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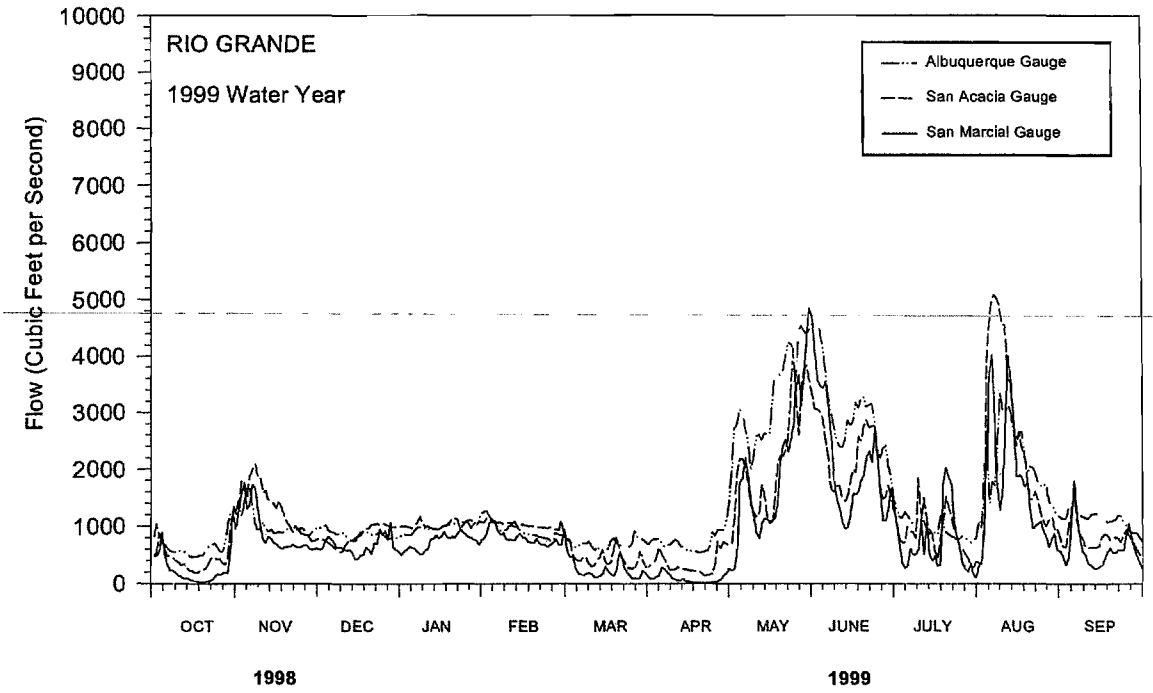
1999 POPULATION MONITORING OF RIO GRANDE SILVERY MINNOW

Final Report



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23 March 2000

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INTRODUCTION

Population information on Rio Grande silvery minnow and the associated Middle Rio Grande (Rio Grande between Velarde, New Mexico and Elephant Butte Reservoir) fish community has been gathered regularly since 1987. The first studies were conducted by Platania (1993a) from 1987-1992 to determine spatial and temporal changes in the ichthyofaunal community and to provide resolution of species-specific habitat use patterns. A key purpose of those preliminary studies was to supply 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 cooperated to fund numerous ichthyofaunal studies in the Middle Rio Grande. Among these studies was the long-term monitoring of the distribution and relative abundance of the Middle Rio Grande fish community at numerous sites between Angostura Diversion Dam and Elephant Butte Reservoir. While Rio Grande silvery minnow was the primary focus of these efforts, these research activities were designed to provide information about the entire fish community.

The objective of the 1999 collecting activities was to monitor populations of Rio Grande silvery minnow and the associated fish community. Seasonal and spatial differences in population structure and species densities were examined to determine the ecological 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 both of which 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 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 southern Colorado and northern New Mexico provides the majority of water for the Rio Grande, but transmontane diversions from the San Juan River drainage (Colorado River basin) supplement flow. The highest flow in the Rio Grande generally occurs during spring snowmelt, while the lowest flow usually 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 and 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 is defined as the reach between Velarde, New Mexico 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 the Middle Rio Grande was the current range of Rio Grande silvery minnow (i.e., below Cochiti Dam to the inflow of

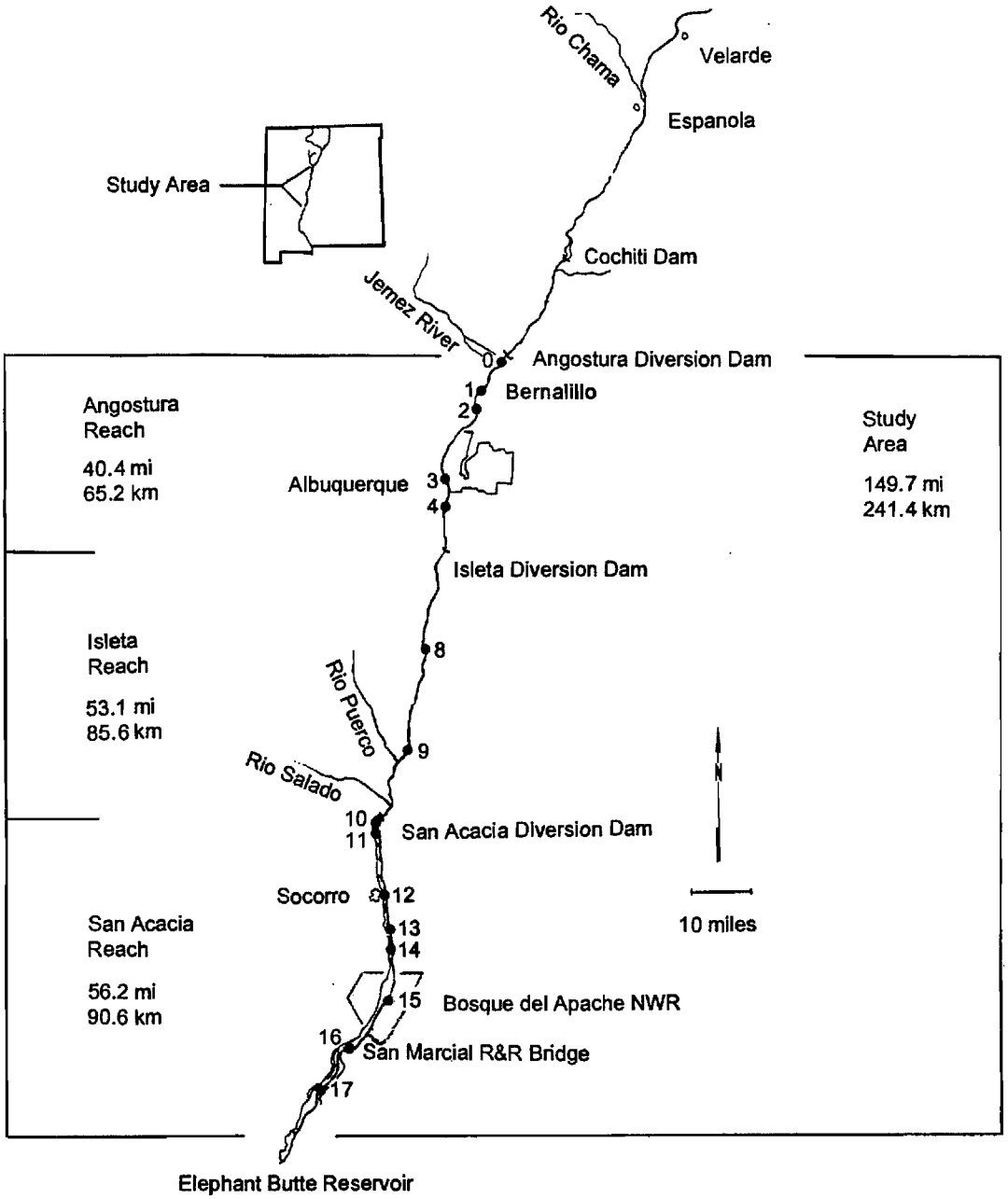

Figure 1. Map of the Middle Rio Grande and study area (numbered dots are sampling localities—see Table A-1).

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Elephant Butte Reservoir). The Cochiti Reach portion of the Rio Grande (between Cochiti Dam and Angostura Diversion Dam) passes first through Cochiti Pueblo, then Santo Domingo Pueblo, and finally San Felipe Pueblo; access is currently limited within this entire reach. The last comprehensive ichthyofaunal surveys of the Rio Grande in the Cochiti Reach documented the presence and low abundance of Rio Grande silvery minnow on Santo Domingo and San Felipe pueblos (Platania, 1995) but no Rio Grande silvery minnow were present on Cochiti Pueblo (Platania, 1993b).

Flow in the Rio Grande is regulated by five mainstem reservoirs on the rios Chama and Grande and numerous smaller irrigation diversion dams throughout the drainage. The complex system of ditches, drains, and conveyance channels provide water for extensive irrigated agriculture in the Rio Grande Valley. Cochiti Reservoir, located 76 km above Albuquerque and operational in 1973, is the primary flood control reservoir on the mainstem of the Middle Rio Grande.

The section of river from Angostura Diversion Dam to Bernalillo was a transition zone where the river channel became more braided, the floodplain widened, and substrata was primarily sand and silt. From Bernalillo downstream to Albuquerque, the river channel often exceeded 100 m in width and lower velocity habitats were more common. Backwaters were more abundant in this reach than between Cochiti and Angostura diversion dams and substrata larger than sand was rare.

Downstream of Albuquerque, the Rio Grande was a wide and meandering river with a predominantly sand substrata, high suspended silt load, and a broad variety of mesohabitats. The mainstem channel was generally wide (100-200 m), <1 m deep, and had a current velocity of <1 m/s. 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 during this study (Figure 2). There was a general trend of lower flow at downstream locations (i.e., U.S. Geological Survey (USGS) San Acacia Gauge [#08354900] and USGS San Marcial Gauge [#08358400]) compared to upstream ones (i.e., USGS Albuquerque Gauge [#08330000]). Since 1973, flow in the Rio Grande has been largely dictated by releases from Cochiti Dam. In 1999, flow was continuous in the Angostura Reach, low but continuous (i.e., no river drying observed) in the Isleta Reach, and discontinuous in the San Acacia Reach.

The lowest flows during the 1999 sampling period occurred in April. Flow in the Rio Grande during that period was discontinuous (consisting of isolated pools) from near the northern boundary of the Bosque del Apache National Wildlife Refuge downstream to the inflow of Elephant Butte Reservoir (Appendix B). The highest sustained flows during 1999 monitoring activities occurred in May and June due to late season precipitation and subsequent snowmelt. Flows declined in July but increased in August due to monsoonal moisture.

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 bimonthly sampling efforts during this study allowed for determination of general spatial and temporal changes in population structure and species densities. Previous population monitoring efforts relied on quarterly sampling, but bimonthly collections clearly provided a more detailed assessment of population dynamics. The rapid changes in YOY densities that occur after the relatively short duration of spawning by Rio Grande silvery minnow appear to have been more accurately documented as a result of the modest increase in sampling effort.

During pre-1998 monitoring years, sampling was done by season and usually occurred during February (winter), May (spring), August (summer), and October (autumn). Beginning with the 1999 survey, monitoring will be conducted during February, April, June, August, October, and December.

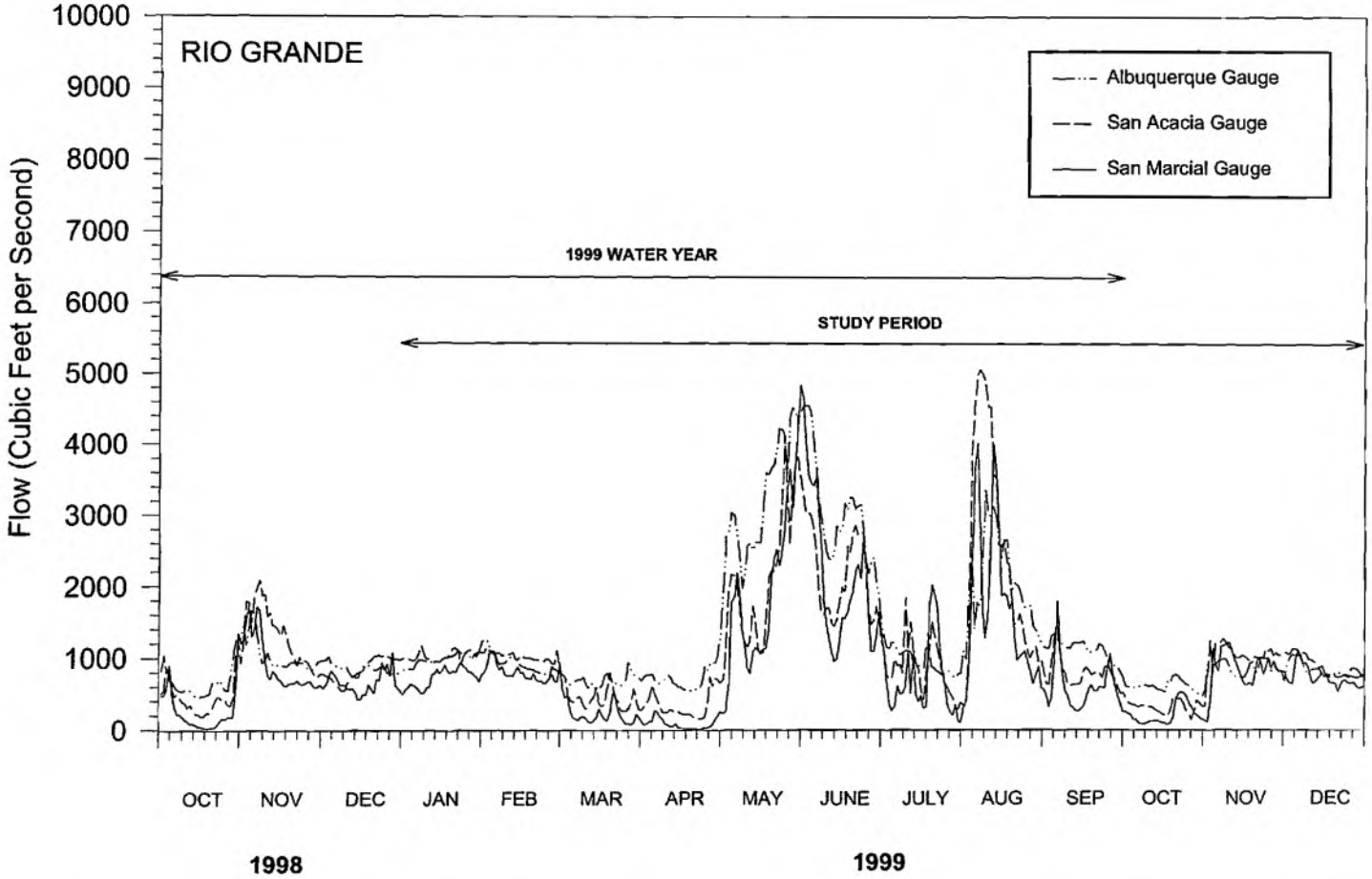

Figure 2. Hydrograph of the Rio Grande, NM at Albuquerque, San Acacia, and San Marcial for the 1999 water year and study period.

The June 1999 sampling effort was actually conducted in early July. To avoid confusion in this and subsequent monitoring reports, that sampling effort will still be referred to as the June sample.

Monitoring of the Middle Rio Grande ichthyofaunal community was conducted annually between 1993-1997. However, changes in federal endangered species collection permitting procedures instituted in 1998 impacted this study. These changes resulted in a profusion of permit applications which overwhelmed the already limited resources of the U.S. Fish and Wildlife Service Regional permitting office. A consequence of this situation was that a collecting permit was not available until late 1998 and, because of that, fish monitoring activities for that year (1998) could not be conducted.

Reach names are taken from the diversion structure at the upstream boundary of that reach of river. The Angostura Reach (Angostura Diversion Dam to Isleta Diversion Dam) had five sampling localities and the Isleta Reach (Isleta Diversion Dam to San Acacia Diversion Dam) had two collecting sites. There were eight sampling localities in the San Acacia Reach (San Acacia Diversion Dam to Elephant Butte Reservoir). No sampling was conducted in the Cochiti Reach for reasons previously stated.

Fish were collected 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). Large fish (e.g., > 300 mm standard length, SL) were released at the site of capture. 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 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 retained Rio Grande silvery minnow were measured to the nearest 0.1 mm SL and those data used to construct length-frequency histograms for this species (Appendix A). Graphs of fish catch per unit effort are provided for the 10 focal species (the 10 most common taxa that occur throughout the study area) for each collection locality by sampling period (Appendix A). A total of 2,311 Rio Grande silvery minnow were released, alive, at their site of capture. Released individuals were included in graphs of fish catch per unit effort but were not available for length-frequency histograms. Scientific and common names of fishes in this report generally follow Robins et al. (1991; Table 1). Common names, arranged in phylogenetic order, are used in tables and the report.

The terms "discontinuous flow" and "river drying" are used frequently in this report and are meant to represent discrete stages in the continuum between a flowing river and dry river bed. Discontinuous flow refers to a river reach of indeterminate length which retains some standing water but no longer maintains measurable flow. Initially, a discontinuous reach will consist of one single pool that dissipates to become a series of smaller isolated pools. The term "river drying" is applied when water no longer remains in a relatively extensive portion of the river, as opposed to the dry reach between isolated pools.

The most important difference between duration of discontinuous flow and duration of river drying is that the former condition denotes the presence of some standing water in which fish could presumably survive for at least a short time. In the case of discontinuous flow, information on duration of the event is important as likelihood of survival is negatively correlated with duration. Reconnection of isolated pools and restoration of continuous flow before fish, and other members of the aquatic community, succumb is dependent on many factors including tenure of isolation and climatic conditions. In the case of river drying, surface water is no longer present and as a result all aquatic organisms have died. Duration of drying, in these situations, is irrelevant as the organisms in question are just as dead one day after drying as 10 days after drying. The need for these distinctions become evident when fallacious attempts are made to exculpate a river drying event by invoking its short duration.

Table 1. Scientific and common names and species codes of fish collected from the Middle Rio Grande for 1999.

Scientific Name	Common Name	Code
Order Clupeiformes		
Family Clupeidae	herrings	
Dorosoma cepedianum	gizzard shad	(GZS)
Order Cypriniformes		
Family Cyprinidae	carps and minnows	
Carassius auratus	goldfish	(GLD)
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)
Ictiobus bubalus	smallmouth buffalo	(SMB)
Order Siluriformes		
Family Ictaluridae	bullhead catfishes	
Ameiurus melas	black bullhead	(BBH)
Ameiurus natalis	yellow bullhead	(YBH)
Ictalurus punctatus	channel catfish	(CCT)
Order Salmoniformes		
Family Salmonidae	trouts	
Oncorhynchus mykiss	rainbow trout	(RBT)
Order Cyprinodontiformes		
Family Poeciliidae	livebearers	
Gambusia affinis	western mosquitofish	(MOS)

Table 1 (continued). Scientific and common names and species codes of fish collected from the Middle Rio Grande for 1999.

Scientific Name	Common Name	Code
Order Perciformes		
Family Percichthyidae	temperate basses	
Morone chrysops	white bass	(WHB)
Family Centrarchidae	sunfishes	
Lepomis cyanellus	green sunfish	(GNS)
Lepomis macrochirus	bluegill	(BGL)
Micropterus salmoides	largemouth bass	(LMB)
Pomoxis annularis	white crappie	(WCR)
Pomoxis nigromaculatus	black crappie	(BCR)

RESULTS

SUMMARY OF 1999 COLLECTING ACTIVITIES

Rio Grande silvery minnow

The number of Rio Grande silvery minnow collected within a particular study reach in 1999 varied both within and between seasons. Catch rate of Rio Grande silvery minnow also varied noticeably in and between sampling reaches (Figures 3 and 4). The Angostura Reach yielded the fewest silvery minnow (n=30) in 1999, followed by the Isleta Reach (n=74), and San Acacia Reach (n=7,187).

In 1999, catch rate and the number of Rio Grande silvery minnow taken was lowest during February (n=368), April (n=338), and October (n=412) in all reaches (Figure 5). Changes in number or catch rate of Rio Grande silvery minnow in 1999 in the Angostura Reach were minor as so few individuals were present. This fish was absent from 1999 collections at the two upstream-most Angostura Reach sites. Samples from the remaining three sites in the Angostura Reach yielded very few Rio Grande silvery minnow. Isleta Reach collections yielded none or very few Rio Grande silvery minnow except during August. That sample (August-Isleta Reach) contained several YOY (young-of-year) Rio Grande silvery minnow. Conversely, the San Acacia Reach consistently yielded relatively high Rio Grande silvery minnow catch rates and produced nearly 70 times the number of individuals as the Angostura and Isleta reaches, collectively. Peaks in Rio Grande silvery minnow abundance occurred in June and August in the San Acacia Reach with June catch rates being about twice that recorded during August.

A total of 273 seine hauls were taken during the February 1999 sampling foray of which 60 (hauls) contained Rio Grande silvery minnow. That sampling effort yielded two Rio Grande silvery minnow from the Angostura Reach and none from the Isleta Reach. Both individuals from the Angostura Reach were collected in pools near the shoreline. Over 99% of Rio Grande silvery minnow taken in February were from localities downstream of San Acacia Diversion Dam with the largest number of individuals occurring at the upstream-most sites in that reach (sites 10-13). The number of Rio Grande silvery minnow taken at downstream San Acacia Reach localities (sites 14-17) during February 1999 ranged from 5 to 24. This species was most frequently collected in shoreline or low velocity habitats associated with instream debris.

There were slightly fewer Rio Grande silvery minnow collected in April (n=338) than during the February sampling foray (n=368). In April 1999, two Rio Grande silvery minnow were collected in the Angostura Reach and one was taken in the Isleta Reach. Most of the remainder of the Rio Grande silvery minnow catch was from the upstream sites in the San Acacia Reach. Flow in the river downstream of San Acacia Diversion Dam dropped markedly during the April 1999 sampling period initially resulting in discontinuous flow and ultimately in widely scattered isolated pools. More detailed accounts on the aforementioned low flow period were provided in a supplemental report on flow and the status of fish between San Acacia Diversion Dam and San Marcial Railroad bridge crossing from 14-26 April 1999 (see Appendix B).

The June sampling foray yielded substantially more Rio Grande silvery minnow than the previous two 1999 sampling forays. However, only one site in the Angostura Reach yielded Rio Grande silvery minnow (n=3) and none were collected in the Isleta Reach. The majority of Rio Grande silvery minnow were again collected in the San Acacia Reach and most individuals (n=3,276; 93%) were taken at downstream localities (sites 15-17). The two upstream-most sites in the San Acacia Reach produced seven Rio Grande silvery minnow during the June sampling foray. Conversely, site 17 had a catch rate of YOY Rio Grande silvery minnow about 20 times (776 individuals/100 m^2) that measured at other San Acacia Reach sites (except site 15). The majority of

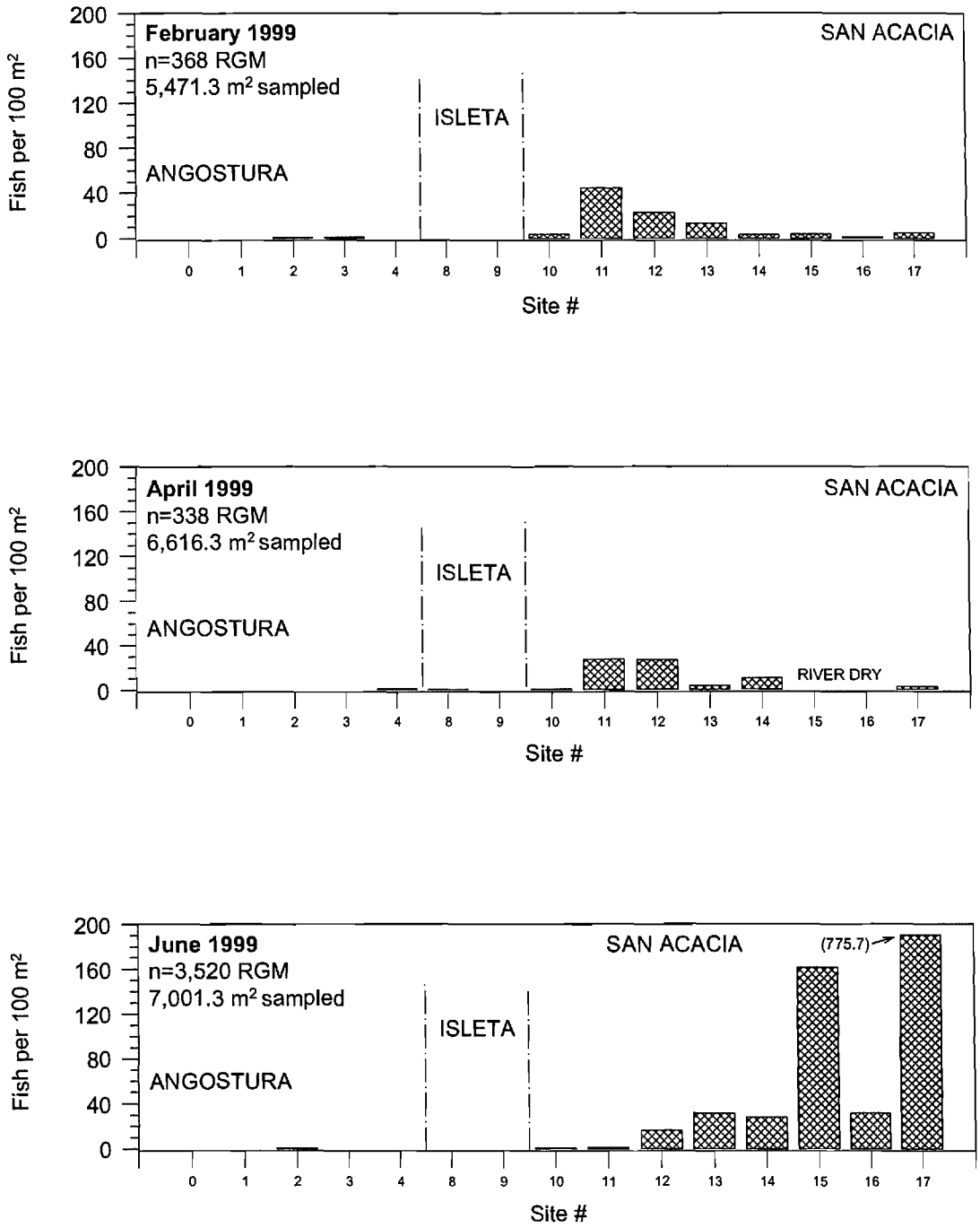

Figure 3. Rio Grande silvery minnow (RGM) catch rates (CPUE) for February, April, and June of 1999 for each collection locality in the Middle Rio Grande.

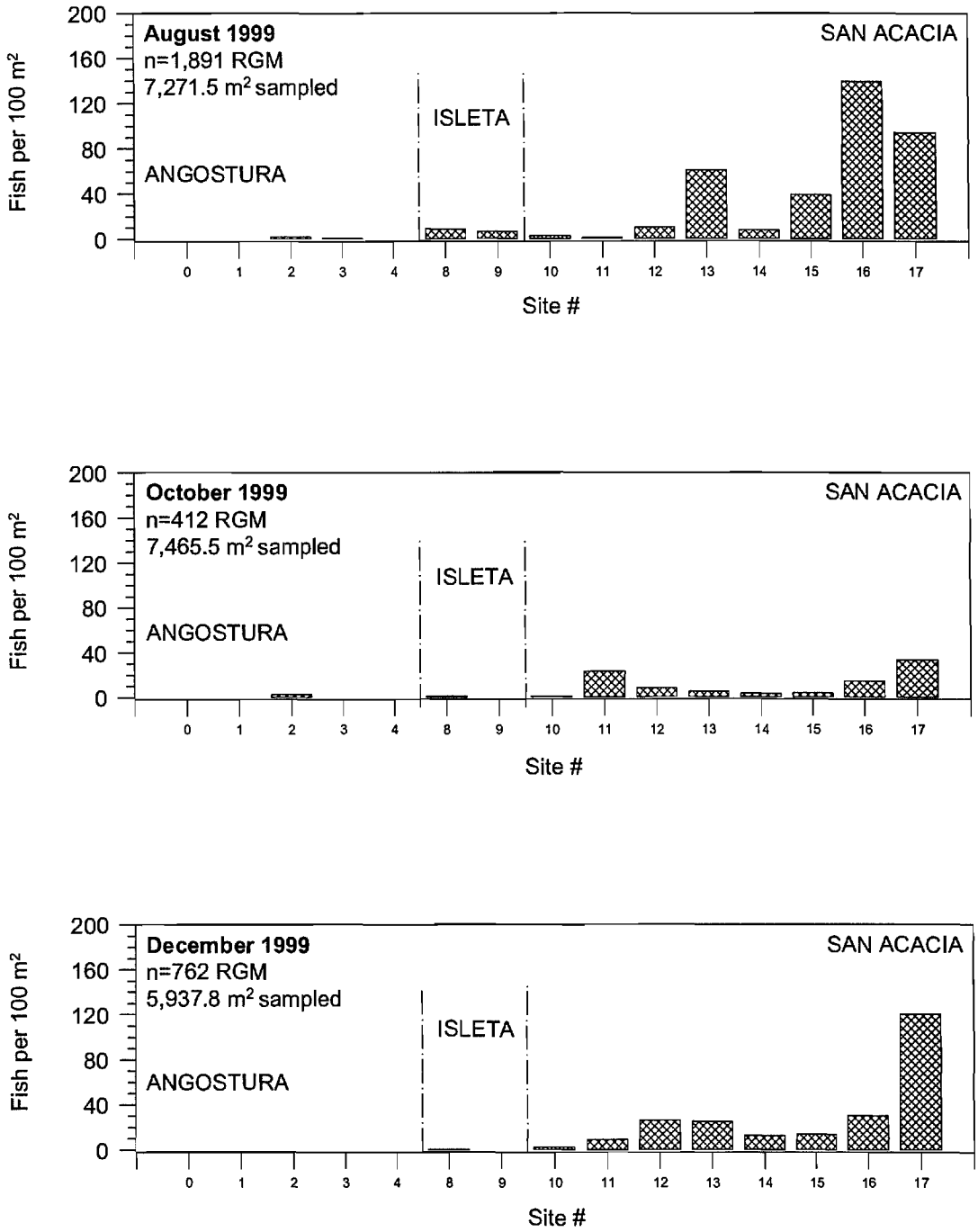

Figure 4. Rio Grande silvery minnow (RGM) catch rates (CPUE) for August, October, and December of 1999 for each collection locality in the Middle Rio Grande.

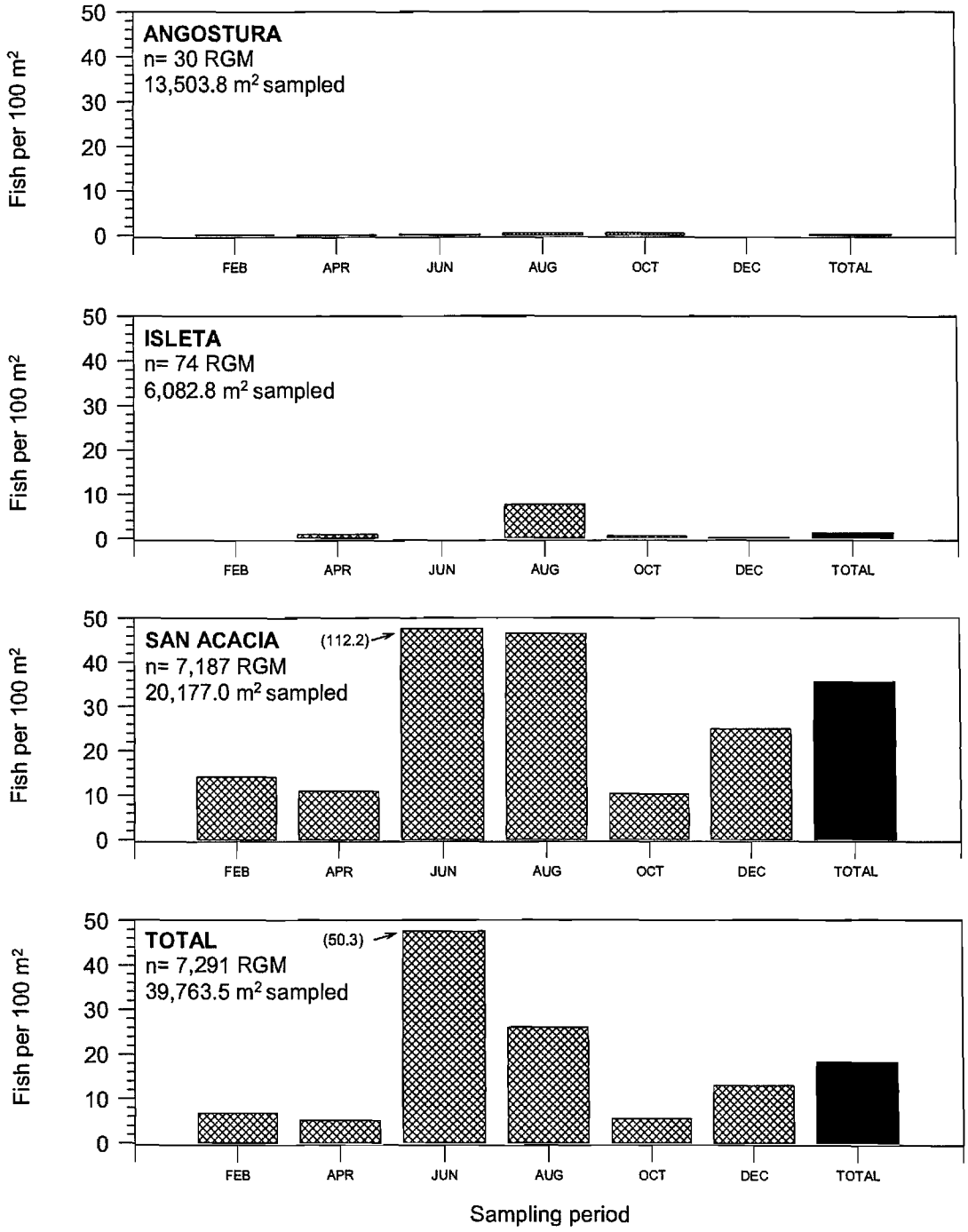

Figure 5. Rio Grande silvery minnow (RGM) catch rates (CPUE) by river reach for each sampling period of 1999 in the Middle Rio Grande.

Rio Grande silvery minnow at site 17 were taken in backwater habitats. We estimate, based on catch rate and individuals enumerated (n=2,137), that these backwaters contained tens-of-thousands of YOY Rio Grande silvery minnow. While not as dramatic as site 17, site 15 also yielded a large number of individuals (n=987) and a high catch rate (161 individuals/100 m^2) of Rio Grande silvery minnow. Most of the site 15 YOY Rio Grande silvery minnow were collected in backwaters or shoreline pool mesohabitats.

The general distribution of Rio Grande silvery minnow, as determined from August collections, was similar to that observed during June. Two of five Angostura Reach sites yielded Rio Grande silvery minnow (n=11); 10 of the 11 were YOY individuals. This species was also present at both sites in the Isleta Reach (n=67) and those samples included only YOY Rio Grande silvery minnow. The August sampling effort in the Angostura and Isleta reaches (combined) yielded more Rio Grande silvery minnow (n=88) at more sites (n=4) in those two reaches than any of the other five 1999 sampling forays. During the August 1999 sampling foray in the San Acacia Reach, Rio Grande silvery minnow were most abundant at the two most downstream sites (16 and 17). Catch rate of Rio Grande silvery minnow at site 16 increased from 32 individuals/100 m^2 in June to 139 individuals/100 m^2 in August. However, the catch rate at site 17 for this fish declined substantially from June (776 individuals/100 m^2) to August (94 individuals/100 m^2).

October (autumn) catch rates throughout the study reach resembled those encountered during the April (spring) sampling effort (i.e., before spawning) with the exception of the dry sites. Only a few Rio Grande silvery minnow (n=17) were collected in the Isleta and Angostura reaches and those individuals were taken at sites 2 and 8. All San Acacia Reach sites continued to produce Rio Grande silvery minnow but the cumulative and site-specific catch rates for this reach in October had declined compared to August. The exception to this San Acacia Reach trend was at site 11 where both the number (n=82 versus 6) and catch rate (23 versus 1 individuals/100 m^2) of Rio Grande silvery minnow increased between August and October.

December sampling produced more Rio Grande silvery minnow than did October efforts. No Rio Grande silvery minnow were taken in the Angostura Reach during December and only one individual was collected in the Isleta Reach. Rio Grande silvery minnow catch rates in the San Acacia Reach, which generally increased between October and December, was markedly higher at site 17. The December sample of Rio Grande silvery minnow from the San Acacia Reach yielded about 760 individuals and included at least two age-classes (age-0=1999 year class and age-1=1998 year class). Most of these individuals were found in the low velocity and debris containing mesohabitats that Rio Grande silvery minnow commonly utilize during winter.

Fish Community

The ichthyofaunal community in the Middle Rio Grande between Angostura Diversion Dam and Elephant Butte reservoir was numerically dominated by cyprinids (Table 2). The native ichthyofauna consisted of seven species (red shiner, Rio Grande silvery minnow, fathead minnow, flathead chub, longnose dace, river carpsucker, and smallmouth buffalo) that were represented by sample numbers between 1 and 10,269. Smallmouth buffalo (n=1) was the least abundant native fish with longnose dace (n=203) being the second least collected native taxon. Red shiner was the most abundant native species in collections (n=10,269) followed by Rio Grande silvery minnow (n=7,291), river carpsucker (n=1,415), flathead chub (n=698) and fathead minnow (n=639). Some of the more abundant introduced species, were channel catfish (n=953), western mosquitofish (n=884), gizzard shad (n=547), common carp (n=290), and white sucker (n=202). The other ten nonnative fish species were present but at lower abundances (i.e., < 40 individuals) than the other nonnatives.

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Table 2. Summary of ichthyofaunal composition and collection data from the Middle Rio Grande for 1999.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	% OF TOTAL
HERRINGS			
gizzard shad	I	547	2.32
CARPS AND MINNOWS			
goldfish	I	2	<0.01
red shiner *	N	10,269	43.66
common carp *	I	290	1.23
Rio Grande silvery minnow *	N	** 7,291	31.00
fathead minnow *	N	639	2.72
flathead chub *	N	698	2.97
longnose dace *	N	203	0.86
SUCKERS			
river carpsucker *	N	1,415	6.02
white sucker *	I	202	0.86
smallmouth buffalo	N	1	<0.01
BULLHEAD CATFISHES			
black bullhead	I	39	0.17
yellow bullhead	I	5	0.02
channel catfish *	I	953	4.05
TROUTS			
rainbow trout	I	1	<0.01
LIVEBEARERS			
western mosquitofish *	I	884	3.76
TEMPERATE BASSES			
white bass	I	31	0.13
SUNFISHES			
green sunfish	I	2	<0.01
bluegill	I	2	<0.01
largemouth bass	I	4	0.02
white crappie	I	39	0.17
black crappie	I	2	<0.01
TOTAL		23,519	

N = native; I = introduced
* indicates one of the 10 focal taxa used in all community composition figures
** includes 2,311 released individuals

There were notable annual and bimonthly changes in the relative abundance of the ten focal species for 1999 (Figures 6 and 7). Red shiner was the most abundant species during all sampling forays except June and August when Rio Grande silvery minnow was the most abundant taxon. Comparison of February and April sampling forays revealed little change in relative abundance in any species except red shiner, which increased in abundance. Rio Grande silvery minnow and river carpsucker abundances increased between the April and June sampling efforts presumably as a result of the infusion of the age-0 cohort. Most species were slightly more abundant in June samples than in previous sampling efforts. Individual species catch rates in August were similar to June except that densities of Rio Grande silvery minnow and river carpsucker had declined. October and December samples catch rates were similar to those recorded for February.

Besides temporal variation in the relative abundances in the fish community, there were longitudinal differences and patterns in fish abundances (Figure 8). Red shiner catch rates were highest in the Isleta Reach and lowest in the Angostura Reach. River carpsucker and channel catfish exhibited a shared pattern of higher catch rates in the Isleta Reach compared to the Angostura Reach. Rio Grande silvery minnow was most abundant in the downstream reach (San Acacia), rare in the Isleta Reach, and extremely rare in the Angostura Reach. Conversely, longnose dace and white sucker were most abundant in the Angostura Reach and less common downstream. Density of western mosquitofish did not appear to vary notably or exhibit a consistent between-reach pattern across sampling periods, but was most abundant overall in collections from the Angostura Reach.

Relative abundance of fish in 1999 fluctuated between sampling periods for each of the river reaches (Figure 9). An increase, of varying magnitudes, in the relative abundances of fish was discerned in April, June, and August samples compared to February, October, and December. Notable increases in fish catch rate in the Angostura and San Acacia reaches occurred in April and June although the relative density of fish was much higher in the San Acacia Reach. Isleta Reach fish catch rates were highest in April and then gradually declined through October. However, the small number of sampling stations (n=2) in the Isleta Reach preclude extensive interpretation.

Catch rates of individual taxa in the study reaches varied extensively by sampling period (Figures 10 and 11). Fish catch rates in the Angostura Reach were consistently low for most of the focal species except red shiner which were consistently higher. Rio Grande silvery minnow catch rates in this reach were extremely low throughout 1999. Relative abundances of river carpsucker and white sucker in the Angostura Reach increased during the June sampling foray but declined by August. Channel catfish and western mosquitofish were both more abundant in samples from the Angostura Reach during summer months than at other times of the year.

Fish catch rates in the Isleta Reach, like those in the Angostura Reach, also peaked during summer as compared to spring or winter. Red shiner was an exception to this trend as it was most abundant in April (spring) in 1999 Isleta Reach collections. Rio Grande silvery minnow abundance in the Isleta Reach was relatively low, even during the August sample when YOY were collected. River carpsucker were present at low to moderate abundances in this reach throughout the year except for the June sample when it was more common.

The relative abundance of red shiner in the San Acacia Reach peaked in April and remained at moderate levels throughout the rest of 1999. Rio Grande silvery minnow catch rates in the San Acacia Reach were consistently higher than in the Angostura or Isleta reaches throughout 1999. Other species (common carp, fathead minnow, flathead chub, longnose dace, river carpsucker, white sucker, channel catfish, and western mosquitofish) present at relatively low abundance levels in the San Acacia Reach throughout 1999, generally peaked in abundance during summer.

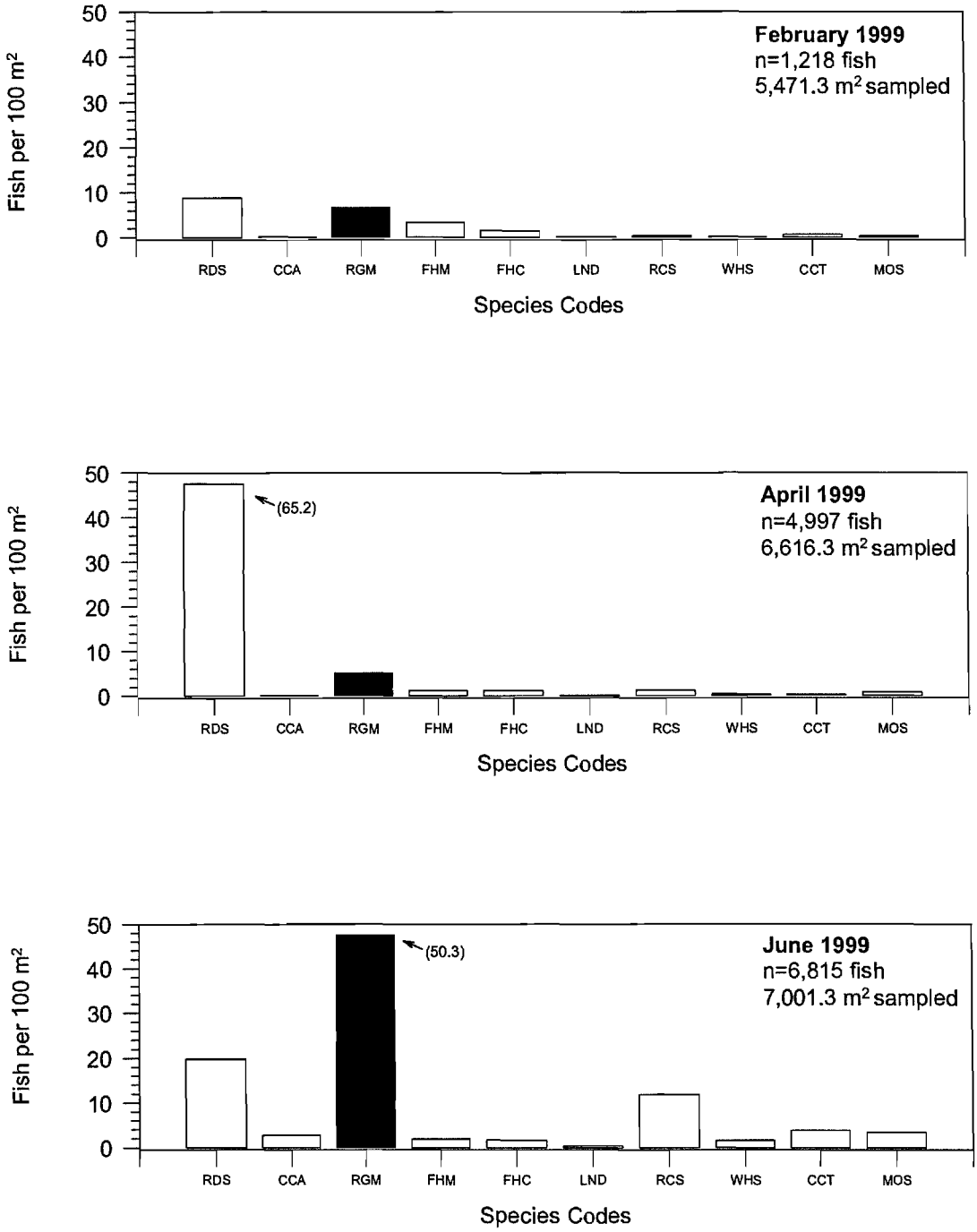

Figure 6. Fish catch rates (CPUE) for February, April, and June of 1999 for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

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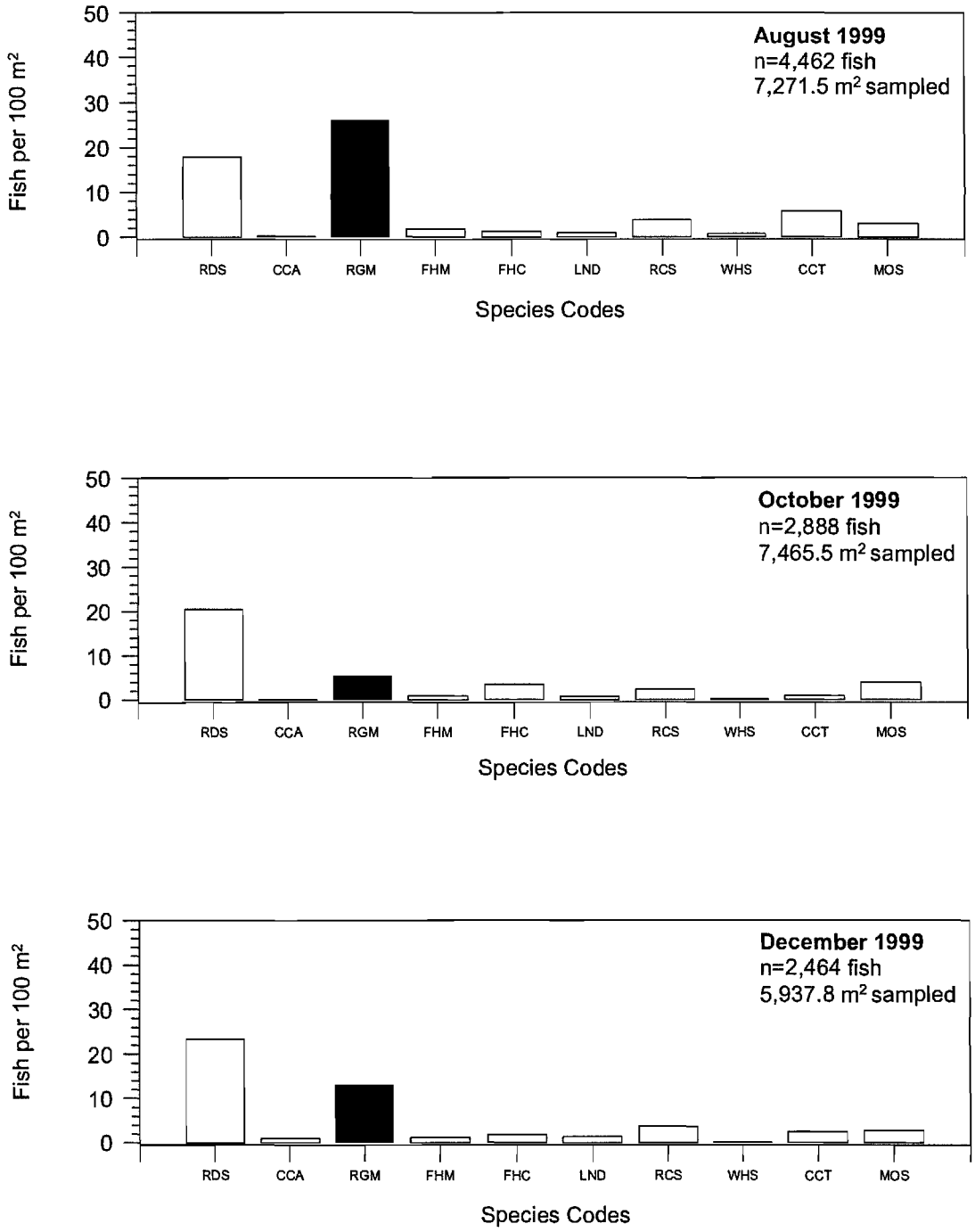

Figure 7. Fish catch rates (CPUE) for August, October, and December of 1999 for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

[redacted]

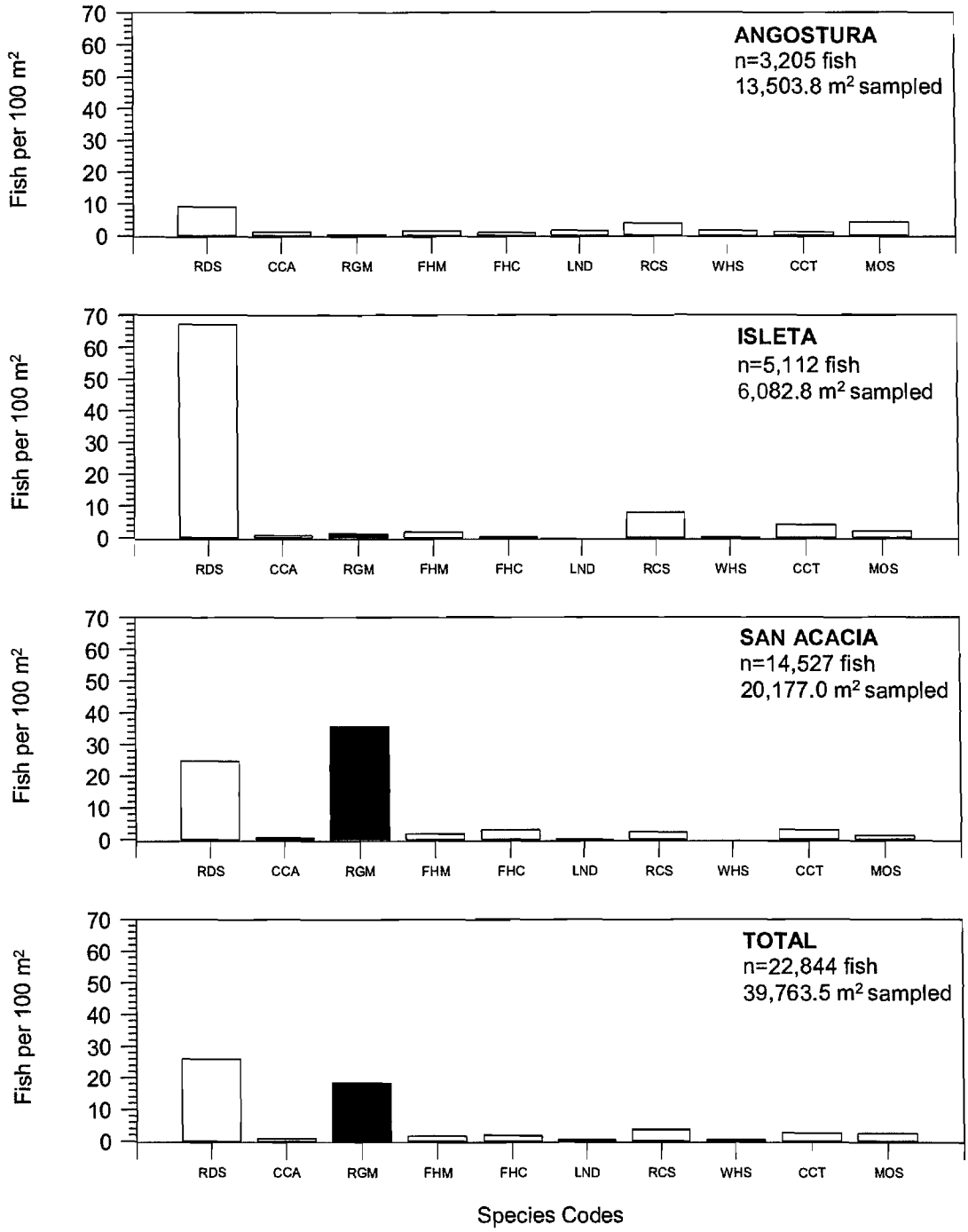

Figure 8. Fish catch rates (CPUE) by river reach for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

[redacted]

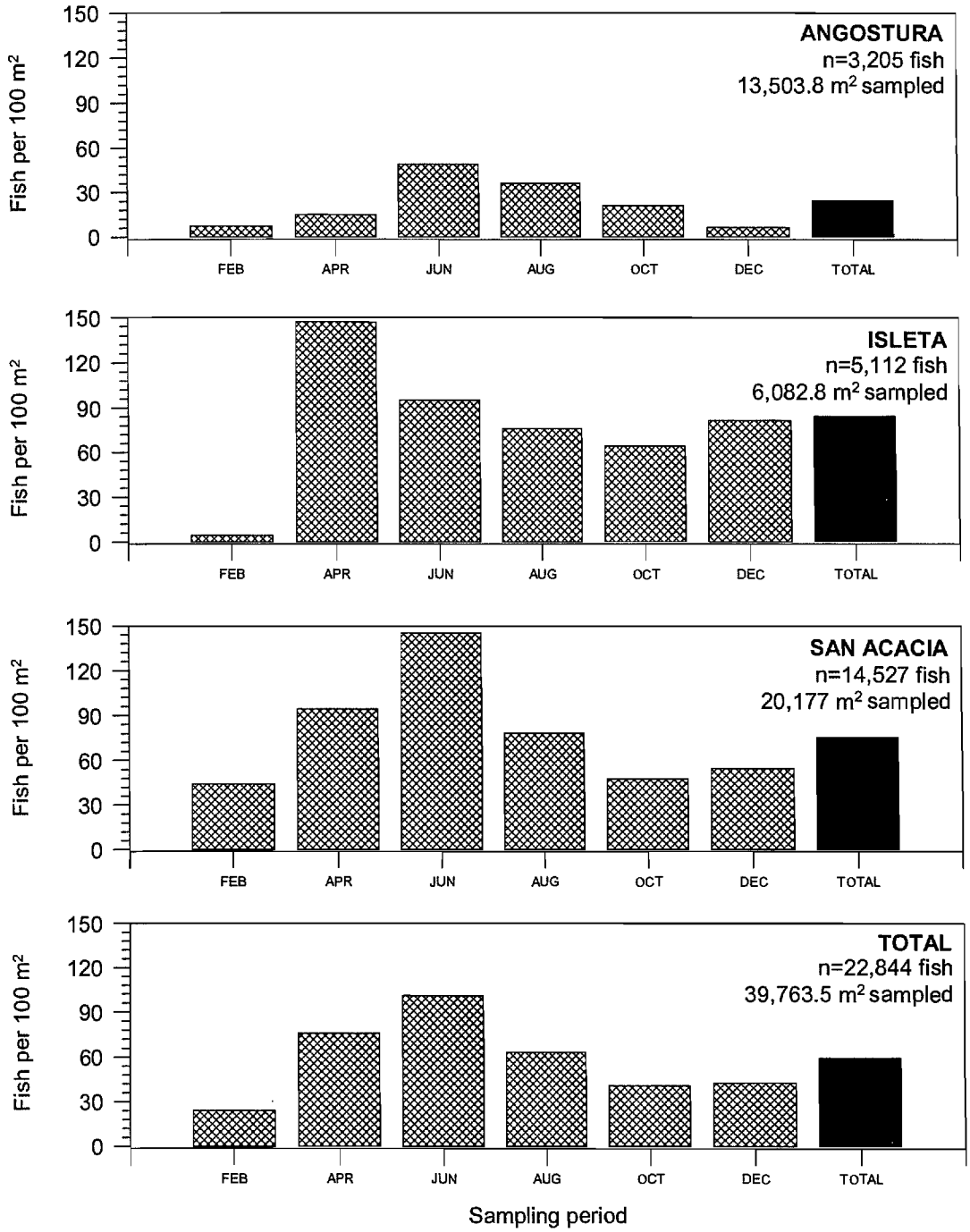

Figure 9. Fish catch rates (CPUE) by river reach for each sampling period in the Middle Rio Grande for 1999.

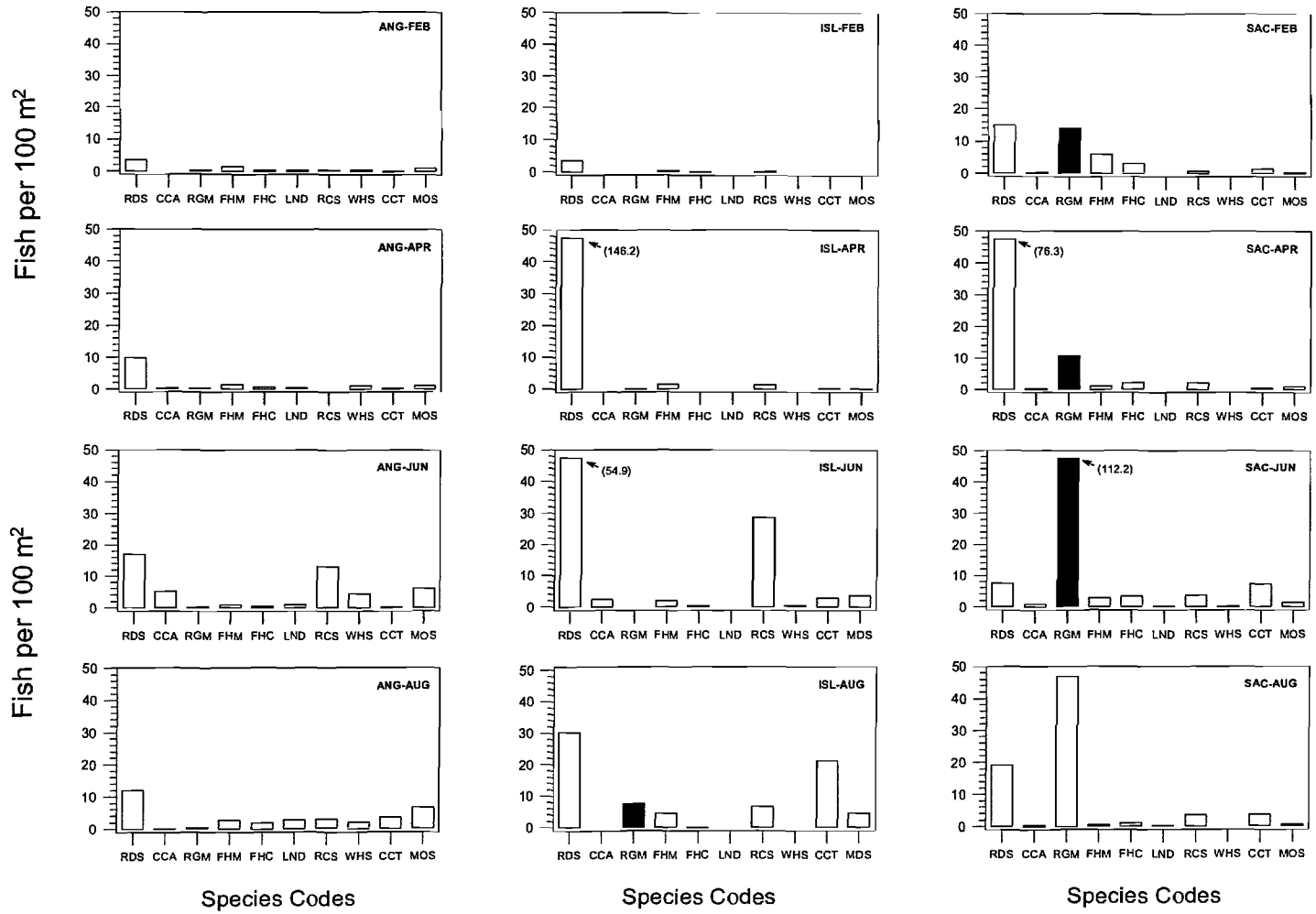

Figure 10. Fish catch rates (CPUE) by river reach for February, April, June, and August of 1999 for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande (ANG=Angostura, ISL=Isleata, and SAC=San Acacia). Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

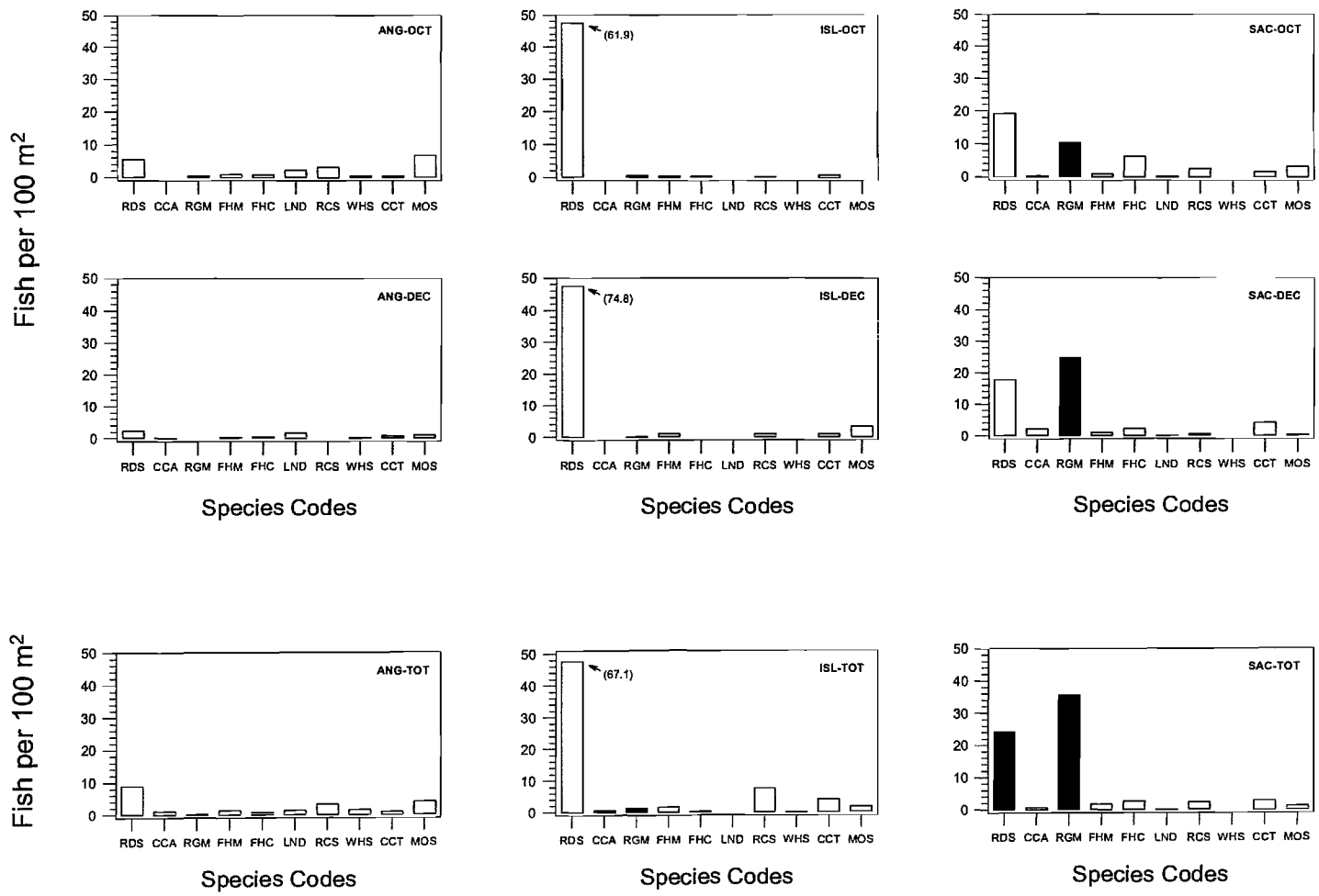

Figure 11. Fish catch rates (CPUE) by river reach for October, December, and annual total for 1999 for each focal species (see Table 1 for species abbreviations)in the Middle Rio Grande (ANG=Angostura, ISL=Isleata, and SAC=San Acacia). Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

DISCUSSION

Spawning by Rio Grande silvery minnow occurs during spring and is initiated, in part, by increases in flow. Spring runoff (from high mountain snowmelt) was likely the historical source of this reproductive stimulus. Dams and reservoirs now moderate the magnitude, amplitude, and duration of spring discharge. During years of sufficient snowpack, flow through the Middle Rio Grande will remain continuous through June. Flows during spring non-drought years are of sufficient magnitude to result in spawning by Rio Grande silvery minnow. Young-of-year Rio Grande silvery minnow appear in collections soon after this period of elevated flow.

An exact accounting of the number of adult Rio Grande silvery minnow that died as a result of discontinuous flow and drying of portions of the river channel during April 1999 in the San Acacia Reach was not practical. However, the absence of continuous discharge in the San Acacia Reach (prior to Rio Grande silvery minnow spawning) that caused this loss of gravid adults resulted in fewer age-0 Rio Grande silvery minnow than would be expected during years with continuous flow. Rio Grande silvery minnow abundance in 1999 increased following May spawning and returned to pre-spawning levels during October.

The 1999 population levels of Rio Grande silvery minnow, as determined from this monitoring effort, were especially low in the Angostura and Isleta reaches. There were very few adults and a near absence of YOY Rio Grande silvery minnow in either of these two reaches. Over 98% (n=7,187) of the total 1999 Rio Grande silvery minnow catch, by number (n=7,291), were taken in the San Acacia Reach of the Rio Grande. Rio Grande silvery minnow catch rates during 1999 in the San Acacia Reach were about 160 times greater than those recorded in the Angostura Reach and about 30 times more than in the Isleta Reach.

The upper three sites (sites 0-2) in the Angostura Reach are characterized by cooler waters and a more armored substrata (i.e., loss of silt and sand) than is present at more downstream sampling localities. Habitats at the two lower-most sites in this reach (sites 3-4) are characterized by a sand or sand-silt substrata and are more similar to downstream than upstream sites. Despite these habitat differences, the near absence of Rio Grande silvery minnow in the Angostura Reach is probably not due to a lack of available habitat as this species was recently (1994-1997) more abundant (Dudley and Platania, 1997; 1999) than 1999 collections indicate. There does not appear to be, at least superficially, a post-1996 loss in the amount or composition of aquatic habitats in the Angostura Reach that would account for the decline in Rio Grande silvery minnow abundance. Dewatering can not be advanced as the reason for the decline in abundance of Rio Grande silvery minnow in the Angostura Reach as flow has been continuous (in this reach) throughout the 1990s.

The most plausible explanation for the decline in Rio Grande silvery minnow abundance in the Angostura Reach appears to be the fragmentation of their range and longitudinal displacement of their propagules (drifting eggs and larvae) below the instream barriers of Isleta Diversion Dam and San Acacia Diversion Dam. These channel-wide structures do not preclude downstream passage of fish or their reproductive products but do prevent fish movement upstream of the diversion dam structures. Given the reproductive ecology of this species, reach lengths, and diversion dam placement, the sequential decline and loss of this species from upstream to downstream was predicted (Platania and Altenbach, 1998). The fragmentation of this species range in the Middle Rio Grande as a result of Angostura, Isleta, and San Acacia diversion dams has been identified as an issue of paramount importance that requires resolution for recovery of Rio Grande silvery minnow (U.S. Fish and Wildlife Service, 1999).

The Isleta Reach is an intermediate reach, not only in geographic position but also in regards to flow. This reach does not maintain the volume or consistency of discharge as the Angostura Reach but, because of the numerous points of irrigation returns, has had an increased likelihood of maintaining some continuous flow compared to the San Acacia Reach. The 1999 Isleta Reach samples produced

more Rio Grande silvery minnow than the Angostura Reach but with only 1.2 individuals/100m^2 sampled, they were <1/3 as abundant in this reach as in 1997 (4.3 individuals/100m^2). Issues regarding range fragmentation and downstream transport of silvery minnow propagules in the Angostura Reach are equally as important in the Isleta Reach. The decline in the Angostura Reach Rio Grande silvery minnow population will result in fewer eggs and larvae being transported into the Isleta Reach and will thereby negatively affect population levels in the latter reach. Likewise, fewer individuals in the Isleta and Angostura reaches will likely result in lower Rio Grande silvery minnow populations in the San Acacia Reach.

The barrier to upstream movement imposed by San Acacia Diversion Dam, reduced number of Rio Grande silvery minnow in upstream reaches, and downstream transport of silvery minnow eggs and larvae (especially those produced in the San Acacia Reach) into Elephant Butte Reservoir continue to adversely impact the San Acacia Reach population of this species. However, most of the decrease in Rio Grande silvery minnow abundance in the San Acacia Reach between 1997 and 1999 was probably primarily the result of periods of discontinuous flow or river drying. In 1996, extensive portions of the San Acacia Reach were dewatered resulting in the death of 1,000s of gravid, pre-spawning Rio Grande silvery minnow. River drying in 1996 included reaches in which Rio Grande silvery minnow had been very abundant. The most immediate population impact from the loss of reproducing individuals was a reduction in ability to produce age-0 fish (1996 year class) but impacts were not limited to the 1996 year class. The consequences of that event to Rio Grande silvery minnow population levels would continue for at least two years (life span of cohort) and has subsequently been affected by periods of low or no flow through portions of the San Acacia Reach.

The most recent occurrence of discontinuous flow and river drying in the San Acacia Reach was during April 1999 (Appendix B). As in 1996, this event occurred in April (spring) during a year of low winter precipitation (mountain snowpack). In contrast to 1996, the 1999 event did not affect as large a portion of the river. Regardless of the length of river impacted, the 1999 population monitoring study again illustrates the extremely deleterious effects that discontinuous flow and river drying have on populations of this endangered species. The need to maintain flow throughout the downstream most reach (San Acacia Reach) which currently supports the vast majority of remaining Rio Grande silvery minnow can not be overemphasized. The 1996 and 1999 death of numerous pre-spawning adults along with the effects of instream barriers continue to adversely impact Rio Grande silvery minnow abundance. Neither condition are beneficial for Rio Grande silvery minnow or other obligate riverine organisms.

ACKNOWLEDGMENTS

Many people collaborated with us to make this project possible. We thank W. Howard Brandenburg (MSB), Stephen R. Davenport (MSB), Michael A. Farrington (MSB), Donald E. Gibson (MSB), and Joshua R. Walters (MSB) for assistance with field portions of the study. Continued assistance with all aspects of curation of specimens and database management was provided by Alexandra M. Snyder (MSB). Much of the technical and logistical support for this project was provided by Gary L. Dean (USBR), Jennifer Fowler-Propst (USFWS), David L. Propst (NMGF), and James P. Wilber (USBR). This work was funded by the U.S. Army Corps of Engineers and U.S. Bureau of Reclamation under a cooperative agreement (98-FC-40-0500) with the latter agency. Fish were collected under a Federal Endangered Species Collecting Permit (TE001623-0) and a New Mexico Department of Game and Fish scientific collecting permit (#1896).

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Table A-1. Collection localities for 1999 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality
ANGOSTURA REACH SITES	
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 Wastewater Treatment 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
ISLETA REACH SITES	
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
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

Table A-1 (continued.). Collection localities for 1999 population monitoring of Rio Grande silvery minnow.

Site #	Site Locality

SAN ACACIA REACH SITES

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 the Low Flow Conveyance Channel bridge, east and upstream of Socorro Wastewater Treatment Plant, 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

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 Channel 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

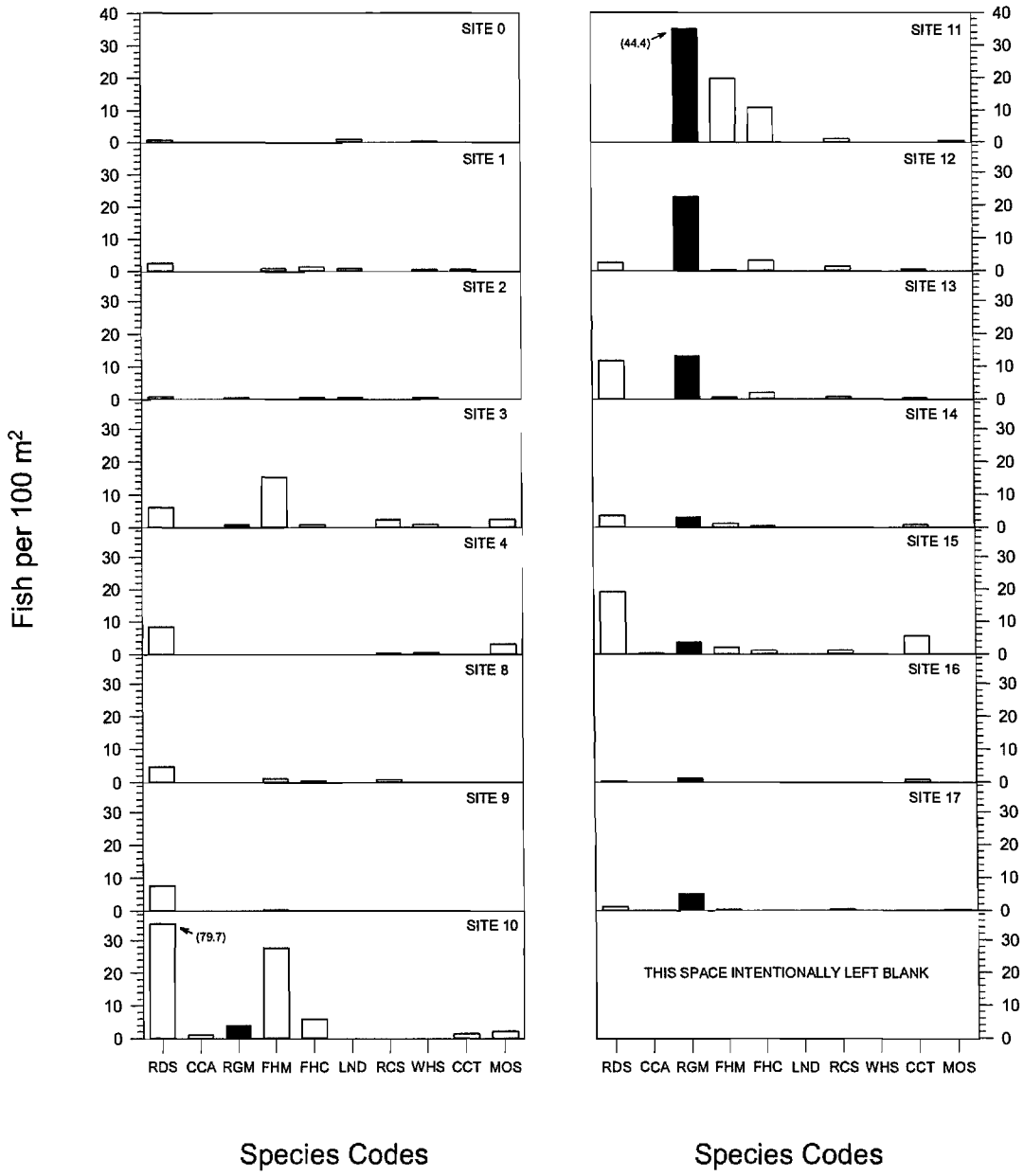

Figure A-1. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for February of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

[redacted]

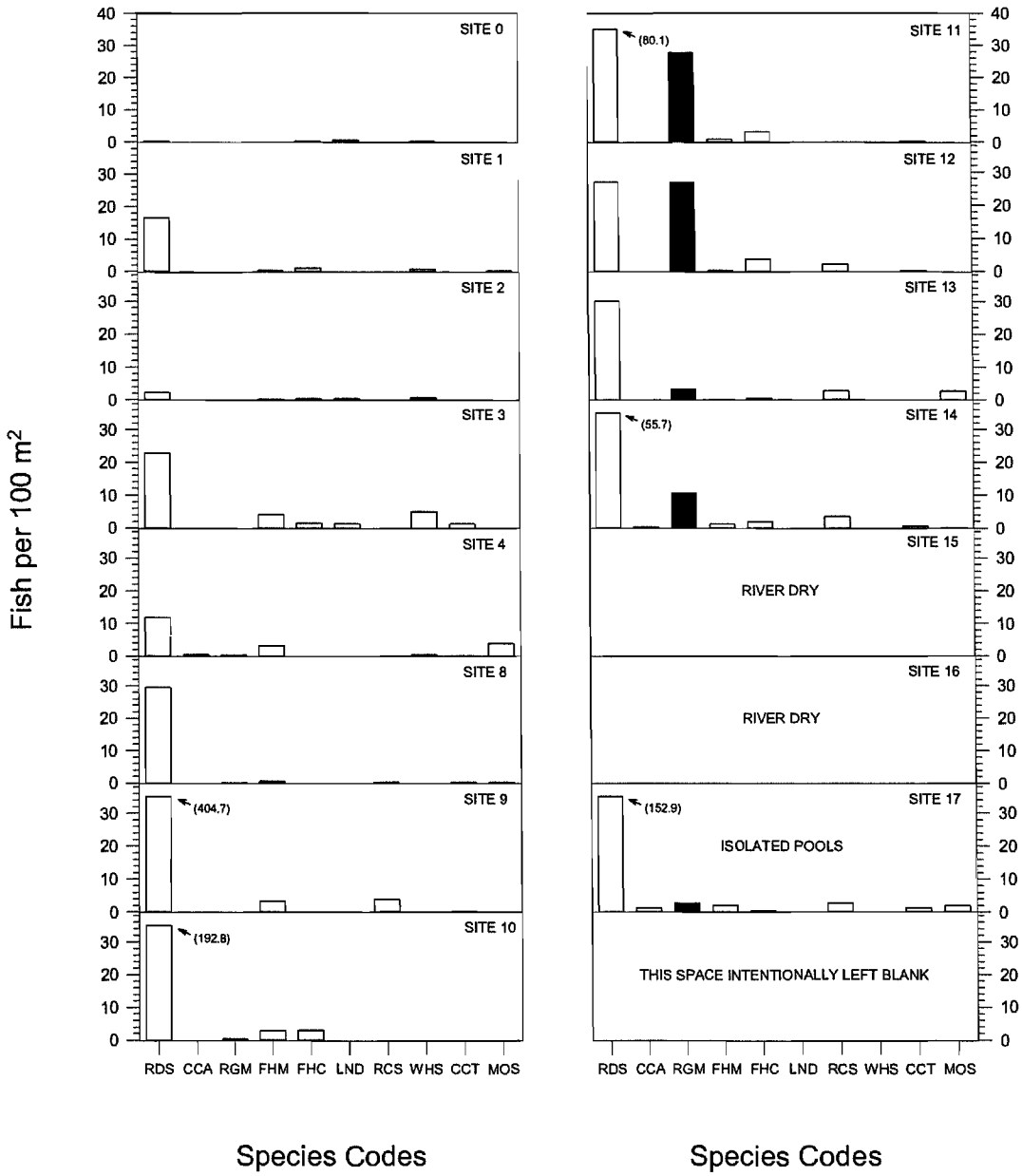

Figure A-2. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for April of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

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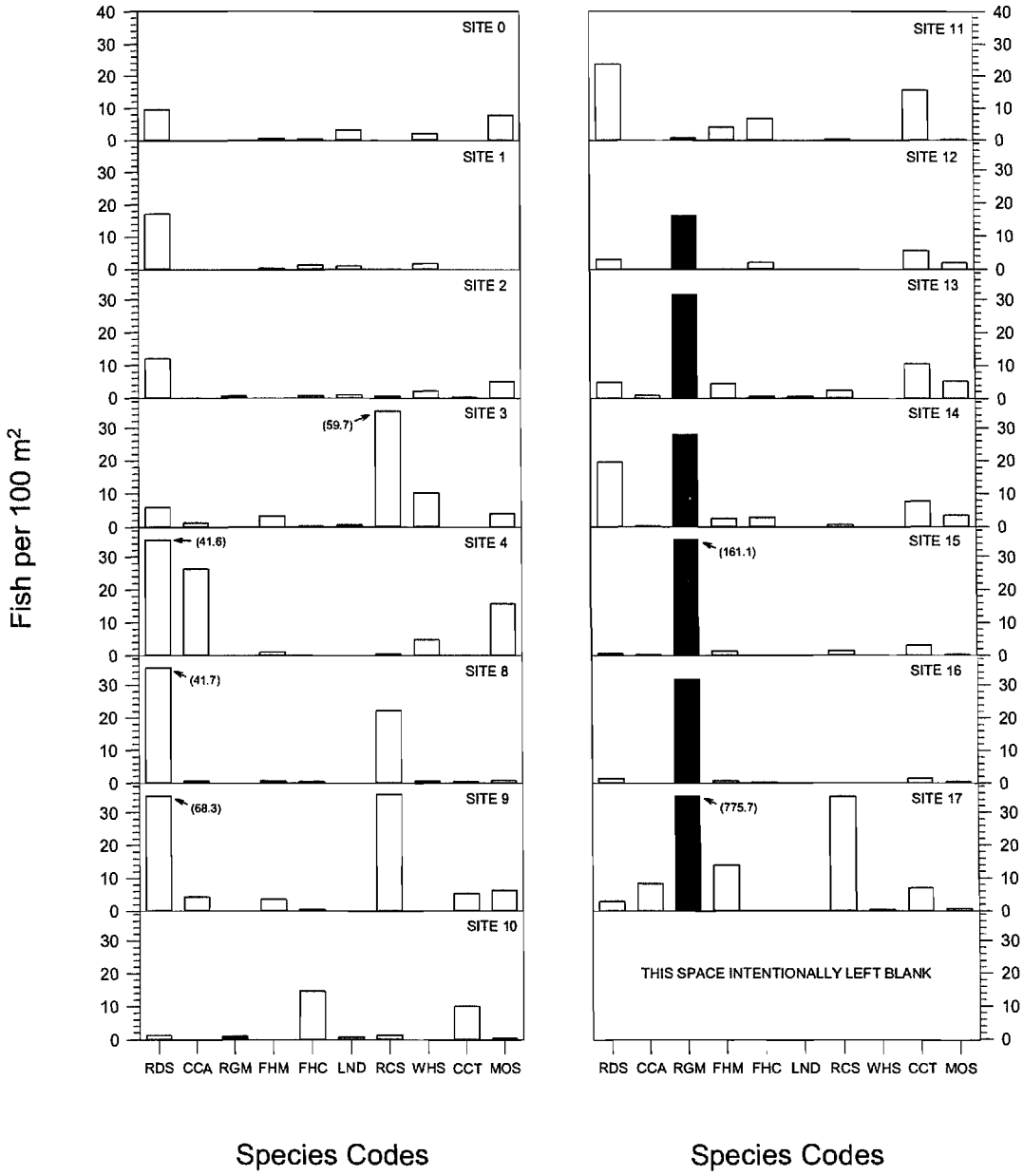

Figure A-3. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for June of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

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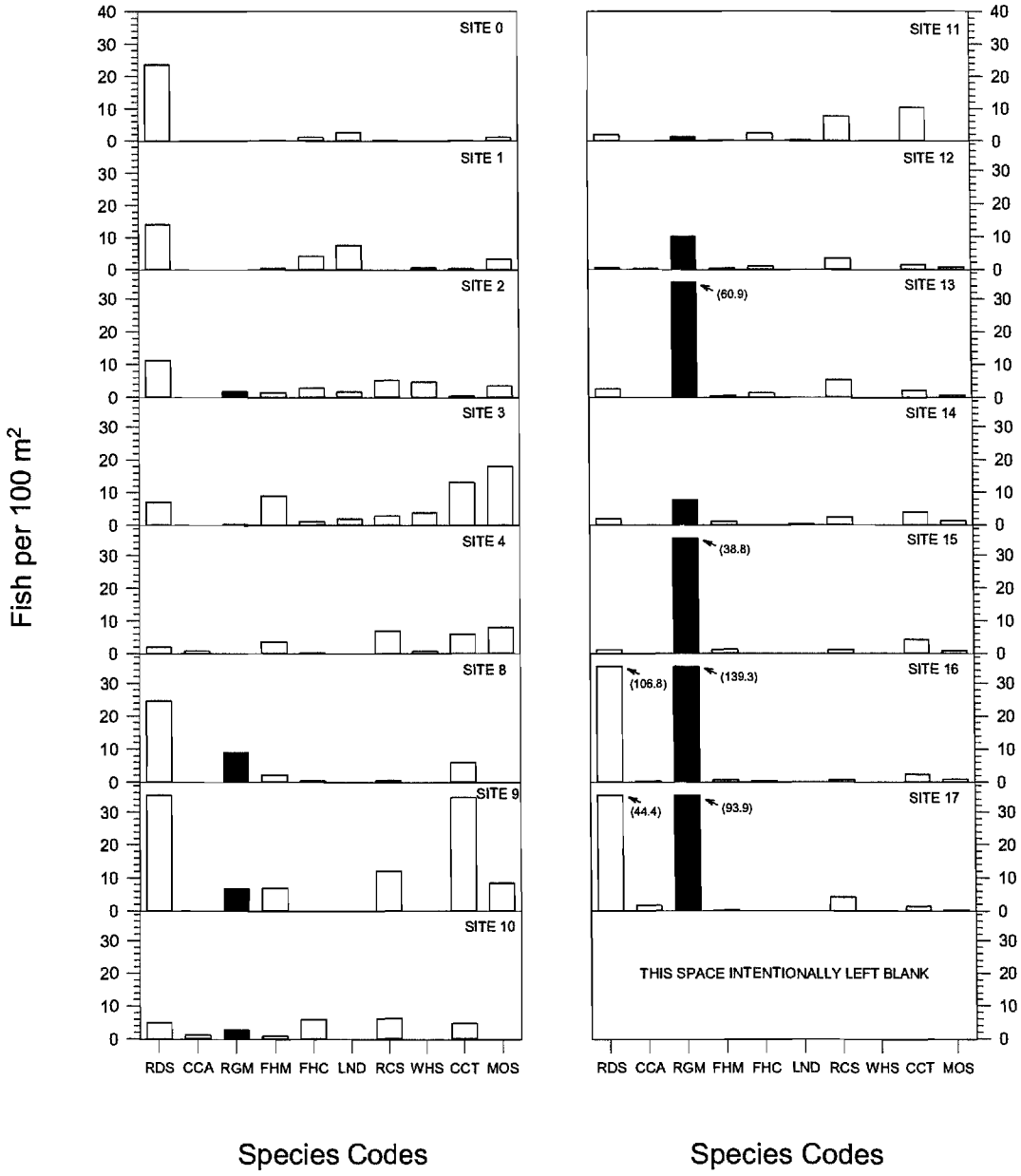

Figure A-4. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for August of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

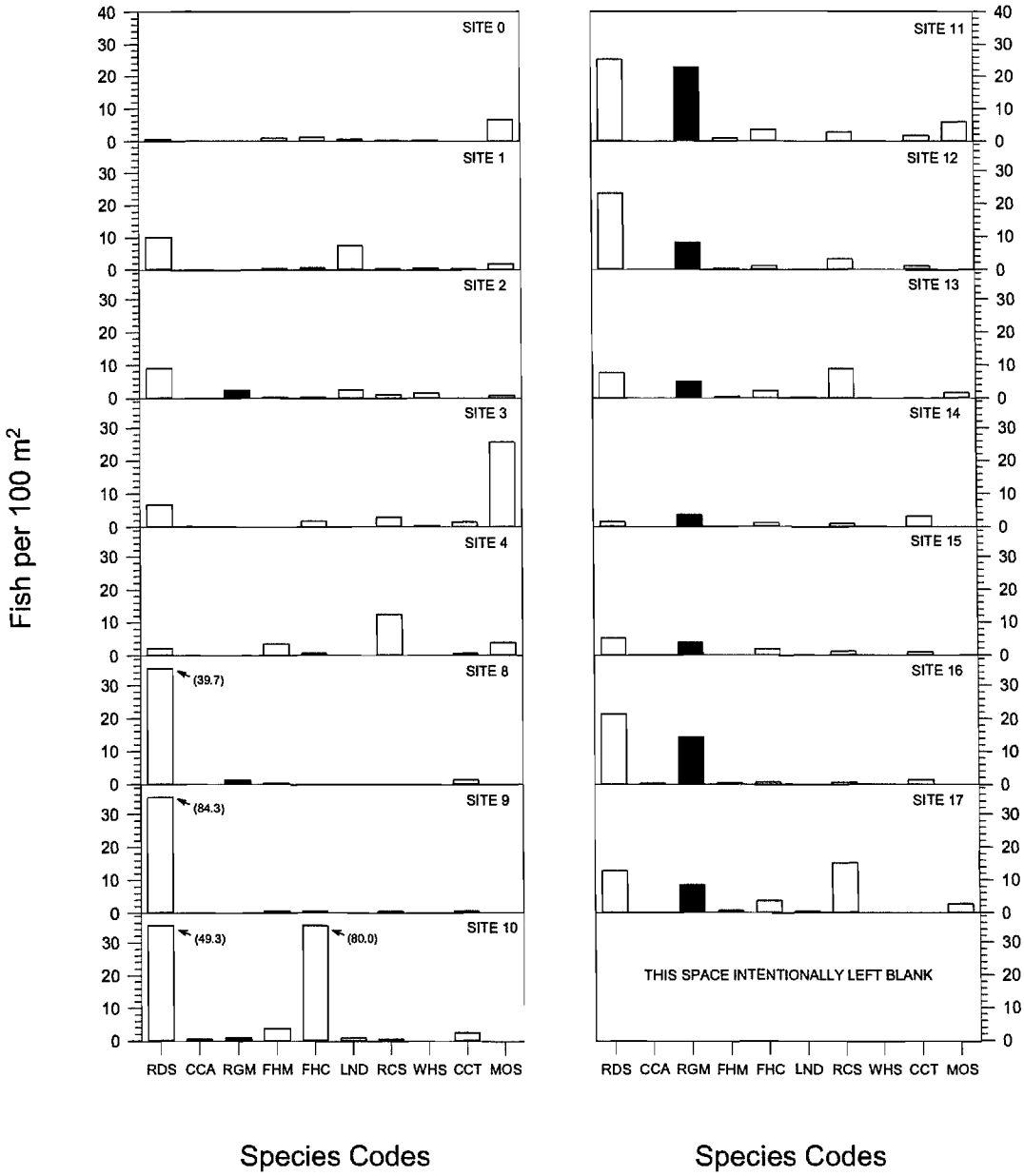

Figure A-5. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for October of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

[redacted]

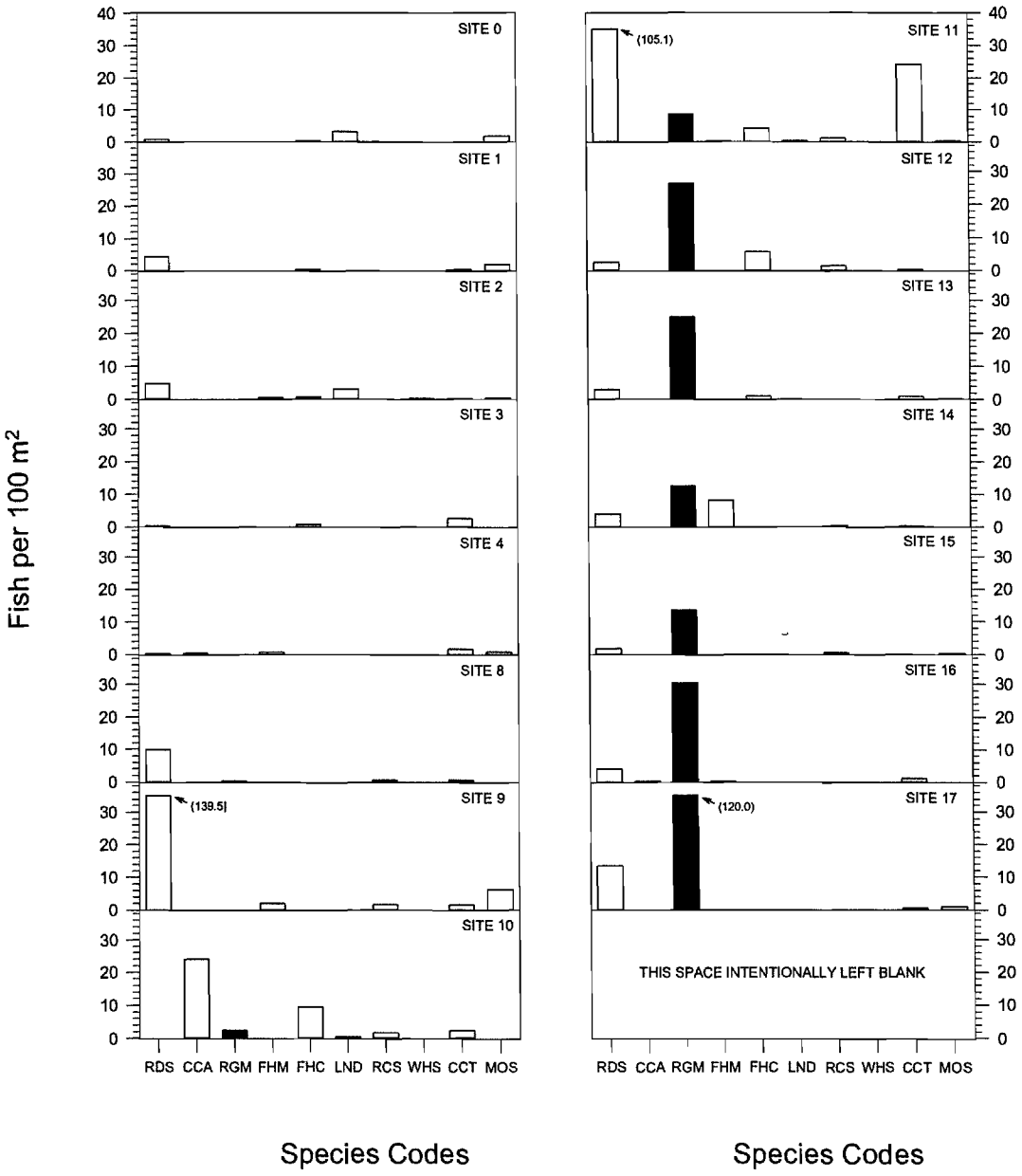

Figure A-6. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for December of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

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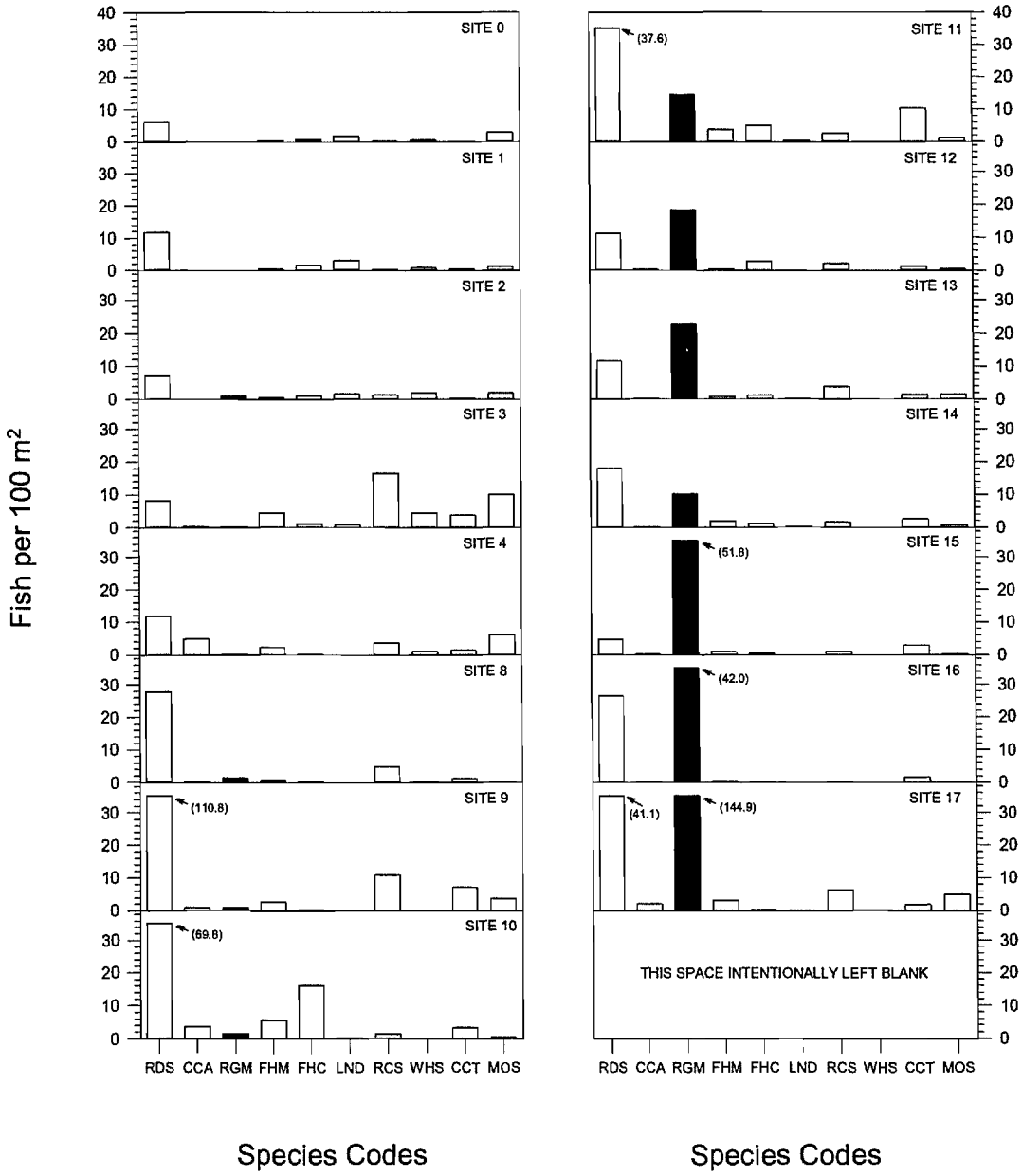

Figure A-7. Fish catch rates (CPUE) by collection locality for each focal species (see Table 1 for species abbreviations) in the Middle Rio Grande for all of 1999. Histogram bar for Rio Grande silvery minnow (RGM) is black to highlight this species.

[redacted]

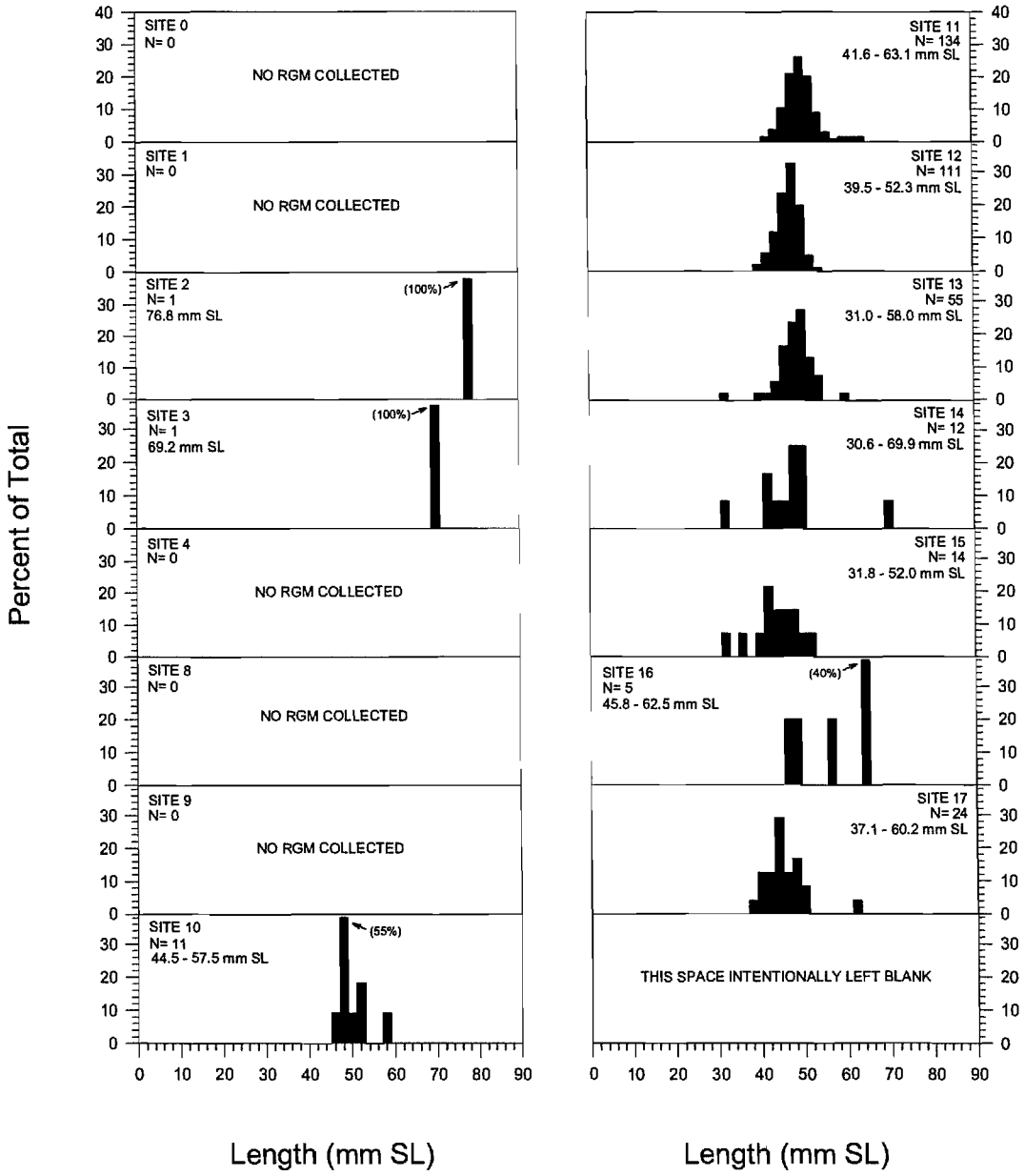

Figure A-8. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for February of 1999.

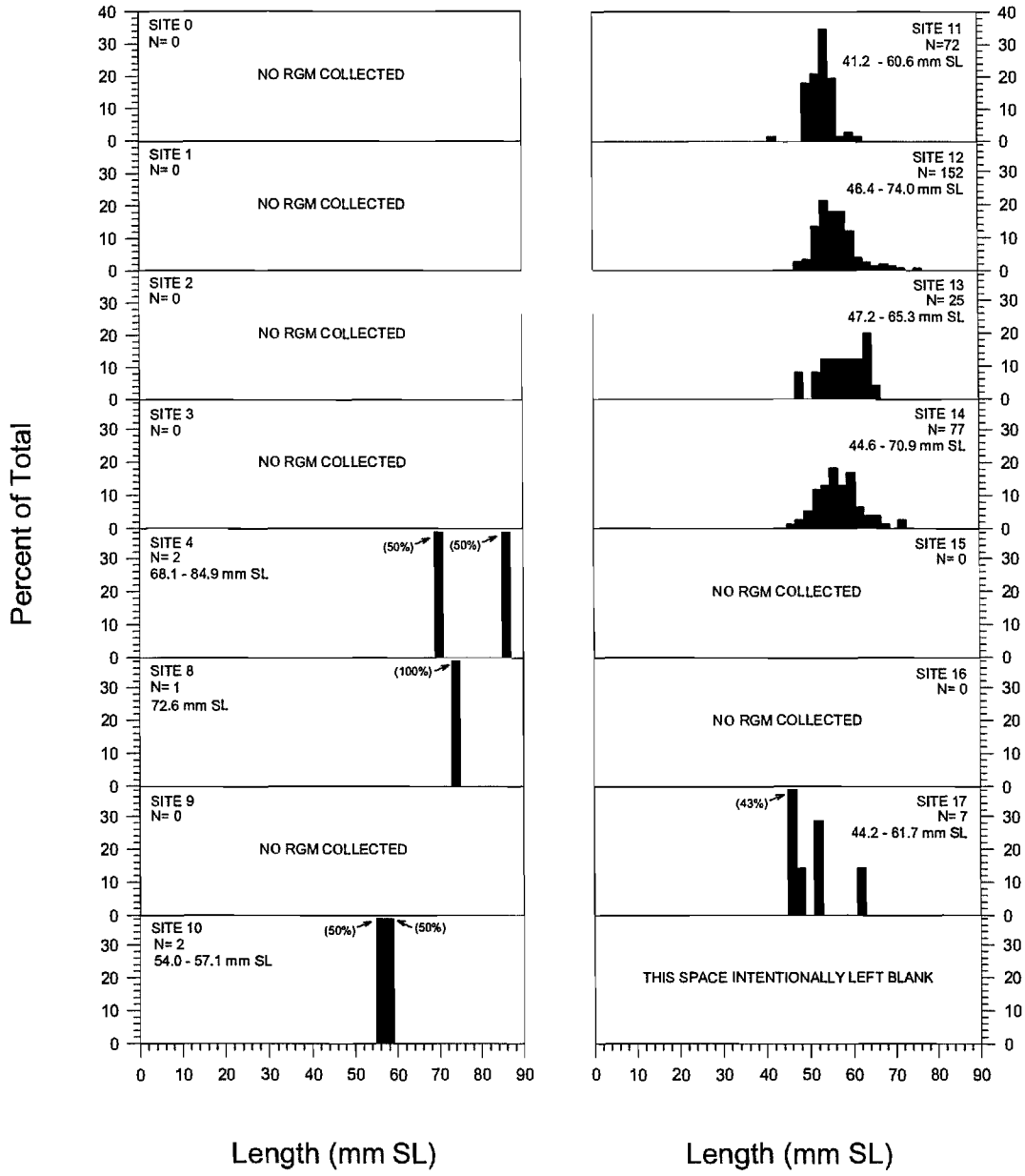

Figure A-9. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for April of 1999.

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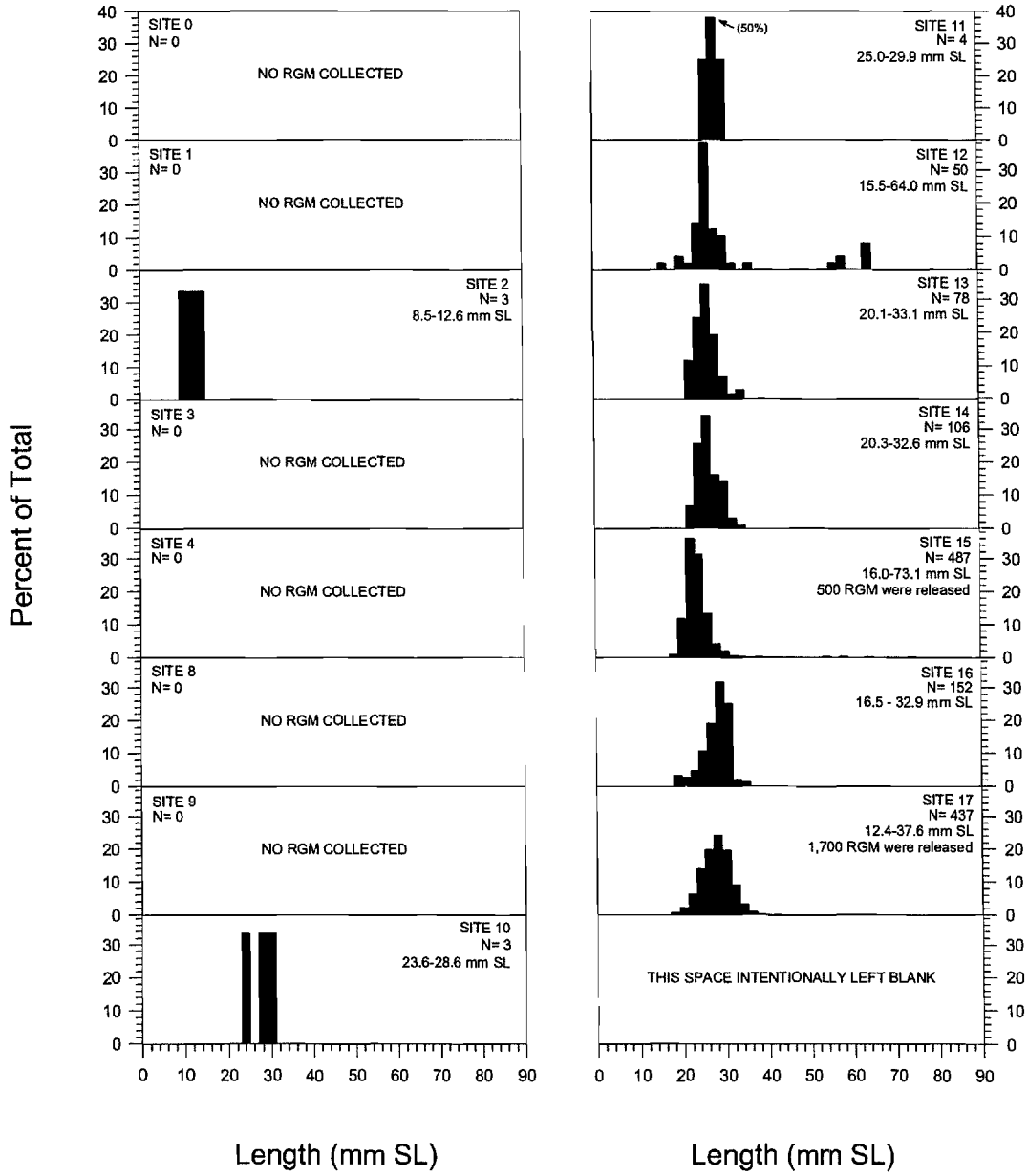

Figure A-10. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for June of 1999.

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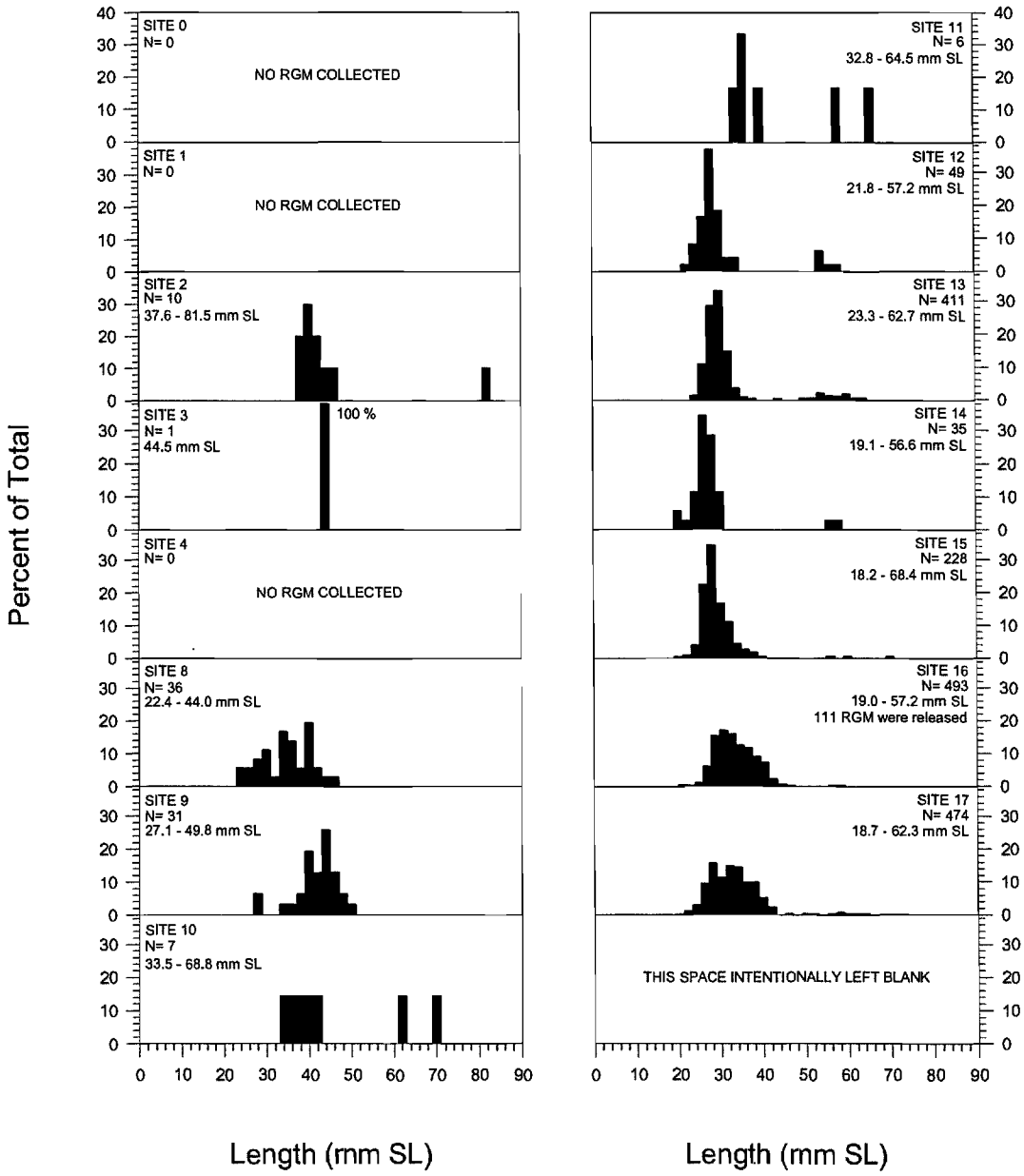

Figure A-11. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for August of 1999.

[redacted]

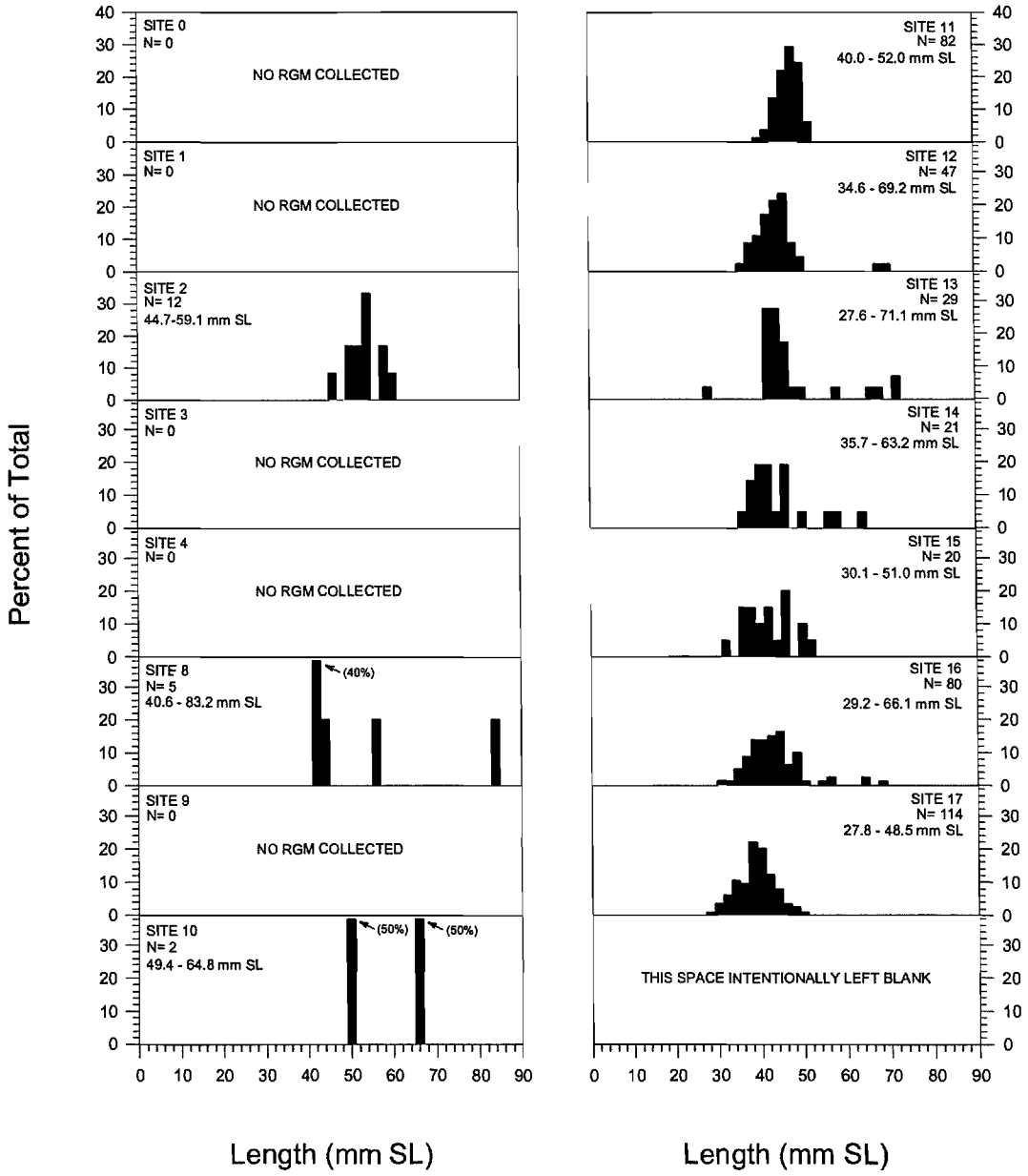

Figure A-12. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for October of 1999.

[redacted]

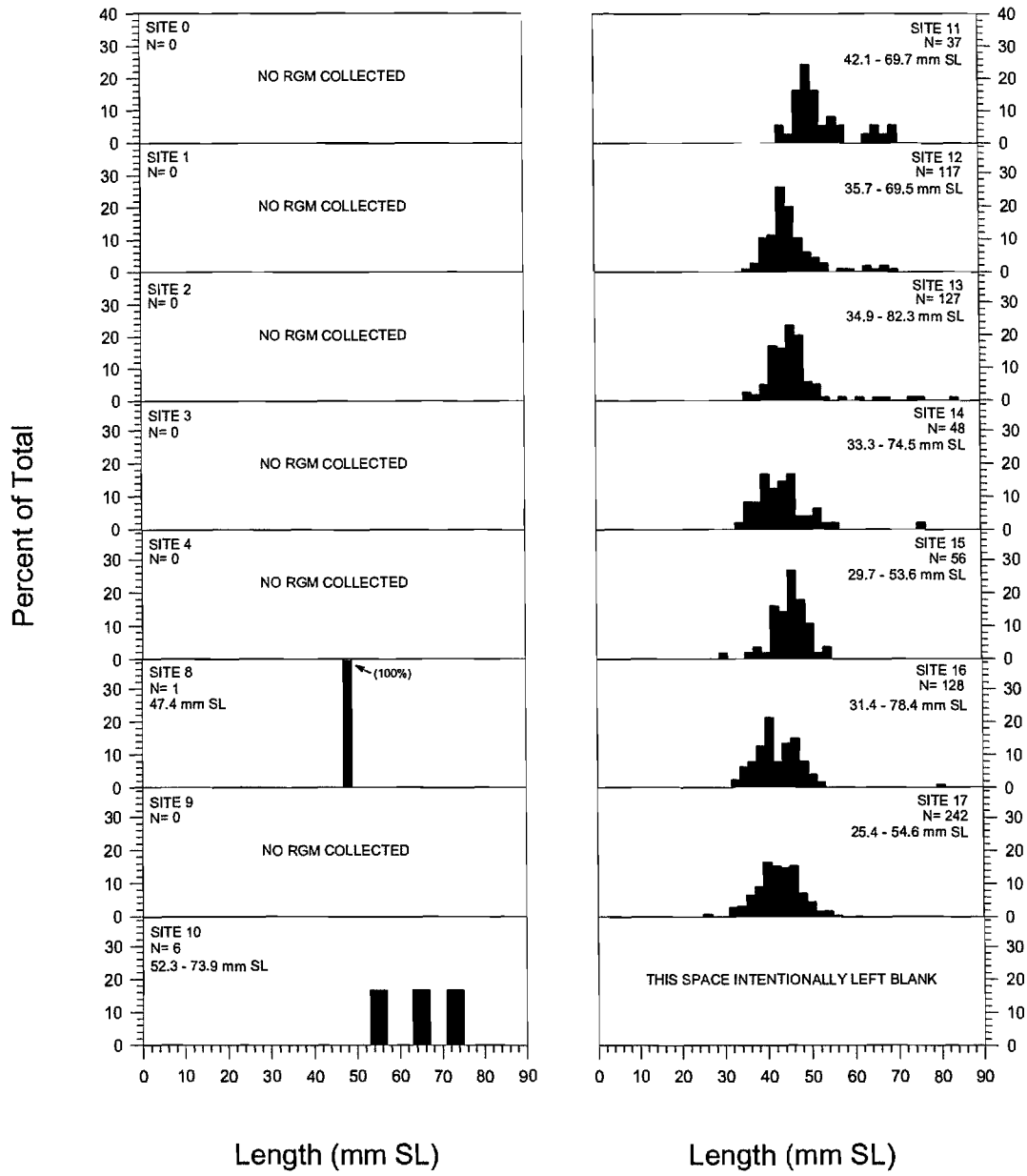

Figure A-13. Rio Grande silvery minnow (RGM) length-frequency histograms by collection locality in the Middle Rio Grande for December of 1999.

Appendix B

Draft summary of aquatic conditions in the Middle Rio Grande
between San Acacia Diversion Dam and San Marcial Railroad bridge crossing
for the period 14 through 26 April 1999

prepared for:

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3 May 1999

[redacted]

14 April 99 (Wednesday) We initiated our survey of the Rio Grande with trips to San Marcial Railroad bridge crossing (11:00), Bosque del Apache (13:00), and San Antonio (15:00). Flow was continuous from San Acacia Diversion Dam downstream past San Marcial Railroad bridge crossing. We established river staff gauges and measured discharge at these three localities on 14 April 1999 (Figures B-1, B-2, and B-3). The river channel at San Marcial was 22.0 m wide with depths (taken every 0.5 m) ranging between 6 - 37 cm (mean = 18 cm) and velocity ranging between 2 - 37 cm/s (mean = 24 cm/s). Discharge at San Marcial Railroad crossing was 81 cfs and there were considerable aquatic habitats available. There were also large pools at the base of the eastern-most two San Marcial Railroad bridge pylons. Water visibility was about 17 cm.

> We want to add a note of caution regarding our discharge readings. First, these are point measures as opposed to mean daily discharge measures compiled by USGS. Second, these data have not been verified and as such are and must be acknowledged as provisional. In addition, it is not advisable that this very limited discharge data set be used to extrapolate transport efficiencies, evaporation rates, or river reach/morphology dynamics. The stochastic nature of the river and anthropogenic patterns of water use-and-release render all, except extremely broad, assumptions suspect. One of the intentions of this work is to provide a baseline dataset that can be incorporated with flow data gathered in future studies to provide the answers to pertinent questions regarding water transport in the Middle Rio Grande.

Our discharge reading from Bosque del Apache National Wildlife Refuge was taken at the southern boundary of the refuge. There was no suitable place at the Middle Bosque del Apache site (one of our Rio Grande silvery minnow spawning periodicity sampling sites) to obtain an accurate discharge measurement (due to very wide and braided river channel). The Rio Grande, at the southern boundary of the Bosque (on 14 April 1999 at 13:00), was 13.7 m wide, with depths between 18 - 76 cm (mean = 54 cm), velocities between 13 - 29 cm/s (mean = 25 cm/s), and discharge of 66 cfs.

The Rio Grande at San Antonio was 24.8 m wide, flowing at 113.9 cfs, and had a wide variety of well-watered aquatic habitats. Depth and velocity measures were recorded at 1 m intervals along a cross-section (located about 75 m downstream of the bridge) that ran perpendicular to flow. Water depth at San Antonio ranged between 3 - 82 cm (mean = 43 cm) and velocity ranged between 0 - 44 cm/s (mean = 23 cm/s).

15 April 99 (Thursday) We completed our initial survey of the Rio Grande between San Acacia Diversion Dam and the San Marcial Railroad bridge crossing and established river discharge monitoring cross-sections at our San Acacia (1.5 miles downstream of the Dam; River Mile 114.5) and Socorro (River Mile 99.5) sites (Figures B-4 and B-5). The discharge of the Rio Grande at our San Acacia site was 300.6 cfs (at 13:00). Mean water depth was 36 cm (range = 9 - 49 cm) and mean velocity was 40 cm/s (range = 1 - 59 cm/s). The river was bank full at this site; no islands or channel braiding was observed.

Discharge at Socorro on 15 April 1999 was 204.5 cfs with a wetted river channel 34.6 m wide. In the reach where we measured discharge at Socorro, flow was confined to a single (western edge) channel. Mean water velocity was 43 cm/s (range = 14 - 57 cm/s) and mean depth was 38 cm (range = 23 - 85 cm). Water temperature at both the San Acacia and Socorro sites was 15°C.

> We set thermographs during the week of 29 March 1999 at nine stations (= Bernalillo, Albuquerque, Los Lunas, Bernardo, San Acacia, Socorro, San Antonio, Bosque del Apache, San Marcial) in the Rio Grande between Bernalillo and San Marcial Railroad bridge crossing. These devices were programmed to record water temperature hourly. We plan to download those data on approximately a monthly basis. Once downloaded (first download planned for week of 10 May 1999), these data will be forwarded.

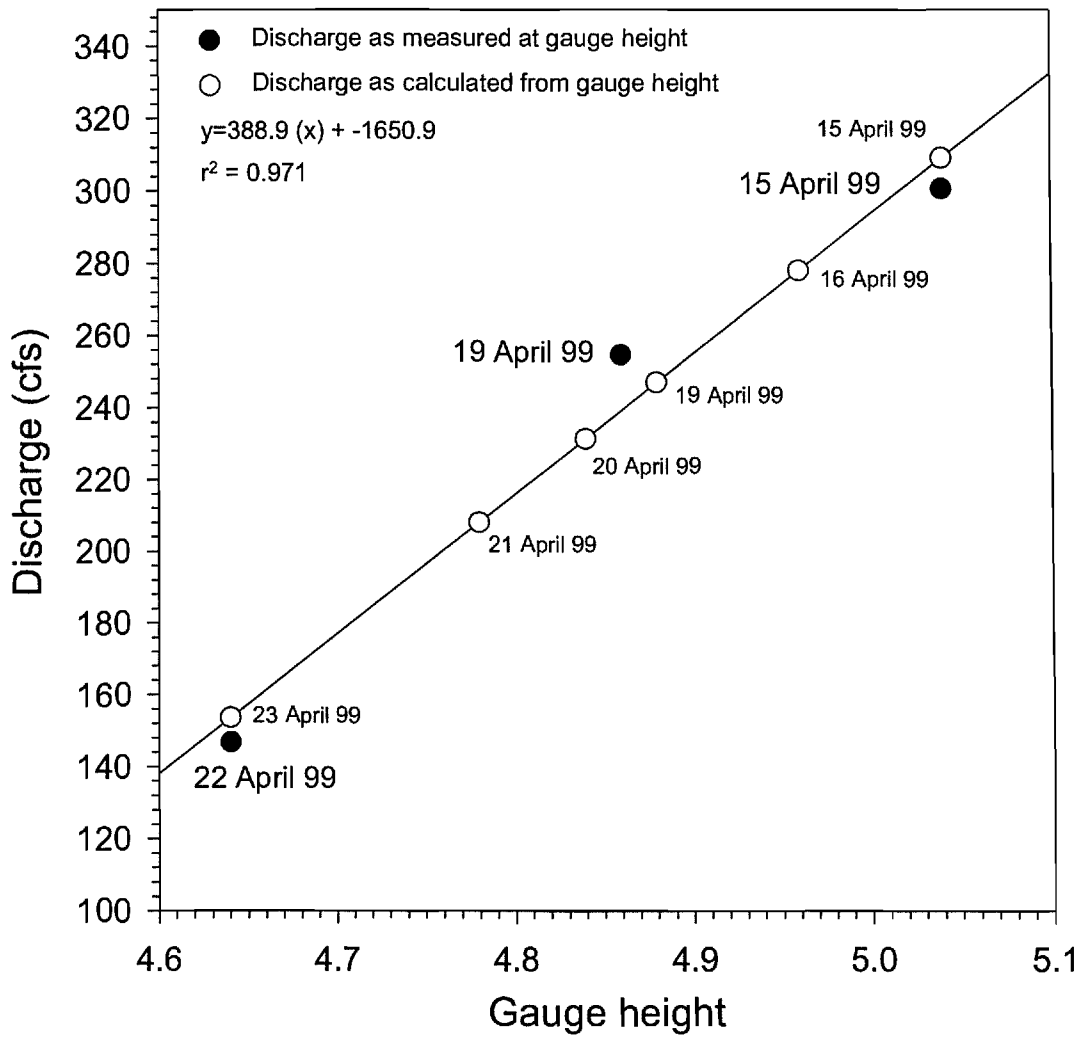

Figure B-1. Point discharge measures and estimates in the Rio Grande at San Acacia for the period 15 - 22 April 1999.

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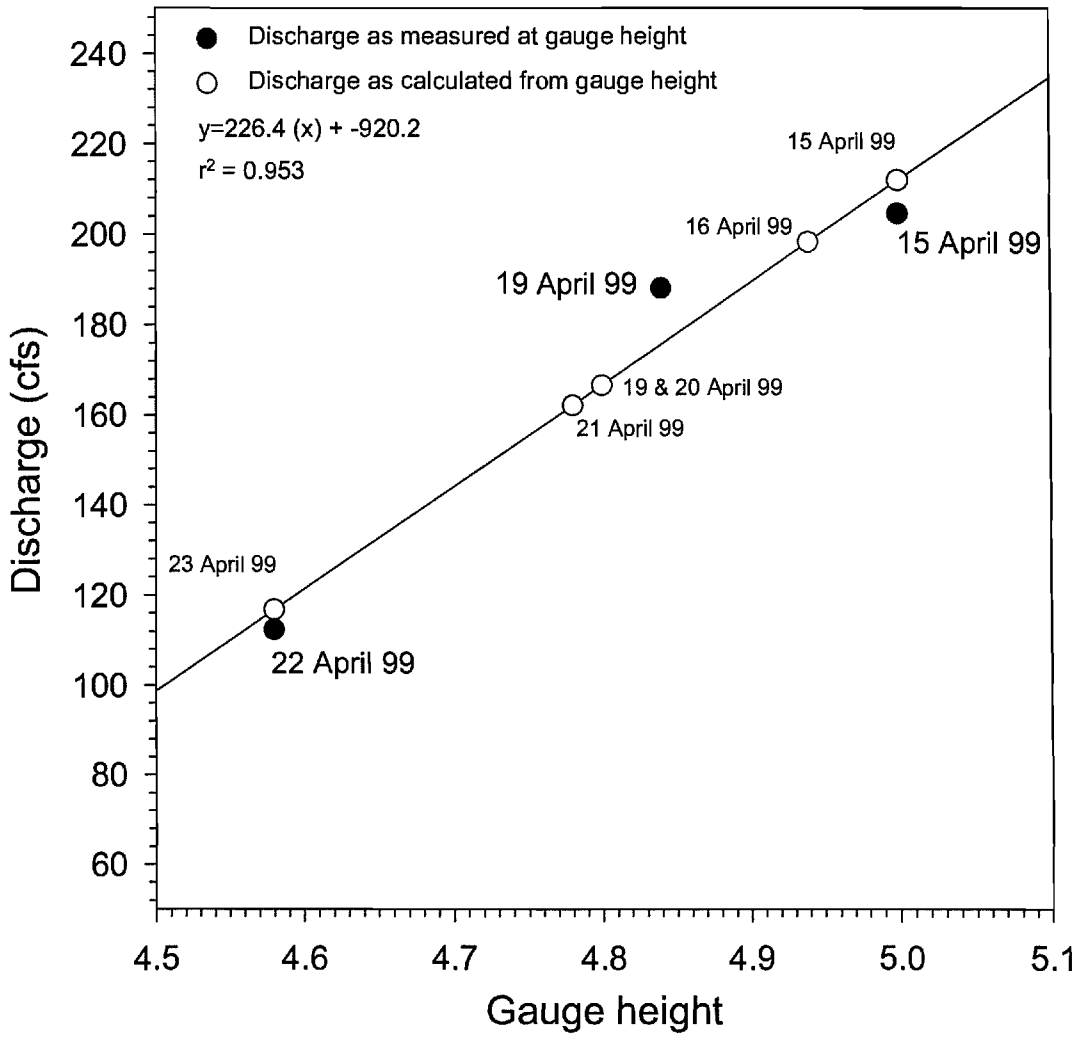


Figure B-2. Point discharge measures and estimates in the Rio Grande at Socorro Riverine Park for the period 15 - 23 April 1999.

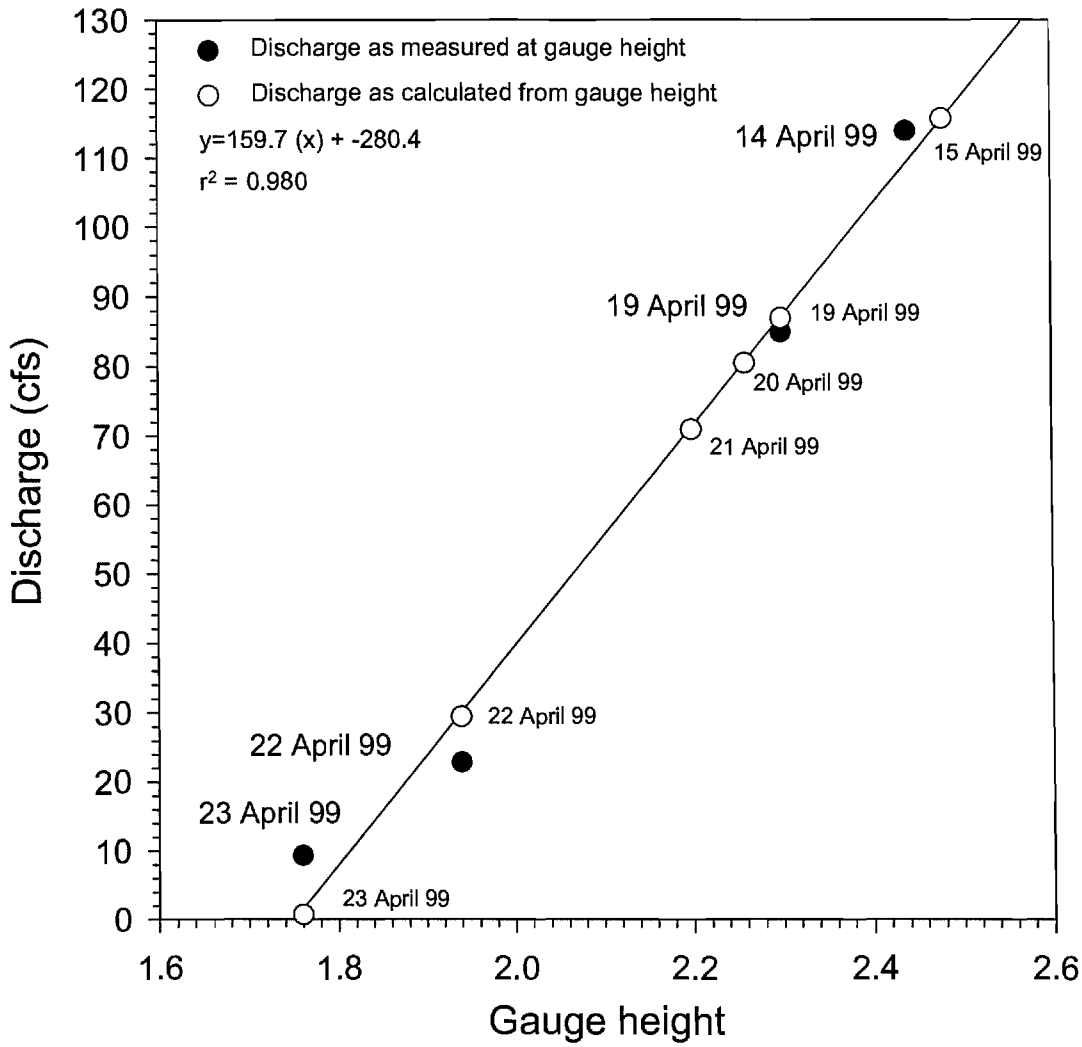


Figure B-3. Point discharge measures and estimates in the Rio Grande at San Antonio bridge crossing for the period 14 - 23 April 1999.

[redacted]

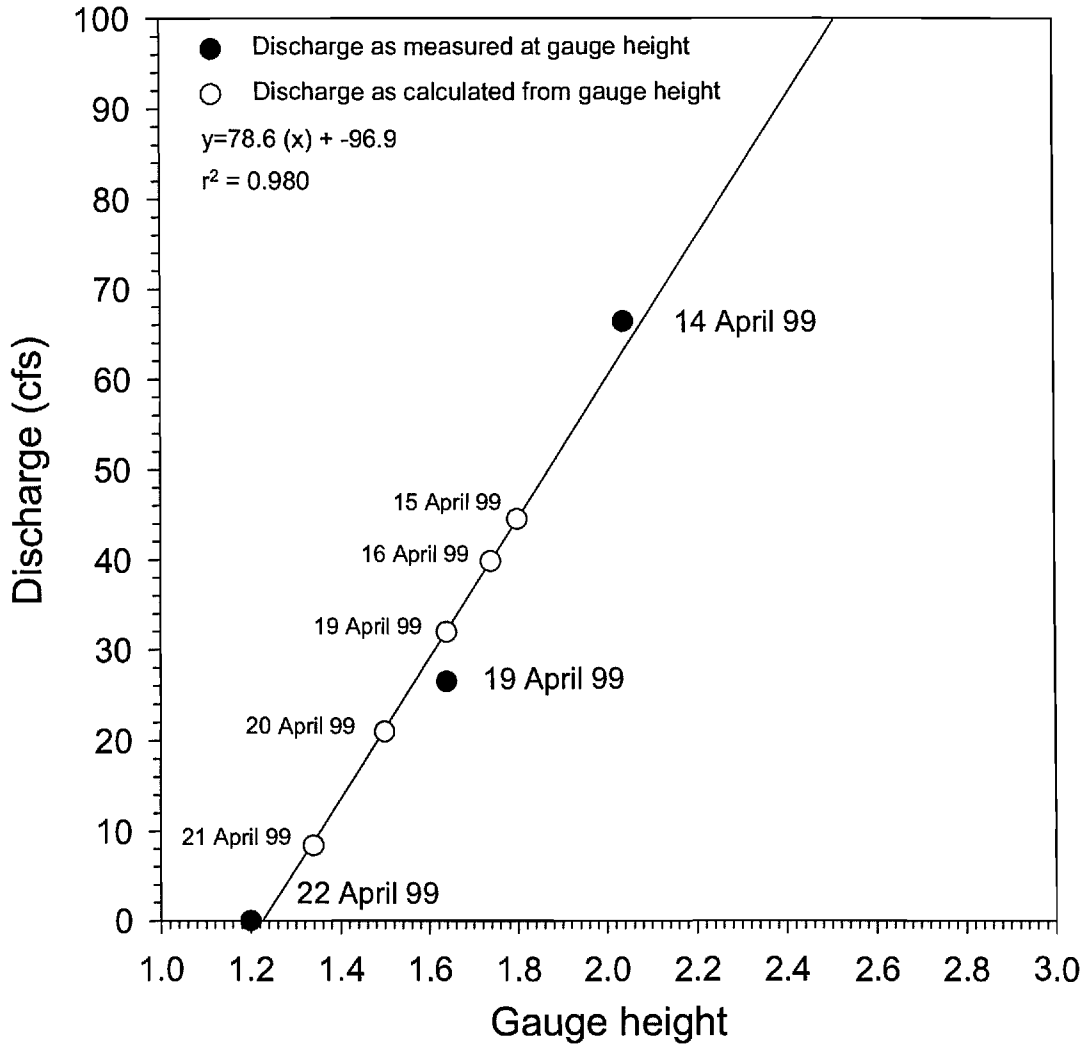


Figure B-4. Point discharge measures and estimates in the Rio Grande at Bosque del Apache National Wildlife Refuge for the period 14 - 22 April 1999.

[redacted]

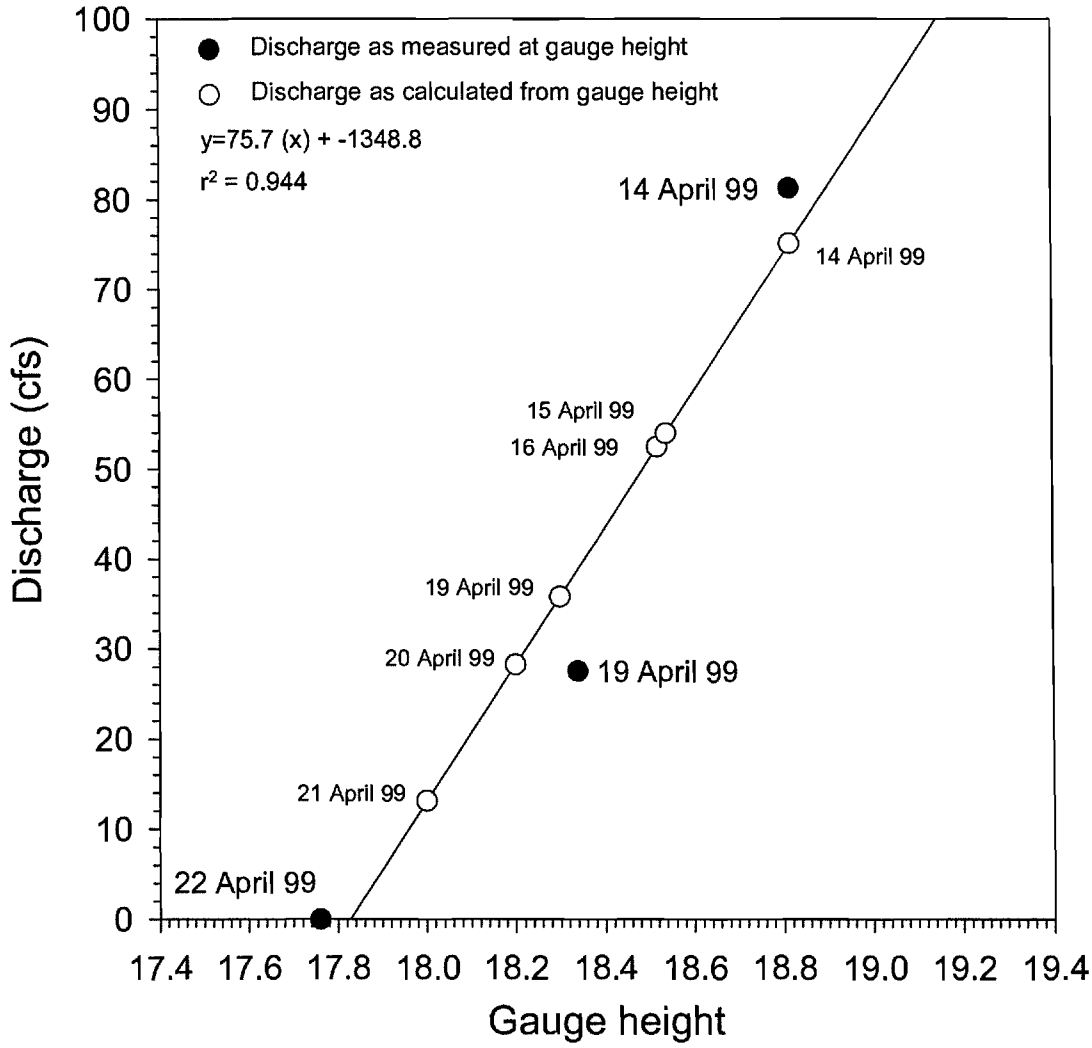


Figure B-5. Point discharge measures and estimates in the Rio Grande at San Marcial Railroad bridge crossing for the period 15 - 22 April 1999.

[redacted]

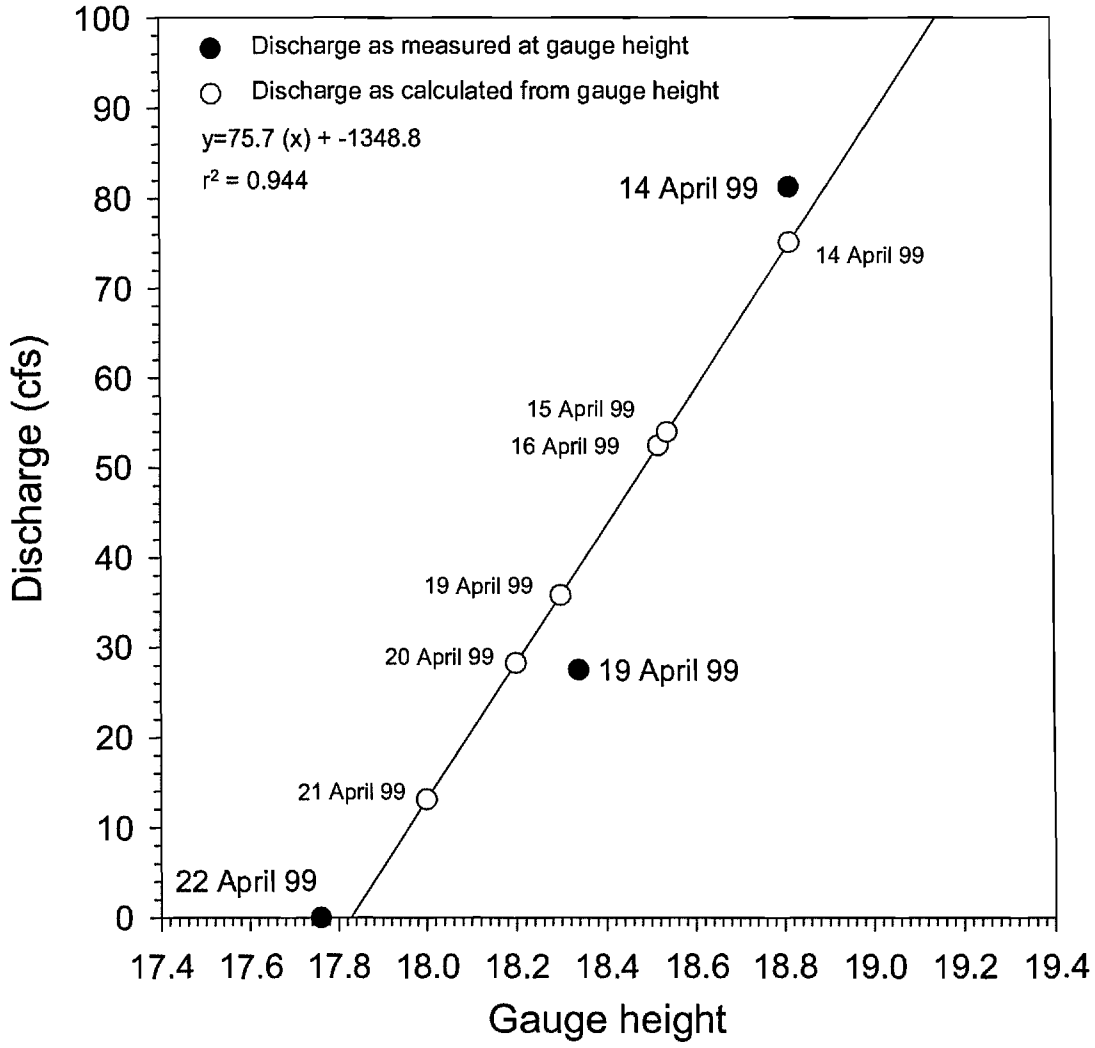


Figure B-5. Point discharge measures and estimates in the Rio Grande at San Marcial Railroad bridge crossing for the period 15 - 22 April 1999.

[redacted]

19 April 1999 (Monday) We were aware that flow in the river was dropping due to the lack of precipitation and previously planned USBR operations designed to gradually reduce flow (in an attempt to avoid stranding or isolating fish in pools). We measured discharge at our five river cross-sections between San Acacia Diversion Dam and San Marcial Railroad bridge crossing. We verified the following decreases in discharge (cfs) from the first week of the survey (14-15 April) to the second week (19 April 1999): San Acacia: 301 to 255; Socorro: 205 to 188; San Antonio: 114 to 85; Bosque del Apache: 66 to 27; San Marcial: 81 to 28. Flow was continuous throughout the San Acacia Reach of the Middle Rio Grande and maintained past San Marcial Railroad bridge crossing. While there were noticeable changes in river morphology (channel width and depth) on 19 April 1999, especially at downstream localities, there were no main channel isolated pools. In addition, there appeared to be sufficient aquatic habitats (under those flows) for long-term survival of the aquatic community. Upstream winds were intense (up to 50 mph) and accelerated rates of evaporation. Given the drop in flow, we were in daily contact with our biologists (who are studying spawning periodicity of Rio Grande silvery minnow at sites between Bernalillo and San Marcial) to access river level. Daily reports of river condition were also relayed to USBR (Jim Wilber) and USFWS (Jude Smith and/or Dennis Coleman). Photographs provided.

21 April 1999 (Wednesday) Water was still flowing at San Marcial Railroad bridge crossing but had dropped 0.8- foot from the previous Wednesday (14 April 1999) and 0.3-foot from Monday. On Monday (19 April 1999, when discharge was 28 cfs), our biologists sampled 460 cubic feet of water during his 90-minute sampling tenure. On Tuesday (22 April 1999), the water volume sampled our biologist at San Marcial (90-minute sample) dropped to 305 cubic feet. Conversely, only 44 cubic feet of water was sampled at San Marcial during the 90 minute set on 21 April 1999. These data verify that, by 21 April 1999, flow at San Marcial was negligible and suggested that the river would soon be discontinuous. Persistent and strong upstream winds continued affecting rates of evaporation.

22 April 1999 (Thursday) We measured discharge at San Antonio and found it about 23 cfs (compared to 85 cfs on Monday) and was about 0.4-foot lower than on Monday (19 April 1999). We performed population monitoring activities at this site (San Antonio) and collected numerous gravid Rio Grande silvery minnow. Their extremely distended abdomens suggested that they were ready to spawn. We examined about 10 off channel isolated pools but observed the stranding of only one river carpsucker (60 mm TL) and saw no sign of isolation (and death) of large numbers of fish. A low-velocity habitat located on the west bank of the river channel and originating under the US Hwy 380 bridge was deemed a potential "trap" that could isolate numerous fish. This habitat was somewhat unique as there was a large, deep pool (2 m x 4 m) at its head and a shallow (<10 cm), narrow outlet about 15 m downstream. In addition, there was a large woody debris pile in the head-pool which provided additional cover for fish. We believed that the natural tendency of fish to select deeper waters would result in them moving to the pool instead of leaving this habitat and moving downstream as the river water-level dropped. After sampling this habitat for our population monitoring study (which produced >25 large Rio Grande silvery minnow), we decided to attempt to collect the remaining fish from this mesohabitat and relocate them to main channel habitats (<5 m away). This effort (5 seine hauls) yielded about 200 Rio Grande silvery minnow and 200-300 additional fish (red shiner, river carpsucker). Photographs provided.

There was no longer any measurable flow of water at either Bosque del Apache National Wildlife Refuge or San Marcial Railroad bridge crossing on 22 April 1999 and water levels were continuing to drop at both sites. We again called representatives of the USBR and USFWS to alert them that river channel drying was occurring and isolation of fish in pools was inevitable (so they needed to be prepared to move fish). Strong upstream winds continued.

[redacted]

23 April 1999 (Friday) We arrived at San Marcial Railroad bridge crossing at approximately 10:30 and discovered that there was no longer any water in the former river channel and were no isolated pools except for those at the base (pylons) of the railroad bridge crossing. The water had dropped about 0.7-foot from the previous day's reading on the river staff gauge. Although there was no surface water observed, water was present (in the sand) only 1-5 cm below the river bed. We did not attempt to sample fish in the isolated pools at the base of the bridge as USFWS-FRO indicated that they would be collecting and trans-locating specimens from this locality. We performed an extensive survey up and downstream of the railroad crossing but failed to observe evidence of fish that had become isolated (and died) in pools. There were, however, numerous animal tracks throughout the river channel especially in recently dried pools suggesting possible predation. Given the absence of flow, our researcher did not sample (for spawning periodicity) at this site. Photographs were taken to document the conditions (provided).

We next went to the Middle Bosque del Apache National Wildlife Refuge and found that there was very little water in the river channel, no flow, and the only water present was in small and deep isolated pools. At the southern boundary of the Bosque del Apache National Wildlife Refuge we also observed standing pools of water. The normal river channel (at this latter site) is very confined (<20 m wide compared with 200 m for the Middle Bosque site) and would be expected to retain water longer than upstream (wider) Bosque del Apache NWR sites. Water at the southern boundary of the Bosque del Apache NWR had dropped 0.5-feet between Thursday and Friday. Photographs provided.

We measured discharge at the San Antonio bridge crossing and determined that the river level had dropped 0.2-foot and flow had decreased from 23 cfs (on 22 April 1999) to 9 cfs. The decrease in discharge was also noted by our researcher investigating spawning periodicity who sampled (during the 90-minute sampling foray) 500 cubic feet of water on Monday, 129 cubic feet on Thursday, and only 45 cubic feet on Friday.

The drop in water level at San Antonio on 23 April 1999 **stranded fish in isolated pools** along the west bank of the channel. There were also **dead fish in pools** that no longer had water. We took 151 dead Rio Grande silvery minnow from a single, small (< 1 ft^2), dry pool which was a remnant of the pool that we had sampled the previous day (in our effort to move fish to the main channel). Our concern that fish would become isolated in that habitat was justified and we were fortunate that we had been able to collect and move 200 Rio Grande silvery minnow the previous day. The dead fish we found on 23 April 1999 had only recently died (estimated 6-10 hours) as indicated by their state of desiccation and decay. We collected and preserved an additional 72 dead Rio Grande silvery minnow from 10-15 other small (< 1 ft^2) isolated pools. A very small isolated pool (100 cm x 30 cm x 4 cm deep) that retained water contained 35 live Rio Grande silvery minnow. Those specimens were collected by hand and released into main channel aquatic habitats. Photographs were taken to demonstrate that this species does not burrow into the sand during periods of river desiccation (proviided). Additional sampling efforts in isolated pools upstream and downstream of the US Hwy 380 bridge produced between 25-35 Rio Grande silvery minnow, all of which were moved to the main channel. Again, numerous animal tracks were observed throughout recently dried pools. Photographs were taken of dead fish, live-isolated fish, and sampling activities (provided).

We spent the rest of Friday (23 April 1999) assessing river conditions up and downstream of the San Antonio bridge crossing. There was continuous flow in the river from 4.6 miles upstream of the US Hwy 380 bridge to about 2.2 river miles downstream of that bridge. There was no standing water in the river at the northern boundary of the Bosque del Apache National Wildlife Refuge (which is about

3 river miles downstream of the US Hwy 380 bridge). Photographs of the dry river channel at the northern boundary of the Bosque del Apache National Wildlife Refuge were taken (provided).

Several telephone calls were made between 11:00-13:00 to the USFWS (Jude Smith) and USBR (Jim Wilber) to alert them of the situation regarding the drying of the river and presence of dead fish.

All dead Rio Grande silvery minnow were retained (SPP99-052) and taken to the Fish Division of the Museum of Southwestern Biology, University of New Mexico. We implemented a chain of custody protocol with the specimens that had died due to desiccation of river-water in case they were needed for any legal action. The chain of custody involved transferring specimens to Ms. Alexandra (Lex) M. Snyder (Collections Manager, Fish Division, Museum of Southwestern Biology), who took charge of the specimens and secured them in a locked cabinet to which only she has keys. Parties and witnesses to the transfer signed, dated, and noted time on a Museum of Southwestern Biology, Division of Fishes invoice to attest to the transfer.

26 April 1999 (Monday) Scattered rainstorms during the previous weekend (24-25 April 1999) provided much needed flow to the river downstream of San Acacia Diversion Dam. We measured discharge of 350 cfs at San Acacia Diversion Dam and 143 cfs at Socorro. These values were higher than discharge measures of 147 cfs and 112 cfs at San Acacia and Socorro (respectively), taken only four days earlier (Thursday, 22 April 1999). The value of 350 cfs at San Acacia and only 143 cfs at Socorro suggested that the pulse of water traveling downstream (and measured at San Acacia) had not yet reached the Socorro site. In addition, there was a minimal increase in flow at San Antonio (25 cfs on 26 April 1999 versus 9 cfs on Friday, 23 April 1999). Our intention was to track the movement of the pulse of water. We did not see any additional dead fish at San Antonio this day, although the rise in water level had re-inundated the previously (23 April 1999) dry portions of the river channel. No other sites were visited this day.

27 April 1999 (Tuesday) We arrived at San Marcial Railroad bridge crossing (10:30) and found several hundred dead and dying fish in the large isolated pool at the base of the eastern-most railroad bridge pylon (the one with the USGS staff gauge) where we had been four days earlier. The pool was at least 10 m long, 5 m wide, and 2 m deep (estimate for the deepest point) and contained thousands of dead and dying fish. Water temperature of the pool was 15°C and fish were at the water surface gulping air. We estimated that there were between 500-1,000 channel catfish and several hundred Rio Grande silvery minnow gulping air. This behavior suggested low dissolved oxygen (in the water) which was probably the primary cause of death (we did not have equipment available to determine water chemistry parameters). We preserved dead Rio Grande silvery minnow located on the perimeter of the pool (n=144). Additional dead (and dying) Rio Grande silvery minnow had sunk to the bottom and were observed in the center of the pool but were not taken. We also observed a few dead flathead chub and one dead walleye (we retained the latter). Dead channel catfish were also noted during the tenure of this visit but they were rare compared to the number of dead cyprinids. Our counts are only indicative of the number of fish along the shoreline of the pool; the number of dead fish are certainly not indicative of total mortality as dead, decomposing, and partially eaten fish were also seen on the bottom of the pool. A substantial algal bloom transformed the formerly (23 April 1999) clear water in the pool green and limited visibility to less than 30 cm. We informed USFWS-FRO of these facts via cellular telephone communication immediately after observing them. Numerous photographs were taken at this site on 27 April 1999.

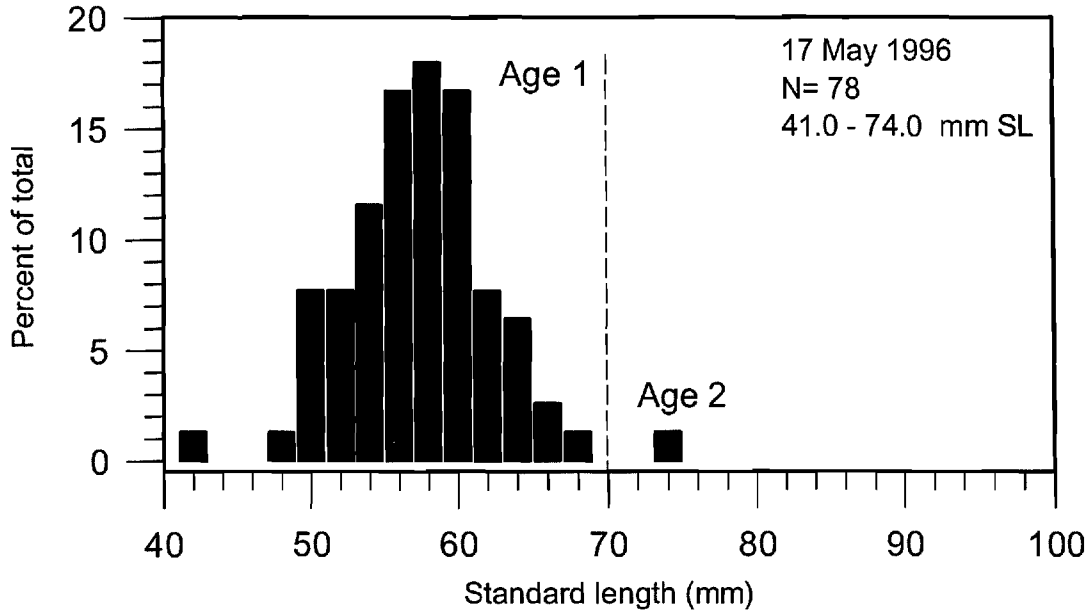
[redacted]

The sample taken at this site (SPP99-055) was deposited in the Fish Division of the Museum of Southwestern Biology, University of New Mexico following the chain of custody protocol addressed above. The 144 Rio Grande silvery minnow taken in sample SPP99-055 represent primarily age 2 individuals and some of the largest specimens ever recorded from the Middle Rio Grande, New Mexico (maximum length of specimens taken in SPP99-055 = 91.5 mm SL, 109.2 mm TL). This sample also represents the largest collection of age 2 Rio Grande silvery minnow from New Mexico. Of the 144 dead individuals retained, at least 80 were gravid females with abdomens distended due to the presence of large numbers (ca. 5000) of developing eggs. Length frequency histogram of Rio Grande silvery minnow (SPP99-055) is appended along with a 1996 Rio Grande silvery minnow length frequency histogram from spring population monitoring at San Marcial Railroad bridge (Figure B-6). These histograms serve to illustrate the large size and proportion of the sample that the 1999 age 2 dead Rio Grande silvery minnow comprised.

We arrived at the San Antonio bridge crossing site about 12:00, and noted that water level increased 0.8-foot since the previous day (Monday) and increased 0.1-foot during the 90-minute sampling foray (Tuesday). The rise in water level suggested that the water pulse was greater than we had estimated on Monday. Of primary concern was if the pulse was large enough to reach San Marcial Railroad bridge - and if the pulse was large enough, how long would it take to reach that point. That hundreds to thousands of fish were dying in the pool at San Marcial Railroad bridge crossing due to a lack of dissolved oxygen confounded concern regarding travel time of the pulse of water.

28 April 1999 (Wednesday) We returned to San Marcial Railroad bridge crossing arriving at 10:30. The flow we had seen the previous day at San Antonio had not yet arrived at San Acacia. We walked to the isolated pool to assess the status of the remaining fish. Before we reached the pool, we looked upstream and realized that the pulse of water was traveling down the channel at a rapid rate (ca. 1 m/s) and would be arriving at the railroad bridge within three to five minutes (estimate). We quickly went back to the truck and got a seine and camera. One of us took a series photographs of the approaching flow while the other two individuals took a few rapid seine hauls through the large isolated pool (taking 45 live Rio Grande silvery minnow). There were numerous dead and dying channel catfish and Rio Grande silvery minnow within and surrounding the pool. Unfortunately, we did not have enough time to count dead fish prior to the arrival of the flow. Water began pouring into the pools at the base of the pylons at 10:35 A.M. After only five minutes, the pulse of water had filled the pools, re-wetted the river channel, and was traveling downstream of San Marcial Railroad bridge crossing.

We estimated 200 dead channel catfish and 100-200 dead Rio Grande silvery minnow along the perimeter of the pool. We will have to use the photographs to obtain a more accurate count of dead Rio Grande silvery minnow from 28 April 1999. As on 27 April 1999, Rio Grande silvery minnow were gravid (as indicated by their extremely distended abdomens). We did not obtain a discharge reading at San Marcial Railroad bridge crossing on 28 April 1999 as the continual increase in discharge would have made the value generated from measures relatively useless.



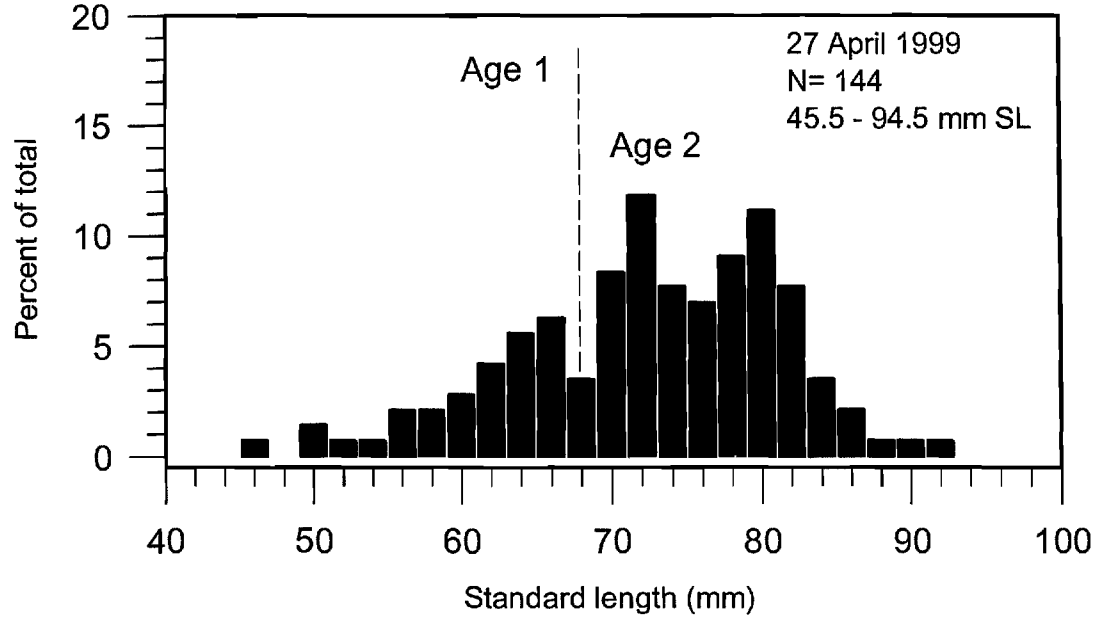


Figure B-6. Length frequency histograms of Rio Grande silvery minnow collected at San Marcial Railroad bridge crossing in spring, 1996 and 1999. Dashed lines indicate hypothesized separation, by length, of different age classes.

[redacted]