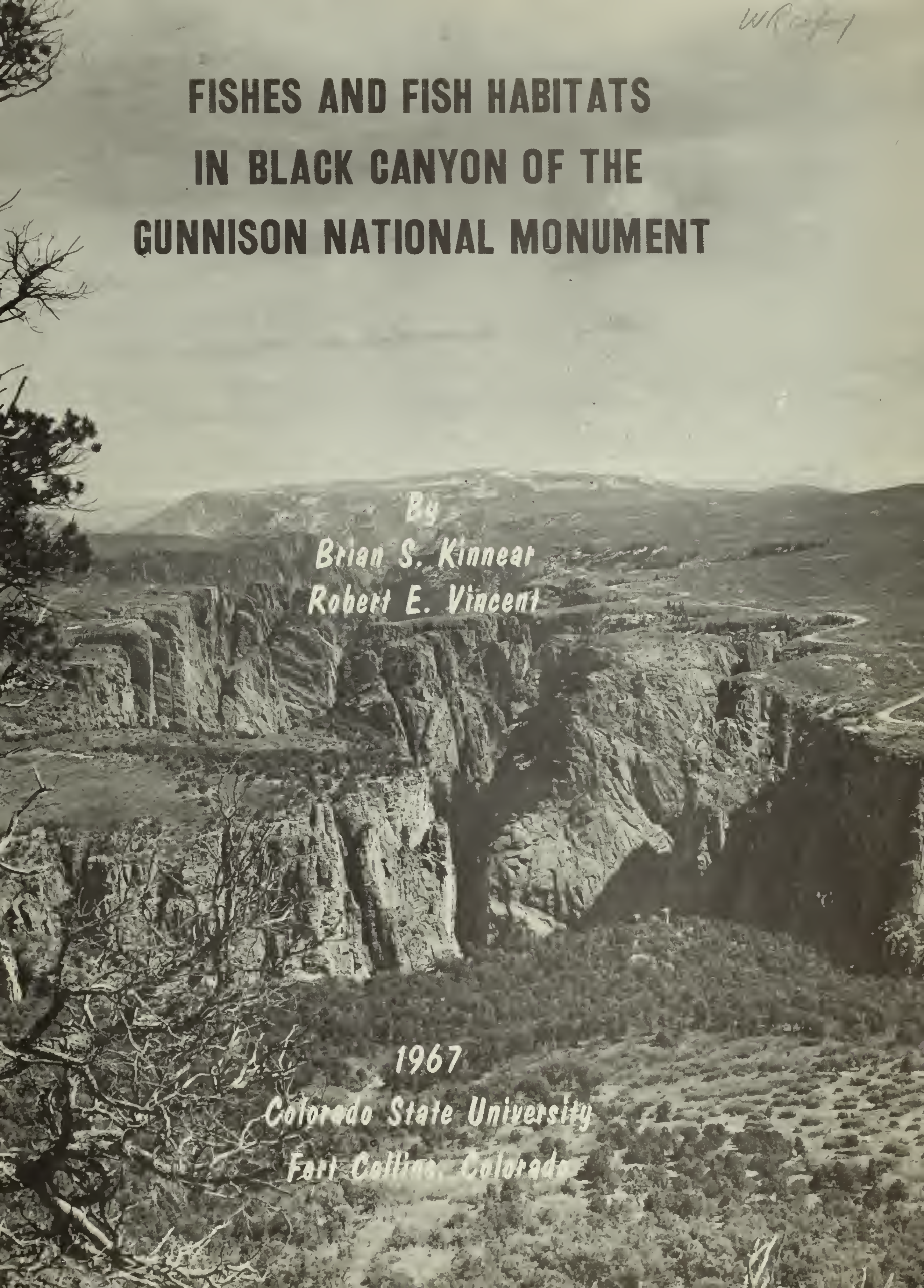
FISHES AND FISH HABITATS IN BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT



By
Brian S. Kinnear
Robert E. Vincent

1967
Colorado State University
Fort Collins, Colorado

COVER: Black Canyon of the Gunnison National Monument, Photo by National Park Service

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I am also indebted to my brother, Leslie Kinnear, to my wife Judi Kinnear, to fellow students of the Cooperative Fishery Unit, and to Deanna Hicks, Unit secretary.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Water, and its efficient use, is of major importance in the arid and semi-arid west. This significance is manifest in large and numerous water storage projects throughout western America. Economic studies of the impact of these projects indicate that many benefits have accrued to the region. Ecological impact of these projects on the native flora and fauna are less well known.

BACKGROUND TO THE STUDY

In 1956, the 86th Congress authorized the Curecanti river-storage unit of the Gunnison River as one of four initial units of the larger Colorado River storage project (House Document No. 201, 1960). The Curecanti storage unit will consist of three dams in Black Canyon of the Gunnison River. Their purposes will be to provide hydro-electric power, water storage for irrigation, flood control, and recreation. The first of these dams, Blue Mesa, began storage of water in October, 1965.

As a result of the water control provided by these structures, changes are expected in water quality, habitats, and in fish populations that now exist downstream from the reservoirs. Neel (1963) presented an excellent discussion of similar changes below reservoirs and Jenkins (1965) compiled an extensive bibliography of articles concerning reservoirs and tailwaters.

Pfitzer (1954) discussed major ecological changes in rivers below large dams in the Tennessee Valley. He indicated that reduction of temperature extremes; lower average temperature; and erratic, seasonal dissolved oxygen patterns resulted in these rivers. Furthermore, many of the minnow species disappeared and only a few of those remaining were

reproducing. The bottom fauna changed from large warmwater species to small coldwater species and algae dominated the plant community.

Some changes in the Gunnison River have been recorded as a result of earlier impoundment. Williams (1951) indicated that Taylor Reservoir, approximately 60 miles upstream from the Curecanti Project, decreased silt loads and lowered summer water temperatures. Wiltzius (1966), after analyzing willow fly (Pteronarcys californica) emergence dates, suggested that Taylor Reservoir has a warming effect on the Gunnison River during early spring.

In anticipation of changes in aquatic fauna within the Monument, determination of water temperature regimen, flow characteristics, river habitats, fish species present, condition factor, and fish distribution before, and during upstream impoundment was sought.

The objective of this study is to provide a base for detection of subsequent changes in the fish fauna within the Monument. This study is qualitative due to the severe physical nature of the study area that limited access and types of gear used.

LOCATION AND DESCRIPTION OF BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT

Black Canyon of the Gunnison River is in southwestern Colorado between Sapinero and Montrose, Colorado. Most of the Canyon is in Gunnison and Montrose counties. The region, topographically, is a transition zone between the Southern Rocky Mountains to the east and Colorado Plateau to the west.

Black Canyon of the Gunnison National Monument (Figure 1) comprises approximately 10 miles of the narrowest, deepest, and most spectacular portion of the 50 mile canyon. Canyon walls range in height from 1,700 to 2,400 feet. Width at the rim is as narrow as 1,300 feet while the

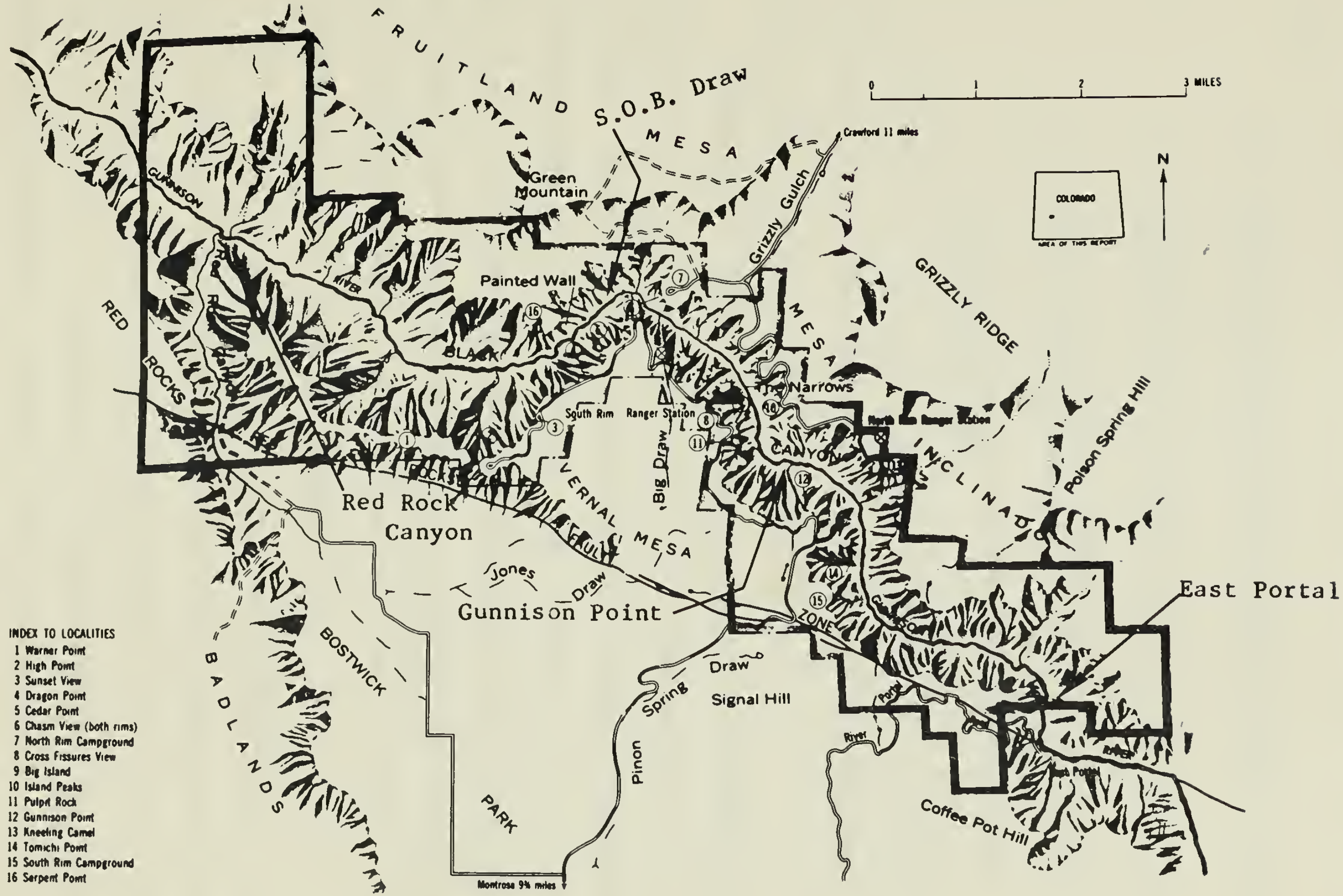

FIGURE 1. Black Canyon of the Gunnison National Monument and vicinity, Colorado. Study areas marked by arrows (from Hansen, 1965).

least width at the canyon floor is approximately 40 feet.

Access to the river is generally restricted by the terrain to four areas:

(1) Eastern boundary section reached via East (River) Portal Tunnel Road.

(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.

(4) Red Rock Canyon section reached via foot trail from Bostwick Park.

Although the river can be reached at other places, lateral movement along the river is restricted. Floating through the Monument canyon is nearly impossible, and hiking through is hazardous.

Geologically, Black Canyon results from the entrenchment of a prehistoric river in a landscape that has been superimposed upon a modern landscape. The entrenched river eroded into the hard Precambrian rock of the Gunnison uplift. Rocks that form the walls and floor of Black Canyon are of two main classes: "metamorphic rocks transformed by heat and pressure from pre-existing rocks and igneous rocks intruded into the metamorphic rocks as hot molten masses" (Hansen, 1965). These basement rocks are over 1½ billion years old.

The uplift stands above most of the surrounding country. As a result only minor intermittent tributaries drain directly into the river in the Monument. Thus, little lateral erosion has occurred. Erosion into the basement or Precambrian rocks that form Black Canyon began approximately two million years ago. To reach its present average depth of 2,000 feet, the rate of downcutting has been approximately one foot per 1,000 years.

CHAPTER II

METHODS AND EQUIPMENT

Standard fishery techniques and equipment were used. Names of all fishes are from Special Publication No. 2, American Fisheries Society, (1960).

Field collections were divided into two major types of data: physical and biological. These data were collected throughout the summer and fall of 1965 and again for two weeks during the summer of 1966. Twenty-one trips (totaling more than 900 man-hours) were made into the Monument Canyon during this time.

PHYSICAL DATA

These data consist of water temperature, water volume, gradient, habitat types, and water chemistry.

Water temperature was recorded over a 27 month period by a continuous recording thermograph located near the upstream boundary of the Monument. Maximum and minimum water temperatures occurred at 12 hour intervals. These temperatures were interpolated to the nearest degree Fahrenheit and averaged for a seven day period.

Water volume was obtained from records of the U.S. Geological Survey gaging station near the upstream boundary. Flow records from October, 1903, to September, 1964, have been published (Geological Survey, 1954, 1964a, and 1961, 1962, 1963, 1964b, and 1965). Uncorrected and unpublished data for the 1965 and 1966 water years were obtained from the Geological Survey office at Grand Junction, Colorado. Gradient was determined by interpolating contour lines from the Grizzly Ridge and Red Rock Canyon quadrangle topographic maps.

Five river habitat types were arbitrarily named and described because measurement of physical characteristics such as velocity, depth, width, or height of fall rarely was possible. These types are:

CATARACT	Broken water - gradient or force of current over or around an obstruction eliminates standing waves (Figure 2).
RAPIDS	Broken water - generally with regular cresting, standing waves caused by channel constriction, submerged or protruding obstructions, or gradient (Figure 3).
RUN	Smooth surface - current flows in center of stream and/or eddies compose less than one-third of stream width (Figure 4).
RIFFLE	Surface broken - water depth is "shallow" (Figure 5).
POOL	Smooth surface - main current flows to one side of center and/or eddies compose more than one-third of stream width (Figure 6).

Location and length of each type was marked on a map. The percentage of each type was derived by dividing the total length of each type by the stream length.

Data on water chemistry were derived from Wiltzius (1966) and Morgan (1959).

BIOLOGICAL DATA

Biological data consist of fish species identification, distribution, age and condition determination, aquatic plant samples, and aquatic insect samples.

Fish samples were collected with: 1) variable mesh gill-nets, 2) electro-fishing units, 3) set lines, 4) rod and reel, and 5) seines.

Gill-nets were 125 feet by 6 feet and were divided into five sections of one inch, one and one quarter inch, one and one-half inch, one and three-quarters inch, two inch square mesh. The nets were set in

FIGURE 2. Cataract at low flow near S.O.B. Draw, Black Canyon of the Gunnison National Monument.

FIGURE 3. Rapid at low flow, with standing waves, downstream from East Portal, Gunnison River.

FIGURE 4. Run at low flow downstream from East Portal, Gunnison River.

FIGURE 5. Riffle at low flow between S.O.B. Draw and Red Rock Canyon, Black Canyon of the Gunnison National Monument

FIGURE 6. Pool at moderate flow at East Portal, Gunnison River. Gill net floats mark eddy.

pools and slack-water areas and remained in the water overnight. Largest mesh was generally in swiftest water.

Two electro-fishing units were used. One was a 115 volt alternating current generator with a 50 to 700 volt variable-voltage regulator, and selector for direct current. This unit was mounted on a back-pack frame and was carried into Gunnison Point section. It was used at the East Portal section also. The second and larger unit consisted of a MITE-E-LITE generator, a Coffelt Model II variable-voltage regulator and 300 feet of electrical cord on a spool. It was used only at the East Portal section.

Set-lines and rod and reel were used to sample the swift water areas. Seines were ineffective under existing water conditions.

Data analyzed from the fish samples were: 1) age, 2) condition factor, and 3) species identification.

Scales , for age determination, were taken from a diagonal scale row below the dorsal fin, above the lateral line on the left side of the fish. The scales were then cleaned in a one percent solution of potassium hydroxide and were dry mounted between microscopic slides. Age was determined by examining an image projected on a ground-glass screen by a Bioscope Projector. If agreements were not reached for two of three successive readings, the scale was discarded.

Fork length (length from tip of snout to fork of tail) was used as the standard measure and was recorded to the nearest one-eighth of an inch. Weight of each fish was determined on an Ohaus spring scale and was recorded to the nearest ounce. Some standard and total length measurements were taken for conversion purposes.

A coefficient of condition using C (English system) was calculated as described by Lagler (1956). The formula used is expressed as $C = \frac{W}{L3}$

where W is weight in ounces and L is the fork-length in inches.

Fish samples were brought to the laboratory and identified using the following taxonomic keys: Beckman (1952), Ellis (1914), Simon (1946), Koster (1957), and Sigler and Miller (1963). These keys are not entirely satisfactory, even in combination, and positive identification of suckers was not possible in all cases.

Data on aquatic plants and insects were taken from Reed and Norton (1963) and were included in the appendix for completeness of the aquatic biota and for ease of reference.

CHAPTER III

PRESENTATION OF DATA

Data from field collections and laboratory analyses are presented as physical or biological data. All raw data are on file at the Cooperative Fishery Unit; Colorado State University; Fort Collins, Colorado.

PHYSICAL DATA

Maximum water temperatures in the Monument canyon occurred from late July to August. These temperatures in 1964, 1965, and 1966 were 67, 64, and 61 degrees F., respectively. Minimum temperatures, approximately 32 degrees, persisted from late November to March. Seven-day means of maximum and minimum water temperatures for 1964, 1965, and 1966 are represented in Figure 7 and Appendix A.

From April, 1965, to July, 1965, the average temperature at 3:00 AM was equal to, or greater than, the average temperature at 3:00 PM. During 1966, this inversion existed from March to June.

The 1909 water year had the highest mean water flow, 2,767 cfs, recorded in the Monument canyon. (A water year is the 12 month period between October 1 and September 30). Twelve of the highest 14 mean flows recorded were between 1906 and 1926. The lowest mean flow, 301 cfs, occurred during the 1954 water year and the second lowest mean flow, 375 cfs (uncorrected), occurred during the 1966 water year (Figure 8). The low flow of 1966 is a direct result of water storage in Blue Mesa Reservoir.

The largest single day discharge recorded in the Monument canyon, 19,000 cfs, occurred on June 15, 1921. Maximum single day discharge of 1965 water year was 10,100 cfs on June 21 while maximum single day discharge of the 1966 water year was 2,750 cfs on June 2.

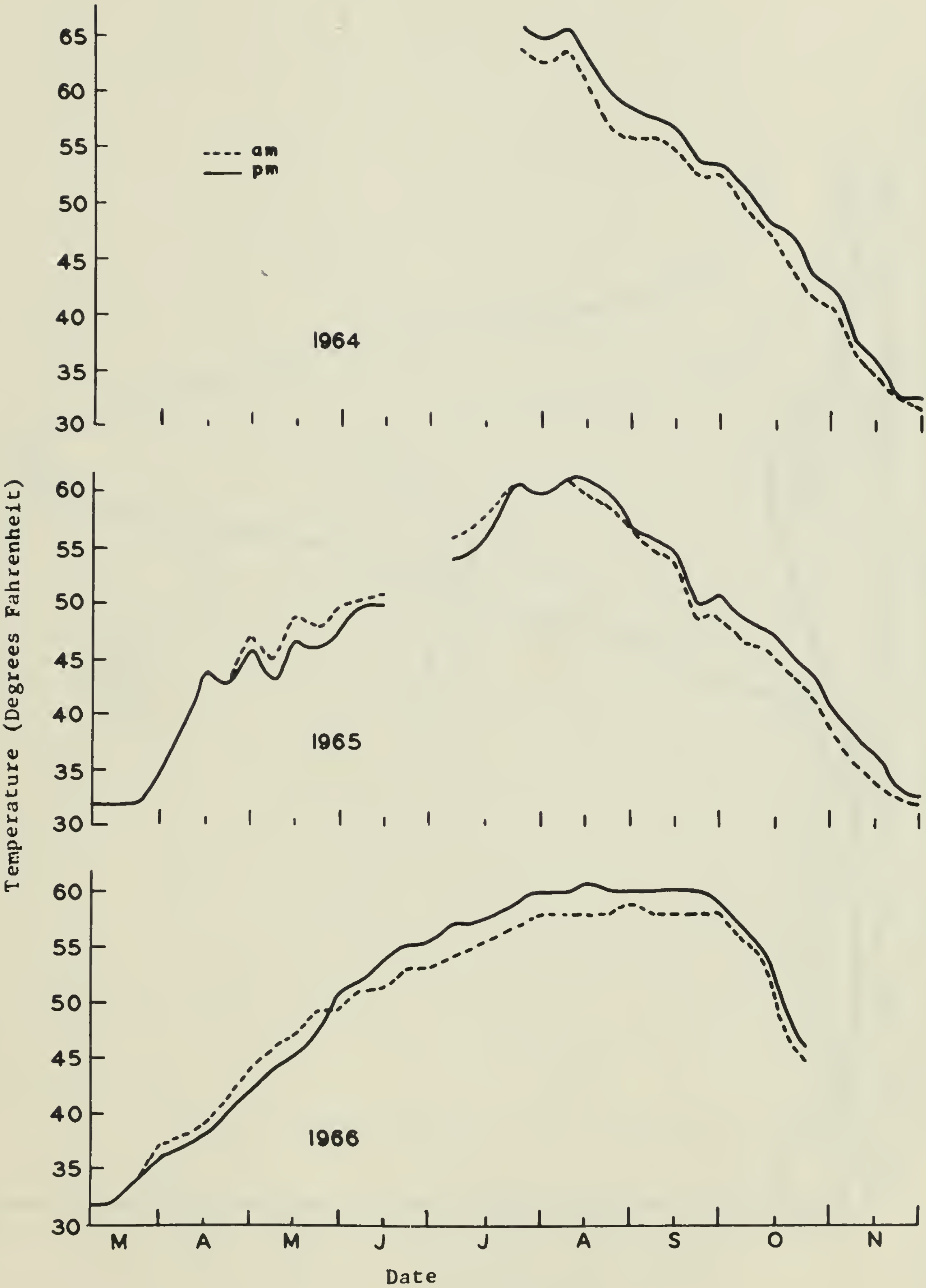

FIGURE 7. Average high and low water temperatures at the Geological Survey gaging station, East Portal, Gunnison River, 1964-1966.

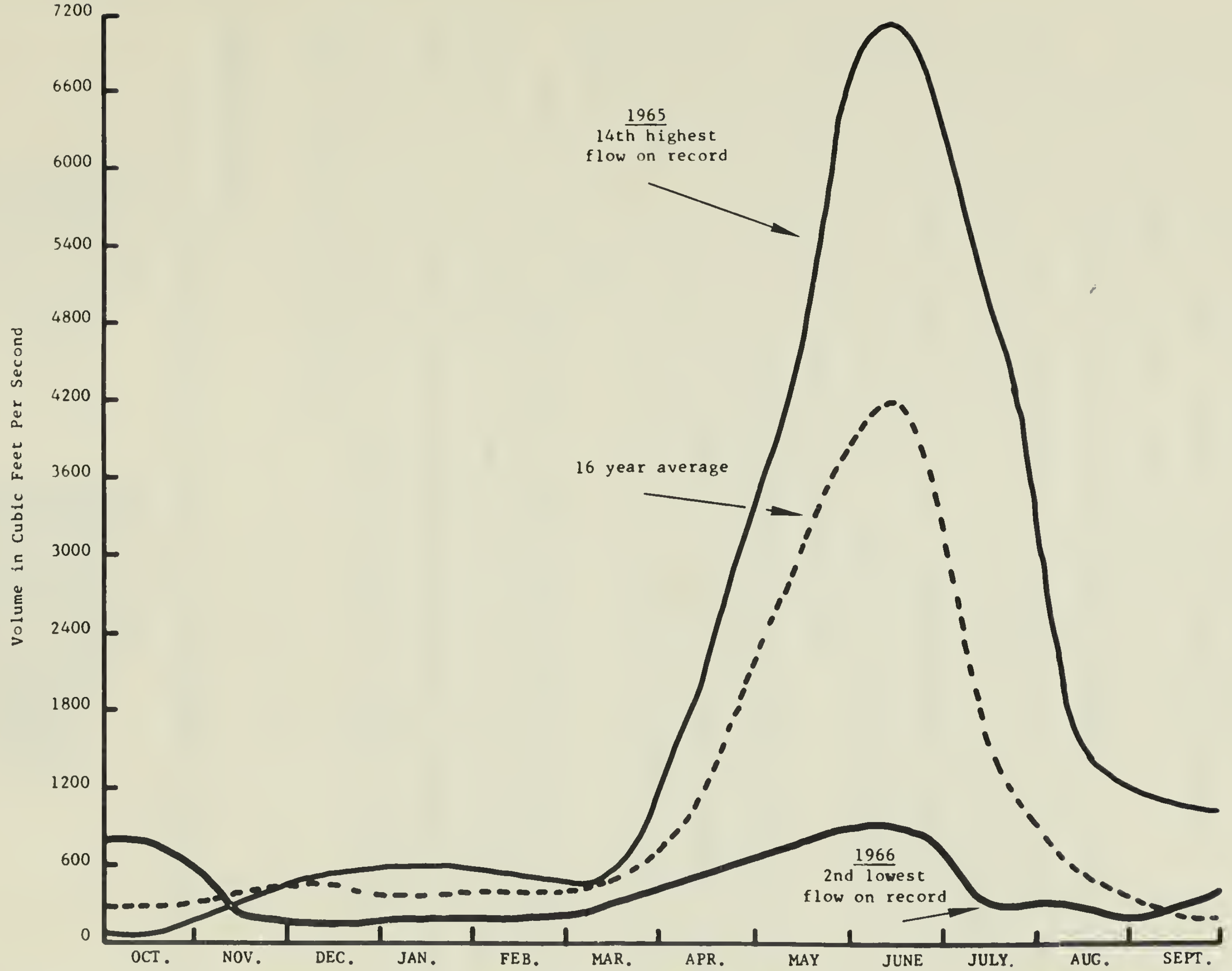

FIGURE 8. Average monthly flows at Geological Survey gaging station, Gunnison River, 1965-1966.

All water was diverted through the East Portal Tunnel on September 25, 26, 1939; October 8, 1949; and September 5, 6, 15, and 16, 1950, and zero flow was recorded at the Geological Survey gaging station. Minimum flow recorded during the 1965 water year was 50 cfs on October 21, 24, 26, and 27, 1964. Minimum flow during the 1966 water year was 60 cfs on November 30, 1965 (Appendix B).

River elevation at the upstream Monument boundary is 6,530 feet. The river has a fall of approximately 1,170 feet over the 12 mile course through the Monument (Figure 9). Average gradient is approximately 97 feet per mile and as much as 180 feet in one half-mile section. The Falls of Sorrow, (Torrence Falls), largest of four individual falls in this section, probably does not exceed 20 feet.

Each habitat type composes a different percentage of the total area with different water levels (Figure 10). Velocity and discharge decrease concurrently. The overall trend is to increase slow water areas and decrease the fast areas.

Morgan (1959) and Wiltzius (1966) have compiled the most complete records of the physical and chemical properties of the Gunnison River (Table 1). Additional data concerning the Gunnison drainage are found in Geological Survey Records (1964a), Knight and Argyle (1962), and House Document No. 201 (1960).

BIOLOGICAL DATA

There are seven species of fishes in the Monument canyon (Table 2):

brown trout	(*Salmo trutta*)
rainbow trout	(*Salmo gairdneri*)
western white sucker	(*Catostomus commersoni*)
bluehead sucker	(*Pantosteus delphinus*)
flannelmouth sucker	(*Catostomus latipinnis*)
speckled dace	(*Rhynichthys osculus*)
bonytail chub	(*Gila robusta*)

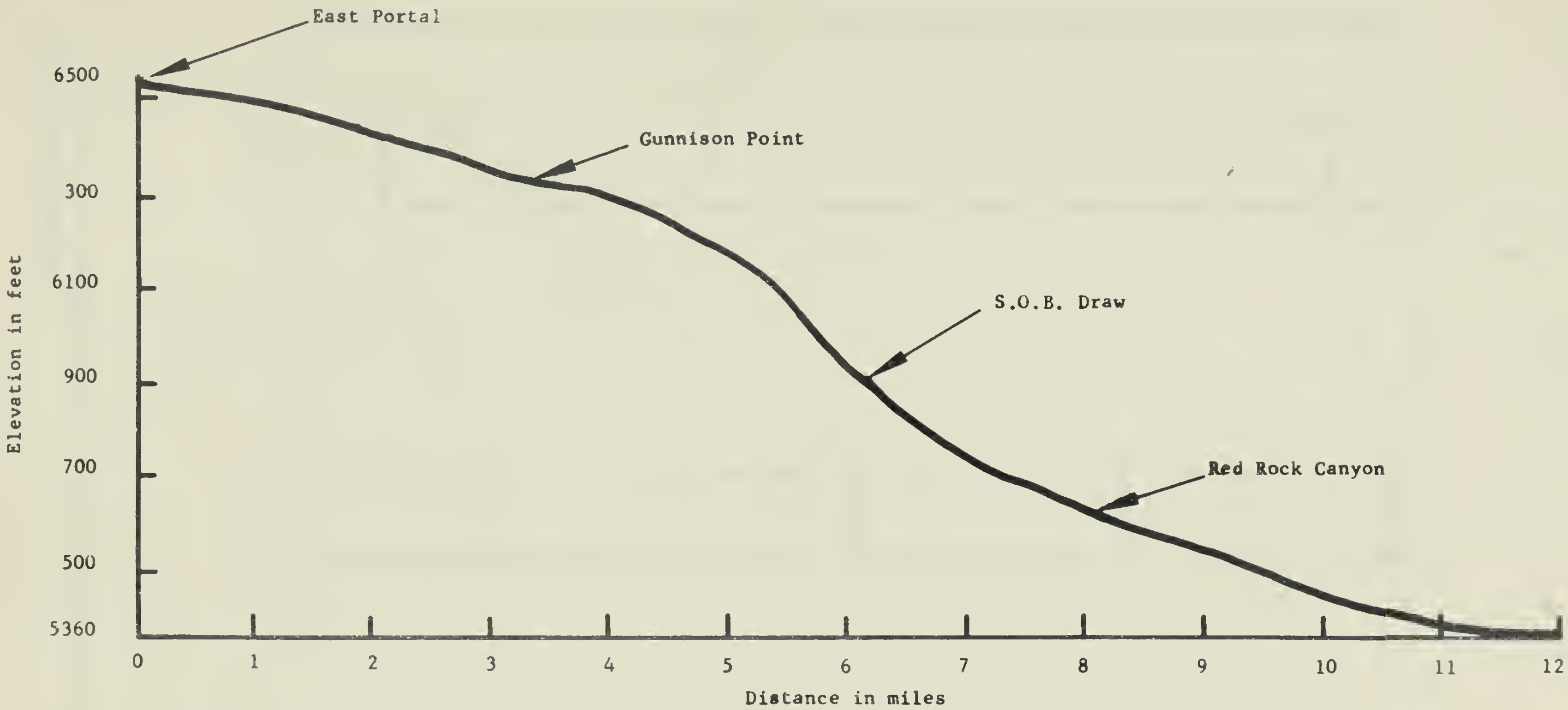

FIGURE 9. Profile of the Gunnison River in Black Canyon of the Gunnison National Monument.

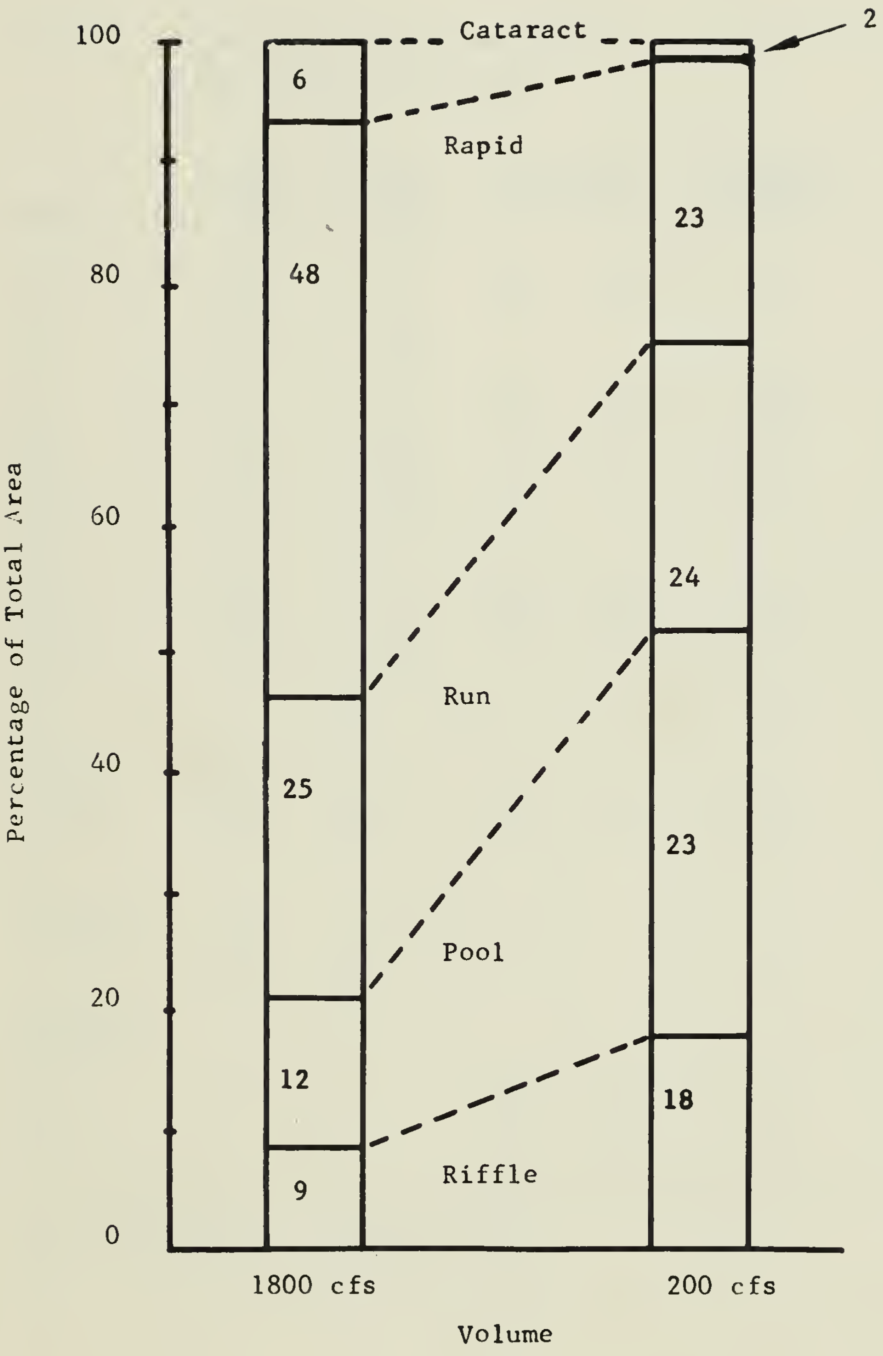

FIGURE 10. River habitat composition in Black Canyon of the Gunnison National Monument.

TABLE 1. Physical and chemical properties of the Gunnison River, 1959, 1964-1965.

Analyses	Above* Gunnison 1959	Below* Gunnison 1959	Below Highway** 149 Bridge 1964	1965	Below Highway** 50 Bridge 1965	Cimarron* 1959	Above North** Fork 1964	1965
As	.001	.001						
Ca	32.9	33.4	36.0		11.0	77.5	47.9	21.6
Cl	17.8	16.8	1.0	1.5	1.5	27.3	2.0	1.5
Cr	0	0				0		
Cu	.08	.06				.06		
F	.11	.09				.19		
Fe	.32	.37	0.0	.07	.06	.67	0	.07
K			5.0		3.4			2.8
Mg	21.1	22.2	9.3	7.3	5.9	38.1	21.7	10.2
Mn	.019	.021				.042		
Na	41.5	47.7	1.6	0.8	0.7	57.3	9.5	1.1
Nh_3	.06	.045				.11		
NO_3	.12	.14				.04		
Se	0	0				0		
SiO_2	9.2	9.7	1.6	21.3	31.7	7.5	7.1	64.9
SO_4	10.2	15.1	18.0	20.0	16.9	23.2	92.3	26.5
U_3O_8	.104	.13				.12		
V_2O_5	.27	.39				.99		
Zn			0.0	0.8	.075		0.0	.032
Alkalinity								
PH-TH	0	0	0	0	0	0	0	0
TOT-MO	108	109	113	70	62	141	113.5	58
Solids								
Suspended	5.2	7.3				22.1		
Dissolved	108	111				357		
EDTA Hardness (ppm $CaCO_3$)								
Total			128	96	74		212	98
Ca			90	66	50		124	54
Mg			38	30	24		88	44
Non CO_3			15	21	12		97	40

* From Morgan (1959). All measurements in Mg/L

** From Wiltzius (1966). All measurements in ppm

TABLE 2. Number and species of fishes collected within Black Canyon of the Gunnison National Monument

Area	Brown trout	Rainbow trout	White sucker	Bluehead sucker	Flannelmouth sucker	Bonytail chub	Speckled dace	Hybrid sucker	Total
East Portal	16	69	62	2	13		53	13	228
Campground Draw	18	27	18	3	3				69
Tomichi Point	5	8	9		4			4	30
Gunnison Point	62	50	24	5	3		1	3	142
S.O.B. Draw	43	10	30		8			2	93
Warner Draw	11	3	4	66	8			4	96
Red Rock Canyon	27	9	36	108	84	4	8	11	287
TOTAL	182	176	183	184	123	4	62	37	951

Problems arose in determining the age of fishes from the Monument canyon. Haphazard appearance of annulae of white, bluehead, and flannelmouth sucker scales in the Monument canyon did not meet Hile's (1941) requirements for validity as year marks. Geen, Northcote, Hartman, and Lindsey (1966) also reported that scales did not provide reliable indications of the age of white suckers. A pronounced circulae change, perhaps due to diet shift (Olson, 1963), may or may not be related to annulae formation.

Difficulties were experienced in determining age of large trout from scales due to absorption of scale edges. Interpolation beyond five years was not attempted. A stocking check was recognizable on rainbow trout that had been stocked in March, 1965. Stocked rainbow trout have been eliminated from subsequent computations.

Mean length, length range, and mean condition factor for each species are presented in Table 3.

Reed and Norton (1963) recorded 54 genera and 94 species of algae in Black Canyon National Monument (Appendix C). Flowers (1962) and Flowers, Hall, and Reynolds (1962) reported 38 genera and 63 species from the Blue Mesa and Morrow Point Reservoir basins while Morgan (1959) recorded 13 genera in the upper Gunnison River. Flowers (1962) dealt with a greater variety of habitats in the reservoir basins and recorded a greater number of aquatic vascular plants than did Reed and Norton (1963). (Collection of Reed and Norton, Appendix D).

Reed and Norton (1963) also reported that four orders, 15 families and 19 genera of aquatic insects were represented in the Monument (Appendix E). Wiltzius (1966) collected and compiled considerable data on the aquatic insects of the Gunnison Basin from his own collections and from Pratt (1938), Richardson (1962), Reed and Norton (1963), Argyle and

TABLE 3. Some growth statistics of fishes in Black Canyon of the Gunnison National Monument

Year	Species	N	Mean		Length Range by Age			
			Length	Condition	2	3	4	5+
1965	Brown trout	51	9.8	0.577	7.0-7.8	7.1-8.8	8.3-10.4	10.0-16.8
1966		13	10.0	0.625				
1965	Rainbow trout	34	8.9	0.639	5.8-7.8	7.5-9.4	9.3-11.3	11.5-17.0
1966		7	11.5	0.693				
1965	White sucker	56	11.5	0.622	5.9	-	-	15.5
		13	13.5	0.735				
1965	Flannelmouth sucker	41	14.7	0.547	9.4	-	-	20.0
1965	Bluehead sucker	33	10.6	0.558	7.8	-	-	15.8

Edmunds (1962), Riley and Eastin (1962) and House Document No. 201 (1960). He omits Morgan (1959) and Burkhard (1965) who also collected aquatic insects but identified only to order.

CHAPTER IV

DISCUSSION

Distribution of fishes is governed by ability to disperse and to adjust to changing environmental conditions. If fishes were moved artificially, dispersal would not become a problem but adjustment to new environments might. When the environment changes, existing species adjust to the altered environment by increasing or decreasing numerically. New species may invade the altered environment.

Some data were collected before upstream impoundment in 1965, and some immediately after, in 1966, because this investigation was not initiated until impoundment construction was well advanced and because of the unusually high river flow the first field season. Physical characteristics of the river reflect impoundment influence faster than biological organisms that had little time to adjust to the environmental change. Distribution of fishes was comparable the few months after impoundment to previous distribution.

PHYSICAL DATA

Temperature influences fishes in many vital ways. In the Monument canyon two distinct changes in water temperature occur: a spring temperature inversion when water temperatures are warmer at night than day, and an annual increase and decrease caused by seasonal climate. Upstream impoundment will continue to modify both patterns.

In 1965, inversion began in late April and persisted through much of July: approximately 13 weeks (Figure 7). During 1966, inversion persisted for nine weeks, from late March to early July. The inversion began a month earlier in 1966 than in 1965 and ended almost two months earlier. Temperature inversion appears to be a characteristic of the

Gunnison River within Black Canyon and is probably related to the limited sunlight in the canyon. The duration of the inversion may be affected by flow volume since it was shortened but not eliminated by water control at Blue Mesa Dam.

The seasonal pattern of temperature fluctuation in the Monument canyon appears to have been modified (Figure 11). During 1965 water temperature increased erratically until reaching a maximum from which it immediately decreased. Temperatures increased over a five month period, spring and summer; decreased over three and one-half months, fall; and uniform low temperatures occurred over the remaining three and one-half months, winter. In 1966 water temperatures increased uniformly over four and one-half months, spring and early summer; abruptly decreased over two and one-half months, fall; and unform low temperatures again occurred over the remaining three and one-half months, winter. Temperature recording instruments will continue to maintain the water temperature patterns observed thus far in the Monument canyon to determine further change.

Water control exercised at Blue Mesa Dam in 1966 reduced maximum flows but raised minimum flows slightly. More uniform flows will result in more stable plant and insect communities that will benefit fish populations.

Neel (1963) indicated that fish growth is stimulated below reservoirs where stream modification increased benthic algae and bottom animals; however, species composition in these populations may differ from the original.

General location of fish habitat types shifted with changes in volume. High volume cataract areas, which were unsuitable as fish habitat, became rapid habitat at lower volumes. Rapid habitat may serve as escape and food producing areas for some species of fish. Although the

FIGURE 11. Schematic comparison of water temperatures at Geological gaging station, East Portal, Gunnison River, 1965-1966.

percentage of run did not decrease as volume decreased (Figure 10), location changed: rapids became run type habitat. Humpback sucker (Xyrauchen texanus) and bonytail chub are examples of fishes that have evolved body forms specifically adapted for swift, turbulent areas.

Much of the higher volume run changed to pool habitat with decreasing volume. Pools were the principle feeding and resting areas for suckers. Percentage of riffle within high volume rapid, run, and pool habitat areas increased as volume decreased. Burkhard (1965) also found that with decreasing flow, the area of his "deep fast" category decreased and his riffle, pool, and slow shallow categories increased. In the Monument canyon, riffle areas were richest in variety and number of immature insects, providing more trout food than other areas (Reed and Norton, 1963).

Therefore, during high spring runoff periods, optimum habitat for most indigenous fishes and introduced trouts is limited. At lower flows pool and riffle areas increased providing a greater area of suitable habitat. Those few species that have adapted morphologically to large volume, swift rivers will have reduction in habitat. If rapid and run areas are sufficiently restricted, the competitive advantage of these highly adapted species will be lessened.

None of the concentration levels of the chemical determinations in Table 1 were lethal to fishes now found in Gunnison River. Water quality in Gunnison River below the reservoirs will be affected. Changes in quality due to impoundment will vary with age of impoundment, extent and duration of thermal stratification, frequency of density currents, depth of water releases through or over dams, operational objectives, extent of drawdown and refill, type of release structures, and chemical nature of drainage basins (Neel, 1963). Toxic conditions of water

leaving the upstream reservoirs, due to presence or absence of dissolved gasses, should be corrected by aeration because of the physical nature of the river in Black Canyon. No chemical levels lethal to fish are anticipated in the Monument canyon.

BIOLOGICAL DATA

Sensitivity of fishes to fluctuations in the environment is reflected in changes in reproduction and in growth as measured by condition.

Reproduction in 1965 appeared to be poor. No trout young-of-the-year were observed or captured and fewer than 30 sucker young-of-the-year were observed or captured. Fluctuations in flow and temperature were probably responsible.

Trout fry were observed in 1966 in addition to large numbers of sucker fry. Sucker reproduction expanded enormously over the previous year but trout reproduction remained low. Table 2 indicates that the three species of suckers are the dominant group of fishes in the Monument canyon. Unless they are affected by temperature, or controlled flows, suckers will remain the dominant fish group due to utilization of a low trophic level, high reproductive potential, and long life span.

High condition factors of small samples taken in the spring of 1966 suggested that white sucker, rainbow trout, and brown trout were in better condition in 1966 than in 1965, probably because of lower flows and more uniform increases in temperature. Rainbow trout consistently had higher condition factors than brown trout, and white sucker had higher condition factors than bluehead or flannelmouth suckers (Table 3).

Optimum trout growth occurs between temperatures of 50 and 60 F. (Pentelow, 1939; Davis, 1953). Wingfield (1940) found that the growth rate of brown trout increased with increasing temperatures, up to 62 F,

then decreased above this temperature. Growth appeared to cease near 42 F. Below 42 F, trout require 25 to 44 hours of digestion time to obtain maintenance energy from food organisms (Reimers, 1957). Additional studies by Brown (1957) indicated that optimal growth of brown and rainbow trouts occurred between 45-48 F and between 59-61 F.

Food supply and potential food producing area (area beneath the water surface) is affected by velocity and volume of flow. Curtis (1959) reported the relationship between the area beneath the surface (wetted perimeter) as non-linear because perimeter decreases much less rapidly than volume of flow. However, mean velocity changes over every point of the channel bottom as volume changes and velocity changes at a greater rate than does the wetted perimeter. This may change the insect populations, not only qualitatively but quantatively and thus indirectly affect the fish populations. Under conditions of fluctuating water levels, midges and oligochaetes will burrow but other genera will migrate with the waterline (Denham, 1938; Reed and Norton, 1963). Apparently many types of organisms can survive such changes in habitat (Gerking, 1963).

In a relatively productive river as the Gunnison, food may not be as limiting as physical microhabitats. The extremely high average gradient of nearly 100 feet per mile places a premium on slow-water resting areas.

Fish distribution can be approached in three ways:

(1) distribution of an individual over a home range.

(2) distribution of a population within the species range.

(3) distribution of the species over time.

Of the five habitat types designated in the Monument canyon, only the cataract type is not included in a home range of an individual fish.

Cataracts within the Monument have acted as partial barriers to upstream movement by bluehead and flannelmouth suckers and as complete barriers to bonytail chub. These cataracts will likely be complete barriers to all upstream immigration at low flow. The four remaining habitat types can probably be included at some time within the home range of individuals of each species in the Monument canyon.

In a generalized pool (Figure 12) rainbow trout will be near the head in run and riffle areas as well as in the turbulent interfaces of eddies. Brown trout are closely associated with protection afforded by depth and by rocks whether close to shore, in the slack water of pools, slow moving tail of pools, or in protected eddies. Bluehead sucker are taken nearer the head of pools than are the other suckers although both bluehead and flannelmouth suckers will feed in riffle areas. Dace occupy the shallow backwaters of pools and side-channel riffle sections. Bonytail chub are found in the moderate current sections of pools at any depth.

Species distribution trends throughout the Monument canyon may be artifacts of gear selectivity and intensity of sampling (Table 2). However, in moving downstream from East Portal to Red Rock Canyon, brown trout increased in frequency and rainbow trout decreased. Rainbow trout have been maintained near East Portal by stocking.

White suckers were uniformly distributed in the Monument canyon while both bluehead and flannelmouth suckers were much more abundant in the lower one-third than the upper two-thirds. Hybrid suckers of undetermined taxonomic relationship occurred throughout the Monument canyon in low numbers. Hubbs and Miller (1953) found sucker hybrids in other parts of the Colorado basin. Speckled dace also occurred throughout the Monument; the number of dace at East Portal is biased by

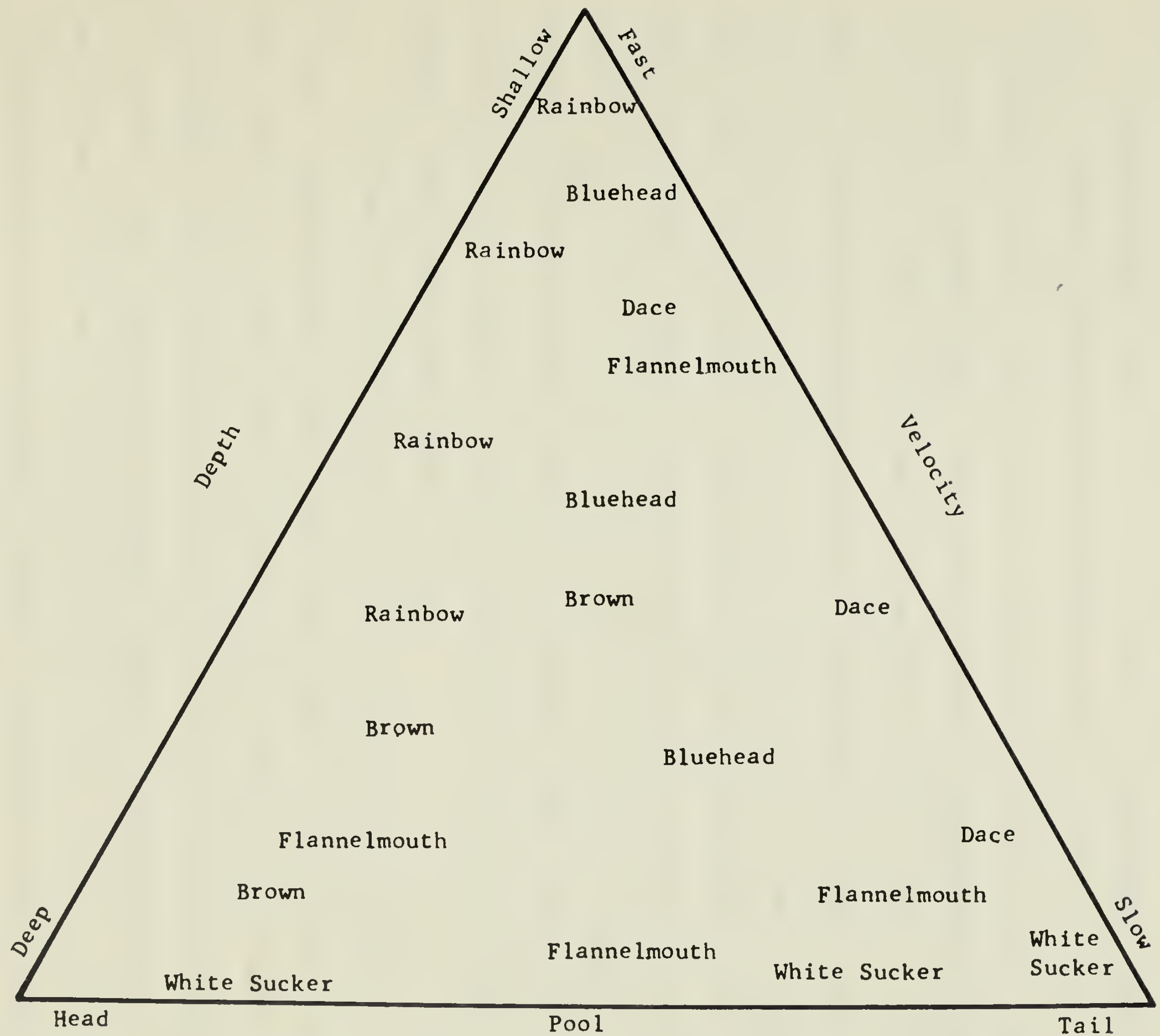

FIGURE 12. Distribution of fishes in a generalized pool in Black Canyon of the Gunnison National Monument

sampling intensity. Bonytail chub were not found above Red Rock Canyon section.

Jordan (1891) found eight native and one introduced species in the Gunnison River. Three were found above Black Canyon (Colorado cutthroat trout, Salmo clarki; speckled dace, and brook trout, Salvelinus fontinalis). Seven species were found below Black Canyon (humpback sucker, flannelmouth sucker, bluehead sucker, bonytail chub, speckled dace, mottled sculpin, Cottus bairdi; and Colorado squawfish Ptychocheilus lucius). In 1937 Pratt (1938) found flannelmouth sucker, bluehead sucker, rainbow trout, brook trout, and brown trout above Black Canyon. Brook trout were introduced into the Gunnison River in 1883; rainbow trout in 1888, and brown trout in 1893-94; white sucker have been present since 1937 (Wiltzius, 1966). Rainbow trout have hybridized with, and ecologically replaced, the native cutthroat trout. Jordan (1891) may have missed catching suckers above Black Canyon since Wiltzius (1966) indicated that permits were sought for removing suckers from tributaries of the Gunnison River above Black Canyon in 1902.

Black Canyon acts as barrier to natural distribution of fishes through falls and water velocity and through temperature. Of the native fish fauna only cutthroat trout, speckled dace, bluehead sucker, and flannelmouth sucker have been able to live in or move upstream through the canyon, while bonytail chub, Colorado squawfish, humpback sucker, and mottled sculpin have been restricted by the canyon area. A number of introduced species are present a few miles downstream from the canyon. The number of species in the Monument is less than half the total number of species in the Gunnison River. Wiltzius (1966) suggested that 15 species are in the Gunnison River (seven occur within the Monument). This number is probably minimal. The Monument canyon is an ecological

threshold area between the upper and lower reaches of the Gunnison River. Comparatively slight environmental changes can thus precipitate extensive distributional adjustments.

CHAPTER V

SUMMARY

Ecological impact of reservoirs on the native flora and fauna of rivers of the arid and semi-arid west are not well known. In October, 1965, Blue Mesa Reservoir, the first of three units of the Curecanti Project, Gunnison River, Colorado, began to store water.

The National Monument is immediately downstream from the last of these units and the river within the Monument will be affected by water manipulation. Objective of this study is to provide a base for detection of subsequent changes in the fish fauna within the Black Canyon of the Gunnison National Monument. Data on water temperature regimen, flow characteristics, river habitats, fish species present, condition factor, and distribution were collected.

Sampling was done in summer and fall of 1965 prior to upstream impoundment. Temperature data were collected for 27 months with a continuous recording thermograph. Data concerning flows were obtained from the Geological Survey. Fish samples were collected with gill-nets, electro-fishing equipment, rod and reel, and set-lines.

A diel temperature inversion during the spring months was noted. The inversion was influenced by water control at Blue Mesa Dam.

Average flow for 1965 was the 14th highest flow on record and the 1966 flow was the second lowest on record.

Five river habitat types were described: cataract, rapid, run, riffle, and pool. Percentage of riffle and pool type increased and other habitat types decreased as volume and velocity decreased.

Seven species of fishes were collected within the Monument canyon. Rainbow trout, brown trout, and white sucker have been introduced.

Flannelmouth sucker, bluehead sucker, speckled dace, and bonytail chub are native to the drainage. Taxonomic position of hybrid suckers in the Monument was not determined.

In 1965 and 1966 rainbow trout had a higher condition factor than brown trout. In 1966, white sucker, rainbow trout, and brown trout had a higher condition factor than in 1965. Growth statistics were not determined for speckled dace or bonytail chub.

With the exception of the bonytail chub, the remaining species were distributed throughout the length of the Monument. In proceeding downstream, rainbow trout decreased while brown trout increased. The white sucker appeared to be evenly distributed while bluehead and flannelmouth suckers occurred more frequently in the lower one-third of the Monument. Speckled dace occurred frequently in the upper one-third whereas bonytail chub were found only in the lower one-third of the Monument. Black Canyon is an ecological threshold between the upper and lower reaches of the Gunnison River.

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APPENDIX A. Mean weekly water temperatures at the Geological Survey gaging station, East Portal, Gunnison River, 1964-1966, (Degrees Fahrenheit).

DATE	1964			1965			1966		
	3:00PM	3:00AM	MEAN	3:00PM	3:00AM	MEAN	3:00PM	3:00AM	MEAN
18-24 March							32	32	32
25-31 March				32	32	32	34	34	34
1- 7 April				35	35	35	36	37	36
8-14 April				39	39	39	37	38	37
15-21 April				44	44	44	38	39	38
22-28 April				43	44	43	40	41	40
29 April - 5 May				46	47	46	42	44	43
6-12 May				43	45	44	44	46	45
13-19 May				47	49	48	45	47	46
20-26 May				46	48	47	47	49	48
27 May - 2 June				48	50	49	51	49	50
3- 9 June				50	50	50	52	51	51
10-16 June				50	51	50	54	51	52
17-23 June							55	53	54
24-30 June							55	53	54
2- 8 July				54	56	55	57	54	55
9-15 July				55	57	56	57	55	56
16-22 July				58	59	58	58	56	57
23-29 July	66	64	65	61	61	61	59	57	58
30 July - 5 August	65	63	64	60	60	60	60	58	59
6-12 August	66	64	65	61	61	61	60	58	59
13-19 August	63	61	62	61	60	60	61	58	59
20-26 August	60	57	58	60	59	59	60	58	59
27 August - 2 September	59	56	57	57	57	57	60	59	59
3- 9 September	58	56	57	56	55	55	60	58	59
10-16 September	57	55	56	55	54	54	60	58	59
17-23 September	54	53	53	50	49	49	60	58	59
24-30 September	54	53	53	51	49	50	59	58	58
1- 7 October	52	50	51	49	47	48	57	56	56
8-14 October	49	48	48	48	46	47	55	54	54
15-21 October	48	45	46	46	44	45	49	48	48
22-28 October	44	42	43	44	42	43	46	45	45
29 October -4 November	43	41	42	41	39	40			
5-11 November	38	37	37	39	38	38			
12-18 November	36	35	35	37	36	36			
19-25 November	33	33	33	34	33	33			
26 November- 2 December	33	32	32						

APPENDIX B. Monthly and yearly mean discharge of the Gunnison River at Geological Survey gaging station, East Portal, 1904-1966, in cubic feet per second.

Water year	Oct.	Nov..	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
1904	641	519	413	390	416	535	1,503	3,851	3,292	1,103	1,232	896	1,234
1905	1,020	500	340	330	340	700	1,217	5,246	8,383	2,039	1,130	560	1,820
1906	519	491	475	465	460	750	2,270	6,620	8,830	3,510	1,470	1,060	2,248
1907	905	620	475	470	460	990	2,500	4,400	10,500	6,620	2,400	1,310	2,643
1908	986	640	450	450	450	700	1,940	2,690	4,880	2,170	1,630	698	1,473
1909	634	510	475	460	450	750	1,950	7,160	10,800	5,470	1,880	2,600	2,767
1910	1,270	610	470	460	460	1,730	3,703	6,292	5,336	1,337	882	464	1,923
1911	467	550	480	470	460	700	2,309	6,251	8,696	4,456	1,436	836	2,293
1912	2,114	886	610	540	500	800	2,793	7,156	8,883	4,423	1,292	674	2,557
1913	981	562	480	450	420	590	2,269	4,685	4,250	1,225	538	756	1,436
1914	785	709	525	475	450	900	2,187	7,521	8,268	3,762	1,450	759	2,325
1915	1,014	909	520	490	480	890	1,672	2,529	5,084	1,735	322	241	1,329
1916	409	510	440	400	390	730	2,173	5,726	8,232	2,692	2,039	706	2,037
1917	1,038	700	550	420	490	550	1,548	3,563	10,770	4,410	1,015	279	2,113
1918	419	580	450	420	540	650	1,259	5,088	8,961	2,169	1,105	1,100	1,913
1919	746	660	470	340	400	680	1,614	4,882	3,286	1,285	490	189	1,259
1920	340	640	500	450	500	850	943	8,436	10,343	3,146	763	207	2,261
1921	680	760	540	530	500	660	815	5,063	11,235	3,309	1,263	592	2,163
1922	253	650	500	500	520	660	1,205	6,087	6,411	1,146	339	25	1,527
1923	28	487	430	390	430	570	958	5,477	7,714	3,132	1,442	764	1,823
1924	758	732	500	500	520	610	2,067	5,487	6,381	825	34	32	1,534
1925	342	553	470	450	490	780	2,354	3,870	3,340	1,204	513	744	1,260
1926	472	670	450	360	460	600	1,563	4,156	5,813	1,291	314	81	1,347
1927	387	526	490	440	500	640	1,524	6,450	6,146	2,276	982	1,525	1,828
1928	1,113	910	700	620	580	950	1,344	8,613	7,132	2,138	513	60	2,061
1929	201	599	420	380	420	860	1,539	6,528	8,294	2,566	2,097	2,447	2,199
1930	1,353	979	580	400	450	550	3,282	2,979	5,010	934	1,182	80	1,481
1931	333	432	500	430	440	480	324	657	1,220	138	46	34	418
1932	203	527	480	400	390	520	1,427	5,113	5,594	2,101	501	48	1,443
1933	42	415	400	380	370	650	386	3,047	6,012	707	166	51	1,050
1934	16	269	469	410	450	435	469	1,573	208	63	47	31	383
1935	17	116	420	380	370	520	329	1,885	7,204	1,606	298	204	1,109
1936	385	501	350	390	400	550	3,089	6,942	3,622	632	745	202	1,486
1937	189	440	360	360	410	470	1,674	5,766	2,583	524	70	8	1,075
1938	136	500	440	390	340	600	2,654	4,914	8,161	1,796	279	705	1,741
1939	424	598	441	420	300	926	1,550	3,335	2,358	215	243	230	922
1940	111	471	360	310	250	470	556	2,257	1,608	61	69	24	547
1941	339	497	330	320	360	480	617	5,230	5,139	1,659	143	205	1,307
1942	1,017	849	605	480	440	570	2,930	4,881	7,191	1,545	328	120	1,746
1943	66	483	412	370	424	420	2,514	3,449	4,666	1,066	1,093	487	1,286
1944	225	510	434	368	429	331	654	5,521	6,985	2,162	310	99	1,502
1945	93	376	353	399	389	352	451	3,746	3,759	1,504	888	70	1,035
1946	295	468	403	388	435	505	1,137	1,580	3,666	401	171	67	790
1947	199	268	365	340	352	307	575	4,239	5,647	2,525	631	420	1,326
1948	589	568	603	536	544	590	2,523	7,418	6,184	1,367	354	151	1,786
1949	113	356	466	359	386	463	1,808	3,747	7,341	2,880	402	213	1,544
1950	280	644	419	377	414	402	1,402	2,013	3,360	524	199	53	838
1951	36	216	411	394	394	527	388	2,129	3,673	864	333	68	786
1952	83	298	408	450	439	450	2,268	6,505	8,788	2,024	764	431	1,934
1953	315	292	516	484	432	481	516	1,709	4,928	890	413	130	925
1954	143	458	460	373	404	356	177	696	123	224	110	83	301
1955	213	260	377	325	279	299	672	1,350	2,118	342	342	80	555
1956	61	334	461	376	329	431	1,034	2,994	2,982	271	203	33	792
1957	58	413	322	317	377	445	989	4,073	11,670	8,468	2,237	610	2,498
1958	459	884	878	543	535	595	1,627	8,060	6,170	485	309	76	1,718
1959	39	390	474	411	422	328	303	1,194	2,708	177	268	79	566
1960	584	550	381	395	443	880	2,414	1,883	3,958	550	200	136	1,031
1961	90	426	397	331	341	496	428	2,025	1,996	232	218	217	600
1962	840	765	506	465	522	460	3,032	5,171	5,294	2,228	403	278	1,664
1963	240	404	393	323	435	860	613	1,595	845	220	251	60	520
1964	89	451	321	294	308	313	503	3,316	3,071	689	401	198	830
1965	90	322	449	454	404	487	2,114	4,439	7,196	5,212	1,475	1,081	1,974
1966	670	144	141	143	155	248	564	722	859	355	257	244	375

APPENDIX C. Algae of Black Canyon of the Gunnison National Monument. (From Reed and Norton, 1963).

PHYLUM CHLOROPHYTA

Green Algae

Actinastrum hantzschi
var. fluviatile Schroed.
Ankistrodesmus falcatus (Corda) Ralfs.
Chlamydomonas nivalis (Bauer) Wille.
f. kuetzingiana (Grun.) Heer.
Closterium acerosum (Schrank) Ehr.
Closterium leibleini Kuetz
Closterium moniliferum (Bory) Ehr.
Closterium siliqua West & West
Cocystis crassa Witt.
Cosmarium subcrenatum Hantz.
Gongrosira lacustris Brand.
Mougeotia sp.
Oedogonium sp.
Pediastrum tetras (Ehr.) Ralfs.
Scenedesmus dimorphus (Turp.) Kuetz.
Scenedesmus opoliensis P. Rickt.
Scenedesmus quadricauda (Turp.) Breb.
Spirogyra sp.
Staurastrum paradoxum
var. longipes Nordst.
Staurastrum punctulatum Breb.
Stigeoclonium flagelliferum Keutz.
Tetraspora gelatinosa (Vauch.) Desuanx
Ulothrix zonata (Weber & Mohr) Keutz.

PHYLUM EUGLENOPHYTA

Trachelomonas lacustris Drexep.

PHYLUM CHRYSOPHYTA

Achnanthes linearis
f. *curta* H.L. Smith
Achnanthes minutissima Kuetz
Achnanthes spp.
Amphipleura pellucida Keutz
Asterionella formosa Hass.
Asterionella sp.
Caloneis amphisbaena (Bory) Cleve.
Ceratoneis arcus Kuetz.
Cocconeis pediculus Ehr.
Cocconeis placentula Ehr.
Cyclotella bodanica Eulenst.
Cyclotella glomerata Bach.
Cymatopleura elliptica
f. *spiralis* (Ehr.) Grun.
Cymatopleura solea (Breb.) Wm. Smith
Cymbella mexicana (Ehr.) A.S.
Cymbella prostrata (Berk.) Cleve
Cymbella spp.
Cymbella tumida (Breb.) Van Heurck
Cymbella ventriocosa Keutz
Diatoma elongatum Ag.
Diatoma hiemale
Diatoma vulgare Bory.
Epithemia argus Keutz.
Epithemia ocellata (Ehr.) Kuetz.
Epithemia sorex Keutz
Epithemia turgida (Ehr.) Kuetz.
Fragilaria brevistriata Brun.
Fragilaria construens (Ehr.) Grun.
Fragilaria crotonensis Kitton
Fragilaria pinnata Ehr.
Frustulia rhomboides
var. *amphipleuroides* Grun.
Gomphoneis herculeum (Ehr.) Cleve
Gomphonema constrictum Ehr.
Gomphonema geminatum (Lyngb.) Ag.
Gomphonema olivaceum Lyngb.
G. olivaceum
var. *calcarea* Cleve.
Gomphonema spp.
Gyrosigma acuminatum (Kuetz.) Rabh.
Hantzschia amphioxys (Ehr.) Grun.
Melosira graulata
var. *angustissima* Muell.
Melosira jurgensi C.A.A.g.

Melosira varians C.A.A.g.
Navicula cuspidata Kuetz.
Navicula dicephala (Ehr.) Wm. Smith
Navicula gracilis Ehr.
Navicula radiosa Kuetz.
Navicula salinarum Grun.
Navicula spp.
Navicula viridula Kuetz.
Neidium affine
f. hercynica (A. Mayer) Hust.
Nitzschia acicularis (Kuetz.) Wm. Smith
Nitzschia palea
var. tenuirostris Grun.
Nitzschia sigmoidea (Ehr.) Wm. Smith
Nitzschia spp.
Nitzschia sublinearis Hust.
Nitzschia vermicularis (Kuetz.) Grun.
Pinnularia sp.
Rhoicosphenia curvata (Kuetz.) Grun.
Rhopalodia gibba (Ehr.) Muell.
Surirella ovalis Breb.
Surirella ovata Kuetz.
Synedra ulna (Nitz.) Ehr.

PHYLUM CHRYSOPHYTA

Yellow-green Algae (non-diatoms)

Dinobryon sertularis Ehr.
Hydrurus foetida (Vill.) Trev.
Vaucheria geminata (Vauch.) D.C.

PHYLUM CYANOPHYTA

Blue-green Algae

Entophysalis leminae (Ag.) Dr. & Daily.
Lyngbya taylori Dr. & Strick.
Oscillatoria tenuis C.A. Ag.
Phormidium autumnale (C.A. Ag.) Gom.
Phormidium tenue (Menegh.) Gom.

PHYLUM PYRROPHYTA

Dinoflagellates

Ceratium hirundinella (Muell.) Schrank.

APPENDIX D. Vascular plants below high water line in the Black Canyon of the Gunnison National Monument. (From Reed and Norton, 1963)

Alopecurus aequalis Sobol.
Chenopodium capitatum (L.) Asch.
Chenopodium sp.
Epilobium halleanum Housskn.
Equisetum hyale L.
Juncus sp.
Lappula redowski (Hornem.) Greene.
Limosella aquatica L.
Mentha sp.
Mimulus sp.
Potentilla biennis Greene
Rorippa nasturtium-aquatioum (L.) Schniz & Thell.
Rumex triangulivalvis (Douser) Rech.
Thalspi arvense L.
Veronica americana Schwein
Veronica peregina
var. *xalapensis* (H.B.K.) Pennell.

APPENDIX E. Aquatic insects of Black Canyon of the Gunnison National Monument. (From Reed and Norton, 1963).

Plecoptera - Stoneflies

- Perlidae
  - *Acroneuria*
- Perlodidae
  - *Arcyopteryx*
  - *Isogenus*
  - *Isoperla*
- Chloroperlidae
  - *Hastaperla*
- Pteronarcidae
  - *Pteroarcys*
  - *Pteronarcella*

Ephemeroptera - Mayflies

- Heptogeniidae
  - *Heptogenia*
  - *Rhithrogenia*
- Baetidae
  - *Baetis*
  - *Pseudocloen*
  - *Ameletus*
- Ephemerellidae
  - *Ephemerella*
- Tricorythidae
  - *Tricorythodes*

Trichoptera - Caddisflies

- Hydropsychidae
  - *Hydropsyche*
  - *Arctopsyche*
- Brachycentridae
  - *Brachycentrus*
- Glossosomatidae
  - *Glossosoma*

Diptera - True Flies

- Tendipedidae
- Simulidae
- Tripulidae
- Rhagionidae
  - *Atherix*

ABSTRACT

FISHES AND FISH HABITATS IN BLACK CANYON OF THE GUNNISON NATIONAL MONUMENT

Gunnison River is being impounded by a series of dams that comprise the Curecanti River Storage Project. Impoundment will affect aquatic flora and fauna downstream. Flora and fauna, and their environments, must be known before impoundment in order to evaluate subsequent changes.

Seven species of fishes were captured in Black Canyon of the Gunnison National Monument: rainbow trout, brown trout, white sucker, bluehead sucker, flannelmouth sucker, speckled dace, and bonytail chub.

In 1965 condition factors of rainbow trout, brown trout, white sucker, bluehead sucker, and flannelmouth sucker were: 0.639, 0.577, 0.622, 0.558, and 0.547 respectively. Suckers dominated the fish fauna.

Two water temperature patterns exist within the Monument canyon. A diel temperature inversion developed from April to May. Temperature at 3:00 AM averaged two degrees F warmer than temperatures at 3:00 PM. An annual increase and decrease in water temperatures existed due to seasonal climate. Highest water temperature recorded in 1964, 1965, and 1966 was: 68, 64, 61 F respectively and lowest temperature recorded each year was 32 F.

Maximum water flows through the Monument canyon occur in June and minimum flows occur in September. Average flow during the 1965 water year was the 14th highest recorded and average flow in the 1966 water year was the second lowest recorded.

Five habitat types were described: cataract, rapid, run, pool, and riffle. Percentage of pool and riffle increased and the others

decreased as water volume and velocity decreased.

Black Canyon was an ecological threshold between the upper and lower reaches of the Gunnison River.

Brian S. Kinnear
Department of Fishery and Wildlife Biology
Colorado State University
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