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Aquatic and Terrestrial
Resource Management and Problem Solving

Final Report

DOCUMENTATION OF CHANGES IN THE MACROINVERTEBRATE AND FISH POPULATIONS IN THE GREEN RIVER DUE TO INLET MODIFICATION OF FLAMING GORGE DAM

PR-16-5

by

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INTRODUCTION

Flaming Gorge Dam on the Green River of northeastern Utah became operational in November of 1962. A rainbow trout fishery was established in the first 26 miles of the dam's cold tailwaters in Utah. From 1963 until 1967 this section of river was considered one of the best cold water fisheries in the U.S. This fishery declined significantly in the late 1960's and 1970's and overly cold water temperatures were hypothesized to be the reason (Mullan et al. 1976). The dam, with its reservoir and cold tailwaters, along with a pre-impoundment fish eradication program, has been implicated as a major decimating factor of native Green River fish populations, especially those of the Colorado squawfish (*Ptychocheilus lucius*) and humpback chub (*Gila cypha*), presently considered "endangered" (Miller 1963, Seethaler 1978). Modifications of the penstock inlets of Flaming Gorge Dam were installed in early 1978 for the purpose of warming the tailwaters so the trout fishery could be improved. It was also anticipated that the warmer flows would enhance the conditions necessary for successful reproduction of the rare fish populations in Dinosaur National Monument, especially Colorado squawfish. These modifications became operational on June 30, 1978. The Water and Power Resources Service funded two studies to monitor the effects of the inlet modification. The Utah Division of Wildlife Resources (DWR) studied the trout fishery from the dam to the Utah border (29 miles below the dam, hereafter MBD); BIO/WEST, Inc., studied macroinvertebrates for 85 miles below the dam and the fishes for 75 miles below the Utah DWR trout fishery study area for three years.

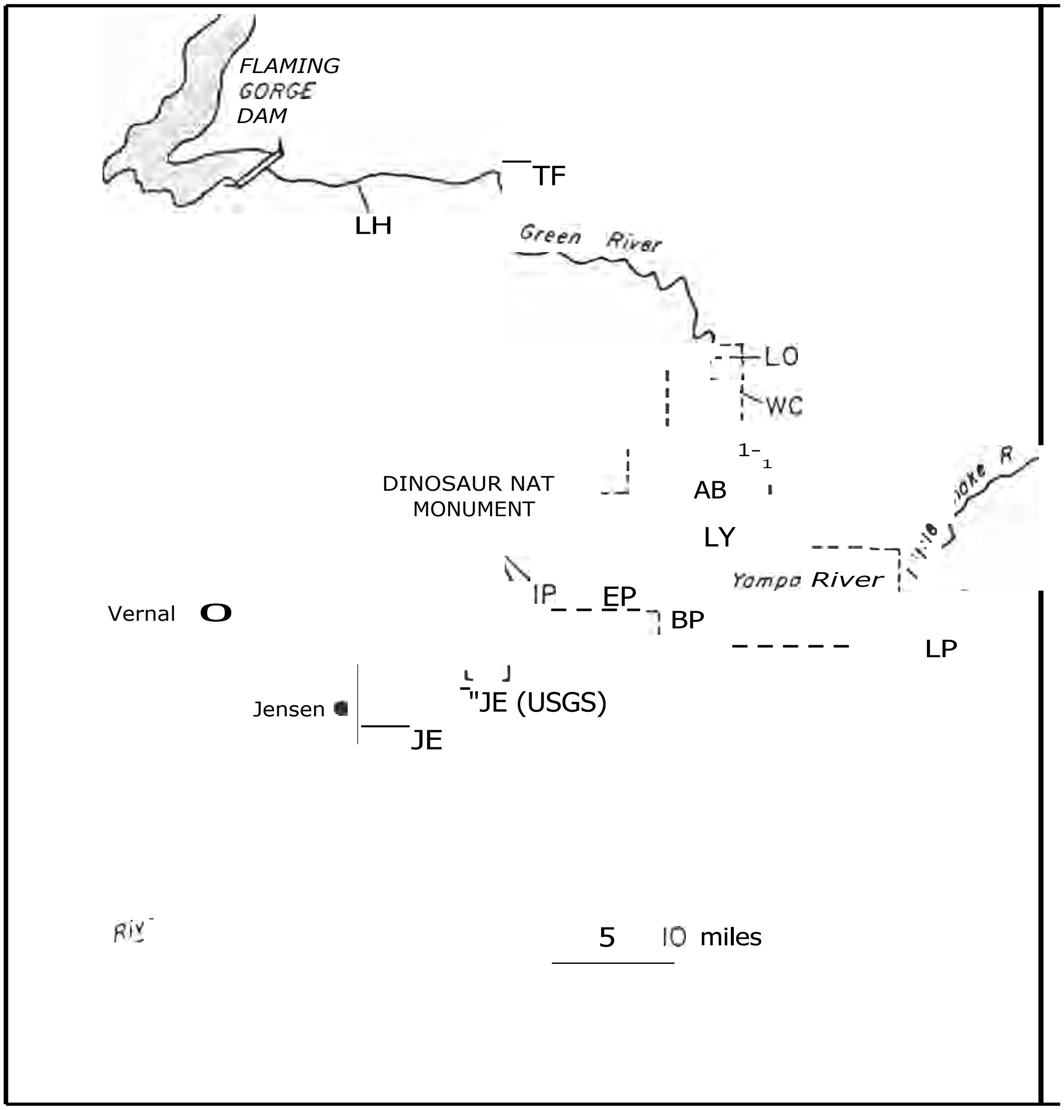
ition, Dinosaur National Monument and the U.S. Fish and Wildlife ice (Western Energy and Land Use Team, Ft. Collins, Colorado) lied additional funding to BIO/WEST for macroinvertebrate and fish fes on the Yampa River, a major tributary of the Green River (Figure The sampling stations established in the Yampa River were used as trol points for the Green River stations. Thi report details the !undertaken by BIO/WEST during this study. The objectives of the y were:

1. Document existing species composition and relative abundance of benthic macroinvertebrates and fishes.
- Compare the composition and relative densities of benthic macroinvertebrates before and after penstock modifications.
- Assess changes in the distribution and reproduction of native and introduced river fishes associated with altered temperature regimes.

STUDY AREA

The study area encompasses the Green River from Flaming Gorge Dam to near the town of Jensen, Utah, a distance of 110 miles, and the Yampa River from the mouth of Cross Mountain Gorge (Lily Park) to its mouth, a distance of 55 miles.

Macroinvertebrates were sampled at Little Hole (7 MBD), Taylor Flats (16.5 MBD), Wade and Curtis (49 MBD), and the Jensen U.S.G.S. gaging station (94 MBD) on the Green River, and the mouth of Cross Mountain Gorge in Lily Park, and Box Elder Park on the Yampa River (Figure 1).



KEY

INVERTEBRATE STATIONS

Little Hole (LH)
Taylor Flats (TF)
Wade and Curtis (WC)
Jensen (JE (USGS))
Box Elder (BP)
Lily Park (LP)

FISH STATIONS

Lodore (LO)
Alcove Brook (AB)
Echo Pork (EP)
Island Park (IP)
Jensen (JE)
Lower Yampa (LY)
Lily Park(LP)

Figure 1. Green and Yampa River study area showing sample stations.

All macroinvertebrate samples were taken from similar habitats; cobble, riffle areas.

Fishes were sampled at Lodore, Alcove Brook, Echo Park (mouth of Yampa River), Island Park, and Jensen in the Green River and at Lower Yampa and Lily Park in the Yampa River (Figure 1). A general description o? each of these sites follows; sketches of the stations are in Appendix I.

Lodore (46 MBD)

The river at this point is rather slow. Bottom substrate is almost 100% sand. At low flows the river is braided with many sand bar islands; at high flows it is bounded by high banks. Habitats are not very diverse; runs are predominant, with few eddies and backwaters. During high flows, the backwaters are washed out. Considerable daily fluctuation due to Flaming Gorge releases occurs at this station. The station is 1.2 miles long.

Alcove Brook (61 MBD)

This station, in the lower portion of Lodore Canyon, exhibits a variety of habitat types. The substrate is approximately 75% cobble-rubble and 25% sand. Pools and riffles are common. At low flows, cobble bars become exposed. Banks are often steep rock cliffs. Backwaters are relatively scarce. Considerable daily fluctuations due to Flaming Gorge release occurs at this station. The station is 1.0 miles long.

Echo Park (65 MBD)

This station begins just below the mouth of the Yampa River. The integrity (individual nature of the water) of both rivers is preserved (i.e., limited mixing) for over a mile below their juncture. Habitat is very diverse in this station, with riffles, pools, eddies, and backwaters all common. Also, Poo' Creek, a small, permanent, clear stream enters the Green River in this station. Substrate is nearly 50% cobble-rubble and 45% sand, with 5% silt along the shores and in backwaters. The station is 1.0 mile long.

Island Park (78 MBD)

The river breaks out of Whirlpool Canyon to form this area. Velocity is slower than in the canyon area, with 70% of the substrate composed of sand, 25% of cobble-rubble, and 5% silt. Much of the station is braided with sand islands in low water, although long riffles are found in the upper portion. Habitat is diverse, with an abundance of riffles, runs, backwaters, and eddies. The station is 1.0 mile long.

Jensen (110 MBD)

This station is located below the U.S. Highway 40 bridge and, similar to Lodore, has a 100% sand bottom. Habitat is not very diverse, with runs predominating, especially in high water. Backwaters around sand islands are common in low flows. Ashley Creek, a permanent, highly saline irrigation return stream enters this station, as does a drain from Stewart Lake, a waterfowl management area. These two streams, along with a dry wash, provide backwaters during high flows. The station is 1.5 miles long.

Lower Yampa

This station is located 1-2 miles above the mouth of the Yampa River. Substrate is primarily cobble (75%) with small areas of sand (25%). The area has riffles, runs, pools, and a few backwaters at low and medium flows. At high flows, most of the area becomes a swift run. The station is 1.2 miles long.

Lily Park

The Lily Park station starts at the mouth of Cross Mountain Gorge and extends downstream for about a mile. The area has almost totally a cobble substrate, and long riffles and runs predominate. Backwaters are scarce, especially during high flows.

A station in Split Mountain was sampled in 1978, but was dropped in 1979 and 1980 because it added little new information over surrounding stations.

METHODS

General

Three full years of seasonal field collections were made, 1978, 1979, and 1980. Sampling the first year was intended to determine pre-modification conditions; unfortunately, the study was not initiated early enough to obtain a full year's field data. Therefore, "before" conditions were determined with the aid of a literature review, as well as portions of the 1978 data.

Field sampling was conducted in March, June, August, and October of all years. A July sample was added in 1978 in an attempt to increase the amount of "before" data. Macroinvertebrates and fish samples were both taken during each sampling period. Yampa River samples were taken only in June, August, and October of 1978, and the Lower Yampa station was not sampled in March of 1979 and 1980 due to inaccessibility.

Macroinvertebrates

Macroinvertebrates were sampled in cobble-rubble substrates in a stratified random sampling design at each of the six stations. A Hess type invertebrate sampler was used to obtain a one square foot sample. Four samples were taken at each station. The samples were preserved in 70% ethyl alcohol in Whirl-Pak bags, and transported to BIO/WEST's lab for analysis. High water samples were avoided in the Green River above Echo Park by proper timing of collection, except at Wade and Curtis.

Samples containing fewer than 400-500 organisms were sorted in their entirety. Samples with larger numbers of organisms were initially sorted to remove large organisms such as stoneflies and any uncommon smaller organisms. The sample was then subdivided by a rotary device which portions the sample into eight equal subsamples. Subsamples were randomly chosen and counted. The number of subsamples enumerated was dependent on the numbers of organisms. Generally, the larger the numbers of invertebrates in a sample, the fewer the number of subsamples necessary. In each case, at least ¼ of each sample was picked to avoid errors which may result with organisms that tend to clump together (EPA 1973).

The invertebrates were identified to genus, or the lowest practical taxonomic level using a variety of taxonomic references (Merritt and Cummins 1978; Edmunds 1976; Baumann 1977; Musser 1962; Edmondson 1959; Wiggins 1977; Usinger 1956; Pennack 1953).

The results of the four benthic samples at each station were pooled and, from this, the mean, standard deviation and coefficient of variation were computed. Species diversity for each station was determined, using the Shannon Weaver species diversity index (EPA 1973).

Fishes

Fishes were collected using an electrofishing unit consisting of a 115 volt A.C. generator and a Coffelt Model II-C VVP, and seines (30' x 6' x ¼" and 15' x 4' x 1/8"). Electrofishing runs were timed, and the area seined was recorded. Fish were identified, enumerated, sufficient numbers measured to provide length-frequency data and all but a few reference specimens returned alive. Fish over 200 mm TL were tagged with coded Floy spaghetti tags. Rare fish were tagged with small modified Carlin dangler tags. Habitat type, substrate, and a sketch of the area sampled were recorded for each seine collection. Shocking runs usually covered a variety of habitats and substrates, so physical data recorded for these samples were more generalized.

When rare fish [Colorado squawfish, humpback chub, bonytail chub (*Gila elegans*), and humpback sucker (*Xyrauchen texanus*)] were captured, depth, velocity, substrate and habitat type were measured at the exact location of capture (see Appendix IV for data).

The pattern of sampling at each station was similar during each sampling period within the confines of the station as indicated above. The intent of the study was not to catch every fish possible, but rather to representatively sample all available habitats, with emphasis on locating all the species present, especially young fish. Each station was sampled intensively for about 4 hours, with areas above and below the station being sampled less intensely for up to 2 additional hours. This latter effort was aimed at finding rare fish.

Additional samples were taken at Lodore and Alcove Brook in March 1979 to test the efficiency of sampling under a high and a low river flow. The Water and Power Resources Service provided flows of 1200 cfs for low flow samples and 4000 cfs for high flow samples. The flows were produced on consecutive days at each of the stations, thus decreasing the chance that fish populations had changed between the samplings. Sampling areas and procedures were the same for the two samples within each station. Data given in the text of this report refers to the catch during the 1200 cfs flow unless otherwise noted, since most samples were taken at Lodore and Alcove Brook during low flows.

PRE-MODIFICATION CONDITIONS - LITERATURE REVIEW

Tem erature and Flow

The Green River in the study area can be analyzed in three time periods based on temperatures and flows prior to 1978. The first period was before closure of Flaming Gorge Dam when the river was natural. Temperatures at Greendale, Utah, one-half mile below the dam site, and those at the Jensen U.S.G.S. gage, 94 miles downriver, were similar (Tables 1 and 2). Flows at Jensen wer higher due to the inflow of the Yampa River between those points (Figure 1, Tables 1 and 2).

The second period was from 1963 until 1967, when the dam was closed and the reservoir was filling. The natural low, cold flows of winter, and high, warm flows of spring and early summer were replaced with fairly constant, cold, low flows year-round at Greendale (Table 1). Daily fluctuations due to power demands replaced the unaltered, seasonal pattern. Below the mouth of the Yampa River, temperatures were more natural (Table 2) as the Yampa ameliorated the cold, low flows of the Green (Vanicek, Kramer, and Franklin 1970).

The third period includes 1967 to 1978, after the reservoir was filled, stabilized and normal operational procedures were initiated. Temperatures of the outlet waters were slightly cooler than those of the 1963-66 years. Flows were increased considerably though, nearly double the 1963-66 levels for most months of the year (Table 1). As a result, temperatures below the mouth of the Yampa declined slightly in mid-summer (Table 2) because the Yampa was less able to compensate for the higher, colder flows of the Green.

Macroinvertebrates

The closing of Flaming Gorge Dam in 1962 and the resulting altered temperature and flow regimes since that time have had a definite effect on a portion of the Green River (Pearson 1967). Prior to 1962, at least

Table 1. Mean daily flow (cfs) and temperature (°C) for the Green River at Greendale, Utah (0.5 MBD), 1951-1977 (U.S.G.S. data).

	1951-62		1963-66		1967-77	
Month	Flow	Temp.[1]	Flow	Temp.	Flow	Temp.
Jan.	597	0.6	1497	5.0	2507	5.4
Feb.	792	0.6	1641	3.2	2265	4.4
Mar.	1413	2.2	1410	3.3	1692	4.3
Apr.	2752	7.2	1578	3.8	1765	4.4
May	4462	11.1	1009	4.6	2512	4.6
June	6996	15.5	1155	5.7	2535	5.0
July	3375	21.1	1178	6.9	2625	5.6
Aug.	1635	20.0	1128	7.8	2748	6.6
Sept.	913	15.5	1281	7.9	2327	7.6
Oct.	920	10.0	1192	10.0	2294	8.3
Nov.	814	1.7	1395	12.6	2501	9.0
Dec.	628	0.6	1511	8.7	2832	7.9

[1] Data for 1957-59 only.

Table 2. Mean daily flow (cfs) and temperature (°C) for the Green River at Jensen, Utah (94 MBD), 1951-1977 (U.S.G.S. data).

	1951-62		1963-66		1967-77	
Month	Flow	Temp.[1]	Flow	Temp.	Flow	Temp.
Jan.	955	0.6	1992	0.0	3106	1.1
Feb.	1222	0.6	2192	0.9	2930	2.6
Mar.	2590	2.2	2596	3.9	2962	5.5
Apr.	6513	8.9	4211	8.8	4847	9.2
May	12159	13.3	7695	13.8	10833	13.0
June	13939	17.8	6898	16.8	10815	16.7
July	5189	22.2	2671	20.1	4789	19.2
Aug.	2238	21.1	1679	19.2	3283	17.7
Sept.	1274	17.8	1742	15.6	2620	15.5
Oct.	1444	10.0	1660	11.9	2853	9.9
Nov.	1333	3.3	1645	7.2	3093	5.4
Dec.	1005	1.1	1908	1.1	3322	2.5

[1] Data for 1957-59 only.

66 different macroinvertebrate forms inhabited the Green River between the site of Flaming Gorge Dam and Ouray, Utah (Table 3) (Binns 1965). After closure of the dam, 52 invertebrate taxa were recorded in the same study area between 1962 and 1965 (Table 3). Thirty-eight of these taxa were found both above and below the confluence of the Green and Yampa rivers. Seven taxa were found only above the confluence and seven taxa were found only below the confluence. Pearson et al. (1968)) indicated that the macroinvertebrate community had not been markedly altered below the mouth of Lodore Canyon (65 MBD), though profound changes occurred in its composition near the dam.

Little data is available on macroinvertebrate populations in the Green River since 1965. However, a study by Pearson in 1967 on benthic composition at Little Hole indicated considerable changes in macroinvertebrate populations since 1965 (Table 3). The number of samples taken in 1967 was only 13, therefore, the invertebrate community may not have been adequately sampled.

Fishes

The Green River, prior to Flaming Gorge Dam, was inhabited with the normal complement of Colorado basin large river fishes and several exotics (Bosley 1960; Smith 1960; McDonald and Dotson 1960; Vanicek, Kramer, and Franklin 1970) (Table 4). Most of the pre-impoundment studies (before 1962) were not as thorough as was the post-impoundment study of Vanicek, Kramer, and Franklin (1970) and other more recent studies (Holden and Stalnaker 1975; Seethaler, McAda, and Wydoski 1976).

Table 3. Occurrence of invertebrates in the Green River (Utah and Colorado), 1962-1977.

	Reported before 1962	Reported 1964-65		Reported 1967-77	
		Above Yampa River	Below Yampa River	Above Yampa River[1]	Below Yampa River
Coleoptera					
Haliplidae					
Dytiscidae					
Gyrinidae					
Hydrophilidae					
Hydraenidae					
Dryopidae					
Lampyridae					
Heteroceridae					
Helodidae					
Odonata					
Argia					
Megaloptera					
Corydalus					
Hemiptera					
Gerridae					
Notonectidae					
Naucoridae					
Corixidae					data
Nematoda					
Ol					
Hirudinea	x				
Amphipoda					
Hyalella					
Gammarus					
Hydracarina					
Diptera					
Blepharoceridae					
Tipulidae					
Psychodidae					
Simuliidae					
Chironomidae					
Ceratopogonidae	x				
Stratiomyidae					
Tabanidae					
Rhagionidae					
Anthomyiidae					
Empididae					
Muscidae					

[1] Incomplete data; based only on a series of samples from Little Hole.

[2] Reported as *Baetis* sp. ... by Pearson (1967).

[3] Reported by Binns 1965; this record questionable (Pearson et al.

Table 3. Continued

	Reported before 1962	Reported 1964-65		Reported 1967-72	
		Above Yampa River	Below Yampa River	Above Yampa River	Below Yampa River
Ephemeroptera					
Siphlonurus	X				
Genus et species novum					
Isonychia					
Lachlania powelli	X		X		
Heptagenia	X		X		
Rhithrogena	X				
Pseudiron	1				
Ametropus albrighti	X		X		
Callibaetis	X	X			
	X	X			
			X		
Brachycercus	X	X	X		
Tricorythodes minutus					
Tricorythodes sp.	X	X			
Ephemerella		X	X		
Leptophlebia	X				
Paraleptophlebia callioes		X			
Choroterpes					
Traverella			X		
Pentagenia?					
Ephemera	X				
Ephoron album					
Pseudocloeon					
Plecoptera					
Isoperla	X	X			
Isogenoides					
Acroneuria abnormis					
Claassenia					
Perlesta placida					
Pteronarcidae					
Nemouridae					
Trichoptera					
Cheumatopsyche					
Hydropsyche			X		
Hydroptila					
Leptocerus			X		
Brachycentrus					

Table 4. Presence (X) and reproductive success (R) of fishes in the Green River from Flaming Gorge Dam to Jensen, Utah (110 MBD), 1959-1977.

Species	Above Yampa			Below Yampa		
	1959-60[1]	1963-66[2]	1967-77	1959-60[1]	1963-66[2]	1967-77[3]
Salmonidae						
Rainbow trout		X			X	X
Brown trout		X			X	X
Cutthroat trout						X
Mountain whitefish						X
Cyprinidae						
Utah chub						
Roundtail chub	R	R		R	R	
Bonytail chub	R			R	R	X
Humpback chub	R	X		R	X	X
Colorado squawfish	R	X[5]		R	R	X
Speckled dace	R	R[4]		R	R	R
Redside shiner	R?	R[4]		R	R	R
Fathead minnow	R?	R		R	R	R
Red shiner						R
Carp	R	R[4]		R		R
Creek chub		X			R	R
Catostomidae						
Flannelmouth sucker	R	R[4]		R	R	R
Bluenead sucker	R	R[4]			R	R
White sucker						X
Razorback sucker	X			R?	X	X
Ictaluridae						
Channel catfish	R?	X		R	R	R
Black bullhead	R	X		R	R	X
Centrarchidae						
Green sunfish					X	X
Percidae						
Walleye				X	X	
Cottidae						
Mottled sculpin	X			R?	X	R

[1] Data from McDonald and Dotson (1960); Bosley (1960); and Vanicek, Kramer, and Franklin (1970).

[2] Data from Vanicek, Kramer, and Franklin (1970).

[3] Data from Holden (1973), Holden and Stalnaker (1975), and Seethaler, McAda, and Wydoski (1976).

[4] Reproduced in 1965 only.

[5] Fairly uncommon in the 1-2 miles immediately above the mouth of the Yampa River.

Vanicek, Kramer, and Franklin (1970) studied the distribution of fishes in the Green River below the dam from 1963 to 1966. Their study showed that several native species, notably Colorado squawfish, were not found above the mouth of the Yampa River, except for the 1-2 miles immediately above the Yampa's mouth (unpublished data sheets, Utah Coop. Fish Unit). They indicated that reproduction of all native species was doubtful, in this area, except in 1963 and 1965 (Table 4) when flows were low and temperatures high. Below the mouth of the Yampa River, native fish reproduction, including Colorado squawfish, was similar to before the dam, prompting Vanicek, Kramer, and Franklin (1970) to conclude that the dam had not affected native fishes below that point.

Studies conducted from 1969-1971 found no young-of-the-year Colorado squawfish in the Green River from Echo Park to Jensen (Holden and Stalnaker 1975), an indication of failure to reproduce successfully. Seethaler, McAda, and Wydoski (1976) supported this observation in the mid-1970's. Both of these recent studies concentrated in the area below the mouth of the Yampa River. There is little data available for the Green River above the mouth of the Yampa River for the period 1967-1977. Comparison of 1967-77 flow and temperature data for this area, with that of the 1963-66 information (Table 1), would suggest that fish presence would have been similar to what Vanicek, Kramer, and Franklin (1970) found, but that reproduction of native fishes above the mouth of the Yampa probably did not occur because of cold temperatures. Therefore, the 1967-77 portion of Table 4 was left blank and data from the field portion of this study will be used to fill in this gap.

FIELD RESULTS

General

The field results of this study are presented in this report to show changes since inlet modification in June 1978. Therefore "before" data include the March, June, and July samples of 1978. July was included for it was assumed that fishes would not react that quickly to the warmer flows and the data tend to support that assumption. The major comparisons made are between years to show what changes occurred. Differences in samples between the various months of a year, except for 1980, are not discussed in detail here, but were discussed in the annual reports for 1978 and 1979 (Holden and Crist 1979, 1980). Therefore, this report focuses on the major results of the study.

Physical Factors

Table 5 summarizes the temperatures and flows of the Green River at Greendale and Jensen for the three years of the study. Releases from the dam were considerably lower in 1978 than the mean for 1967-1977 (Table 1). Flows in 1979 were higher than the 1967-1977 norm in February through April, but lower in May through October. Flows in 1980 were also high in January and February, but were fairly low March through July, especially in June and July when compared to the other two years. Flows in August and September 1980 were slightly higher than 1979 levels.

Temperatures at Greendale increased markedly in June of 1978, when inlet modifications became operational. Since that time,

Table 5. Mean daily flow (cfs) and temperature (°C) for the Green River at Greendale (0.5 MBD) and Jensen (94 MBD), Utah, 1978-1979 (U.S.G.S. unpublished records).

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.
Greendale, Utah											
Flow	1978	1229	1266	1610	1243	1075	1649	2030	1713	1542	
	1979	2248	2836	2349	2083	1464	1468	2022	1539	1400	1274
	1980	2292	2286	1687	1371	1047	1216	1360	1618	1657	
Temperature	1978	6.1	-	4.5	4.5	4.3	7.6	13.2	13.1	13.2	-
	1979	-	4.5	4.5	4.8	8.3	10.5	12.7	12.7	12.7	12.3
	1980	4.0	4.0	4.0	4.4	7.2	10.6	12.8	13.0		
Jensen, Utah											
Flow	1978	1628	1679	2715	5274	9538	13540	6003	2459	1990	
	1979	2713	3393	3356	5570	11198	10550	4456	2238	1633	
	1980	2721	3680	3174	5441	13390	9772	3225	1942	1931	
Temperature	1978	1.0	1.5	6.2	9.4	12.2	-	20.0	19.6	16.0	
	1979	0	2.7	4.9	9.6	17.1	19.5	23.6	21.1	19.3	12.3
	1980	3.1	2.7	5.8	9.2	9.9	13.9	22.3	21.3	17.0	11.5

substantially warmer flows have been released from April through October (Table 5).

Macroinvertebrates

Total Abundance

Spatial Trends. Total mean abundance of macroinvertebrates for each station by sample period is summarized in Table 6. Highest densities during each sample period usually occurred at either Little Hole, Taylor Flats, or Wade and Curtis on the Green River above the confluence with the Yampa River.

Seasonal Trends. Stations located on the Yampa River (Boxelder and Lily Park) and at Jensen on the Green River exhibited seasonal patterns of total abundance with lowest densities occurring during the spring runoff and highest densities occurring during the late summer and early fall. Stations located on the Green River above the Yampa River did not exhibit well defined seasonal patterns of total abundance.

Annual Trends. Yearly changes in total numerical abundance of macroinvertebrates were noted during the span of this study at Little Hole and Taylor Flats. Total densities increased from 1978 to 1979, then decreased in 1980 to levels only slightly above 1978 populations. Single classification analysis of variance indicated that there was a significant difference in total densities from 1978 to 1980 at these stations. Changes in total densities may also have occurred at Wade and Curtis on the Green River between 1978-1980. However, wide variation in sample abundances due to sampling at widely different

Table 6. Total mean abundance of benthic invertebrates for each station and sample period, 1978, 1979, 1980.

	1978					1979				1980			
	Mar.	June	July	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Green River													
Little Hole													
x̄ =	65,309.5	9,182.0	10,527.4	15,404.0	6,307.9	11,433.4	12,346.2	56,629.0	18,655.9	13,207.8	8,163.6	1,895.6	12,624.5
s =	34,168.4	2,115.2	4,908.5	6,318.6	2,712.6	3,728.6	5,648.4	44,181.0	3,541.9	4,884.6	7,527.0	2,305.2	5,322.1
C.V. =	.52	.23	.47	.41	.43	.33	.46	.78	.19	.36	.90	1.20	.42
Taylor Flats													
x̄ =	24,025.8	5,947.3	700.0	3,283.0	22,077.5	25,176.8	18,510.0	49,655.0	22,967.0	10,180.9	14,639.4	5,283.1	24,206.9
s	8,650.7	2,787.9	312.2	2,422.0	6,060.3	10,065.3	7,233.0	16,983.9	9,386.0	3,965.6	4,352.7	3,432.0	3,217.8
C.V.	.36	.47	.45	.77	.27	.40	.39	.34	.41	.38	.30	.64	.20
Wade and Curtis													
x̄	7,513.5	9,171.2	1,410.1	753.5	18,046.3	2,495.0	17,317.2	12,596.8	4,272.0	226.0	17,518.5	8,212.0	212.1
s	4,134.9	3,547.9	302.5	328.3	7,439.2	586.4	2,893.5	4,011.8	1,417.8	130.5	12,549.4	3,588.4	108.5
C.V. =	.55	.39	.21	.44	.41	.24	.19	.32	.33	.57	.72	.40	.51
Jensen													
x̄ =	23,358.5	91.5	958.0	1,335.0	8,320.8	1,864.3	172.0	11,612.9	6,746.2	3,173.5	1,047.4	8,884.7	10,199.2
s =	6,627.4	37.7	243.3	344.5	4,331.5	517.7	89.2	2,552.7	3,821.5	1,090.4	923.4	4,266.8	3,932.1
C.V. =	.28	.41	.25	.26	.52	.28	.52	.22	.57	.30	.88	.50	.40
Yampa River													
Lily Park													
x̄ =		689.0		5,920.3	2,405.8	1,530.6	801.1	5,508.6	4,354.8	957.8	667.4	5,837.5	8,559.9
s		426.3		3,003.2	1,431.6	1,121.6	221.5	1,703.2	1,847.3	1,367.5	356.9	1,138.2	888.8
C.V. =		.62		.51	.60	.73	.28	.31	.42	1.40	.53	.19	.10
Boxelder Park													
x̄ =		19.0		3,315.4	3,035.5		109.7	2,900.0	5,286.0		16.1	2,907.4	7,345.5
=		10.2		2,863.3	1,765.3		76.3	851.6	3,573.5		26.4	3,305.3	3,570.5
C.V. =		.54		.86	.58		.70	.29	.67		1.63	1.20	.48

[1]Includes 35,339 copepods.
[2]Includes 4,305 copepods.
[3]Includes 7,212 copepods
[4]S [illegible] relatively new substrate

x̄ - mean
S - standard deviation
C.V. - coefficient of variation

flows made comparisons unrealistic and caused statistical testing to show non-significant differences. Stations on the Yampa River and at Jensen on the Green River did not show significant differences in total densities between years.

Species Occurrence and Distribution

Spatial Trends. Occurrence of individual taxa for each station from 1978 through 1980 is listed in Table 7. Individual taxa densities for each sample period from 1978 to 1980 are presented in Table 27 of Appendix II. *Baetis* spp., *Simulium* sp., Chironomidae, and *Gammarus lacustris* all exhibited highest densities near the dam at Little Hole (7 MBD) and Taylor Flats (16.5 MBD) (Figure 2) and were the dominant taxa present at these stations. Wade and Curtis (49 MBD) supported many of the same taxa as Little Hole and Taylor Flats (Table 7). However, greater numbers of organisms which occurred sporadically at the upper two stations such as *Ephemerella inermis*, *Brachycentrus* sp., *Hydropsyche* sp., and *Hydroptila* sp. were often observed at this station. Dominant taxa at Wade and Curtis included *Baetis* spp., Chironomidae and *Brachycentrus* sp. Stations on the Yampa River and the lower Green River (Jensen) supported many additional taxa, primarily Ephemeroptera and Trichoptera, not found in the Green River immediately below Flaming Gorge. Dominant taxa at these stations varied seasonally, dependent on the life histories of the organisms involved. *Baetis* spp. and Chironomidae tended to dominate spring and early summer samples while seasonally abundant species such as *Traverella albertana*, *Tricorythodes* spp., *Hydropsyche* sp., and

Table 7. Occurrence of taxa for each station and year of Fl[redacted] study, 1978, 1979, and 1980.

	Little Hole			Taylor Flats			Wade and Curtis			Jensen			Lily Park			Boxelder		
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Ephemeroptera																		
Ameletus												X						
Anapeorus rusticus												X			X			
Baetis spp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Choroterpes sp.										X	X	X	X		X	X	X	X
Cinygma sp.																	X	
Dactylobaetis warreni	X			X						X		X	X		X	X		X
Ephemerella inermis	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ephoron album											X	X	X	X	X		X	
Heptagenia sp.	X							X	X	X	X	X	X	X	X	X	X	X
Lachlania powelli												X		X				
Paraleptophlebia pallipes										X			X					
Paraleptophlebia sp.						X			X									
Pseudocleon sp.													X			X		
Rhithrogena sp.			X	X		X	X			X	X	X	X	X	X	X	X	X
Traverella albertana							X	X	X	X	X	X	X	X	X	X	X	X
Tricorythodes sp. I				X	X	X		X	X	X	X	X	X	X	X	X	X	X
Tricorythodes sp. II									X	X	X	X	X	X	X	X	X	X
Plecoptera																		
Acroneuria abnomis							X					X						
Chloroperlidae						X												
Classenia sabulosa												X		X			X	X
Cultus sp.												X						
Isogenoides elongatus	X			X	X		X		X	X	X	X	X	X	X	X	X	X
Isoperla bilineata								X	X			X		X	X		X	
Isoperla ebria												X						
Malenka sp.					X	X								X				
Neoperla sp.															X			

	I e.			Taylor			and Curtis											
	1978	1979	1980	1978	1979	1980	1978	1919	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Plecoptera (Continued)																		
Perlesta placida				X												X		
Perlodidae											X			X			X	
Taenionema sp.															X			
Trichoptera																		
Brachycentrus sp.	X				X		X	X	X		X	X	X	X	X	X		
Cheumatopsyche sp.							X				X	X	X	X	X	X	X	X
Culoptila sp.												X		X	X		X	X
Helicopsyche borealis															X			
Hydropsyche sp. I	X		X		X	X	X	X	X		X	X	X	X	X	X	X	X
Hydropsyche sp. II			X										X	X	X			
Hydropsyche (P)												X						
Hydroptila sp.		X	X		X	X	X	X	X		X	X				X		X
Limnephilidae (P)				X														
Nectopsyche sp.																		X
Neotrichia sp.																	X	
Oecetis sp.												X			X		X	X
Potamyia sp.													X					
Psychoglypha subborealis						X												
Rhyacophila sp. I	X		X		X	X	X		X				X					
Rhyacophila sp. II				X	X		X							X				
Rhyacophila (P)					X	X												
Coleoptera																		
Agabus		X																
Cleptelmis sp.																		
Cylloepus sp.								X										
Dubiraphia sp.										X								
Euphcrytus		X																
Hydrobius sp.			X															
Lampyridae				X														

	[illegible] le Hol			Taylor			Wade and Curt			Jensen								
	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Coleoptera (Continued)																		
Microcylloepus sp.									X	X	X	X	X	X	X			
Optioservus sp.			X	X		X	X	X	X			X	X					
Ordobrevia sp.											X			X				
Ordobrevia sp. (A)								X						X				
Peltodytes sp.									X									
Stenelmus sp.															X			
Zaitzevia sp.						X	X						X					
Diptera																		
Atherix variegata															X			
R[illegible] cephala sp.																X	X	X
Chironumidae	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chironwidae (P)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chironomidae (A)			X			X			X			X						
Dactylolabis sp.																		X
Dolichopodidae			X	X		X	X											
Hemerodromia sp.	X	X	X			X			X		X	X		X	X		X	
Hemerodromia sp. (P)			X		X				X	X								
Hexatoma sp.				X										X			X	X
Holorusia sp.	X									X								
Limnophora sp.	X			X														
Palpomyia sp.						X					X	X		X	X		X	X
Simulium sp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Simulium sp. (P)	X	X	X	X	X	X	X	X		X		X			X	X		
Tahanidae															X			
Tipula spp.			X		X	X			X						X			X
Odonata																		
Erpetogom[illegible] sp.													X	a				
Gomphus sp.														X			X	
Ophiogomphus servus								X			X	X		X	X			

	Little Mole						[illegible]									Boulder		
	1978	1919	1980	1978	1979	1980	1978	1979	1980	1978	1979	1900	1978	1979	1980	1978	1979	1980
Megaloptera																		
Corydalus cornutus																		
Other																		
Oaphnia sp.	X																	
Diaptomus sp.									X									
Gammarus lacustris	X	X	X		X	X	X	X	X	X		X						
Harpactacoida	X			X			X											
Hirudenea	X																	
Hydracarina	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Isotomurus sp.				X														
Lumbricidae			X															
Naidadae	X	X	X	X	X	X	X	X	X	X	X	X		X	X			
Nematoda	X			X							X							
Ostracoda	X																	
Paragyractis sp.												X		X	X			X
Physa spp.			X			X									X			
Planaria	X	X	X	X	X	X	X											
Unknown						X			X			X						
Total number of taxa	22	11	20	22	18	26	23	18	25	20	26	39	27	33	37	20	28	27

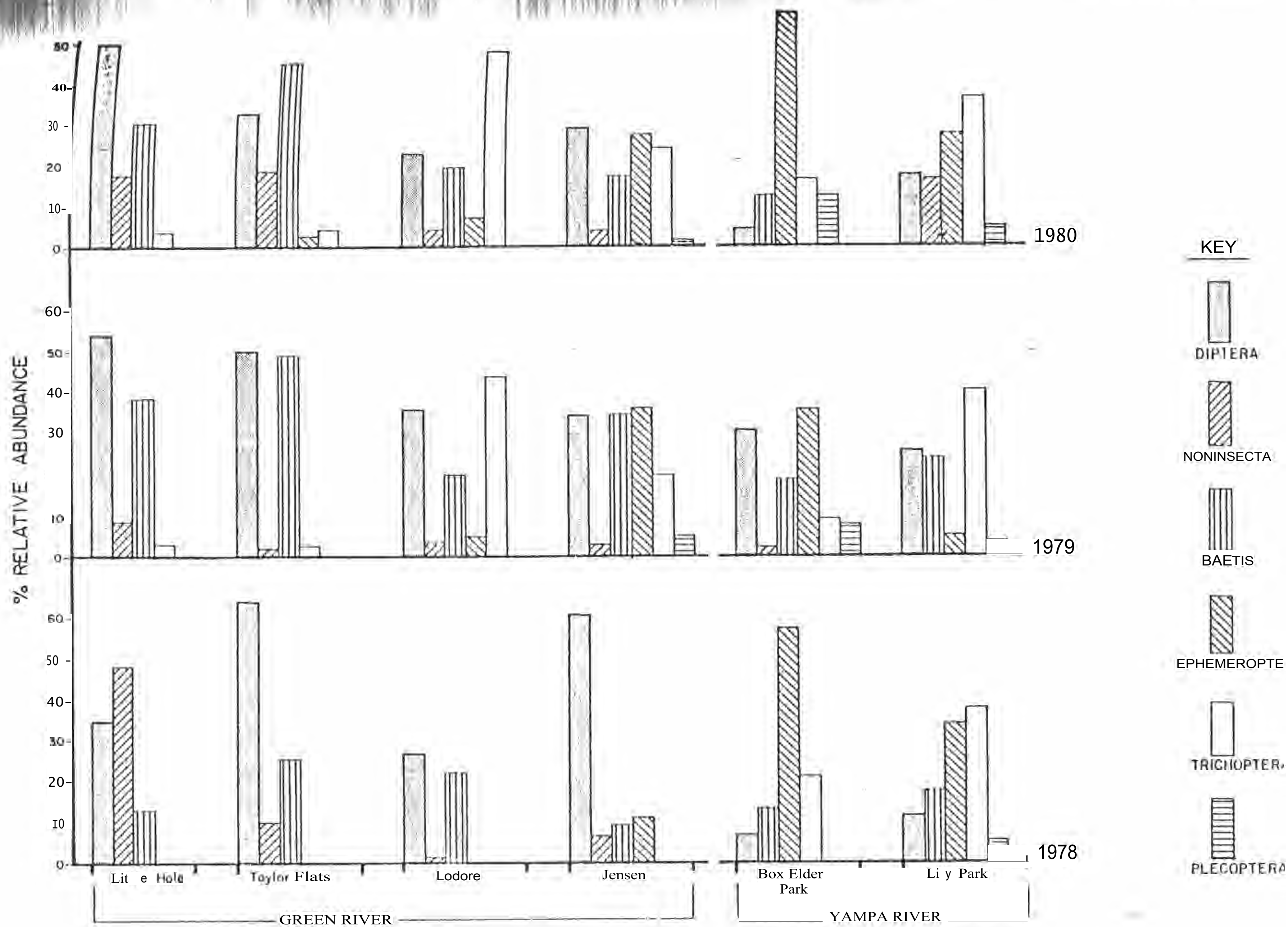


Figure 2. Average relative abundance of major macroinvertebrate groups at each station from 1978-1980.

Cheumatopsyche sp. dominated summer and fall samples. Table 26, Appendix II, lists many species found in this study and whether they were most common in the regulated (Little Hole, Taylor Flats, and Wade and Curtis) or unregulated (Lily Park, Boxelder Park, and Jensen) portions of the Green and Yampa rivers.

Annual Trends. Little Hole and Taylor Flats exhibited differences in abundance of certain taxa between 1978 and 1980. Peak densities of Hydroptila sp. increased from 0 at Little Hole and Taylor Flats in 1978 to $724/m^2$ and $886/m^2$, respectively, in 1980. Gammarus lacustris exhibited peak abundances at Little Hole increasing from $452/m^2$ in 1978 to $3225/m^2$ in 1979 to $3992/m^2$ in 1980. Taylor Flats also had increased peak populations of this species which ranged from $0/m^2$ in 1978 to $617/m^2$ in 1980. Yampa River stations showed no comparable increase of these taxa during the same time period. Other taxa which exhibited slight to moderate increases in abundance at these two stations included Ephemerella inermis, Malenka sp., Hydropsyche, and Planaria. Annual changes in abundance of individual taxa at Wade and Curtis were difficult to assess due to the small numbers involved and the large variation present.

Species Diversity

S atial Trends. Shannon-Weaver species diversity values calculated for each sample period from 1978-1980 are presented in Table 8. Figure 3 shows mean yearly diversity values for each station on the Green River from 1978-1980.

Table 8. Shannon-Weaver species diversity values for 1978, 1979, 1980.

	1978					1979							
	Mar.	June	July	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oc
Green													
Little Hole	1.80	1.34	1.84	1.88	1.89	1.66	1.55	1.57	2.15	1.96	1.85	2.44	2.
Taylor Flats	1.21	1.71	1.65	1.26	1.64	1.04	1.47	1.40	1.40	1.40	1.29	2.63	3.
Lodore	0.80	2.14	2.07	2.47	1.93	1.05	2.17	1.92	1.37	2.19	2.33	2.03[1]	2.
Jensen	1.90	0.72[1]	2.74[1]	2.98	3.25	1.90	1.80[1]	2.94	3.90	1.93	2.49[1]	2.99	3.
Yampa													
Lily Park	–[2]	2.60[1]	3.04		2.56	1.70	2.28[1]	2.42	2.70	2.67	2.82	3.05	2.
Box Elder Park	–[2]		2.45		2.50	–[2]	2.60[1]	2.82	3.36	–[2]	0.91[1]	1.91	2.

[1]Samples taken during high flows.

[2]Station inaccessible.

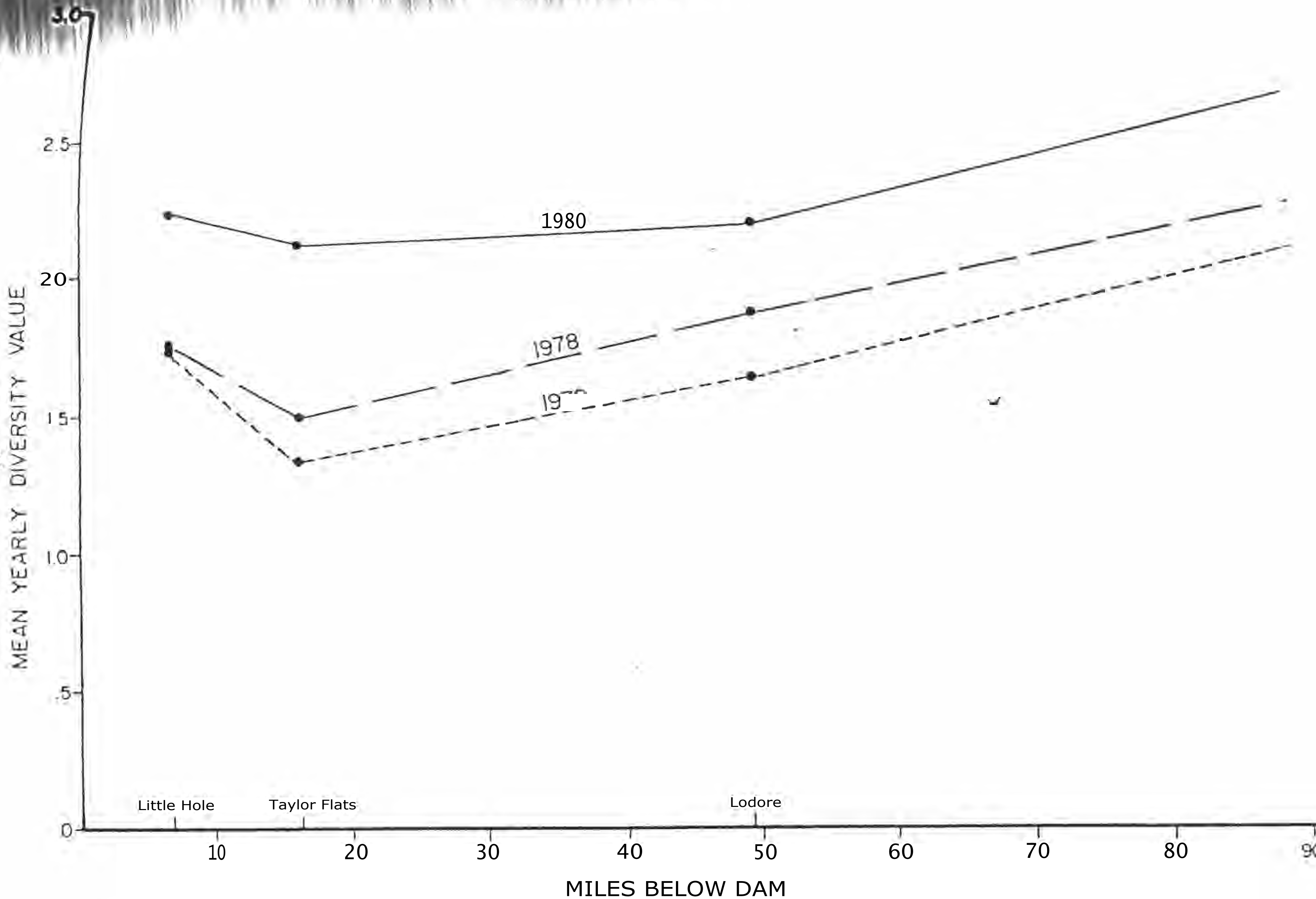


Figure 3. Mean yearly Shannon-Weaver diversity value for each station on the Green River, 1978-1980.

average values occurred near the dam at Little Hole and Taylor Flats; highest average values were recorded at Jensen. Yampa River stations sustained species diversity indices similar to Jensen on the Green River. Single classification analysis of variance and the Student-Newman-Keuls multiple comparisons among means test were used to test for significance of difference among mean values for each year illustrated in Figure 3 and to group similar stations on the basis of macroinvertebrate diversity (Table 9). It should be noted that in these tests only August and October samples each year were used since late summer and early fall were the periods of maximum diversity and it eliminated the bias of samples taken during spring runoff on the Yampa River and at Jensen on the Green River.

Results of these analyses for each year indicated that during 1978, mean diversity values during late summer were similar at the upper three stations on the Green River (Little Hole, Taylor Flats, and Wade and Curtis). Jensen on the lower Green River and the two Yampa River stations (Boxelder and Lily Park) were also similar, but this set exhibited significant differences from the set of stations comprising the upper Green River. Wade and Curtis, Boxelder, and Lily Park were not significantly different nor were the sets of Little Hole, Wade and Curtis, and Boxelder Park. During 1979, the three stations on the upper Green again formed a set which was significantly different from the Yampa River stations and Jensen. The two Yampa

Table 9. Diagramatic summary[1] of differences between mean $\bar{d}$ values for all stations on the Green and Yampa rivers during 1978, 1979, and 1980; calculated by student-Newman-Keuls test.

1978

Taylor Flats	Little Hole	Wade and Curtis	Boxelder Park	Lily Park	Jensen
—	—	—			
			—	—	—
	—	—	—		
		—	—	—	

1979

Taylor Flats	Wade and Curtis	Little Hole	Boxelder Park	Lily Park	Jensen
—	—	—			
			—	—	
				—	—

1980

Little Hole	Taylor Flats	Wade and Curtis	Jensen	Boxelder Park	Lily Park
—	—	—	—	—	—

[1]Mean species diversity values for each set of stations underlined were not significantly different; stations not linked were significantly different ($P < .05$).

River stations comprised another set of similar stations as well as Jensen and Lily Park. During 1980, due primarily to increased diversity at Little Hole and Taylor Flats, no significant differences were found in mean species diversity between any stations.

Annual Trends. Diversity values were also examined on a yearly basis. Mean diversity at all Green River stations decreased from 1978 to 1979 then increased to the maximum levels observed during the study in 1980. Single classification analysis of variance indicated that there were significant differences ($P<.01$) in species diversity between 1978, 1979, and 1980 at Little Hole and Taylor Flats together. Wade and Curtis exhibited no significant differences between the three years but this was due primarily to large sample variation. Jensen and the Yampa River stations also exhibited no significant differences in species diversity between 1978 and 1980. Mean species diversity at Little Hole for each year of this study was also compared with mean values generated from abundance information collected by Pearson et al. (1968) for 1965 and 1967 by an a posteriori Student-Newman-Keuls test. Results showed that mean diversity values at Little Hole were similar in 1965, 1967, 1978, and 1979. The mean diversity value for 1980, however, was significantly higher ($P<.05$).

Fishes

General

Table 10 lists the fishes collected during this study by station and age class. Twenty-eight species and three hybrids were collected, including 11 native and 17 introduced species. Over 63,000 fish were

	Upper 1978							1979				Upper		
	Mar.	June	Jul.	Aug.				tug.	Sep.			June		Oct.
Mountain whitefish *Prosopium williamsoni*														
Rainbow trout *Salmo gairdneri*	3	3							6					
Cutthroat *Salmo clarki*														
Brown trout *Salmo trutta*														
Northern pike *Esox*														
Carp *Cyprinus* :3r:',														
Speckled dace* *Rhinichthys osculus*							129 4					257		
Creek chub *Semotilus atromaculatus*														
Colorado squawfish* *Ptychocheilus lucius*														
Roundtail chub* *Gila robusta*														
Bonytail chub* *Gila*														
Humpback *Gila cypha*														
Utah chub *Gila atraria*														
Redside *Richardsonius balteatus*														
Fathead minnow *Pimephales promelas*								3						
Red shiner *Notropis lutrensis*													3	
Sand shiner *Notropis stramineus*														
Razorback sucker* *Xyrauchen texanus*														
Mountain sucker *Pantosteus*							16							
Bluehead sucker* *Pantosteus discobolus*				OO.	30		13 3	143 - -				21		
Flannelmouth sucker* *Catostomus latipinnis*			11	0004	15	03 12	- 110 2	120 - 12	15			- 113	122 3 1	5 10 12
White sucker *Catostomus commersoni*														
• Flannelmouth hybrid														
Razorback X Flannelmouth hybrid														
▪ Bluehead hybrid														
Channel catfish *Ictalurus punctatus*														
Black bullhead *Ictalurus melas*														
Plains killifish *Fundulus zebrinus*														
Mottled sculpin* *Cottus bairdi*														
Walleye *Stizostedion vitreum*														
Green sunfish *Lepomis cyanellus*														

- = none caught

	Age	Alcove Brook 1979					Alcove 1978				Alcove Brook 1978			
		Mar.	Jun	Jul.	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Mountain whitefish Prosopium williamsoni														
Rainbow trout Salmo gairdneri		5				[illegible]	1	[illegible]			41			
Cutthroat trout Salmo clarki		1	1	2			5		1					
Brown trout Salmo trutta		3		2	3	5	4		1	[illegible]	4	1	1	
Northern pike Esox lucius														
Carp Cyprinus carpio	A	46	16	14	6	4	11	19	5	1	11	-		[illegible]
Speckled dace Rhinichthys osculus	1 3 4	- 1 1	[illegible] 11	- - 1	[illegible] 12 -	[illegible] 1	- 2	[illegible] 32 3	501 15 1	20 2 -	- 38 2	[illegible] 37	50 9 -	2 - -
Creek chub Semotilus atromaculatus								-			1			
Colorado squawfish Ptychocheilus lucius	1 3 4								-					
Roundtail chub Gila robusta	1 3 4			1	3 1		3	3	2			33	70	
Bonytail chub Gila elegans														
Humpback chub Gila cypha														
Utah chub Gila atraria	1 4													
Redside shiner Richardsonius balteatus			15	[illegible]	48			11	319	10		13	432	39
Fathead minnow Pimephales promelas	1 4		12		5			29	74	3 10		13	22	
Red shiner Notropis lutrensis					30	30		170	529	116		34	97	243
Sand shiner N. stramineus													-	
Razorback sucker Xyrauchen texanus				1										
Mountain sucker Pantosteus platyrhynchus	1										-			
Bluehead sucker Pantosteus discobolus	1 3 4		- - 3	- - 15	3 - 9				[illegible]	13	- - 15	3 3	[illegible] 4	16
Flannelmouth sucker Catostomus latipinnis				17	2 19	21	11	3 17	3	5 15	-	41 4	15 10	12
White sucker Catostomus commersoni	3 4							1		-		6	1	
White x Flannelmouth hybrid														
Razorback x Flannelmouth hybrid									1				1	
White x Bluehead hybrid														
Channel catfish Ictalurus punctatus	3 4	[illegible]	4					2		-		-		-
Black bullhead Ictalurus melas														
Plains killifish Fundulus kansae														
Mottled sculpin Cottus bairdi	3 4	3							1	5	13	2		-
Walleye Stizostedion vitreum														
Green sunfish Lepomis cyanellus														

- = none caught

Prosopium williamsoni														
Rainbow trout *Salmo gairdneri*		[illegible]	1			3	[illegible]				17	[illegible]		
Cutthroat trout *Salmo* ___														
Brown trout *Salmo trutta*						3					[illegible]			
Northern pike *Esox lucius*			[illegible]					[illegible]						
Carp ___ *carpio*	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Speckled dace *Rhinichthys osculus*	[illegible]	:3	51 / 12	30	10	[illegible]	[illegible]	[illegible]	46	[illegible]	:7	102	[illegible]	[illegible]
Creek *Semotilus* ___			[illegible]	•0				[illegible]						[illegible]
Colorado squawfish ___ *lucius*	[illegible]							[illegible]	[illegible]		[illegible]	[illegible]		
Roundtail *Gila robusta*	[illegible]	5	304	756 / 4	:3 / :34	[illegible]	37	254	257	9	[illegible]	[illegible]	24	105
Bonytail chub *Gila elegans*														
Humpback chub *Gila cypha*												[illegible]		
Utah chub *Gila atraria*														
Redside shiner *Richardsonius balteatus*			759	548	173	4	79	[illegible]	[illegible]		54	30	[illegible]	
Fathead minnow *Pimephales promelas*	[illegible]	[illegible]	[illegible]	[illegible]	5	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Red shiner *Notropis lutrensis*			[illegible]	[illegible]		[illegible]	[illegible]		34	[illegible]	[illegible]			
Sand shiner *Notropis stramineus*			21	16			[illegible]	[illegible]			[illegible]	[illegible]		
Razorback sucker *Xyrauchen texanus*														
Mountain sucker *Pantosteus platyrhynchus*														
Bluehead sucker *Pantosteus discobolus*	[illegible]	4 / 5	[illegible]	[illegible] / 2	5 / - / 3	[illegible] / 2		[illegible]	44 / 3	- / 3		[illegible] / 2	5 / 3	
Flannelmouth sucker *Catostomus latipinnis*	[illegible]	2	5 / 9	- / 32 / 2	[illegible] / V	[illegible] / 5 / 16	- / 5 / 2	[illegible]	335 / [illegible] / 9	[illegible] / 5 / 5	-	[illegible]	- / 5	23
White sucker *Catostomus commersoni*	[illegible]							[illegible]						
White X Flannelmouth hybrid														
Razorback X Flannelmouth hybrid														
White X Bluehead hybrid														
Channel catfish ___ *punctatus*	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]			[illegible]
Black bullhead *Ictalurus melas*														
Plains killifish *Fundulus kansae*														
Mottled sculpin *Cottus bairdi*	4	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Walleye *Stizostedion vitreum*					[illegible]									
Green sunfish *Lepomis cyanellus*														

- = none caught

	Island Park 1978					Island Park 1979				Island Park 1980			
	Mar.	June	Jul.	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Mountain whitefish *Prosopium williamsoni*													
Rainbow trout *Salmo gairdneri*	[illegible]		1							[illegible]			
Cutthroat trout *Salmo clarki*													
Brown trout *Salmo trutta*						1							
Northern pike *Esox lucius*													
Carp *Cyprinus carpio*	6	3	503 17 2	10 5					3	2		2 14	3
Speckled dace *Rhinichthys osculus*	18			18 14	3	20	3	37 1		132	118	5	32 56
Creek chub *Semotilus atromaculatus*												7	
Colorado squawfish *Ptychocheilus lucius*			3									3	
Roundtail chub *Gila robusta*		2	– 232	311 52	607* 2	.4	216	41 139	21	45	12	22 119	
Bonytail *Gila elegans*													
Humpback chub *Gila cypha*													
Utah chub *Gila atraria*													
Redside shiner *Richardsonius balteatus*		502	206	522		2	122	90		33	17		
Fathead minnow *Pimephales promelas*		– 500	156	– 43	49	1				72	2	– 22	24
Red shiner *Notropis lutrensis*			5	660	1200	.0	121	217	1533	214	13	334	[illegible]
Sand shiner *Notropis stramineus*			33	2				3	10	7		15	123
Razorback sucker *Xyrauchen texanus*					3			2					
Mountain sucker *Pantosteus platyrhynchus*													
Bluehead sucker *Pantosteus discobolus*			– 203 22	1269 3 19	775* – 32	2	– 28	1836 – 12	115	25	5	2 37	– 18
Flannelmouth sucker *Catostomus latipinnis*		– 11	– 203 16	1266 19	[illegible] 17	3 4	– II!	1552 4 12	52 1 7	– 141 3	7	10	– 19
White sucker *Catostomus commersoni*													
White x Flannelmouth hybrid													
Razorback x Flannelmouth hybrid							[illegible]						
White x Bluehead hybrid							[illegible]						
Channel catfish *Ictalurus punctatus*	1	2	2	2	2		[illegible]	[illegible]	2	1			3
Black bullhead *Ictalurus melas*													
Plains killifish *Fundulus kansae*													
Mottled sculpin *Cottus bairdi*				[illegible]				3		[illegible]	[illegible]		
Walleye *Stizostedion vitreum*													
Green sunfish *Lepomis cyanellus*													

* one caught

13 equipment failure, no electrofishing was conducted.

Rainbow trout *Salmo gairdneri*														
Cutthroat trout *Salmo clarki*														
Brown trout *Salmo trutta*										1				
Northern pike *Esox*											1			
Carp *Cyprinus carpio*	4	10	136.	10 13	39 5	5	5	17	669 12	4 1	70	18	23 20	
Speckled dace *Rhinichthys osculus*		5 3					31	3	2	20	59	56	5	19 4
Creek chub *Semotilus atromaculatus*														
Colorado squawfish *Ptychocheilus lucius*	4		3 4	2	1	16		2		8				
Roundtail chub *Gila robusta*	3		1	23	[illegible]	21		14	6 3	15	5	5	11 2	1
Bonytail chub *Gila elegans*														
Humpback chub *Gila cypha*														
Utah chub *Gila atraria*														
Redside shiner *Richardsonius balteatus*				74	3				11	1	24	24	3	
Fathead minnow *Pimephales promelas*				20	5	:CO 46	3	22	10	1	10	10	37	
Red shiner *Notropis lutrensis*		22	57	252	3330	1000+	78	774	721	1112	160	.371	367	72:5
Sand shiner *Notropis stramineus*				1										
Razorback sucker *Xyrauchen texanus*			18	2	1			12			8	2		
Mountain sucker *Pantosteus platyrhynchus*														
Bluehead sucker *Pantosteus ...s*	4	1		:CO 3	105 1	502+ 2	1	25	382 5 4	21 5	95	21	99	11
Flannelmouth sucker *Catostomus latipinnis*	4		3	131 2	105 1	535 4	21 4	22 1	221 21 1	56 16	54 8	30	309 5	18
White sucker *Catostomus commersoni*	3		3		1			3 1	-1		1			
White x Flannelmouth hybrid								1						
Razorback x Flannelmouth hybrid														
White x Bluehead hybrid			1											
Channel catfish *Ictalurus punctatus*	4		3	1		2				8				1
Black bullhead *Ictalurus melas*			1											
Plains killifish *Fundulus ...*														
Mottled sculpin *Cottus ...*	4									1				
Walleye *... vitreum*			1					2						
Green sunfish *Lepomis cyanellus*								1	1					

- = None caught

Mountain whitefish *Prosopium williamsoni*		Not Sampled		Not Sampled										
Rainbow trout *Salmo gairdneri*														
Cutthroat trout *Salmo clarki*														
Brown trout *Salmo trutta*														
Northern pike *Esox lucius*														
Carp *Cyprinus carpio*														
Speckled dace *Rhinichthys osculus*			8		3		5 5	111	16 3	22		28		
Creek chub *Semotilus atromaculatus*														
Colorado squawfish *Ptychocheilus lucius*														
Roundtail chub *Gila robusta*			11		12 31	2 13	46	3	21					
Bonytail chub *Gila elegans*														
Humpback chub *Gila cypha*														
Utah chub *Gila atraria*														
Redside shiner *Richardsonius balteatus*			50		329	73	18	14	3	136	66	22	525	3
Fathead minnow *Pimephales promelas*	1		25		16		5						2	
Red shiner *Notropis lutrensis*					5	1	15	2						
Sand shiner *Notropis stramineus*			12		17				7	37			36	
Razorback sucker *Xyrauchen texanus*														
Mountain sucker *Pantosteus platyrhynchus*														
Bluehead sucker *Pantosteus discobolus*			3		3 13+	5 43+	2	15	12					
Flannelmouth sucker *Catostomus latipinnis*			25		1 12 37	5 18+	19	24	22	15		3 78	16	
White sucker *Catostomus commersoni*														
White X Flannelmouth hybrid														
Razorback X Flannelmouth hybrid														
White X Bluehead hybrid														
Channel catfish *Ictalurus punctatus*					34				28					13
Black bullhead *Ictalurus melas*														
Plains killifish *Fundulus kansae*			1	F	1									
Mottled sculpin *Cottus bairdi*							2							
Walleye *Stizostedion vitreum*														
Green sunfish *Lepomis cyanellus*														

- = none caught

	Lower 'amoa 1979					Lower 'amoa 1979				'amoa 1980			
	Mar.	June	Jul.	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Mountain whitefish williamsoni													
Rainbow trout Salmo gairdneri													
Cutthroat trout Salmo clarki													
Brown trout Salmo													
Northern pike Esox													
Carp Cyprinus carpio													
Speckled dace		24		5	29		27	'1 1	23		36	13	
Creek chub atromaculatus													
Colorado squawfish Ptychocheilus lucius													
Roundtail chub Gila robusta	1	38 3		-5	54		254	53 11	23		253	23 50	
Bonytail chub Gila elegans													
Humpback chub Gila cypha					1								
Utah chub Gila atraria													
Redside shiner Richardsonius balteatus		322		205	26		22	163	15		413	183	
Fathead minnow Pimephales promelas							.						
Red shiner lutrensis				197	221		3	.13	221		3		
Sand shiner stramineus													
Razorback sucker Xyrauchen texanus													
Mountain sucker Pantosteus platyrhynchus													
Bluehead sucker Pantosteus discobolus		2					61 3	'2					
Flannelmouth sucker Catostomus latipinnis							22	51 133 3	21 17		25	12	22
White sucker Catostomus commersoni													
White x Flannelmouth hybrid													
Razorback x Flannelmouth hybrid													
White x Bluehead hybrid													
Channel catfish punctatus					2								
Black bullhead Ictalurus melas													
Plains killifish Fundulus kansae													
Mottled sculpin Cottus bairdi													
Walleye Stizostedion													
Green sunfish Lepomis													

- = none caught

with an asterisk. Tables 11 and 12 list electrotishing and seining effort, respectively, for the study.

Distribution

Native Fishes. The speckled dace, roundtail chub, bluehead sucker, and flannelmouth sucker were found at all stations during the study. Colorado squawfish were found at all stations except Lodore.

Speckled dace and flannelmouth suckers were found at all stations before and after inlet modification.

Roundtail chubs were not found at Lodore until October of 1979, when one was caught, although fishermen reported their capture earlier in 1979 on hook and line. No roundtails were captured at Lodore in 1980. One roundtail was found at Alcove Brook in July 1978. They became more frequent in the catch after that time at this station. Roundtails were found more consistently throughout the study at all of the other stations.

Bluehead suckers were not found at Lodore until August 1978. They were found more consistently at Lodore in 1979 and 1980. No change in bluehead distribution was noted at any of the other stations.

Adult Colorado squawfish were found sporadically at all stations except Lodore. They were found at Echo Park and Lower Yampa in 1979 and 1980, but not in 1978. Young and/or juvenile squawfish were found all three years at Island Park and Jensen, and at Lower Yampa and Echo Park in 1980 only.

Table 11. The amount of time (min.) each habitat type was sampled with electrofishing gear, Flaming Gorge Study, 1978-1980.

		Run			Run Along Shore			Riffle			Backwater			Eddy		
		1978[a]	1979	1980	1978[a]	1979	1980	1978[a]	1979	1980	1978[a]	1979	1980	1978[a]	1979	1980
Lodore	Mar.	0	20	6	24	92	84	0	0	0	0	0	0	0	0	0
	June	7	3	30	29	49	49	0	0	0	0	7	0	0	0	0
	July	9		-	38			0			0			0		
	Aug.	4	7	10	40	52	53	0	0	0	0	0	0	0	0	0
	Oct.	7	13	28	34	59	61	3	0	1	0	0	0	0	0	0
Alcove Brook	Mar.	10	23	11	23	48	45	10	5	3	0	0	15	6	0	1
	June	10	10	0	19	32	34	5	30	3.5	0	10	10	3	0	8
	July	1			24			3		-	0			11		
	Aug.	9	7	5	20	14	47	4	6	17	4	0	4	3	6	3
	Oct.	16	10	17	15	24	47	1	14	4.0	0	7	0	6	5	1
Echo Park	Mar.	17	10	2	34	29	42	4	0	3.5	2	0	0	10	17	15
	June	6	0	0	15	18	56	2	3	0	0	0	0	16	5	0
	July	3			18			1			0			16		
	Aug.	4	20	22	16	27	25.5	3	0	8	[illegible]	0	0	6	10	12
	Oct.	10	13	35	22	55	54	3	10	5	0	5	3	5	12	3
Island Park	Mar.	4	10	6	9	37	68	0	0	3	0	0	0	8	6	7
	June	0	0	0	17	36	0	2	0	0	7	6	0	0	13	0
	July	3			15			0			0			12		
	Aug.	0	21	30	5	6	69	7	8	8	0	c	0	7	0	
	Oct.	2	15	31	29	34	43	2	7	5	5	.0	0	0	0	3
Jensen	Mar.	0	0	0	10	51	45.5	0	0	0	10	0	30.5	0	0	0
	June	0	0	0	30	34	72	4	0	0	[illegible]	58	0	2	0	0
	July	0			35			0			10			0		
	Aug.	0	10	0	45	47	53	4	0	0	8	12	10	4	0	7
	Oct.	0	0	0	18	50	45	0	c	0			14	2	2	5
Lily Park	Mar.	-	40	11		0	5		15	4		0	20		4	0
	June	0	0	0	28	39	36	0	0	0	8	0	0	12	12	0
	Aug.	4	60	0	41	3	0	11	18	0	11	0	0	4	15	0
	Oct.	4	10	52	27	30	0	6	0	0	3	0	0		0	0
Lower Yampa	Mar.														-	
	June	0	0	0	20	53.5	55	3	2	0	0		0		6	0
	Aug.	4	0	14	24	54.0	36	5	0	4	0		3	11	2	0
	Oct.	4	38	33	28	19	11	2	0	0	0	2	0	11	0	0

[a] 1978 times were estimated.

Table 12. The amount (ft^2) of each habitat type sampled with seines, Flaming Gorge Study, 1978-1980.

		Run			Backwater			Eddy			Riffle		
		1978	1979	1980	1978	1979	1980	1978	1979	1980	1978	1979	1980
Lodore	Mar.	2250	23025	22475	3000	7370	2050		375	300			
	June	6900	10250	8250	6000	14275	1500		-				
	July	2250	NS	NS	6750	NS	NS		NS	NS		NS	NS
	Aug.	3500	4700	5950	6000	5800	3025			-			
	Oct.	6625	6850	7880	8750	9300	4650			375		750	
Alcove Brook	Mar.	4500	9460	5065	300		1250			6065		1650	4250
	June	10500	12450	8225	2250	2550	1175		375	1500	450	450	1550
	July		NS	NS	3750	NS	NS	2000	NS	NS	3750	NS	NS
	Aug.	9000	6150	7250			1500		450	775	3000	3000	3150
	Oct.	3750	7800	9575		500		4500	900	3000	3000	1950	2600
Ecno Park	Mar.	2700	4280	12650	-	1630	5400	2250	1600	1800	1500	1000	1000
	June	3000	1000	2250	6000	1500	450	900			900	2500	2700
	July	11775	NS	NS	8200	NS	NS		NS	NS		NS	NS
	Aug.	12750	24450	8400	4050	4725	2100	3000	450			3000	2400
	Oct.	14750	8450	11300	5300	2795	7800	3000	1200	2475		-	900
Island Park	Mar.	9825	-	2500	2000	2595	6955		1000			300	1800
	June	3750	2250	900	750	2200	1125	-			750		2175
	July	9050	NS	NS	7900	NS	NS	4500	MS	US	3000	NS	NS
	Aug.	4500	2250	9575	15300	14200	11250	2000	-		2000	3125	1875
	Oct.	6000	2400	4225	7550	3300	8300	3000	800	3975		1200	1600
Jensen	Mar.	3100	1125	4000	-	2625	8350			2150			
	June			-	750	1270	600						1800
	July	2250	NS	NS	5000	NS	NS	3500	NS	NS		NS	NS
	Aug.	6000	1500	3500	8000	10050	2470	2000					
	Oct.	1875	1250	1125	5250	2250	4800	1500		2100			
Lily Park	Mar.	NS		4150	NS		450	NS	1950	340	NS	200	
	June	1500		1875	3500	-		3500		800			1800
	Aug.	3500	600	4660	6500	600	1600	1500	1100				400
	Oct.	2000	1186	4000	2000	1186	2000		5886				
Lower Yampa	Mar.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	June	1000	1600		3000	1650	625	450	750	S75			900
	Aug.	6300	700	4320	-	2340	1400	1000					1500
	Oct.	4400	9275	14975	750	5200	11000	1500					

One adult bonytail chub was found at Lower Yampa in 1979. Adult humpback chubs were found there in 1978 and 1979, and at Echo Park in 1979.

Razorback suckers were found at all stations except Lodore and Lower Yampa, but were found each year only at Island Park and Jensen.

The mottled sculpin, a cool water species, was found consistently at Alcove Brook and Echo Park, and more sporadically at Island Park, Jensen, and Lily Park.

The mountain whitefish and mountain sucker are also native species, although they are generally restricted to the upper Yampa River and smaller tributaries, respectively. Mountain whitefish were found at Lily Park in 1979 and 1980, and at Lower Yampa in 1980 and Lodore in 1979. Mountain suckers were found once at both Lily Park and Lower Yampa; they were found all three years at Lodore and in 1979 and 1980 at Alcove Brook.

Introduced Fishes. The 17 introduced species in the study area (Table 10) can be broken into 3 groups: 1) the cold water fishes - rainbow trout, cutthroat, and brown trout; 2) the very rare species - northern pike, creek chub, Utah chub, white sucker, black bullhead, plains killifish, walleye, and green sunfish; 3) the common species - carp, redside shiner, fathead minnow, red shiner, sand shiner, and channel catfish.

The cold water forms (trouts) were generally found at Lodore and Alcove Brook at all times of the year, and at Echo Park and other stations primarily in March (Table 10). The rare species were found be difficult to observe.

The common exotic species showed considerable changes in distribution. Carp and fathead minnows were found at all stations before and after inlet modifications. Redside shiners and channel catfish were not found at Lodore until June 1979 and October 1980, respectively; red shiners were not found at Lodore in this study until August 1980 and Alcove Brook until August 1978. Sand shiners also were not found at Alcove Brook until August 1979. These species were found at all other stations before and after inlet modification, except sand shiners were never found at Lodore.

Relative Abundance

General - Table 13 shows the total number of fish captured at each station during each sampling period. Lodore generally had the fewest number of fish caught. Lily Park also had low numbers in March and October. Echo Park, Island park, and Jensen generally had the highest catch.

March samples usually had the lowest number of fish captured. August and October usually had the highest catch. Changes in the numbers of fish between sampling periods were primarily due to changes in number of juvenile and young fish, rather than changes in the number of adult fish (Table 10).

The total catch at Lodore, Alcove Brook, Echo Park, and Island Park declined in June, August, and October 1980 from previous years,

Table 13. Total number of fish collected, by sample period and station.

		Mar.	June	Aug.	Oct.
Lodore	1978	8	15	430	100
	1979	122	554	310	114
	1980	43	425	141	56
Alcove Brook	1978	68	85	157	137
	1979	58	332	1153	819
	1980	127	260	708	379
Echo Park	1978	94	1471	617	620
	1979	817	956	1207	1077
	1980	850	354	455	540
Island Park	1978	38	1029	4309	5532
	1979	91	717	3834	2889
	1980	990	202	3317	1045
Jensen	1978	47	254	3567	2343
	1979	795	907	2594	1279
	1980	465	545	1127	1305
Lily Park	1978	-	164	687	229
	1979	163	385	150	420
	1980	129	199	842	84
Lower Yampa	1978		728	762	487
	1979	-	454	619	426
	1980	-	846	648	285

high number of 1979. This change was due to fewer num-
-ile and young fish of all species.

14 shows the number of species collected at each station sampling period. Lowest diversity was seen at Lodore, all stations were fairly equal. The number of species at Lodore and Brook increased after July 1978. Diversity at other stations fairly stable throughout the study.

Species - Bonytail chub and humpback chub were found in such numbers that changes in abundance could not be assessed.

Speckled dace abundance increased at Lodore and Alcove Brook in 1979 1980 over 1978 levels. The increase was primarily in juvenile and fish. Speckled dace abundance at other stations remained fairly throughout the study.

Adult squawfish were not found at Echo Park or Lower Yampa in 1978. were found at each station in 979, and two at Echo Park and one at Lower Yampa in 1980. One adult squawfish was found at Island Park each year. Numbers of adults captured at Jensen decreased from 6 in 1978 to 1 in 1979 and 1 in 1980. Single adult squawfish were found at other stations sporadically, except for Lodore where none were found.

Small numbers of juvenile squawfish were found at Island Park and Jensen each year, young-of-the-year were found in small numbers at Jensen all years, and at Lower Yampa, Echo Park, and Island Park in 1980.

Few roundtail chub adults were found during the study, but juveniles and young were common. Only one roundtail was found at Lodore in 1979, especially the high number of 1979. This change was due to fewer numbers of juvenile and young fish of all species.

Table 14 shows the number of species collected at each station during each sampling period. Lowest diversity was seen at Lodore, all other stations were fairly equal. The number of species at Lodore and Alcove Brook increased after July 1978. Diversity at other stations remained fairly stable throughout the study.

<u>Native Species</u> - Bonytail chub and humpback chub were found in such small numbers that changes in abundance could not be assessed.

Speckled dace abundance increased at Lodore and Alcove Brook in 1979 and 1980 over 1978 levels. The increase was primarily in juvenile and young fish. Speckled dace abundance at other stations remained fairly stable throughout the study.

Adult squawfish were not found at Echo Park or Lower Yampa in 1978. Four were found at each station in 1979, and two at Echo Park and one at Lower Yampa in 1980. One adult squawfish was found at Island Park each year. Numbers of adults captured at Jensen decreased from 6 in 1978 to 2 in 1979 and 1 in 1980. Single adult squawfish were found at other stations sporadically, except for Lodore where none were found.

Small numbers of juvenile squawfish were found at Island Park and Jensen each year, young-of-the-year were found in small numbers at Jensen all years, and at Lower Yampa, Echo Park, and Island Park in 1980.

Few roundtail chub adults were found during the study, but juveniles and young were common. Only one roundtail was found at Lodore in 1979,

Table 14. Number of species of fish collected at each station, including hybrids.

	Lodore 46 MBD			Alcove Brook 61 MBD			Echo Park 65 MBD			Island Park 78 MBD			Jensen 110 MBD			Lily Park			Lower Yampa		
	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80
March	1	10	7	8	9	11	10	13	14	9	9	15	6	6	13	-	16	9	-	-	
June	4	8	9	8	13	13	11	15	10	8	14	9	11	13	9	9	7	9	9	12	8
July	4			11																	
August	7	6	6	12	15	11	10	12	9	11	14	14	11	10	9	12	7	8	10	13	11
October	8	8	7	10	13	10	12	10	13	9	9	10	9	12	9	9	8	6	9	10	11
Total Species	11	14	12	19	20	17	16	19	15	16	18	17	17	17	13	12	12	13	12	15	12

although fishermen reported catching others in 1979 and 1980. Roundtail juvenile abundance at Alcove Brook increased dramatically in 1980 (Table 10). Numbers caught at other stations were similar throughout the study, except at Echo Park where they declined in 1980.

The number of razorback suckers collected at Jensen declined from 1978 to 1980. June catches were greatest each year and dropped from 38 in 1978 to 12 in 1979 and 2 in 1980. Numbers at other stations were very low throughout the study.

Flannelmouth and bluehead suckers were found in relatively high numbers at all stations. Numbers of captured young and juvenile increased dramatically at Lodore in August 1978. Catch remained fairly high during the remainder of the study, except bluehead numbers declined considerably in 1980. Increased numbers of juvenile and young of these two suckers were also found at Alcove Brook after 1978. Catch of these young suckers declined at Echo Park in 1980, but remained fairly stable at other stations.

Mottled sculpin captures increased at Alcove Brook, Echo Park, and Island Park in March and June 1980.

<u>Introduced Fishes</u> - Numribers of trout captured declined at Lodore and Alcove Brook in 1979 and 1980, compared to 1978 numbers, except during March of 1979 and especially 1980. A large increase in rainbow trout was noted at Alcove Brook in March 1980 when 41 were caught, compared to more normal numbers of 6 to 8. Numbers captured at Echo Park and Island Park were also higher than normal in March of 1980.

Numbers of rare introduced fishes collected were generally too small and too sporadic to indicate changes in populations. Three Utah chubs were found at Lodore in 1979, and 6 young white suckers were found at Alcove Brook in 1980; both numbers were greater than generally seen during the study.

Changes in the abundance of redside and red shiners were noted at Lodore and Alcove Brook. There was an increase in the number of these species at these two stations in 1979 and 1980, compared to 1978 figures. At Alcove Brook, these species showed increases in numbers in August of 1978. Redside abundance declined at Island Park during the course of the study.

Carp at Alcove Brook declined in 1979 and 1980 from 1978 captures, especially during March samples. Numbers of carp caught at other stations were generally similar through the study except at Jensen. Large numbers of carp were caught at Jensen in June 1978 and 1979 by electrofishing. It was decided, after extensive tagging in 1978, that measuring and tagging the large number of carp that were caught in June took too much time. Therefore, the 17 adult carp shown in June 1979 is much lower than the number present. Numbers in June 1980, however, were considerably lower than the 1978-1979 levels.

Fathead minnow abundance declined in 1979 and 1980 over 1978 levels at all stations except Lodore, Alcove Brook, and Jensen, where they remained fairly stable. Channel catfish abundance did not appear to change during the study. They were generally found in low numbers except at Lily Park in August 1978 and 1979 and October 1980 when fairly large numbers were caught.

Reproduction

General - Reproductive success of a species at a particular station was determined by the presence or absence of young-of-the-year or yearlings in that area. Since most of the species found in the study area spawn in late spring or summer, young-of-the-year were generally not sampled until the August or October sample. Collection of young-of-the-year in the August or October samples was considered evidence of successful reproduction in that general area. Since the study did not begin until 1978, reproductive success was difficult to determine "before" the inlet modification. This was especially true at Lodore and Alcove Brook where no recent pre-1978 samples were available. We therefore decided to use the presence of yearling fish as a reasonable determination of reproductive success if young-of-the-year data was not available. This was done at Lodore and Alcove Brook because the young noted in 1978 were also noted as yearlings in 1979 at these stations. This indicated that if young had been produced at these stations in 1977, yearlings should have been found in 1978. A similar reasoning was applied to yearling Colorado squawfish found at Island Park.

Native Species - The only yearling native species found in the Green River above the mouth of the Yampa River in 1978 was speckled dace (Table 10). Reproduction of speckled dace and flannelmouth and bluehead suckers occurred at all stations each year of the study (Table 15), except no young blueheads were found at Lodore in 1980. Roundtail chubs

Table 15. Successful reproduction of fishes by station as determined by presence of young-of-the-year or yearlings, 1978-1980.

Species	Lodore			Alcove Brook			Echo Park			Island Park			Jensen Park			Lily Park			Lower Yampa		
	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80	78	79	80
Carp	X							X	X	X			X	X							
Speckled Dace	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Creek Chub									X			X									
Squawfish									X			X	X	X	X						X
Roundtail Chub					X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Redside Shiner					X			X			X			X		?	X	X	?	X	
Fathead Minnow		X			X		X	X	X	X	X	X	X	X	X		X				X
Red Shiner					X		X	X	X	X	X	X	X	X	X				X	X	X
Sand Shiner									X			X						X			X
Bluehead Sucker	X	X		X	X	X	X	.X	X	X	X	X	X	X	X	X	?	X	X	X	X
Flannelmouth Sucker	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Channel Catfish															X						
Mottled Sculpin					X			X	X								X				
Green Sunfish																					

reproduced at Alcove Brook in 1979, and at all other stations except Lodore all 3 years of the study.

Colorado squawfish young-of-the-year were found at Jensen all three years, and at Lower Yampa, Echo Park, and Island Park in 1980. Yearling squawfish were found at Island Park and Jensen each year, suggesting reproduction in 1977, 1978, 1979, and 1980 at Island Park, as well as Jensen.

Mottled sculpin young were found sporadically at Alcove Brook, Echo Park, and Lily Park.

No young bonytail chub, humpback chub, razorback sucker, mountain whitefish, or mountain sucker were found during the study.

<u>Introduced Species</u> - The fathead minnow was the only introduced fish that reproduced at all stations during the study, although reproduction was sporadic in the Green River above the mouth of the Yampa, and in the Yampa River stations.

Young redside shiners were found sporadically at all stations except Lodore. Young red shiners were found at all stations except Lodore and Lily Park.

Carp was the only introduced species that reproduced in the Green River above the mouth of the Yampa River in 1978. Redside shiners, fathead minnows and red shiners reproduced in the Green River above the mouth of the Yampa River in 1979. No young of any introduced species were found at either Lodore or Alcove Brook in 1980.

Young of redside shiners, fathead minnows, and red shiners were difficult to determine. The reason is these small fish probably reproduce all summer, and young are difficult to separate from juveniles when they become large enough to be caught in our seines. Young are caught, but they are not nearly as easy to separate by length/frequency as are the other fish which are considerably larger as adults and juveniles. Therefore, the number of shiners or fatheads at a station may be a better indication of reproduction than size.

Length/Frequency and Growth

Figures 4, 5, and 6 show length/frequency histograms for speckled dace, roundtail chubs, and bluehead suckers, respectively, all common native fishes. Similar graphs for other common species can be found in Appendix III. Graphs of the three years of the study show very similar size-growth relationships, no obvious changes since inlet modification.

Figure 7 compares young flannelmouth suckers at Lodore-Alcove Brook (above the mouth of Yampa) to Echo-Island Park (below the mouth of the Yampa River) for 1979 and 1980. The 1979 data indicate yearling fish in March were of similar size in both areas, but the Lodore-Alcove fish were larger in June. In August, young-of-the-year appeared and were of similar size at both locations. By October, the Echo-Island young-of-the-year were noticeably larger.

The 1980 data showed similar results in March, but not in June, yearlings in both areas were of similar size. August young-of-the-year were again similar, but by October, the Lodore-Alcove fish appeared slightly larger.

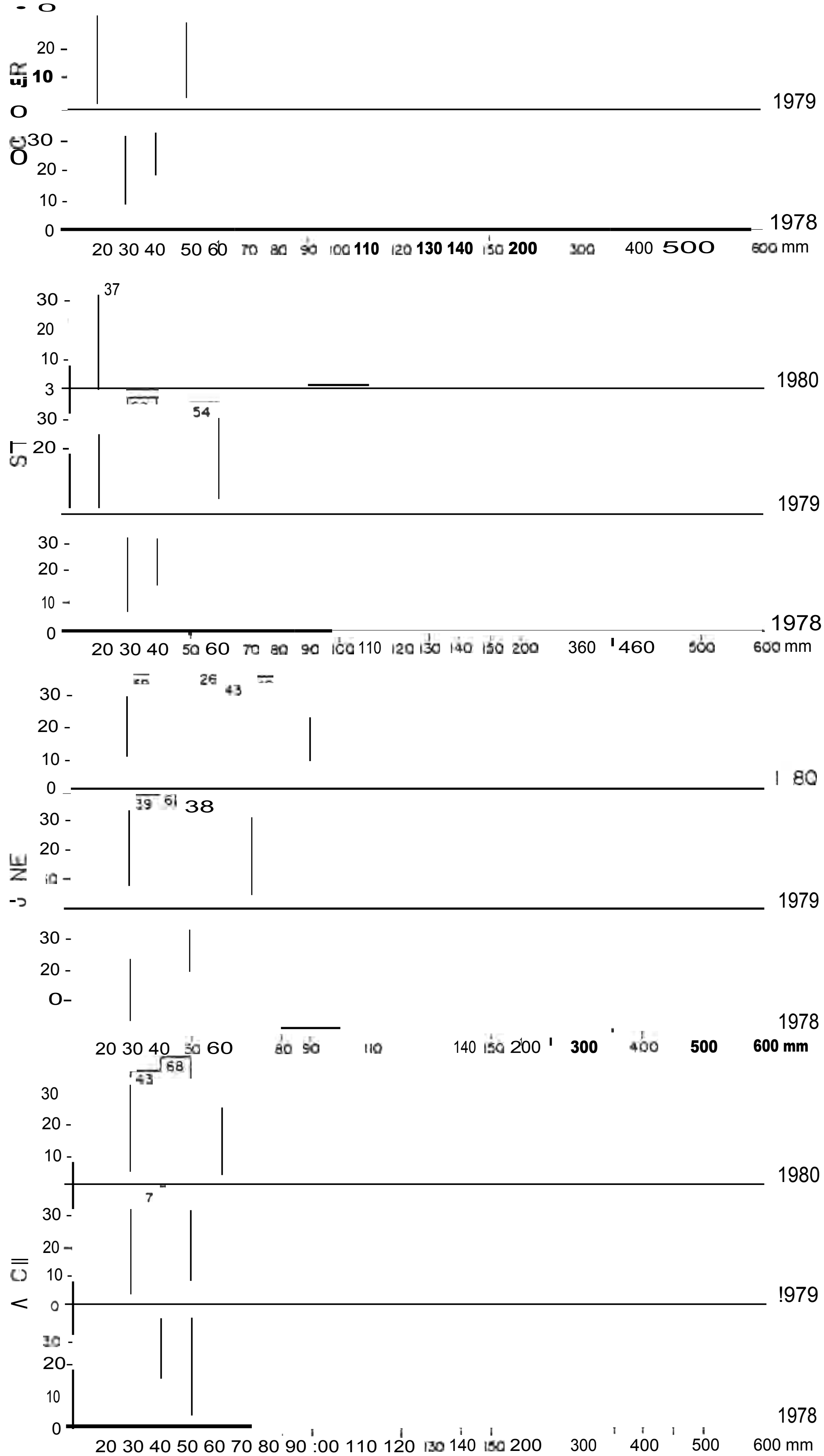


Figure 4. Length/frequency histograms for speckled dace, Flaming Gorge Study, 1978-1980.

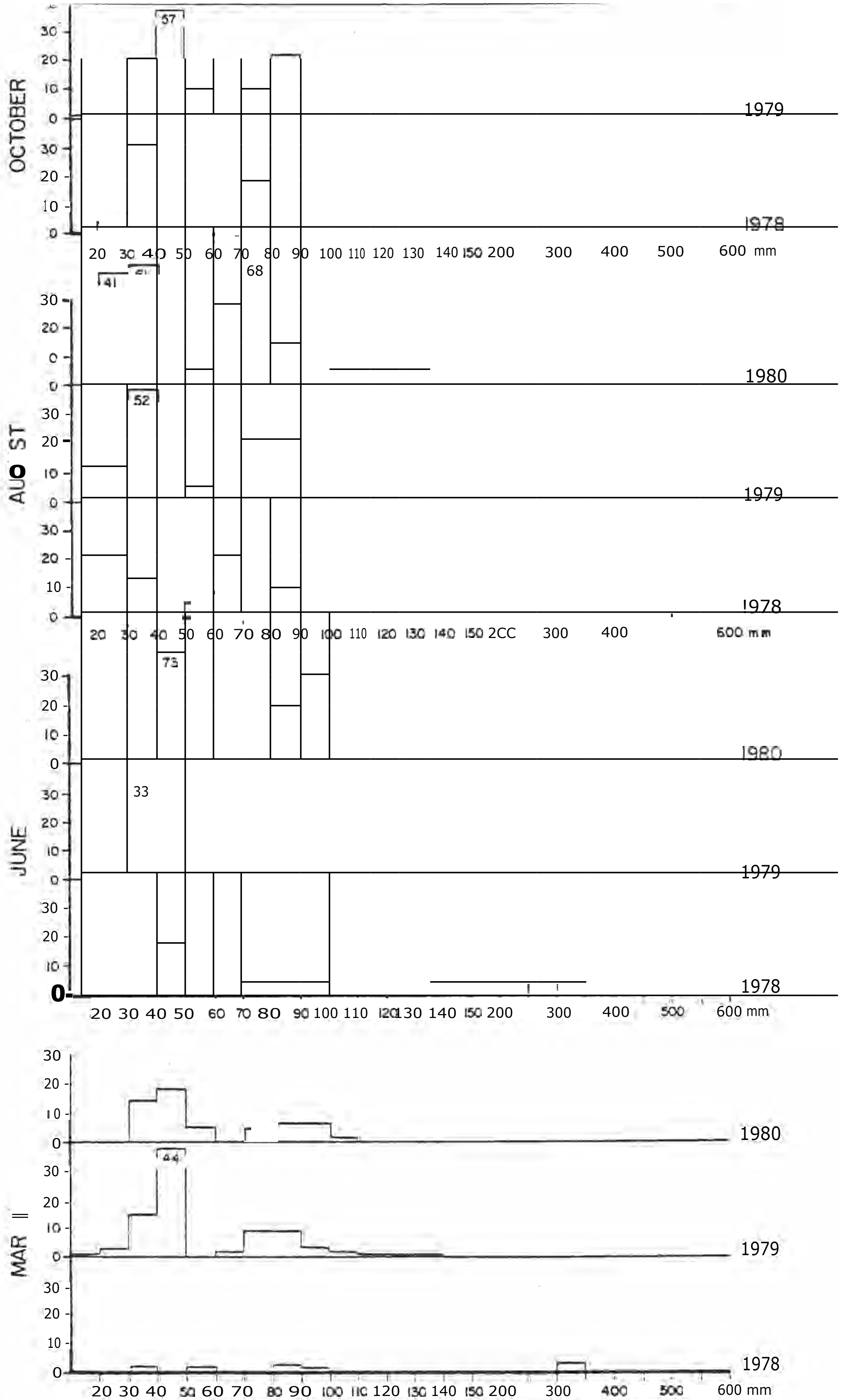


Figure 5. Length/frequency histograms for roundtail chubs, Flaming Gorge Study, 1978-1980.

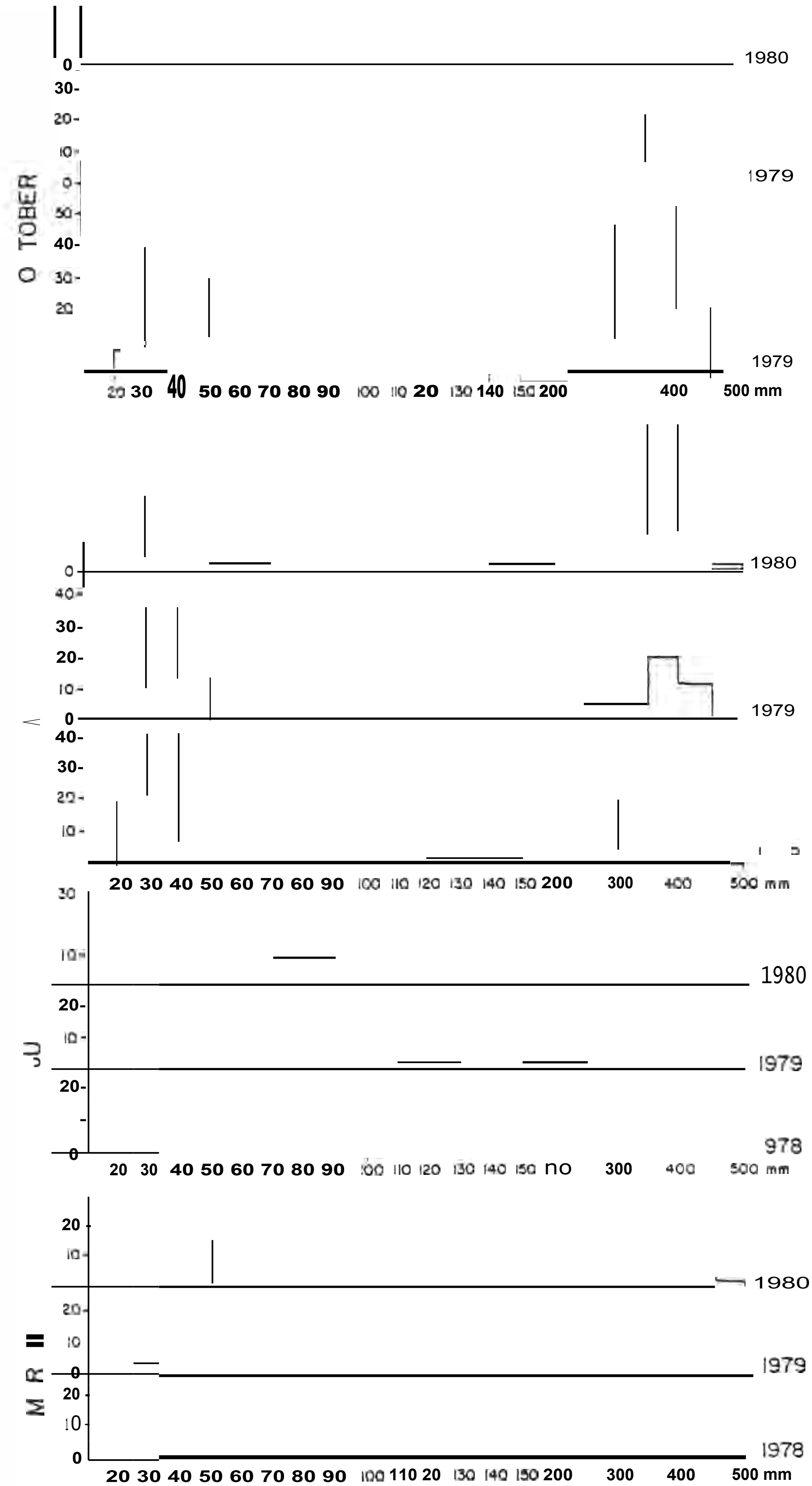


Figure 6. Length/frequency histograms for bluehead suckers, Flaming Gorge Study, 1978-1980.

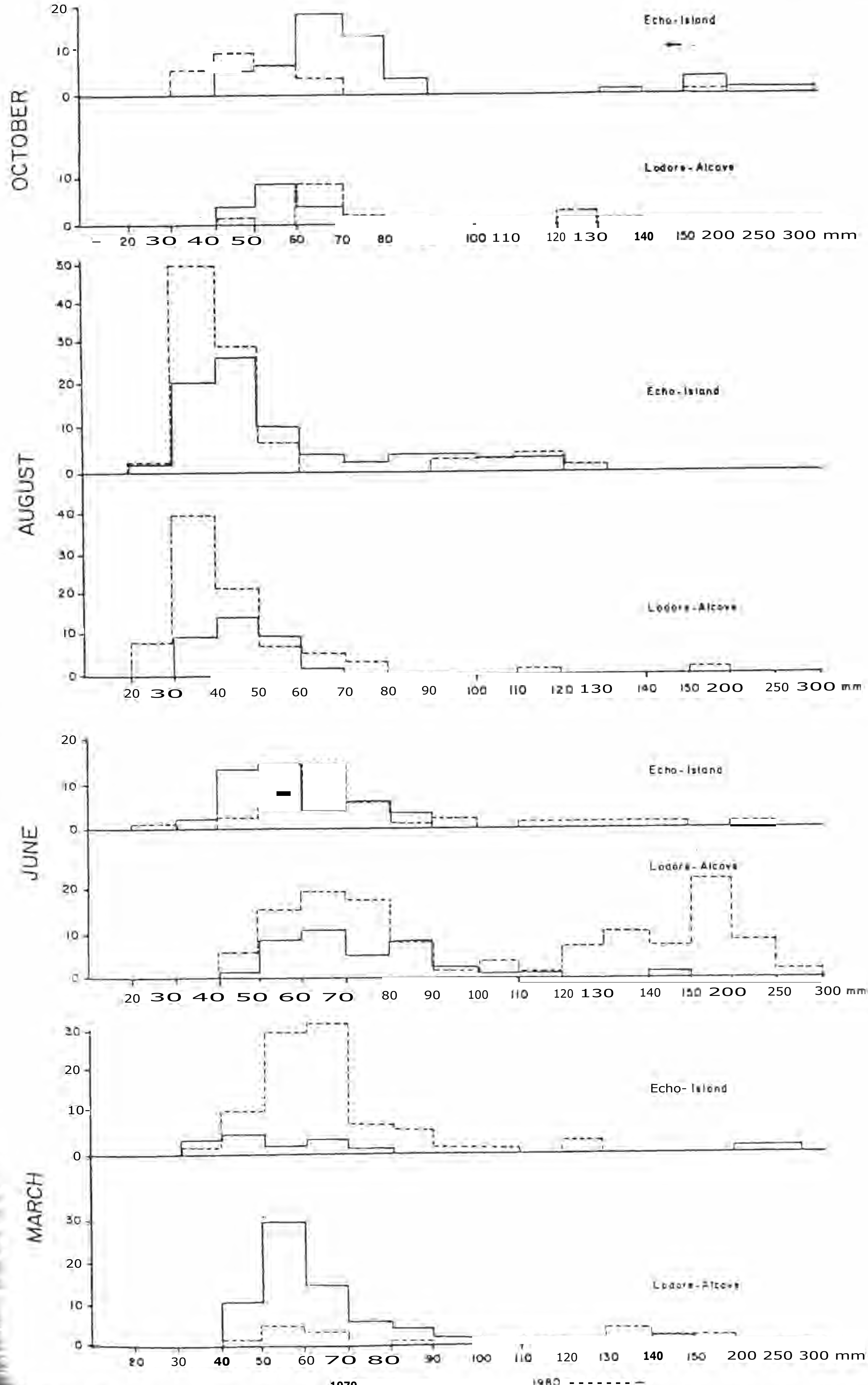


Figure 7. Length/frequency histograms of young flannelmouth suckers, comparing 1979 and 1980 above and below the mouth of the Yampa River.

Movements

Table 16 shows the number of fish tagged each year of the study with individually numbered tags. Flannelmouth suckers were the main species tagged, bluehead suckers and carp also were tagged in high numbers. Thirty-two Colorado squawfish and 40 razorback suckers were tagged, whereas only 41 roundtail chubs were tagged.

Trout were planted by the Utah Division of Wildlife Resources near Flaming Gorge Dam and dye-marked with florescent pigments. A number of these fish were captured each year of the study. Most of these fish were captured at Lodore and Alcove Brook, with smaller numbers at Echo Park and Island Park. The Utah Division of Wildlife Resources provided a black light for identification of these fish in 1979 and 1980 (Table 17).

Table 18 lists the fish recaptured that had been tagged during this study, or by other researchers in the Green River. Fifty-five fish representing 9 species and 1 hybrid were recaptured. Most fish were recaptured in the same area in which they had originally been tagged. Some moved considerable distances. One rainbow tagged at Echo Park in 1978 was caught a year later by a fisherman at Jones Hole,-4 miles downstream. A cutthroat tagged in Split Mountain in 1978 was caught 4 months later in Browns Park, over 50 miles upstream. Another cutthroat tagged at Alcove Brook in March 1979 was caught about 50 miles upstream in July. Brown trout and carp showed little movement, even after more than a year. Two roundtail chubs were recaptured, both were released in lily Park in October 1979. One was caught 4 days later by Ed Wick of

Table 16. The number of fish tagged with numbered Floy tags in the study area, 1978-1980.

Species	Number			Total
	1978	1979	1980	
Rainbow trout	41	26	55	122
Brown trout	17	10	9	36
Cutthroat trout	6	11	) 2	19
Mountain whitefish	-	1	-	1
Catfish	56	43	27	126
Carp	209	166	89	464
Roundtail chub	19	6	6	31
Bonytail chub[1]	-	1	-	1
Utah chub	1	-		0
Humpback chub[1]		2	-	2
Colorado squawfish[1]	10	15	7	32
Flannelmouth sucker	373	328	332.	1033
Bluehead sucker	256	160	161	577
White sucker	4	4	5	13
Razorback sucker[1]	22	13	5	'40
Mountain sucker	-	1	1	2
Walleye	3	3	1	7
Northern pike	-	-	1	1
White X Bluehead	1	-	-	1
White X Flannelmouth	2	1	-	3
Bluehead X Flannelmouth	-	-	2	2
Flannel X Razorback	2	1	1	4
Rainbow X Cutthroat	-	-	3	3

'Rare fish were tagged with numbered dangler tags rather than Floy tags.

Table 17. Dye-marked trout captured during 1979 and 1980 sampling of Green River stations.

Species	Dye color	Release point	Date	Recapture point	Date
Cutthroat trout	yellow		1978	Lodore	8-7-79
			1978	Above Echo Park	8-7-79
"			1978	Echo Park	3-20-79
Rainbow trout			1978	Lodore	3-25-79
			1978		3-25-79
	pink-orange	Browns Park	1978		3-25-79
	yellow		1978		3-26-79
	pink-orange	Browns Park	1978		3-26-79
			1978		3-26-79
	yellow	a	1978	Alcove Brook	3-28-79
	yellow	a	1978		3-29-79
		a	1978		3-29-79
		a	1978	Echo Park	3-30-79
		a	1978	Alcove Brook	6-7-79
	yellow	Taylor Flat Bridge	7-3-79	Lodore	3-25-80
	yellow-green	b	7-27-79	Lodore	3-26-80
	green	a	1979	Alcove Brook	3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-28-80
	yellow	a			3-27-80
	green	a	1979		3-27-80
		a	1979		3-27-80
		a	1179		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
		a	1979		3-27-80
"		a	1979	"	3-27-30
	yellow-green	b	1979	Alcove Brook	3-27-80
			7-27-79	"	3-27-80
	green		1979	Echo Park	3-28-80
		a	1979	" "	3-28-80
		a	1979		3-28-80
			1979		3-23-80
			1979		3-28-80
			1979		3-28-80
			1979		3-28-80
			1979		3-28-80
			1979		3-28-80
	yellow-green	b	7-27-80		3-28-80
"		Taylor Flat Bridge	7-3-79		3-28-80
	red-green	Little Hole	7-27-79	Island Park	3-29-80

[a]Exact point of release unavailable but between Flaming Gorge Dam and Browns Park.

[b]Released immediately below Flaming Gore Dam.

Table 18. Tagged fish that were recaptured in the study area, 1978-1980.

Species	Tag No.	Release Point	Date	Recapture Point	Date
Rainbow trout	28	Lodore	6-10-78	Lodore	10-29-78
	69	"	10-2-78	"	10-29-78
"	548	Alcove Brook	3-28-79	Alcove Brook	3-29-79
" "	628	Echo Park	6-12-78	Jones Hole	6-79
"	109	Lodore	3-25-79	Lodore	5-79
"	712	Echo Park	10-4-78	Echo Park	6-7-80
Cutthroat trout	385	Alcove Brook	6-11-78	Alcove Brook	7-5-78
"	1232	Split Mt.	3-16-73	Browns Park	7-8-78
"	564	Alcove Brook	3-29-79	Little Hole	7-23-79
	1975	Lodore	8-7-79	Wade and Curtis	8-13-79
Brown trout	314	Alcove Brook	3-13-78	Alcove Brook	10-3-78
" "	463	" "	8-16-78	" "	10-3-78
	367	" "	7-5-78	" "	8-8-78
"	848	Echo Park	6-7-79	Jones Hole	7-79
	441	Alcove Brook	7-5-78	Alcove Brook	3-27-80
"	560	" "	3-29-79	" "	3-27-80
Carp	961	Island Park	7-7-78	Island Park	10-5-78
	563	Alcove Brook	3-29-79	Alcove Brook	6-7-79
	563	" "	6-7-79	" "	10-7-79
"	1989	"	8-9-79	Alcove Brook	10-7-79
	510	"	10-3-78	" "	6-7-79
	538	" "	3-28-79		3-27-80
	510	"	6-7-79	"	3-27-80
	1755	Echo Park	7-25-79	Lower Yampa	10-12-80
Colorado squawfish	780	Jensen	5-7-78	Jensen	6-15-78
Roundtail chub	1638	Lily Park	10-7-78	Lily Park	10-11-78
" "	1702	" "	10-7-78	Echo Park	10-9-30
Razorback sucker	40 USU	Sand Wash	12-74	Jensen	6-15-78
		Jensen	6-15-78	"	7-9-78
	1102	Island Park	10-5-78	Island Park	8-11-79
	232	Jensen	5-16-79	Jensen	6-10-79
	1113	Island Park	10-5-78	Jensen	6-10-79
	610	Walker Hollow	4-11-79	Jensen	6-10-79

Table 18. Continued

Species		Tag No.	Release Point	Date	Recapture Point	Date
Bluehead sucker		1102	Island Park	10-5-78	Island Park	8-11-79
		527	Alcove Brook	10-3-78	Alcove Brook	6-5-80
		3715	Island Park	7-26-79	Alcove Brook	10-10-80
Flannelmouth sucker		1639	Lily Park	10-7-78	Lily Park	10-11-78[2]
"	"	1540	" "	8-21-78	" "	10-11-78[2]
"	"	676	Echo Park	8-17-78	Island Park	(no data)
		1649	Lily Park	10-7-78	Lily Park	8-12-79[2]
"	"	1625	Jensen	10-6-78	Island Park	10-9-79
"	"	26	Lodore	6-10-78	Lodore	3-26-79
[1]		505	Alcove Brook	10-3-78	Alcove Brook	3-28-79
"	"	552	" "	3-29-79	" "	6-7-79
"	"	1089	Island Park	10-5-78	Echo Park	6-7-80
	"	637	Echo Park	6-12-78	" "	6-7-80
"	"	2235	Lily Park	6-16-79	Lily Park	[1]6-8-80
[1]		2079	Alcove Brook	10-7-79	Alcove Brook	8-7-80
	"	1022	Island Park	8-18-78	Island Park	8-9-80
		1890	Island Park	8-11-79	Island Park	8-9-80
	"	531	Alcove Brook	3-28-79	Alcove Brook	10-8-80
"	"	2046	Island Park	10-9-79	Island Park	10-10-80
"	"	2044	" "	10-9-79	" "	10-10-80
Razorback X Flannelmouth		85	Lower Yampa	10-7-78	Alcove Brook	8-9-79

[1]Fish caught by fishermen.

[2]Fish caught by Ed Wick, Colorado State University.

Colorado State University at Lily Park, the other was recaptured in October 1980 at Echo Park. The one recaptured Colorado squawfish had not moved significantly in a month.

Three of the six razorback suckers recaptured were found at the same station as they were released. Of the other three, one was tagged at Sand Wash in 1974 by Charles McAda, then of Utah State University, and recaptured at Jensen in 1978, 93 miles upstream; one was released in October 1978 at Island Park and recaptured in June 1979 at Jensen; the third fish was tagged by BIO/WEST crews in April 1979 and recaptured at Jensen, 5 miles upstream, in June 1979.

Three bluehead suckers were recaptured, only one had moved (12 miles upstream) even though one recapture was nearly 2 years later.

Only 3 of 17 recaptured flannelmouth suckers had changed stations. Two moved upstream, one from Jensen to Island Park, the other from Island Park to Echo Park. The other fish moved downstream from Echo Park to Island Park.

Two carp were caught twice, one was released in March 1979 at Alcove Brook, caught in the same station in June 1979, and again in October. The other was also released at Alcove Brook in October 1978, recaptured in June 1979, and again in March 1980, still at Alcove Brook.

It is also interesting to note that 17 of the 55 recaptured fish were released and recaptured at Alcove Brook. No other station had nearly that many recaptures. Also, 5 of the 25 brown trout caught at Alcove Brook were recaptured. This suggests movement at this station was fairly low, and that catch efficiency, especially for brown trout, was very high.

Percentage of recaptures to released tagged fish are traditionally used to calculate population estimates. Although the data presented here does not meet the assumptions of no mortality or no movement necessary for such estimates, relative frequency is an index to population size. For example, the 17 recaptured flannelmouth, compared to the 1033 tagged is only 1.6%, indicating a large population. The 4 razorbacks recaptured that had been tagged during this study, compared to the 40 tagged, is 10%, indicating a smaller population size. The brown trout at Alcove Brook as noted above with 20% recaptures, probably also have a relatively small population at that station. Although not extremely accurate, this method does give some insight into relative population sizes.

Gear Efficiency

Table 19 shows the number of fish caught at Lodore and Alcove Brook during a test of gear efficiency in March 1979. The Water and Power Resources Service released flows from Flaming Gorge Dam to provide this comparison of sampling at 1200 and 4000 cfs. Numbers of fish found were small, which is typical for most of the stations in this study during cold months of the year (Table 10). Most fish were found at both stations during low flows, primarily due to the ability to seine a larger area more efficiently. During high flows, increased water depth as well as loss of habitat, such as backwaters, reduced the amount of seining that could be conducted. Figures 9 and 11 in Appendix I show that for

Table 19. Comparisons of numbers of fish caught at two stations during high (4000 cfs) and low (1200 cfs) flows.

	Lodore		Alcove Brook	
Species	4000 cfs	1200 cfs	4000 cfs	1200 cfs
Mountain whitefish		1		
Rainbow trout	4	4	3	6
Cutthroat trout	1		2	3
Brown trout		2		2
Carp	2	3	4	7
Speckled dace	8	9	1	7
Fathead minnow	1			
Mountain sucker		3		
Bluehead sucker	3	6	3	2
Flannelmouth sucker	11	64	8	4
Mottled sculpin				2
Total	30	93	22	33

both stations, the 4000 cfs flow minimized habitat diversity and no sand or gravel bars (prime seining sites) were exposed. Therefore, the major difference in numbers seen in Table 19 is created by more young suckers at Lodore and more speckled dace at Alcove Brook during low flows.

Little difference was seen in the species caught at the two flows, although more species were found during low flows at both stations. The species that were only caught at one flow level were rare, with only one, two, or three individuals found. This suggests the difference in number of species caught was of relatively low significance.

Tables 20 and 21 indicate the catch rates for seining and electrofishing, respectively, during the gear efficiency test. The seining rates at Lodore were considerably higher at low flows, primarily attributable to a higher rate for young flannelmouth suckers (1.9 to 0.4). The higher rate at Alcove Brook during the low flow situation (1.2 to 0.6) reflects an increase in speckled dace, and also more species caught (6 to 3).

Electrofishing catch rates were much closer at both stations than the seining rates. Considerable variation occurred within a species, but overall, little change was seen (Table 21). This is probably due to the smaller number of fish collected.

The results of this gear test indicate that electrofishing efficiency is not impaired much by high flows, but that seining catches are seriously affected, at least at the two stations sampled. Loss of habitat that is used by small fish (backwaters), and is easily seined, is the primary cause of loss of seining effectiveness.

Table 20. Comparisons of catch rates for fish caught by seines at two stations during high (4000 cfs) and low (1200 cfs) flows (no./1000 ft^2).

Species	Lodore 4000 cfs	Lodore 1200 cfs	Alcove Brook 4000 cfs	Alcove Brook 1200 cfs
Rainbow trout				0.1
Cutthroat trout				0.1
Speckled dace	0.6	0.3	0.2	0.6
Fathead minnow	0.1			
Mountain sucker		0.1		
Bluehead sucker	0.1	0.2	0.2	0.1
Flannelmouth sucker	0.4	1.9	0.2	0.1
Mottled sculpin				0.2
Total	1.2	2.5	0.6	1.2

Table 21. Comparisons of electrofishing catch rates for fish caught at two stations during high (4000 cfs) and low (1200 cfs) flows (no./hr.).

Species	Lodore		Alcove Brook	
	4000 cfs	1200 cfs	4000 cfs	1200 cfs
Mountain whitefish		0.5		
Rainbow trout	3.3	2.1	4.1	5.5
Cutthroat trout	0.8		3.1	1.6
Brown trout		1.1		1.7
Carp	1.6	1.6	4.1	7.9
Mountain sucker		0.5		
Bluehead sucker	0.8		3.1	0.8
Flannelmouth sucker	5.7	5.9	5.1	6.3
Total	12.2	11.7	19.5	23.7

The data from other stations can be used to evaluate the above results. Seining catch rates for 1979 are shown in Table 22. June catch rates, during high water, and low flow August catch rates can be compared. Echo Park and Jensen had higher June seining catch rates than August, Island Park had lower seining catch rates in June. This suggests that high flow rates may not necessarily reduce seining catch rates and that factors other than flow must also be important. Table 12 indicates that a relatively small amount of habitat was seined at each of the above stations in June, compared to August. Since seining effort generally reflects habitat availability, a reasonable conclusion would be that high flows decrease available habitat for young fish, just as our study at Lodore and Alcove Brook suggested. The higher catch rate at Echo Park and Jensen suggests the habitat that was available during high flows at these stations, was more preferred than the available habitat at Island Park and Lower Yampa. In other words, fish were more concentrated during high flows at stations with high catch rates than at those with low rates. Therefore, habitat quality, something difficult to appraise, probably plays the larger role in determining catch and efficiency than does flow level. Flow level, in turn, reflects what habitat will be available at any given area. High flows at some stations, Echo Park and Lily Park, provide a few high quality habitats that small fish are attracted to. High flows at the other stations, reduce the habitat availability to small fish and do not provide areas of excellent quality.

Table 22. Seine catch per 1000 ft^2 for all habitats combined, Flaming Gorge Study, 1979.

	Lodore				Alcove Brook				Echo Park				Island Park				Jensen				Lily Park				Lower Yampa			
	Mar.	June	Aug	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar	June	Aug.	Oct.	Mir.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Rainbow trout				0.1	<0.1				0.2																			
Cutthroat trout					<0.1																							
Rainbow X Cutthroat																												
Northern pike										0.3																		
Carp						0.1					0.1							0.8	61.0	1.1								
Speckled dace	0.3	5.7	1.0	3.7	0.6	3.7	54.4	2.0	5.7	43.3	1.7	3.6	5.1	1.8	4.5	0.9	6.4	6.3	0.2	5.7	1.7	634.7	8.5	2.0		9.8	4.9	2.1
Creek chub						0.1				0.5				0.2														
Colorado squawfish														0.2	0.1			0.8		1.7								
Roundtail chub						0.3	0.5	0.3	9.6	63.3	8.0	2.4	0.5	48.5	26.9	3.9		11.0	0.8	4.6	11.2		11.0	2.1		65.[illegible]	[illegible]	1.9
Utah chub		0.1																										
Redside shiner	<0.1	0.2				0.6	31.1	0.9	8.6	101.3	1.9	1.1	1.8	29.7	22.8	1.2			1.0	0.3	5.1	28.6	1.1	24.2		7.8	53.6	1.0
Fathead minnow		1.5	0.8	0.8		2.0	3.5	1.2	1.6	1.3	0.1	0.2	0.8	8.5	19.3	0.8	0.6	18.1	46.1	0.9	2.2			0.1		1.0	0.3	
Sand shiner							0.2		2.5	5.0				0.2	0.4	1.3							9.6	8.2		1.0	1.0	0.1
Red shiner						11.6	20.3	64.2	63.6	2.8	2.8	74.6	9.2	27.2	30.4	329.0	164.3	610.2	60.9	317.7	8.5	6.1	1.8	0.9		2.0	39.1	20.1
Mountain sucker	0.2	0.7																									0.3	
Bluehead sucker	1.9	1.3	13.6	0.2	<0.1	0.1	0.4	0.1	0.1	6.8	2.4	0.1	0.5	16.9	83.6	15.1	0.4	13.4	32.6	6.0	0.2	8.2				15.3	8.2	6.2
Flannelmouth sucker	1.9	12.7	12.3	0.6		0.2	1.0	0.5	0.8	9.5	19.9	1.7	2.3	25.8	79.5	19.6	4.3	17.3	21.0	19.1	0.7		1.4			5.8	63.2	1.5
White sucker				0.1		0.1				0.8					0.1			2.4										
Mottled sculpin					0.2		0.1	0.7	0.1	1.0	0.2	0.4			0.1													
Green sunfish																		0.8	0.1									
Total	4.4	22.2	27.7	9.9	1.1	18.8	111.5	69.9	92.8	235.9	38.9	84.1	20.2	159.0	267.7	371.8	176.0	681.1	223.7	357.1	29.6	677.6	33.4	38.0		108.5	194.0	32.9

DISCUSSION

Macroinvertebrates

Prior to 1978, Flaming Gorge Dam had increased the standing crop and decreased the diversity of the macroinvertebrate community immediately below the dam, when compared to the pre-dam conditions or to more natural downstream reaches (Pearson et al. 1968). A decrease in standing crop was noted from 1965 to 1967, primarily due to colder, higher flows in 1967. The inlet modification of 1978 may be responsible for changes in the standing crop (density) and has apparently increased macroinvertebrate diversity immediately below the dam.

The high standing crop of macroinvertebrates found during this study at Little Hole and Taylor Flats is similar to that reported by Pearson (1967) and Pearson, Kramer, and Franklin (1968) for the same area in 1964, 1965, and 1967. High densities in this area of the Green River, as compared to lower downstream reaches, is related to several factors which have been demonstrated below Flaming Gorge as well as other deep release reservoirs. Pearson et al. (1968) found that below Flaming Gorge increased seasonal flow constancy increased stability of substrate below the dam, despite moderate to large daily flow fluctuations, by reducing high flows associated with spring runoff. Ward and Stanford (1979) stated that release of cool, clear waters from reservoirs (e.g., Flaming Gorge) stimulates periphyton development providing a substantial food base for collector-gatherer-scraper functional groups. In addition, Ward (1976a) also found that thermal stability or winter-warm summer-cool conditions in rivers such as the Green River below Flaming

Gorge eliminate many species which require seasonal cues to complete their life cycles, particularly predator species such as some Plecoptera. This in turn allows space monopilization by prey species such as Baetis spp. which can tolerate isothermal conditions.

Diversity of macroinvertebrates varied during this study at Little Hole and Taylor Flats, the stations nearest the dam, with 1979 values considerably higher than 1978 or 1980 values, which were similar. Several factors appeared important in causing this variation. Part of the variation was probably due to the inability of four seasonal samples to accurately reflect a changing macroinvertebrate community. Pearson et al. (1968) reported an unstable community below Flaming Gorge and related this to large fluctuations in density caused by short-term shifts in taxa abundance due to emergence and other life history aspects of individual species dependent primarily on temperature. This suggests that monthly or seasonal changes in flow, and therefore temperature, affect the density of invertebrates by cuing life history phenomena, such as emergence, differently during adjacent years. Therefore, samples taken at similar times of different years may not be sampling taxa in the same life history phase.

Some changes in total density can probably be related to temperature and flow changes resulting from the inlet modification between years. The increase in standing crop between 1978 and 1979 concurrent with increased water temperatures during late 1978 and 1979 suggests temperature as the major factor. Pearson et al. (1968) also hypothesized a direct macroinvertebrate density-temperature relationship at Little Hole when standing crops of invertebrates decreased after water temperatures dropped and flows increased in the Green River subsequent to the filling of Flaming Gorge between 1965 and 1967.

Decreased standing crops at Little Hole and Taylor Flats from 1979 to 1980 are difficult to reconcile with observed yearly temperature data since 1980 release temperatures were similar to 1979 values. The decrease noted in 1980 may be due to monthly or seasonal flow patterns which caused changes in life history aspects of the invertebrates as indicated above. This suggests that flow, and the effect of flow on temperature, may be important in determining short-term density fluctuations of the invertebrate community. Additional study on this point should be made, especially in light of proposed power peeking at Flaming Gorge.

Changes in standing crop may also have occurred at Wade and Curtis during this study but were not detected due to large sample variations. Large sample variation at this station was the result of the sampling schedule and the inability to wait for low flows to take invertebrate samples. In contrast, invertebrate samples at Little Hole and Taylor Flats were generally taken at similar, low flows. Jensen and Yampa River stations showed no trends in total standing crops between years, indicating little change in habitat parameters.

Individual taxa were distributed spatially within the Green and Yampa rivers according to their ecological preferences. Dominant species at Little Hole and Taylor Flats such as <u>Baetis</u> sp., <u>Simulium</u> sp. and <u>Gammarus lacustris</u> are commonly found in the regulated lotic environments which occur below reservoirs due primarily to their ability to tolerate relatively isothermal conditions (Spence 1971, Ward 1976a, Williams 1979). Entrainment of organisms from the reservoir apparently did not contribute many taxa or much biomass to these upper stations with the exception of copepods which were occasionally abundant.

As temperature and flow regimes became less affected with increasing distance from Flaming Gorge Dam, particularly below the Yampa River, increased numbers of taxa occurred. Baetis, Simulium, and Chironomidae tended not to dominate invertebrate communities downstream of Taylor Flats year round. Instead, dependent on their life histories and time of year in which samples were taken, taxa such as Brachycentrus, Tricorythodes, Ephemerella, Hydropsyche, Cheumatopsyche, Rhithrogena, Heptagenia, or Traverella albertana predominated. Taxa found at Jensen and on the Yampa River were typical of those recorded in large, unregulated, southwestern rivers. Taxa present at Wade and Curtis included species which might be found in both regulated and unregulated streams (Williams and Winget 1979).

Invertebrate taxa occurring near the dam were comprised almost exclusively of collector and scraper functional groups which feed primarily on detritus and algae. Farther downstream, particularly at Jensen and on the Yampa River, predators formed an important segment of the invertebrate community though still relatively small.

In addition to spatial variations in species presence and abundance, yearly changes in occurrence of some taxa were noted below the dam. Hydroptila, a cased caddisfly and the amphipod Gammarus lacustris both increased significantly in abundance between 1978 and 1980 at Little Hole and Taylor Flats. Both species utilize cladophora and other epilithic algae in riffle areas extensively (Hynes 1970) and their abundance may be related more to changes in periphyton below the dam rather than directly to temperature. Evidence of increased periphyton near Flaming Gorge was provided by Annear (1980) who recorded increased chlorophyll a ciincentrations in benthic samples taken below Flaming Gorge between the late summer of 1978 and 1979. Ephemerella inermis, a widespread mayfly, also increased in abundance during the three years of this study at Taylor Flats. None of the taxa which exhibited increased abundance at Little Hole and Taylor Flats showed similar increases at Jensen or the Yampa River stations. This indicates that the trends were in fact either direct or indirect effects of altered temperature and flow regimes below the dam. Other taxa which increased slightly in abundance in the Green River above the Yampa River included the stonefly Malenka and caddisfly Hydropsyche. The increases, however, were small enough that they could be attributed to random sampling variation.

Species diversity values calculated for the macroinvertebrate community during 1978 and 1979 showed significant increases with increasing distance from the dam. The increase in diversity downstream from Flaming Gorge was primarily related to the appearance of new taxa as water temperatures and flows became more natural. Ward and Stanford (1979) and Holden, Twedt, and Richards (1980) demonstrated similar trends for other areas downstream of hypolimnion release reservoirs. During 1980, however, there was no significant difference in mean species diversity between any of the stations on the Green and Yampa rivers. The primary reason for this was increased diversity values noted at Little Hole and Taylor Flats during 1980, coupled with relatively large variations in diversity values which made small differences in mean species diversity difficult to substantiate statistically. Further statistical comparisons of species diversity values at only Little Hole for the years 1965, 1967, 1978, 1979, and 1980 showed that mean diversity from 1965-1979 was similar but that 1980 was significantly higher. The higher diversity values in 1980 were partially attributable to increased abundance of some species formerly absent or less common at that station such as Hydroptila sp. and Gammarus lacustris. Much of the increased diversity, however, was seen not as the result of the appearance of many more taxa at the station but in a more equitable distribution of numbers of individuals between taxa already present with no one taxa dominating numerically and consequently causing low a values. Thus, even though mean diversity values were higher near Flaming Gorge Dam in 1980, these values in fact reflect a period in the invertebrate community when no single organism is dominating rather than the appearance of many new taxa. Ward and Stanford (1979) reviewed the effects of seasonal constancy of temperature on macroinvertebrate diversity and found temperature range to be positively correlated with diversity. At Flaming Gorge, the inlet modification has increased the range of seasonal temperatures and caused the macroinvertebrate community to shift more towards what Hutchinson (1953) calls a nonequilibrium community in which different species are favored as conditions change and diversity generally increases.

In summary, Little Hole, Taylor Flats, and to a lesser extent Wade and Curtis, exhibited the most response to the inlet modification of Flaming Gorge. Jensen and the Yampa River stations exhibited no significant impacts.

Total abundance or standing crop of invertebrates was greatest at stations near the dam (Little Hole and Taylor Flats). Differences in standing crop at Little Hole and Taylor Flats between 1978 and 1980 reflect a basically unstable community responding to changes in temperature and flow from Flaming Gorge Dam. Standing crops at Little Hole and Taylor Flats appear to be inversely related to water temperature but also are subject to other factors such as flow and periphyton development.

Individual taxa which have benefited either directly or indirectly from the inlet modification on Flaming Gorge include *Ephemerella inermis*, *Gammarus lacustris*, and *Hydroptila* sp.

Species diversity values increased at Little Hole and Taylor Flats during this study as a result of inlet modification. The increased diversity at Little Hole and Taylor Flats, however, does not reflect an equilibrium community with relatively stable seasonal species successions and densities but rather one still in the process of change.

Fishes

Pre-inlet Modification

The temperature and flow patterns of the Green River below Flaming Gorge Dam have had a marked impact on the fishes of that area. Native species were replaced with introduced trout when the dam became operational in 1962, but the trout fishery declined in the late 1960's. The major reason given for this decline was colder flows emanating from the dam reduced growth and increased migration in the first 29 miles below the dam. The hypothesis used to explain this decline indicated that when the reservoir filled and stratifi.A in 1966-1967, the penstocks began drawing colder water through the dam (Holden 1973; Bureau of Reclamation 1976; Mullan et al. 1976; Peters 1978). The data presented in Table 1 do not support this hypothesis. Outlet temperatures declined only 1-2° C in the 1967-77 period, over the 1963-66 period. Flows though were nearly doubled in the 1967-77 period from those of the 1963-66 period. We hypothesize that the reduction in tailwater temperatures resulted from a decreased ability of ambient conditions to warm the outflow waters because of increased flow. The 1964-66 low flows moved slowly through the area below the dam, and since they were also shallow, warmed considerably in the first several miles below the dam. The higher flows of 1967-77 were deeper and moved much more rapidly, hence solar and ambient air heating was less effective in raising temperatures. Temperatures of rivers are highly influenced by solar radiation and ambient air conditions. Our data show that the Green River warmed 8°C in mid-June 1978 in the 46 miles between the dam and Lodore. This warming was effected during low flows similar to the 1963-66 conditions. We have no comparative data for typical 1967-77 June flows, but suspect that temperatures would have risen only 3-5°C. Much of the warming of the Green River above Lodore probably occurs in the Utah trout fishery area.

The effect of temperature and flow on fishes below the mouth of the Yampa River was less dramatic, but no less important, as shown by Colorado squawfish spawning records. In the period 1963-66, the low, relatively cool flows of the Green were ameliorated sufficiently by the Yampa River that temperatures were adequate for successful Colorado squawfish reproduction (Vanicek, Kramer, and Franklin 1970). After 1967, the Yampa apparently could not compensate for the higher, colder flows of the Green River, and temperatures became too low for successful reproduction of Colorado squawfish between Echo Park and Jensen (Holden and Stalnaker 1975) except for the limited reproductive success noted in this study at Island Park in 1977. Unfortunately, there were no temperature recorders between Echo Park and Jensen to record actual values. The temperatures at Jensen (Table 2) show only slight decreases in 1967-77. It is probable that the warming of the river in the 30 miles between the Jensen U.S.G.S. gage, and Echo Park, ameliorated the impact of the cool inflow of the Green River. Data from this study, as well as Holden (1977), indicate that Colorado squawfish successfully reproduced in the Jensen area between 1967 and 1976.

Other flow related factors may also have been important contributors to the decline in Colorado squawfish reproductive success in Dinosaur National Monument after 1967. Since 1967, the August through December flows have been higher than either the 1962-66 levels or the natural flows. Although not shown in U.S.G.S. data (Table 1), the level of daily fluctuations due to power peaking may also have increased and created conditions unsuitable for young fishes. Since all the other native species present in the Monument, which all spawn in cooler temperatures than squawfish (Joseph et al.), were apparently not affected in 1967 or thereafter, the influence of factors other than temperature appears relatively slight.

Effects of the Inlet Modification

Changes in fish distribution, abundance, and reproduction that were caused by the inlet modifications were generally restricted to Lodore and Alcove Brook (Table 23). Pre-modification conditions have to be taken from our rather limited 1978 data. Vanicek, Kramer, and Franklin (1970) found roundtail chubs, redside shiners, and channel catfish at Lodore in 1964-66. These species were not found there during this study in 1978. Bluehead suckers were common at Lodore in 1964-66, but were not found there until August 1978. All four of these species were found at Alcove Brook before August 1978, although only one roundtail was found and that in July. Therefore, the fish fauna of Lodore changed considerably from 1966 to 1978, and the 1978 fauna at Alcove Brook was similar to the 1966 Lodore fauna.

This change in the fish fauna at Lodore from 1966 to early 1978 was undoubtedly caused by the higher, colder flows that occurred after 1966. Reproduction of warm water species was eliminated, except perhaps for fathead minnows. At Alcove Brook more warm water species were present for two major reasons: 1) It was fairly close to a warm water area

Table 23. Presence (X) and successful reproduction (R) of fishes in the Green River at Lodore and Alcove Brook, 1977-1980, before and after inlet modification.

Species	Lodore		Alcove Brook	
	Before	After	Before	After
Mountain whitefish				
Rainbow trout			X	X
Cutthroat trout			X	X
Brown trout			X	X
Carp	X		X	X
Speckled dace	X		R	R
Colorado squawfish			X	X
Roundtail chub			X	R
Utah chub	X			X
Redside shiner			R?	R
Fathead minnow			R	R
Red shiner				R
Sand shiner				X
Razorback sucker			X	X
Mountain sucker				X
Bluehead sucker			X	R
Flannelmouth sucker	X		X	R
White sucker				R
Channel catfish			X	X
Black bullhead				X
Mottled sculpin			R	R

(Echo Park), and 2) Habitat was better than at Lodore. Speckled dace and perhaps fathead minnows and redside shiners reproduced at Alcove Brook.

Several fishes appeared to react very quickly to the temperature increases in the Green River above the mouth of the Yampa River in 1978. Red shiners and sand shiners moved up to Alcove Brook. Fisherman catches indicated roundtail chubs and channel catfish moved further up the river. Flannelmouth suckers, bluehead suckers, carp, and speckled dace reproduced at Lodore and all but the carp at Alcove Brook. The trend of increased numbers of warm water fishes at Lodore and Alcove Brook continued in 1979 and 1980.

Concommitant with the increase in warm water fishes, cool water species, primarily trout, declined in abundance at Lodore and Alcove Brook, except during March when water temperatures were cool.

These changes in the fish fauna at Lodore and Alcove Brook reflect a change from a cold water habitat to a warm water habitat. Warm water species invaded this area and reproduced successfully, whereas the cold water trout were forced to seek more appropriate habitat.

The inlet modification did not appear to change the fish fauna below the mouth of the Yampa River, or in the Yampa itself. The only change that was noted at other stations was successful reproduction of Colorado squawfish, as evidenced by young-of-the-year, at Lower Yampa, Echo Park, and Island Park in 1980. Young squawfish were first found by Colorado Division of Wildlife personnel in August 1980 in the lower 9.5 miles of the Yampa River. They were subsequently found in the lower Yampa River

Lo crie numbers collected by Vanicek (1967) in 1964 and 1966 (275 and 650 young, respectively). Most of Vanicek's young were taken at Echo Park (Holden 1980) and 1965 was a similar year to 1980 as only 42 young-of-the-year squawfish were found. Holden (1980) showed that 1965 was an abnormally cold year as recorded by the number of days above 60 F (15.5°C) at the Jensen USGS gage by June 30. A similar calculation from 1980 indicates that only 4 days were above 60°F, compared to 17 in 1965. Table 5 also shows that 1980 had a very cold sliring-early summer. A similar compar4on for 1978 and 1979 indicated 50 n 63 days, respectively (Hol en 1980). Therefore, Colorado squawfish\reproduction in 1980 woul not have been expected to be very successful *ed on comparisons with earlier years. The previous year, 1979, should hav been successfu though.

This information suggests hat, based on temperatures, inlet modification should have ai ed s uawfish reproduction in 1979, but ambient weather conditions shoul have reduced reproductive success in 1980. Just the reverse actuall urred. Reasons for this phenomena are not known; the following hypothesis is offered as the best possibility at this time.

Young squawfish produced in the lower Yampa River accounted for the young found at Echo Park in 1980. The yearlings found at Island Park in 1978, 1979, and 1980 were not Yampa River fish, but were spawned in and the Green River at Echo Park and Island Park by BIO/WEST and the U.S. Fish and Wildlife Service. Numbers of young that have been found by all researchers have been relatively small (less than 100), especially when compared to the numbers collected by Vanicek (1967) in 1964 and 1966 (275 and 650 young, respectively). Most of Vanicek's young were taken at Echo Park (Holden 1980) and 1965 was a similar year to 1980 as only 42 young-of-the-year squawfish were found. Holden (1980) showed that 1965 was an abnormally cold year as recorded by the number of days above 60 F (15.5°C) at the Jensen USGS gage by June 30. A similar calculation from 1980 indicates that only 4 days were above 60°F, compared to 17 in 1965. Table 5 also shows that 1980 had a very cold spring-early summer. A similar comparison for 1978 and 1979 indicated 50 and 63 days, respectively (Holden 1980). Therefore, Colorado squawfish reproduction in 1980 would not have been expected to be very successful based on comparisons with earlier years. The previous year, 1979, should have been successful though.

This information suggests that, based on temperatures, inlet modification should have aided squawfish reproduction in 1979, but ambient weather conditions should have reduced reproductive success in 1980. Just the reverse actually occurred. Reasons for this phenomena are not known; the following hypothesis is offered as the best possibility at this time.

Young squawfish produced in the lower Yampa River accounted for the [illegible]g found at Echo Park in 1980. The yearlings found at Island Park in [illegible]978, 1979, and 1980 were not Yampa River fish, but were spawned in

Island Park or thereabouts. Young squawfish at Jensen and below were also spawned at several separate areas. The information supporting these conclusions are the lack of young squawfish at Echo Park or Lower Yampa in 1978 and 1979, as well as the lack of young fish in previous investigations (Holden and Stalnaker 1975, Seethaler, McAda, and Wydoski 1976) in Dinosaur National Monument.

The question remains whether Yampa River spawned squawfish were found by Vanicek (1967) at Echo Park. We suspect so based on the location of the fish (Personal communication, David Vanicek, Sacramento State University, Calif.). If this is accurate, why then did squawfish stop reproducing successfully in the Yampa in 1967 or 1968, yet began again in 1980? Holden and Stalnaker (1975a and b) found large numbers of ripe male squawfish in the lower Yampa in 1968, 1969, and 1970 in July and August. A look at flow and temperatures in the Yampa River during that time provides no definitive answers as to loss of reproductive success as no changes are obvious (see Holden 1980).

It is suspected that Colorado squawfish that spend most of their year in the Echo Park-Whirlpool Canyon area, traditionally moved into the lower Yampa to spawn. Cold temperatures from the Green River in 1967 or 1968, and continuing until 1978, prohibited reproduction. It is not known what the actual mechanism was, but we suspect egg maturation in females was impaired by the colder flows, similar to that suggested by Gerking et al. (1979) for other fish. Reproduction was effectively eliminated for over 10 years and the warmer flows of 1979 were too large a change to be responded to quickly by the remaining adults. It is possible the number of adults in the Echo Park area declined considerably during this 10-year reproductive drought. Adult numbers may have increased in 1979 and 1980 due to warmer flows, thus increasing the number of fish available for reproduction. Our data suggests this may have happened, especially in 1979. The cold weather of early 1980 reduced the success of squawfish spawning in 1980.

The above hypothesized series of events suggests the inlet modification has helped Colorado squawfish reproductive success, although it was overshadowed in 1980 by ambient weather conditions. Several additional years of data will be needed to see if this hypothesis is correct.

Several other changes or observations occurred during the study that were not related to the inlet modification. The sand shiner, first found in the upper Yampa River in 1976 (Prewitt et al. 1976), has continued to extend its range downstream. The red shiner has become'more abundant in the study area as a whole, moving up from the Colorado River since the early 1960 s (Holden and Stalnaker 1975a).

The large number of planted rainbow trout caught, especially in 1980, apparently reflect some change in winter releases from Flaming Gorge Dam. Several studies are presently being conducted to analyze this situation (Personal communication, Reed Harris, Water and Power Resources Service, Salt Lake City, Utah).

The reduction in the number of fish reproducing successfully at Lodore and Alcove Brook in 1980 over that in 1979, and the decreased numbers of young fish at Echo Park and Island Park, suggest something occurred in 1980 that affected fish reproduction. The colder, late spring temperatures recorded at Jensen appeared to be a likely factor, except fish at the Yampa River stations and Jensen did not appear to be affected. Flows emanating from the dam were generally lower in early summer in 1980, then higher in late summer than the other two years (Table 5). This may have created problems for spawning or larval fish survival. The reasons for the decline in numbers captured are not known but the extent and variation of fluctuations from Flaming Gorge Dam appear to be a likely factor since those stations closest to the dam showed the greatest changes. Further study of the effects of flow fluctuations from Flaming Gorge Dam are needed to resolve this question

The 1979 growth data (Figure 7) for young flannelmouth suckers suggested that growth at Echo Park-Island Park was faster in late summer and fall, but winter growth at Lodore-Alcove was faster. Holden and Crist (1980) hypothesized that the warmer winter flows created year-round growth conditions at Lodore-Alcove, but daily fluctuations and reduced food availability reduced the overall growth rate. Echo-Island, more natural areas due to the input of the Yampa River, showed high (normal) summer growth and no winter growth.

The 1980 data (Figure 7) supported the winter growth portion of the hypothesis, but young-of-the-year in 1980 showed similar growth at both locations. The difference in the two years growth may have been caused by a number of factors, but temperature and food availability would appear to be the most likely. It would appear that this change in growth patterns in 1980 may have been caused by the same factors that caused lowered numbers of young fish in the stations most influenced by flow from Flaming Gorge Dam.

SUMMARY

The outlet modification of Flaming Gorge Dam was expected to increase downstream water temperatures during spring, summer, and fall periods, which it did. This caused the Green River above the mouth of the Yampa River to follow a more natural yearly temperature regime. This in turn created conditions acceptable for more benthic invertebrate taxa, because cues for life history development were present. Increased diversity, due to a more equitable distribution of abundance among taxa, was a significant result. The fish fauna also increased in diversity and reproductive success of warm water species above the mouth of the Yampa River. Cold water species declined in abundance and predominance.

Below the mouth of the Yampa River, no significant changes were noted except increased reproductive success of Colorado squawfish in 1980. The temperature modification may have been responsible for this change, but additional years data will be required to prove this point.

Besides meeting the objectives of the study, several additional pieces of information were found. The historical relationship between temperature and flow below Flaming Gorge Dam was elucidated. Additional notes on movement, distribution, abundance, and reproductive success of native and introduced fishes were also made.

RECOMMENDATIONS

The primary reason for construction of the inlet modification was to increase trout productivity below Flaming Gorge Dam. The Utah Division f Wildlife is studying this potential benefit. A secondary benefit of the modification was the potential for returning successful reproduction of Colorado squawfish to Dinosaur National Monument. This study investigated that aspect and no definitive conclusion can be drawn at this time, although preliminary indications are positive. Additional studies for at least several years should be made to answer this question. The study should focus on the Lower Yampa-Echo Park-Island Park area.

The invertebrate portion of the study also indicated the inlet modification was positive, at least in terms of providing higher densities and a greater diversity of fish food organisms near the dam. This suggests that such a system could be manipulated to provide the best fish-invertebrate production possible. Additional intensive invertebrate studies below Flaming Gorge Dam could provide answers useful in managing the trout fishery, as well as data for predicting changes that might occur under different operational strategies in the future.

The implication of negative benefits to invertebrates, warm water fish and cold water fish from Flaming Gorge flows, as seen in 1980, is also worthy of additional study. The proposed power peaking of Flaming Gorge could have serious consequences to the downstream invertebrate and fish populations. Intensive studies in areas such as Lodore, which are very much affected by fluctuating flows, would greatly increase our understanding of how varied fluctuations may affect fish further down the Green River in the future. This would be especially pertinent when other water development projects come on line in the Green River system. Such a study would mesh well with the present Colorado River Fishery Project studies.

Another recommendation, that has been made in both previous Annual Reports of this study, is that temperature recorders be placed in various parts of the river so actual temperature changes can be verified. Such information would have been very useful in this study.

The data from this study indicates that warming the flow from Flaming Gorge Dam increased warm water fish habitat, but replaced an excellent trout fishery in Lodore Canyon. The question remains whether additional increases in temperature may raise the utilization of Lodore Canyon by Colorado squawfish or other rare fishes. We do not think that additional temperatures would greatly improve the Lodore Canyon area for rare fish. The reasons for this belief are:

1. Lodore is strongly influenced by the daily fluctuations from the Dam.
2. Flows in Lodore are generally reduced to levels that are probably lower than required by most of the rare fish.
3. Habitat in Lodore has been greatly altered by the direct influence of the clear, regulated releases of the Dam. This includes loss of habitat diversity, armoring of the channel and loss of high flows.

Increased release temperatures from the Dam may increase rare fish utilization of the Green River below the mouth of the Yampa River. It is our opinion that present temperatures may be sufficient to provide for Colorado squawfish reproduction although this needs to be verified in future years. An additional increase in temperature may increase young squawfish recruitment. A relase temperature which would recreate the original pre-dam temperatures in Lodore Canyon would undoubtedly best serve the rare fish. Since flow level is important in determining the change in temperatures from the dam to the mouth of the Yampa, the creation of a natural temperature regime may not be practical. Also, the loss of the present trout fishery below the dam may not warrant a large increase in release temperature for rather minimal benefits.

The ability to manage the selective withdrawal system to provide optimum temperatures for both the trout fishery and the rare fish below the mouth of the Yampa River has many existing possibilities. Considerable additional study of temperature-flow relationships, and the effect of the mixing of the two rivers at Echo Park, would be required, along with required temperature levels and timing for successful reproduction of Colorado squawfish and other species. Such a study could be included in an assessment of the effects of power peaking on this rather delicate system.

LITERATURE CITED

Annear, T. A. 1980. A characterization of Yampa and Green River ecosystems. Unpublished M.S. thesis, Utah State University, Logan, UT.

Baumann, R. W., A. R. Gaufin, and R. F. Surdick. 1977. The stoneflies (Plecoptera) of the Rocky Mountains. Memoirs Am. Entomol. Soc. No. 31.

Binns, N. A. 1965. Effects of rotenone treatment on the fauna of the Green River, Wyoming. Unpubl. M.S. Thesis, Oregon State Univ., Corvallis.

Bosley, C. F. 1960. Pre-impoundment study of the Flaming Gorge Reservoir. Wyo. Game and Fish Comm., Cheyenne. Fish. Tech. Rpt. 9, Fed. Aid Proj. F-25-R-1.

Bureau of Reclamation. 1976. Negative determination of environmental impact, penstock intake modification, Flaming Gorge Dam, Utah. Upper Colorado Region, Salt Lake City (Mimeo).

Edmondsen, W. T. (Ed.). 1959. Freshwater Biology (2nd edition). John Wiley and Sons, Inc., N.Y., N.Y.

Edmunds, G. F., S. L. Jensen, and L. Berner. 1976. The mayflies of north and central America. Univ. of Minn. Press. Minneapolis.

Environmental Protection Agency. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Gerking, S. D., R. Lee, and J. B. Shrode. 1979. Effects of generation long temperature acclimation on reproductive performance of the desert pupfish, Cyprinodon n. nevadensis. Physiological Zoology 52(2):113-121.

Holden, P. B. 1973. Distribution, abundance, and life history of the fishes of the upper Colorado River basin. Unpubl. Ph.D. Dissertation, Utah State Univ., Logan.

Holden, P. B. 1977. A study of the habitat use and movement of the rare fishes in the Green River from Jensen to Green River, Utah, August and September, 1977. PR-13-1, BIO/WEST, Inc., Logan, Utah.

Holden, P. B. 1980. The relationship between flows in the Yampa River and success of rare fish populations in the Green River system. BIO/WEST PR-31-1, Logan, Utah.

Holden, P. B. and L. W. Crist. 1979. Documentation of changes in the macroinvertebrate and fish populations in the Green River due to inlet modification of Flaming Gorge Dam. BIO/WEST PR-16-2, Logan, Utah.

Holden, P. B. and L. W. Crist. 1980. Documentation of changes in the macroinvertebrate and fish populations in the Green River due to inlet modification of Flaming Gorge Dam. BIO/WEST PR-16-4, Logan, Utah.

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

Holden, P. B. and C. B. Stalnaker. 1975b. Distribution of fishes in the Dolores and Yampa river systems of the upper Colorado basin. The Southwestern Naturalist 19(4):403-412, Jan. 20.

Holden, P. B., T. M. Twedt, and C. Richards. 1980. An investigation of the benthic, planktonic, and drift communities and associated physical components of the San Juan River, New Mexico and Utah. BIO/WEST PR-20-1, Logan, Utah.

Hutchinson, G. E. 1953. The concept of pattern in ecology. Proc. Acad. Nat. Sci., Phila. 105:1-12.

Hynes, H. B. N. 1970. The ecology of running waters. Univ. of Toronto Press, Buffalo, NY.

Joseph, T. W., J. A. Sinning, R. J. Behnke, and P. B. Holden. 1977. An evaluation of the status, life history, and habitat requirements of endangered and threatened fishes of the upper Colorado River system. FWS/OBS Report No. 24.

McDonald, D. B. and P. H. Dotson. 1960. Fishery investigations of the Glen Canyon and Flaming Gorge impoundment areas. Utah Fish and Game Dept., Salt Lake City. Infor. Bull. 60-3.

Merritt, R. W. and K. W. Cummins. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Miller, R. R. 1963. Is our native underwater life worth saving? Natl. Parks Mag. 37(188):4-9.

Mullan, J. W., V. J. Starostka, J. L. Stone, R. W. Wiley, J. F. Osborn, C. H. Hillman, and W. J. Wiltzius. 1976. Factors affecting upper Colorado River reservoir tailwater trout fisheries. In Instream Flow Needs, Vol. II. Am. Fish. Soc., Bethesda, MD.

Musser, R. S. 1962. Dragonfly nymphs of Utah. Univ. of Utah Biol. Ser. 12(6).

Pearson, W. D. 1967. Distribution of macroinvertebrates in the Green River below Flaming Gorge Dam, 1963-1965. Unpubl. M.S. Thesis, Utah State Univ., Logan.

Pearson, W. D., R. H. Kramer, and D. R. Franklin. 1968. Macroinvertebrates in the Green River below Flaming Gorge Dam, 1964-65 and 1967. Proceedings of Utah Acad. of Sci., Arts and Letters, 45(1):148-167.

Pennack, R. W. 1953. Fresh-water invertebrates of the United States. The Ronald Press Co., NY, NY.

Peters, J. C. 1978. Modification of intakes at Flaming Gorge Dam, Utah to improve water temperature in the Green River. Bur. of Reclamation, Denver, Colo. (Mimeo)

Prewitt, C. G., D. E. Snyder, E. J. Wick, and C. A. Carlson. 1976. Baseline survey of aquatic macroinvertebrates and fishes of the Yampa and White Rivers, Colorado. Rept. Zoo. and Ent., Colo. State Univ., Ft. Collins (Annual Rept. to BLM, Colo.).

Radford, D. S. and R. Hartland-Rowe. 1971. A preliminary investigation of bottom fauna and invertebrate drift in an unregulated and regulated stream in Alberta. J. Appl. Ecol. 8:883-903.

Seethaler, K. H. 1978. Life history and ecology of the Colorado squawfish (Ptychocheilus lucius) in the upper Colorado River basin. Unpubl. M.S. Thesis, Utah State Univ., Logan.

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, Logan.

Smith, G. R. 1960. Annotated list of fishes of the Flaming Gorge Reservoir basin, 1959. Pgs. 163-168 in A. M. Woodbury, Ed., Ecological studies of the flora and fauna of Flaming Gorge Reservoir basin, Utah and Wyoming. Univ. Utah Dept. Anthropol., Anthropol. Pap. No. 48, Upper Colo. Basin Ser. No. 3.

Spence, J. A. and H. B. N. Hynes. Differences in benthos upstream and downstream of an impoundment. J. Fish. Res. Board Can., 28:35-43.

Usinger, R. L. 1956. Aquatic insects of California. Univ. of Calif. Press, Berkeley.

Vanicek, C. D. 1967. Ecological studies of the native Green River fishes below Flaming Gorge Dam, 1964-66. 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, 1964-66. 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. Southwest. Nat. 14(3):297-315.

Ward, J. V. 1976a. Effects of thermal constancy and season temperature displacement on community structure of stream macroinvertebrates. In Thermal Ecology II, G. W. Esch and R. W. McFarlane (Eds.). ERDA Symposium Series (CONF-750425), pp. 302-307.

Ward, J. V. 1976b. Effects of flow patterns below large dams on stream benthos: A review. In Instream Flow Needs Symposium, Vol. II, J. F. Orsborn and C.H. Allman (Eds.). Amer. Fish. Soc., pp. 235-253.

Ward, J. V. and J. A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. In The Ecology of Regulated Streams. J. V. Ward and J. A. Stanford (Eds.). Plenum Press.

Wiggins, G. B. 1977. Larvae of the North American caddisfly Genera (Trichoptera). Univ. of Toronto Press, Buffalo, NY.

Williams, R. D. and R. N. Winget. 1979. Macroinvertebrate response to flow manipulation in the Strawberry River, Utah. In The Ecology of Regulated Streams, J. V. Ward and J. A. Stanford (Eds.), Plenum Press.

APPENDIX I

Fish Sampling Station Sketches

Key

direction of flow

7:D eddy

large rock

..t. boulders

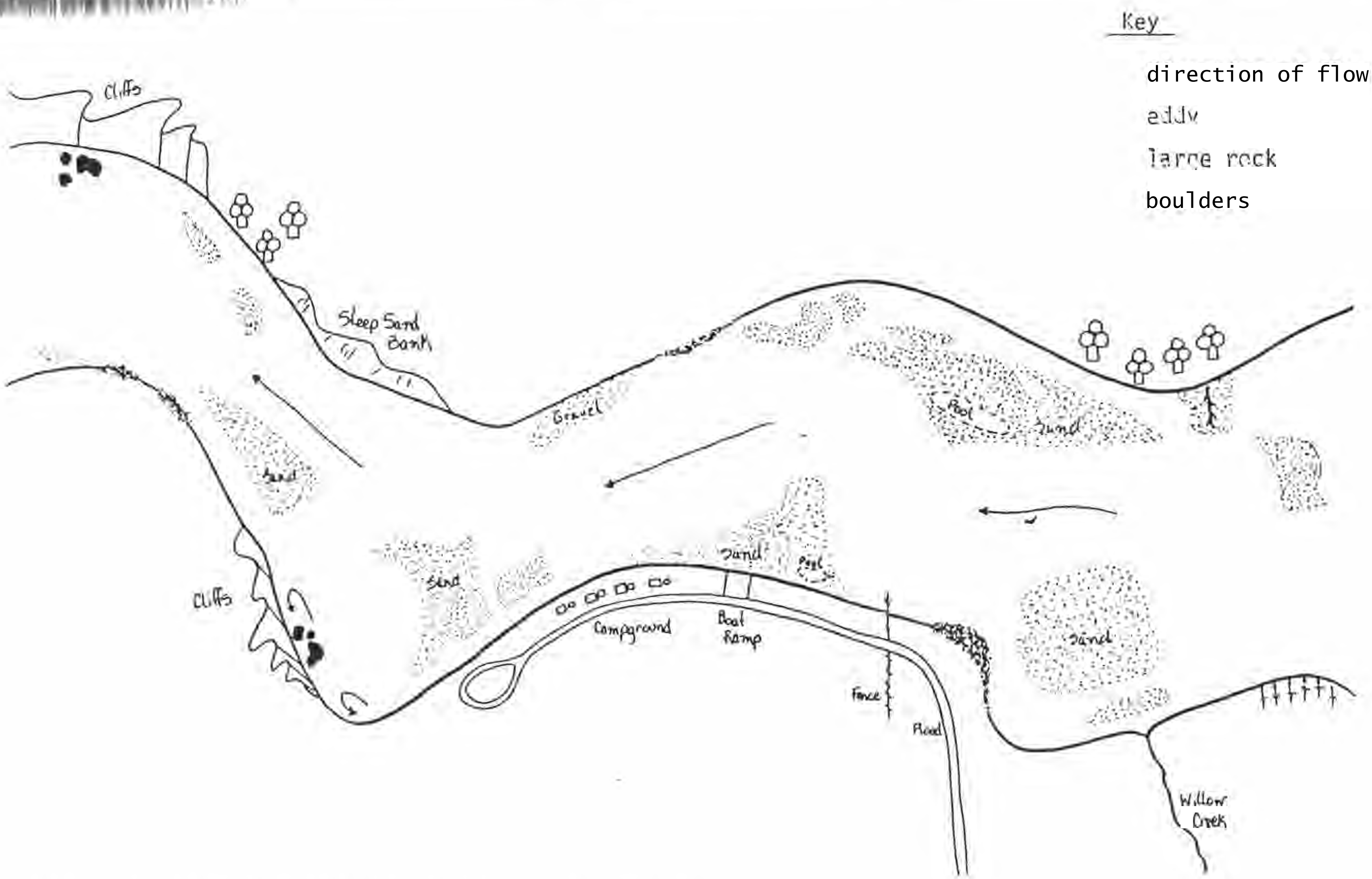


Figure 3. Sketch of the Lodore station at 1200 cfs.

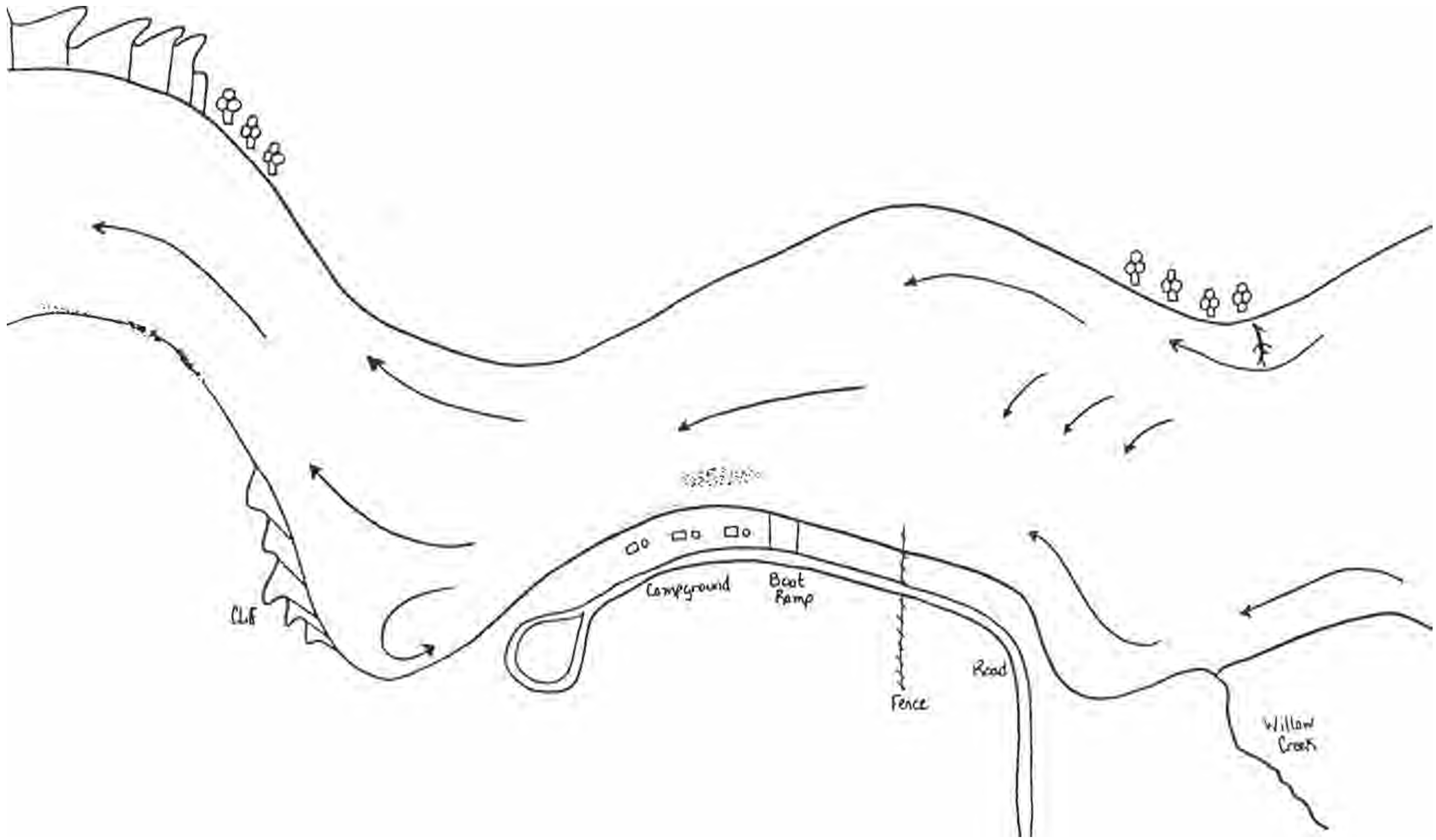


Figure 9. Sketch of the Lodore station at 4000 cfs.

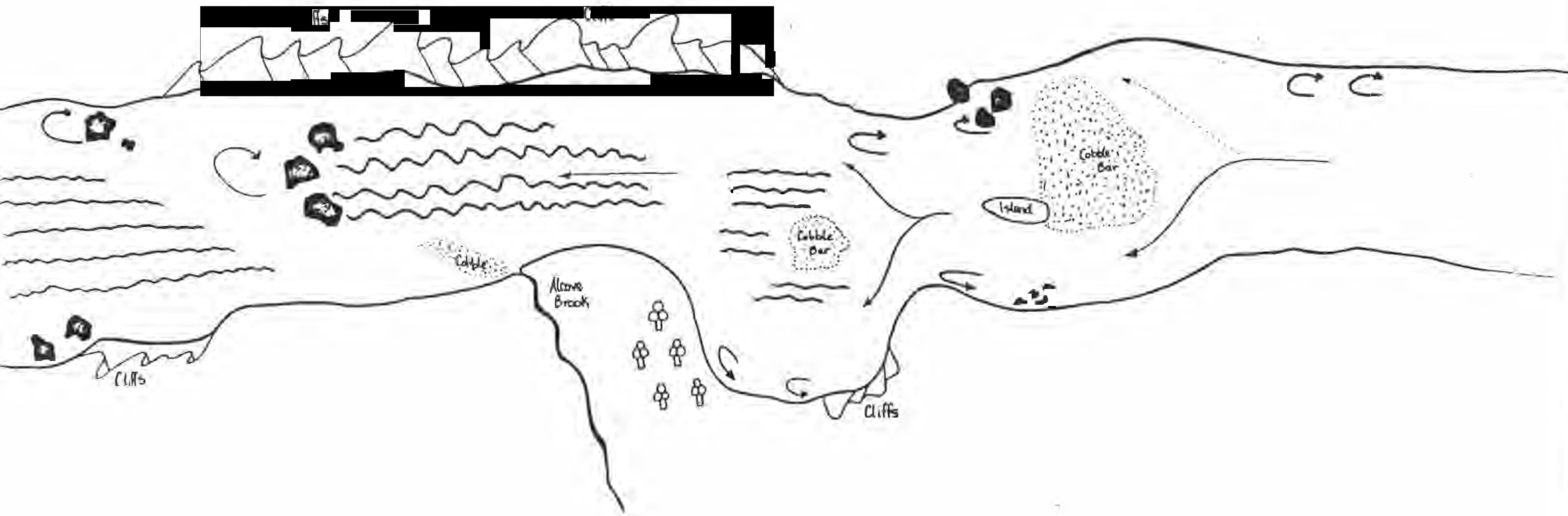


Figure 10. Sketch of the Alcove Brook station at 1200 cfs.

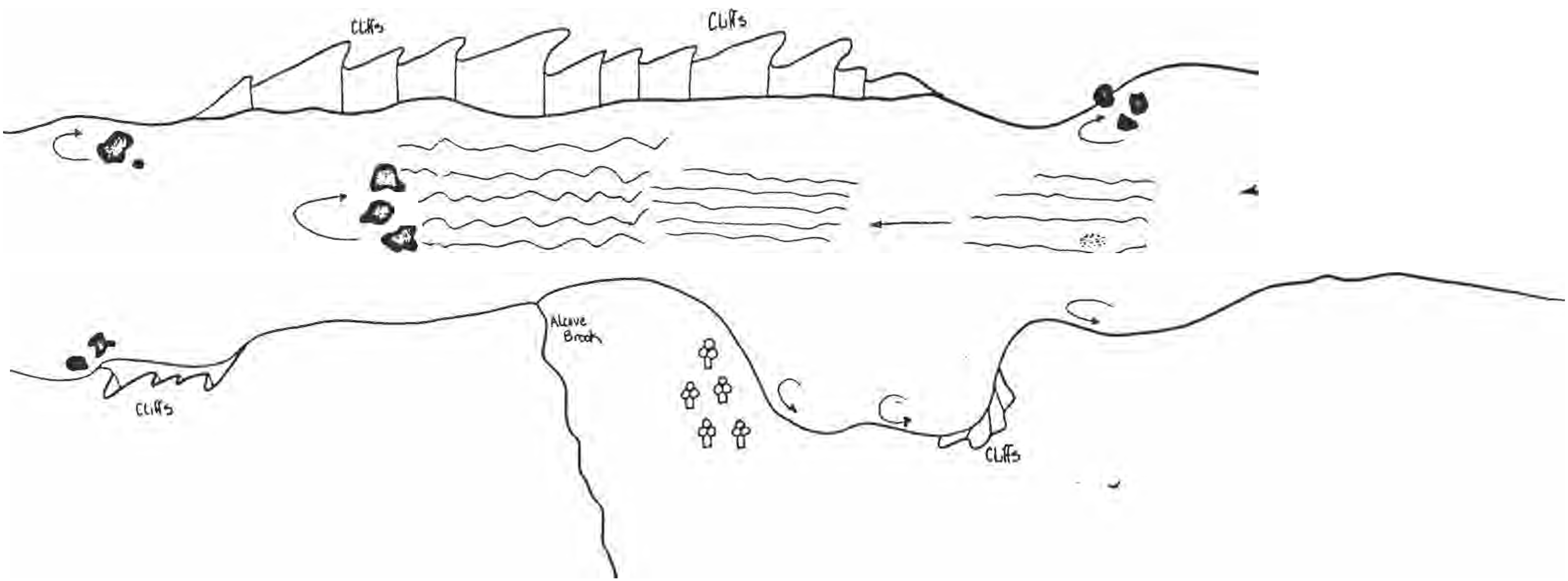


Figure 11. Sketch of the Alcove Brook station at 4000 cfs.

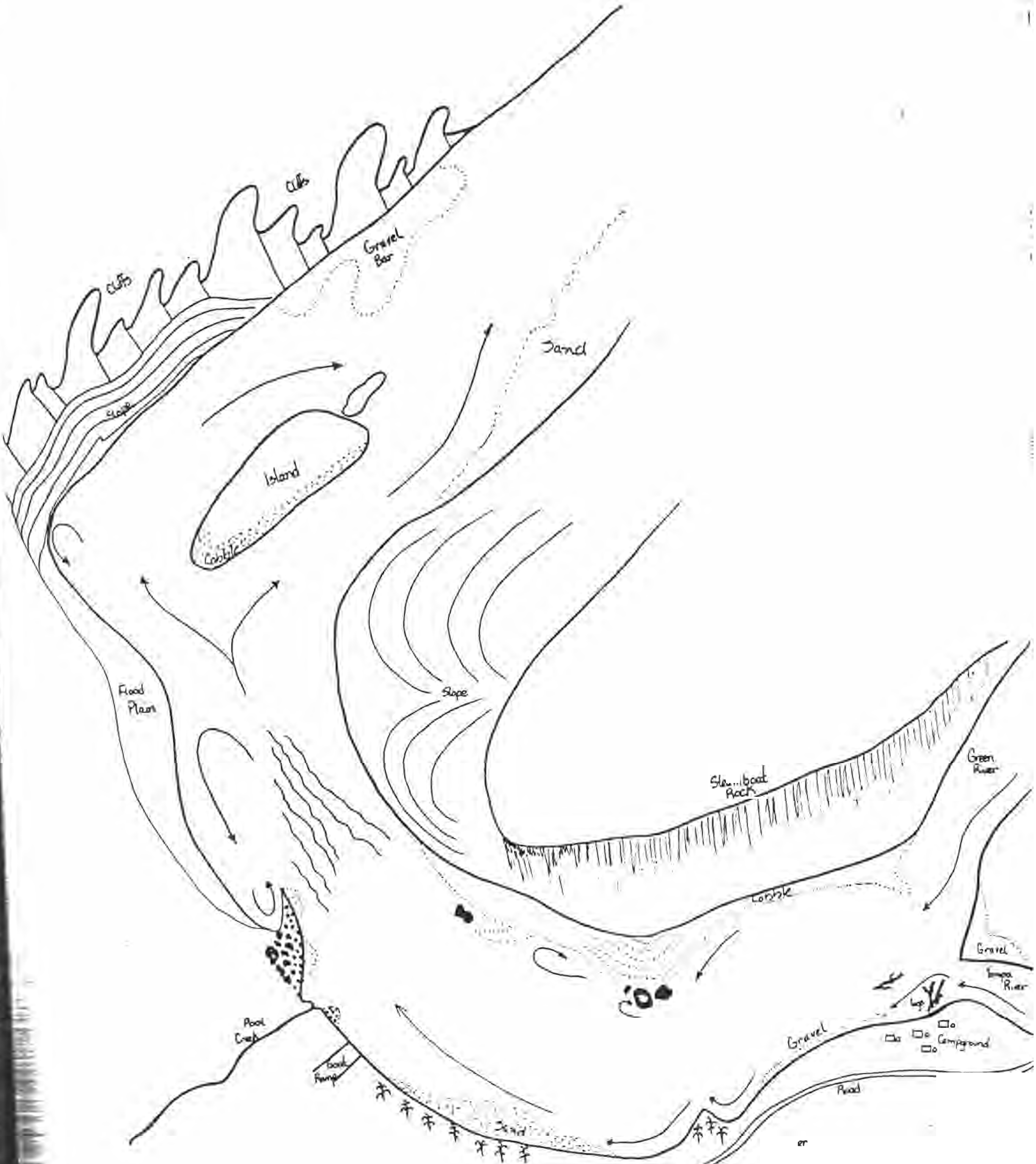


Figure 12. Sketch of the Echo Park station at 4660 cfs.

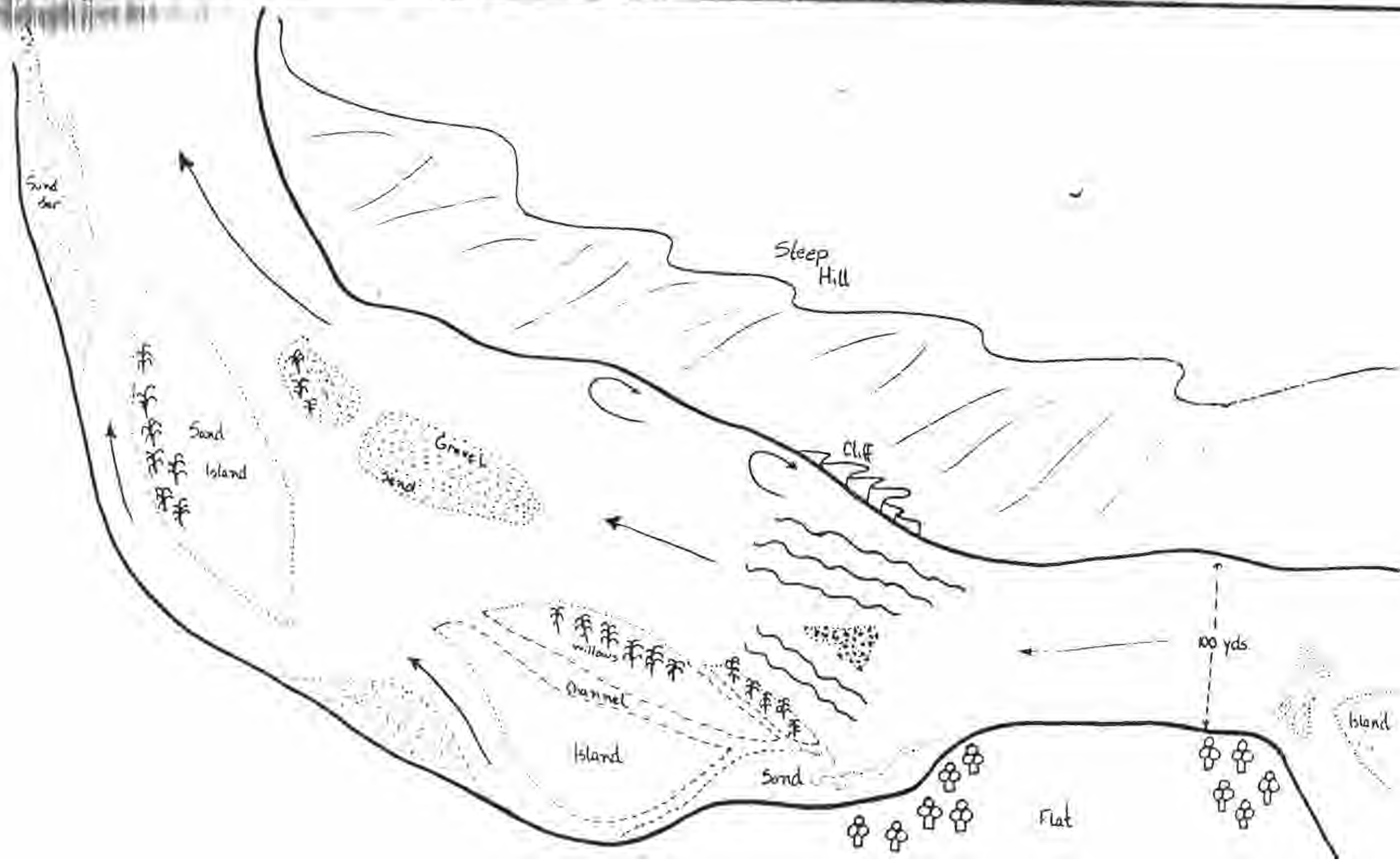


Figure 13. Sketch of the Island Park station at 4580 cfs.

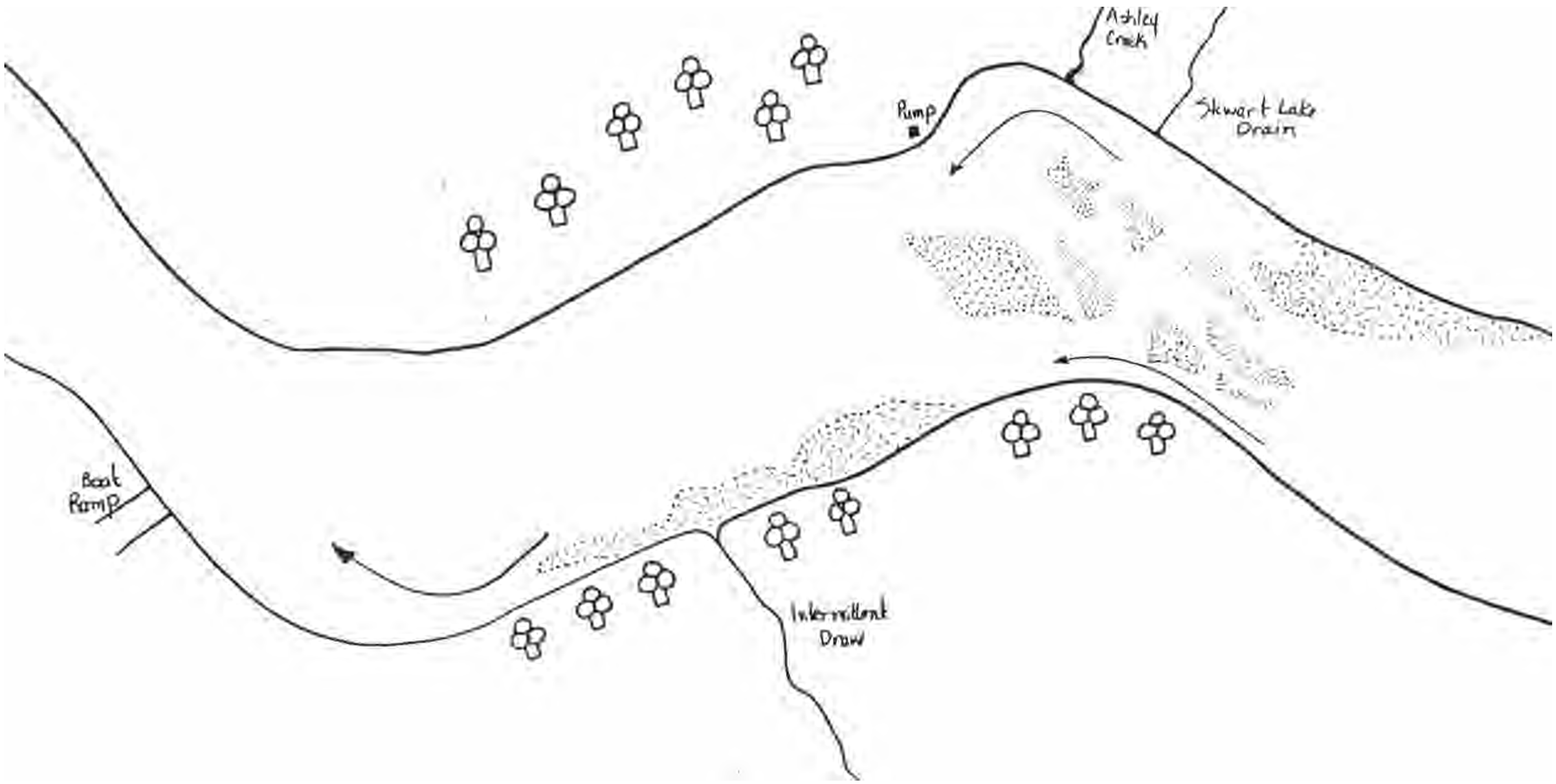


Figure 14. Sketch of the Jensen station at 4580 cfs.

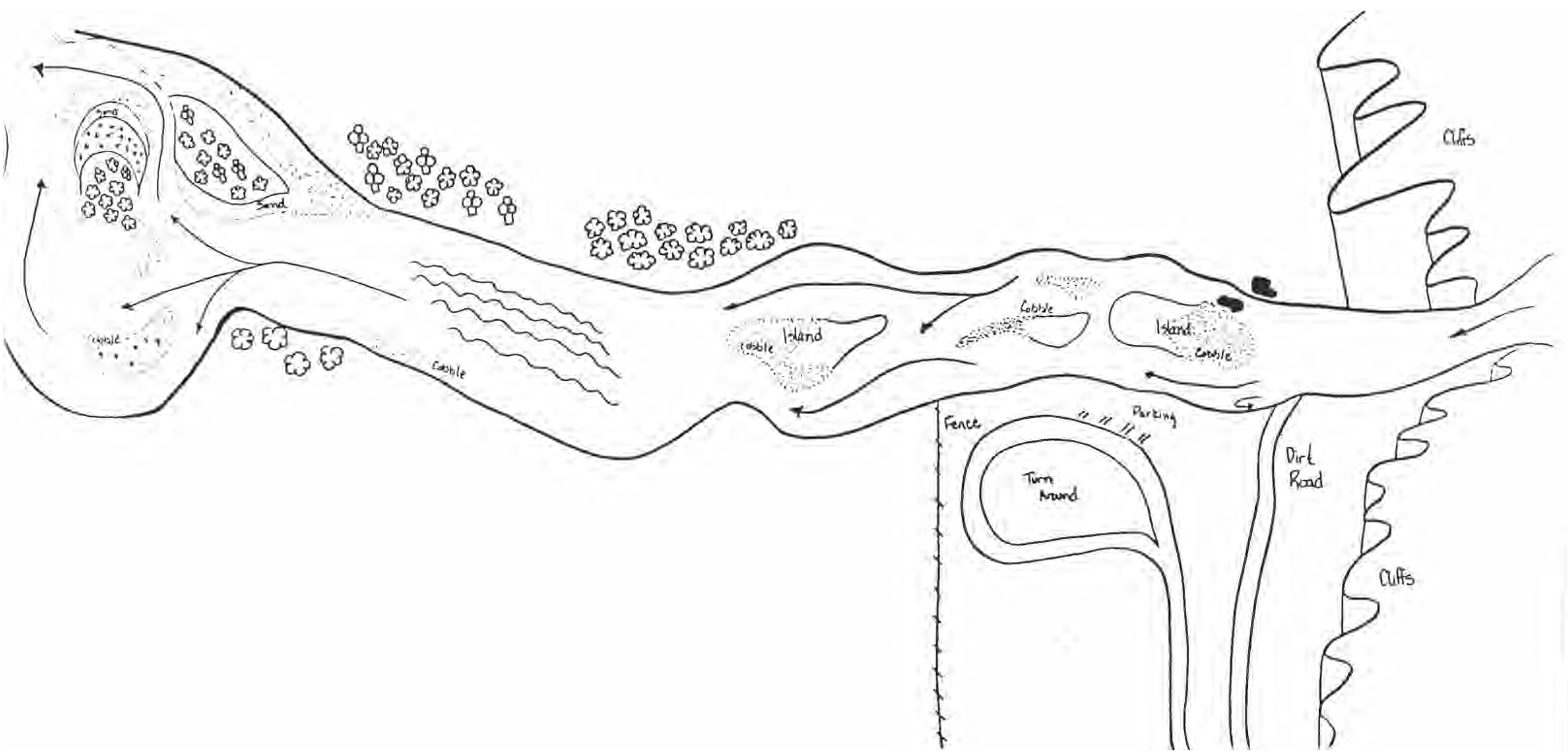


Figure 15. Sketch of the Lily Park station at 1700 cfs.

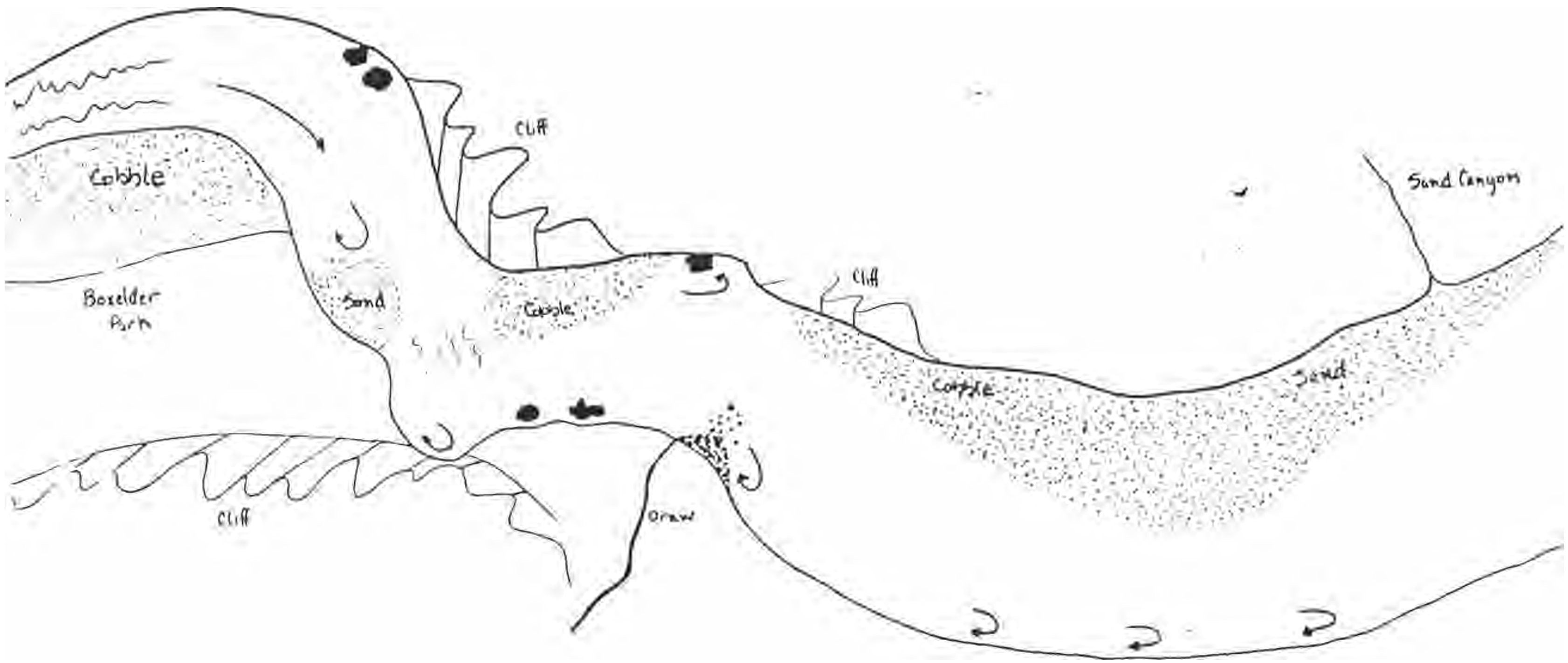


Figure 16. Sketch of the Lower Yampa station at 2000 cfs.

APPENDIX II

... preference for regulated unregulated[1] portions of the Green-Yampa rivers.

Ephemeroptera		Trichoptera (continued)	
Anapeorus rusticus	U	Hydroptila sp.	V
Baetis spp.	R	Nectopsyche	U
Choroterpes sp.	U	Oecetis sp.	U
Dactylobaetis warreni	V	Rhyacophila spp.	R
Ephemerella inermis	V	Diptera	
Ephoron album	U	Atherix variegata	U
Heptagenia sp.	U	Bibiocephala sp.	U
Lachlania powelli	U	Chironomidae	R
Rhithrogena sp.	U	Simulium	R
Traverella albertana	U	Megaloptera	
Tricorythodes sp. I	U	Corydalus cornutus	U
Tricorythodes sp. II	U	Odonata	
Plecoptera		Ophiogomphus servus	U
Classenia sabulosa	U	Amphipoda	
Isogenoides elongatus	V	Gammarus lacustris	R
Isoperla bilineata	U	Other	
Trichoptera		Hydracarina	R
Brachycentrus sp.	R	Planaria	R
Cheumatopsyche sp.	U	Oligochaeta	R
Culoptila sp.	U		
Helicopsyche borealis	U		
Hydropsyche sp. I	U		

[1]Unregulated -
U - Most abundant or common in Yampa River or lower Green River (Jensen);
Regulated -
R - Most abundant or common in Green River above the confluence with the Yampa;
V - Variable.

Table 25. Mean number (n = 4) of benthic invertebrates per square meter at six stations on the Green and Yampa rivers, 1978-1980.

LITTLE HOLE

Taxa	1978 Mar.	1978 June	1978 July	1978 Aug.	1978 Oct.	1979 Mar.	1979 June	1979 Aug.	1979 Oct.	1980 Mar.	1980 June	1980 Aug.	1980 Oct.
Ephemeroptera													
Baetis spp.	3,457.0	6,071.0	2,056.0	2,067.0	936.0	5,661.8	4,228.0	23,408.6	3,129.0	5,134.6	2,578.0	794.4	2,189.5
Dactylobaetis warreni				11.0									
Ephemerella inermis		43.0									21.5		29.1
Heptagenia sp.					11.0								
Rhithrogena sp.												3.2	
Plecoptera													
Isogenoides elongatus					5.0								
Trichoptera													
Brachycentrus sp.		11.0											
Hydropsyche sp. I				11.0						43.1			
Hydropsyche sp. II											3.2		
Hydroptila sp.									806.5		89.3	64.6	724.4
Rhyacophila [illegible]	11.0										3.2		21.5
Coleoptera													
Agabus sp.							2.2						
[illegible]rptus sp									10.8				
Hydrobius sp.												3.3	
Optioservus sp.											3.2		
Diptera													
Chironomidae (A)												261.6	
Chironomidae	20,915.0	2,433.0	3,670.0	4,844.0	2,400.0	4,240.0	6,786.0	3,559.1	3,215.1	5,866.5	3,932.2	455.3	1,980.6
Chironomidae (P)	108.0		161.0	161.0	22.0	549.0	275.3	96.8	32.3	1,181.3	242.1	3.2	61.4
Dolichopodidae												8.6	
Hemerodromia sp.	32.0						10.8	10.8			64.6		4.3
Hemerodromia sp. (P)												5.4	
Holorusia sp.			22.0										
Limnophora sp.	11.0		75.0										
Simulium sp.	11.0	118.0	22.0	404.0	2,454.0	581.2	344.1	26,666.7	7,935.5	667.4	455.3		2,746.0
Simulium sp. (P)					183.0		10.8	32.3					7.5
Tipula spp.										21.5			
Other													
Daphnia sp.			5.0										
Gammarus lacustris	108.0	11.0	32.0	452.0	54.0	188.4	66.7	2,506.6	3,225.8	172.2	186.2	229.3-	3,992.5
Harpactacoida	35,339.0		4,305.0	7,212.0									
Hirudenea	5.0												
Hydracarina	4,446.0	22.0		43.0	5.0			53.8	161.3	43.1	70.0	5.4	115.2
Lumbricidae													150.7

Table 25. Continued

LITTLE HOLE

Taxa	1978					1979				1980			
	Mar.	June	July	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Nematoda	323.0												
Naidadae	3,445.0	194.0	75.0	86.0	226.0	195.9	621.5	220.4	139.8		21.5	30.1	412.3
Ostracoda	205.0		43.0										
Planaria		269.0	22.0	22.0		26.9					493.0	3.2	180.9
Physa spp.												19.3	8.6

	[illegible]					1979				1980			
	Mar.	June	Jul.	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar.	June	Aug.	Oct.
Ephemeroptera													
Baetis spp.	1,324.0.	2,508.0	213.0	339.0	9,666.0	18,955.2	9,376.3	21,935.5	4,709.7	7,205.3	9,020.4	2,366.0	5,565.1
Dactylobaetis warreni				9.0									
Ephemerella inermis					65.0		21.5		75.3	30.1	387.5		640.5
Paraleptophlebia sp.													10.8
Rhithrogena sp.					22.0						10.8		
Tricorythodes sp. 1				11.0					10.8				10.8
Plecoptera													
Chloroperlidae													10.8
Isogenoides elongatus					86.0		2.2						
Isoperla sp.													
Malenka sp.									10.8				10.8
Perlesta placida					5.0								
Trichoptera													
Brachycentrus sp.							10.8						
Hydropsyche sp. I								21.5					32.3
... ptila sp.								21.5	96.8	10.8		336.9	885.9
Limnephilidae (P)					5.0								
Psy ... ypha subborealis												8.6	
Rhyacophila sp. I						26.9	10.8	21.5	32.3		53.8		
Rhyacophila sp. II					5.0	10.0	2.2						
Rhyacophila (P)							10.8				32.3		
Coleoptera													
Cleptelmis sp.											10.8		
Lampyridae			5.0										
Microcylloepus sp.													
Optioservus sp.			5.0									21.5	64.6
Zaitzevia sp.											10.8		
Diptera													
Chironomidae	17,836.0	2,438.0	385.0	2,530.0	2,820.0	596.0	7,419.4	3,559.1	2,419.4	2,210.0	4,058.1	659.8	5,855.8
Chironomidae (P)	65.0		30.0	81.0		172.2	139.8			218.5	10.8	26.9	10.8
Chironomidae (A)										14.0			
Dolichopodidae			8.0									3.2	
Hemerodromia sp.												37.7	
Hemerodromia sp. (P)								21.5					
Hexatoma sp.	22.0												
Limnophora sp.			5.0		5.0								
Palpomyia sp.												8.6'	10.8

TAYLOR-VA.ST

Continued

TAYLOR FLATS

Taxa	1978 Mar.	1978 June	1978 Jul.	1978 Aug.	1978 Oct.	1979 Mar.	1979 June	1979 Aug.	1979 Oct.	1980 Mar.	1980 June	1980 Aug.	1980 Oct.
Simulium sp.	194.0	470.0	32.0	242.0	8,956.0	861.0	1,311.8	23,698.9	15,236.6	48.4	441.3	229.3	4,305.7
Simulium sp. (P)		5.0	5.0	19.0	43.0			118.3				5.4	107.6
Tipula spp.						10.0					5.4	5.4	
Other													
Gammarus lacustris						10.0	10.8	43.0	225.8	5.4	118.4	616.8	86.1
Harpactocoida	3,724.0												
Hydracarina	108.0	5.0			127.0			86.0	75.3	21.5	10.8	10.8	505.9
Isotomurus sp.	22.0												
Naidadae	646.0	100.0	22.0	65.0	9.0	129.0	43.0	21.5	75.3	32.3	145.3	164.7	1,991.4
Nematoda	86.0												
Physa spp.												75.3	
Planaria		382.0			271.0	40.9	150.5	53.8		304.6	322.9	697.5	4,101.2
Unknown												8.6	

Taxa	Mar.	June	Jul.	Aug.	Oct.	Mar.	June	Aug.	Oct.	Mar	June	Aug	Oct.
						1979				1980			
Ephemeroptera													
Ametis spp.	775.0	3,601.0	479.0	142.0	3,490.0	1,928.9	2,010.8	2,284.9	268.8	30.1	4,263.7	519.9	19.4
Ephemerella inermis	43.0	633.0			174.0	23.7	397.8		3.2		1,622.2	3.2	
Heptagenia sp.								65.6				3.2	
Paraleptophlebia sp.												3.2	
Rhithrogena sp.				5.0									
Traverella albertana				9.0	127.0			247.3	129.0			143.2	
Tricorythodes sp. I									3.2			35.5	
Tricorythodes sp. II												14.0	
Plecoptera													
Acroneuria abnormis					5.0								
Isogenoides elongatus		5.0		5.0	24.0						32.3		
Isoperla bilineata							60.2				43.0		
Trichoptera													
Brachycentrus sp.		2,029.0	131.0	22.0	6,157.0		3,871.0	7,419.4	3,186.0	8.6	6,702.9	4,513.4	
Cheumatopsyche sp.		11.0											
Hydropsyche sp. I					228.0	10.0	10.0		21.5		107.6	204.5	
Hydroptila sp.				5.0	3,600.0		10.8	28.0		3.2	197.0	659.8	
Rhyacophila sp. I		22.0								5.4			
Rhyacophila sp. II		32.0											
Coleoptera													
Cleptelmis sp.				5.0									
Cylloepus sp.									7.5				
Microcylloepus sp.											10.8		
Opposervus sp.		11.0		13.0	194.0		64.5	77.4				32.3	
Ordobrevia sp.								21.5					
Peltodytes sp.												3.2	
Zaitzevia sp.		11.0											
Diptera													
Chironomidae	6,426.0	425.0	670.0	436.0	1,841.0	441.0	3,182.8	1,040.9	2/2.0	150.7	1,074.0	1,5 9	26.9
Chironomidae (P)	54.0		13.0	16.0		21.5	43.0	29.0	7.5	8.6	79.6		3.2
Chironomidae (A)										14.0			
Dolichopodidae			11.0										
Hemerodromia sp.										5.4			
Hemerodromia sp. (P)												5.4	
Simulium sp.	118.0	2,217.0	37.0	156.0	2,080.0	66.2	5,602.2	1,023.7	360.8		2,853.6	48.4	10.8
Simulium sp. (P)				5.0				11.8					
Tipula spp.													5.4
Odonata													
Ophiogomphus servus							2.2						
Other													
Diaptomus sp.												21.5	
Gammarus lacustris	54.0	75.0	13.0	18.0	54.0		64.5	284.9			21.5	48.4	

Table 25. *Continued*

WADE AND CURTIS

Taxa	1978 Mar.	June	Jul.	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1900 Mar.	June	Aug.	Oct.
Harpactacoida	43.0		5.0										
Hydracarina				5.0	59.0			66.7	3.2		499.5	403.7	3.2
Naidadae			48.0	38.0					7.5		10.8	10.8	134.6
Planaria		16.0											
Unknown												3.2	8.6

Taxa	1978 Mar.	June	July	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1980 Mar.	June	Aug.	Oct.
Ephemeroptera													
tus													10.8
Anapeorus rusticus												3.2	255.1
Baetis spp.	2,325.0	5.0	97.0	32.0	3Q4.0	906.3	77.4	2,605.4	1,578.8	1,835.3	156.1	692.1	1,194.8
Choroterpes sp.				129.0				7.5				53.8	
Dactylobaetis warreni			41.0	16.0	945.0							85.0	
Ephemerella inermis	1,636.0	11.0				209.9	64.5	32.3	350.5	156.1	204.5	8.6	265.9
Ephoron album								30.1				28.0	
Heptagenia sp.		45.0	16.0	56.0	210.0		16.1	10.8	122.6	3.2	94.7	80.7	
Lachlania powelli												4.3	
Paraleptophlebia pallipes				5.0									
Paraleptophlebia sp.													
Rhithrogena sp.	22.0			5.0		11.0			358.1	175.5		52.2	46.3
Traverella albertana				45.0				2,965.6				2,608.2	
Tricorythodes sp. I			30.0	239.0	84.0			745.2	12.9	10.8	14.0	1,454.2	156.1
Tricorythodes sp. II				48.0				532.3				328.3	
Plecoptera													
Acroneuria abnormis										35.5			
Claassenia sabulosa										70.0			
Cultus sp.											3.2		
Isogenoides elongatus	172.0	5.0	5.0	9.0	81.0	34.4		92.5	78.5	67.8		113.0	91.5
Isoperla bilineata											5.4	8.6	
Isoperla ebria											8.6		
Perlodidae								64.5	190.3				
Trichoptera													
Brachycentrus sp.								86.0	3,186.0		387.5	50.6	155.0
Cheumatopsyche sp.								43.0		24.8	3.2	91.5	1,096.9
Culoptila sp.												3.2	50.6
Hydropsyche sp. I						10.0		793.5	21.5		19.3	1,018.3	922.5
Hydropsyche sp. (P)										75.3		16.2	
Hydroptila sp.								564.5		16.2		62.4	777.2
Oecetis sp.													646.9
Coleoptera													
Cylloepus sp.									10.8				
Dubiraphia sp.			5.0								3.2		10.8
Microcylloepus sp.			5.0		5.0				11.8	11.8	5.4	21.5	91.5
Optioservus sp.												1.5	
Ordobrevia sp.								18.3					
Diptera													
Chironomidae	14,252.0	13.0	196.0	454.0	4,370.0	575.9		2,696.8	354.8	595.3	40.9	1,714.7	3,818.1
Chironomidae (P)	861.0	5.0		67.0	9.0			147.3	2.2	26.9	5.4	70.0	7.5
Chironomidae (A)										3.2			
Hemerodromia sp.						10.0		7.5	46.2	16.2			87.5
Hemerodromia sp. (P)			5.0										

Table 25. Continued

JENSEN

Taxa	1978 Mar.	June	July	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1900 Mar.	Jinx	Aug.	6ct.
Holorusia sp.					5.0								
sp.									2.2		3.2		10.8
Simulium sp.	43.0		24.0	5.0	52.0	10.0	8.6	150.5	64.5		10.8	3.2	
Simulium sp. (P)			22.0								57.8		
Odnnata													
Ophiogomphus servus									2.2		3.2		4.3
Other													
Ganmorus *lacustris*				5.0								122.2	
Hydracarina	1.335.0		183.0	91.0	549.0			21.5	47.3	24.8	21.5		401.5
Naidadae				19.0	67.0				37.6	24.8	3.2	93.6	
Nematoda						99.0							
Parogyractis sp.												46.3	87.2
Unknown												8.6	

[1]Early instar nymphs, unidentifiable to genus.

Table 25

Taxa							1979				1980	
	Mar.	June	July	Aug.	Oct.	Mar.	June	Aug.	Oct	Mar.	June	Aug.	Oct.
Ephemeroptera													
Anapeorus rusticus													
Baetis spp.				185.0	616.0		26.9	623.7	828.0			290.6	815.9
Choroterpes sp.				48.0	45.0			233.3				3.2	
Cinygma sp.								3.2					
Dactylobaetis warreni				181.0								336.9	
Ephemerella inermis					1,216.0		5.4		406.5				783.6
Ephoron album								18.3					
Heptageni- sp.				5.0	22.0			158.1	152.7			64.6	90.4
Pseudocleon sp.					5.0								
Rhithrogena sp.				84.0	167.0		23.7		1,088.2			139.9	2,678.2
Traverella albertana				1,685.0	73.0			107.5	12.9			1,623.3	29.1
Tricorythodes sp. 1				30.0	52.0			494.6	2.2			21.5	8.6
Tricorythodes sp. II				27.0				93.5				40.9	
Plecoptera													
Classenla sabulosa									2.2				7.5
Isogenoides elongatus				43.0	156.0			92.5	10.8			105.5	1,130.3
Isoperla bilineata							5.4						
palcid				11.0									
Perlodidae								64.5	651.6				
Trichoptera													
Brachycentrus sp.					5.0								
Chcumatopsyche sp.				428.0	565.0			21.5	277.4	4-)		30.1	642.6
Culoptila sp.	No		No						8.6				277.7
Hydropsyche sp. I				242.0	24.0		2.2	64.5	360.2			148.5	493.0
Hydroptila sp.				22.0									32.3
Nectopsyche sp.												3.2	
Neotrichia sp.									2.2				
Oecetis sp.									2.2				42.0
Dip tera													
Bibiocephala sp.					9.0				2.2				21.5
Chironomidae		5.0		231.0	67.0		10.8	971.0	962.4		5.4	43.1	191.6
Chironomidae (P)				5.0				21.5					
Dacty'olabis sp.													10.8
Hemerodromia sp.									21.5				
Hexatoma sp.									18.3			3.2	
Palpomyia sp.									80.6				29.1
Simulium sp.		5.0		81.0	8.0		30.1	10.8	212.9		10.8	37.7	
Simulium sp. (P)		5.0											
Tipula spp.													7.5
Odonata													
Erpetogomphus sp.													
Gomphus sp.								10.8					

Table 25. Continued

BOXELDER

Taxa	1978 Mar.	June	July	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1980 Mar.	June	Aug.	Oct.
Megaloptera			Not Sampled			Not Sampled				Not Sampled			
Corydalus cornutus									8.6			3.2	
Other													
Hydracarina					5.0			10.8	51.6				36.6
Paragyractis sp.													3.2

Taxa	1978 Mar.	June	July	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1980 Mar.	June	Aug.	Oct.
Ephemeroptera													
Anapeorus rusticus													44.1
Baetis spp.		113.0		495.0	842.0	465.0	397.8	981.7	978.5	376.7	177.6	242.2	1,776.1
Choroterpes sp.				235.0								78.6	
Dactylobaetis warreni				385.0								382.1	
Ephemerella inermis				38.0	75.0	26.9	88.2		83.9		51.7	8.6	528.5
Ephoron album		34.0						67.7				19.4	
Heptagenia sp.		19.0		65.0	45.0		10.8	43.0	88.2	26.9	3.2	166.8	14.0
Lachlania powelli								3.2					
Paraleptophlebia pallipes				398.0									
Pseudocloeon		5.0			5.0								
Rhithrogena sp.				65.0	81.0	16.1	12.9		80.6	51.7	46.3	30.1	268.0
Traverella albertana				267.0				315.1	2.2			581.3	
Tricorythodes sp. I		118.0		24.0		10.0		50.5		26.9	26.9	283.1	204.5
Tryorythodes sp. II				845.0			2.2	82.8				1,340.2	
Plecoptera													
Claassenia sabulosa									2.2				
Isogenoides elongatus		5.0		54.0	293.0	180.8			24.7	17.2		67.8	559.7
Isoperla bilineata							37.6			48.4	24.8		
Malenka sp.								3.2					
Neoperla sp.										3.2			
Perlodidae									73.1				
Taenionema sp.										3.2			
Trichoptera													
Brachycentrus sp.				54.0	11.0			10.8	5.4			67.8	
Cheumatopsyche sp.				116.0	59.0		18.3	537.6	451.6	78.6	100.1	428.4	905.3
Culoptila sp.									34.4				1,098.0
Helicopsyche borealis													92.8
Hydropsyche				2,368.0	428.0	26.9	8.6	2,502.7	1,220.4	40.9	59.2	1,687.8	1,073.2
Hydroptila sp.				226.0	70.0			3.2				24.8	3.2
Oecetis sp.													45.2
P. tamyia sp.		5.0											
Rhyacophila sp. I					5.0								
Rhyacophila sp. II									2.2				
Coleoptera													
Cylloepus sp.									18.3				
Dubiraphia sp.		45.0									8.6		
Microcylloepus sp.		5.0		52.0	5.0				32.3			16.1	43.1
Optioservus sp.					5.0								
Ordobrevia sp.								67.7					
Ordobrevia sp. (A)								21.5	12.9				
Stenelmus sp.												3.2	
Zaitzevia sp.		5.0											
Diptera													

Table 25. Continued

LILY PARK

Taxa	1978 Mar.	June	July	Aug.	Oct.	1979 Mar.	June	Aug.	Oct.	1980 Mar.	June	Aug.	Oct.
Atherix variegata													5.4
Chironomidae		167.0		110.0	457.0	807.3	48.4	777.4	1,137.6	274.5	132.4	366.0	1,770.7
Chironomidae (P)						10.0				3.2	3.2	3.2	32.3
Hemerodromia sp.									5.4			3.2	18.3
Hexatoma sp.								3.2					
Palpomyia sp.							2.2						10.8
Simulium sp.		145.0		32.0			10.9	21.5	96.8		26.9		10.8
Simulium sp. (P)											3.2		
Tabanidae										3.2			
Tipula spp.										3.2			
Odonata													
Erpetogomphus sp.				32.0									
Gomphus sp.								7.5					
Ophiogomphus servus								3.2				3.2	
Other													
Hydracarina					5.0							8.6	3.2
Naidadae							2.2					8.6	48.4
Paragyractis sp.									2.2			16.1	4.3
Physa spp.											3.2		

APPENDIX III

Length/Frequency Histograms

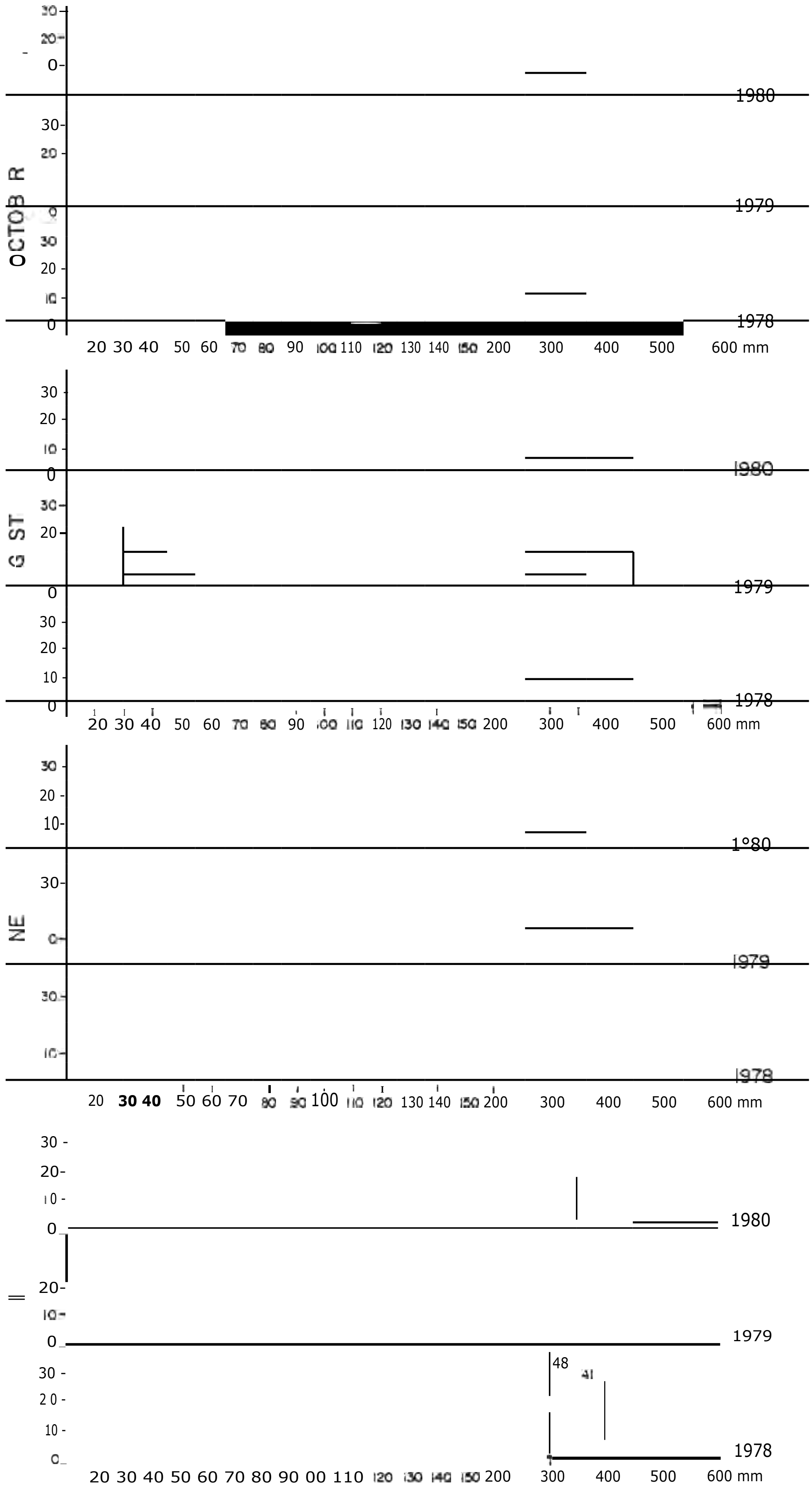


Figure 17. Length/frequency histograms of carp, Flaming Gorge Study, 1978-1980.

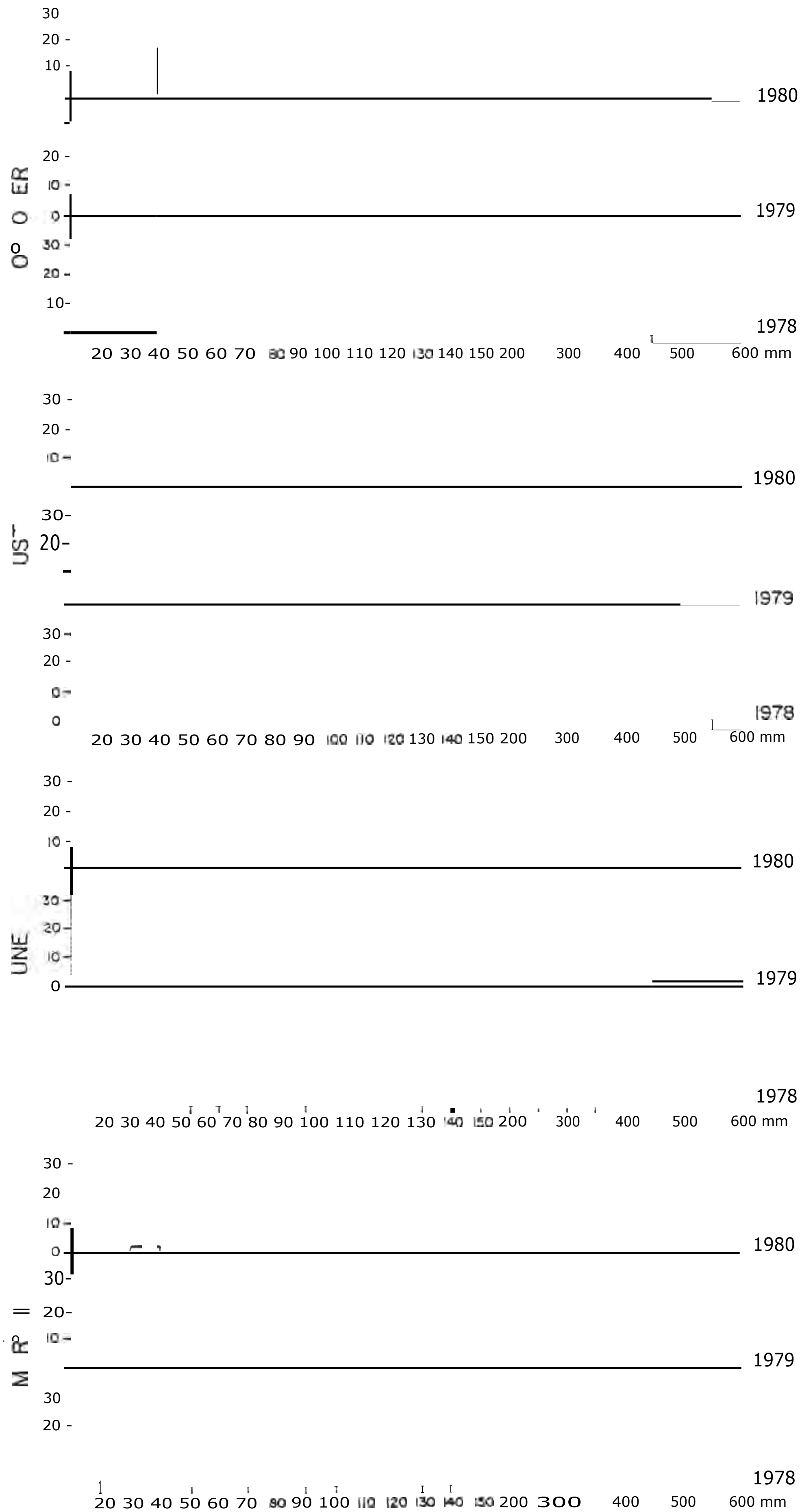


Figure 18. Length/frequency histograms of Colorado squawfish, Flaming Gorge Study, 1978-1980.

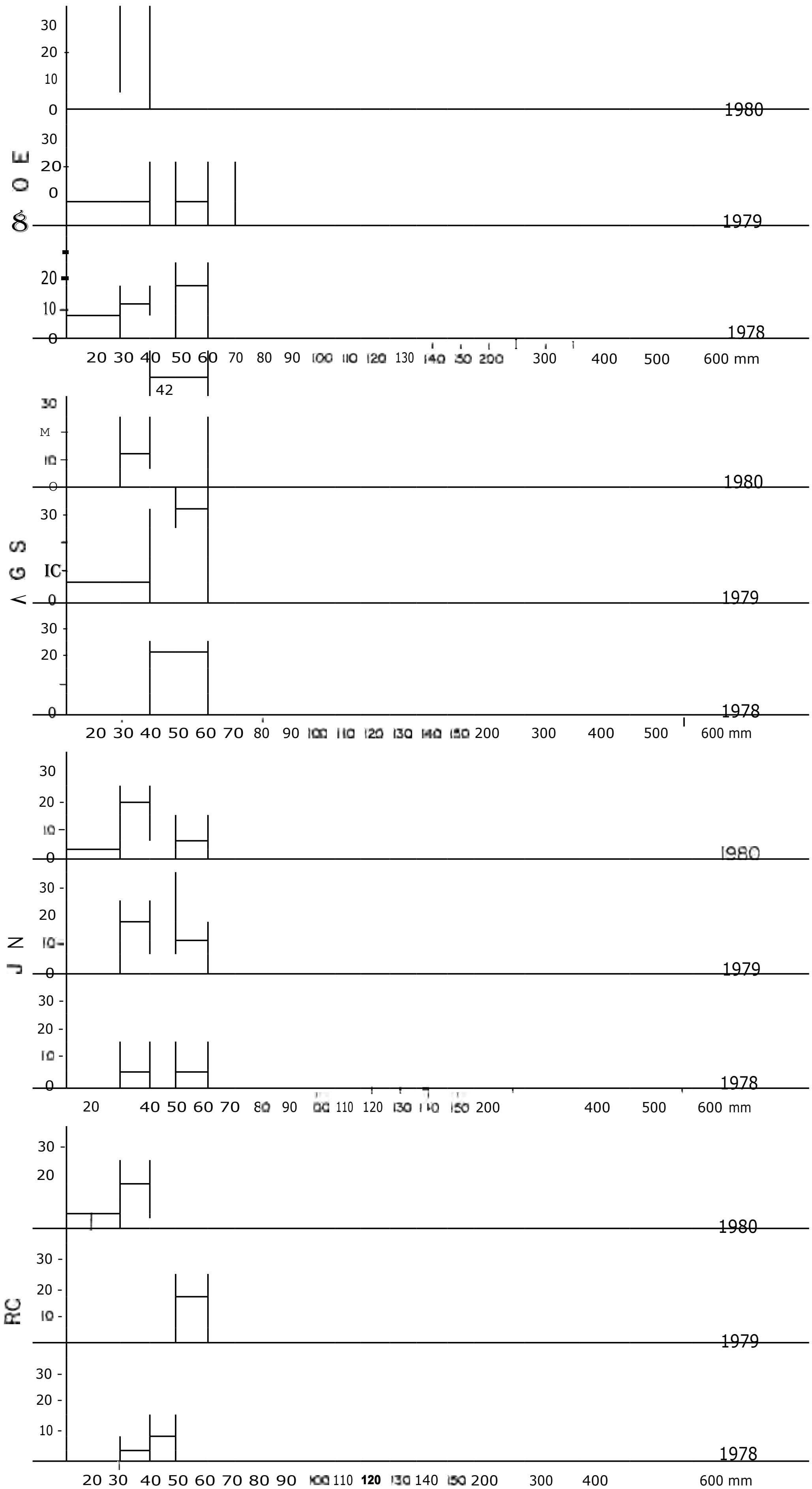


Figure 19. Length/frequency histograms of fathead minnow, Flaming Gorge Study, 1978-1980.

APPENDIX IV

Table 26. Habitat data for rare fishes caught in the study area, 1978-1980.

Date	Station	Size (mm)	Tag No.	Depth	Velocity (fps)	Substrate	Habitat type
			1978				
Colorado squawfish							
June 13	Island Park	625	943	2.0	0	sand	backwater
June 15	Jensen	376 104	1524 -	4.0	0	silt	backwater
June 15	Jensen	381 479	1500 1501	5.0	0	silt	backwater
July 5	Alcove Brook	523	427	4.0	0.7	sand	run
July 7	Island Park	55 38 60	- - -	0.7	0	sand	backwater
July 9	Jensen	121 124		2.0	0	sand	backwater
July 9	Jensen	507	1534	7.0	2.0	sand	run
July 9	Jensen	123 123	- -	3.5	0.2	sand	eddy
July 9	Jensen	475	1535	3.0	0.5	sand	eddy
Aug. 19	Jensen	146		1.5	0	sand and silt	backwater
Aug. 21		452		7.5	0.1	silt	pool
Oct. 6		41 40 34 42 44 35		1.0	0	sand and silt	backwater
Oct. 6	Jensen	41 34		2.0	0	silt	backwater
Oct. 6	Jensen	28 30		3.0	0	silt	backwater
Oct. 6	Jensen	29 36 30 37 35		1.0	0.1	silt	eddy
Razorback sucker							
Mar. 13	Echo Park	500	600				
Mar. 15	Island Park	545	901	2.0	1.0	sand	run
June 15	Jensen	521 544 515 505 542	1502 1503 1505 1506 1507	4.0	0	silt	backwater
June 15	Jensen	34 adults (433-562 mm)	1512-1521	2-4	0-0.2	silt	Ashley Creek
July 5	Alcove Brook	525	368	4.0	0	sand	eddy
July 9	Jensen	512 498	- -	6-8	0	silt	Ashley Creek
Aug. 19	Jensen	591	1536	1.5	C	sand	backwater
Oct. 5	Island Park	531 461	1111 1112	3.7	1.6	gravel	run
Oct. 5	Island Park	539	1113	2.7	0.3	silt	eddy
Humpback Chub							
Oct. 7	Lower Yampa	256		3.7	0.5	sand	run

Date	Station	Size (mm)	Tag No.	Depth	Velocity (fps)	Substrate	Habitat type
			1979				
Colorado squawfish							
June 7	Alcove Brook	394	630	2.0	<1	Silt and brush	run
June 8	Echo Park	525	644	2.5	.75	silt	run along shore
June 9	Island Park	428	669	1.5	0	silt	backwater
June 9	Island Park	37		1.0	0	sand and gravel	backwater
June 10	Split Mt. to Jensen	447	690	2.0	0	silt	backwater
June 10	"	499	699	1.3	0.2	silt-sand	eddy
June 11	Jensen	442	688	6.0	0	silt	backwater
June 10	Jensen	415	680	3.0		silt	backwater
June 11	Lower Yampa	564	602	5.8	2	sand	run along shore
Aug. 9	Alcove Brook	665	655	3.2	.25	sand	eddy
Aug. 10	Echo Park	533	603	2.4	1.65	sand	run
Aug. 10	Echo Park	505	687	2.4	1.65	sand	run
"		444	611	7.0+	1.5	sand	run
Aug. 11	Island Park	133		2.0	0	sand-silt	backwater
Aug. 28	Lower Yampa	533	841	1.7	8	cobble	run
Aug. 28	Lower Yampa	560	638	4.3	.1	silt	run
Oct. 10	Above Jensen	36		2.0		"	backwater
"	"	40		2.0		o	"
	"	36		2.0		"	
	..	35		2.0		0	
Oct. 10	Jensen	41		.5		0	"
"		44		.5			"
		120		1.5			
	"	127		1.5		"	
	"	43		1.5			
0	0	41		1.5			
Razorback sucker							
June 8	Echo Park	480	867			sand	run
June 10	Jensen	530	232	6.0	0	silt	backwater
		527	1170			0	
		521	1171				
o		532	1172			o	
		539	1173				
		556	1113				
		522	1174				
		511	1175				
		535	610			"	
		483	1176				
		538	1177				
		513	1178				
Aug. 9	Alcove Brook	543	1832				eddy

Table 26. Continued

Date	Station	Size (mm)	Tag No.	Depth	Velocity (fps)	Substrate	Habitat type
			1979 (continued)				
Razorback sucker (continued)							
Aug. 11	Island Park	569	1940	1.5		cobble-boulder	riffle
"		498	1941	1.5			
Humpback Chub							
June 11	Lower Yampa	381	1197				run along shore
Aug. 10	Echo Park	305	681	10.0+			eddy
Bonytail Chub							
Aug. 28	Lower Yampa	275	819	4.3	1	silt	run
			1980				
Colorado squawfish							
Mar. 28	Echo Park	520	628	4.8	1.15	sand	run
Apr. 8	Island Park	510	677				
Apr. 9	Jensen	40		1.0	0	silt	backwater
Apr. 9	Jensen	543	664	2.0	0	silt	backwater
June 7	Echo Park	470	692	1.6	1.5	sand	run
Aug. 9	Island Park	449	303	3.3	1.8	sand	run
Aug. 9	"	96		0.7	0	silt	backwater
Aug. 9	"	127)- 75)		1.0	0	silt-cobble	backwater
Aug. 11	Lower Yampa	450	643	8.0	1.2	gravel	run
Oct. 9	Echo Park	37		1.0	0	sand	backwater
Oct. 9		26		1.5	0	silt	backwater
Oct. 9	"	29)- 33)		1.0	0	silt	backwater
Oct. 9		25)- 31) 28)		2.5	0	silt	backwater

Table 26. Continued

Date	Station	Size (mm)	Tag No.	Depth	Velocity (fps)	Substrate	Habitat type
			1980 (continued)				
Colorado squawfish (continued)							
Oct. 9	Whirlpool Canyon	24)- 26)		3.01	0	silt	backwater
Oct. 10	Island Park	25		1.5	0	"	"
Oct. 10		24		2.0	0	"	"
Oct. 10	Island Park	40)- 38) 40)		3.0	0	sand and cobble	"
Oct. 10	island Park	37 - 38 38 39 36) 35) 28)		1.0	0.5	silt and cobb%	run (backwater)
Oct. 11	Jensen	34		3.0	0	silt-sand	backwater
Oct. 11		45		1.5	0.5	sand-silt	eddy
Oct. 12	Lower Yampa	565	2692	2.5	0.5	sand	run
Oct. 12		34 36 36		2.0	0	silt-cobble	backwater
Razorback suckers							
Mar. 29	Island Park	545	662			sand	run
Apr. 9	Jensen	537	634	2.0	0.3	"	eddy
June 9	"	490	2287			"	run
June 9	"	468	2286			"	run
Oct. 13	Lily Park	443	2789	4.0	0.2	run	boulders