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THE FISHERY OF HYALITE RESERVOIR, MONTANA, WITH AN EVALUATION OF CUTTHROAT TROUT REPRODUCTION IN ITS TRIBUTARIES

by

Raymond John Zubik, Jr.

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Fish and Wildlife Management

MONTANA STATE UNIVERSITY
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VITA

Raymond John Zubik, Jr. was born May 2, 1951 in Waterbury, Connecticut to Raymond Sr. and Irene Zubik. He graduated from Watertown High School, Watertown, Connecticut in 1969 and attended Northwestern Connecticut Community College the following September where he received an Associate's degree in Liberal Arts and Science in 1971. He joined the U. S. Air Force in December, 1974 and married Donna L. Barberet of Thomaston, Connecticut on March 1, 1975. After completion of duty in 1978, he entered Montana State University and received a Bachelor of Science degree in Fish and Wildlife Management in 1981. He began graduate studies at Montana State University in June, 1981.

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- Introduction
- Yellowstone cutthroat trout--McBride strain
- Spawning
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- Known-age fish

Location:

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Water Referred to:

- Hyalite Reservoir 09-8512
- East Fork Hyalite Creek 09-1672
- West Fork Hyalite Creek 09-6802

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ABSTRACT

A summer creel census was conducted to estimate fishing pressure, catch rates and harvest of fish and to determine if the introduced McBride strain of cutthroat trout were reproducing in the tributaries at Hyalite Reservoir during 1981 and 1982. Estimated catch rates were 0.28 fish/hour in 1981 and 0.23 fish/hour in 1982. Fishing pressure was estimated to be 19,981 hours in 1981 and 17,733 hours in 1982. The estimated harvest was 6,064 fish in 1981 and 4,204 fish in 1982. Cutthroat trout contributed 5,862 and 4,032 fish to the harvest in 1981 and 1982, respectively, while less than 200 Arctic grayling and 28 brook trout were harvested in each year of the study. Creeled cutthroat trout averaged 308 mm in total length and 278 g in 1981 and 317 mm and 322 g in 1982. Spawning by cutthroat trout in both the West and the East Fork was documented. In the West Fork, upstream movements began in early June and coincided with increased stream temperatures and flow. Total numbers of cutthroat trout captured first entering the West Fork in 1981 and 1982 were 236 and 269, respectively. Spawning cutthroat trout were significantly longer and heavier in 1981 than in 1982. Although heavy angler harvest of spawning age fish was documented, the age structure of trapped spawners was older in 1982. Successful fry production was documented in both the East and West Forks during 1981. Cutthroat trout fry averaged 24.5 mm in total length and 99% moved downstream at night. In 1982, an estimated 19,359 cutthroat trout fry emigrated from the West Fork and a total of 2,878 fry were captured moving downstream in the East Fork. These downstream movements began in late August and ended in late September during both years of the study.

INTRODUCTION

Hyalite Reservoir has been the site of a popular fishery for cutthroat trout (Salmo clarki) in southwestern Montana for at least a decade. In 1974 and 1975 the estimated fishing pressures were about 9,600 and 8,400 hours (h) and harvests about 2,500 and 1,000 fish, respectively (Wells, 1976).

From 1953-1973, the Montana Department of Fish, Wildlife and Parks (MDFWP) supported the reservoir fishery with plants of Yellowstone Lake cutthroat trout in various numbers and sizes. From 1968-1972 approximately 10,000 fish about 100 millimeters (mm) in total length (TL) were released in the reservoir yearly. In 1973, the plant was changed to approximately 5,000 fish about 225 mm TL. No plants were made in 1974 and 1975 while the status of the fishery was investigated .

During 1975, Wells (1976) evaluated the natural reproduction of cutthroat trout in the tributaries of the reservoir. His evaluation indicated there were no fry produced naturally and that the fishery was being sustained by hatchery plants. This conclusion was also supported by the significantly lower harvest and catch rate of cutthroat trout in 1975 due to the absence of plants in 1974 and 1975 (Wells, 1976).

Upon learning about the lack of natural reproduction by cutthroat trout, personnel of the MDFWP reassessed the management strategy for Hyalite Reservoir. As a result, they attempted to establish a self-sustaining wild cutthroat trout population in Hyalite Reservoir by introducing the McBride Lake variety of cutthroat trout. They chose this strain because it had shown greater reproductive success and growth rates than the Yellowstone Lake variety in mountain lakes with physical and chemical characteristics similiar to Hyalite Reservoir. Annually in July - September of 1976-1980, about 20,000 McBride Lake cutthroat trout fry (25-50 mm TL) were planted directly into the reservoir and an equal number were planted in the West Fork of Hyalite Creek. The plants in the creek were an attempt to imprint the fish to the stream and establish a spawning run there when they became sexually mature. Each annual plant after 1976 was spray marked with a different colored fluorescent pigment to identify the location and year of stocking.

This study was conducted on the fishery of Hyalite Reservoir to (1) measure the expected increased pressure on the fishery due to the rapid growth in the population of the Gallatin Valley and (2) evaluate the attempt to establish a self sustaining wild cutthroat trout population. Intensive field work was conducted from June through September, 1981 and 1982.

DESCRIPTION OF STUDY AREA

Physical-Chemical Characteristics

Hyalite Reservoir is located in southwestern Montana in Gallatin County approximately 17.5 air kilometers (km) south of Bozeman (Figure 1). It lies in an elongate basin in the Gallatin Range at an elevation of 2,012 meters (m) and drains 2,332 hectares (ha) of steep mountain slopes belonging to the Gallatin National Forest and the Burlington Northern Railroad (Wells, 1976).

The reservoir was created by the construction of a 500 m long and 34 m high earth filled dam across Hyalite (Middle) Creek. Work on the dam began in 1939 but because of World War II it was not completed until February, 1951 (Wells, 1976).

At maximum capacity Hyalite Reservoir contains 991 hectare-meters (ha/m) of water, has a surface area of 84.2 ha and a maximum depth of 27 m. Originally, the reservoir was created to supply water to the Gallatin Valley for irrigation. Since 1957, it has also provided water to the City of Bozeman for municipal use. These uses and weather patterns result in the reservoir typically being filled to capacity in mid-June to late July, drawn down through the deep water outflow during the remaining summer and fall and then maintained at low levels from October until the onset

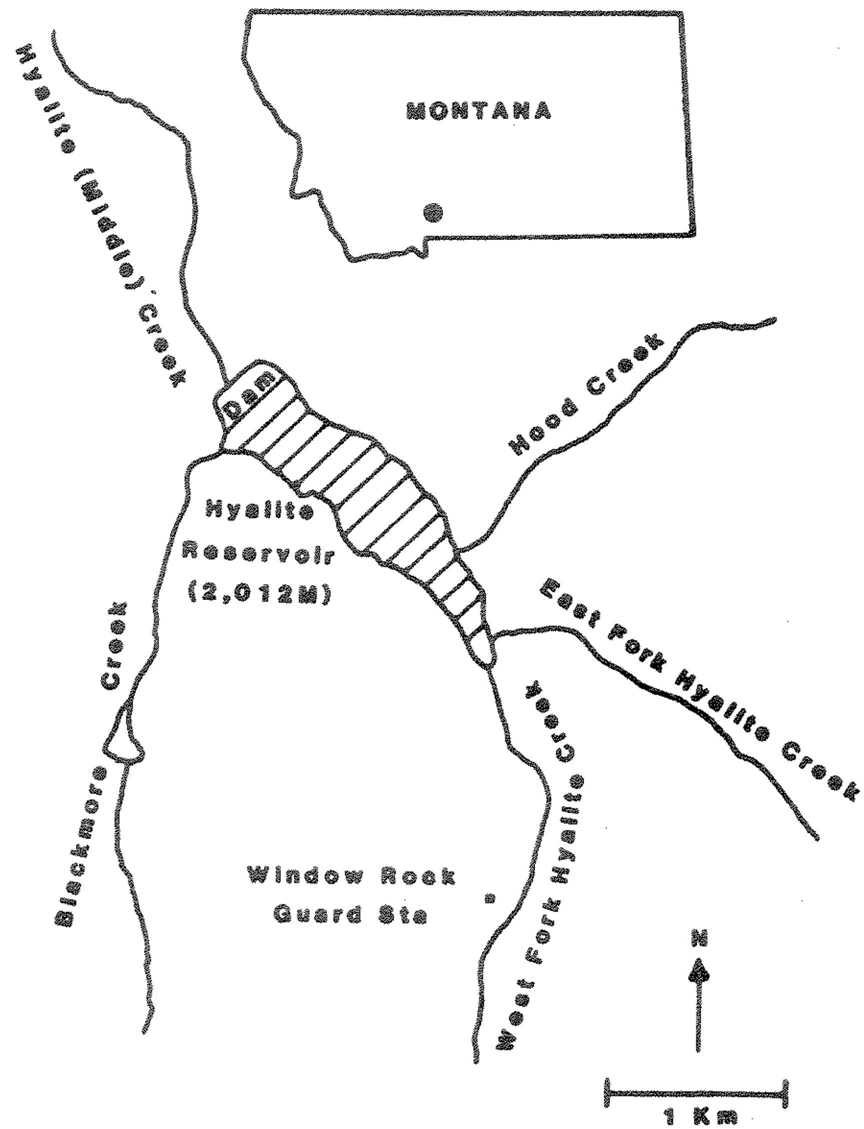

Figure 1. Map of the study area showing inlet streams and outflow.

of spring runoff. Because of this pattern, the reservoir is subject to vertical fluctuations of up to 8 m (Wells, 1976). The volumes of water stored and patterns of fluctuations in the reservoir during 1981 and 1982 are shown in Figure 2.

Most of the spring runoff appears to enter the reservoir from the East and West Forks of Hyalite Creek. During 1981, the West and East Forks contributed an average daily flow of 0.69 m^3 and 0.41 m^3 to the reservoir.

The selected physical and chemical characteristics of Hyalite Reservoir and its tributaries measured during the summer of 1981 are given in Table 1. These measurements indicate that Hyalite Reservoir has suitable temperatures and dissolved oxygen levels for trout (U.S. EPA, 1976). Low turbidities, specific conductance, alkalinity and hardness all suggest low biological productivity. The tributaries are colder and chemically less enriched than the reservoir. The low levels of dissolved minerals in the reservoir and its tributaries are the result of the dominance of volcanic rocks in the watershed (Chadwick, 1969).

Alkalinity, hardness and conductivity levels in the reservoir generally increased throughout the summer. Marcus et al. (1978) found this progression also and related it to the decreasing importance of surface run-off and the increasing importance of ground water contributions.

Marcus et al. (1978) classified Hyalite Reservoir as

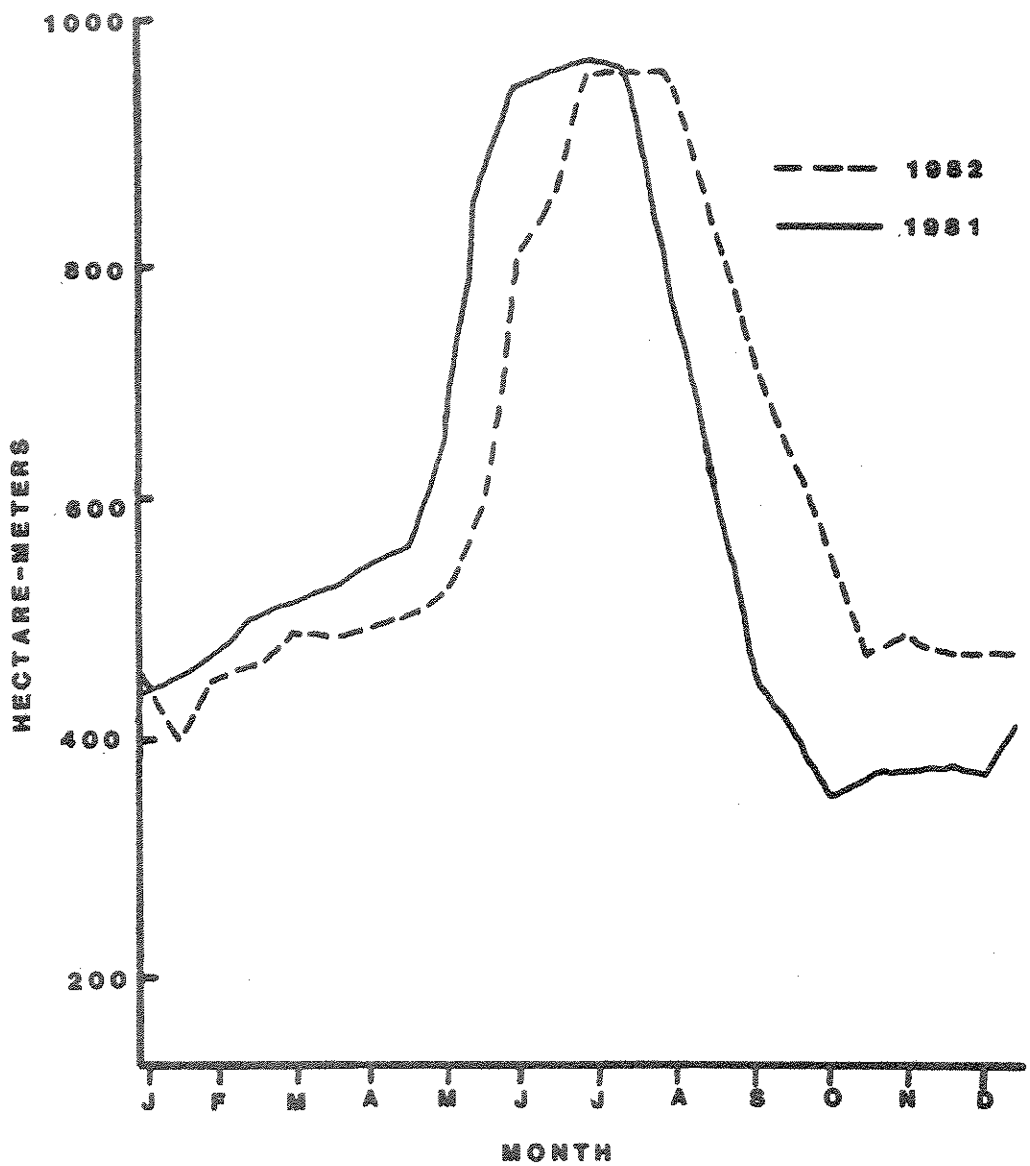

Figure 2. Volume of water stored in Hyalite Reservoir from January 1981 through December 1982. (Data from Montana Dept. of Nat. Resources, 1983).

Table 1. Ranges and means (in parentheses) of selected chemical and physical properties of Hyalite Reservoir and the West and East Forks of Hyalite Creek measured on July 17, August 9, September 3 and October 1981.

Location	Temp(C)	Dissolved oxygen (mg/l)	Turbidity (JTU)	Specific conductance (umhos/cm at 25 C)	pH	Total alk. (mg/l)	Hardness (mg/l)
Reservoir							
Depth(m)							
Subsurface[1]	11.0-16.0 (14.8)	7.2-8.5 (8.1)	2.0-3.3 (2.1)	60-72 (64.3)	7.5-9.0	10-40 (17.5)	15-30 (23.8)
Mid-water	10.0-13.0 (11.9)	7.0-9.2 (8.1)	1.0-2.7 (1.7)	60-72 (68.0)	7.4-8.4	5-50 (28.8)	15-40 (33.8)
Bottom[2]	8.0-11.5 (9.3)	6.0-9.3 (7.9)	1.5-2.7 (2.2)	75-80 (75.0)	7.4-8.4	10-40 (27.5)	30-50 (37.5)
West Fork	5.5-10.0 (8.3)		0.5-2.5 (1.0)	55-90 (70.0)	7.2-7.7	20-30 (25.0)	20-60 (35.0)
East Fork	5.5-9.0 (8.3)		0.5-2.5 (1.0)	55-80 (68.8)	7.2-8.1	20-30 (25.0)	20-60 (37.5)

1 Subsurface = 1m below the surface
2 Bottom = 1m above the bottom

mesotrophic based on chlorophyll productivity estimates. They found the reservoir and tributaries to be primarily nitrogen limited and to be similiar to Quake and Hebgen Lakes which are also influenced by the volcanic rocks of this region.

Biota

Cutthroat trout (*Salmo clarki*) was the predominant game species in Hyalite Reservoir. Arctic grayling (*Thymallus arcticus*) were moderately abundant and small numbers of brook trout (*Salvelinus fontinalis*) were present. Mottled sculpin (*Cottus bairdi*) was the only other fish found in the reservoir.

A dense bloom of *Aphanizomomenon*, a blue-green alga, developed from early August through the end of September, 1981. This caused the Secchi disk reading to progressively decline from 5.4 m in early July to 2.5 m by early October 1981.

Accessibility

The reservoir and its adjacent camping facilities are available to public use by a graded but unsurfaced road from late May or June, when the road generally becomes passable, through December or early January when accumulating snows block access. It is also accessible to wheeled vehicles throughout the winter in years when the road is plowed to facilitate logging. Otherwise, accessibility is limited to snowmobilers and skiers.

METHODS

Creel Census

A partial creel census was conducted at Hyalite Reservoir from June 13 - September 19, 1981 and from June 7 - September 12, 1982 using a sampling design modified after the method of Neuhold and Lu (1957). Each sampling season was divided into seven 2-week periods called strata which were further separated into substrata of (1) weekdays and (2) weekend-holidays. Each substratum of weekdays then consisted of 10 weekdays and each substratum of weekend-holidays normally contained 4 days. The 2 weekend-holidays substrata containing Independence Day and Labor Day each had 5 days. The beginning dates of each stratum during the study are given in Table 2.

Fifty percent of the weekdays and weekend days in each substratum were surveyed. Weekdays to be sampled within a substratum were randomly chosen without repetition with the restriction that at least 2 weekdays per week were censused. A weekend day from the first weekend of the first substratum in each season was randomly drawn and the subsequent alternate weekend days were surveyed throughout the sampling period. All holidays were surveyed. Thus in each stratum, every day of the week was sampled at least once.

During the summer of 1981, four counts of fishermen

Table 2. The beginning dates of strata during the summer creel survey of 1981 and 1982.

Stratum	Beginning date	
	1981	1982
I	Jun 13	Jun 7
II	Jun 27	Jun 21
III	Jul 11	Jul 5
IV	Jul 25	Jul 19
V	Aug 8	Aug 2
VI	Aug 22	Aug 16
VII	Sep 5	Aug 31

were made on each census day which consisted of 15 h. The first count on each day was made at either 0600, 0700, 0800, or 0900 and each of the three subsequent counts were made at 4 h intervals. In 1982, the initial count times were changed to 0630, 0730 and 0830 to better correspond to the observed fishing day and a census day thus consisted of 14 h. The number of daily counts were increased to five at 3 h intervals during 1982 in an attempt to decrease the variance found in the 1981 survey.

The starting hour for counts on weekdays in each substratum was randomly chosen from the initial count times. The initial counts on subsequent weekdays within each substratum were advanced by 1 h until the latest initial count time was used, after which the next count began at the earliest starting time. The first and subsequent count times for weekend days were assigned in the same manner as for weekdays except initial count times were not randomly redrawn for each substratum. Initial count times on the two holidays censused were randomly chosen. This procedure provided good coverage of the fisherman day.

The numbers of shore fishermen and boats with fishermen were recorded separately at the time of each count. Counts were made with the aid of a motor vehicle, 7X35 binoculars and a 20-45 power spotting scope. Counts took less than 30 minutes to conduct and were considered to be instantaneous (Neuhold and Lu, 1957).

As many fishermen as possible were interviewed between the hours of the initial and final counts on each census day. Fishermen were interviewed individually and the following data were collected: The size of the fishing party, fishing mode (shore or boat), total hours fished by each individual in the party, the number and species of fish kept and released, the residence and sex of the fishermen and the type of bait used.

It was not always possible to accurately count the number of fishermen per boat directly. Therefore, number of boat fishermen in each count was estimated by multiplying the number of boats in the count by the average number of fishermen per boat as determined from interviews.

Total fishermen hours were calculated as the product of the average number of fishermen per count and the total possible fishing hours in the fishing day which was considered to consist of 15 h in 1981 and 14 h in 1982. The estimates of the total number of fish harvested were calculated as the products of the catch rates and fishermen hours. The estimated biomass of all species harvested was determined by multiplying the estimated number of fish harvested by the average weight of creeled fish.

During both years of the study creeled fish were measured for total length, weighed and examined for fin clips and tags. Scales were taken for age and growth analyses. During 1981, a portable ultraviolet light was used to inspect creeled fish for fluorescent pigments.

Fish Trapping

Traps were installed to capture adult fish entering and leaving the West Fork of Hyalite Creek in the spring of 1981 and in both the West and East Forks in 1982. In both streams traps consisted of fyke nets and wings constructed of nylon netting with a 2.54 centimeter (cm) square mesh. The basic design was modified after Montana Department of Fish and Game (1979). Traps were placed at the stream-reservoir interface when the reservoir was at maximum pool and enclosed the entire width of the stream.

After fish were first captured or observed entering the streams, the traps were operated daily and checked as often as practical. The West Fork trap was in operation from May 4 - July 18, 1981 and from June 10 - July 28, 1982. The East Fork trap was operated from June 25 - August 10, 1982.

Fish caught in the traps were identified to species, counted, classified by sex and sexual development, weighed and measured (TL). Scales were taken for age and growth analyses, each was affixed with a numbered T - tag behind the dorsal fin and released in the direction of its movement. All cutthroat trout captured in 1981 were also examined for fluorescent pigment retention.

Rectangular drift nets 15X61 cm were installed on July 12 and 13, 1981 in the West and East Forks respectively, to sample the emigration of cutthroat trout fry. No attempt was made to estimate the total number of fry that moved downstream from these tributaries to the reservoir. The nets sampled about 13 and 17% of the stream width of the West and East Forks, respectively. The contents of the traps were collected twice daily, in early morning and late evening. Fry were separated from debris, identified and counted in the field. Live fry were released below the trap and dead fry preserved in 10% formalin for later total length and weight measurements.

In 1982, more complete trapping of fry was attempted. The stationary trap installed in the West Fork covered about 63% of the 5.7 m wide stream and was operated from August 25 through September 27. It was constructed with wings of nylon netting having a 0.7 cm Delta mesh attached to a 0.6 m^2 plywood and screen (0.7 cm) holding box containing a baffle to create slack water. The remaining untrapped 37% of the West Fork was periodically sampled at four stations on a transect across the stream with a 0.5 m^2 trap having the same mesh size and screening as the larger trap but with a smaller holding box which was modified after the design of Porter (1973).

The East Fork weir covered the entire 3.5 m wide stream and was operated from September 11 to September 27, 1982.

Fry were captured with two traps of the same design and mesh size as that used to sample the four stations on the West Fork.

All holding boxes were equipped with 1.3 cm^2 wire mesh screen at the entrance to prevent predation by trout and sculpins. A 2.54 cm mesh wing was placed across and upstream from the fry traps to intercept large stream debris. All traps were checked daily in the early morning with captured fry counted and released.

Age and Growth

Scales were taken from between the dorsal fin and lateral line of 20 cutthroat trout in each 25 mm size group collected in the creel and/or spawning traps during 1982. Scales were pressed on slides of cellulose acetate and examined at 72X magnification using a microfiche projector.

Statistical Analyses

Data from counts and interviews were analyzed with a computer program designed by Dr. D. E. Burkhalter of the Montana State University Computer Sciences Department. The FIRE I age and growth program (Hesse, 1977) was used to derive regression lines for body length at annulus formation and correlation coefficients for data obtained from scales using the linear Dahl-Lea, Rosa M. Lee and corrected Rosa M.

Lee methods and the Monastyrsky logarithmic method of back calculation. The latter method was ultimately chosen because of its higher correlation coefficient. The actual back calculations were derived from the MONASK and AGEMAT computer programs used by the MDFWP Fisheries Division.

Calculations of mean lengths, weights, condition factors and age composition of cutthroat trout captured were performed with the SPSS statistical packages (Nie et al., 1975). All confidence intervals and Student's t statistics were calculated according to the methods of Snedecor and Cochran (1967). P values were calculated with the MSUSTAT statistical package (Lund, 1979) and differences were considered significant at the $p \leq 0.050$ level.

RESULTS

Creel Census

Interviews

Interviews were conducted with 1,197 anglers during 1981 of which 710 were shore and 487 were boat fishermen. In 1982, a total of 1,083 anglers were interviewed of which 473 were shore and 610 were boat fishermen. Data on residency, fishing gear used and sex of fishermen were not collected from all anglers interviewed in 1982.

Fishermen Characteristics

The residence, sex and fishing gear used by fishermen were similar during both years of the study (Table 3). Most of the anglers at Hyalite Reservoir were local males who used bait. About 69% of the 1,685 fishermen interviewed during 1974 and 1975 were local anglers (Wells, 1976).

Catch Rates

The estimated seasonal catch rate for all fishermen in 1981 was slightly less than 0.3 fish per hour (Table 4). The seasonal catch rate for boat fishermen was about 0.06 fish per hour greater than for shore fishermen ($p=0.030$). The seasonal catch rate of fishermen on weekend-holidays was not different from that of weekday anglers ($p>0.500$). Boat

Table 3. Selected characteristics of fishermen interviewed at Hyalite Reservoir from June - September, 1981 and 1982 with percentages of yearly totals (in parentheses).

Characteristic	1981 Number(%)	1982 Number(%)
Residence		
Local (<81km from Bozeman)	888(74)	729(77)
State Resident (>81km from Bozeman)	108 (9)	125(13)
Nonresident	201(17)	92(10)
Total	1,197(100)	946(100)
Sex		
Male	793(66)	721(75)
Female	207(17)	96(10)
Juvenile (unlicensed)	197(19)	141(15)
Total	1,197(100)	958(100)
Fishing gear		
Bait*	719(60)	535(53)
Artificial lures	222(19)	197(19)
Artificial flies	110 (9)	104(10)
Combinations	146(12)	186(18)
Total	1,197(100)	1,022(100)

*Worms, corn, marshmallows, salmon eggs, etc.

Table 4. Estimated catch rates, in fish per hour, for shore and boat fishermen at Hyalite Reservoir during substrata and strata from June - September, 1981 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.02	0.01
II	0.22	0.52	0.36	0.13	0.24	0.18	0.16	0.34	0.25
III	0.19	0.37	0.28	0.25	0.35	0.30	0.20	0.38	0.29
IV	0.30	0.28	0.29	0.31	0.36	0.35	0.27	0.33	0.30
V	0.10	0.05	0.08	0.38	0.36	0.37	0.11	0.13	0.12
VI	0.80	0.38	0.73	0.52	0.92	0.62	0.73	0.57	0.67
VII	0.33	0.22	0.32	0.52	0.31	0.45	0.39	0.24	0.36
Season total	0.27 (±0.04)	0.31 (±0.06)	0.29 (±0.04)	0.24 (±0.05)	0.33 (±0.06)	0.28 (±0.04)	0.26 (±0.03)	0.32 (±0.04)	0.28 (±0.03)

fishermen catch rates were 0.04 fish per hour greater than shore fishermen rates on week days (p=0.235) and 0.09 fish per hour greater on weekend-holidays (p=0.019). Seasonal catch rates were greatest in Stratum VI for all categories of fishermen.

The estimated seasonal catch rate for all fishermen in 1982 was slightly less than 0.25 fish per hour (Table 5). The seasonal catch rate for boat fishermen was about 0.08 fish per hour greater than for shore fishermen (p=0.003). Seasonal catch rates on weekend-holidays were not different from weekdays (p=0.477). Boat fishermen catch rates were 0.09 fish per hour greater than shore fishermen rates on weekdays (p=0.015) and 0.09 fish per hour greater on weekend-holidays (p=0.178). Seasonal catch rates were greatest in Stratum IV for all categories of fishermen.

The estimated seasonal catch rate for all fishermen in 1982 was about 0.05 fish per hour less than in 1981 (p=0.018). Seasonal catch rates for boat and shore fishermen, during weekdays and weekend-holidays in 1982 were similar to rates in 1981. The seasonal catch rate for 1981 was about 0.08 and 0.16 fish per hour greater than was found in 1974 and 1975, respectively. The 1982 seasonal catch rate was about 0.03 and 0.11 fish per hour greater than was found in 1974 and 1975, respectively (Wells, 1976), although this study consisted of seven 2-week strata while the previous study had six 2-week strata.

Table 5. Estimated catch rates, in fish per hour, for shore and boat fishermen at Hyalite Reservoir during substrata and strata from June - September, 1982 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	0.11	0.24	0.17	0.05	0.24	0.19	0.10	0.24	0.18
II	0.05	0.33	0.20	0.00	0.16	0.12	0.03	0.23	0.15
III	0.30	0.35	0.33	0.04	0.36	0.29	0.21	0.35	0.31
IV	0.36	0.50	0.41	0.23	0.42	0.31	0.32	0.46	0.37
V	0.06	0.20	0.13	0.11	0.16	0.14	0.07	0.18	0.13
VI	0.23	0.11	0.17	0.36	0.24	0.30	0.30	0.18	0.24
VII	0.20	0.14	0.17	0.00	0.26	0.24	0.20	0.20	0.20
Season total	0.20 (±0.05)	0.29 (±0.05)	0.24 (±0.04)	0.16 (±0.06)	0.25 (±0.05)	0.22 (±0.04)	0.19 (±0.04)	0.27 (±0.04)	0.23 (±0.03)

The catch rate for each species shows about 96% of the total catch rate during each year of the study consisted of cutthroat trout (Table 6). Arctic grayling and brook trout contributed less than 4 and 1% to the total catch rate, respectively. A similar situation was seen during 1974 when cutthroat trout comprised about 94% of the catch rate (Wells, 1976).

Table 6. Estimated catch rates in fish per hour for species of fish harvested for Hyalite Reservoir, from June - September, 1981 and 1982 with 95 percent confidence intervals (in parentheses).

	1981			1982		
Species	Shore	Boat	Total	Shore	Boat	Total
Cutthroat trout	0.2400	0.320	0.2700	0.180	0.260	0.230
Arctic grayling	0.0100	0.008	0.0100	0.060	0.007	0.006
Brook trout	0.0004	0.000	0.0002	0.004	0.002	0.003
Total	0.26 (±0.03)	0.32 (±0.04)	0.28 (±0.03)	0.19 (±0.04)	0.27 (±0.04)	0.24 (±0.03)

Fish Caught and Released

About 28 and 24% of the fish landed were released in 1981 and 1982, respectively. With released fish included, seasonal catch rates would have increased by 0.11 and 0.08 fish per hour for 1981 and 1982, respectively. Most fish were released because fishermen felt that they were too small to keep although there were no size restrictions.

Very few individuals interviewed were strictly catch and release fishermen.

Party Size/Trip Length

The mean party sizes of both shore and boat fishermen were slightly over 2.2 persons during each year of the study (Table 7). These averages were about 0.1 and 0.2 persons less than Wells (1976) found in 1974 and 1975, respectively.

Table 7. Mean party size and mubers of hours fished per person (completed trips only) for shore and boat fisherment at Hyalite Reservoir from June-September 1981 and 1982 with 95 percent confidence intervals (in parentheses).

	Mean party size			Mean hours fished/person		
Year	Shore	Boat	Total	Shore	Boat	Total
1981	2.22	2.32	2.26(±0.09)	2.60	3.21	2.93(±0.15)
1982	2.25	2.21	2.23(±0.09)	2.84	3.20	3.05(±0.13)

The length of the average fishing trip was about 3.0 h during each year of this study (Table 7) with boat anglers fishing about 0.5 h longer than shore fishermen. Both boat and shore anglers fished about 0.7 h longer in 1981 and 1982 than in 1974 and 1975 (Wells, 1976).

Fishing Intensity

During 1981, the average number of boat fishermen per count was about 1.3 anglers greater than for shore fishermen

(Table 8). Counts of boat and shore fishermen were about equal during weekdays but boat fishermen averaged about 4.5 persons more on weekend-holidays.

The average number of boat fishermen per count during 1982 was about 3.6 persons greater than for shore fishermen. Counts of boat fishermen were about 1.6 and 8.7 persons greater than for shore fishermen on weekdays and weekend-holidays, respectively.

In 1982, the average number of boat and shore fishermen were about 0.4 more and 1.9 less people per count, respectively, than in 1981. The numbers of boat fishermen on weekend-holidays in 1982 appeared to be greater than in 1981 while the average number of shore fishermen in 1982 seemed to decrease on both weekend-holidays and weekdays.

Fishing Pressure

The seasonal fishing pressure of nearly 20,000 h for 1981 (Table 9) contained about 1,300 more hours by boat fishermen than by shore fishermen (p=0.108). Total fishing pressure was nearly 3,000 h greater on weekdays than on weekend-holidays (p=0.006). Shore and boat fishing pressures were nearly identical on weekdays but boat fishing pressure exceeded shore pressure by about 1,400 h on weekend-holidays (p=0.035). Pressure from boat and shore fishermen was greatest in Stratum II and III, respectively and generally decreased thereafter.

Table 8. Average number of shore and boat fishermen per count during substrata and strata at Hyalite Reservoir from June - September 1981 and 1982.

	Substrata					
	Weekdays		Weekend-holidays		Combined	
Stratum	Shore	Boat	Shore	Boat	Shore	Boat
			1981			
I	2.75	3.39	7.13	7.19	4.00	4.57
II	7.15	10.84	11.06	24.38	8.41	16.48
III	7.60	11.21	13.75	15.84	2.73	2.87
IV	6.65	6.68	8.13	19.19	7.82	9.70
V	4.15	2.70	7.13	7.75	2.68	3.75
VI	3.55	1.33	7.63	5.00	4.43	3.18
VII	6.70	1.53	5.00	3.38	6.89	2.16
Grand mean	5.51	5.45	9.12	13.65	6.59	7.91
			1982			
I	4.00	5.41	11.90	20.70	6.26	9.76
II	4.00	6.10	4.70	20.18	4.20	10.24
III	3.72	9.19	6.00	18.87	4.37	11.99
IV	5.60	5.19	8.00	15.03	6.29	7.87
V	4.12	6.28	4.10	9.90	4.11	7.27
VI	3.20	2.59	7.70	14.50	4.70	6.41
VII	1.88	2.47	5.50	10.28	2.91	4.69
Grand mean	3.81	5.43	6.84	15.55	4.69	8.38

Table 9. Estimated number of shore and boat fishermen hours at Hyalite Reservoir during substrata and strata from June - September, 1981 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	413	509	921	428	431	859	841	940	1,781
II	1,072	1,626	2,698	664	1,463	2,127	1,736	3,089	4,825
III	1,140	1,681	2,821	825	951	1,776	1,965	2,632	4,597
IV	998	1,002	2,000	488	1,152	1,639	1,486	2,154	3,640
V	623	405	1,028	428	465	893	1,051	870	1,921
VI	533	195	728	458	300	757	991	495	1,486
VII	1,005	230	1,234	300	203	503	1,305	433	1,738
Season total	5,782 (±274)	5,647 (±1,066)	11,429 (±436)	3,589 (±778)	4,964 (±1,030)	8,553 (±1,291)	9,371 (±1,195)	10,611 (±1,513)	19,981 (±1,889)

During the 1982 season, the total fishing pressure was nearly 18,000 h (Table 10). Boat anglers contributed nearly 5,000 h more fishing pressure than shore fishermen ($p=0.071$). Total fishing pressure on weekend-holidays was nearly identical to that on weekdays. Boat fishermen pressure exceeded shore fishermen pressure in the weekend-holiday and weekday substrata by about 3,500 ($p<0.001$) and 1,500 h ($p=0.341$), respectively. Pressure from boat and shore fishermen was greatest in Strata III and IV, respectively and generally decreased after these periods.

About 2,000 fewer hours were fished in 1982 than 1981 ($p=0.064$). The closure of Hood Creek campground for the removal of dead timber may have been responsible for some of the decreased usage in 1982 since it contains over one-half of the serviced camping facilities located on the periphery of the reservoir. Shore fishermen seemed to be most affected by this closure. Shore and boat fishermen pressures were similar in 1981 ($p=0.108$) but shore fishermen pressure was only about 56% of that for boat fishermen in 1982 ($p=0.071$). Total pressures for weekend-holidays were similar to those on weekdays in both years of this study indicating that Hyalite Reservoir receives a substantial amount of fishing pressure on the weekends and holidays since they make up about 29% of the available fishing days.

Table 10. Estimated number of shore and boat fishermen hours at Hyalite Reservoir during substrata and strata from June - September, 1982 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	560	758	1,318	666	1,159	1,826	1,226	1,917	3,143
II	560	849	1,409	263	1,730	1,393	823	1,979	2,802
III	521	1,286	1,807	336	1,057	1,393	857	2,343	3,200
IV	784	727	1,511	488	842	1,290	1,232	1,569	2,801
V	577	880	1,457	230	554	784	807	1,434	2,241
VI	448	362	810	431	812	1,243	879	1,174	2,053
VII	263	346	609	308	576	884	571	922	1,493
Season total	3,713 (±549)	5,208 (±779)	8,920 (±953)	2,682 (±545)	6,130 (±1,019)	8,812 (±1,156)	6,395 (±774)	11,337 (±1,283)	17,733 (±1,498)

The seasonal fishing pressures during both years were generally greatest from early to midseason and then progressively decreased throughout the summer. This trend was similiar to that found by Wells (1976). Total fishing pressure averaged about 6.4 h per week per surface acre at maximum pool during the study, about 178% of that found in 1974 and 1975 (Wells, 1976).

Harvest

More than 6,000 salmonids were estimated to have been harvested in 1981 (Table 11). Boat fishermen harvested more fish (58% of the total) than bank fishermen (p=0.027). More fish (57% of the total) were harvested on weekend-holidays than on weekdays (p=0.039). About 25% of the total was harvested in Stratum II of 1981 which comprised about 14% of the season.

Slightly over 4,200 fish were harvested in 1982 (Table 12). More fish (75% of the total) were harvested by boat fishermen than by shore fishermen (p=0.066). Similiar numbers of fish were harvested on weekend-holidays and on weekdays (p=0.300). About 26% of the total were harvested in Stratum IV which comprised about 14% of the season.

About 1,860 less fish were captured in 1982 than in 1981 (p=0.001). Over both seasons, boat anglers harvested about 65% of all fish while 44% were harvested on weekend-holidays. The 1982 harvest was about 69% of the 1981

Table 11. Estimated numbers of salmonids harvested by shore and boat fishermen at Hyalite Reservoir during substrata and strata from June- September, 1981 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	0	14	14	0	0	0	0	14	14
II	231	850	1,082	85	352	437	316	1,202	1,518
III	217	618	835	203	330	533	420	948	1,368
IV	295	279	574	151	417	568	446	696	1,142
V	55	23	78	162	166	328	217	189	406
VI	425	73	498	239	277	516	664	350	1,014
VII	334	51	385	155	63	218	489	114	603
Season total	1,557 (±369)	1,908 (±566)	3,465 (±675)	994 (±324)	1,605 (±451)	2,599 (±556)	2,552 (±491)	3,513 (±724)	6,064 (±875)

Table 12. Estimated numbers of salmonids harvested by shore and boat fishermen at Hyalite Reservoir during substrata and strata from June- September, 1982 with 95 percent confidence intervals (in parentheses).

	Substrata								
	Weekdays			Weekend-Holidays			Combined		
Stratum	Shore	Boat	Total	Shore	Boat	Total	Shore	Boat	Total
I	64	183	247	30	273	303	94	456	550
II	26	282	308	0	176	176	26	458	484
III	158	455	612	12	377	389	170	832	1,002
IV	285	363	647	102	353	455	387	716	1,103
V	35	176	211	25	87	112	60	263	323
VI	103	41	144	156	192	347	259	233	492
VII	53	49	102	0	149	149	53	198	251
Season total	724 (±219)	1,548 (±378)	2,272 (±437)	325 (±146)	1,606 (±436)	1,931 (±460)	1,049 (±264)	3,514 (±577)	4,204 (±635)

harvest but still about 174 and 421% greater than the harvests reported by Wells (1976) for 1974 and 1975, respectively. However, this study was two weeks longer each year than the 1974 and 1975 study.

Cutthroat trout made up about 97 and 96% of the creeled fish and were estimated to comprise about 5,800 and 4,200 of the fish caught and kept in 1981 and 1982, respectively (Table 13). Less than 200 Arctic grayling and 28 brook trout were estimated to have been harvested during 1981 and 1982. The 1982 cutthroat trout harvest was about 69% of the 1981 harvest and about 174 and 528% greater than the 1974 and 1975 harvests, respectively (Wells, 1976).

Table 13. Estimated numbers of fish harvested by species at Hyalite Reservoir from June - September, 1981 and 1982.

	1981			1982		
Species	Shore	Boat	Total	Shore	Boat	Total
Cutthroat trout	2,430	3,432	5,862	993	3,039	4,032
Arctic grayling	119	81	200	38	86	124
Brook trout	3	0	3	18	28	46
Total	2,552	3,513	6,064	1,049	3,154	4,204

The mean length of cutthroat trout harvested in the 1981 creel (Table 14) was less than in 1982 (p=0.001). The mean weights ($p>0.500$) and condition factors ($p=0.118$) of cutthroat trout harvested in 1981 were not different from those taken in 1982.

Table 14. The mean lenghts and condition factors (K) for cutthroat trout creeled at Hyalite Reservoir from June - September, 1981 and 1982 with 95 percent confidence intervals (in parentheses).

Year	Number	Mean length(mm)	Number	Mean weight(g)	Mean K
1981	749	308(±4.0)	278	327(±28.4)	0.9713(±0.0137)
1982	547	317(±3.7)	287	322(±16.5)	0.9570(±0.0118)

Marked age I hatchery cutthroat trout first appeared in the fishermen's creel in September, 1981; five of them averaged 239 mm TL. Twenty-one of these marked fish were captured by ice fishermen in December, 1982 at which time they averaged 260 mm TL.

In 1981, 278 cutthroat trout averaged 327 g (Table 14) and seven Arctic grayling 589 g for an estimated biomass harvest of 2,019 kg or 24.0 kg/ha at maximum pool. In 1982, 287 cutthroat trout averaged 322 g (Table 14), seven Arctic grayling 339 g and five brook trout 164 g for an estimated biomass harvest of 1,349 kg or 16.0 kg/ha at maximum pool. The combined average biomass estimate of fish harvested during this study was about twice that found by Wells (1976) and about 8.0 kg/ha less than that found by Drummond and Tanner (1960) for the cutthroat trout fishery of the 116 ha Trapper's Lake in Colorado.

Spawning Fish

Seasonal Movements

On May 4, 1981 a trap was placed in the West Fork prior to any observed spawning activity in the stream. Upstream movement of cutthroat trout began on May 30, 1981 (3 days after total reservoir ice-off), coinciding with increased stream flows and temperatures (Figure 3). Upstream movement peaked on June 18 and ended on July 18 as stream flow decreased. Downstream movement ended on July 21 signaling the completion of spawning activity.

During 1982, the trap was not installed until migrating cutthroat trout were observed entering the stream. Upstream moving cutthroat trout were first observed and trapping begun on June 10 (12 days after total reservoir ice-off), as stream flows and temperatures increased. Upstream movement peaked on June 26 and ended on July 24, 1982 as stream flows decreased (Figure 4). The last downstream migrant was captured on July 28, 1982. The 1982 spawning season thus began 11 days and ended 7 days later than in 1981.

Cutthroat trout apparently use temperatures and/or flows as cues for spawning movements. Wells (1976) reported that cutthroat trout first entered the West Fork as stream

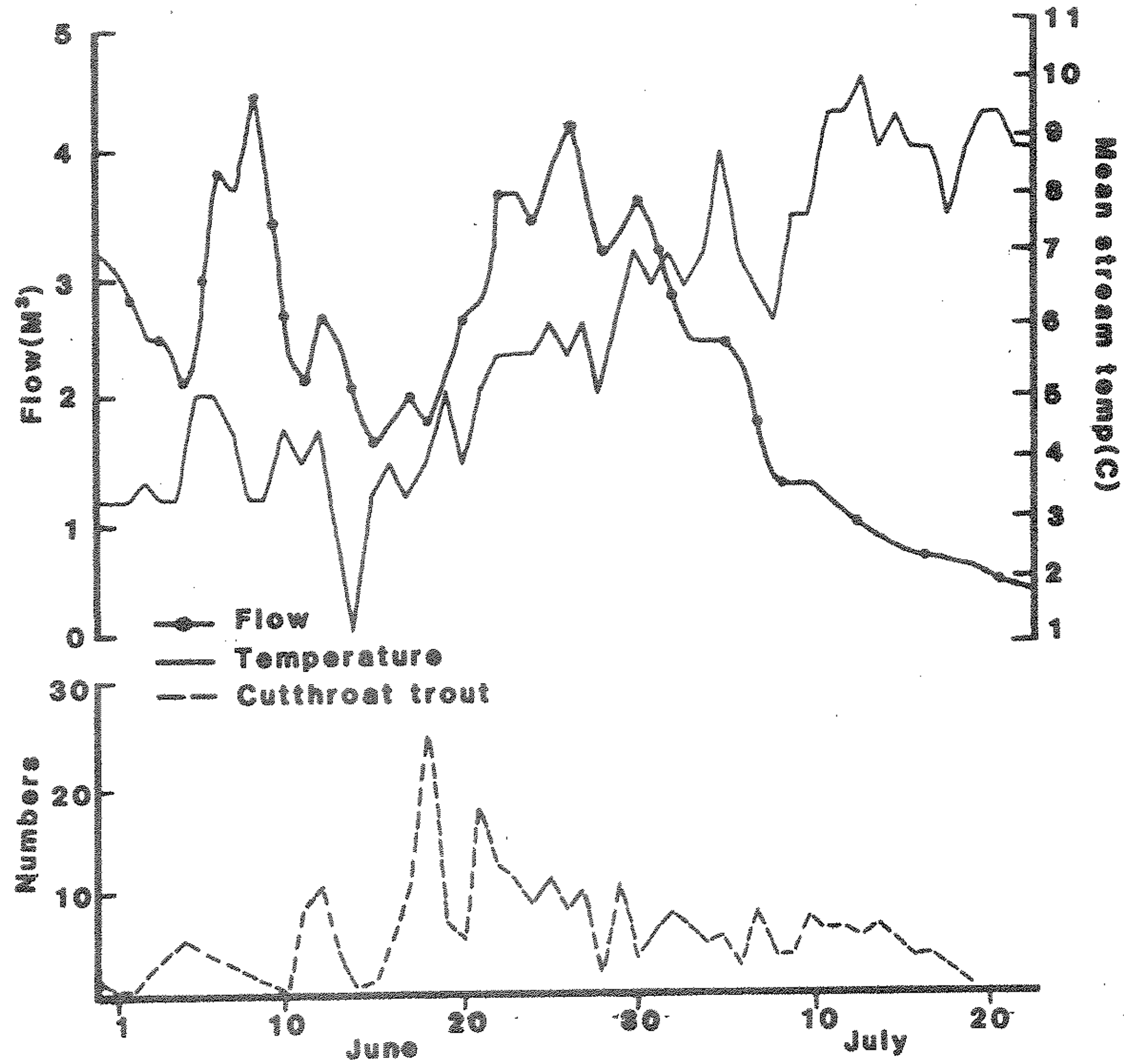

Figure 3. The mean daily flows and temperatures and numbers of cutthroat trout captured moving into the West Fork of Hyalite Creek during 1981.

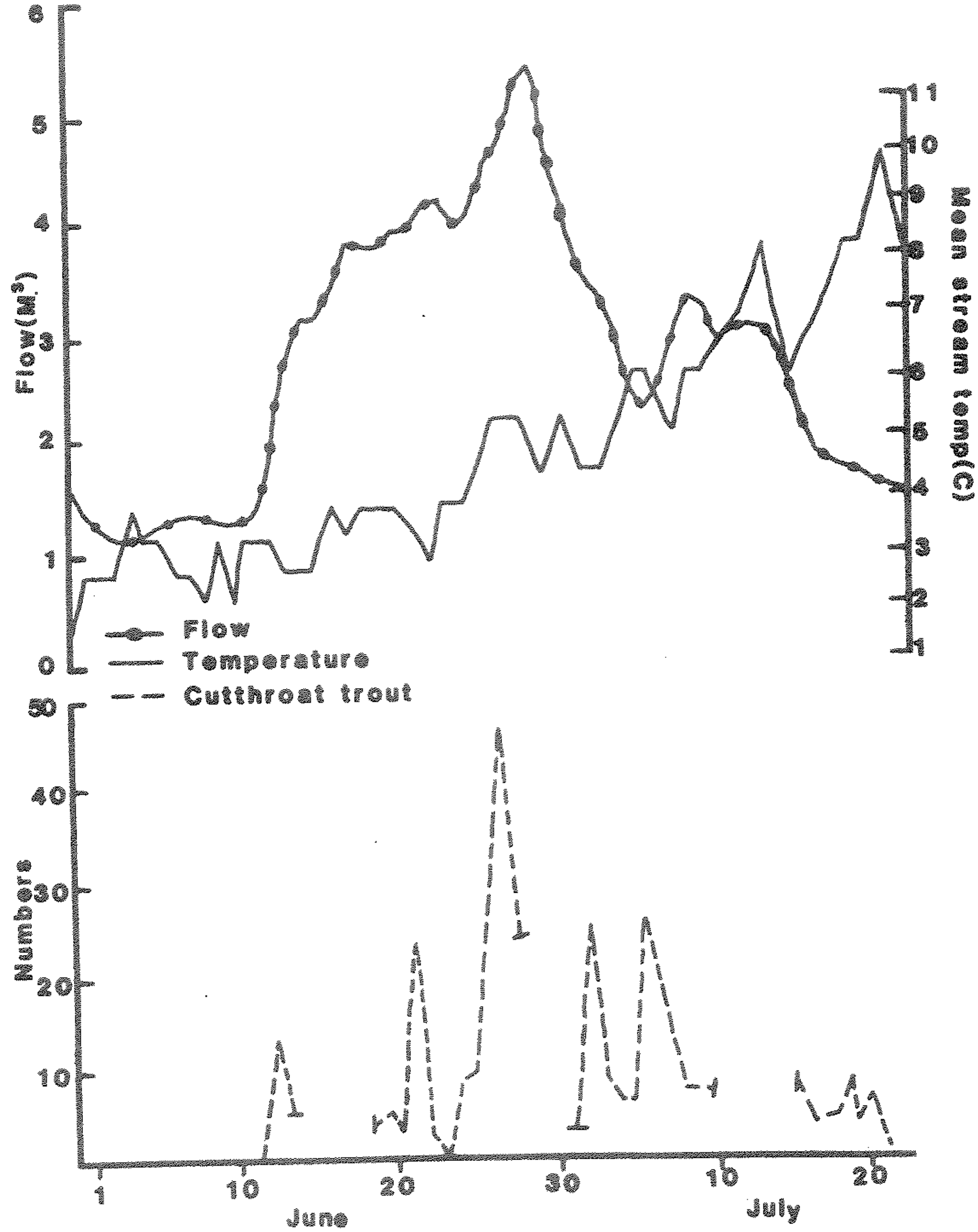

Figure 4. The mean daily flows and temperatures and numbers of cutthroat trout captured moving into the West fork of Hyalite Creek during 1982.

flow increased and when the mean daily stream temperature was about 3 C. Snyder and Tanner (1960), and Lund (1974) reported increased upstream movement by cutthroat trout as stream flows increased. Jones et al. (1982) also found rapid increases in the number of upstream moving cutthroat trout from Yellowstone Lake coinciding with increasing temperatures which, however, occurred with decreasing flow.

Diel Movements

During the spawning runs, upstream movements of cutthroat trout were inhibited by sharply lower daily stream temperatures and accelerated by sharply higher temperatures as was found by Lund (1974). When stream temperatures approached 5.5 C in the late morning or early afternoon, cutthroat trout began to enter the trap and their numbers increased throughout the afternoon. Numbers then decreased rapidly as evening approached when the stream temperatures decreased and flows increased due to the snow melt arriving from higher elevations.

In 1981, traps were not usually operated at night due to the higher stream flows but were successfully operated both day and night on 12 dates. On these days, 90% of the cutthroat trout moving upstream were captured during the day and 65% of those moving downstream did so at night (Table 15). Jones et al. (1982) found that all cutthroat trout that they trapped in the tributaries of Yellowstone Lake moved upstream during the day. They also found that downstream movement during the early weeks of spawning was associated with increased stream flows at night. When these flows decreased later in the spawning run, the majority of downstream movment occurred in the afternoon and evenings. Traps in both the West and East Forks were rarely operated at night in 1982 due to the significantly higher stream flows in that year. During the few days that the traps were run daily, too few fish were captured to conduct an analysis.

Table 15. Numbers and percent (in parentheses) of cutthroat trout captured moving upstream and downstream during diel trapping of the West Fork of Hyalite Creek in 1981.

	Numbers moving upstream		Numbers moving downstream	
Date	Day	Night	Day	Night
June 13	3	0	1	4
21	14	2	2	1
22	10	1	6	9
23	13	3	---	---
24	5	0	7	8
25	11	1	3	13
26	6	1	1	8
28	2	0	2	7
29	10	1	5	2
30	2	0	7	9
July 3	5	0	5	18
5	---	---	2	14
Totals	81(90%)	9(10%)	51(35%)	93(65%)

Spawning Population

During 1981, a total of 236 cutthroat trout were first captured entering the West Fork. Of these, 119 released sex products when handled. These fish had a male : female sex ratio of 1.08:1.00. This is similiar to the 1.2:1.0 sex ratio found by Kruse (1959) for cutthroat-rainbow hybrid trout in spawning runs at Grebe Lake but less than the 1:2 sex ratio found by Lund (1974) and Jones et al. (1982) for cutthroat trout in spawning runs at Elk and Yellowstone Lakes. During the 1981 spawning run, 24 cutthroat trout initially tagged in the West Fork showed no visible presence of eggs or milt. These fish were later recaptured and released sex products when handled with 18 (75%) producing eggs. The addition of these fish to those sexed when first handled resulted in a sex ratio of 0.88:1.00. These data indicated that some females ripen while in the stream and that most males are ripe by the time they enter the streams. The findings of Jones et al. (1982) suggested this also.

The age classification of these ripe fish (Table 16) indicated the run consisted of fish II-V years of age. Males appeared to become sexually mature earlier and were shorter lived than females. A majority of the males were III years of age and most of the females were IV. Lund (1974) found a similar age range for the spawning cutthroat trout of Elk Lake.

Table 16. The age and sex of ripe cutthroat trout captured entering the West Fork of Hyalite Creek during 1981 and 1982.

Age	Sex		Total(%)
	Males	Females	
	1981		
II	2	0	2(2%)
III	41	23	64(54%)
IV	19	29	48(40%)
V	0	5	5(4%)
Totals	62	57	119(100%)
	1982		
II	8	0	8(6%)
III	35	17	52(38%)
IV	24	36	60(43%)
V	4	14	18(13%)
Totals	71	67	138(100%)

All of the spawning age cutthroat trout captured entering and leaving the tributaries during 1981 were examined for fluorescent pigments. No pigments were seen, however.

During 1982, a total of 269 cutthroat trout, or 16% more than in 1981, were first captured entering the West Fork. The sex ratio of fish taken in 1982 was 1.06:1.00, virtually the same as in 1981. Twenty-one (95%) of the 22 initially unripe cutthroat trout were females. The addition of these to the initially sexed fish resulted in a sex ratio of 0.89:1.00, similar to the 1981 findings. As in the first year of the study, males comprised all of the age II fish captured in the run. Unlike 1981, some males V years of age were found. The age structure of the 1982 run appeared to be shifting to older fish than was found in the 1981 run.

Males captured in the West Fork during 1981 averaged 35 mm shorter, weighed 264 g less and had lower condition factors than females (Table 17). This male to female relationship was also present within age groups where both sexes were captured.

In 1982, males averaged 43 mm shorter, were 289 g lighter and had lower condition factors than females. Males captured in 1982 were 23 mm shorter and 133 g lighter than in 1981. Females were 15 mm shorter and 108 g lighter than in 1981. As a result, the mean length ($p=0.001$), weight

Table 17. The mean lengths, prespawning weights and condition factors of aged male and female cutthroat trout (with numbers in parenthesis) captured first entering the West Fork of Hyalite Creek during 1981 and 1982 with 95 percent confidence intervals of all fish in brackets.

	Mean length(mm)		Mean prespawning weight(g)		Mean condition factor	
Age	Males	Females	Males	Females	Males	Females
			1981			
II	321(2)	---	288(2)	---	0.835(2)	---
III	388(41)	403(23)	580(37)	647(20)	1.000(37)	1.020(20)
IV	440(19)	458(29)	866(17)	1041(27)	1.015(17)	1.073(27)
V	---	499(5)	---	1465(4)	---	1.158(4)
Mean	402(62)	437(57)	656(56)	920(51)	0.999(56)	1.059(51)
Grand mean	420(119) [±8.4]		782(107) [±59.7]		1.027(107) [±0.0216]	
			1982			
II	280(8)	---	207(6)	---	0.971(6)	---
III	363(35)	369(17)	468(35)	512(16)	0.970(35)	1.006(16)
IV	411(24)	424(36)	666(19)	794(36)	0.937(19)	1.029(36)
V	500(4)	479(14)	899(3)	1201(14)	0.769(3)	1.078(14)
Mean	379(71)	422(67)	523(63)	812(66)	0.951(63)	1.034(66)
Grand mean	399(138) [±9.1]		671(129) [±50.00]		0.993(129) [±0.0216]	

(p=0.005) and condition factor (p=0.003) for all spawning cutthroat trout captured in 1982 were less than for those spawing fish captured in 1981.

Because ripe cutthroat trout were found in the East Fork during 1981, a trap was placed in this stream on June 25, 1982. However, the steeper gradient and high stream flows precluded efficient trapping until July 4, 1982. As a result, only 133 cutthroat trout were first captured in the East Fork and 120 of these were caught in the downstream trap. Spawning fish were last captured on August 9 about 2 weeks after the West Fork run had ended. Ages of spawning cutthroat trout were similar to those in the West Fork except two age VI fish were captured. Wells (1976) found spawning activity of cutthroat trout limited almost entirely to the West Fork and spawning age groups ranging from III-V.

Straying

Thirteen cutthroat trout spawners were captured while electrofishing the East Fork on June 30, 1981. Of these, four had been first caught and tagged in the West Fork.

Of the 269 cutthroat trout that were first caught and tagged in the West Fork during 1982, 46 (17%) strayed into the East Fork. Of the 131 cutthroat trout that were first caught and tagged in the East Fork during 1982, 11 (8%) strayed into the West Fork. Since both traps were not operated continuously these estimates of straying are minimums. Two major reasons probably account for this apparent high level of straying. First, spawning traps were located at the stream-reservoir interface and fish involved in a preliminary search for their home stream might be captured even though they may not intend to ascend that stream. Secondly, the hatchery fry planted in the reservoir were not imprinted to either stream and might search in both before selecting a spawning site.

Spawning Areas in the East and West Forks

The lower 4.3 km of the West Fork are available to spawning fish where Grotto Falls acts as a natural barrier to fish movements. Inspections of the West Fork during the 1981 spawning run indicated that cutthroat trout used only the lower 2.0 km of the West Fork for spawning. Further information was obtained by electrofishing three different sections of this stream. Twenty spawning cutthroat trout were captured in the 1.4 km section from Window Rock Station to the reservoir on June 12. One and zero cutthroat trout, respectively were captured in the 305 m sections lying about 2.0 and 2.7 km above the reservoir on June 24 and 30, confirming earlier observations on spawner use of the West Fork.

During the 1981 spawning run the first 1.6 km of the East Fork were also inspected. Spawning cutthroat trout were observed throughout this reach but in lesser numbers than in the lower 1.4 km of the West Fork. On June 30, 1981 two 305 m sections were electrofished at points 0.3 and 1.6 km above the reservoir and yielded eight and five cutthroat trout, respectively.

On July 7, 1982 a section of the East Fork beginning about 1.6 km above the reservoir and extending about 2.5 km upstream was inspected for spawning cutthroat trout. Only one spawning pair were observed in this section. No spawning cutthroat were observed in Hood or Blackmore Creeks, the only other tributaries to the reservoir, during 1981 and 1982.

Mortality Rates of Spawning Fish

A total of 227 marked fish entered the reservoir fishery following the spawning run in 1981. Of the 756 cutthroat trout examined in the 1981 creel, 23 or 3% were fish marked entering the tributaries. Applying this percentage to the total estimated harvest of cutthroat trout (Table 11) indicated that about 178 or 78% of the 227 total marked during the 1981 spawning run were harvested by September 18 of that year. No marked cutthroat trout were found during the winter creel survey conducted from December 21, 1981 - January 15, 1982 (Zubik, 1982). However, one was creeled during the following summer making the estimated total harvested in the 1982 summer season seven, or 3% of the total marked. This brought the estimated number harvested in the two seasons to 184 or 81% of the total marked in 1981. During 1982, 16 (7%) of the adults marked in 1981 returned to the West Fork and 8 (4%) returned to the East Fork. The estimated numbers harvested and the numbers returning accounted for 92% of the number originally marked indicating the total estimates of mortality were good approximations.

In 1982, an estimated 176 (45%) of the 389 cutthroat trout spawners marked that spring had been caught and kept by September 12. This was well below the 78% rate in 1981. Furthermore, mortality at the traps was only 14 fish (3.2%) which was also less than the 7.4% trap mortality found in 1981. These reduced mortalities may result in a greater spawner return in 1983.

Fry

Recruitment 1981

In 1981, one drift net was placed at each of the mouths of the West and East Forks on July 12 and 13, respectively, to determine if cutthroat trout fry were being produced in these streams. Fry were captured in the nets, thus identifying both streams as producing fry.

The chronology of fry production in the two streams differed (Figure 5). Emigrating cutthroat trout fry were

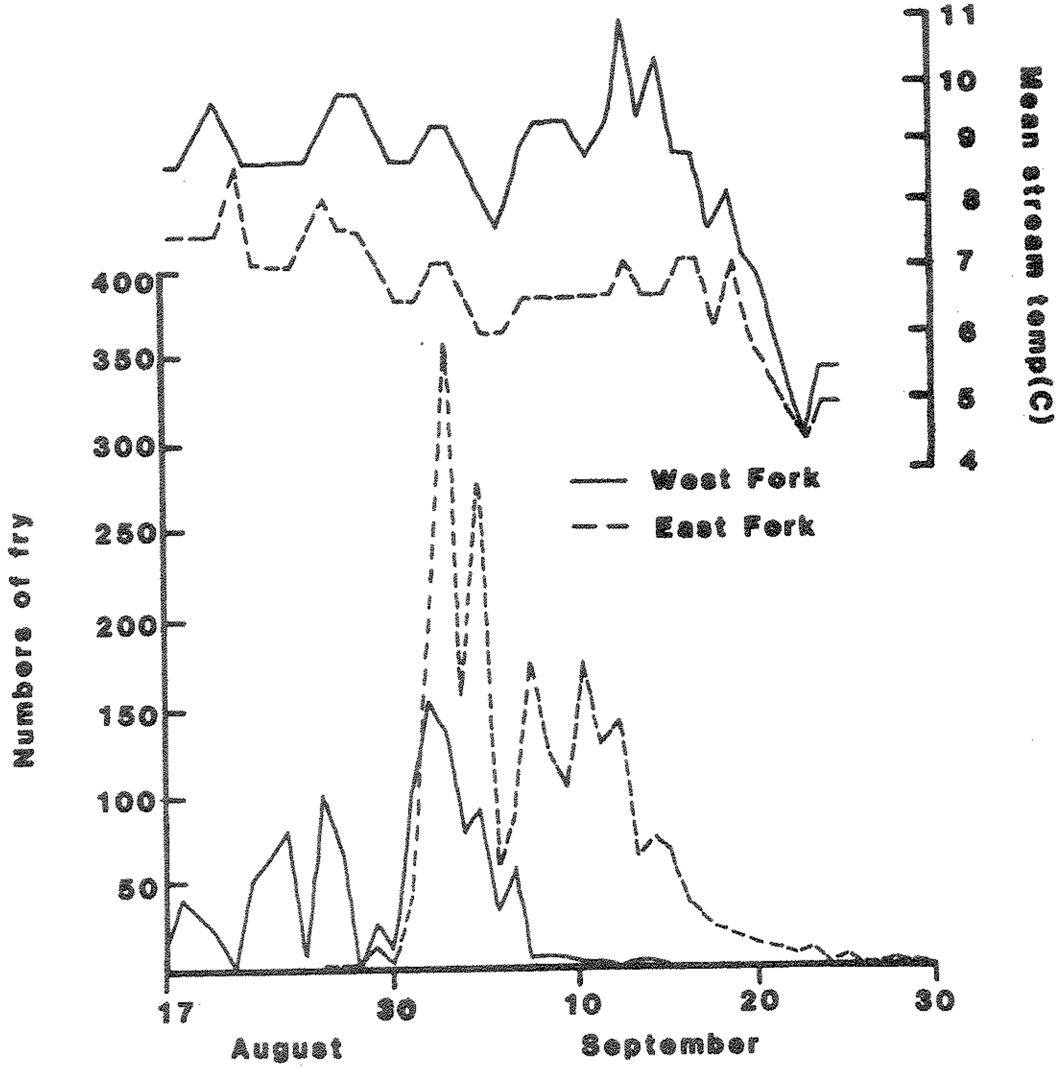

Figure 5. The number of cutthroat trout fry captured in one drift net in the West and East Forks of Hyalite Creek and mean daily stream temperatures from August 17 - September 30, 1981.

first captured in the West Fork on August 17, were most abundant on September 1 and were last taken on September 15, 1981. In contrast, fry were first captured in the East Fork on August 27 some 10 days later than the West Fork. Peak numbers were captured on September 2, only 1 day later than in the West Fork. Fry were last trapped on September 30, 1981, some 15 days later than in the West Fork. No attempt was made to estimate the total numbers of fry produced in either stream during 1981 nor were the numbers captured indicative of the relative production between streams.

The daily emigration of fry appeared to be depressed by lower stream temperatures (Figure 5). Also, the later emigration of cutthroat trout fry in the East Fork may have been the result of its consistently cooler stream temperatures relative to the West Fork.

Ninety-nine percent of the cutthroat trout fry captured moved downstream at night. Lund (1974) found that 95% of the cutthroat, rainbow and hybrid trout fry in Narrows Creek moved downstream between 2000 and 0800 and Jones et al. (1979) reported that about 92% of all cutthroat trout fry emigration from Hatchery Creek occurred at night.

A sample of 107 cutthroat trout fry taken daily from both tributaries over the entire period averaged 24.50 mm in total length and weighed 0.106 g (preserved). No significant difference in length ($p>0.500$) was found between fry collected before or after peak emigration. Snyder and Tanner (1960) and Lund (1974) reported that cutthroat trout fry leaving the streams after peak emigration had significantly greater lengths than those before.

To determine if fry were produced in the upper reaches of the West Fork a drift net was installed at a point about 2.0 km above the reservoir and operated from August 27 - September 14, 1981. Only one cutthroat fry was captured which was consistent with the evidence obtained from observations and electrofishing that essentially no spawning occurred in the upper reaches of this stream.

Recruitment 1982

Emigrating cutthroat trout fry were first captured in the stationary West Fork trap on August 26, were most abundant on September 7 and were not captured after September 27, 1982 (Figure 6). The beginning, peak and completion of fry emigration were 10, 6 and 12 days later, respectively, in 1982 than in 1981 (Figure 5). A period of winter-like weather from September 8-16 cooled stream temperatures in the West Fork and appeared to depress fry emigration.

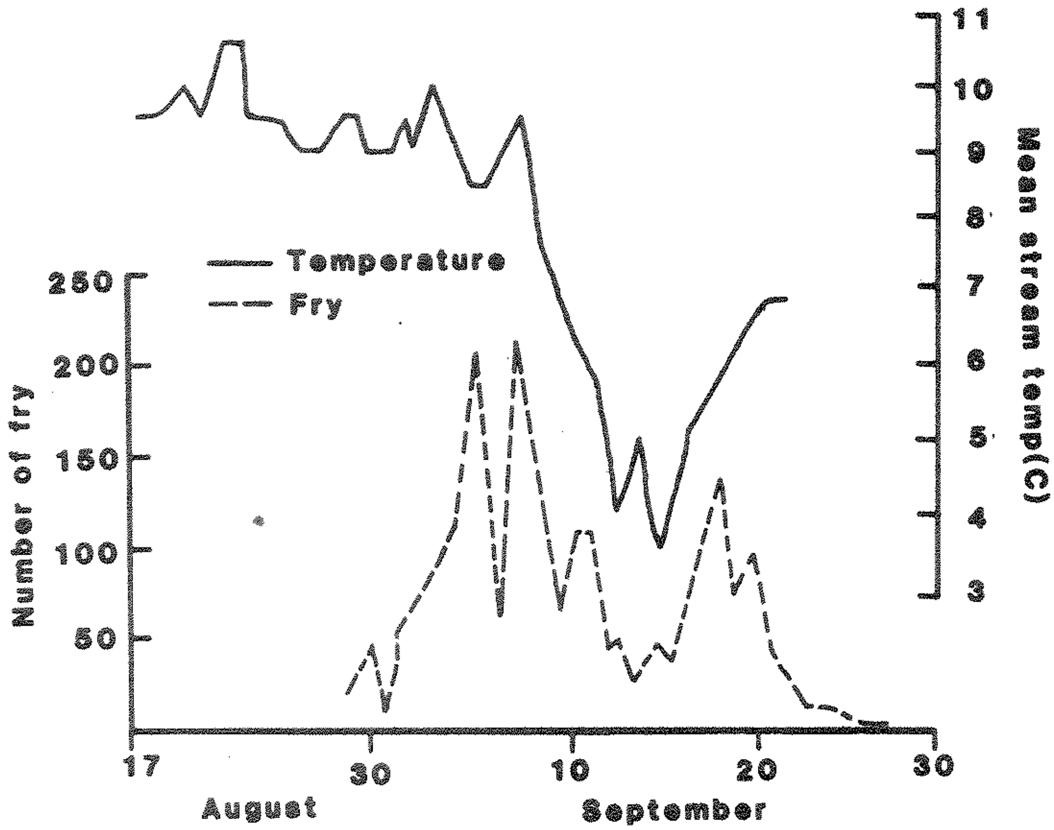

Figure 6. The total numbers of cutthroat trout fry captured in the stationary trap on the West Fork of Hyalite Creek from August 17 - September 30, 1982 with mean daily stream temperatures.

In 1982, the total cutthroat fry production in the West Fork was estimated to be about 19,000 (Table 23). This estimate was obtained by adding the numbers of fry captured in the continuously trapped portion of the stream to those estimated to have emigrated in the remainder of the stream as indicated by subsampling. The greatest numbers of fry per day were captured at Stations 4 and 5 (Table 23) which were situated in the deeper faster portion of the stream. Although spawning and subsequent fry emigration in the West Fork were later in 1982 than 1981, the number of days and temperature units between the initiation of spawning and the beginning of fry emigration were similar in the 2 years (Table 18). This same similarity was also found between the peak of spawning and peak of fry emigration during both years. Temperature units were calculated by averaging the daily maximum and minimum stream temperature, acquiring the degrees Celsius above freezing by subtraction and then adding the daily values together.

Table 18. Number of days and temperature units between beginning and peak of spawning and fry emigration for cutthroat trout captured in the West Fork of Hyalite Creek for 1981 and 1982.

Year	Dates: Initial spawning	Dates: Initial fry emigration	Number of days	Temperature units
1981	May 30	Aug 17	80	549
1982	Jun 10	Aug 22	74	545
	Peak spawning	Peak fry emigration		
1981	Jun 18	Sep 1	76	614
1982	Jun 26	Sep 7	74	626

The entire East Fork was trapped in 1982. Cutthroat trout fry were first captured on September 8 (Figure 7). The number of fry taken peaked on September 19 and ended on September 27, 1982. The beginning and peak of fry emigration were 12 and 14 days earlier in 1982 than in 1981 (Figure 5). However, East Fork fry emigrated in a more concentrated period and therefore completed downstream movement at about the same date as in 1981. The 1982 emigration of fry from the East Fork began 13 days later than in the West Fork in 1982 (Figure 6) but was completed on the same day during the two years.

A total of 2,878 cutthroat trout fry were captured in the East Fork during 1982. The combined total of cutthroat trout fry produced from both tributaries during 1982 was

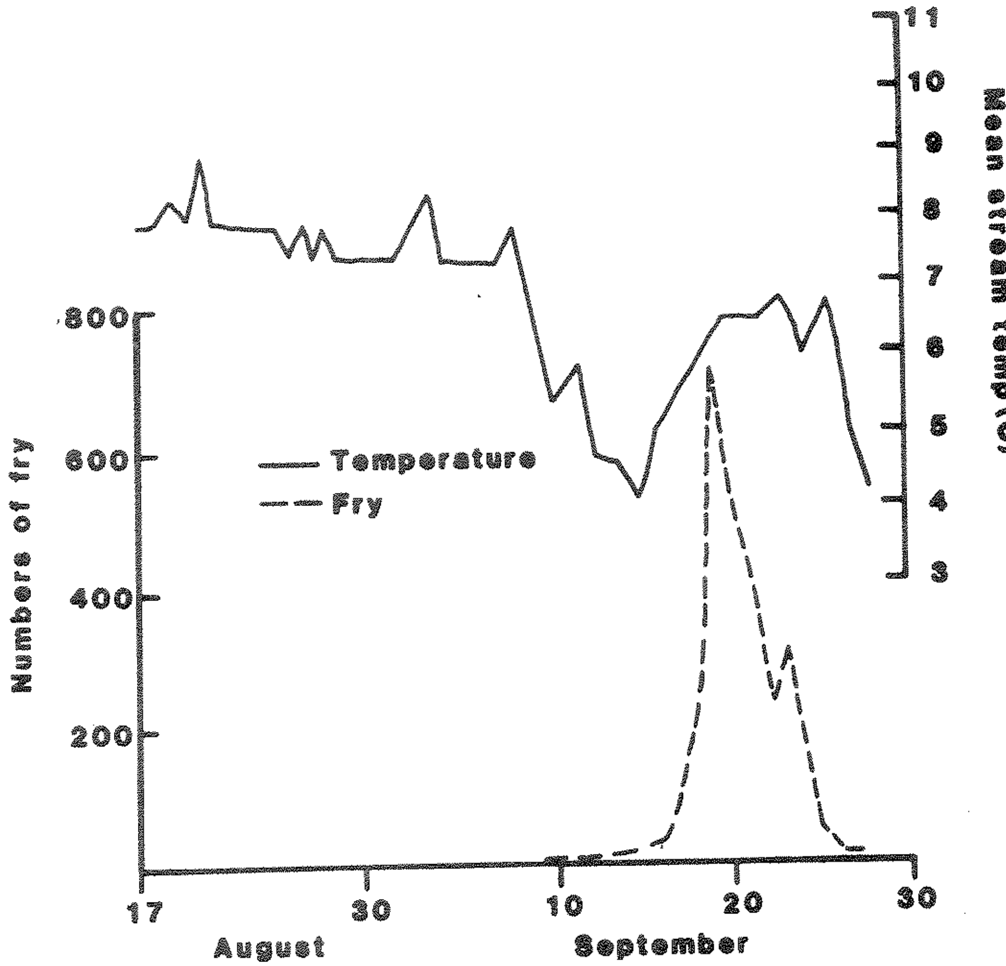

Figure 7. The total number of cutthroat trout fry captured emigrating from the East Fork of Hyalite Creek from August 17 - September 30, 1982 with mean daily stream temperatures.

therefore estimated to be about 22,000.

Recruitment to the 1982 year class may have been lower than to the 1981 year class. The drift net used in the East Fork during 1981 was placed along the edge of a typical U-shaped cross section of stream bottom and sampled about 17% of the stream width. This net captured 2,351 cutthroat trout fry while only about 500 more fry were captured in 1982 when the entire stream was trapped. This apparent lower production may have resulted from higher stream discharges during spawning. In 1982, peak stream discharges were 3.7 and 5.4 m^3 for the East and West Forks, respectively. In 1981, peak flows were 2.6 and 4.5 m^3 for the East and West Forks, respectively. Mean peak stream flows from 1975 - 1982 were 3.0 and 5.0 m^3 for the East and West Forks, respectively. Bulkley and Benson (1962), Farnes and Bulkley (1964) and Drummond and McKinney (1965) have reported an inverse correlation between stream flow during cutthroat trout spawning periods and the resulting year class strength. Production in the West Fork during 1981 and 1982 could not be compared because different sampling sites were used in the 2 years.

Rearing

A 305 m section of the West Fork at the Window Rock Station (Figure 1) was electrofished on October 21, 1981 and baited minnow traps were fished in observed spawning reaches of the East and West Forks from June 11 - 14, 1982 to determine if cutthroat trout fry reared in these tributaries. No wild cutthroat trout fry were captured by either method. This finding was similar to that of Snyder and Tanner (1960) who estimated that less than 1% of cutthroat trout fry remained in Cabin Creek after emigration but in opposition to those of Lund (1974) and Bulkley and Benson (1962) who found that some and many cutthroat trout fry remained in Narrows and Pelican Creeks, respectively, during their first winter.

Electrofishing and baited minnow traps did, however, capture a total of 43 marked hatchery fish in the East and West Forks during 1981 and 1982 (Table 24). Cutthroat trout with right - pelvic fin clips were captured in the West Fork during October, 1981 and in both the East and West Forks during June, 1982 indicating that these hatchery fry, which were planted in the reservoir on August 18, 1981, had entered and overwintered in at least the West Fork. Fish bearing other marks that had been planted in the reservoir in 1979 and 1980 were also captured in the West Fork during both years indicating that they too remained in that stream for at least 2 years. Also, some hatchery fish planted directly into the stream may remain there for at least 2 years.

Age and Growth

Back Calculated Lengths at Age

The back calculated lengths at annulus for unmarked cutthroat trout collected in 1982 show that growth rates were similiar and most rapid in the first and second year of life and then progressively declined through age V (Table 19).

Table 19. The average calculated total length at annuli and annual increments of growth for cutthroat trout of Hyalite Reservoir collected from June - September, 1982.

Age group	Number (% of total)	Mean length at capture	1	2	3	4	5
II	48(22%)	254	127	225			
III	77(35%)	332	141	273	326		
IV	67(31%)	422	137	306	375	417	
V	25(12%)	491	140	329	401	446	490
Grand mean			137	279	357	425	490
Increments			137	142	78	68	65
Number 217(100%)			217	217	169	92	25

The older the age group of fish used in the back calculation the greater the length for age II and older fish. This phenomenon was also found in the other three back calculations methods tested. This may reflect the population expansion of the McBride Lake strain. They were first planted in 1976 when Yellowstone cutthroat trout numbers in the reservoir were low (Wells, 1976) which would have resulted in more food available per fish initially than during later years when the population increased.

About 6% of all the cutthroat trout examined had scales which appeared to be missing a first annulus and were consequently excluded from the age and growth analysis. Brown and Bailey (1952) documented this phenomenon in cutthroat trout fry from Yellowstone Lake. All of the 31 age I right-pelvic clipped hatchery cutthroat trout captured during June, 1982 appeared to have a first annulus indicating that some wild cutthroat trout produced in the tributaries may not form a first annulus.

The average back calculated lengths at age for McBride Lake cutthroat trout collected in 1982 were 14, 63, 47 and 45 mm greater for ages I-IV respectively, than for comparable age groups of wild-appearing Yellowstone cutthroat trout collected in 1974 and 1975 (Wells, 1976). Average annual back calculated increments of growth for McBride fish were 14 and 49 mm greater than ages I and II but 16 and 2 mm less than age III and IV wild-appearing Yellowstone cutthroat trout captured in 1974 and 1975.

Growth of Tagged Fish

The growth increments for cutthroat trout captured in 1981 and then recaptured in the 1982 spawning runs are shown in Table 20. Mean growth increments for each age group was significantly less than mean back calculated growth increments of unmarked fish (Table 19). This indicates that tagging or the physiological stress of consecutive year spawning or both inhibited growth.

Table 20. The mean total lengths with 95 percent confidence intervals (in parentheses) and annual growth increments of cutthroat trout marked in 1981 and recaptured in 1982.

	Year				
	1981		1982		
Number	Age	Mean length(mm)	Age	Mean length(mm)	Growth increment(mm)
3	II	310(±27)	III	332(±48)	22
5	III	399(±12)	IV	410(±14)	11
11	IV	468(±27)	V	485(±30)	17
1	V	495	VI	508	13

Growth of Known Age Fish

Age 0 hatchery fish were about 38 mm larger than their wild counterparts when they were planted in the reservoir in August, 1981 (Table 21). They maintained their advantage over winter and were 35 mm larger in June 1982. Wells (1976) also found that increments of growth for known age, marked, hatchery cutthroat trout were similiar to back calculated increments of growth for wild-appearing cutthroat trout.

Table 21. The mean length of known age hatchery and wild cutthroat trout examined at Hyalite Reservoir.

		Hatchery		Wild	
Date	Age	Mean length	Number	Mean length	Number
Aug, 81	0	65*	22,178	25	109
Jun, 82	I	89	31	54	2

*Determined by personnel of the Big Timber Hatchery, MDFWP

Fifteen known age I hatchery cutthroat trout (determined by fin clips or fluorescent pigments) captured in the East and West Forks during June of 1981 and 1982 averaged 96 mm TL. Eight known age II hatchery fish from the triburtaries averaged 133 mm in June of the 2 years while back calculated age II fish from the reservoir were 146 mm larger. These poor growth rates were probably a result of low productivity and cold temperatures in the tributaries (Table 1).

DISCUSSION

The fishery of Hyalite Reservoir has increased dramatically since it was last studied 7 years ago. In 1981 and 1982 combined, the summer fishing pressure had increased by 109%, catch rates were 67% greater, harvest had increased by 221% and the biomass of the harvest increased by 150% compared to those parameters from the combined 1974 and 1975 seasons for cutthrout trout (Table 22). The present summer creel survey consisted of 14 weeks yearly while Wells (1976) survey consisted of 12 weeks yearly, however. These measured increases were far greater than those caused by the population growth in the surrounding area alone, indicating that local fishermen increased their use of the reservoir considerably. From 1975-1981, the population in Gallatin County (P. Brooks, pers. comm.) was estimated to have increased from about 37,900 to 43,300 (14%) while fishing pressure approximately doubled.

Table 22. The summer fishing pressures, catch rates, numbers harvested and biomass harvested for cutthroat trout at Hyalite Reservoir in 1974 and 1975 and the present study.

Year	Pressure (h)	Catch rate (fish/h)	Numbers harvested	Biomass harvested (kg)
1974	9,663	0.19	2,318	726
1975	8,384	0.11	764	595
1981	19,981	0.27	5,862	2,019
1982	17,733	0.23	4,032	1,349

The introduction of the McBride Lake strain into Hyalite Reservoir has created an improved fishery that is now supported by indigenous reproduction. Both the West and East Forks of Hyalite Creek are documented spawning areas producing wild recruits for the fishery. Even with the severe cropping of spawning age fish by anglers, it appeared the age structure of trapped spawners was moving towards older fish, perhaps indicating a greater production of recruits in the future. Because of these findings, the MDFWP stocked the reservoir only in 1981 and plans no further plantings.

In addition to the summer fishery, Hyalite Reservoir has supported a popular ice fishery for local anglers in recent years. A partial creel census conducted at night from December 21, 1981 - January 15, 1982 showed fishing pressure was 1,078 (±435) h, catch rate 1.4 (±0.2) fish per hour and harvest was 1,454 (±639) cutthroat trout during this period (Zubik, 1982). The size of this winter fishery largely depends upon the length of time the road to the reservoir is kept open. During the winter of 1981-1982, the road was not plowed and consequently the reservoir was accessible to wheeled vehicles for about 46 fishing days. In some years, the road is plowed throughout the winter making the reservoir available to fishermen until melting snows force road closures in the spring. The Forest Service presently plans to pave the gravel road to the reservoir by 1985 and may also keep it plowed during the winter months. This could cause a dramatic increase in the winter and summer fishing pressure and reduce the present quality of the fishery. Periodic monitoring will be required to provide the management data needed to maintain this high quality cutthroat trout fishery at Hyalite Reservoir. The establishment of McBride Lake cutthroat trout in Hyalite Reservoir documents the successful management strategy of using a strain of fish which is better suited to a particular environment. In waters with similiar chemical and biotic characteristics where the fishery has deteriorated, the introduction of this strain is recommended.

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APPENDIX

Table 23. The numbers of cutthroat trout fry captured at sampling stations on the West Fork of Hyalite Creek from August 26 - September 27, 1982. Percentages express the relationship of the numbers taken at the subsampled sites to the numbers taken at the stationary sampling site (Station 1).

	Sample station				
	1	2	3	4	5
Sep 8	152				407
9	69				494
10	103				210
11	103				210
18	135				201
19	68				242
20	89				307
21	38				255
22	26				213
23	13				91
24	13				51
25	11				93
26	1				61
27	1				20
Total	823				2,855(347%)
Sep 12	38			170	
13	44			101	
Total	82			271(330%)	
Sep 14	22		30		
15	46		33		
Total	68		63(93%)		
Sep 16	37	29			
17	90	93			
Total	127	122(96%)			
Estimated station totals	2,004	1,924	1,864	6,613	6,6954
Estimated Grand Total	19,359				

Table 24. The dates and location of marked hatchery McBride cutthroat trout fry plants later recaptured in the East and West Forks of Hyalite Creek.

	Plants		Recaptures		
Date	Mark	Location	Date	Location	Number
Sep, 1979	Red pigment	Reservoir	Jun, 1981	West Fork	1
Sep, 1979	Light green pigment	West Fork	Oct, 1981	West Fork	1
			Jun, 1981	West Fork	5
Jul, 1980	Orange pigment	West Fork	Jun, 1982	East Fork	2
			Oct, 1981	West Fork	5
			Jun, 1981	West Fork	7
Aug, 1981	Right-pelvic clip	Reservoir	Jun, 1982	West & East Forks	8
			Oct, 1981	West Fork	14