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# Commercial Fishing Potential for Searun Arctic Charr, Koukdjuak River and Nettilling Lake, Northwest Territories

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1991

## Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2120

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Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2120

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# COMMERCIAL FISHING POTENTIAL FOR SEARUN ARCTIC CHARR, KOUKDJUAK RIVER AND NETTILLING LAKE, NORTHWEST TERRITORIES

by

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This is the 21st Manuscript Report

from the Central and Arctic Region, Winnipeg

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Cat. no. Fs-97-4/2120E ISSN 0706-6473

Correct citation for this publication is:

KRISTOFFERSON, A.H., R.D. SOPUCK, and D.K. McGOWAN. 1991. Commercial fishing potential for searun Arctic charr, Koukdjuak River and Nettilling Lake, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 2120: v + 38 p.

## TABLE OF CONTENTS



## LIST OF FIGURES

## LIST OF TABLES



## LIST OF APPENDICES

## ABSTRACT

Kristofferson, A.H., R.D. Sopuck, and D.K. McGowan. 1991. Commercial fishing potential for searun Arctic charr, Koukdjuak River and Nettilling Lake, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 2120: v + 38 p.

The commercial fishing potential for searun (anadromous) Arctic charr of the Koukdjuak River and Nettilling Lake was evaluated based on fishing history and biological data gathered during 1974-77. Koukdjuak River charr are relatively slow growing. Fishing in Nettilling Lake proper yielded heavily parasitized nonanadromous charr. Searun charr of excellent quality were harvested during the upstream migration in the Koukdjuak River on the fishing grounds near Nikku Island. Gillnets proved successful in harvesting approximately 22 000 kg of charr annually over the four-year period. An apparent failure of the 1976 fishery was attributed to harsh environmental conditions which resulted in poor condition of the fish and an early upstream migration, some of which was missed by the fishermen. A Schaefer mark-recapture estimate of the number of charr in the 1976 upstream migration suggests a run of approximately 126 000 anadromous charr ≥ 45 cm in length. This is believed to be a conservative estimate, given the evidence that the run was already in progress at the time tagging began. The strong performance of the fishery in 1977 suggests no decline in abundance since 1976. Thus, an annual harvest of about 22 000 kg does not appear to have been detrimental to the stock. Therefore, a Safe Harvest Level (SHL) of 22 000 kg, round weight, is recommended for the anadromous Arctic charr stock of the Koukdjuak River and Nettilling Lake at this time.


Key words: abundance; anadromous migrations; commercial fishing; experimental fishing; river fisheries; Salvelinus alpinus.


## RESUME

Kristofferson, A.H., R.D. Sopuck, and D.K. McGowan. 1991. Commercial fishing potential for searun Arctic charr, Koukdjuak River and Nettilling Lake, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 2120: v + 38 p.

On évalue la possibilité de pêcher commercialement l'omble chevalier (anadrome) de la rivière Koukdjuak et du lac Nettilling à partir des relevés de prises et données biologiques recueillis entre 1974 et 1977. La croissance de l'omble de la rivière Koukdjuak est relativement lente. L'omble non anadrome pêché dans le lac Nettilling même était fortement parasité. De l'omble anadrome d'excellente qualité a été capturé au cours de la montaison dans la rivière Koukdjuak, sur les territoires de pêches près de l'île Nikku. A l'aide de filets maillants, on a capturé environ 22 000 kg d'omble par année pendant les quatre années. L'échec apparent de la pêche en 1976 a été attribué aux rudes conditions environnementales, qui ont produit un poisson de qualité médiocre et une montaison précoce que les pêcheurs ont manquée en partie. Une évaluation, par la méthode marquage-recapture de Schaefer, du nombre d'ombles compris dans la montaison de 1976 laisse croire que ce nombre s'élevait à environ 126 000 ombles anadromes de ≥ 45 cm de longueur. On croît qu'il s'agit d'une évaluation prudente, étant donné que la montaison était déjà en cours au début du marquage. La forte prise de 1977 indique que la population n'a pas diminué depuis 1976. Ainsi, une prise annuelle de 22 000 kg environ ne semble pas avoir eu d'effet nuisible sur la population. Par conséquent, on recommande pour le moment un taux de capture sécuritaire (SHL) de 22 000 kg, poids brut, pour la population d'omble chevalier anadrome de la rivière Koukdjuak et du lac Nettilling.


Mots-clés: abondance; migrations anadromes; pêche commerciale; pêche expérimentale; pêche en rivière; Salvelinus alpinus.

## INTRODUCTION

Nettilling Lake is the largest lake in the Canadian Arctic Archipelago (Oliver 1964) and, with a surface area of 5699 $km^2$, the sixth-largest in Canada. Roughly triangular in shape, it is located at 66°30'N, 70°55'W on south-central Baffin Island (Fig. 1). The northeast and south shores border on the Precambrian Shield while the west side is underlain by Ordovician sedimentary rock. The lake is drained by the Koukdjuak River which flows 80 km west through the Great Plain of the Koukdjuak into Foxe Basin. From the lake to the sea the river drops approximately 30 m. With a minimum width of 1.6 km, it is about 4 km wide at the outlet of the lake. Along most stretches the current is fast. The main inlet to Nettilling Lake is the Amadjuak River, which enters Burwash Bay at the southern end of the lake. Several large unnamed rivers enter the lake from the northeast and east. For a detailed description of the area see Oliver (1964).

The fish fauna of Nettilling Lake consists of three species: Arctic charr, *Salvelinus alpinus* (L.); ninespine stickleback, *Pungitius pungitius* (L.); and threespine stickleback, *Gasterosteus aculeatus* L. (Thomson 1957; Oliver 1964). The Arctic charr is the only species of economic importance. Thomson (1957) suspected that the charr of Nettilling Lake consisted of a searun (anadromous) and a "landlocked" (nonanadromous) form. He based this assumption on apparent differences in growth rates, size and age at maturity, colour, and some other characteristics although conclusive evidence was lacking at the time.

Since the early 1960's numerous attempts have been made to establish a commercial fishery for Arctic charr at this location. This report provides an assessment of the commercial fishing potential for searun Arctic charr of the Koukdjuak River and Nettilling Lake based on biological data collected during the 1974-77 commercial fishery and on the fishing history to date. Recommendations for future development are made.

## MATERIALS AND METHODS

### HISTORY OF THE FISHERY

The first attempts at commercial fishing for Arctic charr in Nettilling Lake occurred in the early 1960's. Exploratory gillnet fishing, sponsored by Canada's Department of Indian Affairs and Northern Development (DIAND), and involving the Fisheries Research Board (FRB) of the Department of Fisheries, was carried out over three seasons, 1963-65 inclusive, to assess the potential for a commercial charr fishery (Budgell 1967). What follows is a summary of Budgell's (1967) description of the fishery.

Fishing crews, in 1963, were located at Amadjuak River and Burwash Bay at the south end of the lake, Mirage Bay at the north end of the lake and the Koukdjuak River on the west shore, (Fig. 1). Results from the fishery in the lake indicated an abundance of charr; however, the high incidence (40%) of parasitic infestation (*Diphyllobothrium* spp.) of charr caught in the lake and the generally poor quality of the fish made their commercial value somewhat questionable. In contrast, fishermen based at Koukdjuak River found evidence of an upstream migration of searun charr that were quite suitable for marketing. Unfortunately, the termination of air transportation in early September forced the fishing crew to leave, before they could determine the extent or duration of the migration.

The following year, 1964, a camp was established on Nikku (also Niko) Island in the Koukdjuak River (Fig. 2) for the express purpose of fishing for the returning searun migrants. Fishing took place in August and early September. Results suggested that a harvest of 22 700 kg (50 000 pounds) round weight was feasible over a three-week season provided sufficient effort was expended. Once again the fishing party was forced to leave at the termination of the flying season.

The objective for the 1965 season was to limit the development of the fishery because information to date did not justify a substantial investment in capital equipment. A crew was flown to Nikku Island on 18 August with instructions to salt-cure the catch. By 18 September, twenty-seven barrels of salt-cured charr (2 700 kg dressed weight) had been put up. Daily catch rates confirmed that a seasonal harvest of about 22 000 kg was possible but this was not achieved because of lack of air transportation (only two supply flights all season) which curtailed the supply of barrels and salt and forced the crew at season's end to travel over land and water to Pangnirtung.

In summary, the results of the pilot project carried out over three seasons indicated that the searun form of Arctic charr was more desirable than the lake (nonandromous) form for commercial purposes. Setting nets in the lake increased the proportion of the latter form in the catch. In the river, the searun migration was believed to continue for about three weeks, peaking about 9-12 September. Fishing success was better on the south side of the Koukdjuak River than on the north side. Nets could be lifted frequently during the run and it was practicable to make four lifts per day with an average harvest of 250 kg per lift. On that basis, a harvest of 22 000 kg over the three-week season was possible. Weather conditions after mid-September were harsh, thus shelter for workers was necessary. Transport of the product and workers would have to be overland to Pangnirtung due to the non-availability of air transportation at the end of the fishing season. The conclusion was that a commercial fishery was not viable at that time due to 'environmental circumstances' (Budgell 1967).

The 'environmental circumstances' referred to are the freezing conditions encountered in early September. The only available aircraft with a suitable payload during the course of the project was a twin-engined Canso amphibian (2 200 kg payload) capable of landing on the water at Nettilling Lake and on the runway at Iqaluit. The airline company operating the aircraft had a policy that amphibious operations would cease after 10 September due to the risk of the wheel landing gear freezing in the retracted position after a water landing (Budgell 1965). Therefore, the company was not prepared to provide air transportation at or after the peak of the fishing season. The investigators felt that this problem could be overcome if an airstrip was constructed to accommodate aircraft with a suitable payload at the fishing site. They felt that conditions on Nikku Island were ideal for the construction of a 1200 m x 45 m (4000' x 150') landing strip at reasonable cost (Budgell 1965). Thus it was felt that a commercial fishery might prove feasible in future as regional development progressed (Budgell 1967).

## COMMERCIAL FISHING 1974-77

Interest in the Koukdjuak River/Nettilling Lake fishery was rekindled in 1974 when the Fish and Wildlife Service, Government of the Northwest Territories (GNWT), constructed an airstrip on Nikku Island. A commercial gillnet fishery was conducted near the site in August and September of that year, the specific objective of which was to exploit the returning searun Arctic charr as they made their way up the Koukdjuak River to overwinter in Nettilling Lake. A quota of 22 700 kg (50 000 pounds) round weight was set for these searun Arctic charr by the Fisheries and Marine Service, Department of the Environment (now Department of Fisheries and Oceans) based on what was believed to be catchable as a result of the previously-mentioned efforts of the 1960's. The project was repeated in 1975 with a quota of 27 200 kg (60 000 pounds). Details are provided by Land and Bourque (1974) and Land and Ransom (1975).

The Department of Economic Development and Tourism (ED&T), GNWT, ran the project in 1976 and 1977. An increase in the quota over previous years was requested in 1976, and, based on the past success, the quota was raised to 34 000 kg (75 000 pounds). However, the 1976 harvest fell far short of the quota, and given the possibility of overfishing, the 1977 quota was reduced to the original 22 700 kg.

The commercial fishing camp was located for the duration on Nikku Island in the Koukdjuak River. Each year, fishermen used nylon or monofilament gillnets of 127 mm (5 inch) and 139 mm (5.5 inch) mesh, stretched measure. Most nets were 45.7 m (50 yd) long and 24-34 meshes deep. A few nets were 91 m (100 yd) and 122 m (133 yd) long. Some shallow nets (15 meshes deep) were used in 1975. Nets were generally set in water less that 3.7 m deep. At times, as many as 100 nets (5 183 m) were in the water. Most fishing was done along the south shore of the Koukdjuak River from a point about 8 km downstream from Nikku Island to the outlet of Nettilling Lake and, at times, as far as 5 km into Nettilling Lake proper, along the east shore (Fig. 2). The nets were lifted daily and the catch was brought to shore to be dressed (gills and viscera removed). A record of daily catch and effort was kept. The catch was shipped by air to Iqaluit where it was frozen and sold.

## BIOLOGICAL SAMPLING 1974-77

Sampling was conducted by Fish and Wildlife Service (GNWT) staff in 1974 and 1975 and by Fisheries and Marine Service (DFO) staff in 1976 and 1977. Each day during the fishery one tub of fish (approximately 30-50 charr) was chosen at random from the landed catch. All charr in the tub were examined and fork length (±1 mm), round weight (±50 g) and sex were recorded for each. Stage of maturity was determined only during 1976 and followed Homans and Vladykov (1954) for males and Vladykov (1956) for females. Sagittal otoliths were removed from all fish sampled during all years and were used to estimate age. The procedure is described in Kristofferson and Carder (1980) and assignment of age follows Grainger (1953).

Age- and length-frequency histograms were constructed to display catch composition by year. Mean fork length at age was plotted to provide a visual representation of growth rate. Weight-length relationships were calculated using least squares regression analysis on logarithmic transformations of fork lengths and round weights. Relative condition factor (K) was calculated as:

$$K = \frac{W \times 10^5}{L^3}$$

Where: W = weight in grams
L = fork length in millimetres

Instantaneous total mortality (Z) was calculated from least squares regression lines fitted to the descending limb of the catch curves. Annual survival rate (S) and annual mortality rate (A) were calculated from Z (Ricker 1975).

## POPULATION ESTIMATE 1976

### Fish weir

An attempt was made to estimate the size of the searun population of charr migrating up the Koukdjuak River into Nettilling Lake in 1976. The Schaefer (1951) mark-recapture method was used as described by Ricker (1975). Charr were captured in a weir which was constructed of 5.0 cm x 10.0 cm (2"x4") wooden frames covered with 2.54 cm (1 inch) square wire mesh. The weir spanned a channel between an island and the south shore of the Koukdjuak River, about 12 km downstream of Nikku Island (Fig. 2). The wings of the weir, supported by wooden A-frames, formed a Vee with the apex upstream. A rectangular trap, 1.2 m wide, 2.4 m long and 1.8 m deep, was situated at the apex. Charr migrating upstream were directed into the trap by the wings of the weir. Once inside the trap they were captured by closing a drop gate on the downstream side. The charr were then measured, tagged and released upstream to continue their migration. The weir operated from 27 August until 11 September with the exception of 9 September when it was inundated by high water.

All catchable charr were tagged with serially-numbered Floy anchor tags. A catchable charr was defined as being at least 45 cm in fork length and thus vulnerable to the commercial gillnets. All tagged charr were measured (fork length ±1 mm) and weighed (±50 g). All charr <45 cm were counted. Ten of these were selected at random each day and sampled similarly to those from the commercial fishery. Twenty randomly-selected charr, tagged 3 September, were retained in a holding pen for three days to investigate short-term tagging mortality.

### Schaefer population estimate

Schaefer's (1951) population estimate for migratory fish requires that the fish are tagged at one place during their migration and recovered at another place along their migration route. The recapture mechanism in our population estimate was the commercial fishery located upstream of the weir. Each day the entire commercial catch was examined and the number of tagged fish recovered was recorded. After Ricker (1975), time of marking was divided into periods (days) denoted by 'i' and time of recovery was divided into periods (days) denoted by 'j'.

Then:

N = estimated population size
Mi = number of fish marked in the 'i'th period
Cj = number of fish caught and examined in the 'j'th period of recovery
Rij = number of fish marked in the 'i'th marking period which are recaptured in the 'j'th marking period
Ri = total recaptures of fish tagged in the 'i'th period
Rj = total recaptures of fish during the 'j'th period

Thus:

$$N = \Sigma\, Nij = \Sigma \left( Rij \cdot \frac{Mi}{Ri} \cdot \frac{Cj}{Rj} \right)$$

Note that this population estimate is of the number of fish passing the point at which they were marked.

Chapman and Junge (1954) provide an approximation of the variance as follows:

$$\sigma^2(N) = \Sigma\ \Sigma\ \frac{Nij\ (Ni\ Nj)}{Mi\ Cj}$$

Where:

Ni = estimated number of fish in the 'i'th stratum of the marking period.
Nj = estimated number of fish in the 'j'th recovery stratum
Nij = estimated number of fish in the 'i'th marking stratum and the 'j'th recovery stratum.

During the first four days of tagging (27 August - 30 August), only charr ≥53 cm in fork length were tagged as this was expected to be the minimum size vulnerable to the commercial gillnets. It soon became apparent, however, that the commercial fishery was catching charr smaller than 53 cm, and the minimum size was revised downward to 45 cm as described earlier. Thus, in order to estimate the number of charr ≥45 cm in length but <53 cm in length that passed the trap between 27 August and 30 August, the population estimate was done by size category. The first estimate was of charr ≥53 cm passing the trap from 27 August to 11 September. Because the calculation was comprised of daily estimates, this overall estimate was divided into an estimate of charr passing the trap from 27 August to 30 August (A) and one of those passing the trap from 31 August to 11 September (B). The second estimate was of charr ≥45 cm and <53 cm in length (C) passing the trap from 31 August to 11 September. Assuming the ratio of charr ≥45 cm and <53 cm to those ≥53 cm over the period 31 August - 11 September was the same as that for the period 27 August - 30 August, the unknown number (X) of charr ≥45 cm and <53 cm from 27 August to 30 August was derived as follows:

$$X = \frac{AC}{B}$$

Thus:

$$N = A + B + C + \frac{AC}{B}$$

The number of fish in the daily commercial catch (Cj) was adjusted by size category based on the results of each day's biological sample of the catch. Charr <45 cm taken by the commercial fishery were thus excluded from the above estimates.

## RESULTS AND DISCUSSION

### COMMERCIAL FISHING 1974-77

#### Harvest statistics

Target harvest levels (quotas) were met or exceeded during three of the four years the fishery operated (Table 1). We use the term target quota to describe a harvest objective that was not based on biological data, but rather on what was believed to be catchable given expenditure of reasonable daily effort over the duration of the fishing season. No biological data were available at the outset of the fishery upon which to base a Total Allowable Catch (TAC) for the searun Arctic charr in this system.

The 1974 fishery achieved it's objective. In fact, the target quota was exceeded by a considerable amount. The overharvest was attributed to the experimental nature of the fishery whereby fishing took place over a long period of time in order to determine the timing of the upstream migration. As a result, a considerable portion of the quota (27%) had already been harvested before the main migration began. The considerable effort expended, plus the dramatic increase in catch-per-unit-effort (CPUE) at peak migration, resulted in large landings in a short period of time. The effort was reduced by nearly 50% during the last five days of fishing but still resulted in an overharvest of the quota. These large landings were interpreted as an indication that charr were very abundant in this system, and, in an attempt to improve the economic prospects of the fishery, target quotas were increased for 1975 and 1976. As the results indicate, the 1975 fishery harvested the quota but the 1976 fishery fell far short of the goal. In fact, the 1976 fishery harvested only about 33% of the target quota and, as such, was considered a failure. Managers, concerned that the failure might be an indication of overfishing, reduced the 1977 target quota to the original level set in 1974. Results show that the quota was harvested (in fact exceeded) in 1977 (Table 1). In summary, the harvest objectives of the 1974, 1975 and 1977 fisheries were met, whereas the 1976 fishery failed.

The 1976 harvest was the lowest in terms of number of charr, and charr in the catch also had the lowest mean weight (Table 1). In comparison to the 1975 mean of 2.08 kg per charr, the 1976 value was only 1.44 kg. A decline in the number and mean size of fish in the catch can indicate overfishing. Indeed the poor catch in 1976 was preceded by the largest catch to date (13 458 charr) in 1975 (Table 1) and the mean weight had declined the preceeding year. However, the harvest in 1977, immediately following the failure in 1976, was the largest (14 136 charr) of the four-year fishery, and the mean weight of the catch had increased to 1.75 kg from 1.44 kg the previous year. These observations suggest that perhaps overfishing was not a primary factor in the failure of the 1976 fishery. Of course, this information was not available to fishery managers immediately following the 1976 fishery. Therefore, to suspect overfishing as a cause was not inappropriate at the time. The biological effects of the fishery on the charr stock as well as the decline in mean weight will be discussed in a later section of this report. The failure of the 1976 fishery compared to the other years appears to be related to the extent and timing of fishing effort in relation to the timing of the run during that year.

#### Fishing effort and timing of the fishery

The effort, catch-per-unit-effort and timing of the fisheries are summarized in Table 2. The 1976 fishery had the latest start and was the shortest in duration, only 23 days, from 27 August to 18 September. However, the short duration of the 1976 fishery does not, by itself, account for the low catch. Daily effort in 1976 was second only to that in 1977 and seasonal effort expressed in net-days (mean number of nets set per day x number of days) was lower in 1975 (1624) than in 1976 (1909) although the former produced the highest catch in total landed weight (Table 1).

Catch-per-unit-effort provides a measure of the availability of fish to a fishery (Ricker 1975). The mean CPUE was highest in 1975 (8.29 charr per net-day) and lowest in 1976 (4.12) (Table 2). Thus, the availability of charr appears to have varied from year to year. However, availability is not necessarily an indication of stock size. We do not interpret the relatively high CPUE observed in 1975 as an indication that the stock was large that year nor do we interpret the low CPUE observed in 1976 as an indication of a smaller stock size. The difficulty in interpretation arises because a migration or 'run' of fish is involved. The strategy employed by this fishery was to intercept the migration of searun Arctic charr as they journeyed upstream in the Koukdjuak River from feeding areas in the sea to overwintering areas in and around Nettilling Lake. The fishing grounds were located, for the most part, in the river near Nikku Island (Fig. 2). Thus catches (and CPUE) would be low before the charr arrived at the fishing grounds, increase as the charr passed through the grounds and, ultimately, decline as the charr moved upstream past the fishing grounds and into

Nettilling Lake. We therefore choose to interpret CPUE as a measure of the availability of charr to the fishery rather than as a measure of stock size. The timing of the fishery in relation to the timing of the run then becomes a critical factor in determining success or failure.

The fishery during all four years continued, more or less, until about mid-September (Table 2). However, the start dates varied considerably. The three successful fisheries started no later than 21 August whereas the relatively unsuccessful fishery in 1976 started late, on 27 August. The implications of this late start are visualized in Fig. 3.

The CPUE in 1974 increased from 20 August to 23 August and then declined until 30 August. We interpret this to mean that a concentration of charr moved through the fishing grounds during that time. By the end of August, sufficient effort had been expended to have harvested about 27% of the total catch that year. The CPUE began to increase again during the first week of September and continued to increase up to a peak on 14 September followed by a decline until the fishery ceased after 18 September. We interpret this as an indication that the main body of the run had reached the fishing grounds by the beginning of September and was beginning to leave the grounds by the time the fishery ceased operations.

A somewhat similar pattern is observed for 1975. The CPUE rose sharply in early September and continued to rise until the end of the first week. Similar to 1974, the CPUE then began to decline after the first week and continued to do so up until 17 September when the quota was reached and fishing stopped for the year. The 1976 data show a very different pattern. The CPUE was relatively high at the outset of the fishery during the last week in August and increased, although not sharply, until the first week in September. It then continued to decline steadily until the fishery ceased operations on 18 September because of low catches and freezing conditions. The initial high CPUE at the outset of this fishery suggests that the main migration had already reached the fishing grounds by the time the fishery started on 27 August and moved out of the area into Nettilling Lake before the quota could be reached. In other words, the fishery appears to have caught the tail end of the run. Similar to 1974 and 1975, CPUE in 1977 began to increase in early September signalling the onset of the run. However, unlike the three previous years, the 1977 CPUE showed no decline by the time fishing terminated. This suggests that the peak of the run had not yet reached the fishing grounds by the time the quota was harvested.

There is evidence from 1976 to indicate that CPUE is a fairly reliable indicator of the upstream movement of charr. The daily number of char counted as they migrated through the weir in 1976 is compared (Fig. 4) with daily CPUE from the gillnet fishery one day later. The weir was located about 15 km downstream from the main fishing grounds (Fig. 2) or, about a day's travel for the charr. With the exception of 30 August, the plots are remarkably similar.

Arctic charr return to freshwater from the sea in fall to avoid freezing (de Vries 1971), as cited in Johnson (1980). In winter, freshwater temperatures never fall below zero in Arctic lakes but in the sea, temperatures as low as -1.5°C exist (Johnson 1980). However, the timing of the return migration from the sea varies between and within systems (Johnson 1980; Dempson and Kristofferson 1987). The upstream migration of Arctic charr in the Union River on Somerset Island in the Canadian Arctic Archipelago peaked between 17 August and 2 September in 1977 but about 10 August in 1976 (de March et al. 1978). Dempson found that some of the variation in migratory timing could be explained by environmental conditions (Dempson and Kristofferson 1987) but other factors are likely involved as well. Mundy (1982) cautions against using univariate explanations of variability in migratory timing because of the difficulty of describing multivariate phenomena with univariate models.

Dempson (1982) noticed that, on several occasions, large numbers of charr passed through a counting weir on the Fraser River, Labrador, on or shortly after spring tide conditions at the mouth of the river. The weir was located 65 km upstream from the sea. The spring tide, which occurs about twice a month, is very important to the upstream migration of charr in the Sylvia Grinnell River on Baffin Island because the elevated water levels are necessary to enable the charr to surmount an otherwise impassable waterfall near the mouth of the river (Grainger 1953). The timing of that run is, therefore, quite predictable. Although no such barriers exist along the Koukdjuak River watercourse, there is some evidence that spring tides may play a part in the timing of the upstream migration into Nettilling Lake.

A rise in CPUE in the commercial gillnets was noticed 5-6 days after a spring tide in mid-August 1974 and again about the same time following a spring tide at the end of August. Similarly, CPUE was relatively high 5-6 days after spring tides in 1975, 1976 and 1977. The fishery at Nikku Island was about 65 km from the outlet to the sea. If, in fact, charr were entering the river on the spring tide, a swimming speed of 13 $km \cdot day^{-1}$ would be required to cover the distance in 5 days. From tagging studies, Dempson (1982) determined a swimming speed of 16.4 $km \cdot day^{-1}$ for some charr.

Directed migration of fish is very costly from an energetic standpoint (Weihs 1987). The greatest part of the energy requirement is used to overcome drag produced by resistance to the fish's movement through the water. The simplest way to minimize this energy expenditure is to take advantage of existing currents (Weihs 1987). Tidal currents can reduce or even reverse temporarily the discharge velocity of a river at it's mouth. Upstream migrating charr may thus take advantage of spring tides to minimize energy expenditure when entering rivers. If the mouth of a river is very shallow, spring tides can also provide easier passage for upstream migrants, particularly during low water years. An early onset of cold weather, such as was observed in 1976, could prompt some charr to return on an earlier spring tide. One occurred on 9 August that year. An early migration could thus have passed by the fishing grounds on or about mid-month, well before the fishery began on 27 August. During the other years, favorable environmental conditions could have allowed the charr to return on a later spring tide which occurs in late August or early September. Although the above reasoning is somewhat speculative, in the absence of additional information, it may provide fishermen with some capability to predict the onset of the upstream migration of searun charr in the Koukdjuak River.

Summary

The results of the 1974-77 fisheries indicate that searun Arctic charr can be successfully harvested with gillnets in the Koukdjuak River as they migrate upstream to overwinter in Nettilling Lake. Suitable fishing grounds include the area around Nikku Island (Fig. 2) and are thus in close proximity to the airstrip located there.

Experience has shown that most charr are taken in shallow water on the south side of the river with little or no success on the north side or in the middle. Due to the shallow water, it has been found that nets of 30-40 meshes are too deep while nets as shallow as 15 meshes deep are adequate. Minimum mesh size for commercial fisheries for searun Arctic charr is 139 mm (5.5 inch) stretched measure (Northwest Territories Fishery Regulations 1988). Gillnets of about 50 m in length are effective although longer nets can be used as well. Fishermen should have as much as 5000 m of gillnet on hand. Experience has shown that a crew of six fishermen (three boats) can handle this amount of gear.

During three of the four years of fishing, the main run did not arrive at the fishing grounds before the beginning of September. However, in order to avoid missing the onset of the run, as appeared to have happened in 1976, fishermen should be on site no later than 15 August. This recommendation was made by Land and Bourque (1974) but for some reason was not acted upon in 1976. Initial effort should be kept to a minimum, possibly only 200-300 m of gillnet daily. Daily CPUE should be monitored. Catch-per-unit-effort in excess of 10 charr per 100 m gillnet per day following a spring tide could indicate the arrival of the run. Effort can then be increased as required. Past experience suggests that 2000-2500 net-days (50 m per net) of effort may be required to harvest 22 000 kg of charr in this manner.

BIOLOGICAL ASSESSMENT

Anadromous vs nonanadromous

The objective of the 1974-77 commercial fishery, as previously stated, was to catch anadromous Arctic charr as they migrated upstream into Nettilling Lake. However, Dick and Belosevic (1981) have shown that, at least for 1977, this objective may not have been entirely met. Using prevalence, intensity and abundance values of freshwater parasites (*Diphyllobothrium* spp.) and marine parasites (*Brachyphallus crenatus*, *Bothrimonus sturionis*, *Prosorhynchus squamatus*) to differentiate between anadromous and nonanadromous Arctic charr, they estimated that approximately 80% of the 1977 commercial catch was comprised of anadromous charr and 20% of nonanadromous charr. These results came from a random sample of 600 charr. They further state that the sensitivity was such that daily catches were noted to contain from 0-50% nonanadromous charr. Apparently the variation was directly related to fishing location, an observation that was made as early as 1963 (Budgell 1967). Nets set downstream of Nikku Island (Fig. 2) usually contained 100% anadromous charr whereas nets set in the lake sometimes had up to 50% nonanadromous charr. Unfortunately, no such data exist for the 1974, 1975 and 1976 catches. However, it should be assumed that these catches were also comprised of a mixture of anadromous and nonanadromous charr because fishing patterns were similar during all four years. Although it is likely that the majority of charr taken each year were indeed anadromous, interpretation of the biological data collected from samples of the commercial catch must be done with caution.

Growth

Length-at-age: The presence of sympatric populations of anadromous and nonanadromous Arctic charr in overwintering lakes is well documented (Johnson 1980). Generally, anadromous populations exhibit a faster growth rate and attain a greater size by taking advantage of the relatively abundant food resources of the marine environment. Size distribution of charr in anadromous populations tends to be less variable than in nonanadromous ones. Amongst nonanadromous charr, dwarf populations of mean size under 160 mm may occur throughout the range of the species and at the other extreme are lakes in which at least some of the nonanadromous charr approach the length of anadromous populations (Johnson 1980).

The size of anadromous and nonanadromous Arctic charr (identified by parasites) from the Koukdjuak River/Nettilling Lake system (1977) is compared in Fig. 5. Although the data are somewhat limiting, it is obvious that there is no great difference in size between the two life history types over the age range compared. Dick and Belosevic (1981) suggest that the similarity in size at age may be the result of nonanadromous charr feeding on insect larvae concentrated at the outlet of the lake. Skreslet (1969), as cited in Johnson (1980), suspects that nonanadromous charr may undergo a phase of rapid growth after adopting a cannibalistic life style. The high incidence of parasitism observed in the nonanadromous charr from Nettilling Lake may be consistent with the latter hypothesis. Whatever the cause, the similarity in size-at-age between the anadromous and nonanadromous charr taken by the commercial fishery during 1974-77 precludes using this character to discriminate one life history type from the other.

The relative contributions of anadromous and nonanadromous charr to the catch notwithstanding, the overall growth rate of charr from the Koukdjuak River/Nettilling Lake fishery is compared in Fig. 6 with the growth rate of anadromous charr from other systems. Tree River charr are famous for their large size (Johnson 1980) and rapid growth (Moshenko et al. 1984). On the other hand, charr from the Sylvia Grinnell River on south Baffin Island showed a very slow growth rate as of 1976-77 (Kristofferson and Sopuck 1983). Conversely, charr from the Robertson River on north Baffin Island grew rapidly and reached a large size (Moshenko 1981). However, charr from the Koukdjuak River are not particularly fast growing nor do they appear to reach a very large size. Asymptotic length, $L_\infty$, estimated from a Walford plot using 1976 data was 720 mm and the Brody growth coefficient (K) was 0.22. Dempson (1982) found values of $L_\infty = 640$ mm and $K = 0.24$ for charr from the Fraser River in Labrador, based on one year's growth of tagged fish and $L_\infty = 695$ mm and $K = 0.17$ based on two years' growth. A larger K means a smaller $L_\infty$ and thus slower growth (Ricker 1975). Dempson (1982) concluded that growth rate of Fraser River Arctic charr was relatively slow in comparison with other North American anadromous charr populations.

The largest charr taken by the Koukdjuak River commercial fishery in 1974, when the stock was essentially unexploited, was 721 mm in length and weighed 3.37 kg. Only 15% of the catch that year exceeded 600 mm in length. This compares with 58% of the 1988 catch in excess of 600 mm in length from the Ekalluk River near Cambridge Bay (Carder and Stewart 1989). The gear used is similar and the latter fishery has been relatively heavily exploited since 1977.

The usefulness of a detailed examination of the growth of Koukdjuak River charr, based on data from the commercial catch, is somewhat questionable given the size selectivity of the gillnets and the probable admixture of anadromous and nonanadromous charr in the catch. Nevertheless, the data presented do show that, relative to other charr populations, Koukdjuak River charr grow rather slowly. The empirical growth rate of Koukdjuak River charr is portrayed in Fig. 7. From ages 7 to 9 years, annual growth increments averaged 3.7 cm. After age 9, growth in length slows to about 1.3 cm annually.

Weight-length relationship: The relationship between a fish's length and body weight is curvilinear and is generally described by the equation: $W = aL^n$, where a and n are constants (Le Cren 1951), as cited in Johnson (1980). Transforming with logs provides the linear relationship: $\log W = \log a + n(\log L)$. An n value of around 3 indicates more or less isometric growth. Table 3 compares weight-length relationships of Arctic charr taken from the 1974-77 commercial fisheries at Koukdjuak River with values for charr from other systems. The Koukdjuak River data are similar and it appears growth is isometric.

Johnson (1980) concludes that weight-length relationships tend to be unsatisfactory for assessing differences between stocks because values produced by the largest and smallest fish tend to exert an exaggerated influence and differences between stocks tend to become blurred. Also, the weight of a fish of given length can vary considerably within a year and between years. Therefore comparisons between stocks using data collected at different times can be difficult to interpret and may only reflect internal differences within a stock rather than between stocks.

Condition factor: Year to year variations in weight increase in the summer can be quite high (Johnson 1980). The condition factor (K), a measure of the "plumpness" of a fish, is useful for year to year comparisons within a stock. Table 4 shows that mean condition factor of Koukdjuak River charr was relatively good in 1974 ($K = 1.05$), 1975 ($K = 1.17$) and 1977 ($K = 1.06$) but poor in 1976 ($K = 0.91$). The relative condition factor is influenced by the availability of food and time spent at sea (Johnson 1980). The poor condition of charr in the 1976 catch suggests that food availability and/or time spent at sea was less than in other years, and is reflected in low mean weight of charr in the catch (Table 1). Interestingly, 1976 was a poor year for charr migrating up the

Sylvia Grinnell River as well (Kristofferson and Sopuck 1983) where the mean condition factor that year was 0.94 (Table 4). This suggests that some rather widespread factor, such as weather, may have been involved. Similar to the Koukdjuak River charr, condition of Sylvia Grinnell River charr improved to 1.06 in 1977.

Maturity

In 1976, 98% of the males and 95% of the females examined were classified as immature. That is, gonads were not developed to the extent that spawning that fall was likely. This is typical of many charr populations in the central Arctic (Johnson 1980). Most current-year spawners spend the summer in fresh water prior to spawning. Some mature charr were taken in the fishery, however, and, if they are representative of the spawners in general, the onset of maturity may be about 10 years of age for Koukdjuak River charr. Grainger (1953) estimated that charr in the Sylvia Grinnell River first spawn at age 12. Kristofferson et al. (1982) found that the youngest anadromous spawner captured in a headwater lake on the Ekalluk River system was 13 years old.

Length- and -age-frequency distributions

Length-frequency distributions of charr from the 1974-77 commercial catches are compared in Fig. 8. Length ranged from 293 mm to 758 mm. The length- frequency distributions differed significantly (Chi-square, $P < 0.001$) between all years except 1974 and 1977 ($P>0.05$). With the exception of 1976, modal length remained constant at 550-600 mm. The mode for 1976 was 500-550 mm.

The difference was caused, for the most part, by a paucity of charr in the 550-600 mm length interval in the 1976 catch. In 1976, a steady decline in mean length by day was evident from 1 September to 7 September (Fig. 9a). During that time period, 46% of the commercial catch was taken. Dempson (1982) noted a tendency for the mean size of charr to decrease progressively throughout the duration of the upstream migration in the Fraser River. The daily decrease in size noted in Fig. 9a is consistent with the hypothesis, stated earlier in this report, that the 1976 fishery targeted the latter part of the run. No such decrease in size was noted during the 1977 fishery (Fig. 9b). During 1977, the target quota was harvested before the run had peaked (Fig. 3).

Modal age was 12 years in 1974 and 1975, 13 years for 1976 and 16 years for 1977 (Fig. 10). Estimated ages ranged from 7 to 23 years. Although no significant difference in age distribution was found between the catches in 1974 and 1975 (Chi-square, $P>0.05$), significant differences were found between 1975 and 1976 ($P<0.001$) and 1976 and 1977 ($P<0.001$). These differences may be due to the presence of a number of strong year classes moving through the fishery. The 1974 catch was dominated by 11-, 12-, 13- and 14-year-old charr (Fig. 10). Ages 12, 13 and 14 dominated the 1975 catch, followed by ages 13, 14 and 15 in 1976 and, ultimately, ages 14, 15, 16 and 17 in 1977. Perhaps the 1960, 1961, 1962 and 1963 year classes were indeed stronger than others. Coincident increases in length were not obvious. This could be due to the wide variation in length-at-age and the slow growth after age 9 (Fig. 7). According to Fig. 7, it would take 4 years for a Koukdjuak River charr to grow in length from 500 mm to 550 mm.

Indeed, differences were noted in the length- and age-frequency distributions of the commercial catch over the four year study period and some possible causes of these differences have been discussed. However, it appears that four years of harvesting at a mean level of about 12 000 charr annually has not had a detectable detrimental effect on the stock. The length-frequency distribution was the same in 1977 as it had been in 1974 and the age-frequency distribution consisted of older charr at the end of the fishery compared with the beginning. Care must be used in interpreting these results because Johnson (1989) observed no change in modal size of anadromous Arctic charr in Nauyuk River between 1974 and 1979, despite a significant (70%) decline in abundance. Eventually, in 1984, a significant reduction in the length-frequency distribution was observed.

Mortality

Instantaneous total mortality (Z), calculated for ages 13-18 years was 0.59 in 1974, 0.57 in 1975, 0.45 in 1976 and 0.11 in 1977 (Fig. 11). Mortality for ages 15-20 in 1977 was 0.61. Thus, annual survival rate (S) ranged from 55% in 1974 to 57% in 1975, 64% in 1976 and for ages 13-18, 90% in 1977. For ages 15-20 in 1977, S was 54%. The relatively consistent survival rates observed throughout the duration of the fishery suggest that the few years of fishing did not have a detrimental effect on the Koukdjuak River charr stock.

POPULATION ESTIMATE 1976

A total of 8 008 charr were counted through the weir from 27 August to 11 September. Of these, 3 304 were tagged and 215 were recovered (Table 5) to provide the data for the Schaefer population estimate. Tag and recapture data for charr ≥53 cm in length that migrated upstream from 27 August to 11 September (Table 6) provide an estimate of 23 663 charr (Table 7). The estimate was then subdivided into the number of these charr which migrated past the tag site from 27-30 August (6 979), and the remainder (16 684), which migrated from 31

August to 11 September. The tag and recapture data for the estimate of charr ≥45 cm but <53 cm in length which migrated past the trap site from 31 August to 11 September (Table 8) provide an estimate of 72 291 charr (Table 9). The values are thus:

A = 6 979 ( ≥53 cm, 27 Aug. - 30 Aug.)
B = 16 684 ( ≥53 cm, 31 Aug. - 11 Sept.)
C = 72 291 ( ≥45 cm and <53 cm, 31 Aug. - 11 Sept.)

The unknown quantity X, representing charr ≥45 cm but <53 cm that migrated past the tag site from 27 August to 30 August is solved as:

$$X = \frac{AC}{B} = \frac{(6\ 979)(72\ 291)}{16\ 684} = 30\ 240$$

Therefore, the total population estimate of charr 45 cm and larger which migrated past the tag site from 27 August to 11 September is:

$$N = A + B + C + \frac{AC}{B}$$
$$= 6\ 979 + 16\ 684 + 72\ 291 + 30\ 240$$
$$= 126\ 194$$

The calculation of X is essentially done by ratio, assuming that the ratio of charr in the length interval 45 cm ≤ X <53 cm to charr in the length interval X ≥53 cm was the same during the time interval from 27 August to 30 August as it was from 31 August to 11 September. The data in Table 10 support this assumption, showing that the ratio in question remained relatively stable from 31 August to 8 September. However, the proportion of smaller charr rose after 4 September, similar to observations of other runs (Dempson 1982) where smaller charr appeared near the end of the migration.

The 95% confidence limits for the total population estimate were calculated as:

$$N \pm 1.96 \sqrt{\text{Var } N}$$

$$126\ 194 \pm 1.96\ (16\ 406)$$
$$126\ 194 \pm 32\ 156$$

Upper 95% CL = 158 350
Lower 95% CL = 94 038

Based on these data, there could have been as many as 158 350 charr or as few as 94 038 charr ≥ 45 cm in size migrating past the tag site in the Koukdjuak River from 27 August to 11 September 1976. However, the catch-per-unit-effort data discussed earlier (Fig. 3) strongly suggest that the upstream migration was in progress at about the time the population estimate was initiated (27 August). Undoubtedly, an unknown number of charr had already migrated past the tag site into Nettilling Lake before any tagging began. Therefore, the figure of 94 038 charr should be regarded as a minimum population estimate, with the upper 95% limit of 158 350 perhaps being more realistic. Under these circumstances, the population estimate of 126 194 charr is probably conservative. At any rate, this is a relatively large run in comparison to some other anadromous runs as follows:

| | | | |
|---|---|---|---|
| Koukdjuak R. | (≥45 cm) | 126 000 | (This Study) |
| Ekalluk R. | (≥20 cm) | 183 000 | (McGowan 1990) |
| Jayco R. | " | 139 000 | " |
| Diana R. | " | 69 000 | (McGowan 1987) |
| Halovik R. | " | 21 000 | (McGowan 1990) |
| Lauchlan R. | " | 11 000 | " |
| Thomsen R. | " | 16 000 | (Sopuck 1987) |
| Nauyuk R. | " | 10 000 | (Johnson 1980) |

The Schaefer estimate of the Arctic charr population of the Koukdjuak River/Nettilling Lake is based on certain assumptions. All fish must behave independently with respect to capture, survival and migration (Arnason 1973). In our case, it seems unlikely that charr would not behave independently between strata, but this assumption is difficult to prove conclusively. A second assumption is that all fish in one stratum at any one time have the same probability of capture, survival and migration although these probabilities may differ among areas and sampling times (Arnason 1973). There was no 'recycling' of marked charr through the weir and charr moved away quickly from the tag site onto the commercial fishing grounds, based on tag returns. They did, however, stay for longer periods on the fishing grounds. A third assumption is that tagging and subsequent sampling must take a constant fraction of the successive strata (Chapman and Junge 1954). This assumption would be fulfilled under conditions of constant effort during tagging and subsequent sampling. Fishing effort at the weir was constant throughout the tagging period and very nearly so during the commercial fishery as well. The fourth assumption is no tag loss or mortality due to tagging. Tagging mortality during the course of the study was not significant. No mortalities were observed amongst 20 tagged charr held in a pen from 3 - 6 September. In short-term mark and recapture experiments, the effects of tagging are likely to be minimal.

The length-frequency distribution of charr counted through the weir in 1976 (Fig. 12) is representative of the upstream run because the weir captured charr of all sizes greater than 20 cm. Charr in the 20-25 cm length interval are probably smolts (Johnson 1980). From the data presented here, it appears that approximately 36% of the upstream run consisted of charr <45 cm in length. The Schaefer population estimate used in this study dealt only with charr ≥45 cm, thus the estimate of 126 000 charr pertains only to charr ≥45 cm in length. Using proportions, it is possible that an additional 71 000 charr (126 000 x 0.36 ÷ 0.64), which were less than 45 cm in length, also migrated past the tag site during the study period. Thus, as many as 197 000 charr of all sizes greater than about 20 cm may have been involved in the migration.

The length-frequency distribution of the 1976 commercial catch is included in Fig. 12 for comparative purposes. As stated previously, only charr ≥45 cm in length were tagged for the population estimate. Charr of this size were fully vulnerable to the commercial fishery, which is important because the commercial fishery was used as the recovery mechanism. However, charr in the 40-45 cm length interval were also taken by the commercial fishery, although not in proportion to their frequency (18%, Fig. 12) in the run. Using proportions, there may have been (197 000 x 0.18) 35 000 charr of this size in the run. Thus, as many as (126 000 + 35 000) 161 500 charr could have been vulnerable to the commercial fishery in 1976. Again, considering that the run was already in progress when tagging began, this is probably a conservative estimate as well.

An additional complicating factor in the 1976 population estimate is the possible presence of nonanadromous charr in the commercial catch such as the 20% estimated by Dick and Belosevic (1981) for 1977. Very likely, the vast majority of charr tagged in 1976 were anadromous, given the location of the tag site (Dick and Belosevic 1981). However, the presence of nonanadromous charr in the commercial catch, which were not tagged in the first place, would tend to inflate the population estimate. If 20% of the 1976 commercial catch consisted of nonanadromous charr, similar to 1977, the population estimate would then have to be reduced by that amount to represent anadromous charr. Unfortunately, such data are not available for the 1976 catch. Given the likelihood that the population estimate carried out in 1976 was representative of only part of the run, as our data suggest, we have chosen to ignore the possible incidence of nonanadromous charr in the 1976 commercial catch. It's effect, if any, would probably be damped by the conservative population estimate.

## RECOMMENDED HARVEST LEVEL

The complexity of Arctic charr population dynamics makes the development of management plans exceptionally difficult (Johnson 1980). Perhaps the best strategy, at present, is to apply levels of harvest that have been shown in the past to be tolerable. Estimates of yield for new fisheries should purposely be conservative.

Although considerable data were collected by sampling the commercial catch over the four years of commercial fishing, evidence presented by Dick and Belosevic (1981) strongly suggests that the samples, at least for 1977, were not from a homogeneous population but consisted of an admixture of anadromous and nonanadromous charr. This likely occurred in a variable but unknown proportion during the other years as well. The significant change in the population parameters observed in the 1976 sample, compared with the other years, is a further complicating factor in the interpretation of the data. Considering the above, attempts to establish a Total Allowable Catch (TAC) based on such data would be tenuous at best. Rather, a Safe Harvest Level (SHL), based on a conservative population estimate and the actual performance of the fishery over the 1974-77 period is recommended.

Johnson (1980) found that an annual harvest rate of 11% for charr ≥40 cm in the upstream run in the Nauyuk River was excessive and contributed to a significant (67%) decline in population size over a four-year period. An annual harvest rate of 5% appears to have had no detrimental effect on an anadromous Arctic charr population exploited by the Cambridge Bay commercial fishery over a 15 year period (Kristofferson et al. unpublished). Exploitation rate (u) is defined as the fraction, by number, of the fish in a population which is caught and killed by man (Ricker 1975). It can be calculated from mark-recapture studies as:

$$u = \frac{R}{M}$$

where: M = number of fish marked and
R = number of recaptured marks in the sample

Thus, an estimate of the exploitation rate of anadromous Arctic charr in the Koukdjuak River in 1976 is:

$$u = \frac{215}{3304}$$

$$= 6.5\%$$

Because the exploitation rate is based entirely on tagged charr, it is probably representative of anadromous charr only. As discussed earlier, only anadromous charr were likely to be tagged, given the location of the tag site. Also, it is probably representative of exploitation of only the latter part of the run because the data suggest that the run was already in progress when fishing started. Therefore, the 1976 harvest of 7 870 charr (Table 1) probably represents exploitation of less than 6.5% when that portion of the run missed by the fishery is taken into consideration.

An attempt was made in 1977 to duplicate the Schaefer population estimate of 1976. Tagging at the weir began on 18 August and continued until 8 September. This coincided with the commercial fishery (Table 2) and began early enough such that the start of the run was not missed (Fig. 3) as it appeared to have been the previous year. Unfortunately, persistent strong westerly winds over many days often produced a wind tide (seiche) on Nettilling Lake to the extent that discharge into the Koukdjuak River was reduced at times. During these times, water levels at the weir receded to the point where charr could not enter the trap. As a result, only 697 charr were counted and only 376 were tagged during the study. Too few charr were tagged and recaptured on a daily basis to make the Schaefer estimate effective. However, a total of 35 charr were recaptured by the commercial fishery that year and these data were used to calculate an exploitation rate for anadromous charr of 9.3%. The harvest of anadromous charr in 1977 was about 11 300 or 80% of the total harvest of 14 136 (Table 1), given the 20% incidence of nonanadromous charr in the catch (Dick and Belosevic 1981). However, similar to 1976, the fishery appears to have exploited only a portion of the run. As Fig. 3 clearly shows, the commercial fishery (and the tagging program) ceased to operate before the run had peaked in 1977. Undoubtedly, many more charr continued to migrate through the fishing grounds after the fishery had terminated. Therefore, the 1977 harvest of about 11 300 anadromous Arctic charr probably represents exploitation of less than 9.3% of the entire run.

The mark and recapture data were used to calculate a rough Petersen estimate of the 1977 anadromous run. Although tagging and recapture took place over several days, both were considered as single events. As in 1976, only charr ≥45 cm in length were tagged and very few charr <45 cm were taken by the commercial fishery (Fig. 10). Thus, the estimate, for charr ≥45 cm, is as follows:

$$N = \frac{(M + 1)(C + 1)}{(R + 1)} - 1$$

where: C = catch in numbers (11 300)

Thus, for 1977:

$$N = \frac{(376 + 1)(11\ 300 + 1)}{(35 + 1)} - 1$$

$$= 118\ 347$$

The 95% Poisson confidence limits (Ricker 1975) are:

Upper 95% CL = 224 311
Lower 95% CL = 111 755

This estimate is in agreement with the 1976 Schaefer estimate and, similar to 1976, it is also very likely a conservative estimate.

The fishery harvested an average of 12 200 charr annually during the four-year operation (Table 1). The similarities in catch composition between samples taken during the first and last years of this fishery suggest that this rate of fishing did not have a negative impact on the stock. The similarity of the two population estimates, although subject to the qualifications already discussed, does not suggest a decline in the abundance of charr as a result of fishing at this rate. This observation is supported by the strong performance of the fishery during the last year (1977). Thus, a Safe Harvest Level (SHL) appears to be about 12 000 charr annually. Using the mean weight of 1.83 kg observed over the duration of the fishery (Table 1), which takes into account years when the charr were in good and in poor condition, a recommended SHL for the anadromous Arctic charr stock of the Koukdjuak River/Nettilling Lake at this time is 22 000 kg, round weight. With the exception of 1990, when approximately 5 000 kg of charr were harvested with gillnets near Nikku Island (D. Pike, Department of Fisheries and Oceans, Iqaluit, N.W.T. pers. commun.), this stock has remained virtually unexploited since 1977.

## SUMMARY

Early efforts at commercial fishing for Arctic charr in Nettilling Lake in the 1960's indicated that the catch from the lake consisted primarily of heavily parasitized fish of questionable market quality. However, fishing in the Koukdjuak River near Nikku Island during early September produced good catches of highly desirable searun charr. The commercial fishery during 1974-77 proved that fishermen could harvest about 22 000 kg of charr, given sufficient effort, during the 2-3 week period of the upstream migration. Shallow gillnets set along the south shore worked the best. Catches indicated that the main portion of the run arrived on the fishing grounds near Nikku Island during the first two weeks of September in three of the four years. However, the 1976 experience indicated that the run could arrive as much as two weeks earlier, given unfavorable environmental conditions.

Nonanadromous Arctic charr were encountered with increasing incidence the closer the nets were set to Nettilling Lake proper. Although of comparable size to the anadromous charr, the heavy incidence of parasites in the former makes their market quality questionable. Attempts were made in September 1989 and again in 1990 to capture anadromous Arctic charr in Burwash Bay (Fig. 1) at the south end of Nettilling Lake (D. Pike, DFO, Iqaluit, N.W.T. pers. commun.). Success was apparently limited in both years and led to the earlier-mentioned contingency gillnet fishery in 1990. Although two anadromous charr, tagged going upstream in the Koukdjuak River in 1976, were captured in Burwash Bay by angling on 3 July 1977, they may

well have been current-year spawners. Otherwise, they should have been at sea feeding at that time. Hence, fishing for anadromous charr in Burwash Bay could target spawners. Equally important, for practical reasons, is the likelihood, as shown in this study and the early efforts of the 1960's, that the majority of the catch would be comprised of heavily parasitized nonanadromous charr. Also, experience has shown that the anadromous run does not usually arrive at Nikku Island until the first week or two of September, and thus would arrive at Burwash Bay at an even later date. Weather conditions at that time of year are very unpredictable and freezing conditions, such as happened in 1976, can be encountered as early as mid-month. A gillnet or trapnet fishery undertaken at that time of year in Burwash Bay would be very vulnerable to freezing conditions and the probability of long-term success would be marginal.

Fish weirs provide an excellent alternative to gillnets for some charr fisheries (Kristofferson et al. 1986). The fish weir was used successfully to catch over 8 000 charr for the population estimate at Koukdjuak River in 1976. However, the lack of success noted in 1977, due to fluctuating water levels, suggests caution must be exercised if weirs are to be used for commercial fishing at this location.

Experience during the 1974-77 fishery suggests that an annual harvest of 12 200 charr did not appear to have a detrimental effect on the Koukdjuak River charr stock. Although there were problems with population estimates, 126 000 charr, ≥45 cm in length, was considered a conservative estimate, based on the 1976 data. This was supported, to some extent, by the 1977 data. Considering the slow growth of the anadromous Arctic charr of the Koukdjuak River/Nettilling Lake, and the other factors discussed, an annual Safe Harvest Level of 22 000 kg, round weight, is recommended for this stock at present.

## RECOMMENDATIONS

1. An annual Safe Harvest Level (SHL) of 22 000 kg, round weight, is recommended for anadromous Arctic charr of the Koukdjuak River/Nettilling Lake system.

2. Fishing using gillnets, 139 mm minimum mesh size (stretched measure) in the vicinity of Nikku Island is the recommended method of harvest. Fishermen should avoid fishing in Nettilling Lake proper to minimize the incidence of heavily parasitized nonanadromous charr in the catch.

3. It is recommended that fishermen be on site no later than 15 August in the event that the upstream run of anadromous charr is early. Initial effort should be limited to 200-300 m of gillnet daily until a consistent increase in catch-per-unit-effort indicates the arrival of the run on the fishing grounds.

4. If commercial fishing for searun Arctic charr takes place in the Koukdjuak River in future, the catch should be sampled annually to establish a biological data base to which yield models can be applied in order to establish a Total Allowable Catch (TAC).

## ACKNOWLEDGMENTS

The authors wish to recognize the considerable efforts of the late Mr. Al Bourque, Mr. Sam Ransom, Mr. Ellis Land, Mr. Syd Kirwan and Ms. Hanne Roemer, all of the Government of the Northwest Territories, which resulted in the commercial fishery taking place in 1974-77.

The Inuit fishermen from Iqaluit and Pangnirtung, N.W.T., are thanked for their efforts. Fishing camp manager during 1974-76 was Mr. Jack Jones. Mr. Murray Ransom managed the camp in 1977. DFO staff included Mr. Lothar Dahlke and summer students Ms. Donna Larsen and Messrs. Gerald Lacho, Barry Corbett, Dennis Rudy, Doug Leroux, Mitch Minchau, Andre Desrosiers, Laurent Tetreault and Larry Chyzyk.

Mr. W.A. Bond and Dr. R.A. Bodaly reviewed the manuscript and provided many helpful suggestions.

## REFERENCES

ARNASON, A.N. 1973. The estimation of population size, migration rates and survival in a stratified population. Ref. Popul. Ecol. 15: 1-8

BUDGELL, H.M. 1965. Nettilling Lake fishery project. unpublished. Letters to file 251-1-1061 Ottawa 4, September 30, 1965; October 28, 1965. by H.M. Budgell, Project Section, Industrial Division. Department of Indian Affairs and Northern Development.

BUDGELL, H.M. 1967. Nettilling Lake test fishery. Appendix N, In G. Higgins (ed.) The south coast of Baffin Island, an area economic survey. A.E.S.R. #67/2. Department of Indian Affairs and Northern Development. 235 p.

CARDER, G.W., and D.B. STEWART. 1989. Data from the commercial fishery for Arctic charr, *Salvelinus alpinus* (L.) in the central and Keewatin regions of the Northwest Territories, 1987-88. Can. Data Rep. Fish. Aquat. Sci. 766: vi + 47 p.

CHAPMAN, D.G., and C.O. JUNGE. 1954. The estimation of the size of a stratified animal population. Ann. Math. Stat. 27: 375-389.

de MARCH, L., B. de MARCH and W. EDDY. 1978. Limnological, fisheries and stream zoobenthic studies at Stanwell-Fletcher Lake, a large high arctic lake. Can. Rep. Ind. North. Aff. ESCOM Report A1-04: xiv + 84 p.

DE VRIES, A.L., 1971. Freezing resistance in fishes. pp. 157-190. In W.S. Hoar and D.J. Randall (ed.) Fish Physiology, Vol. 6, Academic Press, London (cited by Johnson 1980).

DEMPSON, J.B., 1982. Ecology and comparative population dynamics of anadromous Arctic charr, Salvelinus alpinus (Linnaeus 1758), in Northern Labrador. MSc Thesis. Memorial University, St. John's, NF. 190 p.

DEMPSON, J.B., and A.H. KRISTOFFERSON. 1987. Spatial and temporal aspects of the ocean migration of Anadromous Arctic charr. Am. Fish. Soc. Symp. 1: 340a-357.

DICK, T.A., and M. BELOSEVIC. 1981. Parasites of Arctic charr Salvelinus alpinus (Linnaeus) and their use in separating sea-run and non-migrating charr. J. Fish. Biol. 18: 339-347.

FALK, M.R., and L.W. DAHLKE. 1979. Data on the Arctic charr sport fishery at Tree River, Northwest Territories, 1978. Can. Fish. Mar. Serv. Data Rep. 153: iv + 32 p.

GRAINGER, E.A. 1953. On the age, growth, migration, reproductive potential and feeding habits of the Arctic char (Salvelinus alpinus) of Frobisher Bay, Baffin Island. J. Fish. Res. Board Can. 10: 326-370.

HOMANS, R.E.S., and V.D. VLADYKOV. 1954. Relation between feeding and the sexual cycle of the haddock. J. Fish. Res. Board Can. 11: 535-542.

JOHNSON, L. 1980. The Arctic charr, Salvelinus alpinus, p. 15-98. In E.K. Balon (ed.) Charrs; Salmonid fishes of the genus Salvelinus. Dr. W. Junk, The Hague.

JOHNSON, L. 1989. The anadromous Arctic charr, Salvelinus alpinus, of Nauyuk Lake, NWT. Canada. Physiol. Ecol-Japan, Spec. Vol. 1: 201-227.

KRISTOFFERSON, A.H., and G.W. CARDER. 1980. Data from the commercial fishery for Arctic charr, Salvelinus alpinus (Linnaeus), in the Cambridge Bay area, Northwest Territories, 1971-78. Can. Data Rep. Fish. Aquat. Sci. 184: v + 25 p.

KRISTOFFERSON, A.H., D.R. LEROUX, and J.R. ORR. 1982. A biological assessment of Arctic charr, Salvelinus alpinus (L.) stocks in the Gjoa Haven - Pelly Bay area of the Northwest Territories, 1979-80. Can. Manuscr. Rep. Fish. Aquat. Sci. 1591: vi + 51 p.

KRISTOFFERSON, A.H., and R.D. SOPUCK. 1983. The effects of exploitation on the Arctic charr population of the Sylvia Grinnell River, Northwest Territories. Can. Manuscr. Rep. Fish. Aquat. Sci. 1721: v + 35 p.

KRISTOFFERSON, A.H., D.K. McGOWAN, and W. J. WARD. 1986. Fish weirs for the commercial harvest of searun Arctic charr in the Northwest Territories. Can. Ind. Rep. Fish. Aquat. Sci. 174: iv + 31 p.

LAND, E., and A. BOURQUE. 1974. Nettilling Lake test fishery, 1974. Unpublished report prepared for Superintendent of Game Management, Government of the Northwest Territories, 64 p. plus appendix.

LAND, E., and S. RANSOM. 1975. Nettilling Lake test fishery, 1975. Unpublished report prepared for Superintendent of Game Management, Government of the Northwest Territories. 15 p. plus appendix.

Le Cren, E.D., and C. KIPLING. 1963. Some marking experiments on spawning populations of charr, S. willughbii, in Windermere, England. Int. Comm. Northwest Atl. Fish. Spec. Publ. 4: 130-139.

McGOWAN, D.K. 1987. Data on Arctic charr, Salvelinus alpinus (L.) from the Diana River, Northwest Territories, 1986. Can. Data Rep. Fish. Aquat. Sci. 666: iv + 19 p.

McGOWAN, D.K. 1990. Enumeration and biological data from the upstream migration of Arctic charr, Salvelinus alpinus (L.), in the Cambridge Bay area, Northwest Territories, 1979-1983. Can. Data Rep. Fish. Aquat. Sci. 811: iv + 27 p.

MOSHENKO, R.W. 1981. A preliminary assessment of the Arctic charr sport fishery on the Robertson River (Koluktoo Bay), Northwest Territories 1979. Can. Data Rep. Fish. Aquat. Sci. 306: iv + 9 p.

MOSHENKO, R.W., R.F. PEET, L.W. DAHLKE and D.H. DOWLER. 1983. The Arctic charr sport fishery at Tree River, Northwest Territories; Canada, 1964-78. p. 349-364. In L. Johnson and B. Burns (ed.) Biology of the Arctic charr, Proceedings of the International Symposium on Arctic charr, Winnipeg, Manitoba, May 1981. University Manitoba Press, Winnipeg.

MUNDY, P.R. 1982. Computation of migratory timing statistics for adult chinook salmon in the Yukon River, Alaska, and their relevance to fisheries management. N. Am. J. Fish. Manage. 2: 359-370.

OLIVER, D.R., 1964. A limnological investigation of a large arctic lake, Nettilling Lake, Baffin Island. Arctic 17: 64-83.

RICKER, W.E. 1940. Relation of "catch per unit effort" to abundance and rate of exploitation. J. Fish. Res. Board Can. 5: 43-70.

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Board Can. Bull. 191: 382 p.

SCHAEFER, M.B. 1951. Estimation of size of animal populations by marking experiments. U.S. Fish Wildl. Serv. Bull. 69: 189-203.

SEKERAK, A.D., D.THOMSON, H. BAIN and J. ACREMAN. 1976. Summer surveys of the marine ecology of Creswell Bay, Somerset Island and Assistance Bay, Cornwallis Island, N.W.T. 1975. LGL Ltd. Environmental Research Associates, Toronto, ON. 215 p.

SKRESLET, S. 1969. The ecosystem of arctic lake Nordlaguna, Jan Mayen Island. I. General features and hydrology. Astarte 2: 27-34 (cited by Johnson 1980).

SOPUCK, R.D. 1987. A report on the assessment of the Arctic charr, Salvelinus alpinus (L.), population of the Thomsen River, Duke of York Bay, Southampton Island, Northwest Territories in 1987. Unpublished MS.

THOMSON, J.A.C. 1957. On the biology of the Arctic char, Salvelinus alpinus (L.), of Nettilling Lake, Baffin Island, N.W.T. MSc. Thesis. McGill University, Quebec, PQ. 95 p.

VLADYKOV, V.D., 1956. Fecundity of wild speckled trout (Salvelinus fontinalis) in Quebec Lakes. J. Fish. Res. Board Can. 13: 799-814.

WEIHS, D. 1987. Hydromechanics of fish migration in variable environments. Am. Fish. Soc. Symp. 1: 254-262.

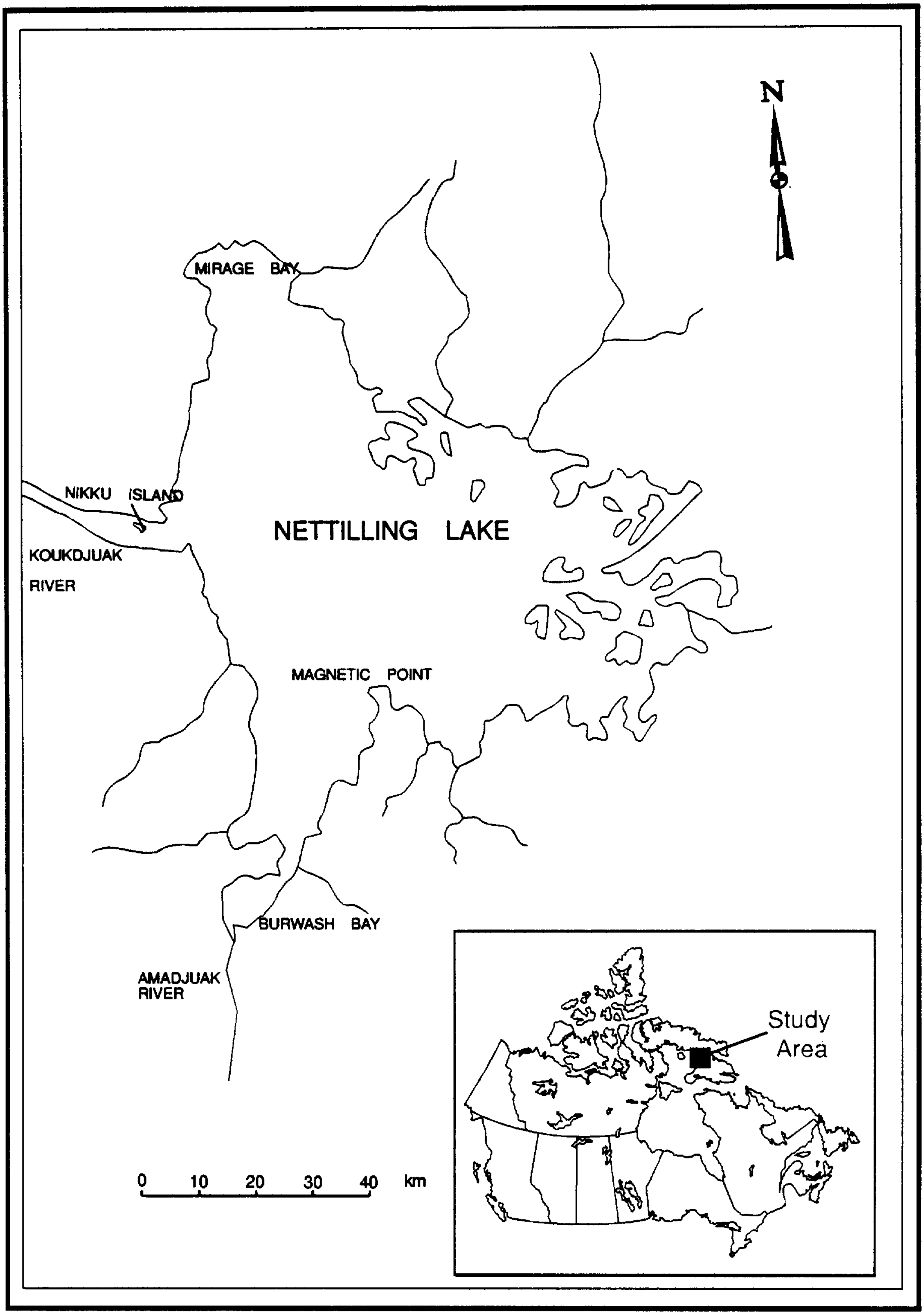


Fig. 1. Map of Nettilling Lake showing outlet to the Koukdjuak River.

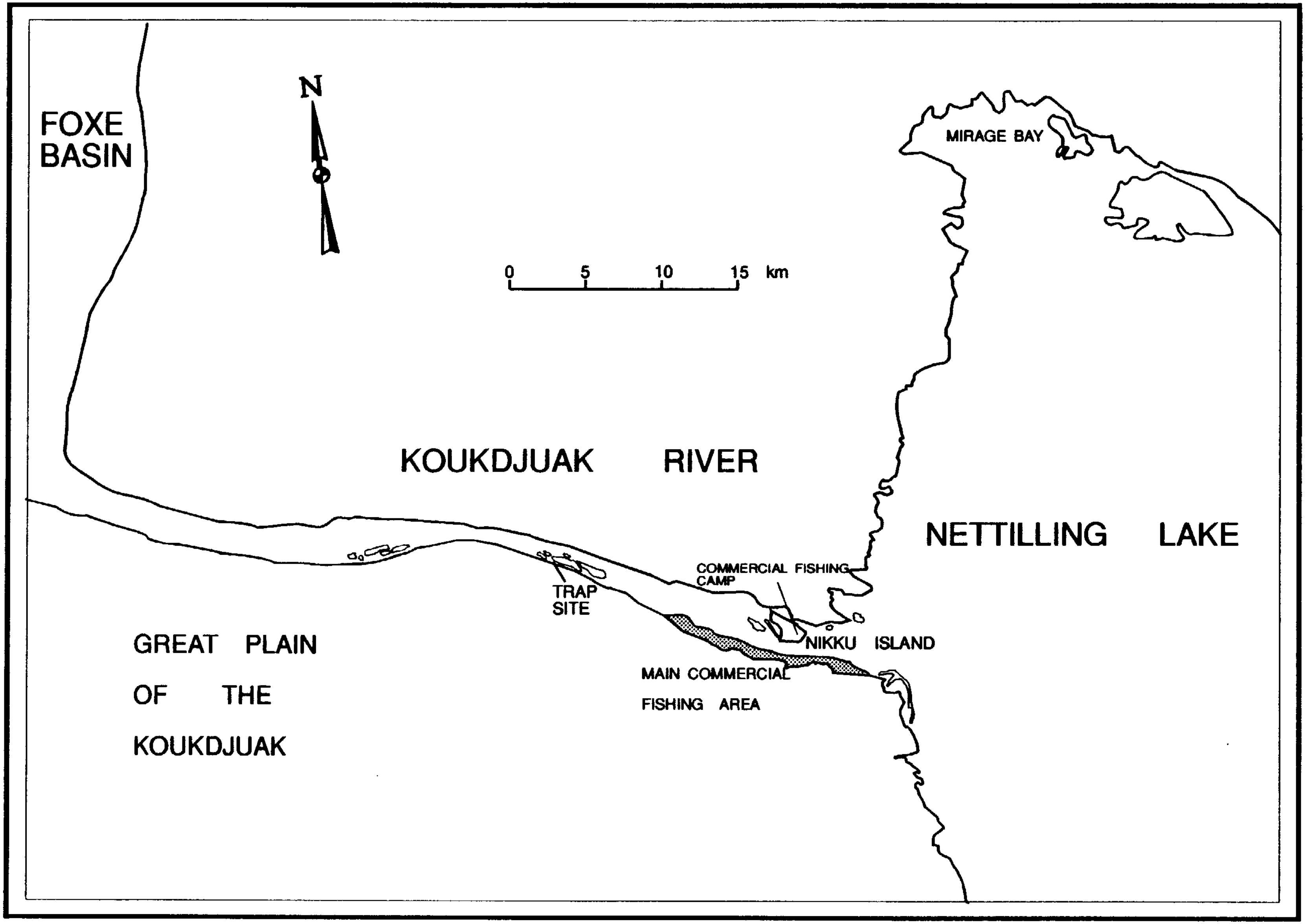


Fig. 2. Map of the Koukdjuak River showing fishing grounds and weir (trap) site.

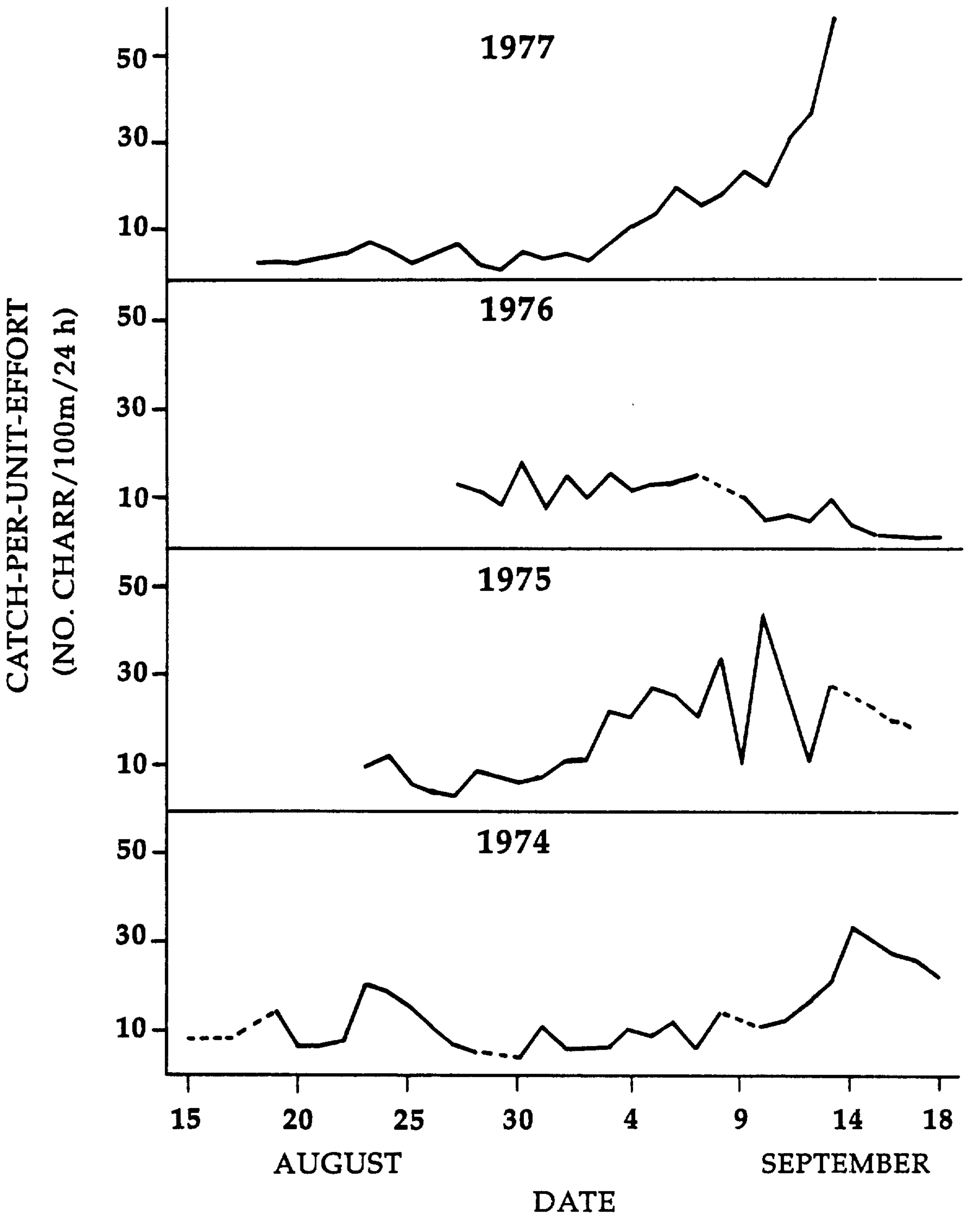


Fig. 3. Daily catch-per-unit-effort during the 1974-77 commercial fishery for Arctic charr at Koukdjuak River/Nettilling Lake.

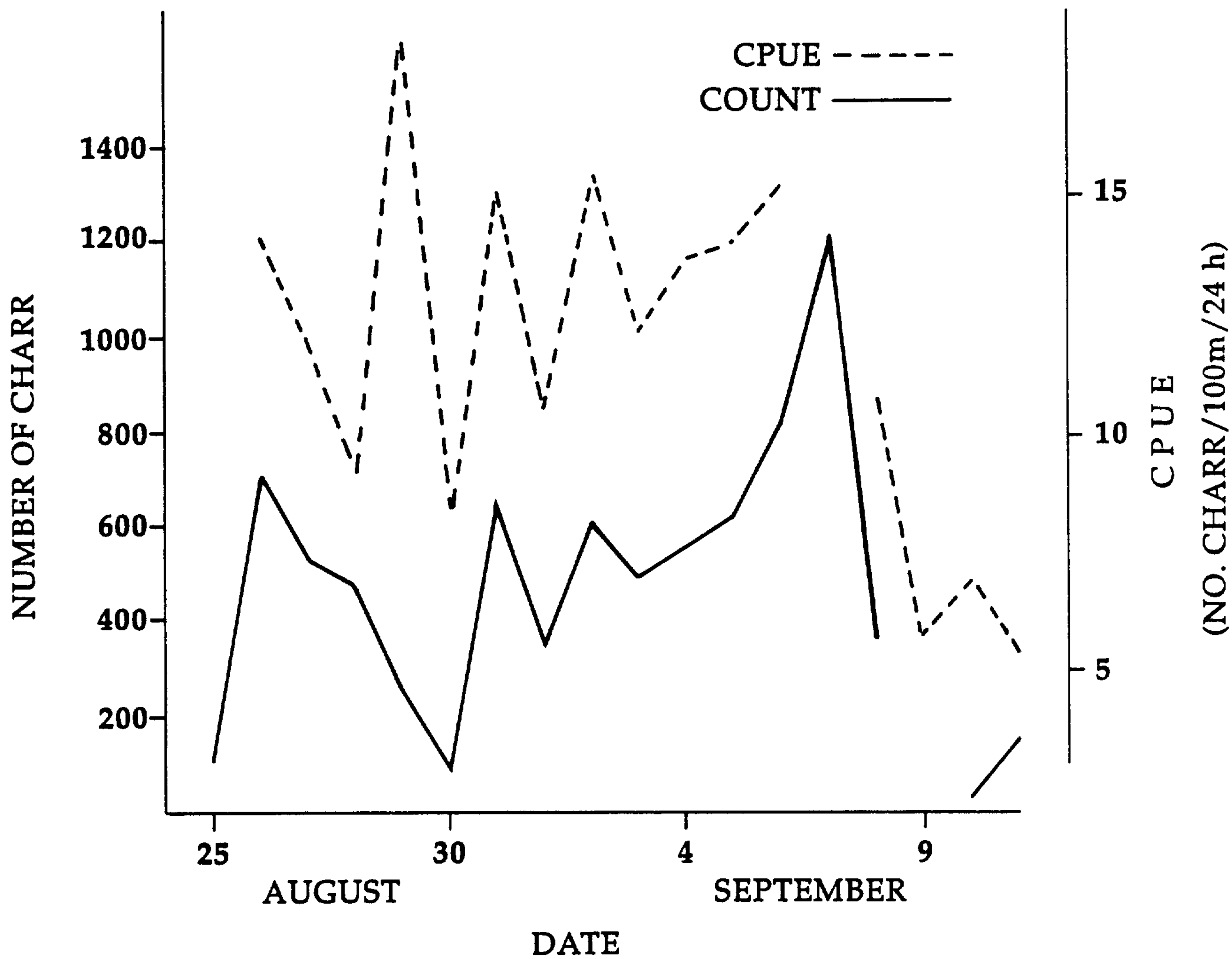


Fig. 4. A comparison of the daily count of Arctic charr caught in the weir in 1976 with the daily catch-per-unit-effort from the 1976 commercial fishery one day later.

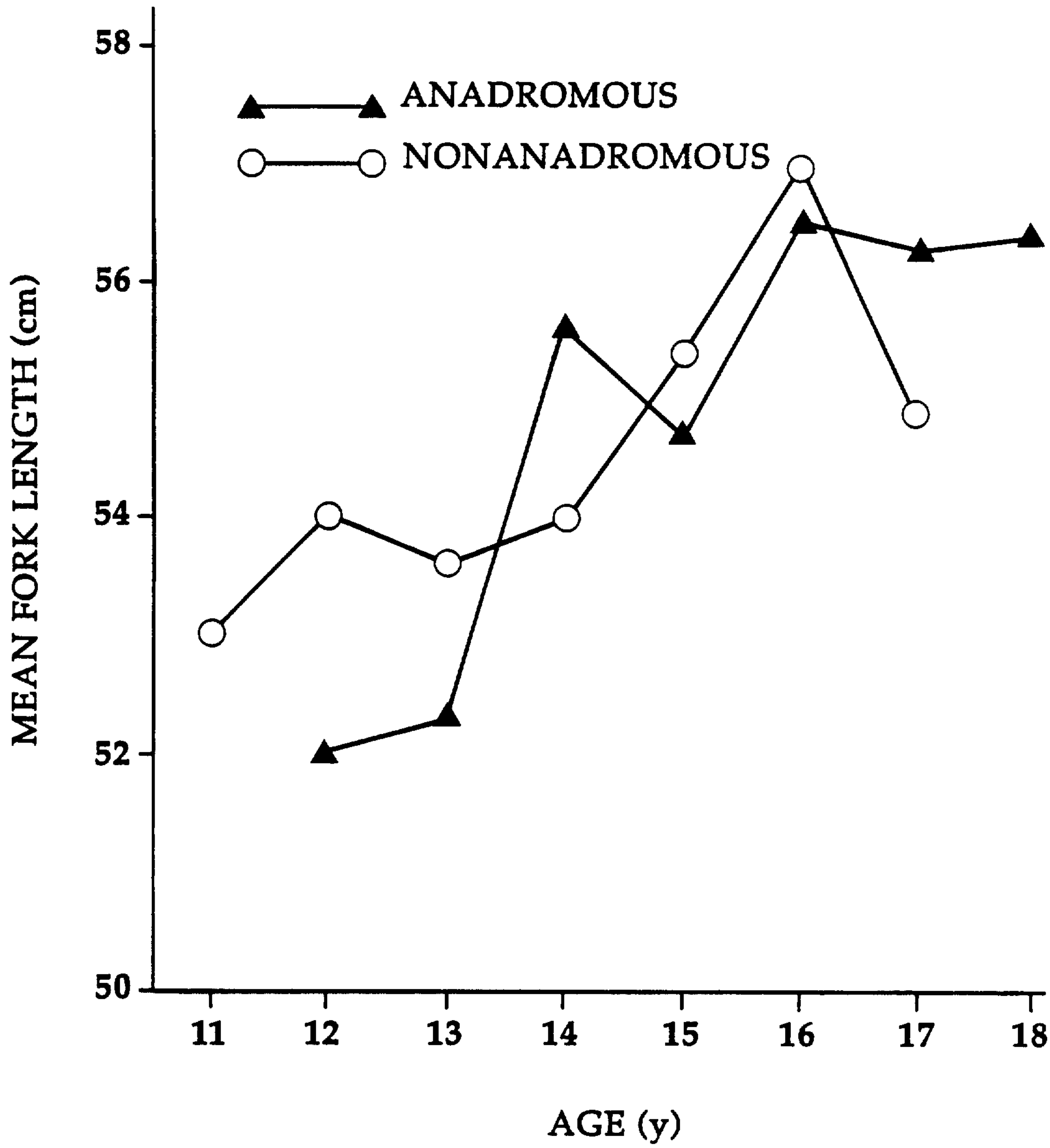


Fig. 5. A comparison of the size of anadromous and nonanadromous Arctic charr taken by the 1977 commercial fishery in Koukdjuak River/ Nettilling Lake.

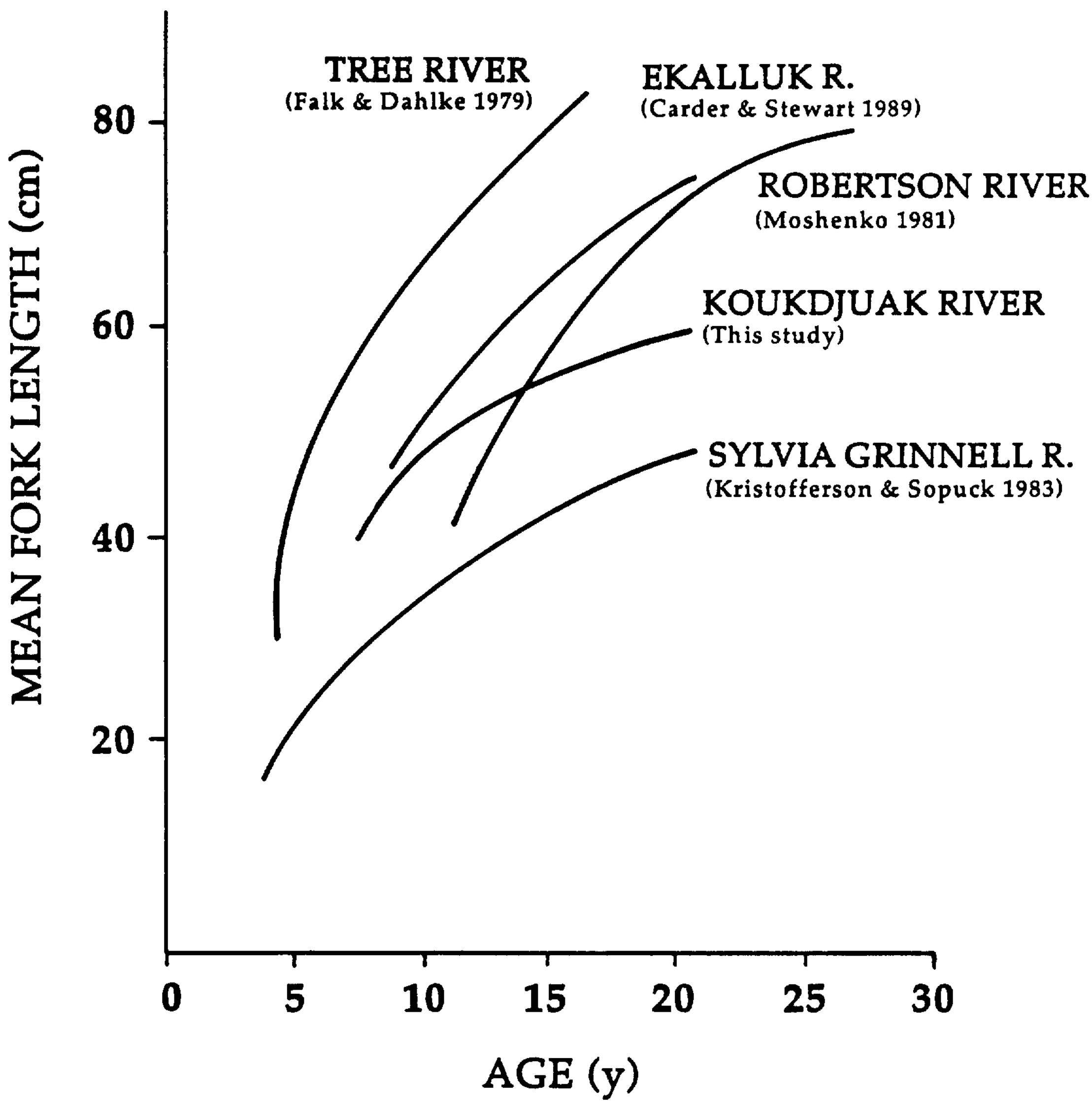


Fig. 6. A comparison of the growth rate of Arctic charr taken in the Koukdjuak River/Nettilling Lake commercial fishery during 1974-77 with growth rates of anadromous Arctic charr from other systems in the Canadian Arctic.

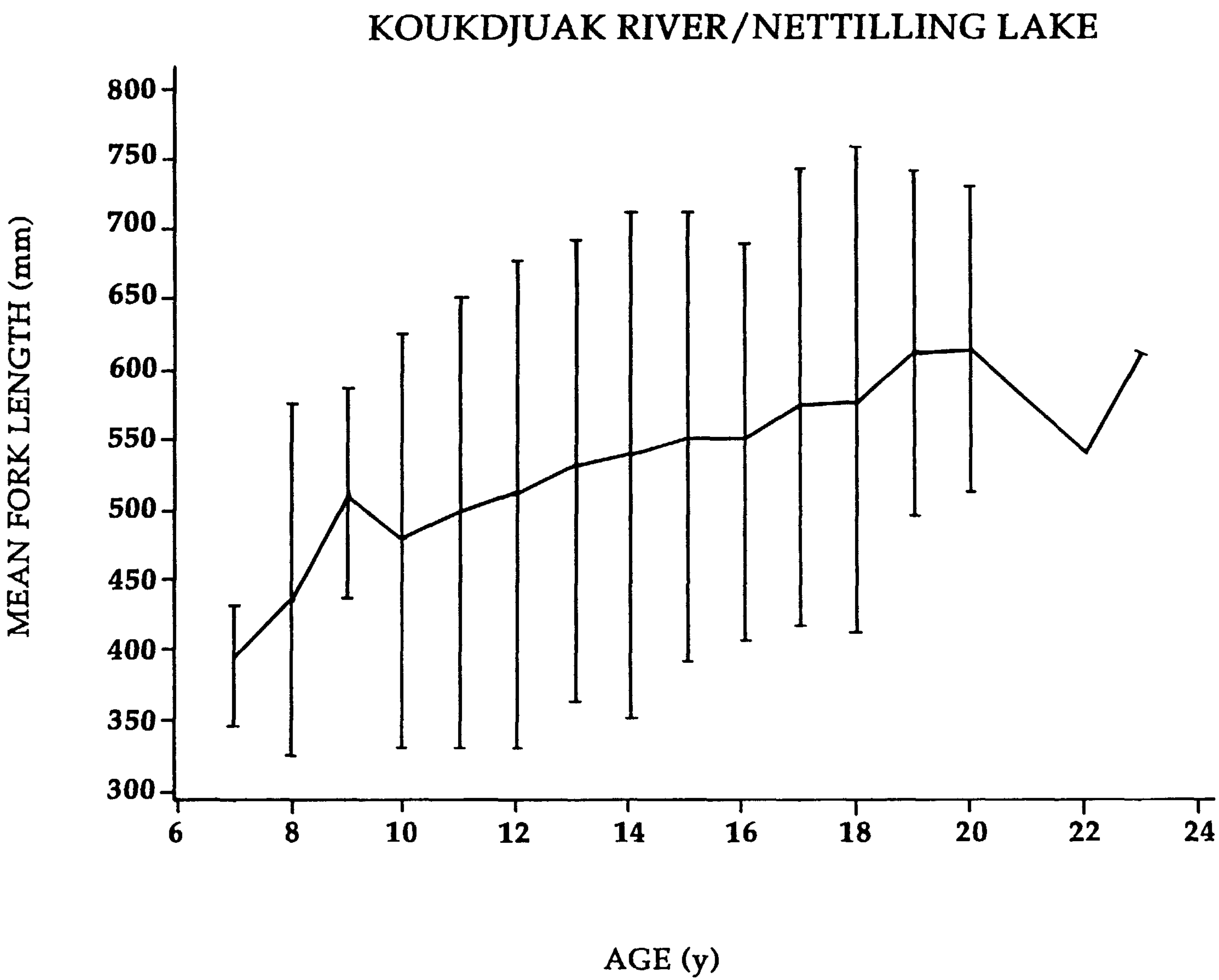


Fig. 7. The empirical growth rate of Arctic charr from the Koukdjuak River/Nettilling Lake system.

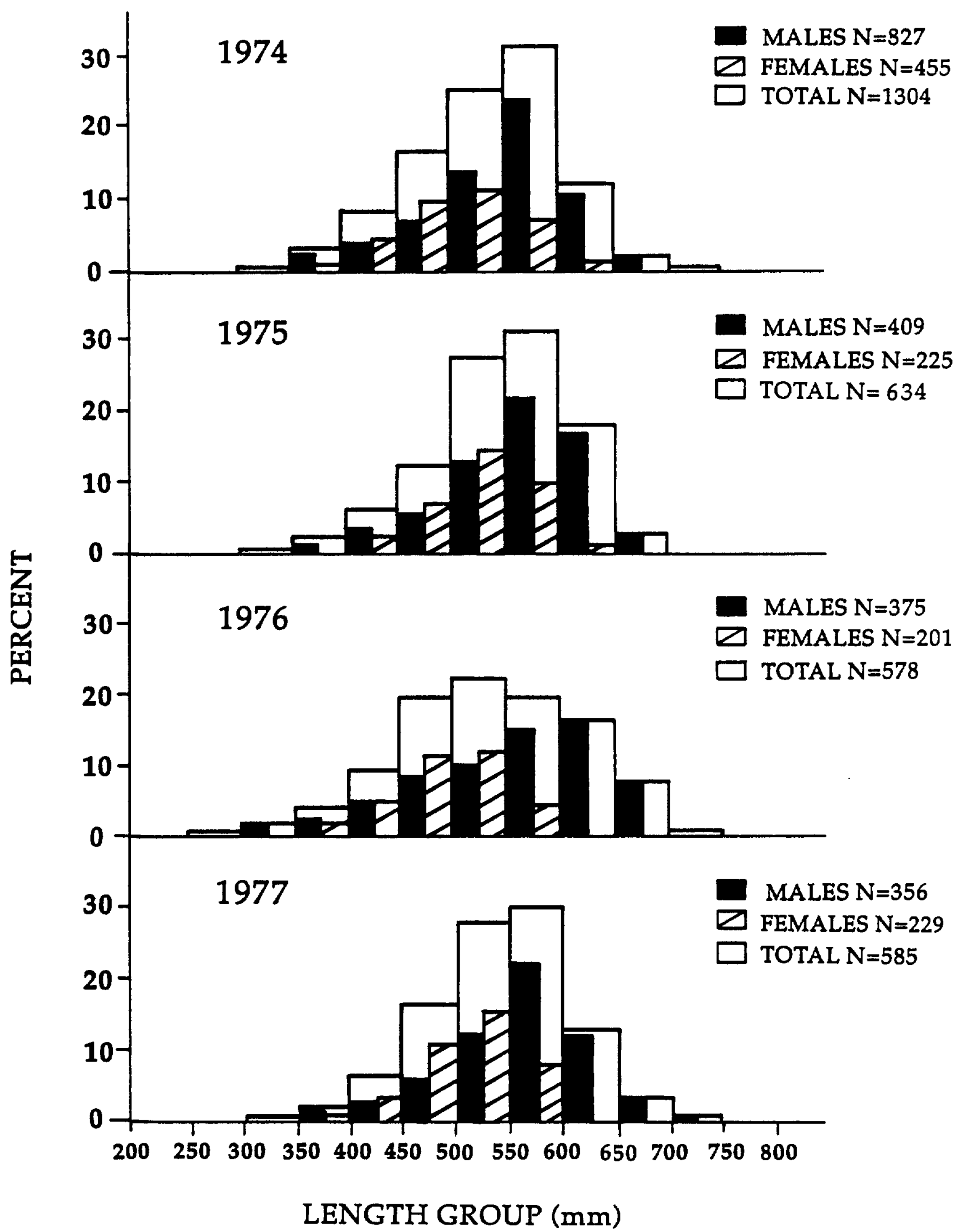


Fig. 8. Length-frequency distributions of samples of Arctic charr taken by the Koukdjuak River/Nettilling Lake commercial fisheries during 1974-77.

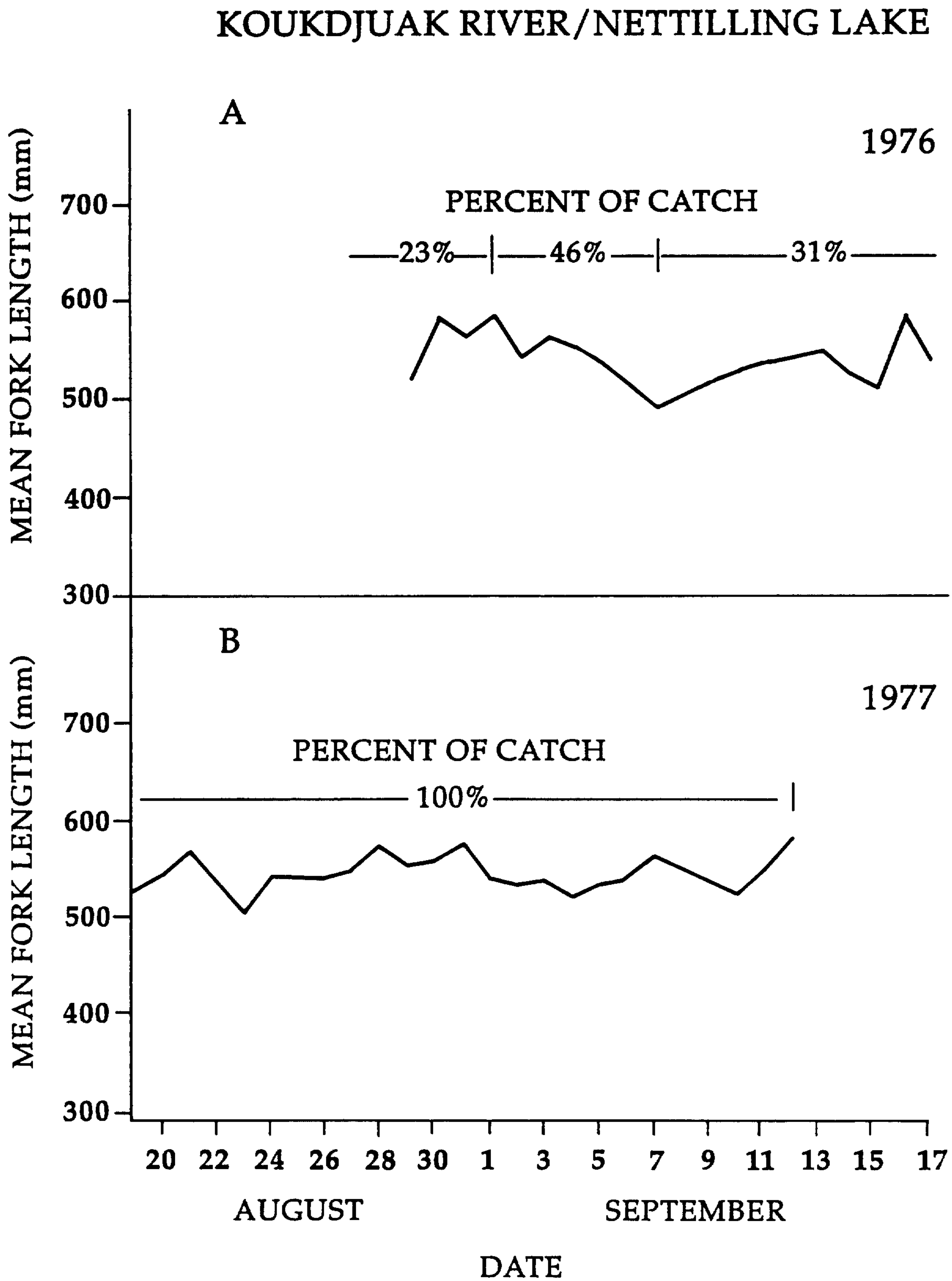


Fig. 9 (a,b). Mean daily fork length of Arctic charr from the 1976(a) and 1977(b) commercial fisheries at Koukdjuak River/Nettilling Lake and proportion of the total harvest by time interval.

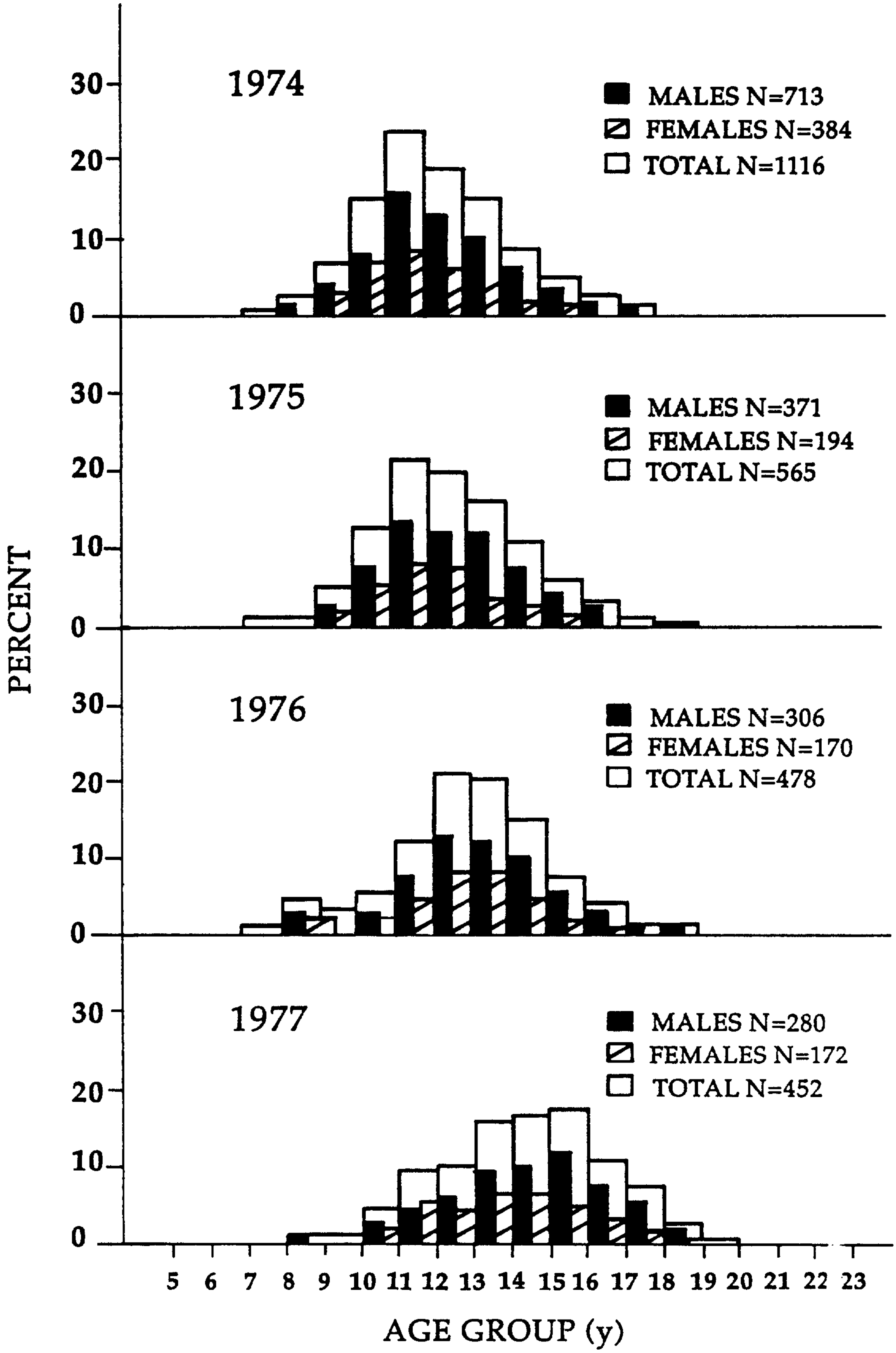


Fig. 10. Age-frequency distribution of samples of Arctic charr taken by the Koukdjuak River/Nettilling Lake commercial fisheries during 1974-77.

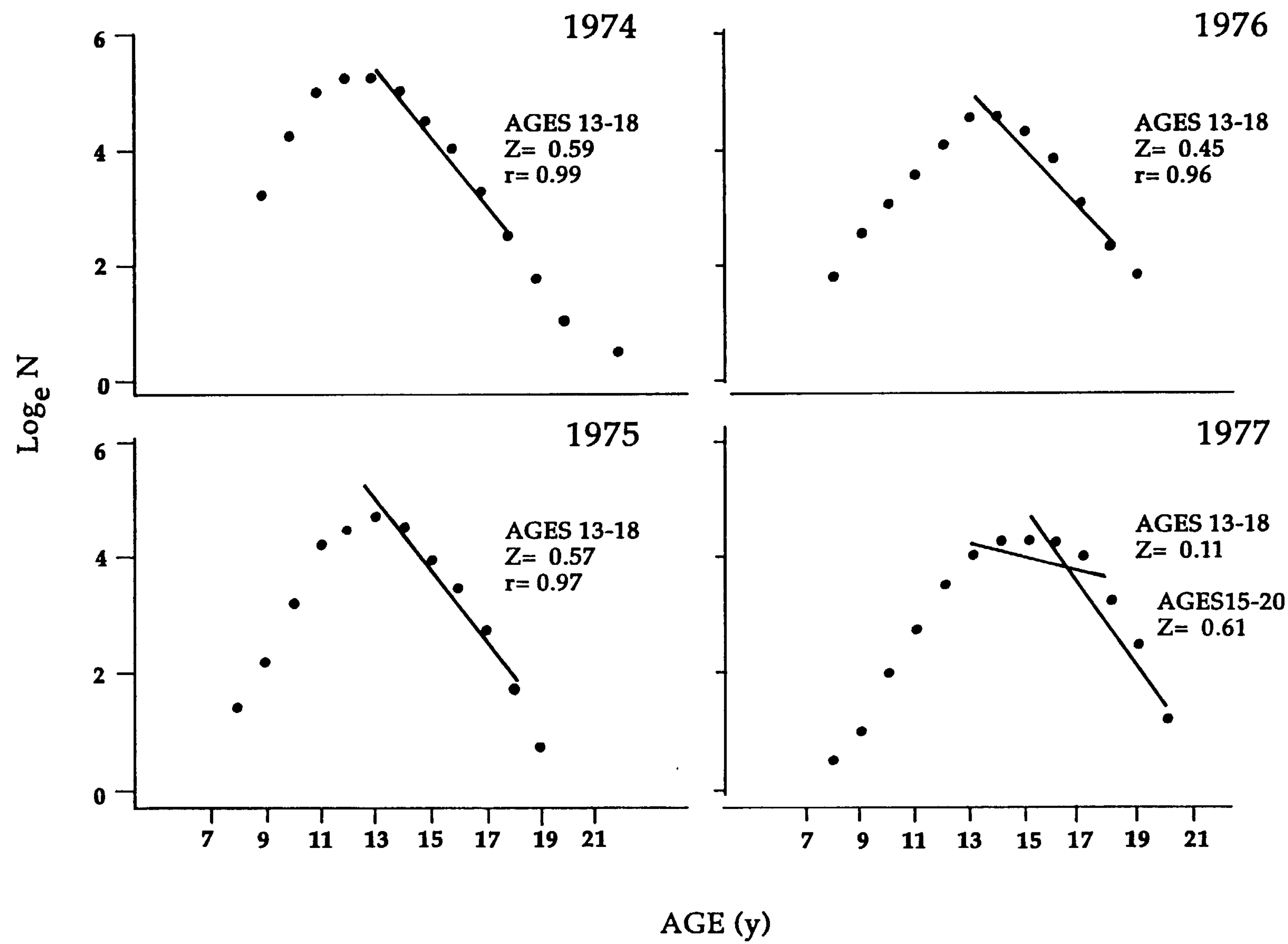


Fig. 11. A comparison of catch curves and instantaneous total mortality for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 1974-77.

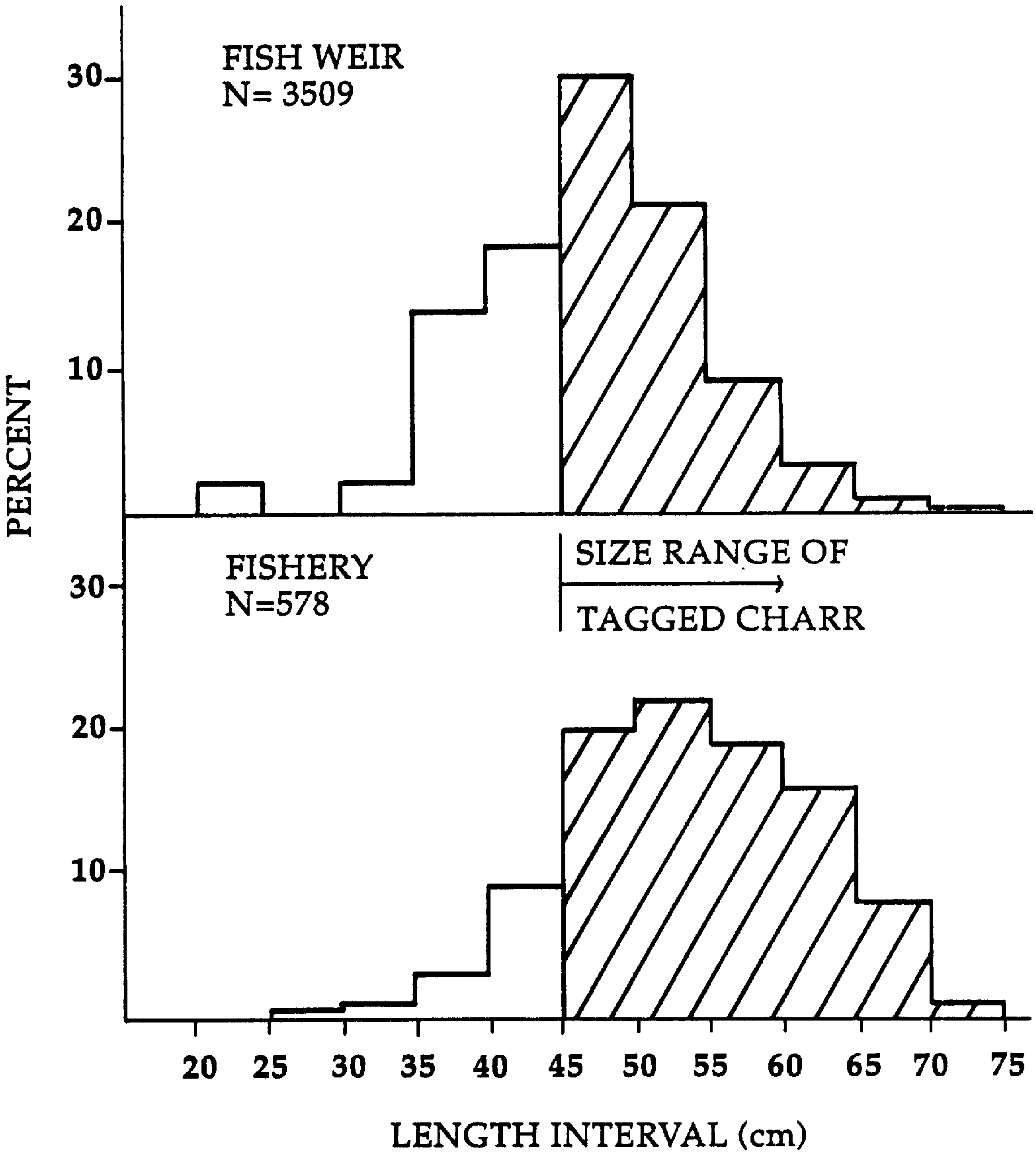


Fig. 12. A comparison of the length-frequency distribution of Arctic charr counted through the weir and taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 1976.

Table 1. Harvest statistics from the commercial fishery for searun Arctic charr, Koukdjuak River/Nettilling Lake, 1974-77.

| Year | Quota[a] (kg rd Wt) | Harvest kg rd Wt | % of Quota | Number of Charr | Mean Weight (kg)[b] |
|---|---|---|---|---|---|
| 1974 | 22 700 | 25 600 | 113 | 13 400[c] | 1.91 |
| 1975 | 27 200 | 27 200 | 103 | 13 458 | 2.08 |
| 1976 | 34 000 | 11 335 | 33 | 7 870 | 1.44 |
| 1977 | 22 700 | 24 700 | 109 | 14 136 | 1.75 |

a Quota originally in pounds. Figures rounded when converted to kilograms.

b Mean weight calculated by dividing total landed weight by total number of charr harvested.

c No daily count after 13 September in 1974. Number of charr harvested from 14-18 September, estimated by dividing total landed weight for that period by 2.09 kg (mean wt. on 11-12-13 September 1974).

Table 2. Catch and effort data from the commercial fishery for searun Arctic charr, Koukdjuak River/Nettilling Lake, 1974-77.

| Year | Fishing Period | No. Days Fished | Mean No.[a] Nets/Day (Range) | No. Net-Days | Catch Total No. Charr | CPUE[b] |
|---|---|---|---|---|---|---|
| 1974 | 10 Aug - 18 Sept | 36 | 58 (10-100) | 2088 | 13 400[c] | 6.42 |
| 1975 | 21 Aug - 17 Sept | 28 | 58 (3-77) | 1624 | 13 458 | 8.29 |
| 1976 | 27 Aug - 18 Sept | 23 | 83 (30-104) | 1909 | 7 870 | 4.12 |
| 1977 | 18 Aug - 13 Sept | 27 | 93 (70-100) | 2511 | 14 136 | 5.63 |

a Calculated based on all nets being 45.7 m (50 yd) in length. Maximum no. of nets set was 100, but 1976 shows 104 because some nets exceeded 100 m in length.

b Mean number of charr per net per day

c Estimated. See Table 1.

Table 3. A comparison of weight-length relationships of Arctic charr from a number of locations with those from the Koukdjuak River/Nettilling Lake commercial fishery, 1974-77. Log W = log a + n log L, where W = weight in grams, L = fork length in millimetres. Data tabulated by Johnson (1980).

| LOCATION | DATE | n | Log a |
|---|---|---|---|
| Koukdjuak River | 01/7 to 13/9/74 | 3.1383 | -5.3788 |
| Koukdjuak River | 23/7 to 10/9/75 | 3.0430 | -5.0554 |
| Koukdjuak River | 29/8 to 17/9/76 | 2.9881 | -5.0214 |
| Koukdjuak River | 19/8 to 12/9/77 | 3.0003 | -4.9752 |
| Robertson River[a] | 26/8/75 | 3.0041 | -4.993 |
| Creswell Bay[b] | 30/7 to 13/8/75 | 3.2653 | -5.688 |
| Nauyuk Lake[c] | 1/8 to 10/9/75 | 3.1087 | -5.228 |

a Peet (unublished).

b Sekerak et al. (1976).

c Johnson (unpublished).

Table 4. A comparison of condition factor (K) of Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 1974-77, with those of charr taken at Sylvia Grinnell River in 1976 and 1977.

| Year | Koukdjuak River | | Sylvia Grinnell River[a] | |
|---|---|---|---|---|
| | N | K | N | K |
| 1974 | 1304 | 1.05 | - | - |
| 1975 | 634 | 1.17 | - | - |
| 1976 | 578 | 0.91 | 255 | 0.94 |
| 1977 | 585 | 1.06 | 847 | 1.06 |

a Data are from Kristofferson and Sopuck (1983).

Table 5. Number of Arctic charr tagged, date of tagging and date of recovery at the Koukdjuak River in 1976.

| Date | No. Tagged | Date of Recovery: August 28 | 29 | 30 | 31 | September 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| August | | | | | | | | | | | | | | | | | | | | | | | |
| 27 | 30 | 1 | 1 | 6 | | 1 | | 1 | 1 | 1 | | | | | | | | | | | | | |
| 28 | 76 | | 3 | 6 | 1 | 1 | 2 | | 2 | 3 | 1 | | | | | 1 | | 1 | | | | | |
| 29 | 47 | | | 2 | 2 | | 3 | 1 | 2 | | | | | 1 | | | | | | | | | |
| 30 | 24 | | | | | 1 | 3 | 2 | | 1 | | | | | | | | | | | | | |
| 31 | 410 | | | | | 2 | 4 | 3 | 6 | 5 | 2 | 2 | | 4 | | | | 2 | 1 | | 1 | | 2 |
| September | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 284 | | | | | | 5 | 10 | 1 | 1 | 2 | 1 | | 4 | | 1 | | 1 | 1 | | | | |
| 2 | 452 | | | | | | | 3 | 3 | 7 | 3 | 2 | | 3 | 1 | 1 | | | 1 | | | | 1 |
| 3 | 350 | | | | | | | | 2 | 5 | 7 | 6 | | 1 | | | | | | | | | |
| 4 | 334 | | | | | | | | | 2 | 3 | 4 | | 7 | | | | | | | | | |
| 5 | 328 | | | | | | | | | | 1 | 2 | | 4 | 1 | | | | | | | | |
| 6 | 301 | | | | | | | | | | | | | 5 | | | | 1 | 2 | | | | |
| 7 | 422 | | | | | | | | | | | | | 8 | 4 | 2 | 2 | 1 | | | | | |
| 8 | 172 | | | | | | | | | | | | | | 2 | | | 1 | 1 | 1 | | | |
| 9 | | NO TAGGING | | | | | | | | | | | | | | | | | | | | | |
| 10 | 13 | | | | | | | | | | | | | | | | | 1 | | | | | |
| 11 | 61 | | | | | | | | | | | | | | | | | 1 | | | | | |

Table 6. Recovery of Arctic charr ≥53 cm tagged on successive days at the Koukdjuak River trap in 1976 together with the total number tagged each day (Mi) and the estimated number recovered and examined for tags (Cj).

| | | Date of Tagging (i) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | August | | | | | September | | | | | | | | | | | Tagged Fish Re- covered | Estimated No. of Fish Recovered (≥53 cm) | Cj/Rj |
| | | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | | |
| Date of Recovery (j) | | | | | | | | | | | | | | | | | | Rj | Cj | |
| August | 28 | 1 | | | | | | | | | | | | | | | | 1 | 157 | 157.00 |
| | 29 | 1 | 3 | | | | | | | | | | | | | | | 4 | 175 | 43.75 |
| | 30 | 6 | 6 | 2 | | | | | | | | | | | | | | 14 | 580 | 41.43 |
| | 31 | - | 1 | 2 | - | | | | | | | | | | | | | 3 | 221 | 73.67 |
| September | 1 | - | 1 | - | 1 | 2 | | | | | | | | | | | | 4 | 395 | 98.75 |
| | 2 | - | 2 | 3 | 3 | 3 | 4 | | | | | | | | | | | 15 | 246 | 16.40 |
| | 3 | 1 | - | 1 | 2 | 2 | 8 | 2 | | | | | | | | | | 16 | 391 | 24.44 |
| | 4 | 1 | 2 | 2 | - | 2 | - | 1 | 1 | | | | | | | | | 9 | 248 | 27.56 |
| | 5 | 1 | 3 | - | 1 | 4 | 1 | 4 | 4 | 1 | | | | | | | | 23 | 278 | 12.09 |
| | 6 | - | 1 | - | - | - | - | 3 | 3 | 2 | - | | | | | | | 9 | 182 | 20.22 |
| | 7 | - | - | - | - | 2 | 1 | 1 | 3 | 1 | 2 | - | | | | | | 10 | 156 | 15.60 |
| | 8 | | | | | NO FISHING | | | | | | | | | | | | | | |
| | 9 | - | - | 1 | - | 2 | 4 | 3 | 1 | 5 | 1 | 4 | 6 | | | | | 27 | 303 | 11.22 |
| | 10 | - | - | - | - | - | - | 1 | - | - | 1 | - | 3 | 2 | | | | 7 | 96 | 13.71 |
| | 11 | - | 1 | - | - | - | - | 1 | - | - | - | - | 2 | - | | - | | 4 | 112 | 28.00 |
| | 12 | - | - | - | - | - | - | - | - | - | - | - | 1 | - | | - | | 1 | 111 | 111.00 |
| | 13 | - | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 1 | 1 | | - | 1 | 7 | 226 | 32.29 |
| | 14 | - | - | - | - | - | 1 | - | - | - | - | 2 | - | - | | - | - | 3 | 99 | 33.00 |
| | 15 | - | - | - | - | - | - | - | - | - | - | - | - | - | | - | - | 0 | 47 | |
| | 16 | - | - | - | - | 1 | - | - | - | - | - | - | - | - | NO TAGGING | - | - | 1 | 100 | 100.00 |
| | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | | - | - | 0 | 45 | |
| | 18 | - | - | - | - | 2 | - | 1 | - | - | - | - | - | - | | - | - | 3 | 48 | 16.00 |
| Tagged fish recovered (Ri) | | 11 | 21 | 11 | 7 | 21 | 20 | 17 | 12 | 9 | 4 | 7 | 13 | 3 | | 0 | 1 | | | |
| Total no. of fish (≥53 cm) tagged (Mi) | | 30 | 76 | 47 | 24 | 120 | 102 | 136 | 81 | 69 | 68 | 71 | 101 | 57 | | 10 | 24 | | | |
| Mi/Ri | | 2.73 | 3.62 | 4.27 | 3.43 | 5.71 | 5.1 | 8 | 6.75 | 7.67 | 17 | 10.14 | 7.77 | 19 | | 0 | 24 | | | |

Table 7. Computed estimates of Arctic charr ≥53 cm passing the Koukdjuak River trap in 1976.

| Date of Recovery (j) | | Date of Tagging (i) | | | | | | | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | August | | | | | September | | | | | | | | | | | |
| | | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| August | 28 | 393 | | | | | | | | | | | | | | | | 393 |
| | 29 | 110 | 476 | | | | | | | | | | | | | | | 586 |
| | 30 | 622 | 900 | 354 | | | | | | | | | | | | | | 1876 |
| | 31 | - | 267 | 630 | - | | | | | | | | | | | | | 897 |
| September | 1 | - | 358 | - | 339 | 1128 | | | | | | | | | | | | 1825 |
| | 2 | - | 119 | 211 | 169 | 281 | 335 | | | | | | | | | | | 1115 |
| | 3 | 62 | - | 105 | 168 | 280 | 998 | 392 | | | | | | | | | | 2005 |
| | 4 | 69 | 187 | 236 | - | 315 | - | 221 | 187 | | | | | | | | | 1215 |
| | 5 | 31 | 132 | - | 42 | 277 | 62 | 387 | 327 | 93 | | | | | | | | 1351 |
| | 6 | - | 732 | - | - | - | - | 486 | 410 | 311 | - | | | | | | | 1939 |
| | 7 | - | - | - | - | 179 | 80 | 125 | 316 | 120 | 531 | - | | | | | | 1351 |
| | 8 | | | | | NO FISHING | | | | | | | | | | | | |
| | 9 | - | - | 48 | - | 129 | 229 | 270 | 76 | 431 | 191 | 456 | 524 | | NO TAGGING | | | 2354 |
| | 10 | - | - | - | - | - | - | 110 | - | - | 234 | - | 320 | 521 | | | | 1185 |
| | 11 | - | 102 | - | - | - | - | 224 | - | - | - | - | 436 | - | | | | 762 |
| | 12 | - | - | - | - | - | - | - | - | - | - | - | 863 | - | | - | | 863 |
| | 13 | - | 117 | - | - | 185 | 165 | - | - | - | - | 328 | 251 | 614 | | - | 775 | 2435 |
| | 14 | - | - | - | - | - | 127 | - | - | - | - | 502 | - | - | | - | - | 629 |
| | 15 | | | | | | | | | | | | | | | | | |
| | 16 | - | - | - | - | 571 | - | - | - | - | - | - | - | - | | - | - | 571 |
| | 17 | - | - | - | - | - | - | - | - | - | - | - | - | - | | - | - | 0 |
| | 18 | - | - | - | - | 183 | - | 128 | - | - | - | - | - | - | | - | - | 311 |
| TOTAL | | 1289 | 3390 | 1584 | 718 | 3528 | 1996 | 2343 | 1316 | 955 | 956 | 1286 | 2394 | 1135 | | 0 | 775 | 23663 |

Table 8. Recovery of Arctic charr ≥45 cm but <53 cm tagged on successive days at the Koukdjuak River trap in 1976 together with the total number tagged each day (Mi) and the estimated number recovered and examined for tags (Cj).

| | | Date of Tagging (i) | | | | | | | | | | | | | | | | Tagged Fish Re- covered | Estimated No. of Fish Recovered (≥53 cm) | Cj/Rj |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | August | | | | | September | | | | | | | | | | | | | |
| | | 27 | 28 | 29 | 30 | 31 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | | |
| Date of Recovery (j) | | | | | | | | | | | | | | | | | | Rj | Cj | |
| August | 28 | | | | | | | | | | | | | | | | | | | |
| | 29 | | | | | | | | | | | | | | | | | | | |
| | 30 | | | | | | | | | | | | | | | | | | | |
| | 31 | | | | | | | | | | | | | | | | | | | |
| September | 1 | | | | | 1 | | | | | | | | | | | | 1 | 160 | 160.00 |
| | 2 | | | | | 1 | 1 | | | | | | | | | | | 2 | 127 | 63.50 |
| | 3 | | | | | 1 | 2 | 1 | | | | | | | | | | 4 | 193 | 48.25 |
| | 4 | | | | | 4 | 1 | 2 | 1 | | | | | | | | | 8 | 199 | 24.88 |
| | 5 | | | | | 1 | - | 3 | 1 | 1 | | | | | | | | 7 | 155 | 22.14 |
| | 6 | | | | | 2 | 2 | - | 4 | 1 | 1 | | | | | | | 10 | 204 | 20.40 |
| | 7 | | | | | - | - | 1 | 3 | 3 | - | - | | | | | | 7 | 223 | 31.86 |
| | 8 | | | | | | | | | NO FISHING | | | | | | | | | | |
| | 9 | | | | | 2 | - | - | - | 2 | 3 | 1 | 2 | | | | | 10 | 242 | 24.20 |
| | 10 | | | | | - | - | - | - | - | - | - | 1 | - | | | | 1 | 53 | 53.00 |
| | 11 | | | | | - | 1 | - | - | - | - | - | - | - | | | | 1 | 123 | 123.00 |
| | 12 | | | | | - | - | - | - | - | - | - | 1 | - | | - | | 1 | 65 | 65.00 |
| | 13 | | | | | 1 | - | - | - | - | - | - | - | 1 | | 1 | - | 3 | 160 | 53.33 |
| | 14 | | | | | - | - | 1 | - | - | - | - | - | 1 | | - | - | 2 | 85 | 42.50 |
| | 15 | | | | | - | - | - | - | - | 1 | - | - | 1 | | - | - | 2 | 43 | 21.50 |
| | 16 | | | | | - | - | - | - | - | - | - | - | - | NO TAGGING | - | - | | 16 | |
| | 17 | | | | | - | - | - | - | - | - | - | - | - | | - | - | | 17 | |
| | 18 | | | | | - | - | - | - | - | - | - | - | - | | 1 | - | 1 | 29 | 29.00 |
| Tagged fish recovered (Ri) | | | | | | 13 | 7 | 8 | 9 | 7 | 5 | 1 | 4 | 3 | | 2 | 0 | | | |
| Total no. of fish (≥45 cm but <53 cm) tagged (Mi) | | | | | | 290 | 187 | 316 | 269 | 265 | 260 | 230 | 321 | 115 | | 3 | 0 | | | |
| Mi/Ri | | | | | | 22.31 | 26.71 | 39.5 | 29.89 | 37.86 | 52 | 230 | 80.25 | 38.33 | | 1.5 | 0 | | | |

Table 9. Computed estimates of Arctic charr ≥45 cm but <53 cm passing the Koukdjuak River trap in 1976.

| Date of Recovery (j) | | Date of Tagging (i): August 27 | 28 | 29 | 30 | 31 | September 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| August | 28 | | | | | | | | | | | | | | | | |
| | 29 | | | | | | | | | | | | | | | | |
| | 30 | | | | | | | | | | | | | | | | |
| | 31 | | | | | | | | | | | | | | | | |
| September | 1 | | | | | 3570 | | | | | | | | | | | 3570 |
| | 2 | | | | | 1417 | 1697 | | | | | | | | | | 3114 |
| | 3 | | | | | 1125 | 2578 | 1906 | | | | | | | | | 5609 |
| | 4 | | | | | 2221 | 665 | 1966 | 744 | | | | | | | | 5596 |
| | 5 | | | | | 494 | - | 2624 | 662 | 861 | | | | | | | 4641 |
| | 6 | | | | | 911 | 1090 | - | 610 | 793 | 1060 | | | | | | 4464 |
| | 7 | | | | | - | - | 1259 | 2768 | 3715 | - | - | | | | | 7742 |
| | 8 | | | | | | | | | NO FISHING | | | | | | | |
| | 9 | | | | | 1080 | - | - | - | 1881 | 3776 | 5566 | 3885 | | | | 16188 |
| | 10 | | | | | - | - | - | - | - | - | - | 4254 | - | | - | 4254 |
| | 11 | | | | | - | 3286 | - | - | - | - | - | - | - | | - | 3286 |
| | 12 | | | | | - | - | - | - | - | - | - | 5217 | - | NO TAGGING | - | 5217 |
| | 13 | | | | | 1190 | - | - | - | - | - | - | - | 2045 | | 80 | 3315 |
| | 14 | | | | | - | - | 1679 | - | - | - | - | - | 1629 | | - | 3308 |
| | 15 | | | | | - | - | - | - | - | 1118 | - | - | 825 | | - | 1943 |
| | 16 | | | | | - | - | - | - | - | - | - | - | - | | - | 0 |
| | 17 | | | | | - | - | - | - | - | - | - | - | - | | - | 0 |
| | 18 | | | | | - | - | - | - | - | - | - | - | - | | 44 | 44 |
| TOTAL | | | | | | 12008 | 9316 | 9434 | 4784 | 7250 | 5954 | 5566 | 13356 | 4499 | | 124 | 72291 |

Table 10. Daily estimates of the ratio of the number of charr ≥45 cm but <53 cm to the number of charr ≥53 cm passing the Koukdjuak River trap from 31 August to 8 September 1976.

| Date | | Ratio |
|---|---|---|
| August | 31 | 3.49 |
| September | 1 | 4.67 |
| | 2 | 4.03 |
| | 3 | 3.64 |
| | 4 | 7.59 |
| | 5 | 6.23 |
| | 6 | 4.33 |
| | 7 | 5.58 |
| | 8 | 3.96 |

APPENDIX 1. Biological data by age group for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 1 July to 13 September 1974.

| AGE | MALES | | | | | | | FEMALES | | | | | | | COMBINED | | | | | | | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LENGTH(MM) | | WEIGHT(G) | | | | | LENGTH(MM) | | WEIGHT(G) | | | | | LENGTH(MM) | | WEIGHT(G) | | | |
| (YR) | N | % | MEAN | SD | MEAN | SD | K | N | % | MEAN | SD | MEAN | SD | K | N | % | MEAN | SD | MEAN | SD | K | FEMALE |
| 8 | 5 | 1 | 449 | 81 | 966 | 421 | 1.03 | 2 | 1 | 455 | 78 | 1134 | 642 | 1.13 | 7 | 1 | 451 | 73 | 1014 | 440 | 1.06 | 29 |
| 9 | 15 | 2 | 453 | 70 | 1128 | 677 | 1.09 | 10 | 3 | 473 | 75 | 1198 | 581 | 1.03 | 25 | 2 | 461 | 71 | 1156 | 629 | 1.06 | 40 |
| 10 | 41 | 6 | 493 | 72 | 1458 | 696 | 1.11 | 34 | 9 | 460 | 56 | 1057 | 418 | 1.03 | 76 | 7 | 479 | 67 | 1273 | 613 | 1.07 | 45 |
| 11 | 86 | 12 | 529 | 72 | 1766 | 719 | 1.11 | 76 | 20 | 508 | 46 | 1442 | 448 | 1.07 | 165 | 15 | 519 | 61 | 1615 | 623 | 1.09 | 47 |
| 12 | 172 | 24 | 545 | 59 | 1839 | 610 | 1.09 | 92 | 24 | 503 | 58 | 1417 | 537 | 1.06 | 265 | 24 | 531 | 62 | 1694 | 618 | 1.08 | 35 |
| 13 | 142 | 20 | 550 | 60 | 1850 | 673 | 1.06 | 66 | 17 | 503 | 51 | 1402 | 574 | 1.05 | 212 | 19 | 535 | 62 | 1702 | 680 | 1.05 | 32 |
| 14 | 112 | 16 | 558 | 58 | 1948 | 639 | 1.08 | 52 | 14 | 514 | 53 | 1449 | 466 | 1.04 | 168 | 15 | 545 | 60 | 1791 | 631 | 1.06 | 32 |
| 15 | 69 | 10 | 555 | 56 | 1865 | 597 | 1.06 | 21 | 5 | 487 | 56 | 1181 | 475 | 0.98 | 95 | 9 | 541 | 66 | 1704 | 641 | 1.04 | 23 |
| 16 | 37 | 5 | 561 | 44 | 1775 | 446 | 1.00 | 16 | 4 | 521 | 42 | 1441 | 403 | 1.00 | 54 | 5 | 549 | 46 | 1676 | 453 | 1.00 | 30 |
| 17 | 17 | 2 | 596 | 66 | 2136 | 750 | 0.97 | 8 | 2 | 525 | 50 | 1471 | 546 | 0.98 | 25 | 2 | 573 | 69 | 1923 | 750 | 0.97 | 32 |
| 18 | 10 | 1 | 588 | 50 | 1996 | 661 | 0.96 | 4 | 1 | 521 | 74 | 1446 | 450 | 1.01 | 14 | 1 | 569 | 63 | 1839 | 645 | 0.97 | 29 |
| 19 | 3 | 0 | 590 | 10 | 1966 | 312 | 0.95 | 1 | 0 | 640 | - | 3119 | - | 1.19 | 4 | 0 | 603 | 26 | 2254 | 631 | 1.01 | 25 |
| 20 | 2 | 0 | 645 | 120 | 2240 | 1002 | 0.81 | 2 | 1 | 525 | 21 | 1049 | 160 | 0.72 | 4 | 0 | 585 | 99 | 1644 | 903 | 0.77 | 50 |
| 22 | 1 | 0 | 540 | - | 1418 | - | 0.90 | - | - | - | - | - | - | - | 1 | 0 | 540 | - | 1418 | - | 0.90 | - |
| 23 | 1 | 0 | 610 | - | 1701 | - | 0.75 | - | - | - | - | - | - | - | 1 | 0 | 610 | - | 1701 | - | 0.75 | - |
| TOTAL | 713 | | | | | | | 384 | | | | | | | 1116 | | | | | | | |
| MEAN | | | 545 | 65 | 1816 | 660 | 1.07 | | | 502 | 56 | 1377 | 515 | 1.04 | | | 530 | 66 | 1661 | 647 | 1.06 | 35 |
| MEAN AGE | 13.0 | | | | | | | | | 12.5 | | | | | | | 12.8 | | | | | |

APPENDIX 2. Biological data by length interval for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 1 July to 13 September 1974.

| LENGTH INTERVAL | MALES | | | | | | FEMALES | | | | | | COMBINED | | | | | | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LENGTH(MM) | WEIGHT(G) | | | | | LENGTH(MM) | WEIGHT(G) | | | | | LENGTH(MM) | WEIGHT(G) | | | |
| (MM) | N | % | MEAN | MEAN | SD | K | N | % | MEAN | MEAN | SD | K | N | % | MEAN | MEAN | SD | K | FEMALE |
| 300 | 1 | 0 | 330 | 340 | - | 0.95 | 2 | 0 | 328 | 284 | 80 | 0.80 | 3 | 0 | 328 | 302 | 65 | 0.85 | 67 |
| 350 | 25 | 3 | 379 | 504 | 66 | 0.92 | 12 | 3 | 375 | 499 | 77 | 0.95 | 37 | 3 | 378 | 502 | 68 | 0.93 | 32 |
| 400 | 51 | 6 | 428 | 765 | 130 | 0.97 | 55 | 12 | 425 | 771 | 152 | 1.00 | 108 | 8 | 426 | 764 | 143 | 0.98 | 52 |
| 450 | 88 | 11 | 472 | 1050 | 206 | 0.99 | 125 | 28 | 474 | 1090 | 190 | 1.02 | 215 | 17 | 473 | 1072 | 196 | 1.01 | 59 |
| 500 | 179 | 22 | 526 | 1617 | 255 | 1.10 | 145 | 32 | 519 | 1523 | 260 | 1.09 | 328 | 25 | 523 | 1573 | 262 | 1.09 | 45 |
| 550 | 313 | 38 | 572 | 2034 | 304 | 1.09 | 94 | 21 | 565 | 1859 | 313 | 1.03 | 414 | 32 | 570 | 1990 | 316 | 1.07 | 23 |
| 600 | 140 | 17 | 615 | 2472 | 382 | 1.06 | 17 | 4 | 616 | 2508 | 531 | 1.07 | 159 | 12 | 615 | 2476 | 396 | 1.06 | 11 |
| 650 | 22 | 3 | 664 | 3031 | 566 | 1.03 | 3 | 1 | 660 | 2230 | 965 | 0.79 | 26 | 2 | 663 | 2923 | 644 | 1.00 | 12 |
| 700 | 7 | 1 | 723 | 3513 | 780 | 0.93 | - | - | - | - | - | - | 8 | 1 | 721 | 3371 | 825 | 0.89 | - |
| TOTAL | 826 | | | | | | 453 | | | | | | 1298 | | | | | | |
| MEAN | | | 547 | 1825 | 664 | 1.06 | | | 505 | 1391 | 520 | 1.04 | | | 532 | 1671 | 650 | 1.05 | 35 |

APPENDIX 3. Biological data by age group for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 23 July to 10 September 1975.

| AGE | MALES | | | | | | | FEMALES | | | | | | | COMBINED | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LENGTH(MM) | | WEIGHT(G) | | | | | LENGTH(MM) | | WEIGHT(G) | | | | | LENGTH(MM) | | WEIGHT(G) | | | % |
| (YR) | N | % | MEAN | SD | MEAN | SD | K | N | % | MEAN | SD | MEAN | SD | K | N | % | MEAN | SD | MEAN | SD | K | FEMALE |
| 7 | 2 | 1 | 420 | 14 | 950 | 71 | 1.28 | - | - | - | - | - | - | - | 2 | 0 | 420 | 14 | 950 | 71 | 1.28 | - |
| 8 | 5 | 1 | 392 | 42 | 800 | 308 | 1.27 | 1 | 1 | 430 | - | 950 | - | 1.19 | 6 | 1 | 398 | 41 | 825 | 282 | 1.26 | 17 |
| 9 | 2 | 1 | 410 | 14 | 800 | 71 | 1.16 | 4 | 2 | 448 | 90 | 1300 | 812 | 1.29 | 6 | 1 | 435 | 73 | 1133 | 681 | 1.24 | 67 |
| 10 | 16 | 4 | 498 | 75 | 1540 | 740 | 1.15 | 13 | 7 | 480 | 61 | 1415 | 490 | 1.22 | 29 | 5 | 490 | 69 | 1484 | 632 | 1.18 | 45 |
| 11 | 42 | 11 | 535 | 67 | 1988 | 745 | 1.23 | 31 | 16 | 522 | 44 | 1808 | 468 | 1.24 | 73 | 13 | 530 | 58 | 1912 | 645 | 1.23 | 42 |
| 12 | 76 | 21 | 557 | 58 | 2169 | 700 | 1.21 | 46 | 24 | 528 | 50 | 1808 | 565 | 1.18 | 122 | 22 | 546 | 57 | 2033 | 673 | 1.20 | 38 |
| 13 | 67 | 18 | 564 | 66 | 2215 | 803 | 1.17 | 45 | 23 | 524 | 44 | 1774 | 516 | 1.20 | 112 | 20 | 548 | 62 | 2038 | 732 | 1.18 | 40 |
| 14 | 70 | 19 | 582 | 53 | 2379 | 720 | 1.17 | 22 | 11 | 521 | 43 | 1705 | 545 | 1.16 | 92 | 16 | 567 | 57 | 2217 | 738 | 1.17 | 24 |
| 15 | 45 | 12 | 568 | 54 | 2161 | 675 | 1.15 | 16 | 8 | 500 | 47 | 1400 | 455 | 1.08 | 61 | 11 | 550 | 60 | 1961 | 707 | 1.13 | 26 |
| 16 | 25 | 7 | 567 | 53 | 2034 | 475 | 1.11 | 9 | 5 | 530 | 45 | 1644 | 587 | 1.07 | 34 | 6 | 557 | 53 | 1931 | 527 | 1.10 | 26 |
| 17 | 14 | 4 | 563 | 29 | 2119 | 327 | 1.19 | 5 | 3 | 548 | 43 | 1940 | 599 | 1.15 | 19 | 3 | 559 | 33 | 2072 | 405 | 1.18 | 26 |
| 18 | 3 | 1 | 552 | 29 | 1633 | 161 | 0.99 | 3 | 2 | 543 | 16 | 1617 | 104 | 1.01 | 6 | 1 | 548 | 21 | 1625 | 121 | 1.00 | 50 |
| 19 | 2 | 1 | 683 | 81 | 2800 | 2404 | 0.78 | - | - | - | - | - | - | - | 2 | 0 | 683 | 81 | 2800 | 2404 | 0.78 | - |
| 20 | 1 | 0 | 640 | - | 3100 | - | 1.18 | - | - | - | - | - | - | - | 1 | 0 | 640 | - | 3100 | - | 1.18 | - |
| TOTAL | 370 | | | | | | | 195 | | | | | | | 565 | | | | | | | |
| MEAN | | | 557 | 66 | 2126 | 752 | 1.18 | | | 518 | 50 | 1707 | 539 | 1.18 | | | 544 | 64 | 1982 | 714 | 1.18 | 35 |
| MEAN AGE | 13.2 | | | | | | | | | 12.7 | | | | | | | 13.0 | | | | | |

APPENDIX 4. Biological data by length interval for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 23 July to 10 September 1975.

| LENGTH | MALES | | | | | | FEMALES | | | | | | COMBINED | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INTERVAL | | | LENGTH(MM) | WEIGHT(G) | | | | | LENGTH(MM) | WEIGHT(G) | | | | | LENGTH(MM) | WEIGHT(G) | | | % |
| (MM) | N | % | MEAN | MEAN | SD | K | N | % | MEAN | MEAN | SD | K | N | % | MEAN | MEAN | SD | K | FEMALE |
| 300 | 1 | 0 | 340 | 450 | - | 1.14 | 1 | 0 | 330 | 450 | - | 1.25 | 2 | 0 | 335 | 450 | 0 | 1.20 | 50 |
| 350 | 8 | 2 | 374 | 568 | 101 | 1.08 | 4 | 2 | 380 | 592 | 17 | 1.09 | 12 | 2 | 376 | 576 | 81 | 1.08 | 33 |
| 400 | 22 | 5 | 422 | 848 | 144 | 1.12 | 15 | 7 | 427 | 795 | 101 | 1.02 | 37 | 6 | 424 | 826 | 129 | 1.08 | 41 |
| 450 | 36 | 9 | 474 | 1172 | 202 | 1.10 | 44 | 19 | 476 | 1202 | 189 | 1.11 | 80 | 13 | 475 | 1189 | 194 | 1.10 | 55 |
| 500 | 81 | 20 | 527 | 1780 | 269 | 1.21 | 92 | 41 | 523 | 1724 | 291 | 1.20 | 173 | 27 | 525 | 1750 | 282 | 1.20 | 53 |
| 550 | 137 | 34 | 572 | 2208 | 254 | 1.18 | 62 | 27 | 568 | 2211 | 258 | 1.21 | 199 | 31 | 571 | 2209 | 255 | 1.19 | 31 |
| 600 | 104 | 25 | 618 | 2791 | 415 | 1.18 | 8 | 4 | 609 | 2669 | 198 | 1.18 | 112 | 18 | 617 | 2782 | 404 | 1.18 | 7 |
| 650 | 18 | 4 | 660 | 3463 | 673 | 1.20 | - | - | - | - | - | - | 18 | 3 | 660 | 3463 | 673 | 1.20 | - |
| 700 | 1 | 0 | 740 | 4500 | - | 1.11 | - | - | - | - | - | - | 1 | 0 | 740 | 4500 | - | 1.11 | - |
| TOTAL | 408 | | | | | | 226 | | | | | | 634 | | | | | | |
| MEAN | | | 558 | 2131 | 747 | 1.17 | | | 520 | 1702 | 546 | 1.17 | | | 544 | 1978 | 712 | 1.17 | 36 |

APPENDIX 5. Biological data by age group for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 29 August to 17 September 1976.

| AGE | MALES | | | | | | | FEMALES | | | | | | | COMBINED | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LENGTH(MM) | | WEIGHT(G) | | | % | | LENGTH(MM) | | WEIGHT(G) | | | % | | LENGTH(MM) | | WEIGHT(G) | | | % |
| (YR) | N | MEAN | SD | MEAN | SD | K | MAT | N | MEAN | SD | MEAN | SD | K | MAT | N | MEAN | SD | MEAN | SD | K | MAT |
| 7 | 2 | 383 | 53 | 538 | 301 | 0.90 | 0 | - | - | - | - | - | - | - | 2 | 383 | 53 | 538 | 301 | 0.90 | 0 |
| 8 | 4 | 377 | 45 | 506 | 213 | 0.90 | 0 | 2 | 373 | 36 | 475 | 106 | 0.91 | 0 | 6 | 375 | 38 | 496 | 172 | 0.91 | 0 |
| 9 | 13 | 411 | 55 | 694 | 226 | 1.02 | 0 | 10 | 410 | 44 | 618 | 248 | 0.85 | 0 | 23 | 410 | 50 | 661 | 234 | 0.95 | 0 |
| 10 | 11 | 432 | 85 | 868 | 654 | 0.93 | 0 | 5 | 467 | 37 | 915 | 234 | 0.88 | 0 | 17 | 448 | 74 | 910 | 542 | 0.92 | 6 |
| 11 | 14 | 480 | 73 | 1175 | 613 | 0.96 | 0 | 12 | 460 | 59 | 873 | 308 | 0.87 | 0 | 26 | 471 | 66 | 1036 | 511 | 0.92 | 0 |
| 12 | 36 | 511 | 64 | 1338 | 596 | 0.94 | 0 | 22 | 480 | 60 | 1019 | 383 | 0.88 | 5 | 59 | 497 | 67 | 1202 | 553 | 0.91 | 2 |
| 13 | 61 | 560 | 68 | 1764 | 664 | 0.95 | 2 | 39 | 486 | 46 | 1038 | 302 | 0.89 | 0 | 100 | 531 | 70 | 1481 | 655 | 0.93 | 1 |
| 14 | 57 | 598 | 66 | 2110 | 630 | 0.96 | 7 | 39 | 515 | 40 | 1178 | 295 | 0.85 | 0 | 98 | 564 | 69 | 1726 | 689 | 0.91 | 5 |
| 15 | 50 | 600 | 61 | 1997 | 570 | 0.90 | 2 | 20 | 505 | 60 | 1163 | 486 | 0.86 | 5 | 72 | 571 | 75 | 1741 | 664 | 0.89 | 6 |
| 16 | 27 | 594 | 53 | 1878 | 508 | 0.88 | 0 | 8 | 515 | 37 | 1241 | 329 | 0.90 | 0 | 36 | 573 | 62 | 1710 | 550 | 0.88 | 3 |
| 17 | 16 | 600 | 58 | 1970 | 529 | 0.90 | 6 | 5 | 559 | 79 | 1475 | 553 | 0.83 | 0 | 21 | 590 | 64 | 1852 | 564 | 0.88 | 5 |
| 18 | 7 | 567 | 72 | 1643 | 563 | 0.88 | 0 | 1 | 486 | - | 1250 | - | 1.09 | 0 | 8 | 557 | 73 | 1594 | 539 | 0.91 | 0 |
| 19 | 6 | 625 | 76 | 2171 | 741 | 0.87 | 17 | 1 | 505 | - | 1150 | - | 0.89 | 0 | 7 | 608 | 83 | 2025 | 779 | 0.87 | 14 |
| 20 | 2 | 620 | 36 | 1950 | 212 | 0.82 | 0 | 1 | 578 | - | 1850 | - | 0.96 | 0 | 3 | 606 | 35 | 1917 | 161 | 0.87 | 0 |
| TOTAL | 306 | | | | | | | 165 | | | | | | | 478 | | | | | | |
| MEAN | | 557 | 87 | 1715 | 720 | 0.93 | | | 490 | 58 | 1065 | 382 | 0.87 | | | 533 | 84 | 1482 | 694 | 0.91 | |
| MEAN AGE | 13.7 | | | | | | | | 13.2 | | | | | | | 13.5 | | | | | |

APPENDIX 6. Biological data by length interval for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 29 August to 17 September 1976.

| LENGTH INTERVAL | MALES | | | | | | FEMALES | | | | | | COMBINED | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LENGTH(MM) | WEIGHT(G) | | | % | | LENGTH(MM) | WEIGHT(G) | | | % | | LENGTH(MM) | WEIGHT(G) | | | % |
| (MM) | N | MEAN | MEAN | SD | K | MAT | N | MEAN | MEAN | SD | K | MAT | N | MEAN | MEAN | SD | K | MAT |
| 250 | 1 | 293 | 600 | - | 2.39 | 0 | - | - | - | - | - | - | 1 | 293 | 600 | - | 2.39 | 0 |
| 300 | 5 | 338 | 315 | 42 | 0.81 | 0 | 2 | 343 | 375 | 35 | 0.93 | 0 | 8 | 338 | 328 | 45 | 0.84 | 0 |
| 350 | 11 | 379 | 498 | 92 | 0.90 | 0 | 10 | 381 | 460 | 73 | 0.82 | 10 | 21 | 380 | 480 | 84 | 0.87 | 5 |
| 400 | 26 | 426 | 686 | 99 | 0.88 | 0 | 26 | 424 | 702 | 145 | 0.91 | 0 | 52 | 425 | 694 | 123 | 0.90 | 0 |
| 450 | 48 | 473 | 952 | 114 | 0.90 | 0 | 64 | 475 | 954 | 130 | 0.89 | 3 | 112 | 474 | 953 | 123 | 0.89 | 2 |
| 500 | 59 | 523 | 1355 | 198 | 0.94 | 5 | 68 | 521 | 1193 | 165 | 0.84 | 3 | 128 | 522 | 1267 | 197 | 0.89 | 4 |
| 550 | 85 | 576 | 1851 | 254 | 0.97 | 4 | 27 | 565 | 1592 | 232 | 0.88 | 11 | 112 | 573 | 1789 | 272 | 0.95 | 5 |
| 600 | 92 | 623 | 2258 | 297 | 0.93 | 4 | 2 | 606 | 2000 | 71 | 0.90 | 50 | 94 | 623 | 2253 | 297 | 0.93 | 5 |
| 650 | 43 | 669 | 2631 | 319 | 0.88 | 0 | 2 | 673 | 2425 | 106 | 0.80 | 0 | 45 | 669 | 2622 | 315 | 0.87 | 0 |
| 700 | 5 | 713 | 2865 | 304 | 0.79 | 0 | - | - | - | - | - | - | 5 | 713 | 2865 | 304 | 0.79 | 0 |
| TOTAL | 375 | | | | | | 201 | | | | | | 578 | | | | | |
| MEAN | | 558 | 1716 | 700 | 0.93 | | | 494 | 1083 | 372 | 0.87 | | | 535 | 1493 | 678 | 0.91 | |

APPENDIX 7. Biological data by age group for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 19 August to 12 September 1977.

| AGE | MALES | | | | | | | FEMALES | | | | | | | COMBINED | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LENGTH(MM) | | | WEIGHT(G) | | | % | LENGTH(MM) | | | WEIGHT(G) | | | % | LENGTH(MM) | | | WEIGHT(G) | | | % |
| (YR) | N | MEAN | SD | MEAN | SD | K | MAT | N | MEAN | SD | MEAN | SD | K | MAT | N | MEAN | SD | MEAN | SD | K | MAT |
| 7 | 1 | 413 | - | 850 | - | 1.21 | 0 | | - | - | - | - | - | - | 1 | 413 | - | 850 | - | 1.21 | 0 |
| 8 | - | - | - | - | - | - | - | 1 | 325 | - | 350 | - | 1.02 | 0 | 1 | 325 | - | 350 | - | 1.02 | 0 |
| 9 | 4 | 439 | 92 | 1138 | 598 | 1.22 | 0 | 2 | 384 | 6 | 663 | 53 | 1.17 | 0 | 6 | 420 | 76 | 979 | 525 | 1.21 | 0 |
| 10 | 2 | 455 | 64 | 950 | 424 | 0.97 | 0 | 1 | 444 | - | 1000 | - | 1.14 | 100 | 4 | 461 | 41 | 1094 | 354 | 1.09 | 50 |
| 11 | 11 | 467 | 63 | 1166 | 624 | 1.05 | 9 | 2 | 541 | 23 | 1800 | 283 | 1.13 | 50 | 20 | 480 | 59 | 1285 | 554 | 1.09 | 45 |
| 12 | 19 | 509 | 80 | 1534 | 718 | 1.07 | 47 | 7 | 471 | 46 | 1107 | 286 | 1.04 | 43 | 44 | 505 | 63 | 1434 | 570 | 1.06 | 68 |
| 13 | 27 | 546 | 80 | 1759 | 739 | 1.01 | 56 | 8 | 503 | 30 | 1434 | 457 | 1.10 | 75 | 47 | 527 | 68 | 1601 | 633 | 1.04 | 70 |
| 14 | 42 | 559 | 61 | 1999 | 694 | 1.10 | 71 | 8 | 505 | 37 | 1475 | 493 | 1.13 | 63 | 73 | 543 | 61 | 1847 | 659 | 1.11 | 79 |
| 15 | 46 | 564 | 62 | 1946 | 632 | 1.04 | 78 | 16 | 524 | 50 | 1653 | 563 | 1.11 | 75 | 76 | 548 | 58 | 1798 | 599 | 1.06 | 82 |
| 16 | 55 | 574 | 55 | 2117 | 624 | 1.10 | 93 | 9 | 519 | 25 | 1442 | 203 | 1.02 | 78 | 79 | 553 | 61 | 1882 | 665 | 1.08 | 92 |
| 17 | 34 | 570 | 39 | 1970 | 457 | 1.05 | 91 | 5 | 546 | 31 | 1675 | 432 | 1.01 | 80 | 50 | 558 | 46 | 1862 | 490 | 1.05 | 92 |
| 18 | 24 | 571 | 60 | 2046 | 818 | 1.06 | 79 | - | - | - | - | - | - | - | 33 | 554 | 58 | 1863 | 765 | 1.05 | 85 |
| 19 | 11 | 584 | 46 | 2157 | 509 | 1.06 | 82 | 2 | 556 | 34 | 2025 | 389 | 1.17 | 100 | 14 | 576 | 45 | 2095 | 488 | 1.08 | 86 |
| 20 | 3 | 584 | 20 | 2025 | 205 | 1.01 | 100 | - | - | - | - | - | - | - | 3 | 584 | 20 | 2025 | 205 | 1.01 | 100 |
| 21 | 1 | 432 | - | 775 | - | 0.96 | 100 | - | - | - | - | - | - | - | 1 | 432 | - | 775 | - | 0.96 | 100 |
| TOTAL | 280 | | | | | | | 61 | | | | | | | 452 | | | | | | |
| MEAN | | 555 | 68 | 1905 | 689 | 1.07 | | | 506 | 54 | 1461 | 500 | 1.09 | | | 538 | 65 | 1740 | 649 | 1.07 | |
| MEAN AGE | 15.1 | | | | | | | 14.2 | | | | | | | 14.8 | | | | | | |

APPENDIX 8. Biological data by length interval for Arctic charr taken by the commercial fishery at Koukdjuak River/Nettilling Lake, 19 August to 12 September 1977.

| LENGTH | MALES | | | | | | FEMALES | | | | | | COMBINED | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INTERVAL | LENGTH(MM) | | WEIGHT(G) | | | % | LENGTH(MM) | | WEIGHT(G) | | | % | LENGTH(MM) | | WEIGHT(G) | | | % |
| (MM) | N | MEAN | MEAN | SD | K | MAT | N | MEAN | MEAN | SD | K | MAT | N | MEAN | MEAN | SD | K | MAT |
| 300 | 1 | 312 | 350 | - | 1.15 | 0 | 1 | 325 | 350 | - | 1.02 | 0 | 2 | 319 | 350 | 0 | 1.09 | 0 |
| 350 | 7 | 374 | 539 | 64 | 1.04 | 0 | 4 | 387 | 644 | 43 | 1.12 | 25 | 11 | 378 | 577 | 76 | 1.06 | 9 |
| 400 | 15 | 428 | 798 | 102 | 1.02 | 20 | 19 | 429 | 846 | 129 | 1.07 | 95 | 34 | 428 | 825 | 119 | 1.05 | 62 |
| 450 | 33 | 473 | 1087 | 174 | 1.04 | 39 | 62 | 482 | 1158 | 232 | 1.03 | 92 | 95 | 479 | 1133 | 215 | 1.03 | 74 |
| 500 | 72 | 530 | 1593 | 224 | 1.07 | 63 | 90 | 520 | 1477 | 208 | 1.04 | 89 | 162 | 525 | 1529 | 222 | 1.06 | 77 |
| 550 | 130 | 572 | 1972 | 235 | 1.05 | 87 | 47 | 569 | 2044 | 265 | 1.11 | 96 | 177 | 571 | 1991 | 244 | 1.07 | 89 |
| 600 | 71 | 619 | 2523 | 341 | 1.06 | 90 | 5 | 613 | 2535 | 178 | 1.10 | 100 | 76 | 618 | 2524 | 332 | 1.07 | 91 |
| 650 | 21 | 667 | 3167 | 489 | 1.06 | 95 | 1 | 655 | 2750 | - | 0.98 | 100 | 22 | 666 | 3148 | 485 | 1.06 | 95 |
| 700 | 5 | 714 | 3470 | 566 | 0.95 | 80 | - | - | - | - | - | - | 5 | 714 | 3470 | 566 | 0.95 | 80 |
| 750 | 1 | 758 | 5100 | - | 1.17 | 100 | - | - | - | - | - | - | 1 | 758 | 5100 | - | 1.17 | 100 |
| TOTAL | 356 | | | | | | 229 | | | | | | 585 | | | | | |
| MEAN | | 561 | 1941 | 696 | 1.06 | | | 512 | 1464 | 473 | 1.06 | | | 542 | 1754 | 661 | 1.06 | |