Fishery Data Series No. 93-11

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## ABSTRACT

Three Arctic grayling *Thymallus arcticus* populations in the Tanana River drainage were assessed using mark-recapture experiments in 1992. Investigations focused on the estimation of abundance and stock composition. Arctic grayling were captured using pulsed-DC electrofishing. Population abundance estimated for Arctic grayling greater than 200 millimeter fork length in the Salcha River was 7,706 fish (standard error of 2,555 fish) for a density of 209 fish per kilometer. The Chatanika River population was assessed in three contiguous study sections along a 112 km reach of the middle drainage. Each section differed in capture probability, size and age composition, and density. Abundance of fish greater than 150 millimeter fork length was 19,095 fish (standard error of 1,778 fish) and ranged from 271 fish per kilometer in the upstream section to 89 fish per kilometer in the midstream section. Abundance estimated in three sections of the lower 50.0 kilometers of the Goodpaster River was 6,886 fish greater than 150 millimeter fork length (standard error of 809 fish). As in the Chatanika River, capture probabilities, composition, and density differed among sections. Density was highest in the downstream section (192 fish per kilometer) and least in the upstream section (84 fish per kilometer).



KEY WORDS: Arctic grayling, *Thymallus arcticus*, population abundance, age composition, size composition, Relative Stock Density, electrofishing, movements, Salcha River, Chatanika River, Goodpaster River, Tanana River drainage.

## INTRODUCTION

The Salcha and Chatanika rivers presently support two of the largest Arctic grayling *Thymallus arcticus* fisheries in the Tanana River drainage of interior Alaska. Although these fisheries are large, very little is known about the population dynamics of Arctic grayling in these streams. In contrast, the Goodpaster River supports a relatively small Arctic grayling fishery. However, Arctic grayling from the Goodpaster River stock are harvested in at least five other fisheries including the Delta and Richardson Clearwater rivers (Ridder 1991). This is a major concern since the fishery in the Delta Clearwater River supports, on average, the fifth largest Arctic grayling fishery in interior Alaska (Mills 1977-1991).

Arctic grayling fisheries in the Salcha, Chatanika, and Goodpaster rivers have some distinct differences that affect the progress of stock assessment work. Hydrologic characteristics, methods of access, watershed development, and history of the recreational fishery are factors which describe in part the particular qualities of each fishery. Precise knowledge of fishery characteristics and the dynamics of Arctic grayling populations in these streams is of growing importance to fishery managers. Thus, a multi-year study of Arctic grayling populations in the Salcha, Chatanika, and Goodpaster rivers was initiated in 1989. This report is the third in a series designed to summarize this information.

In conjunction with the present study, this report summarizes stock assessment work performed on the Salcha, Chatanika, and Goodpaster rivers from 1952 to 1991 (Appendices A, B, and C, respectively). By presenting all data pertinent to these fisheries, decisions regarding future research goals can be made. Summarized data will allow managers to assess the status of Arctic grayling stocks in the Salcha, Chatanika, and Goodpaster rivers.

The research objectives for 1992 were to estimate:

1) the abundance of Arctic grayling greater than 149 mm fork length in a 36.8 km study area of the Salcha River;

2) the abundance of Arctic grayling greater than 149 mm fork length in a 113.0 km study area of the Chatanika River;

3) the abundance of Arctic grayling greater than 149 mm fork length in the lower 50.0 km of the Goodpaster River;

4) the age composition of Arctic grayling in these study areas of the Salcha, Chatanika, and Goodpaster rivers; and

5) the Relative Stock Density (RSD) of Arctic grayling in these study areas of the Salcha, Chatanika, and Goodpaster rivers.

## GENERAL METHODS

### Estimation of Abundance

Specific methodologies have been developed to estimate abundance of Arctic grayling in rivers of interior Alaska. Sampling schemes have evolved from multiple-sample mark-recapture experiments in short "index" areas (Van Hulle 1968) to single-sample experiments in relatively longer "study areas" (Clark and Ridder 1987). These advances were made possible, in part, by the use of electrofishing equipment mounted on jet propelled riverboats and analysis of behavioral responses of Arctic grayling to the gear. The efficiency of electrofishing is offset by its tendency for bias due to size-selectivity (Reynolds 1983). However, mark-recapture methodology can be used to correct for the inherent bias of electrofishing gear without sacrificing the efficacy of sampling programs.

Long study areas (>36 river km) were chosen, in general, to minimize immigration and emigration of fish during the experiments. Collection of mark and recapture data was segregated by section to facilitate the estimation of fish movement within the study area. To quantify this movement, each study area was divided into three sections of approximately equal length based on the total number of electrofishing runs. An electrofishing run was defined as the distance covered by a 20 minute downstream pass of an actively fishing electrofishing boat. It was approximately 1.8 river km long.

Each electrofishing boat had a crew of two "dippers" and a driver. Each boat was equipped with a pulsed DC variable voltage pulsator (Coffelt Model VVP-15) powered by a 3,500 W single-phase gasoline generator. Anodes were four 15 mm diameter steel cables 1.5 m long arranged perpendicular to the long axis of the boat and 2.1 m forward of the bow. The unpainted bottom of the aluminum boat was the cathode. Pulsator settings were standardized at a duty cycle 50% and a pulse width of 60 Hz. Voltages were influenced not only by the conductivity of the river but also substrate type and water depth. As a general rule, voltages were varied to maintain peak output at approximately 5 amperes to minimize injury.

Each sampling event started at the upstream boundary of the study area. Sampling consisted of electrofishing along each bank for 20 minutes to collect as many Arctic grayling as possible. At the end of each 20 minute run, electrofishing ceased and all captured fish were sampled for age, length (to the nearest 1 mm in fork length), marked with an internal anchor tag, fin-clipped for a double mark, and released. The boat then returned to the upstream boundary of the run and fished the opposite bank. The next run downstream was then begun shortly below this ending point to minimize capturing fish just released. To maintain run boundaries, their locations were either marked with flagging, or a unique landmark noted in field notes or on a topographic map.

Population abundance of Arctic grayling greater than 149 mm FL was estimated with single-sample mark-recapture methods (Seber 1982), which in these experiments assume:

1) the population is closed (no change in the number of Arctic grayling greater than 149 mm FL in the population during the estimation experiment);

2) all Arctic grayling have the same probability of capture during the first sample <u>or</u> in the second sample <u>or</u> marked and unmarked Arctic grayling mix randomly between the first and second samples;

3) marking of Arctic grayling does not affect their probability of capture in the second sample;

4) Arctic grayling do not lose their mark between sampling events; and,

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

Assumption 1 was not tested directly, but movement of fish out of the study area was inferred from analysis of movements of fish between the three sections. Other factors possibly contributing to the failure of assumption 1 (mortality and growth recruitment) were assumed to be negligible. The short duration of the experiments (six to seven days separate the two events) should have precluded appreciable mortality or growth.

Assumptions 2 and 3 were tested with two Kolmogorov-Smirnov two-sample statistical tests and a chi-squared contingency table test. The first test compared the length frequency distributions of recaptured Arctic grayling with those captured during the marking sample. The second test compared the length frequency distributions of Arctic grayling captured during the marking sample with those captured in the recapture sample. The results of these two tests determined the methodology used to alleviate bias in abundance estimation (see Appendix D1). A third test compared the rates of recovery (number recaptured per number examined) among the three sections in a study area. This chi-square test was performed after the two Kolmogorov-Smirnov tests, stratified by length if necessary. If recovery rates were similar among sections, then assumption 3 was met at least in terms of length and area related differences in capture probability. Recovery rates among sections are generally the same because sampling was conducted with equal effort along the entire study area (Clark 1990). If recovery rates were not equal, the data were stratified by section and estimation procedures followed the methodology set out in Appendix D2.

Assumption 4 could be tested because double marking was employed to allow estimation of tag loss. Assumption 5 was valid because only recaptures recovered by experienced sampling crews during the experiment (and not angler returns after the experiment) were used to estimate abundance.

If tests of assumptions 2 and 3 indicated that capture probabilities were not equal among all size classes or river sections, data were stratified into size classes or sections and separate abundance estimates calculated for each data set. Size classes were chosen by maximizing the difference in capture probabilities among sizes of fish marked. Difference in capture probabilities was maximized by observing significance levels in a series of chi-squared tests. These tests compared numbers of fish marked and not seen in the second sample versus numbers of fish marked and seen in the second sample. The number of size classes used for chi-squared tests was restricted to two because further stratification could possibly reduce overall precision while gaining very little additional accuracy.

Next, mark-recapture data were examined for directed movement of fish (assumption 1). If movement was not detected or determined to be insignificant (less then 15% of fish being recaptured outside of their marking section), the modified Petersen estimator of Bailey (1951, 1952; Appendix D3, equations D3.1 and D3.2) was used to estimate abundance and variance of the estimate. If there was significant movement, then the modified Petersen estimator of Evenson (1988; Appendix D3, equations D3.3 through D3.5) was used to estimate abundance. Variance of this estimator was estimated with bootstrapping methods (Efron 1982). The bootstrapping procedure was as follows: first, capture history of each fish was recorded. Two columns of data were constructed; the first column represented the first, or marking event, and the second column represented the second, or recapture event. A capture in a particular event was denoted by the section of capture (a 3 for the upstream section, 2 for the midstream section, and 1 for the downstream section); if the fish was not seen during the event, this was denoted by a zero. The total number of capture histories was the sum of fish marked in the first event plus fish examined in the second event minus the number of fish seen in both events (recaptures). These capture histories were then resampled at random with replacement 1,000 times by computer. Each replication of the estimation experiment involved sampling of "the total number of capture histories" and then calculated an abundance estimate. After 1,000 replications the mean and sample variance were calculated for all replicates (Appendix D4, equations D4.1 and D4.2). The estimate of variance of abundance by bootstrapping was used as an estimate of variance for the modified Petersen estimator of Evenson (1988).

When data were found to be biased by size selectivity and/or differing capture probability by river section, they were stratified by length and/or section and separate abundance estimates calculated for each size stratum or section. Abundance and variance of abundance were estimated for all sizes/sections by adding the independent abundance estimates and variances.

<u>Estimation of Age and Size Composition</u>

A sample consisting of two scales was taken from each newly captured fish for aging. All scales were collected from an area centered approximately six scale rows above the lateral line just posterior to the insertion of the dorsal fin. The scales were cleaned in a solution of hydrolytic enzyme and then mounted on gum cards. These gum cards were used to make impressions of the scales on triacetate film (30 seconds at 137,895 kPa, at a temperature of 97°C). Ages were determined by counting annuli on these impressions with the aid of a microfiche reader. Determination of age was performed only once for each readable set of scales.

The accuracy of age and size composition estimates are dependent on the selectivity of the sampling gear. The extent of this bias can be inferred from the results of the Kolmogorov-Smirnov tests as described above (Appendix D1). If size selectivity was not inferred from the capture-recapture data, the sampled ages and sizes should accurately represent the age and size composition of the stock. In this case, the proportion of fish at age was estimated directly and variance was estimated with the binomial (Appendix D5, equations D5.1 and D5.2). If size selectivity was inferred, age and size data were stratified as in the abundance estimate. Recapture to mark ratios were used to adjust numbers of fish in each age or size class for differential capture probability by size of fish with equations D5.3 through D5.5 of Appendix D5. The proportions of fish in each class were then reevaluated with equation D5.6 of Appendix D5. Variances of these proportions were estimated by bootstrapping recapture to mark ratios 1,000 times in samples of "the number of capture histories" as described above.

If data were stratified by river section due to unequal catchabilty, age and size proportions were first estimated for each section either directly or adjusted if size selectivity was present. The proportions were then weighted by the ratio of the section abundance to total abundance and summed for composition estimates for the study area using equation D5.7 in Appendix D5. The variance for this estimate was calculated with equation D5.8 in Appendix D5.

Size composition of the stock was described with the incremental Relative Stock Density (RSD) indices adopted from Gabelhouse (1984). The RSD categories for Arctic grayling 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). If selectivity was not inferred from the capture-recapture data, equations D5.1 and D5.2 of Appendix D5 were used to estimate the proportion of fish in each RSD category and the variance of these proportions. If selectivity by size and/or river area was inferred from the capture-recapture data, the adjustment factors used to estimate age composition were also used to adjust RSD estimates (Appendix D5).

All data pertaining to age, length, sampling induced mortality, tag identification numbers and colors, capture location (by run and river section), fin-clips, recapture status, and tag loss from this study were recorded on mark sense forms and electronically stored for analysis and archival (see listing of data files in Appendix E1).

## SALCHA RIVER

### Fishery Description and Study Area

The Salcha River is a clear water, rapid run-off stream that flows south out of the Tanana Hills into the Tanana River (Figure 1). The river intersects the Parks highway at milepost 348, approximately 70 km south of Fairbanks. The river is characterized by high gradient, with long shallow runs and exposed gravel bars. Holmes (1984) described four separate sections encompassing the lower 192 km of the Salcha River. The upstream section is characterized by a narrow (~18 m wide), shallow (~0.5 m deep) channel with numerous protruding boulders. Average water velocity in late June is 1 m/sec,

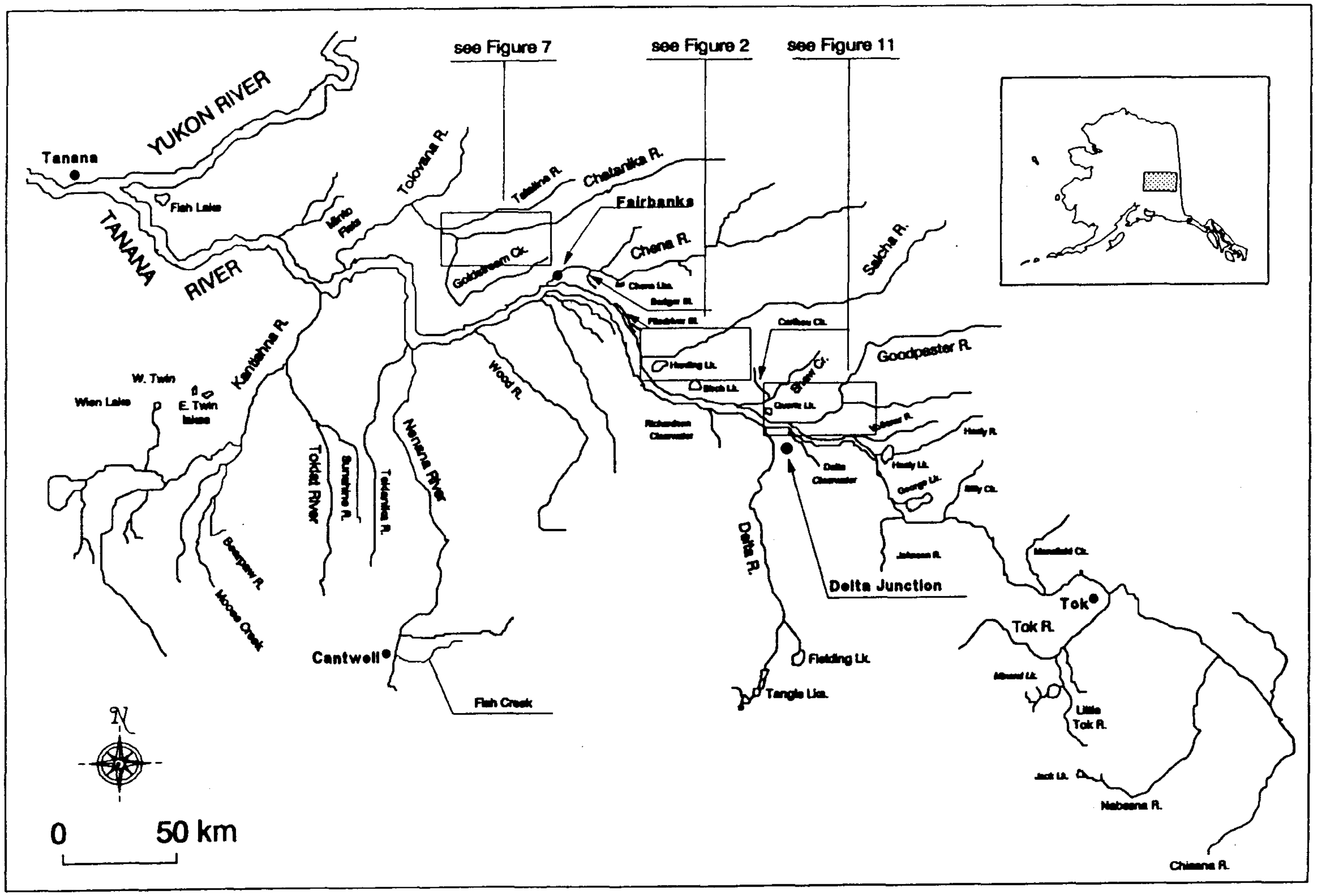


Figure 1. The Tanana River drainage.

with a gradient of 4.2 m/km. The upper midstream section is characterized by a wider (~33 m), deeper (~1.2 m) channel with no protruding boulders. Water velocity and gradient are similar to the upstream section. The lower midstream section is characterized by a 68 m wide and 2.1 m deep channel. Average velocity in this section is 0.8 m/sec, while average gradient is 1.8 m/km. The downstream section is characterized by a single, wide channel with a water velocity of 0.8 m/sec and a gradient of 1.1 m/km. Average stream flow in the downstream section during summer (May-July) has ranged from a low of 50.95 $m^3$/sec in 1980 to a high of 123.86 $m^3$/sec in 1984 (USGS 1976-1990). The majority of recreational fishing occurs in the downstream section (river kilometer 0 to river kilometer 80).

Recreational fishing targets primarily Arctic grayling and chinook salmon *Oncorhynchus tshawytscha* and, to a lesser extent, summer chum salmon *O. keta*, northern pike *Esox lucius*, burbot *Lota lota*, and whitefish *Family Coregonidae*. The Salcha River is road accessible at the Richardson Highway crossing at river kilometer 3.2. Access by car is limited to a 1.6 km area adjacent to the Salcha River State Recreation Area where a boat ramp, parking, and camping are available. Riverboats and airplanes provide much of the access to upstream areas of the Salcha River. Landing strips are located at Caribou Creek at river kilometer 96, and Pasco Creek at river kilometer 104. In 1987, regulations were promulgated to protect the Arctic grayling fishery from decline. These regulations were designed to:

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

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

3) eliminate the harvest of Arctic grayling during the spawning period (1 April to the first Saturday in June).

Prior to 1977 very little data were collected from the recreational fishery. A creel survey was conducted during the summers of 1953 through 1958. Harvest was not estimated, but angler harvest rates ranged from 0.48 Arctic grayling per hour to 1.09 Arctic grayling per hour (Warner 1959b). Angler harvest rate surveys were also conducted in 1963 and 1964; harvest rates were 0.67 and 0.64 fish per hour, respectively (Roguski and Winslow 1969). The first harvest and effort survey was conducted in 1968. A total of 7,048 Arctic grayling was harvested in 7,035 angler-hours for a harvest rate of 1.00 fish per hour (Roguski and Winslow 1969). A harvest and effort survey was also conducted in 1974, with an estimated 4,728 Arctic grayling harvested in 11,284 angler-hours (Kramer 1975).

Since 1977, Mills (1979-1992) has estimated harvest and angling effort on the Salcha River through a postal survey. Annual harvest of Arctic grayling has averaged 6,031 fish, ranging from 1,688 in 1991 to 13,305 in 1984 (Table 1). Angling effort for all species of sport fish has averaged 10,646 angler-days, ranging from 7,494 angler-days in 1988 to 14,126 angler-days in 1982.

Table 1. Recreational Arctic grayling harvest and angling effort on the Salcha, Chatanika, and Goodpaster rivers, 1977-1991 (Mills 1979-1991).

| Year | Salcha River | | Chatanika River | | Goodpaster River | |
|---|---|---|---|---|---|---|
| | Harvest[a] | Effort[b] (angler-days) | Harvest | Effort (angler-days) | Harvest | Effort (angler-days) |
| 1977 | 6,387 | 8,167 | 6,737 | 9,925 | ND[d] | ND |
| 1978 | 9,067 | 9,715 | 9,284 | 10,835 | ND | ND |
| 1979 | 5,980 | 14,788 | 6,121 | 4,853 | ND | ND |
| 1980 | 5,351 | 8,858 | 5,143 | 5,576 | ND | ND |
| 1981 | 3,983 | 8,090 | 3,808 | 4,691 | ND | ND |
| 1982 | 6,843 | 14,126 | 6,445 | 9,417 | ND | ND |
| 1983 | 9,640 | 11,802 | 9,766 | 10,757 | 3,021 | 1,989 |
| 1984 | 13,305 | 8,449 | 4,180 | 8,605 | 1,194 | 766 |
| 1985 | 5,826 | 13,109 | 7,404 | 10,231 | 2,757 | 2,844 |
| 1986 | 7,540 | 13,792 | 2,692 | 7,783 | 1,508 | 933 |
| 1987[d] | 4,762 | 10,576 | 5,619 | 11,065 | 1,702 | 3,061 |
| 1988[d] | 2,383 | 7,494 | 8,640 | 11,642 | 1,273 | 1,037 |
| 1989[d] | 5,721 | 9,704 | 6,934 | 12,210 | 1,964 | 1,930 |
| 1990[d] | 1,992 | 9,783 | 4,237 | 11,801 | 760 | 2,083 |
| 1991[d] | 1,688 | 11,242 | 2,642 | 8,085 | 636 | 786 |
| Average | 6,031 | 10,646 | 5,977 | 9,165 | 1,696 | 1,760 |

[a] Harvest is the estimated number of Arctic grayling taken.
[b] Effort is the number of angler-days expended for all species of fish.
[c] ND - data not available.
[d] Special regulations were in effect on the Salcha River in 1988 through 1991. These special regulations are: 1. Catch and release Arctic grayling fishing from 1 April to the first Saturday in June; 2. 12 inch (305 mm) minimum length limit; and, 3. artificial lures or flies only.

In addition to harvest data provided by Mills (1988), Baker (1988) conducted a creel survey of Salcha River anglers in 1987 (May through August). Catch rate was estimated at 0.66 (SE = 0.40) Arctic grayling harvested per angler-hour.

The study area was a 36.8 km reach of the lower Salcha River bounded upstream at river km 40.0 and downstream at river km 3.2 (the Richardson Highway bridge). This study area has been used yearly since 1989 and also encompasses areas used in earlier studies (see Appendix A). The study area was subdivided into three sections each approximately 12.2 km long (Figure 2).

## Methods

The mark event ran from 15 through 18 June and utilized two electrofishing boats, each sampling one bank of the river. Due to difficulties in meeting sample size goals in 1991 (Fleming et al. 1992), two complete passes were made through the study area to maximize the number of marked fish. Each pass took two days to complete and ran consecutively. After a five day interval, the recapture event ran from 22 through 25 June and utilized one electrofishing boat which took two passes, one along each bank, to sample the study area. Captured Arctic grayling were sampled and released at the end of each electrofishing run. A left pectoral fin clip was used as the second mark and fish were tagged in each event.

Water conditions were generally high and turbid during the experiment. Water level rose 1.6 m from 15 to 18 June then gradually fell 1.3 m by 25 June (data from the United States Geological Survey gauging station at river km 3.4). Water clarity was good on 15 June and deteriorated to turbid conditions for all but the last day of the experiment. During the experiment, pulsator voltage ranged from 225 to 250 VDC while amperes ranged from 3 to 5. At river km 40 on 15 June, conductivity was 120 $\mu$S (standardized to 25°C) and water temperature 9.0°C; on 17 June, conductivity was 80 $\mu$S and water temperature 6.0°C. Between 22 and 25 June, water temperatures ranged from 8.5°C in the mornings to 10.5°C in late afternoon.

Length data were collected during both sampling events while age data was collected during the first event. The length data showed a significant difference in capture probability by size class. Therefore, age and size samples were most likely different than the true age and size composition and the data was stratified by size class. The same size class strata used for abundance estimation were used to estimate adjustment factors for age and size composition estimates. Equations D5.3 through D5.6 of Appendix D5 were used to adjust for differences in capture probability and estimate age and size composition.

## Results

A total of 1,439 Arctic grayling ($\geq$ 150 mm FL) were captured over the eight days of sampling. During the marking event from 15 to 19 June, a total of 782 Arctic grayling were marked and released. During the recapture event, 643 fish were examined for marks and included 52 fish recaptured from the marking event. Only one recaptured fish had shed its tag for a tag shedding rate of

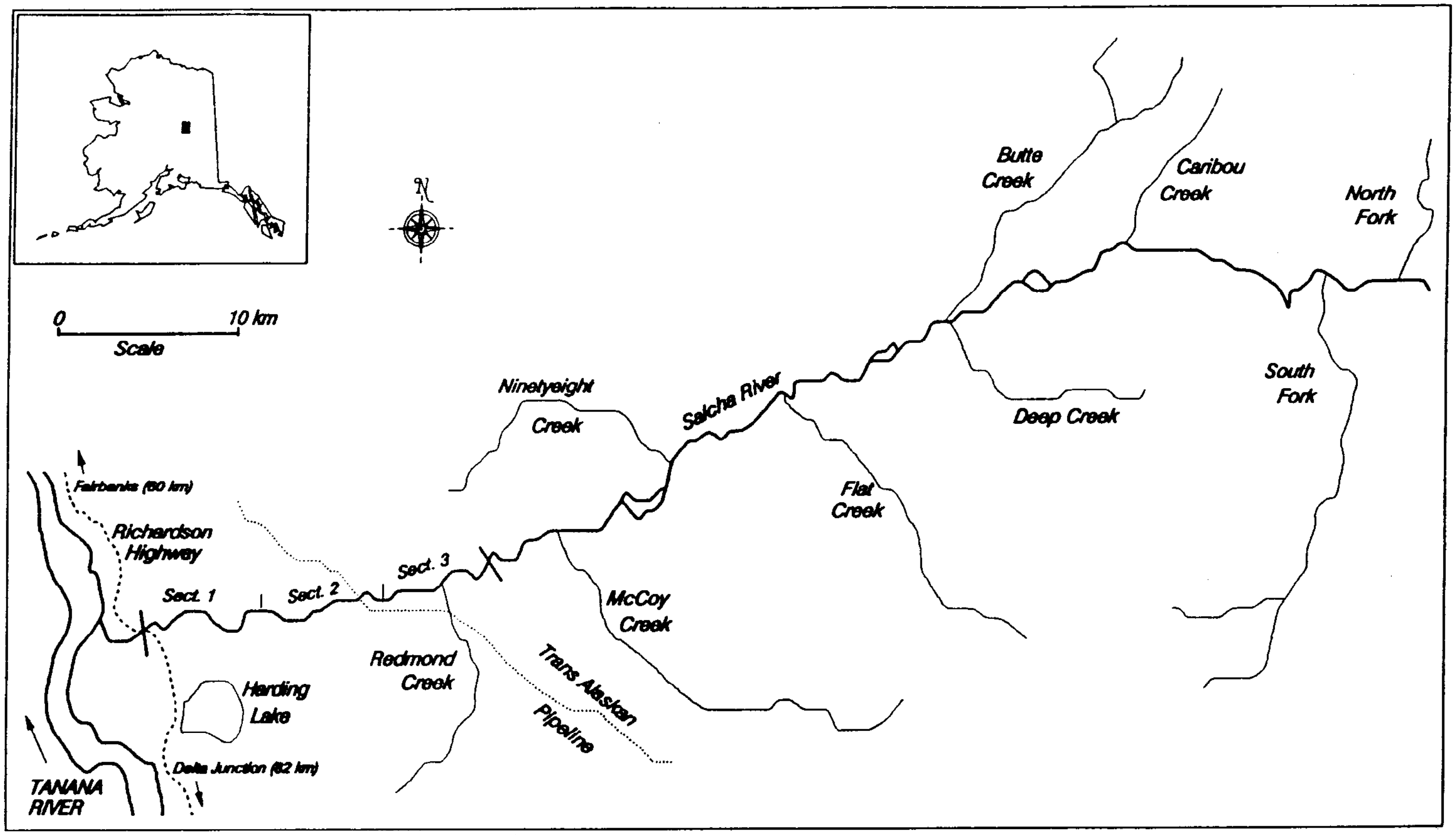


Figure 2. Study sections of the Salcha River in 1992.

1.9%. The immediate mortality rate for the experiment was 1.5% based on 21 lethally injured Arctic grayling. Recaptures of Arctic grayling tagged in previous studies totaled 183, or 13.2% of the total sample (recaptured fish from 1992 marking excluded).

Abundance:

The comparison of Cumulative Distribution Functions (CDF's) of lengths of fish marked during the first event and fish recaptured during the second event indicated they were significantly different (Kolmogorov-Smirnov two-sample test: $D = 0.29$, $P = 7.00 \times 10^{-4}$; Figure 3A). The second Kolmogorov-Smirnov test failed to detect a significant difference between the lengths of fish in the marking and recapture sampling events ($D = 0.05$, $P = 0.26$; Figure 3B). The combined results of the tests indicated unequal capture probabilities by size class of fish occurred during each event and stipulated stratification of the data set by size class (Case III, Appendix D1). An iterative series of chi-square tests indicated that the maximal difference in capture probability occurred at 261 mm FL which was then set as the minimum length for large fish.

With no recaptures of fish between 150 and 199 mm FL, the data set was truncated to include only fish greater than 199 mm FL. The smallest recaptured Arctic grayling was 207 mm FL. A total of 73 fish between 150 and 199 mm FL were marked and released during the first event. During the second event, a total of 65 unmarked fish between 150 and 199 mm FL were captured. In comparison, 52 recaptures were observed out of 578 fish examined with lengths greater than 199 mm FL. Due to the lack of recaptures in the smaller size category, it was thought that the least biased abundance estimate would be obtained using only fish that were greater than 199 mm FL. Re-examination for size selectivity with this data set again indicated that size bias due to unequal capture probabilities occurred during both events (from the first test in Appendix D1: $D = 0.23$, $P = 9.00 \times 10^{-3}$; from the second test: $D = 0.06$, $P = 0.28$) so the data were stratified into small (≤260 mm FL) and large (≥261 mm FL) fish.

In addition to size bias, there was considerable movement of tagged fish between the mark and recapture events (Table 2). Of the 51 recaptured fish with known capture histories (there was 1 tag loss), 31 fish (61% of all recaptures) exhibited inter-run movement. Within this group, 17 fish, 33% of all recaptures, had moved into a different section. This movement was almost entirely downstream; only 3 of these 17 fish were recaptured in an upstream section. The probability of downstream movement ($\theta_d$) was estimated at 0.31 (SE = 0.07) and of upstream movement; 0.10 (SE = 0.04; Table 3). In spite of, or because of this movement, there was no significant difference in section-specific capture probabilities ($\chi^2 = 0.72$, df = 2, $P = 0.66$). From these results, abundance was estimated for each size class using both the Bailey and Evenson estimators (Case II, Appendix D2).

Based on a large difference in abundance estimated with the two estimators and apparent movement of fish out of the study area between events, the estimator of Evenson, stratified by size, was chosen as most appropriate (Table 3). The abundance for fish ≥200 mm FL was 7,706 (SE = 2,555 fish, CV = 33%) as estimated by the Evenson modification (Table 3). The estimate for small fish

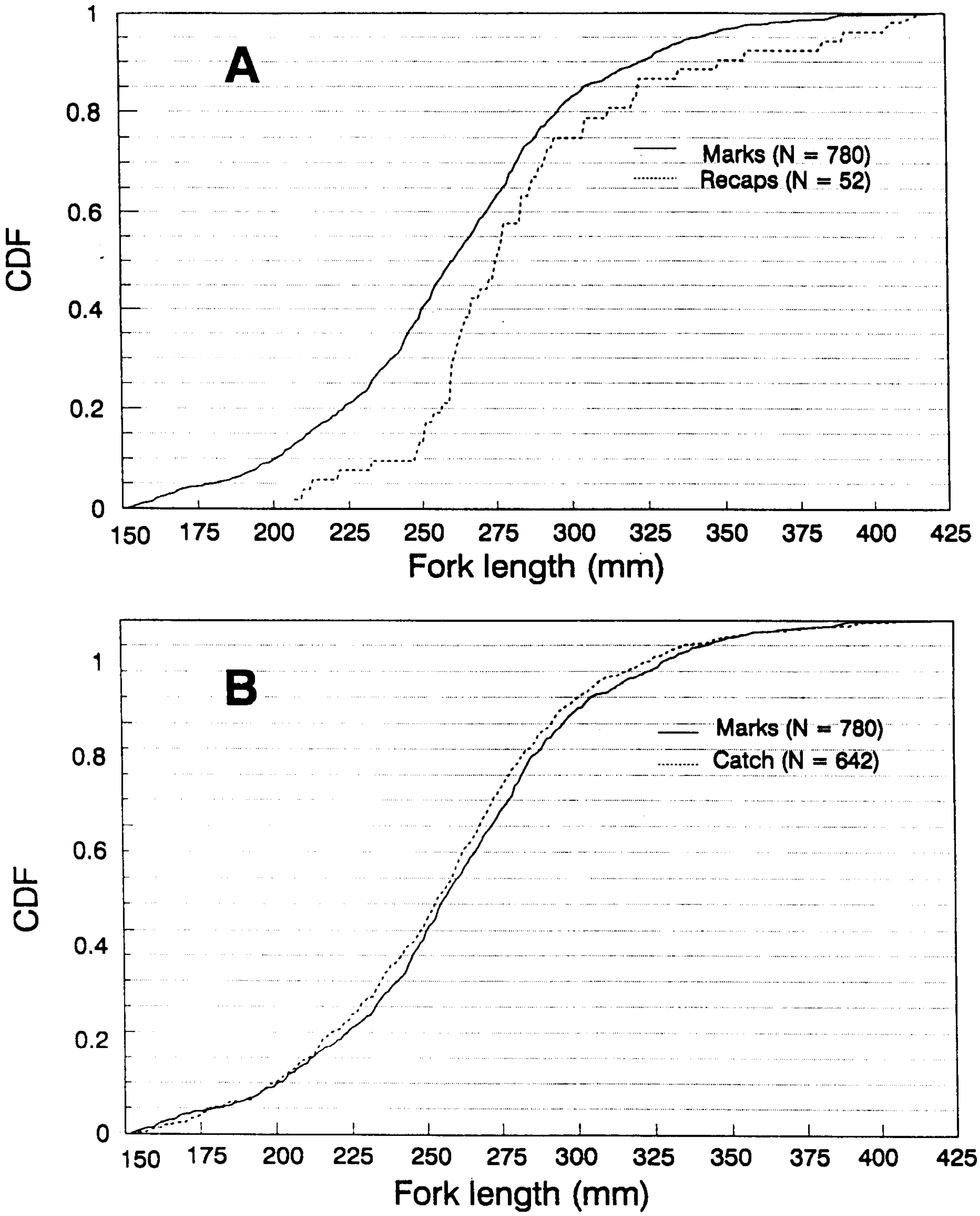


Figure 3. Cumulative distribution functions of lengths of Arctic grayling marked versus lengths of Arctic grayling recaptured (A) and versus lengths of Arctic grayling examined for marks (B) for a 36.8 km section of the Salcha River, 15 through 25 June, 1992.

Table 2. Summary of inter-section and inter-run[a] movements of Arctic grayling (≥ 150 mm FL) based on recaptures (R) in the lower 36.8 km of the Salcha River, 15 through 25 June 1992.

| | | Recapture | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Section 3 | | | | | Section 2 | | | | | Section 1 | | | | | | | | |
| Section | Mark Run # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | $R_{NM}$[b] | $R_M$[c] | Total Recaptured | Total Marked |
| | 1 | 1 | | | | | | | | | | | | | | | 1 | 0 | 1 | 108 |
| | 2 | 1 | 0 | | | | | | | | | | | | | | 0 | 1 | 1 | 40 |
| 3 | 3 | | 1 | 5 | | 2 | 1 | | | | | | | | | | 5 | 4 | 9 | 71 |
| | 4 | | | 1 | 2 | | 1 | 1 | | | 1 | | | | | 1 | 2 | 5 | 7 | 76 |
| | 5 | | | | | 3 | | 2 | 2 | | | | | | | | 3(11) | 4(14) | 7 (25) | 48 (343)[d] |
| | 6 | | | | | | 0 | | | | 1 | 1 | | | | | 0 | 2 | 2 | 42 |
| | 7 | | | | | | | 0 | 1 | | | 1 | | | | | 0 | 2 | 2 | 45 |
| 2 | 8 | | | 1 | | | | | 4 | | 2 | | | | | 1 | 4 | 4 | 8 | 75 |
| | 9 | | | 1 | | 1 | | | | 0 | | 2 | | | | | 0 | 4 | 4 | 41 |
| | 10 | | | | | | | | | | 0 | | | | | | 0(4) | 0(12) | 0 (16) | 19 (222) |
| | 11 | | | | | | | | | | | 0 | 1 | | | | 0 | 1 | 1 | 39 |
| | 12 | | | | | | | | | | | | 1 | | | | 1 | 0 | 1 | 24 |
| 1 | 13 | | | | | | | | | | | | | 1 | 3 | 1 | 1 | 4 | 5 | 58 |
| | 14 | | | | | | | | | | | | | | 0 | | 0 | 0 | 0 | 32 |
| | 15 | | | | | | | | | | | | | | | 3 | 3(5) | 0(5) | 3 (11[e]) | 64 (217) |
| | | Upstream | | | | | Midstream | | | | | Downstream | | | | | | | | |

[a] Locations are broken into river sections (see Methods) and run number. A run is approximately 2.4 km long, the distance covered by a 20 minute downstream pass of an electrofishing boat. Run 1 starts at river km 40.0 and run 15 ends at river km 3.2.

[b] $R_{NM}$ = Fish recaptured in same run as marked.

[c] $R_M$ = Fish recaptured either up or downstream of marking location.

[d] Numbers in parentheses are totals.

[e] Includes one fish that shed its tag (so the run it was marked in is unknown) and was recaptured in run 15.

Table 3. Population abundance estimate of Arctic grayling (≥ 200 mm FL) in the lower 36.8 km of the Salcha River, 15 through 25 June, 1992.

| | Calculated or Known Value | | | Bootstrap Estimate | | |
|---|---|---|---|---|---|---|
| Parameter[a] | 200 - 260mm | ≥261mm | Sum | 200 - 260mm | ≥261mm | Sum |
| $M_1$ | 118 | 69 | 187 | 118 | 69 | 187 |
| $M_2$ | 62 | 127 | 203 | 62 | 127 | 203 |
| $M_3$ | 122 | 197 | 319 | 122 | 197 | 319 |
| $C$ | 267 | 311 | 578 | 267 | 311 | 578 |
| $R_{..}$ | 13 | 39 | 52 | 13 | 39 | 52 |
| $R_{12}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| $R_{21}$ | 1 | 4 | 5 | 1 | 4 | 5 |
| $R_{22}$ | 1 | 7 | 8 | 1 | 7 | 8 |
| $R_{23}$ | 0 | 3 | 3 | 0 | 3 | 3 |
| $R_{2.}$ | 2 | 14 | 16 | 2 | 14 | 16 |
| $R_{32}$ | 1 | 7 | 8 | 1 | 7 | 8 |
| $\theta_d$ | 0.34 | 0.31 | 0.32 | 0.38 | 0.32 | 0.31 |
| SE | --- | --- | --- | 0.31 | 0.10 | 0.07 |
| $\theta_u$ | 0 | 0.14 | 0.10 | 0 | 0.14 | 0.10 |
| SE | --- | --- | --- | 0 | 0.05 | 0.04 |
| Evenson (1988) Estimator: | | | | | | |
| Stratified | | | | | | |
| $\hat{N}$ | 5,020 | 2,686 | 7,706 | 5,805 | 2,725 | 8,530 |
| SE | --- | --- | --- | 2,526 | 383 | 2,555 |
| Unstratified; | | | | | | |
| $\hat{N}$ | --- | --- | 6,760 | --- | --- | 6,865 |
| SE | --- | --- | --- | --- | --- | 589 |
| Bailey (1951) Estimator: | | | | | | |
| Stratified | | | | | | |
| $\hat{N}$ | 6,049 | 3,065 | 9,114 | Bootstrap not performed. | | |
| SE | 1,521 | 447 | 1,585 | Bootstrap not performed. | | |
| Unstratified; | | | | | | |
| $\hat{N}$ | --- | --- | 7,745 | Bootstrap not performed. | | |
| SE | --- | --- | 1,005 | Bootstrap not performed. | | |

[a] Parameter definitions are: $M_x$ (x = 1, 2, 3) = the number of Arctic grayling marked during the first event in the downstream (1), midstream (2), and upstream (3) areas; $C$ = the number of Arctic grayling examined for marks during the second event (regardless of area); $R_{xy}$ (x and y = 1, 2, 3) = the number of marked Arctic grayling recovered during the second event that were released in area x during the first event and recovered in area y during the second event (an ellipsis denotes all areas summed); and, $\theta_x$ = the probability of downstream (d) or upstream (u) movement between sampling events.

[b] Number of bootstrap replications was 1,000.

was 5,020 fish (SE = 2,526 fish, CV = 50%) and for large fish was 2,686 fish (SE = 383, CV = 14%). The probability of downstream movement was 0.38 (SE = 0.31) for small fish and 0.32 (SE = 0.10) for large fish (Table 3). The probability of upstream movement was 0 for small fish and 0.14 (SE = 0.05) for large fish (Table 3).

Composition:

Based on results of the K-S tests, age and size composition were adjusted for differential capture probability by size. Of fish 200 mm FL and larger, age 4 fish were most abundant, comprising 48% of estimated abundance (Table 4). Age 5 fish comprised 25% of estimated abundance while ages 6 and older comprised approximately 13% of estimated abundance. RSD indices indicated that 71% of estimated abundance (≥ 200 mm FL) was of stock size fish, 25% were quality size and 4% were preferred size (Table 5).

## Discussion

Stock assessment work has been conducted on the same study section of the Salcha River for four consecutive years. Although more Arctic grayling were captured in 1992 than in any of the previous three years' experiments, the study objectives of estimating abundance, age, and size composition of Arctic grayling ≥ 150 mm FL were not met. This is the second consecutive year that these objectives have not been met on the Salcha River, due to the low capture probability of fish between 150 and 199 mm FL (primarily age 2 and 3 fish).

A simple catch curve was constructed using the unadjusted proportion of fish at age in the mark event. Judging by the shape of this curve, Arctic grayling were not fully recruited to the gear until age 4; age 2 and age 3 fish are then underrepresented in the sample (Figure 4). This result coincides with the poor catchability of fish < 200 mm FL; 96% of age 2 fish are < 200 mm FL, as are 35% of age 3 fish. By comparison, 99% of age 4 fish are ≥ 200 mm FL. When historic data are truncated to exclude age 2 and age 3 fish, estimated age and size compositions are similar from year to year (Figure 5). To minimize bias in stock parameter estimates, future stock assessment on the Salcha River should be restricted to Arctic grayling ≥ 200 mm FL.

The downstream movement of marked fish between sampling events was most likely a reaction to the rapid rise in water level. Given such a high water event in early summer, however, contemporary theory on Arctic grayling movement patterns would have predicted an upstream movement of fish. Of the fish that moved, 67% were ≤ 280 mm FL, and 97% of the recaptured fish ≤ 280 mm FL moved downstream (Figure 6). The size range of these fish indicates that this downstream movement was primarily of immature fish (<304 mm FL, Clark 1992).

Density of Arctic grayling in the Salcha River this year was the second highest ever estimated for this river section (209 fish/km), although it would be even higher if fish < 200 mm FL were included (Appendix A2). Relative Stock Density estimates are similar to estimates from 1991; 1991 estimates were also estimated using only fish ≥ 200 mm FL. The component of quality size fish (41%), is the largest ever estimated in this river section (Appendix A4). Estimated annual harvest for 1990 and 1991 are less than one-third of

Table 4. Estimates of age class composition and standard error for Arctic grayling (≥150 mm FL and ≥200 mm FL) captured in the Salcha River, 15 through 18 June, 1992.

| | ≥150 mm FL | | | ≥200 mm FL | | | |
|---|---|---|---|---|---|---|---|
| Age Class | n[a] | p[b] | SE[c] | n | p | p[d] | SE[e] |
| 2 | 25 | 0.04 | 0.01 | 1 | <0.01 | <0.01 | <0.01 |
| 3 | 96 | 0.14 | 0.01 | 62 | 0.10 | 0.15 | 0.03 |
| 4 | 254 | 0.38 | 0.02 | 251 | 0.40 | 0.48 | 0.04 |
| 5 | 183 | 0.27 | 0.02 | 183 | 0.30 | 0.25 | 0.03 |
| 6 | 66 | 0.10 | 0.01 | 66 | 0.11 | 0.07 | 0.02 |
| 7 | 28 | 0.04 | 0.01 | 28 | 0.05 | 0.03 | 0.01 |
| 8 | 18 | 0.03 | 0.01 | 18 | 0.03 | 0.02 | 0.01 |
| 9 | 5 | 0.01 | <0.01 | 5 | 0.01 | 0.01 | <0.01 |
| 10 | 1 | <0.01 | <0.01 | 1 | <0.01 | <0.01 | <0.01 |
| Totals | 676 | 1.00 | --- | 615 | 1.00 | 1.00 | --- |

[a] n = sample size.
[b] p = proportion.
[c] SE = standard error of the proportion.
[d] p = adjusted proportion (from Appendix D5).
[e] SE = standard error of the adjusted proportion.

Table 5. Summary of RSD indices for Arctic grayling (≥150 mm FL and ≥200 mm FL) in the Salcha River, 15 through 18 June, 1992.

| | RSD Category[a] | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| <u>≥150 mm FL</u>: | | | | | |
| Number sampled | 450 | 290 | 42 | 0 | 0 |
| Sample RSD | 0.58 | 0.37 | 0.05 | --- | --- |
| Standard Error | 0.02 | 0.02 | 0.01 | --- | --- |
| CV (%) | 3 | 5 | 20 | --- | --- |
| <u>≥200 mm FL</u>: | | | | | |
| Number sampled | 377 | 290 | 42 | 0 | 0 |
| Sample RSD | 0.53 | 0.41 | 0.06 | --- | --- |
| Adjusted RSD[b] | 0.71 | 0.25 | 0.04 | --- | --- |
| Standard Error[c] | 0.08 | 0.07 | 0.01 | --- | --- |
| CV (%) | 11 | 28 | 25 | --- | --- |

[a] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984):
- Stock - 150 mm FL;
- Quality - 270 mm FL;
- Preferred - 340 mm FL;
- Memorable - 450 mm FL; and,
- Trophy - 560 mm FL.

[b] RSD proportions were adjusted to reflect the unequal capture probabilities of Arctic grayling between 200 - 260 mm FL and those over 260 mm FL (Appendix D5).

[c] Standard error of the adjusted RSD.

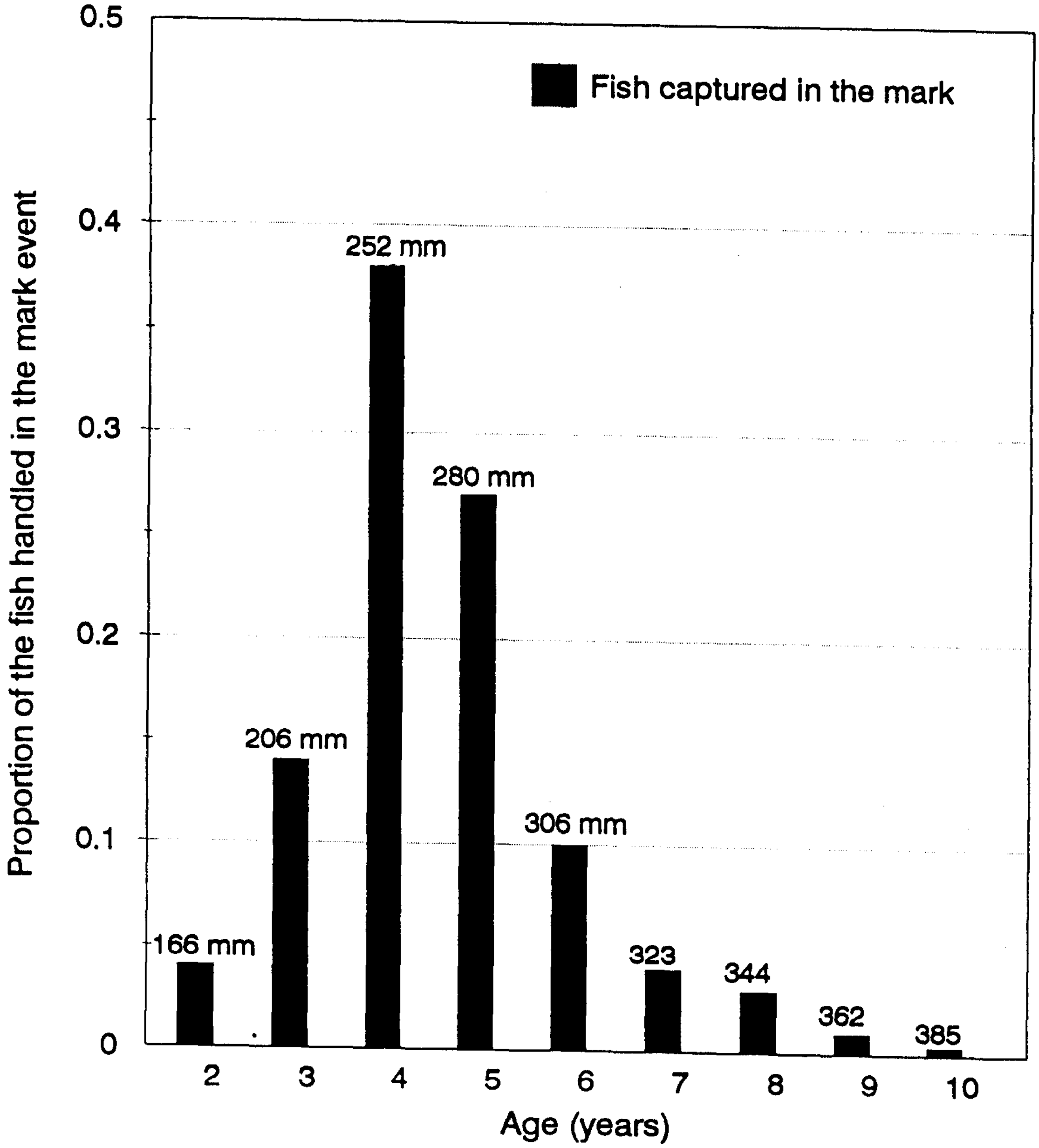


Figure 4. Arctic grayling catch curve resulting from captures using a pulsed DC electrofishing boat on the Salcha River, 15 through 25 June, 1992.

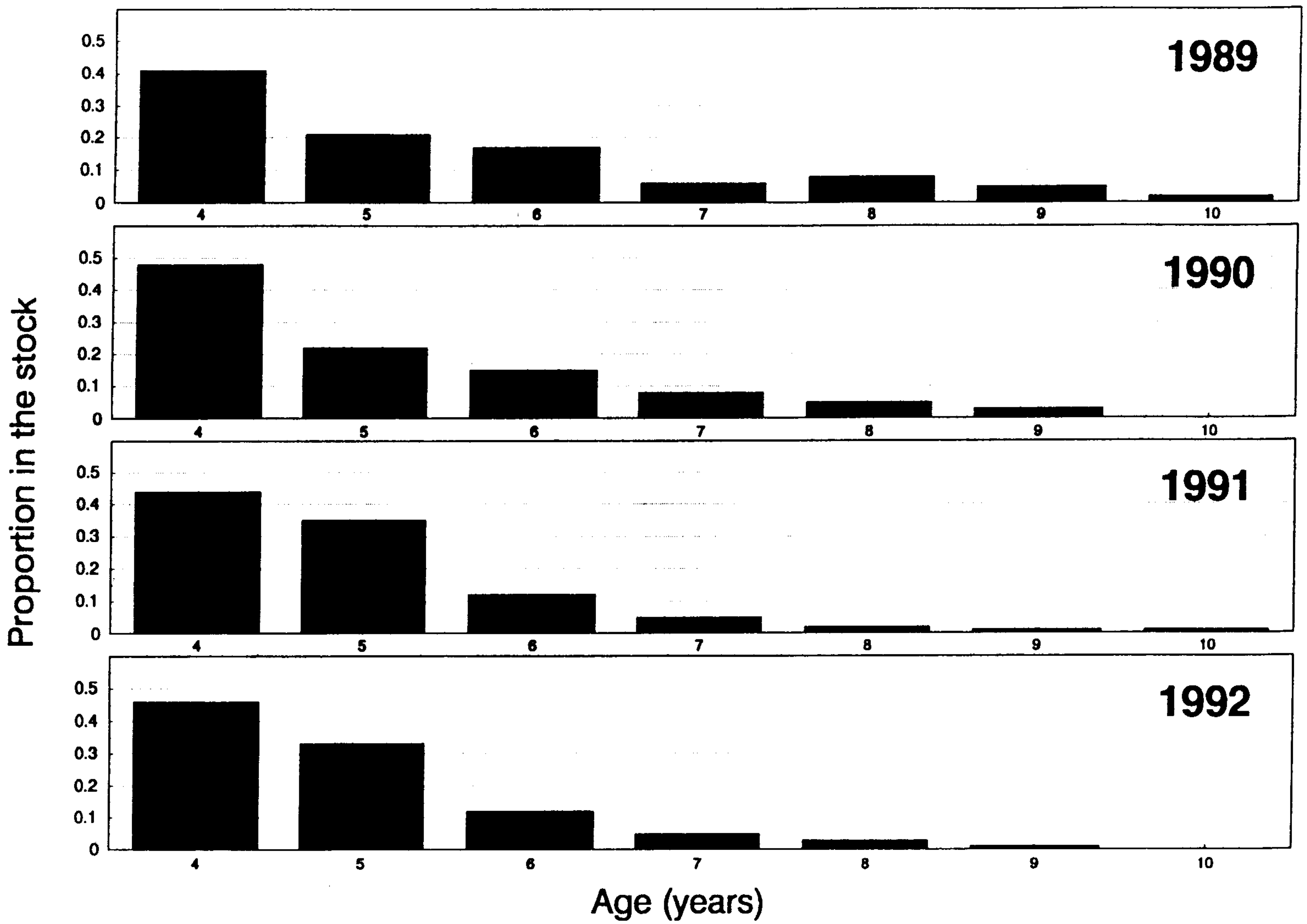


Figure 5. Historical age compositions of age 4 fish and older, for a 36.8 km section of the Salcha River. Data from adjusted age compositions were used for the 1991 estimates.

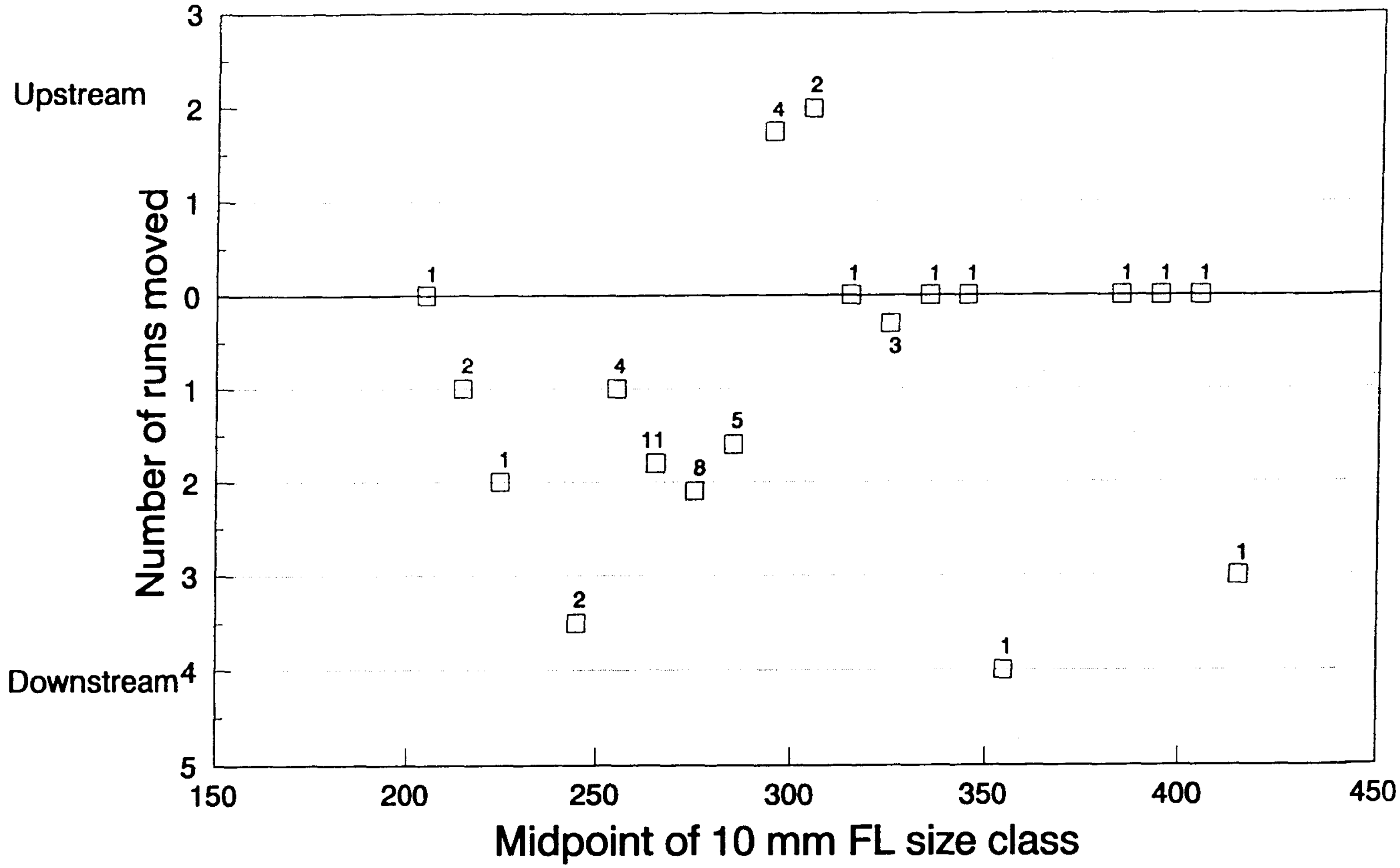


Figure 6. Movements of tagged Arctic grayling by length group based on mark and recapture locations, 15 through 25 June, 1992. Numbers above boxes represent sample size.

the estimated annual average (1977-1991; Table 1). These results may indicate that the sport fishing regulations enacted on the Salcha River in 1987 may have been effective in reducing the negative impacts of harvest on the stock.

## CHATANIKA RIVER

### Fishery Description and Study Area

The Chatanika River is a rapid run-off stream that flows southwest out of the White Mountains, draining through Minto Flats into the Tolovana River (Figure 7). Formed by the confluence of Faith and McManus creeks, the Chatanika River parallels the Steese Highway for approximately 70 km. The Chatanika River is also crossed at kilometer 18 of the Elliott Highway. Townsend (1987) described three reaches of the Chatanika River. Much of the upper reach (Long Creek to the headwaters) is accessible from the Steese Highway and supports recreational fishing for Arctic grayling, three species of whitefish, and two species of Pacific salmon. The middle reach is also accessible from the Steese and Elliott highways and supports fishing for these species as well. The lower reach is accessible by riverboat from the Elliott Highway and the Murphy Dome Road Extension. This reach of the Chatanika River supports Arctic grayling, northern pike, sheefish *Stenodus leucichthys*, and burbot fishing. In 1992, regulations for the Arctic grayling fishery were promulgated to protect the fishery from decline. These regulations were designed to:

1) restrict the harvest of Arctic grayling to fish 305 mm (12 in) or greater in total length in that portion of the drainage upstream from a point 1.6 km above the Elliot Highway bridge; and,

2) eliminate the harvest of Arctic grayling during the spawning period (1 April to the first Saturday in June).

The Chatanika River is much more accessible than the Salcha or Goodpaster rivers, mainly due to a long history of placer mining in the area. As of 1986, there were placer mining operations on portions of Faith, Sourdough, No Name, and Flat creeks of the upper Chatanika River (Townsend 1987). Townsend (1987) also reported mining activity on Goldstream Creek in the lower Chatanika River. There are four recreation sites on the Chatanika River; 63-km Steese Highway campground, 18-km Elliott Highway (one campground and one picnic area), and 98-km Steese Highway campground.

Although extensive studies of the Chatanika River Arctic grayling fishery were performed before statehood (Warner 1959b), very little creel survey data were obtained prior to 1977. Angler catch rates were estimated during the summers from 1953 through 1958, ranging from 0.13 Arctic grayling per hour in 1955 to 0.78 Arctic grayling per hour in 1954 (Warner 1959b). Fishery managers during this period thought that excessive harvest of sub-adult Arctic grayling was causing declines in fish abundance and angler catch rates (Wojcik 1954, 1955). A 305 mm (12 inch) minimum length limit for Arctic grayling was enforced between 1955 and 1958, but was removed in 1959 (Warner 1959b).

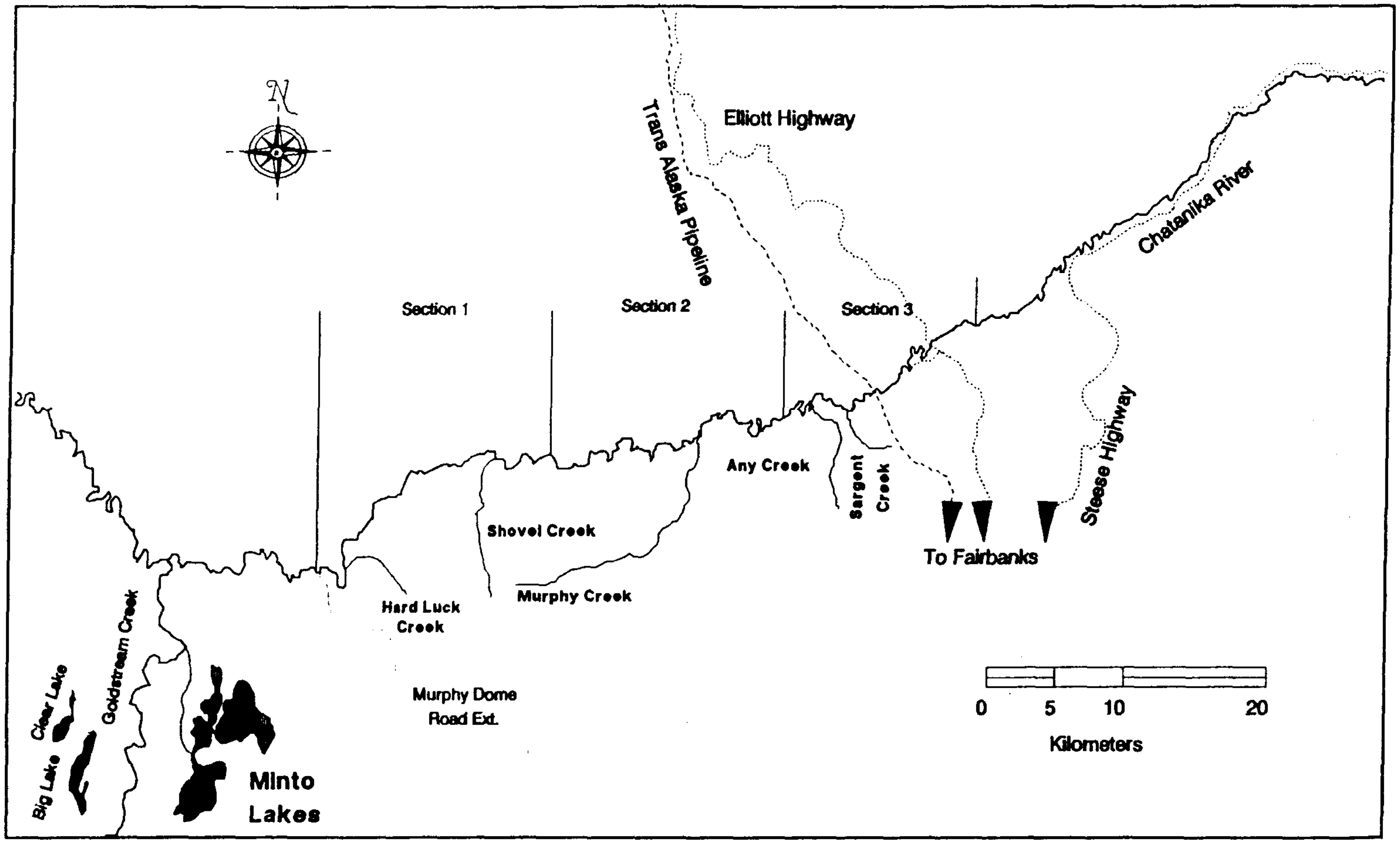


Figure 7. Study sections of the middle Chatanika River in 1992.

A creel survey of the Chatanika River Arctic grayling fishery along the Steese Highway was conducted by Kramer (1975) in 1974. An estimated 27,250 angler-hours were expended with a catch rate of 1.02 Arctic grayling per hour. Baker (1988) conducted a creel survey around the Elliott highway crossing in 1987 (May through June) and estimated a catch rate of 0.02 Arctic grayling harvested per angler-hour. From 1977 through 1991, harvest of Arctic grayling was estimated by Mills (1979-1992). The average annual harvest was 5,977 fish during this period, with 9,165 angler-days of effort (Table 1). Annually, harvests ranged from 2,642 fish in 1991 to 9,766 fish in 1983.

The study area encompassed areas used for stock assessment in 1972 (Tack 1973); 1981 (Hallberg 1982); 1982, 1984, and 1985 (Holmes 1983, 1985 and Holmes, et al. 1986); 1990 (Clark, et al. 1991); and 1991 (Fleming et al. 1992). It covered a 112 km reach of the Middle Chatanika River starting at a point 3.2 km above the Elliot Highway crossing and extending downstream to the Murphy Dome Road Extension (Figure 7). To quantify movements, the study area was partitioned into three sections after the experiment by equalizing the number of runs in each. This provided for equal effort in each section but not equal distances. The upstream section, section 3, was approximately 29 km long and extended from 3 km upstream of the Elliott Highway crossing to below the confluence of Any Creek. This section is nearly identical to the area used in 1990 and 1991. Sections 2 and 1 then extended 83 km downstream to the Murphy Dome Road and were identical to the lower area in 1991 (Fleming et al. 1992).

Methods

Two 5 day sampling events were conducted in conjunction with a whitefish mark-recapture experiment. The marking event ran from 17 to 21 August and the recapture event ran from 24 to 28 August. The time interval between sampling events at any one point of the river was seven days. Sampling consisted of electrofishing along both banks to collect as many Arctic grayling and whitefish as possible. Sampling both banks from run 1 through 19 required only one pass of the electrofishing boat due to the river's narrow width (~10-15 m wide). The entirety of either bank of the river was not sampled completely. From run 20 to the lower boundary, sampling utilized two electrofishing boats each fishing a bank. At the end of each run, all captured fish were sampled and released. Two different fin clips were used: a partial clip of the upper lobe of the caudal fin during the marking event and a similar clip of the lower lobe during the recapture event. The former clip was used to allow determination of mark status if a tag was shed. The latter clip was used to prevent sampling redundancy and confusion in determination of tag loss since fish were not being tagged during the second event.

Pulsator voltage ranged from 200 to 250 VDC while amperes ranged from 2 to 7. Conductivity was 130 $\mu$S (standardized to 25°C) for the first four days of the experiment. Water temperature was 9.5°C at each conductivity measurement. Water level was moderate to low and water clarity was good during the experiment. Water level fell approximately 0.1 m between the start of the two events.

Length data were collected during both sampling events and age data collected from every fifth fish during the second event. The length data showed a significant difference in capture probability by both size class and section. Therefore, age and size samples taken with the electrofishing boat were most likely different than the true age and size composition. The same size class and section strata used for abundance estimation were used to estimate adjustment factors for age and size composition estimates. Equations D5.3 through D5.8 of Appendix D5 were used to adjust for differences in capture probability and estimate age and size composition.

Results

Total electrofishing effort of 44.3 hours captured 4,051 Arctic grayling (≥150 mm FL) which were used in the experiment. In the marking event, 17 through 21 August, 2,446 Arctic grayling were marked and released. In the recapture event, 24 through 28 August, 1,605 Arctic grayling were captured and examined for marks and 265 were found to be recaptures from the first event. During the experiment, immediate sampling mortality rate was 0.3% as 22 Arctic grayling were either killed or severely injured. Recaptures of Arctic grayling tagged in previous studies totaled 221, or 5.8% of the total sample minus recaptures from 1992 marks.

Abundance:

The data were stratified by area and length to alleviate biases in capture probability and size selectivity. Contingency tests found significant differences in capture probability between sections ($\chi^2 = 27.67$, $df = 2$, $P = 9.8 \times 10^{-7}$; Figure 8). Within each section, cumulative function distributions (CDF's) inferred size selectivity which required further stratification by size class (from the first test in Appendix D1: for the lower section: $D = 20$, $P < 0.01$; for the middle section (2): $D = 0.13$, $P = 0.07$; for the upper section (3): $D = 0.26$, $P = 0.01$; Figure 9A). The two size strata for each section, representing "small" fish and "large" fish were determined through an iterative series of chi-square tests and were dissimilar between sections (Table 6). After size stratification of the three section's data, no recaptures were found in the 150 to 199 mm FL range of the middle section's small fish stratum (150 - 306 mm FL). (The other sections each had one recapture.) The number of fish less than 200 mm FL marked and captured in the middle section, 19 and 15 fish respectively, represented only 4% of the small fish stratum. Since random chance could be responsible for no recaptures of fish less than 200 mm FL, the data was not truncated to exclude them and the estimated population of small fish in the middle section can apply to their full size range.

No significant movement of marked fish was detected during the experiment and the Bailey modification of the Petersen estimator was used to estimate abundance. While 46 recaptured fish showed inter-run movement, only 26 fish (9.8% of all recaptures) showed significant movement (more than one run downstream or one or more runs upstream; Table 7). Twenty-three of these latter fish moved upstream and three fish moved downstream yet only two fish (0.8% of all recaptures) moved between study sections; one moved downstream 4 runs and one moved upstream 1 run. The probability of movement was considered

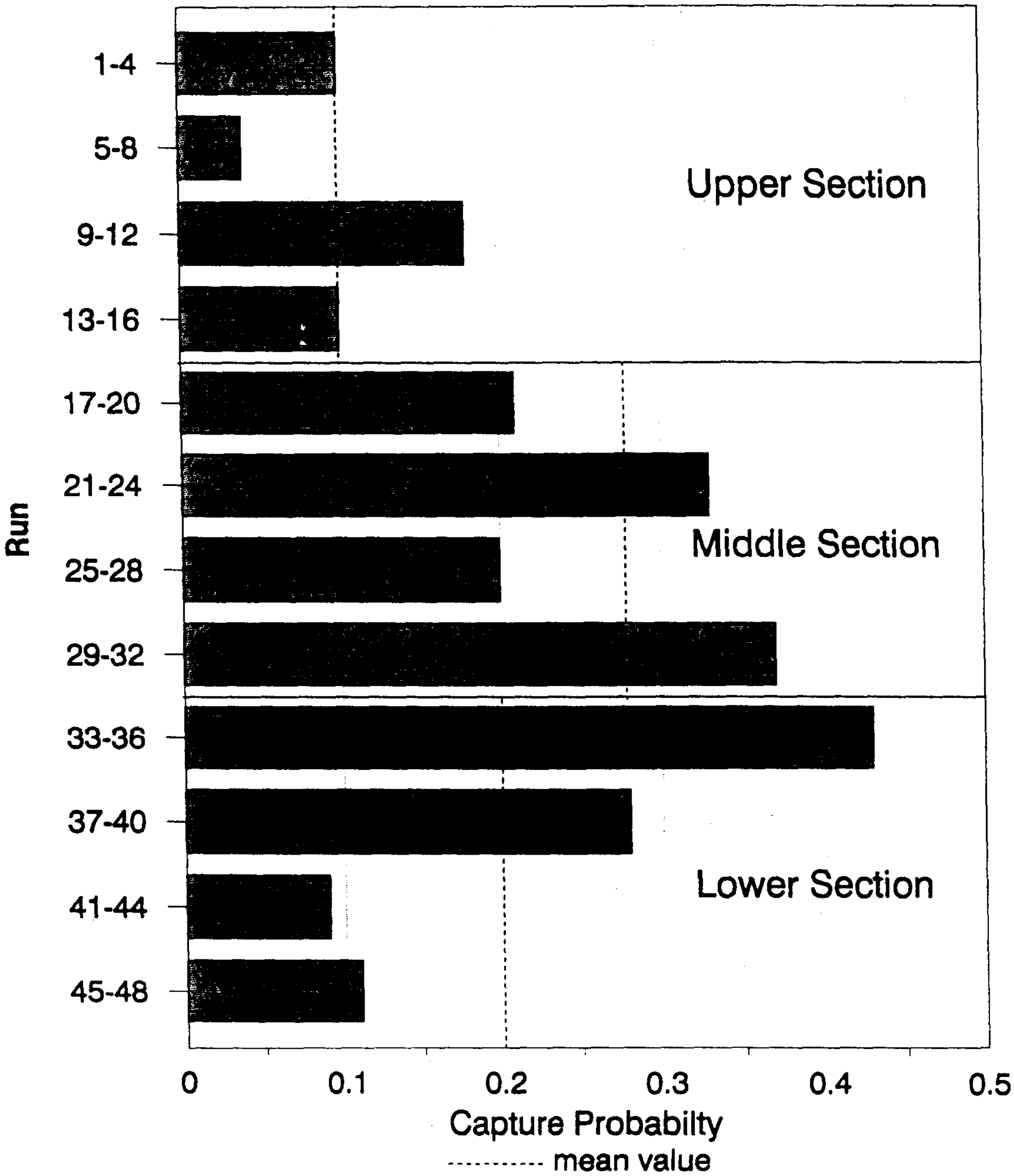


Figure 8. Estimated capture probabilities for Arctic grayling in three study sections within a 112 km reach of the middle Chatanika River, 1992.

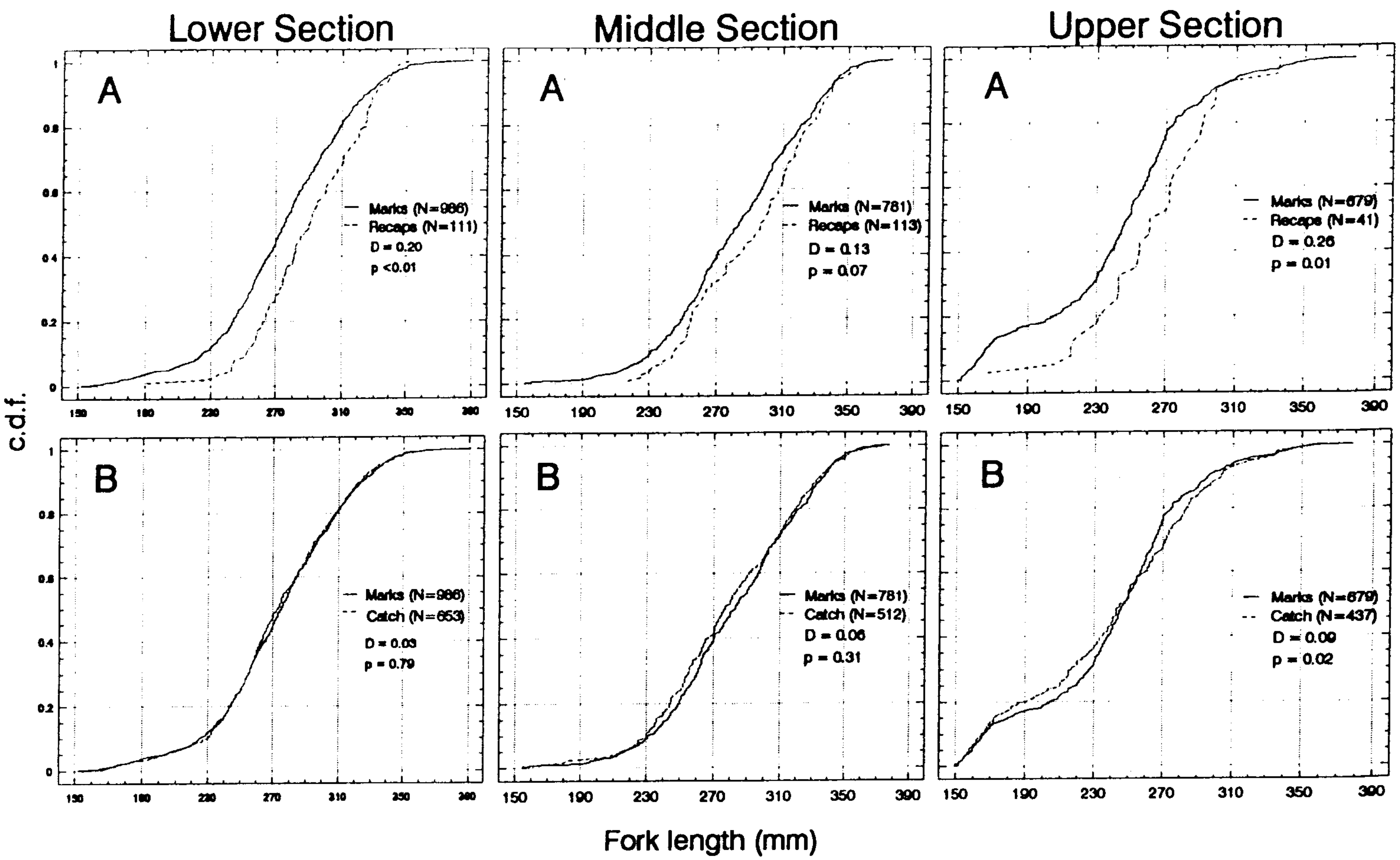


Figure 9. Cumulative distribution functions of lengths of Arctic grayling marked versus lengths of Arctic grayling recaptured (A) and versus lengths of Arctic grayling examined for marks (B) for three sections within a 112 km reach of the middle Chatanika River, 17 through 28 August 1992.

Table 6. Stratified and unstratified estimates of Arctic grayling (≥ 150 mm FL) capture probability and abundance in three sections of the Middle Chatanika River, 17 through 28 August, 1992.

| Length category | Mark M | Catch C | Recap R | $\rho$[a] | SE[$\rho$][b] | $N$[c] | SE[$N$][d] |
|---|---|---|---|---|---|---|---|
| Upper Section | | | | | | | |
| 150 to 271 mm | 526 | 305 | 22 | 0.04 | 0.01 | 6,998 | 1,374 |
| ≥ 272 mm | 153 | 132 | 19 | 0.13 | 0.02 | 1,017 | 205 |
| Total | 679 | 437 | 41 | --- | --- | 8,016 | 1,389 |
| Unstratified | 679 | 437 | 41 | 0.06 | 0.01 | 7,081 | 1,027 |
| Middle Section | | | | | | | |
| 150 to 306 mm | 543 | 355 | 65 | 0.12 | 0.01 | 2,929 | 323 |
| ≥ 307 mm | 238 | 157 | 48 | 0.20 | 0.03 | 767 | 90 |
| Total | 781 | 512 | 113 | --- | --- | 3,696 | 335 |
| Unstratified | 781 | 512 | 113 | 0.14 | 0.02 | 3,515 | 289 |
| Lower Section | | | | | | | |
| 150 to 257 mm | 326 | 213 | 14 | 0.04 | 0.01 | 4,394 | 1,025 |
| ≥ 258 mm | 659 | 439 | 96 | 0.15 | 0.01 | 2,989 | 267 |
| Total | 986 | 653 | 111 | --- | --- | 7,383 | 1,059 |
| Unstratified | 986 | 653 | 111 | 0.11 | 0.01 | 5,758 | 493 |
| Sections Summed | | | | | | | |
| Total | 2,446 | 1,602 | 265 | --- | --- | 19,095 | 1,778 |
| Unstratified | 2,446 | 1,605 | 265 | 0.11 | <0.01 | 16,353 | 1,175 |

[a] $\rho$ is the probability of capture determined from bootstrap methods.
[b] SE[$\rho$] is the standard error of $\rho$ determined from bootstrap methods.
[c] $N$ is the estimated abundance in a stratified length category or unstratified population, determined through bootstrap methods.
[d] SE[$N$] is the bootstrap standard error of $N$.

Table 7. Summary of movements[a] of Arctic grayling in a 112 km section of the Chatanika River, 17 through 28 August 1992.

| | Recapture: Upstream Section 3 | | | | | | | | | | | | | | | | Midstream Section 2 | | | | | | | | | | | | | | | | Downstream Section 1 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| n[b] | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| 1 | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | 6 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | 0 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | 1 | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | 0 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | 4 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | 7 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | 2 | 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | | | | | | | 1 | | 19 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | | | | | 1 | | | | 2 | 7 | 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 23 | | | | | | | | | | | | | | | | | | | | | | | 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | | | | | 1 | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | | |
| 27 | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | 3 | | | | | | | | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 5 | | | | | | | | | | | | | | | | | | |
| 31 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 10 | | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | 9 | | | | 1 | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 7 | | | | | | | | | | | | | | | |
| 34 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 0 | | | | | | | | | | | | | | |
| 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 10 | 3 | | | | | | | | | | | | |
| 36 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 9 | 2 | | | | | | | | | | | |
| 37 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 1 | 1 | | | | | | | | | | |
| 38 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 9 | | | | | | | | | | |
| 39 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | 2 | | | 6 | 1 | 1 | | | | | | | |
| 40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 15 | | | | | | | | |
| 41 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | 1 | | | | | | |
| 42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | | | | | | |
| 43 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | | |
| 44 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 8 | | | | |
| 45 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | | |
| 46 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 2 | | |
| 47 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 | |
| 48 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 4 |

- continued -

Table 7. (Page 2 of 3).

| n | $R_{NM}$[c] | $R_M$[d] | Total R | Total M |
|---|---|---|---|---|
| 1 | 4 | 0 | 4 | 92 |
| 2 | 6 | 1 | 7 | 96 |
| 3 | 3 | 0 | 3 | 42 |
| 4 | 0 | 0 | 0 | 39 |
| 5 | 0 | 1 | 1 | 22 |
| 6 | 1 | 1 | 2 | 35 |
| 7 | 0 | 0 | 0 | 39 |
| 8 | 0 | 0 | 0 | 48 |
| 9 | 4 | 0 | 4 | 67 |
| 10 | 0 | 1 | 1 | 29 |
| 11 | 5 | 0 | 5 | 50 |
| 12 | 5 | 0 | 5 | 41 |
| 13 | 1 | 0 | 1 | 15 |
| 14 | 0 | 1 | 1 | 17 |
| 15 | 4 | 1 | 5 | 34 |
| 16 | 1 (34) | 1 (7) | 2 (41) | 13 (679)[e] |
| 17 | 8 | 0 | 8 | 76 |
| 18 | 7 | 1 | 8 | 100 |
| 19 | 7 | 0 | 7 | 49 |
| 20 | 2 | 2 | 4 | 34 |
| 21 | 19 | 1 | 20 | 82 |
| 22 | 7 | 6 | 13 | 90 |
| 23 | 5 | 0 | 5 | 38 |
| 24 | 2 | 1 | 3 | 42 |
| 25 | 1 | 0 | 1 | 37 |
| 26 | 2 | 2 | 4 | 25 |
| 27 | 3 | 1 | 4 | 27 |
| 28 | 2 | 0 | 2 | 24 |
| 29 | 2 | 1 | 3 | 10 |
| 30 | 5 | 1 | 6 | 43 |
| 31 | 10 | 0 | 10 | 33 |
| 32 | 9 (93) | 4 (20) | 13 (113) | 71 (781) |
| 33 | 7 | 1 | 8 | 43 |
| 34 | 0 | 2 | 2 | 17 |
| 35 | 10 | 3 | 13 | 66 |
| 36 | 9 | 4 | 13 | 59 |
| 37 | 1 | 2 | 3 | 21 |
| 38 | 9 | 0 | 9 | 88 |
| 39 | 6 | 5 | 11 | 110 |
| 40 | 15 | 0 | 15 | 121 |
| 41 | 3 | 1 | 4 | 52 |
| 42 | 1 | 0 | 1 | 54 |
| 43 | 3 | 0 | 3 | 72 |
| 44 | 8 | 0 | 8 | 65 |
| 45 | 4 | 0 | 4 | 46 |
| 46 | 2 | 1 | 3 | 41 |
| 47 | 4 | 0 | 4 | 54 |
| 48 | 4 (92) | 0 (19) | 4 (111) | 77 (986) |

- continued -

Table 7. (Page 3 of 3).

[a] Recapture locations are broken into river sections (see Methods) and run number. A run is approximately 1.8 km long, the distance covered by a 20 minute downstream pass of an electrofishing boat. Run 1 starts at the head of the uppermost river section.

[b] n - run number.

[c] $R_{NM}$ - Fish recaptured in same run as marked. Since marked fish were released at the end of a run, recaptures of these fish in the next run downstream were considered to be recaptured in the same location.

[d] $R_M$ - Fish recaptured either up or downstream of marking location.

[e] Numbers in parentheses are totals.

insignificant, 0.4% upstream and 0.5% downstream. Yet, inter-run upstream movement was apparent in the data and most pronounced in the lower two sections. To re-examine movement, the data set was truncated to exclude the upper section. After partitioning into three subsections (11, 10, and 11 km long, respectively), inter-section movement increased to 5 fish (2.3% of 216 recaptures). The probability of movement here was also unlikely to bias the Bailey estimate (0.5% downstream and 2.0% upstream).

The abundance of Arctic grayling in the 112 km reach of the Chatanika River stratified by area and size class was 19,095 fish (SE = 1,778, CV = 9; Table 6). The unstratified abundance estimate for the 112 km reach was 16,353 fish (SE = 1,175, CV = 7%). The stratified estimate was considered more appropriate since the difference between estimates was 2,742 fish. The density of Arctic grayling was greatest in the upper section with 271 fish per kilometer (abundance = 8,016 fish, SE = 1,389 fish, CV = 17%) and least in the middle section with 89 fish per kilometer (abundance = 3,696 fish, SE = 335, CV = 9%). The lower section had 178 fish per kilometer (abundance = 7,383 fish, SE = 1,059, CV = 14%).

Composition:

CDF's of fish marked versus fish examined for marks showed size selectivity occurred in both events in the lower two sections and in the second event for the upper section (test 2 in Appendix D1; for the lower section: $D = 0.03$, $P = 0.79$; for the middle section (2): $D = 0.06$, $P = 0.31$; for the upper section (3): $D = 0.09$, $P = 0.02$; Figure 9B). The tests stipulated that age and length data from both events could be used to estimate composition in sections 1 and 2 (Case III, Appendix D1) but only data from the second event be used in the upper section (Case IVa, Appendix D1). Sectional estimates of RSD's and age from these events were adjusted for the different capture probabilities in each section and then weighted and summed for the composition of the study area.

Size composition was skewed to small fish (< 259 mm FL) in the upper and lower sections and to large fish (> 260 mm FL) in the middle section (Figure 10). RSD's were thus significantly different between sections ($\chi^2 = 16.12$, $df = 4$, $P < 0.01$; Table 8). Stock size fish comprised 84 and 72% of the adjusted sample in the upper and lower sections and 46% in the middle section. Quality and preferred sizes were 54% of the adjusted sample in the middle section and 16 and 29% in the upper and lower section. Stock size fish predominated in the entire 112 km reach at 72% of the weighted sample. No memorable or trophy size fish were captured.

Age composition followed the trend of size composition with younger fish predominant in the upper and lower sections and older fish in the middle section (Table 9). Age 5 and younger fish comprised 87 and 84% of the sample in the former two sections, respectively, and 53% in the middle section. Age 5 fish predominated in entire study area comprising 36% of the combined sample. Age 4 were the next most numerous age class at 22%.

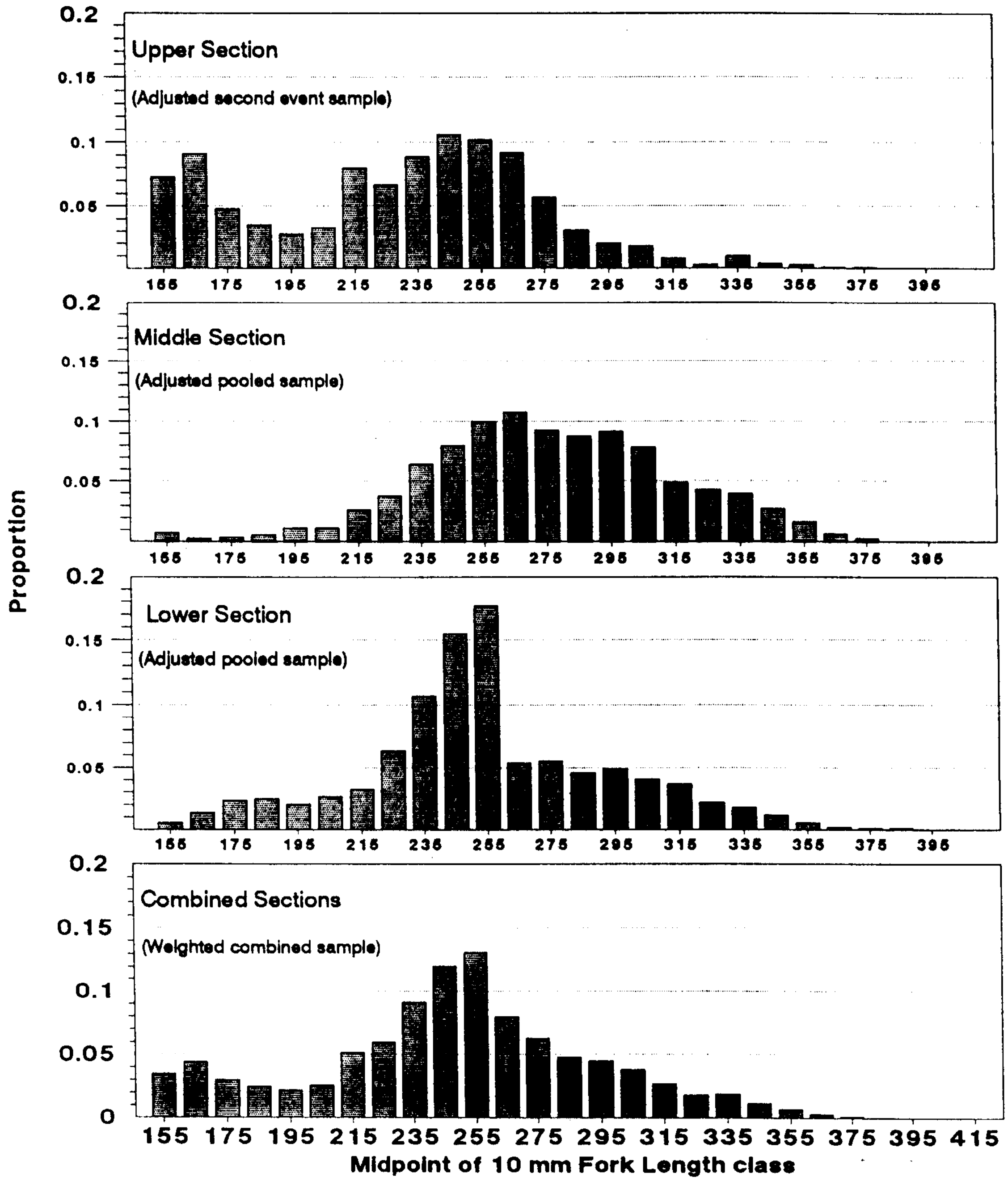


Figure 10. Estimated incremental size compositions for Arctic grayling (≥ 150 mm FL) in three study sections within a 112 km reach of the Middle Chatanika River, 1992.

Table 8. Summary of RSD indices for Arctic grayling (≥ 150 mm FL) in three sections of the Chatanika River, 17 through 28 August 1992.

| | RSD Category[a] | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| Upper Section | | | | | |
| Number sampled | 294 | 134 | 9 | 0 | 0 |
| Sample RSD | 0.67 | 0.31 | 0.02 | --- | --- |
| Adjusted RSD[b] | 0.84 | 0.15 | 0.01 | --- | --- |
| Standard Error | 0.03 | 0.03 | <0.01 | --- | --- |
| CV (%) | 4 | 20 | 30 | --- | --- |
| Middle Section | | | | | |
| Number sampled | 512 | 672 | 109 | 0 | 0 |
| Sample RSD | 0.40 | 0.52 | 0.08 | --- | --- |
| Adjusted RSD | 0.46 | 0.48 | 0.06 | --- | --- |
| Standard Error | 0.02 | 0.02 | 0.01 | --- | --- |
| CV (%) | 4 | 4 | 17 | --- | --- |
| Lower Section | | | | | |
| Number sampled | 738 | 835 | 66 | 0 | 0 |
| Sample RSD | 0.45 | 0.51 | 0.04 | --- | --- |
| Adjusted RSD | 0.71 | 0.27 | 0.02 | --- | --- |
| Standard Error | 0.05 | 0.04 | <0.01 | --- | --- |
| CV (%) | 7 | 15 | 18 | --- | --- |
| All Sections | | | | | |
| Number sampled | 1,543 | 1,641 | 185 | 0 | 0 |
| Sample RSD | 0.46 | 0.49 | 0.06 | --- | --- |
| Adjusted RSD | 0.72 | 0.26 | 0.02 | --- | --- |
| Standard Error | 0.04 | 0.04 | <0.01 | --- | --- |
| CV (%) | 6 | 15 | 23 | --- | --- |

[a] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984):
- Stock - 150 mm FL;
- Quality - 270 mm FL;
- Preferred - 340 mm FL;
- Memorable - 450 mm FL; and,
- Trophy - 560 mm FL.

[b] RSD proportions were adjusted to reflect the unequal capture probabilities of Arctic grayling of different size categories (Appendix D5).

Table 9. Estimates of the sampled and adjusted age composition of Arctic grayling (≥ 150 mm FL) captured in three 38 km sections of the Middle Chatanika River, 17 through 28 August, 1992.

| | Upper Section | | | | Middle Section | | | | Lower Section | | | | All Sections | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sampled: | | Adjusted:[a] | | Sampled: | | Adjusted: | | Sampled: | | Adjusted: | | Sampled: | | Adjusted: | |
| Age Class | n[b] | p[c] | p[d] | SE[e] | n | p | p | SE | n | p | p | SE | n | p | p | SE |
| 2 | 42 | 0.18 | 0.23 | 0.04 | 6 | 0.04 | 0.04 | 0.01 | 8 | 0.05 | 0.09 | 0.03 | 56 | 0.10 | 0.14 | 0.03 |
| 3 | 15 | 0.06 | 0.08 | 0.01 | 9 | 0.05 | 0.06 | 0.02 | 8 | 0.05 | 0.09 | 0.02 | 32 | 0.06 | 0.08 | 0.01 |
| 4 | 31 | 0.13 | 0.16 | 0.02 | 12 | 0.07 | 0.08 | 0.03 | 40 | 0.26 | 0.34 | 0.04 | 83 | 0.15 | 0.22 | 0.03 |
| 5 | 94 | 0.40 | 0.40 | 0.04 | 51 | 0.30 | 0.35 | 0.04 | 53 | 0.35 | 0.32 | 0.05 | 198 | 0.36 | 0.36 | 0.03 |
| 6 | 26 | 0.11 | 0.08 | 0.02 | 31 | 0.18 | 0.20 | 0.03 | 24 | 0.16 | 0.09 | 0.02 | 81 | 0.15 | 0.11 | 0.01 |
| 7 | 9 | 0.04 | 0.02 | 0.01 | 19 | 0.11 | 0.09 | 0.02 | 2 | 0.01 | 0.01 | <0.01 | 30 | 0.05 | 0.03 | 0.01 |
| 8 | 9 | 0.04 | 0.02 | 0.01 | 23 | 0.13 | 0.11 | 0.02 | 7 | 0.05 | 0.03 | 0.01 | 39 | 0.07 | 0.04 | 0.01 |
| 9 | 5 | 0.02 | 0.01 | <0.01 | 17 | 0.10 | 0.07 | 0.02 | 6 | 0.04 | 0.02 | 0.01 | 28 | 0.05 | 0.03 | 0.01 |
| 10 | 2 | 0.01 | <0.01 | <0.01 | 4 | 0.02 | 0.02 | 0.01 | 4 | 0.03 | 0.02 | 0.01 | 10 | 0.02 | 0.01 | <0.01 |
| 11 | 0 | --- | --- | --- | 1 | 0.01 | <0.01 | <0.01 | 0 | --- | --- | --- | 1 | <0.01 | <0.01 | <0.01 |
| Totals | 233 | 1.00 | 1.00 | | 173 | 1.00 | 1.00 | | 152 | 1.00 | 1.00 | | 558 | 1.00 | 1.00 | |

[a] Age composition is adjusted to compensate for length bias in the electrofishing sample.
[b] n - sample size.
[c] p - proportion of sampled grayling (≥ 150 mm FL).
[d] p - adjusted proportion of grayling (≥ 150 mm FL).
[e] SE - standard error of the adjusted proportion.

Discussion

This is the third year of assessing a portion of the Chatanika River Arctic grayling population that utilizes methodology that has been standard in the assessment of other rapid run-off rivers of the Tanana River drainage. This methodology requires that sampling design, timing, study area, and data analysis be held nearly constant across years. This is to ensure meaningful assessment of populations that are highly migratory and subject to size stratification according to season and river section (Tack 1980; Ridder 1991). Still, it is difficult to compare the abundance and composition estimates (Appendix B) without first partitioning the estimates into river sections, since methodology and timing have differed within the study area between years. The only study section where stock assessments have been consistently performed during the three years has been the 30 km reach hereafter referred to as the Elliot Highway area. This area has the Elliot Highway crossing as the upstream boundary and the confluence with Any Creek as the downstream boundary. This area has been referred to as: the upper section (this study); the Middle Chatanika River (Fleming et al. 1992); and, the Chatanika River (Clark et al. 1991).

With the exception of density, parameter estimates of the Arctic grayling population in the Elliot Highway area have been relatively constant over the three year study period. The density of 271 Arctic grayling per kilometer (SE = 47 fish/km) estimated in 1992 is essentially unchanged from the density estimated in 1991 (312 fish/km, SE = 62 fish/km; Appendix B2). Both estimates are less than half of the 1990 density of 670 fish/km (SE = 111 fish/km). The significance of this difference is questionable since the 1990 estimate was considered biased due to its magnitude and the likely influence of fall movements (the study occurred from 27 August to 7 September), high water levels and low temperatures (Clark et al. 1991). Size composition has been similar with 84% of the population being stock sized fish in both 1991 and 1992 and 90% being stock sized in 1990 (Appendix B5). Gross age compositions were also similar with 87% of the fish being Age 5 and younger in 1992, 85% in 1991, and 90% in 1990 (Table 8 and Appendix B3, respectively). Specifically, age compositions in all three studies reflected the strong recruitment of the 1987 year class.

As in 1990 and 1991 (Clark et al. 1991, Fleming et al. 1992) movement was detected but was not a significant factor despite a pattern of upstream movement. This movement was most apparent in the lower two sections where capture probabilities were relatively high ($p = 0.14$ and $p = 0.11$; Tables 6 and 7). The low capture probability in the upstream section which was nearly half that of the other sections ($p = 0.06$, Table 7) likely prevented better detection of upstream movement. This upstream movement is also noteworthy in that movement patterns in the two previous years have been generally downstream. The movement was likely influenced by the upstream movement of least cisco and humpbacked whitefish to spawning areas as documented by Fleming (in prep.).

Length structure was different between sections, especially between section 2 and the others with smaller fish in the upper and lower sections and larger fish in the middle (Figure 10). While angling could be the cause of the preponderance of smaller fish in the vicinity of access points (Murphy Dome Road and the Elliot Highway) as hypothesized in 1991 (Fleming et al. 1992), it is unlikely. Habitat preferences and related gear efficiency are more likely the cause. The upper and lower sections contain more shallow riffle and run areas than the middle section which is generally deep and devoid of riffles.

Considering that the time interval of the recent studies encroaches upon the fall migration, it is important to ask just what portion of the Chatanika Arctic grayling population has been assessed. Is this population resident to the area or is it a mixture of fish from other reaches of the system and thus a representative sample of the population? An analysis of intra-stream movements can provide an answer. If recaptures of fish tagged in previous years are consistently made in the same locations then we are dealing with a static population. It may be a mixture of fish from throughout the system but, at a specific time of year, mid to late August, in a specific location, the population mix is the same. The large number of tags recaptures made in 1992 (n = 221), plus those recovered in previous studies should be analyzed for annual intra-stream movement.

The differences found in density and composition within the study area and the timing of the studies should alert managers and researchers. Assessments of the Chatanika River stock can not be realistically made from small study areas or from comparing data from studies that are spatially and temporally dissimilar.

## GOODPASTER RIVER

### Fishery Description and Study Area

The Goodpaster River is a typical rapid run-off stream of interior Alaska. Draining an area of approximately 4,100 $km^2$, the Goodpaster River originates in the Tanana Uplands and flows southwest for 224 km to its confluence with the Tanana River, 16 km north of Delta Junction (Figure 1). The river has 13 named tributaries, the largest of which are the Eisenmenger Fork (38 km long) at river kilometer 184 and the South Fork (64 km long) at river kilometer 53.

Below the confluence of the South Fork at river kilometer 52.3, the river can be characterized as generally shallow (< 1 m deep) but wide (60 m across), slow moving, meandering, slightly tannic stained, and susceptible to rapid fluctuations in water level. Van Wyhe (1964) described this reach as quite low in productivity due to little aquatic vegetation and a bottom type consisting primarily of sand. He described the river above the South Fork confluence as having a predominantly coarse gravel bottom with a high density of aquatic vegetation and food organisms.

The Goodpaster River Arctic grayling population has been included in 27 Federal Aid in Fish Restoration studies since 1955. These studies can be broken into two main categories: inter-stream migration studies from 1955 through 1966 and stock assessment studies from 1969 to the present. The migration studies presented very little data on age and size compositions of the tagged fish and instead presented quantitative data of number tagged and recovered by area. These quantitative data were partially summarized and interpreted by Reed (1961), Nagata (1963), and Roguski (1967). Generally stated, they hypothesized that the Goodpaster River served as a spawning and nursery stream for part of the summer Arctic grayling populations found in the Richardson and Delta Clearwater rivers (Figure 1), two of the largest spring-fed tributaries of the Tanana River drainage. While presenting no quantitative data, Reed (1961) stated that the majority of Goodpaster River fish were tagged as two and three year olds while the recoveries of these fish in the clearwater streams were at ages five and greater. He suggested an age-size relationship for inter-stream movements. Ridder (1991) summarized recovery data from 4,946 fish tagged in the Goodpaster River in May and August from 1982 through 1989. Based on angler reports, tagged fish were recovered in six fisheries besides the Goodpaster River. Recovery rates in these locations were related to when the fish were tagged and supported the hypothesis of the early researchers. More than half (58%) of the 64 recoveries of fish tagged during spring spawning came from other waters, predominantly the Delta Clearwater River but reaching as far downstream as the Salcha River. Of fish tagged in August, only 16% of the 98 recoveries came from outside the Goodpaster. Stock separation data from scale pattern analysis of age 3 fish showed that the Goodpaster River could be the source of, at the most, 51% of the Delta Clearwater River Arctic grayling population (Ridder 1983).

Past stock assessment studies presented data on age and size compositions, population abundance (whole river and index sections), and intra-stream movements. Data on the former two parameters are included in Appendix B. Tack (1974, 1980) found and described an upstream, pre- and post-spawning movement in late May and early June followed by a mid-summer period of little movement. During this mid-summer period, juveniles and sub-adults occupied the lower 53 km, a mix of these groups were found in the middle drainage, and adults dominated above river kilometer 98.

The recreational fishery on the Goodpaster River is primarily for Arctic grayling and is conducted from approximately 15 May through 20 September. Most anglers are summer or permanent residents of the Delta Junction area. Some anglers target northern pike and burbot. Some round whitefish *Prosopium cylindraceum* are also harvested. While the river supports a small run of chinook and chum salmon, the fishery on salmon is closed by regulation. The river is accessible only by riverboat or airplane. Boat launches are located at Big Delta on the Tanana River (22.4 km downstream) and at Clearwater Lake (11.2 km upstream). Riverboat access is feasible only in the lower 98 km of the river and the lower 5 km of the South Fork. Floatplane access occurs only in the lower 36 km. Landing strips are located at Central Creek at river kilometer 118 and at Tibbs Creek, a tributary of the Eisenmenger Fork. There are approximately 50 cabins on the river used by summer residents. All but five cabins are located between river kilometers 11 and 48. No summer cabins lie above Central Creek. The Fairbanks Daily News Miner (4 September 1987) reports, "More than a hundred families own property in the area and transient use has grown rapidly during the past five years."

Data on the recreational fishery in the Goodpaster River are sparse. Tack (1974) conducted an on-site creel survey program in 1973. A check station at river kilometer 1 was used to interview and count angler arrivals and departures with a stratified random sampling schedule. He estimated a harvest of 2,236 Arctic grayling with a monthly harvest rate that ranged from 0.69 to 1.63 Arctic grayling harvested per hour. He reported 241 mm FL as the mean length of the sampled harvest (n = 241), that the harvest came predominantly from the lower 53 km of the river, and that the estimated 899 angler-days of effort were mainly by residents of the area. No other data were available until the statewide harvest survey (Mills 1984-1992) began to obtain estimates of harvest and effort in 1983 (Table 1). Annual harvests since then have averaged 1,696 Arctic grayling. Effort for all species has averaged 1,760 angler-days for the same period.

The study area encompassed a 50 km reach of the lower Goodpaster River. The study area and sections are similar to those used since 1988 (Ridder 1989; Clark and Ridder 1990; Clark et al. 1991, and Fleming et al. 1992) and encompassed areas used in all previous studies. The upstream boundary of the present study area was at river kilometer 52.3 (the confluence of the South Fork of the Goodpaster River) while the lower boundary was at river kilometer 2.7 (Figure 11). The mouth of the river was to be the lower boundary but high flows in the Tanana River had backed up the river and produced high turbidity and ineffective electrofishing. The study area was subdivided into three study sections. Section 1 was 16 km long and extended from the downstream boundary to approximately river kilometer 19. Section 2 was 15 km long and extended to river kilometer 34. Section a 3, the upstream section, was 18 km long.

Methods

The marking event ran from 4 to 6 August and the recapture event ran from 11 to 14 August. The time interval between the start of each event was seven days. The mark event lasted 3 days and used two electrofishing boats which each sampled one bank. The recapture event lasted 4 days and used one electrofishing boat. Due to manpower and time constraints, both banks were not completely sampled. During a run, the boat alternated river banks targeting the outside bends of the meandering river. Arctic grayling favor these areas over the inside of bends which are typically shallow with substrata of sand and no cover. In areas where both sides of the river offered favorable habitat, both banks were sampled. These areas were contiguous occurring in higher frequency in the upper and lower areas of sections 1 and 2, respectively. During both events, captured Arctic grayling were tagged and given a partial right pelvic fin clip.

Output voltage of the pulsator ranged from 250 to 325 VDC and output current ranged from 1 to 4 amperes. Mid-day water temperatures during the experiment ranged from 10.5°C to 12.5°C during the first week and 11.5°C to 13.5°C during the second. Conductivity was 100 μS (standardized to 25°C) on 4 August and 120 μS on 14 August.

Water level dropped consistently over the course of the experiment while clarity remained the same. At the start of the marking event, 4 August, water level was moderate and water clarity was clear, yet tannic stained. On 11 August at the forks, the water level was low having dropped 26 cm in six days.

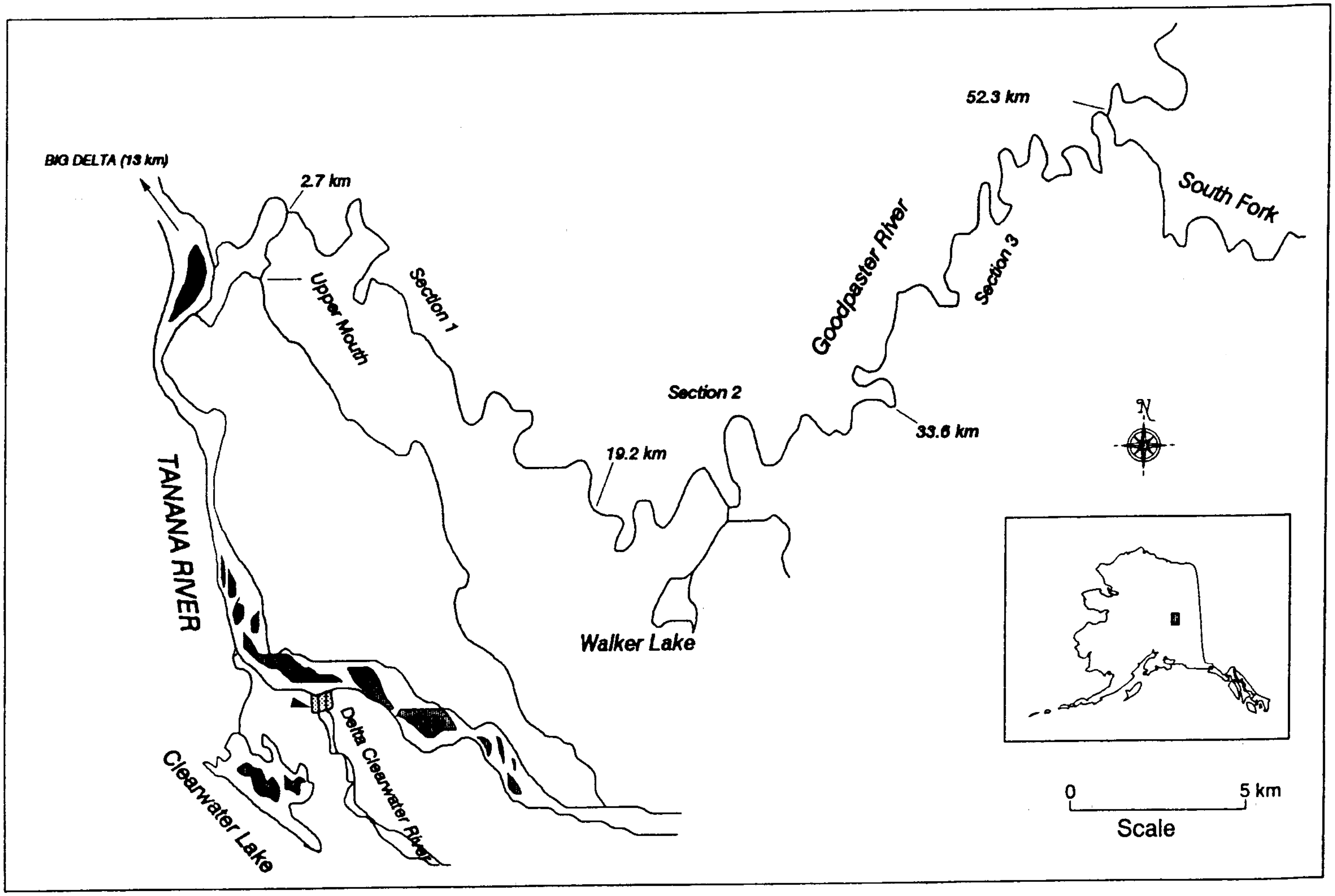


Figure 11. Study sections of the Goodpaster River in 1992.

Length data were collected during both sampling events and age data collected only during the first event. A size selective bias in the first sample was inferred from the data, so only the second sample was included in composition estimates. With no age data from the second sample, the data from the first was used, realizing estimates could be different than the true age and size composition. The same sections used for abundance estimation were used to partition the estimates of age and size composition (from Equations D5.1 and D5.2 from Appendix D5). Equations D5.7 and D5.8 of Appendix D5 were used to combine these estimates.

Results

Total electrofishing effort was 24.7 hours and captured 1,483 Arctic grayling (≥150 mm FL) which were used in the mark-recapture experiment. In the marking event, 921 Arctic grayling were marked and released. After a one week hiatus, 562 Arctic grayling were captured, examined for marks and 80 were found to be recaptures from the first event. During the experiment, immediate sampling mortality was 0.5% as eight Arctic grayling were either killed or severely injured. Recaptures of Arctic grayling tagged in previous years totalled 175, or 12.5% of the sample, excluding the experiment's recaptures from the first event.

Abundance:

While cumulative function distributions (CDF's) inferred that capture probabilities were the same for all sizes of fish ($D = 0.12$, $P = 0.28$), contingency tests found significant differences in capture probability between sections ($\chi^2 = 8.22$, $df = 2$, $P = 0.02$; Figure 12). Thus the data were stratified by section and abundance was estimated in each. Within each section, CDF's showed that capture probabilities were similar for all sizes of fish so stratification by length was not necessary (from the first K-S test in Appendix D1: for section 1: $D = 0.26$, $P = 0.12$; for section 2: $D = 0.16$, $P = 0.21$; for section 3: $D = 0.19$, $P = 0.95$; Figure 13A).

No significant movement of marked fish was detected during the experiment. While 14 fish moved between sampling events, only seven of these were meaningful (movement of more than one run downstream or one or more runs upstream; Table 10). Of these seven fish, only one moved between study sections, being marked in run 13 (section 2) and recaptured in run 25 (section 3). With the assumption of a closed population being valid, the Bailey modification of the Peterson estimator was used to estimate abundance for each section.

The abundance of Arctic grayling in the lower 50 km of the river was 6,886 fish (SE = 809, CV = 12%; Table 11). The density of Arctic grayling was greatest in the downstream section (section 1) with 192 fish per kilometer (abundance = 3,077 fish, SE = 603 fish, CV = 20%) and least in the upstream section (section 3) with 84 fish per kilometer (abundance = 1,510 fish, SE = 457, CV = 30%). If the data were not stratified by section, the abundance estimate would have been 6,408 fish (SE = 655, CV = 10%) with a bias of 7.5%. While differences between estimates are minimal, the stratified estimate was

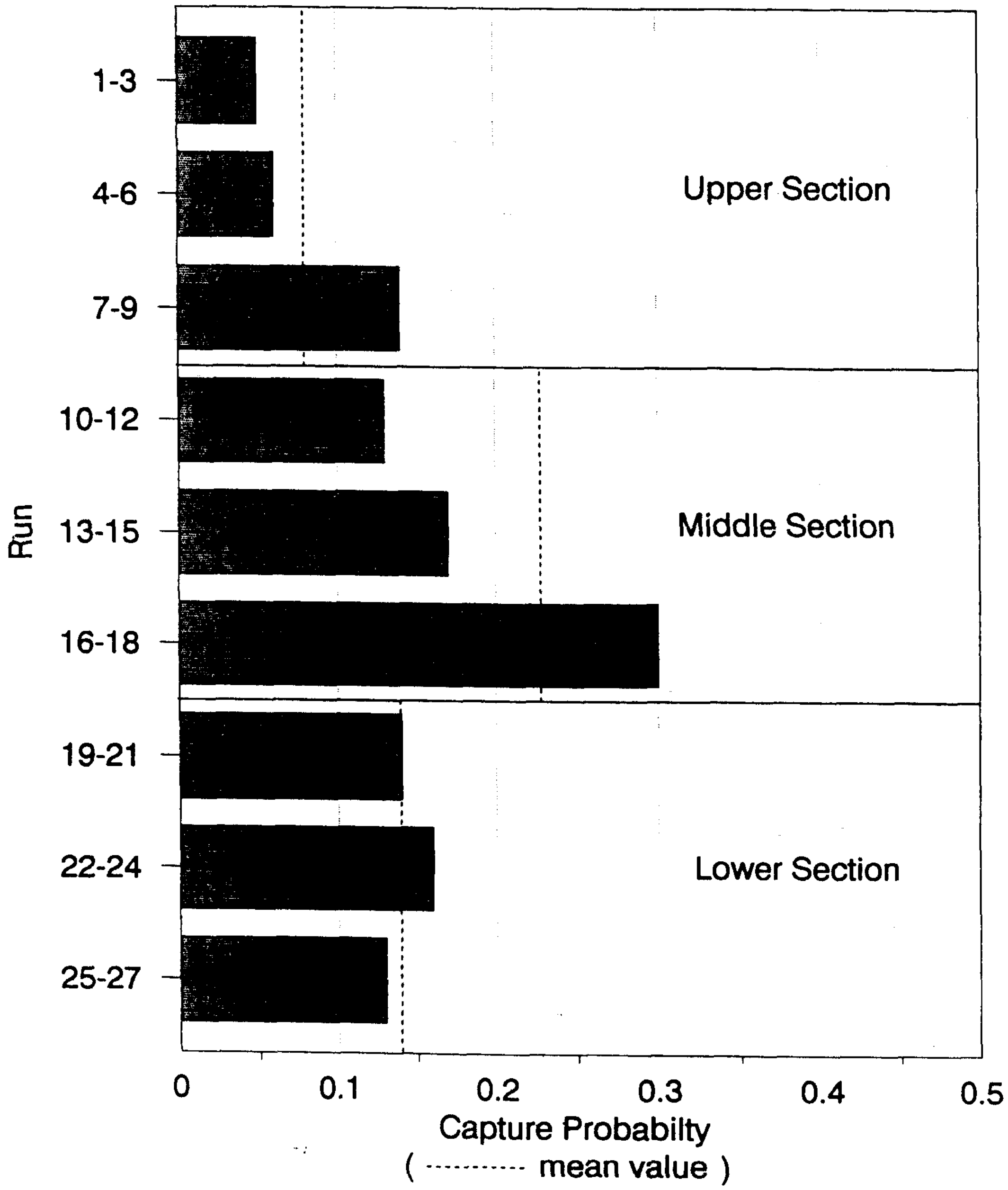


Figure 12. Estimated capture probabilities for Arctic grayling in three study sections within the lower 50 km of the Goodpaster River, 1992.

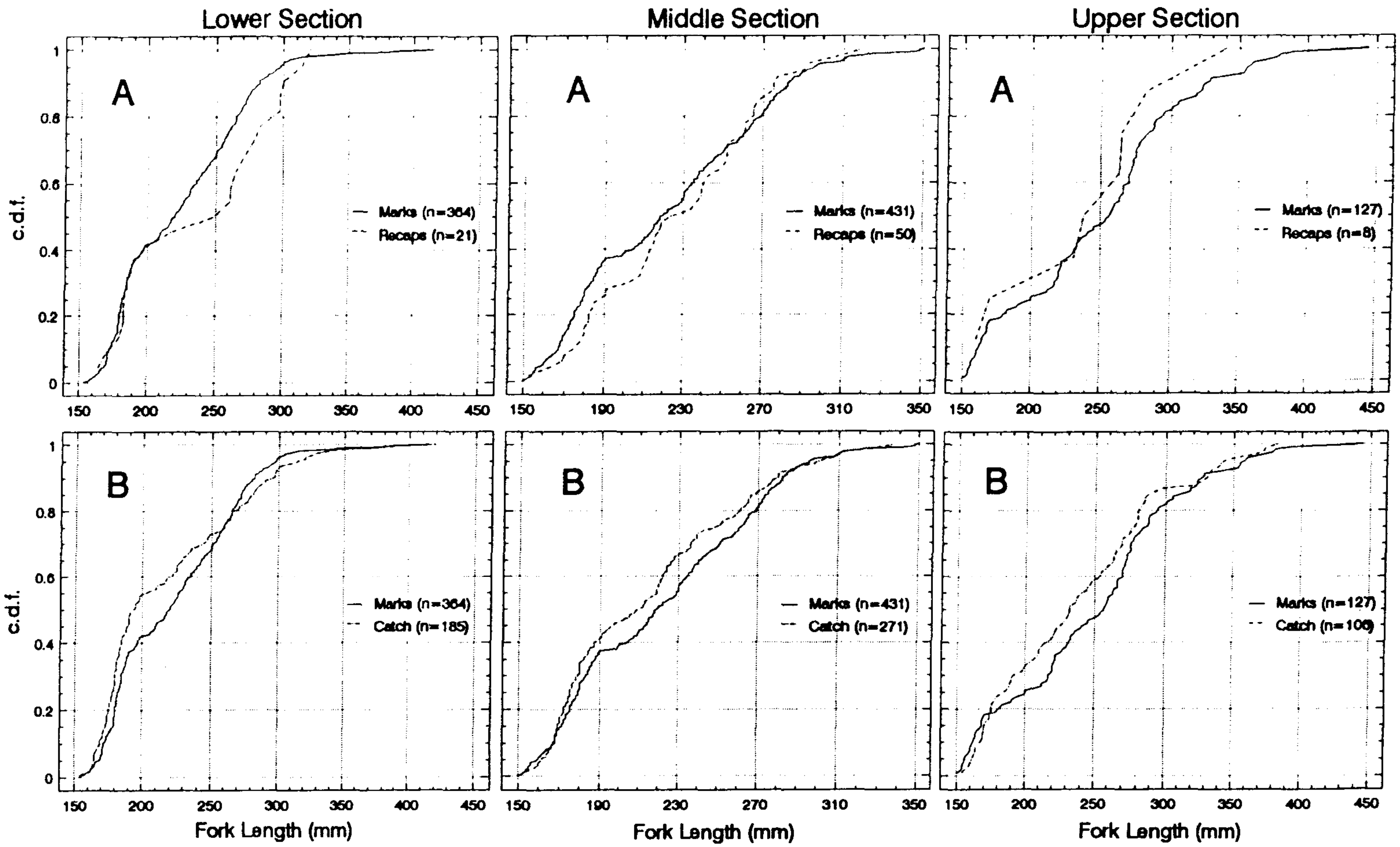


Figure 13. Cumulative distribution functions of lengths of Arctic grayling marked versus lengths of Arctic grayling recaptured (A) and versus lengths of Arctic grayling examined for marks (B) for a 50.0 km section of the Goodpaster River, 4 through 14 August 1992.

Table 10. Summary of inter-section and inter-run[a] movements of Arctic grayling (≥ 150 mm FL) based on recaptures (R) in the lower 50.0 km of the Goodpaster River, 4 through 14 August 1992.

| Mark: | Recapture: Section 3 | | | | | | | | | Section 2 | | | | | | | | | Section 1 | | | | | | | | | | | Total | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | $R_{NM}$[b] | $R_M$[c] | R | M |
| 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 1 | 16 |
| 2 | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 1 | 33 |
| 3 | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 14 |
| 4 | | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 8 |
| 5 | | | | | 1 | | | | | | | | | | | | | | | | | | | | | | | 1 | 0 | 1 | 11 |
| 6 | | | | | | 0 | 2 | | | | | | | | | | | | | | | | | | | | | 0 | 2 | 2 | 10 |
| 7 | | | | | | | 2 | 1 | | | | | | | | | | | | | | | | | | | | 2 | 1 | 3 | 11 |
| 8 | | | | | | | | 0 | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 9 |
| 9 | | | | | | | | | 0 | | | | | | | | | | | | | | | | | | | 0 (5) | 0 (3) | 0 (8) | 15 (127)[d] |
| 10 | | | | | | | | | | 1 | | | | | | | | | | | | | | | | | | 1 | 0 | 1 | 25 |
| 11 | | | | | | | | | | | 0 | 2 | | | | | | | | | | | | | | | | 0 | 2 | 2 | 31 |
| 12 | | | | | | | | | | | | 2 | | | | | | | | | | | | | | | | 2 | 0 | 2 | 20 |
| 13 | | | | | | | | | | | | | 5 | | | | | | | | | | | | 1 | | | 5 | 1 | 6 | 28 |
| 14 | | | | | | | | | | | | | 1 | 2 | | | | | | | | | | | | | | 2 | 1 | 3 | 42 |
| 15 | | | | | | | | | | | | | | 1 | 4 | 1 | | | | | | | | | | | | 4 | 2 | 6 | 44 |
| 16 | | | | | | | | | | | | | | | | 8 | | 1 | | | | | | | | | | 8 | 1 | 9 | 59 |
| 17 | | | | | | | | | | | | | | | | | 12 | 1 | | | | | | | | | | 12 | 1 | 13 | 99 |
| 18 | | | | | | | | | | | | | | | | | | 9 | | | | | | | | | | 9 (43) | 0 (8) | 9 (51) | 83 (431) |
| 19 | | | | | | | | | | | | | | | | | | | 1 | | | | | | | | | 1 | 0 | 1 | 49 |
| 20 | | | | | | | | | | | | | | | | | | | | 2 | | | | | | | | 2 | 0 | 2 | 60 |
| 21 | | | | | | | | | | | | | | | | | | | | | 2 | | | | | | | 2 | 0 | 2 | 42 |
| 22 | | | | | | | | | | | | | | | | | | | | | | 2 | | | | | | 2 | 0 | 2 | 47 |
| 23 | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | | 3 | 0 | 3 | 37 |
| 24 | | | | | | | | | | | | | | | | | | | | | | | | 3 | | | | 3 | 0 | 3 | 46 |
| 25 | | | | | | | | | | | | | | | | | | | | | | | | | 4 | | 1 | 4 | 1 | 5 | 52 |
| 26 | | | | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | | 1 | 2 | 3 | 21 |
| 27 | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 0 (18) | 0 (3) | 0 (21) | 10 (364) |

[a] Locations are broken into river sections (see Methods) and run number. A run is approximately 1.8 km long, the distance covered by a 20 minute downstream pass of an electrofishing boat. Run 1 starts at river km 52.3 and run 27 ends at river km 1.7.

[b] $R_{NM}$ - Fish recaptured in same run as marked. Since marked fish were released at the end of a run, recaptures of these fish in the next run downstream were considered to be recaptured in the same location in movement analysis.

[c] $R_M$ - Fish recaptured either up or downstream of marking location.

[d] Numbers in parentheses are totals.

Table 11. Estimates of Arctic grayling (≥ 150 mm FL) capture probability and abundance stratified into three sections of the lower 50.0 km of the Goodpaster River, 4 through 14 August, 1992.

| Section (km) | Mark M | Catch C | Recap R | $\rho$[a] | SE[$\rho$][b] | $N$[c] | SE[$N$][d] |
|---|---|---|---|---|---|---|---|
| Upper (18) | 127 | 106 | 8 | 0.08 | 0.03 | 1,510 | 457 |
| Middle (16) | 431 | 271 | 50 | 0.23 | 0.03 | 2,299 | 287 |
| Lower (16) | 364 | 185 | 21 | 0.14 | 0.03 | 3,077 | 603 |
| Total | 922 | 562 | 79 | 0.17 | 0.02 | 6,886 | 809 |
| Unstratified | 922 | 562 | 80[e] | 0.17 | 0.02 | 6,408 | 655 |

[a] $\rho$ is the probability of capture.
[b] SE[$\rho$] is the standard error of $\rho$.
[c] $N$ is the estimated abundance in a stratified length and/or area category or unstratified population.
[d] SE[$N$] is the error of $N$.
[e] An additional recapture is available in an unstratified estimate. This recapture was made in the Lower Section of a fish marked in the Middle Section.

considered more appropriate due to the differences in capture probability and size composition between the sections.

Composition:

Size selective bias was inferred in the first but not in the second sample event in two of the three sections of the study area (from the second K-S test in Appendix D1: for section 1: $D = 0.13$, $P = 0.03$; for section 2: $D = 0.12$, $P = 0.01$; for section 3: $D = 0.13$, $P = 0.33$; Figure 13B). The tests (both tests in Appendix D1) stipulated that only data from the second event should be used to estimate composition in sections 1 and 2 (Case II, Appendix D1). Although the second test inferred that events could be pooled for section 3, the CDF's were not functionally different from the other two sections and so the data from section 3 were treated similarly. Since age data were only collected in the first sample, bias was present in the following composition estimates. Size data were collected during both events but only that from the second event were used to calculate the composition estimates.

Size composition was skewed to small fish (< 230 mm FL) in the lower two sections and to larger fish (> 260 mm FL) in the upper section (Figure 14). RSD's were thus significantly different between sections ($\chi^2 = 21.83$, $df = 4$, $P = 0.0002$; Table 12). Stock size fish comprised 85 and 80% of the adjusted sample in the lower sections and 71% in the upper section. Quality and preferred sizes were 23% of the sample in the upper section and 15 and 18% in the lower two sections. Stock size fish predominated in the entire 50 km reach at 80% of the weighted sample. No memorable or trophy size fish were captured.

Age composition followed the trend of size composition with older fish predominant in the upper section and younger fish in the lower sections (Table 13). Age 5 fish comprised 32% of the sample in the upper section while Age 2 fish comprised 43 and 39% of the samples in the lower sections 1 and 2, respectively. Age 2 fish predominated in the combined samples with a proportion of 28%. Age 3 and 5 fish were the next most numerous with compositions of 24 and 23%, respectively.

## Discussion

The abundance of Arctic grayling in the Goodpaster River has not changed significantly in the past 5 years, ranging from 138 to 161 fish per km. The high precision, low variability, and small magnitude of these abundance estimates is in extreme contrast to those estimated in previous years. During 1975 through 1987, estimates of abundance had low precision and high inter-annual variability, but were usually twice as large as those from 1988 through 1992 (Figure 15; Appendix C1). The significance of these comparisons is somewhat in question since recent experimental design has improved the accuracy and precision of the estimates, included a larger reach of river, and changed the timing of stock assessments (Appendix C1). However, the recent abundance estimates may be indicative of a depressed population since they are also less than the estimate from 1973 when a similar design (low sampling intensity and same reach of river) gave an estimated 480 fish per km.

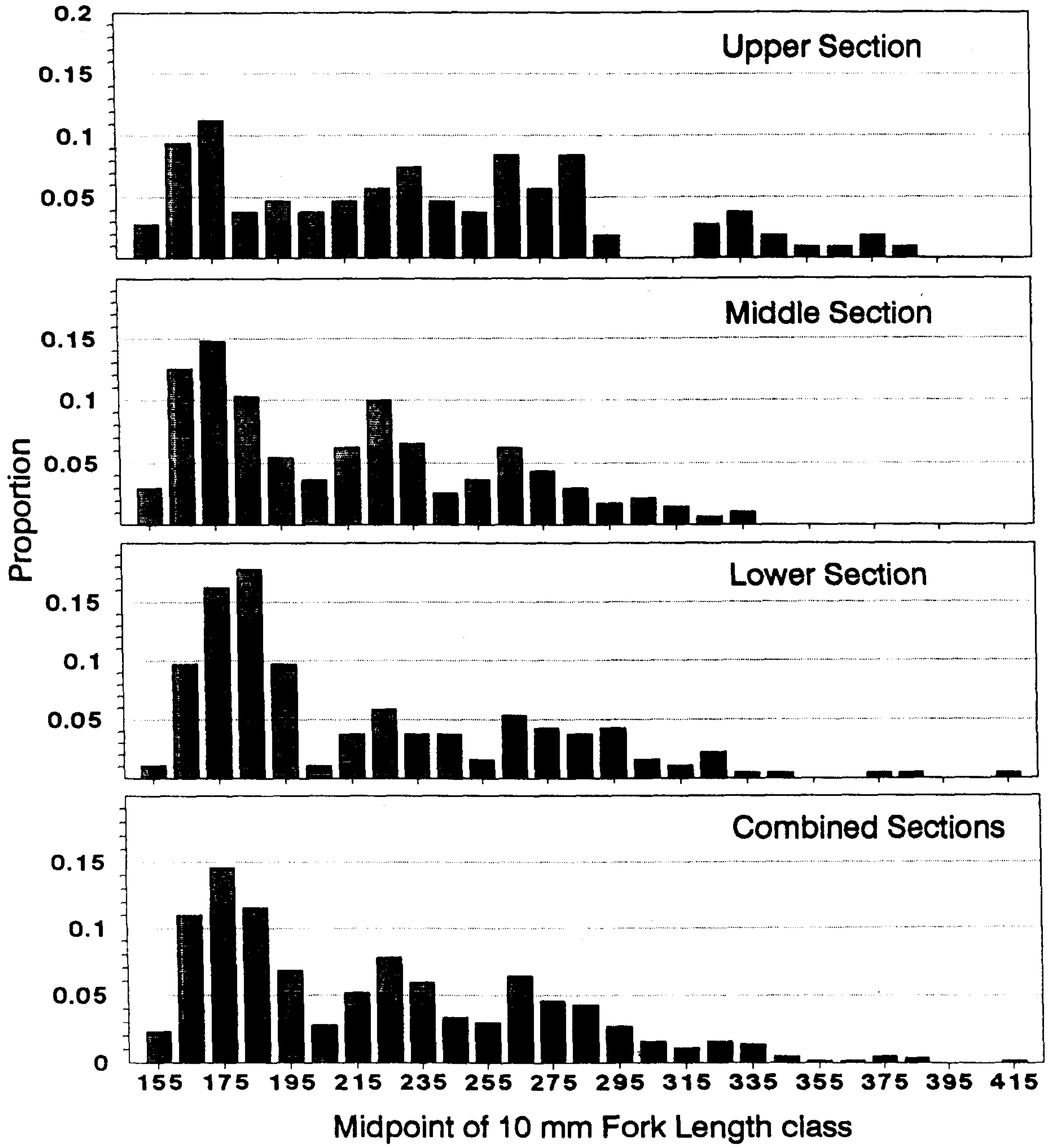


Figure 14. Estimated incremental size compositions for Arctic grayling (≥ 150 mm FL) in three study sections of the Goodpaster River, 1992.

Table 12. Summary of RSD indices for Arctic grayling (≥ 150 mm FL) in three sections of the Goodpaster River, 11 through 14 August 1992.

| | RSD Category[a] | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| Upper Section | | | | | |
| Number sampled | 75 | 24 | 7 | 0 | 0 |
| Sample RSD | 0.71 | 0.23 | 0.07 | --- | --- |
| Standard Error | 0.04 | 0.04 | 0.02 | --- | --- |
| CV (%) | 6 | 17 | 29 | --- | --- |
| Middle Section | | | | | |
| Number sampled | 231 | 672 | 0 | 0 | 0 |
| Sample RSD | 0.85 | 0.15 | --- | --- | --- |
| Standard Error | 0.02 | 0.02 | --- | --- | --- |
| CV (%) | 2 | 13 | --- | --- | --- |
| Lower Section | | | | | |
| Number sampled | 148 | 33 | 4 | 0 | 0 |
| Sample RSD | 0.80 | 0.18 | 0.02 | --- | --- |
| Standard Error | 0.03 | 0.03 | 0.01 | --- | --- |
| CV (%) | 4 | 17 | 50 | --- | --- |
| All Sections | | | | | |
| Number sampled | 454 | 97 | 11 | 0 | 0 |
| Sample RSD | 0.81 | 0.17 | 0.02 | --- | --- |
| Adjusted RSD[b] | 0.80 | 0.18 | 0.02 | --- | --- |
| Standard Error | 0.02 | 0.02 | 0.01 | --- | --- |
| CV (%) | 2 | 12 | 50 | --- | --- |

[a] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984):
Stock - 150 mm FL;
Quality - 270 mm FL;
Preferred - 340 mm FL;
Memorable - 450 mm FL; and,
Trophy - 560 mm FL.

[b] Adjusted RSD is determined from methods in Appendix D5.

Table 13. Estimates of the sampled age composition of Arctic grayling (≥ 150 mm FL) captured in three sections within the lower 50.0 km of the Goodpaster River, 4 through 6 August, 1992.

| | Upper Section | | | Middle Section | | | Lower Section | | | All Sections | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | p[c] | SE[d] | n | p | SE | n | p | SE | n | p | SE |
| 1 | 0 | --- | --- | 1 | <0.01 | <0.01 | 0 | --- | --- | 1 | <0.01 | <0.01 |
| 2 | 27 | 0.24 | 0.04 | 154 | 0.39 | 0.03 | 138 | 0.43 | 0.03 | 319 | 0.39 | 0.02 |
| 3 | 26 | 0.23 | 0.04 | 102 | 0.26 | 0.02 | 71 | 0.22 | 0.02 | 199 | 0.24 | 0.02 |
| 4 | 8 | 0.07 | 0.02 | 49 | 0.12 | 0.02 | 24 | 0.08 | 0.02 | 81 | 0.10 | 0.01 |
| 5 | 36 | 0.32 | 0.04 | 71 | 0.18 | 0.02 | 72 | 0.23 | 0.02 | 179 | 0.22 | 0.01 |
| 6 | 7 | 0.06 | 0.02 | 10 | 0.03 | 0.01 | 6 | 0.02 | 0.01 | 23 | 0.03 | 0.01 |
| 7 | 2 | 0.02 | 0.01 | 4 | 0.01 | <0.01 | 6 | 0.02 | 0.01 | 12 | 0.01 | <0.01 |
| 8 | 4 | 0.04 | 0.02 | 3 | 0.01 | <0.01 | 2 | 0.01 | <0.01 | 9 | 0.01 | <0.01 |
| 9 | 1 | 0.01 | 0.01 | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 |
| 10 | 3 | 0.03 | 0.02 | 0 | --- | --- | 0 | --- | --- | 3 | <0.01 | <0.01 |
| 11 | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 | 1 | <0.01 | |
| Totals | 114 | 1.00 | | 394 | 1.00 | | 320 | 1.00 | | 828 | 1.00 | |

[a] Age composition is adjusted to compensate for length bias in the electrofishing sample.
[b] n = sample size.
[c] p = proportion of sampled grayling (≥ 150 mm FL).
[d] SE = standard error of the proportion.

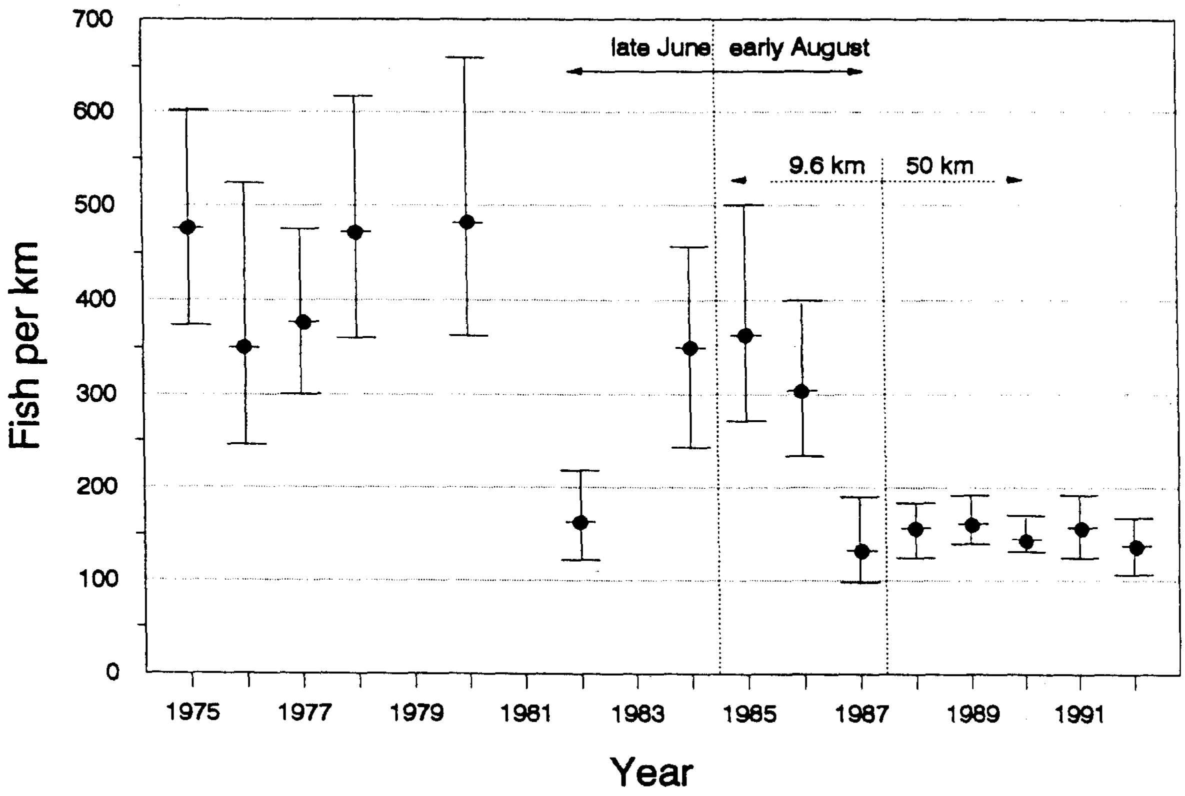


Figure 15. Density (fish per km) and 95% confidence intervals of Arctic grayling (≥ 150 mm FL ) in two reaches of the lower 50 km of the Goodpaster River, June and August, 1975 through 1992.

Table 14. Age composition and abundance for Arctic grayling (≥ 150 mm FL) in the lower 50.0 km of the Goodpaster River, 1988 through 1992.

| | 1988 | | 1989 | | 1990 | | 1991 | | 1992 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | p[a] | N[b] | p | N | p | N | p | N | p | N |
| 1 | 0.00 | 10 | 0.00 | 0 | 0.05 | 363 | 0.01 | 79 | 0.00 | 8 |
| 2 | 0.18 | 1,422 | 0.47 | 3,784 | 0.08 | 580 | 0.53 | 4,161 | 0.39 | 2,686 |
| 3 | 0.07 | 533 | 0.21 | 1,691 | 0.59 | 4,278 | 0.10 | 785 | 0.24 | 1,653 |
| 4 | 0.11 | 869 | 0.04 | 322 | 0.10 | 725 | 0.25 | 1,963 | 0.10 | 689 |
| 5 | 0.40 | 3,160 | 0.09 | 725 | 0.04 | 290 | 0.04 | 314 | 0.22 | 1,515 |
| 6 | 0.04 | 316 | 0.11 | 886 | 0.05 | 363 | 0.02 | 157 | 0.03 | 207 |
| 7 | 0.09 | 719 | 0.03 | 242 | 0.06 | 435 | 0.03 | 236 | 0.01 | 69 |
| 8 | 0.06 | 474 | 0.02 | 161 | 0.01 | 73 | 0.02 | 157 | 0.01 | 69 |
| 9 | 0.03 | 237 | 0.01 | 81 | 0.01 | 73 | 0.01 | 79 | <0.01 | 8 |
| 10 | 0.01 | 79 | 0.00 | 36 | <0.01 | 30 | <0.01 | 21 | <0.01 | 25 |
| 11 | <0.01 | 30 | <0.01 | 9 | 0.00 | 0 | 0.00 | 0 | <0.01 | 8 |
| 12 | <0.01 | 10 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 |
| Total | 1.00 | 7,900 | 1.00 | 8,050 | 1.00 | 7,250 | 1.00 | 7,850 | 1.00 | 6,900 |
| Survival[c] | | 0.40 | | 0.48 | | 0.45 | | 0.70 | | |

[a] p = proportion. From Appendix C2.
[b] N = abundance. From Appendix C1, fish per kilometer estimates multiplied by 50.
[c] Survival is the proportion of fish Age 3 and older in year i alive at Age 4 and older in year i+1.

Estimates of recruitment and survival increased in 1992 while exploitation rates were low. Recruitment of age 3 fish, the first fully recruited age class to the estimated population, was 1,653 fish in 1992; similar to the recent 5 year mean of 1,792 fish (Table 14). Abundance of age 2 fish was the third highest of the five years. Survival of age 3 and older fish, which ranged from 40 percent to 48 percent from 1989 to 1991, was 70 percent between 1991 and 1992. Survival during 1989 through 1991 was unusually low, but coincided with high exploitation rates of 13 and 20 percent (Appendix C14). The high survival between 1991 and 1992 coincided with the lowest exploitation rate (8%) estimated since 1986. For abundance to increase, recruitment will not only need to remain stable, but exploitation rate must remain low.

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# APPENDIX A

## Historic Data Summaries - Salcha River

Appendix A1. Summary of recreational effort and catch rate estimates for Arctic grayling harvested from the Salcha River, 1953-1958, 1960, 1963-1964, 1968, 1974, and 1987[a].

| Year | Interviews | Angler-hours | GR/hr[b] |
|---|---|---|---|
| 1953 | 102 | 344 | 0.48 |
| 1954 | 132 | 646 | 0.84 |
| 1955[c] | 174 | 728 | 1.09 |
| 1956[c] | 391 | 1,659 | 0.83 |
| 1957[c] | 86 | 321 | 0.78 |
| 1958[c] | 108 | 423 | 1.01 |
| 1960 | ND | 2,600 | 1.22 |
| 1963 | 275 | --- | 0.67[c] |
| 1964 | 409 | 1,816 | 0.64 |
| 1968 | 2,013[d] | 7,035[d] | 1.00 |
| 1974 | 827 | 11,284[d] | 0.42 |
| 1987 | 152 | --- | 0.66 |

[a] Statistics taken from Warner (1959b) for 1953-1958, Reed (1961) for 1960, Roguski and Winslow (1969) for 1963-1968, Kramer (1975) for 1974, and Baker (1988) for 1987.
[b] GR/hr is the number of Arctic grayling harvested per angler-hour.
[c] This catch rate includes salmon (Roguski and Winslow 1969).
[d] Data expanded from sample time/area to the entire fishery.

Appendix A2. Summary of population abundance estimates of Arctic grayling in the Salcha River, 1972, 1974, 1985, and 1988-1992[a].

| Dates | Area | Marks | Recaps | Estimate[b] | Confidence[c] |
|---|---|---|---|---|---|
| 8/2-8/4/72 | Redmond Creek | ND[d] | 5 | 503/km | Low |
| 7/10-7/22/74 | Redmond Creek to TAPS[e] | ND | ND | 765/km | 490-5,032/km |
| 7/10-7/22/74 | TAPS to 8 km upstream | ND | ND | 991/km | 690-2,595/km |
| 7/10-7/22/74 | TAPS to 8 km downstream | ND | ND | 551/km | 397-1,174/km |
| 8/5-8/9/85 | Flat Creek | 205 | 6 | 497/km | 128-1,064/km |
| 5/24-6/8/88 | TAPS to 16 km upstream | 208 | 28 | 138/km | SE = 34/km |
| 6/12-6/16/89 | Richardson Hwy. bridge to 36.8 km upstream | 616 | 55 | 188/km | SE = 21/km |
| 6/26-6/27/90 | Richardson Hwy. bridge to 36.8 km upstream | 495 | 40 | 157/km | SE = 18/km |
| 6/25-7/2/91 | Richardson Hwy. bridge to 36.8 km upstream | 439[f] | 27 | 147/km | SE = 28/km |
| | | 382 | 27 | 114/km | SE = 25/km |
| 6/15-6/25/92 | Richardson Hwy. bridge to 36.8 km upstream | 709[g] | 52 | 209/km | SE = 69/km |

[a] Data sources are:
1972 - Tack (1973);
1974 - Bendock (1974) and Kramer (1975);
1985 - Holmes, et al. (1986);
1988 - Clark (1988);
1989 - Clark and Ridder (1990);
1990 - Clark, et al. (1991);
1991 - Fleming, et al. (1992); and,
1992 - this report.

[b] The 1972-1985 estimates were calculated with the modified Schnabel formula (Ricker 1975). The 1988 through 1990 estimates were calculated with a modified Petersen estimate of Evenson (1988). The 1991 estimate was calculated with modified Petersen (Bailey 1952).

[c] Confidence is a crude measure of precision (e.g. Low) or the 95% confidence interval based on a Poisson distribution of recaptures (Ricker 1975). Estimates for 1988-1991 were from bootstrap methods (Efron 1982); a standard error (SE) is reported for these estimates.

[d] ND = data not furnished in original citation.

[e] TAPS = Trans-Alaska Pipeline System.

[f] Mark-recapture experiment results are for Full model (≥ 150 mm Fl; upper) and Reduced model (≥ 200 mm Fl; lower).

[g] Mark-recapture results are for the Reduced model (≥ 200 mm Fl), due to the lack of recaptures of Arctic grayling < 207 mm.

Appendix A3. Summary of age composition estimates and standard error of Arctic grayling (≥ 150 mm FL) collected from the Salcha River, 1985-1992[a].

| | 1985[b] | | | 1986[c] | | | 1987[d] | | | 1988[e] | | | 1989[f] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 2 | 1 | 0.01 | 0.01 | 0 | 0.00 | --- | 2 | <0.01 | <0.01 | 17 | 0.03 | 0.01 | 17 | 0.03 | 0.01 |
| 3 | 13 | 0.06 | 0.02 | 19 | 0.12 | 0.03 | 35 | 0.07 | 0.01 | 116 | 0.20 | 0.02 | 155 | 0.35 | 0.03 |
| 4 | 3 | 0.01 | 0.01 | 25 | 0.16 | 0.03 | 205 | 0.40 | 0.02 | 83 | 0.14 | 0.01 | 143 | 0.26 | 0.02 |
| 5 | 29 | 0.13 | 0.02 | 14 | 0.09 | 0.02 | 120 | 0.23 | 0.02 | 175 | 0.30 | 0.02 | 75 | 0.13 | 0.01 |
| 6 | 69 | 0.32 | 0.03 | 37 | 0.24 | 0.03 | 80 | 0.15 | 0.02 | 58 | 0.10 | 0.01 | 74 | 0.11 | 0.02 |
| 7 | 58 | 0.27 | 0.03 | 26 | 0.17 | 0.03 | 56 | 0.11 | 0.01 | 54 | 0.09 | 0.01 | 24 | 0.04 | 0.01 |
| 8 | 25 | 0.12 | 0.02 | 22 | 0.14 | 0.03 | 15 | 0.03 | 0.01 | 51 | 0.09 | 0.01 | 30 | 0.05 | 0.01 |
| 9 | 18 | 0.08 | 0.02 | 8 | 0.05 | 0.02 | 4 | 0.01 | <0.01 | 22 | 0.04 | 0.01 | 18 | 0.03 | 0.01 |
| 10 | 2 | 0.01 | 0.01 | 3 | 0.02 | 0.01 | 2 | <0.01 | <0.01 | 4 | 0.01 | <0.01 | 3 | <0.01 | <0.01 |
| 11 | 0 | 0.00 | --- | 1 | 0.01 | 0.01 | 0 | 0.00 | --- | 1 | <0.01 | <0.01 | 0 | 0.00 | --- |
| Totals | 218 | 1.00 | | 154 | 1.00 | | 519 | 1.00 | | 581 | 1.00 | | 539 | 1.00 | |

- continued -

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| | 1990[g] | | | 1991[h] | | | 1992[i] | | |
|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE |
| 2 | 45 | 0.22 | 0.03 | 12 | 0.04 | 0.01 | 1(25)[j] | <0.01 | <0.01 |
| 3 | 76 | 0.37 | 0.03 | 45 | 0.16 | 0.02 | 62(96) | 0.15 | 0.03 |
| 4 | 38 | 0.19 | 0.03 | 69 | 0.25 | 0.03 | 251(254) | 0.48 | 0.04 |
| 5 | 18 | 0.09 | 0.02 | 81 | 0.30 | 0.03 | 183 | 0.25 | 0.03 |
| 6 | 13 | 0.06 | 0.02 | 37 | 0.13 | 0.02 | 66 | 0.07 | 0.02 |
| 7 | 7 | 0.03 | 0.01 | 19 | 0.07 | 0.01 | 28 | 0.03 | 0.01 |
| 8 | 5 | 0.02 | 0.01 | 7 | 0.03 | 0.01 | 18 | 0.02 | 0.01 |
| 9 | 1 | <0.01 | <0.01 | 2 | 0.01 | <0.01 | 5 | 0.01 | <0.01 |
| 10 | 0 | 0.00 | --- | 1 | <0.00 | <0.01 | 1 | <0.01 | <0.01 |
| 11 | 0 | 0.00 | --- | 1 | <0.00 | <0.01 | 0 | 0.00 | ---- |
| Totals | 203 | 1.00 | --- | 274 | 1.00 | --- | 552 | 1.00 | |

[a] Source documents are: 1985 - Holmes, et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990 - (Clark et al. 1991); 1991 - (Fleming et al. 1992); and, 1992- this report.

[b] Sampling was conducted with an AC electrofishing boat and hook-and-line gear from river km 64.0 to river km 57.6 (5-9 August 1985).

[c] Sampling was conducted with a DC electrofishing boat and hook-and-line gear from river km 112.0 to river km 4.8 (11-15 August 1986).

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[d] Sampling was conducted with a DC electrofishing boat from river km 38.6 to river km 4.8 (1-9 June 1987).

[e] Sampling was conducted with a DC electrofishing boat from river km 38.6 to river km 16.0 (24 May through 9 June 1988).

[f] Sampling was conducted with a DC electrofishing boat from river km 0 to 38.6 (12 through 16 June 1989). Age composition and standard error are adjusted for differential probability of capture by size of fish.

[g] Sampling was conducted with a DC electrofishing boat from river km 0 to 38.6 (19 through 27 June 1990).

[h] Sampling was conducted with a DC electrofishing boat from river km 0 to 38.6 (25 June through 2 July, 1991).

[i] Sampling was conducted with a DC electrofishing boat from river km 0 to 38.6 (22 June through 25 June, 1992). Age composition and standard error are adjusted for differential probability of capture by size of fish.

[j] Numbers in parentheses represent the number of fish sampled at age that were $\geq$ 150 mm FL.

Appendix A4. Summary of RSD indices of Arctic grayling captured in the Salcha River, 1972, 1974, and 1985-1992[a].

| | | RSD Category[b] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1972 - | Number sampled | ND[c] | ND | ND | ND | ND |
| | RSD | 0.53 | 0.46 | <0.01 | 0 | 0 |
| | SE | ND | ND | ND | --- | --- |
| 1974 - | Number sampled | 153 | 14 | 2 | 0 | 0 |
| | RSD | 0.91 | 0.08 | 0.01 | --- | --- |
| | SE | 0.02 | 0.02 | 0.01 | --- | --- |
| 1985 - | Number sampled | 17 | 155 | 57 | 0 | 0 |
| | RSD | 0.07 | 0.68 | 0.25 | --- | --- |
| | SE | 0.02 | 0.03 | 0.03 | --- | --- |
| 1986 - | Number sampled | 47 | 71 | 56 | 0 | 0 |
| | RSD | 0.27 | 0.41 | 0.32 | --- | --- |
| | SE | 0.03 | 0.04 | 0.04 | --- | --- |
| 1987 - | Number sampled | 275 | 171 | 71 | 1 | 0 |
| | RSD | 0.53 | 0.33 | 0.14 | <0.01 | --- |
| | SE | 0.02 | 0.02 | 0.02 | <0.01 | --- |
| 1988 - | Number sampled | 280 | 217 | 110 | 1 | 0 |
| | RSD | 0.46 | 0.36 | 0.18 | <0.01 | --- |
| | SE | 0.02 | 0.02 | 0.02 | <0.01 | --- |
| 1989 - | Number sampled | 755 | 342 | 124 | 2 | 0 |
| | Adjusted RSD[d] | 0.71 | 0.22 | 0.08 | <0.01 | --- |
| | SE | 0.04 | 0.03 | 0.01 | <0.01 | --- |
| 1990 - | Number sampled | 365 | 95 | 40 | 0 | 0 |
| | RSD | 0.73 | 0.19 | 0.08 | --- | --- |
| | SE | 0.02 | 0.02 | 0.01 | --- | --- |
| 1991 - | Number sampled[e] | 170 | 110 | 12 | 0 | 0 |
| | RSD | 0.58 | 0.38 | 0.04 | --- | --- |
| | SE | 0.03 | 0.03 | 0.01 | --- | --- |
| 1992 - | Number sampled[e] | 377 | 290 | 42 | 0 | 0 |
| | Adjusted RSD[d] | 0.71 | 0.25 | 0.04 | --- | --- |
| | SE | 0.08 | 0.07 | 0.01 | --- | --- |

[a] Data sources: 1972 - Tack (1973); 1974 - Bendock (1974) and Kramer (1975); 1985 - Holmes et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990- Clark et al (1991); 1991 - Fleming et al. (1992); and, 1992 - this report.

[b] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984): Stock - 150 mm FL; Quality - 270 mm FL; Preferred - 340 mm FL; Memorable 450 mm FL; and, Trophy - 560 mm FL.

[c] ND = data not furnished in original citation.

[d] RSD does not correspond to sample size because of adjustments made for differential capture probability by size of fish.

[e] Includes only Arctic grayling ≥ 200 mm Fl.

Appendix A5. Summary of mean length-at-age data collected from Arctic grayling in the Salcha River, 1952, 1974, 1981, and 1985-1992[a].

| | 1952 | | | 1974 | | | 1981 | | | 1985 | | | 1986 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | ND[e] | 103 | --- | 6 | 111 | --- | 20 | 126 | --- | --- | --- | --- | --- | --- | --- |
| 2 | ND | 145 | --- | 88 | 155 | --- | 25 | 162 | --- | 1 | 156 | --- | --- | --- | --- |
| 3 | ND | 185 | --- | 61 | 196 | --- | 11 | 197 | --- | 13 | 223 | 15 | 19 | 218 | 16 |
| 4 | ND | 223 | --- | 26 | 231 | --- | 9 | 224 | --- | 3 | 262 | 18 | 25 | 263 | 25 |
| 5 | ND | 261 | --- | 16 | 278 | --- | 7 | 254 | --- | 29 | 292 | 10 | 14 | 291 | 26 |
| 6 | ND | 289 | --- | 3 | 345 | --- | 5 | 272 | --- | 69 | 313 | 20 | 37 | 316 | 24 |
| 7 | ND | 318 | --- | --- | --- | --- | 8 | 302 | --- | 58 | 332 | 16 | 26 | 328 | 40 |
| 8 | --- | --- | --- | --- | --- | --- | 5 | 335 | --- | 25 | 346 | 15 | 22 | 360 | 30 |
| 9 | --- | --- | --- | --- | --- | --- | 1 | 353 | --- | 18 | 378 | 24 | 8 | 372 | 18 |
| 10 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 2 | 403 | 90 | 3 | 405 | 16 |
| 11 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1 | 364 | --- |
| Totals | 32 | | | 200 | | | 91 | | | 219 | | | 155 | | |

- continued -

Appendix A5. (Page 2 of 2).

| | 1987 | | | 1988 | | | 1989 | | | 1990 | | | 1991 | | | 1992 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1 | 123 | --- | --- | --- | --- | --- | --- | --- |
| 2 | 2 | 138 | 8 | 17 | 174 | 16 | 17 | 176 | 39 | 96 | 182 | 19 | 25 | 167 | 17 | 25 | 166 | 14 |
| 3 | 35 | 203 | 36 | 116 | 200 | 16 | 155 | 214 | 24 | 220 | 213 | 22 | 112 | 206 | 22 | 96 | 206 | 21 |
| 4 | 205 | 241 | 20 | 83 | 241 | 20 | 143 | 252 | 28 | 157 | 252 | 25 | 194 | 234 | 25 | 254 | 252 | 23 |
| 5 | 120 | 275 | 33 | 175 | 280 | 24 | 75 | 273 | 30 | 75 | 283 | 32 | 170 | 264 | 29 | 183 | 280 | 26 |
| 6 | 80 | 311 | 36 | 58 | 302 | 30 | 74 | 302 | 37 | 49 | 317 | 33 | 67 | 290 | 29 | 65 | 306 | 30 |
| 7 | 56 | 339 | 30 | 54 | 332 | 32 | 24 | 315 | 38 | 38 | 346 | 31 | 33 | 301 | 39 | 28 | 323 | 34 |
| 8 | 15 | 356 | 36 | 51 | 348 | 24 | 30 | 341 | 44 | 19 | 370 | 33 | 16 | 320 | 49 | 18 | 344 | 38 |
| 9 | 4 | 371 | 30 | 22 | 373 | 30 | 18 | 368 | 21 | 6 | 396 | 36 | 6 | 356 | 45 | 5 | 362 | 44 |
| 10 | 2 | 444 | 20 | 4 | 394 | 19 | 3 | 407 | 40 | 0 | --- | --- | 2 | 369 | 7 | 1 | 385 | --- |
| 11 | --- | --- | --- | 1 | 463 | --- | 0 | --- | --- | 0 | --- | --- | 1 | 358 | --- | --- | --- | --- |
| Totals | 519 | | | 581 | | | 539 | | | 661 | | | 626 | | | 674 | | |

[a] Data sources: 1952 - Warner (1959b); 1974 - Bendock (1974) and Kramer (1975); 1981 - Hallberg (1982); 1985 - Holmes, et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990 - Clark et al. (1991); 1991 - (Fleming et al. (1992); and, 1992 - this report.

[b] n is the total number of fish aged.

[c] FL is the estimated mean fork length (mm) at age.

[d] SD is the sample standard deviation of FL.

[e] ND = data not furnished in original citation.

## APPENDIX B

### Historic Data Summaries - Chatanika River

Appendix B1. Summary of recreational effort and catch rate estimates for Arctic grayling harvested from the Chatanika River, 1953-1958, 1974, and 1987[a].

| Year | Interviews | Angler-hours | GR/hr[b] |
|---|---|---|---|
| 1953 | 460 | 955 | 0.49 |
| 1954 | 243 | 529 | 0.78 |
| 1955[c] | 69 | 294 | 0.13 |
| 1956[c] | 66 | 223 | 0.27 |
| 1957[c] | 62 | 177 | 0.18 |
| 1958[c] | 68 | 151 | 0.76 |
| 1974 | 408 | 27,250[d] | 1.02 |
| 1987 | 30 | --- | 0.02 |

[a] Statistics taken from Warner (1959b) for 1953-1958, Kramer (1975) for 1974, and Baker (1988) for 1987.
[b] GR/hr is the number of Arctic grayling harvested per angler-hour.
[c] From 1955 through 1958 there was a 305 mm (12 inch) minimum length limit for Arctic grayling on the Chatanika River (Warner 1959b).
[d] Data expanded from sample time/area to the entire fishery.

Appendix B2. Summary of population abundance estimates of Arctic grayling in the Chatanika River, 1972, 1981, 1984-1985, 1990-1992[a].

| Dates | Area | Marks | Recaps | Estimate[b] | Confidence[c] |
|---|---|---|---|---|---|
| 8/10-8/17/72 | Elliot Highway Bridge | 103 | 4 | 305/km | Low |
| 8/24-8/26/81 | Elliot Highway Bridge | ND[d] | 64 | 169/km | 132-197/km |
| 8/15-8/18/84 | Elliot Highway Bridge | ND | 32 | 242/km | 172-352/km |
| 8/20-8/23/85 | Elliot Highway Bridge | 132 | 20 | 117/km | 82-176/km |
| 8/27-9/7/90 | 28.8 km section from 7.5 km above to Elliot Highway bridge downstream | 857 | 36 | 670/km | SE - 111/km |
| 8/12-8/15/91 | 35.2 km section from 9.6 km above to Elliot Highway bridge downstream | 608 | 58 | 312/km | SE - 62/km |
| 7/11-7/16, 8/23-8/26, 9/9-9/14/1991 | 83.2 km section from 25.6 km below the Elliot Highway bridge to Murphy Dome Extension Rd. | 667 | 25 | 242/km | SE - 46/km |
| 8/17-8/28/92 | 29.6 km section from 3.2 km above to Elliot Highway bridge downstream | 679 | 41 | 271/km | SE - 47/km |
| 8/17-8/28/92 | 83.2 km section from 25.6 km below the Elliot Highway bridge to Murphy Dome Extension Rd. | 1,767 | 224 | 140/km | SE - 15/km |

- continued -

[a] Data sources are:
1972 - Tack (1973);
1982 - Holmes (1983);
1984 - Holmes (1985);
1985 - Holmes et al. (1986);
1990 - Clark et al. (1991);
1991 - Fleming et al. (1992); and,
1992 - This report.

[b] All estimates except 1990 through 1992 were calculated with the modified Schnabel formula (Ricker 1975). The 1990 estimate was calculated with the modified Petersen estimate of Evenson (1988) and the modified Petersen estimate of Bailey (1951, 1952). The 1991 and 1992 estimates used the modified Petersen estimate of Bailey (1951, 1952).

[c] Confidence is a crude measure of precision (e.g. Low), the 95% confidence interval based on a Poisson distribution of recaptures (Ricker 1975), or the standard error.

[d] ND = data not furnished in original citation.

Appendix B3. Summary of age composition estimates and standard error of Arctic grayling (≥ 150 mm FL) collected from the Chatanika River, 1984-1992[a].

| Age Class | 1984[b] | | | 1985[c] | | | 1986[d] | | | 1987[e] | | | 1988[f] | | | 1989[g] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | p | SE | n | p | SE | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 2 | 2 | 0.04 | 0.03 | 131 | 0.55 | 0.03 | 0 | 0.00 | --- | 11 | 0.02 | 0.01 | 22 | 0.04 | 0.01 | 24 | 0.09 | 0.03 |
| 3 | 8 | 0.14 | 0.05 | 5 | 0.02 | 0.01 | 119 | 0.31 | 0.02 | 50 | 0.09 | 0.01 | 44 | 0.09 | 0.01 | 47 | 0.18 | 0.04 |
| 4 | 22 | 0.39 | 0.07 | 31 | 0.13 | 0.02 | 16 | 0.04 | 0.01 | 295 | 0.55 | 0.02 | 63 | 0.12 | 0.01 | 31 | 0.12 | 0.03 |
| 5 | 17 | 0.30 | 0.06 | 59 | 0.25 | 0.03 | 71 | 0.18 | 0.02 | 32 | 0.06 | 0.01 | 216 | 0.42 | 0.02 | 30 | 0.08 | 0.02 |
| 6 | 5 | 0.09 | 0.04 | 12 | 0.05 | 0.01 | 119 | 0.31 | 0.02 | 47 | 0.09 | 0.01 | 48 | 0.09 | 0.01 | 88 | 0.23 | 0.04 |
| 7 | 1 | 0.02 | 0.02 | 0 | 0.00 | --- | 47 | 0.12 | 0.02 | 106 | 0.19 | 0.02 | 55 | 0.11 | 0.01 | 54 | 0.14 | 0.03 |
| 8 | 1 | 0.02 | 0.02 | 0 | 0.00 | --- | 12 | 0.03 | 0.01 | 8 | 0.01 | 0.01 | 61 | 0.12 | 0.01 | 47 | 0.12 | 0.03 |
| 9 | 0 | 0.00 | --- | 0 | 0.00 | --- | 2 | 0.01 | 0.00 | 3 | 0.01 | <0.01 | 5 | 0.01 | <0.01 | 15 | 0.04 | 0.01 |
| 10 | 0 | 0.00 | --- | 0 | 0.00 | --- | 0 | 0.00 | --- | 1 | <0.01 | <0.01 | 1 | <0.01 | <0.01 | 2 | 0.01 | <0.01 |
| Totals | 56 | 1.00 | | 238 | 1.00 | | 386 | 1.00 | | 553 | 1.00 | | 515 | 1.00 | | 338 | 1.00 | |

- continued -

Appendix B3. (Page 2 of 3).

| | 1990[h] | | | 1991[i] | | | 1992[j] | | |
|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE |
| 2 | 126 | 0.20 | 0.02 | 26 | 0.05 | 0.01 | 56 | 0.14 | 0.03 |
| 3 | 347 | 0.55 | 0.02 | 88 | 0.17 | 0.02 | 32 | 0.08 | 0.01 |
| 4 | 80 | 0.11 | 0.01 | 226 | 0.44 | 0.02 | 83 | 0.22 | 0.03 |
| 5 | 45 | 0.04 | 0.01 | 46 | 0.09 | 0.01 | 198 | 0.36 | 0.03 |
| 6 | 51 | 0.04 | 0.01 | 36 | 0.07 | 0.01 | 81 | 0.11 | 0.01 |
| 7 | 57 | 0.04 | 0.01 | 47 | 0.09 | 0.01 | 30 | 0.03 | 0.01 |
| 8 | 17 | 0.01 | <0.01 | 29 | 0.06 | 0.01 | 39 | 0.04 | 0.01 |
| 9 | 11 | 0.01 | <0.01 | 12 | 0.02 | 0.01 | 28 | 0.03 | 0.01 |
| 10 | 2 | <0.01 | <0.01 | 4 | 0.01 | <0.01 | 10 | 0.01 | <0.01 |
| 11 | 0 | --- | --- | 1 | <0.01 | <0.01 | 1 | <0.01 | <0.01 |
| Totals | 736 | 1.00 | | 515 | 1.00 | | 558 | 1.00 | |

- continued-

[a] Source documents are: 1984 - Holmes (1985); 1985 - Holmes, et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990 - Clark et al. (1991); 1991 - Fleming et al. (1992); and, 1992 - this report.

[b] Sampling was conducted with an AC electrofishing boat near the Elliot Highway bridge (15-18 August 1984).

[c] Sampling was conducted with an AC electrofishing boat near the Elliot Highway bridge (20-23 August 1985).

[d] Sampling was conducted with a DC electrofishing boat near the Elliot Highway bridge (4-28 August 1986).

[e] Sampling was conducted with a DC electrofishing boat near the Elliot Highway bridge (10-13 August 1987).

[f] Sampling was conducted with a DC electrofishing boat near the Elliot Highway bridge (15-26 August and 7- 20 September 1988).

[g] Sampling was conducted with a DC electrofishing boat downstream of the Elliot Highway bridge (12 through 28 September 1989). Age composition and standard error are adjusted for differential probability of capture by size of fish.

[h] Sampling was conducted with a DC electrofishing boat in a 28.8 km section, beginning 7.5 km upstream of the Elliot Highway bridge and ending 21.3 km downstream of the bridge (27 August through 7 September 1990). Age composition and standard error are adjusted for differential probability of capture by size of fish.

[i] Sampling was conducted with a DC electrofishing boat in a 35.2 km section, beginning 9.6 km upstream of the Elliot Highway bridge and ending 25.6 km downstream of the bridge (5 through 7 August 1991).

[j] Sampling was conducted with a DC electrofishing boat in a 113 km section, beginning 3.2 km upstream of the Elliot Highway bridge and ending downstream at the Murphey Dome Road terminus (24 through 28 August 1992). Age composition and standard error are adjusted for differential probability of capture by size of fish.

Appendix B4. Summary of mean length-at-age data collected from Arctic grayling in the Chatanika River, 1952-1953, 1981-1982, 1984-1992[a].

| | 1952 | | | 1953 | | | 1981 | | | 1982 | | | 1984 | | | 1985 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | ND[e] | 94 | --- | 19 | 96 | --- | 0 | --- | --- | 5 | 95 | --- | 16 | 101 | --- | 0 | --- | --- |
| 2 | ND | 133 | --- | 77 | 144 | --- | 4 | 169 | --- | 29 | 135 | --- | 3 | 149 | --- | 131 | 147 | 15 |
| 3 | ND | 176 | --- | 129 | 190 | --- | 7 | 204 | --- | 22 | 187 | --- | 8 | 172 | --- | 5 | 181 | 25 |
| 4 | ND | 212 | --- | 28 | 207 | --- | 10 | 233 | --- | 23 | 216 | --- | 22 | 196 | --- | 31 | 212 | 22 |
| 5 | ND | 243 | --- | 4 | 226 | --- | 7 | 264 | --- | 5 | 236 | --- | 17 | 225 | --- | 59 | 233 | 24 |
| 6 | --- | --- | --- | 9 | 254 | --- | 3 | 286 | --- | 2 | 280 | --- | 5 | 251 | --- | 12 | 268 | 18 |
| 7 | --- | --- | --- | --- | --- | --- | 1 | 290 | --- | 1 | 252 | --- | 1 | 258 | --- | --- | --- | --- |
| 8 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 1 | 334 | --- | 1 | 301 | --- | --- | --- | --- |
| 9 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Totals | 149 | | | 266 | | | 32 | | | 88 | | | 73 | | | 238 | | |

- continued -

Appendix B4. (Page 2 of 3).

| | 1986 | | | 1987 | | | 1988 | | | 1989 | | | 1990 | | | 1991 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 4 | 125 | 16 | 19 | 125 | 10 | --- | --- | --- |
| 2 | --- | --- | --- | 11 | 157 | 15 | 22 | 170 | 13 | 30 | 159 | 27 | 143 | 167 | 14 | 26 | 165 | 9 |
| 3 | 119 | 195 | 21 | 50 | 200 | 24 | 44 | 205 | 16 | 47 | 203 | 38 | 351 | 195 | 17 | 87 | 204 | 22 |
| 4 | 16 | 231 | 36 | 295 | 228 | 18 | 63 | 238 | 21 | 31 | 234 | 42 | 80 | 242 | 18 | 227 | 227 | 21 |
| 5 | 71 | 248 | 16 | 32 | 265 | 22 | 216 | 259 | 22 | 30 | 267 | 56 | 45 | 269 | 15 | 46 | 264 | 27 |
| 6 | 119 | 267 | 20 | 47 | 273 | 21 | 48 | 278 | 24 | 88 | 286 | 36 | 52 | 282 | 19 | 36 | 285 | 17 |
| 7 | 47 | 292 | 28 | 106 | 288 | 30 | 55 | 298 | 22 | 54 | 305 | 46 | 61 | 297 | 22 | 48 | 300 | 29 |
| 8 | 12 | 304 | 21 | 8 | 319 | 18 | 61 | 312 | 25 | 47 | 313 | 49 | 17 | 324 | 23 | 29 | 314 | 29 |
| 9 | 2 | 283 | 35 | 3 | 296 | 55 | 5 | 328 | 8 | 15 | 334 | 86 | 11 | 329 | 12 | 12 | 317 | 40 |
| 10 | --- | --- | --- | 1 | 325 | ___ | 1 | 352 | --- | 2 | 337 | 147 | 2 | 337 | 34 | 3 | 334 | 6 |
| Totals | 386 | | | 553 | | | 515 | | | 349 | | | 781 | | | 514 | | |

- continued -

Appendix B4. (Page 3 of 3).

| | 1992 | | |
|---|---|---|---|
| Age Class | n | FL | SD |
| 1 | --- | --- | --- |
| 2 | 56 | 175 | 22 |
| 3 | 32 | 213 | 24 |
| 4 | 83 | 248 | 26 |
| 5 | 198 | 262 | 24 |
| 6 | 81 | 289 | 21 |
| 7 | 30 | 310 | 22 |
| 8 | 39 | 320 | 16 |
| 9 | 28 | 337 | 24 |
| 10 | 10 | 329 | 21 |
| 11 | 1 | 350 | --- |
| Totals | 558 | | |

[a] Data sources: 1952-1953 - Warner (1959b); 1981 - Hallberg (1982); 1982 - Holmes (1983); 1984 - Holmes (1985); 1985 - Holmes et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990 - Clark et al. (1991); 1991 - Fleming et al. (1992); and, 1992 - this report.

[b] n is the total number of fish aged.

[c] FL is the mean fork length (mm) at age.

[d] SD is the standard deviation of FL.

[e] ND = data not furnished in original citation.

Appendix B5. Summary of RSD indices of Arctic grayling captured in the Chatanika River, 1952-1954, 1972, 1982, 1984-1992[a].

| | RSD Category[b] | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| 1952 - Number sampled | 95 | 1 | 0 | 0 | 0 |
| RSD | 0.99 | 0.01 | --- | --- | --- |
| SE | 0.01 | 0.01 | --- | --- | --- |
| 1953 - Number sampled | 98 | 8 | 0 | 0 | 0 |
| RSD | 0.92 | 0.08 | --- | --- | --- |
| SE | 0.03 | 0.03 | --- | --- | --- |
| 1954 - Number sampled | 42 | 1 | 0 | 0 | 0 |
| RSD | 0.98 | 0.02 | --- | --- | --- |
| SE | 0.02 | 0.02 | --- | --- | --- |
| 1972 - Number sampled | 121 | 0 | 0 | 0 | 0 |
| RSD | 1.00 | --- | --- | --- | --- |
| SE | --- | --- | --- | --- | --- |
| 1982 - Number sampled | 53 | 3 | 0 | 0 | 0 |
| RSD | 0.95 | 0.05 | --- | --- | --- |
| SE | 0.03 | 0.03 | --- | --- | --- |
| 1984 - Number sampled | 206 | 9 | 1 | 0 | 0 |
| RSD | 0.95 | 0.04 | 0.01 | --- | --- |
| SE | 0.01 | 0.01 | 0.01 | --- | --- |
| 1985 - Number sampled | 146 | 11 | 0 | 0 | 0 |
| RSD | 0.93 | 0.07 | --- | --- | --- |
| SE | 0.02 | 0.02 | --- | --- | --- |
| 1986 - Number sampled | 279 | 121 | 4 | 0 | 0 |
| RSD | 0.69 | 0.30 | 0.01 | --- | --- |
| SE | 0.02 | 0.02 | 0.01 | --- | --- |
| 1987 - Number sampled | 420 | 126 | 7 | 0 | 0 |
| RSD | 0.76 | 0.23 | 0.01 | --- | --- |
| SE | 0.02 | 0.02 | 0.01 | --- | --- |
| 1988 - Number sampled | 361 | 221 | 13 | 0 | 0 |
| RSD | 0.61 | 0.37 | 0.02 | --- | --- |
| SE | 0.02 | 0.02 | 0.01 | --- | --- |

- continued -

Appendix B5. (Page 2 of 3).

| | RSD Category[b] | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| 1989 - Number sampled | 150 | 221 | 4 | 0 | 0 |
| RSD[c] | 0.49 | 0.49 | 0.02 | --- | --- |
| SE | 0.06 | 0.06 | 0.01 | --- | --- |
| 1990 - Number sampled | 1,201 | 309 | 19 | 0 | 0 |
| RSD[c] | 0.90 | 0.09 | 0.01 | --- | --- |
| SE | 0.02 | 0.02 | <0.01 | --- | --- |
| 1991[d] - Number sampled | 516 | 222 | 25 | 0 | 0 |
| RSD[c] | 0.84 | 0.14 | 0.02 | --- | --- |
| SE | 0.03 | 0.03 | <0.01 | --- | --- |
| 1991[e] - Number sampled | 381 | 312 | 56 | 0 | 0 |
| RSD | 0.51 | 0.42 | 0.07 | --- | --- |
| SE | 0.02 | 0.02 | 0.01 | --- | --- |
| 1992[f] - Number sampled | 294 | 134 | 9 | 0 | 0 |
| RSD[c] | 0.84 | 0.15 | 0.01 | --- | --- |
| SE | 0.03 | 0.03 | <0.01 | --- | --- |
| 1992[g] - Number sampled | 1,250 | 1,507 | 175 | 0 | 0 |
| RSD[c] | 0.44 | 0.50 | 0.06 | --- | --- |
| SE | 0.01 | 0.01 | <0.01 | --- | --- |

[a] Source documents are: 1952-1958 - Warner (1959b); 1972 - Tack (1973); 1982 - Holmes (1983); 1984 - Holmes (1985); 1985 - Holmes, et al. (1986); 1986 - Clark and Ridder (1987); 1987 - Clark and Ridder (1988); 1988 - Clark (1988); 1989 - Clark and Ridder (1990); 1990 - Clark et al. (1991); 1991 - Fleming et al. (1992); and, 1992 - this report.

[b] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984):
- Stock - 150 mm FL;
- Quality - 270 mm FL;
- Preferred - 340 mm FL;
- Memorable - 450 mm FL; and,
- Trophy - 560 mm FL.

- continued -

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[c] RSD does not correspond to sample size because of adjustments made for differential capture probability by size of fish.
[d] 28.8 km section from 3.2 km above to Elliot Highway bridge downstream to below Any Creek.
[e] 83.2 km section from 25.6 km below the Elliot Highway bridge to Murphy Dome Extension Rd.
[f] 35.2 km section from 9.6 km above to Elliot Highway bridge downstream to below Any Creek.
[g] 83.2 km section from 25.6 km below the Elliot Highway bridge to Murphy Dome Extension Rd.

Appendix B6. Parameter estimates and standard errors of the von Bertalanffy growth model[a] for Arctic grayling from the Salcha and Chatanika rivers, 1986-1988[b].

| | Salcha River | | Chatanika River | |
|---|---|---|---|---|
| Parameter | Estimate | Standard Error | Estimate | Standard Error |
| $L_\infty$[c] | 489 | 19 | 375 | 11 |
| $K$[d] | 0.16 | 0.02 | 0.19 | 0.02 |
| $t_0$[e] | -0.42 | 0.16 | -1.01 | 0.20 |
| $Corr(L_\infty,K)$[f] | -0.99 | --- | -0.98 | --- |
| $Corr(L_\infty,t_0)$ | -0.88 | --- | -0.89 | --- |
| $Corr(K,t_0)$ | 0.94 | --- | 0.96 | --- |
| Sample size | 1,198 | | 1,469 | |

[a] The form of the von Bertalanffy growth model (Ricker 1975) is as follows: $l_t = L_\infty (1 - exp(-K (t - t_0)))$. The parameters of this model were estimated with data collected during 1986 through 1988. This model was fitted to the data by nonlinear regression utilizing the Marquardt compromise (Marquardt 1963). The range of ages used to model growth were age 1 through age 11 for the Salcha River, and age 1 through age 10 for the Chatanika River.

[b] Source citation is Clark (1988).

[c] $L_\infty$ is the length a fish would achieve if it continued to live and grow indefinitely (Ricker 1975).

[d] $K$ is a constant that determines the rate of increase of growth increments (Ricker 1975).

[e] $t_0$ represents the hypothetical age at which a fish would have zero length (Ricker 1975).

[f] $Corr(x,y)$ is the correlation of parameter estimates x and y.

# APPENDIX C

## Historic Data Summaries - Goodpaster River

Appendix C1. Summary of population abundance estimates of Arctic grayling (≥ 150 mm FL) in the Goodpaster River, 1972 - 1992[a].

| | | | | | | Fish/km[b] | | |
|---|---|---|---|---|---|---|---|---|
| Year | Month | River km | M | C | R | N | 95% CI[c] | Rel.Prec[e] |
| 1972 | 12-14 Jul | 4.8 - 9.6 | 210 | --- | 30 | 189 | --- | --- |
| 1973 | 1 Jun-30 Aug | 0 - 53 | 2,328 | 1,734 | 122 | 480 | 411 - 590 | 19% |
| | | 53 - 98 | 561 | 680 | 16 | 322 | 223 - 732 | 79% |
| | | 98 - 184 | 415 | 410 | 19 | 81 | 57 - 164 | 66% |
| | | 0 - 184 | --- | --- | --- | 241 | 209 - 287 | 16% |
| 1974[d] | 15-29 Jul | 0 - 53 | 1,217 | 489 | 55 | 201 | 155 - 260 | 26% |
| | | 53 - 98 | 479 | 279 | 9 | 298 | 165 - 596 | 72% |
| | | 98 - 184 | 343 | 275 | 27 | 63 | 44 - 93 | 40% |
| | | 0 - 184 | --- | --- | --- | 152 | 124 - 186 | 20% |
| 1975 | 23-27 Jun | 4.8 - 9.6 | 330 | 145 | 31 | 314 | 223 - 456 | 37% |
| | | 24 - 28.8 | 317 | 319 | 34 | 604 | 436 - 863 | 35% |
| | | combined | 647 | 464 | 65 | 475 | 374 - 603 | 24% |
| 1976 | 21-24 Jun | 4.8 - 9.6 | 155 | 99 | 9 | 323 | 178 - 646 | 72% |
| | | 24 - 28.8 | 202 | 165 | 18 | 368 | 238 - 597 | 49% |
| | | combined | 357 | 264 | 27 | 351 | 245 - 524 | 40% |
| 1977 | 21-24 Jun | 4.8 - 9.6 | 234 | 150 | 11 | 613 | 356-1,150 | 65% |
| | | 24 - 28.8 | 396 | 263 | 60 | 357 | 278 - 457 | 25% |
| | | combined | 630 | 413 | 71 | 377 | 300 - 474 | 23% |
| 1978 | 20-23 Jun | 4.8 - 9.6 | 248 | 167 | 19 | 434 | 284 - 694 | 47% |
| | | 24 - 28.8 | 373 | 212 | 32 | 502 | 359 - 726 | 37% |
| | | combined | 621 | 379 | 51 | 473 | 361 - 618 | 27% |
| 1980 | 24-27 Jun | 4.8 - 9.6 | 231 | 153 | 13 | 529 | 318 - 938 | 59% |
| | | 24 - 28.8 | 337 | 213 | 31 | 470 | 334 - 683 | 37% |
| | | combined | 568 | 366 | 44 | 483 | 362 - 658 | 31% |
| 1982 | 29 Jun-2 Jul | 4.8 - 9.6 | 79 | 107 | 9 | 178 | 98 - 356 | 72% |
| | | 24 - 28.8 | 214 | 155 | 39 | 174 | 128 - 242 | 33% |
| | | combined | 293 | 260 | 48 | 163 | 123 - 219 | 30% |
| 1984 | 27-29 Jun | 4.8 - 9.6 | 265 | 91 | 12 | 391 | 153 - 629 | 61% |
| | | 24 - 28.8 | 216 | 169 | 28 | 264 | 161 - 367 | 39% |
| | | combined | 481 | 260 | 40 | 352 | 249 - 455 | 29% |

- continued -

Appendix C1. (Page 2 of 2).

| Year | Month | River km | M | C | R | Fish/km N | 95% CI | Rel. Prec[e] |
|---|---|---|---|---|---|---|---|---|
| 1985 | 25-27 Jun | 4.8 - 9.6 | 189 | 213 | 7 | 459 | 238 - 966 | 79% |
| 1985 | 6-13 Aug | 4.8 - 9.6 | 307 | 455 | 42 | 400 | 296 - 554 | 32% |
| | | 24 - 28.8 | 303 | 424 | 45 | 328 | 245 - 450 | 31% |
| | | combined | 610 | 879 | 87 | 364 | 271 - 502 | 32% |
| 1986 | 11-15 Aug | 4.8 - 9.6 | 230 | 312 | 15 | 403 | 250 - 686 | 54% |
| | | 24 - 28.8 | 293 | 389 | 42 | 256 | 193 - 352 | 31% |
| | | combined | 523 | 701 | 57 | 305 | 234 - 397 | 27% |
| 1987 | 4-10 Aug | 4.8 - 9.6 | 138 | 191 | 14 | 188 | 115 - 324 | 56% |
| | | 24 - 28.8 | 158 | 213 | 24 | 133 | 91 - 203 | 42% |
| | | combined | 274 | 363 | 35 | 134 | 97 - 191 | 35% |
| 1988 | 8-18 Aug | 4.8 - 53 | 1,130 | 1,002 | 139 | 158 | SE= 12/km | |
| 1989 | 8-17 Aug | 3 - 53 | 955 | 984 | 124 | 161 | SE= 15/km<br>139 - 192 | 17% |
| 1990 | 8-16 Aug | 3 - 53 | 1,051 | 554 | 82 | 145 | SE= 15/km<br>131 - 168 | 21% |
| 1991 | 7-14 Aug | 3 - 53 | 780 | 429 | 42 | 157 | SE= 17/km | |
| 1992 | 4-14 Aug | 3 - 53 | 922 | 562 | 80 | 138 | SE= 16/km | |

[a] Data sources: 1972 - 1974, Tack (1973, 1974, 1975); 1975 - 1978, 1980, Peckham (1976, 1977, 1978, 1979, 1981); 1982, 1984, Ridder (1983, 1985); 1985, Holmes, et al. (1986); 1986 - 1987, Clark and Ridder (1987, 1988), Ridder (1989); 1989, Clark and Ridder (1990); 1990, Clark et al. (1991); 1991, Fleming et al. (1992); and, 1992 - this report.

[b] Schnabel estimator in 1972, 1973, 1985 through 1987; modified Petersen (Bailey 1951, 1952) estimator in 1974 through 1984 and 1992; modified Petersen (Evenson 1988) in 1988; bootstrapped modified Petersen (Bailey 1951, 1952) in 1989, 1990, and 1991.

[c] The confidence interval is based on a Poisson distribution of recaptures (Ricker 1975). Estimates for 1988 through 1991 were from bootstrap methods (Efron 1982) and a standard error (SE) is reported.

[d] Estimate was based on total marks in 1973 which were adjusted with a mortality rate of 0.46 (Tack 1975). Number of marks presented shown for 1973 do not include those applied during the final 1973 sampling event.

[e] Rel. Prec. is relative precision.

Appendix C2. Summary of age composition estimates and standard errors for Arctic grayling sampled in the lower 53 km of the Goodpaster River, summer, 1955-1992[a].

| | 1955 29 July - 15 Sept. | | | 1956 summer | | | 1957 11 June - 15 Aug. | | | 1958 7 May - 25 July | | | 1969 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | p[c] | SE[d] | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 1 | 14 | 0.08 | 0.02 | 15 | 0.05 | 0.01 | 3 | 0.01 | <0.01 | 111 | 0.10 | 0.01 | 0 | --- | --- |
| 2 | 49 | 0.27 | 0.03 | 109 | 0.37 | 0.03 | 40 | 0.10 | 0.02 | 532 | 0.48 | 0.02 | 9 | 0.13 | 0.04 |
| 3 | 40 | 0.22 | 0.03 | 115 | 0.39 | 0.03 | 178 | 0.44 | 0.03 | 106 | 0.10 | 0.01 | 13 | 0.19 | 0.05 |
| 4 | 53 | 0.29 | 0.03 | 30 | 0.10 | 0.02 | 122 | 0.30 | 0.02 | 225 | 0.20 | 0.01 | 12 | 0.17 | 0.05 |
| 5 | 14 | 0.08 | 0.02 | 19 | 0.06 | 0.01 | 30 | 0.07 | 0.01 | 100 | 0.09 | 0.01 | 11 | 0.16 | 0.04 |
| 6 | 6 | 0.03 | 0.01 | 5 | 0.02 | 0.01 | 19 | 0.05 | 0.01 | 16 | 0.01 | <0.01 | 9 | 0.13 | 0.04 |
| 7 | 5 | 0.03 | 0.01 | 4 | 0.01 | 0.01 | 6 | 0.02 | 0.01 | 10 | 0.01 | <0.01 | 4 | 0.06 | 0.03 |
| 8 | 0 | --- | --- | 0 | --- | --- | 5 | 0.01 | 0.01 | 4 | <0.01 | <0.01 | 7 | 0.10 | 0.04 |
| 9 | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 | 0 | --- | --- | 4 | 0.06 | 0.03 |
| 10 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | 0.01 | 0.01 |
| 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 181 | 1.00 | | 297 | 1.00 | | 404 | 1.00 | | 1104 | 1.00 | | 70 | 1.00 | |

- continued -

Appendix C2. (Page 2 of 5).

| | 1973[a] 15 June - 15 Aug. | | | 1975 23 June - 24 June | | | 1976 21 June - 22 June | | | 1977 21 June - 22 June | | | 1978 21 June - 22 June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 1 | 0 | --- | --- | 3 | 0.03 | 0.02 | 1 | 0.01 | 0.01 | 8 | 0.07 | 0.02 | 2 | 0.02 | 0.01 |
| 2 | 3 | 0.03 | 0.02 | 3 | 0.03 | 0.02 | 13 | 0.11 | 0.03 | 1 | 0.01 | 0.01 | 23 | 0.22 | 0.04 |
| 3 | 65 | 0.65 | 0.05 | 52 | 0.52 | 0.05 | 13 | 0.11 | 0.03 | 76 | 0.66 | 0.04 | 13 | 0.13 | 0.03 |
| 4 | 27 | 0.27 | 0.05 | 7 | 0.07 | 0.03 | 44 | 0.37 | 0.04 | 6 | 0.05 | 0.02 | 58 | 0.56 | 0.05 |
| 5 | 2 | 0.02 | 0.01 | 29 | 0.29 | 0.05 | 25 | 0.21 | 0.04 | 13 | 0.11 | 0.03 | 8 | 0.08 | 0.03 |
| 6 | 3 | 0.03 | 0.02 | 5 | 0.05 | 0.02 | 22 | 0.18 | 0.03 | 12 | 0.10 | 0.03 | 0 | --- | --- |
| 7 | 0 | --- | --- | 1 | 0.01 | 0.01 | 1 | 0.01 | 0.01 | 0 | --- | --- | 0 | --- | --- |
| 8 | 0 | --- | --- | 0 | --- | --- | 1 | 0.01 | 0.01 | 0 | --- | --- | 0 | --- | --- |
| 9 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 10 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 100 | 1.00 | | 100 | 1.00 | | 120 | 1.00 | | 116 | 1.00 | | 104 | 1.00 | |

- continued -

Appendix C2. (Page 3 of 5).

| | 1980 24 June - 25 June | | | 1982 29 June - 2 July | | | 1984 27 June - 28 June | | | 1985[e] 25 June - 26 June | | | 1985[e] 8 - 11 August | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 1 | 5 | 0.05 | 0.02 | 0 | --- | --- | 7 | 0.07 | 0.03 | 0 | --- | --- | 0 | --- | --- |
| 2 | 26 | 0.27 | 0.05 | 8 | 0.08 | 0.03 | 7 | 0.07 | 0.03 | 3 | 0.02 | 0.01 | 56 | 0.27 | 0.03 |
| 3 | 19 | 0.20 | 0.04 | 21 | 0.22 | 0.04 | 17 | 0.17 | 0.04 | 44 | 0.22 | 0.03 | 27 | 0.13 | 0.02 |
| 4 | 40 | 0.42 | 0.05 | 43 | 0.44 | 0.05 | 48 | 0.48 | 0.05 | 33 | 0.16 | 0.03 | 22 | 0.11 | 0.02 |
| 5 | 6 | 0.06 | 0.03 | 21 | 0.22 | 0.04 | 11 | 0.11 | 0.03 | 79 | 0.39 | 0.03 | 69 | 0.33 | 0.03 |
| 6 | 0 | --- | --- | 4 | 0.04 | 0.02 | 7 | 0.07 | 0.03 | 25 | 0.12 | 0.02 | 18 | 0.09 | 0.02 |
| 7 | 0 | --- | --- | 0 | --- | --- | 3 | 0.03 | 0.02 | 16 | 0.08 | 0.02 | 15 | 0.07 | 0.02 |
| 8 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 4 | 0.02 | 0.01 | 1 | 0.01 | 0.01 |
| 9 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 10 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 96 | 1.00 | | 97 | 1.00 | | 100 | 1.00 | | 204 | 1.00 | | 208 | 1.00 | |

- continued -

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| | 1986[e] 11 - 15 August | | | 1987[e] 3 - 10 August | | | 1988[e] 8 - 11 August | | | 1989[e] 8 - 10 August | | | 1990[e] 8 - 10 August | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE | n | p | SE | n | p[f] | SE[f] | n | p[f] | SE[f] |
| 1 | 0 | --- | --- | 6 | 0.02 | 0.01 | 1 | <0.01 | <0.01 | 0 | --- | --- | 46 | 0.05 | <0.01 |
| 2 | 80 | 0.14 | 0.02 | 55 | 0.15 | 0.02 | 144 | 0.18 | 0.01 | 364 | 0.47 | 0.02 | 79 | 0.08 | <0.01 |
| 3 | 360 | 0.63 | 0.02 | 51 | 0.14 | 0.02 | 58 | 0.07 | 0.01 | 165 | 0.21 | 0.01 | 562 | 0.59 | 0.01 |
| 4 | 26 | 0.05 | 0.01 | 165 | 0.46 | 0.03 | 86 | 0.11 | 0.01 | 37 | 0.04 | 0.01 | 94 | 0.10 | <0.01 |
| 5 | 37 | 0.07 | 0.01 | 9 | 0.03 | 0.01 | 317 | 0.40 | 0.02 | 104 | 0.09 | 0.01 | 36 | 0.04 | <0.01 |
| 6 | 56 | 0.10 | 0.01 | 22 | 0.06 | 0.01 | 34 | 0.04 | 0.01 | 134 | 0.11 | 0.02 | 55 | 0.05 | <0.01 |
| 7 | 8 | 0.01 | 0.01 | 32 | 0.09 | 0.02 | 67 | 0.09 | 0.01 | 44 | 0.03 | <0.01 | 60 | 0.06 | 0.01 |
| 8 | 2 | <0.01 | <0.01 | 12 | 0.03 | 0.01 | 45 | 0.06 | 0.01 | 29 | 0.02 | 0.01 | 13 | 0.01 | <0.01 |
| 9 | 2 | <0.01 | <0.01 | 5 | 0.01 | 0.01 | 20 | 0.03 | 0.01 | 7 | 0.01 | <0.01 | 8 | 0.01 | <0.01 |
| 10 | 0 | --- | --- | 1 | <0.01 | <0.01 | 8 | 0.01 | <0.01 | 4 | <0.01 | <0.01 | 4 | <0.01 | <0.01 |
| 11 | 0 | --- | --- | 0 | --- | --- | 3 | <0.01 | <0.01 | 1 | <0.01 | 0.00 | 0 | --- | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 | 0 | --- | --- | 0 | --- | --- |
| Total | 571 | 1.00 | | 358 | 1.00 | | 784 | 1.00 | | 889 | 1.00 | | 957 | 1.00 | |

- continued -

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| | 1991[e] 7 - 9 August | | | 1992[e] 4 - 6 August | | |
|---|---|---|---|---|---|---|
| Age Class | n | p | SE | n | p | SE |
| 1 | 8 | 0.01 | <0.01 | 1 | 0.01 | <0.01 |
| 2 | 393 | 0.53 | 0.02 | 319 | 0.39 | 0.02 |
| 3 | 72 | 0.10 | 0.02 | 199 | 0.24 | 0.02 |
| 4 | 186 | 0.25 | 0.02 | 81 | 0.10 | 0.02 |
| 5 | 27 | 0.04 | 0.01 | 179 | 0.22 | 0.02 |
| 6 | 18 | 0.02 | <0.01 | 23 | 0.03 | 0.02 |
| 7 | 27 | 0.03 | 0.01 | 12 | 0.01 | <0.01 |
| 8 | 13 | 0.02 | 0.01 | 9 | 0.01 | <0.01 |
| 9 | 5 | 0.01 | <0.01 | 1 | <0.01 | <0.01 |
| 10 | 2 | <0.01 | <0.01 | 3 | <0.01 | <0.01 |
| 11 | 0 | --- | --- | 1 | <0.01 | <0.01 |
| 12 | 0 | --- | --- | 0 | --- | --- |
| Total | 751 | 1.00 | | 828 | 1.00 | |

[a] Data sources and gear type: 1955 - 1956, hook and line (H&L), Warner (1957); 1957, H&L, Warner (1958); 1958, seine, Warner (1959a); 1969, electrofishing boat (EB), Roguski and Tack (1970); 1973 - 1974, EB, Tack (1973, 1974); 1975 - 1980, EB, Peckham (1976, 1977, 1978, 1979, 1980, 1981); 1982 - 1984, EB, Ridder (1983, 1985); 1985, EB, Holmes, et al. (1986); 1986 - 1987, EB, Clark and Ridder (1987, 1988); 1988, EB, Ridder (1989); 1989, EB, Clark and Ridder (1990); 1990, EB, Clark et al. (1991); 1991, EB, Fleming et al. (1992); and, 1992, EB, this report.

[b] n = sample size.

[c] p = proportion.

[d] SE = standard error of the proportion.

[e] For Arctic grayling greater than 149 mm FL only.

[f] Proportions and SE were adjusted to compensate for length bias found in the electrofishing sample.

Appendix C3. Summary of age composition estimates and standard errors for Arctic grayling sampled in the middle (53-98 km) and upper (98-152 km) sections of the Goodpaster River, summer, 1973 and 1979[a].

| | 1973[b] 15 June - 15 Aug middle | | | 1973[b] 15 June - 15 Aug upper | | | 1979 23 - 24 June upper | | |
|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[c] | p[d] | SE[e] | n | p | SE | n | p | SE |
| 1 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 2 | 3 | 0.03 | 0.02 | 0 | --- | --- | 0 | --- | --- |
| 3 | 26 | 0.26 | 0.04 | 0 | --- | --- | 0 | --- | --- |
| 4 | 30 | 0.30 | 0.05 | 11 | 0.11 | 0.03 | 0 | --- | --- |
| 5 | 31 | 0.31 | 0.05 | 15 | 0.15 | 0.04 | 6 | 0.10 | 0.04 |
| 6 | 8 | 0.08 | 0.03 | 17 | 0.17 | 0.04 | 11 | 0.18 | 0.05 |
| 7 | 2 | 0.02 | 0.01 | 35 | 0.36 | 0.05 | 23 | 0.37 | 0.06 |
| 8 | 0 | --- | --- | 6 | 0.06 | 0.02 | 18 | 0.29 | 0.06 |
| 9 | 0 | --- | --- | 7 | 0.07 | 0.03 | 5 | 0.08 | 0.03 |
| 10 | 0 | --- | --- | 4 | 0.04 | 0.02 | 0 | --- | --- |
| 11 | 0 | --- | --- | 2 | 0.02 | 0.02 | 0 | --- | --- |
| 12 | 0 | --- | --- | 1 | 0.01 | 0.01 | 0 | --- | --- |
| Total | 100 | 1.00 | | 98 | 1.00 | | 63 | 1.00 | |

[a] Data sources and gear type: 1973 (middle) electrofishing boat, 1973 (upper) hook and line, Tack (1973, 1974); 1979, hook and line, Peckham (1979).
[b] For Arctic grayling greater than 149 mm FL only.
[c] n - sample size.
[d] p - proportion.
[e] SE - standard error of the proportion.

Appendix C4. Age composition estimates[a] for Arctic grayling weighted by three area population densities, Goodpaster River, 1973 and 1974.

| | 1973 | | | 1974 | | |
|---|---|---|---|---|---|---|
| Age Class | n[b] | p[c] | SE[d] | n | p | SE |
| 2 | ND[e] | 0.03 | ND | --- | --- | --- |
| 3 | ND | 0.45 | ND | ND | 0.07 | ND |
| 4 | ND | 0.28 | ND | ND | 0.52 | ND |
| 5 | ND | 0.13 | ND | ND | 0.20 | ND |
| 6 | ND | 0.05 | ND | ND | 0.06 | ND |
| 7 | ND | 0.04 | ND | ND | 0.06 | ND |
| 8 | ND | 0.01 | ND | ND | 0.01 | ND |
| 9 | ND | 0.01 | ND | ND | <0.01 | ND |
| 10 | ND | <0.01 | ND | ND | <0.01 | ND |
| 11 | ND | <0.01 | ND | --- | --- | --- |
| 12 | ND | <0.01 | ND | --- | --- | --- |
| Total | ND | 1.00 | | 277 | 1.00 | |

[a] Estimates developed from combining age proportions found in three river sections using the estimated population abundance in each section as a weighting factor. Data source is Tack (1974, 1975).
[b] n - sample size.
[c] p - proportion.
[d] SE - standard error of the proportion.
[e] ND - no data in citation.

Appendix C5. Summary of age composition estimates and standard errors for Arctic grayling sampled in the lower 16 km of the Goodpaster River, spring, 1982, 1985, 1986, and 1987[a].

| | 1982 15 - 16 May | | | 1985 22 - 23 May | | | 1986 16 - 17 May | | | 1987 12 - 13 May | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | p[c] | SE[d] | n | p | SE | n | p | SE | n | p | SE |
| 1 | 2 | 0.01 | 0.01 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 2 | 4 | 0.02 | 0.01 | 0 | --- | --- | 9 | 0.03 | 0.01 | 4 | 0.01 | 0.01 |
| 3 | 26 | 0.12 | 0.02 | 11 | 0.03 | 0.01 | 67 | 0.20 | 0.02 | 2 | 0.01 | 0.01 |
| 4 | 30 | 0.14 | 0.02 | 32 | 0.08 | 0.01 | 31 | 0.09 | 0.02 | 49 | 0.16 | 0.02 |
| 5 | 29 | 0.13 | 0.02 | 136 | 0.35 | 0.02 | 34 | 0.10 | 0.02 | 11 | 0.04 | 0.01 |
| 6 | 45 | 0.20 | 0.03 | 53 | 0.14 | 0.02 | 92 | 0.28 | 0.02 | 28 | 0.09 | 0.02 |
| 7 | 29 | 0.13 | 0.02 | 85 | 0.22 | 0.02 | 48 | 0.14 | 0.02 | 72 | 0.24 | 0.03 |
| 8 | 33 | 0.15 | 0.02 | 25 | 0.06 | 0.01 | 32 | 0.10 | 0.02 | 53 | 0.18 | 0.02 |
| 9 | 16 | 0.07 | 0.02 | 31 | 0.08 | 0.01 | 10 | 0.03 | 0.01 | 45 | 0.15 | 0.02 |
| 10 | 7 | 0.03 | 0.01 | 10 | 0.03 | 0.01 | 5 | 0.02 | 0.01 | 16 | 0.05 | 0.01 |
| 11 | 1 | 0.01 | <0.01 | 7 | 0.02 | 0.01 | 2 | 0.01 | <0.01 | 15 | 0.05 | 0.01 |
| 12 | 0 | --- | --- | 0 | --- | --- | 3 | 0.01 | 0.01 | 3 | 0.01 | 0.01 |
| 13 | 0 | --- | --- | 0 | --- | --- | 2 | 0.01 | <0.01 | 2 | 0.01 | 0.01 |
| 14 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 |
| Total | 222 | 1.00 | | 390 | 1.00 | | 335 | 1.00 | | 301 | 1.00 | |

[a] All fish captured with an electrofishing boat. 1982 data from Ridder (1983) and Hop (1985); other data collected during an egg-take program (see Holmes, et al., 1986) and are from office files.
[b] n = sample size.
[c] p = proportion.
[d] SE = standard error of the proportion.

Appendix C6. Summary of age composition estimates and standard errors for adult Arctic grayling sampled in the lower 16 km of the Goodpaster River, spring, 1982, 1985, 1986, and 1987[a].

| | 1982 15 - 16 May | | | 1985 22 - 23 May | | | 1986 16 - 17 May | | | 1987 12 - 13 May | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | p[c] | SE[d] | n | p | SE | n | p | SE | n | p | SE | n | p | SE |
| 5 | 14 | 0.10 | 0.03 | 3 | 0.02 | 0.01 | 1 | 0.01 | 0.01 | 2 | 0.01 | 0.01 | 20 | 0.03 | 0.01 |
| 6 | 41 | 0.29 | 0.04 | 25 | 0.16 | 0.03 | 43 | 0.31 | 0.04 | 22 | 0.10 | 0.02 | 131 | 0.20 | 0.02 |
| 7 | 29 | 0.21 | 0.03 | 62 | 0.39 | 0.04 | 43 | 0.31 | 0.04 | 68 | 0.30 | 0.03 | 202 | 0.30 | 0.02 |
| 8 | 33 | 0.23 | 0.04 | 23 | 0.14 | 0.03 | 32 | 0.23 | 0.04 | 52 | 0.23 | 0.03 | 140 | 0.21 | 0.02 |
| 9 | 16 | 0.11 | 0.03 | 31 | 0.19 | 0.03 | 10 | 0.07 | 0.02 | 45 | 0.20 | 0.03 | 102 | 0.15 | 0.01 |
| 10 | 7 | 0.05 | 0.02 | 10 | 0.06 | 0.02 | 5 | 0.04 | 0.02 | 16 | 0.07 | 0.02 | 38 | 0.06 | 0.01 |
| 11 | 1 | 0.01 | 0.01 | 7 | 0.04 | 0.02 | 2 | 0.01 | 0.01 | 15 | 0.07 | 0.02 | 25 | 0.04 | 0.01 |
| 12 | 0 | --- | --- | 0 | --- | --- | 3 | 0.02 | 0.01 | 3 | 0.01 | 0.01 | 6 | 0.01 | <0.01 |
| 13 | 0 | --- | --- | 0 | --- | --- | 2 | 0.01 | 0.01 | 2 | 0.01 | 0.01 | 4 | 0.01 | <0.01 |
| 14 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | <0.01 | <0.01 | 1 | <0.01 | <0.01 |
| Total | 141 | 1.00 | | 161 | 1.00 | | 141 | 1.00 | | 226 | 1.00 | | 669 | 1.00 | |

[a] All fish captured with an electrofishing boat. Determination of adult fish was made by sexual dimorphism and/or reproductive products. 1982 data from Ridder (1983) and Hop (1985); other data collected during an egg-take program (see Holmes et al., 1986) and are from office files.

[b] n = sample size.

[c] p = proportion.

[d] SE = standard error of the proportion.

Appendix C7. Summary of mean length-at-age data for Arctic grayling sampled in the Goodpaster River, summer, 1969-1992[a].

| | 1969 summer | | | 1973 15 June-15 August | | | 1975 23-24 June | | | 1976 21-22 June | | | 1977 21-22 June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | 0 | --- | --- | 0 | --- | --- | 3 | 82 | ND | 1 | 108 | ND | 8 | 98 | ND |
| 2 | 9 | 126 | ND[e] | 3 | 146 | ND | 3 | 149 | ND | 13 | 149 | ND | 1 | 151 | ND |
| 3 | 13 | 171 | ND | 91 | 181 | ND | 52 | 182 | ND | 13 | 187 | ND | 76 | 175 | ND |
| 4 | 12 | 215 | ND | 68 | 224 | ND | 7 | 207 | ND | 44 | 209 | ND | 6 | 229 | ND |
| 5 | 11 | 265 | ND | 48 | 276 | ND | 29 | 233 | ND | 25 | 240 | ND | 13 | 245 | ND |
| 6 | 9 | 297 | ND | 28 | 317 | ND | 5 | 269 | ND | 22 | 264 | ND | 12 | 273 | ND |
| 7 | 4 | 330 | ND | 37 | 343 | ND | 1 | 346 | ND | 1 | 285 | ND | 0 | --- | --- |
| 8 | 7 | 351 | ND | 6 | 368 | ND | 0 | --- | --- | 1 | 364 | ND | 0 | --- | --- |
| 9 | 4 | 362 | ND | 7 | 396 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 10 | 1 | 378 | ND | 4 | 404 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 11 | 0 | --- | --- | 3 | 417 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 12 | 0 | --- | --- | 1 | 432 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 70 | | | 285 | | | 100 | | | 120 | | | 116 | | |

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| | 1978<br>21-22 June | | | 1979<br>25-28 June | | | 1980<br>24-25 June | | | 1982<br>29-30 June | | | 1984<br>27-28 June | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | 2 | 101 | ND | 0 | --- | --- | 5 | 105 | ND | 0 | --- | --- | 7 | 92 | ND |
| 2 | 23 | 140 | ND | 0 | --- | --- | 26 | 156 | ND | 8 | 133 | ND | 7 | 161 | ND |
| 3 | 13 | 188 | ND | 0 | --- | --- | 19 | 202 | ND | 21 | 191 | ND | 17 | 204 | ND |
| 4 | 58 | 208 | ND | 0 | --- | --- | 40 | 220 | ND | 43 | 218 | ND | 48 | 219 | ND |
| 5 | 8 | 268 | ND | 6 | 281 | ND | 6 | 260 | ND | 21 | 249 | ND | 11 | 259 | ND |
| 6 | 0 | --- | --- | 11 | 320 | ND | 0 | --- | --- | 4 | 270 | ND | 7 | 258 | ND |
| 7 | 0 | --- | --- | 23 | 359 | ND | 0 | --- | --- | 0 | --- | --- | 3 | 289 | ND |
| 8 | 0 | --- | --- | 18 | 379 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 9 | 0 | --- | --- | 5 | 395 | ND | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 10 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 104 | | | 63 | | | 96 | | | 97 | | | 100 | | |

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| | 1985[f] 25-26 June | | | 1985[f] 6-8 August | | | 1986[f] 11-15 August | | | 1987[f] 3-10 August | | | 1988[f] 8-11 August | | | 1989[f] 8-10 August | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 6 | 166 | 17 | 1 | 155 | --- | 0 | --- | --- |
| 2 | 3 | 160 | 6 | 56 | 164 | 15 | 80 | 164 | 9 | 55 | 183 | 15 | 144 | 187 | 13 | 364 | 171 | 11 |
| 3 | 44 | 190 | 12 | 27 | 208 | 10 | 360 | 193 | 19 | 51 | 206 | 14 | 58 | 221 | 14 | 165 | 220 | 14 |
| 4 | 33 | 224 | 14 | 22 | 236 | 14 | 26 | 235 | 15 | 165 | 233 | 13 | 86 | 243 | 16 | 37 | 253 | 17 |
| 5 | 79 | 245 | 19 | 69 | 253 | 17 | 37 | 261 | 12 | 9 | 264 | 15 | 317 | 268 | 17 | 104 | 277 | 19 |
| 6 | 25 | 269 | 20 | 18 | 284 | 13 | 56 | 281 | 22 | 22 | 276 | 14 | 34 | 296 | 17 | 134 | 296 | 18 |
| 7 | 16 | 284 | 21 | 15 | 292 | 20 | 8 | 305 | 23 | 32 | 288 | 17 | 67 | 307 | 20 | 44 | 315 | 19 |
| 8 | 4 | 323 | 25 | 1 | 295 | --- | 2 | 301 | 8 | 12 | 296 | 17 | 45 | 321 | 22 | 29 | 332 | 17 |
| 9 | 0 | --- | --- | 0 | --- | --- | 2 | 387 | 27 | 5 | 341 | 34 | 20 | 336 | 33 | 7 | 354 | 19 |
| 10 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | 311 | --- | 8 | 352 | 15 | 4 | 384 | 21 |
| 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 3 | 376 | 33 | 1 | 378 | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | 391 | --- | 0 | --- | --- |
| Total | 204 | 236 | 37 | 208 | 227 | 47 | 571 | 211 | 72 | 358 | 233 | 38 | 784 | 254 | 46 | 889 | 230 | 59 |

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| | 1990[f] 8-10 August | | | 1991[f] 7-9 August | | | 1992[f] 4-6 August | | |
|---|---|---|---|---|---|---|---|---|---|
| Age Class | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | 46 | 156 | 5 | 8 | 163 | 12 | 1 | 152 | --- |
| 2 | 79 | 182 | 11 | 393 | 189 | 11 | 319 | 176 | 12 |
| 3 | 562 | 214 | 15 | 72 | 217 | 14 | 199 | 224 | 17 |
| 4 | 94 | 252 | 20 | 186 | 245 | 15 | 81 | 256 | 17 |
| 5 | 36 | 278 | 23 | 27 | 276 | 14 | 179 | 273 | 15 |
| 6 | 55 | 297 | 26 | 18 | 294 | 21 | 23 | 308 | 24 |
| 7 | 60 | 311 | 24 | 27 | 313 | 18 | 12 | 318 | 28 |
| 8 | 13 | 321 | 28 | 13 | 328 | 27 | 9 | 339 | 26 |
| 9 | 8 | 345 | 18 | 5 | 348 | 19 | 1 | 318 | --- |
| 10 | 4 | 365 | 57 | 2 | 386 | 4 | 3 | 383 | 6 |
| 11 | 0 | --- | --- | 0 | --- | --- | 1 | 392 | --- |
| 12 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| Total | 957 | 228 | 45 | 751 | 220 | 43 | 828 | 225 | 48 |

[a] Data sources and gear type: 1969, electrofishing boat (EB), Roguski and Tack (1970); 1973 - 1974, EB, Tack (1973,1974); 1975 - 1980, EB, Peckham (1976, 1977, 1978, 1979, 1980, 1981); 1982 - 1984, EB, Ridder (1983, 1985); 1985, EB, Holmes, et al. (1986); 1986 - 1987, EB, Clark and Ridder (1987, 1988); 1988, Ridder (1989); 1989, Clark and Ridder (1990); 1990 - Clark et al. (1991); 1991 - Fleming et al. (1992); and, 1992, this report.

[b] n - sample size.

[c] FL - mean fork length (mm) at age.

[d] SD - sample standard deviation of FL.

[e] ND - no data in citation.

[f] For Arctic grayling greater than 149 mm FL only.

Appendix C8. Summary of mean length-at-age data for Arctic grayling sampled in the lower 16 km of the Goodpaster River, spring, 1982, 1985 through 1986[a].

| | 1982 15 - 16 May | | | 1985 22 - 23 May | | | 1986 16 - 17 May | | | 1987 12 - 13 May | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD |
| 1 | 2 | 96 | 11 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- |
| 2 | 4 | 137 | 21 | 0 | --- | --- | 9 | 133 | 23 | 4 | 183 | 12 |
| 3 | 26 | 195 | 9 | 11 | 193 | 9 | 67 | 175 | 20 | 2 | 160 | 10 |
| 4 | 30 | 217 | 10 | 32 | 224 | 15 | 31 | 221 | 15 | 49 | 224 | 21 |
| 5 | 29 | 262 | 20 | 136 | 250 | 21 | 34 | 252 | 16 | 11 | 280 | 21 |
| 6 | 45 | 293 | 31 | 53 | 279 | 17 | 92 | 276 | 21 | 28 | 303 | 21 |
| 7 | 29 | 311 | 36 | 85 | 301 | 28 | 48 | 305 | 18 | 72 | 328 | 22 |
| 8 | 33 | 337 | 29 | 25 | 323 | 21 | 32 | 317 | 22 | 53 | 338 | 27 |
| 9 | 16 | 349 | 24 | 31 | 355 | 23 | 10 | 378 | 25 | 45 | 363 | 21 |
| 10 | 7 | 368 | 24 | 10 | 365 | 28 | 5 | 385 | 25 | 16 | 379 | 23 |
| 11 | 1 | 383 | --- | 7 | 381 | 16 | 2 | 405 | 24 | 15 | 393 | 20 |
| 12 | 0 | --- | --- | 0 | --- | --- | 3 | 414 | 26 | 3 | 418 | 10 |
| 13 | 0 | --- | --- | 0 | --- | --- | 2 | 416 | 14 | 2 | 371 | 4 |
| 14 | 0 | --- | --- | 0 | --- | --- | 0 | --- | -- | 1 | 472 | --- |
| Total | 222 | 278 | 63 | 390 | 280 | 48 | 335 | 259 | 64 | 301 | 320 | 59 |

[a] All fish captured with an electrofishing boat. 1982 data from Ridder (1983) and Hop (1985); other data collected during an egg-take program (see Holmes et al. 1986) and are from office files.
[b] n = sample size.
[c] FL = mean fork length (mm) at age.
[d] SD = sample standard deviation of FL.

Appendix C9. Summary of mean length-at-age data for adult male Arctic grayling sampled in the lower 16 km of the Goodpaster River, spring, 1982, 1985 through 1987[a].

| | 1982 15 - 16 May | | | 1985 22 - 23 May | | | 1986 16 - 17 May | | | 1987 16 - 17 May | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 5 | 8 | 276 | 11 | 2 | 304 | 49 | 0 | --- | --- | 1 | 339 | --- | 11 | 286 | 30 |
| 6 | 21 | 298 | 35 | 7 | 291 | 17 | 21 | 292 | 19 | 15 | 308 | 24 | 64 | 297 | 27 |
| 7 | 16 | 311 | 42 | 19 | 321 | 30 | 19 | 313 | 17 | 49 | 332 | 22 | 103 | 323 | 28 |
| 8 | 26 | 337 | 30 | 5 | 329 | 13 | 14 | 318 | 18 | 36 | 344 | 28 | 81 | 336 | 28 |
| 9 | 11 | 351 | 24 | 11 | 360 | 21 | 4 | 361 | 22 | 37 | 364 | 21 | 63 | 361 | 22 |
| 10 | 7 | 368 | 24 | 4 | 379 | 35 | 4 | 385 | 23 | 12 | 383 | 25 | 27 | 379 | 27 |
| 11 | 1 | 383 | --- | 2 | 394 | 7 | 2 | 405 | 24 | 12 | 390 | 20 | 17 | 391 | 20 |
| 12 | 0 | --- | --- | 0 | --- | --- | 3 | 414 | 26 | 3 | 418 | 10 | 6 | 416 | 20 |
| 13 | 0 | --- | --- | 0 | --- | --- | 2 | 416 | 14 | 2 | 371 | 4 | 4 | 393 | 25 |
| 14 | 0 | --- | --- | 0 | --- | --- | 0 | --- | --- | 1 | 472 | --- | 1 | 472 | --- |
| Total | 90 | 322 | 41 | 50 | 333 | 39 | 69 | 325 | 42 | 168 | 350 | 36 | 377 | 337 | 41 |

[a] All fish captured with an electrofishing boat. Determination of adult fish was made by sexual dimorphism and/or reproductive products. 1982 data from Ridder (1983) and Hop (1985); other data collected during an egg-take program (see Holmes et al. 1986) and are from office files.

[b] n = sample size.

[c] FL = mean fork length (mm) at age.

[d] SD = sample standard deviation of FL.

Appendix C10. Summary of mean length-at-age data for adult female Arctic grayling sampled in the lower 16 km of the Goodpaster River, spring, 1982, 1985 through 1987[a].

| | 1982 15 - 16 May | | | 1985 22 - 23 May | | | 1986 16 - 17 May | | | 1987 12 - 13 May | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Class | n[b] | FL[c] | SD[d] | n | FL | SD | n | FL | SD | n | FL | SD | n | FL | SD |
| 5 | 6 | 280 | 11 | 1 | 248 | --- | 1 | 253 | --- | 1 | 296 | --- | 9 | 275 | 17 |
| 6 | 20 | 296 | 24 | 18 | 283 | 18 | 22 | 287 | 22 | 7 | 298 | 9 | 67 | 290 | 21 |
| 7 | 13 | 310 | 25 | 43 | 301 | 26 | 24 | 302 | 16 | 19 | 320 | 19 | 99 | 306 | 24 |
| 8 | 7 | 334 | 23 | 18 | 322 | 23 | 18 | 317 | 24 | 16 | 326 | 19 | 59 | 323 | 23 |
| 9 | 5 | 345 | 25 | 20 | 352 | 24 | 6 | 344 | 24 | 8 | 360 | 22 | 39 | 351 | 24 |
| 10 | 0 | --- | --- | 6 | 356 | 17 | 1 | 351 | --- | 4 | 367 | 13 | 11 | 360 | 16 |
| 11 | 0 | --- | --- | 5 | 376 | 16 | 0 | --- | --- | 3 | 405 | 12 | 8 | 387 | 20 |
| Total | 51 | 307 | 30 | 111 | 316 | 37 | 72 | 304 | 27 | 58 | 333 | 33 | 292 | 313 | 34 |

[a] All fish captured with an electrofishing boat. Determination of adult fish was made by sexual dimorphism and/or reproductive products. 1982 data from Ridder (1983) and Hop (1985); other data collected during an egg-take program (see Holmes et al. 1986) and are from office files.
[b] n = sample size.
[c] FL = mean fork length (mm) at age.
[d] SD = sample standard deviation of FL.

Appendix C11. Summary of RSD estimates for Arctic grayling (≥ 150 mm FL) in the lower Goodpaster River, 1955-1992[a].

| | | RSD Category[b] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1955 | Number sampled | 118 | 45 | 10 | 0 | 0 |
| Jul- | RSD | 0.68 | 0.26 | 0.06 | --- | --- |
| Sept | Standard Error | 0.04 | 0.03 | 0.02 | --- | --- |
| 1956 | Number sampled | 204 | 31 | 4 | 0 | 0 |
| Jun- | RSD | 0.85 | 0.13 | 0.02 | --- | --- |
| Aug | Standard Error | 0.02 | 0.02 | 0.01 | --- | --- |
| 1970 | Number sampled | 802 | 42 | 0 | 0 | 0 |
| Aug | RSD | 0.95 | 0.05 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |
| 1972 | Number sampled | 163 | 9 | 0 | 0 | 0 |
| Jun | RSD | 0.95 | 0.05 | --- | --- | --- |
| | Standard Error | 0.02 | 0.02 | --- | --- | --- |
| 1972 | Number sampled | 120 | 2 | 0 | 0 | 0 |
| Aug | RSD | 0.98 | 0.02 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |
| 1975 | Number sampled | 636 | 12 | 1 | 0 | 0 |
| Jun | RSD | 0.98 | 0.02 | <0.01 | --- | --- |
| | Standard Error | <0.01 | 0.01 | <0.01 | --- | --- |
| 1976 | Number sampled | 337 | 18 | 2 | 0 | 0 |
| Jun | RSD | 0.94 | 0.05 | 0.01 | --- | --- |
| | Standard Error | 0.01 | 0.01 | <0.01 | --- | --- |
| 1977 | Number sampled | 633 | 15 | 1 | 0 | 0 |
| Jun | RSD | 0.98 | 0.02 | <0.01 | --- | --- |
| | Standard Error | 0.01 | 0.01 | <0.01 | --- | --- |
| 1978 | Number sampled | 603 | 17 | 0 | 0 | 0 |
| Jun | RSD | 0.97 | 0.03 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |
| 1980 | Number sampled | 588 | 12 | 0 | 0 | 0 |
| Jun | RSD | 0.98 | 0.02 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |

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| | | RSD Category[b] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1982 | Number sampled | 112 | 102 | 37 | 0 | 0 |
| May | RSD | 0.45 | 0.41 | 0.15 | --- | --- |
| | Standard Error | 0.03 | 0.03 | 0.02 | --- | --- |
| 1982 | Number sampled | 314 | 11 | 0 | 0 | 0 |
| Jun | RSD | 0.97 | 0.03 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |
| 1984 | Number sampled | 443 | 39 | 0 | 0 | 0 |
| Jun | RSD | 0.92 | 0.08 | --- | --- | --- |
| | Standard Error | 0.01 | 0.01 | --- | --- | --- |
| 1985 | Number sampled | 217 | 210 | 80 | 0 | 0 |
| May | RSD | 0.43 | 0.41 | 0.16 | --- | --- |
| | Standard Error | 0.02 | 0.02 | 0.02 | --- | --- |
| 1985 | Number sampled | 169 | 35 | 1 | 0 | 0 |
| Jun | RSD | 0.82 | 0.17 | 0.01 | --- | --- |
| | Standard Error | 0.03 | 0.03 | 0.01 | --- | --- |
| 1985 | Number sampled | 322 | 60 | 0 | 0 | 0 |
| Aug | RSD | 0.84 | 0.16 | --- | --- | --- |
| | Standard Error | 0.02 | 0.02 | --- | --- | --- |
| 1986 | Number sampled | 167 | 151 | 28 | 0 | 0 |
| May | RSD | 0.48 | 0.44 | 0.08 | --- | --- |
| | Standard Error | 0.03 | 0.03 | 0.02 | --- | --- |
| 1986 | Number sampled | 560 | 80 | 6 | 0 | 0 |
| Aug | RSD | 0.87 | 0.12 | 0.01 | --- | --- |
| | Standard Error | 0.01 | 0.01 | <0.01 | --- | --- |
| 1987 | Number sampled | 58 | 128 | 130 | 1 | 0 |
| May | RSD | 0.18 | 0.40 | 0.41 | <0.01 | --- |
| | Standard Error | 0.02 | 0.03 | 0.03 | <0.01 | --- |
| 1987 | Number sampled | 290 | 66 | 2 | 0 | 0 |
| Aug | RSD | 0.81 | 0.18 | 0.01 | --- | --- |
| | Standard Error | 0.02 | 0.02 | <0.01 | --- | --- |

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| | | RSD Category[b] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1988 | Number sampled | 1,213 | 725 | 73 | 0 | 0 |
| Aug | RSD | 0.60 | 0.36 | 0.04 | --- | --- |
| | Standard Error | 0.01 | 0.01 | <0.01 | --- | --- |
| 1989 | Number sampled | 1,239 | 515 | 62 | 0 | 0 |
| Aug | Sampled RSD | 0.68 | 0.28 | 0.03 | --- | --- |
| | Adjusted RSD[c] | 0.78 | 0.20 | 0.02 | | |
| | Standard Error[d] | 0.02 | 0.02 | <0.01 | --- | --- |
| 1990 | Number sampled | 1,234 | 244 | 46 | 0 | 0 |
| Aug | Sampled RSD | 0.81 | 0.16 | 0.03 | --- | --- |
| | Adjusted RSD[c] | 0.84 | 0.14 | 0.02 | | |
| | Standard Error[d] | 0.02 | 0.02 | <0.01 | --- | --- |
| 1991 | Number sampled | 686 | 90 | 11 | 0 | 0 |
| Aug | Sampled RSD | 0.87 | 0.12 | 0.01 | --- | --- |
| | Standard Error | 0.01 | 0.01 | <0.01 | --- | --- |
| 1992 | Number sampled | 454 | 97 | 11 | 0 | 0 |
| Aug | Sampled RSD | 0.81 | 0.17 | 0.02 | --- | --- |
| | Standard Error | 0.02 | 0.02 | 0.01 | --- | --- |

[a] Data Sources: 1955-1956, Warner (1957); 1970, 1972, Tack (1971, 1973); 1975- 1982 (June), Peckham (1976, 1977, 1978, 1979, 1983); 1984, Ridder (1985); 1982 (May), 1985, 1986, 1987 (May), Office files; 1987 (Aug), Clark and Ridder (1988); 1988, Ridder (1989); 1989, Clark and Ridder (1990); 1990, Clark et al. (1991); 1991, Fleming et al. (1992); and, 1992, - this report.

[b] Minimum lengths (FL) for RSD categories are (adapted from Gabelhouse 1984):
- Stock - 150 mm
- Quality - 270 mm
- Preferred - 340 mm
- Memorable - 450 mm
- Trophy - 560 mm

[c] RSD adjusted due to bias in length selectivity of the electrofishing boat.

[d] Standard error of the adjusted RSD.

Appendix C12. Summary of RSD estimates for adult Arctic grayling (≥ 150 mm FL) in the lower 16 km of the Goodpaster River, spring, 1982 and 1985 through 1987.

| | | RSD Category[a] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1982 | Number sampled | 17 | 99 | 37 | 0 | 0 |
| | RSD | 0.11 | 0.65 | 0.24 | --- | --- |
| | Standard Error | 0.03 | 0.04 | 0.04 | --- | --- |
| 1985 | Number sampled | 20 | 141 | 80 | 0 | 0 |
| | RSD | 0.08 | 0.59 | 0.33 | --- | --- |
| | Standard Error | 0.02 | 0.02 | 0.03 | --- | --- |
| 1986 | Number sampled | 8 | 109 | 24 | 0 | 0 |
| | RSD | 0.06 | 0.77 | 0.17 | --- | --- |
| | Standard Error | 0.02 | 0.04 | 0.03 | --- | --- |
| 1987 | Number sampled | 1 | 108 | 130 | 1 | 0 |
| | RSD | <0.01 | 0.45 | 0.54 | <0.01 | --- |
| | Standard Error | <0.01 | 0.03 | 0.03 | <0.01 | --- |
| Total | Number sampled | 46 | 457 | 271 | 1 | 0 |
| | RSD | 0.06 | 0.59 | 0.35 | <0.01 | --- |
| | Standard Error | 0.01 | 0.02 | 0.02 | <0.01 | --- |

[a] Minimum lengths (FL) for RSD categories are (adapted from Gabelhouse 1984):
Stock - 150 mm
Quality - 270 mm
Preferred - 340 mm
Memorable - 450 mm
Trophy - 560 mm

Appendix C13. Summary of RSD indices for adult Arctic grayling (≥ 150 mm FL) by sex in the lower 16 km of the Goodpaster River, spring, 1982 and 1985 through 1987.

| | | RSD Category[a] | | | | |
|---|---|---|---|---|---|---|
| | | Stock | Quality | Preferred | Memorable | Trophy |
| 1982 | Males: | | | | | |
| | Number sampled | 10 | 51 | 30 | 0 | 0 |
| | RSD | 0.11 | 0.56 | 0.33 | --- | --- |
| | Standard Error | 0.03 | 0.05 | 0.05 | --- | --- |
| 1982 | Females: | | | | | |
| | Number sampled | 7 | 48 | 7 | 0 | 0 |
| | RSD | 0.11 | 0.77 | 0.11 | --- | --- |
| | Standard Error | 0.04 | 0.05 | 0.04 | --- | --- |
| 1985 | Males: | | | | | |
| | Number sampled | 4 | 39 | 44 | 0 | 0 |
| | RSD | 0.05 | 0.45 | 0.51 | --- | --- |
| | Standard Error | 0.02 | 0.05 | 0.05 | --- | --- |
| 1985 | Females: | | | | | |
| | Number sampled | 16 | 102 | 36 | 0 | 0 |
| | RSD | 0.10 | 0.66 | 0.23 | --- | --- |
| | Standard Error | 0.03 | 0.04 | 0.03 | --- | --- |
| 1986 | Males: | | | | | |
| | Number sampled | 2 | 56 | 20 | 0 | 0 |
| | RSD | 0.03 | 0.72 | 0.26 | --- | --- |
| | Standard Error | 0.02 | 0.05 | 0.05 | --- | --- |
| 1986 | Females: | | | | | |
| | Number sampled | 7 | 66 | 8 | 0 | 0 |
| | RSD | 0.09 | 0.82 | 0.10 | --- | --- |
| | Standard Error | 0.03 | 0.04 | 0.03 | --- | --- |
| 1987 | Males: | | | | | |
| | Number sampled | 1 | 68 | 110 | 1 | 0 |
| | RSD | 0.01 | 0.38 | 0.61 | 0.01 | --- |
| | Standard Error | 0.01 | 0.04 | 0.04 | 0.01 | --- |
| 1987 | Females: | | | | | |
| | Number sampled | 0 | 40 | 20 | 0 | 0 |
| | RSD | --- | 0.67 | 0.33 | --- | --- |
| | Standard Error | --- | 0.06 | 0.06 | --- | --- |

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| | RSD Category | | | | |
|---|---|---|---|---|---|
| | Stock | Quality | Preferred | Memorable | Trophy |
| Total Males: | | | | | |
| Number sampled | 17 | 214 | 204 | 1 | 0 |
| RSD | 0.04 | 0.49 | 0.47 | <0.01 | --- |
| Standard Error | 0.01 | 0.02 | 0.02 | <0.01 | --- |
| Total Females: | | | | | |
| Number sampled | 30 | 256 | 71 | 0 | 0 |
| RSD | 0.08 | 0.72 | 0.20 | --- | --- |
| Standard Error | 0.02 | 0.02 | 0.02 | --- | --- |

[a] Minimum lengths (FL) for RSD categories are (adapted from Gabelhouse 1984):

Stock - 150 mm
Quality - 270 mm
Preferred - 340 mm
Memorable - 450 mm
Trophy - 560 mm

Appendix C14. Arctic grayling abundance, harvest, and angler exploitation estimates for the Goodpaster River, 1972 through 1992.

| Year | Month | Abundance[a] | | Harvest | Angler exploitation[b] | |
|---|---|---|---|---|---|---|
| | | 0-53km | 0-152km | | 0-53 km | 0-152 km |
| 1972 | JUNE | 10,017 | 20,034 | ND[c] | --- | --- |
| 1973 | JUNE | 25,440 | 44,955 | 2,236 | 0.09 | 0.05 |
| 1974 | JUNE | 10,649 | 27,441 | ND | --- | --- |
| 1975 | JUNE | 25,166 | 50,332 | ND | --- | --- |
| 1976 | JUNE | 18,654 | 37,307 | ND | --- | --- |
| 1977 | JUNE | 19,999 | 39,998 | ND | --- | --- |
| 1978 | JUNE | 25,054 | 50,108 | ND | --- | --- |
| 1979 | JUNE | ND | ND | ND | --- | --- |
| 1980 | JUNE | 25,574 | 51,149 | ND | --- | --- |
| 1981 | JUNE | ND | ND | ND | --- | --- |
| 1982 | JUNE | 8,616 | 17,232 | ND | --- | --- |
| 1983 | JUNE | ND | ND | 3,021 | --- | --- |
| 1984 | JUNE | 18,656 | 37,312 | 1,194 | 0.06 | 0.03 |
| 1985 | AUGUST | 19,292 | 38,584 | 2,757 | 0.13[d] | 0.07[d] |
| 1986 | AUGUST | 16,165 | 32,330 | 1,508 | 0.09[d] | 0.05[d] |
| 1987 | AUGUST | 7,102 | 14,204 | 1,702 | 0.19[d] | 0.11[d] |
| 1988 | AUGUST | 8,374 | 16,748 | 1,273 | 0.13[d] | 0.07[d] |
| 1989 | AUGUST | 8,033 | 16,066 | 1,964 | 0.20[d] | 0.11[d] |
| 1990 | AUGUST | 7,113 | 14,226 | 760 | 0.10[d] | 0.05[d] |
| 1991 | AUGUST | 7,836 | 15,672 | 636 | 0.08[d] | 0.04[d] |
| 1992 | AUGUST | 6,886 | 13,772 | ND | --- | --- |
| Averages: | | 14,923 | 29,860 | 1,705 | 0.10[d] | 0.05[d] |

[a] Abundance in the lower 53 km for 1972 and 1975 through 1988 was extrapolated from fish per km estimates (Appendix B1). Abundance for 0 - 152 km for the same years is twice the estimate for the lower 53 km based on the average ratio between the sections estimated in 1973 and 1974 (Appendix B1).

[b] Exploitation rate is harvest divided by abundance.

[c] ND = no data.

[d] Harvests were added to abundance estimates to give an approximation of abundance at start of season prior to calculating exploitation rates.

# APPENDIX D

## Equations and Statistical Methodology

Appendix D1. Methods for alleviating bias due to gear selectivity by means of statistical inference.

| Result of first K-S test[a] | Result of second K-S test[b] |
|---|---|

Case I[c]

Fail to reject $H_0$ — Fail to reject $H_0$

Inferred cause: There is no size-selectivity during either sampling event.

Case II[d]

Fail to reject $H_0$ — Reject $H_0$

Inferred cause: There is no size-selectivity during the second sampling event, but there is during the first sampling event.

Case III[e]

Reject $H_0$ — Fail to reject $H_0$

Inferred cause: There is size-selectivity during both sampling events.

Case IV[f]

Reject $H_0$ — Reject $H_0$

Inferred cause: There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.

a The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. $H_0$ for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

b The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. $H_0$ for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

c Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling event for size and age composition estimates.

d Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

e Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

f Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

Case IVa: If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

Case IVb: If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.

Appendix D2. Methods for alleviating bias due to unequal catchability by river section.

| Result of $\chi^2$ test[a] | Inspection of fish movement[b] |
|---|---|
| <u>Case I</u>[c] | |
| Fail to reject $H_o$ | No movement between sections |
| Inferred cause: There is no differential capture probability by river section or marked fish completely mixed with unmarked fish within each river section. | |
| <u>Case II</u>[d] | |
| Fail to reject $H_o$ | Movement between sections |
| Inferred cause: There is no differential capture probability by river section or marked fish completely mixed with unmarked fish across river sections. | |
| <u>Case III</u>[e] | |
| Reject $H_o$ | No movement between sections |
| Inferred cause: There is differential capture probability by river section or marked fish did not mix completely with unmarked fish within at least one river section. | |
| <u>Case IV</u>[f] | |
| Reject $H_o$ | Movement between sections |
| Inferred cause: There is differential capture probability by river section or marked fish did not mix completely with unmarked fish across river sections. | |

a The chi-squared test compares the frequency of marked fish recaptured during the second event in each river section with the frequency of unmarked fish examined in the second event in each river section. $H_o$ for this test is: capture probability of marked fish in the second event is the same in all river sections.

b Inspection of fish movement is a visual comparison of the frequency of marked fish recaptured in the second event that moved from one river section to another with the frequency of unmarked fish examined in the second event in each river section.

c Case I: Calculate one unstratified abundance estimate using the Bailey (1951, 1952) estimator.

d Case II: Calculate one unstratified abundance estimate using the Bailey (1951, 1952) estimator and calculate one unstratified abundance estimate using the "movement" (Evenson 1988) estimator. If estimates are dissimilar, discard the Bailey estimate and use the movement estimate as the estimate of abundance. If estimates are similar, discard the movement estimate and use the Bailey estimate as the estimate of abundance.

e Case III: Completely stratify the experiment by river section, calculate abundance estimates for each using the Bailey (1951, 1952) estimator, and sum abundance estimates.

f Case IV: Completely stratify the experiment by river section. Calculate abundance estimates for each using the Bailey (1951, 1952) estimator and sum estimates. If movement out of the sample area is neither probable nor possible, calculate abundance with the partially stratified model of Darroch (1961) and compare with the sum of Bailey estimates. If estimates are dissimilar, discard the sum of Bailey estimates and use the Darroch estimate as the estimate of abundance. If estimates are similar, discard the estimate with the largest variance. If movement out of the sample area is probable, calculate abundance with the movement (Evenson 1988) estimator and compare with the sum of Bailey estimates. If estimates are dissimilar, discard the sum of Bailey estimates and use the movement estimate as the estimate of abundance (note: this estimate will be biased). If estimates are similar, discard the movement estimate and proceed as if movement were neither probable nor possible.

Appendix D3. Equations used to estimate abundance and variance.

---

Bailey (1951,1952) estimator and variance

$$\hat{N} = \frac{M\,(C + 1)}{(R + 1)}, \text{ and} \qquad (D3.1)$$

$$\hat{V}[\hat{N}] = \frac{M^2\,(C + 1)\,(C - R)}{(R + 1)^2(R + 2)} \qquad (D3.2)$$

where:
- M = the number of fish marked and released alive during the first sample;
- C = the number of fish examined for marks during the second sample;
- R = the number of recaptured during the second sample;
- $\hat{N}$ = estimated abundance of fish during the first sample; and,
- $\hat{V}[N]$ = estimated variance of $N$.

Movement estimator of Evenson (1988)

$$\hat{N} = \frac{\{\, M_1(1-\hat{\theta}_d) + M_2 + M_3(1-\hat{\theta}_u) \,\}\,(C + 1)}{R_{..} + 1} \qquad (D3.3)$$

The probabilities of movements are estimated by:

$$\hat{\theta}_d = \frac{M_2(R_{32} + R_{21})}{R_{2.}(M_3 + M_2)}, \text{ and} \qquad (D3.4)$$

$$\hat{\theta}_u = \frac{M_2(R_{12} + R_{23})}{R_{2.}(M_1 + M_2)} \qquad (D3.5)$$

where:
- $M_x$ = the number of fish marked in the first event in section $x$ ($x$ = 1, 2, and 3 for the downstream, midstream, and upstream sections, respectively);
- $R_{..}$ = the number of fish recaptured during the second event;
- $\theta_z$ = the probability that a fish will move out of an area in the $z$ direction (upstream or downstream);
- $C$ = the catch made during the second event; and,
- $N$ = the abundance of fish in all sections at the start of the second event.
- $R_{xy}$ = the number of fish that were marked in section $x$ during the first event and were recaptured in section $y$ during the second event; and,
- $R_{2.}$ = the number of fish that were marked in the midstream section during the first event and were recaptured during the second event.

---

Appendix D4. Equations used to calculate bootstrap means, variance, and bias.

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Bootstrap mean

$$\hat{N}_B = \frac{\sum_{i=1}^{j} \hat{N}_i}{j} \qquad \text{(D4.1)}$$

Bootstrap variance

$$\hat{V}[\hat{N}_B] = \frac{\sum_{i=1}^{j} (\hat{N}_i - \hat{N}_B)^2}{j - 1} \qquad \text{(D4.2)}$$

where:

$\hat{N}_B$ = the bootstrap mean of $j$ replicates of the mark-recapture experiment;

$\hat{N}_i$ = the ith bootstrap replicate of the mark-recapture experiment; and,

$\hat{V}[\hat{N}_B]$ = the bootstrap variance of $N_B$.

Bias

$$\text{Bias}(\%) = \frac{|\hat{N} - \hat{N}_B|}{\hat{N}_B} \times 100\% \qquad \text{(D4.3)}$$

where: $\hat{N}_B$ = abundance estimated with bootstrap methods; and,

$\hat{N}$ = point estimate of abundance.

---

Appendix D5. Methods for alleviating bias in age and size compositions due to differential capture probability by size of fish or river section.

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No adjustment needed

$$\hat{p}_k = \frac{x_k}{n} \qquad \text{(D5.1)}$$

$$\hat{V}[\hat{p}_k] = \frac{\hat{p}_k (1 - \hat{p}_k)}{n - 1} \qquad \text{(D5.2)}$$

where: $\hat{p}_k$ = the proportion of fish that are age or size $k$;
$x_k$ = the number of fish sampled that are age or size $k$;
$n$ = the number of fish sampled that were aged or measured; and,
$V[\hat{p}_k]$ = the variance of the proportion.

Adjustment for differential capture probability by size

$$\hat{\rho}_l = \frac{RECAP_l}{MARK_l} \qquad \text{(D5.3)}$$

where: $\hat{\rho}_l$ = the capture probability of fish in size class $l$, regardless of age or size $k$;
$RECAP_l$ = the number of recaptures of in size class $l$; and,
$MARK_l$ = the number of marked fish in size class $l$.

$$\hat{A}_l = \frac{\rho_L}{\rho_l} \qquad \text{(D5.4)}$$

where: $\hat{A}_l$ = the adjustment factor for all fish of size class $l$, regardless of age or size $k$; and,
$\rho_L$ = max($\rho_l$), $l$ = 1, 2, ..., $m$ size classes.

$$\hat{x}_{kl} = \hat{A}_l \, n_{kl} \qquad \text{(D5.5)}$$

where: $\hat{x}_{kl}$ = the adjusted number of fish of age or size $k$ that are also in size class $l$; and,
$n_{kl}$ = the actual number of fish sampled that are age or size $k$ and also in size class $l$.

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$$\hat{p}_k = \frac{\sum_{l=1}^{m} \hat{x}_{kl}}{\sum_{k=1}^{o} \sum_{l=1}^{m} \hat{x}_{kl}} = \frac{\hat{x}_{k.}}{\hat{x}_{..}} \qquad \text{(D5.6)}$$

where: k = 1, 2, ..., *o* ages or sizes; and,
l = 1, 2, ..., *m* size classes.

<u>Adjustment for differential capture probability by river section</u>

$$\hat{\bar{p}}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}} \hat{p}_{ik} \qquad \text{(D5.7)}$$

$$\hat{V}[\hat{\bar{p}}_k] \approx \sum_{i=1}^{j} (\hat{p}_{ik} - \hat{\bar{p}}_k)^2 \frac{\hat{V}[\hat{N}_i]}{\hat{N}^2} + \sum_{i=1}^{j} (\hat{N}_i/\hat{N})^2 \hat{V}[\hat{p}_{ik}] \qquad \text{(D5.8)}$$

where: $\hat{\bar{p}}_k$ = the average weighted proportion of fish in the entire area that were age or size *k*;
$\hat{N}_i$ = the abundance of Arctic grayling in section i;
$\hat{N}$ = total abundance; and,
$\hat{p}_{ik}$ = the proportion of fish in section *i* that were age or size *k*.

APPENDIX E

Data File Listing

Appendix E1. Data files used to estimate parameters of Arctic grayling populations in the Salcha, Chatanika, and Goodpaster rivers, 1992.

| Data file[a] | Description |
|---|---|
| U0050LA2.DTA | Population and marking data for Arctic grayling captured during the first event at the Salcha River, 15 through 19 June 1992. |
| U0050LB2.DTA | Population and marking data for Arctic grayling captured during the second event at the Salcha River, 22 through 25 June 1992. |
| U0040LA2.DTA | Population and marking data for Arctic grayling captured during the first event at the Middle Chatanika River, 17 through 21 August 1992. |
| U0040LB2.DTA | Population and marking data for Arctic grayling captured during the second event at the Middle Chatanika River, 24 through 28 August 1992. |
| U0080LB2.DTA | Population and marking data for Arctic grayling captured during the first event at the Goodpaster River, 4 through 7 August 1992. |
| U0080LA2.DTA | Population and marking data for Arctic grayling captured during the second event at the Goodpaster River, 11 through 17 August 1992. |

[a] Data files have been archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.