1997 Population Monitoring of Rio Grande Silvery Minnow

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Robert K. Dudley and Steven P. Platania

Division of Fishes, Museum of Southwestern Biology
Department of Biology, University of New Mexico
Albuquerque, New Mexico 87131

submitted to:

James P. Wilber & Mark C. Harberg and Richard A. Fike

U.S. Bureau of Reclamation
505 Marquette NW, Suite 1313
Albuquerque, New Mexico 87102

U.S. Army Corps of Engineers
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109

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INTRODUCTION

Population information on Rio Grande silvery minnow (Hybognathus amarus) and the associated Middle Rio Grande (Rio Grande between Velarde, New Mexico and Elephant Butte Reservoir) fish community has been regularly gathered since 1987. The first studies were conducted by Platania (1993) from 1987-1992 to determine spacial and temporal changes in the ichthyofaunal community and to better understand species-specific habitat use patterns. A key purpose of those preliminary studies was to provide additional information on the conservation status of Rio Grande silvery minnow. Quarterly sampling efforts during the summer and autumn of 1989 and 1990 revealed that densities of Rio Grande silvery minnow were extremely low. Based on previous samples, these low densities indicated a rapid decline of this species in its already greatly reduced range. The 90-95% reduction in the range of Rio Grande silvery minnow and threats to its continued persistence in the Middle Rio Grande were central to this species being listed as endangered by the U.S. Fish and Wildlife Service (U.S. Department of Interior, 1994).

From 1992 until present, the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, and U.S. Corps of Engineers have undertaken a cooperative agreement to fund numerous ichthyofaunal studies in the Middle Rio Grande. Among these studies was the long-term monitoring of the distribution and status of the Middle Rio Grande fish community at 17 sites between Bernalillo, N.M. and the San Marcial Railroad crossing. While Rio Grande silvery minnow was the primary focus of these quarterly population monitoring efforts, the study was designed to provide a wealth of information on the overall fish community.

The objective of the 1997 collecting activities was to monitor populations of Rio Grande silvery minnow and the associated fish community. Seasonal and spacial differences in population structure and species densities were examined to determine the dynamics within this system. Annual changes in the distribution, abundance and composition of all fish species were also assessed. Information obtained from this study will allow a more thorough understanding of the current conservation status and population dynamics of Rio Grande silvery minnow. These data are important components for the recovery of this species.

STUDY AREA

The headwaters of the Rio Grande are located in the San Juan Mountains of southern Colorado. The Rio Grande flows for about 750 km through New Mexico. The Rio Chama is the only major perennial tributary of the Rio Grande in New Mexico and confluences with it near the town of Española. Snowmelt from northern New Mexico and southern Colorado provides the majority of water in the Rio Grande, but is supplemented by transmontane diversions from the San Juan River drainage (Colorado River basin). The highest flow in the Rio Grande occurs during spring snowmelt, while the lowest flow occurs in late summer and autumn. Low flow later in the year is due, in part, to the large diversions of water out of the river channel into irrigation canals. Summer thunderstorms periodically augment low flow in discrete reaches, but do not ensure that the river channel will remain wetted. Precipitation in the region is low and averages <25 cm/year (Gold and Denis, 1985).

The Middle Rio Grande was defined as the reach between the rios Grande-Chama confluence (Chamita) and Elephant Butte Reservoir (Figure 1). This reach changes considerably through its 364 km length. At high elevations, the Middle Rio Grande was a narrow, canyon-bound cold river with large substrata and a salmonid-dominated fish community. In contrast, downstream areas were 50-250 m wide, sand-bottomed, and supported a warmwater fish community. Our area of interest within this reach was limited to the current range of the Rio Grande silvery minnow (i.e., below Cochiti Dam to the inflow of Elephant Butte Reservoir).

The stretch from Angostura Diversion Dam to Bernalillo was a transition zone where the river channel became more braided, the flood-plain widened, and substratum was primarily sand and silt. From Bernalillo downstream to Albuquerque the river channel often exceeded 100 m in width and lower velocities habitats were more common. Backwaters were more abundant in this reach than in between Cochiti and Angostura and substratum larger than sand was rare.

Downstream of Albuquerque, the Rio Grande was an ephemeral and wide meandering river with predominantly sand substrate, high silt load, low-velocity, and a variety of habitats. The mainstem channel was generally broad (100-200 m), <1 m deep, and had a current velocity of <1 m/second. From approximately the middle of Bosque del Apache National Wildlife Refuge to Elephant Butte Reservoir, the river channel was generally less than 50 m wide.

Diel and seasonal discharge varied greatly both historically and during this study (Figure 2). There was a general trend of lower flow at downstream locations than upstream. Since 1973, flow in the Rio Grande has been largely dictated by releases from Cochiti Dam and by diversions for irrigation. Highest flow during 1997 monitoring activities occurred in the spring and early summer (April-June) due to snow-melt and irrigation water releases. Lowest flow occurred from July to September when most of the stream flow was diverted for irrigation.

Downstream of Isleta, the Rio Grande was sometimes ephemeral. During the 1980s and 1990s we observed, on numerous occasions, disjunct desiccated reaches often exceeding 20 km in length. Throughout the study area, irrigation water which discharged back into the Rio Grande through the 15 ditch-return outfalls sometimes provided the only surface riverine flow during summer and autumn. During 1997 the river remained wetted for the entire year, with the exception of a few days in September, because of above average snowmelt runoff and summer monsoon rains.

Flow in the Rio Grande is regulated by five mainstream reservoirs on the rios Chama and Grande and numerous smaller irrigation diversion dams throughout the drainage. The complex system of ditches, drains, and conveyance canals provided for extensive irrigated agriculture in the Rio Grande Valley. Cochiti Reservoir, located 66 km above Albuquerque and operational in 1973, was the primary flood control reservoir on the mainstem of the Rio Grande. In addition, there were several irrigation diversions that impounded and diverted water.

METHODS

This study was structured to monitor populations of Rio Grande silvery minnow and the associated fish community at selected sites (see Table A-1) throughout the study area. The quarterly sampling efforts during this study allowed for determination of general spatial and temporal changes in population structure and species densities. The differences in fish population size prior to and following annual reproduction were the basis for sorting the data set into four seasonal categories: Winter (January-March), Spring (April-June), Summer (July-September), and Autumn (October-December). Winter sampling was used as an indication of the relative survival of fishes from the previous year. Spring and summer collections were often when larval fishes first appeared. Autumnal sampling was the final assessment of annual fish spawning success.

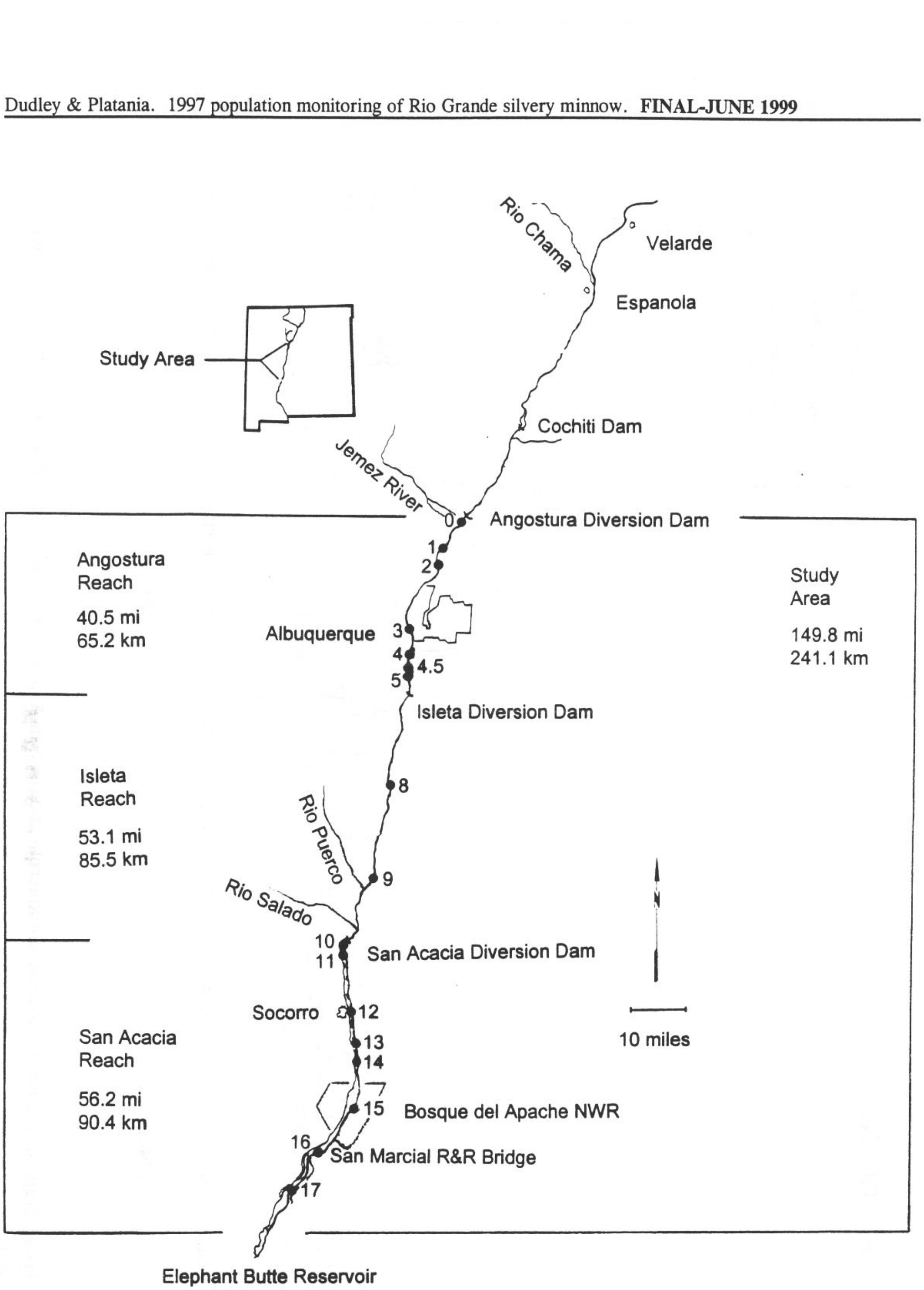

Figure 1. Map of the Middle Rio Grande and study area (numbered dots are sampling localities--see Table A-1).

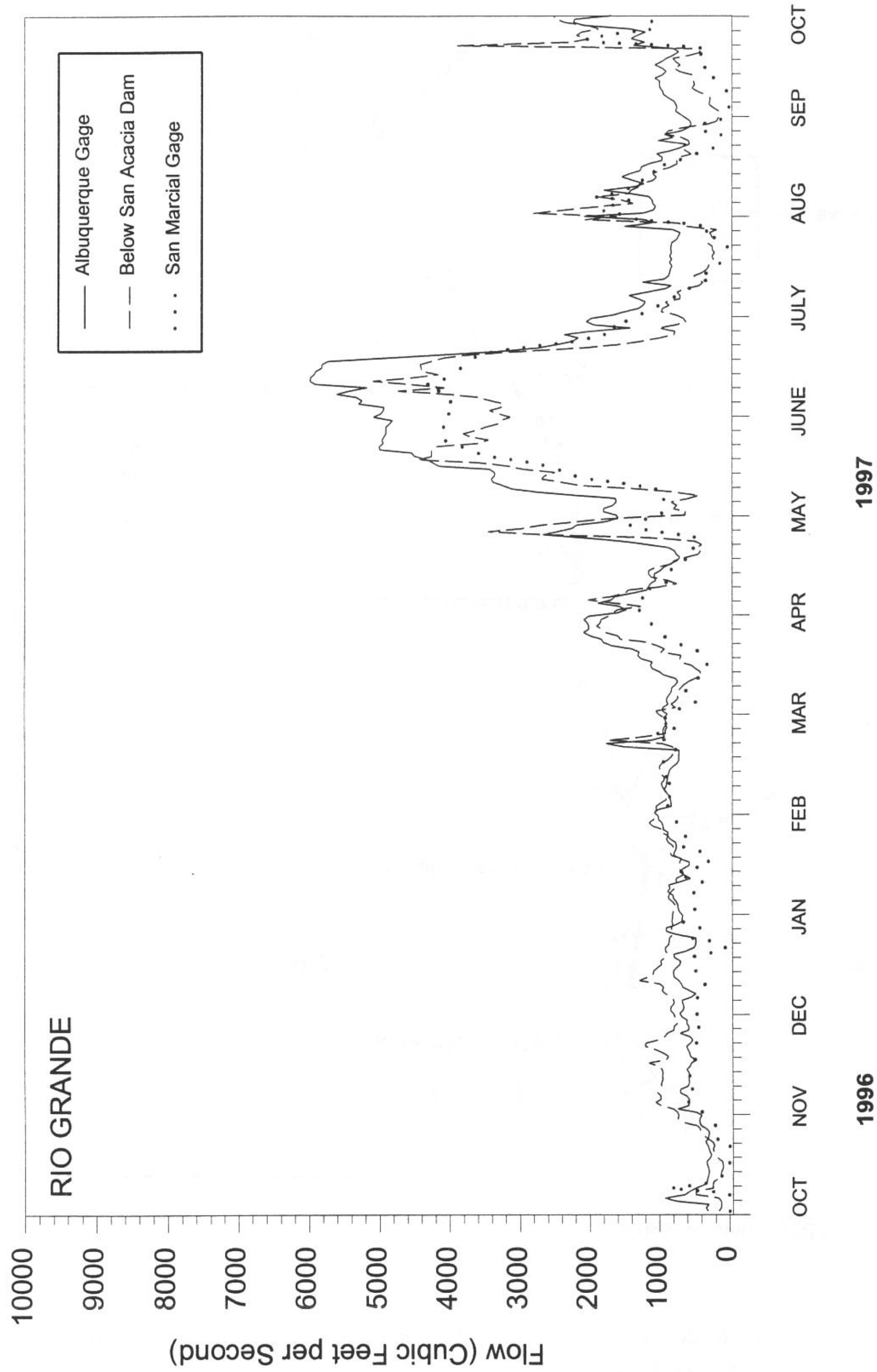

Figure 2. Hydrograph of the Rio Grande at Albuquerque, below San Acacia Dam, and at San Marcial for the 1997 water year.

The reaches sampled (Angostura, Isleta, and San Acacia) were named after the respective diversion structures (DS) that currently block upstream movements of Rio Grande silvery minnow. No sampling was conducted in the Cochiti reach (Cochiti Dam to Angostura DS) due to access problems and because no Rio Grande silvery minnow have been collected there in nearly a decade. The Angosura Reach (Angostura DS to Isleta DS) had seven sampling localities, the Isleta Reach (Isleta DS to San Acacia DS) had two collecting sites, and the San Acacia Reach (San Acacia DS to Rio Grande at former confluence with the low-flow conveyance canal) had eight sampling sites. The Isleta Reach included two sites during the 1997 study, unlike the four sites of previous years, because of the loss of access to Isleta Pueblo sampling localities. Two additional sites (Sites #4.5 and #5 from Table A-1) were sampling only in winter of 1997 and dropped for the remainder of the year due to access problems.

Scientific and common names of fishes in this report follow Robins et al. (1991) (Table 1). Common names, arranged in phylogenetic order, are used in tables and the report. The common and scientific names of species not included in Table 1 are provided in the text.

Fish were obtained by rapidly drawing a two-person 2.1 m x 1.8 m small mesh (0.5 cm) seine through discrete mesohabitats (usually <10 m). Retained fish were fixed in the field in 10% formalin and returned to the laboratory where they were sorted, identified to species, counted, measured (minimum and maximum size; mm standard length, SL), transferred to 70% ethyl alcohol and catalogued into the fish division of the Museum of Southwestern Biology (MSB) at the University of New Mexico. All Rio Grande silvery minnow were measured to the nearest 0.1 mm SL. Graphs of fish catch per unit effort for the ten most abundant species for each site locality are appended by season.

RESULTS

SUMMARY OF 1997 COLLECTING ACTIVITIES

Rio Grande silvery minnow

Catch rate of Rio Grande silvery minnow varied substantially between sampling localities (Figure 3). The Angostura and Isleta reaches generally contained fewer Rio Grande silvery minnow than did the San Acacia Reach. The number of individuals collected within a particular river reach also varied within season and especially between seasons.

The fewest number of Rio Grande silvery minnow were collected in the winter sampling effort (n=286) when six localities produced no individuals. No Rio Grande silvery minnow were collected at the first three sites in the Angostura Reach. These sites were located near the upper distribution of this species. Catch rates in winter were generally low across all sites with the exception of site 16 (San Marcial Bridge site). The catch rate at site 16 exceeded the catch rates of all other sites combined during winter. Winter catch rates of Rio Grande silvery minnow in the Angostura and Isleta reaches were similar.

There were noticeably more fish caught in the San Acacia Reach in the spring than in the winter. Spring catch rates between sites generally varied slightly except for site 14 which yielded a catch rate nearly twice that of any other site. Although Rio Grande silvery minnow were collected at each site, their densities were quite low in the Angostura Reach.

Table 1. Scientific and common names and species abbreviations ( ) of fish collected from the Middle Rio Grande.

Scientific Name	Common Name and Abbreviation	
Order Clupeiformes		
Family Clupeidae	herrings	
Dorosoma cepedianum	gizzard shad	(GZS)
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Campostoma anomalum	central stoneroller	(CSR)
Cyprinella lutrensis	red shiner	(RDS)
Cyprinus carpio	common carp	(CCA)
Hybognathus amarus	Rio Grande silvery minnow	(RGM)
Pimephales promelas	fathead minnow	(FHM)
Platygobio gracilis	flathead chub	(FHC)
Rhinichthys cataractae	longnose dace	(LND)
Family Catostomidae	suckers	
Carpiodes carpio	river carpsucker	(RCS)
Catostomus commersoni	white sucker	(WHS)
Order Siluriformes		
Family Ictaluridae	bullhead catfishes	
Ameiurus melas	black bullhead	(BBH)
Ameiurus natalis	yellow bullhead	(YBH)
Ictalurus punctatus	channel catfish	(CCT)
Pylodictis olivaris	flathead catfish	(FCT)
Order Cyprinodontiformes		
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(MOS)

Table 1 (continued). Scientific and common names and species abbreviations ( ) of fish collected from the Middle Rio Grande.

Scientific Name	Common Name and Abbreviation	
Order Perciformes		
Family Percichthyidae	temperate basses	
Morone chrysops	white bass	(WHB)
Family Centrarchidae	sunfishes	
Lepomis macrochirus	bluegill	(BGL)
Micropterus salmoides	largemouth bass	(LMB)
Pomoxis annularis	white crappie	(WCR)
Family Percidae		
Perca flavescens	yellow perch	(YWP)

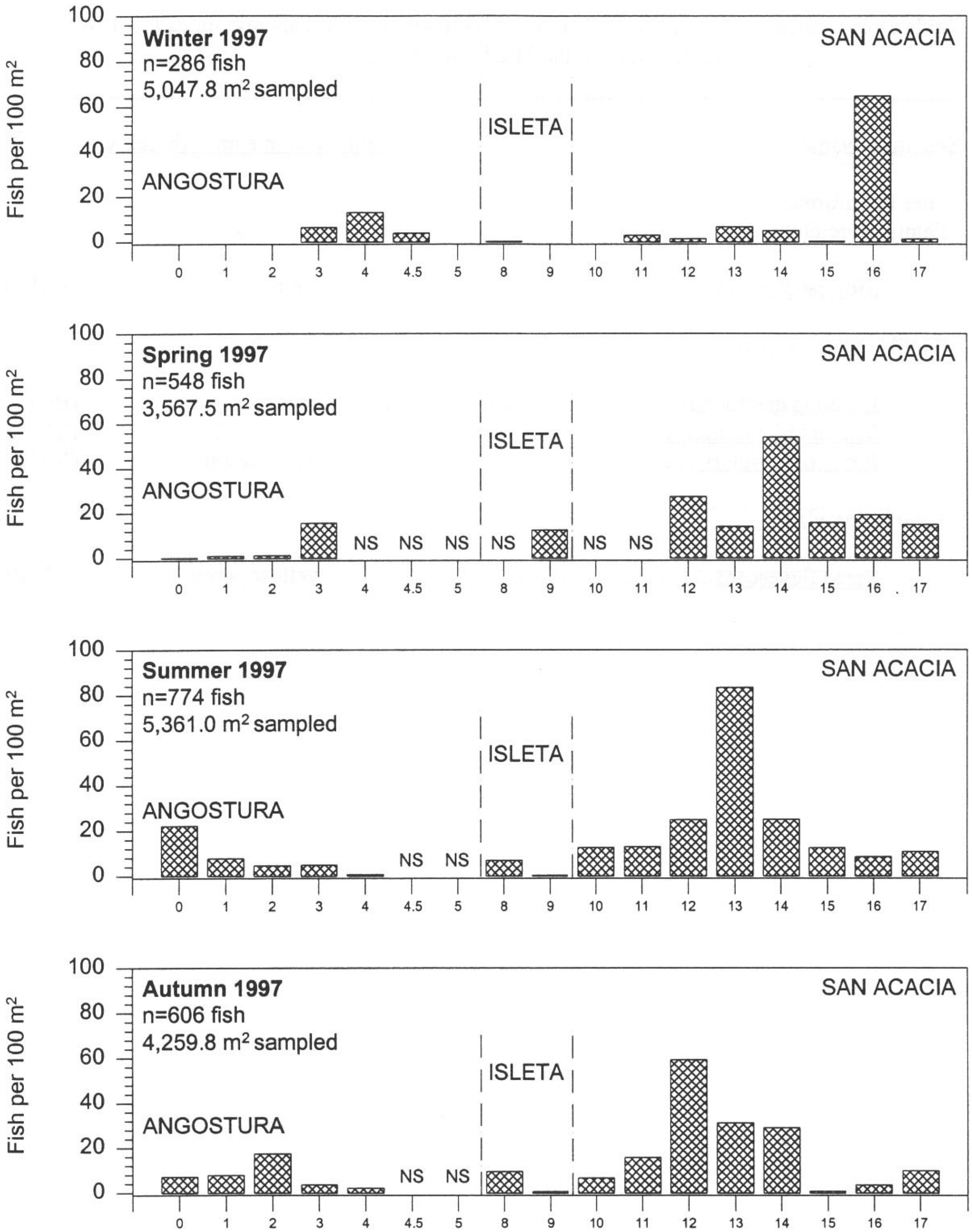

Figure 3. Rio Grande silvery minnow catch rates (CPUE) by season for each sampling locality in the Middle Rio Grande.

Rio Grande silvery minnow density increased at most sites from spring to summer. This species was collected at all sampling localities in all reaches during summer. The San Acacia Reach again produced the most individuals. Rio Grande silvery minnow catch rates within the Angostura and Isleta reaches varied considerably compared to the other seasons. The highest concentration of Rio Grande silvery minnow in the Angostura Reach during summer was immediately below Angostura Diversion Dam. We have also observed this phenomena in both the Isleta and San Acacia reaches. All sites within the San Acacia Reach produced moderate numbers of fish and site 13 had the highest 1997 density of Rio Grande silvery minnow.

The autumn sampling effort also produced moderate numbers of Rio Grande silvery minnow. The autumn catch rates in the Angostura and Isleta reaches approximated those observed during summer despite between site variation. The San Acacia Reach again produced the majority of Rio Grande silvery minnow. Most individuals were collected in the middle portion of this reach and site 12 had the highest autumn density of Rio Grande silvery minnow. There was more between site variation in catch rate within the San Acacia Reach during autumn than during spring or summer.

The density of Rio Grande silvery minnow for all reaches was lowest during winter (Figure 4). There were no observable consistent patterns in Rio Grande silvery minnow catch rates across reaches for the spring, summer and autumn sampling efforts. The Angostura Reach had low Rio Grande silvery minnow catch rates throughout the year but there was an increase during summer and autumn compared to winter and spring. Few Rio Grande silvery minnow were collected in the Isleta Reach (n=101) during 1997 and overall densities of this species were lower in this reach than in any other. Fish catch rates were substantially higher in spring than in winter in the Isleta Reach. However, this difference is attributable to one sampling locality and site 8 could not be sampled. The numbers of Rio Grande silvery minnow captured in the San Acacia Reach increased following winter and remained consistent for the remainder of the year. The cumulative 1997 Rio Grande silvery minnow catch rate (reaches and seasons combined) closely mirrored the pattern observed in the San Acacia Reach. The large number of Rio Grande silvery minnow collected in the San Acacia Reach appears to be generating this pattern.

Fish Community

The ichthyofaunal community was numerically dominated by cyprinids and catastomids (Table 2). Native ichthyofauna consisted of six species (red shiner, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace and river carpsucker) whose numbers varied from 200 to 4,717. The higher-gradient-stream adapted species (flathead chub, n=443 and longnose dace, n=200) were least abundant of the native taxa. Red shiner was the most numerous species (n=4,717) followed by Rio Grande silvery minnow (n=2,214) and the nonnative white sucker (n=2,057). Some of the more abundant introduced species, besides white sucker, were western mosquitofish (n=1,002), channel catfish (n=779), and common carp (n=510). The other ten nonnative fish species were at low densities (e.g., nearly all less than 20 individuals).

The densities of the ten most abundant species did fluctuate to varying degrees through the seasons (Figure 5). Red shiner was generally the most abundant species during each of the seasons. The only exception to this trend was in spring when white sucker was the most abundant species. The density of nearly all fishes increased somewhat during spring and summer collecting

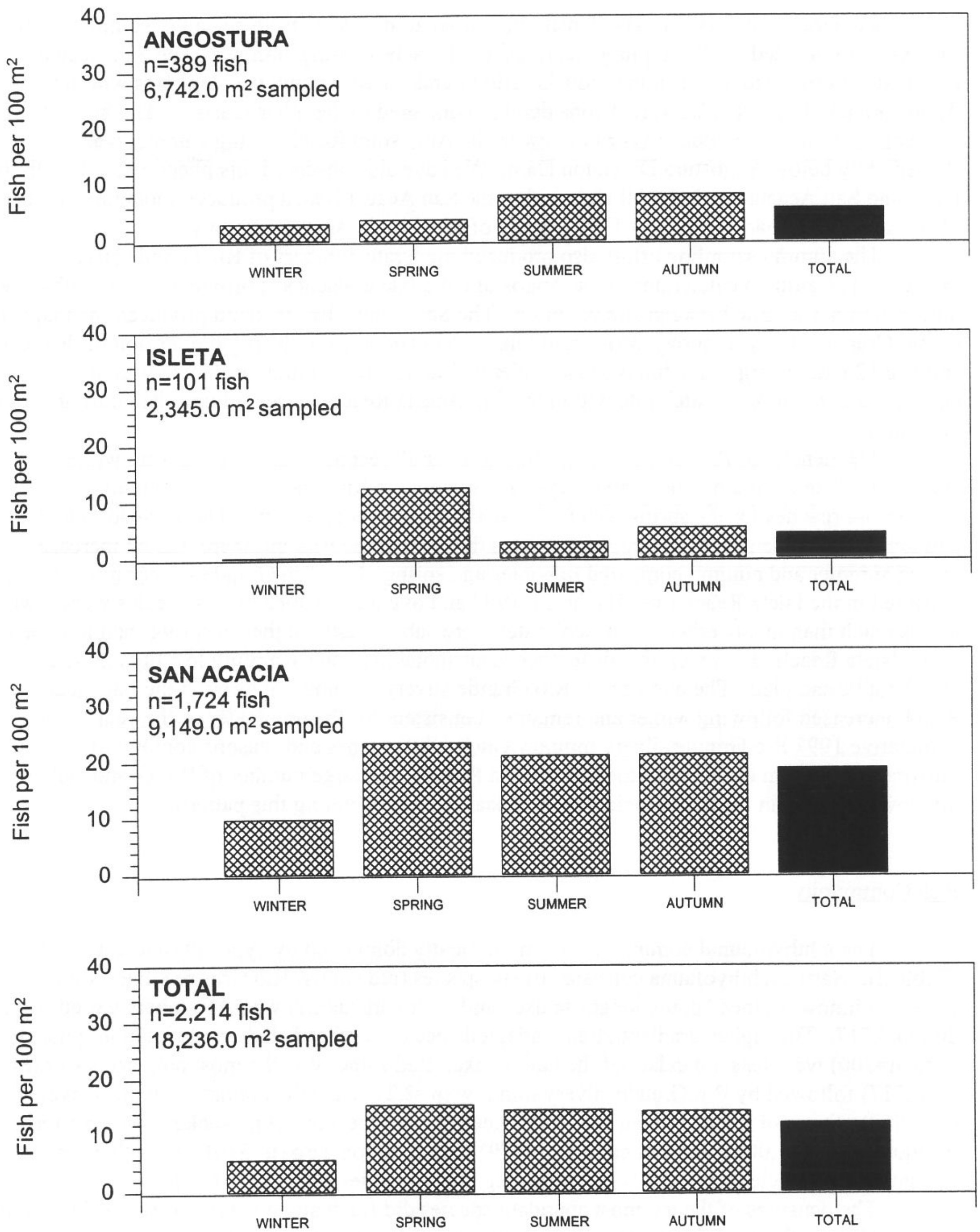

Figure 4. Rio Grande silvery minnow catch rates (CPUE) by river reach for each season in the Middle Rio Grande.

Table 2. Summary of ichthyofaunal composition and collection data in the study area.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	% OF TOTAL
HERRINGS			
gizzard shad	I	100	0.70
CARPS AND MINNOWS			
central stoneroller	I	1	0.01
red shiner *	N	4,717	32.79
common carp *	I	510	3.54
Rio Grande silvery minnow *	N	2,214	15.39
fathead minnow *	N	795	5.53
flathead chub *	N	443	3.08
longnose dace *	N	200	1.39
SUCKERS			
river carpsucker *	N	1,511	10.50
white sucker *	I	2,057	14.30
BULLHEAD CATFISHES			
black bullhead	I	8	0.06
yellow bullhead	I	1	0.01
channel catfish *	I	779	5.41
flathead catfish	I	4	0.03
LIVEBEARERS			
western mosquitofish *	I	1,002	6.96
TEMPERATE BASSES			
white bass	I	5	0.03
SUNFISHES			
bluegill	I	2	0.01
largemouth bass	I	13	0.09
white crappie	I	6	0.04
PERCHES			
yellow perch	I	19	0.13
TOTAL		14,387	

N = native; I = introduced
* indicates one of the 10 most abundant taxa which were used in all community composition figures.

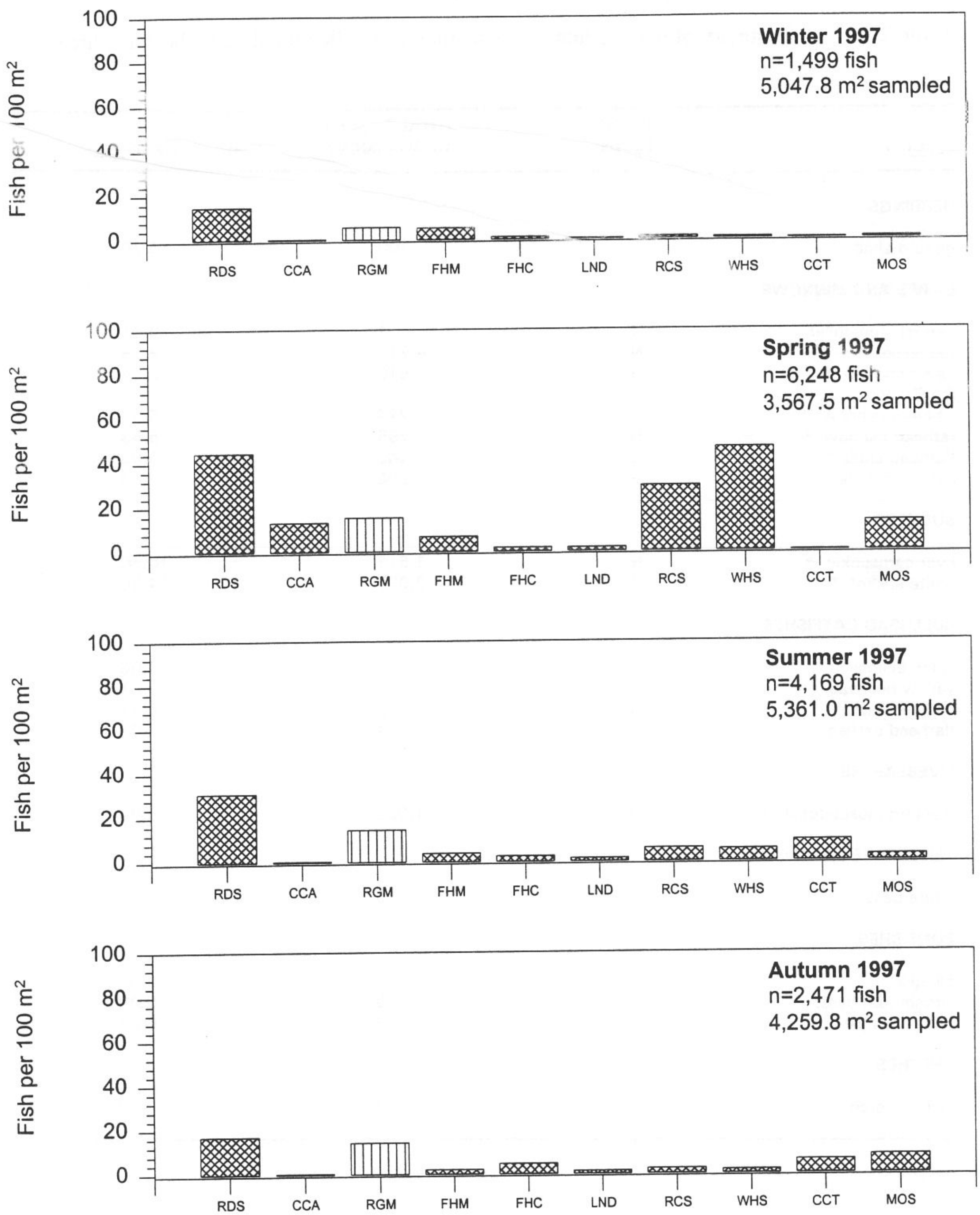

Figure 5. Fish catch rates (CPUE) by season for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande.

efforts. White sucker demonstrated the most dramatic increase (winter to spring) in abundance of any of the species. Density of river carpsucker also increased notably from winter to spring. Several taxa (fathead minnow, flathead chub, and longnose dace) exhibited almost no change in abundance over the year and others (common carp, channel catfish, and western mosquitofish) increased only moderately in density during spring or summer. Rio Grande silvery minnow density increased during summer and remained elevated through autumn.

Fish density also varied between river reaches (Figure 6). Red shiner densities were the highest in the middle reach (Isleta) and lowest in the lower reach (San Acacia). Common carp, river carpsucker and channel catfish also exhibited this general pattern of higher densities in the middle reach. Rio Grande silvery minnow was most abundant in the lowest reach and notably less abundant in the middle (Isleta) and upper reach (Angostura). Conversely, fathead minnow, longnose dace, and especially white sucker which were all most abundant in the Angostura Reach. Density of western mosquitofish did not vary notably between reaches.

Density of fish in 1997 fluctuated between seasons for each of the river reaches (Figure 7). However, the pattern of low winter, high spring, and moderate summer and autumn catch rates were observed across river reaches. Additionally, the overall spring, summer and fall fish density between river reaches were quite similar. The cumulative 1997 catch rate nearly paralleled that observed in the San Acacia Reach.

Catch rates of individual taxa in the three river reaches varied noticeably by season (Figure 8). Density of fish was consistently low for nearly all of the ten species in the Angostura Reach. Rio Grande silvery minnow catch rates increased in summer and autumn but were quite low in winter and especially in spring. Most of the other species were more numerous in summer and autumn with the exception of white sucker and red shiner. Density of these species increased dramatically in spring and then decreased throughout the rest of the year.

Fish catch rates in the Isleta Reach followed a similar pattern as those in the Angostura Reach with most species becoming more numerous in the summer and autumn. Red shiner was again an exception with its density peaking in spring. Almost all common carp were collected in spring. Rio Grande silvery minnow catch rates were at low densities throughout the year in the Isleta Reach but peaked in spring. All species were at low densities in winter.

Rio Grande silvery minnow catch rates in the San Acacia Reach were consistently higher throughout the year than any of those recorded in the Angostura or Isleta reaches. Most species (red shiner, common carp, Rio Grande silvery minnow, fathead minnow, river carpsucker, and western mosquitofish) reached their maximum densities in the spring. Flathead chub and channel catfish were more numerous in summer and autumn. The catch rates of all San Acacia Reach fishes were noticeably low in winter.

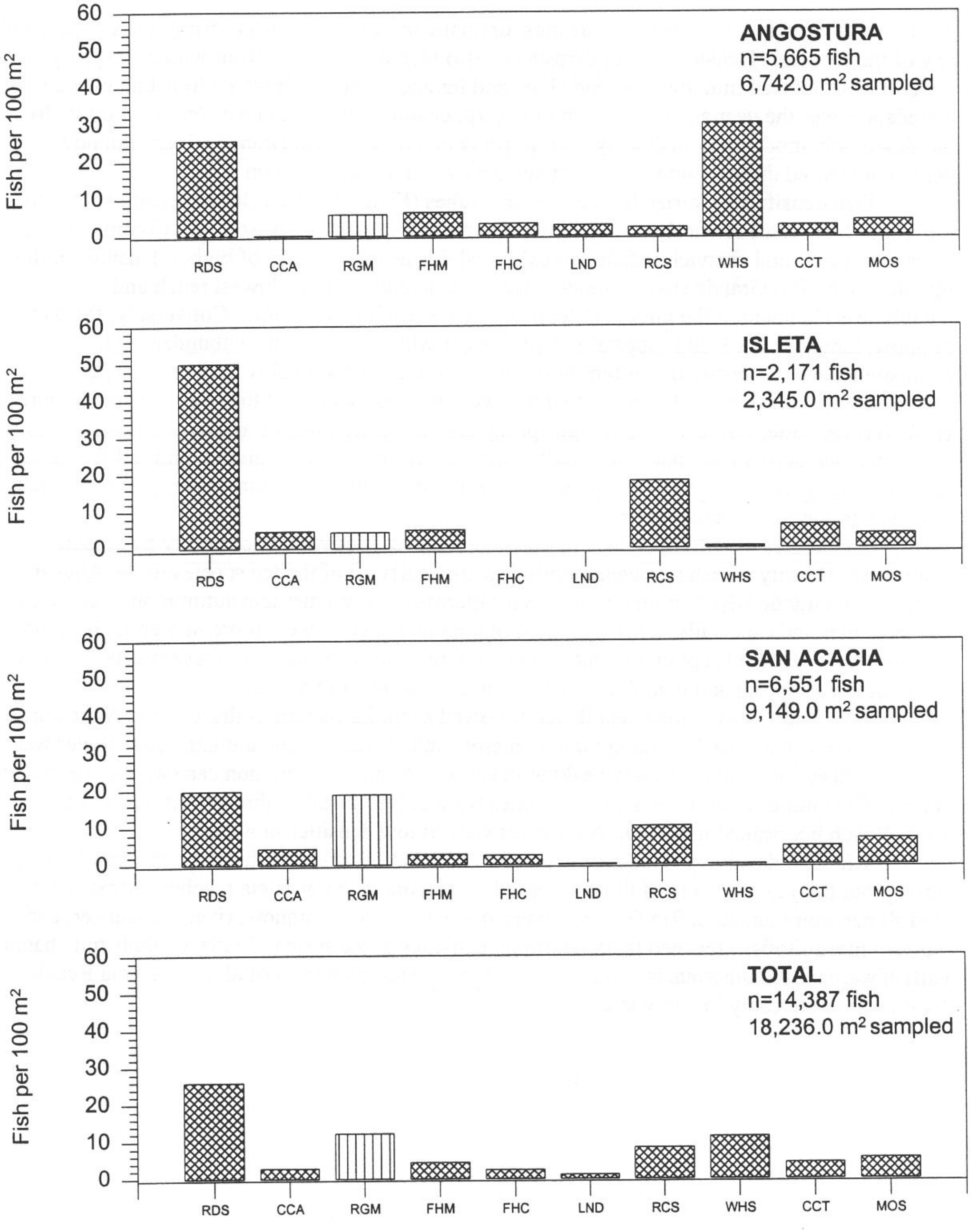

Figure 6. Fish catch rates (CPUE) by river reach for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande.

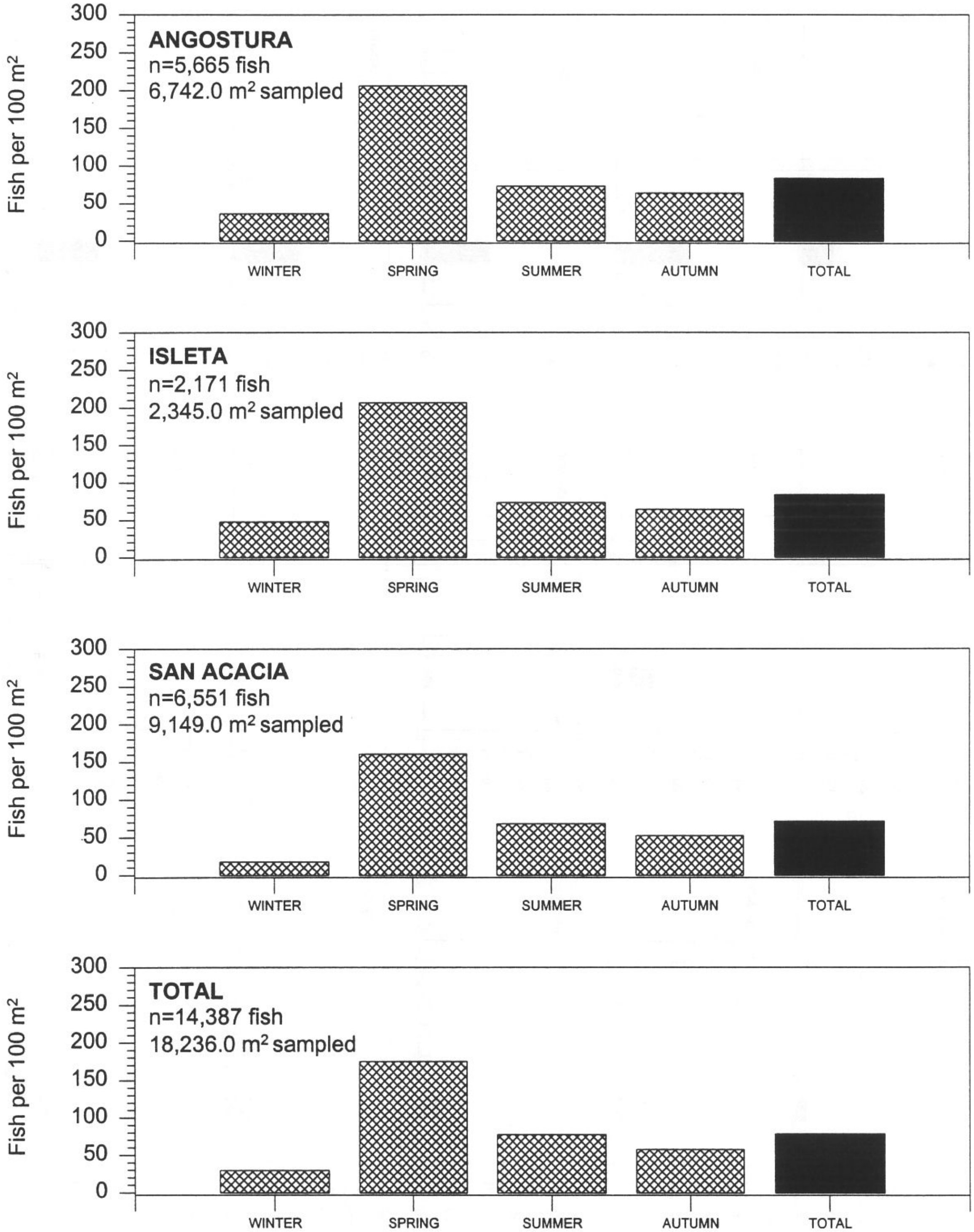

Figure 7. Fish catch rates (CPUE) by river reach for each season in the Middle Rio Grande.

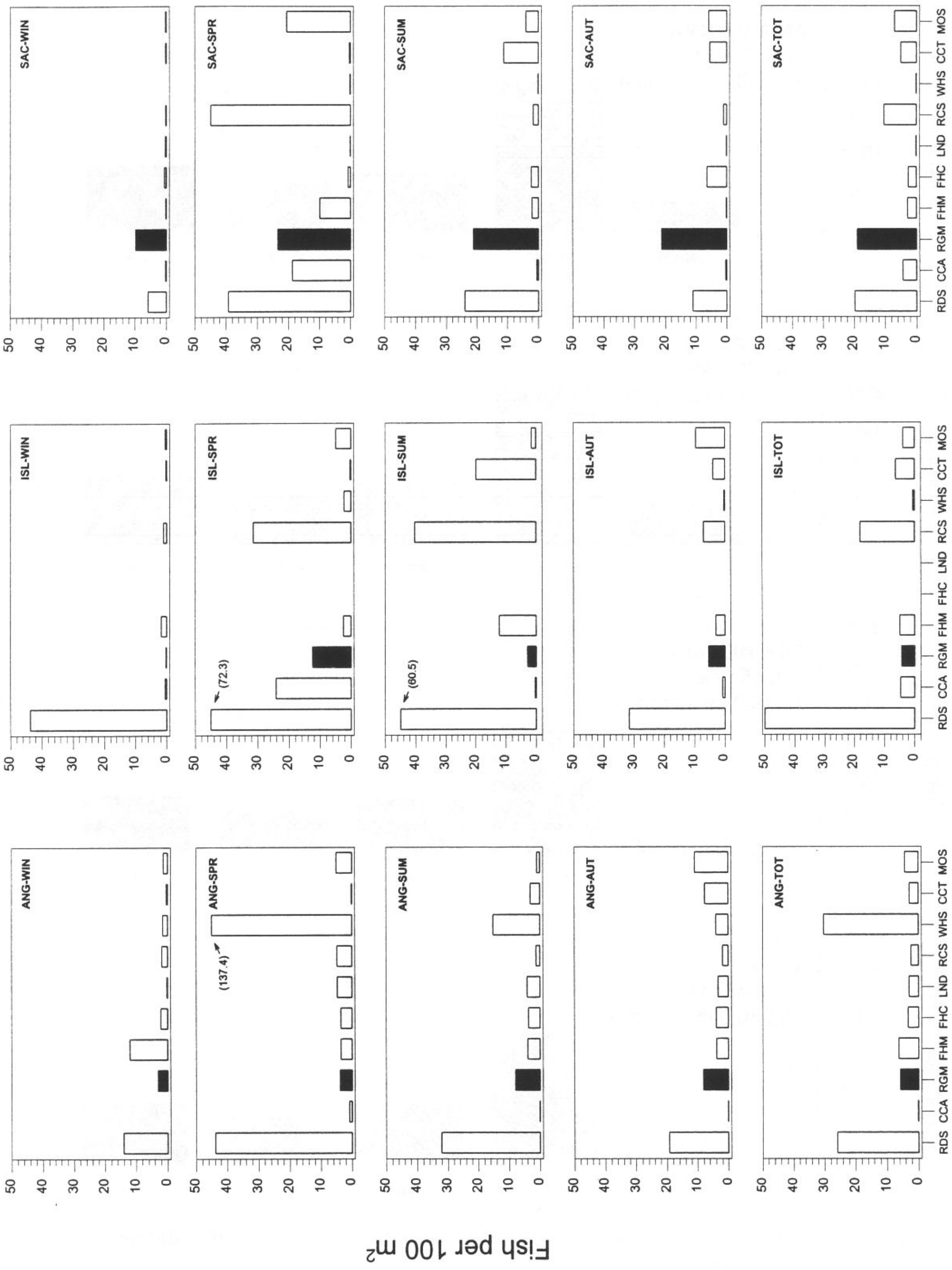

Figure 8. Fish catch rates (CPUE) by river reach and season for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande (ANG=Angostura Reach, ISL=Isleta Reach, SAC=San Acacia Reach)

DISCUSSION

The abundance of Rio Grande silvery minnow varied widely on nearly all scales measured during 1997. The most noticeable difference in abundance occurred spatially throughout the study area. The upstream collecting localities generally produced far fewer Rio Grande silvery minnow than did the downstream sites. The upper sites were typified by cooler waters and also by a more armored substrata (i.e., loss of silt and sand that typify downstream areas). The composition of fishes in the upper reaches was dominated by only a few species (e.g., red shiner and white sucker). Despite changes in habitat and fish assemblage structure, the low abundance of Rio Grande silvery minnow is primarily due to the movement of their drifting eggs and larvae downstream of permanent instream barriers (Isleta and San Acacia diversion dams) which allow the downstream passage of young but block subsequent upstream recolonization. There was a general pattern of increased abundance of Rio Grande silvery minnow when comparing either of the upper reaches, Angostura or Isleta, to the San Acacia Reach and this gradient persisted throughout the year.

Despite this pattern, there was substantial variation even between neighboring sampling localities within both the upstream and downstream reaches. There were numerous differences in the existing habitats between sites and subsequently in the ichthyofaunal community that occupied them. While general patterns of fish community assemblage structure and abundance changed over a broad scale (i.e., the length of the Middle Rio Grande), there were site to site differences that appeared to be due to variation in mesohabitat composition. For example, large numbers of western mosquitofish would occur at one particular site due to the presence of a large backwater but were absent at another site due to its more channelized nature (i.e., abundance of main channel run habitat and subsequent loss of lower velocity habitats).

While the San Acacia Reach produced the most Rio Grande silvery minnow throughout the 1997 study, this difference was not nearly as pronounced as it had been in previous years. This appears to be due directly to extensive stream drying that occurred during and after the spawning season of Rio Grande silvery minnow in 1996 and which subsequently negatively affected 1997 population levels. River drying was noted through some of the areas of the greatest abundance for Rio Grande silvery minnow (i.e., downstream of Socorro, NM) and resulted in the loss of the entire aquatic community in those areas. Since a significant portion of Rio Grande silvery minnow formerly occurred in the areas which were de-watered in 1996, the production of young during 1997 depended on lower densities of adult Rio Grande silvery minnow that survived in upstream wetted refugia. Information gleaned from the 1997 population monitoring study again indicates the extreme deleterious effects that river drying continue to have on this endangered species. The importance of maintaining flow through the last and most suitable remaining river reach occupied by Rio Grande silvery minnow cannot be over emphasized.

The Isleta reach was typified by few Rio Grande silvery minnow as was the Angostura Reach and this trend did not change during the seasonal collections taken during 1997. The most abundant species in the Isleta Reach was red shiner while white sucker and red shiner numerically dominated the Angostura Reach. The increased abundance of these species in the upper reaches appears to be related to the increased availability of their preferred habitats. Cooler water and the presence of a more armored substrata both appear to aid in the establishment of these species, especially white sucker.

The abundance of many fishes, including Rio Grande silvery minnow, increased at nearly all sites during spring and summer. Although the various species occupying the study area spawn at different times of the year, nearly all young are produced during spring or summer. This natural annual cycle is generally reflected in the changing abundance of different species through the year but is not consistent for all sites when examined in detail. The reasons for this variation are probably again due to between site differences in the proportions of mesohabitats and the shifting substrata (e.g., changes in the abundance and location of shallow low velocity habitats where the majority of young would be collected) which characterizes the Middle Rio Grande.

Densities of Rio Grande silvery minnow did not increase as much as expected in the spring and summer of 1997. The spawning season of Rio Grande silvery minnow occurs in the spring triggered, in part, by the increased flows provided by the natural snow melt and young are present soon after this (see Appendix for complete length-frequency histograms). However, this species has also been documented to spawn on summer rainstorm events. There was a relatively small increase in the numbers of Rio Grande silvery minnow following the spawning activities of 1997. The overall decrease in Rio Grande silvery minnow abundance from 1996 to 1997 was probably due to extensive stream drying in 1996. Loss of great portions of the adult spawning population in the previous year could explain why the Rio Grande silvery minnow population in 1997 was lower than in previous years.

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Table A-1. Collecting localities for 1997 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality	
0	New Mexico, Sandoval County, Rio Grande, below Angostura Diversion Dam, Angostura.	
	River Mile 209.7	SAN FELIPE PUEBLO QUADRANGLE
	35°22'49.2"N	106°29'56.6"W
1	New Mexico, Sandoval County, Rio Grande, at NM State Highway 44 bridge crossing, Bernalillo.	
	River Mile 203.8	BERNALILLO QUADRANGLE
	35°19'23.1"N	106°33'24.7"W
2	New Mexico, Sandoval County, Rio Grande, ca. 4 miles downstream of NM State Highway 44 bridge crossing at Rio Rancho waste management plant, Rio Rancho.	
	River Mile 200.0	BERNALILLO QUADRANGLE
	35°16'58.9"N	106°35'53.3"W
3	New Mexico, Bernalillo County, Rio Grande, at Central Avenue (US Highway 66) bridge crossing, Albuquerque.	
	River Mile 183.4	ALBUQUERQUE WEST QUADRANGLE
	35°05'27.4"N	106°40'47.0"W
4	New Mexico, Bernalillo County, Rio Grande, at Rio Bravo Boulevard bridge crossing, Albuquerque.	
	River Mile 178.3	ALBUQUERQUE WEST QUADRANGLE
	35°01'37.6"N	106°40'22.6"W
4.5	New Mexico, Bernalillo County, Rio Grande, ca. 1.8 miles upstream of US Highway I-25 bridge crossing, Albuquerque. (Sampled only one time)	
	River Mile 174.4	ISLETA QUADRANGLE
5	New Mexico, Bernalillo County, Rio Grande, at US Highway I-25 bridge crossing, Albuquerque.	
	River Mile 172.6	ISLETA QUADRANGLE
	34°57'53.5"N	106°40'56.7"W
8	New Mexico, Valencia County, Rio Grande, ca. 1.0 miles upstream of NM State Highway 309/6 bridge crossing, Belen.	
	River Mile 151.5	TOME QUADRANGLE
	34°39'53.5"N	106°44'59.3"W

Table A-1 (continued). Collecting localities for 1997 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality	
9	New Mexico, Socorro County, Rio Grande, at US Highway 60 bridge crossing, Bernardo.	
	River Mile 130.6	ABEYTAS QUADRANGLE
	34°25'03.2"N	106°47'59.4"W
10	New Mexico, Socorro County, Rio Grande, directly below San Acacia Diversion Dam, San Acacia.	
	River Mile 116.2	SAN ACACIA QUADRANGLE
	34°15'25.5"N	106°53'18.4"W
11	New Mexico, Socorro County, Rio Grande, ca. 1.5 miles downstream of San Acacia Diversion Dam, San Acacia.	
	River Mile 114.6	LEMITAR QUADRANGLE
	34°14'36.0"N	106°53'57.8"W
12	New Mexico, Socorro County, Rio Grande, 0.5 miles upstream of Socorro low-flow conveyance canal, Socorro.	
	River Mile 99.5	LOMA DE LAS CANAS QUADRANGLE
	34°04'04.5"N	106°52'28.3"W
13	New Mexico, Socorro County, Rio Grande, ca. 4.0 miles upstream of US Highway 380 bridge crossing, San Antonio.	
	River Mile 91.7	SAN ANTONIO QUADRANGLE
	33°58'48.7"N	106°51'41.2"W
14	New Mexico, Socorro County, Rio Grande, at US Highway 380 bridge crossing, San Antonio.	
	River Mile 87.1	SAN ANTONIO QUADRANGLE
	33°55'09.8"N	106°51'41.2"W
15	New Mexico, Socorro County, Rio Grande, directly east of Bosque del Apache National Wildlife Refuge headquarters.	
	River Mile 79.1	SAN ANTONIO, SE QUADRANGLE
	33°47'45.9"N	106°52'12.0"W

Table A-1 (continued). Collecting localities for 1997 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality
16	New Mexico, Socorro County, Rio Grande, at the San Marcial railroad crossing, San Marcial. River Mile 68.6 SAN MARCIAL QUADRANGLE 33°40'54.5"N 106°59'32.7"W
17	New Mexico, Socorro County, Rio Grande, at its former confluence with the low-flow conveyance canal and 16 miles downstream of the southern end of the Bosque del Apache National Wildlife Refuge. River Mile 60.5 PARAJE WELL QUADRANGLE 33°35'19.0"N 107°03'18.8"W

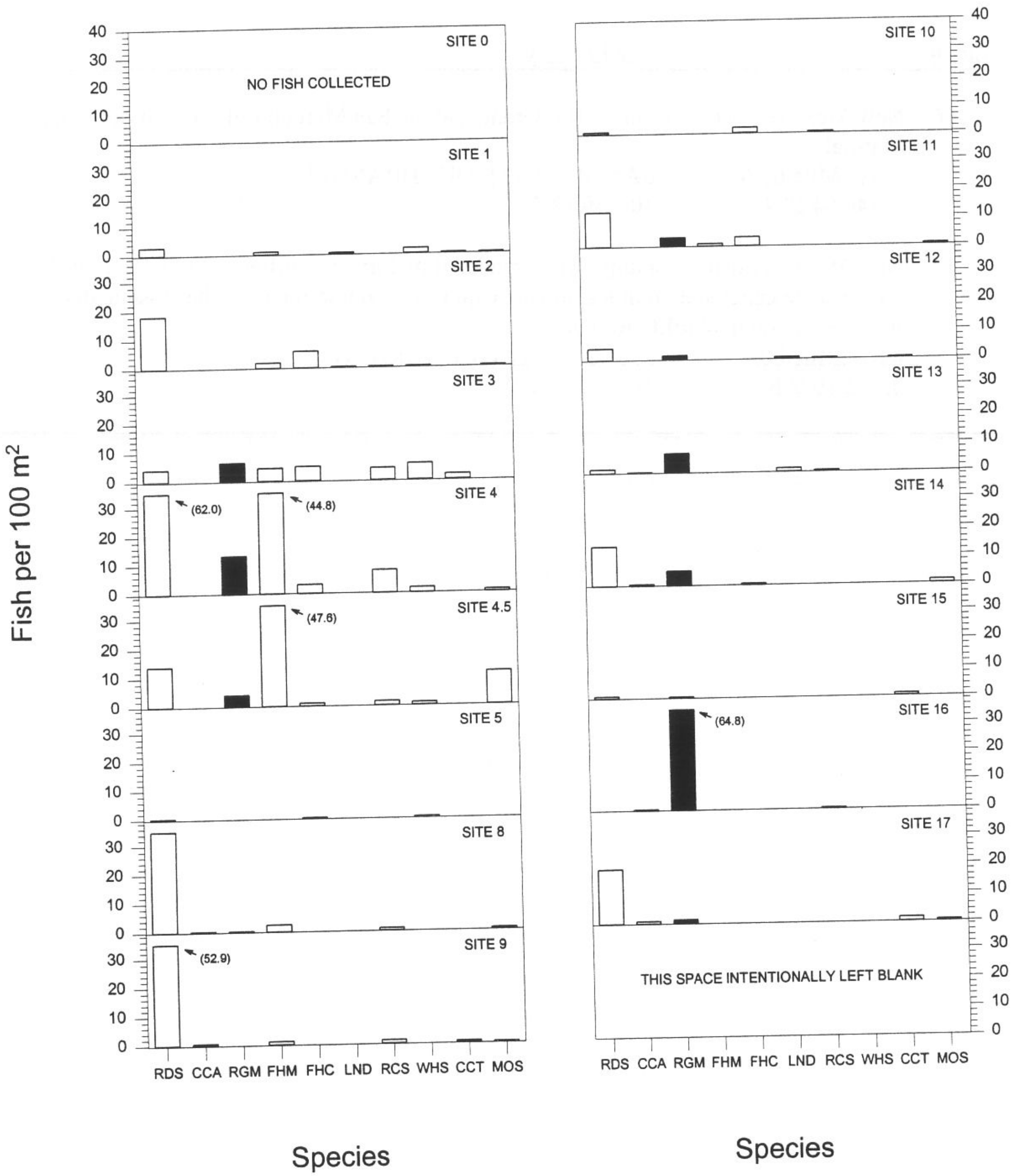

Figure A-1. Fish catch rates (CPUE) by sampling locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for winter of 1997.

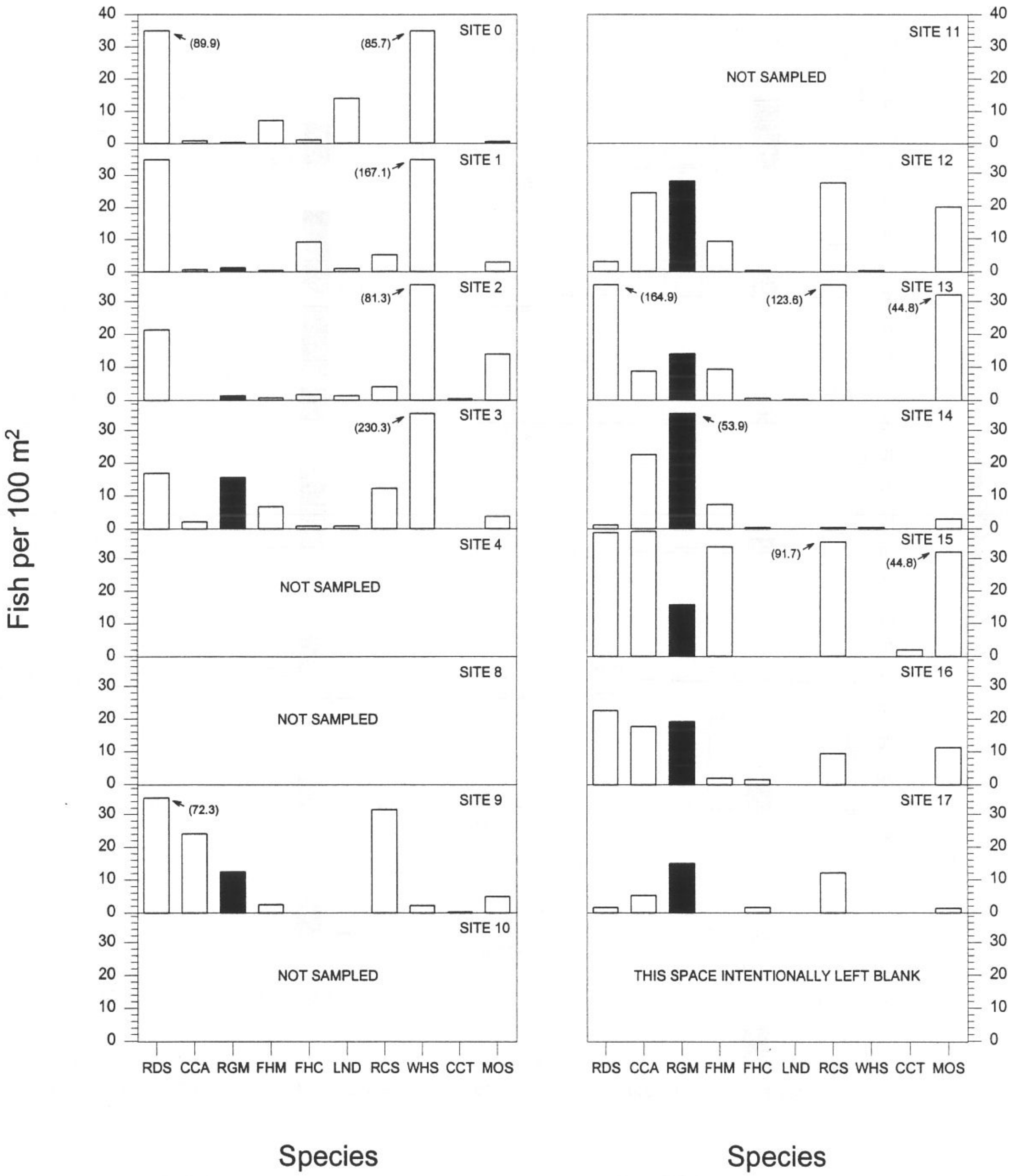

Figure A-2. Fish catch rates (CPUE) by sampling locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for spring of 1997.

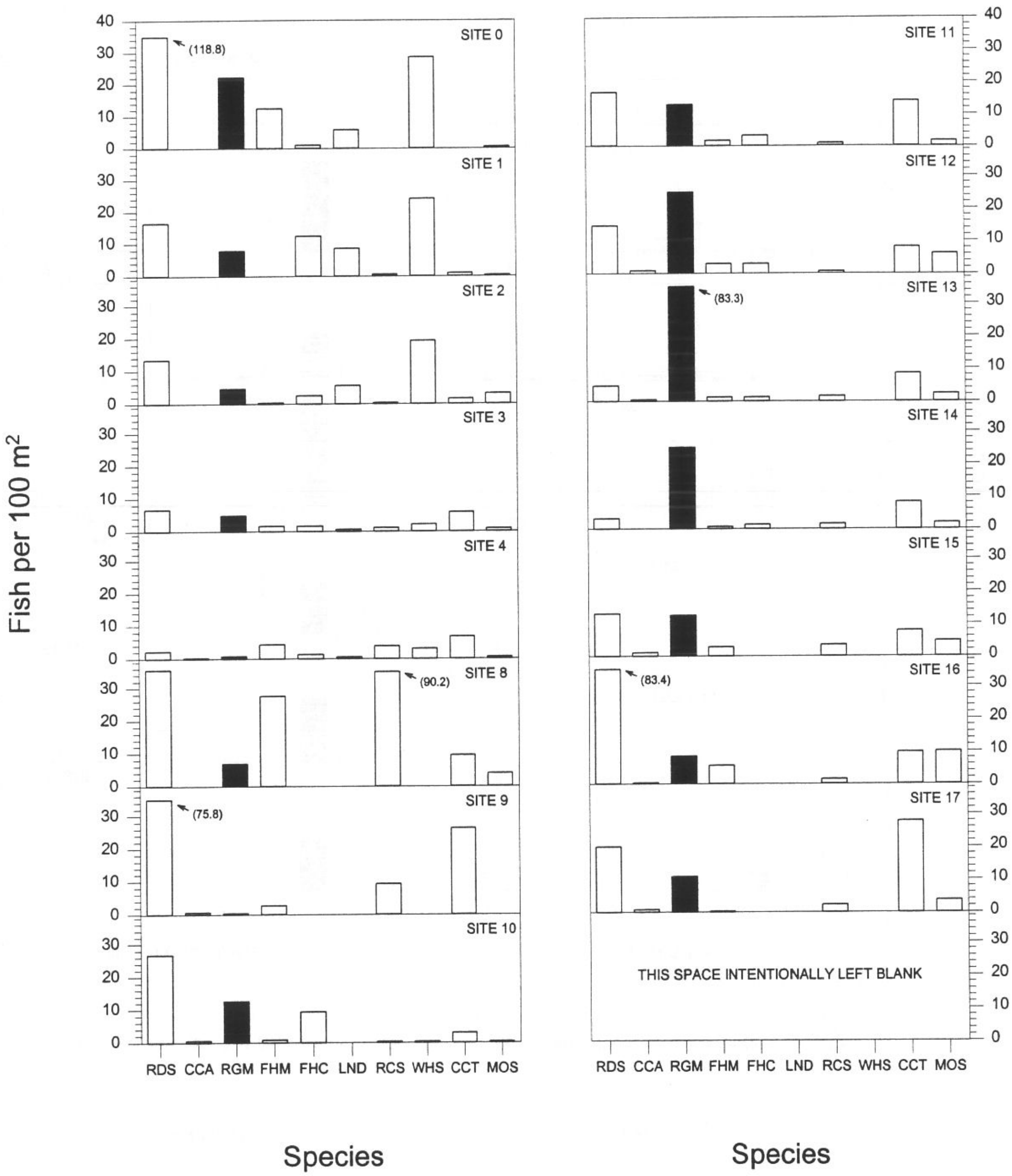

Figure A-3. Fish catch rates (CPUE) by sampling locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for summer of 1997.

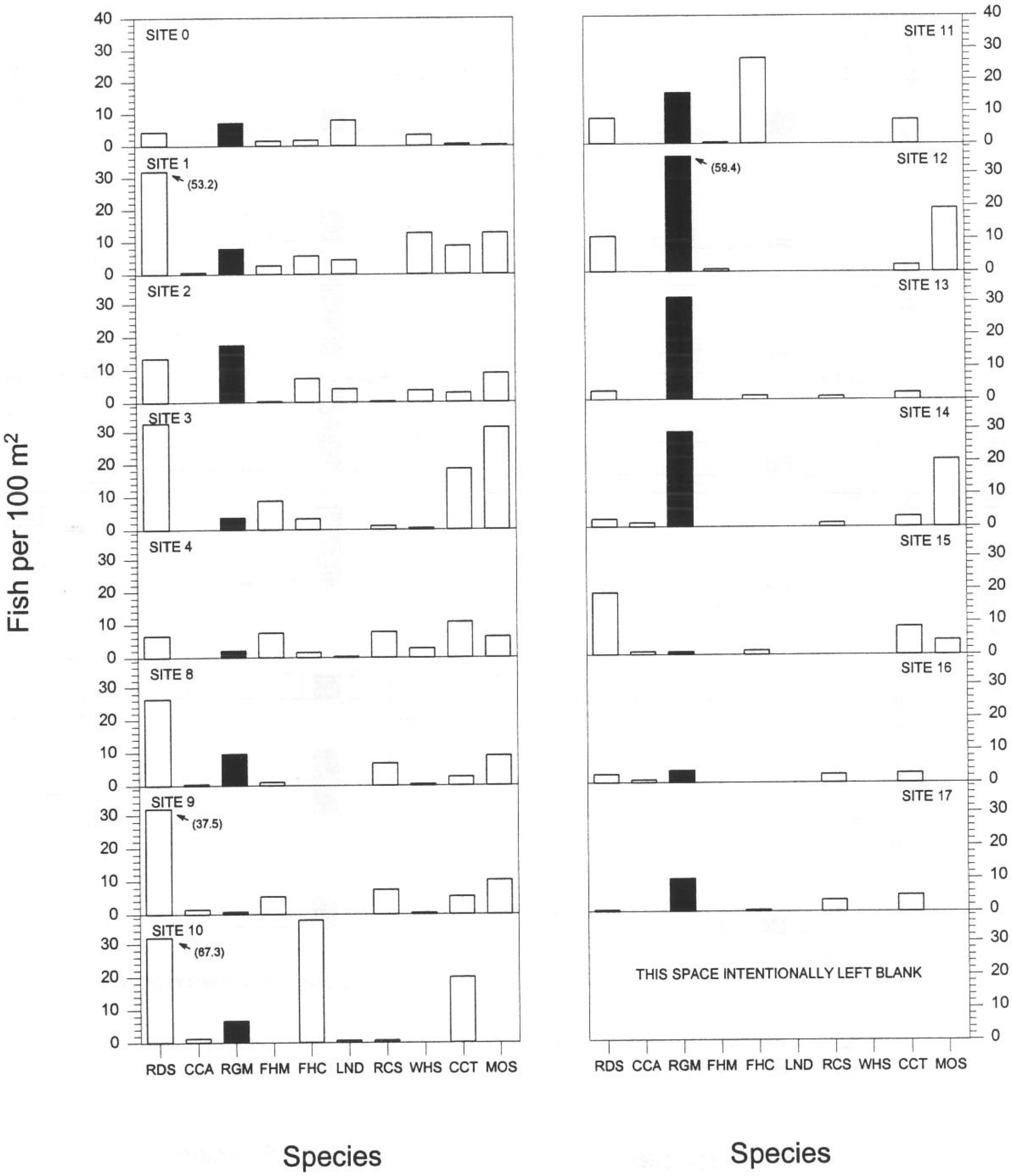

Figure A-4. Fish catch rates (CPUE) by sampling locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for autumn of 1997.

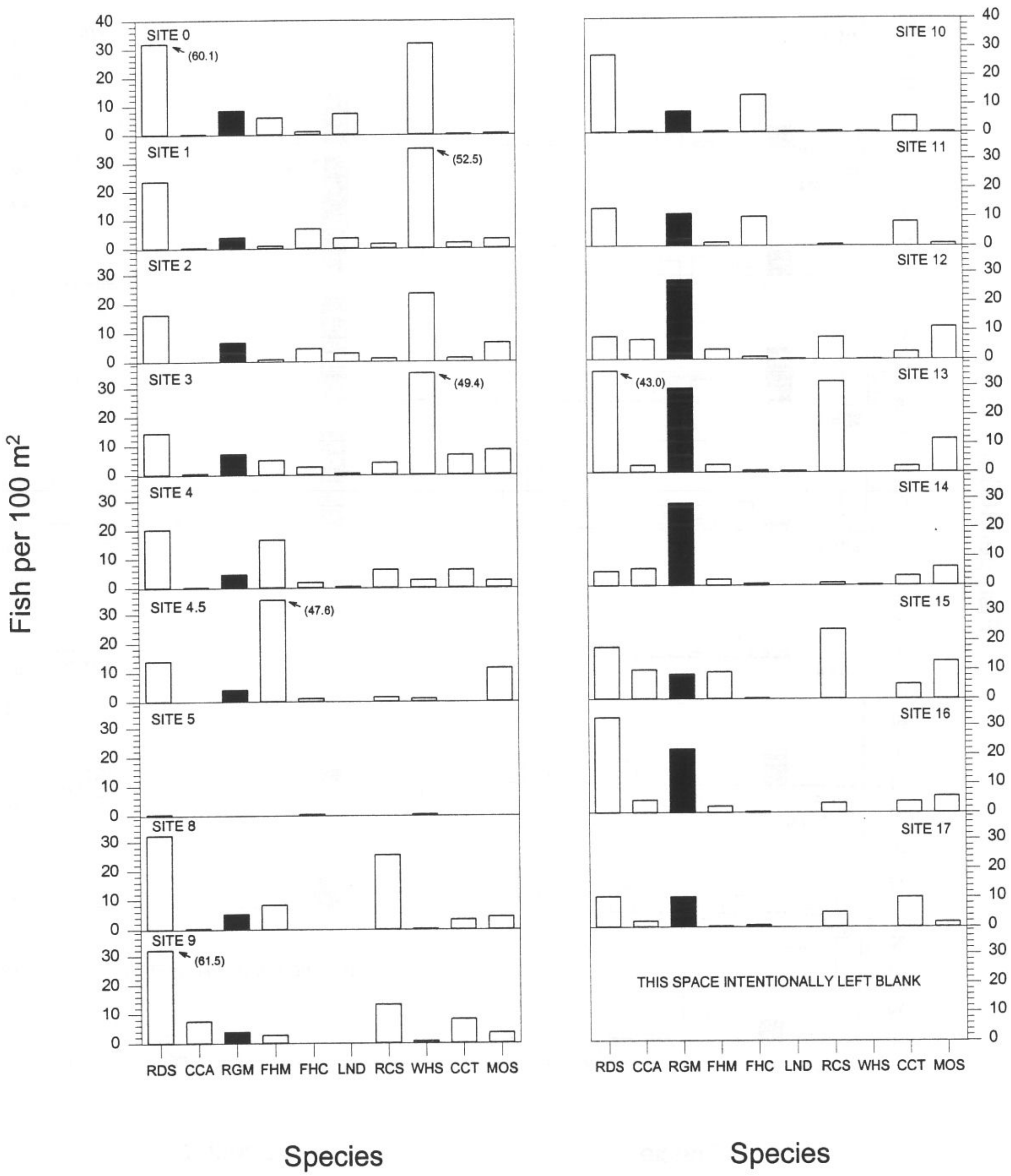

Figure A-5. Fish catch rates (CPUE) by sampling locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for all of 1997.

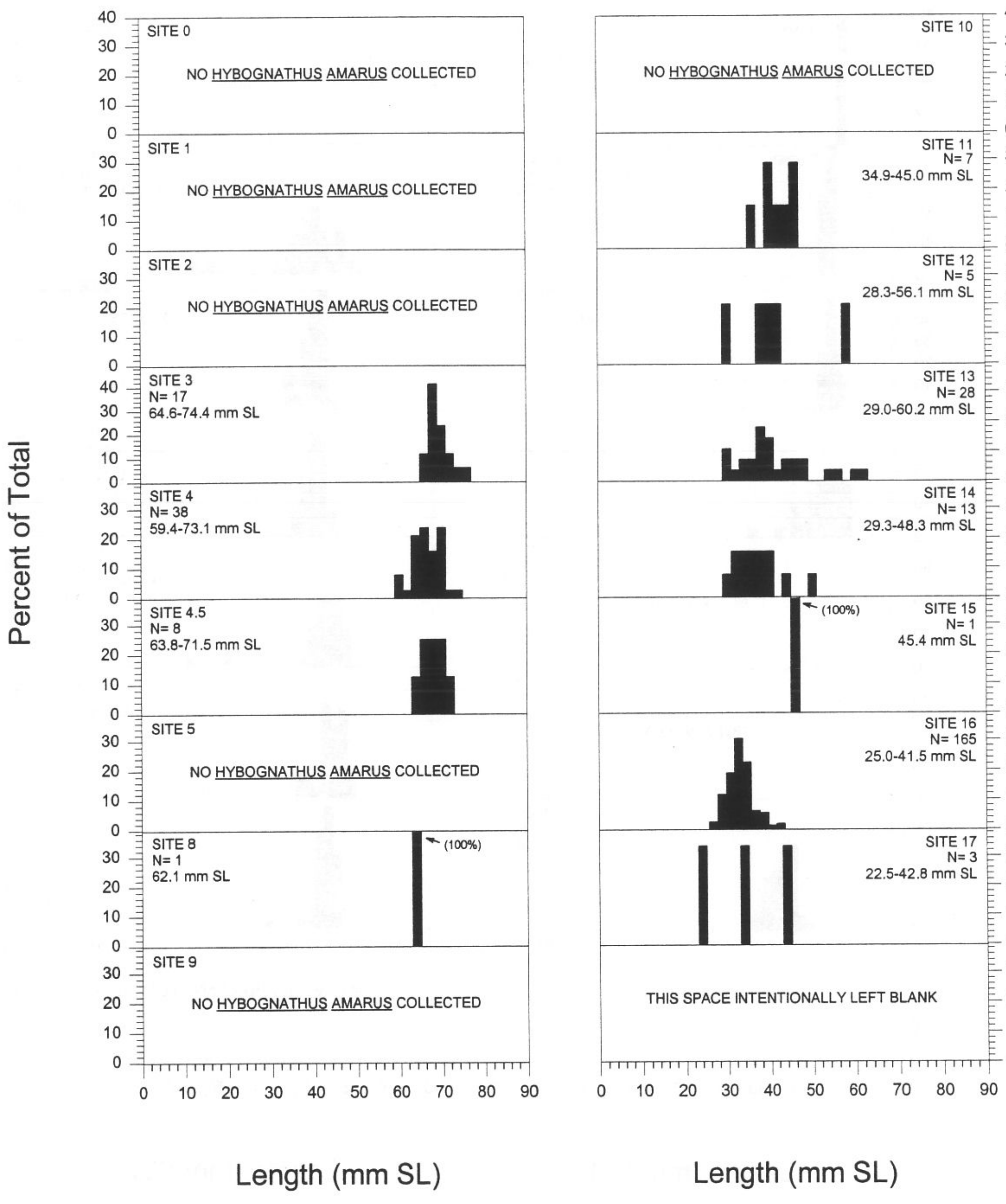

Figure A-6. Rio Grande silvery minnow length-frequency histograms by sampling locality in the Middle Rio Grande for winter of 1997.

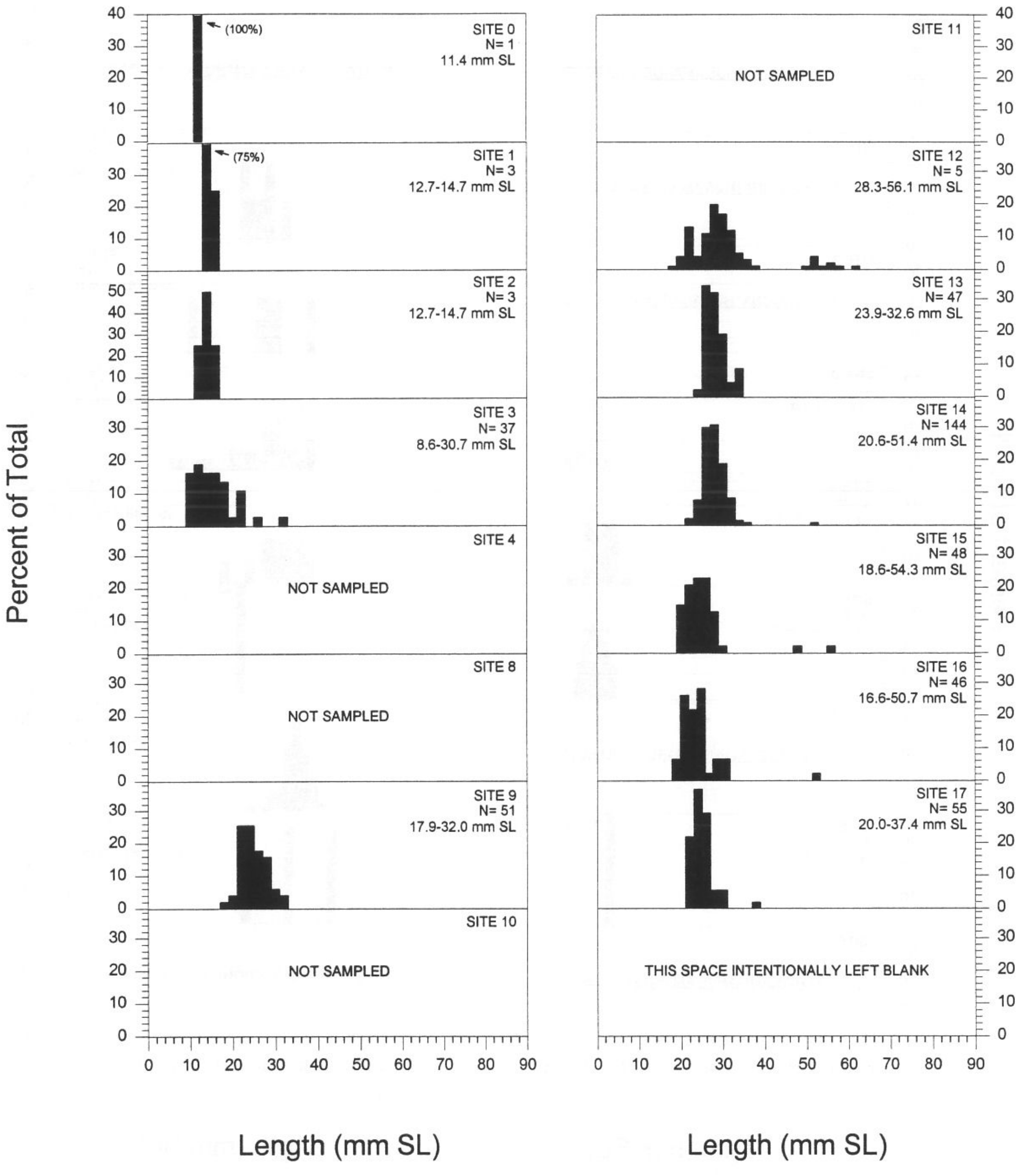

Figure A-7. Rio Grande silvery minnow length-frequency histograms by sampling locality in the Middle Rio Grande for spring of 1997.

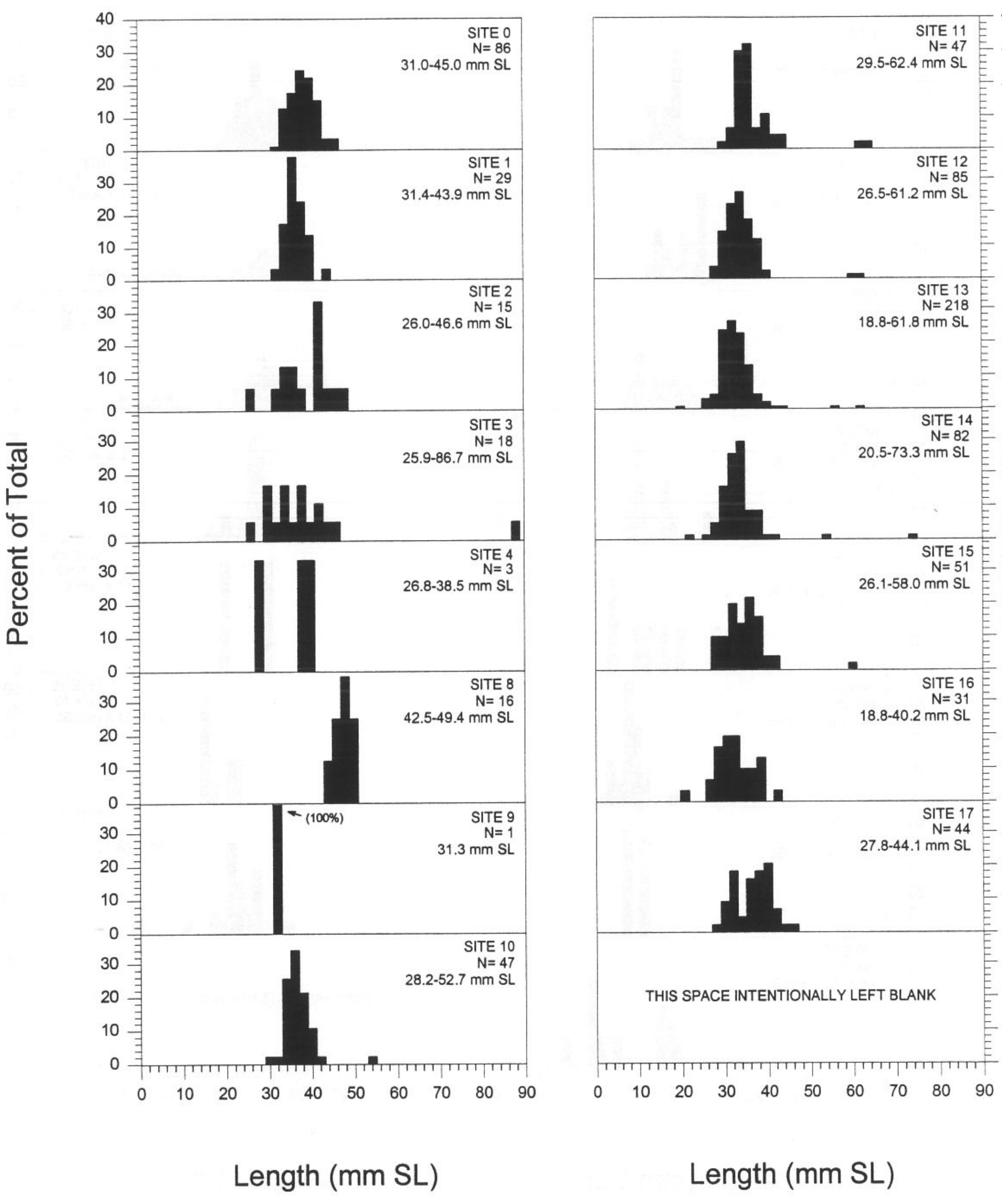

Figure A-8. Rio Grande silvery minnow length-frequency histograms by sampling locality in the Middle Rio Grande for summer of 1997.

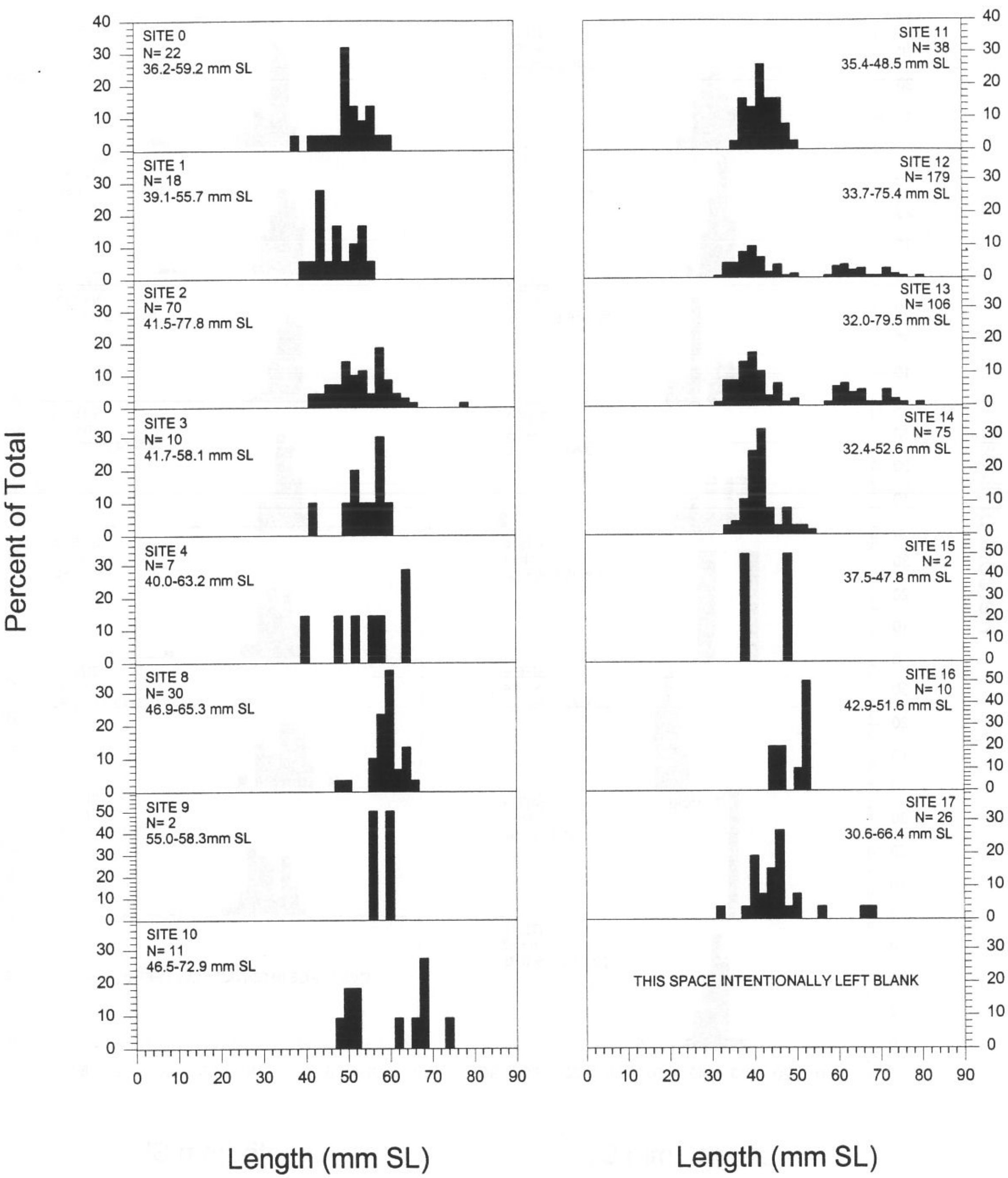

Figure A-9. Rio Grande silvery minnow length-frequency histograms by sampling locality in the Middle Rio Grande for autumn of 1997.