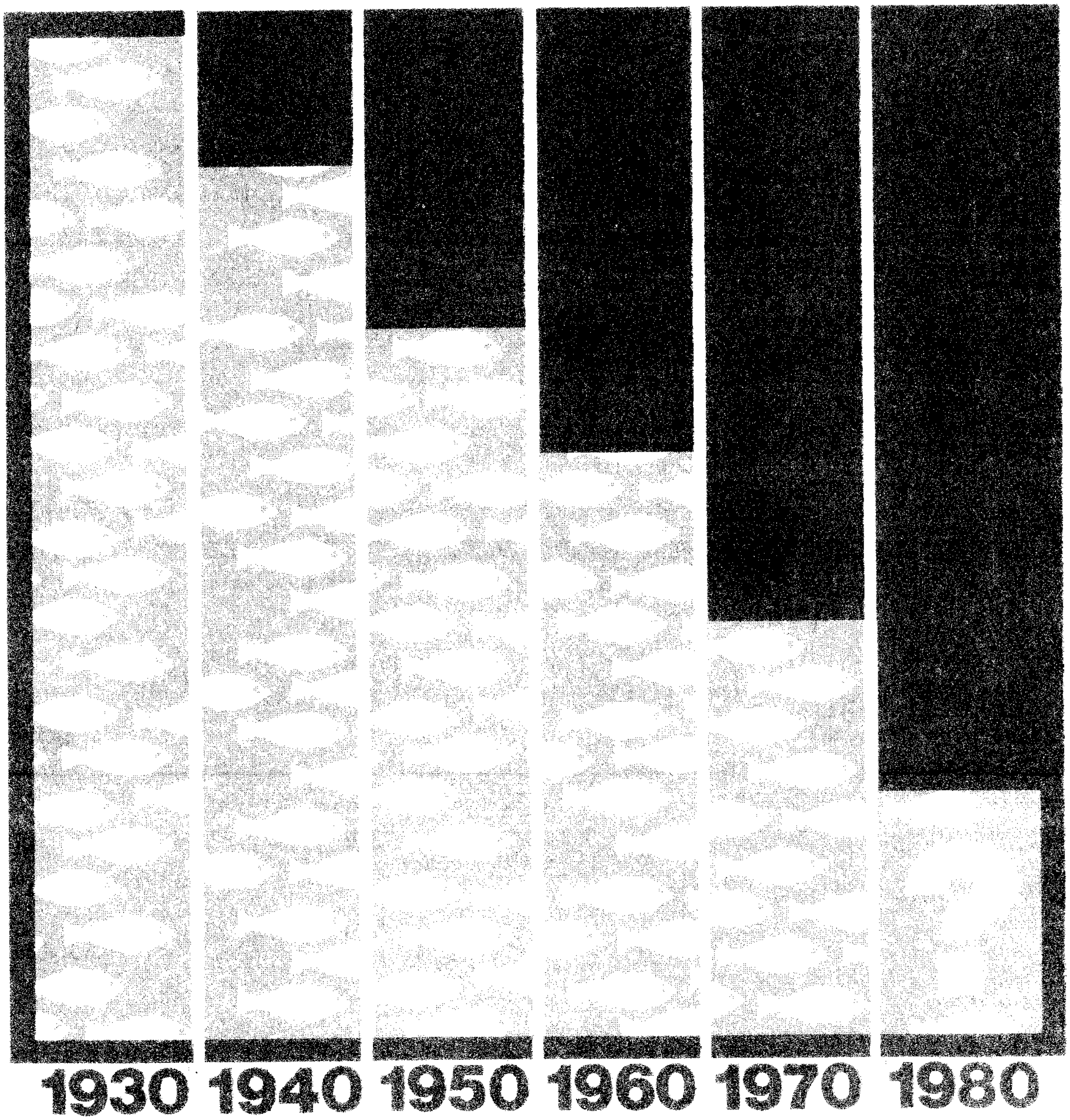
Biological Services Program

FWS/OBS-77/65 October 1977

Habitat Requirements of Juvenile Colorado River Squawfish



Interagency Energy-Environment Research and Development Program
Office of Research and Development • U.S. Environmental Protection Agency

Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-77/65
October 1977

HABITAT REQUIREMENTS OF JUVENILE COLORADO RIVER SQUAWFISH

By

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U.S. Fish and Wildlife Service
Contract Number
14-16-0009-77-050

Interagency Agreement Number
EPA-IAG-D7-E685

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This study was conducted
as part of the Federal
Interagency Energy/Environmental
Research and Development Program
U.S. Environmental Protection Agency

Performed for

Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. DEPARTMENT OF THE INTERIOR

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Library of Congress Catalog Card # 78-600119

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

TABLE OF CONTENTS

Page

INTRODUCTION 1

OBJECTIVES 2

METHODS 3

RESULTS 7

Fish Distribution and Abundance 7

Preferred Habitat of Rare Fishes 12

Physical Components 12

Chemical Components 20

Rare Fish Movements 27

Fishes Associated with the Rare Species 28

DISCUSSION 32

Fish Distribution and Abundance 32

Preferred Habitat of Rare Fishes 33

Rare Fish Movements and Potential Spawning Areas . 37

Competition and Predation 42

Management Implications 43

SUMMARY 45

LITERATURE CITED 47

APPENDIX I - Length/Frequency Histograms of the More Common Fishes Collected During the Study . 48

APPENDIX II - Graphs of Water Chemistry Parameters Measured During the Study 55

TABLE OF CONTENTS (Continued)

		Page
APPENDIX III	- Photographs of Rare Fishes Collected During the Study	59
APPENDIX IV	- Backwaters Used by Young-of-the-year Colorado Squawfish	69

LIST OF TABLES

Table | Page

1. List of species sampled and their general distribution and relative abundance within the study area 8

2. Distribution of rare fishes within the study area by size class and river milepost (miles upstream from Green River, Utah; see Evans and Belknap, 1974) 10

3. Numbers of young-of-the-year Colorado squawfish captured, marked, and recaptured from a backwater on the Green River 28

4. Species composition of samples containing Colorado squawfish and humpback chub indicating the frequency of association of other species . . . 29

LIST OF FIGURES (Continued)

Figure		Page
14.	Length/frequency histograms for carp and speckled dace from the Green River, Utah	49
15.	Length/frequency histograms for the roundtail chub and humpback chub from the Green River, Utah	50
16.	Length/frequency histogram for the Colorado squawfish from the Green River, Utah	51
17.	Length/frequency histograms for the fathead minnow and red shiner from Green River, Utah . . .	52
18.	Length/frequency histograms for the channel catfish and black bullhead from the Green River, Utah	53
19.	Length/frequency histograms for the bluehead sucker and flannelmouth sucker from the Green River, Utah	54
20.	Levels of dissolved oxygen and pH encountered in the Green River, Utah	56
21.	Levels of NH_3, NO_3, NO_2, sulphate, and alkalinity encountered in the Green River, Utah	57
22.	Levels of conductivity and salinity encountered in the Green River, Utah	58
23.	Photograph of a subadult Colorado squawfish from the Green River, Utah, at River Mile 87 . . .	60
24.	Photograph of an adult bonytail chub from the Green River, Utah, at River Mile 164	60
25.	Photographs of chubs from Desolation Canyon of the Green River, Utah, tentatively identified as humpback chub	61
26.	Aerial photographs of two backwaters used by young-of-the-year Colorado squawfish in Gray Canyon, Utah	70

INTRODUCTION

The upper Colorado River basin contains two fishes presently listed as endangered by the U. S. Fish and Wildlife Service, the Colorado squawfish (*Ptychocheilus lucius*) and the humpback chub (*Gila cypha*). Two other species, the bonytail chub (*Gila elegans*) and the razorback sucker (*Xyrauchen texanus*), are also rare and are presently being considered for endangered and threatened status, respectively. The major research need concerning these rare fishes involves determining their requirements for subsistence. This information is needed to enhance recovery efforts of these species and to ensure that future development of natural resources in the upper basin considers the maintenance of rare fish populations and their habitat.

Two factors appear most important in providing the basis for self-sustaining populations of the rare fishes: 1) Adequate spawning and rearing habitat, and 2) Interaction with exotic fishes. Areas with reproducing Colorado squawfish populations, the lower and middle Green River in Utah (Holden and Stalnaker, 1975), are the least altered large river habitat in the upper basin. Adult squawfish are found in other areas, but recruitment is lacking (Kidd, 1977), indicating that spawning and rearing requirements are not being met in these areas. A determination of spawning and rearing habitat requirements of both native and exotic species would shed considerable light on the capabilities of any given river reach to support these species. The following study was conducted to determine the habitat requirements of the rare fishes, primarily young Colorado squawfish, as evidenced by the habitats they use.

OBJECTIVES

1. Determine the physical and chemical parameters of the habitats used by all sizes of rare fishes with emphasis on young fishes.
2. Determine whether spawning occurs in the study area and, if so, where the sites are located.
3. Determine the movements of the size (age) classes of rare fishes encountered.
4. Determine the fish species associated with the study area.
5. Assess the relative importance of various river habitats to the rare fishes.

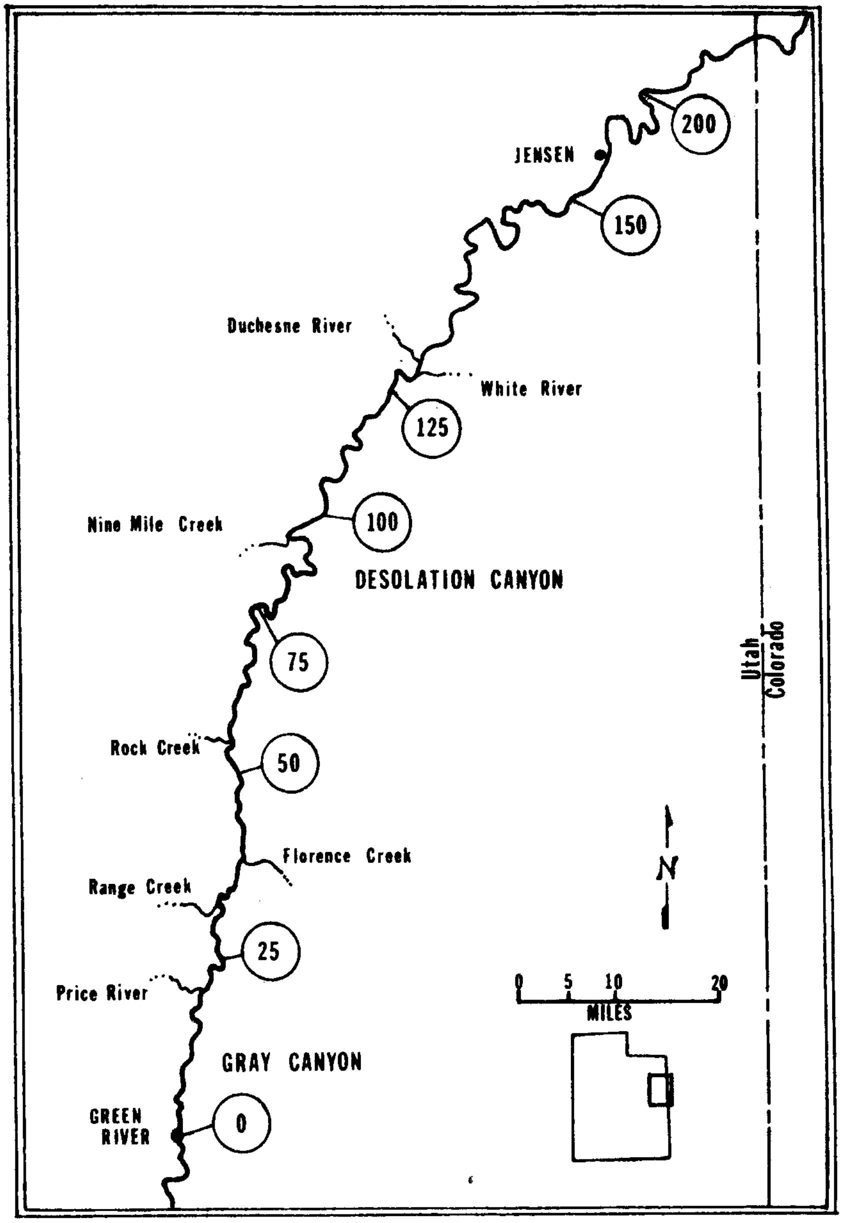


Figure 1. Map of the Green River in east-central Utah. River miles are measured from Green River, Utah, upstream (Evans and Belknap, 1974).

to show the relative size and placement of the habitat sampled. All sampling sites were marked on U.S.G.S. quadrangle maps.

Dissolved chemicals and turbidity were measured daily in the main channel. Dissolved oxygen was measured with a YSI model 54 ARC portable O_2 meter, and conductivity-salinity with a YSI model 33 portable S-C-T meter. Alkalinity, ammonia, nitrate, nitrite, sulphate, and turbidity were measured using a Bausch & Lomb Mini Spec 20, and pH was measured using an Analytical Pocket pH Meter, model 107.

Fish sampling included seining, electrofishing, and use of a fry shovel (Vanicek, 1967), although seines were used most of the time because emphasis was on small fish. Fry traps were available for measuring movement of Colorado squawfish fry. An attempt was made to sample individual habitats where physical components were essentially the same. For example, a seine haul would not be made through part of a run and into an eddy since it would have been impossible to determine in which habitat type the fish were actually caught. Fishes were enumerated and total length measurements taken of sufficient numbers to produce length/frequency relationships and provide an estimate of size (age) classes. Most fishes were returned unharmed to the location of capture. A reference collection of most of the species caught was field preserved in 10% formaldehyde and later transferred to 40% isopropyl alcohol.

The fishery-habitat measurements were analyzed to show preferred habitats of the rare fishes and were expressed as electivity curves. These curves are part of an instream flow methodology recently developed by the Cooperative Instream Flow Service Group (U. S. Fish and Wildlife

Service, Ft. Collins, Colorado). The preferred habitat information, in conjunction with river cross-section measurements, give an indication of the amount of preferred habitat available in a given river reach. Cross-sectional measurements were not included within the scope of the present study, except for one set of measurements taken near a concentration of young-of-the-year Colorado squawfish. It was anticipated that future studies would involve the complete instream methodology, so data during this study were taken to be of maximum use in those future efforts.

Rare fishes of sufficient size, usually over 100 mm TL, were tagged with green plastic, numbered fingerling tags (3/8" x 1/8") that were sewn to the fish just below the dorsal fin with two-pound test monofilament line. Juvenile squawfish less than 100 mm were marked by clipping the end of the anal fin. Postlarval squawfish were planned to be marked with a 50,000-75,000:1 solution of Bismark brown Y stain.

RESULTS

Fish Distribution and Abundance

Over 330 individual samples of fish were taken during the study. These included 125 samples in runs, 121 samples in backwaters, 59 samples in eddies, and 19 samples in riffles. This is approximately proportionate to the availability of these habitat types in the study area.

Nineteen species of fish were collected totaling over 19,500 specimens (Table 1). Length/frequency information from measured specimens provided an estimate of the lengths of most year classes (Appendix I). The introduced red shiner (Notropis lutrensis) was by far the most abundant fish, whereas the flannelmouth sucker (Catostomus latipinnis) was the most abundant native species. The bonytail chub (Gila elegans) was the rarest native fish collected, with only two individuals being caught. The introduced white sucker (Catostomus commersoni), redside shiner (Richardsonius balteatus) and creek chub (Semotilus atromaculatus) were found in very small numbers and only in the upper portion of the study area. They are more abundant upstream from the study area where the river is cooler (Holden and Stalnaker, 1975; Seethaler, McAda and Wydoski, 1976).

Young-of-the-year Colorado squawfish (35-64 mm) were found only in the lower portion of the study area (Table 2). Juvenile squawfish (65-200 mm) were concentrated in the upper and lower portions of the study area, with fewer in the middle portion. Subadult squawfish were found

Table 1. List of species sampled and their general distribution and relative abundance within the study area.

Species	Study Area: Jensen-Ouray	Study Area: Ouray-Sand Wash	Study Area: Sand Wash-Gr. River	Number Caught
Cyprinidae				
Carp - *Cyprinus carpio*	Common[1]	Common	Common	388
Roundtail Chub - *Gila robusta*	Common	Rare	-	269
Bonytail Chub - *Gila elegans*	Rare	-	Rare	2
Humpback Chub - *Gila cypha*	-[2]	Rare	Common	91
Colorado Squawfish - *Ptychocheilus lucius*	Rare	Rare	Rare	202
Speckled Dace - *Rhinichthys osculus*	Rare	Rare	Rare	277
Redside Shiner - *Richardsonius balteaus*	Rare	-	-	19
Fathead Minnow - *Pimephales promelas*	Common	Common	Common	1,951
Red Shiner - *Notropis lutrensis*	Abundant	Abundant	Abundant	13,711
Creek Chub - *Semotilus atromaculatus*	Occasional	-	-	1
Catostomidae				
Flannelmouth Sucker - *Catostomus latipinnis*	Common	Common	Common	918
Bluehead Sucker - *Pantosteus discobolus*	Common	Common	Rare	678
White Sucker - *Catostomus commersoni*	Occasional	-	-	2
Razorback Sucker - *Xyrauchen texanus*	-	Rare	-	8
Ictaluridae				
Channel Catfish - *Ictalurus punctatus*	Common	Common	Common	947
Black Bullhead - *Ictalurus melas*	Rare	Rare	Rare	76

Table 1. Continued

Species	Study Area			Number Caught
	Jensen-Ouray	Ouray-Sand Wash	Sand Wash-Gr. River	
Centrarchidae				
Green Sunfish - *Lepomis cyanellus*	Rare	Rare	Rare	20
Smallmouth Bass - *Micropterus dolomieui*	-	Occasional	-	7
Percidae				
Walleye - *Stizostedion vitreum*	Occasional	-	-	2

[1]Relative abundance terms are defined in terms of frequency of catch; see Holden and Stalnaker (1975) for definitions.

[2]Not encountered.

Table 2. Distribution of rare fishes within the study area by size class and river milepost (miles upstream from Green River, Utah; see Evans and Belknap, 1974).

River Miles	Colorado Squawfish			Chubs (Gila)			Bonytail Chub		Razorback Sucker	
	Y-o-Y (35-64 mm)	Juv. (65-200 mm)	Subadults (200+ mm)	Y-o-Y (30-69 mm)	Juv. (70-150 mm)	Adults (200+ mm)	Juv.	Adults	Juv.	Adults
180-189 (Jensen)		2		16	1					
170-179		20		224	8					
160-169		1		1	3			1		
150-159		3	1							
140-149		1			2					
130-139					11					
120-129 (Ouray)		1	3							2
110-119					1				5	
100-109		2			1				1	
90- 99 (Sand Wash)			1	1						
80- 89			1			2				
70- 79							1			
60- 69					1					
50- 59 (Rock Cr.)					1	3				
40- 49				3	3	3				
30- 39 (Gray Can.)		1		3	4	2				
20- 29	146	2		30	11	7				
10- 19	16	2		13	1					

rather scattered and only six were captured. Three of these fish were caught in a 3 mile section of river near Ouray, Utah.

Young-of-the-year razorback suckers were tentatively identified on the basis of lateral line scales (80-88). Six were found in the middle portion of the study area (Table 2). The only two razorback adults seen during the study were also in this area.

The chubs (Gila) of Desolation and Gray canyons are distinctly different from those collected near Jensen. Table 2 shows the decrease in chubs, especially young-of-the-year, in the middle portion of the study area. The Desolation and Gray canyons specimens seem to represent a population distinct from the one near Jensen. Dorsal-anal fin ray counts (9-9 and 9-10), a narrow caudal peduncle, an obvious nuchal hump in adults, a rather flat head, and a tendency for a subterminal mouth suggest the humpback chub, although the robustness of the fishes and the slightness of the nuchal humping suggest the roundtail chub (Gila robusta) (Appendix III). Until a more thorough analysis of these fishes is finished, the Desolation-Gray canyons specimens will be referred to as humpback chubs, except for one instance where the specimen appeared to be a bonytail chub, as mentioned below.

One adult bonytail chub was collected in the upper portion of the study area (Table 2; Appendix III). A juvenile chub was caught in Desolation Canyon that had dorsal and anal fin ray counts of 10-10, and a less obvious nuchal hump and flattened head than other chub specimens from that area. These characteristics suggest the fish was a juvenile bonytail chub.

Preferred Habitat of Rare Fishes

Physical Components

River temperature varied considerably on a diel basis during this study (Figure 2). Early morning temperatures were generally 3 to 5 C cooler than late afternoon levels. Backwaters were the warmest areas, often warming 3-8 degrees above that of the river proper in late afternoon. Morning temperatures in the Jensen area in August were usually 15-17 C (River Mile 178). Morning temperatures in August in downstream areas varied considerably with local weather conditions, but were generally warmer (19-21 C) than those at Jensen. September temperatures in Desolation Canyon (River Mile 30) were much colder (a low of 10.5 C) due to the cool ambient air.

The level of the Green River in the study area fluctuates daily due to releases from Flaming Gorge Dam. The greatest fluctuation occurred at Jensen where a 16-inch daily rise and fall was noted. Diel fluctuations in Desolation Canyon were only 3 to 4 inches. The large fluctuation noted at Jensen caused a considerable daily change in available habitat. Low flows provided a variety of habitat types, especially backwaters. High flows reduced the number of backwaters and generally created a full channel situation (i.e., wetted area unbroken by sand bars, etc.). In this area, juvenile squawfish were primarily caught either during low river levels when backwaters were available, or in backwaters which were not affected by the fluctuations.

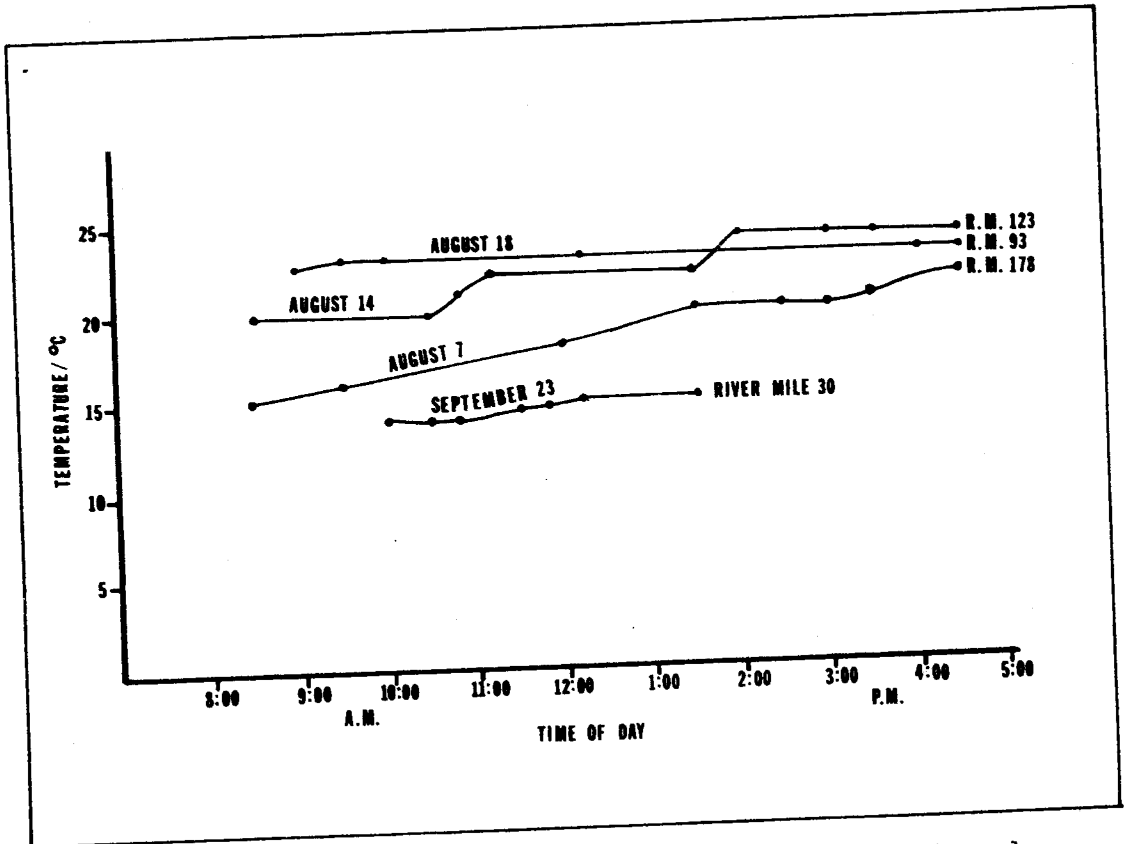


Figure 2. Daily water temperature variation from main channel stations, Green River, Utah, 1977.

Although U. S. Geological Survey flow records for August and September were not available for inclusion in this report, flow levels of the Green River appeared lower than normal. It is quite probable that the low water year experienced in 1977 caused a reduction in river flow. Personal observation indicated the Yampa River was exceptionally low.

The preferred depth, velocity, substrate, habitat type, and temperature of the rare fishes are summarized as electivity curves (Figures 3-10). Colorado squawfish young-of-the-year were found only in backwaters where there was no current, a firm silt bottom, and a depth of one to two feet (Figure 3). Juvenile squawfish also preferred backwaters, no current and a silt bottom, but were less selective with depth (Figure 4). Subadult and adult squawfish (200+ mm) were found in a variety of velocities and depths, but preferred sandy bottomed eddies and runs to backwaters (Figure 5). Squawfish of all sizes showed little preference for temperature as they were found in almost the entire range of temperatures encountered during the study (Figure 6).

The six young-of-the-year razorbacks collected showed a preference for eddies with a velocity of about 0.2 fps (feet per second), a depth of 1.0 foot, and a soft silt bottom.

Humpback chub young-of-the-year (Desolation and Gray canyons fishes) were less selective of microhabitat than were yound squawfish. The young-of-the-year chubs preferred backwaters with no current, a firm silt bottom, and two feet of maximum depth, but also used deeper eddies and runs with velocities from 0.4-0.8 fps (Figure 7). Juvenile humpback chubs used a

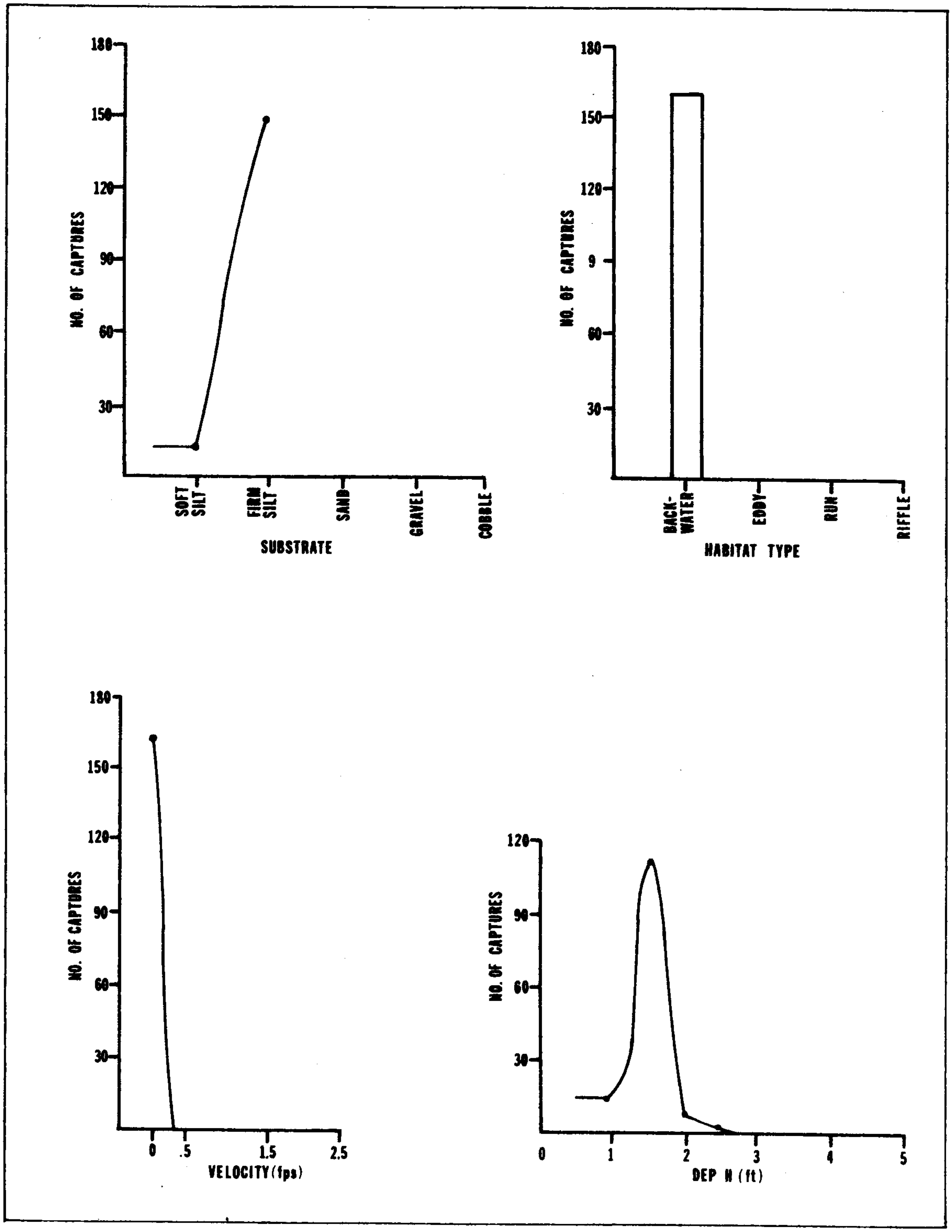


Figure 3. Electivity curves for substrate, velocity, depth, and habitat type for young-of-the-year Colorado squawfish (30-64 mm).

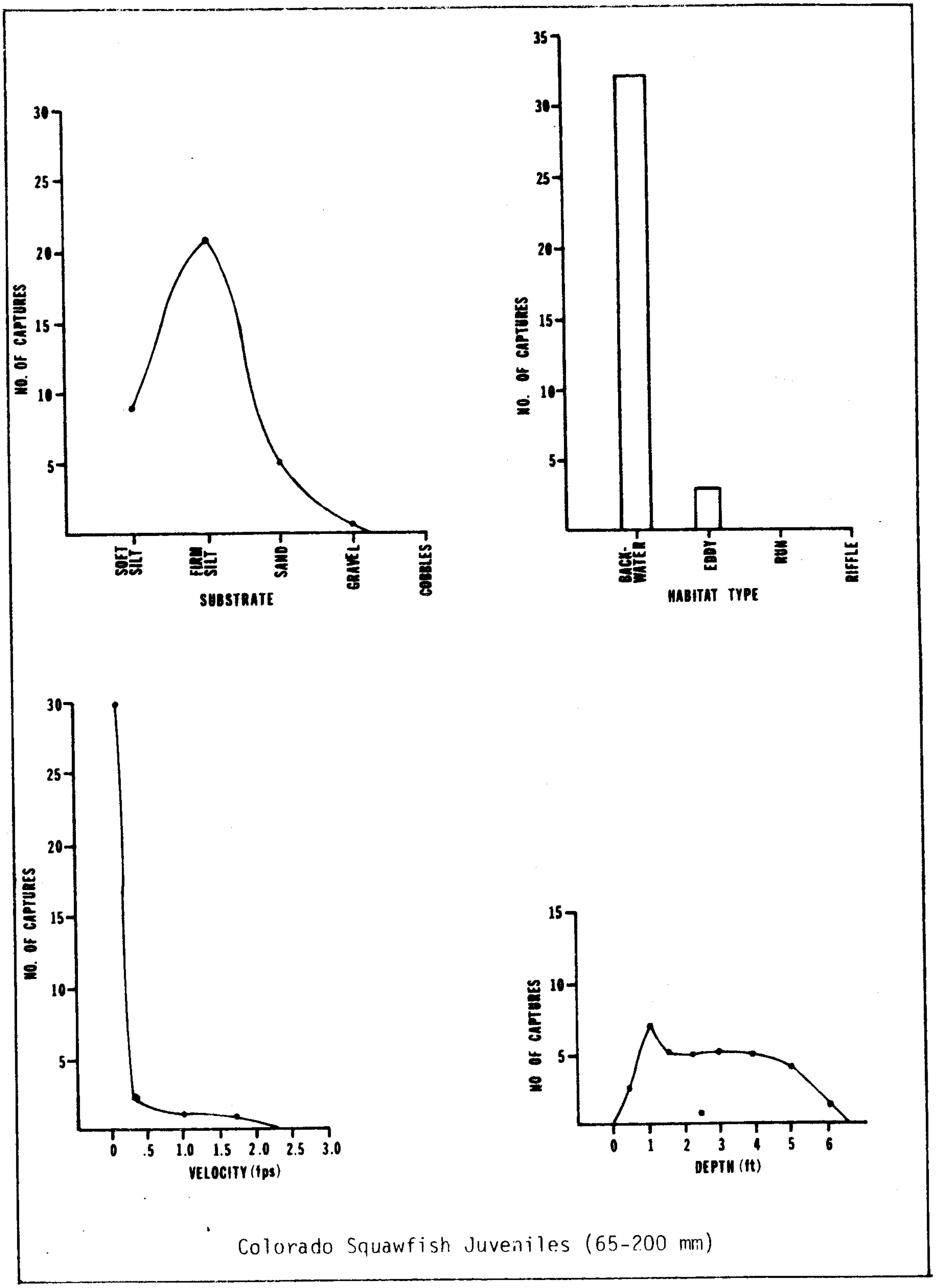


Figure 4. Electivity curves for substrate, velocity, depth, and habitat type for juvenile Colorado squawfish (65-200 mm).

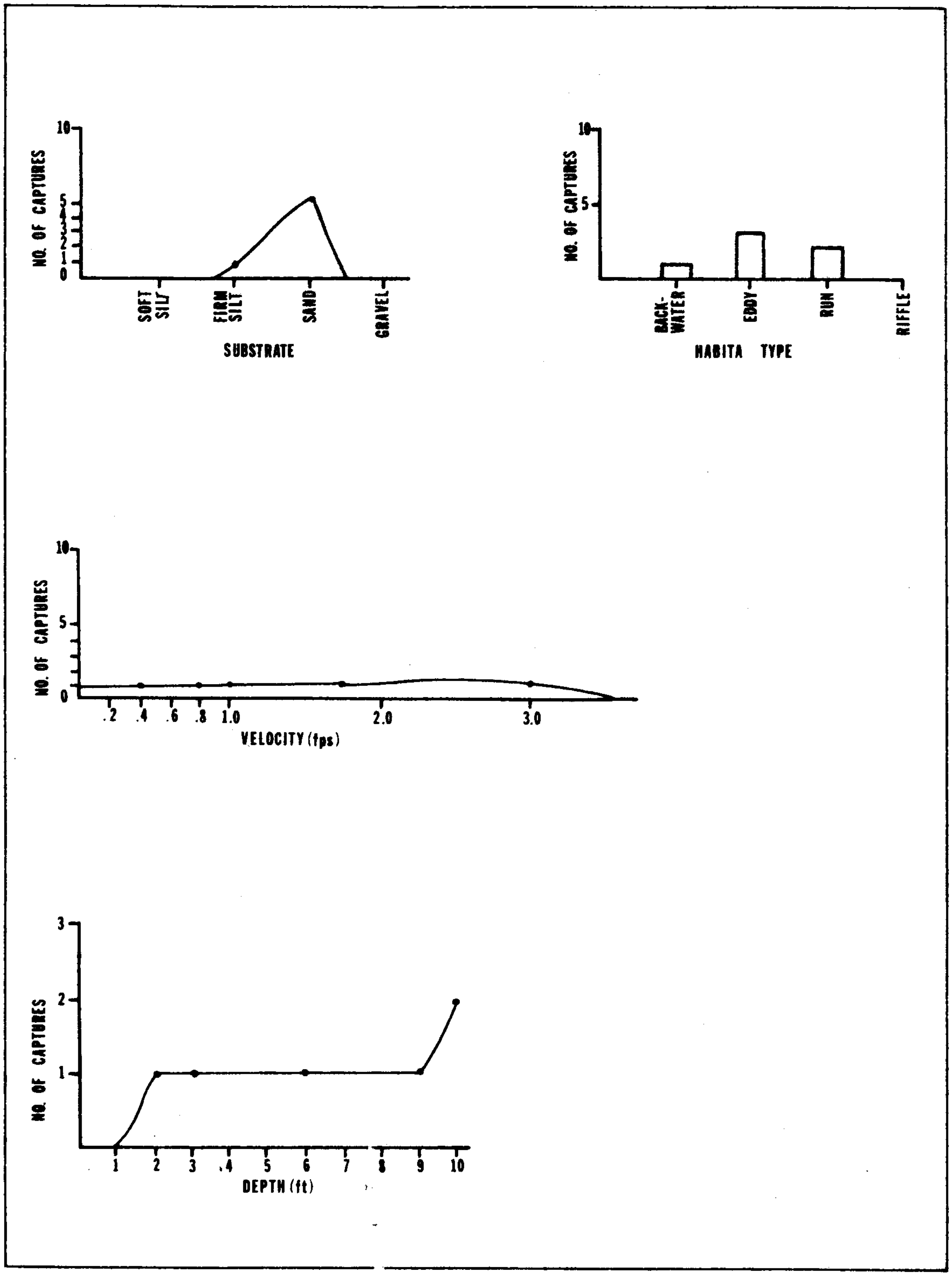


Figure 5. Electivity curves for substrate, velocity, depth, and habitat type for subadult Colorado squawfish (200+ mm).

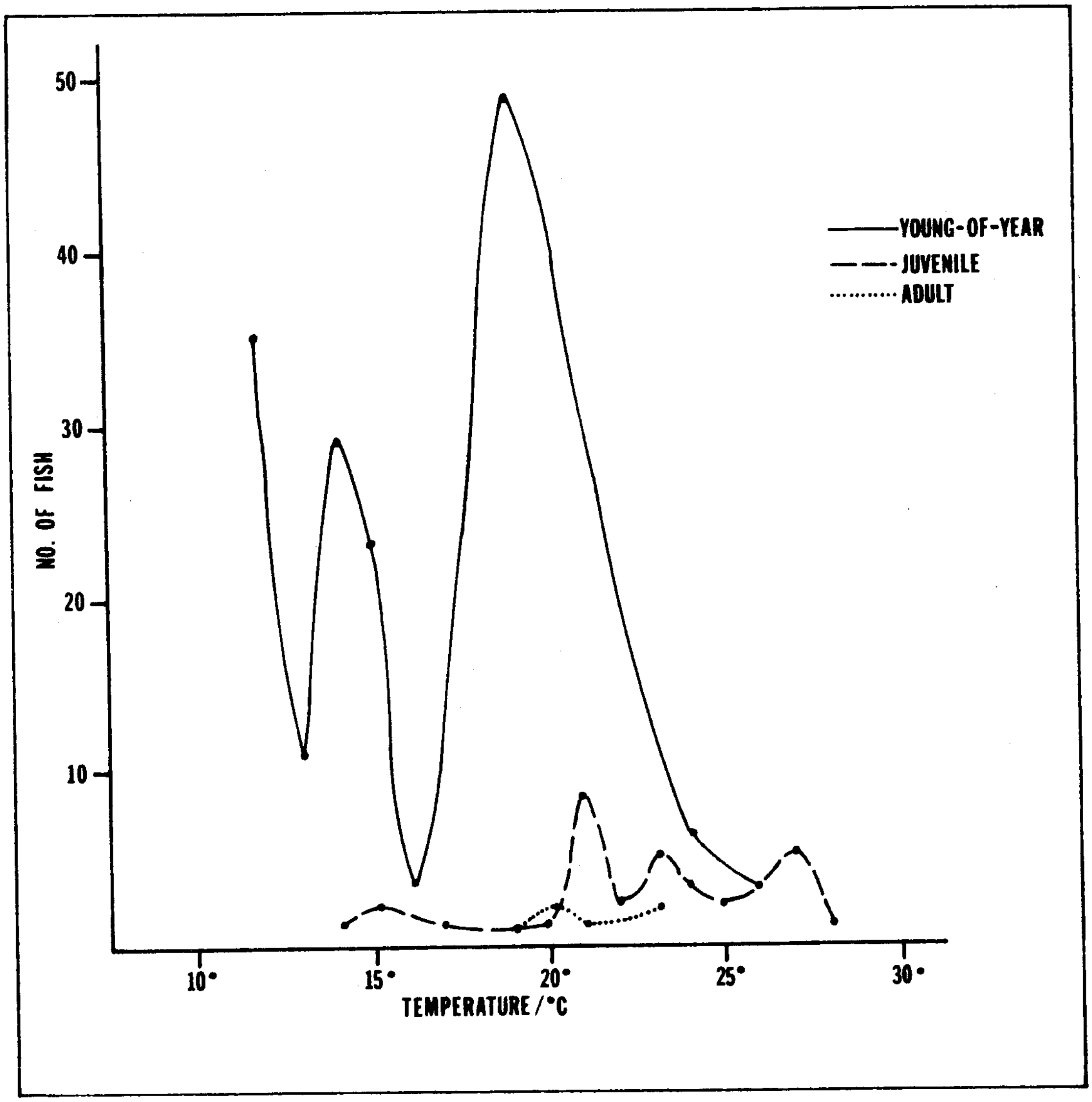


Figure 6. Electivity curve for temperature for all sizes of Colorado squawfish.

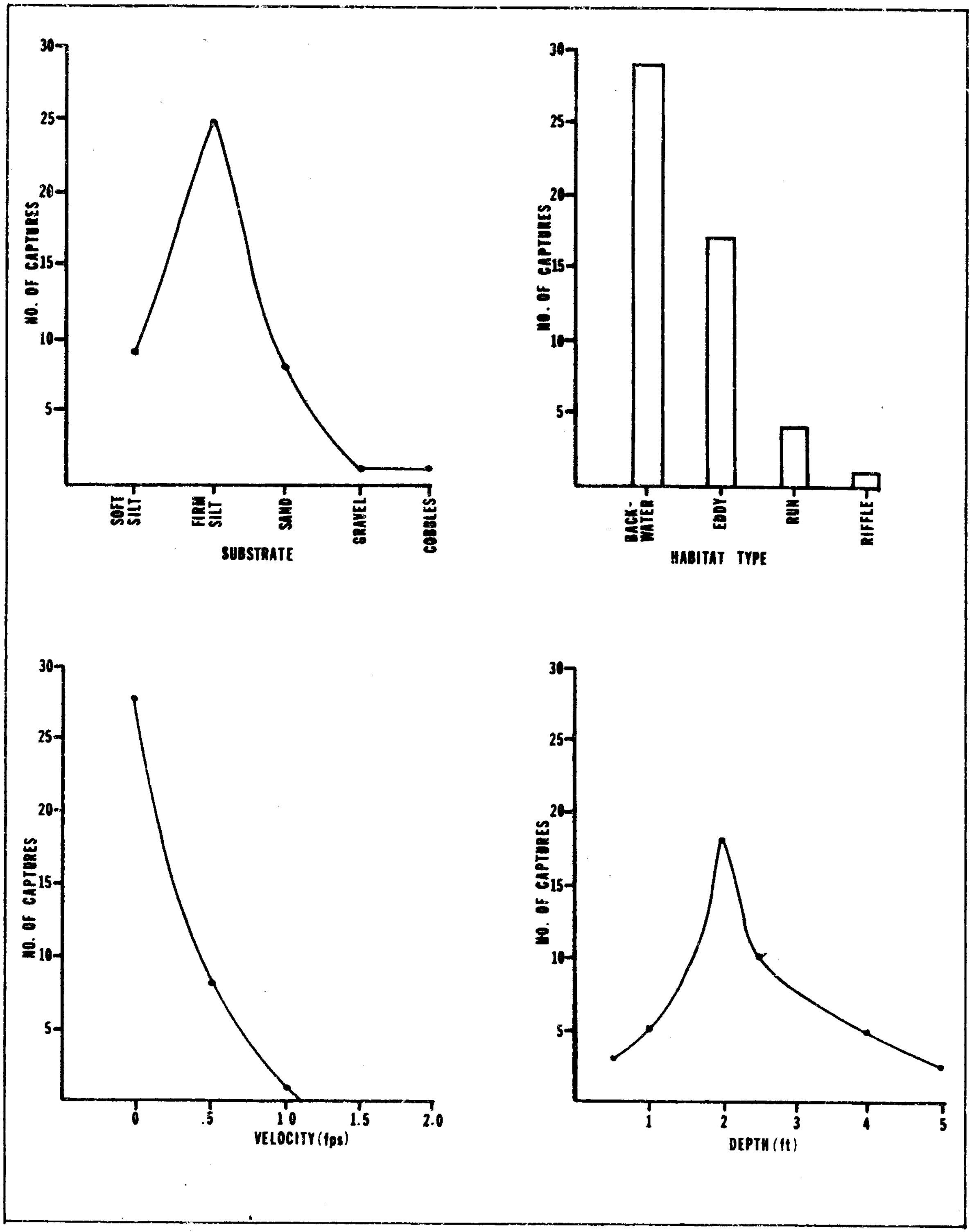


Figure 7. Electivity curves for substrate, velocity, depth, and habitat type for young-of-the-year humpback chub (30-70 mm).

variety of habitats, but preferred no current, a firm silt substrate, and a depth of two feet (Figure 8). Adult humpback chubs were taken primarily in eddies and runs with sand bottoms and a variety of velocities and depths (Figure 9). Temperature did not appear to be selected by any size of humpback chub (Figure 10).

Turbidity varied considerably during the study, and was highest after rainstorms (Figure 11). There is considerable natural variation in the turbidity levels of the Green River because the watershed is highly erodable. The native fishes seldom have the opportunity to select a preferred turbidity as the entire river may change dramatically overnight. They are well adapted to sudden and extensive changes in turbidity, which are usually associated with increases in flow.

River cross-sectional measurements of depth, velocity, and substrate were taken around a backwater where young-of-the-year squawfish were abundant. Figures 12 and 13 show the depth and velocity isolines of the area measured. The area was quite deep, with steep, sloping banks and a well-defined main current with slower areas near the shore.

Chemical Components

Graphs of water chemistry values recorded during the study can be found in Appendix II. Green River water chemistry changed little during the course of the study. Fluctuations of the various parameters are within the normal expected range. Fishes seldom are able to select preferred chemical ranges in the river as all habitats are very similar in chemical analysis.

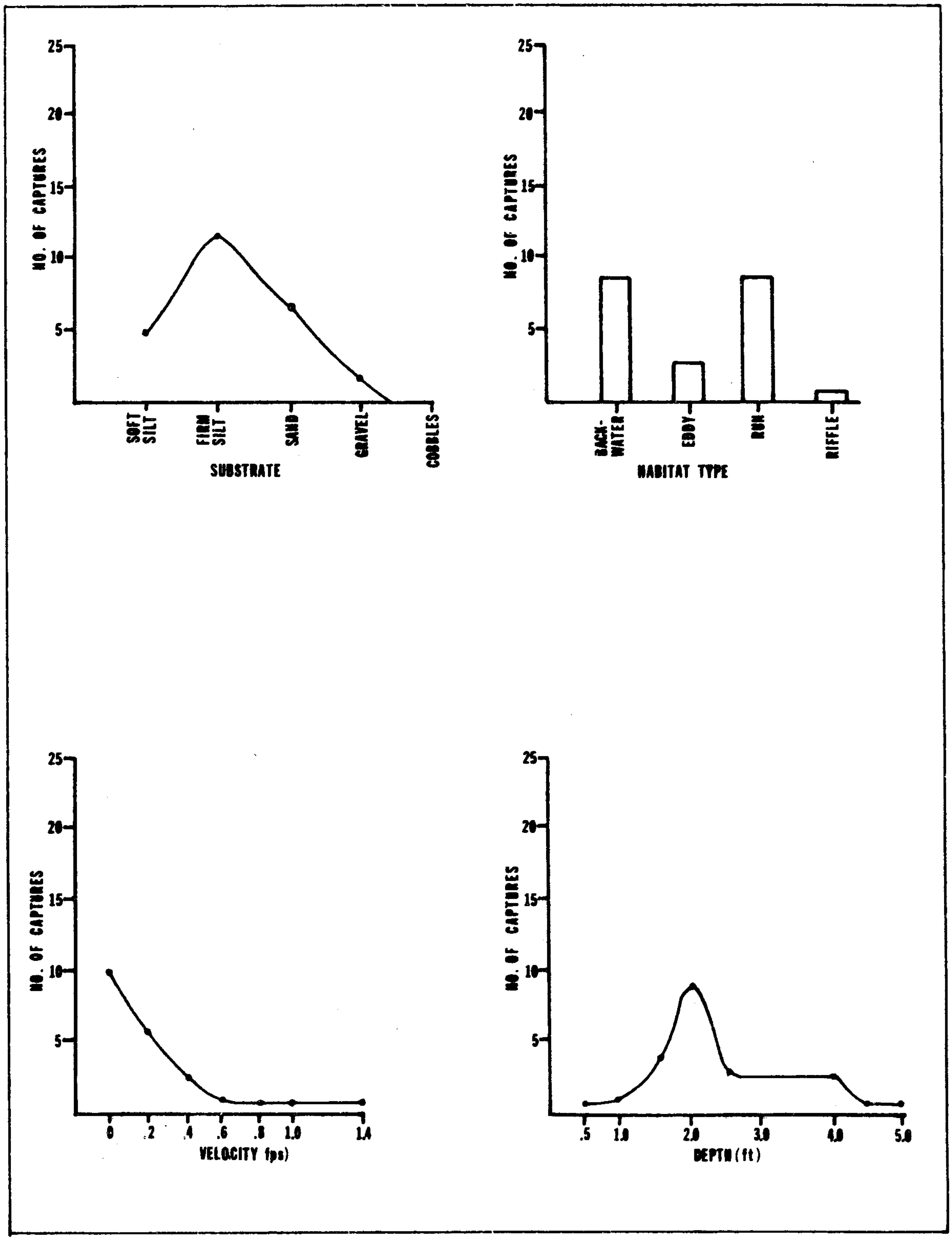


Figure 8. Electivity curves for substrate, velocity, depth, and habitat type for juvenile humpback chub (90-150 mm).

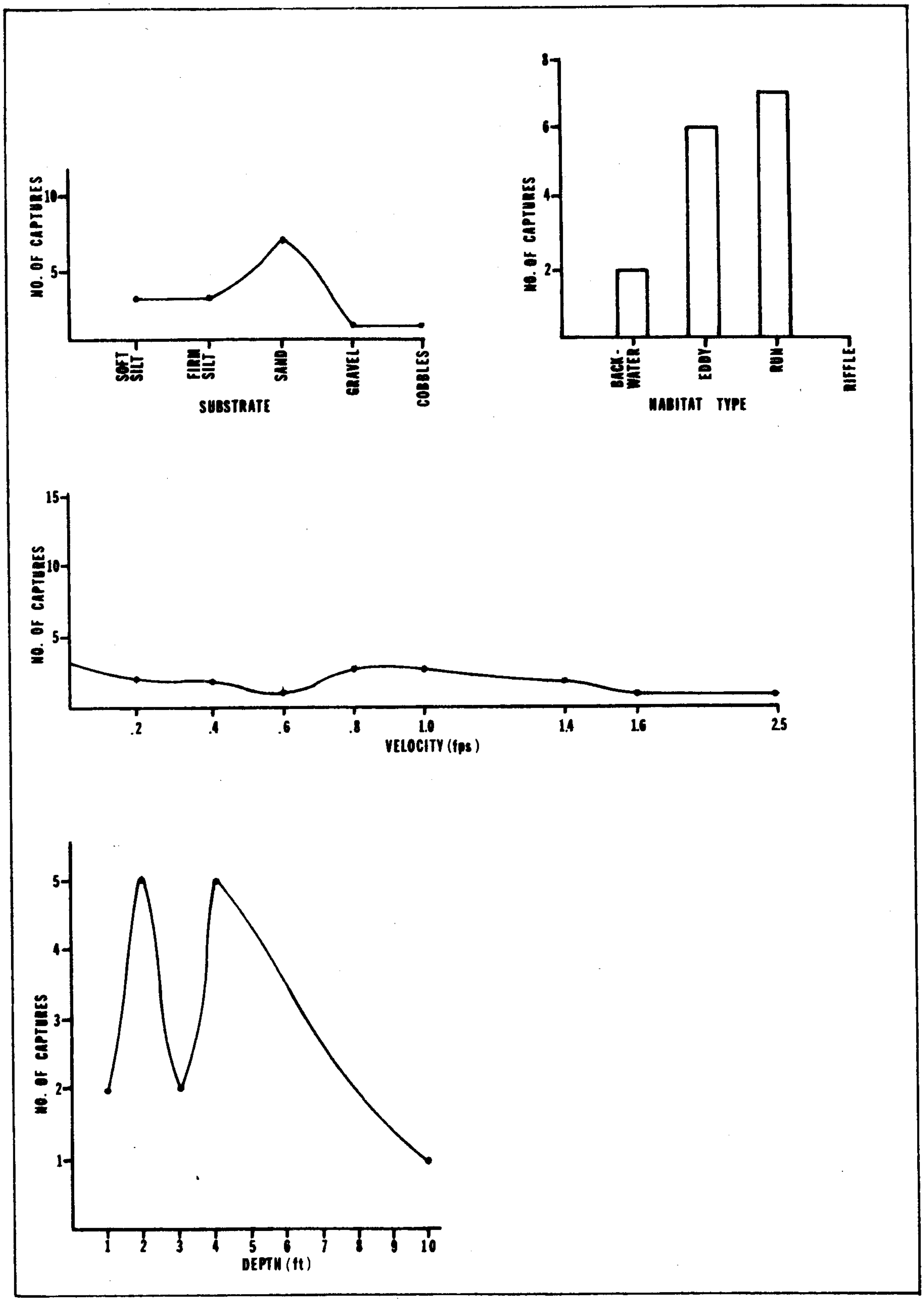


Figure 9. Electivity curves for substrate, velocity, depth, and habitat type for adult humpback chub (200+ mm).

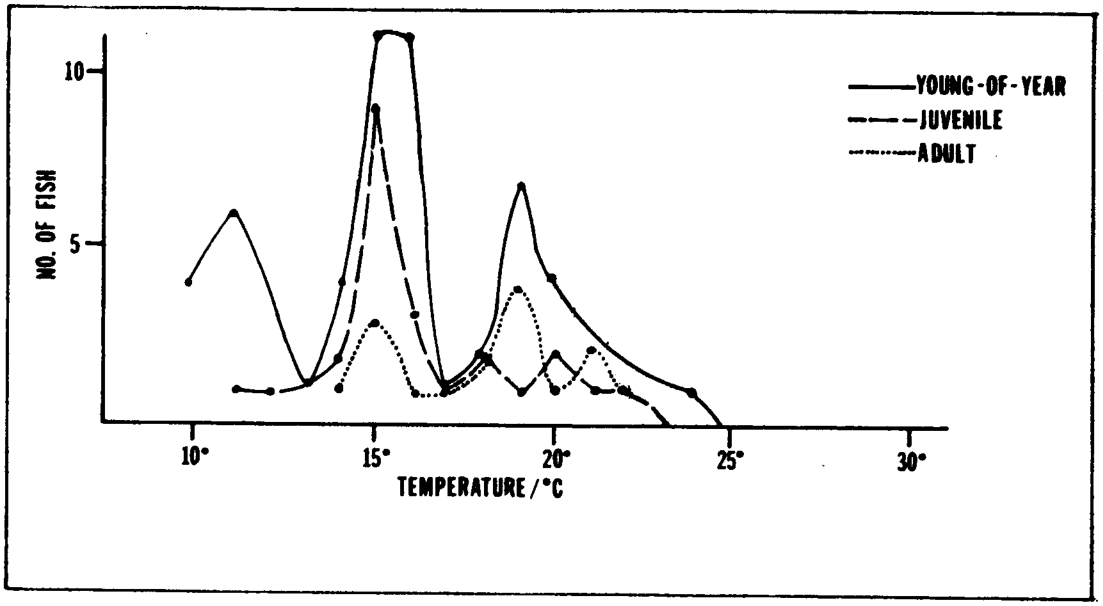


Figure 10. Electivity curve for temperature for all sizes of humpback chub.

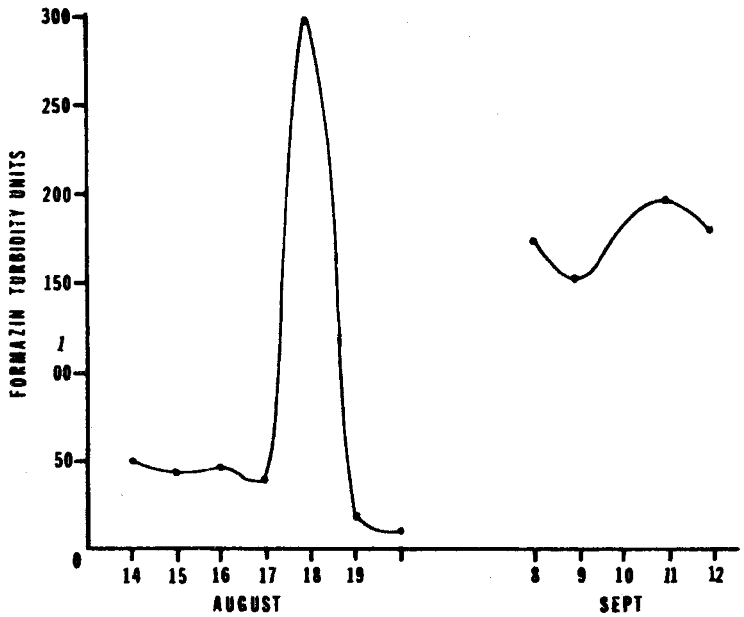


Figure 11. Turbidity levels of the Green River between Jensen and Green River, Utah, as measured during the present study.

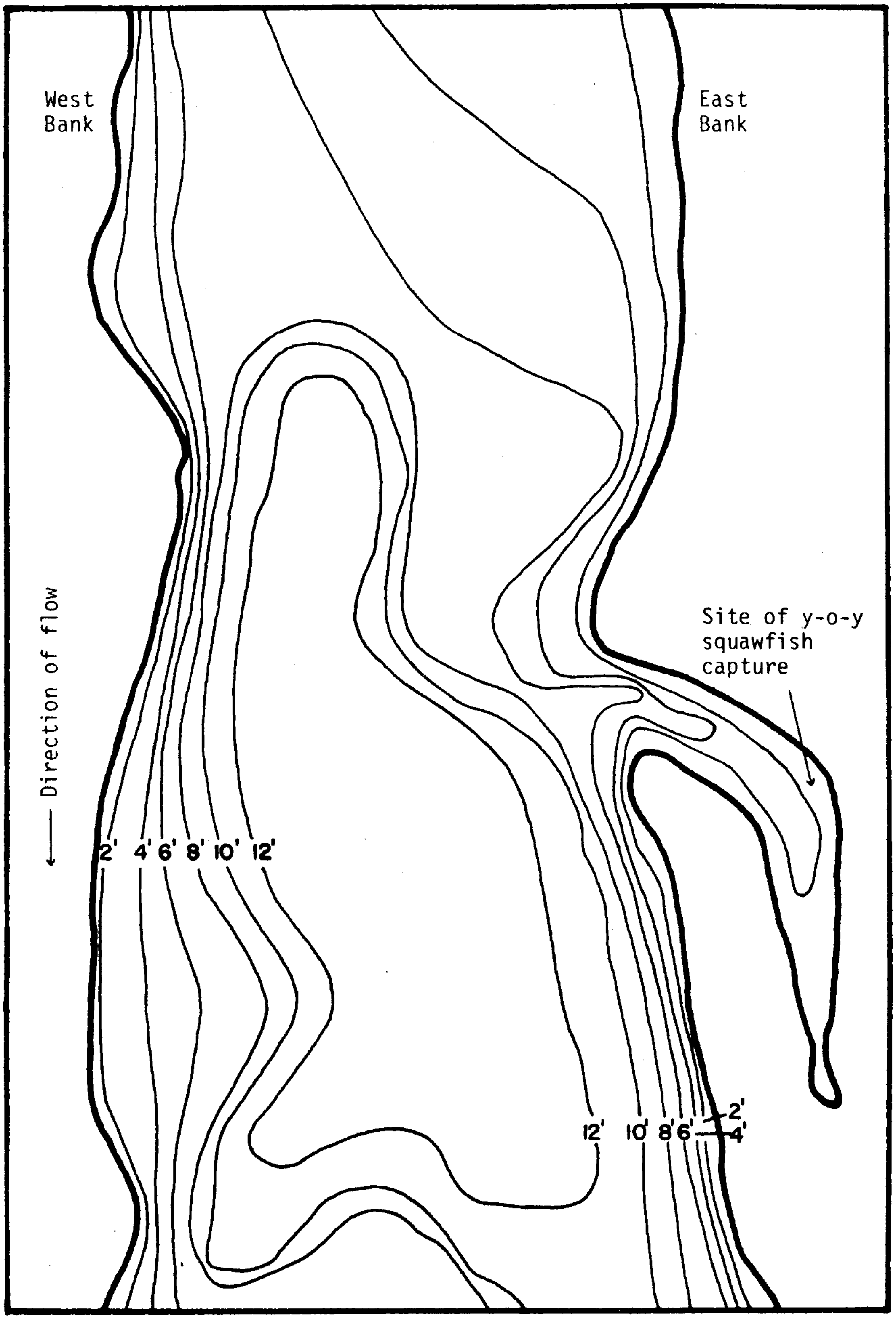


Figure 12. Depth contours of the Green River near a backwater containing young-of-the-year Colorado squawfish.

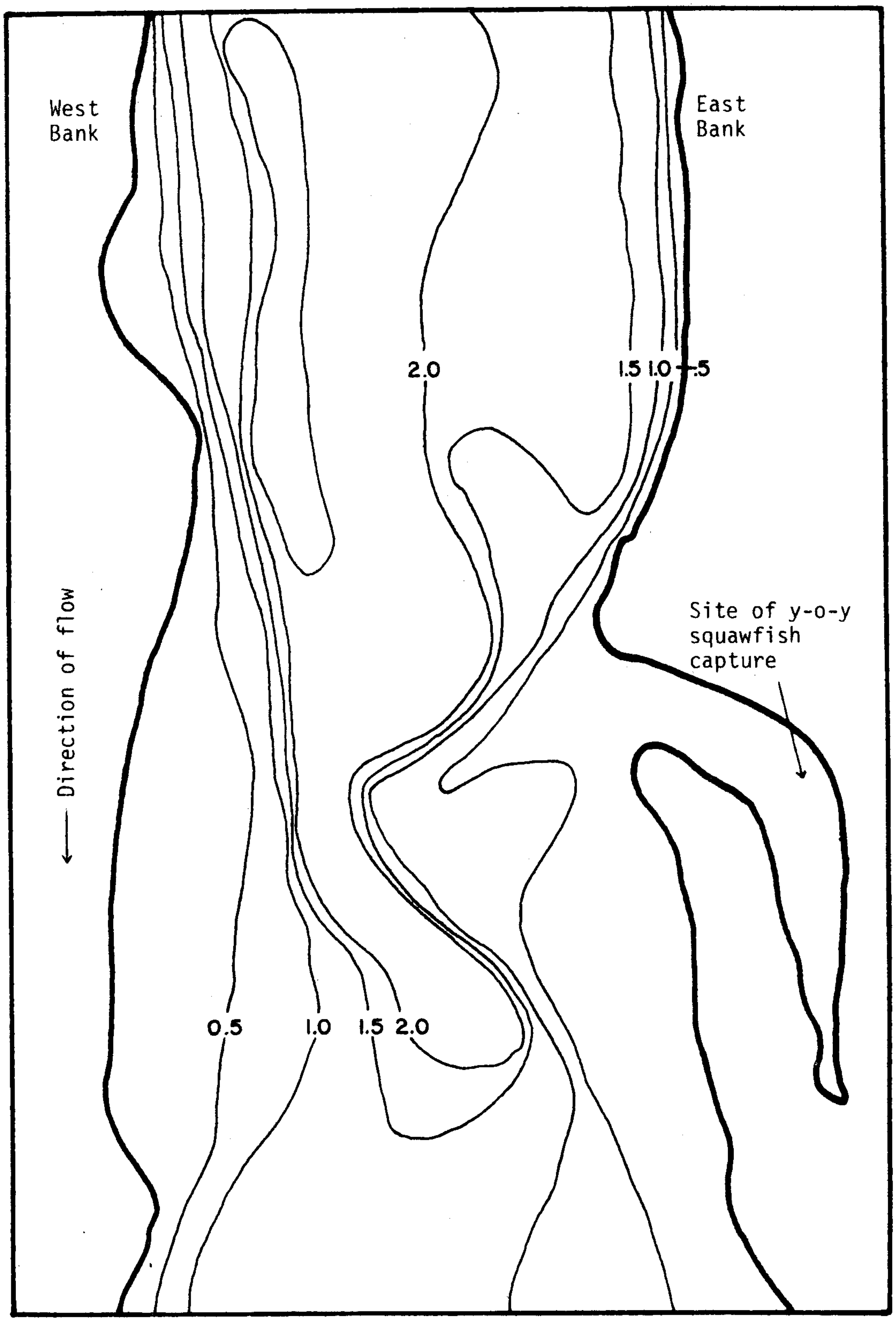


Figure 13. Velocity isolines of the Green River near a backwater containing young-of-the-year Colorado squawfish.

Rare Fish Movements

The original plan of this study called for sampling one section of the Green River (Jensen to Ouray) several times, continuously marking rare fishes and hopefully recapturing some. The study was changed when young-of-the-year squawfish were not found in the original study area. Therefore, emphasis was placed on locating young-of-the-year squawfish rather than recapturing marked juveniles from the primary study area. The marking of rare fishes continued throughout the study with the anticipation that future studies may recapture some of the fishes.

Twenty juvenile squawfish were tagged, 13 more were anal fin clipped. Four subadult squawfish were also tagged. One tagged juvenile was recaptured at the site of release 4-1/2 hours later.

Young-of-the-year squawfish were larger than anticipated (35-55 mm) when encountered in Gray Canyon. A solution of Bismark brown Y dye was tryed on two squawfish. One showed signs of stress in 5 minutes, the other in 15 minutes. Partial anal fin clipping was also tryed as a potential marking technique. Two squawfish were clipped and observed for 30 minutes. No ill effects were noted. Although the samples were small in both tests, it was decided that a partial fin clip appeared the better technique.

Movement of young-of-the-year squawfish was studied in detail in one backwater (see Appendix IV, upper photo). The area was seined five different times during a two-day period (Data sheets 77-293, 294, 300, 301, 302) and 4, 31, 29, 11, and 12 young-of-the-year squawfish were caught, respectively (Table 3). The fish were anal fin clipped during the first four samples and one recapture was found in each of the last three samples. Marked fish were not recovered in other areas near the test site although an extensive seining effort was made to locate them. Fry traps were not used because the young-of-the-year squawfish were large enough to be more efficiently sampled with seines.

Table 3. Numbers of young-of-the-year Colorado squawfish captured, marked, and recaptured from a backwater on the Green River.

	Sample				
	1	2	3	4	5
Number captured	4	31	29	11	12
Number marked	4	31	28	10	0
Number recaptured	-	0	1	1	1

One bonytail chub adult and one juvenile were tagged but not recaptured during the study. Fourteen adult and 9 juvenile chubs from Desolation and Gray canyons were also tagged but none were recaptued.

Fishes Associated with the Rare Species

Table 4 summarizes the fishes, by size class, found in seine samples containing rare species. These data give a preliminary view of potential competition between species. Young introduced species were found more

Table 4. Species composition of samples containing Colorado squawfish and humpback chub indicating the frequency of association of other species.

	Colorado Squawfish		Humpback Chub		
	Young of the Year	Juveniles	Young of the Year	Juveniles	Adults
Number of samples---	(9)[1]	(20)	(28)	(19)	(8)
Species composition---	%	%	%	%	%
Red Shiner	100	95	96	89	75
Fathead Minnow	89	25	54	37	0
Speckled Dace					
Young-of-the-year	44	5	25	16	0
Adults	0	0	4	5	0
Carp					
Juveniles	56	30	11	11	13
Adults	0	0	4	5	0
Roundtail Chub					
Young-of-the-year	0	0	0	5	0
Juveniles	0	40	0	0	0
Humpback Chub					
Young-of-the-year	33	5	-	32	25
Juveniles	11	5	21	-	50
Adults	0	0	7	21	-
Flannelmouth Sucker					
Young-of-the-year	22	40	14	16	13
Juveniles	22	15	4	0	13
Adults	0	0	21	11	13
Bluehead Sucker					
Young-of-the-year	11	40	11	11	0
Juveniles	0	5	0	5	0
Adults	0	0	0	5	0

Table 4. Continued

	Colorado Squawfish		Humpback Chub		
Number of samples---	Young of the Year (9)[1]	Juveniles (20)	Young of the Year (28)	Juveniles (19)	Adults (8)
Species composition---	%	%	%	%	%
Channel Catfish					
Young-of-the-year	56	10	57	58	13
Juveniles	44	10	21	26	25
Adults	11	5	11	5	0
Black Bullhead					
Young-of-the-year	33	10	7	21	0
Adults	11	5	4	5	0
Green Sunfish					
Young-of-the-year	22	10	11	5	0
Adults	11	0	4	0	0
Colorado Squawfish					
Young-of-the-year		21	25	5	0
Juveniles	22	-	4	5	0

[1]Young-of-the-year squawfish were found in 14 samples, but 6 of those were from the same backwater; therefore, catches from that backwater were considered as one data point, thus only 9 different areas were sampled.

often than native fishes in samples containing rare species. Red shiners, more than any other species, were found in the same samples as rare fishes.

The data in Table 4 indicate that young-of-the-year Colorado squawfish were found most commonly with red shiners, fathead minnows, juvenile carp, and young-of-the-year channel catfish. Juvenile squawfish were found most often with red shiners, juvenile roundtail chub, and young-of-the-year flannelmouth and bluehead suckers.

Young-of-the-year and juvenile humpback chubs were found most commonly with red shiners, fathead minnows, and young-of-the-year channel catfish. Adult humpback chubs were found most commonly with red shiners and juvenile humpback chubs.

DISCUSSION

Fish Distribution and Abundance

All fish species previously reported from the study area were caught during this study except for the northern pike (Esox lucius) (Seethaler, McAda and Wydoski, 1976).

Rare fish distribution and relative abundance in the study area has apparently changed little in recent years. Seethaler, McAda and Wydoski, (1976) found one juvenile squawfish and two subadults in the upper portion of the study area (Jensen to Ouray). The Colorado River Fishes Recovery Team sampled the same area in 1976 and caught 10 juveniles and 30 subadult and adult squawfish, and one adult razorback sucker.

Vanicek, Kramer and Franklin (1970) sampled below Ouray in 1964-66 and found adult and young-of-the-year squawfish and adult razorback suckers. Holden and Stalnaker (1975) collected in the area from Ouray to Green River in 1967-73 and found all four rare fish, including young-of-the-year squawfish and juvenile humpback chubs. McAda (personal communication, 1977) sampled Desolation and Gray canyons in June of 1977 and found approximately 35 squawfish, including juveniles and subadults. No recent change in population status is evident, except that squawfish apparently spawned only in the extreme lower portion of the study area in 1977. Thus, the rare fishes appear to be maintaining populations in the study area.

Perhaps the most noteworthy specimens found during the present study were the young-of-the-year razorback suckers. These represent, to our knowledge, the first young razorbacks reported from the upper Colorado Basin. A more detailed taxonomic analysis of these specimens, including comparison with known razorbacks from Willow Beach National Fish Hatchery, will be carried out in the near future to verify the preliminary identification.

Preferred Habitat of Rare Fishes

The data from this study show that young-of-the-year and juvenile squawfish prefer backwaters where there is little or no current and a silt bottom. Juveniles prefer deeper areas than young-of-the-year. Vanicek (1967) indicated that young squawfish (age groups 0-II) were found in areas where "current was slight or lacking." Holden and Stalnaker (1975) found young-of-the-year in shallow backwaters and juveniles in backwaters and eddies 2 to 3 feet in depth.

The data indicate that subadult squawfish prefer runs and eddies as opposed to backwaters. Vanicek (1967) found a similar pattern. Holden and Stalnaker (1975) indicated that slow water was preferred to runs and fast eddies, and backwaters were used during high water. A collecting trip in May of 1976, conducted by the Colorado River Fishes Recovery Team from Jensen to Ouray, produced approximately 30 subadult and adult squawfish. All of these fish were taken in backwaters. These data suggest that larger squawfish in the Green River may change habitat preference with season. During high water (spring and early summer) backwaters appear to be preferred; whereas, during low water (fall) eddies and runs are predominantly used. Kidd (1976) indicated that squawfish used backwaters almost exclusively in the Colorado River near Grand Junction, although times of capture were not noted.

Small humpback chubs have similar habitat preferences to small squawfish but use more of a variety of areas, especially eddies. No previous study has reported on preferred habitats of small humpback chubs.

Habitat preferences of adult humpback chubs have generally included eddies near fast current (Holden and Stalnaker, 1975) and/or depths of 20+ feet (Kidd, 1977). The data collected during the present study show no distinct preference for either depth or velocity, although some humpbacks were caught in very fast currents (2.5 fps) and in very deep areas (20 ft.).

Concerning electivity curves, the Cooperative Instream Flow Service Group has set guidelines for evaluating reliability based on number of fish captured. They suggest the following reliability levels: excellent, 200 individual measurements; good, 50-200 samples; and fair, less than 50 measurements. Using these criteria, none of the curves shown above can be rated excellent, young-of-the-year squawfish and humpback chubs are good, and the others only fair. The additional information from the literature would probably increase the reliability of the young-of-the-year squawfish data, but would add little reliability to the other groups.

It is doubtful that a two-month study of rare Colorado Basin fishes can produce sufficient data for excellent reliability, except for young-of-the-year fish. The endangered status of the Colorado squawfish and humpback chub suggest extreme rareness, as, in fact, they are. Several years' data may be needed to raise the reliability of seasonal data to the excellent category for juvenile and adult fishes.

The question remains whether lack of preferred habitat is a limiting factor for the rare fishes. For example, why were fewer juvenile squawfish caught in the middle portion (Ouray-Sand Wash) of the study area than at either end? Was it because adequate habitat was not available and the fishes were therefore not present in that river reach, or were fish actually present but just not concentrated because of a lack of preferred habitat?

McAda (personal communication, 1977) sampled from Sand Wash to near Green River in June, 1977. He found juvenile squawfish distributed throughout the entire area. The present study sampled the same area more intensively in September, but found juveniles only in the lower portion. McAda caught most of the young squawfish in the mouths of small backwaters, which he indicated were fairly common. Few such areas were found during the present study in the upper part of Desolation, as the water had receded approximately 3 feet by September. In both cases, juvenile density appeared to follow the availability of preferred habitat.

This same pattern was noted in August in the Jensen-Ouray area. Juvenile squawfish were seldom caught in sections of the river that did not contain adequate habitat, i.e. backwaters of more than a foot in depth. Also, juvenile squawfish were often found in relatively large numbers in some backwaters. On two occasions, five juvenile squawfish were found in a backwater, and one time three were found. This evidence indicates that preferred habitat concentrates juvenile squawfish and suggests they may move to areas that contain preferred habitat.

There are several factors that may account for the observed preference of backwaters by young-of-the-year and juvenile Colorado squawfish. These include escape from predation and/or competition and/or the rigors of the river, and the presence of an abundant food supply. Table 3 indicates that a number of potential predators and competitors are found with the young fishes, especially young-of-the-year. Backwaters seldom provide physical protection such as undercut banks and overhanging vegetation. Therefore, escape from competition and predation do not appear to be likely concentrating factors. To escape the rigors of the main river, areas with little current probably would be selected. Many such areas exist in eddies and along the edges of runs, as well as in backwaters. No young-of-the-year squawfish and only a few juveniles were found in such areas. Therefore, escape from the stresses imposed by the river does not appear to be a major concentrating factor.

Backwaters tend to be nutrient rich due to the silt substrate, and warm due to slow water exchange. These habitats are not as dramatically affected by water level fluctuations as are other habitat types. All young-of-the-year less than 30 mm found during the present study were concentrated in these areas. Such areas are the primary large river habitat where crustaceans (Cladocerans and Copepods) and many small aquatic insects can thrive. Vanicek (1967) found that young-of-the-year squawfish fed on these organisms and gradually shifted to larger aquatic insects and small fish as they grew larger. Backwaters, therefore, provide a readily available food source for both young-of-the-year and juvenile squawfish and it appears very likely that an abundance of these preferred habitats may well increase the survival potential of young squawfish, primarily from the standpoint of food availability. If this hypothesis is correct, preferred habitat of young may, in fact, be a limiting factor to rare fishes, especially Colorado squawfish.

The low water levels encountered during the study reduced the available number of small backwaters from normal levels. A large number of potential backwater situations were seen in the study area that, given 1-2 feet of additional flow, would have been preferred young squawfish habitat. The cross-sectional data of Figures 12 and 13 indicate that that particular area had certain depth and velocity categories present. Very little preferred habitat (Figure 2) of young-of-the-year squawfish was present, except in the backwater where they were found. Cross-sectional data from other areas of young-of-the-year squawfish habitat would provide comparative data.

Rare Fish Movements and Potential Spawning Areas

The three young-of-the-year squawfish recaptured in the sample backwater provide little data on movement. The fact that a relatively large number of fish were marked and that successive samples found relatively large numbers of unmarked fish, indicates several possibilities. First, a fairly large population is indicated. Secondly, failure to recapture marked fish suggests either low sampling efficiency or absence of marked fish. The mouth of the backwater (see Figure 12) was too deep to seine. The middle part was seined several times and depths and bottom type suggested an efficient sample except that the entire width could not be sampled in one sweep. Only a few young-of-the-year squawfish were found here. The upper part was thoroughly sampled from bank to bank and produced the majority of the young-of-the-year squawfish. Samples from other backwaters also indicated a preference for upper portions of backwaters with a relatively shallow depth. Therefore, sampling efficiency was excellent in the upper portion of the backwater, good in the middle part and poor or non-existent near the mouth. If just the upper portion is analyzed, a large turnover of squawfish young is indicated.

The question remains, what happened to the marked fish? It is possible they died from the marking and handling process. This is extremely doubtful due to the great amount of caution used in handling the fish and the small amount of anal fin actually clipped.

Another explanation is that the fish moved considerably, either within the backwater, or between that area and other habitats in the immediate area. As mentioned earlier, an intense effort was made to locate the marked fish, especially downstream from the sample backwater. The area above and below the backwater was very deep, which prohibited sampling other than very close to shore (Figure 12). Failure to find marked squawfish, or any young-of-the-year squawfish for that matter, in these adjacent areas suggests either the small fish used the main channel, which is highly unlikely, or moved considerably within the sample backwater. It would appear the latter possibility is the most likely. The failure to find any young-of-the-year squawfish in areas of current supports the possibility of their moving little up or down the river during the time of the study.

The data from this 2-1/2 day study of squawfish movement are inconclusive. Movement is indicated, but the extent of the movement is not known. Data from collections in the vicinity of the sample backwater suggested that young-of-the-year squawfish are seldom found in an area of current. This indicates that the fish move little between habitats, and that movement within the sample backwater may best explain the lack of young-of-the-year recaptures.

Presence of young-of-the-year fishes can be used in determining general spawning sites if movements of larval stages are known. Due to the late starting date of this study, no larval rare fishes were found. The rare fishes spawn at temperatures of 55-70 F (Vanicek and Kramer, 1969; Seethaler, McAda and Wydoski, 1976). It is probable these temperatures were reached earlier than normal this year in Desolation Canyon due to low flows.

Data from the upper Green River indicate that young Colorado squawfish may remain in suspected spawning areas. Vanicek (1967) found all sizes of squawfish, including post larvae (12-20 mm), at Echo Park, the confluence of the Green and Yampa rivers. It is doubtful that these fish moved down the Green River as Vanicek (1967) did not find squawfish of any size in the Green River above the mouth of the Yampa and attributed this to cold water from Flaming Gorge Dam. The young squawfish may have moved down the Yampa River. Vanicek (1967) did not sample the Yampa River.

Holden and Stalnaker (1975) found no squawfish reproduction in the Yampa from 1968-71, nor have other researchers since then (Seethaler, McAda and Wydoski, 1976). Since the Yampa did not change significantly between 1964 and 1975 (see Phase I report, WELUT Project 24), it appears reasonable to assume that squawfish did not spawn there during that period of time. Therefore, the young squawfish Vanicek collected in Echo Park probably hatched there. The information from this example suggests young squawfish did not necessarily move far from the site of hatching.

The question remains, at what sizes do squawfish move and how much do they move? There is no data available to answer this question completely. Hopefully, future studies will recapture some of the juvenile squawfish marked during this study and help answer this question. It appears, from the meager evidence available, that juvenile squawfish, yearlings and older, can and do move up and down the river if they so choose. One bit of information which supports this hypothesis is the wider range of microhabitats used by juveniles than young-of-the-year. Also, the concentrating effect of preferred habitat suggests movement to find such areas. Backwaters are much shorter lived during spring and summer high flows than during low fall and winter flows. Therefore, young-of-the-year squawfish enter the river at a time when preferred areas are rather permanent, and grow to a large enough size to move about in search of preferred areas by the next spring.

Considering the above discussion, and accepting the assumption of little movement by young-of-the-year rare fishes, estimates of spawning sites can be made. The large number of young-of-the-year collected from one backwater below Range Creek in Gray Canyon suggests spawning was probably close to that point. Young-of-the-year squawfish were found in only one backwater above that point, and that particular habitat was a riffle and run situation just a week or two before our sampling. Numbers of young-of-the-year below the point of major concentration was limited, suggesting some degree of downstream movement rather than additional spawning sites. Using this data, it can be inferred that squawfish spawned in Gray Canyon, and nowhere else above that, in the Green River in 1977.

The location of young razorback suckers suggests that spawning occurred in the area, near and just below, Ouray, Utah. The data on young-of-the-year humpback chubs indicates spawning in Desolation and Gray canyons. Both of these species spawn earlier in the year than squawfish, hence their young were more mature and less clumped in distribution than were young-of-the-year squawfish. Less exact estimates of spawning sites can be made for these early spawning species.

As noted earlier, Holden and Stalnaker (1975) found young-of-the-year squawfish near Sand Wash, and Vanicek (1967) found them near Ouray. Therefore, spawning is confirmed from those areas if one accepts the hypothesis that young-of-the-year squawfish move little from the actual spawning site. No young-of-the-year have been found in the area from Jensen to Ouray. Yearling squawfish found during the present study may be indicative of 1976 spawning, but this would assume limited movement by yearling squawfish. Therefore, it is probable that spawning has previously taken place in more of the study area than was evident this year.

Why wasn't spawning successful in these other areas in 1977? The answer to this question is not apparent for most of the study area. The early August temperatures of 15-20 C near Jensen should have been the highest of the year, for that area, but still were not sufficient for squawfish spawning (21 C). This may explain the lack of spawning above Ouray, but not below that area.

Competition and Predation

The data presented in Table 4 show that rare and introduced species use the same microhabitat and suggest that competition and predation are possible. Young exotic species dominated the young-of-the-year collections of both squawfish and humpback chubs, as well as juvenile chubs. Juvenile squawfish associated primarily with native species. The degree that this potential competition-predation limits rare fish populations is not known, nor is there sufficient data available at this time to suggest competitive mechanisms. BIO/WEST has previously discussed that subject in greater depth as part of Phase I, WELUT Project 24.

The addition of the smallmouth bass to the Green River fauna adds another potential predator on rare fishes. However, turbidity levels during spring and early summer, and the rigorous nature of the Green River should limit reproduction of this piscivore.

Management Implications

The data presented above sheds considerable light on rare fish use of an area of the Green River in Utah. It must be remembered that preferred habitats, associated species, and movement patterns may change seasonally, or at least during high and low water. Therefore, the development of management practices from limited data invites criticism.

One major interest in the area between Jensen and Ouray has been the placement of water pumps used for flooding ponds on the Ouray National Wildlife Refuge and for irrigation of private croplands. The information presented above would suggest that pump intakes should not be placed in slow water areas, especially backwaters. Placement of intakes in swift runs would be the best practice for alleviating potential loss of young rare fishes.

Perhaps the greatest management implication of this study involves the capture of all four rare fishes and their young in the study area. This fact alone means that any factor that may change present flows or other habitat parameters must be considered carefully to avoid loss of either habitat or fish populations. Past studies have shown reproduction of squawfish from Ouray to Green River, Utah, but this year it apparently occurred only near Green River. Does this mean that the low flows of 1977 caused changes that reduced the available spawning-rearing habitat? Were the minimum flows needed for successful squawfish reproduction surpassed in 1977? Studies in future years with more normal flow regimes may provide answers to these questions.

This study adds considerably to the data showing the importance of backwaters to rare fishes. Young-of-the-year squawfish use, and may require, backwaters as a primary source of food. Juvenile squawfish and young humpback chubs also prefer backwaters, but use other areas.

Although not analyzed for this report, the data also indicate that several introduced species, primarily green sunfish, black bullhead, and to a smaller extent, fathead minnows, rely almost exclusively on backwaters. Backwaters can be classified as (1) short-lived, those that change significantly with a slight (6") rise or fall in water level; and (2) long-lived, those that are protected well enough to be little affected by slight changes in river level. The first type may change on a daily basis and certainly do several times each spring-summer, whereas the latter type remains constant from early summer until the next spring high flows. Young squawfish and humpback chubs were found in both types of backwaters, young sunfish and bullheads were found only in the latter and fatheads were most abundant in the latter type. This information should caution against the artificial construction of backwaters that are long-lived as a technique for increasing rare fish populations, as exotic fish populations would also be increased. Short-lived backwaters may be sufficient for young-of-the-year squawfish.

The low water of 1977 increased the life of long-lived backwaters. The probable reason for this is that high spring flows were nearly non-existent and backwaters became established earlier than normal. Low flows in August and September sheltered the backwaters from fluctuation due to rainstorms.

SUMMARY

The following discussion summarizes the information gathered to meet each of the five stated objectives.

1. Physical components of the preferred habitat of three size classes of Colorado squawfish and humpback chubs were presented as electivity curves. Backwaters with no current, a silt substrate and over one foot of depth were preferred by the young fishes; larger specimens used faster, deeper eddies and runs. Temperatures encountered during the study were apparently within the tolerance ranges of the rare fishes, as no selection of temperature was noted. Chemical parameters were studied for the main river and also appeared within the acceptable range of rare fishes.
2. Spawning of Colorado squawfish, humpback chub, and razorback suckers apparently occurred in sections of the study area in 1977. The locations of squawfish spawning sites were estimated from the occurrence of young-of-the-year.
3. The extent of the study area was changed when few young-of-the-year squawfish were found in the original primary study site. Therefore, repeated collections in the study area were not made and recapture data for movement analysis were difficult to obtain. One 2-1/2 day study of young-of-the-year squawfish was inconclusive concerning movement but suggested movement within a fairly large backwater. Data from other collections

in that vicinity supported the hypothesis that young-of-the-year squawfish probably seldom used areas of current.

4. All fish species previously reported from the study area were caught, except for the northern pike, which has been taken only once before. Young-of-the-year razorback suckers were tentatively identified during the study and represent the first wild, young razorbacks on record. A high potential for competition and/or predation exists as several other species were found associated with young, rare fishes.
5. The importance of river habitats was assessed primarily through electivity curves which showed preferred habitat. Areas of potential spawning of rare fishes were inferred.

LITERATURE CITED

Evans, L. and B. Belknap. 1974. Desolation River Guide. Westwater Books, Boulder City, Nevada.

Holden, P. B. and C. B. Stalnaker. 1975. Distribution and abundance of mainstream fishes of the middle and upper Colorado River basin, 1967-1973. Trans. Am. Fish. Soc. 104(2):217-231.

Kidd, G. 1977. An investigation of endangered and threatened fish species in the upper Colorado River as related to Bureau of Reclamation projects. Final Report. Bur. Reclamation, Grand Junction, Colorado.

Seethaler, K. H., C. W. McAda, and R. S. Wydoski. 1976. Endangered and threatened fish in the Yampa and Green rivers of Dinosaur National Monument. Utah Coop. Fish. Res. Unit, Utah State University, Logan.

Vanicek, C. D. 1967. Ecological studies of native Green River fishes below Flaming Gorge Dam, 1964-1966. Ph.D. Dissertation, Utah State Univ., Logan.

Vanicek, C. D. and R. H. Kramer. 1969. Life history of the Colorado squawfish, Ptychocheilus lucius, and the Colorado chub, Gila robusta, in the Green River in Dinosaur National Monument, 1964-1966. Trans. Am. Fish. Soc. 98(2):193-208.

Vanicek, C. D., R. H. Kramer and D. R. Franklin. 1970. Distribution of Green River fishes in Utah and Colorado following closure of Flaming Gorge Dam. Southwestern Natl. 14(3):297-315.

APPENDIX I

Length/Frequency Histograms of the More Common Fishes Collected During the Study

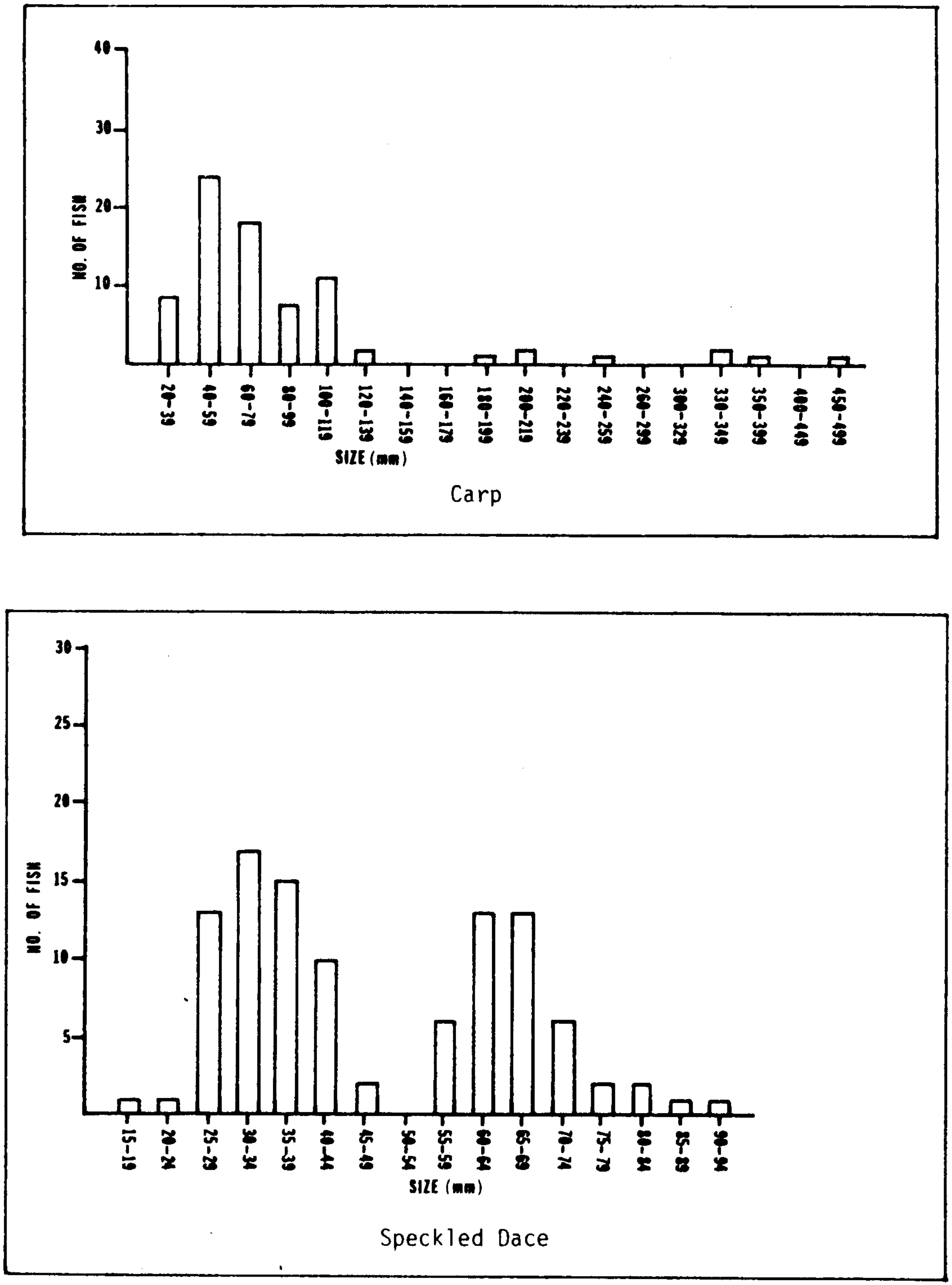
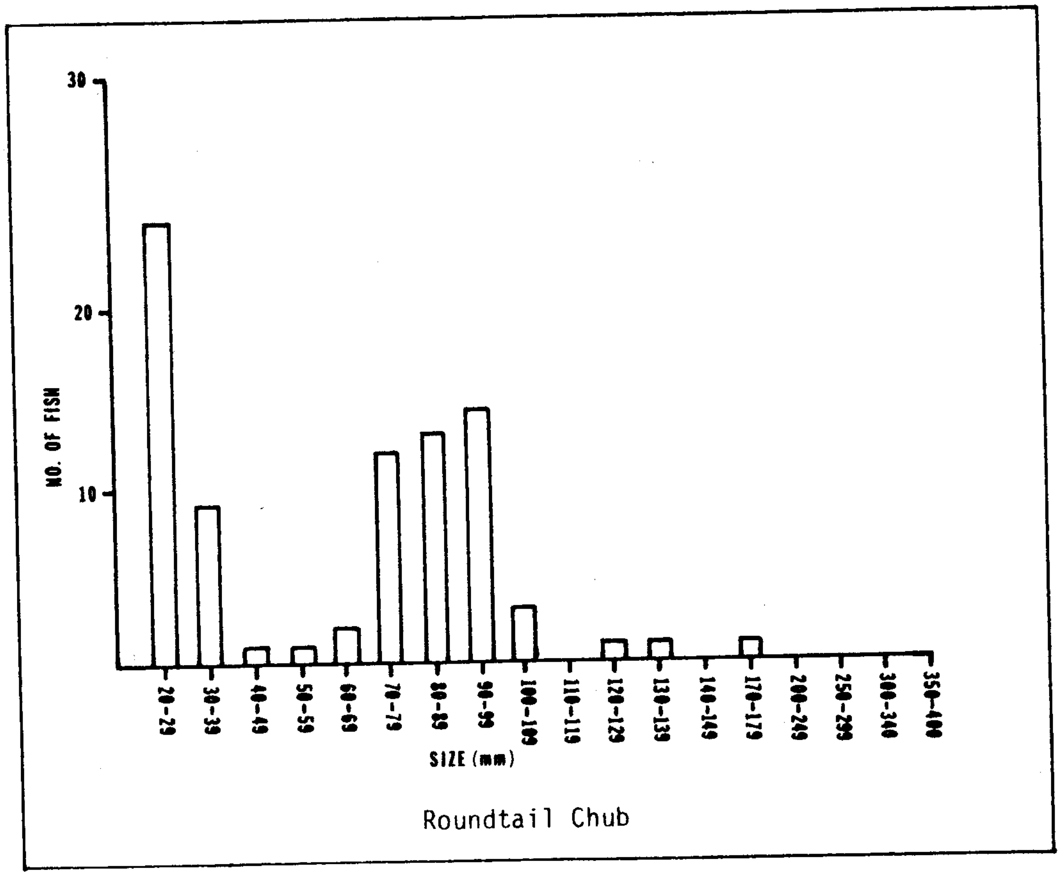


Figure 14. Length/frequency histograms for carp and speckled dace from the Green River, Utah.



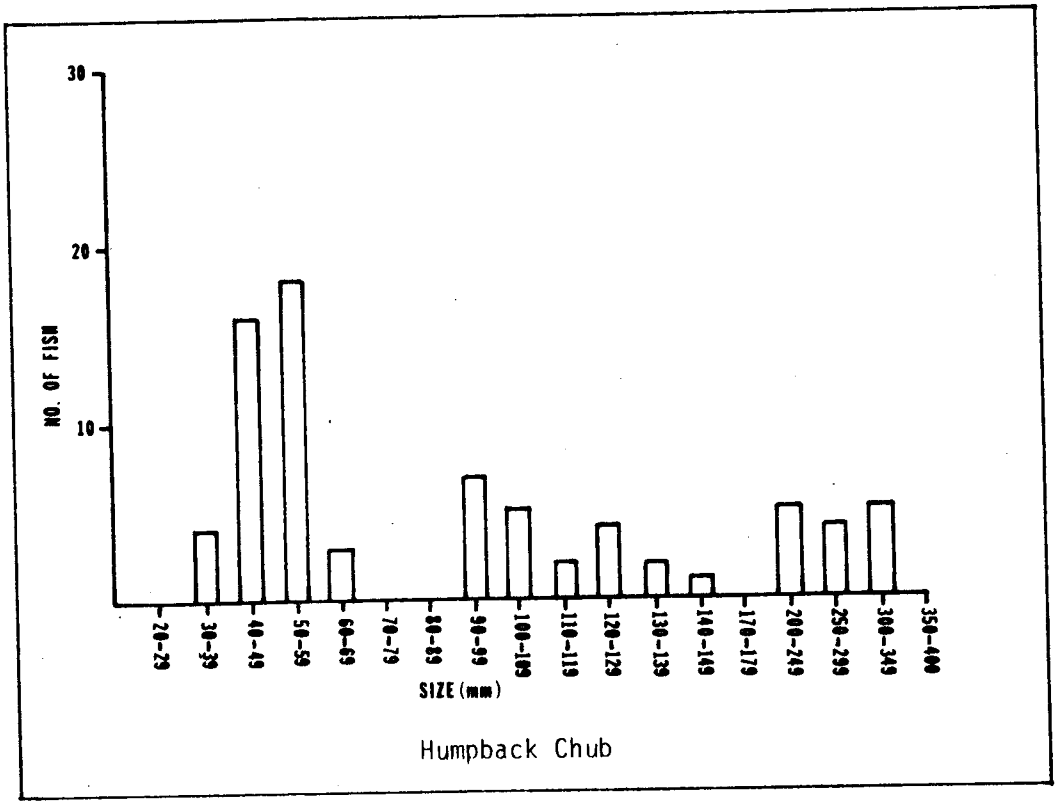


Figure 15. Length/frequency histograms for the roundtail chub and humpback chub from the Green River, Utah.

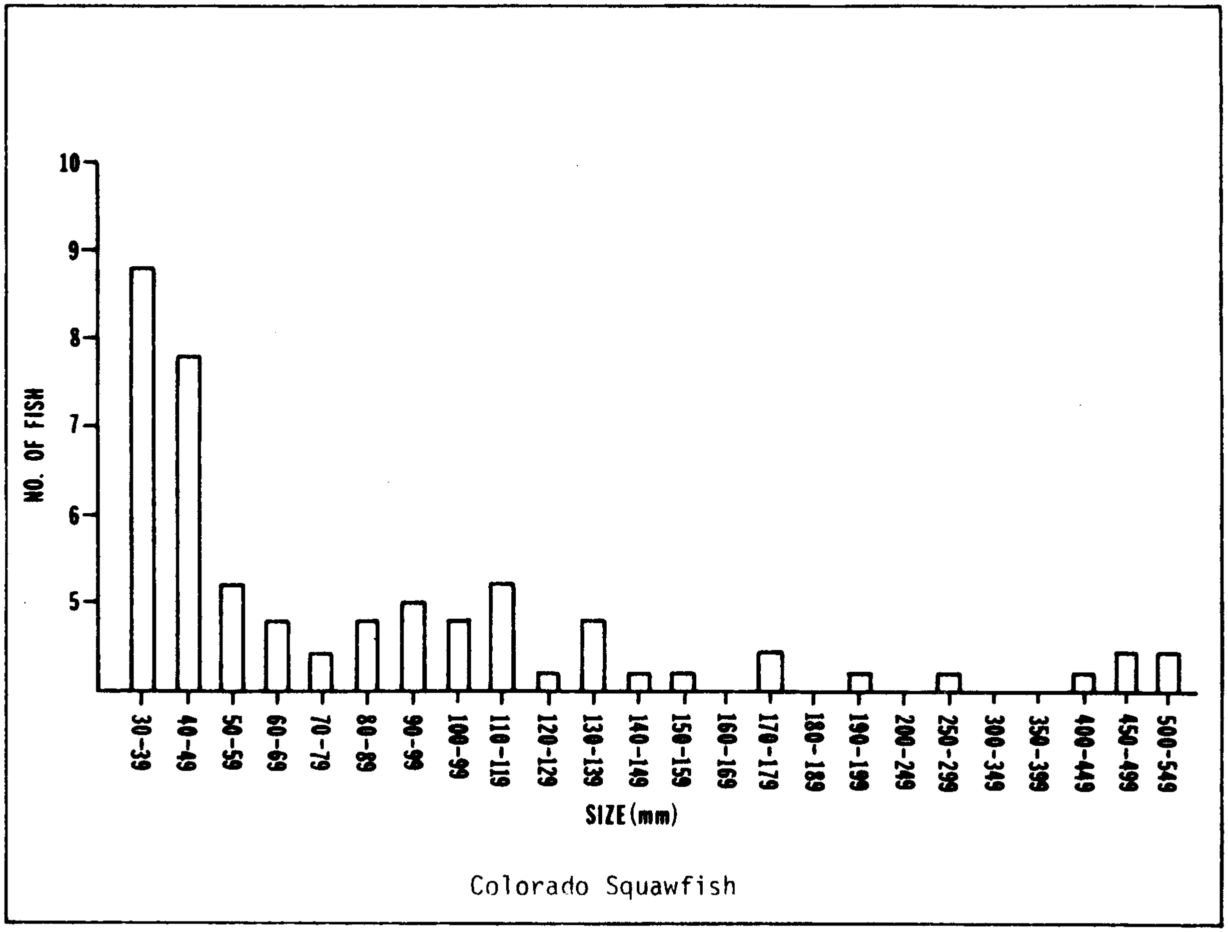
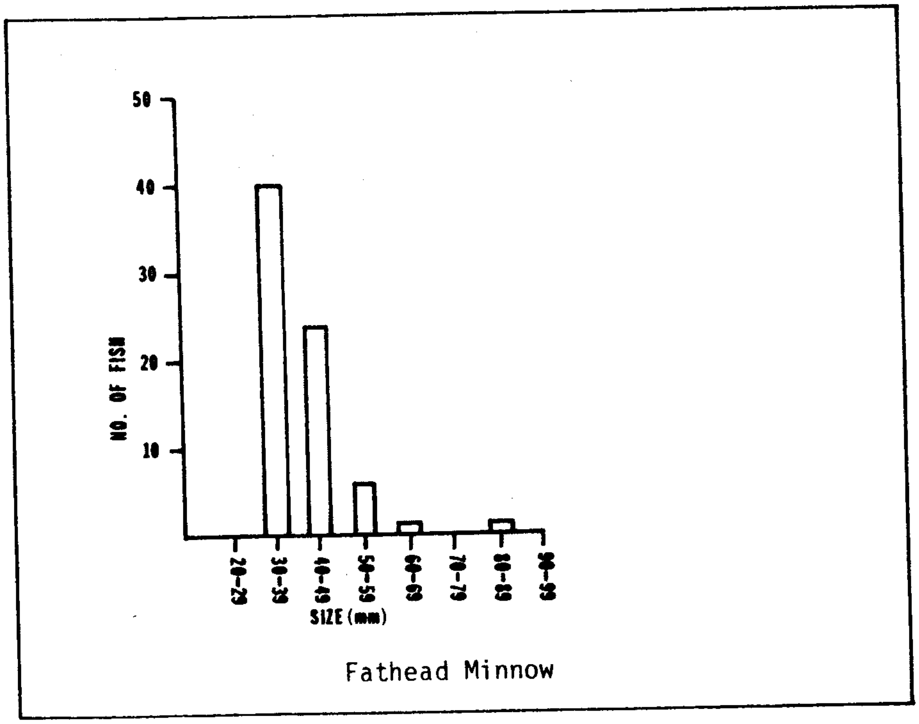


Figure 16. Length/frequency histogram for the Colorado squawfish from the Green River, Utah.



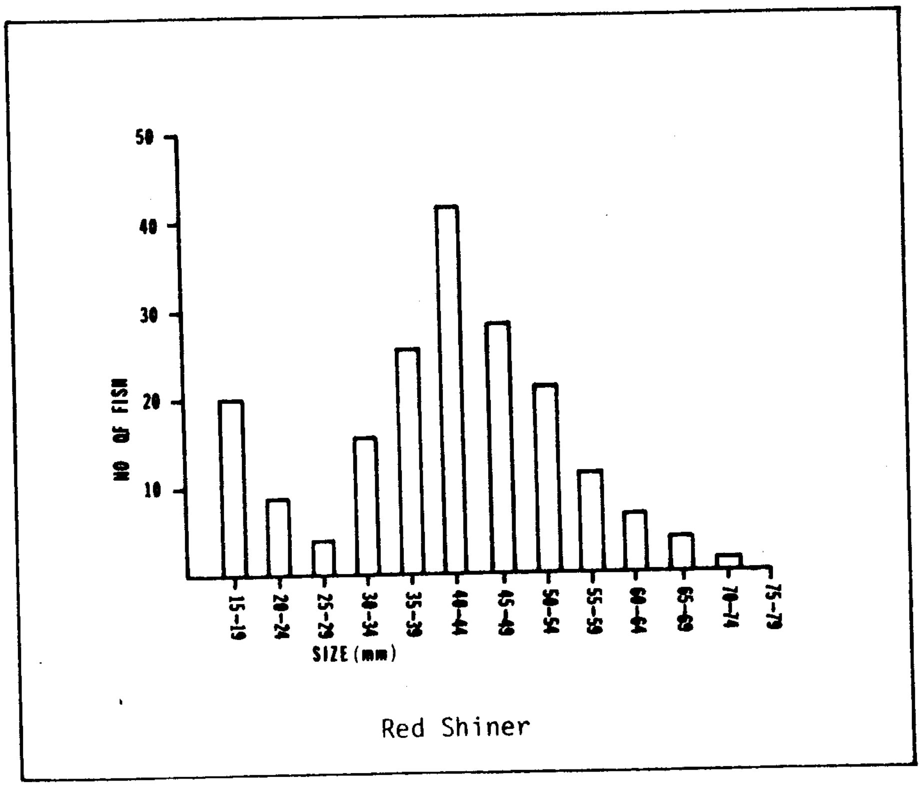
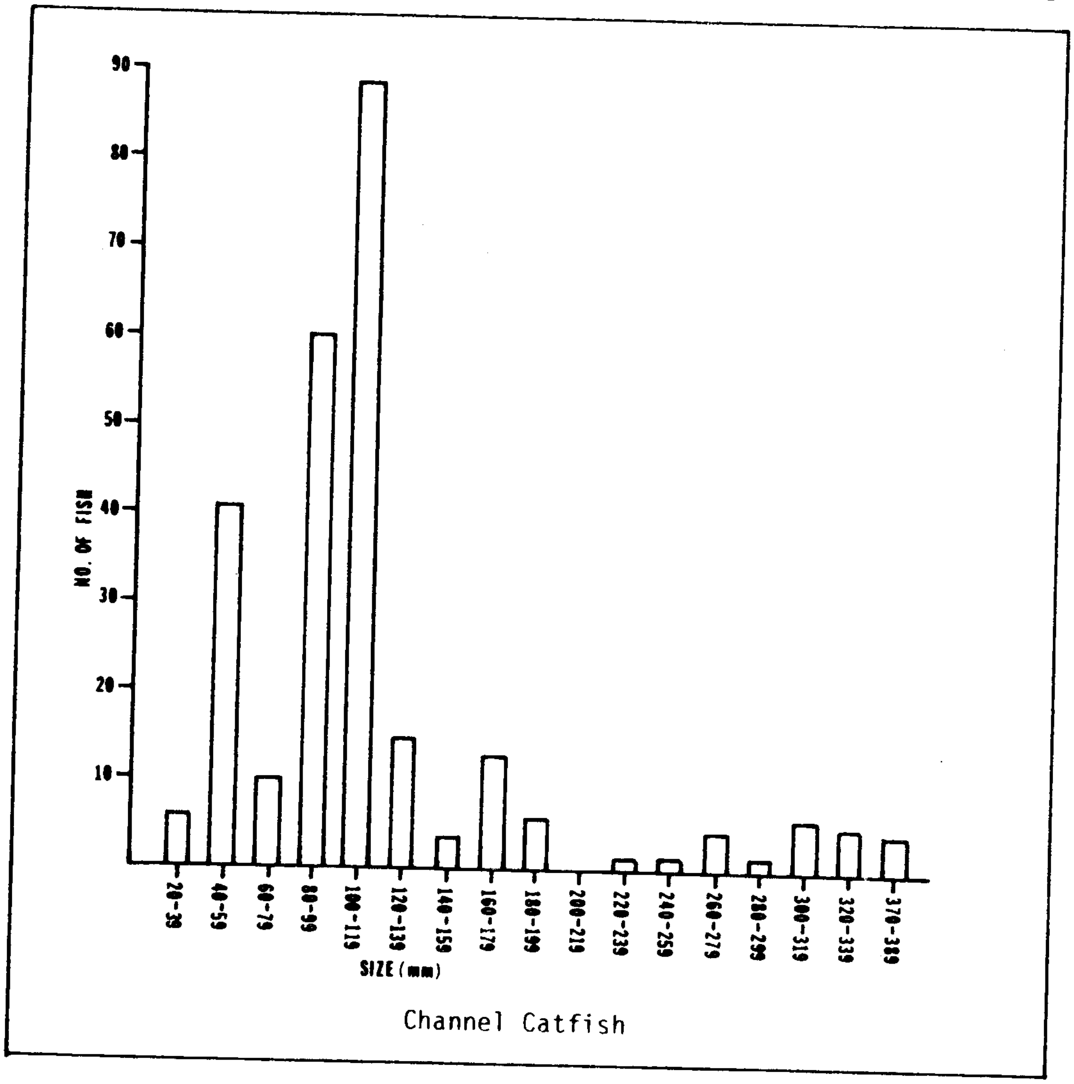


Figure 17. Length/frequency histograms for the fathead minnow and red shiner from Green River, Utah.



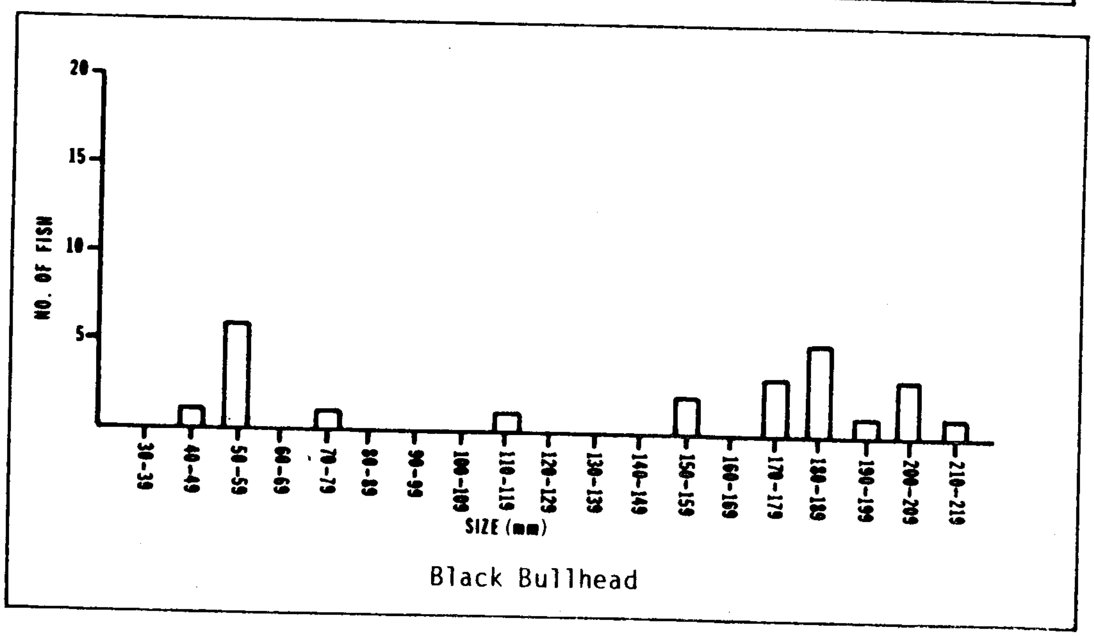
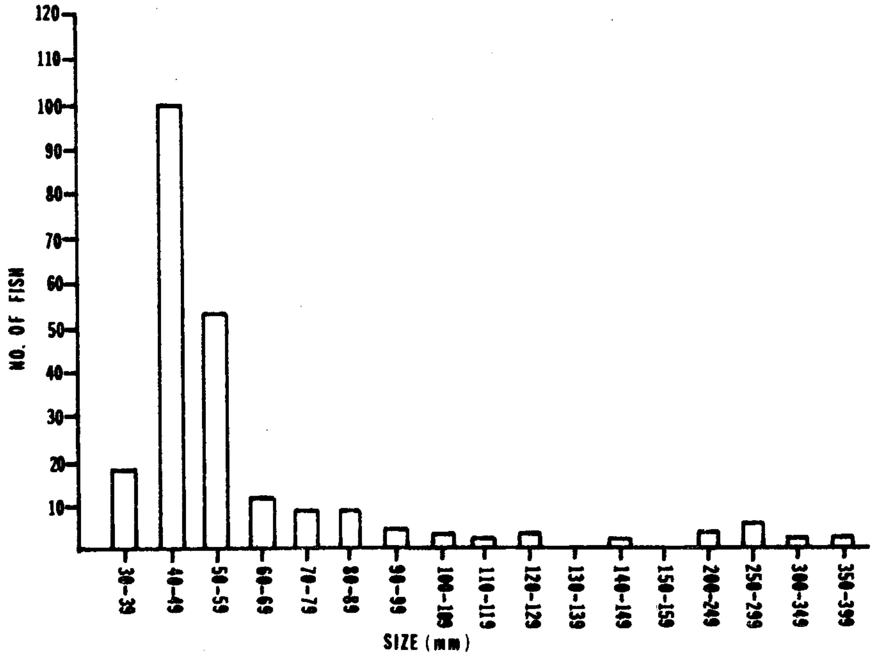
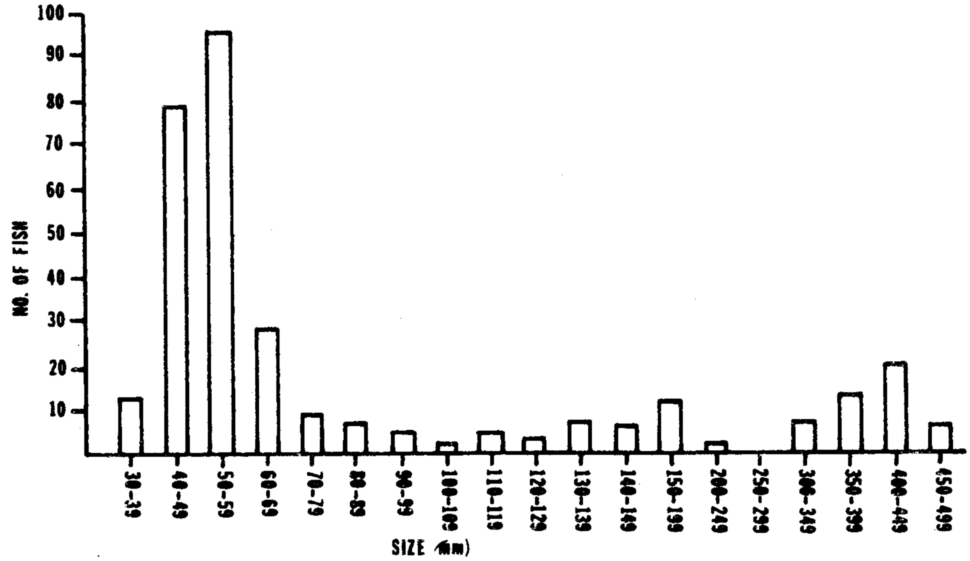


Figure 18. Length/frequency histograms for the channel catfish and black bullhead from the Green River, Utah.



Bluehead Sucker



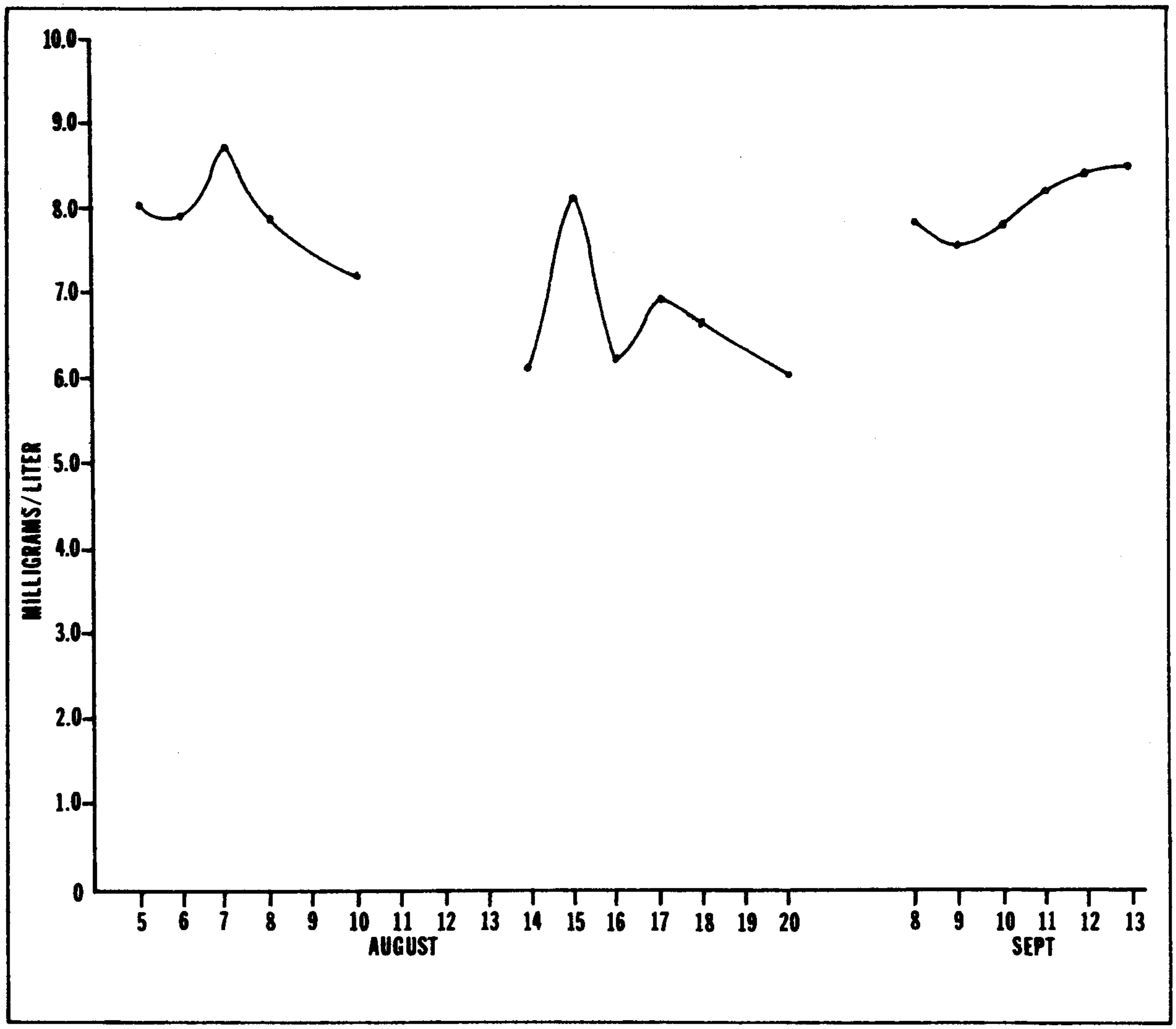
Flannelmouth Sucker

Figure 19. Length/frequency histograms for the bluehead sucker and flannelmouth sucker from the Green River, Utah.

APPENDIX II

Graphs of Water Chemistry Parameters

Measured During the Study



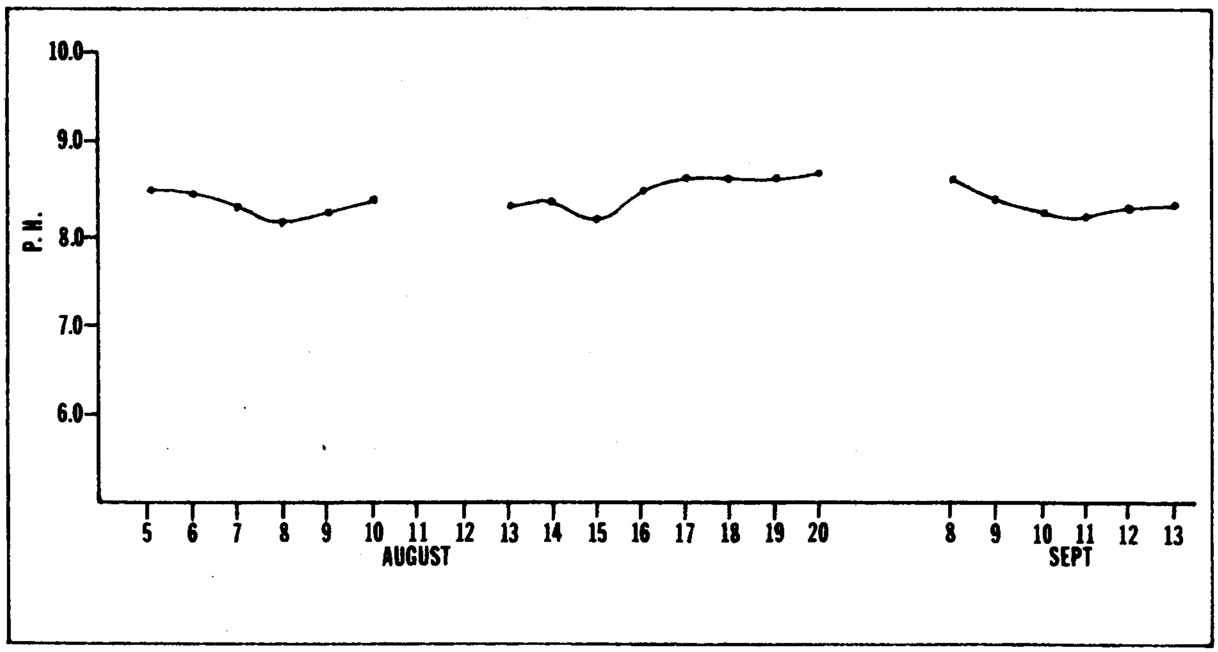
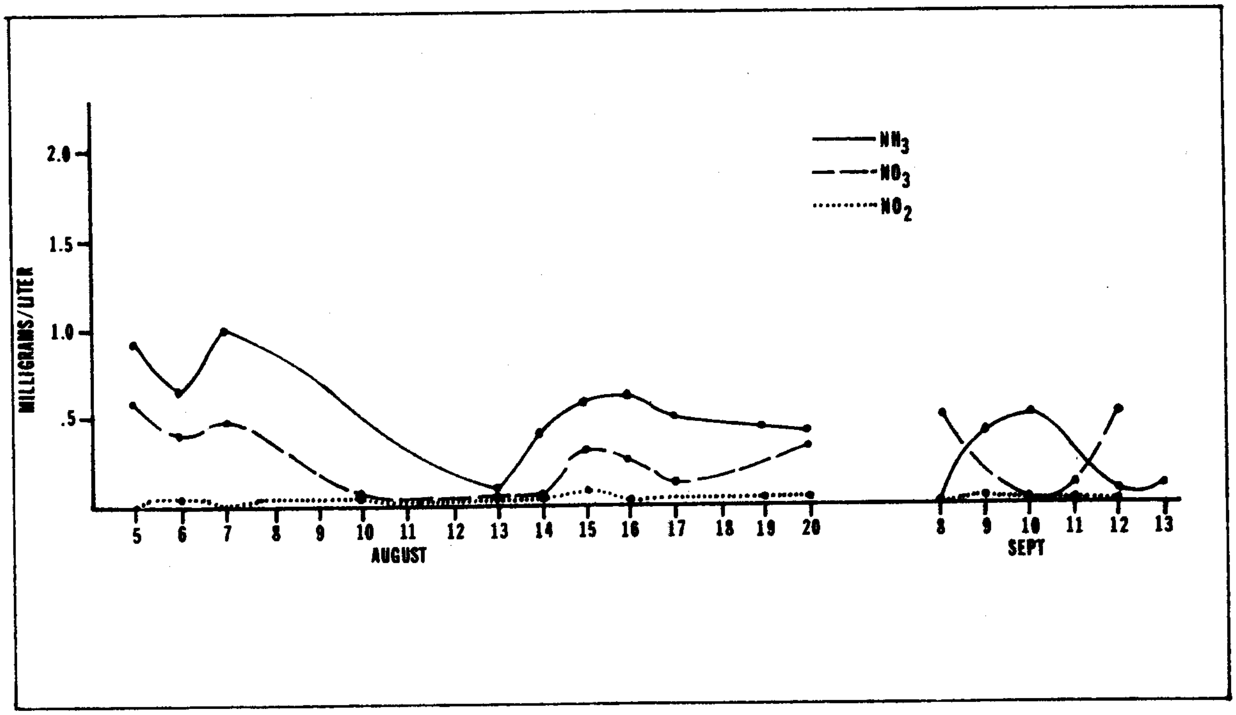


Figure 20. Levels of dissolved oxygen and pH encountered in the Green River, Utah.



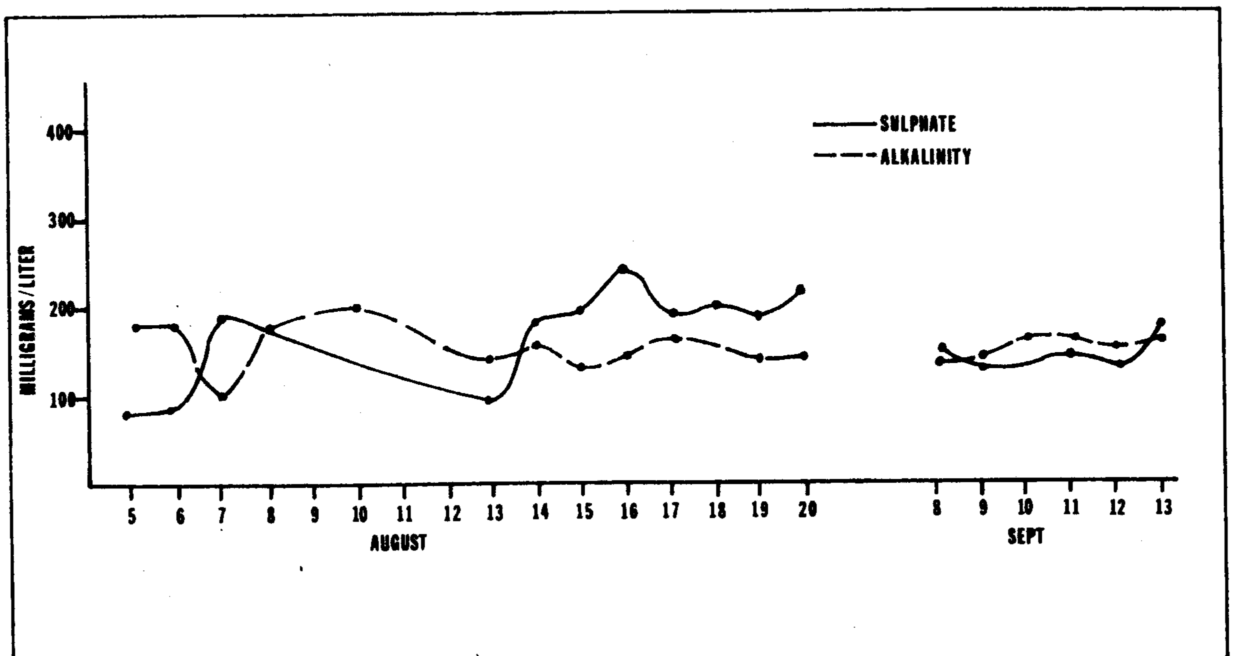
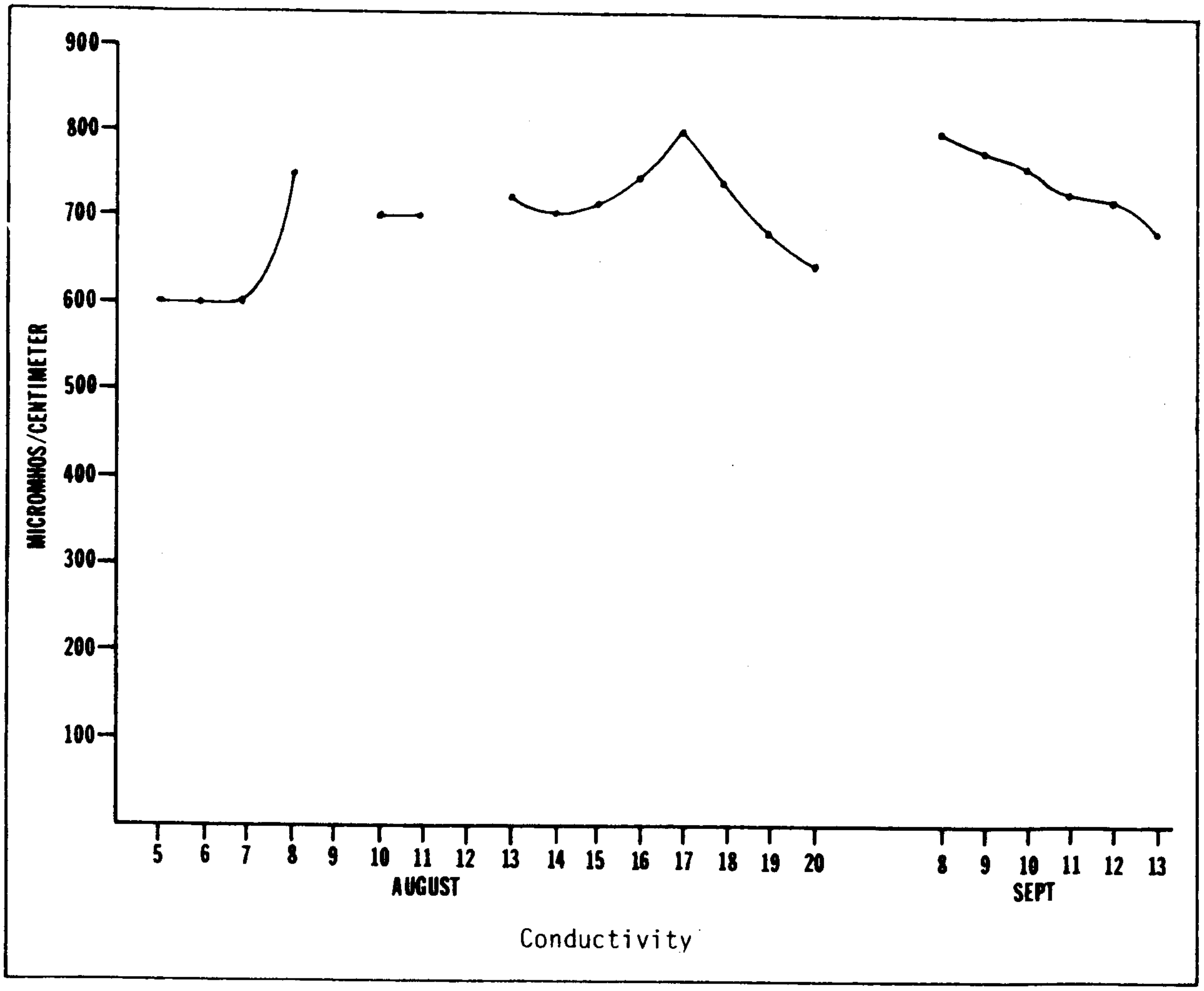


Figure 21. Levels of NH_3, NO_3, NO_2, sulphate, and alkalinity encountered in the Green River, Utah.



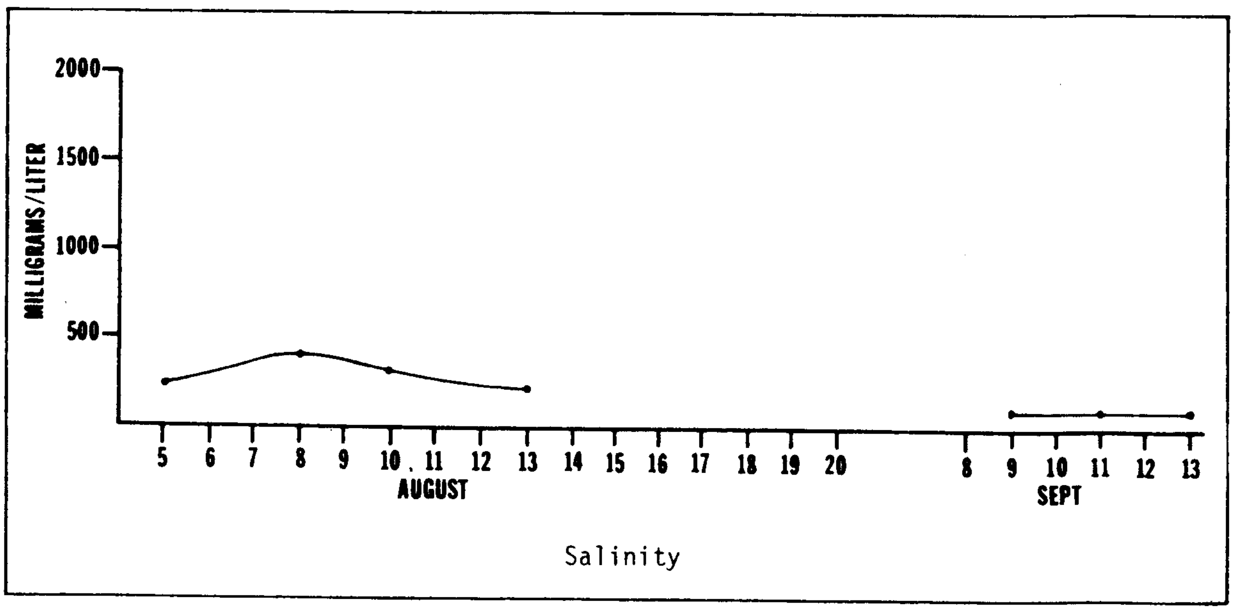


Figure 22. Levels of conductivity and salinity encountered in the Green River, Utah.

APPENDIX III

Photographs of Rare Fishes Collected During the Study

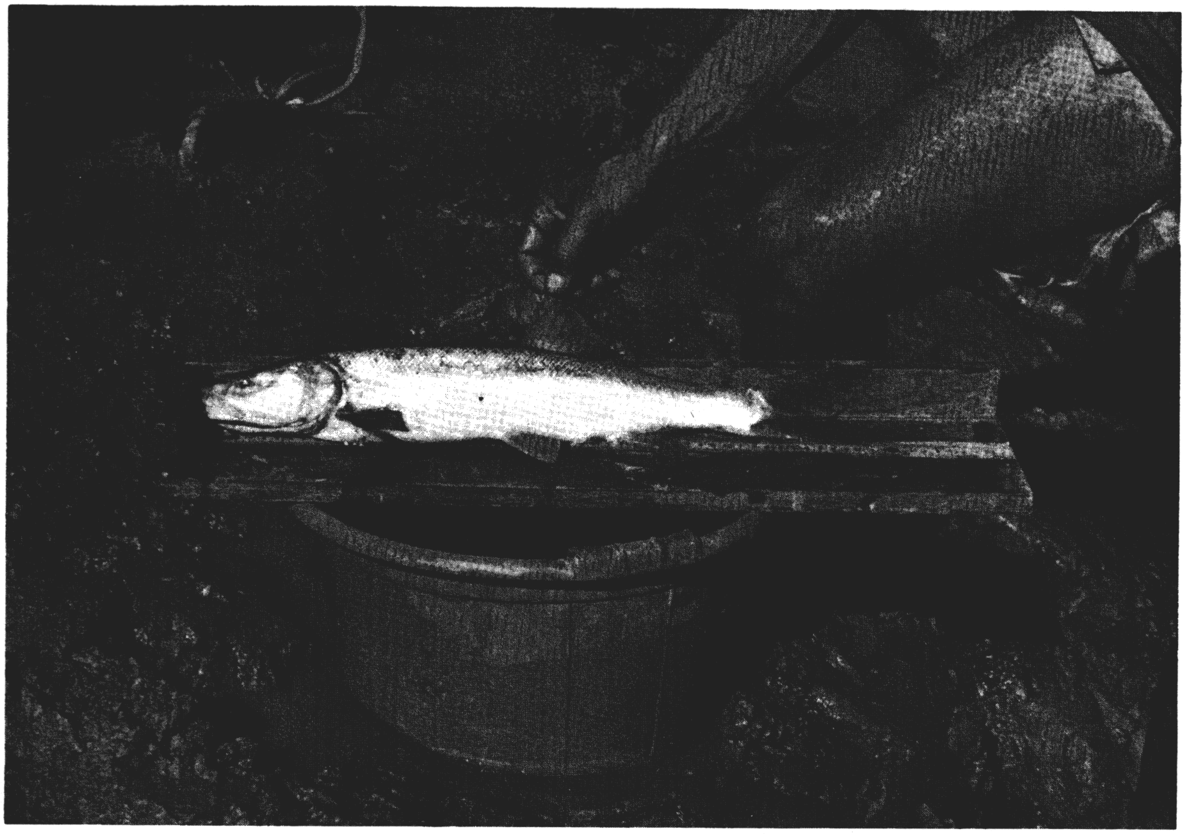


Figure 23. Photograph of a subadult Colorado squawfish (Ptychocheilus lucius) from the Green River, Utah, at River Mile 87.

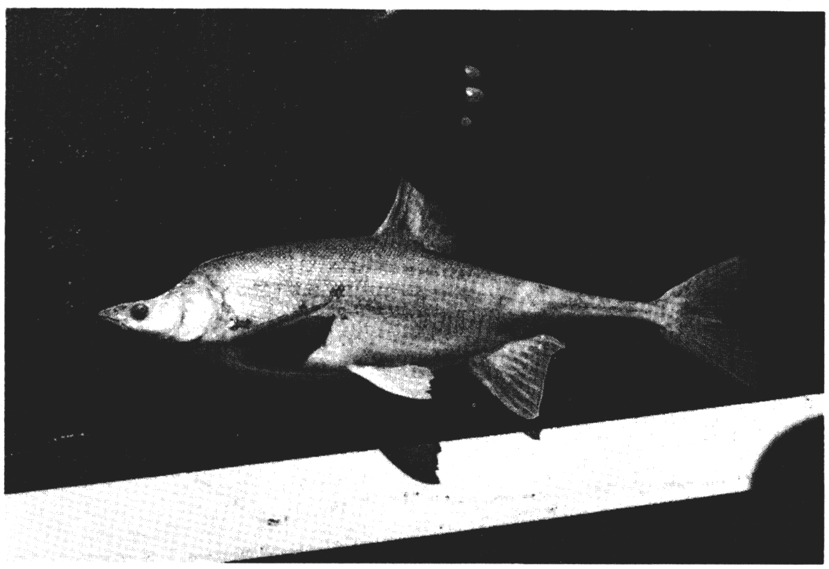
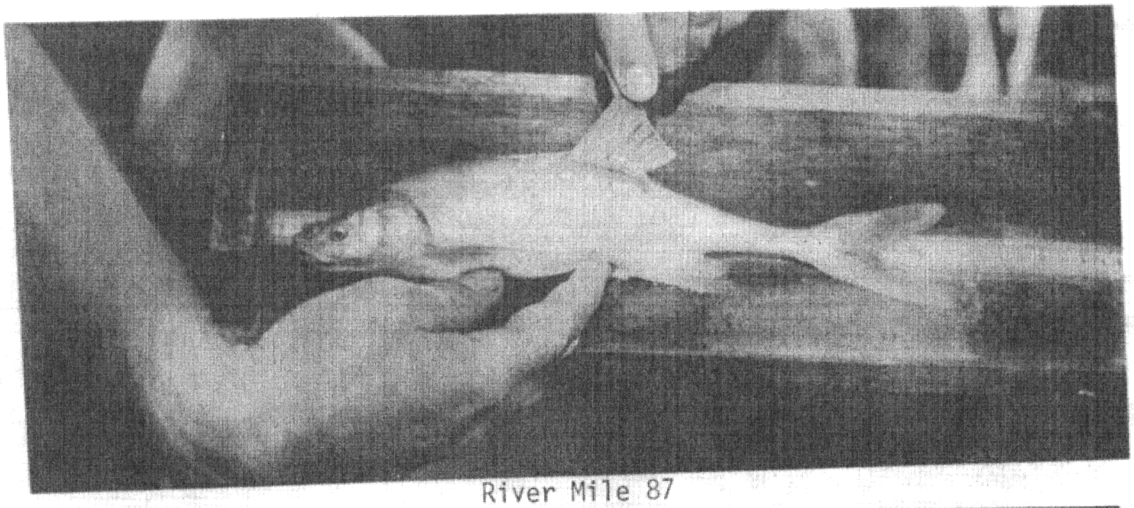
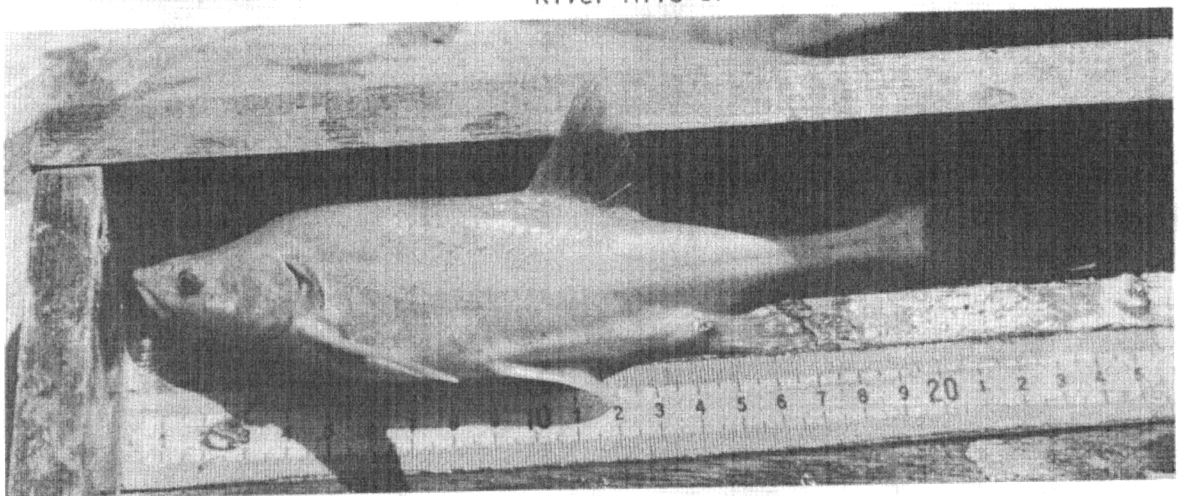


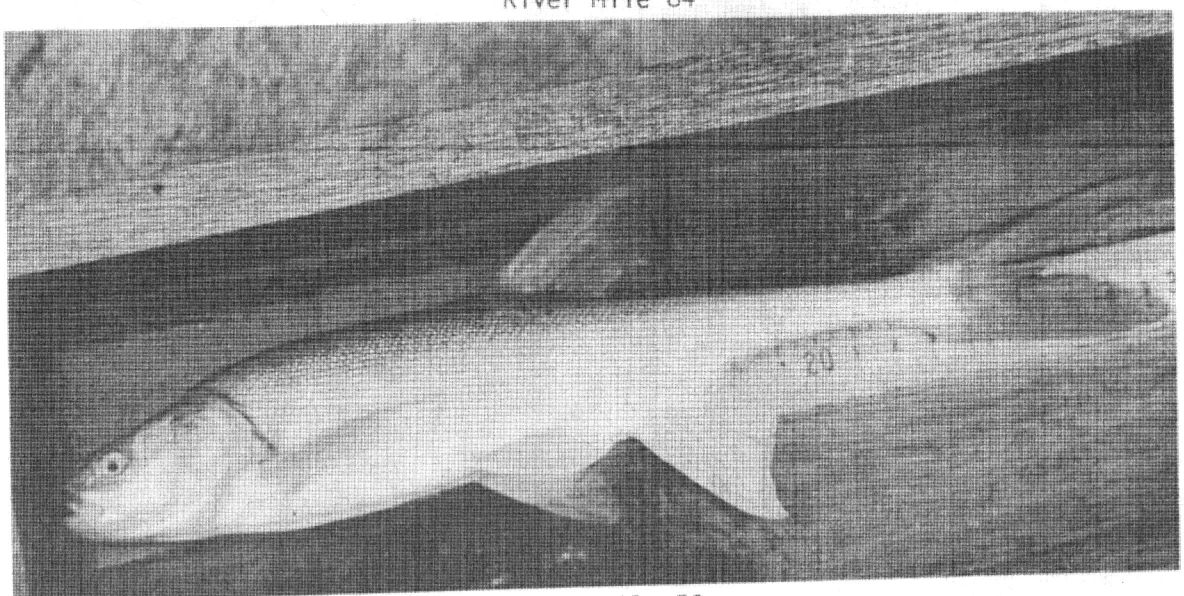
Figure 24. Photograph of an adult bonytail chub (Gila elegans) from the Green River, Utah, at River Mile 164.



River Mile 87

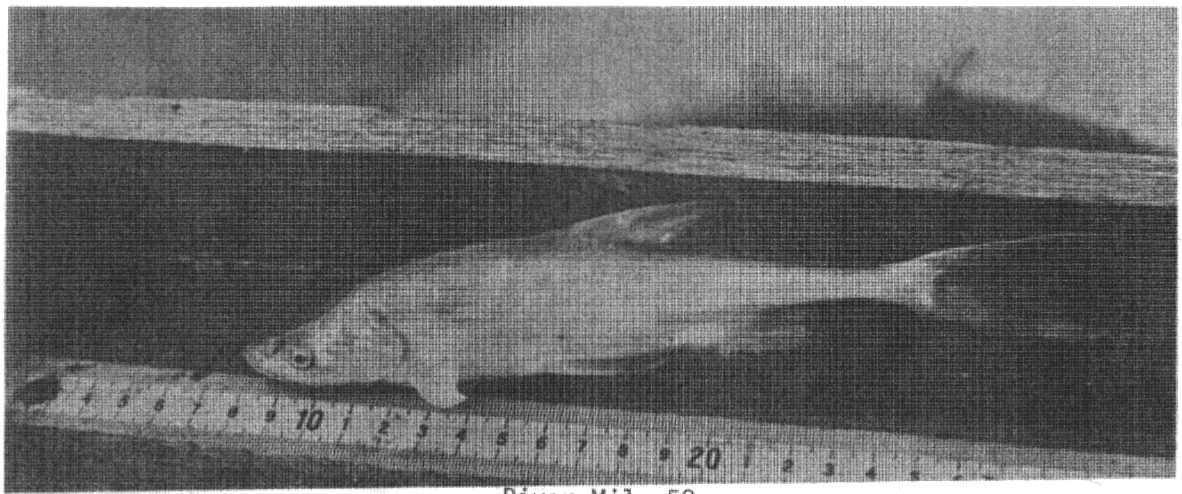


River Mile 84

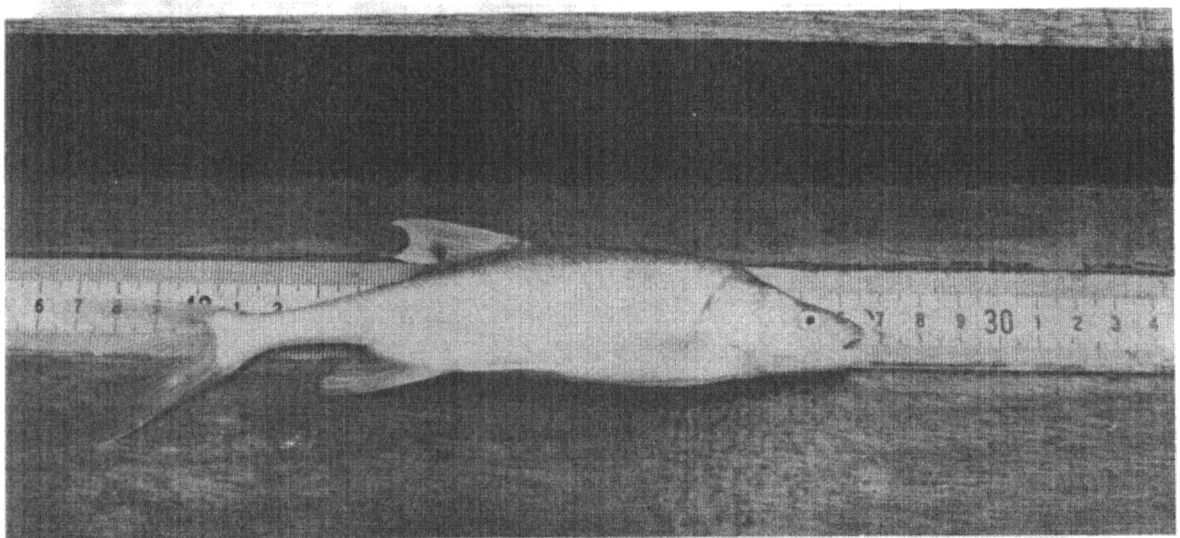


River Mile 58

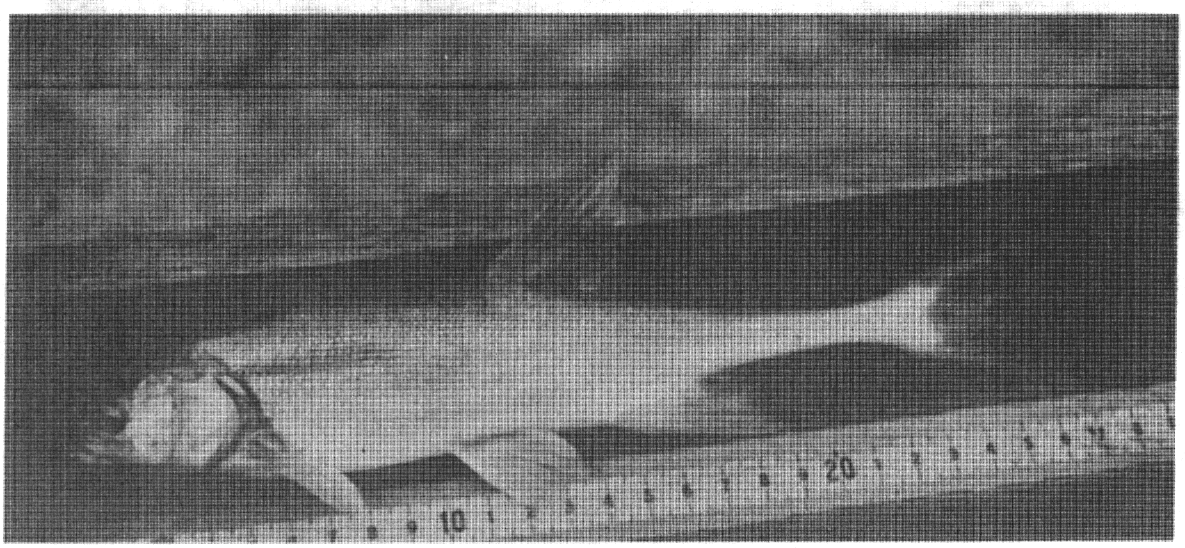
Figure 25. Photographs of chubs from Desolation Canyon of the Green River, Utah, tentatively identified as humpback chub. River mile of collection is indicated below each photograph.



River Mile 58

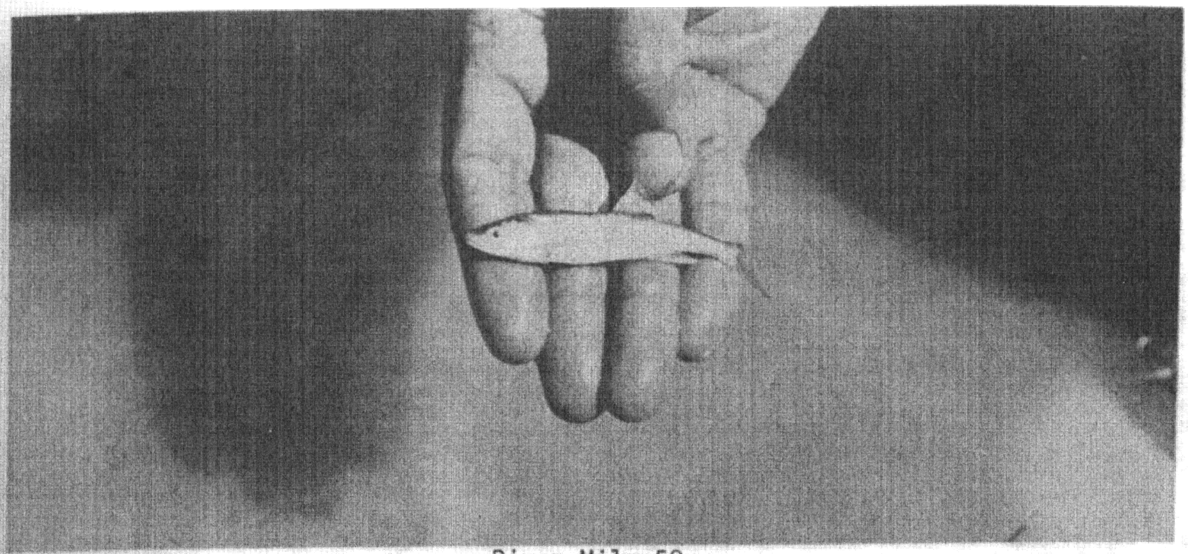


River Mile 58

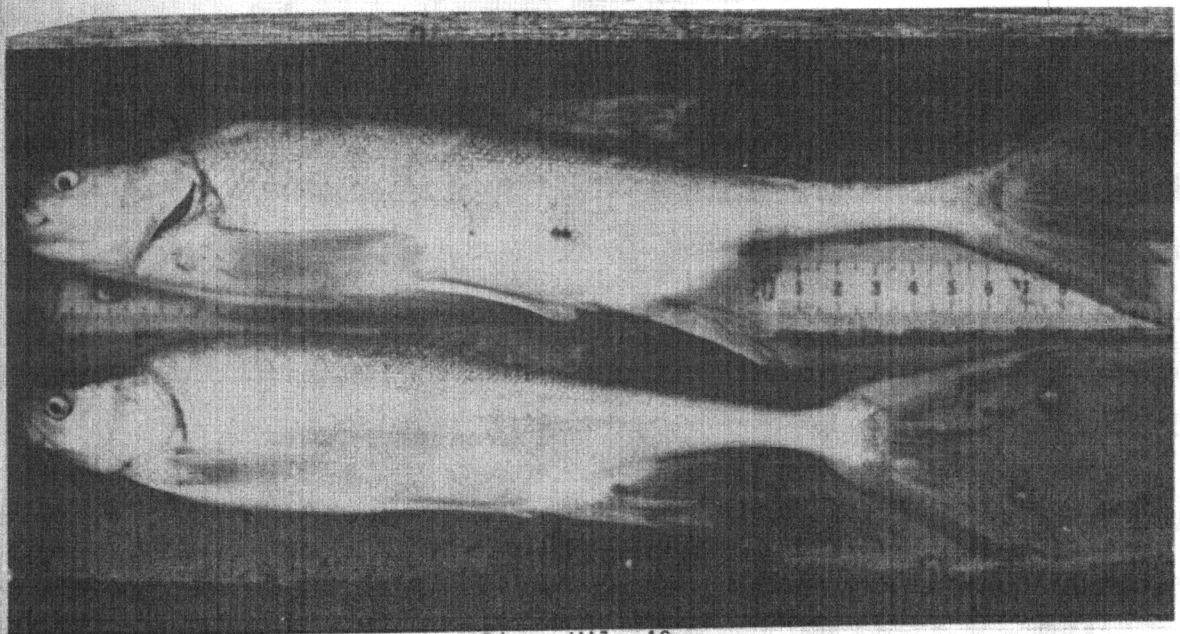


River Mile 58

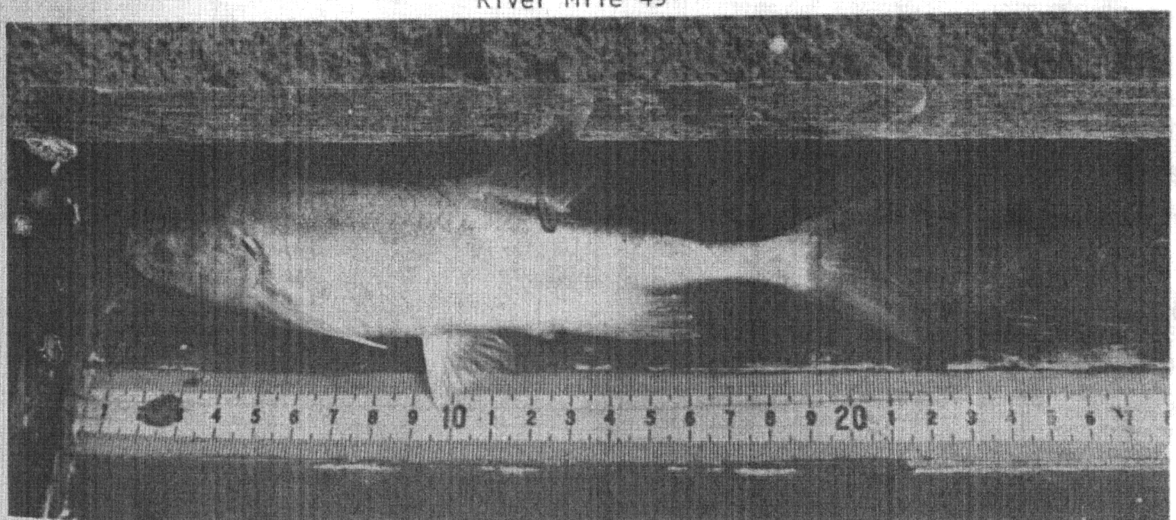
Figure 25. Continued



River Mile 58

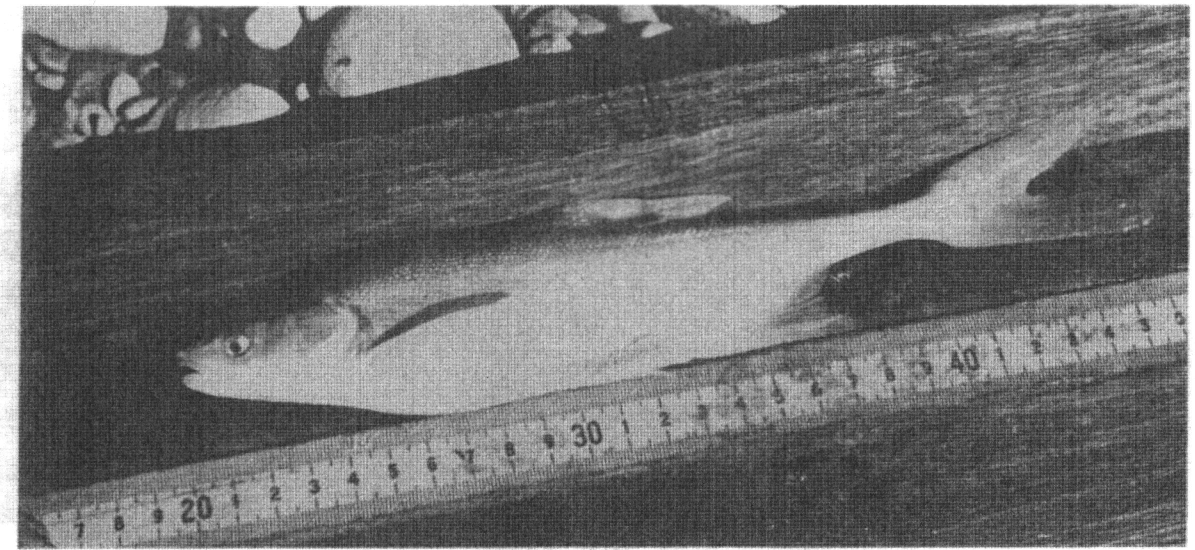


River Mile 49

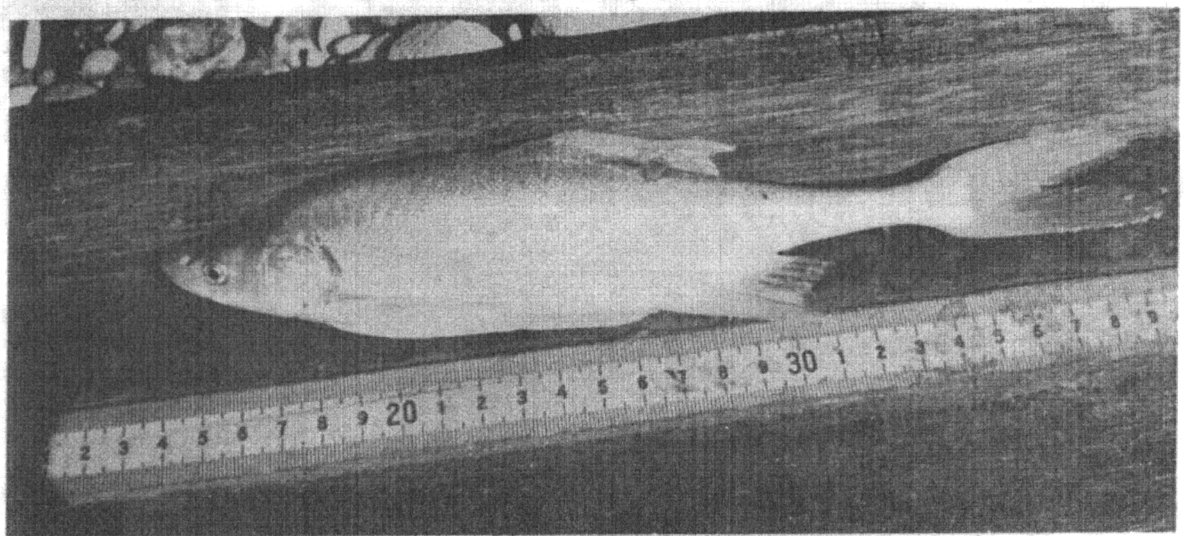


River Mile 46

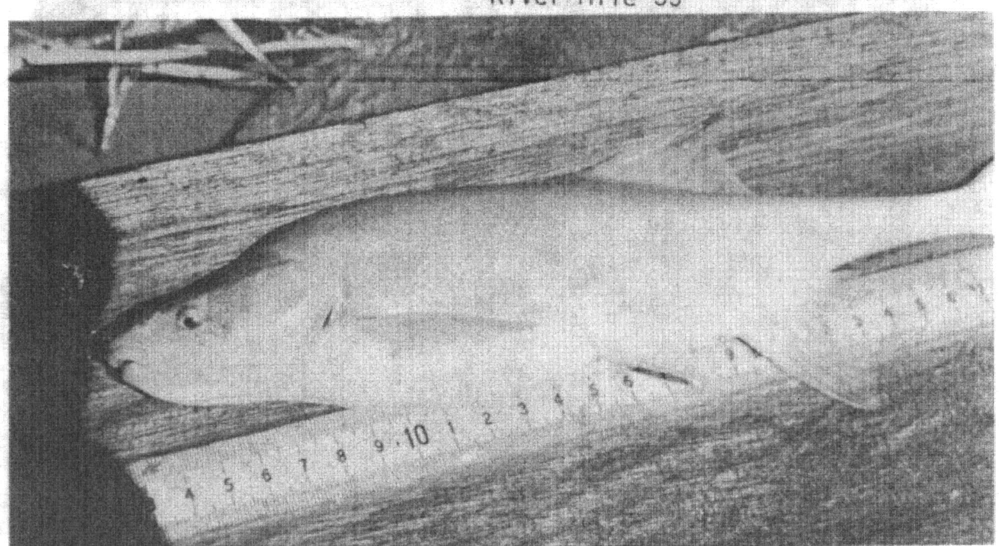
Figure 25. Continued



River Mile 35

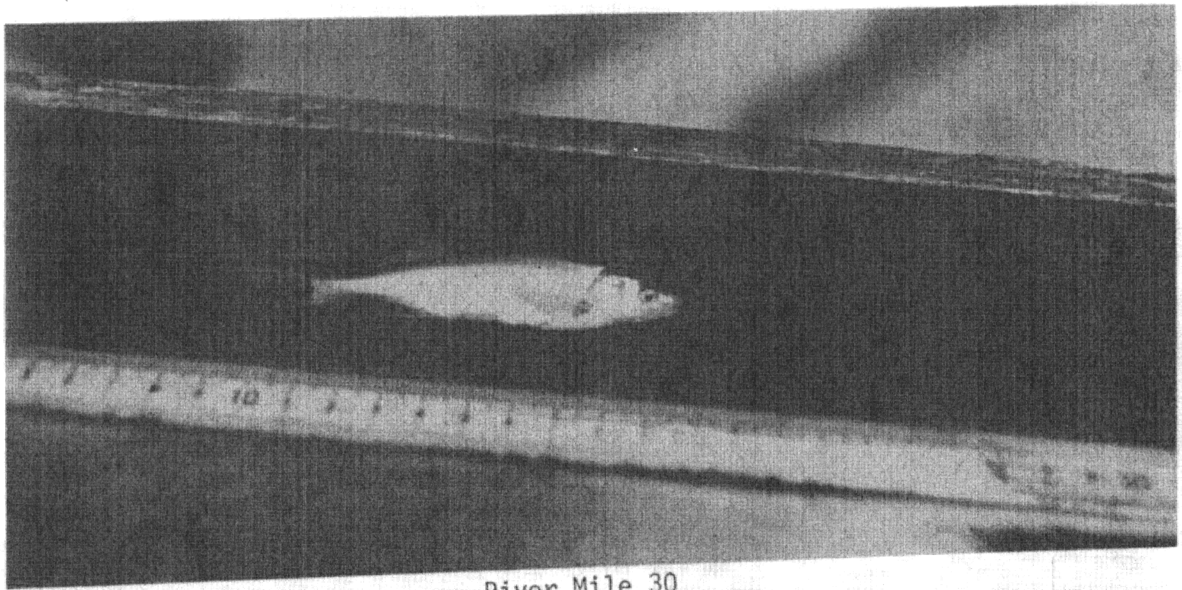


River Mile 35

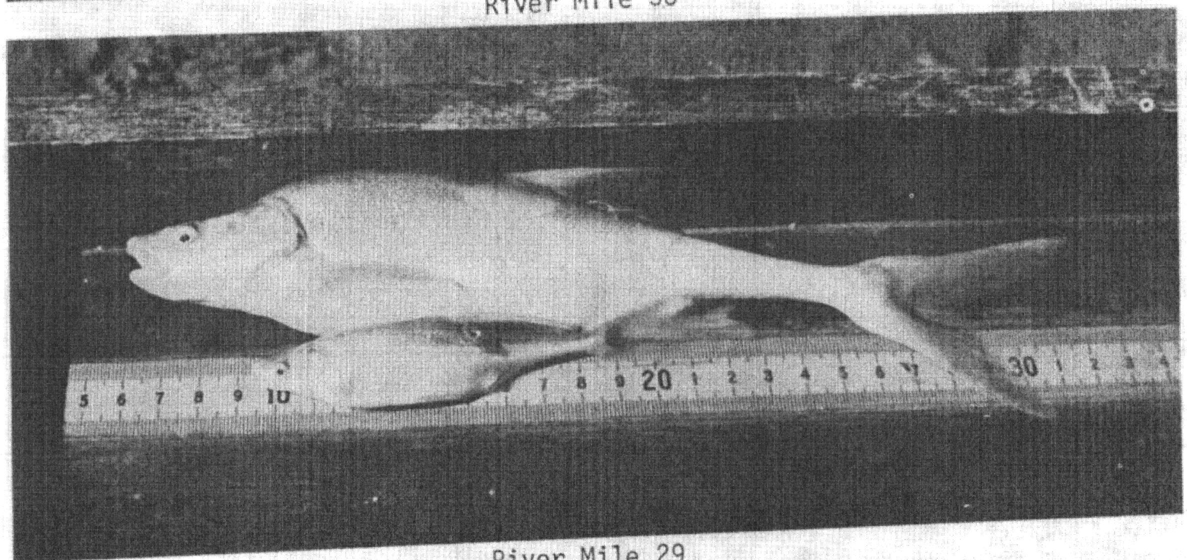


River Mile 35

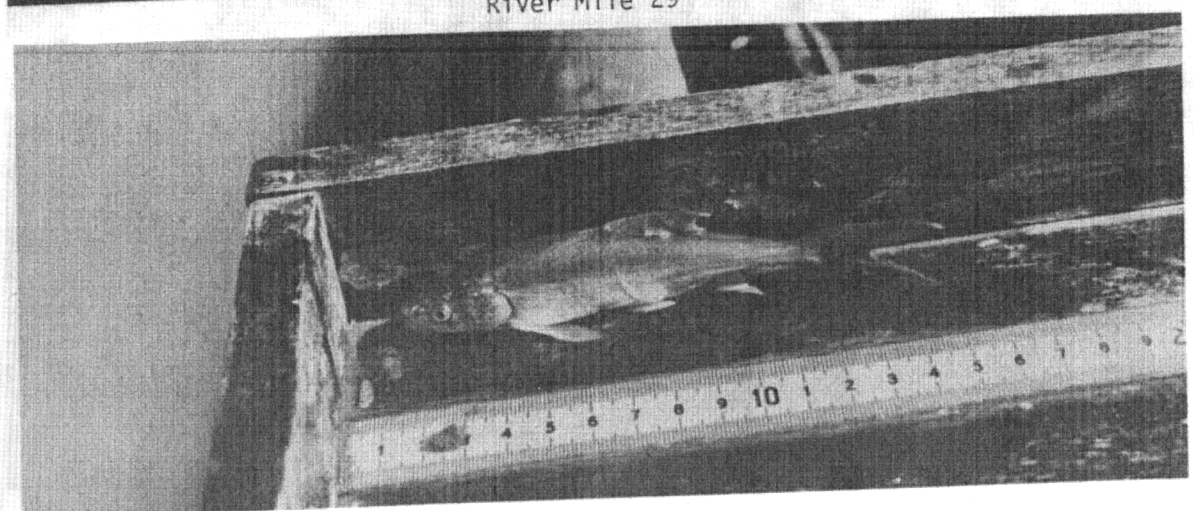
Figure 25. Continued



River Mile 30

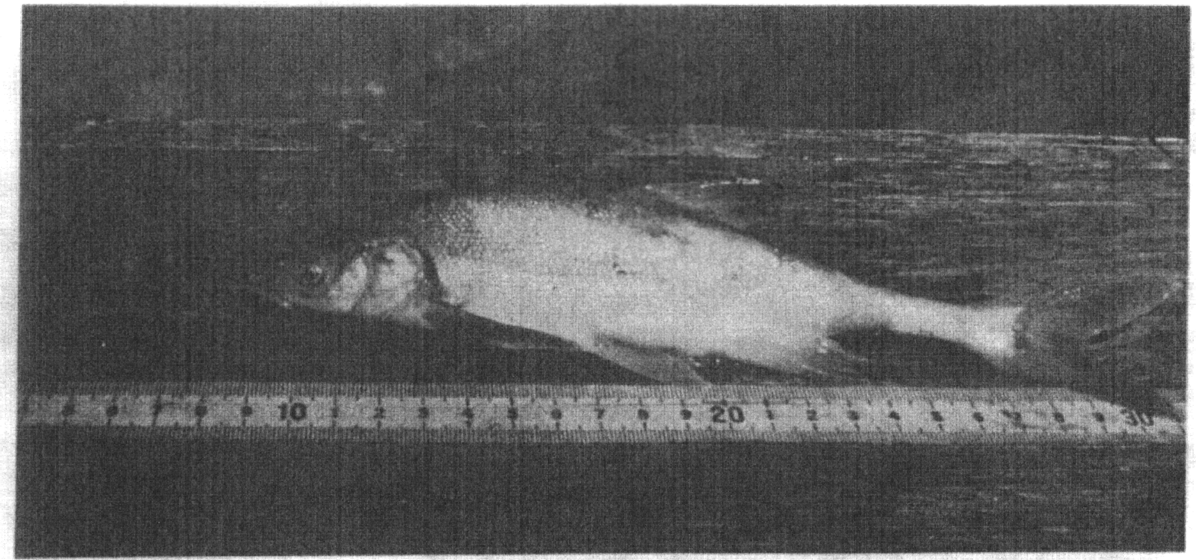


River Mile 29

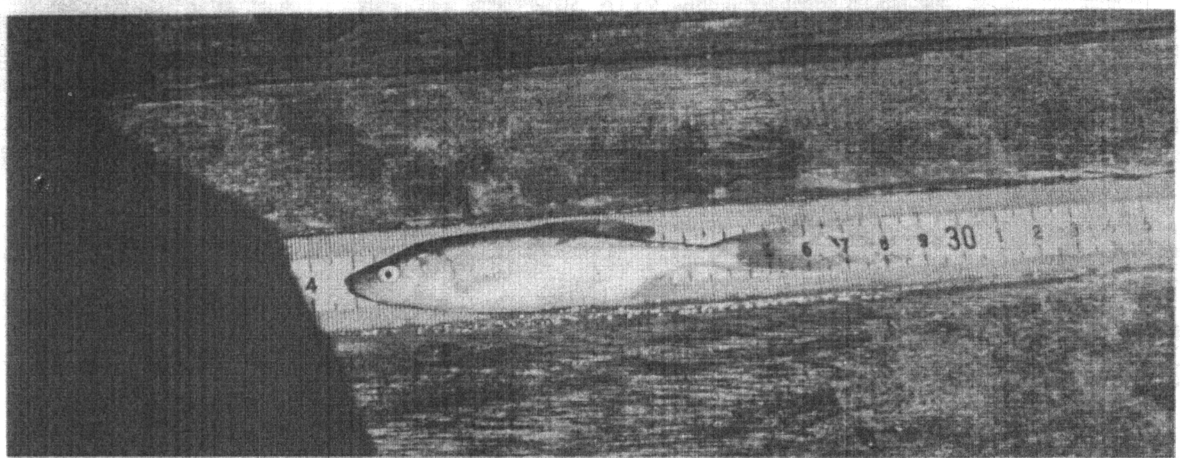


River Mile 29

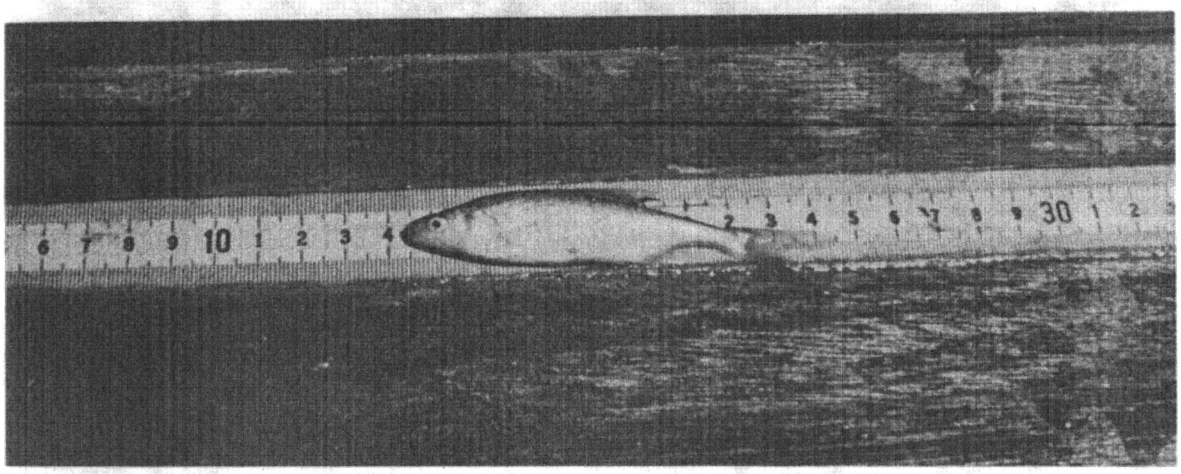
Figure 25. Continued



River Mile 28

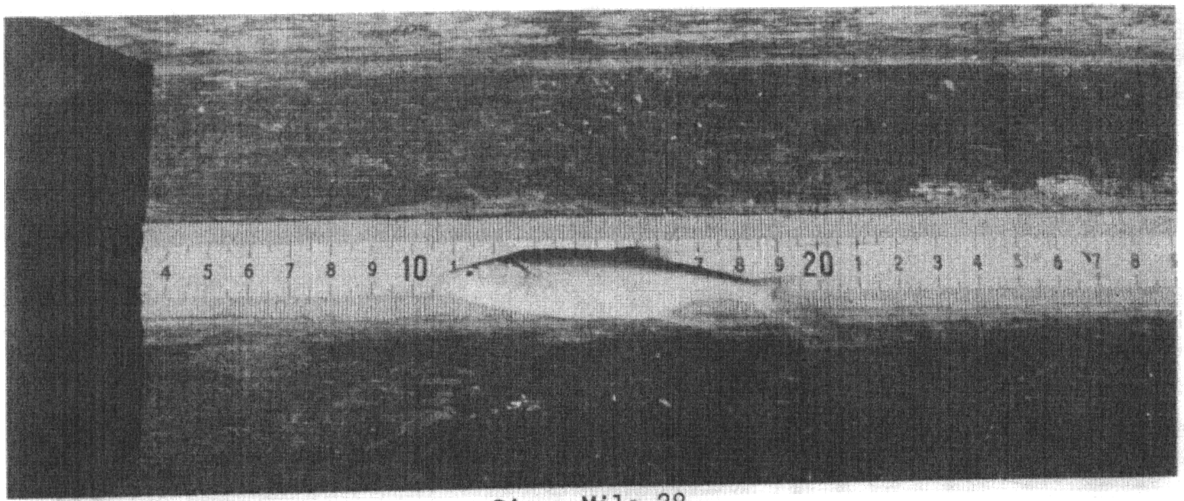


River Mile 28



River Mile 28

Figure 25. Continued



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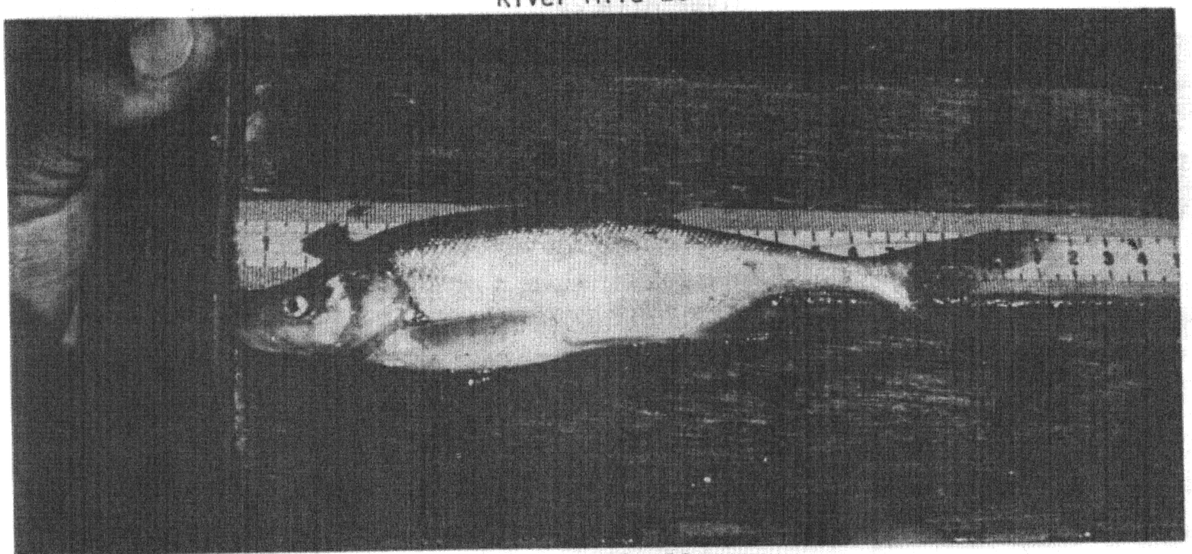

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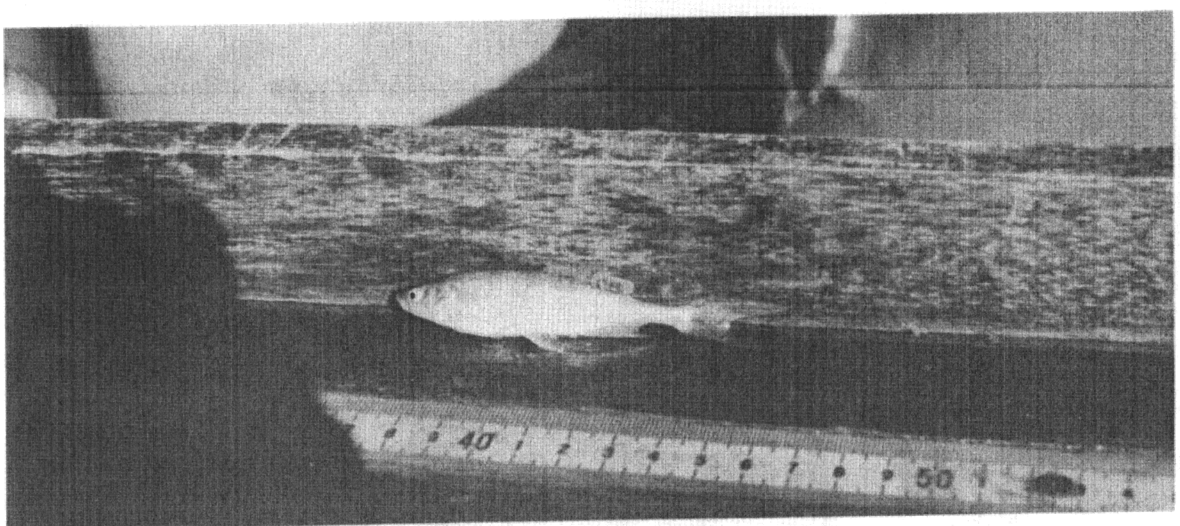
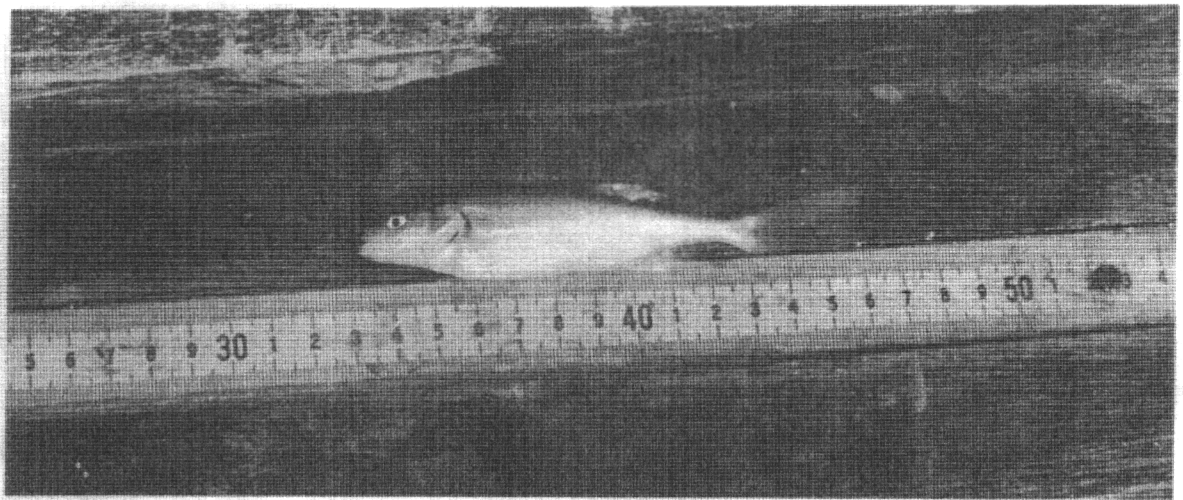
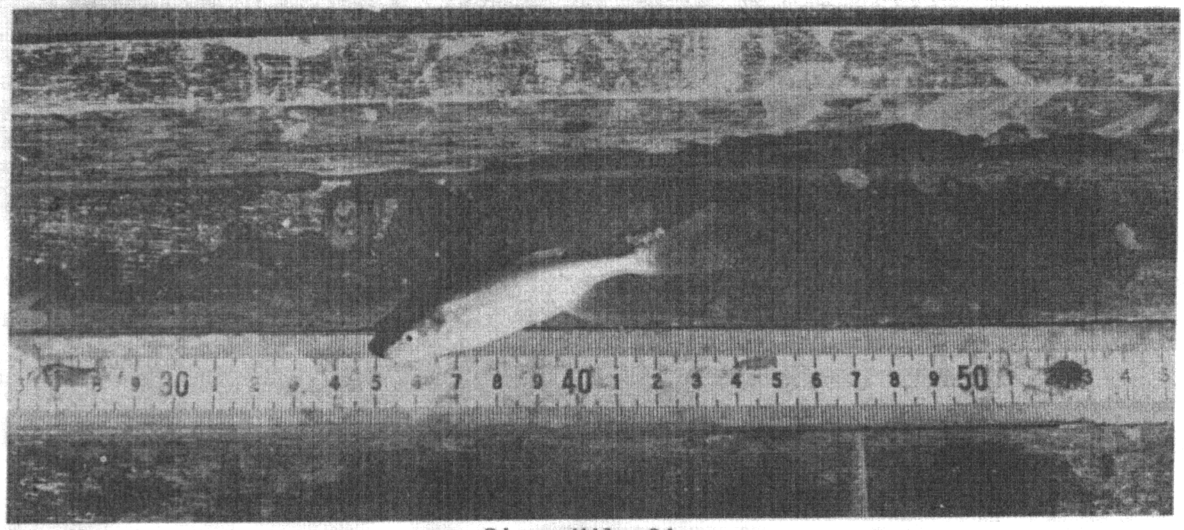


River Mile 27

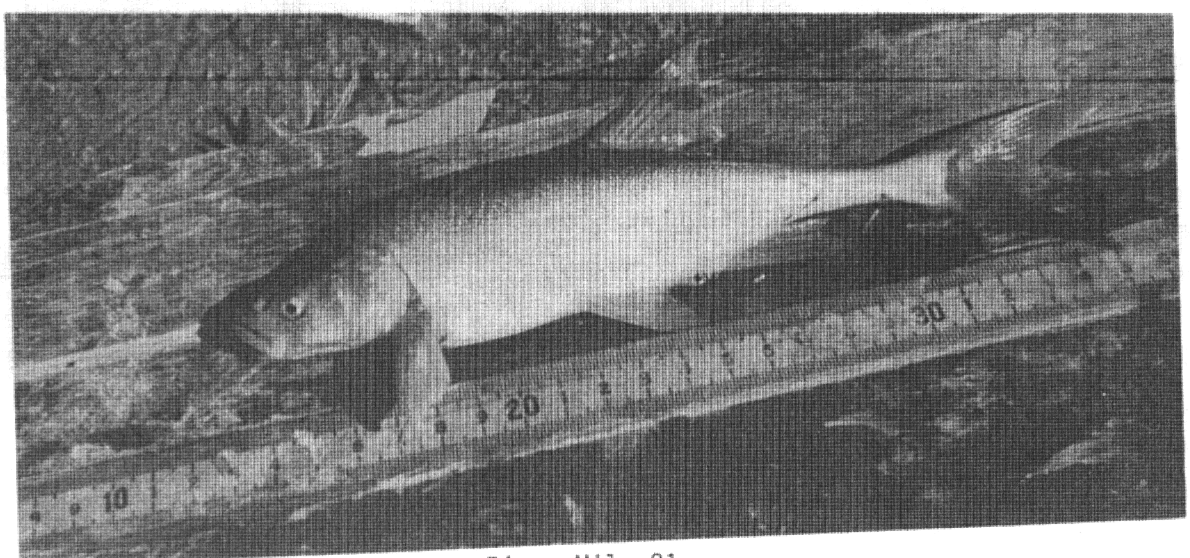
Figure 25. Continued



River Mile 24



River Mile 24



River Mile 21

Figure 25. Continued

APPENDIX IV

Backwaters Used by Young-of-the-year Colorado Squawfish

Figure 26. Aerial photographs of two backwaters used by young-of-the-year Colorado squawfish in Gray Canyon, Utah.