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Annual Performance Report for

THE LIFE HISTORY AND POPULATION DYNAMICS OF EXPLOITED  
STOCKS OF ARCTIC GRAYLING ASSOCIATED WITH THE DELTA  
AND RICHARDSON CLEARWATER RIVERS

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## RESEARCH REPORT

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Job No.: G-III-G Job Title: The Life History and  
Population Dynamics of  
Exploited Stocks of  
Arctic Grayling Associ-  
ated with the Delta and  
Richardson Clearwater  
Rivers

Cooperator: William P. Ridder

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## ABSTRACT

This project is yearly monitors Arctic grayling, Thymallus arcticus (Pallas), populations in spring-fed tributaries in the mid-Tanana River drainage of interior Alaska.

The project includes yearly assessment of the grayling enhancement program and an investigation of local spawning streams to determine the population's recruitment sources and movements.

In 1983, monitoring the Delta Clearwater River indicated that population abundance levels were below or similar to levels found in 1982 and, thus, continued the decline from the highs of 1979-1981. The sport fishery catch rate, 0.48 grayling harvested per angler hour, was only slightly higher than in 1982 (0.42). Comparison of age and length composition to those previous years indicates that reduced recruitment of Age Classes II-IV may be a factor. It is also suggested that the population and past recruitment were affected by the stocking of four year-classes of fingerling grayling into the system between 1975 and 1978. The population was found to be similar to that of years prior to the stocking program.

Comparable monitoring of the Richardson Clearwater River in 1983 showed a similar decline in numbers. Indexing and population estimates gave values approximately half of those found in 1982. Unlike the Delta

Clearwater, the decline was found in older fish. Though lower, comparisons to previous years' monitoring still show the population to be at a high level.

Evaluations on the reliability and accuracy of electrofishing catch rates as an index of relative abundance in spring-fed streams are presented.

Catch statistics derived from creel census activities are shown for the Delta and Richardson Clearwater Rivers and Shaw Creek. Estimates derived from Shaw Creek censusing gave a total harvest of 1,864 grayling, with 2,005 angler hours for the 8-day spring fishery.

Data from the fourth year of weir captures during the postspawning migration of Arctic grayling from Caribou Creek are presented and include age and length compositions, length related sex ratios, delayed mortality experiments, tag loss, recapture and survival rates, and population estimates based on tag recoveries for Caribou Creek and the Shaw Creek drainage. Surveys of four potential spawning streams are described, and catch composition from hook and line sampling is presented.

Assessment of the four year-classes of pond-reared Arctic grayling stocked in the Delta Clearwater River showed them to comprise 12% of the fish sampled during indexing and creel censusing. This percentage is about half of that found in previous years.

The growth and survival of Arctic grayling fry in five rearing ponds and a hatchery are presented, along with stocking methods used in 1983. The pond-reared fish exhibited twice the growth of the hatchery fish. Behavioral differences are noted for the two groups that might relate to stocking success.

#### KEY WORDS

Interior Alaska, Arctic grayling, spring and bog-fed streams, postspawning migrations, tag loss and survival rates, indexing and estimates of populations, stream stocking of Arctic grayling, recruitment.

#### BACKGROUND

The Delta and Richardson Clearwater Rivers are two of the better known of the many spring-fed tributaries to the Tanana River of interior Alaska. They are located near Delta Junction, 100 mi southeast of Fairbanks, near the middle of the drainage (Fig. 1). The Delta Clearwater is the largest of these systems with a length of 20 mi for the main channel and 6 mi for the north fork. It is also the most popular with fishermen and other recreationists due to its road access, state campground, aesthetics, and good Arctic grayling fishing. It supports one of the largest grayling fisheries in the state, with a 5

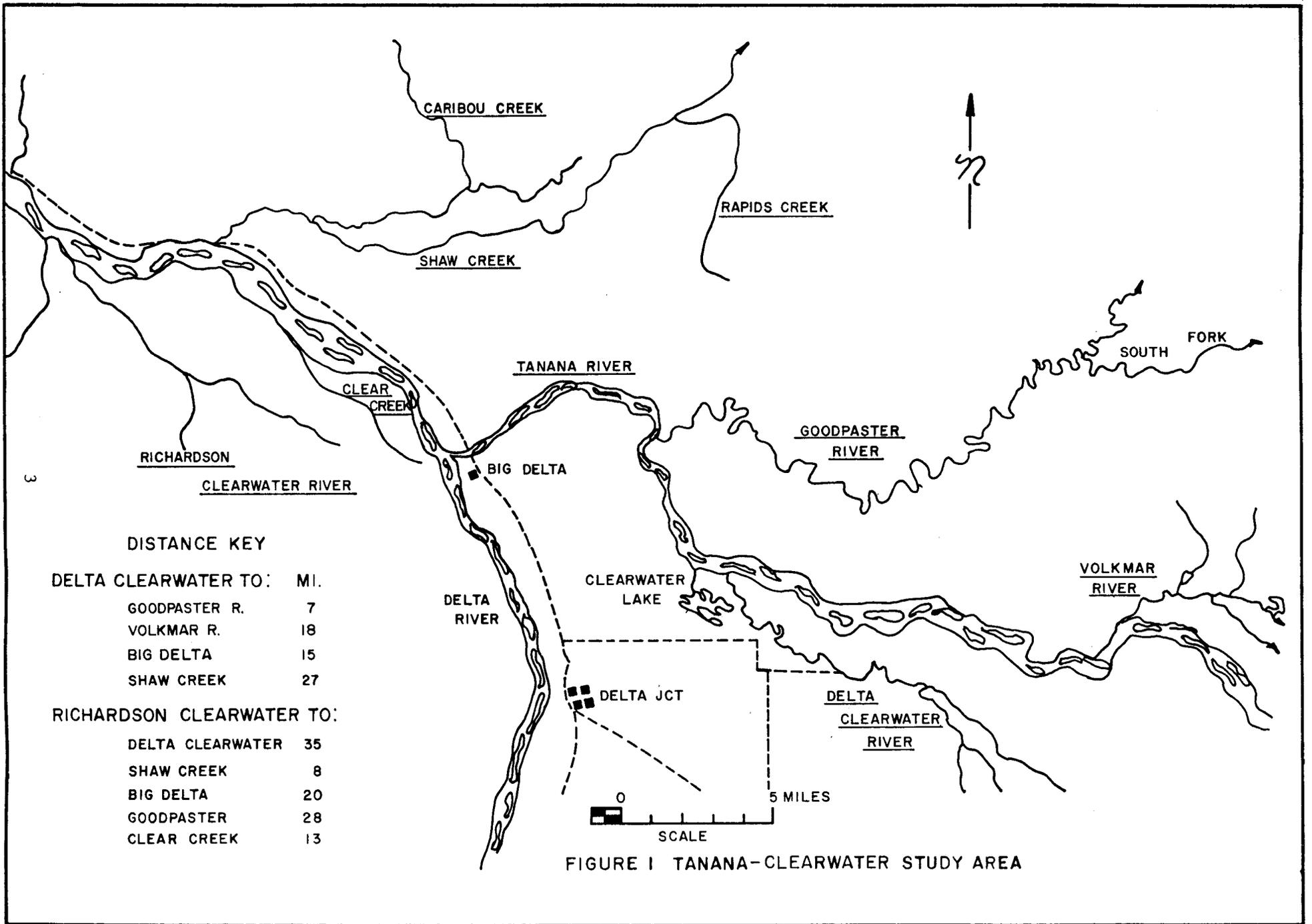


FIGURE I TANANA-CLEARWATER STUDY AREA

year average of 16,956 angler hours and a grayling harvest of 6,662 annually (Ridder, 1982). Of all the spring-fed systems, its drainage is the most impacted by human development. Agricultural development lies along its entire southern flank and also its headwaters; residential development occurs along 4 mi of its bank.

The Richardson Clearwater River is located 35 mi downstream of the Delta Clearwater River. It is among the largest of the clearwater streams with a main channel 14 mi long. Largely inaccessible to the general public since access is limited to boat or float plane, the river's human impact stems predominantly from its 19 recreational cabins. The river's grayling fishery is lightly utilized and offers superb angling. In 1982 the grayling harvest was estimated at 1,729 (Mills, 1983). Agricultural development is proposed for its adjacent lands.

Clear Creek, located approximately 23 mi below the Delta Clearwater River, is a small creek 7 mi long and typical of the majority of the spring systems in the drainage. Its fishery is unknown to the general public, inaccessible by road and is utilized by a few anglers who reside in a small, remote, homestead/farm area near its headwaters. Its grayling population is estimated to be less than 1,000.

These spring-fed systems are characterized by fairly constant temperatures, discharges and crystal clarity due to their ground water sources. Predominant fish species are grayling, round whitefish, coho salmon, and longnose suckers. Of these species, only cohos spawn and overwinter in the systems, the others utilize them as summer feeding areas. Grayling and round whitefish begin arriving in April, with the migration of grayling lasting into June. In general, juvenile grayling and some subadults arrive directly from overwintering areas in the Tanana River and precede the adults and subadults that arrive from various spawning streams in the area. The known spawning streams include the Volkmar and Goodpaster Rivers, and in the Shaw Creek drainage, Caribou and Rapids Creeks. Outmigration begins in late August or early September, continues through the late fall spawning of cohos, and is essentially complete by late November. Table 1 lists the fish species mentioned in this report.

Additional background information on past studies may be found in Ridder, (1982).

#### TECHNIQUES USED

Unless noted in the text, all techniques of capturing, sampling and aging and formulas are the same as in previous years (Ridder, 1983) with the exception that age and weight samples were collected from every third fish captured during the Richardson Clearwater River indexing.

Electrofishing index data were analyzed using the statistical analysis system program of the SAS Institute Inc. as applied by the Biometrics Section of the Sport Fish Division, Alaska Department of Fish and Game.

Table 1. List of common, scientific names, and abbreviations of fish species mentioned in this report.

Common Name	Scientific Name and Author	Abbreviation
Arctic grayling	<u>Thymallus arcticus</u> (Pallas)	GR
Coho salmon	<u>Oncorhynchus kisutch</u> (Walbaum)	SS
Longnose sucker	<u>Catostomus catostomus</u> Forster	LNS
Round whitefish	<u>Prosopium cylindraceum</u> (Pallas)	RWF

## RECOMMENDATIONS

### Management

1. Monitoring of Arctic grayling populations in the Delta and Richardson Clearwater Rivers should be continued by various methods derived from indexing relative abundance and by creel censusing.
2. Transplants of grayling fingerlings into the Delta Clearwater River should continue.
3. Creel censusing the spring grayling fishery at Shaw Creek should continue.

### Research

1. A study on the dynamics and early life history of Arctic grayling in a bog-fed, spawning stream (Caribou Creek) should be initiated.
2. Refinement of the scale analysis method for stock identification should be initiated using fall collections of Age 0 fish from spawning streams and spring collection of Age I fish from spring-fed streams.
3. The evaluation of various methods of stocking grayling for optimum return to the Delta Clearwater River should be continued.
4. Weir operations during the postspawning migration out of Caribou Creek should be continued for population sampling.
5. Tagging studies should be initiated on postspawning grayling populations in all spawning streams within 40 mi of the Delta and Richardson Clearwater Rivers not previously covered in job reports. The Healy River and Kiana Creek should be first priorities.
6. Radio tracking of grayling during and after their fall out-migration from the Delta and Richardson Clearwater Rivers should be initiated for determination of overwintering areas.

## OBJECTIVES

1. To assess grayling population trends and management needs in the Delta and Richardson Clearwater Rivers from electrofishing catch rates, age structure and other population parameters in index sections of these rivers. Population sampling in Clear Creek will be conducted for comparison to the larger systems.
2. To monitor angler use and grayling harvest in the Delta and Richardson Clearwater Rivers through creel census programs.

3. To evaluate the effectiveness and reliability of using electrofishing catch rates as an index of relative abundance of grayling populations in the Delta and Richardson Clearwater Rivers through comparisons to replicate sampling and other indices.
4. To investigate the postspawning migrations of grayling from the Shaw Creek drainage and other spawning locations to determine the mechanism and levels of recruitment they provide to the summer fisheries of the Delta and Richardson Clearwater Rivers.
5. To determine the contribution to year-class strength and angler harvest of four year-classes (1975-1978) of pond-reared grayling stocked as fingerlings into the Delta Clearwater River by analysis of scale samples from indexing and creel censusing.
6. To evaluate various methods of stocking pond-reared grayling for optimum return to the fishery of the Delta Clearwater River.

## FINDINGS

### Assessment of Arctic Grayling Populations

#### Abundance:

The yearly indexing of relative abundance of grayling was conducted on July 12 and 13, 1983 in the Delta Clearwater River and July 19, 1983 on the Richardson Clearwater River. The sampling method and gear were the same as in the past 6 years. Weather conditions ranged from sunny to clouds (100%) with persistent light to moderate winds over the 2 days of the Delta sampling. On the Richardson, indexing was done under an overcast sky which produced intermittent light rain, while wind was minimal. Both rivers' indices (electrofishing catch rates) gave values which indicated that populations were less abundant than in 1982. A summary of 10 years of indexing the Delta Clearwater River is given in Table 2; a summary of the 8 years of indexing the Richardson Clearwater River is in Table 3. Both tables divide the rivers into sections which are described in earlier reports (Ridder, 1980, 1981).

The Delta Clearwater abundance index of 53 is the lowest value found to date and continues the trend begun in 1981. It is a definite decline in numbers when compared to the individual and mean values of the previous 9 years.

In qualifying the trend, it should be noted that the stocking of four year-classes of grayling fingerlings between 1975 and 1978 (approx. 36,000) was found to have a positive impact on grayling abundance in the river (Ridder, 1982) and, thus, on the mean index.

Table 2. Capture rates for Arctic grayling during index sampling, Delta Clearwater River, 1973, 1975-1983.

Date	Mile Sections			Total Captured	Percent Catch* Composition
	4-7	8-13	14-17		
6/27/73	7	20	66	93	16.5
1974	...	...	...	...	...
7/02/75	13	8	43	64	14.0
6/30/76	11	27	41	79	17.6
7/06/77	26	25	49	100	22.9
7/10/78	39	28	9	76	15.8
7/17/79	51	24	74	149	23.1
7/15/80	39	45	98	182	38.6
7/07/81	6/21**	27/26**	40	73/87**	18.3
7/15/82	27	18	18	63	15.7
7/12/83	3	5	45	53	17.0
Mean 1973-1982	24.3/26.0**	24.7/24.6**	48.7	97.7/99.2**	

\* % grayling in total grayling and round whitefish catch.

\*\* Adjusted index for abnormal water levels on 7/7/81.  
See Ridder, 1982.

Table 3. Capture rates for Arctic grayling and round whitefish during index sampling, Richardson Clearwater River, 1977-1983.

Date	Miles 1-7		Miles 7-8.5		Total Captured		Gr Composition %
	GR	RWF	GR	RWF	GR	RWF	
8/30/77	104	123	...	...	104	123	46
8/31/78	117	53	...	...	117	53	69
7/17/79	63	105	...	...	63	105	38
7/17/80	73	33	97	0	170	33	84
7/09/81	58	44	109	0	167	44	79
7/20/82	165	133	159	16	324	149	68
7/19/83	156	61	64	10	220	71	76
Mean	105	79	107	7	166	83	67

At least part of the decline, then, stems from the normal mortality of individuals from these four year-classes. Whether the decline also involves the "wild" population is more difficult to ascertain due to these introductions.

Recruitment of wild fish Age Classes III-V to the fishery seems to have been poor in 1983 as shown by the extremely low catch rates (3 and 5 vs a mean of 24) found in the two lower river sections where these ages predominate. Capture rates of the lowest section ranged from 7 to 13 (mean 10.3) in the years 1973 to 1976, prior to the stocking program's impact. Repetitive indexing of this lower section 3 and 6 days after the first run gave capture rates of 10 and 7, respectively, for 3 of its 4 miles. While still below the 9-year mean, these rates are close to pre-stocking levels.

The Richardson Clearwater's index showed a decline from the record high found in 1982 but was still far higher than any other index (Table 3). The decline was most pronounced in the upper section (less than a half of the 1982 rate) rather than in the lower section as in the Delta Clearwater. The upper sections are frequented by older fish recruited to the river in past years. Thus, the decline here cannot be attributed to poor recruitment. A comparison of these rivers' index rates is at best a general check on the validity of assessing trends.

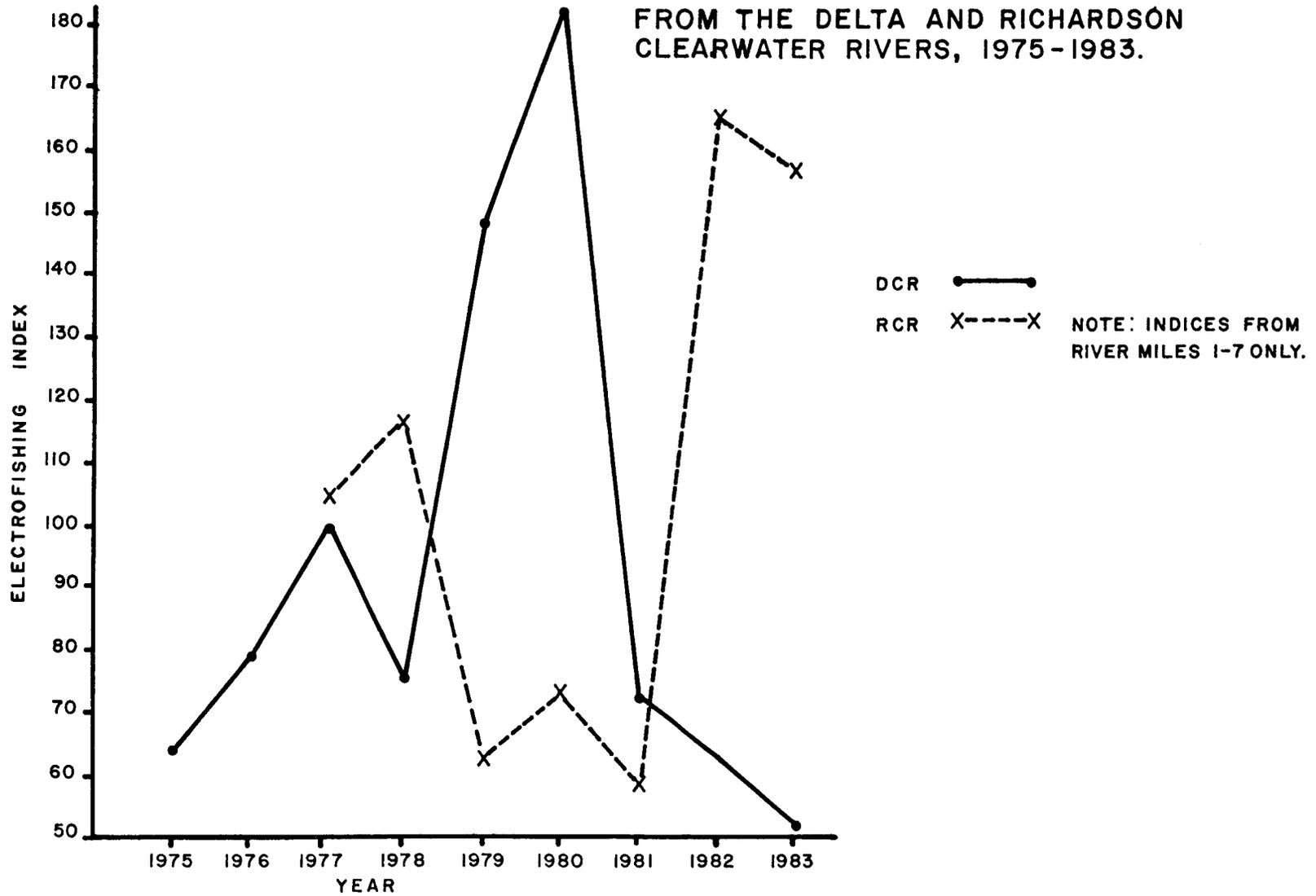
Because of the population enhancement conducted in the Delta Clearwater River, and the different recruitment sources (Ridder, 1983) and fisheries of the two rivers, the rivers' population trends are similar in 1983, as well as for 3 of the 6 other years with data. Of the 3 odd years in which one river's index goes up while the other river's goes down, only 2, 1979 and 1982 show large changes in rates. In the Delta Clearwater, these years correspond to positive impacts from the enhancement program in 1979 and the theoretical negative impacts of agricultural runoff in 1982 (Ridder 1983). A graph of both rivers' indices from 1975 to 1983 is shown in Figure 2.

Sampling of grayling in Clear Creek has been conducted yearly since 1979 as a comparison to both of the larger systems' population structures. The 1983 sampling occurred on August 8 and utilized hook and line and a 6-mile visual drift survey from an impassable beaver dam downstream to the mouth. Other than young-of-the-year cohos immediately below the dam, no other fish were found until one grayling (approx. 280 mm) was seen at the mouth. The creek is small, only 12 feet wide, shallow and the count is therefore considered valid. Fish had been in the creek earlier, since a helicopter flight on June 30 with the same observers aboard noted fish dispersed throughout the section from the dam to the mouth. This is the earliest observation we have made in which the creek was devoid of grayling. The late August sampling in 1979 also found grayling only in the mouth (Ridder, 1980).

#### Population Estimation:

Two estimates of population size in the upper section of the Richardson Clearwater River were obtained over a 3-day period, July 19-21, 1983. A

**FIGURE 2 ELECTROFISHING INDICES OF RELATIVE ABUNDANCE BY YEAR FROM THE DELTA AND RICHARDSON CLEARWATER RIVERS, 1975-1983.**



modified Petersen estimate (Ricker, 1975) was conducted for the 2 miles from Mile 8.5 to approximately Mile 6.5. Total number of marked fish was 212 and 10 were recaptured in a catch of 92. The estimated number of grayling per mile was calculated to be 896 with a 0.95 confidence interval of 508-1,730. Extrapolating to cover the 8 miles of river, which the majority of grayling inhabit, gave an estimate of 7,168 grayling with a 0.95 CI of 4,064-13,840. These estimates are 43% below those found in 1982; 1,582 gr/mile over a 4.75 mi section and 12,656 grayling for the river. In comparison, indexing this upper section (Table 3) gave rates 60% below those of 1982.

A visual estimate was obtained over the same 2-mile section on July 21 under excellent conditions by two observers standing on the deck of the electrofishing boat. A total of 1,078 grayling was counted, which gave 539 gr/mi or 60.2% of the Petersen estimate. Again, this is roughly half of the visual count done in 1982 of 1,175 gr/mi (74.3% of the 1982 Petersen estimate).

It should be noted that on the morning of the day when both estimates were taken, (visual estimate was first, followed by the Petersen estimate) fish were uncharacteristically schooled in two locations, both at heads of riffle areas, rather than dispersed throughout the 2 miles as on the previous 2 days. The fish had dispersed by the afternoon when electrofishing recaptures were made, yet the behavior may have influenced the estimates, especially the visual estimate. Thus, the visual estimate is considered a minimum estimate.

#### Population Structure, Age, Length and Weight:

The age frequencies, lengths and weights of grayling from samples collected in 1983 from indexing the Delta and Richardson Clearwater Rivers are given in Tables 4 and 5, respectively, while the age frequencies and lengths of a sample collected during the 1983 creel censusing of the Delta Clearwater are given in Table 6. A comparison of age frequencies from 1983 and 1982 and the mean value from all previous data years are given for the three sample types in Table 7. A similar comparison of length frequencies of 50 mm groups from the samples for the same years is given in Table 8.

The poor recruitment of young age classes indicated by the Delta Clearwater indexing is again apparent in the sample's (n=49) age structure in which Age Classes I-IV made up only 6% of the total. This composition is down sharply from the 36% found in 1982 and from the 3-year mean of 34%. Samples collected from this year's sport harvest (n=125) showed a similar, though less-sharp, decline. Age Classes I-IV made up 24% of the creel sample in 1983 compared to 40% in 1982 and to the 6-year mean of 43%.

As noted for the Delta Clearwater indexing, the grayling stocking program may have affected the mean frequencies of these Age Classes, I-IV. By growing faster than their wild cohorts, they entered the fishery at an earlier age by becoming susceptible to the capture methods (electricity, hook and line).

Table 4. Age frequency, length and weight of Arctic grayling captured during index sampling, Delta Clearwater River, July 12, 1983.

Age Class	Number	%	Length (mm)		Weight (g)	
			Range	Mean	Range	Mean
IV	3	6	238-318	275	153-329	239
V	15	31	285-342	307	270-477	356
VI	11	22.5	310-344	327	342-513	455
VII	11	22.5	317-381	342	405-639	518
VIII	8	16	344-386	375	486-783	653
XI	1	2	412	412	855	855
	<u>49</u>	<u>100</u>	<u>238-412</u>	<u>331</u>	<u>153-855</u>	<u>468</u>
			(9.4-16.2")	(13.0")	(0.34-1.90 lbs)	(1.04 lbs)

Table 5. Age frequency, length and weight of Arctic grayling captured in the Richardson Clearwater River, July 19, 1983.

Age Class	Number	%	Length (mm)		Weight (g)	
			Range	Mean	Range	Mean
II	1	1	168	168	50	50
III	9	6	193-243	222	90-189	131
IV	25	17	220-282	257	126-275	203
V	35	25	250-322	282	194-419	279
VI	20	14	254-367	314	207-594	392
VII	35	25	275-385	334	270-648	505
VIII	12	8	334-386	358	405-684	576
IX	2	1	360-386	373	567-765	666
X	3	2	343-378	365	531-639	576
XI	1	1	407	407	900	900
	<u>143</u>	<u>100</u>	<u>168-407</u>	<u>301</u>	<u>50-900</u>	<u>369</u>
			(6.6-16.0")		(0.11-2.01lbs)	(0.82 lbs)

Table 6. Age frequency and length of Arctic grayling harvested by anglers, Delta Clearwater River, 1983.

Age Class	Number	Percent	Length (mm)	
			Range	Mean
II	0	...	...	...
III	8	6	212-245	234
IV	22	18	235-288	264
V	59	47	242-352	291
VI	17	14	275-367	313
VII	16	13	282-370	334
VIII	2	2	328-347	338
IX	1	(<1)	395	395
	<u>125</u>		<u>212-395</u>	<u>293</u>
			(8.3-15.6")	(11.5")

Table 7. Age frequencies (percent) of Arctic grayling captured in the Delta Clearwater and Richardson Clearwater Rivers, 1975-1983.

Age Class	Delta Clearwater						Richardson Clearwater		
	Electrofishing			Sport Harvest			Electrofishing		
	1983	1982	$\frac{8 \text{ yr } \bar{x}}{1975-1982}$	1983	1982	$\frac{6 \text{ yr } \bar{x}}{1977-1982}$	1983	1982	$\frac{6 \text{ yr } \bar{x}}{1977-1982}$
I	0	0	(<1)	0	0	0	0	2	(<1)
II	0	0	5	0	1	2	1	0	2
III	0	2	10	6	11	13	6	1	8
IV	6	34	19	18	28	28	17	12	20
V	31	32	26	47	26	30	25	16	27
VI	22.5	18	23	14	22	15	14	31	24
VII	22.5	6	12	13	7	9	25	27	15
VIII	16	2	3	2	1	2	8	10	4
IX	0	2	2	(<1)	2	1	1	1	(<1)
X	0	2	(<1)	0	0	0	2	0	(<1)
XI	2	2	(<1)	0	0	0	1	0	0
Mean Age	6.2	5.3	5.1	5.2	4.8	4.8	5.8	6.0	5.3
Sample Size	49	61	776	125	92	853	143	128	674

Table 8. Length frequencies (percent) of Arctic grayling captured in the Delta and Richardson Clearwater Rivers, 1973-1983.

Length Class (mm)	Delta Clearwater						Richardson Clearwater		
	Electrofishing			Sport Harvest			Electrofishing		
	1983	1982	9 yr $\bar{x}$ 1973-1982	1983	1982	9 yr $\bar{x}$ 1973-1982	1983	1982	3 yr $\bar{x}$ 1980-1982
115-164	(<1)	0	1	0	0	0	0	2	1
165-214	0	2	8	1	2	4	2	1	1
215-264	6	20	19	20	18	26	16	13	14
265-314	32	44	34	50	56	44	26	28	38
315-364	47	24	28	27	20	19	42	44	37
365-414	14	8	9	2	4	6	13	11	8
415-464	(<1)	2	1	0	0	1	1	1	(<1)
Mean Length:									
mm	325	299	292	293	290	287	301	317	308
in.	12.8	11.8	11.5	11.5	11.4	11.3	11.9	12.5	12.1
Sample Size	168*	63	1,226	125	100	1,102	220	325	662

\* Includes grayling captured in repetitive indexing of miles 17-5 and 7-5.

The frequencies of these first four age classes averaged 17.3% for 3 years of indexing from 1975 to 1977 when the oldest stocked grayling would have been Age II. In 1973, however, Pearse (1974) found Age Classes I-IV comprising 42% of his electrofishing sample of 237 grayling collected over a 3-month period.

As expected from the lack of younger fish, the grayling of Age Classes VI and older represented 63% of the 1983 Delta index sample as compared to the 32% found in 1982 and the 40% mean found over 8 years. The creel sample showed hardly any change in these older fish, 29% of its total, when compared to the 32% found in 1982 and the 6-year mean of 27%.

The Richardson Clearwater River's age composition samples for 1982 and 1983 are quite different from the Delta Clearwater's for the same period. In 1982 the Richardson showed poor recruitment to the young age classes (younger than Age VI) and stronger older age groups, while the Delta had strong younger and weak older age classes. Just the opposite situation occurred in 1983 with the Richardson having strong young and weaker older age classes while the Delta had weak young and stronger older age classes. However, the mean age class compositions of these Rivers (1977-1981) are similar, indicating that the last 2 years were abnormal.

Population trends in the two rivers are graphically presented in Fig. 3, where the mean ages of the three samples are plotted against year. It shows the mean age to be increasing in the Delta samples and tapering off in the Richardson. The smooth curves found in the Richardson and in the Delta's creel sample are in contrast to that of the Delta's index sample. This plot may be indicative of the inaccuracies of the sampling method. Such sampling errors are also apparent in the creel sample plot for 1978 (Peckham and Ridder, 1979) where the probability of sampling bias toward larger fish was noted.

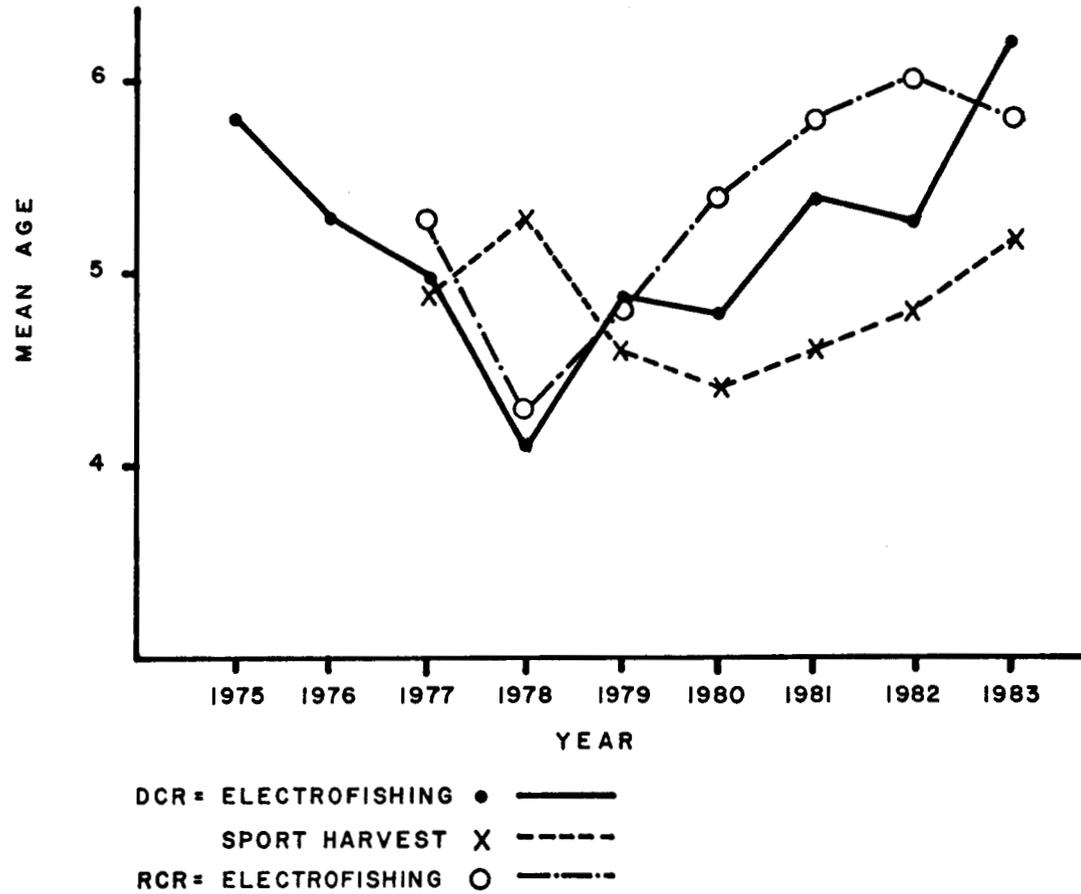
The condition factors ( $K = W/L^3 \times 10^5$ ) of grayling in the Delta and Richardson Clearwater River were computed from the mean values found in their indexing samples (Tables 4 and 5). The  $K = 1.29$  found in the 1983 Delta Clearwater sample compared closely to the  $K=1.27$  found in 1982. The 1983 Richardson Clearwater grayling had a  $K=1.35$ , whereas in 1982, it was 1.29.

The length frequencies of the three samples (Table 8) show comparisons that both agree and disagree with those found in age frequencies. The differences are restricted to the older, larger fish in the Richardson Clearwater River where age compositions showed older fish numbers decreasing from previous years while length frequencies found them the same.

#### Mouth Damage:

The presence of mouth damage noted on Arctic grayling sampled during indexing and at Caribou Creek has been routinely observed since 1980 but was unreported except in 1981 (Ridder, 1982). It is assumed that the major cause of the damage is due to hooking, and includes fish not only

**FIGURE 3** MEAN AGE BY YEAR OF ARCTIC GRAYLING SAMPLED IN THE DELTA AND RICHARDSON CLEARWATER RIVERS, 1975-1983



released by anglers, but also those hooked and lost. Rates of mouth damage (percent of sample) found in the Delta and Richardson Clearwater Rivers and in Caribou Creek in 1983 and previous years are shown in Table 9. Rates in all three streams rose in 1983, with the largest changes found in the Delta Clearwater and Caribou Creek. A change in rates can be interpreted in various ways, considering the value ranges among its dependent variables (fishing pressure, population abundance, recruitment, catchability, etc). The rate changes in 1983 are consistent with other data presented in this report which generally suggest a lower population abundance with similar and/or higher angling pressure.

#### Evaluation of Electrofishing

The evaluation of electrofishing catch rates as an index of the relative abundance of Arctic grayling in spring-fed streams attempted to look at the method's precision (repeatability) and accuracy (representation). For the former quality, the initial indexing of the Delta Clearwater River on July 12 and 13, 1983 was followed at 2-day intervals by two electrofishing runs employing the same indexing methods over two 3-mile sections of the river, miles 15-17 and 5-7. Additional data were from 1973 electrofishing. The data for both years are shown in Table 10A. The latter quality was examined by comparisons of 2 years of population abundance estimates obtained in a 2-mile section of the Richardson Clearwater River by three methods: mark/recapture, visual and relative abundance indexing (Table 10B).

Results of significance tests on the precision of electrofishing indices were ambiguous. At the 0.05 percent probability level chi-square tests showed significant differences between the three total indices of the 1983 data (calculated  $X^2 = 25,000$ , totaled  $X^2 = 5,991$ ) but no significance between the two indices of 1973. The differences in 1983 were found to be due to the indices of the upper section, miles 15-17, (calculated  $X^2 = 23,608$ ) and specifically in miles 17 and 16 (calculated  $X^2$ 's of 30,000 and 6,455 respectively). No significant differences were found in the three indices of the lower section, miles 5-7 (calculated  $X^2 = 4.10$ ) or in mile 15 (calculated  $X^2 = 2.28$ ). Chi-square contingency tables also showed no relationship or pattern between the indices of each section and the sampling data at the 0.05 percent level for 1983 or 1973 (respective probabilities of 0.1990 and 0.4346).

The catch rates from electrofishing are the best indications of the efficiency of the method (Reynolds, 1983). While the variables of technique, gear and river morphology can be kept constant, weather conditions cannot, and undoubtedly affect the efficiency and precision to some untested degree. On the Delta Clearwater River, weather is considered to be the prime determinant of efficiency outside of possible fish movement into and out of the sampling area. Pearse (1974) found fish movements in the river to be minimal during July.

During the 3 days of indexing in 1983, weather was quite variable, ranging from sunny with moderate winds on the first day to total cloudiness and light winds on the second and highest index day. The

Table 9. Percent of Arctic grayling exhibiting mouth damage in catches from Caribou Creek weir and electrofishing the Delta and Richardson Clearwater Rivers 1980-1983. Sample sizes are in parentheses.

Location	Length Range (mm)	Year			
		1980	1981	1982	1983
Delta Clearwater	≥200	26.9 (182)	34.1 (85)	28.6 (63)	37.5 (168)
Richardson Clearwater	≥200	22.4 (170)	19.2 (167)	21.9 (324)	22.3 (220)
Caribou Creek	200-249	...	6.1	2.1	5.8
	250-299	...	12.2	10.9	8.7
	300-349	...	19.9	16.6	19.9
	≥350	...	28.6	21.4	20.8
	≥200	...	11.7	10.9	16.3
			(1,393)	(2,390)	(978)

Table 10A. Successive electrofishing catch rates of Arctic grayling in two 3-mile sections of the Delta Clearwater River, 1973 and 1983.

Mile Section	1983				1973		
	7/12	7/15	7/18	Mean	6/26	6/29	Mean
17	28	59	15	34.0	25	21	23.0
16	2	11	6	6.3	10	20	15.0
15	13	6	8	9.0	22	13	17.5
	<u>43</u>	<u>76</u>	<u>29</u>	<u>49.3</u>	<u>57</u>	<u>54</u>	<u>55.5</u>
7	1	2	1	1.3	4	2	3.0
6	2	4	4	3.3	1	4	2.5
5	0	4	2	2.0	2	4	3.0
	<u>3</u>	<u>10</u>	<u>7</u>	<u>6.7</u>	<u>7</u>	<u>10</u>	<u>8.5</u>
Total	46	86	36	56.0	64	64	64.0

Table 10B. Chi-square tests of three grayling population abundance estimates of a 2 mile section\* of the Richardson Clearwater River, 1982 and 1983.

Year	Mark/Recapture	Visual	Index
1982	2,670	1,175	102
1983	896	539	52
Calculated $X^2$	881.5	253.3	15.6
Tabled ** $X^2$	3.84		
1983:1982	.336	.459	.510

\* Miles 8.5-6.5

\*\*  $\alpha = .05$

last and lowest index day saw persistent rain and light winds. The catch rates in the upper river section reflect the effects these weather conditions can have on the efficiency of the electrofishing. Wind and rain impair the ability of the dippers to locate stunned fish, while sun improves not only the dipper's ability, but also avoidance by the fish. Cloudy weather appears to fall in between to offer the best conditions for improving efficiency. Weather conditions during the 1973 indexing are not known.

If the above variables could be held constant or at least accountable for from year to year, thus assuring the precision of the index, electrofishing catch rates can afford an accurate or representative index of the relative abundance of grayling in spring-fed streams. While the data base is small, chi-square tests on each of the three population estimates in the Richardson Clearwater River (Table 10B) show that each method gave significantly lower values of population abundance in 1983 than in 1982 ( $\alpha = .05$ ). Considering that the methods give one absolute and two relative values, the three ratios of the 1983 estimates to 1982 are significantly different (calculated  $X^2 = 36.76$ , tabled  $X^2 = 5.991$ ,  $\alpha = .05$ ). The ratios of the two relative methods, visual and indexing, however, are not significantly different (calculated  $X^2 = 2.68$ , tabled  $X^2 = 3.84$ ,  $\alpha = .05$ ).

### Creel Censusing

#### Delta Clearwater River:

With the decision to rely on harvest and pressure estimates generated by the Statewide Harvest Survey (Ridder, 1983), creel census effort was directed solely toward catch sampling and determination of catch rates (number of grayling kept per angler hour). The censusing schedule was nonrandom and was predominantly conducted on weekends and holidays, which account for 60% of the total harvest and pressure. The censusing produced 155 angler contacts (Table 11), which is similar to the numbers obtained in 3 previous years (Table 12). Due to the change in technique where anglers were interviewed as they were met on the river, the sampling produced only 24 completed trip interviews. This is approximately 50% of those made in the 3 previous years.

The catch rate in 1983 was 0.48 grayling per hour for all angler contacts and 0.71 grayling per hour for those representing completed trips. This large discrepancy between incomplete and completed trip rates is unusual considering the 5 years of past data (Table 12) and suggests a deficiency in method. Personal observations indicated better fishing success than in 1982 (0.42 grayling per hour for all trips; 0.54 grayling per hour for completed trips) but not up to the rate found this year for completed trips. The lower rate found from all trip types is felt to be more representative of the 1983 fishing and comparable with past data.

Boat anglers represented 67% of the trips, which is similar to previous years. They had a catch rate of 0.81 grayling per hour, which compares to the 0.42 found in 1982 and the 0.70 found in 1981 and 1980. Shore

Table 11. Creel census summary, boat and shore anglers combined, Delta Clearwater River, May 14 through Sept. 5, 1983. Numbers in parentheses are for completed trips only.

Month	Anglers Contacted	Angler Hours	Grayling Caught	Fish Per Angler	Hours Per Angler	Fish Per Angler Hour
May	53	119	55	1.04	2.24	0.46
June	31	64	21	0.68	2.06	0.33
July	60	85	56	0.93	1.42	0.65
August	11	38	14	1.27	3.45	0.37
Totals	155(24)	306(62)	146(44)	0.94(1.83)	1.97(2.58)	0.48(0.71)

Table 12. Statistics from creel censusing the Delta Clearwater River Arctic grayling fishery, 1978-1983.  
 In parentheses are data from completed trip interviews.

	1978	1979	1980	1981	1982	1983	$\bar{x}$
Anglers contacted	453(274)	390(191)	189(59)	163(56)	140(46)	155(24)	...
Hrs/angler	2.30(2.60)	2.20(2.50)	1.60(2.30)	1.80(2.40)	1.80(2.70)	2.00(2.60)	2.00(2.50)
Fish/angler	1.30(1.40)	1.30(1.50)	1.20(1.60)	1.30(1.90)	0.80(1.50)	0.90(1.80)	1.10(1.60)
Fish kept/hr	0.57(0.54)	0.59(0.60)	0.75(0.70)	0.72(0.79)	0.42(0.54)	0.48(0.71)	0.59(0.65)
Fish caught/hr	...	0.68(0.68)	0.81(0.78)	0.78(0.83)	0.55(0.60)	...	0.71(0.72)

anglers represented the remainder of the trips and had a catch rate of 0.46, which is down from the 0.89 in 1982 and the 0.85 in 1981. This drop reflects the small population of the middle section of the river, which is the only area readily accessible to the shore anglers.

The age and length frequencies of the creel sample are shown in Tables 6, 7 and 8.

#### Richardson Clearwater River:

A voluntary creel census program was conducted for the fourth year in 1982, soliciting catch information from the river's summer residents, the predominant users. Based on past returns from the seventeen households, six households were asked to participate in 1983. The program has likely run its course, since only three responses have been received as of January 1, 1984. The responses represented 123 anglers (man-days), 299 total hours and a total catch of 680 grayling, of which 481 were harvested. This calculates out to a total catch rate of 2.29 grayling per hour and a harvest rate of 1.63. In 1982, total catch rate was 1.86 and harvest rate was 1.24.

The catch rates derived from volunteer program are usually viewed with caution. Interviews with six anglers on the river, all of whom had completed their trips, gave a total catch rate of 3.23 fish per hour and a harvest rate of 1.65. Hook and line sampling by Department personnel (10 anglers, 21 total hours and a total catch of 90 grayling) produced a rate of 4.33 grayling per hour and, when combined with the angler interviews, produced a total catch rate of 4.05 fish per hour.

Total harvest for the river is estimated to be similar to past years, 1,500-2,000 grayling.

#### Shaw Creek:

A creel census was conducted at Shaw Creek from April 17-24, 1983, using a random and stratified schedule that sampled 48% of the total fishing hours. This was the third year of censusing the fishery, which resumed in 1981, after a 5-year hiatus due to highway realignment. This is a roadside fishery with a 1983 angler composition of 55% residents, 33% military personnel and dependents and 12% of unknown classification. Its duration is limited to the interval between breakup and ice-up of the Tanana River and of Shaw Creek. The fishery is predominantly on prespawning adult grayling that concentrate at the mouth of the creek awaiting access to upstream spawning areas such as Caribou and Rapids Creeks. This bog-fed system is a major spawning area for fish that later migrate to the Richardson Clearwater River. Censusing the fishery and later the post-spawning out-migration from Caribou Creek provides data that compliment the monitoring activities in the Richardson Clearwater River. A summary of the 1983 census (estimates and catch compositions) is given in Table 13, along with similar data from the 2 previous years.

Table 13. Summary of catch statistics from the Shaw Creek spring grayling fishery, 1981-1983.

Length Range	Related Age Class	Percent		
		1981	1982	1983
180 - 229	III	2	2	(<1)
230 - 269	IV	24	16	8
270 - 309	V-VI	44	39	22
310 - 420	≥VI	30	43	70
Length range (mm)		184-379	215-405	228-415
Mean length (mm)		292	302	325
Mean length (in.)		11.5	11.9	12.8
Male:female		.90:1	1.19:1	1.41:1
Sample size n		271	377	304
Gr harvest/hr		2.14	0.87	0.89
Harvest estimate		4,343	979	1,864
Total angler hrs (est.)		2,029	1,172	2,005
Man-days (est.)		966	555	874
Dates		4/5-4/22*	4/24-5/2	4/17-4/24
Days		18	9	8

\* Closed by emergency order.

Estimates were based upon dividing the fishery into two strata, the first 6 days and the last 2 days. Harvest rate and hours spent fishing per angler differed greatly; 1.21 grayling harvested per hour and 2.1 hours per angler for the first 6 days, versus 0.48 fish per hour and 2.8 hour per angler for the last 2 days. Extrapolations of mean angler counts were made for each stratum and then multiplied by the catch statistics for harvest and pressure estimates: 1,864 grayling harvested and total angler hours of 2,005 (874 man-days). These were twice the 1982 estimates and half of 1981's.

The overall harvest rate of the fishery was 0.89 fish per hour, while the catch rate, representing both grayling hooked and released, plus those taken, was 1.03 fish per hour. While much below the 1981 rates, these are very similar to 1982 statistics. Accessibility and fish locations were the same as in 1982. A change in river channels from 1981 was considered a large factor in the initial drop in catch rates (Ridder, 1983).

The length frequency of the 1983 catch sample (n=304) showed a continuing increase in the percentage of mature grayling harvested and in the sample's mean length. Fish greater than 310 mm (12.2 in.) and predominantly Age Class VI and older represented 70% of the sample, a 30% plus increase over previous years (Table 13). Inversely, immature grayling accounted for 30% less of the sample than in previous years. The mean length in 1983 was 325 mm (12.8 in) versus 302 mm (11.9 in) in 1982 and 292 mm (11.5 in) in 1981.

During the fishery, recoveries of grayling tagged in Shaw and Caribou Creeks since 1979 totaled 77. Creel censusing produced 44 tags or 14.5% of the sampled catch of 304 (Table 16) while anglers returned, by mail or in person, the remaining 33. Multiplying the estimated harvest by the tag percentage found in the catch gives a tag recovery estimate of 207. The total returns represent a tag reporting rate of 28.5% in 1983, which compares to previous rates found in the fishery of 49% and 46% (Ridder, 1983). Due to the inclusion of tags found during censusing, the above rates are biased. Based only on tags returned by anglers, the 1983 rate is 14.6%. In 1982, this rate was 9.7% and in 1981, 41%.

#### Post-spawning Migration Investigations

##### Caribou Creek:

The post-spawning migration of Arctic grayling from Caribou Creek (Fig. 1) was sampled from June 2-20, 1983 using a weir described in Ridder (1982). In 1983, unlike previous years, the two traps of the weir were set to capture only out-migrating fish. The weir was also closed down, preventing out-migration for 2 days, June 6-8 for an electrophoresis study conducted by the Alaska Cooperative Fishery Research Unit, University of Alaska. Water levels during the 19-day period were consistently low, unlike the previous 2 years, yet similar to 1980. The levels (height above weir floor) ranged from 11 to 14 inches, with an approximate flow range of 12-17 cfs. Water temperatures were similar to previous years, 10-17°C.

A total of 1,676 grayling was caught in 1983, and had lengths ranging from 75-420 mm and averaging 211 mm. Of the total, 926 fish were  $\geq 200$  mm (7.9 inches). These had a mean length of 302 mm (11.9 inches), which is an increase over the means of the same group captured in 1981 (267 mm 10.5 inches) and in 1982 (280 mm, 11.0 inches). Numbers of fish in the group, however, were lower than in the 2 previous years, as was the total catch, despite similar trapping intervals. The length frequencies and related age classes of all grayling captured in Caribou Creek from 1980 to 1983 are presented in Table 14.

The length frequencies of the 1983 out-migration generally agree with those found in previous years. The out-migration is composed predominantly of fish greater than 230 mm (9 inches) or of Age Classes IV and older. In all 4 years, fish representing Age Classes II and III (110-229 mm) make up only a small portion of the migration, less than 17% (<5% in 1983) while those of Age Class I (70-109 mm) appear cyclical by alternating between high (>20%) and low (<3%) compositions. In 1983 this age class represented over 40% of the catch, nearly twice the percentage found in the previous high year, 1981. The grayling in the 230-269 mm range (9-10.6 in), Age Class IV, made up 8.1% of the catch, which is unusually low when compared to the 20-30% found in past years. This range was also poorly represented in the sampled creels from the Shaw Creek spring fishery (Table 13).

The sex ratio of the 708 grayling in the catch considered mature was 1.21 males to 1 female and represents a continuing shift over the 3-year period in favor of males. The ratios found in 1982 and 1981 were 1.16:1 and 0.99:1 respectively. This shift has occurred concurrently with the increase in mean lengths of the  $\geq 200$  mm group, as well as those for males and females. In 1983, males (n=387) had lengths ranging from 238 to 420 mm, with a mean of 323 mm; females (n=321) ranged from 235-394 mm with a mean of 300 mm. In 1982 and 1981, males had mean lengths of 315 and 291 mm and females, 290 and 276 mm. The same situation with sex ratios and mean lengths can be seen with the Shaw Creek fishery.

The maturity percentage and sex composition in 10 mm groups of 917 grayling captured at Caribou Creek in 1983 are shown numerically in Table 15 and graphically in Fig. 4. As suggested above by mean lengths, males predominate in lengths over 310 mm and females under 290 mm.

Since the sexing is external there may be a bias towards females in the smaller length ranges. All males in this range do not exhibit the large dorsal fin that is their primary characteristic, while mature females, regardless of length, show a swollen vent. Some males also exhibit a swollen vent but it is more apparent in large fish. In 1982 a 4.4% sexing error was found based on tag recaptures. Males were initially designated females twice as often as the reverse in these errors (Ridder, 1983). The error found in 1983 was 5.2%, based on 173 recaptures where 44% of the errors had males originally sexed as females. The lengths of these nine fish at their first sexing ranged from 253-294 mm, with a mean of 279 mm.

Table 14. Length frequencies and related age classes of Arctic grayling, post-spawning out-migration, Caribou Creek, June 1980-1983.

Length Range (mm)	Related Age Class	6/2-6/12/80* %	6/7-6/19/81** %	6/2-6/20/82 %	6/2-6/20/83 %
70-109	I	2.1	24.6	2.8	40.8
110-169	II	11.5	1.8	6.3	3.0
170-229	III	5.1	7.4	4.9	1.6
230-269	IV	20.9	30.4	21.1	8.1
270-309	V-VI	27.9	28.1	38.2	24.5
≥310	≥VI	32.5	7.7	26.7	22.0
Sample Size		1,482	1,755	2,062	1,676
Length Range (mm)		84-405	70-400	72-408	75-420
Mean Length (mm)		N/A	223	275	211

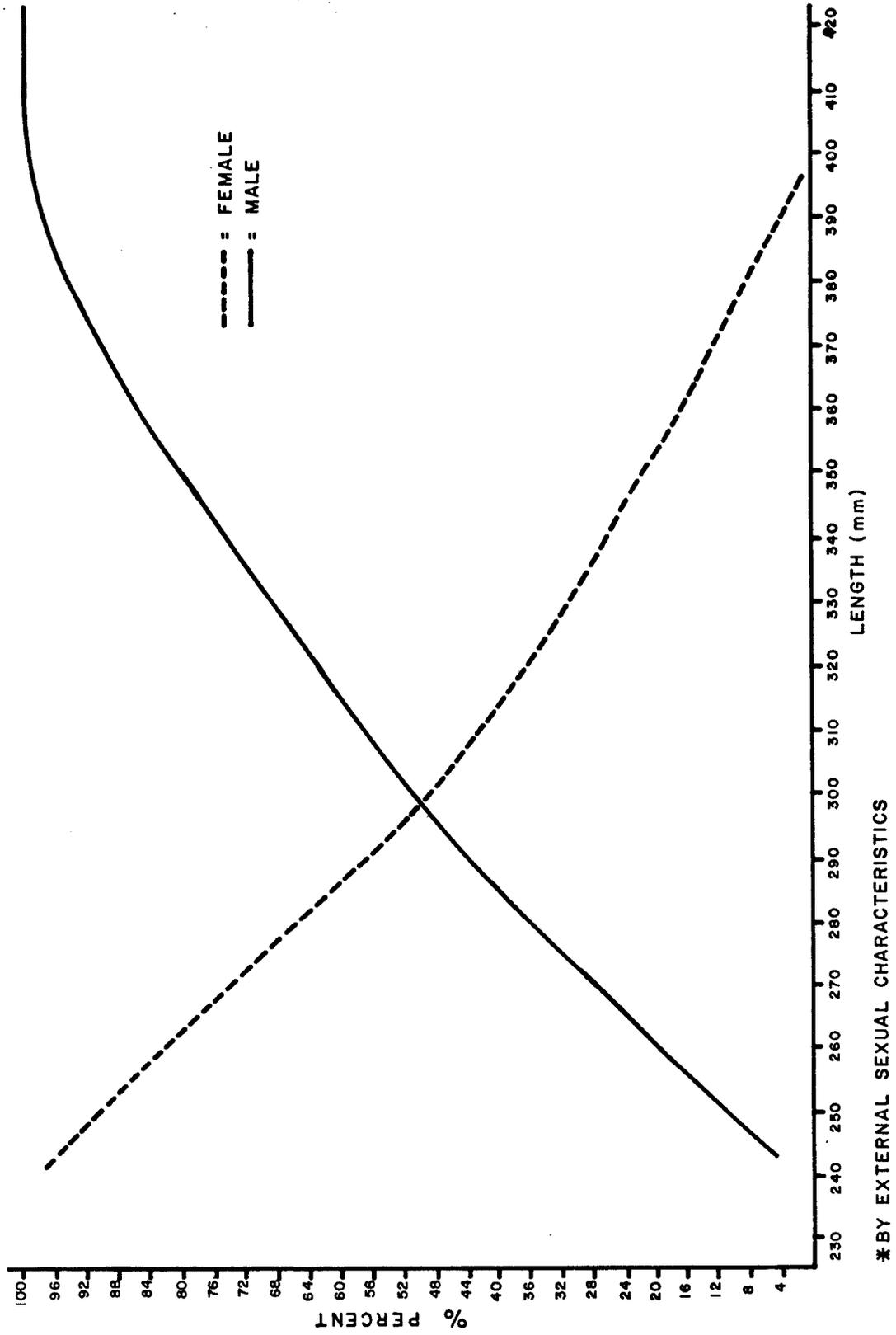
\* Fyke trap

\*\* Weir, 1981, 1982, 1983

Table 15. Maturity as percentage of number caught and by sex of 917 Arctic grayling captured in Caribou Creek, June 2-20,1983.

Length Range	Total Catch	Maturity %		
		Total	Female	Male
230-239	19	21.1	25.0	75.0
240	24	37.5	88.9	11.1
250	31	12.9	100	0
260	64	39.1	76.0	24.0
270	93	51.6	79.2	20.8
280	106	71.7	68.4	31.6
290	111	78.4	49.4	50.6
300	103	90.3	50.5	49.5
310	102	96.1	39.8	60.2
320	72	100	34.7	65.3
330	64	100	37.5	62.5
340	51	100	19.6	80.4
350	26	100	30.8	69.2
360	20	100	5.0	95.0
370	11	100	10.0	90.0
380	10	100	0	100
390	5	100	20.0	80.0
400	3	100	0	100
410	1	100	0	100
420-429	1	100	0	100
n	917	708	321	387

**FIGURE 4 SEX COMPOSITION OF MATURE ARCTIC GRAYLING\* (m=708) IN 10 mm LENGTH GROUPS CAPTURED IN CARIBOU CREEK, JUNE 2-20, 1983.**



The total catch at the weir included 229 recaptures of grayling tagged either in the creek or mainstem Shaw Creek from 1979 to 1982 (n=4,857). Forty-five of these fish represented multiple recaptures at the weir and suggest the homing of some grayling to spawning sites. Of these fish, 31 had been caught for 3 consecutive years at the weir and three had been caught 4 consecutive times. Eleven fish, all tagged in 1980, were recaptured at the weir in 1982 and 1983.

The yearly increase in growth of 34 tagged grayling captured at the weir in each of the past 2 years is as follows:

Sex	Number	Mean Length At Tagging	Growth	
			Year One	Year Two
Male	13	295 mm	18.1 mm	18.2 mm
Female	14	275 mm	21.4 mm	16.0 mm
Immature	7	246 mm	28.3 mm	23.6 mm

Taken together, the sample at first capture had a mean length of 277 mm and an average yearly growth increment of 19.7 mm (0.78 inches). Individually, a year's growth ranged from nothing to 35 mm (1.4 inches). Considering that the tag induced ulcerations on most recaptures, the growth of tagged fish would probably be less than that of untagged fish, and it is, slightly, in comparison to age tables.

The growth increment, found by subtracting the mean length of Age Class IV from Age Class V fish in Tables 4 through 6, ranges from 25 to 32 mm, with a mean of 28 mm.

With all tagged fish handled at the weir in 1982 receiving an adipose fin clip, an estimate of tag loss was found in 1983 by noting the recaptures of these fin-clipped fish (n=156). Thirteen, or 8.3% of these recaptures had lost their internal-anchor tags. A tag loss estimate was also found in the July electrofishing sample (n=441) from the Richardson Clearwater River. Thirty-four recaptures of adipose clipped fish were made, of which 6, or 17.6%, had no tag. This higher rate may be compounded by the tendency of some anglers to remove tags prior to releasing fish. Tack (1975) estimated a tag loss rate of 38.6% for the same type tag in the Goodpaster River (sample size n=88).

Recaptures of fish that were fin-clipped at lengths less than 200 mm when first captured at the weir in 1981 continue to be low. In 1982, recaptures of these now predominantly Age II fish amounted to only 0.9% of the catch in their respective length range (Ridder, 1983). In 1983 as Age III fish, they represented 0.6% of the 171 fish between 150 and 260 mm. No recaptures were made this year of fish marked in 1982 when they were  $\leq$  200 mm (n=1,481). It has been suggested that these juvenile fish are recruited to the Richardson Clearwater River due to their association with the river's adult in-migration. In subsequent years until maturity, they migrate directly to the feeding area rather than to the spawning area. The validity of this suggested manner of recruitment

to the Richardson Clearwater River is strengthened by 1983 recaptures of 1981 and 1982 fin-clipped juveniles which were slightly higher than in Caribou Creek. Of the 79 grayling with lengths less than 264 mm examined, one or 1.3% was from the 1981 marking and three or 3.8% were from 1982.

In 1983 an experiment on delayed mortality due to capture and handling was conducted to determine if this could be another explanation for the lack of recaptures of fish marked as juveniles. One hundred four Age I grayling (81-117 mm,  $\bar{x}$  = 98 mm) were divided into groups by four handling routines: 1) anesthetized, fin-clipped and measured (n=30); 2) anesthetized and measured (n=25); 3) clipped and measured (n=25); and 4) measured (n=24). They were placed in two covered holding pens with groups being differentiated by the fin clip. They were checked four times over the course of 89 hours. Water temperatures rose from 12.1°C on June 15 at the start of the experiment to 15.0°C on June 18. Only two mortalities were recorded. Both fish were from the fourth group and were dead at 36 hours. Both showed hemorrhaging at the base of the pelvic and caudal fins, indicating injuries were received in the trap. Thus, mortality due to handling was found to be negligible. The mean annual survival rate for adult Arctic grayling in Caribou Creek was found to be 53.9%. It is a combined estimate of survival of 20 mm length groups beginning at 290 mm. The length groups (Table 16) were chosen on the basis of the mean yearly growth found from tag recaptures. The Robson and Chapman method was used for calculation of the survival rate where  $S = T/\Sigma N + T - 1$  (Ricker, 1975). The method assumes constant survival, same level of yearly recruitment, and equal vulnerability to the sampling method. These assumptions appear to be satisfied in Table 17, which shows the percentage of Caribou Creek tags found in yearly samples collected from the April fishing at Shaw Creek's mouth, the Caribou Creek weir in June, and the July electrofishing of the Richardson Clearwater River. Considering the average age and adult status of the fish when tagged (Table 14 and 15) and when recaptured (In 1983 Caribou recaptures ranged in length from 239 to 403 mm with a mean of 319 mm), the similarity of the rates of 1980 and 1981 tags in each sample shows a constant average survival rate and equal vulnerability. The table also implies a consistent and very low recruitment rate.

With the tagging and the recaptures shown in Table 15 representing a segment of the grayling population, predominantly adults, of Shaw Creek, and with knowledge of their tag loss, survival rates and homing instincts, population estimates can be derived for both Caribou and Shaw Creeks (Table 18). Following the modified Petersen method, estimates were 8,541 grayling with a 95% confidence interval of 7,079-10,303 for Caribou Creek and 15,082 and a 95% C.I. of 9,858-24,132 for Shaw Creek. These population figures agree with the percentages of 1981 and 1982 tags found in the two samples (Table 17) where Caribou Creek gave rates roughly twice that found at the mouth of Shaw Creek. These estimates are also of the population at the time of tagging, or 1 year earlier. The number of marked fish, (M) in the formula, was adjusted downward by subtracting numbers corresponding to the tag loss rate (.083) and survival rate (.539) from the number tagged 1 year earlier. Similar

Table 16. Number of Arctic grayling in 20 mm length groups sampled at Shaw and Caribou Creeks, 1983.

Length Range (mm)	Shaw Creek	Caribou Creek
	<u>4/17-4/24/83</u> n	<u>6/2-6/20/83</u> n
70-89	0	182
90-109	0	504
110-129	0	28
130-149	0	12
150-169	0	9
170-189	0	14
190-209	0	1
210-229	1	9
230-249	11	43
250-269	13	95
270-289	25	199
290-309	42	214
310-329	71	174
330-349	57	115
350-369	49	46
370-389	30	21
390-409	4	8
410-429	1	2
	<u>304</u>	<u>1,676</u>
Range	228-415 mm	75-420 mm
$\bar{x}$	325 mm	211 mm

Table 17. Percentage of tagged Arctic grayling in samples collected from Shaw Creek, Caribou Creek, and Richardson Clearwater River, 1980-1983 \*.

Year of tagging	Location of tagging	Number tagged	Recaptures (%)												Total Recaptures
			Shaw/April				Caribou/June				Richardson/July				
			1980	1981	1982	1983	1980	1981	1982	1983	1980	1981	1982	1983	
1979	Shaw	156	...	0.3	0.5	0.3	0.2	0.3	0.1	0.1	...	0.5	0.2	0.2	19
1980	Shaw	94	...	0.5	0	0.3	...	0.4	0.1	0.2	0.6	0.5	0.4	0.2	19
	Richardson	30	...	0	0.3	0.3	...	0	0.2	0	0.6	0.5	0.4	0.5	12
	Caribou	1,283	...	3.7	4.6	3.6	...	3.3	3.8	3.4	8.8	4.8	4.4	3.2	284
1981	Caribou	1,323	...	...	4.8	3.6	...	...	9.3	9.1	...	3.2	3.9	4.1	380
1982	Caribou	2,001	...	...	...	6.3	...	...	...	11.5	...	...	5.0	4.3	174
Totals: %			...	4.5	10.2	14.5	0.2	5.2	15.6	24.7	10.0	9.5	14.0	12.5	
	Tags	4,887	...	27	40	44	3	55	323	228	17	18	76	55	888
	Sample Size		...	600	392	304	1,294	1,395	2,390	923	170	189	542	441	

\* All sampling done by ADF&G and represents only fish B200 mm.

Table 18. Population estimates\* from recaptures of Arctic grayling tagged in Caribou Creek one year previously and adjusted for mortality and tag loss.

Location	Year	Marked M	Catch C	Recaptures R	Population Estimate	.95 C.I.**
Caribou Creek	1983	989	923	106	8,541	7,079-10,303
	1982	723	2,390	222	7,752	6,803- 8,879
Shaw Creek	1983	989	304	19	15,082	9,858-24,132
	1982	723	391	19	14,171	9,292-22,673

\*  $N = \frac{M(C+1)}{R+1}$  of grayling  $\geq 200$  mm

\*\* From Ricker, 1975

estimates for both areas were obtained from data collected in 1982 using the above rates and suggest a stable population in 1981 and 1982 (Table 18).

#### Rapids Creek:

In the Shaw Creek drainage, Rapids Creek is the only known spawning location other than Caribou Creek (see Fig. 1). Twenty-two Arctic grayling were tagged in Rapids Creek in May 1979 with a subsequent recovery of three tags; two from the spring fishery at Shaw Creek and one from the Richardson Clearwater River. Additional tagging was done from May 24-26, 1983 to increase recoveries and comparisons to Caribou Creek. No spawning activity was noted and it was probably completed since water temperature ranged from 8-10°C and no gravid females were present in the catch, although a few males were still running milt. A total of 118 grayling was captured by hook and line and had lengths ranging from 145 to 361 mm, with a mean of 255. A total of 108 fish was tagged. Visual estimates over the lower 3 miles put the population at between 500-600 grayling, with adults numbering no more than 200. The length frequency and related age classes of the catch is shown in Table 19.

#### Ptarmigan Creek:

Ptarmigan Creek is located 38 mi up Delta Creek which is a large, glacial drainage 2 mi below the Richardson Clearwater River. The 10-mi long creek has a very steep gradient over most of its length. Bottom type is predominantly large rubble and boulders except for its first ½ mi which is gravel, sand and small rubble. Draining high tundra, its water is slightly humic stained. Pools are infrequent, <25%, and most holding areas are limited to pockets behind boulders. Over a 2-day period, June 13-14, 1983, water temperatures ranged from 6-8°C. Sixty fish were captured by hook and line and backpack shocker (20 were tagged) and had lengths ranging from 120 to 377 mm, with a mean of 193 mm. All fish were considered immature with the exception of one ripe, thin male (377 mm) which was captured in a small spring-fed tributary located 1/4 mi above the creek's mouth. The length frequency of the catch is shown in Table 19. The creek is not considered a major spawning area.

#### Buchanan Creek:

Buchanan Creek is located in the glacial Tanana River tributary of the Little Delta River, approximately 40 river miles west and south of the Richardson Clearwater River. The creek is approximately 20 miles long and has the appearance of being heavily scoured by spring run-off. Surveyed on June 15-16, 1983, the 5 mi section above the mouth is 20-35 ft wide, shallow (12-18 in ) and predominantly sand bottomed in pools and runs. The ratio of pools to riffle areas is about 2 to 1. This section has a distinct sterile appearance and few fish. Thirty-nine grayling were captured by hook and line and ranged in length from 123 to 295 mm, with a mean of 227 mm. Thirty of these fish were

Table 19. Length frequencies and related age classes of Arctic grayling captured by hook and line in four creeks of the mid-Tanana River drainage, 1983.

Length Range (mm)	Related Age Class	Rapids Cr. 5/25		Ptarmigan Cr. 6/13		Buchanan Cr. 6/15		Kiana 6/30	
		n	%	n	%	n	%	n	%
70-109	I	0	...	0	...	0	...	1	5
110-169	II	4	3	19	31	4	10	4	19
170-229	III	23	19	30	50	17	44	7	33
230-269	IV	49	42	10	17	12	31	3	14
270-309	V-VI	27	23	0	...	6	15	6	29
>310	≥VI	15	13	1	2	0		0	
		—		—		—		—	
n		118		60		39		21	
$\bar{x}$ length (mm)		255		193		227		213	
length range (mm)		145-361		120-377		123-295		100-304	
CPUE (fish/hr)		5.50		2.17		N/A		3.50	

tagged. One small tundra/bog-fed tributary, only 5 ft wide, produced the largest grayling and the only adults. The length frequency of the catch is shown in Table 19.

One recapture of a grayling (273 mm) tagged in 1981 in Caribou Creek was made in Buchanan Creek by an angler in September 1982.

#### Kiana Creek:

A tributary to the Tanana River 15 mi below the Richardson Clearwater River, Kiana Creek was surveyed on June 30, 1983. Draining tundra, bog and forest lands the creek is 15-25 ft wide and moderately humic stained. It is similar to Caribou Creek in appearance. Two locations were surveyed and 21 grayling were captured by hook and line with a total of 14 tagged. The fish ranged from 100 to 304 mm in length with a mean of 213 mm (Table 19). The upper section, located 1/4 mi above a short tributary that drains a spring-fed pond, had a silt and sand bottom and short riffle areas separating long pools and runs. Few fish were caught here but those observed ranged from unknown fry to grayling 280 mm long. Water temperature was 12°C. The second section was within 1 mi of its mouth at a small falls caused by an exposed rock ledge. There was less stain to the water here and the temperature was higher, 16°C. More algae and submerged vegetation was present than at the first location. The largest grayling were caught here below the falls. All fish were in excellent condition. Due to the late date, no maturity determinations were possible. Next to Rapids Creek, this creek shows the most potential as an important spawning area and deserves additional effort in tagging.

#### Tag Recaptures:

The 1983 recaptures of Arctic grayling tagged in all waters since 1977 are shown in Table 20. The recaptures represent not only those from Sport Fish Division sampling (Table 17) but also returns by fishermen. The recovery locations, especially those for those fish tagged in the Shaw Creek drainage, reflect destinations similar to those found in previous years. Of notable interest are the Delta Clearwater River recaptures of 1981 Volkmar River tags. The majority of these fish (n=149) represent immature grayling (approx. Age Class III) which were tagged during their out-migration to overwintering areas in the fall (Ridder, 1982). The 1983 recaptures were nearly equal to the number returned during the first 2 years. This generally agrees with the hypothesis on partial recruitment to the Delta Clearwater River occurring at Age Class IV-V as reported by Reed (1961).

The recaptures of fish tagged in Clear Creek in 1982 are also interesting, considering the creek was devoid of fish by early August. While the majority of the recaptures were made downstream in the Shaw Creek drainage, which previous reports showed to be a recruitment source, the rest were from spring-fed systems upstream in the Tanana Drainage (Fig. 1). Tack (1980) cited tagging studies that showed the homing tendency of grayling to return to the same spring-fed systems yearly. These fish bypassed their own small spring-fed system to take

Table 20. 1983 Recaptures of Arctic grayling tagged in the mid Tanana River drainage since 1977.  
In parentheses are total recaptures to date.

Location	Tagging		Recapture Location							
	Year	Number	Delta Clearwater	Richardson Clearwater	Shaw Creek	Caribou Creek	Salcha River	Goodpaster River	Tanana River	Others
Shaw Creek	1979	156	0 (2)	1 (8)	1 (3)	1 (11)	0 (0)	1 (1)	0 (1)	
	1980	94	0 (0)	2 (10)	2 (2)	2 (10)	0 (1)	0 (0)	0 (2)	
Caribou Creek	1980	1,283	0 (4)	20(182)	14(123)	31(210)	0 (4)	0 (0)	0 (1)	
	1981	1,323	1 (1)	28(137)	19 (54)	84(323)	0 (2)	0 (0)	0 (2)	(1) <sup>1</sup>
	1982	2,001	3 (3)	42(140)	39 (54)	108(159)	3 (8)	0 (2)	1 (1)	
Delta Clearwater	1977-1982	2,422	5(332)	0 (3)	0 (0)	0 (0)	0 (0)	1 (1)	0 (4)	(2) <sup>2</sup>
Richardson Clearwater	1980	30	0 (0)	2 (10)	1 (3)	0 (4)	0 (0)	0 (0)	0 (0)	
Clear Creek	1982	62	1 (1)	0 (0)	2 (2)	3 (3)	0 (0)	0 (0)	0 (0)	2(2) <sup>4</sup>
Volkmar River	1980	112	2 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	
	1981	199	3 (7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1(1) <sup>3</sup>
Goodpaster River	1982	116	1 (4)	0 (1)	0 (0)	1 (1)	0 (0)	1 (6)	0 (0)	
Totals		7,798	16 (368)	95 (491)	78 (241)	230 (721)	3 (15)	3 (10)	1 (11)	3 (6)

1 Little Salcha River

2 Volkmar River, Dry Creek

3 Volkmar River

4 Clearwater Lake, Blue Creek

up residences in others. As reported in Ridder (1983), small spring creeks, such as Clear Creek, appear to be used by grayling in a manner different from the larger systems such as the Delta and Richardson Clearwater Rivers.

No recaptures were made of fish tagged this year in Rapids, Ptarmigan, Buchanen and Kiana Creeks. Numbers of tagged fish were low enough (n=64) in the latter three creeks to preclude recoveries. Numbers were sufficient, however, in Rapids Creeks (n=108). Since not all fish in the post-spawning migration from Caribou Creek leave the drainage (Ridder, 1983) perhaps the tagging efforts at Rapids Creek were on fish destined to remain in the drainage.

#### Grayling Stock Enhancement

In 1983 the four year-classes of Arctic grayling stocked into the Delta Clearwater River as pond-reared fingerlings were represented by Age Classes V-VIII. Their representation in the population was based on analysis of scale characteristics in samples from electrofishing (n=91) and creel sampling (n=125) (technique is described in Ridder, 1983). These age classes made up 81% of the two combined samples. Pond-reared fish made up 14% of these age classes and 12% of the total combined samples. These percentages are roughly half of those found in 1982 and 1981. Table 21 shows these and other year-class and sample compositions for the years 1979-1983.

The 50% decrease in the composition of pond-reared grayling is due primarily to the rather sudden and drastic decline in the percentages of the 1975 and 1976 plants. The former plant comprised 20% of all 7-year-old fish in 1982 but 0.0% of 8 year-olds in 1983. The latter plant fell from 35% of their age class in 1982 to 8% in 1983. The 1977 plant's 9% composition in Age Class VI is much below the mean 30% found for the two earlier plants in this age class, but is consistent with its trend of declining compositions over the previous 3 years. The reasons for these declines cannot be pinpointed. The difficulties in aging older fish and small sample sizes may compound the problem. Unless there is differential mortality between pond-reared and wild grayling, increased straying with age or additional recruitment of wild fish to the river beyond the accepted age classes (III and IV, see Ridder, 1983), the percentage of these pond-reared fish in their respective year-classes would be expected to remain relatively stable after the full recruitment of wild fish to the river's population. In Table 22 are shown the compositions of the four year-classes of pond-reared grayling in successive age classes.

One recapture from 651 pond-reared grayling tagged and stocked into the Delta Clearwater River at Age I in 1979 was recorded in 1983. The fish was caught in the Delta Clearwater River within 1 mi of its stocking location. Tag returns from this plant now total 32. Thirty-one were made in the Delta Clearwater and one was made in the Richardson Clearwater River (Ridder, 1982, 1983).

Table 21. Composition of four year-classes, 1975-1978, of pond-reared Arctic grayling stocked into the Delta Clearwater River as percentage of sub-samples of the four year classes and as percentage of total samples, 1979-1983.

Year	Sample Size*	% of 4 yr-classes in sample	Respective age class	Pond-reared Gr (%)	
				in yr classes	in total sample
1979	377	37	I-IV	62	23
1980	313	75	II-V	40	31
1981	233	83	III-VI	29	24
1982	148	88	IV-VII	27	25
1983	216	81	V-VIII	14	12

\* Samples in each year from indexing and creel censusing.

Table 22. Percent composition in successive age classes of 4 year-classes of Arctic grayling stocked into the Delta Clearwater River, 1976-1983.

Age Class	Year-Class			
	1975	1976	1977	1978
	Number Stocked			
	9,100	12,467	6,684	7,209
I	60	76	53	41
II	31	46	28	56
III	52	41	60	35
IV	29	39	32	35
V	21	25	16	22 (90)
VI	25	35	9 (34)	
VII	20	8 (39)		
VIII	0 (11)*			

\* In parentheses is total sample in each age class.

### Evaluation of Stocking Methods:

Efforts to enhance of the Arctic grayling population in the Delta Clearwater River resumed in 1983 with the stocking of 10,967 fingerlings. The plant was near equally divided between fingerlings that were reared in shallow ponds (n=5,481) and those reared at Clear Hatchery (n=5,486). The stocking was done on two different occasions. The first occurred on August 26 and 31 when 2,189 pond-reared and 2,503 hatchery-reared fish were stocked at Mile 8 of the river. The second was on September 23 and 30 when 3,293 pond-reared and 2,983 hatchery fish were stocked at the same location. Each of the four distinct plants received unique fin clips prior to stocking for future evaluations regarding imprinting, year-class compositions and recruitment to the fishing. A summary of the stockings is presented in Table 23.

The mean fork lengths, weights and condition factors of the pond-reared and hatchery-reared grayling differed (Table 24). The pond-reared fish were approximately twice the size of the hatchery fish at each planting. The 4-month-old hatchery fish were about the same size as an 11-month-old stream-reared grayling. The pond-rearing produced fish that approximated the size of Age II wild fish.

Behavior at stocking also differed between the two groups and was also probably due to rearing conditions. The pond-reared fish reacted mildly to the 20 mi transport in a truck-mounted tank but exhibited excited, erratic behavior at stocking wherein the majority headed immediately downstream. The hatchery fish, reared in a raceway, reacted in an opposite manner. They were more excitable during the 170 mi transport, but at stocking immediately orientated themselves in the river and lingered in the eddy near the truck. Although some headed upstream, most slowly dispersed downstream, with some taking up holding positions in backwaters and bottoms of pools.

Mortality from fin-clipping and transport was negligible. Only three hatchery fish were found dead or nearly dead at stocking. During fin-clipping the first batch of hatchery fish in August, 246 fish were divided into three groups and held for 84 hours to determine if handling and treatment induced delayed mortality. One group of 100 was anesthetized and fin-clipped. The second group of 96 was only anesthetized. The third group of 50 served as a control. No mortalities were observed in any group during the experiment (Dave Parks, ADF&G, Clear Hatchery, pers. comm.).

An additional 4,197 fingerlings were trapped out of the ponds listed in Table 24 and transferred to overwintering lakes. Plans are to stock them in the Delta Clearwater River in 1984. Half of the number will be stocked in the spring and the other half in the fall. Other fish may be available from Bolio and Big Lakes, which offer marginal overwintering capabilities.

Early cold weather that produced up to 3 in of ice by September 28 was followed by high winds and 1983's second breakup. Both incidents

Table 23. Summary of Arctic grayling stocked into the Delta Clearwater River, 1983.

Egg <sup>3</sup> Source	Rearing Location	Date Stocked	Number Stocked	Fish/ lb.	Fin <sup>1</sup> clip	Water Temperature (°C)		Mortality	Condition
						Tank	River		
Moose L.	W. Pond	8/26	2,189	40	Ad&Lv	8°	5°	0	excellent
Jack L.	Clear Hatch.	8/31	2,503	194	Rp	8°	5°	1	excellent
Moose L.	West Pond	9/23	348	31	Ad	1°	2°	0	excellent
	Big Lake	9/23	1,870	13	Ad	1°	2°	0	excellent
	Bolio Lake	9/23	1,074	11	Ad	1°	2°	0	excellent
			<u>3,292</u>						
Jack L.	Clear Hatch.	9/30	2,983	82	Rv(n=2500)	10° <sup>2</sup>	3.5°	2	excellent
Totals: Ponds:		5,481							
Hatchery:		<u>5,486</u>							
		10,967							

1 Fin clips: Ad - adipose  
Lv - left pelvic  
Rv - right pelvic  
Rp - right pectoral

2 Tank reduced to 7° C before release

3 Moose Lake is located in the Tolsona Creek drainage, near Glennallen, Jack Lake is located in the Nabesna River drainage, headwaters of the Tanana River.

Table 24. Mean fork lengths, weights, condition factors and survival of pond-reared and hatchery reared Arctic grayling stocked as fry on June 2, 1983.

Location	No. stocked	Sample date	Mean Length (mm)	Mean weight (g)	Condition factor <sup>1</sup>	Water Temp. (°C)	Total Catch	Survival <sup>2</sup> %
West Pond	15,000	08/01	93	8.1	0.99	17°	3,946	26.3
		08/24	108	11.5	0.92	11°		
		09/23	114	14.7	0.98	5°		
Big Lake	25,000	08/01	104	11.7	1.05	17°	2,974	11.9
		09/23	150	33.6	0.99	7°		
Lost Lake	25,000	07/14	68	3.2	1.02	20°	202	0.8
		10/03	157	43.2	1.12	2°		
Spade Lake	25,000	08/03	94	10.1	1.20	14°	0	0
		09/23	...	...	...	4°		
Bollio Lake	50,000	08/03	106	15.0	1.24	18°	2,556	5.1
		09/23	159	43.5	0.99	5°		
Clear Hatch.	N/A	07/27	40	0.6	0.93	13°	N/A	4.0
		08/30	60	2.3	1.06	13°		
		09/30	86	5.5	0.86	13°		

1  $\frac{\text{weight}}{\text{length}^3} \times 10^5$

2 Based on fyke trapping, see text.

hampered trapping efforts. Assuming a near 100% efficiency shown by the trapping method (Peckham and Ridder 1979), the total catches in each pond gave survival rates for fry ranging from 0.8% in Lost Lake to 26.3% in West Pond (Table 24). Increasing water levels in Spade Lake provided an outlet and nearly total out-migration that resulted in no fish captured in 216 hours of fyke trapping. Summer sampling, always done successfully with seine in other rearing ponds, also failed in Spade Lake despite an excellent bottom type. Five grayling were finally caught by 19 hours of fyke trapping on August 3. The poor survival in Lost Lake was also indicated by a catch of only three grayling after 22 hours of under-ice netting with a 250-ft monofilament gill net on October 27, 1983 (Richard Peckham, ADF&G, pers. comm).

Grayling were also to be held overwinter at Clear Hatchery for feeding experiments but had to be destroyed. Routine sampling detected furunculosis in one fish out of 10. Further sampling of 99 fish detected the disease in two more fish. It is not known whether the disease's origin was attributable to either the Jack Lake or Moose Lake stocks. (Dave Parks, ADF&G, pers. comm.). Test results were not known until after the stockings.

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