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ABUNDANCE AND LENGTH COMPOSITION OF SELECTED GRAYLING STOCKS IN THE TANANA DRAINAGE DURING 1986

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ABSTRACT

Arctic grayling, (*Thymallus arcticus* Pallas), were captured by electrofishing, seining, fyke trapping, and weir trapping in seven river systems and two lake systems of the Tanana drainage of interior Alaska in 1986. In four of these systems, population abundance was estimated for a whole system or specific sections of a system. Population estimates ranged from 61,581 Arctic grayling greater than 150 millimeter fork length in the Chena River to 410 Arctic grayling in a 4.8 kilometer section of the Goodpaster River system. There was a continuing trend towards declining population size of Arctic grayling in the river systems of the Tanana Drainage. A first ever population estimate of Arctic grayling in a lake system in Alaska was performed at Fielding Lake. There were 6,578 Arctic grayling greater than 200 millimeter fork length in Fielding Lake during 1986.

Age composition of Arctic grayling in the runoff rivers of the Tanana drainage were similar. The 1983 (age 3) and 1980 (age 6) year classes comprised the bulk of the stock in these river systems. Predictions of year class strength from observed river discharge during the natal year are discussed in relation to implementation of special sport fishing regulations. Based on fyke net catch rate in Mile One Slough of the Delta Clearwater River, there will be weak recruitment to the wild stock 1984 and 1985 year classes during the next two years.

KEY WORDS: Arctic grayling, *Thymallus arcticus*, population size, catch rate, age composition, length composition, relative stock density, bootstrapping, electrofishing, fyke trapping, Tanana River Drainage.

INTRODUCTION

It is generally agreed that Arctic grayling (*Thymallus arcticus* Pallas); hereafter referred to as grayling, are the most valuable sport fishery resource of interior Alaska. Grayling consistently rank second or third in total Alaska freshwater sport harvest by species. Interior waters provide about 60% of this harvest, making the Interior, and particularly the Tanana drainage, the largest grayling fishery in North America. With increasing human population, tourism, and improving access to fishing, angling pressure on Tanana drainage stocks is increasing approximately 5% annually. The popularity of the grayling is exemplified in that it is consistently rated as the number one sport species by interior Alaskan anglers. In 1980, Holmes (1981) found that over 90% of Fairbanks anglers fish for grayling each year. In 1985, Holmes (1987) found that over 85% of Tanana drainage anglers fish for grayling each year.

The Tanana drainage grayling resource consists of stocks that utilize runoff rivers, spring-fed creeks, bog-fed creeks, and lake systems for spawning, feeding, overwintering and rearing. Use of these systems by grayling stocks ranges from a simple single river life history strategy (e.g. Chena River; see Tack 1980) to complex migration patterns (e.g. the

Shaw Creek/Richardson Clearwater River/Tanana River migration pattern; see Ridder 1985). Because of the wide range of life history strategies exhibited by grayling stocks in the Tanana drainage, the status and geographic description of many grayling stocks in the drainage are incomplete at present.

This study was conducted on the naturally occurring grayling populations in the Tanana drainage with the major emphasis directed toward the stocks that support the largest fisheries. These major stocks are found in: the Chena, Salcha, Chatanika, and Goodpaster Rivers, the Delta and Richardson Clearwater Rivers, Shaw Creek, and Fielding and Tangle Lakes (Figure 1). Past studies of Tanana drainage grayling provide a good general knowledge of grayling life history (Roguski and Winslow 1969, Roguski and Tack 1970, Tack 1971-1976, Hallberg 1977-1982, Holmes 1983-1985, Peckham and Ridder 1979, and Ridder 1980-1985). More recent studies have focused on the effects of environmental variables on grayling recruitment and its importance in determining the harvestable surplus of riverine grayling stocks. In addition, recent attempts to model the dynamic interactions of the primary rate functions (mortality and recruitment) of riverine grayling fisheries yielded important insights into the effect of sport fishing on grayling stocks in the Tanana drainage.

In 1985, Holmes et al. (1986) found that significant declines in grayling abundance, catch rates in the fisheries, and harvest in these fisheries had occurred in recent years. Results of a dynamic pool model of the Chena River grayling stock and fishery indicated that severe recruit overfishing was occurring in the Chena River, and that environmental conditions during the grayling's first year of life can significantly affect subsequent recruitment to the harvestable stock (Holmes et al. 1986). Based on modeling results and input from anglers, regulations were promulgated in the spring of 1987 to restrict harvest of grayling in the Chena River, Delta Clearwater River, Richardson Clearwater River, and Shaw Creek. The newly implemented regulations were intended to:

1) restrict the harvest of grayling to fish 305 mm (12 in) or greater in total length;

2) restrict the methods of harvest to unbaited artificial lures only; and

3) eliminate the harvest of grayling during the spawning period.

The long-term goals of this research project are:

1) to develop standard methods to assess grayling stocks in rivers and lakes of the Tanana drainage;

2) to collect population data from the major grayling stocks of the drainage, such that accurate and precise estimates of abundance, growth, mortality, and recruitment can be calculated;

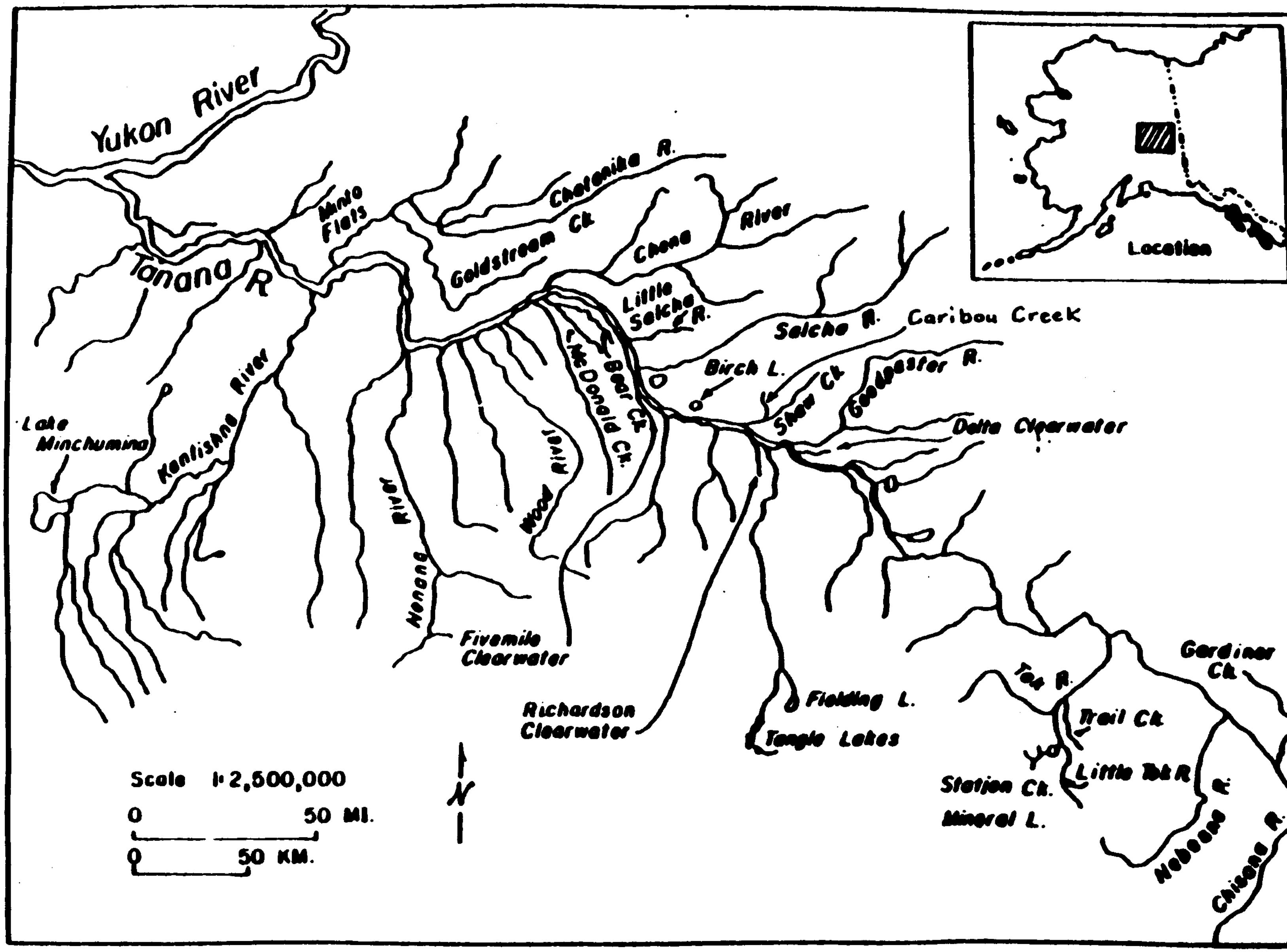

Figure 1. Tanana drainage grayling research areas.

3) to use the aforementioned population statistics in models that accurately describe the interactions of these statistics in the natural environment and that predict the probable consequences of management actions already implemented or contemplated.

The objectives of the 1986 research efforts were:

1) to estimate the absolute abundance of age 3 and older grayling in the Chena and Richardson Clearwater Rivers, Shaw Creek, and Fielding Lake;

2) to estimate the absolute abundance of age 3 and older grayling for each of two, 4.8 km sections of the Goodpaster River;

3) to estimate electrofishing catch rate (CPUE) of age 3 and older grayling in each of two, 4.8 km sections of the Delta Clearwater River as a measure of relative abundance;

4) to estimate fyke trap CPUE of prerecruit (age 1 and age 2) grayling at Mile One Slough of the Delta Clearwater River as a measure of relative abundance of these cohorts;

5) to estimate the mean length at age of grayling for the Chena, Salcha, Chatanika, Goodpaster, Delta Clearwater, and Richardson Clearwater Rivers, Caribou Creek, and Fielding and Tangle Lakes; and

6) to estimate the age composition of grayling in the Chena, Salcha, Chatanika, Goodpaster, Delta Clearwater, and Richardson Clearwater Rivers, Caribou Creek, and Fielding and Tangle Lakes.

METHODS

The methods portion of this document is divided into four specific sections. The first section addresses the estimation of absolute abundance of grayling, either in a whole system (Fielding Lake, Richardson Clearwater River, and Shaw Creek) or a specific area of a system (Chena River and Goodpaster River). The second section addresses the estimation of relative abundance of grayling in the Delta Clearwater River. The third section addresses the estimation of relative abundance of prerecruit grayling at Mile One Slough of the Delta Clearwater River. The last section addresses the estimation of mean length at age and age class composition of grayling stocks of the Tanana drainage.

Estimation of Absolute Abundance

Absolute abundance of age 3 (greater than 150 mm fork length (FL) in rivers except Shaw Creek, and greater than 200 mm FL in lakes and Shaw Creek) and older grayling was estimated in the Chena River, Richardson Clearwater River, Goodpaster River, Shaw Creek, and Fielding Lake. All estimates of absolute abundance were conducted as capture/recapture experiments. These experiments ranged from simple Petersen methods (Chapman 1951) to complex Jolly-Seber methods (Seber 1982).

Captured grayling were measured for fork length (tip of snout to fork of tail) to the nearest 1 mm. Lengths were taken, not only to provide length at age data, but to estimate and correct bias due to length selectivity for abundance estimates conducted with electrofishing gear. All grayling greater than 150 mm FL (200 mm FL for lakes and Shaw Creek) were tagged with individually numbered Floy internal anchor tags and the adipose fin was removed. Data collected from tagged fish were used to estimate mean growth increments from capture to recapture (over one or more seasons), to evaluate possible biases in abundance estimates (differential probability of capture by time period and/or length class and/or sex), and to provide estimates of recruitment during one or more seasons. The adipose fin was removed as a second "mark", allowing for estimation of tag loss rate and accurate documentation of marked fish. When Floy tags were not used, grayling were marked with a partial caudal finclip. Floy tags were not used in the Richardson Clearwater River nor in the Goodpaster River.

Chena River Study Design:

The absolute abundance of grayling age 3 and older was estimated by dividing the lower 152 km of river into four river sections and performing modified Schnabel (Seber 1982) population estimates in two 3.2 km sample units in each river section. Capture/recapture and age-length sampling of the Chena River grayling stock was conducted from 7 July to 6 August. Sampling was postponed for 5 days in the middle of this sampling period (19 July to 24 July) because of high and muddy water. An AC (alternating current) electrofishing boat was used for all sampling except the Upper A and Upper B 3.2 km sections. In these two sections an experimental pulsed-DC (direct current) electrofishing system (same boat) was used to capture grayling. The first section (hereafter called the Lower Chena) encompassed the lower 40 km of the Chena River. The second section (hereafter called Middle Chena 1) encompassed river kilometers 41.6 to 80. The third section (hereafter called Middle Chena 2) encompassed river kilometers 81.6 to 112. The last section (hereafter called the Upper Chena) encompassed river kilometers 113.6 to 152.

Two 3.2 km sample units of the river were randomly selected in each of the four river sections. Absolute abundance of grayling greater than 150 mm FL was estimated in each of the eight sample units. Usually, two of the 3.2 km sample units were electrofished once every day for five days.

Richardson Clearwater River Study Design:

The absolute abundance of age 3 and older grayling was estimated by a capture/recapture experiment using a boat-mounted AC (alternating current) electrofishing system. The modified Schnabel estimating formulae (Seber 1982) were used to calculate an abundance estimate. Electrofishing took place in three river sections and each section was electrofished once each day in a five day period between 21 and 30 July. Each river section is physically distinct, with section II separated from the other two sections by large pools (hereafter called "ponds") formed by old beaver dams. Section I is the deepest of the three sections and extends from the mouth upstream approximately 4.8 km to the longest "pond". Section II starts upstream of the longest "pond" and extends upstream 4.8 km to the smaller "pond". Section II is the widest and shallowest of the three sections and is essentially one long riffle. Section III is 3.2 km long and the narrowest of the three sections, extending upstream from the upper "pond" to a small tributary stream. The two downstream sections are 0.8 km shorter than the old "lower section" used in abundance estimation prior to 1985 (see Ridder 1980 - 1985). The upper section has been used for abundance estimation since 1982.

Goodpaster River Study Design:

The absolute abundance of age 3 and older grayling was estimated by electrofishing capture/recapture methods using a boat-mounted AC system in each of two 4.8 km sections of the Goodpaster River. Past studies, Ridder (1980 - 1985) and Holmes et al. (1986), have used the abundance estimates from the two sections as an index of total abundance in the lower Goodpaster River and the same two river sections have been sampled every year since 1973. The downstream section extends from river kilometer 4.8 to river kilometer 9.6. The upstream section extends from river kilometer 24 to river kilometer 28.8. To facilitate marking and releasing of grayling, each 4.8 km section was electrofished in 1.6 km stretches. After both sides (electrofishing along each bank) of the 1.6 km stretch were sampled, all grayling were measured for length, marked, and released. Each of the 4.8 km sections was electrofished once each day over a period of five days from 11 to 15 August. The modified Schnabel estimator (Seber 1982) was used to estimate abundance in the two sections.

Shaw Creek Study Design:

Since 1981, the absolute abundance of age 4 (greater than 200 mm FL) and older grayling has been estimated with tag recoveries from the spring fishery, using the generalized Jolly-Seber model (see Seber 1982). Grayling were tagged during the previous year (1985) at a weir constructed on Caribou Creek, a major spawning system of Shaw Creek (Figure 1). During the following spring (1986), grayling were sampled from the recreational fishery occurring at the mouth of Shaw Creek (in the Tanana River), just prior to ice break up at Shaw Creek.

Fielding Lake Study Design:

The absolute abundance of age 3 and older grayling was estimated by Chapman's (1951) modification of the Petersen estimator. The abundance estimate was accomplished in two phases. The first phase consisted of capture events performed with two boat-mounted AC electrofishing systems. Sampling occurred immediately following ice break-up in the lake between 24 June and 3 July. The electrofishing systems were fished along the shoreline of the lake once each night. All fish were measured (FL) and sampled for age (scales). Those fish greater than 200 mm FL were tagged, and released in the middle of the lake to facilitate mixing of marked and unmarked fish. Marking of grayling continued for 10 days. Additionally, the outlet of Fielding Lake was sampled with a 15 m beach seine (15 m x 2 m, with 10 mm mesh). All fish of sufficient length were sampled as above and released in the middle of the lake.

The second phase consisted of capture performed with two boat-mounted electrofishing systems and a beach seine. Fielding Lake was sampled in the same manner as in phase one between 2 and 5 September. All grayling captured were examined for marks, sampled for age, and released. Due to the length of time between phase one and phase two of this experiment, a significant amount of recruitment (growth) of grayling less than 200 mm FL into the markable population occurred. A non-parametric procedure developed by Robson and Flick (1965) was used to detect and adjust for recruitment bias in the abundance estimate.

Data Analysis:

The assumptions necessary for accurate estimation of absolute abundance in a closed population are as follows (Seber 1982):

1) The population is closed (no change in the number of grayling in the population during the estimation experiment).

2) All grayling have the same probability of capture in the first sample or in the second sample, or marked and unmarked grayling mix randomly between the first and second samples.

3) Marking of grayling does not affect their probability of capture in the second sample.

4) Grayling do not lose their mark between sampling events.

5) All marked grayling are reported when recovered in the second sample.

Although these assumptions are stated for a two sample experiment (Petersen type point census), they can readily be extended to multi-sample experiments such as the Schnabel estimator by replacing "first sample" and "second sample" with "previous sample" and "subsequent samples". When a Jolly-Seber estimator is used, the assumption of closure can be relaxed, i.e. the population can be demographically open (mortality, recruitment, immigration, and emigration can occur). Geographic closure of the population must occur for any of these estimators to be valid (White et al. 1982).

The analysis of capture/recapture data was performed in two steps. First, the data were grouped according to arbitrary length classes. These frequency data were then subjected to two statistical tests of assumptions necessary for estimating absolute abundance. The first test involved a chi-squared contingency table analysis of the frequencies of those fish recaptured by length group versus those not recaptured by length group

(Seber 1982, p. 71, 82). The hypothesis tested was: the probability of capture of marked fish was the same as that of unmarked fish among all sizes of fish. If we failed to reject this hypothesis, then the data did not need to be stratified into length categories.

The second test involved a chi-squared contingency table analysis of the frequencies of those fish examined as marked by length group versus those examined as unmarked by length group (Seber 1982, p. 74). The hypothesis tested was: recruitment did not change the probability of capture of marked fish relative to unmarked fish in the recapture sample. Alternatively, since we had the individual lengths of fish when captured and when recaptured, a non-parametric method of testing for recruitment and adjusting the abundance estimate for bias due to recruitment was used (Robson and Flick 1965).

These first steps were performed on all Schnabel and Petersen type estimates of abundance. The second step was to choose the appropriate estimator for each of the abundance estimates. The following data analyses illustrates the second step for each of the specific water bodies.

Chena River. Each of the sample unit estimates were calculated with the modified Schnabel formulae, with the data stratified by length category if needed. Holmes et al. (1986) found that three length categories were needed to correct for differential capture probability by length of fish. The stratified estimates of abundance were summed to estimate absolute abundance in a 3.2 km sample unit:

(1) $$\hat{N}_i = \sum_{j=1}^{n} \hat{N}_{ij}$$

where: $\hat{N}_i$ = the estimated abundance of grayling in the ith 3.2 km sample unit;
$\hat{N}_{ij}$ = the estimated abundance of grayling in the jth length category of the ith 3.2 km sample unit; and,
j = 1, 2, ..., n (number of length categories needed).

This calculation was made for each of the eight 3.2 km sample units of the Chena River (i = 1, 2, 3, ..., 8).

The stratified estimates of variance of the abundance estimates were also summed to estimate the variance of the abundance estimate in a 3.2 km sample unit:

(2) $$V(\hat{N}_i) = \sum_{j=1}^{n} V(\hat{N}_{ij})$$

where: $V(\hat{N}_i)$ = variance of the estimated abundance of grayling in the ith 3.2 km sample unit;
$V(\hat{N}_{ij})$ = variance of the estimated abundance of grayling in the jth length category of the ith 3.2 km sample unit; and,
j is defined in equation 1.

This calculation was also made for each of the eight, 3.2 km sample units of the Chena River (i = 1, 2, 3, ..., 8).

Absolute abundance of grayling in the Chena River was then calculated by expansion of the average abundance of grayling in a 3.2 km sample unit (N) by the number of possible 3.2 km sample units available in each river section (R):

(3) $$\hat{N} = R \cdot \hat{\bar{N}}$$

where: $$\hat{\bar{N}} = \frac{\sum_{i=1}^{r} \hat{N}_i}{r}$$; r = 2, 3.2 km sample units,

$\hat{N}$ = the estimated abundance of grayling in a particular river section; and,
R = the number of possible 3.2 km sample units in a particular river section (R = 12.5 for Lower Chena, 12.5 for Middle 1, 10 for Middle 2, and 12.5 Upper Chena).

Variance of this expanded estimate of grayling abundance in each of the particular river sections was then calculated as:

(4) $$V(\hat{N}) = R[R - r]\,\hat{S}^2 + \frac{R^2}{r^2} \sum_{i=1}^{r} V(\hat{N}_i)$$

where: $V(\hat{N})$ = variance of the estimated abundance of grayling in a particular river section;

$$\hat{S}^2 = \frac{\sum_{i=1}^{r} (\hat{N}_i - \hat{\bar{N}}_i)^2}{r(r - 1)};$$

$\hat{\bar{N}}$ = the average abundance of grayling in a 3.2 km sample unit of a particular river section;
$V(\hat{N}_i)$ is defined in equation 2; and,
R is defined in equation 3.

The Lower Chena, Middle 1, Middle 2, and Upper Chena grayling abundance estimates and their variances were each summed to produce estimates of abundance and variance of abundance in the entire Chena River. A 95% confidence interval of the estimated abundance of grayling was approximated by

$$\hat{N} \pm 1.96 \sqrt{V(\hat{N})} \quad (5)$$

where: $\hat{N}$ = the estimated abundance of grayling in the Chena River; and,

$V(\hat{N})$ = the estimated variance of the abundance estimate.

Richardson Clearwater River. The estimate of grayling abundance in the Richardson Clearwater River was calculated with the modified Schnabel formulae. Too few recaptures were available to test for length bias. A 95% confidence interval was calculated by treating the cumulative number of recaptured grayling as a Poisson variable according to procedures given in Ricker (1975).

Goodpaster River. The two, 4.8 km river section estimates of grayling abundance in the Goodpaster River were calculated with the modified Schnabel formulae. A chi-squared test for length bias resulted in non-significant differences and hence length stratification was unnecessary. A 95% confidence interval was calculated as described above for the Richardson Clearwater River.

Shaw Creek. The absolute abundance (and standard error) of grayling in Shaw Creek was estimated with the generalized Jolly-Seber (Jolly 1965, Seber 1965) model. This model allowed for death and emigration (losses in the population) and birth and immigration (gains in the population) to occur during the experiment. Marking of grayling at the Caribou Creek weir began in 1980 and continued through 1986. Recapture runs were made at the Shaw Creek spring grayling fishery, sampling the catch of all anglers leaving the fishery (see results section for additional details).

Fielding Lake. The absolute abundance of grayling in Fielding Lake was estimated with Chapman's modification of the Petersen estimator, with the data stratified by length category due to significance levels found in chi-squared tests. The approximate variance of this estimate was calculated with a formula developed by Seber (1970) and Wittes (1972), and as presented in Seber (1982, p. 60). Bias in estimation of grayling abundance, due to recruitment, was inevitable in an experiment of this type (marking in June and recapturing in September). Therefore, a non-parametric procedure developed by Robson and Flick (1965) was used to detect and adjust for bias due to recruitment.

Estimation of Relative Abundance

The use of electrofishing catch rate as an estimator of relative abundance of grayling has met with limited success in the runoff rivers of interior

Alaska (see Holmes et al. 1986 and Holmes 1985). Ridder (1985) found that electrofishing catches in a 3.2 km section of the Richardson Clearwater River, a spring-fed system, accurately estimated the relative abundance of grayling (≥ 150 mm FL). Holmes et al. (1986) found that low relative precision (high coefficient of variation), due to an insufficient number of recaptures, prevented reliable estimation of absolute abundance in the Delta Clearwater River. In lieu of an estimate of absolute abundance, a relative index of abundance was estimated in the Delta Clearwater River in 1986. Additionally, an index of relative abundance was calculated for the Richardson Clearwater River.

Study Design:

Between 7 and 17 July, two 4.8 km sections of the Delta Clearwater River were sampled with a boat-mounted AC electrofishing system. The furthest downstream of these two river sections extends from river kilometer 6.4 to river kilometer 11.2 and is approximately 15 to 23 m wide. The upper river section extends from river kilometer 22.4 (the junction of the left and right forks of the Delta Clearwater River) to approximately river kilometer 27.6 (locally known as the "upper lake"). The upper section is approximately 8 to 11 m wide. Every other day, the two 4.8 km sections were each sampled once with the electrofishing system, collecting all grayling shocked (if possible).

All captured grayling were measured for length, scale sampled, and released. Sampling was continued for five sampling trips in the two week period and the total number of fish caught (≥ 150 mm FL) during each sampling trip was recorded. Catch rate (CPUE) was defined as the number of grayling greater than 150 mm FL captured per single pass of the electrofishing system through each of the two 4.8 km sections.

Data Analysis:

Due to the small sample size (5 samples) and difficulties in estimating variances of catch rate data, the mean CPUE, variance of mean CPUE, and 95% confidence intervals were calculated with bootstrapping procedures (Efron 1982). The bootstrap mean CPUE was approximated by Monte Carlo methods, randomly sampling the mean of 5 data points (with replacement) 1000 times as follows:

$$(6) \qquad \overline{CPUE}_B = \frac{\sum_{j=1}^{B} \left[\left[\sum_{i=1}^{5} C_{Bi} \right] \div 5 \right]}{B}$$

where: B = the number of bootstrap samples (1000 in this case);
i = 1, 2, 3, 4, 5 random draws from the original data (with replacement);
j = 1, 2, 3, ... , B replications of the sample;

C_{Bi} = the ith random draw from the original data (i.e. a bootstrap sample); and,

$\overline{CPUE_B}$ = the bootstrap mean catch rate.

The bootstrap variance was approximated by the standard variance formula:

$$(7) \qquad V(\overline{CPUE_B}) = \left[\sum_{j=1}^{B} (C_{Bj} - \overline{CPUE_B})^2 \right] \div (B - 1),$$

where: $V(\overline{CPUE_B})$ = the bootstrap variance of $\overline{CPUE_B}$; and, B, j, and $CPUE_B$ are defined in equation 6.

A non-parametric 95% confidence interval was estimated for $\overline{CPUE_B}$ by the percentile method of Efron (1981). This method uses the 100α and $100(1 - \alpha)$ percentiles of the bootstrap histogram as the lower and upper confidence limits of $CPUE_B$ ($\alpha = 0.05$ in this case; see Efron and Gong (1983) for a discussion of this technique).

In addition to relative abundance estimation in the Delta Clearwater River, an index of relative abundance was calculated for electrofishing runs through the three river sections of the Richardson Clearwater River. All calculations discussed above were used in the same manner for CPUE estimates in the Richardson Clearwater River. The CPUE estimates calculated for the Richardson Clearwater River are being collected and used to compare relative abundance (CPUE) with absolute abundance (population estimate) for a series of years. These comparisons will allow the evaluation of electrofishing catch rate as an index of absolute abundance in the future.

Estimation of Fyke Trap CPUE

Fyke-trapping at the mouth of Mile One Slough, where it enters the Delta Clearwater River at river kilometer 1.6, has been conducted as a routine monitoring activity since 1976 (see Ridder 1985). Trapping has been conducted in the last two weeks in April during the seasonal in-migration of juvenile grayling into the Delta Clearwater River. A spring influenced slough of the Tanana River, Mile One Slough is typically 1 to 3°C warmer than the Delta Clearwater River during this time. The slough typically runs clear until the first week of May when the rising, silt-laden Tanana River enters the slough and produces turbidity. It is felt that the temperature differential attracts grayling during their upstream migration. Grayling marked at the slough have routinely been recaptured further upstream in the Delta Clearwater River and also, to a lesser extent, downstream in the Clearwater Lake Outlet (Peckham and Ridder 1979; Ridder 1980). Although this data set is principally used for the evaluation of hatchery and pond reared juvenile grayling (see Skaugstad and Ridder 1987), Ridder (1985) found a significant correlation between CPUE (grayling caught per trap day) at Mile One Slough and the electrofishing relative abundance estimate of grayling in the Delta Clearwater River 2 years later.

Study Design:

A New Hampshire style fyke trap was set at the mouth of Mile One Slough in the third week of April and was fished for 12 consecutive days. The trap and its wings completely blocked the mouth of the slough. Trap location and gear type have been the same since 1976. Timing of trap placement has been constant since 1982 and was based on 6 years of water temperature and catch data (Ridder, 1983). These data show a water temperature of 5°C precedes the majority of the grayling in-migration and that this temperature was reached between April 20 and 23 in 6 of 7 years.

The trap was emptied daily and numbers of captured grayling enumerated. All captured grayling were measured (FL), scale sampled and examined for presence of marks (fin clips and tags). Grayling were then released approximately 0.4 km upstream of the slough in the Delta Clearwater River.

Data Analysis:

The mean CPUE of age 1 and 2 grayling per trap night was calculated and used as an estimate of relative abundance of the prerecruit age classes in the Delta Clearwater River. Age determination for these cohorts was made by length frequency and mark (fin-clip) analyses. The latter analysis determined the presence of stocked (hatchery and pond-reared) grayling in the catch. Stocked grayling are typically longer than wild fish. Total CPUE was calculated as the mean of all individual trap night catches. The variance of the mean catch per day for both groups was calculated using the standard variance formula.

Estimation of Mean Length at Age and Age Composition

Estimates of the mean length at age of grayling captured by electrofishing systems were used to estimate growth rates of grayling residing in the Chena River, Richardson Clearwater River, Fielding Lake, and Tangle Lakes system (includes Tangle River). In other areas sampled, the mean length at age was used to index growth rates of grayling in selected portions of the Chatanika River, Salcha River, Delta Clearwater River, Goodpaster River, and Caribou Creek.

In addition to the mean length at age of grayling in these systems, the proportion of the grayling stock represented in each age class was estimated for either the entire stock, or for fish in a selected area of that system. Age class composition was used to apportion estimates of abundance (if available) into estimates of abundance by age class. With abundance by age class and its variance (collected over a series of years), estimates of age specific total mortality rates can be calculated in future years.

One major problem in the estimation of age class composition is the inherent length selectivity of the gear type used to sample grayling (usually electrofishing boats). The length selectivity of AC, DC, and pulsed-DC electrofishing equipment is generally acknowledged by fishery scientists (see Reynolds 1983 for a general discussion). In general, larger (and therefore older) grayling have a higher probability of capture than do smaller (and therefore younger) grayling. Several analytical solutions to the problem of length selectivity in electrofishing systems are offered by Sullivan (1956), Funk (1958), Junge and Libosvarsky (1965), Stewart (1975), Novotny (1980), Laarman and Ryckman (1982), Zalewski (1983), and Clark (1985). Methodologies for reducing bias range from ignoring the problem to non-linear estimation of absolute efficiency by length class. Bias in age composition estimates can be computationally corrected for by using a capture/recapture experiment to measure relative selectivity among size classes. The probability of capture (number of recaptures divided by the number marked) of grayling in each of the length strata can be used to adjust the numbers of fish at age in each stratum. Using this type of calculation, the age composition estimates of grayling can be adjusted for bias due to length selectivity of electrofishing gear. However, such a technique can only be applied when a reasonably large number of grayling are recaptured. This method of age composition adjustment was applied to the Fielding Lake data set. Due to sample size problems, this source of bias was ignored in all other data sets.

Relative Stock Density (RSD) indices were calculated to quantify the size composition of grayling stocks available relative to sport angler's perceptions of quality, preferred, memorable, and trophy grayling. The length categories used in estimation of RSD are: stock (150 to 269 mm FL); quality (270 to 339 mm FL); preferred (340 to 449 mm FL); memorable (450 to 559 mm FL); and, trophy (greater than 559 mm FL). These categories were adapted directly from analyses performed by Gablehouse (1984) and represent proportions of the sport fishing world record length for grayling.

Chena River Study Design:

Collections of grayling for age-length samples were conducted in conjunction with the capture/recapture experiments. The Lower, Middle, and Upper Chena areas were not sampled with equal intensity (days and kilometers of electrofishing), therefore the number of grayling used for age composition estimates was calculated from the ratio of abundance estimates in these areas.

Chatanika River Study Design:

Collection of grayling for age-length samples was conducted in conjunction with tagging of whitefish species during the Interior Whitefish Research Project. Age-length sampling of the Chatanika River grayling stock was conducted from 4 to 28 August on a 16 kilometer stretch of river upstream and downstream of the Elliot Highway Bridge.

Salcha River Study Design:

Age-length sampling and tagging of the Salcha River grayling stock was conducted from 11 to 15 August. Sampling operations were conducted with a pulsed-DC electrofishing system along a 104 km stretch of river from Pasco

Creek to the Richardson Highway Bridge. The entire 104 km section of river was electrofished at least once and all grayling captured were sampled.

Delta Clearwater River Study Design:

Collection of grayling for age-length samples was conducted in two 4.8 km sections of the Delta Clearwater River in conjunction with relative abundance estimation. From 7 July through 15 July, five runs with an alternating current electrofishing boat were made through each of the two sections, river kilometers 8.0 through 11.2 and river kilometers 24.0 through 27.2.

Mile One Slough:

Collection of grayling for age-length samples was conducted during enumeration of grayling in fyke trap catches. All captured grayling were measured for fork length. Those fish greater than 150 mm FL were scale sampled for age.

Richardson Clearwater River Study Design:

Collection of grayling for age-length samples was conducted along the lower 12.8 km of the Richardson Clearwater River during capture/recapture sampling in early July.

Goodpaster River Study Design:

Collection of grayling for age-length samples was conducted in two 4.8 km sections of the Goodpaster River during capture/recapture sampling.

Caribou Creek Study Design:

Caribou Creek is considered to be the most important of two known spawning areas in the Shaw Creek drainage. Collection of grayling for age-length samples and tagging was conducted at a weir located 100 m upstream of the confluence of Caribou and Shaw creeks. Grayling spawning in Caribou Creek are known to contribute to six major fisheries within 64 km of Shaw Creek (Ridder 1984). Recaptures of these tagged fish during harvest sampling of the late April fishery at the mouth of Shaw Creek have been utilized in a Jolly-Seber estimate of population size at Shaw Creek. Sampling at the weir occurred during the first two weeks of June as grayling left the creek during the post-spawning out-migration of adults to summer feeding areas. Sampling has been conducted yearly during early June since 1980 and has included the tagging of all grayling greater than 200 mm FL. At capture, all grayling were measured (FL) and tagged. Sex was determined externally by the presence of eggs or milt or by morphological characteristics (swollen vent in the female and elongated dorsal fin in the male).

Fielding Lake Study Design:

Collection of grayling for age-length samples was conducted at Fielding Lake in conjunction with capture/recapture sampling. Age class composition of these age-length samples was used to apportion the abundance estimate into abundance by age class. Because the Petersen estimator applied to the total number of fish in Fielding Lake at the time of marking (June), only grayling sampled for age-length in June were used to estimate age class composition.

Tangle Lakes System Study Design:

Collection of grayling for age-length samples was conducted at the Tangle Lakes system in early September. There exists no standard methods for collection of grayling in the Tangle system, such that an accurate estimate of age class composition for the whole system can be calculated. Time and monetary constraints did not permit the estimation of absolute abundance in this system in 1986. Warner (1956) found considerable movement of grayling between lakes, making estimation of absolute abundance (using demographically closed models) by lake difficult. To initially experiment with methods for the accurate collection of age-length data, a boat-mounted AC electrofishing system was fished along the shoreline of Round and Upper Tangle Lake to collect grayling for age-length samples. A 15 m x 2 m x 10 mm mesh beach seine was used to collect grayling in the Tangle River (between Upper and Round Tangle Lakes) and the thoroughfares connecting Round, Shallow, and Long Tangle Lakes (Figure 2). Holmes et al. (1986) found that grayling tend to congregate at these thoroughfares in August. Each of these areas was sampled only once.

Data Collection:

In all of the water bodies discussed above, grayling were sampled for length to the nearest 1 mm FL and a scale smear (at least 2 scales) was taken from the area approximately six rows above the lateral line just posterior to the insertion of the dorsal fin. Scales were processed by cleaning in a solution of soap, hydrolytic enzyme, and water (commercially known as BIZ detergent) and then mounting two scales from each fish on gum cards. These gum cards were used to make triacetate impressions of the scales (30 seconds at 7,000 kg/cm^2, at a temperature of 100 degrees C). Ages were determined by replicate readings of the triacetate impressions with a microfiche reader.

Data Analysis:

The proportion of fish in each age class was estimated as:

$$\hat{p}_i = \frac{y_i}{n} \qquad (8)$$

where: y_i = the number of grayling of age i in the sample; and,
n = the number of grayling in the sample.

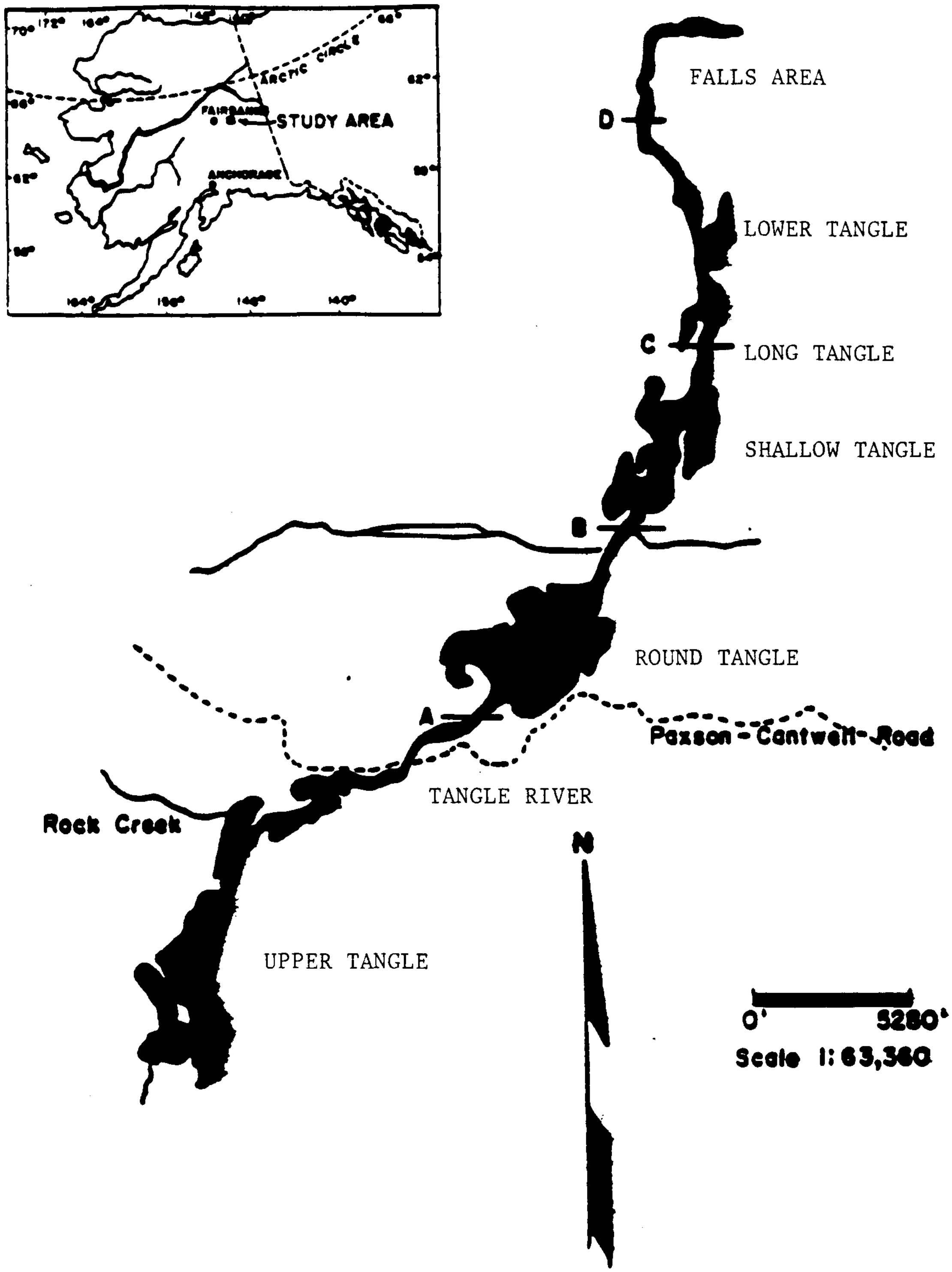

Figure 2. The Tangle Lakes system.

The variance of this proportion was estimated as:

(9)
$$\hat{V}(\hat{p}_i) = \frac{\hat{p}_i (1 - \hat{p}_i)}{n - 1}$$

Mean length at age was calculated by the arithmetic mean of all fish lengths assigned the same age. Variances were calculated with the squared deviations from the mean (standard variance formula).

Age class composition of Fielding Lake grayling was adjusted for bias due to length selectivity of the capture gear (electrofishing and seines) as discussed earlier. Using the recapture to mark ratio as a measure of the probability of capture, the number of grayling in each length stratum was multiplied by the highest capture probability divided by the capture probability in the size stratum as follows:

(10)
$$\hat{x}_{ij} = \frac{p_L}{p_j} \cdot n_{ij}$$

where:
- x_{ij} = adjusted number of grayling of age i that were also in length category j;
- p_L = the highest probability of capture observed among the length categories;
- p_j = the probability of capture of grayling in length category j; and,
- n_{ij} = the number of grayling of age i that were also in length category j.

The result of this adjustment was that all length categories with lower probabilities of capture were adjusted upward, and the length category with the highest probability of capture was adjusted by a multiplier of 1 ($p_L/p_L = 1$). The quantity x_{ij} was then summed across all k length categories to estimate adjusted numbers of grayling of age i as follows:

(11)
$$\hat{x}_i = \sum_{j=1}^{k} \hat{x}_{ij}$$

where:
- $\hat{x}_i$ = adjusted number of grayling of age i;
- x_{ij} = defined in equation 10; and,
- k = the number of length categories.

The number of length categories used in these calculations depended upon the number used to estimate absolute abundance (based on the statistical tests described in the Estimation of Absolute Abundance Section). The proportion of grayling in each age class was estimated by equation 8, substituting x_i for y_i and the sum of the x_i's for n. Variances and 95%

confidence intervals were calculated by bootstrapping the p_i's from the original data set (lengths, ages, and capture history; see Efron 1982 for general methods).

Relative Stock Density was calculated by dividing the number of fish sampled that met a certain length category (either stock, quality, preferred, memorable, or trophy) into the number of fish sampled that are at least of stock size (150 mm FL). The incremental approach of Gablehouse (1984) was used to perform these calculations. The variance of RSD was calculated according to equation 9, the variance of a proportion.

RESULTS AND DISCUSSION

Chena River

Sample unit population estimates of grayling greater than 150 mm FL ranged from 182 fish to 2,944 grayling (Table 1). The Lower Chena section had an estimated population of 4,856 grayling, giving an estimated 121 grayling per km. The estimated abundance of grayling in Middle 1 section was 6,250, giving an estimated 156 grayling per km. Population abundance in Middle 2 section was 14,200, a marked increase in abundance over the lower sections of the Chena River. The estimated number of grayling per kilometer in Middle 2 section was 443. The Upper Chena section had an estimated abundance of 36,275 grayling or 907 grayling per km.

As can be seen from the standard errors of the sample unit population estimates and river section expanded estimates, the relative precision of several of these estimates is low. One possible explanation for the low observed precision is that 3.2 km sections were not large enough to prevent movement of grayling out and into the sample unit areas during the estimation experiment. Fair success in estimation of population abundance has taken place in 4.8 km sections (Holmes et al. 1986) of the Chena River, but only for particular stretches of river. It may be possible to estimate population abundance in longer stretches (16 to 24 km) of river with increased relative precision if the assumption of closure is not being met in these shorter stretches of river.

The age composition of the Chena River stock was highly weighted towards fish that were age 3 (fourth summer) and age 6 (seventh summer). The 1983 and 1980 natal year classes appear to have strongly recruited, in accordance with low river discharge in the months of June and July of these years (Table 2). Approximately 65% of grayling sampled in the Chena River were age 3, representing an estimated 40,028 recruits from the 1983 year class. The relative magnitude of this year class was predicted from river discharge during June and July of 1983 (see Holmes et al. 1986). Because of the predominance of age 3 fish in the stock, the percentage of spawning size grayling (those above 270 mm FL) in the Chena River has dropped from 58% in 1985 (Holmes et al. 1986) to 13% in 1986 (Table 3). The actual number of spawning size grayling decreased from approximately 15,000 to approximately 5,000, a 3-fold reduction.

Table 1. River section abundance estimates and 95% confidence intervals of age 3 and older grayling in the Chena River, July 1986.

River Section	River Km	Dates	Estimated Abundance	Standard Error	±CI
Lower A	12.8-16.0	7-11 July	595	141	276
Lower B	22.4-25.6	7-11 July	182	58	114
Lower	0.0-40.0	7-11 July	4,856	2,549	4,996
Middle 1A	41.6-44.8	14-17 July	412	100	196
Middle 1B	64.0-67.2	15-18 July	588	197	386
Middle 1	41.6-80.0	14-18 July	6,250	1,708	3,348
Middle 2A	80.0-83.2	15-18 July	656	579	1,135
Middle 2B	104.0-107.2	30 July - 1 Aug	2,184	1,251	2,452
Middle 2	81.6-112.0	15 July - 1 Aug	14,200	9,705	19,022
Upper A	137.6-140.8	29 July - 6 Aug	2,860	907	1,778
Upper B	147.2-150.4	28 July - 6 Aug	2,944	3,894	7,632
Upper	113.6-152.0	28 July - 6 Aug	36,275	24,993	48,986
Total	0.0-152.0	7 July - 6 Aug	61,581	26,987	52,895

Table 2. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the test fishery sample (electrofishing) from the Chena River grayling stock, 7 July to 6 August, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
3	755	0.65	0.03	184	1	2
4	79	0.07	0.01	220	2	4
5	110	0.09	0.02	251	2	4
6	153	0.13	0.02	270	2	4
7	42	0.04	0.01	301	4	8
8	22	0.02	0.01	318	6	12
9	5	0.00	0.00	330	7	19
10	1	0.00	0.00	346	---	---
11	1	0.00	0.00	350	---	---
Total	1,168	1.00		212	1	2

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 3. Relative Stock Density (RSD) indices and 95% confidence intervals calculated from test fishery (electrofishing) samples taken from three river grayling stocks in the Fairbanks area, 7 July to 28 August, 1986.

Category	Minimum length: mm	in	Chena River: RSD[1]	±CI[2]	Salcha River: RSD	±CI	Chatanika River: RSD	±CI
Stock	150	5.9	87	2	27	7	69	5
Quality	270	10.6	11	2	41	7	30	5
Preferred	340	13.4	2	1	32	7	1	1
Memorable	450	17.7	0	---	0	---	0	---
Trophy	560	22.0	0	---	0	---	0	---
Sample size			1,457		174		404	

[1] RSD = Relative Stock Density index expressed as a percentage.
[2] ±CI = 95% confidence interval calculated from the normal theory approximation to the binomial distribution.

Although age 3 grayling represented more than half of the Chena River stock, most of the grayling harvested in the upper Chena River fishery in 1986 were age 6, the next most abundant age class in the stock (Clark and Ridder 1987). The 1980 (age 6) year class was the only strongly recruited year class present, of catchable size, and available to the sport fishery in 1986. There is a strong impetus for regulatory protection of the 1983 year class because there probably will be no strongly recruited year classes for the next two years and the 1983 year class will be fully available to the sport fishery as age 4 fish in 1987.

The 305 mm (12 in) minimum length limit, imposed in early 1987, should extend adequate protection to the 1983 year class through the 1987 sport fishing season. The mean fork length of age 4 Chena River grayling is 220 mm, approximately 250 mm total length, so that most of the 1983 year class will fall under the protected portion of the stock until they enter the fishery as age 5 fish in 1988 or as age 6 fish in 1989. The protection of this important cohort will allow increased numbers of fish to spawn.

Chatanika River

The unadjusted age composition was similar to that of the Chena River stock, except that age 6 grayling (1980 year class) occurred as a higher proportion in the Chatanika stock (Table 4). Sixty-two percent of the Chatanika grayling stock in the area sampled were either age 3 or age 6. The poorly recruited year classes (1981 and 1982) occurred in both the Chena and Chatanika grayling stocks. The relative strength of the 1980 year class was evident from a higher percentage of spawning size grayling (over 270 mm FL) in the sample. Approximately 31% of the sample were of spawning size, as compared to 13% in the Chena River sample (Table 3).

The importance of the Chatanika River grayling stock to the recreational fishery in the Tanana drainage is just beginning to be recognized. For the past 5 to 6 years, placer mining operations on tributaries of the Chatanika River have caused considerable turbidity in the mainstem Chatanika during the ice-free period. Compliance with State and Federal regulations concerning filterable residues has recently improved, making the Chatanika River more amenable to sport fishing for a sight feeding fish such as the grayling. As the Chena River stock shows increased signs of recruitment overharvest, more anglers will probably be using alternative stocks for recreational fishing. The Chatanika River may be one of the alternative areas of increased angling effort in future years, as the Chena River stock recovers.

Salcha River

A total of 174 grayling was sampled after capture by electrofishing in the Salcha River in 1986. Most of these fish were captured between Pasco Creek and Ninety-Eight Creek (river kilometer 104 to 53). A total of 168 grayling were greater than 200 mm FL and were tagged. The sample was highly skewed towards larger and older fish. Approximately 73% of the sample was of spawning size, greater than 270 mm FL (Table 3).

Table 4. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the test fishery sample (electrofishing) from the Chatanika River grayling stock, 4 to 28 August, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
3	119	0.31	0.05	195	2	4
4	16	0.04	0.02	231	9	20
5	71	0.18	0.04	248	2	4
6	119	0.31	0.05	267	2	4
7	47	0.12	0.03	292	4	8
8	12	0.03	0.02	304	6	13
9	2	0.01	0.01	283	6	70
Total	386	1.00		244	4	8

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

It is doubtful that the Salcha River stock was sampled in proportion to the abundance of all age classes. Of the 155 fish aged, only 12% were age 3 (Table 5), supposedly one of the strongly recruited year classes in runoff streams of the Tanana drainage. All other runoff stream stocks sampled in 1986 had strong age 3 cohorts (Chena, Chatanika, and Goodpaster Rivers). The age 6 year class was strongly recruited, representing 24% of the sample, but likely weak year classes (1979 and 1982) were also strongly recruited.

Determination of grayling age composition is inaccurate with a sample size of 174 fish. Future sampling will aim towards: 1) increased sample size for age composition estimation; and, 2) additional tagging studies for assessment of seasonal movements and fishery exploitation rate.

<u>Delta Clearwater River</u>

The bootstrap mean CPUE was 4.3 grayling per electrofishing run for the downstream section and 3.0 grayling per run in the upstream section (Table 6). During the previous 12 years of relative abundance estimation in the Delta Clearwater River, only three of these years (1973, 1983, 1985) included multiple runs through the same 4.8 kilometer sections as were sampled in 1986. The 1986 mean CPUE of the upstream section was significantly less than the mean CPUE of 18.0 calculated from 4 runs made in 1985. The downstream section mean CPUE was not significantly different from the mean CPUE of 6.7 in 1983, but was significantly less than the mean CPUE of 8.5 in 1973.

Age 3 and 6 grayling comprised 48% of the sample taken from the Delta Clearwater River (Table 7). Six fish from this sample were from the enhancement program (see Skaugstad and Ridder 1987) and 2 fish were tag recaptures from tagging operations at Caribou Creek (June 1985) and the Goodpaster River (May 1985).

Mile One Slough:

The fyke trap was set at Mile One Slough on 21 April and fished continuously until 2 May. Water temperatures during this period range from 4.0°C in the Delta Clearwater River and 6.0°C in the slough on 21 April to 5.5°C in the river and 7.5°C in the slough on 2 May. River water temperatures of 5.0°C and warmer were not reached until 28 April.

Total catch for the 11 days of trapping was 3,204 grayling, of which 2,957 were of the age 1 and age 2 year classes (Table 8). CPUE (catch per trap night) for all grayling and for the combined age 1 and 2 cohort were 291 and 269, respectively. Because the trap was not emptied daily, variances and standard errors were approximated by assigning equal proportions of the cumulative nightly catches to the unknown and known nightly catches.

Total fyke net catch was probably inflated approximately 23% because some of the same grayling were caught more than once. Of 43 recaptures of tagged grayling, 7 fish were recaptured an additional 10 times at the slough in 1986. These fish were included in the above totals only once.

Table 5. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the test fishery sample (electrofishing) from the Salcha River grayling stock, 11 to 15 August, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
3	19	0.12	0.05	218	4	8
4	25	0.16	0.06	263	5	10
5	14	0.09	0.04	291	7	15
6	37	0.24	0.07	316	4	8
7	26	0.17	0.06	328	8	16
8	22	0.14	0.05	360	6	12
9	8	0.05	0.03	372	6	14
10	3	0.02	0.02	405	12	52
11	1	0.01	0.01	364	---	---
Total	155	1.00		306	4	8

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 6. Catch rate (CPUE)[1] statistics for Arctic grayling (≥ 150mm FL) from each of five electrofishing runs through two, 4.8 kilometer sections of the Delta Clearwater River, 7 - 17 July, 1986[2].

Date	Run	Catch Rate by River Section: KM 24.0-27.2	KM 8.0-11.2
7 July	1	2	4
9 July	2	3	10
11 July	3	0	1
15 July	4	7	2
17 July	5	0	2
	mean	3.0	4.3
	variance	1.3	2.5
	95% C.I.	1.2 - 4.8	2.0 - 7.2

[1] CPUE is the number of grayling caught in one electrofishing run through a section.
[2] Summary statistics developed from bootstrap methods (Efron 1981 and 1982).

Table 7. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling collected by electrofishing the Delta Clearwater River, 7 to 17 July, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
1	1	0.03	0.05	124	---	---
2	3	0.08	0.08	218	8	34
3	10	0.25	0.14	234	7	15
4	2	0.05	0.07	275	2	19
5	6	0.15	0.11	307	7	19
6	9	0.23	0.13	316	11	26
7	7	0.18	0.12	345	8	19
8	2	0.05	0.07	364	6	70
Total	40	1.00		288	9	19

1 n = sample size.
2 p = proportion of sample.
3 Confidence interval based on normal theory approximation of the binomial distribution.
4 SE = standard error of the mean fork length.
5 Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 8. Observed and adjusted[1] catch of Arctic grayling by fyke trap at Mile One Slough, Delta Clearwater River, 21 April to 2 May , 1986.

Date	Observed: Total	Observed: Ages 1 and 2	Adjusted: Total	Adjusted: Ages 1 and 2
April 22	154	123	154	123
April 23	110	109	110	109
April 24	nc[2]	nc	228	204
April 25	457	408	229	204
April 26	nc	nc	201	192
April 27	nc	nc	201	192
April 28	604	577	202	193
April 29	546	542	546	542
April 30	nc	nc	341	340
May 1	683	681	342	341
May 2	650	517	650	517
Total	3,204	2,957	3,204	2,957
Mean catch per day			291	269
Variance			25,679	19,944
Standard error			48	43

[1] The daily catch was estimated for the days the trap was not checked by assigning equal portions of the cumulative nights catch to the unknown daily catches.

[2] nc: fyke trap not checked.

Assuming that the percentage of recaptures also pertained to the untagged portion of the sample, CPUE for the total and combined age 1 and age 2 cohort catch would be 224 and 207 grayling caught per trap night, respectively.

The 1986 grayling catch and mean CPUE at Mile One Slough were the largest in 10 years of CPUE estimation. During the previous nine years, total catch ranged from 248 to 1,632 with a mean of 919 grayling. CPUE for grayling caught during the nine year period ranged from 17 to 148 with a mean of 70 grayling per trap night.

One explanation for the high catch and CPUE in 1986 can be made from the record high number of recaptures of grayling stocked by ADF&G into the Delta Clearwater River during the previous 3 years (see Skaugstad and Ridder 1987). Stocked fish accounted for 61% of the age 1 and 2 cohorts, and 62% of the total catch. Subtracting these stocked fish from observed CPUE gives a combined cohort (ages 1 and 2) and total CPUE for wild fish of 105 and 111 grayling caught per trap night, respectively. CPUE of wild fish during the prior nine years ranged from 18 to 87 with a mean of 53 grayling per trap night.

Age-length data were collected from 3,205 grayling captured in Mile One Slough in 1986. Seventy-five percent of the sample were age 1. Fifty-eight percent of the sample were age 1 grayling that were stocked in 1985 (Table 9). Age 2 grayling accounted for 17% of the sample, while age 3 and older grayling only accounted for 8% of the sample. Skaugstad and Ridder (1987) have more thoroughly analyzed the cohort composition of stocked fish subjected to various enhancement regimes.

Richardson Clearwater River

Electrofishing runs were performed between 21 and 30 July. A total of 11.6 hours was spent capturing 224 grayling giving an average catch rate of 19 grayling per hour of electrofishing. This statistic is 73% less than the 73 grayling per hour of electrofishing in 1985.

The grayling population was estimated to be 1,418 fish greater than 150 mm FL (95% C.I. = 786 to 2,837). Low numbers of recaptures prevented stratification of these estimates by length class to adjust for selectivity of the electrofishing boat. The point estimate of 1,418 grayling is 41% less than the 1985 point estimate, but due to the imprecision of the 1986 estimate, the 1985 and 1986 estimates were not statistically different.

An estimate of relative abundance (CPUE) of grayling was also obtained for the Richardson Clearwater River. Bootstrap methods were used to calculate mean CPUE, variance, and approximate 95% confidence intervals for the whole river and for each river section. The whole river bootstrap mean CPUE was 40.3 grayling per electrofishing run, 70% below the 1985 mean CPUE estimate (Table 10).

The age composition and mean length at age for 209 of the grayling captured during electrofishing indicated a continuing trend towards older,

Table 9. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for wild (W) and stocked (S) Arctic grayling captured by fyke trap at Mile One Slough, Delta Clearwater River, 22 April to 2 May, 1986.

		Age Composition:			Fork Length(mm):		
Age	Source	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
1	W	526	0.16	0.01	85	0	1
	S	1,873	0.58	0.02	110	1	1
	Subtotal	2,399	0.75	0.02			
2	W	476	0.15	0.01	135	1	1
	S	82	0.03	0.01	170	7	14
	Subtotal	558	0.17	0.01			
3	W	188	0.06	0.01	188	1	3
	S	23	0.01	0.00	209	8	18
	Subtotal	211	0.07	0.01			
4	W	30	0.01	0.00	240	3	7
5	W	6	0.00	0.00	272	8	21
6	W	1	0.00	0.00	296	---	---
Total		3,205	1.00				

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 10. The catch rate (CPUE)[1] of Arctic grayling from each of five electrofishing runs through the lower 12.8 kilometers of the Richardson Clearwater River by section and total, 21 to 30 July, 1986.[2]

		Catch Rate:			
Date	Run	Section 1	Section 2	Section 3	Total
21 July	1	14	18	30	62
23 July	2	6	11	13	30
28 July	3	18	9	11	38
29 July	4	20	4	7	31
30 July	5	17	21	7	45
	mean	14.5	10.5	15.3	40.3
	variance	6.0	5.0	15.2	32.6
	95% C.I.	10.4-18.4	6.8-13.8	9.4-22.0	31.8-50.8

1 CPUE is the number of grayling caught in one electrofishing run through a section.

2 See Efron (1981 and 1982) for boostrap technique.

larger fish (Table 11, Holmes et al. 1986). Twenty-seven of the grayling sampled at the Richardson Clearwater were previously marked in other water bodies in past years sampling (24 from Caribou Creek, 1 from Rapids Creek, and 2 from the Goodpaster River). Another indication of the trend towards older and larger grayling in the Richardson Clearwater River was the high percentage of quality sized and larger grayling in the electrofished sample (Table 12). Eighty-eight percent of the sample were quality sized and larger.

Goodpaster River

During 11 to 15 August, two 4.8 km sections of the Goodpaster River were electrofished. A total of 7.3 hours was spent electrofishing section 3, capturing 346 grayling at a rate of 47 grayling per hour. The catch rate in section 6 during 7.7 hours of electrofishing was 57 fish per hour with a total catch of 437. Seven tagged grayling were recaptured during population estimation in the two sections. These fish were tagged in previous years during spring (mid-May) sampling of the lower 9.6 km of the Goodpaster River. Two of the recovered fish were tagged in 1982, two fish were tagged in 1985, and three fish were tagged in the spring of this year (1986).

The population estimates of grayling greater than 150 mm FL were 1,935 fish in section 3 (95% C.I. = 1,200 to 3,292) and 1,230 fish in section 6 (95% C.I. = 926 to 1,689). The number of grayling per kilometer in each section was 403 fish in section 3 and 256 fish in section 6.

The age-length samples from both sections were combined because there were no significant differences in the distribution of ages or lengths among the two sections. The majority of fish sampled during population estimation were age 3 (Table 13). From age samples taken in these two sections, the cohorts from the 1981 and 1982 natal year continue to appear poorly recruited (Holmes et al. 1986). Eighty-six percent of the sample were of stock size and 14% were of quality size and larger (Table 14).

Caribou Creek and Shaw Creek

The post-spawning migration of grayling out of Caribou Creek was sampled from 2 to 18 June. For the first time since 1982 the 1.2 meter high weir was not breached by high water and the weir fished continuously for the entire 16 day period. Water levels reached a high of 91 cm on 3 June and steadily dropped to a low of 43 cm by 18 June. Water temperatures rose from 1°C on 29 May to 9°C on 2 June and then gradually increased to 14°C on 18 June. A total of 817 grayling were captured, of which, 320 were determined to be adults. Based on morphological characteristics and the presence of sex products, 172 males and 148 females were counted, for a male to female ratio of 1.2:1. Of the 711 grayling greater than 200mm, 657 were tagged and 69 were recaptures from prior years tagging. The recaptures included 67 fish tagged at Caribou Creek in previous years, one fish tagged at Clear Creek in 1984, and one fish tagged as a yearling (enhancement fish stocked at age 1) in the Delta Clearwater River in 1985.

Table 11. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling from electrofishing the Richardson Clearwater River, 21 to 30 July, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
2	1	0.00	0.01	146	---	---
3	10	0.05	0.03	234	5	11
4	22	0.11	0.04	258	4	7
5	16	0.08	0.04	292	5	11
6	34	0.16	0.05	314	4	8
7	43	0.21	0.05	334	3	5
8	36	0.17	0.05	354	4	8
9	18	0.09	0.04	378	6	14
10	23	0.11	0.04	389	5	11
11	4	0.02	0.02	409	14	46
12	2	0.01	0.01	376	12	146
Total	209	1.00		333	4	7

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 12. Relative Stock Density (RSD) and 95% confidence intervals calculated for Arctic grayling from the Richardson Clearwater River, 21 to 30 July, and from Caribou Creek population samples, 2 to 18 June, 1986.

	Minimum length:		Richardson Clearwater:		Caribou Creek: Adults:		Caribou Creek: Total sample:	
Category	mm	in	RSD[1]	±CI[2]	RSD	±CI	RSD	±CI
Stock	150	5.9	12	4	4	2	52	3
Quality	270	10.6	38	6	63	5	32	3
Preferred	340	13.4	50	6	33	5	14	2
Memorable	450	17.7	0	---	0	1	0	1
Trophy	560	22.0	0	---	0	---	0	---
Sample size			247		320		817	

[1] RSD = Relative Stock Density expressed as a percentage.
[2] ±CI = 95% confidence interval calculated from the normal theory approximation to the binomial distribution.

Table 13. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the population sample[1] from the Goodpaster River, 11 to 15 August, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[2]	p[3]	±CI[4]	Mean	SE[5]	±CI[6]
2	80	0.14	0.03	164	1	2
3	360	0.63	0.04	193	1	2
4	26	0.05	0.02	235	3	6
5	37	0.06	0.02	261	2	5
6	56	0.10	0.02	281	3	6
7	8	0.01	0.01	305	8	17
8	2	0.00	0.00	301	6	70
Total	569	1.00		211	3	5

1 Sample from river kilometers 4.8-9.6 and 24.0-28.8 of fish ≥ 150mm FL.
2 n = sample size.
3 p = proportion of sample.
4 Confidence interval based on normal theory approximation of the binomial distribution.
5 SE = standard error of the mean fork length.
6 Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 14. Relative Stock Density (RSD) and 95% confidence intervals calculated for Arctic grayling electrofished in the Goodpaster River, 11 to 15 August, 1986.

Category	Minimum length: mm	in	RSD[1]	±CI[2]
Stock	150	5.9	86	3
Quality	270	10.6	13	2
Preferred	340	13.4	1	1
Memorable	450	17.7	0	---
Trophy	560	22.0	0	---
Sample size			713	

[1] RSD = Relative Stock Density expressed as a percentage.
[2] ±CI = 95% confidence interval calculated from the normal theory approximation to the binomial distribution.

Fifty-two percent of the sample were of stock size (Table 12), similar to that found in previous years (Ridder, 1985). Only 4% of the adult fish were of stock size, although this estimate may be biased because of the difficulty in sexing spawned-out fish of the smaller size ranges.

Age 3 and 4 grayling comprised 47% of the sample (Table 15), while age 7 fish predominated in the adult male and female samples (Tables 16 and 17). Male grayling were generally older and larger at age than females in the Caribou Creek sample (Tables 16 and 17).

The 1985 Shaw Creek population estimate of grayling greater than 200 mm FL from Jolly-Seber methods was 5,028 fish (SE = 6,007). This estimate is about half of the estimate for 1984 (N = 9,920, SE = 4,405). Recruitment was poor from 1984 to 1985 with only 608 fish (SE = 1253) recruiting to the spring fishery (see Clark and Ridder 1987 for details of the spring fishery). Low numbers of recaptures (4 from the catch sample) were the cause of imprecision in these estimates of abundance and recruitment. The Shaw Creek spring grayling sport fishery was closed in 1987.

Fielding Lake

Between 24 June and 3 July, 478 grayling were captured in Fielding Lake with an electrofishing boat, fyke traps, and a beach seine. Four hundred and five of these grayling were of sufficient length for tagging (greater than 200 mm FL). Nineteen hours of electrofishing in the lake between midnight and 4 A.M. captured 349 grayling at a rate of 19 grayling per hour. While fish were captured in all areas along the shoreline of the lake, fish were concentrated along the shoreline from the mouth of the Two Bit Lake drainage (Two Bit Creek) to the mouth of the lake's smallest bay. Twenty five grayling were captured by beach seining at night in six hauls at the mouth of Two Bit Creek. During fyke trapping, a total of 35 net-nights were expended in 12 locations along the lake shoreline for a total catch of 105 grayling. One hundred and seventy grayling out of a total catch of 617 fish were tagged during beach seine sampling performed in the outlet of Fielding Lake. In total, 575 fish greater than 200 mm FL were tagged during the June and July sampling effort.

Recapture efforts were conducted from 2 to 5 September. A total of 713 grayling was captured by electrofishing in the lake and 463 grayling were captured by seining the lake outlet. Of the grayling captured during September sampling, 463 were greater than 200 mm FL, with 24 recaptures among these fish. Additional marked and unmarked grayling samples were obtained from creel census samples at Fielding Lake between 4 July and 1 September.

A significant amount of recruitment into the markable portion of the population occurred between marking in late June and the recapture run performed in early September. Recruitment significantly altered the probability of capture of fish between 200 mm and 225 mm FL during the period from July to September. The adjusted number of fish examined for marks in the second sample of this length category was 84 fish, considerably lower than the actual number of 162 fish. The population of marked and unmarked

Table 15. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling from weir and seine samples, Caribou Creek, 2 to 18 June, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
1	14	0.02	0.01	99	3	6
2	15	0.02	0.01	150	5	10
3	168	0.23	0.03	204	2	3
4	176	0.24	0.03	238	1	3
5	93	0.13	0.02	272	2	4
6	92	0.12	0.02	299	2	4
7	104	0.14	0.02	326	2	4
8	63	0.08	0.02	349	3	5
9	11	0.01	0.01	357	4	10
10	6	0.01	0.01	383	6	15
11	1	0.00	0.00	457	---	---
Total	743	1.00		263	2	4

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 16. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for adult male[1] Arctic grayling from weir and seine samples, Caribou Creek, 2 to 18 June, 1986.

	Age Composition:			Fork Length(mm):		
Age	n[2]	p[3]	±CI[4]	Mean	SE[5]	±CI[6]
5	8	0.05	0.03	292	7	16
6	28	0.18	0.06	307	2	5
7	64	0.41	0.08	331	2	5
8	42	0.27	0.07	354	3	5
9	9	0.06	0.04	357	5	12
10	5	0.03	0.03	386	6	17
11	1	0.01	0.01	457	---	---
Total	157	1.00		335	2	5

1 Determined by morphological characteristics and/or sex products.
2 n = sample size.
3 p = proportion of sample.
4 Confidence interval based on normal theory approximation of the binomial distribution.
5 SE = standard error of the mean fork length.
6 Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 17. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for adult female[1] Arctic grayling from weir and seine samples, Caribou Creek, 2 to 18 June, 1986.

Age	Age Composition:			Fork Length(mm):		
	n[2]	p[3]	±CI[4]	Mean	SE[5]	±CI[6]
4	2	0.02	0.02	259	1	13
5	25	0.19	0.07	281	3	7
6	46	0.35	0.08	298	3	5
7	35	0.27	0.08	319	3	7
8	20	0.15	0.06	339	5	11
9	2	0.02	0.02	356	10	127
10	1	0.01	0.01	366	---	---
Total	131	1.00		308	2	5

1 Determined by morphological characteristics and/or sex products.
2 n = sample size.
3 p = proportion of sample.
4 Confidence interval based on normal theory approximation of the binomial distribution.
5 SE = standard error of the mean fork length.
6 Confidence interval based on t-distribution with n-1 degrees of freedom.

fish was stratified into four length categories for population estimation and adjustment of age composition (Table 18). The combined population estimate was 6,578 (SE = 1,150) grayling greater than 200 mm FL in June. Using the original number of grayling examined in the 200 mm to 225 mm length category (162 fish) to estimate population size, the estimate would have been 8,573 fish for an estimate of recruitment between June and September of 1,995 grayling.

The age composition of grayling captured during marking was severely biased because of the selectivity of electrofishing towards larger, and therefore older, fish. It is surprising to note that the highest capture probability was observed in the 226 mm to 274 mm length category and not the 325 mm and larger category (Table 18). Numbers of fish at age were adjusted by the ratio of capture probabilities, giving adjusted numbers of fish at each age (Table 19). The actual number of fish examined for length was used to estimate the mean length at age as summarized in Table 19. Upon examination of the adjusted age composition it is interesting to note that the population of grayling was probably not in a steady state because of the paucity of age 4 and age 5 grayling in the lake in June. The paucity of age 2 fish can be explained by the fact that only fish 200 mm FL and greater were tagged, but the apparent lack of two major age classes available to the sport fishery must be controlled by stock dynamics and/or fishery effects on the stock. The distribution of ages in the Fielding Lake stock is similar in its lack of certain ages to that of riverine grayling stocks of the Tanana drainage, although the strong year classes may be different. Future population estimation and age-length sampling may elucidate the dynamics regulating the Fielding Lake stock.

Relative Stock Density of grayling captured by electrofishing in the lake was significantly different than that of grayling captured by seining in the outlet stream (Table 20). The difference in size structure may be accounted for by the differing use patterns of sub-adult and adult fish in Fielding Lake. In late June and early July, adult fish tended to frequent the shoreline of the lake, whereas the sub-adult grayling inhabited the lake outlet. The outlet stream may be a rearing and feeding area for these prerecruited fish. Future sampling may clarify the seasonal and life history aspects of grayling movements in the lake, its inlet streams, and the outlet stream.

Tangle Lakes System

On 4 September, seining was conducted in the outlets (thoroughfares) of Round and Shallow Tangle Lakes (Figure 2). Seining the thoroughfares was unproductive; no fish were caught below Shallow Tangle Lake in 4 hauls and only 82 fish were captured in 2 hauls below Round Tangle Lake immediately adjacent to Landmark Gap Creek. A week earlier in 1985, these two areas produced 355 grayling in 2 hauls (Holmes et al 1986). Age 2 grayling dominated the sample from the outlet of Round Tangle Lake (Table 21).

During 4 and 5 September, the Tangle River between Upper and Round Tangle Lakes was seined (Figure 2). A total of 351 grayling were caught, of which, 181 fish were tagged. The age composition of this sample indicated

Table 18. Estimated abundance and standard error of grayling ≥ 200mm fork length, by length category, in Fielding Lake, June, 1986.

Length category	Number marked	Number examined	Number recaptured	Petersen estimate	Standard error
200 - 225mm	104	84[1]	3	2,230	955
226 - 274	126	272	17	1,926	396
275 - 324	94	100	8	1,066	306
325+	251	42	7	1,355	401
Total	575	498	35	6,578	1,150

[1] Number examined in 200 - 225mm length category is estimated from a non-parametric bias estimation procedure (Seber 1982).

Table 19. Estimates of the adjusted proportional contributions of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in electrofishing and seining samples from Fielding Lake, 24 June to 3 July, 1986.

	Age Composition:			Fork Length(mm):			
Age	n[1]	p[2]	±CI[3]	n[4]	Mean	SE[5]	±CI[6]
2	3	0.01	0.01	229	142	1	3
3	127	0.25	0.04	409	183	1	2
4	50	0.10	0.03	115	240	2	4
5	31	0.06	0.02	58	295	3	6
6	111	0.22	0.04	99	337	2	4
7	142	0.28	0.04	102	362	2	4
8	51	0.10	0.03	36	383	3	6
Total	515	1.00		1,053	230	3	5

[1] Adjusted number of fish examined for age.
[2] p = adjusted proportion of sample.
[3] Confidence interval calculated from boostrap methods (Efron 1981, 1982).
[4] Number examined for length from all capture methods.
[5] SE = standard error of the mean fork length.
[6] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 20. Relative Stock Density (RSD) and 95% confidence intervals calculated for Arctic grayling from electrofishing Fielding Lake and seining the lake outlet, 24 June to 3 July, 1986.

	Minimum length:		Electrofishing		Seining	
Category	mm	in	RSD[1]	±CI[2]	RSD	±CI
Stock	150	5.9	35	4	91	3
Quality	270	10.6	24	4	8	2
Preferred	340	13.4	41	4	1	1
Memorable	450	17.7	0	---	0	---
Trophy	560	22.0	0	---	0	---
Sample size			454		475	

1 RSD = Relative Stock Density expressed as a percentage.
2 ±CI = 95% confidence interval calculated from the normal theory approximation to the binomial distribution.

Table 21. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the seine sample from the outlet of Round Tangle Lake, 4 September 1986.

	Age Composition:			Fork Length(mm):		
Age	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
0	5	0.06	0.05	67	2	7
1	14	0.17	0.08	132	3	7
2	39	0.48	0.11	182	2	4
3	20	0.24	0.09	222	3	7
4	2	0.02	0.03	244	2	19
5	0	---	---	---	---	---
6	1	0.01	0.02	343	---	---
7	1	0.01	0.02	355	---	---
Total	82	1.00		182	6	11

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

an abundance of age 3 fish in this area of the Tangle Lakes system (Table 22).

During the night of 5 September, the shoreline of Upper Tangle Lake was electrofished. One hundred and thirty-four grayling were captured of which 94% percent were age 0 to age 2 fish (Table 23). Eleven fish greater than 200mm were tagged.

The proportion of quality size and larger grayling ranged from 2 to 4 percent for the various locations sampled in the Tangle Lakes system in 1986 (Table 24).

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Table 22. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling in the seine sample from the Tangle River, 4 and 5 September, 1986.

Age	Age Composition:			Fork Length(mm):		
	n[1]	p[2]	±CI[3]	Mean	SE[4]	±CI[5]
0	30	0.09	0.03	82	1	3
1	80	0.23	0.04	138	1	2
2	91	0.26	0.05	191	1	3
3	124	0.35	0.05	236	1	3
4	22	0.06	0.02	267	5	10
5	3	0.01	0.01	284	4	15
6	1	0.00	0.01	343	---	---
Total	351	1.00		191	3	6

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 23. Estimated proportional contribution of each age class, mean fork length (mm) at age, and 95% confidence intervals for Arctic grayling from electrofishing, Upper Tangle Lake, 5 September, 1986.

Age	Age Composition: n[1]	p[2]	±CI[3]	Fork Length(mm): Mean	SE[4]	±CI[5]
0	24	0.18	0.06	82	1	3
1	60	0.45	0.08	138	1	2
2	41	0.30	0.08	191	1	3
3	7	0.05	0.04	236	1	3
4	1	0.01	0.01	267	5	10
5	0	---	---	284	4	15
6	1	0.01	0.01	343	---	---
Total	134	1.00		191	3	6

[1] n = sample size.
[2] p = proportion of sample.
[3] Confidence interval based on normal theory approximation of the binomial distribution.
[4] SE = standard error of the mean fork length.
[5] Confidence interval based on t-distribution with n-1 degrees of freedom.

Table 24. Relative Stock Density (RSD) and 95% confidence intervals calculated for Arctic grayling captured by two methods in three areas of the Tangle Lakes, 4 and 5 September, 1986.

	Minimum length:		Electrofishing:		Seining:			
			Upper Tangle		Round Tangle[1]		Tangle River	
Category	mm	in	RSD[2]	±CI[3]	RSD	±CI	RSD	±CI
Stock	150	5.9	96	5	96	4	96	2
Quality	270	10.6	2	4	2	3	4	2
Preferred	340	13.4	2	4	2	3	0	---
Memorable	450	17.7	0	---	0	---	0	---
Trophy	560	22.0	0	---	0	---	0	---
Sample size			60		64		249	

1 Outlet of Round Tangle Lake
2 RSD = Relative Stock Density expressed as a percentage.
3 ±CI = 95% confidence interval calculated from the normal theory approximation to the binomial distribution.

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