THE BIOLOGY OF THE ARCTIC GRAYLING IN THE SOUTHERN ATHABASKA DRAINAGE

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THE BIOLOGY OF THE ARCTIC GRAYLING IN THE SOUTHERN ATHABASKA DRAINAGE

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ABSTRACT

In the spring of 1949 and the spring and summer of 1950, a study was made of the biology of the Arctic grayling (*Thymallus signifer*) in the southern parts of the Athabaska drainage.

Measurements which were taken on fish from Alberta and Saskatchewan indicate that no racial differences exist between fish from two widely separated areas. The study of growth rates demonstrated that stream grayling grow at a slightly slower rate in the Athabaska drainage than the lake fish studied by other authors, and that the rate varies from stream to stream. There is an indication of a correlation between growth rate and bottom food. However, grayling are versatile feeders and terrestrial insects are important in the summer diet. Sexual maturity is reached at the end of the third year of life. Spawning takes place in May after the fish have migrated into the smaller streams. Various aspects of the spawning habits are described. After spawning, the fish remain in the stream for the summer, then leave in the autumn before ice formation is extensive.

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INTRODUCTION

There are few fresh water sport fish which are as little known as the Arctic grayling. Because this fish makes its home in the Arctic and Subarctic, man has had little opportunity to observe its habits thoroughly, and only in recent years has it been studied at all. Its distribution is widespread throughout the Arctic and extends into the Churchill drainage system, the numerous rivers and lakes of northern Saskatchewan that drain into Lake Athabaska, and the Athabaska River system in Alberta. It is in this latter drainage system that the author has made observations on the biology of this fish.

The grayling has been well known to the people of northern Alberta for many years. Sportsmen are familiar with its fine sporting and eating qualities; and it has been pursued vigorously. In recent years fewer have been caught and catches are made up of smaller fish. This condition has become so alarming that conservation measures must be taken in the near future or this fine fish may disappear from our local streams altogether. Before conservation can be practised, however, it is necessary to learn more about the grayling. With this purpose in mind, the author began preliminary investigations in the spring of 1949 when the Alberta

Government set up its first spawn camp for these fish at Cold Creek. Further studies were carried out at the same place during the spawn-taking in 1950, and these investigations were then carried on throughout the summer in various other streams of the Athabaska drainage. The purpose of this paper is to record the findings and to present as clear a picture as possible of the life history and habits of the Arctic grayling living in the more southern parts of the Athabaska drainage system.

Review of the Literature on Grayling

Little has been published on the habits and activities of the Arctic grayling. R. B. Miller (1946) calculated the growth rates of 104 fish caught in Great Bear Lake. He includes calculated growth rates for 23 fish from Great Slave Lake, and 15 fish from Lake Athabaska, plus a comparison of these rates with the rates of growth of Montana grayling (*Thymallus montanus*) from Ford Lake, Michigan. Scale formation is reported to take place when fry are about 50 mm. in length. A brief analysis of the contents of 102 stomachs showed a very mixed diet, and demonstrated that, during the summer, terrestrial insects are a very important food source. Maturity is attained during the fourth and fifth summers.

D. S. Rawson (1949) gives the distribution of grayling in northern Saskatchewan as "wide in the Athabaska

drainage, general in the Reindeer Lake area, and doubtful in the remainder of the Churchill drainage." Spawning is said to occur about the last week in May, temperatures at this time being 42° F. to 48° F. Dr. Rawson also mentions a very interesting difference in the dorsal fins of the male and female after reaching sexual maturity. From analyses of the stomach contents of 26 specimens from Athabaska, Reindeer and Wollaston Lakes, Dr. Rawson outlines the great variety of insect food utilized by grayling and indicates that terrestrial insects make up over fifty percent of the food volume during the summer. Of equal interest is information on the spawn-taking and on the development of the eggs. In water ranging from 44° F. to 48° F., the eggs 'eyed' in 12 days, and hatched in 4-6 more days in water ranging from 48° F. to 52° F. The yolk sac was absorbed in about 8 days. The fry were then reared on commercial goldfish food for 3 days. Later, this was supplemented by "alfalfa meal, milk powder and soy bean meal".

In the report of fishery survey work to the Alberta Provincial Government (1948), R. B. Miller notes that growth of fish in seven tributaries of the McLeod drainage is rather poor for the climate, and that poorest growth seems to be associated with the poorest supply of bottom food. Sexual maturity of fish examined in these streams is usually reached at the end of the third year, which is at least one year earlier than that of the fish of Great Bear Lake.

Some present-day authors believe there is very little difference between ~~in~~ the Arctic and Montana species of grayling, and that the latter is better treated as a subspecies of the former. Considerably more investigations have been undertaken on the Montana species.

J. W. Leonard (1938) reports on the feeding habits of the Montana grayling in Ford Lake, Michigan, and shows that these fish have different kinds of food in their stomachs in May than they have in October. Even the time of day has its influence on the food items taken. Not only does this illustrate the varied diet of the species, but also the fact that they select items as they are available.

C. J. D. Brown (1938) investigated the food items utilized by Montana grayling in various lakes and streams in Montana. He also used stomach contents in his study. In the smaller fish from Meadow Creek he found that 70.1% of the total stomach contents was made up of debris, and in the larger fish this weight was 58.8%. Aquatic insects made up 66.5% of the food items in the smaller fish and 55% in the larger. Predominant foods were mayflies, damselfly nymphs and Coleoptera. Terrestrial insects were taken more by the larger fish while Crustacea and Cladocera were taken fairly frequently by the smaller fish. In Roger's Lake, debris was rarely found in the stomachs of fingerlings but amounted to 25% in the 150-250 mm. fish and 72.6% in the largest specimens. The 150-250 mm. fish ate 74.7% aquatic food. The main items taken were midges, Amphipoda

and Cladocera. From Grebe Lake the stomach contents consisted of midge larvae and small mayfly nymphs for the fry. Midges and damselflies made up the bulk of the 76.9% of the aquatic organisms, and the 2% terrestrial insects were Coleoptera. Debris was 38.3% of the weight. Agnes Lake fish had 56.5% debris. Midges (39.4%) and mayflies (10.5%) made up the bulk of the aquatic food. Terrestrial insects (13.1%) were all Coleoptera. Brown states that "The season of the year and the habitat of the fish almost certainly have greater influence on what is eaten than any selection these fish have demonstrated by their stomach content."

Brown (1938) made observations on the breeding habits and life history of the Montana grayling. He describes the spawning act in detail, but there seems some doubt as to whether or not there is any lengthy spawning migrations. The numbers of eggs taken from some fish are reported. However, few actual egg counts were made. Males produce very small quantities of milt. Many of the Montana grayling are reported to spawn at the end of their second year.

The age and growth of Montana grayling from Ford Lake, Michigan, Roger's, Meadow, Agnes, Georgetown and Grebe Lakes in Montana and Yellowstone National Park were also studied by Brown (1943). He calculated the standard lengths at the end of each year of life separately for the fish from each lake. The average calculated standard lengths were then compared. There was a considerable variation between the rates of growth in the lakes. Grayling in Agnes Lake

had the slowest growth and those in Georgetown the fastest. However, the first year fish from Agnes Lake were longer than those from Grebe Lake or Ford Lake. Thus, the superiority gained in the first year need not necessarily continue in the years that follow. No significant length-weight differences between the sexes could be found. The oldest fish, which was from Grebe Lake, was interpreted as being six years old.

Clarence A. Tryon (1947) writes a very graphic account of the spawning habits of the Montana grayling in the inlet to Roger's Lake. Water temperature during his observations remained at 40° F. He noted that no attempts were made to build nests - nor was there any definite pairing off among the fish. Males would take up a favored location, defend it against other males, and mate with any female that came near and was willing. The spawning act lasted for ten seconds, during the latter part of which the violent vibrating movements stirred up a cloud of sand and obscurred the eggs. The spawning occurred on sandy bottom.

James A. Henshall (1907) outlines the methods used to propagate grayling eggs. Fertilization is carried out by the dry process and results in 95 percent fertility. The stripping is a bit difficult to start but the eggs flow freely thereafter. The eggs must be eyed in jars because they tend to stick together, but once eyed, can be safely placed in trays. The eye spot appears in about a week or ten days at a temperature of 50° F., and incubation is

completed within two weeks. The yolk sac is absorbed in a week or ten days, at which time the fish are about half an inch long and very delicate.

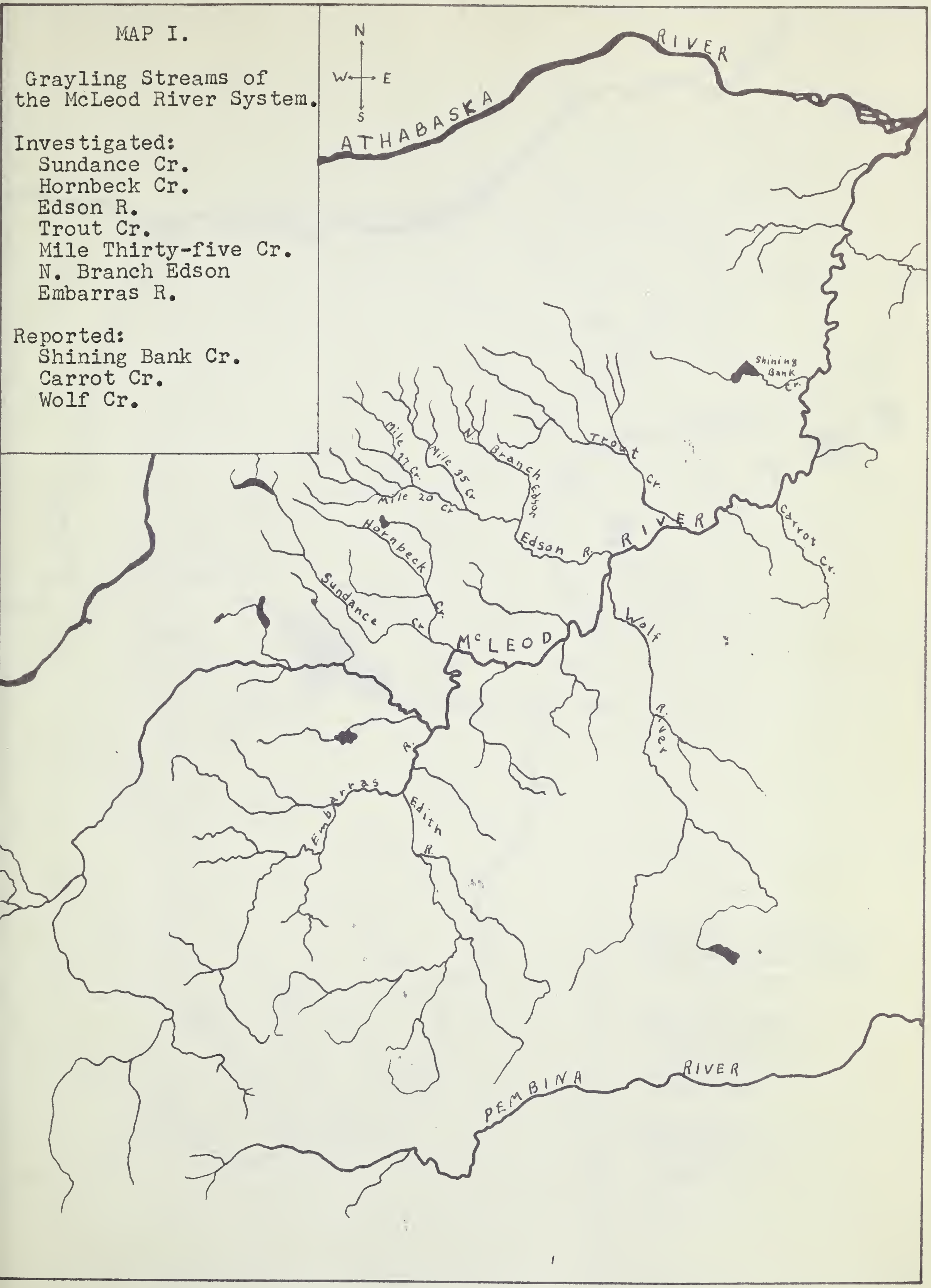
Alberta Grayling Streams

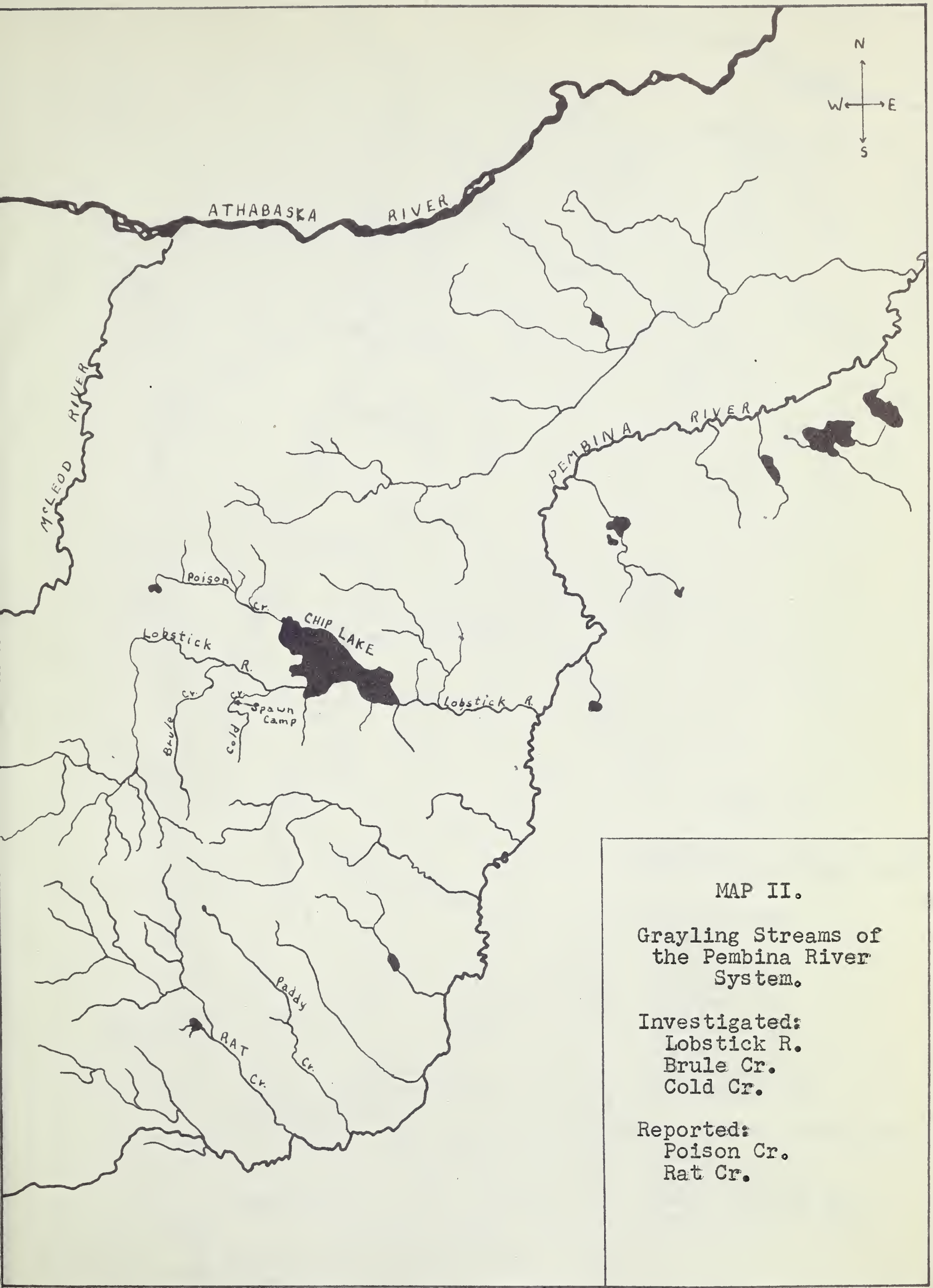
In Alberta, the Arctic grayling is found in streams ~~whose~~ waters of which eventually end up in the Arctic Ocean. The two main drainages are the Peace River and Athabaska River systems. Though there is little doubt that grayling occur in the larger rivers at various seasons of the year, it is in the smaller feeder streams that they seem to spend most of the summer months. Any stream that varies in width from two or three feet to thirty or forty feet, does not reach a summer maximum in excess of 65° F. (except perhaps for short periods), and which carries little silt during most of the summer months, is a potential grayling stream. Strangely, the grayling is rarely found in the clear mountain streams. The reason for this is not known, but it may be the more violent fluctuations in water level. Most often the streams are those that run through muskeg areas throughout part of their course so that the water is stained brown, but this is not always the case. The author has found grayling in streams which were perfectly clear, though they were tributaries of "brown-water" streams.

The most well known grayling streams are those tributaries of the McLeod and Pembina Rivers which do not

fit the category of "mountain" streams. Many grayling streams are found along the Athabaska River from approximately 80 water miles upstream from Whitecourt down to the entrance of the Lesser Slave River. Most rivers and streams flowing into both Lesser Slave Lake and Lesser Slave River have grayling populations, though in many cases the fish are now found many miles upstream where conditions have been less altered by activities of man. Map I shows the grayling streams known to the author in the McLeod drainage; Map II shows those of the Pembina system; Map III the Lesser Slave Lake streams and Map IV the Athabaska River streams.

Grayling have also been caught by the author in many streams in the Peace River country, though in recent years changing conditions have altered many that once were beautiful grayling waters. No map has been included for these streams because they have not been investigated properly and do not come within the scope of this thesis. No doubt there are many unknown grayling waters in the more northerly sections of the province, but these areas are too inaccessible for the average sportsman to fish. We will deal mainly with two streams in the Lesser Slave Lake area, one from the McLeod drainage, and one from the Pembina drainage. General data will include streams in the Whitecourt area, and a few others in the aforementioned areas, from which only a few specimens were obtained.


MAP I.
Grayling Streams of the McLeod River System.
Investigated:
Sundance Cr.
Hornbeck Cr.
Edson R.
Trout Cr.
Mile Thirty-five Cr.
N. Branch Edson
Embarras R.
Reported:
Shining Bank Cr.
Carrot Cr.
Wolf Cr.
N
W
E
S
ATHABASKA RIVER
Shining Bank Cr.
Trout Cr.
N. Branch Edson
Mile 35 Cr.
Mile 27 Cr.
Mile 20 Cr.
Edson R.
RIVER
Carrot Cr.
Hornbeck Cr.
Sundance Cr.
McLEOD
Wolf River
Embarras R.
Edith R.
PEMBINA RIVER

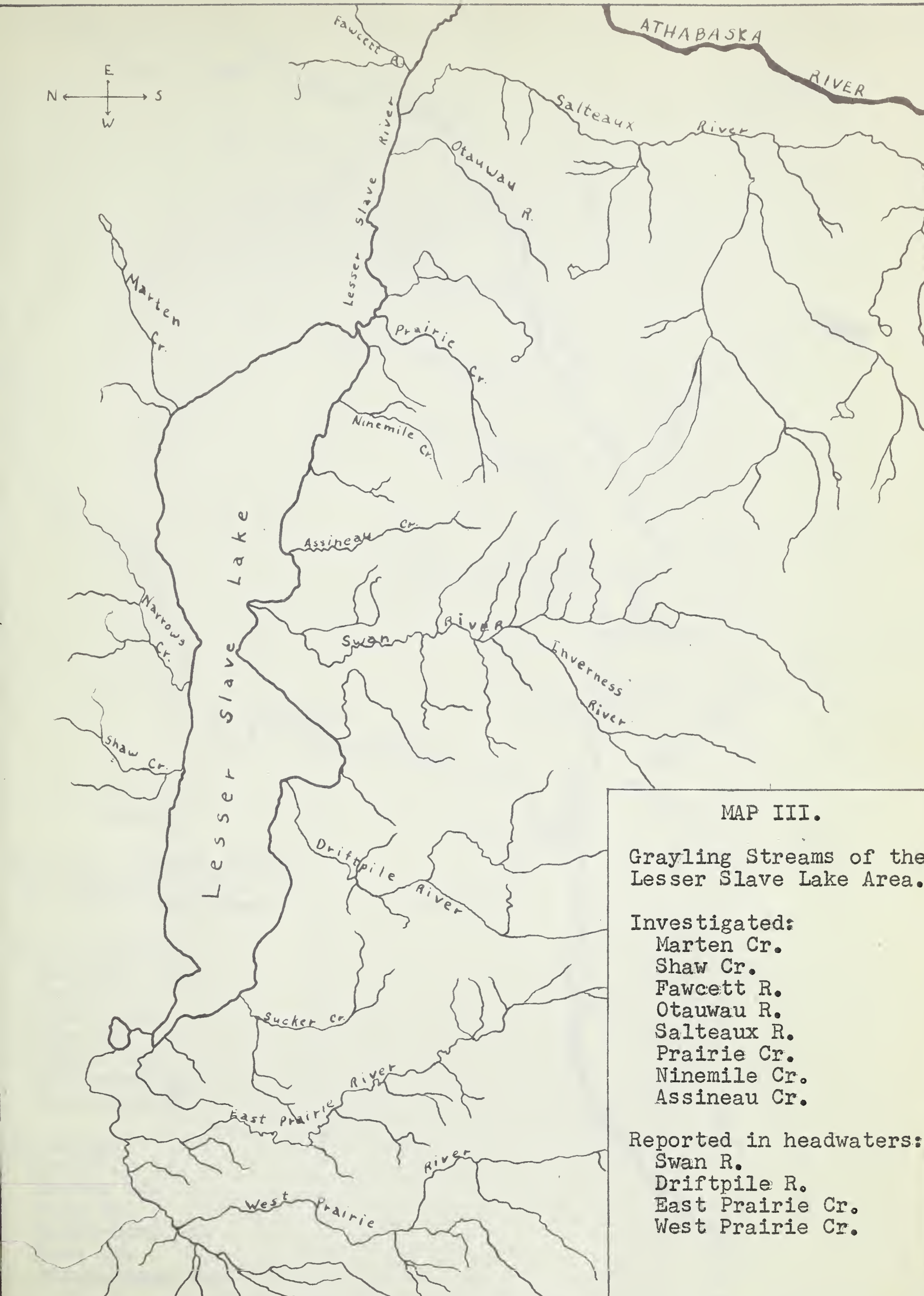


MAP II.

Grayling Streams of the Pembina River System.

Investigated:
Lobstick R.
Brule Cr.
Cold Cr.

Reported:
Poison Cr.
Rat Cr.

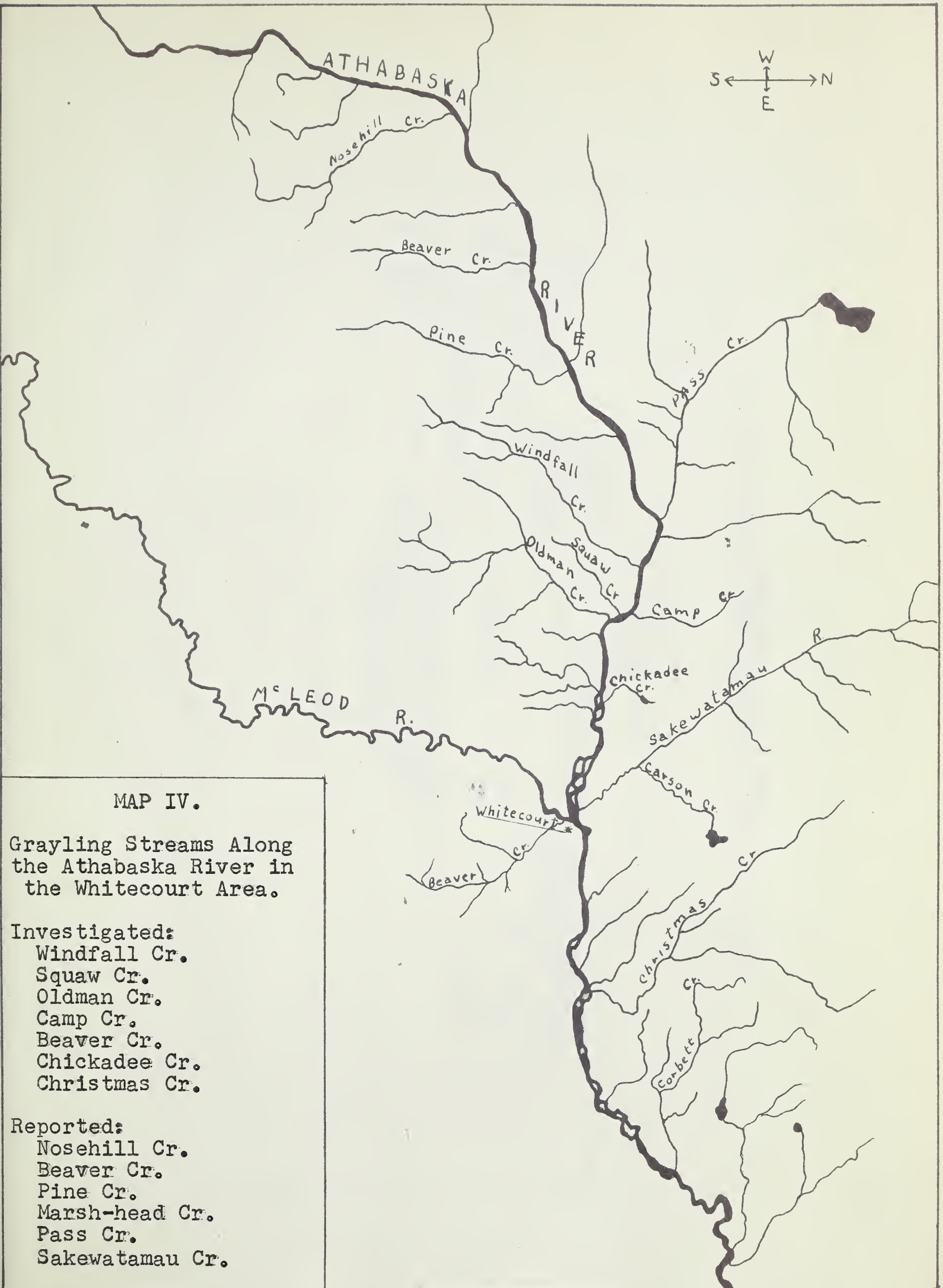


MAP III.

Grayling Streams of the Lesser Slave Lake Area.

Investigated:
- Marten Cr.
- Shaw Cr.
- Fawcett R.
- Otauwau R.
- Salteaux R.
- Prairie Cr.
- Ninemile Cr.
- Assineau Cr.

Reported in headwaters:
- Swan R.
- Driftpile R.
- East Prairie Cr.
- West Prairie Cr.



MAP IV.

Grayling Streams Along the Athabaska River in the Whitecourt Area.

Investigated:
- Windfall Cr.
- Squaw Cr.
- Oldman Cr.
- Camp Cr.
- Beaver Cr.
- Chickadee Cr.
- Christmas Cr.

Reported:
- Nosehill Cr.
- Beaver Cr.
- Pine Cr.
- Marsh-head Cr.
- Pass Cr.
- Sakewatamau Cr.

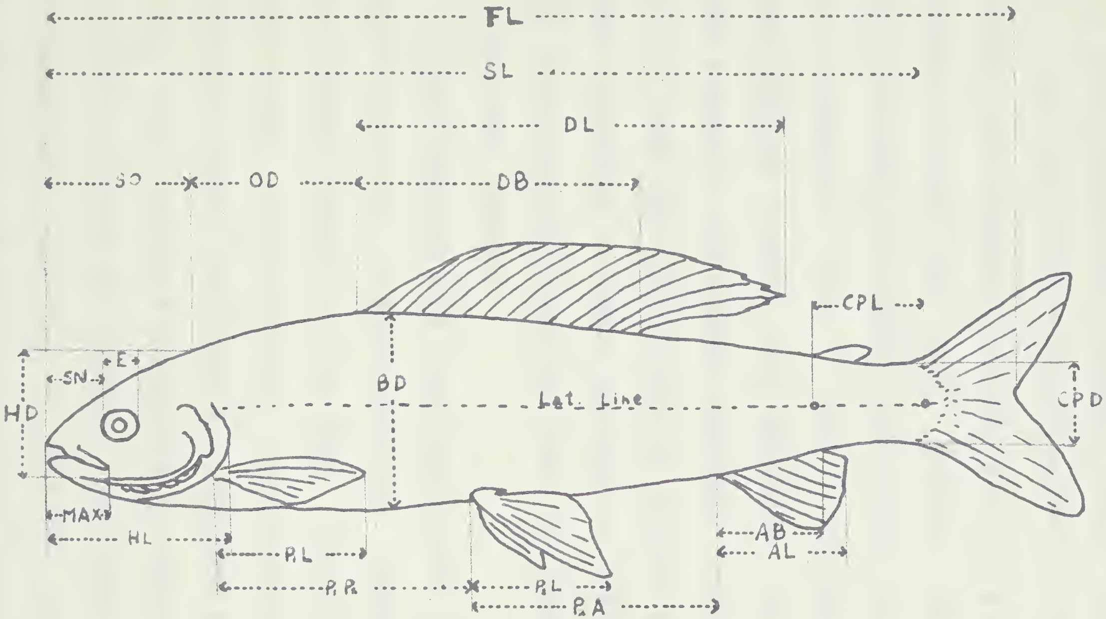


Figure 1. Main taxonomic measurements made on the Arctic grayling.

MORPHOLOGY

Taxonomic measurements were made on 27 preserved grayling taken during the spawning migration at Cold Creek in 1949. All these fish were preserved in 10% formalin. In addition, measurements were made on 13 grayling from Saskatchewan, kindly lent by Dr. Rawson. Some of these fish had been preserved in formalin and others in alcohol. During the summer of 1950, 25 fresh specimens from four different Alberta streams were measured. The measurements taken are shown in the column headings in Table XV (appendix) and most of them are illustrated in Figure 1. Measurements were made according to Hubbs and Lagler (1947). The membrane on the opercular plate was not included in the measurement of the head length.

The measurements taken were used to plot the logarithms of the sizes of each body part against the logarithms of the standard lengths of the fish. This was done on log-log graph paper, rather than by calculating the logarithms. The resultant curves are known as relative growth curves. These were first used and explained by Huxley (1932). The procedure was to plot the Alberta fish first, males and females separately, and then to plot the Saskatchewan fish on the same graphs to find how closely these points would fit the line. This was done for ten of the measurements chosen at random; except for the dorsal fin length measurement

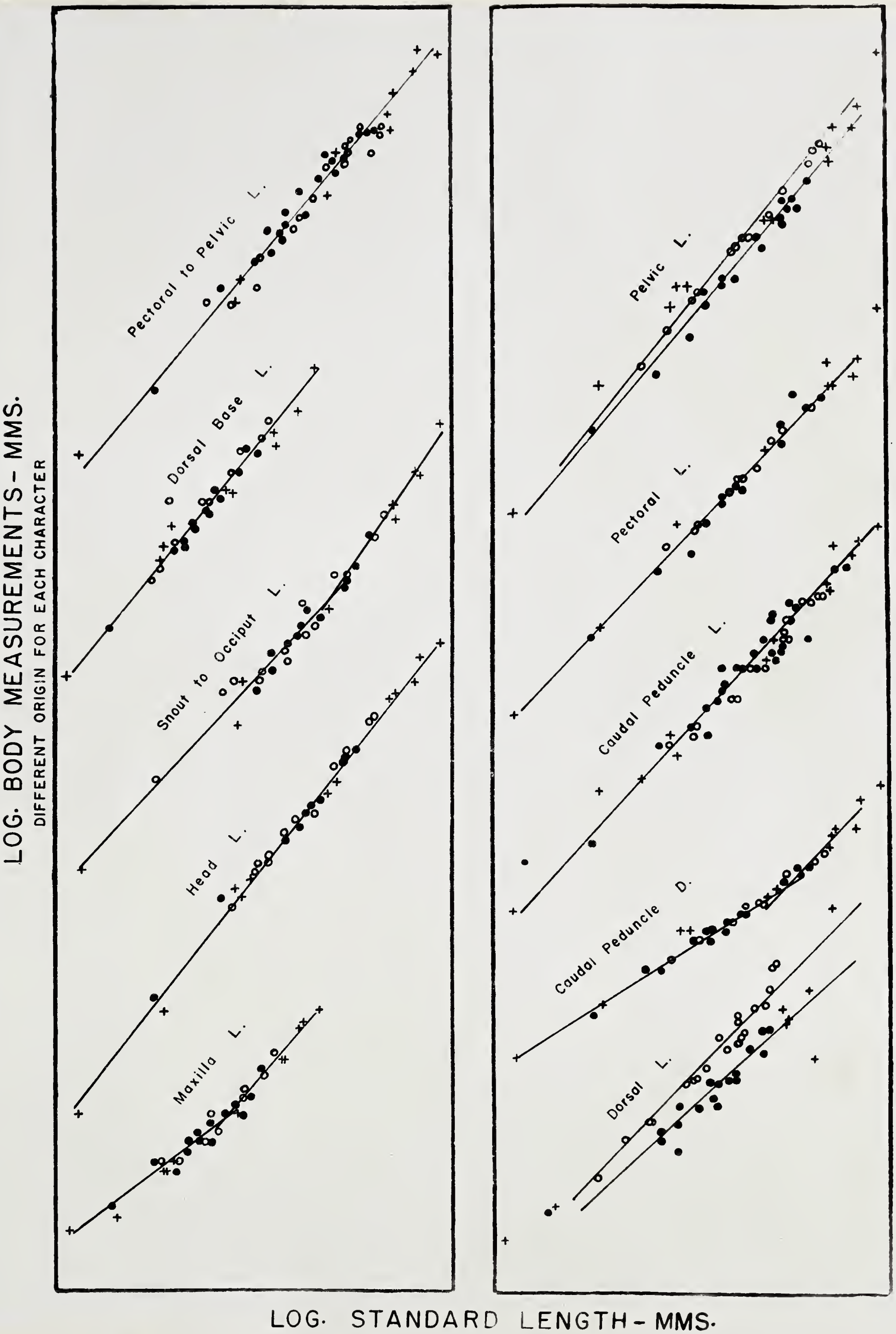


Figure 2. Log of various body measurements plotted against the log of the standard length. Open circles used for males, closed circles for females, and crosses for the Saskatchewan fish.

which was included for a special reason to be discussed later. These graphs are shown in Figure 2. Open circles were used for males, closed circles for females, and crosses for Saskatchewan fish. The graphs in this figure do not show all the points plotted on the log-log paper, as the points in the centre fall so closely together that they could not be separated for illustration purposes. Measurements of both preserved and fresh fish were used on the same graphs with no significant deviations from the lines being noted.

Homogeneity of Species

The study of the distribution of the points on Figure 2 shows that they tend to fall into one or more straight lines. In no case do the Saskatchewan species make any conspicuous deviations from the lines, as they should if there is any significant difference between the fish. Therefore, the fish appear to be all of the same species.

The graphs indicate some other points of interest. Those for the measurements of caudal peduncle length, pectoral length, pectoral to pelvic length, length of dorsal base and head length are all straight lines. Points for males and females freely intermix and no sexual differences are shown. The only feature worthy of comment here is the slight differences in the slopes of the lines. This indicates that there are small differences in the rate at which the various parts of the fish are growing in relation to the

growth in length. Were the parts growing at the same rate as the body, we should expect a slope of 1 for each line. The slopes of these lines are shown in Table I.

Table I.

GROWTH GRADIENTS FOR FIVE MEASUREMENTS MADE ON ARCTIC GRAYLING AS SHOWN IN FIGURE 2.

Measurement	Growth Gradient
Caudal peduncle length	1.11
Pectoral length	1.07
Pectoral to pelvic length	1.15
Length of dorsal base	1.27
Head length	1.26

Of the measurements under discussion, only those for length of dorsal base and head length deviate to any extent from the theoretical 1. This deviation indicates that length of the base of the dorsal fin and the length of the head are proportionally greater in older fish than in young fish.

The graphs for maxilla length, snout to occiput length and caudal peduncle depth are different from those already mentioned. There are really two lines which meet at a point, the top one having a greater slope than the

bottom one. The top line represents an increase in the rate of growth over that expressed by the lower line. The differences in the slopes are recorded in Table II, together with the approximate standard lengths of the fish at which the rate of growth increases.

Table II.

CHANGES IN GROWTH GRADIENTS FOR THREE MEASUREMENTS ON ARCTIC GRAYLING AS SHOWN IN FIGURE 2.

Measurement	Growth Gradient I	Growth Gradient II	Place of Change
Maxilla length	0.792	1.13	260 mm.
Snout to occiput length	1.090	1.50	260 mm.
Caudal peduncle depth	0.650	1.04	280 mm.

The reason for the increase in growth rate at these lengths cannot be due to arrival at sexual maturity. According to calculated size and age of maturity studies reported later in this paper, the rate changes when the fish are between four and five years old. Sexual maturity is reached in the third and fourth years.

Sexual Differences

The graphs for dorsal fin length and pelvic fin length show sexual differences in the growth rate. Dr. Rawson

(1949) reported that the dorsal fin was larger and of different shape ~~than~~ from that of the female. He states: "That of the male is longer, extending back to the adipose. It is also low in front and high behind. The female dorsal is shorter, about 1.5 inches short of the adipose, and unlike that of the male, it is high in front and low behind." The author observed this difference in the larger fish examined, and also noted that the blue spots on the dorsal fin of the male were much brighter than those on the dorsal of the female. The graph for dorsal length illustrates the difference between the male and female dorsals. The male's grows at a more rapid rate as illustrated by the slopes of the lines recorded in Table III, but the differences are not very great.

Table III.

SEXUAL DIFFERENCES IN GROWTH GRADIENTS SHOWN IN FIGURE 2.

Measurement	Growth Gradient, Male	Growth Gradient, Female
Dorsal length	1.080	0.93
Pelvic length	1.285	1.24

The size differences would not become obvious until the fish were large, and after sexual maturity had been reached. This could be the reason for this characteristic

passing unnoticed by investigators handling smaller fish. The differences in the shape of the dorsal fin could not be measured, but the photograph (Figure 3) shows a male and female with dorsals extended, and the differences noted by Dr. Rawson show up clearly. The graph for pelvic length shows that the males have a slightly longer pelvic fin than have the females. The difference is too slight to be observed on the fish. It is a constant difference that arises early in the development and does not change throughout life.

AGE AND GROWTH STUDIES

In the spring of 1949 and throughout the spring and summer of 1950 a total of 207 grayling was taken for age and growth studies. The fork lengths of these fish were measured in millimeters immediately after capture and a sample of their scales taken from the left side between the dorsal fin and the lateral line. The fish captured in the springs of 1949 and 1950 were taken from the spawning run by means of traps. Those taken during the summer of 1950 were captured by angling. A number of the scale samples were from fish captured by Dr. Miller in the summer of 1946.

The scale samples were cleaned, mounted in glycerine, and the age determined with the aid of a binocular microscope. A few of the scales were used to make impressions in plastic squares. This was done by dipping the scale in acetone and

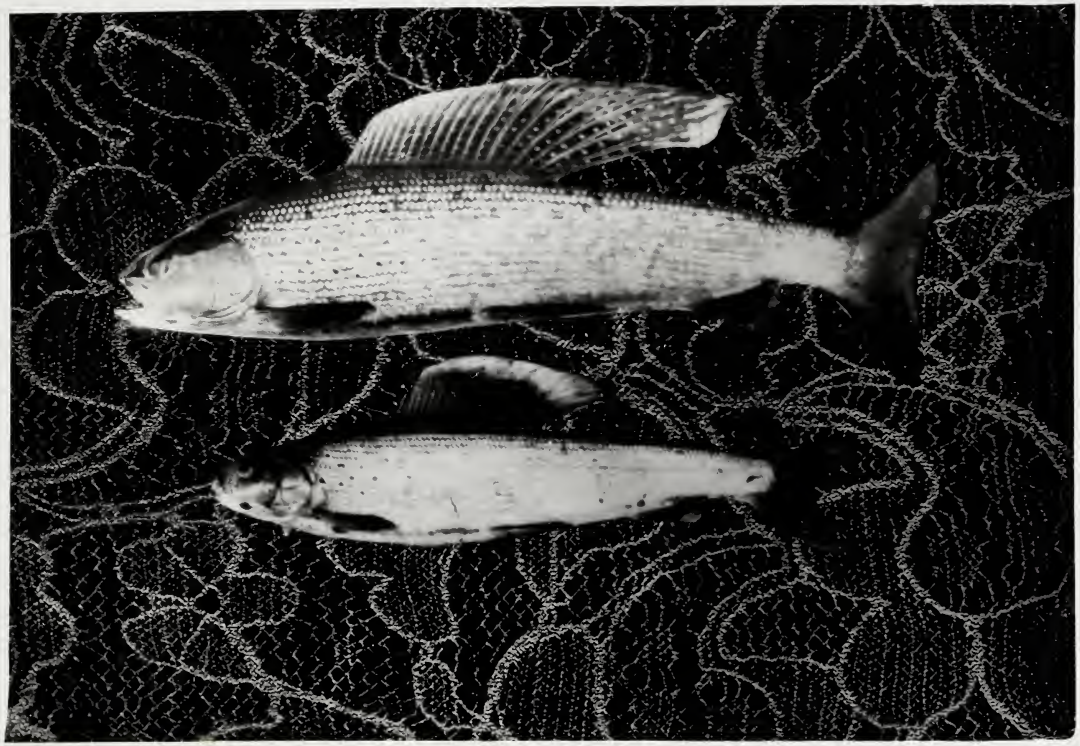


Figure 3. Upper male, lower female grayling illustrating the difference in shape of the dorsal fins.

applying pressure with a stamp made from a notary's seal. This method worked satisfactorily for the larger scales after a little practice. After the age was determined, the scales were measured and the age determinations checked by projecting the images of the scales on a piece of paper, using a magnification of 19.5. Annuli were determined by the presence of incomplete circuli, erosion and crossover. Annuli were more readily seen along the antero-lateral radius, but the measurements were taken along the antero-posterior diameter. To do this, it was first necessary to locate the annuli on the antero-lateral radius and then follow the circuli carefully around the scale. This method may have resulted in some small error, but it is believed the readings are accurate enough for practical purposes. It was felt a better relationship between the annulus diameter and fork length might be obtained in this manner.

The relationship between the fork length of the fish and the antero-posterior diameter of the scale was treated as linear when calculating the lengths of the fish at the end of the previous year's growth. A plot of scale diameter against fork length (Figure 4) did not produce a straight line; the growth calculations will therefore be liable to error, but, since the line is only slightly curved, the error will be small.

No young fingerlings were captured. Thus, the length at which scale formation takes place could not be determined through the study of specimens. Miller (1946)

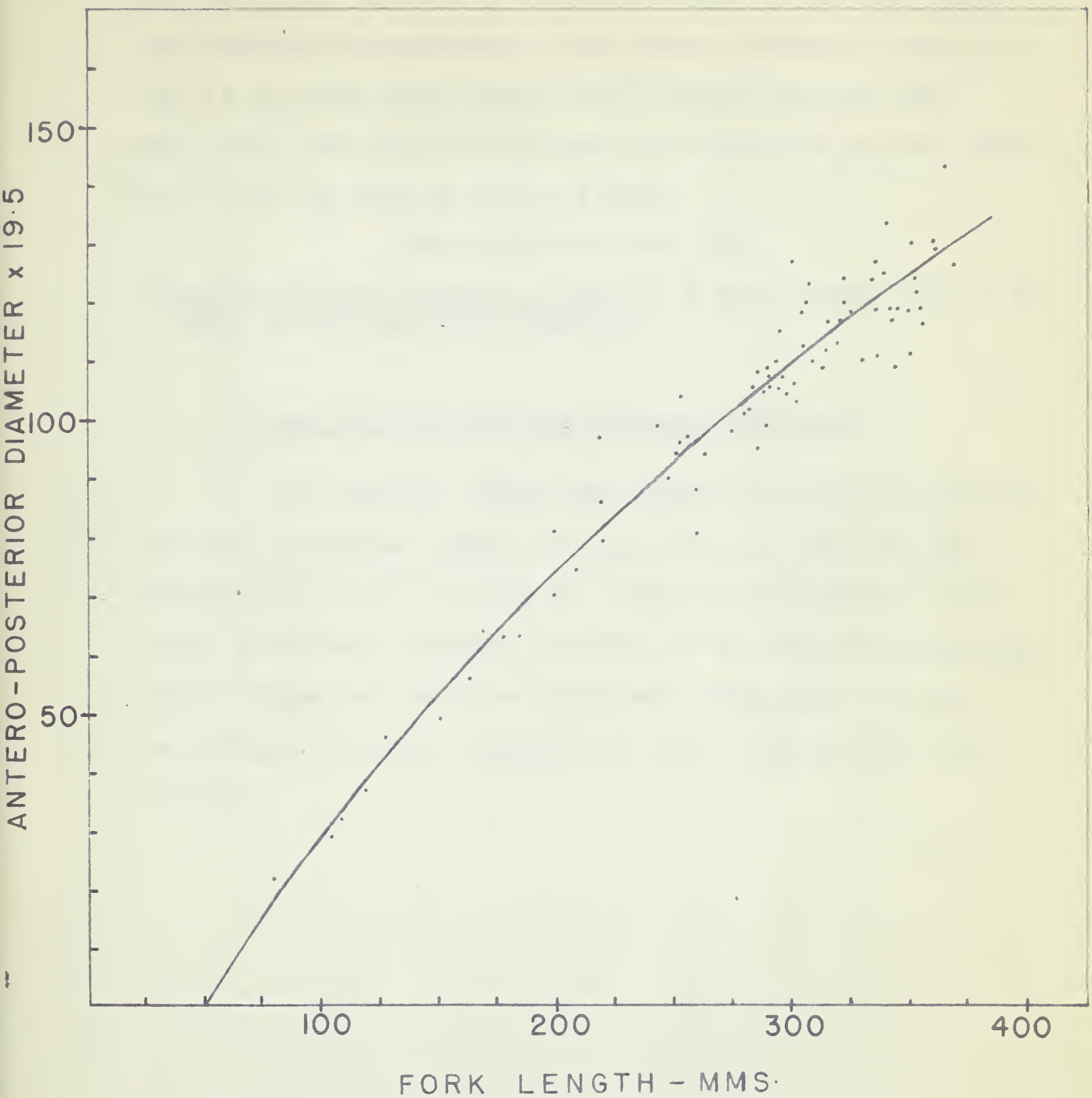


Figure 4. The relationship between antero-posterior scale diameter and fork length.

found that scale formation in Arctic grayling from Great Bear Lake took place at a length of about 50 mm. and, since the downward extrapolation of the curve in Figure 4 cuts the axis at the same fork length, this figure has been used. The formula used for calculations was described by Lee (1920) and is the one used by Miller (1946):

$$\text{Fork length at year } x = \left(\frac{\text{antero-posterior diameter at year } x}{\text{whole antero-posterior diameter}} \times \text{fork length} - 50\right) + 50$$

Rate of Growth in the Athabaska Drainage

The average lengths and weights at capture together with the calculated lengths for each year of life for 207 grayling are shown in Table IV. These fish represent those caught in fifteen different streams of the Athabaska drainage. Because there were only two specimens seven years of age, the average calculated lengths for these fish are not very reliable.

Table IV.

AVERAGE FORK LENGTHS AND WEIGHTS AT CAPTURE AND AVERAGE CALCULATED FORK LENGTHS FOR EACH YEAR OF LIFE OF 207 ARCTIC GRAYLING FROM THE ATHABASKA DRAINAGE

Age	Av. Fork Length (mm.)	Av. Wt. (oz.)	No. of Spec.	Average Calculated Lengths 1	2	3	4	5	6	7
1	148.8	1.9	13	114.4						
2	202.8	3.4	15	111.3	174.8					
3	240.4	5.6	54	108.6	173.4	224.1				
4	283.2	8.6	75	103.6	166.5	225.6	265.7			
5	307.7	15.7	32	115.1	173.6	224.7	262.4	291.8		
6	338.3	16.0	16	116.8	182.2	233.1	275.8	301.9	324.7	
7	337.5	16.2	2	103.9	158.1	223.6	264.9	288.4	308.3	325.9
	Grand Average			110.5	171.4	226.2	267.2	294.0	316.5	325.9

Four of the streams from which the greatest number of fish was taken have been selected for comparative purposes. The average lengths and weights at capture and the calculated lengths at the end of each year of life for Prairie Creek, for Marten Creek, for Trout Creek, and for Cold Creek are shown in Table V, page 27. All the calculated growth rates are graphically represented in Figure 5, page 26.

The numbers of samples used to compute the growth rates for these streams are not as large as they should be for accurate calculations. However, it is felt they are large enough to make comparisons with the average calculated growth rates from all the fish of the Athabaska drainage.

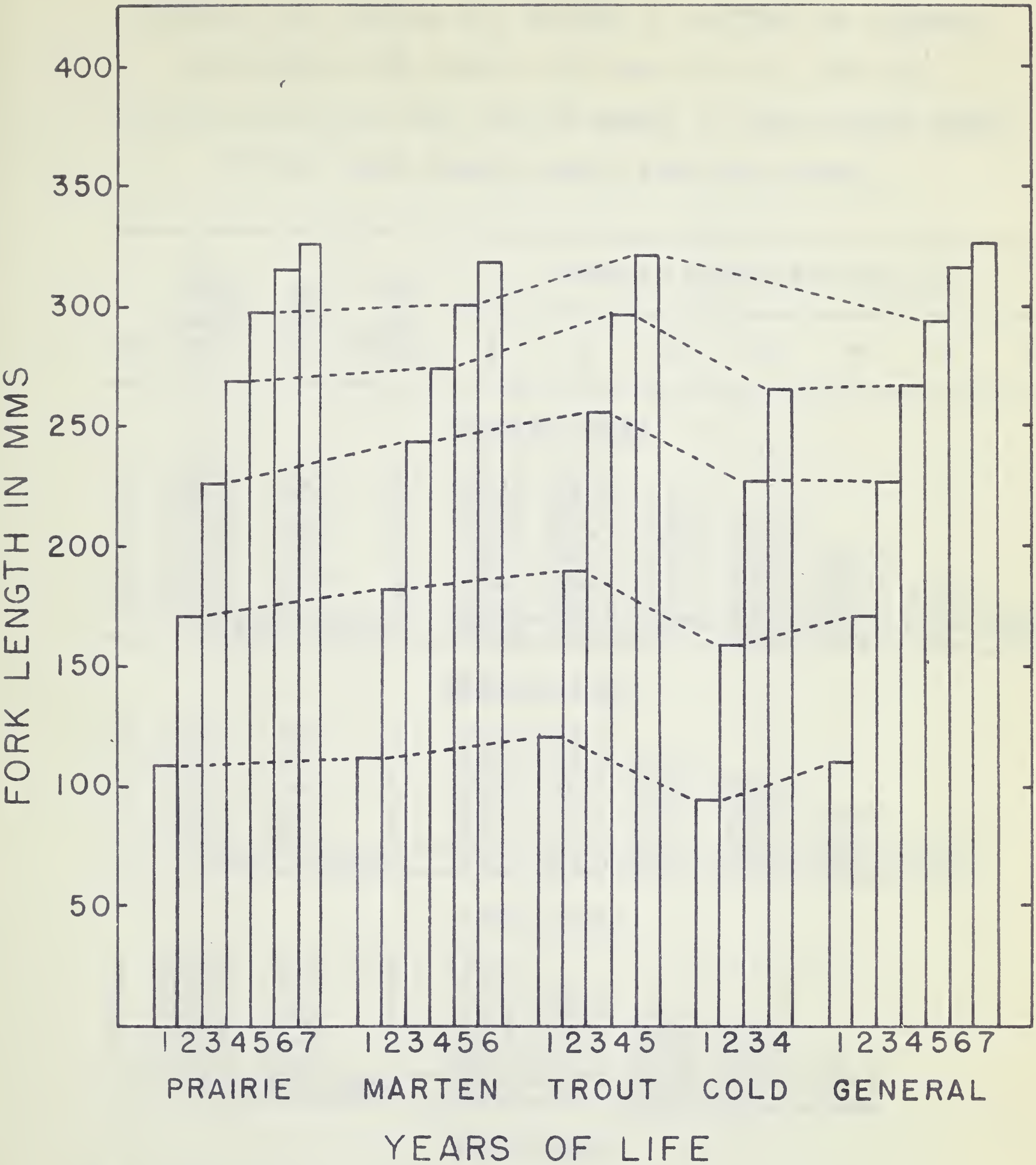


Figure 5. Average calculated standard lengths at the end of each year of life for grayling from four streams. The average values for all Alberta collections combined are shown in the diagram on the right.

Table V.

AVERAGE FORK LENGTHS AND WEIGHTS AT CAPTURE AND AVERAGE CALCULATED FORK LENGTHS FOR EACH YEAR OF LIFE OF 34 ARCTIC GRAYLING FROM PRAIRIE CREEK, 17 FROM MARTEN CREEK, 25 FROM TROUT CREEK, AND 25 FROM COLD CREEK.

Age	Av. Fork Length (mm.)	Av. Wt. (oz.)	No. of Spec.	Average Calculated Lengths						
				1	2	3	4	5	6	7
				Prairie Creek						
2	189.7	3.0	4	109.1	173.7					
3	258.6	79.0	11	115.4	174.2	238.9				
4	285.8	10.3	9	109.9	167.3	218.4	266.7			
5	316.8	13.1	6	103.8	180.2	227.8	269.2	301.9		
6	334.5	15.0	2	114.7	176.2	219.6	274.0	303.3	323.2	
7	337.5	16.2	2	103.9	158.1	223.6	264.9	288.4	308.3	325.9
Grand Average				109.5	171.6	225.7	268.7	299.9	315.7	325.9
				Marten Creek						
2	198.0	4.0	1	90.2	153.6					
3	288.0	10.7	2	119.6	223.2	273.0				
4	293.2	11.2	4	109.5	170.4	233.8	275.0			
5	329.2	15.6	5	120.2	199.1	251.9	288.9	314.4		
6	335.2	15.9	5	120.7	172.0	220.1	260.6	288.3	318.3	
Grand Average				112.0	183.7	244.7	274.8	301.3	318.3	
				Trout Creek						
1	178.2	1.9	5	130.9						
2	224.0	5.0	3	117.9	180.0					
3	293.0	10.5	3	121.6	199.4	263.4				
4	320.3	13.2	9	113.1	193.8	253.8	299.2			
5	342.2	17.6	5	120.9	187.8	251.6	293.7	322.2		
Grand Average				120.9	190.2	256.3	296.4	322.2		
				Cold Creek						
4	277.0	7.7	25	94.3	159.2	227.3	265.5			

The growth of fish from Prairie Creek follows, almost identically, the general average growth of all fish. The two seven-year-old fish used in the calculations are the same in each table. The fish from Marten Creek show a slight increase in growth at all ages over that of the Prairie Creek fish. Trout Creek fish show a considerable increase in growth over the fish from either of these two streams. The five-year-old fish in Trout Creek are almost as large as six-year-old fish from Prairie or Marten Creeks. The fish from Cold Creek show the poorest growth. The three first-mentioned creeks are roughly the same size, but Cold Creek is approximately one-fifth as large. All the fish measured in this stream were four-year-olds, which may make the calculations of growth less accurate than for fish of the other streams. Because Cold Creek is the smallest from which grayling were taken, it is remarkable that the growth of fish there does not deviate to a greater extent from the general average.

Growth Rate and Food Supply in Four Creeks

Miller (1948) noted that the poorest growth occurred in grayling from streams having the poorest food supply. His work was done on streams of the McLeod River drainage, and included Cold Creek. He found that the fish from this stream showed a greater growth than those from the other six small streams examined, and he also found the

bottom food in largest supply - 1.3 cc. per square foot. The author also took bottom samples in Cold Creek but obtained less than one-quarter this volume of bottom organisms per square foot. This stream is very prone to anchor ice formation so that the bottom food could show considerable variation from year to year. Three bottom samples were taken from the riffles of each of the streams under consideration; one each from the upper, middle and lower reaches, except for Trout Creek. The upper reaches of this stream were devoid of riffles, the flow being slow and the bottom of silt and debris. The amount of food in the four streams is shown in Table VI, with a list of the genera of the organisms included.

It will be noted that Trout Creek had the greatest volume of food and Cold Creek the least. Prairie and Marten Creeks fall between in the order of the growth rates of their fish populations. Thus, it would seem that there is some indication that greatest growth occurs in streams with the greatest food supply. The differences in the volumes of bottom food are not very great, and, since various authors have shown that grayling feed extensively on terrestrial insects during the summer months, it is not surprising that the correlation is not exact. Especially in the first two years, Prairie Creek fish show a higher rate of growth than Cold Creek fish; yet the volume of bottom food is not much larger than it is in Cold Creek. Trout Creek fish have a much faster growth rate than Marten Creek fish,

Table VI.

BOTTOM SAMPLES FROM FOUR CREEKS OF THE ATHABASKA DRAINAGE

	Prairie June 14-23	Marten July-17-18	Trout Aug 26-31	Cold May 27-28
Number of samples	3	3	2	3
Total volume of samples in ccs.	1.1	1.8	1.3	0.9
Average volume per sq. ft. (cc.)	0.367	0.6	0.65	0.3
Bottom Organisms				
Mayfly Nymphs				
Cynigma		3		
Arthroplea	3	18		69
Iron	7	25		
Baetis	33	29	39	30
Ephemerella	6	8	14	10
Ameletus	3	14		
Paraleptophlebia			4	15
Tricorythodes			5	
Stonefly Nymphs				
Isogenus	7	9		
Acroneuria	2			
Taeniopteryx				5
Alloperla	3		8	
Chloroperla		7		
Nemoura	1		24	
Perla			7	
Peltoperla			1	
Pteronarcella		16		
Caddis Fly Larvae				
Rhyacophila		35	5	1
Setodis (?)	1	1		2
Hydropsyche			37	
Brachycentrus	1		22	
Limnophilidae	1		14	
Dipterous Larvae				
Simulium	232	186	2	8
Chironomus	13	5	2	21
Palpomyia				1
Rhaphidolabis				2
Antocha			2	
Miscellaneous				
Corixa	1			
Elmidae or Parnidae		1	27	6
Gammarus		3	4	
Oligochaeta		4		20
Newly hatched fry (sucker)	3			
Sucker egg	1			

yet the quantity of bottom food is almost the same in both streams. Therefore, the terrestrial food available to the grayling in the streams must also have a bearing on the rates of growth.

The rates of growth for Great Slave Lake, Lake Athabaska, and Great Bear Lake were determined by Miller (1946). Of these lakes, the fish from Great Bear Lake showed the slowest rate. Rawson (1949) gives the rate of growth in Reindeer Lake as about the same as that of Lake Athabaska for the first two years and more rapid thereafter. Montana Lake grayling (Brown, 1943) grow at about the same rate as those from Reindeer Lake. Grayling from the Athabaska streams grow slightly faster than those from Great Bear Lake until three years of age and more slowly thereafter. The slowing of the rate of growth as the fish become larger may be due to the more rigorous life led by the stream fish or perhaps the food supply is smaller at some, or all, seasons of the year.

The rates of growth for males and females were calculated separately to determine if there was any difference between the sexes. The calculated forklengths at the end of each year of life are given in Table VII.

Table VII.

THE AVERAGE CALCULATED FORK LENGTHS (MM.) AT THE END OF EACH YEAR OF LIFE OF 81 MALES AND 94 FEMALES.

Age	1	2	3	4	5	6
Males	111.8	176.7	230.2	270.5	301.3	333.0
Females	110.9	172.6	224.4	266.0	292.8	314.7

Males show a slight tendency to grow at a more rapid rate than females. This tendency also shows up in calculations made by Miller (1946) although only in the older fish.

Few grayling were examined for degree of sexual maturity. Miller (1948) found that maturity is reached in the third year for both sexes, and the data shown in Table VIII indicates this is generally the case.

Table VIII.

CONDITIONS OF THE SEX ORGANS OF 59 GRAYLING, 2 AND 3 YEARS OF AGE.

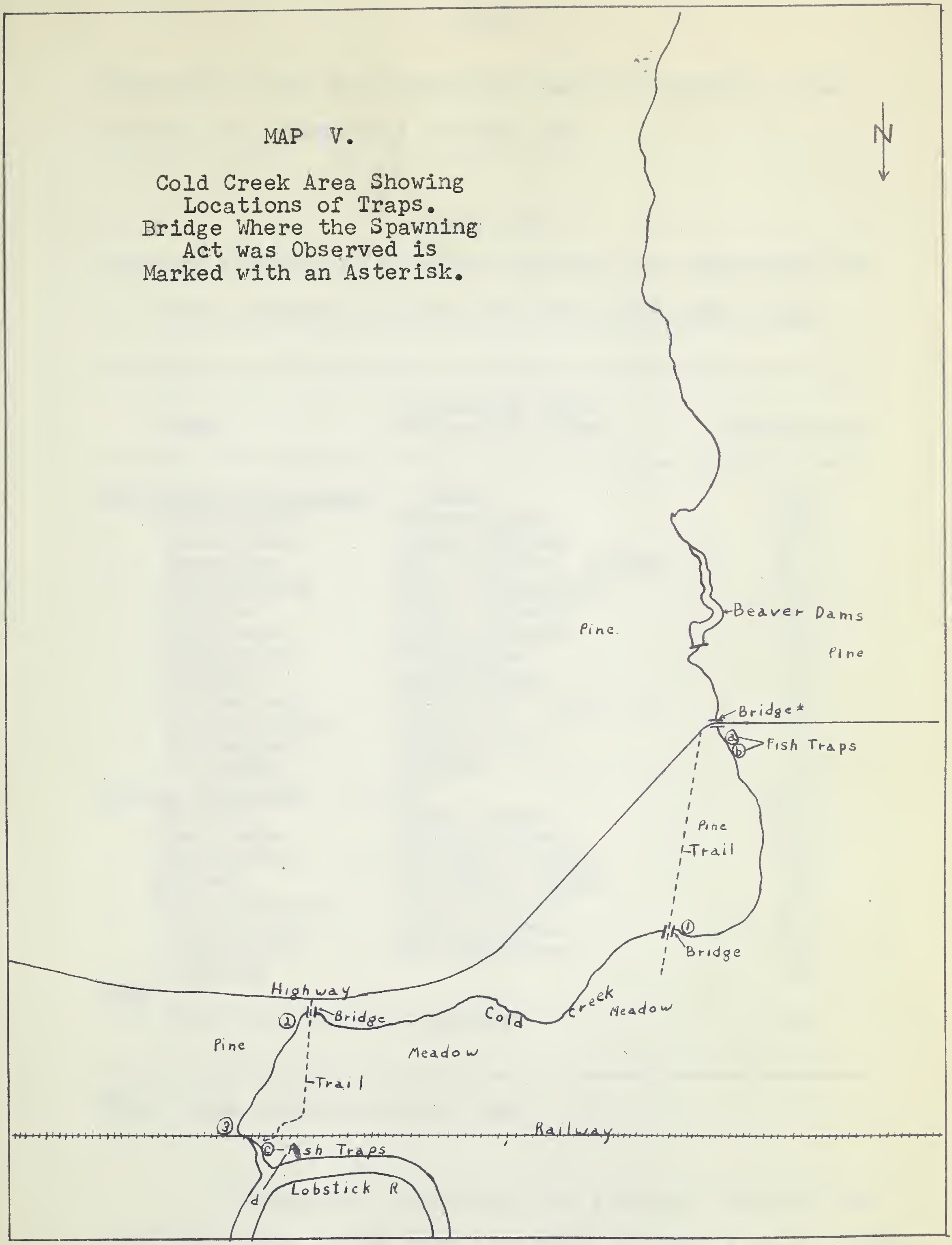
Age	Mature		Maturing		Immature	
	Male	Female	Male	Female	Male	Female
2 years	1	0	2	3	3	3
3 years	20	15	0	4	4	4

Seventy-five percent males and females together are mature by the time they are three years old; 8.5 percent are maturing; and 16.5 percent are immature. All four-year-old fish examined were found to be mature.

The oldest Arctic grayling caught were two in their ~~seventh~~ eighth year of life. These were specimens from Prairie Creek. Brown (1943) captured one Montana grayling that was six years old. Miller (1946) found Arctic grayling in Great Bear Lake up to twelve years old. Apparently the farther north the fish are, the slower they develop and the longer they live.

FEEDING HABITS

Forty-seven stomachs were removed from grayling caught mainly in June and September, and preserved in 5% formalin. The majority of these were from stream fish but twelve came from the beaver dams shown in Map V, page 34. The contents of the stomachs were examined in the laboratory and the undigested organisms from each were recorded. No quantitative measurements of individual organisms were made, but the volumes of the debris and of the total food items in each stomach were measured by water displacement in a graduated tube. The digested material which could not be recognized was measured with the food items. Organisms were keyed to the orders only; the member of the order most



MAP V.

Cold Creek Area Showing Locations of Traps. Bridge Where the Spawning Act was Observed is Marked with an Asterisk.

frequently found was determined whenever possible. The findings are summarized in Table IX.

Table IX.

STOMACH CONTENTS OF 47 ARCTIC GRAYLING, IN PERCENTAGE OF TOTAL STOMACHS IN WHICH THE ORGANISMS WERE FOUND.

Order	Organisms Most Frequently Found	Percentage
Terrestrial Organisms	(total)	76.6
Orthoptera	Grasshoppers	31.9
Coleoptera	Great variety	61.7
Homoptera	Leaf hoppers, aphids	31.9
Hymenoptera	Ants, Ichneumons	44.7
Diptera	Great variety	48.9
Hemiptera	Great variety	19.2
Plecoptera	Stoneflies	4.3
Odonata	Damselflies	8.5
Lepidoptera	Moths and larvae (2)	10.6
Ephemeroptera	Mayflies	2.1
Trichoptera	Caddis flies	2.1
Arachnids	Spiders	4.3
Bottom Organisms	(total)	100.0
Diptera	Midge larvae	30.0
#Hemiptera	Water boatmen	53.2
Placoptera	Stonefly nymphs	23.0
#Odonata	Damselfly nymphs	8.5
#Ephemeroptera	Mayfly nymphs	25.1
Trichoptera	Caddis larvae	51.1
Coleoptera	Hydrophilidae	20.8
Gammarus		6.4
Fish		
One 2-inch Arctic grayling		2.1

#Main items eaten in beaver dams

Terrestrial organisms were found in 76.6% of the stomachs, while bottom items occurred in every stomach (100%).

Several of the beaver dam samples were nearly empty while some of the others were gorged almost completely with a single kind of organism. Two of these stomachs (16.6%) contained terrestrial insects and the remainder contained aquatic forms. The specimens from the dams were taken late in the season (September 20th-30th), at the time when terrestrial insects were becoming scarce, so that selection probably depended on the forms available. Of the samples from the streams, all contained bottom items and 94.4% contained terrestrial forms.

Debris amounted to 21.7% of the total volume of material found in the stomachs. This was chiefly composed of caddis cases, but small sticks, spruce needles, small stones, seeds and one feather were also found.

In most cases, terrestrial and bottom items were found in the same stomach. It would appear that food items are eaten at random as the opportunity arises. No evidence of selection is apparent. During the summer months the stream fish eat large quantities of terrestrial food as well as bottom food. Beaver dam fish probably consume considerable quantities of terrestrial food during the summer, but this was not apparent in the samples taken late in the season. Evidently the diet of the grayling is a varied one, and depends mainly on what is available at the time.

Detailed studies of the food of grayling have been made in Ford Lake, Michigan by Leonard (1938) and in Montana lakes by Brown (1938). Both investigators found that the

Montana grayling lived on a diet of both terrestrial and aquatic organisms of all kinds. The great variety of food taken is emphasized by Rawson's studies (1949), who lists 36 families of insects taken by Arctic grayling. Miller (1946) lists a varied diet for Great Bear Lake grayling and points out that terrestrial insects are eaten to a greater extent during the summer (93%) than are bottom organisms (21.6%). All investigators list some plankton as part of the stomach contents of lake grayling, but none was observed in the stomachs studied by the author. Stream fish rarely have the opportunity to obtain this type of food. Small fish are more apt to feed on such minute organisms and none of the fish studied was under eight inches. It is not surprising, therefore, that no plankton was found. All studies that have been made on the food eaten by grayling show that this fish is very versatile in its feeding habits, choosing whatever food items are available when it is hungry.

SPAWNING HABITS

The spawning run was first observed at Cold Creek in the spring of 1949. The camp was set up the first week of April and several streams in the district were examined to determine if they would be suitable for trapping. The streams were running but there was both floating and anchor

ice in all of them. Due to the unusually warm days, the snow was practically gone. The nights were cold enough to cause the streams to freeze over, thus eliminating any flooding that might have hampered operations. It took several days to make traps (Figure 6) because the banks of the streams and, in many places, the bottoms were frozen solid. By April 18th, the traps were installed and awaiting the arrival of the fish.

During the lengthy waiting period the author had the opportunity to explore Cold Creek more fully. On April 20th, five grayling were observed a few hundred yards above the point where Cold Creek enters the Lobstick River. These fish were making their way upstream in a leisurely fashion. Temperature of the water at this time was 34° F. On April 23rd it was found that the beaver dams (see Map V, page 34) contained numerous grayling which, at this time, were grouped in the upper dam (Dam #4, Map VI, page 42). Although a few were feeding, most of them were just moving about in a restless manner. Accordingly, we placed another trap in the stream just above Dam #4. On the same day, more fish were seen downstream from our trap near the highway, the nearest being about two miles below the trap. The first grayling was caught in the trap on April 24th; it was a male, not yet ripe. Thereafter, no more fish arrived in the Cold Creek trap until the real run began.

On May 3rd the grayling began to arrive at the Cold Creek trap. There were only a few at the beginning,

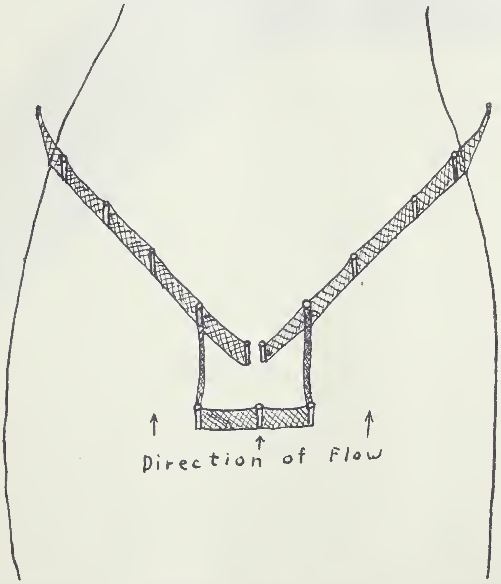


Figure 6. Upper photograph, lower sketch, of the type of trap used to capture grayling in 1949.

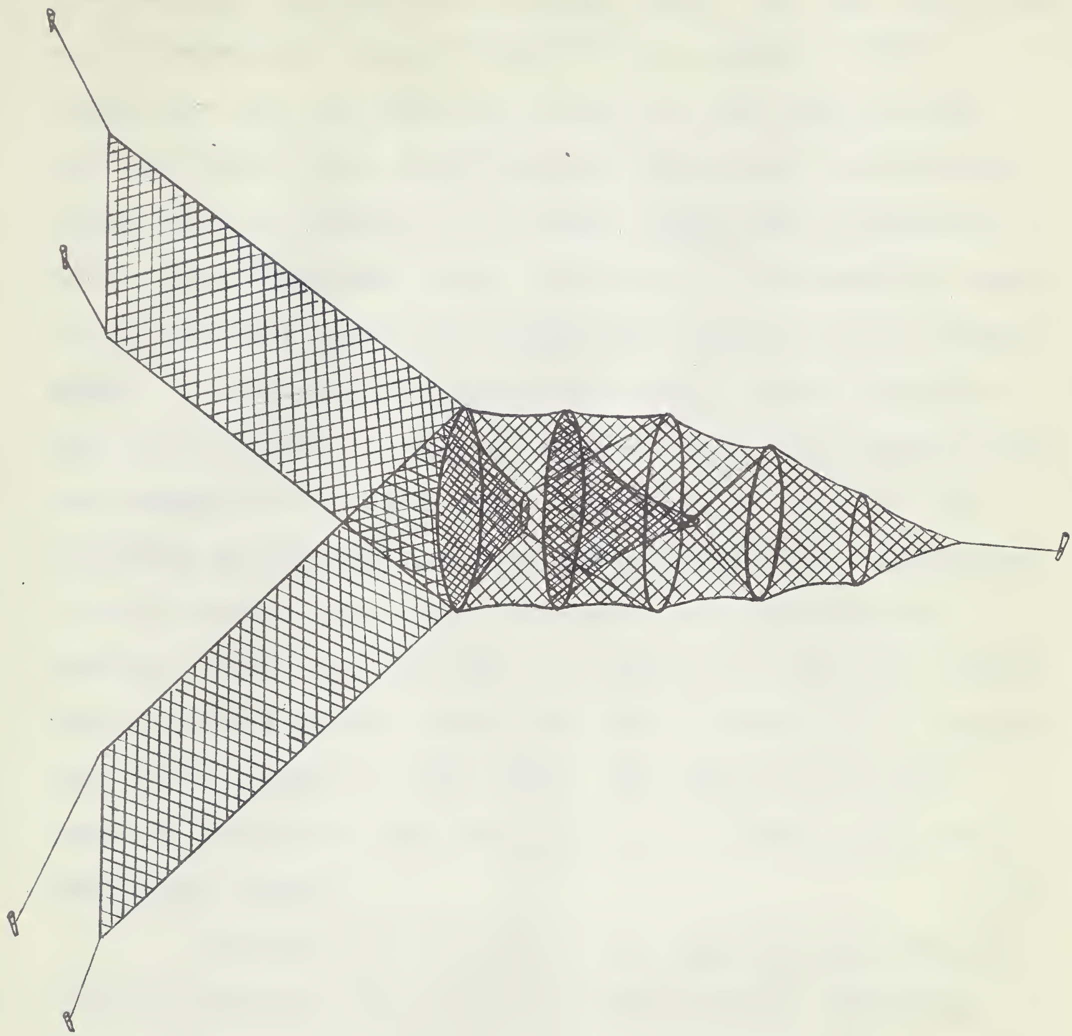


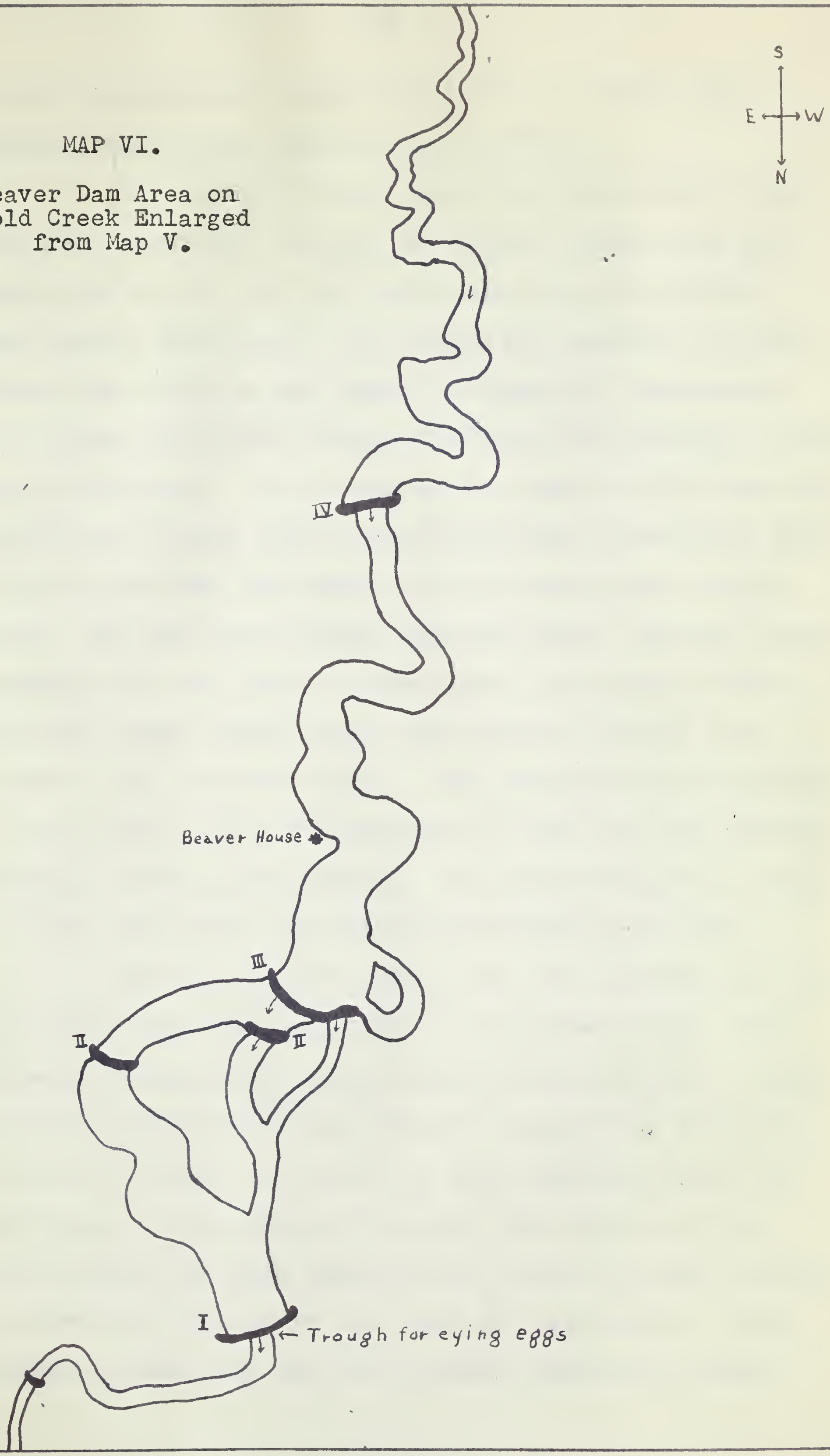
Figure 7. Hoop trap used to capture grayling.

but by May 5th they were being caught at the rate of about one hundred per day. Most of these fish were not yet ripe; the few that were ripe were mainly males. At this time, the water temperature ranged from 37° F. at night to 45° F. during the day. No fish were caught in our traps in the Lobstick River or in Brule Creek. Subsequent investigation showed that the migration in these creeks was obstructed by beaver dams below the traps. Which one of the numerous dams on the Lobstick River was causing the hold-up was not determined. The dam on Brule Creek was found, and by dropping a hoop trap (Figure 7) into the stream below this dam, 97 fish were caught in the first hour. This was on May 4th. The following day another 110 fish were caught here. Thereafter, no more entered this trap. Most of these fish were in spawning condition, and were all stripped by May 8th. Water temperatures in Brule Creek were consistently 2-3° F. higher than in Cold Creek at this time. The run in Cold Creek began to slacken by May 10th, and by May 13th no more fish were being caught.

The natural spawning of the grayling was studied in Cold Creek over the course of several days, beginning May 6th and ending May 12th, 1949. Maximum daytime temperatures during this period increased from 49° F. to 56° F., while minimum temperatures rose from 39° F. to 48° F. In 1950, the spring run-off was considerably later, spawning at the same spot taking place between May 18th and May 25th.

MAP VI.

Beaver Dam Area on
Cold Creek Enlarged
from Map V.



Maximum temperatures ranged from 43° F. to 52° F. and minimum temperatures from 40° F. to 47° F.

The spawning ground where the observations were made was immediately beneath the highway bridge over the creek (see Map V). At this spot there were two riffles about twenty feet apart. The bottom was composed of small stones from three to ten inches in diameter, interspaced with rather fine gravel ranging in size from one-half to one inch in diameter. At the head of the upper riffle there was a solid bed of this small gravel which had accumulated from gravel thrown into the stream as cars crossed the bridge above. The fish were readily observed here. However, more spawning acts took place in the faster and rougher water above the second riffle where more natural pockets were formed by the scattered rocks. The grayling did not attempt to build nests, but took advantage of small hollows between stones or in the solid gravel. The picture (Figure 8, page 44) shows the gravel bed where observations were made.

The fish observed performing the spawning act were those which had been caught by our Cold Creek trap. Most had been stripped, but a few females were released to spawn naturally, and others were probably incompletely stripped. The ratio of males to females on this spawning ground was about 3:1. At the time of trapping, the ratio was very nearly 1.5:1, but some females were killed by being stripped too severely, and others were used for egg-counts. Other spawning grounds may have had slightly different ratios.

Figure 8. Natural spawning bed used by Arctic grayling in Cold Creek. Note tagged male resting in his chosen territory.

Figure 9. Two pictures illustrating the apparatus used to "eye" the grayling eggs - Cold Creek.

Fish were also seen spawning in riffles below our trap, but the nature of the water was such that detailed observations were impossible. However, it was possible to see that there was no difference in the performance between the latter fish and those clearly seen on the spawning grounds beneath the bridge.

The spawning procedure was first observed carefully on May 9th at 4:00 p.m. When the stream was approached the group of six fish then present on the spawning beds dashed down through the riffle to the pool below, but were back again almost immediately. They ~~were not~~ did not appear frightened thereafter by any movement made during the observations.

Each of three of the larger males in the immediate vicinity apparently had appropriated a territory. Here he was stationed most of the time, moving out only when driving off other males that came too close or when following a female that came near. The smaller males followed the females constantly, upstream and down, but were never seen to perform the spawning act. Instead, while one of the larger males was performing, a smaller male would dash in on the opposite side of the female and join the performance. When a female entered the territory of one of the males, she would select the most suitable spot and the male would drift quietly alongside and attempt to press his body tightly against her. Often the female would ease away, but when she was properly stimulated, she would return the pressure so that they were in contact from the pectoral fin to the area

of the vent. The male's huge dorsal fin was arched over the back of the female and vigorous vibrating movements began. Within two to three seconds, their mouths would open and their bodies appeared to be in strong tension. As the climax was reached, their tails dropped lower in the water and a cloud of fine sand was churned up by the intense quivering. This took four to five seconds; then both ceased abruptly. The male recovered immediately, but the female usually rested quietly for a few moments before swimming away. The whole spawning act, from start to finish, fluctuated between eight and twelve seconds duration. The procedure here is very similar to that described by Tryon (1947).

At the time the eggs and sperm were released, the cloud of sand obscured the view and it was impossible to see the sexual products ejected. By using a bottom sampler and stirring up the gravel in the area, it was possible to recover a number of the eggs. This was done a few days after spawning had taken place. Forty-seven eggs were collected in one area, and twelve from another. Out of all these, only two were not fertilized. This represents a natural fertility of approximately ninety-six percent. Since the number of eggs collected was rather small, this figure may not represent the true natural fertility, but there is little doubt that it is high.

Several females were selected for egg-counts. These were stripped rather severely into separate containers. The eggs were left to harden, then counted. The following

table shows the numbers of eggs obtained from each fish. Measurements of length and weight were made before the fish were stripped.

Table X.

THE NUMBERS OF EGGS OBTAINED FROM NINE FEMALE GRAYLING FROM COLD AND BRULE CREEKS.

Length in Inches	Weight in Ounces	Numbers of Eggs
10.0	6.0	2,117
10.0	5.5	1,872
10.9	7.5	574
10.4	7.0	3,433
11.3	9.5	3,831
12.8	15.0	5,963
13.5	17.0	7,039
11.5	10.0	4,630
10.9	9.75	3,383
Total	87.25	32,842
Average	9.69	3,649

Number of eggs per ounce of fish - 376

Brown (1938) gave the following egg counts for some Montana grayling from which the eggs were actually counted.

Table XI.

NUMBERS OF EGGS OBTAINED FROM 15 FEMALE MONTANA GRAYLING AS REPORTED BY BROWN (1938).

Numbers of Fish	Weight in Ounces	Numbers of Eggs
1	12	5,563
1	4	1,248
1	4	416
9	15 (av.)	5,828 (av.)
3	32 (av.)	12,946
		12,642
		8,135
Total	131	46,778
Average	18.7	6,683
Average number of eggs per ounce of fish - 357		

The difference in these figures cannot be considered significant, as Brown does not state whether or not the weights given were taken before or after the eggs were removed for counting.

All investigators who have reported on the stripping of grayling have commented on the small amount of milt produced by the males. This was also found to be true of the males used in our operations. The amount varied from a drop or two to a teaspoonful. It was found that males which

were retained after being used once were capable of producing an equal amount of milt in a day or two, and could occasionally be used a third time. The males producing the greatest quantity of milt the first time continued to give larger amounts than fish which gave but a drop or two. Egg fertility from artificial fecundation was considerably below that reported for natural spawning. The "wet" method was used, i.e., a small quantity of water was placed in the pan receiving the eggs and sperm. The fertility of these eggs was not investigated but it was judged to be between seventy and eighty percent. This is lower than the ninety-five percent fertility reported by Henshall (1907) when using the "dry" method (no water used at all) on Montana grayling.

Egg diameter was determined by the measurement of two batches of eggs. The first samples, taken three days after incubation was started, averaged 0.139 inches in diameter. The second, after five days of incubation, averaged 0.149 inches. The former figure represents about 25,000 eggs per quart, the latter 20,450 eggs per quart (from tables in Lagler, 1949). Henshall (1907) reported Montana grayling eggs to vary between 750 and 850 per fluid ounce.

The development of the eggs and fry could not be investigated very thoroughly. The first batch of eggs, taken in 1949, was eyed in jars using a beaver dam at Cold Creek for the water supply (Figure 9, page 44). The eggs were then transported to the Calgary hatchery where hatching was completed. Unfortunately, the water supply became contaminated

and the fry died. The fact that they died before trout fry in the same hatchery were affected indicates that they are very delicate when first hatched, and require pure water for survival. The operations for 1950 were even less successful. The eyed eggs were allowed to become too warm during transportation to the hatchery and none survived. The development of the grayling eggs is shown in the following table.

Table XII.

NUMBERS OF DAYS, TEMPERATURE UNITS, AND AVERAGE TEMPERATURES RECORDED FROM IMPREGNATION OF THE EGGS TO HATCHING.

	No. of Days	Av. Temp. ° F.	Temp. Units ° F.#
Impregnation to eyed 1950	12.5	45.5	168.7
To hatching 1949	8.0	43.0	88.0
Total	20.5		256.7

#No. of days x ° F. above 32

The approximate number of Fahrenheit units required to hatch Arctic grayling eggs is 256.7.

Rawson (1949) reported that Arctic grayling eggs reared in Saskatchewan took twelve days to reach the eyed stage in water of 43° F. to 48° F., and four to six days in temperatures ranging from 48° F. to 52° F. to hatch. This represents approximately 250 temperature units.

SEASONAL MOVEMENTS

Accounts in the literature give conflicting reports on the distances grayling travel on their spawning migrations. Henshall (1907) reports that "Unlike the Rocky Mountain trout (Salmo clarkii), but like the salmon, the grayling will go long distances, if necessary, to find suitable spawning grounds." He mentions one migration fourteen miles in length. Brown (1938) does not agree and states that the grayling is much more limited in its runs. Tryon (1947) indicates that old-timers in the region of the Madison River speak of great runs up this river, but states that such runs are a thing of the past. Distribution of Montana grayling is now restricted mostly to lakes and the migrations confined to short runs into the inlets. Rawson (1949) states that in certain areas grayling are reported to run into the mouths of small streams to spawn.

The author was familiar with the spawning migrations of Arctic grayling many years before undertaking investigations into their habits. In the years 1936 to 1939 there was a very spirited spawning run into the Beaverlodge River, which is in the Peace River country. The Northern Alberta Railway Company had installed a dam in the river near the village of Hythe, which interfered with the migration of the fish. Up to this time, the presence of such a run of fish had not come to the attention of the local people, though

grayling under twelve inches in length were commonly caught throughout the summers. It was not long before everyone in the country was there to help themselves to the spoils and to watch the beautiful leaps performed by the fish as they attempted to surmount the six-foot falls. Few of the fish succeeded in overcoming the barrier unless they used the fish ladded provided. On many occasions, there must have been twenty or thirty fish in the air at one time, and the water below the spillway was alive with fish. Four-foot leaps were common in the persistent attempts made by the fish to reach the top. The number of fish is emphasized by the fact that one farmer took home a wagon-box full of grayling after one afternoon of wielding a dip net below the falls. Fish caught at that time ranged between fourteen and twenty-two inches in length. Needless to say, the practice of catching the fish with dip nets together with changing stream conditions due to removal of forests at the headwaters, soon reduced the number of grayling. Now, this same stream floods violently in the spring and is dry by midsummer. The fish that were observed on these early migrations must have come from the Wapiti River, some sixty miles by stream, for the Beaverlodge River was too shallow in the autumn to maintain fish for the winter. Fish as large as those caught on the spawning run were never seen in the stream at other times of the year.

In all likelihood, the fish caught in our traps on Cold Creek in both 1949 and 1950 did not travel nearly

this distance. It was possible for these fish to come from the Lobstick River, about eight water-miles distant; from Chip Lake, about fourteen miles; or from the Pembina River, about forty miles. There is no doubt, however, that the fish ran the last eight miles to the location of the traps. Careful observations of Cold Creek revealed no fish in the stream before the spawning run began. A trap was placed in Cold Creek in the fall of 1950 to catch all fish coming downstream (Trap C, Map V). This was set in place on September 15th and maintained until October 14th. In this period, a total of 25 grayling, 64 northern pike (Esox lucius), 11 suckers (Catostomidae) and 2 burbot (Lota lota maculosa) were captured. This would indicate that the fish which spend the summer in Cold Creek move out in the autumn to spend the winter in deeper water. In the spring of 1949 a trap was constructed above the one used to capture fish from the spawning migration (Figure 6, page 39). It faced upstream in order to catch any fish that might have wintered above and which might possibly come downstream in the spring. Not a single fish was caught in this trap. Therefore, there seems little doubt that the fish in Cold Creek do not spend the winter there, but migrate into the stream to spawn, spend the summer, and leave again in the fall.

Marking Experiments in 1949

Many of the fish captured during the spawning runs

in 1949 were marked by means of fin-clipping. The marking and recovery of these fish are summarized in Table XIII.

Table XIII.

MARKING AND RECOVERY RECORD OF 218 ARCTIC GRAYLING FROM COLD CREEK AND 58 FROM BRULE CREEK.

Marking Record, 1949

Date	Place Released	No. Fish	Fin Clipped
May 7	Cold Creek (b)	7	Left pelvic
8	Cold Creek (b)	67	Left pelvic
9	Cold Creek (b)	43	Left pelvic
12	Cold Creek (b)	101	Left pelvic
5	Brule Creek	21	Right pectoral
7	Brule Creek	37	Right pectoral

Recovery Record, 1950

May 16	Cold Creek (a)	3	Left pelvic
18	Cold Creek (a)	5	Left pelvic
20	Cold Creek (a)	6	Left pelvic
21	Cold Creek (a)	1	Left pelvic
14	Brule Creek	2	Right pectoral
Sept. 30	Cold Creek (c)	3	Left pelvic
Oct. 3	Cold Creek (c)	1	Left pelvic

Recovery of these fish took place during the spawning run in 1950 and a few in the fall of the same year. All those from Cold Creek were released, with the left

pelvic fin clipped, in the vicinity of trap B, (Map V). Those from Brule Creek had the right pectoral fin clipped and were released about three miles upstream from the Lobstick River, below the beaver dams obstructing their migration.

Fifteen grayling, with their left pelvic fins clipped, were recovered from the spawning run in 1950, at trap A. A larger number of similarly marked fish were captured; the author was re-tagging these with numbered plastic tags, and had several fish in a retainer which was raided by local citizens before records were made of the fish contained therein. Two marked fish were recovered from Brule Creek during the run in 1950, both with the right pectoral fin clipped. In the autumn of 1950, four fish with the left pelvic fin mark were captured at trap C. The recovery of marked fish was small compared to the number clipped. Those caught came from the stream from which they were originally captured and in which they had been released. This possibly indicates that the fish return to the same stream in successive years - perhaps to the stream in which they hatched. The evidence is not conclusive; more marking and recovery over a period of several years will be required to provide reliable data on the movements of grayling.

Tagging Experiments in 1950

Thirty-two fish were tagged with numbered plastic

tags of the type that are held in place by a pin inserted through the body below the dorsal fin. These were released in Cold Creek in May, 1950, in the vicinity of trap A. Nineteen were similarly tagged and released in the Lobstick River one hundred yards south of the main highway. All were taken during the spawning runs. Those in Cold Creek included all recaptures from the 1949 fin-marked fish. The reported recovery of these fish during the summer of 1950 was disappointing. Only three tagged fish were reported caught by anglers. It is known that many more were captured by local citizens, who, having no angling permits, did not report their catches. The tagging and recovery records are shown in Table XIV.

Table XIV.

MARKING AND RECOVERY RECORD FOR 32 ARCTIC GRAYLING FROM COLD CREEK AND 19 FROM THE LOBSTICK RIVER, MAY TO SEPTEMBER, 1950.

Marking Record				Recovery	
Date	Place Released	No. Fish	Tag Nos.	Tag No.	Place
May 16	Cold Creek trap (a)	8	801-08	812	Lobstick River, $\frac{1}{2}$ mile upstream, August
May 16	Lobstick River	4	809-12		
May 18	Cold Creek trap (a)	12	813-24	814	Cold Creek, below dam, July
May 20	Lobstick River	15	825-39		
May 20	Cold Creek trap (a)	11	840-50	817	Cold Creek, $\frac{1}{4}$ mile, south, June
May 21	Cold Creek dams	1	851		

Of the three fish reported, one was caught in the Lobstick River and two in Cold Creek. The Lobstick recovery was one that had been released about half a mile downstream from where it was caught. The two Cold Creek fish had been released in this stream. One was caught just below the first beaver dam and as far upstream as it could travel; the other

was about half this distance upstream from where it was released. Apparently, the fish continued to move upstream after being stripped and tagged. This tendency was also noted when several tagged fish were recaptured by our traps the day following their tagging and release in the area below the trap. This movement upstream, after being stripped, was probably due to a continuation of the spawning urge. The fish would very likely distribute themselves along the stream in the favored locations for the summer months, drifting slowly back downstream with the onset of freeze-up.

Winter Habitat

An attempt was made to discover where the fish go after leaving the smaller streams, but the effort met with little success. Small mesh gill nets were set in one of the deep holes in the McLeod River, starting the last week in August, and once a week thereafter until the last week in September. This spot, locally known as the "Big Eddy", was one recommended by the people of the district. No grayling were caught. Reliable reports received since indicate that grayling were in the McLeod River during this time, but were located in rapids where nets could not be set.

It seems a logical assumption that the fish would spend the winter in any place where sufficient depth of water prevents the danger of freezing to the bottom. It is known that many grayling spend the winter in beaver dams

such as those on Cold Creek. One local fisherman in the Whitecourt area claims to have caught grayling through the ice in mid-winter. This was on Windfall Creek in a deep hole created by log-jams in the stream. A few grayling are captured by commercial fishermen in Lesser Slave Lake, mainly during the winter and spring. Many of the streams inhabited by grayling during the summer are too shallow throughout the greater part of their lengths for wintering to be safe in the average pool. Thus, the grayling must spend the winter in the larger rivers, in the lakes, and in very deep pools.

SUMMARY

The purpose of this study has been to gather information regarding the biology of the Arctic grayling, Thymallus signifer, in Alberta in order that proper management techniques may be carried out. It is hoped the information will be useful to officials who carry out conservation measures, and that it will provide a nucleus of information for those who undertake additional investigations. Briefly, this is what has been accomplished.

1. A brief survey is given of Alberta streams known to contain grayling population, together with maps of these streams.

2. A short morphological study has brought out

at least one characteristic by which the sexes may be recognized after they reach sizeable proportions. This may be useful to the angler as well as the scientific observer and to those engaged in field work with grayling. This study also indicates that no differences exist between fish from Alberta and Saskatchewan. They are the same species, but the average size of the Saskatchewan fish is ~~larger~~ greater, giving them a somewhat different appearance. The taxonomic measurements recorded in the appendix may be useful to future investigators.

3. Growth rate studies indicate that the larger stream grayling average smaller than lake specimens. This is probably due to a more rigorous life and poorer food supply. Growth varies from stream to stream. Sexual maturity is reached at the end of three years of life.

4. Grayling are very versatile in their feeding habits, making them an ideal fish for streams and lakes where the food supply acts as a limiting factor to fish which are more specific in the food they select.

5. Various aspects of the spawning habits have been presented. The Alberta grayling spawn in May when the stream temperatures reach 40° to 50° Fahrenheit. They were observed to spawn in the fast water of riffles in small gravel. The number of eggs of spawning females is in the neighborhood of 375 per ounce of fish. The number of ~~heat~~ temperature units required to hatch the eggs is approximately 250.

6. Evidence has been presented which indicates

that grayling do not spend the winter months in the streams where they pass the summers. They migrate sometimes considerable distances, into suitable small streams in the spring, and drift back out in the autumn. This makes them suitable for streams in which fish cannot winter successfuly. They are valuable for providing angling in many streams that cannot support trout populations. Shallow streams in which anchor ice formation causes a poor supply of bottom food can be utilized by grayling because they feed extensively on surface food items during the summer, and do not depend on the stream's bottom food in winter.

The Arctic grayling is therefore a very valuable sporting fish. They create fine fishing in streams where other fish could not survive for long. Their chief drawback is that they are relatively easy to catch, and they will not live in clear mountain streams. Management practices should be designed which ensure that each stream continues to have a sufficient breeding population. Watershed protection is necessary to prevent violent flooding in the spring and abnormally low water levels in summer with temperatures reaching higher than 65° F. Grayling also favor streams which are well shaded and have good bank cover.

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APPENDIX

Table XV.

TAXONOMIC MEASUREMENTS

Key to Column Headings

FL - fork length; SL - standard length; HL - head length; HD - head depth; Max - length of upper jaw; SN - snout length; Eye - eye diameter; IO - interorbital width; SO - snout to occiput length; OD - occiput to dorsal length; DB - length of dorsal base; DL - length of dorsal fin; BD - body depth; CPL - caudal peduncle length; CPD - caudal peduncle depth; BW - body width; P_1L - pectoral fin length; P_2L - pelvic fin length; AB - length of anal base; AL - length of anal fin; P_1P_2 - pectoral to pelvic length; P_2A - pelvic to anal length; LLS - lateral line scales; GR - gill rakers.

BRULE CREEK AND

FL	SL	HL	HD	Max	SN	Eye	IO	SO	OD	DB	DL	BD
262	237	47	31	19	13	12	9	36	48	63	89	52
327	295	60	47	22	16	13	15	44	62	86	125	73
193	176	38	24	15	9	10	9	29	35	43	59	38
263	238	50	33	20	13	12	13	39	44	66	107	54
284	257	51	35	20	14	12	14	37	52	67	94	51
201	182	37	26	15	10	10	10	30	33	46	72	38
232	213	43	29	16	11	11	12	33	42	52	73	49
269	243	49	33	17	13	11	14	38	51	62	90	51
311	281	58	40	20	14	13	16	41	60	76	107	71
249	225	46	30	17	11	11	12	34	45	57	83	47
247	224	46	30	18	12	11	13	33	45	59	83	52
149	131	29	18	11	7	7	8	22	25	32	42	26
365	333	71	49	28	18	16	19	53	64	98	191	76
350	318	67	46	25	17	15	19	48	58	90	166	71
257	233	48	33	17	13	11	12	35	45	66	105	47
314	295	60	42	23	16	14	18	43	57	85	149	64
220	199	41	26	14	11	10	11	29	43	51	72	44
234	214	43	29	17	11	11	10	31	44	53	76	47
300	273	57	40	21	15	12	15	43	50	76	125	61
312	282	59	39	22	14	12	15	42	62	76	109	70
277	246	49	33	18	11	11	11	36	46	70	112	56
222	200	42	26	15	10	11	10	30	42	53	83	44
249	223	45	31	17	12	11	11	32	41	57	81	42
268	244	49	32	17	13	11	12	35	47	66	106	52
225	203	42	28	15	11	11	10	31	37	53	82	44
344	312	66	46	26	16	15	18	49	69	84	122	76
232	211	42	28	17	10	10	10	33	45	54	77	47

COLD CREEK FISH

CPL	CPD	BW	P_1L	P_2L	AB	AL	P_1P_2	P_2A	LLS	GR	Sex
34	20	28	42	38	28	37	79	65	91	6 - 11	♀
43	26	39	60	52	31	46	97	72	89	6 - 9	♀
25	14	23	30	26	19	24	54	50	91	6 - 10	♀
30	20	32	43	43	29	37	71	67	87	6 - 10	♂
34	21	33	45	45	30	40	83	73	92	6 - 10	♀
25	15	23	33	31	22	29	51	47	86	6 - 10	♂
29	18	29	36	34	23	32	68	60	86	6 - 10	♀
34	20	31	41	41	27	39	72	68	91	6 - 10	♀
36	24	37	49	48	33	42	88	82	86	6 - 10	♀
32	19	28	40	38	26	36	73	64	86	6 - 9	♀
34	19	33	40	37	26	36	65	62	90	6 - 10	♀
17	10	15	23	21	15	21	36	35	86	6 - 9	♀
45	28	46	59	65	43	50	102	87	86	6 - 11	♂
44	27	43	57	60	39	46	92	91	88	7 - 11	♂
30	19	32	41	42	29	35	68	63	87	6 - 10	♂
38	25	41	52	54	39	43	95	89	86	6 - 10	♂
27	17	27	32	30	22	32	60	52	89	6 - 10	♀
26	17	31	36	34	25	34	62	58	85	7 - 11	♀
36	22	33	50	49	35	38	86	78	81	7 - 10	♂
37	25	35	53	52	30	43	90	80	87	6 - 11	♀
34	21	30	45	45	33	39	77	73	86	6 - 9	♂
26	17	23	35	35	24	32	54	54	85	6 - 8	♂
31	18	27	39	37	25	36	69	59	85	7 - 10	♀
33	21	31	43	45	28	35	72	68	85	6 - 13	♂
27	17	23	36	36	23	31	61	57	88	6 - 10	♂
38	26	45	57	56	35	47	99	89	87	6 - 11	♀
29	18	28	36	36	23	35	58	60	84	6 - 10	♀

DR. RAWSON'S PRESERVED

FL	SL	HL	HD	Max	SN	Eye	IO	SO	OD	DB	DL	BD
420	388	82	60	33	20	18	24	61	79	103	117	115
411	378	75	56	32	18	18	23	62	67	110	170	98
454	420	86	70	35	24	18	29	74	67	126	257	126
381	355	72	48	27	18	17	20	52	68	87	148	85
293	266	52	36	21	14	12	14	38	48	70	104	62
376	346	71	51	27	19	16	20	55	62	93	144	86
303	276	54	39	20	14	14	16	41	53	69	110	68
372	342	71	49	27	16	17	21	52	68	87	155	89
208	185	38	27	14	8	-	12	30	35	52	79	45
110	99	22	13	9	5	-	6	17	22	23	29	20
203	183	39	24	14	8	-	11	26	34	48	74	40
154	132	28	18	10	6	-	8	22	26	34	45	28
217	198	40	28	15	9	-	11	30	35	58	84	45

FISH FROM SASKATCHEWAN

CPL	CPD	BW	P_1L	P_2L	AB	AL	P_1P_2	P_2A	LLS	GR
56	37	-	69	75	47	63	139	108	88	6 - 10
53	32	46	64	69	47	58	127	113	92	6 - 11
59	40	56	84	93	58	69	136	106	90	6 - 10
55	32	-	62	69	38	48	116	104	95	4 - 10
35	22	32	48	48	32	45	78	77	93	6 - 10
46	31	42	62	60	36	53	101	98	93	6 - 10
38	23	39	50	48	29	42	92	80	93	6 - 10
47	29	-	68	64	40	53	107	101	84	7 - 9
24	18	-	36	37	21	31	56	54	89	5 - 10
13	7	-	17	15	10	15	28	28	93	5 - 8
26	16	19	33	34	21	29	51	52	90	6 - 10
21	11	15	24	25	15	22	36	40	86	6 - 10
27	18	20	34	37	23	32	51	59	88	6 - 11

FRESH

FL	SL	HL	HD	Max	SN	Eye	IO	SO	OD	DB	DL	BD
												Prairie
299	272	52	39	20	13	13	13	40	59	71	104	62
244	220	41	31	17	12	12	11	37	39	56	80	47
301	276	55	38	21	14	13	13	43	58	69	104	65
250	228	48	33	19	11	12	13	38	42	59	90	54
280	257	50	33	19	12	13	12	37	53	66	100	59
182	165	35	23	14	8	11	9	24	36	40	55	38
												Marten
320	295	58	40	22	14	15	15	42	61	80	117	70
333	308	62	43	24	16	14	16	44	64	78	124	72
360	333	68	46	27	18	-	19	49	60	91	193	79
335	309	63	45	25	15	15	16	45	62	83	156	74
315	290	56	43	24	14	14	15	42	56	78	122	70
290	267	54	37	20	14	13	13	39	51	66	103	64
305	281	56	40	22	14	14	14	41	61	70	104	66
												Shaw's
354	323	66	45	27	18	17	19	45	61	92	172	74
335	309	60	44	24	16	15	16	44	61	80	122	75
342	312	60	44	24	17	16	18	45	61	82	139	74
352	320	65	44	25	17	16	17	47	61	90	140	78
350	320	62	45	24	17	15	17	46	64	86	128	76
322	299	56	41	23	14	14	15	42	52	78	115	73
												Cold
293	267	53	40	20	14	13	14	38	55	71	133	61
313	287	55	39	22	16	14	15	42	57	79	145	63
314	287	55	40	21	15	14	15	43	57	78	129	64
320	298	56	39	21	16	14	15	45	58	83	135	68
318	291	57	39	21	15	13	14	42	54	80	132	62
269	248	46	32	17	11	11	10	33	51	64	88	53

SPECIMENS

CPL	CPD	BW	P_1L	P_2L	AB	AL	P_1P_2	P_2A	LLS	GR	Sex
Creek											
35	23	35	45	43	30	40	89	75	92	5 - 10	♀
30	18	31	37	36	24	33	67	58	87	4 - 7	♀
42	23	40	46	44	29	41	85	72	94	6 - 8	♀
29	19	29	40	37	24	32	73	65	93	5 - 9	♀
36	21	32	43	40	24	36	80	74	84	5 - 9	♀
22	14	20	28	27	16	25	51	48	90	5 - 9	♂
Creek											
40	23	40	53	50	31	43	98	85	98	6 - 9	♀
46	25	42	52	50	33	42	100	94	85	6 - 9	♀
45	26	43	59	64	39	42	99	93	88	6 - 11	♂
44	24	43	55	55	33	42	102	85	89	6 - 10	♂
39	23	44	51	47	32	43	95	84	86	5 - 10	♀
38	21	38	50	43	29	39	92	78	87	6 - 10	♀
35	21	41	48	45	28	38	91	83	92	5 - 10	♀
Creek											
41	25	43	59	63	40	46	100	92	97	7 - 10	♂
41	24	45	53	51	32	44	99	88	94	7 - 10	♀
41	25	44	53	55	36	45	101	90	92	7 - 11	♀
44	27	47	56	58	35	48	100	93	90	7 - 11	♀
40	25	42	56	56	39	50	106	95	92	6 - 10	♀
41	24	42	50	49	34	42	97	90	88	7 - 9	♀
Creek											
34	20	36	47	48	34	41	87	78	88	6 - 9	♂
40	22	37	52	53	34	43	95	82	88		♂
39	23	42	48	51	33	40	88	83	89	7 - 11	♂
38	23	43	52	55	37	44	91	88	90	7 - 10	♂
41	22	41	49	50	33	44	92	78	89	7 - 10	♂
36	19	35	43	37	24	36	82	73	86	7 - 9	♀