The biology and population characteristics of the Arctic grayling in Lake Agnes, Montana
by Larry George Peterman

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of
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Abstract:
The biology and population dynamics of the grayling in Lake Agnes were studied during the summers of 1970 and 1971. In 1971, the ice cleared from the lake on May 28, and the peak of spawning migrations occurred from June 15 to 24. A diurnal movement of spawning grayling into and out of the inlet stream was closely correlated to daily fluctuations in stream temperatures. The sex ratio of 9,364 fish captured in the spawning run was 2.5 females for every male. Intensive territorial behavior between spawning males was noted along the shoreline and at the mouth of the inlet and probably deterred many males from entering the stream. Male grayling generally averaged larger in size and grew faster than females. Grayling from Lake Agnes showed the slowest average growth rate of any reported in Montana. A few grayling matured at age II, however, most matured at age III. Only one adult grayling out of 559 was aged as over 6 years old. The number of eggs per female increased with the size of the fish and averaged 356 eggs per ounce of fish. The adult population was estimated using the Peterson method and the Schnabel method. The total estimate based on the Peterson method was 24,214 with a standing crop of 72.8 kg/ha.

Total population estimates were in close agreement between both methods, however, male and female estimates based on the Schnabel method were 47.5 percent higher and 18.1 percent lower, respectively, than comparable Peterson estimates. Reasons for past fluctuations in numbers and size of fish are discussed.

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A thesis submitted to the Graduate Faculty in partial fulfullment of the requirements for the degree

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ABSTRACT

The biology and population dynamics of the grayling in Lake Agnes were studied during the summers of 1970 and 1971. In 1971, the ice cleared from the lake on May 28, and the peak of spawning migrations occurred from June 15 to 24. A diurnal movement of spawning grayling into and out of the inlet stream was closely correlated to daily fluctuations in stream temperatures. The sex ratio of 9,364 fish captured in the spawning run was 2.5 females for every male. Intensive territorial behavior between spawning males was noted along the shoreline and at the mouth of the inlet and probably deterred many males from entering the stream. Male grayling generally averaged larger in size and grew faster than females. Grayling from Lake Agnes showed the slowest average growth rate of any reported in Montana. A few grayling matured at age II, however, most matured at age III. Only one adult grayling out of 559 was aged as over 6 years old. The number of eggs per female increased with the size of the fish and averaged 356 eggs per ounce of fish. The adult population was estimated using the Peterson method and the Schnabel method. The total estimate based on the Peterson method was 24,214 with a standing crop of 72.8 kg/ha. Total population estimates were in close agreement between both methods, however, male and female estimates based on the Schnabel method were 47.5 percent higher and 18.1 percent lower, respectively, than comparable Peterson estimates. Reasons for past fluctuations in numbers and size of fish are discussed.

INTRODUCTION

The Arctic grayling *Thymallus arcticus* (Pallas), commonly occurs throughout northwestern Canada in and north of the Peace, Athabaska, and Churchill Rivers, and in Alaska. As a result of glacial activity which is believed to have extended their range southward, relict grayling populations historically have been present in Michigan and Montana (Vincent 1962). Although once fairly abundant in both of these locations, the grayling has become extinct in Michigan and has had its range and numbers greatly reduced in Montana.

The original range of the grayling in Montana encompassed the headwaters of the Missouri River above Great Falls. Here they were chiefly found in the Jefferson, Madison, Gallatin and Smith Rivers and their tributaries, and in the Sun River.

Today, the only important remnant of these original populations occurs on the Red rock Lakes National Wildlife Refuge in southwestern Montana. Latest records indicate that there are 39 self-sustaining grayling populations in lakes and 14 in streams throughout western Montana. With the exception of the Red Rock Lakes area and the Upper Big Hole Drainage, most of these populations are the result of introductions (Holton 1971).

Lake Agnes is considered one of the best grayling lakes in Montana. In the past, the grayling of this lake have shown considerable fluctuation in numbers of fish and size of individuals. The principal

objectives of the present study, conducted during the summers of 1970 and 1971, were to determine the present status of the population and gather additional information on the biology of the species.

DESCRIPTION OF STUDY AREA

Lake Agnes is located in the Pioneer Mountains of southwestern Montana, approximately 40.2 kilometers north of Dillon. It lies in a high mountain basin at an elevation of 2.3 kilometers and is surrounded by conifer-covered hills which slope steeply to the shore. In the early 1930's, grayling were introduced into the lake which was originally devoid of fish. The introduction was successful and from 1940 until the early 1960's, these grayling were the primary source of eggs for the Montana Fish and Game Department. The number of eggs taken per year varied from 300,000 to almost 4,500,000.

Lake Agnes is one of three natural lakes in the Rock Creek Drainage which are used for irrigation purposes. The natural outlet of the lake was modified through the installation of a headgate to regulate the withdrawal of water which usually begins in late summer. In 1970 and 1971, drawdown began on August 22 and 15, respectively. During both years, the lake level was lowered approximately 1.5 meters, but a 2.1 meter drawdown is possible when the lake is filled to capacity. At high water in 1970 and 1971, the lake contained 40.9 hectares (101 surface acres) of water and after drawdown, 37.5 hectares. At high water, the lake has a shoreline development of 1.54.

The maximum depth of Lake Agnes at high water was 17.7 meters (58 feet). At this time, 22 percent of the lake area was 6.1 meters deep or less and 44 percent was 12.2 meters deep or more. During July and August of 1971, a thermocline was present at the 6.1 meter depth. By August, there was a progressive decline in the amount of dissolved oxygen below 9.1 meters and at a depth of 12.2 meters or more, the concentration was less than 1 ppm. Other chemical and physical characteristics of Lake Agnes for the summer of 1971 are listed in Table 1.

Table 1. Chemical and physical properties of Lake Agnes - summer 1971.

	Range	Average
pH	7.56 - 8.05	----
Total Alkalinity (ppm $CaCO_3$)	71.4 - 71.8	71.6
Total Hardness (ppm $CaCO_3$)	28.0 - 31.8	29.7
Conductivity (micro ohms)	80.0 - 82.0	80.7
Turbidity (JTU)	7.0 - 8.0	7.5
Water Temperatures 0.6 meters below surface (Maximum)	10.0 C - 19.0 C	15.4 C
Water Temperatures 0.6 meters below surface (Minimum)	6.0 C - 13.0 C	10.8 C

The primary inlet stream enters the lake from the west and is the major spawning area. It has its source, principally from runoff, in the surrounding hills and meanders through several abandoned beaver impoundments before reaching the lake. The period of high flow for the inlet stream occurs in June and coincides with the spawning season of the grayling. At this time, the stream flows as much as 3.4 to 5.1 m^3/min (2-3 cfs), however, by the end of July the flow is much reduced. In the past when beaver were active during a low water year, little or no water flowed below the dams and available stream spawning area was practically eliminated (Robert A. Mitchell - personal communication). The stream is still in the process of eroding its way through old beaver impoundments. As a result, the stream bed and banks are very unstable and bank cave-ins during the period of high flow are not uncommon. Due to the changing nature of the stream, natural obstructions for migrating grayling periodically occur and the portion of the stream available for spawning may vary greatly from year to year. Brown (1938) found that in 1936, about 91.4 meters (100 yards) of stream adjacent to the lake were available for spawning. In 1970, 181.0 meters were available for spawning, but only 43.9 meters in 1971. The stream bottom consisted of a coarse, granular sand; 57 percent of the particles being from 10.0 to 1.981 mm in diameter, 28 percent from 1.980 to 0.833 mm, and the remainder made up of smaller material. Two small tributaries enter the lake along the south shore, but only about 3.1 to 6.1 meters of each

were available for spawning. These ceased flowing by the beginning of August.

The major aquatic plants of Lake Agnes were *Potamogeton praelongus*, *Potamogeton nodosa*, *Potamogeton robbinsii*, and *Myriophyllum* sp. These occurred in thick beds along the shore, many of them at depths of over 1.5 meters. Also present in lesser quantities were *Potamogeton pectinatus* and *Potamogeton* sp. *Chara* sp. was quite common throughout much of the lake and *Nitella* sp. was also present.

METHODS

The grayling population of Lake Agnes was estimated during the summer of 1971 by two mark and recapture methods. Population estimates using the Peterson method were based on data obtained by marking fish in the inlet and recapturing fish in the lake by trapping. Population estimates using the Schnabel method were based entirely on data obtained by trapping fish in the lake. Formula 5 of the Michigan Institute for Fisheries Research (1960) was used for population estimates based on the Peterson method (Bailey modification) with confidence intervals computed using formula 6. Population estimates based on the Schnabel method were made using formula 3.12 of Ricker (1958) with confidence intervals computed using formulas 3.13 and 3.14.

Spawning grayling were captured at random in the inlet throughout the spawning runs of 1970 and 1971 by herding them downstream into live boxes. Capture runs were started in late morning when sufficient

numbers of fish had concentrated below the barrier and were repeated throughout the day until the number of marked fish exceeded the number of unmarked fish in the sample. Length, weight, and sex were recorded and scale samples were taken from each fish captured in 1970. Due to the large number of fish handled in the 1971 spawning season, lengths, weights, and scale samples were taken from approximately 50 fish of each sex for each centimeter size interval. In addition, lengths were taken on about 30 percent and sex was determined on all fish captured. In 1970, a variety of artificial tags were used, but in 1971 all fish were marked by clipping the adipose fin.

Determination of sex of mature fish was based on the size and shape of the dorsal fin (Ward 1951). Immature grayling were separated from mature fish by visual inspection. Immatures had silvery bodies and small, light colored dorsal fins. Adults had larger, more brilliantly colored dorsal fins and darker bodies. In addition, many mature males still exuded a small amount of milt when handled and females had very flaccid abdomens.

Grayling were trapped in the lake with modified fyke nets. Each net consisted of a 3.7-meter long hoop net with a 0.9-meter diameter opening, preceded by a 0.9 x 1.8 x 0.6 meter box of mesh covered steel frames. Leads, 1.2 meters high, were attached to the box and varied in length from 7.6 to 15.2 meters. In 1970, two modified fyke nets were used and only a small portion of the lake was sampled. In 1971,

four modified fyke nets were used and the traps were moved to a new location each day until all of the suitable portion of the shoreline, about 75 percent, was sampled. Portions not trapped were primarily three areas where the bottom sloped too steeply (Fig. 1).

All trapped fish were measured, sexed, marked, and released near their point of capture. In 1971, the lake was divided into five areas and the fish captured in each area were marked with a distinctive partial fin clip. Holes punched in the anal fin were used to indicate the number of times a fish had been recaptured in a particular area. While traps were in operation, a partial creel census was conducted to determine the proportion of marked to unmarked fish harvested.

Prior to and during the early part of the spawning run in 1971, females were collected to obtain egg samples. Females were preserved in 10 percent formalin and the eggs later removed and stored in 40 percent isopropal alcohol until counted. Fry and fingerlings were collected by dip netting along the shore and electrofishing the shoal areas.

A constant recording Taylor thermograph was placed in the inlet in 1971 to monitor stream temperatures during the spawning run. Taylor maximum-minimum thermometers were placed in two positions 0.6 meters below the surface of the lake during the summer months. Temperature profiles were obtained with an ARA model FT3 All-Weather Hydrographic Thermometer. Water chemistry analysis followed procedures outlined in Standard Methods for the Examination of Water and Waste Water (1971).

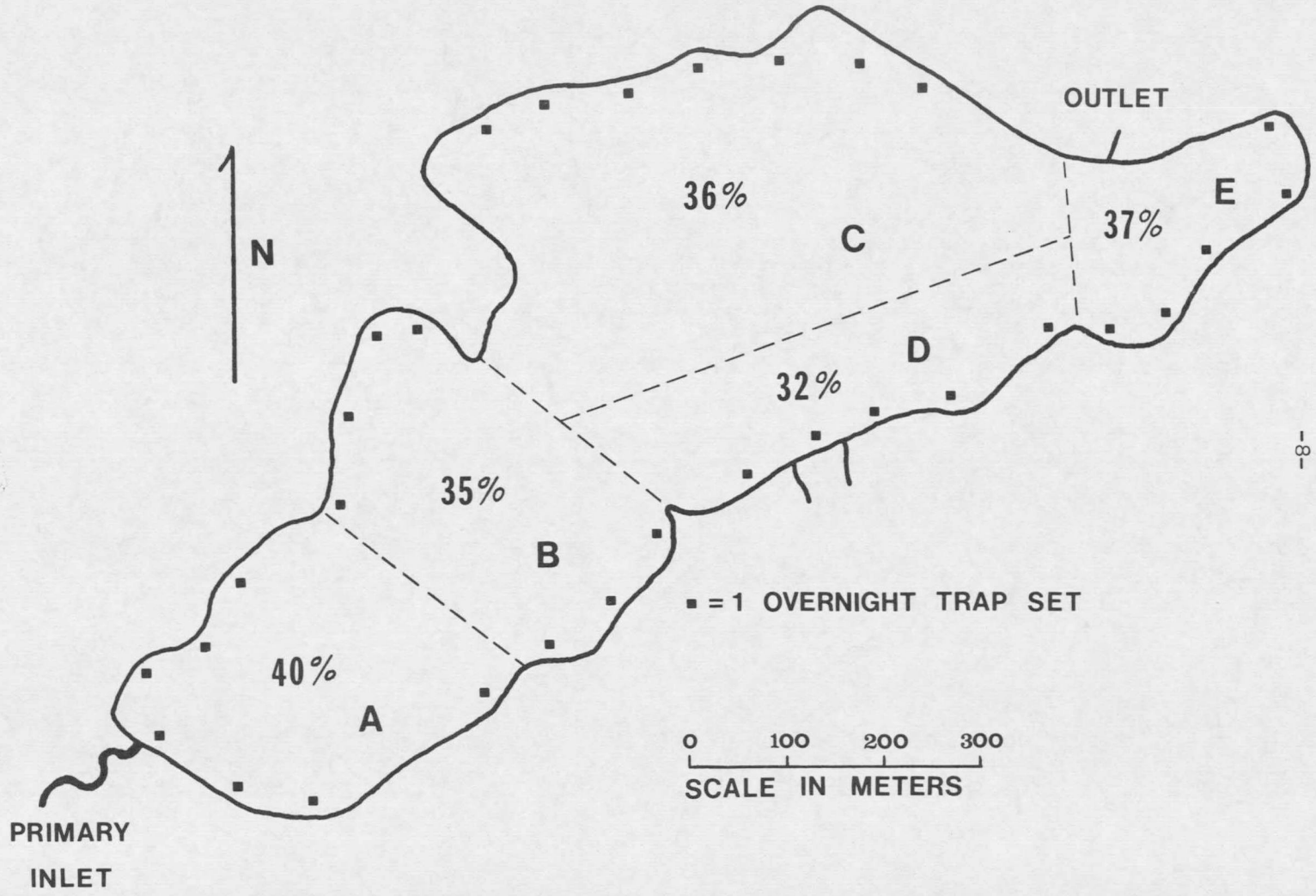


Figure 1. Map of Lake Agnes showing trap locations and the percent of the total number of grayling caught in trap nets in each area that had been marked in the spawning run.

RESULTS

Spawning

The ice cleared from Lake Agnes on May 28, 1971. Grayling first appeared in the inlet for spawning on June 7. The peak of the spawning run occurred from June 15 to 24, and gradually tapered off until July 6, when few fish were seen. Fish apparently began moving into the inlet when the average daily stream temperatures approached 2.8 C (37 F) (Table 2). The surface lake water warmed more rapidly than the stream

Table 2. Summary of spawning stream temperatures and average catch per day of unmarked grayling, 1971.

Time Period	Maximum Temp.	Minimum Temp.	Average Daily Temp.	Average hours/day Over 4.4 C	Average Catch Per Day
5/28-5/31	6.8 C (44.5 F)	0.6 C (33.0 F)	1.9 C (35.5 F)	1.3	----
6/1-6/4	5.3 C (41.5 F)	0.6 C (33.0 F)	1.8 C (35.4 F)	0.7	----
6/5-6/8	6.7 C (44.0 F)	0.6 C (33.0 F)	2.4 C (36.7 F)	4.4	----
6/9-6/12	6.7 C (44.0 F)	1.1 C (34.0 F)	2.4 C (36.7 F)	1.6	548
6/13-6/16	7.2 C (45.0 F)	1.1 C (34.0 F)	2.9 C (37.6 F)	6.4	1,240
6/17-6/20	8.3 C (47.0 F)	1.3 C (34.5 F)	3.4 C (38.4 F)	7.5	935
6/21-6/24	10.6 C (51.0 F)	2.2 C (36.0 F)	5.1 C (41.3 F)	11.6	906
6/25-6/28	8.3 C (47.0 F)	2.2 C (36.0 F)	3.9 C (39.0 F)	6.0	133

and may have influenced movements of the grayling prior to and during the run. From June 11 to 24, the maximum and minimum temperatures of the lake water were 2.8 C°(5 F°) to 4.4 C°(8 F°) higher than stream temperatures. Ice cleared from the lake on June 2, 1970, and the peak of the run occurred from June 11 to 20.

Grayling exhibited a marked diurnal fluctuation in numbers present in the inlet during the spawning run both years. Around mid-day, large schools were observed entering the stream and peak numbers were reached by late afternoon. Fish began moving downstream in early evening and only a small number of fish remained in the stream overnight. Bishop (1971) found a similar diurnal movement of spawning grayling in Providence Creek, Canada, with no fish observed in the creek during the night and large numbers moving upstream around noon. On larger or longer tributaries, similar diurnal movements have not been reported (Nelson 1954, Kruse 1959).

The diurnal movement in and out of the spawning stream was closely related to temperature. Large numbers of fish entered the inlet when stream temperatures were 4.4 C (40 F) or higher, and this seldom occurred before noon. Maximum temperatures were reached between 3:00 and 6:00 p.m. and fell below 4.4 C by late evening. Cold, cloudy days with rain or snow lowered maximum stream temperatures and this in turn, had a depressing effect on the numbers of fish moving upstream. Fabricius and Gustafson (1955) concluded that the daily rhythm of water temperatures

was very marked in shallow streams and was the most important stimulus affecting the grayling's rhythm of spawning and defense of territory.

Spawning fish were also observed in the two small tributaries. Several of these fish had been previously caught in the primary inlet stream and marked. In addition, spawning activity was noted along the shoreline of the lake. This appeared quite intensive at times with as many as six observations in 30 minutes. All of the observations were made in shallow water over small gravel or coarse sand bottoms, however, visibility was limited in deeper waters and over darker mud-bottom types.

During the spawning season, certain male grayling appeared to establish territories and actively defend them against intruding males. This antagonistic behavior was most frequently observed along the shoreline and at the mouth of the inlet. Little or no antagonism was noted in the stream at the peak of the run when spawning densities were extremely high, however, considerable conflict was observed at the mouth of the inlet at this time. This may have deterred many males from entering the stream. No aggressive behavior of males towards females or between females was noted.

A total of 9,364 grayling from the 1971 spawning run was marked from June 11 to 28. The sex ratio of these fish was 1 male to 2.5 females. The sex ratios by days of capture show a marked increase in the proportion of females during the latter part of the run (Table 3).

Table 3. Catch statistics and sex ratios of grayling in the 1971 spawning run.

Date	Total Number of Fish Marked	Sex Ratio ♂/♀	Total Number of Recaptures	Sex Ratio (Recaptures) ♂/♀
6/11/71	370	1/2.7	---	-----
6/12/71	727	1/2.3	207	-----
6/15/71	976	1/2.3	277	-----
6/16/71	1,503	1/2.1	627	1/2.7
6/17/71	733	1/3.0	612	1/3.1
6/19/71	1,055	1/2.5	498	1/3.0
6/20/71	1,017	1/2.8	354	1/4.2
6/22/71	871	1/2.1	498	1/1.9
6/23/71	1,035	1/2.3	622	1/3.0
6/24/71	811	1/3.1	717	1/3.0
6/27/71	208	1/4.5	178	1/3.1
6/28/71	58	1/6.2	48	1/2.7
Total	9,364	1/2.5[1]	4,638	1/2.9[1]

[1]Average

In 1970, a sample of 512 fish revealed a sex ratio of 1 male to 1.8 females. Both of these sex ratios are significantly different from an expected 1:1 ratio (χ^2 values 1695 and 45 respectively). Brown (1938) reported a male-to-female ratio of 1.5:1 in his study section on the inlet to Lake Agnes. Kruse (1959) found a sex ratio of 1:1 in the spawning run of grayling in Grebe Lake, Wyoming. Bishop (1971) found

a male-to-female ratio of 1.3:1 in a sample of 168 grayling from the spawning run in Providence Creek, Canada, but did not consider this statistically different from a 1:1 ratio. The higher proportion of females in the samples of recaptured fish would indicate that females entered the stream more frequently or stayed longer than males (Table 3).

The length-frequency of adult fish captured in the 1971 spawning run is shown in Figure 2. Females averaged 26.3 cm in total length and ranged from 22.4 to 33.5. Males averaged 27.9 cm and ranged from 24.0 to 35.8.

Population Estimates

Trapping fish in the lake in 1971 began on July 2 and was discontinued after July 16. During June and the first week of July, large schools of grayling were observed swimming along the shore. The average catch per overnight trap set in shallow water from July 2 through 9 was 142 fish. After this period, few fish were observed frequenting the shoal areas and the average catch per overnight set fell to 69. Warm surface water temperatures were believed to have forced the grayling into deeper waters. Gill nets set on the bottom at 12.2 to 15.2 meters on July 20 and 21 yielded no grayling, however, one set at about the 9.1 meter depth caught 83 fish. Abundant dissolved oxygen was present at 9.1 meters but less than 0.5 ppm at the deepest sets.

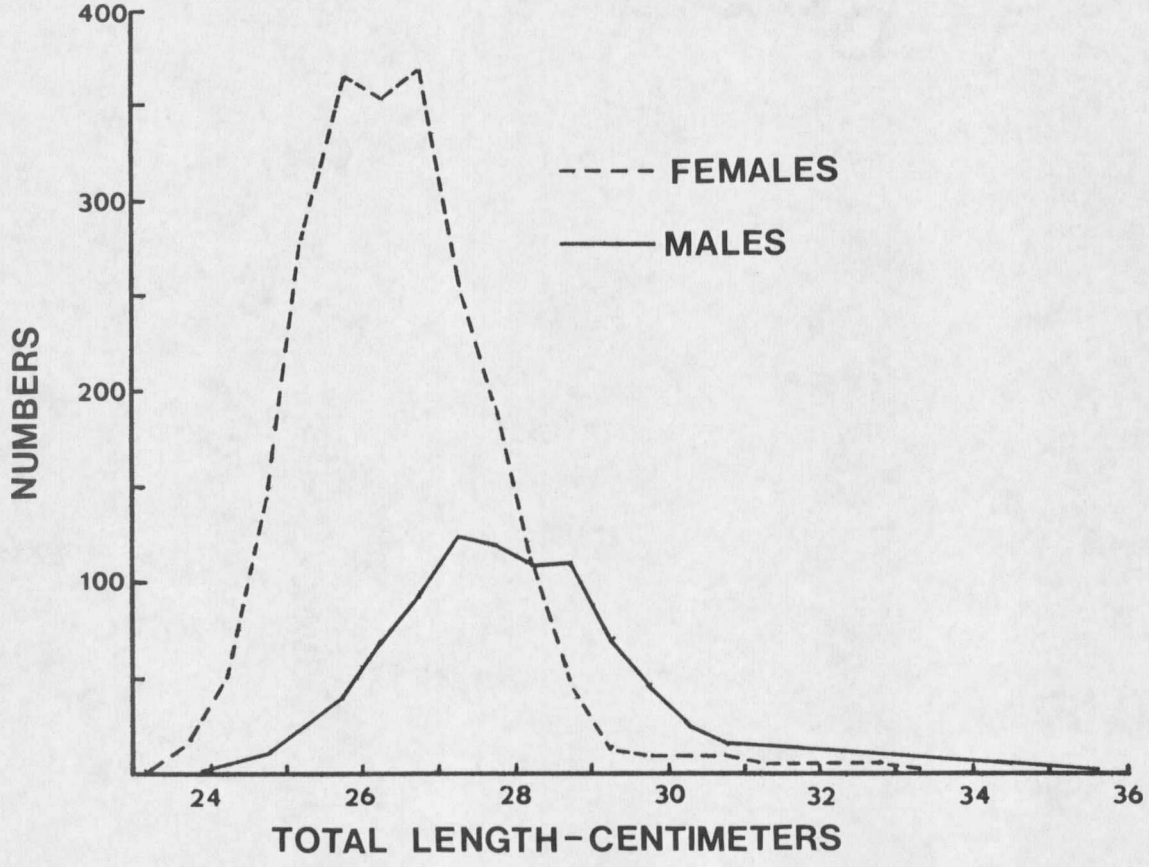


Figure 2. Length-frequency of 2,212 female and 870 male grayling captured in the 1971 spawning run.

A total of 31 trap days of effort (1 trap day = 1 overnight set) resulted in a catch of 1,189 adult males, 1,386 adult females, and 489 immatures. Of the adult fish trapped, 331 males (27.8%) and 600 females (43.3%) had previously been marked in the spawning run.

The sex ratio of the-trap caught adults was 1 male to 1.2 females. This was statistically different from an expected 1:1 ratio (χ^2 value 15) and from the sex ratio of the spawning run (χ^2 value 286). The more nearly 1:1 sex ratio in the lake and the lower percent recapture of males would indicate that a smaller proportion of the male population than the female was present in the spawning stream. The antagonistic behavior noted between males at the mouth of the inlet probably caused this.

The length-frequency for all fish trapped in 1971 is shown in Figure 3. The smallest grayling captured in the traps was 9.8 cm and the largest was 32.4 cm. The average length of adult males was 27.2 cm and ranged from 23.8 to 32.4. Adult females averaged 25.9 cm and ranged from 23.0 to 29.2. A mode of immature grayling appeared between 21.8 and 25.0 cm. These fish averaged 23.5 cm and scale analysis revealed their age as II+. Fish in another mode, between 9.8 and 18.3 cm, averaged 13.9 and all were yearlings.

A basic assumption in making population estimates is that the marked fish distribute themselves randomly throughout the population being estimated (Ricker 1958). An indication of the distribution of fish marked in the spawning run was obtained by comparing the percent

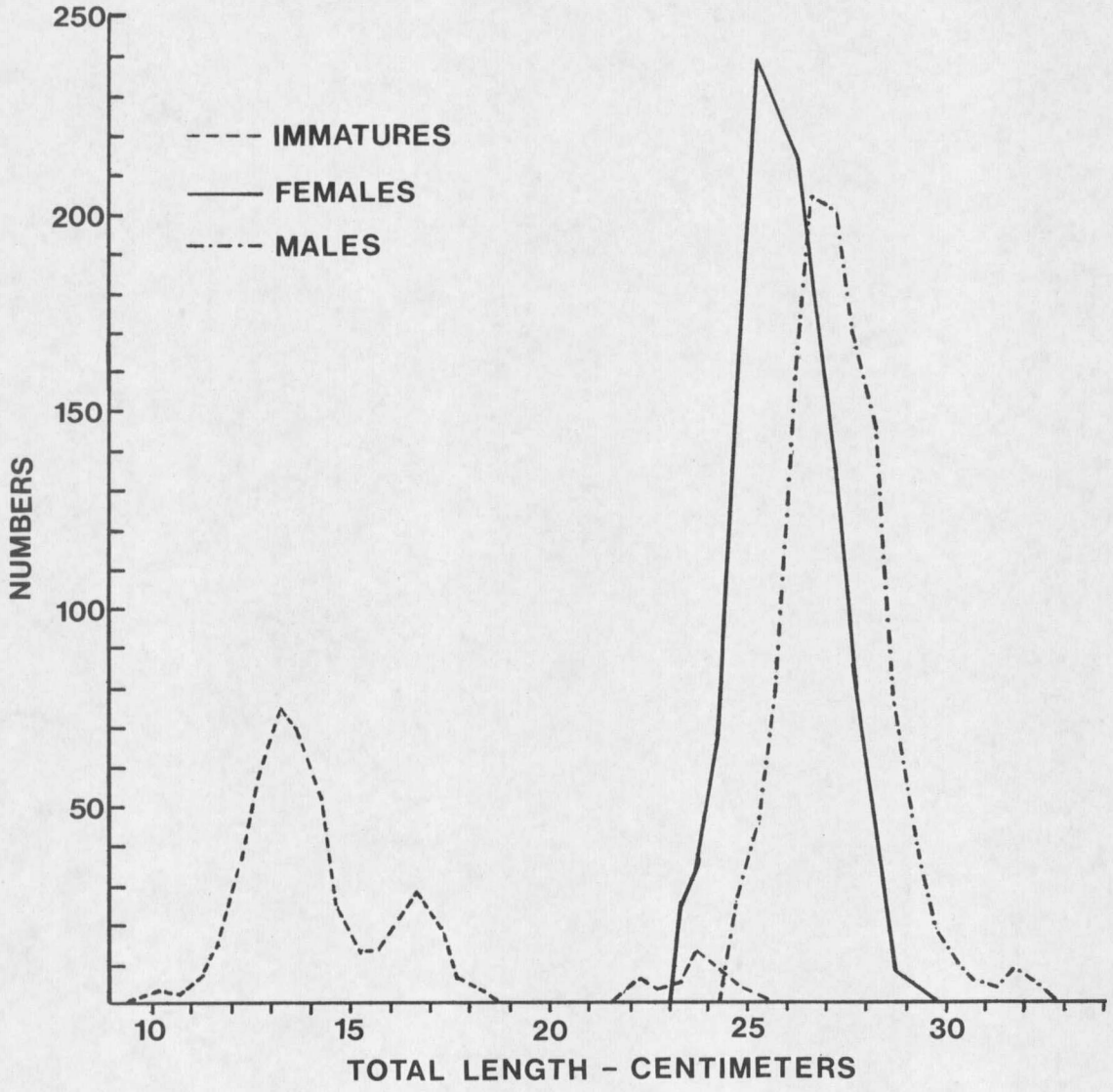


Figure 3. Length-frequency of 1,189 mature male, 1,386 mature female, and 489 immature grayling captured in traps during July 1971.

of the total number of grayling caught in each area that were recaptures (Fig. 1). These ranged from 32 to 40 percent with the area farthest from the point of marking having 37 percent recaptures. Recaptures for the entire lake averaged 35 percent. Also, 32 percent of fish caught by fishermen had been marked in the spawning run and most of the catch occurred in areas C, D, and E. Thus, for the Peterson estimate, the assumption of random distribution was met.

To determine random distribution of trap-caught fish in the lake for the Schnabel method, a comparison was made between the number of fish recaptured in the area of initial marking to the number recaptured in other areas (Table 4). The percent of recaptures occurring in the

Table 4. A comparison between the numbers of grayling recaptured in and outside the area of initial marking (percent in parentheses).

Area of Marking	Area of Recapture				
	A	B	C	D	E
A	4 (20)	9 (45)	2 (10)	1 (5)	4 (20)
B	8 (23)	7 (20)	16 (45)	2 (6)	2 (6)
C	2 (6)	7 (20)	13 (37)	8 (23)	5 (14)
D	3 (17)	6 (33)	3 (17)	5 (28)	1 (5)
E	2 (14)	2 (14)	1 (7)	4 (29)	5 (36)

area of initial marking varied from 20 to 37 percent. In two out of five cases, the area with fewest recaptures was also farthest from the area of initial marking, however, sample sizes of recaptures were small. To overcome potential bias from non-random mixing of trap-marked fish,

all of the suitable shoreline received approximately equal pressure and the traps were moved to a new location each day.

For estimates of the population based on the Peterson method, grayling were grouped into four size intervals for each sex to avoid possible bias due to a smaller proportion of the male population being marked and trap selectivity based on size. The interval estimates were then combined to give adult male and female estimates and a total adult population estimate (Table 5). This resulted in an estimate of 14,997 adult females and 9,217 adult males, for a total of 24,214.

Females from 24.0 to 27.9 cm and males from 26.0 to 29.9 cm comprised the bulk of the adult population. Standing crop of adults using this estimate was 72.8 kg/ha (64.8 lbs/acre). Kruse (1959) found a standing crop of 70.2 lbs/acre for grayling over 4.3 inches in Grebe Lake in 1953 and 70.9 lbs/acre for grayling over 8.4 inches in 1954.

Estimates of the population by the Schnabel method were based on 119 recaptures from 2,418 marked fish. Due to the small number of recaptures, grayling were grouped by sex only for these estimates. The total population estimate by the Schnabel method was 25,889. This was only 5.2 percent higher than the total Peterson estimate, but the confidence intervals were four times as great (Table 6). Also, Schnabel estimates for the adult male and female population were 47.5 percent higher and 18.1 percent lower, respectively, than comparable Peterson

Table 5. Catch statistics (1971) for adult grayling with Peterson population estimates, confidence intervals (CI), and standing crop for each sex and size group.

Size Group cm	Sex	Marked at Large	Total Capture	Total Recapture	Estimated Numbers (CI)	Total Weight kg	Standing Crop kg/ha
22.0-23.9	♀	53	59	15	199 (116-282)	18.7	0.5
24.0-25.9	♀	2,540	669	264	6,422 (5,810-7,034)	655.0	16.0
26.0-27.9	♀	3,522	609	299	7,161 (6,573-7,749)	895.1	21.9
28.0-33.9	♀	559	49	22	1,215 (851-1,579)	209.0	5.1
Total	♀	6,674	1,386	600	14,997 (14,069-15,925)	1,777.8	43.5
24.0-25.9	♂	219	151	28	1,148 (771-1,525)	111.1	2.7
26.0-27.9	♂	1,242	726	179	5,016 (4,369-5,663)	597.7	14.6
28.0-29.9	♂	1,034	282	106	2,735 (2,320-3,150)	419.0	10.3
30.0-35.9	♂	195	30	18	318 (230-406)	69.7	1.7
Total	♂	2,690	1,189	331	9,217 (8,356-10,078)	1,197.5	29.3
Pooled Total		9,364	2,575	931	24,214 (22,946-25,478)	2,975.3	72.8

Table 6. A summary of adult grayling catch statistics with Peterson and Schnabel population estimates and confidence intervals (CI) for the male, female, and total population.

Population Estimated	Type Estimate	Total Capture	Marked at Large	Total Recapture	Estimated Numbers (CI)
Adult male	Peterson	1,189	2,690*	331	9,217 (8,356-10,078)
	Schnabel	1,233	1,229**	47	13,600 (10,177-20,493)
Adult female	Peterson	1,386	6,674*	600	14,997 (14,069-15,925)
	Schnabel	1,450	1,289**	72	12,289 (9,569-16,886)
Total adult	Peterson	2,575	9,364*	931	24,214 (22,946-25,478)
	Schnabel	2,683	2,418**	119	25,889 (21,336-31,596)

*Fish marked in spawning run.

**Fish captured and marked in lake.

estimates. Due to the higher percent of recaptures and the smaller confidence intervals, the Peterson estimates are considered the most accurate.

Age and Growth

Age and growth data were obtained from analysis of scales taken from 559 grayling collected during the spawning run of 1971 and 80 collected in trap nets (Table 7). The average total length of adult females at the time of capture ranged from 1.4 cm smaller than adult males for age group II to 3.2 cm smaller for age group VI. Average calculated total length of females at annulus one was 0.9 cm smaller than males and 3.2 cm smaller at annulus six. Although there were exceptions, males generally grew faster than females in each year of life. Other authors reported similar differences in size and growth rates between sexes (Ward 1951, Kruse 1959). Reed (1964) found that sexually immature grayling showed little growth differences between sexes in Alaska, however, mature males grew faster than females.

The average growth of grayling in Lake Agnes was less than the average reported for six lakes and two streams in Montana (Peters 1964) (Fig. 4). Combined age and growth data obtained from 353 fish in Upper Red Rock Lake and Red Rock Creek (Nelson 1954) showed the best reported growth for grayling in Montana. Brown (1943) found the calculated standard length in centimeters at each annulus for ten grayling from Lake Agnes to be 11.4 - 1st year, 19.3 - 2nd year, 25.0 - 3rd year,

Table 7. Average calculated total lengths in centimeters at each annulus for grayling collected during 1971.

Age Group	Sex	Number	Average total length at capture	Calculated length at each annulus					
				1	2	3	4	5	6
I	I*	56	14.2	10.7					
II	I*	24	23.7	11.0	22.6				
	♂	16	26.9	14.4	25.0				
	♀	25	25.5	9.9	24.2				
III	♂	84	28.1	11.5	22.4	27.0			
	♀	99	26.6	12.1	22.0	26.3			
IV	♂	113	27.9	11.6	20.9	25.0	27.6		
	♀	116	26.4	8.8	18.9	23.4	26.2		
V	♂	57	29.2	7.3	17.8	22.9	26.1	28.6	
	♀	41	27.2	7.8	17.6	22.1	25.0	27.2	
VI	♂	5	31.2	8.9	18.7	22.9	26.4	28.8	31.2
	♀	3	28.0	8.1	16.0	21.0	23.8	26.3	28.0
	I*	80		10.8	22.6				
Totals	♂	275		10.8	20.9	25.1	27.1	28.6	31.2
	♀	284		9.9	20.2	24.3	25.8	27.1	28.0
	All	639		10.3	20.6	24.7	26.5	28.0	30.0

*Immature

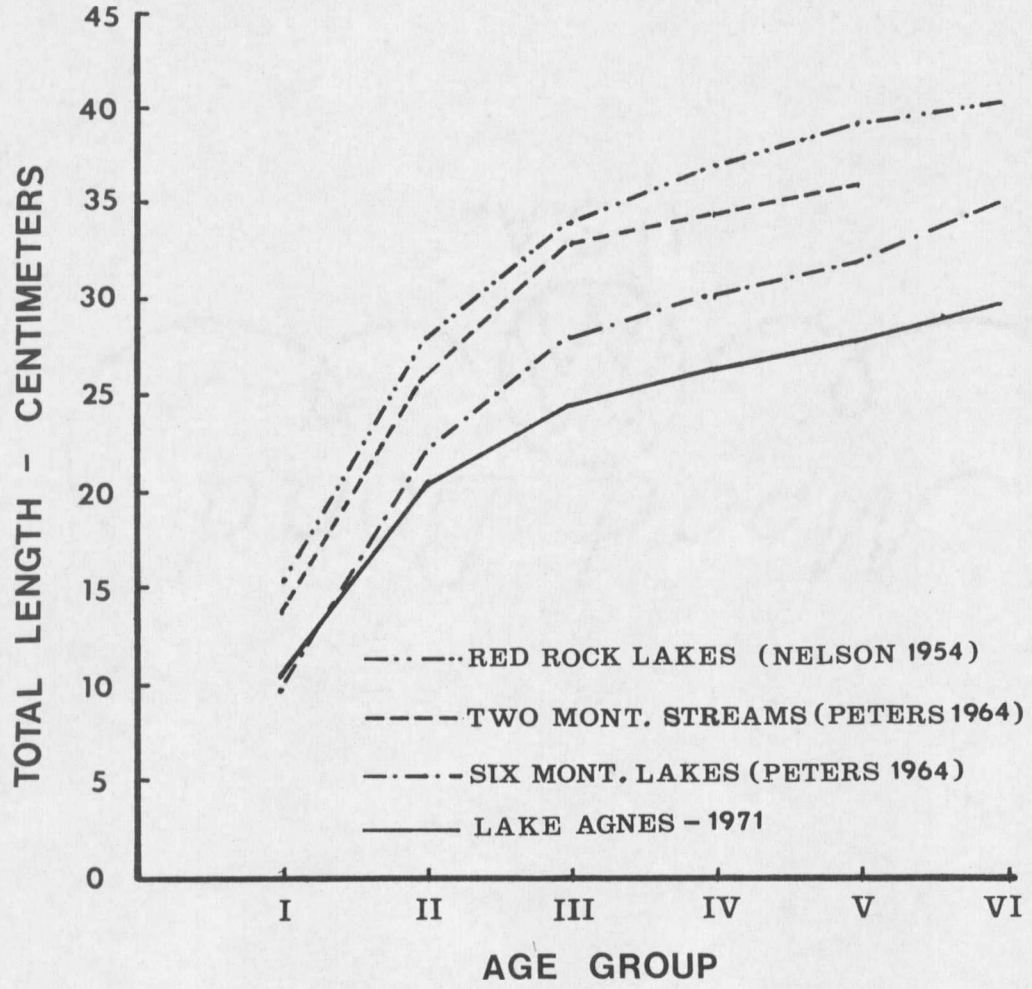


Figure 4. Comparison of growth rates for grayling in Montana.

27.6 - 4th year, and 27.9 - 5th year.

In the southern portion of their range, grayling usually mature at age III with a few maturing at age II (Kruse 1959, Ward 1951, Nelson 1954). In the 1971 spawning run, the percent of females in each age group were: 9.5 - II, 38.8 - III, 38.2 - IV, 12.7 - V, and 0.8 - VI. For males the percents were: 6.3 - II, 31.1 - III, 41.8 - IV, 19.4 - V, and 1.4 - VI. The lower percent of males than females in age groups II and III may have been the result of the antagonistic behavior between males deterring smaller and possibly younger ones from entering the inlet. Wojcik (1955) reported that grayling did not reach sexual maturity in Alaska until 5 or 6 years old.

Grayling seldom live longer than 6 years in lakes in the southern part of their range. The oldest grayling found by Brown (1943) was 6 years old. Nelson (1954) found two grayling in the Red Rock lakes region which were 6 years old, however, one grayling from Lower Twin Lake (elevation 9,100 ft) was aged at 10 years old and four at 9 years. Only one male, 32.2 cm long, was judged to be 7 years old from Lake Agnes. Bishop (1971) found grayling up to 11 years old in Providence Creek, Canada, and Reed (1964) found grayling up to 8 years old in Alaska.

A sample of 40 fingerlings collected on September 25, 1970, averaged 7.7 cm in length and ranged from 6.4 to 8.7. A sample of 18 collected on August 30, 1971, averaged 3.8 cm in length and ranged from 2.7 to 4.7.

Fecundity

Eggs were taken from 27 grayling prior to and during the 1971 spawning run. The number of eggs per female increased with length, ranging from 799 eggs for a 22.0 cm fish to 4,346 eggs for a 30.5 cm fish (Table 8). The average number of eggs per fish for the entire sample was 1,750 or 12.6 per gram of fish (356 per ounce). Brown (1938) found three large females in Georgetown Lake, Montana, which averaged 2 pounds in weight and contained 12,946, 12,462, and 8,135 eggs, respectively. This is approximately 351 eggs per ounce. Ward (1951) found 376 eggs per ounce for grayling in Canada and Bishop (1971) reported 310.9 per ounce.

During both years of the study, a number of females were taken during July and August which were apparently egg-bound. In 1971, 49 egg-bound females were captured in traps and comprised 3.5 percent of the total female catch. The abdomens of these fish were extremely distended, giving the fish a bloated appearance. Internal examination revealed a watery mass of eggs, most of which were crushed. These fish were more fragile than other grayling and suffered a high mortality through trapping and handling.

Table 8. Average number of eggs per female by size groups for 27 grayling taken in 1971.

Size Interval (cm)	Number of Fish	Average Size (cm)	Average Weight (grams)	Mean # of Eggs per Fish	Range
22.0-22.9	3	22.4	89	916	799 - 1,134
23.0-23.9	4	23.7	105	1,552	935 - 2,812
24.0-24.9	6	24.4	122	1,347	869 - 1,982
25.0-25.9	4	25.3	126	1,743	1,096 - 2,110
26.0-26.9	4	26.4	148	1,805	1,427 - 2,152
27.0-27.9	3	27.3	187	2,403	1,770 - 3,345
29.0-31.5	3	30.3	230	2,994	1,864 - 4,346
Average		25.5	139	1,750	

DISCUSSION

Indications of population fluctuations in Lake Agnes based on numbers and size of fish in the spawning run have been noted during spawn-taking operations conducted in the past, but few records were kept (Vern Campbell, Robert Mitchell - personal communication). During the spawn-taking operations in 1960, the total number of grayling passing through a fixed trap in the primary inlet was 604. These ranged in length from 10.5 to 16.5 inches and averaged around 15 inches. Weights ranged 0.8 to 1.8 pounds. In 1971, 9,364 grayling were captured from the spawning run and these represented only a portion of the total. Their average size was 26.8 cm (10.5 inches) and weights ranged from 64 g (0.14 lbs) to 322 g (0.71 lbs). Grayling from Lake Agnes currently show slower growth than the average reported for most Montana lakes and streams. The marginal nature of the spawning stream with its shifting sand bottom and frequent bank cave-ins, and the variable amount of stream available to spawning fish between years are believed to be the most important factors contributing to the population fluctuations. At the present time, the grayling in this lake are abundant to the point of overcrowding and stunting. If fewer fish of a larger size are desired, the inlet stream may be periodically blocked off in an attempt to curtail the major portion of the spawning activities.

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