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MONITORING OF THE RIO GRANDE FISH COMMUNITY (VALENCIA COUNTY, NEW MEXICO) IN REFERENCE TO THE INSTALLATION OF A NATURAL GAS PIPELINE BY TRANSWESTERN PIPELINE COMPANY

PROJECT NUMBER S35015

A FINAL REPORT:

MONITORING OF THE RIO GRANDE FISH COMMUNITY IN THE VICINITY OF THE TRANSWESTERN NATURAL GAS PIPELINE, TURN, NEW MEXICO

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INTRODUCTION

Fish assemblages in most of the arid regions of North America have been affected by man-induced disturbances such as water development, habitat alteration, and the introduction of non-native species. Over half of the cyprinid taxa recently listed as endangered, threatened, or of special concern were from desert streams in the American Southwest or west (Williams et al. 1989). Included in that list were several taxa from the Rio Grande basin.

The Rio Grande is one of the longest rivers in North America traversing almost 2,000 miles from its headwaters in the San Juan Mountains of southern Colorado before emptying into the Gulf of Mexico. The Rio Grande, the second largest drainage basin in the American Southwest, is surpassed in size only by the Colorado River Basin. In New Mexico, the mainstem is approximately 500 miles long and drains nearly 20% of the state.

The native ichthyofauna of the New Mexico 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 were endemic to the basin. Of the latter, Rio Grande shiner, phantom shiner, and Rio Grande bluntnose shiner no longer occur in the New Mexico portion of the Rio Grande (Bestgen and Platania 1990). Rio Grande shiner was known from 81 specimens in eight collections in the Rio Grande in New Mexico and has not been taken there since 1949 (Platania 1991). Phantom shiner and Rio Grande bluntnose shiner, both reported as extirpated (Chernoff et al. 1982; Bestgen and Platania 1990), were last collected in the Rio Grande in 1939 and 1964, respectively (Chernoff et al. 1982; Bestgen and Platania 1990). Rio Grande silvery minnow is the only endemic Rio Grande fish surviving in New Mexico and occurs in <5% of its total former range (Bestgen and Platania 1991).

The aforementioned four species comprised a guild of short-lived (3-5 years) mainstream cyprinids which were apparently especially susceptible to reduction and alteration of stream discharge. Changes in stream hydrology were most closely associated with construction of mainstream dams and irrigation withdrawals. Additional factors which were thought to have contributed to the decline and demise of the native Rio Grande fish fauna were channel modifications, municipal, agricultural, and industrial pollution, and the introduction of several non-native predaceous game fishes.

Rio Grande silvery minnow formerly was relatively abundant and widespread in the Rio Grande, occurring from near Española to the Gulf of Mexico (Bestgen and Platania 1991). Recent studies in the Rio Grande basin documented the loss of this species from Rio Grande upstream of Cochiti Dam and downstream of Elephant Butte Reservoir. Rio Grande silvery minnow has been extirpated from its former range in the Pecos River and replaced by a congener, plains minnow. This 90-95% reduction in range was due, in part, to water resource development and resulted in the listing of this endemic cyprinid as a federal endangered species (U.S. Department of the Interior 1994). Critical habitat has been proposed as the Rio Grande between the NM State Highway 22 bridge (directly below the out-fall of Cochiti Dam) and the San Marcial Railroad bridge. This study was a short-term monitoring effort that attempted to assess potential impact of construction activities and conservation measures on Rio Grande ichthyofauna.

In late July 1996, Transwestern Pipeline Company (Transwestern) began installation of a 3,200 foot section of natural gas pipeline (30 inch diameter) in Valencia County, New Mexico. The pipeline was a replacement of an aerial segment, that crossed the Rio Grande, and was damaged in an explosion in August 1994. For reasons of safety, it was determined that the replacement section of pipeline was to be buried. The geotechnical study undertaken to

determine the feasibility of installing the pipeline through direction drilling under the Rio Grande indicated that the local soil conditions were not suitable for this means of installation and that the open cut method of pipeline installation would have to be employed. Concern was expressed by the U.S. Fish and Wildlife Service regarding potential affects of instream construction activities on Rio Grande silvery minnow.

Under consultation with the U.S. Fish and Wildlife Service and New Mexico Ecological Services State Office, Transwestern agreed to limit construction activities in the Rio Grande channel to a 30 day period between mid-July and 1 November. Those dates corresponded to the period of low flows in the proposed study construction reach of the Rio Grande. Construction associated with the river crossing started on the west bank and began about 1 August 1996. Concrete (Jersey) barriers were installed in a semicircular pattern across about 60% of the river thereby diverting flow to the remaining 40% of the river channel. A visqueen plastic was placed over the barriers and anchored with sand bags forming a seal and ensuring isolation from the rest of the river. High volume water pumps, designed to remove water from this isolated reach, were subsequently installed. Once all standing water had been removed and subsurface flow had been diverted, an open trench was excavated across about 55% of the river channel and a prefabricated pipeline was placed in the trench and covered. This process was than repeated to install the rest of the pipeline.

Two separate fish sampling efforts were conducted as part of this study. The larger effort was comprised of pre-and-post construction ichthyofaunal sampling (=monitoring) at collecting stations up and downstream of the impacted reach. That investigation provided benchmark datasets to assess any potential impacts that might have resulted during the planned activities. The other sampling activity was conducted only at the construction site and involved translocation of fishes that had became been isolated from the river by construction barriers. This document reports the results of both monitoring activities and the relocation of fish that had been separated from the main channel and trapped in the enclosures.

STUDY AREA AND SAMPLING METHODOLOGY

The study area consisted of the Rio Grande near the Village of Turn, about 2.5 miles upstream of NM State Highway 346 bridge, in Valencia County, New Mexico. Riverine habitat at this site was typical of the Rio Grande between Isleta and San Acacia Diversion dams. The river channel was broad and meandered over sand substrate and consists primarily of runs, with pools occurring at low flows near channel margins and overhanging vegetation. There were no tributaries to the Rio Grande in this reach.

Three monitoring sampling stations were selected based on accessibility of the reach and habitat diversity. The uppermost site was an aerial pipeline crossing (El Paso pipeline bridge) about 0.5 miles upstream of the Transwestern pipeline construction site and three miles upstream of NM State Highway 346 bridge at Turn, New Mexico. This site was chosen because of its proximity, lack of disturbance, and high degree of habitat heterogeneity. The second monitoring station was at the Transwestern pipeline construction site (ca. 2.5 miles upstream of NM State Highway 346 bridge). Fish monitoring at the second sampling station was conducted immediately up and downstream of construction activities and did not include fish taken from within the enclosure. The lowermost collection locality was about 0.5 miles downstream of the Transwestern pipeline crossing. Like the uppermost locality, this site was easily accessible and had a relatively high amount of instream habitat heterogeneity. In

addition, because of its close proximity to the construction site, this sampling station was deemed to be a good locality to monitoring for potential impacts from upstream sources. Fish collected at these three localities were retained and yielded information about the composition of the ichthyofaunal community.

For the monitoring portion of this investigation, fish were collected with 10' x 6' x 3/16"-mesh seine. Length of each discrete seine haul was measured so that catch rate by site could be quantified. Samples were taken prior to instream construction activities (25 July 1996), at the beginning of instream construction activities (29 July 1996), and about one month after the cessation of instream construction activities (2 October 1996). All available habitats in a selected reach were sampled. Upon capture, fish were fixed in 10% formalin and returned to the laboratory for identification. Retained specimens were curated into the Fish Division of the Museum of Southwestern Biology at the University of New Mexico, as stipulated by New Mexico Department of Game and Fish collecting permit regulations.

During the tranlocation portion of this study, fish were collected with small mesh seines and temporarily held in a 150-gallon polypropylene stock-tank filled with river water prior to being released. The number of seine hauls was recorded but, for this portion of the project, length of each seining effort was not recorded. All fish collected were subsequently identified to species, enumerated, and released alive in the main channel about 50 m downstream of construction activities. Specimens collected during this phase of the study (=translocation) were not included in the totals calculated for the monitoring portion of the project. Fish collecting in the west isolated river reach was conducted on 5,6,7,8 and 10 August 1996 and on 15 August 1996 in the east reach.

RESULTS

Monitoring

The three monitoring sites produced 7,515 specimens represented by five families and 12 species (Table 1). Red shiner was numerically the most dominant fish occurring in all nine samples and accounting for about 73% of the total catch. This species was over nine times more abundant than the second most common species, fathead minnow. These two species combined to account for about 80% of the total sample and 97% of the cyprinid (minnows and carps) catch. Members of the family cyprinidae were, collectively, the greatest portion (83%, n=6,283) of the total monitoring catch.

The three least abundant minnows were Rio Grande silvery minnow, flathead chub, and longnose dace. The relative rarity of the latter two species from this reach was expected as this portion of the Rio Grande is generally void of their preferred habitat (cool-water and gravel substrate). The limited number of Rio Grande silvery minnow (n=30) was probably an artifact of the extreme drought conditions experienced in the Middle Rio Grande Valley during the spring and early summer 1996. Silvery minnow were present in seven of the nine samples (78%) but were never represented by more than eight individuals. A total of 21 of the 30 (70%) Rio Grande silvery minnow collected during the monitoring portion of this investigation were captured during the first sampling foray. Only one individual was taken during the last July collection (at the uppermost site) while eight were captured during the final sampling effort. All of the Rio Grande silvery minnow collected during the monitoring study were Age I fish or older.

Table 1. Summary of ichthyofaunal composition from the three Rio Grande monitoring sites, July-October 1996, Turn, New Mexico. Data do not include specimens collected as part of the translocation portion of the project.

SPECIES	RESIDENCE STATUS[1]	TOTAL NUMBER OF SPECIMENS	% OF TOTAL	FREQUENCY OF OCCURRENCE[2]	% FREQUENCY OF OCCURRENCE[2]
CARPS AND MINNOWS					
red shiner	N	5,459	72.6	9	100.00
common carp	I	195	2.59	9	100.00
Rio Grande silvery minnow	N	30	0.40	7	77.78
fathead minnow	N	585	7.78	9	100.00
flathead chub	N	12	0.16	5	55.56
longnose dace	N	2	0.03	2	22.22
SUCKERS					
river carpsucker	N	557	7.41	9	100.00
white sucker	I	1	0.01	1	11.11
BULLHEAD CATFISHES					
yellow bullhead	I	8	0.11	3	33.33
channel catfish	I	175	2.33	9	100.00
LIVEBEARERS					
western mosquitofish	I	488	6.49	9	100.00
SUNFISHES					
largemouth bass	I	3	0.04	2	22.22
TOTAL		7,515			

[1] N = native; I = introduced
[2] Frequency and % frequency of occurrence in total number of collections (n=9)

River carpsucker, the third most abundant fish, was present in all nine samples. The only other sucker species taken during the sampling was a single 53 mm SL white sucker collected at the lowermost site. As with flathead chub and longnose dace, this species prefers cool-waters and gravel substrate and is more abundant in the more northern reaches of the Rio Grande.

Channel catfish was a relatively ubiquitous species occurring in all nine samples and comprising about 2% of the total catch. Most of the individuals we obtained were Age 0 or Age 1 fish and were less than 100 mm SL. The absence of larger channel catfish from this portion of the study was most likely due to their ability to avoid capture with seines. Channel catfish >100 mm SL were taken from isolated pools during the August 1996 translocation portion of this study.

The number of native and non-native species encountered during or study was the same (n=6). However, native fish comprised a significantly larger portion of the total catch collectively and at each of the three sites, than non-native fishes. There was little difference in the native versus non-native composition by site with values ranging from 87.57% to 89.52% for native species and 10.48% to 12.43 % for non-native taxa. Red shiner (native) was primarily responsible for the high incidence of naive fishes as accounted for at least 69% of the total catch at each site.

There was a notable increase in catch rate of fish from upstream to downstream. The uppermost site yielded the second highest number of specimens but had the lowest overall catch rate (6.43 fish/10^2 sampled). The middle site (at the pipeline crossing) produced the fewest fish but had a catch rate about three time greater than the upper site (Table 2). The lowest site produced both the most specimens and the highest catch rate (34.84 fish/10^2 sampled). There were over five times as many fish collected per m^2 of water sampled at the lowest site as compared with the upper-most station. The mean catch rate for the three sampling stations was about average for that reach of the Rio Grande.

Translocation of fishes

In the two enclosures at the construction site, we collected and released 1,072 fishes, represented by nine species. Red shiner and western mosquitofish were the first and second most abundant species, respectively (Table 3). These two species collectively accounted for 61% of the fish that had been isolated. Rio Grande silvery minnow (n=8) and flathead chub (n=1) were taken only in the west reach while black bullhead (n=1) was taken only at the east site. All other species were represented by at least 60 specimens and were present at both east and west translocation collection sites (Table 4).

There was a gradual decrease in the number of fish taken per visit at the west site. About 52% of the total west site sample was taken during the first collecting foray (5 August) with 32% taken on 6 August (Table 5). The final three sampling efforts at this site produced 69, 59, and 12 specimens. None of the five species taken during the final sampling foray was represented by more than five individuals.

Due to the low volume of water contained in the east bank isolated reach, we only needed to conduct a single sampling foray (15 August) to collect all fish at this site. Most of the fish trapped in that reach were channel catfish (56%), western mosquitofish (22%), or red shiner (15%). A total of 107 (97%) of the 110 channel catfish collected at the two isolated sites were taken at the east locality with over 50 of those individuals being >100 mm SL. None of the other four species present at the east locality were represented by more than six specimens.

Table 2. Summary of ichthyofaunal composition, by date, at the three Rio Grande monitoring sites, July-October 1996, Turn, New Mexico. Data do not include specimens collected as part of the translocation portion of the project.

SPECIES	RESIDENCE STATUS[1]	SITE 1	SITE 2	SITE 3	TOTAL NUMBER OF SPECIMENS
CARPS AND MINNOWS					
red shiner	N	1,637	1,508	2,314	5,459
common carp	I	54	59	82	195
Rio Grande silvery minnow	N	9	9	12	30
fathead minnow	N	264	93	228	585
flathead chub	N	4	1	7	12
longnose dace	N	2	0	0	2
SUCKERS					
river carpsucker	N	163	129	265	557
white sucker	I	0	0	1	1
BULLHEAD CATFISHES					
yellow bullhead	I	2	2	4	8
channel catfish	I	41	53	81	175
LIVEBEARERS					
western mosquitofish	I	197	130	161	488
SUNFISHES					
largemouth bass	I	1	0	2	3
TOTAL		2,374	1,984	3,157	7,515
NUMBER OF SPECIES		11	9	11	12
NUMBER OF NATIVE SPECIES		6	5	5	6
NUMBER OF INTRODUCED SPECIES		5	4	6	6
PERCENT OF NATIVE FISH		87.57	87.70	89.52	88.42
PERCENT INTRODUCED FISH		12.43	12.30	10.48	11.58
AREA SAMPLED (m^2)		3,691	1,073	906	5,670
FISH CATCH RATE PER 10 m^2		6.43	18.50	34.84	13.25

[1] N = native; I = introduced

Table 3. Summary of fishes collected during the translocation phase of the study in the Rio Grande at the Transwestern Pipeline crossing, August 1996. Data do not include specimens collected as part of the monitoring portion of the project.

SPECIES	RESIDENCE STATUS[1]	NUMBER OF SPECIMENS	RANK ABUNDANCE	FREQUENCY OF OCCURRENCE	% OF TOTAL
red shiner	N	342	1	6	31.90
common carp	I	62	6	6	5.78
Rio Grande silvery minnow	N	8	7	3	0.74
fathead minnow	N	134	3	6	12.50
flathead chub	N	1	8	1	0.09
river carpsucker	N	105	5	6	9.79
black bullhead	I	1	8	1	0.09
channel catfish	I	110	4	3	10.26
western mosquitofish	I	309	2	6	28.82
TOTAL		1,072			

[1] N = native; I = introduced

Table 4. Summary, by date, of fishes collected during the translocation phase of the study in the Rio Grande at the Transwestern Pipeline crossing, August 1996. Data do not include specimens collected as part of the monitoring portion of the project.

	COLLECTION DATES					
SPECIES	AUG 5	AUG 6	AUG 7	AUG 8	AUG 10	AUG 15
red shiner	249	52	3	7	2	29
common carp	23	12	12	8	1	6
Rio Grande silvery minnow	5	2	1	--	--	--
fathead minnow	56	43	17	14	2	2
flathead chub	--	1	--	--	--	--
river carpsucker	48	30	17	5	2	3
black bullhead	--	--	--	--	--	1
channel catfish	2	1	--	--	--	107
western mosquitofish	78	140	19	25	5	42
TOTAL	461	281	69	59	12	190
# SPECIES	7	8	6	5	5	7

Table 5. Percent, by date, of fishes collected during the translocation phase of the study in the Rio Grande at the Transwestern Pipeline crossing, August 1996. Data do not include specimens collected as part of the monitoring portion of the project. Data corresponds with Figure 1.

	COLLECTION DATES				
SPECIES	AUG 5	AUG 6	AUG 7	AUG 8	AUG 10
red shiner	79	17	1	2	1
common carp	41	21	21	15	2
Rio Grande silvery minnow	63	25	12	--	--
fathead minnow	42	33	13	11	1
flathead chub	--	100	--	--	--
river carpsucker	47	29	17	5	2
channel catfish	67	33	--	--	--
western mosquitofish	29	52	7	10	2
TOTAL	52	32	8	7	1

All Rio Grande silvery minnow (n=8) taken during the translocation portion of the study were collected at the west (first isolated) site. Five individuals were taken during the first foray, two during the second and the last specimens was taken during the third west site sampling effort. The final two west site samples failed to yield additional Rio Grande silvery minnow. The Rio Grande silvery minnow taken were Age I individuals (50-80 mm SL) that appeared healthy, were not gravid, and were released unharmed. There was no evidence that any Rio Grande silvery minnow perished as a result of the construction of the two enclosures.

The catch rate of fishes taken during the five west-side collecting efforts were indicative of depletion sampling. All except one of the seven species represented by more than one specimen demonstrated a continual decline in the number of specimens taken. The one exception, western mosquitofish, was captured most frequently (52% of mosquitofish taken) during the second sampling foray. There was a 20 cm drop in water level in the isolated reach, compared with the previous day, which resulted in greater isolation of fish and less available cover for seclusive species, such as western mosquitofish, to hide (Figure 1). Fathead minnow and river carpsucker demonstrated the most gradual decline in catch per day while red shiner (the most abundant species) exhibited the greatest decline (62%) between two consecutive forays.

DISCUSSION

This study provided the opportunity to access the impacts of the construction activities, associated with the placement of the natural gas pipeline, on the fish community in that reach of the river. The monitoring effort did not suggest any adverse affects from those activities as the population levels before and after construction were not significantly different. Most of the impact was confined to the narrow reach of river immediately up-and-downstream of the pipeline. We feel that the most significant findings from this study was the ease in which we were able to collect and translocate fish.

Our attempt to remove fish from riverine portion of the Transwestern Pipeline construction reach was very successful for several reasons. The aspect of the project most responsible for this success was the continual communication and cooperation by Transwestern representatives overseeing the construction. We were given unrestricted construction site access and worked closely with site foremen. These individuals freely explained project procedures, kept us abreast of scheduling, sought our input for means of minimizing environmental impacts, and respected the needs of maintaining the health of the fish community and survival of individual Rio Grande silvery minnow. Without this communication and cooperation, we would have had to keep an individual on site at all times to monitored the progress of construction and determine when we needed to be present to remove fish from the enclosures.

Our initial sampling (5, 6, 7 August 1996) was probably not necessary as it would have been more efficient to wait until water levels had been reduced prior to removing fish. However, given that the construction site was within the range of Rio Grande silvery minnow and the possibility that these activities had trapped 1000s of larval silvery minnow, we needed to error on the side of caution. Therefore, we began our fish removal activities within hours of the closure of the semicircular site by barriers (5 August 1996). Sampling on 5 August was valuable in that it provided information on the community composition of trapped fishes. It also indicated that Rio Grande silvery minnow were not abundant and that larval Rio Grande

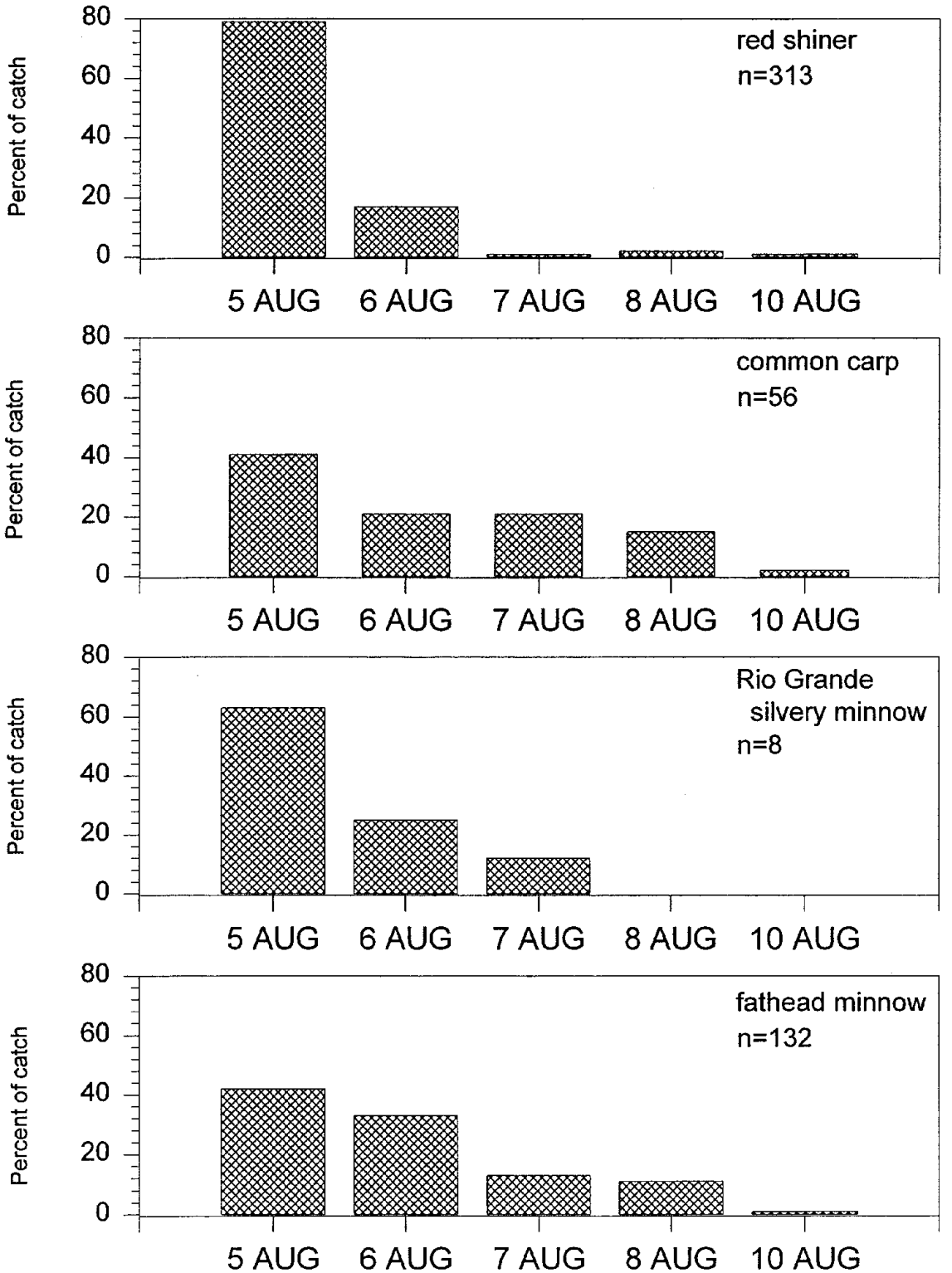

Figure 1. Depletion catch rates of fishes at the west enclosure during the translocation phase of the study.

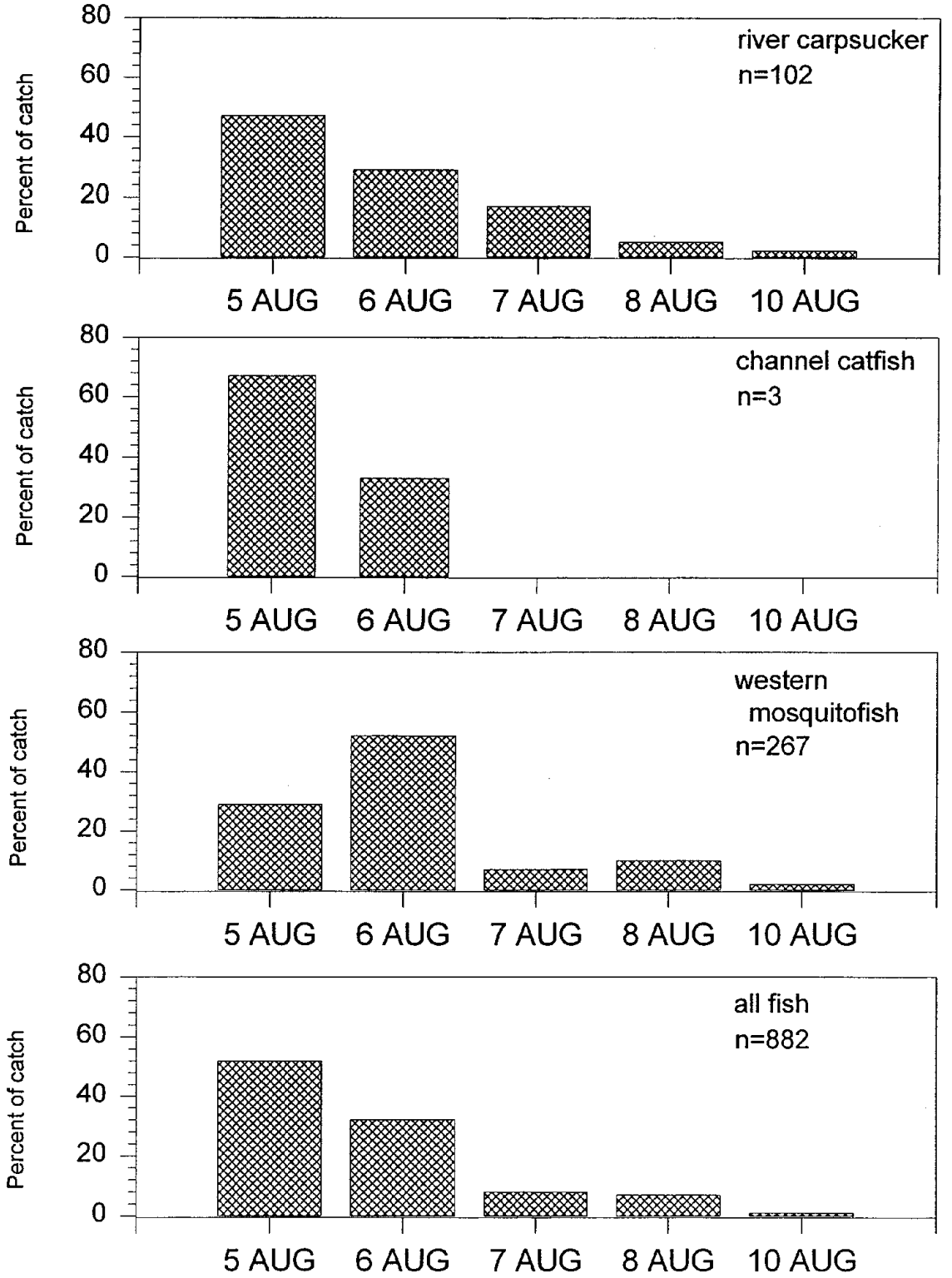

Figure 1. continued.

silvery minnow were probably not present. We continued our sampling on 6-7 August while wells, which would be used to remove surface water, were being set. Until the pumping units were operational, water levels inside of the enclosure fluctuated in response to the volume of water in the river. This phenomena was observed on 5-7 August during which time an initial decrease in river discharge (5-6 August) followed by an increase in flow (6-7 August) was manifested within the enclosure. By the last sampling effort in the west enclosure (10 August 1996), very little water was present and extant fish were easily captured.

The east enclosure was smaller and more easily constructed than the west site. Given the information on the fish community obtained from our previous five sampling forays, we waited until the pumps were in place in the east enclose before beginning to collect and remove fish. We continued to sample fish in the east enclosure until our catch rate had decline precipitously. At that time, we asked that the pumps be activated and so that water levels in the enclosure could be lowered. We kept collecting fish as water levels decreased and were able to enlist the assistance of several construction employees to help dig channels that connected peripheral pools to one large main pool. This allowed us to concentrate all fish in this reach in one small collecting area (< 4 m^2) and facilitated their easy removal.

RECOMMENDATIONS

As this project proceeded smoothly and successfully, we felt it important to document the reasons for this accomplishment. Our understanding of construction methods, sequence, and time-frame was essential. This information needs to be relayed to biologists by construction foremen. At the same time, biologists at such studies must understand that there may be numerous unforeseen delays in construction activities and be able to incorporate those into their schedule. This problem is easily resolved by maintaining daily communication with a contact person at the construction site.

Sampling prior to the initiation of construction activities provides the biologist with accurate information on species composition, relative abundances, reproductive status, and population structure of the fish community. In addition, sampling should begin soon after closure of reaches. While this may not be the most efficient time to collect fish, it does provide biologists with the opportunity to access the fish community of the enclosure, and allows for a significant portion of that community to be removed. This also provides some protection from complete loss of fish due to an unforeseen event (ex. low dissolved oxygen or temperature stress).

One should know the schedule of the construction crew and be prepared to do the most intensive work during the periods that crews are on break. We found that we could arrive at site by 9:00, set-up fish holding tanks, meet with foremen, access construction progress, and begin sampling by 9:30. Break time for construction workers (half-hour) began at 10:00 at which time we would access portions of the study site that contained heavy-equipment. Such scheduling provided for maximum safety of both biologists and construction workers while minimizing conflicts.

Both groups should prepare contingency plans for unexpected events. These could result from natural events (ex. high flow breaching the enclosure barriers), construction delays, or unexpected biological concerns (ex. too many fish and unfavorable water quality). Finally, any information gained from such programs should be documented so that it can be passed onto future workers. Such data will provide them with the opportunity to learn from both the successes and failures of past works.

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LITERATURE CITED

Bestgen, K. R. and S. P. Platania. 1990. Extirpation of Notropis simus simus (Cope) and Notropis orca Woolman (Pisces: Cyprinidae) from the Rio Grande in New Mexico, with notes on their life history. Occasional Papers of the Museum of Southwestern Biology 6:1-8.

Bestgen, K. R., and S. P. Platania. 1991. Status and conservation of the Rio Grande silvery minnow, Hybognathus amarus. Southwestern Naturalist 36(2):225-232.

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. Occasional Papers of the Museum of Zoology, University of Michigan 698:1-49.

Hatch, M. D. 1985. Native fishes of the major drainages east of the Continental Divide, New Mexico. Unpublished M.S. thesis, Eastern New Mexico University, Portales, New Mexico, 85 pp.

Platania, S. P. 1991. Fishes of the Rio Chama and upper Rio Grande, New Mexico, with preliminary comments on their longitudinal distribution. Southwestern Naturalist 36(2):186-193.

Propst, D. L., G. L. Burton, and B. H. Pridgeon. 1987. Fishes of the Rio Grande between Elephant Butte and Caballo Reservoirs, New Mexico. Southwestern Naturalist 32(3):408-411.

Smith, M. L., and R. R. Miller. 1986. The evolution of the Rio Grande Basin as inferred from its fish fauna. Pp. 457-485, in Zoogeography of North American freshwater fishes (C. H. Hocutt and E. O. Wiley, eds.). John Wiley and Sons, New York, 866 pp.

Williams, J. E., J. E. Johnson, D. A. Hendrickson, S. Contreras-Balderas, J. D. Williams, M. Navarro-Mendoza, D. E. McAllister, and J. E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries 14(6):2-20.

U.S. Department of the Interior. 1994. Endangered and Threatened Wildlife and Plants; Final Rule to List the Rio Grande Silvery Minnow as an Endangered Species. Federal Register 59(138):36,988-36,995.