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Trophic structure of landlocked Arctic char (*Salvelinus alpinus*) in Iqalugaajuruluit Lake

M.Sc. Thesis

By

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FACULTY OF GRADUATE STUDIES

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TABLE OF CONTENTS

HISTORICAL REVIEW

MATERIAL AND METHODS

<u>Data collection</u>

<u>Analysis</u>

RESULTS

DISCUSSIONS

Abstract

A comparative study of food consumption, parasite community and the result of stable isotope analysis was conducted to define the trophic structure of landlocked Arctic char of Iqalugaajuruluit Lake (Wormy Lake). The effect of parasite infection on reproductive status of Wormy Lake char was also observed. The length-frequency distribution of Arctic char indicated the presence of three size groups (tri-modal distribution) with small (FL< 125 mm, N=58, Age 0-4 years), medium (FL 125 mm- 250 mm, N=125, Age 4-11 years) and large (FL> 300 mm, N=25, Age 8-15 years) fishes. The char samples presented a sigmoid growth pattern with small char having slow growth rate, medium char with moderate growth rate and large char with exponential growth rate. The stomach content analysis of Arctic char indicated, the small char mostly fed on benthic and epibenthic habitat (planktons and aquatic insects), the large fishes mostly fed from pelagic habitat (stickleback and char), whereas, the medium char presented a diet overlap by consuming benthic/epibenthic food materials (plant material, chironomid larvae, different types of insects) and pelagic fishes. The piscivorous food habit of large char seemed to provide extra nutritional benefit, which helped them to maintain the exponential growth rate. However this study could not ascertain specific reasons for rapid niche shift and piscivory (cannibalism in some fish) of char samples. The prevalence and range of abundance of parasitic species in small and medium char indicated that they fed at the same trophic level. The significant increase in *Diphyllobothrium* infection in large char, suggested a piscivorous food habit. The parasites identified from Wormy Lake char samples mostly use copepods as intermediate hosts in their life cycles. This implied that copepods were a common food item of the char samples, although very few copepods were detected in their stomach. The $\delta^{13}C$ and $\delta^{15}N$ signature of the char samples confirmed the presence of two trophic levels, with large fishes having significantly higher $\delta^{15}N$ value in comparison to small and medium char. Mean carbon signature of small, medium and large char did not reflect any significant difference among the size groups, although the limited range of $\delta^{13}C$ value in the large char implied restriction in food types. The combined study of char data and the parasite community indicated that the small char had proportionally more energy storage in the form of visceral fat, medium char were most important in terms of gonad development and large fishes had maximum soma weight but exhibited least fat storage and gonad development. Limited number of large fishes among the entire fish samples (only 25 out off 275 collected fish) seemed to provide indirect evidence of parasite induced host mortality in the case of big fishes. However, the parasite infection failed to indicate any significant effect on other internal organs (such as liver, stomach) except the reproductive system of the char samples.

In summary, the comparative study of food choice, parasitic infection and stable isotope analysis indicated that the Wormy lake char samples occupied two trophic levels in the lake. The small and medium char mostly fed on planktons and aquatic insects and shared the benthic and epibenthic zone, whereas the piscivorous large char utilized the pelagic zone of the lake. The high intensity of parasitic infection, especially in large fishes, seemed to have detrimental effects on reproductive maturity of the large char.

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LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Appendix 1

Appendix 2

Appendix 3

Introduction

Arctic char *(Salvelinus alpinus)* is a circumpolarly occurring polymorphic fish species, which uses both freshwater and marine organisms as their energy source. It exists as anadromus (migrating annually to sea) and non-anadromus (landlocked or living entirely in freshwater) forms. Both forms show variations in their life pattern for adaptation to local environments. Extensive research has been done on different aspects of char biology for several decades. Evolution, distribution, morphological and genetic variations, trophic status, fish energetics, immunity and parasitic infections, were the areas of major research interest. Study on the trophic status of char populations is influenced by the habitat selection, food preference, age, growth rate and maturity of the fish species (Adams *et al.* 1998, 2003). The trophic structure of char population was developed by combining the data obtained from stomach content analysis and the result obtained from stable isotope study of the fish species. Undoubtedly there is some valuable published information on landlocked char populations however, there are numerous gaps in our current understanding of char feeding pattern. Some researchers estimated that 20% of the total energy in small Arctic lakes comes from zooplanktons (Hammer, 1998a). But since zooplanktons are rarely found in char stomach, it may be concluded that zooplanktons are not important energy source for Arctic char. On the other hand, there are some common parasitic species which heavily infect all size classes of freshwater char and these parasites are only transmitted to fish through copepods. Obviously char must feed on copepods to some extent as all size classes of char harbor these parasites. Furthermore, we know very little about the energy transfer in the littoral and sub littoral zone, where most of the juvenile chars and stickleback are collated. Do these small fish feed primarily on zooplankton or micro benthic organisms? What type of parasite do they harbor? The size bimodality, rapid niche shift and cannibalism are considered as most interesting aspects of life history of Arctic char (Hammer, 19998a, 1998b). What are the causes and factors controlling the bimodal size distribution of char? How strongly it is related to niche shift? What are the conditions that influence the cannibalism of Arctic char? It is well documented that all fish in north temperate arctic environment require sufficient fat reserve for gonad development (Adams *et al.* 1998). What is the trade off between the energy required for reproduction and energy required for other metabolic process? How far parasitic community effects the reproduction of landlocked Arctic char? Is there any specific threshold level of parasitic infection to affect the reproductive status of the char population? Clearly this needs more research and probably a combined study of food items consumed, parasitic communities and stable isotope analysis may provide better insight about the matter.

Johnson *et al.* (2001) and Johnson and Dick (2004) worked on yellow perch, *Perca flavesceus*, and reported that a combined data analysis from stable isotope and existing parasitic community of the fish is more explanatory than diet or stable isotope alone to understand the trophic status of the fish. Does this also apply in the case of landlocked Arctic char? The objective of my research was to define the trophic structure of char samples of Iqalugaajuruluit Lake (Wormy Lake) through a combined study of food consumption, parasitic community and the result of stable isotope analysis. My research was also intended to determine the effect of parasite infection on reproductive status of Wormy Lake char.

HISTORICAL REVIEW

Distribution

Arctic char *(S. alpinus)* has a circumpolar distribution and is a polymorphic fish species, which can use both freshwater and marine resources to meet their energy needs. It exists as anadromus (migrating annually to sea) and non-anadromus (landlocked or living entirely in freshwater) forms. Distribution of Arctic char is extremely complex (Carney and Dick, 2000). The Arctic ocean connects the northern borders of the earth's major landmasses and the coastline of these landmasses is the major center of distribution of anadromus char (Cavender, 1980). The present distribution of Arctic char is very much influenced by the climatic events of the Pleistocene period. The advance and retreat of the ice-sheet, the submergence and emergence of the land under ice and formation of proglacial lakes are of major importance. The landlocked char is blocked from the sea by some physical barrier, inhabiting in springs, rivers, and deep lakes in the Arctic and Sub-arctic region and even far south as Maine, Switzerland and Scotland. There appears to be no northern limits to anadromus and landlocked stocks of char population and they are reported from most northerly freshwater lakes, where no other freshwater fishes are reported so far. Landlocked Arctic char is commonly found in cold deep glacial lakes, which are mostly oligotrophic with high levels of dissolved oxygen and pristine water quality. These lakes are very common in inland areas of Sweden, Norway, Finland and British Isles, in the Alpine area of Central Europe, central Siberia and even in the south of Soviet Union, America and Canada (Johnson, 1980, Wilson *et al.* 1996).

The subpopulations of 'Arctic char Complex'

Arctic char is one of the most complex polymorphic species with significant differences in morphology, life history and taxonomic characters within and among various allopatric and sympatric populations. In 1976, Svardson suggested that, 'The species name *alpinus* includes the whole complex of probably three species, which of them is the real *alpinus* and what should be the name of two others, are matter that have not yet been made clear by science.' The works of various authors (Nyman, 1972, 1989, Behnke, 1972, 1980, Savvaitova 1980a) regarding Char systematics provides a range of opinions, which are confusing and divergent from each other in terms of describing evolutionary relationships among different subpopulations of Arctic char (*S. alpinus*). Moreover, the systematics of Arctic char (*S. alpinus*) and its most closely related species, Dolly Varden Char (*S malma*), was a matter of great confusion over the last few decades. McPhail (1961) and McPhail and Lindsey (1970) synonymised Dolly Varden char as *S. alpinus* based on their study of North western population of Dolly Varden from Alaska. Savvaitova (1980a, 1980b) also expressed the strong belief that Dolly Varden and Arctic char should be considered as the same species. Later Behnke (1984) reorganized the systematics of the genus *Salvelinus* and suggested that, Arctic char and Dolly Varden might share a common ancestor but they are undoubtedly two separate species. Behnke (1984) also pointed out three major centers of evolution of Arctic char complex and identified three different subpopulations of Arctic char. They are:

1) *Salvelinus alpinus alpinus,* having a north European origin.
2) *Salvelinus alpinus salvelinus* having central European origin.
3) *Salvelinus alpinus erythrinus* having Siberian origin.

Among these three groups, the Siberian chars have the maximum distribution, ranging from Tarmyr Pennisula of Siberia to Eastern Asia, North West America, Finland, Northern Sweden, Norway, Great Britain and Ireland.

Behnke (1984) separated Arctic char from Dolly Varden based on differences in morphology (size and pattern of body spot, snout length), gillraker counts and number of vertebrae and pyloric caeca. Behnke (1984) mentioned that the 'Arctic char complex' typically has 63-64 vertebrae, 30-50 pyloric caeca and 21-28 gillrakers whereas; Dolly Varden is reported to have 66-68 vertebrae, 25-30 pyloric caeca and 21-23 gillrakers. Behnke also mentioned that Arctic char and Dolly Varden are reported sympatrically over a wide range of Asia and North America, without showing any evidence of hybridization. This also implies that these fishes are reproductively separated from each other and they should be considered as separate species.

Habitat and food choice of Arctic char

The Arctic char (*S. alpinus*) is a generalist and opportunistic feeder with a fundamental food niche embracing many different prey types, including fish (Johnson, 1980). Due to their different ontogenetic age and size groups, Arctic char show large seasonal variation in their food habit and even diet overlap with extensive niche shift throughout their life cycle (Hammer, 1987, 1989, 1998a, 1998b). Their food choice and habitat specificity also changes according to their distribution and local environmental conditions (Scott and Crossman, 1973, Scott, 1979, Hinder and Johnson, 1982, 1993). The allopatric populations of Arctic char at high latitudes (Arctic and sub-arctic) and high altitudes (Alpine region) are restricted to four food types: benthos, zooplanktons, aquatic insects and fish. In the ice-free season, Arctic char < 100 mm feed mostly on benthic and epi-benthic micro and macro crustaceans, chironomids and terrestrial insects. Medium char (100-190 mm) feed on insect larvae in early summer but shift to benthic, epi-benthic micro and macro crustacean in late summer. Whereas, char > 200 mm feed on profundal benthos, cladocerans and chrinomids in early summer (Martin and Olver, 1980) but they shift to a mixed diet including fish (cannibalism) in early fall (Hammer, 2000).

In almost all of the allopatic populations of landlocked char, bimodality, rapid ontogenetic niche shift and cannibalism have been considered as the most important and least understood aspects of life history of Arctic char (Hammer, 1984, 1991, 1998a, 1998b). Cannibalism has been proposed as a possible regulatory mechanism in the fish population and few studies have verified it as an important density-dependent regulatory factor in fish. Several studies have been done on piscivory and cannibalism of Arctic char, but the results are sometime confusing and even contradictory in several cases. There is a general view that cannibalism does not occur by char smaller than 40 cm in length, whereas quite high proportions of char in the large size class feed on conspecifics. Cannibalism may also be enhanced by aggregation of small and large char in same habitat like littoral and sub-littoral zone, under special circumstances, as in winter (Amundsen, 1994). It can be influenced by temporary reduction of water volume by water regulation in some lakes and it may have a negative correlation with the availability of alternate prey. In Arctic and sub-arctic regions, due to low temperature there is a normal scarcity of invertebrate diversity and a seasonal limitation of alternate prey species. The juvenile char generally have a retarded growth pattern (Moore and Moore, 1974, Martin and Olver, 1980), but 10-15 years old char often shift from a small-sized slow growing individual to a large-sized fast growing fish. At this stage they shift either to piscivory or cannibalism to get more nutritional benefits for their growth and reproduction (Hammer, 1991, 1998a, 1998b, 2000). Hammer considered cannibalism as an important strategy for survival of landlocked char in the high Arctic.

It is believed that there are several factors, which control the prey selection of piscivorous char. Adams *et al.* (1998) studied trophic polymorphism of Arctic char from Loch Rannoch, Scotland and concluded that there was some relation between the body morphology and anatomy of char population and choice of prey. Adams et al (1998) found three distinct char morphs, according to their body color and head anatomy, especially on the variations of jaw structure and gape size. Char with a larger gape size had the capacity to capture large prey, but at the same time it was clear that benthivorous char are able to handle larger prey items than the planktivorous fish with the same estimated gape size. Adams *et al.* (1998) and Adams and Huntingford (2002) suggested that there was an inherited morphological difference between the morphs that determine their mouth capacity and it indirectly restricted the prey selection. Amundsen *et al.* (1995) found a general relationship between prey length (y) and predator length (x) of char ($r^2 = 0.39$, $p < 0.001$), represented by the regression line:

$$Y = 0.257\,X + 1.045$$

This indicates that there is a trend towards an increase in minimum prey size with an increase in char size and there seems to be a positive correlation between the maximum prey length and the length of predator. Amundsen *et al.* (1995) found that, the upper limit of prey size is approximately 40% of the predator length, whereas the mean length of the consumed prey is 22% of the predator length and the maximum is only 28%. Therefore, they suggested that the exclusion of the largest prey from the diet was probably not due to just a chance factor or some physical limitation as gape size, but there must be some other factors affecting their choice of prey size. Webb (1978) suggested that the larger prey are more difficult to handle and they have greater ability to avoid attacks of predators than smaller fishes. According to their optimal foraging theory, Townsend &

Winfield (1985) proposed that the predators should feed on prey, which provide the highest energy return relative to the cost of search, pursuit and handling. The selection of the smallest fish prey might be somehow related to this cost–benefit ratio in case of Arctic char.

Arctic char is also believed to be opportunistic feeder. Although, Amundsen and Damsgard (1995) and Amundsen *et al.* (1995) found that the prey choice is unique even among the individuals of the same fish population. Individuals restrict themselves to specific food habit, if they are exposed to various food items. Amundsen *et al.* (1995) carried out their experiment with Arctic char of same strain (total length 34.9+ 0.2 mm) exposing them to two alternate food items and found three different groups of fish according to their food choice. The groups were cannibals, pellet eating and non-feeding fish. Both the pellet eating and the cannibals increased in body weight during the course of experiment, but the non-feeding type lost weight. The cannibals exhibited their greatest weight gains when fish prey was offered, whereas the pellet feeders had the best gain when pellets were offered. This was also clearly seen by examination of changes in specific growth rate (SGR) of these two groups.

The trophic pattern of sympatric char is significantly different than allopatric fish population (Nilsson, 1955-1978) of high altitude and latitude (Hammer, 1998b). Arctic char is commonly sympatric with brown trout or Dolly Varden char or lake trout. The interaction between char and trout might be described as a conflict between a generalist and specialist, as char is more adapted to an Arctic environment. The inter-specific interaction between these fishes generally leads to summer segregation in food and habitat choice (Hammer, 1998b, Jonsson and Jonsson, 2001). Arctic char and brown trout had similar size distribution and food choice when allopatric whereas, Arctic char rarely shifts to piscivory and/or cannibalism in sympatric situations. Sympatric char mostly feed on pelagic, epipelagic plankton and crustacea whereas brown trout feed on macro and micro invertebrates of littoral/benthic zone. Trout also were reported to feed on small char in some cases (Nilsson, 1964, Hammer, 1998b).

Age, growth rate and reproductive maturity of Arctic char

Growth in unexploited allopatric populations of Arctic char generally represent sigmoid pattern (Griffiths, 1994, 1997, Hammer 1987, 1998a, 1998b). Char grow up to a certain level followed by a sudden acceleration in their growth rate resulting bimodality in most populations of Arctic char. Hammer suggested that sudden changes of growth pattern might be due to migration to sea for anadromus char or due to piscivory and/or cannibalism in case of non-anadromous char. This change in their life history occurs at an age of 10-15 years and a body length of 200-300 mm. However, Johnson (1980) and Hammer (1998a, 1998b) mentioned that bimodal size distribution is also common in non-piscivorous char population, which implies that piscivory or cannibalism might not be the only factor effecting the size distribution and growth rate of Arctic char populations. Nordeng (1983) proposed that the segregation of anadromous and non-anadromus char depend on their genetic constitution, food choice and some congenital factors, such as parasite infection. Nordeng (1983) found the growth rate and age at sexual maturity of char is variable among different morphs and is controlled by the inherited genetic difference among the morphs, though they share the same gene pool.

Depending on origin, distribution, habitat choice and food Arctic char vary considerably in size, age, morphology and coloration (Dutil, 1983, Sandlund *et al.*, 1992). Char can reach to weights of 15-16 kg and survive more than 25 years. The size frequency distribution of landlocked Arctic char population mostly reflects the presence of two modal groups with very few intermediate individuals, though the presence of unimodal and trimodal size distribution is also reported from literature (Hammer, 1998a, 1998b). In bimodal size distribution each mode contains fish in the same phase of the life cycle, but not necessarily of the same age. Johnson (1980) suggested the moment of transfer between the two modal groups is dependent on the size and opportunity than the age of individual.

In terms of reproductive maturity Arctic char populations can differentiated into three groups 1) small reproductively active group 2) medium reproductively inactive group and 3) large cannibalistic reproductively active group. Char achieve sexual maturity at 3-4 years of age and during the period of September to mid August. In a complete life cycle char pass through two reproductively active phases, having an intermediate non-reproductive phase, where they shift to an accelerated growth rate with maximum body development (Parker and Johnson, 1991, Row and Thorpe, 1990a, 1990b, Hammer, 1998a, Jonsson and Jonsson, 2001).

Hammer (2000) mentioned, piscivorous char populations generally demonstrate a female-biased sex ratio and higher intensity of parasite infection whereas, non-piscivorous char, mainly those feeding on amphipods, represent a male biased sex ratio and low parasite burden. Fecundity of female increases with body length and egg size increases with age of female. The gonad somatic index (GSI) is maximum at age 4-7 and 9-10 years.

Thorpe (1994) proposed a model based on *Salmon salar L*, defining the relationship between seasonality, growth and onset of sexual maturation. He suggested that the acquisition of surplus energy both in the form of lipid deposition (the stored energy) and body growth in winter, prior to reproduction, was shown to determine the probability of sexual maturation of the species. In Arctic char, fast growth may not be associated with early maturation (Svedang, 1990). There are two potential explanations for this observation. First, Arctic char may be inherently different from Atlantic salmon in the factors that control growth and sexual maturation, or second, there may be some intra-population variations in growth rate and maturation among various populations of Arctic char (Adams and Huntingford, 1997).

Adams and Huntingford, (1997) tried to correlate the growth and maturation strategies of Arctic char with other salmonids. The average weight of fish that matured during the study period was greater than that of the fish, which failed to do so. But this result was not significantly different between maturing and non-maturing males but it was significantly different and steeper in maturing female. Growth rates of maturing and non-maturing females also differed significantly over the study period and it was found to be negatively correlated with lipid deposition and positively correlated with fecundity and the gonad somatic index of the females. From these findings Adams and Huntingford, (1997) suggested that Thorpe's model based on other salmonid could be applicable to Arctic char, though there may be some discrepancy due to the high polymorphic variation of this species.

Parasite community of Arctic char

More than one hundred parasite species have been reported to infect Arctic char throughout its wide geographical distribution. Different types of parasites, such as protozoa, helminth, crustacea have been found to infect Arctic char as their definitive or intermediate host (Makhovenko, 1972, Hicks, 1973, Mudry and McCart, 1976, Murdy, 1976, Mudry and Anderson, 1977, Burton, 1978, Beverly and Burton, 1978, Hoffman, 1999). Several factors, such as distribution (Johnson, 1980, Dick, 1984) (Table1, Table 2), local environmental condition (Johnson and Dick, 2004), availability of intermediate hosts (Klemtsen *et al.*, 1985, Kundsen *et al.,* 2001, 2004), food and habitat choice (Frandsen *et al.,* 1989, Amundsen *et al.,* 1995, Curtis *et al.*, 1995, Kundsen, 1995, 1997, Kundsen and Klemetsen, 1994, Kundsen *et al.*, 1996, 1999, 2001, 2002, 2004), size, age (Johnson *et al.,* 2004), sex of infected individual (Curtis, 1979, 1984), influence the parasitic infection of char population. Sixty-six parasitic species from North America, eighteen from Europe, and sixty-nine parasites from former U.S.S.R have been reported, although no protozoa and acanthocephala have been reported from Europe and only one protozoa has been identified from North America (Dick, 1984).

According to their distribution the parasites of Arctic char can be separated into two categories, one group has a holarctic distribution and the other is mainly restricted to water bodies near the Arctic Ocean and its connecting seas. *Crepidostomum farionis, Phyllodistomum* sp, *Diphyllobothrium dendriticum*, *D. ditremum*, *Cystidicola* sp., *Philonema* sp., *Salmincola* sp. are those parasite reported to infect Arctic char through out the holarctic. The parasitic species infecting anadromous and non-anadromous char populations are also believed to be different. Information on parasites from sea-run char is limited but *Brachyphallus* sp., *Bothrimonus* sp., *Diplocotyle* sp., *Corynosoma* sp., *Echinorhynchus* sp., *Prosorhynchus* sp., *Lecithaster* sp. are the most common parasites infecting char in North America and Russia. Whereas, *Crepidostomum farionis, Cyathocephalus*, *Diphyllobothrium dendriticum, D. ditremum*, *Cystidicola* sp., *Philonema* sp., *Salmincola* sp., *Eubothrium* sp., *Proteocephalus* sp., *Phyllodistomum* sp., *Metechinorhynchus, Neoechinorhynchus* are the common and abundant parasites infecting landlocked char populations of North America, Europe, Russia (Due and Curtis, 1995, Dick, 1984, Lankester and Smith, 1980, Kennedy, 1974, 1977, 1978a, 1978b, Kundsen, 1995, 1997).

Some parasites have been used as biological tags to distinguish anadromous and non-anadromous char population (Eddy and Lankester 1978, Dick and Belosevic 1981, Dick 1984). Dick (1984) studied 98 non-migrating char collected from Nettling Lake; Baffin Island and 9 parasitic species were detected. Three of them *Diphyllobothrium* sp. *Eubothrium salvelini* and *Proteocephalus longicollis* showed the maximum abundance (around 97.53% of total parasitic count) among the landlocked Arctic char. Whereas, 15 parasites were recognized from migrating char of Koukdjuak River system of Baffin island and three of them, *Brachyphallus crenatus*, *Bothrimonus sturionis* and *Prosorhynchus squamatus*, showed maximum abundance (about 96.4%) in sea-run char. Some parasites, such as, *Diphyllobothrium* sp., *Eubothrium salvelini* and *Crepidostomum farionis* were found to effect both migrating and non-migrating form, but the dominance value decreases significantly from non-migrating (in *Diphyllobothrium* sp, dominance value was 52.04) to migrating (*Diphyllobothrium* sp, 0.29) char (Dick, 1984).

Parasite of Arctic char could be separated according to feeding specialization of the population. Arctic char contain several groups according to their food choice and habitat specificity (Hanek and Monar, 1974, Frandsen *et al.,* 1989, Kundsen, 1995, Kundsen *et al.*, 1996, 2001, 2004). Small and large benthivorous char, pelagic and epi-pelagic planktivores and piscivorous char. Generally, the type of parasitic infection and the intensity and abundance of parasites is significantly different in the case of zooplanktivores than benthivorous char. Benthivorous char, those mostly feeding on amphipod *Gammarus lacustris*, are infected with *Cystidicola farionis* and *Cyathocephalus truncatus*. Whereas, the char population feeding on pelagic copepods, are infected with *Diphyllobothrium dendriticum*, *D. ditremum*, *Eubothrium salvelini, Proteocephalus longicollis* and *Philonema* sp. *Crepidostomum farionis*, is also common in clam eating char through out the circumpolar range. On the other hand, *Salmincola edwardsii,* the only parasite with a direct life cycle in char, is rarely reported in Arctic conditions (Kennedy, 1977, 1978, Dick, 1984, Vik, 1958).

Among all these parasites, *Diphyllobothrium* spp., the parasitic cestode, is the most common parasite of Arctic char (Henricson, 1978). *D. ditremum* and *D. dendriticum,* use copepods and Arctic char as their intermediate host. *D. ditremum* use loon or duck and *D. dendriticum* use gull as definitive host. Both small and large fish of landlocked char population are found to be infected by the plerocercoid (larval stage) of these parasites. *D. detremum* generally encysts on the stomach wall of char, but *D. dendriticum* is more mobile and can encyst in other tissues like liver, gonad and body tissue. Piscivorous and/or cannibalistic char are reported to have massive infection by these parasites, which also effect their gonad development in both the sexes, particularly in female and increase the mortality of the fishes (Curtis, 1984). Parasitic infection is also related to age and size of fish (Hammer, 1998). The intensity of infection steadily increases with size and age of char. Prevalence reaches approximately 100% for fish exceeding 14 years of age and over 250 mm of fork length (Curtis, 1984).

Diphyllobothrium is the only char parasite found to infect human population and Diphyllobothriasis is a well-documented human disease in North and South America, Russia and Japan (Dick, Nelson and Choudhury 2001). This disease can be caused by several species of *Diphyllobothrium*, such as, *D. latum, D. dendriticum, D. dalliae* and infection occurs by ingestion of plerocercoids (larval stage) of the parasite present in raw or insufficiently cooked fish. The pathogenic effect is negligible, with mild indigestion, gas in digestive track, nausea but it is easily curable by self-immunity or by application of specific drags (Dick, Nelson and Choudhury 2001).

Eubothrium salvelini and *Eubothrium crassum* are also common parasite of various salmonids (Hernandez and Muzzall, 1998). *Eubothrium salvelini* comprises two races; European race and North American race (Hanzelova *et al.*, 2002). The European freshwater race is specific to *Salvelinus alpinus* and its life cycle complete in two hosts, copepod, the intermediate host and Arctic char, the definitive host. The anadromus char get infected during their period of fresh water residency and carry the parasite with them. Char returning from the sea still carry the parasite, but both parasitic intensity and incidence of infection are reduced greatly. The American race, found throughout N. America and East Asia, infect species of *Salmo, Salvelinus, Oncorhynchus* and *Cristivomer* and its biology is more or less similar to the European race. *Eubothrium* *crassum* is found both in freshwater and marine environment infect *Salmon trutta, Salmo salar* but never detected in *Salvelinus alpinus* (Kennedy, 1978). *Proteocephalus longicollis* is one of the most abundant parasites of landlocked char population (Mudry and Anderson, 1977, Sholz and Hanzelova, 1999, Hanzelova and Sholz 1999) and both *Eubothrium salvelini* and *Proteocephalus longicollis* also have detrimental impact on their host (Hammer, 1998).

Among other parasites of Arctic char, *Cystidicola farionis* occurs widely in N. America and Eurasia (Black, 1983, Black and Lankester, 1980, 1984) and infects fish hosts of genus *Salvelinus, Brachymystax, Coregonus, Salmo* and *Stenodus* (Eddy and Lankester, 1978, Margolis and Arthur, 1979, Lankester and Smith, 1980). Individual Arctic char specialized on feeding amphipods; especially *Gammarus* have a high prevalence of infection by *Cystidicola farionis*. Long-term infection of the swim bladder nematode can create mechanical irritation causing lesions in the swim bladder of the infected fish. This might increase the rate of parasite induced host mortality in Arctic char population (Anderson and Gordon, 1982, Giaever *et al.* 1991, Moravec, 1994, Kundsen *et al.*, 2001, 2004).

Gammarus is also the intermediate host of *Cyathocephalus truncatus,* another common parasite of landlocked Arctic char. High parasitic infection by *Cyathocephalus truncatus* increases the mortality rate in infected char and this parasite also can alter the behavior of its intermediate host, by increasing their predation rate significantly (Brown and Thompson, 1986, Hurd, 1990, 1999, Moore, 1995, Kundsen *et al.,* 2001, 2004, Poulin *et al.*, 1994).

Stable isotope analysis and trophic ecology in Arctic char

The morphotypes of Arctic char within a lake can be distinguished on the basis of a number of traits including use of trophic resources, habitat, individual growth rate, age and size of sexual maturity, time and place of spawning, coloration, morphological and meristic characteristics. The adaptation to utilize a specific food resource that results in distinctive morphologies within a population is referred as "Trophic Polymorphism" (Guigner *et al.*, 2002). It is easy to obtain data on trophic feeding of an organism from its stomach content, but this provides limited information on post consumption food materials. The use of stable isotopes provides a time-integrated measure of energy assimilation since analyses are performed on body tissues, built from the diet assimilated over time (Tieszen *et al.*, 1983, Fry and Sheer, 1984, Paterson and Fry, 1987, Fry, 1988).

Over the last decade, stable isotope analysis had been used to solve several biogeochemical questions in ecosystem (Johnson *et al.*, 2004). It was found to be particularly useful regarding the study of diet-nutrition relation and construction of trophic structure within and between the populations (Johnson *et al.*, 2004). Several experiments have shown that diet is clearly the primary determinant of the isotopic ratio of the organisms (Thomas and Cahoon, 1993). The carbon signature of animal tissue is isotopically similar to diet and the nitrogen value is on average 3-5% heavier than the diet (Johnson *et al.*, 2004). Nitrogen in a consumer's tissue is derived from the assimilated food, but not from the digested stuff and the overall protein turn over rate of a consumer also varies with basic metabolic rate from time to time. The isotopic examination of various tissues may provide dietary information over different time periods. The trophic fraction of $\delta^{13}C$ is typically smaller than $\delta^{15}N$, but this isotope together with S, may be considered as more reliable indicator of primary energy source of the organism (Hobson and Welch 1995). The collective study of C and N isotope can give a prominent idea about the trophic pyramid of a specific ecosystem (Tieszen *et al*, .1983).

Hobson and Welch (1992) determined the trophic relationship of the marine ecosystem of Lancaster Sound region of Arctic Canada. The objective of their research was to evaluate the use of stable isotope analysis to determine the trophic pathway of the marine ecosystem. The results indicated that the marine food web is relatively large and complex, with polar bears occupying the highest (fifth) trophic position and Arctic cod and some other invertebrates playing a significant role in energy transfer within the ecosystem. But the detailed process of energy transfer among the lower organisms was poorly understood. The nitrogen signature indicated a steady enrichment with increased trophic position of the organisms and it was found to be particularly useful tracing the trophic pathway within the ecosystem. There was an average 3.8 % increase of δ N value with every shift of trophic level and the trophic position of each individual was described by the equation:

$$TL = 1 + (Dm - 5.4) / 3.8$$

Where, TL implied the trophic level of each consumer, Dm indicated the δ N value of the consumer's tissue, 5.4 was mean δ N value of particulate organic matter and 3.8 was the mean increase of nitrogen signature per trophic level. The change of δ C value among various trophic levels was not significant and it was predicted that the absence of step-wise enrichment of carbon signature could be due to differential lipid content in body tissue of different organisms (Hobson and Welch, 1992).

Hobson and Welch (1995) reported for a landlocked Arctic char population in Char Lake and described the food web the char along with other organisms of the ecosystem. The char samples of the lake were slow growing, with modal length of 14-15 cm and a mean age of 13.5 years. Results of stomach analysis indicated that small and medium char fed mainly on chirinomids, *Mysis* and *Apatania* to some extent, but the large char were mostly cannibalistic. Prior to their stable isotope analysis, it appeared that the lake ecosystem had four distinct tropic levels, primary producers, various detritivores and herbivores and two types of char. Result from stable isotope analysis (Hobson and Welch, 1995) produced a general pattern of $\delta^{15}N$ enrichment starting from moss, having the minimum value of $\delta^{15}N$ range of 2.1% and the cannibalistic char having the maximum value of 14.5%. Invertebrates had an average for $\delta^{15}N$ of 4.2±0.6 %. Surprisingly, there were three different values of $\delta^{15}N$ value in three different size groups of char. The small group (fork length 8-10.5 cm) had values of 5.7±1%; the intermediate group (fork length 12-36.5 cm) with $\delta^{15}N$ of 10.0±0.5% and the large group (fork length 42-66.3 cm) had values of 13.7±0.8%. Previously it was believed that the small and intermediate groups of char have the same food preference (mainly fed on *Mysis*, Chrinomid and *Apatania*) but these results indicated that there was some difference in food choice between the small and intermediate forms. As the mean nitrogen signature between two trophic levels generally differs from 3-4% (Hobson and Welch, 1992), the difference in $\delta^{15}N$ values among these three size groups was significantly different and placed them in three separate trophic levels. The intermediate char had an average $\delta^{15}N$ of 5.8% above invertebrates, which also indicated that they were not restricted to invertebrate food items but had some additional contribution in their diet from organisms at a higher trophic level. Hobson and Welch (1995) suggested that this form consumes char ranging from 1-3 cm and that increased the nitrogen content in their body tissue. The large char above 40 cm showed an abrupt enrichment of $\delta^{15}N$ value with respect to all other forms and provided strong evidence in favor of cannibalism. No regular pattern of $\delta^{13}C$ enrichment was recorded from the experiment, but there was a considerable variation in carbon isotope values among the organisms. Overall, carbon signature provided information about primary carbon source of different organism and the $\delta^{15}N$ value helped to differentiate the consumer levels of the lake and off course to reconstruct the trophic structure of the entire ecosystem (Hobson and Welch, 1995).

Guigner *et al.* (2002) examineds differences in the feeding ecology of sympatric morphs of Arctic char of Lake Hazen, of Arctic Canada. The result was similar to Hobson & Welch (1995). The large (FL >400mm) and small (FL < 400 mm) morphotypes showed very clear and a significant difference in carbon and nitrogen signature with the large forms having more depleted $\delta^{13}C$ and more enriched $\delta^{15}N$ values than the juvenile (reproductively immature char), small and unknown forms (those could not be separated as small, large or juvenile char). Mean nitrogen values were 9.7, 9.8, 13.8 and 10.0 respectively. The increase in nitrogen signature of large chars was 3.8-3.9% than the juvenile and small fish. This represents their long-term dependence on other fish, as their food source. On other hand a $\delta^{13}C$ signature in small char was found to be more enriched than other char. Mean carbon isotope values for juvenile, small, large and unknown form fish were -21.9, -18.1, -21.5 and -20.9% respectively. The data revealed that there is a linear relationship between $\delta^{13}C$ and $\delta^{15}N$ values and fork length (FL) of juvenile (reproductively immature char), small (FL < 400 mm) and large char (FL >400mm). $\delta^{15}N$ values showed a positive correlation with fork length of small and large form, where as the juvenile char showed a negative relationship. One of the basic objectives of study of Guigner *et al.*, (2002) was to relate size bimodality and cannibalism of Arctic char with the values of stable isotope analysis. Within Lake Hazen, cannibalism appeared to be size-limited and on the basis of the nitrogen value, it seemed to be restricted to large individuals > 400mm. Hobson & Welch (1995) also mentioned 40 cm as the threshold value for cannibalism on the basis of their experiment. The difference in $\delta^{13}C$ signature between the small and large char was more helpful to explain the concept of cannibalism. The small form of char was most enriched in $\delta^{13}C$, with values ranging from -20.0 to -16.1% and showed little overlap with large char (-22.9 to -19.3%). Almost 3.4% of $\delta^{13}C$ difference between small and large char was large enough to indicate the predator-prey relationship between the forms. However the concept of size bimodality was not clear from the result. Guigner *et al.* (2002) found that large char mostly consumed fish of <250mm, whereas the mean fork length of the small char in the population was 353.3 mm. So the observed cannibalism by large char was not sufficient to maintain the bimodal length-frequency distribution in char population.

Adams *et al.* (2003) used stable isotope analysis to determine if there was a correlation between morphological variation and food choice among the sexually mature Arctic char population of Loch Tay. Arctic char captured from Loch Tay showed clear bimodal size distribution with no overlap between two size classes. Chars >180 mm were grouped as upper mode fish and chars < 150 mm were grouped as lower mode fish. Adams *et al.* hypothesized that the reasons for the bimodality of the fish population were 1) Genetic differences in growth rate of fishes. 2) Inherent differences in energy expenditure between two morphs, effecting their growth and metabolism. 3) Difference in food choice, indicating difference in available energy for growth of fish. Results from carbon and nitrogen signature of the fish muscle indicated significant differences in mean $\delta^{13}C$ and $\delta^{15}N$ values between two groups of fish. This demonstrated a difference in their food choice and trophic position between two morphs. There was some overlap in the range of $\delta^{13}C$ and $\delta^{15}N$ values for the two morphs, indicating the partial dietary segregation, where the two morphs might have some degree of overlap in their feeding. However, the overall results supported the hypothesis, that the difference in food habits was significant among the morphs and might have a significant effect on size bimodality of the char population.

Studies by Hobson and Welch (1992, 1995), Guigner *et al.* (2002) and Adams *et al.* (2003) suggest that the use of stable isotope analysis was quite effective for single-system study. However, the use of this technique might be limited for comparative studies of many lakes and it is mainly due to the among system variation of the nitrogen signature of different primary producers at the base of food web (Cabana and Rasmussen, 1996). The isotopic signature of the baseline organisms (such as bacteria, phytoplankton), which transform inorganic nitrogen to organic compounds, shows great variation in different systems. These differences might cause significant variations in δ^{15}N values of higher organisms, occupying similar trophic position in different ecosystem. Cabana and Rasmussen (1996) tried to solve this problem by measuring the trophic position of higher organisms in relation to a common primary consumer, the unionid mussels. These mussels were large, long-lived, filter feeders of bacteria and phytoplankton in water column and served as integrator of temporal variation of baseline nitrogen signature. The measurement of trophic position of higher organism in relation to the mussel, allowed the researchers to get a continuous measure of trophic position suitable for among-system comparisons. Later, Zanden *et al.* (1997) and Zanden and Rasmussen (1999) also used the δ^{15}N value of primary consumers, instead of primary producer, as a base line indicator in their comparative study of trophic status of several fish species from different lakes. Although the efficiency of this method is also system dependent as, the nitrogen signature of primary consumers from different lakes can also vary substantially and δ^{15}N value of any specific organism may not reflect the other primary consumers even within the same system (France 1997, Zanden and Rasmussen 1999).

Johnson and Dick (2004) proposed a complementary way of predicting trophic structure of organism, which might be applicable for both single and multiple system studies. Johnson and Dick (2004) worked on yellow perch, *Perca flavesceus* and suggested the comparative study of stable isotope and parasite community might give a better indication of trophic levels of aquatic ecosystem. Many larval parasites infect intermediate hosts and transmission of some of these parasites usually requires ingestion of the intermediate host by the fish species. Generally larval forms of parasites are restricted to a few intermediate hosts and many parasites accumulate on host for an extended time period. So, detection and identification of the parasites might be very useful to predict some of the food items not directly available from stomach content and it could be also very useful to verify the results from stable isotope. They argued that this method might be applicable to identify trophic position of other fish species.

MATERIAL AND METHODS

Study area

Two hundred seventy five Arctic char were collected form Iqalugaajuruluit Lake (Wormy Lake) in spring and summer, 2004. Wormy Lake (Fig: 1, 2) is situated (N 63^0 $41^/$ $19.8^{//}$, W$68^0 22^/ 29.0^{//}$) in the coast of Frobisher Bay. It covers a total surface area of 119 hectors and with average depth of 4.4 meters.

Data collection

Fish and parasite collection and ageing of fish

Two hundred seventy five Arctic char were collected in 2004. Two hundred fifteen specimens were collected in summer and sixty in winter. Samples were collected with Swedish experimental gill net and by electro-fishing. Morphmetric and meristic data were collected (see Necropsy procedures) from two hundred ten char and the data are summarized in Appendix 1. Otoliths were removed, washed in water, stored dry in envelopes and used for age determination. Some of the otoliths were too thick for the growth rings to be clearly seen and they were polished either with 1200 grit SiC paper or with Metaseru 2000 grinder polisher. Once polished, otoliths were placed in a Petri-dish containing 100% flax seed oil. Annuli were counted with the aid of a compound microscope (x20). Age determination was done following Grainger (1953), by counting the central core of the otolith as the first annulus. Sex and maturity of char were also determined and egg diameters were measured. Stomach, liver, gonad and visceral fat were removed, weighed and examined for parasites.

Stomach contents were removed and examined (see Necropsy procedures) in order to identify prey items (Appendix 3) and the stomach contents of 70 fishes were preserved for future reference. Organs and tissues of each fish were examined separately in order identify the parasites from different organs. Parasite identification was done by using several keys (Margolis and Arthur 1979, Bousfield 1988, Moravec 1994 and Hoffman 1999). Tissues for stable isotope analysis were also collected from all fish samples.

Figure 1: Location of Iqalugaajuruluit (Wormy) Lake

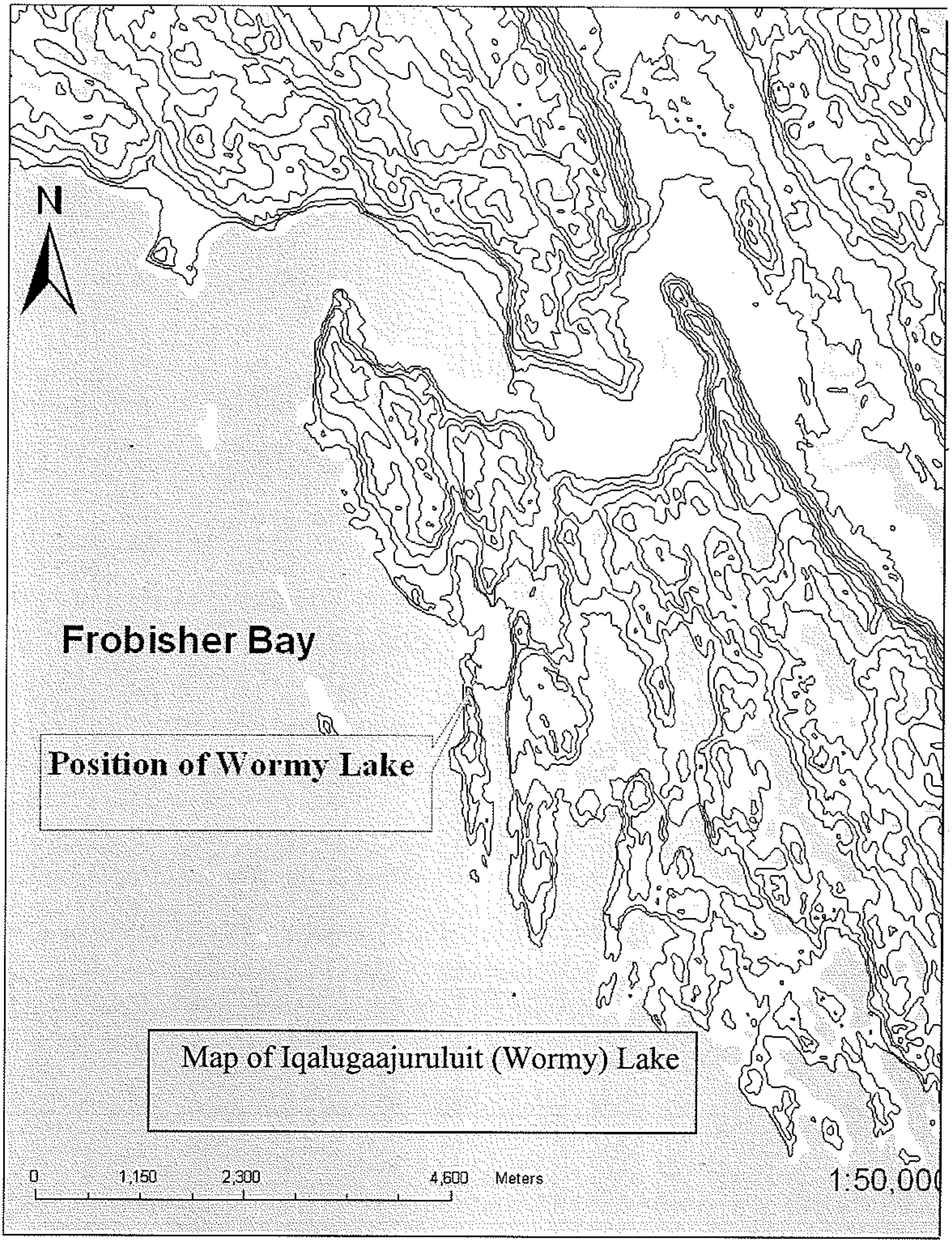
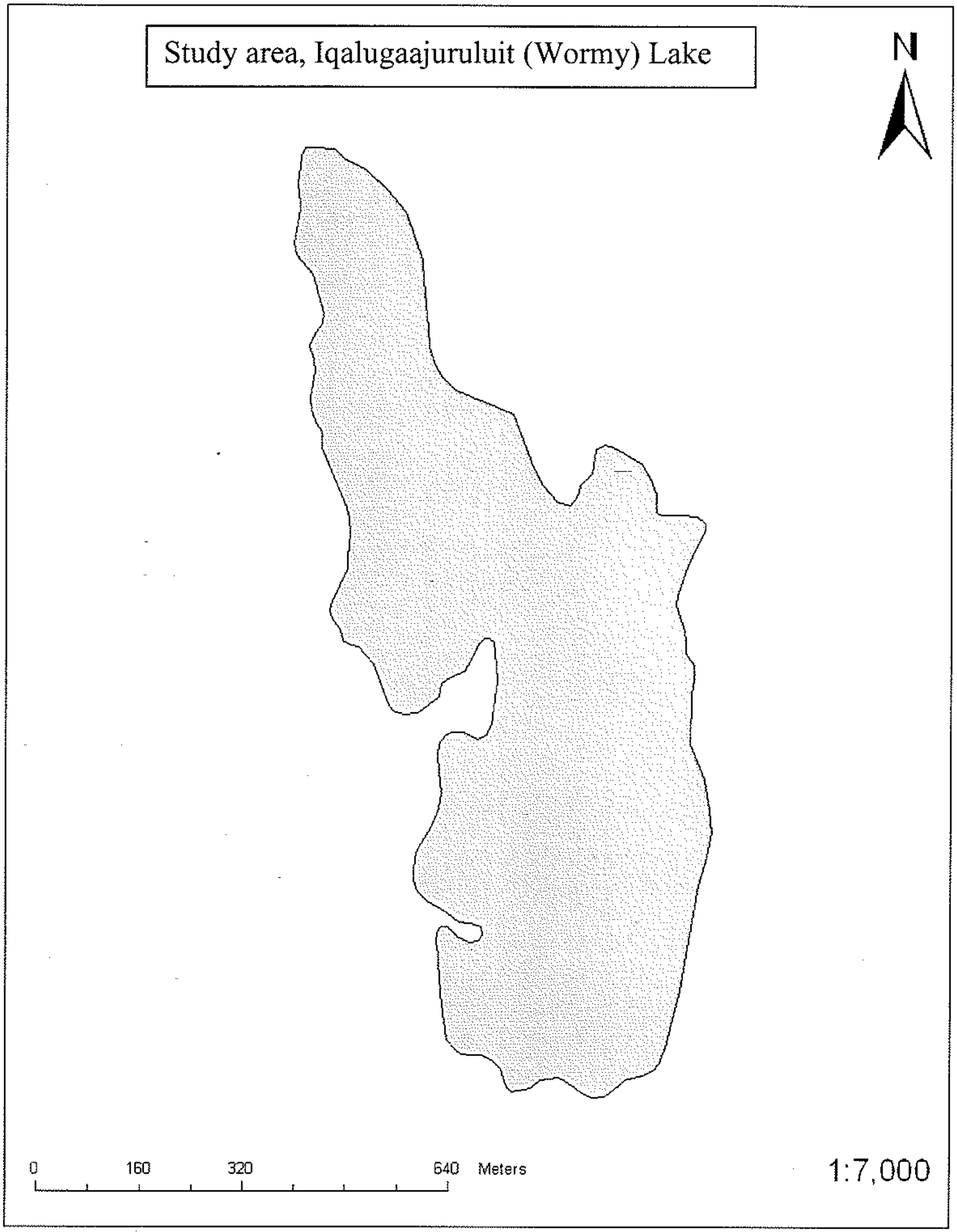

N
Frobisher Bay
Position of Wormy Lake
Map of Iqalugaajuruluit (Wormy) Lake
0
1,150
2,300
4,600
Meters
1:50,00

Figure 2: Study area, Iqalugaajuruluit (Wormy) Lake



Study area, Iqalugaajuruluit (Wormy) Lake

Necropsy procedure

The mouth lining and body surface of each fish was first examined for ecto-parasites. The heart, gills, stomach, intestine, pyloric caecae, gonads, liver and kidneys were then removed and placed in separate Petri-dishes with 0.6% saline. The surface of individual organs was checked and parasites were collected. Separation of each organ prevented mixing of the parasites. Stomach (full and empty) weight, liver weight, gonad and visceral fat weight were measured separately. The surface of the heart, kidneys and liver were examined before being squashed under glass. Compressing allowed the detection of transparent or concealed parasites within thick tissues such as liver. A section of muscle from each fish was examined for encysted parasites. The stomach, intestine, caecae were carefully cut open and scraped into a Petri-dish containing 0.6% saline. The contents were gently separated and examined for parasites using dissecting microscope. Stomach contents were identified and were stored (70 fishes) in 70% ethanol for future reference. Trematodes, cestodes and acanthocephalans were fixed in AFA for 48 hours and were placed in 70% ethanol for storage prior to staining and mounting.

Staining and mounting of parasites

Staining and mounting procedures were used according to Humason (1962). Trematodes, cestodes and acanthocephalans were stained by acetocarmine. Specimens were placed in the acetocarmine solution for 20 minutes to 1 hour (depending on the thickness/size of the specimen). Once properly stained, the parasites were washed in 70% ethanol and placed into a Petri-dish containing acidic 70% for 1 to 5 minutes or until excess stain was removed. The parasites were then washed with basic 70% ethanol for an equal amount of time to neutralize the acid. Each specimen was dehydrated through several 1-hour changes each of 70%, 90%, 95% and 100% ethanol. After complete dehydration, each parasite was transferred to Slide Bright© until the specimen became transparent. After several changes in Slide Bright© specimens were mounted on slides using Permount.

Method of stable isotope analysis

Methods for stable isotope analysis were adopted from Thomas and Cahoon (1993). A sample of white muscle tissue from each fish was frozen until stable isotope analysis was performed. Each sample was lyophilized and ground into a fine powder, to be used directly for carbon and nitrogen analyses. Isotopic compositions were measured on an automated mass spectrometer, and delta values (i.e. parts per thousand) were determined as follows:

$$\delta^{15}N \text{ or } \delta^{13}C = (\frac{(R_{sample}) - 1 \quad x\ 100\%)}{(R_{standard})}$$

Where $R = {}^{15}N/{}^{14}N$ or ${}^{13}C/{}^{12}C$

Isotope values were expressed as $\delta^{15}N$ or $\delta 13C$ relative to Pee Dee Belemnite for carbon, and air for nitrogen. These isotopic values were compared for each fish and combined with stomach content analyses and parasite data to determine trophic level of the fish samples.

Analysis

Terminology

Liver Somatic Index (LSI), Gonad Somatic Index (GSI) and Visceral Fat Index (VFI) of char samples were calculated. The liver somatic index (LSI) was calculated by measuring the weight of the liver (in mg) and dividing it by the total body weight of the fish and multiplying it by 100. GSI and VFI were calculated by measuring the gonad weight and visceral fat weight and then by following the same formula. Prevalence, mean intensity and abundance of each parasitic species were calculated according to Margolis et al. (1982). Prevalence is the number of infected hosts by a specific parasite species/ number of hosts examined. Mean intensity is the total number of particular parasitic species infecting host population/ number of infected hosts examined. Abundance is the total number of individuals of a particular parasite in a host sample/ total number of individuals of the host species, i.e. prevalence x mean intensity. Study of the parasite community was used in comparison with stomach content and stable isotope analysis to trace the trophic structure of char samples. Prevalence of food types of small, medium and large char were also calculated and compared to differentiate the food choice and habitat utilization among three modal groups of char.

Statistical methods

Frequency distribution

The length-frequency and age-frequency distribution of Arctic char samples of Iqalugaajuruluit Lake (Wormy Lake) were calculated according to the method of fish capture (electro fishing and gill-netting) and also combined to present the distribution pattern of all fish samples. Descriptive statistics (mean, standard deviation, variance, skewness, kurtosis etc.) of the char samples were calculated according to the method of fish capture. Kolmogorov-Smirnov test and Shapiro-Wilk test of normality were conducted and the normal Q-Q plot of fork length plotted against normal expected value to check the normality assumption of the length and age-frequency data. Fork length (FL) and age of the char samples was plotted with respect to each other.

Stomach content analysis

Stomach contents of char samples were identified and % prevalence of food types were calculated and plotted for small, medium and large fish. The feeding percentage of different food types for summer and winter char of Iqalugaajuruluit (Wormy) Lake were calculated and plotted to determine if there were significant variations in food choice of char samples according to season.

Fish data analysis

Fork length and round weight of char samples were plotted to detect the growth pattern of Arctic char. Data regarding liver weight, gonad weight and visceral fat weight were analyzed to see the trend of body development and reproductive maturation of char. Both, Kolomogorov-Smirnov test and Shapiro-Wilk test of normality for liver weight, gonad weight and visceral fat weight were conducted to check the normality status and modified Levene test was performed to check the homogeneity of variances of the data. Liver Somatic Index (LSI), Gonad Somatic Index (GSI) and Visceral Fat Index (VFI) were calculated to determine the trend of body development, reproductive maturity and energy utilization with increase of soma weight of the char samples. The non-parametric correlations of LSI, GSI, VFI and fork length were calculated to find the correlations among energy storage (in form of visceral fat deposition), reproductive maturity and body development of char. The regression analysis LSI, GSI and VFI were conducted to confirm their correlations with increased size of char. The GSI and VSI of Arctic char samples were also separated according to their sex. The correlations of GSI and VFI with respect to fork length and mean GSI and VFI of male and female fishes were compared to see if there were any significant differences in growth and reproductive maturation between male and female fishes.

Parasite community

The parasite species, infecting Arctic char were identified. Regression analysis of total parasite count in individual char was plotted against fork length and age of the fishes. Mean intensity, prevalence and abundance of the parasites were calculated according to the modal groups and compared.

Stable isotope analysis

The nitrogen and carbon signatures of the entire char samples were plotted according to their size, age and with respect to each other. However, the comparative study of carbon and nitrogen signature of different modal groups of char (with respect to fork length and age) was also performed. The non-parametric correlations among fork length, age, nitrogen and carbon signature of the entire char sample and of different modal groups (small, medium and large) were calculated. Carbon and nitrogen signature of parasite infected and non-infected fish was plotted with respect to each other. Independent t-tests were done to compare the mean of carbon and nitrogen signature in piscivorous and non-piscivorous char and modified Levene test was performed to check the homogeneity of variances of the data.

Combined study of fish data, parasite community and stable isotope analysis

The non-parametric correlations among Fulton's condition factor, fork length, age, total parasite count, LSI. GSI and VFI of char samples were calculated separately for small, medium and large char to detect the variations among gonad development, fat deposition, health status and the effect of parasite load among the size groups. The number of parasites per gram of stomach weight and liver weight of char were calculated and regression analysis was done with respect to fork length and age to determine the effect of parasite load in those internal organs. The carbon and nitrogen signature of char were also correlated with parasite count of the entire char sample of Wormy Lake.

RESULTS

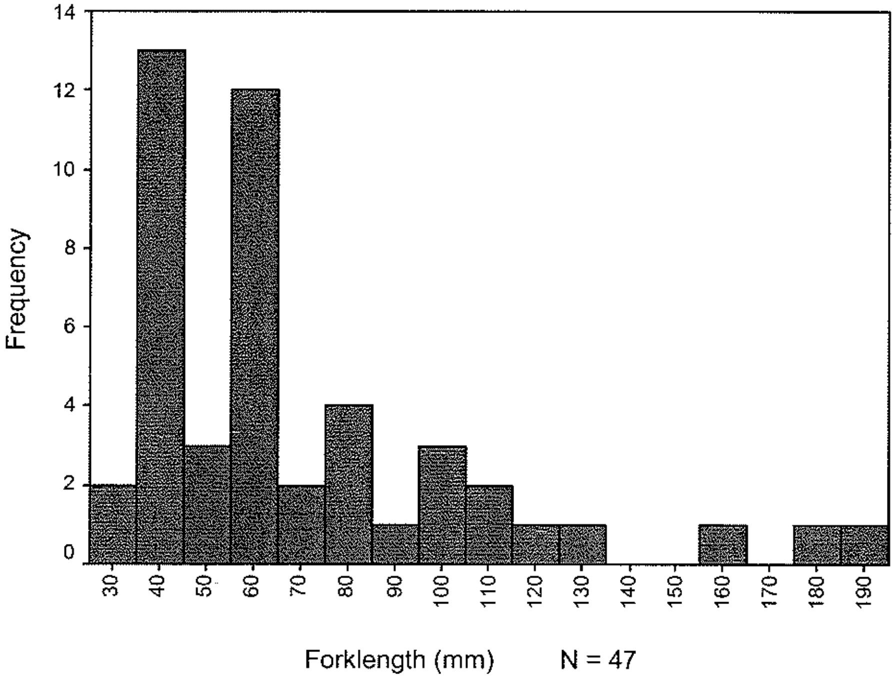
Frequency distribution

The length-frequency distribution of the Arctic char of Iqalugaajuruluit Lake (Wormy Lake) was separated according to the method of fish capture (electro fishing, Figure 3A and gill-netting Figure 3B) and it was also combined for the entire fish sample (Figure 4). Small char (FL 30-130 mm) were mostly caught by electro fishing, whereas, the bigger fishes were mostly collected by Swedish gill net. The length-frequency distribution of the char samples indicated the presence of three modal group or size groups (Figure 4), the small fishes (FL <125 mm), the medium fishes (FL 125-250 mm) and the large fishes (FL > 300). The descriptive statistics of length-frequency distribution (Appendix 2, Table 1.1 and 1.2), the test of normality (Appendix 2, Table 3) and the normal Q-Q plot (Figure 8A) of fork length plotted against normal expected value, indicated non-normal distribution of char samples. The values of skewness and kurtosis were found to be significantly higher than expected ('0' in case of normal distribution) both in electro-fishing (1.597 and 2.40 in Appendix 2, Table 1.1) and gill-netting (2.099 and 5.544 in Appendix 2, Table 1.2). In the test of normality (Appendix 2, Table 3), both in case of Kolmogorov-Smirnov test (0.155) and Shapiro-Wilk test (0.872), the test statistics were significantly higher than expected value (0.000) and it confirmed the non-normal length-frequency distribution of char samples.

The age-distribution of the char samples (Figures 5.1, 5.2 and Figure 6) and the age plotted with respect to fork-length (Figure 7) of char indicated that, the small fishes were mainly aged between 0-4 years and the medium and large fishes were aged between 4-12 years. There were very few fishes aged more than 14 years in the entire fish sample. The positive values of skewness and kurtosis (1.747, 3.222 in Appendix 2, Table 2.1 and 0.641, 0.936 in Appendix 2, Table 2.2) in the descriptive statistics of the age-frequency distribution, the results of normality test (Appendix 2, Table 3) and the normal Q-Q plot (Figure 8B) of age data confirmed the non-normal age-distribution of Arctic char.

Figure 3: Length-frequency distribution of Arctic char captured by electro-fishing (A) and gill-netting (B).

A


14
12
10
8
6
4
2
0
Frequency
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
Forklength (mm)
N = 47

B

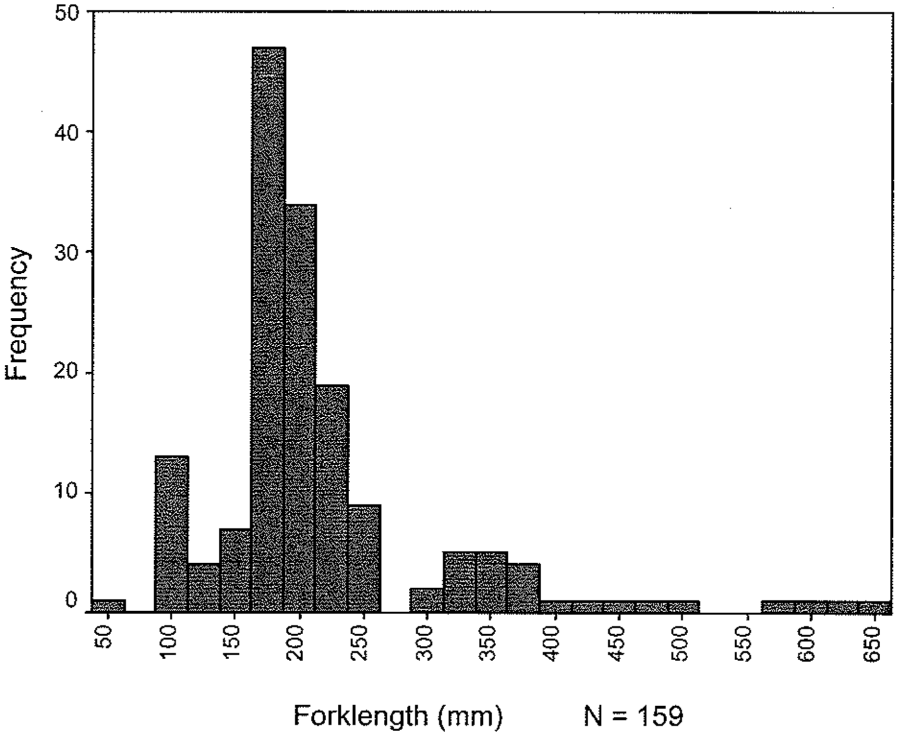

50
40
30
20
10
0
Frequency
50
100
150
200
250
300
350
400
450
500
550
600
650
Forklength (mm)
N = 159

Figure 4: Length-frequency distribution of the total Arctic char samples from Iqalugaajuruluit (Wormy) Lake

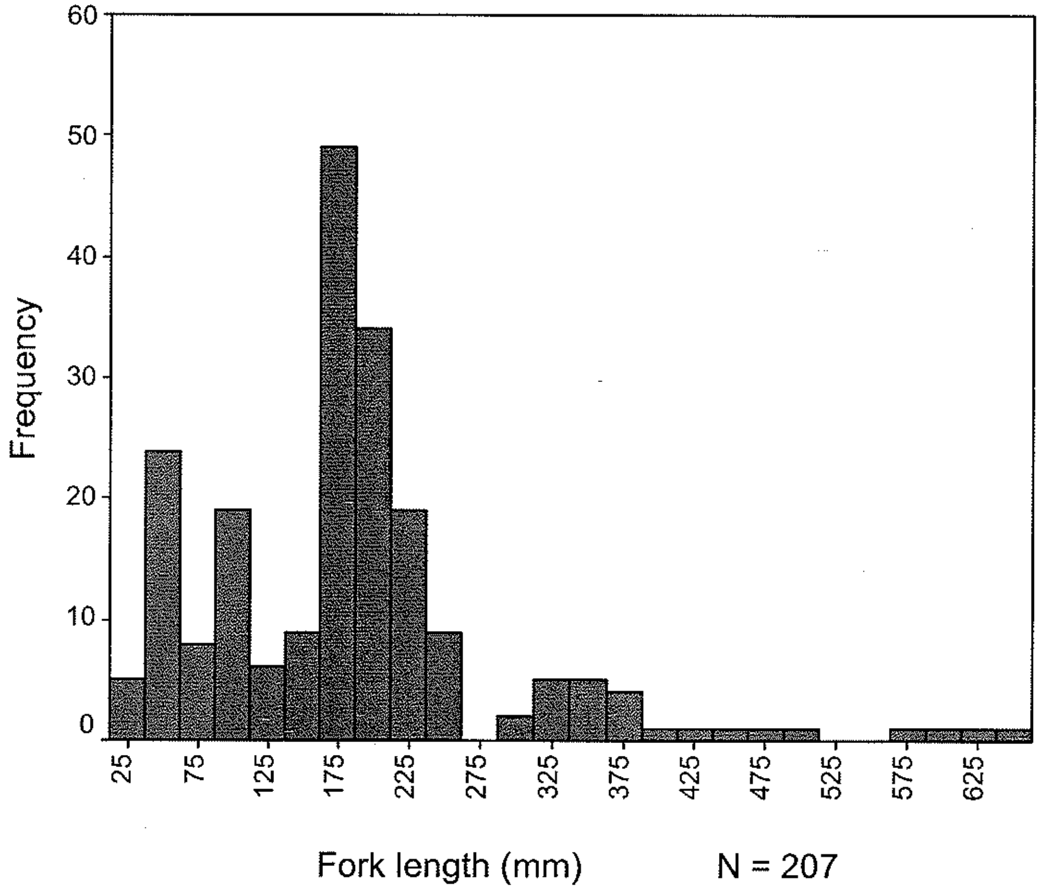
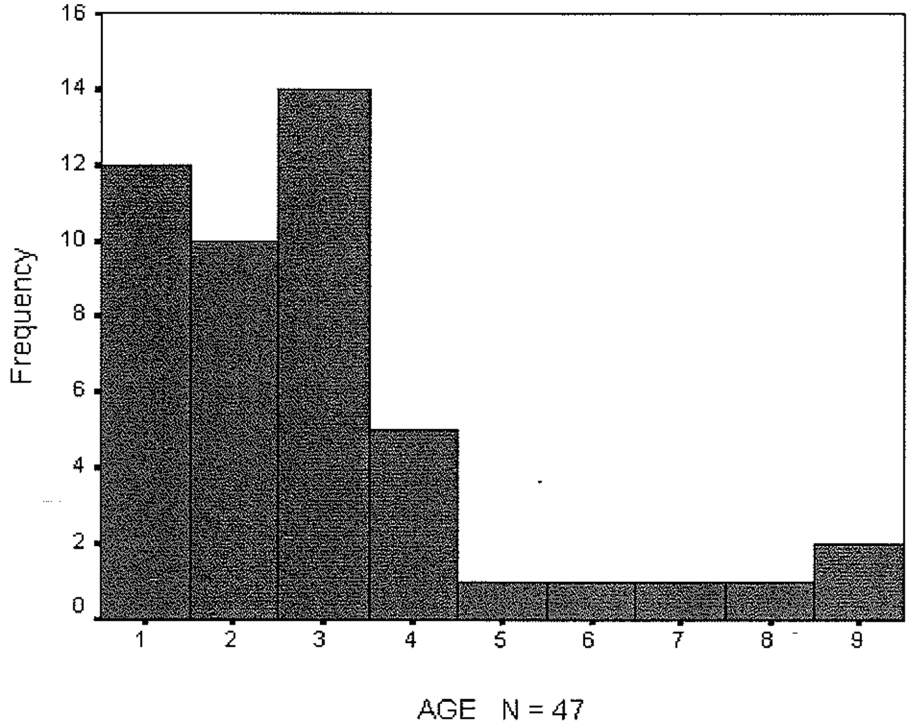

60
50
40
30
20
10
0
Frequency
25
75
125
175
225
275
325
375
425
475
525
575
625
Fork length (mm)
N = 207

Figure 5: Age frequency distribution of Arctic char captured by electro-fishing (A) and gill-netting (B).

A


16
14
12
10
8
6
4
2
0
Frequency
1
2
3
4
5
6
7
8
9
AGE N = 47

B

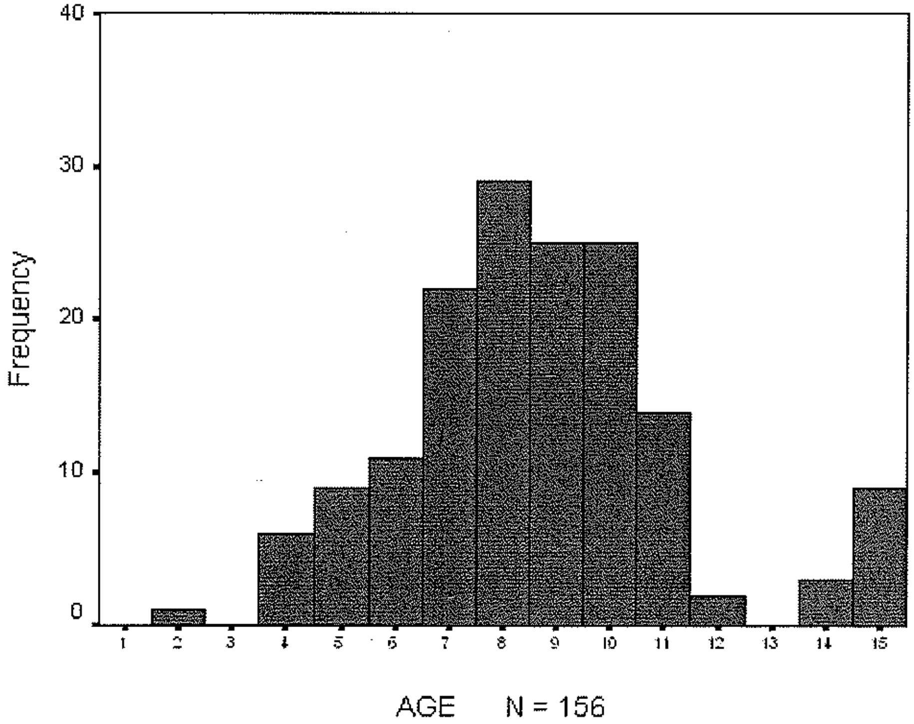

40
30
20
10
0
Frequency
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
AGE N = 156

Figure 6: Age-frequency distribution of the total Arctic char samples from Iqalugaajuruluit (Wormy) Lake

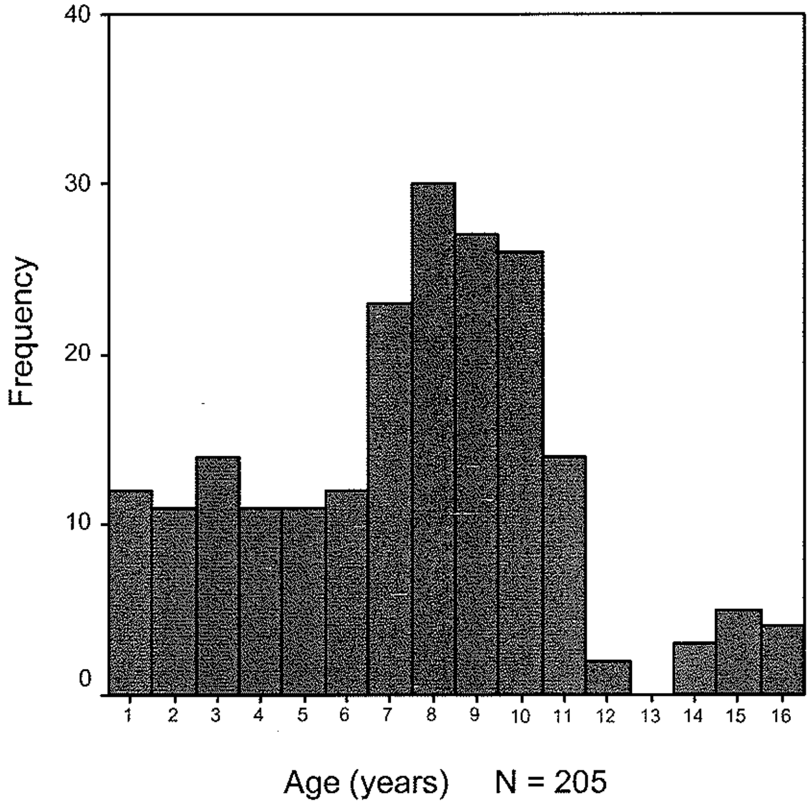

40
30
20
10
0
Frequency
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Age (years)
N = 205

Figure 7: Plot of fork length and age of Arctic char of Iqalugaajuruluit (Wormy) Lake

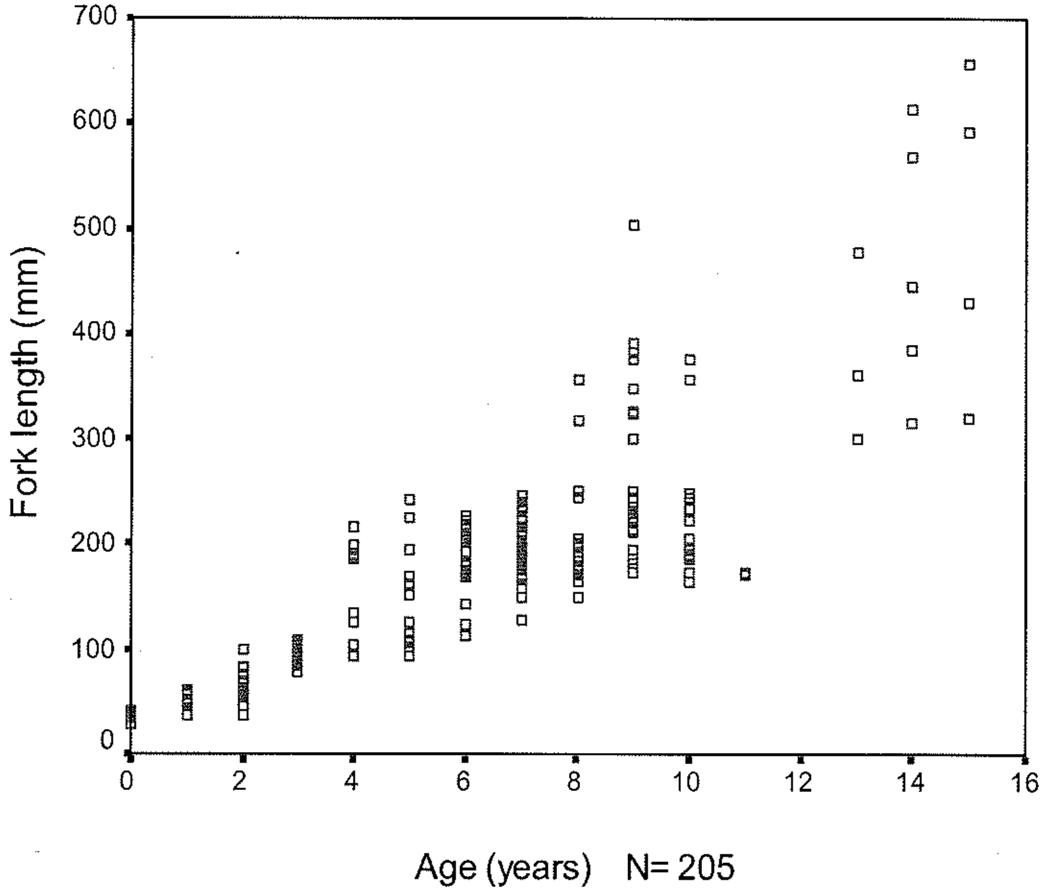
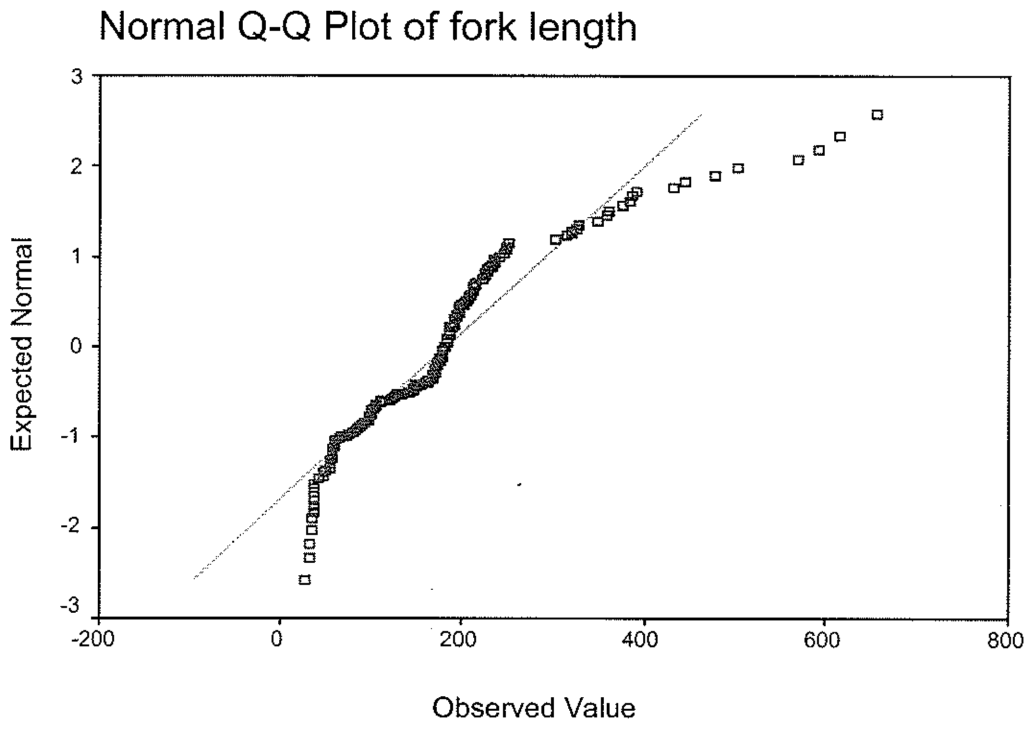
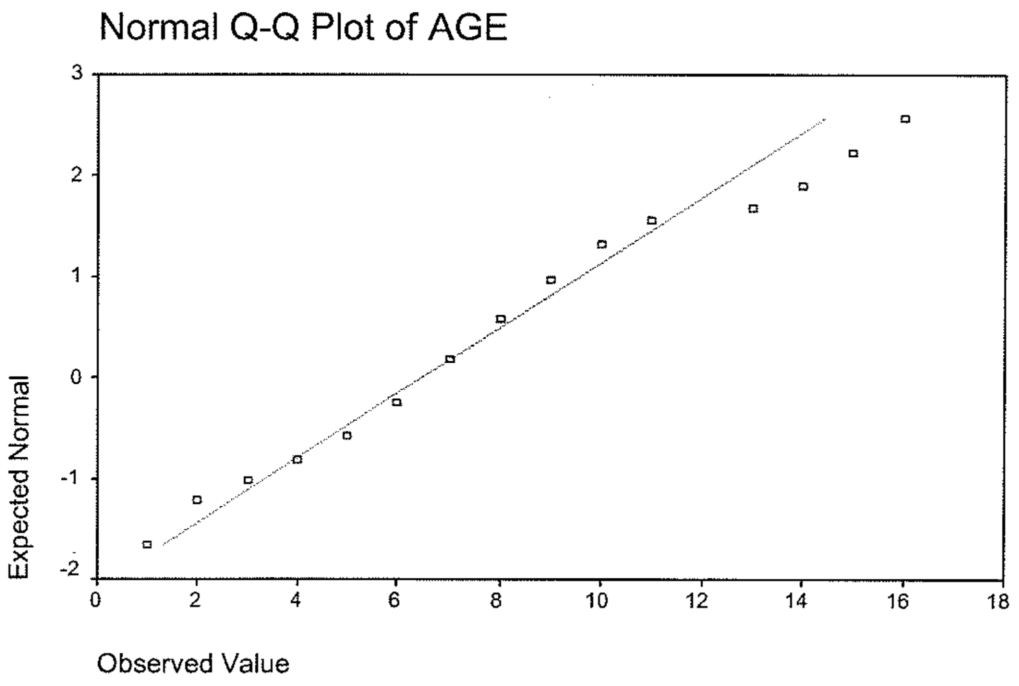

700
600
500
400
300
200
100
0
Fork length (mm)
0
2
4
6
8
10
12
14
16
Age (years) N= 205

Figure 8: Normal Q-Q plots for length (A) and age (B) frequency distribution of Arctic char population

A


Normal Q-Q Plot of fork length
Expected Normal
3
2
1
0
-1
-2
-3
-200
0
200
400
600
800
Observed Value

B


Normal Q-Q Plot of AGE
Expected Normal
3
2
1
0
-1
-2
0
2
4
6
8
10
12
14
16
18
Observed Value

Stomach content analysis

The prey types of all char size groups were identified (Appendix 3) and the prevalence of food items was calculated (Figure 9A, Table 1A). Small char (FL< 125 mm) were mostly benthivorous, with chironomid larvae being the most prevalent in the diet. They also fed on Cladocera, Collembola, Copepods, Diptera, wasps, water mites and other aquatic insects. The medium char (FL 125-250 mm) fed on caddis fly larvae, clams, chironomid, plant material, other aquatic insects etc (Table 1A), but some fish bones were also identified from the stomach contents of some medium sized fish (with FL > 184 mm). Aquatic insects were the most prevalent food item in medium char. The large char (FL > 300 mm) were mainly piscivorous and some were cannibals. Stickleback was the most prevalent food item, but fish bone, small Arctic char and some caddis fly larvae were also identified from their stomach. The feeding percentage of different food types for summer and winter char of Iqalugaajuruluit (Wormy) Lake was calculated and plotted (Figure 9B, Table 1B) to determine if there were significant variations in their food choice. In summer, Arctic char fed on, caddis fly larva (4.7 %), chironomid (20.7 %), clams (1.3 %), plant material (2.0 %), fish bone (6.0 %), stickleback (4.7 %), small char (0.7 %) and different types of aquatic insects (Cladocera, Collembola, Copepod, Diptera, wasp and water mites) (47.3 % of total food). Aquatic insects and chironomid larvae were the most common food items of summer samples. By contrast, stomach contents of winter char contained chironomid (63.8 %), plant material (8.6 %), caddis fly larvae (5.2 %), clams (10.3 %), fish bone (6.9 %), stickleback (5.2 %) and Arctic char (6.9 %) with chironomid being the most common food item in winter char.

Fish data analysis

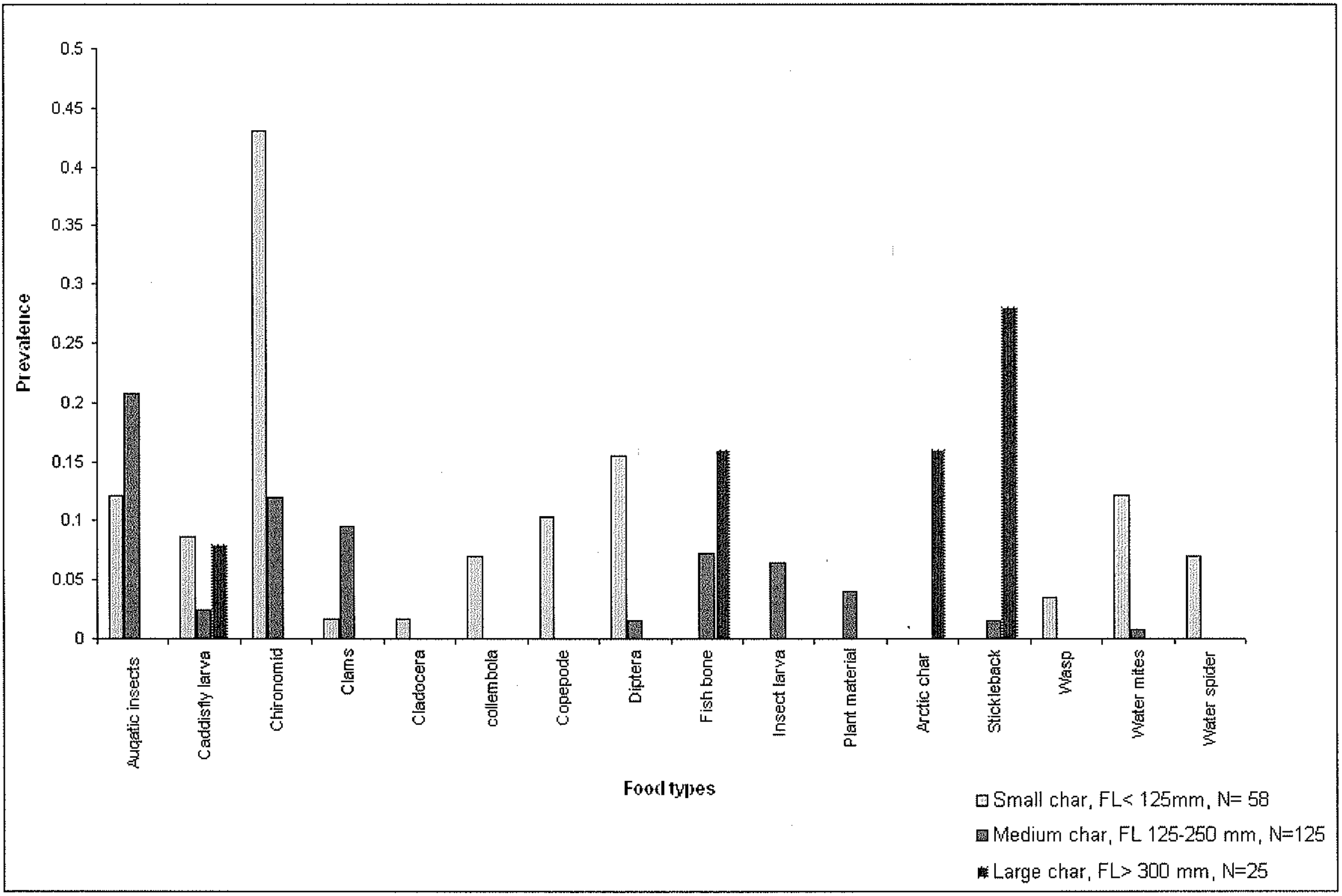
Figure 10 illustrates a sigmoid growth pattern of Arctic char population. The small char (FL <125 mm) had a slow growth rate, medium char (FL 125-250 mm), moderate growth rate and large char (FL >300 mm) had an exponential growth rate. Data regarding liver weight, gonad weight and visceral fat weight were analyzed to see the trend of body development and reproductive maturation. Both, Kolomogorov-Smirnov test and Shapiro-Wilk test of normality for liver weight, gonad weight and visceral fat weight

(Appendix 2, Table 4) produced significantly higher result than the expected value (0.00), indicating non-normal distribution in all cases. The Levene statistics, checking homogeneity of variances (Appendix 2, Table 5), were also significantly higher than expected value (0.00) in case of liver weight, gonad weight and visceral fat weight data, indicating homogeneity assumption had been violated in all the cases. The non-parametric correlations of Liver Somatic Index (LSI), Gonado Somatic Index (GSI) and Visceral Fat Index (VFI) with respect to fork length were calculated (Appendix 2, Table 6). Liver Somatic Index and Gonado Somatic Index represented negative relation with respect to fork length. However, Visceral Fat Index presented a statistically significant negative relation with respect to fork length. The regression analysis of LSI, GSI and VFI with respect to fork length (Figures 11A, B, C) also supported these findings. GSI and VSI of Arctic char were separated according to sex, to see if there were any significant differences in growth and reproductive maturation between male and female char. Mean GSI and VSI of female Arctic char were significantly higher than male fish (Appendix 2, Table 7). However, the non-parametric correlations among GSI, VFI, (Appendix 2, Table 8, Table 9) with respect to fork length, in both sex, indicated negative correlations and failed to reflect any major differences from each other.

Parasite community

The total parasite count per individual Arctic char was plotted against fork length (Figure 12 A) and age (Figure 12 B) of char. There was a significant increase of parasite burden in fishes having fork length greater than 300 mm and age over 9 years. The parasitic species infecting char samples were identified and separated according to the different size groups of fish. Six parasitic species, *Crepidostomum farionis*, *Diphyllobothrium ditermum, D. dendriticum, Eubothrium salvelini, Neoechinorhychus pungitius* and *Proteocephalus longicolis* were identified from small (FL <125mm) and large char (FL >300 mm) and one more parasite, *Phylonema agubernaculum* was identified from medium size group (FL 125mm-250mm). Among these parasites, *Diphyllobothrium ditermum, D. dendriticum, Eubothrium salvelini* and *Proteocephalus longicolis* mostly use copepod as intermediate host and char as definitive host in their life cycle. The mean intensity, prevalence and abundance of parasites were calculated according to the size groups and compared (Figures 13-15, Table 2). In the case of small and medium char *Proteocephalus longicolis* had the highest intensity, prevalence and abundance in comparison to the other parasites. In large char, *Diphyllobothrium* was the most dominant parasite, with *D. ditremum* having highest and *D. dendriticum* having the second highest mean intensity, prevalence and abundance among all parasites. The comparison of range of abundance among these three size groups (range, small char 0.069-2.310, medium char 0.016-0.20.320 and large char 0.840-434.052) highlighted a significant increase in parasitic intensity in large char. Figure15 illustrates that the sudden increase of parasite burden in large char in mainly due to a significant increase of *Diphyllobothrium* infection in those fishes.

Figure 9: Prevalence of food items in small, medium and Large Arctic char (A) and comparison of % food types of char in summer and fall 2004(B)


Prevalence
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Augatic insects
Caddisfly larva
Chironomid
Clams
Cladocera
collembola
Copepode
Diptera
Fish bone
Insect larva
Plant material
Arctic char
Stickleback
Wasp
Water mites
Water spider
Food types
Small char, FL< 125mm, N= 58
Medium char, FL 125-250 mm, N=125
Large char, FL> 300 mm, N=25

B

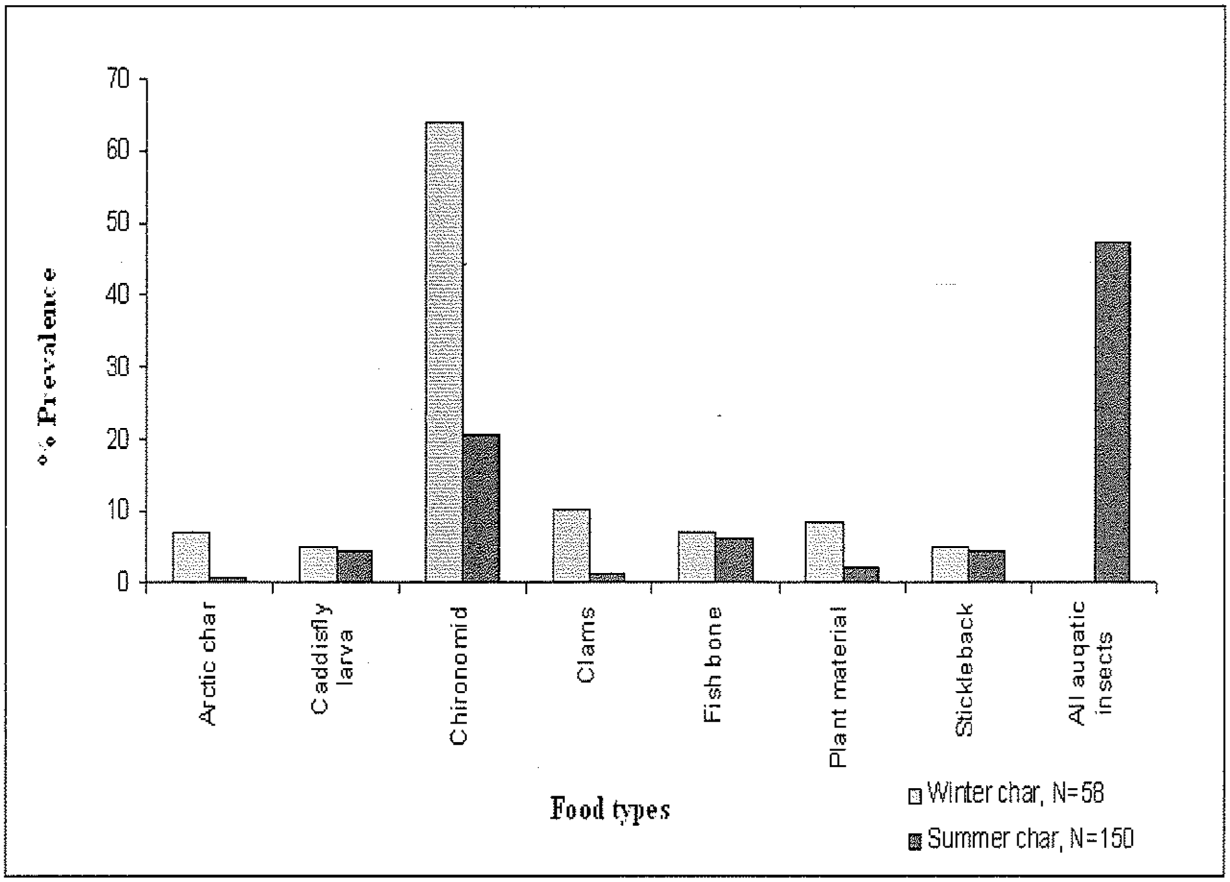

70
60
50
40
30
20
10
0
% Prevalence
Arctic char
Caddisfly larva
Chironomid
Clams
Fish bone
Plant material
Stickleback
All auqatic insects
Food types
Winter char, N=58
Summer char, N=150

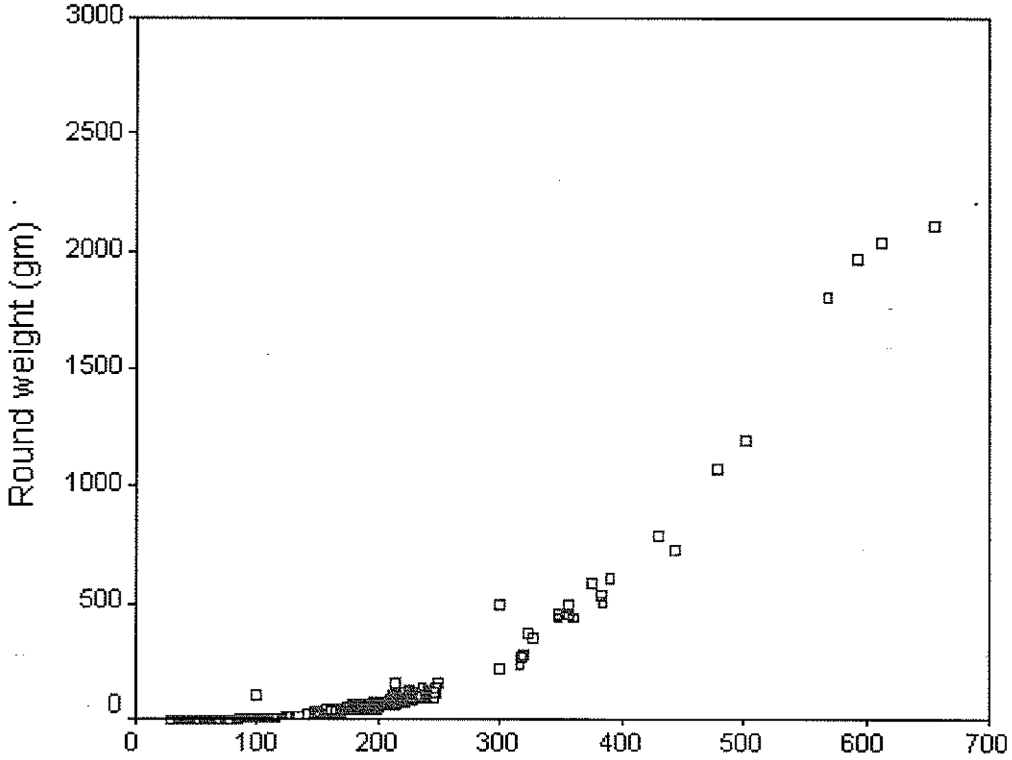
Table 1A: Prevalence of food types of Arctic char population

Type of fish	Food	% Prevelance
	Other aquatic insects	12.1
Small char	Caddisfly larva	8.6
N=58	Chironomid	43.1
FL<125 mm	Cladocera	1.7
	Collembola	6.9
	Copepode	10.3
	Diptera	15.5
	Wasps	3.4
	Water mites	12.1
	Water spiders	6.9
Medium char		
N=125	Other aquatic insects	20.8
FL 125 -250 mm	Caddisfly larva	2.4
	Chironomid	12.0
	Clams	9.6
	Diptera	1.6
	Fish bone	7.2
	Insect larva	6.4
	Plant material	4.0
	Sticklebacks	1.6
	Water mites	0.8
Large char		
N= 25	Arctic char	16.0
FL> 300 mm	Caddisfly larvae	8.0
	Fish bone	16.0
	Sticklebacks	28.0

Table 1B: Comparison of % food types of Char samples of fall and summer, 2004.

Fall 2004, N =58		
Food types	No of Fish	% Prevalence
Arctic char	4	6.9
Caddisfly larva	3	5.2
Chironomid	37	63.8
Clams	6	10.3
Fish bone	4	6.9
Plant material	5	8.6
Sticklebacks	3	5.2
Summer 2004, N =150	No of Fish	
Arctic char	1	0.7
All aquatic insects	71	47.3
Caddisfly larva	7	4.7
Chironomid	31	20.7
Clams	2	1.3
Fish bone	9	6.0
Plant material	3	2.0
Sticklebacks	7	4.7

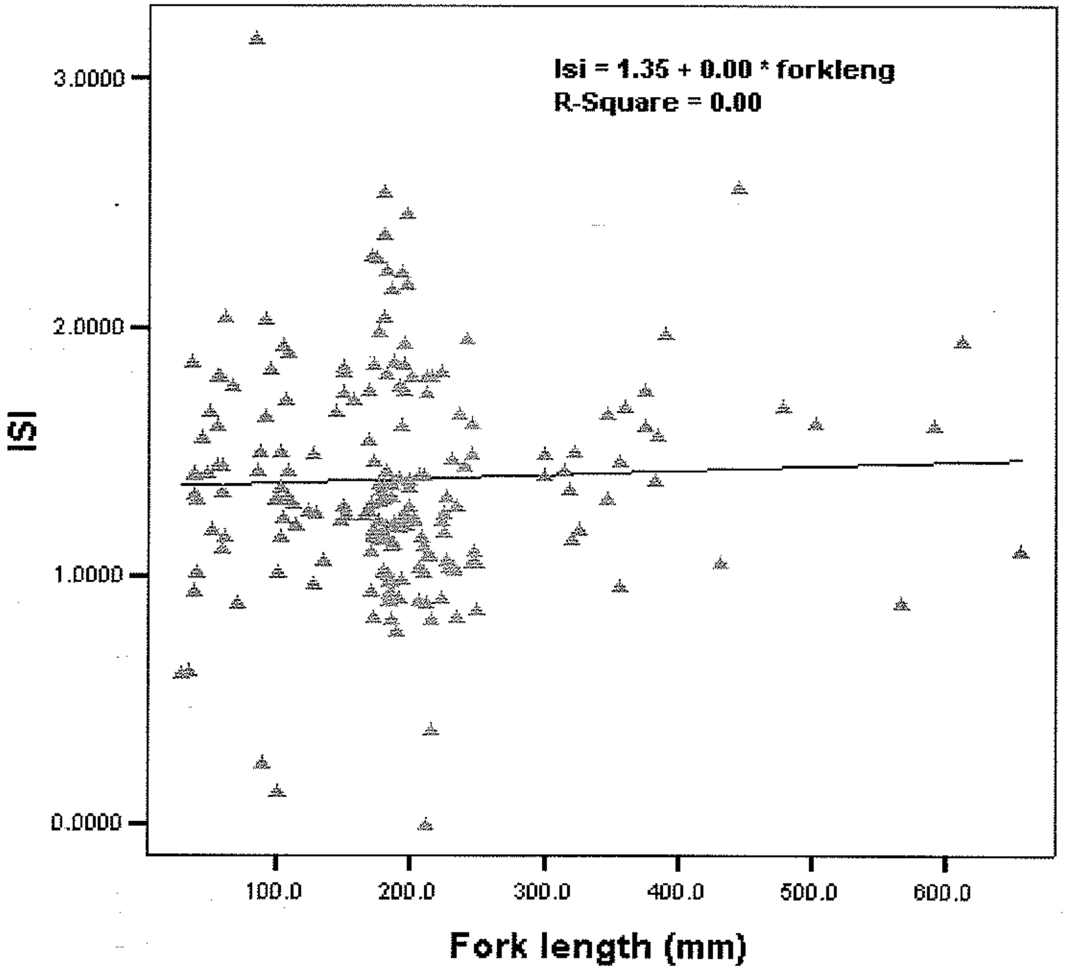
Figure10: Growth pattern of Arctic char from Iqalugaajuruluit Lake



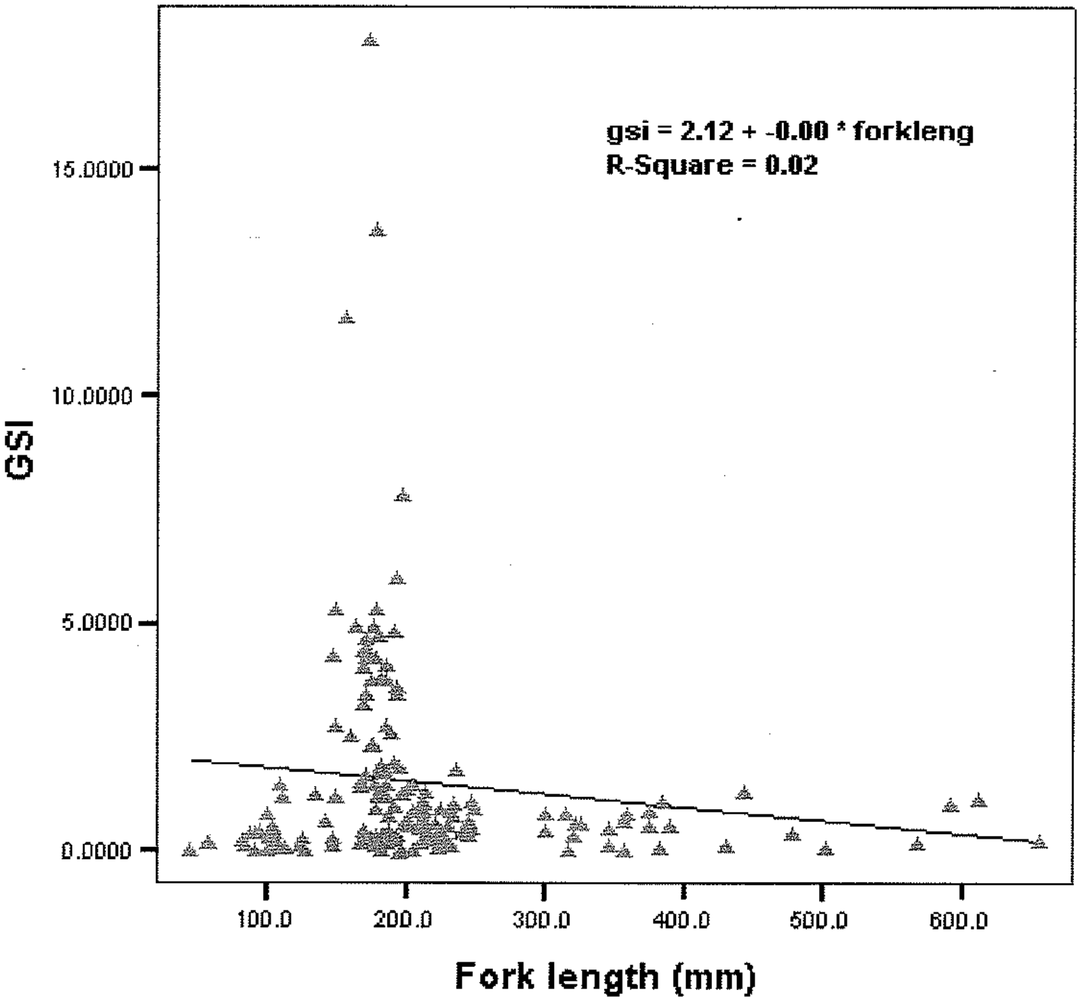
Fork length (mm) N= 206

Figure 11: Plot of fork length and Liver Somatic Index (LSI) (A), fork length and Gonado Somatic Index (GSI) (B), fork length and Visceral Fat Index (VFI) (C) of Arctic char

A


Isi = 1.35 + 0.00 * forkleng
R-Square = 0.00
3.0000
2.0000
1.0000
0.0000
ISI
100.0
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

B


gsi = 2.12 + -0.00 * forkleng
R-Square = 0.02
15.0000
10.0000
5.0000
0.0000
GSI
100.0
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

C

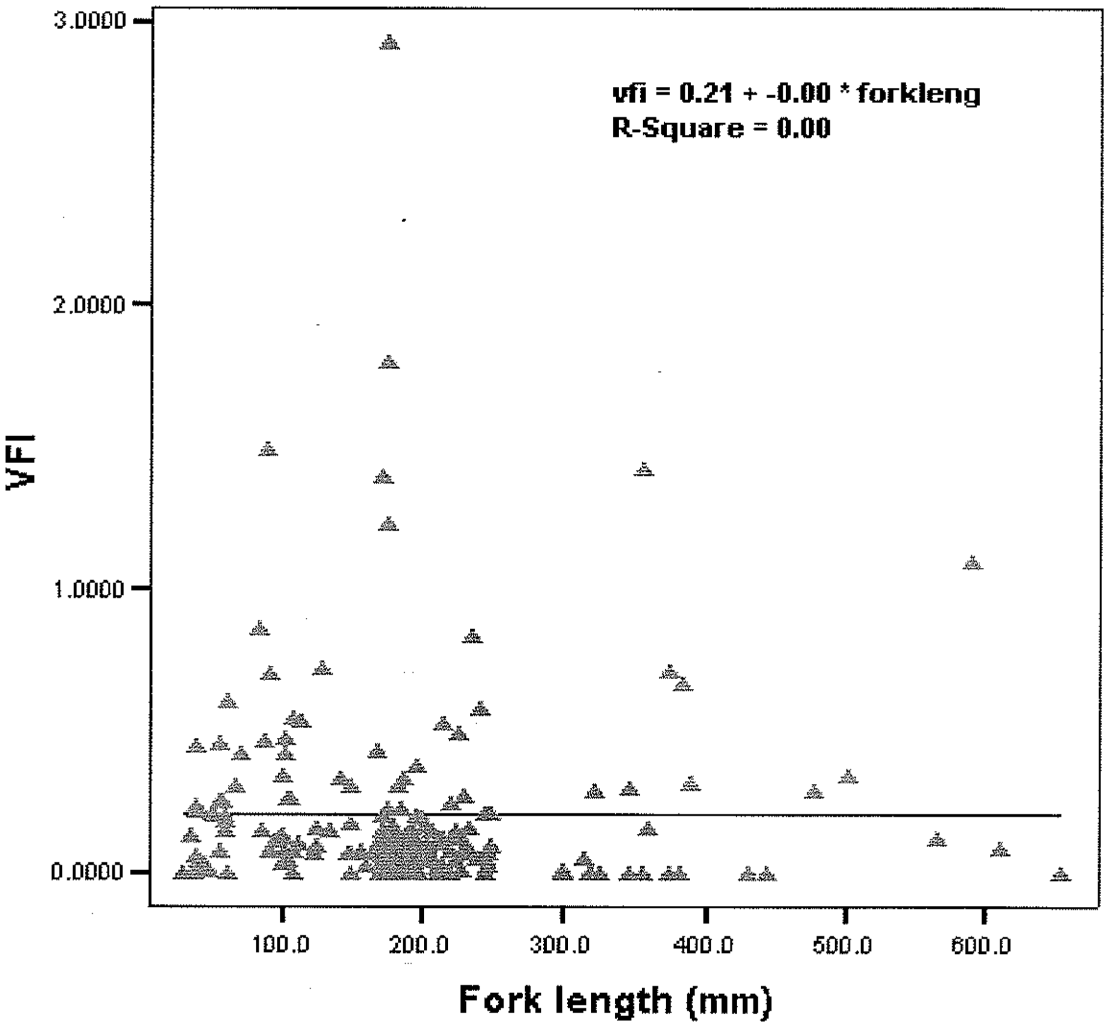
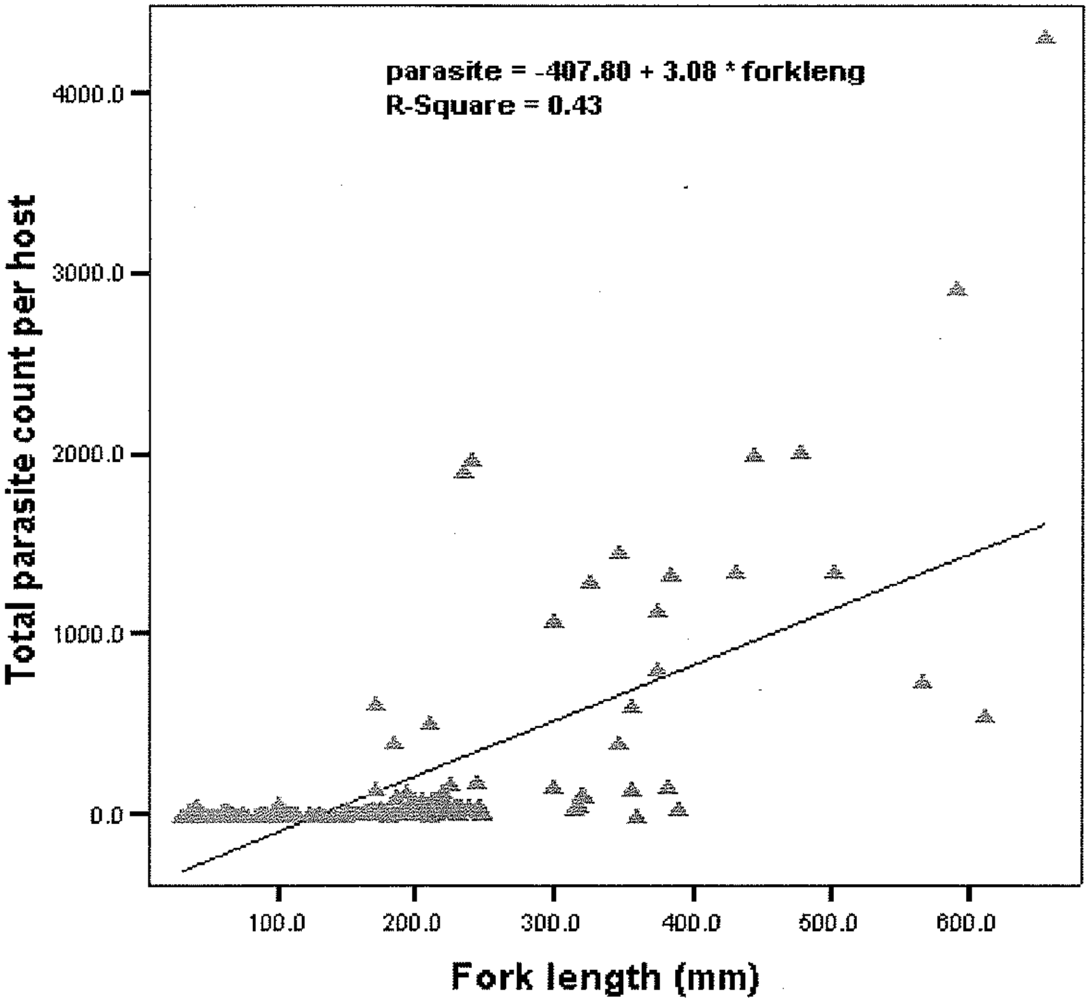

vfi = 0.21 + -0.00 * forkleng
R-Square = 0.00
VFI
3.0000
2.0000
1.0000
0.0000
100.0
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

Figure 12: Plot of fork length and total parasite count (A) and age and total parasite count (B) in individual host of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

A


parasite = -407.80 + 3.08 * forkleng
R-Square = 0.43
Total parasite count per host
4000.0
3000.0
2000.0
1000.0
0.0
100.0
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

B

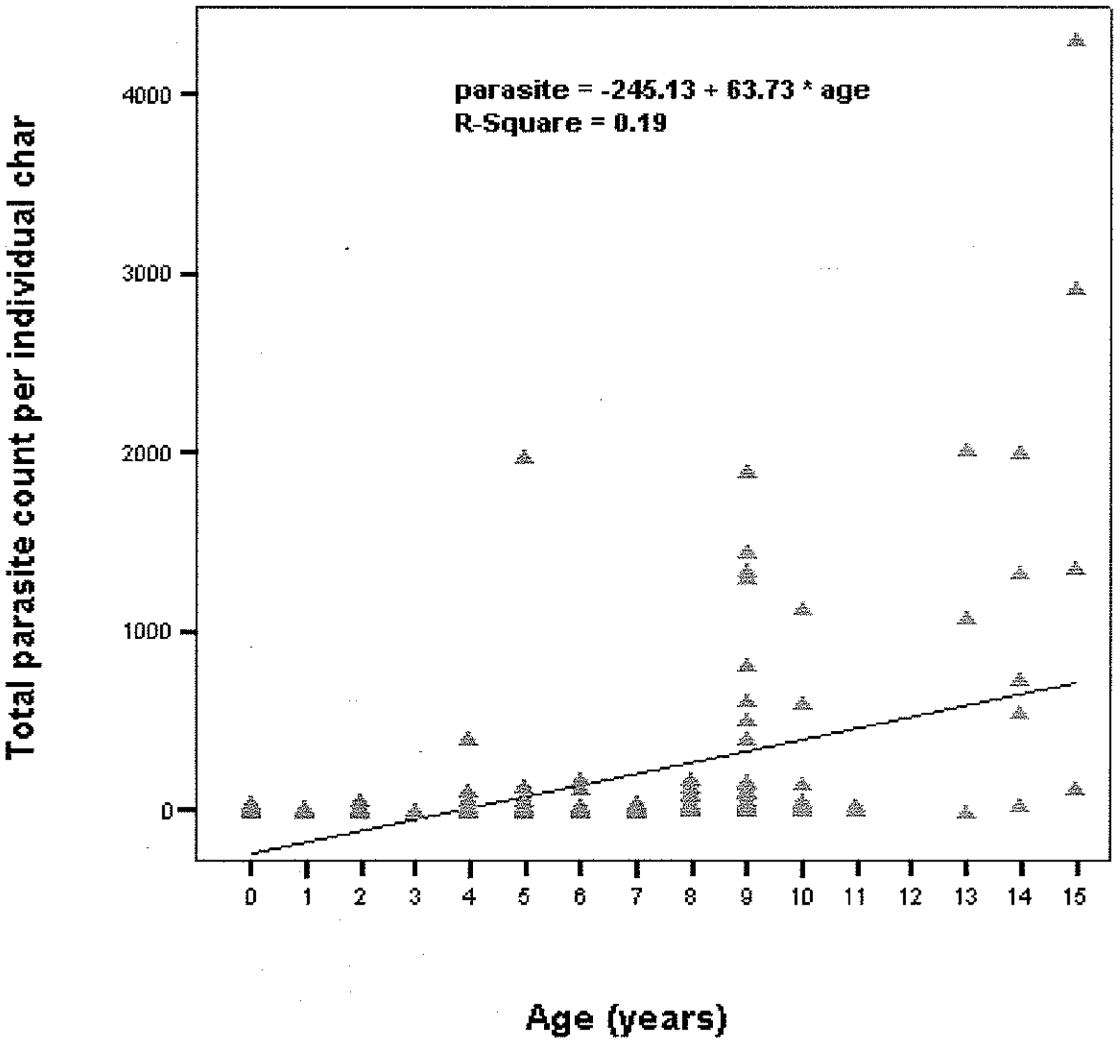

parasite = -245.13 + 63.73 * age
R-Square = 0.19
Total parasite count per individual char
0
1000
2000
3000
4000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Age (years)

Figure 13: Mean intensity of different parasitic species of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

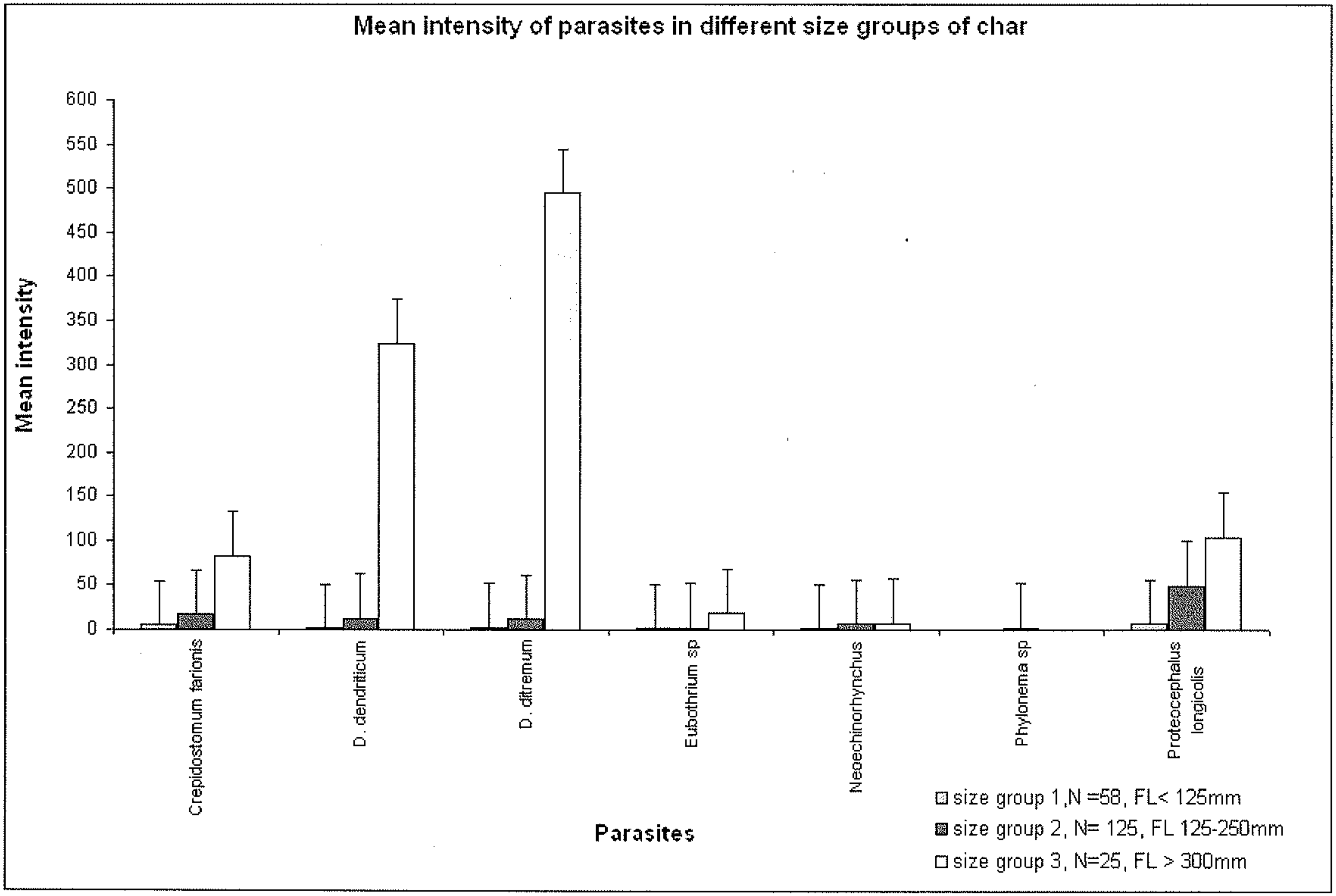

Mean intensity of parasites in different size groups of char
Mean intensity
600
550
500
450
400
350
300
250
200
150
100
50
0
Crepidostomum farionis
D. dendriticum
D. ditremum
Eubothrium sp
Neoechinorhynchus
Phylonema sp
Proteocephalus longicolis
Parasites
▨ size group 1, N =58, FL< 125mm
▨ size group 2, N= 125, FL 125-250mm
☐ size group 3, N=25, FL > 300mm

Figure 14: Prevalence of different parasitic species of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

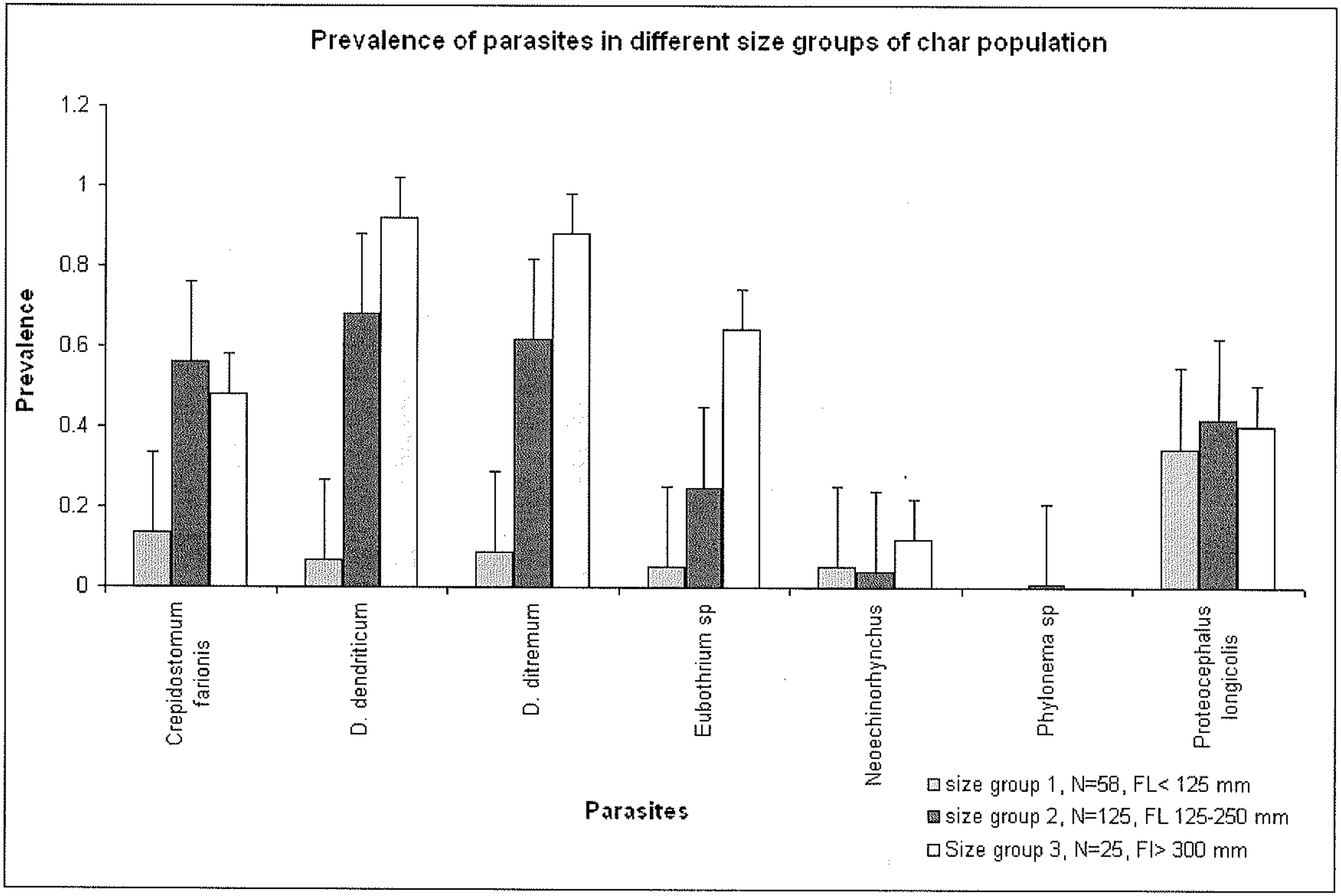

Prevalence of parasites in different size groups of char population
Prevalence
1.2
1
0.8
0.6
0.4
0.2
0
Crepidostomum farionis
D. dendriticum
D. ditremum
Eubothrium sp
Neoechinorhynchus
Phylonema sp
Proteocephalus longicolis
Parasites
size group 1, N=58, FL< 125 mm
size group 2, N=125, FL 125-250 mm
Size group 3, N=25, Fl> 300 mm

Figure 15: Abundance of different parasitic species of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

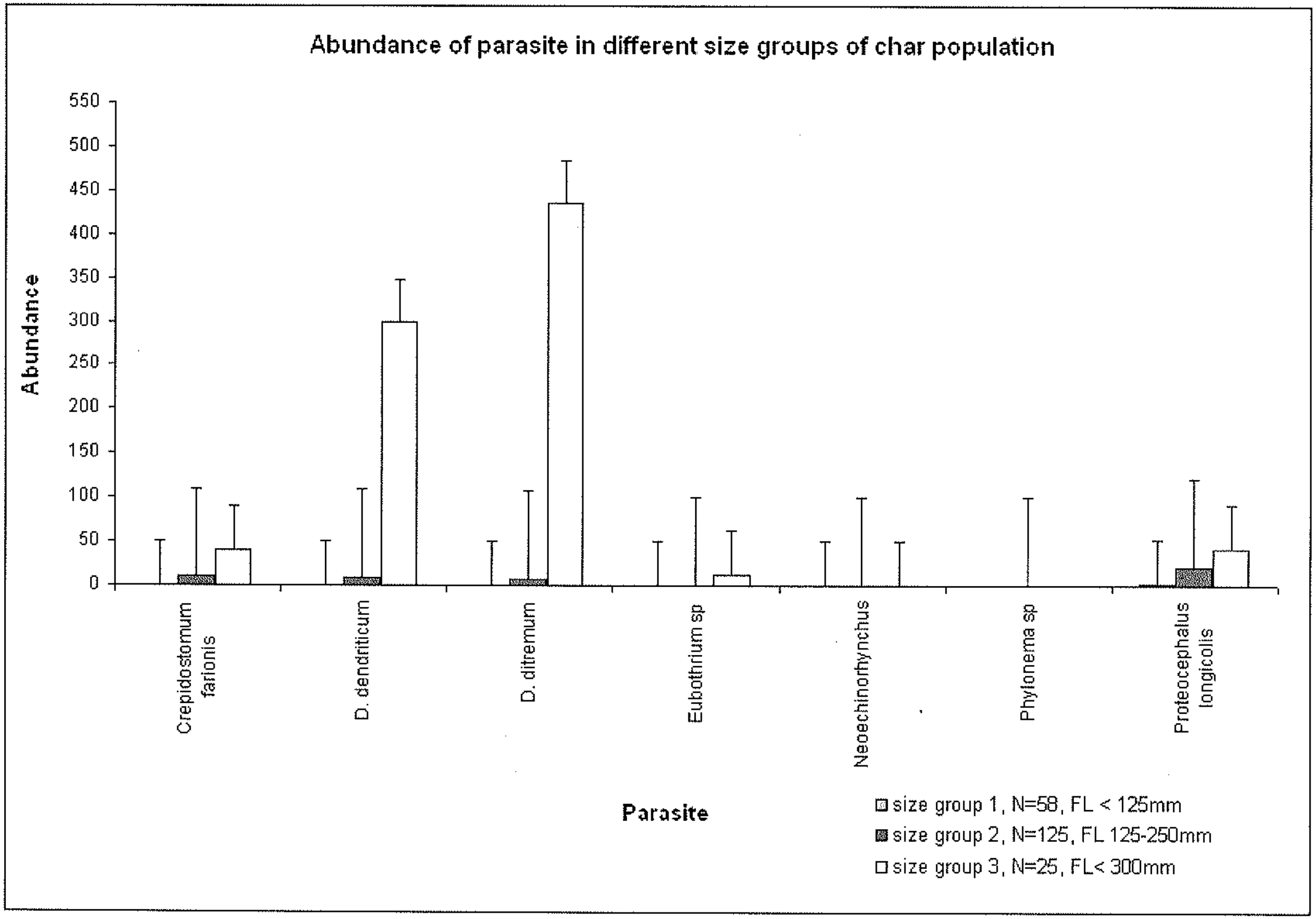

Abundance of parasite in different size groups of char population
550
500
450
400
350
300
250
200
150
100
50
0
Abundance
Crepidostomum farionis
D. dendriticum
D. ditremum
Eubothrium sp
Neoechinorhynchus
Phylonema sp
Proteocephalus longicolis
Parasite
▨ size group 1, N=58, FL < 125mm
▩ size group 2, N=125, FL 125-250mm
☐ size group 3, N=25, FL< 300mm

Table: 2 Comparison of parasite intensity, prevalence and abundance in small, medium and large char.

Parasitic species	**no of infected fish**	**total no of parasite**	**mean intensity**	**Prevalence**	**Abundance**
Small char (FL<125mm, N=58)					
Crepidostomum farionis	8	37.0	4.625	0.138	0.638
D. dendriticum	4	4.0	1.000	0.069	0.069
D. ditremum	5	10.0	2.000	0.086	0.172
Eubothrium salvelini	3	4.0	1.333	0.052	0.069
Neoechinorhynchus pungitius	3	4.0	1.333	0.052	0.069
Proteocephalus longicolis	20	134.0	6.700	0.345	2.310
Medium char (FL125-250 mm, N=125)					
Crepidostomum farionis	70	1198.0	17.114	0.560	9.584
D. dendriticum	85	1097.0	12.906	0.680	8.776
D. ditremum	77	902.0	11.714	0.616	7.216
Eubothrium salvelini	31	80.0	2.581	0.248	0.640
Neoechinorhynchus pungitius	5	32.0	6.400	0.040	0.256
Phylonema agubernaculum	1	2.0	2.000	0.008	0.016
Proteocephalus longicolis	52	2540.0	48.846	0.416	20.320
Large char (FL>300 mm, N=25)					
Crepidostomum farionis	12	986.0	82.167	0.480	39.440
D. dendriticum	23	7459.3	324.317	0.920	298.372
D. ditremum	22	10876.3	494.377	0.880	435.052
Eubothrium salvelini	16	301.0	18.813	0.640	12.040
Neoechinorhynchus pungitius	3	21.0	7.000	0.120	0.840
Proteocephalus longicolis	10	1040.0	104.000	0.400	41.600

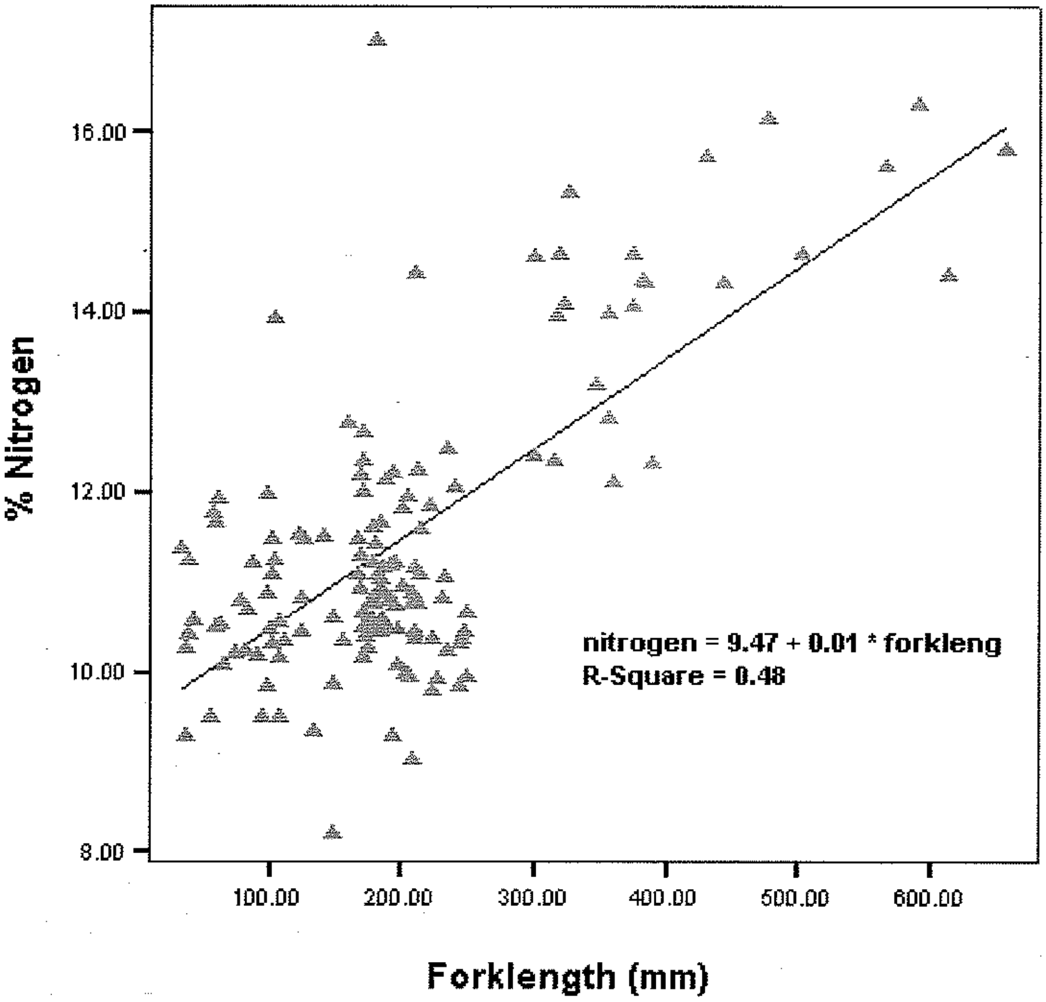
Stable isotope analysis

The nitrogen signature of Arctic char samples had significant positive relations with size and age (Figures 16A, 17A, Table 3). Where as, the carbon signature was negatively correlated with increased fork length and had no relation to age (Figures 16B, 17B, Table 3). The nitrogen signature presented a negative correlation with carbon value for the entire char sample (Figure 18, Table 3). Descriptive statistics of nitrogen signature of char (Appendix 2, Table 10) indicated that the mean nitrogen value of large char (FL > 300 mm) was significantly higher than the other two groups (small char, FL< 125 mm, medium char, FL 125-250 mm). However, medium char had a wide range of nitrogen values (9.32-13.97 in small char and 8.25-17.04 in medium char) in comparison with small char, implying some higher energy sources and diet overlap with large fishes. Descriptive statistics of the carbon signature of small, medium and large char (Appendix 2, Table 11) did not reflected any significant difference in mean carbon values among the modal groups, although, the large char had shorter carbon range than the other fishes. However, the comparative study of carbon and nitrogen signatures of the different modal groups (small, medium and large) of char (with respect to fork length and age), provided interesting but contradictory results. The carbon and nitrogen signature of three size groups of char were analyzed separately. Figure 19 illustrates that in small char, the nitrogen signature was positively correlated with fork length (Table 4), in medium char, nitrogen signature showed a negative correlation with fork length (Table 5), where as, in large char, nitrogen signature had significant positive correlation (Table 6) with fork length. The $\delta^{15}N$ values of three size groups plotted against age (Figure 20) provided a non-significant positive relation in small char (Table 4), almost no relation in medium char (Table 5) and statistically significant positive relation (Table 6) in case of large char. On the other hand, the carbon signature of small char was negatively correlated both with fork length and age (Figures 21, 22 Table 4). There was a slight positive correlation both, with age and fork length in case of medium char (Figures 21, 22, Table 4). In large char, the carbon value had significant negative relation with fork length (Figure 21, Table 6) and non-significant negative relation with age (Figure 22, Table 6). In summary, the nitrogen signature of small and medium char presented contradictory results when plotted against fork length and age and the nitrogen signature of medium char was also contradictory with the overall trend of char population. On the other hand, the carbon signature of medium char provided similar contradiction in comparison with small char and also in comparison with the over all trend of entire char samples of Wormy Lake.

Comparison of parasite infected to parasite non-infected Arctic char (Figure 23) indicated that non-infected fishes had small range of both carbon and nitrogen values, indicating that non-infected char mostly fed on zooplanktons and benthic food stuff. Comparison of the nitrogen and carbon signature in piscivorous and non-piscivorous char (Figures 24, 25) showed that piscivorous char had higher nitrogen and lower carbon values than non-piscivorous forms. The mean nitrogen and carbon signature of piscivorous and non-piscivorous char were significantly different from each other (Appendix 2, Table 12, Table 13). The results from Levene test also confirmed that the homogeneity of variance (Appendix 2, Table 12 and13) was violated both for carbon and nitrogen signatures of char samples.

Figure 16: Plot of fork length and nitrogen signature (A) and fork length and carbon signature (B) of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

A


% Nitrogen
16.00
14.00
12.00
10.00
8.00
100.00
200.00
300.00
400.00
500.00
600.00
Forklength (mm)
nitrogen = 9.47 + 0.01 * forkleng
R-Square = 0.48

B

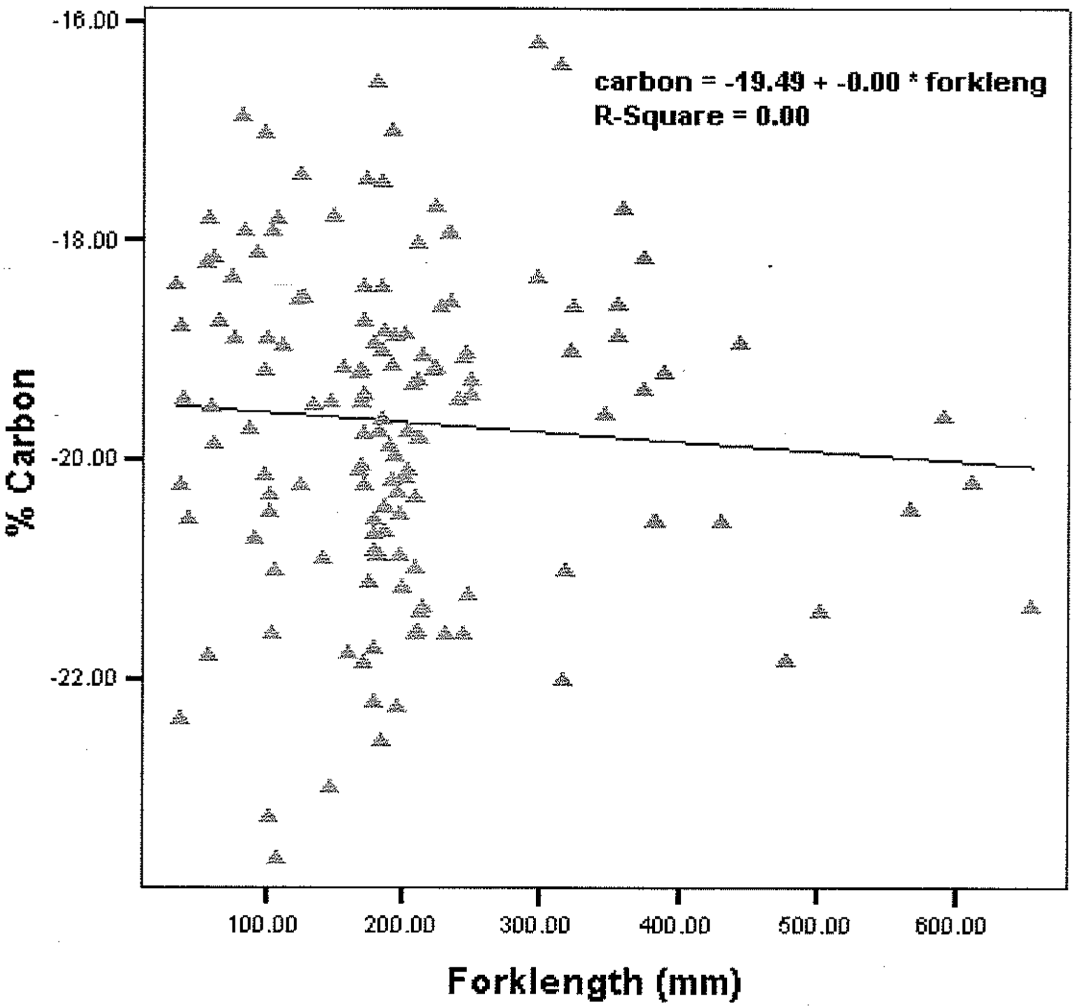
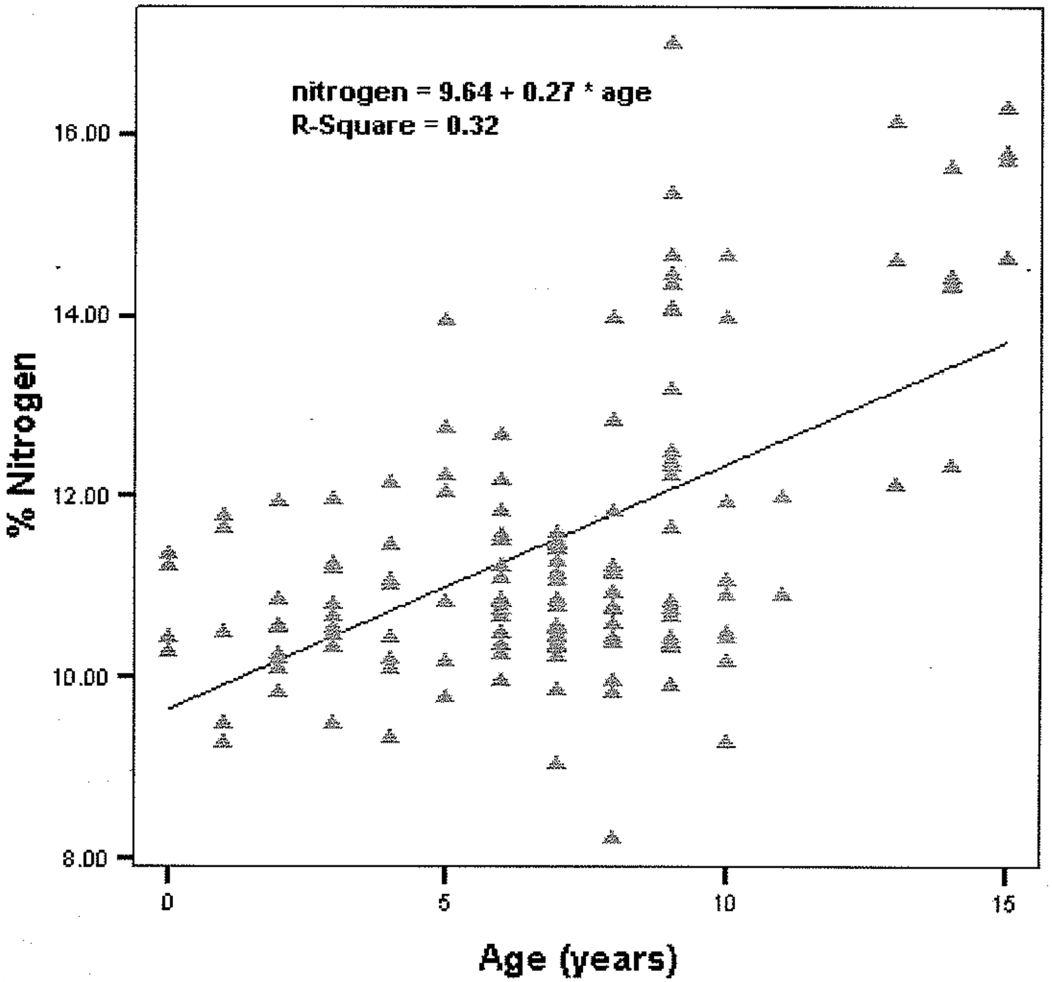

carbon = -19.49 + -0.00 * forkleng
R-Square = 0.00
-16.00
-18.00
-20.00
-22.00
% Carbon
100.00
200.00
300.00
400.00
500.00
600.00
Forklength (mm)

Figure 17: Plot of age and nitrogen signature (A) and age and carbon signature (B) of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

A


nitrogen = 9.64 + 0.27 * age
R-Square = 0.32
% Nitrogen
16.00
14.00
12.00
10.00
8.00
0
5
10
15
Age (years)

B

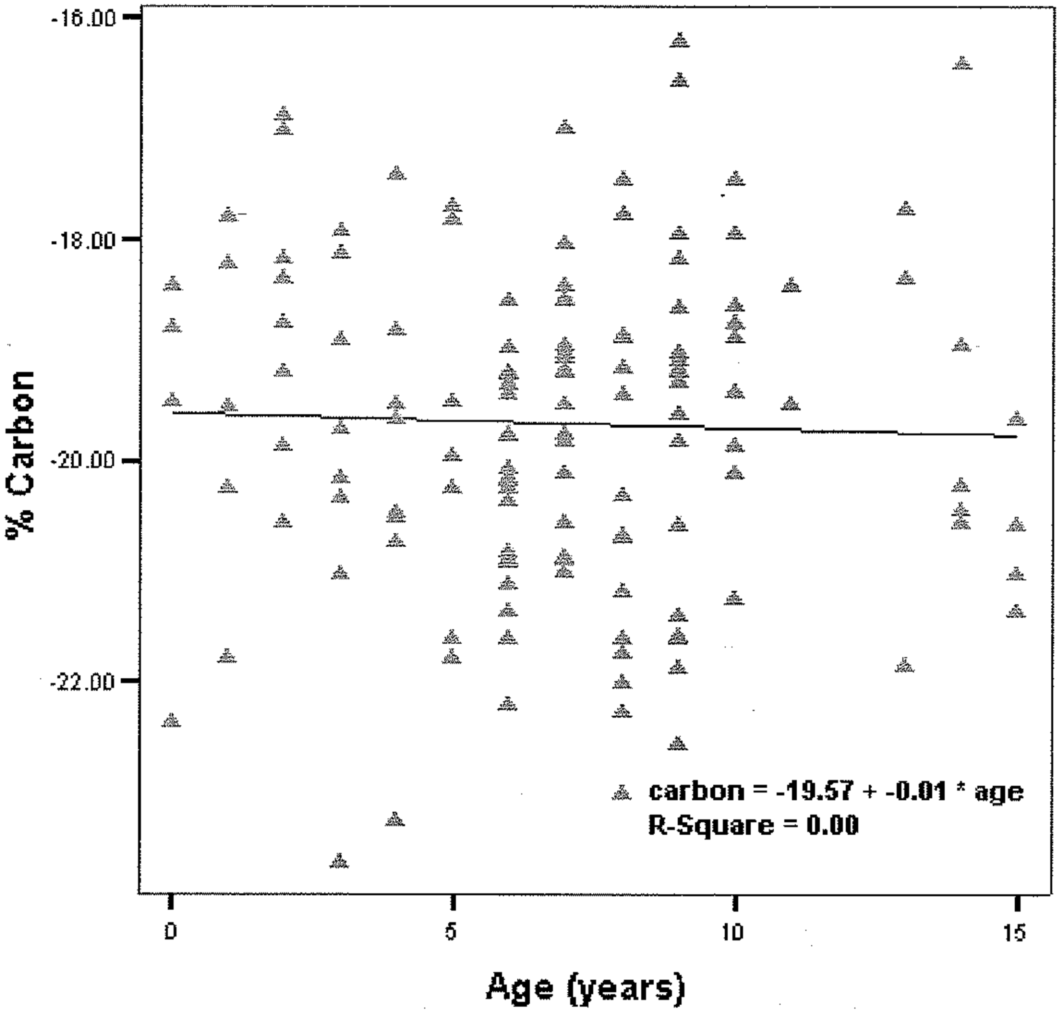

-16.00
-18.00
-20.00
-22.00
% Carbon
0
5
10
15
Age (years)
carbon = -19.57 + -0.01 * age
R-Square = 0.00

Figure 18: Plot of nitrogen and carbon signature of Arctic char samples from Iqalugaajuruluit (Wormy) Lake.

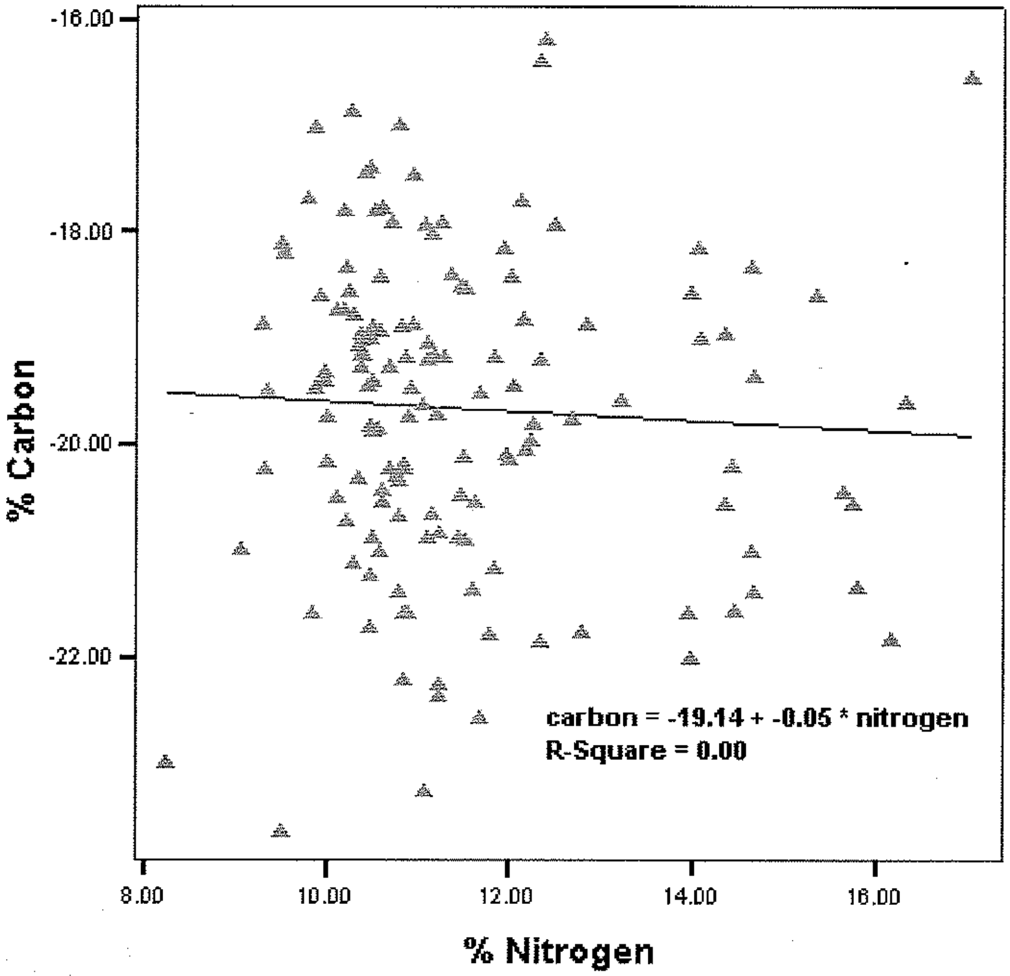

-16.00
-18.00
-20.00
-22.00
% Carbon
8.00
10.00
12.00
14.00
16.00
% Nitrogen
carbon = -19.14 + -0.05 * nitrogen
R-Square = 0.00

Figure 19: Comparison of relations between fork length and nitrogen signature in small, medium and large char

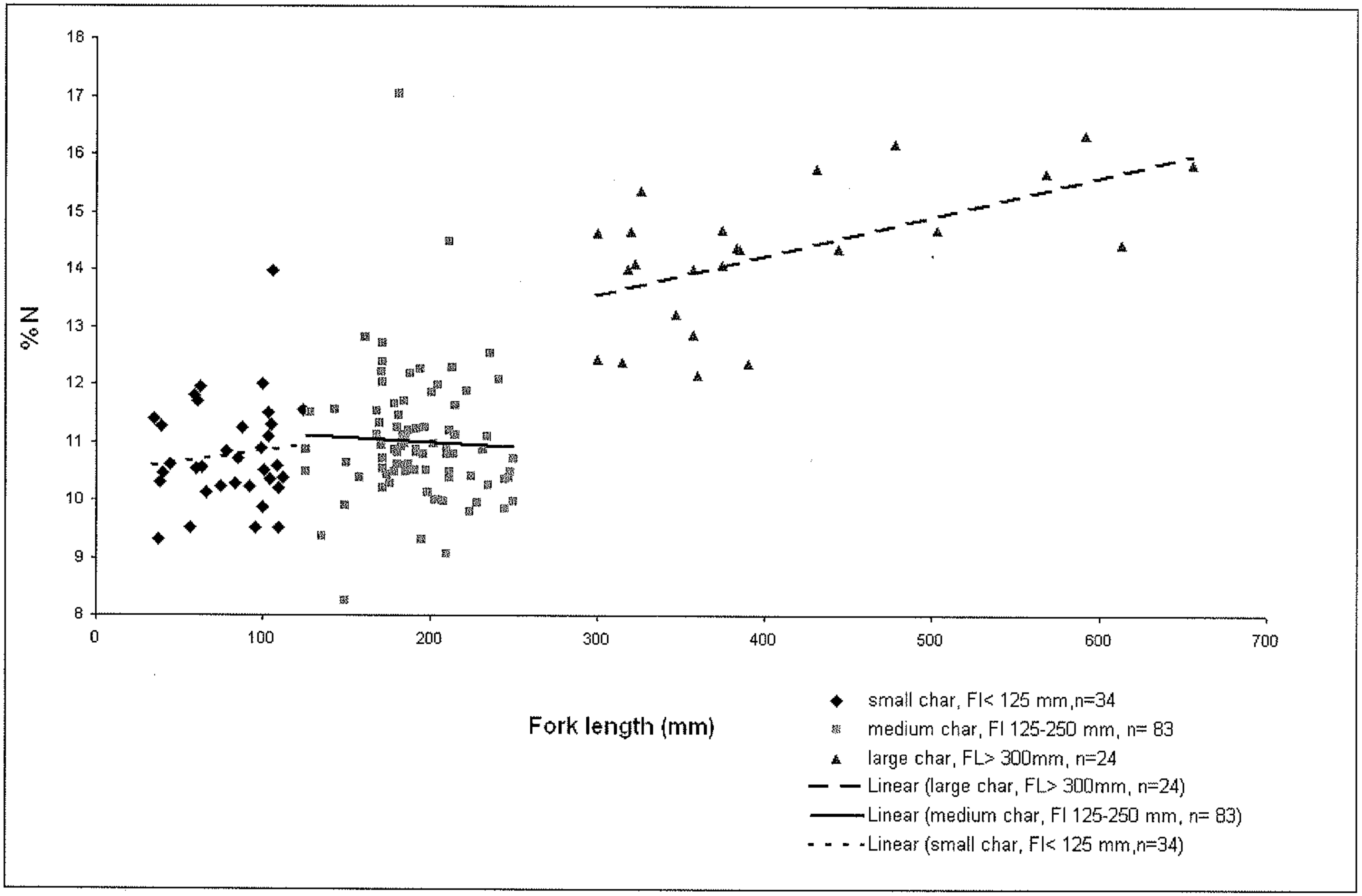

18
17
16
15
14
13
12
11
10
9
8
% N
0
100
200
300
400
500
600
700
Fork length (mm)
◆ small char, Fl< 125 mm,n=34
▨ medium char, Fl 125-250 mm, n= 83
▲ large char, FL> 300mm, n=24
Linear (large char, FL> 300mm, n=24)
Linear (medium char, Fl 125-250 mm, n= 83)
Linear (small char, Fl< 125 mm,n=34)

Figure 20: Plot of age and nitrogen signature in small, medium and large char

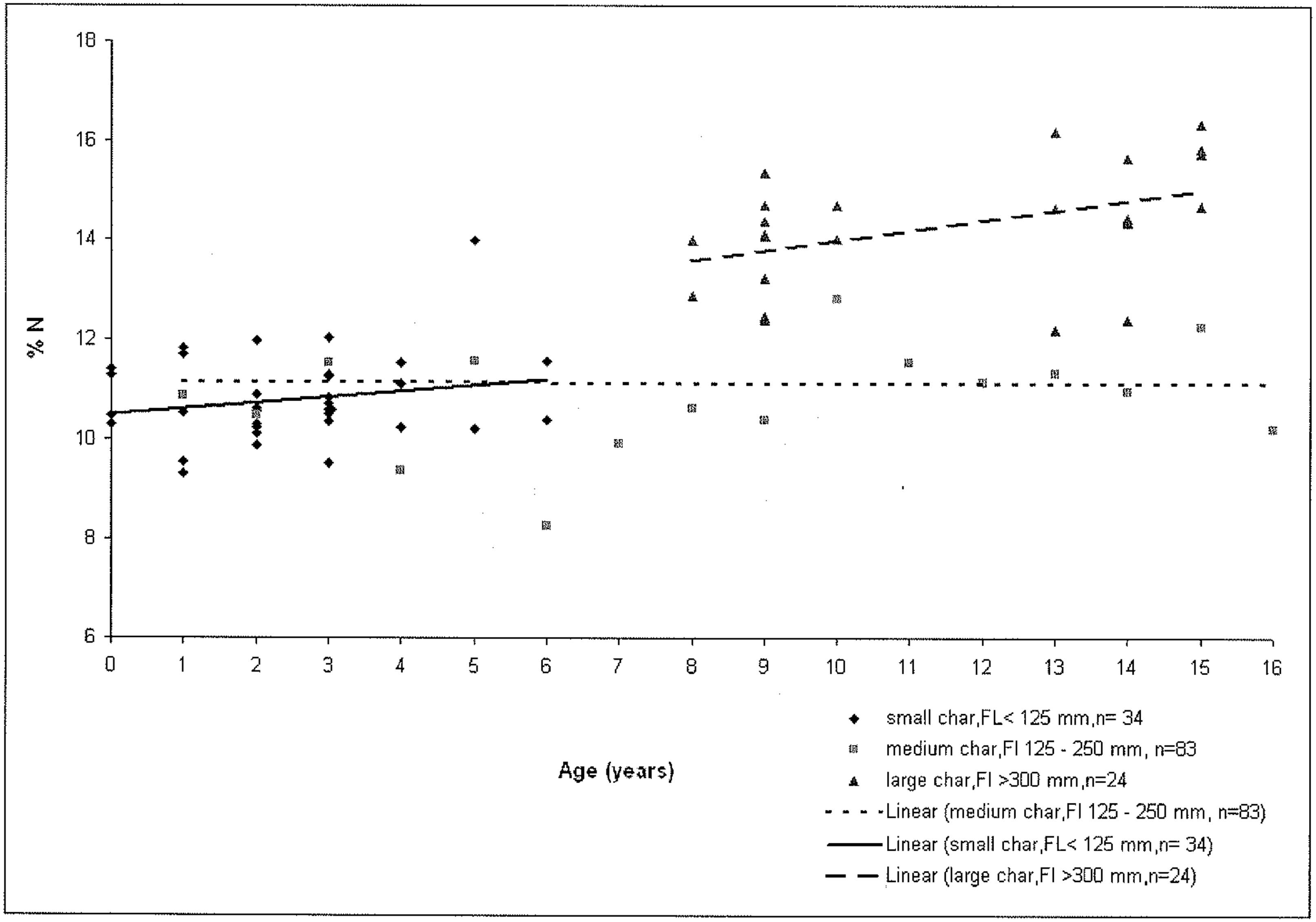

% N
18
16
14
12
10
8
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Age (years)
◆ small char,FL< 125 mm,n= 34
▨ medium char,Fl 125 - 250 mm, n=83
▲ large char,Fl >300 mm,n=24
Linear (medium char,Fl 125 - 250 mm, n=83)
Linear (small char,FL< 125 mm,n= 34)
Linear (large char,Fl >300 mm,n=24)

Figure 21: Plot of fork length and carbon signature in small, medium and large char

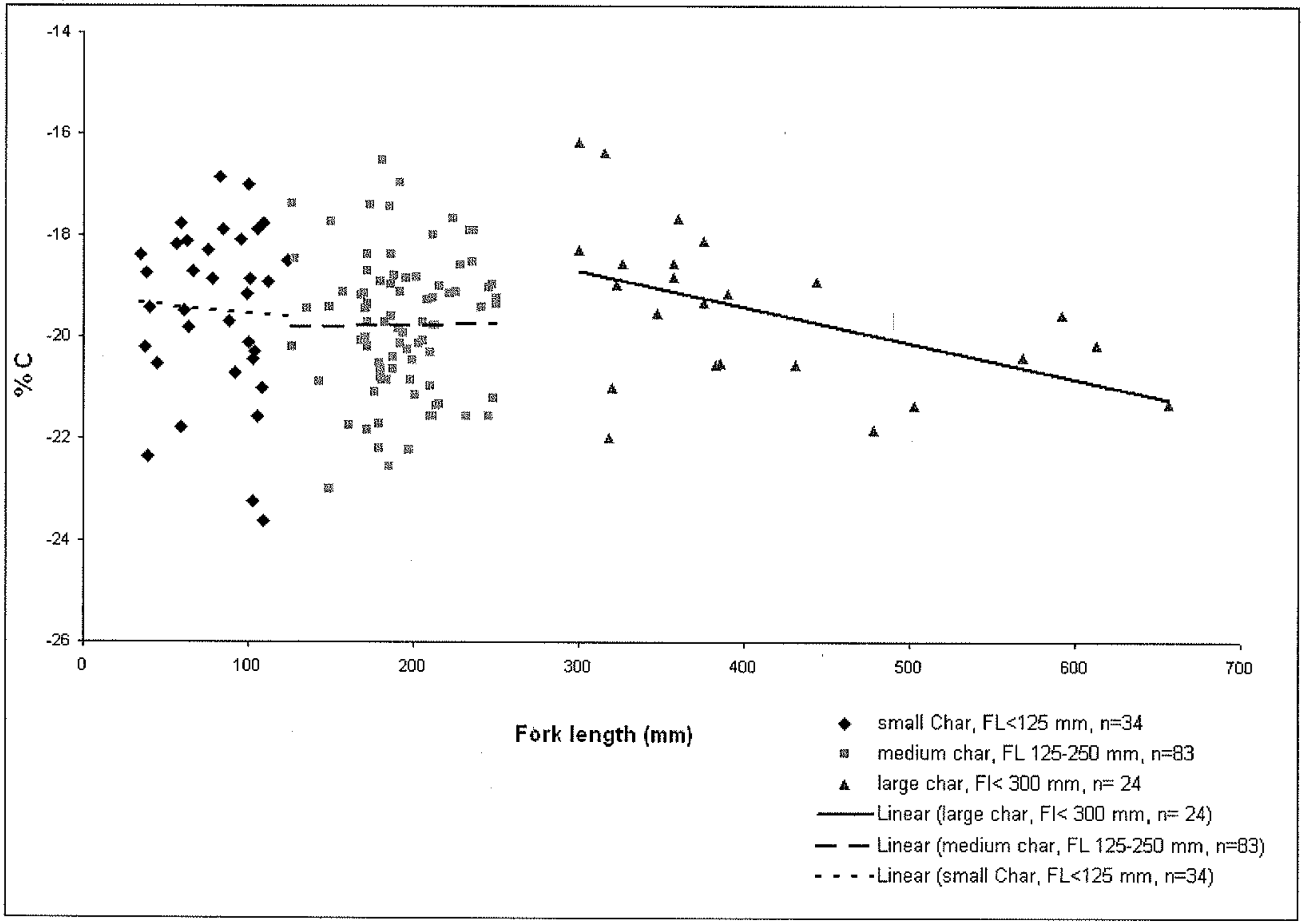

-14
-16
-18
-20
-22
-24
-26
% C
0
100
200
300
400
500
600
700
Fork length (mm)
small Char, FL<125 mm, n=34
medium char, FL 125-250 mm, n=83
large char, Fl< 300 mm, n= 24
Linear (large char, Fl< 300 mm, n= 24)
Linear (medium char, FL 125-250 mm, n=83)
Linear (small Char, FL<125 mm, n=34)

Figure 22: Plot of age and carbon signature in small, medium and large char

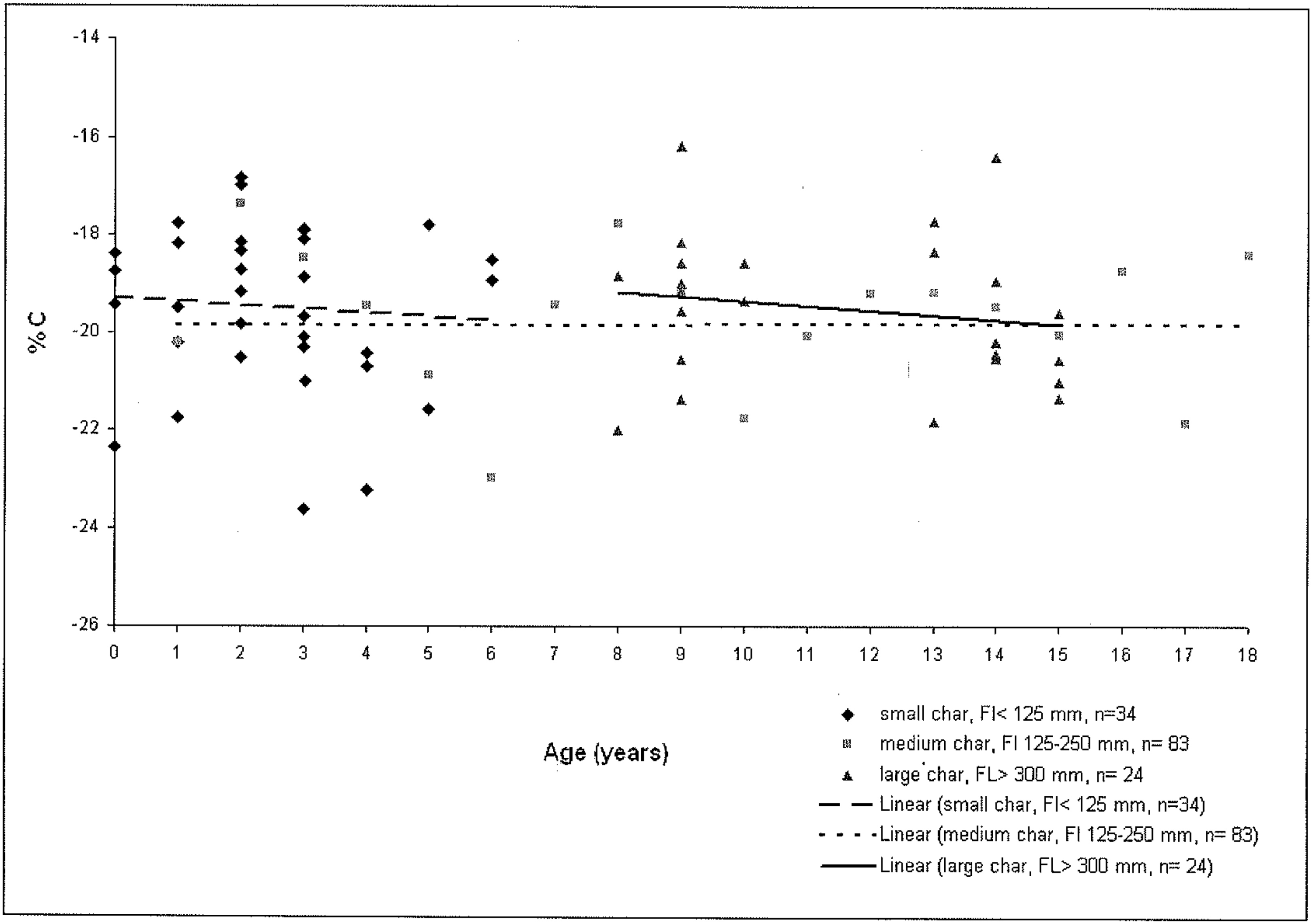

-14
-16
-18
-20
-22
-24
-26
% C
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Age (years)
◆ small char, Fl< 125 mm, n=34
▨ medium char, Fl 125-250 mm, n= 83
▲ large char, FL> 300 mm, n= 24
Linear (small char, Fl< 125 mm, n=34)
Linear (medium char, Fl 125-250 mm, n= 83)
Linear (large char, FL> 300 mm, n= 24)

Figure 23: Plot of stable isotope values for carbon and nitrogen signature in infected and uninfected char

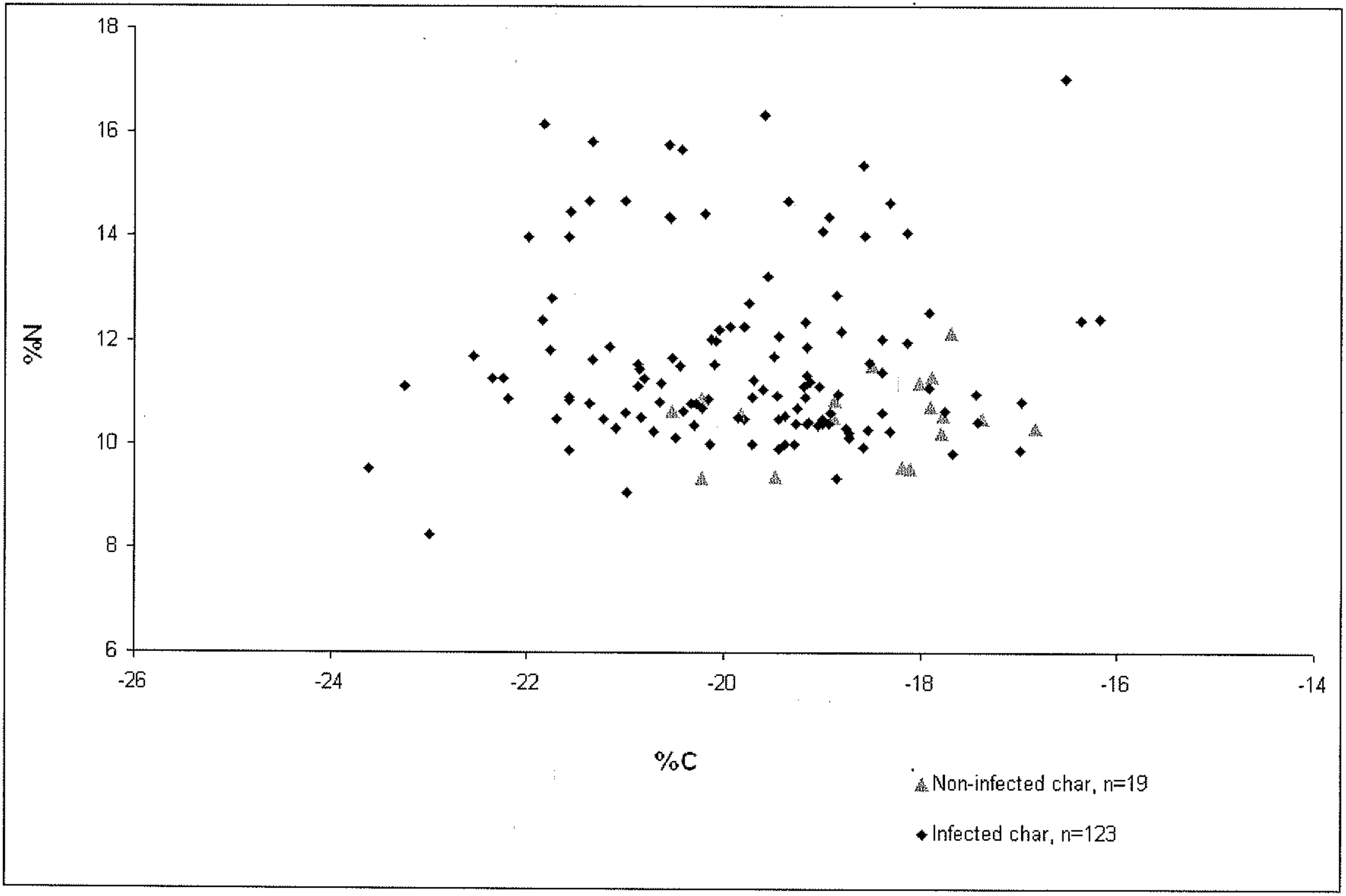

18
16
14
12
10
8
6
%N
-26
-24
-22
-20
-18
-16
-14
%C
▲ Non-infected char, n=19
◆ Infected char, n=123

Figure 24: Plot of fork length and nitrogen signature in piscivorous and non-piscivorous char

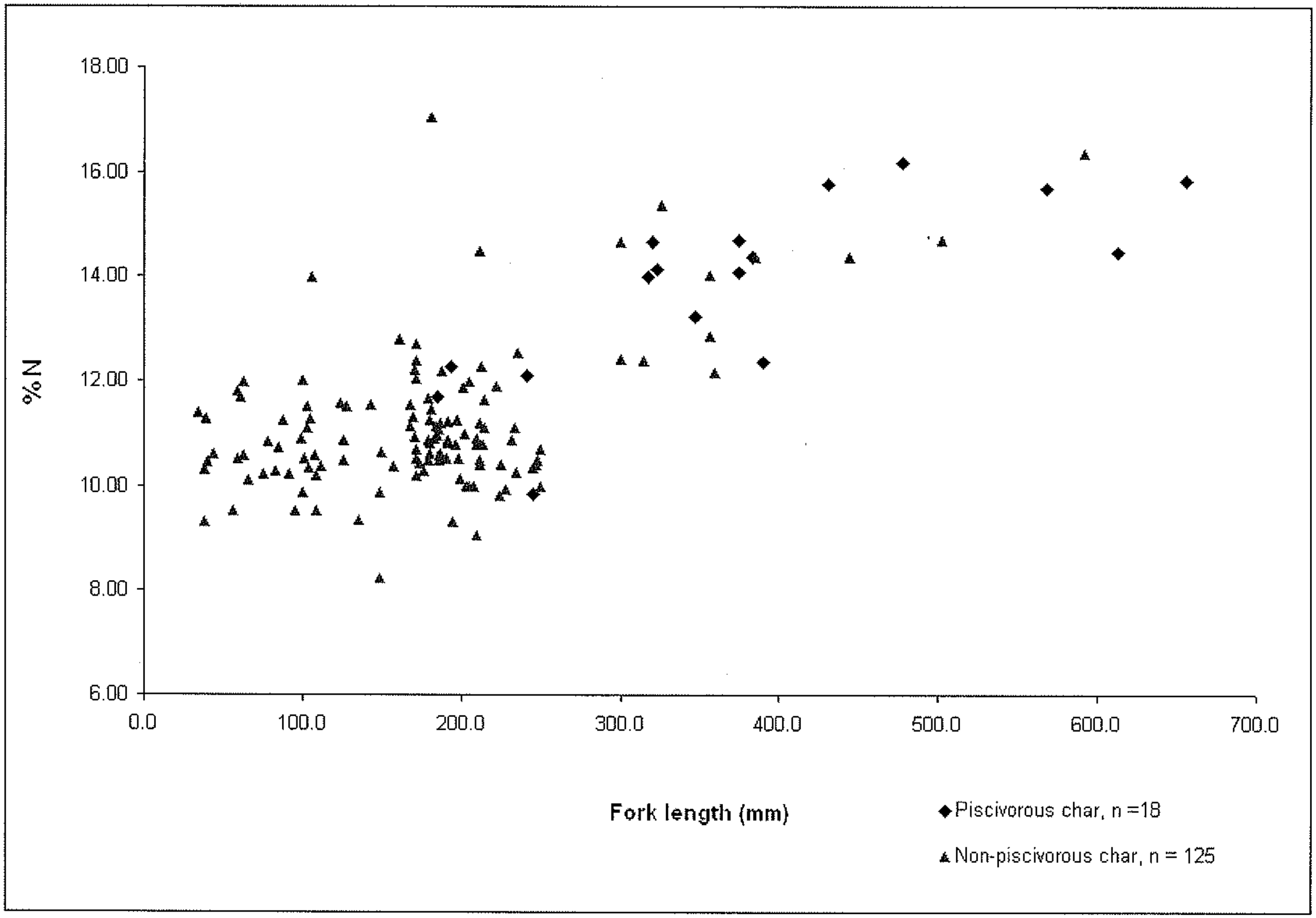

18.00
16.00
14.00
12.00
10.00
8.00
6.00
% N
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
Fork length (mm)
◆Piscivorous char, n =18
▲Non-piscivorous char, n = 125

Figure 25: Plot of fork length and carbon signature in piscivorous and non-piscivorous char

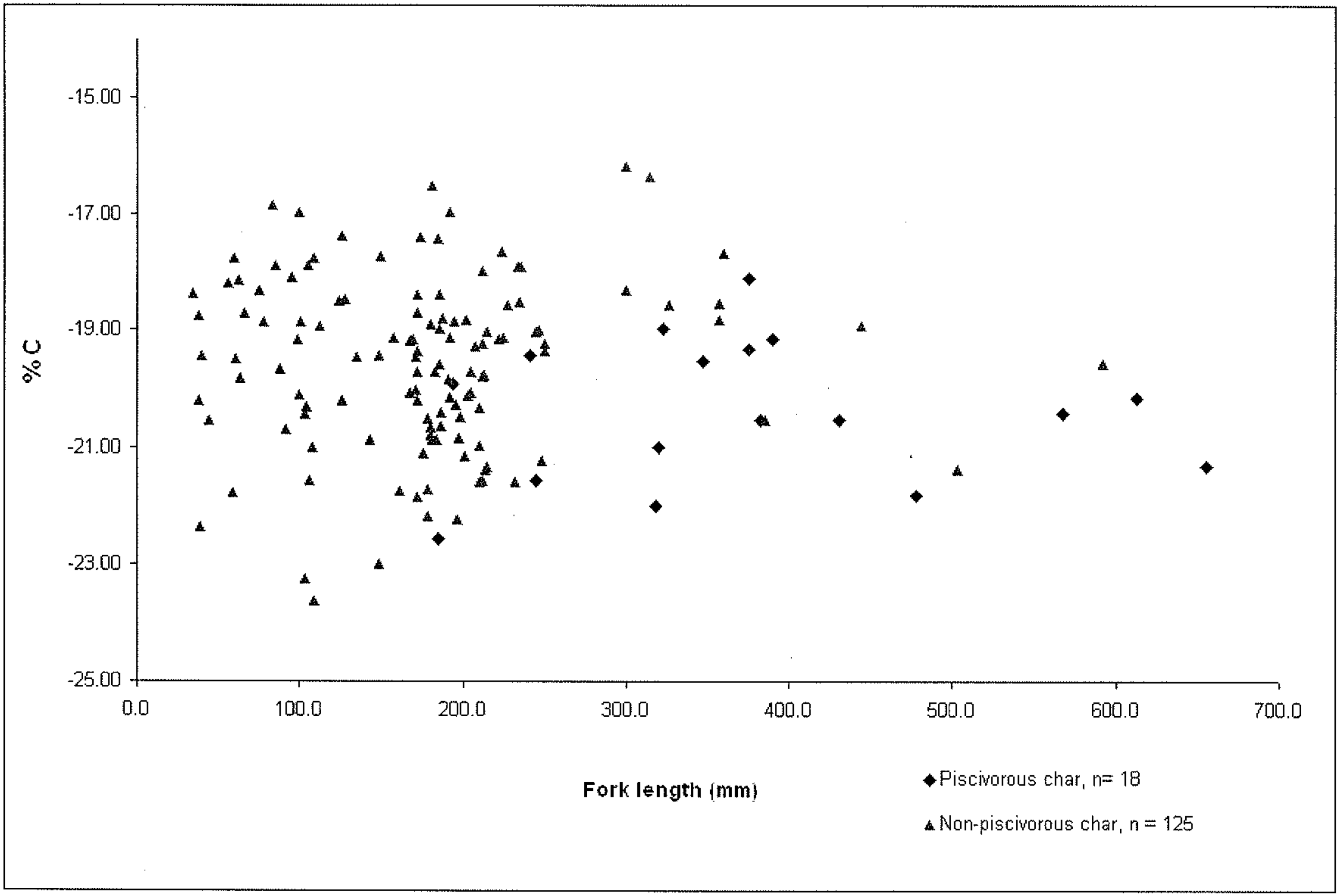

-15.00
-17.00
-19.00
-21.00
-23.00
-25.00
% C
0.0
100.0
200.0
300.0
400.0
500.0
600.0
700.0
Fork length (mm)
◆ Piscivorous char, n= 18
▲ Non-piscivorous char, n = 125

Table: 3 Correlations among fork length, age, nitrogen and carbon signature of the entire Arctic char samples from Wormy Lake.

Correlations

			FORKLENG	AGE	CARBON	NITROGEN
Kendall's tau_b	FORKLENG	Correlation Coefficien	1.000	.658**	-.040	.296**
		Sig. (2-tailed)	.	.000	.480	.000
		N	141	140	141	141
	AGE	Correlation Coefficien	.658**	1.000	-.015	.303**
		Sig. (2-tailed)	.000	.	.800	.000
		N	140	140	140	140
	CARBON	Correlation Coefficien	-.040	-.015	1.000	-.084
		Sig. (2-tailed)	.480	.800	.	.139
		N	141	140	141	141
	NITROGEN	Correlation Coefficien	.296**	.303**	-.084	1.000
		Sig. (2-tailed)	.000	.000	.139	.
		N	141	140	141	141
Spearman's rho	FORKLENG	Correlation Coefficien	1.000	.802**	-.066	.425**
		Sig. (2-tailed)	.	.000	.438	.000
		N	141	140	141	141
	AGE	Correlation Coefficien	.802**	1.000	-.027	.422**
		Sig. (2-tailed)	.000	.	.752	.000
		N	140	140	140	140
	CARBON	Correlation Coefficien	-.066	-.027	1.000	-.119
		Sig. (2-tailed)	.438	.752	.	.161
		N	141	140	141	141
	NITROGEN	Correlation Coefficien	.425**	.422**	-.119	1.000
		Sig. (2-tailed)	.000	.000	.161	.
		N	141	140	141	141

**. Correlation is significant at the .01 level (2-tailed).

Table: 4 Correlations among fork length, age, nitrogen and carbon signature of small char (FL <125 mm, n =34)

Correlations

			FORKLENG	CARBON	NITROGEN	AGE
Kendall's tau_b	FORKLENG	Correlation Coefficient	1.000	-.050	.041	.774**
		Sig. (2-tailed)	.	.678	.733	.000
		N	34	34	34	34
	CARBON	Correlation Coefficient	-.050	1.000	-.193	-.088
		Sig. (2-tailed)	.678	.	.109	.494
		N	34	34	34	34
	NITROGEN	Correlation Coefficient	.041	-.193	1.000	.088
		Sig. (2-tailed)	.733	.109	.	.494
		N	34	34	34	34
	AGE	Correlation Coefficient	.774**	-.088	.088	1.000
		Sig. (2-tailed)	.000	.494	.494	.
		N	34	34	34	34
Spearman's rho	FORKLENG	Correlation Coefficient	1.000	-.066	.040	.892**
		Sig. (2-tailed)	.	.711	.820	.000
		N	34	34	34	34
	CARBON	Correlation Coefficient	-.066	1.000	-.251	-.121
		Sig. (2-tailed)	.711	.	.152	.495
		N	34	34	34	34
	NITROGEN	Correlation Coefficient	.040	-.251	1.000	.093
		Sig. (2-tailed)	.820	.152	.	.600
		N	34	34	34	34
	AGE	Correlation Coefficient	.892**	-.121	.093	1.000
		Sig. (2-tailed)	.000	.495	.600	.
		N	34	34	34	34

**. Correlation is significant at the .01 level (2-tailed).

Table: 5 Correlations among fork length, age, nitrogen and carbon signature of medium char (FL 125-250 mm, n = 83)

Correlations

			FORKLENG	CARBON	NITROGEN	AGE
Kendall's tau_b	FORKLENG	Correlation Coefficient	1.000	.028	-.093	.182*
		Sig. (2-tailed)	.	.714	.217	.024
		N	83	83	83	82
	CARBON	Correlation Coefficient	.028	1.000	-.077	.084
		Sig. (2-tailed)	.714	.	.306	.295
		N	83	83	83	82
	NITROGEN	Correlation Coefficient	-.093	-.077	1.000	-.017
		Sig. (2-tailed)	.217	.306	.	.829
		N	83	83	83	82
	AGE	Correlation Coefficient	.182*	.084	-.017	1.000
		Sig. (2-tailed)	.024	.295	.829	.
		N	82	82	82	82
Spearman's rho	FORKLENG	Correlation Coefficient	1.000	.042	-.138	.249*
		Sig. (2-tailed)	.	.706	.214	.024
		N	83	83	83	82
	CARBON	Correlation Coefficient	.042	1.000	-.115	.117
		Sig. (2-tailed)	.706	.	.299	.295
		N	83	83	83	82
	NITROGEN	Correlation Coefficient	-.138	-.115	1.000	-.016
		Sig. (2-tailed)	.214	.299	.	.886
		N	83	83	83	82
	AGE	Correlation Coefficient	.249*	.117	-.016	1.000
		Sig. (2-tailed)	.024	.295	.886	.
		N	82	82	82	82

*. Correlation is significant at the .05 level (2-tailed).

Table: 6 Correlations among fork length, age, nitrogen and carbon signature of large char (FL 300 mm, n = 24)

Correlations

			FORKLENG	CARBON	NITROGEN	AGE
Kendall's tau_b	FORKLENG	Correlation Coefficient	1.000	-.350*	.409**	.345*
		Sig. (2-tailed)	.	.017	.005	.028
		N	24	24	24	24
	CARBON	Correlation Coefficient	-.350*	1.000	-.422**	-.144
		Sig. (2-tailed)	.017	.	.004	.357
		N	24	24	24	24
	NITROGEN	Correlation Coefficient	.409**	-.422**	1.000	.392*
		Sig. (2-tailed)	.005	.004	.	.012
		N	24	24	24	24
	AGE	Correlation Coefficient	.345*	-.144	.392*	1.000
		Sig. (2-tailed)	.028	.357	.012	.
		N	24	24	24	24
Spearman's rho	FORKLENG	Correlation Coefficient	1.000	-.502*	.556**	.435*
		Sig. (2-tailed)	.	.012	.005	.034
		N	24	24	24	24
	CARBON	Correlation Coefficient	-.502*	1.000	-.573**	-.194
		Sig. (2-tailed)	.012	.	.003	.364
		N	24	24	24	24
	NITROGEN	Correlation Coefficient	.556**	-.573**	1.000	.516**
		Sig. (2-tailed)	.005	.003	.	.010
		N	24	24	24	24
	AGE	Correlation Coefficient	.435*	-.194	.516**	1.000
		Sig. (2-tailed)	.034	.364	.010	.
		N	24	24	24	24

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

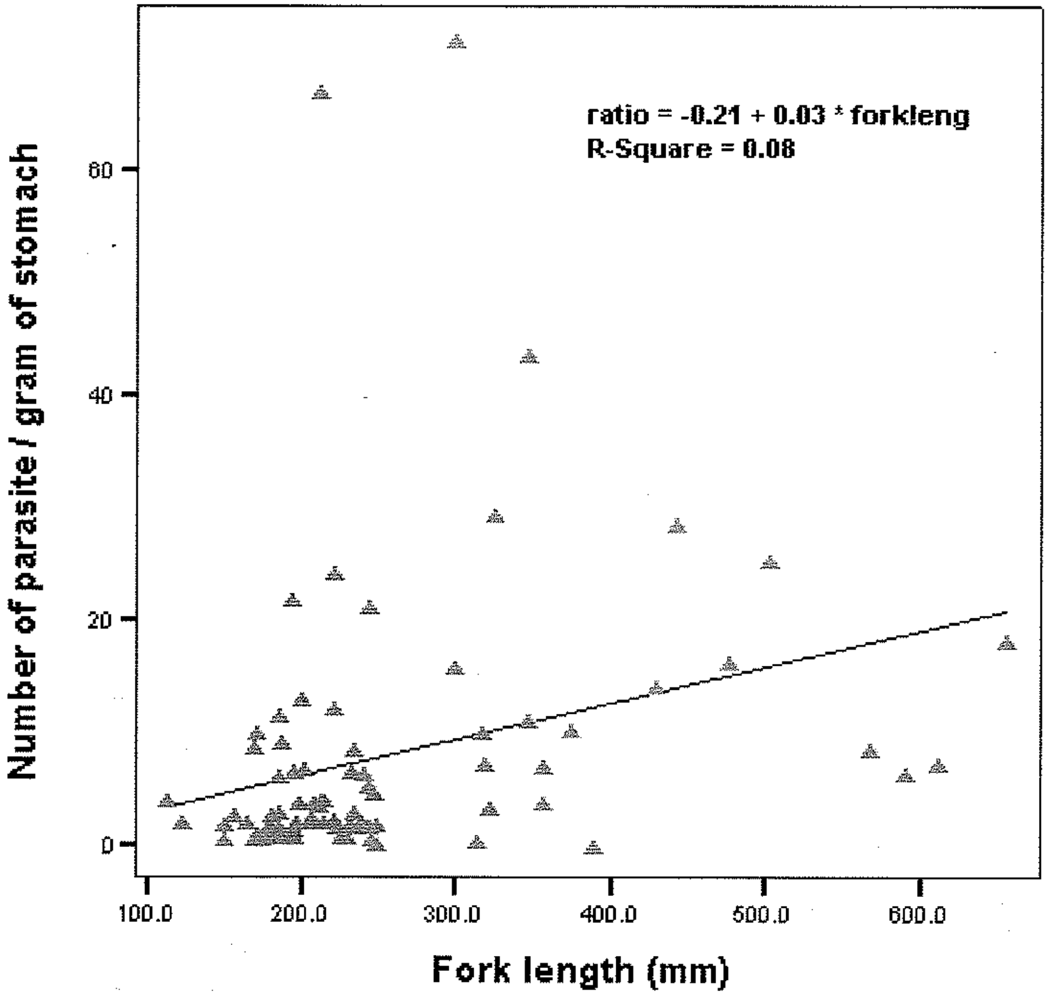
Combined study of fish data, parasitic data and stable isotope analysis of Arctic char

The non-parametric correlations among Fulton's condition factor, fork length, age, total parasite count, LSI. GSI and VFI of char population were calculated separately for three different size groups (Appendix 2, Table 14-16). The small char had maximum stored energy in the form of fat deposits (Appendix 2, Table 14), with moderate health status and low gonad development. The parasite community was significantly correlated with an increase in length and age of small char. The medium char had the most gonad development, energy storage and heath status; however there was a significant decrease in gonad development with an increase in fork length and parasite load and a significant decrease in fat deposits with an increase in age (Appendix 2, Table 15). The large char had a lower health status, with low fat deposits and state of sexual maturity. The parasite count increased significantly with length and age but was negatively correlated with both with GSI and VFI in large char (Appendix 2, Table 16). Regression analysis of parasite number/gram of stomach weight and liver weight of char samples (plotted with respect to fork length and age) found no significant effect of parasite infection on the internal organs of the char samples (low r^2 values in all the cases, Figures 26, 27).

The combined study of stable isotopes and parasite community (Appendix 2, Table 17) reflected that nitrogen signature of Arctic char had a significant positive relation with increased length (fork length and parasite have statistically significant positive relation, Appendix 2, Table 14-16) and parasite count of the entire char sample. However, the carbon signature presented an inverse relation with the increased body length and parasite burden of the fishes. These results provided strong support in favor of food limitation and higher trophic status of the large char.

Figure 26: Plots of number of parasites/per gram of stomach with respect to fork length (A) and age (B) of Arctic char

A


ratio = -0.21 + 0.03 * forkleng
R-Square = 0.08
Number of parasite / gram of stomach
0
20
40
60
100.0
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

B

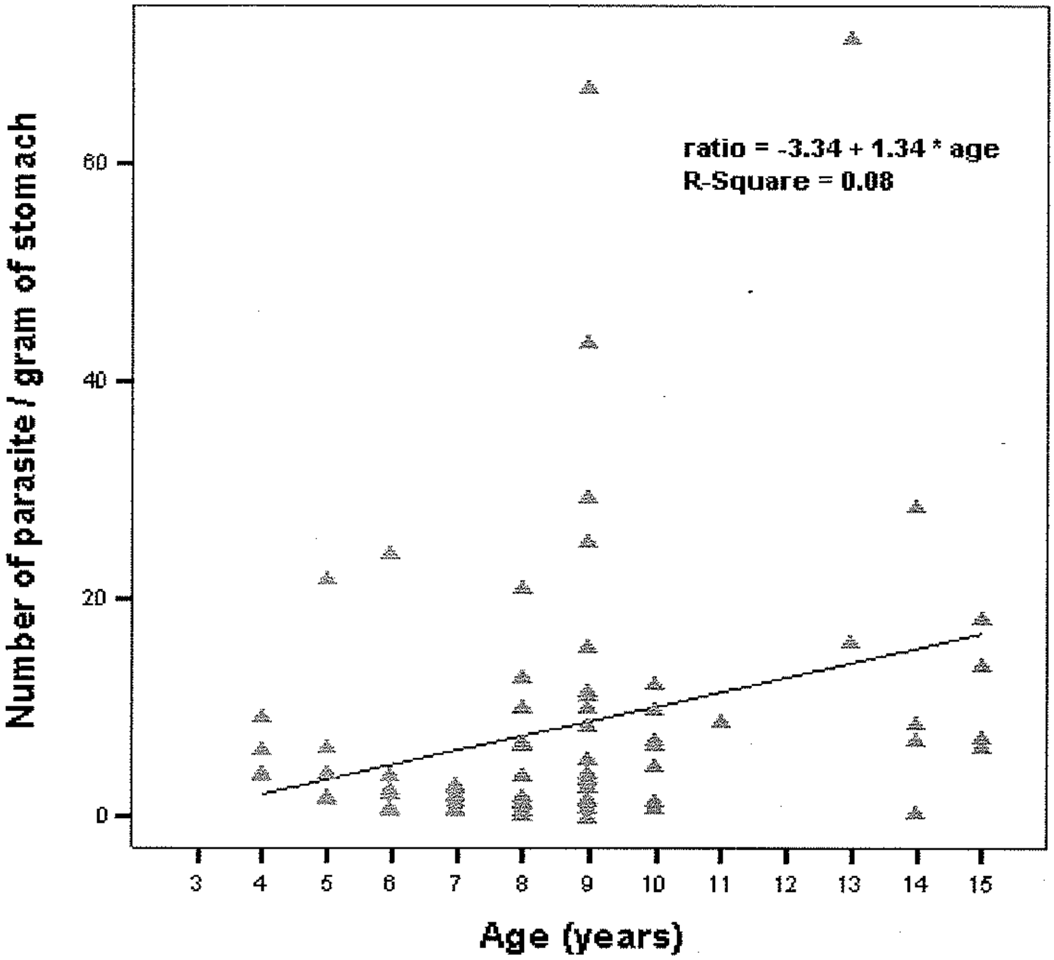
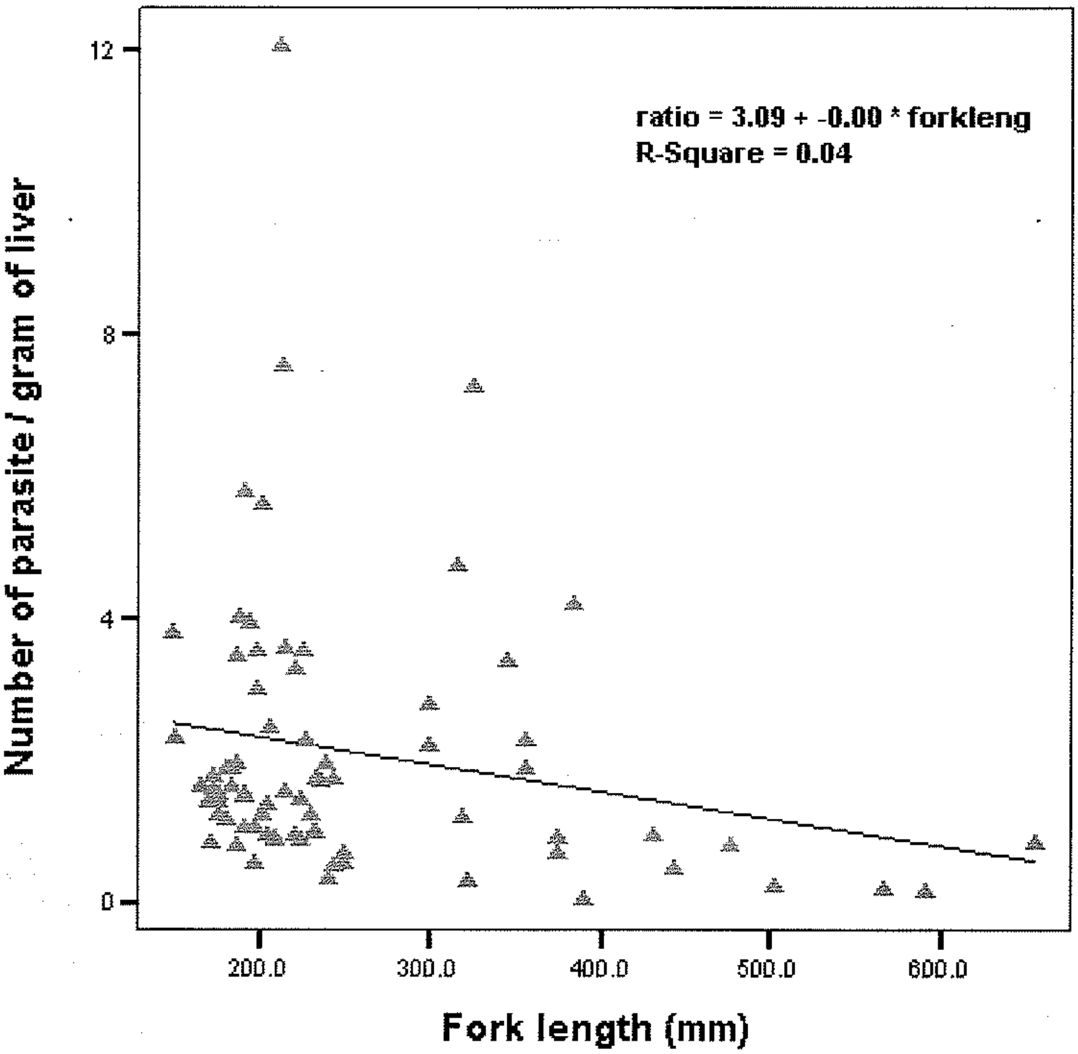
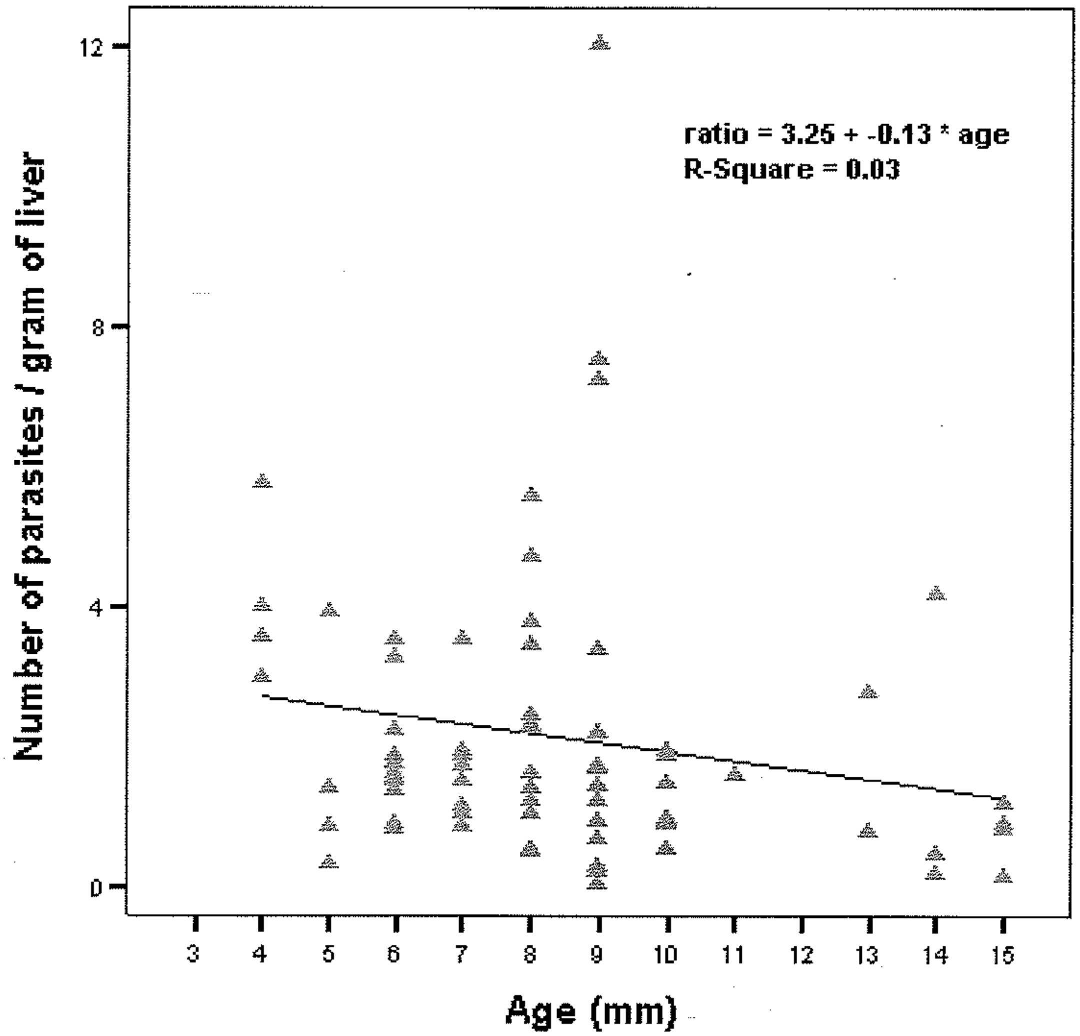

ratio = -3.34 + 1.34 * age
R-Square = 0.08
Number of parasite / gram of stomach
0
20
40
60
3
4
5
6
7
8
9
10
11
12
13
14
15
Age (years)

Figure 27: Plots of number of parasites/per gram of liver with respect to fork length (A) and age (B) of Arctic char

A


ratio = 3.09 + -0.00 * forkleng
R-Square = 0.04
Number of parasite / gram of liver
0
4
8
12
200.0
300.0
400.0
500.0
600.0
Fork length (mm)

B


ratio = 3.25 + -0.13 * age
R-Square = 0.03
Number of parasites / gram of liver
Age (mm)
0
4
8
12
3
4
5
6
7
8
9
10
11
12
13
14
15

DISCUSSIONS

Population structure

Arctic char is a circumpolarly distributed polymorphic fish species, which is ideal for studies of niche utilization, speciation and inter and intraspecific interaction (Svardson, 1976). The allopatric landlocked char populations are mainly distributed in high latitudes and high altitudes. According to the literature, the frequency distribution of landlocked char populations represents unimodal, bimodal and even trimodal size groups (Johnson, 1980, 1983); however, bimodal populations are most common and well studied in literature. The length frequency distribution of char samples of Iqalugaajuruluit Lake (Wormy Lake, N $63^0\ 41^{/}\ 19.8^{//}$, W $68^0 22^{/} 29.0^{//}$) indicated the presence of three modal groups (Figures 3A, 3B, 4) with small char having fork length FL < 125 mm (N = 58), medium char with FL range of 125mm - 250 mm (N = 125) and large char with FL > 300mm (N= 25). The age-distribution of char samples of Wormy Lake (Figures 3A, 3B, 4) indicated that the small char are 0-4 years, medium char 4-11 years, where as the large char consisted of two age groups (Figure 7), some are 8-10 years old and rest 13-15 years. The wide range of age distribution of Wormy lake char samples in each size groups supported Johnson's (1980, 1983) idea regarding modal distribution and modal segregation of Arctic char. Johnson (1980, 1983) found that the different modal groups of char generally remain in the same phase of life cycle but not necessarily at the same age. Johnson (1980, 1983) also mentioned that transfer of individuals among modal groups is more dependent on size and opportunity than the age of the fish population. The wide age distribution of Wormy lake char, especially for medium and large char, indicated that individuals of different modal groups had age overlap and their modal segregation was totally dependent on their size.

In almost all of the allopatic populations of landlocked char, size modality, rapid ontogenetic niche shift and cannibalism have been considered as the most important and least understood aspects of their life history (Hammer, 1984, 1991, 1998a, 1998b). Hammer proposed that rapid niche shift and cannibalism are two important factors influencing the population structure of Arctic char. So, it is important to look at the feeding pattern and habitat utilization of char samples of Wormy Lake to understand their inter-modal interaction and modal segregation among different size groups.

Food choice and habitat utilization

The Arctic char (*S. alpinus*) is a generalist and opportunistic feeder (Johnson, 1980) and they are believed to be restricted to four food types: benthos, zooplankton, surface insects and fish. In Iqalugaajuruluit Lake (Wormy Lake), the small char (FL< 125 mm) were mostly benthivorous, with chironomid larvae being the most prevalent in their diet. They also fed on Cladocera, Collembola, Copepod, Diptera, wasps, water mites and some other aquatic insects. Medium char (FL 125-250 mm) fed on different aquatic insects (most prevalent), caddis fly larvae, clams, chironomid, plant material (Table 3A), but some fish bones were also identified from their stomach (fish with fork length > 180 mm). Large chars (FL > 300 mm) were mainly piscivorous (Stickleback is the most prevalent food) and some of them were found to be cannibals. Some caddish fly larvae were also identified from their stomachs. Therefore, by looking at the food choice of three different size groups, it was clear that the small char mostly fed from benthic and epibenthic zone, the large char mostly fed from pelagic zone whereas, the medium fishes presented a diet overlap by eating both from benthic/ epibenthic (plant material, chironomid larvae, different types of insects) and pelagic habitat (fish). Small and medium char shared the benthic and epibenthic habitat but large char showed a sudden change of food habit (being piscivorous) with a rapid niche shift and occupied the pelagic zone of the lake. The diet overlap, rapid niche shift and piscivory /cannibalism of fish samples of Wormy Lake seem to supports other studies for non-anadromus populations of Arctic char. However, it failed to indicate any specific reason for modal segregation especially, for the large fishes. Griffith (1994) and Hammer (1984, 1991, 1998a, 1998b) suggested that lack of alternate prey species, cannibalism and inter and intra specific genetic differences are the reasons for changes in food habits and rapid niche shift of Arctic char. The feeding percentage of different food types of summer and winter samples of Wormy Lake had been calculated and plotted (Figure 9B, Table 3B) to determine if there was a significant variation in their food choice. In summer, Arctic char fed on, caddis fly larva (4.7 %), chironomid (20.7 %), clams (1.3 %), plant material (2.0 %), fish bone (6.0 %), sticklebacks (4.7 %), small char (0.7 %) and various aquatic insects (Cladocera, Collembola, Copepod, Diptera, wasps and water mites) (47.3 % of total food). For summer samples, aquatic insects and chironomid larvae were the most common food items for char samples. On the other hand the stomach content of winter samples contained chironomid (63.8 %), plant material (8.6 %), caddis fly larva (5.2 %), clams (10.3 %), fish bone (6.9 %), sticklebacks (5.2 %) and Arctic char (6.9 %). Chironomid was the most important food item in winter fishes. Comparison of food items of summer and winter samples produced some valuable information. In winter samples no aquatic insects were detected from fish stomach, implying limitations of food choice for Arctic char. It also seemed to support Hammer's idea of lack of alternate prey species as a possible cause of change of food habit, rapid niche shift and cannibalism in char population. A comparison of feeding patterns between summer and winter samples of Wormy Lake showed that char during the winter mostly fed on chironomid (63.8 % of total diet). They also consumed significantly larger amount of clams (10.3 % in winter and 1.3 % in summer), plant material (8.6 % in winter and 2.0 in summer) and small char (6.9 % in winter and 0.7 % in summer) in winter, although there was no difference in the piscivorous food habits (fish bone 6.9 % in winter and 6.0 % in summer, stickleback 5.2 % in winter and 4.7 % in summer). Limitations of food variety in winter failed to explain either the cause of rapid niche shift or the cause of piscivory of the large char. Perhaps it influenced increased cannibalism by char. The piscivory by char may result better growth and more nutritional benefit for large char, but it did not explain what induced the rapid niche shift and size distribution in large char.

Growth pattern and reproductive maturity of Arctic char

The Wormy lake char samples represented a sigmoid growth pattern (Figure 10) with small char (FL < 125 mm, N=58, Age 0-4 years) having slow growth rate, medium char (FL 125 mm- 250 mm, N=125, Age 4-11 years) having moderate growth rate and large char (FL > 300 mm, N=25, Age 8-15 years) with exponential growth rate. The extra nutritional benefit in the case of large piscivorous fishes helped them to maintain their higher growth rate in comparison to other char samples. The char samples of different modal groups were also significantly different in terms of body development and reproductive maturation. Data analysis regarding liver weight, gonad weight and visceral fat weight of char samples provided some interesting variations among different size groups. The non-parametric correlation of LSI with respect to fork length (Appendix 2,

Table 6) presented almost no relation with increased size of char implying no significant difference of liver development among the fish samples. However, GSI and VFI of char samples represented negative relations (Appendix 2, Table 6) with length implying poor gonad development, reproductive maturation and less visceral fat deposits in large char. Regression analysis of LSI, GSI and VFI (Figure 11) also supported the same trend of development and gonad maturation. Fulton's condition factor (FCF) presented a statistically significant positive correlation with both GSI and VFI but it was negatively correlated with increased age and length supporting the idea of poor health in large char.

The overall study of growth pattern, body development and maturation of Arctic char of Wormy Lake demonstrated that the small char had the maximum stored energy in form of visceral fat deposits in comparison to other char size groups. The medium char had fat deposits with maximum gonad development. This group was most important in terms of reproductive maturation. Whereas, in spite of their exponential growth rate, the large char had the least gonad development and lowest fat deposits compared to all other char. Hammer (2000) mentioned the presence of reproductively active large fishes in allopatric landlocked population of Arctic char. However, the large char from Wormy Lake were found to have heavy parasite infections which seemed to be the major cause of the low energy storage and reproductive maturation.

GSI and VSI of Arctic char were separated according to sex, to determine if there were significant differences in growth and reproductive maturation between male and female char. The char samples of Wormy Lake represented female dominance as the number of female fishes were more than four times than the male char. Hammer (2000) also mentioned that the piscivorous char populations generally demonstrate a female-biased sex ratio and high intensity of parasite infection, whereas non-piscivorous char populations are generally male biased with low parasite infection. Mean GSI and VSI of female Arctic char of Wormy Lake were significantly higher than male fishes (Appendix 2, Table 7), but the non-parametric correlations among GSI, VFI, (Appendix 2, Table 8, Table 9) with respect to fork length, in both sex, indicated negative correlations and did not reflect any major differences from each other.

Parasitic infection in char

The parasitic species infecting the char populations are believed to be different in case of anadromous and non-anadromous char (Dick, 1984). *Crepidostomum farionis*, *Cyathocephalus* sp., *Diphyllobothrium dendriticum*, *D. ditremum*, *Cystidicola* sp., *Philonema* sp., *Salmincola* sp., *Eubothrium* sp., *Proteocephalus* sp., *Phyllodistomum* sp., *Metechinorhynchus* and *Neoechinorhynchus* are the most common and abundant parasites of landlocked char population. Among these parasites, *Diphyllobothrium dendriticum*, *D. ditremum* and *Proteocephalus longicolis* were considered as bio-indicators of non-anadromus fishes (Dick, 1984). From Wormy Lake fish samples, *Crepidostomum farionis, Diphyllobothrium dendriticum*, *D. ditremum, Eubothrium salvelini*, *Proteocephalus longicolis* and *Neoechinorhynchus pungitius* were detected from small and large fishes and one more parasite, *Philonema agubernaculum* was detected from medium char.

According to literature, there are several factors, such as distribution (Johnson, 1980, Dick, 1984), local environmental conditions (Johnson and Dick, 2004), availability of intermediate hosts (Klemtsen *et al.*, 1985, Kundsen *et al.,* 2001, 2004), food and habitat choice (Amundsen *et al.,* 1995, Curtis *et al.*, 1995, Kundsen, 1995, 1997, Kundsen and Klemetsen, 1994, Kundsen *et al.*, 2002, 2004), size, age (Nelson and Dick, 2002, Johnson and Dick, 2004), sex of infected individuals (Curtis, 1979, 1984), influencing the parasitic infections in Arctic char populations. The intensity and abundance of parasitic infection is significantly different among benthivorous, pelagic and epi-pelagic planktivorous and piscivorous char. Benthivorous char mostly feed on amphipod *Gammarus lacustris* and are infected by *Cystidicola farionis* and *Cyathocephalus truncates*. Char feeding on pelagic copepod; are infected by *Diphyllobothrium dendriticum*, *D. ditremum*, *Eubothrium salvelini, Proteocephalus longicollis* and *Philonema agubernaculum.* Whereas, the piscivorous char are reported to have heavy infection of *Diphyllobothrium dendriticum* and *D. ditremum* (Curtis, 1984).

In Wormy Lake char samples, parasite infection varied according to their size, food choice and habitat. The mean intensity, prevalence and abundance of parasite were calculated according to the size groups and compared (Figures 13-15, Table 4). In small and medium char, the parasite abundance ranged between 0.069-2.310 and 0.016-20.320

respectively and *Proteocephalus longicolis* had the highest prevalence and abundance in these two modal groups. In large char, parasite abundance ranged between 0.840-434.052 and *Diphyllobothrium* was the most dominant parasite, with *D. ditremum* having highest and *D. dendriticum* having the second highest mean intensity, prevalence and abundance in this modal group. This marked increase of parasite burden in large char was mainly caused by the huge increase of *Diphyllobothrium* spp. infections and it could explain the reason for the low reproductive maturity and less visceral fat deposition in large char.

The study of parasite community was also important to show the niche segregation and trophic level identification of Wormy lake char samples. Identification of *Crepidostomum farionis, Diphyllobothrium dendriticum, D. ditremum, Eubothrium salvelini*, *Proteocephalus longicolis* and *Neoechinorhynchus pungitius* from small and medium char with *Proteocephalus longicolis* being the most prevent parasite, directly indicated that they fed from benthic, epi-benthic zone of the lake and copepod was one of the most common food (as copepod is the intermediate host of most of these parasites) among their food items, though it was detected from stomach content of very few fishes. Whereas, the significant increase in parasitic intensity (especially *Diphyllobothrium*) in large char indicated that they were mostly piscivorous.

Diphyllobothrium dendriticum and *D. ditremum*, are believed to have detrimental effect on health condition and reproductive maturity of Arctic char. No reproductively active Arctic char was found with more than 30 plerocercoids per 100 gram of char. (Curtis, 1984). Hammer (1998) also mentioned that char harboring 1500-2000 plerocercoids generally did not have mature gonads. Large char (FL > 300 mm) of Wormy Lake had 409 ±186 parasites on average (range 38-4317) and only one large char of 25 showed some gonad development. The non-parametric correlations among parasite count of individual fish with respect to fork length, age, (GSI, VFI and Fulton's condition factor represented a negative correlation in each case (Appendix 2, Table 14) indicating poor health status, low energy storage and reproductive maturation in large char. These results were similar to those reported in the literature on the effect of *Diphyllobothrium* spp. infections on char, although Wormy Lake char seemed to harbor more parasites. The number of large fishes among the entire fish samples (only 25 out off 275 collected fish) of Wormy Lake seemed to provide indirect evidence of parasite induced host mortality in the case of large char.

Stable isotope analysis

The use of stable isotope analysis is common to identify the trpohic structure and niche shift, to detect the reasons and the effect of cannibalism and to find the trophic polymorphism of Arctic char (Hobson and Welch, 1992, 1995, Adams *et al.* 2003). Stable isotope data from Iqalugaajuruluit Lake (Wormy Lake) char samples was consistence with the trophic level identification both from stomach content analysis and from the study of parasitic community. The data analysis of different size groups also provided some interesting details about the food habit of individual fish samples, as well as, of each size group. The nitrogen signature of Wormy Lake char samples reflected an overall statistically significant positive relation with increased size and age. This indicated a gradual shift from a lower to higher trophic level with increased length and age of the fishes. The carbon signature reflected a negative correlation with increase of fork length and almost no relation with increase of age. As, carbon signature decreases with increase of trophic level according to char literature i.e. maximum in case of benthivorous and minimum in piscivorous char (Hobson and Welch, 1992, 1995), the $\delta^{13}C$ value in Wormy lake fish samples also supported the same pattern of niche utilization and food choice. The nitrogen and carbon signature were inversely proportional to each other indicating that the benthivorous and zooplantivorous fishes had less nitrogen assimilation than piscivorous char and vice versa. Comparison of nitrogen and carbon signature in piscivorous (mostly large fishes) and non-piscivorous char (Figures 20, 21) highlighted that piscivorous char had higher nitrogen and lower carbon values than non-piscivouors form indicating differences in their trophic level. The mean nitrogen and carbon signature of piscivorous and non-piscivorous char were significantly different from each other

The $\delta^{13}C$ and $\delta^{15}N$ data of small, medium and large char were analyzed separately to compare the variations of food choice among the three modal groups and to evaluate the possibility of individual dietary specialization of the char samples. The descriptive statistics of the nitrogen signature of small, medium and large char (Appendix 2, Table

10) reflected that mean nitrogen value of large char (14.2846) was significantly higher than small (10.7724) and medium fishes (10.9988), indicating that large char fed from higher trophic level than the small and medium fishes. The medium char had a wide range of nitrogen value (8.25-17.04) in comparison with small char (9.32-13.97), suggesting some higher energy sources and diet overlap with large fishes. Descriptive statistics of the carbon signature of different modal groups (Appendix 2, Table 11) did not reflected any significant difference in mean carbon values in small (-19.4856), medium char (-19.7878) and large char (-19.5025). The $\delta^{13}C$ and $\delta^{15}N$ values of small, medium and large char were plotted separately with respect to fork length and age of the fish samples. In small char, the nitrogen signature had slight positive correlation with fork length, in medium char it had slight negative correlation with fork length and in large char, $\delta^{15}N$ presented significant positive correlation (Tables 4-6) with increased fork length. The $\delta^{13}C$-age plots of three modal groups reflected a non-significant positive relation in small char (Table 4), almost no relation in case of medium char (Table 5) and statistically significant positive relation (Table 6) in case of large char. This comparative result of three modal groups implied that only in large fishes there was significant change in the amount of carbon depletion and nitrogen assimilation which provided strong support in favor of their niche segregation and change of food habit in comparison with small and medium char samples. On the other hand, although the carbon and nitrogen signature of small and medium fishes were inverse to each other, they did not reflect any significant deviation, supporting their similar food choice and niche overlap in these two modal groups.

The inverse $\delta^{13}C$ and $\delta^{15}N$ signature of small and medium fishes might be explained by the intra-system base line variation and individual dietary choice of char samples. Cabana and Rasmussen (1996) observed that the isotopic signature of the baseline organisms (such as bacteria, phytoplankton), those who transform inorganic nitrogen to organic compounds, shows great variation even within the same system. These differences might cause significant variations in $\delta^{15}N$ and $\delta^{13}C$ values of higher organisms, occupying similar trophic position of an ecosystem. On the other hand, Amundsen *et al.* (1995) mentioned that although Arctic char are also believed to be opportunistic feeder, the prey choice is unique among the individuals of the same fish population and they generally restrict themselves to a specific food habit, even if they are exposed to various food items. Adams *et al.* (2003) also supported this idea of individual long-term stability of Arctic char. Therefore, it was very much possible that Wormy lake char samples also maintained their individual food specificity and there were some variations in carbon and nitrogen fixation among different food items of small and medium fishes. However, these variations did not make any significant change of the modal food habit, as all the fish samples of small and medium size groups shared the same trophic level.

Hobson and Welch (1995) did extensive study on stable isotope analysis and reported that small, medium and large char occupy three different trophic levels within same ecosystem. On the other hand, Guigner *et al.* (2002) and Adams *et al.* (2003) observed the presence of two trophic levels in allopatric landlocked char population with only large char having significant difference of isotope values in comparison with other fishes. The overall study of stable isotope analysis of Wormy Lake char samples indicated that char fed from two trophic levels. Small and medium fishes mostly use benthic/epi-benthic zone feeding on planktons and aquatic insects, whereas, large fishes were piscivorous, being restricted to pelagic zone of the lake. This result did not match with Hobson and Welch (1995) but were similar to recent published data.

Combined study of stomach content analysis, parasite community and stable isotope analysis of char

The combined study of stomach content and stable isotope analysis is very common in detection of the trophic level of organisms. Johnson and Dick (2004) introduced a new idea of predicting the trophic status of organism. Johnson and Dick (2004) suggested a comparative study of stable isotope analysis and parasite community might provide a better indication of trophic levels in an aquatic ecosystem. They worked on yellow perch, *Perca flavesceus* and suggested that this method might be applicable to identify trophic status of other fish species. The objectives of my research were to determine the trophic structure of the char samples of Iqalugaajuruluit Lake (Wormy Lake) by a combined study of food consumption, parasitic community and the result of stable isotope analysis and also to detect the effect of parasite infection on reproductive status of char. The application of this combined technique seemed to be effective for Wormy Lake char samples. The morpohmetric data analysis of Arctic char indicated the presence of three size groups, small (FL< 125 mm, N=58), medium (FL 125 mm- 250 mm, N=125) and large (FL> 300 mm, N=25) fishes. The age-frequency distribution indicated that the small char were aged between 0-4 years, medium char were between 4-11 years and the large char had two age groups, some of them were aged between 8-10 years and rest were of 13-15 years. This also suggested that size distribution of char samples was not dependent on char age. Stomach content analysis of Arctic char indicated that small char fed mostly on benthic and epibenthic zone, the large fishes mostly fed in the pelagic zone whereas, the medium fishes consumed organisms from benthic/ epibenthic (plant material, chironomid larvae, different types of insects) and the pelagic zone. Small and medium char shared the benthic and epibenthic habitat but large char represented a sudden change of food habit with a rapid niche shift to occupy the pelagic zone of the lake. The piscivorous food habit of the large char also provided extra nutritional benefit and helped to maintain the exponential growth rate of these fishes. Hammer, 1991, Amundsen *et al.,* 1995 and Adams *et al.*, 2003 mentioned that the piscivorous/cannibalistic char generally have fork length greater than 40cm, but in Wormy lake fish samples, fish bone was detected from stomach content of char having fork length < 184 mm. The comparison of food items of summer and winter char indicated the lack of aquatic insects in stomach of winter samples, implying limitation of alternate prey in this season. However, the winter char consumed large quantity of chironomid (63.8%), which compensated for the loss of some food items in the winter samples and as a consequence there was not a major shift to piscivory. Therefore, the lack of food items does not explain either the cause of the rapid niche shift or the reason for piscivory of large char. The study of parasite community indicated that the small and medium fishes were mostly infected by some parasites, those use copepods as intermediate hosts in their life cycle. This implied that copepods are common food item for small and medium char and these fishes were mostly restricted to benthic/epi-benthic habitat. On the other hand, the large fishes had significant increase of *Diphyllobothrium* spp. infection, indicating they occupy higher trophic level of the lake and supporting their piscivorous food habit. The stable isotope analysis of the char samples confirmed the presence of two trophic levels within Wormy Lake char; with large fishes having significantly higher $\delta^{15}N$ value in comparison to small and medium char. Mean carbon signature of small, medium and large char did not show any significant difference among the size groups, although the range of $\delta^{13}C$ value in large char was limited implying their restriction in higher trophic level. The comparative study of piscivorous, non-piscivorous fish data indicated most of the large fishes were fish feeder, although no fish had been detected from stomach of some big char. In summary, the combined study of stomach content, parasite community and stable isotope analysis were quite effective to detect the trophic structure of Wormy Lake char samples and the study of parasite community was most effective in detection of post consumed food material and individual dietary specialization of char samples. The combined study of fish data and parasite community indicated that the small fishes were most important in energy storage in the form of visceral fat deposition, medium fishes were most important in terms of gonad development and large fishes had maximum growth rate but they represented the least fat storage and reproductive maturation within the entire sample. The large fishes of Wormy lake char samples were also found to harbor more parasites than reported in the literature. Nordeng (1983) suggested that, the growth rate and sexual maturity of char are variable among different morphs and are controlled by the inherited genetic differences among individual char, though all the morphs share same gene pool. However, the heavy parasitic infection in the large char appeared to affect their reproductive status. The limited number of large char in sample (25 off 275) provides indirect evidence of parasite induced host mortality in the case of large char. Moreover, these extensive parasite infections induced severe adhesions with most of the visceral organs attached to the body wall and was most pronounced for the stomach and liver. These adhesions plus the loss of normal gonad development suggests significant effects on large piscivorous char.

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Appendix: 1 Morphometric and meristic data of Arctic char population continued

Fish ID	TL (mm)	FL (mm)	Head length (mm)	Pec. Length (mm)	Depth (mm)	CP (mm)	IOW (mm)	Jaw length (mm)	Dorsal rays	Pec. Rays	Pelv. Rays	Anal rays	Gonad wt (g)	Liver wt. (g)	Visceral fat weight (g)
AC-1-04	115.00	108.00	22.00	17.00	16.00	6.00	7.00	100.00	10.00	11.00		12.00		0.19	0.00
AC-2-04	108.00	103.00	21.00	15.00	17.00	7.00	6.00	9.00	9.00	12.00	9.00	8.00	0.03	0.11	0.01
AC-3-04	110.00	104.00	23.00	17.00	18.50	8.00	6.00	11.00	10.00	14.00	9.00	8.00	0.06	0.20	0.03
AC-4-04	115.00	109.00	23.00	18.50	18.00	9.00	7.00	10.00	9.00	13.00	8.00	8.00	0.02	0.15	0.01
AC-5-04	195.00	187.00	38.00	28.00	20.50	10.50	10.50	18.00	10.00	15.00	9.00	10.00	0.58	0.57	0.00
AC-6-04	232.00	214.00	41.50	29.00	32.00	12.50	13.00	19.00	12.00	14.00	10.00	11.00	0.36	0.79	0.02
AC-7-04	182.00	171.00	38.00	30.00	30.00	12.00	11.00	19.50	12.00	13.00	10.00	10.00	0.22	0.59	0.04
AC-8-04	192.00	185.00	38.00	28.00	27.00	11.50	11.00	17.00	10.00	14.00	9.00	10.00	0.58	0.65	0.02
AC-9-04	192.00	180.00	36.00	27.00	30.50	12.00	10.50	16.50	10.00	15.00	9.00	10.00	0.48	0.52	0.03
AC-10-04	192.00	181.00	37.00	24.50	31.00	11.00	11.00	17.00	12.00	14.00	10.00	10.00	0.64	0.60	0.05
AC-11-04	216.00	205.00	40.00	28.00	31.00	13.00	12.00	18.00	10.00	15.00	9.00	10.00	1.04	1.00	0.12
AC-12-04	244.00	228.00	45.00	34.00	37.50	14.00	13.00	21.00	11.00	16.00	10.00	10.00	0.13	0.97	0.01
AC-13-04	339.00	320.00	63.00	41.00	55.00	19.00	19.00	31.50	10.00	14.00	10.00	10.00	1.01	3.21	0.00
AC-14-04	211.00	198.00	39.50	29.50	30.00	13.00	11.00	19.00	10.00	15.00	10.00	9.00	0.70	0.70	0.00
AC-15-04	192.00	181.00	28.00	27.00	29.00	11.00	10.50	19.00	11.00	14.00	10.00	10.00	0.86	0.87	0.04
AC-16-04	196.00	185.00	39.00	31.50	32.00	12.00	11.00	19.50	10.00	14.00	9.00	9.00	0.20	0.50	0.00
AC-17-04	259.00	245.00	46.50	35.00	41.00	14.00	14.50	21.50	10.00	15.00	9.00	10.00	0.80	1.80	0.00
AC-18-04	320.00	300.00	57.00	36.00	50.50	18.50	18.00	28.00	12.00	15.00	10.00	10.00	1.00	3.10	0.02
AC-19-04	682.00	656.00	147.50	116.00	124.50	37.20	46.60	92.50	10.00	14.00	8.00	10.00	5.50		0.00
AC-22-04	108.00	102.00	21.00	15.20	16.20	6.70	5.90	10.10	10.00	13.00	9.00	9.00	0.03	0.14	0.04
AC-23-04	121.00	112.00	24.10	18.50	18.40	7.70	6.30	10.50	10.00	14.00	9.00	9.00	0.15	0.16	0.01
AC-24-04	228.00	213.00	42.10	30.20	33.40	12.90	12.80	19.10	11.00	15.00	9.00	9.00	0.72	0.82	0.01
AC-25-04	337.00	315.00	66.70	49.90	46.30	18.70	21.10	33.30	11.00	14.00	9.00	10.00	1.99	3.43	0.12
AC-26-04	159.00	149.00	33.90	20.10	22.40	9.00	10.00	16.90	10.00	14.00	8.00	9.00	0.04	0.42	0.00
AC-27-04	411.00	390.00	74.00	52.30	67.50	21.80	21.70	37.50	11.00	14.00	10.00	9.00	3.50	12.10	1.97
AC-28-04	630.00	613.00	132.20	102.00	111.90	38.30	40.20	77.40	11.00	13.00	10.00	10.00	24.00		1.80
AC-29-04	443.00	431.00	89.10	63.80	77.10	24.10	33.30	51.50	10.00	14.00	9.00	10.00	1.06	8.23	0.00
AC-30-04	391.00	300.00	71.90	50.60		21.90	21.90	36.80	10.00	13.00	9.00	7.00	4.20	7.40	0.00
AC-31-04	226.00	212.00	48.20	36.20	41.00	13.50	12.60	25.20	10.00	12.00	7.00	6.00	0.80	1.90	0.00
AC-32-04	181.00	172.00	32.90	27.00	29.00	9.10	9.00	16.80	9.00	12.00	8.00	8.00	0.80	0.70	0.02
AC-33-04	183.00	172.00	36.60	27.10	34.90	10.30	9.60	17.10	8.00	13.00	8.00	7.00	0.20	0.40	0.03
AC-34-04	179.00	168.00	32.60	20.50	27.80	10.90	9.40	14.10	10.00	13.00	8.00	9.00	0.70	0.80	0.20
AC-35-04	190.00	184.00	36.60	27.70	33.90	11.70	11.50	17.20	11.00	12.00	8.00	8.00	0.20	0.60	0.00
AC-36-04	204.00	192.00	39.90	29.00	33.10	11.30	11.20	16.70	9.00	11.00	8.00	7.00	0.20	0.60	0.10
AC-37-04	191.00	186.00	36.00	28.50	28.10	10.80	11.00	16.80	10.00	11.00	7.00	8.00	0.10	0.40	0.00
AC-38-04	191.00	179.00	37.10	29.10	32.00	11.20	10.40	17.10	10.00	13.00	6.00	8.00	0.10	0.80	0.10
AC-39-04	196.00	187.00	39.00	37.80	28.20	11.10	11.70	19.50	10.00	12.00	8.00	8.00	0.20	0.50	0.02
AC-40-04	205.00	194.00	39.50	26.30	32.90	11.40	11.50	18.60	10.00	13.00	8.00	8.00	0.20	1.00	0.00
AC-41-04	155.00	143.00	28.10	21.10	25.30	10.10	8.40	11.90	10.00	12.00	8.00	7.00	0.20	0.50	0.10

Appendix: 1 Morphometric and meristic data of Arctic char population continued

Fish ID	TL (mm)	FL (mm)	Head length (mm)	Pec. Length (mm)	Depth (mm)	CP (mm)	IOW (mm)	Jaw length (mm)	Dorsal rays	Pec. Rays	Pelv. Rays	Anal rays	Gonad wt (g)	Liver wt. (g)	Visceral fat weight (g)
AC-42-04	224.00	212.00	42.70	29.80	38.20	13.30	12.30	19.60	10.00	13.00	8.00	7.00	0.90	1.50	0.10
AC-43-04	192.00	180.00	34.90	24.10	31.60	11.60	10.00	16.00	10.00	13.00	8.00	8.00	0.80	0.70	0.04
AC-44-04	240.00	222.00	48.70	33.70	32.80	12.30	14.40	23.50	10.00	13.00	10.00	9.00	0.20	1.00	0.00
AC-45-04		95.00	20.00	15.10	16.70	7.00	5.80	8.70	11.00	14.00	10.00	9.00	0.04	0.16	0.01
AC-46-04		105.70	21.30	17.00	18.30	8.00	6.40	8.20	10.00	12.00	9.00	8.00	0.05	0.22	0.03
AC-47-04		92.00	19.40	15.20	15.70	6.60	5.50	8.00	10.00	13.00	8.00	8.00	0.00	0.13	0.01
AC-48-04		114.00	25.20	17.30	18.50	7.50	6.10	10.00	10.00	12.00	9.00	9.00	0.01	0.16	0.07
AC-49-04			19.30	13.60	15.70	6.30	5.00	8.00	10.00	12.00	8.00	8.00	0.03	0.16	0.06
AC-50-04	158.00	149.00	29.10	22.30	27.60	10.00	8.10	12.50	10.00	13.00	9.00	9.00	0.10	0.60	0.10
AC-51-04	495.00	478.00	101.10	66.50	89.40	28.10	34.60	55.10	10.00	13.00	8.00	8.00	4.50		3.10
AC-52-04		100.00	21.70	15.30	18.10	7.30	6.30	8.80	10.00	11.00	8.00	8.00	0.08	0.10	0.01
AC-53-04		169.00	33.30	25.40	29.00	11.20	8.90	14.30	10.00	13.00	8.00	7.00	0.10	0.69	0.04
AC-54-04		88.00		14.50	15.70	6.30			10.00	13.00	8.00	8.00	0.03	0.10	0.03
AC-55-04		103.00		16.10	17.40	7.50		8.00	10.00	14.00		8.00	0.05	0.15	0.05
AC-56-04		318.00	63.00	44.00	50.10	18.10	19.00	29.80	10.00	13.00	8.00	8.00	0.04	3.57	0.00
AC-57-04	59.10	568.00	136.50	97.70	110.60	35.00	43.10	79.90	10.00	14.00	9.00	7.00	4.00		2.20
AC-59-04	611.00	592.00	124.50	89.10	105.50	35.20	41.00	67.50	10.00	14.00	10.00	8.00	21.00		21.60
AC-60-04	520.00	503.00	103.40	72.00	87.80	30.00	35.10	57.10	11.00	14.00	9.00	9.00	1.20		4.10
AC-61-04	461.00	444.00	92.30	61.80	75.10	26.60	29.70	49.10	10.00	14.00	9.00	7.00	9.60	18.70	0.00
AC-62-04	232.00	215.00	41.80	18.40	35.00	11.30	11.10	19.40	9.00	13.00	9.00	9.00	0.37	0.62	0.04
AC-63-04	164.00	148.00	37.00	26.10	28.15		9.85	179.00	10.00	11.00	9.00	9.00	1.83	0.52	0.03
AC-64-04	182.00	174.00	35.60	40.19	30.15			27.10	10.00	12.00	9.00	9.00	8.10	1.04	0.01
AC-65-04	189.00	176.00	35.60	30.40	27.50	11.80	10.20	29.10	10.00	11.00	9.00	9.00	2.10	1.10	0.01
AC-66-04	207.00	195.00	39.40	41.20	40.60	18.50	15.90	27.70	10.00	10.00	8.00	9.00	2.81	1.44	0.03
AC-67-04	191.00	172.00	30.70	41.00	36.70	16.50	17.90	31.80	10.00	9.00	11.00	9.00	2.40	0.61	0.10
AC-68-04	191.00	187.00	40.10	40.80	40.30	20.10	16.40	30.60	11.00	12.00	8.00	10.00	2.61	1.19	
AC-69-04	159.00	150.00	22.60	30.40	30.10	13.00		17.00	11.00	9.00	11.00	11.00	0.99	0.66	0.06
AC-70-04	184.00	175.00	30.89	41.80	40.60	18.90	13.80	23.30	11.00	13.00	9.00	10.00	0.16	0.64	1.00
AC-71-04	209.00	191.00	32.00	34.90	41.30	16.10	22.00	32.40	10.00	12.00	8.00	9.00		0.64	0.03
AC-72-04	192.00	181.00	37.90	39.30	40.70	14.00	16.20	24.70	9.00	11.00	9.00	9.00		0.83	0.04
AC-73-04	189.00	177.00	33.10	38.40	39.90	15.90	14.80	25.80	12.00	12.00	8.00	8.00	2.95		0.07
AC-74-04	186.00	175.00	32.80	40.20	39.90	18.90	15.10	26.40	9.00	12.00	8.00	9.00	0.15	0.79	0.72
AC-75-04	198.00	184.00	32.00	35.70	35.60	18.00	14.80	22.70	11.00	12.00	10.00	10.00	0.02	0.55	0.17
AC-76-04	193.00	186.00	28.10	35.90	36.00	17.10	16.30	20.60	12.00	10.00	11.00	9.00	0.92	0.61	0.15
AC-77-04	184.00	181.00	36.00	39.40	38.60	14.90	16.00		9.00	9.00	10.00	10.00	2.80	1.32	0.09
AC-78-04	35.00	34.80	8.10	3.70	6.10	2.70	2.40	3.70	12.00	12.00		9.00			
AC-79-04	40.70	38.00	9.00	5.60	7.30	2.40	1.50	3.40							
AC-80-04	60.70	59.50	13.30	10.30	9.90	4.10	3.30	7.10							
AC-81-04	40.10	38.90	9.80	5.40	7.80	2.20	1.90	3.20							
AC-82-04	63.10	60.30	14.20	11.80	8.60	4.10	2.80	5.60	12.00	14.00		9.00			
AC-83-04	79.20	75.00	17.50	12.70	13.20	5.50	4.20	18.90	11.00	15.00	9.00	9.00			
AC-84-04	40.30	40.00	9.70	6.40	7.50	3.20	2.10	3.40	10.00		10.00				
AC-85-04	82.60	78.20	17.00	12.60	12.90	5.00	4.00	7.00	11.00	15.00	10.00	9.00			
AC-86-04	641.00	62.60	14.80	10.20	12.10	4.70	3.90	6.00	10.00	13.00	9.00	10.00			
AC-87-04	67.00	63.30	15.40	10.40	11.10	4.90	3.60	6.30	10.00	15.00	10.00				

Fish ID	TL (mm)	FL (mm)	Head length (mm)	Pec. Length (mm)	Depth (mm)	CP (mm)	IOW (mm)	Jaw length (mm)	Dorsal rays	Pec. Rays	Pelv. Rays	Anal rays	Gonad wt (g)	Liver wt. (g)	Visceral fat weight (g)
AC-88-04	181.00	172.00	35.20	37.40	36.00	16.10	14.80	19.80	12.00	10.00	10.00	9.00	2.05	0.55	0.67
AC-89-04	218.00	210.00	35.20	39.10	40.30	18.40	17.00	23.10					0.75	1.11	
AC-90-04	131.40	123.80	26.80	20.20	23.00	7.40	6.70	11.30	9.00	14.00	9.00	9.00	0.03	0.23	0.01
AC-91-04	182.00	163.50	31.30	57.50	39.00	11.00	9.80	13.50	10.00	11.00	7.00	8.00	2.30	0.52	0.03
AC-92-04	206.00	196.00	41.50	73.50	43.50	20.00	21.50	33.00	10.00	10.00	9.00	8.00	0.00	1.16	0.20
C-93-04	220.00	195.00	37.00	66.50	37.50	13.50	12.50	14.50	6.00	12.00	6.00	9.00	2.24	0.81	0.05
AC-94-04	175.00	170.00	31.30	41.50	25.00	10.00	12.00	14.00	10.00	10.00	9.00	8.00	2.06	0.44	0.04
AC-95-04	191.50	179.00	35.50	65.50	33.30	10.00	10.00	18.00	10.00	11.00	7.00	8.00	2.34	1.13	0.01
AC-96-04	211.50	192.00	35.00	67.00	33.00	10.30	12.50	12.00	12.00	12.00	9.00	9.00	3.47	1.59	0.01
AC-97-04	220.00	205.00	34.00	59.00	32.00	11.00	12.50	16.00	10.00	12.00	9.00	9.00	0.69	0.70	0.08
AC-98-04	205.00	191.50	35.00	62.00	26.00	12.50	12.00	17.50	11.00	12.00	9.00	9.00	1.30	0.92	0.08
AC-99-04	215.00	201.00	32.50	61.00	40.00	13.00	14.00	18.00	10.00	9.00	13.00	9.00	1.10	1.42	0.16
AC-100-04	243.00	232.50	36.50	60.50	35.00	12.50	12.50	20.00	10.00	14.00	9.00	9.00	0.88	0.99	0.09
AC-101-04	227.00	210.00	38.00	66.00	40.00	13.00	11.00	20.00	9.00	12.00	10.00	7.00	0.47	1.04	0.10
AC-102-04	175.00	157.50	31.00	52.00	36.00	10.00	11.00	16.00	1.00	13.00	8.00	7.00	6.24	0.91	0.04
AC-103-04	259.00	241.00	44.50	77.00	40.10	12.50	14.20	22.00	10.00	13.00	10.00	9.00	0.59	2.58	0.76
AC-104-04	225.00	208.00	42.50	64.00	34.60	12.00	12.00	19.60	10.00	12.00	9.00	9.00	0.74	0.90	0.12
AC-105-04	253.00	234.00	45.00	78.00	39.50	14.30	13.60	21.60	11.00	10.00	13.00	10.00	1.20	0.96	0.18
AC-106-04	263.00	245.00	50.00	84.00	36.20	15.60	16.50	24.50	10.00	11.00	8.00	9.00	0.36	1.67	0.22
AC-107-04	231.00	215.00	42.00	69.00	37.50	12.60	14.50	19.20	10.00	9.00	14.00	9.00	0.35	1.94	0.57
AC-108-04	154.00	150.00	33.30	57.00	29.00	11.50	10.30	15.50	10.00	8.00	12.00	8.00	1.76	0.42	0.02
AC-109-04	187.00	172.00	36.00	61.00	27.60	10.50	12.00	16.50	11.00	12.00	9.00	9.00	1.55	0.84	0.07
AC-110-04	203.00	196.00	37.00	63.00	30.80	12.20	13.30	18.20	9.00	12.00	8.00	8.00	1.21	0.78	0.04
AC-111-04	189.00	178.00	3.70	6.50	31.30	13.60	11.60	18.20	10.00	13.00	11.00	9.00	1.35	0.78	0.04
AC-112-04	238.00	222.00	42.00	70.00	38.50	15.50	13.30	21.00	11.00	13.00	10.00	9.00	0.70	2.11	0.29
AC-113-04	190.00	176.00	36.00	58.00	26.30	11.00	11.00	16.50	11.00	13.00	9.00	9.00	0.09	0.64	0.11
AC-114-04	192.00	180.00	35.00	60.00	31.40	11.30	9.50	14.70	11.00	14.00	9.00	8.00	2.86	1.36	0.08
AC-115-04	196.00	191.00	38.00	61.00	32.00	12.40	10.40	16.50	11.00	12.00	9.00	10.00	0.15	1.03	0.05
AC-116-04	241.00	231.00	45.00	77.00	39.40	15.50	13.00	21.00	10.00	12.00	8.00	9.00	0.59	1.57	0.29
AC-117-04	241.00	233.00	38.00	62.00	38.40	16.80	10.60	21.00	10.00	12.00	8.00	8.00	0.17	1.11	0.08
AC-118-04	184.00	172.00	34.00	59.00	27.80	11.40	12.40	16.60	10.00	12.00	8.00	9.00	2.22	0.58	0.04
AC-119-04	198.00	186.00	37.00	62.00	29.40	11.70	12.30	16.50	10.00	12.00	9.00	9.00	2.28	1.29	0.04
AC-120-04	142.00	135.00	28.30	48.90	19.30	9.90	8.80	13.70	10.00	13.00	8.00	8.00	0.27	0.23	0.03
AC-121-04	236.00	225.00	42.00	73.00	41.20	16.30	14.30	21.00	10.00	13.00	9.00	8.00	1.04	1.35	0.16
AC-122-04	215.00	199.00	41.00	66.00	32.00	12.40	13.40	19.40	9.00	12.00	8.00	8.00	0.46	0.99	0.07
AC-123-04	173.00	161.00	32.00	52.00	25.00	7.60	9.60	18.50	10.00	12.00	9.00	9.00	0.96		0.01
AC--124-04	197.00	188.00	37.00	62.00	34.00	13.50	11.40	16.30	10.00	14.00	8.00	8.00	0.51	0.74	0.22
AC-125-04	181.00	170.00	34.00	64.00	30.00	12.70	11.00	19.00	10.00	11.00	8.00	8.00	2.10	0.57	0.00
AC-126-04	192.00	183.00	37.00	66.00	29.00	12.60	11.00	15.00	10.00	11.00	9.00	9.00	2.05	0.51	0.03
AC-127-04	182.00	171.00	34.00	62.00	29.90	13.60	13.00	30.00	9.00	11.00	8.00	8.00	1.60	1.12	0.06
AC-128-04	181.00	165.00	36.20	63.00	27.80	11.30	11.50	17.40	8.00	11.00	9.00	8.00	2.36	0.60	0.03
AC-129-04	200.00	192.00	38.00	62.00	30.80	13.00	11.40	18.20	10.00	12.00	9.00	9.00	0.62	1.00	0.07
AC-130-04	2.50	194.00	39.30	66.80	35.00	14.90	13.30	17.50	11.00	13.00	10.00	9.00	3.94	1.27	

Appendix: 1 Morphometric and meristic data of Arctic char population continued

Fish ID	TL (mm)	FL (mm)	Head length (mm)	Pec. Length (mm)	Depth (mm)	CP (mm)	IOW (mm)	Jaw length (mm)	Dorsal rays	Pec. Rays	Pelv. Rays	Anal rays	Gonad wt (g)	Liver wt. (g)	Visceral fat weight (g)
AC-131-04	19.80	18.60	38.50	62.50	33.80	11.80	14.50	17.50	9.00	15.00	9.00	9.00	1.02	0.78	0.06
AC-132-04	254.00	240.00	45.00	77.00	33.90	17.70	15.80	22.00	10.00	13.00	10.00	6.00	0.45	1.50	0.06
AC-133-04	206.00	197.00	44.00	74.00	33.80	15.50	13.00	22.30	10.00	12.00	8.00	8.00	0.94	0.92	0.15
AC-134-04	198.00	183.00	41.00	66.00	34.30	16.00	10.40	19.00	10.00	12.00	8.00	9.00	1.10	0.52	0.03
AC-135-04	222.00	202.00	43.00	73.00	32.30	14.00	13.60	21.00	10.00	13.00	8.00	8.00	0.46	0.79	0.05
AC-136-04	190.00	181.00	36.00	62.00	30.00	14.00	10.80	18.60	10.00	12.00	9.00	8.00	0.65	0.62	0.07
AC-137-04	218.00	203.00	39.00	65.00	39.40	13.40	13.00	18.00	11.00	12.00	10.00	9.00	0.41	0.86	0.05
AC-138-04	229.00	212.00	39.00	58.00	34.50	12.30	12.00	22.30	10.00	12.00	9.00	8.00	0.85	0.86	0.02
AC-139-04	26.50	25.00	5.10	8.70	46.30	17.80	16.80	34.00	10.00	14.00	9.00	10.00	0.70	1.70	0.16
AC-140-04	161.00	151.00	31.60	53.00	25.50	9.40	95.00	16.00	11.00	13.00	9.00	10.00	0.40	0.41	
AC-141-04	262.00	245.00	48.80	84.00	36.40	15.40	13.60	23.00	11.00	13.00	9.00	8.00	0.74	1.27	0.06
AC-142-04	235.00	222.00	45.00	60.00	38.40	15.00	14.60	22.00	10.00	12.00	9.00	10.00	0.37	0.89	0.08
AC-143-04	220.00	215.00	43.00	66.00	41.00	15.60	14.00	22.00	10.00	12.00	8.00	8.00	1.21	0.77	0.12
AC-144-04	237.00	224.00	49.00	79.00	39.40	14.60	13.30	24.60	10.00	13.00	9.00	9.00	0.10	1.10	0.04
AC-145-04	13.80	12.80	27.00	48.00	20.00	8.50	8.20	13.00	10.00	14.00	9.00	9.00	0.01	0.25	0.14
AC-146-04	247.00	226.00	47.00	79.00	46.90	15.00	14.30	19.00	10.00	13.00	10.00	9.00	0.62	1.67	0.62
AC-147-04	137.00	126.00	26.80	44.40	23.50	8.80	7.50	12.30	10.00	10.00	9.00	8.00	0.06	0.18	0.02
AC-148-04	214.00	206.00	41.40	65.80	35.30	15.50	10.50	19.70	10.00	13.00	9.00	10.00	0.04	0.80	0.04
AC-149-04	248.00	235.00	49.00	76.00	40.00	15.00	15.50	22.00	10.00	13.00	9.00	9.00	0.87	1.41	0.09
AC-150-04	223.00	210.00	43.00	71.00	39.00	15.30	11.40	19.30	10.00	12.00	8.00	8.00	0.16	0.89	0.05
AC-151-04	181.00	168.00	33.00	54.00	38.50	13.60	10.70	14.60	10.00	12.00	9.00	8.00	0.66	0.59	0.05
AC-152-04	190.00	175.00	41.00	71.00	32.30	12.00	12.00	20.00	8.00	11.00	8.00	8.00	1.31	0.69	1.64
AC-153-04	192.00	179.00	37.00	59.00	18.60	11.30	9.00	13.40	10.00	13.00	9.00	10.00	0.16	0.46	0.02
AC-154-04	200.00	191.00	38.00	64.00	30.60	11.60	11.40	20.70	9.00	11.00	8.00	9.00	1.44	0.66	0.03
AC-155-04	202.00	189.00	42.00	68.00	32.00	12.50	11.30	17.00	10.00	11.00	7.00	8.00	0.29	0.48	0.06
AC-156-04	209.00	197.00	38.00	65.00	33.60	13.40	11.60	18.80	11.00	12.00	8.00	10.00	5.48	1.72	0.08
AC-157-04	247.00	236.00	45.40	77.00	48.40	16.00	15.30	20.50	10.00	13.00	9.00	9.00	2.49	2.30	1.16
AC-158-04	61.90	58.90	13.30	8.20	10.20	3.50	2.70	5.80	10.00	11.00	8.00	10.00	0.00	0.03	0.00
AC-159-04	216.00	198.00	39.00	66.00	27.30	12.40	10.80	14.60	10.00	13.00	10.00	9.00	0.02	0.84	0.03
AC-160-04	225.00	212.00	43.00	67.00	34.90	12.40	12.10	19.00	11.00	13.00	10.00	9.00	0.90		0.10
AC-161-04	191.00	186.00	38.00	67.00	33.00	12.50	12.30	20.00	10.00	13.00	10.00	8.00	1.52	0.62	0.05
AC-162-04	46.00	44.30	10.20	8.20	7.80	2.80	2.90	4.00	10.00	14.00	9.00	7.00	0.00	0.01	0.00
AC-163-04	89.30	84.80	19.50	14.10	13.90	5.40	3.90	8.30	11.00	12.00	9.00	10.00	0.01	0.08	0.01
AC-164-04	188.00	180.00	38.40	65.00	36.30	11.30	11.50	20.60	10.00	13.00	9.00	9.00	8.87	1.54	0.05
AC-165-04	261.00	247.00	49.00	79.60	40.00	17.00	14.50	18.40	11.00	14.00	10.00	9.00	0.64	1.31	0.04
AC-166-04	269.00	248.00	49.40	80.00	43.00	17.00	12.00	24.40	10.00	14.00	9.00	8.00	1.54	1.51	0.11
AC-167-04	245.00	227.00	47.00	82.00	44.00	17.20	16.30	22.70	10.00	13.00	8.00	10.00	0.35	1.30	0.15
AC-168-04	262.00	250.00	51.80	86.60	44.00	16.00	16.00	24.50	11.00	14.00	10.00	9.00	1.45	1.36	0.33
AC-169-04	135.00	126.00	26.00	45.00	21.60	8.30	12.70	11.30	10.00	13.00	8.00	8.00	0.05	0.28	0.03
AC-170-04	11.00	105.00	22.30	56.60	15.40	7.00	7.00	105.00	10.00	12.00	9.00	9.00	0.01	0.12	0.00

Appendix: 1 Morphometric and meristic data of Arctic char population

h ID	TL (mm)	FL (mm)	Head length (mm)	Pec. Length (mm)	Depth (mm)	CP (mm)	IOW (mm)	Jaw length (mm)	Dorsal rays	Pec. Rays	Pelv. Rays	Anal rays	Gonad wt (g)	Liver wt. (g)	Visceral fat weight (g)
171-04	114.00	109.00	23.50	38.00	20.00	7.00	12.20	11.40	11.00	12.00	9.00	8.00	0.18	0.16	0.07
172-04	109.00	100.00	21.40	35.60	18.40	6.80	5.40	10.80	12.00	14.00	10.00	9.00	0.04	0.15	0.04
173-04	88.00	83.00	18.50	30.00	13.30	5.00	5.50	5.80	12.00	13.00	7.00	7.00	0.01	0.15	0.04
174-04	106.00	99.00	2.30	3.80	16.50	7.00	5.60	10.00	9.00	12.00	9.00	8.00		0.11	0.01
175-04	65.00	61.00	12.00	22.50	10.40	3.00	3.50	6.50	11.00	13.00	9.00	8.00		0.04	0.01
176-04	70.00	66.00	13.80	25.00	9.00	4.40	4.00	7.00	10.00	14.00	10.00	6.00		0.04	0.01
177-04	107.00	101.00	22.60	38.00	17.40	12.40	6.60	10.40	12.00	14.00	7.00	8.00		0.15	0.04
178-04	97.00		19.30	33.50	15.30	5.60	6.60	9.40	10.00	14.00	9.00	10.00		0.02	0.11
179-04	74.00	70.00	14.30	26.00	10.70	5.60	4.40	10.10	11.00	13.00	8.00	8.00		0.03	0.01
180-04	60.00	56.00	12.50	21.40	9.00	3.00	3.00	8.40	11.00	12.00	9.00	7.00		0.03	0.01
181-04	63.00	59.00	12.40	22.40	11.00	4.00	4.40	7.40	11.00	12.00	–8.00	7.00		0.04	0.01
182-04	347.00	323.00	65.00	105.60	60.40	22.00	20.30	31.60	10.00	14.00	8.00	10.00	2.31	5.60	1.10
183-04	344.00	326.00	68.00	110.50	73.00	18.60	22.60	32.60	12.00	18.00	12.00	10.00	2.12	4.10	
184-04	352.00	342.00	70.40	115.00	70.50	23.00	21.40	36.00	10.00	13.00	9.00	10.00	0.74	7.20	1.32
185-04	450.00	383.00	78.00	132.00	75.00	25.60	24.30	32.00	11.00	13.00	9.00	10.00	0.62	7.40	
186-04	38.70	37.70	7.20	6.50	7.20	2.80	2.50		11.00	14.00	8.00	9.00		0.01	0.00
187-04		40.00												0.00	0.00
188-04	370.00	34.70	73.60	111.00	72.00	24.00	22.60	40.00	10.00	14.00	9.00	10.00	2.40	6.10	
189-04	400.00	375.00	8.50	14.40	83.00	23.30	11.00	43.30	12.00	13.00	11.00	9.00	5.20	9.50	
190-04	384.00	357.00	71.30	109.00	68.20	21.60	21.30	38.40	9.00	13.00	9.00	9.00	0.20	4.30	
191-04	380.00	357.00	74.70	118.50	79.00	19.00	23.30	37.00	11.00	13.00	10.00	11.00	3.50	7.30	7.10
192-04	377.00	360.00	71.30	103.80	72.00	22.30	22.00	34.60	10.00	14.00	9.00	13.00	3.70	7.40	0.70
193-04	400.00	385.00	78.00	124.00	75.00	20.70	27.00	42.60	11.00	14.00	9.00	8.00	5.70	8.00	3.40
194-04	395.00	375.00	81.00	123.00	83.40	24.50	24.40	42.80	10.00	12.00	9.00	9.00	3.30		4.20
195-04	65.00	61.40	13.00	22.50	10.40	4.30	4.00	6.00	10.00	10.00	9.00	9.00		0.02	
196-04	60.00	58.00	12.30	22.20	9.50	3.50	2.80	5.00	12.00	13.00	10.00	8.00		0.03	0.00
197-04	40.30	36.60	8.80	14.60	7.50	2.50	2.50	5.00	10.00	12.00	9.00	9.00		0.01	
198-04	38.20	36.60	8.40	4.60	5.10	2.40	2.00	2.60	12.00	14.00	11.00			0.03	0.00
199-04	30.90	29.00	7.50	4.40	4.70	1.80	0.90	2.40	11.00		11.00	10.00		0.00	0.00
200-04		35.10	8.50	4.10	5.80	2.50	1.70	2.70	9.00	13.00	9.00	10.00		0.00	0.00
201-04	62.50	60.10	14.30	10.40	10.30	3.80	3.80	4.90	11.00	11.00	9.00	8.00		0.02	0.00
202-04	61.00	58.30	13.30	9.70	9.10	3.90	2.50	5.20	9.00	14.00	10.00	9.00		0.02	0.00
203-04		39.00	9.60	5.10	8.10	2.60	2.10	3.50	10.00	13.00	9.00	9.00		0.01	0.00
204-04	40.20	38.50	9.10	6.30	6.80	2.50	1.90	3.20	10.00	13.00	10.00	9.00		0.01	0.00
205-04	41.10	39.91	9.90	60	7.10	3.10	1.90	4.00	9.00	15.00	9.00	9.00		0.01	0.00
206-04		50.10	11.50	8.40	8.10	3.00	2.80	3.80	12.00	14.00	9.00	8.00		0.02	0.00
207-04	61.51	58.60	13.70	10.30	10.50	3.40	3.60	5.40	11.00	14.00	10.00	9.00		0.02	0.00
208-04	51.10	48.60	12.50	7.70	8.80	3.20	2.20	3.30	12.00	14.00	10.00	9.00		0.01	0.00
209-04		55.90	14.30	10.50	11.90	3.40	3.20	5.10	9.00	13.00	9.00	8.00	0.00	0.03	0.00
210-04	41.51	38.90	8.80	5.60	6.60	2.60	1.90	3.70	11.00	9.00	9.00	9.00		0.01	0.00

Appendix: 2

Table: 1 Descriptive statistic of length-frequency distribution of Arctic char captured by electro-fishing (1.1) and gill netting (1.2)

Table: 1.1 Statistics: for Arctic char caught by electrofishing

FORKLENG

N	Valid	47
	Missing	0
Mean		69.451
Std. Deviation		37.2621
Variance		1388.4669
Skewness		1.597
Std. Error of Skewness		.347
Kurtosis		2.402
Std. Error of Kurtosis		.681
Minimum		29.0
Maximum		186.0

Table: 1.2 Statistics: for Arctic char caught by gill-netting

FORKLENG

N	Valid	159
	Missing	0
Mean		218.24
Std. Deviation		98.053
Variance		9614.489
Skewness		2.099
Std. Error of Skewness		.192
Kurtosis		5.544
Std. Error of Kurtosis		.383
Range		597
Minimum		59
Maximum		656

Table: 2 Descriptive statistic of age-frequency distribution of Arctic char captured by electro-fishing (2.1) and gill netting (2.2)

Table: 2.1 Statistics: for Arctic char caught by electrofishing

AGE

N	Valid	47
	Missing	0
Mean		1.96
Std. Deviation		2.095
Variance		4.389
Skewness		1.747
Std. Error of Skewness		.347
Kurtosis		3.222
Std. Error of Kurtosis		.681
Minimum		0
Maximum		9

Table: 2.2 Statistics: for Arctic char caught by gill-netting

AGE

N	Valid	156
	Missing	3
Mean		7.70
Std. Deviation		2.658
Variance		7.063
Skewness		.641
Std. Error of Skewness		.194
Kurtosis		.936
Std. Error of Kurtosis		.386
Range		14
Minimum		1
Maximum		15

Table: 3 Test of normality of length-frequency and age-frequency distribution of Arctic char.

Test of Normality	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
Fork length	0.155	207	0.000	0.872	207	0.000
Age	0.120	193	0.000	0.955	193	0.000

Table: 4 Test of normality of liver weight, gonad weight and visceral fat weight of Arctic char population.

Test of Normality	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Liver weight	.369	195	.000	.404	195	.000
Gonad weight	.299	169	.000	.477	169	.000
Visceral fat weight	.417	186	.000	.188	186	.000

Table: 5 Test of homogeneity of variance of liver weight, gonad weight and visceral fat weight of Arctic char population.

Test of Homogeneity of Variances				
Factor	Levene Statistic	df1	df2	Sig.
Liver weight	111.771	2	191	.000
Gonad weight	15.580	2	163	.000
Visceral fat weight	3.097	2	183	.048

Table: 6 Non-parametric correlations among fork length, LSI, GSI and VFI of Arctic char

Correlations

			FORKLENG	LSI	GSI	VFI
Kendall's tau_b	FORKLENG	Correlation Coefficient	1.000	-.037	-.068	-.122*
		Sig. (2-tailed)	.	.446	.195	.013
		N	197	193	167	192
	LSI	Correlation Coefficient	-.037	1.000	.131*	.141**
		Sig. (2-tailed)	.446	.	.013	.004
		N	193	193	165	189
	GSI	Correlation Coefficient	-.068	.131*	1.000	.004
		Sig. (2-tailed)	.195	.013	.	.939
		N	167	165	167	163
	VFI	Correlation Coefficient	-.122*	.141**	.004	1.000
		Sig. (2-tailed)	.013	.004	.939	.
		N	192	189	163	192
Spearman's rho	FORKLENG	Correlation Coefficient	1.000	-.054	-.072	-.168*
		Sig. (2-tailed)	.	.453	.357	.020
		N	197	193	167	192
	LSI	Correlation Coefficient	-.054	1.000	.190*	.207**
		Sig. (2-tailed)	.453	.	.014	.004
		N	193	193	165	189
	GSI	Correlation Coefficient	-.072	.190*	1.000	.014
		Sig. (2-tailed)	.357	.014	.	.864
		N	167	165	167	163
	VFI	Correlation Coefficient	-.168*	.207**	.014	1.000
		Sig. (2-tailed)	.020	.004	.864	.
		N	192	189	163	192

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

Table: 7 Descriptive statistics of GSI and VFI of female and male Arctic char

Arctic char	Mean	St. Deviation	Number
Sex: Female			
Fork length	202.369	89.723	141
GSI	1.816928	2.4867314	134
VSI	1.34	.3681608	137
Sex: Male			
Fork Length	235.600	131.4411	33
GSI	.225625	.1755716	32
VSI	.155333	.3247834	33

Table: 8 Non-parametric correlations among fork length, GSI and VFI of female Arctic char.

Correlations: Female char

			FORKLENG	GSI	VSI
Kendall's tau_b	FORKLENG	Correlation Coefficien	1.000	-.096	-.129*
		Sig. (2-tailed)	.	.100	.026
		N	141	134	137
	GSI	Correlation Coefficien	-.096	1.000	-.099
		Sig. (2-tailed)	.100	.	.097
		N	134	134	130
	VSI	Correlation Coefficien	-.129*	-.099	1.000
		Sig. (2-tailed)	.026	.097	.
		N	137	130	137
Spearman's rho	FORKLENG	Correlation Coefficien	1.000	-.090	-.183*
		Sig. (2-tailed)	.	.303	.033
		N	141	134	137
	GSI	Correlation Coefficien	-.090	1.000	-.145
		Sig. (2-tailed)	.303	.	.100
		N	134	134	130
	VSI	Correlation Coefficien	-.183*	-.145	1.000
		Sig. (2-tailed)	.033	.100	.
		N	137	130	137

*. Correlation is significant at the .05 level (2-tailed).

Table: 9 Non-parametric correlations among fork length, GSI and VFI of male Arctic char.

Correlations: Male char

			FORKLENG	GSI	VSI
Kendall's tau_b	FORKLENG	Correlation Coefficient	1.000	-.069	-.188
		Sig. (2-tailed)	.	.581	.133
		N	33	32	33
	GSI	Correlation Coefficient	-.069	1.000	-.013
		Sig. (2-tailed)	.581	.	.922
		N	32	32	32
	VSI	Correlation Coefficient	-.188	-.013	1.000
		Sig. (2-tailed)	.133	.922	.
		N	33	32	33
Spearman's rho	FORKLENG	Correlation Coefficient	1.000	-.125	-.260
		Sig. (2-tailed)	.	.497	.143
		N	33	32	33
	GSI	Correlation Coefficient	-.125	1.000	-.021
		Sig. (2-tailed)	.497	.	.909
		N	32	32	32
	VSI	Correlation Coefficient	-.260	-.021	1.000
		Sig. (2-tailed)	.143	.909	.
		N	33	32	33

Table: 10 Descriptive statistics of nitrogen signature of small, medium and large char

Descriptives

N

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	34	10.7724	.91334	.15664	10.4537	11.0910	9.32	13.97
2	83	10.9988	1.13763	.12487	10.7504	11.2472	8.25	17.04
3	24	14.2846	1.22862	.25079	13.7658	14.8034	12.15	16.33
Total	141	11.5035	1.67612	.14116	11.2244	11.7825	8.25	17.04

Table: 11 Descriptive statistics of carbon signature of small, medium and large char

Descriptives

C

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	34	-19.4856	1.66833	.28612	-20.0677	-18.9035	-23.62	-16.84
2	83	-19.7878	1.35271	.14848	-20.0832	-19.4925	-22.99	-16.53
3	24	-19.5025	1.55433	.31728	-20.1588	-18.8462	-21.99	-16.18
Total	141	-19.6664	1.46493	.12337	-19.9103	-19.4225	-23.62	-16.18

Table: 12 Comparison of mean nitrogen signature between piscivorous and non-piscivorous char

Group Statistics

	FOODTYPE	N	Mean	Std. Deviation	Std. Error Mean
N	1.00	16	13.7819	1.75851	.43963
	2.00	124	11.1839	1.40010	.12573

Note: Food type 1: piscivorous, Food type 2: non-piscivorous

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
N	Equal variances assumed	2.603	.109	6.776	138	.000	2.5980	.38342	1.83987	3.35614
	Equal variances not assumed			5.682	17.540	.000	2.5980	.45725	1.63554	3.56047

Table: 13 Comparison of mean carbon signature between piscivorous and non-piscivorous char

Group Statistics

	FOODTYPE	N	Mean	Std. Deviation	Std. Error Mean
C	1.00	16	-20.4525	1.21814	.30454
	2.00	124	-19.5676	1.47328	.13230

Note: Food type 1: piscivorous, Food type 2: non-piscivorous

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
C	Equal variances assumed	.898	.345	-2.301	138	.023	-.8849	.38457	-1.64534	-.12450
	Equal variances not assumed			-2.665	21.105	.014	-.8849	.33203	-1.57521	-.19463

Table: 14 Non-parametric correlations among condition factor, fork length, age, total parasite count per host, LSI, GSI and VFI in small char (FL < 125 mm)

Correlations

			CFACTOR	FORKLENG	AGE	PARASITE	LSI	GSI	VFI
Kendall's tau_b	CFACTOR	Correlation Coefficient	1.000	.060	.152	-.049	.019	.056	.209*
		Sig. (2-tailed)	.	.501	.114	.610	.850	.711	.035
		N	59	59	59	59	49	23	49
	FORKLENG	Correlation Coefficient	.060	1.000	.785**	.023	-.026	.216	.140
		Sig. (2-tailed)	.501	.	.000	.809	.796	.153	.157
		N	59	59	59	59	49	23	49
	AGE	Correlation Coefficient	.152	.785**	1.000	-.063	.037	.246	.154
		Sig. (2-tailed)	.114	.000	.	.541	.726	.127	.145
		N	59	59	59	59	49	23	49
	PARASITE	Correlation Coefficient	-.049	.023	-.063	1.000	-.063	.009	-.054
		Sig. (2-tailed)	.610	.809	.541	.	.562	.957	.619
		N	59	59	59	59	49	23	49
	LSI	Correlation Coefficient	.019	-.026	.037	-.063	1.000	.128	.136
		Sig. (2-tailed)	.850	.796	.726	.562	.	.397	.170
		N	49	49	49	49	49	23	49
	GSI	Correlation Coefficient	.056	.216	.246	.009	.128	1.000	.431**
		Sig. (2-tailed)	.711	.153	.127	.957	.397	.	.004
		N	23	23	23	23	23	23	23
	VFI	Correlation Coefficient	.209*	.140	.154	-.054	.136	.431**	1.000
		Sig. (2-tailed)	.035	.157	.145	.619	.170	.004	.
		N	49	49	49	49	49	23	49

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

Table: 15 Non-parametric correlations among condition factor, fork length, age, total parasite count per host, LSI, GSI and VFI in medium char (FL 125-250 mm)

Correlations

			CFACTOR	FORKLENG	AGE	PARASITE	LSI	GSI	VSI
Kendall's tau_b	CFACTOR	Correlation Coefficient	1.000	-.217**	-.122	-.066	.093	.240**	.245**
		Sig. (2-tailed)	.	.000	.069	.289	.135	.000	.000
		N	120	120	117	120	118	117	116
	FORKLENG	Correlation Coefficient	-.217**	1.000	.102	.287**	-.133*	-.267**	-.022
		Sig. (2-tailed)	.000	.	.131	.000	.035	.000	.726
		N	120	121	118	121	118	117	116
	AGE	Correlation Coefficient	-.122	.102	1.000	.086	-.050	.115	-.138*
		Sig. (2-tailed)	.069	.131	.	.204	.464	.093	.044
		N	117	118	118	118	116	114	114
	PARASITE	Correlation Coefficient	-.066	.287**	.086	1.000	-.038	-.172**	-.034
		Sig. (2-tailed)	.289	.000	.204	.	.550	.006	.589
		N	120	121	118	121	118	117	116
	LSI	Correlation Coefficient	.093	-.133*	-.050	-.038	1.000	.223**	.113
		Sig. (2-tailed)	.135	.035	.464	.550	.	.000	.076
		N	118	118	116	118	118	115	114
	GSI	Correlation Coefficient	.240**	-.267**	.115	-.172**	.223**	1.000	.001
		Sig. (2-tailed)	.000	.000	.093	.006	.000	.	.984
		N	117	117	114	117	115	117	113
	VFI	Correlation Coefficient	.245**	-.022	-.138*	-.034	.113	.001	1.000
		Sig. (2-tailed)	.000	.726	.044	.589	.076	.984	.
		N	116	116	114	116	114	113	116

**. Correlation is significant at the .01 level (2-tailed).

*. Correlation is significant at the .05 level (2-tailed).

Table: 16 Non-parametric correlations among condition factor, fork length, age, total parasite count per host, LSI, GSI and VFI in large char (FL > 300 mm)

Correlations

			CFACTOR	FORKLENG	AGE	PARASITE	LSI	GSI	VSI
Kendall's tau_b	CFACTOR	Correlation Coefficient	1.000	-.134	-.263	.053	.060	.269	.098
		Sig. (2-tailed)	.	.350	.086	.709	.674	.080	.537
		N	25	25	25	25	25	22	23
	FORKLENG	Correlation Coefficient	-.134	1.000	.350*	.423**	.175	-.096	.139
		Sig. (2-tailed)	.350	.	.023	.003	.224	.534	.384
		N	25	25	25	25	25	22	23
	AGE	Correlation Coefficient	-.263	.350*	1.000	.307*	.030	.239	-.045
		Sig. (2-tailed)	.086	.023	.	.045	.847	.148	.792
		N	25	25	25	25	25	22	23
	PARASITE	Correlation Coefficient	.053	.423**	.307*	1.000	.013	-.017	-.098
		Sig. (2-tailed)	.709	.003	.045	.	.926	.910	.537
		N	25	25	25	25	25	22	23
	LSI	Correlation Coefficient	.060	.175	.030	.013	1.000	.340*	.416**
		Sig. (2-tailed)	.674	.224	.847	.926	.	.028	.009
		N	25	25	25	25	25	22	23
	GSI	Correlation Coefficient	.269	-.096	.239	-.017	.340*	1.000	.060
		Sig. (2-tailed)	.080	.534	.148	.910	.028	.	.728
		N	22	22	22	22	22	22	20
	VSI	Correlation Coefficient	.098	.139	-.045	-.098	.416**	.060	1.000
		Sig. (2-tailed)	.537	.384	.792	.537	.009	.728	.
		N	23	23	23	23	23	20	23

*. Correlation is significant at the .05 level (2-tailed).

**. Correlation is significant at the .01 level (2-tailed).

Table: 17 Non-parametric correlations among total parasite count per host, nitrogen and carbon signature of Arctic char

Correlations

			PARASITE	NITROGEN	CARBON
Kendall's tau_b	PARASITE	Correlation Coefficient	1.000	.343**	-.079
		Sig. (2-tailed)	.	.000	.168
		N	208	141	141
	NITROGEN	Correlation Coefficient	.343**	1.000	-.084
		Sig. (2-tailed)	.000	.	.139
		N	141	141	141
	CARBON	Correlation Coefficient	-.079	-.084	1.000
		Sig. (2-tailed)	.168	.139	.
		N	141	141	141
Spearman's rho	PARASITE	Correlation Coefficient	1.000	.476**	-.122
		Sig. (2-tailed)	.	.000	.150
		N	208	141	141
	NITROGEN	Correlation Coefficient	.476**	1.000	-.119
		Sig. (2-tailed)	.000	.	.161
		N	141	141	141
	CARBON	Correlation Coefficient	-.122	-.119	1.000
		Sig. (2-tailed)	.150	.161	.
		N	141	141	141

**. Correlation is significant at the .01 level (2-tailed).

Appendix: 3

Table 1: Food types of winter Arctic char captured in 2004 ……………..continued

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Plant materials	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-01-04	3/2/04	Y	Y	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-02-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-03-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-04-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-05-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-06-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-07-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-08-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-09-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-10-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N
AC-11-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N
AC-12-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	Y	N
AC-13-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
AC-14-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-15-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
AC-16-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-17-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-18-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-19-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
AC-22-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-23-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-24-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-25-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-27-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N
AC-28-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-29-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-30-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-31-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-32-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-33-04	3/2/04	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-34-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-35-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
AC-36-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-37-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-38-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-39-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-40-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	N

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Plant materials	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-41-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-42-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-43-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-44-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-45-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-46-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-47-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-48-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-49-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
AC-50-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-51-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N
AC-52-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-53-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N
AC-54-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-55-04	3/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-56-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-57-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-59-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-60-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-61-04	3/2/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-26-04	6/2/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Table 2: Food types of summer Arctic char captured in 2004 ....continued

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Macrophytes	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-127-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-91-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-92-04	13/07/04	N	N	N	N	N	Y	N	N	Y	N	N	N	N	Y	N	N	N	N	N
AC-93-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-94-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-95-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-97-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-98-04	13/07/04	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-99-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-103-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	Y	N	N
AC-104-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	y	N	N	N	N	N	N	N	N
AC-105-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	Y	N
AC-107-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	Y	N	N
AC-111-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-113-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-115-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-116-04	13/07/04	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-121-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	Y	N
AC-124-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-134-04	13/07/04	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
AC-139-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-141-04	13/07/04	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N
AC-142-04	13/07/04	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N
AC-143-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-145-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-150-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-167-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-182-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	Y	N	N
AC-193-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-194-04	13/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-131-04	13/07/04	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
AC-67-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-71-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-72-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-73-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-74-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-77-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-88-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-89-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Table 2: Food types of summer Arctic char captured in 2004 ....continued

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Macrophytes	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-75-04	13/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-206-04	13/7/2004	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-207-04	13/7/2004	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-208-04	13/7/2004	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-209-04	13/7/2004	N	Y	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-133-04	14/04/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
AC-96-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-100-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-108-04	14/07/04	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N
AC-109-04	14/07/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-110-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-112-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N
AC-114-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
AC-117-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-118-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	Y	N
AC-119-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-120-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-122-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-123-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-126-04	14/07/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-128-04	14/07/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-129-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-130-04	14/07/04	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
AC-132-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-136-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-137-04	14/07/04	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
AC-140-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-147-04	14/07/04	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
AC-151-04	14/07/04	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-152-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-153-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-154-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
AC-155-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y
AC-157-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-158-04	14/07/04	Y	Y	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-159-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	Y
AC-160-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-162-04	14/07/04	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-163-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N

Table 2: Food types of summer Arctic char captured in 2004 ....continued

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Macrophytes	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-165-04	14/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	Y	N
AC-166-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-168-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-183-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-185-04	14/07/04		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-189-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-191-04	14/07/04	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-192-04	14/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-69-04	14/1/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-63-04	14/7/04	Y	N	N	N	N	Y	N	N	Y	N	y	N	N	N	N	N	N	Y	N
AC-65-04	14/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-68-04	14/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-101-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-106-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-125-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-135-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N
AC-138-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-144-04	15/07/04	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N
AC-146-04	15/07/04	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
AC-148-04	15/07/04	N	N	N	N	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
AC-149-04	15/07/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-156-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-184-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N
AC-188-04	15/07/04	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-190-04	15/07/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-66-04	15/7/04	Y	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	Y	N
AC-70-04	15/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-76-04	15/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-62-04	17/7/04	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
AC-64-04	17/7/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-102-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-169-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-170-40	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-171-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-172-04	22/08/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-173-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-174-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-175-04	22/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-195-04	22/08/04	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-196-04	22/08/04		N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-197-04	22/08/04		N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N

Table 2: Food types of summer Arctic char captured in 2004

Fish ID	Date of capture	Chironomid larvae	Chironomid pupae	Chironomid adult	Copepod	Cladocera	Ostracod	Coleoptera	Caddisfly larvae	Aquatic insects	Insect larvae	Macrophytes	Fish bones	Adult Diptera	Water mites	Water spider	Arctic char	Stickleback	clams	Daphnia
AC-90-04	22/8/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-198-04	22/8/04	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
AC-199-04	22/8/04	Y	N	N	N	Y	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
AC-200-04	22/8/04	N	Y	Y	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N	N
AC-201-04	22/8/04	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-202-04	22/8/04	Y	N	N	N	Y	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
AC-203-04	22/8/04	N	N	Y	Y	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N
AC-204-04	22/8/04	N	Y	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N
AC-205-04	22/8/04	Y	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
AC-210-04	22/8/04	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
AC-161-04	23/08/04	N	N	N	N	N	N	N	N	N	N	y	N	N	N	N	N	N	N	N
AC-164-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-176-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-177-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-178-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-179-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-180-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-181-04	23/08/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-78-04	23/8/04	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
AC-79-04	23/8/04	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
AC-80-04	23/8/04	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N
AC-81-04	23/8/04	Y	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
AC-82-04	23/8/04	Y	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N
AC-83-04	23/8/04	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N
AC-84-04	23/8/04	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N
AC-85-04	23/8/04	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
AC-86-04	23/8/04	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N
AC-87-04	23/8/04	Y	N	N	N	N	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N
AC-186-04	23/8/04	N	Y	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N
AC-187-04	23/8/04	Y	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N