Stas Olpinski

# The Arctic charr (*Salvelinus alpinus*) Experimental-Commercial Winter Fishery in Kangiqsualujjuaq, Québec, November, 1988-April, 1989

By:

Thomas Boivin
Stas Olpinski
Peter May

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Makivik Corporation
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Kuujjuaq Research
Centre, Makivik Corp.,
Kuujjuaq, Québec.
J0M 1C0.

Fritz Axelsen
M.A.P.A.
1665 boul. Wilfrid Hamel O.,
Edifice 2, 1st floor,
Quebec, Qc.
G1N 3Y7

March 30, 1990

Dear Fritz,

I am enclosing a copy of the scientific report from the 1988-89 experimental-commercial winter fishery in Kangiqsualujjuaq, Quebec. A copy has also been sent to Louis Roy for his comments. Give me a call to tell me your comments, or send them by letter or fax. Thank you.

Sincerely,

Tom Boivin

Tom Boivin

## Abstract

The commercial and subsistence arctic charr harvests of the community of Kangiqsualujjuaq, Quebec were monitored between November 27, 1988 and April 24, 1989. A total of 7185 charr were harvested in the subsistence and commercial fisheries. Arctic charr accounted for over 91.7% of all fish species harvested by the community. 70.7% of the total subsistence harvest (5375 charr) originated from the Koroc River. A total of 1810 charr were harvested from 7 locations during the commercial fishery; 1515 were tagged for commercial sale, representing 25.5% of the total allocated quota (5930 charr). Catch per unit of effort was highest at Lake Tasikallak, where an average of 77.6 kg were captured per net-day, and lowest at Napaartulik where 7.8 kg were harvested per net-day. There was a general trend of increasing mean fork length and age of the commercial catch with distance of fishing site from the community. Subsistence areas located near the community appear to be heavily exploited, whereas more distant systems are lightly fished; however, rates of mortality and exploitation calculated in this study were less conclusive than those calculated during the 1987-88 winter fishery. It is recommended that the subsistence and commercial fisheries continue to be closely monitored. The collection of further data on the charr stocks of this region, and a compilation of existing data will prove invaluable for determining if present harvest levels are sustainable in the long-term.

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## Acknowledgements

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## Introduction

### Background

The second year of the experimental-commercial winter arctic charr (*Salvelinus alpinus*) fishery in Kangiqsualujjuaq, Quebec (58$^{o}$ 42'N, 66$^{o}$00'W) was undertaken from November 27, 1987 to April 15, 1988. This fishery is unique, since fish are captured with gillnets set beneath the ice of freshwater lakes. The two other commercial fisheries for arctic charr in Canada are undertaken in northern Labrador and the Cambridge Bay area of the Northwest Territories; both these fisheries are summer operations which capture charr in the sea with gillnet, or using counting fences in freshwater (Dempson and Kristofferson 1987). The Kangiqsualujjuaq fishery provides an opportunity to examine the feasibility of harvesting charr commercially in northern Québec during winter, and also will add to our biological data on the charr stocks of eastern Ungava. Biological data collected during the 1987-88 winter commercial fishery, and a description of the operation of this project is discussed by Boivin et al. (1988) and Olpinski et al. (1989).

Our current knowledge of arctic charr biology in northern Québec, athough still limited, is increasing rapidly. Most previous studies were conducted in the Ungava Bay region, particularly from the George River (Grainger 1953; LeJeune 1967; Gillis et al. 1982; Gillis 1988). However, in recent years, studies have also been conducted on other charr stocks of the Kangiqsualujjuaq region (Barton et al. 1985; Boivin 1987; Boivin et al. 1988). The collection of further biological data on the charr of this area is essential for developing and managing the winter commercial fishery.

Commercial arctic charr fisheries in northern Quebec during the early 1960's were failures, because allocated quotas were too high, and the effects of exploitation on this species were unknown (Gillis et al. 1982). With this past experience in mind, fisheries managers must be cautious when determining exploitation rates for each fishing location in the region. Of foremost concern are the subsistence harvests (NHR 1982; Boivin 1987), which must take precedence over the commercial fisheries.

This report will deal with results obtained during the second year of operation of the Annanack and Son's experimental-commercial winter arctic charr fishery in Kangiqsualujjuaq, Québec. Biological data collected from the commercial fishery will be examined, as well as results from a subsistence harvest study.

Throughout this document, the name 'charr' refers to the arctic charr (*Salvelinus alpinus*). Spellings of Inuit place names follows Müller-Wille and Avataq Cultural Institute (1987).

## Fish species captured

According to the NHR (1982) study, the main fish species harvested by Inuit of Kangiqsualujjuaq, in decreasing order of importance (total edible weight) are: arctic charr, lake charr (*Salvelinus namaycush* ), brook charr (*S. fontinalis* ), Atlantic salmon (*Salmo salar* ), lake whitefish (*Coregonus clupeaformis* ), sculpins ( *Myoxocephalus* spp.) and cod (*Gadus morhua* and *G. ogac* ). The latter three species are captured during the short summer fishery. White suckers (*Catostomus catostomus* ) and burbot (*Lota lota*) are also harvested on occasion in the George River. Table 1 lists the salmonid fish species harvested by gillnet from river and lake systems in the Kangiqsualujjuaq area.

## Sites fished commercially and for subsistence

The commercial quotas allocated to the proponent generally increase with distance of system from the community (Appendix 1). Of the 12 systems listed in the proponent's fishing permit (Figure 1), only 7 were fished commercially in 1987-88 (George River, Koroc, Qarliik, Tasikallak, Akilasaaluk and Napaartulik and Sanirarsiq). Conversely, 10 systems were fished for subsistence use during the winter of 1988-89 (Table 2). In general, the fishing sites closest to the community ( George R., Koroc, Tasikallak) are the most important in terms of subsistence use; more distant systems (Akilasaaluk and Ijjurittuq) are seldom fished for subsistence during winter (Boivin 1987).

Commercial fishing for arctic charr (for sale to beneficiaries both in Kangiqsualujjuaq and other communities) has taken place in this area for at least 10 years. During these intensive fishing periods, most charr were captured from Koroc and Tasikallak; 71% of the total subsistence-commercial catch during the winter of 1985-86 originated from these 2 sites (Boivin 1987).

Fishing activities in the Kangiqsualujjuaq area in winter are restricted by two main factors: trail conditions and weather. In November and early December, the river and lake ice are stable enough to permit travel to nearby fishing sites. Koroc R. receives most of the early winter fishing effort and is fished intensively by many local fishermen. By mid-December, weather and ice conditions permit travel on the sea ice, and more distant locations may then be fished. Once distant systems are accessible, subsistence fishing effort drops dramatically at Koroc R. and becomes more dispersed. In spring, as trail conditions deteriorate, Koroc R. is once again the only accessible fishing site, and fishing effort increases. Fishing activities at this time also take place in the Tunulliq and Amarurtaliup areas west of Kangiqsualujjuaq.

## Methods

Fieldwork was conducted between 27 November, 1988 and 24 April, 1989 in Kangiqsualujjuaq, Quebec. Research staff travelled by snowmobile with the proponent to all sites commercially-fished and sampled the commercial catch at each site. The methods outlined here are discussed further in Olpinski et al. (1988; 1989) and are similar to those used by Boivin (1987).

### Subsistence Harvest Study

To obtain an estimate of the total subsistence catch by the community, harvest booklets were distributed between 30 November and 1 December, 1988 to all households in the community (N=87); a total of 115 potential fishermen were surveyed. Fishermen were asked to record: date, location fished, number of nets used, and number of charr (or other species) captured by net, jigging or kakivak (fishing spear). Fishermen were visited once over the course of the winter (25-28 April, 1989) to check whether harvest records were up-to-date. If not, the hunter was asked to answer a questionnaire concerning catch and harvest effort. Estimates of the total fish harvest of the community were calculated from both booklet and questionnaire data; reported catches in booklets were used to estimate the total harvest according to the method outlined by Dumas et al. (1984).

Fishing effort

At the fishing sites, a record was kept of number of fishermen, number of nets set, length and mesh size of net, time nets were set beneath the ice and the time of each net check. In this study, catch per unit of effort (C.P.U.E.) is expressed in terms of numbers and total weight (kg) captured per gillnet-day.

Biological sampling

All fish processed for commercial sale and a sub-sample of rejected charr (N=1577) were sampled by the research team. In the field, fishing effort, M.L.C.P. commercial tag number, sex (determined by examination of gonads) and coloration (silver or red charr) was noted. Coloration is used to as an indicator of maturity status; 'silver' charr are designated as not having spawned the previous fall, whereas 'red' charr are described as contributing to the fall spawning run. The accuracy of this index of maturity was confirmed by examining the gonads of a sub-sample of the total catch in 1987-88 (Boivin et a. 1988).

In the community, frozen fish were measured for fork length (±0.5 cm) and eviscerated weight (±25 g). Correction factors for eviscerated weights and frozen lengths were calculated from a sub-sample of 30 fish measured fresh in the field, and sampled again later when frozen. All frozen lengths were corrected to fresh by dividing by a factor of 1.02; eviscerated weights were adjusted by a factor of 1.12.

A minimum of 150 charr (or the entire quota if less than 150 fish) were systematically-sampled for aging. Saggital otoliths were first examined with reflected light and a stereoscopic microscope according to the method of Nordeng (1961). Second readings were performed after otoliths were sectioned and mounted on microscope slides. Each of the 3 readers verified the aging technique with the other researchers to ensure uniformity of results.

### Statistical analyses

Statistical analyses were performed primarily with the MacIntosh program 'Statview' (Brainpower, Inc. 1985). For all statistical tests, assumptions of normality and homoscedasticity were verified. Normality of data was tested using a graphic test of frequency distributions (Sokal and Rohlf 1981); homogeneity of variance was verified by checking for correlation between plots of means and standard deviations of samples.

Statistical analyses for comparisons of mean lengths, weights, and ages between locations were performed using analysis of variance (ANOVA) according to the procedure outlined by Statview (Brainpower, Inc. 1985). Unplanned comparisons of means were performed using the Tukey-Kramer method, as described in Sokal and Rohlf (1981). Instantaneous rate of mortality (Z) was calculated from catch curves (natural logarithm of frequency of ages in the catch plotted vs age) according to the method described by Ricker (1975). Linear regressions were calculated by the method of least squares. The maximum probability of a Type-1 error was set at 0.05.

## Results

### Total catch and species composition of the winter harvest

#### i) Subsistence Fishery

The result of the subsistence harvest study (Table 2) indicate that a total of 5375 arctic charr were harvested by the community during the winter of 1988-89; the combined subsistence and commercial catch was 7185 charr. 70.7% of the total 1988-89 winter subsistence harvest came from Koroc River (n=3802). Lake Tasikallak harvests were second with 888 charr (16.5% of total) while George River provided 405 (7.5%) of the total community's subsistence catch.

Of the 5 other fish species reported captured in the subsistence fishery (lake whitefish, Atlantic salmon, brook charr, lake charr and burbot; Table 3), 34.7% of the total (486 fish) were captured from George River, and 30.2% from the Koroc River.

76.9% (n=169) of the George River catch was whitefish. A total of 3 Atlantic salmon were reported captured at Koroc River, and 4 at George River.

The percentage contribution of each species to the total subsistence catch is shown in Table 4 . Of the 5375 fish harvested for subsistence purposes, 91.7% were arctic charr, 3.6% were brook trout, 2.3% lake charr, 2.2% were whitefish, and the remainder were salmon and burbot.

ii) Commercial fishery

During the winter gillnet fishery, the proponent harvested a total of 1810 arctic charr from 7 locations; of the total, 1515 were tagged for commercial sale (Appendix 1). The remainder included charr which were captured after the quota had been reached, or were rejected due to small size or scars. The maximum harvest at any one site was 535 (Akilasaaluk), and the minimum was 35 (Napaartulik). The 1515 charr sold commercially represent 25.5% of the total allocated quota (N=5930 charr).

Arctic charr was the only fish species harvested at Koroc River, Tasikallak, Qarliik and Akilasaaluk. Lake trout were captured in the commercial fishery at Napaartulik (N=3) and Sanirarsiq (N=10). A total of 7 species were harvested from the George River: charr (N=378), whitefish (N=156), lake trout (N=25), burbot (N=5), salmon (N=4), sucker (N=3) and brook trout (N=1).

Fishing effort:

C.P.U.E. (Table 5) was highest at Lake Tasikallaq, where an average of 77.6 kg were captured per net-day (42.5 charr per net-day). At this location, an average of 183 m of gill net was used for the 2 fishing days. C.P.U.E. at Akilasaaluk was second highest in terms of total weight harvested per net-day (29.6 kg), and in numbers of charr captured per net-day (15.1). C.P.U.E. was lowest at Napaartulik; fishermen harvested only 7.8 kg per net-day (2.9 charr per net-day).

Length, Weight and Age of the Catch:

The average fork length of the commercial catch was 56.8 cm and average whole weight was 1944.8 g (N=1577) (Table 6). The smallest charr were sampled at Lake Qarliik (54.2 cm), and the largest at Sanirarsiq (61.6 cm); there was a general trend of increasing mean fork length and whole weight with distance from the community; this difference was highly significant (ANOVA; p<0.0001). However, mean lengths were almost identical at George River, Koroc River, Qarliik, and Tasikallak (Tukey-Kramer; p>0.05); mean fork lengths from all other locations were significantly larger than those recorded from these locations (p<0.05). Sanirarsiq fork lengths were greater that that recorded at all other locations (p<0.05) except Napaartulik (p>0.05). No differences were recorded between Akilasaaluk and Napaartulik charr (p>0.05). However, the sample size of charr from Napaartulik was small (N=35), and this likely influenced comparisons for this location.

The length-frequency distribution of the commercial catch is shown in Figures 2 and 5. The modal size of fish captured at all locations was 55-60 cm; however, for Sanirarsiq charr captured, the mode was at 65 cm. The weight-frequency distribution of the commercial catch (Figure 3) showed a similar pattern. Weights of charr were generally in the 1.5-2 kg mode; the modal weight of Sanirarsiq and Napaartulik charr was between 2-2.5 kg.

The general trend of increasing mean morphometric variables with distance from the community was also apparent for age data (Table 7). The mean age of the commercial catch was 9.9 years. The oldest charr (18) were harvested at Akilasaaluk and Napaartulik while the youngest (4) was captured at the George River. The widest range of ages captured at any commercial site was at Akilasaaluk (11 yrs).

There was a trend of increasing mean age of the commercial catch with distance from the community (p<0.0001). Mean ages of George and Koroc River charr were very similar (p>0.05) and were significantly different from ages recorded at all other locations (p<0.05). No differences were found between ages of charr captured at Tasikallak, Qarliik, Akilasaaluk and Napaartulik (p>0.05). Sanirarsiq charr were older than those sampled at all other locations (p<0.05). The age-frequency distribution of the commercial catch is shown in Figure 4. The mode of George River charr was at age 7, age 8 for Koroc charr, and between ages 10-12 for Sanirarsiq. At all other locations, the mode was at either age 10 or 11.

The length, weight and age distribution of the entire commercial catch are presented in Figure 6. In the total catch, the modal length was 55 cm, modal weight was 2.0 kg and modal age was undefined, but between ages 10-11.

Sex ratio, Coloration and Maturity:

The total commercial catch was equally distributed between males and females, with the male:female ratio equal to 1.03:1 (791:766) (Table 8). Females represented 49.2% of the total commercial catch. At Tasikallak, females represented only 31.3% of the total catch, but at Qarliik the reverse was true (62.7% female).

Silver charr also dominated the catch at all locations; only 19.0% of the catch from all locations was red (spent) charr. The percentages of red charr in the catch ranged from 5.3% (Akilasaaluk) to 37.4% (George River). The youngest spent charr was age 7 (2 samples from Koroc, 1 from George River, and 1 from Sanirarsiq) and the oldest age 15 (1 sample from Tasikallak).

Growth

The growth curves (length vs age) of charr samples (both sexes combined) obtained from the commercial fishing locations show a high variation in growth rate (Tables 9-15) from different areas. Growth of Koroc River charr appears to be faster that that recorded at lightly-exploited systems such as Akilasaaluk and Sanirarsiq. Perhaps the most striking feature of the growth data is the overlap of length ranges between different age groups; this is particularly evident at George River, Qarliik and Tasikallak, where growth appears to be slow between ages 8-12. As a result, the growth rate of charr from these location appears to be intermediate between the heavily- and lightly-exploited charr populations of the region.

Mortality

Only that portion of the stock which is completely succeptible to the fishing gear employed was used in the analysis of mortality data. Plots of the natural logarithm of age frequency versus age were examined to determine ages used in mortality calculations. Furthermore, 2 separate calculations of exploitation rate (u) are presented, since it is believed that those systems which are lightly-exploited year-round (eg. Sanirarsiq) are best characterized as Type-1 fisheries (natural mortality occurs during a time of year other than the fishing season), whereas heavily-exploited systems (eg. Koroc) are probably best-described as Type-2 fisheries (natural mortality occurs along with fishing). Ricker (1975) states that mortality statistics for both Type-1 and 2 fisheries may be calculated over seasons and time if neither model fits a particular fishery. Since winter is a season of continuous heavy fishing pressure on some systems, while others receive only sporadic effort, both calculations of u are presented here.

Instantaneous total mortality (Z) (Table 16) for various systems is estimated to be as follows: George River (0.94; ages 10-12); Koroc (0.82; ages 8-11); Qarliik (0.84; ages 11-14); Tasikallak (0.94; ages 11-13); Akilasaaluk (1.01; ages 10-13); and Sanirarsiq (0.91; ages 12-14). It appears that values for Z are quite similar between locations. The actual mortality rate (A) ranged from 0.64 (Akilasaaluk) to 0.56 (Koroc). The survival rate (S) is highest for the Koroc stock (0.44) and lowest at Akilasaaluk (0.36).

Instantaneous rate of fishing mortality (F) was calculated assuming an instantaneous rate of natural mortality (M) of 0.20. This conservative value for M is used by Dempson and Ledrew (1986) for the Labrador charr fishery. Values of F ranged from 0.81 (Akilasaaluk) to 0.62 (Koroc).

Exploitation rate

Rate of exploitation ($u_1$) for Koroc was 0.46, indicating that approximately 46% of the fish available to the fishery are removed each year ($u_2$=0.42). Akilasaaluk exploitation rate was considerably higher ($u_1$=0.56; $u_2$=0.51). Lightly-fished Sanirarsiq had an exploitation rate which was intermediate between the Koroc River and Akilasaaluk ($u_1$=0.51 ; $u_2$=0.47 ).

## Discussion

The subsistence harvest of arctic charr by the Inuit of Kangiqsualujjuaq is considerable. In this study, 5375 charr were used for subsistence; this result is comparable, although slightly higher, to Boivin et al. 's (1988) estimate of subsistence charr harvest in the winter of 1987-88 (4101 charr). During the winter of 1985-86, subsistence harvests by Kangiqsualujjuamiut totalled 3740 charr (Boivin 1987). The 1988-89 harvest of 3802 charr from Koroc River represents 70.7% of the total community catch. This is the highest recorded harvest at Koroc River since harvest studies were started in 1985 (Boivin 1987; Boivin et al. 1988). Only 888 charr (16.5% of the total harvest) were captured at Tasikallak in this study. The proportion of total subsistence catch from Tasikallak has remained constant over the past 2 years; in 1988-89, this location accounted for 16.3 % of the total.

During the winter of 1985-86, catches of charr were almost equal at both Koroc and Tasikallak (2100 and 2075 charr respectively), and these two locations accounted for 71% of the total community catch (Boivin 1987). The total 1988-89 subsistence catch from George River (405 charr) was intermediate between that recorded in 1985-86 (247 charr), and in 1988-89 (643 charr). It appears that total winter harvests of charr from Koroc River have increased substantially in recent years, and catches from other locations are considerably lower.

Arctic charr accounted for 91.7% of the the total number of fish harvested by the community. This figure is almost identical to that recorded in 1988-89 (91.5%) (Boivin et al. 1988), but slightly below the 95.6% reported by Boivin (1987).

In the commercial fishery, 1515 charr were harvested, representing 25.5% of the total allocated quota. Only 7 of the 12 systems listed for commercial exploitation were fished by the proponent. Sanirarsiq was the most distant system fished, and Akilassaluk was the site with the highest commercial harvest (489 charr). Although more distant systems have the largest commercial quotas, no fishing was attempted at any of these sites (Olpinski et al. 1989). C.P.U.E. was highest at Lake Tasikallak during both years of the winter commercial fishery, and during the subsistence harvests of 1985-86 (Boivin 1987). Lake Napaartulik had the lowest C.P.U.E. of all locations commercially-fished; catches at this location were the poorest recorded at any location during the first 2 years of the winter fishery. Fishing success at Koroc was better in 1988-89 than in the previous year; in 1987-88, Koroc C.P.U.E. was lowest of all locations commercially fished.

The general trend of increasing mean length, age and mortality rates of the commercial harvest with distance from the community provides evidence that subsistence areas such as George River, Koroc River, Qarliik and Lake Tasikallak are more heavily exploited than Lake Akilasaaluk, Napaartulik and Sanirarsiq. This trend was also observed in the 1987-88 data from commercial harvests in Kangiqsualujjuaq (Boivin et al. 1988).

The growth curves (length at age data) appear to indicate that charr are slow-growing at locations distant from Kangiqsualujjuaq, whereas the growth is faster at heavily-fished subsistence areas. At Sanirarsiq, the charr population appears to have a very slow growth rate; this lightly-exploited systems probably are still mainly comprised of old and large individuals, as is commonly found in other unexploited arctic fish populations (Johnson 1976; Power 1978). Conversely, a faster growth rate is apparent for the heavily-exploited stocks (George River, Koroc, Tasikallaq and Qarliik); few large or old individuals were harvested from these locations. Akilasaaluk charr have a growth rate which is comparable to that found for the heavily-exploited systems, yet has received minimal fishing pressure in the past. Differences in growth may at least partly be due to the varying rates of exploitation experienced between systems; however, there may also be natural variation in growth among stocks (Gillis et al. 1982).

An interesting finding in this study was the high degree in overlap in length-at-age data. Similar findings have been made for charr populations in the N.W.T. (Johnson, 1980). However, some caution should be used in interpreting age data presented here, since detailed analyses of the best ageing technique for eastern Ungava arctic charr has not yet been completed. Overlaps in length-at-age data may be an indication of problems with the ageing technique (Barber and MacFarlane 1987).

Mortality data reported from data collected during the 1987-88 winter fishery (Boivin et al. 1988) provided evidence of increased exploitation rates with distance of charr system from the community. However, the mortality data cited in this report is not as conclusive. All locations sampled showed high rates of instantaneous total mortality, and low survival rates. Strangely, 1988-89 values of Z for the Koroc stock were lower than that recorded at both Akilasaaluk and Sanirarsiq. It appears that fishing mortality (F) of the Akilasaaluk stock is exceptionally high (0.81); this result could be due to several factors including: a fishing rate which is too high, non-representative sampling of the stock in the commercial catch, or problems with the ageing technique. Values of F from all locations is considerably higher than what is experienced at the Nain Assessment Unit in the Labrador charr fishery (average value for F, 1983-85=0.39; Dempson and Ledrew 1986). Further analysis of the data collected in the first 2 years of the fishery, plus data obtained in the winter of 1989-90 will prove invaluable for determining the possible causes of the sharp increases in mortality cited in this report.

Kristofferson et al. (1982) suggested a rate of exploitation in a developing fishery should be adjusted to a value of 0.32 ($u_1$) (F=0.40). Using this value, it appears that all locations fished in 1988-89 exceed the guideline. The exploitation rate at Akilasaaluk (.56) is substantially higher than that recorded by Boivin et al. (1988) (0.34). An average of 544 charr were harvested from this small system in the first 2 years of this fishery; therefore, it is possible that adverse effects of commercial fishing are being seen for this location. Analysis of the 1989-90 data will help to identify if such changes in population dynamics are occuring at this location.

The exploitation rate at Sanirarsiq was low in 1987-88 ($u_1$ =0.18; Boivin et al. 1988), but was significantly higher in this study. However, it is unlikely that the high rate of exploitation reported in this study is accurate, since Boivin and Vandal (1989) reported that approximately 6800 arctic charr were counted at a weir set at this location in the summer of 1988. It is more likely that the commercial sample was not representative of the population structure of the stock; mortality data calculated from catch curves can sometimes provide inaccurate information (Ricker 1975). A comparison of mortality rates calculated from winter gillnet data and from data obtained from counting fences at Lakes Sanirarsiq and Sapukkait would be valuable to determine if there is any bias in mortality rates calculated from catch curves.

Commercial fisheries at systems proximate to Kangiqsualujjuaq (George River, Koroc, Qarliik and Tasikallaq), should proceed with caution, in order to ensure that the subsistence fishery is not jeopardized. Since the experimental-commercial winter charr fishery is still in its development phase, it is suggested that quotas at subsistence areas remain conservative, and that the fishery continue to be monitored closely to avoid overharvesting. Further analysis of data collected from Sanirarsiq and Akilasaaluk, including examination of bias in mortality rates calculated from catch curves, will be necessary before final conclusions may be made about the status of these 2 stocks. A compilation of data collected from the winter fishery study, and from research using counting fences in eastern Ungava Bay, will prove valuable for determining if present harvest levels at all systems are sustainable in the long-term.

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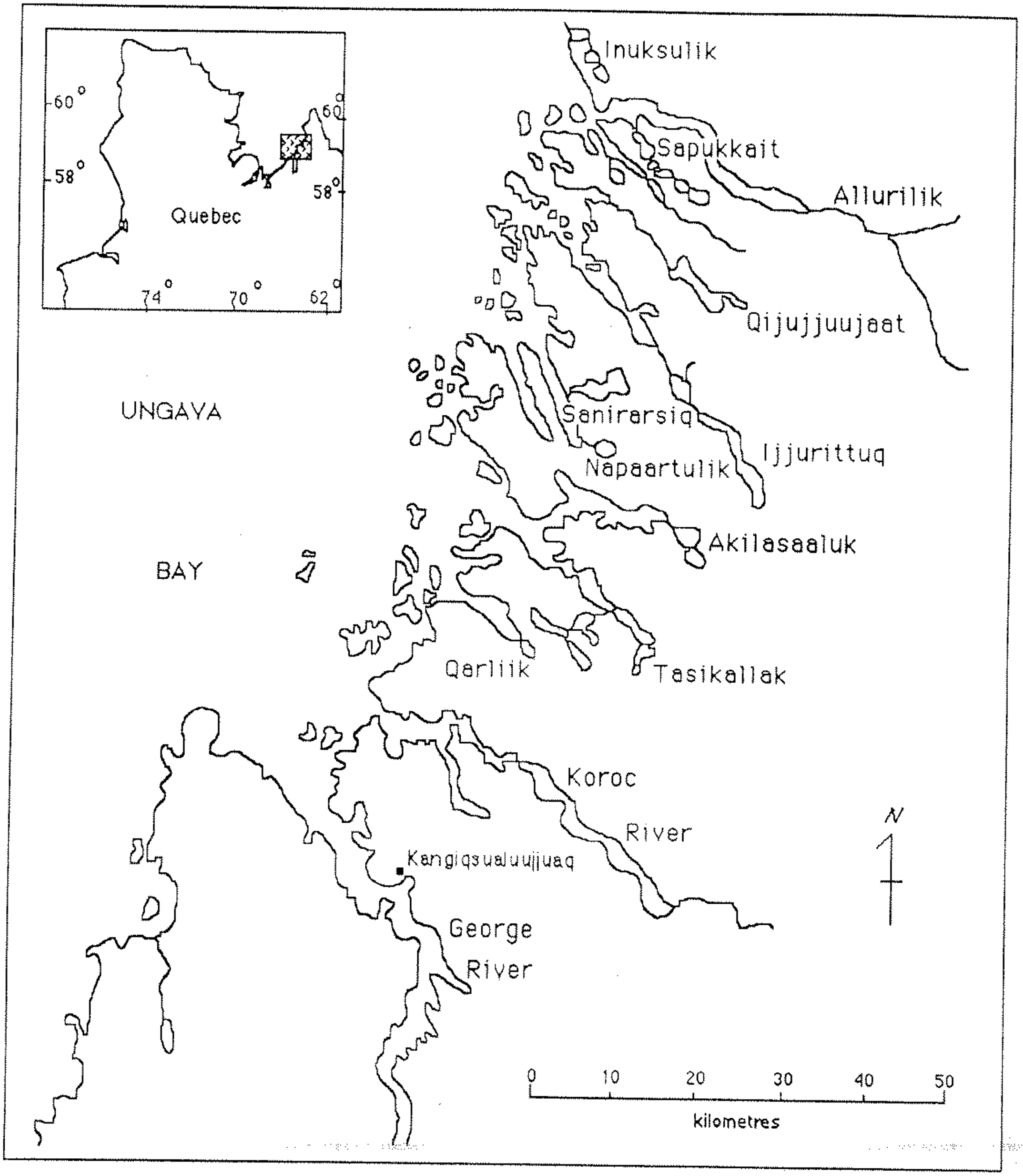


Figure 1: Arctic charr systems located near the community of Kangiqsualujjuaq.

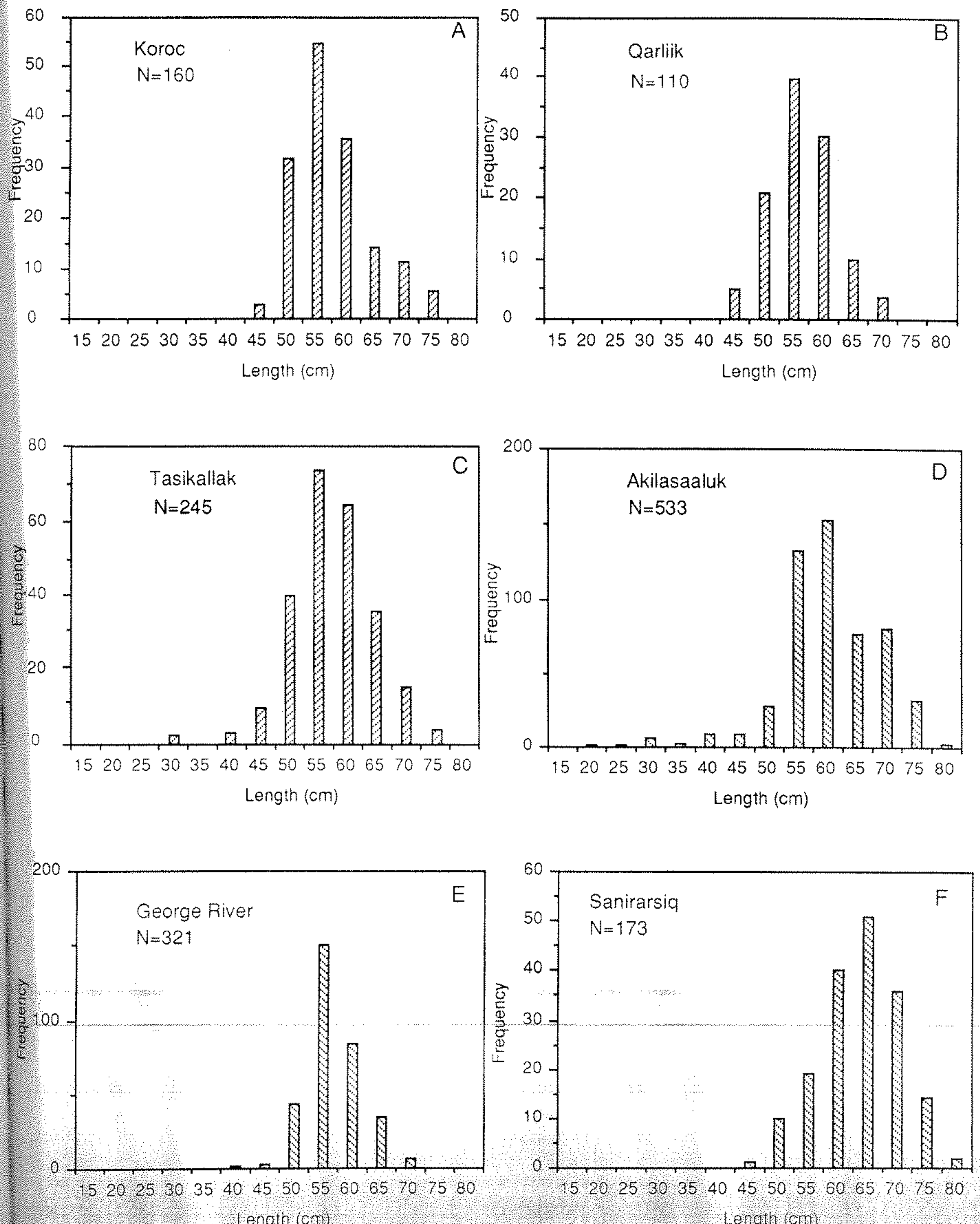


Figure 2. Length-frequency distribution of the 1988-89 winter arctic charr catch by location

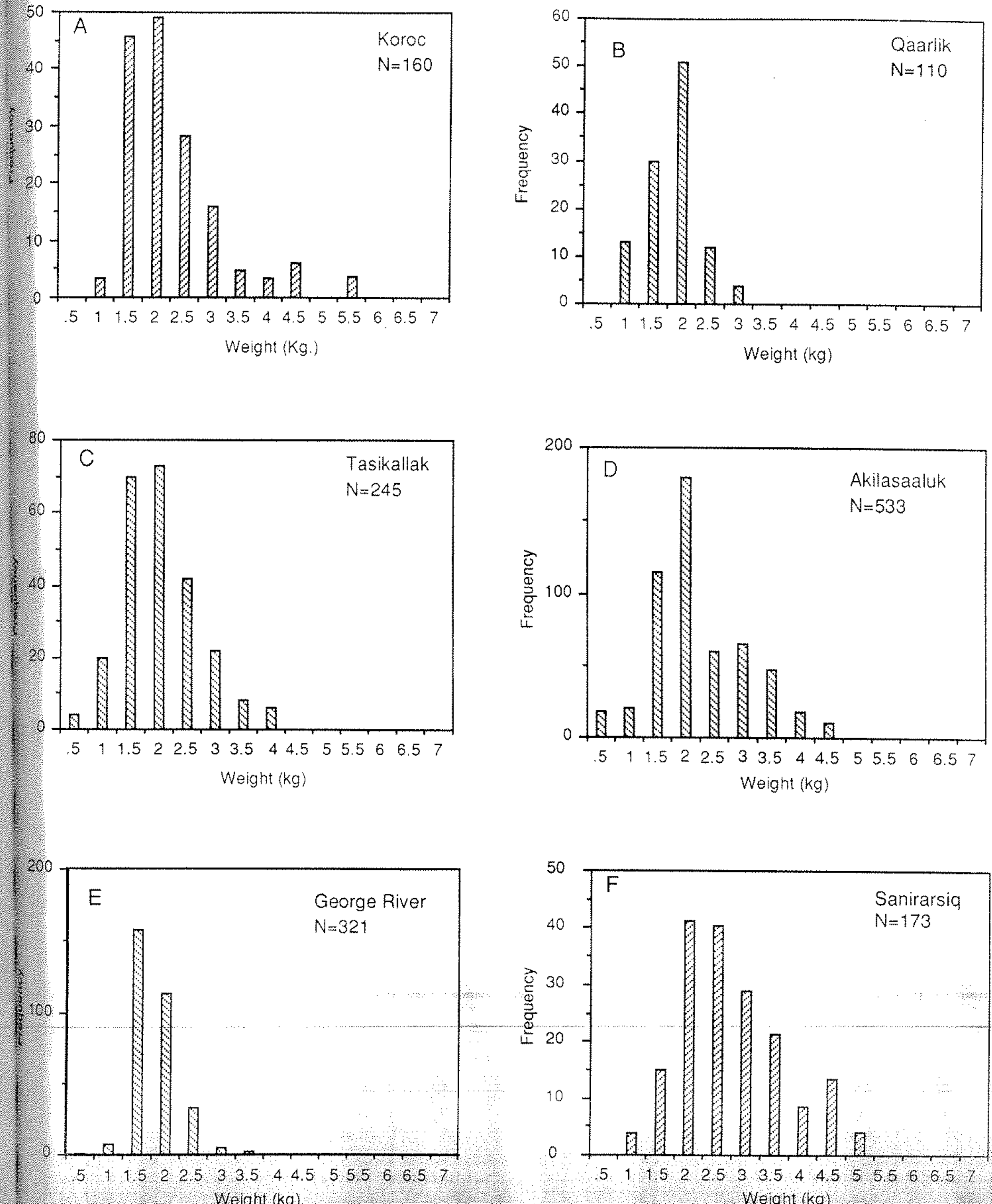


Figure 3. Weight-frequency distribution of the 1988-89 winter arctic charr catch by location

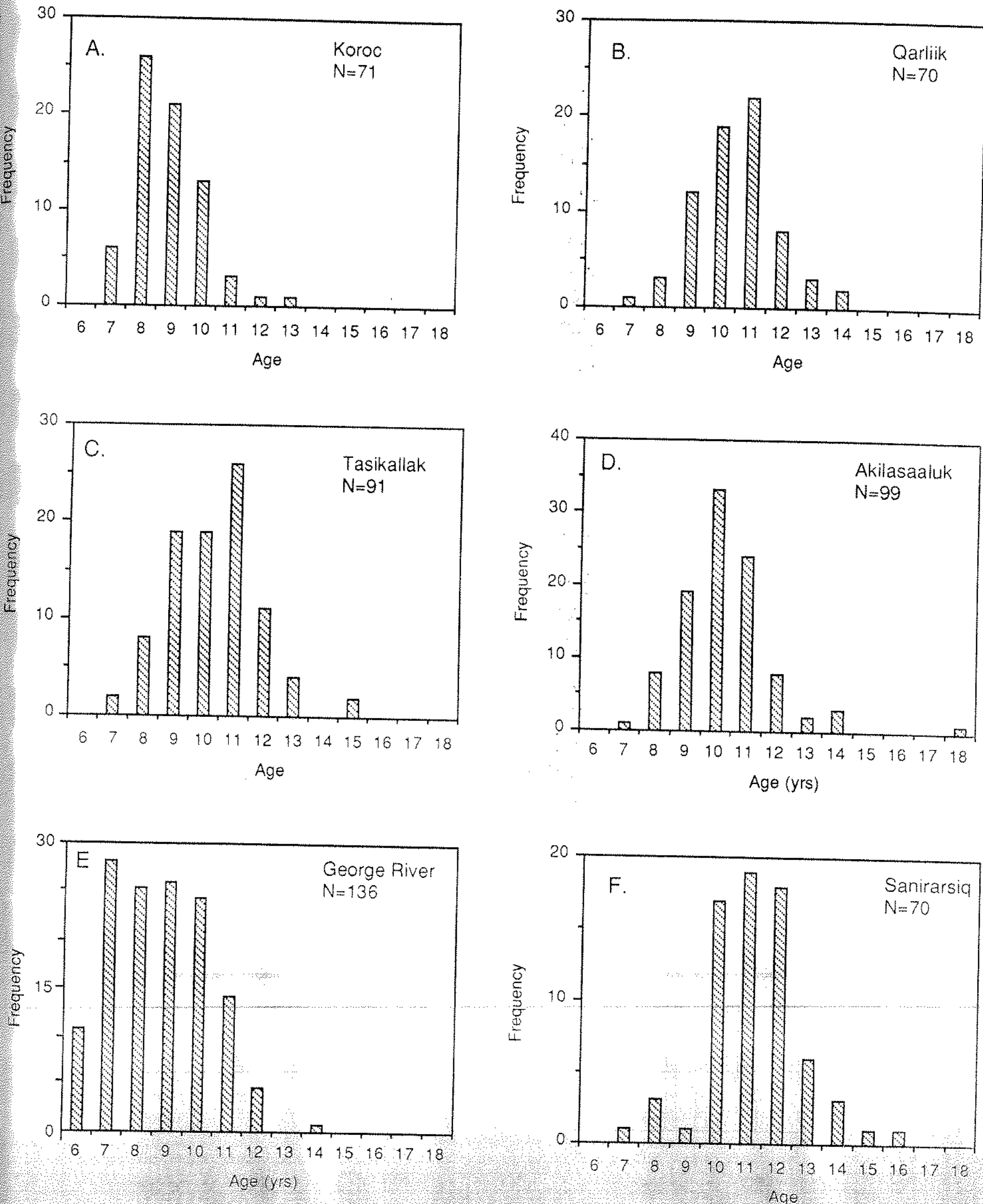


Figure 4. Age-frequency distribution of the 1988-89 winter arctic charr catch by location.

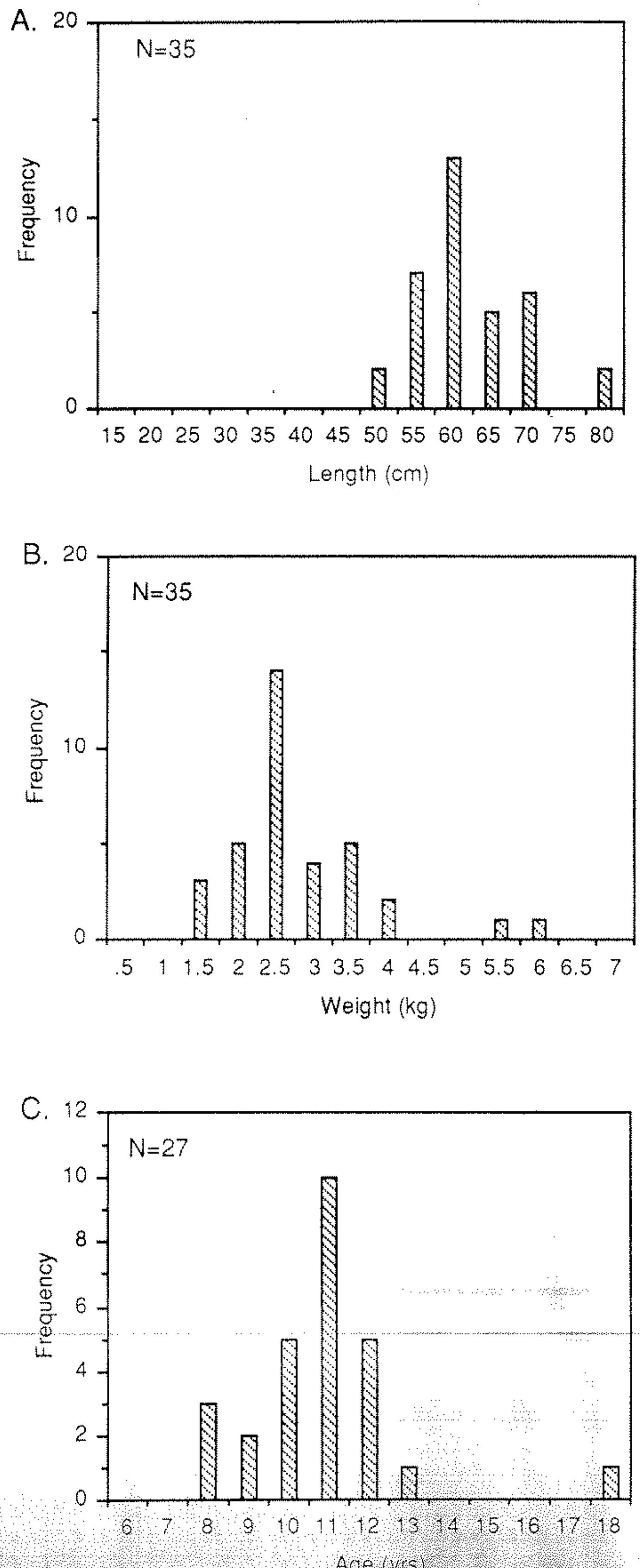


Figure 5. A) Length, B) weight and C) age-frequency distributions of the Napaartulik winter arctic charr harvest in 1988-89.

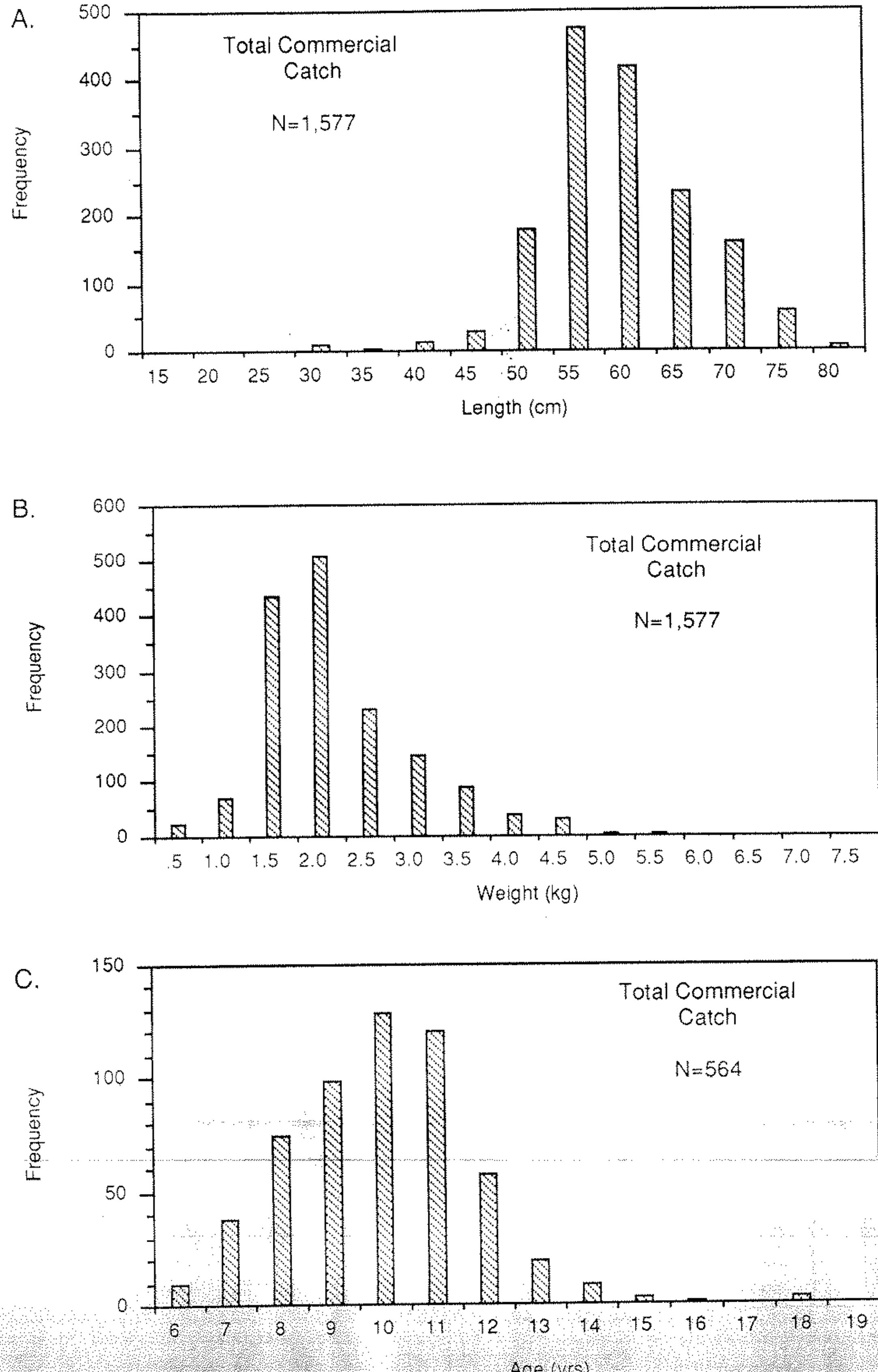


Figure 6. A) Length, B) weight and C) age-frequency distribution of the 1988-89 winter arctic charr catch from all locations.

Table 1: Salmonid fish species harvested by gillnet from river and lake systems in the Kangiqsualujjuaq area. x=known occurrence of species.

| System | Char | Salmon | L. trout | B. trout | Whitefish | Burbot |
|---|---|---|---|---|---|---|
| Koroc | x | x | x | x | | |
| Qarliik | x | | | | | |
| George R. | x | x | x | x | x | x |
| Tasikallak | x | | | | | |
| Akilasaaluk | x | | | x | | |
| Ijjurittuq | x | | | x | | |
| Napaartuliq | x | | x | x | | |
| Sanirarsiq | x | | x | x | | |
| Ujarasujjuliq | x | | x | | | |
| Tunnuliq | x | | x | | x | |
| Ammartuliq | x | | x | | | |

Source: Boivin (1987); Boivin et a. (1988); this study

Table 2: Results of arctic char subsistence harvest study conducted in Kangiqsualujjuaq between November, 1988- April, 1989. Total catches are separated by fishing methods; estimated net catches calculated from questionnaire data.

| Location | Reported Net Catch | Estimated Net Catch | Jigging | Kakivak | Total |
|---|---|---|---|---|---|
| George River | 310 | 95 | 0 | 0 | 405 |
| Koroc | 3294 | 147 | 291 | 70 | 3802 |
| Qarliik | 54 | 0 | 0 | 0 | 54 |
| Tasikallak | 661 | 136 | 73 | 18 | 888 |
| Akilasaaluk | 0 | 35 | 0 | 0 | 35 |
| Ijjurituk | 0 | 0 | 0 | 0 | 0 |
| Sanirarsiq | 9 | 35 | 4 | 3 | 51 |
| Napaartulik | 89 | 0 | 0 | 0 | 89 |
| Tunulliq | 40 | 0 | 0 | 0 | 40 |
| Ammartuliq | 0 | 0 | 5 | 0 | 5 |
| Ujarasujjulik | 0 | 0 | 6 | 0 | 6* |
| TOTAL | 4457 | 448 | 379 | 91 | 5375 |

* Land-locked arctic charr

Table 3: Results of subsistence harvest survey conducted in Kangiqsualujjuaq between November, 1988 and April, 1989. Catches of other fish species (by gillnet) in known arctic char systems.

| | Species | | | | | |
|---|---|---|---|---|---|---|
| Location | Salmon | Whitefish | B. trout | L. trout | Burbot | Total |
| Koroc | 3 | - | 66 | 80 | - | 147 |
| George R. | 4 | 130 | 3 | 30 | 2 | 169 |
| Napaartuliq | - | - | 18 | 2 | - | 20 |
| Ujarasujjuliq | - | - | - | 18 | - | 18 |
| Tunnuliq | - | - | - | 1 | - | 1 |
| Ammartuliq | - | - | - | 3 | - | 3 |
| Tutututuuq | - | - | 126 | - | - | 126 |
| Total | 7 | 130 | 213 | 134 | 2 | 486 |

Table 4: Species composition of subsistence gillnet fishery in Kangiqsualujjuaq, November, 1988-April, 1989.

| Species | N | % |
|---|---|---|
| Charr | 5375 | 91.7 |
| Whitefish | 130 | 2.2 |
| L. trout | 134 | 2.3 |
| Salmon | 7 | 0.1 |
| B. trout | 213 | 3.6 |
| Burbot | 2 | <0.1 |
| TOTAL | 5861 | 100.0 |

Table 5: Commercial fishing effort (expressed in terms of gillnet-days) for all fishing locations (average (m) total net length/day is included).

| Location | Total net Length/day | # net-days | #Charr | Total Weight(kg) | #Charr/ net-day | Weight(kg)/ net-day |
|---|---|---|---|---|---|---|
| George River | 191 | 37.6 | 378 | 601.3 | 10.1 | 16.0 |
| Koroc | 110 | 12.0 | 163 | 334.6 | 13.6 | 27.9 |
| Qarliik | 198 | 13.0 | 110 | 194.2 | 8.5 | 14.9 |
| Tasikallak | 183 | 8.0 | 340 | 620.7 | 42.5 | 77.6 |
| Akilasaaluk | 232 | 35.5 | 535 | 1049.3 | 15.1 | 29.6 |
| Napaartulik | 110 | 12.0 | 35 | 94.0 | 2.9 | 7.8 |
| Sanirarsiq | 199 | 43.6 | 249 | 670.2 | 5.7 | 15.4 |
| TOTAL | 174.7 | 161.7 | 1810 | 3564.3 | 11.2 | 22.0 |

Table 6: Mean fork lengths (cm) and whole weights (g) ( ± SEM) of arctic char sampled at commercial fishing locations.

| Location | Mesh | N | Length (cm) | SEM | N | Weight (g) | SEM |
|---|---|---|---|---|---|---|---|
| George R. | 11.5 | 321 | 54.7 | 0.3 | 321 | 1599.5 | 23.0 |
| Koroc | 11.5 | 160 | 55.7 | 0.5 | 160 | 2083.9 | 74.1 |
| Qarliik | 11.5 | 110 | 54.2 | 0.5 | 110 | 1601.1 | 43.7 |
| Tasikallak | 11.5 | 245 | 55.3 | 0.4 | 245 | 1807.9 | 44.5 |
| Akilasaaluk | 11.5 | 533 | 58.0 | 0.4 | 533 | 2014.0 | 36.7 |
| Napaartulik | 11.5 | 35 | 59.9 | 1.2 | 35 | 2572.9 | 161.1 |
| Sanirarsiq | 11.5 | 173 | 61.6 | 0.5 | 173 | 2528.7 | 67.4 |
| TOTAL | | 1577 | 56.8 | 0.2 | 1577 | 1944.8 | 20.2 |

Table 7: Mean age (years) ( ± SEM; range) of arctic char sampled at commercial fishing locations.

| Location | Mesh | N | Age (yrs) | SEM | Range |
|---|---|---|---|---|---|
| George R. | 11.5 | 136 | 8.6 | 0.1 | 4-14 |
| Koroc | 11.5 | 71 | 8.8 | 0.1 | 7-13 |
| Qarliik | 11.5 | 70 | 10.5 | 0.2 | 7-14 |
| Tasikallak | 11.5 | 91 | 10.3 | 0.2 | 7-15 |
| Akilasaaluk | 11.5 | 99 | 10.3 | 0.2 | 7-18 |
| Napaartulik | 11.5 | 27 | 10.9 | 0.4 | 8-18 |
| Sanirarsiq | 11.5 | 70 | 11.2 | 0.2 | 7-16 |
| TOTAL | | 564 | 9.9 | 0.1 | 4-18 |

Table 8: Sex ratio, coloration and maturity of arctic char sampled at commercial fishing locations. M=Male F=Female.

| Location | Sex (M:F) | % F | Colour (silver:red) | % red |
|---|---|---|---|---|
| George R. | 117:197 | 62.7 | 199:119 | 37.4 |
| Koroc | 66:40 | 37.7 | 94:12 | 11.3 |
| Qarliik | 66:42 | 38.9 | 83:25 | 23.1 |
| Tasikallak | 156:71 | 31.3 | 181:46 | 20.3 |
| Akilasaaluk | 254:273 | 51.8 | 499:28 | 5.3 |
| Napaartulik | 16:16 | 50.0 | 4:1 | 25.0 |
| Sanirarsiq | 116:127 | 52.3 | 180:59 | 24.7 |
| TOTAL | 791:766 | 49.2 | 1240:290 | 19.0 |

Table 9: Length at age data for George River arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 4 | 1 | 53.5 | - | - |
| 5 | 2 | 58.0 | 8.5 | 49.5-66.5 |
| 6 | 11 | 53.5 | 0.7 | 49.0-57.0 |
| 7 | 28 | 52.5 | 0.7 | 45.5-61.0 |
| 8 | 24 | 56.0 | 0.9 | 48.0-65.5 |
| 9 | 25 | 56.0 | 0.7 | 49.0-62.5 |
| 10 | 24 | 55.5 | 0.8 | 48.0-62.5 |
| 11 | 13 | 57.1 | 2.1 | 36.5-64.0 |
| 12 | 4 | 57.3 | 2.1 | 51.0-60.0 |
| 13 | 0 | - | - | - |
| 14 | 1 | 66.5 | - | - |

Table 10: Length at age data for Koroc arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 7 | 5 | 49.8 | 1.5 | 46.0-54.5 |
| 8 | 26 | 53.1 | 0.9 | 46.5-62.0 |
| 9 | 20 | 58.5 | 5.9 | 51.5-74.0 |
| 10 | 12 | 58.2 | 1.7 | 51.5-71.5 |
| 11 | 3 | 70.7 | 2.1 | 66.5-73.5 |
| 12 | 1 | 73.5 | | |
| 13 | 1 | 70.0 | | |

Table 11: Length at age data for Qarliik arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 7 | 1 | 45.0 | | |
| 8 | 2 | 54.3 | 9.3 | 45.0-63.5 |
| 9 | 12 | 54.9 | 1.4 | 48.0-63.5 |
| 10 | 17 | 54.8 | 1.3 | 46.0-65.5 |
| 11 | 21 | 55.43 | 0.9 | 48.0-63.5 |
| 12 | 6 | 55.6 | 2.6 | 46.0-63.5 |
| 13 | 3 | 61.7 | 4.9 | 52.0-67.5 |
| 14 | 2 | 53.5 | 1.5 | 52.0-55.0 |

Table 12: Length at age data for Tasikallak arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 7 | 2 | 62.8 | 3.3 | 59.5-66.0 |
| 8 | 9 | 52.4 | 1.0 | 49.0-56.0 |
| 9 | 17 | 57.0 | 0.9 | 51.0-64.5 |
| 10 | 18 | 56.6 | 1.3 | 47.0-70.0 |
| 11 | 25 | 58.6 | 1.3 | 48.0-70.5 |
| 12 | 11 | 60.3 | 1.7 | 54.0-70.5 |
| 13 | 3 | 52.8 | 1.0 | 51.0-54.5 |
| 14 | | | | |
| 15 | 2 | 56.0 | 4.0 | 52.0-60.0 |

Table 13: Length at age data for Akilasaaluk arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 7 | 1 | 55.0 | | |
| 8 | 7 | 53.6 | 0.9 | 50.5-57.0 |
| 9 | 17 | 57.1 | 0.9 | 50.5-63.5 |
| 10 | 27 | 59.4 | 1.3 | 49.0-72.0 |
| 11 | 23 | 61.7 | 1.3 | 50.5-72.5 |
| 12 | 9 | 64.9 | 1.7 | 57.0-73.5 |
| 13 | 2 | 71.8 | 4.8 | 57.0-73.5 |
| 14 | 2 | 60.3 | 2.3 | 58.0-62.5 |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | 1 | 61.0 | | |

Table 14: Length at age data for Napaartulik arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 8 | 3 | 51.0 | 1.0 | 50.0-53.0 |
| 9 | 2 | 62.8 | 4.8 | 58.0-67.5 |
| 10 | 4 | 59.0 | 3.0 | 55.0-67.5 |
| 11 | 9 | 60.4 | 2.6 | 51.0-77.0 |
| 12 | 5 | 60.8 | 2.6 | 53.0-67.5 |
| 13 | | | | |
| 14 | | | | |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | 1 | 60.0 | | |

Table 15: Length at age data for Sanirarsiq arctic char (both sexes combined). F.L.=Fork length

| Age | N | Mean F.L. (cm) | SEM | Range |
|---|---|---|---|---|
| 7 | 1 | 48.0 | | |
| 8 | 2 | 55.8 | 5.3 | 50.5-61.0 |
| 9 | 1 | 70.5 | | |
| 10 | 17 | 60.7 | 1.4 | 48.0-70.5 |
| 11 | 20 | 65.5 | 1.0 | 56.0-73.5 |
| 12 | 16 | 61.3 | 1.7 | 47.0-71.5 |
| 13 | 6 | 67.8 | 1.6 | 63.5-72.5 |
| 14 | 3 | 68.5 | 4.0 | 62.5-76.0 |
| 15 | 1 | 74 | | |
| 16 | 1 | 70.5 | | |

Table 16: Instantaneous total mortality (Z), annual mortality (A), annual survival (S), instantaneous fishing mortality (F), and exploitation rate ($u_1$ and $u_2$) for commercially-fished locations in the Kangiqsualujjuaq area, winter 1988-89.

| Location | $r^2$ | Z | A | S | F | $u_1$ | $u_2$ |
|---|---|---|---|---|---|---|---|
| George R. | .95 | 0.94 | 0.61 | 0.39 | 0.74 | 0.52 | 0.48 |
| Koroc | .85 | 0.82 | 0.56 | 0.44 | 0.62 | 0.46 | 0.42 |
| Qarliik | .97 | 0.84 | 0.57 | 0.43 | 0.64 | 0.47 | 0.43 |
| Tasikallak | .99 | 0.94 | 0.61 | 0.39 | 0.74 | 0.52 | 0.48 |
| Akilasaaluk | .94 | 1.01 | 0.64 | 0.36 | 0.81 | 0.56 | 0.51 |
| Sanirarsiq | .98 | 0.91 | 0.60 | 0.40 | 0.71 | 0.51 | 0.47 |

Note: Calculations from Ricker (1975)

M=0.20

$u_1=1-e^{-1}$ (Assumes that natural mortality does not occur concurrently with fishing mortality)

$u_2=FA/Z$ (Assumes that natural and fishing mortality occur concurrently)

## Appendix

Appendix 1. Allocated quotas (numbers of charr), commercial harvest and mesh sizes employed at each system in the 1988-89 fishery.

| Location | Quota (#) | Harvest ** | Rejects | Surplus | Total | Mesh (cm) |
|---|---|---|---|---|---|---|
| Koroc | 150 | 150 | 13 | 0 | 163 | 11.4 |
| Tasikallak | 200 | 200 | 32 | 108 | 340 | 11.4 |
| Qarliik | 100 | 100 | 10 | 1 | 110 | 11.4 |
| Akilasaaluk | 545 | 489 | 46 | 0 | 535 | 11.4 |
| Ijjurittuq | 1250 | not fished | | | | |
| Sanirarsiq* | 900 | 241 | 8 | 0 | 249 | 11.4 |
| George River | 300 | 300 | 37 | 41 | 378 | 11.4 |
| Napaartulik | 425 | 35 | 0 | 0 | 35 | 11.4 |
| Qijujjuujaat | 770 | not fished | | | | |
| Allurilik | 520 | not fished | | | | |
| Sapukkait* | 770 | not fished | | | | |
| Inuksulik | 770 | not fished | | | | |
| TOTAL | 5930 | 1515 | 146 | 149 | 1810 | |

* these locations will be commercially-fished using counting fences in the summer of 1989

** commercially-tagged Arctic charr