THE FISHERY OF HYALITE RESERVOIR DURING 1974 AND 1975

by

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of the requirements for the degree

of

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in

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VITA

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Thanks are due Mr. Ross McPherson, U.S.F.S. District Ranger, who allowed access to the study area during vehicular closure periods and fellow graduate students who assisted in the field work. Mr. Robert Chew assisted in the computer programming and statistical analyses.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES
(Continued)

LIST OF FIGURES

ABSTRACT

A partial creel census was conducted to estimate the fishing pressure, catch rates, and harvest of fish at Hyalite Reservoir from June to September 1974 and 1975. Fishing pressure was estimated to be 9663 hours in 1974 and 8384 hours in 1975. Estimated catch rates were 0.20 fish/hour in 1974 and 0.12 fish/hour in 1975. The estimated harvest was nearly 2500 fish in 1974 and 1000 fish in 1975. The lower catch rate and harvest in 1975 were due to the absence of hatchery cutthroat trout entering the fishery. Cutthroat trout, Arctic grayling and brook trout, respectively, made up 96, 3 and 1 percent of the harvest in 1974 and 76, 18 and 4 percent in 1975. Hatchery cutthroat trout made up 72 percent of the total estimated harvest in 1974 but only 25 percent in 1975. The use of the East and West Forks of Hyalite Creek by cutthroat trout and grayling in spawning condition was investigated during 1975. Over 98 percent of the presumed spawners were captured in the West Fork. Twenty-two ripe cutthroat (ages III-V) and 134 ripe grayling (ages III-VI) were captured in this stream. Sexually mature cutthroat trout first entered the stream when flow was increasing from spring runoff and mean daily stream temperature was near 3 C. No distinct peak in their numbers was observed. All were wild appearing fish. Spawning grayling entered the stream after peak flows when mean daily stream temperature was near 6 C. A distinct peak was observed in the seventh day of their run. No cutthroat trout fry and nearly 2,000 grayling fry were captured migrating into the reservoir.

INTRODUCTION

Hyalite Reservoir was created by the construction of an earth filled dam across Hyalite (Middle) Creek. Construction was begun in 1939 by the Montana State Water Board under a permit granted by the United States Forest Service. Work was interrupted during World War II with the dam being completed in February, 1951. The reservoir was created to supply water to the Gallatin Valley for irrigation. Presently, it also provides water to the City of Bozeman for municipal use and receives substantial fisherman use because of its accessibility, scenic setting, adjacent camping facilities and proximity to a population center.

The reservoir presently contains cutthroat trout *(Salmo clarki)*, Arctic grayling *(Thymallus arcticus)*, brook trout *(Salvelinus fontinalis)* and cutthroat-rainbow trout hybrids. The species resident in the drainage above the dam at its completion are unknown. However, records show the Montana Department of Fish and Game began planting hatchery Yellowstone cutthroat trout in Hyalite Reservoir in 1953 and released approximately 10,000 fish of 4" length into the reservoir annually from 1968 through 1972. The approximately 10,000 cutthroat planted as 4" fish in September were marked with a right pectoral fin clip. In June 1973 an additional 5,000 cutthroat of 9" length were marked with an adipose fin clip and released into the reservoir. Both

groups of marked fish were clearly identifiable during 1974 and 1975. Plants were discontinued in 1974.

Intensive field work was conducted on the fishery of Hyalite Reservoir from June through September, 1974 and 1975. The primary purpose of the study was to determine the fisherman use, harvest and contribution of hatchery fish to the harvest during 1974 and 1975. The natural reproduction of cutthroat trout and Arctic grayling in the inlets to the reservoir was also investigated during 1975.

DESCRIPTION OF STUDY AREA

Hyalite Reservoir is located in southwestern Montana in Gallatin County approximately 17.5 air kilometers south of Bozeman. The reservoir is situated in an elongate basin in the Gallatin Range at an altitude of 2012 meters. It drains 2332 hectares (5760 acres) of steep slopes belonging to the Gallatin National Forest and the Burlington Northern Railway. An unsurfaced road provides easy access to Hyalite Reservoir and its campgrounds during the snow-free months. The road is not maintained during the winter months but snowmobile traffic is allowed.

At maximum capacity Hyalite Reservoir contains 991 hectare-meters (8,027 acre-feet) of water, has a surface area of 84.2 hectares (208 acres) and a maximum depth of 27 meters (88.6 feet). However, it is subject to extreme fluctuations in water level with an annual drawdown of up to 8 vertical meters. Typically, the reservoir is filled to capacity in early summer and then drawn down through the fall with water maintained at low levels from October until the onset of spring runoff. Most of the runoff enters by way of the East and West Forks of Hyalite Creek (Fig. 1). High water in the West Fork occurred in mid-June, 1974 and early July, 1975 (Fig. 2). Peak flow in the East Fork also occurred in early July, 1975. Water levels of the reservoir during 1974 and 1975 are shown in Figure 3.

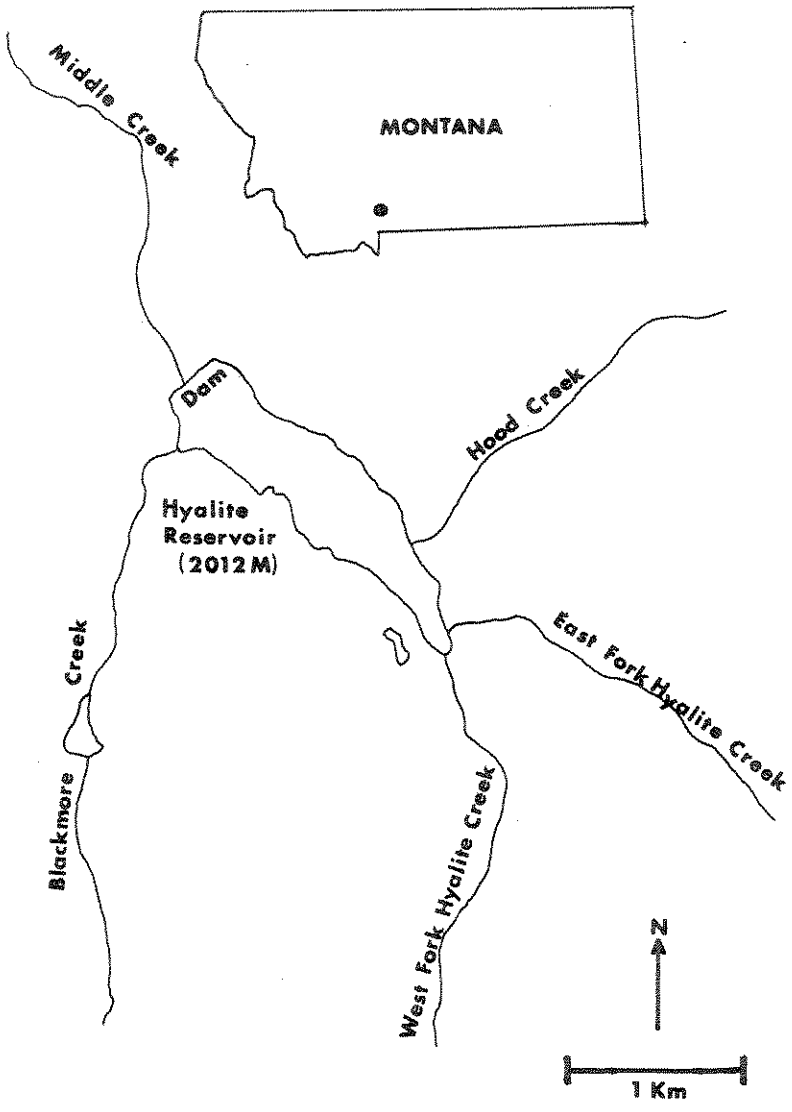

Figure 1. Map of the study area showing major inlet streams and outflow (Middle Creek).

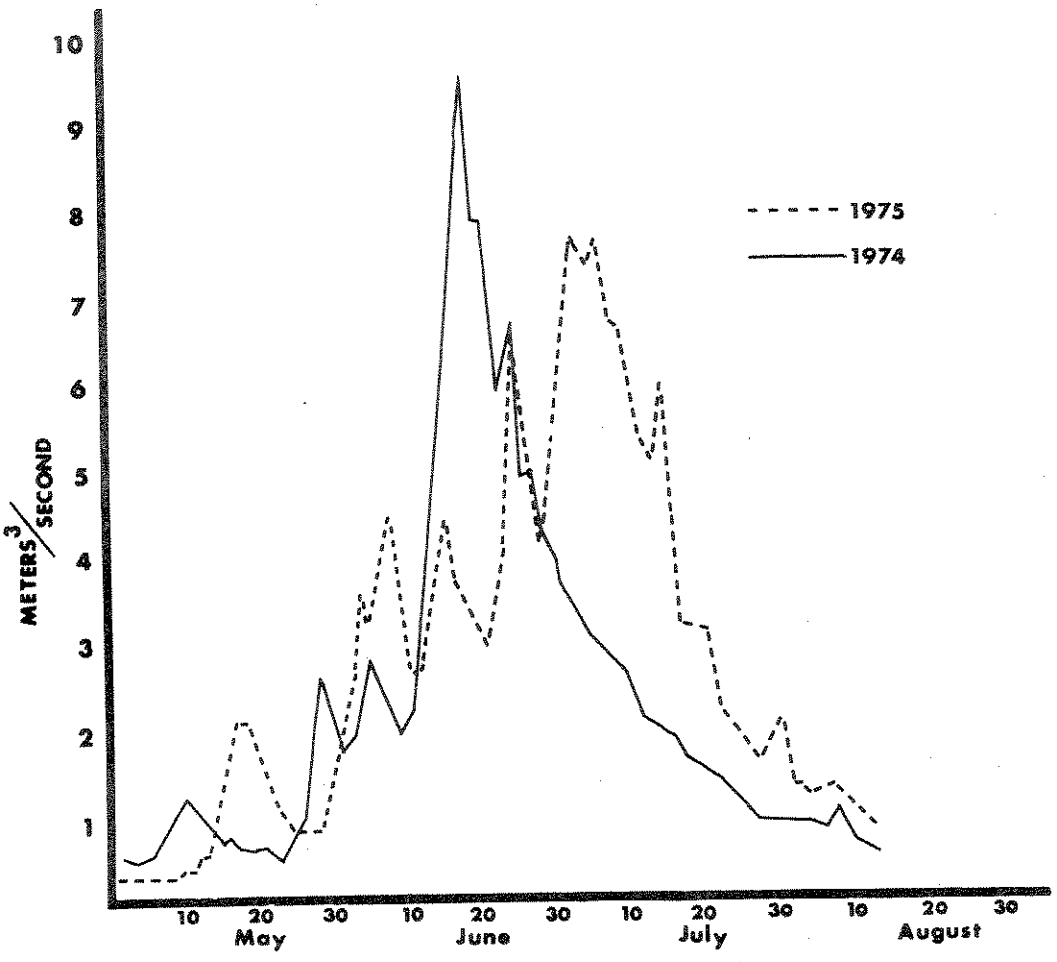

Figure 2. Stream flow in the West Fork of Hyalite Creek from May through August 1974 and 1975. (Data from Montana Dept. of Nat. Resources)

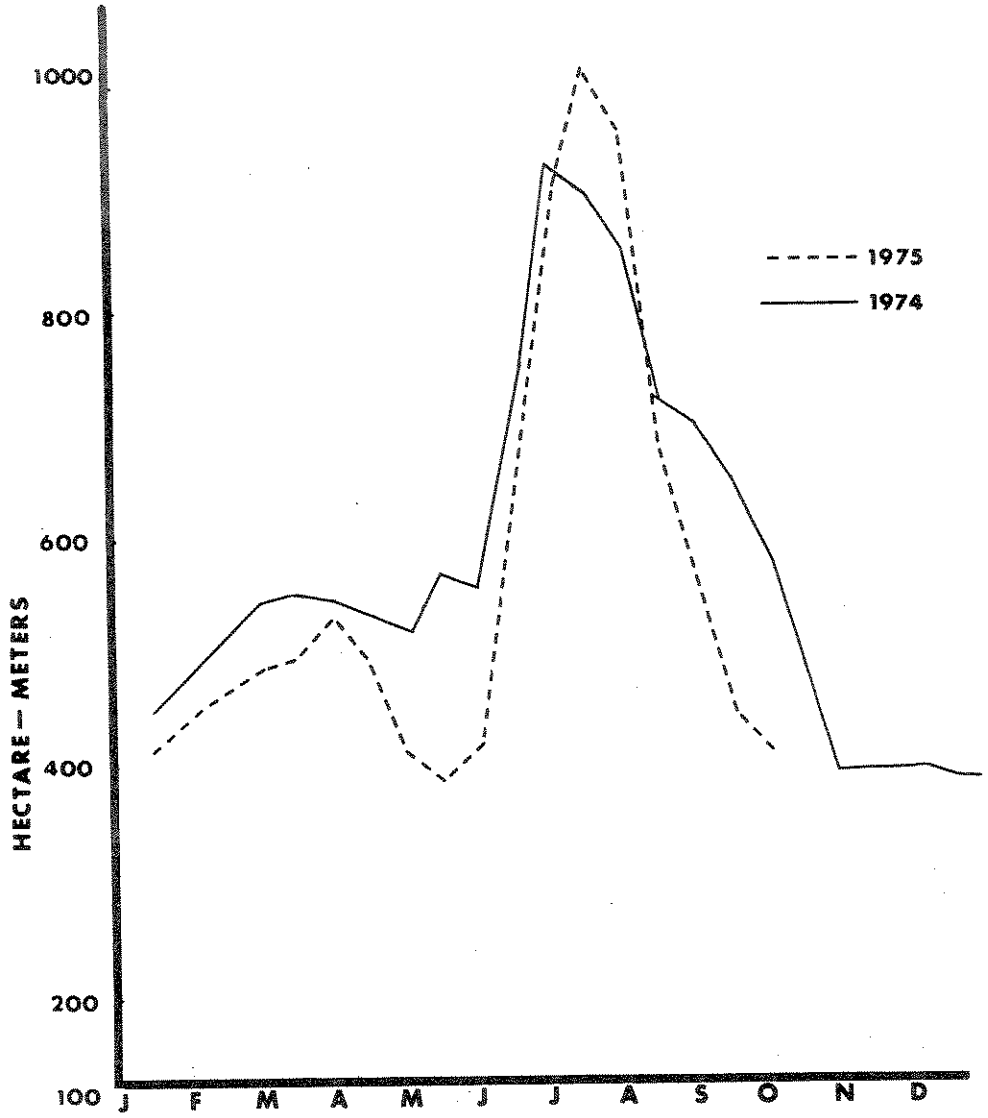

Figure 3. Volume of water stored in Hyalite Reservoir from January 1974 through September 1975. (Data from Montana Dept. of Nat. Resources)

Selected physical and chemical characteristics of Hyalite Reservoir measured during the summer of 1975 are given in Table 1. A thermocline was present on June 26 at approximately 6 meters and descended to approximately 9 meters by August 28. Dissolved oxygen in the water column ranged from 11.05-5.20 ppm with the maximums occurring from the surface to the thermocline. Total alkalinity varied from 0.30-0.54 me/l consisting of bicarbonate. A dense bloom of *Aphanizomenon*, a blue-green algae, was observed during August in 1974 and 1975. Other chemical characteristics of the reservoir have been described by Bissonnette (1971).

TABLE 1. RANGES AND (MEANS) OF SELECTED PHYSICAL AND CHEMICAL PROPERTIES OF HYALITE RESERVOIR, ITS OUTFLOW AND THE EAST AND WEST FORKS OF HYALITE CREEK MEASURED FROM JUNE 20-AUGUST 31, 1975.

	Temp. (°C) Range (Mean)	Dissolved Oxygen (ppm) Range (Mean)	Turbidity (JTU) Range (Mean)	Specific Conductance (μmhos/cm) Range (Mean)	pH Range	Total Alk. (me/l) Range (Mean)
Reservoir						
Depth (m) 0	4.8-14.9 (11.75)	9.4-10.9 (9.8)				
0, 2, 4 (Composite)	4.8-13.6 (10.1)	9.5-10.8 (10.1)	6.7-16.0 (7.8)	53.0-65.8 (56.2)	7.5-7.8	0.43-0.50 (0.46)
6, 8, 10 (Composite)	4.7-11.0 (8.0)	10.3-11.0 (10.2)	7.8-18.0 (9.8)	63.1-28.0 (71.0)	7.6-8.0	0.50-0.52 (0.51)
15	4.5-10.1 (7.7)	10.4-10.9 (10.2)	7.6-14.2 (8.6)	44.4-67.8 (58.0)	7.5-7.6	0.30-0.52 (0.42)
20	4.1-10.1 (8.0)	7.8-10.9 (10.0)	8.2-20.2 (10.9)	43.8-79.8 (66.3)	7.5-7.6	0.36-0.54 (0.46)
24 (Bottom)	4.1-9.75 (8.5)	5.2-10.4 (9.2)	7.5-21.0 (12.6)	71.0-98.6 (81.0)	7.5-7.9	0.41-0.54 (0.49)
West Fork	0.1-11.8 (7.2)	---	6.25-56.0 (15.1)	33.6-78.1 (41.6)	7.4-7.7	0.25-0.60 (0.34)
East Fork	0.1-10.0 (6.8)	---	4.1-30.0 (8.1)	35.3-55.8 (38.7)	7.5-7.6	0.25-0.40 (0.32)
Outflow	3.8-10.1 (8.2)	---	6.0-18.0 (9.0)	47.4-72.0 (60.2)	7.7-8.0	0.40-0.52 (0.48)

METHODS

A partial creel census was conducted on Hyalite Reservoir from June 9-September 2, 1974 and from June 7-September 2, 1975. In the census, fishermen were counted in a sampling design based on the method of Neuhold and Lu (1957).

Each sampling season was divided into six periods called strata. The first five strata were two weeks long and the sixth was 15 days in 1974 and 17 days in 1975. Each stratum was separated into weekend days and weekdays. Fifty percent of the weekend days and weekdays in each stratum were censused. The first weekend day of the first stratum each season was censused and subsequent weekend days throughout the entire period were censused in alternate order (Saturday, Sunday, Saturday, etc.). Weekdays to be censused within a stratum were randomly chosen without repetition with the restriction that at least two weekdays per week be censused. Thus in each two week stratum, every weekday (Monday, Tuesday, Wednesday, etc.) was sampled once. All holidays were censused.

Four counts of fishermen were made on each census day. The first count on each day was made at either 6, 7, 8 or 9 A.M. and each of the three subsequent counts were made at 4 hour intervals. The time of the first count on the initial weekend day in each season was randomly chosen. The time of the initial counts on each subsequent

weekend day was advanced by one hour until the 9 A.M. count was made. The 6 A.M. starting time followed the 9 A.M. count. The hour of the initial count on the two holidays censused each season was randomly chosen.

The starting hour for counts on weekdays in each stratum was randomly chosen from the four starting times. The initial counts on subsequent weekdays were made in the same manner as for the weekend days. This procedure provided good coverage of the fisherman day, considered to run from 6 A.M.-9 P.M. in each stratum.

The numbers of shore and boat fishermen and the number of boats containing fishermen were recorded separately at the time of each count. Counts were made with the aid of a boat and 8X50 binoculars. Counts took less than 30 minutes to make 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. In each interview the size of the fishing party, residence of each fisherman and total hours fished by the party was recorded. The catch of each party interviewed was examined to determine the number of each species creeled. Each undressed fish was weighed, measured and examined for fin clips or tags. As much information as possible was obtained from dressed fish.

Data from counts and interviews were analyzed at the Montana State University Statistical Laboratory using methods described by Neuhold and Lu (1957).

Experimental gill nets were fished in the reservoir from September 30-October 2, 1974 and from August 11-25, 1975. Captured fish were weighed, measured, marked with a fin clip or an individually numbered T-tag and released. Both forks of Hyalite Creek were electrofished at least twice a week from June 1-July 23, 1975. Captured fish were sexed, weighed, measured, marked with a fin clip or affixed with a T-tag and released. Water temperatures of both forks of Hyalite Creek were monitored from late May through September 1, 1975 using recording thermographs.

RESULTS

Interviews

Interviews were conducted with 836 and 849 fishermen during 1974 and 1975, respectively. These consisted of 557 shore and 279 boat fishermen in 1974 and 525 shore and 324 boat fishermen in 1975.

The catch rates of fishermen interviewed are shown in Table 2. During 1974 the catch rate for all fishermen was 0.20 fish per hour. The catch rate for boat fishermen was over twice as great as for shore fishermen. The catch rates for total, boat and shore fishermen progressively declined after Stratum II, II and III, respectively.

During 1975 the catch rates of total, boat and shore fishermen were less than the respective catch rates during 1974. Boat fishermen had twice the catch rate of shore fishermen during 1975. Catch rates for total, boat and shore fishermen tended to decrease as the season progressed.

Catch rates appeared to be associated with physical and biological factors in the reservoir. The highest total catch rates tended to occur during Stratum I of both years. Stratum I occurred during or just after ice-off when water levels in the reservoir were low. Ice-off began at the southern end of the reservoir where the forks of Hyalite Creek enter. Both fish and fishermen appeared to congregate in this area producing a high catch rate. The catch rate during

TABLE 2. ESTIMATED CATCH RATES OF FISHERMEN AT HYALITE RESERVOIR, IN FISH PER HOUR, FROM JUNE TO SEPTEMBER 1974-75 WITH 95 PERCENT CONFIDENCE INTERVALS FOR YEARLY TOTALS.

1974				1975			
Stratum	Shore	Boat	Total	Stratum	Shore	Boat	Total
I	0.22	0.39	0.31	I	0.18	0.43	0.31
II	0.04	0.61	0.33	II	0.11	0.20	0.16
III	0.22	0.31	0.27	III	0.02	0.11	0.06
IV	0.05	0.16	0.11	IV	0.10	0.11	0.11
V	0.09	0.14	0.12	V	0.11	0.03	0.07
VI	0.07	0.12	0.10	VI	0.01	0.09	0.05
1974	0.11 (±0.04)	0.29 (±0.06)	0.20 (±0.07)	1975	0.08 (±0.03)	0.16 (±0.06)	0.12 (±0.07)

the first two days of Stratum I in 1974 was 0.56 fish per hour. However, on June 11, a landslide occurred on a steep clear-cut area and infused large quantities of soil into the West Fork of Hyalite Creek. The turbidity in the southern end of the reservoir increased and the catch rate during the remainder of the stratum decreased markedly. The rapid filling of the reservoir during Strata II of 1974 and III of 1975 tended to increase the turbidity of the water near the shore as it was inundated and appeared to lower the catch rates of shore fishermen. In Strata V and VI of both years a dense bloom of the blue-green algae *Aphanizomenon* occurred, which appeared to depress catch rates.

The catch rates for each species and group of marked hatchery fish taken during 1974 and 1975 are shown in Table 3. Cutthroat trout were the most frequently taken species during both years. In 1974, catch rates of cutthroat were highest for two-year-old hatchery fish with right pectoral fin clips (planted as 4" fish in September, 1972), while during 1975 wild appearing cutthroat were taken more readily than hatchery fish. Cutthroat trout were termed wild appearing if they bore no fin clips and possessed no structural anomalies in their fins. Although catch rates for brook trout and grayling were less than 0.03 fish per hour in each year of the study, they increased by factors of 3 and 2, respectively, from 1974 to 1975.

TABLE 3. ESTIMATED CATCH RATES OF FISH BY SPECIES AND GROUP AT HYALITE RESERVOIR, IN FISH PER HOUR, FROM JUNE TO SEPTEMBER 1974 AND 1975 WITH 95 PERCENT CONFIDENCE INTERVALS FOR YEARLY TOTALS.

1974					1975				
Species	Group	Shore	Boat	Total	Species	Group	Shore	Boat	Total
Cutthroat Trout	Hatchery (Rp)	0.07	0.20	0.14	Cutthroat Trout	Hatchery (Rp)	0.04	0.04	0.04
	Hatchery (A)	0.01	0.03	0.02		Hatchery (A)	0.005	0.006	0.006
	Wild Appearing	0.02	0.04	0.03		Wild Appearing	0.05	0.07	0.06
Brook Trout		0.002	0.002	0.002	Brook Trout		0.004	0.008	0.006
Hybrid Trout (CtXRb)		0.000	0.001	0.001	Hybrid Trout (CtXRb)		0.000	0.002	0.001
Grayling		0.01	0.01	0.01	Grayling		0.02	0.03	0.02
Total		0.11 (±0.04)	0.29 (±0.06)	0.20 (±0.07)	Total		0.09 (±0.03)	0.16 (±0.06)	0.12 (±0.07)

(Rp) = Right pectoral fin clip.
(A) = Adipose fin clip.

Each fisherman interviewed was classified as a local (residing less than 50 miles from the reservoir), Montana resident (residing in the state but more than 50 miles from the reservoir) or as an out of state resident. Of fishermen interviewed in 1974, 575 (69%) were locals, 159 (19%) were Montana residents and 102 (12%) were out of state residents. In 1975, 591 (70%) were locals, 142 (17%) were Montana residents and 116 (13%) were out of state residents.

In 1974 there was an average of 2.36 shore fishermen per party and 2.32 fishermen per boat. Shore fishermen fished an average of 1.88 hours per person and boat fishermen 2.52 hours. In 1975 the averages were 2.30 shore fishermen per party and 2.54 fishermen per boat. Shore fishermen fished an average of 2.08 hours per person and boat fishermen 2.52 hours.

Fishing Intensity

The average number of shore and boat fishermen per count in each stratum of the study are given in Appendix Table 4. Since it was not always possible to accurately count the number of fishermen per boat directly, the average number of boat fishermen per count in each stratum was estimated by multiplying the average number of boats with persons actively fishing per count by the average number of fishermen per boat as determined from interviews within each stratum.

The average number of shore and boat fishermen per count on weekdays and weekends-holidays are given in Appendix Table 5. The average number of shore fishermen per count on weekends-holidays was 1.6 and 2 times greater than on weekdays in 1974 and 1975, respectively. For boat fishermen, the average number per count was nearly 3 times as great on weekends-holidays as on weekdays in both years of the study.

Fisherman hours in each stratum were calculated as the product of the average number of fishermen per count and the total possible fishing hours in that stratum with each fishing day considered to consist of 15 hours. The estimated number of shore, boat and total fisherman hours with 95 percent confidence limits are given in Table 6. About 1300 more hours were fished in 1974 than in 1975. Estimates of fisherman hours on weekdays versus weekends-holidays were not calculated since the number of weekends-holidays counts within each stratum were too few to provide reliable variance estimates.

During 1974 and 1975, shore fishermen accounted for about 56 and 60 percent of the total fishing pressure, respectively. Pressure from shore fishermen was greatest in Stratum I of 1974 and Stratum II of 1975. Pressure from shore fishermen tended to decrease throughout the season after these highs. In 1975, the pressure from shore fishermen in Stratum I was probably depressed by the partial ice cover and deep snow surrounding the reservoir. The several days of cold, rainy

TABLE 6. ESTIMATED NUMBER OF FISHERMAN HOURS AT HYALITE RESERVOIR FROM JUNE TO SEPTEMBER, 1974 AND 1975 WITH 95 PERCENT CONFIDENCE INTERVALS FOR SHORE AND BOAT FISHERMEN AND YEARLY TOTALS.

1974				1975			
Stratum	Shore	Boat	Total	Stratum	Shore	Boat	Total
I	1245±390	1007±481	2252	I	980±333	174±139	1154
II	878±246	1400±528	2278	II	1613±470	961±370	2574
III	900±279	1029±387	1929	III	656±292	1255±589	1911
IV	604±218	832±336	1436	IV	338±170	914±334	1252
V	630±192	470±222	1100	V	443±163	268±166	711
VI	401±143	267±166	668	VI	327±120	455±326	782
Total	4658±629	5005±922	9663±1390		4357±697	4027±865	8384±1240

weather in Stratum IV of that year also appeared to depress shore fishing intensity.

During 1974, boat fishermen pressure was greatest in Stratum II. In 1975 it was greatest in Stratum III. The three-day weekend of July 4th occurred during both of these strata. Pressure from boat fishermen decreased from these respective strata. The low boat fishermen pressure in Stratum I of 1975 was probably due to the reservoir being partially ice covered and the road to the boat launching area being blocked by deep snow during most of the stratum.

The average hourly fishing intensities for shore and boat fishermen on weekdays and weekends-holidays during 1974 and 1975 are shown in Figure 4. During both years the peak of weekday shore fishing intensity occurred at about 8 P.M. The peak of weekday boat fishing intensity during both years was between 6 P.M. and 8 P.M. in the evening (Fig. 5).

The weekends-holidays hourly intensity curve for shore fishing in 1974 (Fig. 6) was nearly bell shaped with the peak occurring at 2 P.M. In 1975, this curve was trimodal with peaks at 10 A.M., 2 P.M. and 6 P.M. (Fig. 6). This trimodal pattern of fishing intensity has been noted by Cope (1957) on Yellowstone Lake, who termed it characteristic of a resort type fishery. Weekends-holidays boat fishing hourly intensity curves were essentially trimodal in both years (Fig. 7). In 1974, the greatest intensity was at 3 P.M. with

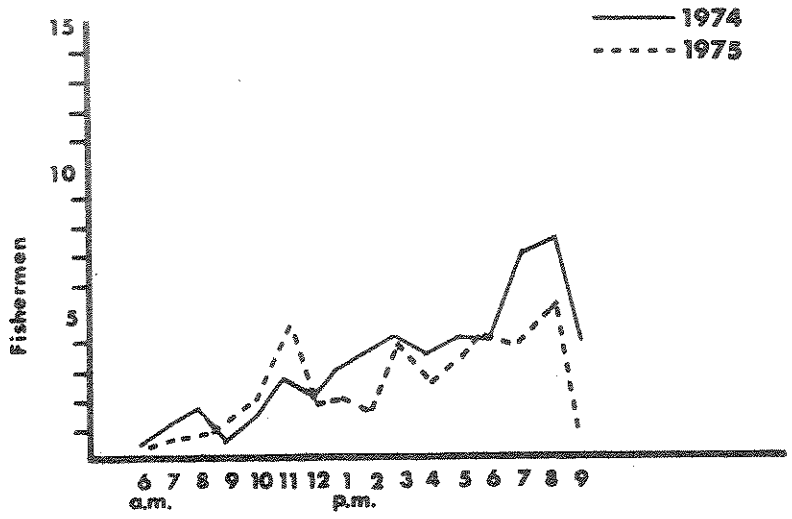

Figure 4. The average number of weekday shore fishermen per count at Hyalite Reservoir in 1974 and 1975.

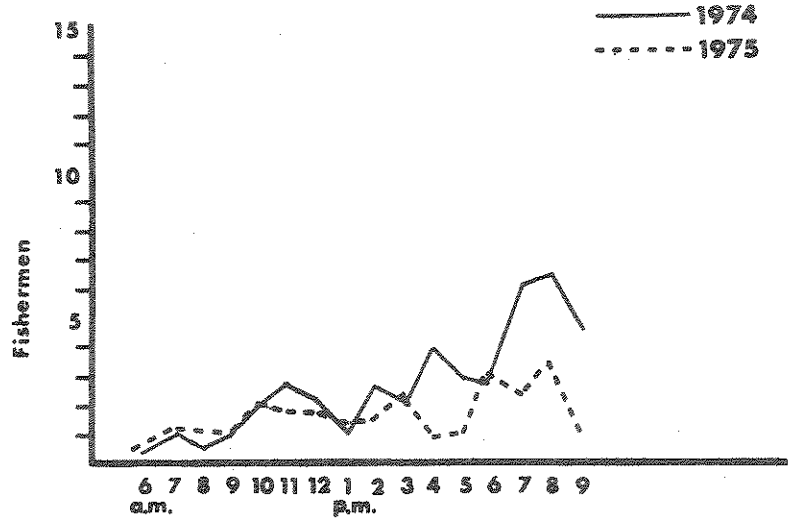

Figure 5. The average number of weekday boat fishermen per count at Hyalite Reservoir in 1974 and 1975.

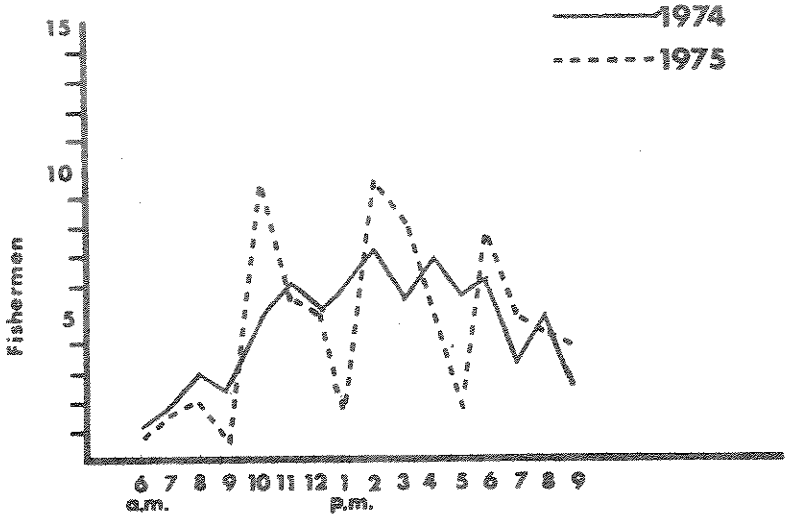

Figure 6. The average number of weekends-holidays shore fishermen per count at Hyalite Reservoir in 1974 and 1975.

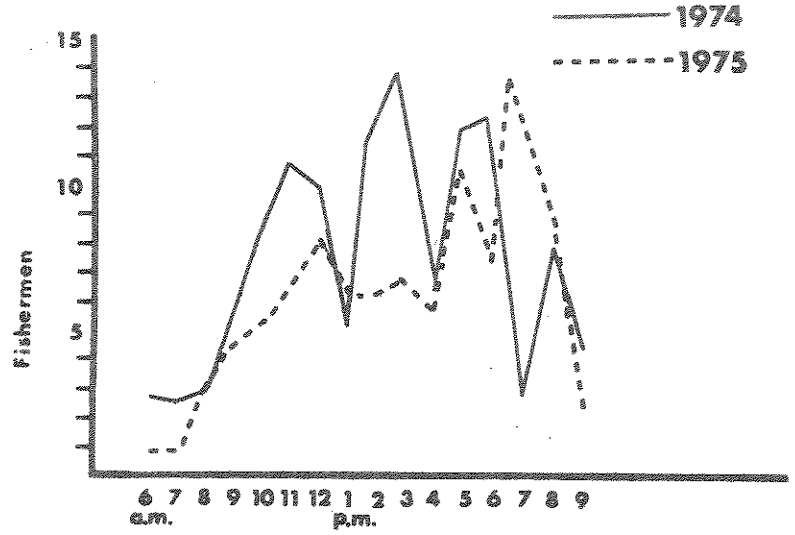

Figure 7. The average number of weekends-holidays boat fishermen per count at Hyalite Reservoir in 1974 and 1975.

lesser peaks occurring at 11 A.M. and 6 P.M. During 1975, the greatest intensity was at 7 P.M. with lesser peaks present at 5 P.M. and 12 P.M.

Hyalite Reservoir received a great deal of fishing pressure averaging 43.4 hours fished per surface acre at maximum pool during my study. This was over three times as great as the summer pressure found by Lund (1974) on the cutthroat and grayling fishery of Elk Lake, Montana and nearly 1½ times as great as the summer fishing pressure on the cutthroat fishery of Trappers Lake, Colorado (Drummond and Tanner, (1960).

Harvest

The estimates of the total number of fish harvested (game fish caught and kept) during 1974 and 1975 (Table 7) were calculated as the

TABLE 7. ESTIMATED TOTAL NUMBER OF SALMONIDS HARVESTED FROM HYALITE RESERVOIR FROM JUNE TO SEPTEMBER, 1974 AND 1975 WITH 95 PERCENT CONFIDENCE INTERVALS FOR YEARLY TOTALS.

1974				1975			
Stratum	Shore	Boat	Total	Stratum	Shore	Boat	Total
I	278	396	674	I	178	74	252
II	32	855	887	II	173	191	364
III	195	317	512	III	10	132	142
IV	27	136	163	IV	34	102	136
V	57	67	124	V	49	7	56
VI	28	32	60	VI	4	45	49
Total	617±159	1803±679	2420±926	Total	448±208	551±209	999±412

products of the catch rates and number of fisherman hours. The estimated 2420 creeled fish in 1974 was more than twice as great as that in 1975. Boat fishermen harvested 74.5 percent of the total in 1974 and 55.2 percent in 1975. In both years the number of fish harvested was greatest in Stratum II and decreased as the season progressed.

The estimated number of fish harvested by species and hatchery group (Table 8) was determined by multiplying the catch rate for

TABLE 8. ESTIMATED NUMBERS OF FISH HARVESTED BY SPECIES AND GROUP AT HYALITE RESERVOIR FROM JUNE TO SEPTEMBER, 1974 AND 1975.

	1974			1975		
	Shore	Boat	Total (%)	Shore	Boat	Total (%)
Ct (Rp)	391	1344	1735(71.6%)	114	137	251(25.1%)
Ct (A)	54	152	206(8.5%)	18	6	24(2.4%)
Ct (W)	102	275	377(15.5%)	195	294	489(48.9%)
Ct (Total)	547	1771	2318(95.6%)	327	437	764(76.4%)
BK	15	3	18(0.7%)	28	11	39(3.9%)
CtXRb	5	5	10(0.4%)	0	13	13(1.3%)
G	50	24	74(3.3%)	93	90	183(18.3%)
Total	617	1803	2420(100%)	448	551	999(100%)

(Rp) = Right pectoral fin clip.
(A) = Adipose fin clip.
(W) = Wild appearing.

individual species or hatchery group by the number of fisherman hours. Cutthroat trout decreased substantially in numbers harvested and percentage of the numbers harvested from 1974 to 1975. An estimated 2318 cutthroat trout were taken in 1974 and only 764 in 1975. Cutthroat

trout made up 96 and 76 percent of creeled fish in 1974 and 1975, respectively.

Hatchery cutthroat trout marked with a right pectoral fin clip (planted as 4" fish in September, 1972) made up nearly 72 percent of the total number of fish harvested in 1974, the year they first entered the fishery, and 25 percent their second year in the fishery. Hatchery cutthroat marked with an adipose fin clip (planted as 9" fish in June, 1973) were in their second and third year in the fishery in 1974 and 1975 and contributed less to the total harvest than the 1972 plant or wild appearing cutthroat trout. Although the estimated number of harvested wild appearing cutthroat increased only slightly from 1974 to 1975, their percentage in the total harvest increased by 3 times.

The harvest of hatchery cutthroat decreased in 1975 following the cessation of stocking, and the harvest of wild appearing cutthroat, grayling, brook and hybrid trout increased. Grayling increased by two and five fold in estimated numbers creeled and percentage of the total harvest, respectively, from 1974 to 1975. Brook and hybrid trout together increased by nearly two and five fold in estimated numbers creeled and percentage of the total harvest, respectively, from 1974 to 1975.

The biomass of the harvest was determined by multiplying the estimated number of fish harvested by the average weight of creeled

fish. The average weight of 386 fish examined from the creel in 1974 was 300 g (0.66 lb.) and the estimated total harvest was 726 Kg (1601 lbs.) or 8.8 Kg/hectare (7.8 lbs./acre) at maximum pool. In 1975, the average weight of 176 fish examined from the creel was 596 g (1.31 lb.) and the estimated total harvest was 595 Kg (1312 lbs.) or 7.2 Kg/hectare (6.4 lbs./acre) at maximum pool. Drummond and Tanner (1960) found a harvest of 27.8 Kg/hectare (24.7 lbs./acre) in the cutthroat fishery of 286 acre Trappers Lake in Colorado.

Age and Growth

Scales were taken from between the lateral line and dorsal fin from fish collected by fishermen, gill netting and electrofishing in 1974 and 1975. Impressions of scales were made on slides of cellulose acetate and examined using a Bausch and Lomb microprojector. Total fish length was regressed on anterior scale radius and graphed with the resulting line cutting the ordinate at a positive length. Growth was back calculated using a direct-proportionality formula first proposed by Fraser (1916):

$$l_n - c = \frac{s_n}{s}\,(l - c)$$

where: l_n = length of fish at annulus n

l = length of fish at time scale was taken

s_n = radius of annulus n (at length l_n)

s = total scale radius

c = ordinate intercept of body:scale regression

The back calculated lengths at annuli and annual increments of growth for 100 wild appearing cutthroat trout collected in 1974-75 are shown in Table 9. Growth was most rapid in the first year of life,

TABLE 9. THE AVERAGE CALCULATED TOTAL LENGTHS AT ANNULI AND ANNUAL INCREMENTS OF GROWTH FOR THE WILD APPEARING CUTTHROAT TROUT OF HYALITE RESERVOIR COLLECTED IN 1974 AND 1975.

Age Group	Number of Fish (% of Total)	Avg. Length At Capture (mm)	Year of Life 1	2	3	4
I	21(21%)	179	126			
II	46(46%)	267	123	209		
III	23(23%)	347	123	222	306	
IV	10(10%)	384	118	232	320	380
Grand Averages			123	216	310	380
Increments			123	93	94	70
Number of Fish	100		100	79	33	10

decreased slightly to similar growth rates in the second and third years of life and declined in the fourth. The growth rate of wild appearing cutthroat trout in Hyalite Reservoir was similar to those in Mystic Lake (Poore, 1973) in a nearby drainage. Increments of growth for known age marked hatchery cutthroat trout (Table 10) were similar to back calculated increments of growth for wild appearing cutthroat trout.

TABLE 10. GROWTH OF KNOWN AGE HATCHERY CUTTHROAT TROUT IN HYALITE RESERVOIR.

Group	Date of Plant	Age at Plant	Approx. Length at Plant	Avg. Length in 1974 (n)	Avg. Length in 1975 (n)
Ct(Rp)	Sept., 1972	0+	100mm	291mm(130)	381mm(49)
Increment				*191mm	90mm
Ct(Rp)	June 1973	I	225mm	322mm	415mm(12)
Increment				97mm	93mm

(Rp) = Right pectoral fin clip.
(A) = Adipose fin clip.
*Represents the increment of growth from September 1972 to 1974 summer average.

The back calculated lengths at annuli and annual increments of growth for 383 Arctic grayling collected in 1974-75 are shown in Table 11. Grayling grew more rapidly during their second year of life than during their first. Young of the year grayling did not enter the reservoir until mid-August, 1975, therefore, the time between entering the reservoir and formation of first annulus appears to be less than one year. The annual growth rate of grayling declined markedly after the third year of life. Grayling in Hyalite Reservoir grew more rapidly than those reported on by Kruse (1959), Brown (1943) and Peterman (1972) in lakes of this region but slightly slower than those in Elk Lake, Montana (Lund, 1974).

TABLE 11. THE AVERAGE CALCULATED TOTAL LENGTHS AT ANNULI AND ANNUAL INCREMENTS OF GROWTH FOR THE ARCTIC GRAYLING OF HYALITE RESERVOIR COLLECTED IN 1974 AND 1975.

Group	Number of Fish (% of Total)	Avg. Length At Capture (mm)	Year of Life 1	2	3	4	5
I	103(28%)	182	88.7				
II	93(24%)	316	84.5	237.3			
III	124(32%)	372	90.0	249.9	354.0		
IV	35(9%)	399	83.7	247.3	344.8	398.5	
V	28(7%)	417	85.1	248.5	352.5	391.9	418.0
Grand Averages			86.4	245.8	350.4	395.2	418.0
Increments			86.4	159.4	104.6	44.8	22.8
Number of Fish 383			383	280	187	63	28

Spawning and Recruitment 1975

From June 3, prior to ice-off in the reservoir, to July 23, each fork of Hyalite Creek was electrofished at least twice a week to determine the chronology and species composition of their spawning runs. The East Fork has a steep gradient, very few shallow riffle areas, and few side channels. Only three adult cutthroat trout and one grayling were captured in the East Fork. The West Fork has a slight gradient for two Km. above the reservoir, many shallow riffle areas with good spawning gravel and several side channels. Spawning activity of both species was limited almost entirely to the West Fork where 22 adult cutthroat and 134 adult grayling were captured.

Chronology of the West Fork Spawning Migrations

Sexually mature cutthroat trout and cutthroat-rainbow hybrids were captured from June 4-July 21 (Fig. 8). Their numbers remained small and no distinct peak was observed. They first entered the stream when flow was increasing from spring runoff (Fig. 2) and mean daily stream temperature was approximately 3 C. Snyder and Tanner (1960) also found spawning cutthroat trout to first enter the inlet streams to Trappers Lake, Colorado, when stream flows increased with runoff.

Sexually mature grayling were first observed and captured on July 10. They first entered the stream nearly one month after ice-off and five weeks after the first presumed cutthroat spawners were captured. Brown (1938) reported that grayling often ran before cutthroat trout, just after ice-off, but Kruse (1959) found cutthroat-rainbow hybrids entered spawning streams up to three weeks earlier than grayling at Grebe Lake, Yellowstone National Park. Grayling first appeared when the mean daily stream temperature was 6.1 C and stream flow was subsiding (Fig. 2). Highest numbers were captured on July 16 when the mean daily stream temperature was 7 C and surface temperature of the reservoir was 11.2 C. Kruse (1959), Peterman (1972) and Lund (1974) found grayling spawning runs were heaviest when stream temperatures were between 7-10 C.

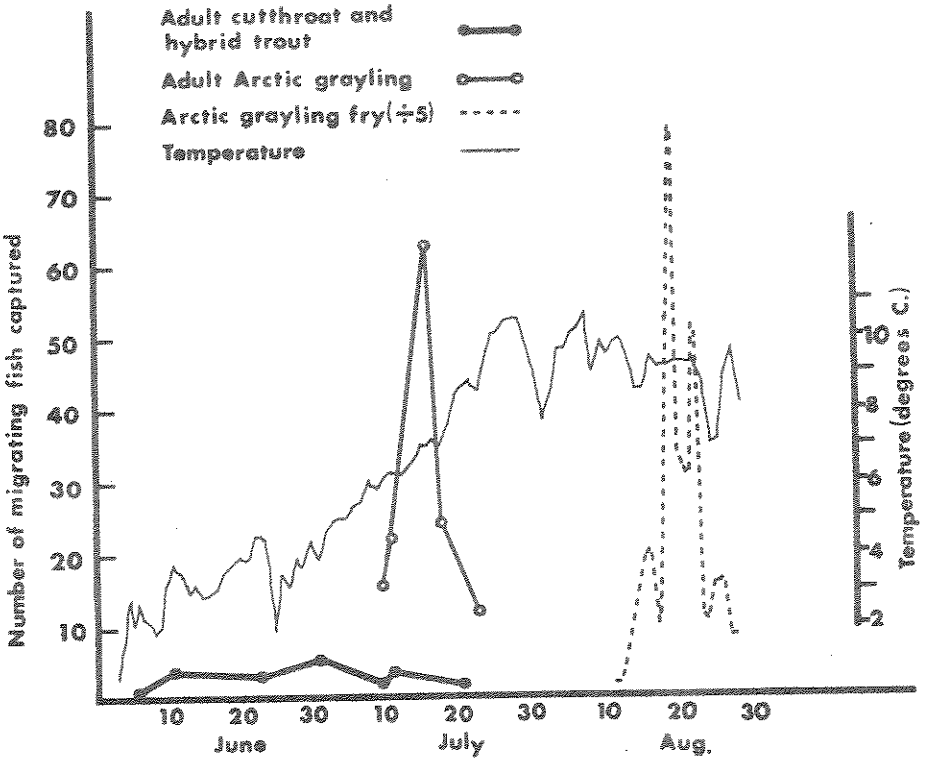

Figure 8. Numbers of adult cutthroat trout, hybrid trout and Arctic grayling captured migrating upstream; Arctic grayling fry captured migrating downstream and mean daily stream temperature in the West Fork of Hyalite Creek during 1975.

Composition of the West Fork Spawning Migrations

The numbers, lengths and ages of captured ripe fish by species and sex are shown in Table 12. Sex was determined by the observable presence of eggs or milt. The 134 grayling captured dominated the spawning migration, making up 82 percent of captured fish.

Age III, IV, V and VI grayling made up 58.2, 22.4, 16.4 and 3.0 percent of captured grayling spawners. Nelson (1954) has reported that grayling usually become sexually mature at age III in the southern portion of their range with some maturing at age II.

There was a preponderance of males in age classes III and IV but females outnumbered males in age classes V and VI. The overall sex ratio for captured spawning grayling was 1.7 males to 1 female. Female grayling outnumbered males in the spawning runs out of Agnes (Peterman, 1972) and Elk Lakes (Lund, 1974). However, both of these lakes had smaller inlet streams with fewer suitable spawning areas than the West Fork of Hyalite Creek. Peterman attributed the preponderance of females to antagonistic behavior between males for a limited number of spawning territories. Although antagonistic behavior between males was also observed during this study, the availability of suitable sites did not appear to be limited since grayling were observed spawning in shallow riffles, backwaters and side channels up to 1.8 Km. above the mouth of the West Fork.

TABLE 12. NUMBERS, TOTAL LENGTHS AND AGES OF SPAWNING FISH BY SPECIES AND SEX CAPTURED IN THE WEST FORK OF HYALITE CREEK IN 1975.

Species	Age	Sex	Number	Total Length Range (mm)	Total Length Mean (mm)
Grayling	III	Male	58	297-382	362
		Female	20	328-380	353
	IV	Male	18	387-420	401
		Female	12	372-410	390
	V	Male	7	385-437	419
		Female	15	398-444	416
	VI	Male	0	---	---
		Female	4	412-432	421
Cutthroat Trout Wild Appearing	III	Male	9	302-375	339
		Female	2	325-365	345
	IV	Male	3	379-423	397
		Female	3	405-421	413
	V	Male	1	450	450
		Female	4	445-530	477
Cutthroat-Rainbow Hybrids	III	Male	3	334-344	339
		Female	1	350	350
	IV	Male	1	379	379
		Female	1	428	428
	V	Male	1	554	554
		Female	1	540	540

The mean lengths of male grayling in age classes III-V were greater than those of females, however, in a T-test only males in age classes III and IV had significantly greater lengths than females of the same age ($p<0.05$) (Table 13). Reed (1964) found the mean lengths of three-year-old male grayling to be significantly greater than those of females of the same age in the Tanana River drainage of Alaska.

TABLE 13. COMPARISON OF MEAN LENGTHS OF MALE AND FEMALE GRAYLING AGE III AND IV. T-TEST FOR TWO INDEPENDENT GROUP MEANS.

Age	Male (n)	Total Mean Length (mm)	Female (n)	Total Mean Length (mm)	Difference (mm)	T	2-Tailed P Value
III	58	361.5	20	352.5	9.03	2.35	0.020
IV	18	401.2	12	389.7	11.56	2.61	0.014

Only 13 male and 9 female sexually mature cutthroat trout were captured from June 3-July 23, all were wild appearing fish. Age III, IV and V cutthroat made up 50.0, 27.3 and 22.7 percent of the cutthroat captured. No marked hatchery cutthroat were captured in the stream even though they were all in their fourth summer of life (age III). Forty-six (46) marked hatchery cutthroat (28 males and 18 females) taken from the reservoir in the first three weeks of June by fishermen were examined and found to have little or no gonadal development. Lund (1974) found that hatchery cutthroat trout did not make any significant contribution to the spawning run out of Elk Lake until age IV.

Five male and three female cutthroat-rainbow hybrid trout were captured in the spawning run. Age III, IV and V fish made up 50.0, 25.0 and 25.0 percent of the hybrids captured.

Recruitment

A rectangular drift net (15 cm by 61 cm) was installed August 10 in each fork of Hyalite Creek to subsample the downstream migration of fry. Each drift net covered approximately one-sixth of the stream. The contents were collected in early morning and evening daily from August 11-August 28 and preserved in 10 percent formalin. Fry were separated from debris at Montana State University, identified by comparison with known fry and counted.

Only two fry, both grayling, were collected from the East Fork. This was consistent with the near absence of spawners captured in the East Fork.

No cutthroat trout fry were captured, however, this does not imply that there was no successful natural reproduction in 1975. Cutthroat trout fry have been shown to remain in their natal streams for up to a year or more (Bjornn, 1957) before migrating to their rearing areas.

One thousand, nine hundred and seventy-five (1975) grayling fry were collected from the West Fork (Table 14). Over two-thirds of these fry were captured between evening and morning. Kruse (1959) found greatest grayling fry downstream movement to be in late evening between 7:30 P.M. and 10:30 P.M. The interval between the apparent peak of grayling spawning activity in the West Fork and the peak of downstream fry migration was 34 days (Fig. 8) with mean daily stream temperature ranging from 7 to 10.7 C.

TABLE 14. NUMBERS OF DOWNSTREAM MIGRATING GRAYLING FRY CAPTURED IN THE WEST FORK OF HYALITE CREEK FROM AUGUST 11 TO AUGUST 29, 1975.

Date	Morning (%)	Evening (%)
August 11	11	0
12	12	0
13	6	20
14	35	31
15	58	37
16	44	59
17	38	13
18	163	92
19	286	109
20	139	36
21	133	25
22	178	82
23	48	13
24	50	7
25	49	30
26	47	35
27	25	18
28	24	22
Totals	1346 (68%)	629 (32%)
Grand Total 1,975		

Species Composition

Experimental gill nets were fished around the periphery of Hyalite Reservoir from September 30 through October 2, 1974 and August 11-25, 1975. The numbers and kinds of fish taken during these operations are presented in Table 15. Cutthroat trout, grayling and brook trout made up between 15 and 21 percent, 61 and 70 percent and 15 and 18 percent of each year's catch, respectively. Grayling in age classes I through V were taken in each year indicating successful

TABLE 15. SPECIES COMPOSITION AND AGE GROUPS OF FISH TAKEN IN GILL NETS IN HYALITE RESERVOIR FROM SEPTEMBER 30 TO OCTOBER 2, 1974 AND AUGUST 11 TO 26, 1975.

Species	Age I	II	III	IV	V	VI	Total (%)
			1974				
Grayling	47	68	7	2	2	2	128 (70%)
Wild Appearing Cutthroat Trout	15	6	3	-	-	-	24 (13%)
Hatchery Cutthroat Trout	--	3	-	-	-	-	3 (2%)
Brook Trout	20	5	3	-	-	-	28 (15%)
							183
			1975				
Grayling	60	29	56	6	7	-	158 (61%)
Wild Appearing Cutthroat Trout	16	13	19	5	-	-	53 (20%)
Hatchery Cutthroat Trout	--	--	2	-	-	-	2 (1%)
Brook Trout	12	24	10	2	-	-	48 (18%)
							261

reproduction occurred from 1969 through 1974. A strong 1972 year class of grayling was indicated by the relatively high numbers captured as two-year-olds in 1974 and three-year-olds in 1975. Wild appearing cutthroat trout were 8 and 26 times more abundant than hatchery cutthroat in the 1974 and 1975 catch, respectively.

Personnel of the Montana Fish and Game Department fished the periphery of the reservoir with experimental gill nets in June, 1972

and captured 104 fish. Cutthroat trout, grayling and brook trout made up 74, 16 and 10 percent of their catch, respectively. The differences in species composition of their sample and mine appear to reflect the change in species composition in the reservoir from 1972 to 1974-75.

Population Estimate of Grayling Age III and Older

The population of grayling age III and older present in July 1975 with 95 percent confidence intervals was estimated to be 808 (±381). One hundred and thirty-two grayling in this age group were marked or affixed with numbered T-tags in the spawning run during July, 1975. In August of that year, 78 grayling age III and older were captured in the reservoir using gill nets. Twelve of these fish bore marks or tags. Marked or tagged fish were taken from all four approximately equal sectors of the reservoir. The estimate was made with Chapman's modification of the Petersen estimator (Ricker, 1958).

DISCUSSION

During 1974 and 1975, the fishery of Hyalite Reservoir was largely dependent on the catch of cutthroat trout with this species making up 96 and 76 percent of the estimated total harvest during the two years, respectively. Fishing success and harvest were dependent on the availability of hatchery cutthroat trout which contributed heavily to the creel during their first year in the fishery but at greatly reduced levels thereafter. In 1974, when a previously unexploited plant of hatchery cutthroat trout entered the fishery, the catch rate and harvest were nearly two and two and one-half times as great, respectively, as in 1975 when no previously unexploited plant was available. Hatchery cutthroat entering the fishery in 1974 made up 72 percent of the total estimated harvest in that year but only 25 percent in 1975, their second year in the fishery. Hatchery cutthroat entering the fishery in 1973 were in their second and third year in the fishery during my study and made up only 9 and 2 percent, respectively, of the total estimated harvest. The combination of angling and natural mortality appeared to limit the longevity of hatchery cutthroat in the reservoir.

The estimated number of wild appearing cutthroat trout harvested remained less than 500 in both years. This is less than 6 fish per surface hectare at maximum pool.

The factors limiting the naturally reproduced population of cutthroat trout in the reservoir are not known. Food does not appear to be limiting since growth rates for wild appearing cutthroat are good even with competition from hatchery cutthroat.

Factors related to reproduction or early life history may be limiting recruitment to the population. Suitable spawning sites appear to be abundant in the West Fork, yet the cutthroat spawning run in 1975 was small and made up exclusively of wild appearing fish (ages III-V). The absence of hatchery cutthroat in the spawning run is perhaps due to their apparent limited longevity in the reservoir and lack of instinct necessary to enter inlet streams to spawn. During 1974, three unmarked female hatchery cutthroat trout from plants prior to 1972 were examined from the creel and contained developed eggs in late July after spawning should have occurred.

The timing of cutthroat trout spawning in relation to stream flow may be detrimental to reproduction. Sexually mature cutthroat trout entered the West Fork during 1975 as flow was increasing from runoff and most spawning appeared to occur before the runoff peak. If the chronology of the cutthroat spawning run in 1975 is typical, high water could be destroying redds and eggs.

No downstream migrating cutthroat trout fry were captured in 1975. This may indicate unsuccessful reproduction or that fry are remaining in the natal stream for a period of time after emergence

rather than migrating downstream to the reservoir. Cutthroat trout fry are planktivorous and may have a greater chance for survival if they migrate downstream to the reservoir with its greater zooplankton food supply after exhaustion of their yolk sacs. Remaining in the West Fork beyond sac fry would also subject the fry to predation by and competition with stream dwelling brook trout. The decline of the cutthroat trout populations in the Priest Lakes of Idaho was attributed by Bjornn (1958) to be in part due to cutthroat juvenile mortality induced by remaining in natal streams for up to three years before migrating back to the lakes.

The majority of fishermen interviewed during my study indicated a decided preference for catching cutthroat trout over grayling and brook trout. They would like an increase in the catch of cutthroat trout from the 1975 level. The introduction of catchable or sub-catchable cutthroat is a relatively expensive way to satisfy their desire. The most economical way of increasing the availability of cutthroat trout would be through increased natural reproduction. The Montana Fish and Game Department is currently planning to stock both forks of Hyalite Creek with the eyed eggs or fry of wild, inlet spawning cutthroat trout from Yellowstone Lake for several consecutive years, beginning in 1976. Homing to natal streams by cutthroat trout has been documented by Ball (1955), among others, and salmonid juveniles are thought to imprint on their natal streams during or just

prior to migration to rearing areas (Hara, 1970). This management plan has great potential if an early maturing parental stock is used that spawns in summer after high water and whose young migrate soon after emergence from the gravel. If successful, the present harvest of cutthroat trout would be supplemented and a substantial spawning migration back to the natal streams may be established.

The decline of Arctic grayling over a portion of the southern extension of their range has been documented by Vincent (1962) and has prompted many people to consider it as a rare or endangered species. Whatever factors are limiting the wild cutthroat trout population in Hyalite Reservoir do not appear to be acting as severely on the Arctic grayling population. The grayling population is a naturally reproducing one and may be the descendents of a population existing in the upper Hyalite drainage prior to the completion of the dam. The age structure of the population, reproductive success in 1975 and annual increments of growth suggest a healthy population that is competing successfully with the cutthroat trout and brook trout populations in the reservoir. The chronology of grayling reproduction in 1975 appeared to be reproductively advantageous. Spawning grayling did not enter the West Fork until stream flow was receding from runoff peak which would minimize dislodgement of their broadcast eggs due to increased stream flow. Grayling fry migrated downstream to the reservoir and its greater zooplankton food supply shortly after emergence.

Downstream fry movement appeared to be greatest after dark, a behavioral mechanism which could be advantageous in evading predators.

APPENDIX

TABLE 4. AVERAGE NUMBER OF SHORE AND BOAT FISHERMEN PER COUNT AT HYALITE RESERVOIR FROM JUNE TO SEPTEMBER, 1974 AND 1975.

1974			1975		
Stratum	Shore	Boat	Stratum	Shore	Boat
I	5.93	4.80	I	4.67	0.83
II	4.18	6.67	II	7.68	4.58
III	4.29	4.90	III	3.12	5.98
IV	2.88	3.96	IV	1.61	4.35
V	3.00	2.24	V	2.11	1.28
VI	1.78	1.19	VI	1.28	1.78
Average	3.68	3.96	Average	3.41	3.13

TABLE 5. AVERAGE NUMBER OF SHORE AND BOAT FISHERMEN PER COUNT ON WEEKDAYS AND WEEKENDS-HOLIDAYS AT HYALITE RESERVOIR FROM JUNE TO SEPTEMBER, 1974 AND 1975.

	Weekdays					Weekends-Holidays			
	Shore		Boat			Shore		Boat	
Stratum	1974	1975	1974	1975	Stratum	1974	1975	1974	1975
I	4.51	4.63	3.10	0.32	I	7.50	5.25	11.00	1.61
II	4.25	5.92	3.21	2.42	II	5.67	11.83	11.28	7.45
III	3.15	1.81	3.43	3.42	III	7.13	7.70	8.57	11.08
IV	2.54	1.06	3.38	2.65	IV	4.00	2.63	5.14	8.94
V	2.95	1.50	1.36	0.78	V	3.13	3.63	4.44	2.52
VI	1.63	1.50	0.67	0.93	VI	2.25	1.73	2.05	2.64
Average	3.17	2.74	2.53	1.75	Average	4.95	5.46	7.08	5.71

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