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CONTRIBUTIONS TO THE BIOLOGY OF THE SALMONIDAE IN GREENLAND I–IV

BY

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WITH 28 FIGURES IN THE TEXT AND 1 PLATE

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INTRODUCTION

Only two species of the family *Salmonidae* occur in Greenland: the Atlantic salmon, *Salmo salar* L., and the char, *Salvelinus alpinus* (L). The present work, carried out at the instance of the Greenland Fisheries Investigations, is a contribution to the elucidation of some aspects of the biology of these two species. Dr. PAUL HANSEN started investigations on the Greenland salmon and char in the 1930's, and he has previously published some preliminary results (PAUL HANSEN 1940). On my engagement with the institution in 1952, I took over the continuation of these investigations.

During the study of these two species of fish in Greenland it has unfortunately been possible to a slight extent only to carry out the investigations along lines planned beforehand, or to work purposefully towards the solution of certain problems. This was simply prevented by the difficult natural conditions prevailing in Greenland. Similarly, owing to the inconsiderable economic importance of the Greenland *Salmonidae*, the time and means that can be spent on the study of these fish are naturally very limited, in particular as compared with the time and means spent on this purpose in other countries. Hence, collections and investigations have had to be made rather at random when time and opportunity offered. From these scattered collections and investigations I have then had to try to make the inferences which the character of the material permitted. It has therefore been impossible in the present work to solve the particular problems as satisfying and exactly as might be desired. Still I considered it of interest to publish these sporadic contributions, which are expected to be followed by others. The biology of the char has previously been only sparsely investigated; and the salmon is found in Greenland near the northern limit of its range, so the distribution and biology of the salmon within this area may be of special interest. The present four papers are independent of one another, but for practical reasons they are gathered into one common publication.

During my work I have received useful information and valuable help from many Greenlanders and Danes in Greenland, to all of whom I owe a great debt of gratitude. Of persons in Greenland from whom I received particularly valuable help, there is special reason to mention

the leader of the laboratory at Godthåb Mr. JENS KREUTZMANN, and the Greenlandic author and painter Mr. JENS ROSING. To the staff of the Greenland Fisheries Investigations I am indebted for assistance in the collecting and working up of the material, and to Dr. phil. ERIK SMIDT, for valuable help in reading through the manuscript. My special thanks are due to the leader of the institution, Dr. phil. PAUL HANSEN, who entrusted me with the task, and who, besides readely providing means and personnel for the work, always willingly placed his great experience and personal assistance at my disposal.

Finally, I thank Mr. E. LEENDERS for drawing of the figures 12, 13, 16 and 23, and Miss E. GLEERUP for the translation of the manuscript into English.

I.

DISTRIBUTION OF THE SALMON (SALMO SALAR L.) IN GREENLAND

Natural Distribution.

In Greenland the Atlantic salmon *(Salmo salar L.)* is found near the northern limit of its range. Owing to the special biological interest that is associated with the occurrence of the salmon in such a boundary area, more comprehensive investigations on its distribution and mode of living have in recent years been carried out by the Greenland Fisheries Investigations.

The salmon is called "kapisilik" (plural "kapisigdlit") by the Greenlanders, while the Danes in Greenland call it "Skællaks" (scale salmon) owing to its bigger scales as compared with the char, *Salvelinus alpinus* (L.), which colloquially is called "salmon" in Greenland.

The salmon was already mentioned by FABRICIUS (1780), who, however, did not see it himself. He records it as rare in Greenland, and states that it occurs at Tunugdliarfik and in a bay near Godthåb, which bay is probably identical with Kapisigdlit.

ADOLF JENSEN (1948) gives the following localities for salmon: Kapisigdlit (Godthåb district), Sarfánguaq (Holsteinsborg district), and in the autumn various places along the shore: Tasermiut fjord and Lichtenau (Nanortalik district), Julianehåb (Julianehåb district), Fiskenæsset (Godthåb district), Ikerasak, Napassoq with nearby fjords, and Agpamiut (Sukkertoppen district).

PAUL HANSEN (1940) states that at the end of the 1930's salmon would seem to be more frequent than before, and says that in 1935 and 1936 it occurred in fairly large numbers both in the Julianehåb, Godthåb, and Sukkertoppen districts. Further, PAUL HANSEN (1953) says that in 1951 a salmon was taken in the stomach of a Greenland shark *(Somniosus microcephalus* SCHNEIDER*)* in Umanak Fjord, the northernmost place in which salmon have been observed. The shark must have swallowed the salmon immediately before, for the salmon was so fresh that the Greenlander who captured the shark could eat the salmon.

From the most recent years a good deal of additional information on the occurrence of salmon in Greenland has been reported. Spawning salmon are only known with certainty from Kapisigdlit river at the

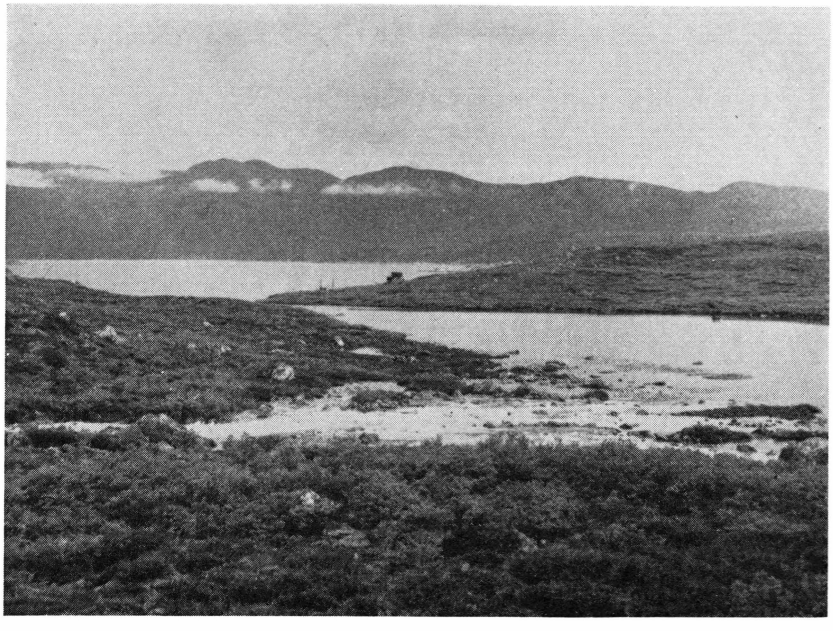

Fig. 1. Kapisigdlit river, lowermost lake.

inner part of Godthåb Fjord (64°26′ N. lat., 50°12′ W. long.) (figs. 1 and 2). Here salmon fishery has been carried out as far back as the memory of now-liwing Greenlanders goes. In 1926 the two Austrian zoologists STEINBÖCK and REISINGER captured two specimens of Salmo salar in the parr stage in Kapisigdlit river, and thus demonstrated that the salmon spawns in this river system (ADOLF JENSEN 1948). Subsequently, in 1938 and in the years from 1952 onwards, the Greenland Fisheries Investigations have captured parr and smolt in large numbers in the same river system. Similarly, the redds of the salmon were found in 1953, and since then have been counted every year in certain areas.

Salmon are not positively known to spawn in other rivers in Greenland, but on two occasions the Greenland Fisheries Investigations have captured salmon in fresh water, which might indicate that salmon may exceptionally spawn in other Greenland rivers also. Thus, on August 31, 1938, an adult salmon was taken in Kûgssuaq river in Tasermiut fjord (Nanortalik district). More detailed information on the state of maturity of the fish is not at hand. In the same river, a few salmon have occasionally been caught by Greenland fishermen. On June 25, 1953, four adult salmon were taken in the lower course of the small Isersiutigdlit river, not very rich in water, in Godthåb Fjord. Two of these were very lean kelts with a coefficient of condition $\left(= \frac{100 \times \text{gram}}{\text{cm}^3}\right)$ of 0.47 and 0.55. (cm = total length in centimetres).

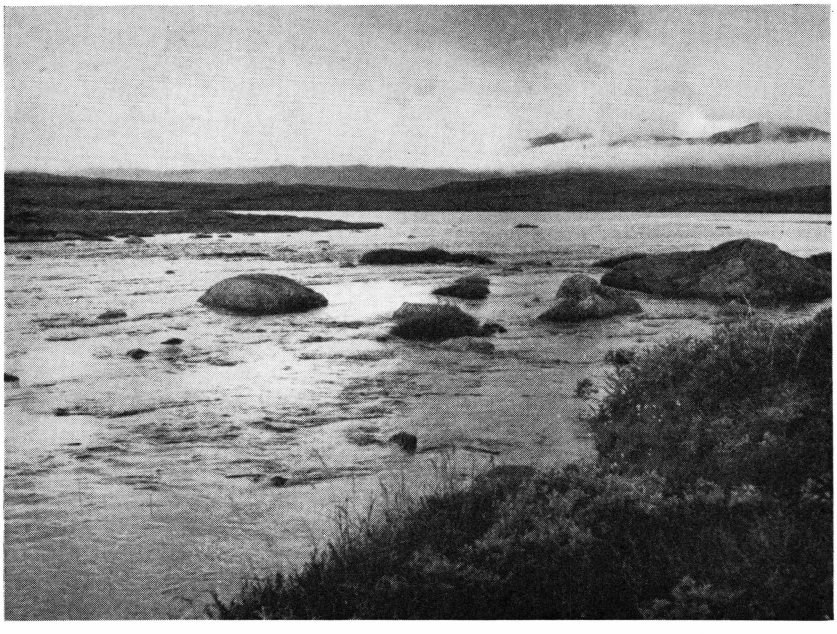

Fig. 2. Kapisigdlit, River III. Spawning ground for salmon.

Both fishes were males, measuring 58 and 59 cm. The other two specimens, a male and a female, were in a good condition and very near spawning. The spawn flowed out of the female when it was taken out of the water. These two specimens were 57 cm (♂) and 71 cm (♀) long, respectively. Greenland salmon fishermen report that they now and then capture salmon near this river and in the lake through which it flows. On repeated electrofishing in the same river, however, I have never caught fry or parr of salmon, only of char.

Greenland fishermen have supplied a great many particulars about the occurrence of salmon—and also of the capture of salmon in or near rivers in the summer. In several of these rivers no salmon, neither adults nor fry or parr, have been caught by electrofishing. Whether salmon normally spawn in other Greenland rivers than Kapisigdlit river, it is difficult to decide with certainty owing to the immense extension of the country and its many rarely visited rivers. It seems little probable, however, that salmon should occur commonly and in fairly large numbers in any Greenland river without this becoming known, in the course of time, to Greenland salmon fishermen and reindeer hunters. In the map, fig. 3, the localities are indicated in which members of the staff of the Greenland Fisheries Investigations have observed or caught salmon, or whence information of captures of salmon has been supplied by persons known by the staff of the Greenland Fisheries Investigations, and whose statements must be regarded as reliable.

Along the west coast of Greenland salmon are rather commonly met with in certain places, especially in the autumn months October—December. In the Nanortalik, Julianehåb, Frederikshåb, Sukkertoppen, and Holsteinsborg districts these salmon have been taken in nets, and similarly, salmon have occasionally been taken in pound nets for cod in the Julianehåb and Frederikshåb districts. From the map in fig. 3 it will be seen where in Greenland salmon have been caught fairly regularly. Fishery of any importance of these salmon is now only carried out in the Sukkertoppen district around the village of Napassoq. Still, in the autumn of 1958 about 500 salmon were taken at the village of Arsuk in the Frederikshåb district, where salmon had not been caught before. Evidently salmon were of more common occurrence along the shores in 1958 than in any previous year. This applies, at any rate, to the Julianehåb and Frederikshåb districts. The Faroese trawlers, however, made no great catches of salmon on the banks in 1958 (see below).

Since 1953 the Greenland Fisheries Investigations have examined samples of scales derived from catches at Napassoq, and it has been demonstrated (JØRGEN NIELSEN 1955 and 1956b) that these salmon hardly, or at any rate hardly exclusively, originate from rivers in Greenland, as the duration of their river-life as parr is much shorter than has been ascertained for the Kapisigdlit salmon or might altogether be expected for salmon from Greenland rivers. Their growth likewise differs from that of the Kapisigdlit salmon. A recapture of a tagged salmon from 1956 would seem to confirm this assumption. At Eqaluk south of Sukkertoppen (64°56′30" N., 52°02′ W.) a salmon of a length of 80 cm was captured on October 15, 1956, it was tagged on November 23, 1955, after stripping in a hatchery and subsequent setting out into Loch na Croic, Blackwater River, Conon District, Ross-shire, Scotland. The distance covered was about 2,800 km, which is one of the longest migrations of salmon ever observed (MENZIES and SHEARER 1957). Thus, as mentioned above, the salmon met with in many places along the coasts of Greenland and on the banks in Davisstrædet (cf. below) in the autumn months are hardly derived from Greenland populations, but should probably be regarded as vagrants from the presumed feeding ground of Scottish and possibly other North European salmon in the North Atlantic near southern Greenland[1]).

[1]) After the completion of the manuscript for the present paper a report was received, stating that a salmon tagged in the estuary of the Miramichi River, New Brunswick, Canada (47°04′N., 65°28′W.) on May 22, 1959, was recaptured at Tasiussaq, Napassoq, south of Sukkertoppen (65°06′ N., 52°08′ W.) on October 10, 1960. The salmon was tagged as a smolt 17.5 cm long and when recaptured had a length of 71 cm. This recapture shows that salmon from both sides of the Atlantic may, during their sea-life, meet in Greenland waters.



Fig. 3. Distribution of salmon in Greenland. Closed circles indicates localities in which capture of salmon frequently takes place.

That fish of the Kapisigdlit population may also be met with among these coast salmon, is shown by the recapture of a salmon tagged in the parr stage (14 cm long, age 3+) in Kapisigdlit river on July 30, 1956, and recaptured at Taserdluk east of Sukkertoppen (65°30′ N., 52°36′ W.) on August 4, 1958. The salmon was then 47 cm long and had covered a distance of about 280 km from the tagging place. This salmon had probably migrated to the sea as a 4-year-old smolt in the summer of 1957.

French, Icelandic, and Faroese trawlers report that they occasionally capture salmon in trawls during cod fishery on the fishing banks in Davisstrædet. Very likely it is these salmon which approach the shore in the autumn, possibly in search of lance *(Ammodytes)* and capelan

(*Mallotus villosus* MÜLL.). In order to obtain more detailed information of the occurrences of salmon on the fishing banks, questionnaires were sent to nine Faroese trawlers, four of which have returned their replies. From these (and from other data obtained) it appears that these captures of salmon were almost exclusively made on Store Hellefiskebanke north of Holsteinsborg (ca.67°30′ N. lat.), only rarely on the more southerly banks (Fylla Banke). The salmon were caught at depths of some 15—20 fathoms, chiefly in September—October. As a rule the trawl hauls yield only a few salmon, but captures of up to half a hundred or more have been made in a single trawl haul for cod. These particulars date from the years after 1945. It has been impossible to obtain information about the conditions before the war, for no Faro trawlers carried on fishery near Greenland before the war—only line fishermen, who have never taken salmon on their hooks.

Salmon are also met with along the east coast of Greenland. Thus, in recent years salmon have repeatedly been taken near Angmagssalik (65°36′ N., 37°38′ W.), and in the autumn of 1957 a great many salmon were taken with jig during fishing for cod at Skjoldungen (63°14′ N., 41°27′ W.). Only very few samples of salmon scales have been collected along the east coast, so it has been impossible to decide whether the east coast salmon agree in growth with the coast salmon from Greenland, or whether—as is perhaps more likely—they show agreement with the Iceland salmon.

Artificial distribution.

Since on closer inspection several of the large West Greenland rivers would seem to offer the same conditions to the salmon as Kapisigdlit river in regard to suitable spawning grounds, temperatures, chemical conditions of the water, ice-covering, etc., experiments with transplanting of salmon in Greenland have been carried out. Thus in the years 1956—59 eggs and fry of Canadian salmon and Norwegian salmon were planted in various rivers in the Godthåb and Julianehåb districts. Salmon eggs were supplied by hatcheries at Hammerfest (Norway) and Newcastle (New Brunswick, Canada). The eggs were forwarded in the eyed stage and set out either as eyed eggs placed in Vibert boxes or as fry hatched at Narssaq (Julianehåb) and Godthåb (fig. 4). Also transfer of parr from Kapisigdlit river to a nearby river in Godthåb Fjord has been attempted. The map in fig. 5 shows where eggs or fry have been set out (JØRGEN NIELSEN 1957 and 1959). It is still too early to say anything about the results of these experiments, as salmon ripe for spawning cannot be expected to return to the rivers till 5—7 years after the eggs were planted. Still, in 1958 some few ascending salmon were taken near Amitsuarssuk river, where parr from Ka-

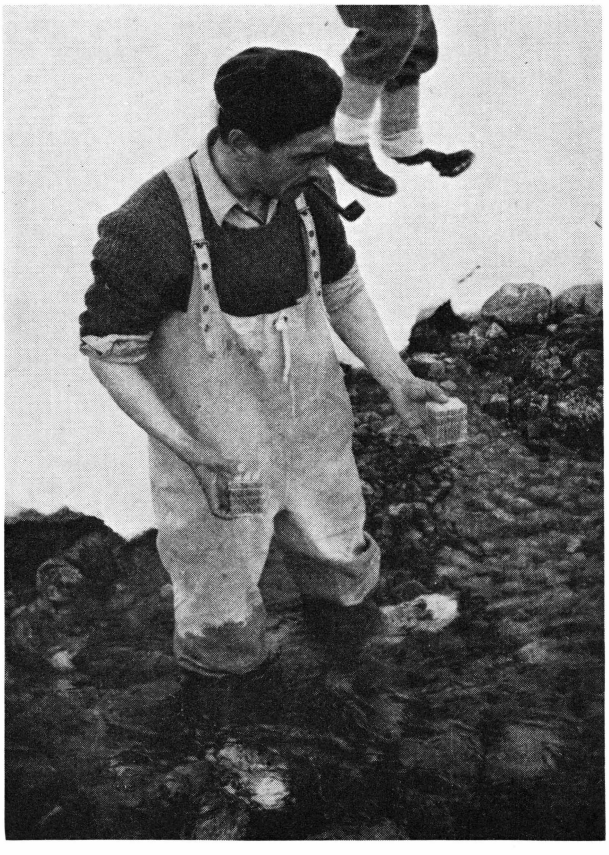

Fig. 4. Salmon eggs are planted in the river in Vibert boxes.

pisigdlit river were planted in 1956. It has also turned out that nearly a hundred per cent of the eggs set out have been hatched, and in one of the rivers in which eggs were planted a great many one-year-old parr were captured by electrofishing the ensuing year. This parr showed a slightly more rapid growth than the parr of Kapisigdlit river.

Summary.

The distribution of the Atlantic salmon (*Salmo salar* L.) in Greenland ranges from Kap Farvel in the south to Umanak (71° N. lat.) on the west coast and to Angmagssalik (66° N. lat.) on the east coast (see fig. 3). Spawning salmon are only known with certainty from one river, namely Kapisigdlit river in the interior of Godthåb Fjord. The occurrence of salmon in this place is mentioned already by Fabricius (1780). In the autumn months salmon are caught along the coast, but

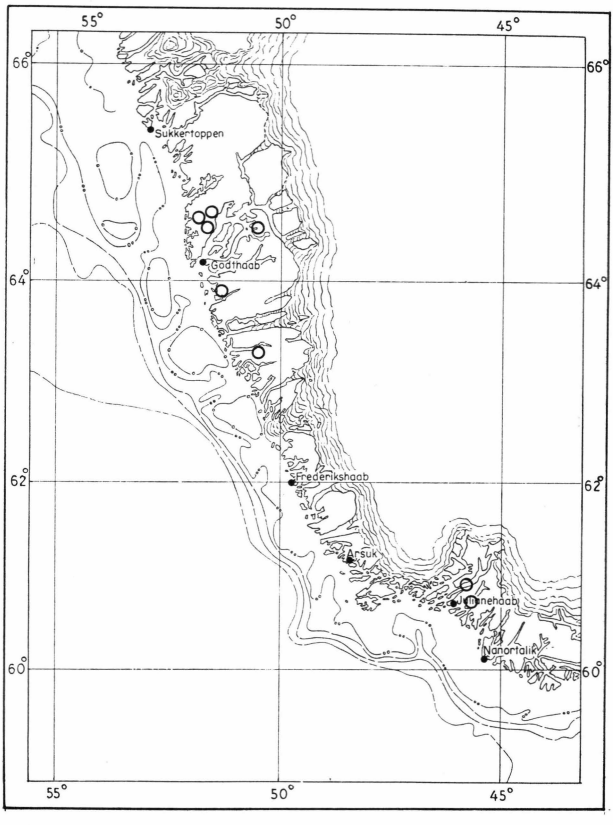

Fig. 5. Map of localities in which artificial planting of eggs or fry of salmon was carried out in the years 1956–1959.

judging by the duration of their stay in the river before their first migration to the sea, these salmon do not all of them originate from Kapisigdlit river or another Greenland river. During fishing of these salmon in the Sukkertoppen district, two recaptures of tagged salmon have been made. One was tagged as parr in Kapisigdlit river, while the other was tagged as kelt in the Conon district, Scotland. This shows that salmon from Kapisigdlit as well as salmon having their provenance outside Greenland, may be met with among these coast salmon. Artificial planting of eggs and fry from Norwegian and Canadian hatcheries was commenced in Greenland in 1956.

II.

SPAWNING AND MIGRATION OF THE GREENLAND SALMON (SALMO SALAR L.)

From early times the salmon *(Salmo salar* L.*)* has been known in Greenland from Kapisigdlit river in the interior of Godthåb Fjord (64°26′ N., 50°12′ W.) (Fabricius 1780). It was not till 1926, however, when the two Austrian zoologists Steinböck and Reisinger caught two salmon in the parr stage, that it was ascertained to spawn in Kapisigdlit river (Adolf Jensen 1948). Since then the Greenland Fisheries Investigations have repeatedly caught salmon parr in the river and the lakes through which it flows. In the spring of 1954 the Greenland Fisheries Investigations visited the river to find the spawning grounds of the salmon, and these were now located for the first time. Since then the river has been visited every year in the autumn and spring for the purpose of counting the redds and finding out the dates of the spawning season and the hatching of the eggs. Kapisigdlit river is the only Greenland river in which the salmon is positively known to spawn.

Spawning grounds.

Redds have been found in River III every year since 1954 (see figs. 2 and 6). In one year up to 62 redds were counted in this ca. 200 m long river. In River II no redds have been met with, nor are there any suitable grounds for spawning. In River I the salmon does not, apparently, spawn every year, but in 1956 and 1957 redds were found in this river at the point where it leaves the lake. Higher up the river system spawning grounds have been looked for in River IV, but none have been found. There is hardly any doubt, however, that spawning grounds are found in this river also, for salmon parr have been captured there. Spawning grounds are undoubtedly likewise found still farther up the river system, Greenland fishermen reporting that in winter salmon occur even in Lake V.

The counting of redds in River III have yielded rather varying figures for the various years. Although the number of redds will, no doubt, vary somewhat from year to year, it is difficult to get a basis for comparison, for at the time the redds were counted, the river was partially

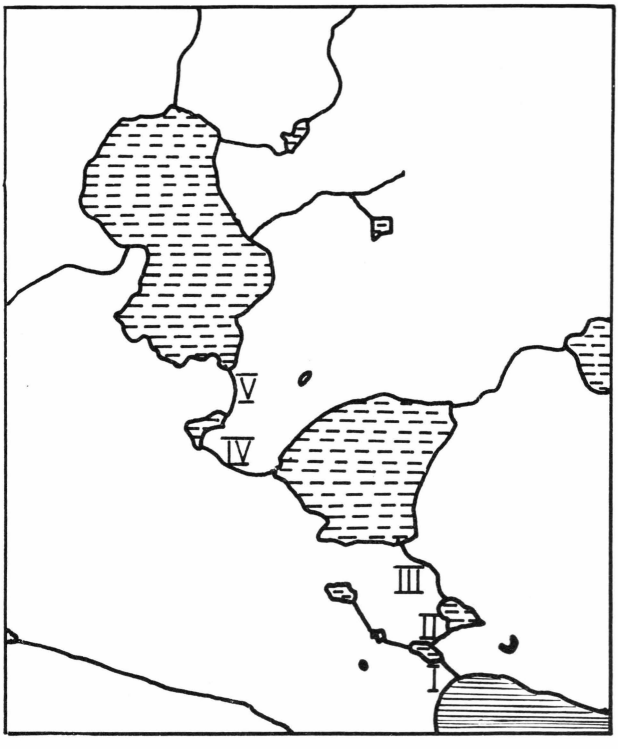

Fig. 6. Map of Kapisigdlit river. Scale 1:50,000.

covered with ice, and many redds were accordingly located below the ice. Counting in the ice-free parts alone will furnish no basis for comparison either, as the size and location of such icefree areas in the river may vary from one year to another.

To fix the spawning and hatching times for the salmon and its eggs, the river has, since 1954, been visited several times during the winter. These visits, however, total only 19, for the river is situated far from the laboratory of the Fisheries Investigations at Godthåb and is often rather inaccessible in the winter, it being impossible to approach it by boat owing to the ice-cover of the interior of Godthåb Fjord. Still, these nineteen visits have furnished a certain basis for an estimation of the spawning season.

Spawning season.

In the month of *October* the river has been visited twice, viz. on October 7, 1954, and October 23, 1957. During the visit in 1954 no fresh redds were observed within the spawning grounds in River III, but two adult coloured males with mature testes were caught, which suggests

that spawning was approaching. During the visit in 1957 no fresh redds with eggs were found, but a single cutting for a redd was seen which might look lige a trial cutting that had been given up again.

In *November* the spawning grounds have been visited thrice. On November 1, 1958, redds were not yet to be seen. On November 6, 1956, nineteen fresh redds were counted in River III. On November 20, 1957, the area was entirely covered with ice and counting or finding of redds was impossible.

In the months of *December to February* the spawning grounds were visited once a month. On December 9, 1954, 15 redds with fresh eggs were counted. In January 1957 and February 1956 the area was entirely covered with ice.

Two visits are recorded from the month of *March*. On March 1, 1956, the area was completely ice-covered. On March 11, 1954, ten redds with fresh eggs were counted.

In *April* the area has been visited thrice. On April 11, 1956, 33 redds with eggs containing rather well developed embryos in the eyed stage were counted within the area. At the same time redds (eleven) were observed for the first time in River I. Here the eggs were a little less developed than in River III. On April 14, 1955, 62 redds with eggs were counted in River III. On April 24, 1958, a great many redds with eggs were found within the area.

In the month of *May* the area has been visited six times. On May 5, 1954, redds with eggs were observed which, however, did not seem to be immediately about to hatch. On May 5, 1959, thirty-three redds with eggs were counted, but in one redd all the eggs were dead. On May 10, 1957, eleven redds were counted in River III. Two of these contained only dead eggs, while all the others still contained fresh eggs in the eyed stage. At the same time ten redds were investigated in River I. The eggs in these redds were now a little more advanced in development than in River III. On May 12, 1956, all the eggs in the spawning redds in River III had been hatched. None of the redds dug up contained eggs. On May 15, 1955, eggs were found in a single redd only. The others were empty, and the eggs probably hatched already. On May 20, 1958, 30 redds were counted, but very likely several more occurred below the ice, which had not yet broken up in the place. Three redds were dug up but no fresh eggs were found in them, so the eggs had probably been hatched already.

The observations made during these few and scattered visits to the spawning grounds indicate that the salmon in Kapisigdlit river spawn at the beginning of November, possibly at the end of October. The first date on which spawning was found to take place is November 6 (1956), but in one year a single cutting was observed on October 23

(1957). This also agrees with the time at which sexually mature parr males are met with in the river. Hatching of the eggs would seem to take place by the middle of May. May 15 (1955) is the latest date on which eggs have been observed in the redds, and then only in one of the redds examined.

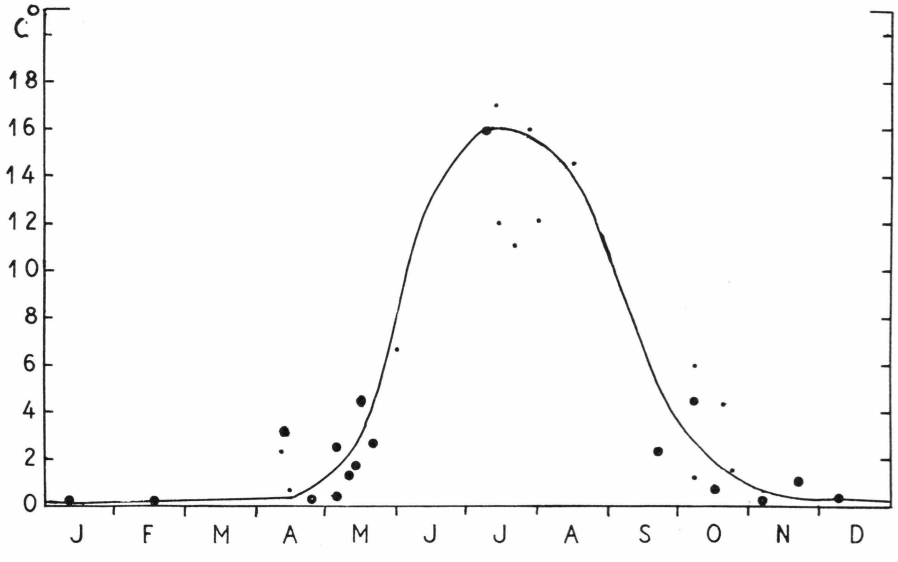

Fig. 7. Temperature curve for Kapisigdlit river, drawn on the basis of temperature readings during five years. ● indicates temperature readings in the spawning ground in River III. • indicates temperature readings in other parts of the river.

In fig. 7 the temperatures in the spawning area in River III at Kapisigdlit are indicated. From the years 1954—59 only few and scattered temperature measurements from the river are available. These temperatures are given in the figure. The temperature curve was drawn free hand on the basis of these temperatures and with regard being taken to temperature measurements on other dates from other parts of the river. The measurements show that during the spawning season the temperature ranges from $^1/_2°$ to 2° C. In spring the rise of the temperature sets in at the end of April, the date varying somewhat from year to year. In a single year (1956) temperatures of 3.2° C were measured as early as the beginning of April. In another year (1958) he temperature on April 24 was still 0.3° C, the usual winter temperature, and in 1959 a temperature of 0.4° C was measured as late as May 5. During the time of hatching about the middle of May the temperature ranges about 2°—5° C.

Spring-spawning salmon?

It will be obvious from the above that the common developmental features of the salmon at Kapisigdlit is: spawning in the autumn and hatching of the eggs in the spring, similarly as is the case in the remaining part of its range. It would seem, however, that there may be exceptions to this rule, as is shown by a few captures of salmon made by the Greenland Fisheries Investigations. On May 5, 1952, I took with spinner in Lake III at Kapisigdlit, through a hole cut in the ice, a female salmon which was so ripe that the eggs streamed out in quantity when it was hauled up. A salmon at that stage of maturity can hardly be supposed not to spawn till October—November, but must be immediately about to spawn. It was confirmed by Greenland salmon fishermen, who often fish from the ice in the months of spring, that the capture of such fully mature females is not uncommon; but is was normal at this time of the year to catch either kelt or, more rarely, silvery ascending salmon not yet sexually mature. On May 11, 1953, I caught in Kapisigdlit river, together with a silvery ascending salmon, a coloured female which had apparently spawned shortly before. A number of eggs were still found in the abdominal cavity, and its ovaries were quite bloody. On June 7, 1959, an apparently spawning female was likewise taken in Kapisigdlit river. When it was hauled ashore, the spawn flowed into the water, and on the ensuing dissection, the fish was found to have about 300 ripe eggs in its abdominal cavity. Finally, on June 17, 1939, a female salmon with a number of big eggs in the ovaries was caught together with eleven spent kelts; possibly this specimen had spawned shortly before.

Observations made in another river in Godthåb Fjord, Isersiutigdlit, seem to indicate that spawning may take place in the spring. This river is quite small and runs through several lakes. Greenlanders report that they have often caught salmon in this river and in the lakes passed by it. In order to find out whether spawning is taking place in the river, I visited it several times and carried out electrofishing in it. However, salmon parr and smolt have never been taken by electrofishing in this river, only parr of char, *Salvelinus alpinus* (L.). But on June 24, 1953, four adult salmon were caught in the river. Two of these were typical, very lean kelts, which must be assumed to have spawned in the river earlier in the year or the previous autumn. The other two, however, were sexually mature fish—a male and a female—which stood at a point in the river where the bottom and the current seemed to be well suited for spawning. When the female was taken out of the water, the eggs flowed out of it. The milt of the male flowed abundantly out of it when slightly pressed. There is hardly any doubt that these two salmon were about to spawn or in the middle of the spawning process.

These two specimens were not examined more closely, but were at once tagged and set out again.

To my knowledge, spawning of salmon in spring and early summer has not been ascertained elsewhere. Undoubtedly, however, it takes place in Greenland, though no doubt exceptionally. At any rate, redds with eggs have not been found in the summer. Possibly the spawning fails totally at this abnormal season of the year.

Spawning migrations.

From June 20 and onwards numerous scale samples from catches of ascending salmon from the river at Kapisigdlit are at hand. It may be taken for granted that the actual run starts about this date. Ascent may however, also take place earlier in the year. The bay in which Kapisigdlit river falls out, is covered with fast ice in the winter till some time in May, but the Greenlanders are of the opinion that the salmon begin to ascend the river while the bay is still ice-covered. The Greenland Fisheries Investigations, however, possess only two samples of scales of ascending salmon caught in the river prior to June 20. These two ascending salmon were taken on May 11 and May 26 (1953 and 1955, respectively). Since kelts have often been taken in the river in the month of May, but only these two ascending salmon, it is most likely that runs before the middle of June are of exceptional occurrence.

After June 20 the run continues on a large scale in July, August, and September, while no ascent later than the beginning of October has been ascertained. The scale samples collected and the measurements of ascending salmon made during the summer—totalling 290 samples—show no tendency in the direction of differences in size or age of the ascending fish in the different months, as is generally the rule elsewhere, but a larger and more uniformly distributed material might perhaps reveal the existence of such a tendency.

The descent of salmon takes place in the spring. It has been impossible to ascertain when it begins, but as late as May numerous kelts have often been captured in the river and in the lakes. Kelts are likewise found in the river in June. As late as June 17 (1939) the Greenland Fisheries Investigations during a visit to the river caught eleven kelts a short distance above the outfall of the river into the sea; probably the kelts were on their way out to the sea. As late as June 23 (1953) I likewise caught two kelts in the lowermost lake, and on June 27 (1952) a kelt was taken in the river mouth. Later in the year kelts have only been taken in fresh water in two instances. Both these salmon were captured in 1959, on August 7 and 12, respectively, but such a late

occurrence of kelts in the river no doubt forms an exception. Possibly these two salmon, both of them females, were spring spawners.

Migrations in the sea.

Only sparse information is available about the migrations of the Kapisigdlit salmon during its stay in the sea. The few salmon taken in sea water in Godthåb Fjord had probably come from Kapisigdlit river. Possibly salmon originating from Kapisigdlit river are also represented in the not inconsiderable catches of salmon which are made in the autumn at Sukkertoppen and other places along the coast of Greenland and on the banks in Davisstrædet, but age analyses of these salmon show that they are, at any rate, neither exclusively nor predominantly salmon from Kapisigdlit, for the river-life of these fish as parr is much shorter than in the case of the Kapisigdlit salmon. Similarly, a recapture at Sukkertoppen of a salmon tagged as kelt in a Scottish river shows that these coastal salmon may be derived from European populations (Menzies & Shearer 1957).

To study the migrations of the Kapisigdlit salmon in the sea a number of 1669 parr and smolts were tagged in Kapisigdlit river in the years 1952—1958 (1233 of them in 1958). Only two have been recaptured as adult salmon. One of the recaptured salmon was marked as parr in Kapisigdlit river on July 30, 1956 (14 cm, age 3 +) and was recaptured at Taserdluk east of Sukkertoppen (65°30′ N., 52°36′ W.) on August 4, 1958. When recaptured, this salmon had a total length of 47 cm, and had covered a distance of 280 km from the place of tagging. This shows that the Kapisigdlit salmon may quite well go northward and mix with the coast salmon that are captured at Sukkertoppen, but, as shown by the determination of the age of these salmon at their first migration to the sea, the majority of the coast salmon do not originate from Kapisigdlit or any other river in Greenland. The other recaptured salmon was tagged as parr in Kapisigdlit river on July 30, 1956, and was recaptured as kelt in the same river on June 7, 1959.

Sex ratio.

Of 274 sexually determined ascending salmon at Kapisigdlit the sex ratio was 70 ♂♂ to 100 ♀♀. Kelts, of which, however, only 42 were sexually determined, had a sex ratio of 56 ♂♂ to 100 ♀♀. It is noticable that the sex ratio of parr in Kapisigdlit river is quite different. Table 1 gives the numbers of males and females from three samples of parr.

Table 1.

Sex ratio for parr from Kapisigdlit.

Date	Number ♂♂	Number ♀♀	Number ?	♂♂/♀♀
13/7 1955	48	34	1	141/100
30/7 1956	38	23	19	165/100
23/10 1957	16	5	0	320/100
Total	102	62	20	166/100

Thus, in contrast to the adult salmon, the parr show a much larger number of males than of females. The sexually determined parr and smolts ranged in age from 2—3 years up to 5 years, and in length from 7 to 22 cm (total length). As it turned out that all the sexually determined parr of a length of 16 cm or more (11.4% of the total number) with a single exception were males, these samples possibly include a small number of non-migratory dwarf males. Hence, the samples perhaps show a slightly higher percentage of males than would be found in a representative pure sample in which all age classes were represented. But even if this is taken into consideration, the number of males among the parr and smolt will be higher than the number of females. The migration age for smolt at Kapisigdlit is for the most part 4 or 5 years, and there is no difference in the migration age for males and females. Age analyses of 236 salmon have shown a difference in the migration age between males and females of less than 0.05 year. On the other hand, it is probable that a great many males will remain in the river as sexually mature dwarf males, possibly without migrating later on. Dwarf males reaching a length of 30 cm and more than 10 years old have been captured in the river, while hitherto a migration age of more than six years for smolts has not been ascertained for adult salmon at Kapisigdlit. Possibly a large number of the parr males which participate in the spawning will die immediately afterwards (G. POWER 1958). This may explain at any rate part of the great alteration of the sex ratio taking place from the parr to the adult fish.

Sexually mature dwarf males.

A fairly large proportion of the male parr in Kapisigdlit river have ripe testes in the autumn. In a sample of 61 parr captured on October 8, 1954, in Kapisigdlit river, nine were males with a degree of maturity of 5—6. The youngest of them was $2^1/_2$ years old and 12 cm long. The oldest were $5^1/_2$ years old and up to 18 cm long. Only some few specimens of this sample of 61 parr have been sexually determined, but if we

apply the above-mentioned sex ratio (166 ♂♂ to 100 ♀♀), 38 of them will be males and 23 females. This means that about one-fourth of the males more than two years old will be sexually mature during the spawning season and will perhaps participate in the spawning.

In October 1957, 21 parr were captured at Kapisigdlit, 16 of which were males. Six of these had ripe testes and flowing sperm.

Summary.

The only locality within Greenland in which the Atlantic salmon (*Salmo salar* L.) is positively known to spawn is Kapisigdlit river. The spawning seems normally to take place from the end of October to the beginning of November, and the eggs are hatched about the middle of May. Since males as well as females with fully mature sexual organs have been captured in May—June, it is assumed that spring spawning may take place, but it is unknown whether this possible spawning will yield eggs that are capable of developing.

The salmon may ascend the river as early as May, but the main run will not normally set in till about June 20, continuing, at any rate, till about October 1st. The descent of salmon probably begins at the breaking up of the ice in May and the first half of June, but kelts have been captured in the river as late as the end of June and on two occasions as late as the first half of August.

The migrations of the Kapisigdlit salmon during their stay in the sea are unknown, apart from a single recapture of a salmon tagged as parr in Kapisigdlit river and recaptured at Sukkertoppen 280 km from the place of tagging. In the autumn months a great many salmon are captured in the sea along the coasts of Greenland. These catches possibly contain salmon from Kapisigdlit river, but the duration of the freshwater stay of these coast salmon, as also a single recapture among these of a salmon tagged in Scotland would indicate that these salmon are for the most part of a more southern, non-Greenlandic origin.

The sex ratio for ascending salmon at Kapisigdlit is 70 ♂♂ as against 100 ♀♀. The sex ratio for 2—6 year old parr in the river, however, is 166 ♂♂ to 100 ♀♀. About one-fourth of the parr males over 2 years of age will grow sexually mature in the parr stage. At any rate, some of these will remain in the river as dwarf males without migrating to the sea, and may attain a length of 30 cm and an age of more than ten years.

III.

PRELIMINARY RESULTS OF TAGGING EXPERIMENTS WITH CHAR, SALVELINUS ALPINUS (L.), IN GREENLAND

In 1949 tagging experiments with char were commenced in Greenland, and these experiments are still being continued. The object of the experiments is to secure information about the migrations of the char, its "homing instinct", the fishing intensity, and supplementary data on its growth. The information obtained of the growth of the char is not recorded in the present paper.

Biology of the char.

To facilitate the understanding of the tagging experiments, a brief account of the way of life of the char will be given.

The char occurs all over Greenland in rivers and in lakes connected with the rivers. A non-migratory form of char is found in lakes without any connection with the sea as well as in rivers together with the anadromous form. The biology of the anadromous char is briefly as follows:

The eggs of the char are hatched at the beginning of or about the middle of April (Godthåb district). The parr remain for 3 to 5 years in fresh water (rivers and lakes) before their first migration to the sea. Every winter the char returns to its native river to pass the winter there and possibly to spawn. The descent to the sea takes place about May (–June). It stays in the sea not far from the river, ascending the river again about July–August. Spawning takes place from the end of August to the beginning of October, when it spawns in deep pools in the rivers or in the lakes. The char grows sexually mature at an age of nine years, it spawns several times during its life, but possibly not every year (Paul Hansen 1940, Paul Hansen and Frede Hermann 1953, Adolf Jensen 1948, Jørgen Nielsen 1954 and 1956a).

Tagging localities.

Up to January 1, 1959, a total of 2602 char have been tagged in Greenland. The tagging was made at 56 stations distributed over 24

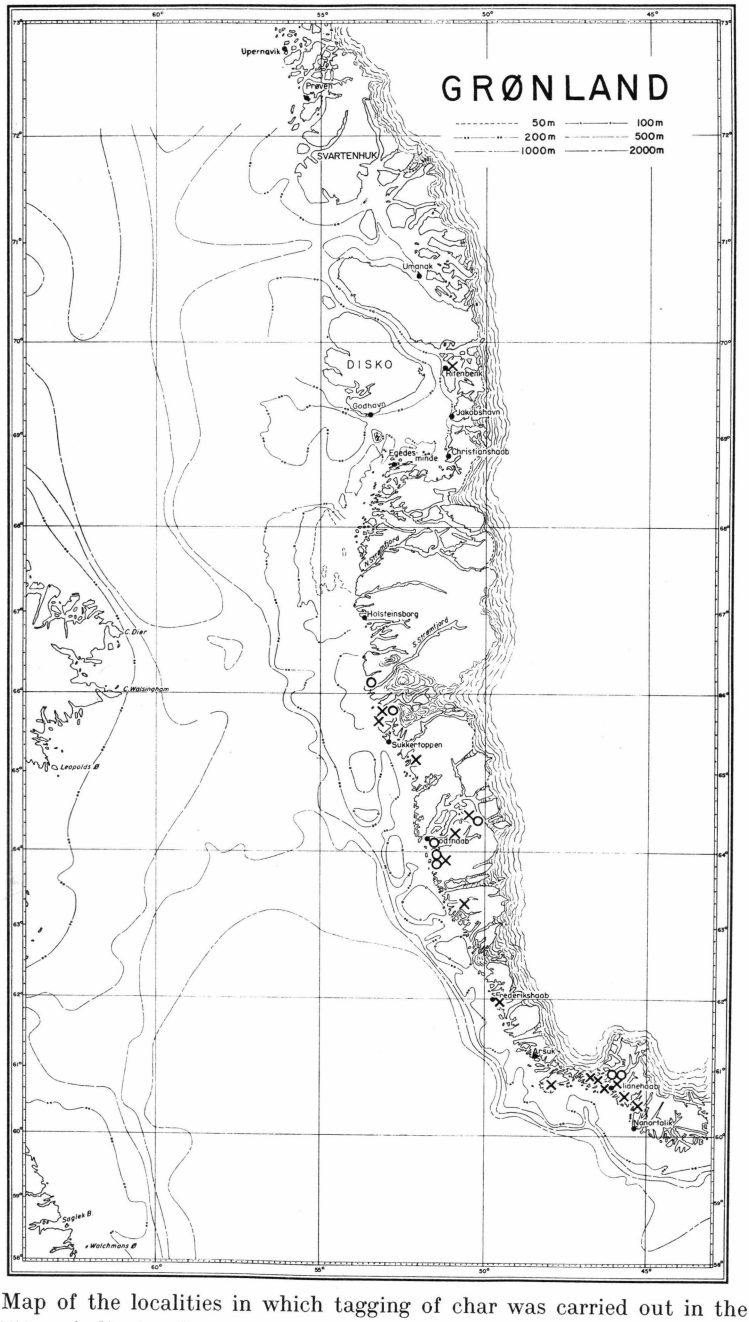

Fig. 8. Map of the localities in which tagging of char was carried out in the years 1949–1958. o indicates the most important tagging experiments dealt with in detail in the text. × indicates other tagging experiments.

different localities within the Julianehåb, Frederikshåb, Godthåb, Sukkertoppen, and Jakobshavn districts. The map in fig. 8 shows the tagging localities. The experiments, however, were chiefly concentrated around eight localities (indicated by open circles on the map): Kangerdluarssúnguaq and Sangmissup-itivnera (Sukkertoppen district), Kapisigdlit, Kobbefjorden, Qarajat, and Kigdlut-iluat (Godthåb district), and Narssap-ilua and Tunugdliarfiup-ilua (Julianehåb district). Up to January 1, 1959, a number of 596 recaptures have been made, that is to say, 22.9 per cent of the total number of tagged char. In table 2 a survey is taken of the taggings made in the various years and the recaptures.

Table 2.

Tagged		Recaptured						
Year	Total	Total	Same year	1 year later	2 yrs. later	3 yrs. later	4 yrs. later	5 yrs. later
1949	30	4	2	2				
1951	3	2		1		1		
1952	44	15	4	8	2		1	
1953	249	77	13	43	7	10	3	1
1954	799	119	29	55	26	6	3	
1955	569	185	67	55	43	20		
1956	250	29	23	4	2			
1957	296	86	41	45				
1958	362	79	79					
	2602	596	258	213	80	37	7	1
per cent		22.9	9.9	8.2	3.1	1.4	0.3	0.04

Collecting and tagging methods.

Tagging of char has been carried out in rivers and lakes as well as in the sea. When the tagging were made in lakes or in the sea, the char were almost always taken by means of seines (hand-seines), which were set around shoals and hauled to the shore (fig. 9). If tagged in rivers, the char have nearly always been taken by electrofishing. A portable electrofishing apparatus, weighing about 50 kg (fig. 10) has been employed. The apparatus consists of a light metal Sachs-Stamo engine, which by a V-belt operates a direct current generator of an efficiency of 300/500 volt and 3 amperes. This apparatus has proved suitable for the capture of char for tagging. In very few cases have char for tagging been captured with spinners or artificial flies.

Various types of tags have been used. They are described in more detail in the section entitled "Comparison of the various types of tags" at the end of the present paper (p. 43).

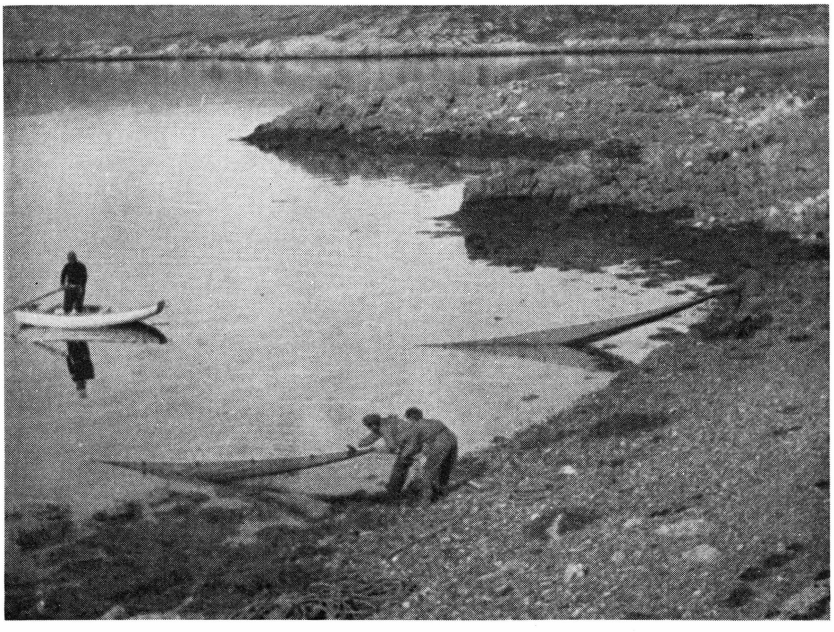

Fig. 9. Haul with hand-seine for char in the sea.



Fig. 10. Electrofishing apparatus employed in recent years for capture of salmon and char in Greenland.

Size of the char tagged.

In the tagging experiments described below chiefly char of a total length of more than 25–30 cm were used. On the whole, primarily char which had stayed for some time in the sea and had attained a certain size, were used in the tagging experiments in Greenland. Parr of char have not been tagged before their migration to the sea. Only about 8 per cent of the total number of tagged char were under 20 cm long. Table 3 shows the number of tagged char distributed over 5-cm groups, and the number of recaptures and the recapture percentages within these groups. In the table these figures are further specified for the various types of tags used. That number of tagged char in this table does not agree with the number given in table 2, is due to the fact that the very few specimens of char marked with other types of tags than the three types mentioned in table 3 have been disregarded, and similarly the few tagging experiments in which the tagged char were not measured have been omitted.

It will be seen from the table that the recapture percentages for small char are much lower than for the bigger specimens. The reason might be that in the first years after the tagging the small char will be less numerously represented in the catches than the bigger ones; not till reaching such a size that they are included in the professional fishery, which is chiefly carried out with nets with a minimum mesh-

Table 3.

Number of tagged and recaptured char up to January 1, 1959, distributed according to size and types of tags employed.

cm	Lea			Plastic/steel			Plastic/terylene			Total		
	Number		Re-capt. %	Number		Re-capt. %	Number		Re-capt. %	Number		Re-capt. %
	Tag-ged	Re-capt.		Tag-ged	Re-capt.		Tag-ged	Re-capt.		Tag-ged	Re-capt.	
10–14				10	0	0	4	0	0	14	0	0
15–19	21	2	9.5	27	0	0	122	1	0.8	170	3	1.8
20–24	51	19	37.3	64	12	18.8	255	16	6.3	370	47	12.7
25–29	62	16	25.8	187	60	32.1	300	36	12.0	549	112	20.4
30–34	76	17	22.4	141	35	24.8	230	50	21.7	447	102	22.8
35–39	80	27	33.8	89	31	34.8	183	51	27.9	352	109	31.0
40–44	45	15	33.3	67	30	44.8	115	38	33.0	227	83	36.6
45–49	17	9	52.9	45	10	22.2	55	18	32.7	117	37	31.6
50–54	3	1	33.3	25	11	44.0	15	3	20.0	43	15	34.9
55–59	2	2	100.0	14	4	28.6	3	2	66.7	19	8	42.1
60–64				5	1	20.0	3	1	33.3	8	2	25.0
65–69							4	1	25.0	4	1	25.0
Total	357	108	30.3	674	194	28.8	1289	217	16.8	2320	519	22.4

size of 50 mm (from knot to knot), will they be more abundantly represented. Recapture of small char from the tagging experiments of the last two to three years would then be expected to be sparse, the tagging experiments as well as the recaptures having been carried up to January 1, 1959. However, this does not seem to be the explanation of the relatively few recaptures of small char as shown by fig. 11.

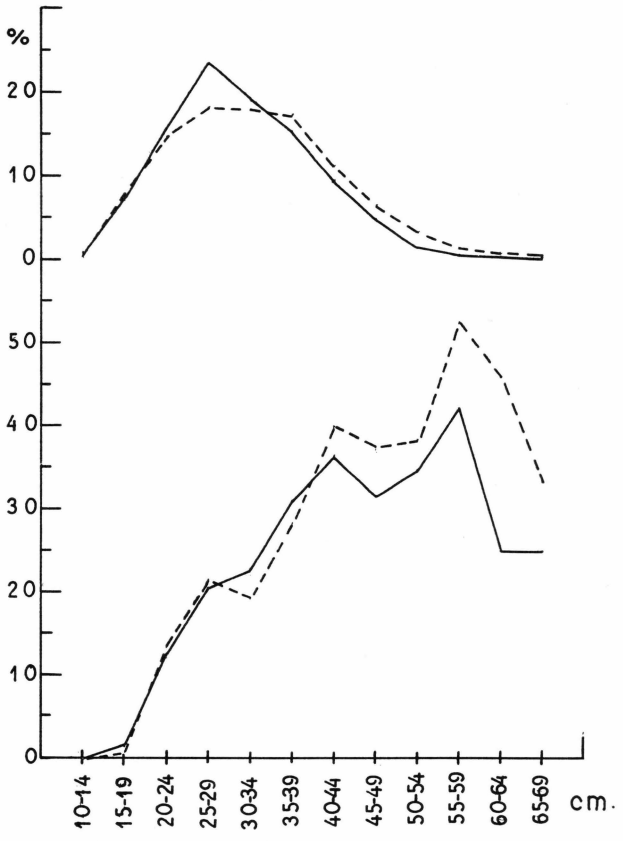

Fig. 11. Size distribution of tagged and recaptured char. Cf. the explanation in the text.

In fig. 11 a comparison is made between the recaptures up to January 1, 1959, from all the tagging experiments made to and including 1958 and all the tagging experiments made to and including 1955. The uppermost two curves show the distribution over size groups of tagged char in per cent of the total number, which for the experiments to and including 1955 (stippled line) amounted to 1,686, while for the experiments to and including 1958 (full line) it was 2,320. It turns out that the distribution over size groups is fairly alike in the two cases, and at the same time the number of tagged fish within the different

size groups is so large that the recapture percentages for the two experiments can be immediately compared. This has been done in the lowermost two curves, the continous curve showing the recapture percentages up to January 1, 1959 of all the taggings made to and including 1958, and the stippled curve shows the recapture percentages up to January 1, 1959, of all the taggings made to and including 1955. It turns out that the recapture percentages for the different size groups are almost the same—showing even the greatest agreement for the smallest size-groups.

The sparse recapture of small char must therefore presumably be due either to the circumstance that the fish die in large numbers as a result of the tagging process, or, perhaps more likely, that the small fish lose the tag before reaching such a size that they must be expected to form part of the commercial fishery.

As to the ratio between the recapture percentages for the different tagging types shown in table 3, the reader is referred to the last chapter of the present paper, entitled "Comparisons between the various types of tags" (p. 43).

The most important tagging experiments.

Below a summary of the most important tagging experiments will be given.

Sukkertoppen district.

I. *Kangerdluarssúnguaq experiments* (see fig. 12).

Tagging experiment no. 15 (table 4): On September 14, 1953, tagging experiments with char taken with seine at the influx of the river to the lowermost lake. About 95 per cent of the fish were strongly coloured and near spawning. Type of tag: yellow and red plastic attached with tery-

Table 4.

Recapture locality	Same place	Simiutaq	Timerdlît	Narssaq	Erfalik	Pâ	Total	%
Distance in km from place of tagging	0	13	49	44	48	34	..	..
Recaptured same year								
1 year later	15	13	1	1	1	..	31	26.3
2 years later	3	..	..	..	..	1	4	3.4
3 — —	8	..	..	1	..	..	9	7.6
4 — —	2	..	..	..	..	..	2	1.7
5 — —	..	..	..	1	..	..	1	0.8
	28	13	1	3	1	1	47	39.8

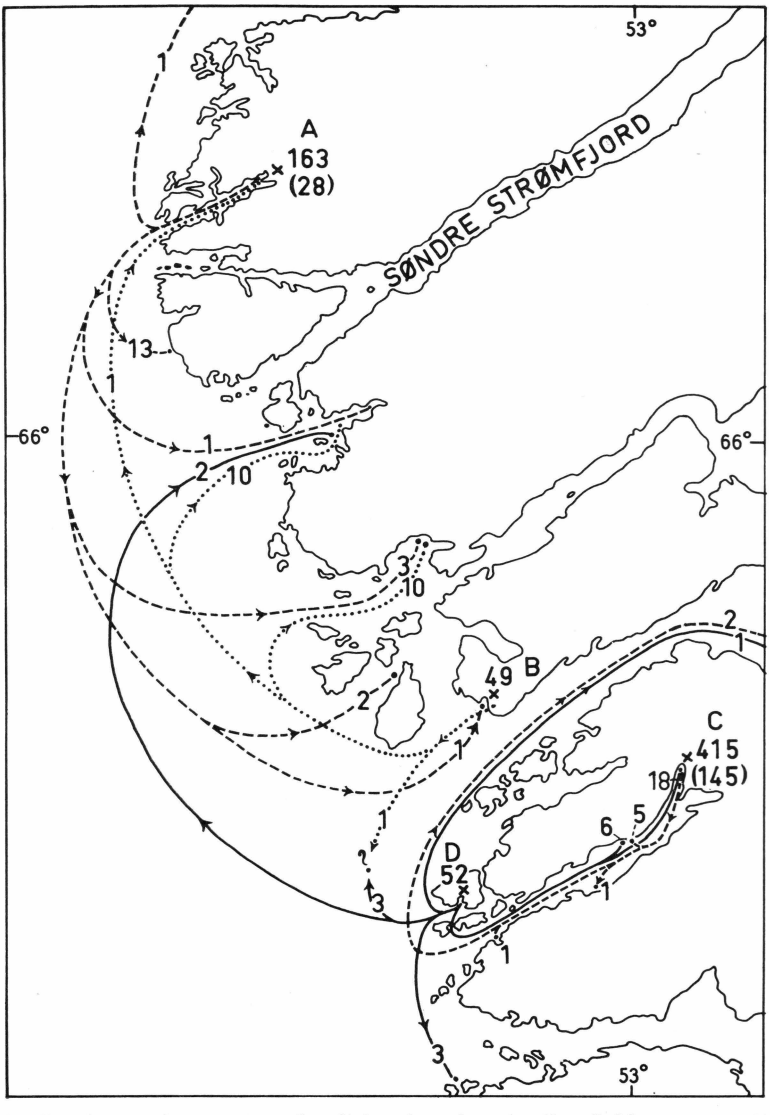

Fig. 12. Tagging and recapture localities for char in the Sukkertoppen district. The letters indicate the tagging localities, A: Kangerdluarssúnguaq, B: Utorqait, C: Sangmissup-itivnera, and D: Avqússuaq. At the tagging localities the number of tagged char, and in parantheses the number of recaptures in the same place are given. The arrows point to the recapture localities, and the figures at these indicate the number of recaptures in the particular locality.

lene, a synthetic polyester fibre, yellow plastic fixed with wire. A total of 118 char were tagged, 47 or 39.8 per cent of which have been recaptured.

Of the recaptured char, one is known with certainty to have migrated to another river (Erfalik) the succeeding year. The chars re-

captured at Narssaq and Pâ are possibly such as have migrated to other rivers, while Simiutaq is a summer habitat of the char. In this locality there is no river in which to ascend.

Tagging experiment no. 51. Tagging was made again in the same place on September 13, 1956. Twenty-six char were captured in the same way and in the same place as in the previous experiment. Type of tag: blue plastic attached with V2A-steel. Altogether 26 char were tagged, two of which (= 7.7 %) were recaptured two years later in the sea north of Kangâmiut. Distance covered 37 km. These two specimens were recaptured in their summer habitat in the sea.

Tagging experiment no. 54. In the same place and in the same way 19 char were captured and tagged on September 26, 1957; none of them have been recaptured so far. Type of tag: blue plastic attached with V2A-steel.

II. *Sangmissup-itivnera experiments* (see fig. 12).

Tagging experiment no. 37. (Table 5). On July 25, 1955, tagging experiments were made with char captured either by electrofishing in the river or by seine in the lowermost lake. Type of tag: red plastic attached with terylene. A total of 138 char were tagged, of which 68 or 49.2 per cent have been recaptured.

Table 5.

Recapture locality	Same place	Itivnerssuaq	Total	%
Distance in km from tagging place	0	9	..	..
Recaptured same year	26	..	26	18.8
1 year later	13	..	13	9.4
2 years later	24	1	25	18.1
3 — —	3	1	4	2.9
	66	2	68	49.2

Tagging experiment no. 53. (table 6). On September 23, 1957, tagging experiments were made with char taken with seine in the lowermost lake. Type of tag: red and blue plastic attached with V2A-steel, yellow plastic attached with terylene. A total of 277 char were tagged, of which 86 or 31.0 per cent have been recaptured.

The two recaptures at Tasiussaq are, no doubt, specimens which had migrated to another river. All the other recaptures in other localities

Table 6.

Recapture locality	Same place	Itivnerssuaq	Ivnapatâ	Natsîtsoq	Tasiussaq	Total	%
Distance in km from tagging place.....	0	9	20	12	47	..	..
Recaptured same year ...	41	..	..	..	..	41	14.8
1 year later.....	38	3	1	1	2	45	16.2
	79	3	1	1	2	86	31.0

than the tagging locality, however, were hardly migrations to other rivers, for all these recaptures were made in the early summer, when the run in the tagging river had far from ceased.

III. *Utorqait and Avqússuaq experiments.* (see fig. 12).

These tagging experiments were made in the early summer in the summer habitats of char in the sea.

Tagging experiment no. 31. (table 7). On June 29, 1955, tagging experiments were made with char captured in seine in the sea in a bay at Utorqait. Type of tag: red plastic attached with terylene. Forty-nine char were tagged, of which 21 or 44.9 per cent have been recaptured.

Table 7.

Recapture locality	Narssaq	Pâ	Kangerdluarssúnguaq	?	Total	%
Distance in km from place of tagging ...	13	29	52	?	..	..
Recaptured same year	4	4	1	..	9	18.4
1 year later	2	5	..	1	8	16.3
2 years later	2	..	..	..	2	4.1
3 — —	2	1	..	..	3	6.1
	10	10	1	1	22	44.9

Tagging experiment no. 32 (table 8). On June 30, 1955 tagging experiments were made with char captured in seine in the sea in a bay at Avqússuaq. Type of tag: red plastic attached with V2A-steel. Fifty-two char were tagged, of which 33 or 63.5 per cent have been recaptured.

All the recaptures were made in rivers or at river mouths so late in the summer that it must be assumed that all the above-mentioned localities for recapture are places of ascent for the char recaptured in

Table 8.

Recapture locality	Sang-missup-itiv-nera	Itiv-ner-ssuaq	Pâ	Alán-gua	Tasiu-ssaq	?	Total	%
Distance in km from place of tagging	23	14	35	14	28	?	..	..
Recaptured same year.	11	1	1	1	..	1	15	28.8
1 year later	5	2	1	..	..	2	10	19.2
2 years later	2	2	..	2	1	..	7	13.5
3 — —	..	1	..	..	..	..	1	1.9
	18	6	2	3	1	3	33	63.4

the particular places. This shows that in the summer habitats in the sea the char populations from different rivers will be largely mixed. The same observation is reported by several Greenland salmon fishermen, who are often able to distinguish the char from different rivers on the basis of their appearance. The char at Utorqait, however, seem for the most part to be fish coming from the rivers at Narssaq and Pâ, 90.9 per cent of the recaptured char being derived from these two rivers. The greater number of the Avqússuaq-char seem to belong to the rivers of the Kangerdluarssuk fjord (Sangmissup-itivnera and Itivnerssuaq), 72.7 per cent of the recaptured char originating from these two rivers.

The recapture percentages, 44.9 and 63.5, respectively, testify to a rather intensive char fishery in the rivers within this region. About one-fourth of the tagged fish from the two experiments were recaptured already the same summer.

Godthåb district.

IV. *Kigdlut-iluat experiments* (see fig. 13).

Tagging experiment no. 27 (table 9). On October 12, 1954, char captured in the river by electrofishing were tagged. Type of tag: yellow

Table 9.

Recapture locality	Same place	Qarajat	Southern Qarajat	Total	%
Distance in km from place of tagging	0	13	14	..	..
Recaptured same year	..	..	..	..	..
1 year later	18	2	1	21	11.4
2 years later	14	..	..	14	7.6
3 — —	2	..	..	2	1.1
4 — —	1	..	..	1	0.5
	35	2	1	38	20.6

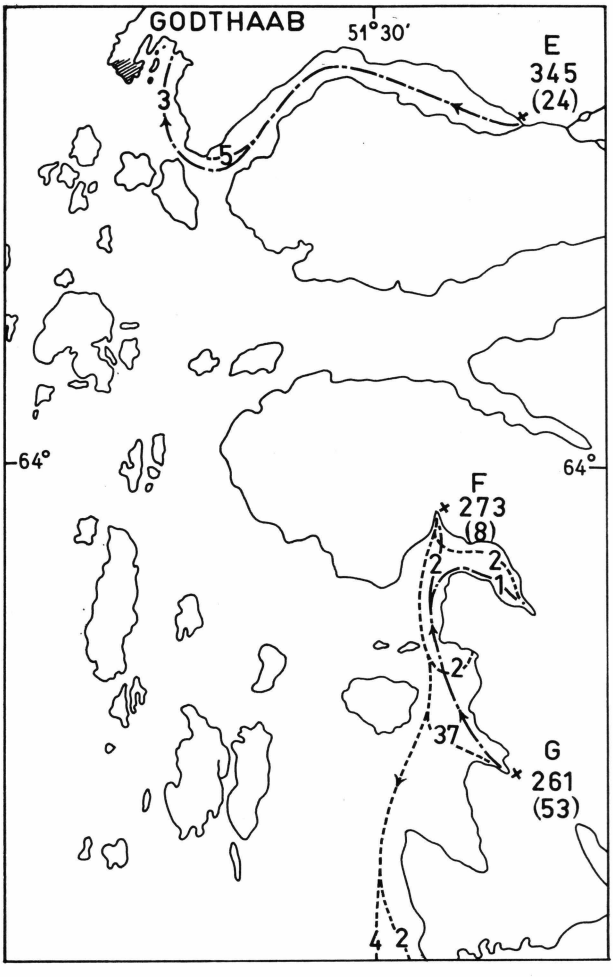

Fig. 13. Tagging and recapture localities for char in the Godthåb district. Cf. the explanation to fig. 12. E: Kobbefjord, F: Qarajat, and G: Kigdlut-iluat.

plastic attached with terylene and Lea tags. A total of 184 were tagged, of which 38 or 20.7 per cent have been recaptured.

Tagging experiment no. 29. May 20, 1955. Electrofishing. Type of tag: red plastic with terylene. Six char tagged, none recaptured.

Tagging experiment no. 40 (table 10). August 20, 1955. Electrofishing. Type of tag: red plastic attached with terylene. Sixty specimens were tagged, of which 12 or 20.0 per cent have been recaptured.

Tagging experiment no. 48. August 9, 1956. Electrofishing. Type of tag: Carlin tags. Two specimens tagged, one of which has been recaptured in the same place.

Table 10.

Recapture locality	Same place	Total	%
Distance in km from tagging place	0	..	..
Recaptured same year .	6	6	10.0
1 year later	3	3	5.0
2 years later	2	2	3.3
3 — —	1	1	1.7
	12	12	20.0

Table 11.

Recapture locality	Same place	Total	%
Distance in km from place of tagging.....	0	..	..
Recaptured same year .	4	4	44.4
1 year later	1	1	11.1
	5	5	55.5

Tagging experiment no. 49 (table 11). August 17, 1956. Electrofishing. Type of tag: blue plastic attached with terylene. Nine char tagged, five of which or 55.6 per cent have been recaptured.

V. *Qarajat experiments* (see fig. 13).

A number of tagging experiments have been carried out at Qarajat, which is a summer habitat for char in the sea. Only a quite small river is found here, in which there is a very sparse or no run of char. All the specimens were caught in seines.

Tagging experiment no. 10 (table 12). July 9, 1953. Type of tag: yellow plastic attached with terylene. Fifteen char were tagged, three of which or 20.0 per cent, have been recaptured.

Tagging experiment no. 16 (table 13). June 20, 1954. Type of tag: yellow plastic attached with terylene. A number of 162 char were tagged, 23 of these or 14.2 per cent, have been recaptured.

Tagging experiment no. 33 (table 14). July 7, 1955. Type of tag: red plastic attached with V2A-steel. A total of 96 char were tagged, of which 29, or 30.2 per cent, have been recaptured.

Table 12.

Recapture locality	Same place	Kigdlut-iluat	Total	%
Distance in km from place of tagging	0	13	..	..
Recaptured 1 year later	2	..	2	13.3
2 years later	..	..	..	..
3 — —	..	..	..	..
4 — —	..	1	1	6.7
	2	1	3	20.0

Table 13.

Recapture locality	Same place	Kigdlut-iluat	Southern Qarajat	Total	%
Distance in km from place of tagging	0	13	5	..	..
Recaptured same year	2	7	..	9	5.6
1 year later	3	6	2	11	6.8
2 years later	..	2	..	2	1.2
3 — —	..	1	..	1	0.6
	5	16	2	23	14.2

Table 14.

Recapture locality	Same place	Kigd-lut-iluat	Íkátoq	Tasi-ussaq	Igdlut-siait	Total	%
Distance in km from place of tagging	0	13	59	27	9	..	..
Recaptured same year	..	4	..	..	..	4	4.2
1 year later	..	9	2	..	..	11	11.5
2 years later	..	3	..	2	..	5	5.2
3 — —	1	4	2	..	2	9	9.4
	1	20	4	2	2	29	30.3

All the recapture-localities are places of ascent for char, where the recaptured fish were taken either in the river itself or near it during the period of ascent. An exception is perhaps formed by Igdlutsiait, which is a summer habitat for char, but in addition there is here a river with a considerable run. It will be seen that as in the Utorqait and Avqússuaq experiments, char from various river systems meet in the summer habitat at Qarajat, even though the majority of the char met with at Qarajat are from the river Kigdlut-iluat. Of the total number of recap-

tures from rivers, 78.7 per cent were captured at Kigdlut-iluat. To this it should, however, be added that more intensive fishing is carried out at this than at the other rivers that may come into question in this connection—though with the exception of Íkátoq, where comprehensive fisheries are carried on during the period of ascent.

None of the char from Qarajat seem to migrate northward, where the nearest large river is found som distance up Ameralik fjord, on the south side, 35 km from Qarajat. At Kobbefjord river north of Ameralik fjord, where tagging experiments have been carried out (see below), no char tagged at Qarajat have been recaptured.

VI. *Kobbefjord experiments* (see fig. 13).

Tagging experiment no. 25 (table 15). October 1, 1954. Captured by electrofishing. Type of tag: yellow and red plastic attached with terylene, red plastic attached with V2A-steel. Number of char tagged: 182, of which 17, or 9.3 per cent, have been recaptured.

Table 15.

Recapture locality	Same place	Mouth of Kobbefj.	Lille Malene	Total	%
Distance in km from place of tagging	0	16	23	..	..
Recaptured 1 year later...	10	..	2	12	6.6
2 years later.....	1	2	1	4	2.2
3 — —	..	..	..	..	..
4 — —	1	..	..	1	0.5
	12	2	3	17	9.3

Tagging experiment no. 30 (table 16). May 23, 1955. Electrofishing. Type of tag: red plastic attached with terylene. A total of 81 char were tagged, of which 5, or 6.2 per cent have been recaptured.

Table 16.

Recapture locality	Same place	Mouth of Kobbefjord	Total	%
Distance in km from place of tagging	0	16	..	..
Recaptured same year	4	..	4	4.9
1 year later.....	..	..	..	..
2 years later	..	..	..	..
3 — —	..	..	..	..
4 — —	..	1	1	1.2
	4	1	5	6.1

Tagging experiment no. 41. August 24, 1955. Capture by electrofishing. Type of tag: red plastic attached with terylene. Fifteen char were tagged, one of which (= 6.7 per cent) was recaptured in the same. year and the same place.

Tagging experiment no. 42 (table 17). September 30, 1955. Capture by electrofishing. Type of tag: red plastic attached with terylene and V2A-steel. A number of 42 char were tagged, 9 of which, or 21.4 per cent, have been recaptured.

Table 17.

Recapture locality	Same place	Mouth of Kobbefjord	Total	%
Distance in km from place of tagging	0	16–19	..	..
Recaptured 1 year later	5	2	7	16.7
2 years later	1	..	1	2.4
3 — —	1	..	1	2.4
	7	2	9	21.5

Tagging experiment no. 52. October 15, 1956. Electrofishing. Type of tag: red plastic attached with terylene. Twenty-five char tagged, none recaptured.

The tagging experiments show that the char of Kobbefjord during their stay in the sea in summer hardly migrate southwards across Ameralik fjord to Qarajat, but chiefly northwards to bays at the mouth of Kobbefjord and to Lille Malene bay near Godthåb[1]).

VII. *Kapisigdlit experiments.*

In Kapisigdlit river at the inner part of Godthåb Fjord a total of 189 char were marked in the years 1952–1956. All the char were captured in fresh water either by electrofishing, seine fishing, or spinner fishing. Up to January 1, 1959, a number of 51, or 27.0 per cent, had been recaptured. All the recaptures were made in or near the same river up to four years after the tagging.

Julianehåb district.

VIII. *Narssaq experiments.*

In Narssap-ilua and Tunugdliarfiup-ilua in the Julianehåb district tagging experiments have been carried out i. a. to ascertain whether

[1]) After the completion of the manuscript for the present paper a report was received stating that a char tagged in Kobbefjord river had been recaptured at Eqaluit, which is located on the south side of Ameralik fjord right at its mouth. We are here, no doubt, concerned with a casual migration to another river.

migration takes place between the two rivers located at a distance of 21 km from one another. Of 372 char tagged at Narssap-ilua, all the recaptures, totalling 86, were made in the same place. Seventy-three char were recaptured in the same year in which the tagging took place. At Tunugdliarfiup-ilua, where 166 char were tagged, 25 were recaptured in the same year and place, while three were recaptured at Narssap-ilua. These three migrators were captured and tagged in the early summer in sea water off the mouth of Tunugdliarfiup-ilua and recaptured in the same summer during their run in Narssap-ilua. Thus it would seem that migration of fish from one of the two rivers to the other may take place, though the experiments suggest that such migrations are rare.

Migrations to other rivers.

As shown by the tagging experiments, the char is a fish with a well-developed "homing instinct". Normally the char will return every year to the same river to spawn (or to winter without spawning). So far, however, no tagging experiments have been made with parr to ascertain whether they return to the river in which they grew up. From the tagging experiments carried out with adult char in fresh water (totalling 2,111 char), 434 or 20.6 per cent have been recaptured in the tagging river 0 to 4 years later. 44 or 2.1 per cent have been recaptured in their summer habitats in sea water 0 to 5 years later, while only 7 or 0.3 per cent migrated to other rivers. It must therefore be regarded as exceptional that the char migrate to other rivers, even though such migrations may occasionally take place. Of the 441 char tagged in rivers and recaptured in rivers, only 7, or 1.6 per cent, have been recaptured in other rivers than that in which they were tagged.

Distances of migration.

The longest distance covered by a char, as shown by the tagging experiments, is 62 km. The char in question had been tagged at Ritenbenk and was recaptured at Jakobshavn. On the whole recaptures of char in their summer habitats in the sea show that they rarely move more than 50 km from their native river. In table 18 the distances covered by tagged char are recorded. It will be seen that during their stay in the sea, the majority of the char keep within a distance of 10–25 km from their native river. Thus, 86.4 per cent of the char which were not taken in the locality in which they were tagged or less than 5 km from it, had migrated less than 30 km from their native river.

Table 18. Char recaptured 5 km or more from locality of tagging.

Distance migrated in km	5–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	Total
Number..	11	60	19	25	13	4	3	4	4	1	3	1	148
%.....	7.4	40.5	12.8	16.9	8.8	2.7	2.0	2.7	2.7	0.7	2.0	0.7	99.9

Fishing intensity.

The total recapture percentage of 22.9 for the tagging experiments with char carried up to January 1, 1959, furnishes no suitable basis for an estimation of the fishing intensity. The figure is computed from experiments made from 1949 to the end of 1958, so the recaptures from the first experiments must be assumed to have ceased, while from the last experiments a large number of recaptures will probably continue to be made in the coming years. Moreover, the tagging was carried out in highly different localities. Thus, for instance, tagging experiments have been carried out in rivers in which fishery is normally rare, and just as high recapture percentages cannot be expected from such rivers as from rivers in which a comprehensive professional fishery is going on. Similarly, tagging experiments have been made in rivers in which electrofishing frequently takes place, and thus a larger number of recaptures have been secured than would have been the case if the recaptures were due to the fishing of the Greenlanders alone. The tagging experiments in the individual rivers, however, may furnish information of the fishing intensity, even though, unfortunately, we do not know the amount of the professional fishery in the particular rivers.

In the professional exploited rivers in which tagging experiments have been made, rather intensive fishing would seem to be carried on. Thus an experiment at Kangerdluarssúnguaq in the Sukkertoppen district gave a recapture percentage of 39.8 per cent in the course of well over five years. Of these, 26.3 per cent were recaptured already the next year, when about half the number were taken in the summer habitats in the sea, while the other half were taken during fishery for ascending fish near the river. It may be added, however, that fishing for char in the summer habitats in the sea is hardly going on with the same intensity after the introduction of new preservation regulations, according to which seine fishery for char is prohibited.

At the Sangmissup-itivnera river in the Sukkertoppen district, where the Greenlanders from the nearby village carry on rather intensive

professional fishery, an experiment showed a recapture percentage of 49.3 in the course of three and a half years, while another experiment in the same place showed a recapture percentage of 31.0 after one year. In the first experiment 18.8 per cent, in the second experiment 14.8 per cent of the tagged fish were recaptured in the lake immediately after being tagged, so quite possibly the Greenlandic salmon fishermen made greater efforts to capture the tagged char shortly after the tagging, owing to the reward paid for recaptures.

In the two tagging experiments with char made within the same district in the summer habitats in the sea, 44.9 and 63.4 per cent, respectively, of the tagged fish were recaptured three years later. About one-fourth of these were recaptured the same summer during their run up the river.

At Kigdlut-iluat in the Godthåb district a tagging experiment showed 20.7 per cent recaptures in the course of a little more than four years, and another experiment 20.0 per cent in the course of well over three years. Inconsiderable professional fishery for char, but rather intensive fishing for salting and home consumption are carried out in this river.

Thus it would seem that rather intensive fishing for char takes place near the rivers where professional fishing is carried out, notably if the slow growth of the char is taken into consideration. Thus for instance, an examination of the professional captures at Kangerdluarssúnguaq in 1955 showed that 86.6 per cent of the catch came within the age groups 8 to 15 years, the majority in the 10-year group (cf. JØRGEN NIELSEN, 1956c).

In Kobbefjord river near Godthåb fishing for char is for the most part sport fishing. It is not uncommon, however, that permanently engaged Greenlanders go to the river during the weekend to secure char for winter stores by net fishing, and net fishing of the Kobbefjord stock, is likewise carried on in the early summer in a bay near Godthåb (see fig. 13). Nevertheless the recapture percentage for this river are much lower than for professionally exploited rivers. Thus a tagging experiment gave a recapture percentage of 9.3 in the course of little more than four years, and another experiment gave 6.2 per cent in little less than four years. Similarly, analyses of the char population in this very short river has shown that in the autumn it harbours an exceptionally good population of spawning fish.

As previously mentioned, no satisfactory statistics of the captures are available for the rivers in Greenland, which statistics in connection with the tagging experiments might form a basis for more far-reaching computations of the fishing intensity. But the recapture percentages alone show distinctly that as for the professionally exploited rivers where

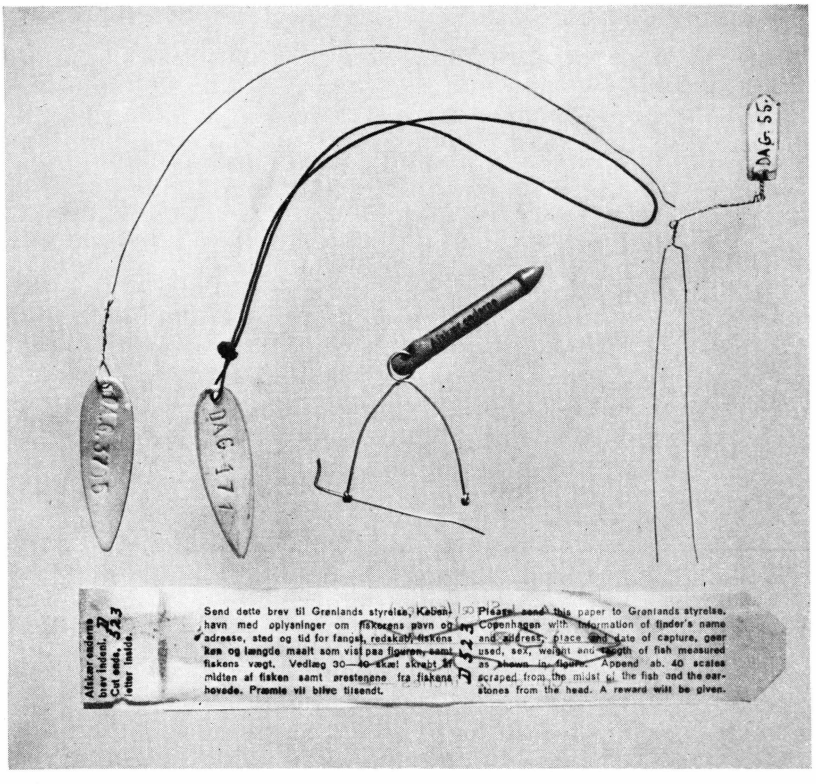

Fig. 14. Various types of tags employed in tagging of char in Greenland. From left to right, plastic tag with V2A-steel, plastic tag with terylene, Norwegian hydrostatic tag (Lea tag), and Swedish tag (Carlin tag). At the bottom, the slip of paper enclosed in the Lea tags.

tagging experiments have been made, very intensive fishing is carried on. Still, only a small number of the Greenland salmon rivers are exploited professionally.

Comparison of the various types of tags.

In the tagging experiments with char, three different types of tags have been employed: Norwegian hydrostatic tags (Lea tags), plastic tags, and tags of the Swedish type (Carlin tags) (see fig. 14). All these tags were attached to the base of the anterior edge of the dorsal fin. The Lea tag was fastened with a wire clamp and wire through the back. The plastic tags (yellow, red, and blue tags have been employed) were fastened either with terylene, a synthetic polyester fibre (most often black spinner line of breaking strength 11 lbs.) or wire, of which two types have been used: ordinary stainless steel wire (diameter 0.40 mm) and a special surgical wire, the so-called V2A wire (diameter 0.35 mm).

Table 19.

Comparative tagging experiments on char. The types of tags employed are as follows: hydrostatic tags (Lea), yellow and red plastic tags attached with steel wire (PSY and PSR), and yellow and red plastic tags fastened with terylene (PTY and PTR).

Date	Number of char tagged	Number recaptured	Recapture percentage	Type of tag	Number of char tagged	Number recaptured	Recapture percentage	Recaptured									
								Same year		1 year later		2 years later		3 years later		4 years later		5 years later	
								Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
July	31	14	45.2	PTY	12	3	25.0	1	8.3	2	16.7	..	..	..	..	..	..	..	..
1952	..	..	..	Lea	19	11	57.9	3	15.8	5	26.3	2	10.5	0	0.0	1	5.3	..	..
June	38	16	42.1	PTY	19	7	36.8	4	21.1	2	10.5	1	5.3	..	..	..	..	..	..
1953	..	..	..	PSY	19	9	47.4	3	15.8	3	15.8	2	10.5	1	5.3	..	..	..	..
Sept.	118	47	39.8	PTR	18	6	33.3	0	0.0	6	33.3	..	..	..	..	..	..	..	..
1953	..	..	..	PTY	78	23	29.5	0	0.0	16	20.5	2	2.6	5	6.4	..	..	..	..
	..	..	..	PSY	22	18	81.8	0	0.0	9	40.9	2	9.1	4	18.2	2	9.1	1	4.5
Aug.	101	28	27.7	PTY	5	0	0.0	..	..	..	..	..	..	..	..	..	..	..	..
1954	..	..	..	PTR	58	13	22.4	10	17.2	2	3.4	1	1.7	..	..	..	..	..	..
	..	..	..	PSR	38	15	39.5	8	21.1	3	7.9	2	5.3	2	5.3	..	..	..	..
Oct.	182	17	9.3	PTY	151	9	6.0	0	0.0	8	5.3	1	0.7	..	..	..	..	..	..
1954	..	..	..	PTR	12	1	8.3	0	0.0	1	8.3	..	..	..	..	..	..	..	..
	..	..	..	PSR	19	7	36.8	0	0.0	3	15.8	3	15.8	0	0.0	1	5.3	..	..
Oct.	184	38	20.7	PTY	110	9	8.2	0	0.0	6	5.5	3	2.7	..	..	..	..	..	..
1954	..	..	..	Lea	74	29	39.2	0	0.0	15	20.3	10	13.5	3	4.1	1	1.4	..	..
Sept.	42	9	21.4	PTR	23	2	8.7	0	0.0	2	8.7	..	..	..	..	..	..	..	..
1955	..	..	..	PSR	19	7	36.8	0	0.0	5	26.3	1	5.3	1	5.3	..	..	..	..
Total	Plastic/terylene				486	73	15.0	15	3.1	45	9.3	8	1.6	5	1.0	..	..	.	..
	Plastic/steel				117	56	47.9	11	9.4	23	19.7	10	8.5	8	6.8	3	2.6	1	0.9
	Lea				93	40	43.0	3	3.2	20	21.5	12	12.9	3	3.2	2	2.2	..	..

The Carlin tag and the blue plastic tag have only been employed in such recent experiments that they are not included in the subjoined comparisons of the applicability of the tags and fastening designs; experiments carried out later than 1955 are not included.

Table 19 is a survey of seven comparative experiments carried out from 1952 to 1955. In these comparative experiments, various types of tags and fastening methods were employed in the tagging of char within the same size groups at the same time and place. In 1957 and 1958 additional experiments for comparison of the different types of tags were made, but these experiments are of such a recent date that

a fairly large number of recaptures to supplement the results may still be expected. However, the recaptures from these experiments in 1957 and 1958 already show results agreeing with the experiments described here. In the other taggings only one type of tags has, as a rule, been used in the individual experiments. The recapture percentages for the different types of tags are accordingly not directly comparable for all the tagging experiments together, but, as will appear from table 3 (p. 28), the re-

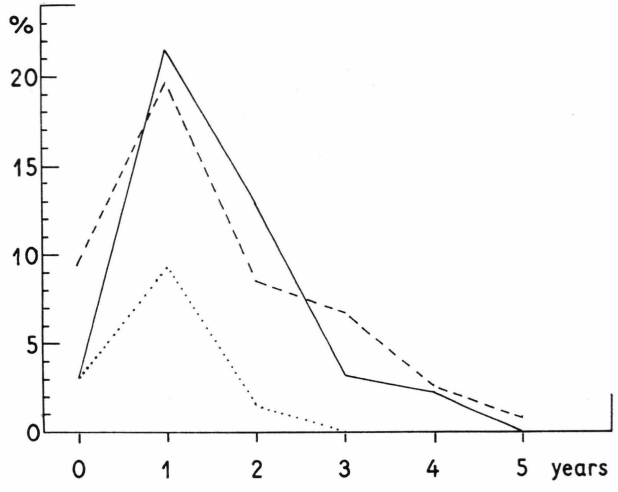

Fig. 15. Recapture percentages of char marked with tags of various types. Full line: Lea tags, stippled line: plastic tags attached with wire, and dotted line: plastic tags fastened with terylene.

capture percentages for the various types of tags seem to show that plastic/terylene altogether give fewer recaptures than the other types of tags.

As regards the colours of the plastic tags, no very great difference in the recapture results for the yellow and the red plastic tags have been noted. But the material by which they are fastened to the fish, evidently plays an important role. Fig. 15 shows—still for the comparative experiments in the period 1952 to 1955—the recapture percentages in the various years after the tagging, for Lea tags (full curve), plastic tags attached with wire (stippled curve), and plastic tags fastened with terylene (dotted curve). As to the recaptures the same year, there is no great difference between the various types of tag. And the agreement is even greater than shown by the curves; for the various experiments were carried out partly in the summer and partly in the autumn. As for the autumn experiments, no recaptures can be expected in the same year—and none have been made, either. Since the different types of tags were not employed in the same mutual proportions in the summer

and the autumn experiments, a comparison of the two series of experiments will give misleading percentages for the recaptures within the same year. Actually, the recapture percentages of the same year for the summer experiments alone were 16.0, 19.3, and 15.8, respectively. It is only for the recaptures in the years after the tagging that there is a decisive difference between the three different types of tags. Already the succeeding year the plastic/terylene tags proved to give much fewer recaptures than the other two types, and no recapture of

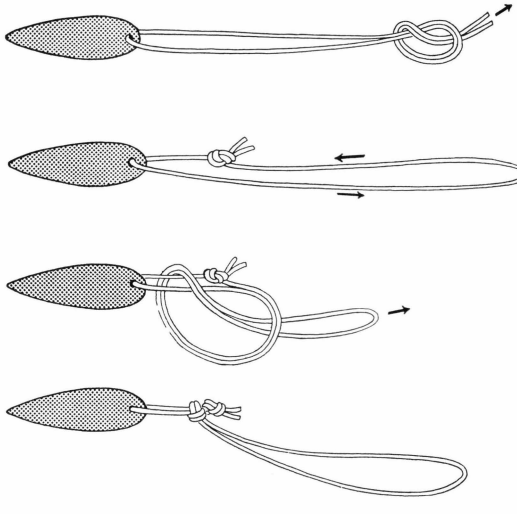

Fig. 16. Type of knot for fastening plastic tag with terylene.

fish tagged with plastic/terylene has been made more than three years after the tagging. As for the other two types, there seems to be no great difference, though the plastic/steel type seems to give more recaptures than the Lea tags three years or more later. According to table 3 (p. 28), however, the Lea tags seem to give the greatest number of recaptures among small fish.

In the recaptured char which I have had an opportunity to examine, the wound around the terylene would seem to heal up just as well as around steel wires, but quite possibly the terylene knots will loosen during the stay of the fish in the water. An ordinary reef-knot on a terylene thread, even if tightened very hard, will, as a rule, loosen already after twenty-four hours in water, while the special knot employed in the fastening of the plastic tags with terylene in the experiments in question, have in several case proved to last for three years (see fig. 16). As a considerable part of the recaptured char were taken in nets, and since fish tagged at the dorsal fin with tags fastened with

Table 20.

Results of recaptures up to July 1, 1959, of small cod marked with different types of tags at the same time and in the same place in 1951.

Type of tag	Number tagged	Number recaptured	Recapture percentage
Plastic/terylene	216	8	3.7
Plastic/steel	67	9	13.4
Lea	193	19	9.8

Table 21.

Results of recaptures up to July 1, 1959, of small cod tagged with different types of tags at the same time and in the same place in 1955.

Type of tag	Number tagged	Number recaptured	Recapture percentage
Plastic/terylene	144	17	11.8
Plastic/steel	100	18	18.0

steel wire will, no doubt, more easily be retained in the nets than fish with tags fastened with terylene, this will undoubtedly also contribute to a higher recapture percentage for the wire-tagged fish.

It may be added that corresponding comparative experiments have been made with 213 specimens of salmon parr *(Salmo salar* L.*)* in Greenland. These experiments with the same three types of tags exhibit recapture results agreeing with those of the above-recorded experiments with char. Similar conditions were also found by comparative tagging experiments with small cod in Greenland (tables 20 and 21).

Summary.

Tagging experiments with char in Greenland have been made in order to provide information of the "homing instinct" of this species, its migrations in the sea, and its growth. In the present paper the data obtained by these experiments as regards the growth of the char are not mentioned.

In the years 1949–1958 a total of 2,602 specimens of char were tagged; up to January 1, 1959, 596 of these, or 22.9 per cent, had been recaptured. The longest interval between tagging and recapture hitherto ascertained is five years. The experiments show that the char with very few exceptions

will return to the same river year after year. The longest distance covered, and ascertained so far, is 62 km, but as a rule the char do not migrate very far from their parent river during their summer stay in the sea. Of the recaptured char not taken in the place of tagging, 86.4 per cent had, during their stay in the sea, migrated less than 30 km from their parent river. The fishing intensity seems to be high in rivers in which professional fishing is carried on. In the paper a survey is taken of the types of tags employed, including a discussion of their advantages and drawbacks.

IV.

AGE AND GROWTH OF THE FRESH-WATER STAGE OF ANADROMOUS CHAR, SALVELINUS ALPINUS (L).

The present paper is the record of an investigation of the age and growth of the fresh-water stage of the anadromous form of the Greenland char. During one year samples have been collected from the river Kigdlut-iluat south of Godthåb (63°53′ N., 51°22′ W.) with a view to a study of the nutrition and growth of the char parr in fresh water. If possible, the samples were collected every month, but in the winter months of December–April it was impossible to collect samples owing to the ice-covering and too much snow around the river.

The following samples were collected from Kigdlut-iluat:

Sample	I – Nov. 17, 1956	80	specimens
—	II – May 4, 1957	78	—
—	III – July 16, 1957	134	—
—	IV – Aug. 7, 1957	66	—
—	V – Sept. 4, 1957	67	—
—	VI – Oct. 19, 1957	64	—
	Total ...	489	specimens

Furthermore, a sample of 30 alevins of char was collected in the same place on April 15 and 17, 1956, and a sample of 75 small char, judging by the size of the fish they were for the most part fry from the same summer, was collected on August 17, 1956. As the fish from these samples were preserved in formalin, reading of their age from their otoliths is impossible.

Some few samples of juvenile char have occasionally been collected from other rivers in the Godthåb and Sukkertoppen districts. Samples were likewise collected in four rivers in East Greenland in the summer of 1959. These samples will be dealt with separately in the last chapter of this paper (p. 70).

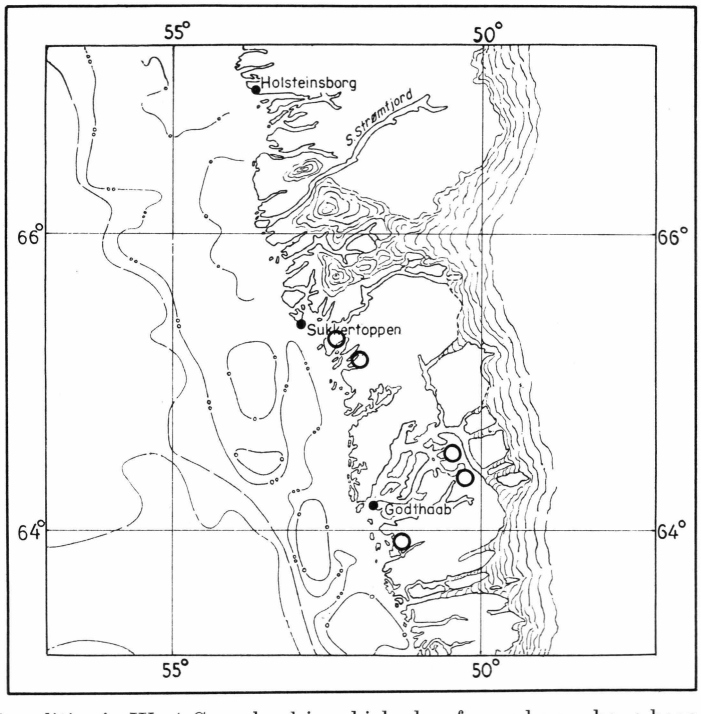

Fig. 17. Localities in West Greenland in which char fry and parr have been collected by electrofishing in rivers.

A. West Greenland.

Sampling localities.

The sampling localities in West Greenland are indicated in the map in fig. 17. The majority of the samples were taken in the Kigdlut-iluat river, located about 40 km south of Godthåb. This river, about 11 km long, takes its rise from two lakes situated at an altitude of ca. 500 m above the sea. Near the sea the river passes through a lake about 2 km long. In the 700 m stretch of the river from this lake to the sea, where spawning places for char have been found, most of the collections were made. About 8 km from the seashore the river forms a fall up beyond which the char do not pass.

In its lower course the river is 10–15 m broad. In summer the flow of water is 60 m^3 per minute, at the most, but it may be much higher at springtime. Above the fall to which the char ascend the river runs through barren rocky ground. Below the fall as far as the lake it passes through a flat meadow and swampy terrain. The river bottom is here chiefly made up of gravel. From the lake down to the coast the river flows through a mountain valley with a vegetation of *Empetrum*, *Salix*,

and *Betula nana*. The river bottom here consists predominantly of solid rock and large stones.

As a rule the lake freezes up at the beginning of October, the river some time later. The lake is most often covered with ice till the beginning of June, while the river as a rule breaks up when thaw sets in about

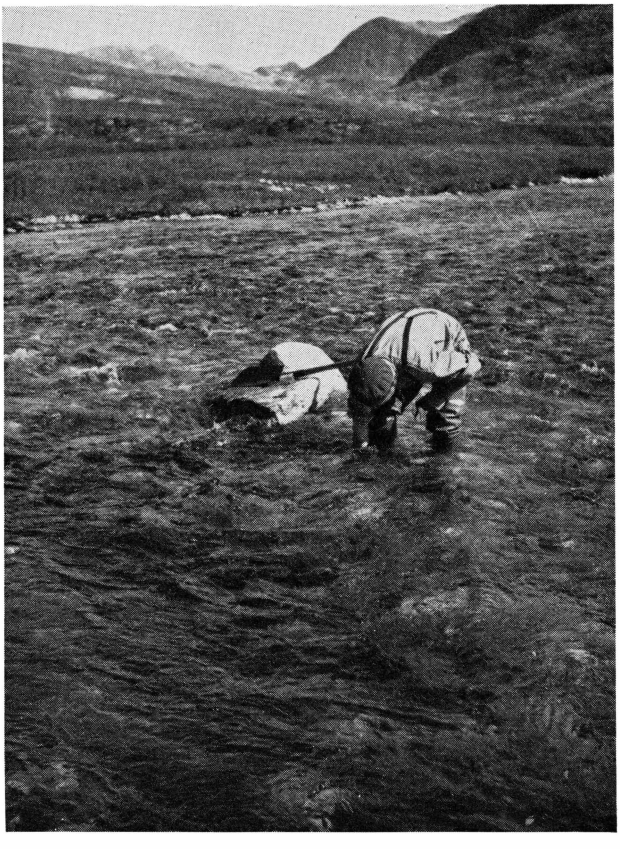

Fig. 18. Kigdlut-iluat. River section above the lake, photographed in July.

May 1st. In winter a great many open spaces are usually found in the lower course of the river, while above the lake the river is most often entirely covered by ice and snow (cf. figs. 18 and 19).

Temperature measurements have been made whenever the river was visited during the years 1954–58; they amount, however, to only 13 mesaurements. The temperatures are recorded in fig. 20, and a temperature curve was drawn freehand, regard being paid to temperature measurements in other rivers with similar temperature conditions. The temperature measurements inserted were made in the lower course of the river. Above the lake the temperatures of the river are lower in

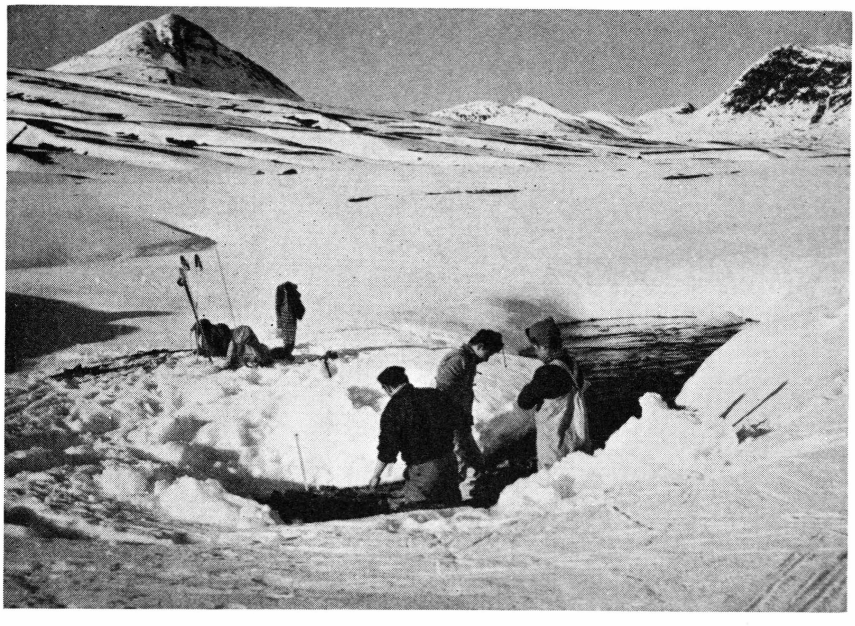

Fig. 19. Kigdlut-iluat. Same place as in fig. 18, photographed in April.

spring and autumn, the growth season in the upper sections of the river being accordingly a little shorter than in the lower course. The lowermost lake acts as a heat reservoir.

The river harbours a population of anadromous char which is fairly large for its size, and land-locked char of slow growth are likewise met with in the lake and the river. The Greenlanders have for many years carried on summer fishery in this river during the period of ascent. The output of this fishery is difficult to ascertain, for the greater part of the catch is not bought from the Greenlanders, but is used for private consumption in salted or dried conditions. The size of the char captured in nets is usually about 45 cm (total length from the tip of the snout to the tip of the caudal fin), and its total weight is about 1 kg.

Of other fish, only three-spined stickleback (*Gasterosteus aculeatus* L.) is found in the river.

In addition, small samples of char parr have been collected from two rivers falling into Godthåb Fjord, viz. Kapisigdlit (64°26′ N., 50°12′ W.) and Amitsuarssuk (64°33′ N., 50°27′ W.). The river at Kapisigdlit is the only river in Greenland in which the salmon (*Salmo salar* L.) is positively known to spawn. Judging by direct observations during electrofishing, char parr in this river seem to be ousted by salmon parr and smolt. In fig. 7 (p. 18) a curve is drawn on the basis of scattered temperature measurements carried out in the years 1952–58. This curve,

too, must be accepted with great reserve, for temperature measurements are only at hand from 28 dates. The summer temperature is somehwat higher in Kapisigdlit than in Kigdlut-iluat, and similarly, the duration of the growth season seems to be almost one month longer in Kapisigdlit than in Kigdlut-iluat. This difference is probably due to the fact that Kapisigdlit river passes through a system of large lakes, which act as heat reservoirs, and the location of the river in the interior of a fjord in contrast to that of Kigdlut-iluat at the outer coast, must exert some influence on the summer temperature.

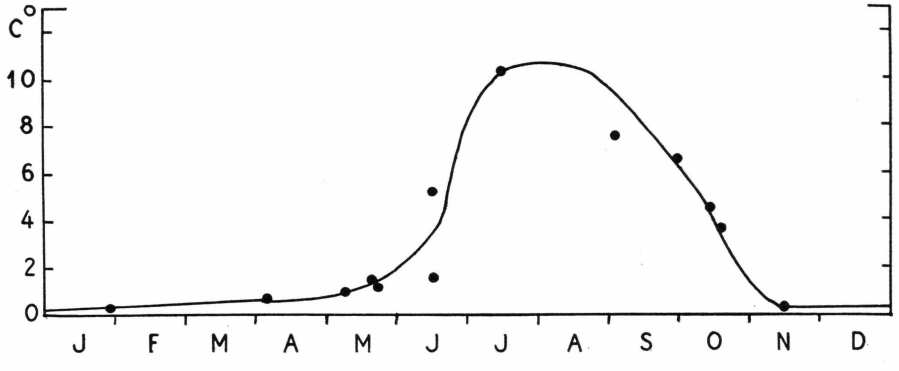

Fig. 20. Temperature curve for Kigdlut-iluat.

Collections of char parr are further at hand from two rivers located in the Sukkertoppen district, viz. Qôrqut (65°12′ N., 52°07′ W.) and Amitsuarssuaralak (65°20′ N., 52°20′ W.). All the localities mentioned are indicated on the map in fig. 17.

Measurements of the hydrogen ion concentration have been made in all the above-mentioned rivers, where it ranges about 5–5.5. The conductivity of the water in Kigdlut-iluat is 122 μmho, and in Kapisigdlit 24 μmho (at 20 degrees centigrade).

Methods of collecting.

For the collection of alevins of char, a plastic tube about 2 m long and about 15 mm in diameter was used as a syphon. In the other collections of small char a portable electrofishing apparatus (fig. 10, p. 27) was used. The apparatus, of a total weight of about 50 kg, consists of a light metal Sachs-Stamo engine which works a direct current generator of an efficiency of 300/500 volt and 3 ampere. This apparatus has turned out to be particularly suitable in Greenland rivers, but only in quite small rivers is it possible to carry out such effective fishing as would be required for a precise counting of the stock. In larger swift-flowing rivers too many fish will, if stunned, be carried away by the current

before they can be taken with the dip net. Similarly, barring of certain sections of such rivers will be impossible.

Electrofishing for small char in Kigdlut-iluat was carried out in the lower part of the river along the stretch from the sea to the lake (apart from the sample from August 17, 1956). On such occasions electrofishing has not been carried out along the whole of this stretch of the river, but random small broads in which the small char are known to be most numerous and most easily captured, have been selected. If the river was ice-covered, the fisheries were restricted to the few scattered openings in the ice- or snow-covering. Accordingly the samples collected, as will be seen later, were hardly representative in regard to the distribution of the age classes. As to the size of the fish within the different age groups, however, there is reason to assume that a representative selection has been obtained, though with the exception of the first two age classes, of which principally the largest individuals have, most likely, been secured.

The char collected were treated as soon as possible after their capture. The length of the fish (always the total length, that is, the length from the tip of the snout to the tip of the upper flap of the caudal fin) was measured in millimetres. In most cases the fish were weighed (in tenths of grammes), their stomach contents were weighed and examined, the otoliths were taken out and determined as to age, and the sex was, as a rule, determined. It was noted down whether the fish had a typical parr dress, or it was silvery. If the samples could not be taken to the laboratory of the Greenland Fisheries Investigations at Godthåb shortly after the capture, is was impossible to weigh them.

Determination of age.

For determination of the age of both juvenile char and adult char exclusively the otoliths were used.

Several authors have used the scales of the char for age determinations (DAHL 1926, SLASTNIKOV 1935, DUSSART 1952 and 1954, SPRULES 1952, MARTIN 1955). SLASTNIKOV (1935) and DUSSART (1952) give photographs of scales with formation of annuli, but Slastnikov does not regard the scales as suitable for age determinations.

A large material of scales of Greenland char was collected, but the scales turned out to be unfit for determinations of the age of the Greenland char. This may perhaps be due to the circumstance that owing to the very slow growth of the char in this area there will be no distinct formation of annuli in the very small scales. A great many scales were microphotographed, and the distance between the individual circuli was measured and set down in graphic curves to enable us to find out whether there is any difference between "winter" zones with smaller

distances between the circuli and "summer" zones with greater intervals. It has not been possible to demonstrate any regular system within such narrower and broader zones, and nothing at all which showed agreement with the circuli of the otoliths of the same fish. These comparisons were made on scales taken from larger char 8–12 years old. The use of scales for age determinations of the Greenland char has therefore been given up.

Age determination of char by means of the bones of the operculum have been carried out by SLASTNIKOV (1935), who regards the opercular bones as more suitable for this purpose than scales or fin rays. Opercular bones together with otoliths have been collected from some few hundred specimens of Greenland char of all age classes. After cleaning and drying, these bones were examined under the microscope, and showed distinct formation of annuli. In most cases, however, it was impossible to coordinate the number of "winter" rings on the bones of the operculum with the number of rings on the otoliths. Apparently secondary rings, which it is difficult or impossible to distinguish from the normal "winter" rings, are much more frequent on the operculum. Hence, the bones of the operculum likewise proved to be unsuitable for age determinations of the Greenland char.

The possibilities for using scales or the bones of the operculum for determinations of age have been rather thoroughly investigated, for the otoliths are often exceedingly difficult to interpret, and it is easier for not specially trained personnel to collect scales or gill-covers than to collect the small otoliths.

Age determinations of the char by means of the otoliths have been carried out by FRIDRIKSSON (1939), HANSEN (1940), GRAINGER (1953), and ANDREWS and LEAR (1956). In the determinations of the age of the Greenland char the largest of the otoliths, the sagitta, was used. The otoliths vary in size from ca. 0.4 × 0.3 mm in the 0-group to ca. 5.3 × 2.8 mm in the full-grown fish of a total length of 60–70 cm.

Age determinations by means of the otoliths have been made of 6650 Greenland char. Both otoliths were used, if one was not missing or deformed, as may sometimes be the case (plate I, figs. 1–5). With a very few exceptions, agreement between the two otoliths was always ascertained. The otoliths were examined in xylene under a binocular microscope at a magnification of 25 to 40 times and under reflected light. A powerful source of light as near "spotlight" as possible is of great importance for a reliable determination, in particular of the first "winter" rings. The otoliths were examined from the level surface, in very few cases only on a transverse fracture surface. As a rule, grinding of the otolith will be required, and if so, most often and in particular of the central part.

Under reflected light a dark field will be seen in the centre of the otolith, and round this dark field broader light zones ("summer zones") alternating with narrower dark zones ("winter zones") occur. Often dark secondary rings are found, which usually differ from the normal "winter" rings and are distinguishable from these latter. Most often they are narrower and more sharply defined and often they do not form a closed oval. But in some cases it is impossible to distinguish with certainty between normal "winter" rings and secondary rings. A deter-

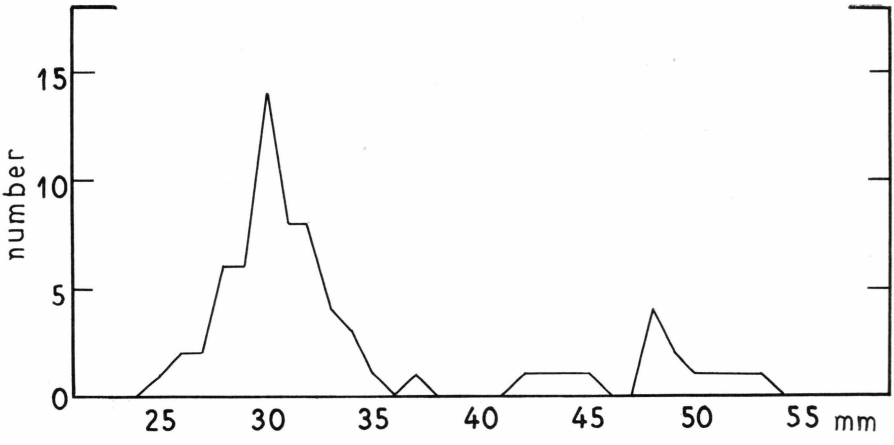

Fig. 21. Size distribution of char fry from a sample from Kigdlut-iluat, August 17, 1956.

mination of the age of char by means of the otoliths will therefore always be subject to some uncertainty, which, however, in the present investigations has not been considered greater than in corresponding age determinations of many other fish. Almost all the otoliths were read by the author, in many cases, in addition, by one or two laboratory assistants. In such cases the readings generally showed good agreement, though with some variation according to the age of the otoliths read. As for otoliths of juvenile char, there is rarely any doubt as to the age.

Some uncertainty apparently prevails as regards the interpretation of the dark central core of the char otolith. Some authors include the dark central core in the number of "winter" rings, while others do not. In the age determinations of Greenland char recorded below, the central core is not included, the winter rings being accordingly counted as shown in plate I, fig. 5. In Greenland the spawning season of char is September–October, and the eggs are hatched about April 1st. When the yolk-sac is used up, the alevins are about 20–25 mm long. The otolith will then have been formed, it is now almost circular, and will have a diameter of 0.2–0.3 mm. It was impossible to secure the otoliths from

Table 22.

Measured sample of 25 alevins from Kigdlut-iluat, April 15, 1956. Yolk sac but slightly absorbed. At the same time a number of not yet hatched eyed eggs were collected. On April 17, 1956, two specimens of small char 20 mm long, and 3 small char 21 mm long, with the yolk sac almost absorbed, were captured in the same place.

mm	Number	
13	1	
14	2	
15	0	
16	3	
17	1	Average length: 18.6 mm.
18	1	
19	3	
20	9	
21	5	

such small char if these had not been preserved in formalin, and if so, the otoliths could not be read. The smallest char whose age was determined were 35–40 mm long (in October–November). As compared with the measured sample from August (fig. 21) and that of small char alevins from April (table 22), char of this size must be taken to be hatched in the spring and accordingly to belong to the 0-group (one summer old).

In the age readings, the 0-group comprises fish hatched in the spring and till about one year old next April 1st, after which date they belong to the 1-group until succeeding April 1st, when they will be about 2 years old, etc. The otoliths of these 35–40 mm long char have a dark central core, around this a light-coloured "summer" zone, and otoliths of fish from October–November in addition, in the extreme outer edge, an initial formation of "winter" rings (plate I, figs. 4–5). Figs. 1–5 in plate I show otoliths of different ages.

Age distribution and age at first migration.

In the char samples collected such specimens as had stayed in the sea were separated out. These are, as a rule, recognisable not only from their size, but also from their appearance. Thus, after a stay in the sea they will be more or less silvery, dependent on whether at the particular time they have just returned to the river, or they have stayed there for some time. The adult fish may have assumed their spawning dress during their stay in the fresh water.

Non-migratory char, as stated above, likewise occur in Kigdlut-iluat, as in most other Greenland rivers. Whether the difference between migratory and non-migratory char is genotypic or phenotypic, has not been established. However, experiments made by me have shown that

non-migratory char tolerate direct transfer to sea-water. Non-migratory char from Kigdlut-iluat have been taken directly from the river and placed in sea-water, where they have been kept alive for more than 48 hours, after which they were tagged and released in the sea near the mouth of the river. One was recaptured in the river after one year. After attaining a certain age, the anadromous and the non-migratory form can be readily distinguished from one another, either on the basis of the appearance and shape of the fish, the location of the annuli on the otoliths, or the rate of growth. On the collection of small char for examination of the fresh-water stage, all non-migratory char recognisable as such were sorted out from the samples.

Among the char parr proper, that is, fish up to 4–6 years old, two forms differing as to their conditions of growth do not, apparently, occur. It must be regarded as probable, also, that during the first years of their life, non-migratory and anadromous char will have the same growth. The difference in growth will not set in till after the stay of the anadromous form in the sea. If a young char does not migrate to the sea at the age at which migration normally takes place, but remains as a non-migratory fish in fresh-water, its growth as compared with that of the anadromous form will be retarded, though in different degree, according to the character of the water system and the nutritive conditions. From this retardation in growth of non-migratory fish it follows that the annuli of the otoliths will be of a different character and will be located at closer intervals. If a char remains in the river after the normal age of migration, it seems in no case to migrate to the sea later on, for this would, at any rate, be recognisable on the otoliths of the adult anadromous char, of which 5,000 from Greenland have been examined.

Thus, both non-migratory and anadromous fish would, no doubt, have developed later on from the char parr found in the samples, though by far predominantly the latter, for the number of non-migratory char in Kigdlut-iluat is quite low as compared with the number of anadromous char. Since, as mentioned above, there is hardly any difference in growth between the parr of the two forms, the samples collected undoubtedly provide a reliable picture of the growth of the anadromous char parr.

On the other hand, the samples secured can hardly be regarded as absolutely representative in regard to the distribution of the year-classes within the individual samples. In first place, the smallest char parr—that is to say, at any rate the 0- and the 1-groups—will be only sparsely represented in the samples. These small fish are difficult to secure by electrofishing. For the electric current hardly affects the small fish as strongly as the larger ones, and the small parr moreover easily disappear among the pebbles of the river bottom when paralysed by the electric current. If the 0-group is at all represented in the catch,

it will only be in the autumn, when the fish have attained a size of about 40 mm. Secondly, the age composition will depend in some measure on the degree to which the electrofishing is concentrated about the quite shallow areas, where principally fry and parr of the first two age classes occur, while the larger parr and smolts are found in a little deeper and more swift-flowing water. As previously mentioned, the character of most of the rivers in Greenland does not permit the barring of a limited section of the river for effective and thorough fishing. Similarly, in winter electrofishing will have to be restricted to such parts of the river in which the natural conditions give rise to small openings in the ice- and snow-covering. What areas will be thoroughly fished by collecting char parr, will likewise depend in some measure on the person or persons undertaking the electrofishing. In the particular experiments, the fishing was carried out by three different persons.

Table 23.

Average age, length, and weight for the individual samples of char parr from Kigdlut-iluat.

Sample	I	II	III	IV	V	VI
Date	17/11 1956	4/5 1957	16/7 1957	7/8 1957	4/9 1957	19/10 1957
Average age in number of winters	1.99	3.73	2.40	2.09	2.70	2.42
Average length in mm	89.5	107.5	76.0	75.7	110.7	93.5
Average weight in grams	8.06	12.49	3.94	3.77	23.34	12.52

In table 23 a comparison is made between the various samples. Thus, the average age, length, and weight of the fish found in the individual samples are shown. Apart from sample II, the average age varies less than nine months, and a number of the differences in length are due to the different seasons of the year at which the samples were taken. Sample II, however, contains much larger and older fish than the other samples. The difference in the length of the specimens is even greater between this and the other samples than is indicated by the average figures, for sample II dates from the beginning of May, when the summer increase had not yet set in. This may be due to the spring flood of the river at this time, which makes even bigger parr, possibly owing to the heavy flood, take refuge in small sheltered coves, where the electrofishing was carried out. Furthermore, there will naturally be a decrease of the average age and average length from sample II to sample III, if, as will be mentioned later, a migration of smolt took place in the interval between the taking of the two samples. Sample V, too, shows a somewhat

greater average length than the other samples. This sample is characteristic by containing some few big fish, resulting in a rise of the average length for this sample.

An estimate of the representative value of the samples may be made on the basis of fig. 22. This figure shows graphically the percentage distribution of the various year-classes in the individual samples. As the char parr will hardly migrate to the sea before reaching an age of three years, at the earliest, as will be seen later, it might be expected

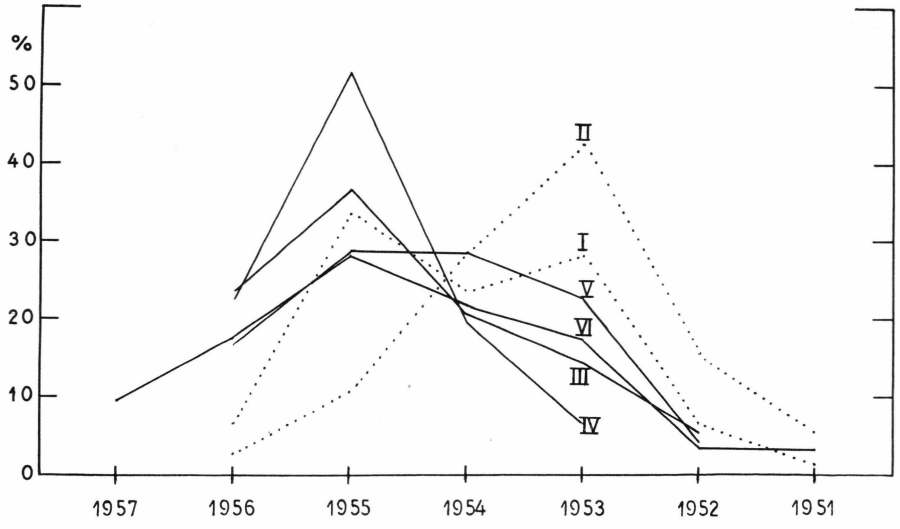

Fig. 22. Percentage age distribution of char parr in various samples from Kigdlut-iluat.

that even at different times of the year representative samples would give a tolerably uniform distribution of the first three year-classes. This is not altogether so, i. a. for the reasons mentioned above. However, the number of the 1954 year-class (fish three years old in 1957) is almost constant for the various samples. This also applies to some extent to the 1955 year-class with the exception of sample II, which, as mentioned above, contained relatively few small fish, and sample IV, which contained many small fish and shows a somewhat greater number of 2-year-old fish than the other samples. Sample I and II, from November 1956 and May 1957, differ distinctly from the remaining samples by containing a comparatively large number of the 1953 year-class and older fish. This is most probably due to a migration of a number of 4-year old (year-class 1953) and older fish in the interval between the taking of samples II and III, that is, in the period between May 4 and July 16.

Although the available samples from Kigdlut-iluat are not fully representative on account of the aforementioned deficiencies of the

collecting technique, which it was impossible to remedy under the circumstances, still the particular samples may form a basis for determination of the growth of the char parr and the age at the first migration. The duration of the river life cannot be read from the otoliths of the Greenland char, as may be done from the scales of e. g. salmon and trout. In Greenland it has not been possible, either, to set weirs in the rivers for catching char smolts during their migration to the sea. Hence, it has been necessary to try to determine the age at the first migration on the basis of the samples at hand.

The rather sparse literature available on char supplies only scanty information on the duration of the river life prior to the migration. YESSIPOV (1935) and SLASTNIKOV (1935) say about the char of Novaya Zemlya that "the char enters the sea for the first time in its third, rarely in its fourth year". DAHL (1926) states that the char of Spitsbergen chiefly migrate as 2-year-old (43 %) and 3-year-old (50 %), only few as 4-year-old (7 %) fish. As for the char of Iceland, STEWART (1951, 1957), who has studied the anadromous char of Hrutafiorðará, gives the age at migration as two to three years. As to Arctic Canada, GRAINGER (1953) says that the char in Frobisher Bay, Baffin Island, are 5–7 winters old when they migrate. Since in calculating the age, Grainger regards the dark central core of the otolith as representing the first winter, these age determinations correspond to an age of 4–6 years as indicated in the present paper. Finally, the age at migration of char in Greenland is recorded by PAUL HANSEN (1940) as probably 4 years.

Table 24.

Distribution according to age of char parr in the samples from Kigdlut-iluat.

Sample	I 17/11 1956	II 4/5 1957	III 16/7 1957	IV 7/8 1957	V 4/9 1957	VI 19/10 1957	Total	%
Age								
0–0+	5	..	..	..	..	6	11	2.2
1–1+	27	2	32	15	11	11	98	20.0
2–2+	19	8	49	34	19	18	147	30.1
3–3+	23	19	27	13	19	14	115	23.5
4–4+	5	33	19	4	15	11	87	17.8
5–5+	1	12	7	..	3	2	25	5.1
6–6+	..	4	..	..	..	2	6	1.2
	80	78	134	66	67	64	489	99.9

As no parr older than six years have been found in the rivers, the char must be assumed to migrate at that age, at the latest. It will be seen from table 24 that the sample from October 19th contained two

six-year-old fish. As they can hardly be expected to migrate till the succeeding spring, char smolt may perhaps in rare cases migrate at an age of seven years, but it is more likely that these two six-year-old char will be non-migratory. Even five-year-old fish are so sparsely represented in samples taken after May 4th that the greater number of char would seem to migrate as smolts at an age of five years, at the latest.

At what time of the year the char smolts migrate to the sea, has not been definitely ascertained, but direct observations in the rivers and on the occurrence of char smolts in the sea indicate that the migration takes place in the early summer. During the whole first summer the char smolts apparently remain quite near the river mouth, probably migrating to and fro between the fresh water and the sea, for silvery smolts with food animals from the tidal zones of the river mouth in their stomach contents may be captured in the river throughout the summer. In summer, shoals of very small silvery char, which judging by their size must be assumed to have migrated to the sea the same summer, are often seen in the sea near the river mouth, but in very few cases only have more than some few specimens been captured. However, char parr younger than three years have never (at any rate along the west coast of Greenland) been taken in the sea, and three years must therefore be regarded as the minimum duration of the fresh-water life of the char parr. The distribution according to age and the length range for four such samples of char parr captured in the sea are given in table 25. The fish were captured by hand-seines hauled ashore at the seaside. As will appear from the table, a fairly large number of these parr migrated to the sea even as three-year-old fish; it should be pointed out, however, that the last-mentioned three of these samples are derived from the southernmost part of Greenland, where the growth season is longer than at Kigdlut-iluat and the age at first migration therefore perhaps lower.

Table 25.

Percentage age distribution of small char captured in the sea.

Locality	Quvneq Sukkertoppen	Taylers Havn Ivigtut	Taylers Havn Ivigtut	Tunugdliarfik Julianehåb
Date	24/7 1955	15/7 1937	22/7 1937	10/7 1947
Length in cm ..	10–25	13–18	15–25	11–18
Number.....	34	14	44	19
3+	29.4	42.9	15.9	42.1
4+	44.1	50.0	34.1	42.1
5+	20.5	7.1	43.2	5.3
6+	5.9	..	4.5	10.5
7+	..	..	2.3	..

If we assume that only an inconsiderable number of the parr migrate to the sea at an age of 3 years, the number of 3-year-old parr in the river must be fairly constant all summer, and considering their size, we may expect them to be more uniformly represented in the samples than the smaller 1-year-old and 2-year-old fish.

Table 26.

Distribution of year-classes in the different samples. The 1954 year-class (3-year-old parr in 1957) is fixed at 100, and the numbers of the other year-classes calculated proportionately.

Sample	I 17/11 1956	II 4/5 1957	III 16/7 1957	IV 7/8 1957	V 4/9 1957	VI 19/10 1957
Year-class						
1957	..	..	..	..	..	42
1956	27	11	119	115	54	79
1955	142	42	181	261	100	129
1954	100	100	100	100	100	100
1953	122	174	70	31	79	79
1952	27	63	26	..	16	14
1951	6	21	..	..	..	14

In table 26 the number of the 3-year-old char (year-class 1954) in each sample is taken to be 100, and the numbers of the other year-classes computed in proportion. The number of 1-year-old and 2-year-old parr show rather great variations in the table, but hardly greater than was to be expected if the collecting methods are taken into consideration. Though perhaps with the exception of sample II, in which special conditions, as already mentioned, may have exerted their influence. As to the 4-year-old parr (year-class 1953), a decline has taken place from an average of 148 for the autumn of 1956-spring 1957 to an average of 65 (95% symmetric confidence interval 42–88) for the summer of 1957. This show that the number of 4-year-old fish has decreased between the taking of sample II (May 4) and the later samples, and indicate a migration to the sea of 4-year-old fish.

In fig. 23 the individual fish from all the samples are marked by dots on millimeter paper. The abscissa gives the time at which the samples were taken, and the ordinate the length of the char in millimetres. The individual year-classes are indicated by different symbols. On the basis of the dots, growth curves for the various year-groups were drawn freehand. For the 0- to the 1-year-old fish and the 1- to 2-year-old fish the growth curves are normal, that is to say, increasing gradually, with the strongest increase in summer and a slight or no increase in winter.

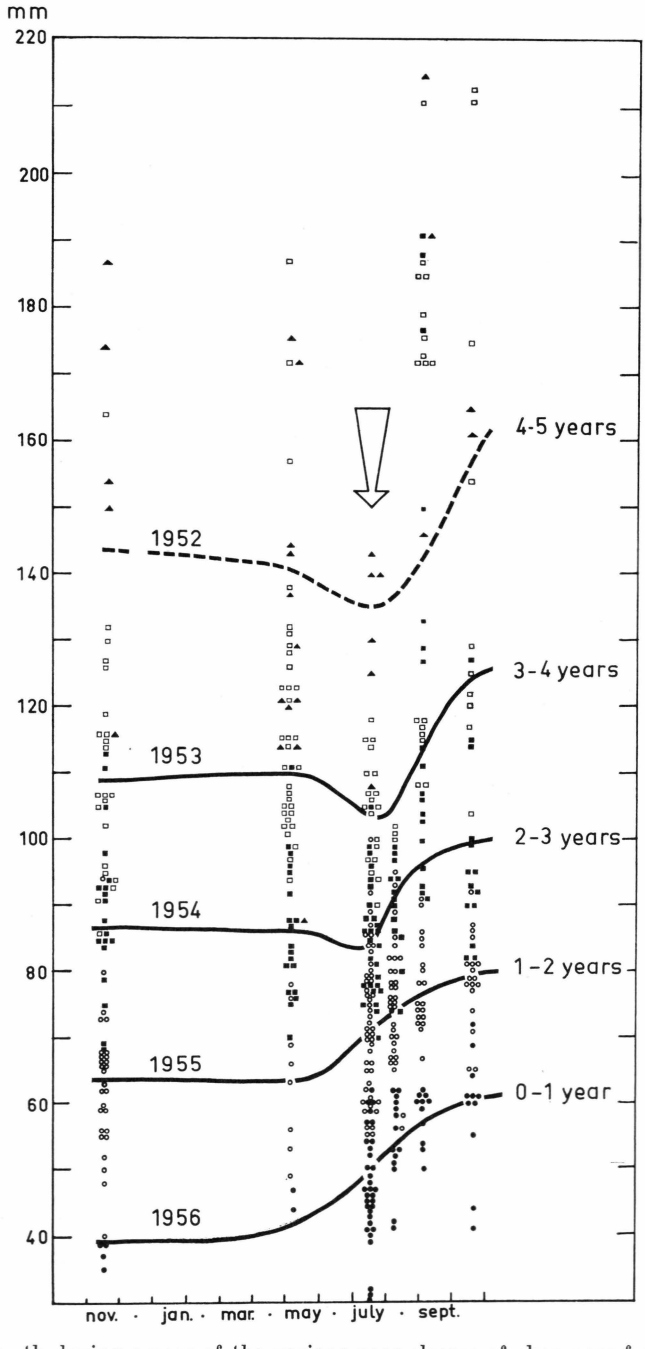

Fig. 23. Growth during a year of the various year-classes of char parr from Kigdlutiluat. • year-class 1956, ○ year-class 1955, ■ year-class 1954, □ year-class 1953, ▲ year-class 1952.

For the 2- to 3-year-old fish a fall in the growth curve is noticeable between May and July, which can only be explained by the assumption that a number of the largest fish of this year-class have migrated from the river in the interval between the two dates. The fall of the growth curve is less than for the next two year-classes, accordingly it must be assumed that the number of fish migrating at an age of about three years, is less than the number of 4–5-year old migrators.

Thus it would seem that the char at Kigdlut-iluat for the most part migrate to the sea at an age of four or five years. Judging by table 25, it would seem that in other (more southerly?) rivers a fairly considerable migration of char takes place already when they are about three years old.

Growth.

Calculation of the growth of char parr on the basis of the otoliths was attempted in a small number of parr. However, the method has been abandoned again, it being often difficult to detect a sharp dis-

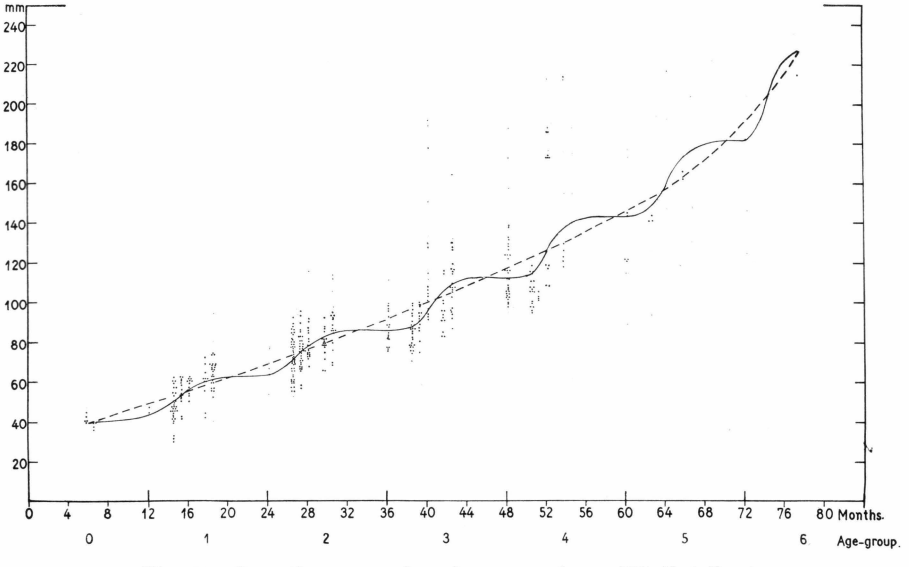

Fig. 24. Growth curves for char parr from Kigdlut-iluat.

tinction between the "winter" and the "summer" rings on the otoliths. The method is, no doubt, also encumbered with certain grave defects if employed on Greenland char. Thus, for instance, it would seem that the length growth of the fish in the early summer sets in some time before the formation of the "summer" ring on the otolith. In this connection it may be mentioned that the ratio between the length of the fish and the breadth of the otolith is rather variable, and that by re-

gression analyses of two samples from two different rivers this relation was found to be different for the two rivers.

In fig. 24 all the char from the samples from Kigdlut-iluat are indicated by dots, with their age in months as the abscissa and their length in millimetres as the ordinate. Two curves were then drawn freehand. The full line illustrates the growth from month to month, while the broken line is an average growth curve. From the full curve it will be seen that the growth mainly takes place in the summer halfyear, as, of course, was to be expected. The growth season ranges from about May/June to November, corresponding to the period in which the temperature of the river exceeds 1°–2° C.

Table 27.

Annual increase in length of char parr from Kigdlut-iluat. Calculated as differences in length between two consecutive year-classes. The number is the smallest number of fish in the two year-classes.

Sample	I 17/11 1956		II 4/5 1957		III 16/7 1957		IV 7/8 1957		V 4/9 1957		VI 19/10 1957		Average mm	Calculated length at
Growth from	Number	mm	Number	mm	Number	mm	Number	mm	Number	mm	Number	mm		
														0 year 25 mm
0+ - 1+	5	24.3	..	..	..	..	..	..	..	..	6	16.9	20.3	1 — 45.3 mm
1+ - 2+	19	25.2	2	18.1	32	24.6	15	20.8	11	22.0	11	19.8	22.6	2 — 67.9 mm
2+ - 3+	19	22.1	8	22.7	27	13.0	13	14.7	19	42.7	14	18.3	22.1	3 — 90.0 mm
3+ - 4+	5	45.0	19	32.1	19	19.9	4	12.2	15	36.1	11	46.6	31.7	4 — 121.7 —
4+ - 5+	1	46.8	12	13.2	7	20.9	..	..	3	25.3	2	19.4	18.6	5 — 140.3 —
5+ - 6+	..	..	4	31.9	..	..	..	..	..	..	2	39.0	34.3	6 — 174.6 —

The mean annual increase in length given in table 27 was computed as differences in length between two consecutive year-classes. The increment is indicated for the individual samples, as is also the number of fish from which the increase was computed. This number is the smallest number of fish in the sample for two consecutive year-classes. Then follows the mean value of the annual increase, and at the extreme right of the table the computed length for the individual years, starting from an estimated length at hatching of 25 mm and gradually adding the calculated annual increases. In fig. 25 these calculated lengths are set out in a growth curve (full line). The growth curve (broken line) in fig. 24 is inserted for comparison.

Relation between length and weight.

All the char from the Kigdlut-iluat samples were weighed in a fresh state in tenths of grammes. A graphic illustration of the relation

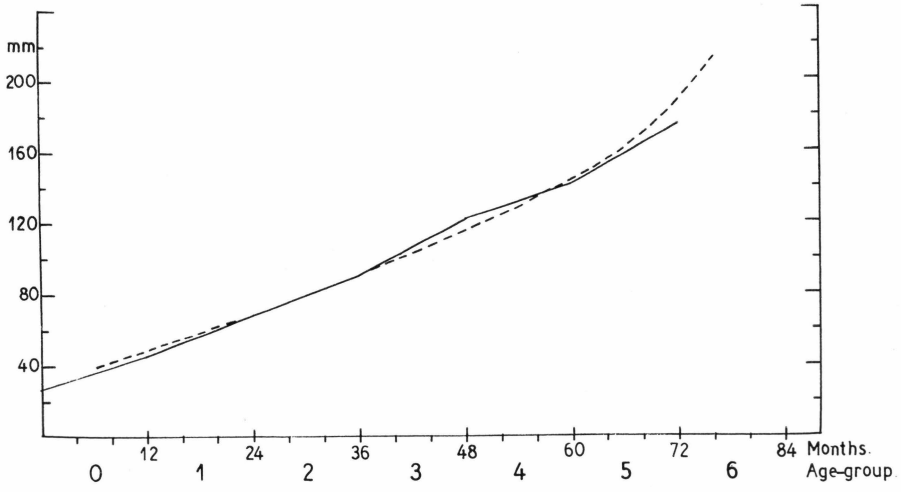

Fig. 25. Growth curves for char parr from Kigdlut-iluat. The full line is a growth curve calculated on the basis of the annual increase in length as shown in table 27. The growth curve given in fig. 24 (stippled line) has been inserted for comparison.

Table 28.

Average weights for char from Kigdlut-iluat.

Length in mm	Number	Weight in gram.
30– 39	9	0.4
40– 49	31	0.6
50– 59	42	1.3
60– 69	61	2.1
70– 79	75	3.3
80– 89	63	4.7
90– 99	58	6.5
100–109	42	8.8
110–119	34	11.2
120–129	22	15.0
130–139	8	19.9
140–149	7	24.6
150–159	5	30.0
160–169	4	40.0
170–179	12	53.4
180–189	7	70.5
190–199	2	72.5
200–209	2	124.5
210–219	4	99.0
220–229	–	–
230–239	1	107.0
Total	489	

between the length and the weight of the individual samples shows very nearly identical curves, though, as might be expected, with a slight

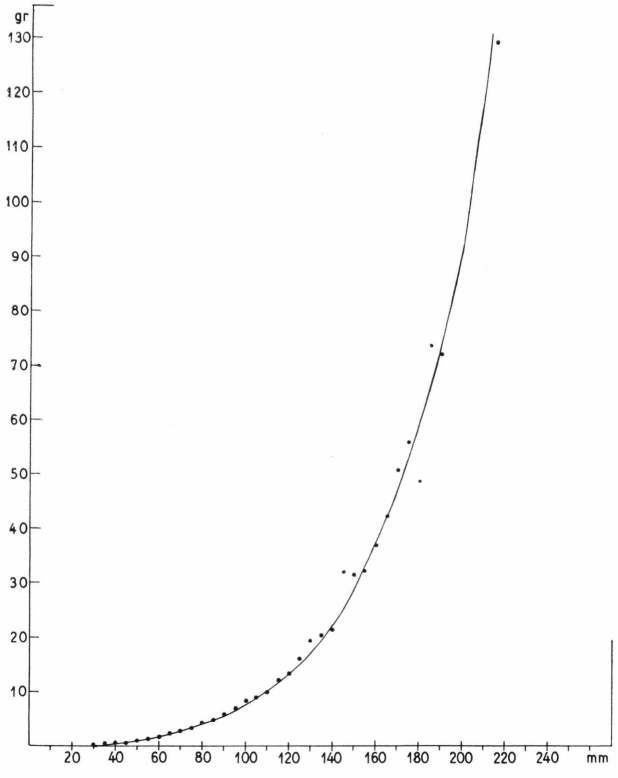

Fig. 26. Length-weight relationship for char parr from Kigdlut-iluat.

tendency to a greater weight in proportion to the length of the late summer samples. In table 28 the mean weights for all the samples

Table 29.

Coefficient of condition for char parr from Kigdlut-iluat.

Sample ...	I 17/11 1956	II 4/5 1957	III 16/7 1957	IV 7/8 1957	V 4/9 1957	VI 19/10 1957	I–VI
mm							
30– 59....	85	81	62	77	82	62	71
60– 89....	79	81	69	82	86	85	78
90–119....	76	75	69	77	86	83	77
120–149....	74	77	68	..	109	85	80
150–179....	75	76	..	..	115	93	95
180–209....	76	80	..	..	123	..	103
210–239....	..	..	..	..	114	89	99
Average ...	79	78	67	80	95	82	

together are given for 10 mm groups. The relation is shown graphically in fig. 26. The coefficient of condition (K = 100 × gram/cm^3) was computed for the individual samples for 30 mm groups and is indicated in table 29. It will be seen that the coefficient of condition shows a tendency to increase in the course of the growth season, and as a rule it likewise increases with the size of the fish.

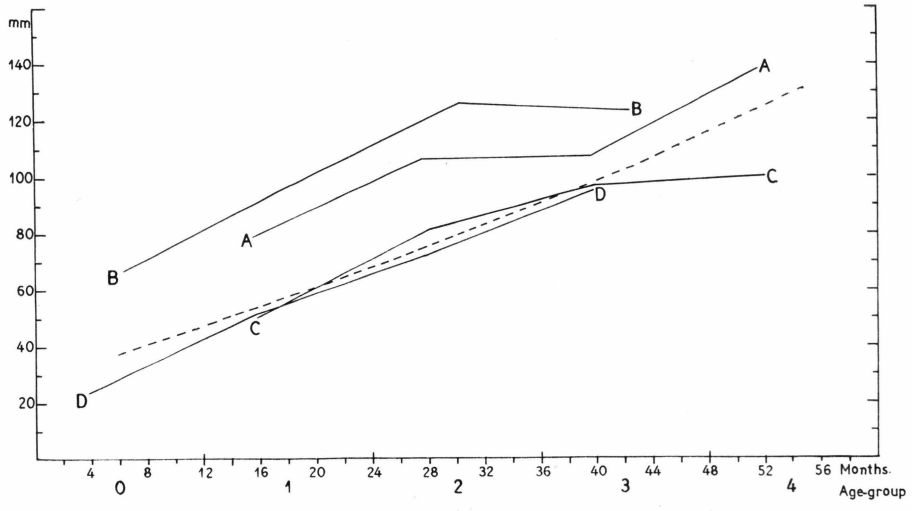

Fig. 27. Growth curves for char parr from various rivers in West Greenland. A: Amitsuarssuk, B: Kapisigdlit, C: Amitsuarssuaralak, D: Qôrqut, stippled line: Kigdlut-iluat.

Other rivers.

Samples of char have only been collected from the west coast from four rivers in addition to Kigdlut-iluat and with a single exception these samples are quite small. Two of them are derived from the Sukkertoppen district, the other two from the Godthåb district (see fig. 17). The distribution of year-classes in the samples does not differ very much from that found in the samples from Kigdlut-iluat, and the age at migration, therefore, is probably almost the same as in Kigdlut-iluat. In fig. 27 a comparison of the growth curves for the different populations is made. These growth curves were drawn on the basis of the mean lengths of the different year-classes and will accordingly depend on the time of summer at which the samples were taken. Curve A is from Amitsuarssuk, Godthåb, July 14, 1955, curve B from Kapisigdlit, Godthåb, October 8, 1955, sample C from Amitsuarssuaralak, Sukkertoppen, July 22, 1955, and sample D from Qôrqut, Sukkertoppen, July 21, 1955. Finally, the stippled curve is the growth curve for Kigdlut-iluat shown in fig. 24. For the rivers in the Sukkertoppen district, the growth of the parr does not differ very much from that in Kigdlut-iluat. Curves A

and B, however, show a somewhat more rapid growth, characterised by a higher-lying curve with a somewhat steeper inclination. As shown by the temperature curves in figs. 7 and 20, the duration of the growth season is longer at Kapisigdlit river and probably also in the nearby Amitsuarssuk than in Kigdlut-iluat.

B. East Greenland.

Only some few and random samples of char are avilable from the east coast of Greenland. The first sample from the east coast was collected in the summer of 1957, when some small char were taken with hand-

Table 30.

Age composition of char parr from sea-water, taken at Eqalungmiut. Length from 60 to 179 mm.

Age	Number	Per cent
1+	2	8.5
2+	11	47.8
3+	9	39.1
4+	1	4.3
	23	

seine in sea-water off the mouth of Eqalungmiut river (63°28′ N., 41° 56′ W.). The age composition will appear from table 30. This sample proved to be of particular interest, for it consisted for the main part of 2-year-old fish, which might indicate that in East Greenland the char migrate to the sea for the first time at a younger age than at the west coast. At the outset it seemed rather improbable that the majority of the char of the east coast should migrate at an age of 2 years, considering that char younger than three years have never been captured in the sea along the west coast. The migration age of the char is presumably determined, among other factors if not exclusively, by the size of the char at migration. To my knowledge no studies of the optimum temperature of the char parr are available, so possibly it is of no great importance for the growth of the fresh-water stage that the rivers in East Greenland do not reach as high temperatures as the West Greenland rivers; but it is probably of importance for the growth that the growth season with temperatures above 1°–2° C in East Greenland is shorter than in West Greenland. In 1959 I visited the particular place myself, but in spite of repeated attempts I did not succeed in catching any small char in the sea. However, the place where the sample was taken in 1957, was pointed out to me. It is true that it is located outside the river mouth proper, but the fjord is quite shallow a long distance outside

this point, and at ebb-tide large stretches are dry. Thus, at ebb-tide the char parr may perhaps go outside the river mouth in the almost fresh water without actually migrating and without the consequent fysiological transformations taking place. Personally I had, unfortunately, no opportunity to examine the fish from the sample taken in 1957, so it has not been established whether these char were silvery smolts, or whether they still retained their parr dress. It is doubtful, therefore, whether in this case an actual migration of smolt has taken place. As will be mentioned below, the other samples from the rivers of the east coast do not point to a very much lower age at first migration than that of the char of the west coast.

Unfortunately we did not succeed in securing samples of small char from other sea localities in East Greenland. But in 1959 four samples of char parr were collected from the following rivers within the Angmagssalik district: Outer Sehested (62°59′ N., 41°36′ W.), August 14, Tasîssârssik (65°49′ N., 37°13′ W.), August 25, Âmagâ (65°37′ N., 37° 40′ W.), September 9, and Angmagssalik (65°36′ N., 37°38′ W.), September 10. The samples from the last-mentioned two rivers contained parr as well as silvery smolts, while these latter did not occur in the samples from the first-mentioned two rivers. Most likely the char which migrated to the sea as smolts in the summer of 1959, and perhaps also in the previous summers, had returned to the rivers for wintering in the interval between August 25 and September 9. Since during the first summer spent by the char smolts in the sea, the 8–10 large dark parr marks along the sides of the fish are distinctly visible below the silvery smolt dress, and since the smolts after their return to the fresh water for wintering gradually loose some of the bright silvery tint, it was impossible in the last-mentioned two samples to distinguish with absolute certainty between non-migratory parr and smolts which had returned from the sea; still, there have been only few cases of doubt.

Localities in which collections were made.

With the exception of Tasîssârssik, the other three East Greenland rivers are moderately large rivers which pass through one or more lakes. Outer Sehested river is of the size of Kigdlut-iluat, while Âmagâ river and Angmagssalik river are a little smaller. Tasîssârssik river is a small short river, which does not pass through any lake, but flows directly from two glaciers down to the fjord. The length of the river is only a little over two kilometres. No temperature measurements carried out at different times of the year are available from any East Greenland river, but readings made in various rivers in August, when the river temperature must be taken to reach maximum, have been from 4.2° to 10.5° C. Thus, the East Greenland rivers apparently fail to reach as

Table 31.
Age distribution of char parr in four East Greenland rivers.

Locality	Outer Sehested	Tasîssârssik	Âmagâ		Angmagssalik	
			Parr	Returned smolts	Parr	Returned smolts
Age						
0+	..	18	..	..	..	..
1+	34	30	20	0	9	0
2+	15	33	4	1	11	0
3+	9	24	15	4	13	0
4+	13	12	2	28	4	6
5+	4	5	1	27	1	13
6+	3	2	0	7	0	5
Total	78	124	42	67	38	24

high temperatures as the rivers in southern and middle West Greenland. Similarly, the growth season, when the river temperature is above 1°–2° C, must be somewhat shorter in the East Greenland rivers than in West Greenland, as the summer on the east coast, owing to the East Greenland polar current, is colder and shorter than on the west coast, due to the warm Atlantic current which flows up along this coast. The melting of the snow and the succeeding rise of the temperature of the rivers will therefore set in later on the east coast.

Age at migration.

In table 31 the age composition of the four samples is tabulated; in the last two a distinction is made between parr, which have not yet migrated to the sea, and parr that have been in the sea, but have returned to the river to pass the winter there (here termed returned smolts). As stated above, this distinction is not absolutely reliable. The age composition indicates that the migration of smolts takes place when they are three to six years old, as is also the case in the west coast rivers. If we compare the number of char not yet migrated, and returned smolts in the last two samples in the table, it will be seen that a single char from Âmagâ river migrated to the sea at an age of only two years, but that the migration chiefly seems to take place when the char are four years old. No three-year-old char from Angmagssalik river had visited the sea the same summer, while 21.1 per cent of 3-year-old fish from Âmagâ river migrated the same summer.

Growth.

Fig. 28 shows the growth curves for the four samples. The curve for Kigdlut-iluat is given in broken line for comparison. As stated in

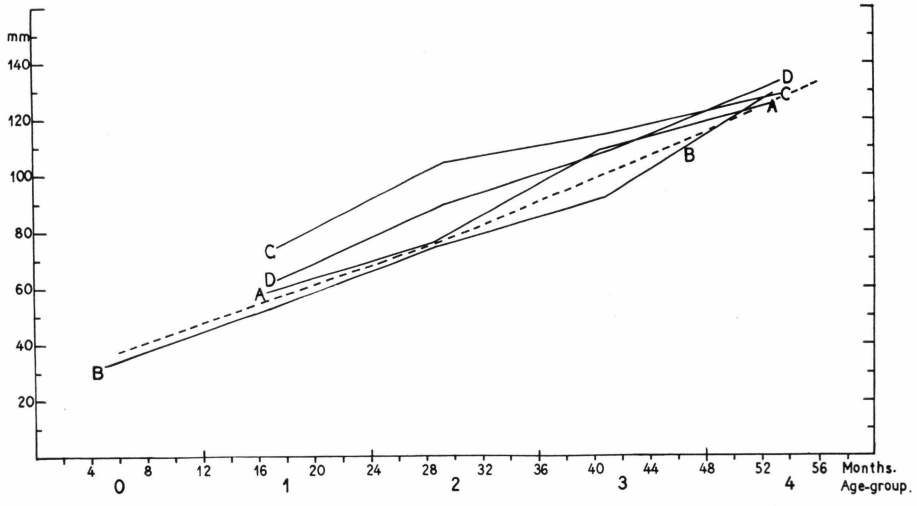

Fig. 28. Growth curves for char parr from various rivers in East Greenland, with growth curve for Kigdlut-iluat (stippled line) inserted for comparison. A: Outer Sehested, B: Tasîssârssik, C: Âmagâ, D: Angmagssalik.

the chapter on the growth of the west coast char, growth curves drawn exclusively on the basis of samples taken in the late summer will show a slightly higher average than a curve based on samples taken all the year round. It appears from the curves that the growth of the char in the East Greenland rivers does not differ essentially from the growth of the char parr in Kigdlut-iluat being more rapid rather than slower. Only the Tasîssârssik river presents a somewhat slower growth than Kigdlut-iluat, which may be due to the small size of the river and the absence of lakes, which may act as heat reservoirs.

Summary.

The present paper is an account of an investigation of the age and growth conditions of char parr in Greenland, especially in Kigdlut-iluat river south of Godthåb. After a description of the localities and methods for collecting (pp. 50–54), the methods for age reading (p. 54 ff.), for which the otoliths were employed, are explained. It is demonstrated that the small char as a rule stay for four to five years in the river before migrating. The migration apparently takes place in the early summer, May–June. The growth is illustrated through growth curves (figs. 24 and 25). The length/weight relationship is given in fig. 26 and table 28. Samples of char parr from four other West Greenland and four East Greenland rivers have been examined. Growth curves for the char populations in these rivers are given in figs. 27 and 28.

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Færdig fra trykkeriet den 19. maj 1961.

Plate 1.

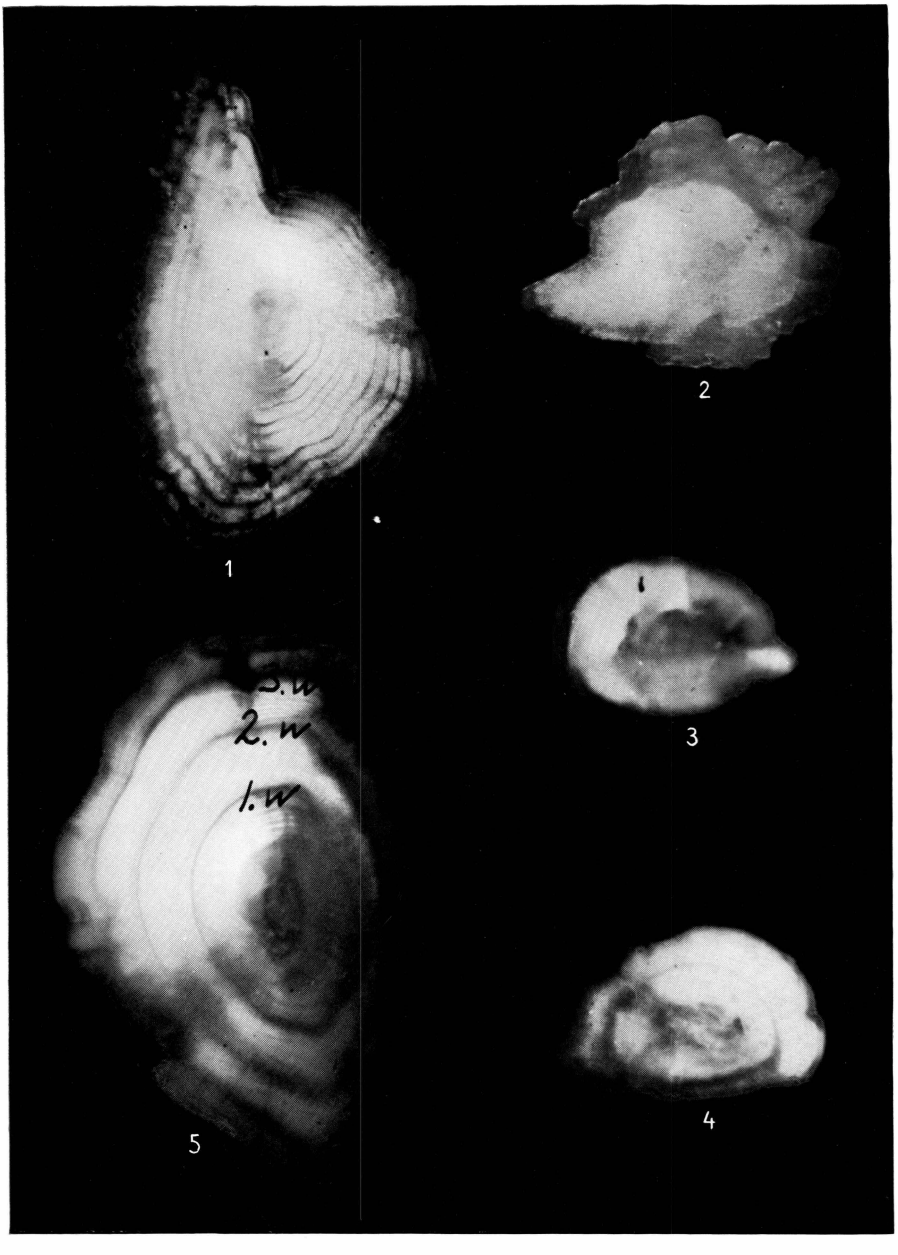
Fig. 1. Otolith of anadromous char, 60 cm, 12 years.

Fig. 2. Deformed otolith of char.

Fig. 3. Otolith of char parr, 48 mm, 1 year old. In the edge of the otolith, "winter" ring and initial stage of second "summer" ring.

Fig. 4. Otolith of char parr, 52 mm, captured in November. Age 1+, with initial "winter" ring in the edge.

Fig. 5. Otolith of char parr, 114 mm, taken in November. Age 3+, with initial "winter" ring in the edge.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