Upper Rio Grande Basin Water Operations Review and EIS
ARCHIVE FORM (6/18/01)

514 R-136

No.	AQ-11	Keep Confidential?	

Author: Platania, S.P.

Date: 1991

Title: Fishes of the Rio Chama and Upper Rio Grande, New Mexico, with preliminary comments on their longitudinal distribution.

Publication: ***The Southwestern Naturalist*** 36(2):186-193

Organization:

Organization Location:

Document Location: SWCA Library

Type of Document (Check One):

	Published Document		GIS Data (Complete metadata form)
	Agency Report or Document		Contact Report (Complete next page)
	Memo/Correspondence		Internal Data
	Map	X	Other (specify): Journal Article

Relevant Topics (Check All Applicable):

	Purpose and Need		Earth Resources (Geology, Soils)
X	Baseline Data		Water Quality
	Alternatives	X	Riparian and Wetlands
	Climate	X	Aquatic Systems
	Water Operations		Cultural Resources
	URGWOM		Land Use
	Facilities		Aesthetics
	Geomorphology		Socioeconomics
	Sedimentation		Environmental Justice
	Hydrology		Agriculture
	Hydraulics		Recreation
	Surface Water		Public Involvement
	Groundwater	X	Other (specify): T&E Species

Key Words: RGSM

Completed By (Name): Janelle Harden; SWCA Albuquerque **Date:** 11 June 2004

Address: 7001 Prospect Place NE, Ste. 100, Albq. NM 87110 **Phone:** (505) 254-1115

Comments/Summary:

AQ-11

Checked

910

39

THE SOUTHWESTERN NATURALIST 36(2):186–193 JUNE 1991

FISHES OF THE RIO CHAMA AND UPPER RIO GRANDE, NEW MEXICO, WITH PRELIMINARY COMMENTS ON THEIR LONGITUDINAL DISTRIBUTION

STEVEN P. PLATANIA

Museum of Southwestern Biology, Department of Biology, University of New Mexico, Albuquerque, NM 87131

ABSTRACT—The Rio Grande of northern New Mexico historically supported at least 16 native freshwater fish species. Of these, four cyprinids (speckled chub, *Hybopsis aestivalis*; Rio Grande shiner, *Notropis jemezanus*; phantom shiner, *Notropis orca*; Rio Grande bluntnose shiner, *Notropis simus simus*) have been extirpated and a fifth (Rio Grande silvery minnow, *Hybognathus amarus*) appears to be declining in both range and abundance. Based on collections in 1984, the ichthyofauna of this region consists of at least 21 species, 13 of which were introduced. Non-native forms were primarily ictalurids and centrarchids. Native cyprinids numerically dominated the samples from 1984, accounting for 75% of the specimens taken. Nine species, five native and four introduced, were collected in the largest New Mexican tributary of the Rio Grande, the Rio Chama. Recently-discovered stocking information from the late 1920s suggests that mosquitofish (*Gambusia affinis*) is not native to the upper Rio Grande.

The Rio Grande is one of the longest rivers in North America, traversing 3,000 km from its headwaters in the San Juan Mountains of southern Colorado before emptying into the Gulf of Mexico. In New Mexico, the mainstem is approximately 760 km long and drains 68,100 km^2 or nearly 20% of the state (United States Geological Survey, 1985*a*).

The native ichthyofauna of the New Mexican portion of the Rio Grande is believed to have consisted of between 16 and 27 species (Hatch, 1985; Smith and Miller, 1986; Propst et al., 1987), four of which are endemic to the upper basin. Of the latter, Rio Grande shiner (*Notropis jemezanus*), phantom shiner (*Notropis orca*), and Rio Grande bluntnose shiner (*Notropis simus simus*), no longer occur in the New Mexican portion of the Rio Grande (Bestgen and Platania, 1990). *Notropis jemezanus* is known from only 81 specimens in eight collections in the Rio Grande in New Mexico and has not been taken there since 1949. *Notropis orca* and *N. simus simus*, both reported as extirpated (Chernoff et al., 1982; Bestgen and Platania, 1990) were last collected in the upper Rio Grande in 1939 and 1964, respectively (Chernoff et al., 1982; Bestgen and Platania, 1990). The Rio Grande silvery minnow (*Hybognathus amarus*), is the only endemic of the Rio Grande surviving in New Mexico (Bestgen and Platania, 1990).

Despite the ease of sampling and the unique ichthyofaunal composition of this drainage, there is little information on the distribution, life history, and abundance of the fishes of the Rio Grande in New Mexico. Cope and Yarrow (1875) listed species captured at a single locality (San Ildefonso) and described *N. jemezanus* and *N. simus*. Koster (1957) presented cursory life history and abundance notes in his species accounts; Hatch (1985) produced a species checklist and Smith and Miller (1986) summarized the zoogeographic knowledge of the drainage based on the ichthyofauna. Chernoff et al. (1982) addressed the distribution and taxonomic status of *N. orca* and *N. simus*, and Bestgen and Platania (1990) reviewed the decline, extirpation, and life history of these two species. The report by Propst et al. (1987) on fish in a 23-km reach of the Rio Grande between Caballo and Elephant Butte reservoirs is the only published account on the composition of the ichthyofaunal community in a specific reach of the Rio Grande in New Mexico.

The intent of this paper is to document the present occurrence of fishes in the Rio Grande between Velarde and the Valencia-Socorro county lines and the Rio Chama below Abiquiu Res-

ervoir, present preliminary information on their longitudinal distribution in the mainstem of the Rio Grande, and address the resident status of mosquitofish (*Gambusia affinis*), in the upper Rio Grande, New Mexico.

MATERIALS AND METHODS—The 33-km reach of the Rio Chama and 200-km section of the Rio Grande sampled in 1984 were located in north-central New Mexico (Fig. 1). These rivers were fed primarily by melting snowpack from high elevations in northern New Mexico and southern Colorado and by localized thunderstorms and were supplemented by transmontane diversions from the San Juan River drainage (Colorado River basin). Precipitation in the area was low, averaging <25 cm/year (United States Geological Survey, 1985*a*).

The Rio Chama, the largest tributary of the Rio Grande in New Mexico, joined the latter near Espanola. It was a highly regulated system with two mainstem dams, El Vado and Abiquiu (closed in 1935 and 1963, respectively) and contributed a significant volume to the Rio Grande. In 1984, the Rio Chama accounted for 40% of the mean annual discharge of the Rio Grande (United States Geological Survey, 1985*b*) approximately 20 km below the confluence of the two rivers. Instantaneous discharge in the Rio Chama below Abiquiu Dam averaged 7.9 m^3/s the day collections were made. Seventeen irrigation canals and one groundwater pump removed water from the Rio Chama below Abiquiu Reservoir (United States Geological Survey, 1985*b*).

In the study area, the Rio Chama was a fairly wide (50 m), low gradient (3.6 m/km), meandering stream with a rubble-gravel substrate and considerable habitat heterogeneity. It flowed through an agricultural valley as a series of relatively shallow runs, riffles, and pools. The three study sites on this river were located 9, 15, and 23 km downstream from the hypolimnetic outflow of Abiquiu Reservoir.

The Rio Grande exhibited considerable physical change through its 200-km length in the study area. In the northernmost portion (near Velarde), the Rio Grande, having emerged from a narrow canyon, was confined to a relatively narrow channel where water velocity was high, substrate was primarily boulder and rubble, and habitat heterogeneity was low (pools and runs). In the lowermost section, the Rio Grande was a wide meandering river with high silt load, low velocity, shifting sand-silt substrate, and a variety of habitats. Cochiti Reservoir, located 66 km above Albuquerque and closed 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 and may have been barriers to upstream fish dispersal.

Mean instantaneous discharge in the Rio Grande during the study period ranged from 9.8 to 11.3 m^3/s at the uppermost site and 8.0 to 14.0 m^3/s at the most downstream locality (United States Geological Survey, 1985*b*). Twenty localities were sampled in the Rio Grande as well as associated irrigation and flood canals from Velarde in Rio Arriba County south to the Valencia-Socorro county lines.

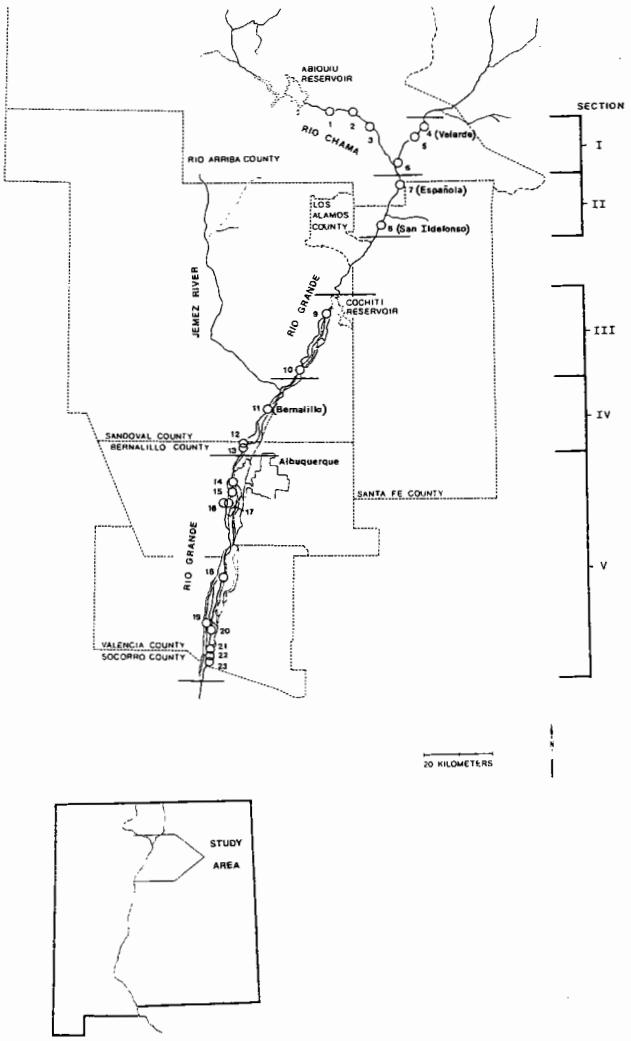
Fishes were collected with a 3-m by 3-m seine (1-cm mesh) at 23 localities from 15 to 21 August 1984. Collecting effort was intense because a primary objective was to survey for *N. s. simus* in the northern portion of its historic range. Sites were selected to represent a variety of habitat types including main and secondary channels, runs, riffles, backwaters, eddies, pools, borrow pits, and flood and irrigation canals. Deep areas of the river were inaccessible to our sampling, which probably accounted for the lack of large individuals of some species in the samples.

All preserved specimens were identified, counted, and catalogued into the ichthyological collection of the U.S. Fish and Wildlife Service National Ecology Research Center, Fort Collins, Colorado. Historic distribution and abundance data were compiled from published and unpublished literature and museum records (UMMZ = University of Michigan Museum of Zoology).

To illustrate preliminary longitudinal distribution patterns, the river was divided into sections within which similar physical attributes were observed. Sections I, II, and III were cool-water reaches and IV and V were warm-water reaches. Those species whose distribution in the upper Rio Grande best illustrated a longitudinal gradient pattern (Rio Grande chub, *Gila pandora*; flathead chub, *Hybopsis gracilis*; longnose dace, *Rhinichthys cataractae*; *H. amarus*; red shiner, *Cyprinella lutrensis*) were selected for discussion. Collection data within sections were pooled. Sampling locations in the Rio Chama (sites 1, 2, and 3) were not included in the longitudinal distribution analysis because of the limited area of coverage. Irrigation and flood control canal sites (sites 12, 16, 19, 21, and 22) were not included because they were not representative of the river's ichthyofauna.

RESULTS—*Ichthyofaunal Composition and Abundance*—Twenty-one species representing five orders and seven families were taken in the 23 collections made during this survey. Nine species were collected in the Rio Chama, and 20 in the Rio Grande and associated irrigation canals (Table 1). Ictalurids, cyprinodontids, and poeciliids were taken only in the Rio Grande and rainbow trout (*Oncorhynchus mykiss*) was collected only in the Rio Chama. The 10 most abundant species comprised 97% (n = 9,324) of the total number of specimens collected while 11 species accounted for the remaining 3% (n = 314).

Eight of the 16 species presumed to be native



to the upper Rio Grande were present in the collections. In addition, 13 introduced forms were collected. Although the number of native species of fish was low, they constituted 79% (n = 7,607) of the total number of specimens taken. *Hybognathus amarus*, *C. lutrensis*, *R. cataractae*, and *H. gracilis*, all native, were the four most abundant species. White sucker (*Catostomus commersoni*) was the most common non-native fish and was the fifth most abundant species. Ten non-native species, composed of cyprinids, catostomids, ictalurids, poeciliids, and centrarchids, accounted for 99.9% (n = 2,028) of the introduced forms. Single specimens of rainwater killifish (*Lucania parva*), smallmouth bass (*Micropterus dolomieui*), and *O. mykiss* represented the remaining introduced species.

The most abundant and species-rich family in the study reach was Cyprinidae. The seven cyprinid species collected, six of which were native, accounted for 76% of the total catch. Centrarchidae, represented by five non-native species, was the second most species-rich family but accounted for <1% (n = 91) of the total catch. Centrarchids were distributed from the lowermost Rio Grande locality to the upper-most Rio Chama site, occurring at 15 of the 23 study sites. The three catostomid species collected comprised 12% (n = 1,171) of the total catch with the introduced *C. commersoni* comprising 70% of the catostomid catch by number. *Catostomus commersoni* was the most frequently encountered species of fish, occurring at 21 sites. Conversely, Rio Grande sucker (*Pantosteus plebeius*), was one of the least frequently collected species, occurring at only three sites, one in the Rio Grande and two in the Rio Chama. The low number of *P. plebeius* taken in this survey was probably an artifact of the paucity of collections in its preferred habitat (cool, clear, swift-flowing tributaries of the Rio Grande). Ictaluridae was represented by three species, all introduced, and accounted for 5% (n = 448) of the total catch. Ictalurids were collected at 13 sites and, at 10 of these, were one of the five most abundant species. Salmonidae, Cyprinodontidae, and Poeciliidae were each represented by single species and, for the first two families, single specimens.

Longitudinal Distribution—The of section I consisted of five nativ troduced species and was numeric by species indicative of relatively c flowing water (*G. pandora*, *H. g cataractae*). Although they were n the Rio Grande during this study, brown trout (*Salmo trutta*) inhabit t obser.).

The next section (II) was loca confluence of the Rio Grande an and above Cochiti Reservoir (sites transition between sections I and most dramatic change in communi as seven species were added and o *plebeius*). None of the additions w to the Rio Chama. The addition *lutrensis*; river carpsucker, *Carpiod* bullhead, *Ictalurus melas*; channel *lurus punctatus*; *G. affinis*; green su *cyanellus*; largemouth bass, *Mi moides*) were typically found in w moving water.

Section III was the most species the river with 17 species. Compare II, the ichthyofaunal community i gained four species without any l *nathus amarus*, which typically occu slow-moving, silt-laden water, rea upstream distribution in this sectio

Section IV appeared to be a tr from cool to warm-water habitats. I the river widened, silt loads increas peratures were higher, and velocit The number of species between se IV was reduced from 17 to 14, wi four and the addition of yellow bullh *natalis*). Below this point, there w additions, only losses.

In section V, *C. lutrensis*, *H. an carpio*, were the most numerous of taken in this reach and comprised the catch. These three species thrive low-velocity water and shifting s characteristic of this section.

The three species (*G. pandora*, and *H. gracilis*) most common in the es (sections I to III) comprised a gu

←

FIG. 1—Rio Grande drainage in northern New Mexico. Collection sites are denoted by op circles; sections are designated by Roman numerals.

TABLE 1—Distribution and number of fish collected in the Rio Grande and Rio Chama. Sample sites correspond to those in Fig. 1. Resident status refers to native (N) or introduced (I).

						Rio Grande sections and sites				
			Rio Chama sites			I			II	
No. of sites	Resident status	Species	1	2	3	4	5	6	7	8
1	I	*Oncorhynchus mykiss*		1						
16	N	*Cyprinella lutrensis*[1]							2	4
14	I	*Cyprinus carpio*	1	5			1		1	4
10	N	*Gila pandora*[1]	31	90	10	253	15	25	1	
12	N	*Hybognathus amarus*[1]								
17	N	*Hybopsis gracilis*[1]	4	5	27	10		7	92	49
19	N	*Pimephales promelas*	51	64	3		4	3	134	6
19	N	*Rhinichthys cataractae*[1]	135	51	76	156	151	33	228	229
14	N	*Carpiodes carpio*							12	5
21	I	*Catostomus commersoni*	102	212		112	8	4	91	9
3	N	*Pantosteus plebeius*	1	1		4				
3	I	*Ictalurus melas*								1
9	I	*Ictalurus natalis*								
13	I	*Ictalurus punctatus*								6
1	I	*Lucania parva*								
16	I	*Gambusia affinis*							2	1
7	I	*Lepomis cyanellus*	2						1	
2	I	*Lepomis macrochirus*								
1	I	*Micropterus dolomieui*								
9	I	*Micropterus salmoides*							5	1
8	I	*Pomoxis annularis*								

[1] This species for sites 4 to 11, 13 to 15, 17, 18, 20, and 23 was used in longitudinal distributional analysis.

cool, fast-flowing water over rubble or gravel substratum. Of these, *G. pandora* had the most restricted distribution (Fig. 2) and, apparently, the narrowest environmental tolerances. It was most common above the confluence of the Rio Chama and Rio Grande. The only downstream location (section III) where *G. pandora* was common (n = 49) was immediately below the hypolimnetic release of Cochiti Dam (site 9), a site which physically resembled northern sections.

Rhinichthys cataractae had the second widest distribution of the upper-river forms. It was first or second in abundance at all of the upper sites (4 to 9), but became progressively less common below Albuquerque. *Rhinichthys cataractae* persisted in generally unsuitable stretches if there was a patch of suitable habitat of gravel and rubble with water of sufficient velocity. There was a noticeable decrease not only in number but also in the mean and maximum size of the specimens taken downstream.

Hybopsis gracilis, the most widespread cool-water species, was common at all sites, except 5, in sections I and II. It reached its greatest abundance in sections III and IV and persisted at reduced levels (n < 8) at five of the six sites in section V. This species was most commonly associated with gravel bars in fast-moving water in depths of approximately 1 m (pers. obser.). *Hybopsis gracilis*, like *G. pandora*, was very abundant below Cochiti Reservoir. *Hybopsis gracilis* persisted in downstream reaches (sections IV and V) in areas where small patches of suitable habitat (submerged gravel bars) were present.

Hybognathus amarus was present at all sites in sections III, IV, and V but was most abundant in section IV and the lowermost sites in section V. A shared characteristic among sites where large collections of this species were made was a shifting sand-silt substrate.

Cyprinella lutrensis was collected as far upstream as Espanola (site 8); however, it was not a common constituent of the ichthyofaunal community until site 10, downstream of Cochiti Reservoir. From site 18 south, it was either the first or second most abundant species.

TABLE 1—Extended.

Rio Grande sections and sites												
III		IV			V							
9	10	11	12	13	14	15	16	17	18	19	20	21
29	203	16	11	10	27	12		1	907	5	163	2
1	2		2	1	1	1				2	2	
49		1					6					
5	97	99	581	340	13	5		4	18		470	3
544	59	44	2	2	8	4		1	3			
2	31	6	13	1	1	2			1	20	11	
90	239	241	53	24	21	7	16	3	2			
1	22	10	7	20	36	12		8	31	1	142	
83	28	15	51	13	18	6	29	10	4	1	10	
	21		2									
			16	7	30	30		36	22	4	12	
	7	6	7	31	67	45	1	24	21	1	1	
										1		
19	159	3	52	12	61	21	33	1	11	220	23	6
5	5	1	2				1					
13	1											
1												
19			1		1		2		2	1		1
	1	5	3	4	6	5				1		

DISCUSSION—The earliest documented fish collection from the New Mexican portion of the Rio Grande was made by Cope and Yarrow (1875) at San Ildefonso (section II; site 8) in 1874. Cope and Yarrow (1875) reported 10 species, two of which were previously undescribed (*N. jemezanus* and *N. simus*). Since then, three (*H. aestivalis*, *N. jemezanus*, and *N. simus*) of those 10 species have been extirpated from the New Mexican portion of the Rio Grande. The collections made in section II during this study revealed a shift in the ichthyofaunal community from a fauna comprised only of native species and dominated by cyprinids in 1874 to a community where seven of 13 species were introduced.

The proportion of non-native species in the Rio Grande increased downstream and peaked at eight of 14 species in section V. Despite the increase in the number of non-native species, native forms dominated the catch in this study, accounting for almost 80% of the total number of individuals. Most of the introduced species (eight of 13) were either ictalurids or centrarchids. Densities of these species were generally lower than th short-lived cyprinids.

While there is little question that native to the lower Rio Grande (F Smith and Miller, 1986; Propst et Smith and Miller (1986) considered i to the upper reaches. They based thi on the lack of *G. affinis* in the ear collection of fish (1874) in the upper (Cope and Yarrow, 1875). A collect *finis* in 1936 from an irrigation can buquerque (UMMZ 110467; n = 1) of barriers to prevent natural upstrea were primary factors which led Propst to speculate it was native (D. L. F comm.), as did Hatch (1985).

Information recently found in earl provided support for the position tak and Miller (1986). Troxel (1939) fo *affinis* was quite common in irrigation sloughs in the Albuquerque area in th and cited Barber et al. (1929) as source of the introductions. Barber e

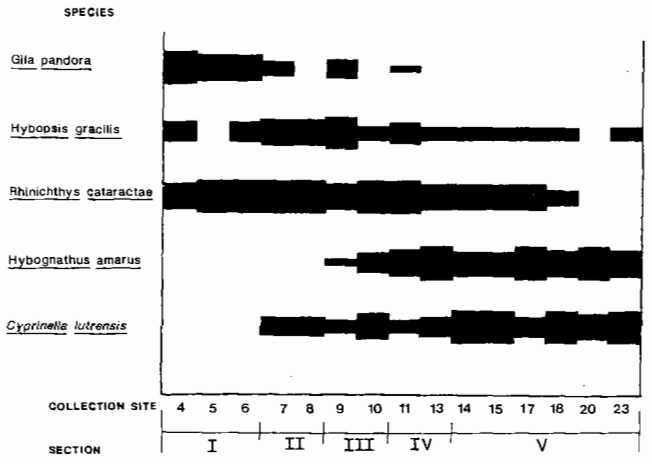


FIG. 2—Longitudinal distribution and relative abundance of five cyprinids in the Rio Grande. Bar width (one of five thicknesses) indicates abundance, relative to the other four species. Thickest bar represents most common of the five species. Collection sites and sections correspond to those in Fig. 1.

reported transplanting *G. affinis* from Mississippi to Rio Arriba and Santa Fe counties in northern New Mexico (near Espanola) in 1928 and 1929 to control mosquitos and malaria. The lack of *G. affinis* from the Cope and Yarrow (1875) collection in 1874, and subsequent widespread introductions of this species support Smith and Miller's (1986) contention that this species is not native to the upper Rio Grande of New Mexico.

Longitudinal transition in fish faunas are well documented (Kuehne, 1962; Harrel et al., 1967; Sheldon, 1968; Jenkins and Freeman, 1972; Evans and Noble, 1979; Maurakis et al., 1987). In the Rio Grande, the progressive downstream pattern of species addition and replacement mirrored changes in physical habitat. The upper section (I) was the least diverse (seven species) whereas downstream species richness increased and peaked in section III below Cochiti Reservoir (17 species). From that point south, the number of species decreased but still remained at least as high as the two uppermost sections. The most notable downstream additions were catfishes and centrarchids.

Ward and Stanford (1983*a*) stated in their discussion of the serial discontinuity concept that in riverine ecosystems there is a continuum of physical, biological, community, and ecosystem parameters. Damming of these ecosystems can cause the shift to upstream conditions of any or all parameters. In this study, a shift of physical habitat below Cochiti Dam (sites 9 and 10) was reflected by the fish fauna. Suspended sand and silt are trapped by the reservoir and hypolimnetic releases reduce downstream water temperature. Apparently, these changes in habitat enabled comparatively large numbers of *H. gracilis* (n = 544) and *G. pandora* (n = 49) to inhabit a site that might otherwise have been only marginally suitable.

Sites below dams may also exhibit characteristics typical of those described by Ward and Stanford (1983*b*) in their intermediate disturbance hypothesis of lotic ecosystems. This theory contends that some disturbance of the ecosystem maintains the community in a non-equilibrium state. It is in these situations of moderate disturbance that there is a maximum spacio-temporal habitat heterogeneity which allows a greater number of species to exist. The large number of

species and individuals taken at this location lend support to this hypothesis.

This study was funded by the Office of Endangered Species, U.S. Fish and Wildlife Service, Albuquerque, New Mexico. I thank J. E. Johnson (United States Fish and Wildlife Service) for administering this contract, and D. A. Hendrickson, R. R. Miller, and D. L. Propst for providing helpful comments which improved this manuscript. I am especially indebted to G. H. Clemmer for assistance in all phases of the data collection.

LITERATURE CITED

BARBER, M. A., W. H. W. KOMP, AND C. H. KING. 1929. Malaria and the malaria danger in certain irrigated regions of southwestern United States. U.S. Public Health Rept., 44:1300–1315.

BESTGEN, K. R., AND S. P. PLATANIA. 1990. Extirpation and notes on the life history of *Notropis simus simus* and *Notropis orca* (Cypriniformes: Cyprinidae) from the Rio Grande, New Mexico. Occas. Papers Mus. Southwestern Biol., 6:1–8.

CHERNOFF, B., R. R. MILLER, AND C. R. GILBERT. 1982. *Notropis orca* and *Notropis simus*, cyprinid fishes from the American Southwest, with description of a new subspecies. Occas. Papers Mus. Zool., Univ. Michigan, 698:1–49.

COPE, E. D., AND H. C. YARROW. 1875. Report upon the collections of fishes made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during 1871, 1872, 1873, and 1874. Rept. Geogr. Geol. Exploration Surv. West 100th Meridian (Wheeler Survey), 5(6):637–700.

EVANS, J. W., AND B. L. NOBLE. 1979. The longitudinal distribution of fishes in an east Texas stream. Amer. Midland Nat., 101:333–343.

HARREL, R. C., B. J. DAVIS, AND T. C. DORRIS. 1967. Stream order and species diversity of fishes in an intermittent Oklahoma stream. Amer. Midland Nat., 78:428–436.

HATCH, M. D. 1985. Native fishes of the major drainages east of the Continental Divide, New Mexico. Unpubl. M.S. thesis, Eastern New Mexico Univ., Portales, 85 pp.

JENKINS, R. E., AND C. A. FREEMAN. 1972. Longitudinal distribution and habitat of the fishes of Mason Creek, an upper Roanok tributary, Virginia. Virginia J. S

KOSTER, W. J. 1957. Guide to d Mexico. Univ. New Mexico Pre 116 pp.

KUEHNE, R. A. 1962. A classific illustrated by fish distributions ir tucky creek. Ecology, 43:608–61

MAURAKIS, E. G., W. S. WOOLC JENKINS. 1987. Physiographic a gitudinal distribution of fishes i nock River, Virginia. Assoc. So gists Bull., 34:1–14.

PROPST, D. L., G. L. BURTON, AND 1987. Fishes of the Rio Grande Butte and Caballo Reservoirs, Ne western Nat., 32:408–411.

SHELDON, A. L. 1968. Species div tudinal succession in stream fis 193–198.

SMITH, M. L., AND R. R. MILLER. lution of the Rio Grande Basin as fish fauna. Pp. 457–485, in Zooge American freshwater fishes (C. H O. Wiley, eds.). John Wiley and 866 pp.

TROXEL, R. B. 1939. Notes on th ecology of *Gambusia patruelis*. Un Univ. New Mexico, Albuquerqu

UNITED STATES GEOLOGICAL SURVE Mexico: surface-water resources summary. U.S. Geol. Surv. Wat 2300:341–346.

———. 1985*b*. Water resources da water year 1985. U.S. Geol. S Rept., NM 85-1:1–482.

WARD, J. V., AND J. A. STANFORD. 1 discontinuity concept of lotic eco 42, in Dynamics of lotic ecosyste taine, III, and S. M. Bartell, eds.). lishers, Ann Arbor, Michigan, 49

———. 1983*b*. The intermediate pothesis: an explanation for biotic in lotic ecosystems. Pp. 347–356, lotic ecosystems (T. D. Fontaine Bartell, eds.). Ann Arbor Publish Michigan, 494 pp.