ON THE BIOLOGY OF THE ARCTIC CHAR,

SALVELINUS ALPINUS (L.) OF

NETTILLING LAKE

BAFFIN ISLAND

N.W.T.

by

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Fig.1. Arctic Char (Salvelinus alpinus)in normal
and nuptial livery. Nettilling Lake 1956.

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INTRODUCTION

The object of this work is to present data relating to the biology of the arctic char (Salvelinus alpinus (L.)) of Nettilling Lake, Baffin Island, District of Franklin. The data presented were collected by the author during the summer of 1956 when the first limnological investigation of the lake was undertaken. Observations were made on the habits and distribution of the char; the length, weight, sex, stomach contents, and condition of the gonads were recorded; otoliths for age determinations, parasites, egg samples, and whole specimens were brought back for further analysis. The scope of this work does not include taxonomy of the species. Although significant differences between this and other populations have been found, the author does not feel that any attempt to divide the species can be made until samples are available from more areas.

REVIEW OF THE LITERATURE

Salvelinus alpinus (L.) belongs to one of the ten genera of the family Salmonidae, in the order Isospondylii. It is closely related to the Atlantic Salmon, Salmo salar, the trout, S. trutta, the Pacific Salmon, Onchorhynchus, and the Whitefish, Leucichthys. One of the features of this family is its primitiveness which is expressed in a high degree of plasticity and a wide variation between populations and individuals. The characteristics of the genus Salvelinus have been described by Kendall (1914) as vomer boat shaped, shaft strongly depressed without teeth, teeth confined to head or chevron more or less prolonged backwards and free from the shaft, scales comparatively small. According to Dymond (1947) Salvelinus alpinus is characterized by sides with light or pinkish spots, hyoid teeth present, tail less deeply forked than in Cristovomer (Salvelinus) namaycush, back and sides evenly coloured. To this description may be added that of Jordan and Evermann (1896): gill rakers numerous, 6 - 12 - 16, head large, body stout, and belly orange in the breeding season. Vladykov (1954) further describes the arctic char as having 10 - 11 branchiostegal rays, 21 - 23 gill rakers, 65 vertebrae, and 20 - 50 pyloric caecae, a crescent-like narrow and long bony plate, and a narrow and short second uroneural in the caudal skeleton. Svardson (1945) determined that S. alpinus had 80 chromosomes.

Walters (1955) in a key to the fishes of Western Arctic America, describes the arctic char, Salvelinus alpinus as follows;

a. Teeth well developed; more than 120 scales in first row above lateral line;

b. Anal fin with less than 12 branched rays, vomer teeth variable, shaft never toothed, light spots equal to or smaller than the diameter of the eye, on sides, back, dorsal, caudal, and/or adipose fin;

c. Adipose fin without light spots.

Walters further recognized the complexity of the group but made no attempt to separate varieties. He comments that Berg recognizes 16 alpinoid chars from Russian arctic waters. Legendre (1952) and Scott (1952) repeat most of the characteristics of the arctic char mentioned above, using the absence of teeth on the shaft of the vomer as the distinguishing difference between Salvelinus alpinus and other members of the genus. This characteristic seems to be one of the most important, yet it is not absolutely rigid. This is shown by the work of Walters (1953) who found two arctic char in which the dentition was closer to that found in <u>Cristovomer (Salvelinus) namaycush</u>. Evidently there is a wide range within the species, both in number and pattern of vomerine teeth.

The taxonomy of <u>Salvelinus alpinus</u> and of the chars in general has been the subject of much controversy. Linnaeus (1758) first described the red char, placing it in the genus <u>Salmo</u>. O. Fabricius (1780) described two char from Greenland, <u>S. carpio</u> and <u>S. alpinus</u>, now considered to be the same fish in and out of nuptial colouring, further, <u>S. stagnalis</u> and <u>S. rivalis</u> were described as landlocked forms from Greenland lakes. Nillsson (1832) originated the genus <u>Salvelinus</u> to include the chars. This genus was used by Richardson (1836), Günther (1877) Dresel (1884), Jordan (1855), Jordan and Evermann (1896) and others to describe a variety of species which are now for the most part believed to be only geographic, seasonal or individual variants. Jordan and Evermann (1896) described four chars from North America, one of which was <u>Salvelinus alpinus</u> (L.). Tate Regan (1911 and 1913) separated the chars of the British Isles into 15 species, based on colouration and geographic location. According to Frost, (personal communication) the taxonomy of the chars in Britain is in need of revision, with the discovery of two populations separated by spawning times, redd preference, and gill raker number. This work is now ready for the press. The 15 chars of Britain have been considered as separate species, or as sub-species of *S. alpinus*. Some modern European workers still use the classification of Linnaeus and refer to *Salmo alpinus*, i.e. E. Fabricius (1954).

In Canada, Halkett (1913) described four species of northern char. Delacy and Morton (1942) postulate the existance of 11 alpinoid chars in America. Recently the trend has been to gather together the local variants, some of which are based on single fish, and to consider *Salvelinus alpinus* as a group complex that cannot be divided until further specimens are available. Dymond (1947) lists three species, *Salvelinus alipes*, *S. arcturus*, and *S. naresi* and considers them to be local variants. He suggests that *S. marstoni* (Günther), the red trout of Quebec,and *S. malma* (Walbaum), the Dolly Varden of the Pacific Coast should be regarded as sub-species of *S. alpinus* (L.). Vladykov (1954) subscribes to the group concept mentioned above. The present work deals with one sample of this group and thus will be considered as dealing with *Salvelinus alpinus* (L.) without attempting any further classification. A full account of the history of the taxonomy of the species is given by Grainger (1949).

Early works on the biology of the Arctic Char have been confined to scattered references on a few individuals, along with observations on migration and spawning times. These, together with notes on the geographical distribution of the species, have been summarized by Grainger (1949). The arctic char has a circumpolar distribution. It occurs in Northern Norway, Northern Siberia, Bear Island, Novaya Zemlya, Spitzbergen, Iceland, Greenland, and Northern Canada as a migratory form, spawning in fresh water but migrating to the sea in order to feed. It is found as a stationary form, remaining in fresh water,in the areas mentioned above, and in lakes in Sweden, Finland, Southern Norway, the Alps, England, Ireland, Scotland, the Orkneys and Shetlands,and in the U.S.S.R. in the Ladoga, Onega and Baikal (Jensen 1948). The northern record has been reported from Ellesmere Island at a latitude of 82 North.(Günther 1877). In Canada it extends as far south as the north shore of the St. Lawrence as far west as Cape Trinity as an anadromous form(Dymond 1942). As a landlocked form it has been found in Walton Lake, New Brunswick. There it was identified as a variety of S. alpinus by Scott and Dymond, and recorded as growing to a weight of 3 pounds 5 ounces.(Catt 1950)

Little work has been done on the age and growth of the arctic char. Sprules (1952) determined the age of char from the west coast of Hudson Bay for landlocked and anadromous fish. Grainger (1953) calculated a growth rate for the char of the Sylvia Grinnell River in Frobisher Bay, and determined the age of char in the Bay of Two Rivers, the George River and from Herschel Island. Martin (1955) recorded the ages of char taken from the Ungava Crater and vicinity, in Quebec. The char of the Labrador Coast were aged by Andrews and Lear (1956). The author has determined the age of char from Nettilling Lake, Rowley Island in Foxe Basin, and the west coast of Melville Peninsula. The growth of the char from Svalbard was determined by Dahl (1926). Hansen (1940) examined char from various fishing ports on the West Greenland coast. Runnström (1951) recorded the ages of char from a Swedish lake in connection with a study of the effects of regulation of the water level. Slastnikov (1935) examined the migrating char of Novaya Zemlya. The results of these works will be discussed below and compared with the growth of char in Nettilling Lake.

Much of the recent work on the biology of the arctic char has come from Sweden. Alm (1951) working on non-reproductive migrations in the char of Lake Vattern, showed that there was a separation of the population into groups which schooled together and which returned to the same spawning grounds. In this lake the mean weight of the char was between 0.8 and 1.5 Kgs. and the mean length was 42 cms. Runnström (1951) studied the char with respect to a change of environment. He found that after the water level was artificially raised, the growth rate changed in all year classes, the mean length decreasing by as much as 9.5 cms. in the five-year-old class. It was also noted that the char rapidly made use of the new spawning grounds, in some instances changing their habits to become river spawners instead of remaining in the lake. E. Fabricius has published a series of papers dealing with the spawning habits and courting behaviour of the char. (Fabricius 1950, 1952, 1954 with Lindroth). These studies made in the aquaria under controlled conditions, had several interesting results. Char were found to have a well developed preference for gravel in the spawning beds. They maintained control over a definite territory, the males guarding the area. The presence of another male or of a coloured model in the territory was enough to release fighting behaviour mechanisms. Males were observed to be successively polygamous in the aquaria, capable of spawning with a number of females up to an observed maximum of six. Lindström (1954) continued the work of Alm (1951) with similar results. A study of the schooling habit was made and the results showed that the school depended on differences in spawning time and habitat to preserve its identity. This separation of a population has also been observed by Frost (1955) working on Salvelinus alpinus willoughbii (Günther). Further reference to these papers will be made below in the appropiate sections dealing with the biology of the char of Nettilling Lake.

DESCRIPTION OF THE AREA

Nettilling Lake lies between 66°,20' and 68°,north latitude in the western lowlands of Baffin Island. Approximately 2200 sq. miles in area, it is the sixth largest lake lying within the Canadian borders. The northern, eastern, and part of the southern shoreline lies within the Canadian Shield. The western shore is composed of Ordovician and Silurian limestone overlaid with recent marine sediments.

Two large rivers drain into the lake. One, the Amadjuak River , enters the lake at the southern extremity in Burwash Bay. This river drains the large lakes to the south including the Amadjuak and the Mingo. The other river rises in the western section of the Penny Highland Icecap and makes its way north, then south, to enter Nettilling Lake at the north east corner of Camsell Bay. This river clearly demonstrates its glacial origin. A wide area about the mouth is discoloured by the silt and for many miles the lake is murky. Numerous other rivers drain the surrounding plains.

Nettilling Lake is drained by the great Koukdjuak River which starts about two-thirds of the way up the western side and runs in an almost straight line westwards into Foxe Basin. The river falls one and two-thirds of a foot per mile and is 48 miles long; the current is fast, but there are no falls or serious rapids in its course. (Soper 1928) It is two and one-half feet deep at its mouth but deepens to eight feet about 3 miles inland. The current has been estimated to be six miles-per-hour and the flow to be 140,000 cubic-feet-per-second. Some concept of its size can be derived from the observation that the water in Foxe Basin is more or less fresh two to three miles from the mouth. (Manning 1943) The height of the lake above sea level has been given as 85 feet (Soper 1926), 103 feet (Weeks 1932), and 108 feet (Burwash, in Bethune 1932). Early maps refer to Lake Kennedy, but the name, Nettilling Lake, is now officially recognized.

Although Boas was the first white man to record a visit to the lake, it was Crawford Noble, a Scottish trader, who in 1902 first sailed around Nettilling Lake. His diaries contain a reference to the large number of "salmon, and very fine eating they were too."

After Noble, Bernard Hantzsch, the German explorer, crossed the lake in 1910. He spent some time on the lake but recorded no available observations on the fish of the area. Missionaries and traders visited the lake along with Eskimo hunting parties from Pangnirtung and Cape Dorset. In 1924, Burwash, of the Geological Survey

Board, passed over the lake on his way south to Amadjuak. He was followed by J. Dewey Soper in 1926 who spent some time on the lake collecting birds and mammals. Soper brought back the first fish from the area, and described the habits of the species. Halkett (in Soper 1928) says, "As regards the Arctic Char of which there are a number in the collection, probably when all the reputed varieties are better known, it may be found that all are referable to one and the same species." With this reservation, Halkett placed the specimens in Salvelinus alpinus. Soper notes that the fish were speared in the lake and gives the size of the largest as 22 inches long and weighing three pounds. (Soper 1928) The geological survey team of Weeks and Haycock visited the lake the following year (1927) and recorded the height of the lake as being 103 feet above high tide level.(Weeks 1932) Manning (1942) visited the coast near the mouth of the Koukjduak River and later crossed the lake to Pangnirtung. According to the Royal Canadian Mounted Police, the last Eskimo hunting parties to the area were in 1942. Since that time neither the Cape Dorset nor the Pangnirtung natives have penetrated to the lake proper. In 1955 the Dewline surveyors established a beacon post at the lake, but no records of a biological nature were made.

The author and D. R. Oliver landed on the lake on the 10th of May 1956 and established camp at Magnetic Point. (Figure 2). At this time the ice cover varied from 1.5 to 1.9 metres in thickness. The surface temperature of the water under the ice was under 1°C. During the summer the surface water warmed up to 2°C. before the ice melted away and reached a maximum of 3.5°C. in the middle of the lake in the month of August. The following description of the lake is based on the work of that summer. "The west side of the lake is comparatively shallow with a deeper area extending from southwest of Magnetic Point to north of the islands south of Caribou Point. The maximum depth in the area was 65 metres and many soundings of over 40 metres were taken. The eastern section of the lake has a very irregular bottom, the maximum depth being recorded in the northeast section as 131 metres." (Oliver 1956)

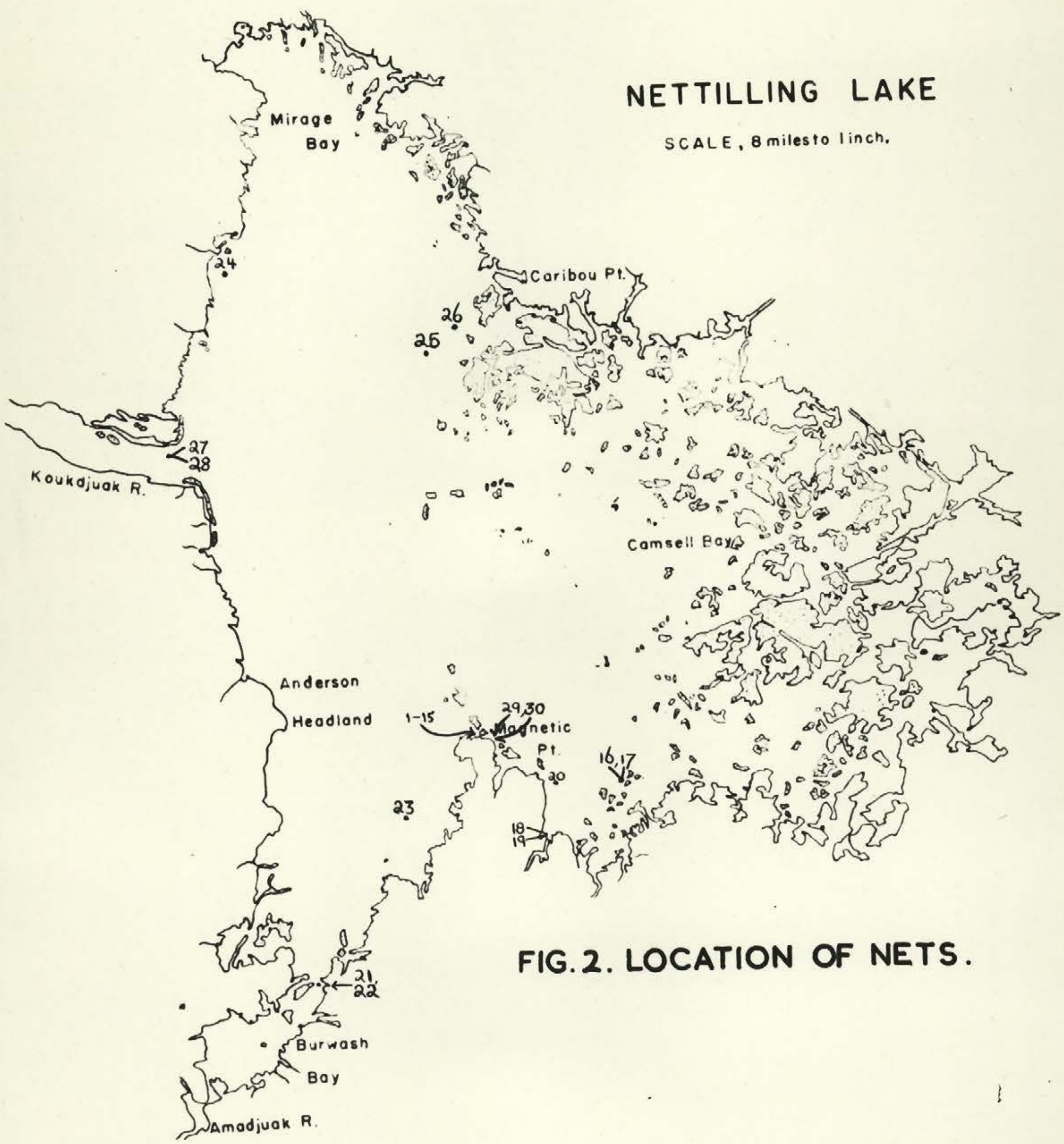


FIG. 2. LOCATION OF NETS.

MATERIALS AND METHODS

Fishing started on the first of July in the open leads around the shore near base camp. As the leads widened, the fishing area was extended. At the end of July a trip was made to the south east bay, and the area was fished. When the ice cleared from the lake on the 11th of August, two trips were made; one to the south western bay, and one to the north end of the lake. Nets were set in several locations throughout these areas. The last net was set on the 8th of September in the base camp area. Figure 2 shows the location of all net sets in the lake.

Nylon gill nets were used, arranged in a standard gang. This consisted of 50 yard sections of mesh sizes (stretched) 1.5, 2, 3, 4, 5, and 5.5 inches, making up 300 yards of net. The nets were about 5 feet deep. All nets were set on the bottom, usually parallel to the shore. The nets were always left in the lake over night, although the total fishing time varied. Table 1 records the date, length of net used, fishing time, number of fish caught, and depth of water of all net sets.

Table 1. RECORD OF NET SETS.

No.	Date.*	Depth.(m.)‡	Time.	No.of Char.	Type of Net.
1.	1.7.56	2.- 2.- 2.	19 hrs.	2	50 yds. 3" mesh.
2.	2.7.56	2.- 2.- 2.	23 "	1	50 " 3" "
3.	3.7.56	2.- 2.- 2.	23 "	5	50 " 3" "
4.	4.7.56	2.- 2.- 2.	24 "	9	50 " 3" "
5.	9.7.56	2.- 2.- 2.	24 "	4	Standard Gang.
6.	10.7.56	2.- 2.- 2.	24 "	0	" "
7.	11.7.56	2.- 2.- 2.	23 "	7	" "
8.	12.7.56	4.- 3.- 3.	23 "	5	" "
9.	13.7.56	4.- 3.- 3.	25 "	3	" "
10.	14.7.56	1.- 3.- 3.	22 "	13	" "
11.	15.7.56	2.- 2.- 2.	11 "	6	50 yds.1½" mesh.
12.	16.7.56	2.- 2.- 2.	22 "	2	50 " 1½ mesh.
13.	20.7.56	2.-10.- 9.	36 "	26	Standard Gang.
14.	21.7.56	2.-10.- 9.	18 "	19	" "
15.	22.7.56	3.-20.- 3.	22 "	21	" "
16.	28.7.56	10.-14.- 9.	14 "	27	" "
17.	29.7.56	10.-12.-16.	21 "	23	" "
18.	30.7.56	3.-13.- 2.	16 "	0	" "
19.	31.7.56	2.- 3.- 6.	22 "	3	" "
20.	2.8.56	20.-20.-14.	17 "	2	" "
21.	8.8.56	6.- 9.- 6.	23 "	16	" "
22.	9.8.56	6.- 9.- 6.	20 "	43	" "
23.	10.8.56	39.-35.-37.	17 "	8	" "
24.	22.8.56	2.- 2.- 3.	20 "	71	" "
25.	23.8.56	53.-51.-49.	20 "	0	" "
26.	24.8.56	33.-40.-41.	20 "	3	" "
27.	25.8.56	3.- 3.- 3.	16 "	21	" "
28.	26.8.56	3.- 3.- 3.	20 "	56	" "
29.	8.9.56	3.- 8.- 4.	15 "	8	" "
30.	9.9.56	3.- 8.- 4.	24 "	9	" "

Total No.Caught 412 (7 lost or damaged.)

Average No. per Net Set 14.8

‡) Depth measured at both ends and middle of net.

*) Date net lifted.Nets set the previous night.

The gill nets accounted for the bulk of the catch; but, to supplement the sample, some small fish were caught by hand nets, taken from stomach samples, or trapped in streams. In one river 8 fish were caught by rod, line, and spinners. Table 2 records the source of the sample studied.

Table 2. SOURCE OF SAMPLE

Method	No. of Char.
Gill net	405
Stomach Samples	18
Rod and line	8
Hand net, etc.	5
Total	436

The fish were studied as soon as possible after removal from the net. Records were taken of the fork length (tip of snout to indentation of the caudal fin), weight, sex, condition of the gonads, stomach contents, parasites, and colouration. Up to ten fish in each 2.5 cms. length group were subjected to further measurements as suggested by Vladykov (1954). Heads, tails, and/or skeletons of some char were dried, and otoliths for age determinations were kept, dry in envelopes. Representative collections were made of ovaries, stomach contents, and parasites.

The largest fish caught was 67.0 cms. long and weighed 6.5 lbs., the smallest fish was caught in a dredge sample and was 2.2 cms. long. The average length of fish caught in the gill net was 36.93 cms. long and the average weight, 19.4 ounces. The sex ratio of the sample was 45.25 per cent female and 54.75 per cent male.

The length frequency of the sample is plotted in Figures 3 and 3a. The latter histogram shows two points which deserve comment; one, that the largest fish are predominately male, and two, that the nets did not catch fish below 18 cms. in fork length. This last point is discussed below in the analysis of the growth rate.

There is a relationship, as expected, between the size of mesh used and the fork length of the fish caught. While this is more apparent in other species, it nevertheless does hold for char. The range of lengths caught by any one size is very wide. This is due, in part, to the fact that char are snagged by the teeth rather than gilled. Table 3 illustrates the relationship.

Table 3. MESH SIZE RELATED TO MEAN FORK LENGTH

Mesh Size	Range (cms.)	Mean (cms.)	Number
1.5 ins.	13.0 - 67.0	31.58	117
2.0 "	19.5 - 62.0	34.09	154
3.0 "	24.0 - 67.0	44.08	82
4.0 "	32.5 - 63.5	47.59	31
5.0 "	31.0 - 65.0	48.82	14
5.5 "	33.0 - 67.0	49.85	7

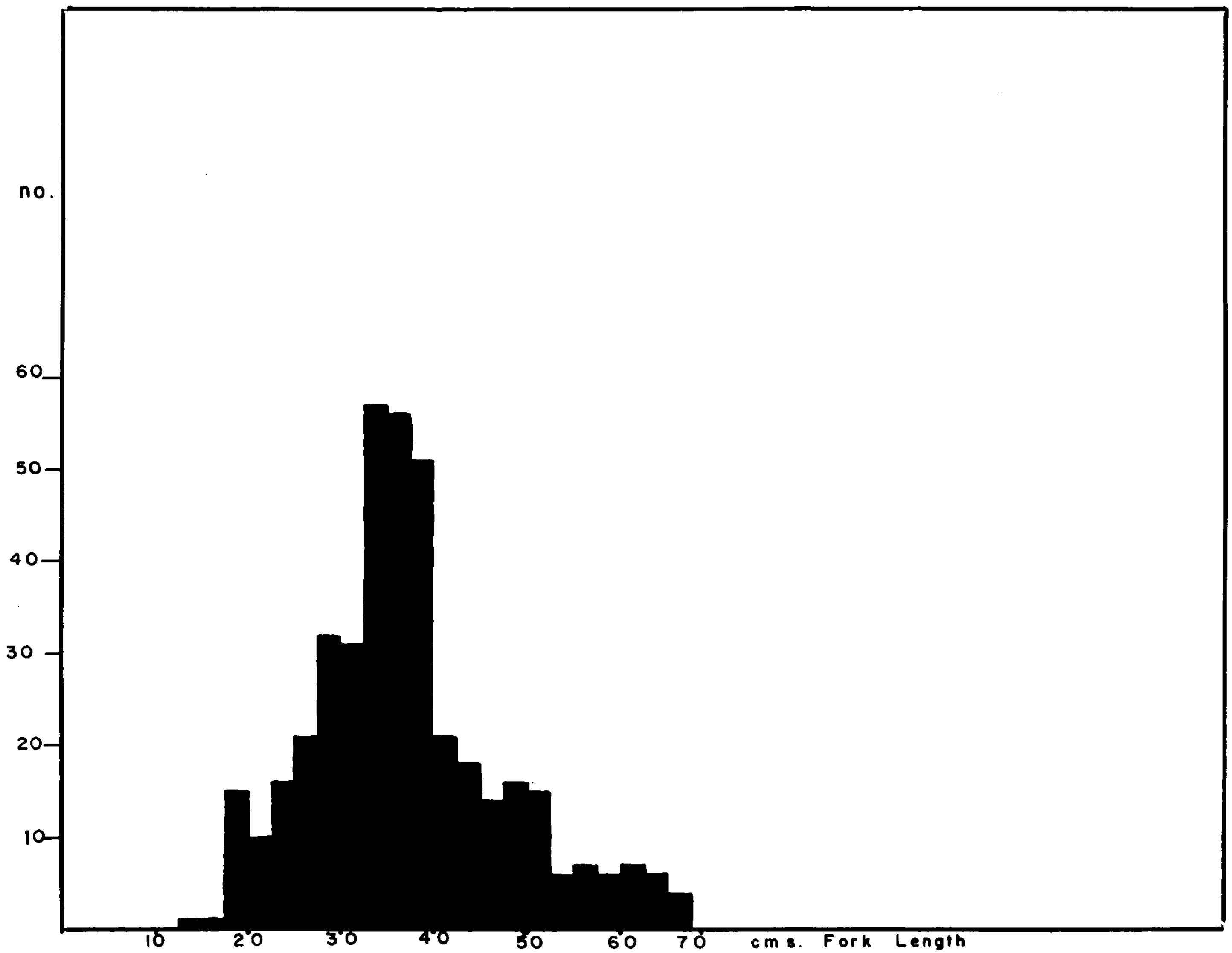


FIG. 3. LENGTH FREQUENCY OF GILL NET CATCH.

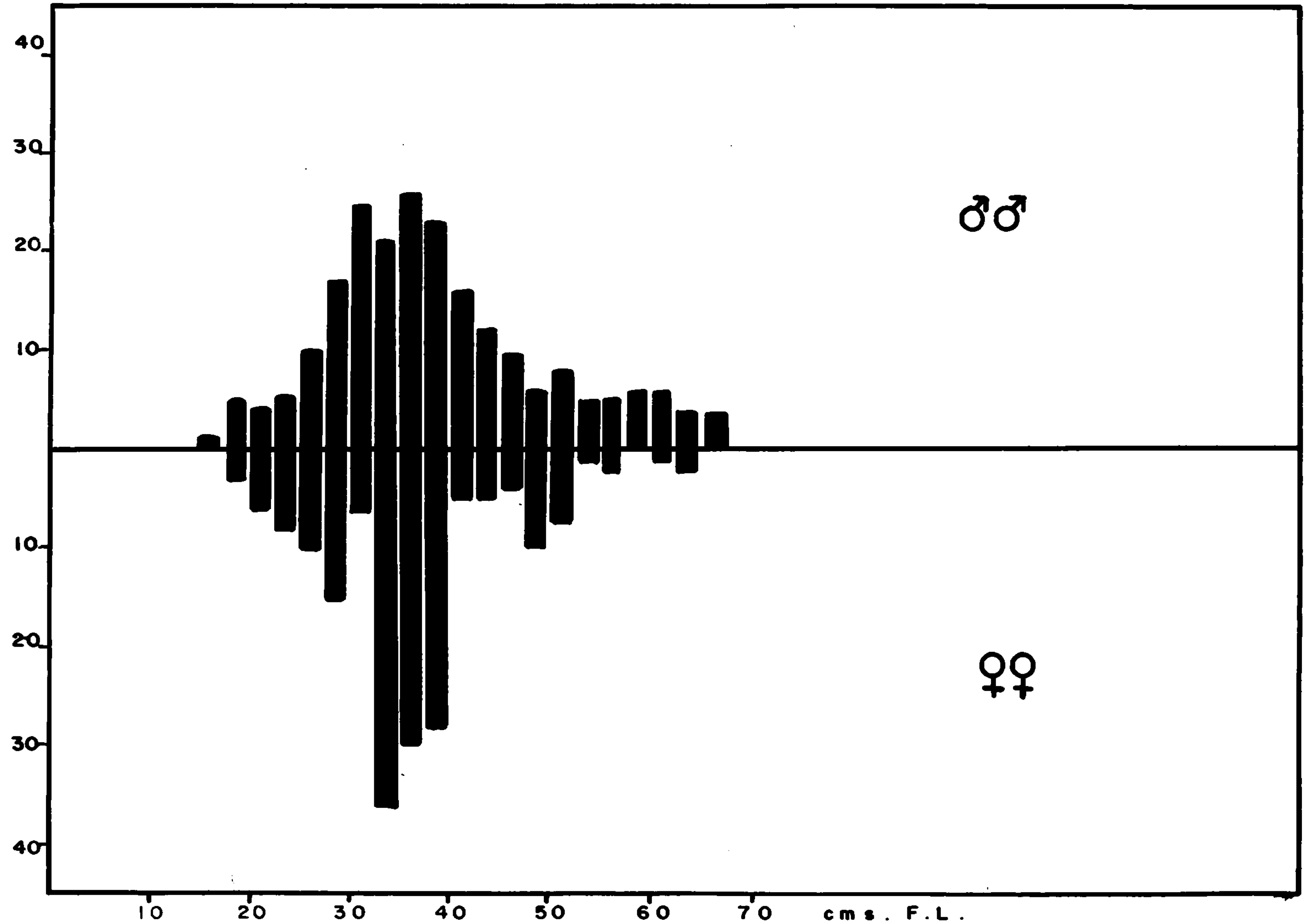


FIG. 3 a. LENGTH FREQUENCY OF THE SEXES.

THE AGE AND GROWTH OF CHAR

Review of the Literature

The use of otoliths for the determination of the age of fish was introduced by Riebisch in 1899, using the plaice as an example. Even though the scales of most fish are considered to be superior for age determinations, the otolith method has retained considerable interest over the years. Many workers have been tempted to use various other bony structures which exhibit a lamellar type of growth, with varying success. The pectoral bones, vertebrae, opercular bones, and fin rays are among the structures used by different authors. A review of these works has been made by Menon (1950).

Differences in shape, size, and chemical composition of the otoliths of different fish have been recorded. Comparisons have been made by Scott (1906), Frost (1928), and Shepard (1910), to name but a few. McMurrich (1912) recorded differences between the otoliths of the five species of pacific salmon of the genus Onchorhynchus . A review of the comparative and analytical works on otoliths has been compiled by Grainger (1953 b).

Although the char have typically small scales, many authors have preferred to use these structures in preference to otoliths for age determinations. This is especially true of the European workers, such as Runnström (1951), and Dahl (1926). Sprules (1952) used the scales for determining the age of char from the west coast of Hudson Bay. Martin (1955) likewise used scales from char taken in the region of the Ungava Crater, in Quebec, although he echoes Dahl's (1926) complaint that the smallness of the scales gave rise to difficulties. Slastnikov (1935), finding the scales of char from Novaya Zemlya unreadable, used ridges on the opercular bones for determination of the age. Hansen (1940) was the first to record the age of char using otoliths. Grainger (1949) collected the otoliths from the char of Frobisher Bay, and they were read at St. Andrews Biological Station. Some difficulty was found in the case of those otoliths which had been preserved in a glycerine-water mixture. In 1951 and 1952 Grainger preserved the otoliths from the char of the Sylvia Grinnell River, dry, with better results. Following the work of Lea (1910), Grainger then evolved a formula to express the relationship between the otolith width and the fish length. The formula used was as follows:

$$\underline{\text{Log (fish length)}} = \underline{-1.503} + \underline{1.982 \text{ Log (otolith width)}}$$

The figures are constants derived for that particular population. With this formula, back calculations could be made by measuring the width of any ring and thus calculating the length of the fish at that time. In this way year classes that had been inadequately sampled could be strengthened, thus balancing any bias in the catching method. Although variation in otolith widths within any one year class were found, these variations were less than those observed in the lengths of the fish. This method requires a large number of otoliths since only those in which the rings could be counted, and measured, in a straight line perpendicular to the long axis of the otolith, could be used. Therefore out of 830 pairs of otoliths that were suitable for age determinations, Grainger was able to use only 300 for the calculation. The smaller sample collected by the author was not suitable for such treatment, therefore the following method was used. The lengths of the fish in each age group were summed and the average value calculated, this method was used by Grainger (1953) for the smaller samples he obtained from the Bay of Two Rivers, the George River, and Herschel Island. The great disadvantage of this method is that it will reproduce any bias present in the sampling technique. However in the absence of a very large sample, it is the only method available.

Graham (1929) has reviewed the literature dealing with the growth of fishes. A more recent treatment of the question appears in Sea Fisheries, edited by Graham (1956).

The Otoliths of the Char

Under reflected light the otolith is seen to have a dark core. This is surrounded by concentric alternating light and dark rings. The light rings are considerably wider than the dark rings and are presumed to represent the summer period of relatively fast growth. Char taken in early summer do not show a light margin on the otolith, while those taken in the fall do. The light margin present on the otolith of fish captured in the fall is not as wide as completed rings of the same age. This indicates the existence of a time lag between the start of the period of fast growth, and the formation of the light ring. (See below, and Figures 5 and 6.)

The dark core is frequently lightened or obscured by the presence of cracks which run radially out from the centre. These cracks are artifacts, and it has been suggested that they are caused by stresses set up within the otolith during drying.

There is no direct evidence as to when the otolith starts to form. Grainger (1953 b.) suggests that since the eggs are laid in the fall, and since the core is dark and thus indicative of winter growth, the otolith begins to grow as soon as the fish begins to develop. The dark core then will represent the first winter of the char's life, the first light ring will then be laid down during the first summer, and the start of the first dark ring will mark the completion of one year in the life of the char. It is on this assumption that the rings were counted on the otoliths of the char of Nettilling Lake. The age of the char given throughout the body of this work therefore refers to completed years of growth.

The Age Determinations of the Nettilling Lake Char

For the determination of the age of the Nettilling Lake char, otoliths were removed from 320 specimens. The otolith used was the sagitta, the largest one present in the char which resides in the sacculus of the inner ear. This otolith is longer than it is broad, the medial side being bisected by a deep groove while the lateral side is smooth and slightly convex. It is on this side that the readings are made. The otoliths were kept dry in envelopes following the advice of Grainger (1953 b.) and Johnston (1938). In the laboratory, the otoliths were first cleaned manually and then mounted on a black slide, they were then covered by a 10 per cent aqueous solution of glycerine and read using a stereoscoptic microscope. Readings were made at random to avoid bias and in most cases on both otoliths. Where one otolith was deformed or otherwise unreadable, readings were made on the other. In some cases where readings did not coincide between right and left otoliths or between first and second readings, the otoliths were discarded, thus although 320 pairs were collected, final readings were made on 295 pairs only.

Figures 4 to 7 illustrate the lateral aspect of otoliths from different age groups. Figure 4 shows an otolith with 6 dark or winter rings; the dark core is obscured by cracks as mentioned above. Figure 5 demonstrates the appearance of an otolith with 9 dark rings. In this figure, a light margin on the otolith may be observed on the lower left hand side; this is the beginning of a summer ring. The otolith was taken from a char captured late in July. Figure 6 illustrates an otolith taken from a 12 year-old char; again a light ring can be seen in the lower left hand corner; the last few rings are out of focus due to the convex curvature of the surface. Figure 7, showing an otolith from a 14 year-old char, illustrates a common condition; the rings on the left hand side are obscured by a growth that does not show the lamellar construction typical of the otolith (These growths could in some cases be removed by grinding with fine carborundum powder until the underlying rings became evident.). The serrated margin on the right hand side of the figure is also typical of otoliths taken from larger and older fish.

FIG.4.OTOLITH WITH 6 WINTER RINGS. FIG.5.OTOLITH WITH 9 WINTER RINGS.

FIG.6. 12 YEAR OLD OTOLITH. FIG.7. 14 YEAR OLD OTOLITH.

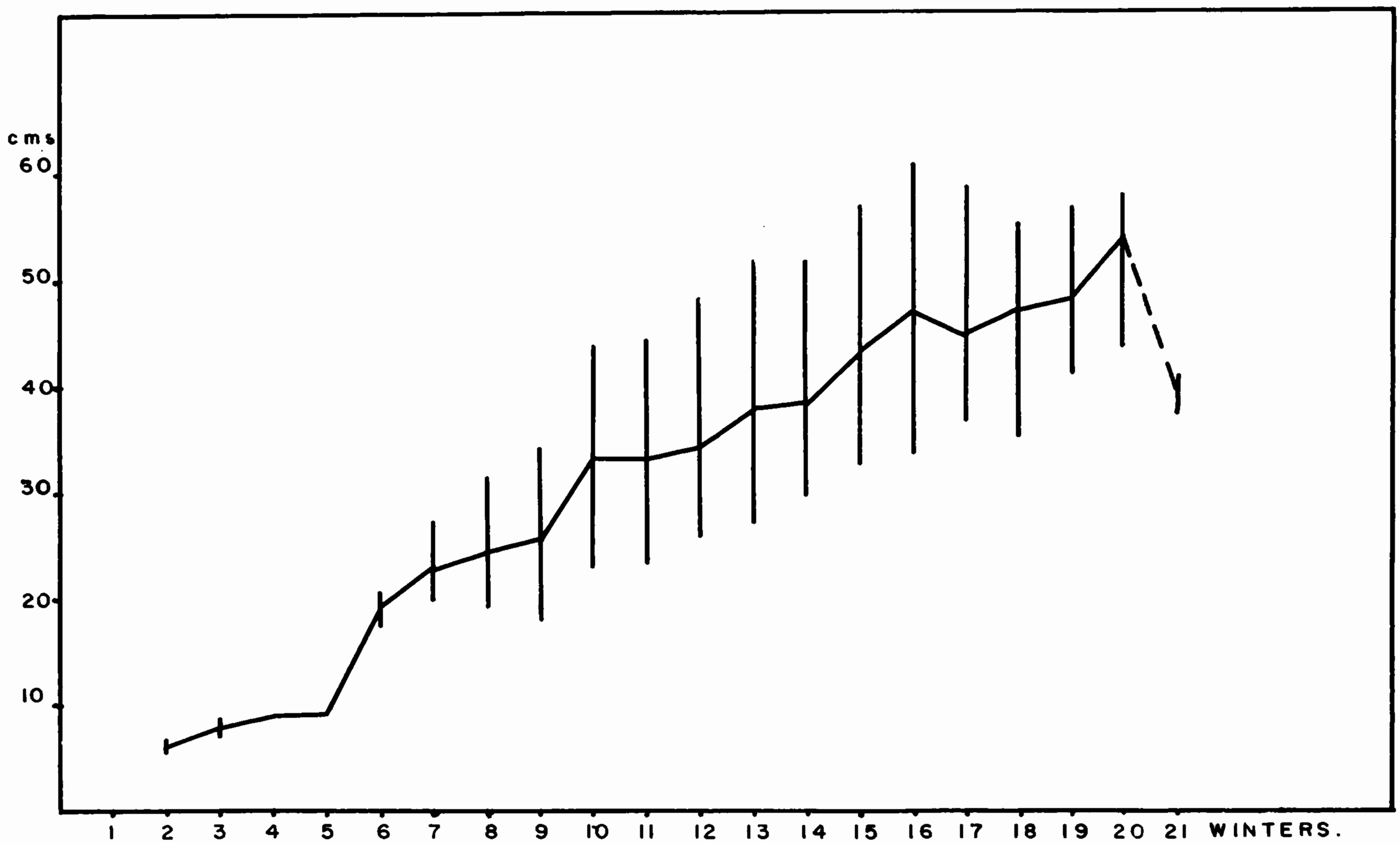
The readings obtained from the otoliths of 295 char from Nettilling Lake were plotted against the individual fork lengths. The mean fork length was then calculated for each year class and is presented in Table 4. These results are also shown graphically in Figure 8. The same methods were used to determine the age of char from Rowley Island in Foxe Basin and from the west coast of Melville Peninsula.

Table 4. MEAN FORK LENGTH OF CHAR IN RELATION TO AGE

				MALES			FEMALES		
Age	No.	Range	Mean	No.	Range	Mean	No.	Range	Mean
2	7	5.5- 6.5	6.07						
3	6	7.0- 8.5	7.83						
4	4	9.0- 9.0	9.00						
5	2	9.0- 9.0	9.00						
6	3	17.5-20.5	19.00	3	17.5-20.5	19.00			
7	4	20.0-27.0	23.13	2	20.0-22.0	21.00	2	23.5-27.0	25.25
8	12	19.5-31.5	24.37	5	19.5-27.5	24.10	7	20.0-31.5	24.57
9	16	18.0-34.0	25.75	9	19.5-34.0	27.16	7	18.0-34.0	23.90
10	19	23.0-44.0	33.50	8	29.0-44.0	34.62	11	23.0-39.0	32.68
11	45	23.5-44.5	33.31	25	26.0-41.5	33.14	20	23.5-44.5	33.58
12	49	26.0-48.5	34.51	22	27.0-48.5	35.52	27	26.0-48.0	33.68
13	40	27.0-52.0	38.23	22	27.0-52.0	37.68	18	27.0-51.5	38.88
14	26	30.0-52.0	38.55	13	30.0-47.5	38.73	13	30.0-52.0	38.38
15	20	33.0-57.5	43.25	10	33.0-57.5	44.60	10	34.5-52.0	41.90
16	18	34.0-61.0	47.38	16	34.0-61.0	48.53	2	36.5-40.0	38.25
17	10	37.0-59.0	44.80	4	39.5-59.0	48.13	6	37.0-50.5	42.58
18	5	35.5-55.5	47.50	2	52.5-55.5	54.00	3	35.5-49.0	43.17
19	4	41.5-57.0	48.38	1	41.5-41.5	41.50	3	44.0-57.0	50.66
20	3	49.0-58.5	54.63	2	57.0-58.5	57.75	1	49.0-49.0	49.00
21	2	42.5-46.0	44.50	2	42.5-46.0	44.50	0		

N.B. The Range and Mean Fork Length (cms.) of the total population are shown in Figure 8. The frequency distribution, and the sex ratio of the year classes are plotted in Figure 10. The difference between males and females is discussed below, and the values plotted in Figure 11.

FIG. 8. RANGE & MEAN LENGTH OF AGE GROUPS.



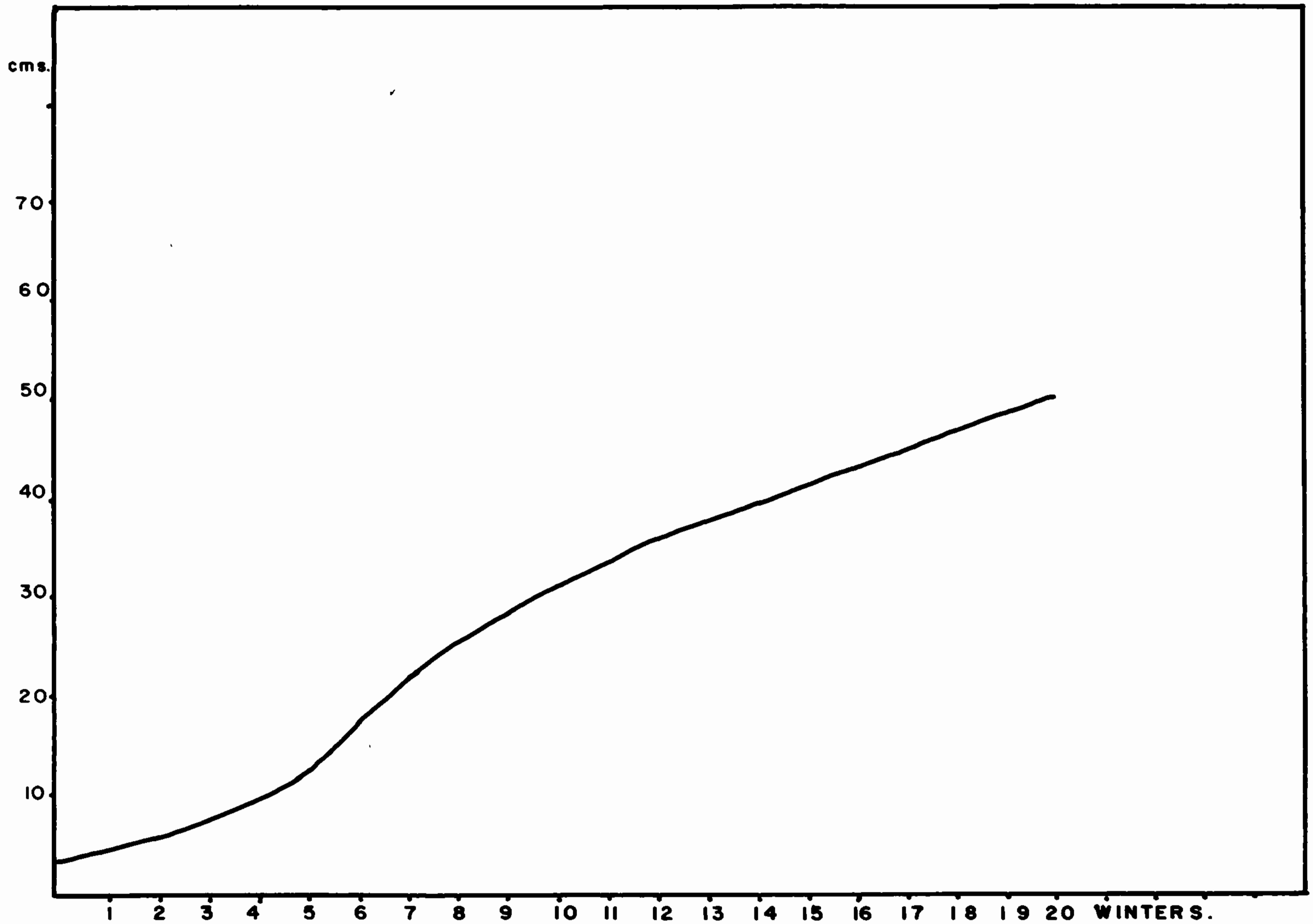


FIG. 9 AGE, LENGTH SMOOTHED GROWTH CURVE.

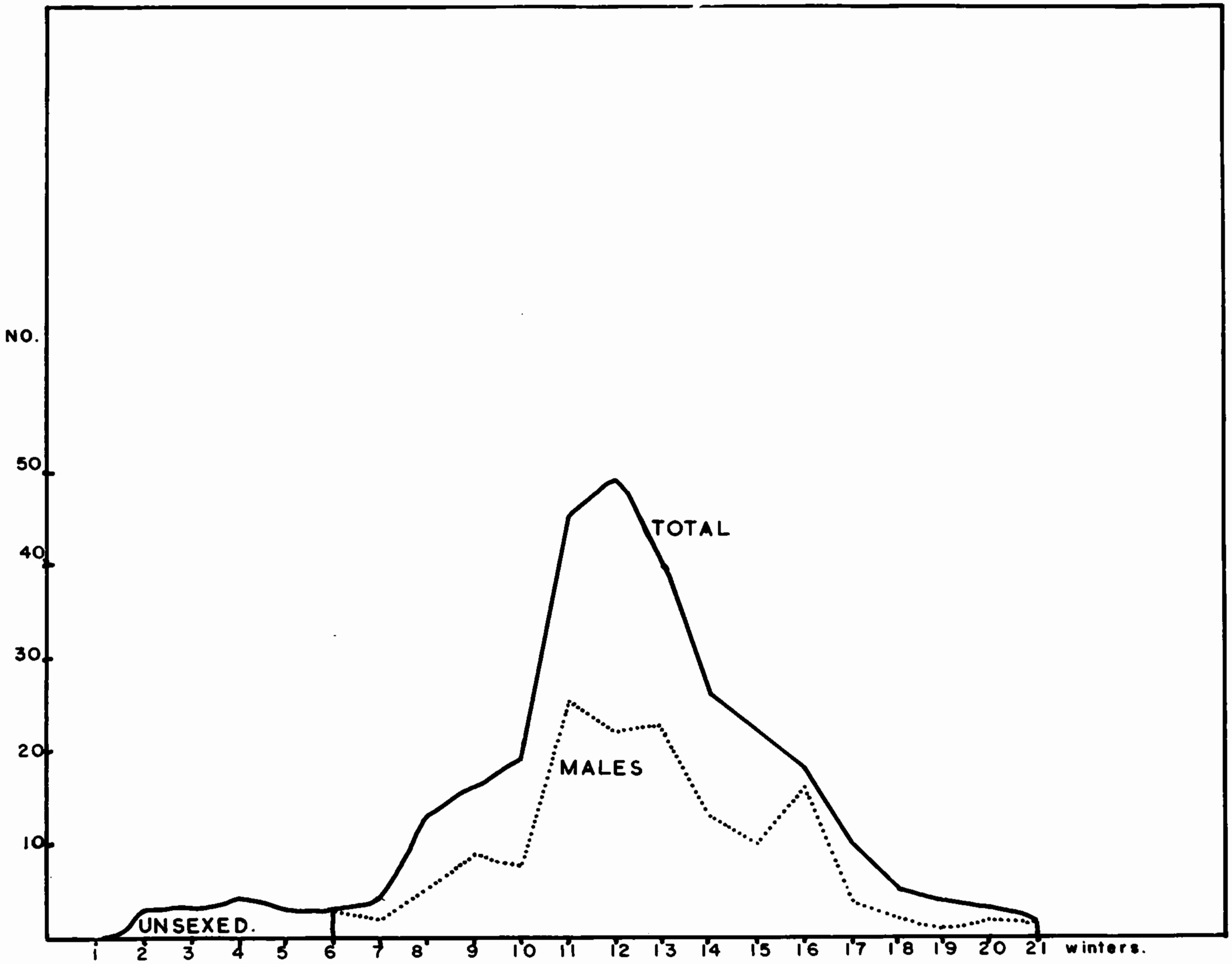


FIG. 10. AGE FREQUENCY OF SAMPLE.

Analysis of the Growth Rate

Various statistical methods were applied to the above data (Table 4.) for the purpose of calculating a growth curve. In all cases the small size of the sample and the unequal weights of each year class defeated the statistic. Figure 9 shows the growth curve obtained by smoothing the line in Figure 8 by means of a 5 year running average. This was done after due consideration of the following points. First, the apparent rapid growth between the ages of 5 and 6. This is due in part to the fact that the nets did not sample the population below 18. cms. fork length. Therefore only the larger members of the 5, 6, and 7 year old classes were sampled, thus raising the mean fork length to an artificial height. Secondly, the fish in the very young year classes (2 to 5) were obtained from stomach samples,(Table 2) thus this sample is also biased but towards the smaller fish in these groups. The variation towards the end of the graph in the higher age groups can be attributed to the small numbers in these groups. Figure 10 illustrates the age and sex frequency of the year classes.

Sex Differences in the Growth Rate

The author is indebted to Dr. G. I. Paul of the Genetics Department, McGill University, for the following analysis of the data (Table 4). A weighted regression line was fitted to the average lengths of males and females in each year class from six to 20 years. The equations for the regression lines are:

<u>Males:</u> $\hat{y} = 3.872 + 2.5657\ x$

<u>Females:</u> $\hat{y} = 14.61 + 1.668\ x$

These lines are shown in Figure 11. A comparison of regression coefficients by means of a Fisher-Behrens test was made, the test taking into account the heterogenous variance of the sample. This comparison showed that the males had a significantly higher growth rate than the females. A comparison of the initial points of the lines showed that the difference was not significant, thus proving that males and females began growth at the same size. Further analysis showed that the regression of average length on age was linear in the case of the males but nonlinear in the case of the females.

This difference has raised several questions. Since the growth curves differ both in form and rate between the sexes, the suggestion has been made that the general growth rate cannot or should not be treated as a whole. The non-linearity in the females may be due to gonadal growth which presumably would take more and more energy on the part of the fish as it grew larger, thus leaving less and

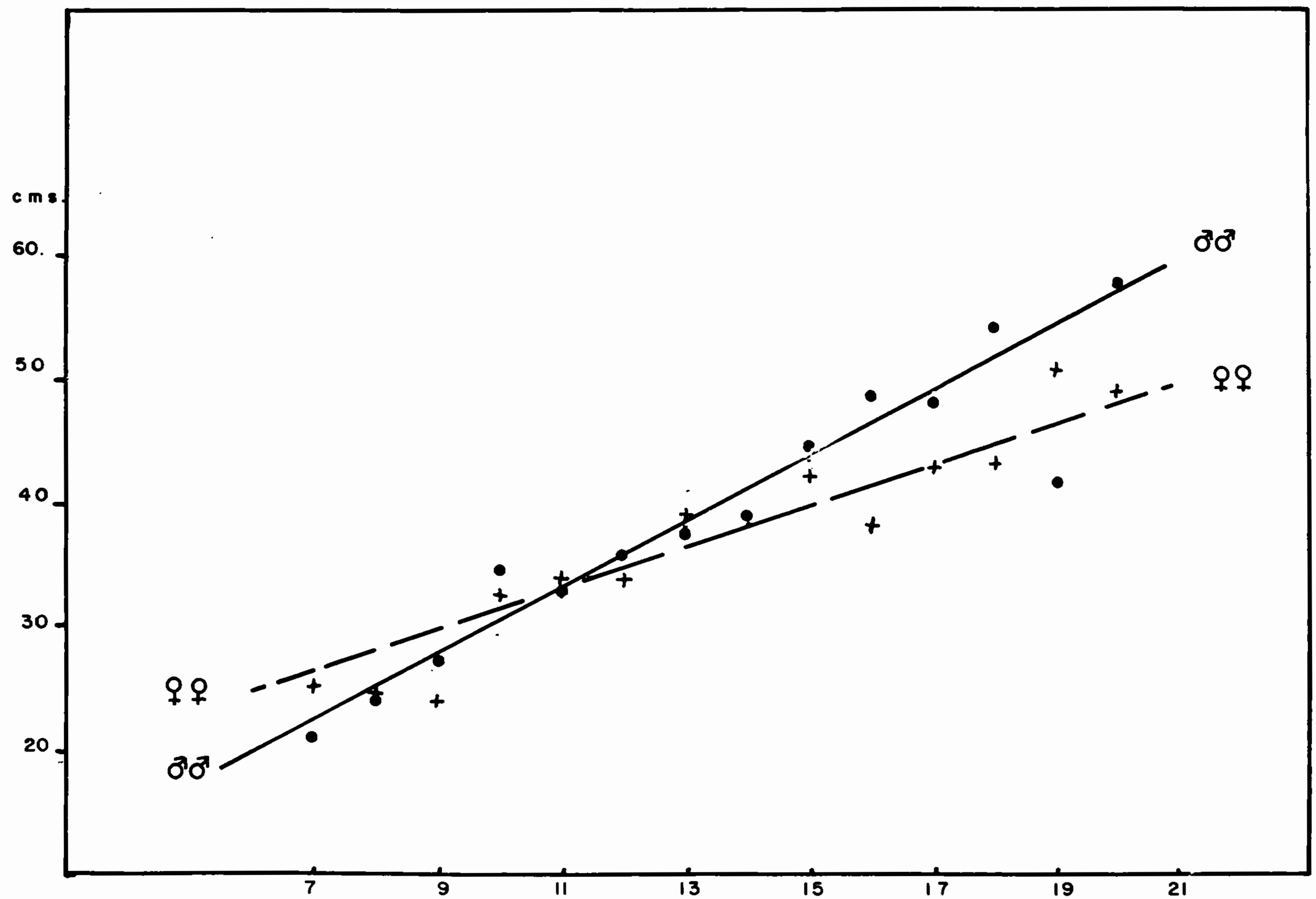


FIG II. WEIGHTED REGRESSION OF AVERAGE LENGTH ON AGE.

less energy available for somatic growth. Since a larger fish not only produces more eggs but larger eggs as well (Måår 1950), and if mortality is not considered, there must come a time when the food taken in is just enough to account for the movement of the fish and the development of the ovaries. Even though the females do not spawn every year, there must be a period devoted to restoring the fish to normal condition by replacing substances drained from the body during the final months before spawning. This concept of a state of equilibrium where the fish does not grow may derive support from a consideration of the decreasing annual increment in growth which all fish show. The work of Grainger (1953) has shown that in the case of the Char of the Sylvia Grinnell River, this state has not been reached by the end of the twenty-fourth year. Much more work is needed on larger samples before a complete analysis of this matter can be presented.

COMPARISON OF THE GROWTH RATES

There are only a few papers which deal with the growth of char. Grainger (1953) calculated a growth rate for the char of the Sylvia Grinnell River based on a relationship between otolith width and fish length. Other populations described by Grainger included samples from the George

River, the Bay of Two Rivers, and Herschel Island. In addition to the char of Nettilling Lake, the author has examined small samples from Rowley Island, and Melville Peninsula. Sprules (1949) examined 94 anadromous and 46 landlocked char from the west coast of Hudson Bay, using scales for determining the age but "difficulties were experienced". Andrews and Lear (1956) examined char obtained from commercial catches from four fishing ports on the Labrador Coast, using otoliths to determine the age groups. Although Andrews and Lear treated the samples from each of the ports separately, for the purpose of comparison the results have been summed and the mean lengths of the total population calculated. The same treatment has been used on the work of Hansen (1940) who examined 671 char from West Greenland fishing ports using otoliths for age determinations. The age and length of the char of Svalbard have been recorded by Dahl (1926) using scales, while those of Novaya Zemlya were studied by Slastnikov (1935) using the opercular bones. Other workers have given the age and length of char without attempting to plot a growth curve. In these cases the samples were usually small such as that collected by Martin (1955) from Ungava Crater in Quebec. Runnström (1951) studied the growth of char in a Swedish lake to determine the changes following regulation of the water level. Nillsson (1954) reported on the age and length of two populations of char in Lake Korsvattnet, Sweden; one of the populations was termed "dwarf" by the author. These latter workers have all used scales for determining the age of char. Frost (1951) has aged three populations of the char of Lake Windermere, Salvelinus alpinus willoughbii (Gunther) two of which were normal while the other was dwarf, similar to that recorded by Nillsson (1954). Since the char of Lake Windermere is considered to be a separate sub-species or species from Salvelinus alpinus the above work is not included in the following comparison.

The results of these works are presented in Table 5 and are compared with the values found for the Nettilling Lake char as shown in Figures 8 and 9. The comparison is illustrated in Figures 12 and 13. Wherever possible, the curves used by the original authors have been reproduced but in those cases where no curve was given, a line has been fitted by hand to the recorded points.

TABLE 5: COMPARISON OF MEAN FORK LENGTHS (CMS.) OF AGE GROUPS

Age-Completed Years of Growth	Nettilling Lake Rough Data	Nettilling Lake Smoothed Curve	Sylvia Grinnell Frobisher Bay	Labrador Coast Combined	Hudson Bay Anadromous	West Greenland Combined	Svalbard	Novaya Zemlya	Bay of Two Rivers Baffin Island	Herschel Island	Melville Peninsula (East Coast)	George River Ungava	Rowley Island Foxe Basin	Hudson Bay Landlocked	Ungava Crater and Vacinity	Lake Korsvattnet	Lake Korsvattnet Dwarfs	Lake Alm Before Regulation	Lake Alm After Regulation
0															4.9				
1		4.5	1.4												7.4	11.0	5.0	11.0	8.5
2	6.7	6.0	2.5					5.8						16.5	10.2	20.0	10.0	18.0	14.5
3	7.83	7.5	5.0				24.5							16.5	11.6	28.0	13.0	25.0	19.5
4	9.0	9.5	8.0		32.0	19.0	34.0	18.5		20.1				18.5	15.3	30.0	17.0	30.4	22.5
5	9.0	12.5	11.6	44.5	38.0	21.3	36.9	20.0		25.5				19.0		34.0		34.5	25.0
6	19.0	17.5	15.4	45.4	41.0	27.8	41.2			33.2				23.0		40.0	28.0		
7	23.13	21.5	19.6	46.8	44.5	31.4	48.3			37.3		40.8		26.0	23.0	42.0	29.0		
8	24.37	25.0	24.0	48.0	47.0	38.9	53.3			39.0		43.7		27.0	28.0	57.0	31.0		
9	25.75	28.5	28.5	48.6	49.5	44.6	61.1			38.6		43.0		28.0	41.2	60.0	33.0		
10	33.5	31.0	33.5	48.3	52.0	47.4	67.0			48.1				31.0	38.8				
11	33.31	33.5	38.2	52.1	56.5	48.3	70.0		48.5	51.1				30.5	48.0				
12	34.51	35.5	42.7	50.4	60.0	53.3							40.7	35.0	36.5				
13	38.23	37.5	46.8	51.2	63.5	55.7			54.0				48.2	34.5	44.5				
14	38.5	39.5	50.3	52.9	63.5	60.2			59.0				51.9	35.0	49.5				
15	43.25	41.0	53.5	57.1		54.0					61.5		51.3	38.0	55.0				
16	47.38	43.0	56.3	59.2	68.0	66.8			66.0				51.4						
17	44.8	45.0	58.6		79.0				64.5		66.0		51.7						
18	47.5	46.5	60.4		75.0				65.0		64.7								
19	48.38	48.5	62.3						69.0		73.1		57.7						
20	54.0	50.0	63.9								64.5		58.5						
21	48.0		65.3								64.3		58.5						
22			66.4		82.0				64.5				62.0						
23			67.5						67.4		68.5								
24			68.5																
No.	286	CALC	CALC	496	94	671	-	-	16	15	19	10	28	46	53	-	-	-	-

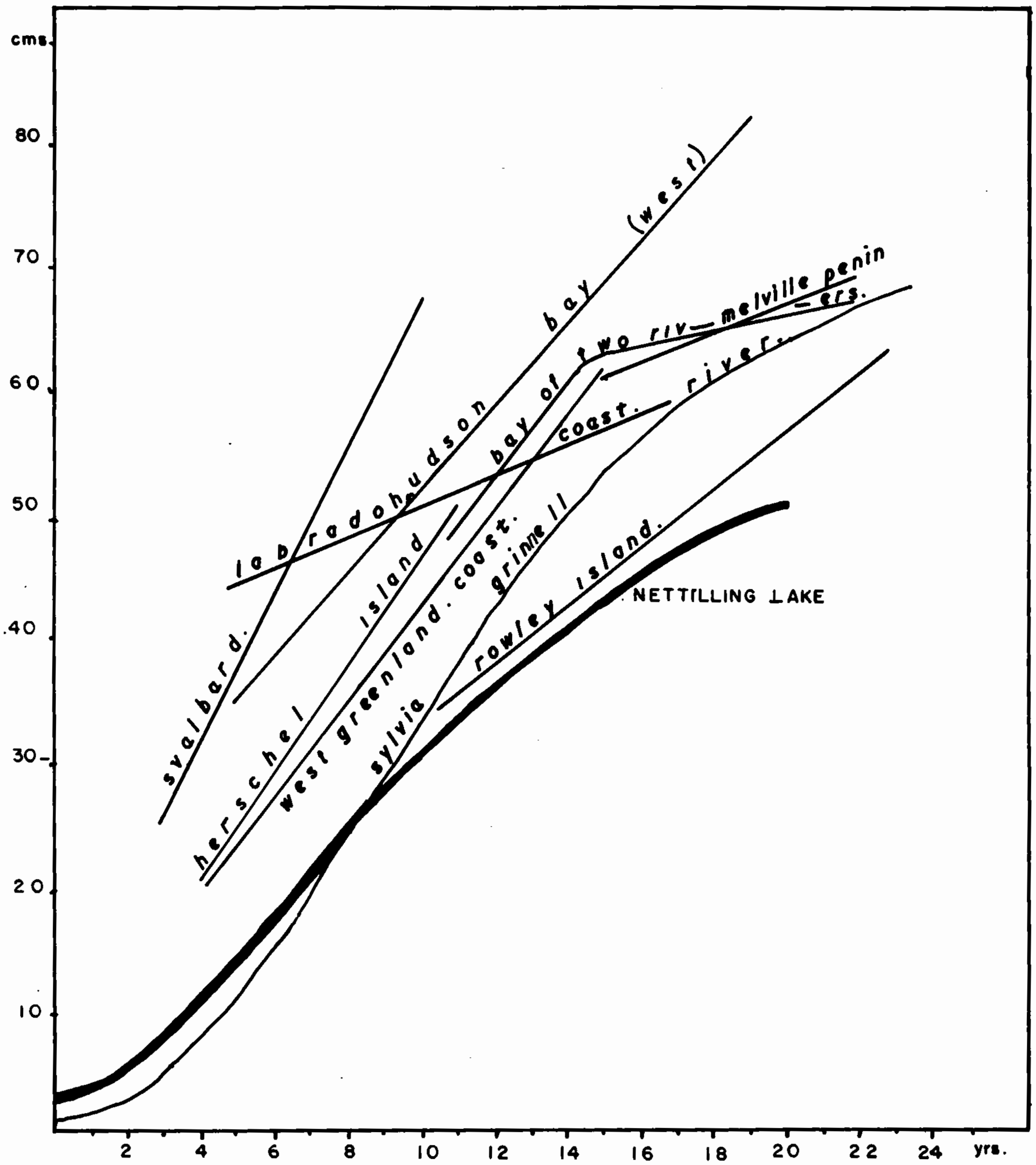


FIG. 12. COMPARISON OF GROWTH RATES.
ANADROMOUS POPULATIONS.

Figure 12 shows the growth of char in Nettilling Lake compared to the growth determined for anadromous populations. In this graph, the lower growth rate, found for the Nettilling Lake char, is demonstrated. The small population from Rowley Island cannot be considered as significantly different from the Nettilling Lake char, since in the first place the Rowley Island values lie within the values of the Nettilling Lake char, and secondly the nets used to capture these char were larger than those used in Nettilling Lake (6 and 6½ inch mesh size compared to 5½ inch.). The slope of the curve determined for the char of the Labrador coast shows the result of a sampling bias, these char were obtained from commercial catches and the nets used in commercial fishing are of such a size as to eliminate the smaller fish from the catch; therefore only the larger members of the younger year classes were present in the sample.

When the curve determined for the growth of char in Nettilling Lake (fig.9) is compared to the curve calculated for the char of the Sylvia Grinnell River, the following points arise. The rate of growth up to the age of eight is similar, but older fish from the river, reach a larger size than that attained by Nettilling Lake char. Even though Grainger (1953 b.) used nets that were larger than those used by the author, the difference is still significant. In general, the slope of the growth curve shown for the Nettilling Lake char is similar to that found for Sylvia Grinnell char and other populations though the average fork lengths are lower. The older fish are decidedly smaller in Nettilling Lake than in any other area.

Figure 13 shows the growth of the char of Nettilling Lake compared with that of landlocked populations from Sweden, Ungava, and western Hudson Bay. In this comparison the char of Nettilling Lake are shown to have a slower growth rate than the char from Sweden. This fact may no doubt be explained by the higher temperatures and the longer growing periods that are to be found in Sweden. The char of Ungava Crater seem to show a growth rate similar to that determined for Nettilling Lake, however the older year classes in the Ungava population are represented by very few fish and this section of the curve is considered questionable by the original author (Martin 1955). The higher values in young fish found in the landlocked char of Hudson Bay may be explained by a consideration of the higher temperature and a longer ice-free season in Littlefish Lake as compared to Nettilling Lake.

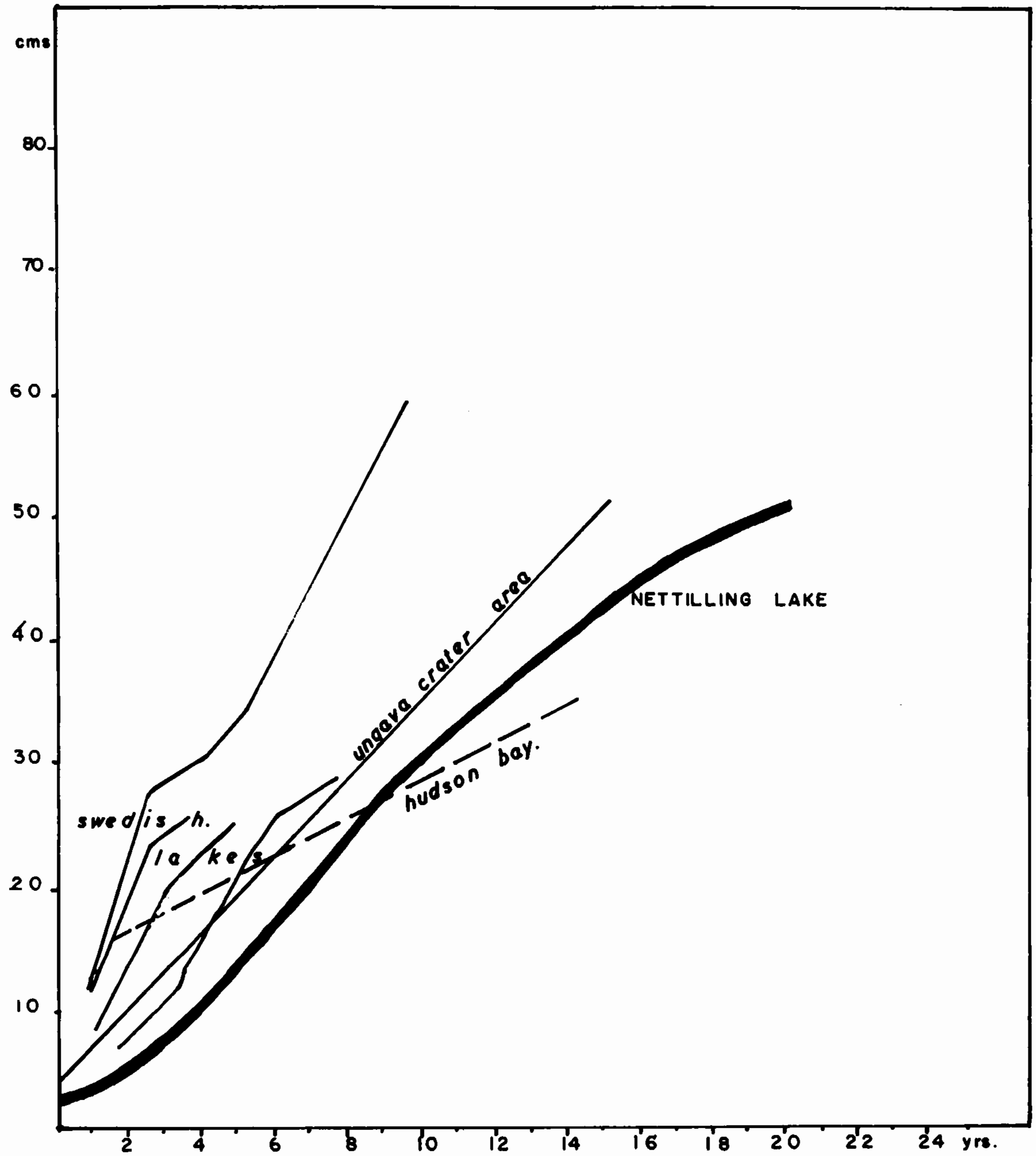


FIG.13. COMPARISON OF GROWTH RATES.
FRESHWATER ("LANDLOCKED") POPULATIONS.

THE GROWTH WITH RESPECT TO WEIGHT

The weights of all fish were recorded with respect to age, and the average weight of each year class calculated, this is shown in Table 6.

Table 6. AGE AND WEIGHT OF NETTILLING LAKE CHAR

Age	Range (oz.)	Mean	No.
6	1.75- 3.25	2.42	3
7	2.5 - 6.75	4.25	4
8	2.5 - 9.0	5.02	12
9	2.25-14.0	6.21	16
10	3.75-29.0	12.56	19
11	3.25-28.0	11.56	45
12	5.5 -39.0	14.14	49
13	6.25-41.0	18.56	40
14	8.0 -47.0	18.07	26
15	12.0 -57.0	28.15	20
16	13.0 -68.0	36.47	18
17	16.0 -64.0	28.00	10
18	14.0 -55.0	34.60	5
19	19.0 -56.0	31.75	4
20	33.0 -45.0	41.00	3
21	21.0 -35.0	28.00	2

When these figures are separated into the mean weights for male and female, the males show a higher mean weight than the females, especially with increasing age. However, the samples are so small and the range so wide, that no analysis has been attempted. The difference between the sexes, with respect to weight, is shown below in Table 7, but a larger sample would be required before any estimation of the difference in rate of growth could be made.

Table 7.

MEAN WEIGHT OF MALES AND FEMALES WITH RESPECT TO AGE.

Age	Mean Wt. Males	Mean Wt. Females
6	2.5 oz.	2.25 oz.
7	2.875 "	5.625 "
8	5.1 "	4.96 "
9	6.97 "	5.25 "
10	13.84 "	11.63 "
11	10.81 "	12.475 "
12	15.70 "	12.88 "
13	17.84 "	19.43 "
14	18.3 "	17.8 "
15	31.2 "	25.1 "
16	39.06 "	17.5 "
17	35.5 "	23.0 "
18	46.5 "	26.66 "
19	19.0 "	36.0 "
20	45.0 "	33.0 "
21	28.0 "	----- -

COMPARISON OF GROWTH RATES (WEIGHT)

The mean weight of the char from Nettilling Lake in each age group is plotted in Figure 15. There, they are compared with the figures obtained for the growth of the char of the Sylvia Grinnell River (Grainger 1953), and for the char of Hudson Bay and Littlefish Lake (Sprules 1949). The values of the mean weight of char as determined by these authors, are given below in Table 8.

Table 8. MEAN WEIGHTS WITH RESPECT TO AGE OF CHAR FROM SYLVIA GRINNELL RIVER, HUDSON BAY, AND LITTLEFISH LAKE.

Age	Hudson Bay	Littlefish Lake	Sylvia Grinnell R.
2		1.0 oz.	
3		1.5 "	
4	12.0 oz.	2.0 "	
5	24.0 "	4.5 "	
6	32.0 "	4.5 "	
7	37.0 "	7.0 "	
8	43.0 "	8.0 "	
9	54.0 "	9.0 "	
10	60.0 "	10.0 "	16.0 oz.
11	78.0 "	12.5 "	
12	100.0 "	14.5 "	29.0 "
13	107.0 "	15.5 "	
14	118.0 "	20.0 "	45.0 "
15	--- -		
16	132.0 "		61.0 "
17	185.0 "		
18	192.0 "		80.0 "
19			
20			81.5 "
21			
22			93.0 "
23			
24			87.0 "

Note :- The values given for the mean weight of char from the Sylvia Grinnell River, are the mean weights of all fish in two successive year classes, for example, the mean weight of all 10 and 11 year old char is 16.0 ounces. (Grainger 1953.)

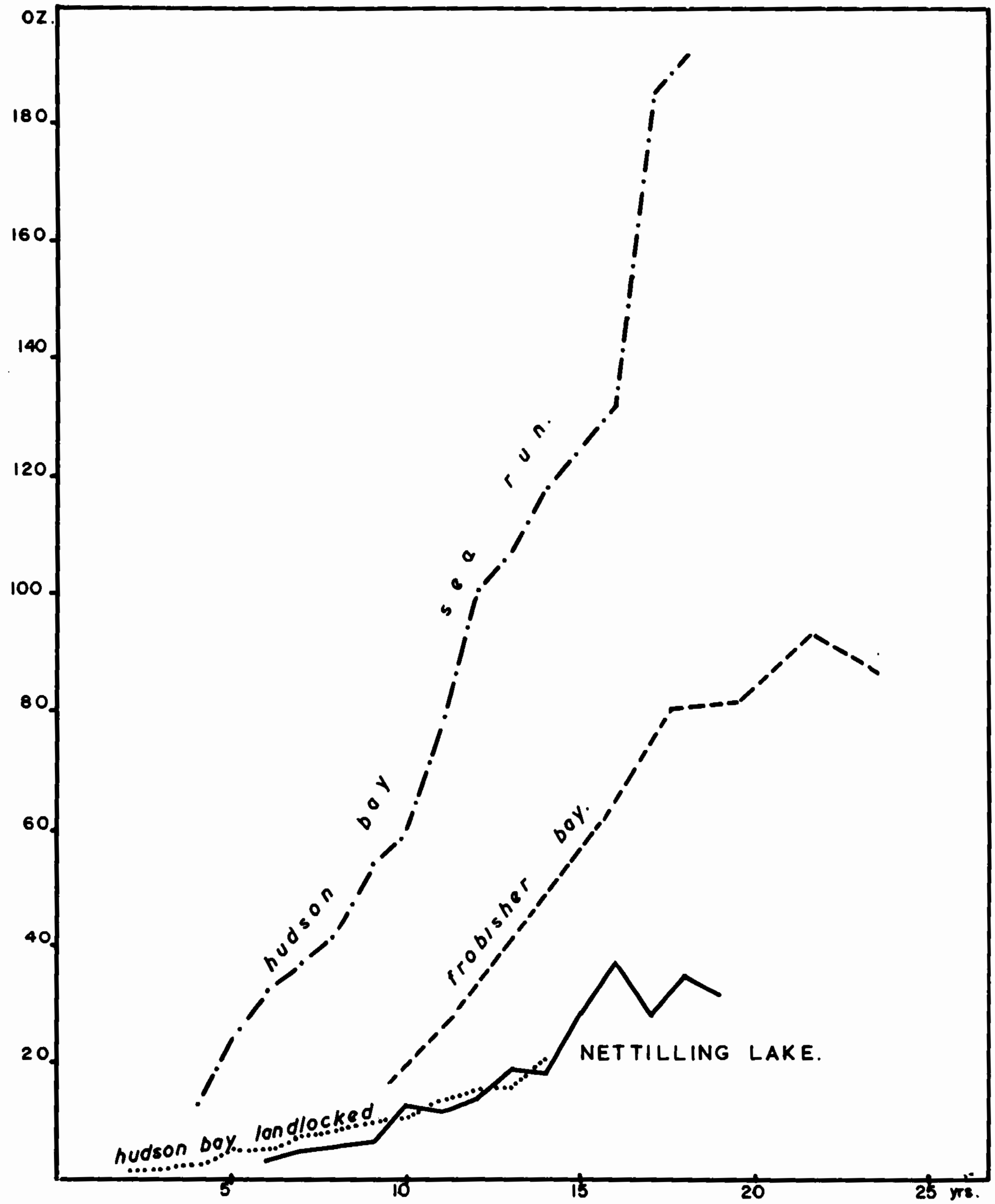


FIG. 15. COMPARISON OF AGE-WEIGHT CURVES.

Figure 15 which is derived from Tables 6 and 8, clearly shows that the weights of the char from Nettilling Lake fall far below the values recorded for Frobisher Bay and Hudson Bay. The low values at higher ages cannot be attributed solely to sampling error, as the nets used, though smaller than those used by Sprules and Grainger, yet were capable of holding fish of weights up to 104 ounces maximum. The conclusion drawn by the author is that there is a limit to the maximum size that may be attained by the char of Nettilling Lake, this limit being imposed on the fish by the food supply available. The working hypothesis has been that the char of Nettilling Lake represent a landlocked population, this point will be discussed below in greater detail. For the moment it will be enough to draw attention to the close relationship between the mean weights of char from Nettilling and Littlefish Lakes, especially in the younger year classes. The very rapid growth shown by the sea-run char of Hudson Bay is presumably due to the higher temperature and a greater food supply than is found in Frobisher Bay; however there is not enough direct evidence to support this point.

Few authors have treated the growth of char with respect to weight, or given data from which such a relationship might be derived. In order to pursue this line of investigation further, a comparison of Length Weight relationships has been made, between the char of Nettilling Lake, of Frobisher Bay (Grainger 1953), of the Labrador coast (Andrews and Lear 1956), of Svalbard (Dahl 1926), and of Bear Island (Sergeant,personal communication). This comparison is shown in Table 9 and presented graphically in Figure 14. In the following Table the char of Nettilling Lake have been treated as follows; fork lengths have been grouped into 5 centimetre lengths and the average weight calculated for each group. For the other populations, the empirical points as given by the authors were first plotted and a line fitted by hand, the values in the table were then read off the graph to correspond with the lengths taken for the Nettilling Lake char.

Table 9. COMPARISON OF LENGTH WEIGHT RELATIONSHIPS OF CHAR FROM NETTILLING LAKE SYLVIA GRINNELL RIVER, LABRADOR COAST, SVALBARD, AND BEAR ISLAND

Fork Length	Nettilling L.	S. Grinnell R.	Labrador	Svalbard	Bear Island
20.-24.5 cms.	2.0 Oz.				
25.-29.5 "	4.5 "	8.0 oz.			
30.-34.5 "	8.2 "	10.0 "			
35.-39.5 "	15.0 "	17.5 "	21.0 oz.	25.0 oz.	13.0 oz.
40.-44.5 "	22.1 "	27.0 "	32.0 "	32.0 "	20.0 "
45.-49.5 "	32.0 "	38.5 "	45.0 "	41.0 "	27.0 "
50.-54.5 "	42.5 "	53.0 "	63.0 "	53.0 "	35.0 "
55.-59.5 "	52.5 "	70.5 "	81.0 "	78.0 "	41.0 "
60.-64.5 "	67.5 "	93.0 "	105.0 "	88.0 "	-- -
65.-69.5 "	80.0 "	115.0 "	126.0 "	130.0 "	
70.-74.5 "	-- -	134.5 "	--- -	166.0 "	
75.-79.5 "		163.0 "		--- -	

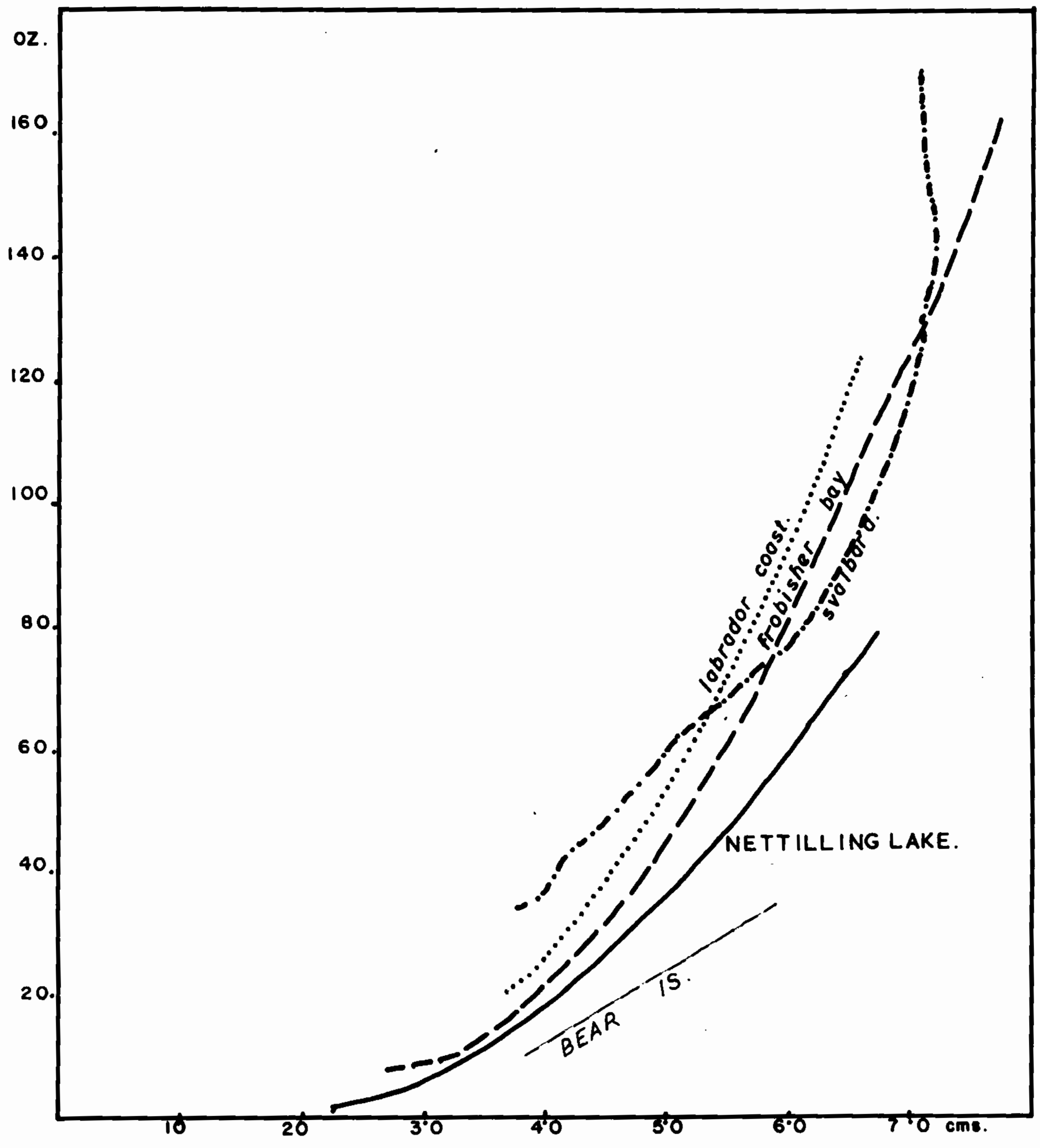


FIG.14. COMPARISON OF LENGTH-WEIGHT RELATIONSHIPS.

Figure 14 shows that the Length Weight relationships of the char of Frobisher Bay, Labrador and Svalbard all follow the same trend (the roughness in the latter curve is due to the smallness of the sample). The curve for the char of Nettilling Lake is not only lower but becomes progressivly so as higher values are reached. This is but another aspect of the picture shown in Fig.15 where the weight to age curve flattens out in the older year classes. The small sample from Bear Island, presumed to be landlocked, shows a lower Length Weight relationship than that found for Nettilling Lake char. This sample of 20 char was taken in Lake Laksvattnet which is about .8 sq.miles in area and is connected by a rapid river to the sea.

The largest char recorded, attained a weight of 16 kgs.(35 lbs.), this was in Novaya Zemlya and was reported by Yessipov (1935). Wynne-Edwards (1952) gives 9 kgs.(20 lbs.) as an exceptional weight. Dahl (1926) reported that the char of western Svalbard reached a weight of 4.7 kgs.(10.3 lbs.). Fowler and Harper (1947) report the existance of a photograph of an arctic char which was said to be 36 inches long and weighed 26 pounds; it was caught by Mr. Ingebritson in Hudson Bay. The maximum weight recorded by Grainger (1953) was 11.9 lbs. All these are higher than the maximum found by the author.

THE FOOD OF CHAR

The stomachs of 399 char from Nettilling Lake were examined in the field, the records show that 50.4 per cent (201 char) had food in the stomach or oesophagus. This estimate is probably too low since char were observed to regurgitate food under the stresses of capture and handling. Out of these 201 fish, 96.5 per cent (174) were feeding predominately on insect material; of the rest, the majority, 12.5 percent were feeding on fish, either young char or sticklebacks (*Gasterosteus aculatus* and *Pungitius pungitius*). The remainder were feeding on plankton, copepods mostly, or amphipods (*Gammarus lacustris*).

The insect material consisted for the most part of chironomids, all life stages were present in the stomachs but the majority were pupae. The taxonomy of the chironomids is under revision by D.R.Oliver and the stomach samples have not yet been identified. However, the following results based on bottom-fauna samples may well be applied to the chironomids in the stomach samples. "The chironomid larvae and a few pupae dominated the macroscopic bottom-fauna comprising 98 per cent of the total number .... Four sub-families, Daimesinae, Tanypodinae, Chironominae and Orthocladiinae are represented. The greater part of the chironomids collected belonged to the Orthocladiinae and the Diamesinae." (Oliver 1956) Adult chironomids, caddis flies and mosquitos were also present in the stomachs.

Nillsson (1954) reports that " feeding habits vary seasonally as well as annually." and that the bottom fauna is of little importance in the ice-free season. This was observed in the case of the Nettilling Lake char. At the beginning of the season, when the lake was still covered with ice, the char were feeding on larval insects and fish. With the onset of the emerging of chironomids, the dominant food changed to chironomid pupae. Only in late August were adult insects found in the stomachs. Later on in the year, plankton and fish reappeared in the diet. Nillsson also stated that 75 per cent of the char in Lake Korsvattnet, Sweden were feeding on insects, this agrees fairly closely with the results shown above for the Nettilling Lake char. Lindström (1954) discovered that the bulk of the food of char in Lake Ånn, Sweden was made up of Bosmina, gravid Daphnia, Bytotrephus and Holopedium. He suggested that the char "inhabit the top layers of the lake when feeding on plankton". Since the top layers of Nettilling Lake were not sampled by the nets (see above) these organisms were not found in the stomach samples. Retovsky (1935) reported chironomid larvae, gnats and flies from the stomachs of young char in Novaya Zemlya. Dunbar and Hildebrand (1952) report insect larvae, sticklebacks and young char from the stomachs on a population of char in fresh water in the area of Ungava Bay. Fabricius and Gustafson (1953) and Frost (1952) both state that the char is a major predator of the eggs of char, both of the loose eggs and of the redds themselves. It seems plausible to assume that the char would feed on small fish, bottom fauna, and eggs during the winter in Nettilling Lake.

THE COLOURATION OF CHAR

The colouration of the char has been used by many anthors in the past as a taxonomic feature. Otto Fabricius (1760) in "Fauna Groenlandica" separated Salmo carpio and S. alpinus on a colour basis. The former was described as having a dark green-blue back, with silvery sides and belly and spots white; the latter had a black back, blueish sides and a red-yellow belly. Fabricius himself doubted the validity of specific differentiation and suggested that the latter form was more heavily coloured because it spent more time in fresh water. Jensen (1948) comments that there can be little doubt that both forms are arctic char (Salvelinus alpinus) the one being in nuptial dress. Johansen (1912) also described two varieties from Greenland, one with the dorsum metallic green blue to greyish black with an even transition to silver on the sides, fading through lilac to white on the belly, the spots being yellow red; the second variety had an orange flank and belly. Johansen also comments that in the case of landlocked char the bright nuptial colouration is attained only at maturity and remains throughout life, the silvery stage being produced only in fish which have entered salt water. The following description by Dr. Vladykov was given to the author who translated it from the French. It is included here in its entirety.

Description of a male arctic char (Salvelinus alpinus) No. 3621R taken in Lake Ransareu, Sweden, by Dr. E. Fabricius. The description was made after the specimen had been in 5 per cent formalin for 20 months.

The Body: The body is deep and laterally flattened and has a deep green colouration on the back and sides. The spots are pale and more numerous below the lateral line. They have a variable diameter, but on the average they are about half the diameter of the eye (pupil). It is supposed that in life these spots have an orange colour. The sides, belly, and the isthmus at the base of the anal fin are yellow-orange without trace of spots or dark pigmentation.

The Head: The top and sides are dark with a few pale spots on the operculum. On the ventral side, the membrane and the branchiostegal rays are dark up to the chin. The sides of the mandible are touched with dark pigment posteriorly but remain uncoloured in front. The inside of the mouth has uncoloured membranes above and below, the palate, tongue, and two brachial arches being darkly pigmented. The interior of the maxillaries is rather dark.

The Fins: The dorsal and caudal fins are dark and have an orange border on the top and back. The pectoral fin is orange with dark pigment and has a yellowish margin. The inner side of the ventral fins is dark in the centre but a deep orange forms the anterior margin. This fin is probably entirely orange in life. There is a free lobe on the anterior margin which surpasses (in length) the rest of the fin. The anal fin is dark grey with a medium orange border in front and a deep orange border behind. The adipose fin is dark with a light centre. The apical appendage is short, stocky, and orange. (Vladykov, personal communication.)

The char of Nettilling Lake exhibited all varieties of colouration between the silvery stage and the intense orange-red. Figure 1 shows arctic char in two extremes of colouration. The upper char is 36 cms. in fork length, the lower 39.5 cms., both are female.

Field notes included descriptions of the colouration of the chars and from these the following points emerge. Approximately 70 per cent of the fish captured were placed in the silvery class. The rest showed some trace of orange, either on the belly, or on the ventral fins. As the colouration became righer, the contrast in the pelvic and anal fins became more pronounced. In the latter, the leading edge became a brilliant white with the body of the fin a deep orange scattered with black. The darkening became more pronounced towards the posterior edge. There was not always a definate correlation between the intensity of colouration and the condition of the gonads. Some of the most vivid fish were males whose testes were minute and dark. Likewise, a few females with few eggs, all small, showed intense colouring on the sides and belly. Conversly, mature fish with well developed ovaries and testes carried the silvery livery with only the faintest trace of orange. The colour of the back was quite variable ranging between olive green to deep blue-black. Most of the fish, however, could be described as dusky green, the "foncée" of Vladykov.

The presence of dark transverse bands along the flanks of small char was also noted. Jensen (1948) records this marking in small fish stating that they are distinct in char of 15 cms. length and can be traced more or less distinctly in fish of 24 cms. length. All char in Nettilling Lake smaller than 15 cms. possessed these marks, and they were found in fish up to 31 cms. in length, one of which had an age of 13 years. The number of bands, which were similar to the parr marks of salmon, varied between 10 and 11. One female, 23.5 cms. long and 10 years old, with well developed ovaries which seemed ready for spawning that year, showed these marks clearly.

The flesh colour of all Nettilling Lake char was red.

THE PARASITES OF CHAR

As the char were examined and measured, notes were taken on the condition of the viscera and on the presence of parasites. Representative samples of the parasites found were taken and preserved for future study. These specimens were given to Miss Betty June Myers of the Institute of Parasitology, MacDonald College, for identification and study. At the time of writing, complete identification of the parasites has not been possible. According to Miss Myers, there is a possibility of two new species being recorded from the char of Nettilling Lake.

Field records were confined for the most part to the presence or absence of parasites. Those recognized in the field were Copepods, Tapeworms, Nematodes, and the condition described as "Cysts". This latter condition was due to the presence of Diphyllobothrium type larvae, and will be discussed below.

The degree of infestation may be deduced from the following figures. Out of 399 char examined, 35.8 per cent (143) were parasitized. These parasitized fish may be divided as follows: 25.8 per cent (37) were infested with Copepods, 22.3 per cent (32) by Tapeworms and 10.4 per cent were parasitized by Nematodes (15 char) 67.5 per cent (97) were described as " cysted".

The copepods were found, without exception, in the buccal cavity, attached to the palate, and the sides of the tongue. The number present in a single individual varied from 1 to 6 ; they were all female with prominent egg cases. Miss Myers has been able to identify the copepods as belonging to the genus <u>Salmincola</u>, but specific identification has not yet been finished. A letter to D.E.Sergeant from Dr. G. Friend of Edinburgh mentions copepods of this genus parasitic on the char of Bear Island. The copepods on the gills were <u>S. alpina</u> while those in the mouth were <u>S. carpionis</u> . No copepods were observed on the gills of the char of Nettilling Lake.

Nematoda: these were observed free in the body cavity or lying coiled in cysts on the wall of the testis. Miss Myers has placed the nematodes collected in the genus <u>Philonema</u> until further examination can be made. The nematodes that were encysted may belong to a new species, if so an account will be published later. Andrews and Lear (1956) recorded the presence of <u>Philonema</u> sp. from the char of Labrador and gave the following description, " adult <u>Philonema</u> were taken from the body cavity only, but immature stages of roundworms were encysted in the liver, gonads, spleen, peritoneum, and viscera in general". The number of nematodes present in any one fish varied from 1 to 21 in a large, emaciated female.

Cestoda: Adult Tapeworms were found in the pyloric region, the scolex was attached to the inner wall of one of the pyloric caeaae, with the proglottids extending back into the intestine. In all cases the degree of infestation was heavy, the proglottid chains twisted about so as to block the whole intestine. Counts of over 100 tapeworms were made frequently. Miss Myers has placed the adults in the family *Bothriocephalidae* until further examination may be made. Wardle (1932) records the following cestodas from arctic char and related sub-species in the Hudson Bay drainage system: *Diplocotyle olrikii* (Krabb) and *Eubothrium crassum* from *Salvelinus alpinus marstoni* and *S. a. stagnalis*, *Eubothrium salvelini* from *Salvelinus alpinus malma*, and *Diphyllobothrium* larvae from all three. Andrews and Lear (1956) found that the char of Labrador were parasitized by *Eubothrium salvinale*, the degree of infestation was "heavy" and the percent infected varied from 40 to 97 for the various fishing ports. Dombroski (1955), working on a sample of over 3000 yearling sockeye salmon, discovered that cestode infection by *Eubothrium salvelini* had an inhibitory effect on growth. Vladykov (1956) has noted that the presence of plerocercoid cysts of Diphyllobothrium larvae retarded the maturation of speckled trout (*S. fontinalis*). The sample from Nettilling Lake was too small to permit similar studies and observations. One cestode specimen was found in the body of a 9 spined stickleback and was identified as Bothriocephalus clavipes (Goeze 1782) by Miss Myers. The condition referred to above as"cysted" is described below. The external wall of the stomach was covered by small white or yellow bumps, about 2 mm. in diameter. These bumps were not visible on the internal wall of the stomach. In cases where infestation was heavy, (100 plus) the visceral mass was stuck to the inner peritoneal lining and would not fall free when the fish was gutted as was the case in unparasitized fish. Miss Myers has identified the cysts as being due to the presence of Diphyllobothrium type larvae. Jensen (1948) quotes Paul Hansen as saying that some specimens of char from a Greenland lake, had small yellow tumours or "cysts" in the intestine. Martin (1955) records that the larger char from Ungava Crater were heavily parasitized by plerocercoid cysts of Diphyllobothridae.

Cysts found in the liver of two chars were found to contain parasites of the family Acanthocephala, but further identification has not been possible at the time of writing.

THE MATURITY OF CHAR

Field records of the condition of the gonads with reference to appearance, colour, and width in males, size of ovary and egg diameter in females, were kept. In addition 42 complete egg samples were preserved in 5 per cent formalin and brought back for further analysis.

Egg diameter in the field was measured to the nearest millimetre. In the laboratory, an eyepiece micrometer was used to measure 10 eggs, the mean was calculated and expressed in millimetres.

Egg counts in the laboratory were done using a volumetric method after the technique of Vladykov and Legendre (1940). The two ovaries were dried superficially and immersed in a graduated cylinder, the displacement was then measured to the nearest cubic centimetre (small samples to the nearest half centimetre). A sample approximating 10 per cent of the total volume was taken and all the eggs counted,(in no case was the sample less than 2 ccs.). No correction was made for ovarian tissue since the sample would also contain connective tissue in a proportionate ammount. Total counts were made on 5 samples to check the method, the results showed a maximum error of 1.1 percent.

Some of the terminology used could bear definition. Maturity, strictly an irreversible process, has in the following sections, been used to indicate only those fish which would spawn that year. Immature and unripe fish are thus classed together. It may be questionable to consider a large fish with unripe gonads as immature, but the author is not aware of any sure method of determining if a fish has already spawned one or more times before capture.

MALES

Males were considered to be ripening when the testes were white in colour and more than 5 - 7 mms. wide, depending on the length of the fish. Testes that were dark, liver-coloured, were considered as inactive. This category included immature fish and large males that looked "spent" and which did not seem to be preparing to spawn that year. This division is, of course, highly subjective. No males with running milt were observed nor could any milt be expressed from the testes without first rupturing the whole organ. It is therefore suggested that the male char of Nettilling Lake were not ready to spawn by early September.

The number of males maturing at any age is expressed as a percentage of the total number of males in that age group. This is shown in Figure 16. In order to use the complete sample as well as the aged fish the following treatment was used; the male char were grouped into classes of 5 cms. fork length and the number of maturing males was again expressed as a percentage of the total number in each group. The age groups have been scaled to agree with the mean length of each group as shown in Figure 9; the above work is also shown in Figure 16.

These figures show that, at age 7, half the males show signs of maturity. With regard to length, at 25 cms. one quarter of the males taken showed similar signs. The presence of non-maturing or inactive males throughout the length range suggests that all the males do not mature every year. Although all males at age 21 were maturing, this is based on 2 char and should not be regarded as typical.

Little mention of the maturity of the male alone is present in the literature, there are no references to figures or standards for comparison. A general comparison of age and length at maturity, of char, is included below.

FEMALES

Field observations substantiated the findings of earlier authors, (Grainger 1953, Hickling and Rutenberg 1936, Vladykov 1956) with regard to eggs of different sizes in the ovaries. Earlier writers, noting that the

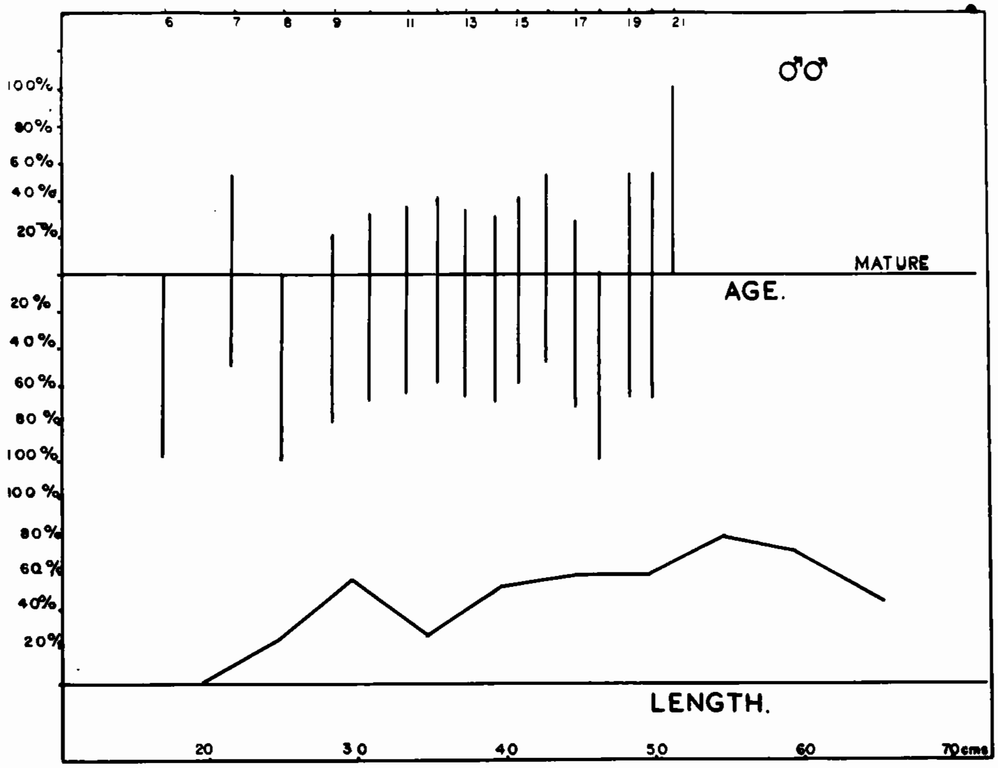


FIG. 16. PERCENT OF MALES MATURING AT ANY LENGTH OR AGE.

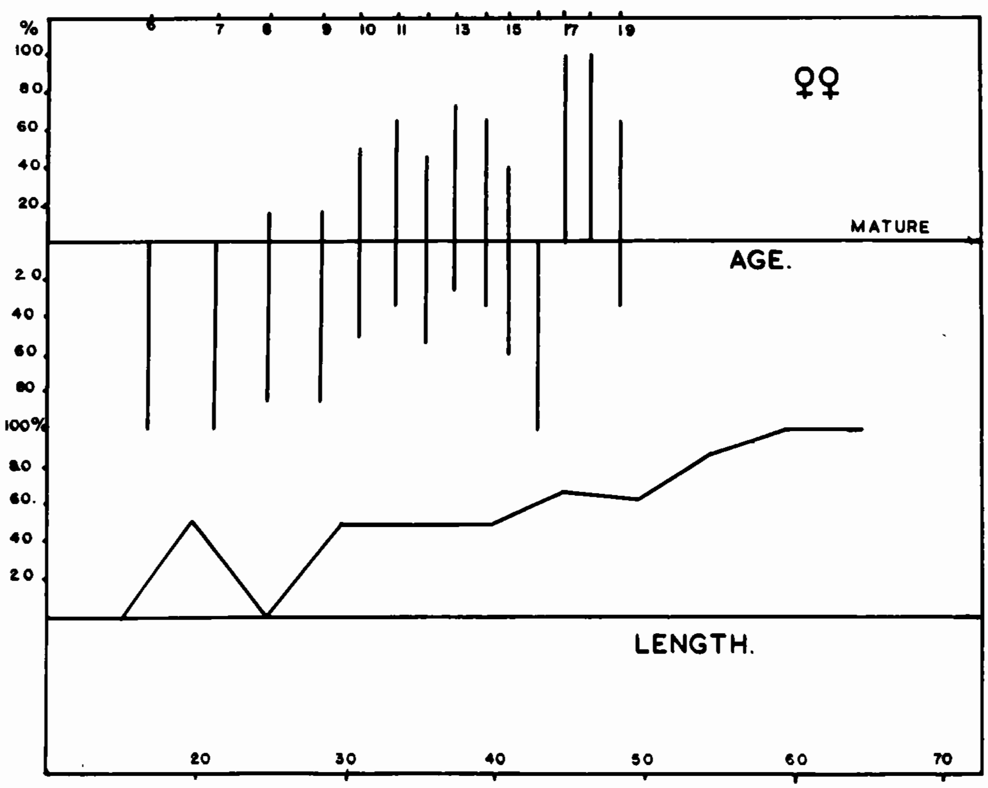


FIG 17 PERCENT OF FEMALES MATURING AT ANY LENGTH OR AGE

eggs of fish preparing to spawn,fell into two sizes, described one group as large, yellow and yolky and termed these maturing, the others were small, white, and non-maturing. Vladykov (1956) has further divided the eggs of adult speckled trout (S. fontinalis) into three classes. The first, referred to as class A, were small eggs, white with no yolk, these were considered as recruitment stock. Class B was composed of maturing eggs,large yellow and yolky, these were the eggs that would be shed at spawning. Class C was derived from class B and was composed of atretic eggs, white and irregular in outline. According to Vladykov, " in the process of maturing,the number of eggs in class B progressivly decreases due to atresia but their diameter becomes greater." This work has raised doubts concerning the validity of the term "fecundity" when it refers to the number of maturing eggs; since this is now considered as a function of time, egg counts should only be made on the ovaries of fish that are ready to spawn. The egg samples taken from the Nettilling Lake char cover the summer, and include maturing and non-maturing eggs, therefore no estimate of fecundity will be given.

Måår (1950) produced a relationship between fork length and size of egg at maturity. Grainger (1953) and Vladykov (1956) have noted this for the case of the arctic char and speckled trout respectively. Again the data collected by the author do not permit such a conclusion. Egg samples taken from large fish early in the season yield egg diameters that are far too small. It is however a safe assumption that during the season such eggs would have increased in size sufficiently to come into line.

Table 10 records the fork length and weight of char, the volume of the ovaries and the number and diameter of the eggs. In cases where they were present only maturing eggs were counted and measured, in other cases where there was no differentiation in size of egg, all eggs were counted. The dates are given in two week periods starting with the first of July.

Table 10. RESULTS OF EGG COUNTS

Date	Fork L.		Weight		Volume of Ovaries		Diameter of Eggs		No. of Eggs
July 1-15	33.5	cms.	11	oz.	4.0	ccs.	0.9	mms.	2731
	34.0	"	10	"	1.5	"	0.8	"	1992
	35.5	"	12	"	2.0	"	0.9	"	2037
	36.0	"	11	"	2.8	"	1.0	"	3136
	36.0	"	12	"	7.0	"	3.5	"	369
	36.5	"	12	"	10.0	"	3.0	"	990
	39.5	"	15	"	4.0	"	1.5	"	2564
	44.0	"	21	"	5.0	"	1.83	"	1090
	45.0	"	26	"	9.0	"	1.0	"	2492
	50.0	"	31	"	10.0	"	1.0	"	2701
	55.5	"	54	"	28.0	"	2.0	"	2582
	61.5	"	80	"	58.5	"	3.03	"	3931
	63.0	"	64	"	88.0	"	3.24	"	3630
	64.0	"	72	"	37.0	"	2.16	"	3189
July 16-31	22.0	"	3.25	"	0.75	"	0.75	"	2735
	31.5	"	9	"	1.25	"	1.0	"	1764
	31.5	"	7.5	"	5.0	"	2.16	"	545
	32.0	"	9	"	6.0	"	1.68	"	2560
	32.0	"	10	"	8.5	"	3.00	"	561
	32.5	"	9	"	4.0	"	1.4	"	2122
	33.0	"	10	"	9.0	"	3.0	"	360
	33.0	"	11	"	0.9	"	0.6	"	2764
	33.5	"	11	"	1.7	"	1.0	"	1833
	33.5	"	10	"	3.6	"	1.65	"	1606
	34.0	"	10	"	22.0	"	3.64	"	898
	34.0	"	11	"	17.0	"	3.5	"	635
	34.0	"	10	"	1.5	"	0.8	"	1992
	34.5	"	12	"	7.0	"	3.0	"	441
	35.0	"	11	"	1.3	"	0.8	"	2972
	35.0	"	11	"	5.0	"	2.16	"	505
	35.0	"	12	"	15.0	"	2.83	"	2245
	35.5	"	13	"	1.95	"	0.92	"	2055
	36.0	"	11.5	"	4.7	"	1.3	"	1429
	36.0	"	14	"	2.1	"	1.5	"	2740
	37.5	"	15	"	18.5	"	4.00	"	787
	38.5	"	17	"	1.3	"	0.7	"	1968
	40.0	"	18	"	3.2	"	1.05	"	1929
	53.0	"	40	"	9.0	"	2.0	"	1421
Aug. 1-15									
Aug. 16-31	18.0	"	2.25	"	6.0	"	3.33	"	281
	35.5	"	14	"	31.0	"	3.66	"	1135
	37.0	"	16	"	6.5	"	1.02	"	702
	51.0	"	25	"	11.5	"	1.32	"	3335
Sept. 1-15	33.5	"	13	"	34.0	"	3.76	"	1156

A subjective criterion of maturity was developed based on egg size. Grainger (1953) suggests that for the Sylvia Grinnell char, all eggs over 2.5 mm. in diameter are maturing. Vladykov (1956) for the speckled trout, places this figure lower, about 1.1 mm. For the Nettilling Lake char, the level was set at 2.- 2.5 mm. depending on the date and length of the individual. In general all fish whose ovaries showed a clear division of eggs into two size groups were considered to be maturing, and to be ready to spawn that fall. On this basis the number of fish maturing or ripening in any age group were expressed as a percentage of the total number in that group. In order to use the total sample, the fish were grouped into classes of 5 cms. fork length, and the number of maturing females expressed as a percentage. As in the case of the males the age groups were scaled to correspond with the mean lengths of each group as shown in Figure 9. These percentages are shown in Figure 17.

The youngest fish with mature eggs was eight years old and the smallest was in the 20 - 24.5 cms. length group. The figures indicate that the char of Nettilling Lake do not spawn every year. This is in accordance with the findings of Grainger (1953), Fabricius (1954), and Sprules (1952).

Dunbar and Hildebrand (1952) state that anadromous char of Ungava spawn at a size of 25 - 50 cms. Grainger (1953) records 45 cms. as the minimal length in mature females and 10 winters as the minimal age (1 specimen) with 12 winters being more common from Frobisher Bay. This figure is higher than that of the Svalbard char, since Dahl (1926) records mature females as low as 36 cms. fork length and as young as five winters. Hudson Bay anadromous char mature at 48 cms. and nine years according to Sprules (1952). Yessipov (1935) states that the char of Novaya Zemlya reach maturity at an age of six to seven years. Char in the George River matured at a length of 37.5 cms. and as early as seven winters (Grainger 1953). These reports indicate that the char of Nettilling Lake spawn for the first time at an earlier age than most, and at a smaller size than any of the anadromous populations.

Many workers have noted the precociousness of land-locked forms of char. Vladykov (1933) reported mature landlocked char from western Hudson Bay as small as 10.5 cms. in length. Sprules (1952) found two 2 year-old char in Littlefish Lake on the west coast of Hudson Bay that appeared ready to spawn. The mean fork length of these fish was 16.5 cms. Dunbar and Hildebrand (1952) report mature males at 8 cms. in length, and maturing females at 6.5 - 9.5 cms.

In these females the egg count is typically low, varying from 17 - 24 eggs. Martin (1955), in an examination of the char of the Ungava Crater, found that they matured at an age of two years and a length of four inches (10.16 cms.). He notes that the char of this area do not spawn every year. Fabricius (1952) records the fact that char from the mountain lakes of Jämtlandt in Sweden usually reach sexual maturity at an age of three to five years. It is to be noted that landlocked char reach maturity at a younger age and a smaller size than do the char of Nettilling Lake. This point is discussed below.

There is no information on the time of spawning of the Nettilling Lake char. Since various workers have suggested that the char spawn in the late fall in other areas, it may be inferred that the char of Nettilling Lake also spawn at the same time.

The largest eggs obtained from the Nettilling Lake char measured 6.5 mm. in diameter. These were found in two females captured on August 26 at the head of the Koukdjuak River. The eggs were found free in the body cavity and were white with a yellow pole. They were few in number (27 in one, 43 in the other). The condition of the fish was poor, the head being large, the body long and emaciated, and the weight well below the mean for their length. Vladykov (1956) has suggested that mature eggs may remain in the body cavity for 10 - 11 months. It is suggested that these eggs were remnants from the previous winter's spawning. If this is so, it lends support to the idea that char do not spawn every year or even every second year. In this instance the fish had minute ovaries, with eggs less than 1 mm. in diameter. The ovaries seemed less mature than those in which no differentiation as to size had taken place, such as in fish which presumably would be ready to spawn the following winter, ie. 1957. In accordance with these findings, several large males were captured late in July with minute testes, mostly blood vessels and fluid, dark and liver-coloured. These males, averaging 52 cms. in length, had smaller testes than unmature specimens of 18 - 20 cms. in length.

MERISTIC MEASUREMENTS

Vladykov (1954) gives a list of 16 measurements which he found useful for separating the species of char. Following his advice, the author measured 240 char from Nettilling Lake according to this plan.

The analysis of the variance of the data has proved to be far too complex for the author to attempt in this work. The variation between individuals is immense although the mean values show the same trend of growth in all fish. There was no significant difference between fish from the north and south ends of the Lake. The range of the various measurements may be seen below. These were taken from seven char, all of the same fork length, 37.0 cms.

Total length: snout to line through posterior tips of caudal fin	38.5 - 39.5 cms.
Head length: snout to posterior edge of bone of gill cover	6.9 - 8.0 "
Maxilla length:	2.5 - 3.2 "
Snout length: to anterior margin of orbit	3.0 - 3.6 "
Postorbital head length: posterior margin of orbit to last bone of gill cover	3.1 - 3.7 "
Interorbital head width: between dorsal orbit margins	2.2 - 2.4 "
Snout to insertion of Pelvic fin:	16.5 - 18.0 "
Snout to insertion of Dorsal fin:	10.0 - 16.0 "

Insertion of Pectoral to insertion of Pelvic fin:	10.0 - 12.2 cms.
Insertion of Pelvic to insertion of Anal fin:	6.7 - 8.9 "
Length of Pectoral fin:	4.8 - 5.5 "
Length of Pelvic fin:	3.8 - 4.7 "
Length of Caudal Peduncle: along lateral line from insertion of anal fin to last scales:	9.8 - 11.2 "
Maximum depth of body:	5.1 - 6.8 "
Fork indentation: Total length minus Fork length:	1.5 - 2.5 "
Length of apical appendage:	1.4 - 1.9 "
Number of Pyloric Caecae:	31 - 37

The average number of Pyloric Caecae of 220 char was 37.9 as compared with 39.1 (Vladykov 1954). The growth of the maxilla differs in the sexes, males of a given length (longer than 34.0 cms.) having a longer maxilla than females of the same length. The value of meristic measurements is open to question, especially in the case of char where a wide variation is typical. For example the variation in Head length, with respect to Total length is shown in Figure 18. The dots represent the values found for individual fish.

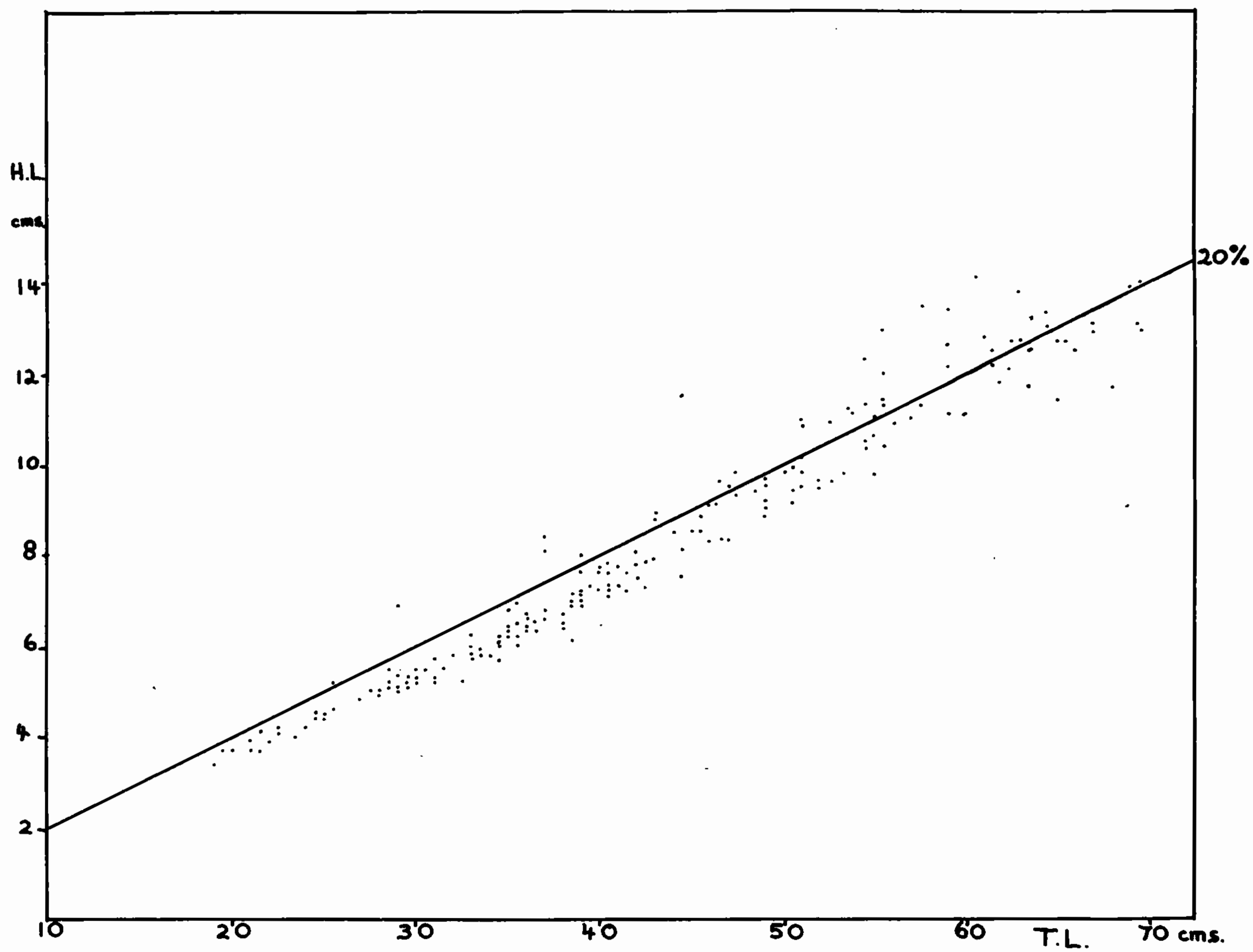


FIG. 18. HEAD LENGTH TO TOTAL LENGTH.

POINTS ARE INDIVIDUAL CHAR. LINE REPRESENTS 1. TO 5. RATIO. SEE TEXT.

DISCUSSION

Throughout this work one main question has been left untouched; are the char of Nettilling Lake landlocked or anadromous. This question cannot be answered with certainty, but some suggestions referring to this matter are presented below. The data in this work supports both views equally, but the evidence is not conclusive for either one side or the other.

Those facts which suggest a landlocked population within the lake are as follows. The primary point is the existence of char in the lake. Manning (1942, 1943) reported large schools of char congregating off the mouths of rivers draining into Foxe Basin late in July and early in August. He suggests that the up-stream migration does not begin till mid-August, reaching a peak towards the end of the month. This is a little later than the times recorded for the Sylvia Grinnell char, late July (Grainger 1953b); or for the Greenland char, late July with the peak in August or September (Jensen 1904, 1925, 1948); but the time of breakup is usually late in Foxe Basin. However Table 1 shows that over 170 char were captured before the end of July and from areas at least 85 miles from the sea. All authors agree that the time of the seaward migration is early spring, even before the lakes are free of ice.

The comparison of the growth rates also tends to support the case for a landlocked population. The growth rate of the Nettilling Lake char is lower than that reported for all anadromous populations. This is particularly true with respect to weight. There is a very close resemblance in age-weight relationships between the landlocked char of Hudson Bay and those of Nettilling. While the char of Nettilling Lake do not show the rapid growth characteristic of the char of Swedish lakes (Runnström 1951, Nillsson 1954), this is, no doubt, due to the lower temperatures and shorter ice-free season encountered in the North. Brown (1946) and Miller (1947) have studied the effects of temperature on the growth of such forms as the Brown Trout (Salmo trutta) and Lake Trout (Cristovomer - (Salvelinus) namaycush) and have demonstrated the retarding effect of low tempererratures on growth and development. Miller (1947), in particular, found no evidence of adaptation in C. (S.) namaycush, the only Salvelinid studied, as was found in the pike, Esox lucius. The work of Wilder (1952) on the brook trout Salvelinus fontinalis shows a significant difference in the weight-length regression lines plotted for landlocked and anadromous populations; these differences were most marked in the slope of the line as is the case in Figure 14 where the char of Nettilling Lake are compared with populations in other areas. The fact, noted above, that the char of Nettilling Lake do not approach the maximal values recorded by other authors for length, weight, or age lends support to this argument. Since the time of Otto Fabricius (1780) authors have commented on the bright livery worn by landlocked chars in and out of the breeding season. Furthermore, most authors consider late fall as the probable breeding time of the char (Grainger 1953); save Weed (1934) who found char in the sea in July ready to spawn. Therefore, the finding of brightly hued char throughout the season in all stages of ripeness in Nettilling Lake also supports the landlocked population theory. Unfortunately, colouration is a double-edged sword in this argument as will be demonstrated below. The identification of parasites can lend little help one way or the other. The absence of sea lice such as are found on other Salmonoids, for example Lepeophtheirus, cannot be counted as proof. The time required to ascend the Koukdjuak River would also be time enough to kill and remove such forms (Cameron 1956). A comparison of minimum size and age of maturity has already been made above. This showed that the char of Nettilling Lake attained maturity at an earlier age than most, and a smaller size than any other anadromous population. It is true that they did not show the precociousness commonly associated with landlocked forms but this early maturity and reduced egg count are not necessarily a criterion of landlocked char. Nillsson (1954) records two populations in Lake Korsvattnet, Sweden, one of which was "dwarf" while the other was similar to char in other Swedish lakes. Frost (1951) has reported the same state of affairs in Lake Windermere where she has found three populations of landlocked char, Salvelinus alpinus willoughbii (Günther). One of these populations is typically "dwarf", while the other two are similar to other British chars and differ between themselves in time of spawning and in the pattern of the gill rakers. These latter populations do not exhibit the precociousness of the former (Frost, personal communication). McLaren (verbal communication) has mentioned a similar state of affairs in the Cape Dorset area, Baffin Island, where the Eskimos have different names for the two varieties encountered in the lakes. Günther (1877) found two varieties of char in the lakes of northern Ellesmere Island, one of which was mature at 20 cms., the other at 30 cms. length. Unfortunately, no ages were recorded, but the lengths are within the range found for the Nettilling Lake char.

As can be readily appreciated, many of these arguments are double-edged and can be applied in both directions. While the presence of char in the lake in late June cannot be denied, there is no barrier to prevent them from making a migration to and from the sea. Soper (1928) reported that the Koukdjuak River was smooth at the head, but that there were rapids further downstream. Aerial photographs do not reveal the presence of any falls or serious obstacles to impede the progress of the char. Distance, the other limiting factor, cannot apply in this case for Wynne-Edwards (1952) reports char running 100 miles upstream in the Thelon River, Keewatin. The comparison of the growth rates shows that the form of growth is very similar to that found by Grainger (1953) for an undoubted sea run population. Furthermore, the char from Rowley Island do not differ significantly in average length from the char of Nettilling Lake. These char were caught in the sea, in the area where char, born in Nettilling Lake, might be expected to live, during the summer growing season. The value of arguments based on maturity have already been assessed above. Colouration can also be used to support this side of the picture. The presence of large numbers of char in the silvery dress shown in Figure 1 would seem to require the entry of anadromous char into the lake. Johansen (1912) states categorically "where this (migration to the sea) does not occur, the fish can hardly assume the pale silvery dress at any time but retain throughout the year the blackish-green or orange-red dress." There remains only the work of Jensen (1948) who recorded a difference in the proportions of char from fresh and salt water. Quoting Otto Fabricius, Jensen states that the landlocked char of Greenland are characterized by larger heads than the salt water forms. The head length in landlocked varieties "is contained only four and two-thirds (times) in the total length, measured from snout to a line drawn (perpendicular to the lateral line) between the tips of the caudal fin; while the length of the head in migrating specimens is contained five to five and a half times in the total length." Figure 18 shows the relationship between the head length and the total length for the Nettilling Lake char. The line drawn represents the one to five ratio mentioned above. If the work mentioned above is valid, the char (represented by dots) below the line are all sea-run while those above the line are landlocked. Thus the graph would seem to indicate a division of the population, but the author feels that all it does show is the wide variation between individuals.

Recent reports from year-round residents in the Arctic, unfortunately all hearsay, may indicate the solution to the problem. These reports state that char can be found at any time of the year in lakes, such as

Hall Lake in Keewatin, which support an anadromous spawning population in the winter. The number available varies, but it seems that not all char perform a seaward migration after spawning, even though there is no barrier to stop them. Since most workers and fishermen, including the author, set their nets in areas where there are fish to be caught, these small residual or "resting" populations may have been overlooked. If these reports are true, this idea would explain much of the problem; the presence of "spent" fish, in red colouration, in the lake in early July and August, for instance. The author feels that, if char have been caught in Hall Lake all year round, then char might well remain in Nettilling Lake as well. If this is the case, the vast area of the lake, which has only weak and diffuse currents in some areas and the amount of food available in the form of insects and small fish, might easily support a considerable population of char throughout the summer. These summers spent in the lake where the food, though adequate, is not as rich as in the sea, would serve to decrease the mean length and weight of the older age classes. Furthermore, since Nettilling Lake is larger than the lakes on the Sylvia Grinnell River, or on the rivers draining Greenland, Hudson Bay, Svalbard, etc., it would be expected to have a greater residual population thus having a greater dampening effect on the average growth of the population than that exerted by smaller lakes.

This suggestion raises another point that has more authority in the published literature. The work of Frost (1951) and Nillsson (1951) has already been mentioned with respect to separate populations within a lake. Alm (1951) and Lindström (1954) have studied the non-reproductive migrations of the char in Lake Vattern, Sweden. Their results, based on tagged-char returns, show a strong schooling tendency and a separation of the population into groups. These schools are separated by their choice of breeding grounds, and they preserve their identity throughout the year returning to their natal ground in the fall. This schooling habit may also be seen in anadromous forms; Yessipov (1935) comments that mature and immature fish perform the same spawning migration together simply to preserve the school. Frost (1954) has suggested the existence of morphological differences between groups or schools, and has found one such difference in Lake Windermere. This has led the author to try and find some difference within the sample from Nettilling Lake. Separating the char from north and south areas of the Lake, and comparing the meristic measurements did not show any difference or trend worthy of comment. A more satisfactory result was obtained by separating 70 char caught at the head of the Koukdjuak River from the total sample and recalculating the average length of each year class in each group. Not only did the "river" char have a longer mean length in each age group, they were longer than the average length based on the total population. The same was true with respect to weight. However, the smallness of the sample and the wide variation defeated the method and no significant statistical difference could be shown. There was, however, a definite trend, and a larger sample might have proved the point.

It does seem plausible that there should be different populations within a body of water as large as Nettilling Lake. If such a separation of char can be presumed to exist, then it is an easy step to assume that one of the populations may be landlocked. At this point, the old complaint must be restated, it needs more work on a much larger sample before such presumptions may be made with any real confidence. However, such a mixture of populations could account for the depression of the mean length shown in Figure 12, especially since the other populations were migrating char and thus presumably a single group.

SUMMARY

1) A brief introduction to the history of research on the arctic char, *Salvelinus alpinus* (L.), is given; the keys are reviewed and the present state of the taxonomy stated.

2) A description of the area, Nettilling Lake, and a short summary of the results of the 1956 field party are given.

3) The source, size, and length frequency of the sample are given, the collecting methods noted, and the method of age determination recorded.

4) The growth rate with respect to length and weight is compared with the rates determined for other populations. Nettilling Lake char are found to grow at a lower rate than any anadromous population; reasons for this are discussed.

5) Notes are presented concerning the Food, Colouration, Parasites, Meristic Measurements, and Maturity of the char of Nettilling Lake. There is a comparison of minimum age and length at which maturity is reached in different populations.

6) The type of population, anadromous or landlocked, is discussed. The question of separate populations within the sample is commented upon. The author's opinion that the char of Nettilling Lake represent a mixed population is presented, with a discussion of the arguments for and against such an opinion.

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