SMALL-BODIED FISH MONITORING

SAN JUAN RIVER

1998 – 2003

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EXECUTIVE SUMMARY

The primary objectives of small-bodied fish monitoring in San Juan River are to document occurrence and habitat of rare native fishes (i.e., roundtail chub, Colorado pikeminnow, and razorback sucker), determine responses of fish species to changes in flow regime of San Juan River, and to characterize long-term trends in abundances of native and nonnative fishes in the San Juan River. Data needed to meet objectives of small-bodied fish monitoring effort are collected annually during autumn. Annual autumn monitoring of the small-bodied fish assemblages of San Juan River primary channel and secondary channels between Shiprock, New Mexico and Sand Island, Utah began in 1998. In 1999, backwater sampling was added to the monitoring effort and the study reach was extended upstream to the confluence of Animas and San Juan rivers (Farmington, New Mexico) and downstream to Clay Hills Crossing, Utah. Fishes were collected with drag seines at each sample location (100 to 200-m sites every third river mile in primary channel, all secondary channels, and all backwaters >50m^2). Primary channel collections were made from shoreline habitats while secondary channel fishes were collected across the breadth of the channel. All mesohabitats present within a site were sampled in rough proportion to their availability. Readily identified native fishes were measured (total length, mm) and released alive; all other fishes were retained for identification and measurement in the laboratory.

Monitoring of San Juan River small-bodied fishes was undertaken to characterize responses (changes in distribution, abundance, populations size-structure, and recruitment) of native and nonnative fishes to a mimicked natural flow regime, to document occurrence of protected species (roundtail chub, Colorado pikeminnow, and

razorback sucker), and to characterize long-term abundance trends of common native and nonnative fish species.

Since 1998, mean daily discharge during spring runoff has averaged >5,000 cfs only two months (May 1998 and June 1999). In 2002, monthly average mean daily discharge did not exceed 1,000 cfs. In contrast, monthly average mean daily spring discharge was >5,000 cfs from 1993 through 1995, and nearly so in 1997. In 1998 and 1999, average mean daily discharge during summer was comparatively high; that of 1999 (4333 cfs) was greater than average mean daily discharge that spring (2712 cfs). Since 1999, San Juan River summer discharge has been characterized by periods of extended low discharge, interspersed with large-volume storm-induced flow spikes.

Between 1999 and 2002, red shiner was almost always the most common species in primary channel, secondary channels, and backwaters. Its abundance was frequently an order of magnitude greater than the next-most common species. Other comparatively common nonnative species were fathead minnow, channel catfish, and western mosquitofish. Bullhead catfishes and centrarchids were rare, but found in most years. speckled dace was typically the most common native species; bluehead sucker and flannelmouth sucker were uncommon in most years. Several specimens of Colorado pikeminnow and roundtail chub were collected in 1998, 1999, and 2000.

In 2003, red shiner remained the most common species in primary channel, secondary channels, and backwaters. Speckled dace was comparatively common in primary channel and secondary channels and flannelmouth sucker was more common than it had been in preceding years. Channel catfish density was markedly higher in 2002 than it had been in previous years, and remained comparatively high in 2003. Backwater

fish assemblages were numerically dominated by red shiner; native fishes were rare in backwater habitats. No protected species (roundtail chub, Colorado pikeminnow, and razorback sucker) was collected in 2003.

In the primary channel, native fish density declined from 1998 (0.249 fish/m^2) to 2000 (0.047 fish/m^2), increased to 0.206 fish/m^2 in 2002 and dropped slightly to 0.173 fish/m^2 in 2003. In secondary channels, native fish density declined from 0.325 fish/m^2 in 1998 to 0.093 fish/m^2 in 1999, but steadily increased to 0.276 fish/m^2 in 2003. Lowest density (0.232 fish/m^2) of nonnative fishes in the primary channel was in 1999 and greatest (4.758 fish/m^2) in 2000; nonnative fish density in 2003 (0.567 fish/m^2) was comparatively low. Nonnative fishes secondary channels density followed the same pattern, with lowest density (0.257 fish/m^2) in 1999, greatest in 2000 (7.463 fish/m^2), and 2003 comparatively low (1.389 fish/m^2). Except for speckled dace in Reach 4, there was no difference in primary and secondary channel densities (1998 through 2003) of commonly collected native and nonnative fishes. In 2003, primary channel density of each commonly collected native species was greatest in Reach 6 and declined in a downstream direction. Secondary channel densities of both native sucker species were highest in Reach 6 and declined in downstream reaches. Secondary channel density of speckled dace was greatest in Reach 5. Red shiner, fathead minnow, and western mosquitofish primary and secondary channel densities generally declined in a downstream direction, but that of channel catfish increased.

In both primary and secondary channels in Reaches 5 and 4, autumn density of bluehead sucker was positively associated with number days summer discharge <500 cfs. flannelmouth sucker autumn density was positively associated with number days summer

discharge <500 cfs in primary channel Reaches 4, 3, and 2, but only Reach 5 secondary channel. Primary channel autumn density of flannelmouth sucker was negatively related to mean daily spring discharge in Reaches 5, 3, and 2 while that of bluehead sucker was negatively related in Reaches 4 and 3. Primary channel autumn density of no nonnative species was associated with any discharge attribute. In secondary channels, red shiner autumn density was negatively associated with spring discharge in Reach 6 and positively associated with number days summer discharge <500 cfs. The power of these analyses, however, is diminished by small sample size (n = 6; one sample per year from 1998 through 2003 for each reach). In addition, the atypical discharge (below average spring discharge and above average summer discharge) regimes of the past six years confound interpretation of discharge-density associations as well as species distributions and recruitment success.

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 Basin Recovery Implementation Program Biology Committee. Accordingly, autumn sampling of San Juan River small- and large-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 Monitoring Plan and Protocols (Propst et al. 2000).

Data on small-bodied fishes reported herein were collected from primary channel shoreline habitats and secondary channels since 1998 and backwaters since 1999. In 1998, primary and secondary channels sampling was limited to Reaches 5 through 2. Since 1999, autumn monitoring of the primary channel and backwaters has been conducted in Reaches 6 through 1 and that of secondary channels in Reaches 6 through 3. No secondary channel occurs in Reaches 2 and 1.

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 the characterization and quantification of responses of native and nonnative fishes to flow regimes designed to mimic a natural hydrograph. 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, as well as that of other small-bodied fishes; determining effects of different flow regimes on autumn densities of commonly collected native and nonnative species; and comparing densities of commonly-collected species among primary and secondary channels. Data collected will be used to characterize long-term trends in status (abundance, population size-structure, and recruitment) of individual species.

METHODS

In 1998, autumn monitoring of small-bodied fishes in San Juan River primary and secondary channels and backwaters (including embayments) occurred from Shiprock, New Mexico (RM 149, Reach 5) downstream to Chinle Creek, Utah (RM 68, 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, however, excluded a large proportion of secondary channels (30 to 50%, depending upon point that 3-mile intervals for sampling began). Beginning in 2000, all secondary channels having surface water were sampled. All backwaters (greater than 50 m^2), regardless of occurrence within designated miles, were sampled.

Small-bodied fishes were collected from primary channel habitats at 3-mile intervals. Starting point of 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.

Primary channel sample sites were about 200 m long (measured along shoreline). Secondary channel sample site length was variable, 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 availability within in a site. Beginning in 2003, data from each sampled mesohabitat were segregated. Most primary channel mesohabitats sampled were along stream margins, but off-shore riffles and runs (<0.75 m deep) were also sampled. Secondary channel sampling was across the breadth of the wetted channel. All mesohabitats within each site were sampled and sampled area of each was roughly proportionate to its total area within a site. Some mesohabitats (e.g., debris pools and riffle eddys) were sampled in greater proportion than their availability. A minimum of 5 seine hauls was made at each sample site; however, if habitat was homogeneous, fewer seine hauls were made. All backwaters >50 m^2 were sampled. Typically, 2 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.

Fishes were collected with a 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 >75 mm total length (TL). Length of each native fish found (protected and >75 mm TL) was determined, recorded, and specimen released. All other specimens were fixed in 10% formalin and returned to laboratory. Length and width of each seine haul was delimited with surveyor flags. Following specimen collection, seined area of each sampled mesohabitat was determined and recorded.

Retained specimens were identified and enumerated in the laboratory. Total length was determined for all retained specimens, except collections having more than 250 specimens of a species. For these collections, lengths were obtained for a sub-sample (at least 200 specimens). Identification of retained protected species was verified

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

Attributes of spring and summer discharge were obtained from USGS Water Resources Data, New Mexico (1993 et seq.). Shiprock gauge (#09368000) data were used for all calculations. Spring was 1 March through 30 June and summer was from 1 July through 30 September. Species density data were segregated by Geomorphic Reach (Bliesner and Lamarra 2000). 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. For each Geomorphic Reach, mean density of each commonly collected species was calculated by averaging densities of each species from all samples within a reach. Standard error for density estimate of each species from each reach was standard deviation of mean density divided by number of samples within respective reach. Densities presented in tables were determined by dividing total number of specimens (species, native and nonnative species, and total) by total area sampled within a reach. Pearson product-moment correlation was used to compare spring and summer discharge attributes to density of commonly collected secondary and primary channel species from 1998 through 2003. To reduce the effect of disproportionately large values, fish densities were $\log_{10}(x + 1)$ transformed. Paired t tests were used to compare primary and secondary channel densities of commonly collected species within each geomorphic reach. Mesohabitats were grouped into four categories based on water velocity. Rapid-velocity mesohabitats included riffle-plunge, riffle, and riffle-run; moderate-velocity included run, mid-channel run, shoal, and pool-run; slow-velocity included riffle eddy, eddy, shoal pool, and pool; and embayments

and isolated pools were grouped with backwaters. Percent of each commonly collected species in a mesohabitat class was plotted alongside percent that mesohabitat was of total area sampled in each geomorphic reach to provide a crude estimate of habitat use patterns of each species. Discharge at time of sampling ranged from 420 to 1730 cubic feet per second (cfs), but regression analysis showed that discharge at time of sampling had little effect on fish densities.

RESULTS

DISHCHARGE

Since 1998, monthly mean daily discharge during spring exceeded 5,000 cfs only in May 1998 and June 1999 (Table 1) and did not exceed 2000 cfs in 2002 or 2003. In 1998, 1999, and 2001, mean daily discharge exceeded 5,000 cfs about one-fourth of the days, but did not exceed 5,000 cfs in 2002 or 2003. Since 1998, spring mean daily discharge has not exceeded 10,000 cfs for a single day and exceeded 8,000 cfs only one day (2001).

Table 1. Average mean daily discharge (cubic feet/second; cfs) of San Juan River during spring runoff and attributes of spring discharge, 1998 - 2003. Data from USGS Shiprock gauge (#09368000).

	WATER YEAR					
MONTH	98	99	00	01	02	03
March	1141	869	941	1033	664	653
April	1425	1087	1652	1384	533	532
May	5250	3175	2311	4781	644	1621
June	3970	5716	2011	4760	433	1243
Mean (cfs)	2947	2712	1729	2989	569	1015
Days Q >3,000 cfs	48	41	18	47	0	9
Days Q >5,000 cfs	24	26	1	29	0	0
Days Q >8,000 cfs	0	0	0	1	0	0
Days Q >10,000 cfs	0	0	0	0	0	0

In 1998 and 1999, summer mean daily discharge exceeded 1000 cfs, but was less than 1000 cfs in subsequent years (Table 2). During 2000 and 2001, no summer discharge spike exceeded 3,000 cfs mean daily discharge. Summer mean daily discharge was less than 500 cfs at least 15 days in all years, except 1999 when summer mean daily

discharge was never <500 cfs. Since 2000, mean daily discharge did not exceed 500 cfs at least 20 days and did not exceed 500 cfs for 74 days in 2002.

Table 2. Average mean daily discharge (cubic feet/second; cfs) of San Juan River during summer and attributes of summer discharge, 1998 – 2003. Data from USGS Shiprock gage (#09368000).

	WATER YEAR					
MONTH	98	99	00	01	02	03
July	1665	3116	324	690	378	575
August	959	5725	602	1132	368	642
September	655	4157	649	552	1126	1286
Mean (cfs)	1089	4333	525	791	624	829
Days Q >5,000 cfs	0	31	0	0	2	2
Days Q >4,000 cfs	1	42	0	0	2	3
Days Q >3,000 cfs	1	71	0	0	2	3
Days Q >2,000 cfs	11	89	0	5	3	3
Days Q >1,000 cfs	37	92	1	18	7	13
Days Q <1,000 cfs	55	0	91	74	85	79
Days Q <750 cfs	42	0	80	59	79	67
Days Q <500 cfs	15	0	45	23	74	44
Number Q spikes	4	1	1	1	1	4
Spike duration (days)	37	92	7	18	13	12
Spike mean (cfs)	1802	4333	850	1596	2130	2645

PRIMARY CHANNEL FISHES

Six native and nine nonnative fish species were captured in San Juan River primary channel mesohabitats during small-bodied fish sampling from 1998 through 2003 (Table 3). Native speckled dace, bluehead sucker, and flannelmouth sucker were captured in all years, roundtail chub was found in 1998 and 1999, Colorado pikeminnow in 1998, and mottled sculpin in 1999. Native razorback sucker was not collected during small-bodied fish sampling. Nonnative red shiner, fathead minnow, and channel catfish were collected in all years. Plains killifish and western mosquitofish were found in all

years, except one (1999). Other nonnative fish species were collected in one-half, or fewer, of years since 1998.

Table 3. Occurrence of small-bodied fishes in San Juan River primary channel during autumn, 1998-2003. I = introduced and N = native. Six-letter code derived from first three letters of genus and first three from species.

COMMON	SCIENTIFIC	CODE	STATUS	1998	1999	2000	2001	2002	2003
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X		X	
Red shiner	*Cyprinella lutrensis*	CYPLUT	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
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X					
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	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
Flannelmouth x bluehead	*C. lattipinnis* x *C. discobolus*	LATDIS			X				X
Black bullhead	*Ameiurus melas*	AMEMEL	I					X	
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	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
Green sunfish	*Lepomis cyanellus*	LEPCYA	I		X				X
Largemouth bass	*Micropterus salmoides*	MICSAL	I				X		
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X				
NATIVE			6	5	5	3	3	3	3
NONNATIVE			9	5	5	6	6	7	6

Red shiner was the most common species in all years (Table 4). Speckled dace was second-most common in 1998, 1999, 2001, and 2003. In 2000, western mosquitofish was second-most common and fathead minnow was second-most common in 2002.

Among all years, red shiner and western mosquitofish abundance was greatest in 2000, that of fathead minnow, speckled dace, and bluehead sucker was greatest in 2002, and flannelmouth sucker, channel catfish, and plains killifish was greatest in 2003. Lowest abundance of red shiner, fathead minnow, and western mosquitofish was in 1998. bluehead sucker, channel catfish, and plains killifish were least abundant in 1999. Flannelmouth sucker abundance was lowest in 1998 and 1999 (8 specimens each year) and speckled dace abundance was lowest in 2000. Red shiner abundance was an order of magnitude, or more, greater than the next most-common species in almost all years. Four Colorado pikeminnow specimens were collected in 1998 and one roundtail chub was found in each 1998 and 1999.

Table 4. Fishes collected in San Juan River primary channel during autumn inventories, 1998 – 2003. Geomorphic Reaches 6 and 1 not sampled in 1998.

1998		1999		2000		2001		2002		2003	
Species	N	Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	590	CYPLUT	1071	CYPLUT	20159	CYPLUT	3591	CYPLUT	6622	CYPLUT	1715
RHIOSC	461	RHIOSC	395	GAMAFF	1070	RHIOSC	344	PIMPRO	1116	RHIOSC	511
ICTPUN	187	PIMPRO	48	PIMPRO	188	PIMPRO	146	RHIOSC	533	ICTPUN	366
PIMPRO	32	CATLAT	8	RHIOSC	161	GAMAFF	59	ICTPUN	231	CATLAT	142
CATLAT	8	ICTPUN	8	CATLAT	33	CATLAT	20	GAMAFF	165	PIMPRO	90
PTYLUC	4	GAMAFF	6	ICTPUN	31	CATDIS	8	CATLAT	141	GAMAFF	37
CATDIS	5	CATDIS	3	CATDIS	18	ICTPUN	13	CATDIS	61	CATDIS	27
GAMAFF	2	CYPCAR	1	CYPCAR	7	FUNZEB	3	CYPCAR	23	FUNZEB	21
GILROB	1	GILROB	1	FUNZEB	3	CYPCAR	1	FUNZEB	15	LEPCYA	2
FUNZEB	1	LATDIS	1			MICSAL	1	AMEMEL	4	LATDIS	1
		LEPCYA	1								
		COTBAI	1								
TOT N	1291		1544		21670		4184		8911		2911
AREA	1601		4883		4510		3091		3564		3935
DENSITY	0.806		0.316		4.805		1.354		2.500		0.740

During 2003, 14 primary channel mesohabitat types in reaches 6 through 1 were sampled (Table 5). Among reaches, rapid-velocity mesohabitats (riffle, riffle plunge, and riffle run) accounted for 11.5% of total area sampled, moderate-velocity mesohabitats (run, mid-channel run, shore run, shoal, and pool run) accounted for 69.1%, slow-velocity

mesohabitats (riffle eddy, eddy pool, and pool) accounted for 13.7%, and backwaters (including embayments and isolated pools) comprised 5.8%. About 10 m^2 were seined for each stream kilometer in reaches 6 and 5, about 14 m^2 in reaches 4, 2, and 1, and about 17 m^2 in reach 3.

SECONDARY CHANNELS

Since 1998, six native and 11 nonnative fish species have been captured in San Juan River secondary channels (Table 6). Speckled dace, bluehead sucker, and flannelmouth sucker were found in all years. Roundtail chub was found in 1998 and 1999, Colorado pikeminnow in 1998, 1999, and 2000, and mottled sculpin in 1999. Nonnative red shiner, fathead minnow, channel catfish, and western mosquitofish were found in all years. Common carp and plains killifish were found in all years, except 1999 Other nonnative fish species were irregularly collected. Total fish abundance was greatest in 2000 and least in 1999 (Table 7). Red shiner was the most abundant species in all years. Speckled dace was second-most common in 1998 and 1999, but fathead minnow was second-most common in subsequent years. Abundances of speckled dace and channel catfish were greatest in 1998; that of red shiner, western mosquitofish, and common carp were greatest in 2000; fathead minnow, plains killifish, and bluehead sucker abundances were greatest in 2002; and that of flannelmouth sucker was highest in 2003. Each of these species was least abundant in 1999. Colorado pikeminnow was found in 1998, 1999, and 2000. Roundtail chub was collected in 1998 and 1999. Centrarchids were irregularly collected in low numbers. Black bullhead was not common, but was collected in all years, except 1999 and 2000.

Table 5. Area of mesohabitats sampled in San Juan River primary channel during autumn 2003 monitoring. Mesohabitats are arranged from rapid (left) to slow (right) water velocity.

			Mesohabitat													
			Rapid Velocity				Moderate Velocity			Slow Velocity				Backwater		
Reach	Reach length (km)	Total area (m^2)	Riffle	Riffle plunge	Riffle run	Run	Mid channel run	Shore run	Shoal	Pool run	Riffle eddy	Eddy pool	Pool	Embayment	Backwater	Isolated pool
6	40.0	407.0	43.7	0	5.6	0	67.2	49.0	103	14.3	0	18.8	31.0	71.4	3	0
5	38.4	390.8	19.3	8.8	62.0	25.6	28.6	116.6	44	20.8	40.6	0	3.3	0	21.2	0
4	38.4	529.9	48.1	0	36.7	83.0	62.7	109.0	77.2	0	13.2	51.5	25.4	19.8	4.4	0
3	62.4	1077.3	25.5	0	109.4	50.6	318.1	240.9	109.6	23.1	102.3	17.6	30.4	39.4	10.4	0
2	81.6	1147.2	42.6	0	49.1	37.0	181.6	512.2	24.1	91.7	87.7	40.0	50.1	20.1	0	14
1	27.2	382.8	0	0	0	33.4	95.9	171.7	0	26.6	0	0	27.7	24.3	0	0

Table 6. Occurrence of fishes in San Juan River secondary channels during autumn, 1998 – 2003, 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	1998	1999	2000	2001	2002	2003
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	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
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X	X			
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N	X	X	X	X	X	X
Rainbow trout	*Oncorhynchus mykiss*	ONCMYK	I				X		
Black bullhead	*Ameiurus melas*	AMEMEL	I	X			X	X	X
Yellow bullhead	*Ameiurus natilis*	AMENAT	I	X			X		
Channel catfish	*Ictalurus punctatus*	ICTPUN	I	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				
Largemouth bass	*Micropterus salmoides*	MICSAL	I			X	X		X
Mottled sculpin	*Cottus bairdi*	COTBAI	N		X				
NATIVE			6	5	6	4	3	3	3
NONNATIVE			11	9	5	7	10	7	8

Table 7. Fishes collected in San Juan River secondary channels during autumn sampling, 1998 – 2003.

1998		1999		2000		2001		2002		2003	
Species	N	Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	739	CYPLUT	272	CYPLUT	11135	CYPLUT	1847	CYPLUT	6424	CYPLUT	1627
RHIOSC	600	RHIOSC	114	PIMPRO	1503	PIMPRO	226	PIMPRO	1781	PIMPRO	310
PIMPRO	162	PIMPRO	20	GAMAFF	1314	RHIOSC	193	GAMAFF	470	RHIOSC	232
ICTPUN	140	CATDIS	4	CYPCAR	309	GAMAFF	113	RHIOSC	224	CATLAT	153
GAMAFF	113	CATLAT	4	RHIOSC	158	CATLAT	27	CATLAT	99	ICTPUN	65
CATLAT	13	ICTPUN	4	CATLAT	45	ICTPUN	20	FUNZEB	60	GAMAFF	32
FUNZEB	4	GAMAFF	3	ICTPUN	27	FUNZEB	19	CATDIS	53	CATDIS	24
CYPCAR	2	COTBAI	2	CATDIS	17	CATDIS	11	ICTPUN	37	FUNZEB	11
GILROB	2	GILROB	1	MICSAL	9	AMEMEL	3	CYPCAR	27	AMEMEL	7
CATDIS	2	PTYLUC	1	FUNZEB	5	CYPCAR	2	AMEMEL	8	CYPCAR	2
PTYLUC	1	LEPCYA	1	PTYLUC	3	AMENAT	1			MICSAL	1
AMEMEL	1					ONCMYK	1				
AMENAT	1					MICSAL	1				
LEPCYA	1										
TOT N	1781		426		14508		2464		9183		2464
AREA	1904		1356		1914		1346		1468		1480
DENSITY	0.936		0.315		7.580		1.831		6.255		1.665

Fourteen mesohabitat types were sampled in San Juan River secondary channels in 2003 (Table 8). Rapid-velocity mesohabitats (riffle, riffle plunge, and riffle run) were 15.2% of those sampled, moderate-velocity mesohabitats (run, mid channel run, shore run, shoal, and pool run) accounted for 60%, slow-velocity mesohabitats (riffle eddy, eddy pool, and pool) accounted for 17.5%, and backwaters (including embayments and isolated pools) were 7.3%.

Table 8. Area of mesohabitats sampled in San Juan River secondary channels during autumn 2003 monitoring. Mesohabitats are arranged from rapid (left) to slow (right) water velocity.

			Mesohabitat													
			Rapid Velocity				Moderate Velocity			Slow Velocity				Backwater		
Reach	Number secondaries	Total area (m^2)	Riffle	Riffle plunge	Riffle run	Run	Mid channel run	Shore run	Shoal	Pool run	Riffle eddy	Eddy pool	Pool	Backwater	Embayment	Isolated pool
6	4	235.4	19.6	0	23.2	68.8	37.6	11.2	0	35.2	0	0	0	0	11.2	28.6
5	7	302.2	21.1	9.9	34.0	33.0	13.2	13.2	15.4	56.5	16.5	17.6	71.7	0	0	0
4	9	475.7	30.4	0	47.1	0	76.7	114.8	0	62.7	24.0	0	85.3	0	22.0	12.1
3	7	467.2	14.6	0	24.4	18.9	179.3	65.9	17.6	68.2	9.6	17.2	17.6	15.0	18.9	0

BACKWATER FISHES

Since 1999, four native and 10 nonnative fish species have been collected in San Juan River backwaters in Reaches 6 through 1 (Table 9). Data from small backwaters (<50 m^2) within primary and secondary channel sample sites are reported with those efforts. Native speckled dace and flannelmouth sucker were collected in backwaters in all years, bluehead sucker was found in all years, except 1999, and Colorado pikeminnow was collected in 1999 and 2000. Nonnative red shiner, fathead minnow, and channel catfish were found in all years. Western mosquitofish was present in all years, except 1999. Other nonnative fish species were found less frequently. Greatest abundance of fishes in backwater habitats occurred in 2000 (Table 10). Red shiner was the most common species and fathead minnow was second-most common in backwaters in all years. Native fish species were typically uncommon in backwaters, rarely being more than fourth-most common; the exception was bluehead sucker in 2001 when it was third-most common. One specimen of Colorado pikeminnow was collected in each 1999 and 2000. No roundtail chub or razorback sucker was found in backwaters.

Table 9. Occurrence of fishes in San Juan River backwaters during autumn, 1999 – 2003, 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
Red shiner	*Cyprinella lutrensis*	CYPLUT	I	X	X	X	X	X
Common carp	*Cyprinus carpio*	CYPCAR	I		X	X	X	
Fathead minnow	*Pimehales promelas*	PIMPRO	I	X	X	X	X	X
Colorado pikeminnow	*Ptychocheilus lucius*	PTYLUC	N	X	X			
Speckled dace	*Rhinichthys osculus*	RHIOSC	N	X	X	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	CATLAT	N	X	X	X	X	X
Bluehead sucker	*Catostomus discobolus*	CATDIS	N		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
Plains killifish	*Fundulus zebrinus*	FUNZEB	I		X	X	X	
Western mosquitofish	*Gambusia affinis*	GAMAFF	I		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			
NATIVE			4	3	4	3	3	3
NONNATIVE			10	3	9	9	7	6

Table 10. Fishes collected in San Juan River backwaters during autumn inventories, 1999 – 2003. Backwaters not sampled in 1998.

1999		2000		2001		2002		2003	
Species	N	Species	N	Species	N	Species	N	Species	N
CYPLUT	438	CYPLUT	23898	CYPLUT	4408	CYPLUT	4453	CYPLUT	309
PIMPRO	8	PIMPRO	878	PIMPRO	401	PIMPRO	1634	PIMPRO	129
RHIOSC	8	GAMAFF	659	CATDIS	71	GAMAFF	132	GAMAFF	17
CATLAT	3	AMEMEL	106	GAMAFF	39	CYPCAR	35	AMEMEL	12
ICTPUN	1	ICTPUN	44	RHIOSC	19	RHIOSC	37	ICTPUN	10
PTYLUC	1	CYPCAR	46	CATLAT	6	ICTPUN	40	CATLAT	6
		CATLAT	33	CYPCAR	4	AMEMEL	14	CATDIS	3
		CATDIS	27	ICTPUN	4	CATLAT	22	RHIOSC	3
		MICSAL	24	FUNZEB	3	CATDIS	5	LEPCYA	1
		RHIOSC	5	AMEMEL	3	FUNZEB	9		
		FUNZEB	3	LEPCYA	1	LEPCYA	3		
		LEPMAC	2						
		PTYLUC	1						
N	459		25727		4957		6385		490
Area	242		1576		607		559		313
Density	1.897		16.324		4.855		11.422		1.565

REACH 6—PRIMARY CHANNEL

Four native and six nonnative fish species have been collected in Reach 6 primary channel since 1999 (Table 11). Total fish density was greatest in 2000, and red shiner comprised the large majority of specimens collected. Speckled dace was the most common species in 1999 and 2003, red shiner was most common in 2000 and 2002, and fathead minnow was most common in 2001. Bluehead sucker and flannelmouth sucker were uncommon in 1999, 2000, and 2001, but were moderately common in 2002 and 2003. Density of no commonly collected species in Reach 6 was related to mean daily spring discharge, mean daily summer discharge, or days summer mean daily discharge <500 cfs (Table 12). Assemblage diversity (H) was greatest in 2001 and least in 2000 (Figure 1).

Moderate-velocity mesohabitats represented about 57% of the area sampled in Reach 6 primary channel, rapid velocity about 12%, slow velocity about 12%, and backwaters about 18% in 2003. Over 80% of speckled dace were found in moderate- and slow-velocity mesohabitats (Figure 2). Most specimens of speckled dace captured in slow-velocity habitats were found in riffle eddys. Bluehead sucker was found fairly evenly distributed among mesohabitats, but flannelmouth sucker was more common in slow-velocity and backwater mesohabitats. Almost all specimens of red shiner were found in moderate-velocity habitats. Both fathead minnow and western mosquitofish were most common in backwaters, but fathead minnow was also common in moderate-velocity habitats.

Table 11. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 6 during autumn, 1999 – 2003.

1999			2000			2001			2002			2003		
SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY	SPECIES	N	DENSITY
RHIOSC	228	0.407	CYPLUT	2058	7.221	PIMPRO	51	0.108	CYPLUT	316	0.704	RHIOSC	123	0.302
PIMPRO	17	0.030	GAMAFF	202	0.712	RHIOSC	48	0.102	PIMPRO	299	0.666	CATLAT	101	0.248
CYPLUT	7	0.013	PIMPRO	38	0.133	CYPLUT	35	0.074	CATLAT	74	0.164	CYPLUT	55	0.136
CATLAT	4	0.007	RHIOSC	2	0.007	GAMAFF	26	0.055	GAMAFF	40	0.089	CATDIS	21	0.052
ICTPUN	1	0.002	CATLAT	2	0.007	CATLAT	12	0.026	CATDIS	35	0.078	GAMAFF	19	0.047
LEPCYA	1	0.002	CATDIS	1	0.004	CATDIS	5	0.011	RHIOSC	33	0.073	PIMPRO	14	0.034
COTBAI	1	0.002	FUNZEB	1	0.004	CYPCAR	1	0.002	FUNZEB	5	0.011			
						FUNZEB	1	0.002						
TOTAL N	259			2304			179			802			333	
AREA	560			285			471			449			407.2	
DENSITY	0.462			8.084			0.380			1.786			0.818	
H	0.517			0.401			1.649			1.435			1.498	

Table 12. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 6 primary channel (1999-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs.

	SPRING Q		SUMMER Q		DAYS < 500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES	-0.165	0.791	-0.334	0.583	-0.177	0.776
RHIOSC	0.243	0.694	0.781	0.119	-0.629	0.255
CATDIS	-0.866	0.057	-0.464	0.431	0.812	0.095
CATLAT	-0.791	0.111	-0.394	0.512	0.589	0.296
NONNATIVES	-.0292	0.710	-0.416	0.486	0.369	0.541
CYPLUT	-0.229	0.710	-0.416	0.486	-0.369	0.541
PIMPRO	0.618	0.267	-0.398	0.507	0.796	0.107
GAMAFF	-0.137	0.826	-0.421	0.480	-0.286	0.641

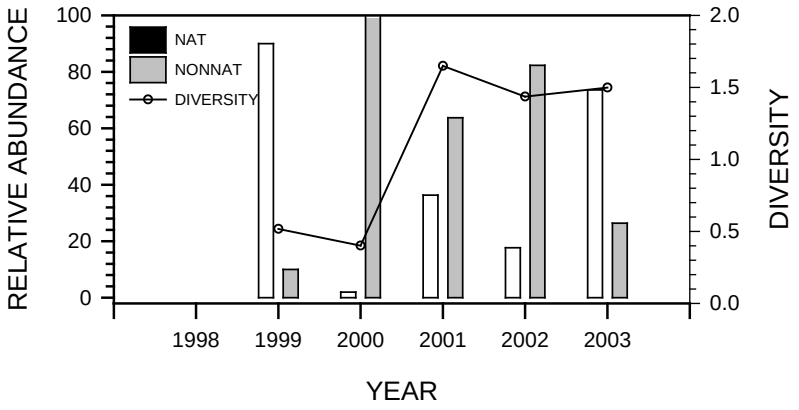


Figure 1. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 6 primary channel, San Juan River, 1999 - 2003.

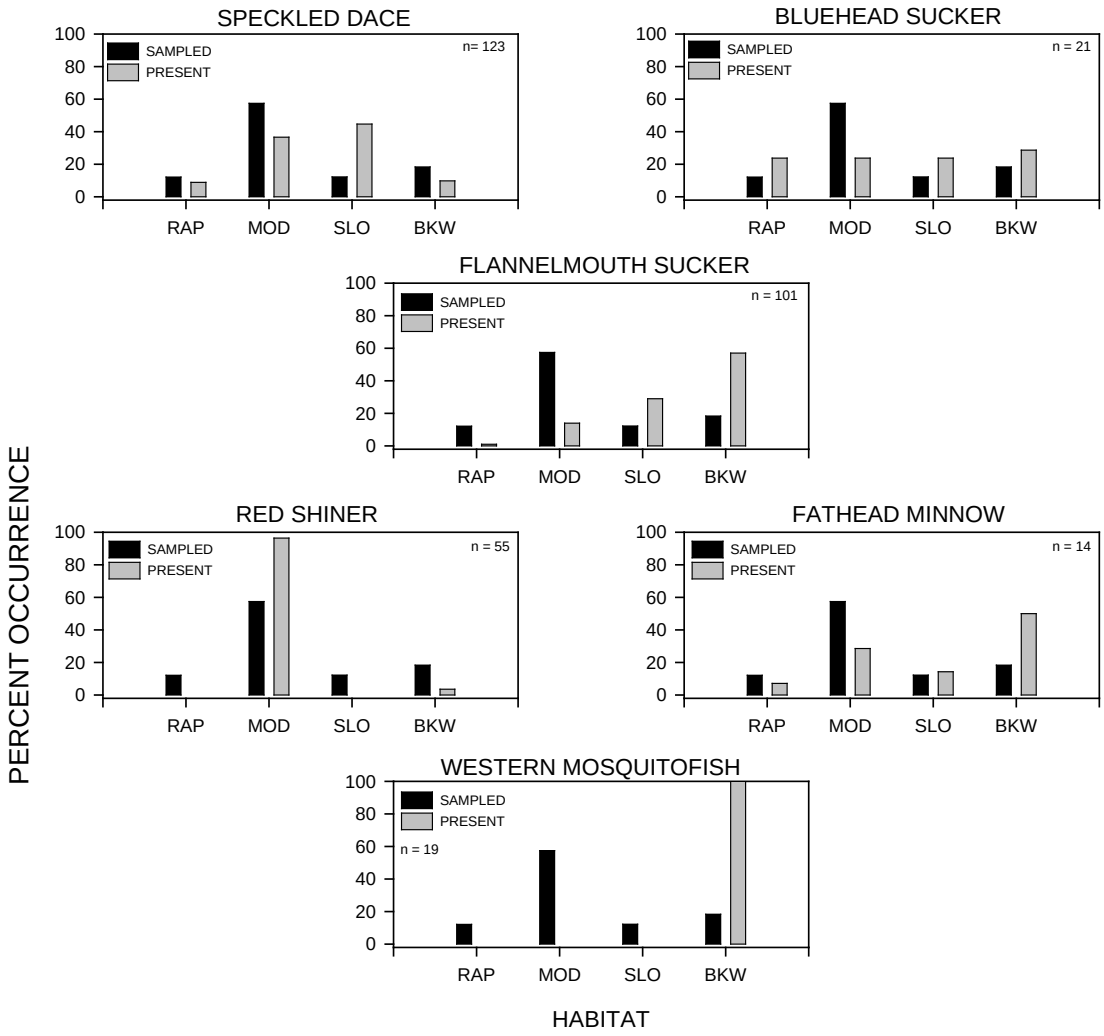


Figure 2. Occurrence of commonly-collected native and nonnative fishes in Reach 6 primary channel mesohabitats, San Juan River, 2003.

REACH 6—SECONDARY CHANNELS

Native fishes were never particularly abundant in Reach 6 secondary channels; Speckled dace was present all years, but bluehead sucker and flannelmouth sucker were each absent one year (Table 13). Speckled dace and flannelmouth sucker densities were greatest in 2003, and that of bluehead sucker was greatest in 2002. Red shiner was absent in 1999 and comparatively uncommon from 2000 through 2002, but was

Table 13. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 6 (RM 180 – RM 155) during autumn 1999-2003.

1999			2000			2001			2002			2003		
Species	N	Density	Species	N	Density	Species	N	Density	Species	N	Density	Species	N	Density
RHIOSC	23	0.460	GAMAFF	87	0.713	GAMAFF	25	0.073	PIMPRO	415	4.428	CYPLUT	570	2.421
COTBAI	2	0.040	CYPLUT	58	0.475	RHIOSC	20	0.058	GAMAFF	269	2.892	CATLAT	100	0.425
			CYPCAR	9	0.074	CYPLUT	19	0.056	CYPLUT	246	2.631	RHIOSC	64	0.272
			PIMPRO	5	0.041	PIMPRO	18	0.053	FUNZEB	36	0.387	PIMPRO	54	0.229
			MICSAL	4	0.033	CATDIS	9	0.026	CATLAT	29	0.312	GAMAFF	21	0.089
			RHIOSC	2	0.016	FUNZEB	1	0.003	CATDIS	27	0.289	CATDIS	19	0.081
			CATLAT	1	0.008	MICSAL	1	0.003	RHIOSC	8	0.086	CYPCAR	2	0.008
			CATDIS	1	0.008	ONCMYK	1	0.003	CYPCAR	5	0.053	MICSAL	1	0.004
			FUNZEB	1	0.008									
N		25			168			94			1035			831
Area		50			122			342			93			235.4
Density		0.500			1.377			0.275			11.129			3.530
H		0.279			1.203			1.649			1.434			1.090

the most abundant species in 2003. Autumn density of no commonly collected native species was related to average mean daily spring discharge, average mean daily summer discharge, or days mean daily summer discharge less than 500 cfs (Table 14). Total nonnative fish density was negatively related to average mean daily spring discharge and positively related to days mean daily summer discharge less than 500 cfs. Red shiner was the only species whose autumn density was related to a discharge attribute (average mean spring daily discharge). Except for 1999, when native species were the only fishes collected, nonnative relative abundance was always substantially greater than that of native fishes (Figure 3).

In 2003, about 18% of mesohabitats in Reach 6 secondary channels were rapid-velocity, 65% moderate velocity, and 17% backwaters; no moderate-velocity mesohabitats were sampled in Reach 6 secondary channels. Common native fish species occurrence in mesohabitats was roughly proportional to occurrence of mesohabitats (Figure 4). Red shiner and western mosquitofish were found almost exclusively in moderate-velocity mesohabitats. Fathead minnow was most common in backwaters.

Table 14. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 6 secondary channels (1999-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance

	SPRING Q		SUMMER Q		< 500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVE	-0.045	0.942	0.608	0.277	-0.394	0.512
RHIOSC	0.212	0.733	0.856	0.064	0.610	0.275
CATDIS	-0.780	0.120	-0.396	0.509	-0.823	0.087
CATLAT	-0.851	0.067	-0.383	0.524	-0.644	0.241
NONNATIVES	-0.921	0.026*	-0.552	0.334	0.950	0.013*
CYPLUT	-0.963	0.009*	-0.521	0.368	0.831	0.081
PIMPRO	-0.717	0.173	-0.326	0.592	0.791	0.111
GAMAFF	-0.712	0.177	-0.447	0.450	0.860	0.062

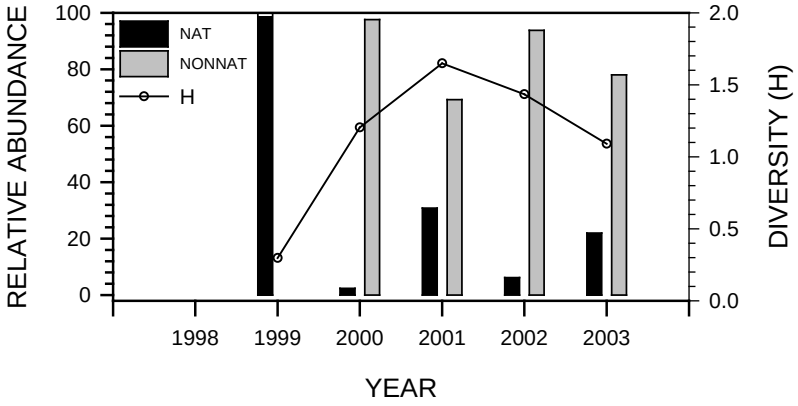


Figure 3. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 6 secondary channels, San Juan River, 1999 - 2003.

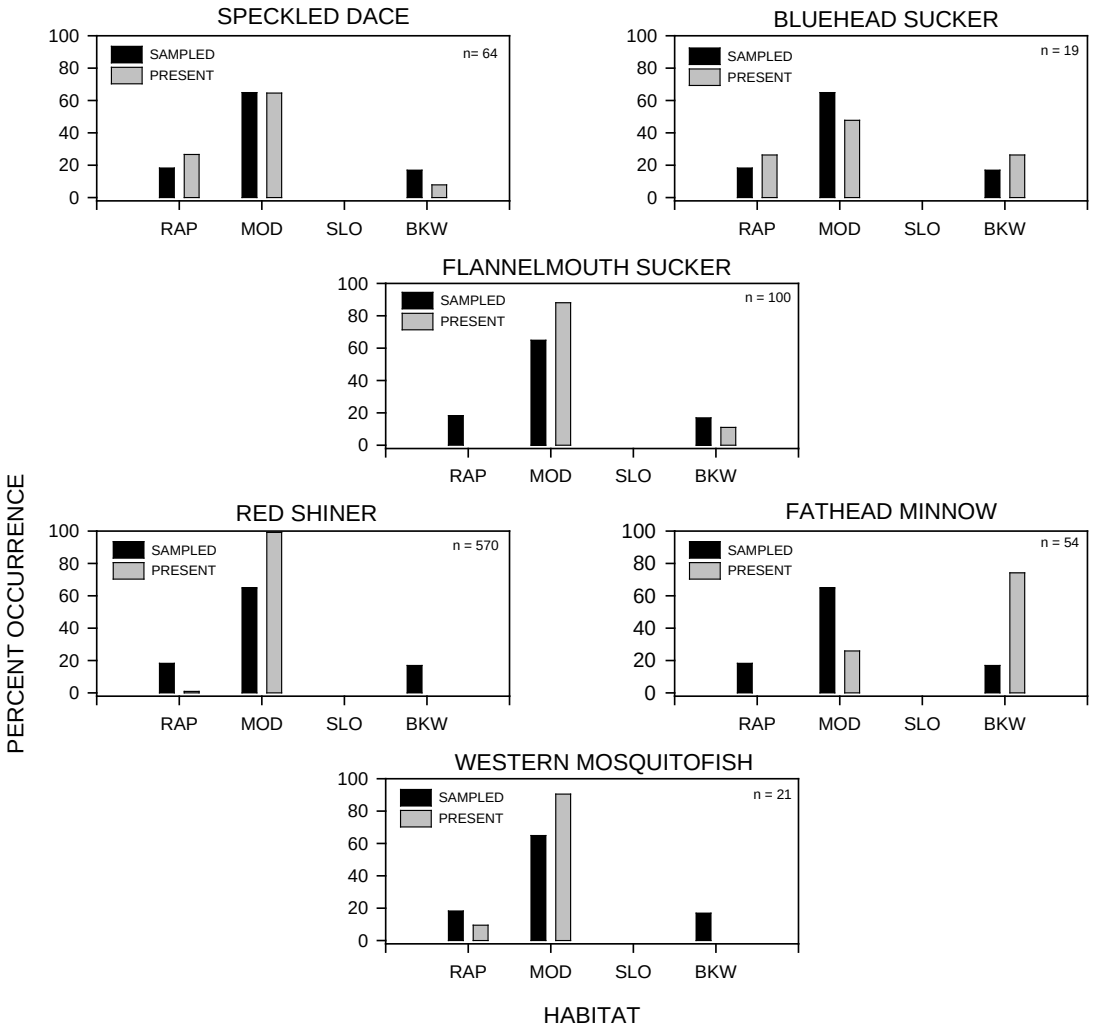


Figure 4. Occurrence of commonly collected native and nonnative species in Reach 6 secondary channel mesohabitats, San Juan River, 2003.

BACKWATERS—REACH 6

No backwater was present in Reach 6 in 1999 or 2002. Nonnative red shiner and fathead minnow were first- and second-most abundant in all other years (Table 15). Except for 2001 when bluehead sucker was moderately common, native fish species were rare or absent in Reach 6 backwaters.

Table 15. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 6 (RM 180 – RM 155) during autumn, 1999 – 2003.

1999	2000			2001			2002	2003		
	SPECIES	N	DEN	SPECIES	N	DEN		SPECIES	N	DEN
N							**N**			
O	CYPLUT	481	4.076	CYPLUT	708	23.600	**O**	CYPLUT	10	0.333
	PIMPRO	162	1.373	PIMPRO	191	6.367		PIMPRO	8	0.267
B	GAMAFF	66	0.560	CATDIS	70	2.333	**B**	CATLAT	2	0.067
A	MICSAL	16	0.136	GAMAFF	25	0.833	**A**	GAMAFF	2	0.067
C	CATDIS	6	0.051	FUNZEB	2	0.067	**C**			
K	CYPCAR	5	0.042	CYPCAR	1	0.033	**K**			
W	RHIOSC	2	0.017	RHIOSC	1	0.033	**W**			
A	CATLAT	2	0.017	CATLAT	1	0.033	**A**			
T	FUNZEB	2	0.017	AMEMEL	1	0.033	**T**			
E							**E**			
R							**R**			
S							**S**			
BKWS N			3			2				2
N			741			1001				22
AREA			118			30				30
DENSITY			6.280			33.367				0.733
H			1.025			0.885				1.162

REACH 6—PRIMARY AND SECONDARY COMPARISONS

Only one channel catfish specimen has been collected in Reach 6 small-bodied fish sampling (primary channel in 1999). Native fishes numerically dominated primary channel collections in 1999 (speckled dace) and 2003 (speckled dace and flannelmouth sucker). In secondary channels, speckled dace numerically dominated collections in 1999, but in subsequent years nonnative fishes (red shiner, western mosquitofish, and fathead minnow) numerically dominated. Red shiner was the most-common species in the primary channel in 2000 and 2002, but was the most-common species in secondary channels only in 2003. Generally, density of common native species in secondary channels mirrored their densities in the primary channel (Figure 5). Commonly-collected nonnative species densities, however, did not (Figure 6). For example, red shiner was

quite common in the primary channel in 2000, but much less common in secondary channels. Greatest density of fathead minnow was in secondary channels in 2002, but it considerably less common in the primary channel that year.

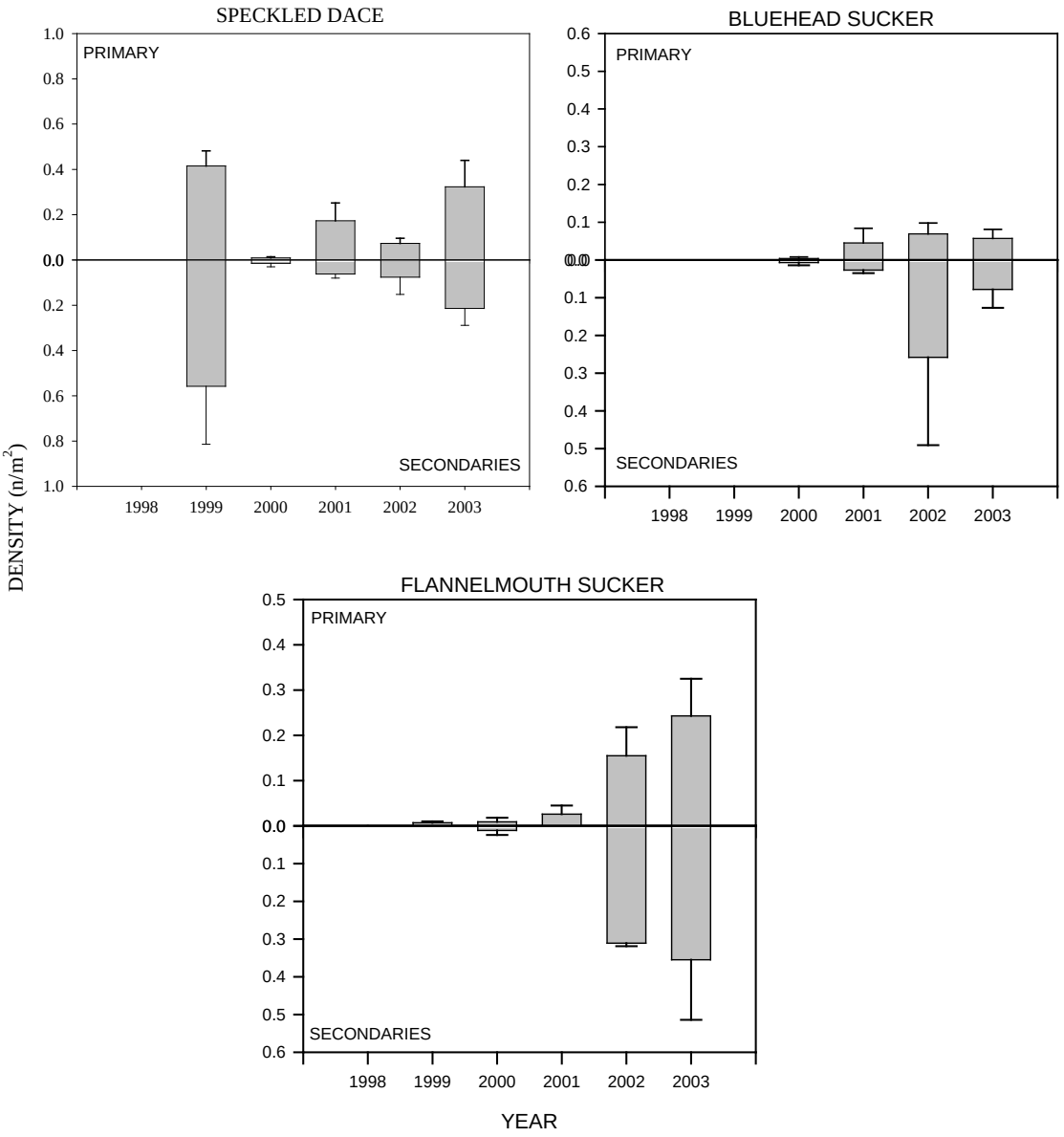


Figure 5. Primary and secondary channels densities of commonly collected native fish Reach 6, San Juan River, 1999 - 2003.

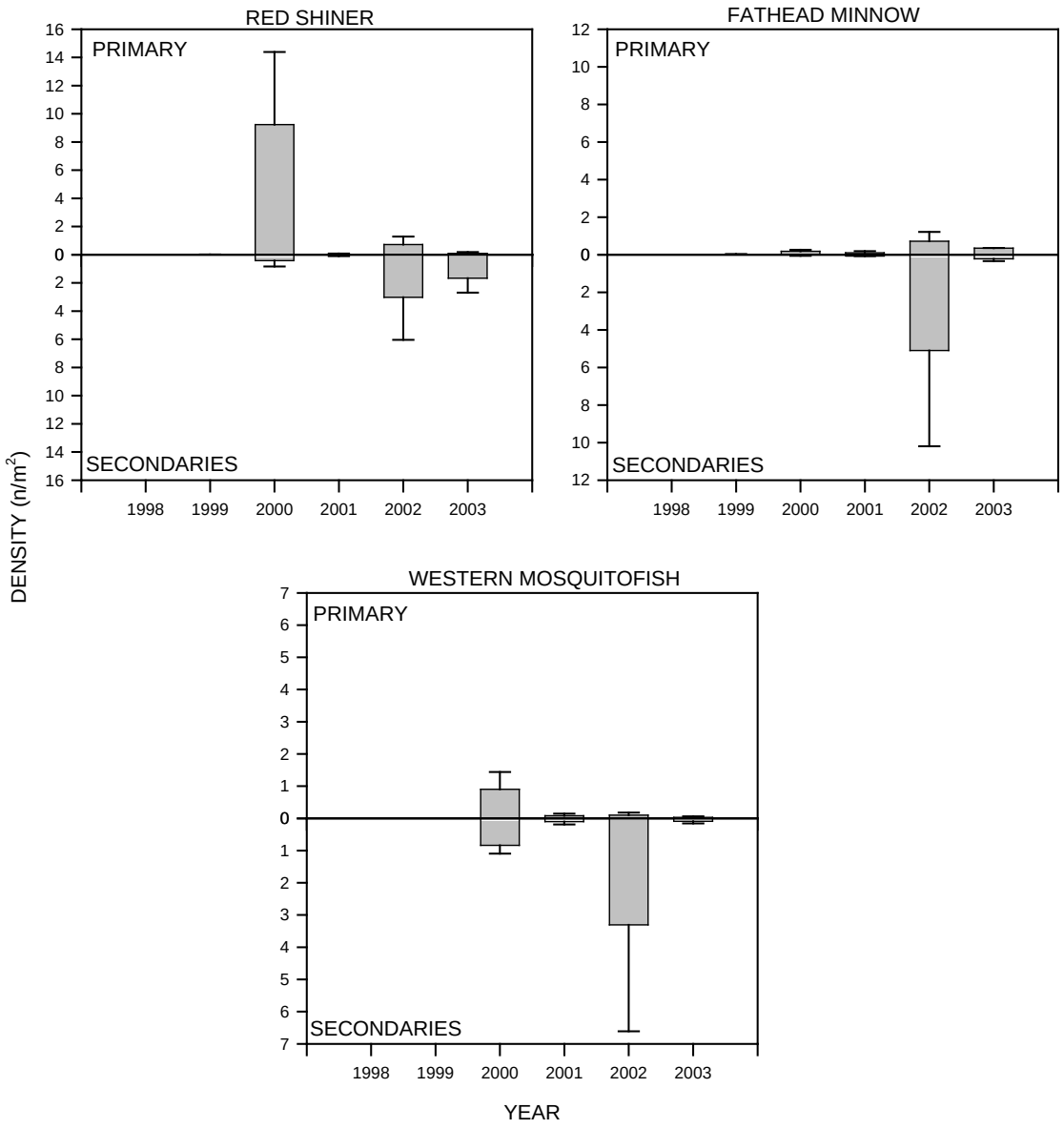


Figure 6. Primary and secondary channels densities of common-collected nonnative fish species in Reach 6, San Juan River, 1999 - 2003.

REACH 5—PRIMARY CHANNEL

Since 1998, four native and seven nonnative fish species have been collected in Reach 5 primary channel (Table 16). Speckled dace was the most common species in 1998 and 1999, but nonnative red shiner was most abundant in subsequent years. Native

Table 16. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 5 during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	78	0.236	RHIOSC	65	0.114	CYPLUT	5219	10.522	CYPLUT	376	0.855	CYPLUT	1033	2.311	CYPLUT	363	0.929
CYPLUT	54	0.164	CYPLUT	20	0.035	GAMAFF	250	0.504	RHIOSC	122	0.277	PIMPRO	206	0.461	RHIOSC	49	0.125
ICTPUN	12	0.036	PIMPRO	4	0.007	RHIOSC	44	0.088	PIMPRO	19	0.043	GAMAFF	80	0.179	GAMAFF	15	0.038
PIMPRO	3	0.009	CATLAT	3	0.005	PIMPRO	42	0.085	GAMAFF	14	0.032	RHIOSC	81	0.181	CATLAT	14	0.036
CATDIS	3	0.009	CATDIS	2	0.004	CATLAT	10	0.020	CATDIS	2	0.005	CATDIS	10	0.022	ICTPUN	14	0.036
CATLAT	2	0.006	ICTPUN	2	0.004	CATDIS	6	0.012	ICTPUN	2	0.005	CATLAT	9	0.020	PIMPRO	7	0.018
GAMAFF	2	0.006	CYPCAR	1	0.002	FUNZEB	1	0.002	CATLAT	1	0.002	ICTPUN	7	0.016	CATDIS	2	0.006
PTYLUC	1	0.003							MICSAL	1	0.002	CYPCAR	2	0.005			
N	155			97			5572			537			1428			464	
AREA	330			568			496			440			447			390.8	
DEN	0.470			0.171			11.234			1.220			3.195			1.187	
H	1.208			1.040			0.296			0.865			0.940			0.838	

suckers were uncommon in all years. One specimen of Colorado pikeminnow was collected in 1998; no other protected species was collected in Reach 5 primary channel. Densities of fathead minnow and western mosquitofish were low in all years, except 2000 (western mosquitofish) and 2002 (fathead minnow). Other than channel catfish, no other ictalurid was collected in Reach 5 primary channel, and it was uncommon in all years. Largemouth bass was the only centrarchid collected in Reach 5. Relative abundance of native fishes was greater than that of nonnatives in 1998 and 1999, but in 2000 nonnative numbers increased dramatically (particularly red shiner) and nonnatives have numerically dominated Reach 5 collections since then (Figure 7). Assemblage diversity was lowest in 2000, when red shiner numbers were high, and did not attain pre-2000 levels from 2001 through 2003. Among native fishes, bluehead sucker autumn density was negatively related to average mean daily spring discharge and positively related to days mean daily summer discharge was less than 500 cfs (Table 17). No other native species (including native fishes combined) was related to any discharge attribute.

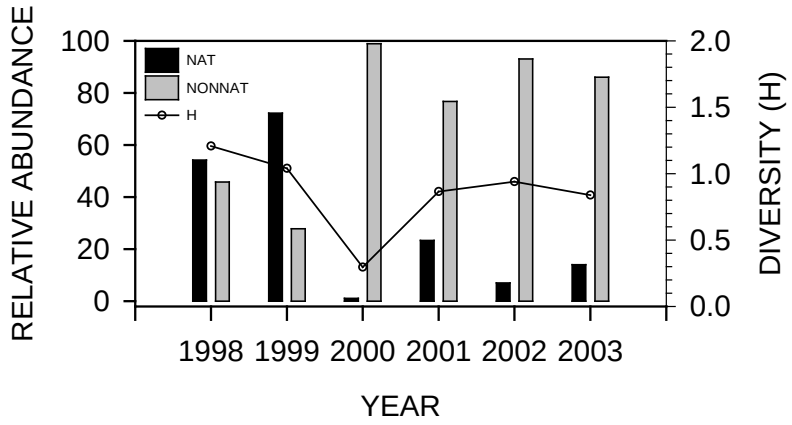


Figure 7. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 5 primary channel, San Juan River, 1998 - 2003.

Table 17. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 5 primary channel (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES	0.349	0.497	-0.276	0.596	-0.104	0.845
RHIOSC	0.405	0.425	-0.294	0.571	-0.135	0.798
CATDIS	-0.710	0.114	-0.473	0.344	0.844	0.035*
CATLAT	-0.855	0.030*	-0.408	0.422	0.648	0.164
NONNATIVES	-0.472	0.344	-0.571	0.237	0.646	0.166
CYPLUT	-0.272	0.603	-0.389	0.446	0.403	0.428
PIMPRO	-0.693	0.127	-0.347	0.501	0.828	0.042*
ICTPUN	-0.267	0.609	-0.268	0.608	0.074	0.889
GAMAFF	-0.402	0.430	-0.434	0.390	0.547	0.262

Fathead minnow autumn abundance was positively related to days mean daily summer discharge was less than 500 cfs.

Moderate-velocity mesohabitats represented about 51% of those sampled in Reach 5 primary channel, rapid velocity comprised 28%, slow velocity about 14%, and 7% were backwaters. Speckled dace occurrence in mesohabitats was similar to occurrence of mesohabitats, except speckled dace was not found in backwaters (Figure 8). Almost all specimens of flannelmouth sucker were found in moderate-velocity mesohabitats. Like speckled dace, red shiner occurrence generally tracked occurrence of mesohabitats. Fathead minnow and western mosquitofish were found exclusively in backwaters. Channel catfish was found mainly in moderate-velocity mesohabitats, but also was collected from backwaters.

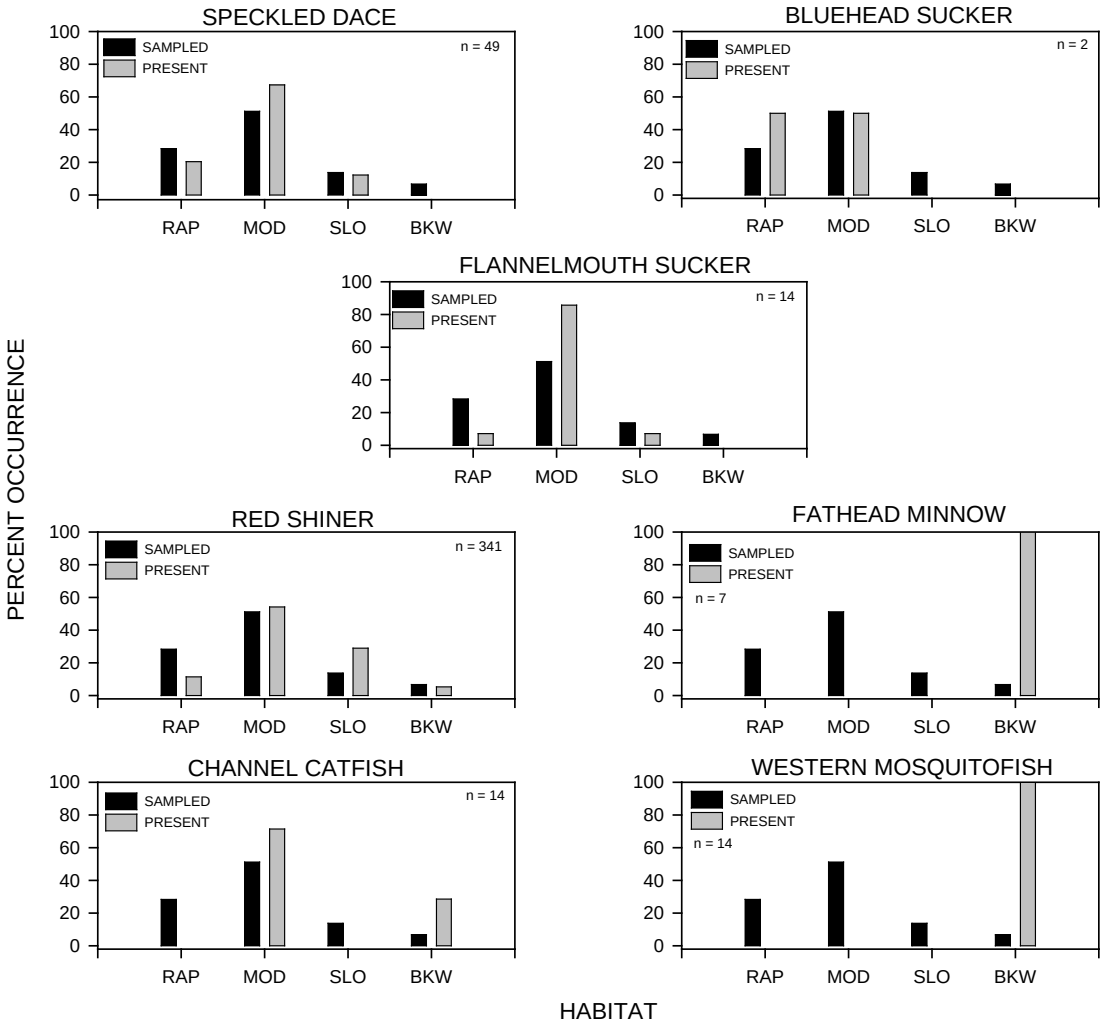


Figure 8. Occurrence of commonly-collected native and nonnative fishes in Reach 5 primary channel mesohabitats, San Juan River, 2003.

REACH 5—SECONDARY CHANNELS

Four native and nine nonnative fish species have been collected in Reach 5 secondary channels since 1998 (Table 17). Greatest density of fishes was in 2000 and least in 1999. In 2000, the combined density of the four most-common nonnative species (red shiner, fathead minnow, western mosquitofish, and common carp) was 27.784/m^2 while that of native fishes (speckled dace, flannelmouth sucker, and bluehead sucker) was 0.163/m^2. Red shiner had greatest density of any species in all years, except in 1999

when speckled dace density was greatest. Fathead minnow had the second-greatest density in all years, except 1998 and 1999. Bluehead sucker and flannelmouth sucker were rare in all years, except 2002 when flannelmouth sucker was comparatively common. One specimen of Colorado pikeminnow was collected in each 1998 and 1999. Density of western mosquitofish was comparatively high in 2000 and 2002, but was much less in other years. Centrarchids (green sunfish and largemouth bass) and ictalurids (channel catfish and black bullhead) were irregularly collected and not common. Although relative abundance of nonnative fishes was always greater than that of native fishes, the difference was more pronounced from 2000 through 2003 than in 1998 and 1999 (Figure 9). Autumn density of bluehead sucker was negatively related to average mean daily spring discharge and positively related to days mean daily summer discharge less than 500 cfs (Table 19). Flannelmouth sucker density was positively related to days mean daily summer discharge less than 500 cfs. Autumn density of no nonnative species was related to any discharge attribute.

Moderate-velocity mesohabitats represented about 44% of area sampled in Reach 5 secondary channels, rapid-velocity areas about 21 %, and slow velocity 35%; no backwater was sampled. The largest proportion of speckled dace collected were found in slow-velocity mesohabitats (Figure 10), and most of these individuals were from riffle eddys. Red shiner, fathead minnow, and western mosquitofish were rare or absent in rapid-velocity mesohabitats and common in slow-velocity areas. Channel catfish was most common in moderate-velocity areas.

Table 18. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 5 (RM 155 – RM 131) during autumn 1998 - 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	267	0.478	RHIOSC	36	0.086	CYPLUT	8984	22.074	CYPLUT	219	0.619	CYPLUT	2790	6.906	CYPLUT	426	1.410
RHIOSC	106	0.190	CYPLUT	32	0.076	PIMPRO	1352	3.322	PIMPRO	38	0.107	PIMPRO	592	1.465	PIMPRO	143	0.473
GAMAFF	87	0.156	PIMPRO	14	0.033	GAMAFF	812	1.995	RHIOSC	35	0.099	GAMAFF	195	0.483	RHIOSC	81	0.268
PIMPRO	46	0.082	CATDIS	2	0.005	CYPCAR	160	0.393	GAMAFF	29	0.082	CATLAT	51	0.126	ICTPUN	6	0.020
CATLAT	7	0.012	CATLAT	2	0.005	RHIOSC	48	0.118	FUNZEB	2	0.006	RHIOSC	49	0.121	GAMAFF	4	0.013
ICTPUN	4	0.007	PTYLUC	1	0.002	CATLAT	10	0.025	CATLAT	1	0.003	FUNZEB	16	0.040	CATDIS	3	0.010
CATDIS	2	0.004	ICTPUN	1	0.002	CATDIS	8	0.020	ICTPUN	1	0.003	CATDIS	14	0.035	CATLAT	3	0.010
CYPCAR	1	0.002	LEPCYA	1	0.002	MICSAL	3	0.007				CYPCAR	11	0.027	FUNZEB	3	0.010
PTYLUC	1	0.002										AMEMEL	1	0.002			
AMEMEL	1	0.002															
FUNZEB	1	0.002															
LEPCYA	1	0.002															
N	524		89			11377			325			3719			669		
AREA	559		419			407			354			404			302		
DENSITY	0.937		0.212			27.953			0.918			9.205			2.214		
H	1.354		1.347			0.725			1.039			0.842			1.994		

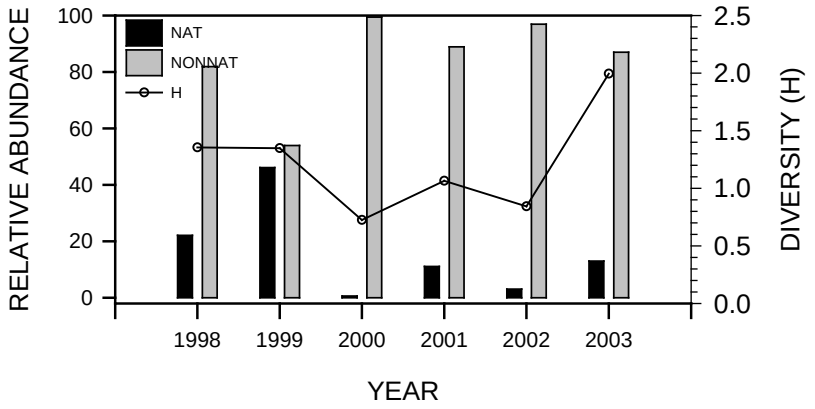


Figure 9. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 5 secondary channels, San Juan River, 1998-2003.

Table 19. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 5 secondary channels (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVE	-0.443	0.379	0.215	0.682	0.049	0.927
RHIOSC	-0.399	0.433	-0.374	0.465	0.172	0.745
CATDIS	-0.844	0.035*	-0.361	0.483	0.883	0.020*
CATLAT	-0.727	0.102	-0.321	0.535	0.819	0.046*
NONNATIVE	-0.576	0.231	-0.565	0.243	0.716	0.109
CYPLUT	-0.600	0.208	-0.553	0.255	0.736	.095
PIMPRO	-0.609	0.199	-0.496	0.317	0.714	0.111
ICTPUN	-0.235	0.654	-0.147	0.781	-0.034	0.949
GAMAFF	-0.296	0.569	-0.423	0.403	0.461	0.357

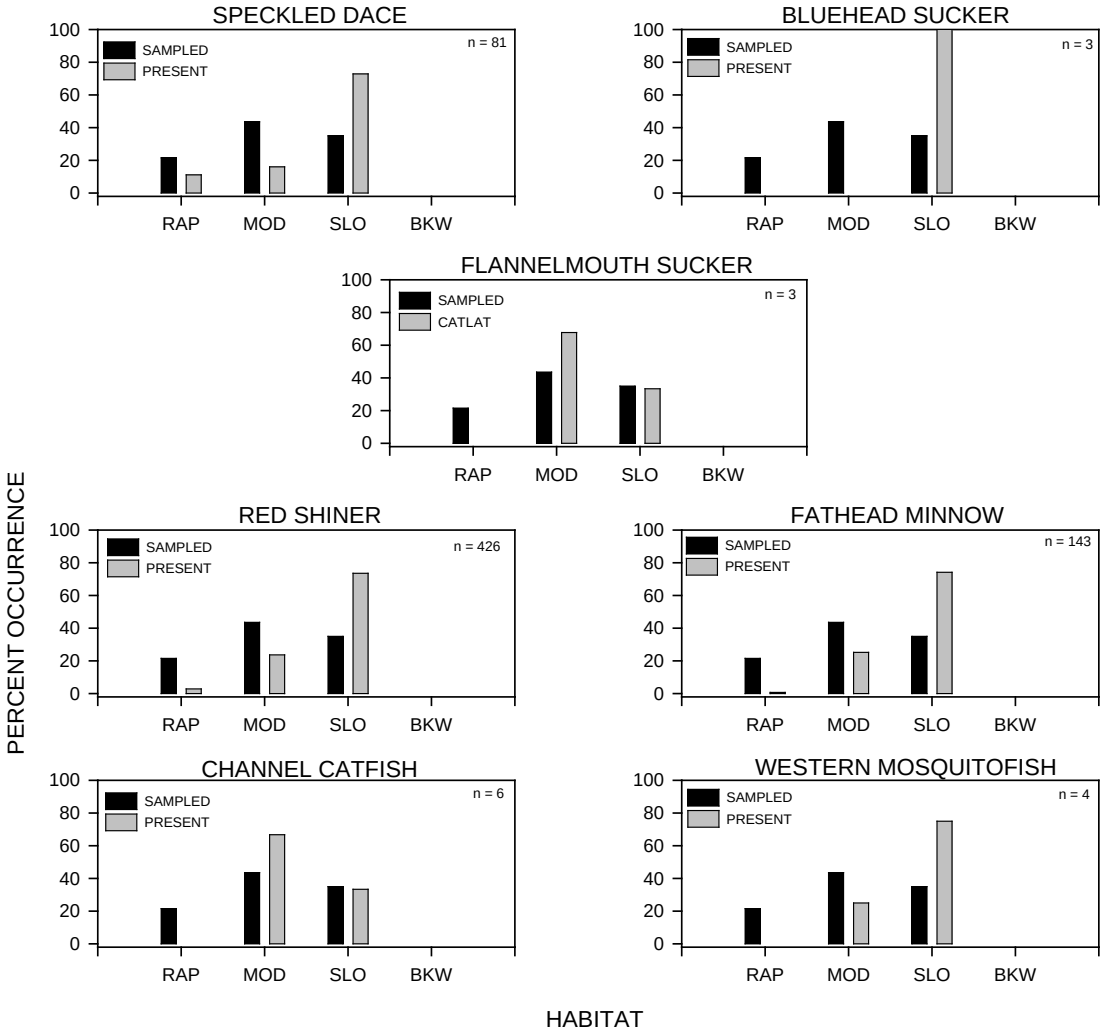


Figure 10. Occurrence of commonly-collected native and nonnative fishes in Reach 5 secondary channels, San Juan River, 2003.

REACH 5—BACKWATERS

Only one backwater was sampled in 1999, but in subsequent years backwaters were more common. Greatest density of fishes in backwaters occurred in 2000, but was also high in 2002 (Table 20). Red shiner was the most-common species in Reach 5

Table 20. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 5 (RM 155 – RM 131) during autumn, 1999 – 2003.

1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	7	0.700	CYPLUT	4965	15.965	CYPLUT	909	5.476	CYPLUT	875	8.413	PIMPRO	101	0.842
PTYLUC	1	0.100	PIMPRO	274	0.881	PIMPRO	65	0.392	PIMPRO	250	2.404	CYPLUT	98	0.817
			GAMAFF	118	0.379	RHIOSC	3	0.018	GAMAFF	12	0.115	CATLAT	4	0.033
			CATDIS	8	0.026	CATDIS	1	0.006	CATLAT	7	0.010	GAMAFF	4	0.033
			CYPCAR	4	0.013	CATLAT	1	0.006	CATDIS	1	0.010	CATDIS	2	0.017
			CATLAT	3	0.010	GAMAFF	1	0.006	CYPCAR	1	0.010	RHIOSC	1	0.008
			RHIOSC	1	0.003	LEPCYA	1	0.006	FUNZEB	1	0.010			
			ICTPUN	1	0.003									
			MICSAL	1	0.003									
BKWS N	1			9			6			6			5	
N	8			5375			983			1147			210	
AREA	10			311			166			104			120	
DENSITY	0.800			17.289			3.944			11.058			1.750	
H	0.377			0.333			0.310			0.636			0.928	

backwaters in all years, except 2003 when fathead minnow was the most-common species. Other than red shiner, fathead minnow was the only comparatively common species in Reach 5 backwaters. Native fish species were rare or absent. One Colorado pikeminnow specimen was collected in 1999.

REACH 5—PRIMARY AND SECONDARY CHANNEL COMPARISONS

Generally, speckled dace density in the primary channel was not mirrored in secondary channels; if it was comparatively high in one, it was comparatively low in the other (Figure 11). Bluehead sucker was present in all years in the primary channel and absent from secondary channels in 2001, but its secondary channel densities in 2000 and 2002 were substantially greater than those of the primary channel. In most years flannelmouth sucker density was greater in secondary channels than the primary; in 2000, 2002, and 2003 differences were substantial. Despite some differences in primary and secondary channels densities of each native species for given years, these differences were not significant. Secondary channel densities of red shiner, fathead minnow, and western mosquitofish in 2000 were substantially greater than their densities any other year in either secondary or primary channel habitats (Figure 12). Each of these species tended to be more common in secondary channels than the primary. In contrast, channel catfish was almost always more common in the primary channel and was absent from secondary and primary channels in 2000. None of these differences, however, was significant.

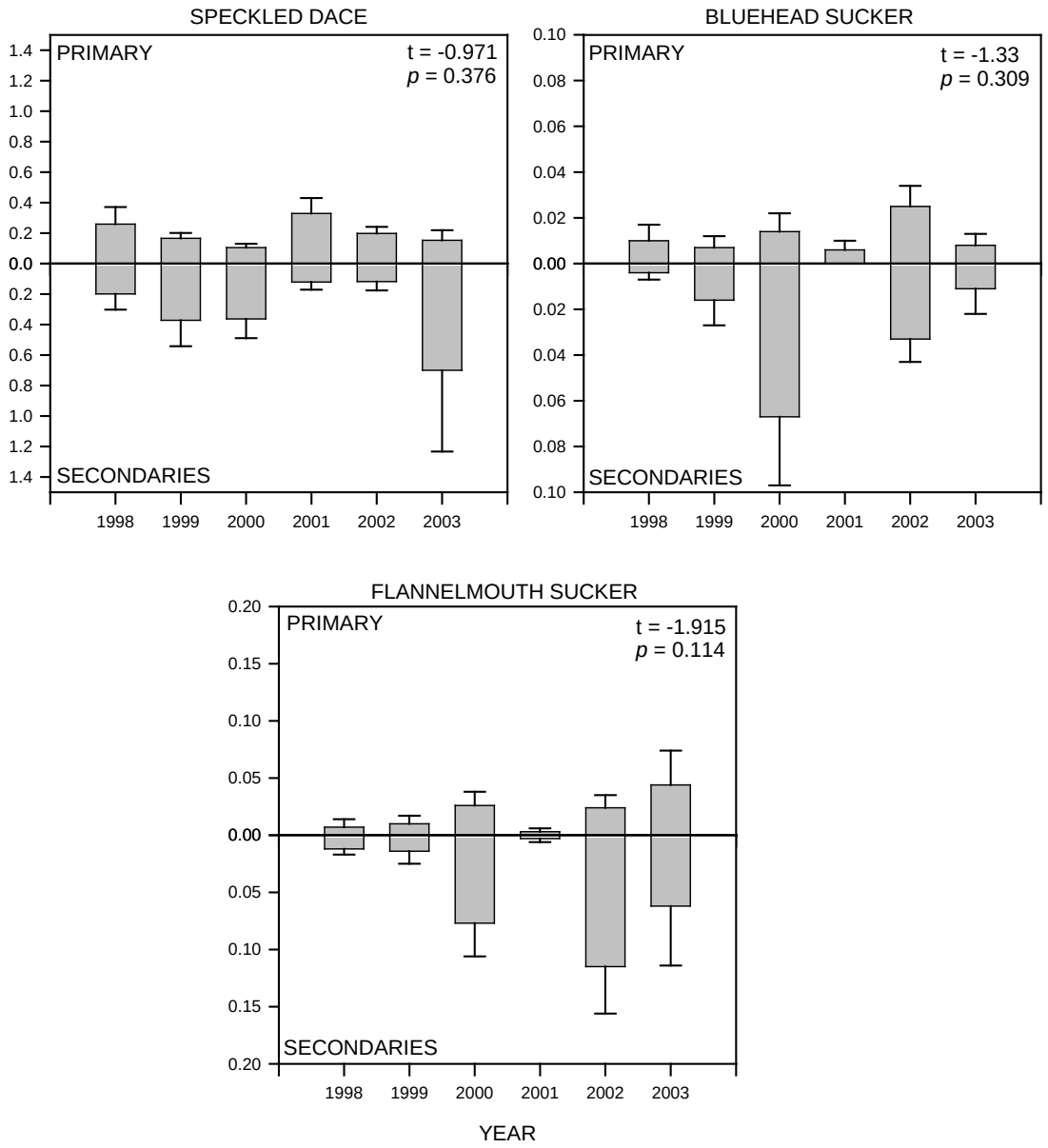


Figure 11. Densities of commonly collected native fishes in Reach 5 primary and secondary channels, San Juan River, 1998 - 2003.

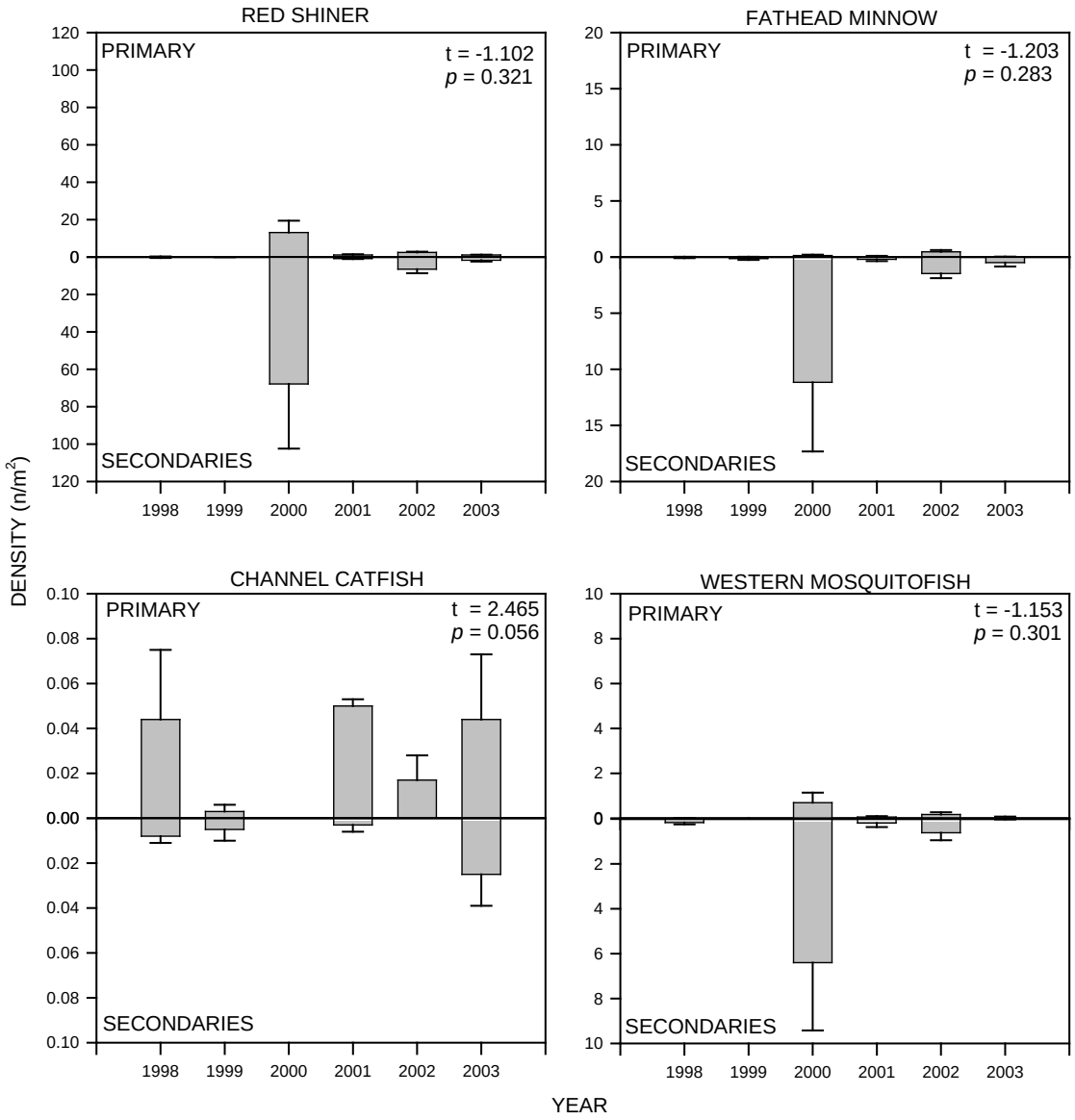


Figure 12. Densities of commonly collected nonnative fishes in Reach 5 primary and secondary channels, San Juan River, 1998 - 2003.

REACH 4—PRIMARY CHANNEL

Five native and eight nonnative fish species were collected in Reach 4 primary channel from 1998 through 2003 (Table 21). Greatest total fish density was in 2002 and least in 1999. Red shiner was the most common species in all years. Speckled dace was

Table 21. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 4 during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	342	1.072	CYPLUT	198	0.294	CYPLUT	3616	3.649	CYPLUT	1102	3.649	CYPLUT	1704	3.221	CYPLUT	370	0.698
RHIOSC	105	0.329	RHIOSC	63	0.094	RHIOSC	50	0.051	RHIOSC	62	0.205	PIMPRO	151	0.327	RHIOSC	127	0.240
ICTPUN	38	0.119	GILROB	1	0.002	GAMAFF	11	0.011	PIMPRO	12	0.040	RHIOSC	92	0.200	ICTPUN	37	0.070
PIMPRO	13	0.041	LATDIS	1	0.002	CYPCAR	4	0.004	GAMAFF	5	0.017	ICTPUN	34	0.074	PIMPRO	30	0.057
GILROB	1	0.003				CATLAT	4	0.004	CATLAT	2	0.007	GAMAFF	17	0.037	CATLAT	5	0.009
PTYLUC	1	0.003				ICTPUN	4	0.004	FUNZEB	2	0.007	CATLAT	17	0.037	FUNZEB	4	0.008
CATLAT	1	0.003				PIMPRO	3	0.003				CATDIS	7	0.015	CATDIS	2	0.004
						CATDIS	1	0.001				CYPCAR	4	0.009	LATDIS	1	0.002
						FUNZEB	1	0.001				FUNZEB	2	0.004	LEPCYA	1	0.002
												AMEMEL	1	0.002			
N	501			263			3694			1090			2029			577	
AREA	319			674			991			302			461			530	
DENSITY	1.570			0.390			3.727			3.609			4.401			1.091	
H	0.916			0.598			0.129			0.334			0.671			1.065	

second-most common in all years, except 2002 when fathead minnow was second-most common. Flannelmouth sucker and bluehead sucker were uncommon in all years. One specimen of Colorado pikeminnow was collected in 1998 and one of roundtail chub in each 1998 and 1999. Except for 2002, fathead minnow was uncommon in all years. Channel catfish was absent in 1999 and 2001, and not common in other years. Native fish relative abundance declined from about 20 % in 1998 to less than 2% in 2000, but increased to nearly 20% by 2003 (Figure 13). Assemblage diversity was lowest in 2000 (when rfed shiner numerically dominated collections); diversity index values in 2003 were similar to those of 1998.

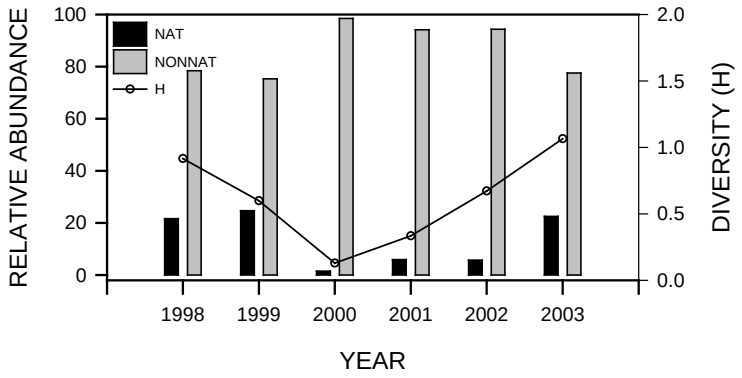


Figure 13. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 4 primary channel, San Juan River, 1998 - 2003.

Autumn density of no nonnative species was related to discharge attributes (Table 22). Bluehead sucker autumn density was negatively related to average mean daily spring discharge and positively related to days mean daily summer discharge less than 500 cfs. Flannelmouth sucker density was positively related to days mean daily summer discharge less than 500 cfs.

Table 22. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 4 primary channel (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES	-0.206	0.695	-0.394	0.440	0.142	0.798
RHIOSC	0.004	0.994	-0.337	0.513	-0.006	0.992
CATDIS	-0.830	0.041*	-0.327	0.527	0.851	0.032*
CATLAT	-0.753	0.084	-0.410	0.420	0.850	0.032*
NONNATIVES	-0.280	0.591	-0.725	0.103	0.629	0.181
CYPLUT	-0.192	0.715	-0.712	0.112	0.588	0.220
PIMPRO	-0.699	0.122	-0.355	0.490	0.783	0.066
ICTPUN	0.342	0.507	-0.352	0.494	0.246	0.639
GAMAFF	-0.491	0.323	-0.436	0.387	0.757	0.081

About 63% of the area sampled in Reach 4 primary channel was moderate-velocity, rapid velocity comprised 16%, slow 17%, and backwaters represented about 5% of total area. Over 60% of speckled dace collected were from rapid-velocity mesohabitats (Figure 14). Red shiner and channel catfish were most commonly found in moderate-velocity mesohabitats. Red shiner was also comparatively common in other mesohabitats.

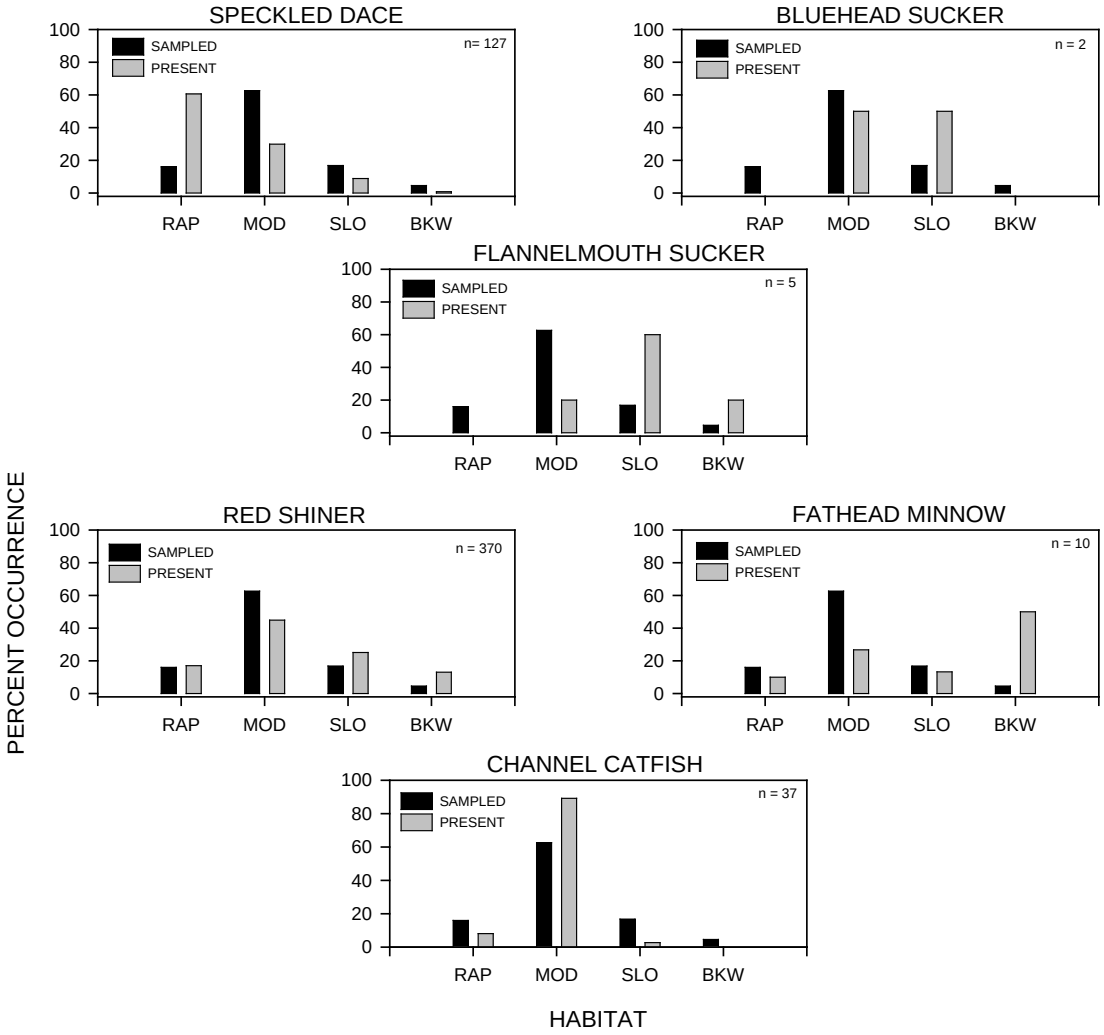


Figure 14. Occurrence of commonly-collected native and nonative fishes in Reach 4 primary channel, San Juan River, 2003.

REACH 4—SECONDARY CHANNELS

Five native and nine nonnative fish species were collected in Reach 4 secondary channels (Table 23). Red shiner was the most common species in all years. Speckled dace was the second-most common species in 1998 and 1999, common carp in 2000, and fathead minnow in subsequent years. Bluehead sucker and flannelmouth sucker were rare in all years, except 2003 when flannelmouth sucker was comparatively common. Two specimens of roundtail chub were collected in 1998 and one in 1999. Three

specimens of Colorado pikeminnow were found in 2000. Western mosquitofish was rare in all years, except 2000 and 2001 when it was comparatively common. Channel catfish was comparatively common in 1998, rare from 1999 through 2002, and again comparatively common in 2003. Other than channel catfish, no ictalurid was collected from 1998 through 2000, but at least one bullhead catfish (black or yellow) was found in subsequent years. Relative abundance of native fishes exceeded 20% in 1998 and 1999, but declined to less than 2% in 2000 and was never greater than 15% in subsequent years (Figure 15). Assemblage diversity was lowest in 2000.

Autumn density of bluehead sucker was positively related to days mean daily summer discharge less than 500 cfs, but autumn density of no other native species was related to any discharge attribute (Table 24). Density of red shiner was likewise positively related to days mean daily summer discharge less than 500 cfs. Autumn densities of other commonly collected nonnative species were not related to discharge attributes.

In Reach 4 secondary channels, about 53% of area sampled was moderate-velocity mesohabitats, 16% was rapid velocity, 23% slow velocity, and 7% was backwaters. Speckled dace was most common in rapid-velocity mesohabitats (Figure 16), but was also common in slow-velocity areas (mainly riffle eddys). Almost all flannelmouth sucker specimens were found in slow-velocity areas. Red shiner was most common in moderate-velocity mesohabitats, but was also common in slow-velocity areas and backwaters. Over 70% of each fathead minnow and channel catfish specimens were found in moderate-velocity areas.

Table 23. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 4 during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	251	0.378	CYPLUT	35	0.084	CYPLUT	2792	5.132	CYPLUT	708	2.192	CYPLUT	1502	4.457	CYPLUT	467	0.981
RHIOSC	122	0.184	RHIOSC	23	0.055	CYPCAR	118	0.217	PIMPRO	131	0.406	PIMPRO	509	1.510	PIMPRO	102	0.214
ICTPUN	73	0.110	ICTPUN	3	0.007	GAMAFF	77	0.141	RHIOSC	43	0.133	RHIOSC	24	0.071	CATLAT	48	0.101
PIMPRO	65	0.098	PIMPRO	2	0.005	PIMPRO	74	0.136	GAMAFF	38	0.118	CATLAT	10	0.030	RHIOSC	44	0.092
GAMAFF	7	0.010	GILROB	1	0.002	RHIOSC	31	0.057	FUNZEB	16	0.050	CYPCAR	8	0.024	ICTPUN	25	0.053
GILROB	2	0.003	CATDIS	1	0.002	CATLAT	9	0.016	CATLAT	4	0.012	CATDIS	8	0.024	FUNZEB	7	0.015
CYPCAR	1	0.001				PTYLUC	3	0.005	ICTPUN	3	0.009	ICTPUN	6	0.018	AMEMEL	4	0.008
CATLAT	1	0.001				CATDIS	2	0.004	CATDIS	1	0.003	AMEMEL	3	0.009	GAMAFF	4	0.008
FUNZEB	1	0.001				ICTPUN	2	0.004	AMENAT	1	0.003	GAMAFF	3	0.009	CATDIS	2	0.004
						MICSAL	2	0.004	CYPCAR	1	0.003	FUNZEB	2	0.009			
						FUNZEB	1	0.002									
N	524			65			3111			946			2075			703	
AREA	664			418			544			323			337			476	
DENSITY	0.789			0.155			5.719			2.929			6.220			1.477	
H	1.352			1.078			0.483			0.892			0.741			1.149	

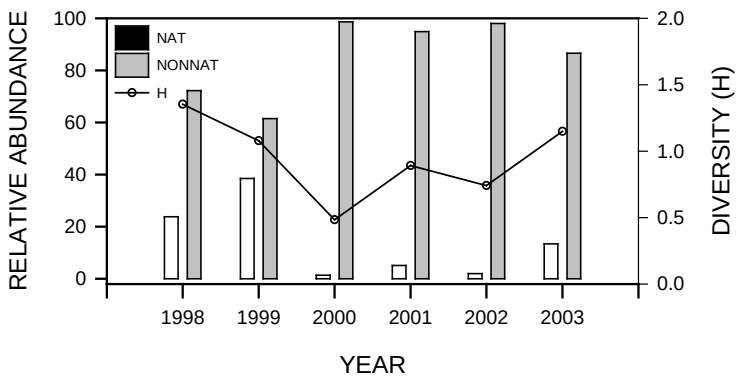


Figure 15. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 4 secondary channels, San Juan River, 1998 - 2003.

Table 24. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 4 secondary channels (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPR Q		SUM Q		<500 CFS	
	r	*p*	r	*p*	R	*p*
NATIVES	-0.264	0.613	-0.173	0.743	0.092	0.862
RHIOSC	0.444	0.378	-0.311	0.548	-0.316	0.542
CATDIS	-0.744	0.090	-0.296	0.569	0.830	0.041*
CATLAT	-0.671	0.145	-0.352	0.494	0.459	0.360
NONNATIVES	-0.506	0.306	-0.671	0.144	0.793	0.060
CYPLUT	-0.536	0.273	-0.698	0.123	0.811	0.050*
PIMPRO	-0.636	0.175	-0.453	0.368	0.810	0.051
ICTPUN	0.079	0.882	-0.198	0.707	-0.187	0.722
GAMAFF	0.232	0.659	-0.730	0.395	0.082	0.877

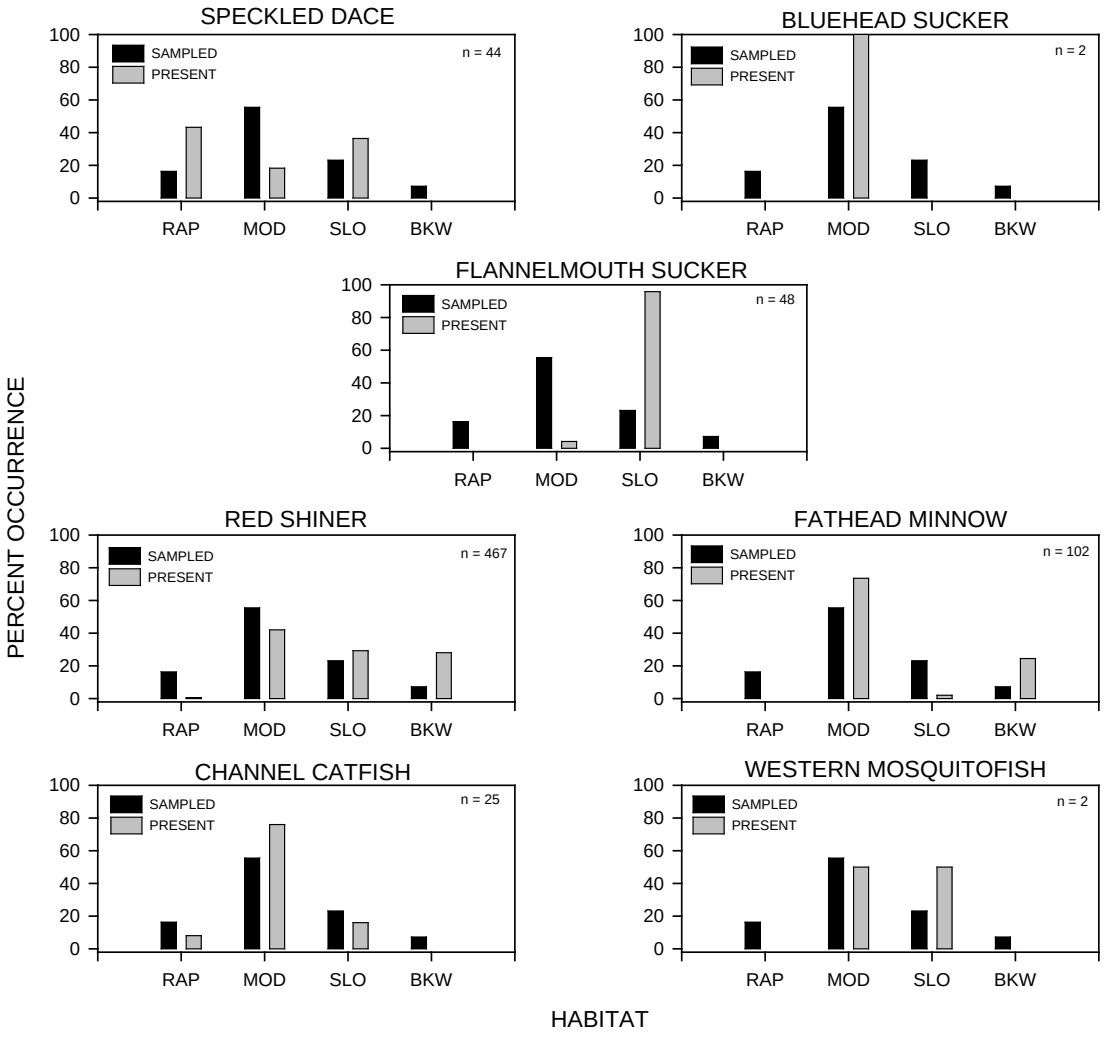


Figure 16. Occurrence of commonly-collected native and nonnative fishes in Reach 4 secondary channels, San Juan River, 2003.

REACH 4—BACKWATERS

Three native and seven nonnative fishes were collected in Reach 4 backwaters. Density of fishes in Reach 4 backwaters peaked in 2000 at 32.9 fish/m^2, when red shiner comprised almost 98% of fishes collected. Red shiner was the most common species in Reach 4 backwaters from 1998 through 2003 (Table 25). Except for 1998 when speckled dace was second-most common, fathead minnow was the second-most common species. flannelmouth sucker and bluehead sucker were always rare or absent. No protected

species was found in Reach 4 backwaters. Channel catfish was collected only in 2002. Black bullhead was absent from 1998 through 2001, but several individuals of the species were collected in each 2002 and 2003.

Table 25. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 4 (RM 131 – RM 107) during autumn, 1999 – 2003.

1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	214	4.864	CYPLUT	7979	32.173	CYPLUT	611	4.629	CYPLUT	1442	12.325	CYPLUT	123	1.640
RHIOSC	1	0.023	PIMPRO	157	0.633	PIMPRO	31	0.235	PIMPRO	455	3.889	PIMPRO	16	0.213
			CYPCAR	11	0.044	RHIOSC	11	0.083	CYPCAR	14	0.120	AMEMEL	11	0.145
			CATLAT	5	0.020	CYPCAR	1	0.008	GAMAFF	9	0.077	CATDIS	1	0.013
			GAMAFF	3	0.012				AMEMEL	7	0.060	RHIOSC	1	0.013
			CATDIS	1	0.004				CATLAT	6	0.051			
									RHIOSC	4	0.034			
									ICTPUN	3	0.026			
									CYPCAR	3	0.026			
									CATDIS	3	0.026			
									FUNZEB	1	0.008			
									LEPCYA	1	0.008			
BKWS N	1		5			6			6			3		
N	215		8156			654			1945			152		
AREA	44		248			132			117			75		
DENSITY	4.886		32.887			4.954			16.624			2.027		
H	0.025		0.085			0.213			0.443			0.664		

REACH 4—PRIMARY AND SECONDARY CHANNELS COMPARISIONS

Speckled dace primary channel density was always greater, and significantly, than that in secondary channels (Figure 17). Bluehead sucker was present in secondary channels in all years, except 1998, and its secondary channel densities were usually greater than those in the primary channel. Flannelmouth sucker also was typically more common in secondary channels than the primary channel. Red shiner density in the primary channel generally mirrored that in secondary channels (Figure 18). Both fathead minnow and western mosquitofish were typically more common in secondary channels than the primary channel. When channel catfish was present in primary channel collections, its density there was usually greater than in secondary channels. However, no difference observed in primary versus secondary channel densities of any commonly collected nonnative species was significant.

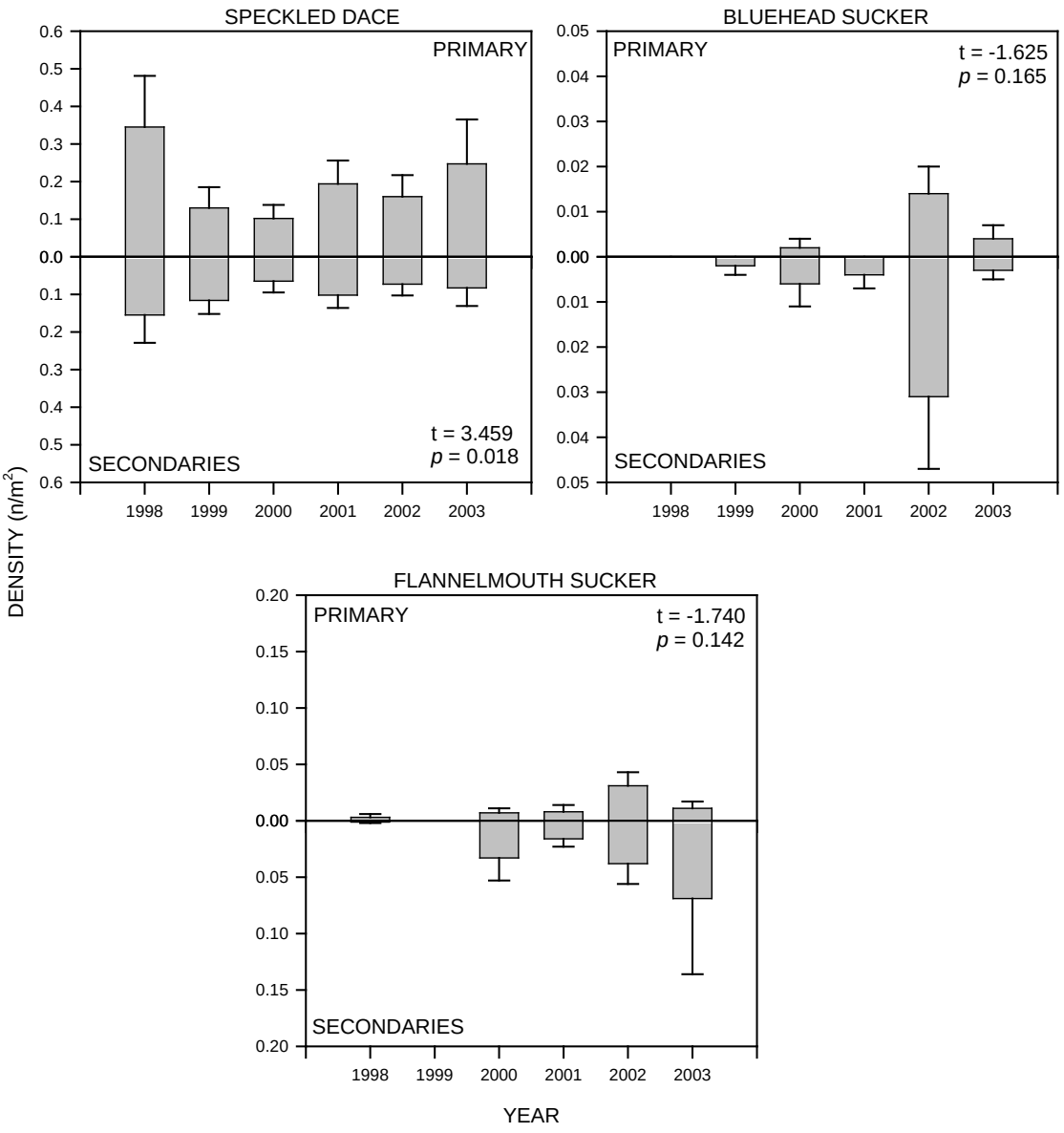


Figure 17. Densities of commonly collected native fishes in Reach 4 primary and secondary channels, San Juan River, 1998 - 2003.

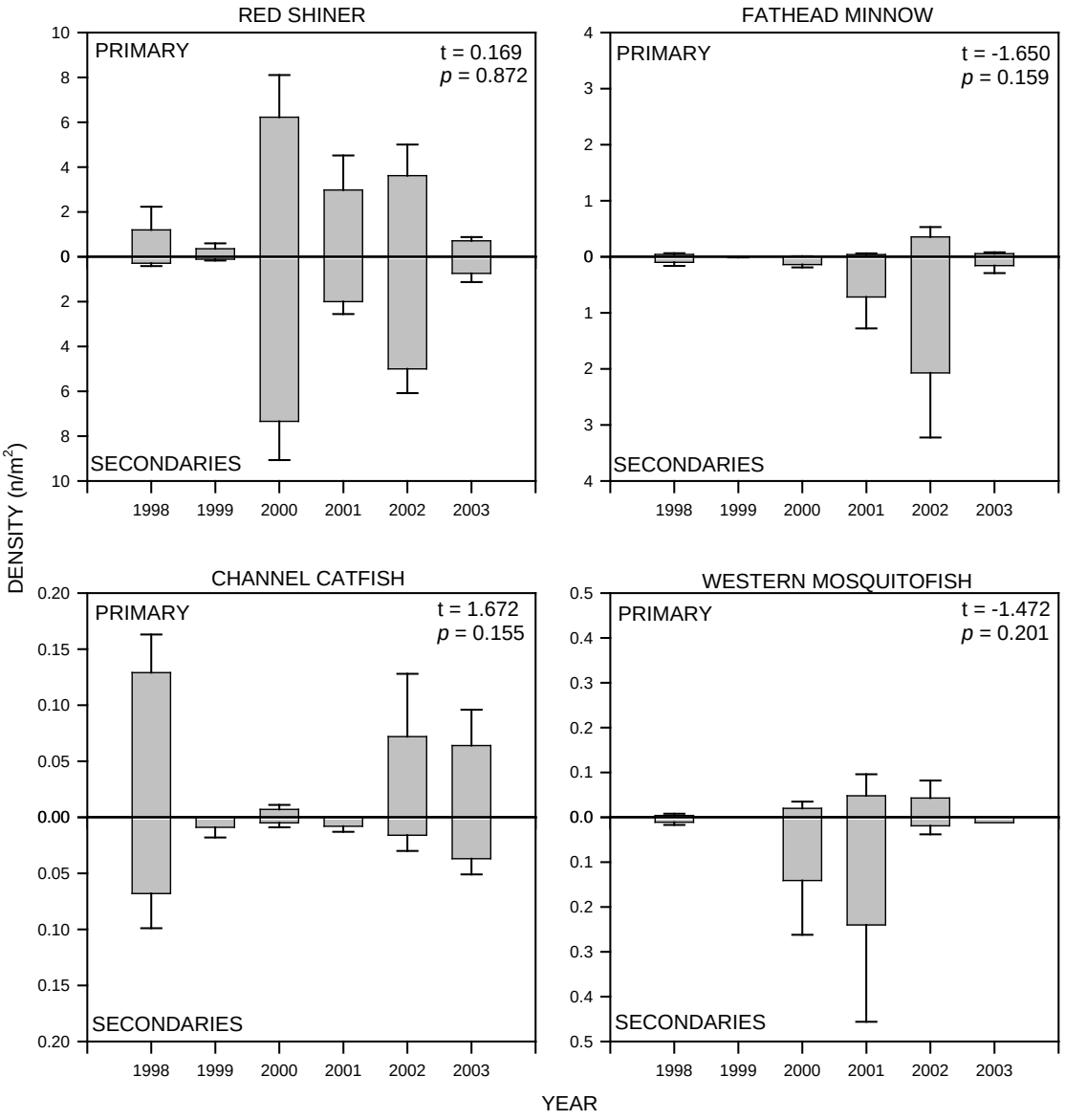


Figure 18. Densities of commonly collected nonnative fishes in Reach 4 primary and secondary channels, San Juan River, 1998 - 2003.

REACH 3—PRIMARY CHANNEL

Between 1998 and 2003, four native and seven nonnative species were collected the Reach 3 primary channel (Table 26). Red shiner was the most common species in all

Table 26. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 3 during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	165	0.254	CYPLUT	65	0.069	CYPLUT	3247	3.286	CYPLUT	1298	1.940	CYPLUT	3162	3.639	CYPLUT	719	0.668
CYPLUT	96	0.148	RHIOSC	21	0.022	GAMAFF	182	0.184	RHIOSC	93	0.139	PIMPRO	413	0.475	RHIOSC	181	0.168
ICTPUN	87	0.134	PIMPRO	1	0.001	PIMPRO	69	0.070	PIMPRO	43	0.064	RHIOSC	269	0.310	ICTPUN	117	0.109
PIMPRO	12	0.019	CATLAT	1	0.001	RHIOSC	48	0.049	GAMAFF	11	0.016	ICTPUN	55	0.061	PIMPRO	37	0.034
CATLAT	4	0.006	CATDIS	1	0.001	CATLAT	14	0.014	CATLAT	3	0.005	GAMAFF	25	0.028	CATLAT	12	0.011
PTYLUC	2	0.003				ICTPUN	7	0.007	ICTPUN	2	0.003	CATLAT	21	0.024	FUNZEB	12	0.011
CATDIS	1	0.002				CATDIS	3	0.003				CYPCAR	13	0.014	CATDIS	2	0.002
FUNZEB	1	0.002				CYPCAR	3	0.003				FUNZEB	8	0.009	GAMAFF	2	0.002
												CATDIS	4	0.004			
												AMEMEL	2	0.002			
N	368			89			3573			1450			3972			1082	
AREA	649			939			988			669			869			1077	
DENSITY	0.567			0.095			3.616			2.167			4.571			1.005	
H	0.922			0.492			0.326			0.339			0.560			1.050	

years, except 1998 when speckled dace was most common. Density of red shiner was greatest in 2002, but was also high in 2000 and 2001. Speckled dace was the second-most common species in 1999, 2001, and 2003; western mosquitofish was second-most common in 2000 and Fathead minnow in 2002. Bluehead sucker and flannelmouth sucker were uncommon in all years. Two specimens of Colorado pikeminnow were collected in 1998. Channel catfish was comparatively common in 1998 and 2003, but was uncommon in other years. Relative abundance of native and nonnative fishes was nearly equal in 1998, but diverged through 2000 when nonnative fishes comprised over 98% of collections (Figure 19). From 2000 through 2003, native fishes relative abundance gradually increased to 18% of collection in 2003.

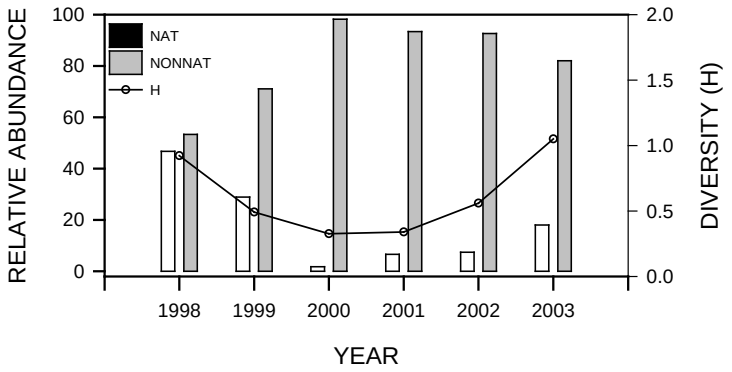


Figure 19. Relative abundance of native and nonnative fishes and assemblage diversity Reach 3 primary channel, San Juan River, 1998 - 2003.

Autumn density of bluehead sucker and flannelmouth sucker was negatively related to average mean daily spring discharge (Table 27). Autumn density of Flannelmouth sucker was positively related to days summer discharge less than 500 cfs.

Table 27. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 3 primary channel (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		< 500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVES	-0.119	0.822	-0.404	0.427	-0.050	0.925
RHIOSC	0.445	0.377	-0.558	0.250	-0.536	0.273
CATDIS	-0.821	0.045*	-0.401	0.431	0.793	0.060
CATLAT	-0.888	0.018*	-0.620	0.189	0.980	0.001*
NONNATIVES	-0.526	0.084	-0.630	0.180	0.806	0.053
CYPLUT	-0.518	0.293	-0.652	0.161	0.804	0.054
PIMPRO	-0.690	0.130	-0.377	0.461	0.831	0.040*
ICTPUN	-0.314	0.544	-0.349	0.498	0.159	0.763
GAMAFF	-0.190	0.718	-0.356	0.489	0.340	0.510

Fathead minnow was the only nonnative species having a significant relationship with any discharge attribute; that was with days summer discharge less than 500 cfs.

Seventy percent of the area sampled in Reach 3 primary channel was moderate velocity. About 12% was rapid velocity, 14% slow velocity, and 4% backwaters. Speckled dace was most common in slow-velocity mesohabitats (mainly riffle eddys), but was also present in rapid- and moderate-velocity mesohabitats (Figure 20). Flannelmouth sucker was most commonly found in rapid- and moderate-velocity areas. Red shiner and fathead minnow were commonly found in all mesohabitats, except rapid velocity. Almost all channel catfish specimens were found in moderate-velocity mesohabitats.

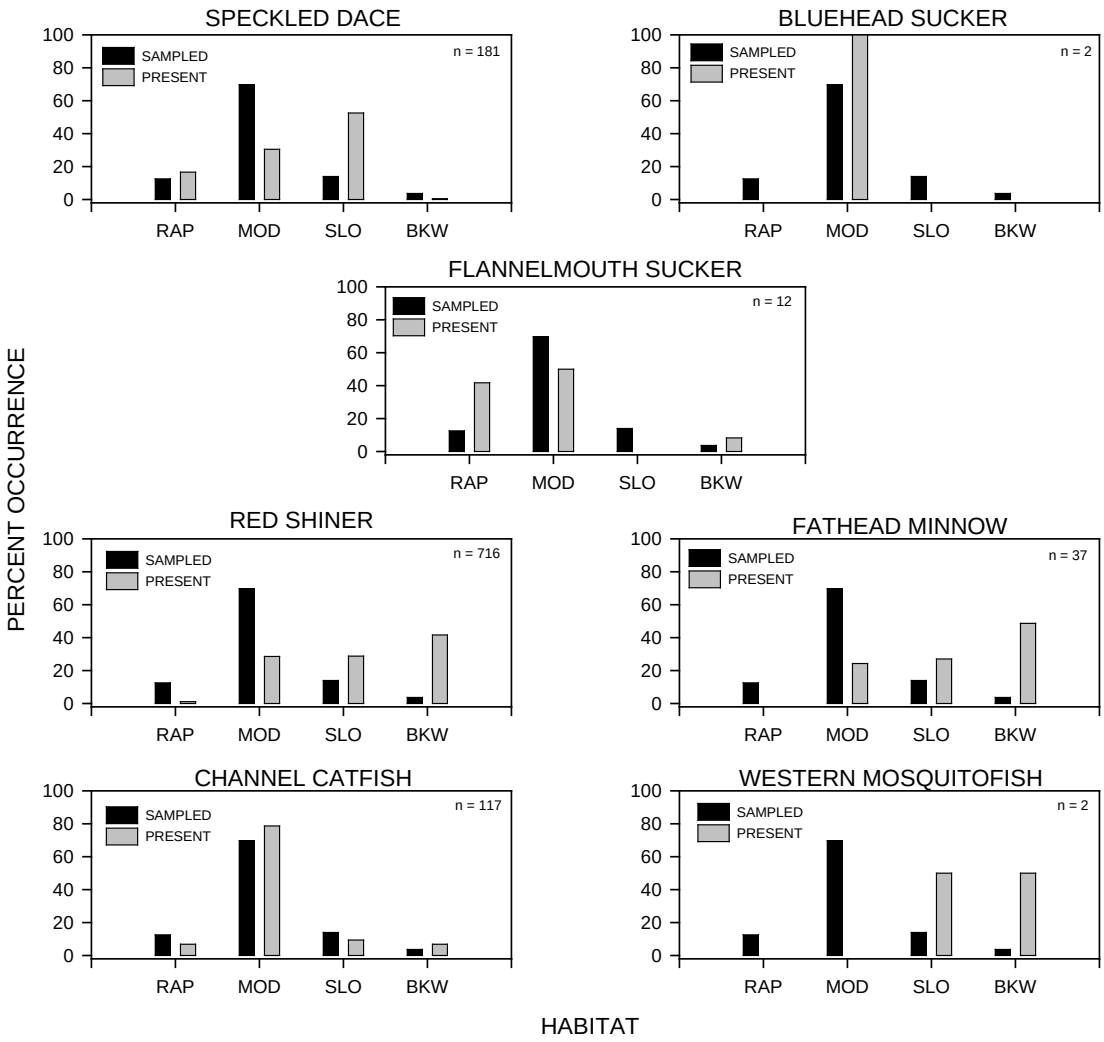


Figure 20. Occurrence of commonly-collected native and nonnative fishes in Reach 3 primary channel, San Juan River, 2003.

REACH 3—SECONDARY CHANNELS

Three native and eight nonnative fish species were collected in Reach 3 secondary channels between 1998 and 2003 (Table 28). Red shiner was the most common species in all years, except 1998 when speckled dace was most common. Speckled dace was the second-most common species in all years, except 1998 (when it was most common) when Red shiner was second-most common, 2000 when western mosquitofish was, and 2002 when fathead minnow was second-most common. Red shiner density was an order of

magnitude greater than the next most common species in all years, except 1998. Bluehead sucker and flannelmouth sucker were rare or uncommon in all years. Western mosquitofish was common in 2000, but uncommon or rare in all other years. Channel catfish was comparatively common in all years. One or a few specimens of bullhead catfishes (black and yellow) were collected in all years, except 1999 and 2000. No centrarchid was collected in Reach 3 secondary channels from 1998 through 2003. Relative abundance of native fishes was slightly greater than that of nonnative fishes in 1998, but in subsequent years relative abundance of nonnative fishes was considerably greater than that of native fishes (Figure 21). Assemblage diversity declined from 1998 through 2000 and generally increased thereafter. No protected species was collected in any Reach 3 secondary channel from 1998 through 2003.

Table 28. Number and density (number/m^2) of fishes in San Juan River secondary channels in Geomorphic Reach 3 (RM 106 – RM 68) during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RHIOSC	372	0.546	CYPLUT	205	0.550	CYPLUT	4885	5.073	CYPLUT	901	1.347	CYPLUT	1886	3.742	CYPLUT	164	0.351
CYPLUT	221	0.324	RHIOSC	32	0.086	GAMAFF	338	0.351	RHIOSC	95	0.142	PIMPRO	265	0.526	RHIOSC	43	0.092
ICTPUN	63	0.092	PIMPRO	4	0.011	RHIOSC	77	0.080	PIMPRO	39	0.058	RHIOSC	143	0.283	ICTPUN	34	0.073
PIMPRO	51	0.075	GAMAFF	3	0.008	PIMPRO	72	0.75	CATLAT	22	0.033	ICTPUN	31	0.061	PIMPRO	11	0.024
GAMAFF	19	0.028	CATLAT	2	0.005	CATLAT	25	0.026	GAMAFF	21	0.031	CATLAT	9	0.018	AMEMEL	3	0.006
CATLAT	5	0.007	CATDIS	1	0.003	ICTPUN	25	0.027	ICTPUN	16	0.024	FUNZEB	6	0.012	GAMAFF	3	0.064
FUNZEB	2	0.003				CYPCAR	22	0.023	AMEMEL	3	0.004	CATDIS	4	0.008	CATLAT	2	0.004
AMENAT	1	0.001				CATDIS	6	0.006	CYPCAR	1	0.001	AMEMEL	4	0.008	FUNZEB	1	0.002
						FUNZEB	3	0.003	CATDIS	1	0.001	CYPCAR	3	0.006			
												GAMAFF	3	0.006			
N	734		247			5456			1099			2354			261		
AREA	681		373			963			669			504			467		
DENSITY	1.078		0.662			5.666			1.643			4.671			0.559		
H	0.894		0.446			0.351			0.568			0.540			1.149		

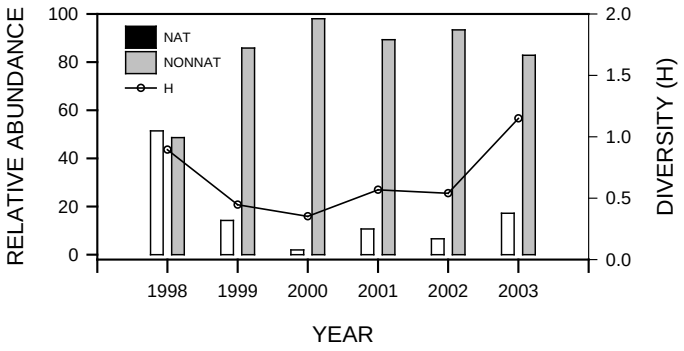


Figure 21. Relative abundance of native and nonnative fish species and assemblage diversity Reach 3 secondary channels, San Juan River, 1998 - 2003.

Autumn density of no commonly-collected native or nonnative species was related to any discharge attribute (Table 29).

Table 29. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 3 secondary channels (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPGQ		SUM Q		<500 CFS	
	r	*p*	r	*p*	r	*p*
NATIVE	-0.064	0.904	-0.207	0.694	0.185	0.726
RHIOSC	0.099	0.852	-0.240	0.647	0.012	0.982
CATDIS	-0.532	0.277	-0.110	0.836	0.649	0.163
CATLAT	0.128	0.809	-0.489	0.325	0.277	0.595
NONNATIVE	-0.467	0.350	-0.347	0.500	0.699	0.123
CYPLUT	-0.427	0.399	-0.433	0.391	0.675	0.142
PIMPRO	-0.517	0.294	-0.470	0.347	0.696	0.125
ICTPUN	-0.400	0.432	-0.582	0.225	0.354	0.491
GAMAFF	-0.036	0.947	-0.300	0.563	0.173	0.743

Moderate-velocity mesohabitats were 75% of those sampled in Reach 3 secondary channels. Almost equal areas of other mesohabitats were sampled in the reach. Speckled

dace was almost equally common in rapid- and slow-velocity (mainly riffle eddys) mesohabitats (Figure 22). All commonly collected nonnative species were most common in moderate-velocity mesohabitats.

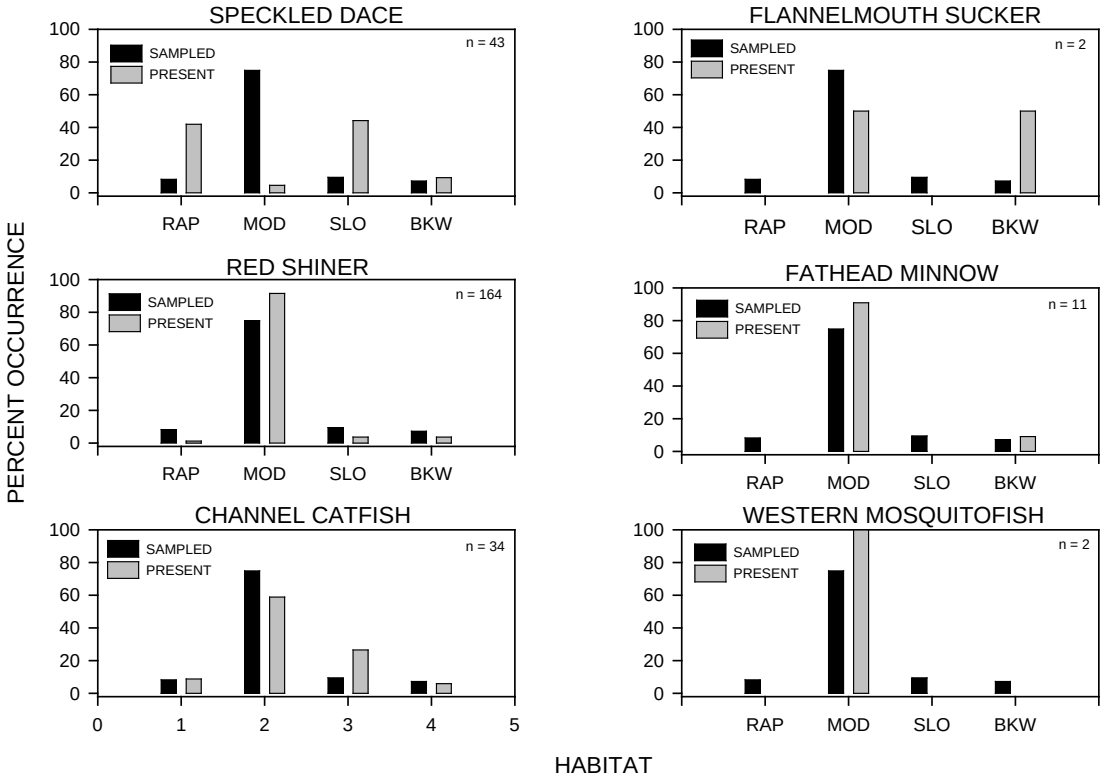


Figure 22. Occurrence of commonly-collected native and nonnative fishes in Reach 3 secondary channel, San Juan River, 2003.

REACH 3—BACKWATERS

Between 2000 and 2003 (no backwater present in 1999), four native and seven nonnative fish species were collected in Reach 3 backwaters (Table 30). Total fish density was high from 2000 through 2002, but was comparatively low in 2003. Nonnnative fishes (red shiner, fathead minnow, and western mosquitofish) numerically dominated collections in all years. Black bullhead was comparatively abundant in 2000, and found in all subsequent years, except 2001. Native fish species, if present, were

never represented by more than a few individuals. One specimen of Colorado pikeminnow was collected in 2000.

REACH 3—PRIMARY AND SECONDARY CHANNELS COMPARISONS

Among years, differences in densities of native fishes in primary and secondary channels were generally small, and not significant (Figure 23). In Reach 3, native fishes tended to be more common in secondary channels than the primary. Secondary channel densities of red shiner, fathead minnow, and western mosquitofish were usually greater than in the primary channel, but not significantly so (Figure 24). Channel catfish primary and secondary channel densities were similar in most years.

Table 30. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 3 (RM 107 – RM 68) during autumn, 1999 – 2003.

1999	2000			2001			2002			2003		
N	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
O												
	CYPLUT	2606	7.642	CYPLUT	2053	12.293	CYPLUT	1881	8.214	CYPLUT	63	1.340
B	GAMAFF	267	0.783	PIMPRO	104	0.623	PIMPRO	674	2.943	GAMAFF	11	0.234
A	PIMPRO	83	0.243	GAMAFF	12	0.072	GAMAFF	45	0.196	PIMPRO	3	0.064
C	AMEMEL	106	0.311	RHIOSC	3	0.018	RHIOSC	28	0.122	ICTPUN	2	0.043
K	CATLAT	5	0.015	CYPCAR	1	0.006	ICTPUN	22	0.096	AMEMEL	1	0.021
W	CYPCAR	4	0.012	ICTPUN	1	0.006	CYPCAR	17	0.074	RHIOSC	1	0.021
A	ICTPUN	2	0.006	FUNZEB	1	0.006	AMEMEL	6	0.026			
T	PTYLUC	1	0.003				CATLAT	6	0.026			
E	FUNZEB	1	0.003				FUNZEB	5	0.022			
R							LEPCYA	2	0.009			
S							CATDIS	1	0.004			
BKWS N		8			8			8			2	
N		3072			2175			2687			81	
AREA		341			167			229			47	
DENSITY		9.009			13.024			11.734			1.723	
H		0.447			0.190			0.582			0.789	

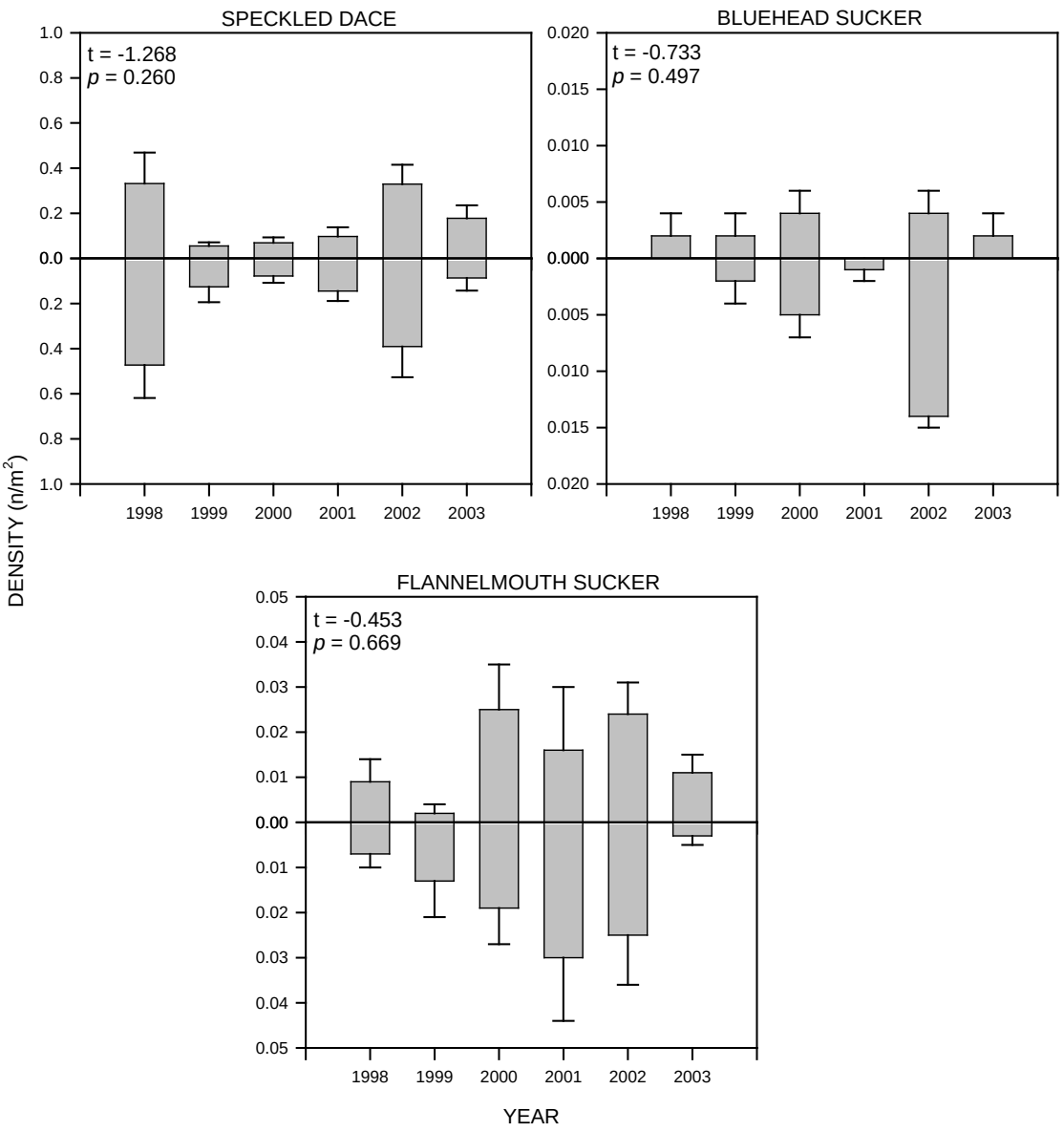


Figure 23. Densities of commonly-collected native fish species in Reach 3 primary and secondary channels, San Juan River, 1998 - 2003.

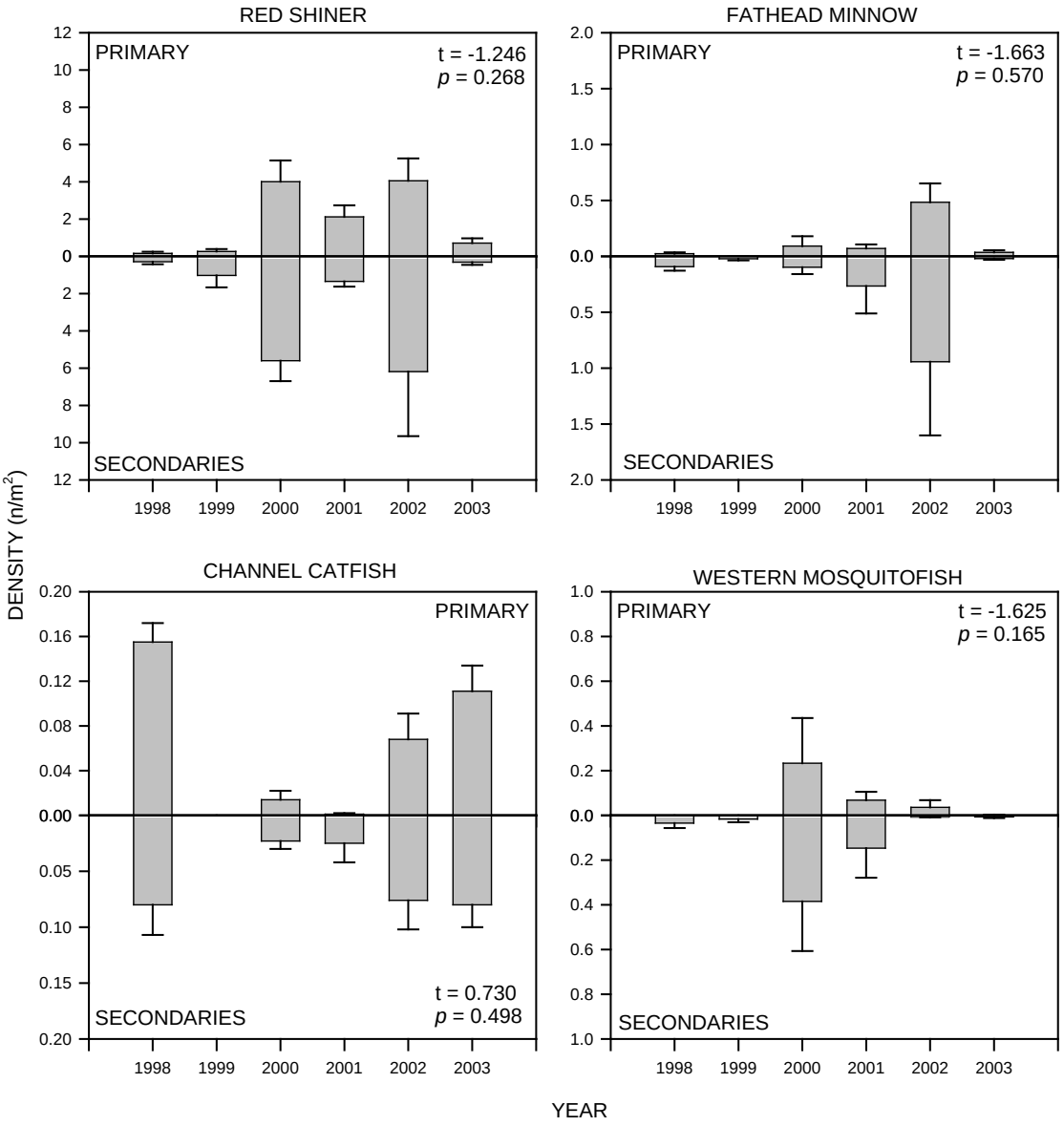


Figure 24. Densities of commonly-collected nonnative species in Reach 3 primary and secondary channels, San Juan River, 1998 - 2003.

REACH 2—PRIMARY CHANNEL

Three native and eight nonnative species were collected in Reach 2 primary channel between 1998 and 2003 (Table 31). Greatest density of fishes occurred in 2000 and least in 1999. Red shiner was the most common species in all years, except 1998 and

Table 31. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 2 during autumn, 1998 – 2003.

1998			1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
RIHIOSC	113	0.242	CYPLUT	173	0.259	CYPLUT	2323	2.074	CYPLUT	638	0.618	CYPLUT	407	0.392	ICTPUN	162	0.141
CYPLUT	98	0.210	RHIOSC	16	0.024	GAMAFF	44	0.039	RHIOSC	18	0.017	ICTPUN	105	0.101	CYPLUT	132	0.115
ICTPUN	50	0.107	ICTPUN	4	0.006	ICTPUN	24	0.021	PIMPRO	16	0.016	RHIOSC	43	0.041	RHIOSC	29	0.086
PIMPRO	4	0.009	PIMPRO	3	.004	PIMPRO	19	0.017	ICTPUN	7	0.007	PIMPRO	32	0.031	CATLAT	8	0.007
CATDIS	1	0.002				RHIOSC	16	0.014	GAMAFF	3	0.003	CATLAT	17	0.016	FUNZEB	4	0.003
CATLAT	1	0.002				CATDIS	6	0.005	CATDIS	1	0.001	CATDIS	4	0.004	GAMAFF	1	0.001
						CATLAT	2	0.002				GAMAFF	3	0.003	LEPCYA	1	0.001
												CYPCAR	3	0.003	PIMPRO	1	0.001
												AMEMEL	1	0.001			
N	267			196			2434			683			615			338	
AREA	467			669			1120			1033			1038			1147	
DENSITY	0.572			0.293			2.173			0.682			0.592			0.295	
H	0.782			0.348			0.205			0.264			0.810			0.771	

2003 when speckled dace and channel catfish, respectively, were most common. In addition to 2003, channel catfish density was comparatively high in 1998 and 2002. Densities of other commonly collected nonnative species were comparatively low in all years in Reach 2 primary channel. Speckled dace density was comparatively high in 1998, but low in subsequent years. Bluehead sucker and flannelmouth sucker were rare, if present, in all years in Reach 2 primary channel habitats. No protected species was collected in Reach 2 primary channel between 1998 and 2003. Relative abundance of native fishes declined from a high of 43% to a low of 1% in 2000 (Figure 25). Thereafter, native fishes relative abundance increased to about 11% through 2003. Assemblage diversity was less than 1.0 from 1998 through 2003. Speckled dace density declined from 1998 through 2000 and then increased through 2003 (Figure 26). In contrast, red shiner density increased from 1998 through 2000 and then declined.

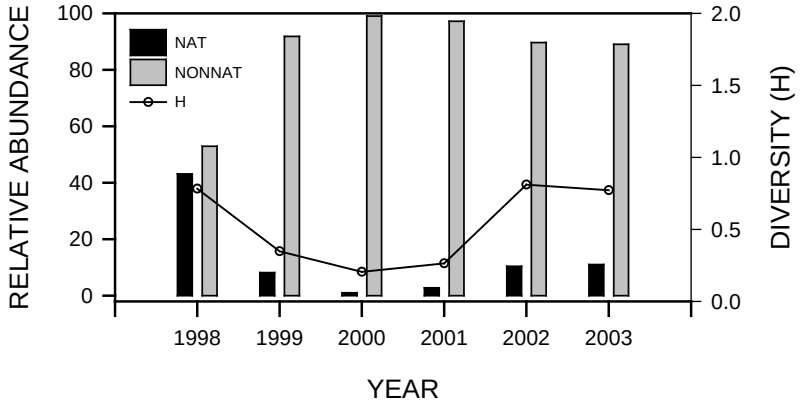


Figure 25. Relative abundance of native and nonnative fishes and assemblage diversity in Reach 2 primary channel, San Juan River, 1998 - 2003.

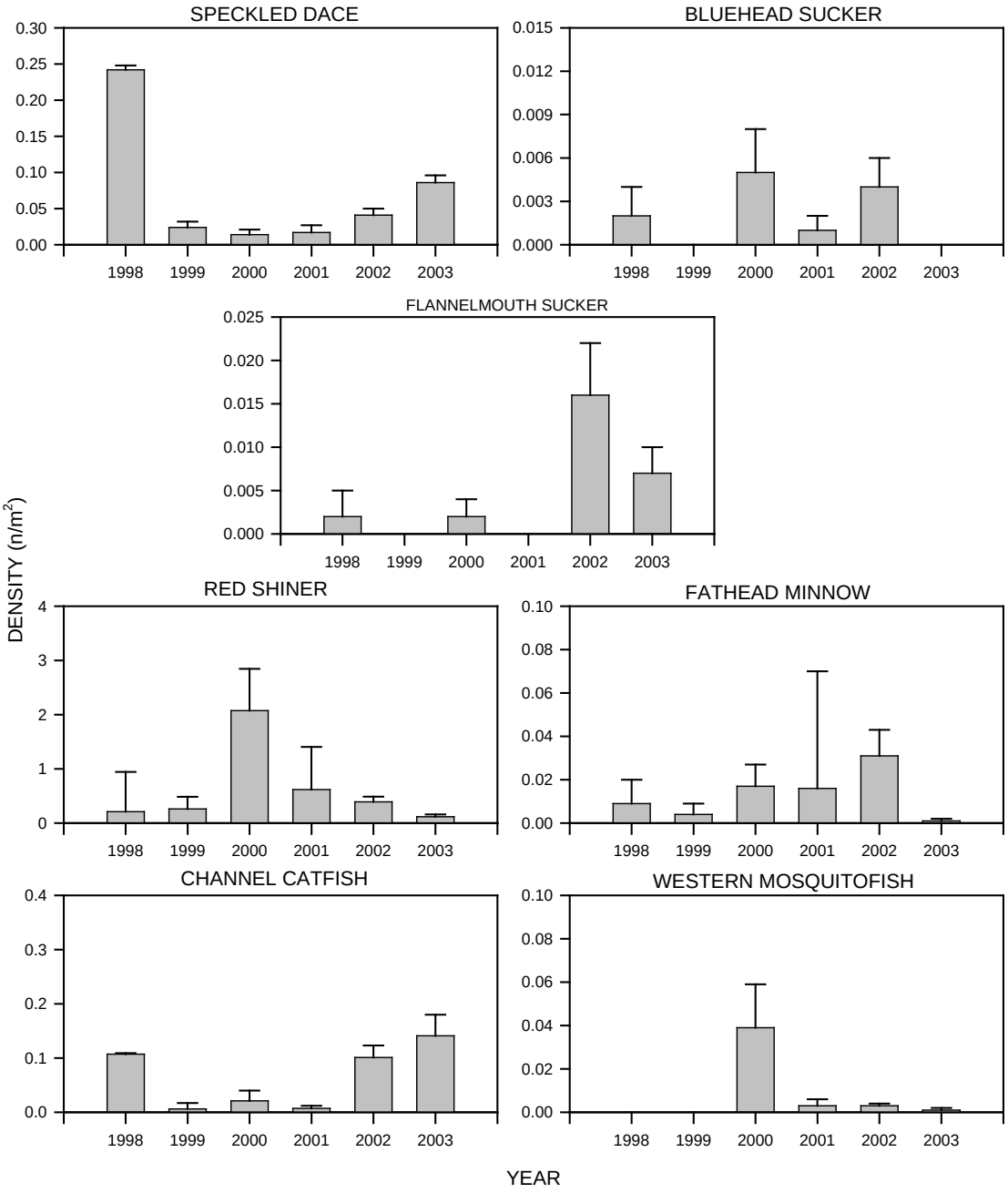


Figure 26. Densities of commonly-collected native and nonnative fish species in Reach 2 primary channel, San Juan River, 1998 - 2003.

Autumn density of flannelmouth sucker was significantly, and negatively, related to average mean daily spring discharge and positively related to days summer discharge less

than 500 cfs (Table 32). Densities of no other native and no nonnative species were related to any discharge attribute.

Table 32. Results of regression analysis of density of commonly-collected native and nonnative fishes in San Juan River Reach 2 primary channel (1998-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		<500 CFS	
	r	*p*	r	*P*	r	*o*
NATIVES	0.250	0.633	-0.773	0.072	-0.427	0.399
RHIOSC	0.201	0.703	-0.169	0.750	-0.245	0.639
CATDIS	-0.344	0.505	-0.558	0.250	0.579	0.229
CATLAT	-0.855	0.030*	-0.381	0.457	0.828	0.042*
NONATIVES	-0.472	0.344	-0.478	0.337	0.752	0.089
CYPLUT	0.012	0.982	-0.490	0.324	0.276	0.597
PIMPRO	-0.337	0.513	-0.526	0.284	0.654	0.159
ICTPUN	-0.404	0.427	-0.381	0.456	0.256	0.624
GAMAFF	-0.133	0.801	-0.313	0.546	0.255	0.625

Sampled Reach 2 primary channel mesohabitats were largely (74%) moderate velocity. Slow-velocity areas comprised 15% of that sampled, rapid 8%, and backwaters 3%. A large proportion (55%) of speckled dace was found in rapid-velocity areas (Figure 27). Most, or all, individuals of each commonly-collected nonnative species was found in moderate-velocity mesohabitats.

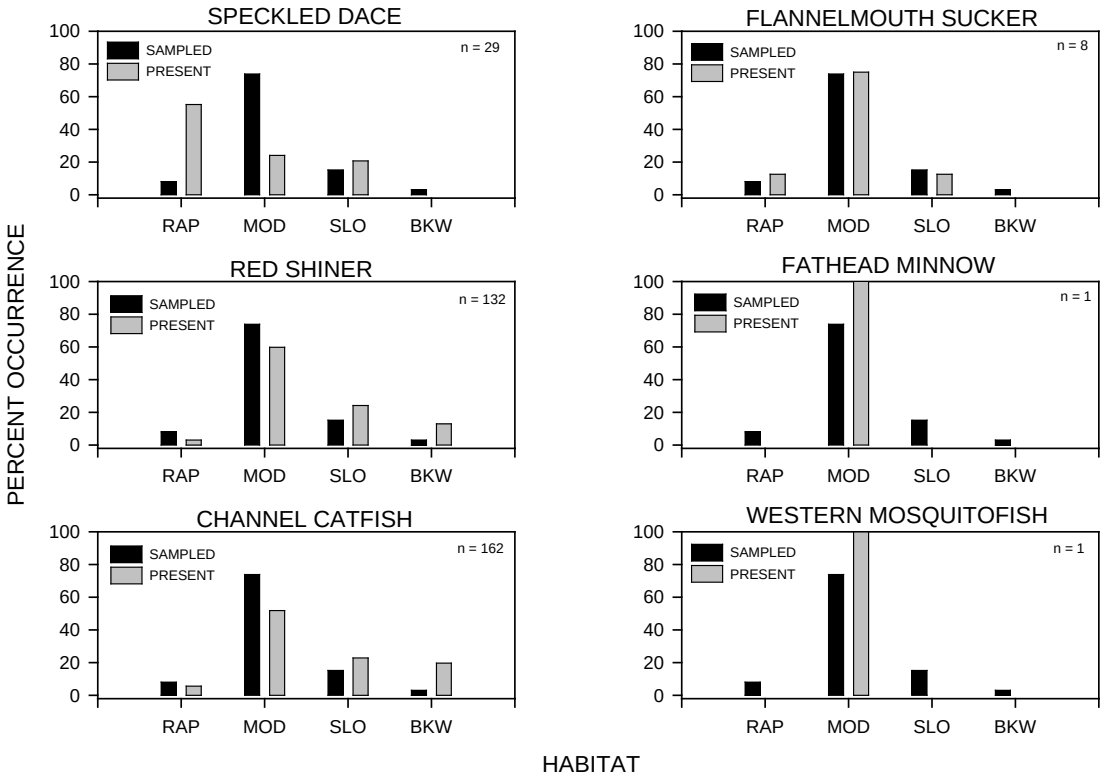


Figure 27. Occurrence of commonly-collected native and nonnative fishes in Reach 2 primary channel. San Juan River, 2003.

REACH 2—BACKWATERS

Three native and seven nonnative fish species were collected in Reach 2 backwaters between 1999 and 2003 (Table 33). Total fish density was greatest in 2000 and least in 2001. Red shiner was the most common species in all years. Fathead minnow was second-most common from 2000 through 2002, but speckled dace was second-most common in 1999 and channel catfish in 2003. Flannelmouth sucker was collected in low numbers in all years, except 2003, and bluehead sucker was collected only in 2000. No protected species was found in Reach 2 secondary channels from 1999 through 2003.

Table 33. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 2 (RM 68- RM 17) during autumn, 1999 – 2003.

1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	130	1.182	CYPLUT	2750	8.567	CYPLUT	30	0.417	CYPLUT	49	0.754	CYPLUT	18	0.439
RHIOSC	7	0.064	PIMPRO	144	0.449	PIMPRO	9	0.125	PIMPRO	36	0.554	ICTPUN	8	0.195
PIMPRO	2	0.018	GAMAFF	114	0.355	CATLAT	1	0.014	CYPCAR	2	0.031	PIMPRO	1	0.024
ICTPUN	2	0.018	ICTPUN	37	0.115				CATLAT	1	0.015	LEPCYA	1	0.024
CATLAT	1	0.009	CATLAT	9	0.028				ICTPUN	1	0.015			
			CYPCAR	5	0.016									
			CATDIS	3	0.009									
			RHIOSC	2	0.006									
			MICSAL	1	0.003									
BKWS N	2			8			5			4			2	
N	141			3065			40			89			25	
AREA	110			321			72			65			41	
DENSITY	1.282			9.548			0.556			1.369			0.610	
H	0.280			0.351			0.428			0.467			0.317	

REACH 1—PRIMARY CHANNEL

Three native and six nonnative fishes were collected in Reach 1 primary channel from 1999 through 2003 (Table 34). Greatest total fish density occurred in 2000 and least in 2003. Red shiner was the most common species in all years. Fathead minnow and channel catfish were each second-most common in two years (1999 and 2001, 2002 and 2003, respectively). Speckled dace, bluehead sucker, and flannelmouth sucker were usually rare, and both suckers were absent at least one year. No protected species was found in Reach 1 primary channel habitats. Greatest density of all commonly collected nonnative species, except channel catfish (2002), was in 2000 (Figure 28). Greatest density of speckled dace and flannelmouth sucker was in 2002 and that of bluehead sucker was 1999 and 2001. As a proportion of each annual collection in Reach 1, native fishes never exceeded 5% (Figure 29). Despite an increase in relative abundance from less than 1% in 1999 to 4% in 2003, total number of native fishes never exceeded 20 specimens in Reach 1. Autumn density of no native fish species was related to any discharge attribute (Table 35). Total nonnative fishes density was significantly, and negatively, related to average mean daily spring discharge and positively related to days summer discharge less than 500 cfs. Red shiner was the only nonnative species having a significant relationship with any discharge attribute (average mean daily spring discharge).

Table 34. Number and density (number/m^2) of fishes in San Juan River primary channel in Geomorphic Reach 1 during autumn, 1999 – 2003.

1999			2000			2001			2002			2003		
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN
CYPLUT	608	1.369	CYPLUT	3651	14.318	CYPLUT	142	0.686	CYPLUT	502	2.154	CYPLUT	76	0.198
PIMPRO	23	0.052	GAMAFF	336	1.318	PIMPRO	3	0.014	ICTPUN	30	0.113	ICTPUN	36	0.094
GAMAFF	6	0.013	PIMPRO	17	0.067	CATLAT	2	0.010	PIMPRO	15	0.056	CATLAT	2	0.005
RHIOSC	2	0.004	CATLAT	1	0.004	ICTPUN	2	0.010	RHIOSC	15	0.056	RHIOSC	2	0.005
ICTPUN	1	0.002	RHIOSC	1	0.004	RHIOSC	1	0.005	CATLAT	3	0.011	CATDIS	1	0.003
			CATDIS	1	0.004				CATDIS	1	0.004	FUNZEB	1	0.003
			CYPCAR	1	0.004				CYPCAR	1	0.004	PIMPRO	1	0.003
N	640			4008			150			567			119	
AREA	444			255			207			266			383	
DENSITY	1.441			15.718			0.725			2.132			0.311	
H	0.191			0.245			0.259			0.387			0.906	

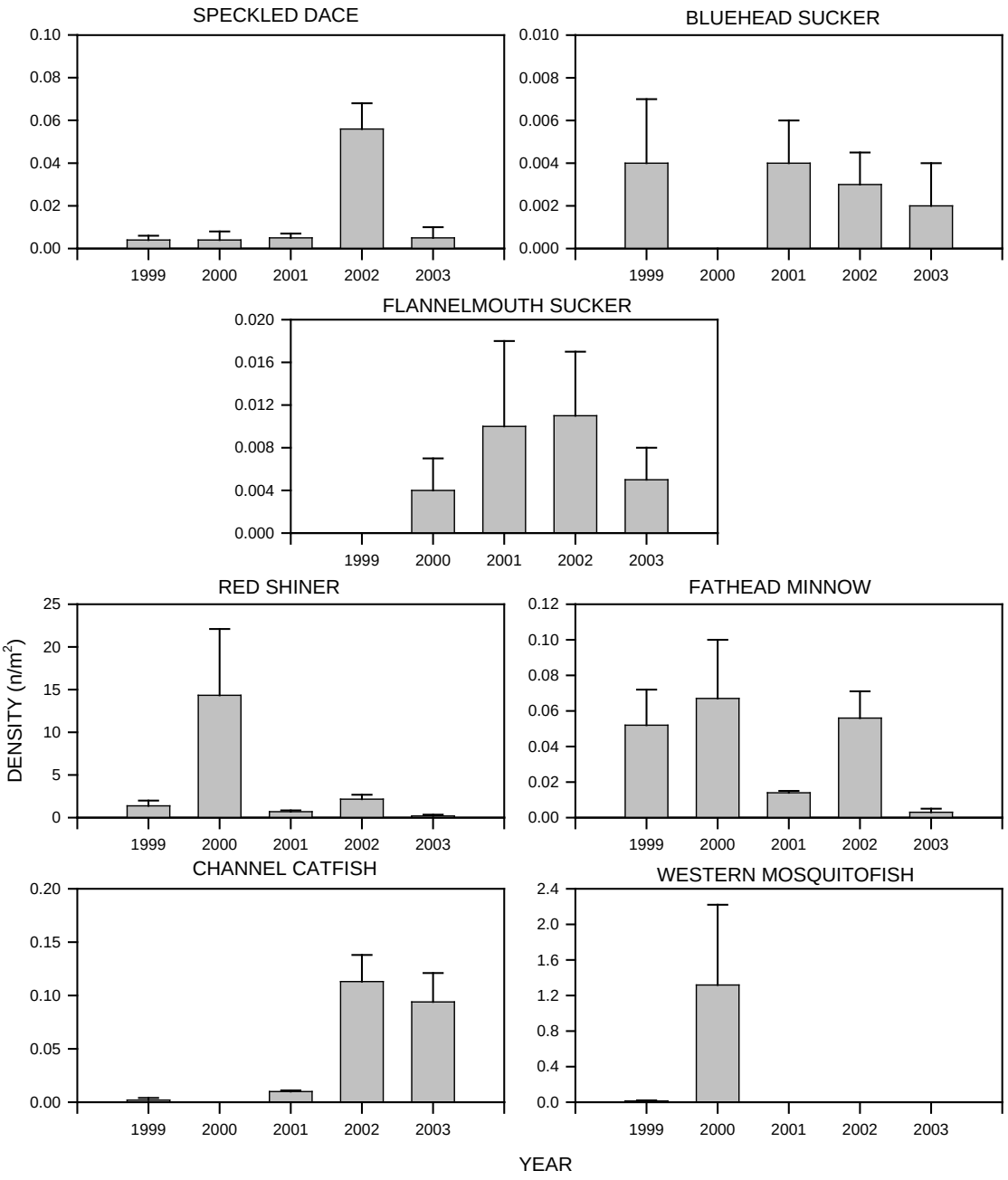


Figure 28. Densities of commoly-collected native and nonnative fish species in Reach 1 primary channel, San Juan River, 1999 - 2003.

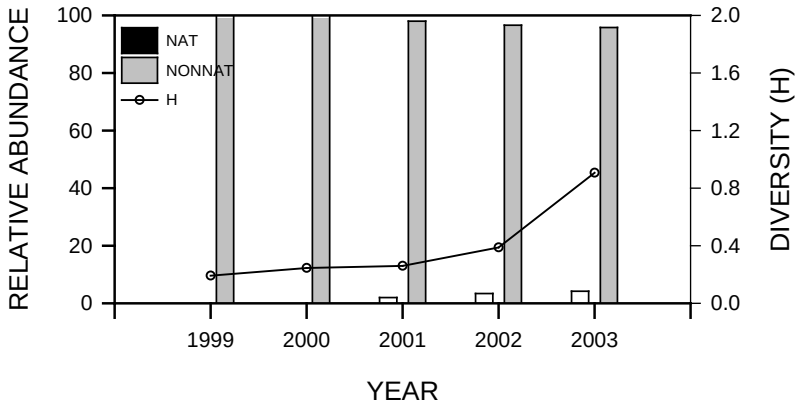


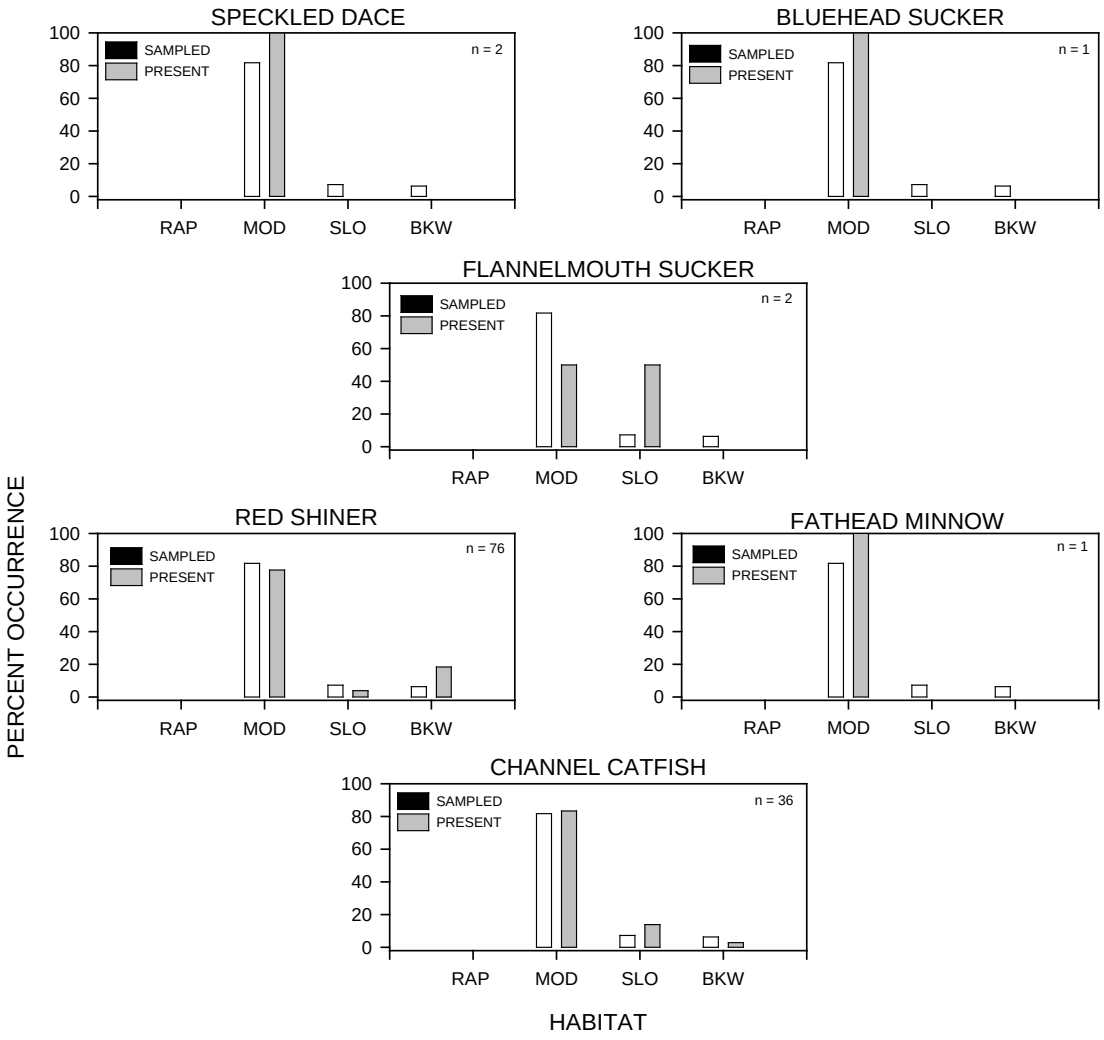
Figure 29. Relative abundance of commonly-collected fish species and assemblage diversity in Reach 1 primary channel, San Juan River, 1999 - 2003.

Table 35. . Results of regression analysis of density of commonly collected native and nonnative fishes in San Juan River Reach 1 primary channel (1999-2003) versus average mean daily spring discharge, average mean daily summer discharge and days mean daily summer discharge less than 500 cfs. An asterisk indicates significance.

	SPG Q		SUM Q		<500 CFS	
	r	p	r	p	r	*p*
NATIVES	-0.045	0.942	0.608	0.277	-0.394	0.512
RHIOSC	0.212	0.733	0.856	0.064	-0.610	0.275
CATDIS	-0.780	0.120	0.396	0.509	0.823	0.087
CATLAT	-0.851	0.067	-0.383	0.524	0.644	0.241
NONNATIVES	-0.921	0.026*	-0.552	0.334	0.950	0.013*
CYPLUT	-0.963	0.009*	-0.521	0.368	0.831	0.081
PIMPRO	-0.617	0.173	-0.326	0.592	0.791	0.111
GAMAFF	-0.712	0.177	-0.447	0.450	0.860	0.062

Over 85% of the area sampled in Reach 1 was moderate velocity. No rapid-velocity mesohabitats were sampled and slow-velocity areas and backwaters were each about 7.5% of area sampled. Few native fishes were collected and almost all were found

in moderate-velocity mesohabitats (Figure 30). Almost all specimens of red shiner and channel catfish were found in moderate-velocity areas.



Figue 30. Occurrence of commonly-collected native and nonnative fishes in Reach 1 primary channel, San Juan River, 2003.

REACH 1—BACKWATERS

No backwaters were present in Reach 1 in 2003. From 1999 through 2002, red shiner was the most common species in Reach 1 backwaters (Table 36). Greatest total density of fishes occurred in 2000, when red shiner comprised over 96% of the

collections. No native fish species was common and none was present in all years. No protected species was found in Reach 1 backwaters.

Table 36. Number and density (number/m^2) of fishes in San Juan River backwaters in Geomorphic Reach 1 (RM 17 – RM 0) during autumn, 1999 – 2003.

1999			2000			2001			2002			2003
SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	SPECIES	N	DEN	**NO**
CYPLUT	87	1.115	CYPLUT	4769	31.977	CYPLUT	97	2.425	CYPLUT	99	2.250	
PIMPRO	6	0.077	GAMAFF	91	0.419	PIMPRO	1	0.025	PIMPRO	14	0.318	**B**
CATLAT	2	0.026	PIMPRO	57	0.263	RHIOSC	1	0.025	ICTPUN	8	0.182	**A**
			CATLAT	9	0.042	ICTPUN	1	0.025	CYPCAR	1	0.023	**C**
			CATDIS	9	0.042	GAMAFF	1	0.025	AMEMEL	1	0.023	**K**
			ICTPUN	4	0.018	CATLAT	1	0.025	GAMAFF	1	0.023	**W**
			CYPCAR	3	0.014							**A**
			LEPMAC	2	0.009							**T**
												E
BKWS N	2			7			4			2		**R**
N	95			4944			104			124		
AREA	78			217			40			44		
DENSITY	1.218			22.783			2.600			2.818		
H	0.256			0.157			0.325			0.501		

SPECIES LONGITUDINAL DISTRIBUTIONS—2003

In 2003, density of commonly-collected native fish species in primary and secondary channels generally declined in a downstream direction (Figure 31). The trend of bluehead sucker and flannelmouth sucker was more pronounced (in both primary and secondary channels) than that of speckled dace. Primary channel density of speckled dace in Reaches 6 through 3 varied, but not substantially, with its highest density being in Reach 6. In contrast, greatest secondary channel density of speckled dace, in Reach 5, was substantially greater than that in other reach secondary channels. Density of red shiner was low in Reach 6 primary channel, was greatest in Reach 5, and generally

declined through Reach 1 (Figure 32). Secondary channel density of red shiner in Reaches 6 and 5 was nearly equal, and declined through Reach 3. Fathead minnow primary channel density was comparatively low in all reaches in which it occurred in 2003. In secondary channels its density increased from about 0.2 in Reach 6 to about 0.4 fish/m^2 in Reach 5 and from there declined to less than 0.1 fish/m^2 in Reach 3. No channel catfish was captured in Reach 6 primary or secondary channels. In primary and secondary channels, its density steadily increased through primary channel Reach 2 and secondary channels Reach 3. Western mosquitofish was most common in upper primary and secondary channels (primary channel Reaches 6 and 5, and secondary channels Reach 6).

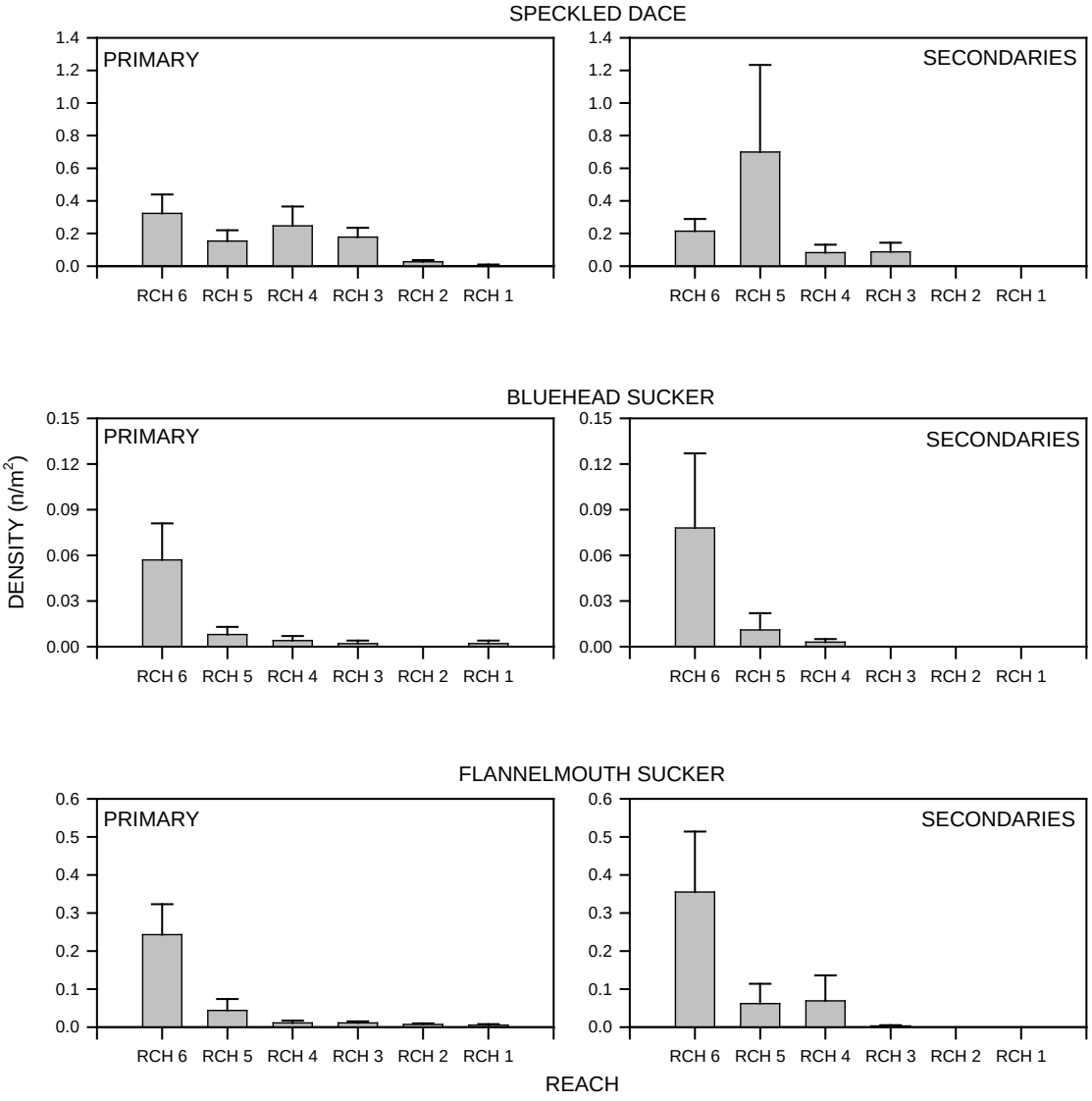


Figure 31. Longitudinal density patterns of commonly-collected native fish species in primary and secondary channels, San Juan River, 2003.

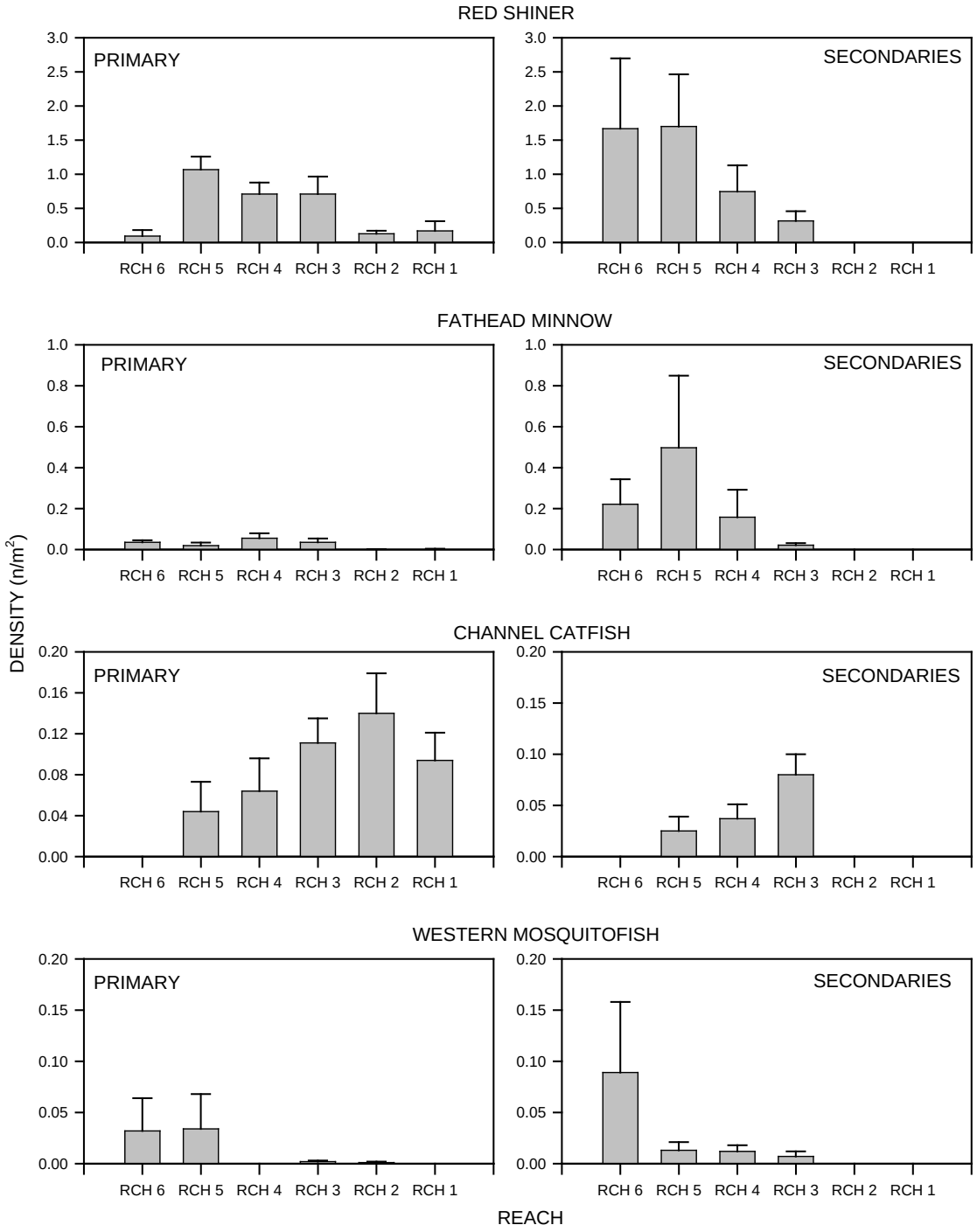


Figure 32. Longitudinal density patterns of commonly-collected nonnative fish species in primary and secondary channels, San Juan River, 2003.

SUMMARY

PRIMARY CHANNEL

1. Since 1998, six native and nine nonnative fishes have been captured in San Juan River primary channel (Reaches 6 through 1).
2. In 2003, three native (speckled dace, bluehead sucker, and flannelmouth sucker) and six nonnative (red shiner, fathead minnow, channel catfish, plains killifish, western mosquitofish, and green sunfish) were captured in San Juan River primary channel (Reaches 6 through 1).
3. Greatest total fish density (4.805 fish/m^2) in San Juan River primary channel was in 2000 and least (0.316 fish/m^2) was in 1999.
4. Greatest total native fish density (0.249 fish/m^2) was in 1998 and least (0.047 fish/m^2) was in 2000. Greatest nonnative fish density (4.758 fish/m^2) was in 2000 and least (0.507 fish/m^2) was in 1998.
5. In 2003, total native fish density in San Juan River primary channel was 0.173 fish/m^2 and nonnative fish density was 0.567 fish/m^2.
6. Red shiner was the most common species in all years and speckled dace was second-most common in all years, except 2000 (western mosquitofish) and 2002 (fathead minnow).
7. Bluehead sucker and flannelmouth sucker were uncommon (<50 individuals/year) from 1998 through 2001, but flannelmouth sucker was comparatively common (>100 individuals/year) in 2002 and 2003 and bluehead sucker in 2002.

8. Channel catfish was comparatively common (>100 individuals/year) in 1998, 2002, and 2003, but was uncommon (<50 individuals/year) in 1999, 2000, and 2001.

9. Colorado pikeminnow (n = 4) was collected in San Juan primary channel in 1998, but not in subsequent years.

10. One specimen of roundtail chub was found in each 1998 and 1999.

11. Other than channel catfish, black bullhead was the only other ictalurid found (2002) in San Juan River primary channel from 1998 through 2003.

12. Centrarchids (green sunfish and largemouth bass) were rare (<5 individuals/year) and none was found in all years.

13. In 2003, greatest density of each commonly collected native fish species was in Reach 6. Density of each generally declined in a downstream direction.

14. In 2003, density of red shiner was greatest in Reach 5 and from there generally declined in a downstream direction. Fathead minnow density was low and similar in Reaches 6 through 3 and zero in Reaches 2 and 1. Channel catfish was absent in Reach 6, steadily increased from Reach 5 through 2, and decreased slightly in Reach 1. Western mosquitofish density was almost equal in Reaches 6 and 5, and was zero, or nearly zero in downstream reaches.

15. Bluehead sucker autumn density was positively associated with days summer discharge <500 cfs in Reaches 5 and 4. Flannemouth sucker autumn density was positively associated with days summer discharge

<500 cfs in Reaches 4, 3, and 2. There was a negative relationship between spring discharge and flannelmouth sucker autumn density in Reaches 5, 3, and 2. Autumn density of bluehead sucker in Reaches 4 and 3 was negatively related to spring discharge.

16. Autumn density of fathead minnow was positively associated with days summer discharge <500 cfs in Reaches 5 and 3. Autumn density of red shiner was negatively related to spring discharge in Reach 1.
17. Native fishes were most commonly found in moderate-velocity mesohabitats, but were also frequently found in rapid-velocity mesohabitats. Speckled dace was commonly found in riffle eddys (slow-velocity habitat) in Reaches 4 and 3.
18. Nonnative fishes were most commonly found in moderate-velocity mesohabitats, but were also common in backwaters.

SECONDARY CHANNELS

1. Since 1998, six native and 11 nonnative fish species have been captured in San Juan River secondary channels (Reaches 6 through 3).
2. In 2003, three native (speckled dace, bluehead sucker, and flannelmouth sucker) and eight nonnative (red shiner, common carp, fathead minnow, black bullhead, channel catfish, plains killifish, western mosquitofish, and largemouth bass) fish species were collected in San Juan River secondary channels.
3. Greatest total fish density (7.580 fish/m^2) in San Juan River secondary

channels was in 2000 and least (0.315 fish/m^2) was in 1999.

4. Greatest total native fish density (0.325 fish/m^2) was in 1998 and least (0.093 fish/m^2) was in 1999. Total native fish density has steadily increased since 1999.
5. In 2003, total native fish density was 0.276 fish/m^2, the highest since 1998. Total nonnative fish density was 1.389 fish/m^2, the lowest density since 1999.
6. Red shiner was the most common fish species in all years. Speckled dace was second-most common in 1998 and 1999, but fathead minnow was second-most common in subsequent years.
7. Bluehead sucker and flannelmouth sucker were uncommon (<50 individuals/year) from 1998 through 1998 through 2001. Flannemouth sucker was comparatively common (>100 individuals) in 2003.
8. Channel catfish was comparatively common (>100 individuals) in 1998, but was uncommon (<50 individuals/year) from 1999 through 2002.
9. Colorado pikeminnow was collected in San Juan River secondary channels in 1998 (n = 1), 1999 (n = 1), and 2000 (n = 3).
10. Two specimens of Roundtail chub were collected in 1998 and one in 1999 in San Juan River secondary channels.
11. Black bullhead and yellow bullhead were found in low numbers (<5 individuals) in most years.
12. Green sunfish and largemouth bass were the only centrarchids found in

San Juan River secondary channels and neither was collected in all years, nor common when present.

13. In 2003, greatest secondary channel density of speckled dace was in Reach 5 and substantially less in other reaches (6, 4, and 3). Densities of both bluehead sucker and flannelmouth sucker were highest in Reach 6 and declined through Reach 3.

14. Reach 6 and 5, red shiner secondary channel density was nearly equal, and declined through Reach 3. Fathead minnow density was greatest in Reach 5. Channel catfish was absent in Reach 6 and increased from Reach 5 through 3. Western mosquitofish density was greatest in Reach 6 and declined through Reach 3.

15. Bluehead sucker autumn density was positively associated with days summer discharge <500 cfs in Reaches 5 and 4, and that of flannelmouth sucker was positively associated with days summer discharge <500 cfs in Reach 5.

16. Red shiner autumn density was negatively associated with spring discharge in Reach 6 and positively associated with days summer discharge <500 cfs in Reach 4.

17. Commonly collected native fish species were commonly found in all secondary channel mesohabitats, except backwaters. Speckled dace was most frequently found in rapid- and slow (mainly riffle eddys)-velocity mesohabitats; bluehead sucker was mainly in moderate-velocity areas, but also occupied slow-velocity habitats; and flannelmouth sucker occurred

mainly in moderate- slow-velocity mesohabitats, but was common in backwaters in Reach 3.

18. Each commonly collected nonnative species, except fathead minnow, was found mainly in moderate- and slow-velocity mesohabitats. Fathead minnow regularly occurred in moderate- and slow-velocity areas, but was also common in backwaters.

BACKWATERS

1. Comparatively few backwaters were present in 2003. Fourteen backwaters were sampled in Reaches 6 through 1; greatest number (n = 5) was in Reach 5 and none was in Reach 1.
2. Since 1999, four native and 10 nonnative fish species have been collected in San Juan River backwaters (including embayments and isolated pools) in Reaches 6 through 1.
2. In 2003, three native (speckled dace, bluehead sucker, and flannelmouth sucker) and six nonnative (red shiner, fathead minnow, black bullhead, channel catfish, western mosquitofish, and green sunfish) fish species were collected in San Juan River backwaters.
3. Greatest total fish density (16.324 fish/m^2) in backwaters occurred in 2000, but total fish density (11.422 fish/m^2) was also high in 2002. Lowest total fish density (1.565 fish/m^2) was in 2003.
4. Greatest native fish density (0.158 fish/m^2) was in 2001 and least (0.038 fish/m^2) was in 2003. Greatest nonnative fish density (16.282 fish/m^2)

was in 2000 and least (1.527 fish/m^2) was in 2003.

5. Red shiner and fathead minnow were first- and second-most common, respectively, in all years.
6. Native fish species were uncommon (<50 individuals/year) in all years. Speckled dace was most common (n = 37) in 2002, bluehead sucker (n = 71) in 2002, and flannelmouth sucker was most common (n = 33) in 2000.
7. One specimen of Colorado pikeminnnow was collected in each 1999 and 2000.
8. Black bullhead was collected in all years, except 1999, and was comparatively common (n = 106) in 2000.
9. At least one centrarchid specimen (bluegill, green sunfish, or largemouth bass) was collect in all years, except 1999.

LITERATURE CITED

Bliesner, R., and V. Lamarra. 2002. Hydrology, geomorphology, and habitat studies; final report. San Juan River Basin Recovery Implementation Program, U.S. Fish and Wildlife Service, Albuquerque, NM.

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