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Biology and Commercial Exploitation of Anadromous Arctic Charr (*Salvelinus alpinus*) in Eastern Ungava Bay, Northern Québec 1987 - 1992

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Biology and Commercial Exploitation of Anadromous Arctic Charr (Salvelinus alpinus) in Eastern Ungava Bay, Northern Québec 1987-1992

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Ministère de l'Agriculture,des Pêcheries et de l'alimentation
and
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By

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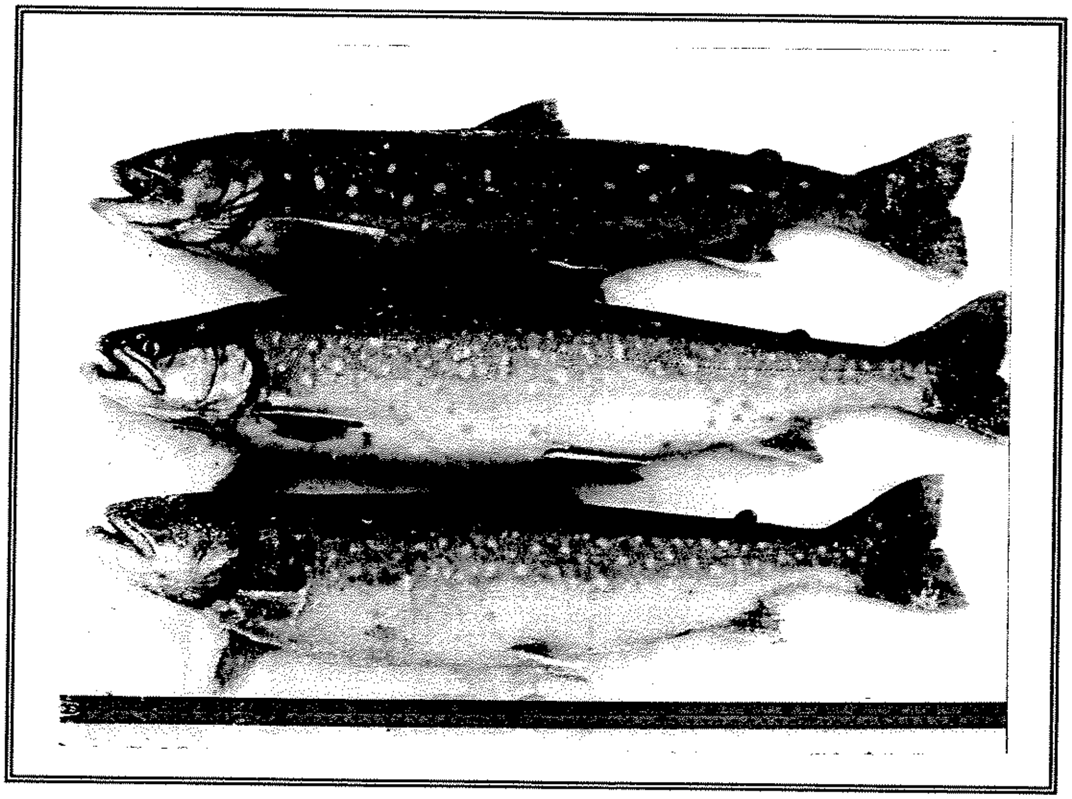

T. Boivin

Arctic charr from eastern Ungava Bay, Northern Quebec.

FOREWORD

This report was produced to provide biological information on the Arctic charr stocks of eastern Ungava Bay, which was collected between 1987-1992 by the Ministère du Loisir, de la Chasse et de la Pêche, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation and Makivik Corporation. Data are still being collected by these organizations on the charr stocks of eastern Ungava, with the goal of determining management strategies for the development and conservation of subsistence, sport and commercial fisheries.

Several recommendations presented in this report are already being implemented in whole or in part. The Ministère du Loisir, de la Chasse et de la Pêche, Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, Makivik Corporation and the Inuit community of Kangiqsualujjuaq continue to work together to collect information on the eastern Ungava charr stocks.

However, the opinions expressed by the author do not necessarily represent the position of the Government of Québec.

Please note that the scientific name (*Salvelinus alpinus*) used in this report for Arctic charr is largely acknowledged by the international scientific community. However, the official and legal name of the species in Québec is *Salvelinus salvelinus*.

ABSTRACT

The biology and commercial harvest of the Arctic charr (*Salvelinus alpinus*) resources of eastern Ungava Bay, Northern Quebec, were studied between 1987-1992. Data on seven charr systems were collected from monitoring of experimental-commercial winter gillnet fisheries, and another 2 systems were studied extensively using counting fences. Over 2200 Arctic charr were tagged at Lake Sapukkait in 1988 and 1989, and the movements, migrations and growth of these individuals were recorded over a period of 4 years. Population data were collected at both Lake Sapukkait and Sannirarsiq before and after commercial exploitation occurred on the stocks. As a result of intensive fishing pressure, the proportions of larger individuals (>50 cm fork length) in both populations declined dramatically. However, at Sapukkait, strong recruitment since 1990 has resulted in little change in the numbers of upstream migrants over time. The migration patterns of eastern Ungava charr were found to be complex, and appear to be related to individual size and state of maturity. Significant differences in growth rate of male and female charr were observed, and beyond age 6 males grew faster than females. Growth of both sexes appears to be rapid after charr begin annual sea migrations, but slows considerably after age 10. Arctic charr stocks located near the community of Kangiqsualujjuaq are heavily exploited for subsistence purposes, and charr from these sites were significantly smaller and younger than those sampled at locations distant from the village. Data collected from monitoring upstream migrations using counting fences was found to provide better estimates of population parameters and exploitation than that collected from winter gillnet samples. To ensure stability of the stocks, it is recommended that commercial exploitation be limited to those areas where there is no conflict with subsistence fisheries. The present rates of exploitation on most stocks are excessive, and should be limited to a maximum of 15% of the stock $\geq$50 cm (or $\geq$45 cm) fork length. Continuation of harvest studies is essential to obtain data on exploitation levels of systems used for subsistence purposes. Although the long-term impact of intensive exploitation on charr stocks is unknown, an experimental pulse fishery should be attempted. It is also recommended that northern fisheries biologists work closely with local agencies in the management of the eastern Ungava charr stocks.

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ACKNOWLEDGMENTS

This report could not have been completed without the assistance of several individuals from the Inuit community of Kangiqsualujjuaq, the Ministère du Loisir, de la Chasse et de la Pêche (MLCP), the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPA) and Makivik Corporation. First and foremost, I would like to acknowledge the contribution of Louis Roy, who for several years was the MLCP biologist working on this project. Louis Roy, Michel Laplante (MLCP) and Fritz Axelsen (MAPA) made significant contributions to the planning, design, implementation and data analysis in this project. Denis Vandal and Gilles Ouellette (MLCP) supervised the production of this report, and provided valuable comments and advice to the author. Jackie Koneak, Stas Olpinski, and Lorraine Brooke provided essential support from Makivik Corporation throughout the development of this project. The past and present staff of the Kuujjuaq Research Centre (Réjean Dumas, Bill Doidge, Gregory Kaminski, Alix H. Gordon, Peter May, Chesley Mesher, Morrie Portnoff and Mae Saunders) provided logistical support and made a significant contribution to the field and analytical components of this study. Mr. Marcel Bernard and Mark Kooktook (MLCP, Kuujjuaq) assisted in all aspects of this study and provided substantial amounts of time to fieldwork. Mr. Gilles Ouellette provided advice with regards to analysis of data (including von Bertalanffy growth modelling) and Ms. Krista Jakobsen (Hatfield Consultants Ltd.) assisted with the figures. Finally, I would like to thank Brian Dempson (Department of Fisheries and Oceans, St. John's, Newfoundland) Geoff Power and Patrice Simon (University of Waterloo, Waterloo, Ontario), Gilles Ouellette, Fritz Axelsen, Bill Doidge and Greg Kaminski for providing comments on a draft of this document.

Funding for the Arctic charr research program in eastern Ungava Bay came from a variety of sources, including the Economic Regional Development Agreement (ERDA) Program, MLCP, MAPA, Makivik Corporation, the Kativik Regional Government, the Department of Fisheries and Oceans, and the Department of Indian Affairs and Northern Development. To all of these agencies, the author would like to express his gratitude. An army of individuals made their way at one time or another to Lake Sapukkait, or provided background support to the field team. A complete list of the research team involved in this project between 1987-1992 is provided in Appendix 1.

1.0 INTRODUCTION

1.1 General Introduction

Arctic charr (*Salvelinus alpinus*) management and conservation has been an important issue in the Inuit communities of Nunavik (Northern Quebec) for decades. The charr resources form an essential component of the subsistence economy of the Inuit, and there is increasing demand to develop commercial and sport fisheries throughout the territory. Given the rapid rate of increase in the local population in recent years (2.8% per annum [Robitaille and Choniere 1985]), and the high rate of unemployment, there is a desire to create jobs based on the renewable resources. Of primary concern is the preservation of the subsistence harvest and the evaluation of the status of the resource for sustainable development.

Commercial fisheries for Arctic charr have been undertaken in Northern Quebec since the early 1960's (LeJeune 1967); however, the early fisheries led to a collapse of the stocks in some areas of Ungava Bay, because little biological data were available on the stocks, commercial quotas were too high and subsistence harvests were not accounted for in total harvests (Gillis 1988). The stocks took several years to recover from the high rate of exploitation, and the subsistence fishery suffered. As a result of these experiences, management strategies for eastern Ungava Arctic charr stocks must account for the susceptibility of this species to over-exploitation, and place priority on the preservation of the systems near the communities for subsistence use (Boivin et al. 1991b).

Between 1987 and 1992, Makivik Corporation, the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPA) and the Ministère du Loisir, de la Chasse et de la Pêche (MLCP) conducted several research projects on the Arctic charr stocks of eastern Ungava Bay under the Economic Regional Development Agreement (ERDA) between the federal and provincial governments (Table 1). This research was undertaken to obtain baseline information for the development of a locally-based experimental-commercial Arctic charr fishery in the Kangiqsualujjuaq area.

The Inuit residents of Kangiqsualujjuaq (population approximately 500) re-established an Arctic charr winter gillnet fishery in 1987-1988 on a total of 12 Arctic charr systems in the region (Figure 1). As part of the monitoring program for the fishery, counting fences were installed on 2 experimental systems, Lakes Sapukkait and Sannirarsiq, to enumerate the charr populations and collect biological data on the stocks. With the success of the 1988 summer weir research, the counting fences were later used as commercial fishing devices in 1989, in a similar manner to the Cambridge Bay, NWT fishery (Kristofferson et al. 1986). The eastern Ungava fishery has now been in operation for over 5 years, but has concentrated efforts on only a few key charr systems in the region.

The objectives of the Arctic charr research projects conducted between 1987-92 in eastern Ungava Bay were:

i) to collect baseline biological data on the Arctic charr stocks of eastern Ungava (including determining harvest levels, population dynamics and rate of exploitation of the stocks), by monitoring the subsistence and experimental-commercial fisheries in winter and summer;

ii) to undertake an intensive study of one 'model' system (Lake Sapukkait), and examine the life cycle, population structure, movements and migrations of one Arctic charr stock; and,

iii) to examine the impacts of intense commercial fishing on a 'virgin' charr population, and monitor the change in population characteristics over time. This objective also included examining the feasibility of using counting fences as a commercial fishing method in eastern Ungava.

This report presents data collected between 1987-1992 on the biology and exploitation of the Arctic charr of eastern Ungava Bay. The report concentrates on the analysis of charr data from the summer weir research and commercial fisheries at Lakes Sapukkait and Sannirarsiq conducted between 1988-1992, and on experimental-commercial winter gillnet harvests between 1987-1992. Also presented are fisheries management guidelines for the Arctic charr stocks of eastern Ungava Bay, and recommendations for monitoring of the charr resources in the future.

1.2 Life History of Arctic charr

Arctic charr are an anadromous and/or freshwater salmonid fish species which have a circumpolar distribution (Scott and Crossman 1973). In Canada, substantial anadromous charr populations are found throughout the Northwest Territories, Labrador, and in Northern Quebec. In Nunavik, this species is distributed as far south as northern James Bay, and inhabits most river systems which provide access to freshwater overwintering areas. Anadromous charr populations in Nunavik vary greatly according to size, from less than 500 migrating charr in the Salmon River, northern James Bay (Bouillon 1985), to potentially as many as 30,000 individuals in the Payne River system (Gillis 1988). A detailed summary of the life cycle of this species is presented in Johnson (1980); an excellent presentation on the life history of northern Quebec charr (directed towards a northern audience) is provided by Power et al. (1989).

The life history of this species is complex, and varies considerably among populations (Johnson 1980). Anadromous Arctic charr in northern Quebec spawn in the fall, usually at the end of September (Cunjak et al. 1986). The young fry emerge in April (Stenzel 1987) and reside in freshwater 2-7 years before undertaking their first sea migration (Boivin et al. 1990). Once charr enter the sea, their growth rate increases rapidly due to the abundant food resources available in the estuaries (Adams et al. 1989). Little or no feeding takes place during winter, and a marked depletion of lipid reserves occurs in some individuals (especially spawners) (Boivin and Power 1989). However, general condition of non-reproductive charr changes little throughout the winter period (Plate 2).

Non-reproductive charr (both smolts and adults) make annual migrations to the sea, and return to freshwater each fall to overwinter; it is not uncommon for fish to overwinter in systems other than their natal streams in those years when they do not spawn (Johnson 1980; Dempson and Kristofferson 1987). The energetic costs associated with reproduction limit the ability of charr to spawn 2 years in succession; the ability to recover after spawning is greatly reduced in later years (Dutil 1984; 1986). For northern Quebec populations, charr aged 8-15 years represent most of the biomass in the population, and generally few individuals live past age 20 (Boivin et al. 1991b).

1.3 History of Commercial Arctic Charr Fisheries in Northern Quebec

A detailed history of commercial Arctic charr fisheries in the Nunavik territory has been prepared by Gillis (1988); a summary of the historical charr fisheries in eastern Ungava and particularly the George River area is discussed in Boivin et al. (1989b). Both these assessments of northern Quebec's historical fisheries were partly based on the work of Power (1976), who summarized the Hudson Bay Company's (HBC) Atlantic salmon (*Salmo salar*) fisheries in the Ungava Bay area. The HBC fishery in the George River area commenced in the early 1880's and continued for at least 50 years (Power 1976). Gillis (1988) searched the HBC records for historical charr harvests between 1926-1937 for all the Nunavik HBC posts. Unfortunately, little of the information obtained from the George River post was found to be useful for management purposes.

Under the Industrial Division of the Department of Indian Affairs, commercial Arctic charr fisheries were reinstated in various regions of Nunavik, including the Kangiqsualujjuaq area, between 1959-1963. Initial projections on the size of the exploitable resource in the George River were outrageously high; Iglauer (1966) reported that '100,000 pounds of Arctic charr could be harvested annually from the George River without depleting the stocks'. Between 1960-61, the fishery was conducted primarily in the inner estuary of the George River; between 1962-1967 the boundary was extended to include the eastern Ungava coast as far north as Abloviak Fjord (Allurilik). In its first 5 years of operation, an average of 7,370 kg of charr were harvested annually (LeJeune 1967; Gillis et al. 1982). The fishery collapsed in the mid-1960's due primarily to excessive harvesting which did not account for the subsistence requirements of the community (Gillis 1988).

In 1987, the Kangiqsualujjuamiut decided to once again attempt commercial fishing for Arctic charr in their territory. The local Anguvigapik (Wildlife Management Committee) met in the spring of 1986 to discuss the issue, and to determine fishing sites and commercial quotas (Appendix A2). The quotas were revised (downwards) by the Quebec government agencies responsible for fisheries management, but generally respected the distribution of the catch as presented by the Inuit. Through consultations with MLCP, MAPA and Makivik Corporation, commercial quotas were finalized for 12 systems in the eastern Ungava area (George R., Koroc R., L. Qaarlik, L. Tasikallak, L. Akilasaaluk, L. Napaartulik, L. Sannirarsiq, Ijjurittuuq R., L. Qijujjujaq, L. Sapukkait, Allurilik R. and L. Inussulik; Figure 1). The substantial local harvests (Boivin 1987) were incorporated into the quotas to ensure that no overharvesting would occur on those systems important for subsistence purposes. The collaboration of the Quebec government and Inuit in the organization of this fishery was an important step in developing a management framework for the charr resources of this region.

The commercial operation began as a winter gillnet fishery in November 1987. With the successful installation of counting fences at Lakes Sapukkait and Sannirarsiq in 1988, this technology was then used as commercial fishing gear at these two sites. Commercial fishing using gillnets and weirs continued between 1987-1991 by Mr. David Annanack; from 1992 onwards, Mr. Bobby Baron became the new promoter for the charr fishery.

1.4 Previous Research on Arctic Charr in Northern Quebec

Several studies have been undertaken on the Arctic charr of Nunavik, most of which were related to the development of commercial fisheries in the region. The earliest records of commercial charr harvests (catch and effort data) were for those charr captured as by-catch of the HBC's Atlantic salmon fishery in Ungava Bay in the late 1800's (Power 1976). LeJeune (1961a; 1961b; 1967; 1968) monitored the 1960's charr fishery in the Kangiqsualujjuaq area, and collected biological data on the stocks, including length, weight and age of the commercial catch.

Between 1976-1980, Makivik undertook an intensive 5-year harvest study in 11 Inuit communities in Nunavik (James Bay and Northern Quebec Native Harvest Research Committee [NHR] 1980). Data were not collected in the villages of Povungnituk and Ivujivik. This research included estimations of harvests of all species harvested by Inuit, including the quantification of harvests of anadromous and resident Arctic charr and other fish species.

In the early 1980's, Gillis et al. (1982) conducted a detailed assessment of the George, Payne and Kovik River charr stocks in northern Quebec, and provided valuable baseline data for the management of these charr populations. In their study, they examined aspects of life history and population biology, and discussed management implications of subsistence fisheries on these stocks. However, data were collected for only one field season, and therefore did not provide information necessary for long-term management of these stocks.

In the mid-1980's, extensive research on the Arctic charr stocks of Ungava Bay was undertaken by Makivik Corporation and the University of Waterloo (Barton et al. 1985; Boivin et al. 1985; Power and Barton 1987). The goal of these studies was to determine the feasibility for habitat enhancement of existing charr systems in Nunavik. This research resulted in several years of stream enhancement work being undertaken by many northern Quebec communities, and improved access for charr to reach overwintering systems (Dumas 1989; 1990).

From 1985 to 1988, the University of Waterloo undertook several studies on the Koroc River system, with Masters level students conducting research under the direction of Dr. G. Power. This research resulted in several Masters theses and publications on Arctic charr, and made a significant contribution to our knowledge of the eastern Ungava stocks (Cunjak et al. 1986; Boivin 1986, 1987; Adams 1987; Stenzel 1987; Boivin and Power 1988, 1990; Adams et al. 1988, 1989; Stenzel et al. 1989; Boivin et al. 1989b; Bunn et al. 1989; Holierhoek 1989; Stenzel and Power 1990; Zondervan et al. 1990). Specific areas of research under this program included juvenile charr production, ecology, and behavior, summer and winter feeding ecology of adults, reproductive habitat and behavior, winter physiology and changes in condition over winter, and the impact of winter subsistence fishing on the stocks. The University of Waterloo continues to conduct charr research in Nunavik; between 1992 and 1993 Patrice Simon examined aspects of juvenile charr ecology at Sapukkait.

Also in the mid-1980's MLCP and Makivik Corporation undertook tagging studies (using spaghetti tags) to estimate Atlantic salmon populations in the George and Whale Rivers (Laplante 1986). During the George River study, 300

Arctic charr captured as a by-catch in the salmon research were also tagged. Several of these tagged fish were reported captured in subsequent years in both the George and Koroc River systems.

Several charr research programs were conducted in Northern Quebec between 1987-1992 as part of the Economic Regional Development Agreement (ERDA) Program between the federal government and Quebec government. This program provided funding for northern research and fisheries development programs, and resulted in a dramatic increase in the number of scientific studies undertaken in northern Quebec (including this study).

Charr research using counting fences has also been undertaken at Lake Iqalukkait in the Kangiqsujuaq (Hudson Strait) area in 1989 (Olpinski 1990), at the Ivitaarquit River in north-eastern Hudson Bay in 1990 (Roy and Bernard 1991), at Iqaluppisiuqviq River in Richmond Gulf in 1992 (Doidge and May 1993), and on the Salmon River in northern James Bay in 1985 (Bouillon 1985). The goal of the 2 former studies was to determine if sufficient resources were available for the development of commercial charr fisheries in these areas; the Richmond Gulf research was directed primarily towards stream enhancement and the improvement of the subsistence charr resource for the village of Umiujaq (Doidge and May 1993).

1.5 Other Fish Species Captured By The Kangiqsualujjuamiut

Besides anadromous and land-locked Arctic charr, several other fish species are harvested for subsistence purposes by the Kangiqsualujjuamiut. These include Atlantic salmon, lake trout (*S. namaycush*), brook trout (*S. fontinalis*), lake whitefish (*Coregonus clupeaformis*), burbot (*Lota lota*). In summer, cod (*Gadus morhua* and *G. ogac*) and sculpins (*Myoxocephalus* spp.) are also harvested (NHR 1980; Boivin 1987).

1.6 Importance of the Subsistence Fishery

Arctic charr resources in northern Quebec play a major role in the subsistence economy of the Inuit. For centuries, this species has provided a reliable source of country food for northern people. In Nunavik, charr is second only to caribou in terms of total edible weight of country foods consumed (NHR 1980). In the past, Arctic charr were primarily harvested using saputit (stone weirs) during their autumn upstream migration; vast quantities were dried and stored for consumption during the winter (Balikci 1969; 1980). However, with modern fishing technology and transportation methods, this species is harvested by Inuit throughout the year, and is consumed fresh, frozen, dried and smoked. The most common fishing method used is by Kangiqsualujjuamiut is the multifilament gillnet; however, jigging, fishing rod and kakivak (fishing spear; Plate 1) are also popular methods (Boivin 1987).

Between 1976-80, 11 of the 14 Inuit communities harvested approximately 100,000 Arctic charr per annum from 175 charr systems (NHR 1980). Subsistence harvests accounted for 92.0% of the total charr harvest. Sport fisheries represented only 1.5% of all charr harvests in the territory, and commercial catches 6.5%.

More recently, Boivin (1987) conducted a detailed assessment of the winter subsistence fishery for Arctic charr by the Inuit of Kangiqsualujjuaq. In his study, Arctic charr accounted for over 95% of all fish species harvested by the community; over 5900 charr were harvested by the community in a period of 6 months. This translated as approximately 100 g of charr per day (36 kg per year) consumed per resident of Kangiqsualujjuaq. The majority of fishing pressure was found to take place on a few traditional fishing locations, and most fishermen concentrated their effort on systems close to the community. Gillis (1988) also observed that the most intensive fishing pressure on northern Quebec charr stocks was on those systems located adjacent to the communities.

1.7 Regulations Pertaining to Commercialization of Arctic Charr in Nunavik

In Quebec, the legal basis for fisheries management is the federal Fisheries Act. However, management of freshwater and anadromous species, including Arctic charr, are under the jurisdiction of the provincial government. Current regulations permit commercial fishing (Q.F.R., section 7) and marketing (R.S.Q., c. C-61.1 r. 38) for Arctic charr and whitefish. No commercial quota is permitted for lake trout due to the susceptibility of this species to overharvesting, and to preserve stocks for subsistence and sport harvests. Captures of other species in the Kangiqsualujjuaq fishery, especially Atlantic salmon or brook trout, are only permitted to be consumed locally, or marketed to beneficiaries according to the provisions of the James Bay and Northern Quebec Agreement (1975).

1.8 Specifications of the Commercial Permit

A commercial permit authorizing the capture and sale of Arctic charr and whitefish was issued to Annanack and Son's fisheries in November 1987. A detailed protocol for the monitoring of an exploratory and experimental fishery in the Kangiqsualujjuaq area (developed by MLCP, MAPA and Makivik) was included as a requirement of the permit. It specified guidelines for the collection of biological and harvest data on the stocks, so that baseline data would be available for management purposes. It was emphasized in the original protocol that "the fishing project is experimental, and its goal is to evaluate the medium and long-term opportunities and potential for development of a fishery...an accurate and enlightened assessment of the potential requires that comprehensive, detailed information on Arctic charr populations and exploitation be gathered".

To ensure that essential data were collected, the protocol stipulated that the promoter and biologists cooperate in the monitoring process. Furthermore, all commercially-harvested Arctic charr were to be identified with a brown numbered tag affixed to the mouth of the fish or through the caudal peduncle. The minimum size of marketable charr was set at 50 cm fork length. An official record of catches and harvest statistics were to be provided regularly to the Quebec government (MAPA). A revised version of this form, adapted to the northern context, was later developed for the promoter. The record included fishing locations, dates of fishing, total effort (type, number and total length of gillnets set each day), and total catch (uneviscerated weight of each species captured).

The following specifications were included on the permit:

- names of Annanack and Sons' fishing assistants;
- fishing period: date of issue until March 31 (each year);
- bodies of water exploited and quotas;
- type of fishing gear, authorized number and size of mesh authorized;

- license holder's obligation to use the authorized fishing gear;
- license holder's obligation to tag his catches on the fishing site with the official tag provided by the government; and
- license holder's obligation to cooperate in data collection.

Biological data to be collected on the stocks included fork length, whole weight, sex, age and stage of maturity. To ensure consistency in data collection between years, it was recommended that the promoter use one mesh size per system, and utilize the same mesh size each year. As a result, Annanack and Son's decided to use 11.4 cm mesh nets on all systems, except Ijjurittuuq where a 14 cm mesh was employed. Also, experimental fishing using gang-mesh nets was recommended to obtain more extensive baseline data on one stock. Lake Sannirarsiq was chosen as the "model" system prior to the 1987-88 fishery. Collection of harvest data was also a requirement, to ensure that subsistence needs were not jeopardized by the commercial operation (see Section 2.2.1 for complete description of sampling methodology).

1.9 Description of Study Sites

The following is a brief description of Arctic charr fishing locations exploited in the subsistence and commercial fisheries in the eastern Ungava Bay region (Figure 1). Several systems, including Inussulik, 'Allurilik and Qijujjujaq, have never been commercially exploited, despite having commercial quotas since 1987. As a result, no descriptions have been provided for these unexploited sites. Spellings of all Inuit place names are taken from Muller-Wille and Avataq Cultural Institute (1987).

1.9.1 Lake Sapukkait (59°28'N; 65°18'W)

Lake Sapukkait is situated approximately 65 km by plane (100 km by canoe) from the village of Kangiqsualujjuaq, near the mouth of Abloviak Fjord (Figure 1). Until recently, this system contained a virtually-unexploited population of anadromous and land-locked Arctic charr, anadromous and resident brook trout, lake trout and three-spine sticklebacks (*Gasterosteous aculeatus*). Before 1960, this location was used for subsistence fishing using stone weirs (saputit), but until 1989 had received little fishing effort. Remnants of old stone weirs are still visible, and several fish caches may be found on the banks of the river. The system consists of a series of 9 lakes, the first 8 of which are accessible to charr for overwintering. Lake number 8 is the area most likely to contain a major spawning site in the system.

1.9.2 Lake Sannirarsiq (59°12'N; 65°26'W)

Lake Sannirarsiq is situated approximately 45 km by plane (70 km by canoe) from the village of Kangiqsualujjuaq, and also received limited fishing effort until the development of the winter commercial fishery in 1987. Some subsistence fishing activity occurs at this location each spring. The river exiting Sannirarsiq is narrow and swift; migrating Arctic charr must negotiate a series of waterfalls to reach the overwintering lakes (Barton et al. 1985). According to Dumas (1990), the waterfalls and rapids of this system are perhaps near the upper limit of which charr can surpass. Besides anadromous Arctic charr, lake trout and brook trout are also present in this system. An ancient archaeological tent site is present at Sannirarsiq, which indicates long-term use of this system by Inuit.

1.9.3 Kangiqsualujjuap (George) River (58°47'N; 66°10'W)

The George River, on which the community of Kangiqsualujjuaq is located, is fished intensively in the summer, and to a lesser extent in late winter of each year. The Annanack family of Kangiqsualujjuaq traditionally settled on this system, upriver of the present location of the community. Due to late freeze-up on this system, winter fishing activities may only be undertaken after January 1.

More than 2500 Arctic charr are harvested annually for subsistence from this system (Boivin et al. 1991b). Several outfitting camps are located on this river, but only 2 have substantial sport harvests of charr. Arctic charr, lake trout, brook trout, lake whitefish (*Coregonus clupeaformis*), burbot, white suckers (*Catostomus catostomus*) and a major population of Atlantic salmon are present in this river. According to local hunters, charr spawn in two main tributaries of the George River, Iqaluniavik and Kooraluq, but overwinter in the main portion of the river (Boivin 1987). Charr are present in the system as far inland as Helen's Falls, about 25 km upriver of the community.

1.9.4 *Kurujjuaq (Koroc) River (58°50'N; 65°46'W)*

This large river system, located 30 km north of Kangiqsualujjuaq, has been an important Inuit hunting and fishing area for centuries. The system has a catchment basin of 4050 km^2 and is 134 km long (OPDQ 1984). The Baron and Etok families of Kangiqsualujjuaq had traditional camps on this system. Because of its proximity to the community, the Koroc is heavily fished soon after freeze-up in early November of each year. Over 3500 charr are taken annually in the subsistence harvest alone, and this system also supports a small sport fishery (Boivin et al. 1991b). Most fishing occurs along a 5-km lake-like stretch of river known locally as "Kuurujjuap Qullinga", about 5 km inland from the Ungava coast (Boivin and Power 1990). Several fish species are captured here, including anadromous and land-locked Arctic charr, brook trout, lake trout, and Atlantic salmon. The spawning areas for Arctic charr are located upriver on the Koroc, as far inland as Korluktuk Falls (Cunjak et al. 1986).

1.9.5 *Lake Qaarlik (58°55'N; 65°44'W)*

This system is situated between Koroc River and Lake Tasikallak, and is used occasionally for subsistence fishing during winter. Akuliak Camp, which is operated during the summer for caribou hunting and fishing, is located near the mouth of this system. Commercial fishing at this location was suspended after the first 2 years of operation, in order to preserve the charr for subsistence and sport fisheries. The Inuit have noted that the fish captured in this system are smaller than charr harvested at other locations in the region.

1.9.6 *Lake Tasikallak (58°55'N; 65°23'W)*

A relatively small lake (1.5 km^2), Lake Tasikallak is a key winter subsistence fishing area used by Kangiqsualujjuamiut. Located within a 3-hour snowmobile ride from the community, annual harvests often exceed 1000 charr (Boivin et al. 1991b). The Morgan family of Kangiqsualujjuaq had a traditional settlement at this location, and relied heavily on the local charr resource. Anadromous Arctic charr is the only fish species ever recorded in subsistence and commercial catches. A substantial spawning area is located at the north end of the lake, but most fishing is undertaken at the south end. This system was the site of stream enhancement work in 1988 and 1989, which improved access for charr to the overwintering lake (Dumas 1989).

1.9.7 Lake Akilasaaluk (59°03'N; 65°24'W)

This system, located approximately 40 km by plane (60 km by canoe or snowmobile) from the community, is comprised of 2 small lakes. Both anadromous Arctic charr and resident brook trout are captured here. However, prior to 1986, this system was seldom ever used for subsistence fishing (Boivin 1987). The first lake in the system appears to contain most of the overwintering stock, and the second lake is the main spawning area for this location.

1.9.8 Ijjurittuuq River (59°14'N; 65°18'W)

Ijjurittuuq River is a large Arctic charr system which is comprised of a series of 5 lakes inland from the river mouth. It is situated approximately 50 km by plane (75 km by canoe) from the village of Kangiqsualujjuaq, and has also received limited fishing effort in the past. The system contains a population of large Arctic charr (Boivin 1987), and supports a caribou and fishing camp at the river mouth.

1.9.9 Lake Napaartulik (59°08'N; 65°26'W)

Both Arctic charr and lake trout are captured in this small lake located near Lake Sannirarsiq. Situated approximately 45 km by plane (70 km by canoe) from the village of Kangiqsualujjuaq, this system has received limited fishing pressure by Kangiqsualujjuamiut. Stone weirs were used on this river in the past to harvest Arctic charr.

2.0 MATERIALS AND METHODS

2.1 Harvest Studies

The total annual subsistence fish catch by the community of Kangiqsualujjuaq between 1987-1992 was calculated through the use of harvest booklets and questionnaire surveys. Since 1987, fishermen have been asked to record: date of fishing, location fished, number of nets used, and number of charr (or other species) captured by net, jigging or kakivak in harvest booklets provided to them in November of each year. Fishermen were visited at least twice annually (second survey was usually conducted in June of each year) 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). Examples of the harvest study booklet and questionnaire are provided in Appendix 4.

2.2 Winter Sampling

2.2.1 Commercial Fishery

In both the 1987-88 and 1988-89 winter fisheries, research staff traveled by snowmobile with the commercial fishermen to all sites commercially-fished and sampled the charr catch at each site. For the 1989-90 to 1991-92 fisheries, most charr were sampled upon the fishermen's return to Kangiqsualujjuaq. Corrections were applied to account for the different sampling techniques used, and for fresh whole and frozen eviscerated charr (see Correction factors, Section 2.6). Fishing generally took place between November and April of each year.

In the field, records were 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. The methodology used by Kangiqsualujjuamiut to set nets beneath the ice is described in detail by Boivin and Power (1988; see Plate 3).

All fish captured in the commercial fishery were sampled by the research team before being processed for sale. Fish were measured for fork length (±0.1 cm) and whole weight (±25 g). Between 1988-1990, otoliths were collected for aging from a systematic sample of the catch. Sex of Arctic charr was determined by examination of gonads, except in the 1987-88 winter fishery when inspection of external characteristics (including shape and size of head and degree of kype formation) was used (Boivin 1987). In 1988 maturity was estimated using two general categories (non-spawner or spent) from visual characteristics and coloration ('silver' charr were designated as not having spawned the previous fall, whereas 'red' charr were described as contributing to the fall spawning run (Boivin and Power 1990)). Both sex and maturity of the 1988 sample were confirmed by examination of the gonads of a sub-sample of the total catch (Boivin et al. 1988).

Saggital otoliths were removed from a minimum of 150 charr from each site (or the total harvest if less than 150 fish) in each year of the winter fishery, except in 1990-91 when no samples were collected. Heads of Arctic charr were removed in the field, kept in freezer facilities, and the otoliths later extracted at the Kuujjuaq Research Centre. In 1987-88, otoliths were systematically sampled from the fishery; in all other years, the first 150 charr captured were sampled for otoliths. The ageing techniques used are discussed in Section 2.4.

2.2.2 Scientific Fishery at Sannirarsiq, 1988

Lake Sannirarsiq was the site chosen for a detailed biological study during the 1987-88 winter commercial fishery. The goal of this study was to collect baseline biological data on an unexploited stock, which could then be compared to information collected at other commercial fishing locations.

Between 10 March and 14 April, 1988, 4 geometric gang-mesh nets (stretched measures (cm): 15.2, 11.4, 7.6, 6.4, 5.1, 3.8 and 2.5) were used to sample the Lake Sannirarsiq charr population. Sampling sites were randomly chosen, and included selection of 5 different fishing zones on the lake. Besides the aforementioned biological data collected at commercial fishing sites, qualitative data regarding the selectivity of the gear was collected.

2.2.3 Sapukkait Winter Lake Surveys, 1990-1991

To compare winter gillnet harvests with summer counts of the charr population, sampling was undertaken at Lake Sapukkait between March 7-14, 1990, and April 12-19, 1991. In 1990, 3 multi-filament nylon gillnets identical to those used in the winter commercial fishery (11.4 mm) were set beneath the freshwater ice of 6 of the 9 lakes in the system. One gillnet of 12.7 cm stretched measure was also employed. All gillnets were 45 m long, and had a height of 1.8 m. Successful harvests of Arctic charr were made at lakes 1, 3, 4 and 5; poor catch per unit of effort was experienced at lakes 6 and 8, and therefore no samples were obtained from these sites. In 1991, lakes 1 and 3 were sampled using a variety of gillnets (stretched measure 11.4, 12.7 and 14.0 cm multi-filament nets and a 14.0 cm mono-filament net).

In the winter sampling program in 1990 and 1991, Sapukkait charr were sampled for fork length, whole weight ($\pm$ 50 g), sex, external coloration, state of maturity, gonad weight, stomach contents and otoliths. The presence of tags, or adipose fin clips from previous years were noted. In 1991, additional data was collected on gear selectivity and sexual maturity, and samples were collected to determine egg counts and diameters (as described below).

2.2.4 Processing of the Winter Commercial Catch

All fish captured in the winter fishery were first removed from the gillnet by the fishermen, and given to the biologists/technicians for sampling. Charr were usually tagged through the mouth with MLCP plastic commercial fish tags; in those cases where age data were collected, the head was removed, and the fish was tagged through the caudal region.

Any fish which were below commercial size (<50 cm fork length), scarred, or excessively skinny (spent), were classified as 'rejects' and were not included in the commercial quota. A detailed summary of the commercial harvest between 1987-1992, including the numbers of rejects in the catch, is provided in Appendix 3. All rejects were kept for subsistence purposes.

Following biological sampling, charr designated suitable for commercial sale were eviscerated by the fishermen. Viscera, including kidneys, were removed, as were the gills. Charr were thoroughly washed to remove blood and mucous. A string was looped either through the opercular opening or around the tail, and fish were suspended from a tent-like rack; fish were suspended to ensure they remained straight during freezing, and to avoid theft by predators. Since the average mid-winter temperature was -25°C, charr froze solid in 10-15 minutes. On some occasions (i.e. at Ijjurittuuq River), charr were placed in an open stream to wash away blood and mucous (Plate 4) .

Once fishing activities were completed, each fisherman transported his catch back to Kangiqsualujjuaq via snowmobile and qamutik (sled). The total catch was then re-weighed in an outdoor shed near the proponent's home, and a record was kept of each fisherman's total catch. The frozen charr were then glazed, placed in individual plastic bags, sealed with a twist-tie or knot, and then placed in cardboard shipping containers for transport via Air Inuit to Kuujjuaq. Charr were usually sold in Kuujjuaq, or were transported to Montreal via Canadian Airlines or First Air.

2.3 Summer Research Using Counting Fences

Counting fences similar to that employed by Anderson and McDonald (1978) and Caron and Mercier (1987) were installed annually at Lake Sapukkait between 1988-1992, and at Lake Sannirarsiq in 1988, 1989, 1991 and 1992. The holding cage was constructed of wood and was originally covered with Vexar® plastic fencing of mesh size 1.9 cm. Details of the dimensions of the trap and counting fence are described by Boivin and Vandal (1989). In 1991, the mesh size was reduced to 1.3 cm in an effort to reduce mortality of juveniles entering the trap. The wings of the trap consisted of wire fence 180 cm in height with a mesh size of 2.5 cm, and were supported by a series of metal T-bars anchored in the riverbed. In some areas rock walls were constructed in the river beds to complete the obstruction to charr passage.

The counting fences were installed within 400 m of the river mouth at both locations. At both Sapukkait and Sannirarsiq, the river was approximately 30 m wide at the site of installation; at the former site, the average water depth at the weir was approximately 1 m, whereas at Sannirarsiq, the trap was set in 2 m of water. Because of the higher water depth at Sannirarsiq, a walkway and working platform were constructed in the river. All fish handling and manipulation at Sapukkait was carried out on the shore beside the weir.

At Sapukkait, the upstream movements of Arctic charr were monitored between mid-July and the third week of September in 1988, 1989 and 1990 thereby encompassing most of the upstream charr run; in 1991 and 1992, the weir was installed in mid-August and removed in the third week of September (see Figure 2). At Sannirarsiq, the weirs were operated from July 19-September 7 (1988), August 17-September 18 (1989), August 27-September 15 (1991), and August 28-September 6 (1992) (Figure 3). The holding cages were checked daily at 0830 and 1500; however, checking times varied slightly during the peak of the migration, depending upon the numbers of charr captured.

At Sapukkait, captured fish were removed from the holding cage with a dipnet (Plate 5), and then transferred to the holding tank/tagging box for measurement and tagging (Plates 6 and 7). All fish removed from the trap were counted, fork length was measured (± 0.1 cm), sex was determined from examination of external characteristics for all fish ≥ 50 cm, and adipose fins were clipped. In 1988, a horizontal clip was made across the dorsal surface of the adipose fin, and in 1989 a vertical clip was made (Figure 20). Thus, up to and including the 1990 summer field season, it was possible to identify all fish according to the year and number of migrations made. In 1990, 1991 and 1992, a vertical clip was also administered to all fish; it was therefore not possible to identify migration patterns for individual fish (except for tagged individuals) after the 1990 field season.

In 1988 and 1989, every third charr entering the trap at Sapukkait was systematically selected for marking using Carlin (Carlin 1955) or streamer tags. Carlin tags were secured using stainless steel wire. The total handling time for each fish was approximately 2-3 minutes. Handled charr were released upstream of the weir at both locations. In 1988, there was a bias towards the tagging of larger individuals; to compensate for this, efforts were made to include more smaller fish (<50 cm fork length) in the 1989 tagging sample (see Figure 21). No tagging or fin clipping was undertaken at Sannirarsiq.

At Sannirarsiq, all fish entering the trap were counted. However, in 1988, only every 3rd fish was measured for fork length. In 1989, 1991 and 1992 all fish were measured, and biological samples were obtained from the commercial harvest (fish ≥ 50 cm). In both 1988 and 1989, the weir was washed out in September following heavy rain storms. Since incomplete counts of the Sannirarsiq upstream migration are available, total run estimates were calculated using the proportion of Sapukkait charr counted on those days when the Sannirarsiq weir was not in operation.

Each year, charr which were harvested for subsistence consumption or which died after entanglement in the Sapukkait weir were sampled for fork length, whole weight (± 25g for fish >0.5 kg; ±5 g for charr <0.5 kg), sex and gonad weight. Otoliths were collected for age determination. In 1990, 1991 and 1992, a random selection of 200 fish (<50 cm fork length) from the entire run was undertaken to provide information on age, maturity and degree of gonadal development (Kesteven 1960); fish ≥ 50 cm were selected for autopsy from the commercial harvest. A random selection of fish sampled between 1990-1992 was used to determine population age structure, growth data, mortality and exploitation rates.

State of maturity was classified according to the Kesteven (1960) classification, and were ranked from 1-7 as follows:

- 1) virgin (very small gonads, eggs invisible to naked eye);
- 2) maturing virgin (length of gonads half, or less than half, of ventral cavity. Eggs visible);
- 3) developing (gonads occupy about half of ventral cavity. Eggs granular);
- 4) developing (gonads occupy two-thirds of ventral cavity. Eggs clearly discernible and opaque);
- 5) gravid (gonads fill ventral cavity. Some eggs transluscent and ripe);
- 6) spawning (roe and milt run extracted with slight pressure. Most eggs translucent, with few opaque eggs; and
- 7) spent (not yet fully empty. No opaque eggs left in ovary).

In 1990 and 1991, ovaries were removed from sampled fish, weighed to the nearest 0.1 g, and egg diameter was calculated. Diameters were determined by measuring the total length of 30 or 60 eggs (3 readings), and then calculating the mean value. One ovary was preserved in Gilson's liquid, and egg counts were performed by gravimetric method (Bagenal 1978). Egg counts and diameters were performed only on those charr exhibiting a state of maturity ≥ 3 (Kesteven 1960). A 2 cm section of gonad was preserved in Bouin's solution for histological analysis of gonadal development. Histological analysis included mounting of gonadal tissue on microscope slides and examination under a stereoscopic microscope according to the method outlined by Carrier (1992).

2.3.1 Commercial Fishing Using Counting Fences

For the 1989, 1991 and 1992 summer commercial fisheries at both locations, charr ≥50 cm were selected from the holding cage. After measurement, charr were transferred by dipnet to a holding pen constructed in the river. When substantial numbers of charr had been collected in the pens, the commercial harvest began. No commercial fishery was undertaken in 1990, as the commercial fishing proponent decided not to fish that year.

Charr harvested in the commercial fishery were sampled for fork length, whole weight, sex, state of maturity (Kesteven 1960) and gonad weight (±0.1 g), and heads were removed from a sub-sample for otolith extraction. Otoliths were collected from the first 200 charr sampled in the commercial fishery (random selection of the total harvest); this sampling was found to be representative of the total length sample of the commercial harvest (Section 2.6). All fish with Carlin tags were also collected for ageing. Gonad samples were collected for egg counts and histological study (as described above).

Processing of the summer weir catch was similar to that conducted in winter; however, warm summer temperatures complicated the preservation of the catch. All fish were first removed from the holding pen with a dipnet, and given to the biologists/technicians for sampling. As was the case in the winter fishery, charr were tagged through the mouth or caudal region with MLCP plastic commercial fish tags, depending on whether the head was removed for otolith extraction. Following biological sampling, all charr were eviscerated by the fishermen. All viscera, including kidneys were removed, as were the gills. Charr were thoroughly washed in the river to remove blood and slime.

Fresh charr were placed in plastic fish totes, and transported via freighter canoe back to Kangiqsualujjuaq. This trip generally took 5-6 hours from Sapukkait (3-4 hours from Sannirarsiq) with a full load of fish. Once the fishermen returned to the community, the catch was placed in freezer facilities in the community. Once frozen, the catch was placed in individual plastic bags, and stacked in cardboard shipping containers, and shipped to markets in Kuujjuaq or Montreal.

2.3.2 Sapukkait Summer Lake Survey, July 1989

In order to determine if charr remained in the overwintering lakes during the summer, sampling was undertaken on 6 of the 9 lakes in the Sapukkait system between July 19-24, 1989. Gillnets 45 m in length, 1.8 m deep and stretched measure 11.4 cm and trammel nets (25.0 cm mesh outer walls, 2.5 cm mesh inner wall) were used to collect charr. 16 Arctic charr were captured live and released after fork lengths were determined, examination for tags or fin clips, and sex and coloration were noted. Another 8 charr were sampled to confirm sex and state of maturity.

Juvenile Arctic charr, typically those less than 14.9 cm fork length, were sampled from the overwintering lakes in 1989 using dipnets and small traps; length ($\pm$ 0.1 cm) whole weight ($\pm$ 0.1 g), and sex were determined, and scales were collected for ageing. Juveniles were preserved in alcohol for future examination, and otoliths removed using a microscope.

2.4 Age Determination

The majority of age determinations in this study were made by technicians of Makivik's Kuujjuaq Research Centre (Makivik Corporation). In January 1989, Makivik Corporation and MLCP conducted a workshop in Kuujjuaq on the subject of ageing of Arctic charr (Boivin et al. 1989c). The goal was to develop a consensus among biologists and technicians on the "best" technique for ageing Northern Quebec charr. The ageing methodology used in this study was developed primarily as a result of the Kuujjuaq workshop.

In this study, several methods were employed to determine age. Methods attempted include surface reading of saggital otoliths with a stereoscopic microscope under reflected light according to the method of Nordeng (1961). Burning and sectioning of otoliths (Power 1978) was also attempted, as well as sectioned fin rays (Barber and McFarlane 1987). Various storage techniques were also tested, including keeping otoliths dry and in glycerine.

The following is a brief summary of the results of the ageing workshop, and the methodology adopted for Arctic charr age determination. Annuli were found to be more clearly discernible in saggital otoliths than in finrays, and were therefore selected as the structure to be used for ageing Arctic charr. Burning and sectioning of otoliths did not provide additional clarity to otoliths, and was also found to be very time-consuming to conduct. The best technique was found to be surface reading of otoliths with a stereoscopic microscope under reflected light. Preferably, age determinations were performed immediately after otoliths were extracted from frozen fish heads; however, otoliths which were removed in the field were stored dry in glassine envelopes, and were permitted to soak in glycerine for 1-2 hours prior to reading.

At least 2 individual readings were performed for each otolith, by 2 different individuals. The second reading by each individual was performed at least 24 hours after the first reading. A third reading was done in the case where discrepancies arose between readers or between ages determined by the same reader. Otoliths were discarded if a consensus on the final age (i.e. any difference in age interpretations between readers) was not reached after the third reading.

A record of otolith "quality' was kept for each sample. Otolith clarity was recorded according to the following categories:

- a) excellent; no problem to determine age;
- b) good; age determined is acceptable;
- c) fair; final age difficult to determine; and
- d) poor; unacceptable for age determination.

Only otoliths of quality a) or b) were deemed acceptable, and were used as final ages in this study.

At the Kuujjuaq workshop, a comparison of ageing determinations among several readers was undertaken with charr otolith samples from Koroc River and Lake Sannirarsiq; these readers were all employees of Makivik or MLCP (Boivin et al. 1989c). Comparisons were also made of the ages determined on the same otoliths by one reader after a period of one year (1988 and 1989).

In 1991, MLCP conducted a comparative analysis of age determinations by Makivik and MLCP employees, and an independent consultant in southern Quebec. In both comparative studies, at least 2 readings were made to determine final ages (as discussed above). The percentage agreement among readers and maximum differences in final ages were used as general indices of accuracy in age determination. Back-calculation was also performed on a sample of 40 charr otoliths from Lake Sapukkait. Total otolith radius (mm), radius of each annulus, radius of last complete annulus and radius of the "plus (+)" section of the otolith were measured using an ocular micrometer (Bagenal 1978). A plot of charr length vs otolith radius was used to determine the length:otolith relationship. This relationship was found to be linear, but the line did not pass through the origin. Therefore, the standard regression technique using the method of least squares was employed as follows:

$$l=a+bS$$

where: *a* is the intercept on the length axis; and

b is the regression coefficient (Bagenal 1978).

2.5 Statistical Analysis

Statistical analyses and data treatment were performed using the Macintosh and IBM versions of SPSS (SPSS Inc. 1990), Microsoft Excel 4.0 (Microsoft Corporation 1992) and Statview for the Macintosh (BrainPower Inc. 1985). For all statistical tests, normality of data and homogeneity of variance was tested according to the method described by SPSS (SPSS Inc. 1990).

Analysis of variance (ANOVA) was used to test for differences in fish data between locations, and t-Tests were used to test for differences in growth rate between sexes (Sokal and Rohlf 1981). Examinations of differences in length-frequency distributions of migrating charr between years were undertaken using the Kolmogorov-Smirnov 2 sample test (Sokal and Rohlf 1981). The maximum probability of a Type-I error was 0.05.

Length, weight and age data were pooled from fish sampled between 1987-1992 at the Sapukkait and Sannirarsiq counting fences and commercial fisheries to determine average length-at-age for each stock. A random selection of age samples collected at Sapukkait between 1990-1992 was used to determine population age structure of the upstream migrants. For the winter fishery, age-length data were obtained from systematic sampling of charr captured by gillnet.

Age at sexual maturity for females randomly sampled at the Sapukkait counting fence between 1990-1992 was calculated according to the method of Lysak (1980) as follows:

$$Z = \frac{A_1K_1 + A_2(K_2\text{-}K_1) + A_3(K_3\text{-}K_2) + \ldots + A_n(K_n\text{-}K_{n-1})}{K_1 + (K_2\text{-}K_1) + (K_3\text{-}K_2) + \ldots + (K_n\text{-}K_{n-1})}$$

where: Z = age at maturity;

A = age (years); and

K = percentage of mature individuals for a given age class.

From these data, Abrasov's 't' value was calculated, which provides an estimate of the amount of time (years) which fish are able to reproduce, as follows:

$$t = O - Z$$

where: O = average age of the female population; and

Z = age at sexual maturity.

The length-weight relationship for the various charr populations were expressed by the following equation:

$$W = aL^b$$

a logarithmic transformation gives the linear relationship:

$$\log W = \log a + b \log L$$

where: *a* is the intercept on the y-axis, *b* is the regression coefficient or slope of the regression line, *W* is whole weight in grams and *L* is fork length in centimeters.

The von Bertalanffy growth model was used to provide a generalized description of growth patterns for eastern Ungava charr stocks. The following expression of length (l_t) at age *t* as a function of *t* was calculated as:

$$l_t = L_\infty \{1-\exp[-K(t-t_0)]\}$$

where: L_∞ = the mathematical asymptote of the curve (often referred to as the 'final' or 'maximum' size);

K = a measure of the rate at which the growth curve approaches the asymptote; and

t_0 = a time scaler equivalent to the (hypothetical) starting time at which the fish would have been zero-sized if they had always grown according to the above model (Ricker 1975; Bagenal 1978).

As an index of general condition of fish, Fulton's condition factor (K) was calculated as follows:

$$K=100W/L^3$$

where: W is the wet weight in grams and L is the fork length in centimeters (Bagenal 1978).

The relationship of fecundity (number of eggs produced) and fork length of Sapukkait and Sannirarsiq charr was expressed as follows:

$$F = ax^b$$

where: F = Fecundity;

x = fork length;

a = a constant; and

b = an exponent.

A logarithmic transformation gives the linear relationship:

$$logF = loga + blogx$$ (Bagenal 1978).

Total instantaneous mortality data were obtained from catch curve analysis as described by Ricker (1975). Natural mortality (M) was assumed to be 0.20; exploitation was estimated using the following equations: $u_1=1-e^{-F}$ (assumes that natural mortality does not occur concurrently with fishing mortality) and, $u_2=FA/Z$ (assumes that natural and fishing mortality occur concurrently). Since the total harvest from Lakes Sapukkait and Sannirarsiq could be accurately determined, a third index of exploitation was also used: u_3=percentage exploitation from total harvest. A second estimation of survival was also calculated using the Robson and Chapman (1961) method.

2.6 Correction Factors

Differences in length and weight of fresh (whole) and frozen (eviscerated) Arctic charr were determined by measurement and weighing a subsample of the winter commercial catch (n=65 charr) both in the field (fresh) and in the community (frozen). Length data collected from frozen samples were corrected to fresh lengths by multiplying by factor of 1.02. In winter, the ratio of whole weight:eviscerated weight for these charr was 1.12:1; this was slightly higher than the 1.11:1 factor calculated in the 1985-86 winter by Boivin (1987). At Sapukkait in 1990, a random sample of 235 charr from the summer weir research were also used to calculate whole:eviscerated weight ratios; a ratio of 1.13 was recorded for that sample.

Due to differences in lengths measured between the tagging box and measuring board, a correction factor of 1.8 cm was added to all charr measured in the tagging box. In 1990, a sample of 97 tagged charr were measured at both the tagging box and using a measuring board to determine if there were any differences in lengths using these 2 methods. No significant difference (t-Test $t=0.91$, $p=.367$ $df=96$) was found in the length distribution of charr measured using the tagging box and measuring board.

To ensure that the charr ≥ 50 cm sampled in the commercial weir fishery were representative of the total migrating population ≥ 50 cm, the length-frequency distributions in 1990 at Sapukkait were compared using the Kolmogorov-Smirnov (K-S) 2 sample test. No differences were observed in the distributions between these 2 samples (K-S; $D_{0.05}=0.064$). A similar test was undertaken to determine if there was any difference in the length distribution of charr selected for age determination in 1989 with the total commercial harvest. No difference (K-S; $D_{0.05}=0.182$) was observed between these two samples.

3.0 RESULTS

The data presented in this report include results from over 10 research studies conducted between November 1987-September 1992. A great deal of the data generated through this research were summarized in a series of annual field and scientific reports, as well as scientific advice papers (Table 1). To simplify the presentation of data in this document, I have generally avoided making specific references to the individual annual reports in which the data were first presented.

3.1 Biology and Life History of Sapukkait and Sannirarsiq Arctic charr

3.1.1 Total Upstream Counts and Timing of Migration

Between 1988-1992, an average of 4300 (range 4092-4503) Arctic charr were counted during their upstream migration at Lake Sapukkait (Table 2; Figure 2). The weir was operated during the peak period of the run each year; the minimum period in which complete upstream counts were made was August 19-September 20 (1990). Between 1988-1990, complete weir counts were made each year, since the gear was monitored between mid-July and the third week of September. Length data were collected on a total of 21,269 migrants (98.9% of the average annual count). In 1993, 9,031 Arctic charr were counted migrating upriver at Sapukkait, more than twice the maximum recorded in 1988 (n=4,503) (G. Ouellette, MLCP, pers. comm.).

At Sannirarsiq, incomplete counts were made on the upstream migration due to high water levels (1988 and 1989), and the weir operated only during the commercial fishing season in 1991 and 1992 (Table 3; Figure 3). The minimum period of weir operation was August 28-September 6 (1992). No commercial fishing or research was undertaken at Sannirarsiq in 1990.

Estimates of the Sannirarsiq charr upstream migration (pre-exploitation) are 8317 (1988) and 8615 (1989) (Table 3; Figure 3). Total numbers of upstream migrants in 1991 and 1992 are difficult to quantify, but rough estimates are 5857 and 4162 charr, respectively. Unlike at Lake Sapukkait, there was an annual decrease in the total numbers of Arctic charr migrating upriver at Sannirarsiq each year; the 1992 estimated count (4162) represents only 48.3% of the number of migrants in 1989 .

The daily counts of Arctic charr passing through the Sapukkait and Sannirarsiq weirs between 1988-1992 are shown in Figures 2 and 3, respectively. The maximum number of charr which passed through the Sapukkait weir on any given day between 1988-1992 was 450 (September 4, 1991); for Sannirarsiq, the maximum was 554 (September 12, 1989). In general, more charr were enumerated per day at the Sannirarsiq weir than at Sapukkait. In 1993, a maximum of 564 charr were enumerated at Sapukkait on September 3 (G. Ouellette, MLCP, pers. comm.).

Few charr migrated upriver during the month of July at Sapukkait (1988-1990 data) and Sannirarsiq (1988 data); on average, only 5% of the total Sapukkait upstream migration had passed through the weir by August 19 (Table 4). However, the average numbers of charr counted daily increase rapidly after August 20. Over 80% of the upstream charr run at Sapukkait occurs between August 25 and September 15 each year; less than 5% were counted after September 19. However, in 1993, 23% of the total run (n=2141 individuals) were enumerated at the Sapukkait weir between August 18-25, inclusive (G. Ouellette, MLCP, pers. comm.). Therefore, to coincide with the largest number of annual migrants in an given year, optimal operation of the Sapukkait weir is between August 20-September 20.

Data from the 1988-1990 runs provided daily counts of upstream migrants between mid-July and late September (Figure 4). There was considerable variation in the length-frequency distribution of the run recorded at different times of the summer. Before the peak of the run (i.e. before August 20), larger charr (≥50 cm fork length) predominated. Smaller individuals were more common during the peak and end of the run. Larger charr, many of which appeared likely to spawn in the fall of 1988 and 1989, migrated upriver earlier than smaller individuals. Large males with developing kypes were among the first migrants at both Sapukkait and Sannirarsiq. Males larger than 70 cm were most commonly captured at the end of the run at both locations (Boivin and Vandal 1989; Boivin et al. 1990). However, few large individuals were recorded at Sapukkait both before and after the peak of the 1990 run (Figure 4). A possible cause of this decline is the intensive commercial fishery which occurred at this site in the fall of 1989 (see Section 3.1.9).

3.1.2 Length, Weight and Age data

The length-frequency distribution of Arctic charr migrating upriver at Sapukkait between 1988-1992 is presented in Figure 5. The minimum length of first-time returning migrants was 9 cm (1 fish in both 1988 and 1991), however, few charr <15 cm fork length have completed one summer at sea. The majority of first-time returning migrants are between 15-19.9 cm. The largest charr recorded migrating upriver at Sapukkait was 80.8 cm (1988). However, in 1993, one individual 82.0 cm fork length was recorded at the weir (G. Ouellette, MLCP, pers. comm.).

Significant changes in the population length structure are evident between 1988-1992. The 1988 length-frequency was bi-modal, with peaks in both the 25-30 cm and 55-60 cm range. In 1989 (pre-commercial exploitation), the distribution was relatively equal for all length classes, with a single mode between 55-60 cm (Figure 5). After the start of commercial fishing in 1989, marked changes occurred in the Sapukkait length-structure. A consistent decline in numbers of fish ≥50 cm was observed in the 1990-1992 length distributions, and the modal length shifted to smaller length-classes. The 1990 length distribution indicates a strong recruitment of fish 15-25 cm in the population. The mode shifted to 25-30 cm in 1991 and 30-35 cm in 1992, indicating a continued strong recruitment of the first-time migrants since 1990.

There has been a significant change in the proportions of fish <50 cm and ≥50 cm fork length observed at the Sapukkait weir between 1988-1992 (Table 2; Figure 6). In 1988, charr ≥50 cm comprised 49.6% of the total upstream run; by 1992, this proportion had decreased to 16.2% (and to 9.0% in 1993 [G. Ouellette, MLCP, pers. comm.]).

At Lake Sannirarsiq, a varying number of upstream migrating charr were measured each year (Table 3). The best length data were collected in 1989, when 83.0% (n=7154) of the run was measured; numbers sampled in 1988 (21.2% of the run), 1991 (40.6%) and 1992 (36.2%) were considerably lower. No data are available for 1990. Length data from the Sannirarsiq weir may be biased towards the larger size-classes; there is evidence that some small fish (<20 cm) may have been able to avoid the trap, and hence were not sampled. As a result, length-frequency data for each year (except 1989) may be biased towards the larger size classes.

The length-frequency distribution of Lake Sannirarsiq Arctic charr is presented in Figure 7. The minimum length of first-time returning migrants was 18 cm; however, the majority of first-time returning migrants were between 20-25 cm. The largest charr recorded migrating upriver at Sannirarsiq was 77.5 cm (1989).

Following winter and summer commercial fisheries, significant changes in the population length structure occurred at Sannirarsiq (Figure 7). In 1988-89, the length-distribution was skewed towards the larger size classes; the mode in both years was between 55-60 cm. After the weir commercial fishery in the summer of 1989, significant changes occurred in the Sannirarsiq length-structure. A consistent decline in numbers of fish ≥50 cm has been observed in the length distributions between 1990-1992 (Table 3). In 1988, charr ≥50 cm comprised 56.6% of the total upstream run; by 1992, this proportion had decreased to 27.2%.

The cumulative frequency of Arctic charr ≥50 cm sampled at Sannirarsiq in 1988, 1989 and 1991 depicts the decline in numbers of larger fish in the population (Figure 8). Data from 1992 did not include date of measurement for fish ≥50 cm.

Biological samples collected during the summer weir operations, winter research and experimental fisheries at Sapukkait and Sannirarsiq provide data on the status of the stock and proportions of the population exploited. Mean fork length, total weight and total age data for charr sampled at Sapukkait are presented in Table 5. From the random sample of the Sapukkait population collected in 1990, 1991 and 1992, a slight decline in average mean fork length was recorded (37.6, 36.4 and 34.8 cm, respectively). A similar decline was noted in mean total weight each year (949.1, 852.8 and 721.9g, respectively). Mean age, however, remained constant at 6.2 years for samples collected each year.

During the summer weir commercial fishery (Table 5), the average fork length of the Sapukkait catch ranged from 60.0 cm (1990, 1991 and 1992) to 61.5 cm (1989). Mean total weight, however, declined each year (1989-2763 g; 1990-2724 g; 1991-2498 g and 1992-2351 g). Mean age was similar between years, ranging from 9.8 years (1992) to 10.3 years (1990).

To compare length, weight and age data collected from the summer weir research with data collected from winter gillnet samples, winter research programs were conducted on Lake Sapukkait in 1990 and 1991; data collected during the 1987-88 experimental winter gillnet survey at Lake Sannirarsiq were used in the comparison.

Larger charr were captured during the winter research fishery at Sapukkait in 1990 and 1991 than were recorded during summer research (Table 5). Average fork length of winter gillnet samples in both years was 63.6 cm and mean total weight ranged from 2971 g (1991) to 3062 g (1990). Mean age was 9.3 years (1990) and 9.6 years (1991). The modal length was 60-70 cm in both 1990 and 1991, and modal weight was 3.5-4.0 kg and 2.5-3.0 kg, respectively (Figure 9). Modal age was 10 years in 1990 and 11 years in 1991. Gillnet selectivity may at least partly explain the differences in size of fish captured during the winter and summer research.

Commercial catches from the Sannirarsiq summer weir and winter gillnet fishery (Table 6) indicate that charr from this stock are generally smaller than those captured at Sapukkait. Charr harvested in the weir fishery average between 58.7 cm (1990) and 61.2 cm (1991). Mean weights were also variable, ranging from 2374 g (1992) to 2662 g (1991). Mean total age was 9.1 years in 1989, 10.4 years in 1991 and 9.5 years in 1992.

Charr harvested in the winter experimental gillnet fishery at Sannirarsiq in 1988 averaged 61.0 cm fork length (Table 6); the winter commercial fishery in 1989 harvests a similar average size (61.6 cm). Fish captured in the 1988 winter research fishery were the heaviest of all Sannirarsiq charr sampled (average 2685 g) and were also the oldest (mean total age of 11.0 years). The Inuit experimental-commercial winter gillnet fishery in 1989 also harvested large (average 2529 g) and relatively old (average age 10.0 years) fish compared to those sampled in the 1989-92 summer weir fisheries (Table 6). The modal length was >60 cm in both 1987-88 and 1988-89, and modal weight was 2.0-2.5 kg, respectively (Figure 10). Modal age was 10 years in both studies.

Between 1990-1992, random samples of the upstream migration at Sapukkait indicate a modal age of upstream migrants of 4-5 years (Figure 11). However, there has been a marked shift from older to younger individuals over time. The modal age of charr sampled during the commercial weir fisheries was 10 years in 1989, 11 years in 1990, 8 years in 1991 and 9 years in 1992 (Figure 12).

The length-frequency distribution of charr sampled during the Lake Sannirarsiq weir fishery also indicate a marked decline in the numbers of charr greater than age 10 after 1989 (Figure 13). Conversely, the majority of charr sampled in the winter gillnet fishery were 10 years and older (Figure 10) .

3.1.3 Age and Growth

Accurate age data is of paramount importance in the assessment and management of Arctic charr stocks. As a result, comparative studies of age determinations by different readers were performed on two occasions: in 1989 by Makivik (Koroc River and Lake Sannirarsiq otoliths), and in 1991 by MLCP (Lake Sapukkait otoliths). These results are presented here, in order for the reader to consider the variation between the results obtained by different age readers.

There was relatively good agreement in the ages of Koroc River charr determined by 2 independent Makivik readers during the Kuujjuaq ageing workshop in 1989 (Table 7). Of the 30 otoliths read by the two readers, identical ages were obtained for 16 (53%), and for 13 otoliths (43.3%) the disagreement was by only one year. The maximum difference was 4 years.

A test of variation in ages determined by the same Makivik reader (Reader #2) over time provided less reliable results; only 13/30 (43.3%) of the ages determined by the same reader one year later were identical. The maximum difference was 3 years (Table 7).

There was also a high degree of variation in ages determined by the three independent readers in the 1991 MLCP study (Table 8). Ages were compared between a Makivik technician (Reader #2) and biologists from MLCP and Schooner Environmental Consultants. Complete agreement between all 3 readers was reached on only 3/36 otoliths read (8.3%). The MLCP and Schooner biologists provided identical ages for 19 samples (52.7%), and disagreed by one year on 11 otoliths (30.6%). All disagreements in ages between the two individuals were of 2 years or less.

Conversely, the Makivik technician was in agreement with the 2 biologists on only 7 otoliths (19.4%), and disagreed by one year on 13 others (36.1%). Over 25% of the ages determined by the Makivik employee were 3 or more years different. The maximum difference between the readers was 6 years. In general, the ages provided by the Makivik reader were consistently lower than those provided by the MLCP and Schooner biologists. These differences in interpretation may be seen in the results of back-calculations performed on a sample of 40 Sapukkait charr (Appendix 5; Figure 19; see below). The Makivik reader's results indicate a faster growth rate for Sapukkait charr, especially after age 5. Conversely, the MLCP and Schooner biologists provided nearly identical data (Figure 19).

No reference collections of ages are available for Nunavik charr. As a result, interpretations of ages vary between and among readers, according to differing opinions as to what is the 'correct' final age. The majority of the age data presented in this report were from otoliths read by Makivik's Reader #2 (followed by Reader #1).

In this study, otolith quality data (classification of readability as excellent [A], good [B], fair [C], or poor [D]) was recorded for each otolith surface read (Table 9). Of the 2314 age determinations performed for Sapukkait charr, 1924 (83.1%) were classified as quality A or B, and were therefore deemed acceptable for reporting. Age data from the remaining 16.8% (n=390) were rejected and not used in statistical analyses. Most rejected ages were for fish (believed to be) over the age of 12 years; over 25% of charr otoliths between the ages of 12-15 years were not used in this report. However, these rejected data account for only 2.7 % (n=62) of the total number of ages determined. Although it is possible that rejection of some data may have biased our results by underestimating the average age of the population, we believe that the large sample size and low percentage of rejected ages has not significant affected our data.

Age data for Sapukkait charr collected between 1988-1992 are presented in Table 10 and Figure 14. The sexes differed significantly in fork length for 8 of 13 age classes (T-Test; $p<0.01$ for all tests). Length-at-age data were similar up to age 6, after which males grew significantly faster than females (Table 10). Growth is relatively rapid for both sexes for the first 6-7 years, and then plateaus after age 10.

Fork length of young-of-the-year (age 0+) charr, sampled at Sapukkait, averaged 3.8 cm (n=20) (Table 10). First-time migrants returned from the sea at an average age of 3+ (average length=17.1 cm; n=101), but sometimes as early as age 2+ (average length=11.8 cm; n=12). The oldest first-time smolt (charr <15 cm fork length captured migrating upriver) was 6+. The oldest fish sampled were age 17+ (n=2, 69.1 and 71.7 cm).

For Sapukkait charr, a comparison of growth data before commercial exploitation (1988-89) and after commencement of the commercial fishery (1990-92) revealed significant differences in length at age (both sexes combined) for 6 of 12 age classes (t-Test; $p<0.01$ for all tests). As a result, length-at-age data are presented for both pre- and post-exploitation (Figure 15). Growth of younger charr (ages 2-4) was slightly faster post-exploitation than pre-exploitation; length-at-age data for ages 2-4 were significantly different (t-Test, $p<0.01$; for ages 2-4). However, it is unclear whether the differences in growth rate noted above reflect the actual impact of exploitation on the stock, or are the result of natural variability in the sample. The long-term effects of exploitation on length-at-age of Sapukkait charr may only be determined several years from now.

Length-at-age data for Sannirarsiq charr indicate a slower growth rate than that recorded at Sapukkait (Table 11, Figure 15). The sexes differed in fork length at Sannirarsiq for charr between the ages of 5 and 8 (t-Test; $p<0.01$ for all tests). Males grew significantly larger than females, especially after age 9 (Table 11). The oldest Sannirarsiq charr was age 18+ (75.5 cm; n=1), and the youngest age 4+ (23.2 cm). No significant difference was recorded in mean length-at-age between Sannirarsiq charr sampled before the commercial weir fishery (1987-1988) and after commencement of exploitation (t-Test; $p>0.05$; 8 age classes tested) .

The von Bertalanffy model was used to provide another estimate of growth of the Sapukkait and Sannirarsiq charr populations (Table 12; Figure 17). Data which best fit the model for Sapukkait were from the 1989 weir commercial fishery; Sannirarsiq data are from the 1987-88 experimental gillnet fishery, and from the 1989, 1991 and 1992 weir commercial fisheries. The growth model indicates a maximum size (L_{∞}) of 71.2 cm for Sapukkait charr and 76.3 cm for Sannirarsiq.

In general, the von Bertalanffy model (Table 12) provides a similar estimate of growth to the average length-at-age data (Table 10; Figure 14), and to the growth estimated from the tagging study (see Section 3.1.5). However, a larger length-at-age was obtained using the von Bertalanffy growth model than was obtained from the average size-at-age data for Sapukkait fish below age 6. The opposite result was recorded for Sannirarsiq charr (Table 11, Figure 16).

Back-calculation performed in 1991 provided information on the relationship between otolith growth and fish length (Figure 18). Despite some variation in the data, the charr otoliths appear to grow at a relatively constant rate with fish length. From otolith measurements, the regression equation of fish length versus otolith radius for Sapukkait Arctic charr is as follows:

$$\log(\text{fish length})=1.402 + 1.242 \log(\text{otolith radius})$$
$$(n=77;\ r^2=0.74;\ p=0.0001)$$

A regression equation of fish age versus otolith radius was also performed for Sapukkait Arctic charr, and may be described as follows:

$$\log(\text{fish age})=1.437 + 0.470 \log(\text{otolith radius})$$
$$(n=77;\ r^2=0.74;\ df=93;\ p=0.0001)$$

Length-at-age data from back-calculation by 3 individual readers also provided insight into the accuracy of age determination. Figure 19 and Appendix 5 depict length-at-age data for Sapukkait charr determined from back-calculation of annulus radius by 3 individual readers. The MLCP and Schooner biologists generally provided similar growth curves to that presented in Table 10 and Figure 14, whereas the Makivik reader's results from back-calculation indicate a faster rate of growth. All 3 readers provided similar data up to and including age 5, after which the Makivik reader provided different results.

The length-weight relationships for Arctic charr sampled from Lake Sapukkait and Sannirarsiq in both the summer weir research and winter gillnet programs are presented in Table 13. The different values of *a* reported for both Sapukkait and Sannirarsiq may be an indication of differences in growth parameters between these stocks. However, the coefficient *b* was similar for both stocks. Variation in values of *a* may be due to sex, season, or state of maturity (Bagenal 1978).

3.1.4 Movements and Migrations

In 1988, a total of 1460 Arctic charr at Lake Sapukkait were tagged with Carlin (Carlin 1955) or streamer tags. In 1989, an additional 755 charr were tagged. Adipose fins were clipped from all fish passing through the weir each year; different clip angles were administered in 1988 and between 1989-92 (Figure 20). Therefore, up to and including the 1990 season, the migration patterns of individual fish could be identified. After 1990, clipping was continued to provide estimates of numbers of first-time migrants and adult 'strays' from other systems. However, identification of adipose clips for fish <30 cm was often difficult due to the small size of these fins.

The length-distribution of tagged charr (Figure 21) indicates that a larger proportion of fish >50 cm fork length were tagged in 1988 than were smaller fish. To compensate for this, the 1989 tagging program concentrated on charr <50 cm. Significant numbers of Carlin tags were lost after the first year of application, primarily caused by tags not being taut when applied. Handling of fish in the weir and with dipnets also contributed to tag loss, as tags often became entangled in the mesh. Tags applied in 1989 were placed more securely on the fish, and tag loss was reduced. Several tags applied in 1988 were replaced or adjusted in 1989 to reduce further loss.

A summary of annual tag recaptures is provided in Table 14. Of the 1460 charr tagged in 1988, 498 (34.1%) were recaptured in 1989; in 1992, only 52 (3.6%) returned to the weir. In 1989, an additional 755 charr were tagged, most of which were <50 cm fork length. After one year, 436 (57.7%) of the 1989 tagged fish were recaptured, 39.5% after 2 years, and 25.6% after 3 years of tagging. There was significant tag loss after the 1988 season due to improper application. From field records, it is estimated that approximately 15% (220) tags applied in 1988 were lost after the first year.

A total of 1827 recaptures of tagged charr were recorded between 1989-1992 (including multiple recaptures; Table 14). This number is sufficient to reveal the general pattern of migration at Sapukkait (Tables 15a and 15b). A variety of migration patterns are apparent. Of the 1460 charr tagged in 1988 (1448 with length data available), 840 (58.0%) were never observed again at Sapukkait (Table 15a). Most of these 'lost' charr were >50 cm fork length at the time of tagging. Tag loss may account for the majority of these 'lost' fish. Tag loss was less evident for fish tagged in 1989 (Table 15b). Of the 750 tagged in 1989, 257 (34.3%) were never observed again at Sapukkait.

The most common migration pattern was the following: charr were tagged in 1988, then returned to the weir in 1989 but were not observed again (n=309 or 21.3%). A few fish were observed returning to the Sapukkait weir each year after tagging (1989, 1990, 1991 and 1992; n=7); these charr were all between 35-50 cm at the time of tagging in 1988 (Table 15a).

The most common migration pattern for charr >50 cm (at the time of tagging) was to make odd-year migrations; 21.3% (n=309) of charr tagged in 1988 returned to the weir only in 1990 but were not observed in 1989. Conversely, Arctic charr <50 cm were more likely to make annual migrations to the sea and return to the Sapukkait weir each year. This was especially apparent for the charr tagged in 1989 (Table 15b). Of the charr tagged in 1989, 16.4% (n=123) returned to the weir each year after tagging.

Sapukkait charr tagged in 1988 undertook every possible combination of migration patterns except one (no fish followed the following pattern: 1988 [tagged], 1991 [returned to weir] and 1992 [returned to weir]). The complexity of migration patterns, especially among larger charr, provides evidence of either emigration in some years or, the possibility that Sapukkait charr remain in the overwintering lakes the summer before spawning. The latter possibility was verified during summer sampling in the overwintering lakes of Sapukkait in July 1989.

The July 1989 summer lake survey at Sapukkait provided valuable data on the component of the stock which remained in the lakes during summer, and did not contribute to the upstream migration. Of the 21 fish captured by gillnet, 12 were males and 9 were females. Sixteen (76.2%) were in spawning colors, 4 were silver charr and 1 was land-locked. Of 20 inspected for adipose clips, 15 (75%) had 1988 clips; no individuals had 1989 clips. Four tagged individuals (69.0 cm, 70.0, 71.5 and 72.8 cm fork length) were among the sample; all were males in spawning colour, and none were observed passing through the counting fence that summer. In August 1992, a tagged male in spawning colour was captured and released from Lake #3 (Patrice Simon, U. of Waterloo, pers. comm. May 14, 1993); this individual had been tagged in 1989, was next observed in at the weir in 1991, but had not passed through the weir in 1992.

Tagged Sapukkait charr have been recaptured at Lake Sannirarsiq (1991), Lake Napaartulik (1991) and Koroc River (1990). The Koroc River recapture had been tagged at Sapukkait in 1988, was recaptured at the weir in 1989, and was not seen at the weir in 1990. No tag numbers or biological information are available for the Sannirarsiq and Napaartulik recaptures. Given the low rate of exploitation at Napaartulik (primarily subsistence) and the distance of Koroc River from Lake Sapukkait, this is evidence that some Sapukkait fish complete substantial summer migrations and overwinter in other systems. At least one Arctic charr tagged in the George River in 1985 has also been recaptured in the Koroc River (MLCP/Makivik, unpub. data).

3.1.5 Growth from Tagged and Recaptured Charr

For the purposes of determining average annual growth increments for Sapukkait charr, data from tagging in both 1988 and 1989 was pooled for analysis. Length data from a total of 1637 individual recaptured charr over a period of one to four years were obtained between 1987-1992 (Figure 22). The annual growth of Sapukkait charr from tag recaptures is presented in Figures 22 and 23.

Small charr (tagged at 15-25 cm fork length) exhibited the most rapid annual growth; these fish averaged 7.7 cm year^{-1} and 11.1 cm year^{-1} increase, respectively, in fork length one year after tagging (n=68 recaptures). After 2 years, fish in this length class grew an average of 15.5 cm and 15.6 cm (n=43 recaptures), respectively, and 20.8 cm and 24.1 cm after 3 years, respectively (n=34 recaptures). No data are available for recaptures of fish 15-25 cm after 4 years of tagging. These data indicate a similar (but slightly faster) growth rate for the Sapukkait stock as depicted by the average length-at-age data (Table 10) and the von Bertalanffy growth model (Table 12).

Charr tagged at 45-50 cm fork length grew an average of 5.0 cm year^{-1} after one year, 9.2 cm after two years, 12.8 cm in the third year, and 14.3 cm four years after tagging. Therefore, the number of charr >45 cm fork length recorded at Sapukkait in any given year will likely reach commercial size (≥50 cm) the following year.

Annual growth of larger charr (>50 cm) was much slower than for smaller individuals. Charr 50-55 cm grew an average of 3.8 cm year^{-1} after 1 year (n=75), 5.2 cm after 2 years (n=38), 5.4 cm after 3 years (n=19) and 8.4 cm after 4 years (n=10). Similarly, charr tagged between 65-70 cm grew an average of 2.8 cm year^{-1} (n=44) after 1 year, 3.3 cm after 2 years (n=18), 3.4 cm after 3 years (n=5), and 5.7 cm (n=1) after 4 years. For larger charr, the decline in annual growth rate recorded from tag recaptures is reflected in both the length-at-age data (Table 10) and the von Bertalanffy model (Table 12, Figure 17).

3.1.6 Sex Ratio

Sex determination from examination of external characteristics proved to be unreliable. A random sample of 509 Sapukkait charr collected between 1990-1992 was sexed both visually and following examination of gonads. Sexing by external characteristics provided a ratio of males:females of 178:331; when checked internally, the true sex ratio was 225:284. As a result, only data collected from internal examination of gonads was used in this study.

The sex ratio of Arctic charr sampled at Lakes Sapukkait and Sannirarsiq between 1987-92 is presented in Table 16. Sex was determined from visual inspection of gonads for 2028 charr at Sapukkait; the overall ratio was nearly equal, with males (n=1041; 51.3%) slightly outnumbering females in the sample. In the random sample of the Sapukkait run collected between 1990-1992, females were more common (n=457; 54.6%) than males. During winter gillnet research at Sapukkait, a much higher proportion of males (n=124; 64.6%) were captured than females.

The Lake Sannirarsiq sex ratio was similar to that of Sapukkait (Table 16). Males outnumbered females in the winter gillnet catch (n=294; 57.1%); however, the sample collected during the weir commercial fishery was predominantly female (n=916; 57.4%).

3.1.7 Maturity and Reproduction

Maturity data (Kesteven 1960) were collected from a total of 1839 upstream migrants at Sapukkait and 1169 at Sannirarsiq (Table 17). Most Sapukkait charr randomly sampled from the 1990-1992 migrations were non-reproductive at the time of capture (Kesteven [1960] stage 3 or less); only 16 fish (0.9%) of the upriver migration were potential spawners in these 3 years. The relationship between gonad weight, fork length and total weight of Sapukkait charr confirms that the majority of fish sampled at the weir between 15-68 cm and 100-3500 g were sexually immature at the time of sampling (Figure 24).

Slightly higher numbers of potential spawners were among the commercial weir sample from both Sapukkait (5.2% and 6.5% of the 1989 and 1991 samples, respectively) and Sannirarsiq (10.4% and 25.1% and 22.3% of the 1989, 1991 and 1992 samples, respectively; Table 17). Most adult upstream migrants sampled at Sapukkait and Sannirarsiq therefore do not contribute to the fall spawning run.

A random sample of Arctic charr collected between 1990-1992 which exhibited a state of maturity 3 or greater were used to determine age at maturity (Abrozov 1969). Length, weight and age data from a total of 175 females were used to examine proportions of mature/maturing fish in the upstream migration;

data from 38 males are also provided (Table 18). Of the 175 females, 93.3% (n=162) were stage 3; all but 3 males exhibited this state of maturity. The average length, weight and age of the females was 51.9 cm, 1711 g and 8.8 years, respectively. Males averaged 62.7 cm, 2991 g and 10.3 years. From these data, the average age at sexual maturity for female charr was estimated to be 7.6 years. A value of 8.8 years was obtained for Abrozov's 't' (Abrozov 1969). Therefore, it appears that, given the current mortality rate, Sapukkait female charr have slightly more that 1 year to reproduce before being harvested.

From dissections of 8 spawners collected in the 1989 Sapukkait lake survey, the youngest maturing female (state of maturity=5) was age 8; for males, the youngest confirmed spawner was age 9. Spent charr were also collected from Lakes Sapukkait and Sannirarsiq during the winter research and experimental-commercial fisheries. At Lake Sapukkait, 7 spent males were among the captures in 1990; 1 male was age 9, 4 were age 10 and 2 were age 11. In the 1991 winter research fishery, 7 spent females were captured; 3 individuals were age 9, 3 aged 11, and 1 was age 12. At Sannirarsiq, 23 spent females and 36 spent males were captured in the 1987-88 and 1988-89 winter fisheries; the average age of spent females was 11.7 years (range 10-18 years), and for spent males was 11.9 years (range 10-15 years). Thus, it appears that age at first maturity is generally reached at age 8-10 years for Sapukkait and Sannirarsiq Arctic charr.

Data on fecundity of Sapukkait and Sannirarsiq charr, including number of eggs per female, egg diameter, and gonado-somatic index are provided in Tables 19 and 20. These data were collected form upstream migrants, and included fish between 39.3 cm and 67.2 cm at Sapukkait (ages 6-16) and between 53.0 cm and 69.5 cm at Sannirarsiq (ages 9-14). All charr examined exhibited a state of maturity ranging from 3-5 (Kesteven [1960]). Sapukkait charr sampled were classified as state of maturity 3 and 4; Sannirarsiq charr included 4 individuals of maturity stage 5. Female charr from Sapukkait averaged 5291 eggs (range 2218-8122); Sannirarsiq charr had slightly higher numbers of eggs (5583). The maximum number of eggs was 10,692 in one individual from Sannirarsiq. Egg diameters for Sannirarsiq charr (average 3.67 mm) were also larger than the Sapukkait sample (2.07 mm); the same relationship was found for gonado-somatic index (3.98% for Sapukkait, 10.05% for Sannirarsiq).

The relationship between fecundity parameters and fork length of Sapukkait and Sannirarsiq charr provide comparative data between these two stocks (Table 21; Figure 25). Sapukkait charr 45-50 cm fork length averaged 2583 eggs and a mean egg diameter of 1.39 mm. Sapukkait and Sannirarsiq charr >50 cm fork length had much higher numbers of eggs, and larger mean egg diameters (Table 21). In general, the average number of eggs for fish >50 cm was similar between the two locations, but egg diameters were larger at Sannirarsiq. Charr 65-70 cm fork length averaged 6952 eggs at Sapukkait (3.09 mm egg diameter) and, at Sannirarsiq, 7013 eggs (3.77 mm egg diameter).

The relationship between fecundity (number of eggs produced) and fork length of Sapukkait charr (Figure 25) can be expressed by:

$$\text{fecundity} = -2.295 \text{ fork length}^{3.368} \quad r^2=0.56$$

For Sannirarsiq charr, the relationship did not provide highly significant results. The equation was expressed by:

$$\text{fecundity} = 1.494 \text{ fork length}^{1.061} \quad r^2=0.12$$

No estimates of the numbers of spawning fish in the Sapukkait and Sannirarsiq stocks are available. The inaccessibility of the region and poor weather conditions during the spawning season (late September and October) has hampered our abilities to collection this essential data. From the July 1989 lake survey, individuals in spawning coloration were most abundant in Sapukkait Lake #8 (the furthest lake accessible upstream); red charr were also observed in Lakes #3 and #4.

3.1.8 Condition Factor (k)

The condition factors of Sapukkait Arctic charr of various length classes are presented in Table 22. From random samples of the Sapukkait population collected in 1990 and 1991, average condition factors ranged between 0.99 (15-19.9 cm) to a maximum of 1.31 for charr 55.0-59.9 cm (1990). Condition of smaller charr (<35 cm) was highest during the 1992 field season; the maximum average recorded was for charr 20-24.9 cm (1.22). Overall averages for Sapukkait charr sampled in 1990, 1991 and 1992 was 1.11, 1.08 and 1.11, respectively.

Condition factors for Arctic charr sampled during the winter research and summer weir fisheries at Sapukkait and Sannirarsiq are presented in Table 23. In general, condition factor values were similar between winter and summer. The lowest condition factor value was recorded at Sannirarsiq during the 1988-89 commercial winter fishery (1.05) and the highest at Sannirarsiq during the weir fishery in 1989 (1.19).

3.1.9 Exploitation of the Sapukkait and Sannirarsiq Arctic Charr Populations

The most significant exploitation of the Lakes Sapukkait and Sannirarsiq Arctic charr stocks occurred during the summer commercial fishery. Commercial fishing using the counting fences was first attempted at Lakes Sapukkait and Sannirarsiq during the summers of 1989. Between 1989-1992, a total of 1097 charr $\geq$50 cm fork length were removed from Lake Sapukkait (Table 24) and 2010 from Lake Sannirarsiq (Table 27). The maximum commercial harvest in any one year was 599 at Sapukkait and 876 at Sannirarsiq (both in 1989). A total of 661 charr were also removed during the weir fishery at Sannirarsiq in 1991.

In the 1989 weir fishery at Sapukkait, there were relatively equal proportions of fish in the 55-60 cm, 60-65 cm and 65-70 cm length classes (Figure 26). Most charr sampled in the fishery were greater than 2.5 kg whole weight (Figure 27). The length- and weight-frequency distributions for Lake Sannirarsiq charr follow a similar pattern (Figures 28 and 29). By 1992, marked declines were observed in the relative proportions of individuals >60 cm fork length and heavier than 2.5 kg whole weight in the commercial fishery at both Sapukkait and Sannirarsiq.

The history of exploitation of the Sapukkait charr stock is presented in Tables 24, 25 and 26. Since this system was rarely fished by Inuit in the past, we were able to account for all fish removed from the population during the study period. Fish have been removed from Sapukkait for subsistence, commercial and research purposes. A total of 2645 charr have been removed from the population during the past 5 years (Table 26). The most intense exploitation was during the summer of 1989, when 20.6% of the stock was harvested. The 1991 fishery was also intensive, accounting for an exploitation level of 17.5% of the population.

Significant exploitation has occurred on both the proportion of the Sapukkait stock ≥50 cm fork length (number removed=1373; 51.9% of the total harvest) and <50 cm (n removed =1272; 48.1%) (Tables 24 and 25). However, because the commercial fishery targets large fish, as well as the larger proportions of smaller fish (<50 cm) in the total Sapukkait population, the effect of exploitation has been more intensive on the fish ≥50 cm (Table 3). The 1989 weir harvest exploited approximately 35.8% of all fish ≥50 cm in the Sapukkait stock (n=642 charr harvested). However, the 1991 weir fishery and research program resulted in the removal of 48.7% of the total number of charr ≥50 cm counted that year.

The effects of the intensive rate of exploitation may clearly be seen in the numbers of fish ≥50 cm observed at the Sapukkait weir in 1992. Only 714 charr ≥50 cm were observed in 1992, which represents 32.2% of the number counted in 1988. Exploitation of the smaller size classes (charr <50 cm; Table 25) in the Sapukkait stock between 1988-1992 was low, ranging from <0.1% in the winter of 1991 to 9.5% during the summer weir research in 1991. Most smaller charr were removed from the stock during research sampling and/or trap-induced mortality.

Exploitation of the Sannirarsiq charr population >50 cm (Table 27) has not been as intense as at Sapukkait, but has still appears to have resulted in a decline in numbers of charr ≥50 cm in the stock. The most intensive exploitation occurred in the summer of 1991, when 29.6% of the estimated number of charr ≥50 cm were removed for commercial and subsistence purposes; a similar level of harvest was recorded in 1989 (28.3%). The 1134 charr ≥50 cm estimated to have migrated upriver at Sannirarsiq in 1992 represents 24.1% of the 1988 population.

3.1.10 Mortality Rates from Catch Curves

Mortality and exploitation rates were also calculated by analysis of catch curves (Ricker 1975; Table 28). Survival (S) was calculated both from catch curves and by the Robson and Chapman (1961) method. For Sapukkait, age frequency data from the 1989 weir harvest (Figure 12), from the random sampling program in 1990-1992 (Figure 11), and the 1990 winter research fishery (Figure 9) were used to determine total instantaneous rate of mortality (Z). Age-frequency data for the Sannirarsiq commercial weir harvests in 1989, 1991 and 1992 (Figure

13) and winter research and commercial sampling (Figure 10) also were used to provide estimates of mortality.

An estimate of Z for the Sapukkait stock for the 1989 commercial harvest was 0.98 (Table 28). Survival (S; catch curve) was 0.37, S' (Robson and Chapman [1961]) was 0.44, and fishing mortality (F) was 0.78. Total exploitation rate was 0.54 (u_1) 0.50 (u_2) and 0.36 (u_3 [calculated from total numbers removed from the population]). For the random sample of the Sapukkait population, overall mortality rates were much lower. Values for Z ranged from 0.27 (1990) to 0.46 (1992), S' from 0.60 (1992) to 0.72 (1990), F between 0.07 (1990) and 0.26 (1992) and exploitation rate (u_1) from 0.07 (1990) to 0.23 (1992).

Sannirarsiq mortality from catch curve analysis (Table 28) indicates a higher rate of exploitation than recorded at Sapukkait. Values of Z ranged from 0.21 (1991) to 0.98 (1989). Values of F were 0.78 (1989), 0.01 (1991) and 0.35 (1992). S' ranged from 0.32 (1989) to 0.71 (1991). Exploitation rate (u_1) was 0.54 (1989), 0.01 (1990) and 0.27 (1992). The mortality rates estimated for the 1991 fishery are likely under-estimated; caution should be exercised in mortality calculated from catch curve analysis alone (Ricker 1975). Hence, the value of (u_3) recorded in 1991 (0.30) gives a more accurate estimate of exploitation for the 1991 Sannirarsiq population.

3.1.11 Predicted Numbers of Upstream Migrating Charr ≥50 cm at Sapukkait and Sannirarsiq in 1993

From data collected at Sapukkait and Sannirarsiq during the past 5 years, some predictions may be made on the expected number of fish migrating upriver in 1993. The prediction is based on the number of charr ≥ 50 cm released in 1992, the expected recruitment into the commercial size class from fish 45-49.9 cm (Section 3.1.5), and accounts for natural mortality. The estimated total number of migrating charr ≥ 50 cm expected at Sapukkait between mid-August and late September in 1993 is <u>779</u> (Table 29). However, predictions of the run using this method have over-estimated the total run in the past (1989 and 1991). Interchange between systems may also result in variations in the numbers predicted, since some charr may overwinter in lakes other than their natal systems (Dempson and Kristofferson 1987). (Note: the actual number of charr ≥ 50 cm fork length counted migrating upriver in 1993 was 817 [G. Ouellette, MLCP, pers. comm.]).

Since only partial counts of the Sannirarsiq population were made in the past 2 years, it is more difficult to predict the number of migrating charr expected in 1993 (Table 30). Furthermore, recruitment estimates are unavailable for this system. Data from Sapukkait on proportions of new recruits in the 45-49.9 cm size class of 1992 was used to estimate Sannirarsiq recruitment. The estimated total number of charr ≥50 cm expected to migrate upstream to the Sannirarsiq weir in 1993 is 990.

3.2 Total Subsistence, Sport and Commercial Harvests of Arctic Charr

3.2.1 Subsistence Harvests

The Kangiqsualujjuamiut harvested a total of over 95,000 Arctic charr per year between 1976-1980 (Table 31; NHR 1980). The Inuit of Kangiqsualujjuaq led all northern Quebec communities in total annual harvests with an average of 19,014 per year (19.5% of the Nunavik total); Inukjuaq, on the Hudson Bay coast, was second in terms of charr harvests with 71,256 reported during the study period (an average of 14,251 per year). Arctic charr was the main fish species harvested by all communities surveyed, primarily by gillnet, followed by lake trout, lake whitefish, brook trout and Atlantic salmon.

The Kangiqsualujjuamiut harvest a variety of fish species from river and lake systems in their territory (Table 32). The targeted species is primarily Arctic charr and most other species are captured as a by-catch of the charr fishery. However, heavy fishing effort is directed towards Atlantic salmon during the upstream migration on the George River in August of each year. Substantial numbers of brook trout are also captured in the spring (by jigging). A detailed description of the subsistence harvests of fish species other than Arctic charr is presented in Boivin (1987).

The total subsistence harvests of the Inuit of Kangiqsualujjuaq are presented in Tables 33 and 34. Between 1988-1992, more than 33,000 Arctic charr were harvested by the community; for a population of 500, this represents approximately 100 g of Arctic charr per person per day (36 kg per person per year). Subsistence harvests by Kangiqsualujjuamiut averaged 6230 charr per year.

Intensive subsistence fisheries for Arctic charr occurs on three systems: Koroc River, George River, and Lake Tasikallak. Each has been a traditional fishing site for centuries. During the period 1987-1992, 44.0% (n=14,655) of the total charr harvest came from the Koroc River (mostly during winter), 32.2% (n=10,729) from the George R. (primarily summer) and 17.8% (n=5931) from L. Tasikallak (during winter) (Table 33). Average annual harvests for these 3 systems were 2931, 2146 and 1186 charr per year, respectively. Subsistence harvests from most other areas were low, with the exception of Lake Qaarlik (average of 126 charr per year). Sapukkait and Sannirarsiq play a marginal role in the total subsistence harvest; the total catch from these locations between 1988-1992 was 311 and 133 charr, respectively.

3.2.2 Sport Harvests

A 1990 survey of Nunavik outfitters indicated that an average of 785 Arctic charr are harvested annually in the sport fisheries in the Kangiqsualujjuaq area, primarily in the estuaries of the George, Koroc, Tunnulialuk, Ijjurittuuq and Allurilik Rivers, and near the outlet of Lake Qaarlik (Boivin et al. 1991b). Presently, sport fisherman are allowed to have in their possession 10 Arctic charr. However, to preserve subsistence harvests, the Landholding Corporation and Municipal Council of Kangiqsualujjuaq decided in 1990 to set an annual possession limit of 5 Arctic charr per fisherman for the George and Koroc River tourist lodges.

3.2.3 Winter and Summer Commercial Harvests

The commercial quotas for Arctic charr systems in eastern Ungava, as set by the Kangiqsualujjuaq Landholding Corporation and MLCP in 1987, are presented in Table 35. A total of 12 charr systems were originally given winter (gillnet) commercial fishing quotas, totaling 6700 charr. Lower quotas (maximum 300 fish) were given to those systems of prime importance in the subsistence fishery (George and Koroc Rivers, and Lakes Tasikallak and Qaarlik). The highest quotas were for those systems distant from the community, and for which few charr were recorded harvested for subsistence purposes (Boivin 1987). The maximum quota was 1250 (Ijjurittuuq River).

Based on the success of the 1988 Sapukkait-Sannirarsiq summer research program using counting fences, and the Cambridge Bay, NWT weir fishery (Kristofferson et al. 1986), the winter commercial quotas for Sapukkait and Sannirarsiq were transferred to a fall weir fishery. A summer commercial permit was also allowed for Inussulik. However, both winter gillnet and summer weir fisheries were not conducted on the same system in any given year. The summer weir harvests have previously been discussed in Section 3.1.9.

After the 1988-89 winter, commercial quotas were removed from the George River, Koroc River and Lake Qaarlik amid concerns that these systems could not withstand the pressure from both the subsistence and commercial fisheries. As a result, charr systems located near Kangiqsualujjuaq were subsequently reserved for subsistence use. Adjustments to the Sapukkait and Sannirarsiq commercial quotas were made in 1992 (Roy et al. 1992b) after biological data indicated a high rate of exploitation on these stocks. The present commercial quota of 3960 charr is distributed among 8 systems (Table 35).

Between 1987-1992, a total of 8357 charr were harvested in the commercial fishery (Table 36, Appendix 3). Annual harvests have declined each year after a peak catch of 3286 Arctic charr in 1988-1989. The minimum harvest was 388 charr in 1991-92.

Of the 12 commercial fishing locations, only Lake Tasikallak was fished each year between 1987-1992. The Sannirarsiq stock has sustained the highest commercial fishing pressure from both winter gillnet and summer weir fisheries with a total of 2010 charr harvested. For locations fished exclusively during winter, the highest catches have been recorded at Ijjurittuuq River (1854 charr) and Lake Akilasaaluk (1393 charr).

The Sapukkait and Sannirarsiq weir fisheries accounted for 2835 (34.1%) of the total commercial charr catch; a further 5461 charr (65.8%) were harvested during the winter gillnet fishery (Table 36).

3.2.4 Winter Gillnet Catch Per Unit of Effort (CPUE)

In general, total fishing effort has declined each year since the 1988-89 season (Tables 37-41). In the 1988-89 fishery, effort was distributed over 7 fishing locations, but after 1990 only 2 locations were exploited each winter. Total fishing effort reached a maximum of 269 net-days in the 1989-90 fishery (Table 39), but only 4.8 Arctic charr were captured per net-day.

During the 1987-88 and 1988-89 winter fisheries, CPUE averaged 11.3 and 11.2 charr per net-day, respectively (Tables 37 and 38). The total harvest in 1987-88 was 4976 kg and in 1988-89, 3564 kg. Despite the high CPUE recorded in the 1992 fishery (23 charr per net-day; 42.0 kg per net day), very little effort (6 net-days) was expended by the commercial fishermen (Table 41).

3.3 Biological Data Collected from Charr Systems During the 1987-1992 Experimental-Commercial Winter Gillnet Fishery

As part of the winter fishery monitoring program, data were collected on lengths, weights and ages of the annual commercial catch. Between 1987-1992, a total of 5409 length measurements, 5221 whole weights, and 1874 age determinations were made from Arctic charr captured during the winter commercial fishery (Tables 42-44, Figures 30-42).

3.3.1 George River

Commercial harvests were conducted on the George River only during the 1988-89 winter. The average length of 321 fish sampled was 54.7 cm, average weight was 1600 g, and average age 8.4 years (Tables 42-44). The modal length of fish sampled was 55-60 cm, modal weight 1-1.5 kg and modal age 7 years (Figure 30).

3.3.2 Koroc River

Due to its proximity to the community, the Koroc River was the first location fished during the 1987-88 and 1988-89 winter commercial fisheries. Average fork lengths, whole weights and total ages were nearly identical in both years (55.6

and 55.7 cm, respectively; 2053 g and 2084 g, respectively; and 9.1 and 8.8 years, respectively; Tables 42-44). There were no significant differences in average lengths, weights or ages of Koroc River Arctic charr sampled between the 1987-88 and 1988-89 winter fisheries (t-Test, p>0.05).

The length-, weight- and age-frequency distributions of Koroc River charr were similar between years (Figure 31). Modal lengths from each year were between 50-55 cm, modal weights 1-2 kg, and modal age 9 years in 1987-88 and 8 years in 1988-89. Sample sizes differed between the two years; the 1988-89 age data was based on far fewer samples (n=59) than that of 1987-88 (n=142).

3.3.3 Lake Qaarlik

Like the Koroc River, Lake Qaarlik was fished only during the 1987-88 and 1988-89 winter commercial fisheries. This lake was usually fished immediately after completion of the Koroc River fishery. Lake Qaarlik contains the smallest charr of all commercially-fished systems, in terms of mean fork length and whole weight (Tables 42 and 43).

There were no significant differences in average length or age of Lake Qaarlik Arctic charr sampled between the 1987-88 and 1988-89 winter fisheries (t-Test, p>0.05) . However, average weights in 1988-89 (1601) were significantly lower (p<0.01) than in 1987-88 (1767). The average ages of fish captured at Lake Qaarlik in 1987-88 and 1988-89 (9.8 and 10.2 years, respectively), were similar to that recorded at Lakes Tasikallak and Akilasaaluk (Table 44).

Length-, weight- and age frequency distributions were similar in both years (Figure 32). Modal lengths were between 50-60 cm, model weights ranged from 1.0-2.0 kg, and modal age was 10 years for both 1987-88 and 1988-89.

3.3.4 Lake Tasikallak

The only system to be commercially-fished each year of the winter fishery, Lake Tasikallak remains one of the most popular subsistence and commercial fishing spots for Kangiqsualujjuamiut. Average fork lengths declined significantly between years (t-Test, p<0.001), ranging from 50.9 cm (1991-92) to 61.4 cm

(1990-91) (Table 42). The average fork length of Tasikallak charr harvested in the commercial fishery increased each year, except in 1991-92. However, the mode of the length-frequency distribution was in the 50-60 cm range each year, except in 1990-91 when much larger fish (>60 cm) predominated (Figure 33).

The average whole weight of sampled fish varied considerably between years, ranging from 1413 g (1991-92) to 2053 g (1989-90) (Table 43). Weight data were not collected in 1990-91. However, the weight frequency distributions were similar in the first 3 year of the commercial fishery, with modal weights ranging between 1.0-2.5 kg (Figure 34).

The average age of Lake Tasikallak charr sampled in the commercial catch has declined significantly over time (t-Test, p<0.001) (Table 44). In 1987-88, the average age was 10.4 years; the age has dropped an average of 1 year per annum, to a low of 7.7 years in 1991-92 (note: no age data were collected in 1990-91). This decline is apparent in the age-frequency distribution, which has declined from a modal age of 10 years in the first 2 years of the fishery to 8-9 years in 1989-90, and 7-8 years in 1991-92 (Figure 35).

3.3.5 Lake Akilasaaluk

Lake Akilasaaluk was fished intensively during the first 3 years of the commercial fishery, but was not fished after the 1989-90 season. Average fork length has changed little between years, which ranged from 56.7 cm (1987-88) to 59.6 cm (1989-90) (Table 42); however, average lengths were significantly different between years (t-Test, p<0.001). The length distribution of the commercial catch (Figure 36) was similar between years, with the modal length between 50-60 cm each year.

No significant change in mean whole weight has occurred between years (t-Test, p>0.05) (Table 43). The weight frequency distribution has remained stable (Figure 37); modal weights ranged between 1.0-2.5 kg each year.

The average age of Arctic charr sampled at Lake Akilasaaluk was significantly different (t=Test, p<0.01) between the fisheries in 1988-89 (10.0

years) and 1989-90 (8.1 years) (Table 44). However, the modal age has remained relatively constant, ranging from 9-10 years (Figure 38).

3.3.6 Ijjurittuuq River

Ijjurittuuq, the system with the highest commercial quota, was fished in alternate years of the commercial fishery (1987-88, 1989-90 and 1991-92). Arctic charr sampled at this site were consistently among the largest captured of all fishing locations in the eastern Ungava area. One individual from this location was 87 cm long; the heaviest individual was 7150 g; the oldest was 19 years (3 different individuals).

Fork length showed a slight, but highly significant decline each year, from 63.3 cm in 1987-88 to a low of 58.9 cm in 1991-92 (t-Test, p=0.001) (Table 42). The length-frequency distribution, however, was similar between years, consistently showing several strong modes in the 50-70 cm range (Figure 39).

The average whole weight of Ijjurittuuq charr sampled in the 1987-88 winter fishery (3078 g) was the largest recorded in the 5 years of the commercial operation (Table 43). In the 1991-92 season, the average weight was almost 1 kg lower, at 2191 g. This significant difference in average weight (t-Test, $p<0.01$) is reflected in the weight-frequency distribution (Figure 40), which declined from a modal weight of 2.5-3.0 kg in 1987-88 to 1.5-2.0 kg in 1991-92. However, these estimates are based on widely different sample sizes; only 73 charr were sampled in the 1991-92 fishery compared to 964 in 1987-88.

A significant decline in average age of Ijjurittuuq River charr sampled in the commercial fishery has been recorded between years (t-Test, $p<0.001$). In 1987-88, the average age was 11.1 years; in 1989-90 it was 9.6 years, and in 1991-92 8.7 years (Table 44). The modal age has shifted accordingly, from 10 years in both 1987-88 and 1989-90 to 8 years in 1991-92 (Figure 41). However, only a small number of charr were sampled for ages in 1991-92 (n=40) .

3.3.7 Lake Napaartulik

Few Arctic charr have been harvested from Lake Napaartulik during the 5 years of the commercial fishery. Commercial harvests were conducted only in the 1988-89 and 1990-91 fisheries; on both occasions, only 35 charr were harvested for commercial sale. As a result of the small number of fish harvested, there is little available data for this fish stock.

The average fork length of Napaartulik charr was 59.9 cm in 1988-89 and 61.6 cm in 1990-91 (Table 42). Corresponding average whole weights were 2573 g and 2405 g (Table 43). Based on 21 otoliths collected in 1988-89, the average age was 10.2 years (Table 44). The length-, weight- and age frequency distributions for these samples are presented in Figure 42.

3.3.8 Comparisons Between Locations

Average length, weight and age of eastern Ungava Arctic charr sampled during the winter fisheries of 1987-88 and 1988-89 were compared. In both years, significant differences in mean fork length and whole weight were recorded between fishing locations (t-Test, $p<0.001$). In general, charr sampled at locations close to the community of Kangiqsualujjuaq (Koroc River, Lake Qaarlik and Lake Tasikallak) were smaller than those captured at distant locations (Lake Akilasaaluk and Ijjurittuuq River). No differences were found in mean length between Koroc River, Lake Qaarlik and Lake Tasikallak charr (t-Test, $p>0.25$).

Average ages of the commercial catch varied considerably between fishing sites. In the 1987-88 fishery, there was a significant difference in mean age of the catch between locations, and a general trend of increasing mean age with distance of fishing site from the community (t-Test, $p<0.001$). No differences were recorded in mean age between Lake Qaarlik and Lake Akilasaaluk charr (t-Test, $p>0.25$) .

In the 1988-89 fishery, average age did not differ between Koroc and George River charr (t-Test, $p>0.05$), but charr harvested from these two locations were significantly smaller (t-Test, $p<0.001$) than those sampled from other fishing locations. No differences were recorded in mean age between charr captured at Lakes Tasikallak, Qaarlik, Akilasaaluk and Napaartulik in 1988-89 (t-Test, $p>0.05$).

3.3.9 *Age and Growth*

Length-at-age data (both sexes combined) for Arctic charr sampled from winter fishing locations are shown in Table 45. The majority of fish captured in the winter fishery were between ages 8-11. In general, the sample sizes are small for ages above or below this range.

The youngest fish sampled in the commercial fishery was age 4 (George River) and the oldest 19 (Ijjurittuuq River). Average length-at-age varied considerably between locations. In general, charr sampled at locations nearest the community (George and Koroc Rivers, Lakes Tasikallak and Qaarlik) exhibited a smaller length-at-age than those sampled from distant locations. At all locations, there appears to be very little increase in length between ages 8-11.

The von Bertalanffy model was used to provide a second estimate of growth for the eastern Ungava charr populations (Table 46). Data which best fit the model were from Tasikallak and Akilasaaluk (Figure 43). The growth model indicates a maximum size (L_{∞}) of 61.5 cm for Tasikallak charr and 65.4 cm for Akilasaaluk. Maximum size was smallest for the George River stock (57.9 cm), and largest for Koroc River charr (78.9 cm).

The length-weight relationships for Arctic charr sampled during the winter commercial fishery are presented in Table 47. Values of *a* reported in this study were generally lower than that described for the subsistence fishery by Boivin (1987). Differences in values of *a* between stocks, season or state of maturity are common (Bagenal 1978). However, the coefficient *b* was similar in both 1985-86 (Boivin 1987) and this study.

3.3.10 *Sex ratio*

The sex ratio of Arctic charr sampled at winter fishing locations between 1987-92 is presented in Table 48. Sex was determined from visual inspection of gonads for a total of 4415 charr from the 7 locations; males predominated in the commercial catch, accounting for 57.0% (n=2515) of the total sample. Males outnumbered females captured at all locations except for the George River, where females accounted for 62.7% (n=197) of the 1988-89 harvest. The highest proportion of males (67.5%; n=438) was recorded at Lake Tasikallak.

3.3.12 Maturity and Coloration

In the 1987-1988 winter fishery, state of maturity (non-reproductive or spent) and coloration (silver or red) data were collected to obtain information on the numbers of spawners (from the previous fall) captured in the commercial fishery (Table 49). This technique was employed, since Boivin and Power (1990) reported that external coloration provided an accurate assessment of non-reproductive and spent charr captured during winter. Comparisons were made between these two methods in 1987-88 to verify if coloration provided an accurate estimation of state of maturity. A total of 1224 charr from 6 locations were used in the analysis (Table 49). External coloration was noted, and state of maturity verified by examination of gonads. At all locations, spent charr accounted for 21.1% of the catch; the overall proportion of red charr sampled was 20.3%. There was no significant difference (t-Test; p=0.096) between the use of these two methods to determine state of maturity. As a result, external coloration data collected between 1987-1992 was found to provide a suitable index of state of maturity.

The average length and age of spent charr (determined from external coloration) captured in the 1987-1992 winter fisheries ranged between 37.0-79.6 cm and 4-15 years (Table 50). The youngest spent fish was a female from George River, while the oldest were males captured at Tasikallak, Ijjurittuuq and Sannirarsiq. Spent male charr ranged in age from 7-15, while the oldest spent female was age 12 (Table 50). Average age of spent males ranged from 8.8 years (Koroc R.) to 11.8 years (L. Sannirarsiq); for females, the average ranged from 9.2 years (George R.) to 11.2 years (L. Qaarlik). Spent females were of smaller mean length (56.6 cm) than males (63.1 cm). From these data, it appears that age at maturity for the eastern Ungava stocks ranges between ages 8-10.

3.3.12 Condition Factor (k)

Condition factors ranged between 0.91 (Tasikallak in 1989-90) and 1.19 (Ijjurittuuq River in 1987-88) (Table 51). At Akilasaaluk, a decline in average condition factor was recorded between the 1987-88 (1.06), 1988-89 (0.97) and 1990-91 (0.88) fisheries. Average condition factors at Ijjurittuuq in 1989-90 (0.98) and 1991-92 (1.03) were considerably lower than that recorded in the first year of the winter fishery.

3.3.13 Mortality

Mortality and exploitation rates (Table 52) were calculated from catch curves of commercial harvests (Ricker 1975). Estimates of total instantaneous rate of mortality (Z) for the winter fishing locations ranged from 0.45 (George River 1989) to 1.01 (Ijjurittuuq River 1991-92). In general, values of Z, F (fishing mortality), and u (exploitation) were highest at the intensively-fished subsistence sites (Koroc River, Lake Tasikallak and Lake Qaarlik). Lower values of these parameters were recorded at Lake Akilasaaluk and Ijjurittuuq River.

Charr from Ijjurittuuq River showed high fishing mortality (0.81) and low survival (0.36) in 1991-92 (n=40 fish). This may reflect the heavy fishing pressure in previous years; however, total instantaneous mortality has increased since the beginning of the commercial fishery in 1987.

Problems with estimating mortality rates for the winter gillnet fishery from catch curve analysis (Ricker 1975) are apparent when one examines the Lake Tasikallak data (Table 52). Calculated values of Z have fluctuated markedly between years (range 0.40-0.94), as have estimates of exploitation (u_1; range 0.18-0.53). No pattern in mortality data is evident between years; hence, it appears that the age and mortality data calculated using catch curves for this location may not accurately represent the present status of this stock.

4.0 DISCUSSION

4.1 Biology and Life History of Eastern Ungava Arctic Charr

Anadromous Arctic charr research in Northern Quebec has increased considerably in the past 10 years, especially since the re-establishment of the experimental-commercial fishery in 1987. Our knowledge of the harvest levels, biology and life history of this important species has improved accordingly. Unlike areas of northern Labrador and the NWT where Arctic charr tagging studies and counting fence research has been undertaken since the mid 1970's (Dempson and Green 1985; Johnson 1980, 1989; McGowan 1990; Gyselman and Broughton 1991; Read and Roberge 1991), these methods were employed for the first time in northern Quebec in 1988. Essential biological data on seven other eastern Ungava charr stocks have been obtained through monitoring of winter gillnet fisheries between 1987-1992. The Arctic charr fishery in eastern Ungava has renewed interest in other areas of northern Quebec for the development of similar commercial operations (Olpinski 1990; Roy and Bernard 1991).

The upstream migration of Arctic charr in eastern Ungava Bay occurs between mid-July and late September each year, a similar time to that in the Cambridge Bay area, NWT (Johnson 1980), and northern Labrador (Dempson and Green 1985). At Sapukkait and Sannirarsiq, the peak of the run is in late August or early September, and less than 5% of the total migrate upstream before August 20th. Large charr enter the river early in the migration, followed later by smaller charr. Males larger than 70 cm were common at the end of the run in both 1988 and 1989 (Boivin and Vandal 1989; Boivin et al. 1990). Many of these large males were recovering from spawning the previous fall and were in poor condition, despite having spent more than 90 days feeding at sea (Adams 1987). Similar observations have been made during the upstream migrations of other charr stocks (Grainger 1953; Johnson 1980; Dempson and Green 1985; Dutil 1986). The energetic cost associated with reproduction restrict charr to a minimum of a 2 year interval between spawnings (Dutil 1984; 1986).

The average number of upstream migrants at Sapukkait between 1988-1992 (4300) at Sapukkait and Sannirarsiq (6700) is similar to the numbers recorded at Nauyuk Lake (Johnson 1980) and in the Fraser River in 1978

(Dempson and Green 1985) (Table 53). Few charr were observed at counting fences in the Hudson Strait (Olpinski 1990) and eastern Hudson Bay (Roy and Bernard 1991 [partial count only]; Doidge and May 1993) areas of northern Quebec. However, the Sapukkait and Sannirarsiq stocks are considerably smaller than those in recorded in the Jayco River, NWT (138,795 charr; Kristofferson et al. 1986) and in Freshwater Creek, NWT (39,559 charr; McGowan and Low 1992). High variation in the number of upriver occurs between systems and within the same system between years (Johnson 1980). At Sapukkait in 1993, more than 9000 charr were observed in the upstream migration, more than double the number counted between 1988-1992 (Gilles Ouellette, MLCP, Quebec, pers. comm.).

The smallest sea-run Arctic charr observed in this study was 9 cm, but most charr were at least 15 cm when returning from their first summer at sea. The youngest sea-run charr was age 2; however, most first-year migrants are between ages 3 and 5. Stenzel (1987) also observed that some Koroc River charr made their first sea migration as early as age 2, but the occurrence of smolts of this age was rare. In Northern Labrador, the youngest charr captured in the sea was 3 years old and the smallest was 8.7 cm (Dempson and Green 1985).

The largest and oldest charr sampled in this study were from Ijjurittuuq River. Boivin (1987) also found that the largest eastern Ungava charr captured in the subsistence fishery originated from this site. The largest charr recorded in northern Quebec are captured in the Finger Lakes, near the community of Tasiujaq (Leaf Bay). In the mid 1980's, it was not uncommon for charr greater than 13.5 kg to be captured at this location (Makivik Corporation, unpublished data).

Few data are available regarding timing and location of spawning in eastern Ungava charr, except for a descriptive account provided by Cunjak et al. (1986) for the Koroc River, and from information provided by Inuit hunters. Cunjak et al. (1986) reported that Koroc charr spawn in the mainstem of the river and did not appear to use tributaries for mating. However, Inuit have noted that spawning areas in the George River are located in two tributaries, Iqaluniavik and Kooraluq (Boivin 1987). At Sapukkait, charr in spawning coloration have been recorded in Lakes 3, 4 and 8 (the farthest upstream lake), the latter of which appears to be a major spawning site. Since no major tributaries are present at Sapukkait, it is likely that most spawning occurs near the shorelines of the lakes.

Most adult upstream migrants sampled at Sapukkait and Sannirarsiq do not contribute to the fall spawning run. Less than 1% of Sapukkait charr randomly sampled between 1990-1992 migrations were mature or maturing at the time of capture. Conversely, 21% of the winter gillnet catch was comprised of spent fish. This value is likely an over-estimate of the true proportions of spawners in the population, since gillnets tended to selectively harvest larger and older charr than were sampled at the counting fence (see below).

Fecundity of Sapukkait and Sannirarsiq charr was high, averaging over 5,500 eggs per female. This is similar to the average value provided by Moore (1975a, 1975b) for Cumberland Sound, Baffin Island (5400), but considerably higher than recorded at Nauyuk Lake (4781; Johnson [1980]), and in Northern Labrador (4665; Dempson and Green [1985]). Egg diameters for Sapukkait charr sampled in August ranged from 0.2-4.7 mm, and at Sannirarsiq 2.4-4.8 mm. Moore (1975b) recorded an average egg diameter of 3.2-4.3 mm for ripe charr from Cumberland Sound, and Johnson (1980) reported a mean of 5.1 mm at Nauyuk Lake. Carrier (1992) estimated that average egg diameter of potential spawners sampled from Sapukkait in August was approximately 2.0 mm; this value may therefore be used as a general indicator of potential spawners in the upstream migration at Sapukkait.

Johnson (1980) estimated that the spawning segment of the Nauyuk Lake charr stock represented only 5-10% of the total population. No population estimates are available for numbers of spawning charr in the Sapukkait stock. However, given the low number of mature fish recorded at the Sapukkait weir each year (and the proportions estimated from winter gillnet catches), it is reasonable to assume that the value reported by Johnson (1980) would be similar for the Sapukkait population. Before commercial exploitation (1988), 4500 charr were enumerated migrating upriver at Sapukkait. A rough estimate of the spawning stock in 1988, therefore, are 225-450 individuals. A major proportion of the larger and older individuals were removed during research and commercial fishing at this site. As a result, it is likely that a significant reduction in the spawning population occurred between 1989-1991 (see below).

Johnson (1980) reported that age at sexual maturity varied considerably among Arctic charr stocks throughout their geographic distribution. Age at maturity ranged between ages 10-18 for Nauyuk Lake charr (Johnson 1980), 11-19 at Cumberland Sound (Moore 1975b) and 14-22 for the Sylvia Grinell stock (Grainger 1953). In this study, average age of maturity for females from Sapukkait was estimated to be 7.6 years (range 5-9 years). This is slightly higher than that reported by Dempson and Green (1985) for the Fraser River in Northern Labrador (Fraser River 6.9 years), but lower than the 10.0 years at Nachvak Fjord (Glova and McCart 1978). In the 1987-1992 winter fishery, the youngest spent individual (age 4 years) was recorded from the George River; most sexually mature fish sampled ranged between ages 7-12. Gillis et al. (1982) reported that 50% of George River charr were sexually mature at age 4, and 100% at age 7. Conversely, 100% of Payne River charr reached sexually mature only at age 12 (Gillis et al. 1982). In this study, age at first maturity for eastern Ungava charr was determined to be between ages 7-10.

For sexually mature females sampled at Sapukkait, a value of 8.8 years was obtained for Abrozov's 't' (Abrozov 1969). The difference between this value and the mean age of spawners provides a general indication of the well-being of the population. Given the current mortality rate, Sapukkait female charr have slightly more that 1 year to reproduce before being harvested. This value is dangerously low, and suggests overexploitation of the spawning segment of the stock. Continued collection of mean age of the fish stock, and mean age at sexual maturity may provide a useful index of fishing stress under commercial exploitation (Reid and Momot 1985).

The accurate determination of age for Arctic charr and other northern fish species has been the subject of several investigations (Nordeng 1961; Barber and McFarlane 1987; Baker and Timmons 1991). Both Nordeng (1961) and Baker and Timmons (1991) found surface reading of otoliths to provide the most reliable results for age determination in this species. However, Barber and McFarlane (1987) suggest that burnt otolith sections are the best method to use for determining age of Arctic charr. Otolith quality data reported in this study indicated that over 83% of otoliths surface read provided reliable results. From the experience gained in our examination of ageing techniques (Boivin et al. 1989c), we agree with Baker and Timmons (1991) that surface reading of otoliths appears to be the easiest and most reliable method.

Differences in age interpretation were recorded between Makivik, MLCP and independent consultants. Results of back-calculated lengths-at-age also suggest that significant differences occur between readers. However, the growth rates reported here for Lake Sapukkait charr from otolith interpretation, tag recaptures and using the von Bertalanffy growth model were similar using each method. Growth was found to be rapid for charr between 20-50 cm, after which the rate declined dramatically. After fish reached 50 cm, there is a higher degree of variation in growth, both between individuals and between sexes. The highest variation in growth, and the point where age interpretation becomes difficult, were for those charr greater than age 10.

In this study, over 25% of otoliths were discarded for those charr over the age of 12. As a result, these data were not included in our analyses. Although it is possible that rejection of some data may have biased our results by underestimating the average age of the population, we believe that the large sample size and low percentage of rejected ages has not significantly affected our interpretation of the data. It appears that age interpretations vary between and among readers according to differing opinions as to what is the 'correct' final age. As a result of the continued uncertainty associated with age determination for Arctic charr, care must be taken when interpreting age data from northern fisheries (Power 1978; Beamish and McFarlane 1987).

The growth rate of eastern Ungava charr appears to be relatively slow during the juvenile stage, increases after they begin making annual migrations to sea, and then slows after fish reach 60 cm fork length. Similar growth patterns for other charr populations were observed by Johnson (1980), who stated that this phenomenon helped to explain the bi-modality of the length-frequency distribution. High variation in length-at-age was apparent in our study, for other charr systems in Northern Quebec, and for NWT and Labrador stocks (Table 54). Eastern Ungava charr stocks exhibited a faster growth rate than that recorded for Hudson Strait (Olpinski 1990) and Richmond Gulf (Boivin and Power 1985; Doidge and May 1993) stocks, and was also faster than that reported for northern

Labrador (Dempson and Green 1985) and the NWT (Grainger 1953; Gyselman and Broughton 1991).

Significant differences were recorded in Arctic charr growth rates between sexes. Male and female charr sampled from Sapukkait and Sannirarsiq exhibited similar growth rates until the age of 6 years at Sapukkait and 8 years at Sannirarsiq; after these ages, males were significantly larger than their female counterparts of the same age. Gillis et al. (1982) reported significant differences in length-at-age data for charr sampled from the George, Payne and Kovik Rivers in northern Quebec. However, Dempson and Green (1985) reported no difference in growth rate between sexes for Labrador charr.

From Carlin tag recaptures, Dempson and Green (1985) reported that charr 40.0-44.9 cm grew an average of 5.1 cm $year^{-1}$, while charr >55.0 cm grew less than 1.5 cm/year. In our study, mark and recapture data (also Carlin tags) indicated a similar annual growth for charr 40.0-44.9 cm (5.0 cm $year^{-1}$), but a slightly higher annual growth rate for charr 50.0-64.9 cm. However, once Sapukkait charr reached 65-70 cm, their annual growth rate was almost identical to that reported for the Fraser River by Dempson and Green (1985). Growth data from tag recaptures presented in this study are invaluable for predicting the strength of different year-classes in the Sapukkait charr stock. Ricker (1969) states that fisheries assessment calculations are best carried out with growth data from individuals, rather than population growth data (including back-calculated growth), since population growth data incorporates the effects of size-selective mortality.

Lake Sapukkait charr exhibit a variety of migration patterns, which are dependent on size and stage of maturity. Smaller individuals (<45 cm) make annual migrations to the sea for feeding and return to the same system each year. Larger charr commonly make biennial or intermittent migrations, and are seldom seen returning through the weir each year. The complexity of migration patterns, especially among larger charr, provides evidence of either emigration in some years or, more likely, the possibility that Sapukkait charr remain in the overwintering lakes the summer before spawning. This behavior has also been recorded for charr in both the NWT and Labrador (Johnson 1980; Dempson and Kristofferson 1987).

Recaptures of Sapukkait Arctic charr at Lake Sannirarsiq, Lake Napaartulik and Koroc River provide evidence of emigration; however, the extent of immigration of charr from other systems is not known. The sea migrations and movements of Arctic charr in northern Labrador and the Northwest Territories are known to occasionally cover considerable distances, and overwintering in different systems between years has been recorded (Dempson and Kristofferson 1987).

The length-frequency distribution of Sapukkait Arctic charr sampled in 1988 showed the typical bi-modal shape which is characteristic of many unexploited charr populations (Johnson 1980). In 1989, larger charr (>50 cm) predominated in the run, but all length classes were equally represented. After 1990, commercial exploitation and research fishing occurred on these systems, and the proportion of larger individuals in the populations declined accordingly.

Despite the high commercial exploitation of the larger individuals from the Sapukkait stock, the total numbers migrating upriver between 1987-1992 has not changed over time. Mean length, weight and age of the adult portion of the stock has remained fairly constant, despite a marked decline in total abundance. Stable modal length, weight and age are also characteristic of the heavily-exploited Labrador charr populations (Dempson and Green 1985). This lack of major change in population parameters makes it difficult to predict the impacts of commercial fishing on charr stocks, which are often only seen after irreparable damage has been done. The stability of charr populations allows them to retain their modal size and age despite intensive exploitation (Johnson 1989). However, once modal size begins to decline, the change in the status of the stock can be dramatic.

Strong recruitment of juveniles occurred at Sapukkait in the first few years after exploitation, especially since 1990 when the population mode shifted as a result of a large influx of smolts between 15-25 cm fork length. This strong year-class has continued to dominate the length distribution, and in 1992 individuals of this year class had moved to the 25-35 cm length class. Although this recruitment is encouraging, it is likely composed primarily of charr which were present in the system before commercial exploitation began. Future monitoring of the counting fence (perhaps including an assessment of the downstream migration in spring) will verify whether this recruitment will continue in the future, or if the effects of commercial exploitation of the larger individuals (spawning stock) will be reflected in the numbers of young produced.

Unlike the situation at Sapukkait, the total numbers of Arctic charr migrating upriver at Sannirarsiq has decreased since commercial fishing began. Since complete counts are unavailable, it is not possible to determine whether this decrease is solely a result of overfishing, or whether other environmental factors are involved (i.e. natural variation in numbers migrating). However, the evidence suggests that the Sapukkait and Sannirarsiq systems are presently overexploited. The numbers of fish >50 cm fork length in the population have declined consistently since the start of the commercial fisheries and research sampling in 1988; the 1992 count of large charr at Sapukkait (n=714) represented only 32.2% of the original population of large individuals. Similarly, only 24.1% (n=1134) of the original number of charr >50 cm in the Sannirarsiq stock remain in the population. The current exploitation rates on the Sapukkait and Sannirarsiq charr stocks are too high, and should be reduced significantly (or the stocks should be allowed to remain fallow for a period of 3-5 years) to ensure sufficient numbers of spawning fish.

Noticeable changes in population parameters over time have also been recorded for other eastern Ungava stocks commercially exploited in the winter gillnet fishery. Charr systems located close to the community of Kangiqsualujjuaq have been heavily exploited for subsistence purposes, which is reflected in smaller average length, weight and age of the catch compared to sites distant from the community. However, some distant systems, such as Lake Tasikallak and Ijjurittuuq River, are also beginning to show signs of overharvesting. Mean age of the catch has declined at both these locations, and hunters have indicated that catches in recent years have not been as good as in the past.

The long-term exploitation rates which can be withstood by Arctic charr stocks remain unclear (Gillis 1988). The combined subsistence and commercial harvests on systems close to Kangiqsualujjuaq, and the intensive commercial harvests at Sapukkait (exploitation rate of 48.7% of charr >50 cm in 1991) and Sannirarsiq (exploitation rate of 29.6% in 1991) are too high. Johnson (1989) observed an 80% decline in abundance of the Nauyuk Lake stock despite no apparent change in length-frequency distribution of the population, and a modest exploitation rate (11%). Exploitation rates (u) of 32% were common in the northern Labrador fishery in the mid-1980's, with no apparent decline in overall populations (Dempson and LeDrew 1985). Downing and Plante (1993) suggested that only a small fraction (0.2% of standing biomass) of Arctic charr stocks in the high arctic could be removed on a sustainable basis. If the sustainable yield for northern Quebec charr is similar, then the present exploitation levels on most systems must be significantly reduced.

4.2 Commercial Arctic Charr Fisheries Development

The objectives of the 1987-1992 Arctic charr experimental-commercial fishery in eastern Ungava have been met with limited success. After 5 years of operation, there are few signs that the fishery will generate significant stable employment or income for many residents of the community. During the 1987-88 and 1988-89 winter fisheries, there was considerable enthusiasm on the part of the commercial proponent and fishermen, but the original commercial quota of 6700 charr per year (approximately 15,000 kg) was never obtained. Even after the use of counting fences was allowed in the summer of 1989, the maximum annual commercial catch was less than half of the total quota (1988-89; 3286 charr; 7350 kg). This level of harvest is less than ten percent of the annual landings recorded in the northern Labrador fishery (Dempson and Shears 1992).

The use of counting fences in eastern Ungava has facilitated the determination of commercial quotas, since exploitation rates may be adjusted according to the strength of the annual upstream migration. This relatively simple technology has proven effective as a commercial fishing method in the NWT (Kristofferson et al. 1986). The benefits of using weirs for commercial harvest include better control on total numbers harvested, the ability to select specific size classes for exploitation, and the total quota may be obtained in a short period of time. Also, non-commercial species may be released unharmed, and fish harvested using weirs reach market in better condition than those obtained from gillnet fisheries.

Several reasons may be the cause for the lack of success in the eastern Ungava Arctic charr fishery. To preserve the subsistence requirements of the community, low commercial quotas were originally placed on those systems near Kangiqsualujjuaq. After the 1988-89 season, once additional subsistence harvest data were obtained, commercial quotas were removed from 3 traditional fishing sites (George River, Koroc River and Lake Qaarlik). Most of the remaining commercial sites were less familiar to the fishermen, and considerable effort had to be spent locating the largest concentrations of fish in each system. Furthermore, these distant systems could only be fished using gillnets in mid-winter, when fishing conditions were less than ideal (see below).

From the counting fence research, it is apparent that most Arctic charr stocks in eastern Ungava are small (<10,000 upstream migrants) and do not support large populations. The rapid decline in numbers of Arctic charr of commercial size at the Sapukkait and Sannirarsiq weirs between 1988-1991 resulted in significant reductions in the annual commercial quotas. The present annual commercial quota for 8 systems is 3960 charr (approximately 8700 kg); this is less than 10% of the quotas applied to Arctic charr fisheries in Nain, Northern Labrador (Dempson 1992a; 1992b), Baffin Island (Axelsen and Mauger 1990; Kristofferson et al. 1991) or Cambridge Bay area (Kristofferson et al. 1984; 1986). The small commercial quotas set for the eastern Ungava fishery have reduced the overall economic viability and attractiveness of this operation from the promoter's standpoint (Axelsen and Boivin 1994 [in prep]).

Other factors which influence and limit the operation of the fishery include climatic conditions and inaccessibility of the region. In mid-January, fishermen can be working in temperatures below -30°C. In general, Kangiqsualujjuamiut undertake little subsistence fishing effort or hunting activities in the months of January and February (Boivin et al. 1989b). The cold temperatures are not conducive to cleaning and tagging fish, and also result in equipment failures (Olpinski et al. 1988). Although late summer temperatures are perfect for processing the commercial weir catches, the commercial fishermen also must deal with difficult navigation conditions (especially heavy fog and winds) which are common in the eastern Ungava area. Since most transport of the commercial catch is by freighter canoe, these conditions can be treacherous. The long traveling distances required to reach Lakes Qijujjujaq, Inussulik, and Allurilik River resulted in no attempts ever being made to fish these systems during winter. The potential exists for conducting harvests on Qijujjujaq and Inussulik using weirs in summer; in 1993, commercial fishing was attempted on the latter site (G. Kaminski, Makivik, pers. comm.).

The low market value for wild Arctic charr at source ($2.75-$3.30 per kg to the fishermen between 1987-1992) results in little profit or incentive for the fishermen. Furthermore, the costs of shipping the product to Kuujjuaq and Montreal (all by air) significantly reduces the profit margin. The anticipated revenues from the commercialization of charr in northern Quebec have never been realized.

Many fishermen in Kangiqsualujjuaq treat commercial fishing as an extension of their subsistence activities. In the winter of 1985-86, fishermen sold their largest charr to the George River Cooperative for cash, and kept the smaller fish for their subsistence needs (Boivin 1987). Thus, commercial fishing 'subsidized' their subsistence effort. However, the Co-op fishery is not regulated, and fishermen are able to harvest charr from any system they please (usually Koroc River and Lake Tasikallak). Under current regulations, sales of this nature may be made only between Inuit, and untagged charr (i.e. those without MLCP commercial charr tags) may not be sold to non-beneficiaries of the James Bay Agreement (1975). However, under the Inter-Community Trade Initiative (developed by Makivik Corporation), trade and sales of charr between Inuit may increase in the future.

In 1991, Annanack and Sons' fisheries relinquished their commercial fishing permit for the eastern Ungava area. A new promoter, Mr. Bobby Baron, has since become the owner of the commercial permit. Catches under Mr. Baron's operation have been minimal, but it should be noted that after 1990, commercial quotas were provided only for systems distant from the community. Also, the quotas for Sapukkait and Sannirarsiq were significantly reduced before Mr. Baron took over the operation.

The difficulties encountered in the development of a sustainable commercial fishery are a result of both the inability of the stocks to sustain intensive harvesting, and cost-effectiveness of undertaking such an operation. In 1993, the commercial fishermen decided not to install the Sannirarsiq weir, because the commercial quota of 300 was insufficient to recover his costs (F.

Axelsen, MAPA, pers. comm.). The Sapukkait weir is installed and operated annually as part of the on-going research program; the small quota of 50 charr is selected by the research team as part of the sampling protocol, and was given to the commercial fishermen.

In conclusion, the experimental-commercial winter fishery and summer weir fishery has not been as successful as anticipated. In 1987-88, it was thought that the winter fishery would employ 2-3 full-time commercial fishermen between December and March. Summer weir fisheries were expected to generate employment for another 4-5 Inuit for a 4-6 week period each summer. In the end, the inability of the eastern Ungava stocks to tolerate even a low level of harvest (compared to the Labrador and NWT fisheries), and the poor economic returns to the commercial fishermen have resulted in a decrease in local interest in the fishery. The present weir operation provides the proponent with some supplementary income, and helps subsidize his subsistence hunting and fishing requirements. Apart from the occasional part-time job given to field assistants, no long-term employment opportunities have resulted from the creation of this fishery to date, and the prospective of future job creation is not promising.

4.3 Management Implications and Recommendations

The goal of the Sapukkait research program was to have a 'model' system in eastern Ungava for which extensive biological data could be collected, and to use this system as a benchmark against which other charr populations could be compared. This goal was similar to that described by Johnson (1989) for the Nauyuk Lake project. The question is, have we succeeded in achieving this goal? In many ways we have, but there are gaps in the database which remain to be filled.

Perhaps the most important contribution of the Sapukkait Arctic charr research program has been our understanding of the susceptibility of eastern Ungava charr stocks to overexploitation. Through the use of counting fences, we observed a dramatic change in length structure of the Sapukkait and Sannirarsiq charr populations over time, and reduced harvesting rates accordingly. The experiences gained from commercial fishing using counting fences have also made us more cautious when developing harvest levels for the northern Quebec winter gillnet fisheries.

Commercial gillnet fisheries do not provide representative data on the status of the population due to net selectivity (Hamley 1975). In the eastern Ungava winter fishery, gillnets tended to capture significantly higher proportions of larger and older charr (including spent fish) than was recorded during monitoring of the upstream migrating population at Sapukkait and Sannirarsiq. Gillnet data underestimated the proportions of pre-recruits and young fish in the stock, and therefore provided biased estimates of age distributions, mortality and age-at-maturity. Therefore, caution should be exercized when making assessments of charr fisheries where only gillnet data are available.

Several methods were used in this study to estimate mortality and rate of exploitation of the eastern Ungava charr stocks, including catch curve analysis (Ricker 1975), monitoring of total catch and fishing effort and population estimates using counting fences. Mortality rates calculated using catch curves provided a wide range of exploitation rates (u_1 and u_2) for the Sapukkait population which varied considerably from the known exploitation rate (u_3) calculated from monitoring of the weir. A wide range of fishing mortality (F) and exploitation rates was also obtained using age-frequency data from winter gillnet samples. Catch curve results provide data which often lags several years behind the time the data were collected, and which represent average conditions during the years of recruitment (Ricker 1975). As a result, their usefulness in determining mortality rates is limited. In this study, exploitation rates calculated from monitoring the total harvest and change in population parameters at the Sapukkait counting fence provided more reliable estimates of mortality.

The continuation of the annual charr harvest study in the Kangiqsualujjuaq area must therefore be a priority. As Johnson (1989) stated, "Perhaps the most crucial piece of information, should this be available, is the level of harvest that, in the past, has caused the demise of the fishery". In terms of cost-effectiveness, there are few types of studies which produce more valuable data for management purposes than harvest studies (Usher and Wenzel 1987). Data collected from Kangiqsualujjuamiut harvests provide the only available information on exploitation levels of the Koroc River, George River and Lake Tasikallak stocks, which are important subsistence fishing areas for the community. To ensure accuracy in the collection of catch and effort data, frequent communication between fisheries managers and the community is essential (Boivin 1987).

Commercial Arctic charr fisheries in northern Quebec must only be conducted on those systems which are distant from the communities, and which are not important to the local subsistence or tourist economy (Boivin et al. 1989b). In eastern Ungava, this area includes all stocks situated north of Lake Sannirarsiq, and as far north as Killiniq. There are several populations which may be exploited; however, distance and inaccessibility of the area are factors which will limit commercial development. In other areas of northern Quebec, however, defining commercial fishing 'zones' will be more complicated because of overlapping use of some systems for subsistence needs (Gillis 1988). Wherever possible, weirs should be the gear employed for future Arctic charr commercial fisheries in northern Quebec. For management purposes, the data obtained from monitoring of weir fisheries is superior to information collected from winter gillnet operations.

The susceptibility of charr resources to overexploitation has been documented by many researchers (Johnson 1980; 1984; 1989; Kristofferson and Sopuck 1983; Gillis 1988; Downing and Plante 1993). However, few of these studies have provided long-term data (5 years or more) from which the stock response to exploitation may be monitored. The change in population parameters following exploitation observed at Sapukkait between 1987-1992 has therefore provided a unique data set which will prove valuable for determining harvesting rates for other eastern Ungava stocks.

Changes in size composition of Arctic charr stocks with exploitation have been recorded in both the NWT (Johnson 1980; 1989) and Labrador (Dempson and Green 1985) commercial and research fisheries. Such changes over time are common for 'virgin' fish stocks such as Sapukkait and Sannirarsiq, especially since commercial harvests were directed at the adult segment of these populations. Following intense exploitation, northern fish stocks establish a new 'configuration', with smaller and younger individuals replacing the standing stock of larger, older fish (Johnson 1976; Power 1978). The loss of the larger individuals in the Sapukkait stock, and the strong recruitment recorded at this site since 1990, are evidence that the Sapukkait population is in the process of undergoing a radical shift in size composition. Rates of recovery of charr stocks following intense exploitation have generally been estimated to be approximately 10 years; however, if fishing continues after stock reduction, the population may be permanently affected (Johnson 1989).

If strong recruitment into the Sapukkait fishery continues, and the population continues to exhibit a rapid annual growth rate for fish between 35-50 cm, fisheries managers in northern Quebec may wish to consider reducing the minimum size of the commercial harvest and concentrate effort on the strong biomass of fish in the 45-60 cm length classes. This strategy has been successfully implemented in northern Labrador, where the modal size of the commercial harvest after several years of exploitation is between 50-52 cm (J.B. Dempson, pers. comm.). However, if fishermen in Nunavik wish to maintain annual harvest from selected stocks, it is recommended that future commercial fisheries be restricted to harvesting between 10-15% of the standing stock ≥50 cm (or ≥45 cm) fork length in any given year.

Gillis (1988) and Johnson (1989) suggest that 'pulse' fishing be included as a possible management tool for commercial charr fisheries development. This technique involves undertaking intense exploitation of a stock for a period of one or two years, and then allowing it to lie 'fallow' for a period of up to 10 years. This method of exploitation is similar to that used by the Inuit in the past, when people used stone weirs to intensively fish stocks (Balikci 1980; Gillis 1988; Johnson 1989). However, it is difficult to determine the initial exploitation rate to be used in pulse fisheries (Reid and Momot 1985).

Despite the fact that the long-term impact of intensive exploitation on charr stocks is unknown, an experimental pulse fishery should be attempted (Gillis 1988). From experiences gained during intensive exploitation of the Sapukkait and Sannirarsiq stocks, it is suggested that a maximum pulse fishery exploitation rate of 30% of the standing stock ≥50 cm (or ≥45 cm) fork length be harvested once every 5-7 years. Potential sites in eastern Ungava which may be included in this experimental fishery are Lakes Qijujjujaq, Inussulik, Sapukkait, Sannirarsiq and perhaps Napaartulik. Additional sites between Inussulik and Killiniq may also be suitable. Fishermen could conduct their harvests at these systems on a rotational basis, exploiting one system per year. Future monitoring of the recovery of the Sapukkait and Sannirarsiq populations over time will prove to be the most valuable tool for determining the optimal rate of exploitation rate for a pulse fishery for eastern Ungava systems.

Stock enhancement, including aquaculture, sea-ranching, and stocking have yet to be attempted in Nunavik. Given the recent advances in developing charr aquaculture in Canada (Glebe and Turner 1993), this area of research should be examined seriously. A research program to improve access of Arctic charr to overwintering lakes has proven valuable in the short-term, but the long-term viability of stream enhancement on the production of Arctic charr systems remains to be verified (Dumas 1990). It may be useful to attempt charr enhancement on an experimental system such as Sapukkait, and monitor the effect of such programs over time (using population estimates from counting fences). However, the natural variation in numbers of upstream migrants each year (Johnson 1980) may make it difficult to determine the benefit of stream enhancement activities.

Fisheries biologists working in northern Quebec must make a concerted effort to include the local Landholding Corporations and Municipal Councils in all aspects of the management process. In the present study, the inclusion of the local agencies in decision-making, study design and in determination of harvest levels was a key factor in the success of our research. By incorporating both local knowledge and biological studies in any assessment of the northern fisheries, managers will ensure they have obtained the essential information required to determine the status of local fish populations (Gillis et al. 1982; Boivin 1987; Gillis 1988). Education of young Inuit in resource management and conservation will be essential to develop a core of future fisheries managers; to this end, the Arctic charr manual produced by Power et al. (1989) is an invaluable reference.

The eastern Ungava Arctic charr stocks are complex biological systems which are still only partly understood by biologists. Although we have greatly increased our knowledge of Arctic charr ecology in northern Quebec in the last 10 years, more work remains to be done. Specifically, research should be directed towards a better understanding of Arctic charr population dynamics and habitat conservation requirements. Future research on Arctic charr at Sapukkait should include an assessment of the spawning segment of stock, and estimation of emigration and immigration rates in the population (perhaps from attempting an enumeration of both the downstream and upstream migration in a given year). Also, it is essential that a standardized ageing technique and validation protocol be developed for Nunavik Arctic charr. The collection of harvest data on local catches of Arctic charr should be considered a management priority, so that he subsistence requirements of the growing Inuit population may be quantified.

The data presented in this study provides northern fisheries managers and the community of Kangiqsualujjuaq with some of the information required for management of their Arctic charr resources. It is hoped that the lessons learned from intense exploitation of the eastern Ungava stocks between 1987-1992 will be applied when considering development of commercial or sport fisheries in other regions of Nunavik.

4.4 Summary

The following is a summary of recommendations presented in this document:

1) Commercial Arctic charr fisheries in northern Quebec must only be conducted on those systems which are distant from the communities, and which are not important to the local subsistence economy;

2) Harvest studies should be continued in Kangiqsualujjuaq to obtain data on total catch and effort. Where possible, these data should also be collected from other communities in Nunavik;

3) Fisheries managers must include local residents in management decisions, and include traditional knowledge of Arctic charr ecology in their assessment of the resources;

4) If an annual commercial harvest is desired from individual stocks, it is recommended that future commercial fisheries be restricted to harvesting an annual maximum of 10-15% of the standing stock ≥50 cm (or ≥45 cm) fork length;

5) Monitoring of the upstream migration at Sapukkait should be continued to obtain data on the rate of recovery of the stock from exploitation. Monitoring should be conducted between August 20-September 15 each year (or at least once every two years). The rate of recovery could then be applied to calculate the optimal frequency and rate of exploitation for a pulse fishery at selected sites (Sapukkait, Sannirarsiq, Qijujjujaq, Inussulik and perhaps Napaartulik);

6) If pulse fisheries are attempted, a maximum harvest of 30% of the standing stock ≥50 cm (or ≥45 cm) fork length could be attempted once every 5-7 years. This time period may be adjusted, depending on rate of recovery of the Sapukkait stock;

7) Where possible, counting fences should be used as the fishing method for commercial charr fisheries, since they permit monitoring of population parameters, allow better control over total exploitation rates, and provide superior data to that of winter gillnet fisheries;

8) The minimum data to be collected from counting fence fisheries is total daily count of upstream migrants, total harvest and mean length, age, and age at maturity from a random sample of the catch. For winter gillnet fisheries, mean length, weight, age, coloration, mean age and age at maturity should be monitored;

9) A study of the spawning segment of the Sapukkait stock should be collected to obtain more data on spawning sites, numbers of spawners, fecundity and age at maturity. A comparative study should also be undertaken at an unexploited charr system (e.g. Inussulik); and

10) A standardized ageing technique must be developed to ensure consistency and accuracy in age determination between different readers. Reference collections of otoliths of known ages should be prepared for use by biologists and technicians performing age determinations.

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TABLES

Table 1. Summary of Arctic charr research projects conducted in the eastern Ungava Bay region between 1987-1992. Also included is a list of authors of reports and scientific advice documents produced with each project. See references for titles of each document listed.

Project	Report Produced	Reference
Winter Commercial Fishery		
1987-1988	Field Report Scientific Report	Olpinski et al. 1988 Boivin et al. 1988
1988-1989	Field Report Scientific Report	Olpinski et al. 1989 Boivin et al. 1989a
1989-1990	Field/Scientific Report	Boivin 1990a
1990-1991	Field/Scientific Report	Roy et al. 1992a*
Sapukkait/Sannirarsiq		
1988	Field/Scientific Report	Boivin and Vandal 1989
1989	Field/Scientific Report	Boivin et al. 1990
1990	Field/Scientific Report	Boivin et al. 1991a
1990	Winter Gillnet Research	Boivin 1990b
1992	Field/Scientific Report	Kaminski and Bernard 1993
Eastern Ungava Charr		
1989	Scientific Advice (George & Koroc Rivers)	Roy 1989
1989	Scientific Advice #1	Roy et al. 1989
1991	Scientific Advice #2	Roy et al. 1991
1992	Scientific Advice #3	Roy et al. 1992b
1987-1990	CSEB Presentation	Boivin et al. 1991b

* Includes Sapukkait 1991 winter gillnet research

Table 2. Total annual fish counts and numbers of Arctic charr <50 cm and ≥ 50 cm fork length measured at the Lake Sapukkait counting fence, 1988-1992. Numbers in brackets indicate percentage of annual run in each length class.

	1988	1989	1990	1991	1992	Average
Total # charr counted	4503	4356	4146	4092	4403	4300
<50 cm	2253 (50.4)	2444 (57.7)	2992 (72.5)	3212 (79.6)	3684 (83.8)	2917 (68.6)
≥50 cm	2218 (49.6)	1793 (42.3)	1134 (27.5)	825 (20.4)	714 (16.2)	1337 (31.4)
Total measured	4471	4237	4126	4037	4398	4254
Percent measured	99.3	97.3	99.5	98.7	99.9	98.9

Table 3. Estimated annual fish counts, and numbers of Arctic charr <50 cm and ≥ 50 cm fork length measured at the Lake Sannirarsiq counting fence, 1988-1992. Numbers in brackets indicate percentage of annual run in each length class.

	1988	1989	1990	1991	1992	Average
Total # charr counted	5162	7753	-------	3592	1879	4597
Estimated total # charr	8317	8615	-------	5857	4162	6738
Estimated <50 cm	3611 (43.4)	5255 (61.0)	-------	3514 (60.0)	3028 (72.8)	3852 (57.2)
Estimated ≥50 cm	4706 (56.6)	3360 (39.0)	-------	2343 (40.0)	1134 (27.2)	2886 (42.8)
Total measured	1764	7154	-------	2378	1507	3201
Percent measured	21.2	83.0	-------	40.6	36.2	47.5

Table 4. Average numbers of Arctic charr counted at the Lake Sapukkait counting fence before, during and after the peak of the upstream migration, 1988-1992. Also presented is percent (%) and cumulative percent of the run.

Date (1988-1992)	Average Number Counted	Percent of Total Run (%)	Cumulative Percent of Total Run (%)
Before Peak			
July 16-August 19	223.7	5.07	5.07
During Peak			
August 20-24	263.8	5.98	11.05
August 25-29	699.0	15.85	26.90
August 30-September 3	1051.0	23.83	50.73
September 4-9	1114.6	25.27	76.00
September 10-15	673.8	15.28	91.28
After Peak			
September 16-18	181.4	4.11	95.39
September 19-25	203.2	4.61	100.00

Table 5. Mean fork length (cm), whole weight (g) and total age (years) of Arctic charr (both sexes combined) sampled at Lake Sapukkait between 1988-1992. Includes random population samples (1990-92), summer weir commercial fishery harvests (1989-1992), summer research lake survey (1989) and winter gillnet catches (1990-1991). Numbers in brackets indicate range).

	Fork length (cm)			Whole weight (g)			Total age (years)		
Sample	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
Random Population Samples									
1990	303	37.6 (14.5-75.8)	0.9	300	949.1 (27-5150)	61.2	261	6.2 (2-17)	0.2
1991	296	36.4 (15.0-73.0)	0.9	291	852.8 (31-4300)	56.8	222	6.2 (2-14)	0.2
1992	256	34.8 (13.0-74.3)	0.9	254	721.9 (18-5500)	51.8	190	6.2 (3-17)	0.2
Summer Weir Commercial Fishery									
1989	641	61.5 (48.3-75.0)	0.3	593	2763.3 (1200-5500)	37.0	269	10.1 (6-14)	0.1
1990	62	60.0 (50.1-75.8)	0.8	60	2724.2 (1450-5150)	112.5	51	10.3 (7-17)	0.3
1991	386	60.0 (52.0-76.5)	0.3	386	2498.4 (1500-6400)	37.6	121	10.0 (6-14)	0.2
1992	52	60.0 (51.0-74.3)	0.9	52	2351.0 (1300-5500)	109.7	32	9.8 (8-14)	0.3
Summer Research Lake Survey (Gillnet)									
1989	20	62.8 (42.7-72.8)	1.7	8	2731.3 (850-4200)	37.0	5	10.6 (9-12)	0.5
Winter Research Lake Survey (Gillnet)									
1990	108	63.6 (37.4-76.0)	0.7	105	3061.7 (475-5150)	100.1	74	9.3 (5-12)	0.2
1991	87	63.6 (40.2-74.8)	0.7	87	2971.3 (600-4800)	91.4	61	9.6 (6-12)	0.2

Table 6. Mean fork length (cm), whole weight (g) and total age (years) of Arctic charr (both sexes combined) sampled at Lake Sannirarsiq between 1988-1992. Includes summer weir commercial fishery harvests (1989-1992) and winter gillnet catches (1988-1989). Numbers in brackets indicate range).

	Fork length (cm)			Whole weight (g)			Total age (years)		
Sample	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
Summer Weir Commercial Fishery									
1989	872	58.7 (44.0-76.0)	0.2	868	2470.4 (900-5000)	24.1	331	9.1 (6-13)	0.1
1991	626	61.2 (48.0-83.5)	0.3	658	2661.9 (1200-6700)	31.4	140	10.4 (7-17)	0.2
1992	200	59.5 (51.5-81.5)	0.4	201	2374.0 (1300-5700)	50.2	127	9.5 (7-18)	0.2
Winter Gillnet Fishery									
1988[1]	278	61.0 (12.5-77.0)	0.6	277	2684.9 (8-5450)	67.1	273	11.0 (4-18)	0.1
1989[2]	173	61.6 (44.0-77.0)	0.5	173	2528.7 (900-4950)	67.4	106	10.0 (7-14)	0.1

[1] Experimental gillnet fishery
[2] Inuit winter fishery

Table 7. Comparison of Koroc River Arctic charr ages as determined by two Makivik readers in 1989. Also included are comparative readings at different times (1988 and 1989) by Reader #2. Note that Reader #2 is the same individual who participated in the MLCP age study (Table 8).

Sample #	Age (years) Reader #1 1989	Age (years) Reader #2 1989	Age (years) Reader #2 1988	Maximum Difference (yrs)
1	10	10	10	0
2	13	13	13	0
3	11	11	11	0
4	7	8	7	1
5	10	10	10	0
6	10	10	10	0
7	8	9	10	2
8	11	10	11	1
9	11	11	10	1
10	10	11	12	2
11	9	9	9	0
12	7	7	7	0
13	10	11	11	1
14	12	12	12	0
15	7	7	6	1
16	9	9	10	1
17	9	10	9	1
18	15	14	14	1
19	8	8	8	0
20	11	10	11	1
21	11	11	10	1
22	11	11	9	2
23	8	7	8	1
24	9	8	8	1
25	8	7	7	1
26	11	10	11	1
27	7	7	7	0
28	9	8	9	1
29	17	13	10	7
30	7	7	9	2

Table 8. Comparison of Lake Sapukkait Arctic charr ages as determined by three independent readers (Makivik, MLCP, Schooner) in 1991.

Sample #	Fork Length (cm)	Age (years) Makivik	Age (years) MLCP	Age (years) Schooner	Maximum Difference (yrs)
1	18.9	4	4	4	0
2	20.0	5	4	4	1
3	23.3	5	4	5	1
4	25.2	5	5	4	1
5	29.0	6	6	5	1
6	29.5	5	5	4	1
7	30.3	5	4	5	1
8	33.6	6	6	6	0
9	33.7	4	5	5	1
10	34.6	6	6	6	0
11	57.0	8	10	10	2
12	61.4	8	9	9	1
13	63.5	8	9	11	2
14	68.3	9	12	14	5
15	70.2	9	13	13	4
16	73.2	8	13	14	6
17	75.0	8	12	14	6
18	48.0	6	8	8	2
19	48.4	8	9	9	1
20	49.5	7	8	8	1
21	55.3	8	11	10	3
22	56.0	7	10	11	4
23	58.0	11	12	12	1
24	59.0	10	12	12	2
25	59.5	9	11	11	2
26	63.0	10	11	11	1
27	65.0	9	12	12	3
28	66.5	11	12	11	1
29	68.8	10	14	14	4
30	69.5	13	14	14	1
31	69.5	8	11	13	5
32	69.5	12	12	13	1
33	70.0	12	11	13	2
34	72.5	10	12	13	3
35	73.0	13	11	13	2
36	74.5	11	13	13	2

Table 9. Total number of otoliths read, and quality of otoliths (A,B,C,D) determined for Arctic charr aged during the 1987-1992 study. Numbers in brackets depict percentage of each otolith quality category to the total number aged.

Age	A	B	C	D	Total (%)
0	19 (95.0)	1 (5.0)	0	0	20 (0.9)
1	9 (64.3)	6 (35.7)	0	0	15 (0.6)
2	8 (32.0)	14 (56.0)	1 (4.0)	2 (8.0)	25 (1.1)
3	49 (16.0)	223 (72.9)	34 (11.1)	0	306 (13.2)
4	41 (12.8)	224 (70.0)	51 (15.9)	4 (1.3)	320 (13.8)
5	24 (9.6)	184 (73.9)	40 (16.1)	1 (0.4)	249 (10.8)
6	11 (6.6)	133 (80.1)	21 (12.7)	1 (0.6)	166 (7.2)
7	18 (11.7)	121 (78.6)	12 (7.8)	3 (1.9)	154 (6.7)
8	15 (9.0)	131 (78.4)	19 (11.4)	2 (1.2)	167 (7.2)
9	15 (7.2)	156 (74.6)	33 (15.8)	5 (2.4)	209 (9.0)
10	13 (4.9)	206 (77.7)	39 (14.7)	7 (2.6)	265 (11.5)
11	13 (5.8)	158 (70.5)	46 (20.5)	7 (3.1)	224 (9.7)
12	4 (3.4)	82 (68.9)	30 (25.2)	3 (2.5)	119 (5.1)
13	3 (5.8)	24 (70.5)	16 (35.6)	2 (4.4)	45 (1.9)
14	1 (4.3)	13 (56.5)	8 (34.8)	1 (4.3)	23 (1.0)
15	0	1 (33.3)	2 (66.7)	0	3 (0.1)
16	0 (100)	1	0	0	1 (<0.1)
17	0	3 (100)	0	0	3 (0.1)
TOTAL	243 (10.5)	1681 (72.6)	352 (15.2)	38 (1.6)	2314

Otolith quality A=Excellent; B=Good; C=Fair; D=Poor.

Table 10. Comparison of mean fork length (cm) at age for male and female Arctic charr sampled at Lake Sapukkait between 1988-1992. Numbers in brackets indicate range of lengths. **Significance level p<0.01

	Fork Length (cm)									
	Males			Females				Sexes Combined[1]		
Age	N	Mean	SEM	N	Mean	SEM	t-value	N	Mean	SEM
0								20	3.8 (3.2-4.9)	0.1
1								14	6.6 (3.9-8.1)	0.3
2	7	15.6 (13.7-17.6)	0.5	3	17.7 (16.3-20.0)	1.2	-1.98	22	13.6 (7.6-20.0)	0.8
3	84	18.4 (14.2-26.5)	0.3	91	18.5 (14.9-25.2)	0.2	-0.08	268	17.8 (12.3-26.5)	0.1
4	114	22.5 (14.9-42.9)	0.4	105	22.6 (15.1-33.9)	0.4	-0.14	265	21.8 (13.2-42.9)	0.3
5	99	28.7 (16.5-38.5)	0.5	93	27.6 (14.3-38.5)	0.6	1.43	208	27.8 (14.3-38.5)	0.4
6	65	37.1 (22.8-56.3)	0.7	68	36.7 (15.8-50.7)	0.8	0.35	144	36.3 (13.6-56.3)	0.6
7	58	47.3 (36.7-62.5)	0.8	74	44.2 (21.7-64.0)	0.8	2.68**	139	45.6 (21.7-64.0)	0.6
8	56	53.6 (44.3-63.4)	0.6	77	50.4 (22.4-62.3)	0.7	3.35**	140	51.4 (19.1-63.4)	0.6
9	75	61.0 (42.7-74.5)	0.7	80	56.8 (44.8-69.0)	0.6	4.51**	161	58.7 (42.7-74.5)	0.5
10	106	65.0 (53.8-76.0)	0.5	92	58.5 (48.4-68.8)	0.4	9.94**	205	62.0 (48.4-76.0)	0.4
11	86	67.0 (50.0-75.0)	0.5	57	59.7 (51.6-67.0)	0.5	9.51**	149	63.5 (50.0-75.0)	0.7
12	44	68.1 (58.0-78.5)	0.6	25	60.5 (53.2-67.0)	0.8	7.61**	76	65.3 (53.2-75.8)	0.6
13	18	68.3 (52.8-75.4)	1.1	6	60.1 (54.0-67.3)	1.8	3.68**	25	66.3 (52.8-75.4)	1.2
14	7	70.1 (66.1-73.9)	1.1	7	62.5 (55.1-66.5)	1.4	4.35**	14	66.3 (55.1-73.9)	1.3
15	1	74.9	-					1	74.9	-
16				1	62.0	-		1	62.0	-
17	1	71.7	-	1	69.1	-		2	70.4 (69.1-71.7)	1.3
Total	**821**			**780**				**1854**		

Table 11. Comparison of mean fork length (cm) at age for male and female Arctic charr sampled at Lake Sannirarsiq between 1988-1992. Numbers in brackets indicate range. **Significance level p<0.01

	Fork Length (cm)									
	Males			Females				Sexes Combined[1]		
Age	N	Mean	SEM	N	Mean	SEM	t-value	N	Mean	SEM
4				1	23.2	-		1	23.2	-
5	2	41.1 (22.1-60.0)	19.0					2	41.1 (22.1-60.0)	19.0
6	7	52.7 (45.0-58.8)	1.6					7	52.7 (45.0-58.8)	1.6
7	34	54.0 (46.5-67.0)	0.7	22	54.3 (49.0-62.0)	0.7	-0.28	58	54.0 (46.5-67.0)	0.5
8	82	55.8 (49.8-67.0)	0.4	57	55.1 (49.0-66.3)	0.5	1.08	144	55.4 (49.0-67.0)	0.3
9	50	59.7 (53.0-71.0)	0.6	87	56.3 (50.0-65.0)	0.3	5.17**	141	57.6 (50.0-71.0)	0.3
10	59	63.9 (50.9-81.5)	0.8	110	58.5 (48.0-68.1)	0.4	7.18**	172	60.4 (48.0-81.5)	0.4
11	37	65.8 (55.0-73.5)	0.8	39	60.4 (53.0-68.0)	0.6	5.45**	79	63.2 (53.0-73.5)	0.6
12	17	70.0 (53.0-79.8)	1.5	30	60.0 (50.9-67.6)	0.8	6.59**	47	63.6 (50.9-79.8)	1.0
13	8	70.3 (54.8-83.5)	2.8	11	64.0 (58.0-77.5)	1.7	2.03	20	66.8 (54.8-83.5)	1.6
14	4	69.2 (61.5-73.2)	2.6	10	60.8 (54.3-65.4)	1.1	3.66**	16	62.9 (53.0-73.2)	1.5
15	1	73.5	-					1	73.5	-
16										
17	1	69.0	-	1	64.2	-		2	66.6 (64.2-69.0)	2.4
18	1	75.5	-					1	75.5	-
Total	**303**			**368**				**691**		

([1]=includes unsexed fish)

Table 12 . Length (cm) at age (years) data (both sexes combined) calculated using the von Bertalanffy model for Arctic charr sampled at Lakes Sapukkait and Sannirarsiq.

Age	Sapukkait 1989	Sannirarsiq 1989	Sannirarsiq 1991	Sannirarsiq 1992	Lake Sannirarsiq (winter) 1987-88
3	27.2	30.1	27.3	26.2	24.1
4	33.8	36.7	33.9	32.7	30.6
5	39.5	42.1	39.5	38.4	36.3
6	44.5	46.6	44.3	43.4	41.5
7	48.7	50.2	48.3	47.7	46.1
8	52.4	53.2	51.8	51.4	50.2
9	55.5	55.7	54.7	54.7	54.0
10	58.2	57.7	57.2	57.5	57.3
11	60.5	59.3	59.4	60.0	60.3
12	62.6	60.6	61.2	62.1	62.9
13	64.3	61.7	62.8	64.0	65.3
14	65.8	62.6	64.1	65.6	67.5
15	67.0	63.4	65.2	67.0	69.4
16	68.1	64.0	66.2	68.2	71.1
17	69.1	64.5	67.0	69.3	72.6
18	69.9	64.9	67.7	70.2	74.0
19	70.6	65.2	68.3	71.0	75.2
20	71.2	65.5	68.8	71.7	76.4
N	239	239	156	127	358

Table 13. Length-weight relationships for Arctic charr sampled from Sapukkait and Sannirarsiq in summer (weir) and winter (gillnet). Results presented follow the equation *logW=loga + blogL*, where *a* is the intercept on the y-axis, *b* is the regression coefficient or slope of the regression line. 'n'=sample size.

Sapukkait	a	b	n	r^2	p
Weir Fishery					
1989	-2.020	3.043	633	0.84	0.0001
1991	-1.721	2.872	386	0.87	0.0001
Weir Random Samples					
1990	-2.226	3.176	300	0.99	0.0001
1991	-2.063	3.065	291	0.97	0.0001
1992	-1.890	2.958	254	0.94	0.0001
Winter Gillnet					
1990 Research	-2.165	3.120	105	0.92	0.0001
1991 Research	-1.973	3.012	87	0.88	0.0001
Sannirarsiq					
Weir Fishery					
1989	-1.795	2.926	868	0.87	0.0001
1991	-1.262	2.620	654	0.82	0.0001
1992	-1.281	2.618	200	0.82	0.0001
Winter Gillnet					
1988 Research	-2.633	3.369	277	0.86	0.0001
1989 Commercial	-1.816	2.905	173	0.78	0.0001

Table 14. Summary of annual tag recaptures of Lake Sapukkait Arctic charr tagged in 1988 and 1989. Numbers in brackets depict percentage of total number tagged.

		Recaptures				
Year	No. Tagged	1989	1990	1991	1992	Total
1988	1460	498 (34.1)	255 (17.5)	95 (6.5)	52 (3.6)	900*
1989	755		436 (57.7)	298 (39.5)	193 (25.6)	927*
Total	2215	498	691	393	245	1827*

* Includes multiple recaptures and releases

Table 15a Summary of migration patterns of Sapukkait Arctic charr tagged in 1988. Data presented includes length at tagging, numbers tagged and numbers observed returning to the Sapukkait weir between 1988-1992.

Length (cm) at Tagging (1988)	Number Tagged	Number of Arctic charr returning to the Sapukkait weir in the following years															
		1988 only	1988 & 1989 only	1988 & 1990 only	1988 & 1991 only	1988 & 1992 only	1988, 1989 & 1990	1988, 1989 and 1991	1988, 1989 and 1992	1988, 1990 and 1991	1988, 1990 and 1992	1988, 1991 and 1992	1988, 1989 1990 & 1991	1988, 1989 1990 & 1992	1988, 1989 1991 & 1992	1988, 1990 1991 & 1992	1988, 1989, 1990, 1991 & 1992
15.0-19.9	23	20	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0-24.9	24	19	3	0	0	0	1	0	0	0	0	0	1	0	0	0	0
25.0-29.9	54	35	9	1	0	0	5	0	1	2	0	0	0	1	0	0	0
30.0-34.9	61	27	13	0	0	0	12	0	0	0	0	0	6	3	0	0	0
35.0-39.9	95	40	14	3	1	0	16	1	0	1	1	0	10	4	0	1	3
40.0-44.9	85	31	20	1	0	0	10	1	2	0	0	0	11	6	1	0	2
45.0-49.9	88	45	22	2	1	0	8	4	0	1	1	0	1	2	1	0	0
50.0-54.9	186	108	43	9	1	0	5	7	1	1	4	0	2	3	0	0	2
55.0-59.9	355	213	76	32	0	1	9	10	0	3	2	0	4	5	0	0	0
60.0-64.9	253	151	57	23	0	1	7	6	0	1	2	0	4	0	0	1	0
65.0-69.9	169	108	44	9	1	0	3	3	0	0	0	0	0	1	0	0	0
70.0-74.9	53	41	5	3	0	0	4	0	0	0	0	0	0	0	0	0	0
75.0-79.9	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**1448**	**840**	**309**	**83**	**4**	**2**	**80**	**32**	**4**	**9**	**10**	**0**	**39**	**25**	**2**	**2**	**7**
% of Total Tagged		**58.0**	**21.3**	**5.7**	**0.3**	**0.1**	**5.5**	**2.2**	**0.3**	**0.6**	**0.7**	**0.0**	**2.7**	**1.7**	**0.1**	**0.1**	**0.5**

Table 15b Summary of migration patterns of Sapukkait Arctic charr tagged in 1989. Data presented includes length at tagging, numbers tagged and numbers observed returning to the Sapukkait weir between 1989-1992.

Length (cm) at Tagging (1989)	Number Tagged	Number of Arctic charr returning to the Sapukkait weir in the following years							
		1989 only	1989 & 1990 only	1989 & 1991 only	1989 & 1992 only	1989, 1990 and 1991	1989, 1991 and 1992	1989, 1990 and 1992	1989, 1990 1991 & 1992
15.0-19.9	19	18	0	0	0	0	0	0	1
20.0-24.9	26	14	2	1	0	2	0	1	6
25.0-29.9	73	33	10	0	2	7	2	2	17
30.0-34.9	125	29	27	3	1	22	0	9	34
35.0-39.9	132	24	22	2	0	31	4	7	42
40.0-44.9	127	27	37	3	0	26	3	13	18
45.0-49.9	81	22	17	9	1	21	1	7	3
50.0-54.9	34	12	5	4	0	7	2	4	0
55.0-59.9	55	30	7	12	0	1	0	3	2
60.0-64.9	32	20	8	1	0	2	0	1	0
65.0-69.9	28	15	4	4	0	0	2	3	0
70.0-74.9	17	12	3	1	1	0	0	0	0
75.0-79.9	1	1	0	0	0	0	0	0	0
Total	750	257	142	40	5	119	14	50	123
% of Total Tagged		**34.3**	**18.9**	**5.3**	**0.7**	**15.9**	**1.9**	**6.7**	**16.4**

Table 16. Sex ratios for Arctic charr sampled at Lakes Sapukkait and Sannirarsiq using gillnets in winter and weirs in summer, 1987-1992. Numbers in brackets indicate percentage of total

Location/Year	Males	Females	Total
Sapukkait			
Winter Gillnet Fishery			
1990 (Research)	72	33	105
1991 (Research)	52	35	87
Total	**124**	**68**	**192**
	(64.6)	**(35.4)**	
Summer Weir Fishery			
1989	339	290	629
1991	198	172	370
Total	**537**	**462**	**999**
	(53.8)	**(46.2)**	
Random Samples			
1990	128	175	303
1991	141	151	292
1992	111	131	242
Total	**380**	**457**	**837**
	(45.4)	**(54.6)**	
Grand Total	**1041**	**987**	**2028**
	(51.3%)	**(48.7%)**	
Sannirarsiq			
Winter Gillnet Fishery			
1987-88 (Research)	178	94	272
1988-89 (Commercial)	116	127	243
Total	**294**	**221**	**515**
	(57.1)	**(42.9)**	
Summer Weir Fishery			
1989	383	484	867
1991	204	329	533
1992	94	103	197
Total	**681**	**916**	**1597**
	(42.6)	**(57.4)**	
Grand Total	**975**	**1137**	**2112**
	(46.2%)	**(53.8%)**	

Table 17. Stage of maturity (Kesteven 1960) of Arctic charr sampled at the Lake Sapukkait and Sannirarsiq counting fences during the summers of 1989-1992. Numbers in brackets indicate percentage of each stage of maturity to the total sample.

Location/Year	Stage of Maturity 1	2	3	4	5	6	7	Total
Sapukkait (Random)								
1990	134 (44.5)	75 (24.9)	88 (29.2)	2 (0.7)	1 (0.3)	1 (0.3)	0	301
1991	99 (34.0)	136 (46.7)	53 (18.2)	3 (1.0)	0	0	0	291
1992	105 (42.2)	78 (31.3)	57 (22.9)	8 (3.2)	1 (0.4)	0	0	249
Sapukkait (Commercial)								
1989	5 (0.8)	33 (5.2)	558 (88.7)	31 (4.9)	2 (0.3)	0	0	629
1991	0	114 (30.9)	231 (62.6)	18 (4.9)	6 (1.6)	0	0	369
Sannirarsiq (Commercial)								
1989	2 (0.2)	268 (38.6)	353 (50.8)	52 (7.5)	15 (2.2)	5 (0.7)	0	695
1991	0	39 (14.1)	163 (58.8)	69 (24.9)	6 (2.2)	0	0	277
1992	2 (1.0)	50 (25.4)	101 (51.3)	43 (21.8)	1 (0.5)	0	0	197

Table 18. Average fork length (cm), whole weight (g) and age (years) for female and male Arctic charr from Lake Sapukkait according to state of maturity (3, 4 and 5 [Kesteven 1960]). Samples randomly selected from the 1990-1992 upstream migrations. SEM=Standard error of the mean. Values in brackets indicate range.

Females

	State of Maturity											
	3			4			5			Total*		
Parameter	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
Fork length (cm)	162	51.9 (28.5-66.5)	0.6	10	52.9 (40.1-65.0)	2.7	2	56.9 (49.6-64.2)	7.3	175	51.9 (28.5-66.5)	0.62
Whole weight (g)	161	1719.6 (250-3350)	59.5	10	1507.5 (200-3000)	330.5	2	2550.0 (1800-3300)	750.0	174	1711.4 (200-3350)	59.0
Age (years)	117	8.7 (5-14)	0.2	9	9.4 (7-14)	0.9	2	10.0 (18-12)	2.0	129	8.8 (5-14)	0.2

* Includes 1 female, stage 6 (41.4 cm, 765 g, age 6)

Males

	State of Maturity											
	3			4			5			Total		
Parameter	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
Fork length (cm)	35	62.1 (33.0-75.8)	2.0	3	70.2 (69.5-71.0)	0.4	0	-	-	38	62.7 (33.0-75.8)	1.9
Whole weight (g)	34	2914.7 (400-5150)	224.6	3	3850.0 (3100-4450)	396.9	0	-	-	37	2990.5 (400-5150)	212.1
Age (years)	30	10.2 (5-13)	0.1	2	12.0 (11-13)	1.0	0	-	-	32	10.3 (5-13)	0.4

Table 19. Average fecundity (number of eggs), egg diameter (mm), and gonado-somatic index (%) for Lake Sapukkait Arctic charr according to state of maturity (3, 4 and 5 [Kesteven 1960]). Also includes mean fork length (cm), whole weight (g) and age (years) of charr sampled. SEM=Standard error of the mean. Values in brackets indicate range.

	State of Maturity											
	3			4			5			Total		
Parameter	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
# eggs	-	-	-	20	5298.1 (2218-8122)	369.0	-	-	-	20	5291.1 (2218-8122)	369.0
Egg diameter (mm)	52	1.32 (0.18-3.79)	0.07	28	3.45 (2.19-4.74)	0.15	-	-	-	80	2.07 (0.18-4.74)	0.13
GSI (%)	48	1.06 (0.37-10.51)	0.24	27	9.17 (4.30-15.24)	0.63	-	-	-	75	3.98 (0.37-15.24)	0.53
Fork length (cm)	50	47.59 (39.3-66.8)	0.80	28	60.46 (49.2-67.2)	0.94	-	-	-	78	52.21 (39.3-67.2)	0.93
Whole weight (g)	52	1447.8 (575-4200)	102.3	27	2584.3 (1250-3400)	121.2	-	-	-	79	1836.3 (575-4200)	99.5
Age (years)	38	7.7 (6-16)	0.3	11	9.7 (8-14)	0.6	-	-	-	49	8.1 (6-16)	0.3

Table 20. Average fecundity (number of eggs), egg diameter (mm), and gonado-somatic index (%) for Lake Sannirarsiq Arctic charr according to state of maturity (3, 4 and 5 [Kesteven 1960]). Also includes mean fork length (cm), whole weight (g) and age (years) of charr sampled. SEM=Standard error of the mean. Values in brackets indicate range.

	State of Maturity											
	3			4			5			Total		
Parameter	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
# eggs	1	2326	-	47	5669.4 (2892-10692)	220.9	4	5376.0 (4139-6741)	533.1	52	5582.5 (2326-10692)	212.8
Egg diameter (mm)	1	2.36	-	49	3.65 (3.00-4.51)	0.05	4	4.22 (3.84-4.80)	0.22	54	3.67 (2.36-4.80)	0.06
GSI (%)	1	2.65	-	47	9.92 (5.56-22.6)	0.46	4	13.44 (9.88-19.07)	2.15	52	10.05 (2.65-22.6)	0.48
Fork length (cm)	1	59.2	-	47	61.5 (53.0-69.5)	0.6	4	61.4 (58.3-63.7)	1.2	52	61.5 (53.0-69.5)	0.6
Whole weight (g)	1	2100	-	48	2547.9 (1500-4400)	81.8	4	2475.0 (2300-2700)	103.1	53	2534.0 (1500-4400)	74.8
Age (years)	-	-	-	24	11.21 (9-14)	0.4	2	11.0 (10-12)	1.0	26	11.2 (9-14)	0.34

Table 21. Average fecundity (number of eggs), egg diameter (mm) and gonado-somatic index (%) by length class (cm) for Arctic charr sampled at Lakes Sapukkait and Sannirarsiq. Numbers in brackets indicate range).

Sapukkait

Length class (cm)	Number of eggs			Egg diameter (mm)			GSI (%)		
	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
35.0-39.9	0	-	-	2	1.07 (1.05-1.08)	0.02	2	0.51 (0.46-0.56)	0.05
40.0-44.9	0	-	-	14	1.12 (0.98-1.26)	0.02	14	0.59 (0.37-0.90)	0.05
45.0-49.9	2	2582.5 (2218-2947)	364.5	27	1.39 (1.04-3.60)	0.12	27	1.29 (0.44-9.20)	0.40
50.0-54.9	0	-	-	6	1.73 (0.18-2.81)	0.38	5	3.07 (0.58-8.00)	1.53
55.0-59.9	5	4558.4 (3799-5790)	331.3	9	3.34 (1.71-4.74)	0.34	8	8.89 (4.30-14.50)	1.25
60.0-64.9	13	6004.6 (3223-8655)	448.1	18	2.96 (1.19-4.47)	0.29	18	7.63 (0.84-15.24)	1.10
65.0-69.9	3	6952.0 (6408-8003)	525.6	15	3.09 (1.85-3.87)	0.36	4	9.14 (4.67-11.22)	1.52
Total/Ave.	**23**	**5516.2 (2218-8655)**	**362.6**	**81**	**2.03 (0.18-4.74)**	**0.13**	**78**	**3.90 (0.37-15.24)**	**0.51**

Sannirarsiq

Length class (cm)	Number of eggs			Egg diameter (mm)			GSI (%)		
	N	Mean	SEM	N	Mean	SEM	N	Mean	SEM
50.0-54.9	5	5885.6 (2892-8318)	913.7	5	3.42 (3.02-3.71)	0.15	5	13.54 (7.83-22.6)	3.25
55.0-59.9	10	4242.5 (2326-5542)	285.9	11	3.51 (2.36-4.07)	0.15	10	9.00 (2.65-12.50)	0.87
60.0-64.9	27	5645.6 (3116-8206)	228.3	27	3.75 (3.09-4.80)	0.08	27	9.73 (5.56-19.07)	0.54
65.0-69.9	8	7012.8 (5293-10692)	643.5	9	3.77 (3.00-4.51)	0.13	9	10.52 (7.64-14.97)	0.74
Total/Ave.	**50**	**5607.7 (2326-10692)**	**220.1**	**52**	**3.67 (2.36-4.80)**	**0.06**	**51**	**10.10 (2.65-22.60)**	**0.49**

Table 22. Condition factor (k) values for Arctic charr of various length classes (cm) sampled at the Lake Sapukkait counting fence in the summers of 1987-1992. 'n'= number of samples; SE= standard error of the mean.

Length class	1990 n	1990 K	1990 SE	1991 n	1991 K	1991 SE	1992 n	1992 K	1992 SE
10.0-14.9	1	0.89	–	–	–	–	2	0.84	0.02
15.0-19.9	37	0.99	0.01	45	0.99	0.01	44	1.04	0.05
20.0-24.9	53	1.03	0.01	37	1.03	0.01	23	1.22	0.07
25.0-29.9	37	1.06	0.01	47	1.09	0.01	34	1.16	0.02
30.0-34.9	17	1.07	0.03	34	1.11	0.01	39	1.14	0.03
35.0-39.9	16	1.10	0.04	19	1.09	0.02	30	1.15	0.03
40.0-44.9	35	1.14	0.01	15	1.10	0.02	21	1.15	0.04
45.0-49.9	42	1.21	0.02	35	1.13	0.02	19	1.04	0.07
50.0-54.9	20	1.21	0.02	9	1.09	0.02	13	1.11	0.02
55.0-59.9	11	1.31	0.04	23	1.13	0.02	14	1.06	0.03
60.0-64.9	19	1.22	0.03	16	1.07	0.04	7	1.07	0.03
65.0-69.9	7	1.18	0.06	5	1.10	0.05	6	0.99	0.03
70.0-74.9	4	1.18	0.04	6	1.02	0.06	2	1.18	0.16
75.0-79.9	1	1.18	--	--	--	--	--	--	--
Total/ Average	**300**	**1.11**	**0.01**	**291**	**1.08**	**0.01**	**254**	**1.11**	**0.01**

Table 23. Condition factor (k) values for Arctic charr sampled at Lakes Sapukkait and Sannirarsiq using gillnets in winter and weirs in summer, 1987-1992. 'n'= number of samples; SE= standard error of the mean.

Location/Year	n	K	SE
Winter Gillnet Fishery			
Sannirarsiq			
1987-88 (Research)	277	1.09	0.01
1988-89 (Commercial)	173	1.05	0.01
Sapukkait			
1990 (Research)	105	1.13	0.01
1991 (Research)	87	1.12	0.02
Summer Weir Fishery			
Sannirarsiq			
1989	868	1.19	<0.01
1991	654	1.15	0.01
1992	200	1.11	0.01
Sapukkait			
1989	633	1.15	0.01
1991	386	1.13	0.01

Table 24. History of exploitation of Arctic charr ≥50 cm fork length removed from Lake Sapukkait, 1988-1992. Charr caught in sea during summer are excluded from calculations.

	Summer 1988	Summer 1989	Winter 1989-90	Summer 1990	Winter 1990-91	Summer 1991	Summer 1992	**Total**
A. Total # counted	2218	1793		1134		825	714	**6684**
B. Total number released	2205	1156		942		410	648	**5361**
C. Commercial harvest	0	599		62		386	50	**1097**
D. Subsistence harvest	11	24		0		13	1	**49**
E. Biological sampling[1]	0	0	99	15	86	1	0	**201**
F. Other deaths[2]	2	19		3		2	0	**26**
G. Total removed from population (C+D+E+F)	**13**	**642**	**99**	**80**	**86**	**402**	**51**	**1373**
H. Exploitation rate (%) (G/A)	**0.6**	**35.8**	**8.6[3]**	**7.1**	**9.1[4]**	**48.7**	**7.1**	**—**

[1] Random samples collected in summer research and winter gillnet experimental fishery
[2] Incudes fish killed by weir, and fish found dead up- and down-river of trap.
[3] Total harvest/Total number released in 1989 (B)
[4] Total harvest/Total number released in 1990 (B)

Table 25. History of exploitation of Arctic charr <50 cm fork length removed from Lake Sapukkait, 1988-1992. Charr caught in sea during summer are excluded from calculations.

	Summer 1988	Summer 1989	Winter 1989-90	Summer 1990	Winter 1990-91	Summer 1991	Summer 1992	**Total**
A. Total # counted	2253	2444		2992		3212	3684	**14,585**
B. Total number released	2152	2260		2606		2908	3447	**13,373**
C. Commercial harvest	0	1		0		0	0	**1**
D. Subsistence harvest	1	50		0		32	1	**84**
E. Biological sampling[1]	0	0	9	261	1	237	229	**737**
F. Other deaths[2]	100	179		128		35	8	**450**
G. Total removed from population (C+D+E+F)	**101**	**230**	**9**	**389**	**1**	**304**	**238**	**1272**
H. Exploitation rate (%) (G/A)	**4.5**	**9.4**	**0.4[3]**	**13.0**	**<0.1[4]**	**9.5**	**6.5**	**—**

[1] Random samples collected in summer research and winter gillnet experimental fishery
[2] Incudes fish killed by weir, and fish found dead up- and down-river of trap.
[3] Total harvest/Total number released in 1989 (B)
[4] Total harvest/Total number released in 1990 (B)

Table 26. History of exploitation of all Arctic charr (< and $\geq$ 50 cm fork length) removed from Lake Sapukkait, 1988-1992. Charr caught in sea during summer are excluded from calculations.

	Summer 1988	Summer 1989	Winter 1989-90	Summer 1990	Winter 1990-91	Summer 1991	Summer 1992	**Total**
A. Total # counted	4471	4237		4126		4037	4398	**21,269**
B. Total number released	4357	3416		3548		3318	4095	**18,734**
C. Commercial harvest	0	600		62		386	50	**1098**
D. Subsistence harvest	12	74		0		45	2	**133**
E. Biological sampling[1]	0	0	108	276	87	238	229	**938**
F. Other deaths[2]	102	198		131		37	8	**476**
G. Total removed from population (C+D+E+F)	**114**	**872**	**108**	**469**	**87**	**706**	**289**	**2645**
H. Exploitation rate (%) (G/A)	**2.6**	**20.6**	**3.2**[3]	**11.4**	**2.5**[4]	**17.5**	**6.6**	**—**

[1] Random samples collected in summer research and winter gillnet experimental fishery
[2] Incudes fish killed by weir, and fish found dead up- and down-river of trap.
[3] Total harvest/Total number released in 1989 (B)
[4] Total harvest/Total number released in 1990 (B)

Table 27. History of exploitation of Arctic charr ≥50 cm fork length removed from Lake Sannirarsiq, 1988-1992. Charr caught in sea during summer are excluded from calculations.

	Winter 1987-88	Summer 1988	Winter 1988-89	Summer 1989	Winter 1989-90	Summer 1990	Winter 1990-91	Summer 1991	Summer 1992	**Total**
A. Total # counted Estimated total		1771 8317		7795 8615				3592 5857	1879 4162	**15,037** **26,951**
B. Estimated total <50cm		3611		5255				3514	3028	**15,408**
C. Estimated total ≥50cm		4706		3360				2343	1134	**11,543**
D. Estimated # ≥50cm released		4631		2410				1649	926	**25,024**
E. Commercial harvest[1]	24	0	249	876	0	0	0	661	200	**2010**
F. Subsistence harvest[1]	29	75	51	74	0	10	31	33	8	**311**
G. Biological sampling[2]	305	0	0	0	0	0	0	0	0	**305**
H. Total removed from population (E+F+G)	**358**	**75**	**300**	**950**	**0**	**10**	**31**	**694**	**208**	**2626**
I. Exploitation rate (%) (H/C)	—	**1.6**	**6.5[3]**	**28.3**	**0**	**0.4[4]**	**1.3[4]**	**29.6**	**18.3**	**—**

[1] Fish ≥ 50 cm fork length
[2] Winter gillnet experimental fishery
[3] Total harvest/ Est. Total number >50 cm released in 1988 (C)
[4] Total harvest/Est. Total number >50 cm released in 1989 (C)

Table 28. Instantaneous total mortality (Z), annual mortality (A), annual survival (S), instantaneous fishing mortality (F), and exploitation rate (u) for Lake Sapukkait and Sannirarsiq Arctic charr, 1987-1992.

Sample	Ages	r^2	Z	A	S	F	u_1	u_2	u_3	S'
Sapukkait										
1989 Commercial (weir)	10-13	0.89	0.98	0.78	0.37	0.78	0.54	0.50	0.36	0.44
1990 Winter Research (Gillnet)	10-12	0.98	0.98	0.62	0.38	0.78	0.54	0.50	--	0.30
1990 Random (weir)	4-12	0.83	0.27	0.24	0.76	0.07	0.07	0.06	0.21	0.72
1991 Random (weir)	4-14	0.78	0.36	0.31	0.69	0.16	0.15	0.14	0.17	0.71
1992 Random (weir)	5-10	0.89	0.46	0.37	0.63	0.26	0.23	0.21	0.07	0.60
Sannirarsiq										
1987-88 Winter Research (Gillnet)	10-15	0.98	0.38	0.32	0.68	0.18	0.16	0.15	--	0.61
1988-89 Winter Commercial (Gillnet)	9-11	0.95	0.59	0.45	0.55	0.39	0.32	0.29	--	0.39
1989 Commercial (weir)	10-13	0.89	0.98	0.63	0.37	0.78	0.54	0.50	0.28	0.32
1991 Commercial (weir)	8-14	0.83	0.21	0.19	0.82	0.01	0.01	0.01	0.30	0.71
1992 Commercial (weir)	9-14	0.93	0.55	0.43	0.57	0.35	0.29	0.27	0.18	0.54

Note: Calculations from Ricker (1975)
M=0.20
$u_1=1-e^{-F}$ (Assumes that natural mortality does not occur concurrently with fishing mortality)
$u_2=FA/Z$ (Assumes that natural and fishing mortality occur concurrently)
u_3=Percentage exploitation from total harvest (Tables 17-20)
S'= Survival (Robson and Chapman (1961) method)

Table 29. Predicted total numbers of Arctic charr returning to Lake Sapukkait counting fence, 1988-1992. Estimated recruitment of fish 40-49.9 cm was added to each year's number of fish ≥ 50 cm released from the weir.

Location	1988	1989	1990	1991	1992	1993
Total # charr counted	4503	4356	4146	4092	4403	
≥ 50 cm released	2205	1156	942	410	648	
≥ 50 cm removed from population	13	642	179	488	51	
Estimated recruitment to fishery (45-49.9 cm)	236	306	404	363	311	
Natural Mortality[1]	488	304	290	225	232	
Predicted # charr ≥ 50 cm returning	-----	1953	1086	1098	629	**779**
Actual # charr ≥ 50 cm observed	-----	1793	1134	825	714	?

[1] M=0.2

Table 30. Predicted total numbers of Arctic charr returning to Lake Sannirarsiq counting fence, 1988-1992. Estimated recruitment of fish 40-49.9 cm was added to each year's number of fish ≥ 50 cm released from the weir.

Location	1988	1989	1991	1992	1993
Total # charr estimated	8317	8615	5857	4162	
estimated ≥ 50 cm released	4631	2410	1649	926	
≥ 50 cm removed from population	75	1250	725	208	
Estimated recruitment to fishery (45-49.9 cm)	623	646	439	312	
Natural Mortality[1]	1051	611	418	248	
Predicted # charr ≥ 50 cm returning	-----	4223	2445	1670	**990**
# charr ≥ 50 cm observed (estimated)	-----	3360	2343	1134	?

[1] M=0.2.

ɔle 31. Subsistence harvests of Arctic charr by Inuit of Northern Quebec, 1976-1980. Data from NHR (1980).

Community	1976	1977	1978	1979	1980	Total	Average
Kangiqsualujjuaq	28,972	20,896	17,509	16,461	11,231	95,069	19,014
Kuujjuaq	9,328	10,050	4,329	3,202	4,676	31,585	6,317
Tasiujaq	5,817	4,525	8,775	7,948	4,521	31,586	6,317
Aupaluk	2,371	1,881	2,717	2,685	2,112	11,766	2,353
Kangirsuk	12,961	8,600	9,580	8,770	8,743	48,654	9,731
Quaqtaq	2,357	2,387	678	1,786	1,453	8,661	1,732
Kangiqsujuaq	10,426	8,141	6,340	9,975	15,650	50,532	10,106
Salluit	19,638	7,525	7,792	12,527	17,789	65,271	13,054
Akulivik	21,007	8,267	11,317	14,035	13,361	67,987	13,597
Inukjuaq	19,445	15,284	9,405	13,835	13,287	71,256	14,251
Kuujjuarapik	1,423	1,499	695	334	381	4,332	866
TOTAL	**133,745**	**89,055**	**79,137**	**91,558**	**93,204**	**486,699**	**97,340**

Table 32. F ish species harvested by Inuit from river and lake systems in the Kangiqsualujjuaq area. x=known occurrence of species.

System	Charr	Salmon	L. trout	B. trout	Whitefish	Burbot
George River	x	x	x	x	x	x
Koroc River	x	x	x	x		
Lake Qaarlik	x					
Lake Tasikallak	x					
Lake Akilasaaluk	x			x		
Ijjurittuuq River	x			x		
Lake Napaartuliq	x		x	x		
Lake Sannirarsiq	x		x	x		
Lake Sapukkait	x		x	x		
Uujarasujjulik River	x		x			
Lake Tunullialuk	x		x		x	
Lake Amarurtalik	x		x			

Source: Boivin (1987); this study

Charr=Arctic charr (*Salvelinus alpinus*)
Salmon=Atlantic salmon (*Salmo salar*)
L. trout=Lake trout (*S. namaycush*)
B. trout=Brook trout (*S. fontinalis*)
Whitefish=Lake whitefish (*Coregonus clupeaformis*)
Burbot=*Lota lota*

Table 33. Subsistence harvests (winter and summer combined) of Arctic charr from all locations fished by Kangiqsualujjuamiut in the George River area, 1988-1992.

Location	1988	1989	1990	1991	1992	Total	Average
George R.	3323	2696	2135	1604	971	10,729	2146
Koroc R.	2692	4693	4059	2583	628	14,655	2931
Uujarasujjulik	0	6	20	0	0	26	5
Qaarlik	202	79	145	84	118	628	126
Tasikallak	673	952	1430	1767	1109	5931	1186
Akilasaaluk	30	35	24	5	42	136	27
Napaartulik	0	89	0	29	0	118	24
Sannirarsiq	104	125	10	64	8	311	62
Ijjurittuuq	54	62	24	58	6	204	41
Sapukkait[1]	12	74	0	45	2	133	26
Tunnulialuk	30	40	27	36	0	133	27
Ammarurtalik	0	5	26	0	0	31	6
Tuttutuuq	0	0	7	0	0	7	1
TOTAL	**7120**	**8856**	**7907**	**6274**	**3187[2]**	**33,344**	**6230**

[1] Does not include fish captured during research sampling at this site

[2] Total includes 303 fish captured from other locations

Table 34. Subsistence harvests of Arctic charr from all locations fished by Kangiqsualujjuamiut in the George River area, 1987-1992. Includes both summer and winter catches.

Location	Winter 1987-88	Summer 1988	Winter 1988-89	Summer 1989	Winter 1989-90	Summer 1990	Winter 1990-91	Summer 1991	Winter 1991-92
George R.	643	2680	405	2291	301	1834	25	1579	971
Koroc R.	2564	128	3802	891	4000	59	2415	168	628
Uujarasujjulik	0	0	6	0	20	0	0	0	0
Qaarlik	138	64	54	25	0	145	35	49	118
Tasikallak	673	0	888	64	1430	0	1767	0	1109
Akilasaaluk	30	0	35	0	24	0	0	5	42
Napaartulik	0	0	89	0	0	0	29	0	0
Sannirarsiq	29	75	51	74	0	10	31	33	8
Ijjurittuuq	29	25	0	62	24	0	58	0	6
Sapukkait[1]	0	12	0	74	0	0	0	45	2
Tunnulialuk	20	10	40	0	27	0	36	0	2
Ammarurtalik	0	0	5	0	26	0	0	0	0
Tuttutuuq	0	0	0	0	0	7	0	0	0
2									
TOTAL	**4126**	**2994**	**5375**	**3479**	**5852**	**2055**	**4396**	**1879**	**3189**[2]

[1] Does not include fish captured during research sampling at this site

[2] Total includes 303 fish captured from other locations

Table 35. Commercial quotas for the winter gillnet and summer weir Arctic charr commercial fisheries in the Kangiqsualujjuaq area, 1987-1992.

Location	1987-1988	1988-1989	1989-1990	1990-1991	1991-1992
George R.	300	300	0	0	0
Koroc R.	150	150	0	0	0
Qaarlik	100	100	0	0	0
Tasikallak	200	200	200	200	200
Akilasaaluk	545	545	545	545	545
Napaartulik	425	425	425	425	425
Sannirarsiq	900	900	900	900	200
Ijjurittuq	1250	1250	1000	1000	1000
Sapukkait	770	770	500	450	50
Qijujjujaq	770	770	770	770	770
Allurilik	520	520	520	520	0
Inussulik	770	770	770	770	770
TOTAL	**6700**	**6700**	**5630**	**5430**	**3960**

Table 36. Commercial quotas (1987) & harvests (including rejects and surplus fish) of arctic charr from all locations fished in winter and summer by Kangiqsualujjuamiut , 1987-1992

Location	Original Quota	Harvest 1987-1988	Harvest 1988-1989	Harvest 1989-1990	Harvest 1990-1991	Harvest 1990-1991	Total
George R.	300	0	378	0[1]	0	0	378
Koroc R.	150	170	163	0[1]	0	0	333
Qaarlik	100	118	110	0[1]	0	0	228
Tasikallak	200	241	340	227	120	65	993
Akilasaaluk	545	553	535	305	0	0	1393
Napaartulik	425	0	35	0	35	0	70
Sannirarsiq	900	24	1125[2]	0	661[3]	200[3]	2010
Ijjurittuuq	1250	1029	0	752	0	73	1854
Sapukkait	770	0	600[3]	62	386[3]	50[3]	1098
Qijujjujaq	770	0	0	0	0	0	0
Allurilik	520	0	0	0	0	0	0
Inussulik	770	0	0	0	0	0	0
TOTAL	**6700**	**2135**	**3286**	**1346**	**1202**	**388**	**8357**

1 Quotas for these systems were removed in 1989
2 249 charr in winter fishery 1988-89; 876 charr in summer fishery 1989
3 Summer fishery using weirs (all other data is winter gillnet fishery)

Table 37. Commercial fishing effort (expressed in terms of gillnet-days) for the 1987-88 experimental-commercial winter gillnet fishery for Arctic charr in eastern Ungava.

Location	Total net length(m)/day	# net-days	#Charr	Total Weight(kg)	#Charr/ net-day	Weight (kg)/ net-day
Koroc River	202	21	170	340.3	8.1	16.2
L. Tasikallak	326	7	241	441.0	34.4	63.0
L. Qaarlik	167	9	118	210.2	13.1	23.4
L. Akilasaaluk	186	43	553	1102.3	12.9	25.6
Ijjurituuq R	243	106	1029	2881.9	8.9	27.2
TOTAL/AVE.	225	186	2111	4975.7	11.3	26.8

Table 38. Commercial fishing effort (expressed in terms of gillnet-days) for the 1988-89 experimental-commercial winter gillnet fishery for Arctic charr in eastern Ungava.

Location	Total net length(m)/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 River	110	12.0	163	334.6	13.6	27.9
L. Tasikallak	183	8.0	340	620.7	42.5	77.6
L. Qaarlik	198	13.0	110	194.2	8.5	14.9
L. Akilasaaluk	232	35.5	535	1049.3	15.1	29.6
L. Napaartulik	110	12.0	35	94.0	2.9	7.8
L. Sannirarsiq	199	43.6	249	670.2	5.7	15.4
TOTAL/AVE.	174.7	161.7	1810	3564.3	11.2	22.0

Table 39. Commercial fishing effort (expressed in terms of gillnet-days) for the 1989-90 experimental-commercial winter gillnet fishery for Arctic charr in eastern Ungava.

Location	Total net length(m)/day	# net-days	#Charr	Total Weight(kg)	#Charr/ net-day	Weight (kg)/ net-day
L. Tasikallak	118	17	227	445.6	13.4	26.2
L. Akilasaaluk	113	95	305	596.8	3.2	6.3
Ijjurittuuq R.	104	157	752	1938.1	4.8	12.3
TOTAL/AVE.	112	269	1284	2980.5	4.8	11.1

Table 40. Commercial fishing effort (expressed in terms of gillnet-days) for the 1990-91 experimental-commercial winter gillnet fishery for Arctic charr in eastern Ungava.

Location	Total net length(m)/day	# net-days	#Charr	Total Weight(kg)	#Charr/ net-day	Weight (kg)/ net-day
L. Tasikallak	152	17	120	240.0*	7.1	14.1
L. Napaartulik	91	4*	35	84.2	8.8	21.1
TOTAL/AVE.	122	21	155	324.2	7.4	15.4

*estimation

Table 41. Commercial fishing effort (expressed in terms of gillnet-days) for the 1991-92 experimental-commercial winter gillnet fishery for Arctic charr in eastern Ungava.

Location	Total net length(m)/day	# net-days	#Charr	Total Weight(kg)	#Charr/ net-day	Weight (kg)/ net-day
L. Tasikallak	91	2	65	91.8	32.5	45.9
Ijjurittuuq R.	91	4	73	159.9	18.3	40.0
TOTAL/AVE.	91	6	138	251.7	23.0	42.0

Table 42. Mean fork length (cm) of Arctic charr sampled at commercial fishing locations in the Kangiqsualujjuaq area, 1987-88 to 1991-92. SEM=Standard error of the mean. Values in brackets indicate range of lengths.

Location	1987-1988			1988-1989			1989-1990			1990-1991			1991-1992		
	N	Mean Length	SEM	N	Mean Length	SEM	N	Mean Length	SEM	N	Mean Length	SEM	N	Mean Length	SEM
George R.	-	-	-	321	54.7 (36.5-67.0)	0.3	-	-	-	-	-	-	-	-	-
Koroc R.	170	55.6 (43.0-74.5)	0.5	160	55.7 (42.0-74.0)	0.5	-	-	-	-	-	-	-	-	-
L. Qaarlik	118	54.3 (41.5-66.5)	0.5	110	54.2 (43.0-67.5)	0.5	-	-	-	-	-	-	-	-	-
L. Tasikallak	221	55.0 (31.5-69.0)	0.3	245	55.3 (26.0-72.5)	0.4	220	60.1 (46.3-77.0)	0.4	120	61.4 (22.0-77.0)	1.0	65	50.9 (39.0-68.5)	0.9
L. Akilasaaluk	513	56.7 (31.5-75.0)	0.3	533	58.0 (20.0-76.5)	0.4	304	59.6 (32.0-82.0)	0.5	-	-	-	-	-	-
ijjurittuuq R.	964	63.3 (14.0-80.0)	0.2	-	-	-	751	62.7 (27.0-87.0)	0.3	-	-	-	73	58.9 (49.0-74.8)	0.7
.. Napaartulik	-	-	-	35	59.9 (50.0-77.5)	1.2	-	-	-	35	61.6 (49.0-80.0)	1.4	-	-	-
.. Sannirarsiq	278	61.0 (12.5-77.0)	0.6	173	61.6 (44.0-76.5)	0.5	-	-	-	-	-	-	-	-	-

Table 43. Mean whole weight (g) of Arctic charr sampled at commercial fishing locations in the Kangiqsualujjuaq area, 1987-88 to 1991-92. SEM=Standard error of the mean. Values in brackets indicate range of lengths.

Location	1987-1988 N	1987-1988 Mean Weight	1987-1988 SEM	1988-1989 N	1988-1989 Mean Weight	1988-1989 SEM	1989-1990 N	1989-1990 Mean Weight	1989-1990 SEM	1990-1991 N	1990-1991 Mean Weight	1990-1991 SEM	1991-1992 N	1991-1992 Mean Weight	1991-1992 SEM
George R.	-	-	-	321	1599.5 (500-3450)	23.0	-	-	-	-	-	-	-	-	-
Koroc R.	169	2052.5 (800-5000)	71.1	160	2083.9 (900-5400)	74.1	-	-	-	-	-	-	-	-	-
L. Qaarlik	118	1766.5 (200-3400)	51.1	110	1601.1 (700-2800)	43.7	-	-	-	-	-	-	-	-	-
L. Tasikallak	221	1858.5 (300-4350)	38.1	245	1807.9 (130-3700)	44.5	217	2053.3 (1000-4475)	43.1	-	-	-	65	1412.9 (550-6600)	107.7
L. Akilasaaluk	513	2017.1 (200-4650)	33.1	533	2014.0 (50-4350)	36.7	304	1963.2 (225-4600)	49.7	-	-	-	-	-	-
ijurittuuq R.	964	3078.4 (800-7150)	27.9	-	-	-	704	2626.9 (325-6950)	40.7	-	-	-	73	2190.9 (1125-4600)	82.9
L. Napaartulik	-	-	-	35	2572.9 (1200-5600)	161.1	-	-	-	19	2405.1 (1225-5825)	256.9	-	-	-
L. Sannirarsiq	277	2684.9 (8-5450)	67.1	173	2528.7 (900-4950)	67.4	-	-	-	-	-	-	-	-	-

Table 44. Mean total age (years) of Arctic charr sampled at commercial fishing locations in the Kangiqsualujjuaq area, 1987-88 to 1991-92. SEM=Standard error of the mean. Values in brackets indicate range of ages.

Location	1987-1988			1988-1989			1989-1990			1991-1992		
	N	Mean Age	SEM	N	Mean Age	SEM	N	Mean Age	SEM	N	Mean Age	SEM
George R.	-	-	-	126	8.4 (4-14)	0.2	-	-	-	-	-	-
Koroc R.	142	9.1 (6-14)	0.1	59	8.8 (7-13)	0.2	-	-	-	-	-	-
L. Qaarlik	115	9.8 (6-14)	0.1	62	10.2 (7-13)	0.1	-	-	-	-	-	-
L. Tasikallak	144	10.4 (5-17)	0.1	67	9.8 (8-12)	0.1	99	8.9 (6-14)	0.2	49	7.7 (5-10)	0.2
L. Akilasaaluk	137	9.8 (5-15)	0.1	81	10.0 (7-14)	0.2	106	8.1 (6-12)	0.1	-	-	-
Ijjurittuuq R.	146	11.1 (8-19)	0.2	-	-	-	101	9.6 (6-13)	0.2	40	8.7 (7-13)	0.2
L. Napaartulik	-	-	-	21	10.2 (7-14)	0.4	-	-	-	-	-	-
L. Sannirarsiq	273	11.0 (4-18)	0.1	106	10.0 (7-14)	0.1	-	-	-	-	-	-

Table 45 . Length (cm) at age (years) data (both sexes combined) for Arctic charr sampled during the 1987-1992 winter commercial fishery in eastern Ungava Bay.

Age	George River	Koroc River	Lake Tasikallak	Lake Qaarlik	Lake Akilasaaluk	Ijjurittuuq River	Lake Napaartulik
0							
1							
2							
3							
4	53.5						
5	58.0		38.8				
6	53.2	51.0	48.2	41.5	52.7	46.5	
7	52.6	47.7	51.0	44.0	54.3	54.4	50.0
8	56.0	53.5	54.6	51.1	56.8	56.1	50.0
9	56.3	55.8	56.2	54.2	57.7	60.0	58.3
10	55.4	59.0	57.5	54.7	59.8	64.1	62.8
11	59.6	65.4	58.4	56.1	61.7	66.7	64.7
12	57.3	64.9	56.3	56.4	64.5	67.8	58.8
13		69.3	57.4	59.9	60.8	69.8	
14	66.5	67.0	60.5	57.5	68.0	63.9	64.5
15			54.5		59.5	66.0	
16							
17							
18						65.0	
19						75.0	
N	105	185	337	169	300	280	19

Table 46 . Length (cm) at age (years) data (both sexes combined) calculated using the von Bertalanffy model for various populations of Arctic charr in eastern Ungava Bay.

Age	George River 1988-89	Koroc River 1987-89	Lake Tasikallak 1987-1992	Lake Qaarlik 1987-1989	Lake Akilasaaluk 1988-1990	Ijjurittuuq River (1988-1992)	Lake Sannirarsiq (winter) 1987-88
3	33.8	17.9	30.9	23.7	32.0	28.2	24.1
4	39.9	23.1	37.3	29.4	38.7	35.1	30.6
5	44.5	28.0	42.4	34.3	44.2	41.1	36.3
6	47.9	32.6	46.5	38.5	48.5	46.2	41.5
7	50.4	36.9	49.7	42.0	52.0	50.6	46.1
8	52.3	40.9	52.2	45.0	54.8	54.4	50.2
9	53.8	44.6	54.3	47.6	57.0	57.6	54.0
10	54.8	48.1	55.9	49.8	58.9	60.5	57.3
11	55.6	51.4	57.1	51.7	60.3	62.9	60.3
12	56.2	54.4	58.2	53.3	61.5	65.0	62.9
13	56.7	57.3	59.0	54.7	62.4	66.8	65.3
14	57.0	60.0	59.6	55.9	63.1	68.3	67.5
15	57.2	62.5	60.1	56.9	63.7	69.6	69.4
16	57.4	64.8	60.5	57.7	64.2	70.8	71.1
17	57.5	67.0	60.8	58.4	64.6	71.7	72.6
18	57.7	69.1	61.1	59.1	64.9	72.6	74.0
19	57.7	71.0	61.3	59.6	65.2	73.3	75.2
20	58.8	72.8	61.5	60.0	65.4	73.9	76.4
N	105	185	337	169	300	280	358

Table 47. Length-weight relationships for Arctic charr sampled from various locations during the 1987-1992 winter commercial fishery. Results presented follow the equation *logW=loga + blogL*, where *a* is the intercept on the y-axis, *b* is the regression coefficient or slope of the regression line. 'n'=sample size

	a	b	n	r^2	p
George River					
1988-1989	-1.013	2.421	321	0.69	0.0001
Koroc River					
1987-1988	-2.325	3.214	169	0.88	0.0001
1988-1989	-2.225	3.161	160	0.89	0.0001
Combined data	-2.279	3.190	329	0.89	0.0001
Lake Tasikallak					
1987-1988	-2.094	3.073	221	0.86	0.0001
1988-1989	-2.025	3.016	245	0.79	0.0001
1989-1990	-1.845	2.888	197	0.73	0.0001
1991-1992	-1.763	2.856	65	0.79	0.0001
Combined data	-1.722	2.840	728	0.79	0.0001
Lake Qaarlik					
1987-1988	-2.079	3.059	118	0.62	0.0001
1988-1989	-1.120	2.486	110	0.72	0.0001
Combined data	-1.590	2.768	228	0.64	0.0001
Lake Akilasaaluk					
1987-1988	-2.007	3.017	513	0.79	0.0001
1988-1989	-2.151	3.077	533	0.93	0.0001
1989-1990	-1.454	2.658	286	0.80	0.0001
Combined data	-1.840	2.902	1332	0.84	0.0001
Ijjurittuuq River					
1987-1988	-1.176	2.549	964	0.79	0.0001
1989-1990	-1.957	2.969	701	0.91	0.0001
1991-1992	-2.002	3.010	73	0.92	0.0001
Combined data	-1.645	2.822	1738	0.81	0.0001
Lake Napaartulik					
1988-1989	-1.329	2.656	35	0.72	0.0001
1990-1991	-1.904	2.954	19	0.93	0.0001
Combined data	-1.577	2.787	54	0.80	0.0001

Table 48. Sex ratios for Arctic charr sampled at various locations during the experimental-commercial winter fishery, 1987-1992. Numbers in brackets indicate percentage of total.

Location/Year	Males	Females	Total
George River			
1988-89	117	197	314
Total	**117**	**197**	**314**
	(37.3)	**(62.7)**	
Koroc River			
1987-88	88	80	168
1988-89	66	40	106
Total	**154**	**120**	**274**
	(56.2)	**(43.8)**	
Lake Qaarliik			
1987-88	80	38	118
1988-89	66	42	108
Total	**146**	**80**	**226**
	(64.6)	**(35.4)**	
Lake Tasikallak			
1987-88	176	62	238
1988-89	156	71	227
1990-91	66	54	120
1991-92	41	24	65
Total	**438**	**211**	**649**
	(67.5)	**(32.5)**	
Lake Akilasaaluk			
1987-88	255	295	550
1988-89	254	273	527
Total	**509**	**568**	**1077**
	(47.3)	**(52.7)**	
Ijjurittuuq River			
1987-88	686	343	1029
1989-90	376	330	706
1991-92	60	13	73
Total	**1122**	**686**	**1808**
	(62.1)	**(37.9)**	
Lake Napaartulik			
1987-88	16	16	32
1988-89	13	22	35
Total	**29**	**38**	**67**
	(43.3)	**(56.7)**	
GRAND TOTAL	**2515**	**1900**	**4515**
	(57.0)	**(43.0)**	

Table 49. Comparison of Arctic charr state of maturity (non-reproductive or spent) and external coloration (silver or red) for fish sampled at various locations during the experimental-commercial winter fishery, 1987-1988. Numbers in brackets indicate percentage of total.

Location	State of maturity		Colour	
	Non-reproductive	Spent	Silver	Red
Koroc R.	123 (76.9)	37 (23.1)	121 (75.6)	39 (24.4)
L. Qaarlik	58 (86.6)	9 (13.4)	58 (86.6)	9 (13.4)
L. Tasikallak	9 (40.9)	13 (59.1)	9 (40.9)	13 (59.1)
L. Akilasaaluk	38 (88.4)	5 (11.6)	35 (81.4)	8 (18.6)
Ijjurittuuq R.	527 (79.5)	136 (20.5)	532 (80.5)	129 (19.5)
L. Sannirarsiq	212 (78.2)	59 (21.8)	220 (81.2)	51 (18.8)
TOTAL	**967 (78.9)**	**259 (21.1)**	**975 (79.7)**	**249 (20.3)**

Table 50. Mean fork length (cm) and total age (years) of spent (as determined by external coloration) male and female Arctic charr sampled at commercial fishing locations in the Kangiqsualujjuaq area between 1987-1992. SEM=Standard error of the mean. Values in brackets indicate range of values.

	Males						Females					
Location	N	Mean Length	SEM	N	Mean Age	SEM	N	Mean Length	SEM	N	Mean Age	SEM
George R.	35	59.8 (52.5-66.5)	0.6	16	9.0 (7-14)	0.4	76	54.5 (42.5-64.0)	0.4	26	9.2 (4-12)	0.4
Koroc R.	22	56.8 (45.0-74.5)	1.7	10	8.8 (7-10)	0.3	31	55.4 (44.5-70.5)	0.9	19	9.7 (8-14)	0.3
L. Qaarlik	27	57.8 (50.0-67.0)	0.6	20	10.3 (8-14)	0.3	13	53.1 (43.0-59.0)	1.3	5	11.2 (10-12)	0.4
L. Tasikallak	98	59.1 (42.8-76.0)	0.8	34	10.8 (7-15)	0.3	25	55.8 (41.5-67.0)	0.9	8	10.3 (8-13)	0.6
L. Akilasaaluk	52	60.3 (37.0-72.0)	1.1	13	10.2 (8-12)	0.3	57	55.7 (46.0-65.5)	0.6	11	10.5 (9-13)	0.3
Ijjurittuuq R.	217	66.5 (45.0-79.6)	0.5	34	11.1 (8-15)	0.3	63	62.0 (50.0-75.0)	0.7	18	10.2 (7-14)	0.4
L. Napaartulik	1	75.0	-	-	-	-	-	-	-	-	-	-
L. Sannirarsiq	34	69.5 (58.0-76.5)	0.7	34	11.8 (10-15)	0.2	17	55.7 (51.0-61.0)	0.7	16	10.7 (10-13)	0.3
TOTAL	**486**	**63.1 (37.0-79.6)**	**0.4**	**161**	**10.7 (7-15)**	**0.1**	**282**	**56.6 (41.5-75.0)**	**3.2**	**103**	**10.0 (4-12)**	**0.2**

Table 51. Condition factor (k) values for Arctic charr sampled during the experimental-commercial winter fishery, 1987-1992. 'n'= number of samples; SE= standard error of the mean.

Location/Year	n	K	SE
George River			
1988-89	321	0.97	0.01
Koroc River			
1987-88	169	1.13	0.01
1988-89	160	1.15	0.01
Lake Tasikallak			
1987-88	221	1.09	0.01
1988-89	245	1.03	0.01
1989-90	197	0.91	0.01
1991-92	65	1.00	0.03
Lake Qaarlik			
1987-88	118	1.08	0.01
1988-89	110	0.99	0.01
Lake Akilasaaluk			
1987-88	513	1.06	0.01
1988-89	533	0.97	0.01
1989-90	286	0.88	0.01
Ijjurittuuq River			
1987-88	964	1.19	0.01
1989-90	701	0.98	<0.01
1991-92	73	1.03	0.01
Lake Napaartulik			
1988-89	35	1.17	0.04
1990-91	19	1.04	0.03

Table 52. Instantaneous total mortality (Z), annual mortality (A), annual survival (S), instantaneous fishing mortality (F), and exploitation rate (u) for Arctic charr sampled during the experimental-commercial winter fishery, 1987-1992.

Sample	Ages	r^2	Z	A	S	F	u_1	u_2
George River								
1988-89	7-12	0.83	0.45	0.36	0.64	0.25	0.22	0.20
Koroc River								
1987-88	9-12	0.99	0.77	0.54	0.46	0.57	0.44	0.40
1988-89	8-11	0.91	0.70	0.50	0.50	0.50	0.39	0.36
Lake Tasikallak								
1987-88	10-13	0.98	0.68	0.49	0.51	0.48	0.38	0.35
1988-89	10-12	0.85	0.94	0.61	0.39	0.74	0.53	0.48
1989-90	9-11	0.98	0.40	0.33	0.67	0.20	0.18	0.16
1991-92	8-10	0.99	0.90	0.59	0.41	0.70	0.50	0.46
Lake Qaarlk								
1987-88	10-13	0.99	0.84	0.57	0.43	0.64	0.47	0.43
1988-89	10-12	0.93	0.72	0.51	0.49	0.52	0.41	0.37
Lake Akilasaaluk								
1987-88	9-13	0.89	0.52	0.40	0.60	0.32	0.27	0.25
1988-89	10-12	0.99	0.70	0.50	0.50	0.50	0.39	0.37
1989-90	9-11	0.97	0.65	0.48	0.52	0.45	0.37	0.33
Ijjurittuuq River								
1987-88	10-15	0.95	0.46	0.37	0.63	0.26	0.23	0.20
1989-90	10-13	0.99	0.76	0.53	0.47	0.56	0.43	0.39
1991-92	8-10	0.37	1.01	0.64	0.36	0.81	0.56	0.51

Note: Calculations from Ricker (1975)
M=0.20
$u_1=1-e^{-F}$ (Assumes that natural mortality does not occur concurrently with fishing mortality)
$u_2=FA/Z$ (Assumes that natural and fishing mortality occur concurrently)

Table 53. Total numbers of upstream migrant Arctic charr counted at the Lakes Sapukkait and Sannirarsiq counting fences, 1988-1992, and comparative upstream counts from other charr studies.

Study	Year 1	Year 2	Year 3	Year 4	Year 5
Lake Sapukkait (1988-1992)	4503	4356	4146	4092	4403
Lake Sannirarsiq (1988-1992)	1771*	7795	------	3592*	1879*
L. Iqalukkait, N.Que.[1] (1989)	1379*	------	------	------	------
Ivitaarquit R., N.Que.[2] (1990)	220*	------	------	------	------
Fraser R., Labrador[3] (1975-1979)	3952	2348	2334	-----	6403
Nauyuk Lake, NWT[4] (1974-1978)	10,952	10,755	7701	6246	3517
Nauyuk Lake· NWT[4] (1984 & 1988)	3012	2356	-----	-----	-----
Jayco River, NWT[5] (1980-81)	33,388	138,795	-----	-----	-----
Freshwater Creek, NWT[6] (1982, 88, & 91)	9961	-----	36,933	-----	39,559

* incomplete counts

Data Sources:

[1]Olpinski (1990)
[2]Roy and Bernard (1991)
[3]Dempson and Green (1985)
[4]Johnson (1989)
[5]Kristofferson et al. (1986); McGowan (1990)
[6]McGowan and Low (1992)

Table 54 . Length (cm) at age (years) data (both sexes combined) for various populations of Arctic charr from Northern Quebec, as well as comparative data from other Canadian stocks .

Age	George River 1967(a)	George River(b)	Koroc River (juveniles)(c)	Koroc River(b)	Lake Tasikallak(b)	Lake Qaarlik(b)	Lake Akilasaaluk(b)	Ijjurittuuq River(b)	Lake Napaartulik(b)	Lake Sannirarsiq(b)	Lake Sapukkait(b)	L. Iqalukkait, N. Que.(d)	Richmond Gulf, N. Que.(e)	Fraser R., Labrador(f)	Nauyuk R., NWT(g)	Sylvia Grinnell R., NWT(h)
0			3.9								3.8		4.2	3.9		
1			7.7								6.6		8.8	6.5		1.4
2			10.1								13.6			9.0		2.5
3			11.4								17.8			12.5		5.0
4		53.5	10.0							23.2	21.8	13.3		16.0		8.0
5		58.0			38.8					41.1	27.8	15.9		22.8	47.2	11.6
6		53.2		51.0	48.2	41.5	52.7	46.5		52.7	36.3	26.4	34.1	33.1	46.1	15.4
7	47.3	52.6		47.7	51.0	44.0	54.3	54.4	50.0	54.0	45.6	27.9	40.0	40.2	52.7	19.6
8	49.9	56.0		53.5	54.6	51.1	56.8	56.1	50.0	55.4	51.4	41.1	43.6	43.5	55.2	24.0
9	51.2	56.3		55.8	56.2	54.2	57.7	60.0	58.3	57.6	58.7	46.9	47.4	49.1	57.5	28.5
10	54.1	55.4		59.0	57.5	54.7	59.8	64.1	62.8	60.4	62.0	48.3	57.5	50.2	61.1	33.5
11	57.9	59.6		65.4	58.4	56.1	61.7	66.7	64.7	63.2	63.5	50.9	62.3	54.3	65.4	38.2
12	61.3	57.3		64.9	56.3	56.4	64.5	67.8	58.8	63.6	65.3	68.5	61.9	54.0	68.5	42.7
13	65.2			69.3	57.4	59.9	60.8	69.8		66.8	66.3	62.5	67.5	58.0	71.7	46.8
14	65.0	66.5		67.0	60.5	57.5	68.0	63.9	64.5	62.9	66.3		68.7	55.9	69.3	50.3
15	73.8				54.5		59.5	66.0		73.5	74.9		70.8	60.8	69.0	35.3
16											62.0		72.8	52.8	69.2	56.3
17										66.6	70.4			50.1	66.1	58.6
18								65.0		75.5				53.2		60.4
19								75.0								62.3
N	237	105	155	185	337	169	300	280	19	691	1854	132	534	1130	619	680

Data sources:

a) LeJeune (1967)
b) This study
c) Stenzel and Power (1990)
d) Olpinski (1991)
e) Boivin and Power (1985)
f) Dempson and Green (1985)
g) Gyselman and Broughton (1991)
h) Grainger (1953)

FIGURES

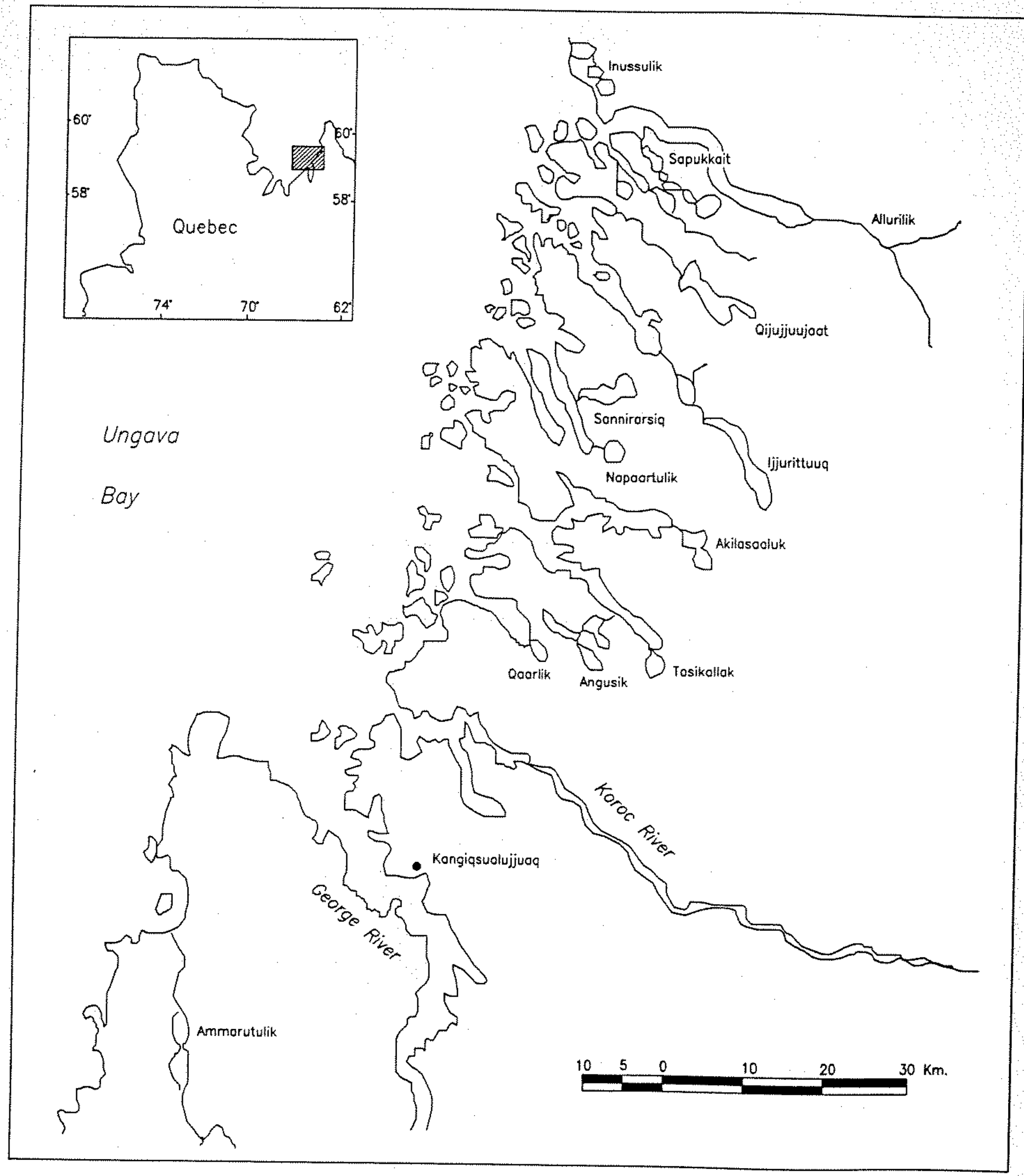


FIGURE 1: Arctic Charr Fishing Locations in the Kangiqsualujjuaq Area.

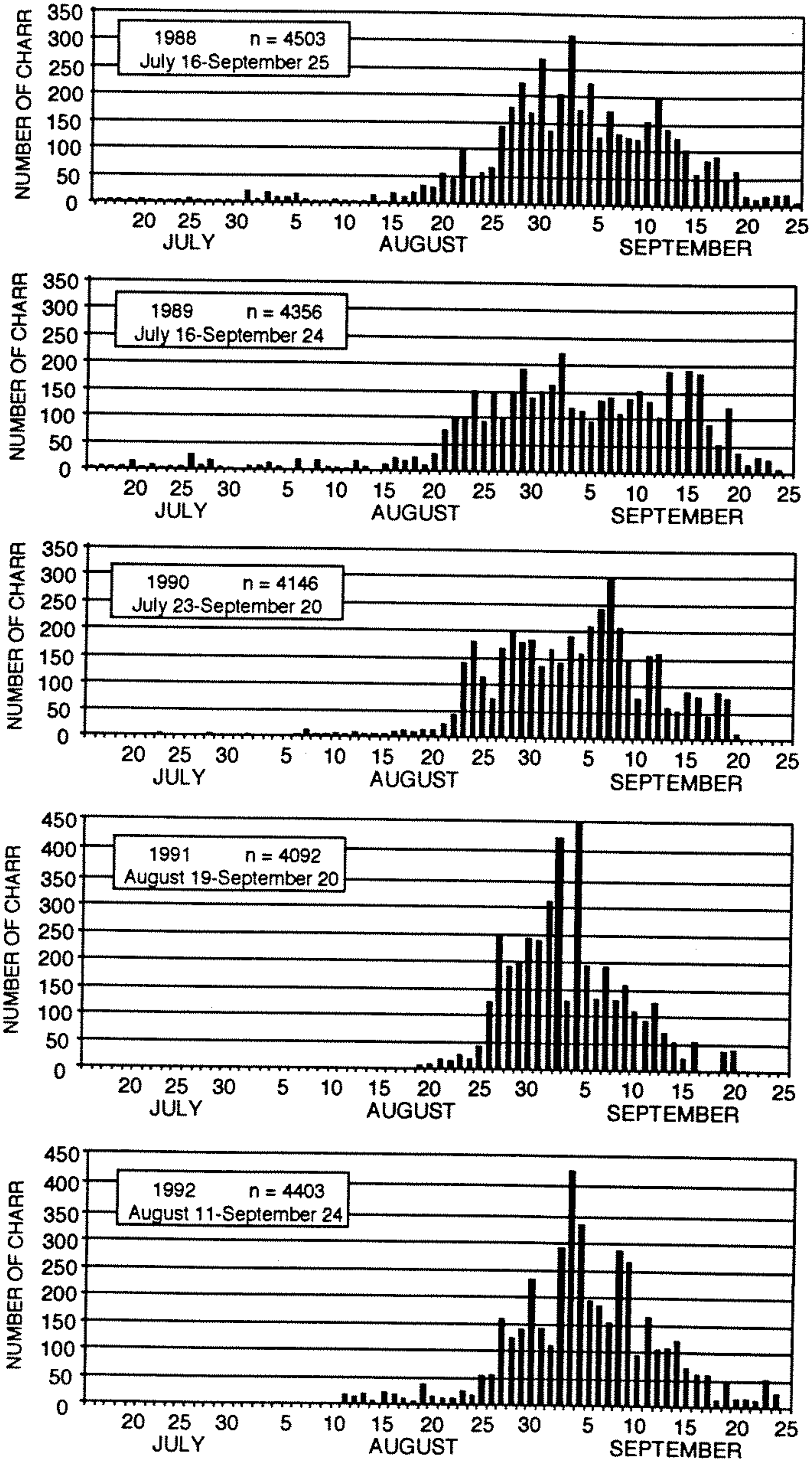


Figure 2. Daily counts of upstream migrant Arctic charr at the Sapukkait counting fence, 1988-1992. 'n' represents the total number of upstream migrants.

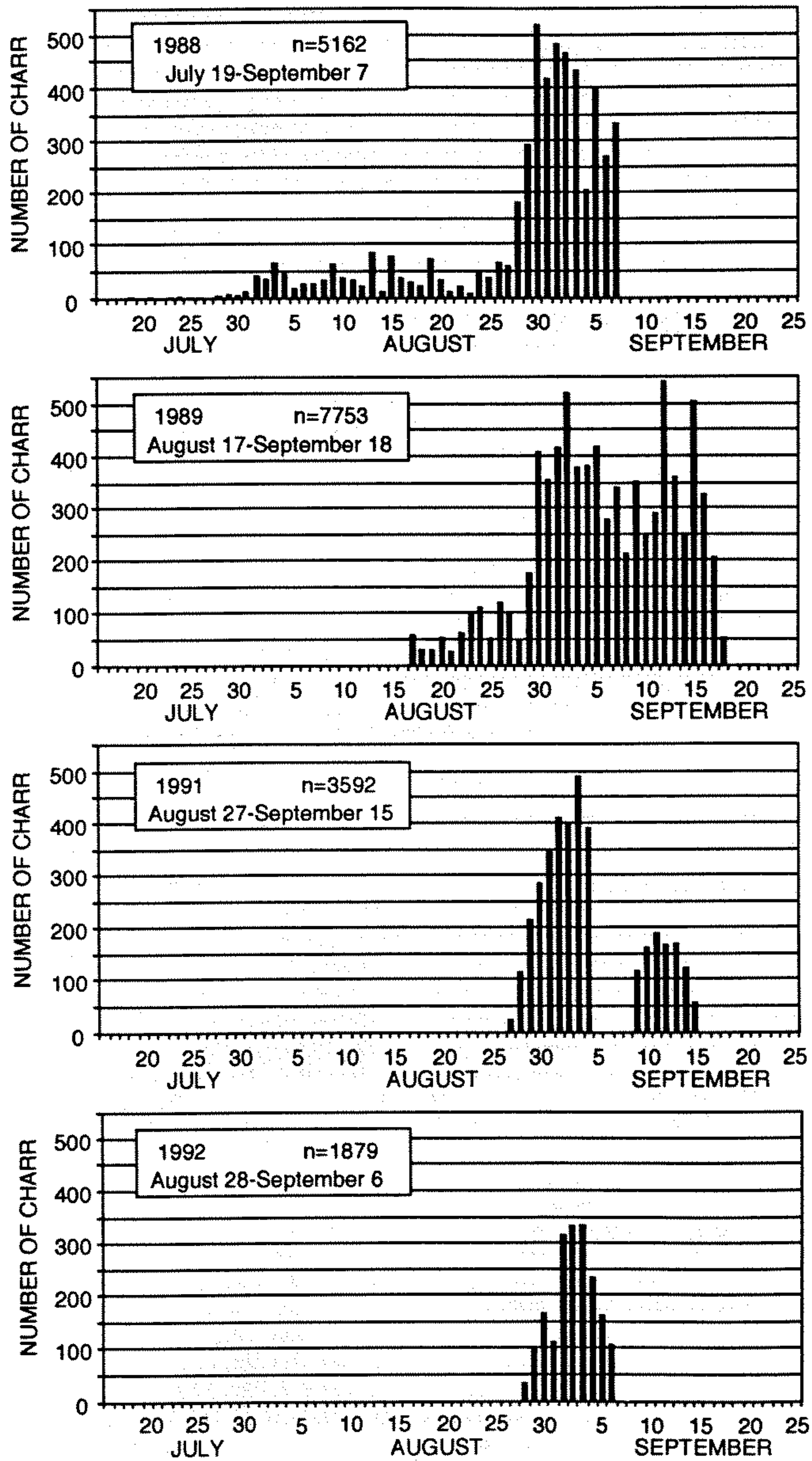


Figure 3. Daily counts of Arctic charr at the Sannirarsiq counting fence, 1988, 1989, 1991 and 1992.

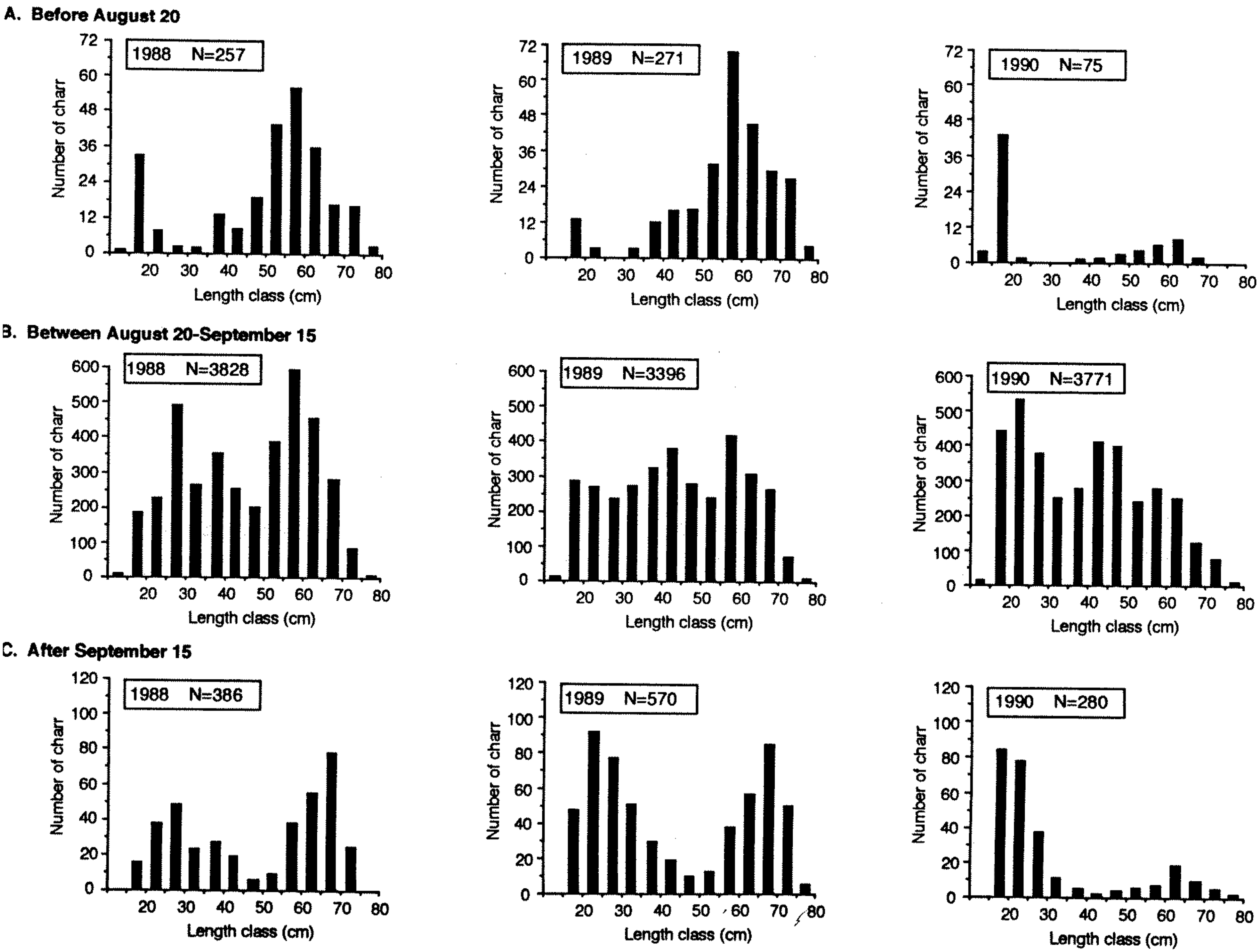


Figure 4. Length-frequency distributions of Lake Sapukkait Arctic charr sampled at the weir A) before, B) during and C) after the peak of the 1988-1990 upstream migrations.

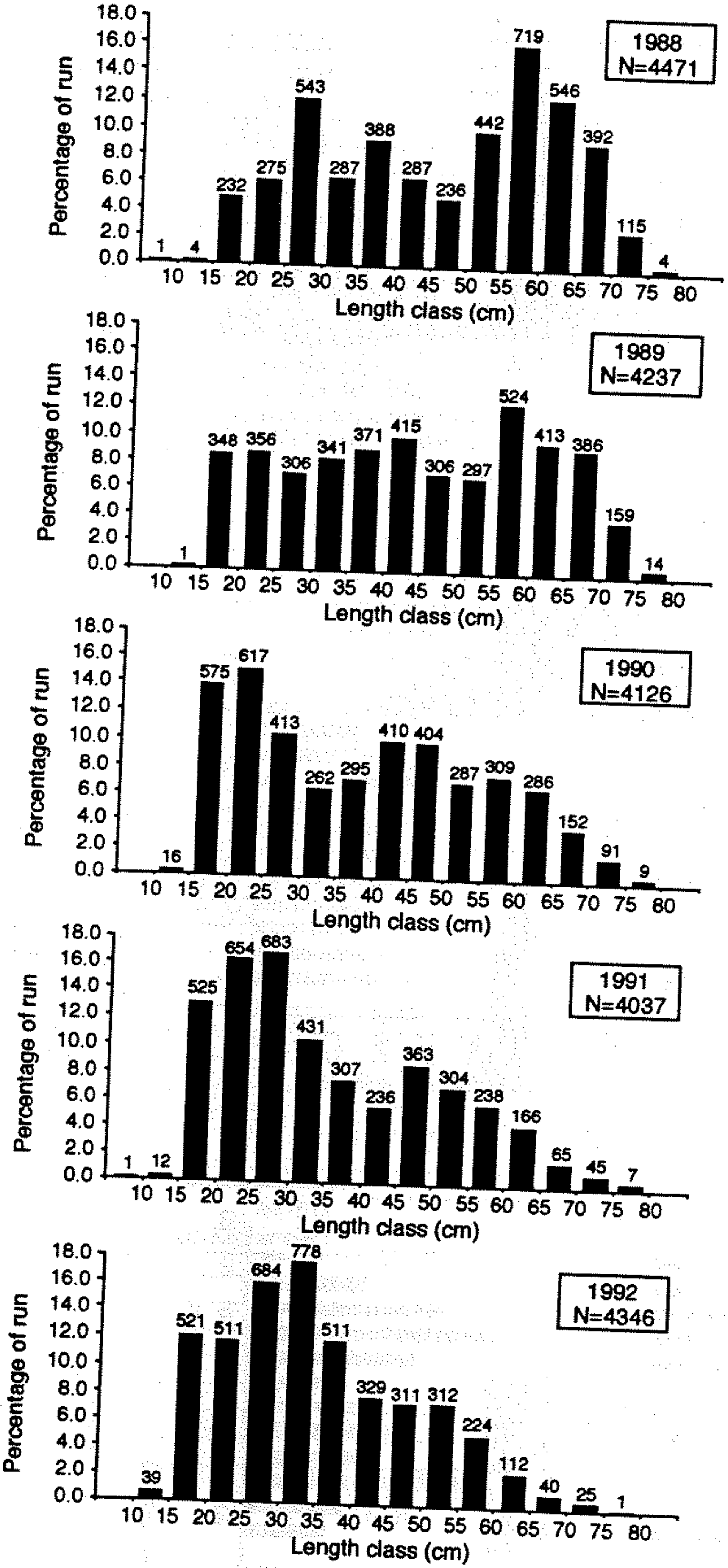


Figure 5. Length-frequency distribution (percentage of each length class (cm) in annual run) of arctic charr migrating upriver at Sapukkait, 1988-1992. Numbers on vertical bars indicate numbers of charr sampled per length class. N=total number of charr sampled.

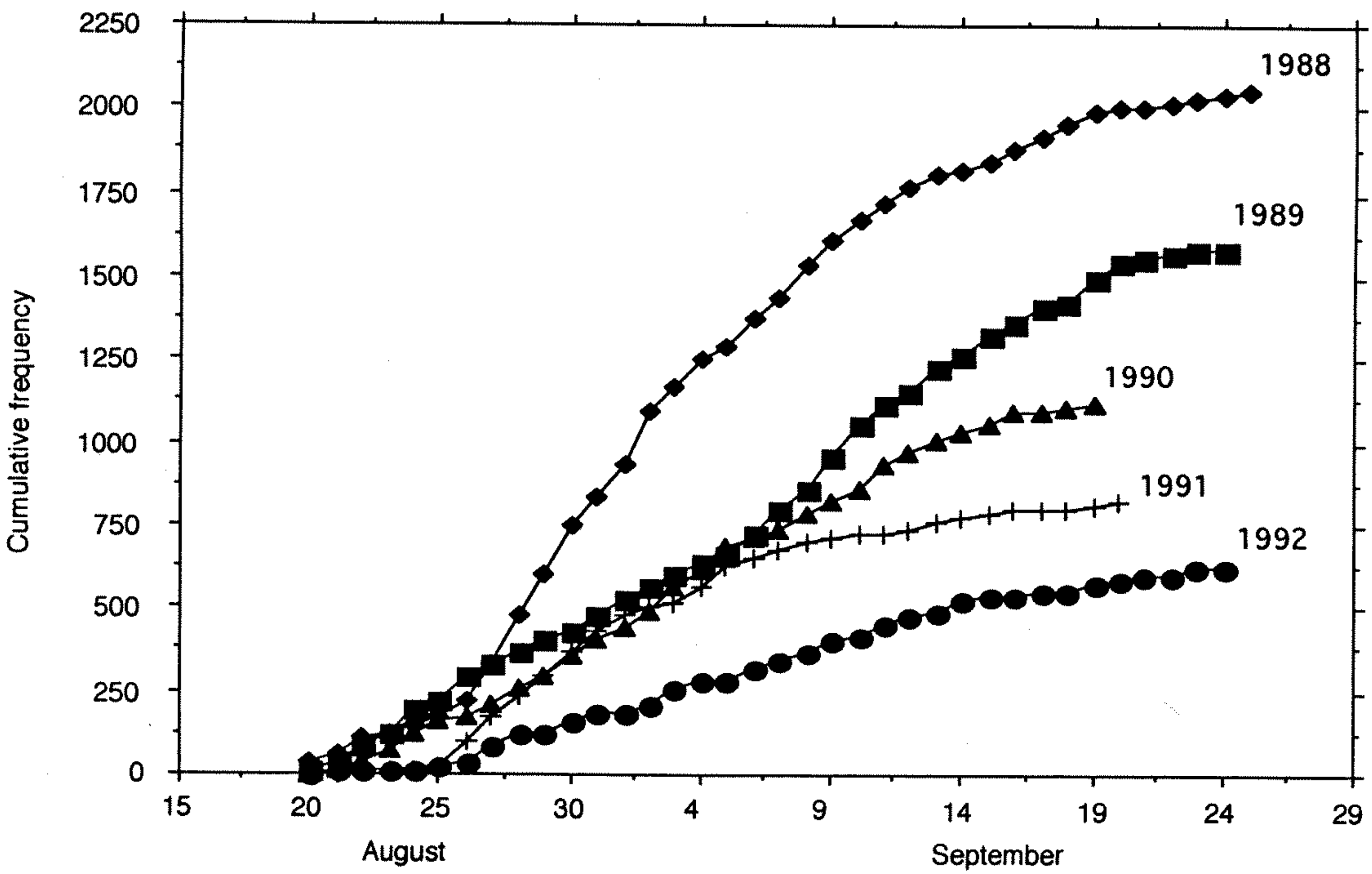


Figure 6. Cumulative frequency of Arctic charr ≥50 cm counted at the Sapukkait weir 1988-1992.

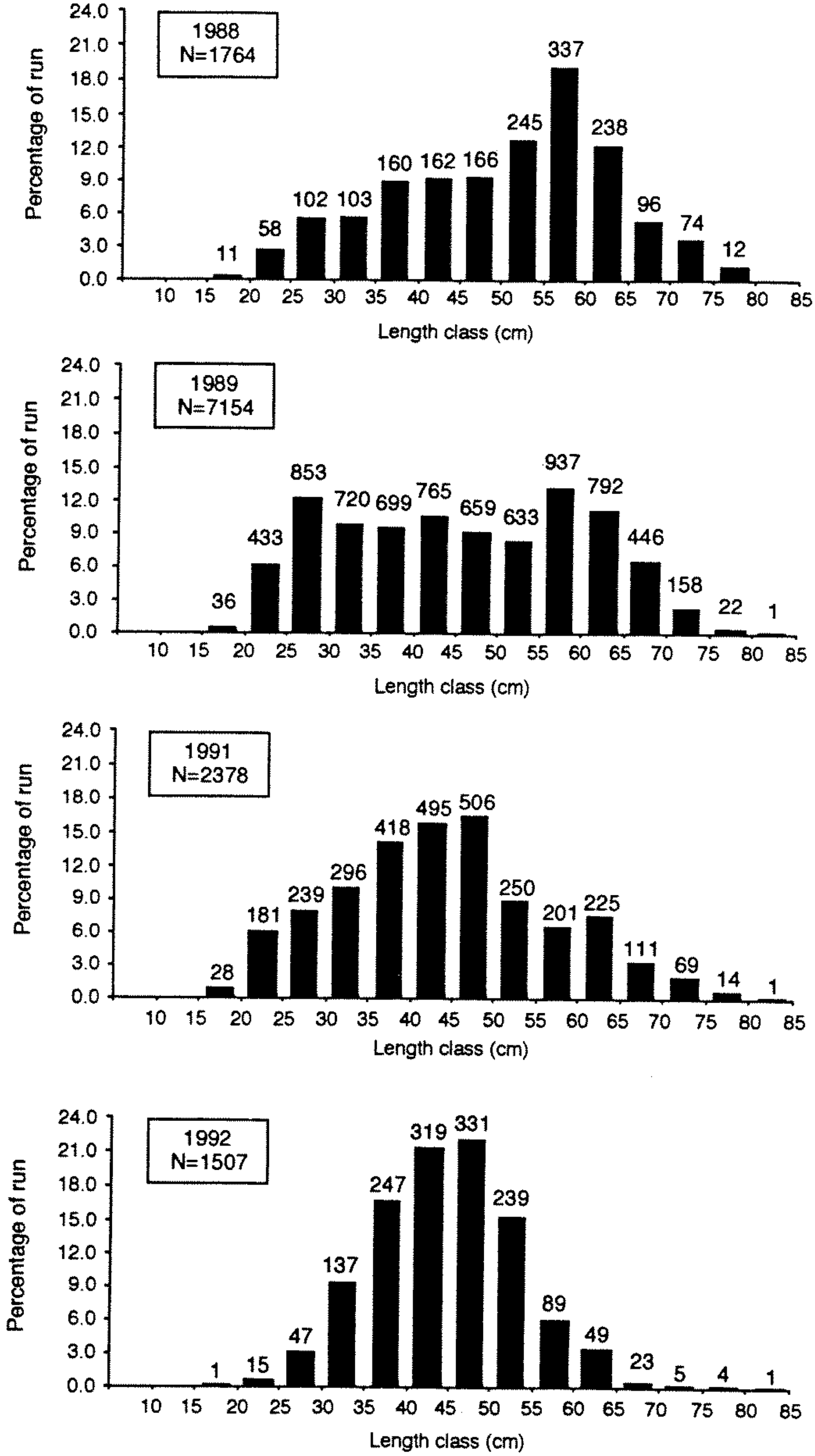


Figure 7. Length-frequency distribution of Arctic charr migrating upriver at Sannirarsiq, 1988, 1989, 1991 and 1992.

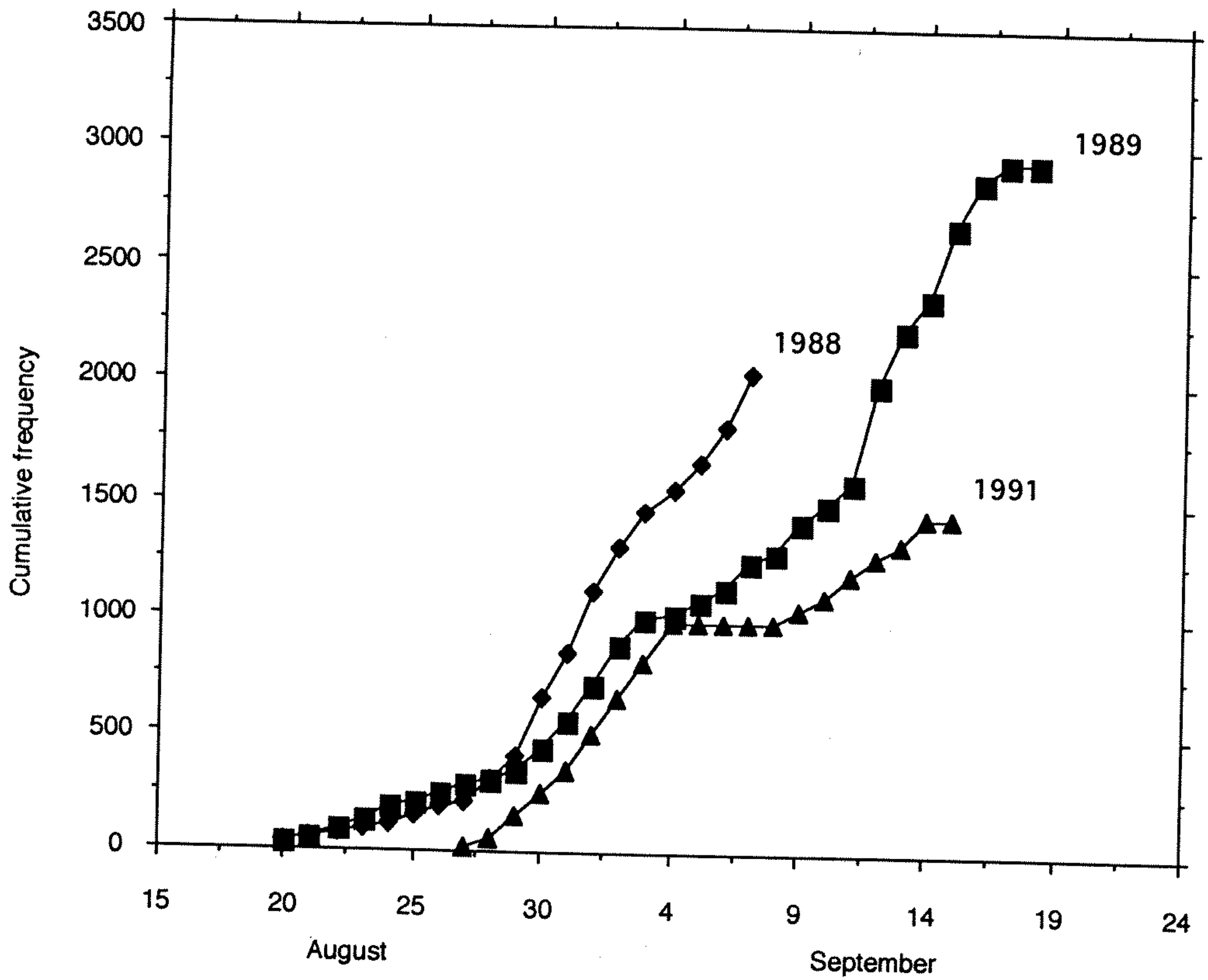


Figure 8. Cumulative frequency of Arctic charr ≥50 cm counted at the Sannirarsiq weir 1988, 1989 and 1991.

Lake Sapukkait

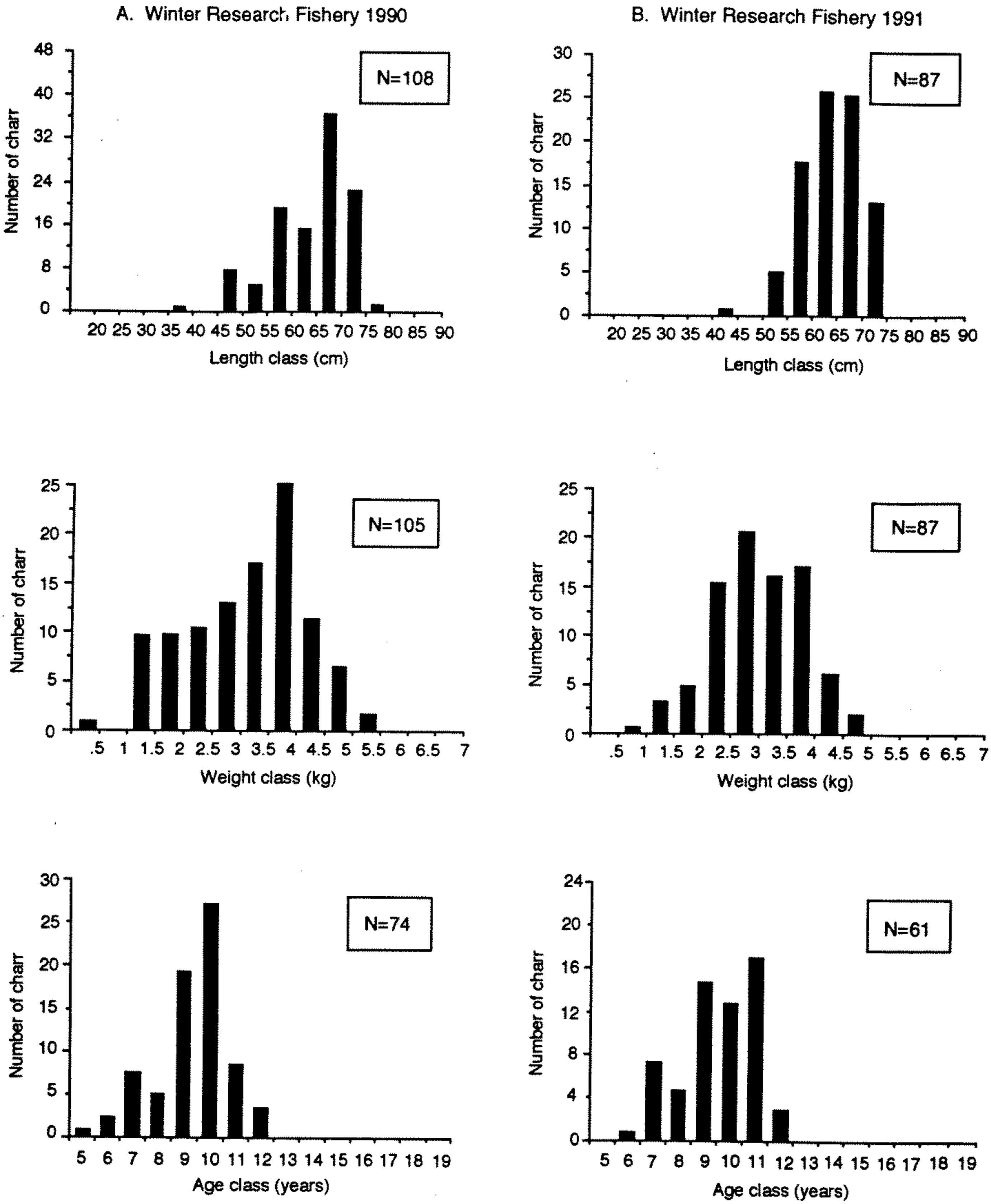


Figure 9. Length-, weight- and age-frequency distributions of Lake Sapukkait Arctic charr sampled during the 1990 and 1991 winter gillnet research fisheries.

Lake Sannirarsiq

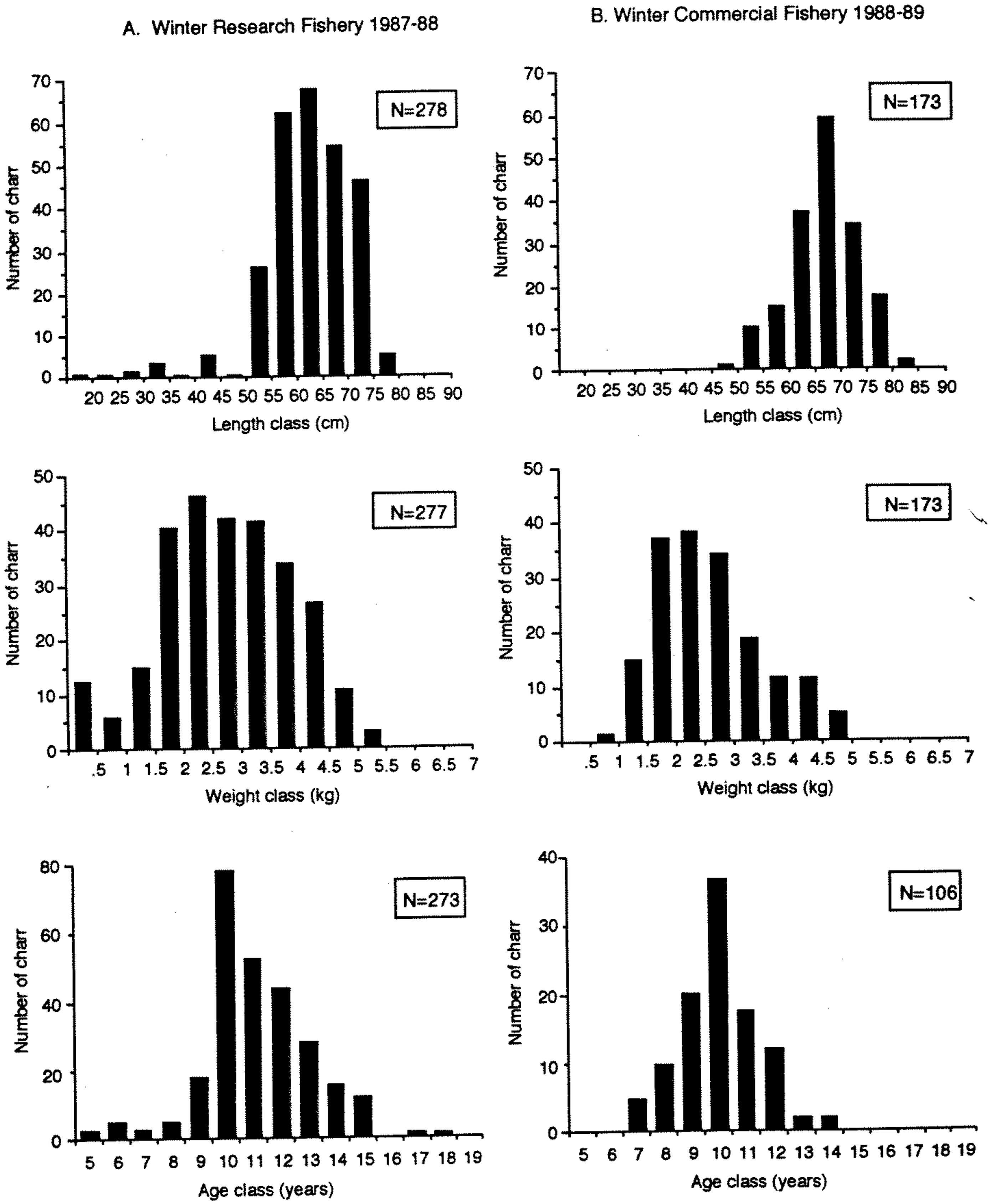


Figure 10. Length-, weight- and age-frequency distributions of Arctic charr sampled at Lake Sannirarsiq in the winter gillnet research fishery in 1987-88 and during the experimental-commercial winter fishery in 1989.

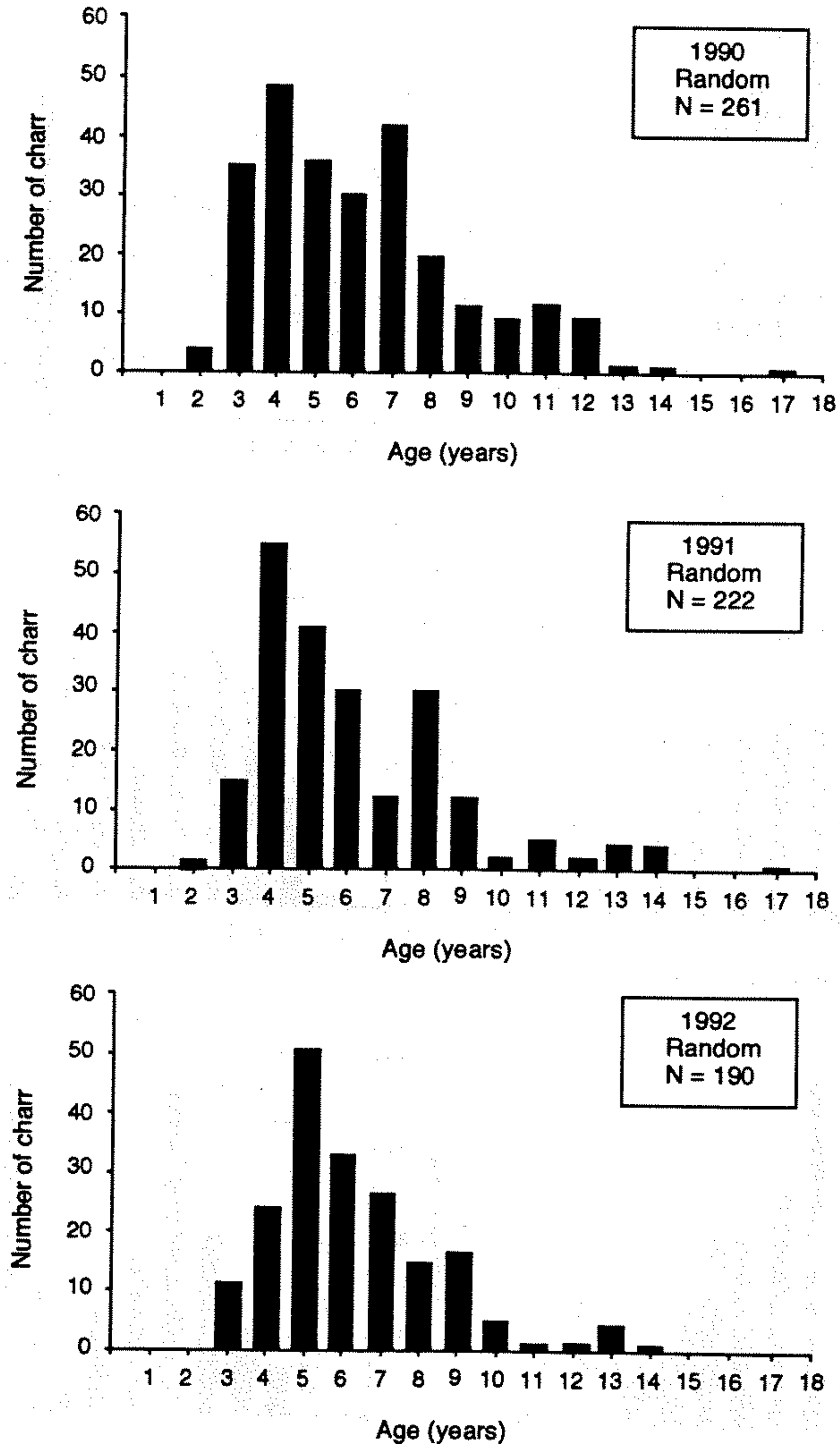


Figure 11. Age-frequency distributions of Arctic charr randomly sampled from the upstream migration at Lake Sapukkait, 1990-92.

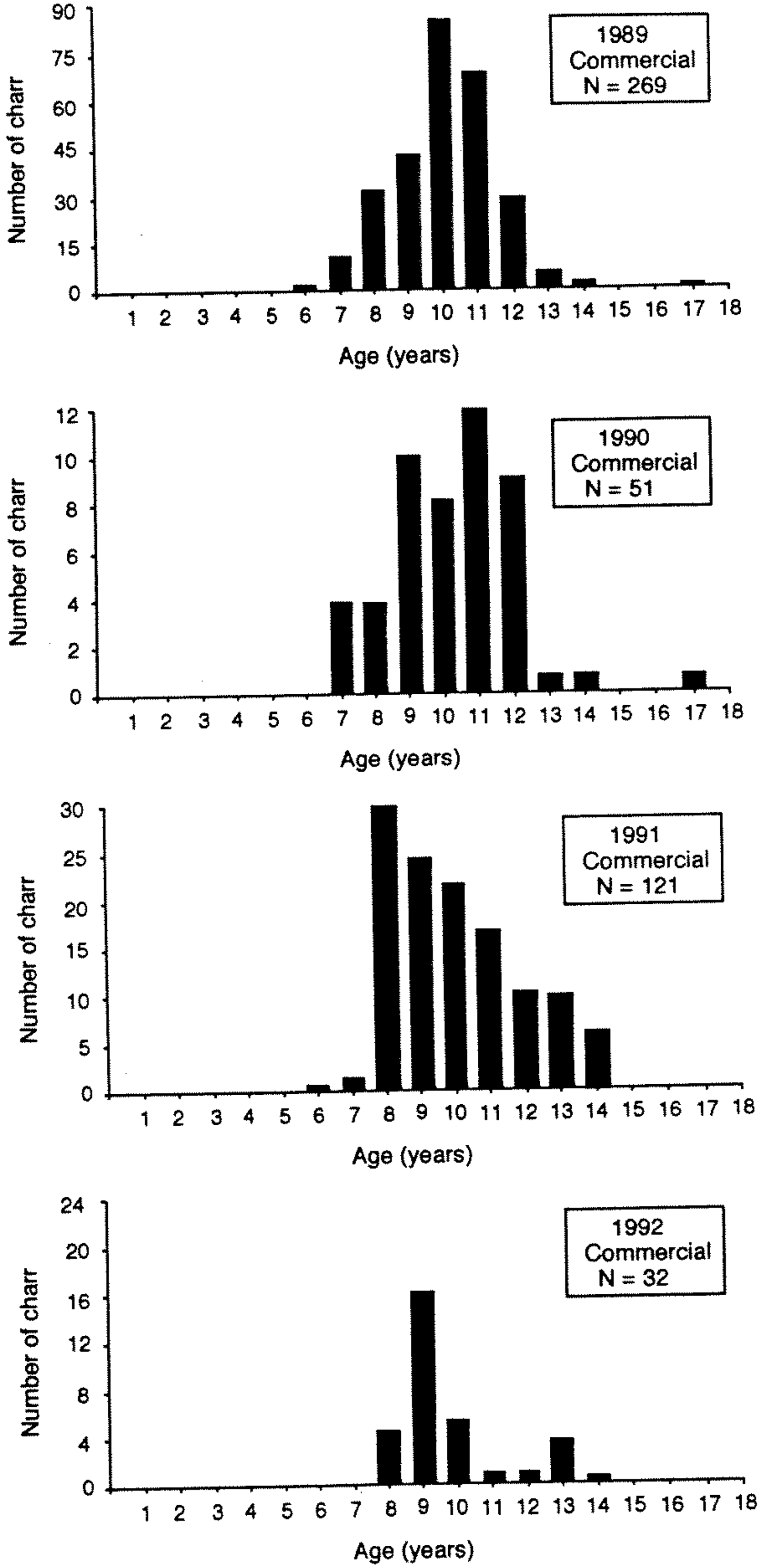


Figure 12. Age-frequency distributions of Arctic charr sampled during the Lake Sapukkait commercial weir fishery between 1989 and 1992.

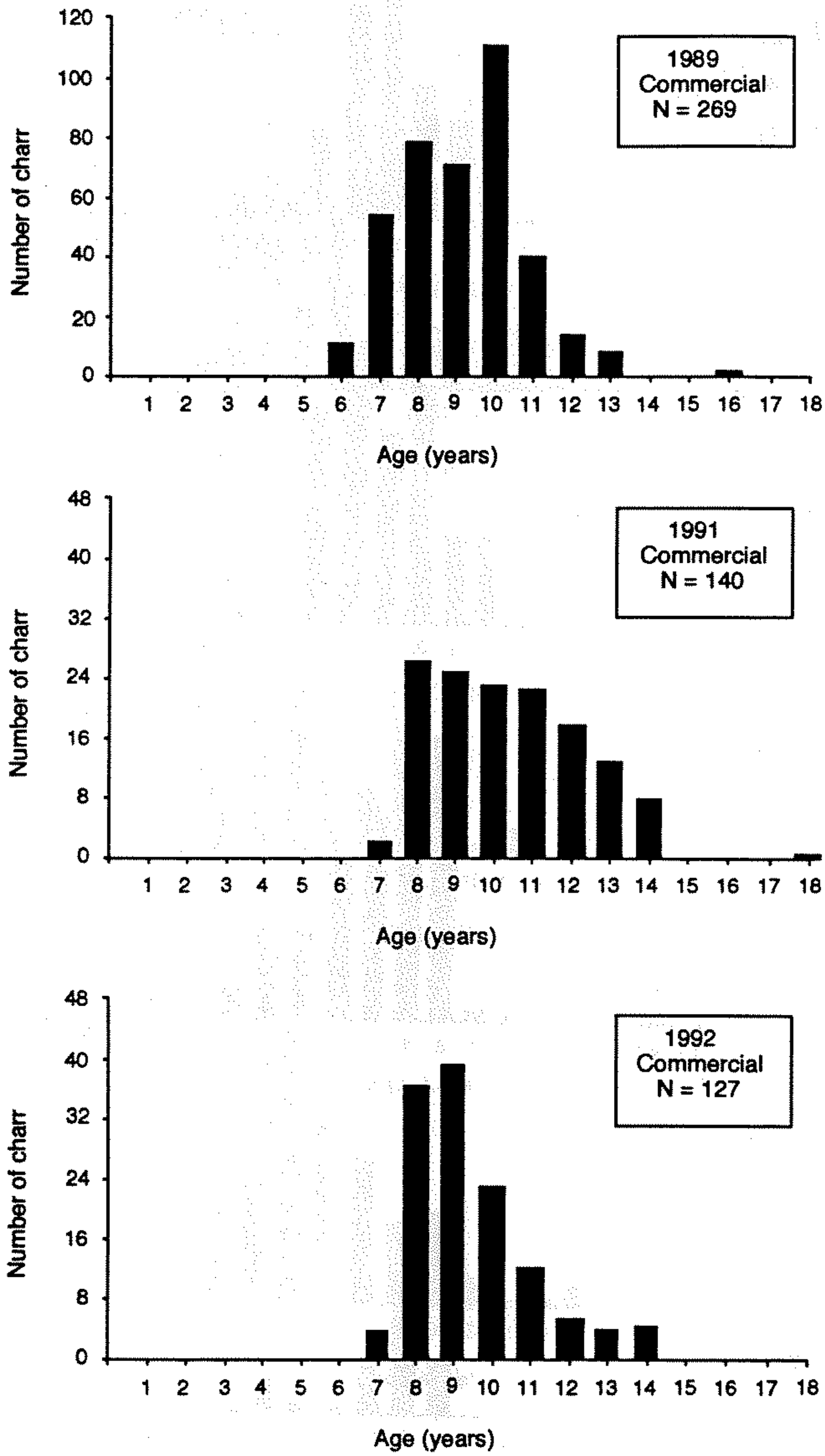


Figure 13. Age-frequency distributions of Arctic charr sampled during the Lake Sannirarsiq commercial weir fishery in 1989, 1991 and 1992.

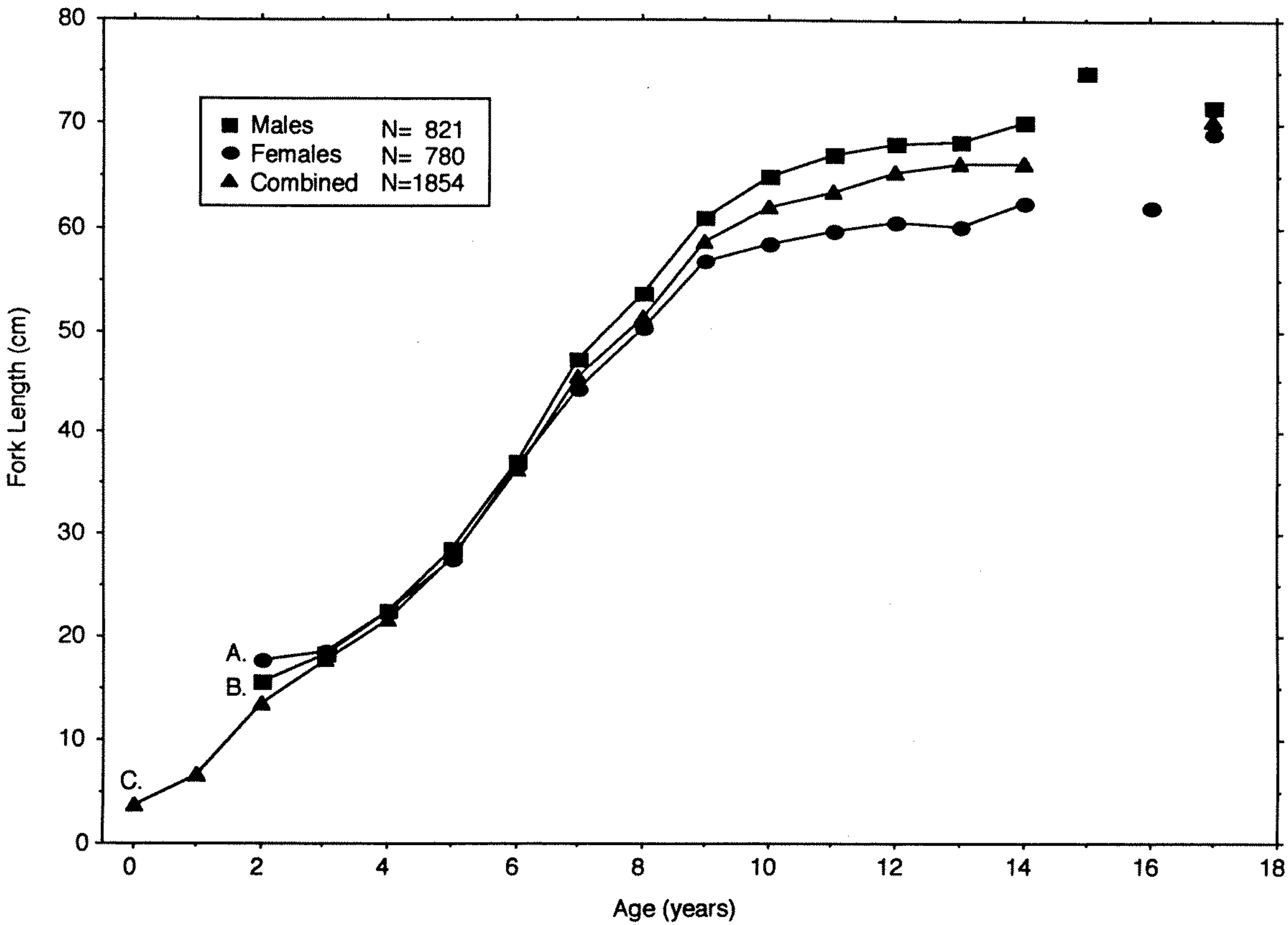


Figure 14. Length-at-age data for Sapukkait Arctic charr sampled between 1988-1992. Data presented are for male, female and both sexes combined.

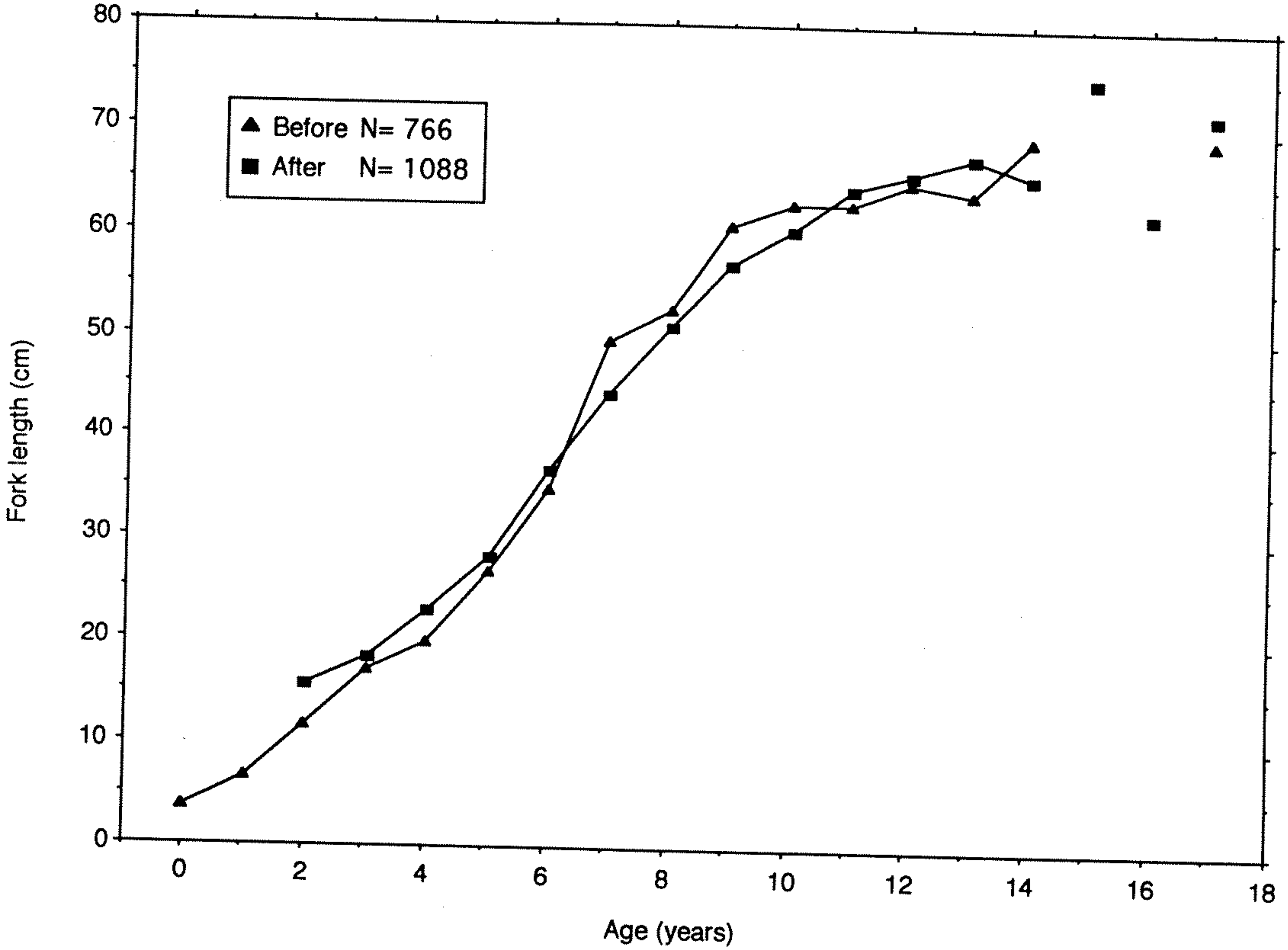


Figure 15. Length-at-age data (both sexes combined) for Lake Sapukkait Arctic charr sampled before commercial exploitation (1988-89) and after commercial exploitation (1990-1992).

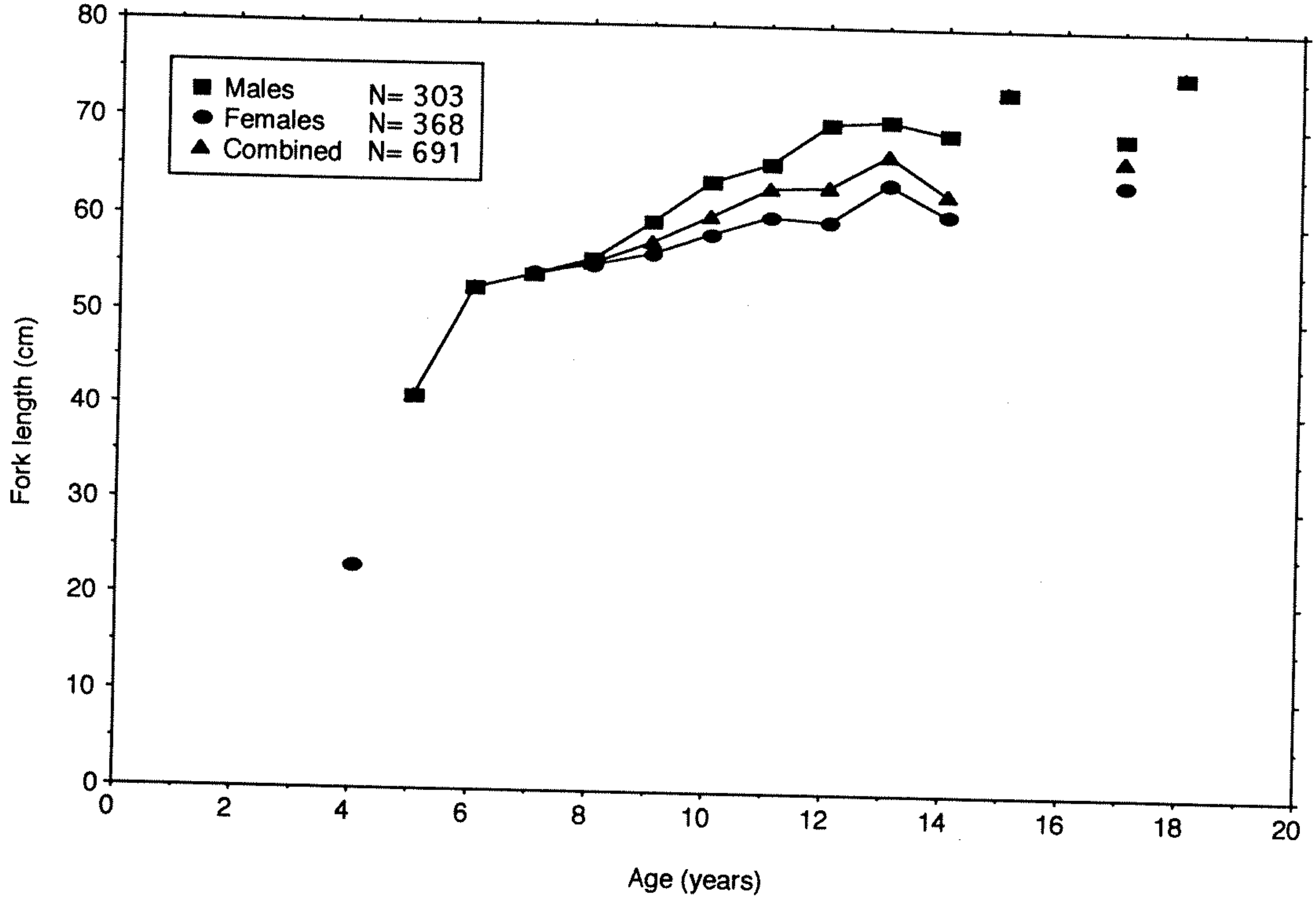


Figure 16. Length-at-age data for Lake Sannirarsiq Arctic charr sampled in 1988, 1989, 1990 and 1992. Data presented are for males, females and both sexes combined.

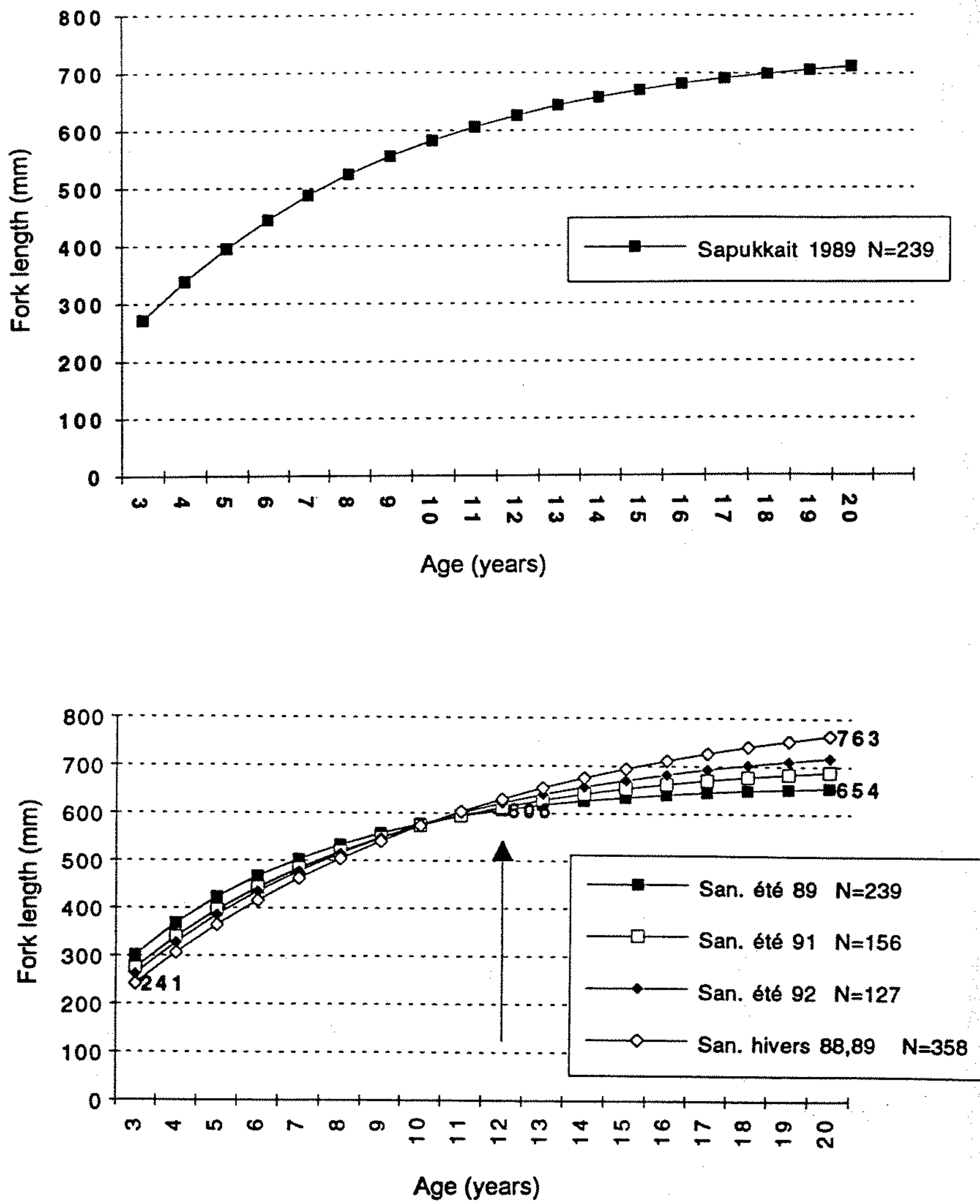


Figure 17. Length-at-age data for Lake Sapukkait and Sannirarsiq Arctic charr as calculated according to the von Bertalanffy model.

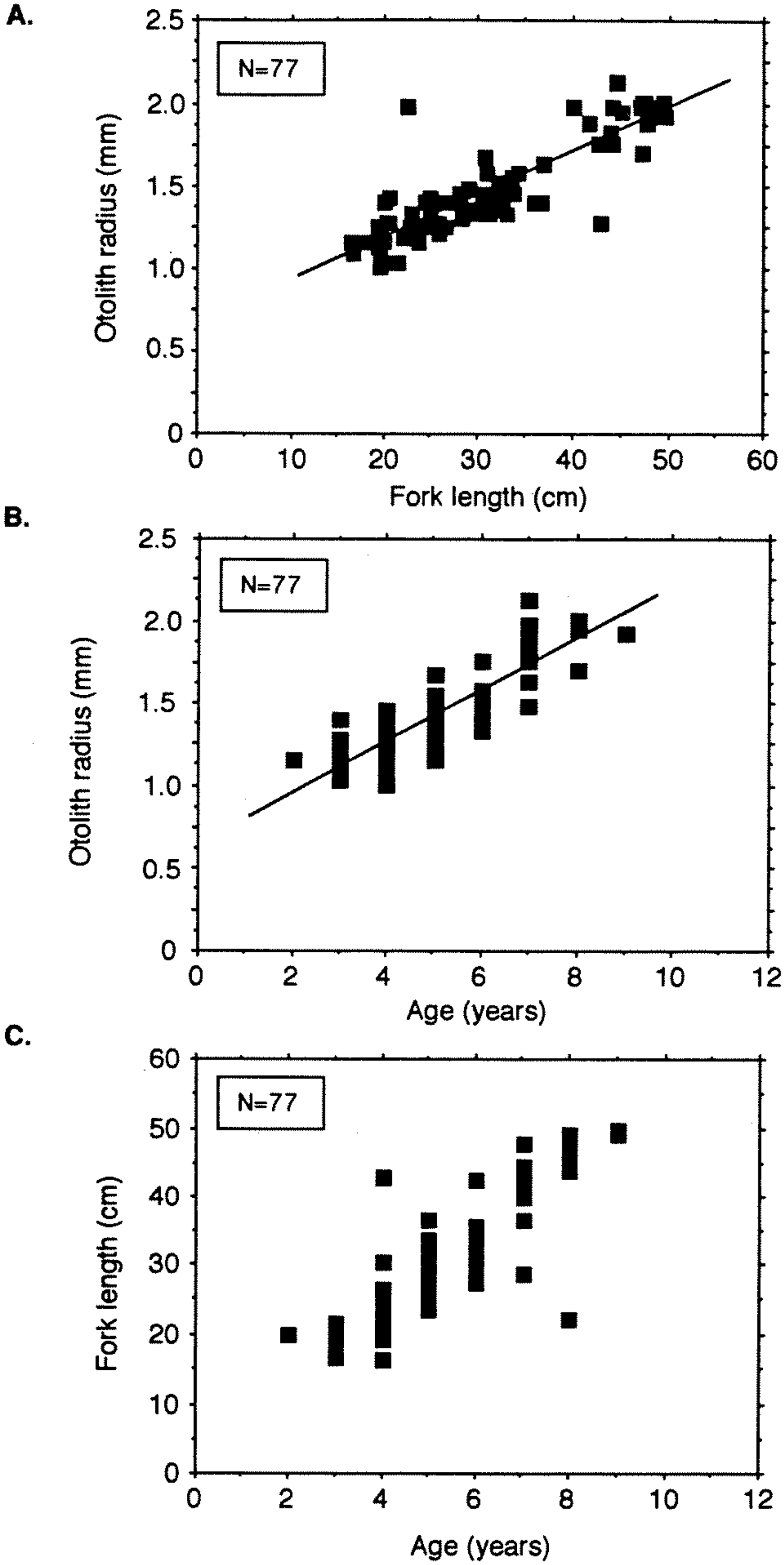


Figure 18. Relationships between Arctic charr fork length (cm) vs otolith radius (mm) (A), final age (years) vs otolith radius (B) and length-at-age data (C) for Lake Sapukkait Arctic char. Includes otolith quality A & B only.

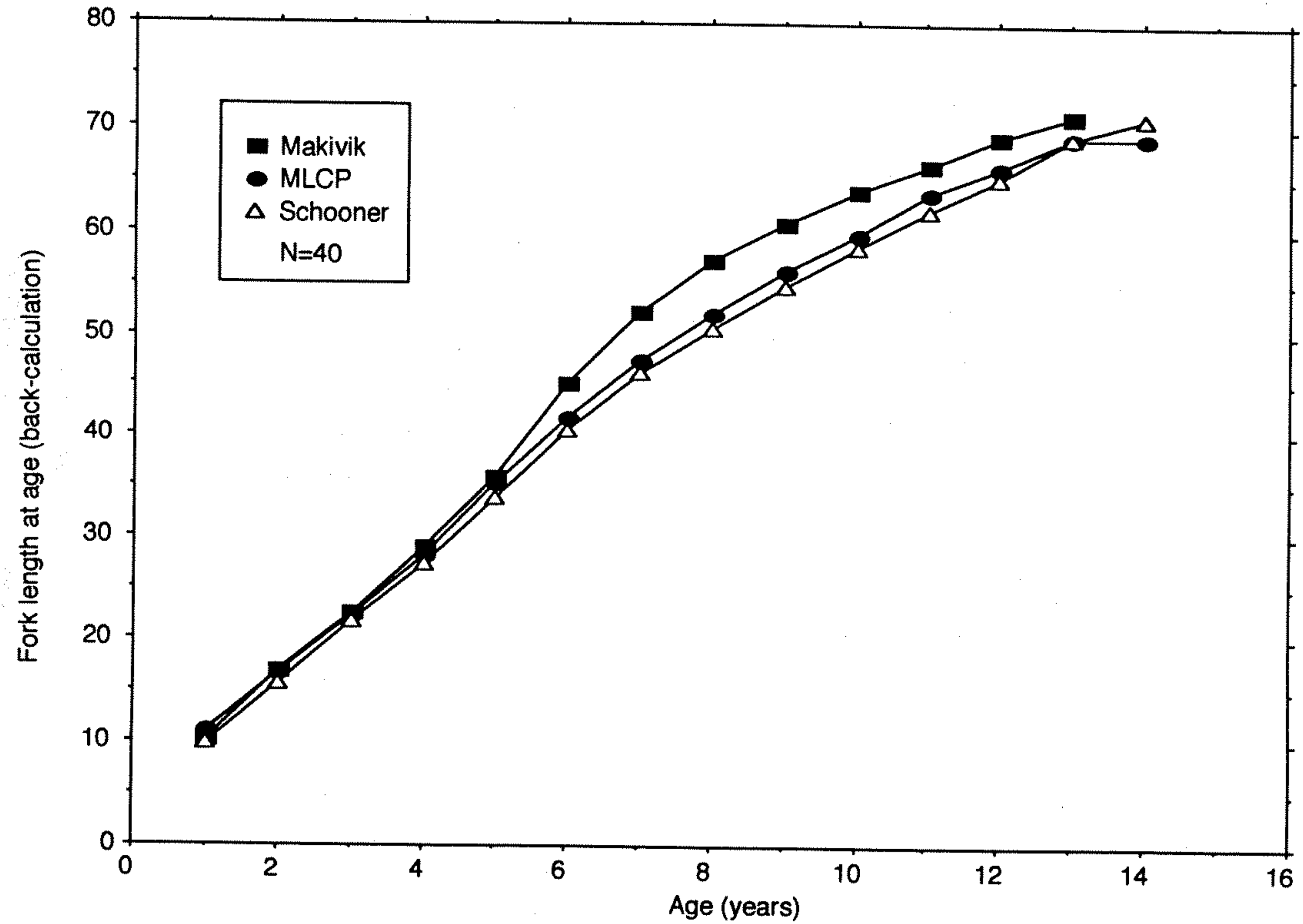


Figure 19. Length-at-age data for Lake Sapukkait Arctic charr as determined by back-calculation. Data are presented for calculations made by individuals from Makivik, MLCP and Schooner Environmental Consultants.

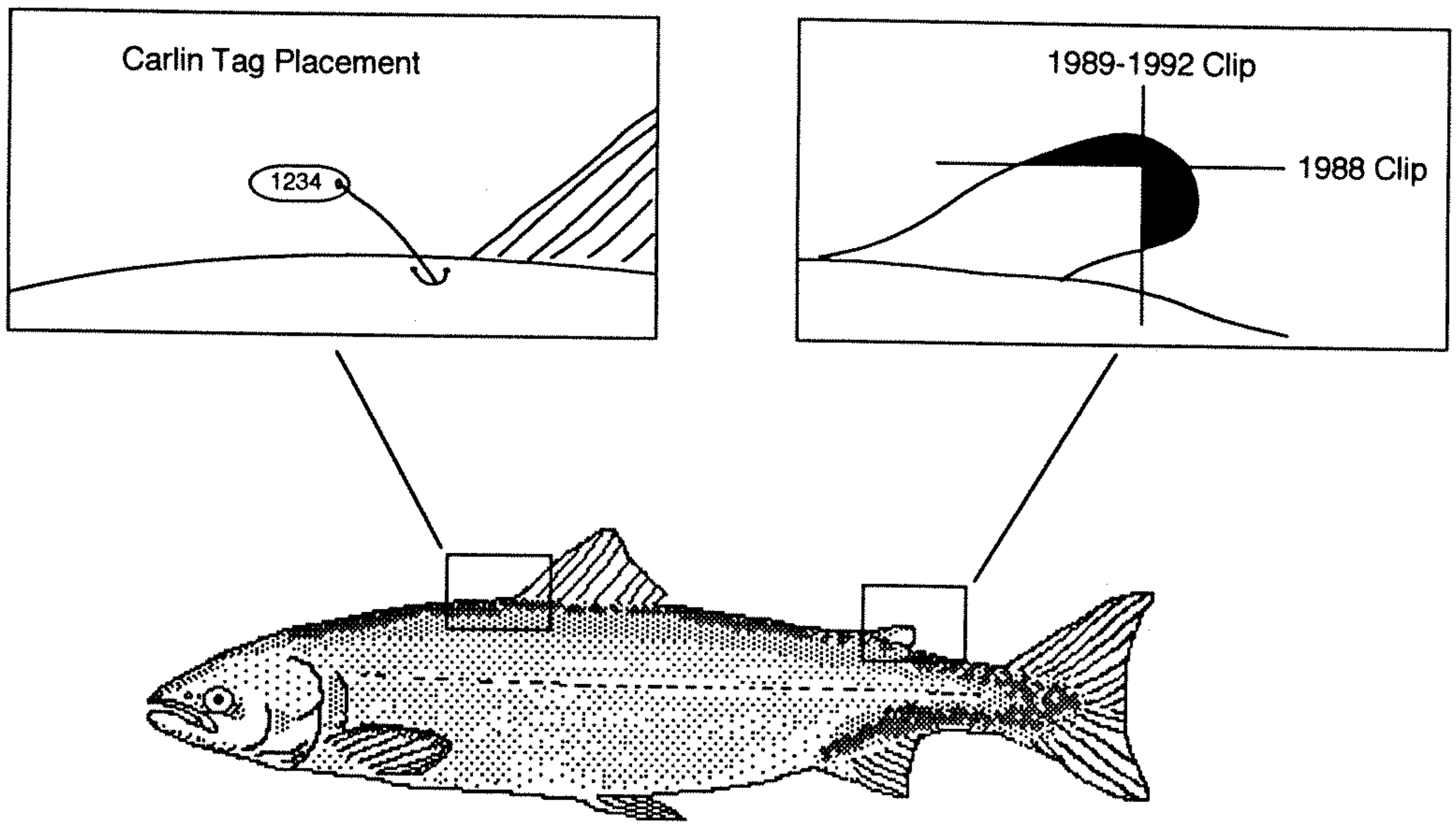


Figure 20. Location of Carlin tag placement and typese of adipose fin clips applied to Arctic charr at Lake Sapukkait between 1988-1992.

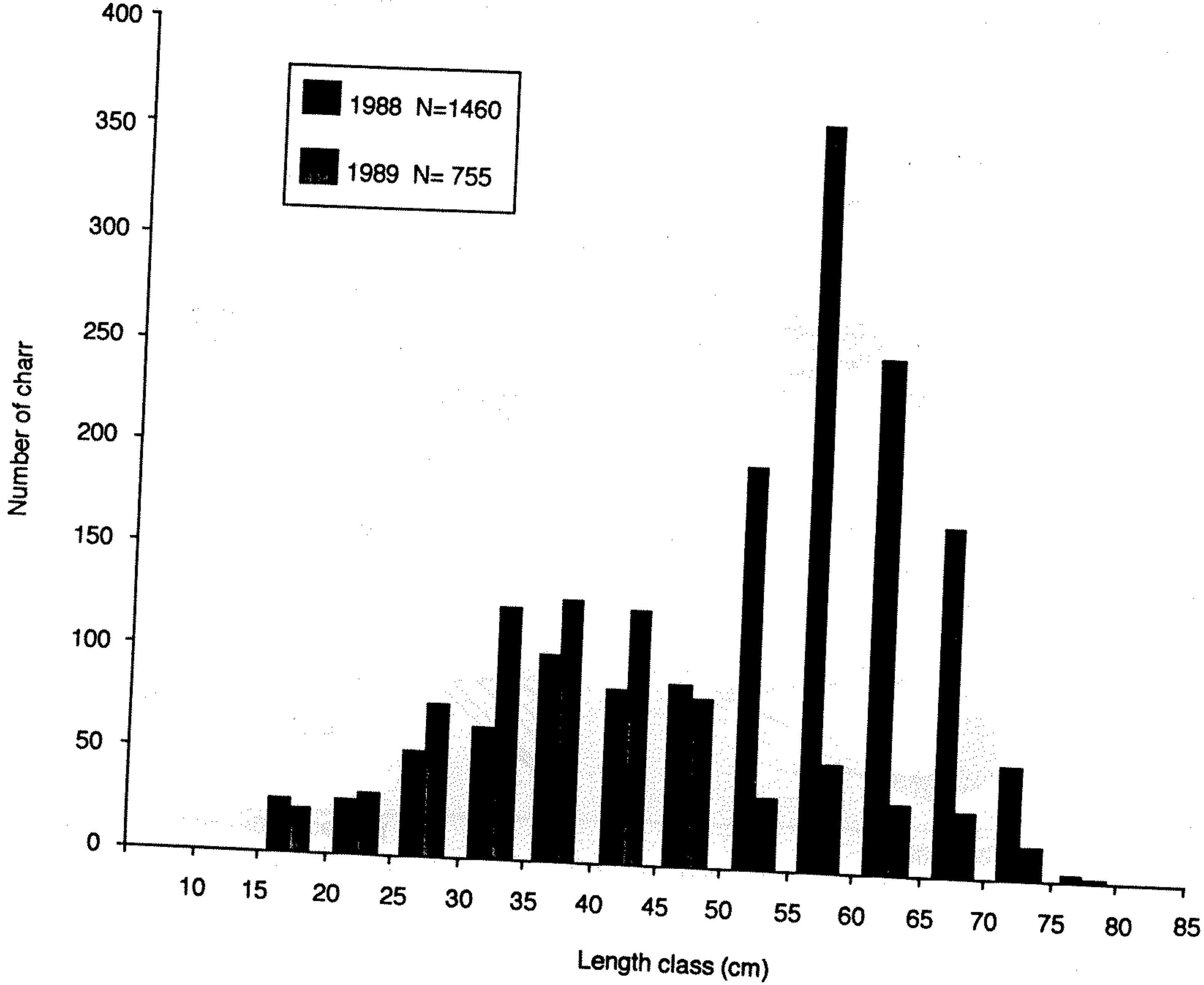


Figure 21. Length-frequency distribution of Arctic charr tagged at the Lake Sapukkait counting fence, 1988-89.

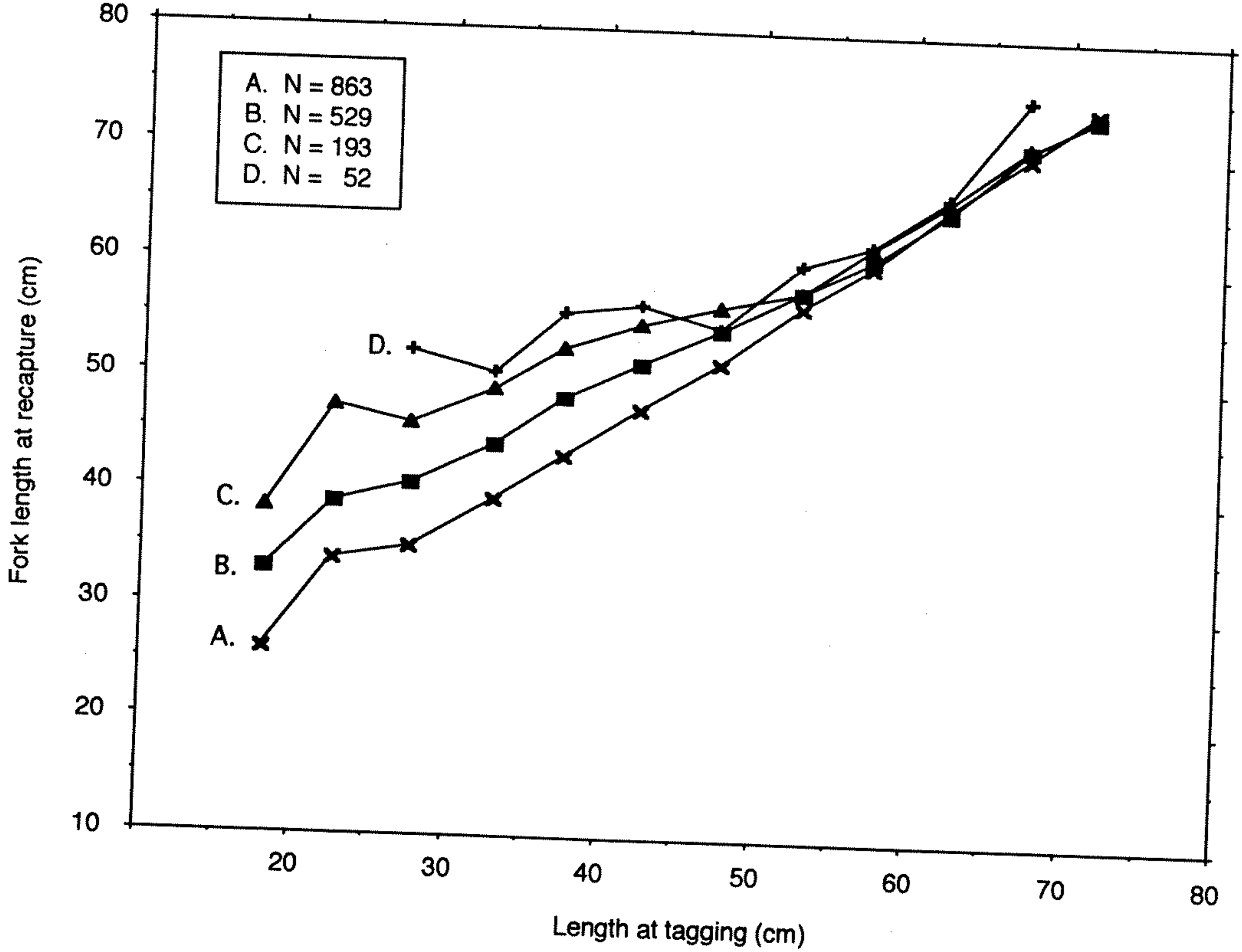


Figure 22. Fork length (cm) of tagged Arctic charr from Lake Śapukkait A) 1 year, B) 2 years, C) 3 years and D) 4 years after tagging in 1988 or 1989.

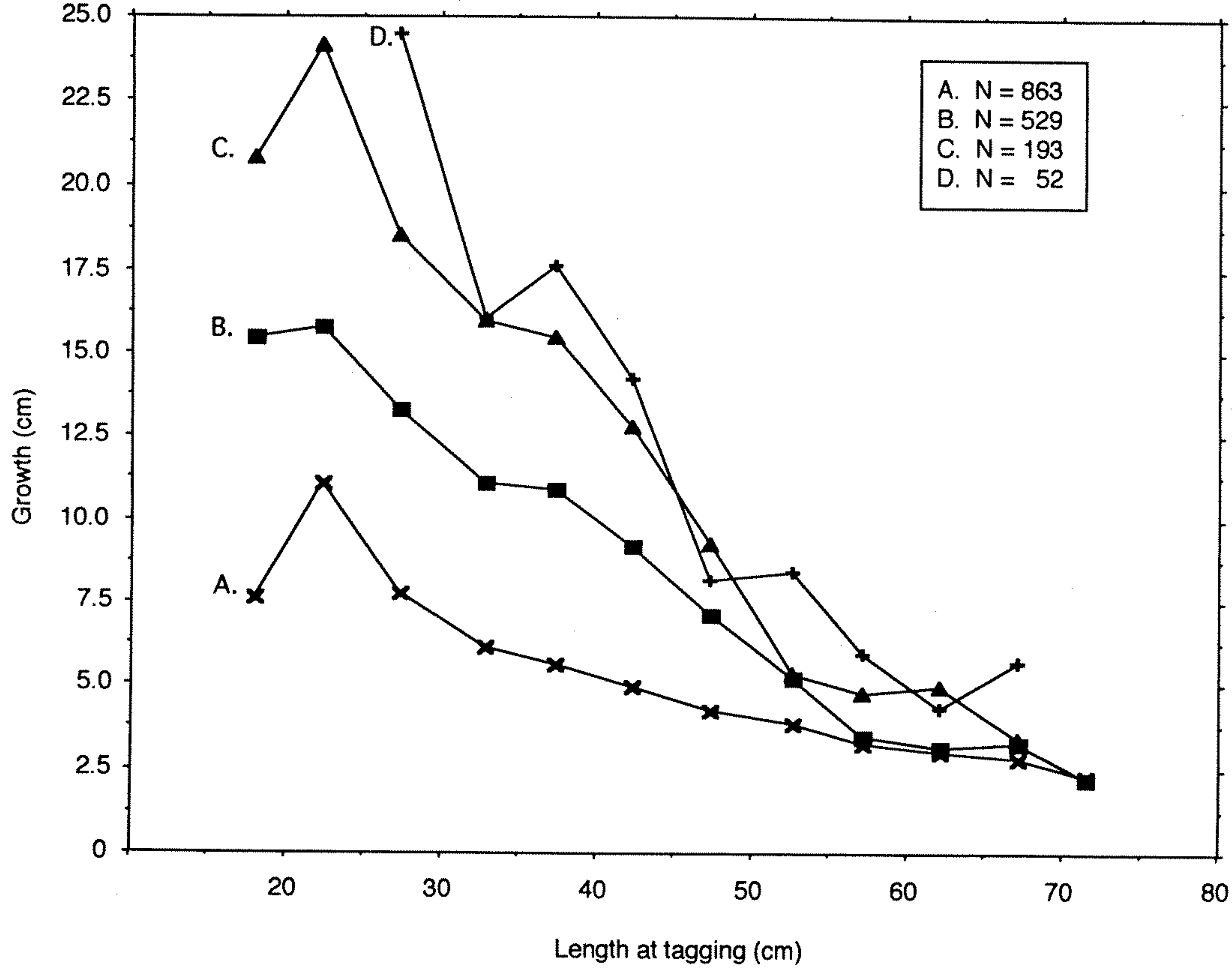
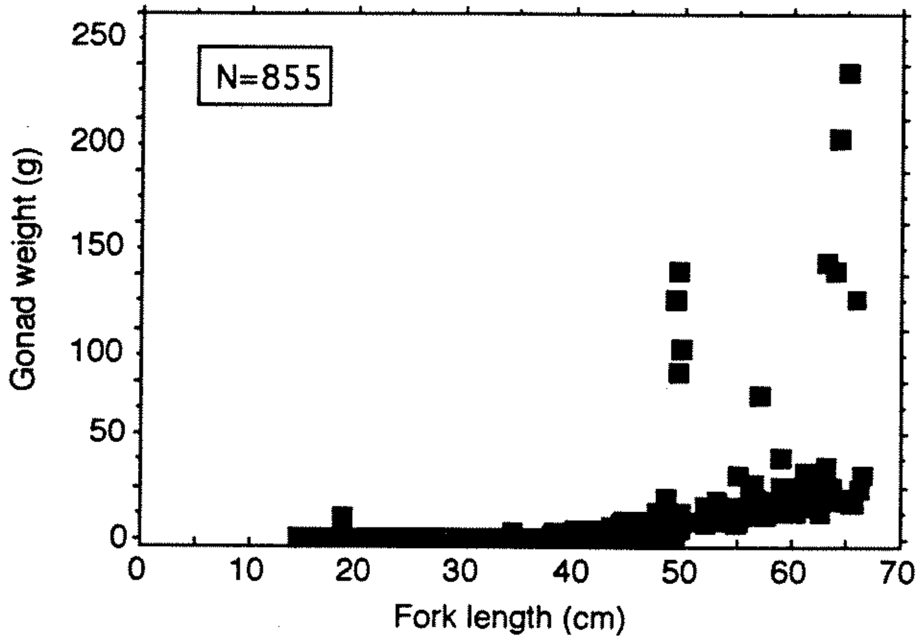


Figure 23. Growth (cm) of Arctic charr from Lake Sapukkait A) 1 year, B) 2 years, C) 3 years and D) 4 years after tagging in 1988 or 1989.



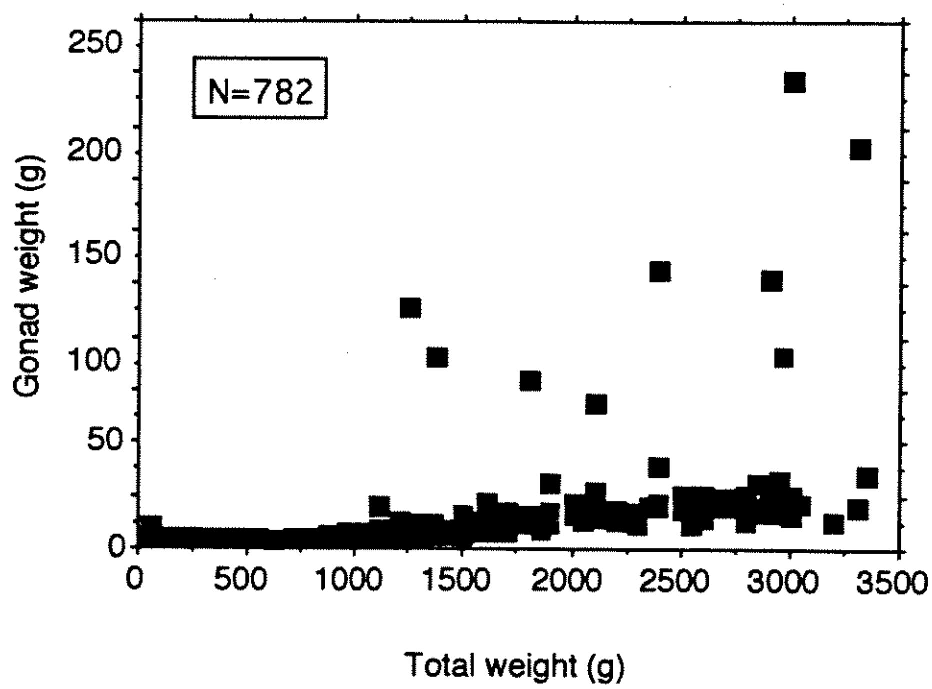
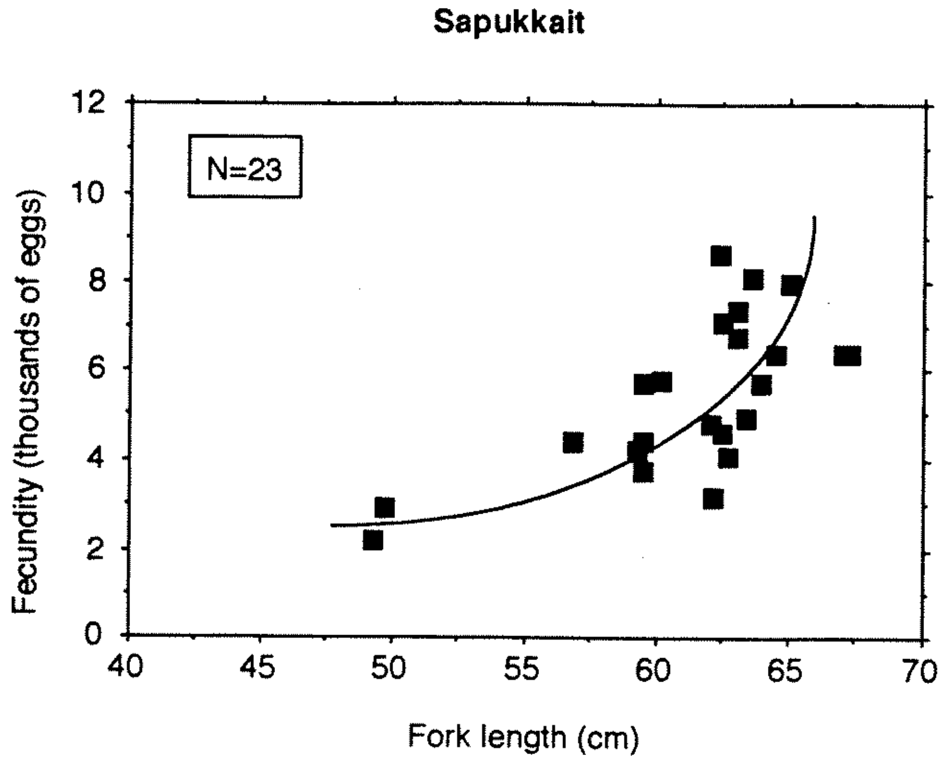


Figure 24. Fork length (cm) and whole weight (g) vs gonad weight (g) of female Arctic charr randomly sampled from the Lake Sapukkait upstream migration, 1990-1992.



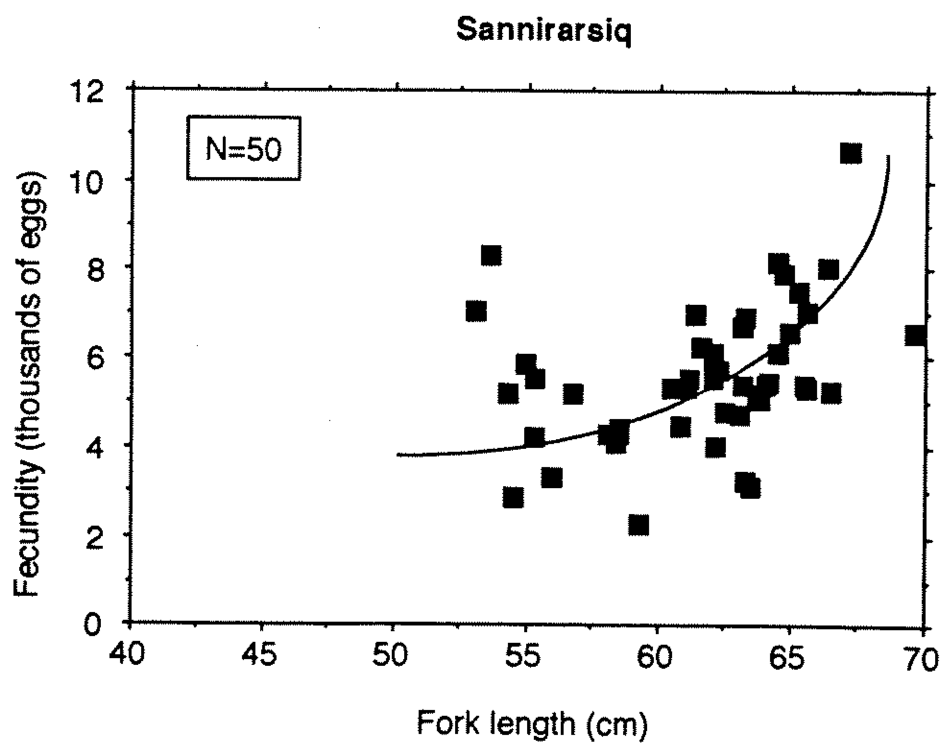


Figure 25. Fork length (cm) vs fecundity (thousands of eggs) of Arctic charr sampled from Lakes Sapukkait and Sannirarsiq.

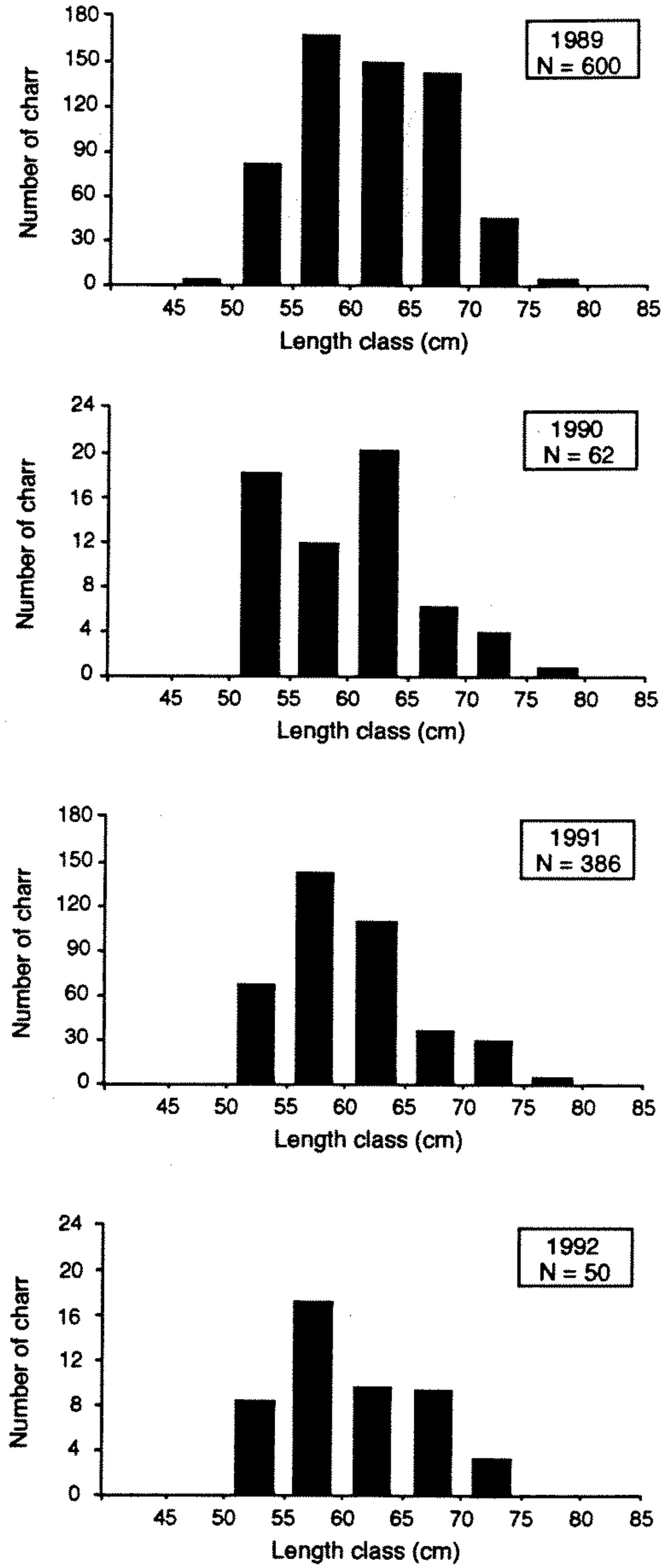


Figure 26. Length-frequency distribution of Arctic charr sampled in the summer weir commercial fishery at Lake Sapukkait, 1989-1992.

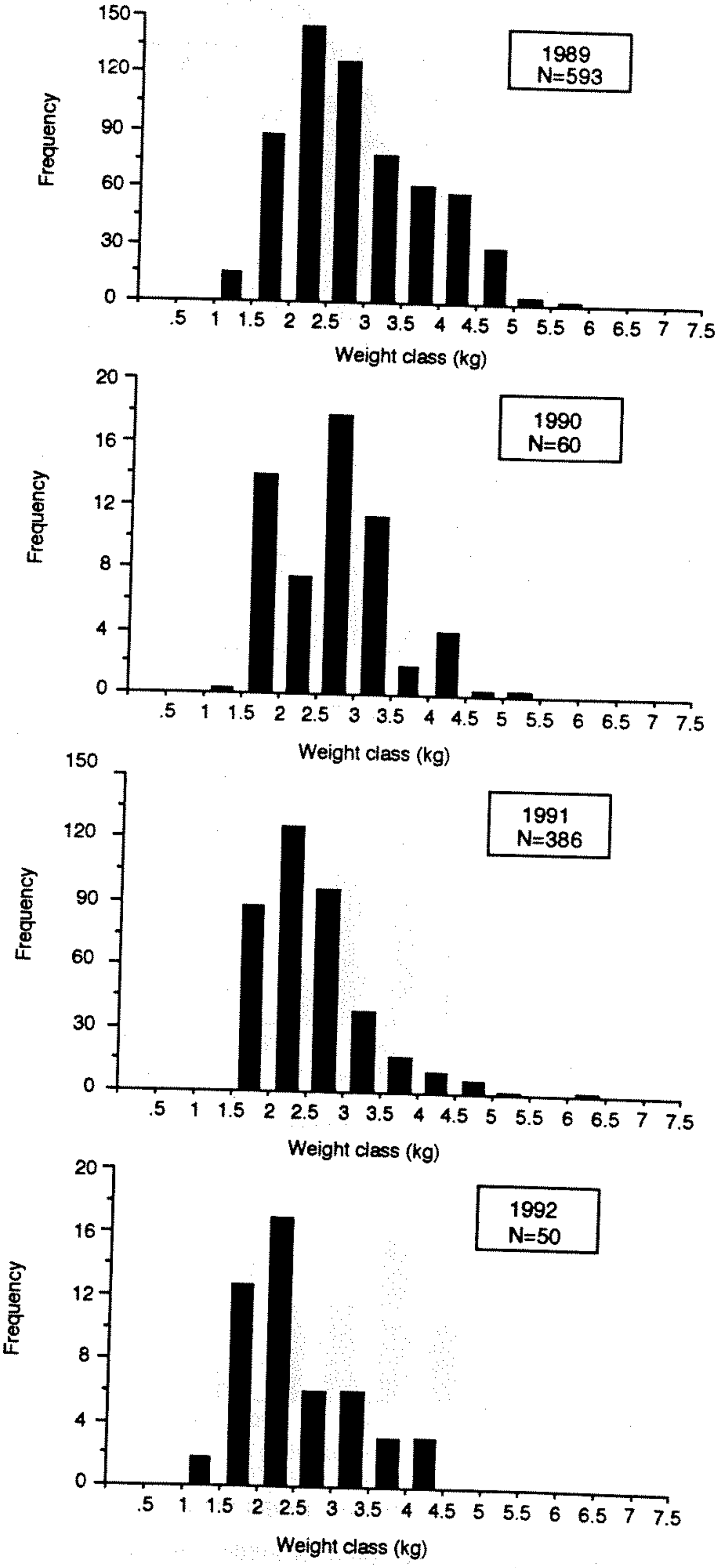


Figure 27. Weight-frequency distribution of Arctic charr sampled in the summer weir commercial fishery at Lake Sapukkait, 1989-1992.

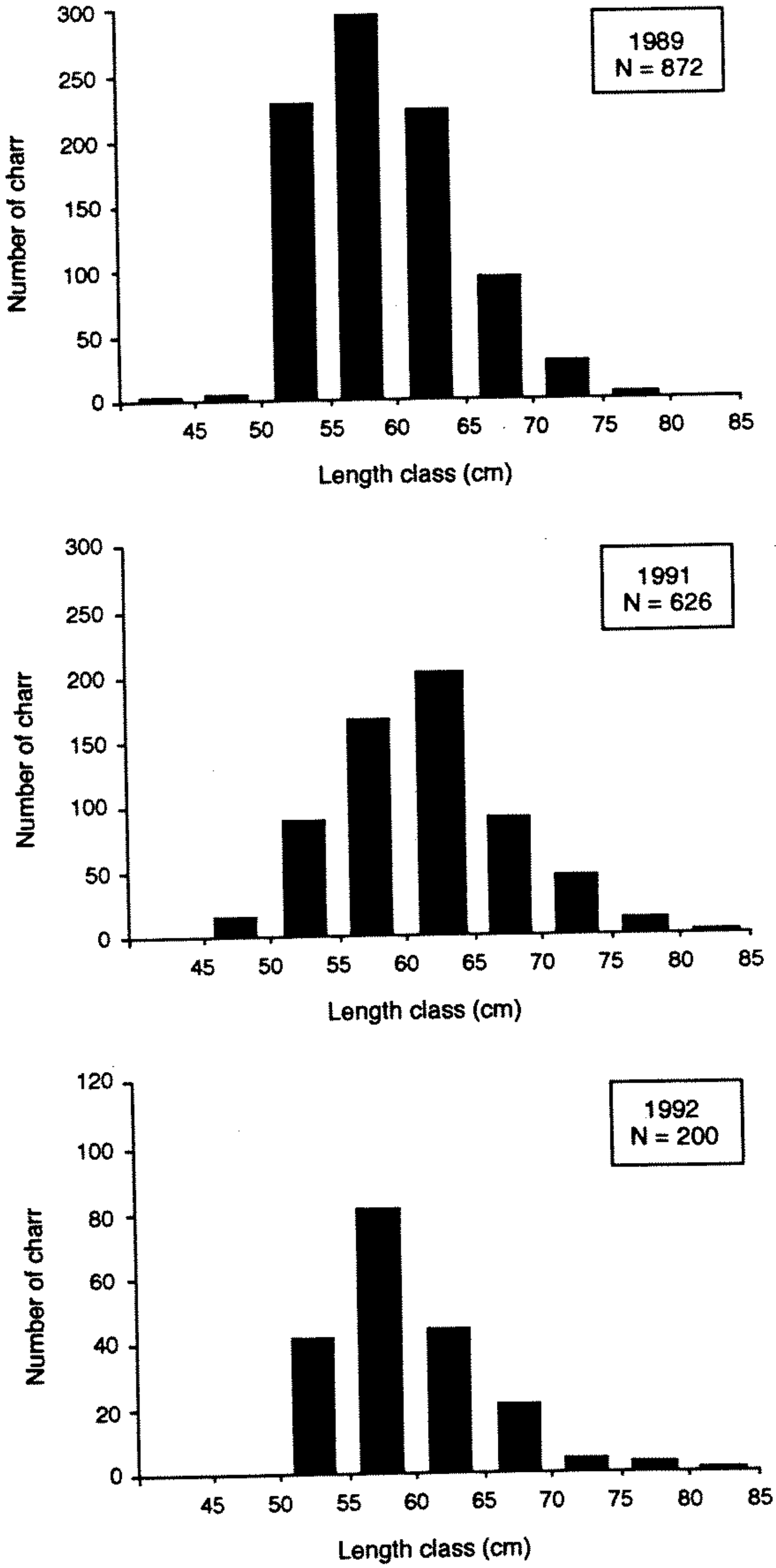


Figure 28. Length-frequency distribution of Arctic charr sampled in the summer weir commercial fishery at Lake Sannirarsiq, 1989, 1991 and 1992.

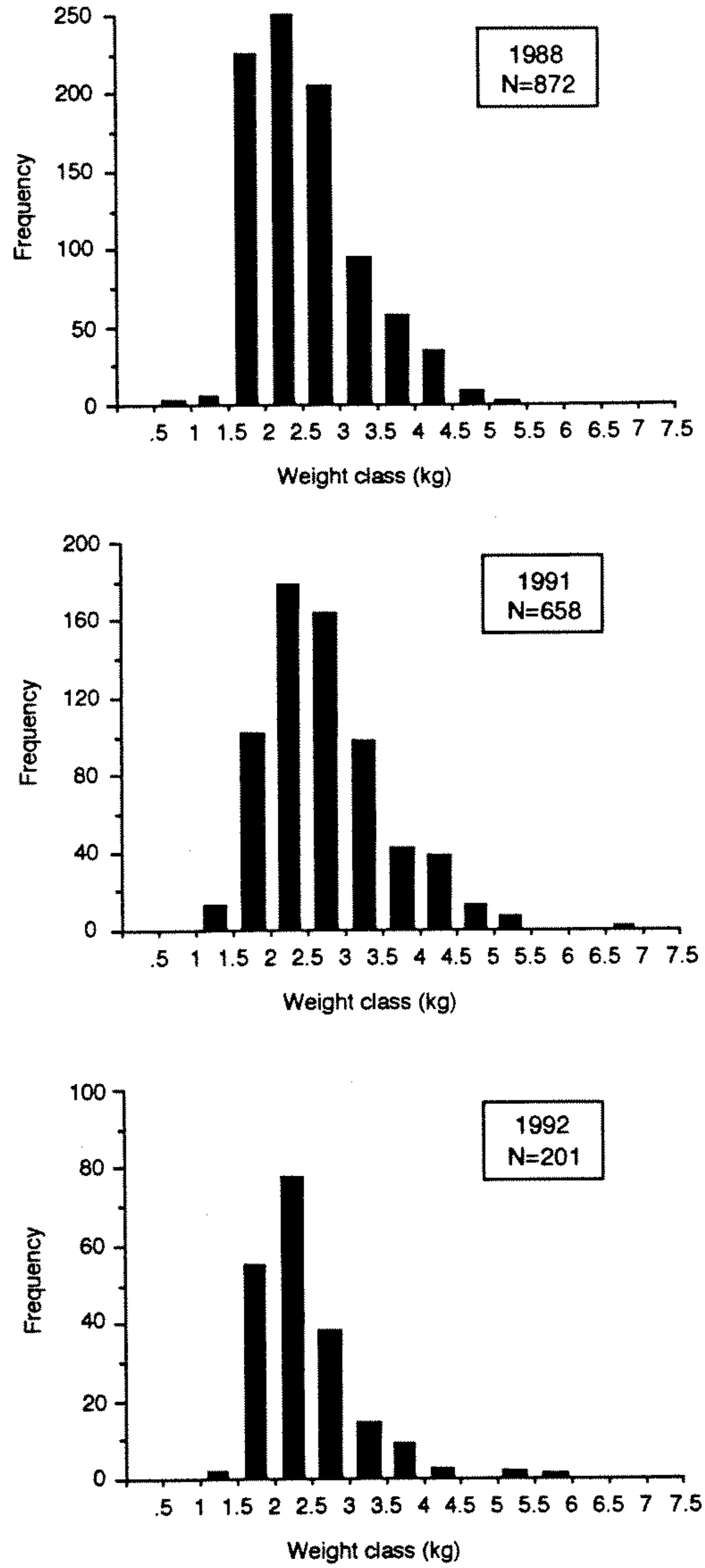


Figure 29. Weight-frequency distribution of Arctic charr sampled in the summer weir commercial fishery at Lake Sannirarsiq, 1989, 1991 and 1992.

George River

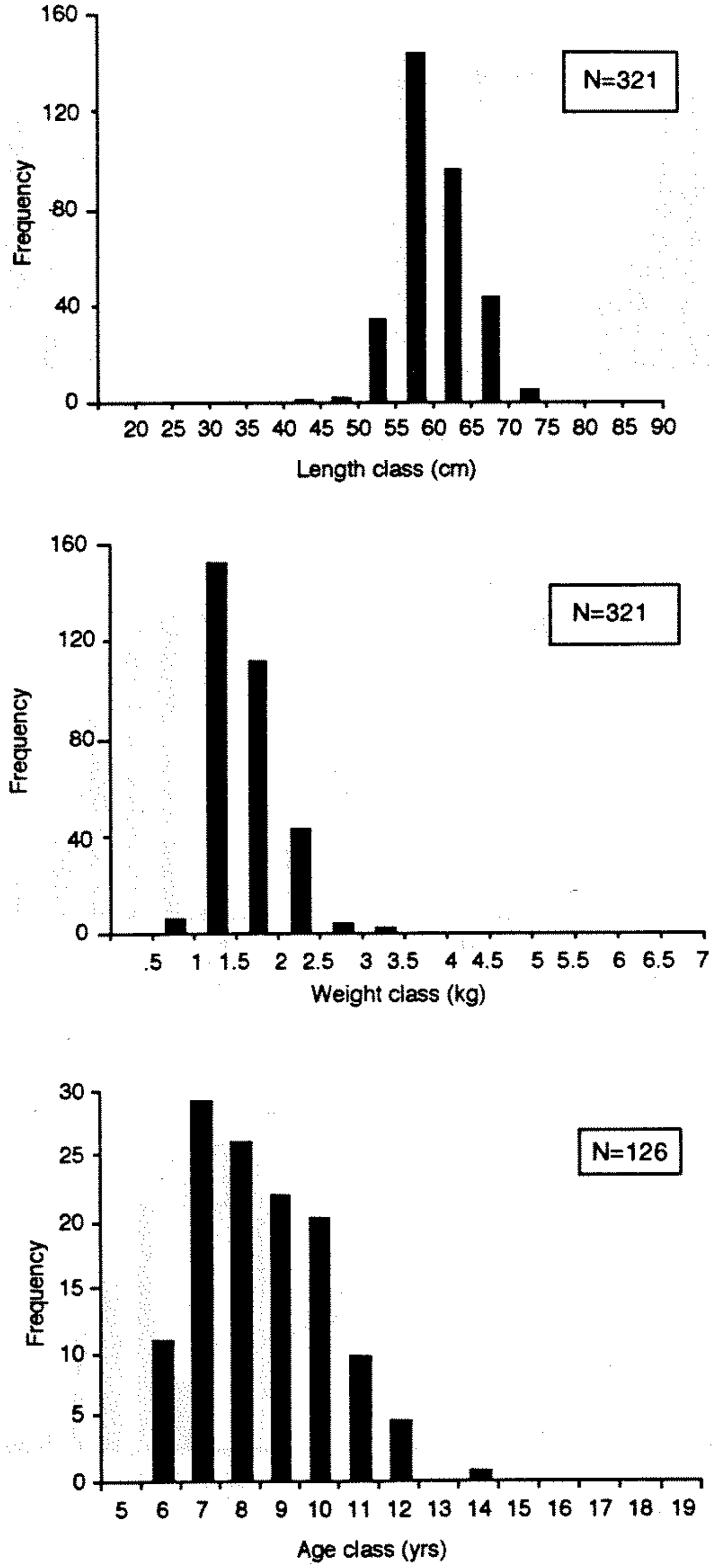


Figure 30. Length-, weight- and age-frequency distributions of Arctic charr sampled from the George River during the 1988-89 winter fishery.

Koroc River

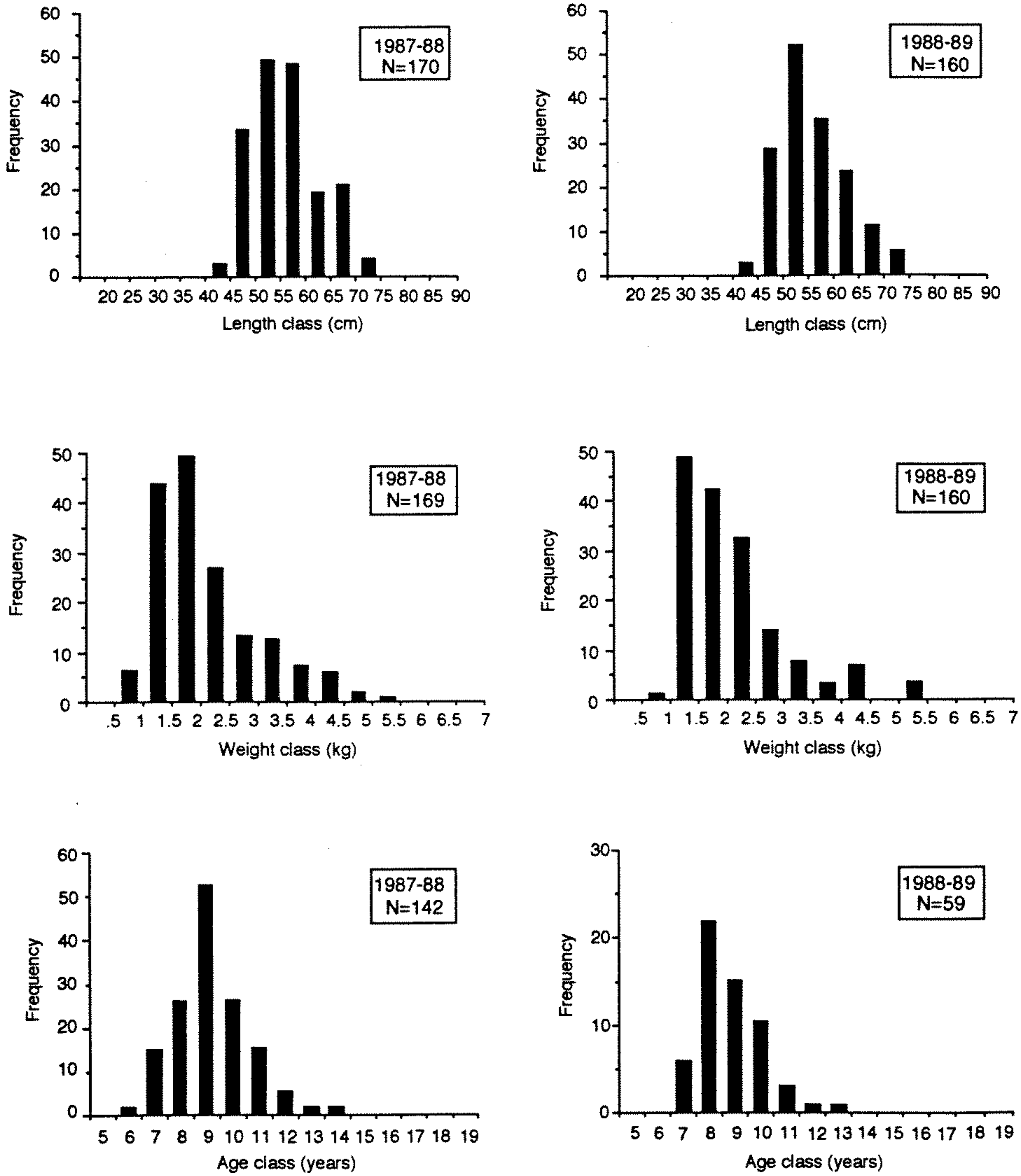


Figure 31. Length-, weight- and age-frequency distributions of Koroc River Arctic charr sampled during the 1987-88 and 1988-89 experimental-commercial winter fisheries.

Lake Qaarlik

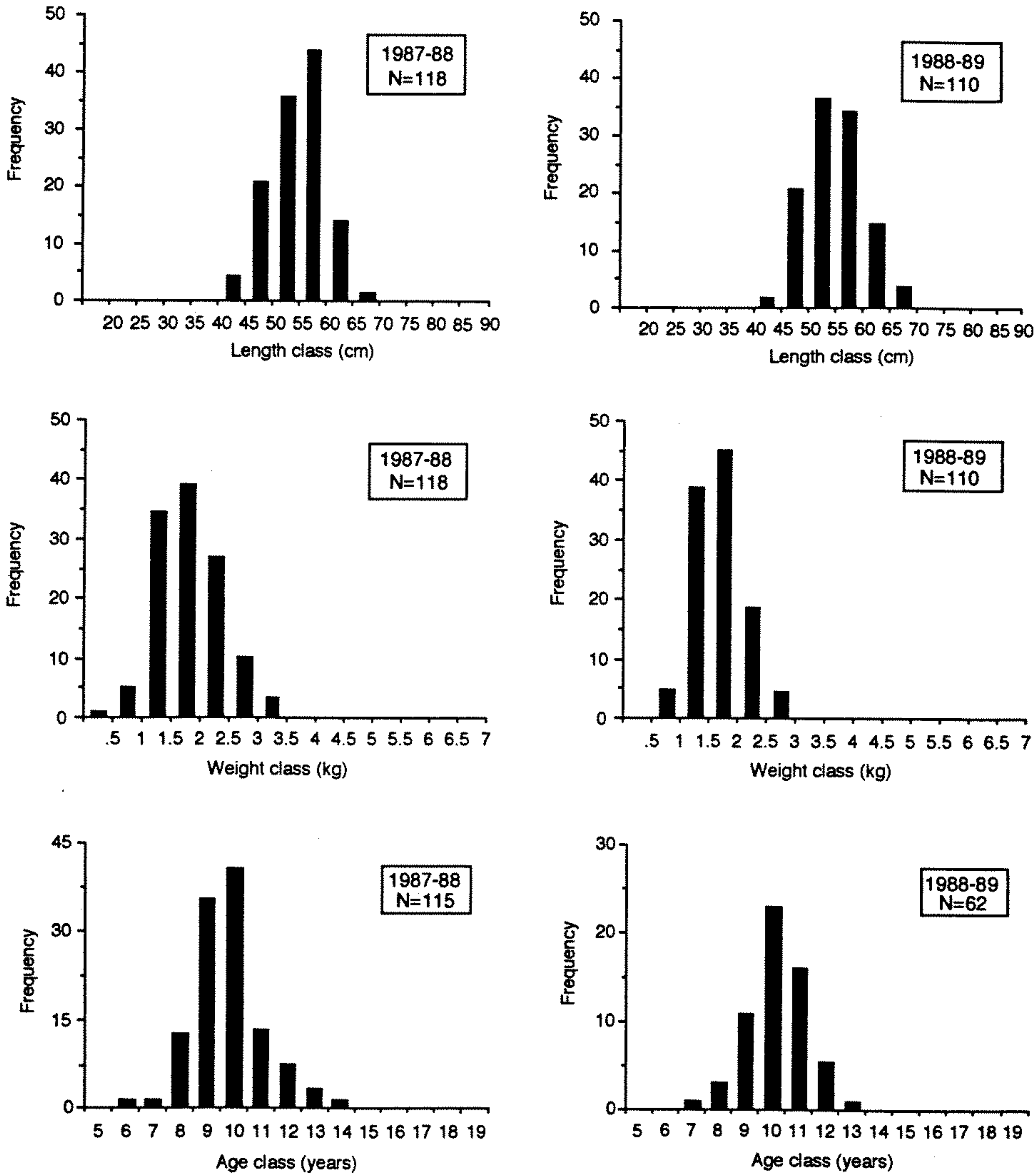


Figure 32. Length-, weight and age-frequency distributions of Lake Qaarlik Arctic charr sampled during the 1987-88 and 1988-89 experimental-commercial winter fisheries.

Lake Tasikallak

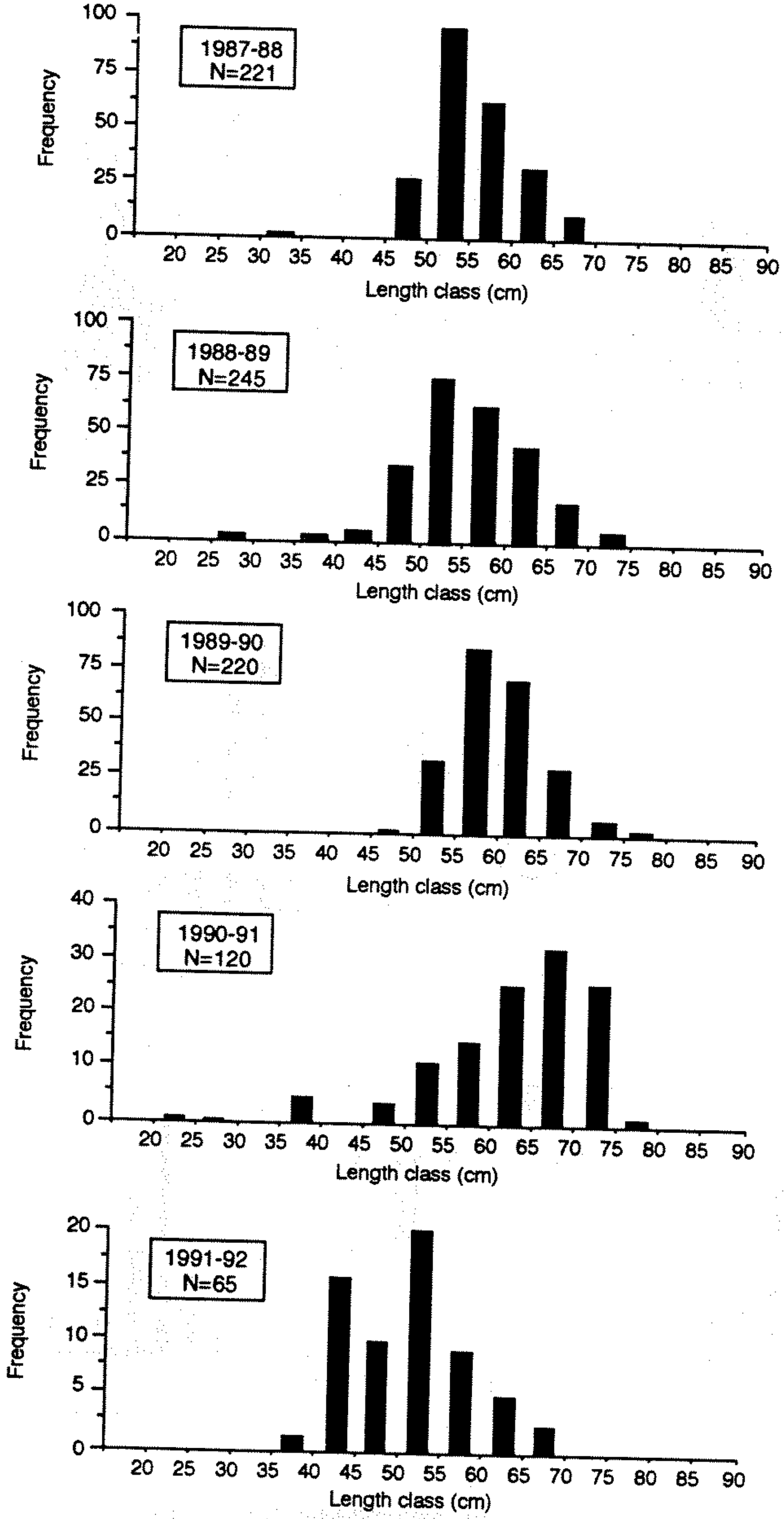


Figure 33. Length-frequency distribution Lake Tasikallak Arctic charr sampled during the 1987-1992 winter fisheries.

Lake Tasikallak

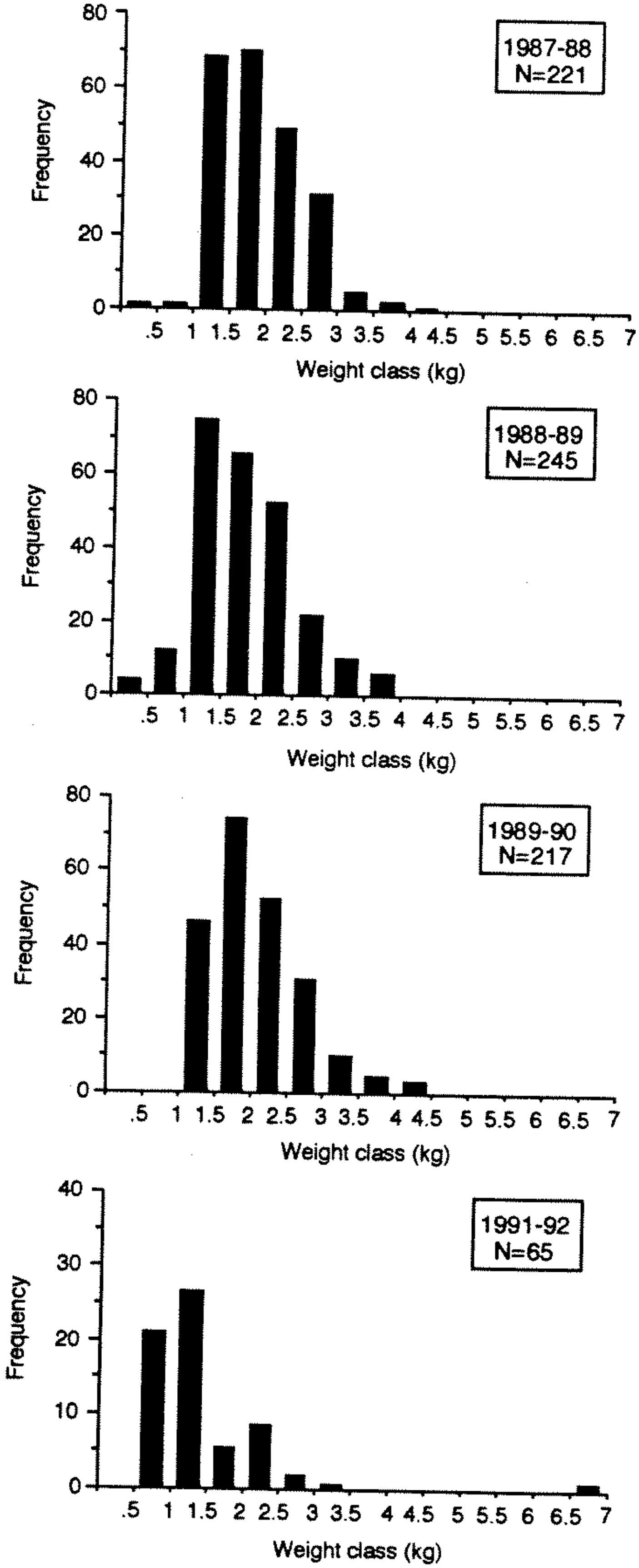
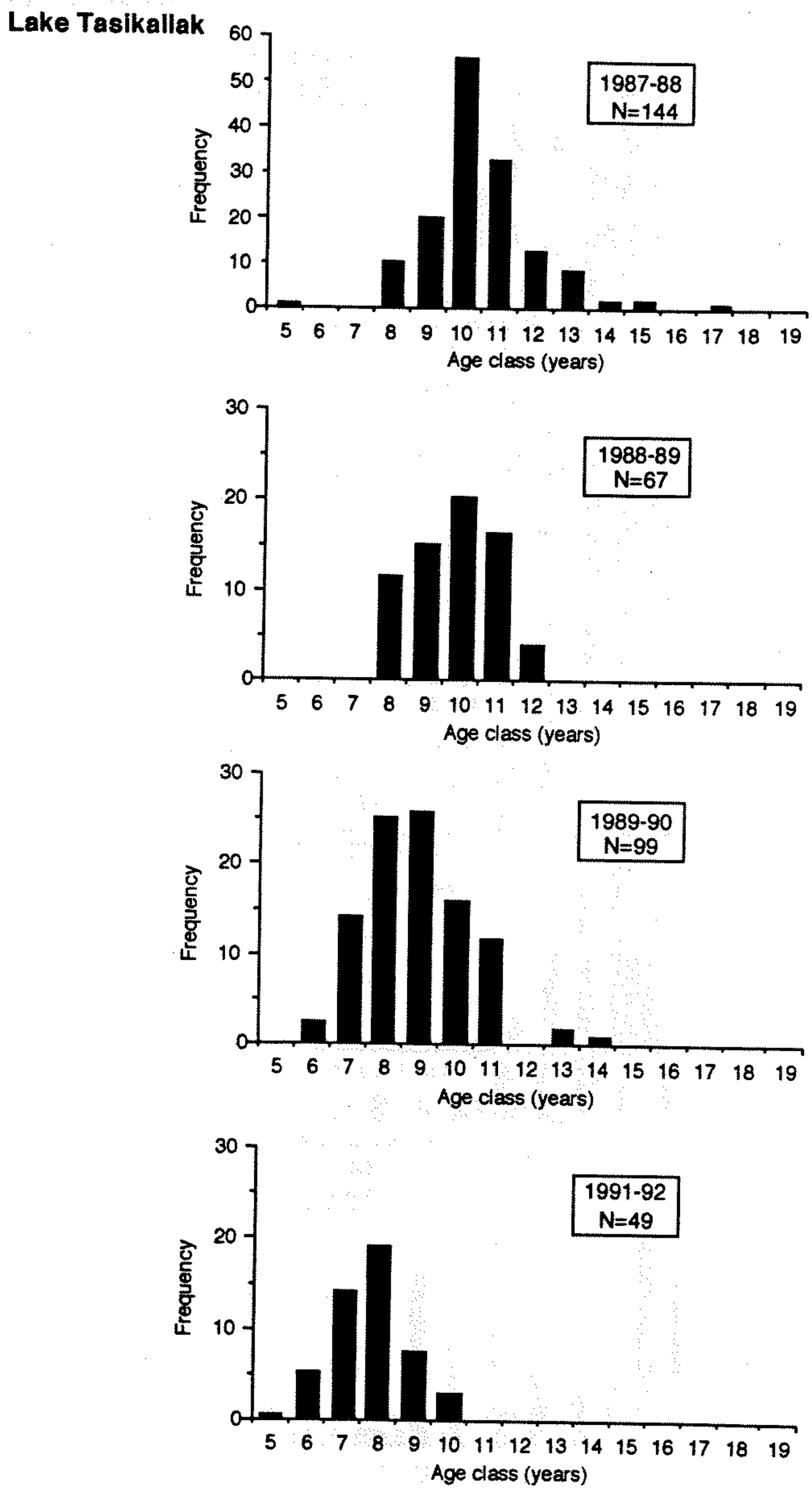


Figure 34. Weight-frequency distribution of Lake Tasikallak Arctic charr sampled during the 1987-88, 1988-89, 1989-90 and 1991-92 winter fisheries.



...re 35. Age-frequency distribution of the Lake Tasikallak Arctic charr sampled during the 1987-88, 1988-89, 1989-90 and 1991-92 winter fisheries.

Lake Akilasaaluk

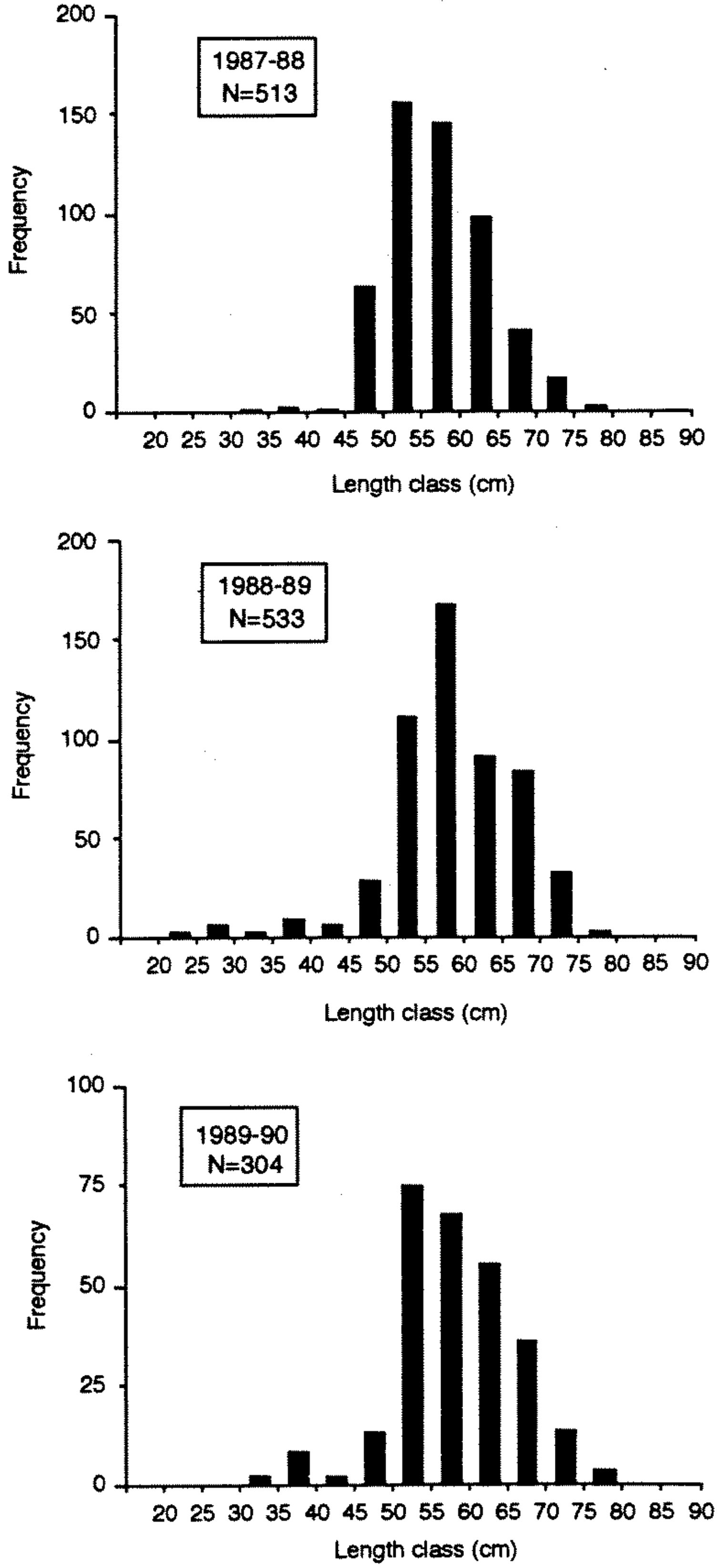


Figure 36. Length-frequency distribution of Lake Akilasaaluk Arctic charr sampled during the 1987-88, 1988-89 and 1989-90 winter fisheries.

Lake Akilasaaluk

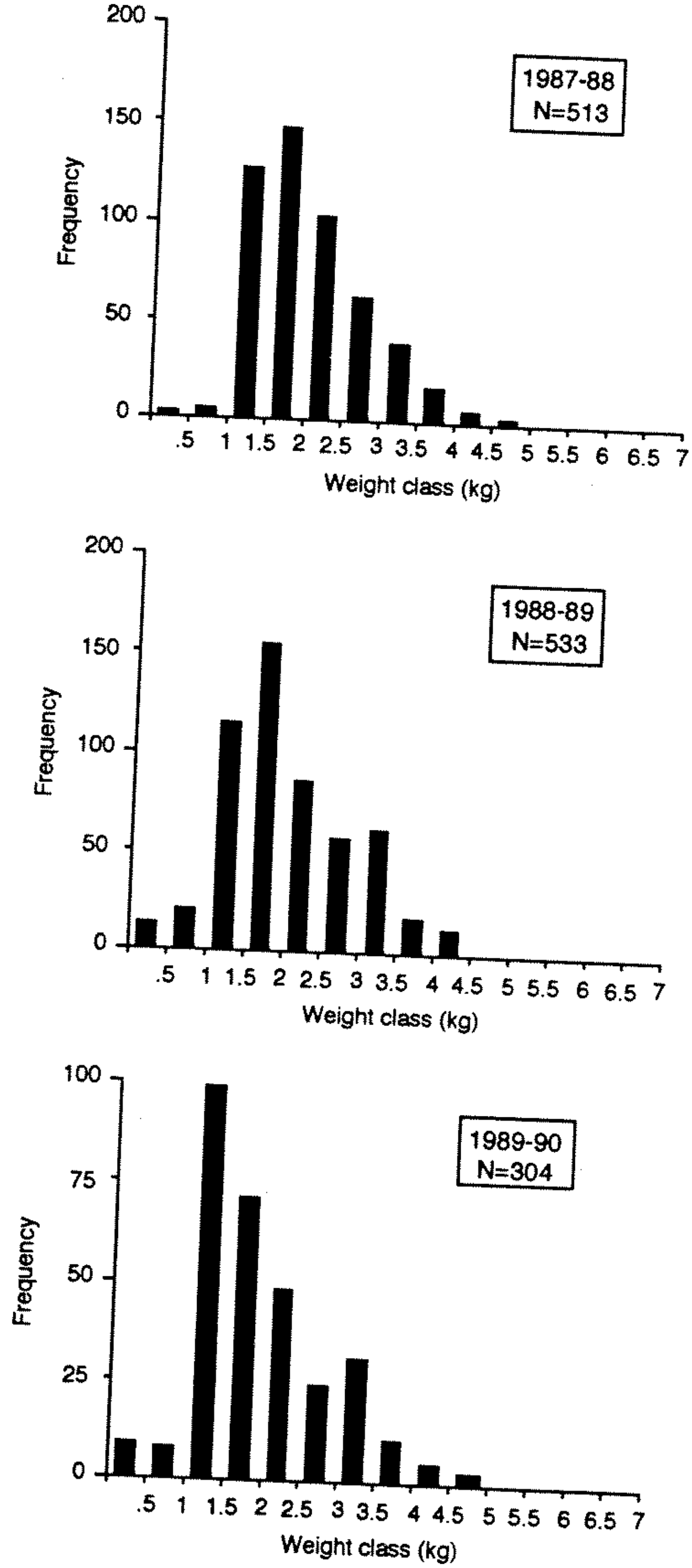


Figure 37. Weight-frequency distribution of the Lake Akilasaaluk Arctic charr sampled during the 1987-88, 1988-89 and 1989-90 winter fisheries.

Lake Akilasaaluk

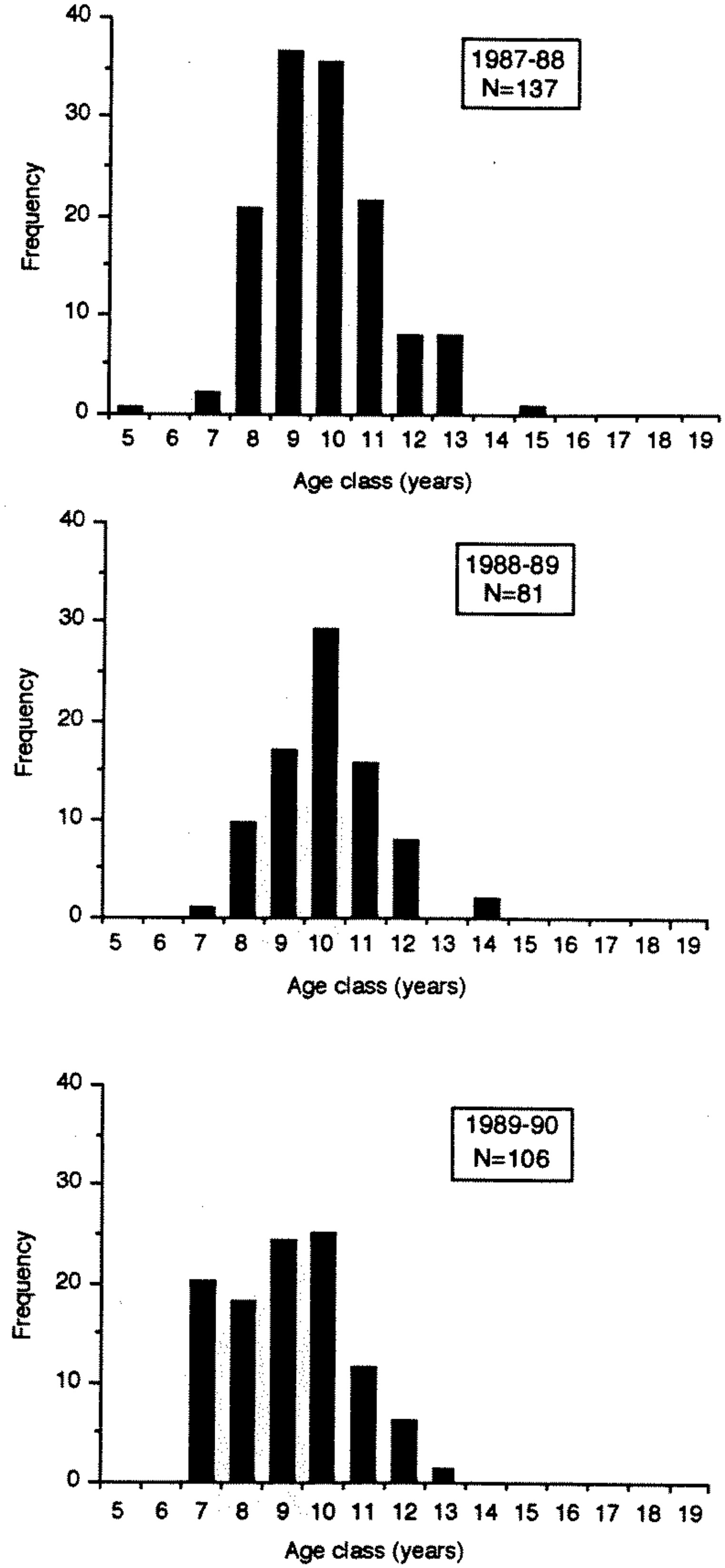


Figure 38. Age-frequency distribution of Lake Akilasaaluk Arctic charr sampled during the 1987-88, 1988-89 and 1989-90 winter fisheries.

Ijjurittuuq River

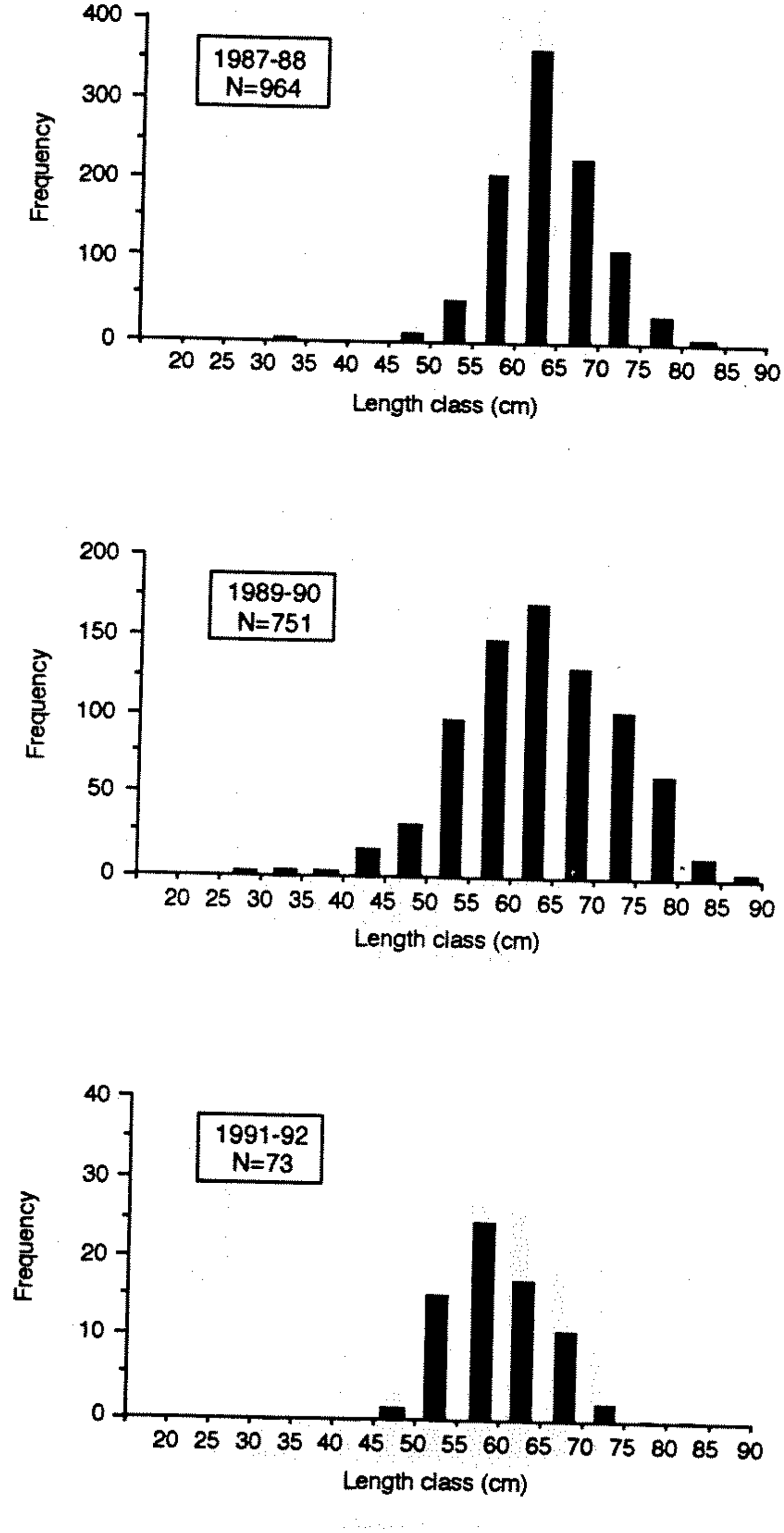


Figure 39. Length-frequency distribution of Ijjurittuuq River Arctic charr sampled during the 1987-88, 1989-90 and 1991-92 winter fisheries.

Ijjurittuuq River

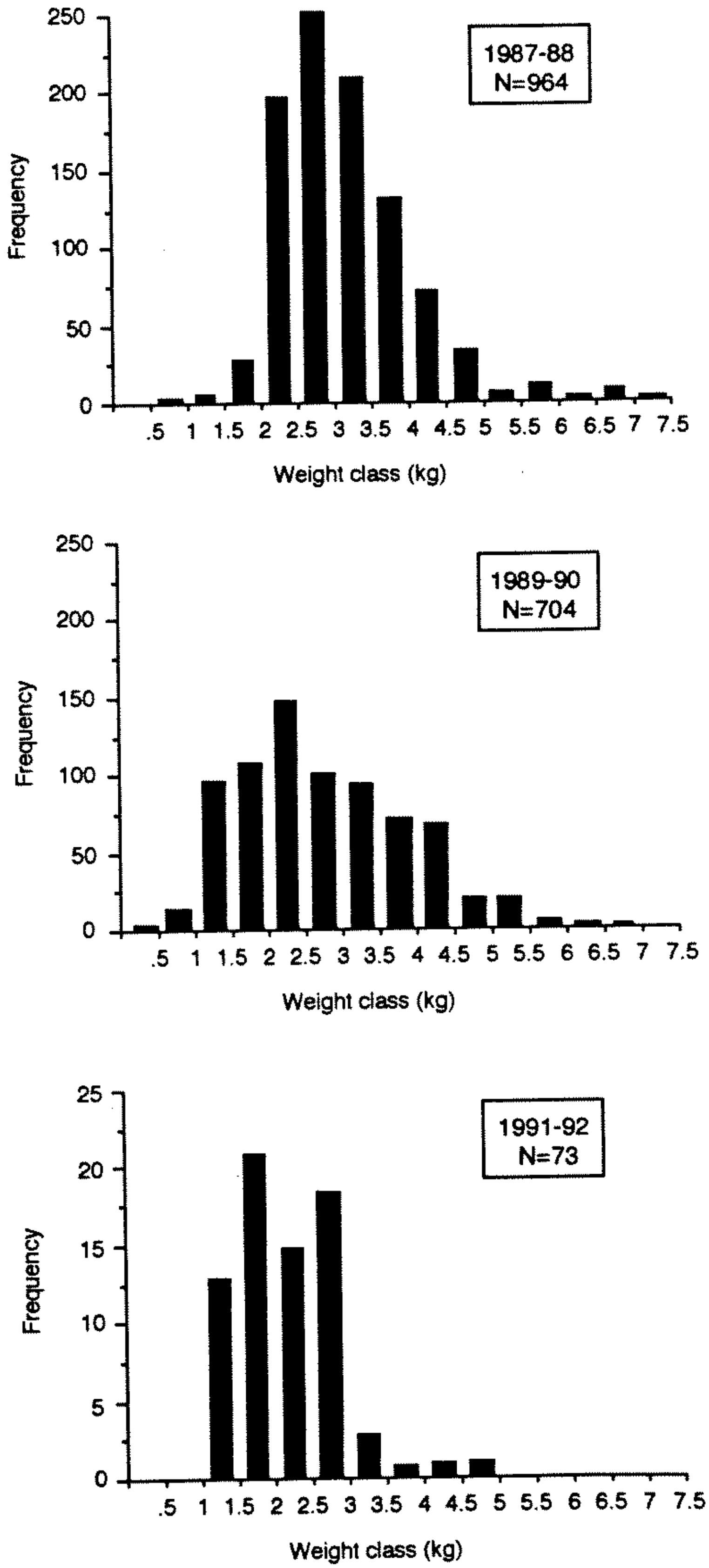


Figure 40. Weight-frequency distribution of Ijjurittuuq River Arctic charr sampled during the 1987-88, 1989-90 and 1991-92 winter fisheries.

Ijjurittuuq River

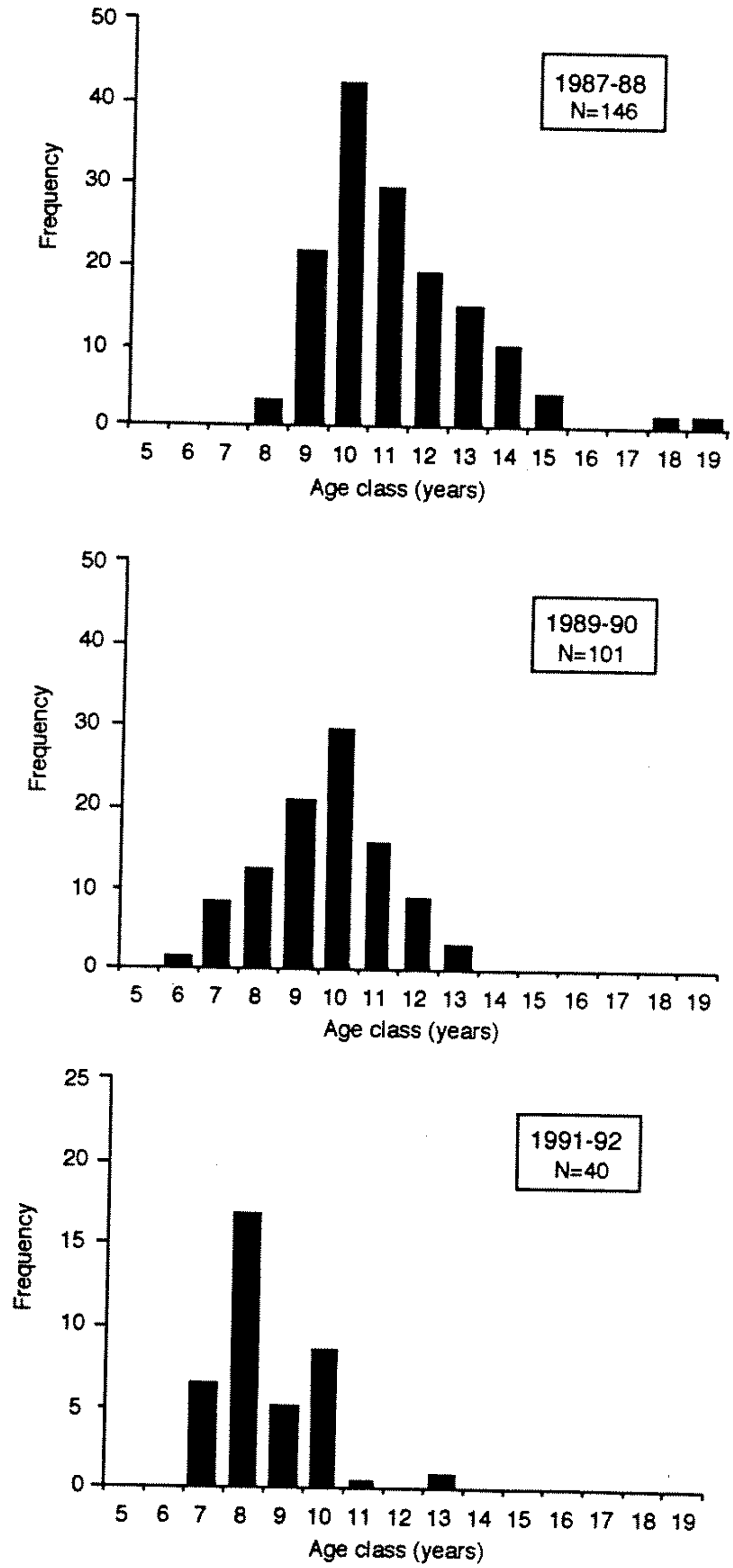


Figure 41. Age-frequency distribution of Ijjurittuuq River Arctic charr sampled during the 1987-88, 1989-90 and 1991-92 winter fisheries.

Lake Napaartulik

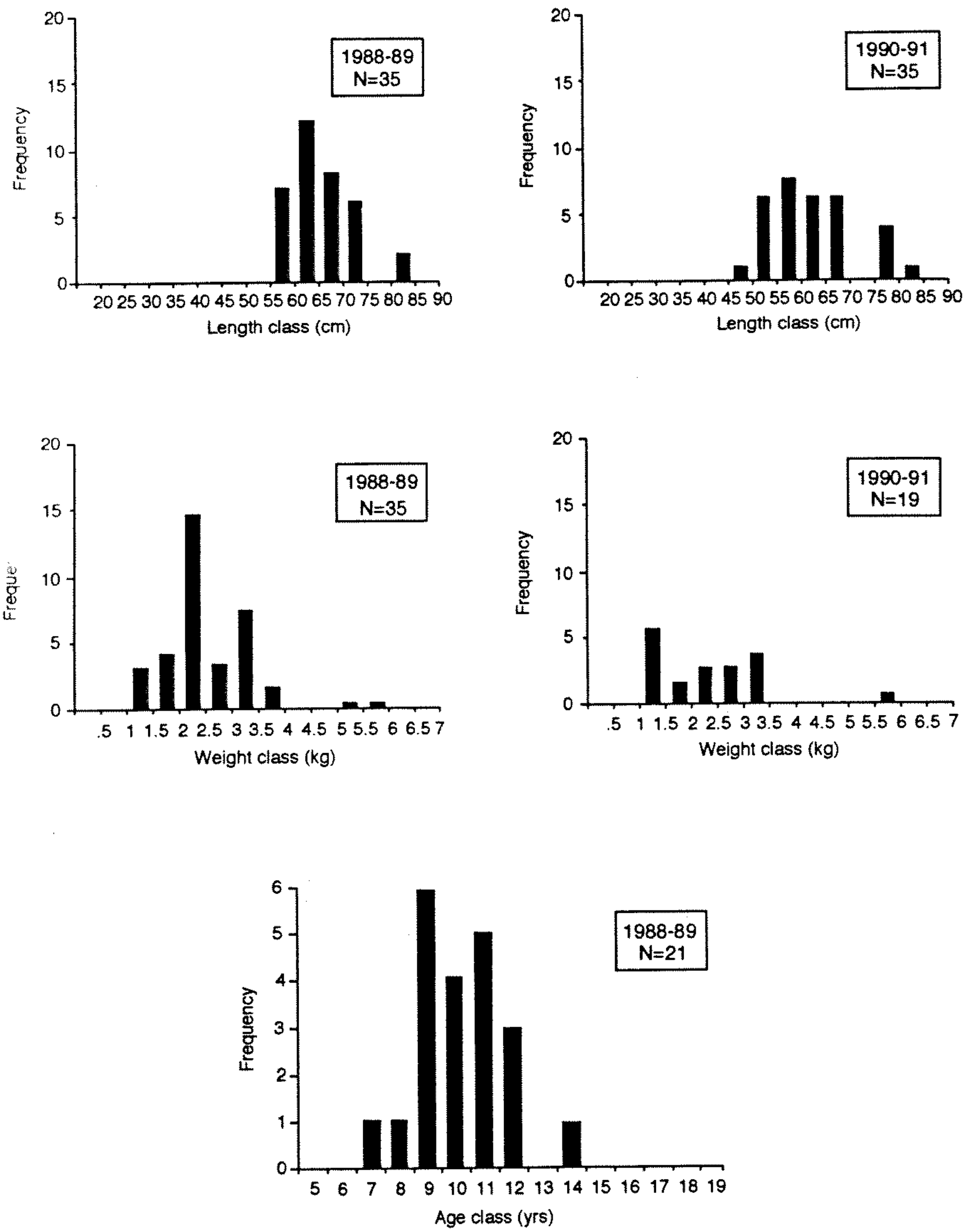
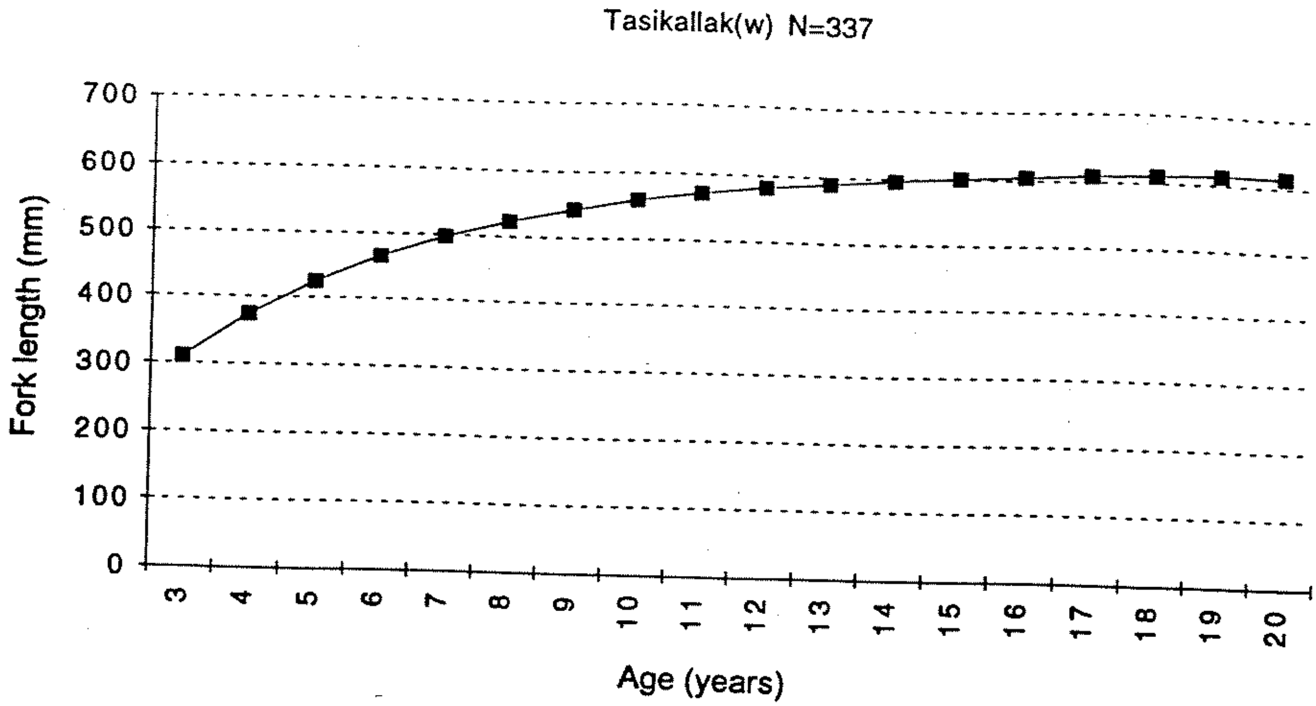


Figure 42. Length-, weight and age-frequency distributions of Lake Napaartulik Arctic charr sampled during the experimental-commercial winter fishery in 1988-89 and 1990-91.



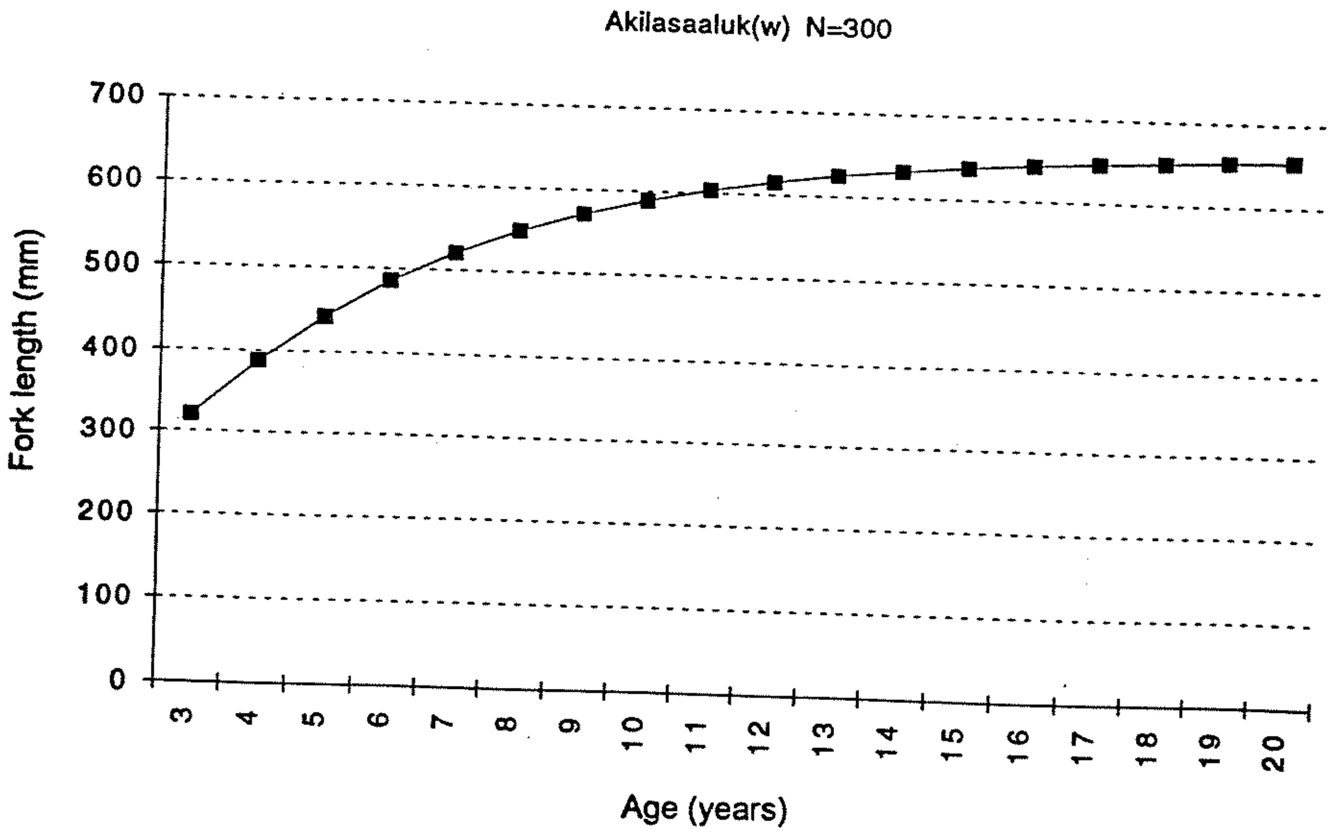
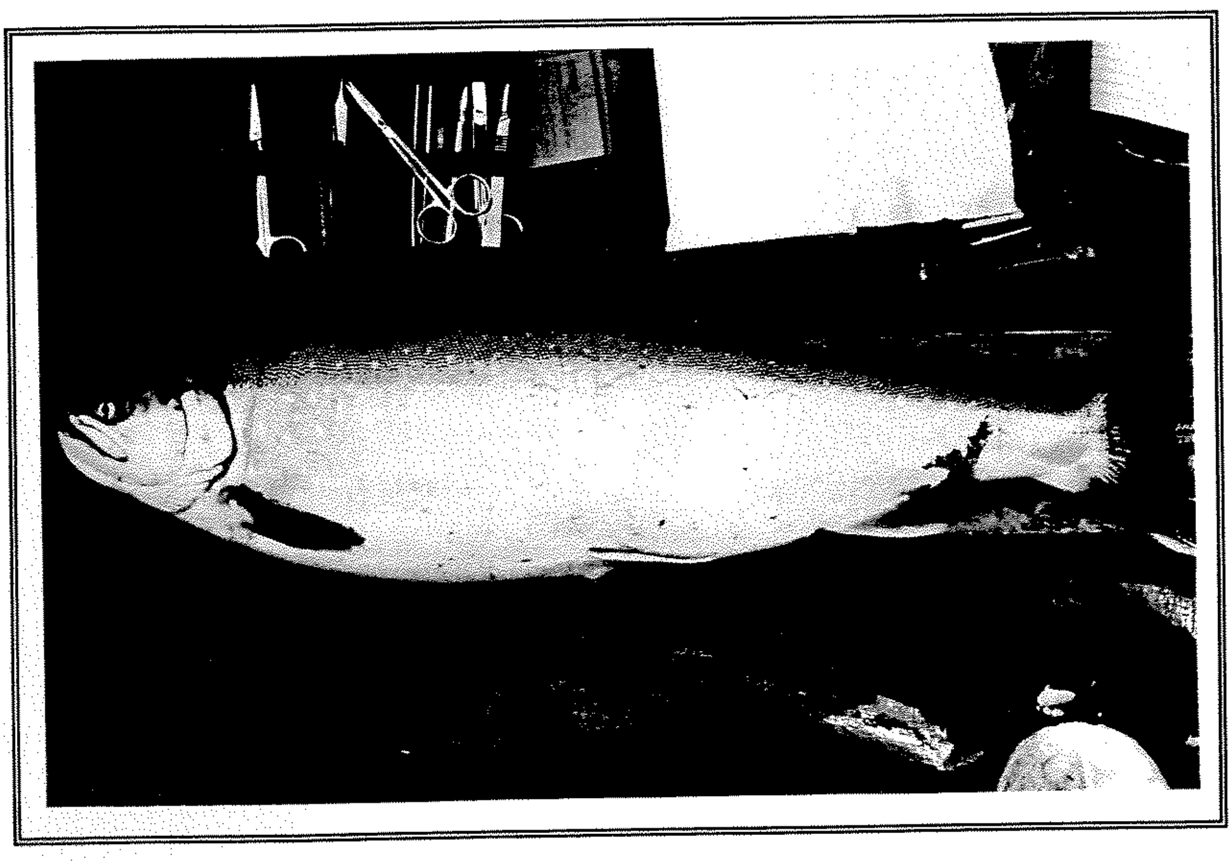


Figure 43. Length-at-age data for Lake Tasikallak and Akilasaaluk Arctic charr as calculated according to the von Bertalanffy model.

PLATES

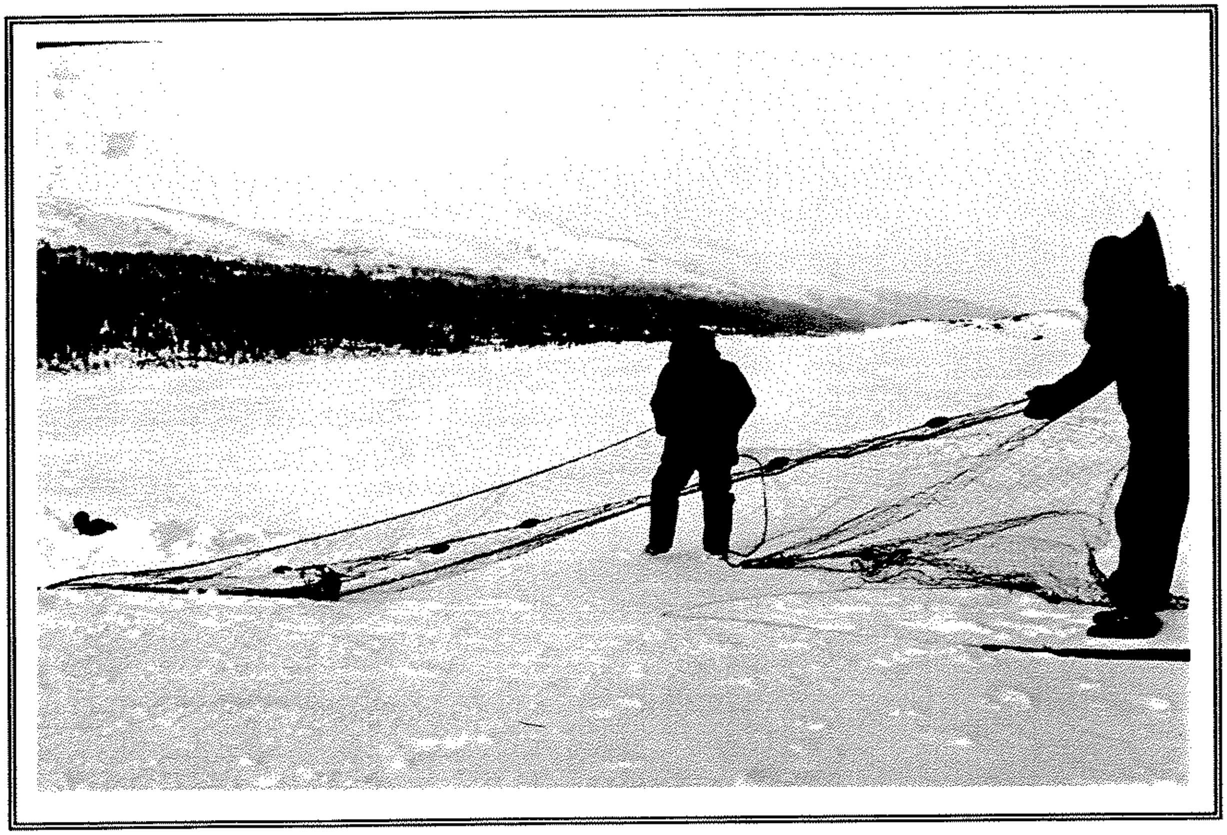
T. Boivin

Plate 1. Subsistence fishing for Arctic charr using kakivak (fishing spear).



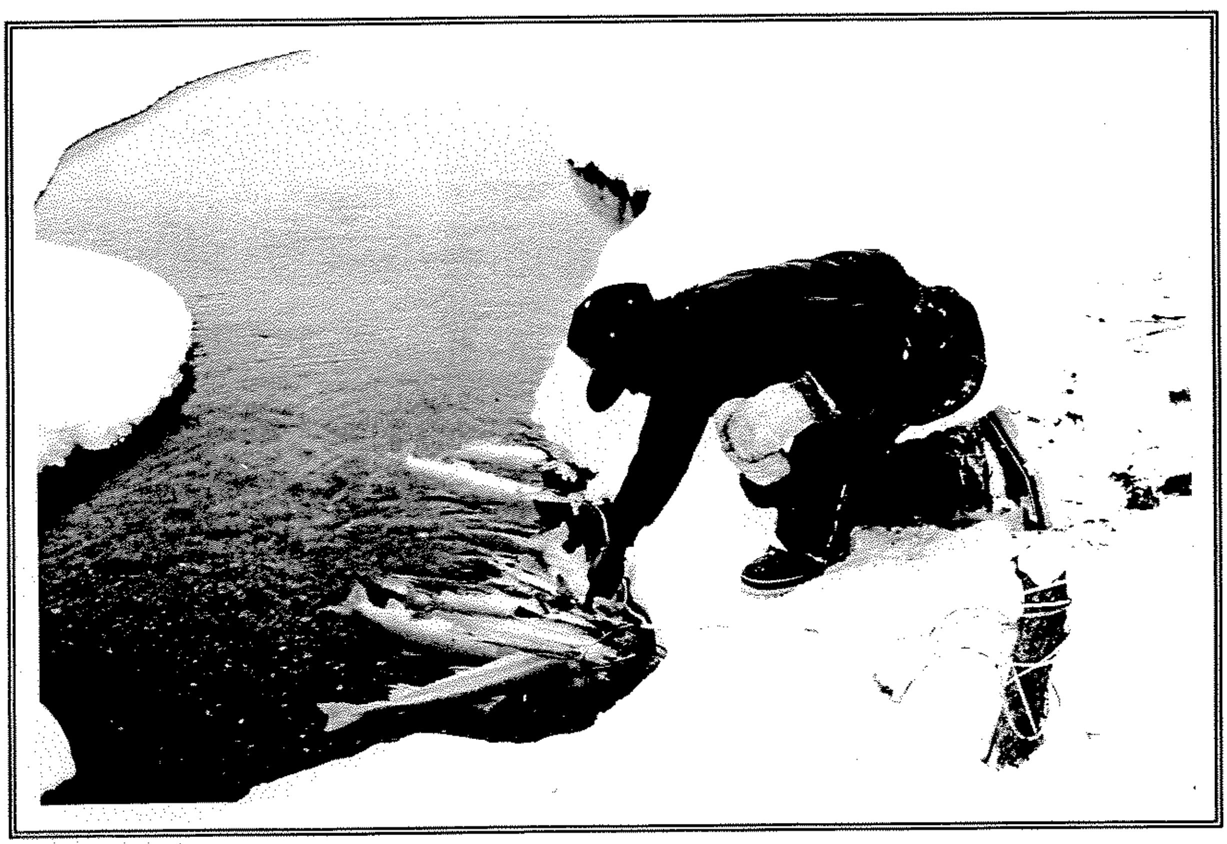
T. Boivin

Plate 2. Female Arctic charr sampled from Lake Tasikallak in late winter (April).



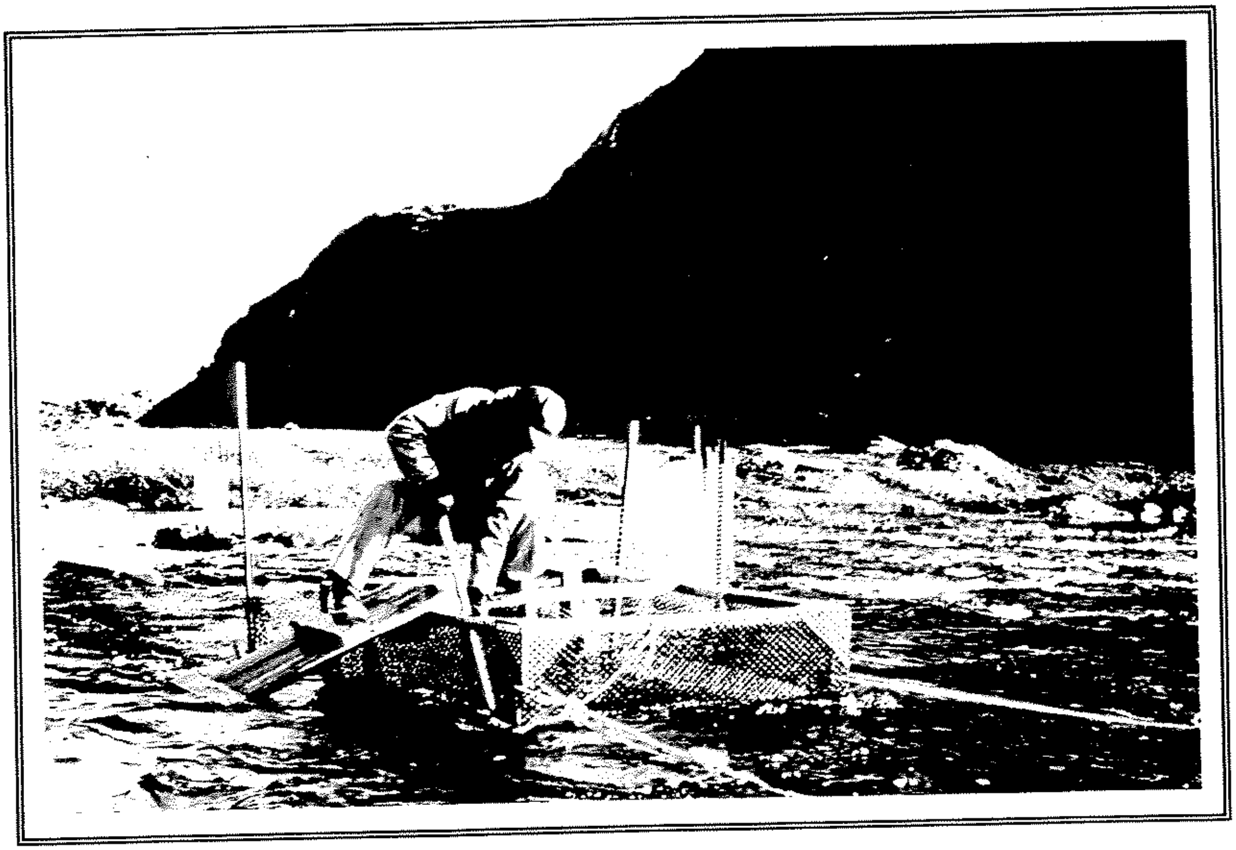
T. Boivin

Plate 3. Winter gillnet fishing for Arctic charr at Lake Tasikallak.



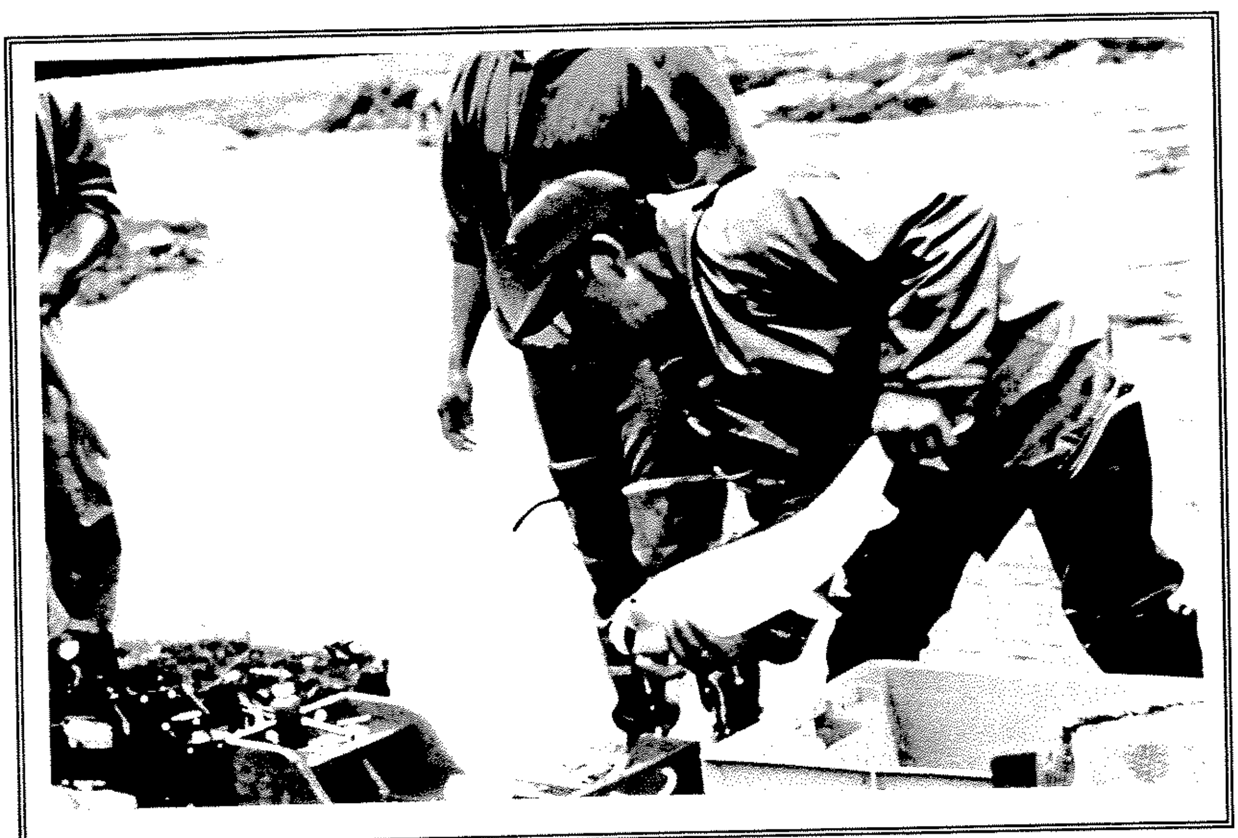
T. Boivin

Plate 4. Cleaning the commercial Arctic charr catch at Ijjurittuuq River.



M. Laplante

Plate 5. Removal of Arctic charr from the Lake Sapukkait counting fence.



M. Laplante

Plate 6. Transfer of Lake Sapukkait Arctic charr to the tagging box (1988).

L. Roy

Plate 7. Lake Sapukkait Arctic charr being released after sampling.

APPENDICES

APPENDIX 1:
RESEARCH TEAM, 1987-1992

APPENDIX 2:
INUIT REQUESTS FOR RE-ESTABLISHMENT OF THE ARCTIC CHARR FISHERY IN EASTERN UNGAVA, 1986

APPENDIX 3:
ALLOCATED COMMERCIAL QUOTAS AND TOTAL HARVESTS OF ARCTIC CHARR IN THE WINTER COMMERCIAL FISHERY, 1987-1992

APPENDIX 4:
HARVEST STUDY BOOKLET AND QUESTIONNAIRE

APPENDIX 5:
LENGTH-AT-AGE DATA FOR SAPUKKAIT ARCTIC CHARR AS DETERMINED BY BACK-CALCULATION

APPENDIX 1:

RESEARCH TEAM 1987-1992

RESEARCH TEAM, 1987-1992

Organization Committee:

Thomas Boivin	Makivik Corporation	Biologist
Louis Roy	MLCP	Biologist
Fritz Axelsen	MAPA	Biologist
Denis Vandal	MLCP	Department Head
Stas Olpinski	Makivik Corporation	Department Head
Lorraine Brooke	Makivik Corporation	Department Head
Jackie Koneak	Makivik Corporation	2nd Vice-President
Marcel Bernard	MLCP	Biologist
Sandy Gordon	KRG	Department Head
Bill Doidge	Makivik Corporation	Biologist
Gregory Kaminski	Makivik Corporation	Biologist

Landholding Corporations of Kangiqsualujjuaq and Taqpangajuk
Municipal Council of Kangiqsualujjuaq

Field personnel/Assistants to project:

Michel Laplante	MLCP	Technician
Thomas Boivin	Makivik Corporation	Biologist
Louis Roy	MLCP	Biologist
Fritz Axelsen	MAPA	Biologist
Denis Vandal	MLCP	Biologist
Marcel Bernard	MLCP	Biologist
Gregory Kaminski	Makivik Corporation	Biologist
Bill Doidge	Makivik Corporation	Biologist
Mark Kooktook	MLCP	Technician
Louis Bazin	MLCP	Technician
Normand Lizotte	MLCP	Technician
Vallee Saunders	MLCP	Conservation
Patrice Simon	U. of Waterloo	MSc. Student
Réjean Dumas	Makivik Corporation	Biologist
David Gillis	Makivik Corporation	Biologist
Chesley Mesher	Makivik Corporation	Technician
Camille Choquette	KRG	Assistant to promoter
Marc Allard	Seaku Fisheries	Manager
Allen Gordon	Makivik Corporation	Technician
Alix H. Gordon	Makivik Corporation	Technician
Peter May	Makivik Corporation	Technician
Elijah Sam Annanack	Kangiqsualujjuaq	Fieldworker
Henry Annanack	Kangiqsualujjuaq	Fieldworker
Minnie Mae Annanack	Kangiqsualujjuaq	Cook
Adamie Annanack	Kangiqsualujjuaq	Fieldworker
Joseph Sam Annanack	Kangiqsualujjuaq	Fieldworker
David Annanack	Kangiqsualujjuaq	Fisherman

Field personnel/Assistants to project (con'd):

Thomas E. Annanack	Kangiqsualujjuaq	Fieldworker
Tommy S. Annanack	Kangiqsualujjuaq	Fieldworker
Mark Sam Annanack	Kangiqsualujjuaq	Fieldworker
Bobby Baron	Kangiqsualujjuaq	Fieldworker/ Fisherman
Jimmy Baron	Kangiqsualujjuaq	Fieldworker
Simeonie Baron	Kangiqsualujjuaq	Fieldworker
Lucas Billy Etok	Kangiqsualujjuaq	Fieldworker
Joe Willie Thomas Etok	Kangiqsualujjuaq	Fieldworker
Tommy George Etok	Kangiqsualujjuaq	Fieldworker
Sanak Unatweenuk	Kangiqsualujjuaq	Fieldworker
Matthew Unatweenuk	Kangiqsualujjuaq	Fieldworker
Willie Snowball	Kangiqsualujjuaq	Fieldworker
Maggie Emudluk	Kangiqsualujjuaq	Translation
Michael Gordon	Kuujjuaq	Translation
Mae Saunders	Kuujjuaq	Translation
Marie Cécile Brasseur	Montréal	Translation
Colin Bird	Montréal	Computer
Danny Gallant	Montréal	Computer
Sammy Cantafio	Montreal	Transportation
Billy May	Kuujjuaq	Transportation
David Koneak	Kuujjuaq	Transportation

Age interpretation:

Peter May	Makivik Corporation
Allen Gordon	Makivik Corporation
Chesley Mesher	Makivik Corporation
Alix H. Gordon	Makivik Corporation
Thomas Boivin	Makivik Corporation
Michel Laplante	MLCP
Normand Lizotte	MLCP
Louis Roy	MLCP

APPENDIX 2:

INUIT REQUESTS FOR RE-ESTABLISHMENT OF THE ARCTIC CHARR FISHERY IN EASTERN UNGAVA

LANDHOLDING CORPORATION OF KANGIQSUALUJJUAQ
RESOLUTION #86-6 APPROVING THE PROPOSED
WINTER ARCTIC CHARR FISHERY, APRIL 24, 1986

RESOLUTION NO. 86-6

Minutes of a meeting of the board of directors of Qiniqtik Corporation held at Kangirsualujjuaq on the 24 day of APRIL. 1986. At the office of Qiniqtik Croporation.

WHEREAS the community of George River has received a request from Annanack and Sons for the approval of this commercial fishing project;

WHEREAS the communities feels it has enough resource for commercial use;

WHEREAS also the community needs more date on the resources potential in the area;

WHEREAS the community needs more jobs that could generate revence;

THEREFORE hereby resolved that Annanack and Sons be given approval for their project under the following conditions:

Catch Limits:

Arctic Char	-	45,000 lbs
Lake Trout	-	10,000 lbs
Landlocked Char	-	6,500 lbs
Total		61,500 lbs

Monitoring: that Annanack and Sons monitor and control fishermen's catches on the designated lakes and river systems of our community and that such information be forwarded to the proper authorties upon request.

Directors of LANDHOLDING CORPORATION here to sign:

ᓱᑕᓕᓵᓐ
President.

ᐊᓄᓇᒃ
Vice-President

ᑕᒥᓯ
Secretary-Tresurer

ᒍ ᐱᓕᒃ
Director

ᕿᒥᐅᖅ ᐸᑐ
Director

ᐸᐃᐸᒃ
Director

Director

COMMERCIAL QUOTAS AS DETERMINED BY THE INUIT OF KANGIQSUALUJJUAQ

PINNANACK AND SONS

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ᓵᓐᓂᑦ	1.000	
ᑕᕐᕆᑲᓐᑦ	2.000	ᑕᕐᕆᓯ ᐅᖃᓕᒪᓴᖅᑲᓄᑦ
ᐸᐅᔪᑦ	2.000	ᑕᓇᐅᓕᒥᒍ
ᐊᑭᓇᓴ ᓄᑦ	3.000	ᐃᓗᓕᖅᓴᐅᓴᑦ
ᓇᓴᑐᓂᑦ	3.000	
ᐃᓴᓂᑦᑐᒃ	15.000	
ᓴᐳᑲᐃᑦ	5.000	
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ᑐᓄᓂᑦ	4.000	
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ᑲᑎᓂᑲ 61.500

ᐃᑲᓗᐱ 45.000

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ᐱᔪᕐᓕᕆᑦ 6.500

ᔭᓄᐊᕆ 27 1986

ᐸᔪᓂᑲᓪᓗ ᑲᑎᖓᔪᓯᐅᓴᕆᔭ ᐊᑭᕈᑎᖏᑦ ᑕᕐᕆᑦ ᐸᓇᐅᖓᓐᓂᖅ ᐃᑲᓗᓂᖅ ᓄᐃᑭᕈᕐᑕᕈᒪ-ᓂᖏᑦ ᓂᕐᕈᑎᖏᑦ ᑐᑕᓄᐃᕐᒪᐅᑎᑦ ᐊᑭᑕᓕᒪᑦ ᑕᕐᕆᓄᑦ ᑕᓇᐅᒥᒍ ᐸᑭᕐᒪᓴᑐᑦ ᐃᑲᓗᐱ 1986ᒥ 45.000ᓂᑦ ᓄᑎᓕᑦ 10.000ᓂ ᐃᓯᐅᖃᑕᑦ 6.500ᓂ ᑲᑎᖓᑦ 61.500 ᐸᖅᑭᑕᒪᑐᑕᑲᓴ ᐊᖅᑭ ᑕᒪᑦ ᐸᑭᑎᐸᑲᑕᓂᐊᑎᑐᕐᑦ ᐱᓴᐅᓂᕐᑦ ᑕᑐᓄᑎ ᑐᖃᓴᑕᐊᓂᕐᑦ ᐃᐱᑎᑐᑎᑦ ᑲᒪᑎᕆᓄᑐᑎ ᐱᓴᕐᑎᑦ ᐸᔪᓂᑲᓪᓗ ᐃᐱᑎᓄᕐᑲᓴᕐᑎᑦ

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ᑐᑦᑕᑦ

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ᑲᑎᑲᕐ ᓴ ᓯᐱᓴᒥᔭᓄᓇ

ᑲᑎᑲᕐ [signature]

ᑲᑎᑲᕐ

LETTER FROM KATIVIK REGIONAL DEVELOPMENT COUNCIL TO QUEBEC GOVERNMENT MINISTRIES

ᒉᕖᒃ ᓄᓇᓕᓕᒫᑦ ᐱᕚᓪᓕᐊᔭᓕᑎᓚᐅᕐᒥᑕ ᑲᑎᑦᑕᑎᕐᒥᑦ

Conseil Régional de Développement KATIVIK

KATIVIK Regional Development Council

C.P. 9, KUUJJUAQ, QUÉBEC, J0M 1C0 • TÉL.: (819) 964-2941

April 30, 1986

Mr. Camille Choquette
SAGMAI coordinator
MAPAQ
Kuujjuaq, Québec
J0M 1C0

Ref.: Experimental - commercial fishing project
Annanack & Sons

Sir,

The object of this letter is to request a commercial fishing permit for Annanack & Sons to catch and distribute 61,500lbs of char and lake trout in the lakes and rivers in the area Kangirsualujjuaq.

According to your criteria, the company has obtained a resolution from its landholding corporation supporting the project as well as the volume of fish to be caught.

This project, like that of Gordon, Koneak, Watt fisheries will be experimental in scope (in that there is no data available) and therefore the company will comply with the obligation of submitting to proper authorities all data pertinent to the sound management of the species and the fishing process.

If you should require additionnal information please do not hesitate to contact David Annanack (819-337-5292) or myself.

Sincerely,

Jean Guy Bousquet
Coordinator

JGB/dt

cc: Pierre Vagneux, MAPAQ
Gilles Harvey, MLCP
Yan Juniper, Aniturvik

Encl.

APPENDIX 3:

ALLOCATED COMMERCIAL QUOTAS AND TOTAL HARVESTS OF ARCTIC CHARR IN THE WINTER COMMERCIAL FISHERY, 1987-1992

APPENDIX 3

Allocated quotas (numbers of charr) for the 1987-1988 winter commercial fisheries, total commercial harvests and mesh sizes employed at each system.

Location	Quota (#)	Harvest *	Rejects	Surplus	Total	Mesh (cm)
George River	300	not fished				
Koroc R.	150	150	14	6	170	11.4
L. Tasikallak	200	201	26	14	241	11.4
L. Qaarlik	100	101	16	1	118	11.4
L. Akilasaaluk	545	499	54	0	553	11.4
Ijjurittuuq R.	1250	944	85	0	1029	14.0
L. Sannirarsiq**	900	24	0	0	305	11.4
L. Napaartulik	425	not fished				
Qijujjujaq R.	770	not fished				
Allurilik R.	520	not fished				
L. Sapukkait	770	not fished				
Inussulik R.	770	not fished				
TOTAL	6700	1919	195	21	2416	

* commercially-tagged Arctic charr
** research gillnet fishery

Allocated quotas (numbers of charr) for the 1988-1989 winter commercial fisheries, total commercial harvests and mesh sizes employed at each system.

Location	Quota (#)	Harvest *	Rejects	Surplus	Total	Mesh (cm)
George River	300	300	37	41	378	11.4
Koroc R.	150	150	13	0	163	11.4
L. Tasikallak	200	200	32	108	340	11.4
L. Qaarlik	100	100	10	0	111	11.4
L. Akilasaaluk	545	489	46	0	535	11.4
Ijjurittuuq R.	1250	not fished				
L. Sannirarsiq	900	241	8	0	249	11.4
L. Napaartulik	425	35	0	0	35	11.4
Qijujjujaq R.	770	not fished				
Allurilik R.	520	not fished				
Inussulik R.	770	not fished				
TOTAL	5930	1515	146	148	1810	

* commercially-tagged Arctic charr

Allocated quotas (numbers of charr) for the 1989-1990 winter commercial fisheries, total commercial harvests and mesh sizes employed at each system.

Location	Quota (#)	Harvest *	Rejects	Surplus	Total	Mesh (cm)
L. Tasikallak	200	200	9	18	227	11.4
L. Akilasaaluk	545	286	19	0	305	11.4
Ijjurittuuq R.	1000	742	10	0	752	14.0
L. Napaartulik	425	not fished				
Qijujjujaq R.	770	not fished				
Allurilik R.	520	not fished				
Inussulik R.	770	not fished				
TOTAL	4230	1228	38	18	1284	

* commercially-tagged Arctic charr

Allocated quotas (numbers of charr) for the 1990-1991 winter commercial fisheries, total commercial harvests and mesh sizes employed at each system.

Location	Quota (#)	Harvest *	Rejects	Surplus	Total	Mesh (cm)
L. Tasikallak	200	120	0	0	120	11.4
L. Akilasaaluk	545	not fished				
Ijjurittuuq R.	1000	not fished				
L. Napaartulik	425	35	0	0	35	11.4
Qijujjujaq R.	770	not fished				
Allurilik R.	520	not fished				
Inussulik R.	770	not fished				
TOTAL	4230	155	0	0	155	

* commercially-tagged Arctic charr

Allocated quotas (numbers of charr) for the 1991-1992 winter commercial fisheries, total commercial harvests and mesh sizes employed at each system.

Location	Quota (#)	Harvest *	Rejects	Surplus	Total	Mesh (cm)
L. Tasikallak	200	65	0	0	65	11.4
L. Akilasaaluk	545	not fished				
Ijjurittuuq R.	1000	73	0	0	73	14.0
L. Napaartulik	425	not fished				
Qijujjujaq R.	770	not fished				
Inussulik R.	770	not fished				
TOTAL	3710	138	0	0	138	

* commercially-tagged Arctic charr

APPENDIX 4:

HARVEST STUDY BOOKLET AND QUESTIONNAIRE

The goal of the Kangiqsualujjuaq Fish Study is to estimate the number of all fish species, especially Arctic char, which are harvested by the community.

It is important that we record the total number of fish harvested by the Kangiqsualujjuamiut. The information obtained will be used to evaluate the fish populations of each area, and to help in the management of the local fishery. The identity of each hunter/fisherman will be kept anonymous.

In order to obtain the best possible information, it is important that the hunters record the following:

1) The location where fish were harvested and date of catch

2) The number of fish (by species) that you catch every day, by net or with other fishing methods (jigging, kakivak, gaff)

3) The number of nets you use every day, <u>even</u> if you did not catch any fish

The family head should record all fish caught by member of his immediate family (spouse and children) who do not have their own booklet

Thank you for your cooperation with this study.

Date:
ᐅᓪᓗᖓ: ______

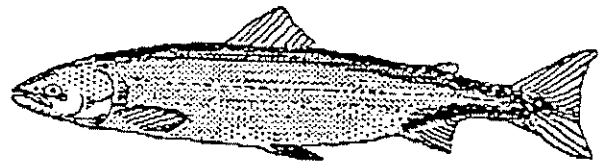
ᓇᓂ ᐃᖃᓗᓯᐅᖅᐱᑦ ᐅᓪᓗᒥ?
Where did you fish today? ______

ᖃᔅᓯᓂᒃ ᓄᓗᐊᓂᒃ ᐊᑐᖅᐱᑦ ᐅᓪᓗᒥ?
How many nets did you use today? [ ]

ᐃᖃᓗᐃᑦ Fish Species	ᓄᓗᐊᓄᑦ Net Catch		Jigging ᐊᐅᓚᓯᖕ	Kakivak or Gaff ᓂᕐᔭᑦᑕᐅᑦ ᑲᑭᕙᑦᑐᓂ
	Good ᒪᒪᓯᒪᔪᑦ	Spoiled ᒪᒪᓯᒪᙱᑦ		
ᐃᖃᓗᒃᐱᑦ Arctic Char				
ᓄᑭᑖᑦ Land Locked Char				
ᐃᓯᐅᕋᓕᒃᑖᖅ Lake Trout				
ᐊᓇᐃᑦ Brook Trout				
ᑲᐱᓯᓕᒃ Whitefish				
ᓴᓚᐃᑦ Atlantic Salmon				
ᖃᓂᕐᑯᖅ/ᑲᓇᔪᐃᑦ Sculpins				
ᐅᒐᐃᑦ Cod Fish				

Have you filled in all the information (date, location, catch)?
ᐊᓪᓚᑭᐊᓂᓕᒪᑦ ᐊᓪᓚᓯᒪᕙᑎᑦ (ᐅᓪᓗᖓ, ᓇᓂᓐᓂᖓ
ᐊᖑᓚᐅᕐᓂᖓ)?

Kangiqsualujjuaq Fish Study
Harvest Questionnaire



Fisherman's name: ____________ # Nets used: 2

Fishing Location: George River # Days fishing by net 2

Date (month/day): Sept 21 91

Mark "X" for net catch; "√" for rod; "*" for Jigging; and "Y" for Kakivak

Fish species	0	1-10	11-20	21-30	31-40	41-50	51-75	76-100	>100 (or approx)
	Number of fish captured								
Arctic charr	☐	☐	☐	☐	☒	☐	☐	☐	☐
Red charr	☐	☒	☐	☐	☐	☐	☐	☐	☐
tlantic salmon	☐	☐	☐	☐	☐	☐	☐	☐	☐
rook trout	☐	☐	☐	☐	☐	☐	☐	☐	☐
ake trout	☐	☒	☐	☐	☐	☐	☐	☐	☐
hitefish	☐	☐	☐	☐	☐	☐	☐	☐	☐
culpins	☐	☐	☐	☐	☐	☐	☐	☐	☐
ther species	☐	☐	☐	☐	☐	☐	☐	☐	☐

f you caught these fish with other fishermen, please name them:

____

Did you catch any tagged fish? ☐ Yes ☐ No Spaghetti tag ☐ Carlin Tag ☐

f yes, where did you catch it? ____________ 1234 •1234

Tag number: ____________ Length of fish ____________

ate of capture ____________ Comments: ____________

APPENDIX 5:

LENGTH-AT-AGE DATA FOR SAPUKKAIT ARCTIC CHARR AS DETERMINED BY BACK-CALCULATION

NO SPEC.	Length (mm) at Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	AGE TOTAL	Total Length (mm)
2782	65.2	104.3	136.9	166.2											4	189.0
2828	53.6	85.7	135.7	185.7											4	200.0
2885	76.1	114.1	171.2	199.7	214.0										5	233.0
2909	70.7	114.9	190.1	229.9											4	252.0
2799	66.9	133.8	185.9	230.5	267.7										5	290.0
2857	83.0	129.1	216.6	258.1											4	295.0
2815	80.2	120.3	169.3	222.8	267.4										5	303.0
2876	77.5	137.8	163.7	206.8	254.2	297.2									6	336.0
2770	86.7	173.3	216.6	260.0	293.7										5	337.0
2900	88.7	133.1	177.4	230.7	292.8	319.4									6	346.0
1111	119.7	188.1	239.4	319.2	376.2	416.1	450.3	490.2	513.0	547.2					10	570.0
1086	117.2	173.0	273.5	340.5	396.3	463.3	513.5	552.6	586.1						9	614.0
1110	107.8	188.7	258.8	312.7	377.4	442.1	474.4	501.4	539.1	571.5	593.0				11	620.0
1085	101.2	213.5	309.1	359.6	421.5	466.4	505.8	539.5	573.2	601.3	623.8				11	635.0
1108	104.5	187.0	247.5	319.0	379.5	451.0	489.5	528.0	566.5	594.0	616.0	638.0			12	660.0
1084		Otolithe brisée													13	682.0
1100	67.2	140.0	190.3	235.1	285.5	347.1	414.3	464.7	503.9	543.0	571.0	615.8	638.2	660.6	14	683.0
1083	89.1	193.8	261.9	335.3	387.7	440.1	497.7	544.8	576.3	618.2	644.4	670.6	691.5		13	702.0
1097	78.8	135.1	197.1	253.4	354.7	411.0	467.4	529.3	574.3	608.1	641.9	670.1	692.6	715.1	14	732.0
1082	96.0	144.0	204.0	264.0	324.0	402.0	468.0	516.0	564.0	612.0	642.0	672.0	702.0	726.0	14	750.0
52	117.3	176.0	229.3	282.7	325.3	378.7	437.3	480.0							8	480.0
62	84.6	150.4	183.3	235.0	300.7	361.8	413.5	451.1	484.0						9	484.0
53	121.1	221.2	258.0	316.0	373.9	421.3	463.4	495.0							8	495.0
9	105.6	170.9	231.3	296.6	341.9	392.1	442.4	482.6	517.8	553.0					10	553.0
61	94.2	146.5	204.1	256.4	329.7	392.5	434.4	465.8	497.2	539.1	560.0				11	560.0
72	92.1	151.8	216.8	260.2	309.0	352.3	412.0	455.3	487.9	520.4	552.9	580.0			12	580.0
8	81.2	135.3	189.4	249.0	286.9	341.0	389.7	433.0	470.9	519.6	562.9	590.0			12	590.0
21	85.0	156.9	248.5	320.4	372.7	425.0	464.2	490.4	536.2	568.8	595.0				11	595.0
59	111.8	172.7	213.4	289.6	350.6	406.5	442.0	497.9	548.7	589.4	630.0				11	630.0
36	123.0	199.1	245.9	316.2	368.9	415.8	462.6	503.6	556.3	591.4	620.7	650.0			12	650.0
20	103.3	180.8	316.4	361.6	419.7	477.8	523.0	574.6	613.3	632.7	665.0				11	665.0
70	110.1	181.6	225.7	280.7	335.7	407.3	462.3	511.9	555.9	583.4	622.0	649.5	671.5	688.0	14	688.0
12	100.8	143.3	207.0	276.0	355.6	403.4	456.5	509.5	541.4	594.5	631.6	663.5	690.0		13	690.0
69	85.5	123.0	165.7	224.5	294.0	358.2	406.3	459.8	497.2	545.3	593.4	636.2	668.3	695.0	14	695.0
16	88.7	162.7	221.8	305.6	374.6	409.1	468.3	517.6	571.8	606.3	630.9	655.6	695.0		13	695.0
18	89.4	129.1	173.8	223.4	273.0	347.5	417.0	466.6	516.3	565.9	610.6	645.4	695.0		13	695.0
35	101.7	161.5	233.3	311.1	382.9	460.7	508.5	550.4	586.3	616.2	646.2	670.1	700.0		13	700.0
71	106.1	176.8	247.6	306.5	394.9	453.9	506.9	554.1	595.3	630.7	672.0	701.4	725.0		13	725.0
58	101.6	152.3	196.8	247.6	349.1	425.3	482.4	526.9	571.3	609.4	641.1	666.5	698.3	730.0	13	730.0
27	107.3	190.7	280.1	357.6	429.1	488.7	542.4	590.0	625.8	655.6	685.4	709.2	727.1	751.0	13	745.0

Length-at-age of Sapukkait Arctic charr as determined by back-calculation performed by Schooner Environmental Consultants.

NO SPEC.	Length (mm) at Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	AGE TOTAL	Total Length (mm)
2782	78.8	112.9	141.8	165.4											4	189.0
2828	60.3	93.2	131.5	175.3											4	200.0
2885	107.5	143.4	179.2	211.5											4	233.0
2909	77.0	119.0	143.5	178.5	231.0										5	252.0
2799	78.8	112.6	140.8	185.8	230.9	264.7									6	290.0
2857	93.5	133.1	172.7	219.5	251.8										5	295.0
2815	69.6	102.4	196.5	253.9											4	303.0
2876	114.3	138.6	166.3	207.8	252.9	301.4									6	336.0
2770	106.0	159.0	223.4	276.4	310.5										5	337.0
2900	86.5	131.5	169.5	221.4	276.8	325.2									6	346.0
1111	139.1	206.5	260.3	327.6	395.0	435.4	471.3	498.2	525.1	552.0					10	570.0
1086	122.8	193.0	271.9	328.9	403.5	469.3	508.7	557.0	592.1						9	614.0
1110	127.3	184.8	254.6	328.5	394.2	447.5	492.7	554.3	587.2						9	620.0
1085	135.5	220.1	304.8	376.8	465.7	499.5	537.6	571.5	601.1						9	635.0
1108	127.9	202.1	264.0	334.1	445.5	495.0	528.0	565.1	594.0	614.6	639.4				11	660.0
1084	118.2	154.6	191.0	250.1	350.1	413.7	468.3	513.8	554.7	591.1	636.5				11	682.0
1100	89.6	153.7	200.6	251.9	290.3	350.0	405.5	452.5	486.6	537.9	580.6	640.3			12	683.0
1083	123.2	205.3	279.2	361.3	402.3	443.4	488.5	546.0	587.1	632.2	660.9	673.3	693.8		13	702.0
1097	135.9	197.2	263.0	306.8	355.0	407.6	469.0	530.4	583.0	609.3	640.0	675.0	705.7		13	732.0
1082	167.7	232.9	298.1	340.1	414.6	484.5	549.7	591.6	633.5	670.8	708.1	726.7			12	750.0
52	122.0	174.9	227.8	276.6	337.6	398.6	447.5	480.0							8	480.0
62	102.7	154.0	183.3	242.0	300.7	363.0	403.3	447.3	484.0						9	484.0
53	136.1	210.4	264.0	309.4	387.8	437.3	470.3	495.0							8	495.0
9	88.8	145.3	209.9	258.3	327.0	371.4	403.6	460.2	504.6	528.8	553.0				11	553.0
61	90.6	127.6	197.6	255.3	329.4	382.9	420.0	473.5	518.8	560.0					10	560.0
72	108.5	166.9	225.3	267.1	317.1	367.2	413.1	454.8	484.0	513.2	550.8	580.0			12	580.0
8	87.6	138.3	193.6	244.3	308.8	354.9	405.6	437.9	488.6	530.1	557.7	590.0			12	590.0
21	119.0	186.3	274.2	331.1	393.2	445.0	481.2	512.2	548.4	574.3	595.0				11	595.0
59	131.6	183.4	227.3	287.1	358.9	414.7	462.5	510.4	554.2	598.1	630.0				11	630.0
36	122.5	183.7	244.9	325.0	372.1	419.2	461.6	508.7	555.8	593.5	626.4	650.0			12	650.0
20	112.5	179.0	230.2	296.7	363.2	424.6	470.6	526.9	572.9	613.8	644.5	665.0			12	665.0
70	119.1	185.2	229.3	286.7	344.0	414.6	476.3	520.4	564.5	599.8	626.3	652.7	670.4	688.0	14	688.0
12	108.1	158.0	203.7	266.0	315.9	378.3	428.1	465.5	507.1	544.5	602.7	636.0	660.9	690.0	14	690.0
69	89.9	130.8	179.9	233.0	298.4	367.9	412.9	462.0	511.0	551.9	601.0	637.8	666.4	695.0	14	695.0
16	116.5	198.0	267.9	357.2	415.4	504.7	543.6	597.9	636.8	675.6	695.0				11	695.0
18	91.9	143.8	215.7	267.6	343.5	415.4	463.3	511.3	559.2	595.1	639.1	695.0			12	695.0
35	158.2	220.5	297.3	407.5	469.9	513.0	551.4	589.7	637.7	661.6	700.0				11	700.0
71	120.8	198.2	265.8	348.0	425.3	483.3	531.7	570.3	609.0	647.7	700.8	725.0			12	725.0
58	146.0	187.7	245.1	349.4	417.1	490.1	531.9	578.8	615.3	677.9	730.0				11	730.0
27	97.8	190.9	270.1	353.9	433.0	493.6	549.4	591.3	619.3	651.9	689.1	712.4	745.0		13	745.0

Length-at-age of Sapukkait Arctic charr as determined by back-calculation performed by MLCP.

NO SPEC.	Length (mm) at Age (years)														AGE TOTAL	Total Length (mm)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
2782	59.7	99.5	129.3	159.2											4	189.0
2828	55.6	88.9	144.4	177.8	188.9										5	200.0
2885	83.2	116.5	133.1	183.1	199.7										5	233.0
2909	66.3	119.4	145.9	185.7	225.5										5	252.0
2799	69.6	116.0	139.2	185.6	232.0	278.4									6	290.0
2857	70.2	126.4	154.5	196.7	252.9										5	295.0
2815	57.7	129.9	158.7	230.9	274.1										5	303.0
2876	112.0	140.0	168.0	210.0	252.0	294.0									6	336.0
2770	107.2	153.2	245.1	275.7											4	337.0
2900	86.5	135.9	160.6	222.4	271.9	321.3									6	346.0
1111	114.0	179.1	244.3	325.7	374.6	423.4	472.3	521.1							8	570.0
1086	122.8	175.4	280.7	350.9	421.0	491.2	543.8	578.9							8	614.0
1110																620.0
1085	138.9	238.1	317.5	377.0	416.7	476.3	515.9	535.8							8	635.0
1108																660.0
1084		Otolithe brisée														682.0
1100	103.5	207.0	269.1	372.5	455.3	517.4	558.8	600.2	641.6						9	683.0
1083	90.0	144.0	198.0	270.0	360.0	486.0	558.0	612.0	648.0						9	702.0
1097	118.1	212.5	283.4	354.2	425.0	519.5	566.7	684.8							8	732.0
1082	113.6	159.1	250.0	363.6	431.8	522.7	590.9	659.1							8	750.0
52	115.9	165.5	215.2	314.5	380.7	480.0									6	480.0
62	88.0	146.7	190.7	234.7	308.0	366.7	410.7	484.0							8	484.0
53	127.7	223.5	255.5	319.4	383.2	447.1	495.0								7	495.0
9	100.5	201.1	268.1	284.9	385.4	435.7	486.0	553.0							8	553.0
61	108.4	162.6	252.9	307.1	397.4	487.7	560.0								7	560.0
72	126.9	181.3	253.8	308.1	362.5	416.9	471.3	507.5	543.8	561.9	580.0				11	580.0
8	101.1	168.6	219.1	286.6	337.1	404.6	455.1	488.9	539.4	590.0					10	590.0
21	124.0	223.1	297.5	421.5	471.0	520.6	545.4	570.2	595.0						9	595.0
59	99.5	198.9	248.7	331.6	397.9	447.6	497.4	547.1	596.8	630.0					10	630.0
36	142.2	223.4	284.4	365.6	426.6	467.2	528.1	568.8	650.0						9	650.0
20	117.4	195.6	254.3	332.5	371.6	430.3	489.0	528.1	567.2	625.9	665.0				11	665.0
70	133.8	191.1	248.4	363.1	401.3	496.9	554.2	592.4	649.8	688.0					10	688.0
12																690.0
69	94.8	158.0	205.3	268.5	347.5	394.9	442.3	505.5	537.0	584.4	631.8	663.4	695.0		13	695.0
16	121.6	191.1	260.6	347.5	486.5	556.0	608.1	695.0							8	695.0
18	97.0	145.5	226.3	274.8	355.6	436.4	484.9	533.4	581.9	630.3	662.7	695.0			12	695.0
35	102.9	164.7	205.9	247.1	329.4	411.8	494.1	555.9	597.1	638.2	679.4	700.0			12	700.0
71	124.3	207.1	290.0	352.1	455.7	517.9	580.0	621.4	662.9	725.0					10	725.0
58	104.3	166.9	208.6	250.3	375.4	458.9	521.4	563.1	604.9	646.6	688.3	709.1	730.0		13	730.0
27	114.6	210.1	305.6	382.1	477.6	554.0	611.3	649.5	687.7	706.8	745.0				11	745.0

Length-at-age of Sapukkait Arctic charr as determined by back-calculation performed by Makivik.