REPORT ON THE ENUMERATION OF THE 1987 UPSTREAM MIGRATION OF ARCTIC CHAR (Salvelinus alpinus L.) IN THE BIG FISH RIVER, N.W.T.

by

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This report was prepared for the Fisheries Joint Management Committee, as part of the implementation terms of the Inuvialuit Final Agreement. The opinions, findings, conclusions and recommendations expressed in this report are those of the Authors and do not necessarily reflect the views of the Fisheries Joint Management Committee.

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1.0 INTRODUCTION

The Big Fish River is one of two rivers on the western edge of the Mackenzie Delta, N.W.T., where anadromous stocks of Arctic char (Salvelinus alpinus L.) are known to overwinter (Stein et al. 1973). Historically it has provided the residents of Aklavik with a source of Arctic char for domestic consumption (Dryden et al. 1973). More recently, a shared commercial quota of 900 kg (for Mackenzie River Delta, Area I) was introduced. However, utilization of the resource has remained primarily on a subsistence basis.

The proximity of the Big Fish River to Aklavik and the scarcity of other Arctic char stocks in the immediate area has resulted in a relatively heavy demand on this system in the past. Previous studies have indicated exploitation rates of over 35% (Stein et al. 1973) which are considered heavy for Arctic char. Concern by the local community over the abundance and size of the Big Fish River char stock has led the Department of Fisheries and Oceans (D.F.O.) to conduct a number of biological evaluations in the past (Gillman et al. 1985; Sparling and Stewart 1986). Results have indicated that despite a decrease in fishing pressure in recent years the population has declined since 1972 (A. H. Kristofferson, D.F.O., Winnipeg, personal communication). However, at present the extent to which the population has been reduced is unknown. As a result of this uncertainty, it was decided by the Fisheries Joint Management Committee (F.J.M.C.) in conjunction with the D.F.O. to close the Big Fish River to all fishing during the summer of 1987.

In order to manage this resource more effectively the D.F.O. on behalf of the F.J.M.C. initiated a study in 1987 to conduct a total stock assessment of

the upstream migration of Arctic char in the Big Fish River. The primary objectives were to: 1) obtain a direct count and biological evaluation of the upstream migration using a weir as a capturing mechanism and 2) conduct a simultaneous Schaefer stratified population estimate as a back-up to the weir and to determine its efficiency for use in enumerating char migrations in other systems. If the first two objectives could not be met a contingency plan to obtain a Petersen estimate on the char overwintering grounds was also considered.

North/South Consultants Inc. was contracted to carry out the study. This report contains a description of the field work conducted in August and September 1987 along with an analysis of the results.

1.1 STUDY AREA

The Big Fish River enters the Mackenzie Delta approximately 55 km northwest of Aklavik, N.W.T. (Fig. 1). The headwaters are located primarily in the Richardson Mountains and drain via four major channels: Cache Creek, Sheep Creek, Summit Creek and Fish River. Cache Creek is the only tributary utilized by anadromous Arctic char. It flows in a northerly direction parallel to the Northwest Territories-Yukon border before converging with the Fish River to form the Big Fish River approximately 10 km upstream of the delta. The water in Cache Creek runs over extensive gravel areas and is subject to significant fluctuations in depth and clarity. A detailed description of Cache Creek and the Big Fish River system can be found in Gillman et al. (1985).

1.2 LIFE HISTORY OF ANADROMOUS ARCTIC CHAR OF THE BIG FISH RIVER

The Big Fish River watershed contains both resident (McCart and Bain 1974) and anadromous (Stein et al. 1973) populations of the western form of Arctic char described by McPhail (1961). The anadromous form descends the river in spring and spends the summer feeding along the Beaufort Sea coast. However, the degree to which current year spawners are involved in this feeding migration is unknown. It is suspected that some journey only to the estuary before making their way back upstream in midsummer (A. H. Kristofferson, D.F.O., Winnipeg, personal communication). The bulk of the return migration back to freshwater generally begins in the second week of August. It is at this time that char are traditionally harvested by gillnet at the mouth of the Big Fish River. In 1986, four fishermen from Aklavik captured 197 char during two weeks at this location (Sparling and Stewart 1986).

Migrating Arctic char reach "Fish Hole" (Fig. 1) at the headwaters of Cache Creek, a tributary of the Big Fish River, during mid-September. This is reported to be the only suitable spawning and overwintering area in the Big Fish River system (Stein et al. 1973). Further upstream movement of char at "Fish Hole" is restricted by the presence of a 3 m waterfall. Spawning is reported to occur over gravel substrates in the riffle areas below the falls and is generally completed by the end of October (Jessop et al. 1974). During October and November domestic fishermen have traditionally fished this location using sweepnets and beach seines. Sparling and Stewart (1986) determined that 1,660 char were taken in 1986 while Stein et al. (1973) report that up to 6000 fish were harvested from this location in 1972.

2.0 MATERIALS AND METHODS

2.1 ENUMERATION AND BIOLOGICAL EVALUATION BY FISH WEIR

2.1.1 Weir Design and Construction

The project biologist and technician arrived in Inuvik on August 2, 1987. Preparation for field work began immediately with the acquisition of weir materials from the D.F.O. and the hiring of three additional workers from Aklavik. The location of a previously selected weir site on Cache Creek was obtained from D.F.O. personnel in Inuvik. A reconnaissance flight by Helio Courier was made to the site by the project biologist on August 4 and a 225 m airstrip suitable for tundra wheel equipped aircraft was marked on the adjacent flood plain. A Twin Otter was not available for shipment of weir material at the time and was subsequently booked for August 8. On August 5, 35 m of stucco wire and 5 A-frame supports were flown into the weir site by Helio Courier and installed across Cache Creek (maximum depth .75 m). This acted as a temporary barrier to prevent any undetected movement of fish prior to installation of the weir.

On August 8, two Twin Otter flights were made to Cache Creek carrying camp gear, weir material and personnel. On arrival it was discovered that high water, resulting from three previous days of precipitation, had caused the temporary barrier to collapse. Maximum water depth had increased to 1.5 m and as a result weir installation was delayed for a further three days. By August 12 water levels had receded sufficiently (maximum depth 1.2 m) to allow access to the creek and construction of the weir was complete by 23:00 hrs.

Design and construction of the weir wings followed that of Anderson and McDonald (1978). The only significant modification was to the spacing of the conduit which was increased to 3.2 cm centres. The trap, which was pre-

fabricated in Inuvik, consisted of spruce "2 x 4's" framing a conduit cage measuring 1.2 x 1.8 x 1.2 m. It was placed facing downstream in 1.0 m of water, 15 m from shore at the apex of the two 21 m wings. Rocks and sand bags were used to anchor the trap in the stream and plastic netting (1.0 cm mesh) was utilized to attach the trap to the adjacent conduit. A further 35 m of plastic netting was used to complete the nearshore ends of both wings. A number of previous studies in the Arctic have used weirs of similar design to enumerate char populations (Gillman and Sparling 1985; Kristofferson et al. 1986; MacDonell 1986). These projects have met with varying degrees of success, primarily depending on the water levels encountered on each river.

The Cache Creek weir was fully operational for seven days commencing on August 13. On August 20, some of the conduit was removed from the west wing to alleviate increased pressure caused by rising water levels. All conduit was replaced at 11:00 hrs. on August 22, but by 16:00 hrs. on August 23 an unforseen rapid rise in water level had occurred which caused the weir to collapse. Maximum depth had once again increased to 1.5 m and recovery of the weir could not be completed until the water level had receded on August 30. Figure 2 illustrates the fluctuations in water levels from the day of weir installation to the day of removal. From August 23 to September 2, a 1.2 m (2.5 cm mesh) hoopnet was fished periodically (water levels permitting) to continue monitoring the char migration.

Weir materials were stored on the east bank above the spring high water level and were to be removed by snowmobile at a later date. The weir site was vacated on September 2 via a Twin Otter.

2.1.2 Biological Evaluation

The trap was generally checked every three to four hours. All fish caught were identified to species and enumerated. Each Arctic char was classified by sexual maturity by noting the presence or absence of secondary sexual characteristics such as spawning colouration and kypes. When possible 50 char per day were tagged, measured and released. Individually numbered blue and green Floy tags were applied using a Dennison tagging gun. Tags were inserted below the posterior half of the dorsal fin and anchored behind the basal pterygiophores. A further 50 char were measured and released each day.

An overall length-frequency distribution for the migration passing through the weir was calculated by summing daily length distributions weighted by the strength of the run each day. To establish a length-age relationship a stratified dead sample was obtained by selecting ten fish from each 5 cm length interval. Fork length (±1mm), round weight (±25g) and dressed weight (±25g) were recorded for each fish. Otoliths were removed and subsequently aged by the D.F.O. in Winnipeg. Sexual maturity was determined through gross examination of the gonads. This procedure also helped to validate the external sexing technique used on live fish.

A further 19 mature female char were sacrificed to obtain ovaries for fecundity analysis. The ovaries were initially stored in formalin and then transferred to Gilsons solution on return from the field. Each ovary was weighed (±1g) and a subsample of 30 eggs was taken from the anterior, middle and posterior sections. These were measured to the nearest millimetre and weighed to the nearest gram. The ovaries were then broken apart and all eggs were counted.

A weight-length relationship was calculated by using a least squares regression analysis on logarithmic transformations of fork length and round weight. The relationship is represented as:

$$Log_{10}W = a + b\ (Log_{10}L)$$

where: W = weight (g)

L = length (mm)

A similar fecundity-length relationship was also calculated and represented as:

$$Log_{10}F = a + b\ (Log_{10}L)$$

where: F = fecundity (number of eggs)

L = length (mm)

The relative condition factor (K) was calculated by:

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

An instantaneous total mortality rate (Z) was obtained by applying the age-length relationship generated from the stratified dead sample to the cumulative daily length-frequency distribution. The percentage of each age in each 5 cm length interval was determined and then applied to the cumulative daily length data. An age-frequency distribution was then calculated and a catch curve fitted to the data. Total mortality was calculated using a least squares regression on the descending limb of the catch curve.

Analysis of biological data was performed using the Statistical Analysis System (1985).

2.2 SCHAEFER STRATIFIED POPULATION ESTIMATE

To effectively estimate a fish migration using the Schaefer method it is necessary to stratify separate groups with respect to the time at which they are moving upstream (Ricker 1975). This can be done by marking fish at one point along their migration route, recovering them later at a different place and then noting the time that it took for them to cover that distance.

This technique was used to estimate the char migration in Cache Creek during August 1987. Coinciding with the operation of the weir, a 1.2m (2.5 cm mesh) hoopnet was set approximately 2.5 km upstream. It faced downstream and covered approximately 1/5 of the creek. The hoopnet was generally checked twice a day and all fish captured were identified to species, enumerated and examined for tags. All numbers of recaptured tags were recorded. The hoopnet was operational from August 14 to August 20 at which time it was removed due to high water levels.

The data was set up in tables and divided into daily cells in the format proposed by Ricker (1975). Computed estimates of the number of char moving upstream were obtained using the equation proposed by Schaefer (1951):

$$N = \sum \left(R_{i,j} \cdot \frac{M_i}{R_i} \cdot \frac{C_j}{R_j} \right)$$

where:
- N = total population
- $R_{i,j}$ = number of fish marked in the i th marking period which are recovered in the j th recovery period
- M_i = number of fish marked in the i th marking period
- R_i = total recaptures of fish tagged in the i th period
- R_j = total recaptures during the j th period
- C_j = number of fish caught and examined in the j th period

2.3 PETERSEN SINGLE CENSUS ESTIMATE

A lack of success in reaching the original two objectives of this study prompted the implementation of a contingency plan to conduct a Petersen estimate of the Big Fish River Arctic char population. The project biologist, technician and a D.F.O. employee flew into the char overwintering location at "Fish Hole" by helicopter on August 12. Using a 30m, 5cm mesh monofilament gillnet, seining was performed along a four mile stretch of river for a period of five days. All accessible stretches of stream were sampled from the braided area upstream to the falls (Fig. 1). All char captured were enumerated, examined for tags and identified as either a current year spawner, silver (sea-run char which will not spawn in the current year) or residual male and then returned to the creek. Data were analyzed using the adjusted Petersen equation as proposed by Chapman (1951) and described in Ricker (1975):

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

where: N = total population
M = total number of fish marked
C = total number of fish taken as census
R = total number of recaptured marks

Upper and lower confidence limits were obtained by taking the corresponding limits to the number of recaptures from a binomial (Poisson) distribution table, and entering them into the adjusted Petersen formula.

3.0 RESULTS AND DISCUSSION

3.1 ENUMERATION AND BIOLOGICAL EVALUATION

3.1.1 Strength, Composition and Timing of the Migration

A total of 3,107 Arctic char passed through the Cache Creek weir from August 13 to August 23, 1987. Daily catches increased from the first day of weir operation until a peak number of char were enumerated on August 17 (1,071) (Fig. 3). A decline in the daily count occurred thereafter and was still in progress when the weir collapsed.

External examination identified 95 char entering the weir as current year spawners. However, sexual classification of migrating char was difficult due to the lack of distinct secondary sexual characteristics on many of the female fish. Apparently the characteristic spawning colours and morphological changes are not fully evident on many of these fish until their arrival at "Fish Hole". Recovery of tags on the spawning grounds in September indicated that some current year spawners had been misidentified as silvers. Therefore, the enumeration of current year spawners is probably an underestimation of the actual number that passed through the weir.

A further 24 Arctic char captured were identified as a resident variety. These fish are apparently associated with the anadromous population but mature without undertaking a seaward migration (McCart 1980). McCart (1980) refers to this component of many western char populations as "residual".

The upstream migration of Arctic char in Cache Creek appeared to commence before installation of the weir on August 13. It is possible that early migrants included current year spawners as observed by Gillman and Sparling (1985) on the Rat River. Observations made in September on the spawning grounds at "Fish Hole" revealed the presence of a substantial number of large

mature char that had not been previously encountered downstream. Additionally, two fish tagged in 1984 and captured on the spawning grounds in 1987 had not been enumerated at the weir. This suggests that these fish either did not migrate or passed upstream before or after operation of the weir.

The capture of sexually mature Arctic char migrating upstream suggests there was some downstream movement of current year spawners during the summer. Whether any of these fish accompany the non-mature char (silvers) to the Beaufort Sea is unknown. However, examination of the domestic catch at the mouth of the Big Fish River by Gillman et al. (1985) and Sparling and Stewart (1986) revealed that the majority of fish captured were current year spawners (up to 95%). This indicates that a significant number of mature char in Cache Creek journey at least as far as the Mackenzie Delta during the summer prior to spawning. Griffiths et al. (1975) concluded that few potential spawners in the Firth River, Yukon Territory, left freshwater and entered the Beaufort Sea. Similarly it is unlikely that sexually mature char from the Big Fish River travel any farther than the Mackenzie Delta in the summer prior to spawning.

Glova and McCart (1974) observed that mature fish arrived in the upper Firth River approximately one month earlier than non-spawners. A similar early migration appears to occur in Cache Creek. A decline in the relative number of spawners in successive daily counts immediately after commencement of the enumeration (Fig. 4) suggests that many current year spawners may have passed upstream prior to installation of the weir. Declines in the daily average length (Table 1) and in the predominance of the 350-399mm length interval in the daily length-frequency distributions (Fig. 5) also indicate that the larger fish migrated earliest. When this early potion of the migration commences or to what degree immature and mature fish are involved could not be determined.

Catches from the hoopnet indicate fish were still migrating as late as September 2, but by this time daily numbers and size had declined significantly (Table 1). Proportional catches of residual char increased toward the end of August and by September 1 made up 60% of the total catch. On September 10 a reconnaissance flight by helicopter downstream of "Fish Hole" revealed few char, suggesting that the migration was complete by this date.

Round whitefish, Arctic grayling and broad whitefish were also encountered at the weir. Total daily counts of all fish caught and tagged are presented in Table 2.

Late installation and the collapse of the weir precluded a total count. Therefore, few inferences on fish numbers can be made from the weir data. However, it can be concluded that at least 3,107 Arctic char were involved in the upstream migration in Cache Creek during the summer of 1987. The run appeared to start before August 13 and was apparently complete by September 10.

3.1.2 Tagging

A total 597 Arctic char were tagged from August 13 to September 2. Of these, 28 were externally identified as current year spawners and 31 were classified as residual char. Tags were applied to 15% (465) of all arctic char entering the weir. An addition 132 char captured by hoopnet after loss of the weir were also tagged. A list of the date, location and length of each fish tagged is given in Appendix I.

3.1.3 Size, Age and Maturity

A calculated length-frequency distribution for the upstream migration of Arctic char passing through the Cache Creek weir is shown in Fig. 6. Modal length was 300-349 mm with a calculated mean length of 338 mm. Less than 2% of all char enumerated at the weir were greater than 450 mm in length. The maximum fork length recorded was 550 mm while the heaviest char had a round weight of 1575 g. A conversion factor for dressed weight to round weight of 1.23 was calculated from the dead sample.

The tendency for larger mature char to migrate upstream before smaller juvenile fish has been demonstrated in a number of studies (Andrews and Lear 1956; Bendock 1977 as cited [p.12] in McCart 1980; Glova and McCart 1974; Griffiths et al. 1975). Results have indicated that a similar pattern also occurs during the upstream migration in Cache Creek. Therefore, due to late installation and early removal of the weir it is presumable that many of the larger and smaller fish in the population were not included in the enumeration. The effect of the exclusion of these fish on the calculated average length is unknown. Similarly, the length-frequency distribution, while representative of the enumerated portion of the migration may not reflect the length frequency distribution of the entire stock. The modal length class is likely more prominent for those fish enumerated at the weir than it is for the entire population.

Anadromous Arctic char sampled from the Cache Creek weir had a mean age of six years and ranged from four to ten years in age. One three year old char was caught in a small mesh hoopnet but was apparently too small to be vulnerable to the weir. Therefore the degree to which three year old fish contributed to the migration is unknown. McCart (1980) states that char in the

western region most commonly migrate to sea for the first time at ages 3 to 4 years. This relatively early age at first seaward migration appears to be consistent in the Big Fish River char stock.

Based on visual observations made at "Fish Hole" it is the author's opinion that larger, older fish would have been encountered in Cache Creek had the weir been in operation at an earlier date. Sparling and Stewart (1986) sampled a number of fish ranging from 11 to 14 years of age from the Big Fish River domestic fishery in 1986. However, these fish accounted for only 4% of the total catch which suggests that a very low proportion of fish in the total stock are over 10 years of age. A short life expectancy is common in other populations west of the Mackenzie River where few fish live for over 12 years.

Sea-run char in Cache Creek were found to be mature as young as age five. This is comparable with the majority of other char populations in the region which in most cases do not mature until age five or older (McCart 1980). Mature char sampled from the Cache Creek weir averaged seven years of age and had a mean length of 398 mm (n=86). A length-frequency distribution of those fish identified as current year spawners is shown in Fig. 7. This is not necessarily representative of the size distribution of all spawners in Cache Creek due to the exclusion of early migrants from the enumeration.

The average length of residual char sampled was 252 mm (n=48). A length-frequency distribution for these fish is shown in Fig. 8. The range in age for residual char was 4 to 9 years with a mean of 5.4. McCart (1980) states that residual char in this region generally mature earlier than the anadromous form, some by age two and nearly all by age six. Residual fish sampled from Cache Creek were all mature by age 4 (n=9).

All residual char sampled (n=12) were mature males with the exception of one immature female. McCart (1980) states that virtually all of this component of the population tends to be male with females being extremely rare. He explains this by suggesting that small size, as a result of a resident life history, is not necessarily detrimental to males as they can still fertilize a portion of the eggs of anadromous females by acting as satellite males.

Residual fish accounted for only 1.5% of all Arctic char examined in 1987 and apparently make up a very low percentage of the Big Fish River Arctic char population.

3.1.4 Growth and Condition

A comparison of weight-length relationships calculated for the Big Fish River Arctic char population is shown in Table 3. The relationship obtained for 1987 possibly indicates that this was a relatively good year for growth as char weighed more at a given length than in the years represented by relationships calculated by McCart (1980) and Sparling and Stewart (1986).

Age data for both sexes are given in Table 4. Average length and range in length for each age of the stratified dead sample are illustrated in Fig. 9. As is common for Arctic char this relationship is loose. A comparison of growth rates with other char stocks is shown in Fig. 10. Populations west of the Mackenzie River (Firth River, Rat River, Big Fish River) display similar growth rates which are much faster between the ages of 4 and 6 than the eastern population at Nauyuk Lake. This is presumably due to their early age at first seaward migration giving them access to the abundant marine food resources of the Beaufort Sea. By age six, when eastern char start their first migrations to sea, growth rates of these stocks far exceed those of the western variety.

Figure 10 also illustrates the low length at age of Big Fish River Arctic char in comparison to other char in the western region. Reasons for this are unknown and need further investigation.

Two char captured during the summer of 1987 had tags which were applied by the D.F.O. in September of 1984. Recapture information, showing the change in fish length over the three year period, is summarized in Table 5. This data provides average growth rates for these fish of 1.7 cm/yr. (WB00241) and 2.6 cm/yr. (WB00348).

The condition of char captured at the weir in 1987 was generally good. Marks from gillnets and seals were found on only 3.9% of all fish examined whereas similar marks were found on 13.3% of the domestic catch in 1986 (Sparling & Stewart 1986). The average condition factor (K) for the stratified dead sample was relatively high at 1.25, and is possibly another indication that 1987 was a good year for growth. Mean condition factors for each age are given in Table 4.

3.1.5 Mortality

Instantaneous total mortality (Z) was calculated from the catch curve using ages 6 through 10 (Fig. 11). A value of .57 was obtained with an r value of .92. Mortality rates of this level are considered moderate and are common for rivers with a history of commercial and domestic fishing. This value is considerably less than those found for some of the commercially fished char stocks in the central Arctic (i.e. Ekalluk River, Z = .75 Kristofferson *et al.* 1982).

However, since this mortality figure is based on only that segment of the population captured at the weir, it should be considered with some caution.

Gillman et al. (1985) calculated a mortality rate of .70 using ages 8 through 11 from the domestic gillnet catch in 1983. This is likely a more accurate estimate of mortality for the Big Fish River Arctic char stock and indicates that this system has been heavily exploited in the past.

3.1.6 Fecundity

A summary of fecundity data collected from Cache Creek Arctic char is presented in Table 6. Average total egg count per female was relatively low at 2,186, and ranged from 1,500 to 2,963. Ovaries weighed an average of 10.1% of the total body weight. This value is similar to one found by Johnson (1980) for Nauyuk Lake char but lower than an 18.6% value determined by Glova & McCart (1974) for Firth River char. Egg size ranged from 2.8 mm in small char sampled in mid August to 5.2 mm in larger fish taken on the spawning grounds later in the month. The average egg size was 4.0 mm. These egg diameters are comparable to those found for other char stocks during August.

A comparison of fecundity data from a number of char studies conducted west of the Mackenzie Delta is shown in Table 7. The difference in values obtained for Cache Creek char between this study and those cited by McCart (1980) can be attributed to the size of fish collected in each sample. McCart (1980) presents data obtained from char with a mean length of 391mm while char sampled in 1987 averaged 435mm. Figure 12 shows the correlation between fecundity and fish length for anadromous Arctic char sampled from Cache Creek in 1987.

The relatively low fecundity values obtained for Cache Creek char are primarily due to the small size of spawners within the stock. However, there is some evidence from the fecundity-length relationships to indicate that Cache

Creek Arctic char are less fecund at a given length than char from other systems in the vicinity. Reasons for this deficiency are unknown and should be investigated further.

3.2 SCHAEFER STRATIFIED POPULATION ESTIMATE

A total of 308 Arctic char were captured in the hoopnet from August 15 to August 20, 1987. Of these, a total of 40 were recaptures of fish previously tagged at the weir (Appendix II). All tagged char took no more than two days to travel the 2.5 km upstream from the weir to the hoopnet, with the majority covering this span in less than 24 hours.

Population estimates work best when either complete random mixing or complete separation of strata occur during tagging and recovery (Ricker 1975). Therefore, greater accuracy in a stratified population estimate would be obtained if strata could be separated as much as possible, yet still allow for random mixing to occur within each stratum before recapture. Tag return data from the hoopnet indicated that the distance between capture mechanisms on Cache Creek permitted random mixing to occur within strata, yet allowed for most char to be recaptured within one day. In this case the stratified estimate approximates a sum of Petersen estimates on a daily basis. However, some mixing of strata still occurred as some char were recaptured up to two days later. Ricker (1975) states that it is in this situation, where a degree of distinctness occurs along with some intermingling, that the Schaefer method performs rather well.

Data were tabulated in Table 8 and total number of migrants estimated in Table 9. A total of 2303 char were calculated to have passed through the weir from August 13 to August 19. The actual count at the weir during this time was

2771. The underestimation of the actual migration can be attributed to the lack of recaptures of fish tagged on the first and last days of weir operation due to late installation and early removal of the hoopnet. Despite this, the Schaefer method was still 83% effective in estimating the actual run.

A variety of gear can be utilized in conducting a Schaefer estimate. Since only subsamples of a migration are required to be tagged and recovered, only partial spans of a river need to be blocked off. Depending on the nature of the river that is to be studied, gillnets, trap nets, partial span weirs, and hoopnets would all be adequate. However, maintaining the gear within a river still remains the single most significant obstacle in completing a Schaefer estimate. High water levels and increased water borne debris forced the removal of the Cache Creek hoopnet on August 20. Further difficulty in keeping the hoopnet in the water was encountered during the following week due to continual fluctuations in water levels. Subsequently, a complete estimate of the migration could not be accomplished.

Despite this, the difficulties in maintaining a full span weir for a direct enumeration far exceed those encountered while conducting a Schaefer estimate. The portability of the gear used for the Schaefer method allows for quick removal at times of high water and in most cases its relatively quick replacement once water levels have receded. Data could then be interpolated and a total estimate of a migration still obtained. This is much more practical than the complete loss of data due to the collapse of a full span weir. Locations for gear placement should be selected so that fluctuations in water levels would have minimal effects on the efficiency and maintenance of the sampling gear.

The major advantage of the Schaefer method is that it still provides information on the start, peak, daily strength, duration and magnitude of a migration yet is much more flexible in its application than is a direct count utilizing a full span weir. It is more cost effective in regard to capital expenditures, easier to transport, simpler to install, and not as dependent on the weather. The probability of successfully enumerating a run is greater and the accuracy of the estimate appears to be quite adequate for management purposes. This method would be extremely useful in situations where full span weirs are not practical such as in fast, deep, rocky rivers or on mountain streams that are subject to flooding. Therefore, due to the greater reliability and financial advantages, the Schaefer method should be given consideration as an alternative to a direct count in future enumerations of Arctic char migrations.

3.3 PETERSEN SINGLE CENSUS ESTIMATE

A total of 1,041 Arctic char were captured and released at "Fish Hole" from September 12 to September 16. Of these, 49 were recaptures of fish that had been previously tagged at the weir (Appendix III). Only two tagged char were captured twice, suggesting that a low percentage of fish were recaptured in successive seine hauls. The total catch consisted of 551 silvers, 414 current year spawners and 76 residual males.

In order to apply the Petersen method to estimate the anadromous char stock in the Big Fish River a number of conditions had to be met. It was assumed that: 1) marked and unmarked fish suffered the same mortality; 2) there was no loss of tags; 3) all tags were recognized and 4) there was no recruitment. Seining downstream of the first riffle in the braided area yielded

no Arctic char and further investigation by helicopter on September 16 did not reveal any char outside the sampling area. Thus, it was assumed that all char in the population were at "Fish Hole" and all were vulnerable to capture.

Upon analysis of the results it was discovered that two essential conditions for a valid Petersen estimate had not been met. Data revealed that the char were: 1) not randomly distributed at "Fish Hole" and as a result 2) not equally vulnerable to the seine. Current year spawners were widely distributed throughout the canyon area below the falls and possibly were already defending spawning territories when sampling commenced. The majority of silvers were more concentrated in their distribution and primarily occupied just two areas: 1) a riffle below the falls and 2) a braided area below the canyon. Virtually all residual males were caught outside the canyon, presumably due to their avoidance of the aggressive territorial behaviour of anadromous males on the spawning grounds. Table 10 shows the locations where char were caught with respect to their sexual maturity.

Seining effort was equally applied throughout the "Fish Hole" area. This created a bias toward the capture of current year spawners due to their diffuse distribution throughout the canyon. In addition, the reluctance of these fish to move away from preselected spawning territories likely made them even more susceptible to the seine. Subsequently, the number of current year spawners caught in relation to silvers was not truly representative of the population. A Petersen estimate performed on the entire sample would not be valid as there was a smaller proportion of tagged to untagged current year spawners than there was tagged to untagged silvers. In this situation fewer tags are recaptured than if the population was randomly distributed, and an over estimation of the population occurs.

To alleviate this sampling error a Petersen estimate was performed on current year spawners and silvers separately. In both cases fish become randomly mixed and equally vulnerable to capture within their own group and subsequently all conditions for conducting valid Petersen estimates can be met. Residual char tag returns were insufficient to allow for their inclusion in the estimate.

Of the 11 tagged current year spawners recaptured at "Fish Hole", 4 had been previously misidentified as silvers at the weir. Therefore, to obtain the most valid Petersen estimate for spawners using the available data, only the positively identified marked and recaptured char were used in the calculation. This left a recapture value of 7 from a total number marked of 28. The resulting estimate for current year spawners is 1504 with 95% confidence limits of 781 and 3167 (Appendix IV).

When applying the Petersen estimate to the non-spawning portion of the population, the 4 misidentified spawners were also excluded from the total number of silvers marked. This left a total of 38 positively identified recaptures from 534 marked fish. The resulting estimate for silvers is 7572 with 95% confidence limits of 5551 and 10623 (Appendix IV). This number might be somewhat of an overestimation as it is possible that more than four silvers could have been misidentified.

Combining the two estimates for silvers and spawners yields a total population estimate for anadromous char in the Big Fish River of 9076. This figure applies only to fish larger than 200 mm in length as smaller fish were not vulnerable to either the weir or the seine.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Comparing the 1987 population estimate to a previous Petersen estimate conducted by Stein et al. (1973) in 1972 (12,000-17,000 char), it is evident that the Arctic char population in the Big Fish River has declined from 25% to 50% over the last 15 years.

Little is known about how heavily exploited char stocks in this region will respond to a sudden withdrawal of fishing pressure. However, despite low fecundity and low numbers the potential appears to exist for a relatively quick recovery. The Petersen estimate in 1987 revealed that as much as 17% of the total population in the Big Fish River consists of current year spawners. Johnson (1980) found that only 2% of the total stock in Nauyuk Lake spawned in any given year, but also determined that 29% of the females in length classes known to spawn did so. Therefore the high percentage of spawners in the Big Fish River Arctic char stock should not be altogether unexpected considering their early age at maturity and short life expectancy. In any given year there are only five to six year classes including the modal length group that are capable of spawning. If each consisted of 29% current year spawners the total proportion of spawners in the entire population would be relatively high compared to stocks in the eastern Arctic where life expectancy and age at maturity are much higher.

The closure of the Big Fish River to all fishing in 1987 is the first significant step in leading to the recovery of this stock. Further fishing activity should be severely restricted until a better understanding can be obtained of the biology and population dynamics of char stocks in this region.

Future investigation would be useful to determine:

1) the accuracy of previous population estimates
2) the extent of the early migration of current year spawners
3) the effect of the fishery closure in recovery of the stock
4) distribution of the stock during the summer migration
5) the relationship between exploitation rate and stock status
6) reasons for the low fecundity and slow growth pattern of the Big Fish River Arctic char stock

Due to the extreme difficulty of maintaining a conduit weir on mountain streams, it is recommended that further studies in this area utilize the Schaefer method to estimate stratified Arctic char populations. It is evident from this study that this method is more reliable and cost effective than a conduit weir and produces results that are adequate for management purposes.

5.0 ACKNOWLEDGMENTS

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Table 1. Daily mean length of Arctic char sampled at the weir location on Cache Creek from August 13 to September 2, 1987.

Date	Gear	N	Mean Length (mm)	Standard Deviation	Total Daily Count
August 13	Weir	29	371	50	30
August 14	Weir	106	358	44	106
August 15	Weir	113	344	39	264
August 16	Weir	119	334	37	397
August 17	Weir	119	341	49	1071
August 18	Weir	104	340	41	589
August 19	Weir	107	336	42	373
August 20	Weir	37	323	28	38
August 22	Weir	102	316	28	136
August 23	Weir	103	318	38	103
August 25	Hoopnet	31	329	26	-
August 26	Hoopnet	21	319	27	-
August 27	Hoopnet	52	312	48	-
August 28	Hoopnet	10	319	19	-
August 31	Hoopnet	1	311		-
September 1	Hoopnet	10	264	38	-
September 2	Hoopnet	10	269	44	-

Table 2. Daily counts of fish passing through the Cache Creek weir from August 13 to August 23, 1987. Brackets indicate numbers tagged.

Date	Arctic char	Arctic grayling	Round whitefish	Broad whitefish
August 13	30 (28)	30	11	2
14	106 (50)	38	35	-
15	264 (51)	28	-	-
16	397 (50)	32	6	-
17	1071 (50)	22	3	-
18	589 (50)	10	5	-
19	373 (50)	6	1	1
20*	38 (36)	-	-	-
21**	-	-	-	-
22#	136 (50)	13	4	-
23+	103 (50)	26	5	-
Total	3107 (465)	205	70	3

* = partial count
** = no count - weir not operational
\# = 1/2 day count
\+ = 2/3 day count

Table 3. Comparison of weight-length relationships calculated for the Big Fish River Arctic char stock.

Weight-Length Equation	r	Source
$Log_{10}W = -5.22 + 3.12\ (Log_{10}L)$	.96	1987 weir data
$Log_{10}W = -4.19 + 2.69\ (Log_{10}L)$	.92	McCart (1980)
$Log_{10}W = -4.35 + 2.77\ (Log_{10}L)$	.96	Sparling and Stewart (1986)

Table 4. Mean fork length, round weight and condition factor by age and sex for the stratified dead sample of Arctic char from Cache Creek, 1987.

AGE (YR)	MALES							FEMALES							COMBINED						
		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%		LENGTH(MM)		WEIGHT(G)			%
	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT	N	MEAN	SD	MEAN	SD	K	MAT
3	-	-	-	-	-	-	-	1	135	-	60	-	-	0	1	135	-	60	-	-	0
4	3	203	45.2	100	75	0.99	67	4	270	36.2	269	97	1.31	0	7	241	51.1	196	121	1.18	29
5	5	263	56.2	225	188	1.07	80	8	330	42.6	522	230	1.38	13	13	304	57.0	408	255	1.26	38
6	9	359	49.2	664	293	1.33	44	7	338	51.8	543	262	1.31	29	16	350	49.7	611	278	1.32	38
7	3	398	62.4	908	364	1.39	67	7	415	34.2	836	174	1.16	86	10	410	41.4	858	226	1.23	80
8	2	459	25.5	1338	301	1.37	0	3	462	89.0	1133	425	1.14	100	5	461	64.3	1215	354	1.23	60
9	1	245	-	125	-	0.85	100	-	-	-	-	-	-	-	1	245	-	125	-	0.85	100
10	-	-	-	-	-	-	-	2	477	26.2	1388	124	1.28	50	2	477	26.2	1388	124	1.28	50
TOTAL	23							32							55						
MEAN		326	90	562	440	1.22			358	86.2	660	382	1.28			345	88.3	619	406	1.25	
MEAN AGE	6.0																				

Table 5. Summary of 1984 Arctic char tag recaptures from Cache Creek, 1987.

1984 D.F.O. Tag #	Location Caught	Date Caught	Date Tagged by D.F.O.	1987 Length (mm)	1984 Length (mm) as recorded by D.F.O.	Remarks
WB00241	Cache Creek Weir	Aug 17, 1987	Sept.4, 1984	550	500	Current year (1987) female spawner
WB00348	Cache Creek "Fish Hole"	Sept.16, 1987	Sept.6, 1984	485	408	Current year (1987) female spawner

Table 6. Synopsis of fecundity data obtained from 19 dead sampled Arctic char from Cache Creek, 1987.

	Mean	Range
Fish Length (mm)	435	372 - 550
Ovary Weight (g)	102.6	28.6 - 237.6
Egg Diameter (mm)	4.0	2.8 - 5.2
Egg Count	2186	1500 - 2963

Table 7. A comparison of the fecundity of the Cache Creek Arctic char stock to three other char stocks in the western arctic.

Location	N	Mean Length	Fecundity Mean	Fecundity Range	Fecundity-length Relationship	r
Sagavanirktok River[1]	66	449	2670	2100-5500	$Log_{10}F=2.03\ Log_{10}L-1.91$	.70
Firth River[2]	20	530	4955		$Log_{10}F=2.82\ Log_{10}L-4.01$	.84
Rat River[3]	27	-	3463	1700-5100	$Log_{10}F=1.74\ Log_{10}L-1.12$	.69
Cache Creek[4]	7	391	1493	1120-2120	$Log_{10}F=3.07\ Log_{10}L-4.80$	.76
Cache Creek[5]	19	435	2186	1500-2963	$Log_{10}F=1.67\ Log_{10}L-1.08$	.75

[1] McCart et al. (1972) as cited [on p.88] in McCart (1980).
[2] Glova and McCart (1974).
[3] Bain (1974) as cited [on p.88] in McCart (1980).
[4] McCart (1980).
[5] 1987 Cache Creek data.

Table 8. Recoveries of Arctic char tagged in successive days from the Cache Creek weir (Ri), divided according to recovery upstream in the hoopnet (R.j); together with the total number tagged each day (Mi) and the number captured and examined for tags (C.j).

Day of Recovery	Day of Tagging							R.j	C.j	C.j/R.j
	13	14	15	16	17	18	19			
15	2	2	3					7	17	2.4
16			2	6				8	32	4.0
17				3	1			4	9	2.3
18					8	4		12	110	9.2
19					2	3	1	6	103	17.2
20							3	3	36	12.0
Ri	2	2	5	9	11	7	4			
Mi	28	50	51	50	50	50	50			
Mi/Ri	14.0	25.0	10.2	5.6	4.5	7.1	12.5			

Table 9. Computed estimates of Arctic char migrating up Cache Creek from August 13 to August 19, 1987 using Schaefer's method.

Day of Recovery	Day of Tagging							Total
	13	14	15	16	17	18	19	
15	67	120	73					260
16			82	134				216
17				39	10			49
18					331	261		592
19					155	366	215	736
20							450	450
Total	67	120	155	173	496	627	665	2303

Table 10. Number of Arctic char, divided according to sexual maturity and location caught, that were examined for tags during the Petersen estimate census conducted at "Fish Hole" on Cache Creek from September 12 to September 16, 1987.

Location	Silvers	Spawners	Residual Males
Braided Area	264 (19)	45	74
Canyon Area Below Cabin*	63 (2)	140 (5)	-
Canyon Area Above Cabin*	224 (17)	229 (6)	2
Totals	551 (38)	414 (11)	76

( ) = Tagged fish included in total count.
* = Cabin is located halfway between the Falls and the braided area.

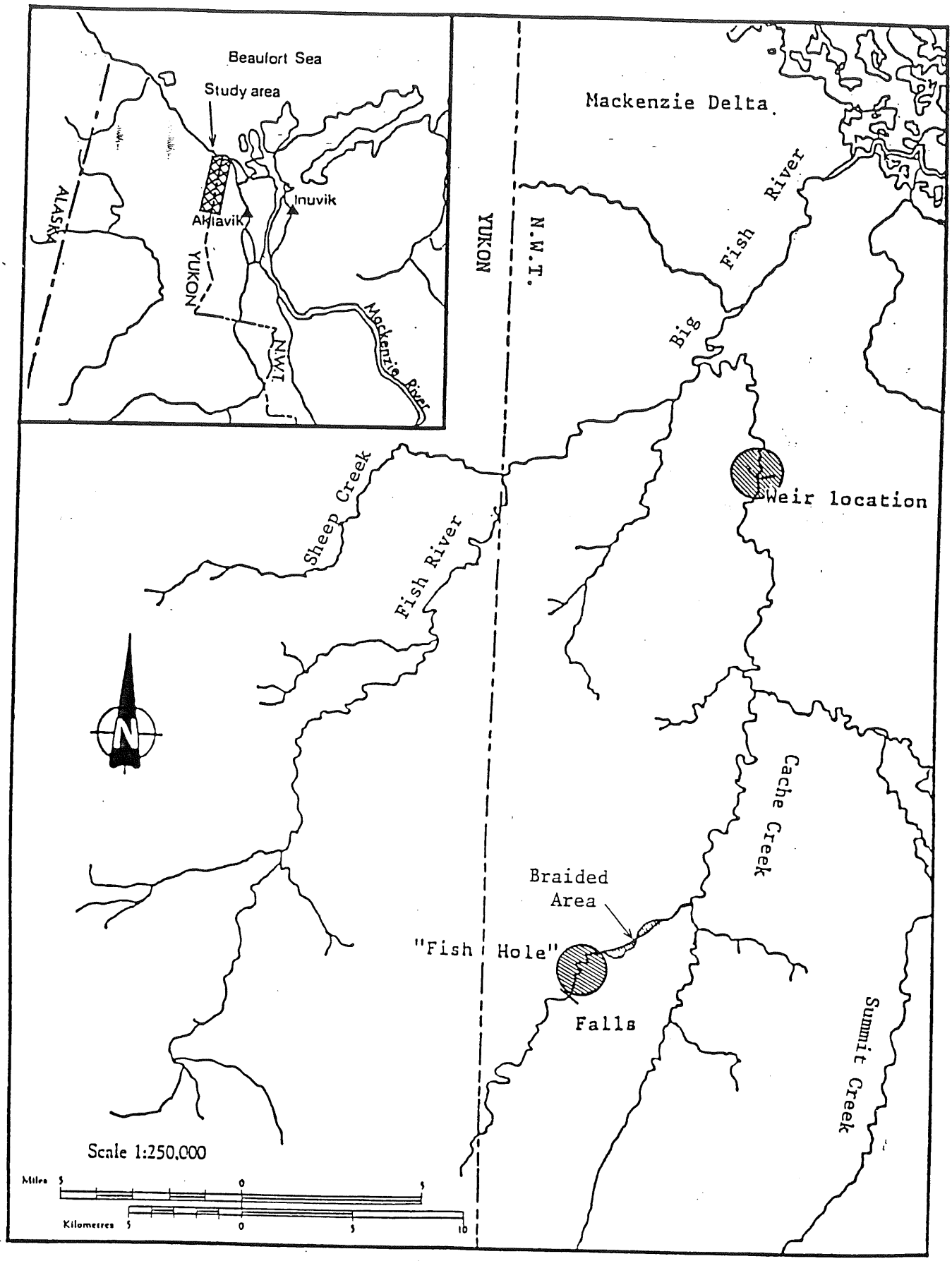


Fig. 1. Map of the Big Fish River drainage showing the 1987 weir location and the "Fish Hole" area of Cache Creek.

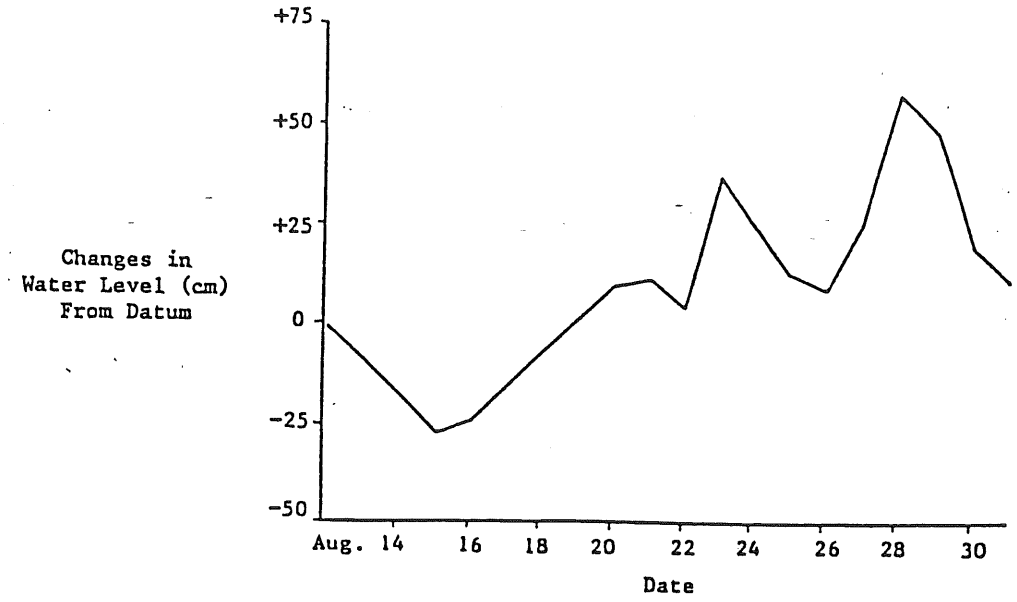


Fig. 2. Changes in water level by day at the Cache Creek weir location from August 13 to August 31, 1987.

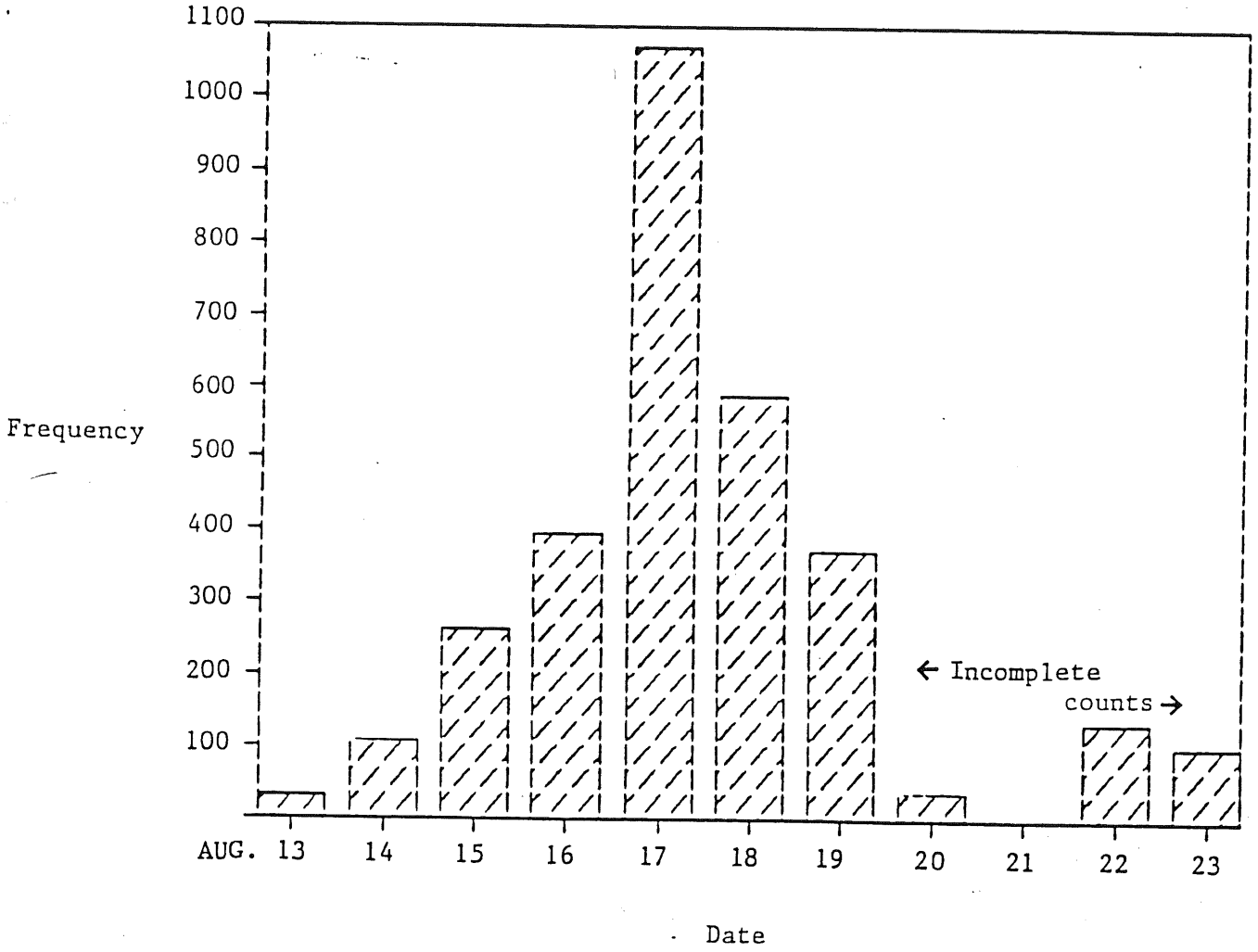


Fig. 3. Daily counts of Arctic char passing through the Cache Creek weir from August 13 to August 23, 1987. Daily counts for August 20-23 are incomplete due to high water levels causing interruptions to weir operation.

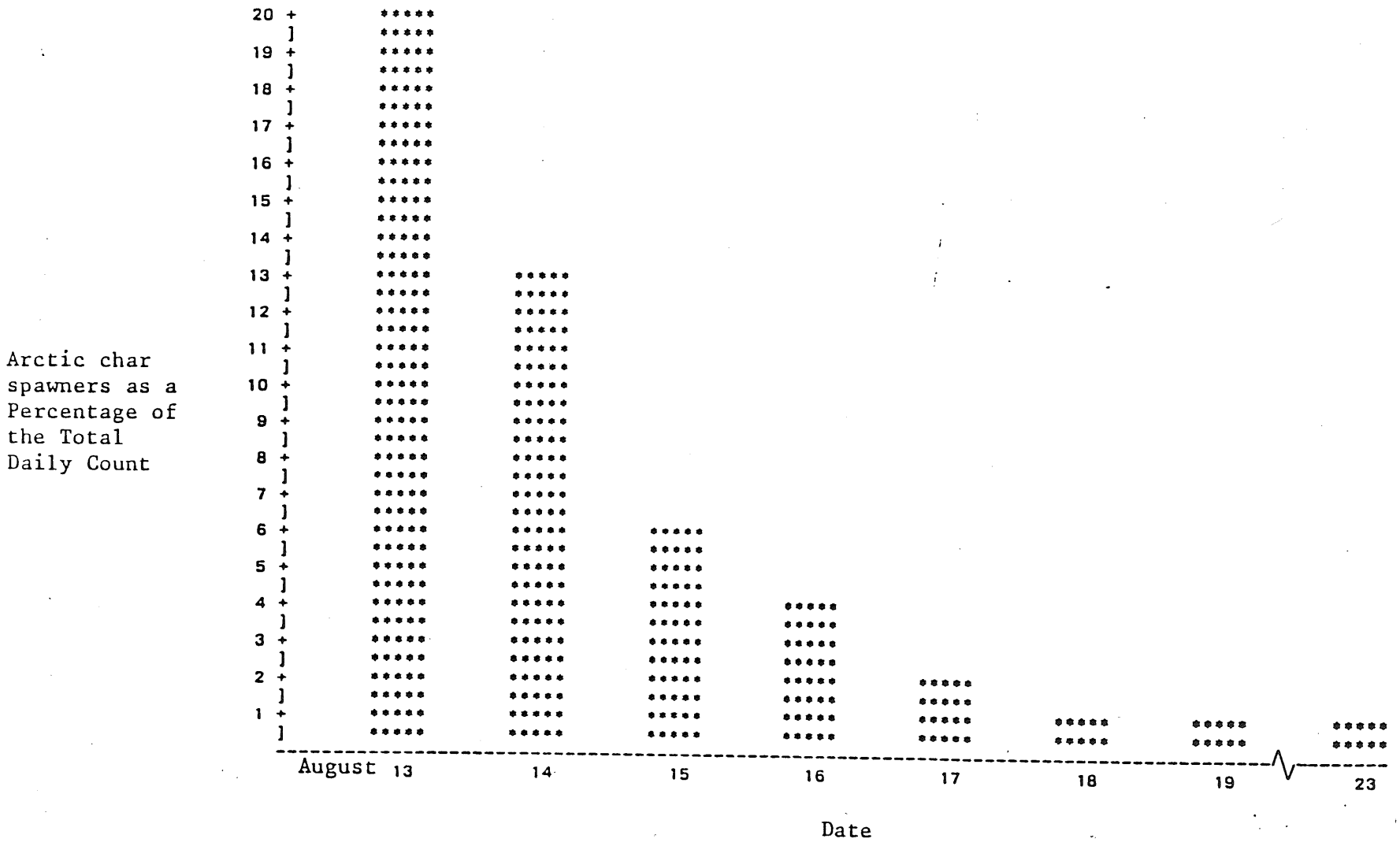


Fig. 4. The percentage of each daily count at the Cache Creek weir that consisted of externally identified current year spawners, from August 13 to August 23, 1987.

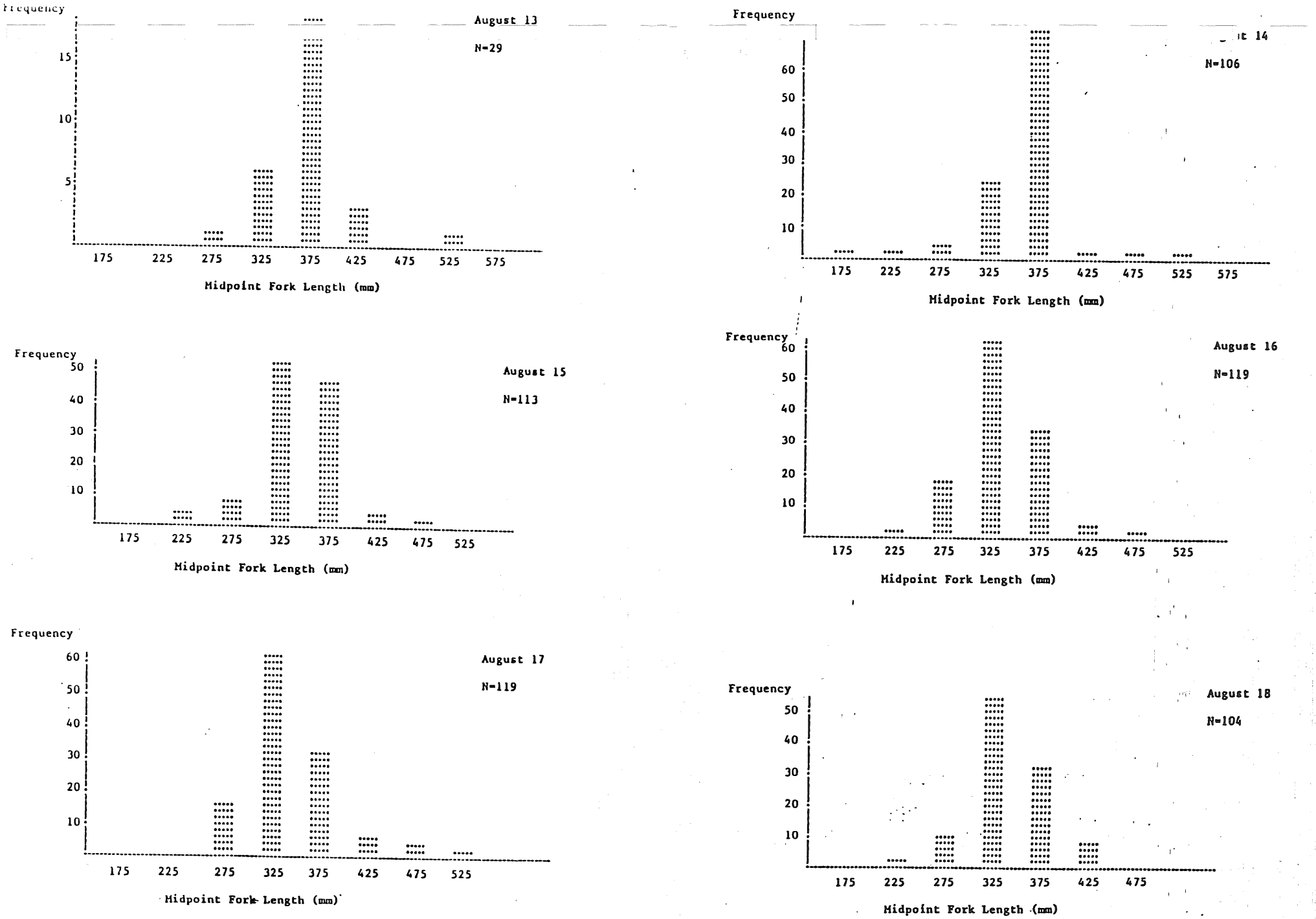
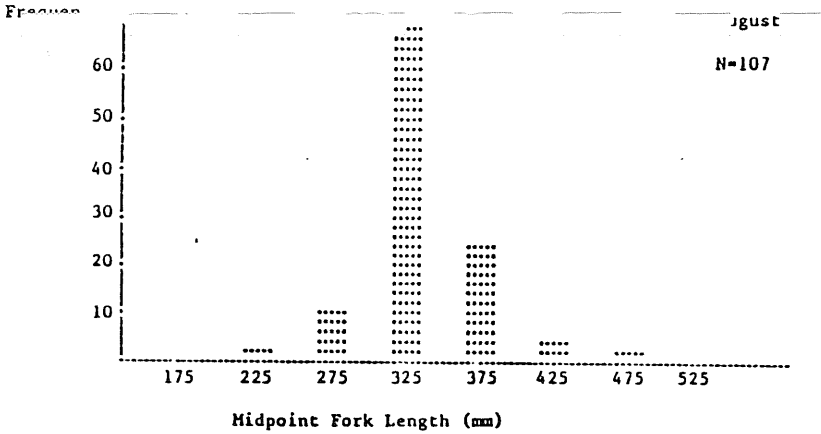
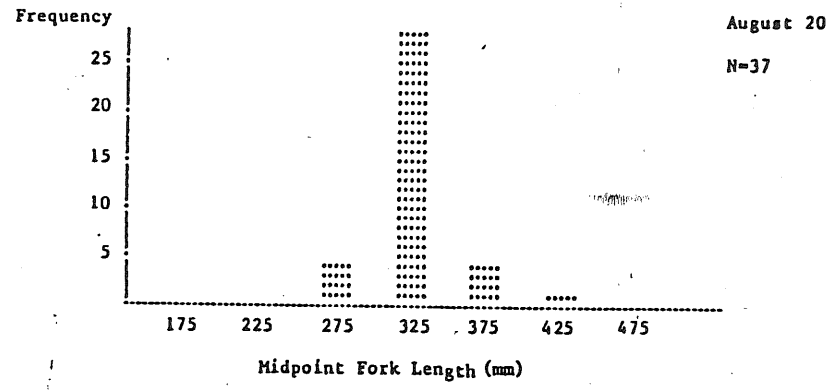
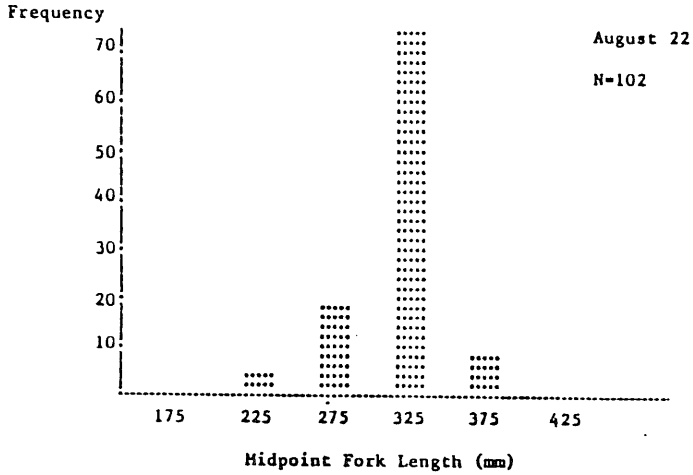
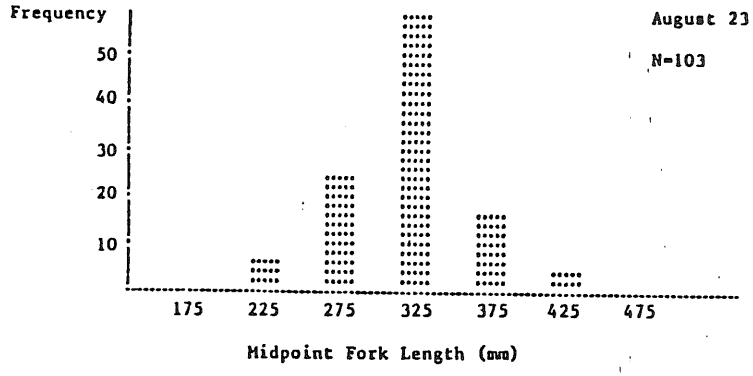


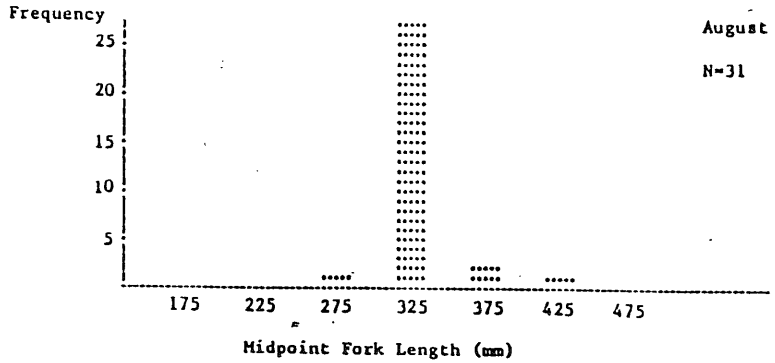
Fig. 5. Daily length-frequency distributions of sampled Arctic char migrating up Cache Creek from August 13 to September 2, 1987.











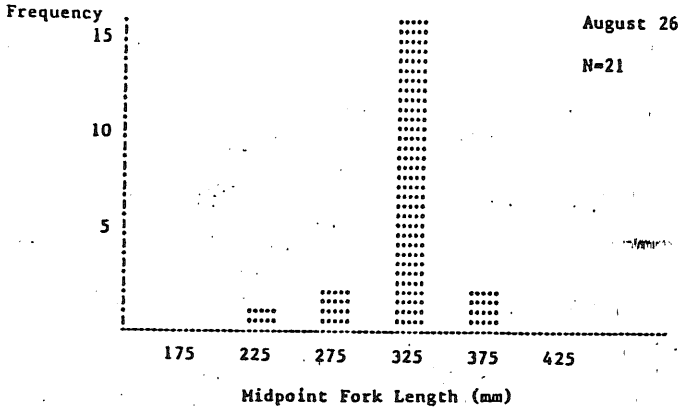
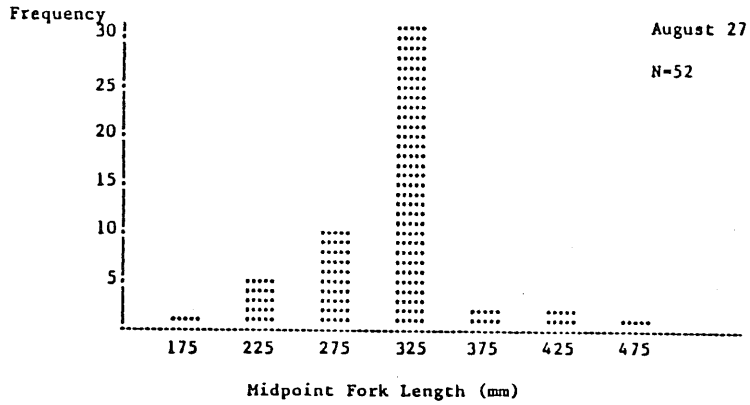
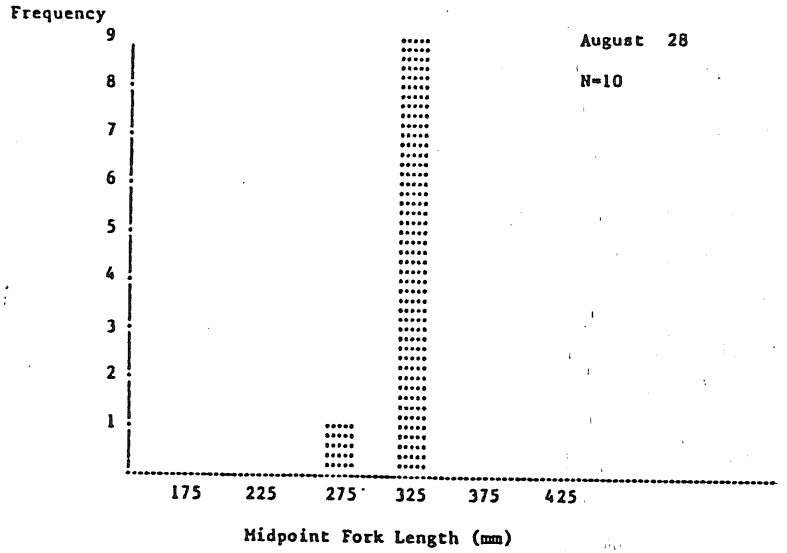
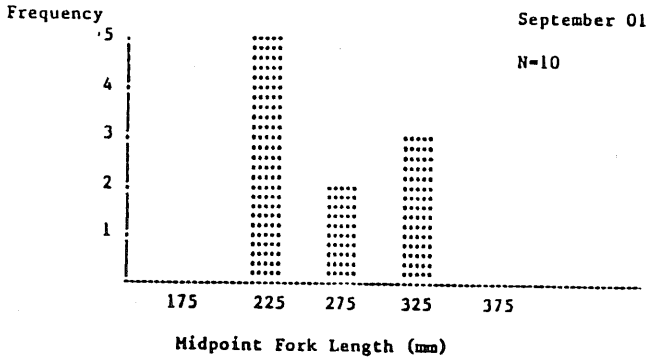


Fig. 5. Continued.







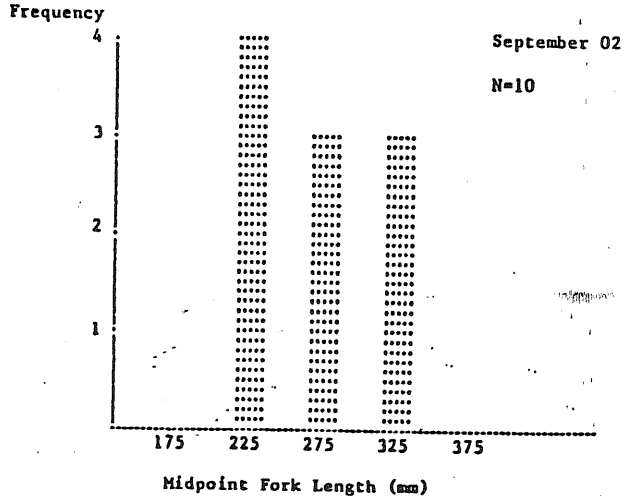


Fig. 5. Continued.

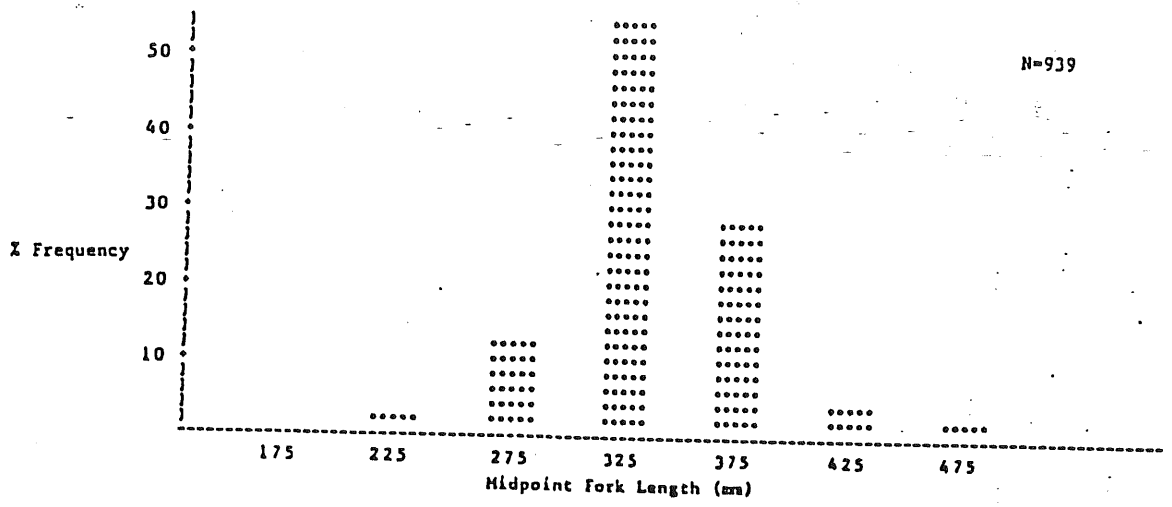


Fig. 6. Calculated length-frequency distribution of all Arctic char passing through the Cache Creek weir from August 13 to August 23, 1987.

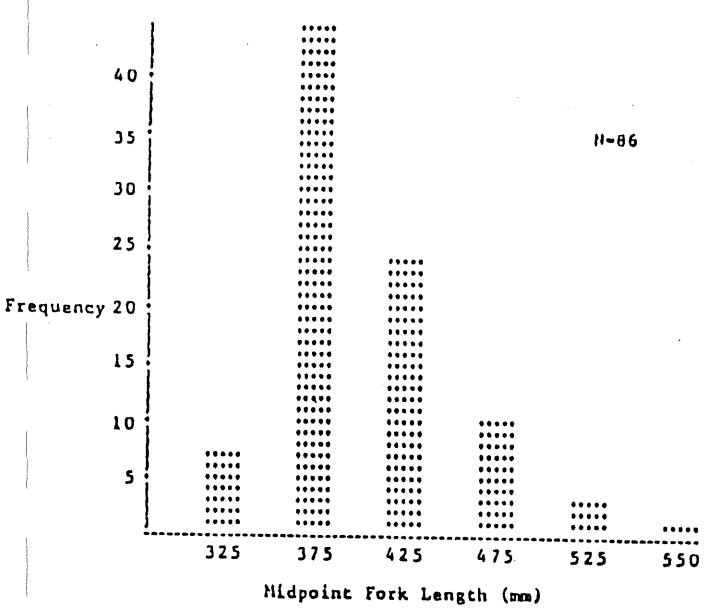


Fig. 7. Length-frequency distribution of the anadramous current year spawners sampled at the Cache Creek weir from August 13 to August 23, 1987.

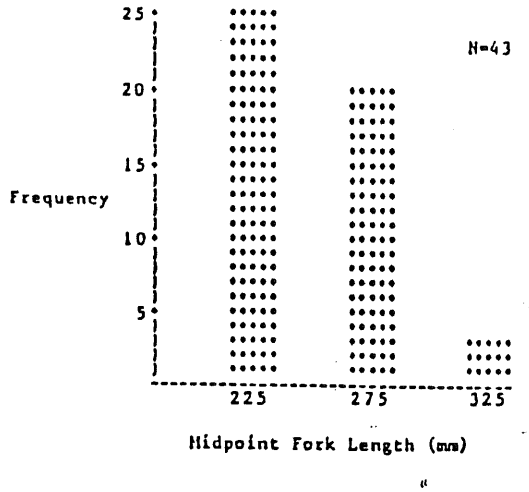


Fig. 8. Length-frequency distribution of residual char sampled at Cache Creek from August 13 to September 2, 1987.

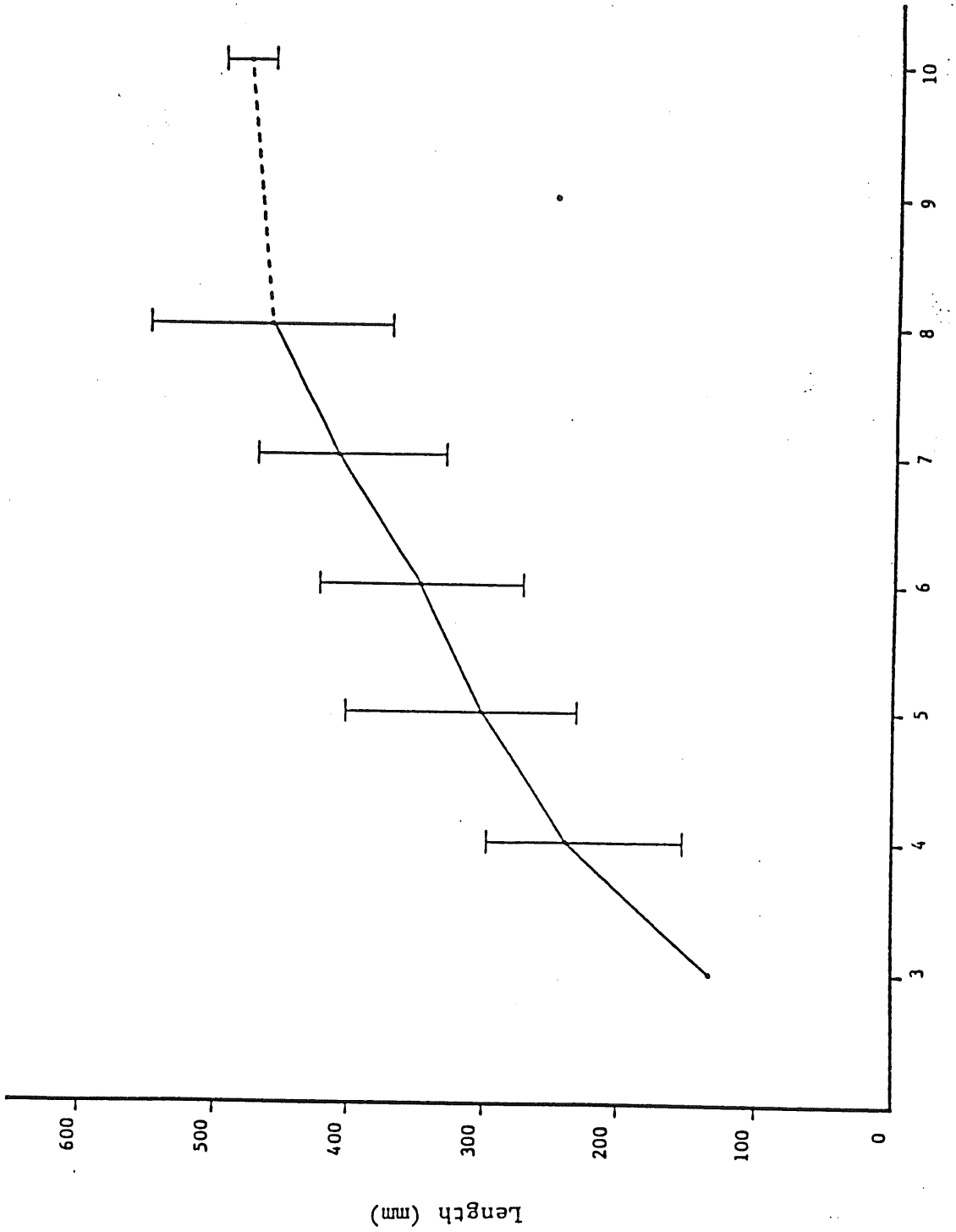


Fig. 9. Mean length at age for Arctic char sampled from the Cache Creek weir, 1987. Bar indicates range of lengths obtained for each age.

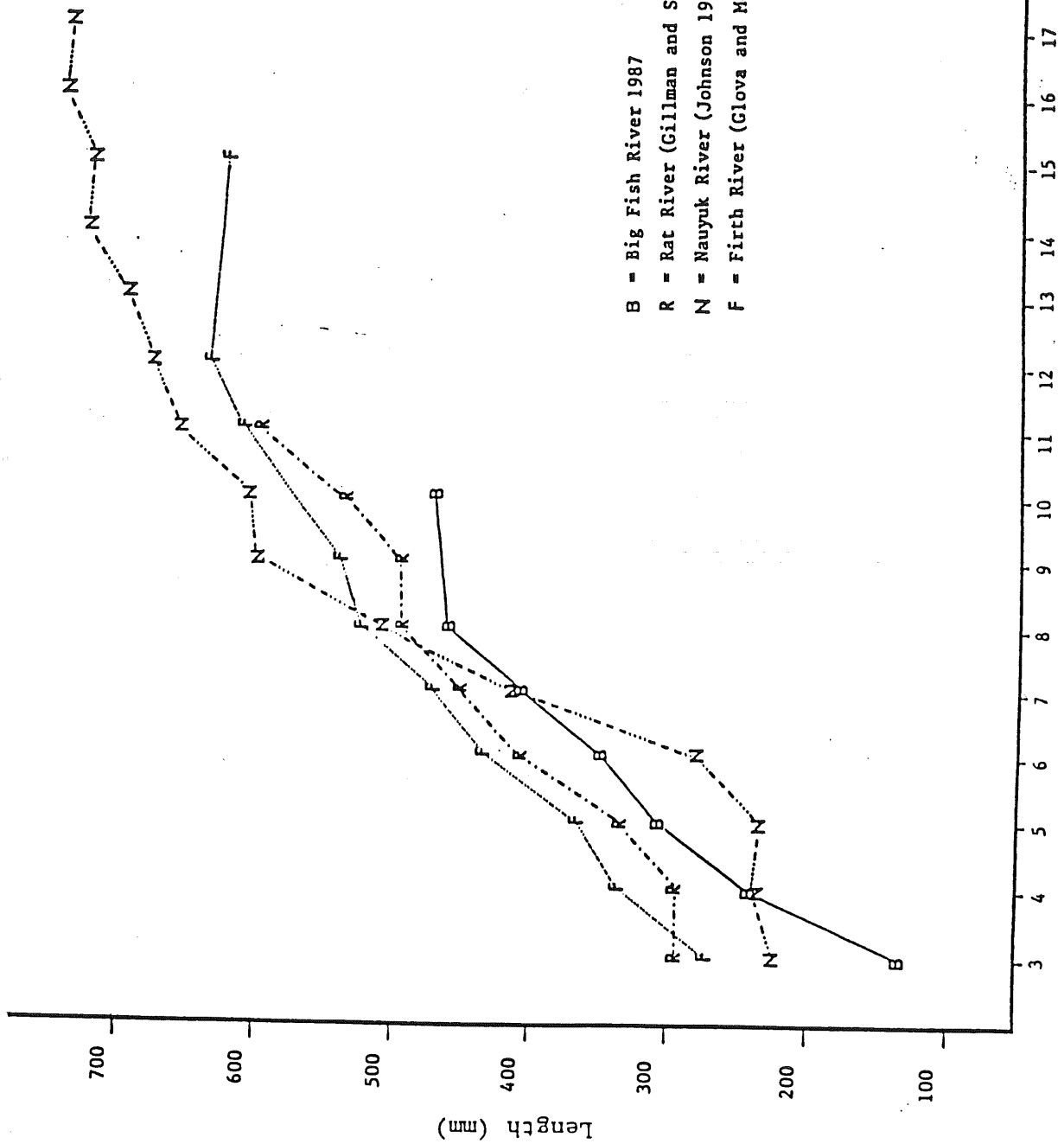


Fig. 10. Comparison of the growth rate of Arctic char from the Big Fish River with those of Arctic char from three other locations.

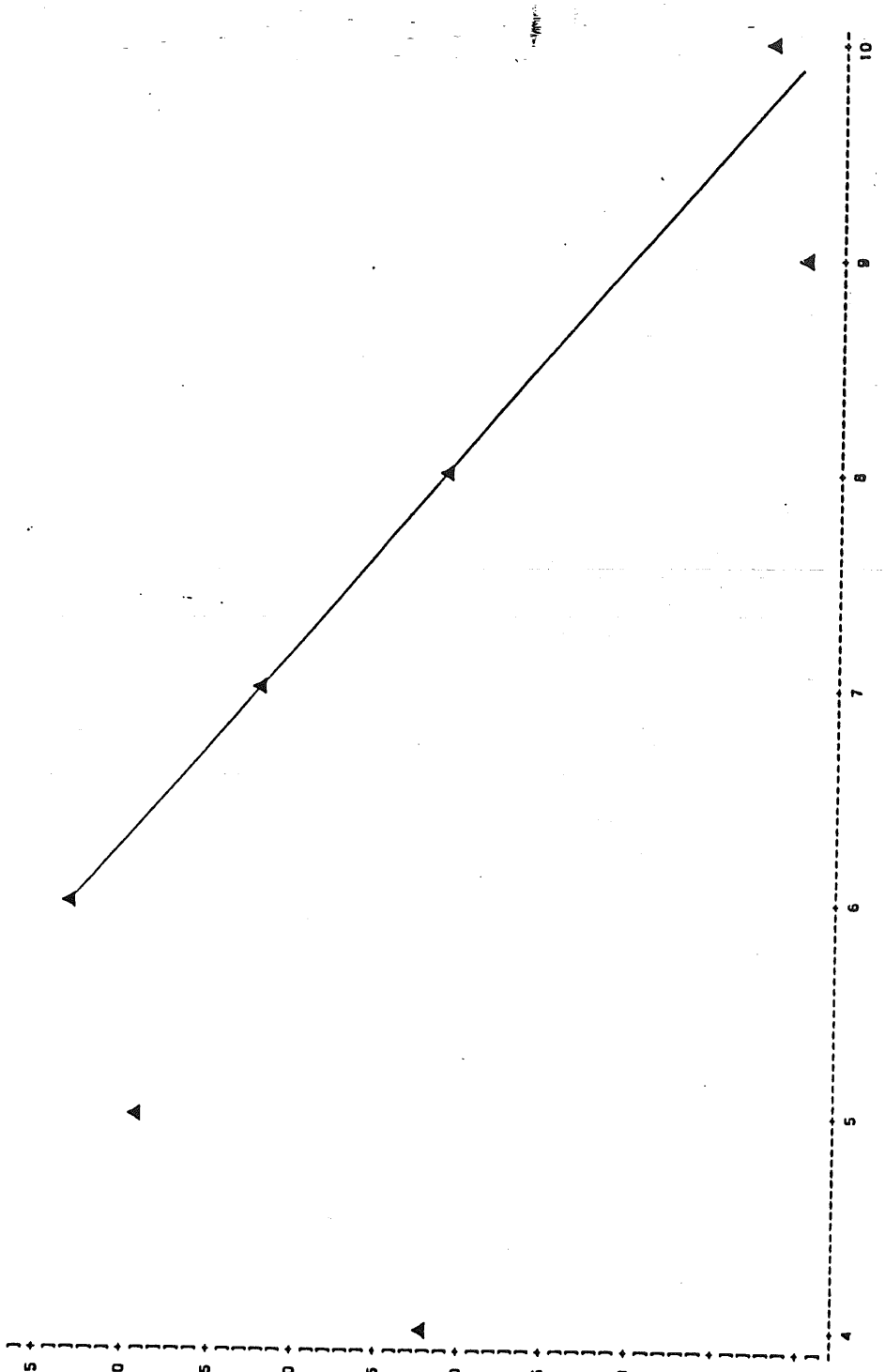


Fig. 11. Calculated catch curve used to estimate instantaneous total mortality (Z) of the Big Fish River Arctic char population.

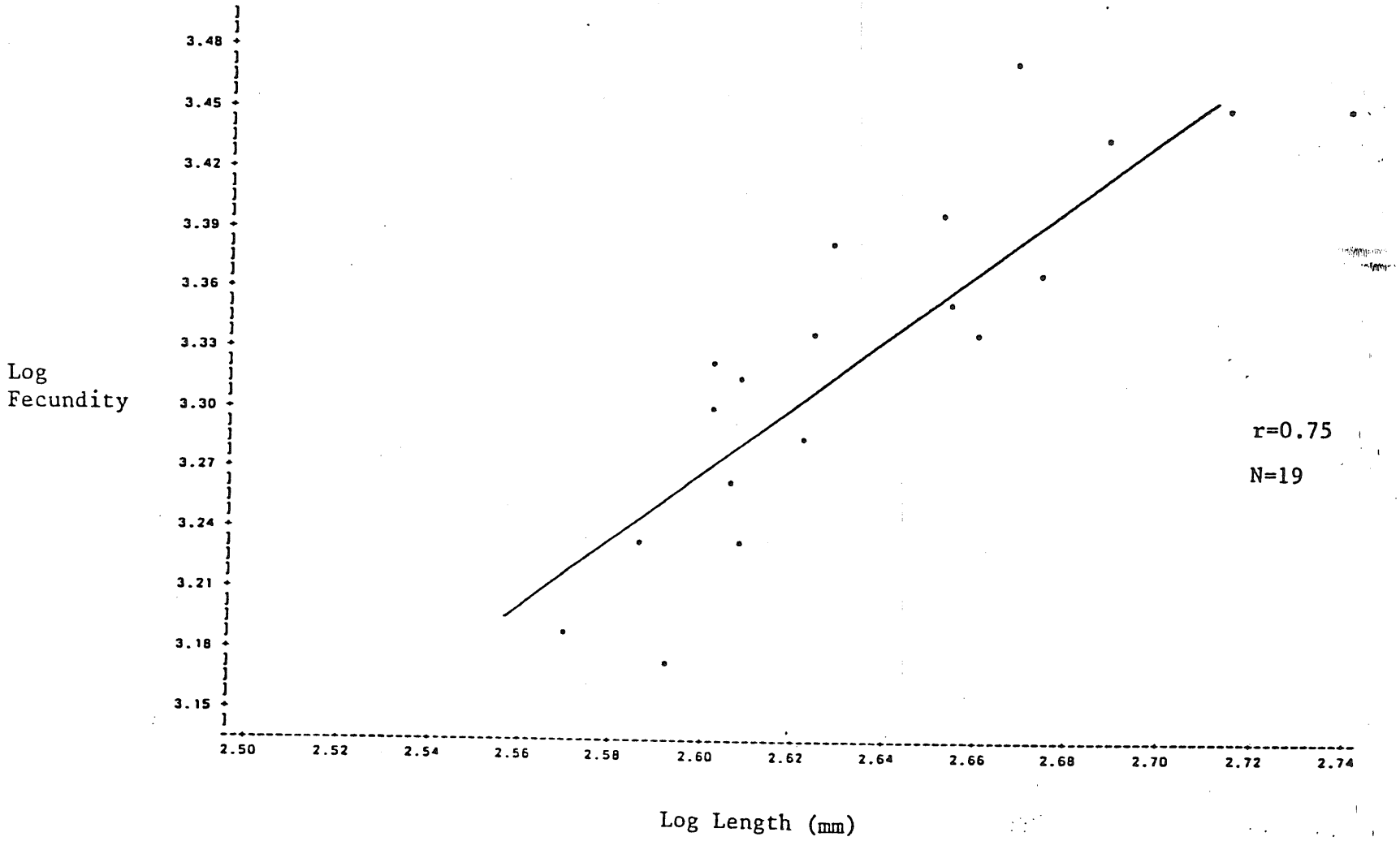


Fig. 12. The relationship between fecundity and fish length for Arctic char from Cache Creek, 1987.

APPENDIX I

List of the fish tagged on Cache Creek between August 13 and September 2, 1987

Appendix I.

Blue Tag Number	Date	Length (mm)	Remarks
62001	Aug.13'87	395	
62002	Aug.13'87	348	
62003	Aug.13'87	301	
62004	Aug.13'87	344	spawner
62005	Aug.13'87	427	spawner
62006	Aug.13'87	364	spawner
62007	Aug.13'87	360	
62008	Aug.13'87	400	spawner
62009	Aug.13'87	378	
62010	Aug.13'87	362	
62011	Aug.13'87	365	
62012	Aug.13'87	355	
62013	Aug.13'87	258	
62014	Aug.13'87	378	
62015	Aug.13'87	378	
62016	Aug.13'87	370	scarred
62017	Aug.13'87	346	
62018	Aug.13'87	367	
62019	Aug.13'87	430	scarred
62020	Aug.13'87	549	spawner
62021	Aug.13'87	323	
62022	Aug.13'87	360	
62023	Aug.13'87	386	spawner
62024	Aug.13'87	306	
62025	Aug.13'87	359	
62026	Aug.13'87	360	
62027	Aug.13'87	400	
62028	Aug.13'87	385	scarred
62029	Aug.14'87	317	
62030	Aug.14'87	398	
62031	Aug.14'87	357	
62032	Aug.14'87	393	spawner
62033	Aug.14'87	391	
62034	Aug.14'87	314	
62035	Aug.14'87	368	
62036	Aug.14'87	363	
62037	Aug.14'87	385	
62038	Aug.14'87	367	
62039	Aug.14'87	386	
62040	Aug.14'87	383	
62041	Aug.14'87	296	
62042	Aug.14'87	375	
62043	Aug.14'87	355	
62044	Aug.14'87	360	scarred
62045	Aug.14'87	387	

Blue Tag Number	Date	Length (mm)	Remarks
62047	Aug.14'87	379	
62048	Aug.14'87	353	
62049	Aug.14'87	340	gillnet marks
62050	Aug.14'87	404	spawner
62051	Aug.14'87	356	spawner
62052	Aug.14'87	315	
62053	Aug.14'87	359	
62054	Aug.14'87	387	
62055	Aug.14'87	373	
62056	Aug.14'87	350	
62057	Aug.14'87	365	
62058	Aug.14'87	368	
62059	Aug.14'87	365	
62060	Aug.14'87	364	
62061	Aug.14'87	360	spawner
62062	Aug.14'87	359	
62063	Aug.14'87	398	spawner
62064	Aug.14'87	368	
62065	Aug.14'87	346	scarred
62066	Aug.14'87	355	
62067	Aug.14'87	366	
62068	Aug.14'87	400	
62069	Aug.14'87	307	
62070	Aug.14'87	367	
62071	Aug.14'87	371	
62072	Aug.14'87	378	scarred
62073	Aug.14'87	543	caudal scar-spawner
62074	Aug.14'87	311	
62075	Aug.14'87	374	
62076	Aug.14'87	312	
62077	Aug.14'87	375	
62078	Aug.14'87	390	
62079	Aug.14'87	384	
62080	Aug.15'87	367	
62081	Aug.15'87	340	
62082	Aug.15'87	360	
62083	Aug.15'87	455	lateral scar-spawner
62084	Aug.15'87	373	
62085	Aug.15'87	352	
62086	Aug.15'87	390	spawner
62087	Aug.15'87	348	
62088	Aug.15'87	375	lateral scar-spawner
62089	Aug.15'87	379	spawner
62090	Aug.15'87	335	

Blue Tag Number	Date	Length (mm)	Remarks
62091	Aug.15'87	322	
62092	Aug.15'87	413	spawner
62093	Aug.15'87	359	
62094	Aug.15'87	349	
62095	Aug.15'87	346	spawner
62096	Aug.15'87	352	lateral scar-spawner
62097	Aug.15'87	375	
62098	Aug.15'87	360	scarred-spawner
62099	Aug.15'87	360	
62100	Aug.15'87	268	resident
62101	Aug.15'87	341	lateral scar
62102	Aug.15'87	365	scarred
62103	Aug.15'87	307	
62104	Aug.15'87	375	
62105	Aug.15'87	368	
62106	Aug.15'87	366	
62107	Aug.15'87	384	lateral scar
62108	Aug.15'87	391	
62109	Aug.15'87	350	
62110	Aug.15'87	372	spawner
62111	Aug.15'87	343	
62112	Aug.15'87	310	
62113	Aug.15'87	356	
62114	Aug.15'87	390	
62115	Aug.15'87	306	
62116	Aug.15'87	335	
62117	Aug.15'87	320	
62118	Aug.15'87	395	
62119	Aug.15'87	326	
62120	Aug.15'87	359	
62121	Aug.15'87	342	
62122	Aug.15'87	394	
62123	Aug.15'87	359	
62124	Aug.15'87	312	
62125	Aug.15'87	291	
62126	Aug.15'87	348	
62127	Aug.15'87	347	
62128	Aug.15'87	325	
62129	Aug.15'87	378	
62130	Aug.15'87	376	
62131	Aug.16'87	308	
62132	Aug.16'87	300	

Blue Tag Number	Date	Length (mm)	Remarks
62133	Aug. 16'87	295	
62134	Aug. 16'87	384	
62135	Aug. 16'87	274	lateral scar
62136	Aug. 16'87	390	
62137	Aug. 16'87	360	
62138	Aug. 16'87	395	
62139	Aug. 16'87	383	
62140	Aug. 16'87	372	
62141	Aug. 16'87	301	
62142	Aug. 16'87	365	
62143	Aug. 16'87	292	
62144	Aug. 16'87	391	
62145	Aug. 16'87	289	
62146	Aug. 16'87	344	
62147	Aug. 16'87	403	spawner
62148	Aug. 16'87	380	
62149	Aug. 16'87	303	
62150	Aug. 16'87	371	
62151	Aug. 16'87	374	
62152	Aug. 16'87	371	caudal scar
62153	Aug. 16'87	330	
62154	Aug. 16'87	331	
62155	Aug. 16'87	390	
62156	Aug. 16'87	381	spawner
62157	Aug. 16'87	318	
62158	Aug. 16'87	369	
62159	Aug. 16'87	323	
62160	Aug. 16'87	297	
62161	Aug. 16'87	316	
62162	Aug. 16'87	373	
62163	Aug. 16'87	365	
62164	Aug. 16'87	302	
62165	Aug. 16'87	313	
62166	Aug. 16'87	353	
62167	Aug. 16'87	315	
62168	Aug. 16'87	310	
62169	Aug. 16'87	299	
62170	Aug. 16'87	300	
62171	Aug. 16'87	313	
62172	Aug. 16'87	316	
62173	Aug. 16'87	319	
62174	Aug. 16'87	303	

Blue Tag Number	Date	Length (mm)	Remarks
62175	Aug.16'87	323	
62176	Aug.16'87	333	
62177	Aug.16'87	335	
62178	Aug.16'87	328	
62179	Aug.16'87	336	
62180	Aug.16'87	323	
62181	Aug.17'87	322	
62182	Aug.17'87	373	
62183	Aug.17'87	363	
62184	Aug.17'87	374	
62185	Aug.17'87	308	
62186	Aug.17'87	314	
62187	Aug.17'87	307	
62188	Aug.17'87	372	
62189	Aug.17'87	480	lateral scar-spawner
62190	Aug.17'87	308	
62191	Aug.17'87	305	
62192	Aug.17'87	306	
62193	Aug.17'87	282	
62194	Aug.17'87	307	
62195	Aug.17'87	386	spawner
62196	Aug.17'87	382	
62197	Aug.17'87	371	
62198	Aug.17'87	330	
62199	Aug.17'87	353	
62200	Aug.17'87	353	
62201	Aug.17'87	375	
62202	Aug.17'87	335	
62203	Aug.17'87	299	
62204	Aug.17'87	359	
62205	Aug.17'87	320	
62206	Aug.17'87	325	
62207	Aug.17'87	308	
62208	Aug.17'87	304	
62209	Aug.17'87	382	spawner
62210	Aug.17'87	327	
62211	Aug.17'87	391	
62212	Aug.17'87	314	
62213	Aug.17'87	346	
62214	Aug.17'87	310	
62215	Aug.17'87	317	
62216	Aug.17'87	313	
62217	Aug.17'87	323	

Blue Tag Number	Date	Length (mm)	Remarks
62218	Aug.17'87	334	
62219	Aug.17'87	364	
62220	Aug.17'87	338	
62221	Aug.17'87	325	
62222	Aug.17'87	395	
62223	Aug.17'87	358	
62224	Aug.17'87	316	
62225	Aug.17'87	308	
62226	Aug.17'87	326	
62227	Aug.17'87	298	
62228	Aug.17'87	385	
62229	Aug.17'87	307	
62230	Aug.17'87	320	
62231	Aug.18'87	324	
62232	Aug.18'87	390	lateral scar
62233	Aug.18'87	351	
62234	Aug.18'87	334	
62235	Aug.18'87	405	
62236	Aug.18'87	372	
62237	Aug.18'87	368	
62238	Aug.18'87	336	
62239	Aug.18'87	261	
62240	Aug.18'87	413	lateral scar
62241	Aug.18'87	341	
62242	Aug.18'87	281	
62243	Aug.18'87	332	
62244	Aug.18'87	305	
62245	Aug.18'87	322	
62246	Aug.18'87	407	
62247	Aug.18'87	303	
62248	Aug.18'87	318	
62249	Aug.18'87	360	
62250	Aug.18'87	264	
62251	Aug.18'87	337	
62252	Aug.18'87	339	
62253	Aug.18'87	326	
62254	Aug.18'87	340	
62255	Aug.18'87	373	
62256	Aug.18'87	320	
62257	Aug.18'87	316	
62258	Aug.18'87	323	
62259	Aug.18'87	313	
62260	Aug.18'87	323	

Blue Tag Number	Date	Length (mm)	Remarks
62261	Aug.18'87	310	
62262	Aug.18'87	406	
62263	Aug.18'87	340	
62264	Aug.18'87	345	
62265	Aug.18'87	400	
62266	Aug.18'87	314	
62267	Aug.18'87	310	
62268	Aug.18'87	311	
62269	Aug.18'87	396	
62270	Aug.18'87	326	
62271	Aug.18'87	294	
62272	Aug.18'87	390	
62273	Aug.18'87	303	
62274	Aug.18'87	303	
62275	Aug.18'87	391	
62276	Aug.18'87	361	
62277	Aug.18'87	381	
62278	Aug.18'87	389	
62279	Aug.18'87	336	
62280	Aug.18'87	324	
62281	Aug.19'87	294	
62282	Aug.19'87	391	
62283	Aug.19'87	390	caudal scar
62284	Aug.19'87	376	
62285	Aug.19'87	320	
62286	Aug.19'87	267	
62287	Aug.19'87	269	
62288	Aug.19'87	314	
62289	Aug.19'87	311	
62290	Aug.19'87	303	
62291	Aug.19'87	319	
62292	Aug.19'87	318	
62293	Aug.19'87	329	
62294	Aug.19'87	395	
62295	Aug.19'87	317	
62296	Aug.19'87	298	
62297	Aug.19'87	305	
62298	Aug.19'87	317	
62299	Aug.19'87	305	
62300	Aug.19'87	290	
62301	Aug.19'87	310	
62302	Aug.19'87	309	
62303	Aug.19'87	393	

Blue Tag Number	Date	Length (mm)	Remarks
62304	Aug.19'87	374	spawner
62305	Aug.19'87	334	
62306	Aug.19'87	390	
62307	Aug.19'87	323	
62308	Aug.19'87	326	
62309	Aug.19'87	384	
62310	Aug.19'87	311	
62311	Aug.19'87	317	
62312	Aug.19'87	321	
62313	Aug.19'87	307	
62314	Aug.19'87	314	
62315	Aug.19'87	377	
62316	Aug.19'87	369	
62318	Aug.19'87	310	
62319	Aug.19'87	400	
62320	Aug.19'87	332	
62321	Aug.19'87	338	
62322	Aug.19'87	388	
62323	Aug.19'87	318	
62324	Aug.19'87	318	
62325	Aug.19'87	321	
62326	Aug.19'87	314	
62327	Aug.19'87	369	
62328	Aug.19'87	327	
62329	Aug.19'87	333	
62330	Aug.19'87	322	
62331	Aug.19'87	388	
62332	Aug.20'87	310	
62333	Aug.20'87	313	
62334	Aug.20'87	317	
62335	Aug.20'87	318	
62336	Aug.20'87	279	
62337	Aug.20'87	298	
62338	Aug.20'87	323	
62339	Aug.20'87	407	
62340	Aug.20'87	303	
62341	Aug.20'87	278	
62342	Aug.20'87	352	
62343	Aug.20'87	325	
62344	Aug.20'87	333	
62345	Aug.20'87	303	
62346	Aug.20'87	397	

Blue Tag Number	Date	Length (mm)	Remarks
62347	Aug.20'87	388	
62348	Aug.20'87	342	
62349	Aug.20'87	324	
62350	Aug.20'87	313	
62351	Aug.20'87	328	
62352	Aug.20'87	366	ventral scar
62353	Aug.20'87	311	
62354	Aug.20'87	316	
62355	Aug.20'87	321	
62356	Aug.20'87	321	
62357	Aug.20'87	308	
62358	Aug.20'87	298	
62359	Aug.20'87	319	
62360	Aug.20'87	310	
62361	Aug.20'87	320	
62362	Aug.20'87	322	
62363	Aug.20'87	318	
62364	Aug.20'87	344	
62365	Aug.20'87	303	
62366	Aug.20'87	315	
62367	Aug.20'87	305	
62368	Aug.22'87	307	
62369	Aug.22'87	302	
62370	Aug.22'87	339	
62371	Aug.22'87	336	
62372	Aug.22'87	324	
62373	Aug.22'87	322	
62374	Aug.22'87	294	
62375	Aug.22'87	310	
62376	Aug.22'87	294	
62377	Aug.22'87	312	caudal scar
62378	Aug.22'87	327	
62379	Aug.22'87	309	
62380	Aug.22'87	333	
62381	Aug.22'87	315	
62382	Aug.22'87	329	
62383	Aug.22'87	352	
62384	Aug.22'87	322	
62385	Aug.22'87	330	
62386	Aug.22'87	333	
62387	Aug.22'87	257	resident
62388	Aug.22'87	279	
62389	Aug.22'87	300	

Blue Tag Number	Date	Length (mm)	Remarks
62390	Aug.22'87	326	
62391	Aug.22'87	303	
62392	Aug.22'87	311	
62393	Aug.22'87	284	
62394	Aug.22'87	295	
62395	Aug.22'87	319	
62396	Aug.22'87	339	
62397	Aug.22'87	322	
62398	Aug.22'87	335	
62399	Aug.22'87	309	
62400	Aug.22'87	335	
62401	Aug.22'87	304	
62402	Aug.22'87	308	
62403	Aug.22'87	396	
62404	Aug.22'87	318	
62405	Aug.22'87	291	
62406	Aug.22'87	314	
62407	Aug.22'87	336	
62408	Aug.22'87	290	
62409	Aug.22'87	396	
62410	Aug.22'87	313	
62411	Aug.22'87	318	
62412	Aug.22'87	237	resident
62413	Aug.22'87	301	
62414	Aug.22'87	341	
62415	Aug.22'87	301	
62416	Aug.22'87	315	
62417	Aug.22'87	300	
62418	Aug.23'87	340	
62419	Aug.23'87	273	resident
62420	Aug.23'87	317	
62421	Aug.23'87	311	
62422	Aug.23'87	357	
62423	Aug.23'87	300	
62424	Aug.23'87	340	caudal scar
62425	Aug.23'87	384	caudal scar
62426	Aug.23'87	307	
62427	Aug.23'87	305	
62428	Aug.23'87	314	
62429	Aug.23'87	323	
62430	Aug.23'87	323	
62431	Aug.23'87	306	

Blue Tag Number	Date	Length (mm)	Remarks
62432	Aug.23'87	330	
62433	Aug.23'87	324	
62434	Aug.23'87	320	
62435	Aug.23'87	366	caudal scars
62436	Aug.23'87	309	
62437	Aug.23'87	338	
62438	Aug.23'87	426	
62439	Aug.23'87	288	
62440	Aug.23'87	382	
62441	Aug.23'87	306	
62442	Aug.23'87	332	
62443	Aug.23'87	350	
62444	Aug.23'87	320	
62445	Aug.23'87	345	
62446	Aug.23'87	317	
62447	Aug.23'87	382	caudal scars
62448	Aug.23'87	300	
62449	Aug.23'87	412	
62450	Aug.23'87	313	
62451	Aug.23'87	291	
62452	Aug.23'87	284	
62453	Aug.23'87	259	resident
62454	Aug.23'87	315	
62455	Aug.23'87	345	
62456	Aug.23'87	237	resident
62457	Aug.23'87	279	resident
62458	Aug.23'87	373	lateral scar
62459	Aug.23'87	299	
62460	Aug.23'87	342	
62461	Aug.23'87	251	
62462	Aug.23'87	335	
62463	Aug.23'87	292	
62464	Aug.23'87	315	
62465	Aug.23'87	340	
62466	Aug.23'87	328	
62467	Aug.23'87	327	
62468	Aug.25'87	319	
62469	Aug.25'87	337	
62470	Aug.25'87	436	lateral scar-spawner
62471	Aug.25'87	315	
62472	Aug.25'87	305	
62473	Aug.25'87	318	
62474	Aug.25'87	333	

Blue Tag Number	Date	Length (mm)	Remarks
62475	Aug.25'87	320	caudal scars
62476	Aug.25'87	324	
62477	Aug.25'87	321	
62478	Aug.25'87	307	
62479	Aug.25'87	345	
62480	Aug.25'87	330	
62481	Aug.25'87	300	resident
62482	Aug.25'87	366	
62483	Aug.25'87	330	
62484	Aug.25'87	327	
62485	Aug.25'87	357	
62486	Aug.25'87	318	
62487	Aug.25'87	320	
62488	Aug.25'87	343	
62489	Aug.25'87	348	
62490	Aug.25'87	304	
62491	Aug.25'87	328	
62492	Aug.25'87	309	
62493	Aug.25'87	336	
62494	Aug.25'87	342	
62495	Aug.25'87	337	
62496	Aug.25'87	311	
62497	Aug.25'87	303	resident
62498	Aug.25'87	312	
62499	Aug.26'87	302	
62500	Aug.26'87	367	

Green Tag Number	Date	Length (mm)	Remarks
62501	Aug.26'87	337	
62502	Aug.26'87	312	
62503	Aug.26'87	300	
62504	Aug.26'87	275	resident
62505	Aug.26'87	357	
62506	Aug.26'87	312	
62507	Aug.26'87	242	resident
62508	Aug.26'87	326	
62509	Aug.26'87	335	
62510	Aug.26'87	321	
62511	Aug.26'87	321	
62512	Aug.26'87	334	
62513	Aug.26'87	308	
62514	Aug.26'87	345	
62515	Aug.26'87	310	
62516	Aug.26'87	315	
62517	Aug.26'87	343	
62518	Aug.26'87	327	
62519	Aug.27'87	324	
62520	Aug.27'87	282	
62521	Aug.27'87	314	
62522	Aug.27'87	319	
62523	Aug.27'87	308	
62524	Aug.27'87	354	dorsal scar
62525	Aug.26'87	320	
62526	Aug.27'87	330	
62527	Aug.27'87	312	
62528	Aug.27'87	339	
62529	Aug.27'87	333	
62530	Aug.27'87	405	
62531	Aug.27'87	313	
62532	Aug.27'87	285	
62533	Aug.27'87	334	
62534	Aug.27'87	310	
62535	Aug.27'87	330	
62536	Aug.27'87	303	
62537	Aug.27'87	254	resident
62538	Aug.27'87	331	
62539	Aug.27'87	350	
62540	Aug.27'87	303	
62541	Aug.27'87	406	ventral cuts
62542	Aug.27'87	353	
62543	Aug.27'87	334	

Green Tag Number	Date	Length (mm)	Remarks
62544	Aug.27'87	340	
62545	Aug.27'87	341	
62546	Aug.27'87	300	
62547	Aug.27'87	324	
62548	Aug.27'87	297	
62549	Aug.27'87	299	
62550	Aug.27'87	302	
62551	Aug.27'87	317	
62552	Aug.27'87	293	
62553	Aug.27'87	333	
62554	Aug.27'87	305	
62555	Aug.27'87	320	
62556	Aug.27'87	322	
62557	Aug.27'87	315	
62558	Aug.27'87	340	lateral scar
62559	Aug.27'87	236	resident
62560	Aug.27'87	256	resident
62561	Aug.27'87	327	
62562	Aug.27'87	240	resident
62563	Aug.27'87	299	resident
62564	Aug.27'87	237	resident
62565	Aug.27'87	325	
62566	Aug.27'87	333	
62567	Aug.27'87	249	
62568	Aug.27'87	246	
62569	Aug.27'87	290	
62570	Aug.28'87	343	
62571	Aug.28'87	327	
62572	Aug.28'87	328	
62573	Aug.28'87	315	
62574	Aug.28'87	323	
62575	Aug.28'87	318	
62576	Aug.28'87	339	
62577	Aug.28'87	316	
62578	Aug.28'87	302	
62579	Aug.28'87	276	resident
62580	Aug.31'87	311	
62581	Sept.1'87	320	
62582	Sept.1'87	268	resident
62583	Sept.1'87	239	resident
62584	Sept.1'87	309	
62585	Sept.1'87	233	resident
62586	Sept.1'87	240	resident

Green Tag Number	Date	Length (mm)	Remarks
62587	Sept.1'87	242	resident
62588	Sept.1'87	319	
62589	Sept.1'87	255	resident
62690	Sept.1'87	218	resident
62591	Sept.2'87	342	
62592	Sept.2'87	329	
62593	Sept.2'87	229	resident
62594	Sept.2'87	315	
62595	Sept.2'87	252	resident
62596	Sept.2'87	274	resident
62597	Sept.2'87	243	resident
62598	Sept.2'87	255	resident
62599	Sept.2'87	219	resident

APPENDIX II

List of tagged fish recaptured by hoopnet on Cache Creek during the Schaefer stratified population estimate conducted between August 15 and August 20, 1987.

Appendix II.

Tag Colour	Tag Number	Recapture Date
Blue	62012	Aug.15'87
	62015	Aug.15'87
	62048	Aug.15'87
	62064	Aug.15'87
	62086	Aug.15'87
	62092	Aug.15'87
	62093	Aug.15'87
	62126	Aug.16'87
	62129	Aug.16'87
	62133	Aug.16'87
	62135	Aug.16'87
	62139	Aug.16'87
	62140	Aug.17'87
	62142	Aug.16'87
	62143	Aug.16'87
	62147	Aug.16'87
	62164	Aug.17'87
	62166	Aug.17'87
	62185	Aug.17'87
	62186	Aug.18'87
	62194	Aug.18'87
	62201	Aug.18'87
	62212	Aug.18'87
	62219	Aug.18'87
	62221	Aug.18'87
	62224	Aug.18'87
	62224	Aug.19'87
	62226	Aug.19'87
	62231	Aug.19'87
	62234	Aug.19'87
	62235	Aug.18'87
	62236	Aug.19'87
	62237	Aug.18'87
	62242	Aug.18'87
	62257	Aug.19'87
	62269	Aug.19'87
	62283	Aug.20'87
	62287	Aug.19'87
	62293	Aug.20'87
	62298	Aug.20'87

APPENDIX III

List of the tagged fish recaptured at "Fish Hole" on Cache Creek between September 12 and September 16, 1987

Appendix III.

Tag Colour	Tag Number	Recapture Date	Location	Remarks
Blue	62002	Sept.14'87	Braided Area	Silver
	62009	Sept.15'87	Braided Area	Silver
	62012	Sept.16'87	Above Cabin	Spawner
	62014	Sept.16'87	Below Cabin	Silver
	62018	Sept.16'87	Below Cabin	Silver
	62019	Sept.13'87	Above Cabin	Spawner
	62023	Sept.14'87	Below Cabin	Spawner
	62030	Sept.14'87	Below Cabin	Spawner
	62043	Sept.16'87	Above Cabin	Silver
	62055	Sept.16'87	Above Cabin	Silver
	62057	Sept.16'87	Braided Area	Silver
	62061	Sept.13'87	Above Cabin	Spawner
	62084	Sept.15'87	Braided Area	Silver
	62089	Sept.16'87	Below Cabin	Spawner
	62092	Sept.14'87	Below Cabin	Spawner
	62098	Sept.16'87	Above Cabin	Spawner
	62108	Sept.16'87	Above Cabin	Silver
	62127	Sept.15'87	Above Cabin	Silver
	62136	Sept.12'87	Braided Area	Silver
	62139	Sept.12'87	Braided Area	Silver
	62142	Sept.15'87	Braided Area	Silver
	62195	Sept.14'87	Below Cabin	Spawner
	62199	Sept.15'87	Above Cabin	Silver
	62201	Sept.14'87	Braided Area	Silver
	62216	Sept.16'87	Above Cabin	Silver
	62225	Sept.16'87	Braided Area	Silver
	62228	Sept.15'87	Above Cabin	Silver
	62255	Sept.14'87	Braided Area	Silver
	62303	Sept.13'87	Above Cabin	Silver
		Sept.16'87	Above Cabin	Silver
	62316	Sept.13'87	Above Cabin	Silver
	62320	Sept.15'87	Braided Area	Silver
	62354	Sept.15'87	Braided Area	Silver
	62361	Sept.15'87	Braided Area	Silver
	62369	Sept.14'87	Braided Area	Silver
	62376	Sept.15'87	Braided Area	Silver
	62383	Sept.15'87	Above Cabin	Silver
	62398	Sept.16'87	Above Cabin	Silver
	62407	Sept.13'87	Above Cabin	Silver
	62449	Sept.15'87	Above Cabin	Silver
	62470	Sept.16'87	Above Cabin	Spawner
	62480	Sept.14'87	Braided Area	Silver
	62485	Sept.14'87	Braided Area	Silver
	62492	Sept.15'87	Above Cabin	Silver
Green	62503	Sept.15'87	Above Cabin	Silver
	62530	Sept.16'87	Above Cabin	Spawner
	62546	Sept.14'87	Braided Area	Silver
		Sept.15'87	Above Cabin	Silver
	62572	Sept.15'87	Braided Area	Silver

APPENDIX IV

Calculation of a Petersen estimate for the Big Fish Arctic Char stock

Appendix IV.

CALCULATION OF A PETERSEN ESTIMATE FOR THE BIG FISH RIVER ARCTIC CHAR STOCK.

	Silvers	Current Year Spawners
Total # tagged in population	534	28
Total # caught during census	551	414
Total # of recaptures during census	38	7
$\frac{(534+1)(551+1)}{(38+1)} =$	7572	$\frac{(28+1)(414+1)}{(7+1)} =$ 1504
95% Confidence Limits		
Upper $\frac{(534+1)(551+1)}{(26.8+1)} =$	10,623	$\frac{(28+1)(414+1)}{(2.8+1)} =$ 3167
Lower $\frac{(534+1)(551+1)}{(52.2+1)} =$	5,551	$\frac{(28+1)(414+1)}{(14.4+1)} =$ 781

Total estimate of the anadromous population of Arctic char (>200 mm) in the Big Fish River:

1504 current year spawners
+ 7572 silvers

9076