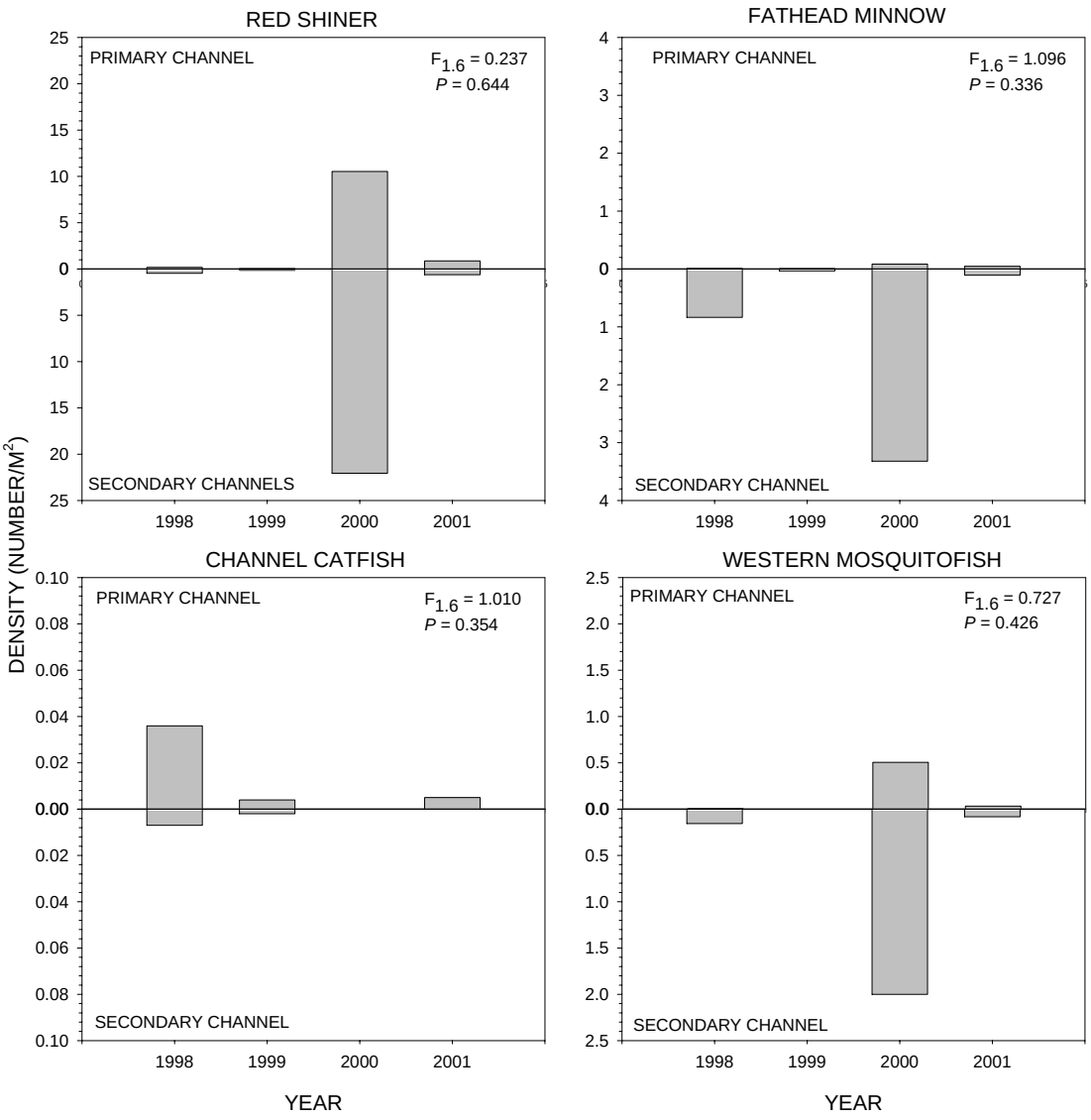

Figure 62. Nonnative fish species autumn densities in San Juan River Reach 5 primary and secondary channels, 1998 - 2001.

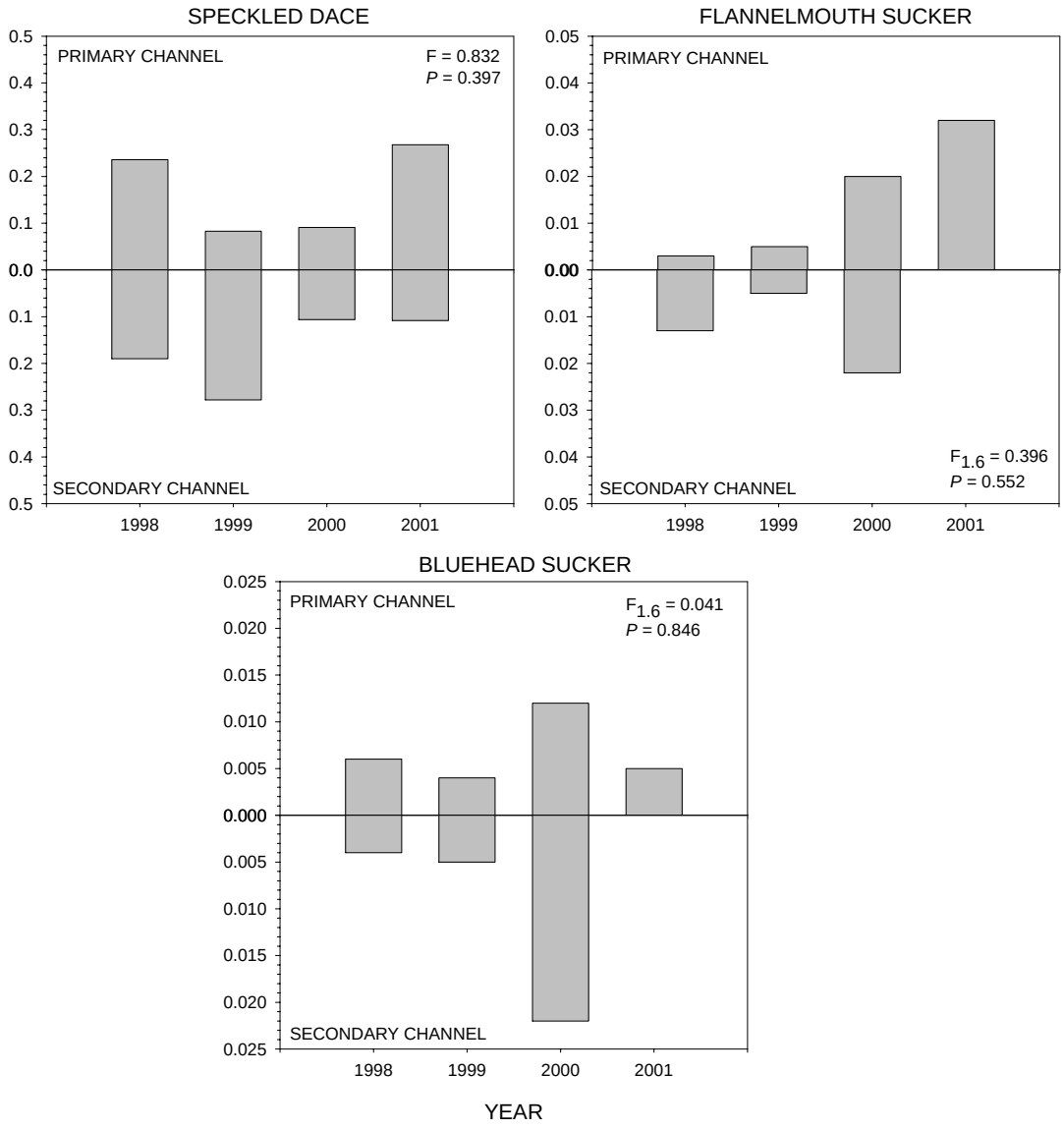

Figure 63. Native fish species autumn densities in San Juan River Reach 5 primary and secondary channels, 1998 - 2001.

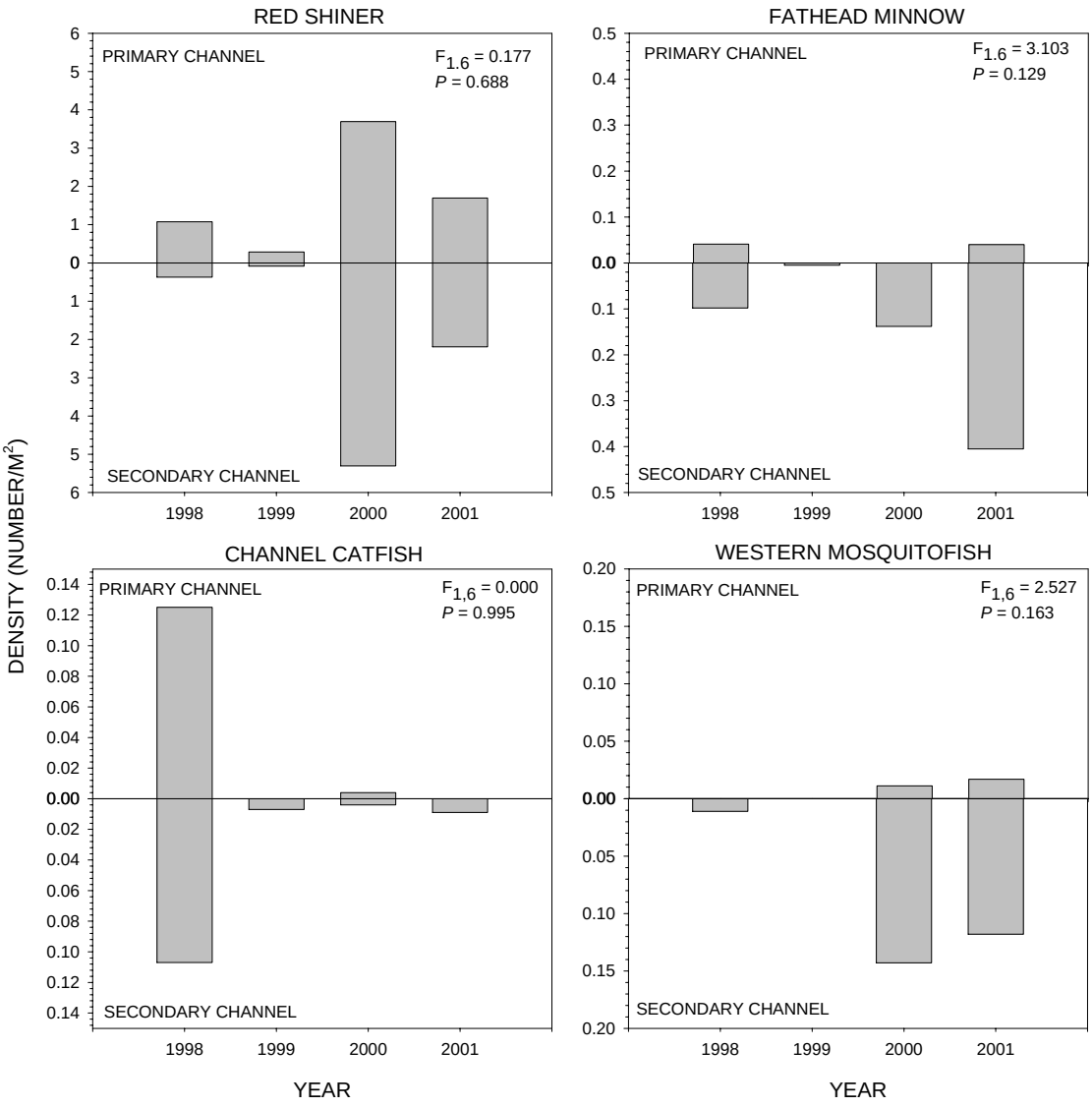

Figure 64. Nonnative fish species densities in San Juan River Reach 4 primary and secondary channels,1998 - 2001.

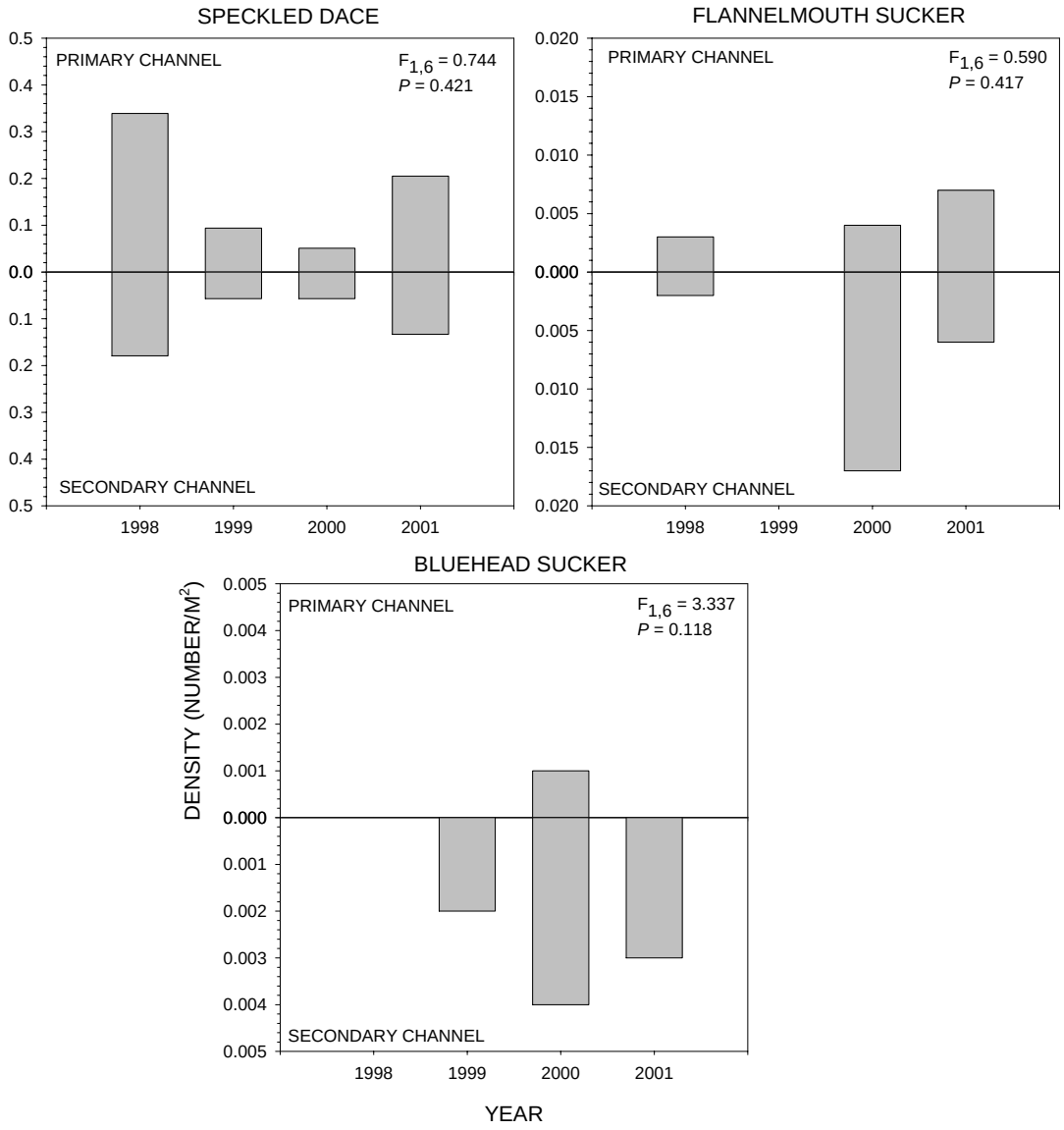

Figure 65. Native fish densities in San Juan River Reach 4 primary and secondary channel 1998 - 2001.

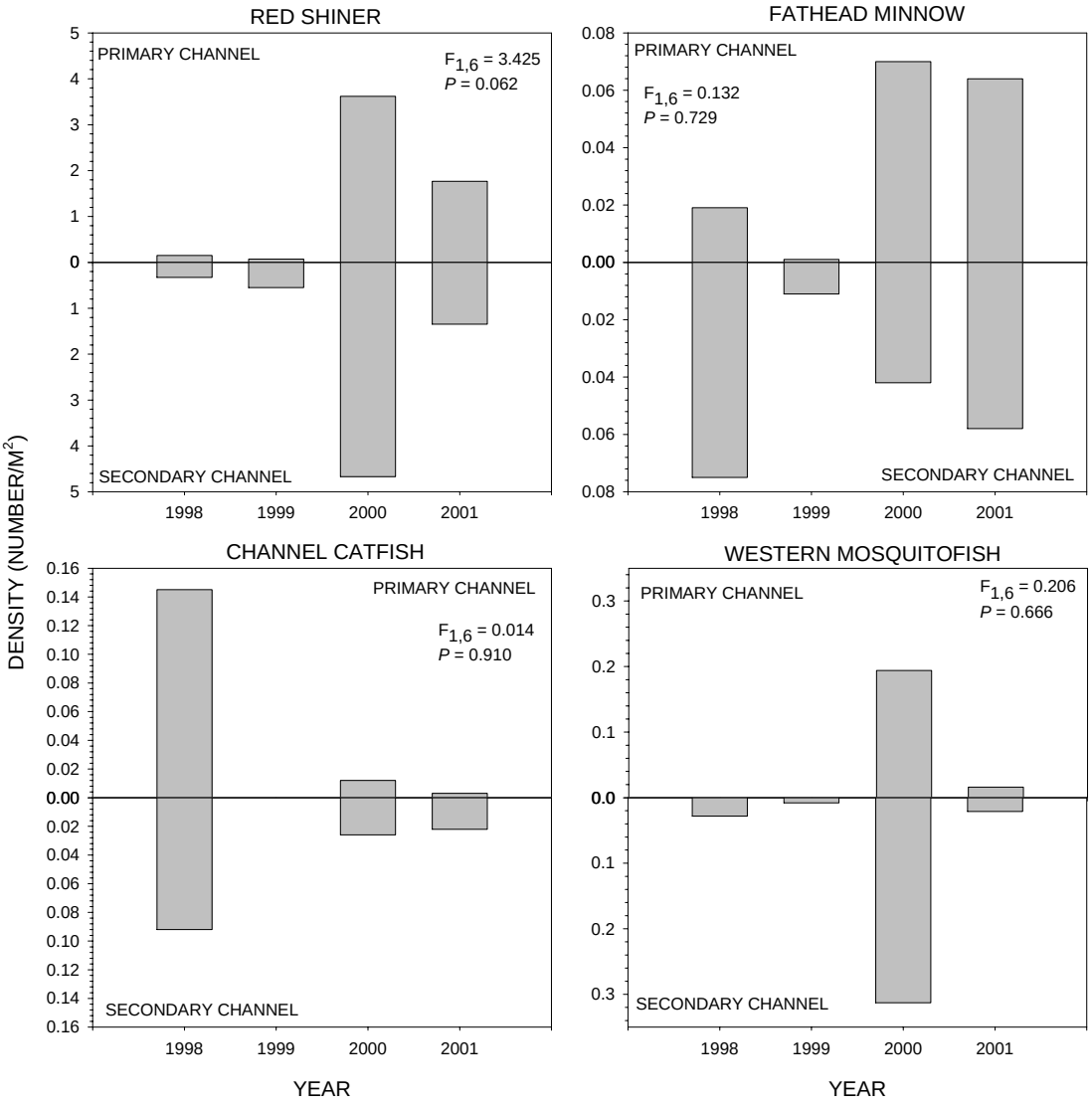

Figure 66. Nonnative fish species densities in San Juan River Reach 3 primary and secondary channels, 1998 - 2001.

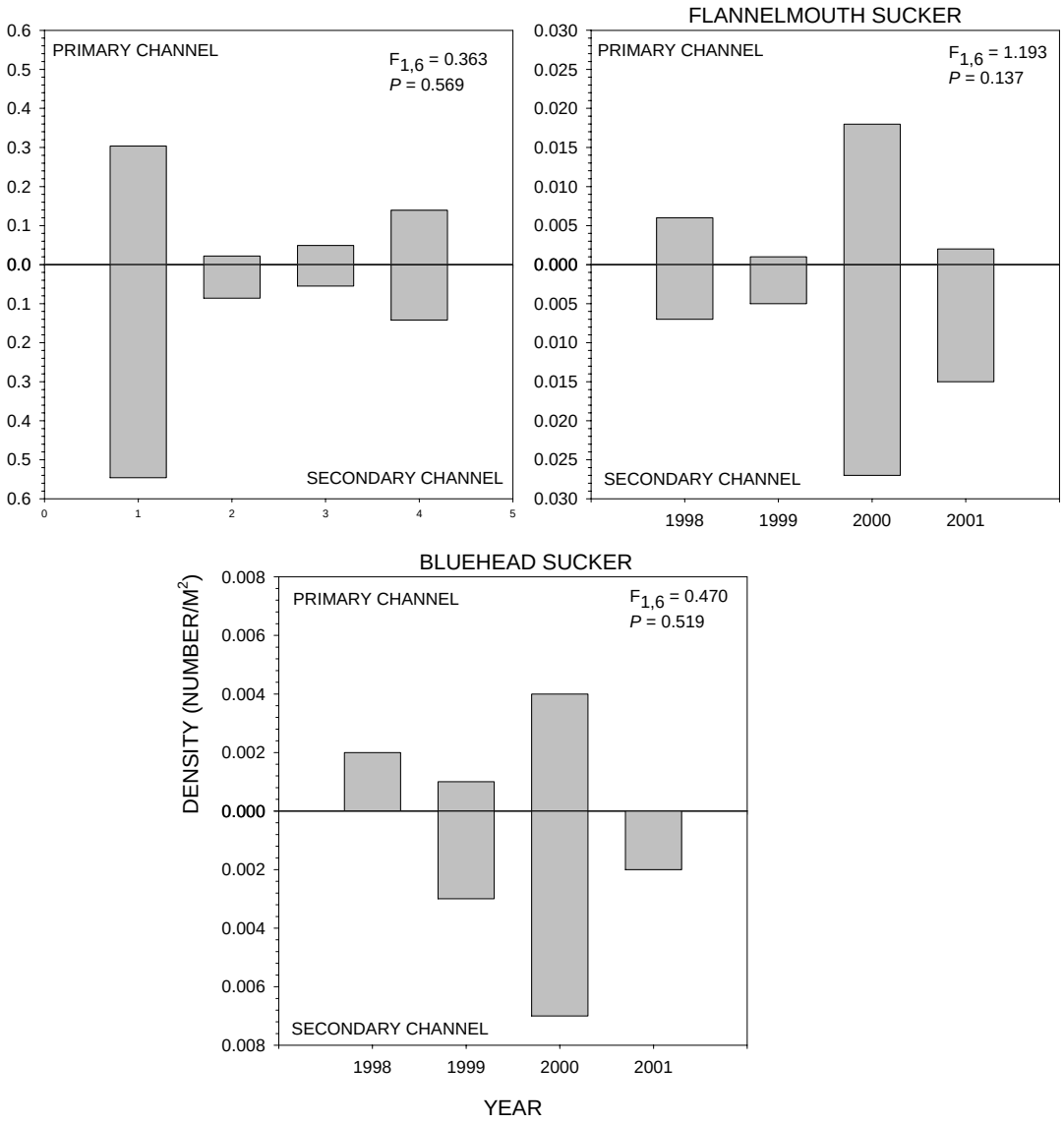

Figure 67. Native fish densities in San Juan River Reach 3 primary and secondary channels, 1998 - 2001.

BACKWATERS

Backwaters were not sampled as part of autumn monitoring in 1998. During autumn 1999 small-bodied fish monitoring, discharge was high (>1500 cfs) and few backwaters were present. Discharge during autumn monitoring in 2000 and 2001 was less than in 1999 and backwaters were comparatively common. Six backwaters were sampled in 1999, 39 in 2000, and 31 in 2001. Between 1999 and 2001, four native and 10 nonnative fish species were collected in San Juan River backwater habitats (Table 17). A Colorado pikeminnow was collected in 1999 (backwater formed by mouth of Chaco Wash in Reach 6) and another was found in a backwater in Reach 3 in 2000. Neither roundtail chub nor razorback sucker was found in a backwater during autumn monitoring.

Table 16. Occurrence of fishes in San Juan River backwaters, Reaches 6 through 1, 1999 – 2001. Nonnative = I and Native = N.

COMMON	SCIENTIFIC	CODE	STATUS	1999	2000	2001
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	
Fathead minnow	*Pimephales promelas*	PIMPRO	I	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X	
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N		X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		X	X
Black bullhead	*Ameiurus melas*	AMEMEL	I		X	
Channel catfish	*Ictalurus punctatus*	ICTPUN	I		X	X
Plains killifish	*Fundulus zebrinus*	FUNZEB	I		X	
Western mosquitofish	*Gambusia affinis*	GAMAFF	I		X	X
Green sunfish	*Lepomis cyanellus*	LEPCYA	I			X
Bluegill	*Lepomis macrochirus*	LEPMAC	I		X	
Largemouth bass	*Micropterus salmoides*	MICSAL	I		X	
TOTAL NATIVE			4	2	4	3
TOTAL NONNATIVE			10	2	9	5

Except for its density in Reach 6 in 2001, native fish density was less than 0.10 fish/m^2 in backwaters in all reaches in all years (Figure 68). Nonnative fish density was comparatively low (<2.5 fish/m^2) in 1999 and high (≈ 10.0/m^2, or greater) in all reaches, except Reach 6, in 2000 (Figure 69). Neither native nor nonnative fishes had a longitudinal density pattern.

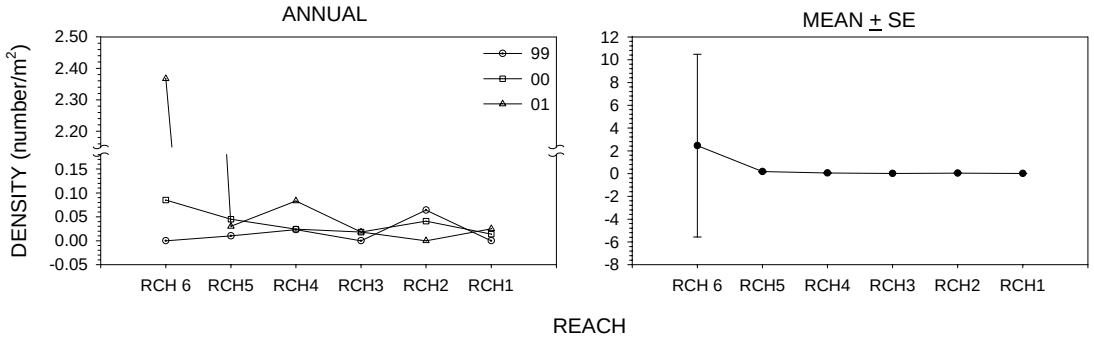

Figure 68. Native fish density in San Juan River backwaters, Reaches 6 through 1, *1999 - 2001.*

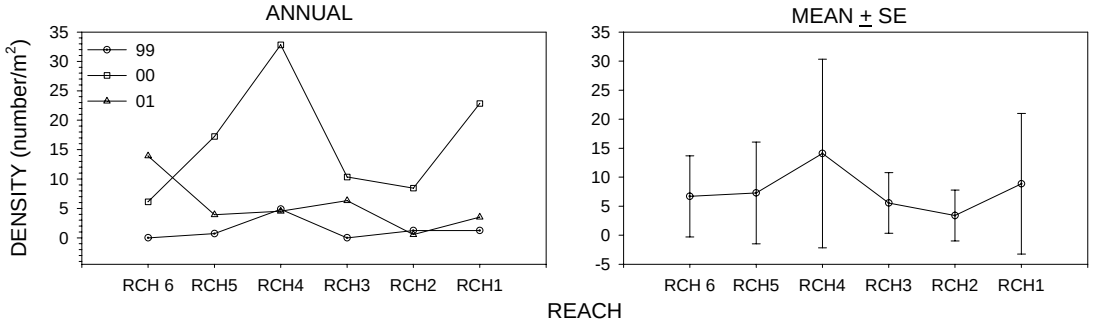

Figure 69. Nonnative fish density in San Juan River backwaters, Reaches 6 through 1, 1999 - 2001.

No backwater was present in Reach 6 in 1999, but a few were in 2000 and 2001. Greatest number of species and highest total density of fishes occurred in 2000 (Table 18). Red shiner and fathead minnow were the most common species in both 2000 and 2001, and native bluehead sucker was comparatively common in 2001.

Table 17. Fishes collected in San Juan River Reach 6 backwaters during autumn inventories, 1999 – 2001.

1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N
N		CYPLUT	481	CYPLUT	200
O		CYPCAR	5	PIMPRO	191
		PIMPRO	162	RHIOSC	1
B		RHIOSC	2	CATDIS	70
A		CATLAT	2	FUNZEB	2
C		CATDIS	6	GAMAFF	25
K		FUNZEB	2		
W		GAMAFF	66		
A		MICSAL	16		
T					
E					
R					
S					
NUMBER BACKWATERS			3		2
TOTAL N			732		489
TOTAL AREA			117.6		30
TOTAL DENSITY			6.224		16.300

Backwater habitats were present in all years in Reach 5. A single Colorado pikeminnow was collected in 1999. Red shiner and fathead minnow were the first- and second-most common species in 2000 and 2001 (Table 19). Western mosquitofish was comparatively common in 2000. Native fishes were uncommon in backwater habitats in all years in Reach 5.

Table 18. Fishes collected in San Juan River Reach 5 backwaters during autumn inventories, 1999 – 2001.

	1999		2000		2001	
	SPECIES	N	SPECIES	N	SPECIES	N
	CYPLUT	7	CYPLUT	4965	CYPLUT	582
	PTYLUC	1	CYPCAR	4	PIMPRO	65
			PIMPRO	274	RHIOSC	3
			RHIOSC	2	CATLAT	1
			CATLAT	4	CATDIS	1
			CATDIS	8	GAMAFF	1
			ICPUN	1	LEPCYA	1
			GAMAFF	118		
			MICSAL	1		
NUMBER BACKWATERS		1		9		6
TOTAL N		8		5377		654
TOTAL AREA		10		311.1		165.8
TOTAL DENSITY		0.800		17.284		3.944

Backwater habitats were present in all years in Reach 4, but species diversity was comparatively low (Table 20). Six species (four nonnative and two native) were found in 2000. Red shiner was the most common species in all years, and represented 95% or more of specimens collected each year. Fathead minnow was the second-most common species collected in 2000 and 2001.

Table 19. Fishes collected in San Juan River Reach 4 backwaters during autumn inventories, 1999 – 2001.

1999		2000		2001	
SPECIES	N	SPECIES	N	SPECIES	N
CYPLUT	214	CYPLUT	7979	CYPLUT	563
RHIOSC	1	CYPCAR	11	PIMPRO	33
		PIMPRO	157	RHIOSC	11
		CATLAT	5		
		CATDIS	1		
		GAMAFF	3		
NUMBER BACKWATERS	1		5		6
TOTAL N	215		8156		607
TOTAL AREA	44		248.2		132.0
TOTAL DENSITY	4.886		32.861		4.598

Although no backwater was present in Reach 3 in 1999, eight were sampled in each 2000 and 2001. Red shiner was the most common species found in both years (Table 21); western mosquitofish was second-most common in 2000 and fathead minnow was second-most common in 2001. A comparatively large number of black bullhead was collected from one backwater in 2000. A single Colorado pikeminnow was collected in a backwater at RM 69.8 in 2000.

Table 20. Fishes collected in San Juan River Reach 3 backwaters during autumn inventories, 1999 – 2001.

	1999		2000		2001	
	SPECIES	N	SPECIES	N	SPECIES	N
	N		CYPLUT	3036	CYPLUT	938
	O		CYPCAR	4	PIMPRO	104
			PIMPRO	112	RHIOSC	3
	B		PTYLUC	1	ICTPUN	1
	A		CATLAT	5	GAMAFF	11
	C		AMEMEL	106		
	K		ICTPUN	2		
	W		FUNZEB	1		
	A		GAMAFF	283		
	T					
	E					
	R					
	S					
NUMBER BACKWATERS				8		8
TOTAL N				3540		1057
TOTAL AREA				341.4		167.0
TOTAL DENSITY				10.369		6.329

Backwater habitats were present in all years in Reach 2. Fishes were substantially more common in 2000 than 1999 or 2001 (Table 22). Red shiner was the most-common species in all years. Three native fishes were collected in 2000, but only speckled dace was found in 1999 and none was collected in 2001.

Table 21. Fishes collected in San Juan River Reach 2 backwaters during autumn inventories, 1999 – 2001.

	1999		2000		2001	
	SPECIES	N	SPECIES	N	SPECIES	N
	CYPLUT	130	CYPLUT	2435	CYPLUT	30
	PIMPRO	2	CYPCAR	5	PIMPRO	9
	RHIOSC	7	PIMPRO	135		
	ICTPUN	2	RHIOSC	2		
			CATLAT	8		
			CATDIS	3		
			ICTPUN	37		
			GAMAFF	95		
			MICSAL	1		
NUMBER BACKWATERS		2		8		5
TOTAL N		141		2721		39
TOTAL AREA		110		320.8		72.0
TOTAL DENSITY		1.282		8.482		0.542

Density of fishes in Reach 1 backwater habitats was greatest in 2000. Red shiner was the most common species found in backwater habitats in all years (Table 23). No native fish species was collected in all years, and none was found in 1999.

Table 22. Fishes collected in San Juan River Reach 1 backwaters during autumn inventories, 1999 – 2001.

	1999		2000		2001	
	SPECIES	N	SPECIES	N	SPECIES	N
	CYPLUT	87	CYPLUT	4810	CYPLUT	97
	PIMPRO	8	CYPCAR	3	PIMPRO	1
			PIMPRO	58	RHIOSC	1
			CATLAT	2	ICTPUN	1
			CATDIS	1	GAMAFF	1
			ICTPUN	4		
			GAMAFF	90		
			LEPMAC	2		
NUMBER BACKWATERS		2		7		4
TOTAL N		95		4970		101
TOTAL AREA		78		217.4		39.6
TOTAL DENSITY		1.218		22.861		2.551

RARE FISH CAPTURES

Five Colorado pikeminnow and two roundtail chub were collected during small-bodied fish monitoring from primary and secondary channel habitats in 1998, one Colorado pikeminnow and two roundtail chub were found in 1999, and three Colorado pikeminnow were collected in 2000 (Table 16). Neither roundtail chub nor Colorado pikeminnow was collected in 2001. Between 1999 and 2001, two Colorado pikeminnow were collected in backwater habitats. No razorback sucker has been collected during small-bodied fish monitoring.

Table 16. Occurrence of rare fishes in San Juan River primary and secondary channels, 1998 through 2001. Dashes indicate no collection effort. Primary and secondary captures of a species separated by slash (primary/secondary).

	REACH 6		REACH 5		REACH 4		REACH 3		REACH 2		REACH 1	
YEAR	GILROB	PTYLUC	GILROB	PTYLUC	GILROB	PTYLUC	GILROB	PTYLUC	GILROB	PTYLUC	GILROB	PTYLUC
1998	---	---	0/0	1/1	0/2	1/0	0/0	2/0	0	0	---	---
1999	0	0	0/0	0/1	1/1	0/0	0/0	0/0	0	0	0	0
2000	0	0	0/0	0/0	0/0	0/3	0/0	0/0	0	0	0	0
2001	0	0	0/0	0/0	0/0	0/0	0/0	0/0	0	0	0	0

SUMMARY

PRIMARY CHANNEL

1. Six native and eight nonnative species were collected in primary channel habitats between 1998 and 2001.
2. Red shiner was the most common species in all years (Reaches 6 through 1 combined) and speckled dace was second-most common in all years, except 2000.
3. No nonnative species evidenced a longitudinal density pattern in primary channel.
4. In 1999 and 2000, speckled dace generally declined in abundance in a downstream direction; neither flannelmouth nor bluehead suckers had apparent density pattern.
5. Assemblage diversity (years averaged) did not vary significantly among reaches; nor did total native fish species density. Relative abundance of native fishes, however, declined in downstream direction (but was not significantly different among reaches).
6. Nonnative fish density and relative abundance did not vary among reaches (years averaged).
7. Overall, native fish density was greatest in 1998 and least in 2000. Nonnative fish density was greatest in 2000 and least in 1999.

SECONDARY CHANNELS

1. Since 1993, six native and 11 nonnative species have been collected in San Juan River secondary channels (Reaches 5 through 3).

2. Overall (Reaches combined), red shiner was the most common species in secondary channels in all years. Speckled dace or fathead minnow was second-most common in all years.
3. Years averaged, assemblage diversity declined significantly from Reach 5 through Reach 3. Reach differences (years averaged) in native and nonnative densities and relative abundances were not significant.
4. Fish density in Reach 5 was greatest in 2000 and least in 1999 (nonnatives comprised 99.5% of 2000 collection).
5. Native fish density in Reach 5 generally declined from 1993 through 2000, with a slight increase in 2001. Nonnative fish density did not evidence temporal pattern or trend.
6. Native fish density in Reach 5 (species combined and separate) was significantly related to mean daily spring discharge, but was not related to mean daily summer discharge.
7. Nonnative fish density in Reach 5 (species combined and separate) was not significantly related to mean daily spring discharge. Autumn nonnative species density was not related to mean daily summer discharge.
8. Autumn density of no native species was related to number of days mean daily summer discharge <14.0 m^3/sec, but that of nonnative red shiner, fathead minnow and western mosquitofish, in Reach 5 was.
9. Density of each common native species was highest in 1993 in Reach 4. Highest density for nonnative species varied; red shiner was highest in 2000, fathead minnow in 1994, channel catfish in 1998, and western mosquitofish in 1996.

10. Total native fish density was positively related to mean daily spring discharge in Reach 4, but that of nonnatives was not.

11. Among native species, only speckled dace density was significantly related to mean daily spring discharge in Reach 4.

12. Nonnative fish density was negatively related to mean daily summer discharge in Reach 4, but that of natives was not. Among nonnative fish species, only red shiner density was related (negatively) to mean daily summer discharge.

13. Nonnative fish density in Reach 4 was positively related to days mean daily summer discharge <14.0 m^3/sec, but that of natives was not. Red shiner and western mosquitofish densities were significantly related to days mean daily summer discharge <14.0 m^3/sec.

14. Red shiner was the most common species in Reach 3 in all years, except 1998 when speckled dace was most common. Speckled dace or fathead minnow was usually the second-most common species.

15. In Reach 3, density of speckled dace was highest in 1998, that of flannelmouth sucker was highest (almost equal) in 1993 and 1994, and bluehead sucker density was highest in 1995.

16. Red shiner density was highest in 2000, but was also high in 1994 and 1995. Fathead minnow density was highest in 1995, channel catfish in 1993, and western mosquitofish was highest in 2000 (and almost as high in 1994).

17. Collectively, neither native nor nonnative fishes density was related to mean daily spring discharge in Reach 3. Individually, density of no species was related to mean daily spring discharge.

18. Collectively, neither native nor nonnative fishes density was related to mean daily summer discharge. Individually, the density of no species was related to mean daily summer discharge.
19. Density of no species was related to days mean daily summer discharge <14.0 m^3/sec in Reach 3.
20. Between the primary channel and secondary channels, there were no differences in density of any nonnative fish species in Reaches 5, 4, or 3.
21. Between the primary channel and secondary channels, there were no differences in density of any native fish species in Reaches 5, 4, or 3.
22. Since 1998, four specimens of Colorado pikeminnow were collected during small-bodied fish sampling in primary channel habitats and five were found in secondary channel habitats.
23. Since 1998, one specimen of roundtail chub was collected during small-bodied fish monitoring in the primary channel and three were collected in secondary channels.
24. Since 1998, no specimen of razorback sucker has been collected during small-bodied fish monitoring in primary or secondary channels.

BACKWATERS

1. In 1999, when discharge during autumn monitoring was comparatively high (<1500 cfs), few backwaters were present and abundance of fishes in backwaters was comparatively low.

2. In 2000, when discharge during autumn monitoring was comparatively low (ca. 500 cfs; and following a summer of low discharge), fish density was high in backwaters in Reaches 6 through 1.
3. Four native fishes (Colorado pikeminnow, speckled dace, flannelmouth sucker, and bluehead sucker) were found in San Juan River backwaters. None was common in any reach in any year.
4. One specimen of Colorado pikeminnow was collected in backwater habitat in each 1999 and 2000.
5. Red shiner was the most common fish in backwater habitats in all reaches in all years (frequently representing >95% of fish collection).

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