FISHERIES RESEARCH BOARD OF CANADA

Aspects of the Biology of the Brook Trout, *Salvelinus fontinalis* (Mitchill) 1815, in the Valley River, Labrador.

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Freshwater and Anadromous Fisheries Management
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A sample of 130 brook trout from the Valley River were studied with respect to size and age structure, growth rates, reproductive biology and food habits. The maximum age recorded was 5+ years, with 92% of the fish in the 2+ and 3+ age groups. The fish ranged in length from 7.5 to 28.9 cm, with a mean fork length of 16.8 cm. The greatest increment in length occurred during the first year of life, while the largest weight increments occurred in the later years. The weight increased as the 2.9026 power of the length. The overall sex ratio was close to 1:1. Both male and female brook trout were predominantly mature at age 2+. Ovaries from fish 12.3 - 23.9 cm in length contained an average of 214 eggs (range of 71-848). Benthic fauna, particularly immature insects, constituted the bulk of the diet. Diptera (blackfly) larvae occurred in a large number (66%) of stomachs.

RÉSUMÉ

Wheeler, J.P. 1977. Aspects of the biology of the brook trout, Salvelinus fontinalis (Mitchill) 1815, in the Valley River, Labrador. Fish. Mar. Serv. MS Rep. 1425: 19 p.

L'auteur a étudié la répartition de la taille et de l'âge, le rythme de croissance, la reproduction et les habitudes alimentaires d'un échantillon de 130 ombles de fontaine de la rivière Valley. Les groupes des deux et des trois ans constituaient 92% de l'effectif, quatre ans étant l'âge maximal. La longueur de poisson variait de 7,5 à 28,9 cm, avec une longueur moyenne à la fourche de 16,8 cm. La plus forte augmentation de la taille se produisait pendant la première année de vie, tandis que celle du poids avait lieu plus tard. Le poids augmentait proportionnellement à la puissance 2,9206 de la longueur. Le rapport global des sexes était près de 1:1. L'âge prédominante de maturation pour mâles et femelles était de deux ans. Chez les poissons de 12,3 à 23,9 cm de longueur, les ovaires contenaient en moyenne 214 oeufs (71 à 848). Les ombles de fontaine se sont nourris surtout aux dépens de la faune benthique, plus particulièrement d'insectes non adultes. On a trouvé un grand nombre (66%) de larves de diptères (mouche noire) dans leur estomac.

Key Words: Salvelinus fontinalis, scale reading, age composition, size distribution, growth, length-weight relationships, sex ratio, fecundity, food organisms.

INTRODUCTION

The brook trout, Salvelinus fontinalis (Mitchill) 1815, was first reported from Labrador by Storer (1850). It was subsequently recorded by Weiz (1866), Stearns (1883), Kendall (1911) and Weed (1934). These observations were made near the coast. Munroe (1949) and Backus (1957) gave specific records for inland lakes and streams.

In 1973, Environment Canada, Fisheries and Marine Service, initiated a long-term program designed to inventory the fish resources of the natural lakes and the Smallwood Reservoir in western Labrador. Investigations of Jacopie Lake (Bruce 1974), and Ten Mile Lake (Parsons 1975) dealt with the biology of large brook trout (10-45 cm).

Subsequently, smaller brook trout (15-25 cm) were observed in the Valley River, not far from the two previous study areas. Information was required on the biology of these smaller brook trout, to compare them to larger brook trout from the area, and to aid in development of sound conservation policies and management practices.

The study was designed to include investigation of size and age structure, growth rates, reproductive biology and food habits.

DESCRIPTION OF THE STUDY AREA

The headwaters of the Valley River (Fig. 1) are approximately 35 km west of the town of Churchill Falls at latitude 53°45' North and longitude 64°31' West. The river has a drainage area of approximately 750 sq km, consisting of a series of ponds and marshes. The river (Fig. 2) flows southeast approximately 18 km and then enters the Churchill River 6 km below the Churchill Falls. Water depths range from 0.4 m to 25.0 m, with a mean width of 6.0 m.

The river valley is forested with scrub black spruce (Picea mariana). White spruce (Picea glauca), balsam fir (Abies balsama), white birch (Betula papyrifera), and mountain ash (Sorbus americana) are also common.

The Valley River is on the edge of the Labrador Plateau, which forms the eastern section of the Canadian Shield. The bedrock of this area is of archaean granites and gneisses dating back to the Cambrian era (Powell, 1971).

The average annual precipitation for the Churchill Falls area is 760 mm. The mean daily temperature for January is -23 C and for July, 13.6 C (CFLCo. News Service Fact. Sheet).

MATERIALS AND METHODS

PHYSICAL AND CHEMICAL STUDIES

Surface water temperatures of the Valley River were recorded by a continuous reading Ryan thermograph from 24 July to 7 August 1975 at water sample station no. 1.

Selected chemical parameters of the Valley River including pH, total hardness, specific conductance at 25 C, total dissolved solids, total alkalinity, turbidity, Ca^{+} concentration, and Cl^{-} concentration, were studied at four stations (Fig. 2). Analysis of these water samples, taken 24 July 1975, was carried out by the Laboratory Services Unit, Fisheries and Marine Service.

BIOLOGICAL STUDIES

Several methods were used to collect brook trout, including: angling, minnow traps and fyke nets. The fyke nets, or live traps, were constructed of 1.9 cm stretched mesh knitted nylon. They consisted of a 30.5 m leader, two 9.1 m wings, a body of one 1.2 m frame, one 0.9 m frame, three 0.61 m frames and a trailing cod end. The leader and wings were 1.8 m in depth. To provide a more unbiased sample, two collecting sites were used. These sites were chosen for their ease of accessibility and their geographical separation. Most of the brook trout were taken by angling; spin-casting and fly rods were used. The fyke net and six minnow traps were fished for two nights each.

A sample of 130 brook trout was obtained using the above mentioned methods. Fork length, the distance from the most anterior extremity to the notch in the caudal fin, was measured to the nearest millimeter. Total weight was measured to the nearest 1 g using a triple beam Dial-O-Gram balance. Excess water was drained off the fish before weighings were made.

Scale samples were removed from the left side of each fish just posterior to the dorsal fin and above the lateral line. They were placed on scale paper and stored in scale envelopes. They were later examined using a Bausch and Lomb microprojector with a magnification of 43 diameters and aged according to the method of annulus formation (Cooper 1951).

The length-weight relationship ($W=aL^{n}$), where 'a' and 'n' are empirical constants determined by computation (Rounsefell and Everhart 1953), was calculated using a Log-Log/Linear Regression Program for a Hewlett Packard Model 9830 A electronic computer.

Sex was determined by gross inspection of the gonads. The stage of maturity was also determined by macroscopic examination. Males were designated immature if the testes were small, narrow and threadlike, and showed no sign of vascularization (Wiseman 1969). Maturing males had larger, prominent, highly vascularized testes. Females were designated immature if the ovaries were small and narrow, with minute eggs less than 1 mm in diameter (Vladykov 1956). The ovaries from 40 ripe females were preserved in 5% formalin; fecundity was later determined by actual egg counts.

The relationships of length-fecundity, weight-fecundity and age-fecundity were calculated using the same Log-Log/Linear Regression Program as for the length-weight relationship.

To evaluate the food habits of the brook trout, stomachs, from the lower esophagus to the pyloric sphincter, were removed and placed in separate vials containing 10% formalin. The contents were examined at a later date, at which time, frequency of occurrence was used as a qualitative method of food assessment.

RESULTS

PHYSICAL AND CHEMICAL ENVIRONMENT

Temperature

The ice-free period for most lakes and rivers in western Labrador is from early June to early November. The surface water temperature of the Valley River varied very slightly from 24 July to 7 August 1975, ranging from 15.5 C to 18.9 C. The mean water temperature during this period was 16.1 C.

Water quality analysis

Analysis of water samples (Table 1) from the four stations showed very little variation in their chemical properties. The range in pH between stations was 6.0 to 6.2, the average being 6.1. The mean specific conductance value (13.6) is similar to the reading (12.6) for a nearby natural system, Ten Mile Lake (Parsons 1975), but is considerably lower than the mean value (38.0) for 354 Newfoundland lakes and rivers (Wiseman 1972).

SIZE AND AGE COMPOSITION

Length

Fork length distribution is shown in Table 2, and in Fig. 3; the fish are grouped into 3.0 cm length classes.

The length distribution is unimodal with the majority of the fish (89%) between 12.5 and 21.5 cm in length. Males and females showed similar length distributions. The largest fish collected were males, and males exceeded females in average length, although the difference was not significant ($t = 1.20$), (d.f. = 98), ($.2 < P < .3$).

Weight

Total weight distribution is shown in Table 3, and Fig. 4; the fish are grouped into 30 g weight classes.

Similar to the length distribution, the weight distribution is unimodal, with 78% of the fish sampled weighing between 10 and 70 g. There was very little difference between males and females, the modal weight classes being similar for both. The heaviest fish collected were males, and males exceeded females in average weight but the difference was not significant ($t = 1.50$), (d.f. = 98) ($.1 < P < .2$).

Age

The age composition of the brook trout is given in Table 4, and Fig. 5. Ages range from 1^+ to 5^+ with 92% of the sample in the 2^+ and 3^+ age classes.

GROWTH

Back-calculation of growth

In back-calculating the growth of brook trout, it is necessary first to determine empirically the actual relationship between the growth of some dimension of the scale, in this case scale length, and the fork length of the fish. These data are presented in Table 5 and Fig. 6. The regression line is a graphic representation of the calculated regression equation, $\log L = 1.1889 \log S + 0.8218$ ($r = 0.98$), while the scatter plots represent the empirical data of average fork lengths and average scale lengths. Regression equations were calculated for males and females separately; for males, $\log L = 1.263 \log S + 0.791$ ($r = 0.92$), for females, $\log L = 1.138 \log S + 0.8207$ ($r = 0.92$).

Length distribution of the age groups

The length distribution of age groups and their corresponding mean lengths is given in Table 6. Overlap in length between age groups occurs, especially in 3+ fish.

Empirical age-length data are given in Table 7. Back-calculated age-length data are given in Table 8 and Fig. 7. The lengths used were calculated from the fork length/scale length regression equations. Discrepancies occurred between Tables 7 and 8; empirical data were higher than back-calculated results. The low result for 4+ males in Table 7 may be due to the small sample size, two fish.

The calculated annual increments of growth in length (cm) during the first five years are: 6.0, 4.8, 4.0, 1.5 and 6.0 respectively. The amount of annual growth decreases with age. The last value (6.0) is based on one fish. Comparisons of growth rates of brook trout for Newfoundland and Labrador are given in Table 9.

Weight distribution of the age groups

The weight distribution of age groups and their corresponding mean weights is given in Table 10. Similar to the length distribution, overlap in weight between age groups occurs, primarily in 3+ and 4+ fish.

Empirical age-weight data are given in Table 11 and the calculated age-weight relationship is given in Table 12 and Fig. 8. The weights in Table 12 were calculated from the length-weight relationships using the back-calculated lengths.

Length-weight relationship

Length-weight equations for sexes separated and combined are given in Table 13. Analysis of covariance was used to determine if there was a significant difference between the slopes and intercepts of the lines for males and females. Since the difference between the slopes was significant ($F = 14.39$; d.f. = 1,96; $p < 0.001$) the combined data were not presented graphically. The mean weights calculated (using the computed length-weight equations) for the mean lengths of fish in each length group are the basis for the curves in Fig. 9. There was good agreement between the empirical and calculated weights for the sexes separated and combined (Table 14). The largest discrepancies occurred in the larger length classes where the number of fish sampled was small.

The exponent or 'n' values for the sexes (Table 13) were close to 3; for males $n = 3.14$, for females $n = 2.58$.

The high 'r' values in Table 13 indicate a good correlation between length and weight.

REPRODUCTIVE BIOLOGY

Sex ratios

The sex ratios by age groups of brook trout sampled are given in Table 15. There was no significant difference for any age group. The overall male to female ratio was 1.27:2.00.

Age at first maturity

The percentage of mature brook trout in each group is given in Table 16. No age 1+ trout of either sex was mature. Both male and female brook trout were all predominantly mature at age 2+. An upper limit of age, at which sexual activity ceases, was not found.

Fecundity

Fork lengths were arranged in 2.0 cm intervals and the mean number of eggs per female was determined for each (Table 17, Fig. 10). The empirical data, fitted to a log regression, gave the equation.

$$\log F = 2.6145 \log L - 0.9234 \quad (r = 0.76).$$

The calculated number of eggs per female was computed from this equation.

Weights were arranged in 20.0 g intervals and the mean number of eggs per female was determined for each (Table 18, Fig. 11). The empirical data, fitted to a log regression, gave the equation

$$\log F = 0.8776 \log W + 0.7909 \quad (r = 0.75).$$

The log relationship between the number of mature eggs per female and age is given in Table 19. The empirical data, fitted to a log regression, gave the equation

$$\log F = 1.5559 \log A + 1.7212 \quad (r = 0.69).$$

In the above equations, F signifies fecundity in number of eggs, L signifies fork length (cm), W signifies whole weight (g), and A signifies age in years.

Variations between actual and calculated egg numbers in Tables 17 and 18 may be due to an insufficiently large sample size.

FOOD HABITS - QUALITATIVE ANALYSIS

In Table 20, each food type is expressed as a percentage of the number of stomachs containing that food type. The principal food organisms by percentage of occurrence were Diptera (blackfly) larvae (66%). Odonata adults (13%), Diptera (blackfly) adults (17%), Ephemeroptera nymphs (16%), Plecoptera nymphs (17%), and Amphipoda (13%) were also common food items.

The unidentifiable insect remains consisted mostly of antennae segments and leg parts. Most of the debris appeared to consist of twigs and stones used in the construction of caddisfly cases.

Fish remains were found in five of the larger fish (Table 21). The average size of these fish was 21.9 cm (125 g).

DISCUSSION

Sampling methods can be biased and influence the conclusions of a fish biology study. Cooper (1953) and Rupp (1955), for example, suggested that angling, the primary method by which fish for this study were collected, captures the faster growing and larger members of each age group. To some extent, this bias was overcome in the present study by the limited use of a fyke net and minnow traps. The minnow traps caught small fish (9.5 - 14.9 cm); the fyke net, a passive fishing method, caught the more active members of the populations.

Sampling time is another factor which can limit the conclusions drawn from such a study. Ideally, the population should be sampled throughout the year. This would allow greater accuracy in fecundity and food habit studies, and in determining the time of annulus formation. Unfortunately, such sampling was impossible in the present study.

With these limitations in mind, the following discussion considers the biology of the Valley River brook trout, comparing them to other Newfoundland (Wiseman 1969) and Labrador (Bruce 1974; Parsons 1975) brook trout.

Size and age composition

The length distribution is unimodal, with a mean length of 16.8 cm. This value is similar to that of Berry Hill Pond brook trout (mean length of 16.7 cm) but smaller than that of most other Newfoundland brook trout, where the average mean length is 20.7 cm (Wiseman 1969). Bruce (1974) and Parsons (1975) reported substantially larger mean lengths for Labrador brook trout, 41.5 cm for Jacopie Lake and 40.2 cm for Ten Mile Lake. Sampling methods differed in the various studies, perhaps causing different biases. Bruce (1974) and Parsons (1975) used experimental gill nets which may be selective for the larger fish within a population. Differences in mean lengths may also be due to the relatively large productive zones of these lakes and hence an increased availability of food. Ricker (1932) suggested that the maximum size attainable by brook trout is correlated with the size of the body of water in which it lives, and with the presence and availability of suitable food.

The age distribution is unimodal, with a maximum age of 5+ years. Bruce (1974) and Parsons (1975) reported unimodal distributions with maximum age of 6+ years in their studies of Labrador brook trout. Wiseman (1969) reported that most Newfoundland brook trout reach a maximum age of 5+ years; however, rarely one will live for 8+ years. He suggested that the upper limit of age in brook trout is governed by the size of the body of water and that longevity is related to the habitat size per fish.

Growth

The body-scale relationship for brook trout is usually curvilinear (Cooper 1949; Allen 1956; Wiseman 1969; Bruce 1974; Parsons 1975). A curvilinear relationship occurs when the increase in scale length differs from the increase in fish length. Usually, scale length increases more slowly than fish length as the fish grows larger. A linear relationship occurs when the ratio of the corresponding increments of body length and scale length remain constant. In this study, linearity was tested by the Lee Method and curvilinearity was tested by the Monastyrsky Logarithmic Method. The equations for both relationships gave identical correlation coefficients between scale length and fork length ($r = 0.98$) and similar back-calculated age-length data. The curvilinear relationship was used in back-calculation in accordance with Cooper (1949), Allen (1956), Wiseman (1969), Bruce (1974) and Parsons (1975).

The discrepancies between empirical and back-calculated age-length data, as shown in the results, may be explained by "plus growth". Cooper (1951) and Allen (1956) state that annulus formation in brook trout occurs from April to June, depending on the locality, water temperature, age and rate of growth of the fish. Younger, faster-growing fish form annuli earlier than older, slower-growing individuals. Wiseman (1969) stated that Newfoundland brook trout form annuli in April or May and that scale growth is advanced by June. Fastest scale growth occurs in late May and June; growth slows down by late July. The time of annulus formation for Valley River brook trout is unknown. The sample was taken in late July; therefore, the increased empirical lengths, as compared to the back-calculated lengths, may be due to growth from the time of annulus formation until the time of capture.

Valley River brook trout (Fig. 12) have slower growh rates than brook trout from Jacopie Lake (Bruce 1974) and Ten Mile Lake (Parsons 1975). Their growth rate for the first three years is similar to the mean growth rate of brook trout of the Avalon Peninsula, Newfoundland (Wiseman 1972), but becomes slower in the last two years. As suggested in the discussion of length, growth rate may be a function of the water body size and of the availability of suitable food. Growth is rapid in the first three years but tapers off in the last two, perhaps suggesting a lack of suitable food for trout or even a genetic difference in this population.

As well as allowing the conversion of length data into weight data and vice versa, the length-weight relationship can be used as an indication of condition or degree of robustness of a population of fish (LeCren 1951). Generally, for brook trout growth, weight is approximately proportional to the cube of length ($n = 3$). For Valley River brook trout, the slope (n) of the length-weight equation is 2.92, suggesting this cubed relationship. Wiseman (1969) reported similar results, an 'n' of 2.97, for Newfoundland brook trout. Bruce (1974) and Parsons (1975) reported 'n' values greater than 3.0, suggesting that Jacopie Lake and Ten Mile Lake brook trout may be in better condition (fatter and more robust) than Valley River or Newfoundland brook trout.

Reproductive biology

There was no significant difference between the numbers of males and females in this study. Wiseman (1969), Bruce (1974) and Parsons (1975) reported similar findings for other populations of Newfoundland and Labrador brook trout. However, males outnumbered females in all except the 1+ age group. This is contrary to the suggestion that the proportion of males decreases in older age groups (McFadden et al 1962).

Wydoski and Cooper (1966) state . . . "the brook trout as a species is inherently capable of maturing and spawning at the end of its first year of life (0+ years)." They suggest that the time of maturation may be affected by many factors including heredity. Generally, faster growing trout mature at an earlier age than slower growing individuals (McFadden 1961). The majority of Newfoundland brook trout (Wiseman 1972) do not mature until age 3+. Valley River brook trout are slow growing but mature at age 2+. No similar information is available for Jacopie or Ten Mile Lake brook trout. Two possible explanations exist for this early maturation. It may be a genetically determined characteristic or it may be related to growth rate. Since growth is fastest in the first two years of life, gonads may develop and mature then as there is a relative abundance of food and the fish are in good condition.

Fecundity, the number of mature eggs per female, increases with size and age of the fish. The 'n' value, or slope of the length-fecundity, weight-fecundity, and age-fecundity equations is a useful comparison of rates of increase of fecundity between populations. Fecundity ranges from 71 to 848 eggs per female for the Valley River. The 'n' value for the length-fecundity equation (2.61) is lower than that for Newfoundland brook trout (3.14), where egg number is approximately proportional to the cube of fork length. For the Valley River, egg number is approximately proportional to fish weight (n = 0.88; Wiseman (1969) reported similar results (n = 1.03) for insular Newfoundland. The 'n' value for the age-fecundity equation (1.55) is lower than that for Newfoundland brook trout (1.82), where egg number is approximately proportional to the square of the age. In all three comparisons, the rate of increase of fecundity is less for Valley River brook trout than for Newfoundland brook trout. Wiseman (1969) suggested that this variation is often related to the productivity of the area, and thus, the nutrition and growth of the trout. As previously shown, the growth rate of mature brook trout in the Valley River is less than that for mature trout in insular Newfoundland.

Food habits

Invertebrates compose the bulk of the diet of brook trout in this study. Bruce (1974) and Parsons (1975) reported similar findings for large brook trout in Labrador. The dominant food organism varies: Diptera in the Valley River, Ephemeroptera in Jacopie Lake and Hemiptera in Ten Mile Lake.

There are two major sources of error in such qualitative food analyses studies, the method and the time of sampling. Angling may be selective for actively feeding fish and fish captured by this method may regurgitate their food (Phillips 1929). In this study, only six stomachs were found empty, discounting the latter problem. Although Diptera occurred most frequently in the stomachs sampled, this may have been a reflection of sampling time as they were emerging in large numbers and hence were easily available to the brook trout when collections were made. Ideally, fish should be sampled by several methods at all times of the year to determine true food habits.

SUMMARY

In July 1975, 130 brook trout were taken, primarily by angling, from the Valley River. From this sample, the following conclusions were drawn.

The biology of the brook trout sampled was more similar to the results of Newfoundland brook trout studies than to studies of other Labrador brook trout.

Valley River brook trout have a mean fork length of 16.8 cm, slightly smaller than most Newfoundland brook trout (20.7 cm), but much smaller than other Labrador brook trout (40.9 cm).

The growth rate of Valley River brook trout is much slower than that of other Labrador brook trout, but is similar to that of Newfoundland brook trout, especially in the first three years of life.

Most Valley River brook trout mature at age 2+. This is earlier than in Newfoundland, where the majority of brook trout do not mature until age 3+.

The rate of increase of fecundity with respect to length, weight and age of Valley River Brook trout is slower than that of Newfoundland brook trout.

Stomach analyses are similar for Newfoundland and Labrador, where invertebrates compose the bulk of the diet of brook trout.

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Table 1. Analyses of water samples taken 24 July 1975 from the Valley River, Labrador.

Station #	pH	Total hardness	Conductivity at 25 C (mhos/cm)	T.D.S.	Total alkalinity	Turbidity	Ca+	Cl-
1	6.1	5.0	12.8	16.2	4.0	1.8	0.8	0.5
2	6.0	6.0	12.4	15.9	4.0	1.5	0.5	0.5
3	6.2	5.0	12.4	15.9	4.0	0.9	0.5	0.5
4	6.0	6.0	16.9	19.1	4.0	2.0	0.8	0.5
Average	6.1	5.5	13.6	16.8	4.0	1.5	0.6	0.5

Table 2. Length distribution of brook trout from the Valley River for sexes combined and sexes separated. (Sample size in parenthesis).

Length class (cm)	Percentage of fish in each length class		
	Males	Females	Combined
6.6- 9.5	-	4.5(2)	2.0(2)
9.6-12.5	1.8(1)	2.5(2)	3.0(3)
12.6-15.5	33.9(19)	25.0(11)	30.0(30)
15.6-18.5	33.9(19)	54.6(24)	43.0(43)
18.6-21.5	23.2(13)	6.9(3)	16.0(16)
21.6-24.5	3.6(2)	4.5(2)	4.0(4)
24.6-27.5	1.8(1)	-	1.0(1)
27.6-30.5	1.8(1)	-	1.0(1)
Totals	100(56)	100(44)	100(100)
Mean length	17.2	16.3	16.8
Range	10.8-28.9	7.5-23.9	7.5-28.9
Std. Dev.	3.59	3.86	3.71
Std. Error	0.48	0.58	0.37

Table 3. Weigth distribution of brook trout from the Valley River for sexes combined and sexes separated. (Sample size in parenthesis).

Weight class (g)	Percentage of fish in each weight class		
	Males	Females	Combined
0- 9	-	2.3(1)	1.0(1)
10-39	30.3(17)	31.7(14)	31.0(31)
40-69	42.8(24)	52.3(23)	47.0(47)
70-99	16.1(9)	9.1(4)	13.0(13)
100-129	5.4(3)	2.3(1)	4.0(4)
130-159	-	-	-
160-189	3.6(2)	2.3(1)	3.0(3)
190-219	-	-	-
220-249	-	-	-
250-279	-	-	-
280-309	1.8(1)	-	1.0(1)
Totals	100(56)	100(44)	100(100)

. . . Cont'd.

Table 3. Continued

Weight class (g)	Percentage of fish in each weight class		
	Males	Females	Combined
Mean weight	62.0	50.0	56.8
Range	12-300	6-179	6-300
Std. Dev.	45.8	29.0	39.7
Std. Error	6.12	4.37	3.97

Table 4. Age composition of brook trout from the Valley River for sexes combined and sexes separated. (Sample size in parenthesis).

Age (years)	Percentage of fish in each age class		
	Males	Females	Combined
1+	1.9(1)	6.8(3)	4.1(4)
2+	58.4(31)	65.9(29)	61.9(60)
3+	34.0(18)	25.0(11)	29.9(29)
4+	3.8(2)	2.3(1)	3.1(3)
5+	1.9(1)	-	1.0(1)
Totals	100(53)	100(44)	100(97)

Table 5. Relationship between fork length of fish (cm) and magnified (X43) scale length of brook trout from the Valley River, Labrador.

Number of fish	Average fork length (cm)	Average scale length (cm)
2	7.5	1.00
6	9.5	1.52
4	11.5	1.65
18	13.5	1.98
46	15.5	2.19
30	17.5	2.15
11	19.5	2.53
7	21.5	2.43
2	23.5	2.85
0	25.5	-
0	27.5	-
1	29.5	3.40

Table 6. Length distribution of the age groups of brook trout from the Valley River. (Percentages shown in parenthesis).

Length interval (cm)	Age group and sex									
	1+		2+		3+		4+		5+	
	M	F	M	F	M	F	M	F	M	F
6.6- 9.5	-	(66.7)2	-	-	-	-	-	-	-	-
9.6-]2.5	(100.0)1	(33.3)1	-	(3.4)1	-	-	-	-	-	-
12.6-15.5	-	-	(53.3)16	(37.9)11	(5.3)1	-	-	-	-	-
15.6-18.5	-	-	(46.7)14	(58.7)17	(26.3)5	(63.6)7	(50.0)1	-	-	-
18.6-21.5	-	-	-	-	(57.9)11	(27.3)3	(50.0)1	-	-	-
21.6-24.5	-	-	-	-	(10.5)2	(9.1)1	-	(100.0)1	-	-
24.6-27.5	-	-	-	-	-	-	-	-	(100.0)1	-
27.6-30.5	-	-	-	-	-	-	-	-	-	-
Totals	1	3	30	29	19	11	2	1	1	-
Mean lengths	10.8	8.8	15.5	15.8	18.9	18.7	19.3	23.9	28.9	-
Overall mean lgths.	9.3		15.7		18.8		20.8		-	

Table 7. Empirical age-length relationship of brook trout from the Valley River, Labrador. (Sample size in parenthesis).

Age (years)	Fork length (cm) Males	Females	Combined
1+	10.8(1)	8.8(3)	9.3(4)
2+	15.5(30)	15.8(29)	15.7(59)
3+	18.9(19)	18.7(11)	18.8(30)
4+	19.3(2)	23.9(1)	20.8(3)
5+	28.9(1)	-	28.9(1)

Table 8. Back-calculated age-length relationship of brook trout from the Valley River, Labrador. (Sample size in parenthesis).

Age (years)	Fork length (cm) Males	Females	Combined
1	5.7(1)	6.1(3)	6.1(4)
2	10.7(30)	10.5(29)	10.9(59)
3	14.4(19)	14.5(11)	14.9(30)
4	14.2(2)	21.3(1)	16.5(3)
5	22.6(1)	-	22.6(1)

Table 9. Comparison of growth rates of brook trout for Newfoundland and Labrador.

Age (years)	Valley River (this thesis)	Jacopie Lake (Bruce, 1974)	Ten Mile Lake (Parsons, 1975)	Newfoundland (Wiseman, 1972)
1	6.1	7.5	10.7	5.5
2	10.9	16.6	18.2	10.7
3	14.9	26.1	25.7	16.0
4	16.5	34.6	32.4	21.4
5	22.6	40.5	38.0	26.7

Table 10. Weight distribution of the age-groups of brook trout from the Valley River. (Percentages shown in parenthesis).

Weight Interval	1^+		2^+		3^+		4^+		5^+	
(g)	M	F	M	F	M	F	M	F	M	F
0 - 9	-	(66.7)2	-	-	-	-	-	-	-	-
10 - 39	(100.0)1	(33.3)1	(53.3)16	(37.9)11	-	-	-	-	-	-
40 - 69	-	-	(46.7)14	(62.1)18	(42.1)8	(54.5)6	-	(50.0)1	-	-
70 - 99	-	-	-	-	(36.8)7	(36.4)4	(100.0)1	-	-	-
100 - 129	-	-	-	-	(15.8)3	(9.1)1	-	-	-	-
130 - 159	-	-	-	-	-	-	-	-	-	-
160 - 189	-	-	-	-	(5.3)1	-	-	(50.0)1	-	-
190 - 219	-	-	-	-	-	-	-	-	-	-
220 - 249	-	-	-	-	-	-	-	-	-	-
250 - 279	-	-	-	-	-	-	-	-	-	-
280 - 309	-	-	-	-	-	-	-	-	(100.0)1	-
Mean Weight	12	11	41	43	78	67	77	179	300	-
Overall mean weight	11		42		74		166			
TOTALS	(100.0)1	(100.0)3	(100.0)30	(100.0)29	(100.0)19	(100.0)11	(100.0)1	(100.0)2	(100.0)1	-

Table 11. Empirical age-weight relationship of brook trout from the Valley River, Labrador. (sample sizes in parenthesis)

Age	Weight (g)		
(years)	Males	Females	Combined
1+	12 (1)	11 (3)	11 (4)
2+	41 (30)	42 (29)	41 (59)
3+	78 (19)	67 (11)	74 (30)
4+	77 (2)	179 (1)	111 (3)
5+	300 (1)	-	300 (1)

Table 12. Calculated age-weight relationship of brook trout from the Valley River, Labrador. (Sample size in parenthesis).

Age (years)	Weight (g) Males	Females	Combined
1	2(1)	4(3)	3(4)
2	12(30)	15(29)	14(59)
3	32(19)	35(11)	36(30)
4	30(2)	93(1)	47(3)
5	131(1)	-	120(1)

Table 13. Length-weight equations (sexes combined and separated) of brook trout from the Valley River, Labrador.

	Log regression form	Exponential form	r
Combined	$\log W = 2.8354 \log L - 1.7680$	$W = 0.0171 L^{2.9206}$	0.97
Males	$\log W = 3.1418 \log L - 2.1440$	$W = 0.0072 L^{3.1418}$	0.97
Females	$\log W = 2.5804 \log L - 1.4624$	$W = 0.0345 L^{2.5804}$	0.97

Table 14. Length-weight relation of brook trout (sexes combined and separated) from the Valley River.

Males Number of fish	Aver. length (cm)	Weight (g) Empir.	calc.	Females Number of fish	Aver. length (cm)	Weight (g) Empir.	calc.
0	8.0	-	-	2	8.0	9	8
1	11.0	12	14	2	11.0	17	17
19	14.0	32	29	11	14.0	35	32
19	17.0	53	53	24	17.0	51	52
13	20.0	82	89	3	20.0	80	79
2	23.0	144	137	2	23.0	148	113
1	26.0	187	201	0	26.0	-	-
1	29.0	300	283	0	29.0	-	-

Sexes combined Number of fish	Aver. length (cm)	Weight(g) Empir.	calc.
2	8.0	9	6
3	11.0	15	15
30	14.0	33	30
43	17.0	52	53
16	20.0	82	85
4	23.0	146	127
1	26.0	187	182
1	29.0	300	250

Table 15. Sex ratios of brook trout, by age group, from the Valley River, Labrador.

Sex	Age (years) 1+ and 2+	3+, 4+ and 5+	Total
Male	31	22	53
Female	32	12	44
X^2 value	0.02	2.94	0.84
Significant difference	none	none	none

Table 16. Percentages of mature brook trout, by age class, from the Valley River, Labrador. (Sample size in parenthesis).

Age (years)	Percentage of mature trout		
	Males	Females	Combined
1+	0.0(1)	0.0(3)	0.0(4)
2+	90.3(31)	96.6(29)	96.7(60)
3+	88.9(18)	100.0(1)	93.1(29)
4+	100.0(2)	100.0(1)	100.0(3)
5+	100.0(1)	-	100.0(1)

Table 17. The relationship between the number of mature eggs per female and fork length (cm) for 40 brook trout from the Valley River, Labrador.

Fork length (cm)	No. of fish	Actual No. of eggs per female	Calc. No. of eggs per female
11.5	1	122	71
13.5	5	117	108
15.5	13	180	155
17.5	16	205	212
19.5	2	287	281
21.5	1	273	363
23.5	2	698	458

Table 18. The relationship between the number of mature eggs per female and weight (g) for 40 brook trout from the Valley River, Labrador.

Weight (g)	No. of fish	Actual No. of eggs per female	Calc. No. of eggs per female
30	10	143	122
50	20	191	191
70	7	234	257
90	1	273	321
110	1	548	382
130	-	-	443
150	-	-	502
170	1	848	560

Table 19. The relationship between the number of mature eggs per female and age (years) for 40 brook trout from the Valley River, Labrador.

Age (years)	No. of fish	Actual No. of eggs per female	Calc. No. of eggs per female
2+	28	162	155
3+	11	290	291
4+	1	848	455

Table 20. Stomach content analysis of 70 brook trout from the Valley River, Labrador.

Food item	Frequency	Percent frequency
Diptera (blackfly) larvae	46	66
Diptera (blackfly) adult	12	17
Diptera (mosquito) pupae	3	4
Diptera (mosquito) adult	1	1
Ephemeroptera nymph	11	16
Plecoptera nymph	12	17
Plecoptera adult	4	6
Odonata larvae	2	3
Odonata adult	9	13
Orthoptera adult	4	6
Trichoptera adult	3	4
Hemiptera	6	9
Hymenoptera	1	1
Neuroptera nymph	1	1
Coleoptera	4	6
Amphipoda	9	13
Unidentifiable insect remains	5	7
Fish remains	5	7
Debris	24	34
Empty	6	9

Table 21. A comparison of the food eaten by brook trout of various sizes in the Valley River, Labrador.

	Frequency and percentage frequency occurrence of organisms: Size group (cm)				
	5.6-10.5 (3)	10.6-15.5 (12)	15.6-20.5 (42)	20.6-25.5 (5)	25.6-30.5 (2)
Diptera (blackfly) larvae	2.(66.7)	9(75.0)	39(71.4)	4(80.0)	1(50.0)
Diptera (blackfly) adult	- -	3(25.0)	9(21.4)	- -	- -
Diptera (mosquito) pupae	- -	- -	2(4.8)	1(20.0)	- -
Diptera (mosquito) adult	- -	- -	1(2.4)	- -	- -
Ephemeroptera nymph	- -	3(25.0)	7(16.7)	1(20.0)	- -
Plecoptera nymph	1 (33.3)	1(8.3)	10(23.8)	- -	- -
Plecoptera adult	- -	2(16.7)	2(4.8)	- -	- -
Odonata larvae	- -	- -	2(4.8)	- -	- -
Odonata adult	- -	4(41.7)	4(9.5)	- -	- -
Orthoptera adult	- -	1(8.3)	3(7.1)	- -	- -
Trichoptera adult	- -	- -	2(4.8)	- -	- -
Hemiptera	1 (33.3)	2(16.7)	2(4.8)	1(20.0)	- -
Hymenoptera	- -	- -	1(2.4)	- -	- -
Neuroptera nymph	- -	- -	1(2.4)	- -	- -
Coleoptera	- -	1(8.3)	1(2.4)	2(40.0)	- -
Amphipoda	- -	2(16.7)	6(14.3)	1(20.0)	- -
Insect remains	- -	2(16.7)	2(4.8)	- -	1(50.0)
Fish remains	- -	- -	1(2.4)	3(60.0)	1(50.0)
Debris	1 (33.3)	5(41.7)	17(40.3)	1(20.0)	- -
Empty	- -	2(16.7)	2(4.8)	2(40.0)	- -

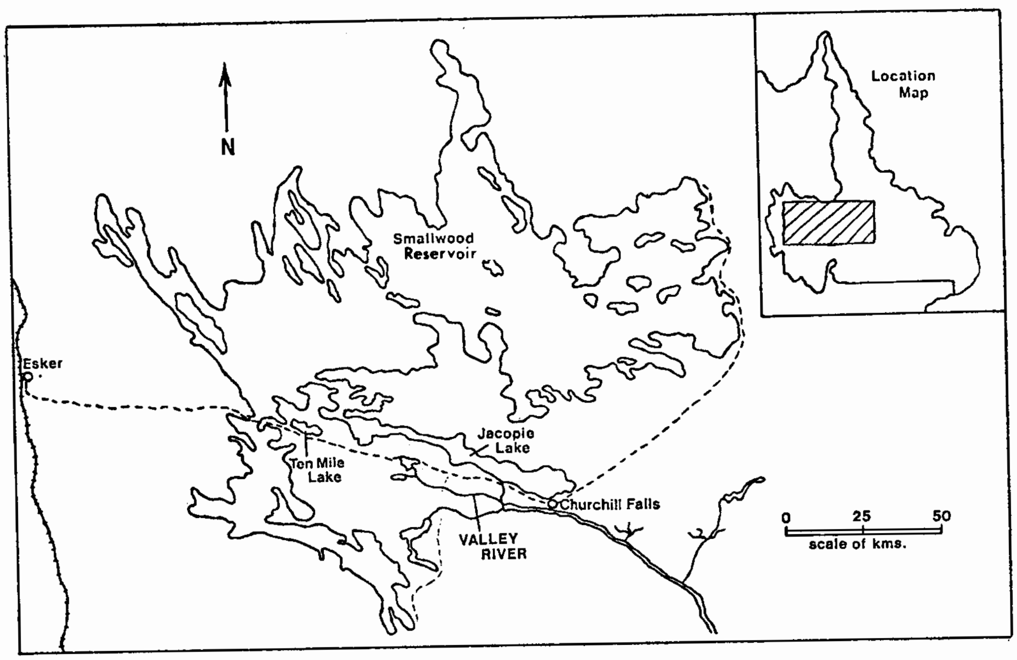

Fig. 1. The Valley River, in relation to Jacopie and Ten Mile Lake, Labrador.

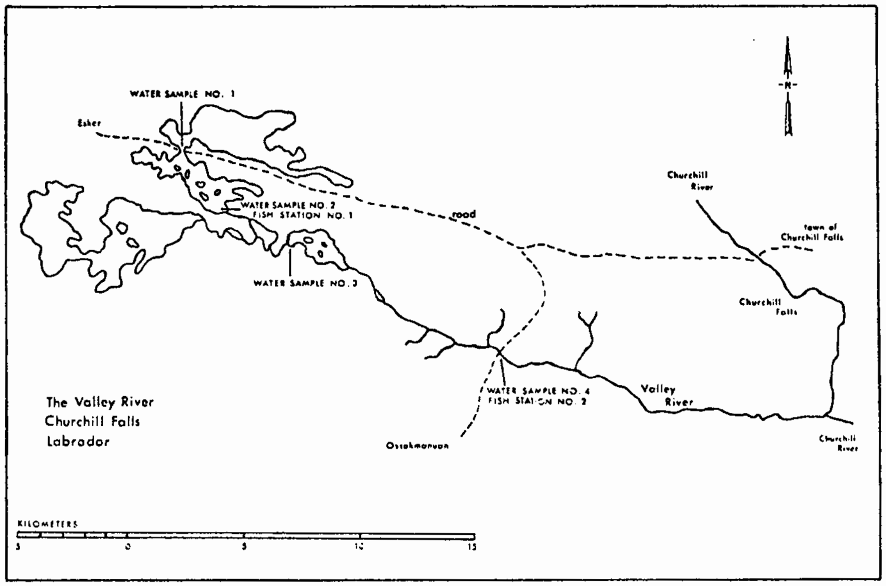

Fig. 2. Locations of water and fish sampling stations on the Valley River.

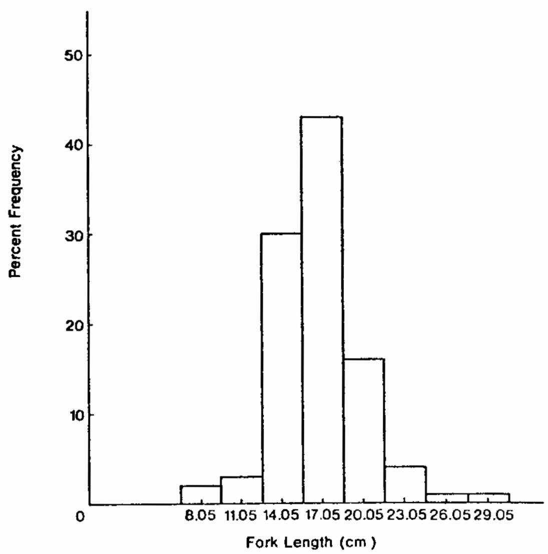

Fig. 3. Fork length distribution of brook trout from the Valley River, Labrador.

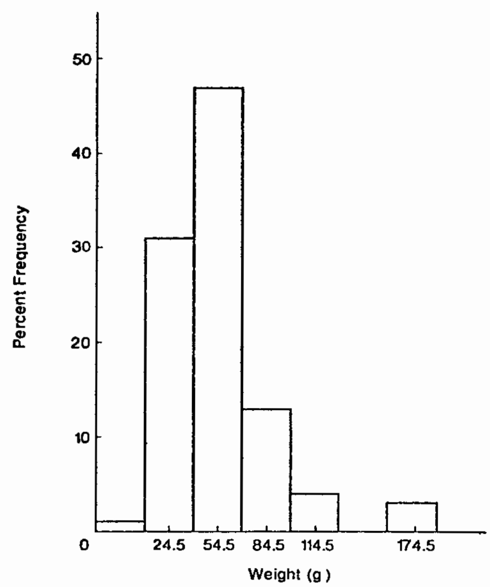

Fig. 4. Weight distribution of brook trout from the Valley River, Labrador.

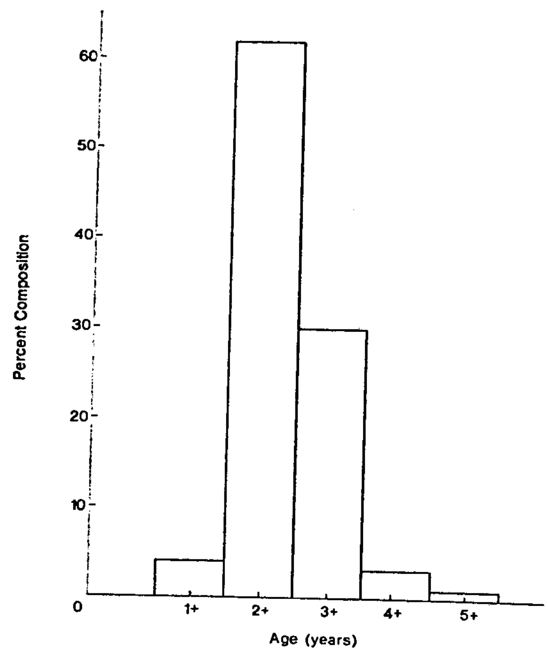

Fig. 5. Age composition of brook trout from the Valley River, Labrador.

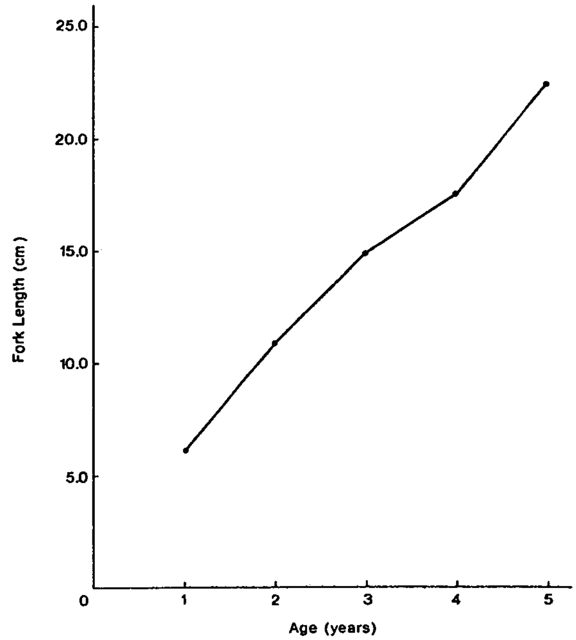

Fig. 7. Calculated average lengths (cm) of the different age groups of brook trout from the Valley River, Labrador.

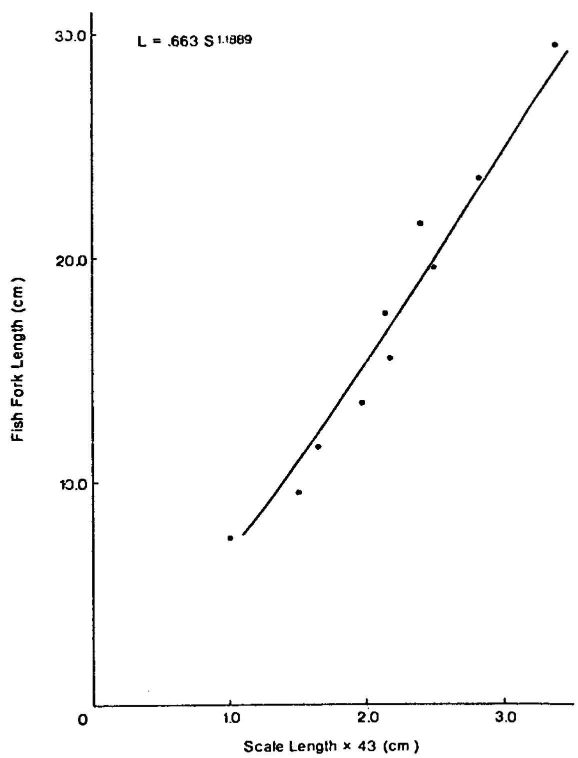

Fig. 6. Body length - scale length relationship for brook trout from the Valley River, Labrador.

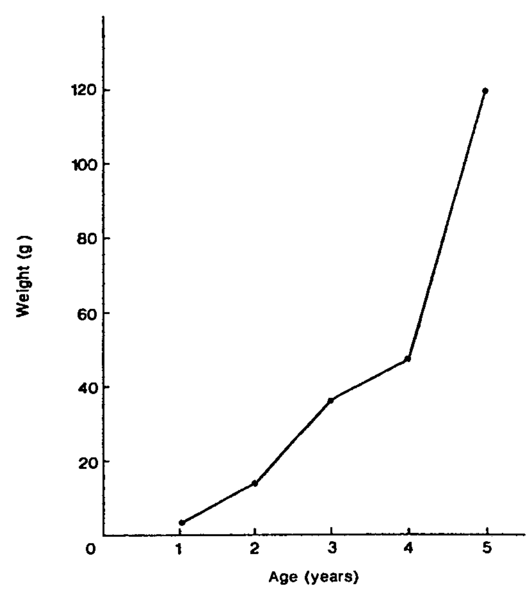

Fig. 8. Calculated average weights (g) from the different age groups of brook trout from the Valley River, Labrador.

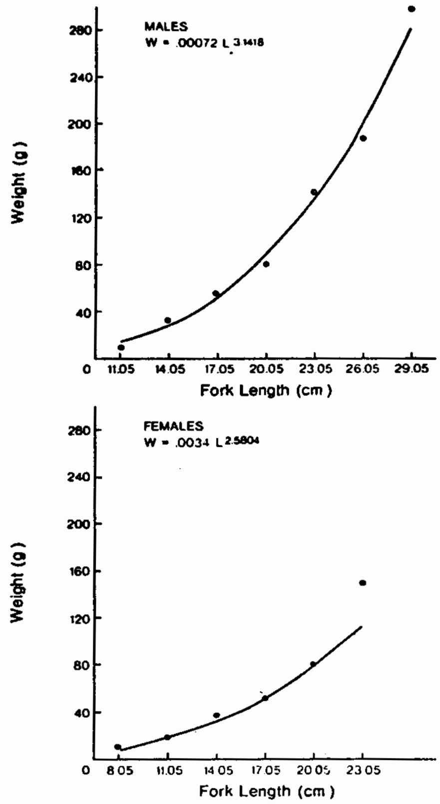

Fig. 9. Length-weight relationship of brook trout from the Valley River, Labrador (sexes separated).

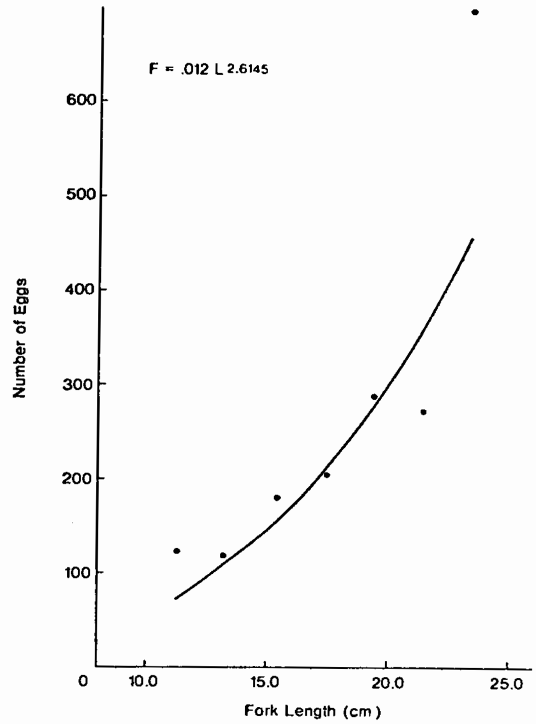

Fig. 10. The relationship between fork length and egg number in brook trout from the Valley River, Labrador.

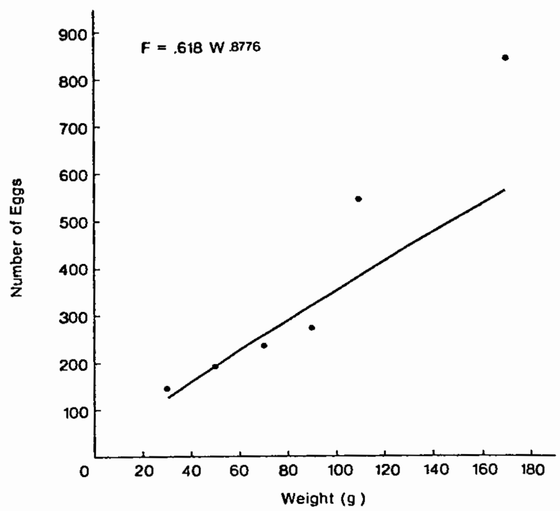

Fig. 11. The relationship between fish weight and egg number in brook trout from the Valley River, Labrador.

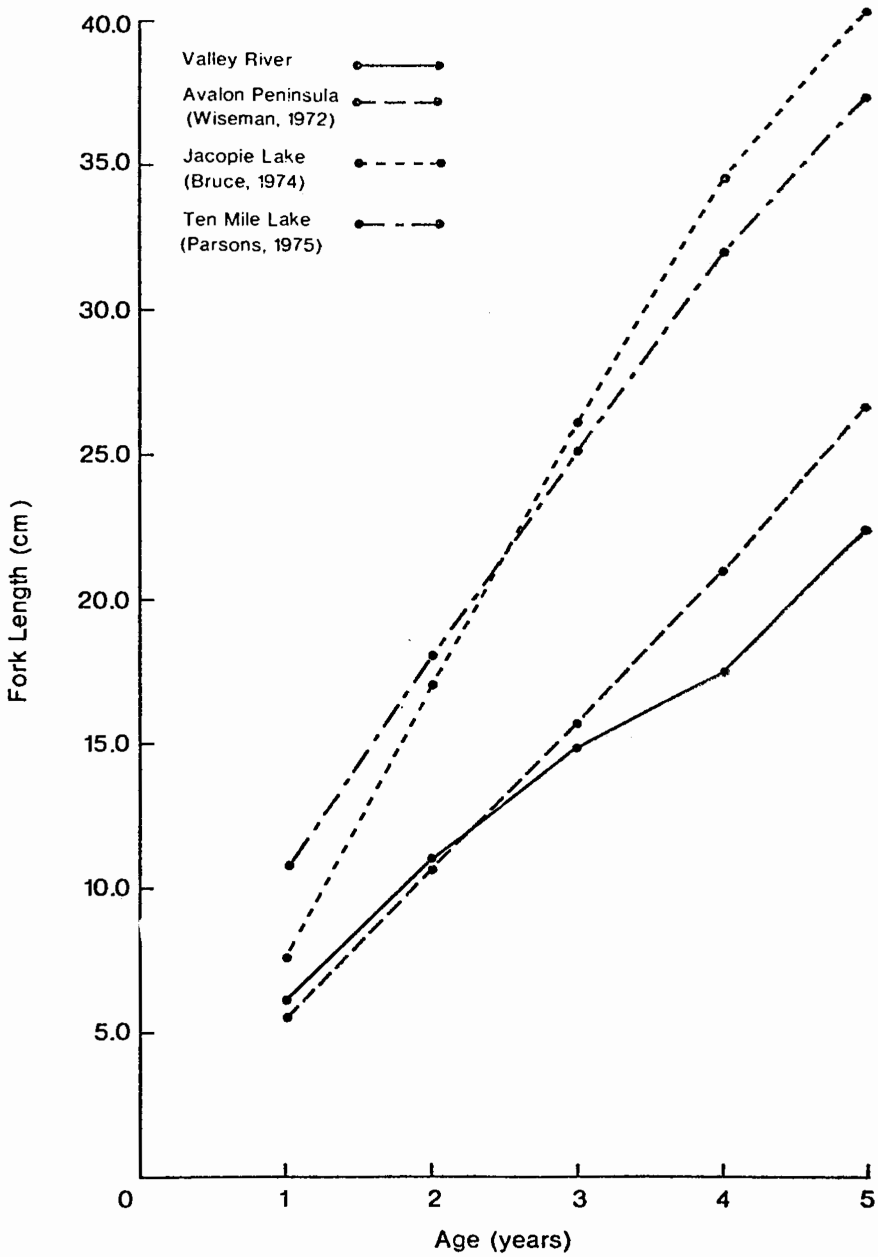

Fig. 12. Comparison of growth rates of brook trout from the Avalon Peninsula of Nfld., and three areas of Labrador.