Fishery Data Series No. 96-20

The Delta Clearwater and Salcha River Creel Surveys Conducted in 1995

by

Jerome E. Hallberg

and

Allen E. Bingham

August 1996

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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Jerome E. Hallberg
Division of Sport Fish, Fairbanks
and
Allen E. Bingham
Division of Sport Fish, Research and Technical Services, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

August 1996

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Jerome E. Hallberg
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599, USA
Allen E. Bingham
Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services,
333 Raspberry Road, Anchorage, AK 99518-1599, USA

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ABSTRACT

Creel surveys were conducted at the Delta Clearwater Arctic grayling *Thymallus arcticus* fishery, and the Salcha River chinook salmon *Oncorhynchus tshawytscha* fishery, during 1995. A single access survey with information obtained from individual (completed-trip) anglers was used to describe the age and length compositions of the Arctic grayling harvest along with angler ratings of the quality of fishing at the Delta Clearwater River fishery. A stratified multistage sampling survey was used to estimate effort, catch, and harvest for the Salcha River chinook salmon fishery. Angler demographics were estimated for both fisheries.

At the Delta Clearwater River, 51% (SE = 3%) of the Arctic grayling sampled in the harvest were of the "preferred" RSD length category. Age 5 Arctic grayling comprised 34% (SE = 3%) of the harvest sample. Thirty-eight percent (SE = 2%) of those anglers interviewed at the Delta Clearwater River rated the quality of fishing as "good".

The creel survey at the Salcha River chinook salmon was conducted from 7 - 20 July. Anglers were counted and interviewed, to estimate 11,395 (SE = 628) angler-hours of effort to catch a total of 1,565 chinook salmon (SE = 175), of which 811 (SE = 72) were harvested.

Key words: Creel survey, Arctic grayling, chinook salmon, age composition, Relative Stock Density, catch, harvest, angler effort, angler demographics, Delta Clearwater River, Salcha River, interior Alaska, Tanana River drainage.

INTRODUCTION

The Arctic-Yukon-Kuskokwim (AYK) Region encompasses an area that covers almost two-thirds of the State of Alaska and includes all of Alaska north of Bristol Bay and the Alaska Range (Figure 1). Within this area, the state's largest river systems (Yukon, Kuskokwim, Colville, and Noatak) are found, along with thousands of lakes, and thousands of miles of streams. These waters support a large number of recreational fisheries for both freshwater and anadromous fish species that include Arctic cisco *Coregonus autumnalis*, Arctic char *Salvelinus alpinus*, Arctic grayling *Thymallus arcticus*, anadromous chinook salmon *Oncorhynchus tshawytscha*, anadromous and land-locked coho salmon *O. kisutch*, anadromous chum salmon *O. keta*, burbot *Lota lota*, Dolly Varden *S. malma*, humpback whitefish *C. pidschian*, lake trout *S. namaycush*, least cisco *C. sardinella*, northern pike *Esox lucius*, rainbow trout *O. mykiss*, round whitefish *Prosopium cylindraceum*, and sheefish *Stenodus leucichthys*.

For sport fishery management purposes, the AYK Region was divided into two areas, the Tanana River drainage (includes all waters within the Tanana River drainage), and the AYK area (includes all waters outside the Tanana River drainage; Figure 1). Even though the AYK Region encompasses a very large area, the majority (approximately 75%) of the recreational angler-effort and harvest occurs near the major population centers (Fairbanks, Delta Junction, and Tok) within the Tanana River drainage (Mills 1979-1994 and Howe et al. 1995; see Figure 2).

From 1977 through 1982, harvest of all fish species increased about 19% annually to a peak of about 179,000 for the Tanana River drainage. A record harvest for the entire AYK Region, of 274,541 fish occurred in 1982 (Figure 2). From 1983 to 1987, harvest decreased in both the Tanana River drainage and AYK Region. The decrease in harvest that occurred in 1983 was probably the result of the overharvest of the major species in the Tanana River drainage in prior years. Because of this decline, restrictive management regulations were instituted for the major fisheries in the Tanana River drainage in 1987 and 1988. In spite of restrictive regulations, harvest and angler effort increased in 1988. Harvest of all sport fish species in the Tanana River

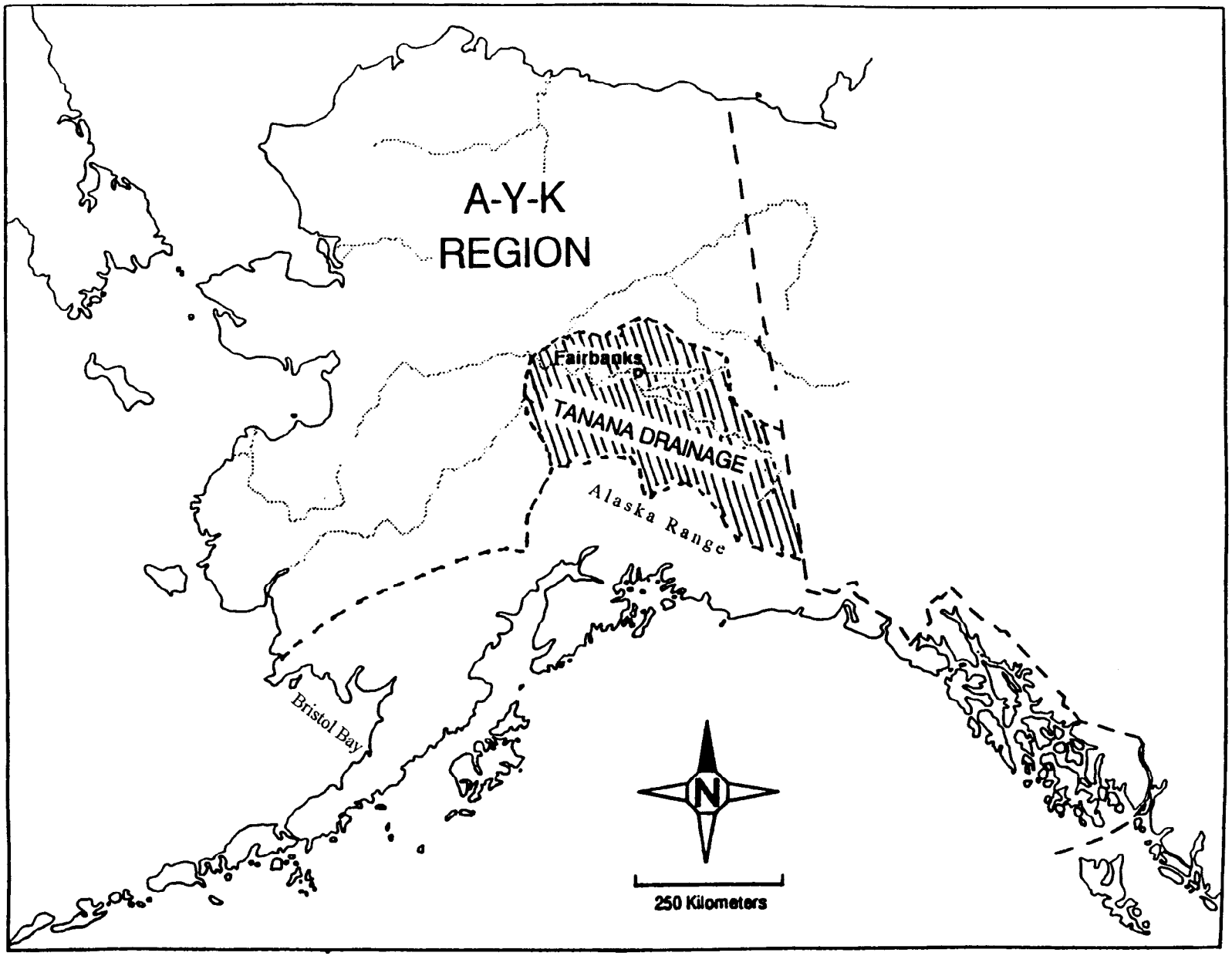

Figure 1.-Map of Arctic-Yukon-Kuskokwim (AYK) Region and Tanana River drainage, Alaska.

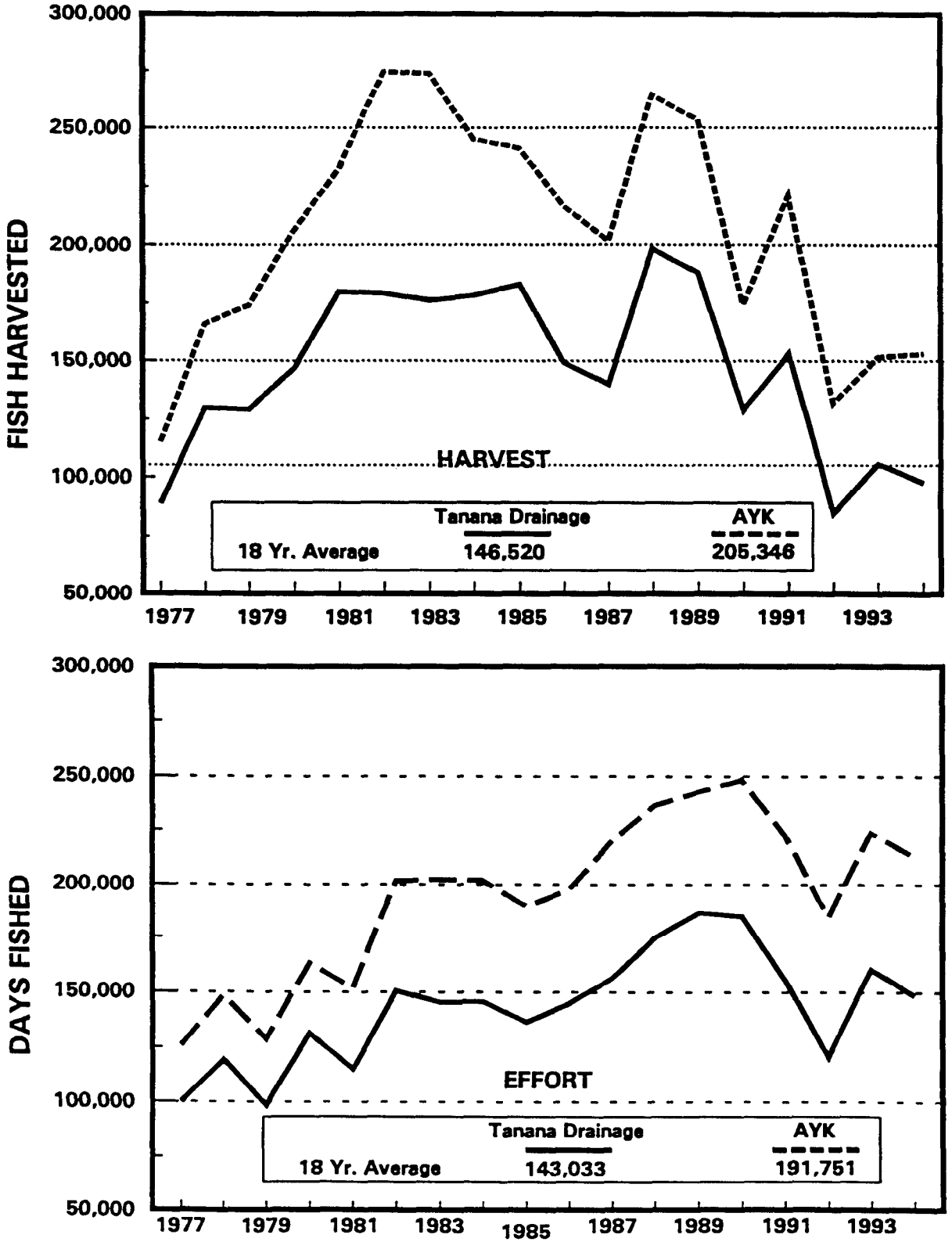

Figure 2.-Effort and harvest by recreational anglers in the AYK Region (includes Tanana River drainage) and Tanana River drainage sport fish management areas, 1977-1994.

drainage dropped substantially since a peak in 1988, and now appear to have stabilized. While days fished have also decreased since 1988, a marked increase occurred between 1992 and 1993 followed by a slight decline in 1994 (Figure 2).

Monitoring of the Tanana River drainage recreational fisheries is important to evaluate the effectiveness of the newly-imposed restrictive regulations on indigenous fish populations. Conservation of indigenous stocks is desired in interior Alaska and one method of assessing the success of conservation efforts is through the use of creel surveys.

The long term goals of the creel survey program are to: (1) develop historical databases to allow monitoring of both the recreational fisheries and the exploited fish populations; (2) develop regulations that reflect the desires of the angling public while ensuring the sustained health of the resource; and (3) estimate the effects of management regulations on the fisheries, fish populations, and recreational angling public.

A comprehensive analysis of data from the creel surveys that were conducted by the Alaska Department of Fish and Game (ADF&G) in the AYK Region during 1995 is presented in this report.

Creel surveys were scheduled to be conducted at three of the major fisheries within the Tanana River drainage. However, the Chatanika River whitefish spear fishery was closed 1 September, 1995, by a Department Emergency Order due to the low abundance of least cisco in the Chatanika River.

DELTA CLEARWATER RIVER ARCTIC GRAYLING FISHERY

INTRODUCTION

The Delta Clearwater River located approximately 13 km northeast of Delta Junction supports a popular Arctic grayling fishery during the summer months. The main channel of the river is approximately 32 km long. The river drains an area of about 1,000 km^2. Public access to the river is available at the State of Alaska Clearwater Campground at kilometer 13 of the river (Figure 3).

Fishing generally begins on the Delta Clearwater River in mid to late May, when larger Arctic grayling begin to migrate to their summer feeding areas in the upper part of the river. From 1977 to 1988, an average of 6,340 angler-days were expended annually to harvest an average 5,158 Arctic grayling (Mills 1979-1989). Angler effort peaked in 1986 at 10,137 angler-days. However, in 1986, harvest dropped to the lowest level (2,343) since 1977. Because of concern for the fishery and the decline in harvest, emergency regulations were set forth on the Delta Clearwater River to protect the Arctic grayling stock(s) in 1987. These emergency regulations became permanent regulations in 1988 and remain in effect today. The regulations implemented were:

1. a 12-inch minimum length limit for Arctic grayling;
2. a no-bait restriction (only artificial flies and lures may be used); and,
3. catch-and-release fishing from 1 April through 1 June (spring closure).

To examine the effects of these new regulations, an onsite creel survey was initiated on the Delta Clearwater River grayling fishery in 1986 and continued until 1990. Since 1991 the ADF&G has

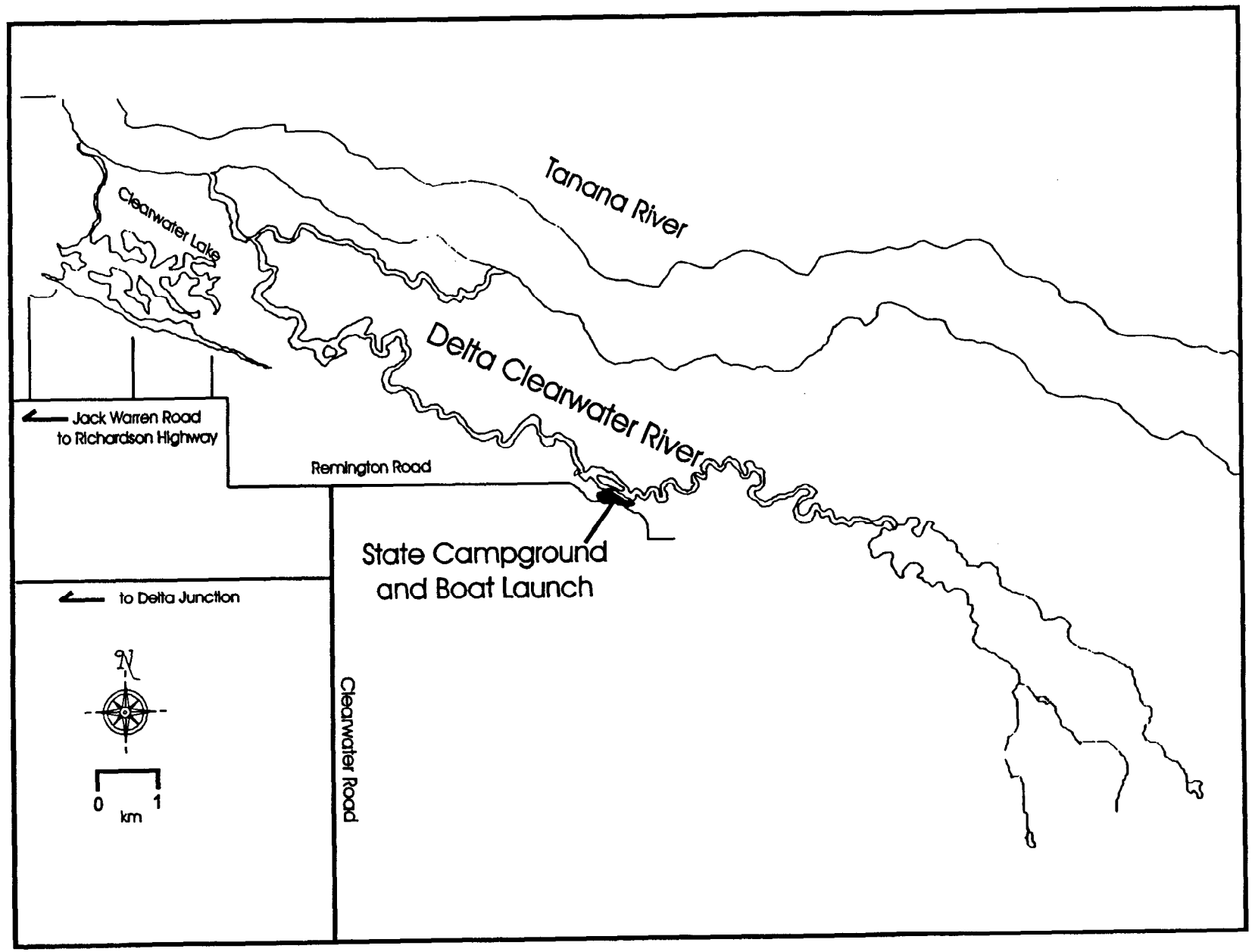

Figure 3.-Map of the Delta Clearwater River, Tanana River drainage, Alaska.

relied upon the Statewide Harvest Survey to provide estimates of catch, harvest of and the effort for Arctic grayling in the Delta Clearwater River. However, the Statewide Harvest Survey does not provide data on the age and size composition of the harvest. In 1994 the onsite creel survey was reinstituted with the objective of obtaining information on the size and age composition of the harvest of Arctic grayling from the Delta Clearwater River. The specific objectives for the 1995 Delta Clearwater River creel survey are listed below.

1. To provide post-season estimates of the percent age composition, and relative stock density (RSD) for Arctic grayling harvested in the Delta Clearwater River sport fishery.
2. To estimate the percent composition within the following demographic categories of anglers interviewed at the Delta Clearwater River:
   a) male/female;
   b) adult/youth;
   c) resident/nonresident;
   d) nonmilitary/military; and,
   e) terminal fishing gear (spinning gear or fly fishing gear).
3. To estimate the percent rating by anglers of the quality of fishing at the Delta Clearwater River.

STUDY DESIGN

A single access survey with information obtained from interviews of individual (completed-trip) anglers was used to estimate all parameters. The majority of anglers fishing the Delta Clearwater River gain access to the river at the State of Alaska Clearwater Campground, consequently all angler interviews were conducted at this location.

In order to maximize angler contacts, sampling was conducted during those times (days and hours) when the most angler-trips and subsequently the most catch and harvest had occurred in the past.

Evaluation of the most recent (1990) creel survey conducted at the Delta Clearwater River indicated that 83% of the anglers interviewed and 60% of the angling effort (angler-hours) occurred on the weekend days, Friday, Saturday and Sunday (Hallberg and Bingham 1991). The 1990 data also showed that 80% of the angler interviews and 63% of the angling effort (angler-hours) occurred between 1500 and 2200 hours. To maximize angler contacts, the creel clerk interviewed all anglers who had completed fishing and were exiting the campground area between 1300 to 2200 hours every Friday, Saturday, and Sunday from 2 June through 13 August 1995. The same type of sampling design was used to survey this fishery in 1994.

Attempts were made to sample all Arctic grayling harvested by anglers exiting the fishery during the sampled periods. All fish were measured to the nearest mm (fork length) and scale sampled.

DATA COLLECTION

The creel survey at the Delta Clearwater River in 1995 focused on obtaining size (RSD) and age composition data from Arctic grayling harvested by those anglers who had completed fishing and

were exiting the Delta Clearwater River at the State of Alaska Clearwater Campground. During the interview the creel clerk measured all Arctic grayling to the nearest mm (fork length) and collected a scale sample for age determination. Scale samples were collected from the preferred area approximately six rows above the lateral line just posterior to the insertion of the dorsal fin. In the laboratory, the scales samples were processed by immersion in a solution of hot water, soap and hydrolytic enzyme and then mounted on gum cards. The gum cards are used to make triacetate impressions of the scales (30 seconds at 137,895 kPa (20,000 psi) at a temperature of 97°C). Ages were then determined by counting the annuli on these impressions with the aid of a microfiche reader. Determination of an individual fish's age was obtained only once for each readable set of scales.

The creel clerk recorded the fish's length, date and location of capture and any other pertinent information directly onto the coin (scale) envelopes. This information was then transferred to standard TAGGING LENGTH FORM VERSION 1.1.

To estimate angler demographic categories, the following information was collected from individual anglers:

1. angler gender (male/female);
2. age class (either youth under 16 years old or adult);
3. Alaskan resident or nonresident;
4. military or nonmilitary; and,
5. type of terminal fishing gear (spinning gear of fly fishing gear).

Anglers were asked to rate the quality of fishing at the Delta Clearwater River using the following ratings; (1) = excellent; (2) = good; (3) = fair; (4) = poor; and (5) = no opinion.

All interview data were recorded on standard ADF&G ANGLER INTERVIEW FORM VERSION 1.1. All age and length data along with the interview data has been archived (Appendix A1).

DATA ANALYSIS

Estimates of age composition for the sampled Arctic grayling were calculated. All data were treated as if they were obtained by a simple random sampling procedure. The age composition data collected from the sampled harvest at Delta Clearwater River were assumed to be the result of a self-weighting sample survey (i.e., equal proportions of the harvest sampled throughout the survey). Accordingly, the resultant age composition estimates should be unbiased for the entire harvest during the surveyed period in 1995.

The proportion of the sampled Arctic grayling harvested that are age u was estimated by:

$$\hat{p}_u = \frac{n_u}{n} \qquad (1)$$

where: n_u equaled the number of the sampled Arctic grayling harvested that were age u; and n equaled the total number of Arctic grayling sampled for age determination.

The variance of the estimated proportion was estimated by the standard equation for the variance of a binomial proportion (Cochran 1977, equation 3.8, page 52, omitting the finite population correction factor):

$$\hat{V}[\hat{p}_u] = \frac{\hat{p}_u(1-\hat{p}_u)}{n-1} \qquad (2)$$

This estimating equation is unbiased for random sampling. However the procedure followed for sampling the harvest is not random but a systematic proportional sample. Since any systematic correlation between age or size compositions for fish samples collected through our sampling procedure is expected to be minor, then the random sampling estimator for variance (i.e. equation (2)) should be relatively unbiased (Wolter 1985).

Standard errors are calculated by taking the square root of the variance estimates.

Estimates of age composition in percentages were calculated simply as the proportions multiplied by 100% (the same conversion is used for the standard errors).

Size composition was estimated in a similar manner, replacing age class with the RSD categories of Gabelhouse (1984) for Arctic grayling. The RSD categories used were: "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).

Estimates of the proportion of angler-trips by demographic, gear type, or angler satisfaction categories were also calculated as described above. The various categories represented the ages (the *u* subscript) and the number of anglers interviewed represented the sample size (n) in equations (1) and (2). As with the age and size composition estimates the estimates obtained by these procedures were assumed to be unbiased if the survey is of the self-weighted type as designed. However, since the schedule only called for sampling on the "weekend days" of Friday-Sunday, then estimates of angler demographics may be biased if the make-up of the fishery varies among the days in the week. Avid anglers (anglers who fish more often than less-avid anglers) were more likely to be interviewed than less-avid anglers. Therefore these estimates are assumed to be only representative of angler-trips[1] not anglers.

RESULTS

The 1995 creel survey began on 2 June and was terminated on 30 July. Sampling occurred as scheduled between 1300 and 2200 hours on every Friday, Saturday and Sunday; and interviews were obtained only from those anglers who had completed fishing and were exiting the Delta Clearwater River at the State of Alaska Clearwater River campground.

A total of 505 anglers were interviewed during this period. Of those anglers interviewed (77%, SE = 2%) were male, adult (84%, SE = 2%), and residents of Alaska (82%, SE = 2%). Only 8% (SE = 1%) of those interviewed were military personal, permanently stationed in Alaska. Fifty-six percent (SE = 2%) of those anglers interviewed were using fly fishing gear (Table 1).

[1] An angler-trip as used in this report refers to each fishing trip on and off the river by one angler. One angler may or may not have multiple angler-trips within a calendar day. Additionally, one angler-trip may or may not span calendar days (e.g., multi-day float-trip). This definition has no relationship to an angler's residence.

Table 1.-Estimates of various angler demographic categories for the Delta Clearwater River Arctic grayling fishery from 2 June through 30 July 1995.

Category	Number Interviewed	Percent	SE (%)
Female	115	23	2
Male	390	77	2
Youth	83	16	2
Adult	422	84	2
Non-Resident	89	18	2
Resident	416	82	2
Military	42	8	1
Non-Military	463	92	1
Spin	285	56	2
Fly	183	36	2
Both	37	8	1

resultant parameter estimates are biased. Valid comparisons between the results obtained in this year's survey with those of 1994 may also be compromised.Of the 279 anglers interviewed who had an opinion as to the quality of fishing at the Delta Clearwater River, 37% (SE = 3%) rated the fishery as excellent, 47% (SE = 3%) rated it as good, 13% (SE = 2%) rated it fair, and 3% (SE = 1%) rated the fishery as poor. A total of 172 anglers expressed that they had no opinion as to the quality of fishing at the Delta Clearwater River in 1995.

Biological data were collected from 259 Arctic grayling harvested during the creel survey. Harvested Arctic grayling ranged in age from 3 to 12 years (Table 2). Age 5 was the predominant age class accounting for 34% (SE = 3%) of the harvest.

Length data were collected from 273 Arctic grayling. The predominant RSD category for the harvested Arctic grayling was preferred, comprising 51% (SE = 3%) of the harvest (Table 2). Forty-eight percent (SE = 3%) of the harvest was of the quality category. One percent (SE = 1%) of the fish were in the memorable category and no fish were harvested in the trophy category.

DISCUSSION

The main emphasis of the 1995 creel survey of the Delta Clearwater River Arctic grayling fishery was to obtain age and size composition of the harvest. The creel survey was originally scheduled to run from 2 June to 13 August but was terminated 14 days earlier on 30 July. Budgetary concerns and resignation of the creel technician were the reasons for the early cancellation. The concern over ending the survey at this time was buffered by the fact that a total of 505 completed-trip angler interviews were obtained, during which a total of 259 and 279 samples were collected for age and length composition, respectively.

While the sample size was slightly larger, the length composition of harvested Arctic grayling in 1995 was almost exactly that observed in the 1994 fishery (Hallberg and Bingham 1995). The preferred category of fish between 340 and 449 mm fork length comprised 52% of both the 1994 and 1995 sample and 51% in 1990 (Hallberg and Bingham 1991). Concurrently, the quality size category (fish between 270 and 339 mm fork length) accounted for 46% in 1994 and 48% in 1995.

The age composition data of Arctic grayling harvested in 1995 differed only slightly from the individual ages observed in the 1994 data. Age 5 fish was the predominant age class in 1994 representing 22% of the sample (Hallberg and Bingham 1995), while age 5 Arctic grayling was again the most abundant age in the 1995 sample with 34%.

The sampling design used both in 1994 and 1995 was a non-random systematic sample survey (every Friday, Saturday, and Sunday, from 1300 to 2200 hours). Since all anglers exiting the fishery during the scheduled samples were interviewed then the interviews obtained were expected to represent a consistent proportion of all anglers exiting the fishery throughout the season during all days and periods of the day. This expectation is based upon the assumption that, in general, the same proportion of the total angler effort occurred during the sampled periods from week to week. So that even though angler effort may wax and wane from week to week, by consistently sampling the same days of the week and the same periods within the sampled days the trends in the number of anglers interviewed reflected the unobserved trends in overall angler effort. This assumption had been shown to be valid for similar surveys in the past, although it was not directly evaluated for this survey. Accordingly, if this assumption was substantially invalid then the

Table 2.-Estimates of the contributions of each age class, mean length at age, and Relative Stock Density of Arctic grayling in the harvest sample from the Delta Clearwater River Arctic grayling fishery, 2 June through 30 July 1995.

	Age Composition			Mean FL
Age	Number	Percent	SE(%)	(mm)
3	2	1	1	292
4	32	12	2	301
5	88	34	3	325
6	52	20	2	344
7	30	12	2	370
8	28	11	2	383
9	10	4	1	400
10	9	3	1	410
11	6	2	1	432
12	2	1	1	431
Total	259	100		

	Relative Stock Density (RSD)			
Category	FL Length Range (mm)	Number	Percent	SE(%)
Small	≤149			
Stock	150-269			
Quality	270-339	130	48	3
Preferred	340-449	141	51	3
Memorable	450-559	2	1	1
Trophy	≥560			
Total		273	100	

The average annual harvest of Arctic grayling from 1977 through 1986 (the 10 years prior to when the special regulations went into effect) was more than 6,500 fish (Mills 1979-1987). The annual harvest of Arctic grayling for the past 8 years (1987-1994) has averaged about 1,800 fish (Mills 1988-1994 and Howe et al. 1995). Angler effort for all sport fish species on the Delta Clearwater River for the past 8 years (1987-1994) averaged just under 5,000 angler-days which is about 25% less than what was reported during the preceding 10 years (1977-1986) when effort averaged more than 6,500 angler-days.

While both effort and harvest have declined, anglers' opinion of the quality of fishing for Arctic grayling in the Delta Clearwater River in 1995 remained high in that 37% of those interviewed who registered an opinion, rated their experience as excellent and (47%) rated it as good. The 1994 survey showed 17% of the anglers who rated the fishery as excellent, and 52% rated the fishery as good. Reasons as to why more than twice the number of anglers in 1995 rated the fishery as excellent than that observed in 1994 remains unclear at this time.

Shortly after the 1995 Delta Clearwater River Arctic grayling fishing season opened (by regulation) on 1 June, the Arctic grayling research staff provided new, (in-season) data that indicated abundance of Arctic grayling in the river had declined. Concerned that the existing rate of harvest on the decreased Arctic grayling abundance may not be sustainable, managers responded (on 13 July) by lowering the legal daily bag and possession limit for Arctic grayling in the Delta Clearwater River from five to two fish. This restriction did not seem to discourage angler participation in the fishery. This became evident when we compared the number of interviews (103) obtained for the two week period following the bag limit reduction in 1995, with the slightly less number (101) of interviews collected for the same period in 1994, when no restrictions were placed on the fishery.

There appears to be considerable catch-and-release fishing for Arctic grayling in the Delta Clearwater River. While the objectives for the 1995 creel survey at the Delta Clearwater River did not include estimating the distribution of Arctic grayling catch and harvests by individual anglers, these statistics along with standard errors were obtained ancillary to other objectives and have been summarized (Appendix A1). The percent distribution of catch and harvest of Arctic grayling among anglers interviewed in 1995 shows 61% of the anglers with zero catches and the majority of the anglers (71%) harvesting zero Arctic grayling, (Appendix A1). The distribution of harvest of Arctic grayling in 1990 showed 10% less anglers harvesting zero fish (61%) and a greater number of the anglers harvesting one or more fish. (Hallberg and Bingham 1991). Another encouraging fact was that no anglers in 1995 were found to have harvested more than the legal limit of five Arctic grayling. In 1990 it was reported that illegal harvest was occurring and the most Arctic grayling harvested by any angler interviewed was nine (Hallberg and Bingham 1991).

SALCHA RIVER CHINOOK SALMON FISHERY

INTRODUCTION

The Salcha River is located about 67 km southeast of Fairbanks on the Richardson Highway (Figure 4). The Salcha River supports a popular chinook salmon recreational fishery that occurs during the month of July. The chinook salmon run in the Salcha River is the largest documented run in the middle Yukon River drainage (Barton 1985). From 1977 to 1994 the chinook salmon

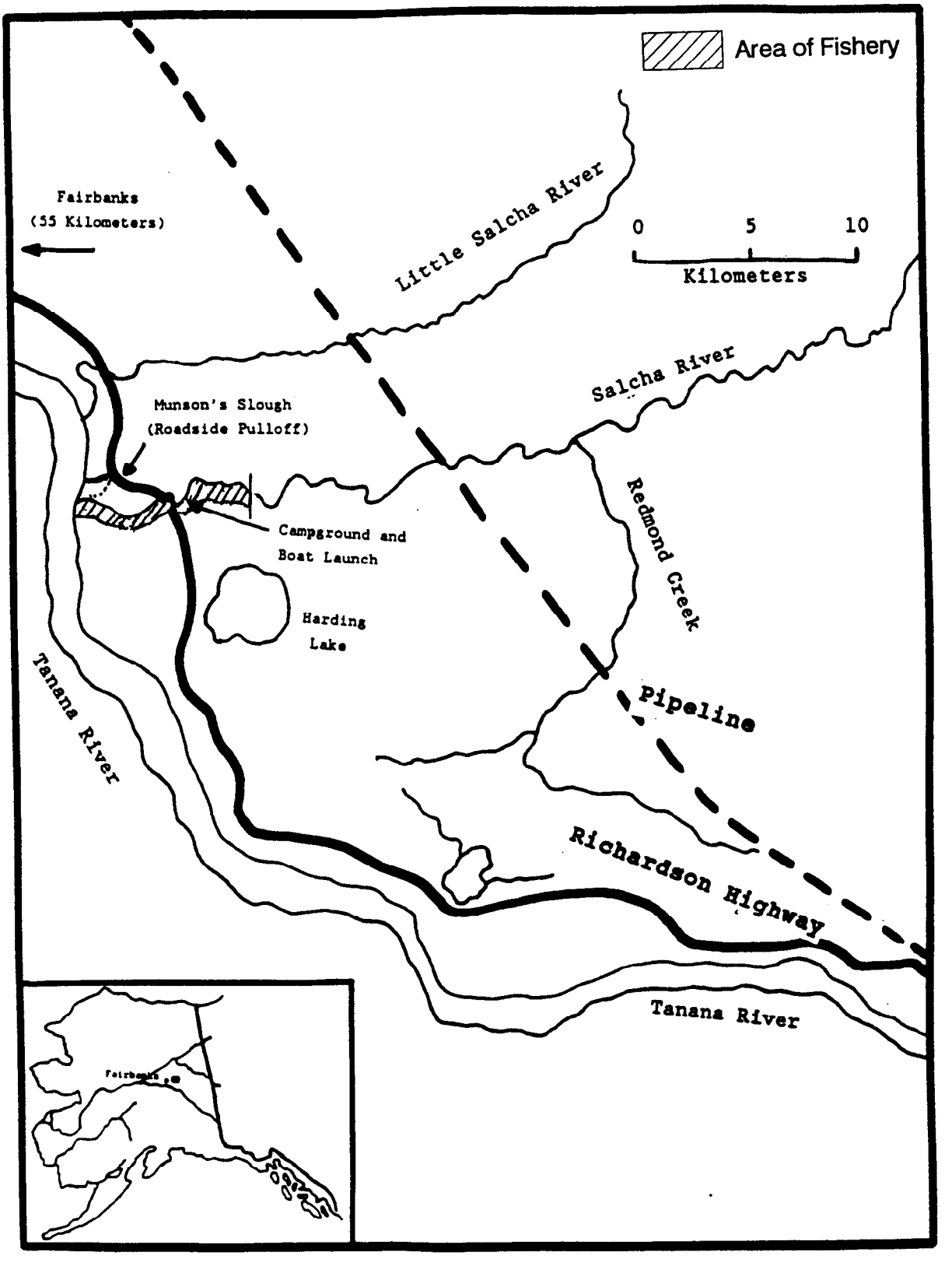

Figure 4.-Map of the Salcha River, Tanana River drainage, Alaska.

harvest from the Salcha River has ranged from 62 to 808 annually, averaging 460 (Mills 1979-1994, Howe et al. 1995). Until 1987, salmon fishing was allowed in the lower 29 km of the river. However, chinook salmon are known to spawn in this lower portion of the river. For this reason, the Alaska Board of Fisheries in 1988 restricted the area open to salmon fishing to the lower 8 km of the Salcha River, and established a guideline recreational harvest range for the Salcha River of 300 to 700 chinook salmon. In order to ensure that the recreational harvest does not exceed the allocated range, and because the Yukon River salmon stocks are being fully utilized by all user groups, it is imperative that the sport harvest of chinook salmon from the Salcha River be monitored.

Chinook salmon usually begin arriving at the Salcha River during the second week of July. For the past several years the majority of the chinook salmon anglers at the Salcha River exited the area at the Munson Slough parking lot located along the Richardson Highway. Since 1989 ADF&G has used this area to conduct single access, direct expansion type creel surveys. However, shortly after the 1993 creel survey began it became apparent that little effort and almost no harvest were reported from anglers who exited the fishery via the Munson Slough area. Further inspection of the lower Salcha River revealed that the river here was turbid to the point where sport fishing was nearly impossible. The source of the silty water was from a slough of the glacial-fed Tanana River which was entering the Salcha River upstream of the traditional fishing area. Anglers responded almost immediately and began fishing for chinook salmon near the Richardson Highway bridge, well above the silty water.

In 1994 the ADF&G anticipated that the lower portion of the Salcha River would remain muddy during the fishing season and redesigned its creel survey utilizing roving-type interviews to obtain catch and harvest information along with counts of fisherman to estimate angler effort.

The ADF&G has established a minimum chinook salmon spawning escapement goal for the Salcha River of 7,100 fish. As part of its annual stock assessment study, ADF&G utilizes the Richardson Highway bridge as a counting tower from which to enumerate the daily passage of chinook salmon up the Salcha River. Data collect by Skaugstad (1994) and Evenson (1995) clearly indicate more than 50% of the annual migration of chinook salmon past the counting tower occurred by 20 July. In fact, their data show that the spawning escapement goal of 7,100 fish had been attained by 20 July for both 1993 and 1994.

The main purpose for the 1995 creel survey was to provide inseason estimates of the harvest of chinook salmon in the Salcha River fishery. Managers believe that by 20 July, the chinook salmon fishery in the Salcha River is more than half over with and that at least 50% of the harvest would have occurred by this time.

In 1995, these data (tower counts and creel information) were used to manage the inriver fishery. Statistics on the sport fishery harvest coupled with the number of chinook salmon that had passed the counting tower by 20 July, provided managers the information needed to decide if the fishery should continue, or to close or restrict the fishery by emergency order, for reasons of conservation.

The specific objectives for the 1995 survey of the Salcha River chinook salmon fishery were to:

1. Estimate angler effort for, catch of, and harvest of chinook salmon in the Salcha River fishery during the 7-20 July period.
2. Estimate the percent composition within the following demographic categories of anglers interviewed at the Salcha River during the 7-20 July period:
   a) male/female,
   b) adult/youth,
   c) resident/nonresident,
   d) military/nonmilitary; and,
   e) fishing gear (spinner gear or fly fishing gear).

STUDY DESIGN

A stratified multistage sample survey was conducted to obtain estimates of angler effort for, catch of, and harvest of chinook salmon in the 1995 Salcha River fishery. Both angler counts and interviews of completed-trip anglers were conducted by one to two technicians (dependent upon sample type).

During the 1994 survey of this fishery two strata were defined: (a) peak time of day (hours of 1601-2400) and (b) non-peak time of day (0001-1600). In 1994, relatively poor precision levels were achieved, primarily due to inclusion of the relatively busy period of 0801-1600 within the relatively undersampled non-peak time of day stratum. Accordingly, the 1995 survey's stratification structure was altered to three time of day strata: (1) Early-Day, being the hours of 0001-0800; (2) Mid-Day, hours of 0801-1600; and (3) Late-Day, hours of 1601-2400.

The entire 8 hours within each sampling day for all strata were defined as a sampling period. The completed-trip anglers who exit the fishery during these period are the 2nd stage sampling units for the estimation of catch per unit effort (cpue) and harvest per unit effort (hpue). Correspondingly, the angler counts represent the 2nd stage units for estimating angler effort within each sampled period. Each angler count took approximately 30 minutes to conduct. Three counts per sampled day were conducted.

The count times were selected at random from the possible systematic combinations (Table 3). The number of angler counts to conduct per sampled day within each stratum was set to the lowest possible number of counts that allows for variance estimation by the procedure recommended by Wolter (1985) for estimating the variance of an estimate from systematic sampling.

Allocation of sampling resources among the strata was set optimally to minimize the total sampling variance vis-à-vis the procedures outlined by Cochran (1977). The creel survey data from 1994 were used to simulate the expected sampling variances for the 1995 survey. Allocation of samples among the strata were then set to the level which minimized the total simulated sampling variance over all strata. The result of this simulation indicated that 10 out of 14 days should be sampled in the Mid-day stratum, whereas 5 and 7 days should be sampled from the Early-Day and Late-Day strata, respectively.

Table 3.-Systematic angler count combinations for the 1995 Salcha River chinook salmon creel survey.

Stratum	Count Combination (one combination chosen at random for each sampled day)	Time for Count 1	Time for Count 2	Time for Count 3
Early-Day	1	0001-0032	0241-0312	0521-0552
	2	0033-0104	0313-0344	0553-0624
	3	0105-0136	0345-0416	0625-0656
	4	0137-0208	0417-0448	0657-0728
	5	0209-0240	0449-0520	0729-0800
Mid-Day	1	0801-0832	1041-1112	1321-1352
	2	0833-0904	1113-1144	1353-1424
	3	0905-0936	1145-1216	1425-1456
	4	0937-1008	1217-1248	1457-1528
	5	1009-1040	1249-1320	1529-1600
Late-Day	1	1601-1632	1841-1912	2121-2152
	2	1633-1704	1913-1944	2153-2224
	3	1705-1736	1945-2016	2225-2256
	4	1737-1808	2017-2048	2257-2328
	5	1809-1840	2049-2120	2329-2400

DATA COLLECTION

The creel survey at the Salcha River in 1995 emphasized the collection of angler-effort data obtained from angler counts along with catch and harvest information and angler demographics from completed-trip angler interviews. The creel clerk (utilizing a boat) conducted three counts per sampled period of anglers actively engaged in fishing along the lower 8 km of the Salcha River. Counts began at the top or bottom of the 8 km section. This starting point and consequently the direction of travel were selected randomly. Between counts the creel clerk interviewed anglers.

During each interview, the following information was collected from individual anglers:

1) the amount of time he or she spent fishing;

2) the number of chinook salmon caught;

3) the number of chinook salmon harvested;

4) angler gender (male/female);

5) age class (either youth under 16 years old or adult);

6) Alaskan resident or nonresident;

7) military or nonmilitary; and,

8) fishing gear used (spinning or fly fishing gear).

Angler count data were entered on to the ADF&G CREEL CENSUS - ANGLER COUNT FORM, VERSION 1.2 mark-sense forms. All interview data were entered on ADF&G ANGLER INTERVIEW FORM VERSION 1.1, mark-sense forms.

DATA ANALYSIS

The procedures outlined below were used to estimate effort for, catch of, and harvest of chinook salmon. These estimation procedures are appropriate for a two-stage roving survey, with days selected randomly as first stage units, and angler interviews and angler counts as second stage units.

Angler Effort

Within each sampled day within each time of day stratum total angler effort (in angler-hours) and its variance was estimated as

$$\hat{E}_{hi} = \bar{x}_{hi} T_{hi} \tag{3}$$

$$\hat{V}\left[\hat{E}_{hi}\right] = \hat{V}\left[\bar{x}_{hi}\right] T_{hi}^2 \tag{4}$$

where $\hat{E}_{hi}$ is estimated fishing effort in angler-hours, $\bar{x}_{hi}$ is the mean number of anglers counted fishing, T_{hi} is the number of hours in each sampled day within a stratum (equal to eight hours for all strata), and $\hat{V}\left[\bar{x}_{hi}\right]$ is the estimated variance of $\bar{x}_{hi}$, obtained by using the successive difference formula appropriate for systematic samples (adapted from Wolter 1985, equation 7.2.4, page 251):

$$\hat{V}\left[\bar{x}_{hi}\right] \approx \frac{\sum_{k=2}^{r_{hi}} \left(x_{hik} - x_{hi(k-1)}\right)^2}{2\, r_{hi}(r_{hi} - 1)} \tag{5}$$

where x_{hik} is the angler count and r_{hi} is the number of angler counts per period. There is no exact estimator for the variance of the mean angler count when starting times for the counts are selected systematically. Wolter (1985) observed that approximation given by equation (5) was slightly conservative for data that follow a trend, which is generally the case for angler counts within a sampling period (i.e., the number of anglers fishing wax and wane in a trend).

Estimates of angler effort within each stratum were calculated by expanding over days:

$$\hat{E}_h = D_h \bar{E}_h \tag{6}$$

where:

$$\bar{E}_h = \frac{\sum_{i=1}^{d_h} \hat{E}_{hi}}{d_h} \tag{7}$$

The stratum estimate of angler effort variance was calculated as:

$$\hat{V}\left[\hat{E}_h\right] = \left(1 - f_{1h}\right) \frac{D_h^2}{d_h} \frac{\sum_{i=1}^{d_h} \left(\hat{E}_{hi} - \bar{E}_h\right)^2}{\left(d_h - 1\right)} + f_{1h} \frac{D_h^2}{d_h^2} \sum_{i=1}^{d_h} \hat{V}\left[\hat{E}_{hi}\right] \tag{8}$$

where f_{1h} is the first-stage sampling fraction (d_h/D_h).

The total angler effort (across all strata) and its variance is simply:

$$\hat{E} = \sum_{h=1}^{L} \hat{E}_h \tag{9}$$

$$\hat{V}\left[\hat{E}\right] = \sum_{h=1}^{L} \hat{V}\left[\hat{E}_h\right] \tag{10}$$

where L is the number of strata.

Harvest and Catch

Within each sampled day within a stratum estimates of mean chinook salmon harvest per unit effort were calculated using a jackknife procedure (Efron 1982) to reduce bias. Data from completed-trip interviews only were used in these calculations. First, the mean harvest of angler-trips was divided by the mean length of trip to estimate the sample ratio of HPUE:

$$\overline{HPUE}_{hi} = \frac{\bar{H}_{hi}}{\bar{e}_{hi}} = \frac{\sum_{l=1}^{m_{hi}} H_{hil} \Big/ m_{hi}}{\sum_{l=1}^{m_{hj}} e_{hil} \Big/ m_{hi}} = \frac{\sum_{l=1}^{m_{hi}} H_{hil}}{\sum_{l=1}^{m_{hi}} e_{hil}} \tag{11}$$

where H_{hil} was the harvest during an angler-trip l, e_{hil} is the effort expended (in hours) during angler-trip l, and m_{hi} is the number of completed angler-trip interviews within each sampled day for each stratum. Since the above estimate of mean HPUE has an inherent bias of order $1/m_{hi}$ (Cochran 1977), the jackknifed estimate of mean HPUE was calculated (Efron 1982):

$$\overline{HPUE}^{*}_{hi} = \frac{\sum_{m=1}^{m_{hi}} HPUE^{*}_{him}}{m_{hi}} \tag{12}$$

where:

$$HPUE^{*}_{him} = \frac{\sum_{\substack{l=1 \\ l \neq m}}^{m_{hi}} H_{hil}}{\sum_{\substack{l=1 \\ l \neq m}}^{m_{hi}} e_{hil}} \tag{13}$$

The jackknifed estimate was used to reduce the inherent bias to order $1/m_{hi}^2$ through the adjustment:

$$\overline{HPUE}^{**}_{hi} = m_{hi}\left[\overline{HPUE}_{hi} - \overline{HPUE}^{*}_{hi}\right] + \overline{HPUE}^{*}_{hi} \tag{14}$$

The variance of $\overline{HPUE}^{**}_{hi}$ is the variance of $\overline{HPUE}^{*}_{hi}$:

$$\hat{V}\left[\overline{HPUE}^{**}_{hi}\right] = \hat{V}\left[\overline{HPUE}^{*}_{hi}\right] = \frac{m_{hi}-1}{m_{hi}} \sum_{m=1}^{m_{hi}} \left[HPUE^{*}_{him} - \overline{HPUE}^{*}_{hi}\right]^2 \tag{15}$$

Mean catch per unit effort (CPUE) was estimated using equations (11)-(15), after first substituting catch C_{hil} for harvest H_{hil}.

Total number of chinook salmon harvested by anglers interviewed during each sampled day within each stratum was then estimated as the product of estimated effort and estimated mean HPUE:

$$\hat{H}_{hi} = \hat{E}_{hi}\,\overline{HPUE}^{**}_{hi} \tag{16}$$

and its variance follows Goodman (1960):

$$\hat{V}\left[\hat{H}_{hi}\right] = \hat{V}\left[\overline{HPUE}^{**}_{hi}\right]\hat{E}^2_{hi} + \hat{V}\left[\hat{E}_{hi}\right]\overline{HPUE}^{**2}_{hi} - \hat{V}\left[\overline{HPUE}^{**}_{hi}\right]\hat{V}\left[\hat{E}_{hi}\right] \quad (17)$$

The total number of chinook salmon harvested for each stratum was estimated by expanding over days:

$$\hat{H}_h = D_h \overline{H}_h \quad (18)$$

where:

$$\overline{H}_h = \frac{\sum_{i=1}^{d_h} \hat{H}_{hi}}{d_h} \quad (19)$$

Its variance was estimated as

$$\hat{V}\left[\hat{H}_h\right] = (1 - f_{1h})\frac{D_h^2}{d_h}\frac{\sum_{i=1}^{d_h}\left(\hat{H}_{hi} - \overline{H}_h\right)^2}{(d_h - 1)} + f_{1h}\frac{D_h^2}{d_h^2}\sum_{i=1}^{d_h}\hat{V}\left[\hat{H}_{hi}\right] \quad (20)$$

Total chinook salmon harvested during the fishery and its variance was estimated by summing over strata:

$$\hat{H} = \sum_{h=1}^{L} \hat{H}_h \quad (21)$$

$$\hat{V}\left[\hat{H}\right] = \sum_{h=1}^{L} \hat{V}\left[\hat{H}_h\right] \quad (22)$$

Catch statistics were estimated similarly, after substituting $\overline{CPUE}^{**}_{hi}$ for $\overline{HPUE}^{**}_{hi}$ in equations (16) through (22)).

Angler Demographics and Gear Type Usage

Estimates of the proportion of angler-trips by demographic or gear type categories were calculated as described above in the data analysis subsection of the Delta Clearwater Arctic grayling study (equations (1) and (2)).

Assumptions

The assumptions necessary for unbiased point and variance estimates of angler effort, catch, and harvest, obtained by the procedures outlined above included the following:

1. anglers interviewed are representative of the total angler population;
2. anglers accurately report their hours of fishing effort, the number of fish released; and,
3. the angler count process was approximately instantaneous, or the survey technician traveled substantially faster than anglers move about or exit or enter the fishery.

Similarly, unbiased point and variance estimates of angler demographics and gear type proportions depend upon the validity of the above assumptions as well as the following additional assumptions:

4. the creel clerk accurately classified anglers and the interviewed anglers accurately reported their demographic characteristics and the gear type used during the trip; and,
5. either the interview data is self-weighting, that is an equal proportion of the total angler-trips were sampled throughout the survey or the parameters of interest did not vary throughout the survey.

There are no direct ways of evaluating or testing the first assumption. Anglers are expected to have a fairly good recollection of the time spent fishing and the total number of fish caught. Numbers of fish harvested were directly observed and recorded by the creel clerk, and as such no similar assumption is listed for estimation of harvest. Similarly, anglers are expected to accurately report their demographic characteristics (assumption 4).

The angler count process was not instantaneous (one-half hour to conduct the count). However, the assumption that the creel technician will travel (and count) the fishery substantially faster than anglers move about the fishery is most likely valid.

The fifth assumption was determined to be valid by an analysis of similarly collected interviews during the 1990, 1991, 1992, and 1994 surveys of this fishery.

RESULTS

The 1995 creel survey began on 7 July and was terminated on 20 July. Sampling (counts and interviews) occurred on all scheduled sampling periods during this time. Interviews were obtained from a total sample of 750 anglers who had completed their fishing trip and were preparing to exit the Salcha River chinook salmon fishery. The majority of anglers interviewed at the Salcha River, were male (87%, SE = 1%), adult (90%, SE = 1%), and residents of the State of Alaska (78%, SE = 2%) (Table 4). Forty-seven percent (SE = 2%) of the anglers were military. Ninety-nine percent (SE = <0.5%) of all anglers interviewed used spinning gear.

A total of 11,395 (SE = 628) angler-hours were expended to catch an estimated 1,565 (SE = 175) chinook salmon of which 811 (SE = 72) were harvested (Table 5).

DISCUSSION

The 1995 fishing season was very similar to the prior two years (1993 and 1994) in that water levels in the Salcha River remained very low and clear. Chinook salmon abundance was again high enough that the minimum spawning escapement goal of 7,100 fish was achieved by 20 July. The fact that the spawning escapement objective had been met by 20 July, allowed for the continuation of the fishery even though harvest was approaching the upper end of the guideline harvest (300-700). If the escapement objective by 20 July had been in jeopardy of being met, restrictions to the fishery would have been implemented regardless of the level of harvest.

Table 4.-Estimates of various angler demographic categories and terminal gear used at the Salcha River chinook salmon fishery from 7 to 20 July 1995.

Category	Number Interviewed	Percentage	SE (%)
Male	653	87%	1%
Female	97	13%	1%
Youth	73	10%	1%
Adult	677	90%	1%
Resident	584	78%	2%
Non-resident	166	22%	2%
Military	349	47%	2%
Non-Military	401	53%	2%
Spinner	746	99%	<0.5%
Fly	4	1%	<0.5%

Table 5.-Estimates of angler effort for, catch of and harvest of chinook salmon at the Salcha River from 7 to 20 July 1995.

	Sampling Stratum			
	Early Day (0001-0800)	Mid-Day (0800-1600)	Late Day (1600-2400)	Total
Number of Days Sampled	5	10	7	
Number of Anglers Interviewed	122	203	425[a]	750
Effort Estimate (angler-hours)	2,554	2,841	6,000	11,395
SE	413	171	442	628
Catch Estimate	403	572	591	1,565
SE	109	66	120	175
Harvest Estimate	135	327	349	811
SE	39	35	50	72

[a] Three anglers interviewed on 16 July 1995 were not used to calculate catch and harvest estimates due to no reported angler effort.

The sampling design used in 1994 provided estimates of insufficient precision for angler effort, especially during the non peak, time-of-day strata. Angling effort during this period (0001-1600 h) of 7,984 angler-hours (SE = 3,634) was 12 % higher than for the peak hours (1600-2400 h) which was estimated at 7,048 angler-hours (Hallberg and Bingham 1995). The large standard error for the non-peak period of 3,634 angler-hours (CV >45%) indicates the estimate was not very precise. In 1995 a second creel technician was utilized which resulted in more angler counts during all time-of-day strata and an increase in angler interviews. This provided a much more precise estimate of angler effort (11,395 angler-hours, SE = 628, CV = 5.5%). It is recommended that two creel technicians be used in any future creel surveys of the Salcha River chinook salmon fishery.

It should be noted that the 1995 chinook salmon fishery at the Salcha River saw a marked increase in catch-and-release fishing as only 811 (52%) of the reported catch of 1,565 chinook salmon were harvested. During the 1994 fishery 774 chinook salmon (or 93%) were retained from a harvest of 832 fish (Hallberg and Bingham 1995).

In order to manage the Salcha River chinook salmon fishery inseason, managers will need timely, accurate information on which to base their decisions. Monitoring the sport fishery inseason and knowing the daily passage of salmon on to the spawning grounds are paramount in making these management decisions, and therefore should be continued.

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APPENDIX A

Appendix A1.-Angler interview, angler count, and biological data files developed for creel surveys in interior Alaska in 1995.

U0060IA5.DTA	Delta Clearwater River Arctic grayling fishery, creel survey angler interview data. Interviews with anglers who had completed there fishing trip and were exiting the Delta Clearwater River at the State of Alaska campground.
U0060LC5.DTA	Delta Clearwater River Arctic grayling tagging length data.
U0050IA5.DTA	Salcha River chinook salmon fishery, creel survey angler interview data. Interviews with anglers who had completed there fishing trip and were exiting the Salcha River .
U0050CA5.DTA	Salcha River chinook salmon fishery, creel survey angler count data.

APPENDIX B

Appendix B1.-Distribution of Arctic grayling catch and harvest among anglers interviewed at the Delta Clearwater River, 2 June through 30 July 1995.

	Catch Distribution			Harvest Distribution		
Number of Fish	n	Percent	SE (%)	n	Percent	SE (%)
0	310	61	2	356	71	2
1	77	15	2	46	9	2
2	36	7	1	46	9	1
3	28	6	1	22	4	1
4	21	4	1	15	3	1
5	3	1	<1	20	4	1
6	12	2	1	0		
7	6	1	<1	0		
8	5	1	<1	0		
9	2	<1	<1	0		
10 or more	5	1	<1	0		
Total	505	100%		505	100%	