SOME FACTORS HISTORICALLY AFFECTING THE DISTRIBUTION AND ABUNDANCE OF FISHES IN THE GUNNISON RIVER

Final Report

for

Fishery Investigations of the Lower Gunnison River Drainage

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Fishery Investigations of the Lower Gunnison River Drainage

by

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Wildlife Researcher C

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INTRODUCTION

The Gunnison River, a major tributary to the upper Colorado River, arises at the junction of the East and Taylor rivers at the town of Almont in southwest Colorado. Prior to Man's intervention, the Gunnison River flowed, sometimes voluminously and with considerable velocity in some sections, for about 150 mi (241 km) before joining the Colorado River at Grand Junction, Colorado. In 1907 the Redlands Power and Diversion Dam was constructed across the Gunnison River about 1.5 mi (2.4 km) above Grand Junction. By 1910, a Tunnel was completed, capable of diverting the entire summer flow of the lower Gunnison River in some years into the arid Uncompahgre Valley. The flows, after being diverted and used for irrigation by the Uncompahgre Valley Water Users, reentered the Gunnison River via the Uncompahgre River near Delta, Colorado.

Historically, the fishes found in the Gunnison River below these two structures were primarily rough fishes, principally members of the family Catostomidae. However, concern over any adverse influence on these fishes in the early years was not voiced by sportsmen nor by most government agencies. Since 1973, with the passage of the Endangered Species Act, considerable concern is now prevalent. Despite the abundance of rough fish in the lower river, the 60-mi (96-km) section of the river above the Gunnison Tunnel was a world-famous trout fishery. The December 15, 1946 issue of Colorado Conservation Comments remarked:

> "For almost half a century the Gunnison River was rated as the best trout stream in the entire United States. This was not a rating by Coloradoans, but the studied opinion of a research committee sent out by the National Geographic Society."

In 1946, sportsmen apparently were getting concerned about the probable adverse influences that the construction in 1937 of Taylor Dam on the Taylor River above Almont may have had on the Gunnison River trout fishery. This reservoir was the storage reservoir for the Uncompahgre Valley Water users. Fortunately, studies of the fishes of the Gunnison River in these upper stretches had been made by Pratt (1937; 1938) prior to the construction of Taylor Park Reservoir, and Williams (1951) also conducted studies relating to some of the effects coldwater releases had on the quality of fishing in the Gunnison River.

In 1956 Congress authorized the Colorado River Storage Project which eventually involved the construction of four major units, viz., Navajo, Flaming Gorge, Glen Canyon, and Curecanti. Some of the effects these units have had on the tail-water fishery below the dams have been recently summarized by Mullan et al. (1976). The Curecanti Unit on the Gunnison River is unique in that it is the only unit of the four with dams constructed entirely in prime trout habitat. The Unit (Fig. 1) is composed of three dams with power plants and reservoirs along a 40-mi (64-km) stretch of the Gunnison River a short distance above the Gunnison National Monument. At times, impounded waters extend to North Beaver Creek, about 6 mi (9.7 km) below the town of Gunnison. The two upper dams, Blue Mesa and Morrow Point, were completed, respectively, in 1965 and 1968, while Crystal Dam began filling early in 1977.

In the 1964-1967 period, preimpoundment investigations were conducted in some river sections above Delta, Colorado. Kinnear and Vincent (1967) conducted fishery investigations totally within the 12-mi (19.3-km) section below the Gunnison Tunnel but within the Black Canyon of the Gunnison National Monument during 1965 and 1966. Wiltzius (1966; 1967;

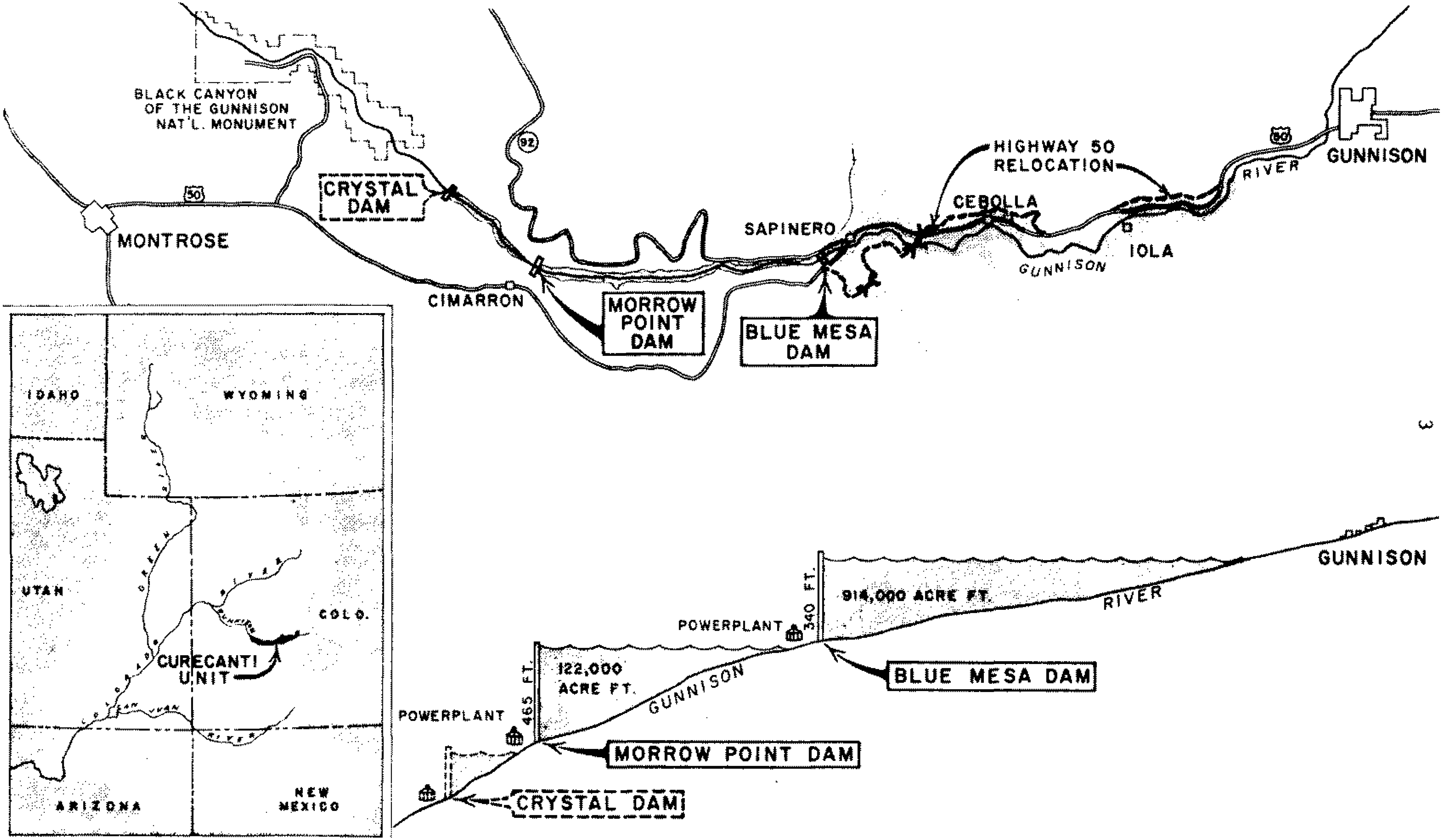


Figure 1. Curecanti Unit - Colorado River Storage Project

1970) was concerned primarily with the Gunnison River sections above Cimarron prior to inundation, but also collected some data in the lower river from Delta to slightly above the North Fork in the 1964-1967 period. Blue Mesa Reservoir, the uppermost of the three reservoirs of the Curecanti Unit, first attained maximum capacity in 1970 when it became Colorado's largest impoundment with nearly 1 million acre-ft of water covering 9,040 surface acres. Intensive fishery investigations were conducted at Blue Mesa in the 1967-1972 period to characterize age, growth, and survival of the various fishes stocked in the reservoir (Wiltzius 1969; 1971; 1974). Annual salmonid yields between 1968 and 1973 for Blue Mesa were also estimated by Wiltzius (1974).

By 1971, it became apparent that the 38-50°F water being released from the Curecanti reservoirs was influencing the downstream distribution of some fishes in the Gunnison River. Fishermen began reporting better catches of trout below the dams and trout were more frequently caught in areas where they were once rare. Interest and speculation naturally occurred as to how far downstream a trout fishery would develop and/or if detrimental effects would occur to any of the fishes living below the reservoirs. As a result, a 5-yr study was begun in July 1973 to determine some of the influences of these dams on the downstream fishery.

Original project objectives included: learning about flow patterns, temperatures, and chemical characteristics; inventorying the species of fish and fish-food organisms; determining fish spawning habitats; determining fisherman access points, fishing pressure, and species harvest success; and lastly, determining fish stocking procedures for Crystal Reservoir and the downstream fishery.

Immediately after sampling was done on the Gunnison River below Morrow Point Reservoir in August 1973, mackinaw trout (*Salvelinus namaycush*) fingerlings were captured; they had been stocked 2 mo earlier in the reservoir's inlet area. The reservoir, since impoundment in 1968, had been receiving heavy stocking of kokanee salmon (*Oncorhynchus nerka*) and comparatively light stocking of mackinaw trout in an attempt to stunt the kokanee to supply prey for the mackinaw. Some fishermen at Morrow Point also reported taking some coho salmon (*Oncorhynchus kisutch*) which had been stocked in the Gunnison drainage above Blue Mesa Reservoir in the 1969-1972 period. However, gillnet sampling in the reservoir in 1973 caught no coho salmon and showed that the game fish abundance was as follows: rainbow trout (*Salmo gairdneri*)>brown trout (*Salmo trutta*)> kokanee>brook trout (*Salvelinus fontinalis*)>mackinaw trout = cutthroat trout (*Salmo clarki*). Kokanee salmon spawners averaged 20 in. Furthermore, in a 2-hr period in December 1973 an average of one 0+ kokanee salmon was observed every 27 sec moving downstream in the tailwaters below Blue Mesa Dam into Morrow Point Reservoir. Many of the kokanee salmon were in distress, unable to swim and sound properly. On one day in December 1974, distressed 0+ kokanee salmon averaging 4.3 in. were so abundant in the swirl area of the Blue Mesa tailwaters that one small minnow seine haul captured 1,219 salmon.

The 1973 findings prompted a temporary discontinuance of stocking in Morrow Point Reservoir and raised the question as to whether the rainbow trout in Morrow Point were primarily migrants from tributaries or migrants from Blue Mesa Reservoir. It also opened speculation as to whether the apparently greater numbers of rainbow trout in the river below the Curecanti dams were being provided by catchables being stocked in the

Gunnison Tunnel and North Fork areas, from fingerlings being stocked in the reservoirs above the Tunnel area, or from natural reproduction. An additional important objective of the recent studies was, therefore, to determine the source of these fish by using marked fish stocked in key locations.

LOCATION AND DESCRIPTION OF STUDY AREA

GUNNISON RIVER DRAINAGE BASIN

The Gunnison River is a major tributary to the upper Colorado River in southwestern Colorado. It yields about 2 million acre-ft of water, constituting slightly more than 14 percent of the total runoff of the Colorado River at Lees Ferry.

Figure 2 is a map showing about 80 percent of the upper drainage area of the Gunnison River basin, along with its associated human population, as of 1965. The basin derives its water supply primarily from the large snow packs that accumulate in the high mountains during the winter. The many tributaries of the drainage carry this water from their sources in all directions, and discharge it into the main channel of the Gunnison River. The Gunnison River originates at the confluence of the Taylor and East rivers at Almont, Colorado and flows for about 150 mi, primarily in a west-northwest direction, before it empties into the Colorado River at Grand Junction, Colorado. At this source it drains 766 sq mi, and by the time it reaches Gunnison, 10 mi downstream, it drains 1,012 sq mi. Other area values along the river's downstream route are: Blue Mesa Dam--3,426 sq mi; Morrow Point Dam--3,637 sq mi; Upper Black Canyon Monument boundary--3,965 sq mi; below its junction with North Fork of Gunnison--5,241 sq mi; and, finally, at Grand Junction--7,928 sq mi.

The Gunnison River, like most large mountain rivers, has a highly variable gradient. From Figure 3, it is apparent that two general areas of high gradient exist: the upper reaches below Taylor Park Reservoir in the Taylor River Canyon, and the Black Canyon. Technically, the

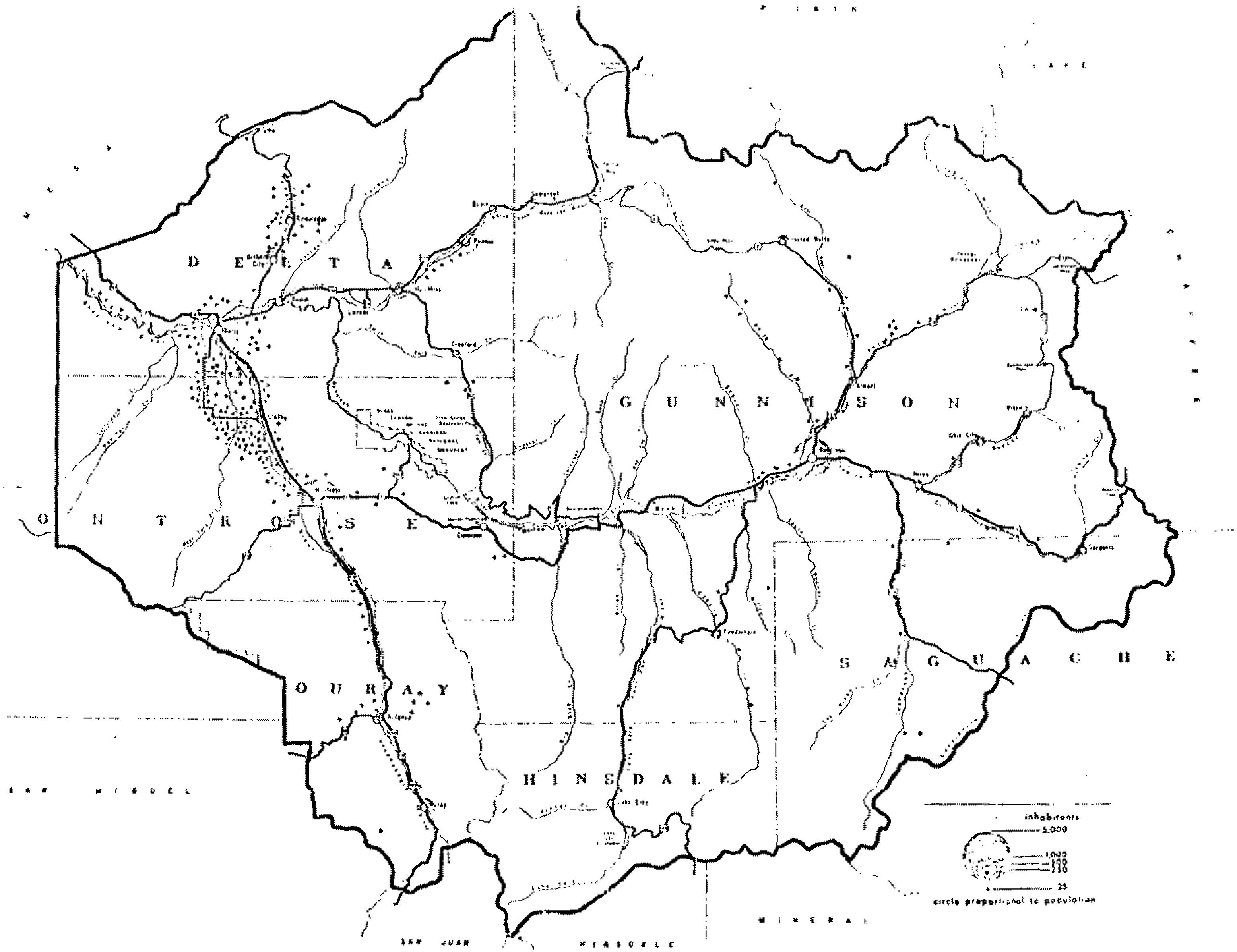


Figure 2. Gunnison-Uncompahgre drainage basin and population, 1965.

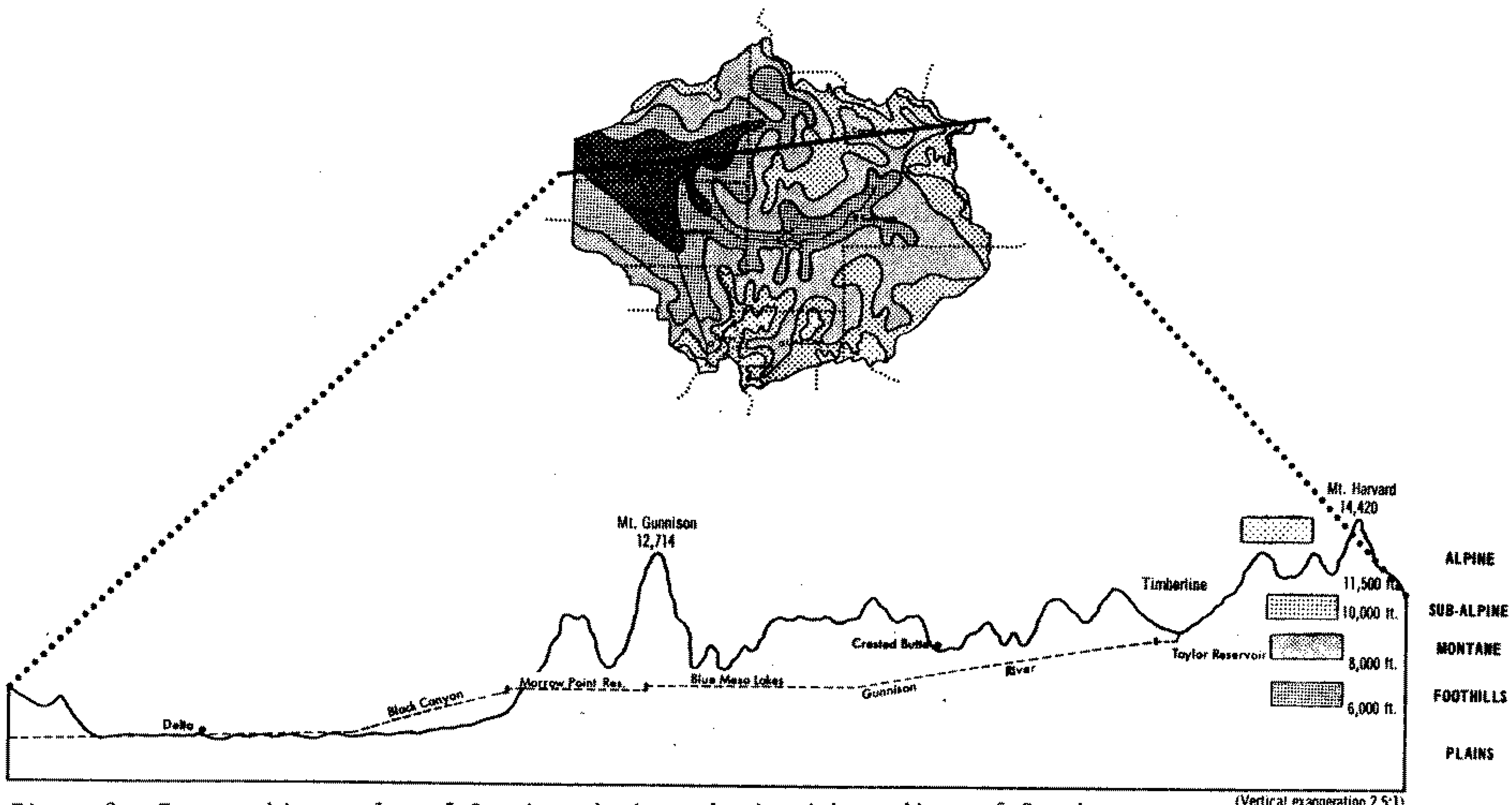


Figure 3. Topographic overlay of Gunnison-drainage basin with gradient of Gunnison River above Delta.

Black Canyon actually extends from the present site of Blue Mesa Dam (near old Sapinero, Colorado) to the junction of the North Fork of the Gunnison, a distance of about 50 mi (80 km). Hansen (1965) noted that the river fell about 2,150 ft (655 m) in this stretch, an average rate of fall of about 43 ft per mi. The steepest area is along the 12 mi of river within the Gunnison National Monument which was established in 1933 (Beidleman 1963). Starting from the upper end of the Monument boundary near the Tunnel (Fig. 4), Warner (1963), a member of the original U.S.G.S. survey of the Monument in 1934, reported that for the first 2 mi the river drops 40 ft per mi. In the third mile, the drop is 75 ft; fourth--55; fifth--110; sixth--200; seventh--260; eighth--140, with a 70-ft drop in 700 ft; ninth--50; tenth--40; eleventh--40; twelfth--50. Within the Monument, the gorge depth ranges from 1,730 to 2,725 ft, while the width narrows to 1,100 ft at the rim and as little as 40 ft at the bottom. At the latter site, the river completely inundates the chasm floor, and is locally called the Narrows. Needless to say, the approximate 28-30 mi of tailwaters that now remain in the Black Canyon are some of the most steep, wild and scenic areas in Colorado. Most people who have gone on a "float trip" through the Monument area will attest to the fact that it was not really a "float trip" but a hike with a boat for crossing deep areas that could not be hiked around. Some of the best authenticated accounts of early trips through the Black Canyon have been reported in Beidleman (1959a) and Vandenbusche (1973).

Kinnear and Vincent (1967) noted that the region including the Gunnison National Monument, topographically, is a transition zone between the Southern Rocky Mountains to the east and Colorado Plateau to the west. They further noted that the Black Canyon acts as a barrier to

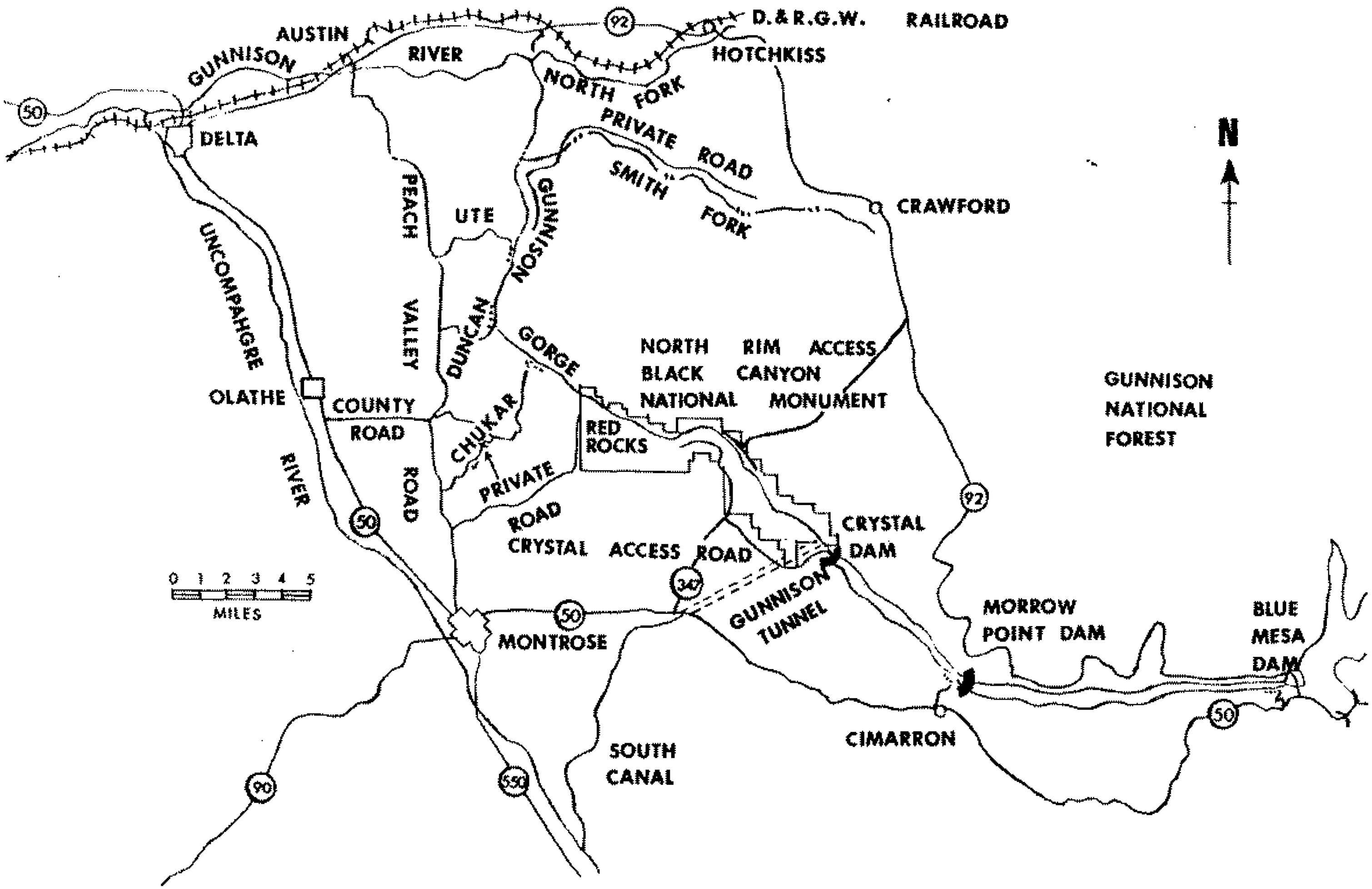


Figure 4. Main fisherman-access roads for Gunnison River below Blue Mesa Dam (see text for details).

natural distribution of fishes through falls and water velocity, that the Monument Canyon was an ecological threshold area between the upper and lower reaches of the Gunnison River, and concluded that comparatively slight environmental changes could thus precipitate extensive distributional adjustments.

Within the immediate area of the National Monument, access to the river is generally restricted by the terrain. Although the river can be reached at a number of places, lateral movement along the river is restricted, and Kinnear and Vincent (1967) described only four access areas for this area:

1) Eastern boundary section, reached via River Portal Tunnel Road. Presently, this road is the only one which permits a vehicle to get near the river without extensive hiking from rim tops and/or foot trails. It actually is a road which was modified to permit heavy equipment transport while Crystal Dam was under construction. In the remainder of the report this road will be referred to as "the Crystal access road". It intersects with the eastern side of Highway 347 a few hundred yards before the main entrance to the Gunnison National Monument (Fig. 4).
2) Gunnison Point section, reached via foot trail from Gunnison Point Overlook.
3) S. O. B. draw section, reached via foot trail from North Rim Campground. This campground is reached by vehicle from Highway 92 either from Crawford to the north or from Blue Mesa Dam to the east.

4) Red Rock Canyon section, reached via foot trail from Bostwick Park. Public access by this trail is presently limited because the existing road is usually chained on the Sanburg property. Many people gain access to the Red Rock Canyon area by one of two alternative routes: a) via foot trail from the south rim at Warner Point within the Monument or, b) by foot trail from the "Chukar access road" below Red Rocks in the Gunnison Gorge. The latter term is locally used to refer to the Gunnison River section below the National Monument but above the North Fork junction. The Chukar access road is a 4-wheel-drive road recently opened by the Bureau of Land Management, circumventing the chained-off road on the Nicolas property. It originates on the east side of the Peach Valley Road about 10 mi north of Montrose, is unmarked, and terminates approximately 7.7 mi to the east on the west rim of the Gunnison Gorge, about 1-1/2 mi below Red Rocks. From this rim, access is by foot trail.

Access into the Gunnison Gorge between the Chukar access and the Smith Fork is limited to two similar, unmarked roads terminating in foot trails from the west rim of the gorge. Both of the roads originate from the Peach Valley Road, and can be driven with a good pickup truck. The first road, locally known as "Duncan" trail, "Bobcat" trail, or "Olathe Gap" takes off of the Peach Valley road east of Olathe, Colorado, about 3.6 mi north of the Chukar access. The road terminates on the west rim about 2.2 mi from the Peach Valley road. From here a foot trail leads to the canyon floor. Access on the gorge bottom is to some extent dependent on the volume of flow in the river. In 1977, when flows were low, a hiker could traverse the gorge upstream by foot with only minor fording all the way to Chukar Trail and even continue up to Red Rocks. Flows in most years would prevent such freedom of movement. Downstream, the hiker could go from Duncan by foot approximately 2.5 mi to the Ute Trail. An additional 4.5 mi of hiking would be necessary to reach the west rim top of the Ute Trail. Here, a pickup could then travel west for about 2.8 mi before intersecting with the Peach Valley Road again. This trail is marked at the rim top but not where it intersects with the Peach Valley Road. In most years one can enter the gorge at Ute and exit at Duncan, or vice versa, but such a procedure requires vehicle coordination if one is to avoid back-tracking on the gorge rim. Lateral movement more than a few hundred yards downstream from the Ute trail is quite limited because the Gunnison River enters a narrow canyon with almost vertical walls and is very swift all the way to the Smith Fork. This section can be traversed by floating but does require some experience in handling the rapids. Although a private road exists along the Smith Fork and goes upstream for some distance on the east rim of the Gunnison Gorge, it is usually chained and seldom used. On five helicopter flights during 1977, nobody was seen in this section. Below the Smith Fork the gorge again widens, and flows are moderate. Access here is primarily by foot from a parking area located on the north bank where the main Gunnison is joined by the North Fork of the Gunnison River. Again, a vehicle must use an unmarked dirt road taking off to the south of Highway 92 east of Austin and west of Lazear, Colorado. This dirt road is a few hundred yds west of the Highway 92 railroad crossing. Fishermen at the North Fork parking area have a variety of choices. They can either proceed up the usually turbid North Fork or down the Gunnison toward Austin or they can, at many times, depending on flow conditions, ford the North Fork and proceed up the less turbid main Gunnison toward the Smith Fork. Although some private roads exist along the Gunnison below the North Fork junction, public access is quite limited in most river sections below there. Considerably more numbers of backwater areas, small irrigation ditches, and side channels exist below the North Fork junction, in contrast to the Gunnison Gorge above. Below Austin the Gunnison River is turbid, largely due to the turbid North Fork of the Gunnison and a considerable number of turbid return irrigation ditches from farms and orchards in the area.

DAMS AND RESERVOIRS

The three dams of the Curecanti Unit (Crystal, Morrow Point, and Blue Mesa) are all located in the Black Canyon of the Gunnison River upstream of the Gunnison National Monument (Fig. 1). Specifications for the dams, reservoirs, and power plants are presented in Table 1.

The uppermost dam, Blue Mesa, began storing water on October 25, 1965 and first attained maximum capacity in 1970. Morrow Point began storing water on January 24, 1968 and first attained maximum capacity November 20, 1968. It was not until early 1977 that Crystal Dam began storing water and it attained maximum capacity soon thereafter. Its powerplant has not yet been completed.

Although all three dams have powerplants, Blue Mesa will be used primarily for flood control and water storage while Crystal Dam will be used to regulate the downstream flows produced by the releases through the high-capacity turbines of the Morrow Point powerplant. Prior to completion of Crystal Dam, Morrow Point turbines could not be operated

Table 1. Curecanti Unit - specifications of dams, reservoirs and powerplants.

	Blue Mesa	Morrow Point	Crystal
DAM			
Type	Earthfill	Concrete, thin arch	Concrete, thin arch
Height above bedrock	390 ft	469 ft	323 ft
Height above streambed	342 ft	418 ft	225 ft
Crest length	800 ft	724 ft	635 ft
Crest width	30 ft	12 ft	10 ft
Base width	1,550 ft	52 ft	29 ft
Volume	3,085,000 cu yd	365,000 cu yd	154,400 cu yd
Crest elevation	7,528 ft	7,165 ft	6,772 ft
Spillway maximum discharge	33,700 cfs	41,000 cfs	42,800 cfs
Freeboard	8.6 ft	350 ft (spillway vertical fall)	16 ft
RESERVOIR			
Capacity	940,800 ac ft	117,000 ac ft	25,000 ac ft
Area	9,180 ac	817 ac	280 ac
Elev. normal water surface	7,519 ft	7,160 ft	6,755 ft
Length	20 mi	11 mi	6 mi
Shoreline	96 mi	24 mi	19.6 mi
POWERPLANT			
Capacity	60,000 kw	120,000 kw	28,000 kw
Number of generating units	2	2	1
Capacity of each generator	30,000 kw	60,000 kw	
Capacity of each turbine	41,500 hp	83,000 hp	39,000 hp

efficiently during "peak-use" periods because of the danger of rapidly rising water levels and flooding in the downstream sections of the canyon. With Crystal Dam in the system this danger is eliminated, but the water level of Crystal Reservoir will necessarily have to be fluctuated drastically in relatively short time-periods to accommodate the peaking discharges of Morrow Point. Morrow Point Reservoir will remain at a relatively constant water level at all times due to replenishment from Blue Mesa to permit maximum head for power generation.

Taylor Park Reservoir, the storage reservoir for the Uncompaghre Project in the upper Gunnison drainage, will be discussed in the next section because of its close association with the Gunnison Tunnel.

DIVERSIONS--Gunnison Tunnel

Man has diverted water for irrigation purposes on practically every stream in the Gunnison River Basin. Most of this is return irrigation water that eventually finds its way back to the main Gunnison River. This is especially true for the higher-elevation sections above the Curecanti Unit where evaporation losses may not be as great as in lower-elevation returns. A short distance below Crystal Dam, however, Man has constructed the Gunnison Tunnel, a structure which, at various times during some years past, actually diverted the entire flow of the Gunnison River into the arid Uncompaghre Valley, leaving only a series of stagnant pools in approximately 30 mi of the Gunnison River above the North Fork junction. It is likely that return flow was considerably reduced by evaporation before the diverted water could re-enter the main Gunnison flow via the Uncompaghre River below Delta, Colorado.

Before the turn of the century, settlers in the Uncompaghre Valley recognized that the Uncompaghre River could not even meet their irrigation needs much less those of additional settlers. According to Beidleman (1959a), much of the agricultural land was abandoned and many valuable houses were deserted because of inadequate water resources. Those settlers who remained naturally began toying with the idea of diverting the greater flow of the Gunnison River into their own valley by means of tunnels and canals. In 1901, Meade Hammond, State Representative from Delta, introduced the Gunnison Tunnel Bill (House Bill No. 195) into the Colorado legislature and on April 11 it was approved, with $25,000 authorized to support the project. The funds soon were exhausted, with little progress on the tunnel and its canals, and interest in new state appropriations lagged. Eventually, the federal government became involved, and, according to Beidleman (1959b), the diversion project, variously called "Uncompaghre Valley Project", "Gunnison River Diversion" or "Gunnison Tunnel Project" was one of the first five projects undertaken by the newly formed Reclamation Service (presently the Bureau of Reclamation). Authorized early in 1903, the Tunnel was not considered completed until 1910, when the first water for irrigation was turned into it on July 6. The total length of the Tunnel is 30,582 ft, with dimensions in cross section of about 10 by 12 ft. The fall of the Tunnel was 2.02 ft per 1,000 ft, while the intake on the Gunnison River was about 7 ft below low-water line. Beidleman (1959b) mentions that the main feeder canal was 30 ft wide at the bottom and 83 ft wide at the top, with the average depth of water being 10 ft. Actually, this feeder canal, commonly called the South Canal, is quite variable in width and depth along its 11.4 mi before entering the Uncompahgre River. Best published accounts of engineering details for the entire project can be found in Powell (1917) and Anonymous (1961). There were 170 mi of associated canals, 400 miles of laterals, and 205 miles of drains in 1909, according to Beidleman (1959b). Anonymous (1961), listed 143 mi of canals, 425 mi of laterals, and 215 mi of drains by 1958. Although the later values do not seem to have changed much historically, it was surmised from Powell (1917) that the capacities of many of the canals and laterals were greatly enlarged or modified just before or soon after the completion of the tunnel.

From its completion to the end of 1931, the Tunnel was operated by the Bureau of Reclamation. Since then, the project has been operated and maintained by the Uncompahgre Valley Water Users Association through a 12-man board of directors (Harris 1962). According to Beidleman (1963), the Gunnison River stretch from the Tunnel to Red Rocks (mostly within the Monument) had been withdrawn from public use by the Reclamation Service, but he did not say exactly when they did this. Presumably, this closure was some time after the Reclamation Service was established in 1902, but probably before 1910 when the primary construction of the Tunnel was completed.

Although the Uncompahgre Project was originally designed to irrigate about 146,000 acres from a combination of the Uncompahgre River flow and the tunnel's theoretical capacity of 1,300 cfs, such values were never attained. Harris (1962), manager of the Water Users at that time, noted the area of project lands irrigated was about 70,000 acres, or half the original estimate. Between 1948 and 1958, lands irrigated have varied between 60,345 and 74,207 acres (Anonymous 1961). Current U.S.G.S. records list Gunnison River diversions through the Tunnel for irrigation of about 75,000 acres. Furthermore, prior to 1918, the maximum amount of flow that was possible to divert through the Tunnel was 900 cfs, according to Thompson (1962), a retired manager of the U.V.W.U.A. Through a number of "betterment programs", the maximum flow increased to about 990 cfs by 1943. In the mid-70's, the Association maintained that 1,000 cfs is the maximum flow for the Tunnel, which agrees with data in Anonymous (1961) and Powell (1917). Harris (1962) listed a number of contracts between the Association and the United States over the years; one of the most important was the construction of Taylor Park Reservoir, the storage reservoir for the Uncompahgre Project.

It was recognized early in history that supplemental water storage would probably be necessary for the Uncompahgre Project. Powell (1917), the chief engineer for the Reclamation Service at that time, pointed out that the Uncompahgre and Gunnison rivers are fed by melting snows and begin to rise when the snow begins to melt in the spring, reaching culmination sometime in June, and then declining irregularly until winter. The maximum demand for irrigation is usually later than the maximum flow of the streams, not declining so rapidly as the flows. He further reported that the combined flow of both streams was usually sufficient for the project, though sometimes there would be a slight shortage in August or September, cautioning that if flows as low as what occurred in 1902, a phenomenally dry year, should again occur, there would be a shortage of over 40 percent. He continued that with this possibility in view, studies had been made of a reservoir site on Taylor River, a tributary of the Gunnison, having a drainage area above the reservoir site of 253 sq mi. According to Powell, a proposed masonry dam at the lower end of Taylor Park, 150 ft above the river bed, would store 106,000 acre-ft of water costing $15-$16 per acre-ft. Actually, historic records in the files of the Uncompahgre Water Users Association revealed that the Gunnison River drainage was surveyed for a storage reservoir site, with the Taylor Park site chosen, as early as 1901. Powell stated that the proposed reservoir would normally obviate deficiencies for the future unless flows in a year as low as 1902 should again occur, in which case the shortage, although much reduced, would not be entirely prevented.

Snow accumulations during the 1910's and 1920's produced flows necessary for the project. Late in this period Steinel and Working (1926), in a short discussion of the water supply relative to the lands being and anticipated irrigated by the Uncompahgre Project, mentioned "It was not likely that the Gunnison Tunnel would have to be completely lined, nor would Taylor Reservoir have to be built for some years." Despite this, Gunnison River flows in 1931 and again in 1934 were considerably less than those of 1902, and probably prompted the approval in 1935 of Taylor Dam construction. This dam, a zoned earthfill type, forming a reservoir with a capacity of 106,200 acre-ft at 9,330 elevation, with a spillway capacity of 10,000 cfs and an outlet works of 1,500 cfs, was financed with funds allotted under the National Industrial Recovery Act and was completed in 1937 (Anonymous 1961).

METHODS AND MATERIALS

LIMNOLOGICAL CHARACTERISTICS

Stream Flows

Mean monthly and annual historic streamflow records were obtained from publications of the U.S. Geological Survey on file at the U.S.G.S. field office in Grand Junction, Colorado. Emphasis was placed on stations with the longest duration of historical records: Taylor River at Almont; below the Gunnison Tunnel; and the Gunnison River near Grand Junction, Colorado. Considerable time was spent during the present study in calculating a hypothetical station, called "Above Gunnison Tunnel," by adding discharges that were historically diverted into the Gunnison Tunnel to the discharges recorded below the Gunnison Tunnel. Means were claculated for time periods associated before and after the construction of the various major structures that now exist in the Gunnison drainage. Discharge data from the Curecanti reservoirs were supplied by the U.S. Bureau of Reclamation Power Operation Office in Montrose, Colorado. Some records were also obtained from the Uncompahgre Valley Water Users in Montrose regarding discharges from Taylor Park Reservoir as well as discharges into the Gunnison Tunnel.

Temperatures

In November 1971, the Bureau of Reclamation installed three continuous recording thermographs in the Gunnison drainage. The uppermost was installed below the Gunnison Tunnel in the same area that Kinnear and Vincent (1967) had operated a thermograph during portions of 1965 and 1966, before Blue Mesa Reservoir was in full operation. A second thermograph unit was installed in the North Fork of the Gunnison River alongside

Hotchkiss National Hatchery near Lazear, Colorado. The third unit was installed near the Highway 50 bridge that spans the Gunnison River at Delta, Colorado. The first and third units, with only rare malfunctions, were operated continually from November 1971 through December 14, 1977, whereas the thermograph at the hatchery was only operated periodically. The weekly charts (0-80^{o}F range) were sent to me by the Bureau of Reclamation, which maintained and operated the thermographs. Maximum and minimum daily temperatures were interpreted from the charts and recorded for each month the units were operated. Some historical temperature records for the Gunnison River near Grand Junction were obtained from the Geological Survey records on file in the Bureau of Reclamation field office at Grand Junction.

In addition to the above data, 45-day continuous recording Ryan thermographs (28-80^{o}F) were operated rather sporadically by my field crews at the following locations: below Blue Mesa and Morrow Point reservoirs; in the Cimarron River about 1 mi above its confluence with the Gunnison River; in the Gunnison River above the confluence of the North Fork; in the North Fork just above its confluence with the Gunnison; in the Uncompaghre River about 2 mi above Delta; and in the Gunnison River at the Escalante bridge. Several factors contributed to the sporadic operation of these stations: (a) some thermograph units were not procured until the study was well underway; (b) some units malfunctioned, either due to defects inherent to the clock or to tampering by fishermen who happened to find the instruments in the streams; (c) five units were actually lost during this study. Consequently, analyses of temperature data presented in this paper will be principally from the two stations having the longest historical records: below the Gunnison Tunnel, and the Gunnison River at Grand Junction.

Water Analyses

Water samples were collected occasionally during this study from various localities in the lower Gunnison River drainage. Main River stations (Appendix I) were: below each of the three Curecanti dams (Blue Mesa, Morrow Point and Crystal); above the North Fork junction; at the Highway 50 bridge in Delta and above the Escalante Creek confluence. Some additional samples (Appendix II) were procured from the other major lower Gunnison River tributaries: Cimarron River, North Fork of Gunnison and the Uncompahgre River.

Most determinations were done by technicians at the Colorado Division of Wildlife Laboratory in Fort Collins, Colorado. The pH and specific conductance of the water was determined in some cases by project members with meters available in Montrose and/or Fort Collins. Determinations of dissolved solids, alkalinity, total hardness and sulfates were made in accordance with standard methods used by the DOW laboratory in Fort Collins. A Hellige turbidimeter was used to determine turbidity on some of the water samples by project personnel. The low level values (μg/l) determined for some of the metals in 1974 samples were analyzed by Mr. Patrick Davies of the DOW Fort Collins office using atomic absorption procedures on extracted samples. Other values for the metals were determined by laboratory technicians at Fort Collins using flame atomic absorption techniques with a Perkin-Elmer Model 303 spectrophotometer.

Bottom Fauna Collection and Identification

Occasionally samples of the stream bottom fauna were taken from various localities between Morrow Point Dam and the Escalante confluence (Appendix III for main Gunnison River samples and Appendix IV for tributary samples). At each sampling station a standard 1-sq ft Surber sampler was placed over the stream bottom at depths not exceeding 2 ft. The bottom rocks were hand rubbed allowing the stream flow to carry fauna into the net of the Surber sampler. A total of 3 Surber samples was procured from each station and all materials collected at a given station and time were placed into a 1-qt jar and preserved with formaldehyde for later examination. In the laboratory the insect fauna were usually sorted to order designation using characteristics and/or keys presented in Usinger (1956) and Edmonson (1959). Individuals from each order of insects encountered were placed in plastic vials and for all orders encountered except Coleoptera and Diptera the individuals were identified to genus and enumerated. Several Coleoptera larval forms were encountered but only two, *Optioserus* and *Narpus* were positively identified to genus. No attempt was made to identify other Coleoptera individuals and they were enumerated as such. Members of the order Diptera were identified and enumerated to the four families encountered viz., Tendipedidae, Simuliidae, Tipulidae and Rhagionidae. Only larval members of the genus *Atherix* are known from the family Rhagionidae, hence the use of the generic name rather than the family name. Non-insect invertebrate fauna collected were enumerated to broad categories such as snails, flatworms, clams, amphipods and annelids.

FISHERIES STUDIES

Fish Collections and Identification

During this study over 11,000 fish were collected by hook-and-line fishing, shocking, seining, and standard 125-ft experimental gillnets. The latter two methods captured most of the samples. Between 1973 and 1975, fish collections were emphasized in sections below the North Fork, for a number of reasons. First, access was easier and more backwater areas exist in this section, which permitted procurement of large numbers of small fish to identify by length-frequency analysis young age-groups for the various species. Vincent (1966) noted considerable difficulty in capturing small, young fish in the National Monument sections. Furthermore, almost all the species that are found in the Gunnison River were collected below the North Fork, and this allowed us to establish early reference collections for the various species and hybrids. Intensity of fish sampling shifted to the areas above the North Fork in 1976 and 1977. Although a few hauls with a 25-ft bag seine were made in 1976 in this area, most fishes were collected by gillnets and some by hook and line. Gillnets were stressed so the data would be more comparable to those collected by Kinnear and Vincent (1967) in 1965-66 before the Curecanti Unit was in full operation. Most (75%) of the fish collected by them were taken in 1965 before the closure of Blue Mesa Dam. Vincent (1966), reporting on 713 fish from the 1965 collections in the Monument, mentioned that seining had been fruitless while fishing with set-line and rod and reel were of limited value. He continued that electrofishing was limited by adverse water conditions and variable-mesh gillnets had proved to be the most efficient type of sampling gear.

During the present study seining was done most frequently in backwater areas where flow was not excessive. For the main river samples, gillnets were usually set overnight parallel with the flow or at a slight angle across the flow. Sets made directly across the stream flow were unproductive because they became clogged with debris and algae carried in the main flow. Nets were normally anchored to the bottom and tied to a tree or rock along the bank, but on occasions were lost due to the debris-algae clogging problem. In most years, fish samples from Morrow Point and Crystal reservoirs were taken primarily with experimental gillnets held at the water surface by means of plastic bottles tied to the float line. The ends of the nets were tied to the bank with ropes of various lengths. Some vertical gillnets were suspended from the middle of the floated gillnet line in Morrow Point Reservoir. A long Bureau of Reclamation barge was necessary to set the 30-ft-wide vertical gillnet used, and, since a similar barge was unavailable on Crystal Reservoir, no vertical gillnets were set there.

Most fish collected by seines were small specimens and were preserved in 10-percent formaldehyde for later identification. Identifications of most species were made using keys and/or characteristics presented by Beckman (1952) and Baxter and Simon (1970). References used for identification of catostomid fishes and their hybrids were Smith (1966); Hubbs and Hubbs (1947); Hubbs, Hubbs, and Johnson (1943); Smith and Koehn (1971); Nelson (1973) and Middleton (1969). The paper of Holden and Stalnaker (1970) was used to discern species of the genus *Gila*, while that of Hubbs and Miller (1953) was used for *Xyrauchen* and related hybrids.

Fish collected in gillnets were usually identified in the field by crew members who were capable of identifying catostomid hybrids. Crew proficiency in identification was obtained from our reference collections and keys made from earlier collections by the present author and Middleton (1969). The collections of Middleton (1969) from Blue Mesa Reservoir were verified by Dr. Behnke of Colorado State University. Furthermore, author proficiency is suggested since hybrid specimens independently collected and identified by Mike Prewitt (graduate student of Dr. Behnke) from the Yampa system in Colorado were in agreement. If identification of a specimen was doubtful it was usually either brought back to the laboratory or various diagnostic characteristics and measurements were taken in the field. Characteristics such as isthmus and peduncle width, peritoneal lining color, principal dorsal ray counts, and scale counts along and above the lateral line were recorded for some catostomid specimens in the 1975 collections and almost all of the catostomids collected in 1977. Techniques and procedures used in these counts and measurements were those described by Beckman (1952). Careful comparison of the 1977 data for field-identified catostomids (Appendix V) with those reported by others for these fishes indicated at least 93-percent accuracy in field identification. Almost all of the questionable catostomids were probably hybrids originally identified as white suckers. The field data collected from these hybrids were insufficient to identify the other parental source. Therefore, they were included with the white suckers as originally identified.

Normally, scale samples from most field specimens were taken and placed in manila envelopes, and each specimen was sexed if of a size so the gonads could be seen and distinguished with the naked eye. In addition, most specimens were measured to the closest 0.1 in, weighed to the closest gram, and, if over 1 lb, weighed to the closest oz. Weights were not taken, however, on most of the fish caught in 1977.

Marked Fish Studies

Fluorescent Pigment Marking

Fluorescent pigment marked rainbow trout and tetracycline-marked kokanee salmon have been used previously by Wiltzius (1971, 1974) in the Blue Mesa Reservoir investigations. Some fluorescent-marked rainbows were taken from Morrow Point Reservoir in routine gillnetting during 1971, and losses of small salmon through the Blue Mesa turbines were also found in 1973. To determine if significant losses of these fish were occurring, marked-fish studies were instigated. One disadvantage of the fluorescent markings is that the marks cannot be seen, unless fluoresced under black light (3600A). Because of this, some rainbow were finclipped so fish could be detected easily in the field.

Wiltzius (1971) described the technique and methods used to mark rainbow trout with fluoescent pigment in 1967-1971 at Blue Mesa Reservoir. Rainbows from the 1971 markings showed less retention than those in previous years, so when the markings for the present study were initiated in 1974 considerable testing of equipment, pressures, distance above fish, etc. was done in an attempt to improve this marking technique. It was found that the pressure delivered in the 1971 marking was inadequate for proper retention of granules. Subsequently, a system was developed and described by Wiltzius and Smith (1976) which was believed could result in extremely high percentages of permanently fluorescent-marked rainbow trout. Recent findings by Mueller (1977) in Wyoming indicate that 82 percent of a fluorescent-marked rainbow lot retained pigment for 42 mo. Our working system uses greater pressures and pigment application, which should result in higher percentages than the Wyoming study. Our new system was used to mark all of the scheduled rainbow fingerlings stocked from Hotchkiss National Fish Hatchery into Blue Mesa Reservoir during 1974-1976 and in Silverjack Reservoir in 1974. Sampling of the rainbow trout harvest from Blue Mesa Reservoir in 1975-1977, using 30 watt ultraviolet lamps in a darkened area at the boat ramps, was used to determine percent retention of the marked groups. In general, at least 95 percent of Age 1+ fish still had pigment. All rainbows collected from Morrow Point and Crystal Reservoirs during this period were also examined for marks, and many of the rainbows from the lower river samplings were also examined.

Tetracycline Marking

This technique involves feeding a diet containing oxytetracycline at the hatchery. The additive leaves a detectable yellow mark in the bones when fluoresced with ultraviolet light. The technique was described in detail by Wiltzius (1971). The only change from that originally described is the duration of the feeding and the size when experimental lots were fed. In May 1974, 800,000 kokanee salmon (approximately 40 percent of all salmon stocked in Blue Mesa that year) at a count-weight of about 1000/lb were fed for 9 consecutive days. A sample of these fish was held indoors at Roaring Judy Hatchery until September 1974, when 99 percent of them were found to contain a detectible mark. It should be noted here that direct sunlight can destroy a tetracycline mark in less than 30 days in smaller salmon held outdoors (Wiltzius 1971). Sampling was therefore scheduled for Blue Mesa Reservoir to determine if the mark was being retained.

In the spring of 1975 the entire plant (240,000) of kokanee scheduled for Taylor Park Reservoir was also marked with tetracycline. Subsequent downstream sampling was done to determine out-migration of the salmon. Generally, the tail section, including the last few vertebrae, was collected from each salmon taken during this study. If the vertebrae could not be examined in the laboratory under a 100-W ultraviolet source with a dissecting microscope, the sample was frozen for later examination. Most bone samples were examined within 24 hrs of collection.

Fin-Clip Marking

In 1977 a detailed creel census was planned for the Gunnison River sections below Crystal Reservoir. The upper section below the dam is annually stocked with catchable rainbow trout, as is a section at the confluence of the North Fork of the Gunnison. To facilitate detection of hatchery-reared rainbow, the entire catchable plant of 4,260 was marked by removing the left ventral fin at Pitkin Hatchery before stocking was begun in the upper section in mid-June. The left pectoral fin was removed from the 780 catchable-size fish stocked in the lower North Fork area.

Creel Census Studies

Early Questionnaires, 1973-74

Data regarding fisherman-use and success are necessary to properly manage any fishing resource. Furthermore, such data would be necessary to determine probable detrimental or beneficial effects of the completed reservoirs on the downstream sections. Little recent use and success data were available on the river sections below the dams when this study was started, except for some rather rough estimates of fisherman-use within the National Monument. However, no data were available on the lower sections, which could gain the most by cold-water releases from the reservoirs. Consequently, a major objective of the present study was to establish present use and success trends for the Gunnison River downstream from the dams at least to the North Fork junction.

Initially we attempted to obtain fisherman-use and success data from a questionnaire (Table 2) given to about 50 "key fishermen" in the Delta-Hotchkiss area. Even though these fishermen were interviewed and given instructions before being given the questionnaires, most returns

Table 2. Quarterly fisherman questionnaire used during 1973-74.

Name ______________________ Phone No.__________ Date__________

Address____________________ City__________ State______ Zip______

LOWER GUNNISON RIVER FISHERMAN QUESTIONNAIRE

April - June, 1974

1. What time during this quarter did you fish the lower Gunnison River?

   A. April 1 - April 15 _____ C. May 1 - May 15_____ E. June 1 - June 15 _____
   B. April 16 - April 30 _____ D. May 16 - May 31_____ F. June 16 - June 30 _____

2. How many times did you fish the river during the above time periods?

   A. No. _____ C. No. _____ E. No. _____ Total Trips_____
   B. No. _____ D. No. _____ F. No. _____

3. A. How many hours (average) were spent during each fishing trip? _____hours.

   B. How many hours (average) were spent actually <u>fishing</u> during each one of these fishing trips? _____ hours.

4. Which section of the Gunnison River did you fish during the past quarter? (Refer to section description below.)

   Section 1. Gunnison River - from its confluence with the Colorado River at Grand Junction to the confluence of Escalante Creek below Delta.

   Section 2. Gunnison River - from the confluence of Escalante Creek below Delta to U.S. 50 bridge at Delta.

   Section 3. Gunnison River - from U.S. 50 bridge to Delta to Colorado Hwy. 92 bridge near Austin.

   Section 4. Gunnison River - from Colorado Hwy. 92 bridge near Austin to the confluence of the North Fork of the Gunnison River.

   Section 5. Gunnison River - from the confluence of the North Fork of the Gunnison River to the confluence of the Smith Fork.

   Section 6. North Fork of Gunnison - from its confluence with the main stem of the Gunnison River to the Colorado Hwy. 92 bridge at Hotchkiss.

   Section 7. North Fork of Gunnison - from Colorado Hwy. 92 bridge at Hotchkiss to Paonia Dam.

   Section 8. Gunnison River - from the confluence of the Smith Fork to Each Portal of the Gunnison Tunnel above the Black Canyon of the Gunnison National Monument.

   Section 9. Gunnison River - from the East Portal of the Gunnison Tunnel to the confluence of the Cimarron River just below Morrow Point Dam.

Section	1	2	3	4	5	6	7	8	9	Total
No. Trips	___	___	___	___	___	___	___	___	___	___
No. Rainbows caught	___	___	___	___	___	___	___	___	___	___
No. Browns caught	___	___	___	___	___	___	___	___	___	___
No. Cutthroat caught	___	___	___	___	___	___	___	___	___	___
No. Suckers caught	___	___	___	___	___	___	___	___	___	___
No. other _____	___	___	___	___	___	___	___	___	___	___
No. other _____	___	___	___	___	___	___	___	___	___	___
No. fishermen encountered during average fishing trip*	___	___	___	___	___	___	___	___	___	___

* Do not include members of your own fishing party in this average of fishermen encountered.

5. In which type of water flow and river condition did you catch the most game fish? (Check all those that apply.)

   High Flow _____ Muddy Water _____ Deep Pools _____
   Intermediate Flow _____ Clear Water _____ Swift Rapids _____
   Low Flow _____ Shallow Pools _____ Riffles _____

6. Which type of fishing method did you use to catch the most game fish?

   Bait _______________ Which kind?_______________

   Flies: (1) Dry Fly _____, (2) Wet Fly _____, (3) Nymph _____, (4) Streamer _____,

   Lures _______________ Other _______________ were useless and it was impossible to interpret accurately the data on fisherman-use in the lower section. Furthermore, the obvious bias in expanding success data from such a select group to the average fisherman prompted discontinuance of this procedure in favor of a random survey.

1977 Random Survey of Lower Gunnison

In this survey we intended to obtain estimates of fisherman-use and total harvest in the period from mid-April through mid-October, the period of heaviest use as determined from earlier questionnaires. We were to cover the area from Crystal Dam to the North Fork confluence. Our basic design was a 2-2-2 system, employing sampling on 2 randomly selected weekend days and 2 randomly selected weekdays, every 2 wks. We began by dividing the study time into thirteen 2-wk intervals from April 16 through October 14, 1977. The randomly selected weekends and weekdays within each 2-wk period are shown in Table 3, as is the starting time for each sample day. These later times for each day were randomly selected on an hourly basis between the hours of 7 A.M. to 12 noon. The starting time was randomized to prevent selective bias which could occur if the crew sampled fishermen only in the same time period every sample day.

Our original plan called for three census-takers to leave Montrose at the randomly selected time and date. One clerk would go to the Crystal Access Road and remain there for the rest of his 8-hr working day minus traveling time back to Montrose. While there, he would interview all fishermen who had finished fishing (terminal check) and record data such as vehicle license number, number of fishermen per vehicle, hours fished, days fished, number of marked rainbows, and numbers of all other

Table 3. Sampling dates for lower Gunnison creel census, 1977.

Sampling period	Weekdays selected		Crew leaves Montrose	Weekends & holidays selected		Crew leaves Montrose	Helicopter counts	Crew leaves Montrose
4/16-4/29	Thur	4/21	10 AM	Sat	4/16	8 AM		
	Wed	4/27	Noon	Sat	4/23	9 AM		
4/30-5/13	Tues	5/ 3	9 AM	Sun	5/ 1	8 AM		
	Tues	5/10	11 AM	Sat	5/ 7	8 AM		
5/14-5/27	Mon	5/16	7 AM	Sun	5/22	9 AM	5/22	10 AM
	Thur	5/19	Noon	Fri	5/27	Noon		
5/28-6/10	Fri	6/ 3	11 AM	Sun	5/29	Noon		
	Tues	6/ 7	7 AM	Mon	5/30	9 AM	5/30	10 AM
6/11-6/24	Mon	6/13	7 AM	Sat	6/18	10 AM	6/13	8 AM
	Fri	6/17	8 AM	Sun	6/19	7 AM	6/18	11 AM
6/25-7/ 8	Wed	6/29	Noon	Sat	6/25	8 AM	6/29	1 PM
	Wed	7/ 6	7 AM	Sat	7/ 2	9 AM	7/ 2	10 AM
7/ 9-7/22	Thur	7/14	7 AM	Sat	7/16	7 AM	7/16	8 AM
	Mon	7/18	9 AM	Sun	7/17	7 AM		
7/23-8/ 5	Thur	7/28	9 AM	Sun	7/24	9 AM	7/24	10 AM
	Tues	8/2	Noon	Sun	7/31	10 AM		
8/ 6-8/19	Thur	8/11	7 AM	Sun	8/ 7	10 AM	8/ 7	11 AM
	Thur	8/18	10 AM	Sun	8/14	10 AM		
8/20-9/ 2	Mon	8/22	7 AM	Sat	8/20	8 AM	8/20	9 AM
	Tues	8/30	11 AM	Sat	8/27	8 AM		
9/ 3-9/16	Thur	9/ 8	10 AM	Sun	9/ 4	9 AM	9/ 4	10 AM
	Mon	9/12	11 AM	Mon	9/ 5	7 AM		
9/17-9/30	Fri	9/23	7 AM	Sat	9/17	11 AM		
	Mon	9/26	10 AM	Sun	9/25	7 AM		
10/1-10/14	Mon	10/ 3	9 AM	Sun	10/ 2	10 AM		
	Tues	10/11	9 AM	Sun	10/ 9	11 AM	10/11	10 AM

species caught. At the time he was preparing to return to Montrose he would place a postcard questionnaire (Fig 5) on those vehicles which were still in the area.

Originally, the second census-taker was to cover only the Duncan and Ute trails, which are both access roads to the Gunnison River canyon rim below the Gunnison National Monument. These were the only public access roads in existence to the Gunnison River below the National Monument. Since all the census clerk would usually see was empty vehicles, he would leave a postcard questionnaire on each vehicle and record the time and license number. If he had enough time, he would then proceed to the North Fork area to help the third census clerk. On his return trip to Montrose, he would recheck the Ute and Duncan trails for additional vehicles entering and leaving the area. Early in May 1977, a 4-wheel-drive accres road (Chukar Trail) which had gone through private land for a short distance was opened to public access by the Bureau of Land Management when they built a short road across public land connecting with the Chukar trail beyond the private section. Checking of this trail was added to the second census taker's route, and the additional time required to include it prevented him from helping at the North Fork station where the third census clerk handled data, as at the Crystal station.

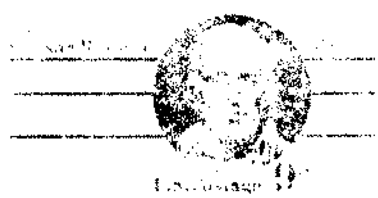
Access within the Black Canyon of the Gunnison National Monument is by means of various foot trails, most of which originate from the top of the South Rim. Parties descending into the Monument are required to check with the rangers to supply them with information as to when they will be going in and coming out. The National Park service agreed to give our postcard questionnaires to each party descending from the

Dear Fishermen: No. 938

The Division of Wildlife is conducting a survey to determine fisherman use and harvest on the Gunnison River. Would you take a few minutes to fill out this questionnaire and return it as soon as possible, even if you don't catch any fish. Thanks very much. Wm. J. Wiltzius, Wildlife Researcher, Div. of Wildlife.

AREA OF RIVER FISHED (Check one or more if applicable)
Crystal Dam to National Monument [] National Monument [] Monument to Smith Fork [] Smith Fork to North Fork [] North Fork [] North Fork to Austin [] Other(Specify)________

1. How many people in your vehicle actually fished?________
2. How much total time (hours) was spent fishing by your party?________
3. Did any of the fishing time cover more than a single day?____ How many days were involved?____ Date(s)________
4. How many of the various species were caught? Rainbow____ Brown____ Suckers____ Kokanee Salmon____ Mackinaw____ Chubs____ Native Cutthroat____ Brook____ Others________
5. How many of the Rainbow Trout were fin-clipped (missing fin?)



COLO. DEPT. OF NATURAL RESOURCES
DIVISION OF WILDLIFE
SW REGIONAL OFFICE
P. O. B[illegible]
MONTROSE, COLORADO 81401

Figure 5. Post-card questionnaire, lower Gunnison River creel survey, 1977.

South Rim trails. The only known access points not covered by the census were the North Rim foot trails to the National Monument and two private access roads, one in the Red Rocks area of the lower National Monument and another along the Smith Fork tributary to the lower Gorge area. Postcards were given to the landowner on the former road to dole out to any fisherman using the Red Rocks trail. The Smith Fork access road was usually chained and the landowner was seldom there, so cards were not given to him.

Sample-day harvest estimates were obtained by expanding the observed data on a sample day (obtained from the terminal checks and postcard returns) by the ratio of observed fishing vehicles encountered that day. For example, on a particular day in a given sampling area, 10 fishing vehicles were encountered. The census clerk obtained pertinent data from three vehicles (terminal checks) and placed questionnaires on the remaining seven vehicles, of which two were subsequently filled out and returned to us. Totals for the various harvest parameters from the five vehicles from which data were obtained were then doubled to obtain the harvest estimate for that day. These sample-day estimates were then porcessed in a computer program developed by David Bowden, a statistician at Colorado State University. This program calculated the final harvest estimate, computed the variance for each parameter for each 2-wk period, and computed the grand totals and their variances. Such a procedure was used on the data procured at the Crystal Access Road and at the North Fork area, the two most heavily used areas where data were obtained on almost all sample days. In the lightly used areas like the Gunnison Gorge trails, only grand-total harvest estimates and their variances were calculated for the entire study period because on many of the sampling days no terminal checks were obtained. Harvest estimates were first separately calculated for weekends and weekdays because nearly 75 percent of the fishing use occurred on weekends. Expansions were then made for each of these categories on the basis of the appropriate number of days in each category during the study period, and then totaled.

It can be deduced from the above description that we considered all of the vehicles encountered, especially on the Gunnison Gorge rim trails, as "fishermen vehicles", when we actually had no direct contact either through census clerk interview or by questionnaire return. A census clerk approaching an unmanned vehicle on the rim trails had no way of knowing whether the people from it were actually fishing in the river below. The clerk could not see the river or fishermen from the rim parking area. Consequently, to gain information on this problem, helicopter flights were scheduled and flown on several sample days, principally weekends, when the pressure was greatest. Although 12 such days were originally scheduled (Table 3), flights were made only on 5/22, 6/29, 7/2, 7/16, 8/7, 8/20, and 9/4/77. The flight course was the same on each day flown. The helicopter left Montrose and proceeded to Blue Mesa Dam, from which it flew downstream over Morrow Point and Crystal reservoirs while an observer with binoculars counted vehicles and boat and bank fishermen. Fishermen and vehicles were then enumerated at the Crystal access road. Once into the Monument and gorge section, the observer counted only fishermen because it was necessary to fly the helicopter at least half way down into the canyon to make observations. Census crew members actually counted the vehicles on the Chukar, Duncan, and Ute trails shortly before each flight was underway. National Park

Service rangers at the South Rim trails kept records of fisherman parties entering the canyon (each party assumed to be in one vehicle) to provide the counts from this area. Vehicle counts below the Smith Fork were made by the flight observer. The flight proceeded over the Gunnison River past the North area to just below Delta, Colorado, from which the helicopter flew up the Uncompaghre River on its return to Montrose, Colorado. Depending on weather conditions and some rechecking of some groups in the canyon, each flight usually took slightly more than 2 hrs.

Expected numbers of fishermen were calculated by multiplying the grand average number of fishermen per vehicle (determined from observations and card returns in each appropriate section during the entire study) by the number of observed vehicles in each particular section. Observed and expected numbers of fishermen in each section were subjected to chi-square tests, using a program in a Compucorp 325 scientist desk computer. The results of these tests showed that all of the vehicles encountered on the three Gorge trails could be considered fisherman vehicles. Even though 3(2.1%) of 143 vehicle questionnaires returned from the study sections prior to August 15, 1977 indicated that they had not fished, no adjustments were made.

Age and Growth

Scales for age determination were collected from most fish collected in this study from an area on the fish body above the lateral line and below the dorsal fin. They were placed in manila envelopes for later examination. For examination, scale samples were immersed in water on micro slides and projected at 45x with a Bausch and Lomb enlarger. The number of annuli observed on the sample scale was recorded as the age for that fish and denoted by Roman numerals. A + sign after the numeral indicates the fish has not completed its current year's growth. For example, a I+ fish has one annulus on its scale and was captured in its second year of life before laying down the second annulus. All samples collected prior to 1977 were aged by the author, while those collected during 1977 were aged by two crew members, one of whom had assisted the author on the 1975 and 1976 collections. No ages were estimated for scaleless species such as bullhead and sculpin, while minnow species were aged primarily by length-frequency analysis (verified to some extent by sub-sampling these for scales).

Length-weight regressions were computed for most species of fish collected in this study with the aid of a computer program originally supplied with the Compucorp 325 desk computer. Because variables such as time of collections, gear used to capture specimens, and sex are known to influence length-weight relationships, regressions have been computed taking these factors into consideration.

STATISTICAL ANALYSES

Most statistical analyses in this study were done with a Compucorp 325 programable desk calculator with the aid of taped programs such as linear and curvilinear regression, correlation, and standard deviation. Some programs were written by the author to allow t-testing of means and chi-square analysis, along with computation of probability levels. These programs were tested for accuracy against examples in Snedecor (1953). Statistics for the 1977 creel survey were calculated from programs written by Dr. David Bowden, statistician at Colorado State University.

RESULTS AND DISCUSSION

During the 13 yrs I have been conducting studies in the Gunnison River drainage, a considerable amount of historical information on the fish and fishery has been accumulated. Using some of these data, Wiltzius (1976) made an attempt to discuss and document many of the factors that were historically influencing the abundance and distribution of the Gunnison River fishes. Because much historical information regarding the average-size trout in the fishery was unintentionally omitted, the 1976 manuscript contains a highly biased account, since it documents primarily historic trout species records, renown trophy-size fish, and contest winners. Furthermore, little information was presented in historic fisherman-use and harvest estimates. The abundant non-salmonid species were discussed only briefly and with emphasis primarily on the suckers. In this report, I intend to rectify the biases and shortcomings of Wiltzius (1976), but I will also include much of the same material.

The historical influences that Taylor Dam, the Gunnison Tunnel, and Curecanti dams have had on the flows, temperatures, chemistry, and bottom fauna of the Gunnison River are discussed. Next, some of the factors that led to and/or influenced the renown of the world-famous trout fishery are documented. Factors unrelated to the dams that I believe influenced the trout fishery are noted. Again, I chronicle the historic trophy catches and species records but I also document historical fishing success rates, species compositions, average sizes of fish in the creels, and correlations between catchable-size stocking of rainbow trout and the catch rate of this, the dominant species in fishermen creels. An attempt is made to estimate what the Gunnison River was providing before inundation, in terms of fisherman-days, number of trout harvested, and pounds yielded. These values, as well as projected estimates, are compared to estimates of what the reservoir-modified Gunnison River has provided. Speculations are made regarding whether the present tailwater rainbow trout fishery is being augmented by natural reproduction or is primarily from stocking. Finally, the distribution and abundance of each non-salmonid fish species or sucker hybrid historically reported from the Gunnison River is discussed. The discussions take note of whether the species are native or introduced. If they are introduced, speculations are made as to when, where, and how the introduction may have occurred. In addition, factors believed responsible for changes in the distribution or abundance of a species are speculated upon.

HISTORIC STREAMFLOWS

Influence of Taylor Dam

Although there are many gauging stations located in the Gunnison drainage, only three have been operated continuously for any length of time to develop historical flow trends. These stations are on the Gunnison River at Grand Junction (Appendix VI), on the Gunnison River about 1.5 mi below Crystal Dam near the upper boundary of the National Monument ("Below Tunnel", Appendix VII), and on the Taylor River at Almont. The "Below Tunnel" station has been operated continuously since October 1903, the longest of any station, and was used to develop historical flow patterns for the river. Although the "Below Tunnel" figures are a reliable indicator of the historical flow patterns through the Monument to the North Fork junction, they are useless to indicate historical patterns for the river above. The reason for this is that large quantities of water are diverted through the Gunnison Tunnel into an irrigation network system for the Uncompahgre Valley Water Users. By adding the "Below Tunnel" flow (Appendix VII) to the flow that was diverted (Appendix VIII), one obtains an estimate of the flow above the diversion, which is believed to best represent the historical flow patterns of the Gunnison River (Appendix IX).

Taylor Reservoir was constructed in 1937 and was operated much the same throughout the 1938-1965 period prior to Curecanti. Its main objective was to store water for delivery via the Tunnel during the primary irrigation season between April 10 and September 31. By analyzing historical mean monthly flow records in the 1910-1937 period, prior to completion of this dam, and means after its completion in the 1938-1962 period at the Almont gauging station, the general effect of the dam on the Taylor River flows was revealed (Table 4). It should be mentioned here, however, that the mean annual flows in the 1938-1962 period were highly significantly less than those in the earlier pre-Taylor period, apparently due to less snow accumulations. The 1910-1937 data were therefore adjusted downward on a mean monthly basis before they were compared with the actual data from the 1938-1962 period. The same procedure was used for the 1965-1974 period when it was compared to the pre-Taylor data. Without these adjustments one would have difficulty attributing the differences to effects of the dam or to lower flow resulting from natural conditions.

Mean flows of the Taylor River at Almont before Curecanti were found to be decreased due to the dam in the November-through-June months, individual monthly means ranging between 10.3 percent reduction in April to 41.8 percent reduction in May. The reduced flows of all months in this period were statistically significant, except for December and

Table 4. Historic mean monthly discharge (cfs) of Taylor River at Almont with estimated effects of Taylor Park and Curecanti reservoirs.

Mo.	1910 - 1937 Before Taylor Park Reservoir	1938 - 1962 After Taylor Park but before Curecanti		1965 - 1974 After Curecanti		Effect of Taylor Dam to Almont flow before Curecanti (%)[b]	Effect of Taylor Dam to Almont flow after Curecanti (%)[b]
	Actual	Adjusted[a]	Actual	Adjusted[a]	Actual		
Jan.	123.66	103.52	74.22	108.72	116.59	- 28.3 H.S.[c]	+ 7.2
Feb	124.44	104.17	70.76	109.41	118.52	- 32.1 H.S.	+ 8.3
Mar	136.96	114.65	79.28	120.42	137.32	- 30.9 H.S.	+ 14.0
Apr	251.63	210.64	188.90	221.23	263.71	- 10.3 N.S. P=.4461	+ 19.2
May	881.59	737.98	429.64	775.09	473.33	- 41.8 H.S.	- 38.9
Jun	1341.00	1122.55	803.84	1179.01	632.22	- 28.4 S.	- 46.4
Jul	578.04	483.88	587.04	508.21	483.44	+ 21.3 N.S. P=.1872	- 4.9
Aug	307.36	256.99	525.96	270.23	458.22	+104.7 H.S.	+ 69.6
Sep	223.31	186.93	582.44	196.33	419.00	+211.6 H.S.	+113.4
Oct	211.44	177.00	204.20	185.90	404.33	+ 15.4 N.S. P-.2651	+117.5
Nov	157.94	132.21	103.52	138.86	255.33	- 21.7 S.	+ 83.9
Dec	125.25	104.85	85.88	110.12	161.87	- 18.1 N.S. P=.15	+ 47.0
Annual Totals	371.89	311.28	311.31	326.96	326.99		

[a]Adjusted value for 1938-62 period = .8371 x 1910-1937 value; The factor was obtained by comparing the actual annual flow with the annual flow in the 1910-37 period. Adjusted value 1965-74 = .8792 x 1910-37 period.

[b]% difference between the adjusted mean and the actual mean is considered the effect in each time period.

[c]H.S. = Highly significant difference; probability less than .01.
S. = Significant difference; probability less than .05.
N.S. = Non significant; probability greater than .05.

April. Increased flows occurred during the July-through-October period and varied between 15.4 percent for October to 211.6 percent in September. The increased flows of July and October were not significant, while those during August and September were highly significant.

Since Taylor Park Reservoir is located above (high water level of 9,330 ft) the Curecanti Reservoirs, the operation of the reservoir releases could be and was changed in the 1965-1974 period. Increased flows at Almont occurred in all months between August and April, with decreased flows only during the May-through-July period. The greatest increases occurred in September and October, both over 100 percent of adjusted pre-reservoir historical patterns. The greatest decrease occurred in June (46.4%). The normal annual spilling of this reservoir in recent years has been slightly delayed into mid- to late June from earlier spilling prior to Curecanti.

Influence of Gunnison Tunnel and Curecanti Dams on Flows

The flow data presented in Table 5 clearly show the historical dewatering that has occurred in the tailwater area below the Tunnel With significantly lower annual discharges in the 1938-1965 period, compared to earlier periods, significantly more water was being diverted. In August, an average of over 66 percent of the entire Gunnison River flow was diverted through the Tunnel in 1938-1965. Even greater percentages were diverted during September, when 77.2 percent of the Gunnison River flow was diverted. In about 50 percent of the years, mean-monthly flows at some times were reduced below 200 cfs. Since Curecanti, there has been increased flow, on the average, through the Black Canyon in the critical August-September period; however, in 43 percent of the

Table 5. Mean monthly and annual flows and diversions at the Tunnel area of the Gunnison River during various time periods, 1904-1975.

Month	Station	Before Tunnel 1904-1909 cfs	Before Taylor Pk Res. but Tunnel operating 1910-1937 cfs	%	After Taylor Pk but before Curecanti 1938-1965 cfs	%	After Curecanti reservoirs 1966-1975 cfs	%
	Above Tunnel	427.5	436.96		392.57		1526.1	
Jan	Diverted	—	0	0	0	0	0	0
	Below Tunnel	427.5	436.96		392.57		1526.1	
	Above Tunnel	429.3	456.79		397.39		1384.5	
Feb	Diverted	—	0	0	0	0	0	0
	Below Tunnel	429.3	456.79		397.39		1384.5	
	Above Tunnel	737.5	711.57		546.32		1372.49	
Mar	Diverted	—	12.46	1.75	52.61	9.6	69.49	5.06
	Below Tunnel	737.5	699.11		493.71		1303.00	
	Above Tunnel	1896.7	1967.54		1833.92		1646.0	
Apr	Diverted	—	295.43	15.01	532.17	29.01	735.7	44.69
	Below Tunnel	1896.7	1672.11		1301.75		910.3	
	Above Tunnel	4994.5	5506.53		4333.39		1919.3	
May	Diverted	—	441.46	8.01	780.93	18.02	887.8	46.25
	Below Tunnel	4994.5	5065.07		3552.46		1031.5	
	Above Tunnel	7780.8	6716.86		5433.67		1896.5	
Jun	Diverted	—	430.14	6.40	734.21	13.51	775.7	40.90
	Below Tunnel	7780.8	6286.71		4699.46		1120.8	
	Above Tunnel	3485.3	2597.14		2348.96		1498.7	
Jul	Diverted	—	624.57	24.04	899.46	38.30	907.7	60.56
	Below Tunnel	3485.3	1972.57		1449.50		591.0	
	Above Tunnel	1623.7	1425.25		1377.39		1483.7	
Aug	Diverted	—	643.68	45.16	911.78	66.19	937.0	63.15
	Below Tunnel	1623.7	781.57		465.61		546.7	
	Above Tunnel	1187.3	942.64		1002.42		1384.60	
Sep	Diverted	—	473.39	50.21	773.71	77.18	844.10	60.96
	Below Tunnel	1187.3	469.25		228.71		540.50	
	Above Tunnel	889.0	823.18		692.96		1102.	
Oct	Diverted	—	279.57	33.96	415.78	60.0	481.70	43.71
	Below Tunnel	889.0	543.61		277.18		620.30	
	Above Tunnel	561.8	666.88		560.55		1264.69	
Nov	Diverted	—	67.67	10.14	107.16	19.11	10.39	.82
	Below Tunnel	561.8	599.21		453.39		1254.30	
	AboveTunnel	447.5	485.78		431.91		1645.4	
Dec	Diverted	—	2.78	.57	.27	.06	0	0
	Below Tunnel	447.5	483.00		431.64		1645.4	
	Above Tunnel	2038.4	1894.76		1612.62		1510.33	
Mean	Diverted	—	272.60	14.38	434.00	26.91	470.80	31.17
Annual	Below Tunnel	2038.4	1622.16		1178.62		1039.53	

years, the mean-monthly flows still fell below 200 cfs in some months. This will all change when the Crystal powerplant is completed. Mean flows are expected never to drop below 200 cfs and, in most years between March and September, flows will probably average above 400 cfs. Such a pattern probably will favor trout production. However, it remains to be seen if fishermen will be able to negotiate these heavier flows, at least in the steepest Monument areas. The continued drop in mean annual flow since the Curecanti reservoirs have existed was actually the result of storage in the reservoirs and not due to below-average water years since 1966. For example, at the end of 1975, 761,056 acre-ft of water was in Blue Mesa and Morrow Point reservoirs. Had this amount of water not been stored and allowed to flow, the average annual discharge in the 10-yr period would have been 1,616 cfs rather than the indicated 1,510 in Table 5. Similar adjustments for Taylor Park Reservoir in the 1938-1965 period would not have increased the 28-yr mean flow by more than 3 cfs, so the large difference between the mean annual discharge during the 1938-1965 period and the 1910-1937 period is actually real, and, as noted earlier, statistically significant.

EFFECTS OF DAMS ON STREAM TEMPERATURE

Taylor Park Reservoir

With the outlet works of Taylor Reservoir at about 143 ft below a full reservoir surface, less than 45°F releases are common. Williams (1951) noted that "cold water" releases in July 1950 (about 42°F) from Taylor Park Reservoir lowered the temperature of the Gunnison River at Iola, Colorado, now the upper end of Blue Mesa Reservoir, by about 6°F. This area is more than 40 mi below Taylor Reservoir. Coldwater releases are most likely to lower river temperatures when the releases constitute a high percentage of the river flow. This most often occurs in low-water or below-average water years, as in 1950. The Taylor River, prior to being dammed, usually contributed less than 25 percent of the theoretical flow reaching the Tunnel area in the July-September period (Table 6). The term "theoretical flow" is used here because many small irrigation diversions exist between Almont and the Tunnel, and some of the diverted water had to be lost. Despite this, the theoretical composition of flows reaching the Tunnel were considerably increased during August and September in the 1938-1962 period. In fact, nearly 54 percent of the actual water being released from Taylor Dam in September could have reached the Tunnel had it not been diminished by the small irrigation ditches. Certainly, such coldwater releases must have cooled the river off for some distance, since the Tunnel is nearly 80 mi from Taylor Dam. The only temperature data that were available on the Gunnison River prior to Taylor Park Dam were those reported by Pratt (1937) for the summer of 1934, primarily above the present Blue Mesa Reservoir area. That year was the lowest mean annual discharge in recorded-flow history to reach the Tunnel area, averaging only 695 cfs. Many photographs of the rivers in the Monument area during that summer have been presented in Warner (1972). Unadjusted mean annual discharges reaching the Tunnel in all periods shown in Table 5 were considerably above the extreme historic low during 1934. Maximum temperature on July 16 was 80°F, and on many days from late June through August maximums were above 70°F. Daily maximums taken during 1966 and 1967 in the area above Blue Mesa never exceeded 69°F. Weekly mean maximums reported by Kinnear and Vincent (1967) in the 1964-1966 period never exceeded 65°F in the Tunnel area.

Table 6. Historical effect of Taylor Dam on flows at various stations below the dam.

Month	Station	Prior to Taylor Dam (1910-1937) cfs	% of above Tunnel flow[a]	After Taylor Dam (1938-1962) cfs	% of above Tunnel flow[a]
	Dam	—		424	18.58
Jul	Almont	578.04	21.88	587.04	25.72
	Above Tunnel	2641.33		2281.80	
	Dam	—		437	32.4
Aug	Almont	307.36	21.60	525.96	39.03
	Above Tunnel	1425.5		1347.24	
	Dam	—		531	53.73
Sep	Almont	223.31	23.68	582.44	58.94
	Above Tunnel	942.64		988.16	

[a]All the % values high because of irrigation losses between the stations.

Actually, the temperatures recorded by them during July 1966 were already being cooled to some extent by Blue Mesa releases. This reservoir began filling October 26, 1965. Temperatures reported by Wiltzius (1971) above Blue Mesa in July 1966 averaged 61.6°F, whereas those recorded downstream at the Tunnel averaged 56.5 for the July 2-29 period. Both August and September temperatures at the Tunnel and below Blue Mesa Reservoir were, however, higher than those above Blue Mesa, and again show the cooling effect of Taylor Park releases on the flows above Blue Mesa.

Curecanti Unit Reservoirs

Since the top of the penstock intake on Blue Mesa Dam is about 146 ft below the surface when the reservoir is full, the releases are usually cold. Temperatures of the release water were monitored daily throughout all of 1973, a year of typical reservoir operations (Table 7). For example, the reservoir had been drawn down so that the penstock elevation was only about 75 ft below the surface in April. Then the reservoir was rapidly filled, so that by July and August the penstock averaged about 142 ft below the surface. After August, the reservoir was lowered through April of the following year, the normal pattern. Temperatures remained a relatively constant 38°F in the January-March period, but then began to rise slightly. Mean monthly temperatures were as follows: April, 39°; May, 40.6°; June, 43.6°; July, 45°; August 47°; September, 50.5°; October, 50.4°; November, 48.5°; and December 44°. In no month during 1973 did more than 5° variation occur. Most months had temperatures which varied less than 3°.

Over the years, it has been found that Blue Mesa release water entering Morrow Point Reservoir (117,000 acre-ft capacity) during the

Table 7. Monthly mean maximum and minimum temperatures (F) of Blue Mesa Reservoir discharge after initial impoundment in October 1965.

	1966			1967			1972			1973			1974			1976		
	Max	Min	Av	Max	Min	Av	Max	Min	Av	Max	Min	Av	Max	Min	Av	Max	Min	Av
Jan	—	—	—	—	—	—	—	—	—	38.1 38-39	38.0 38-39	38.1 38-39	38.6 38-42	38.6 38-41	38.6 38-42	—	—	—
Feb	—	—	—	—	—	—	—	—	—	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	—	—	—
Mar	—	—	—	—	—	—	—	—	—	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	38.0 38-38	—	—	—
Apr	—	—	—	—	—	—	—	—	—	39.0 39-39	39.0 39-39	39.0 39-39	39.3 39-41	39.3 39-41	39.3 39-41	—	—	—
May	—	—	—	—	—	—	—	—	—	40.6 39-42	40.5 39-42	40.6 39-42	—	—	—	—	—	—
Jun	—	—	—	45.2 42-47	44.7 42-47	45.0 42-47	—	—	—	43.6 43-44	43.5 43-44	43.6 43-44	—	—	—	41.7 41-43	41.5 41-43	41.6 41-43
Jul	55.7 54-57	55.1 54-57	55.4 54-57	47.7 47-49	47.4 47-48	47.6 47-49	—	—	—	45.0 44-46	44.9 44-46	45.0 44-46	47.3 46-48	47.2 46-48	47.3 46-48	43.6 43-45	43.4 42-44	43.5 42-45
Aug	59.0 58-60	58.5 57-60	58.5 57-60	50.3 49-52	49.5 49-51	49.9 49-52	—	—	—	47.0 46-49	46.9 46-49	47.0 46-49	—	—	—	45.3 44-46	44.8 44-46	45.1 44-46
Sep	59.7 59-60	59.4 59-60	59.6 59-60	—	—	—	—	—	—	50.5 49-51	50.4 49-51	50.5 49-51	—	—	—	—	—	—
Oct	—	—	—	—	—	—	—	—	—	50.4 49-52	50.3 49-51	50.4 49-52	—	—	—	—	—	—
Nov	44.9 43-47	44.6 43-47	44.8 43-47	—	—	—	—	—	—	48.5 47-49	48.4 47-49	48.5 47-49	—	—	—	—	—	—
Dec	41.2 40-43	41.1 40-43	41.2 40-43	—	—	—	41.8 39-44	41.6 38-44	41.7 38-44	44.0 42-47	43.9 42-46	44.0 42-47	—	—	—	—	—	—

summer will form a massive density current flowing through the reservoir at depths corresponding to the penstock elevation, which is normally 70-90 ft below the surface. Crystal Dam also has its penstock intake at 70-90 ft, has an impoundment that is long and narrow like Morrow Point Reservoir, but only has a capacity of about 25,000 acre-ft. It will be used primarily to "regulate" the discharges from Morrow Point Dam. It will fluctuate considerably, with 20-25 ft drawdowns over a long weekend. Consequently, it now appears that water will go through the entire reservoir system and emerge essentially unchanged in temperature. Comparison of the temperature data at the tunnel with those of the Blue Mesa releases shown in Table 8 does not totally substantiate the above conclusion, but the release water from Morrow Point presently is being modified by the Cimarron River and Crystal Creek between Morrow Point and the Tunnel.

By comparing mean temperatures in the 1972-1975 period with those collected by Kinnear and Vincent (1967), one obtains an estimate, shown in Table 8, of the current effect of the two existing dams on the temperature patterns of the river. It should be emphasized, however, that the temperatures measured in 1964-1965 may have been slightly modified due to the influence of Taylor Park Dam. The 1966 data were not included, for reasons mentioned earlier. Any effect indicated in Table 8 probably would be minimal. Once Crystal Dam is in operation, the probable effect of the dams on the temperatures in the tunnel area will be increased even more, as shown in Table 8. Temperature data were collected in 1977 but were atypical of normal patterns, due to the extreme drought.

The only area where downstream temperatures have been recorded for any length of time prior to the Curecanti dams was at Grand Junction,

Table 8. Mean monthly temperature at various stations below Curecanti reservoirs with estimated effect of the dams on temperatures in the Tunnel area of the Gunnison River.

Month	Mean temp. (F) Tunnel area[a] 1964-1965	Mean temp. (F) Tunnel area[a] 1972-1975	Mean effect (F) of dams at Tunnel area	Mean temp. (F) below Blue Mesa 1973	Maximum probable mean effect (F) of dam to Tunnel area after Crystal
Jan.	32[b]	36.8	+4.8	38.1	+6.1
Feb.	32[b]	36.9	+4.9	38.0	+6.0
Mar.	32[b]	37.6	+5.6	38.0	+6.0
Apr.	40.3	39.7	-0.6	39.0	-1.3
May	46.8	42.9	-3.9	40.6	-6.2
June	--	47.7	--	43.6	--
July	57.5	51.2	-6.3	45.0	-12.5
Aug.	60.3	51.3	-9.0	47.0	-13.3
Sept.	56.9	51.1	-5.8	50.5	-6.4
Oct.	46.4	49.7	+3.3	50.4	+4.0
Nov.	36.3	43.5	+7.2	48.5	+12.2
Dec.	32[b]	39.0	+7.0	44.0	+12.0

[a] Computed from data of Kinnear and Vincent (1967).

[b] Estimated by Kinnear and Vincent since the river was ice covered most of the time.

Colorado, approximately 112 mi from Blue Mesa Dam and 93 mi from Crystal Dam. Comparisons were made of mean monthly temperatures at this station pre- and post-Curecanti during the 1952-1973 period (Table 9). Mean annual discharges in the 1952-1965 period averaged 2,254 cfs, while those in the 1966-1973 period averaged 2,270 cfs. It was only during the August-October period that mean monthly temperatures were significantly reduced at Grand Junction (Tables 9; 10). Many of these decreases were associated with increased flows during those months over historical patterns recorded below the Tunnel. When Crystal Dam is completely operational, temperatures probably will again be lowered, provided Blue Mesa Reservoir is at normally high levels during the summer.

EFFECTS OF DAMS ON WATER QUALITY AND BOTTOM FAUNA

The only main Gunnison River sampling station below the Curecanti dams but above Grand Junction, that was sampled for chemical constituents more than once both before and after the completion of Blue Mesa Dam in October 1965, was the area just above the confluence with the North Fork of the Gunnison River. Here, 7 water samples were taken between August 1964 and September 1965 (Wiltzius 1971). During the post-dam studies between April 1974 and August 1977, 6 water samples were collected from this same area.

Mean values for total hardness, sulfates, calcium, magnesium, potassium, sodium and zinc in water samples taken after dam completion were all higher than in samples taken before dam construction but none were significantly higher. The mean total alkalinity of the Gunnison River above the North Fork confluence was 78.3 ppm prior to dam construction compared to 113.7 ppm after. This is close to being significantly different

Table 9. Mean monthly water temperature (F) of Gunnison River at Grand Junction, Colorado, 1951-1973.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1951										56	44	36
1952	37	41	44	52	58	66	70	73	68	57	43	34
1953	36	38	47	53	57	61	78	74	73	58	45	36
1954	36	46	46	59	64	72	79	74	67	56	46	34
1955	34	34	42	50	56	63	74	77	68	56	41	36
1956	39	37	48	53	59	66	77	71	69	57	38	34
1957	33	37	46	51	53	59	65	71	66	56	41	34
1958	34	42	46	50	57	67	78	81	70	60	45	37
1959	35	42	48	58	62	69	81	76	68	52	41	34
1960				50	56	62	71	70	64	51		
1961				48	54	64	71	71	58	50	38	
1962				48	52	59	65	68	62	55	43	35
1963	32	36	41	49	57	63	71	69	65	57	44	32
1964	32	33	39	48	52	60	70	67	61	53	39	33
1965	34	35	41	46	51	56	63	66	57	51	44	35
1966	32	34	43	48	56	63	72	70	62	51	44	35
1967	32	36	45	48	55	61	71	70	63	52	43	34
1968	32	41	45	45	50	57	63	66	57	49	42	34
1969	35	36	40	47	56	62	70	70	62	49	42	37
1970	35	40	42	45	52	59	66	67	58		44	38
1971	37	39	42	47	54	61	68	68	58	52	43	38
1972	37	39	46	52	57	66	71	70	62	55	44	38
1973	35	40	49	52	55	63	72	69	63			
Before Blue Mesa 1952-65[a]	35.0	39.6	44.9	51.1	56.3	63.3	71.3	71.9	65.4	55.0	42.3	34.6
After Blue Mesa 1966-73[a]	34.7	38.7	44.0	48.0	54.4	61.5	69.5	68.4	60.6	51.3	43.1	36.3
Difference	-.3	-.9	-.9	-3.8	-1.9	-1.8	-1.8	-3.5[b]	-4.8[b]	-3.7[b]	+.8	+1.7
				P=.0576	P=.2127			P=.0139	P=.0139	P=.0136		P=.0636

[a] Means computed from complete data only.

[b] Significant difference. Underlined values incomplete.

Table 10. Historical flow pattern of Gunnison River before and after Curecanti dams at two stations below the reservoirs during some months when temperatures were significantly lowered at Grand Junction, Colorado.

		Prior to Curecanti			After Curecanti		
		1952-1965		% of Grand Junction flow[a]	1966-1973		% of Grand Junction flow[a]
Month	Station	Mean (cfs)	Mean (F)		Mean (cfs)	Mean (F)	
Aug.	Below Tunnel	542.43	--	44.46	582.11	--	43.55
	Grand Junction	1219.93	71.9		1335.56	68.4	
Sept.	Below Tunnel[b]	249.43	--	23.04	564.56	--	33.50
	Grand Junction	1082.50	65.4		1685.11	60.6	
Oct.	Below Tunnel	277.93	--	24.73	614.33	--	33.3
	Grand Junction	1123.64	55.0		1847.38	51.3	

[a] All the % values high because of irrigation losses between staions.

[b] Since 1968, this area has been about 8 miles from Morrow Point Dam, whereas Grand Junction was about 104 miles below this dam.

at the 5 percent level ($t = 2.21$, 10 df). It is probable that the trend for higher ionic concentration in the Gunnison River water subsequent to the dams is related to the higher concentrations found for some cations (Ca, Mg) at depths corresponding to that at which most of the water is released from Blue Mesa Reservoir (Wiltzius 1971). In addition, Wiltzius (1971) found during 1967 that the alkalinity of the surface waters of the reservoir a short distance upstream of Blue Mesa Dam was 77 ppm, but the alkalinity at depths corresponding to the penstock intakes was approximately 100 ppm.

One factor that historically contributed greatly to the fame of the Gunnison River fishery as well as to the well being and growth of trout was the exceptional abundance of the nymphs of the giant stonefly *Pteronarcys californica*. During the early 1960's, this single species contributed more than 90 percent of all stoneflies emerging during June in the river section between Sapinero and Gunnison. With the inundation of most of this section of river by Blue Mesa Reservoir, *P. californica* has largely disappeared. Historically they were never abundant below Sapinero. Very few *Pteronarcys* nymphs remain even above the reservoir since the distribution of these nymphs in the Gunnison River is believed to be directly correlated with the algae *Cladophora* which is scarce above the Tomichi Creek confluence below Gunnison (Pratt 1938; Wiltzius 1966). More recently channelization of the river to alleviate ice-jams at the inlet area of Blue Mesa Reservoir as well as removal of some vegetation along the banks of the river probably has made these insects very rare. Members of the Gunnison chapter of Trout Unlimited recently informed me that they intend to reintroduce

P. californica nymphs to the Gunnison River section above Blue Mesa Reservoir but below Gunnison during the fall of 1978.

Wiltzius (1976) reported that *P. californica* emerged highly significantly earlier (mean time June 10) in the period after Taylor Park Reservoir (1938-1966) than (June 16) in the period prior to the reservoir (1904-1937). It was also shown that the emergence of these insects was highly significantly directly related to the mean flows during June above the Gunnison Tunnel before and after Taylor Park Reservoir, respectively. Consequently, with significantly less flows during June at Almont due to Taylor Dam (Table 4), it is easily seen why the average emergence date of *P. californica* was earlier in the post-Taylor Reservoir period. Additional historical details regarding these nymphs were reported by Wiltzius (1976).

Only the general area in the vicinity of the Gunnison Tunnel has been sampled for bottom fauna more than once at times before and after the Curecanti dams. Reed and Norton (1963) reported the various insect larvae (identified primarily to genera) that occurred in 12 bottom samples collected in the vicinity of the Gunnison Tunnel between September 5, 1962 and June 14, 1963. Unfortunately, they reported neither the numbers of individual organisms encountered in particular samples nor how great an area was sampled in any of the bottom collections. Of the five post-dam collections made between June 1974 and November 1976 in the same general area from below the Gunnison Tunnel to below Crystal Dam (Appendix III) each was comprised of three pooled Surber samples. Consequently, one should be extremely cautious in attributing the differences between the occurence of organisms in the pre- and post- Curecanti collections as direct affects of the dams. Many of the differences which are discussed below could have been due to normal seasonal variations and/or failure to sample identical stream-bottom habitats.

Immature mayflies (Emphemeroptera) appear to have undergone considerable changes in occurrence since Curecanti dams have been in operation. Reed and Norton (1963) found 7 mayfly genera: *Ephemerella, Baetis, Trichorythodes, Heptagenia, Rithrogena, Pseudocloen* and *Ameltus* with *Baetis, Heptagenia* and *Rithrogena* each occurring in over 40 percent of the collections. Only *Ephemerella, Baetis* and *Rithrogena* have been taken from the tunnel area post Curecanti (Appendix III). *Ephemerella* may now be more abundant because recently they were found in 80 percent of the collections whereas prior to the dams they comprised only 8 percent of the collections. *Baetis* was found in 42 percent of the collections prior to the dams and in 60 percent of the collections subsequent to the dams. *Heptagenia* mayflies, which occurred in 50 percent of the pre-dam collections in the tunnel area, were not found in any of the post-dam collections. They were collected, however, at stations further downstream as were mayflies of the genus *Trichorythodes* (Appendix III).

Prior to the Curecanti dams, the large stoneflies (Plecoptera: *Arcynopteryx, Acroneuria* and *Pteronarcys*) occurred in 50, 42 and 25 percent, respectively, of the collections made by Reed and Norton (1963). Recently, *Arcynopteryx* occurred in 60 percent of the post-dam collections but *Acroneuria* and *Pteronarcys* were not collected in the Tunnel area. Wiltzius (1966), however, mentioned that Surber bottom sampling failed to collect *Pteronarcys* nymphs in Gunnison River sections where they were known to be relatively abundant. Consequently, the exclusive use of Surber samplers may be the reason for the lack of *Pteronarcys* nymphs in the post-dam collections. Furthermore, many *Acroneuria* adults were observed emerging during July 1976 in the Gunnison River just upstream of the Crystal dam site but this area has subsequently been inundated. In general, the stonefly fauna appears to be better represented in the post-dam collections than in the pre-dam collections. *Pteronarcella*, *Hastaperla*, *Iosperla*, and *Isogenus* occurred in 20, 40, 60 and 60 percent, respectively, of the recent collections compared to only 8 percent for each of these genera in the pre-dam collections. Furthermore, *Claasenia*, *Alloperla* and *Nemoura* each occurred in 20 percent of the recent post-dam collections but were not represented in the pre-dam collections of Reed and Norton (1963).

Little difference in the occurrence of caddisflies (Tricoptera) was revealed from pre- and post-dam collections. Pre-dam Tricoptera collections by Reed and Norton (1963) were comprised primarily of *Hydropsyche*, *Brachycentrus*, *Arctopsyche* and *Glossoma*. These four genera occurred in 58, 33, 17 and 8 percent of the pre-dam collections, respectively, in contrast to 40, 40, 40 and 0 percent, respectively, of the post-dam collections. *Agraylea* occurred in 20 percent of the post-dam collections but was not found in the pre-dam collections.

Reed and Norton (1963) reported collecting immature insects from four families of the order Diptera: Tendipedidae, Rhagionidae, Simuliidae, and Tipulidae. These families occurred in 50, 42, 17 and 17 percent, respectively, of the pre-dam collections in the area of the Gunnison Tunnel. Comparatively, occurrences of these four families in post-dam collections were 60, 20, 40 and 0 percent, respectively, which suggests that members of Tendipedidae and Simuliidae may have increased while members of Tipulidae and Rhagionidae (*Atherix*) may have decreased. Almost all stomach contents from trout collected in the Tunnel area during June 1977 contained what appeared to be exclusively small Tendipedidae and/or Simuliidae larvae mixed with algae.

GUNNISON RIVER SALMONID FISHERY

Early Renown

Prior to alteration by Curecanti dam-building, the Gunnison River represented one of the truly great trout rivers of North America. Hopkins (1907) noted that of all the trout streams in Colorado, and incidentally in the whole world, there are none that can compare with the Gunnison River on the western slope. The Gunnison Courier of May 19, 1949 remarked that the Gunnison River had been given the title, by the National Geographic Society, as the "finest trout stream in the world". More recently, Wynn Davis, in his "Best Fishing in U.S.," Outdoor Life, August, 1960, stated, "Along with thousands of other anglers, I rate the Gunnison as one of the greatest high-altitude trout streams in the world." Additional notoriety was given the Gunnison in Ben East's widely read "Death Sentence for a River", Outdoor Life, November, 1959, which was reprinted in the Gunnison News-Champion of November 12, 1959. Other recollections of the Gunnison River were recently given by Ernest Schwieberts "Farewell My Lovely Gunnison" in the April 1977 issue of Sports Afield.

Wiltzius (1966) chronicled the exceptional quality and quantity of the salmonid fisheries from 1880, when only Colorado cutthroat trout were present, through the era when large rainbow trout were common (i.e. egg taking from 3,232 Gunnison River rainbow trout ascending North Beaver Creek, averaging 4, but ranging to 13 lbs, in 1903), typical of that time for spawning rainbows in the 22.5 mi of river inundated by

Blue Mesa Reservoir. The average trout in fishermen creels, however, was about 1 lb (Gunnison Tribune, June 6, 1901). Brook, rainbow, and brown trout had been introduced into the drainage in 1883, 1888, and 1893, respectively. Continued or periodic stocking by state and federal agencies of all these species, however, resulted in a predominance of rainbow and brown trout which has persisted since 1908, the brown trout mostly by natural reproduction and the rainbow trout by continual stocking with some natural spawning. Instrumental in the stocking during the early years were Colorado's second state fish hatchery established at Gunnison in 1889, and an egg-eyeing station established at Pitkin in 1906. Egg-taking stations for brook trout from Tomichi Creek and rainbow trout ascending North Beaver Creek were put in operation in 1897, and stocking of these species was widespread shortly thereafter. Cutthroat trout stocking in the Gunnison was not begun until 1902, when eggs of these fish were obtained from Colorado's third state hatchery at Durango. The federal hatchery established at Leadville in 1889 was instrumental in early brown trout stocking in Colorado.

Ellis (1914) noted that, in Colorado, man has changed the fish fauna in at least the following ways: (a) by removing large numbers of native fishes for food without properly restocking the streams; (b) by deflecting water for irrigation, leaving the streams low or even dry in some seasons; (c) by allowing the fishes to run into unscreened ditches only to become stranded and die in the fields; (d) by the introduction of mine and mill waste, the poisons from which often kill large numbers of fish in a single day; and (e) by the introduction of other fish which become competitors of the native species. In these earlier years, mention regarding changes resulting from impoundments was sparse, if even considered, but is added here to the list.

All of the above, with the exception of (a), probably apply to the historical changes in the fish distribution in the Gunnison River. As early as 1901, cutthroat trout were becoming scarce in the main river, and this was believed to have resulted from lack of stocking and competition with rainbow trout. Despite extensive stocking, both the brook trout, common in the main river to at least 1911, and the cutthroat trout were very rare in the main river by 1934. Pratt (1937) attributed the scarcity of brook and cutthroat trout primarily to the warming influence of return-irrigation flows. From June to August, large quantities of water were then taken through irrigation ditches from the Gunnison River and spread over hay fields, to flow back gradually into the river. This water, Pratt maintained, was heated by the sun as it spread over the fields, and, as it entered the river, it was often 10 degrees warmer than that of the main stream. The Gunnison area, at approximately 7,700 ft elevation, usually has extreme solar radiation, with very few days in a year without the sun at least appearing. Temperatures of the main river were measured only during 1934, the recorded historic low flow prior to 1977. On July 16, 1934, Pratt observed a maximum at Iola of 80°F. Had not Taylor Park Reservoir been built, with its consequent coldwater releases during the summer, I wonder if rainbow trout could have persisted in the many sub-normal flows which have occurred since 1938. One, however, cannot ignore (c) and (d) above, considering the strong homing tendency of most salmonids and the extensive placer mining in the drainage prior to 1901. Furthermore, hybridization of rainbow and cutthroat trout probably had adversely affected natural reproduction through sterilization. In addition, Man's destruction of forests and watersheds through fires, clearcutting, and overgrazing, but particularly that destruction of the higher-elevation beaver ponds on the many small tributaries of the Gunnison River, probably adversely affected rainbow and cutthroat trout reproduction. Such destruction no doubt accelerated spring flows, resulting in early turbid discharges at the time of egg incubation, and subsequently resulted in warmer, diminished discharges later in the season. An early example of the extensive beaver ponds that existed in only one of the many tributaries in the Gunnison drainage was noted in the Gunnison News-Champion issue of June 21, 1907, where mention was made of 24 live beaver dams on Ohio Creek, a major upper Gunnison River tributary, on just the Otis Moore ranch. Here, it was pointed out that the backed-up water freezes nearly to the bottom and forms great ice dams that do not melt until July. Such extensive beaver activity has not existed in the drainage for quite some time.

The October 10, 1902 issue of the Gunnison Tribune reported that when settlers first came to the Ohio Valley in 1875, willows stood thickly on the ground, but year after year the willows were removed, until at the present time (1902) there are 200 acres of as pretty meadow as can be found anywhere. It was irrigated then by a 2-mi ditch that had just been built from Ohio Creek. Certainly, considerably more than 200 acres has been under irrigation in that valley since then. Several ranches in the Sapinero area were described in the August 28, 1903 issue of Gunnison News-Champion, where it was also noted that a ditch from Soap Creek, which was to irrigate 300 acres in that tributary valley, was about two-thirds completed. Soap Creek was one of the small streams used early in history by the rainbow trout for spawning. Rainbows also used other tributaries such as Ohio Creek, North and South Beaver Creeks, East and West Elk Creeks, and Red, Cebolla, and Steuben Creeks. Most of these tributaries were already (in 1903), or soon would be, tapped for irrigating hay meadows. Ranching in the Gunnison country was replacing the earlier interests in mining.

By 1934, Pratt (1937) found that rainbow trout usually selected spawning sites in the main river where there was gravel and moderate current with water about 2 ft deep. Regarding brown trout, Pratt mentioned that they spawned in shallower water with a gravel bottom, often going up small side branches and tributaries of the main river. Conditions were reported by Pratt (1937) as ideal for brown trout in the upper portion of the river but not at all favorable in the lower portion. Despite this, Weberg (1954) found brown trout well established, and shocked numerous young-of-the-year in the lower Lake Fork of the Gunnison. Similar findings were also observed in the 1960's in the lower Lake Fork and the lower Cebolla River. Adult brown trout were also found downstream as far as the North Fork during the 1960's, and occasional specimens were taken below Delta. Weberg results (1954) revealed that rainbow trout dominated in the Taylor River in 1954. Sampling during the 1970's showed that brown trout were the dominant fish in the Taylor River. However, rainbows still dominate in the creels of fishermen on the Taylor River. Of 17 Colorado streams shocked by Weberg (1954), the 11 electrofished sections of the main Gunnison River provided 91 (67.9%) of the 134 total 1-3 in. young-of-the-year rainbow trout collected during the survey. During 1965 no rainbow reproduction was found in any of the Gunnison River tributaries associated with the Blue Mesa Reservoir area, but the main river was not sampled due to extremely heavy runoff that year. Kinnear and Vincent (1967) reported trout reproduction lacking in the National Monument section during 1965, but found trout fry present in 1966. Permanent tributaries are not found within the National Monument.

Historically, it appears likely that rainbow trout shifted from primarily tributary spawning to primarily main-river spawning, apparently due to the factors discussed above. Main-river spawning probably was less desirable because of greater predation of the young by the apparently increasing brown trout population. It is likely that, in the early years, the unditched, small, willow-lined nursery streams, the flows of which were better controlled and regulated by the ice-dammed beaver ponds, probably afforded a more hospitable environment for young-of-the-year salmonids. Pratt (1937) also mentioned that increased fishing during 1926-1934 reduced the total number of trout and the average size of the trout, making the number of large trout available for reproduction much less. There is little evidence that this trend has decreased since 1934, except, possibly, for the "war years" (1941-1945), which will later be discussed more fully. Furthermore, the status of recent reproduction below the Curecanti reservoirs will be discussed in the section describing the 1977 lower-Gunnison creel survey. Main-river spawning of rainbow trout was observed in the upper National Monument section during the spring of 1977 and also in the main river between Crystal and Morrow Point dams during 1977.

Shortly before Blue Mesa Reservoir was completed, the government had acquired and eliminated many of the ranches which were tapping the tributaries to irrigate hay meadows. This should have alleviated many of the problems of rainbow reproduction, but recent findings when only flourescent-marked rainbow trout were directly stocked in Blue Mesa Reservoir indicate that no more than 8 percent of the estimated

75,000 rainbows of the 1974 year-class harvested in 1975 could have been from sources other than the marked rainbows. Almost identical values were suggested from the 1976 harvest. Furthermore, unmarked rainbow trout have been stocked annually in the main river above the reservoir, as well as in many of the reservoir's tributaries, and it is likely that some of these fish migrated into the reservoir, possibly making the above-mentioned unmarked percentage of rainbow higher than what it really was. Consequently, it is apparent that naturally reproduced rainbow trout in 1974 contributed little to the Blue Mesa reservoir fishery. Similar results were also obtained from earlier investigations with marked rainbow of the 1967-1971 year-classes, and should dispel any notions that the small 1974 contribution was simply due to bad conditions in the streams that year. The use of primarily fall-spawned rainbow eggs for the stocking and the fact that so few rainbow attain maturity due to extensive harvesting the first year or two after being stocked probably contribute substantially to the lack of naturally reproducing stocks of rainbow trout.

Influence of Railroads

Very early in Colorado's history, the Gunnison river was widely recognized for its trout fishing. The Denver and Rio Grande narrow-gauge railroad probably was the most instrumental factor in publicizing the Gunnison Valley fishing. The first and main rail route across the Colorado rockies with intercontinental connections left Denver, passing through two other major population centers, Colorado Springs and Pueblo, before turning westerly up the Arkansas drainage to Salida, Colorado. From there, the route went over the Continental Divide at Marshall Pass and dropped into the Gunnison Valley as early as August 1881. The route proceeded west, paralleling the river through the eastern 15-mi section of the Black Canyon (now Morrow Point Reservoir) and emerged from the canyon at Cimarron before going over Cerro Summit into Montrose, where the line turned northwesterly, traversing the Uncompahgre River Valley to Delta. Here, it once again followed the lower main Gunnison River to Grand Junction, arriving there November 25, 1882. By late May, 1883, the main line had extended all the way to Ogden, Utah, permitting connections with other rail lines to the Pacific Coast. In addition, the Denver and South Park Railroad had also completed, late in 1882, its line from Denver through the Alpine Tunnel, which resulted in a shorter route to the Gunnison Valley. By 1910, however, this shortcut was inoperable.

Crofutt (1885), in his guide to Colorado, noted that any tenderfoot could catch trout in the Gunnison and San Juan country, and also described Cimarron as a regular meal station on the railroad, where a specialty was made of serving to the passengers, trout caught from the Gunnison River. Considerable early advertisement of the Rio Grande route was also given in Harper's magazine, and, consequently, many eastern sportsmen became aware of the Gunnison River (Beebe and Clegg 1962). Outdoor Life, published originally in Denver, also gave considerable publicity to the Gunnison River in early and later issues.

Many hunting and fishing lodges became established along the rails in the Gunnison Valley, the most notable of which were those in the present Blue Mesa Reservoir site, above Black Canyon at Iola, Cebolla, and Sapinero. Wallace (1965) mentioned that the large hotel (Sportsman Home) built by J. J. Carpenter at Cebolla in 1888 furnished accommocations for many eastern dudes brought in by rail. The original hotel was lost by fire in 1902 and was not replaced until 1903. The Rainbow Hotel, owned by H. S. Carpenter at Sapinero, was similar, and also handled accommodations for travelers and fishermen taking the narrow gauge up to Lake City via the 36-mi narrow-gauge branch, completed in 1889, up the Lake Fork of the Gunnison River (Atheran 1962). This branch was abandoned in 1932, and the tracks were removed in 1936. Wallace (1965) noted that the Lake Fork road bed was converted to auto travel in 1949, as was the section between Sapinero and Cimarron (Hunt 1955). Actually, scheduled rail passenger service had been discontinued between Gunnison and Montrose in 1934, and between Salida and Gunnison in 1940, even though sporadic freight service continued until 1955, when most of the rails were removed in the upper Gunnison Valley (Everett 1966). Despite this, passengers on the early daily trains into the region were sometimes delayed by washouts or purposely disembarked and took advantage of the opportunity to fish along the tracks. According to Wallace (1960) it was nothing for a person to catch a dishpan full of fish in a mile and a half of stream. Many excursion trains were also run, which permitted easy access and subsequent pickup after a fishing trip.

Even though trout were abundant through the rail-accessible eastern sector of the Black Canyon to Cimarron and even in the unrailed section below there for some miles, the areas above the Black Canyon received most of the fishing early in history, as it has recently. A study in 1956 revealed that the 36-mi area above the Black Canyon received 80 percent of the 49,100 fisherman-days estimated on the 80 mi of the Gunnison River above the North Fork of the Gunnison confluence (Anonymous 1960). National Park Service estimates of fisherman-days on the Blue Mesa Reservoir (upper area) have, since 1968, ranged between approximately 80,000 and 140,000 (Appendix X), whereas in the 12-mi Monument area (lower area), since 1970, use has ranged between approximately 682 and 1,365 fisherman-days (Appendix XI). Admittedly, access was always quite restricted in the areas below Cimarron because of the narrow, deep gorge and because the Reclamation Service had the Monument area closed for many years prior to 1932.

Other factors also favored the areas above Black Canyon. Aside from the fact that many lodges existed there in the early years, the passenger train schedule also was more favorable to the upper area, especially for local Gunnison fishermen who made many daily fishing trips. For example, in 1910 a local Gunnisonite could board the westbound train at 10:45 A.M. and arrive at Sapinero, 26 mi downstream, before noon. He could then fish in this area until the eastbound train approached at 3:05 P.M., arriving back in Gunnison at 4:20 P.M. Had a fisherman originally continued through the railed, but roadless, upper Black Canyon to Cimarron, he would have arrived there at 12:40 P.M., but the eastbound return train would have gone by this area at 2:15 P.M., thereby resulting in less fishing time. The fisherman would have had more time to fish had he gotten off anywhere east of Sapinero or fished upstream in an easterly direction from any disembarkment point. Another factor that favored the upper area was the comparative abundance of large stoneflies, commonly called willow flies, which were important items in the trout diet at certain times of the year. Their emergence tended to make fishing more successful (Wiltzius 1976).

Contests, Record Trout, Stocking, and Catch Composition

Starting in 1903, the Gunnison River gained considerable renown as a result of a fishing prize offered by the Denver Post. Wiltzius (1966) pointed out that the Post had offered $50 in gold for a 10-lb trout caught in any of Colorado's running water, and Judge McDougal of Gunnison first claimed the prize with a 28-in, 10 1/4-lb rainbow trout caught in the Gunnison River near Sapinero on July 11, 1903. M. W. Staniforth of Texas claimed the Post's prize for the second time that same year with a 30-in., 12-lb rainbow trout caught in the Gunnison River near Carpenter's Lodge at Cebolla on August 5. The poundage in the Post contest was lowered to 8 lbs by 1910, and the prize had been reduced to $25 before 1915. Notable rainbow trout caught before the Post's prize began were a 10 1/4 pounder caught by Mayor E. P. Shove in 1894 and a 12 pounder taken by T. C. Brown on August 18, 1897. In addition, earlier notoriety resulted from the fact that in August of 1895, a string of "Gunnison River Rainbow Trout" caught by hook and line was sent (likely by rail) to Denver for display. The smallest of the fish weighed 5 1/2 lbs, and the largest was 7 1/2 lbs, dressed, while the collective weight of 10 of them was an even 66 lbs. These rainbow were just a portion of the trout four fishermen had caught in 3 hrs of fishing in the Gunnison River about 2 mi downstream from the La Veta Hotel in Gunnison. A local Gunnisonite, Lee Clay, during the month of June 1896, caught 17 trout ranging between 5 and 8 lbs apiece; most of these probably were rainbow trout.

By 1911, the Post's prize had been claimed only six times, but 4 of the fish were rainbow trout of 10 lbs or more, caught prior to 1908 from the Gunnison River in the vicinity of Cebolla and Sapinero. Despite this, however, a 10-lb rainbow was becoming a rare prize as early as 1908 (Anonymous 1908) even though 7 and 8 pounders were still being caught with regularity. Incidentally, prior to 1890 the largest trout mentioned in Gunnison newspapers as caught in the Gunnison River was a 5 1/4-lb specimen caught by Mrs. T. J. Guinn in 1888. This probably was a cutthroat trout, since rainbow trout were not introduced until that year and brook trout stocking was not extensive until 1892. One trout, probably also a cutthroat and weighing 7 1/2 lbs, was taken in 1892 (Gunnison News, June 25, 1892).

Rainbow trout exceeding 9 lbs have seldom been taken from the Gunnison River since 1908. Some brown trout heavier than the largest rainbow ever caught from the Gunnison River, have been creeled. The Gunnison News-Champion of August 18, 1949, mentions that 20 yrs ago (1929) a 14 1/2-lb "loch" (brown) was caught at Hollenbecks resort. The largest brown trout reported, however, appears to be a 15 1/2-lb specimen taken in August 1959. There was mention of a large 15 pounder, presumably a brown, taken in 1931 by C. J. Kunkle of Trouthaven Lodge reported as the largest fish taken from the Gunnison River until that time (Gunnison News-Champion, September 8, 1932).

The largest rainbow trout that probably was ever taken from the Gunnison River was a 13-lb specimen seined in 1903 by the state spawning crew at North Beaver Creek. It was reported as the largest fish that had been taken until that time (Gunnison Tribune May 15, 1903). An earlier undocumented account in the Gunnison Tribune of July 25, 1901 mentioned that the largest trout yet landed weighed nearly 14 lbs, but information as to where it was caught (stream or lake) was lacking. Some confusion also appears to have resulted in the Gunnison newspapers since 1903 regarding the largest rainbow taken by hook and line, and involves a 12-lb rainbow caught by T. C. Brown in 1897 near the mouth of Ohio Creek. The newspapers show a cropped photograph of the fish and usually reported it as caught in 1903 at a weight at 12 3/4 lbs

(Gunnison News-Champion, May 21, 1931 and July 17, 1947). If it were of that weight, it probably would have been the largest rainbow trout caught from the Gunnison River by hook and line, bettering the 12-lb specimen caught by M. W. Staniforth of Texas in 1903. Actually, an uncropped identical photograph of the rainbow caught by T. C. Brown appeared in Hopkins (1907), and along the upper border of the photograph, above the head of the fish, appeared in plain writing: "Gunnison, Colorado, Aug. 18th/97, caught by T. Brown." Hopkins listed the fish at 10 lbs, but the Gunnison Tribune of August 20, 1897 stated T. C. Brown landed an even 12 pounder in the Gunnison River a couple of miles above town last Wednesday (the 18th). It is, of course, quite possible that Attorney Brown did actually catch a larger specimen than the one he caught in 1897, but no record of it was found in the 1903 issues when he was supposed to have made the 12 3/4-lb record catch. It appears, then, that the hook-and-line record for rainbow trout in the Gunnison River is still jointly held by T. C. Brown and M. W. Staniforth with their 12-lb fish. The largest cutthroat trout, reported in the newspapers as a native, was an 8 1/2-lb specimen documented in the Gunnison Courier, July 20, 1950, and was caught in the Gunnison River below Iola.

In 1932, the Gunnison News-Champion began offering a year's free subscription for trout caught in excess of certain minimum weights. The minimum weight never exceeded 5 lbs. The July 17, 1947 issue summarized the first 15 yrs, revealing details of place caught, size, weight, etc., for those trout 8 lbs and over. Between 1932 and 1946, 11 trout (6 rainbow and 5 brown) from the Gunnison River were described, with only three over 10 lbs, all 12-lb browns. On one brown trout listed as 8 1/2 lbs, caught by Carl E. Schreiner, Lamar, Mo., the date of catch was not reported. Searches of the newspapers revealed that this fish was caught in late June 1938, at Eden's resort but was listed then as an 8 1/4-lb Loch leven (Gunnison Courier, June 23, 1938). Surprisingly, only 3 of the 11 fish (2 browns - 8 1/4 and 12 lbs; one 9-lb rainbow trout caught by H. Pratt September 14, 1934) were caught during the last 8 yrs of the 1930's. The large brown was caught by hand rather than fishing gear by 12-yr-old Jimmy Nelson, October 25, 1938. There was, however, mention of an 8 1/2-lb brown trout as being the largest fish caught during 1932 (Gunnison News-Champion, November 3, 1932). It is likely that this fish, as well as others, were caught by fishermen who were unaware of the News-Champion offer.

Over the first 15 yrs of the offer, the largest rainbow was a 9-lb, 5 oz specimen taken in October 1943. A search of Gunnison newspapers in the May-through-October months between 1947 and 1964 resulted in detailed accounts of 24 Gunnison River trout (19 brown, 4 rainbow, 1 cutthroat) that were 8 lbs or better. None of the rainbow trout were 10 lbs, but 4 brown trout were either exactly at or exceeded 13 lbs, the largest being a 15-lb, 8 oz specimen caught in late August 1959 at the Eagle Rock Resort on the Gunnison River. Actually, tabulations from Gunnison River trout were recorded during this search for all specimens described that exceeded 3 lbs. These included 95 brown trout, 52 rainbow trout, and 1 cutthroat trout in the 18-yrs before the Curecanti dams.

Despite the dominance of trophy-size brown trout in the above period, the rainbow trout was then, and definitely still is, the most common fish species in creels of Gunnison River fishermen. The reason for this is probably because of the extensive historical stocking of rainbow trout

(Tables 11; 12). One important historical exception to the above statement appears worthy of note. R. A. Ray, then a Division of Wildlife superintendent at Pitkin Hatchery in the upper Gunnison drainage, presented a talk to the Rotary Club in Gunnison on May 23, 1949. In this talk, he said, "Prior to the time that heavy plantings of legalized fish was started, back around 1937, increased fishing pressure had reduced the catch of rainbows, on the Gunnison River, to practically nothing. Lochleven (browns) were still providing a fair degree of fishing (representing about 90% of the catch)."

The fact of "increased fishing pressure" certainly appears valid. Pratt (1937) in his extensive studies stated that "it is safe to say that during the nine-year period (1926-1934) the number of anglers has doubled." Conversely, Pratt found that the trends in catch composition along all sections of the Gunnison River in this period were quite the opposite of that described by R. A. Ray above. In the river between Almont and the mouth of the Tomichi (mostly above Gunnison), Pratt found that in 1926 brown trout actually were more numerous than rainbow trout. As the years passed, however, rainbow became more and more numerous in relation to brown trout until, in 1934, there were more rainbow trout caught than brown trout (50.8% rainbow, 45.9% brown, 3.3% brook). Below the mouth of the Tomichi, rainbow trout became consistently more numerous than brown trout during the entire period. Pratt reported that, by 1934, rainbow comprised 86.6 percent, brown 12.8 percent, and brook trout 0.5 percent of the catches in this section. Stocking favored rainbow trout, since Pratt (1937) mentioned no brown trout stocking in the previous 20 yrs. Brown trout, however, were stocked during many of the years since then (Table 11). This probably accounts for their overall

Table 11. Historic creel-census and stocking data from the Gunnison River above the Cimarron River, 1942-1965.

Year	No. fishermen contacted	No. hours fished	No. fish caught	% Composition				CPMH					Average length (in.)					Stocking				
																		Rainbow		Brown		
				Rb	Brown	Brook	Ct.	Rb	Brown	Brook	Ct.	Total	Rb	Brown	Brook	Native	All trout	> 6 in.[a]	< 4 in.	0-2"	2-4"	4-6"
1942[b]	?	?		83.0	15.0	1.0	1.0	1.67	.30	.02	.02	2.01					9.75					
1945[c]	161	455	1,002	86.5	13.5	--	--	1.90	.30	--	--	2.20	9.29	10.47	--	--	9.48					
1946[d]	439	1,639	1,016	76.8	13.3	9.8	0.1	0.48	.08	.06	T[e]	0.62	9.51	11.12	?	?	9.87	60,500		110,000		20,000
1947	305	1,169	725	75.2	22.1	2.7	--	0.47	.14	.01	--	0.62	?	?	?	?	?	59,800				
1950	763	2,739	1,552	73.1	26.5	0.3	0.1	0.42	.15	T	T	0.57	10.74	10.77	8.00	10.50	10.74					
1952	387	1,399	1,502	77.0	22.0	1	P[f]	0.82	.23	.01	T	1.07	8.80	9.49	7.67	9.00	8.94	132,206				68,100
1953	1,275	4,746	4,306	82.0	18.0	P	P	0.74	.16	T	T	0.90	9.14	9.34	9.00	12.00	9.18	136,653				27,900
1954	1,236	4,823	3,607	87.0	13.0	P	P	0.65	.10	T	T	0.75	9.80	11.27	8.58	8.50	9.99	81,678				
1955	1,369	4,558	2,721	78.2	20.6	0.8	0.4	0.47	.12	T	T	0.60	9.90	10.38	8.05	9.73	9.98	?				
1956	510	2,237	1,960	70.0	30.0	P	P	0.62	.18	T	T	0.88	9.45	9.98	6.78	8.00	9.60	151,866	7,700		7,700	
1957	1,013	3,075	3,120	61.0	32.0	7.0	P	0.62	.32	.07	T	1.01	9.50	9.40	7.00	6.60	9.29	146,707			19,430	
1958	866	2,547	2,141	69.0	26.0	4.0	1.0	0.58	.22	.03	T	0.84	9.45	10.45	7.95	10.15	9.66	127,024			32,000	
1959	557	1,460	1,021	78.0	22.0	P	--	0.54	.15	T	--	0.70	9.83	10.15	9.00	--	9.90	126,345			30,240	
1960	1,055	3,204	2,463	76.0	23.0	1.0	--	0.59	.17	T	--	0.77	9.40	10.46	8.70	--	9.64	126,900				
1961	895	2,649	2,350	53.0	46.0	1.0	--	0.47	.41	T	--	0.89	9.47	9.81	9.93	--	9.63	121,265				
1962	439	1,193	777	76.0	21.0	3.0	--	0.49	.14	.02	--	0.65	9.80	10.30	9.00	--	9.88	72,700	60,000			
1963	369	1,152	677	74.0	24.0	2.0	--	0.43	.14	.01	--	0.58	10.00	10.50	8.00	--	10.08	61,634	30,000		50,000	
1964	449	1,337	750	63.0	35.0	2.0	--	0.35	.20	.01	--	0.56	9.50	10.00	8.50	--	9.66	53,197		30,000		
1965	381	1,045	474	76.0	21.0	3.0	--	0.34	.10	.01	--	0.45	10.00	10.00	8.00	--	9.94	64,350	[g]			
1952-65 Mean or Total	10,801	35,425	27,869	73.8	24.3	1.7	0.12	0.58	.19	.01	.0009	0.79	9.51	10.00	7.71	9.57	9.60	1,402,525	97,700	All sizes 265,370		

[a] Number of catchable rainbow stocked in 1952-1965 period highly significantly directly correlated (r=.85; 12 d.f.) with CPMH.

[b] Basic data from Hunter (1943) Colo. Cons. Comments 6(3):1943.

[c] Basic data from letter to Gil Hunter from Lloyd Brittain.

[d] Basic data from partial survey conducted by Wes Nelson and Al Cooter 7/25-31/46 and presented in letter to Gil Hunter.

[e] Denotes less than .01.

[f] Denotes the species was present in the catch but less than 1%.

[g] 25,000 kokanee 0-2" listed in 1965--before Blue Mesa Dam closed--never recovered any from this plant.

Table 12. Creel-census and stocking data for Blue Mesa Reservoir, 1966-1976.

Year	No. fishermen contacted	No. hours fished	No. fish caught	% Composition Rb	Brn	Brk	Cut	Kok	Coho	Mac	CPMH Rb	Br	Brk	Cut	Kok	Coho	Mac	Total	Av. lgth (in.) Rb	All salmonids
1966	185	426	421	63	9	27	1	--	--	--	.62	.09	.27	.01	--	--	--	.99	10	9.6
1967	1,405	6,455	5,075	97	1	1	P[a]	P	--	--	.77	.01	.01	T[b]	T	--	--	.79	11	11.0
1968	578	1,673	1,066	98	1	P	--	1	--	--	.63	.01	T	--	T	--	--	.64	12	12.0
1969	446	1,366	750	87	5	--	--	8	P	--	.48	.03	--	--	T	T	--	.55	12	12.1
1970	609	2,119	1,597	92	6	1	P	P	P	--	.69	.05	.01	T	T	T	--	.75	12	12.0
1971	1,779	5,744	5,351	85	6	P	P	2	7	P	.79	.06	T	T	.02	.07	T	.93	12	12.0
1972	678	1,738	1,960	92	3	--	--	5	P	--	1.04	.03	--	--	.06	T	--	1.13	12	12.0
1973	2,947	9,652	6,403	88	9	--	P	3	P	P	.58	.06	--	--	.02	T	T	.66	11	11.1
1974	2,671	8,585	5,758	88	6	--	P	6	--	P	.59	.04	--	T	.04	--	T	.67	11	11.3
1975	4,942	15,976	8,583	61	9	P	P	29	--	P	.33	.05	--	--	.16	--	T	.54	10	11.3
1976	4,148	12,760	5,288	64	10	P	P	25	--	P	.26	.04	T	T	.10	--	T	.41	12	12.5

Year	Rainbow (mostly <4.2 in.) 6 in.+	Total	Brown 2-3 in.	Kokanee[c] 0-2 inch	Coho[d] 2-12 in.	Mackinaw 2-3 inch	Cutthroat 0-2 inch	Totals
1966	3,000	2,076,465		533,000				2,612,465
1967		2,362,016		985,000				3,347,016
1968		2,773,335		644,000		28,000		3,445,335
1969		3,117,524	18,800	638,000	9,570			3,783,894
1970	8,100	1,567,710		140,000	158,074		22,100	1,895,984
1971		1,634,344		1,019,150	92,000			2,745,494
1972		1,113,205		915,000	163,912	35,200		2,227,317
1973	3,000	1,433,198		1,000,364		24,960		2,461,522
1974		969,919		2,172,400		18,060		3,160,379
1975		1,198,892		1,078,950				2,277,842
1976		1,104,023		1,038,650				2,142,673

[a] P denotes a species was present in the sample but was less than 1%.

[b] T denotes a CPMH of less than .01.

[c] Most kokanee were stocked in tributaries of the reservoir, released from Roaring Judy Hatchery. Recently these have been trucked down closer to the reservoir near North Beaver Creek.

[d] Coho in 1969 and 1970 were released in East River at Roaring Judy Hatchery; after 1970 they were stocked in Quartz Creek near the Pitkin Hatchery.

24.3-percent catch compositions in the 1952-1965 period, which is higher than the earlier periods documented by Pratt. Prior to 1937 almost all trout stocking in the Gunnison River was of fingerlings less than 4 in., but since 1939 most of the stocking has been rainbow trout over 6 in. in length.

Could both Pratt and Ray be correct, leaving us with the conclusion that a complete reversal in species composition actually occurred sometime in the late 1930's? Pratt's extremely high temperature data in 1934, along with several other low-flow years during the 1930's, seems to suggest that conditions may have been becoming more favorable for brown trout. The scarcity of larger, older trout during the 1930's, compared to the sudden appearance of greater numbers of these fish in the 40's and 50's, again suggests that conditions for both species may have been becoming critical in the 1930's.

Influence of Taylor Park Reservoir

As suggested earlier, the coldwater releases from Taylor Park Reservoir could have been instrumental in allowing rainbow trout to persist. Certainly one could attribute the scarcity of large fish in the 1930's to increased pressure causing removal of mostly intermediate-size fish, leaving few to attain large size. Many fishermen probably had more leisure time to fish because of layoffs during the depression. The increased numbers of large fish in the 1940's could be due to wartime conditions. Less fishing pressure, because many fishermen were in the armed services, gas rationing, and discontinuance of rail passenger service to Gunnison in 1940 no doubt occurred during the war years, thereby allowing some of the fish to attain larger size. National Park Service use figures in the National Monument area (Appendix XI) showed decreased use during the war years compared to a few years prior to the war, with more or less steadily increasing pressure after 1945. The continued appearance of large specimens into the 1950's after 4-5 yrs of heavy post-war fishing pressure, however, seems to discredit the above explanation.

In the 1932-1964 period, both 1950 and 1951 stood out as years when considerable numbers of large rainbow and brown trout were caught in the Gunnison River. Dr. Amos Wood, who had been fishing the Gunnison since 1933, reported in the August 10, 1950 issue of the Gunnison Courier that he had never seen such consistently large trout caught as in that year. Furthermore, the Division of Wildlife creel-census records for 1950 (Table 11) confirm that trout averaged larger that year than in any year of record prior to Curecanti in 1965. Five of the big trout that won weekly prizes in the statewide "Dave Cook" contest in Denver were caught in the Gunnison River in 1950. In the June 28, 1951 Gunnison Courier issue, John Isaacs of Rainbow Lodge at Sapinero reported he never saw so many fish from the Gunnison River as in that year. Isaacs continued that "Fishermen are coming back to Rainbow Lodge with young 3-lb rainbows that are the finest trout you ever saw." He did not disclose how he knew these fish were young, however. One could also argue that opening the 15-mi section of the upper Black Canyon to auto travel in 1949 opened a section which apparently had light pressure since the rail passenger service was discontinued in 1934, possibly permitting fish to become larger. None of the larger fish mentioned above, however, were listed as caught from this section of river.

Almost ironically, during this same time period Gunnison newspapers contained the following comments: "Fishermen are again riled at the roiled waters of the Gunnison as this great stream is converted carelessly and needlessly into an irrigation ditch from Taylor Reservoir to the Uncompahgre Valley" (Gunnison Courier, August 31, 1950). In the same issue can be found that "some fisherman went below the tunnel in the Black Canyon and found the river clear and low, catching 36 rainbows and one brown." During this time, Williams (1951) was actually collecting data for his subsequent paper in which he concluded that Taylor Reservoir decreased turbidity by serving as a settling basin. Deep, coldwater releases were found to lower the temperatures of the Gunnison River at Iola many miles below Taylor Dam by about 6°F. Williams further mentioned that the turbidity of the Gunnison River during the study period was not a limiting factor for fly fishing, documenting an overall average fly-fisherman catch-per-man-hour of 0.93, but ranging from 0.57 in July to a high of 1.91 in September 1950. September, coincidentally, was the month when coldwater releases from Taylor Dam averaged the greatest.

Contrarily, arguments and accusations continued, with comments such as "Experienced fishermen tell us that sudden rises of the Gunnison River due to releases at Taylor Dam make fishing unsatisfactory" (Gunnison Courier, August 2, 1951) and "Taylor Dam is operated to hinder fishing" (Gunnison Courier, July 26, 1951). In answer to the latter comment, the President of the Uncompahgre Valley Water Users was quoted in this issue as saying "Taylor Dam helped fishing, not hindered it." After considering all that has been discussed, I tend to agree with him, at least for the Gunnison River fishing below Gunnison. Most of this river fishing, however, subsequently has been inundated with the

Curecanti reservoirs. What effects Taylor Dam may have had on the Taylor River fishery and the upper Gunnison River stretches is another story. Studies on the Taylor River to determine effects of flow manipulation recently have been conducted by the Colorado Division of Wildlife Research Section (Burkhard 1977). It has already been suggested that the resident salmonid populations of the Taylor River may have shifted from predominately rainbow trout in 1954 (Weberg 1954) to predominantly brown trout in the 1970's. Whether migrating spawning brown trout from the upper Gunnison River or from Blue Mesa Reservoir have caused this shift is unknown. A shift in the seasonal flow pattern from Taylor Reservoir has occurred since Blue Mesa Reservoir has been completed (Table 4). Fall flows in October have been considerably above average, and the flows between November and April have all been above the pattern that prevailed prior to Curecanti. These greater fall and winter flows may have favored the establishment of brown trout. However, a similar shift in flow pattern has also occurred below the Gunnison Tunnel due to Curecanti (Table 5), and in this section brown trout have not increased. In fact, they may even be less abundant than they were prior to the Curecanti Unit. Browns are abundant, however, below the Monument to the Ute Trail.

Fisherman Use and Harvest Trends--Pre- and Post-Curecanti

Few attempts have been made historically to estimate fisherman-use and total harvest on the Gunnison River. The Gunnison News Champion of December 26, 1902 remarked that United States Fish Commissioner Tulian and Gunnison Hatchery Superintendent Crooks carefully estimated that 16,000 lbs of fish were caught from the Gunnison River and its tributaries during the year. However, the Gunnison News Champion of

March 21, 1902 stated that Mr. Tulian estimated that about 14,000 lbs of fish are caught each month of the fishing season in Gunnison County. The season usually lasted 4-5 mos at that time and, as already mentioned, the Gunnison Republican of June 6, 1901 stated that the Gunnison River trout averaged 1 lb in weight. Consequently, the best that can be calculated for the early years is a probable maximum estimate of annual trout yield for Gunnison County of 70,000 lbs. What proportion of this total yield was from tributaries is unknown, as is any estimate of numbers of fishermen during the early years.

During the 1950's concern for estimating fisherman-use and harvest for the Gunnison River developed because of the proposed Curecanti Project which would inundate about 40 mi of the choicest trout fishing sections of the Gunnison River. Evans (1957), without explaining how he derived his figures, estimated that during 1954 the Gunnison River within the Blue Mesa Reservoir proposed site had 37,000 fisherman-days of effort that yielded 124,000 trout. He also predicted that if Curecanti were built, Blue Mesa Reservoir would provide only 12,000 fisherman-days annually, with a total annual harvest of a mere 15,000 trout. Mention has already been made of a 1956 study that estimated 49,100 fisherman-days on the main Gunnison River above the North Fork junction but below North Beaver Creek. The Bureau of Sport Fisheries and Wildlife report on the Curecanti Project (Anonymous 1960, p. 79) stated the following:

> "The 1956 trout season in Colorado extended from May 15 through October 31. An investigation of fishing use and harvest was conducted during the period from June 28 through September 12. Additional observations indicated that practically all of the fishing use occurred between opening day and September 30. Various sections of the river and associated tributaries were grouped into work units to facilitate survey by the three crews so engaged. A schedule was developed to assure an adequate random sample of use and harvest for each day of the week. Information so gathered was projected to give an estimate of total use and harvest during the season."

In Table 13 I have summarized the estimates of fisherman-use and harvest secured during the 1956 survey for the various sections studied. In addition, I have also included what use and harvest was projected at that time for some of these sections if the Curecanti Unit was or was not built. Furthermore, I have also included estimates for the last 10 of the first 12 yrs that Blue Mesa Reservoir has existed. The fisherman-use figures at Blue Mesa were obtained from the National Park Service and the harvest estimates were derived from a combination of creel data collected by Colorado Division of Wildlife officers and research staff crews during studies since 1968. Wiltzius (1974) described how the estimates were derived. On none of the estimates given in this table could any statistical precision be employed. They are merely the estimates that could be calculated from the data on hand. I do not feel that there has been any purposely upward bias employed by the National Park Service in estimating fisherman-days at Blue Mesa. Expansion of data obtained from a Division of Wildlife survey questionnaire sent to a small fraction of fishermen in 1975 (regarding the 1974 season) revealed that fisherman-use on Blue Mesa Reservoir may have approached 173,000 man-days, or more than twice the National Park Service estimate for that year. The rather large discrepancy between these two estimates may have been caused by some fishermen on the questionnaire survey confusing days spent on Blue Mesa with days spent on Grand Mesa. I feel the National Park Service estimates may be more reliable since they at least attempted to estimate fisherman-use on a daily basis (usually two counts) and reported the sums for each month. Furthermore, other than the 1974 season, no other data except the National Park Service estimates are available for the fisherman-use at Blue Mesa Reservoir. I assume that the NPS

Table 13. Estimates and projections of fisherman-use and harvest for various sections of the Gunnison River below North Beaver Creek.

					Projected use and harvest					
					With Curecanti Reservoirs built[a]			Without Curecanti Reservoirs		
River section or reservoir	Year	Estimated annual fisherman man-days	Estimated total salmonid harvest	Source of data	Estimated annual fisherman man-days	Estimated annual trout harvest	Source of data	Estimated annual fisherman man-days	Estimated annual trout harvest	Source of data
Beaver Creek to Sapinero (Now Blue Mesa Reservoir)	1954 1956	37,000 37,600	124,000 163,300	Evans(1957) Anon.(1960, p 80)	12,000 17,300	15,000 22,400	Evans(1957) Anon.(1960, p 83-84)	56,400	244,900	Anon.(1960, p 84)
2 miles below Cimarron Creek to Sapinero (Now mostly Morrow Pt.)	1956	9,700	39,000	"	1,500	500	"	14,600	59,000	"
4 miles above Gunnison Tunnel(Now mostly in Crystal Reservoir)	1956	1,200	2,500	"						
Gunnison Tunnel to North Fork	1956	600	1,300	"	2,700	5,700	Anon.(1960, p 81)	2,700	5,700	"
Main Gunnison River (North Fork to Beaver Creek)	1956 Totals	49,100	206,100							
Lake Fork within Blue Mesa site	1956	3,400	22,000	"				5,100	33,000	"
Grand Totals	1956	52,500	228,100		21,500	28,600	Anon.(1960, p 84)	78,800	342,600	Anon.(1960, p 84)
	1968	141,291	367,357	Wiltzius(1974)						
Blue	1969	97,121	221,436	"						
	1970	122,225	371,564	"						
Mesa	1971	108,765	404,606	"						
	1972	102,177	351,489	"						
Reservoir	1973	84,033	228,570	"						
	1974	84,330	239,865	Present study						
	1975	78,025	167,691	"						
	1976	82,655	155,697	"						
	1977	74,285	173,827	"						
10-Year Totals		974,907	2,682,102							

[a] The projections presented here are those primarily of the Bureau of Sport Fisheries and Wildlife. See text for further details.

fisherman-use figures are as precise as the use estimated by the 1956 Gunnison River random survey.

Comparison of some of the projections of the use and harvest anticipated with the Curecanti Unit with those that have occurred (Table 13) indicates some rather gross underestimation by the Bureau of Sport Fisheries and Wildlife for Blue Mesa Reservoir. In a letter dated April 4, 1959 to the Secretary of the Interior from Colorado Governor Steve McNichols (Anonymous 1960, p. XII), mention was made that the BSFW report omits significant portions of the findings of game and fish technicians who did the actual fieldwork on the project, as follows:

> "The trout production of Curecanti Reservoir (Blue Mesa) will be greater than that of the river to be inundated due to the increased area; however, the catch-per-man-hour will probably drop considerably. The average size of the fish caught will probably increase somewhat. The reservoir will be capable of supporting a much greater fishing pressure than the present river."

Presently, the discussions and data which follow tend to verify that Governor McNichol's prophets likely were more accurate than those of other biologists.

Anonymous (1960, p. 80) mentioned that the fisherman-use in 1956 on tributaries other than the Lake Fork was so small that no estimate for total seasonal use for tributaries within the Blue Mesa site was attempted. By adding the 1956 estimate of the Lake Fork (3,400 man-days, 22,000 trout harvested) to the Gunnison River data (within Blue Mesa site shown in Table 13) one derives for 1956 a slightly low estimate of 41,000 fisherman-days and 185,300 total trout harvested within the area to be inundated by Blue Mesa (Table 14). The Division of Wildlife creel census data collected on the Gunnison River in 1956 (Table 11) indicated that an average trout caught that year was 9.6 in long. Using length-weight regressions from data collected by fishermen from the Gunnison River in

Table 14. Comparison of fisherman-use and harvest estimates for some areas of the Gunnison River with that of Blue Mesa Reservoir in various years.

Gunnison River area	Year	Man-days	Total salmonids harvested	Av. length (in.)	Est. av. weight (lbs.)	Est. total pounds harvested	Est. pounds/ man-day	Est. no. fish/ man-day
That inundated by Blue Mesa (main Gunnison River including portion of Lake Fork without Curecanti)	1956	41,000[a]	185,300[a]	9.6	.322	59,667	1.46	4.52
	Projected 50 year annual average	61,500[b]	277,900[b]	9.6	.322	89,484	1.46	4.52
North Beaver Creek to North Fork including Lake Fork (without Curecanti)	1956	52,500[a]	228,100[a]	9.6	.322	73,448	1.40	4.35
	Projected 50 year annual average	78,800[b]	342,600[b]	9.6	.322	110,317	1.40	4.35
Blue Mesa Reservoir	1968	141,291	367,357	12.0	.63	231,435	1.64	2.60
	1969	97,121	221,436	12.1	.65	143,933	1.48	2.28
	1970	122,225	371,564	12.0	.63	234,085	1.92	3.04
	1971	108,765	404,606	12.0	.61	246,810	2.27	3.72
	1972	102,177	351,489	12.0	.62	217,923	2.13	3.44
Average		114,316	343,290			214,837	1.88	3.00
Blue Mesa Reservoir	1973	84,033	228,570	11.1	.48	109,714	1.31	2.72
	1974	84,330	239,865	11.3	.55	131,926	1.56	2.84
	1975	78,025	167,691	11.3	.55	92,230	1.18	2.15
	1976	82,655	155,697	12.5	.68	105,874	1.28	1.88
	1977	74,285	173,827	12.4	.66	114,726	1.54	2.34
Average		80,666	193,130			110,894	1.38	2.39
10-Year Grand Totals		974,907	2,682,102	11.9	.61	1,628,656	1.67	2.75

[a] Use and harvests estimated to have occurred in 1956 when stocking of catchable trout was at its historic high.

[b] What the Bureau of Sport Fishery in 1956 believed the Gunnison River could annually provide over the next 50 years if the Curecanti Project was not built (Anonymous 1960).

1965, a trout of 9.6 in. would average about 0.322 lb. On the basis of these data, I have calculated other parameters in Table 14. For example, it can be seen that during 1956 an estimated 59,667 lbs of trout were probably harvested within the Blue Mesa site, or an average of 1.46 lbs per man-day of fishing. Identical calculations have also been made from the Blue Mesa Reservoir data for 1968-1977. Due to large size of the average trout (nearly 12 in. and 0.6 lbs), the total pounds harvested annually since 1968 has greatly exceeded the estimated yield from the Gunnison River within the Blue Mesa site in 1956. Furthermore, stocking of catchable-size trout in the Gunnison River during 1956 was the highest it has been historically. In Table 11 it can be seen that 151,866 rainbow trout over 6-in. were planted that year above Cimarron, but how many were stocked within the Blue Mesa site is unknown. It is likely that about 108,000 of these rainbows were stocked within the Curecanti site in the main river.

Anonymous (1960, p. 80) mentioned that, considering the sharp upward trend in our human population growth, the increasing numbers of people who fish, and the trend toward more leisure time, it is estimated that annual use of the main Gunnison River below North Beaver Creek (without Curecanti) over the next 50 yrs will average 73,600 man-days of fishing and will furnish an annual harvest of 309,600 trout. In Table 5 of the Bureau of Sport Fisheries and Wildlife report, page 84, (Anonymous, 1960) can be found projected use of 78,800 man-days and 342,600 total trout estimated to be harvested for all sections above the North Fork but below North Beaver Creek. These later, higher values have included what was anticipated if the Lake Fork section were to be inundated. No mention can be found in the Bureau of Sport Fisheries and Wildlife report, however, where they expected the increased yeild to come from. For example, with an historic high of 151,866 catchable rainbows planted during 1956 and an estimated total yield of 228,100 trout that year (Table 13), where did they expect the 114,500 additional trout (342,600-228,100) to come from if it were not from accelerated stocking of catchable trout?

Certainly one could argue that not all catchable trout stocked in a particular year are harvested that same year, with many holding over for later years. Unpublished information from 992 rainbow trout jaw-tagged at about 8.5 in. average size and stocked in the Gunnison River between Iola and Gunnison in 1947 by W. D. Klein of the Colorado Division of Wildlife is that there were 149 reported returns (15.0%) during 1947 and only 3 (0.3%) returns in 1948. No reported captures were received after 1948. The average size at capture in 1947 was 9.05 in., but was 11.92 in. for the three tagged fish reported in 1948. Of the 152 returns that were reported caught, 98.0 percent were caught in the year of stocking. I do not want to imply here that 15.3 percent total returns from catchable plants was normal for the Gunnison River; it is highly probable that many of the tagged fish that were caught were not reported by the fishermen. When pressure is high, returns may approach 90 percent for catchable-size rainbow. During the 1952-1965 period shown in Table 11, the total number of catchable rainbow trout stocked in the Gunnison River during a particular year was highly significantly directly related ($r = .85$) with the catch rate (CPMH) for rainbow trout during that same year, again suggesting that catchables are removed rapidly soon after stocking.
The above relationship may suggest that the Gunnison River fishery was, to a great extent, dependent upon catchable stocking, but the trend could have also been influenced by the reduced catchable stocking during the 1960's, when the fishing pressure probably had been greater than in the earlier years.

At Blue Mesa Reservoir, 4-in. rainbow fingerlings stocked in June reach 8-in. catchable size about mid-September of the year of stocking when fishing pressure is normally dropping off greatly. When pressure significantly increases in May of the following year, most of the rainbows surviving from the previous plant are over 11 in. long. The few that have not been caught by that September (2nd summer) will average about 14 in. Consequently, fingerling plants in Blue Mesa Reservoir contribute to the fishery primarily 1 yr after stocking, and this is the likely reason that the average size of rainbow trout in this reservoir has been greater than those in the Gunnison River, where 8 to 10-in. planted fish were harvested rapidly soon after stocking. Fingerling plants made in rivers have seldom contributed much to its fishery.

It is inferred from the above, and from the fact that in 16 of 18 yrs the mean size of trout caught from the Gunnison River was less than 10 in. (Table 11), that one could not expect the Gunnison River (without the Curecanti Project) to suddenly produce larger trout. Consequently, in computing the total pounds from the 342,600 trout expected to be harvested (Table 14) from the Gunnison River below North Beaver Creek if the Curecanti were not built, I have used the average of 9.6 in. (0.322 lbs each) found during the 1952-1965 period. The maximum projected poundage for these trout would have been 110,317, or 1.40 lbs per man-day, assuming 78,800 man-days annually as projected by the Bureau of Sport Fisheries and Wildlife (Anonymous 1960).

It is during the early years of filling that new reservoirs usually produce maximum yields. Blue Mesa Reservoir, in its early years, (1968-1972) provided an average estimated annual yield of 214,837 lbs of salmonids, or nearly twice what the entire Gunnison River below North

Beaver Creek was projected to provide (Table 14). Furthermore, Blue Mesa provided, in these initial years (1968-1972), an average of 1.88 lbs per man-day of effort, again in excess of the 1.4 lbs per man-day estimated for the entire Gunnison River below North Beaver Creek. Maximum yield at Blue Mesa occurred in 1971 1 yr after the reservoir had initially inundated maximum surface acreage. Sagebrush cover present all through 1970 has subsequently disappeared due to rotting and uprooting caused by shoreline ice-sheets moving when the reservoir was drawn down during the winter and early spring. Probably as a result of lack of cover, predation has increased on the fingerling plants, causing poorer survival. Little vegetation has been established in the drawn-down area, resulting in lack of release of nutrients from rotting plants. Sucker populations have also expanded greatly (Wiltzius 1974). Consequently, this may be why the salmonid yields shown in Table 14 for the last 5 yrs (1973-1977) have averaged only 110,894 lbs annually. Man-days have also decreased, with an average of 80,666 annually in the last 5 yrs compared to an annual average of 114,316 man-days in the earlier years (1968-1972).

Despite the recent declining yields, Blue Mesa Reservoir has in the last 5 yrs provided more man-days of fishing effort (average of 80,666 annually) than the 78,800 projected annually for the entire Gunnison River below North Beaver Creek (including the Lower Lake Fork) and has done it at an average annual rate (1.38 lbs per man-day) nearly equal to the 1.4 lbs per man-day anticipated from the river without the project. There is, however, no guarantee that present yields will be maintained indefinitely. The National Park Service reported that fisherman-use through the first 6 mo of 1978 was 35 percent less than in the same period last year. However, they reported record use by fishermen in July (39,470) and August (33,460) and consequently, the use through August is 49.1 percent ahead of last year. Only in 1968 and 1970 did the fisherman-use through August excede the 96,951 estimated during 1978.

Due to the extreme drought in 1977, Blue Mesa Reservoir was drawn down to levels which have not occurred since 1966, the first summer of the reservoir's existence. Consequently, survival of rainbow fingerlings stocked in 1977 may have been poor, and their yeild in 1978 will probably be dissappointing. Kokanee from the 1975 yr class may provide a large proportion of the harvest. In none of the years that Blue Mesa Reservoir has existed did the reservoir provide the number of fish per man-day that was anticipated from the Gunnison River without the Curecanti Project.

1977 Random Survey of Lower Gunnison

With the initial filling of Crystal Reservoir in 1977, the Curecanti Unit was complete. In Table 13 it is seen that the Bureau of Sport Fisheries and Wildlife survey in 1956 estimated that only 1,300 trout were harvested by 600 man-days of fishing in the Gunnison River in the 29-mi section above the North Fork but below the Gunnison Tunnel. This Tunnel is only about 1.5 mi below Crystal Dam. Of all of their projections for use and harvest if the Curecanti Unit were built, the section below the dams was the only section that the Bureau of Sport Fisheries and Wildlife estimated would provide more use and harvest than that found in 1956. It may be that they felt that the turbid Cimarron River flow would be caught by Crystal Dam and greater volumes of flow would be provided past the Gunnison Tunnel, which in some months historically (August and September) had severely depleted the flows through the Gunnison Gorge. The Bureau of Sport Fisheries and Wildlife projected that this section, in the next 50 yrs, would annually sustain a total harvest of 5,700 trout by 2,700 man-days of effort (Table 13).

It was already obvious by 1971, with only Blue Mesa and Morrow Point in operation, that trout were extending further downstream than they were prior to the Curecanti Unit. Consequently, between April 16 and October 11, 1977, a comprehensive creel census was conducted in the area between Crystal Dam and the North Fork junction to measure present fisherman-use and harvest. In Table 15 I have summarized the results of the study. Harvest estimates on most individual species shown in Table 15 are of low precision. Estimates of total days fished (man-days) usually are more precise than harvest estimates.

The 3,059 man-days estimated at the Crystal access area has 95 percent confidence limits that are ± 20 percent of the estimate, whereas at the North Fork area the limits were ± 16 percent of the 1,847 man-days estimated. The Gorge trails (Chukar, Duncan, and Ute) had the least precise estimates, with limits on the 1,403 man-days estimated at ± 34 percent of the estimate. The estimates from the South Rim trails of the National Monument likely were the most precise, since we had partial data from more than 40 percent of all fisherman parties that used these trails. Despite this, many of the return cards failed to identify the exact dates they had fished, and the National Park Service records were inconsistent as to whether an individual fishing group was tabulated when the group entered or left the Monument. Consequently, I was unable to use the computer program to calculate the standard error of these South Rim trail estimates.

Table 15. Creel-census estimates for various areas of the Gunnison River below Crystal Dam, April 16-Oct. 11, 1977.

Sampling area	Total fishermen	Total days fished	Total hours	Finclipped rainbow[a]	Total rainbow	Total brown	Total cutthroat	Total brook	Total pike	Total green sunfish	Total suckers	Total chub	Total game fish	Total fish
Crystal access area	2,564 (234)[b]	3,059 (312)	10,679 (1,143)	3,895 (577)	6,560 (797)	790 (228)	14 (7)	21 (8)	-- --	-- --	12 (11)	-- --	7,385 (976)	7,397 (975)
South rim trails of National Monument	190	450	1,481	--	825	244	40	40	--	--	--	--	1,149	1,149
Chukar, Duncan, and Ute Trails	984 (147)	1,403 (241)	4,670 (892)	-- --	1,078 (216)	1,015 (234)	12 (12)	18 (17)	-- --	-- --	455 (146)	33 (21)	2,123 (398)	2,611 (469)
North Fork area	1,562 (113)	1,847 (143)	5,249 (466)	-- --	3,171 (438)	480 (91)	7 (6)	21 (7)	5 (5)	4 (3)	1,276 (443)	39 (13)	3,688 (491)	5,003 (735)
Totals	5,300	6,759	22,079	3,895	11,634	2,529	73	100	5	4	1,743	72	14,345	16,160

[a] 4,260 finclipped catchable-size rainbow trout were stocked in a 0.5 mi stretch below Crystal Dam during June-July 1977.

[b] Standard error of estimate in parentheses. Estimate ± twice the standard error = 95 percent confidence limits.

Lower River Rainbow Harvest--from Stocking, Natural Reproduction, or Reservoirs Above?

By adding all the rainbow trout estimated as harvested in 1977 above the Ute Trail (Table 15), one obtains a value of 8,463 rainbow trout. Calculating and summing of the 95-percent lower limits on these sections would indicate that a minimum of 5,612 rainbows, plus an unknown number from the South Rim trails, were harvested. Assuming variances of the South Rim section were similar to those of the Gorge trails, at least 494 additional rainbows, or a minimum of 6,106, were probably caught. In the last 5 yrs the annual stocking of catchable rainbow trout ranged between 3,547 and 4,770 and averaged 4,225. The difference between the probable minimum number of rainbows harvested above Ute Trail (6,106) and 4,260 catchables stocked in 1977 is a minimum of 1,846 rainbows from sources other than catchable stocking.

When the present study was initiated in 1973, I believed that many of the rainbows below the Curecanti reservoirs were being provided by the fingerlings stocked in the reservoirs above. Consequently, to determine what these reservoirs were providing to the lower river I instigated marked-fish studies and recommended that stocking of Morrow Point Reservoir be temporarily discontinued until more evidence was available. Between 1974 and 1976 all the 3,272,834 fingerling rainbows stocked in Blue Mesa were marked with flourescent pigments. In 1974, all the rainbow fingerlings stocked in Silverjack Reservoir in the Cimarron drainage were also marked. In addition, in 1975 about 40 percent of all kokanee stocked in Blue Mesa Reservoir were marked with tetracycline, as were all the kokanee stocked in Taylor Reservoir. Evidence has already been presented to suggest that marked groups retained marks in very high percentages. Kokanee have shown considerable downstream migration. For example, in 1977 the 1975-marked Taylor kokanee comprised an estimated 35 percent of all age II+ kokanee in Blue Mesa Reservoir. Only a few Taylor salmon were captured in Morrow Point during 1977. At Morrow Point in 1977, nearly the entire fishery was marked kokanee salmon that had survived passing through the power turbines of Blue Mesa in November and December of 1974 and 1975, when the Blue Mesa salmon were ages 0+ and I+ respectively. We have never recovered any salmon in the river below Morrow or Crystal reservoirs, but no sampling has been done in these areas in the early winter months when losses were occurring.

Since 1974, more than 300 rainbows were captured in areas below Blue Mesa Reservoir and examined for flourescent marks, but only two (<1%) had been marked. One was taken from Morrow Point Reservoir in 1976 and was from the 1974 Blue Mesa markings, while the other specimen was taken just below the Smith Fork junction and was from the 1975-marked group of Blue Mesa. No spills have occurred at the Curecanti dams while these studies were under investigation. It appears likely, therefore, that most of the 1,846 minimum number of unaccounted-for rainbow trout below the dams likely have been provided either by natural reproduction in the main channel of the Gunnison River or from an unmarked plant of 10,000 2- to 4-in. rainbows that were stocked near the Ute trail in 1975.

Few permanent tributaries exist in the Gorge below Crystal Dam, but when the main Gunnison River was quite low in 1977, main-river spawning activity of rainbow trout was observed a short distance below the Gunnison Tunnel within the National Monument and was also observed in the main river above Crystal Reservoir. If one calculates the upper limits of the numbers of rainbows caught above the Ute trail but below the dams, one secures an estimate of about 10,820 rainbows harvested, with a likely maximum of 6,595 unaccounted-for rainbow (10,820-4,225 catchables) from other sources. Consequently, unaccountable rainbows could have been between a minimum of 1,846 and a maximum of 6,595. If the lower value is the more accurate, it would appear that the 1975 fingerling plant near Ute trail could have supplied most of this, and naturally reproduced rainbow trout would have contributed little to the fishery. However, if the true harvest of rainbows was at or above what was estimated in Table 15, especially if it approached the upper statistical limits, naturally reproduced rainbow trout could have contributed significantly to the lower Gunnison fishery in 1977. I believe that reproduction is contributing most of the unaccountable rainbows because the Gunnison River in the Monument section was known to produce trout naturally before the Curecanti Unit (Kinnear and Vincent 1967), and flows during the spring appear more favorable since the Unit has been in operation. For example, with the dams operating the flows through the Monument in the spring are now less turbid and, of course, of considerably less volume and velocity. Greater flows, turbidity, and velocity may have been more detrimental to rainbow reproduction before the dams.

At times during the lower creel study in 1977, helicopter flights were made from Blue Mesa to Delta, Colorado. We also passed out some questionnaire cards at the Pine Creek access road below Blue Mesa and at the Cimarron access below Morrow Point Dam. From returns from these cards, together with Division of Wildlife and National Park Service creel checks made in these areas, I have made some calculations of the use and harvest in the section between Blue Mesa and Crystal dams.

I was again unable to use the computer program for determining standard errors of the estimates, but the use and harvest estimates are presented in Table 16 which summarizes data for the entire Gunnison River sections between North Beaver Creek at the headwaters of Blue Mesa to Austin, Colorado during 1977.

I have calculated the parameters used in other tables of this report and have also included the estimates of what was anticipated for fisherman-use and harvest in these sections, had not the Curecanti been built. The only section in 1977 not providing what the Bureau of Sport Fisheries and Wildlife had anticipated the Gunnison River would provide was that 18-mi section between Blue Mesa and Crystal Dam. Here it is seen that fisherman-use was estimated at 2,000 man-days, or only 14 percent of what was anticipated. Furthermore, despite the average fish being of considerably larger size, only 6,600 lbs were provided, or about 35 percent of what was anticipated. Fisherman-use no doubt is much less now because the main access road along the river between Cimarron and Sapinero (Blue Mesa Dam) has been inundated. Fisherman access for Morrow Point is now provided primarily by a steep foot trail along Pine Creek below Blue Mesa Dam to a rather short section of the old road along the upper end of the reservoir. Fishermen with small boats or rubber rafts have difficulty getting in and out of Morrow Point. Furthermore, one cannot now float the section below Cimarron to the Gunnison Tunnel because of regulations prohibiting the use of boats on Crystal Reservoir. Boat or raft use on Crystal Reservoir has been, for all practical purposes, eliminated because of the likelihood of very low or very high water conditions in the river above this reservoir. This area is the only feasible launching site for boats or rafts.

Table 16. Comparison of 1977 fisherman-use, harvest and stocking costs for various areas of the Gunnison River below North Beaver Creek with Curecanti (W.C.) and without Curecanti Unit (W.O.C.).[a]

Gunnison River area		Man-days	Total salmonid harvest	Est. av. length	Est. av. weight	Est. total pounds	Pounds/ man-day	No. fish/ man-day	Stocking costs[b] Total	Est.cost/ man-day	Cost/lb. harvested
Within Blue	W.O.C.	61,500	277,900	9.6	0.322	89,484	1.46	4.52			
Mesa Site	W.C.	74,285	173,827	12.4	0.660	114,726	1.54	2.34	93,571[c]	1.26	0.82
Blue Mesa to	W.O.C.	14,600	59,000	9.6	0.322	18,998	1.30	4.04			
Crystal Dam	W.C.	2,000	6,000	14.0	1.100	6,600	3.30	3.00	0[c]	0[c]	0[c]
Crystal Dam	W.O.C.	2,700	5,700	9.6	0.322	1,835	0.68	2.11			
to North Fork	W.C.	6,759	14,336	10.9	0.420	6,021	0.89	2.12	914	0.14	0.10
North Fork	W.O.C.	--	--	--	--	--	--	--	--	--	--
to Austin	W.C.	616	1,100	10.1	0.37	407	0.66	1.79	0	0	0
GRAND	W.O.C.	78,800	342,600	9.6	0.322	110,317	1.40	4.35	44,340[d]	0.56	0.40
TOTALS	W.C.	83,660	195,263	12.3	0.669	127,754	1.53	2.33	94,485	1.13	0.72

[a] Man-days use and total harvest values without the Curecanti were projections made by the Bureau of Sport Fisheries and Wildlife (Anon. 1960); other values and calculations were derived by me from historic creel census and stocking records or from data collected during the present study.

[b] Dollar cost based on 1977 Colorado average hatchery costs.

[c] Based upon 1976 numbers of fingerlings stocked (group supplying harvest in 1977) but using Colorado 1977 average hatchery costs.

[d] This is really a loosely calculated guess. The maximum historic stocking for the Gunnison River was in 1956 when 151,866 catchable rainbow trout were stocked above Cimarron. Stocking below there was minimal. At 1977 costs, 151,866 catchables would total $27,744. An unknown number of these catchables were stocked above North Beaver Creek in 1956 so it is now unknown exactly how many of the 151,866 were stocked in the Curecanti site. I assume that about 108,000 were stocked below North Beaver Creek and above the North Fork where it was estimated that 228,000 trout were harvested in 1956. About 70% of the total harvest was rainbow or 159,000 while the remainder (68,430) were browns. Assuming 85% return on the 108,000 catchables (91,800) then 159,000-91,800=67,870 rainbows from natural reproduction. Adding 67,870 rainbow to 68,430 browns which were all considered natural(?)=136,300 total natural trout. If a total of 342,600 trout were anticipated caught annually for the future by Anonymous (1960), then 342,600-136,300=206,300 stocked trout needed annually. Again assuming 85% return, one would have to stock 242,706 catchables at 1977 costs of $.18269 each which results in the $44,340 estimated. It is likely that by more than doubling the previous maximum historical catchable stocking to supply the increased pressures anticipated without the Curecanti Unit built, that natural reproduction in the Gunnison River would have been curtailed greatly and even more catchables than that estimated would have had to have been stocked to supply the 342.600 trout anticipated. The $44,340 cost shown would then be an underestimate. Therefore the approximate doubling of stocking costs shown due to Curecanti may not be valid.

Despite all of these problems, the reservoir-modified Gunnison River in 1977 still provided slightly more estimated man-days of use than was anticipated by the Bureau of Sport Fisheries and Wildlife. Generally, the river has not provided the numbers of salmonids anticipated, but it has provided more pounds per man-day of effort (1.53) than the 1.40 lbs per man-day anticipated without the construction of the Curecanti Unit. It was estimated in Table 16 that stocking costs in 1977, with the Unit, presently are slightly more than double what was anticipated without the dams. It should be noted, however, that the federal government, since 1970, has sustained about 70 percent of the annual total stocking costs incurred on the Gunnison River sections shown in Table 16 below North Beaver Creek near the maximum high-water level of Blue Mesa.

Fish Growth in Lower Gunnison River (National Monument)

One phenomenon that is difficult to explain is how the rainbow trout in the National Monument section, where considerably colder water has been prevelant as a result of Curecanti dams since 1966, have apparently increased their growth rate. In Table 17 are presented comparative length ranges for various age-groups of rainbow trout collected in the National Monument before and after the Curecanti dams. In 1975 the mean lengths of age-groups 2, 3, and 4 were actually greater than the largest individual sampled from these respective age-groups in 1965, prior to the Curecanti dams. Furthermore, Vincent (1966) reported that the mean total length of rainbow trout taken primarily by gillnet and hook-and-line in 1965 averaged 9.7 in. whereas in 1975 rainbows taken by identical methods averaged 11.2 in. It may be that recently there have been fewer rainbows present than prior to the dams when this section

Table 17. Comparison of rainbow trout total length ranges (in.) for various ages, pre- and post-Curecanti Unit in the Gunnison National Monument.

	Age[a]					Total fish aged
	1	2	3	4	5 or older	
Pre-Curecanti						
1965[b]		6.2-8.4	8.0-10.1	10.0-12.1	12.3-18.2	(34)
$\overline{X}$		?	?	?	?	9.7
Post-Curecanti						
1975	(1)[c] 7.8	(15) 7.0-10.7	(33) 9.0-13.8	(11) 11.0-15.0	(9) 10.8-18.0	(69)
$\overline{X}$	7.8	8.7	10.7	12.7	15.5	11.2

[a] I am assuming that an age 2 fish, for example, as listed by Kinnear and Vincent (1967) is one with two annuli and age 3 fish were those with three annuli on their scales.

[b] Data originally given by Kinnear and Vincent (1967) in fork length has been converted to total length by multiplying by 1.07 factor which was obtained from data presented by Carlander (1953). Vincent (1966) reported the mean total length of rainbow taken in 1965 was 9.7 inches while that of browns was 10.1 inches.

[c] Number of fish in parentheses (42 specimens were collected by hook and line and 27 by gillnet. The gillnet specimens were not statistically larger than hook and line samples).

was receiving very light fishing pressure. Now that most of the choicest river sections have been inundated, increased fishing pressure in the National Monument may have reduced the standing crop of rainbow, thus allowing increased growth. However, all species of fish collected in the National Monument presently are of larger average size than those prior to the dams (Table 18). It may be that the colder water has pushed many of the fishes lower down, which would also tend to reduce the standing crop. Unfortunately, Kinnear and Vincent (1967) failed to relate the catch-per-net-hour for the various fishes caught in gill-nets, which could have provided an index to their relative abundance at that time.

HISTORIC DISTRIBUTION OF NON-SALMONID SPECIES

Historically, the non-salmonids collectively have comprised the majority of fishes sampled from the Gunnison River below Gunnison and have almost totally comprised the fauna below the North Fork junction. Obvious and probable errors in identification of the various species reported from the Gunnison River drainage in previous studies will be noted, but, for the sake of brevity, no attempt will be made to list all of the scientific or common names that each particular species was called, historically. Discussions of name changes will be limited to species which have had confusing taxonomic treatment over the years.

Additional information, such as whether the species is native or introduced and speculations regarding when they had been introduced, along with morphometric differences on some of the catostomid fishes, will be included. Relative abundance for the various river sections during the recent study is derived from comparative catch-per-net-hour

Table 18. Comparison of species composition, mean length (in.), and ranges for the fish captured within the Gunnison National Monument, pre- and post-Curecanti Unit.

Species		Pre-Curecanti 1965[a]	Post-Curecanti 1975-77 totals	1975[b]	1976	1977
Brown trout	% comp.	22.4	7.5	10.1	6.6	7.0
	$\bar{X}$ Length	10.1	13.2	11.7	13.4	14.3
	Range	7.0-16.7	7.5-27.0	8.0-16.3	11.5-18.0	7.5-27.0
Rainbow trout	% comp.	22.7	18.8	48.1	11.8	9.9
	$\bar{X}$ length	9.7	11.7	11.2	11.1	13.8
	Range	4.8-14.6	7.0-18.0	7.0-18.0	8.0-14.1	7.2-17.3
White sucker	% comp.	21.1	13.4	15.2	5.3	21.1
	$\bar{X}$ length	10.1	14.4	14.0	14.5	14.5
	Range	5.7-16.3	10.0-18.1	10.0-16.0	10.2-18.1	10.6-17.3
Bluehead sucker	% comp.	16.3	11.8		12.5	17.6
	$\bar{X}$ length	10.6	14.5		14.7	14.3
	Range	7.5-15.7	8.3-17.1		8.3-17.1	8.8-16.8
Flannelmouth sucker	% comp.	14.3	1.1	2.5	0.7	0.7
	$\bar{X}$ length	14.3	17.1	15.1	18.2	20.0
	Range	9.3-20.0	13.4-20.0	13.4-16.8		
Longnose sucker	% comp.		43.4	22.3	59.9	37.3
	$\bar{X}$ length		11.7	10.4	11.8	11.9
	Range		7.3-15.5	8.0-11.5	7.3-15.5	7.3-15.5
Hybrid sucker	% comp.	not enumerated	3.8	not enumerated	3.3	6.3
	$\bar{X}$ length		14.6		15.0	14.3
	Range		9.3-19.0		11.5-17.5	9.3-19.0
All trout	% comp.	45.2	26.3	58.2	18.4	16.9
	$\bar{X}$	9.9	12.1	11.3	11.9	14.0
	Range	4.8-16.7	7.0-27.0	7.0-18.0	8.0-18.0	7.2-27.0
All suckers	% comp.	52.0	73.5	40.5	81.6	83.1
	$\bar{X}$ length	11.4	12.9	12.0	12.5	13.3
	Range	5.7-20.0	7.3-20.0	8.0-16.8	7.3-18.2	7.3-20.0
All fish	Total no.	713	373[c]	79[c]	152[c]	142[c]
	$\bar{X}$ length	10.7	12.7	11.8	12.4	13.4
	Range	4.8-20.0	7.0-27.5	7.0-27.5	7.0-18.2	7.2-27.0
No. gillnets		Unknown	27	6	10	11
No. hours fished		Unknown	518	91	192	235

[a] Data obtained or derived from Vincent (1966). Most specimens are believed to have been collected by experimental gillnets. Two chubs and 18 dace were also collected in 1965, probably by seining and/or electrofishing.

[b] Samples collected by Day (1975). A total of 136 rainbows from harvest and gillnet samples were examined for fluorescent marks--none found. One 27.5 in. northern pike caught by gillnet at Red Rock Canyon; one eagle sculpin caught by fisherman at Warner Point. No attempt was made to identify sucker hybrids. Samples of white and longnose suckers originally brought to Wiltzius for identification.

[c] These totals are of the fish captured only by gillnets. Some seining was done in 1976. Of 108 fish seined, 46 were speckled dace (42.6%), 35 were longnose sucker (32.4%), 21 were white suckers (19.4%), and 6 were longnose x white hybrids (5.6%).

(CPNH) data for the species taken in experimental gillnets (Appendix XII). Abundances for species taken only by gear other than gillnets is based upon author recollection, taking into consideration the effort involved. The discussions which follow for the various species will be handled by taxonomic family groups in a manner similar to that of Holden and Stalnaker (1975a).

Cyprinidae

Roundtail chub--(*Gila robusta* Baird and Girard).

According to Holden and Stalnaker (1975a), the roundtail chub historically has been the dominant native carnivore of tributaries in the Colorado basin. Jordan (1891) reported *G. robusta* as common to the foot of the mountains and noted it ascends streams farther than its close relative, the bonytail chub, *Gila elegans*, proposed as endangered by U.S. Department of the Interior (federal list) and recognized as endangered by the Colorado Division of Wildlife. Jordan (1891, p. 27) reported the capture of only one *G. elegans* (bonytail) in the Gunnison River at Delta and further noted that his other *Gila* specimens taken from the Gunnison evidently corresponded to *Gila robusta*, the roundtail chub. Jordan also suggested that *G. elegans* was found lower down in the Colorado basin than *G. robusta*. Historically, much confusion regarding the taxonomy of the *Gila* chubs subsequently developed. For example, Ellis (1914) synonymized *G. elegans* with *G. robusta* and later Miller (1946) placed *G. elegans* as a subspecies of *G. robusta*. It was not until recently (Holden and Stalnaker 1970) that *G. elegans* and *G. robusta* were again recognized as two distinct species.

Although Holden and Stalnaker (1970, p. 411) only examined 16 *Gila* chubs from the Colorado River in Colorado, including its tributary, the Gunnison River, all of these specimens were found to be *G. robusta*. Ellis (1914, p. 57), however, reported capturing *Gila* chubs, in the Colorado River near Grand Junction, that fit the early description of *G. elegans*. Recent sampling in 1971 by Holden and Stalnaker (1975a) in the upper Colorado and lower Gunnison rivers revealed only *G. robusta*, the roundtail chub. According to characteristics described by Holden and Stalnaker (1970, p. 415), all of the approximately 500 *Gila* chubs taken from the Gunnison River above Escalante Creek during the present study were definitely the roundtail chub, *Gila robusta*. Consequently, it appears almost certain that the small (less than 4 in.) specimens reported by Wiltzius (1966) as *G. robusta elegans*, and taken just above the North Fork of the Gunnison River, were actually the roundtail chub, *G. robusta*. Furthermore, the four *Gila* chubs taken above there by Kinnear and Vincent (1967) in the lower National Monument, were correctly reported as *G. robusta* but were referred to as "bonytails", the common name used at that time by the American Fishery Society for *G. robusta*. It should also be noted however, that the American Fishery Society Special Publication No. 2, 1960, did not recognize *Gila elegans*, which could have been why Kinnear and Vincent (1967) used *G. robusta*. The common name, bonytail, presently is used to denote *G. elegans*. Despite the confusion, the *Gila* chubs now present in the Gunnison River above Escalante are *G. robusta*, the roundtail chub, and likely have been almost all of that species since 1889.

The farthest upstream any *Gila* chubs have been taken in the Gunnison River is Sapinero, Colorado in 1954. The chubs were not identified but they likely were roundtail chubs since the only record of *G. elegans* for the Gunnison River is the one specimen reported by Jordan (1891). In any event, chubs of either species historically were quite rare above the National Monument. Chubs have never been collected in the Curecanti reservoirs and none were taken in the National Monument during this study. Roundtails were captured, however, about 1.5 mi below the Monument near Chukar trail and in all sections below there. They tend to get consistently more abundant downstream. Natural reproduction was found primarily in backwaters and irrigation channels below the North Fork junction. Roundtail chubs slightly over 18 in. in total length were taken in gillnets during this study. One specimen over 20 in. long was taken by a fisherman in the Delta area in the early 1970's and was identified by Dr. Robert Behnke of Colorado State University as *Gila robusta*.

Although there probably has been a slight downstream recession in the distribution of *G. robusta* historically, the abundance of roundtails in most sections below the National Monument does not appear to have been adversely affected by the Curecanti dams. Roundtails may even be more abundant now than they were prior to the reservoirs. Of 1,171 small fishes seined by Dr. John Greenbank in a side channel near the North Fork junction in October 1943 (Hubbs and Hubbs 1947), only 1.6 percent were roundtail chubs, whereas 17.5 percent of 1,363 small fish seined in this same general area in October-November 1975 were roundtail chubs. Dr. R. R. Miller, curator of the University of Michigan Museum of Zoology in 1962, compiled a list of all Gunnison drainage fish collections in the museum at that time. This list contains species, collection numbers, localities, and year of capture. Although all of these fish collections from the Gunnison River were made at or below the North Fork junction, and most were taken between 1941 and 1952, which is of limited historical significance, one can be certain the fishes were identified correctly.

Colorado squawfish--(*Ptychocheilus lucius* Girard)

The Colorado squawfish is the largest native fish found in the Colorado River drainage and is now considered both a federal and state endangered species. Early settlers in Arizona, Utah, and Colorado observed large springtime migrations of squawfish and humpback suckers into small tributaries and irrigation ditches of the Colorado River. Some of these fish were eaten by the settlers and the surplus was pitchforked into fields for fertilizer (Johnson 1976). Squawfish were reported by Jordan (1891) as generally common in the upper Colorado River system and were said to reach a weight of 80 lbs or more. Jordan captured specimens in 1889 from the Gunnison River at Delta as well as in the Uncompaghre River, a tributary entering the Gunnison River below Delta. Early authenticated reports of squawfish in the Gunnison River during the 20th century are scarce because few reputable collectors made samplings in the lower Gunnison drainage prior to 1941. No reports of squawfish above the Delta area are known. Fisherman reports, although likely reliable for squawfish specimens over 21 in., are primarily unreliable for smaller sizes. Ellis (1914) mentioned that fishermen in the Grand Junction area were calling small roundtail chubs "squawfish". Many fishermen in the Delta area today return roundtail chubs to the river for fear of and/or in the belief that they have caught an endangered squawfish.

Although Ellis (1914) made fish collections in the Colorado River at Grand Junction and in the lower Gunnison River just above Grand

Junction, and in the Uncompaghre River near Montrose during early August of 1912, he apparently did not collect any squawfish. He certainly did not preserve any squawfish specimens from those collections, or they would have appeared in his list of Colorado specimens on page 55.

During an interview in 1977, Dr. Greenbank told me that he could not recall ever seeing or catching a squawfish when he was a boy and extensively fished the Uncompaghre River in the 1913-1920 period. Furthermore, he only collected one squawfish specimen (U.M.M.Z. No. 136920) in 1941 from Roubideau Creek below Delta out of perhaps 2,000 fishes that he seined from the Gunnison drainage in the early 1940's. The lower 0.5 mi of Roubideau Creek was recently electrofished but no fish of any kind were seen.

That some squawfish have been taken from the Gunnison River by fishermen and by a small commercial fishery has been documented. All confirmed historical reports of squawfish in the Gunnison drainage during the 20th century however, were large specimens, which may suggest that most of these fish likely were spawning migrants from the Colorado River. Chamberlain (1946) mentions that one squawfish was reported taken recently from the lower Gunnison; it was said to be over 5 ft long and to weigh over 70 lbs. An authenticated report of one squawfish taken from the Gunnison River near Delta during the summer of 1947 is well documented. Bill Lowe of Delta caught a 28-in., 10-lb squawfish containing a 12-in. trout it had eaten. Photographs of both the squawfish and trout appeared in the September 1947 issue of Colorado Conservations Comments, Volume 10, No. 3, p. 19. Kidd (1977) reported that Mr. Ralph Vernon of Delta, Colorado commercially fished the Gunnison River from approximately 1925 to the early 1950's to supply fish for mink food. Mr. Vernon related that squawfish were fairly common in the Delta area of the Gunnison River up to the late 1950's. Lemons (1954), however, captured no squawfish in 1952 when he surveyed the Gunnison River below Delta, but did take some squawfish from the Colorado and Dolores rivers. Mr. Vernon told Kidd (1977) that he had taken 50 squawfish and a large number of "Razorback" suckers from the Gunnison River in one of the better years but Mr. Vernon apparently did not relate how much effort was involved or how many and what kinds of other fishes were captured in any of the years fished. These squawfish likely were a minor fraction of the fish captured from the river. Flannelmouth sucker likely dominated, because Ellis (1914) mentioned that the Colorado Fish Commission was allowing the use of seines by permit for flannelmouth and other species of suckers below the trout streams for supplying a cheap grade of fish for the market. Just how damaging the commercial fisheries were to the squawfish is unknown. Squawfish apparently have been on the decline for many years, even prior to the Curecanti dams, but a temporary build-up in the abundance of squawfish may have occurred in one short period during the 1940's.

The Colorado Conservation Comments article in 1947 mentioned that field reports indicated squawfish were on the increase in Colorado waters and that they may have also been working upstream in recent years. No other information, however, was supplied to qualify and or quantify the authenticity of these reports. For example, one may wonder if the "field reports" were from fishermen, many of whom are known to confuse squawfish and roundtail chubs, or whether the reports were from more qualified Division of Wildlife officers. It has already been suggested that roundtail chubs have tended to increase historically since 1943. If squawfish were increasing in the lower Gunnison drainage during the 1940's, it probably was related to greater numbers of upstream adult migrants from the Colorado River being able to better negotiate the Redlands Dam, a structure constructed in 1907 across the lower Gunnison River about 1.5 mi above Grand Junction.

Between 1930 and 1940 the upper Colorado River basin had undergone an extreme drought, with consequent low flows over the Redlands Dam that may have retarded upstream migration of squawfish into the Gunnison River in the majority of those years (Table 19). Furthermore, the completion of Hoover Dam in 1935 effectively blocked the migration of squawfish from below the dam. However, in the 1941-1947 period over 50 percent of the mean monthly flows in the lower Gunnison River during May, June, July and August were above the 49-yr averages. These above-average flows may have allowed greater numbers of squawfish to migrate from the lower Colorado basin above Hoover Dam into upper basin waters and subsequently into the Gunnison River above Redlands. Upper-basin dam construction and irrigation diversions likely have subsequently reduced the spring and early summer flows in the Colorado River, which may have retarded upstream spawning migrations of squawfish from the lower basin. Below-average spring and summer flows have certainly been prevalent in the lower Gunnison River since 1948 (Table 19). Evaporation loss of the increasing amounts of water being diverted upstream of Grand Junction for irrigation in the Gunnison drainage no doubt has contributed to the historically lower flows at Grand Junction.

Prior to 1947, only one reservoir, Taylor Park, existed in the Gunnison drainage, and it was in the headwaters. In addition, only two major reservoirs existed in the upper Colorado River: Williams Fork Reservoir, which began storing water in April 1939, and Green Mountain

Table 19. Percent of years with mean monthly flow above long-term historic average flow (cfs) in various historic periods for the Gunnison River at Grand Junction.

Historic period	May	June	July	August
1917-1929	84.6	84.6	61.5	53.8
1930-1940	36.4	27.3	18.2	18.2
1941-1947	57.0	57.0	71.0	57.0
1948-1957	30.0	40.0	30.0	20.0
1958-1965	33.3	33.3	27.8	22.2
1965-1974	0	0	22.2	55.6
1917-1965 long-term average (cfs)	8423	8141	2529	1255

Reservoir, which began storing water late in 1942. Shadow Mountain Reservoir, however, began storing water in April 1947, and dam building greatly accelerated after this; there are now 15 major reservoirs in the Gunnison and other upper Colorado River drainages upstream of Grand Junction. It is seen in Table 19 that above-average flows in the 1948-1965 period, prior to Curecanti, were less frequent than those during the 1941-1947 period when squawfish were thought to be increasing. Consequently, low flows may have contributed to the scarcity and/or decline of squawfish prior to Curecanti. Furthermore, the lower-basin Glen Canyon Dam (1963) has no doubt prevented squawfish from sections below the dam from migrating into upper-basin waters. Between 1965 and 1974 (after Curecanti), no above-average flows have occurred during May or June in the lower Gunnison River, and in only two (22.2%) of the years did above-average flows occur in July. Upstream migrations of squawfish are thought to be over by August.

It was not surprising, therefore, that talks with fishermen and trappers in the Delta area in 1975 revealed they had not caught or seen any squawfish in recent years; the last one was a specimen of about 8 lbs, taken in 1965 by rod and reel in the Escalante Wildlife Area of the Gunnison River below Delta. The runoff at Grand Junction in 1965 was extremely large, being exceeded by only 5 of the 49 yrs since 1917. Holden and Stalnaker (1975a) reported squawfish as rare in 1971 below Delta, but they did not mention how many specimens they captured or where they were taken. In the appendix of the Colorado Squawfish Recovery Plan draft of August 1977, Dr. Paul Holden related to Dr. James Johnson in a letter dated August 28, 1976 that one squawfish was captured and tagged and two other rather large (6-10 lbs) specimens were observed in the lower Gunnison River between the Highway 141 bridge and the mouth of the river on July 21, 1971. No squawfish have been taken above Escalante, the lowest area sampled during the present study, and none were taken by Kidd (1977) who was specifically looking for this species in the Gunnison River below Delta during 1976.

In addition to sub-normal spring and summer flows over the Redlands Dam, it may be that recently slightly-lower water temperatures in the lower Gunnison River as a result of Curecanti dams may have prevented the squawfish of the upper Colorado River from entering the Gunnison River. Some recent captures of the endangered squawfish, in any event, have been made in the upper Colorado River near Grand Junction (Kidd 1974, 1977; McAda 1977).

Probably as a result of the most recent known captures of squawfish (1971) being below the Highway 141 bridge near Whitewater, the U.S. Fish and Wildlife Service recommended in 1977 that the approximate 12 mi of the Gunnison River between this bridge and the river's confluence with the Colorado River at Grand Junction be designated as critical habitat for the Colorado squawfish. Although the discussion above implies that the historical decline of squawfish in the Gunnison River is somewhat correlated to low flows preventing spawner access from the Colorado River into the Gunnison, low flows may have also prevented the establishment or access of young squawfish into limited backwater nursery areas where squawfish have likely been subjected to increasing competition for food and space from the many exotic fishes that have been introduced since 1900. If this is true, then, presently, critical habitat for squawfish likely is backwater areas that are connected with the main river at low flows and not necessarily where adult squawfish are captured in the main river. The stocking of squawfish into such backwater areas, especially if of predatory sizes (greater than 8 in.), may be the most rapid means for the recovery of the Colorado squawfish. Backwater areas lacking catfish and bullheads should be preferred because these fish have sharp spines that could become lodged in the pharnyx or esophagus of the squawfish, causing suffocation or starvation. Some backwater areas in the presently proposed critical habitat section of the Gunnison River are known to contain both bullhead and catfish.

In 1977, about 100 small squawfish specimens from a federal hatchery in Arizona were transferred to Hotchkiss National Fish Hatchery for rearing. This hatchery is located a few miles upstream of the North Fork junction on the north bank of the North Fork of the Gunnison River, south of Lazear, Colorado.

Speckled dace--(*Rhinichthys osculus* Girard)

This species is native and is found throughout the Gunnison drainage. Jordan (1891) captured speckled dace near Gunnison and at Delta. Pratt (1937) also found them in the Gunnison area. They are presently found in the drainage above Gunnison but appear to be more abundant below the North Fork junction. Historically, speckled dace were found in all river sections where the Curecanti reservoirs now exist, but are not now found in those reservoirs. They still persist in river sections above and below the reservoirs, being easily captured in their favored backwater and riffle areas with slow-moving current.

Longnose dace--(*Rhinichthys cataractae* Valenciennes)

The introduced longnose dace was not reported for the upper Gunnison drainage by Wiltzius (1966). Shortly after I wrote the 1966 paper, longnose dace specimens were captured in North Beaver Creek, at the upper end of Blue Mesa Reservoir, and from lower Tomichi Creek during August 1966. Unfortunately, none of the fish specimens from the pre-impoundment collections were saved and I failed to report this species in any of my subsequent papers. Longnose dace were, however, reported from North Beaver Creek by Middleton (1969) on the basis of our earlier collection in 1966, but he also did not preserve any of the 14 dace specimens he collected there. Just recently, in storing pre-impoundment bottom-sample collections, I found one dace specimen in a North Beaver Creek sample dated August 28, 1966. Dr. Robert Behnke of Colorado State University has verified that it is in fact *R. cataractae*, and he told me it likely represents the only verified record of longnose dace in the Colorado River basin. Vincent (1966) reported capturing longnose dace from the National Monument in 1965 but failed to report it in the final report of that study (Kinnear and Vincent 1967). I failed to capture longnose dace in or below the National Monument during the recent studies, so it likely was not very abundant that far downstream in the Gunnison River. A probable erroneous report of longnose dace, as well as *Pantosteus platyrhynchus*, for the North Fork of the Gunnison near Hotchkiss National Fish Hatchery can be found in the storet system, Bureau of Sport Fisheries and Wildlife Water Quality Monitoring Program, for 1971 sampling, which failed to capture the native speckled dace and bluehead sucker which are abundant there. Longnose dace still are found above Blue Mesa Reservoir but not in any of the Curecanti reservoirs. In North Beaver Creek, longnose dace may be more abundant than the native speckled dace.

Fathead minnow--(*Pimephales promelas* Rafinesque)

The introduced fathead minnow, now numerically the most abundant fish taken in most seine hauls in the Gunnison River backwaters below the North Fork, was not represented in the early fish collections by Jordan (1891), Ellis (1914), Pratt (1937, 1938), Feast (1932), and Hubbs and Hubbs (1947) in the Gunnison drainage. Probably the earliest report that fathead minnows had been introduced into the upper Colorado River system is that of Hubbs, Hubbs and Johnson (1943), who described taking this species in a collection containing a particular sucker hybrid in the headwaters of the Colorado River at Hot Sulphur Springs, Colorado. Although they did not mention the exact date of this collection, it was deduced from their account that it was U.M.M.Z. No. 105638, described on page 39 of their paper as a seining collection on July 28, 1938.

The earliest capture of fathead minnows in the Gunnison drainage probably was in 1952. Nine specimens were collected that year from Kannah Creek, a tributary to the lower Gunnison above Grand Junction (U.M.M.Z. collection No. 163905). Furthermore, Lemons (1954) reported collecting fathead minnows in 1952 from all sections of the Colorado River between Rifle and the Colorado-Utah state line and in the Gunnison River below Delta. He further described derrising 7,500 minnows (mostly fatheads) from one small 60x15-ft bay in Hart's Basin (Fruitgrowers Reservoir) in Delta County south of Eckert, Colorado. Overflow and irrigation releases from this reservoir no doubt empty at times into the Gunnison River near Austin, Colorado. The reservoir, according to Lemons, was stocked in 1952 with bass from an unmentioned source and with channel catfish from the Dolores River. Hart's Basin Reservoir had been previously stocked with walley and black bass, but he did not say from when and where they came. He did note that black bass from Las Animas Fish Hatchery (East Slope) were stocked in 1952 in Onion Valley Reservoir, south of Crawford, Colorado. That same year, Payne Siding Reservoir, between Austin and Hotchkiss, Colorado was also stocked with bass. Many of the warmwater rearing ponds at Eastern Slope state hatcheries contain species other than those specifically being reared. In the early 1920's, many private individuals and towns received consignments of warmwater fish species, presumably from the Division of Wildlife East Slope Hatchery at Denver. As early as 1921, Shoshone Reservoir near Glenwood Springs in Garfield County received a consignment of 1,500 bass. Butterfield Lake in Montrose County and Lucas Lake in Garfield County were stocked with yellow perch in 1922, as were city lakes and Connecticut Lake in Mesa County, Harvey Gap Reservoir in Garfield County, and Spring Creek in Montrose County, all during 1925. In 1926, Hart's Basin Reservoir in Delta County received a consignment of 10,000 5.5-in. perch, as did Bell's Sloughs in Montrose County. Consequently, it appears that stockings of this sort could have been instrumental in the early establishment of the now numerous number of Eastern Slope species present in the Gunnison and other drainages on the Western Slope. During the summer of 1965, this author personally witnessed the stocking of many white suckers into the Gunnison River between Almont and Gunnison by one of the Game and Fish Department hatchery trucks that was making a plant of catchable-sized rainbow trout.

Regardless of how and when fathead minnows were introduced, they were frequently taken in seine hauls in backwater areas of the Gunnison River below the North Fork and occasionally as far upstream as Iola in 1965, prior to the closure of Blue Mesa Dam. None, however, were found in 1965 or 1966 by Kinnear and Vincent (1967) in the National Monument section, a condition which still persists today. The lack of fatheads in this section is difficult to explain, since they were quite abundant above there, especially in Blue Mesa Reservoir during the first few years of its fillings and also below the Monument. It may be that sparsity of backwater areas, along with swift water, have prevented fatheads from establishing populations in the Monument section. One might theorize that the lower summer stream temperatures since the Curecanti Unit has been in operation has been their primarily limiting factor, but one may then wonder why fatheads did not establish populations in the Monument when summer temperatures were considerably higher, before the Unit was in operation.

Observations made on spawning fathead minnows during the early years of Blue Mesa Reservoir indicated that the females were depositing their egg masses primarily on the undersides of floating logs and debris and on submerged sagebrush along the shore. Fathead were extremely abundant in Blue Mesa through 1970; since then they have steadily declined. This decline may have been caused by deliberate clearing of the floating debris and/or a decrease of such debris due to its deposition at highwater line in 1973, the last year the reservoir had attained maximum water level. Certainly, the above phenomenon is related to the cover protection that the debris and sagebrush initially supplied. The sagebrush also has disappeared since 1970 due to rotting and uprooting caused by shoreline ice-sheets moving when the reservoir was drawn down during the winter and early spring.

Carp--(*Cyprinus carpio* Linnaeus)

At least 17 shipments of carp, numbering between 15 and 500 fish, were delivered to East Slope Colorado residents in 1879 (U.S.F.C. report for 1882), but exactly when they were introduced into the upper Colorado or Gunnison drainages is unknown. Jordan (1891) captured no carp in 1889 at Gunnison or Delta but mentioned that a number of carp ponds existed in the state of Colorado. Of the 188 fish captured on August 7 and 8, 1912 in the Colorado River near Grand Junction by (Ellis 1914), 137 (72.9%) were carp, 33 (17.5%) were chubs, 10 (5.3%) were goldfish, 5 (2.7%) were flannelmouth sucker, while 3 (1.6%) were humpback sucker. Only 13 fish specimens were taken by Ellis in the Gunnison River above Grand Junction, and they were all flannelmouth suckers. No carp were collected in the extensive seining collections around Delta in the early 1940's by Dr. John Greenbank. Lemons (1954), however, found carp during 1952 in all sections of the Colorado River between Rifle and the state line and in the Gunnison River below Delta. Furthermore, he gillnetted them in Hart's Basin Reservoir (0.24 CPNH), upstream of Delta near Eckart. By the mid 1960's, carp were quite abundant below the North Fork, in the Austin area. Presently, carp can be found in all Gunnison River sections below the Smith Fork. They tend to be most abundant lower in the river but do not appear to be as abundant as they were in the mid-1960's, prior to Curecanti in sections above Delta. Most of the specimens taken were large (up to 5 1/2 lbs), with only a few young-of-the-year specimens taken during the extensive seining collections late in 1975. However, young-of-the-year carp were more frequent in seine collections above Delta during 1977, when stream flows were lower and water temperatures were higher than in 1975.

Red shiner--(*Notropis lutrensis* Baird and Girard)

Shiners of any species are totally lacking from every fish collection known to have been made prior to the 1950's in either the Gunnison drainage or the upper Colorado River. Lemons (1954) appears to be the first to report capturing shiners, viz., common shiner, *Notropis cornutus frontalis*, from the Colorado River at Grand Junction, and an unidentified species of shiner from the Dolores River in 1952. He did not capture any shiners from the Gunnison River below Delta, but mentioned that further survey work would no doubt add a great many species to the four (rainbow trout, white sucker, fathead minnow, and carp) that he actually took or checked from this river. In 1966 or 1967, I seined shiners, killifish, and sunfish in the Gunnison River just below Delta but did not identify nor preserve the specimens. They were captured in a backwater area just upstream of the 5th Street Bridge below Delta on the south side of the River.

It may be that the common shiner reported by Lemons (1954) is in error, since all subsequent collections (Holden and Stalnaker 1975a, 1975b; Kidd 1974, 1977; and present study) found red and sand shiners, but not common shiners. Kidd apparently uses an erroneous common name of "redfin" shiner to denote red shiners. Neither of these names should be taken to denote the redside shiner, *Richardsonius balteatus*, which is found in the Yampa and Green River systems.

According to Li (1968), common shiners are found only in permanent streams which are clear and relatively unpolluted. The Colorado River near Grand Junction is usually very turbid habitat. Consequently, it appears likely that the common shiners of Lemons probably were red shiners, since red shiners have a body shape more similar to that of common shiners than that of sand shiners. If the Colorado River specimens were, in fact, red shiners, it appears to follow that the unidentified shiners found in 1952 by Lemons (1954) in the Dolores River were sand shiners, since he would have called them common shiners if they were like those he had collected that same year from the Colorado River. Holden and Stalnaker (1975a), speculating on the abundance of red shiners in Lake Powell and the upper Colorado River, believed that the most probable explanation was an introduction near Grand Junction in the late 1950's or early 1960's, with subsequent downstream movement. From the above discussion it now appears that red shiners likely were already well established in the upper Colorado River as early as 1952.

In the present study, red shiners were captured in backwater areas from the Gunnison River near its confluence with Escalante Creek, near Roubideau Creek, in several areas around the 5th Street Bridge below Delta, and just above Delta near the Delta sand and gravel pit, with almost 75 percent of the specimens coming from the latter site. Despite their abundance near this pit, no red shiners were taken from the Gunnison River above there. Kidd (1977) reported capturing red shiners in all sections of the Gunnison River below Escalante Creek in 1976 and considered them abundant but, as noted above, used the erroneous common name "redfin" shiner.

Sand shiner--(*Notropis stramineus* Cope)

Holden and Stalnaker (1975b) gave themselves credit for first reporting this species in the upper Colorado basin from collections made in 1971 in the Dolores and Colorado rivers. The possibility that sand shiners may have been captured from the Dolores River as early as 1952 has already been mentioned in the red shiner section above. Furthermore, it is equally possible that sand shiners were inadvertently introduced into the Gunnison drainage with the channel catfish that Lemons (1954) reported were captured in 1952 from the Dolores River and stocked into Hart's Basin and Payne Siding reservoirs above Delta. If not actually stocked in 1952, sand shiners may have been inadvertently stocked soon thereafter, because Lemons recommended that various methods be tried to remove the abundant 8 to 10-in. channel catfish in order to reduce the present population so as to transplant them where they will be more beneficial to recreational fishing.

During the 1975 seining in the Gunnison River, we captured nearly five times more sand shiners than red shiners. They were collected at all areas that red shiners had been and were more abundant than red shiners at every area except the sand and gravel pit area above Delta. Like the red shiner, no sand shiners were taken upstream of this gravel pit. It's likely that a diversion dam a short distance above the gravel pit area prevents further upstream movement. Sand shiners were extremely abundant in one backwater side channel on the north bank of the Gunnison, 2 mi below Delta. Nearly 69 percent of the 473 specimens collected were taken from this area. Talks with some of the landowners in this area revealed that many of their ponds and backwater areas had recently (within the last 10 yrs) been privately stocked with game fish and "minnows" from ponds in the Denver area and/or a variety of West-Slope sources. Kidd (1977) reported sand shiners abundant in all sections of the Colorado River except in the Rifle-Plateau section, where they were common. It is interesting to note that Holden and Stalnaker (1975a) did not capture sand shiners in the Gunnison River during 1971. Langlois (1977) erroneously referred to sand shiners as *Notropis lutrensis*, which is the scientific name for the red shiner.

Catostomidae

Historically, the catostomids (suckers), primarily members of the genus *Catostomus*, have comprised the majority of fishes collected from the Gunnison River in most sections, constituting in many cases more than 95 percent of all fishes. According to Smith and Koehn (1971), throughout much of the North American range of *Catostomus*, two, and occasionally three phenetically divergent kinds of suckers may be found together. Originally, the suckers found in the Gunnison River were the endemic species of the upper Colorado River: flannelmouth, bluehead, and humpback.

Due to the introduction of two East-Slope sucker species, white and longnose, the Gunnison River now has four species found together in some sections. Beacuse of various factors such as common hybridization between unlike forms, the lack of sympatry between similar forms, and the phenetic continuity through the genus, Smith and Koehn (1971) suggested that the biological species concept, as usually defined, may not strictly apply within this group. Despite this, data will be presented and discussed separately for each "species" as well as for each hybrid form that has been found.

Flannelmouth sucker--(*Catostomus latipinnis* Baird and Girard)

Historically, this species appears to have been the most abundant sucker taken from the Gunnison River below Delta. The only known collection in this area that flannelmouth did not dominate was that of Lemons (1954), who reported capturing only white suckers in 1952. He may have misidentified these suckers, since the 1952 collection from Kannah Creek on file at the University of Michigan Museum of Zoology contained no whites but did contain nine flannelmouth, five bluehead, nine roundtail chubs, nine fathead minnows, and one speckled dace. Furthermore, the Lemons report on the distribution of flannelmouth and white sucker in the Colorado River between Rifle and the state line does not appear to agree with other collections. For example, all other detailed collections made in this area show flannelmouth as the dominant sucker, while Lemons reported taking white suckers throughout the entire section and flannelmouth only at Clifton.

Prior to the completion of Taylor Park Reservoir in 1937, flannelmouth suckers had been captured by Pratt (1938) as far upstream as the Gunnison River section between Gunnison and Almont. Flannelmouth suckers made up 40 percent there, compared to 60 percent bluehead suckers, the only other sucker species found at that time above the Black Canyon. Of 780 suckers taken by Pratt from Tomichi Creek, 107 (14%) were flannelmouth suckers and 86 percent were bluehead suckers, percentages which he felt were also typical of the suckers in the Gunnison River section above Black Canyon but below Gunnison. Although Pratt (1938) mentioned that suckers were scarcer above Gunnison than below, he did not mention how far upstream they were found in the drainage. In this regard, Chamberlain (1946) pointed out that old-time residents of Taylor Park insisted that before Taylor Park Reservoir was built in 1937 there were no suckers at that point of the Taylor River or above. Conversely, Dr. C. E. Hagie noted that he had taken suckers opposite the old site of Dorchester and on upper Texas Creek before the construction of Taylor Dam (Colorado Conservation Comments, 1946, Vol. 9, No. 2, p. 20).

All known collections in Taylor Reservoir have been dominated by white suckers, with some longnose suckers.

Flannelmouth suckers in the Gunnison River above Black Canyon apparently declined rapidly after the construction of Taylor Park Reservoir, because only a few specimens were collected in 1964 and 1965 prior to closure of Blue Mesa Dam. Since then, no authenticated flannelmouth sucker specimens have been taken in or above the Curecanti reservoirs. In these reservoirs, only white and longnose suckers are found, with whites dominating in Blue Mesa and Morrow Point and longnose dominating in Crystal Reservoir. Flannelmouth suckers were, however, still well-represented in the National Monument in 1965, when 102 (27.5%) of the suckers taken were of this species (Table 20). As with their disappearance above Black Canyon after construction of Taylor Park Dam, flannelmouth suckers appear to be disappearing rapidly from the National Monument, because only four specimens (1.5% of the suckers) have been taken in 1975-1977. All specimens here were large, indicating no reproduction in recent years. In Table 20 it can also be seen that flannelmouth suckers in the section just above the North Fork (Ute to North Fork) recently made up only 8.35 percent of the suckers, in contrast to 22.5 percent in collections made prior to Curecanti dams. Flannelmouth sucker reproduction is occurring in this section, but young-of-the-year flannelmouth suckers are not as abundant as those of white and bluehead suckers. Comparative composition data are not available historically for the Gunnison Gorge (Monument to Ute trail section). since this study represents the first time collections have been made in this area.

Table 20. Composition comparison for the sucker species taken in various years pre- and post-Curecanti Unit in different sections of the Gunnison River below the dams and above the North Fork junction.

	Pre-Curecanti						Post-Curecanti								
	1943		1966		Grand total		1975		1976		1977		Grand total		
	No. fish	% fish	No. fish	% fish	No. fish	% fish	No. fish	% fish	No. fish	% fish	No. fish	% fish	No. fish	% fish	CPNH
Ute to North Fork															
White	27	2.4	1	3.2	28	2.4	26	44.1	68	31.9	31	49.2	125	37.3	.37
Bluehead	841	73.9	25	80.6	866	74.1	23	39.0	82	38.5	7	11.1	112	33.4	.33
Flannel	258	22.7	5	16.1	263	22.5	10	16.9	7	3.3	11	17.5	28	8.35	.08
Longnose	0		0		0		0		15	7.0	2	3.2	17	5.1	.05
Hybrid	12	1.0	Not attempted		12	1.0	Not attempted		41	19.3	12	19.0	53	15.8	.16
Total no.	1,138		31		1,169		59		213		63		335		1.16
No.nets set	--seining---		--shocking--				3		8		5		16		
Hours							43.5		173		120		336.5		
National Monument to Ute Trail															
White									23	41.8	45	40.9	68	41.2	.48
Bluehead									20	36.4	35	31.8	55	33.3	.39
Flannel											6	5.5	6	3.6	.04
Longnose									11	20.0	16	14.6	27	16.4	.19
Hybrid									1	1.8	8	7.3	9	5.5	.06
Total no.									55		110		165		1.16
No.nets set									5		5		10		
Hours									51.5		90		141.5		
National Monument	1965														
White	153	41.2	30	19.2	183	34.7	12	37.5	8	6.5	30	25.4	50	18.2	.10
Bluehead	116	31.3	68	43.6	184	34.9			19	15.3	25	21.2	44	16.1	.08
Flannel	102	27.5	21	13.5	123	23.3	2	6.3	1	0.8	1	0.9	4	1.5	.01
Longnose	0		0		0		18	56.2	91	73.4	53	44.9	162	59.1	.31
Hybrid			37	23.7	37	7.0			5	4.0	9	7.6	14	5.1	.03
Total no.	371		156		527		32		124		118		274		.53
No.nets set	---Unknown---						6		10		11		27		
Hours	---Unknown---						91		192		235		518		
Grand Totals															
White					211	12.4	38	41.8	99	25.3	106	36.4	243	31.4	.24
Bluehead					1,050	61.9	23	25.3	121	30.9	67	23.0	211	27.3	.21
Flannel					386	22.8	12	13.2	8	2.0	18	6.2	38	4.9	.04
Longnose					0		18	19.8	117	29.9	71	24.4	206	26.6	.21
Hybrid					49	2.9			47	12.0	29	10.0	76	9.8	.08
Total no.					1,696		91		392		291		774		.78
No.nets set							9		23		16		48		
Hours							134.5		416.5		445		996		

The reported number of the principal dorsal fin rays for flannelmouth suckers seem to have slightly increased historically. Jordan (1891) noted that the dorsal rays were usually 11, and sometimes 12 or even 13. Ellis (1914) reported they were usually 11 or 12, ranging to 14, while more recently Hubbs and Miller (1953) found that 90 percent were either 12 or 13 but ranging between 10 and 14. My current data agree with the latter. Whether this slight increasing trend was due to differences in counting techniques or to possible hybridization with humpback suckers is unknown. The humpback sucker is the only upper Colorado River basin sucker that has dorsal ray counts higher (14-16) than those of flannelmouth suckers.

Bluehead sucker--(*Catostomus discobolus* Cope)

The endemic bluehead sucker certainly was the most abundant sucker in the Gunnison drainage above Delta prior to 1937, and likely for some time thereafter. This species comprised 79.3 percent of 357 suckers collected by Ellis (1914) during 1912 in the Uncompaghre River at Montrose, 73.9 percent of 1,138 suckers collected at the North Fork junction area in 1943 (Hubbs and Hubbs 1947), 86.3 percent of 780 suckers taken by Pratt (1938) from Tomichi Creek near Gunnison in the 1930's, and 60 percent of the few suckers also taken by Pratt from the Gunnison River above Gunnison. It has already been mentioned that Pratt considered the composition then found in Tomichi Creek as typical for the Gunnison River section from Sapinero upstream to the confluence of the Tomichi. In one 250-yd Gunnison River study section above the Tomichi confluence, Pratt (1937) observed 800-1,000 suckers, in contrast to 321 trout that actually diminished to 176 due to 74 days of fishing before the study was completed on Sept. 12, 1934.

In 1954, a Division of Wildlife crew shocked 11 sections of the Gunnison River during late July and early August between Sapinero and Almont, but unfortunately they did not specifically identify the suckers. The only published record of this work was that of Weberg (1954) and was concerned only with the small trout taken. Despite the fact that the suckers were not specifically identified, examination of the raw data sheets from the 11 sections indicated that suckers were captured only in main river sections located more than 2 mi below Gunnison. None were taken where Pratt (1937) had observed 800-1,000 suckers over 4-in. in 1934. Very few suckers were taken from this area or above in 1964 and 1965. Apparently the upstream abundance of suckers in the Gunnison River had receded historically between 1934 and 1965 and was likely due to coldwater releases from Taylor Park Reservoir.

Wiltzius (1966) erroneously reported bluehead suckers as common above Black Canyon in 1964-65. These suckers were longnose or bluehead x longnose hybrids. A few specimens were taken which Middleton considered flannelmouth x white hybrids. No bluehead suckers have been taken anywhere in the upper Gunnison drainage above Blue Mesa during the 1970's, and the lower Tomichi Creek, where Pratt had observed 86 percent bluehead suckers in the 1930's, was again sampled. There, only longnose and white suckers were found. The farthest upstream a bluehead sucker was taken in the Gunnison River during the present study was immediately below Morrow Point Dam in 1973. Some bluehead suckers were shocked from the Cimmaron River in 1974. None were taken from Crystal Reservoir during its initial sampling in 1977, as has been the case in all sampling at Blue Mesa (1966-1973) and Morrow Point reservoirs (1971-1977). Apparently, bluehead suckers rapidly disappeared from the upper Gunnison

River drainage in the historic time period after completion of Taylor Park Reservoir in 1937, a time also associated with the likely introduction and subsequent expansion of the two East-Slope species (white and longnose suckers).

In Table 20 it can be seen that bluehead suckers are still abundant below the Curecanti reservoirs, but they no longer appear to be the dominant sucker species that they once were in these sections. Currently, longnose suckers dominate in the National Monument and white suckers dominate the other two sections. Of the three river sections shown in Table 20, bluehead suckers are presently most abundant in the section below the National Monument but above the Ute Trail, as reflected by its 0.39 CPNH there compared to 0.08 in the National Monument and 0.33 in the Ute-to-North Fork section. Overall, suckers presently are of less abundance in the National Monument (0.53 CPNH) than in the two lower Gorge sections (1.16 and 0.99 CPNH, respectively). This phenomenon is likely due to the Monument's proximity to coldwater releases from the Curecanti reservoirs. Such releases from Taylor Park Reservoir were thought to have caused sucker recession earlier in the Gunnison River above Gunnison. Edwards (1978), working primarily with non-salmonid species in the Guadalupe River above and below Canyon Reservoir in Texas, reported that coldwater releases from this reservoir were likely responsible for reduced fish biomass (413 g per collection below the reservoir, compared to 848 g above the reservoir).

According to Holden and Stalnaker (1975a) the bluehead sucker is polymorphic in the Colorado River system, with slender- and deep-peduncled forms present. The slender type is thought to be adapted for swift-water areas (Miller 1946; Smith 1966). Holden and Stalnaker collected both of these forms, as well as intermediates, at most areas, but reported that the deep-peduncled forms were most common in the upper, colder parts of the basin while the slender forms were most common in the middle sections. In the Gunnison River, bluehead suckers with slender peduncles were most common in the swift, upper stretches of the Gunnison Gorge above the North Fork (peduncle depth $\bar{x}$=5.0% of total length) while the deep forms were more common below there where the velocity of the river moderates ($\bar{x}$=5.7% of total length). Similarly, isthmus width measurements (between the ventral corners of the gill apertures) followed the same trend, since those taken from bluehead suckers in the Gorge area were highly significantly less ($\bar{x}$=6.0% of total length) than those ($\bar{x}$=8.1% of total length) taken below the North Fork. Polymorphic isthmus widths have not been reported in the literature for this species, and if slender isthmus widths are unrelated to the hydraulic efficiency advantage as suggested for slender peduncles, the slender isthmus form is most likely the result of introgressive hybridization between bluehead suckers and species with slender isthmus widths, such as white, longnose, and flannelmouth suckers. The bluehead sucker (subgenus *Pantosteus*) actually has the widest isthmus width of any sucker found in the Gunnison River, regardless of sampling locality.

Smith (1966) reported that the most interesting aspect of the variation in isthmus width is the possible correlation between variability and known hybridization. He continued, for example, in samples where hybrids between *Catostomus* and *Pantosteus* are unknown the variation in isthmus width is usually low, but, by contrast, in areas where hybridization is known populations usually show greater variation. Isthmus measurements taken from bluehead and white suckers of the Gunnison drainage conform to the above quite nicely. For example, in Morrow Point Reservoir, where bluehead suckers are not presently found, isthmus widths on white suckers average 3.0 percent of total length (S.D.=.51). Where the two species are commonly found together above the North Fork, the isthmus of white suckers averages 3.6 percent of total length (S.D.= 1.0), and where they are rarer below the North Fork the isthmus averages 3.2 percent (S.D.=.58). In this lower section, by contrast, the isthmus width of bluehead suckers averages 8.1 percent (S.D.=.53), but above the North Fork where the two species are both abundant the isthmus width of bluehead sucker is only 6.0 percent of total length, with a standard deviation of 1.0. It is also in this same section of the Gunnison River that the bluehead x white hybrid is most commonly found.

Plains mountain sucker--(*Catostomus platyrhynchus* Cope)

The plains mountain sucker, none of which were taken in the present study, apparently was quite rare historically in the upper Colorado River drainage, since only a few substantiated records of this species exist. Smith (1966) reported that one specimen was found in a series of bluehead suckers collected by the D. S. Jordan party, probably in 1889 at Delta, Colorado, but he also noted the likelihood of transposition which would render the unique sample questionable. The only other locality that Smith reported for this species in Colorado was from Piceance Creek, a tributary to the White River, where specimens were collected by R. R. Miller in 1960. In addition, Smith (1966) apparently questioned the validity of *Pantosteus jordani*, a synonym of *Catostomus platyrhynchus*, reported by Beckman (1952) to occur in the South Platte drainage, because a specimen collected from this drainage by the Colorado Game and Fish

Department in 1950, and likely identified by Beckman, was reidentified by Smith as *Catostomus plebeius*, the Rio Grande mountain sucker. Smith concluded that the specimen was probably the result of an introduction. Consequently, I wonder if the *Pantosteus jordani* (=*C. platyrhynchus*), collected in 1949-50 from Green Mountain Reservoir in the upper Colorado River drainage and reported by Nelson (1955) to be the most abundant sucker species there, was in fact this species. The large size of those specimens (more than 50% greater than 12 in.) would suggest they were probably bluehead suckers, since the plains mountain sucker seldom exceeds a length of 8.5 in. (Sigler and Miller 1963; Smith 1966). Conversely, the occurence of *C. platyrhnychus* in lakes, although rare according to Smith (1966), is perhaps more common than for other species of the subgenus. As mentioned above, this species was erroneously reported from the North Fork of the Gunnison River near Hotchkiss National Hatchery in 1971. Mr. Clee Sealing of the Colorado Division of Wildlife told me that *C. platyrhynchus* is found in several areas of the northwest region of Colorado.

White sucker--(*Catostomus commersoni* Lacepede)

Historically, the white sucker in Colorado apparently was only native to East-Slope drainages. It was not found in collections in West Slope streams by Jordan (1891), Ellis (1914), and Pratt (1937, 1938). Ellis (1914) reported that white suckers ranged through the western portions of the western tributaries of the Mississippi, east of the Continental Divide. None of the early investigations on West-Slope streams, however, were concerned with collections much above 8,000 ft, which leaves some doubt that so called "East-Slope species" were not present at these higher elevations earlier than is now believed. Just when white suckers were introduced into the upper Colorado drainage is unknown, but it likely was as early as the 1920's. Mr. C. N. Feast and John D. Hart of the Colorado Fish and Game Commission related to Hubbs, Hubbs, and Johnson (1943) that suckers from the Platte River on the East Slope first appeared in the South Mesa Lake country in the Colorado River headwaters about 1926. They thought that these suckers were carried over by bait fisherman, perhaps by Japanese farm laborers, who were brought in about that time. Feast and Hart further suggested that suckers, thought not to be of the native species, have multiplied so fast in the Colorado River waters as to become a problem. The likelihood that white suckers could have been inadvertently introduced in the 1920's with plants of perch and bass, already mentioned in the fathead minnow section of this report, should not be discounted.

There is little evidence that white suckers were multiplying as rapidly as is suggested above, at least during the 1930's, but fish sampling was not too common in that period. Extensive collections by Pratt (1937, 1938), primarily in 1934, failed to capture white suckers in the Gunnison drainage above Black Canyon, but a collection made at Hot Sulphur Springs in the upper Colorado River in 1938 contained five bluehead x white hybrids, which suggested that white suckers had been at least transplanted across the Continental Divide. No white suckers, however, were taken in this collection (Hubbs, Hubbs, and Johnson 1943). The first authenticated capture of white suckers in West-Slope waters appears to be U.M.M.Z. No. 136912 of April 21, 1941, containing one white sucker collected by Dr. John Greenbank in Dry Creek, a tributary of the Uncompaghre River, which is a tributary to the Gunnison River. Dr.

Greenbank took eight additional white suckers from this area in 1941 (U.M.M.Z. No. 136924) and Hubbs and Hubbs (1947) reported that Greenbank collected 27 white suckers from a side channel near the North Fork junction in October 1943. As shown in Table 20 the white suckers in this collection comprised only 2.4 percent of all suckers collected. By the mid-1960's, white suckers were still scarce (3.2%) in the North Fork area but were the dominant sucker in all sections above the National Monument.

The apparent rapid build-up of white suckers in the Gunnison River drainage and the upper Colorado River drainage is likely associated with this species' ability to maintain itself and out-compete other suckers in impoundments (Brown 1971). Beside the construction of Taylor Park Reservoir in 1937 in the upper Gunnison drainage, several impoundments were also constructed in the upper Colorado drainage prior to 1950: Williams Fork Reservoir in April 1939; Green Mountain Reservoir in November 1942; Shadow Mountain Reservoir in April 1947; and Granby Reservoir in September 1949. Dam building declined in the 1950's, with Willow Creek Reservoir constructed in March 1953 and Vega Reservoir in May 1958. After then, construction accelerated again. Storage of water began in February 1961 at Paonia Reservoir in the lower Gunnison drainage; in September 1963, at Dillon Reservoir in the upper Colorado drainage; in October 1965, at Blue Mesa Reservoir in the Gunnison drainage; in January 1968, at Morrow Point Reservoir, also in the Gunnison drainage; and in May 1968, at Ruedi Reservoir in the upper Colorado drainage. During the 1970's, two additional reservoirs in the Gunnison drainage were completed: Silverjack Reservoir in late 1970, and Crystal Reservoir early in 1977. The above list is by no means complete, since it only includes the major reservoirs, but it demonstrates a considerable amount of additional surface acreage that was not in the West-Slope streams prior to inundation. In most of these reservoirs the additional surface acreage has been filled with expanding white sucker populations. Exceptions are Vega and Silverjack reservoirs, where no suckers have been caught. Dillon Reservoir contains only a small number of suckers, and they are primarily of the subgenus *Pantosteus* (personal communication, Clee Sealing, Colorado Division of Wildlife). At Ruedi Reservoir, only suckers of the subgenus *Pantosteus* have been caught (personal communication Larry Finnell, Colorado Division of Wildlife). Although *Pantosteus* dominated in Green Mountain Reservoir during 1949-1950 (Nelson 1955), Mr. Sealing informed me that white suckers now far outnumber *Pantosteus* in this reservoir. Crystal Reservoir is presently dominated by longnose suckers, but this dominance may be short-lived because of constant replenishment of white suckers from spillway and power releases from Morrow Point and Blue Mesa reservoirs, immediately above. These reservoirs are both dominated by white suckers. Many times during this study, live white suckers have been observed passing through the outlet works at both of these dams. No doubt, similar losses of white suckers from Taylor Park Reservoir will add to the already abundant supply in Blue Mesa, as it likely had done earlier in building up white suckers in the upper Gunnison River. As already mentioned, by 1965 the white sucker had completely replaced the bluehead as the dominant sucker in sections above the National Monument.

One can see in Table 20 that white suckers now dominate the two Gunnison River sections below the National Monument and above the North Fork. The lowest section, prior to Curecanti, was dominated by bluehead suckers. Why white suckers do not dominate in the National Monument when they are constantly moving through from the reservoirs above may be related to their avoidance of the lower temperatures there. Such temperatures are obviously more favorable to longnose suckers, which now dominate the Monument section. Longnose suckers were not present in the National Monument as late as 1966.

Comparison of sucker composition shown in Table 20 for the National Monument during 1965 and 1966 seems to indicate declines of both white and flannelmouth suckers in 1966, which was the first year of operation of Blue Mesa Reservoir. These declines are questionable, for two reasons. First, no attempt was made to distinguish hybrids that were present in 1965, which in effect increases the percent composition for the three species reported that year and decreases them in 1966. Secondly, emphasis in sampling during 1966 was primarily in the lower half of the Monument, where Kinnear and Vincent (1967) found bluehead and flannelmouth dominating in both years. Consequently, the lower composition of white suckers (19.2% in 1966, compared to 41.2% in 1965) would be expected and can not be attributed to influences of Blue Mesa Dam operations.

Longnose sucker--(*Catostomus catostomus* Forster)

The first authenticated record of the longnose sucker in the Gunnison drainage is one specimen in U.M.M.Z. collection No. 136923, probably taken by Dr. Greenbank below Delta in 1941. Hubbs, Hubbs, and Johnson (1943) reported that the longnose taken by Dr. Greenbank was the first record of this species in the Colorado River drainage. Longnose suckers were not taken by Greenbank in 1943 at the North Fork junction, nor were they taken farther upstream in the National Monument by Kinnear and

and Vincent (1967) during 1965 or 1966. They were, however, reported above the Monument area by Wiltzius (1966) during 1964 and 1965 and by Middleton (1969) for Blue Mesa Reservoir. Of 521 suckers collected by gillnet in Blue Mesa during 1967 and 1968, Middleton (1969) reported 211 (40.5%) were longnose, 251 (48.2%) were white, and the remaining 59 (11.3%) were hybrids, of which 55 were longnose x white and four were thought to be flannelmouth x white. Similar compositions, at least for the two sucker species (hybrids not enumerated), were found during the gillnetting operations at Blue Mesa in the 1966-1972 period, when over 6,000 suckers were captured (Wiltzius 1974).

Several descrepencies or odd distributional patterns appear in the check list of fishes found by Middleton for the Gunnison drainage (1969 p. 89). *Carpiodes carpio*, listed for two stations at or below the North Fork, should obviously be *Cyprinus carpio*. *Cottus annae* in the Uncompaghre River should probably be *Cottus bairdi*, even though one specimen (likely *C. annae=C. beldingi*) was recently taken in the National Monument. Although longnose suckers have been taken in the Uncompaghre River, they were always much scarcer than either bluehead or flannelmouth suckers, except for Middleton's capture of 11 longnose and no flannelmouth suckers. He may have misidentified the longnose suckers in this collection. Other odd patterns in Middleton's data involve the capture of seven brook trout, only two rainbow, and no brown trout, at stations at or below the North Fork. In addition, the capture of 66 brook trout and only six rainbow and four brown trout from Taylor Park Reservoir does not support the overwhelming stocking of fingerling and catchable rainbow trout that has taken place there. Surprisingly, the capture by Middleton of 14 longnose dace, *Rhinichthys cataractae*, an East-Slope species, in Beaver Creek near the upper end of Blue Mesa Reservoir, may be valid. One dace specimen captured from North Beaver Creek in 1966 had been verified by Dr. Behnke as *R. cataractae*.

Another oddity that appears in the Middleton paper (p. 112) is the number of dorsal rays reported for the 24 longnose sucker specimens he enumerated. Ten specimens had 11 rays, six specimens had 12 rays and eight specimens had 13 rays, for an average of 11.9. These counts more closely fit what is normally found for flannelmouth sucker than for longnose suckers, of which the modal number of rays is 10 (Hubbs, Hubbs and Johnson 1943), or a range of 9-11, according to Scott and Crossman (1973). Of 582 longnose suckers examined by Nelson (1973) in Alberta, Canada), 13 had 9 dorsal rays, 497 had 10 rays, and 72 had 11 rays. The counts of dorsal rays taken from the 1977 river specimens (Appendix V) agree with the latter sources, and not that of Middleton. Although the dorsal ray data of Middleton suggests flannelmouth sucker, this species likely was not present in Blue Mesa Reservoir in the early years (1966-1969), and it certainly has not been present since 1970. Many of the longnose suckers from Blue Mesa Reservoir appear to migrate up the Gunnison River into lower Tomichi Creek for spawning. Movement of longnose suckers downstream through the outlet works at Blue Mesa prior to completion of Morrow Point Dam in 1968 likely supplied the specimens needed to perpetuate this species in the National Monument. Longnose and white suckers are the only suckers which have successfully reproduced in the National Monument. During the present study, longnose suckers were the most abundant suckers in all sections from below Morrow Point to the lower boundary of the National Monument. This area, of course, is the area of summer coldwater temperatures due to its proximity with deep-water releases from the Curecanti reservoirs. Longnose have been captured as far downstream as 2 mi below the North Fork, but appear to get progressively less abundant (Table 20) as the distance away from the Curecanti dams increase (CPNH of 0.31 in National Monument, 0.19 in the Monument-to-Ute Trail section, and 0.05 CPNH in the section between Ute Trail and North Fork).

Humpback sucker--(*Xyrauchen texanus* Abbott)

The endemic humpback sucker is proposed for threatened status (federal list). Apparently it is now quite rare in the Gunnison River, since only one authenticated specimen was taken during the 1970's. It was a male 19.5 in. in length, 4.5 lbs in weight, and is believed to be in its 9th yr. The fish was captured in a gillnet that was set by my field crew, along the North bank of the Gunnison River above the Fifth Street Bridge below Delta in November 1975. Kidd (1977) reported seeing humpback suckers in the Gunnison River near Grand Junction in 1976, but none were collected. David Lemons of the Colorado Division of Wildlife had told me he had taken some humpback suckers in a backwater below the Delta area during the 1950's. Extensive seining in this general area produced no other adult specimens or young-of-the-year humpback suckers. Showing a photograph of a humpback sucker to old-time fishermen and trappers in the Delta area indicated they had never seen this species. Kidd (1977) appears to have found a person who did recall seeing this species. The man, Ralph Veron, reported that he took 50 squawfish and a large number of humpback suckers in one of the better years (?) between 1930-1950, when he had been commercially fishing and feeding fish to mink in the Delta area.

Historically, the humpback sucker was very abundant in the river channels of the upper Colorado River system in 1889 (Jordan 1891). The Jordan party seined the species in the Uncompaghre and Gunnison rivers near Delta, but its numerical comparison with other sucker species in these samples was not reported. The Delta area appears to be the upper terminus of its historic range in the Gunnison River, since no collections or reports of humpback suckers above there are known. Chamberlain (1946) noted that the humpback sucker appears to be common only in the lower portion of the Gunnison River, but Beckman (1952) reported the species to be rare in Colorado. Only two specimens taken from the Gunnison River prior to 1962 are in the University of Michigan Museum of Zoology collections. One (collection No. 142004) was taken in 1944 and the other (No. 156798) in 1949. Ellis (1914) captured no humpback in 1912 in either the Uncompaghre or the lower Gunnison River, but he did take three humpback specimens from the Colorado River near Grand Junction. As already mentioned, however, nearly 73 percent of that collection was carp, which indicates a rather early and rapid decline in abundance of humpback suckers in this area. Today, the Walker Wildlife Area of the Colorado River near Grand Junction, along with the Echo Park area of the Yampa, may be where the species, although rare, is most numerous in the upper Colorado drainage (McAda 1977). The extreme rarity of this species is probably best exemplified by Hubbs and Miller (1953), who related that of about 700 suckers caught in 1946 in the Coloroad River at the mouth of the Gunnison River, only seven were *Xyrauchen*.

Since the humpback sucker in the upper Colorado River apparently was noticeably declining as early as 1912 and quite rare by 1946, it would be illogical to attribute upper-basin dam construction, which did not get underway until 1937, as the primary cause for this species' decline. Certainly, construction of dams in the lower Colorado River basin, where humpback once were very abundant (Minckley 1973), probably has interfered with upstream migration of humpback suckers. However, the early introduction and subsequent rapid expansion of carp and other species of fish like catfish, minnows, and sunfish in competition for limited food and space in preferred back-water habitat appears to best explain the rapid decline of humpbacks. Furthermore, as humpbacks declined numerically it would have been more difficult for mature specimens of one sex to find their mates, with the probable result that they hybridized more frequently with other species of suckers. The most likely candidate for this hybridization would have been the flannelmouth sucker, the most abundant sucker ranging with the humpback in the upper Colorado system. One hybrid between these two species was taken from a pond along the Uncompaghre River by Jordan (1891), named *X. uncompaghre*; others were taken from the upper Colorado River (Hubbs and Miller 1953). Hybridization of the humpback likely has accelerated its decline.

The above explanation cannot totally explain the decline of humpback suckers in the Gunnison River, because, carp, which were very abundant in the Colorado River near Grand Junction as early as 1912, apparently were not abundant in the Gunnison River until after 1940. No carp were taken in the extensive Greenbank collections during the 1940's. It may be that the 1907 construction of the Redlands Diversion Dam across the lower Gunnison River, about 1.5 mi upstream of Grand Junction, retarded the upstream migration of both carp and humpback suckers as well as other species contributing to their upstream scarcity.

This would be especially true if the early humpback sucker populations in the Gunnison drainage were primary migrants from the Colorado River. Subsequent and separate introductions of carp in the area near Delta could then explain the abundance of this species there in the 1950's and 1960's. It is possible, however, that fish, at times, could have negotiated the Redlands Dam, because Kidd (1977) mentioned that during two annual maintenance periods (April 1 and November 1) the dam gates are opened for 3-14 days, which theoretically could allow fish to move upstream. Fish currently abundant in the Colorado River at Grand Junction (catfish, bass, and bullhead) are scarce above the Redlands in the Gunnison River, and this may suggest that these fish seldom move above the Redlands Dam.

Recovery in the abundance of humpback suckers in the lower Gunnison River looks bleak. Preferred back-water channels and sloughs are now primarily occupied by introduced species, and these areas will be cutoff from main-river flows during spring and most of the summer due to reduced controlled flows from reservoirs upstream. It should be re-emphasized that the Curecanti Unit was in no way responsible for the rapid historical decline of humpback suckers in the Gunnison drainage. It has, however, produced some conditions which likely would have caused their decline had they been abundant prior to this Unit's completion.

Bluehead sucker x white sucker hybrid

The hybrid between bluehead and white suckers was first described for the upper Colorado River by Hubbs, Hubbs, and Johnson (1943) from five specimens collected in 1938 at Hot Sulfur Springs. This hybrid was first collected in the Gunnison drainage by Dr. John Greenbank in Dry Creek during 1941, and was also collected by him from the North Fork area of the Gunnison River in October 1943. Although Kinnear and Vincent (1967) did not specifically identify the bluehead x white hybrid in the National Monument, it probably was present, since they took "hybrids" and some bluehead x white hybrids have been taken there in the present study.[1] Holden and Stalnaker (1975a) noted that the bluehead x white hybrid appears to be distributed in the upper parts of the Colorado basin, following the range of the white sucker. They found it in the Yampa River, as did Prewitt (1977), who described it in considerable detail. As already mentioned, the bluehead x white hybrid is most abundant in the area where the two parental species are found in abundance, namely, below the National Monument but above the North Fork. Hubbs, Hubbs, and Johnson (1943) noted that particularly impressive is the approach shown by this hybrid to the peculiar squamation pattern of the bluehead, which has very small scales forward but large ones in the caudal region. I might add here that many of the white suckers recently captured in the Gunnison River also showed this tendency, which may suggest that introgressive hybridization has occurred or that some specimens identified as white suckers were actually bluehead x white hybrids. Some evidence for introgressive hybridization has already been given in the bluehead sucker section. That some white specimens likely were misidentified is suggested by "white" specimens in Appendix V, with lateral line scale counts over 75, the greatest number usually reported for this species in Colorado. However, Nelson (1973) has reported lateral line scales for white suckers in Alberta as high as 85. If the 11 white suckers taken

1. Dr. Behnke informs me that he has identified some suckers collected by Kinnear and Vincent (1967) as bluehead x white hybrids.

with counts greater than 74 in 1977 from the Gunnison River were hybrids, the data collected in the field were insufficient to identify the parents. Six of the fish had small isthmus widths (less than 4% of total length), suggesting the parent other than white was either flannelmouth or longnose, whereas five had isthmus widths over 4 percent, possibly suggesting bluehead parentage with the white.

Flannelmouth sucker x white sucker hybrid

This hybrid likely was first captured from the Gunnison River in the National Monument during 1965 and 1966 by Kinnear and Vincent (1967), even though they failed to specifically identify the fish. It was captured there during 1976 and 1977, but is rare, as is the flannelmouth sucker. Middleton (1969) thought that four specimens taken from Blue Mesa Reservoir in 1967 and 1968 were flannelmouth x white hybrids, but none have been taken from Blue Mesa in recent years. Holden and Stalnaker (1975a) reported capturing one flannelmouth x white hybrid specimen from the lower Gunnison River below Delta in 1971, but also reported that no description of this hybrid had been published. Recently, Prewitt (1977) described in detail the flannelmouth x white hybrid from specimens taken in the Yampa River, using 15 variables in a discriminate function analysis. Of these variables, counts or measurements on only four were taken in the present study: lateral line scale counts, scales above lateral line, caudal peduncle depth, and isthmus width. The means for the two scale count series on the flannelmouth x white hybrid were found by Prewitt (1977) to be intermediate between the parents, a condition which has also been found for the Gunnison River specimens. In general, most characteristics that have been measured and reported historically for other catostomid hybrids have been found to be intermediate (Hubbs,

Hubbs, and Johnson 1943; Hubbs and Hubbs 1947; Hubbs and Miller 1953; Smith 1966; Middleton 1969; and Nelson 1968, 1973, 1974). Despite this tendency for intermediacy of hybrids, some exceptions have been found. Prewitt (1977) presented data that suggested the caudal peduncle depth of the flannelmouth x white hybrid was greater than that of either parent, a phenomenon also observed for the hybrid in the present study. However, Prewitt also presented data suggesting the mean isthmus width of the flannelmouth x white hybrid was less than that of either parent, while the Gunnison River data suggest the converse. The discrepency for this characteristic from the Yampa and Gunnison specimens is probably meaningless, since both parents have slender isthmus widths, the means of which vary less than 1 percent of total length in either stream. Consequently, it appears likely that, with small numbers of hybrids in the samples, their isthmus means could have varied considerably in either direction.

The flannelmouth x white hybrid is presently most abundant in the Gunnison River section above the North Fork but below the Ute Trail. This section, as late as 1966, had primarily bluehead suckers (Table 20). During 1977, 9 of the 12 hybrids collected from this section were flannelmouth x white, which indicates that this hybrid was nearly as abundant as the flannelmouth sucker parent, of which only 11 specimens were gillnetted. Apparently, the flannelmouth sucker is declining in this section, partly due to hybridization with the white sucker which has been rapidly building up its numbers since the Curecanti Unit was constructed. The hybrids, which appear to have normally developed gonads, recently may have been back-crossing with white suckers, which would also contribute to the decline of flannelmouth suckers in this area. Controlled back-cross breeding experiments, none of which have been done with these suckers, would be necessary to prove if the hybrids were fertile and would also aid in subsequent identification of any progeny produced.

Longnose sucker x white sucker hybrid

The hybrid between longnose and white suckers was first described by Hubbs, Hubbs, and Johnson (1943) from five specimens collected in the Platte River system in Colorado, Wyoming, and Nebraska. Of 521 suckers captured from Blue Mesa Reservoir in the upper Gunnison drainage during 1967 and 1968, 55 (10.6%) were believed by Middleton (1969) to be the longnose x white hybrid. This hybrid has also been recently described by Nelson (1973) for Kananaskis Reservoir, Alberta, Canada. During 1977, 6.8 percent of the suckers taken from Morrow Point Reservoir were identified as longnose x white hybrids. None of these hybrids was taken from Crystal Reservoir, but all but one of the suckers taken there were longnose. In the Gunnison River below the reservoirs, the longnose x white hybrid is most abundant in the National Monument, where the two parental species are both abundant. Like the longnose sucker which gets progressively less abundant going downstream, so does the longnose x white hybrid. It has not as yet been captured below the North Fork of the Gunnison River. This hybrid likely is most abundant in the Gunnison River sections just above Blue Mesa Reservoir, but no attempts to identify the sucker hybrids from the upper basin collections has been made in recent years.

Bluehead sucker x flannelmouth sucker hybrid

The hybrid between the two endemic suckers of the Colorado River system was first described by Hubbs and Hubbs (1947) from six specimens collected in Colorado. Three of the hybrids were taken near the North Fork junction of the Gunnison River in October 1943, while the other three were collected from the San Juan River system in 1944. This hybrid has recently been reported from the Yampa River by Prewitt (1977). The incidence of this endemic hybrid apparently is much less than that between the endemic suckers and the exotic white sucker. For example, in Table 20 the Gunnison River collection of 1943 shows the overwhelming dominance of bluehead and flannelmouth suckers in this area at that time, yet only three (0.3%) of the suckers found there were identified by Hubbs and Hubbs (1947) as hybrids between the endemic species. In contrast, 9 of the 12 hybrids were identified as white x bluehead, constituting 1.0 percent of this parental cross. Only one "odd looking" 18.3-in. sucker, taken in 1977 from the Gunnison River, was even thought to be a bluehead x flannelmouth hybrid. Most hybrids taken in the present study were crosses involving white suckers. Admittedly, our sampling was in areas where whites usually dominated, and it is easy to recognize a hybrid involving the white sucker because the white is the only large-scale sucker found in the Gunnison River. Hybrids involving fine-scaled species like blueheads x flannelmouth and bluehead x longnose are much more difficult to identify in the field.

Bluehead sucker x longnose sucker hybrid

This hybrid has not yet been described in detail, but Prewitt (1977) mentions that a recent collection of confirmed bluehead x longnose hybrids from the Colorado River near Granby is in the Colorado State University teaching collection. Hybrids probably involving the bluehead and longnose suckers were thought to have been encountered in the Gunnison River just upstream of the Morrow Point Dam site in 1966 (Wiltzius 1967). These specimens were not saved, but the likelihood of this hybrid is suggested on the basis of the distribution of the two parental forms at that time. In 1965, longnose suckers were not found in the National Monument but were present and apparently rare in the area of Morrow Point Dam near Cimmaron. Although the stream section now inundated by Crystal Reservoir was not sampled then, it appears likely that longnose and bluehead suckers could have been there. Bluehead suckers definitely were found in the National Monument in 1965 and 1966, and one was taken just below Morrow Point Dam in 1973. Furthermore, in 1974, 28 bluehead suckers and six "hybrids" thought to be longnose x bluehead were shocked in the lower Cimmaron River near Morrow Point Dam, but the specimens were not preserved. In 1977, two hybrids taken in the National Monument were identified by Curecanti field-crew members as bluehead x longnose. They definitely were fine-scaled hybrids (greater than 100 scales in lateral line), but the likelihood that they also could have been bluehead x flannelmouth could not be conclusively determined from the field counts and measurements.

Ictaluridae

Channel catfish--(*Ictalurus punctatus* Rafinesque)

The introduced channel catfish is not an abundant species in the Gunnison River. No specimens were taken from the Gunnison River during this study above the Escalante Creek confluence, which was the lowest area sampled. Only two collectors have reported channel catfish for the Gunnison River. Holden and Stalnaker (1975a) reported them as rare during 1971 in the lower Gunnison River below Delta, and Kidd (1977) reported channel catfish as common only below Whitewater in 1976. This species apparently has been stocked in a number of irrigation reservoirs in the

Gunnison drainage (Lemons 1954), and in recent years channel catfish have been privately stocked in some ponds in the Delta area. Kidd (1977) also notes that channel catfish were planted in the lower Gunnison during 1964 and 1965 by the Division of Wildlife.

According to Holden and Stalnaker (1975a), channel catfish were introduced into the lower Colorado basin either in 1892-93 or 1906, and became established throughout the Colorado River system in the early 1900's. Channel catfish were reported by Holden and Stalnaker as common during 1971 in the Grand Junction area and by Kidd (1974) as abundant in this area. Lemons (1954) noted channel catfish were reproducing in the Colorado River. Despite the abundance of catfish in the Grand Junction area, they apparently have not migrated very far upstream into the Gunnison River, which may be due to the Redlands Diversion Dam, about 1.5 mi above Grand Junction. Furthermore, there is some indication that catfish may be losing ground to black bullheads and black bass in some Colorado River sections; this is discussed below under those two species.

Black bullhead--(*Ictalurus melas* Rafinesque)

Like the channel catfish, the introduced black bullhead is not an abundant species in the Gunnison River. Only five specimens were collected from the Gunnison River during the present study. Three adult black bullheads were taken from a stagnant pool in 1975 on the east bank of the Gunnison River, a short distance upstream from the confluence of Escalante Creek. The other two specimens were young-of-the-year captured in 1975 at the mouth of Roubideau Creek, below Delta. The lower

0.5 mi of Roubideau Creek was recently electrofished, but no fish of any kind were captured. Kidd (1977) also found bullheads rare in the Delta-Escalante section during 1976.

Ellis (1914) reported that black bullhead had been introduced successfully into ponds at Grand Junction and at Montrose. Despite this, Lemons (1954) only took one black bullhead during his samplings of the Gunnison drainage during 1952; it was from Hart's Basin Reservoir near Eckert, Colorado. Dr. John Greenbank told me he used to catch quite a few black bullheads from the Uncompaghre River before 1920. Black bullheads apparently declined in the Uncompaghre River, because none were taken in recent samplings. This decline is difficult to explain, especially since black bullheads were stocked and are present in Swietzer Lake, constructed in the early 1950's above Delta and draining into the Uncompaghre River. Despite the scarcity of black bullheads near this likely source, bullheads are commonly found in the Gunnison River below the areas sampled in the present study. It may be that colder water entering the Uncompaghre from the Gunnison Tunnel has tended to force bullheads farther downstream in the drainage. Kidd (1977) reported black bullheads as common below Escalante in the Gunnison River and abundant below Grand Junction in the Colorado River downstream into Utah. The abundance or buildup of black bullheads below Grand Junction may be a rather recent historical phenomenon, since both Lemons (1954) and Holden and Stalnaker (1975a) failed to capture black bullheads in this area in 1952 or 1971, respectively. Kidd (1974), however, working in the 1971-1974 period in this Colorado River section, reported capturing over 500 black bullheads and a similar number of channel catfish. More recently, McAda (1977) collecting fish with trammel nets during the

1974-1976 period in the Walker Wildlife Area below Grand Junction, captured 284 black bullheads and only 46 channel catfish. Such a complete reversal in abundance of these two species since 1971, if real, would be most difficult to explain.

Centrarchidae

Largemouth bass--(*Micropterus salmoides* Lacepede)

The Gunnison Tribune of November 26, 1897 mentioned that Mr. Swan, Colorado Fish and Game Commissioner, sent by rail 15 cans of bass fry from Denver to Provo, Utah. It was further related that two shipments each of 2,500 bass fry were scheduled for the Gunnison and Colorado rivers. If these shipments were actually sent, the bass were likely stocked in these rivers near Grand Junction, due to the proximity of the city to the two rivers. Despite this and other early stockings of bass during the 1920's in several areas of the upper Colorado drainage (fathead minnow section), bass apparently did not establish very rapidly in either the Gunnison River or sections of the Colorado River above the Colorado-Utah state line. Lemons (1954), sampling these sections in 1952, captured no bass. He did, however, mention that the Rod and Gun Club at Palisade requested that bass be stocked in the Colorado River, which also suggests that this species was absent or rare in this area in 1952. Bass were, however, already in Lake Mead in 1939 in the lower basin and were caught in Glen Canyon as early as 1958 (Holden and Stalnaker 1975a). It may be that the private interests for bass in the Grand Junction-Palisade area supplied the initial introduction of bass in the upper Colorado River, or the introduction could have been the Division of Wildlife stockings of bass in irrigation reservoirs above

Delta in the 1950's. The only historical collector, however, who reported bass for the Gunnison River is Kidd (1977), who reported bass as rare-to-occasional below Delta in 1976. No bass were taken in the Gunnison River above Escalante during the present study.

Largemouth bass may be building up in the upper Colorado River sections below Palisade Plateau. Reported as rare in 1971 in the state line-to-Grand Junction section by Holden and Stalnaker (1975a), bass were reported as common-to-abundant by Kidd (1974) in all sections below Palisade Plateau. In addition, bass have been taken frequently in the Walker Wildlife Area by McAda (1977). Of 10 species of fish collected there in 1976 with trammel nets, only the catches of carp (26.4%) and bullheads (23.6%) exceeded those of largemouth bass, which comprised 13.6 percent of all fishes taken.

About 1,800 fingerling smallmouth bass, *Micropterus dolomieui*, were stocked by the Division of Wildlife in the Gunnison River near Delta in 1973, but none subsequently have been captured.

Green sunfish--(*Lepomis cyanellus* Rafinesque)

Holden and Stalnaker (1975a) reported green sunfish were common during 1971 in the Gunnison River below Delta and in the state line-to-Grand Junction section of the upper Colorado River. Green sunfish have also been captured in these areas by Kidd (1974, 1977) and McAda (1977). Holden and Stalnaker (1975a) mentioned that it was not known whether green sunfish moved up the Colorado River from the lower basin, where green sunfish were found as early as 1926, or whether this species was separately introduced into the upper basin. The "warm-water" fish plants made during the 1920's in the upper Colorado River basin (fathead minnow section) suggest that separate introductions into the upper basin most likely accounts for the presence of green sunfish in the upper basin. Green sunfish were captured from the upper Colorado River near Clifton during 1952 (Lemons 1954). Furthermore, (Lemons 1954) reported taking one green sunfish from Hart's Basin Reservoir in the Gunnison River drainage near Eckart, above Delta, which suggests the improbability that upstream movement of green sunfish through the Colorado River system provided the route of introduction into this reservoir. It appears much more probable that downstream losses of green sunfish from this or other reservoirs or ponds provided the establishment of green sunfish in the upper Colorado basin.

Although green sunfish were not considered abundant during the 1975 seining (116 specimens), they were captured in several back-water areas of the Gunnison River. They were taken near Escalante, at the mouth of Roubideau Creek, in some areas near the Fifth Street Bridge below Delta, in the Uncompaghre River above Delta, from the Delta sand and gravel pit above Delta, and from a backwater area near Austin. In addition, four specimens were seined in a side channel near the North Fork during 1977, and one green sunfish was gillnetted during 1976 in the Gunnison River above the North Fork but below the Smith Fork, the farthest upstream that green sunfish have been taken. They appear to be more easily captured below than above Delta.

Cyprinodontidae

Plains killifish--(*Fundulus kansae* Garman)

At this time there appears to be some confusion regarding the species name for the killifish found in the upper Colorado River drainage. The fact that a *Fundulus* species has been introduced into this river system is uncontested. Holden and Stalnaker (1975a) report that the killifish specimens they collected in 1971 from the Colorado and Gunnison Rivers were *Fundulus zebrinus*, the Rio Grande killifish. Kidd (1974) also captured killifish from the Colorado River and called them plains killifish. He used no scientific name, but the plains killifish is *F. kansae*. Ellis (1914) used the name *F. zebrinus*, but found these fish only in the East-Slope drainages of Colorado. Koster 1957) and Li (1968) contend that *F. zebrinus* is a synonym for *F. kansae*, while Minckley (1973) in Arizona, who has worked with *F. kansae* in Kansas, apparently believes *F. zebrinus* and *F. kansae* are two distinct, closely-related forms. Dr. Behnke of Colorado State University contends that only *F. kansae* is present in the East-Slope drainages of Colorado, and, if *F. kansae* and *F. zebrinus* are in fact different, it would be much more logical to believe that *F. kansae* was introduced from the East-Slope drainages of Colorado into the upper Colorado River sections than to believe that *F. zebrinus* migrated from the lower Colorado basin or was introduced from the Rio Grande drainage. Hence, until taxonomists solve this problem I will use *F. kansae* to denote the killifish that is now present in the upper Colorado River system.

The plains killifish appears to be one of the most recent introductions into the Gunnison River, despite the fact that *F. zebrinus* was present in the Little Colorado River of the lower Colorado basin as early as 1938. It appears very likely that killifish were absent or very rare in the upper Colorado drainage during 1952 and were not common until the 1960's. Lemons (1954) did not find this species in his sampling of the Gunnison and Colorado rivers, nor were they reported in Hart's

Basin Reservoir near Eckart where 750 minnows (mostly fatheads) were taken. For such a distinctive-looking fish as the plains killifish, with vertical bars on its side, to go unnoticed by Lemons is doubtful. Prior to my seining "killifish" a short distance below Delta in 1966 or 1967, none of the earlier collections from the Gunnison drainage contained this species. During 1975, a total of 250 plains killifish were collected from the Gunnison River. Although the numbers of killifish in single seine-hauls in back-water areas never exceeded 25, this species was consistently found in all areas sampled between the Roubideau confluence upstream almost to Austin. Plains killifish were found in the main Gunnison River above the diversion, which appeared to prevent the two shiner species from moving upstream. One killifish was also taken in the lower Uncompaghre River, about 1 mi above its confluence with the Gunnison River. Although Holden and Stalnaker (1975a) indicated that killifish were rare during 1971 in the Gunnison and the Colorado River near Grand Junction, Kidd (1974) reported them as common-to-abundant in the Colorado River below Grand Junction in 1971-1974 and occasional for the Gunnison River section below Escalante (Kidd 1977). Whether the expansion of this species distribution has been from the Colorado River upstream into the Gunnison River, or vice versa, is unknown, but I support the latter explanation because of the Redlands Diversion Dam, which possibly prevented upstream migration. Furthermore, ponds in the Delta area are known to have been stocked with catfish and "minnows" from East-Slope sources since 1965.

Cottidae

Mottled sculpin--(*Cottus bairdi* Girard)

The native mottled sculpin, called "blob", "Miller's Thumb", or "Bull-head" by Jordan (1891), was a species that Jordan reported was fond of cold, clear waters. Despite this, Jordan did not collect this species in 1889 in the upper Gunnison drainage, where the waters should have been colder and clear. Of the five stations that Jordan sampled in the Gunnison drainage, he found mottled sculpin only in the Gunnison River at Delta, the lowest station. Jordan (1891) reported, however, that sculpin were captured from higher elevation stations in other West-Slope drainages.

Historically, mottled sculpin were not taken in seining (?) collections by Pratt (1937, 1938), nor were they taken by Weberg (1954), Wiltzius (1966), or Middleton (1969), who sampled primarily with electrofishing gear in many Gunnison River sections and tributaries above Blue Mesa Dam. Furthermore, sculpins were not collected by Kinnear and Vincent (1967) in the National Monument, and they were not present in any of the University of Michigan Museum of Zoology, collections made prior to 1962. Most of the U.M.M.Z. collections for the Gunnison drainage were made prior to 1953 during the 1940's and were almost all made below the North Fork. Dr. R. R. Miller, who compiled the list, however, suspected that mottled sculpin were in the Gunnison drainage.

The farthest upstream that mottled sculpin likely have ever been taken in the main Gunnison River is a short distance above the confluence of the North Fork. They were shocked there in 1965, prior to the Curecanti reservoirs, and were also taken from this area in 1971, 1974, and 1975, indicating the Curecanti Unit has had little adverse affect on the distribution of this species.

Although Jordan (1891) collected mottled sculpin at Delta, the lowest that this species has been taken in the main Gunnison River since 1889 was near Austin, a few miles upstream of Delta. Two mottled sculpins, however, were taken from the Uncompaghre River near Montrose in 1973. This stream empties into the Gunnison River about 2 mi below Delta. Apparently, mottled sculpin are not now and probably never were very abundant in the Gunnison River. The species is most abundant in the lower section of the North Fork of the Gunnison River below Hotchkiss National Fish Hatchery, a short distance above its confluence with the main Gunnison River. The North Fork is usually quite turbid and very warm during the summer. Temperatures over 80°F have been recorded there. The 24 mottled sculpin specimens taken from the North Fork in 1974 probably represent nearly 30 percent of all known mottled sculpins collected in the Gunnison drainage since 1889. The abundance of mottled sculpin in the warm, turbid North Fork does not corroborate the implication of Jordan (1891), Baxter and Simon (1970) and Holden and Stalnaker (1975a) that mottled sculpin are a cool, clear-water species. Furthermore, the uppermost distribution at an elevation approximating 5,100 ft in the main Gunnison River, but likely over 5,600 ft in the Uncompaghre River, does not substantiate the view that mottled sculpin are even a "head-water" species in the Gunnison drainage, as they likely are in the upper Colorado River and some other West-Slope drainages.

Piute sculpin--(*Cottus beldingi* Eigenmann and Eigenmann)

The piute sculpin, previously known in Colorado as the eagle sculpin, *Cottus annae*, is very rare in the Gunnison River. I have seen only one specimen thought to be of this species (one preopercular spine; complete lateral line). A student from Mesa College, fishing in the Warner Point area of the National Monument on July 20, 1975, caught a sculpin and brought the specimen to a National Park Service Ranger for identification.

Not having ever seen such a fish, the ranger brought the specimen to the Division of Wildlife Regional office in Montrose, where I identified it as *C. beldingi*.

Since I personally have never examined a series of *C. beldingi*, the authenticity of the single specimen from the National Monument still may be in doubt. My notes on this specimen indicate that when I dissected the skin from the preopercular bone a very slight rounding or bump existed below the large, single, sharp spine. On mottled sculpins that I have examined from the Gunnison drainage there has always been at least one, but usually two and sometimes three, smaller but obviously sharp spines below the upper larger spine.

Middleton (1969) captured two sculpins near Olathe and four sculpins near Montrose in the Uncompaghre River, but apparently erroneously identified them as *Cottus annae* (=*C. beldingi*). These specimens likely were mottled sculpins since all of the sculpin specimens that I have ever seen from the Uncompaghre River were *C. bairdi*. I did not, however, have the opportunity to examine the six specimens taken by Middleton.

Esocidae

<u>Northern pike</u>--(*Esox lucius* Linnaeus)

Several specimens of the introduced northern pike have been taken from the Gunnison River by fishermen during the 1970's. One of the largest specimens caught was about 12 lbs, but most were smaller than 5 lbs. These fish obviously came from Paonia Reservoir, where they had been stocked by the Colorado Division of Wildlife in 1969 and 1970. Northern pike of ages not corresponding to the Paonia Reservoir plants have never been taken in the lower Gunnison River during the recent study, and this indicates the northern pike have not reproduced successfully in the river and likely not in Paonia Reservoir.

Some of the Paonia Reservoir northern pike apparently migrated downstream in the North Fork and then migrated up the main Gunnison River, because one specimen was taken a short distance below the Smith Fork in 1973 and another specimen (27.5 in., age 5+) was gillnetted in the Red Rocks area of the National Monument in 1975. Their size and age demonstrated that these northern pike had to be from Paonia Reservoir, because the only other place where northern pike have been stocked in the Gunnison drainage was at Taylor Park Reservoir, where a plant of 790 4 to 6-in. fingerlings was made in June 1972. Successful natural reproduction of the Taylor Park northern pike was verified by the capture in this reservoir of several 4 to 7-in. young-of-the-year specimens late in the summer of 1977. Most specimens from the 1972 Taylor Park plant were well over 17 in. by 1977. One northern pike from the original Taylor Reservoir plant was taken from the upper Gunnison River at Almont in 1975. It appears likely that northern pike from Taylor Park Reservoir will soon be showing up in Blue Mesa Reservoir. McAda (1977) took one northern pike from the Walker Wildlife Area of the Colorado River in 1974, but he did not age the specimen or report its length, which could have possibly aided in identifying the original source of the fish. It probably was from Paonia Reservoir. Some specimens have been taken in Lake Powell, but they could have been downstream migrants from Valliceto Reservoir, where northern pike have also reproduced successfully. However, these fish also would have had to pass through Navajo Dam in the San Juan drainage, which makes it less likely that they were from Vallicto Reservoir.

MANAGEMENT PLANS AND RECOMMENDATIONS

BLUE MESA RESERVOIR AND UPPER GUNNISON RIVER

In the approximately 90 mi of the Gunnison River system below North Beaver Creek, where a salmonid fishery existed during 1977, nearly 90 percent of the total fisherman-use and harvest occurred in the section inundated by Blue Mesa Reservoir (Table 16). Consequently, management efforts should be more intense there than in the other sections. Because rainbow trout usually comprised more than 85 percent of the entire salmonid harvest at Blue Mesa and fingerlings>4 in. were found to be more economical than smaller fingerlings, Wiltzius (1974) recommended that annual rainbow trout stocking for the future be 1,200,000 fingerlings of 4.0-4.5 in. I also recommended that future kokanee salmon stocking be between 700,000 and 1,000,000 fish annually at 300-600 per lb.

Prior to 1971, kokanee fry were being released primarily in certain tributary streams of Blue Mesa Reservoir. Emphasis was on releasing kokanee salmon from Roaring Judy Hatchery, located about 22 mi above Blue Mesa Reservoir, in an attempt to establish return spawning runs there where egg-taking would be facilitated. In 1970, sufficient kokanee eggs were taken at Roaring Judy to accelerate the stocking of this species. In addition, kokanee eggs taken at Vallecito and Granby reservoirs since then also have augmented the numbers of kokanee available for stocking in Blue Mesa Reservoir. In Table 12 it can be seen that, since 1971, kokanee salmon stocking has been accelerated. Most of the stocking has been done in tributaries closer to the reservoir. About 300,000 kokanee have been stocked each year since 1971 in East Elk Creek, less than 0.5 mi above Blue Mesa Reservoir. Furthermore, in 1974 about

1,000,000 kokanee (about 600/lb) were released from Roaring Judy Hatchery, and about 870,000 tetracycline-marked salmon of the same size were trucked down to an area a short distance above North Beaver Creek and released in the main Gunnison River. These plants had several purposes:

1. To determine the relative survival in the reservoir between the small fingerlings released at the hatchery and those that had been trucked down.
2. To determine losses or migration of kokanee from Blue Mesa Reservoir.
3. To determine if the marked group which was imprinted at the hatchery and trucked down close to the reservoir would return to the hatchery as adults.
4. To compare costs to the creel of marked kokanee salmon with those of marked rainbow trout.

For the sake of brevity I will not discuss the techniques and procedures used to obtain some of the estimates which follow. By December 1974, it was evident that considerable numbers of kokanee salmon were being lost through the power turbines at Blue Mesa. Between 1974 and 1977 proportions of marked salmon of the 1974 year-class were considerably higher (60%) than the expected 40 percent at release. This indicated that the marked salmon trucked closer to the reservoir had survived much better than the unmarked salmon released at Roaring Judy Hatchery. It was estimated that nearly 62 percent of the 1,000,000 salmon released from the hatchery in 1974 were lost to predation and irrigation ditches before reaching the reservoir. Consequently, I recommended that salmon being reared (imprinted) at Roaring Judy Hatchery in the future be trucked down closer to the reservoir before being released, a procedure that has been in use since 1975. Survival apparently has increased, because kokanee since 1975 have comprised a much larger percentage of the harvest than prior to 1975 (Table 12).

At the time I recommended trucking the kokanee closer to the reservoir, I was convinced from evidence presented primarily by Ricker (1972) that salmon reared at a hatchery located in the same drainage in which they would be released would return to the site of rearing rather than to the release area, provided the distance between the two sites was less than 50 mi. Based upon proportions of marked salmon of the 1974 year-class entering the harvest at Blue Mesa during 1976 and 1977, I estimated that about 80 percent of the 1977 salmon run entering the Gunnison River and expected to return to Roaring Judy should be marked. Extensive sampling of the kokanee run in the Gunnison River during October and November 1977 revealed that 80 percent of the spawners were in fact marked in sections below Gunnison, but the marked percentage declined rapidly for the spawners from all sections of the Gunnison River above Gunnison. Less than 2 percent of the salmon returning to Roaring Judy Hatchery were marked. Consequently, egg-taking at the hatchery was sparse, but adequate numbers of eggs were procured from spawners in some lower-river areas where the kokanee were concentrated and/or blocked due to extremely low flows.

It is unknown whether the low flows of 1977 caused the poor return to the hatchery. Many unmarked salmon that were thought to be from the hatchery release were also more abundant than expected in areas below the hatchery and above Gunnison. Some even attempted spawning in the main river channel rather than moving upstream to the hatchery. Water temperatures in the Gunnison River were high enough ($>42^{\circ}F$) that development of embryos could have been sufficient to carry them over winter. In most years, temperatures in the Gunnison River are too low (<35°F) at time of egg fertilization to permit enough development of the embryos so they can over winter.

Despite considerable losses of kokanee salmon through the Blue Mesa turbines and failure of the spawners to return to the hatchery in proper proportion, the marked 1974 year-class provided an estimated return to the harvest at Blue Mesa of 4 percent of what was originally stocked. Using Colorado's 1977 average hatchery costs, this equates to $0.63 per kokanee harvested. Since they averaged 1 lb each when harvested, the cost per pound creeled was also $0.63. In contrast, the marked rainbow of the 1974, 1975, and 1976 year-classes caught at Blue Mesa have cost, respectively, $0.76, $0.70, and $0.64 per fish. Since rainbow were smaller than kokanee when harvested, costs per lb of rainbow harvested were $1.51 for the 1974 year-class, $1.11 for the 1975 year-class, and $1.02 for the 1976 year-class. This is an average of $1.21-per-lb cost to the creel, or nearly twice that of kokanee. However, costs of kokanee released directly from the hatchery were more than double those that were trucked close to the reservoir before being planted.

Early in 1977 I recommended that the size of rainbow fingerlings at stocking be increased to 5 in. To make total costs comparable to the previous rate of 1,200,000 4-in. fish being stocked, the number of 5-in. rainbow was reduced to 800,000. This stocking rate was begun in 1978. Recent stocking of kokanee at 600-1,000/lb has been about 300,000 in East Elk Creek, a short distance above Blue Mesa Reservoir, and about 700,000 in the main Gunnison River, a short distance above North Beaver Creek. The East Elk kokanee were reared at hatcheries not in the

Gunnison drainage, while the Gunnison River plants were hatched and reared at Roaring Judy Hatchery. Plants made in East Elk Creek have failed to provide spawner concentrations in the Elk Creek bay of the reservoir as originally anticipated.

If the kokanee spawners from year-classes after 1974 return to Roaring Judy and yield a minimum of 2-3 million eggs, a consistent stocking program can be developed. I would then recommend 1,500,000 kokanee salmon of 600-1,000/lb for Blue Mesa Reservoir as well as 400,000 for Taylor Park Reservoir. However, if the recent trucked-down year-classes fail to return to Roaring Judy Hatchery and/or fail to concentrate in areas where minimal numbers of eggs cannot be obtained economically, three other plans are suggested:

1. Obtain kokanee eggs from other sources such as the Granby and Vallecito runs.
2. Imprint kokanee being reared at any hatchery with morpholine, using procedures and techniques obtained from references in Scholz et al. (1978). Pick an area or tributary of the Gunnison River above Blue Mesa, but choose one close to the reservoir, i.e. North Beaver Creek or Eastman side channel and meter the morpholine into the water of the chosen area during the usual time of the run (September-November).
3. Rear as many kokanee over winter at Roaring Judy as the recommended 1,500,000 small kokanee budget ($37,800 using 1977 costs) allows and release them from the hatchery before any of the irrigation ditches are opened in the spring. If kokanee eggs are really in short

supply, over winter rearing may be the only means to increase survival to provide the anticipated 60,000 (4% of 1,500,000) kokanee in the harvest. It may take nearly 250,000 yearling kokanee to supply the 60,000 in the harvest.

MORROW POINT AND CRYSTAL RESERVOIRS

Both of these reservoirs have a common problem--very poor foot access and no boat-launching ramps for the fishermen. Government service roads exist to the top of both dams, but they are not available for use by the public. Furthermore, there is a Bureau of Reclamation policy that prohibits the installation of even a small public boat dock attached to the dams. Such docks, operated by concessionaires with about 10-20 boats available for rental, would likely triple the present fisherman-use on these reservoirs.

An excellent kokanee salmon fishery was available in the lower half of Morrow Point Reservoir during 1977, but it was not utilized by many fishermen because of the poor access and lack of boat-launching facilities. These kokanee were almost all marked salmon originally stocked in Blue Mesa in 1974. Trolling from our 18-ft research boat equipped with a 100 hp engine yielded over 280 kokanee salmon that averaged 15.2 in. in total length and 1.5 lbs in weight.

Unlike Morrow Point and Blue Mesa reservoirs, experimental gill-netting in Crystal Reservoir indicated a predominant gamefish population in 1977. During the entire summer we gillnetted 140 unmarked rainbow trout, 24 brown trout, 1 brook trout, 8 longnose suckers, and 1 white sucker. The rainbow trout ranged between 4.0 and 19.5 in., averaging

11.9 in., while their ages ranged from 1+ to 7+, averaging 3.2 yrs. No fishermen were seen on any of the helicopter flights over Crystal Reservoir.

Considering the poor access and the probable continued replenishment of kokanee salmon from Blue Mesa and Taylor reservoirs, extensive annual stocking of this species for Crystal and Morrow Point reservoirs does not appear to be necessary. Because of the coldwater releases that supply these reservoirs, surface temperatures seldom exceed 65°F which also appears to be ideal for cutthroat trout. Although the Snake River strain of cutthroat trout is being reared at Roaring Judy Hatchery, I would prefer to stock Crystal and Morrow Point reservoirs with the Colorado cutthroat trout, *Salmo clarki pleuriticus*, which is native to the drainage and can be obtained from Trapper's Lake. Colorado cutthroat trout are not as easily confused with rainbow trout as is the Snake River cutthroat trout and they would probably adapt to the coldwater reservoir environments better than the Snake River strain. Sekulich (1974) remarked that preliminary studies showed the Snake River cutthroat (Jackson Hatchery stock-Wyoming) flourished in waters appearing too warm and eutrophic for optimum cutthroat trout existence. Although yellowstone cutthroat trout (*S. clarki lewisi*) have been introduced into Trapper's Lake in some years past, Gold et al. (1978) suggested that they have had no detectable effect on the purity of the present-day native Trapper's Lake *pleuriticus* population. If Trapper's Lake cutthroat fingerlings can be procured, I recommend that annual stocking at Crystal and Morrow Point reservoirs be at rates not exceeding 30 per surface acre (8,400 at Crystal and 24,500 at Morrow Point).

At one time I had considered recommending stocking kokanee salmon in Silverjack Reservoir in the upper Cimarron drainage. I felt that many salmon would move downstream into Crystal Reservoir and a run would subsequently develop in the Cimarron River. However, kokanee salmon are primarily harvested by boat fishermen and boating is prohibited on both reservoirs, so I do not feel that stocking kokanee in these reservoirs is justified. Furthermore, an adequate egg source for kokanee has not yet been assured. If adequate eggs become available, the above plan may be more suitable for Lake San Cristobal in the Lake Fork of the Gunnison drainage above Blue Mesa Reservoir, where boating is extensive.

The installation of foot bridges across the Cimarron River at its confluence with the Gunnison River and across the main Gunnison below Morrow Point Reservoir probably would result in increased fishing pressure and more efficient fishing between Crystal and Morrow Point reservoirs.

LOWER GUNNISON RIVER (BELOW CRYSTAL DAM)

The initial 2-4 mi of river below Crystal Dam is heavily fished and is annually being stocked with about 4,300 catchable rainbow trout. I see no need to stock more than 5,000 catchable rainbows annually, but I would recommend that the plants be more evenly distributed than they were in 1977 when all fish went into two large holes, either above or below the Gunnison Tunnel. Admittedly, it is difficult to find areas where a fish tank truck can get near the river. However, two men using small wash tubs or cream cans could accomplish a more equitable distribution of the fish, especially in the area above the Tunnel where the service road to Crystal Dam closely follows the river.

Now that Crystal Dam is operating, flows below the Tunnel will usually be greater than before. These greater flows will make it more difficult for fishermen to move downstream into the National Monument. The installation of a foot bridge across the Gunnison River below the Tunnel would allow fishermen to fish from both sides of the river and reduce the hazards associated with fording heavy flows.

Some degree of flow manipulation is possible since Crystal Dam has been completed. Every attempt should be made to eliminate extreme daily fluctuations in the releases from this dam. If rapid increased discharges are necessary, they should be confined to times between 10 P.M. and 4 A.M. when fishermen are not likely to be fishing in the river canyon below the dam. Increased spring and early summer flows would be desirable below Delta for enhancing upstream migrations of squawfish and humpback suckers, but such flows may be undesirable for optimal rainbow trout reproduction and/or, fisherman access in the gorge below the Gunnison Tunnel. Consequently, if water is available between April and July in Curecanti reservoirs for increasing discharges, it may be best to route most of the additional water through the Tunnel into the lower Uncompahgre River. By so doing, the flows could be increased below Delta without increasing them in the National Monument and Gunnison Gorge where rainbow trout adults would be spawning and young brown trout would be emerging. Furthermore, flows during late October and November when brown trout are spawning should not excede those of the following April-June period when brown trout eggs will be hatching. Prior to Crystal Dam, Curecanti release flows during November usually averaged higher in the river below the Tunnel than during late spring and early summer (Table 5). It is possible that many brown trout eggs that were deposited in shallow gravels during these high flows were lost by desiccation before emergence in the lower spring flows. Admittedly, November is usually the start of heavy power releases from Curecanti reservoirs, but much of this water could again be routed through the Gunnison Tunnel which is not extensively used during the November-March period.

There are no areas between the upper National Monument boundary and the Smith Fork confluence that would permit fish-truck distribution of catchable-size trout. Fingerling trout could be planted by helicopter, but little is presently known about survival of such plants in this section of the Gunnison River. I therefore do not recommend annual fingerling plants in the Gorge section below the Monument until it can be determined that they could provide economical returns to the creel. If fingerlings are planted they should probably be brown trout, which appear to dominate this section.

Fishing pressure could likely be doubled in the Gorge section by simply marking the three existing access roads (Chukar, Duncan and Ute) from the Peach Valley road to the Gorge rims. However, increased pressure in this area may not be desirable at present because this section of river is being considered for "wild and scenic" designation, as is the National Monument, and adequately stocking the area would be extremely difficult and/or costly.

Below the Smith Fork but above Austin, public access is also quite limited. The only public access road is at the North Fork junction. The Gunnison River section below the Smith Fork to Austin appears to be ideally suited for rubber raft floating, but public access roads are non-existent near the Smith Fork. Efforts should be made to construct an access road from the east, leading to the Gunnison River near the

Smith Fork confluence. Rafters could then launch in this area and egress either at the North Fork junction or at the Austin Bridge. The entire float trip would likely take 5-6 hrs.

An attempt should also be made to secure a public easement through the Bill Overman Ranch near Austin. An existing single-lane road that parallels an irrigation ditch runs along the north bank of the Gunnison River for a few miles. Some improvement in the form of turnouts would be necessary.

A foot bridge across the North Fork near its junction with the Gunnison River would also allow greater fishing pressure in the Gunnison River section below the Smith Fork during high-flow periods when the North Fork cannot be forded. In addition, a long term or perpetuity fishing easement allowing foot traffic across approximately 1 mi of privately-owned land (McClusky property) along the east bank of the Gunnison River between the North Fork and Smith Fork should be secured. Such an easement would assure public access to the 3.25 mi of the lower Gunnison River below the Smith Fork since all of this area except for the McClusky property is publicly owned and managed by the Bureau of Land Management.

If any improvements are made to allow increased pressure in this area, stocking of catchable rainbow trout should be increased to about 5,000 annually. Fishing pressure in this Gunnison River section usually is greater earlier in the season (April-July) than it is in sections above the Smith Fork where pressure is greatest in June-September. Catchable stocking in these areas should be adjusted accordingly.

I do not feel that any additional exotic fishes should be stocked in the lower Gunnison River. Smallmouth bass fingerlings planted near

Delta in 1973 subsequently failed to show up. The section from Ute Trail to the North Fork junction probably would have been a better area for the establishment of smallmouth bass. Survival would likely be sufficient if yearlings were originally stocked, but rearing costs would be quite high.

SUMMARY

At the junction of the East and Taylor rivers at the town of Almont in southwest Colorado arises the Gunnison River, a major tributary to the upper Colorado River. Prior to Man's intervention, the Gunnison River flowed, sometimes voluminously and with considerable velocity in some sections, for about 150 mi before joining the Colorado River at Grand Junction, Colorado. For almost 80 yrs prior to 1965, the initial 60-mi section of the Gunnison River below Almont was a world-renowned trout fishery. Between 1965 and 1977, 40 mi of this renowned section of river were inundated by the three-reservoir Curecanti Unit power complex. The uppermost Blue Mesa Reservoir began filling in October 1965 and became Colorado's largest body of water in 1970, when the reservoir first attained maximum capacity of 9,040 surface acres. The two lower and smaller reservoirs, Morrow Point (817 acres) and Crystal (280 acres), began filling in 1968 and 1977, respectively, and attained maximum capacity a few months thereafter.

About 1.5 mi below Crystal Dam is the Gunnison Tunnel, a diversion dam structure capable since 1910 of diverting the entire summer flow of the Gunnison River into the arid Uncompahgre Valley in low-water years. The flows, after being diverted and used for irrigation by the Uncompahgre Water Users, reenter the Gunnison River via the Uncompahgre River near Delta, Colorado. In 1937, Taylor Dam, which created a storage reservoir for the Uncompahgre Valley Water Users, was completed on the Taylor River about 25 mi above Almont. Subsequently, deep, coldwater releases from the hypoliminon have annually occurred late in the summer to provide irrigation needs of the Uncompaghre Valley Water Users. Another structure, the Redlands Diversion Dam, was constructed in 1907 across the lower Gunnison River about 1.5 mi above Grand Junction. The operation of Taylor Park Reservoir releases was historically changed after the lower Blue Mesa Reservoir was completed. Consequently, effects on the flow due to Taylor Park Dam were analyzed for the two appropriate time periods, before and after Blue Mesa. Mean flows (cfs) of the Taylor River at Almont prior to Blue Mesa were shown to be decreased due to Taylor Dam in the November-June months. Individual monthly means ranged between 10.3 percent reduction in April to 41.8 percent reduction in May. The reduced flows of all months in the November-June period were statistically significant except for December and April. Increased flows occurred during the July-October period and varied between 15.4 percent for October to 211.6 percent in September. The increased flows of July and October were not significant, while those during August and September were highly significant. Since Blue Mesa has been in the system, increased flows at Almont occurred in all months between August and April, with decreased flows only during the May-July period. The greatest increases occurred in September and October, both over 100 percent of historical patterns that existed before Taylor Dam was constructed. The greatest decrease (46.4%) occurred in June.

Alteration in the historical monthly flow patterns at the Tunnel area of the Gunnison River were very similar to those described above for the Taylor River at Almont after completion of Blue Mesa Dam. Increased flows occurred in all months between August and March, with decreased flows only in the April-July period. Significantly less mean annual discharge occurred in the 1938-1965 period (1,613 cfs), compared to the 1910-1937 period when a mean annual discharge of 1,895 cfs reached the Tunnel area. Despite this, nearly 27 percent of the mean annual flow was diverted through the Tunnel in the 1938-1965 period, compared to diversions of only about 14 percent of the mean annual flow in the 1910-1937 period. Furthermore, 31 percent of the mean annual flow in the 1966-1975 period has been diverted through the Gunnison Tunnel when the mean annual flow reaching the Tunnel area was only 1,510 cfs. Consequently, less water has historically reached sections of the lower Gunnison River below the Tunnel. Had the 761,056 acre-ft of water that was stored in Blue Mesa and Morrow Point reservoirs at the end of 1975 been allowed to flow, the mean annual discharge above the Tunnel in the 1966-1975 period would have been 1,616 cfs rather than the observed 1,510 cfs mentioned above.

Most of the releases from Taylor Park and Curecanti reservoirs have been deep, cold, hypoliminon water. It was reported that coldwater releases (about 42°F) in July 1950 from Taylor Park Reservoir lowered the temperature of the Gunnison River by about 6°F in an area over 40 mi below Taylor Dam. Monthly seasonal temperature patterns of the Gunnison River below the Curecanti reservoirs have been altered. Reduced temperatures (0.6-9°F) in the Tunnel area have occurred between April and September, whereas increased temperatures (3.3-7.2°F) have occurred in the October-March period. It was projected that decreases of about 13°F (22% of normal) will occur in August; and increases of about 12°F (37% of normal) in November and December will occur in the Tunnel area once Crystal Dam is operating normally and provided Blue Mesa Reservoir is at its usual high-water level during the summer.

Some changes in the temperatures of the Gunnison River due to the Curecanti reservoirs have been found about 100 mi downstream at Grand Junction. Here, decreases (0.3-4.8°F = 0.9-7.4% of normal) in the

January-October period and increases (0.8-1.7°F = 1.9-4.9% of normal) in November and December have occurred. Statistical comparison of all the monthly temperature means since 1952, pre- and post-Curecanti, revealed that only the decreased temperatures in August (3.5°F = 4.9% of normal), September (4.8°F = 7.3% of normal), and October (3.7°F = 6.7% of normal) were of great enough magnitude to be significant.

Water samples from an area about 30 mi below the dams in the Gunnison River just upstream of the North Fork junction were collected at various times pre- and post-Curecanti dams. Mean values for alkalinity, total hardness, sulfates, calcium, magnesium, potassium, sodium and zinc were all higher in the post-Curecanti samples but none were significantly higher statistically.

The giant stonefly, *Pteronarcys californica*, which historically contributed greatly to the well being and growth of trout in the Gunnison River, emerged highly significantly earlier (mean time June 10) in the period after Taylor Park Reservoir (1938-1966) than (June 16) in the period prior to this reservoir (1904-1937). Although *P. californica* was once abundant in the river section between Gunnison and Sapinero, it has largely disappeared with the inundation of most of this section by Blue Mesa Reservoir.

Several differences in occurrences of various larval insect groups were documented from collections made pre- and post-Curecanti in the Gunnison River area of the Gunnison Tunnel below Crystal Dam. Of seven mayfly genera that occurred in this area in pre-dam collections, only three genera occurred in post-Curecanti collections. In general, stoneflies appeared to be better represented in the post-dam collections than in the pre-dam collections, while little difference was found in pre- and post-dam collections of caddisflies. Larvae of two families of Diptera, Tendipedidae and Simuliidae, occurred more frequently in the post-dam collections, while larvae of two other Diptera families, Tipulidae and Rhagionidae, occurred less frequently. Many of the differences between pre- and post-dam collections could have been due to normal seasonal variations and/or failure to sample identical stream-bottom habitats, rather than to effects of the Curecanti dams.

Prior to 1883, the world-famous Gunnison River trout fishing was composed entirely of Colorado cutthroat trout. No trout over 5.25 lbs was documented in Gunnison newspapers prior to 1892. Brook, rainbow, and brown trout had been introduced into the Gunnison drainage in 1883, 1888, and 1893, respectively. Continued or periodic stocking by state and federal agencies of the three introduced trout species, however, resulted in a predominance of rainbow and brown trout, which has persisted since 1908, the brown trout mostly by natural reproduction and the rainbow trout by continual stocking with some natural reproduction. As early as 1901, cutthroat trout were becoming scarce in the main river, and this was believed to have resulted from lack of stocking and from competition with rainbow trout. One rainbow trout of 10.25 lbs was taken in 1894, just 6 yrs after the original stocking of the species. A rainbow trout of 12 lbs was caught in 1897 and is believed to be the hook-and-line record for this species from the Gunnison River. The state spawning crew seined a 13-lb rainbow trout in 1903, likely the largest rainbow ever taken from the Gunnison River. Some earlier notoriety resulted from the fact that in 1895 a string of "Gunnison River rainbow trout" caught by hook and line was sent (likely by rail) to Denver for display. The smallest of the fish weighed 5.5 lbs, and the largest was 7.5 lbs dressed, while the collective weight of 10 of them was an even 66 lbs. These rainbow were just a portion of the trout four fisherman had caught in 3 hrs of fishing in the Gunnison River about 2 mi downstream from the LaVeta Hotel in Gunnison.

The Denver and Rio Grande narrow-gauge railroad probably was the most instrumental factor in publicizing the Gunnison Valley fishing. Its route, the first across the Colorado rockies with intercontinental connections by 1883, paralleled the Gunnison River for about 40 mi below Gunnison and allowed easy access for fishermen. Many excursion trains were run and they picked up the fishermen after fishing trips.

Despite the renowned trophy catches of trout that early issues of Denver newspapers, Harpers magazine, and Outdoor Life publicized, the average size of trout in creels of fishermen at the turn of the century was about 1 lb. The Gunnison River after 1902 was being annually augmented with heavy stockings of small rainbow, brook, and cutthroat trout fingerlings from the Gunnison and Pitkin hatcheries. Fingerling stocking was a policy that persisted until about 1937, when catchable-size stocking came into vogue even though natural reproduction was known to occur. Although extensive fingerling stocking of these three species of trout continued into the 1930's, both the brook trout, which was common in the main river to at least 1911, and the cutthroat were very rare in the main river by 1934. The scarcity of brook and cutthroat trout was attributed to the warming influence that return irrigation flows had on the river. Considerable increases in irrigation ditches occurred after 1902 as hay-meadow ranching in the smaller tributary valleys of the upper Gunnison River became more frequent. The return-irrigation flow from these meadows was often 10°F warmer than that of the main river.

Prior to 1903, rainbow trout were primarily utilizing small tributary streams for spawning, but by the mid 1930's they were primarily using the main Gunnison River, which may have been less desirable because of the likelihood of increased predation on the young by the larger trout in the main river. Factors suggested as likely reasons for this shift in spawning site were: 1) the deflection of water for irrigation, leaving the tributaries low or even dry; 2) the allowance of the spawners and/or young-of-the-year to run into unscreened ditches, only to become stranded and die in the fields; and 3) the elimination of beaver dams and destruction of watersheds through fires, clearcutting, and overgrazing, which probably accelerated spring flows and resulted in early turbid discharges at the time of egg incubation and warmer, diminished discharges later in the season.

In addition to some of the above phenomena, which had a warming influence on the main river, an extreme drought occurred during the 1930's. A temperature of 80°F in the main Gunnison River near Iola was recorded on July 16, 1934. That year had the historic low flow in the Gunnison drainage prior to 1977. It was implied that, had not Taylor Park Reservoir been built, with its consequent coldwater releases during the summer, rainbow trout, which comprised over 70 percent of all trout harvested at this time, may not have been able to persist in the many sub-normal flows which have occurred since 1938.

Some of the largest trout that have been caught in the Gunnison River were taken in years subsequent to the completion of Taylor Park Reservoir. Between 1947 and 1964, one brown trout of 15.5 lbs was taken from the Gunnison River by hook and line (1959) and three others were exactly at or exceeded 13 lbs. In addition, one cutthroat trout of

8.5 lbs, the largest of that species ever taken from the Gunnison River, was caught below Iola in July 1950. Despite these trophy-size fish, the average-size trout in creels of Gunnison River fishermen exceeded 10.0 in. in only 2 of 18 yrs prior to inundation of Blue Mesa Reservoir late in 1965. In the 1952-1965 period, the average size of trout in creels was 9.6 in. and it was estimated that the average weight for a trout of that length was 0.32 lbs. Nearly 74 percent of all trout harvested in this period were rainbow trout.

Returns from jaw-tagged rainbow trout that had been stocked at an average size of 8.5 in. in the Gunnison River in 1947 indicated that 98 percent were caught that same year at an average size of 9.0 in. The 2 percent of the returns that were reported harvested in 1948 averaged 11.9 in. Furthermore, the total number of catchable-size rainbow trout stocked in the Gunnison River during a particular year between 1952 and 1965 was highly-significantly directly related ($r = .85$) with the catch rate (CPMH) for rainbow trout during that same year, again suggesting that catchables were removed rapidly soon after stocking.

A study to determine fisherman-use and harvest was conducted by the Bureau of Sport Fisheries and Wildlife during 1956, the year of maximum historic stocking of 151,866 catchable rainbow trout above Cimarron. Within the area to be inundated by Blue Mesa Reservoir, it was estimated that 41,000 fisherman-days of effort harvested 185,300 trout. This equates to 59,667 lbs, or an average of 1.46 lbs per man-day of fishing. The study actually encompassed the section of the Gunnison River from North Beaver Creek (now the upper end of Blue Mesa) to the North Fork junction east of Delta. Below the North Fork, no trout fishery existed in 1956.

An estimated 52,500 man-days in the entire study section yielded 228,100 trout, which amounts to 73,448 lbs, or 1.40 lbs per man-day. Considering the sharp upward trend in population growth, the increasing numbers of people who fish, and the trend toward more leisure time, the Bureau of Sport Fisheries and Wildlife further estimated that annual use of the Gunnison River below North Beaver Creek (without Curecanti) over the next 50 yrs would average 78,800 man-days, with a yield of 342,600 trout. This adjusts to 110,317 lbs, or 1.40 lbs per man-day.

By contrast, Blue Mesa Reservoir in its early years (1968-1972) provided an average estimated annual yield of 214,837 lbs of salmonids, or nearly twice what the entire Gunnison River below North Beaver Creek was projected to provide. Despite declining yields and fisherman-use recently, Blue Mesa Reservoir has, in the last 5 yrs (1973-1977), provided more man-days of fishing effort (average of 80,666 annually) compared to the 78,800 projected annually for the entire Gunnison River below North Beaver Creek (including the lower Lake Fork) and has done it at an average annual rate (1.38 lbs per man-day) nearly equal to the 1.4 lbs per man-day anticipated from the river without the project. In none of the years that Blue Mesa Reservoir has existed did the reservoir provide the number of fish per man-day that were anticipated from the Gunnison River without the Curecanti Project.

Below the Gunnison Tunnel, the Gunnison River flows through the Gunnison National Monument, a 12-mi stretch of some of the most steep, wild, and scenic area in Colorado. The gorge depth within the Monument ranges from 1,730 to 2,725 ft, while the width narrows to 1,100 ft at the rim and as little as 40 ft at the bottom. Access to the river is generally restricted by the terrain and is usually accomplished by hiking down steep trails from the gorge rims. Although the gorge widens below the Monument, access is very restricted all the way downstream to the North Fork junction, a distance of about 17 mi below the lower Monument boundary.

The Bureau of Sport Fisheries and Wildlife survey in 1956 estimated that only 1,300 trout were harvested by 600 man-days of fishing in the 29-mi section below the Gunnison Tunnel but above the North Fork. They projected that, in the next 50 yrs, this section would annually sustain a total harvest of 5,700 trout by 2,700 man-days of effort. A statistically designed random survey was conducted on this stretch between April 16 and October 11, 1977, and it was estimated that 14,334 trout were harvested by 6,759 man-days of effort. Of 4,260 finclipped, catchable-size rainbow trout stocked in the Tunnel area during June and July, 3,895, or 91.4 percent, were estimated caught before mid-October. The 95 percent confidence limits for this estimate was ± 1,154.

The only Gunnison River section below North Beaver Creek in 1977 not providing what the Bureau of Sport Fisheries and Wildlife had anticipated the Gunnison River would provide was the 18 mi inundated by Morrow Point and Crystal reservoirs. In this section, fisherman-use was estimated at 2,000 man-days, or only 14 percent of what was anticipated. Furthermore, only 6,600 lbs of salmonids, primarily kokanee from Morrow Point, were provided or about 35 percent of what was anticipated. Loss of pre-reservoir access roads and lack of boat-launching facilities were suggested as the reasons for the lower use and harvest. A trout fishery now exists in the section between the North Fork junction and Austin, an area not providing a trout fishery prior to the Curecanti reservoirs. It was estimated that 616 man-days yielded 1,100 trout in this lower section.

Overall, the reservoir-modified Gunnison River in 1977 provided slightly more estimated man-days of use (83,660) than the 78,800 anticipated by the Bureau of Sport Fisheries and Wildlife. The river has not provided the 342,600 salmonids anticipated, because only 195,263 were estimated caught in 1977. However, the modified river has provided more pounds per man-day of effort (1.53) than the 1.40 lb/man-day anticipated without the construction of the Curecanti Unit. It was roughly estimated that stocking costs in 1977, with the Unit, were slightly more than double what was anticipated without the dams. However, the federal government since 1970 has provided about 70 percent of the annual stocking costs incurred on sections of the Gunnison River below North Beaver Creek.

In recent years, many different marked groups of rainbow trout and kokanee salmon were stocked into various reservoirs in the drainage. Between 1974 and 1976, all rainbow fingerlings stocked in Blue Mesa (over 3 million total) were marked with flourescent pigments of different colors. The entire plant of fingerling rainbows stocked in Silverjack Reservoir (about 40,000), in the Cimarron drainage above Crystal Dam, was also marked with flourescent pigments in 1974. In addition, all of the 280,000 kokanee of the 1975 year-class stocked in Taylor Park Reservoir were marked with tetracycline, as were 40 percent of the approximately 2 million salmon of the 1974 year-class that were stocked in Blue Mesa Reservoir. These marked plants provided the following facts, along with associated implications:

1) Between 1975 and 1977, when no spills occurred at Curecanti reservoirs, only 2 (less than 1%) of more than 300 rainbow trout examined below Blue Mesa Reservoir were found to be

marked. Evidence was presented that loss of marks was negligible. It was therefore suggested that neither the average 4,225 catchable-size rainbow trout annually stocked in the last 5 yrs in the Tunnel area nor losses of rainbows from the reservoirs above the Gunnison Tunnel could have supplied all of the estimated 8,463 rainbows harvested in the lower Gunnison River above the Ute trail during 1977. An unmarked 1975 fingerling plant of 10,000 rainbows in the area of the Ute trail was thought not to provide much to the fishery above there, but this was not proven. Consequently, it was merely implied that successful natural reproduction of rainbow trout in the Gunnison River below Crystal Dam was providing much of the rainbow trout fishery above the Ute trail. It was suggested that the lower and less-turbid springtime flows since the dams have existed may have benefited rainbow reproduction.

2) Despite considerable numbers of tributaries available for rainbow trout spawning above Blue Mesa Reservoir, unmarked rainbow (either from natural reproduction, from some unmarked rainbows stocked in the tributaries, or from loss of marks) constituted less than 8 percent of all rainbow trout harvested from Blue Mesa Reservoir since 1975. Extensive harvesting before maturity and use of fall-spawned eggs for the stocked fingerlings were suggested as likely reasons for so few naturally reproduced rainbow trout from the Blue Mesa tributaries.

3) An estimated 35 percent of the 1975 year-class of kokanee salmon in Blue Mesa and Morrow Point reservoirs during 1977 was from the marked Taylor Reservoir plant, which indicates a considerable amount of downstream migration of kokanee salmon. In addition, considerable numbers of the 1974-marked plant stocked 2 mi above Blue Mesa were found in Morrow Point Reservoir during 1977. Spawners from the 1974-marked group were also expected to return to Roaring Judy Hatchery, 22 mi above Blue Mesa Reservoir, but they failed to do so in proper proportion. Less than 2 percent of the kokanee that returned to Roaring Judy Hatchery were marked; an estimated 80 percent were expected. However, kokanee spawners were in fact 80-percent marked in Gunnison River sections below Gunnison. Low flow during 1977 may have disrupted their upstream migration. Despite these problems, the 1974-marked year-class of kokanee fingerlings (600/lb at stocking) provided an estimated return to the harvest at Blue Mesa of 4 percent of the 870,000 originally stocked. Using Colorado's 1977 average hatchery rearing costs, this equates to $.63 per kokanee harvested; the cost per pound is the same, since the salmon averaged 1 lb each when harvested. In contrast, marked rainbows of the 1974-1976 year-classes caught at Blue Mesa have cost, per fish, $0.76, $0.70 and $0.64, respectively. Because the marked rainbow trout were also smaller than kokanee when harvested, cost/pound, was $1.52, $1.11 and $1.02, respectively, or an average of $1.21

per lb for the 1974-1976 year-classes. However, costs of unmarked kokanee released directly from Roaring Judy Hatchery were more than double those of the marked group that were trucked close to Blue Mesa Reservoir before being planted. It was estimated that 62 percent of the unmarked lot released from the hatchery in 1974 was lost to irrigation ditches and predation before entering Blue Mesa Reservoir.

A considerable amount of space was used in describing the present and historic distribution and abundance of each non-salmonid species and/or sucker hybrids found in the Gunnison River. Collectively, the non-salmonids, primarily suckers, comprised the majority of fishes taken in all sections of the Gunnison River below the town of Gunnison after the mid-1930's. Separate discussions of each species took note of whether the species was native or had been introduced. If a species was introduced, speculations were made as to when, where, and how the introduction may have occurred. In addition, factors believed responsible for changes in the distribution or abundance of a species were discussed.

Prior to 1890, the non-salmonids of the Gunnison River were composed of eight native species: roundtail and bonytail chubs (very rare); Colorado squawfish; speckled dace; flannelmouth, bluehead, and humpback suckers; and another rare species, the mottled sculpin. Since then, 14 non-salmonid species have been introduced, and only one of these, smallmouth bass, has not been collected recently. Beside the smallmouth bass, the known introduced species included: longnose dace; fathead minnow; carp; red and sand shiner; white and longnose sucker; channel catfish; black bullhead; largemouth bass; green sunfish; plains killifish; and northern pike. Two other species and five sucker hybrids were discussed. One sculpin, thought to be a piute sculpin, a species likely native to the upper Colorado River, was captured in the National Monument during 1975. Although no authenticated plains mountain suckers have been taken recently, this species was discussed because it has been reported, likely erroneously, in some areas. The five sucker hybrids discussed were: bluehead x white; flannelmouth x white; longnose x white; bluehead x flannelmouth; and bluehead x longnose. Some evidence was presented which suggested that introgressive hybridization between bluehead and white suckers has occurred recently in the 30 mi of river below Crystal Dam.

Few of the original native species have been unaffected by either the introduced species and/or the alterations in the flows and temperatures resulting from the various structures constructed by Man in the last 70 yrs.

During the 1930's, the only sucker species in the Gunnison River were bluehead and flannelmouth suckers, respectively abundant and common in the river above Gunnison. In one 250-yd section of river above Gunnison, over 800 suckers were observed in 1934. By 1954 no suckers of any kind were sampled above areas in the Gunnison River at least 2 mi below Gunnison. By the mid 1960's, suckers in the main Gunnison River were still scarce in these upper areas but they were almost wholly composed of introduced white and longnose suckers. The downstream recession in the distribution and abundance of suckers was thought to be caused by the coldwater releases from Taylor Park Dam subsequent to 1937. White suckers are now dominant in both Blue Mesa and Morrow Point reservoirs, areas both dominated by native bluehead suckers in the 1930's.

Although only a few suckers were taken in gillnets in Crystal Reservoir in 1977, longnose suckers dominated there. The speckled dace, abundant in all sections of the Gunnison River prior to Curecanti reservoirs, has disappeared in the sections now inundated but is still abundant in the other stream sections.

Just prior to Curecanti reservoirs, bluehead and white suckers were of about equal abundance in the National Monument. Flannelmouth were about 2/3 as abundant as each of the other two species of suckers. In less than 12 yrs of coldwater releases from Blue Mesa and Morrow Point reservoirs, the flannelmouth sucker has almost totally disappeared from this 12-mi stretch, and the longnose sucker, not present as late as 1966, is now the dominant sucker species of this area. Suckers presently are fewer in the Monument than in the gorge sections below there, but it is unknown if this trend existed before Curecanti discharges, because the lower gorge sections were not sampled prior to the dams. Despite lower temperatures recently, the average size of all species in the National Monument was larger than prior to the coldwater releases.

White suckers, comparatively the least abundant species of sucker as late as 1966 in the North Fork area, now dominate here and in all sections above there but below the Monument. These areas historically had been dominated by bluehead suckers. Flannelmouth suckers still dominate, as they have historically in Gunnison River sections below Delta, but white suckers are increasing.

Historically, both the humpback sucker and Colorado squawfish, respectively abundant and common prior to 1890 in the lower Gunnison River, likely never extended upstream farther than Delta. Both species are now quite rare, but they were also rare prior to the coldwater discharges from Curecanti reservoirs in 1965. It was suggested that upstream migrations of squawfish were likely effectively blocked by the following two factors: 1) Migrations from the lower Colorado basin were first effectively blocked by Hoover Dam in 1935 and by Glenn Canyon Dam in 1963; and 2) Upper Colorado basin dam construction since 1937 and irrigation diversions have reduced the spring and early-summer flows in the Colorado River basin. Consistently lower flows since 1947 over the Redlands Diversion Dam probably prevented many migrants from reaching spawning tributaries in the lower Gunnison River. Decline of squawfish likely was related to the fact that young squawfish have been subjected to increasing competition for food and space in limited backwater nursery areas from the many exotic fishes that have been introduced during the present century. These backwater areas in the lower Gunnison River are now dominated by fathead minnows, which appear to become more abundant each year.

Humpback suckers, once very abundant, were apparently on the decline as early as 1912 and were quite rare by 1946 near Grand Junction. Lower Colorado basin dam construction, as well as the Redlands Diversion Dam across the Gunnison, probably interfered with upstream migrations of these suckers, but it was suggested that the early introduction and subsequent rapid expansion of carp, channel catfish, and, possibly, minnows and sunfish in competition for limited food and space in preferred back-water habitat best explained the rapid decline of humpback suckers. Hybridization of the numerically declining humpback suckers with flannelmouth suckers probably had accelerated the decline of humpback suckers.

The least-affected native non-salmonids were roundtail chubs and mottled sculpins. Roundtail chubs, despite a slight recession in their upstream distribution, actually appear more abundant in the lower Gunnison than prior to Curecanti dams. Mottled sculpin apparently were always rare, as they are now. This species was found primarily in the lower North Fork, where temperatures over 80°F are common.

Updated stocking recommendations were given for the three Curecanti reservoirs. It was recommended that the stocking size of rainbow trout fingerlings be increased to 5 in. at Blue Mesa Reservoir and that the numbers stocked there be reduced to 800,000. It was suggested that, if adequate kokanee eggs can be procured, stocking of this species be increased from 1,000,000 to 1,500,000. Three alternate plans for kokanee were discussed if adequate eggs are not procurred from spawners returning to Roaring Judy. Stocking of Colorado cutthroat trout fingerlings from the Trapper's Lake source was recommended for Morrow Point and Crystal reservoirs (30 per acre). Recommendations for the Gunnison River in sections below the dams, as well as the section between Morrow Point and Crystal reservoirs, were primarily ways to improve access for the fishermen, if this is deemed desirable. It was recommended that the flows below the Tunnel during late October and November when brown trout are spawning should not exceed those of the following April-June period when brown trout eggs would be hatching. Further introductions of exotic species for the lower river sections were not recommended.

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APPENDIX I

Physical and chemical properties of water from lower Gunnison River, 1974-1977.

Sampling station	Sampling date	Dissolved solids (mg/l)	Turbidity (mg/l as SiO_2)	Specific conductance (micromhos)	pH	Alkalinity M.O. (mg/l)	Alkalinity phth (mg/l)	Total hardness (mg/l)	Cadmium (µg/l)	Calcium (mg/l)	Copper (µg/l)	Iron (mg/l)	Lead (µg/l)	Magnesium (mg/l)	Manganese (mg/l)	Molybdenum (mg/l)	Potassium (mg/l)	Selenium (µg/l)	Silver (µg/l)	Sodium (mg/l)	Sulfate (mg/l)	Zinc (mg/l)
Gunnison River below Blue Mesa	4/10/74	128	2.5	234	7.52	94	0.0	54	0.13	34	2.3	<0.01	1.1	4.9	0.06	<0.2	1.55	< 10	N.A.	4.5	19	N.A.
	7/22/74	124	3.5	191	7.78	88	0.0	46	<0.05	30	6.4	<0.01	4.5	4.6	<0.01	<0.2	1.45	< 10	<0.10	4.0	23	0.03
	11/18/76	120	N.A.	480	7.60	74	0.0	126	<100	19	<100	<0.20	<500	5.0	<0.10	<0.2	1.00	<500	<200	7.0	18	<0.05
	3/ 1/77	108	N.A.	400	7.60	96	0.0	112	<100	26	<100	<0.20	<500	6.0	<0.10	<0.2	3.00	<500	<200	5.0	5	<0.05
	5/26/77	138	N.A.	380	7.40	100	0.0	100	<100	24	<100	<0.20	<500	6.5	<0.10	<0.2	3.00	<500	<200	6.0	4	0.05
Gunnison River below Morrow Point	1/17/74	148	8.5	196	7.62	84	0.0	96	0.22	33	5.0	<0.01	3.0	4.9	<0.01	<0.2	1.60	10	0.06	4.0	18	0.16
	4/10/74	125	2.5	225	7.57	96	0.0	50	0.73	33	2.3	<0.01	1.1	4.9	0.03	<0.2	1.45	< 10	N.A.	3.5	19	0.38
	7/17/74	122	3.5	179	7.57	82	0.0	42	<0.05	30	7.4	<0.01	1.0	4.4	<0.01	<0.2	1.50	< 10	<0.10	4.0	21	0.03
	11/18/76	102	N.A.	420	7.50	78	0.0	78	<100	17	<100	<0.20	<500	4.0	<0.10	<0.2	3.00	<500	<200	3.0	3	0.10
	3/ 1/77	100	N.A.	400	7.70	96	0.0	100	<100	26	<100	<0.20	<500	6.0	<0.10	<0.2	1.00	<500	<200	5.0	7	<0.05
	5/26/77	132	N.A.	360	7.20	92	0.0	92	<100	22	<100	<0.20	<500	5.5	<0.10	<0.2	1.00	<500	<200	6.0	3	<0.05
Gunnison River below Crystal Dam Site	4/10/74	206	350	343	6.66	100	0.0	72	0.21	59	2.6	<0.01	1.7	11.8	<0.01	<0.2	2.10	< 10	N.A.	16.0	125	0.08
	7/17/74	161	220	235	7.91	90	0.0	50	0.30	36	10.0	<0.01	2.0	70.0	<0.01	<0.2	2.00	< 10	<0.10	8.0	80	0.04
	11/18/76	258	N.A.	520	7.20	60	0.0	124	<100	26	<100	<0.20	<500	10.0	<0.10	<0.2	3.00	<500	<200	15.0	50	<0.05
	5/26/77	164	N.A.	370	7.80	100	0.0	94	<100	22	<100	<0.20	<500	6.0	<0.10	<0.2	3.00	<500	<200	6.0	4	<0.05
	8/24/77	184	N.A.	545	8.20	114	0.0	142	N.A.	32	<100	<0.10	<200	7.0	<0.10	N.A.	1.70	N.A.	N.A.	11.0	N.A.	<0.01
Gunnison River above Confluence with North Fork of Gunnison	4/11/74	271	490	455	7.74	112	0.0	116	0.11	49	6.0	<0.01	<0.2	14.0	<0.01	<0.2	3.50	< 10	N.A.	22.0	210	0.02
	7/18/74	237	3.2	340	8.30	98	6.0	142	0.05	45	11.6	<0.01	1.0	12.2	<0.01	0.5	2.30	< 10	<0.10	16.5	110	0.03
	11/18/76	582	N.A.	1550	7.60	166	0.0	348	<100	64	<100	<0.20	<500	40.0	<0.10	<0.2	4.00	<500	<200	105	210	<0.05
	2/28/76	160	N.A.	580	7.60	106	0.0	122	<100	27	<100	<0.20	<500	8.0	<0.10	<0.2	3.00	<500	<200	8.0	25	<0.05
	5/26/77	162	N.A.	430	7.30	100	0.0	114	<100	24	<100	<0.20	<500	7.5	<0.10	<0.2	3.00	<500	<200	8.0	23	<0.05
	8/24/77	238	N.A.	480	8.00	100	0.0	128	N.A.	29	<100	<0.10	<200	8.0	<0.10	N.A.	1.60	N.A.	N.A.	14.0	N.A.	<0.01
Gunnison River at Austin Bridge Hy 92	5/26/77	394	N.A.	950	7.70	128	0.0	226	<100	46	<100	<0.20	<500	20.0	<0.10	<0.2	3.00	<500	<200	32.0	140	<0.05
Gunnison River at Delta, Hy 50 bridge	1/18/74	243	6.5	359	7.85	110	0.0	152	0.14	48	5.0	<0.01	2.0	12.6	0.02	<0.2	2.10	10	0.11	18.5	90	0.06
	4/11/74	554	43.5	835	7.85	138	0.0	162	0.13	74	4.0	<0.01	0.4	26.0	0.02	<0.2	3.60	< 10	N.A.	50.0	270	0.07
	7/18/74	1000	28.0	1340	8.01	192	0.0	482	<0.05	185	11.0	<0.01	<0.5	50.0	<0.01	<0.2	6.50	< 10	<0.10	100	670	0.05
	11/18/76	1300	N.A.	2200	7.80	176	0.0	652	<100	100	<100	<0.20	<500	80.0	<0.10	<0.2	7.00	<500	<200	100	290	<0.05
	2/28/77	550	N.A.	1150	7.90	140	0.0	294	<100	67	<100	<0.20	<500	35.0	<0.10	<0.2	4.00	<500	<200	56.0	190	<0.05
	5/26/77	422	N.A.	925	7.70	120	0.0	216	<100	45	<100	<0.20	<500	19.0	<0.10	<0.2	4.00	<500	<200	32.0	140	<0.05
	8/24/77	830	N.A.	1600	7.70	180	0.0	404	N.A.	88	<100	<0.10	<200	24.0	<0.10	N.A.	5.20	N.A.	N.A.	58.0	N.A.	<0.01
Gunnison River above Escalante Creek bridge	1/18/74	358	7.0	565	7.76	120	0.0	200	0.22	64	4.0	<0.01	1.0	16.0	0.02	<0.2	2.40	40	0.06	35.0	150	0.70
	4/11/74	717	480	1050	7.89	158	0.0	200	0.13	120	4.0	<0.01	0.4	30.0	<0.01	<0.2	3.85	< 10	N.A.	70.0	420	0.36
	7/18/74	1116	2500	1320	7.74	182	0.0	540	<0.15	225	13.6	<0.01	<0.5	48.0	<0.01	<0.2	5.60	< 10	<0.10	80.0	680	0.05
	11/18/76	1642	N.A.	2000	7.80	158	0.0	582	<100	104	<100	<0.20	<500	80.0	<0.10	<0.2	10.0	<500	<200	270	225	<0.05
	2/28/77	794	N.A.	1650	7.60	164	0.0	390	<100	100	<100	<0.20	<500	40.0	<0.10	<0.2	4.0	<500	<200	72.0	250	<0.05
	8/24/77	1364	N.A.	2175	8.20	162	0.0	700	N.A.	118	<100	0.20	<200	27.0	<0.10	N.A.	5.2	N.A.	N.A.	60.0	N.A.	0.02

APPENDIX II

Physical and chemical properties of water from tributaries of the lower Gunnison River, 1974-1977.

Sampling Station	Sampling Date	Dissolved solids (mg/l)	Turbidity (mg/l as SiO_2)	Specific conductance (micromhos)	pH	Alkalinity M.O. (mg/l)	Alkalinity phth (mg/l)	Total hardness (mg/l)	Cadmium (µg/l)	Calcium (mg/l)	Copper (µg/l)	Iron (mg/l)	Lead (µg/l)	Magnesium (mg/l)	Manganese (mg/l)	Molybdenum (mg/l)	Potassium (mg/l)	Selenium (µg/l)	Silver (µg/l)	Sodium (mg/l)	Sulfate (mg/l)	Zinc (mg/l)
Cimarron River at Cimarron, Colo.	1/17/74	237	13.0	380	7.52	90	0.0	152	0.42	40	7.0	<0.01	1.5	15.6	<0.01	<0.2	2.60	20	0.10	21.0	110	0.12
	4/10/74	483	300	723	7.88	118	0.0	138	0.09	66	4.8	<0.01	<0.2	24.0	<0.01	<0.2	3.95	<10	--	45.0	280	0.10
	7/17/74	608	145	775	8.07	172	0.0	154	1.50	72	11.6	<0.01	<0.5	38.0	<0.01	<0.2	5.20	<10	<0.10	44.5	320	0.03
	11/18/76	742	N.A.	1900	7.90	158	0.0	300	<100	78	<100	<0.20	<500	30.0	<0.10	<0.2	4.00	<500	<200	130	175	<.05
	3/01/77	132	N.A.	675	7.60	98	0.0	144	<100	28	<100	<0.20	<500	14.0	<0.10	<0.2	3.00	<500	<200	20.0	70	<.05
	5/26/77	590	N.A.	1150	8.40	156	0.0	296	<100	56	<100	<0.20	<500	40.0	<0.10	<0.2	4.00	<500	<200	42.0	190	<.05
	8/24/77	660	N.A.	1450	8.50	180	0.0	386	N.A.	50	<100	<0.10	<200	25.0	<0.10	N.A.	5.70	N.A.	N.A.	48.0	N.A.	<.01
North Fork of Gunnison at Hotchkiss National Fish Hatchery	1/18/74	754	15.5	960	7.96	212	0.0	468	0.30	170	4.0	<0.01	0.5	54.0	0.05	<0.2	3.90	10	0.06	70.0	420	0.10
	4/11/74	426	31.0	645	7.68	130	0.0	134	0.05	63	1.3	<0.01	0.2	22.0	0.04	<0.2	2.40	<10	--	35.0	190	0.06
	7/18/74	1551	9.8	1700	8.09	234	0.0	726	<0.05	265	7.6	<0.01	<0.5	90.0	<0.01	<0.2	6.20	<10	<0.01	90.0	800	0.04
North Fork of Gunnison Above Confluence With Main Gunnison	4/11/74	534	21.0	820	8.01	154	0.0	172	0.09	74	3.0	<0.01	0.5	28.0	0.03	<0.2	3.00	<10	--	40.0	240	0.03
	7/18/74	1447	3.1	1470	8.07	222	0.0	748	<0.05	250	6.4	<0.01	<0.5	92.0	<0.01	<0.2	7.50	<10	<0.10	90.0	1000	0.04
	11/18/76	1480	N.A.	2800	7.90	204	0.0	546	<100	110	<100	<0.20	<500	65.0	<0.10	<0.2	4.00	<500	<200	250	260	<.05
	2/28/77	1012	N.A.	2200	8.00	244	0.0	562	<100	113	<100	<0.20	<500	70.0	<0.10	<0.2	7.00	<500	<200	100	250	<.05
	5/26/77	1314	N.A.	2400	8.10	176	0.0	674	<100	110	<100	<0.20	<500	90.0	<0.10	<0.2	8.00	<500	<200	100	250	<.05
Uncompahgre River at Ridgway	1/18/74	469	7.5	690	7.78	118	0.0	360	0.53	170	19.5	<0.01	3.5	10.5	0.22	0.5	2.35	10	0.03	25.0	280	0.16
	4/11/74	472	36.0	687	7.76	108	0.0	150	0.76	140	7.5	<0.01	0.8	7.9	0.16	0.5	2.05	<10	--	22.0	250	0.06
	7/18/74	315	4.5	460	7.68	100	0.0	100	0.60	80	8.0	<0.01	1.5	5.0	0.04	<0.2	1.50	<10	<0.10	10.5	180	0.06
Cow Creek at Highway 550 Bridge	1/18/74	484	6.2	695	7.90	160	0.0	316	0.21	95	5.0	<0.01	1.5	25.0	0.02	0.5	2.45	25	0.05	33.0	200	0.12
	4/11/74	409	35.0	570	7.95	136	0.0	140	0.15	68	2.0	<0.01	<0.5	17.0	<0.01	<0.2	2.40	<10	--	28.0	180	0.02
	7/18/74	545	800	710	7.94	178	0.0	176	0.20	94	13.6	<0.01	<0.5	25.0	<0.01	0.5	3.90	<10	<0.01	26.5	300	0.05
Uncompahgre River at Montrose	1/18/74	902	9.5	1280	8.04	198	0.0	536	0.40	190	9.0	<0.01	1.5	32.0	0.04	<0.2	3.45	25	<0.01	65.0	480	0.10
	4/11/74	440	47.0	595	7.94	124	0.0	140	0.17	80	15.0	<0.01	0.5	17.0	0.02	<0.2	2.55	<10	--	32.0	205	0.02
	7/18/74	402	540	555	7.77	122	0.0	124	0.20	80	1.6	<0.01	1.0	14.0	<0.01	<0.2	2.95	<10	<0.10	23.5	280	0.04
Uncompahgre River at Olathe	1/18/74	1258	22.5	1480	8.21	250	0.0	760	0.35	240	10.5	<0.01	1.5	64.0	0.04	<0.2	4.70	25	0.03	130	700	0.14
	4/11/74	742	220	1035	7.98	152	0.0	198	0.15	130	4.2	<0.01	0.5	28.0	0.02	<0.2	3.55	<10	--	55.0	400	0.03
	7/18/74	648	1200	818	7.70	154	0.0	188	0.40	170	12.4	<0.01	<0.5	25.0	<0.01	0.5	3.90	<10	<0.10	41.5	380	0.04
Loutzenheiser Wash at Highway 50 Bridge	4/11/74	2661	1320	3120	7.98	300	0.0	582	0.24	320	13.8	<0.01	0.3	128	<0.01	0.8	8.00	<10	--	350	1760	0.03
	7/18/74	1888	1200	2100	7.76	200	0.0	442	0.40	305	7.6	<0.01	<0.5	79.0	<0.01	<0.2	8.00	<10	<0.10	225	1200	0.04
Uncompahgre River at Delta	1/18/74	1630	28.0	1960	8.20	268	0.0	952	0.51	280	6.5	<0.01	1.0	88.0	0.06	<0.2	5.30	25	<0.01	210	880	0.14
	4/11/74	1034	470	1370	7.94	180	0.0	310	0.17	160	4.2	<0.01	0.3	38.0	<0.01	<0.2	4.05	<10	--	95	620	0.04
	7/18/74	878	1300	1060	7.71	164	0.0	290	<0.05	180	12.8	<0.01	<0.5	35.0	<0.01	0.5	4.50	<10	<0.01	65	500	0.03
	11/18/76	1132	N.A.	2400	7.50	190	0.0	570	<100	120	<100	<0.20	<500	50.0	<0.10	<0.2	6.00	<500	<200	100	290	<.05
	2/28/77	5394	N.A.	2450	8.00	374	0.0	790	<100	160	<100	<0.20	<500	80.0	<0.10	<0.2	6.00	<500	<200	190	300	<.05
	5/26/77	1928	N.A.	3250	7.90	188	0.0	896	<100	180	<100	<0.20	<500	9.0	<0.10	<0.2	6.00	<500	<200	190	250	<.05

APPENDIX III

Number of bottom organisms collected in three Surber samples at each of various stations of the main Gunnison River between Morrow Point Dam and the Escalante confluence, 1973-1976.

	Below Morrow Point 7/76	Below Morrow Point 11/76	Below Crystal Dam 6/74	Below Crystal Dam 10/75	Below Crystal Dam 8/76	Above Tunnel 11/76	Below Tunnel 11/76	Echo Canyon 9/76	Warner Point 7/76	Duncan Trail 7/74	Ute Trail 8/76	Above Smith Fork 7/73	Above Smith Fork 6/74	Below Smith Fork 7/73	Below Smith Fork 6/74	Above North Fork 10/75	Above North Fork 11/76	At North Fork 10/75	At North Fork 11/76	Below North Fork 7/73	Above Austin 6/74	Austin Bridge 8/73	Below Austin 8/73	Delta Bridge 8/73	Delta Bridge 10/75	Delta Bridge 11/76	Below Uncompahgre R. 8/73	Escalante Bridge 6/74	Escalante Bridge 10/75
Tricoptera																													
Hydropsyche		20		5	5				3	19	37	176	10	19	44			24	43	3	80	211	140	20	64	26	39	85	95
Arctopsyche		2	14			1																							
Brachycentrus						1	1																						
Agraylea							1												3							2			
Oecetis																			17										
Rhyacophila		1																											
Ephemeroptera																													
Ephemerella		3	314		13	4	11		27	32	25	41	61	57	99			277			27	313	32	28		8	34	103	
Baetis		3		16		29	33		25		30									223	13				33	6	41	68	5
Trichorythodes																	7		21							29	3		
Heptagenia									4		3				5	2		11						17					3
Rithrogena			46							2											9		16						
Plecoptera																													
Isoperla		2	9		6		1	2	3				10	4	12			44			31							35	
Hastaperla					3		1						2																
Isogenus			31			4	1																			4			
Arcynopteryx				19		3	7																						
Claassenia					4						2	4	1																
Acroneuria														1	2														
Pteronarcella			2																										
Alloperla					18			3	20				2		3														
Nemoura							5																			1			
Coleoptera																													
Optioservus		2																	1			5		2			7		
Others				1					11	2	1												3						1
Odonata																													
Ophiogomphus																				2									
Lepidoptera																													
Elophila																			2										
Diptera																													
Tendipedidae	97	9		212		12	9							8		24	4	26	19			36	14			19			
Simuliidae	72		56		19			12										41		41		27				4			
Tipulidae		1																											1
Atherix					3			6	4	61	6	12	2		3							2			1				
Others																													
Snails							2									5	8								2				
Planaria									4							3	53												
Leeches									5		2					2	3			2									
Clams											3												2						
Amphipods																							1						
Annelids				59						3			4		14			22							2				
Total Organisms	169	43	472	312	71	54	72	23	106	119	109	233	92	89	182	36	75	445	106	271	160	594	208	50	119	99	124	291	105

APPENDIX IV

Number of bottom organisms collected in three Surber samples at each of the various tributary stations of the lower Gunnison River, 1973-1976.

	Cimmaron River near Cimarron 8/73	Cimmaron River near Cimarron 6/74	Cimarron River near Cimarron 10/75	Cimarron River near Cimarron 11/76	Cimarron River above Gunnison Confluence 10/75	Lower Smith Fork 7/73	Lower Smith Fork 6/74	North Fork above hatchery 7/73	North Fork below hatchery 9/73	North Fork above Gunnison confl. 7/73	North Fork above Gunnison confl. 6/74	North Fork above Gunnison confl. 10/75	North Fork above Gunnison confl. 11/76	Uncompahgre at Hwy 550 near Montrose 8/73	Uncompahgre below Montrose sewage plant 8/73	Uncompahgre at Hwy 90 near Montrose 8/73	Uncompahgre at Olathe 8/73	Uncompahgre at Delta 8/73	Uncompahgre at Delta 10/75
Tricoptera																			
Hydropsyche	16	24	109	44	44		11	17	382	90	84	277	43	3	3	1	1		3
Brachycentrus		21			13									2	1	2			
Agraylea													3						
Oecetis													17						
Ephemeroptera																			
Ephemerella	67	49	5		48			25	68	73	33			25	117	23			
Baetis	10		4	6	20			34		62								17	7
Iron								18											
Trichorythodes										18			21				87		
Heptagenia									6	27	8	3			32				
Rithrogena	1	28																3	
Cinygma		31							7		19						16		
Plecoptera																			
Isoperla					3		1				3			6		9			
Isogenus		16								2									
Arcynopteryx												1							
Classenia			3																
Alloperla								1			1			4					
Coleoptera																			
Optioservus				1						6			1						
Narpus	7		6			26													
Others	2	6	2	2				1	6	8		17							
Odonata																			
Ophiogomphus							1			1									
Lepidoptera																			
Elophila													2						
Diptera																			
Tendipedidae	43	27	22	47	7	18	15				13		19		41		23		
Simuliidae	275	173		3	23		29									3			
Tipulidae					1														
Atherix									4					1		2			
Others																			
Mites			3																
Snails								2	4										
Planaria												1							
Leeches										3									
Clams												1							
Amphipoda																			1
Annelida			97																1
Total Organisms	421	375	251	103	159	44	57	98	477	290	161	300	106	41	194	40	127	20	12

APPENDIX V

Comparison of various counts and proportional measurements for the various suckers captured in the Gunnison River between Crystal Dam and the North Fork junction, 1977.

No. of lateral line scales	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWS x LNS	BHS x LNS	BHS x FMS
50- 54	1								
55- 59									
60- 64	35								
65- 69	46					1			
70- 74	13				1	1	3		
75- 79	7				4	1			
80- 84	3	1			4	1	1		
85- 89		4	1		4	1			
90- 94	1	11	1		1				
95- 99		14	4	1				2	
100-104		18	10	1		1	1		1
105-109		13	22	7	1				
110-114		5	17	5					
115-119		1	6						
120-124				1					
125-129			2						
N	106	67	63	15	15	6	5	2	1
$\bar{X}$	67.19	100.46	107.73	107.20	83.47	80.67	82.60	102.50	105.00
S.D.	5.45	7.52	6.97	6.48	8.66	11.91	10.48	0.71	

APPENDIX V (cont.)

Scales above lateral line	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWS x LNS	BHS x LNS	BHS x FMS
6	1								
7	5								
8	13								
9	12					1			
10	33								
11	23			2	1		1		
12	12	3				1			
13	2	2	4		3		1		
14	8	10	3		1	2	2		
15	1	5	5		3		1		
16		9	9		3	1			
17	1	16	14		3	1		2	
18		6	9	3					1
19		7	7						
20		7	10						
21		3	2	4					
22				5	1				
23				2					
24				1					
N	111	68	63	17	15	6	5	2	1
$\bar{X}$	10.36	16.72	17.27	20.00	15.33	13.83	13.40	17.00	18.00
S.D.	1.91	2.34	2.10	3.81	2.55	2.93	1.52		

APPENDIX V (cont.)

No. principal dorsal fin rays	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWS x LNS	BHS x LNS	BHS x FMS
8		1							
9	2	3	7						
10	18	27	52		1	2	2	1	
11	72	34	7	3	9	4	3	1	
12	21	6	2	12	4				1
13	1			6	1				
N	114	71	68	21	15	6	5	2	1
$\bar{X}$	11.01	10.58	10.06	12.14	11.33	10.67	10.60	10.50	12.00
S.D.	.67	.77	.57	.65	.72	.52	.55	.71	.00

APPENDIX V (cont.)

Isthmus width % of total length (in.)	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWS x LNS	BHS x LNS
0.8-1.0	1							
1.1-1.3					1			
1.4-1.6	2							
1.7-1.9	2							
2.0-2.2	1		1					
2.3-2.5	8		1					
2.6-2.8	10							
2.9-3.1	21		3	2			1	1
3.2-3.4	14		6	2			1	
3.5-3.7	13		15	4	3		1	
3.8-4.0	4		8	2	1	1	1	
4.1-4.3	11	4	11	3	1			
4.4-4.6	5	4	9					
4.7-4.9	8	5	4	2	3	1	1	
5.0-5.2	6	7	3	2	2			1
5.3-5.5	2	2	1	1	1	3		
5.6-5.8	1	13	2	1	2			
5.9-6.1	1	9	2	1	1			
6.2-6.4	2	8						
6.5-6.7		7						
6.8-7.0		7						
7.1-7.3		1						
7.4-7.6		2						
7.7-7.9		2						
8.6-8.8			1					
8.9-9.0		1						
N	112	70	67	20	15	5	5	2
X	3.63	5.95	4.17	4.27	4.55	5.00	3.70	4.11
Range	0.92-6.31	4.19-8.99	2.22-8.71	3.07-6.08	1.21-5.99	3.96-5.51	2.93-4.83	3.14-5.08
S.D.	1.02	.96	.94	.88	1.21	.64	.72	1.37

APPENDIX V (cont)

Peduncle width % of total length (in.)	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWS x LNS	BHS x LNS
4-1-4.3		4						
4.4-4.6		18		3				
4.7-4.9		22	1	3	1			
5.0-5.2	2	13	1	2	1		1	1
5.3-5.5	9	6	1	1				1
5.6-5.8	15	3	11	5	2	1		
5.9-6.1	24	2	21	2		3	1	
6.2-6.4	15		18	2			2	
6.5-6.7	11	1	10	3	4			
6.8-7.0	3		1		1	2		
7.1-7.3	18		1		4		1	
7.4-7.6	8	1	1		2			
7.7-7.9	9		1					
8.0-8.2	1		1					
8.3-8.5	1							
N	115	70	68	21	15	5	5	2
$\overline{X}$	6.53	4.99	6.23	5.60	6.58	6.26	6.20	5.22
Range	5.18-8.54	4.18-7.63	4.85-8.11	4.47-6.58	4.76-7.49	5.66-7.09	5.07-7.39	5.08-5.35
S.D.	.77	.56	.51	.70	.85	.56	.82	.19

APPENDIX V (concl)

Standard length as % of total length	White sucker	Bluehead	Longnose	Flannelmouth	WWS x FMS	WWS x BHS	WWSx LNS	BHS x LNS
77.0-77.2	1							
77.6-77.8	1	1						
77.9-78.1		1						
78.8-79.0	2							
79.1-79.3			1					
79.4-79.6		2	1					
79.7-79.9		1						
80.0-80.2	3							
80.3-80.5	2	2						
80.6-80.8	3	1		1				
80.9-81.1		4		1				
81.2-81.4	3	1		1				
81.5-81.7	4		1	2				1
81.8-82.0	5	2		2		2		
82.1-82.3	3	6	1	1				
82.4-82.6	2	5	1	2	1			
82.7-82.9	7	4	2	1				
83.0-83.2	9	2		3	1	2		
83.3-83.5	10	6	4				1	
83.6-83.8	13	7	2		1			
83.9-84.1	7	4	4	1	2			
84.2-84.4	5	4	3		3			
84.5-84.7	1	4	3		3		1	
84.8-85.0	7	5	3				2	
85.1-85.3	6	3	3	3	1	1		
85.4-85.6	3	2	1	1	1			
85.7-85.9	2		2	1				
86.0-86.2	3	1	5					
86.3-86.5	3	1	6	1			1	1
86.6-86.8	6	1	6					
86.9-87.0	1		5		1			
87.2-87.4			5					
87.5-87.7			3		1			
87.8-88.0	1		3					
88.4-88.6						1		
89.0-89.2			1					
89.3-89.5	1							
92.3-92.5	1							
93.8-94.0			1					
N	115	70	68	21	15	5	5	2
$\bar{X}$	83.80	83.13	85.58	83.21	84.59	84.02	84.79	84.06
Range	77.10-92.39	77.84-86.71	79.52-94.02	80.72-8655	82.45-87.50	81.98-88.48	83.33-86.36	81.72-86.40
S.D.	2.22	1.85	2.23	1.76	1.35	2.49	1.08	3.31

APPENDIX VI

Monthly and yearly mean discharge of the Gunnison River at the Geological Survey gaging station, Grand Junction, 1917-1974.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
					BEFORE TAYLOR PARK RESERVOIR								
1917	850	900	1,300	3,480	10,290	18,310	6,609	1,766	838	909	1,040	902	3,936
1918	899	1,045	1,363	2,728	9,032	11,130	2,426	760	1,308	1,023	1,254	1,113	2,841
1919	812	880	1,322	4,310	8,220	4,910	2,050	1,110	716	905	1,185	975	2,289
1920	919	1,308	1,082	1,863	18,870	16,020	4,621	1,437	744	1,300	1,394	929	4,214
1921	1,050	1,073	1,461	2,148	10,300	17,330	4,662	2,514	1,527	1,068	1,286	1,219	3,807
1922	994	923	1,208	2,982	14,910	10,240	1,864	928	493	743	1,038	997	3,121
1923	891	808	828	2,162	11,580	11,340	4,666	2,941	1,767	1,860	1,502	1,063	3,464
1924	977	993	905	3,484	10,290	9,749	1,547	285	375	1,227	1,349	982	2,678
1925	945	1,030	1,520	4,178	6,126	5,211	2,414	1,554	2,020	2,100	1,350	1,000	2,458
1926	800	1,013	1,134	4,405	8,843	8,609	2,545	810	402	1,346	1,247	1,050	2,687
1927	961	1,044	1,239	3,734	11,860	9,196	3,829	1,815	2,896	2,125	1,657	1,322	3,484
1928	1,334	1,179	1,692	3,065	14,170	9,364	3,118	1,020	722	1,263	1,416	947	3,282
1929	738	837	1,785	3,410	14,460	12,910	4,445	3,543	4,959	2,464	1,928	1,198	4,404
1930	811	1,393	1,173	6,539	6,588	7,474	1,751	2,635	875	1,359	1,192	1,098	2,738
1931	1,080	1,036	846	1,025	2,110	2,133	523	258	389	1,392	1,294	1,077	1,096
1932	765	1,193	1,239	5,747	11,440	8,129	3,138	1,209	707	919	1,127	858	3,040
1933	619	731	1,054	1,263	5,847	9,308	1,335	532	739	901	1,028	934	2,023
1934	750	800	706	1,246	2,520	577	165	153	267	268	516	793	730
1935	720	689	732	993	4,317	9,797	2,403	903	883	1,035	1,024	812	2,024
1936	815	780	897	4,899	10,230	5,074	1,182	1,291	899	836	1,026	859	2,406
1937	721	792	1,055	2,743	10,150	4,149	1,339	452	559	941	1,048	1,006	2,090

APPENDIX VI (cont)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
				AFTER TAYLOR PARK RESERVOIR BUT BEFORE CURECANTI UNIT									
1938	883	817	1,271	5,969	10,480	12,590	2,960	839	1,875	1,245	1,275	1,091	3,441
1939	1,044	997	1,730	3,597	6,127	3,906	573	620	1,028	839	1,004	812	1,856
1940	786	782	998	2,157	5,460	2,731	486	513	823	1,425	1,044	897	1,509
1941	824	910	1,030	2,070	14,170	9,465	3,121	1,548	1,361	3,215	2,039	1,361	3,426
1942	1,150	1,122	1,234	9,184	12,350	11,560	2,720	1,100	933	926	1,097	949	3,694
1943	921	863	912	4,698	6,322	6,677	1,841	2,498	1,466	1,117	1,253	993	2,463
1944	836	834	868	1,714	12,320	11,660	3,747	836	753	948	1,194	1,035	3,062
1945	892	841	848	1,525	10,210	6,841	2,661	1,990	776	1,244	1,223	940	2,499
1946	947	869	950	3,065	3,715	5,393	1,043	914	901	1,123	1,125	906	1,746
1947	737	845	900	1,610	7,395	8,429	3,940	1,954	1,604	1,858	1,614	1,138	2,669
1948	946	1,129	1,230	5,445	13,580	9,179	2,289	1,160	816	927	1,178	1,133	3,251
1949	824	944	1,117	3,955	7,862	10,940	4,304	1,055	898	1,145	1,238	881	2,930
1950	882	1,017	982	3,683	5,029	5,366	1,428	598	767	596	825	977	1,846
1951	766	828	897	1,046	4,305	5,434	1,507	855	628	801	1,005	744	1,568
1952	854	827	868	5,742	13,310	12,750	3,262	1,963	1,285	1,084	1,072	1,165	3,682
1953	1,059	909	995	1,443	3,743	7,346	1,399	1,096	775	938	1,236	839	1,815
1954	788	813	730	1,171	1,796	660	649	509	866	1,048	853	800	890
1955	752	725	953	1,811	4,260	3,676	753	852	596	617	906	928	1,402
1956	817	770	916	2,385	5,266	4,395	599	467	341	561	926	770	1,518
1957	847	986	909	2,277	9,004	19,630	11,700	3,639	1,821	1,727	1,868	1,495	4,659
1958	1,065	1,262	1,336	4,275	14,200	9,577	1,063	693	859	841	1,199	1,058	3,119
1959	924	893	845	927	2,720	4,301	551	831	691	1,564	1,211	818	1,356
1960	798	711	1,420	4,533	4,217	5,645	943	548	632	824	980	831	1,840
1961	672	711	890	1.119	4,333	3,507	554	718	1,680	1,739	1,451	927	1,525
1962	855	1,046	869	6,638	9,345	8,011	3,564	838	1,055	1,142	1,137	874	2,948
1963	783	1,268	1,329	1,719	3,059	1,550	602	842	850	890	1,101	798	1,233
1964	706	788	692	1,307	6,794	5,304	1,348	1,519	1,000	869	1,089	959	1,865
1965	894	806	846	3,840	9,461	11,450	7,676	2,564	2,704	1,887	1,063	983	3,681
						AFTER CURECANTI UNIT							
1966	845	661	1,108	2,795	3,428	2,096	827	625	973	1,060	758	896	1,339
1967	765	755	1,013	1,445	2,330	2,551	971	961	1,177	1,063	1,774	2,683	1,457
1968	1,927	1,670	1,055	1,144	4,363	4,339	967	1,741	1,134	1,409	2,242	2,421	2,034
1969	2,375	1,351	2,355	5,113	5,395	3,262	1,621	1,485	2,002	2,521	2,393	2,088	2,663
1970	2,104	2,189	2,427	2,309	6,573	6,977	2,836	1,639	3,287	3,059	2,864	2,951	3,268
1971	3,194	3,622	3,887	4,467	3,401	3,557	1,859	1,849	2,240	1,949	2,218	2,343	2,882
1972	2,046	1,917	1,774	1,125	1,877	1,974	581	626	1,420	1,687	2,105	2,552	1,640
1973	2,518	1,356	1,349	1,563	7,410	6,960	2,663	2,405	1,842	2,031	1,494	2,765	2,863
1974	3,515	3,844	3,311	2,368	4,251	2,036	836	689	1,091				

APPENDIX VII

Monthly and yearly mean discharge of the Gunnison River at the Geological Survey gaging station, below the East Portal of the Gunnison Tunnel, 1903-1975.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
						BEFORE GUNNISON TUNNEL							
1903										641	519	413	
1904	390	416	535	1503	3851	3292	1103	1232	896	1020	500	340	1256.5
1905	330	340	700	1217	5246	8383	2039	1130	560	519	491	475	1785.8
1906	465	460	750	2270	6620	8830	3510	1470	1060	905	620	475	2286.3
1907	470	460	990	2500	4400	10,500	6620	2400	1310	986	640	450	2643.8
1908	450	450	700	1940	2690	4880	2170	1630	698	634	510	475	1435.6
1909	460	450	750	1950	7160	10,800	5470	1880	2600	1270	610	470	2822.5
						BEFORE TAYLOR PARK RESERVOIR							
1910	460	460	1730	3703	6292	5336	1337	882	464	467	550	480	1846.8
1911	470	460	700	2309	6251	8696	4456	1436	836	2114	886	610	2435.3
1912	540	500	800	2793	7156	8883	4423	1292	674	981	562	480	2423.7
1913	450	420	590	2269	4685	4250	1225	538	756	785	709	525	1433.5
1914	475	450	900	2187	7521	8268	3762	1450	759	1014	909	520	2351.3
1915	490	480	890	1672	2529	5084	1735	322	241	409	510	440	1233.5
1916	400	390	730	2173	5726	8232	2692	2039	706	1038	700	550	2114.7
1917	420	490	550	1548	3563	10,770	4410	1015	279	419	580	450	2041.2
1918	420	540	650	1259	5088	8961	2169	1105	1100	746	666	470	1931.2
1919	340	400	680	1614	4882	3286	1285	490	189	340	640	500	1220.5
1920	450	500	850	943	8436	10,343	3146	763	207	680	760	540	2301.5
1921	530	500	660	815	5063	11,235	3309	1263	592	253	650	500	2114.2
1922	500	520	660	1205	6087	6411	1146	339	25	28	487	430	1486.5
1923	390	430	570	958	5477	7714	3132	1442	764	758	732	500	1905.6
1924	500	520	610	2067	5487	6381	825	34	32	342	553	470	1485.1
1925	450	490	780	2354	3870	3340	1204	513	744	472	670	450	1278.1
1926	360	460	600	1563	4156	5813	1291	314	81	387	526	490	1336.8
1927	440	500	640	1524	6450	6146	2276	982	1525	1113	910	700	1933.8
1928	620	580	950	1344	8613	7132	2138	513	60	201	599	420	1930.8
1929	380	420	860	1539	6528	8294	2566	2097	2447	1353	979	580	2336.9
1930	400	450	550	3282	2979	5010	934	1182	80	333	432	500	1344.3
1931	430	440	480	324	657	1220	138	46	34	203	527	480	414.9
1932	400	390	520	1427	5113	5594	2101	501	48	42	415	400	1412.6
1933	380	370	650	386	3047	6012	707	166	51	16	269	469	1043.6
1934	410	450	435	469	1573	208	63	47	31	17	116	420	353.3
1935	380	370	520	329	1885	7204	1606	298	204	385	501	350	1169.3
1936	390	400	550	3089	6942	3622	632	745	202	189	440	360	1463.4
1937	360	410	470	1674	5766	2583	524	70	8	136	500	440	1078.4

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
				AFTER TAYLOR PARK RESERVOIR BUT BEFORE CURECANTI UNIT									
1938	390	340	600	2654	4914	8161	1796	279	705	424	598	441	1775.2
1939	420	300	926	1550	3335	2358	215	243	230	111	471	360	876.6
1940	310	250	470	556	2257	1608	61	69	24	339	497	330	564.3
1941	320	360	480	617	5230	5139	1659	143	205	1017	849	605	1385.3
1942	480	440	570	2930	4881	7191	1545	328	120	66	483	412	1620.5
1943	370	424	420	2514	3449	4666	1066	1093	487	225	510	434	1304.8
1944	368	429	331	654	5521	6985	2162	310	99	93	376	353	1473.4
1945	399	389	352	451	3746	3759	1504	888	70	295	468	403	1060.3
1946	388	435	505	1137	1580	3666	401	171	67	199	268	365	765.2
1947	340	352	307	575	4239	5647	2525	631	420	589	568	603	1399.7
1948	536	544	590	2523	7418	6184	1367	354	151	113	356	466	1716.8
1949	359	386	463	1808	3747	7341	2880	402	213	280	644	419	1578.5
1950	377	414	402	1402	2013	3360	524	199	53	36	216	411	783.9
1951	394	394	527	388	2129	3673	864	333	68	83	298	408	796.6
1952	450	439	450	2268	6505	8788	2024	764	431	315	292	516	1936.8
1953	484	432	481	516	1709	4928	890	413	130	143	458	460	920.3
1954	373	404	356	177	696	123	224	110	83	213	260	377	283.0
1955	325	279	299	672	1350	2118	342	342	80	61	334	461	555.3
1956	376	329	431	1034	2994	2982	271	203	33	58	413	322	787.2
1957	317	377	445	989	4073	11,670	8468	2237	610	459	884	878	2617.3
1958	543	535	595	1627	8060	6170	485	309	76	39	390	474	1608.6
1959	411	422	328	303	1194	2708	177	268	79	584	550	381	617.1
1960	395	443	880	2414	1883	3958	555	200	136	90	426	397	981.4
1961	331	341	496	428	2025	1996	232	218	217	840	765	506	699.6
1962	465	522	460	3032	5171	5294	2228	403	278	240	404	393	1574.2
1963	323	435	860	613	1595	845	220	251	60	89	451	321	505.3
1964	294	308	313	503	3316	3071	689	401	198	90	322	449	829.5
1965	454	404	487	2114	4439	7196	5212	1475	1081	670	144	141	1984.8
						AFTER CURECANTI UNIT							
1966	143	155	248	564	722	859	355	257	244	251	214	267	356.6
1967	323	319	315	210	216	300	250	155	315	218	1149	2040	484.2
1968	1246	1150	534	271	537	764	178	227	353	360	1500	1837	746.4
1969	1835	821	1796	1465	995	588	454	781	773	1010	1461	1319	1108.2
1970	1474	1625	1861	1224	2165	3942	1926	871	1178	1513	1888	2128	1816.3
1971	2544	3153	3278	2538	575	847	999	1179	1015	871	1379	1674	1671.0
1972	1609	1533	908	292	265	299	162	230	308	288	1278	1881	754.4
1973	1833	799	676	455	1240	1645	856	1356	687	741	749	2048	1090.4
1974	2732	2892	2224	445	501	327	198	183	208	277	1396	1397	1065.
1975	1522	1398	1190	1639	3099	1637	532	228	324	674	1529	1863	1302.9

APPENDIX VIII

Monthly and yearly mean discharge diverted through the Gunnison Tunnel into the Uncompahgre Valley, 1903-1975.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
						BEFORE GUNNISON TUNNEL							
1903													
1904													
1905													
1906				1903-1909		NO DIVERSIONS FOR IRRIGATION							
1907													
1908													
1909													
					BEFORE TAYLOR PARK RESERVOIR								
1910							67	168	215	142	0	0	49.3
1911	0	0	0	0	0	23	17	203	251	32	0	0	43.8
1912	0	0	0	0	29	31	47	292	296	44	0	0	61.6
1913	0	0	0	0	61	181	453	497	288	83	.7	0	130.3
1914	0	0	0	6	48	63	192	296	326	170	0	0	91.8
1915	0	0	0	119	200	100	347	600	381	179	39	8.4	164.5
1916	0	0	0	113	428	280	587	309	416	138	17	0	190.7
1917	0	0	0	28	108	213	435	611	573	222	0	0	182.5
1918	0	0	0	188	668	466	778	813	466	319	0	0	308.2
1919	0	0	0	151	672	679	809	790	585	318	16	0	335.
1920	0	0	0	103	218	327	737	858	689	160	0	0	257.7
1921	0	0	0	481	606	263	674	671	642	567	66	0	330.8
1922	0	0	0	259	440	492	718	810	605	458	52	0	319.5
1923	0	0	0	503	599	709	818	758	611	330	129	0	371.4
1924	0	0	0	265	480	420	891	702	482	255	87	0	298.5
1925	0	0	0	419	589	576	881	844	281	391	63	0	337
1926	0	0	0	171	545	364	835	765	503	288	77	0	295.7
1927	0	0	0	329	568	568	730	787	360	140	90	0	297.7
1928	0	0	0	534	287	485	847	803	706	476	318	0	371.3
1929	0	0	0	193	385	316	687	610	336	191	41	0	229.9
1930	0	0	0	371	696	473	878	736	733	356	143	0	365.5
1931	0	0	27	601	729	856	545	531	346	354	56	0	337.1
1932	0	0	0	349	445	627	278	823	581	455	218	34.3	359.2
1933	0	0	32	539	479	608	796	778	528	377	310	13.3	371.7
1934	0	0	170	748	896	670	439	507	352	323	0	0	342.1
1935	0	0	70	691	638	535	790	828	588	261	59	21.8	373.5
1936	0	0	31	609	797	862	880	880	611	446	98	0	434.5
1937	0	0	19	502	751	857	832	753	504	353	15	0	382.2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly
AFTER TAYLOR PARK RESERVOIR BUT BEFORE CURECANTI UNIT													
1938	0	0	0	147	514	480	781	929	312	341	62	0	297.2
1939	0	0	0	392	874	749	938	937	599	488	0	0	414.8
1940	0	0	11.5	669	766	689	951	910	642	117	0	0	396.3
1941	0	0	1.5	420	424	429	850	832	800	144	13	0	326.1
1942	0	0	0	103	365	469	819	980	779	460	3.5	0	331.5
1943	0	0	161	803	726	668	966	622	746	574	164	0	452.5
1944	0	0	186	514	388	586	842	999	928	433	118	0	416.2
1945	0	0	105	519	621	775	974	869	909	321	104	7.6	433.7
1946	0	0	146	748	930	846	938	971	852	402	235	0	505.7
1947	0	0	184	780	854	524	893	857	748	447	208	0	457.9
1948	0	0	0	158	656	765	951	949	942	483	212	0	426.3
1949	0	0	43	389	941	642	871	969	756	416	0	0	418.9
1950	0	0	28	742	947	928	965	958	830	431	223	0	504.3
1951	0	0	60	836	926	880	954	967	956	509	151	0	519.9
1952	0	0	18	325	743	598	941	929	829	671	311	0	447.1
1953	0	0	112	538	847	862	965	961	935	534	138	0	491.
1954	0	0	121	821	958	951	952	930	637	366	172	0	492.3
1955	0	0	26	480	915	864	956	938	849	458	100	0	465.5
1956	0	0	36	627	943	840	815	823	876	507	14	0	456.8
1957	0	0	25	471	610	494	522	787	667	467	71	0	342.8
1958	0	0	0	455	610	585	963	887	846	530	156	0	419.3
1959	0	0	108	849	945	904	947	933	818	265	81	0	487.5
1960	0	0	0	300	919	759	951	935	876	527	96	0	446.9
1961	0	0	19	445	857	884	945	931	677	71	0	0	402.4
1962	0	0	33	636	950	909	930	963	830	336	125	0	476.0
1963	0	0	0	735	955	955	956	933	658	518	29	0	478.3
1964	0	0	49	592	845	860	965	945	782	559	186	0	481.9
1965	0	0	0	407	837	663	684	886	585	267	28	0	363.1
AFTER CURECANTI UNIT													
1966	0	0	87.5	787	967	931	940	958	913	337	0	0	493.4
1967	0	0	115	919	922	825	948	928	845	648	0	0	512.5
1968	0	0	137	810	945	589	952	774	912	520	0	0	469.9
1969	0	0	69.1	743	957	879	939	955	733	260	4.8	0	461.7
1970	0	0	9.8	677	783	814	949	943	733	362	62.3	0	444.4
1971	0	0	44.1	818	954	813	909	948	785	437	0	0	475.7
1972	0	0	226	906	957	934	959	951	784	411	0	0	510.7
1973	0	0	6.4	496	576	496	784	980	906	548	0	0	399.4
1974	0	0	0	535	908	938	975	966	918	628	0	0	489.0
1975	0	0	0	666	909	538	722	967	912	666	36.8	0	451.4

APPENDIX IX

Monthly and yearly mean discharge of the Gunnison River above the Gunnison Tunnel, 1903-1975.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
						BEFORE GUNNISON TUNNEL							
1903										641	519	413	
1904	390	416	535	1503	3851	3292	1103	1232	896	1020	500	340	1256.5
1905	330	340	700	1217	5246	8383	2039	1130	560	519	491	475	1785.8
1906	465	460	750	2270	6620	8830	3510	1470	1060	905	620	475	2286.3
1907	470	460	990	2500	4400	10,500	6620	2400	1310	986	640	450	2643.8
1908	450	450	700	1940	2690	4880	2170	1630	698	634	510	475	1435.6
1909	460	450	750	1950	7160	10,800	5470	1880	2600	1270	610	470	2822.5
						BEFORE TAYLOR PARK RESERVOIR							
1910	460	460	1730	3703	6292	5336	1404	1050	679	609	550	480	1896.1
1911	470	460	700	2309	6250	8719	4473	1639	1087	2146	886	610	2479.1
1912	540	500	800	2793	7185	8914	4470	1584	970	1025	562	480	2485.3
1913	450	420	590	2269	4746	4431	1678	1035	1044	868	709.7	525	1563.8
1914	475	450	900	2193	7569	8331	3954	1746	1085	1184	909	520	2443.
1915	490	480	890	1791	2729	5184	2082	922	622	588	549	448.4	1398.
1916	400	390	730	2286	6154	8512	3279	2348	1122	1176	717	550	2305.3
1917	420	490	550	1576	3671	10,983	4845	1626	852	641	580	450	2223.7
1918	420	540	650	1447	5756	9427	2947	1918	1566	1065	666	470	2239.3
1919	340	400	680	1765	5554	3965	2094	1280	774	658	656	500	1555.5
1920	450	500	850	1046	8654	10,670	3883	1621	896	840	760	540	2559.2
1921	530	500	660	1296	5669	11,498	3983	1934	1234	820	716	500	2445.0
1922	500	520	660	1464	6527	6903	1864	1149	630	486	539	430	1806.
1923	390	430	570	1461	6076	8423	3950	2200	1375	1088	861	500	2277.
1924	500	520	610	2322	5967	6801	1716	736	514	597	640	470	1783.6
1925	450	490	780	2773	4459	3916	2085	1357	1025	863	733	450	1615.1
1926	360	460	600	1734	4701	6177	2126	1079	584	675	603	490	1632.4
1927	440	500	640	1853	7018	6714	3006	1769	1885	1253	1000	700	2231.5
1928	620	580	950	1878	8900	7617	2985	1316	766	677	917	420	2302.2
1929	380	420	860	1732	6913	8610	3253	2707	2783	1544	1020	580	2566.8
1930	400	450	550	3653	3675	5483	1812	1918	813	689	575	500	1709.9
1931	430	440	507	925	1386	2076	683	577	380	557	583	480	752.
1932	400	390	520	1776	5558	6221	2879	1324	629	497	633	434.3	1771.8
1933	380	370	682	925	3526	6620	1503	944	579	393	579	482.3	1415.3
1934	410	450	605	1217	2469	878	502	554	383	340	116	420	695.3
1935	380	370	590	1020	2523	7739	2396	1126	792	646	560	371.8	1542.8
1936	390	400	581	3698	7739	4484	1512	1625	813	635	538	360	1897.9
1937	360	410	489	2176	6517	3440	1356	823	512	489	515	440	1460.6

APPENDIX IX (cont.)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
				AFTER TAYLOR PARK RESERVOIR BUT BEFORE CURECANTI UNIT									
1938	390	340	600	2801	5428	8641	2577	1208	1017	765	660	441	2072.3
1939	420	300	926	1942	4209	3107	1153	1180	829	599	471	360	1291.3
1940	310	250	481.5	1225	3023	2297	1012	979	666	456	497	330	960.5
1941	320	360	481.5	1037	5654	5568	2509	975	1005	1161	862	605	1711.5
1942	480	440	570	3033	5246	7660	2364	1308	899	526	486.5	412	1952.
1943	370	424	581	3317	4175	5334	2032	1715	1233	799	674	434	1757.3
1944	368	429	517	1168	5909	7571	3004	1309	1027	526	494	353	1889.6
1945	399	389	457	970	4367	4534	2478	1757	979	616	572	410.6	1494.1
1946	388	435	651	1885	2510	4512	1339	1142	919	601	503	365	1270.8
1947	340	352	491	1355	5093	6171	3418	1488	1168	1036	776	603	1857.6
1948	536	544	590	2681	8074	6949	2318	1303	1093	596	568	466	2143.2
1949	359	386	506	2197	4688	7983	3751	1371	969	696	644	419	1997.4
1950	377	414	430	2144	2960	4288	1489	1157	883	467	439	411	1288.3
1951	394	394	587	1224	3055	4553	1818	1300	1024	592	449	408	1316.5
1952	450	439	468	2593	7248	9386	2965	1693	1260	986	603	516	2383.9
1953	484	432	593	1054	2556	5790	1855	1374	1065	677	596	460	1411.3
1954	373	404	477	998	1654	1074	1176	1040	720	579	432	377	775.3
1955	325	279	325	1152	2265	2982	1298	1280	929	519	434	461	1020.8
1956	376	329	467	1661	3937	3822	1086	1026	909	565	427	322	1243.9
1957	317	377	470	1460	4683	12,164	8990	3024	1277	926	955	878	2960.1
1958	543	535	595	2082	8670	6755	1448	1196	922	569	546	474	2027.9
1959	411	422	436	1152	2139	3612	1124	1201	897	849	631	381	1104.6
1960	395	443	880	2714	2802	4717	1506	1135	1012	617	522	397	1428.3
1961	331	341	515	873	2882	2880	1177	1149	894	911	765	506	1102.
1962	465	522	493	3668	6121	6203	3158	1366	1108	576	529	393	2050.2
1963	323	435	860	1348	2550	1800	1176	1184	718	607	480	321	983.5
1964	294	308	362	1095	4161	3931	1654	1346	980	649	508	449	1311.4
1965	454	404	487	2521	5276	7859	5896	2361	1666	937	172	141	2347.8
						AFTER CURECANTI UNIT							
1966	143	155	335.5	1351	1689	1790	1295	1215	1157	588	214	267	850.
1967	323	319	430	1129	1138	1125	1198	1083	1160	866	1149	2040	996.7
1968	1246	1150	671	1081	1482	1353	1130	1001	1265	880	1500	1837	1216.3
1969	1835	821	1865.1	2208	1952	1467	1393	1736	1506	1270	1465.8	1319	1569.8
1970	1474	1625	1870.8	1901	2948	4756	2875	1814	1911	1875	1950.3	2128	2260.7
1971	2544	3153	3322.1	3356	1529	1660	1908	2127	1800	1308	1379	1674	2146.7
1972	1609	1533	1134	1198	1222	1233	1121	1181	1092	699	1278	1881	1265.1
1973	1833	799	682.4	951	1816	2141	1640	2336	1593	1289	749	2048	1489.8
1974	2732	2892	2224	980	1409	1265	1173	1149	1126	905	1396	1397	1554.
1975	1522	1398	1190	2305	4008	2175	1254	1195	1236	1340	1565.8	1863	1754.4

APPENDIX X

National Park Service estimates of monthly fisherman-and boater-use at Blue Mesa Reservoir, 1969-1977.

	1969 Totals		1970 Totals		1971 Totals		1972 Totals		1973 Totals		1974 Totals		1975 Totals		1976 Totals		1977 Totals	
Mo.	Fm	B	Fm	B	Fm	B	Fm	B	Fm	B	Fm	B	Fm	B	Fm	B	Fm	B
Jan	560	0	2,013	0	2,221	0	1,935	0	2,312	0	1,590	0	2,385	0	2,255	0	1,615	0
Feb	1,204	0	2,300	0	1,987	1	2,049	0	3,259	0	3,010	0	3,340	0	1,745	0	2,485	5
Mar	1,680	0	1,755	0	2,793	30	2,372	42	2,476	0	2,540	0	2,285	0	1,230	0	1,155	5
Apr	2,116	225	3,054	48	5,023	1,260	5,485	1,452	1,934	12	3,410	410	1,690	5	1,845	105	3,780	695
May	16,822	8,301	16,162	7,074	17,186	6,885	16,584	9,222	9,849	3,948	8,065	6,315	5,810	3,125	12,540	7,355	12,125	7,830
Jun	16,602	8,979	19,161	10,398	24,490	12,864	17,841	9,639	14,082	7,296	14,095	7,650	14,080	6,500	13,865	9,630	15,610	10,280
Jul	21,157	14,679	30,411	16,650	23,008	13,638	22,597	15,618	16,016	11,292	19,585	12,220	18,045	11,600	19,610	15,575	16,890	11,840
Aug	19,144	11,643	28,405	13,854	16,397	10,053	16,075	10,671	16,552	10,233	18,715	12,520	20,225	19,275	14,935	11,525	11,360	7,750
Sep	12,302	6,132	12,840	7,344	10,140	6,249	11,458	7,623	12,143	7,578	9,590	2,150	6,730	4,585	8,695	6,355	5,945	3,590
Oct	2,786	1,275	4,050	924	3,605	1,803	3,814	1,690	3,995	1,893	2,130	1,500	2,125	980	4,430	1,155	2,010	425
Nov	2,083	579	877	86	981	333	972	63	864	240	970	205	695	210	805	110	855	115
Dec	665	12	1,197	16	934	0	995	24	551	30	630	5	615	5	700	25	455	5
Total	97,121	51,825	122,225	56,394	108,765	53,116	102,177	56,044	84,033	42,522	84,330	42,975	78,025	46,285	82,655	51,835	74,285	42,540
		53.36%		46.13%		48.84%		54.84%		50.60%		50.96%		59.32%		62.71%		57.26%

APPENDIX XI

Summary of annual visitor use at Black Canyon of the Gunnison National Monument, 1936-1976.

Year	South Rim	North Rim	Total	Year	South Rim	North Rim	Inner Canyon[a]	% of total use	Total
1936	N/A[b]	N/A	4,833	1956	56,245	5,740	N/A	N/A	61,985
1937	6,698	2,144	8,842	1957	43,148	5,771	N/A	N/A	48,919
1938	11,362	4,149	15,511	1958	86,918	6,114	N/A	N/A	93,032
1939	11,507	4,534	16,041	1959	94,359	6,435	N/A	N/A	100,794
1940	13,562	5,745	19,307	1960	114,789	7,730	N/A	N/A	122,519
1941	14,384	4,060	18,444	1961	107,724	7,302	N/A	N/A	115,026
1942	6,072	993	7,065	1962	122,618	9,150	N/A	N/A	131,768
1943	2,282	451	2,733	1963	130,127	16,426	N/A	N/A	146,553
1944	1,736	551	2,287	1964	158,648	9,536	N/A	N/A	168,184
1945	3,749	1,082	4,831	1965	176,017	8,015	N/A	N/A	184,032
1946	14,613	2,449	17,062	1966	171,467	9,537	N/A	N/A	181,004
1947	20,126	2,247	22,373	1967	175,522	9,578	N/A	N/A	185,100
1948	23,277	2,961	26,238	1968	205,518	10,353	N/A	N/A	215,871
1949	26,589	3,086	29,675	1969	286,071	16,568	N/A	N/A	302,639
1950	23,059	3,168	26,227	1970	N/A	N/A	1,136	.45	249,043
1951	29,018	2,849	31,867	1971	N/A	N/A	1,177	.50	234,627
1952	35,515	4,392	39,907	1972	N/A	N/A	2,182	.79	273,322
1953	46,461	5,302	51,763	1973	N/A	N/A	1,531	.65	234,842
1954	47,237	4,145	51,382	1974	N/A	N/A	1,754	.65	267,086
1955	52,045	5,160	57,205	1975	N/A	N/A	2,276	.65	348,874
				1976	N/A	N/A	1,900[c]	.60[c]	318,203[c]

[a]Fisherman estimate at 60% to 65% of the Inner Canyon use.

[b]Not Available.

[c]1976 figures are through August.

APPENDIX XII

Comparison of catch-per-net-hour of the various species caught in standard 125-ft experimental gillnets set in various locations between Morrow Point Reservoir and Grand Junction, Colorado, 1975-1977.

Station	Date	No. nets	No. hours	Rainbow	Brown	Brook	Cutthroat	Kokanee	Northern pike	White sucker	Bluehead sucker	Flannelmouth sucker	Longnose sucker	Bluehead x white sucker	Flannelmouth x white sucker	Longnose x white sucker	Humpback sucker	Roundtail chub	Green sunfish	Bullhead	Carp
Morrow Pt.	1976	3	72	.1389	.1250	.0278	.0139	.0556		.2639			.2361			.0139					
	1977	12	255	.0117	.0352	.0078	---	.0901		.1411			.0235			.0117					
Morrow Pt. to Black Canyon Nat. Monument	1976	5	100	.0800						.0400			.1000								
Crystal Res.	1977	14	336	.4196	.0714	.0029				.0029			.0267								
Black Canyon Nat. Monument	1975	6	91	.4176	.0879				.0110	.1319		.0220	.1978								
Nat. Monument	1976	10	192	.0938	.0521					.0417	.0990	.0052	.4740	.0104		.0156					
	1977	11	235	.0595	.0425					.1276	.1063	.0042	.2297	.0042	.0042	.0212					
Black Canyon Nat. Monument to Ute Trail	1976	5	51.5	.0388	.0971					.4466	.3883		.2136					.1359			
	1977	5	90		.1222					.5000	.3888	.0666	.1777	.0222	.0666	.0111		.0444			
Ute Trail to North Fork River	1975	3	43.5	.0690	.0230					.5977	.5287	.2299									b
	1976	8	173	.0462	.0405		.0057			.3931	.4740	.0405	.0867	.0636	.0867	.0867		.1098	.0057		
	1977	5	120	.0500	.0083					.2583	.0583	.0916	.0166	.0250	.0750			.0416			
North Fork R. to Austin	1975	11	202	.0297	.0099					.1584	.1337	.0743		.0099	.0193			.0050			
	1977	2	48	.0208						.2291	.1250	.0625			.0208			.0625			
Austin to Delta	1975	5	102							.0882	.0980	.0294		.0294	.0098						.0098
Delta to Escalanti	1975	11	242.5							.0082	.0371	.1485		.0041			.0041	.0907	.0082	.0041	.0124
Escalanti to Broughton Or.[c]	1976	4	96									.0625						.0104			.0208
Broughton Or. to Bridgeport[c]	1976	2	48															.4167			
Bridgeport to White Water[c]	1976	3	72									.2083						1.9385	.0417	.0417	.0694
White Water to Gr. Junction[c]	1976	2	26									1.9230						.8846			.0385

[a] CPNH for fishes not listed but taken during 1977 were: .0078 for mackinaw in Morrow Point; .0085 for bluehead x longnose in Black Canyon Monument; and .011 for flannelmouth x bluehead in Monument to Ute section.

[b] Seen below Smith Fork.

[c] Basic data supplied by George Kidd.