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Surveys of the Chinook and Coho Salmon Sport Fisheries in the Nushagak and Mulchatna Rivers, Alaska, 1994

by

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and

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September 1995

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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by

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ABSTRACT

During the summer of 1994 fishery surveys were conducted on the chinook salmon *Oncorhynchus tshawytscha* and coho salmon *Oncorhynchus kisutch* sport fisheries that occur along portions of Alaska's Nushagak and Mulchatna rivers. The chinook salmon fishery surveys were conducted on the lower Nushagak River from 20 June through 16 July and from 24 June through 25 July in the middle section of the Mulchatna River. The coho salmon fishery survey on the lower Nushagak River began 29 July and was curtailed 8 August when the sport fishery was closed by emergency announcement. The closure of the sport fishery prevented any coho survey on the Mulchatna River.

Analyses were limited to the chinook salmon fisheries. In the lower Nushagak River, 1,325 anglers were interviewed; 93% of the angler trips caught one or more chinook salmon, and 67% of the trips resulted in harvests of one or more chinook salmon. Thirty-three percent, 27%, and 25% of the angler trips to the lower Nushagak River resulted in daily harvests of 0, 1, and 2 chinook salmon respectively. Over 77% of the lower Nushagak River anglers were guided, 88% were not residents of Alaska, and roughly 96% of the anglers used spin tackle or combined bait with spin tackle.

In the Mulchatna River, 728 anglers were interviewed; 56% of the angler trips caught one or more chinook salmon, and 44% of the trips resulted in harvests of one or more chinook salmon. Twenty percent of the angler trips took one chinook salmon, 9% took two fish, and nearly 15% harvested the full daily bag limit of three chinook salmon. Roughly 50% of the Mulchatna River anglers were guided, 98% were not residents of Alaska, and 49% of the anglers were not citizens of the United States. Anglers used spin tackle in 89% of the trips and fly fishing gear in 11% of the trips to the Mulchatna River fishery.

Results were compared to those from similar surveys conducted in 1991. Angling success appeared to be much better in 1994 in the lower Nushagak River, while gear restrictions along the middle section of the Mulchatna River appear to have reduced angler success there.

Key words: Chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, sport fishing, sport harvest, sport catch, creel survey, fishery survey, angler success, bag limit, guided anglers, unguided anglers, gear type, terminal tackle, Nushagak River, Mulchatna River, Bristol Bay.

INTRODUCTION

The Nushagak River drainage is located on the northern side of Bristol Bay (Figure 1). It is the largest producer of all species of Pacific salmon, except sockeye salmon, in Bristol Bay and supports several varieties of resident species as well. Three areas within the Nushagak River drainage are used extensively by anglers seeking chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch*. Historically, most of the sport effort for chinook salmon has occurred along a 20 km portion of the Nushagak River near the village of Portage Creek (Figure 1). The second major chinook salmon sport fishery occurs along the Mulchatna River from the mouth of the Stuyahok River upstream to the mouth of the Koktuli River (Figure 1). Since the late 1980s, a third chinook salmon sport fishery has slowly developed in the vicinity of the village of Ekwok. A creel survey conducted in 1991 indicated very low levels of recreational effort and harvest of chinook salmon in the Ekwok area and it was not surveyed 1994.

The Nushagak and Mulchatna rivers' chinook salmon stocks averaged 135,000 total return during the period 1966 to 1977 and during the next 6 years (1978 to 1983) returns averaged an unprecedented 293,500 fish (Table 1). Since 1985, returns have declined to normal levels of production, averaging approximately 125,000 fish. Chinook salmon stocks in the Nushagak/Mulchatna drainage are presently considered to be stable at normal levels. Before 1986 chinook salmon escapement into the Nushagak and Mulchatna rivers was estimated by aerial survey. Starting in 1987, side scan sonar was used to estimate the chinook salmon escapement. In the past

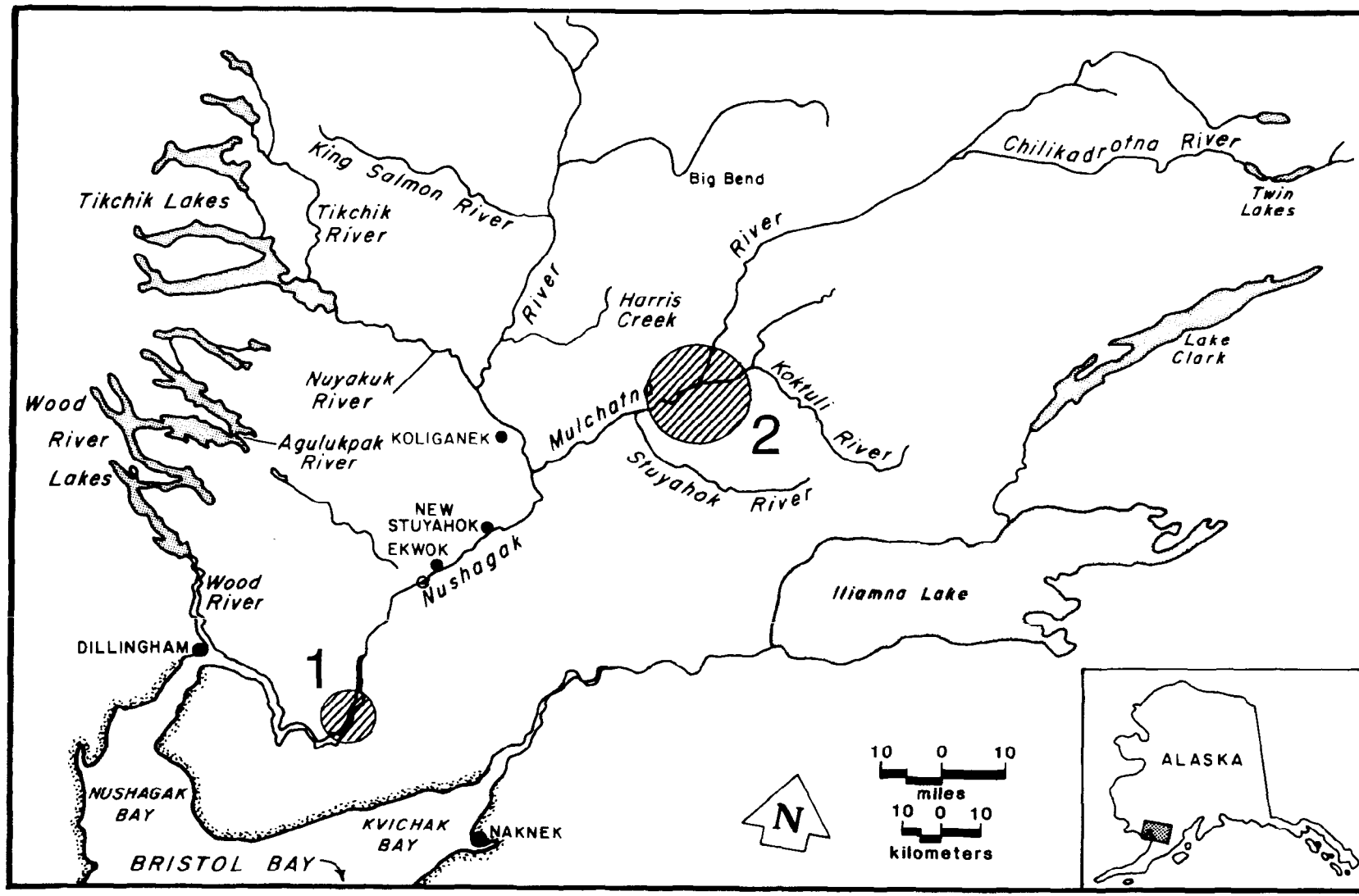

Figure 1.-Location of 1994 fisheries surveys: (1) lower Nushagak River, (2) Mulchatna River.

Table 1.-Chinook salmon commercial, subsistence, and sport harvest plus escapement for the Nushagak drainage, 1966-1994.

Year	Commercial Harvest [a]	Subsistence Harvest [a]	Sport Harvest [b] Nush	Mul	Total	Total Harvest	Escapement	Total Run
1966	58,184	3,700				61,884	40,000	101,884
1967	96,240	3,700				99,940	65,000	164,940
1968	78,201	6,600				84,801	70,000	154,801
1969	80,803	7,100				87,903	35,000	122,903
1970	87,547	6,300				93,847	50,000	143,847
1971	82,769	4,400				87,169	40,000	127,169
1972	46,045	4,000				50,045	25,000	75,045
1973	30,470	6,600				37,070	35,000	72,070
1974	32,053	7,900				39,953	70,000	109,953
1975	21,454	7,100				28,554	70,000	98,554
1976	60,684	6,900				67,584	100,000	167,584
1977	85,074	5,200	402	521	923	91,197	65,000	156,197
1978	118,548	6,600	151	291	442	125,590	130,000	255,590
1979	157,321	8,900	312	342	654	166,875	95,000	261,875
1980	64,958	11,800	611	146	757	77,515	141,000	218,515
1981	193,461	11,500	929	291	1,220	206,181	150,000	356,181
1982	195,287	12,100	1,436	367	1,803	209,190	147,000	356,190
1983	137,123	11,800	1,615	388	2,003	150,926	161,730	312,656
1984	61,378	9,800	1,534	786	2,320	73,498	80,940	154,438
1985	67,783	7,900	1,517	292	1,809	77,492	115,720	193,212
1986	65,783	12,600	1,780	3,534	5,314	83,697	43,434	127,131
1987	45,983	12,200	1,371	1,860	3,231	61,414	84,309	145,723
1988	16,648	10,079	2,383	403	2,786	29,513	56,905	86,418
1989	17,637	8,122	2,807	754	3,561	29,320	78,302	107,622
1990	14,812	12,407	1,594	1,409	3,003	30,222	63,955	94,177
1991	19,718	13,627	3,586	1,894	5,480	38,825	104,351	143,176
1992	47,897	13,588	3,688	889	4,577	66,062	82,848	148,910
1993	62,294	17,709	4,815	965	5,780	85,783	97,812	183,595
All Years Average	73,077	8,937	1,796	890	2,686	84,700	82,082	166,782
Percent	86%	11%			3%			
1989-93 5 Yr Avg	32,472	13,091	3,298	1,182	4,480	50,042	85,454	135,496
Percent	65%	26%			9%			
1994	118,643	14,868			6,000	139,511	95,954	235,465
Percent	85%	11%			4%			

[a] Commercial and subsistence harvest from Francisco et al. (1995). Commercial harvests from 1993-94 are preliminary. Subsistence harvest estimate for 1994 is preliminary.

[b] Sport harvest estimates from Mills (1979-1994). Sport harvest estimate for 1994 is preliminary.

5 years, escapements have averaged 85,454 chinook salmon (Table 1).

The historic harvest distribution among user groups of Nushagak drainage chinook salmon is: 86% by the commercial fishery, 11% were taken by subsistence fishermen, and 3% were taken by sport anglers. The recent 5-year average suggests a redistribution of the harvest has occurred, with subsistence fishermen taking 26% (an increase of 15%), and the sport harvest up 6% to a total of 9% (Table 1).

Sport anglers devote roughly 5,000 angler-days annually in the pursuit of chinook salmon on the Nushagak and Mulchatna rivers. Harvest of chinook salmon by the recreational fishery has averaged 2,686 fish since 1977, and for the period 1989 to 1993 averaged 4,480 fish (Table 1). The sport harvest was greater than 5,000 fish in 1986, 1991, and 1993, and approached 6,000 chinook salmon in 1994 (Table 1).

Since 1965, declines in stock abundance and increasing sport effort prompted restrictive actions on the inshore commercial and sport fisheries. More recently, the Alaska Board of Fisheries adopted the Nushagak and Mulchatna Chinook Salmon Management Plan (the Plan) in January 1992. Under the Plan, the department is to manage chinook salmon fisheries to attain an inriver abundance of 75,000 fish; providing 65,000 spawning fish, a 5,000 fish allocation to the sport fishery, and a reasonable opportunity to harvest chinook salmon in the inriver subsistence fishery. If the inriver abundance exceeds 75,000, but is less than 95,000, the Plan allows a sport harvest of 6,000 fish.

The Nushagak/Mulchatna drainage also produces the largest return of coho salmon in the Bristol Bay area. Within the drainage, four areas of concentrated recreational effort exist: the lower 20 km of the Nushagak River near the village of Portage Creek, the Nushagak River in the vicinity of the village of Ekwok, the Mulchatna River between the Stuyahok and Koktuli rivers, and at the confluence of the Nuyakuk and Nushagak rivers (Figure 1). The majority of recreational effort for coho salmon occurs in the fisheries near Portage Creek, and the mid-Mulchatna River.

From 1984 to 1992 Nushagak coho salmon stocks were managed to achieve a biological escapement goal (BEG) of 150,000 fish, estimated by sonar at Portage Creek. Escapements during that period fell short of the goal, averaging 93,000 coho salmon from 1984 to 1991 (Table 2). The sonar counter did not run long enough in August to provide an estimate of escapement in 1992. Recent spawner-recruit analysis suggests the 150,000 fish goal was too high to produce maximum sustained yield and in 1992 the department lowered the BEG to 90,000 spawners (ADF&G 1992). To achieve 90,000 spawners necessitates managing the commercial fishery to achieve an inriver abundance of 100,000 fish. The additional 10,000 coho salmon are provided for subsistence and sport harvests above the sonar site at Portage Creek.

Recreational angling effort on the Nushagak/Mulchatna drainage coho salmon approaches 4,000 angler-days annually. The annual sport harvest of coho salmon in the Nushagak/Mulchatna drainage has never exceeded 2,000 fish, and has averaged 825 fish since 1989 (Minard and Dunaway 1995) (Table 2). The total annual harvest of Nushagak/Mulchatna drainage coho salmon since 1989 is split between commercial (82%), subsistence (16%), and sport fishermen (2%) (Table 2). The only shift in the distribution of the harvest since 1971 is a growing subsistence component. At present levels, the coho salmon sport fishery has a negligible impact on the overall productivity of Nushagak and Mulchatna drainage coho

Table 2.-Coho salmon commercial, subsistence, and sport harvest plus escapement for the Nushagak drainage, 1971 to 1994.

Year	Commercial Harvest [a]	Subsistence Harvest [a]	Sport Harvest [b] Nush	Mul	Total	Total Harvest	Escapement [c]	Total Run
1971	8,036	2,300				10,336		
1972	3,654	1,000				4,654		
1973	28,709	2,200				30,909		
1974	12,569	4,700				17,269		
1975	7,342	4,300				11,642		
1976	6,778	2,100				8,878		
1977	52,562	4,500	65	90	155	57,217		
1978	44,740	2,500	126	113	239	47,479		
1979	129,607	5,200	212	0	212	135,019		
1980	147,726	5,100	379	129	508	153,334	232,000	385,334
1981	220,290	8,700	216	173	389	229,379		229,379
1982	349,669	8,900	451	52	503	359,072	234,000	593,072
1983	81,338	5,200	849	524	1,373	87,911	51,000	138,911
1984	260,310	8,100	399	37	436	268,846	171,000	439,846
1985	20,230	6,100	0	130	130	26,460	89,500	115,960
1986	68,568	9,400	934	496	1,430	79,398	42,772	122,170
1987	13,263	6,200	595	0	595	20,058	20,220	40,278
1988	52,698	5,223	124	371	495	58,416	131,101	189,517
1989	77,077	8,679	1,586	364	1,950	87,706	84,707	172,413
1990	7,733	5,919	331	95	426	14,078	162,853	176,931
1991	5,399	10,784	415	437	852	17,035	39,595	56,630
1992	84,898	7,103	445	275	720	92,721		
1993	14,244	5,038	124	53	177	19,459	42,742	62,201
All Years								
Average	73,802	5,619	427	196	623	80,044	108,458	188,502
Percent	92%	7%			1%			
1989-93								
5-Yr Avg	37,870	7,505	580	245	825	46,200	82,474	128,674
Percent	82%	16%			2%			
1994	6,814	5,093			200	12,107	82,019	94,126
Percent	56%	42%			2%			

[a] Commercial and subsistence harvests from Francisco et al. (1995). Commercial harvests from 1993-94 are preliminary. Subsistence harvest estimate for 1994 is preliminary.

[b] Sport harvest estimates from Mills (1979-1994). Sport harvest estimate for 1994 is preliminary.

[c] Escapement is estimated by sonar at Portage Creek.

stocks. However, the general growth of sport fishing in the Bristol Bay region, a desire by commercial fishermen to more fully exploit the coho salmon run, and the poor coho salmon returns from 1991 through 1993, have generated a demand for a management plan for Nushagak River drainage coho salmon.

Surveys of the recreational fisheries for Nushagak/Mulchatna drainage chinook and coho salmon were conducted in 1994 to provide current information for evaluating the regulations and management of these stocks. The two main issues are: (1) The sport harvest of chinook salmon is approaching the upper limits permitted in the Nushagak Chinook Salmon Management Plan. (2) In 1992 the Alaska Board of Fisheries directed the Nushagak Advisory Committee to develop a management plan for the coho salmon stocks of the Nushagak/Mulchatna drainage.

Data on the sport fisheries in the Nushagak River drainage include the results of the ADF&G Statewide Harvest Survey (Mills 1979-1994), four onsite creel surveys conducted in 1985, 1986, 1987, and 1991 (Minard and Morstad 1985, Minard 1987, Minard and Brookover 1988, Dunaway and Bingham 1992), and a report to the Board of Fisheries on the stock status of Nushagak River coho salmon (ADF&G 1992). In addition to the results of the Statewide Harvest Survey (Mills 1979-1994), information on the Mulchatna River sport fishery is limited to the results of three onsite creel surveys conducted in 1986, 1990, and 1991 (Lipchak *Unpublished*, Dunaway et al. 1991, and Dunaway and Bingham 1992). The 1986 creel survey was very brief, leaving the 1990 and 1991 surveys as the only intensive work to be done on the middle Mulchatna River sport fishery. Information on the salmon escapements into the Nushagak River drainage is collected annually by the ADF&G Commercial Fisheries Management and Development Division (CFMD) and published annually in their Regional Information Report (RIR) series. Data on subsistence harvests in the area are collected by the ADF&G Subsistence Division and reported in the CFMD RIR series.

STUDY OBJECTIVES

Objectives for the 1994 surveys of the recreational chinook and coho salmon fisheries in the lower Nushagak River and middle portion of the Mulchatna River were to:

1. estimate the distribution of catch and harvest success among chinook and coho salmon anglers by angler-day,
2. estimate the contributions to the total harvest by each fish in anglers' daily bags during the chinook and coho salmon sport fisheries,[1]
3. estimate the percentage of angler-trips by terminal tackle type (flies, bait, or lures) and angler type (residency, guided, unguided, chartered or unchartered, and outfitted or not outfitted) in the chinook and coho salmon sport fisheries,
4. estimate the age and sex composition of chinook and coho salmon harvested by the sport fisheries, and
5. estimate the mean length-at-age and weight-at-age of chinook and coho salmon harvested by the sport fishery.

[1] The contributions to the total harvest of each fish in anglers' daily bags is defined as the percentage of total harvest due to the successive fish in the anglers' daily bag. For example the proportion of harvest due to the first fish in all anglers' daily bag is one such percentage.

METHODS

STUDY LOCATIONS AND DATES

The surveys of the lower Nushagak River chinook and coho salmon sport fisheries were conducted along the Nushagak River from Black Point upstream approximately 20 km (12.5 mi) to points roughly 4.8 km (3 mi) above the village of Portage Creek on both major channels of the river (Figure 1). Occasional excursions were made beyond the survey area to confirm that the boundaries included the area of significant angling effort. The Lower Nushagak River chinook salmon survey commenced on 20 June and ended 15 July; the coho salmon survey was conducted from 29 July through 8 August 1994.

The second fishery survey was conducted along a 24 km (15 mi) portion of the Mulchatna River from 3 km (2 mi) below the mouth of the Stuyahok River, upstream to the mouth of the Koktuli River. As with the lower Nushagak River survey, the creel clerks occasionally ventured outside the survey boundaries to determine whether significant effort was being excluded. The 1994 Mulchatna River chinook salmon survey began 24 June and ended on 25 July when the fishery closed by regulation. The Mulchatna River coho salmon survey began 7 August and only ran for 2 days when extremely low coho salmon escapements observed at the Portage Creek sonar site precipitated a total closure of the sport fishery. The survey had been scheduled to operate until 25 August.

STUDY DESIGN AND DATA COLLECTION

Angler Interviews

Bernard et al. (*In prep*) reported that fishery attributes such as composition of the harvest and distribution of catch and harvest can be estimated without stratification, stratum weights, stages, or sample weights if the sampling is self-weighting. Self-weighting, in this case, implies that sampling is conducted such that an equal fraction of the anglers are interviewed on a given sample day and an equal fraction will be interviewed throughout the fishing season.

Self-weighted roving surveys conducted on a systematic sampling schedule formed the basis of the surveys. During the study period at each site, survey technicians worked 5-day weeks (Friday-Tuesday), spending 7 hours per day (from approximately 1000 hours to 1700 hours) interviewing sport anglers and sampling harvested chinook and coho salmon. One survey technician (assisted for 2 weeks in July by a volunteer) was assigned to the lower Nushagak River surveys and two technicians conducted the Mulchatna River survey. On each sampling day the survey technicians would make up to three passes through the fishery in order to contact every angler fishing in the survey site during the 7-hour sampling period.

The schedule for collecting interviews and samples was selected to correspond to the peaks of the sport fisheries for chinook or coho salmon as determined by angler counts recorded at each site during previous surveys (Minard and Brookover 1988, Dunaway et al. 1991, Dunaway and Bingham 1992) Further, the crew leaders were allowed to select a different 7-hour sample period if necessary based on onsite observations of the fishery. However, when selecting or altering the 7-hour portion of the day to sample and the daily sampling schedule, the crew leader was instructed to be aware that the most important criteria for these surveys was to assure that a consistent proportion of all angler-trips were sampled within each day, within each week, and within the season.

Anglers encountered in the fishery were asked the number and species of fish they had kept and released during that day. At the same time, the anglers were asked if they were

guided or unguided, whether they chartered an air taxi to get to the fishing area, whether they had rented any equipment for their trip, and what type of terminal tackle they used. Anglers were also requested to provide some general demographic information. Both completed-trip angler interviews (anglers who have suspended fishing for the day) and incompleted-trip interviews were conducted by the technicians as they passed through the fishery.

To augment the number of completed-trip interviews, all incompleted-trip anglers encountered were asked to provide their completed-trip information on a voluntary angler report card (Figure 2). Card collection boxes were placed at popular locations throughout the fishery and in each guide camp. In the lower Nushagak River survey, cards given to local residents were stamped and addressed to encourage anglers' responses.

Biological Sampling of Harvested Fish

Sport-harvested chinook and coho salmon encountered during the angler interview portion of the survey were measured to the nearest millimeter for mid-eye to fork-of-tail length, and the sex was identified from external characteristics. Chinook salmon were weighed to the nearest 0.25 kilogram and coho salmon were weighed to the nearest 10 grams.

For each salmon sampled, three or four scales were collected and placed on labeled and numbered adhesive coated cards (scale cards). The scales were removed from the left side of the fish, at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, two rows above the lateral line (Welander 1940, Scarnecchia 1979). When the scales could not be obtained from the preferred area, three scales were taken from as close to the preferred area as possible. However, scales were only taken from the area bounded dorsally by the fourth row of scales above the lateral line, ventrally by the lateral line, and between lines drawn vertically from the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. When no scales were available in the preferred area on the left side of the fish, scales were collected from the preferred area on the right side of the fish.

The completed scale cards were pressed against acetate cards in a heated hydraulic press and the resulting scale impressions displayed on a microfiche projector for age determination. Age determination from the collected scales followed the same procedure used by Lux (1971) for pacific salmon and Clutter and Whitesel (1956) for sockeye salmon. Salmon ages are expressed using the European method. The numeral preceding the decimal is the number of freshwater annuli, the numeral following the decimal is the number of marine annuli. Total age from brood year is the sum of the two numerals plus one.

Data Analysis

Combining Data from Interviews and Cards

Analysis of angler success required data from completed fishing trips. Completed-trip data were available from two sources: (1) anglers who had completed their fishing prior to being interviewed on site, and (2) anglers who were issued voluntary report cards and returned them. We conducted a series of statistical tests in order to determine if and how data from the two sources could be validly pooled to estimate angler success parameters (Appendix A). In summary, these tests found that angler success differed between onsite completed-trip interviews and returned cards, and that the proportion of cards returned declined over the course of the season. Therefore, to estimate angler success and

ALASKA DEPT. FISH & GAME

PLEASE WRITE THE NUMBER OF FISH YOU KEPT AND RELEASED TODAY (00:00 AM TO 23:59 PM).

Time you began fishing _____ Time you quit _____

	Kept	Released	office use
			Date _____
King Salmon	_____	_____	
			Page #_____
Coho Salmon	_____	_____	
			Line #_____
Rainbow Trout	_____	_____	Initials_____

OTHER SPECIES, COMMENTS

Figure 2.-The voluntary angler report card.

harvest analysis parameters, data from returned cards were weighted to reflect the number of cards issued (rather than the number of cards returned), before being combined with onsite interview data. Since card return rate (and therefore the appropriate weighting factor) changed with time, this procedure was carried out by week (Appendix A).

Angler Success

In order to characterize the success of anglers in both fisheries, we estimated the proportion of anglers catching 0, 1 or more, 2 or more, 3 or more, etc., chinook salmon at each location. We also estimated the proportion of anglers harvesting 0, 1 or more, 2 or more, and 3 or more chinook, etc. Procedures from Appendix A were used with data from completed-trips only to estimate these proportions and their standard errors.

Harvest Analysis

In order to assess the possible effects of a changing bag limit on the fishery, it was useful to estimate the proportion of the total harvest contributed by the first fish in anglers' daily bags, the second fish in anglers' daily

bags, etc. Procedures from Appendix A were used with data from completed-trips only to estimate these proportions and their standard errors.

Angler Characteristics

Information on angler characteristics (guided vs. chartered vs. outfitted, use of lures vs. flies) was obtained from anglers in person during onsite interviews. Therefore data from all interviews could be used regardless of whether anglers had completed their fishing trip. Given the self-weighted nature of the survey design, proportions of angler-trips[2] in the above categories were estimated as if the interview information was collected as a simple random sample of the fishery. That is, the estimated proportion of angler-trips with characteristic k was calculated as

$$\hat{p}_k = \frac{m_k}{m}, \qquad (1)$$

where m_k equals the number of angler-trips having characteristic k, and m equals the total number of angler-trips.

The variance of the estimate of p_k followed Cochran (1977:52),

$$\hat{Var}(\hat{p}_k) = \frac{\hat{p}_k(1-\hat{p}_k)}{m-1}. \qquad (2)$$

Standard errors were obtained by taking the square root of the variance estimates.

Age by Sex Composition of the Harvest

Age composition (overall and by sex) were estimated for each fishery. Each proportion and its variance were calculated according to equations 1 and 2, above. In applying equations 1 and 2, the individual age by sex categories defined the "k" categories, and the numbers of fish sampled were used in lieu of the number of angler-trips.

[2] Since each interview represented information collected from one angler during one trip to the surveyed fishery, the proportions estimated by equation (1) are for angler-trips, not anglers.

Mean Length-at-Age and Weight-at-Age

Estimates of mean (and associated standard error) length and weight by age group of chinook and coho salmon sampled from the sport harvest were calculated following Sokal and Rohlf (1981:56, 139).

Assumptions

The degree to which the above parameter estimates were unbiased depends on the following untested assumptions.

1. The number of angler interviews conducted onsite represent a consistent proportion of all angler-trips throughout the progress of each fishery.
2. The number of harvested fish by species sampled represent a consistent proportion of all fish harvested throughout the progress of each fishery or the true values of the parameters to be estimated do not vary during the progression of the fishery (e.g., mean length-at-age is constant throughout the season).
3. Anglers accurately report the number of fish by species released.
4. Anglers who return report cards accurately report their harvest of fish by species.
5. The success of completed-trip anglers who responded by card is the same as for completed-trip anglers whose information was collected in an onsite interview.
6. The success of anglers who were issued a card but did not return it is the same as for anglers who were issued a card and did return it.

Regarding assumptions 1 and 2, systematic sampling of the fishery should have resulted in a consistent proportion of angler-trips interviewed. The technicians onsite were instructed to periodically evaluate their ability to interview all anglers fishing during the daily 7-hour sampling periods. Technicians

attempted to take measurements on every contacted angler's creel in order to sample a consistent proportion of the harvest. Regarding assumptions 3 and 4, anglers were expected to have a good recollection of the number of fish caught and harvested by species (at least for the two species of concern). Note that anglers interviewed onsite had their creel inspected by the survey technicians, and therefore there is no need to assume that the numbers of fish harvested by species for onsite interviews would be incorrect. Assumptions 5 and 6 are addressed in Appendix A.

RESULTS

CHINOOK SALMON FISHERIES

Angler Success

Lower Nushagak River

During the survey on the lower Nushagak River, 1,325 angler interviews were conducted. Only 243 anglers (18%) were interviewed after they had completed their fishing for the day (onsite completed-trip interviews) while the remaining 1,082 anglers were issued voluntary angling report cards. Of the cards issued, 465 or about 43% were properly completed and returned (card completed-trip interviews) to provide a total of 708 completed-trip interviews for the analysis of angler success (Table 3).

Chinook salmon fishing was quite good during the study period with only 6.7% (SE = 1.0%) of the pooled interviews indicating a catch of no fish while 93.3% (SE = 1.0%) of the anglers caught at least one fish (Table 4, Figure 3). Substantial numbers of anglers caught 5 or more salmon (51.3%, SE = 2.0%) and even 12 or more fish in a day (14.2%, SE = 1.4%) (Table 4, Figure 3). Though catch success was very good, 32.7% (SE = 1.9%) of the interview pool kept no fish. An estimated 67.3% (SE = 1.9%) of the anglers kept 1 or more fish, 40.4% (SE = 1.9%) took 2 or more, and 15.2% (SE = 1.4%) of the anglers took the full bag limit of 3 fish (Table 4, Figure 3).

Mulchatna River

On the Mulchatna River fishery survey, the technicians conducted 728 interviews including 82 onsite interviews. Of the 646 voluntary report cards issued, 359 or nearly 56% were correctly completed and returned providing a total of 441 completed-trip interviews for angler success estimates (Table 5).

Chinook salmon fishing success was substantially lower at the Mulchatna River site than at the lower Nushagak River site. Among the pooled interviews, 43.9% (SE = 2.4%) recorded catching no chinook salmon, 56.1% (SE = 2.4%) recorded catching one or more chinook salmon, and very few anglers (2.3%, SE = 0.8%) reported catching 12 or more fish (Table 6, Figure 4). More angler trips resulted in harvesting zero fish (55.6%, SE = 2.3%) than in the Lower Nushagak River fishery and fewer trips resulted in the harvest of one or more fish (44.4%, SE = 2.3%), or two or more fish (24.3%, SE = 2.1%) per day at the Mulchatna River site than in the lower Nushagak River (Tables 4 and 6, Figures 3 and 4). Angler trips taking the daily bag limit of three chinook salmon were very close to 15% at both sites (Lower Nushagak SE = 1.4%, Mulchatna SE = 1.7%) (Tables 4 and 6, Figures 3 and 4).

Harvest Analysis

The percentages of the total harvest represented by the first, second or third fish kept among all anglers were much the same in both fisheries. The first fish taken accounted for 52.3% to 54.1% of the harvest, the second fish contributed nearly 28.6% to 32.5%, and the third fish contributed 13.4% to 19.1% (Tables 7 and 8, Figures 5 and 6).

Table 3.-Summary of completed-trip angler interviews, by type, collected from the lower Nushagak River chinook salmon sport fishery, 20 June through 15 July 1994.

		Interview			Chinook Salmon			
Date	Week	Number	Type[a]	Hours Fished	Caught[b]	Catch /Hour	Kept	Released
6/20/94	25	4	ONSITE	28.92	29	1.00	9	20
6/20/94	25	27	CARD	182.24	85	0.47	25	60
6/21/94	25	14	ONSITE	70.48	27	0.38	16	11
6/21/94	25	17	CARD	125.76	144	1.15	16	128
6/24/94	25	16	ONSITE	80.72	80	0.99	18	62
6/24/94	25	31	CARD	254.91	348	1.37	24	324
6/25/94	26	12	ONSITE	47.72	44	0.92	22	22
6/25/94	26	34	CARD	234.09	289	1.23	56	233
6/26/94	26	35	ONSITE	243.18	185	0.76	59	126
6/26/94	26	27	CARD	222.11	206	0.93	31	175
6/27/94	26	34	ONSITE	250.3	181	0.72	41	140
6/27/94	26	50	CARD	392.76	360	0.92	68	292
6/28/94	26	19	ONSITE	106.19	87	0.82	32	55
6/28/94	26	46	CARD	347.33	267	0.77	62	205
7/1/94	26	4	ONSITE	17.16	5	0.29	5	0
7/1/94	26	25	CARD	114.15	138	1.21	28	110
7/2/94	27	5	ONSITE	15.66	14	0.89	2	12
7/2/94	27	44	CARD	259.38	256	0.99	45	211
7/3/94	27	34	ONSITE	212.6	176	0.83	64	112
7/3/94	27	37	CARD	192.84	198	1.03	49	149
7/4/94	27	10	ONSITE	52.89	26	0.49	17	9
7/4/94	27	25	CARD	184.24	163	0.88	24	139
7/5/94	27	20	ONSITE	123.33	138	1.12	29	109
7/5/94	27	31	CARD	219.68	172	0.78	21	151
7/8/94	27	4	ONSITE	22.17	12	0.54	3	9
7/8/94	27	16	CARD	111.84	77	0.69	22	55
7/9/94	28	11	CARD	75.74	29	0.38	4	25
7/10/94	28	19	ONSITE	112.48	64	0.57	36	28
7/10/94	28	16	CARD	124.73	145	1.16	22	123
7/11/94	28	8	CARD	55	59	1.07	22	37
7/12/94	28	7	ONSITE	38.42	8	0.21	7	1
7/12/94	28	7	CARD	37.33	16	0.43	5	11
7/13/94	28	6	ONSITE	46.02	11	0.24	8	3
7/13/94	28	11	CARD	53.91	27	0.50	16	11
7/15/94	28	2	CARD	11.33	40	3.53	8	32
	Total	243	ONSITE	1468.24	1087	0.74	368	719
	Total	465	CARD	3199.37	3019	0.94	548	2471
Overall Total		708	ALL	4667.61	4,106	0.88	916	3,190

[a] Type = ONSITE interviews were collected from anglers who had completed their daily fishing before being interviewed. CARD interviews are the result of incomplete interviews later completed with data from returned voluntary angler report cards.

[b] Catch = fish kept + fish released.

Table 4.-Distribution of angler catch and harvest success during the chinook salmon sport fishery on the lower Nushagak River, 20 June through 15 July 1994.

CHINOOK SALMON CATCH

Number of Fish	Number of Interviews: Cards Returned	Weighted Cards	Completed Onsite	Pooled	Percent of Trips	Standard Error (%)	90% Confidence Interval: Lower	Upper
0	30	71.6	18	89.6	6.7	1.0	5.1	8.3
1+	435	1010.4	225	1235.4	93.3	1.0	91.7	94.9
2+	382	886.9	192	1078.9	81.4	1.5	78.9	83.9
3+	341	790.5	155	945.5	71.3	1.8	68.3	74.3
4+	291	673.5	123	796.5	60.0	1.9	56.9	63.1
5+	252	580.3	101	681.3	51.3	2.0	48.0	54.6
6+	218	501.4	73	574.4	43.3	2.0	40.0	46.6
7+	186	425.5	51	476.5	35.9	2.0	32.6	39.2
8+	160	365.0	39	404.0	30.4	1.9	27.3	33.5
9+	132	301.5	33	334.5	25.2	1.8	22.2	28.2
10+	112	255.7	25	280.7	21.1	1.7	18.3	23.9
11+	90	204.3	21	225.3	17.0	1.5	14.5	19.5
12+	77	175.5	12	187.5	14.2	1.4	11.9	16.5
13+	59	134.5	7	141.5	10.7	1.3	8.6	12.8
14+	51	116.5	5	121.5	9.2	1.2	7.2	11.2
15+	45	103.1	4	107.1	8.1	1.1	6.3	9.9
16+	37	84.9	4	88.9	6.8	1.0	5.2	8.4
17+	31	71.7	3	74.7	5.7	0.9	4.2	7.2
18+	23	54.2	2	56.2	4.3	0.9	2.8	5.8
19+	17	40.2	2	42.2	3.1	0.8	1.8	4.4
20+	15	35.9	2	37.9	2.8	0.7	1.6	4.0

CHINOOK SALMON HARVEST

Number of Fish	Number of Interviews: Cards Returned	Weighted Cards	Completed Onsite	Pooled	Percent of Trips	Standard Error (%)	90% Confidence Interval: Lower	Upper
0	167	384.9	48	432.9	32.7	1.9	29.6	35.8
1+	298	697.1	195	892.1	67.3	1.9	64.2	70.4
2+	176	411.9	124	535.9	40.4	1.9	37.3	43.5
3+	66	152.6	49	201.6	15.2	1.4	12.9	17.5

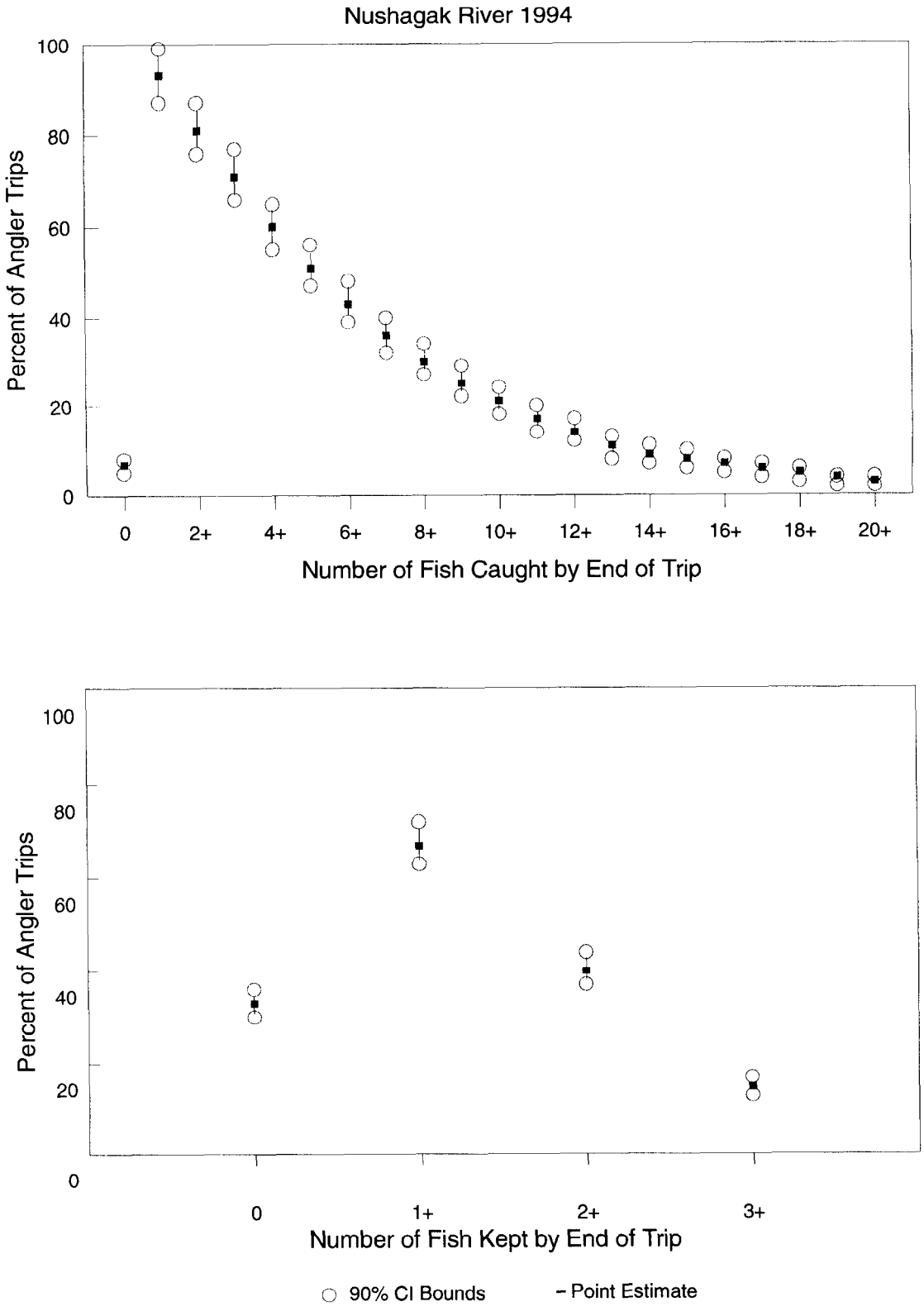

Figure 3.-Distribution of catch and harvest success in the lower Nushagak River chinook salmon sport fishery, 20 June through 15 July 1994.

Table 5.-Summary of completed-trip angler interviews, by type, collected from the Mulchatna River chinook salmon sport fishery, 25 June through 25 July 1994.

		Interview		Hours	Chinook Salmon			Rainbow Trout		
Date	Week	Number	Type[a]	Fished	Caught[b]	Catch/hour	Kept	Caught[b]	Catch/hour	Kept
6/25/94	26	3	CARD	29.60	0	0	0	0	0	0
6/26/94	26	3	ONSITE	20.25	0	0.00	0	0	0.00	0
6/26/94	26	5	CARD	24.51	2	0.08	2	0	0.00	0
6/27/94	26	5	ONSITE	8.75	0	0.00	0	0	0.00	0
6/28/94	26	2	ONSITE	11.5	4	0.35	4	0	0.00	0
6/28/94	26	19	CARD	134.51	21	0.16	12	26	0.19	2
7/1/94	26	2	ONSITE	11.5	10	0.87	6	0	0.00	0
7/1/94	27	21	CARD	183.79	39	0.21	20	14	0.08	2
7/2/94	27	33	CARD	253.18	91	0.36	37	14	0.06	0
7/3/94	27	29	CARD	167.66	76	0.45	48	20	0.12	2
7/4/94	27	10	ONSITE	53.5	41	0.77	15	2	0.04	0
7/4/94	27	28	CARD	206.23	79	0.38	32	10	0.05	0
7/5/94	27	13	ONSITE	73.02	17	0.23	14	3	0.04	0
7/5/94	27	24	CARD	173.41	67	0.39	31	4	0.02	1
7/8/94	27	25	CARD	159.93	75	0.47	11	13	0.08	0
7/9/94	28	6	ONSITE	27	19	0.70	6	0	0.00	0
7/9/94	28	13	CARD	53.33	46	0.86	15	2	0.04	0
7/10/94	28	14	ONSITE	72.66	12	0.17	6	0	0.00	0
7/10/94	28	14	CARD	102.34	98	0.96	30	9	0.09	1
7/11/94	28	1	ONSITE	1	0	0.00	0	0	0.00	0
7/11/94	28	11	CARD	39.25	17	0.43	11	2	0.05	0
7/12/94	28	4	ONSITE	23.34	16	0.69	7	2	0.09	0
7/12/94	28	34	CARD	235	24	0.10	14	10	0.04	0
7/15/94	28	5	ONSITE	15.25	0	0.00	0	0	0.00	0
7/15/94	28	33	CARD	251.97	33	0.13	15	20	0.08	7
7/16/94	29	11	ONSITE	16.5	0	0.00	0	2	0.12	1
7/16/94	29	14	CARD	105.5	53	0.50	12	3	0.03	0
7/17/94	29	16	CARD	130.33	58	0.45	19	16	0.12	5
7/18/94	29	3	ONSITE	6	0	0.00	0	0	0.00	0
7/18/94	29	15	CARD	80.39	50	0.62	7	9	0.11	1
7/19/94	29	11	CARD	68.56	3	0.04	0	4	0.06	0
7/22/94	29	2	ONSITE	0.5	1	2.00	0	0	0.00	0
7/22/94	29	2	CARD	4.92	1	0.20	0	0	0.00	0
7/23/94	30	3	CARD	4.92	1	0.20	0	0	0.00	0
7/24/94	30	1	ONSITE	1.5	0	0.00	0	0	0.00	0
7/24/94	30	3	CARD	29.13	3	0.10	0	0	0.00	0
7/25/94	30	3	CARD	10.5	1	0.10	0	0	0.00	0
Total		82	ONSITE	342.27	120	0.35	58	9	0.03	1
Total		359	CARD	2448.96	838	0.34	316	176	0.07	21
OVERALL		441	ALL	2791.23	958	0.34	373	185	0.07	22

[a] Type = ONSITE interviews were collected from anglers who had completed their daily fishing before being interviewed. CARD interviews are the result of incomplete interviews later completed with data from returned voluntary angler report cards.

[b] Catch = fish kept + fish released.

Table 6.-Distribution of angler catch and harvest success during the chinook salmon sport fishery on the Mulchatna River, 25 June through 25 July 1994.

CHINOOK SALMON CATCH

Number of Fish	Number of Interviews: Cards Returned	Weighted Cards	Completed Onsite	Pooled	Percent of Trips	Standard Error (%)	90% Confidence Interval: Lower	Upper
0	149	268.8	51	319.8	43.9	2.4	40.0	47.8
1+	210	374.4	31	405.4	56.1	2.4	52.2	60.0
2+	149	266.8	22	288.8	39.8	2.3	36.0	43.6
3+	110	196.5	19	215.5	29.6	2.2	26.0	33.2
4+	83	150.0	12	162.0	22.3	2.0	19.0	25.6
5+	70	127.3	10	137.3	18.9	1.9	15.8	22.0
6+	51	93.1	9	102.1	14.0	1.6	11.4	16.6
7+	43	79.0	6	85.0	11.6	1.5	9.1	14.1
8+	33	60.5	5	65.5	9.0	1.4	6.7	11.3
9+	22	40.3	4	44.3	6.1	1.2	4.1	8.1
10+	16	29.1	2	31.1	4.3	1.0	2.7	5.9
11+	12	22.1	0	22.1	3.0	0.9	1.5	4.5
12+	9	16.5	0	16.5	2.3	0.8	1.0	3.6
13+	7	13.3	0	13.3	1.8	0.7	0.6	3.0
14+	6	11.5	0	11.5	1.6	0.7	0.4	2.8
15+	4	7.4	0	7.4	1.0	0.5	0.2	1.8

CHINOOK SALMON HARVEST

Number of Fish	Number of Interviews: Cards Returned	Weighted Cards	Completed Onsite	Pooled	Percent of Trips	Standard Error (%)	90% Confidence Interval: Lower	Upper
0	191	348.2	56	404.2	55.6	2.3	51.8	59.4
1+	168	296.8	26	322.8	44.4	2.3	40.6	48.2
2+	90	159.6	17	176.6	24.3	2.1	20.8	27.8
3+	53	94.5	14	108.5	14.9	1.7	12.1	17.7

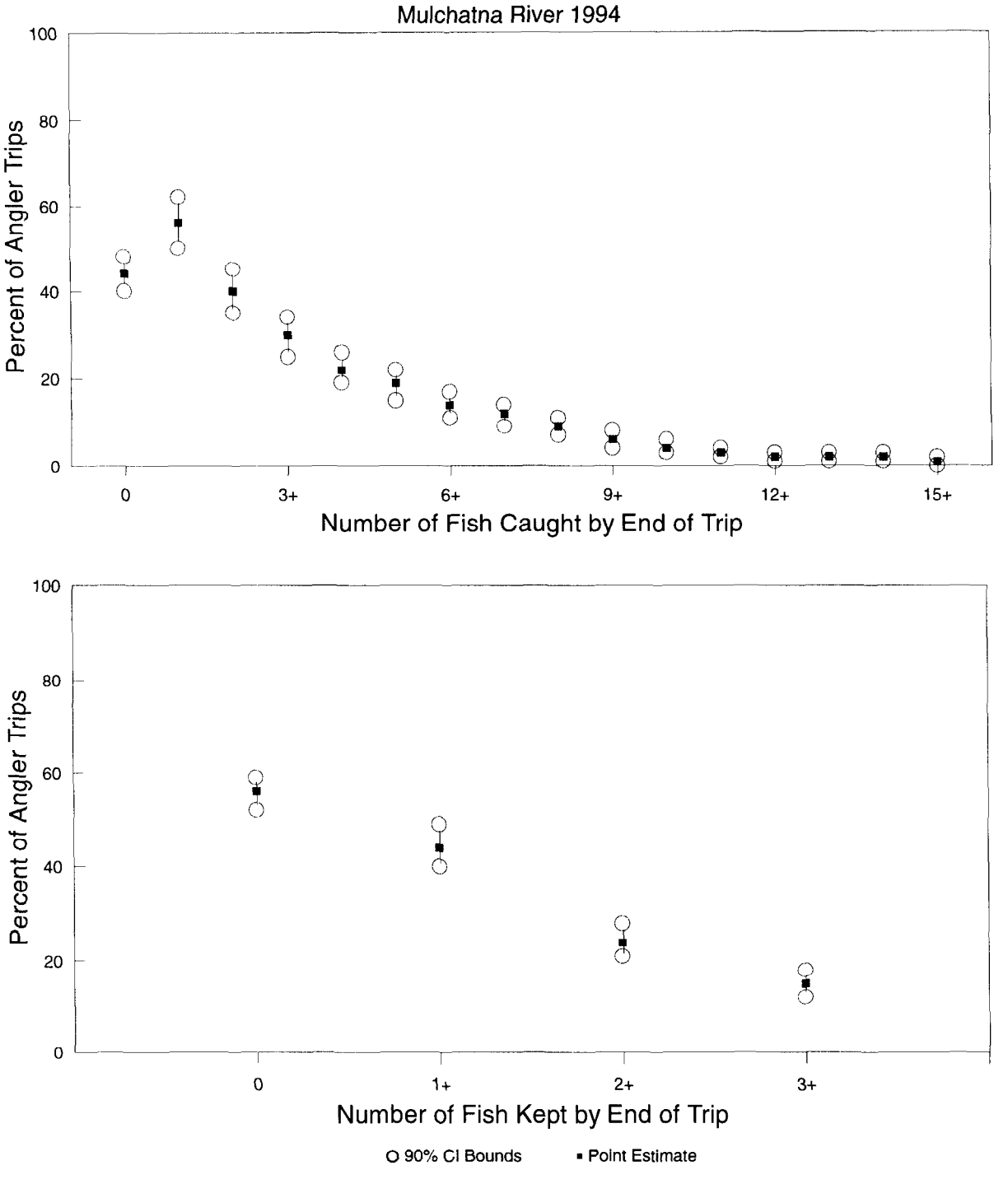

Figure 4.-Distribution of catch and harvest success in the Mulchatna River chinook salmon sport fishery 25 June through 25 July 1994.

Table 7.-Percent of angler trips by number of fish kept and percent of harvest by sequence of fish harvested in the chinook salmon sport fishery on the lower Nushagak River, 20 June through 15 July 1994.

Fish Kept	Angler Trips (Pooled)	Percent of Trips	SE (%)	90% Confidence Interval Lower	Upper	Sequence of Fish Harvested	Contribution to Total Harvest Fish	Percent	SE
0	432.9	32.7	1.9	29.6 -	35.8				
1	356.2	26.9	1.8	23.9 -	29.2	1 st	891	54.1	0.011
2	334.3	25.2	1.7	22.4 -	28.0	2 nd	536	32.5	0.008
3+	201.6	15.2	1.3	12.4 -	18.0	3 rd +	222	13.4	0.009
Total	1,325.0						1,649		

Table 8.-Percent of angler trips by number of fish kept and percent of harvest by sequence of fish harvested in the chinook salmon sport fishery on the Mulchatna River, 25 June through 25 July 1994.

Fish Kept	Angler Trips (Pooled)	Percent of Trips	SE (%)	90% Confidence Interval Lower	Upper	Sequence of Fish Harvested	Contribution to Total Harvest Fish	Percent	SE
0	404.2	55.6	2.2	52.0 -	59.2				
1	146.2	20.1	1.9	17.0 -	23.2	1 st	323	52.3	0.018
2	68.1	9.4	1.4	7.1 -	11.7	2 nd	176	28.6	0.011
3+	108.5	14.9	1.7	12.1 -	17.7	3 rd +	118	19.1	0.014
Total	727.0						617		

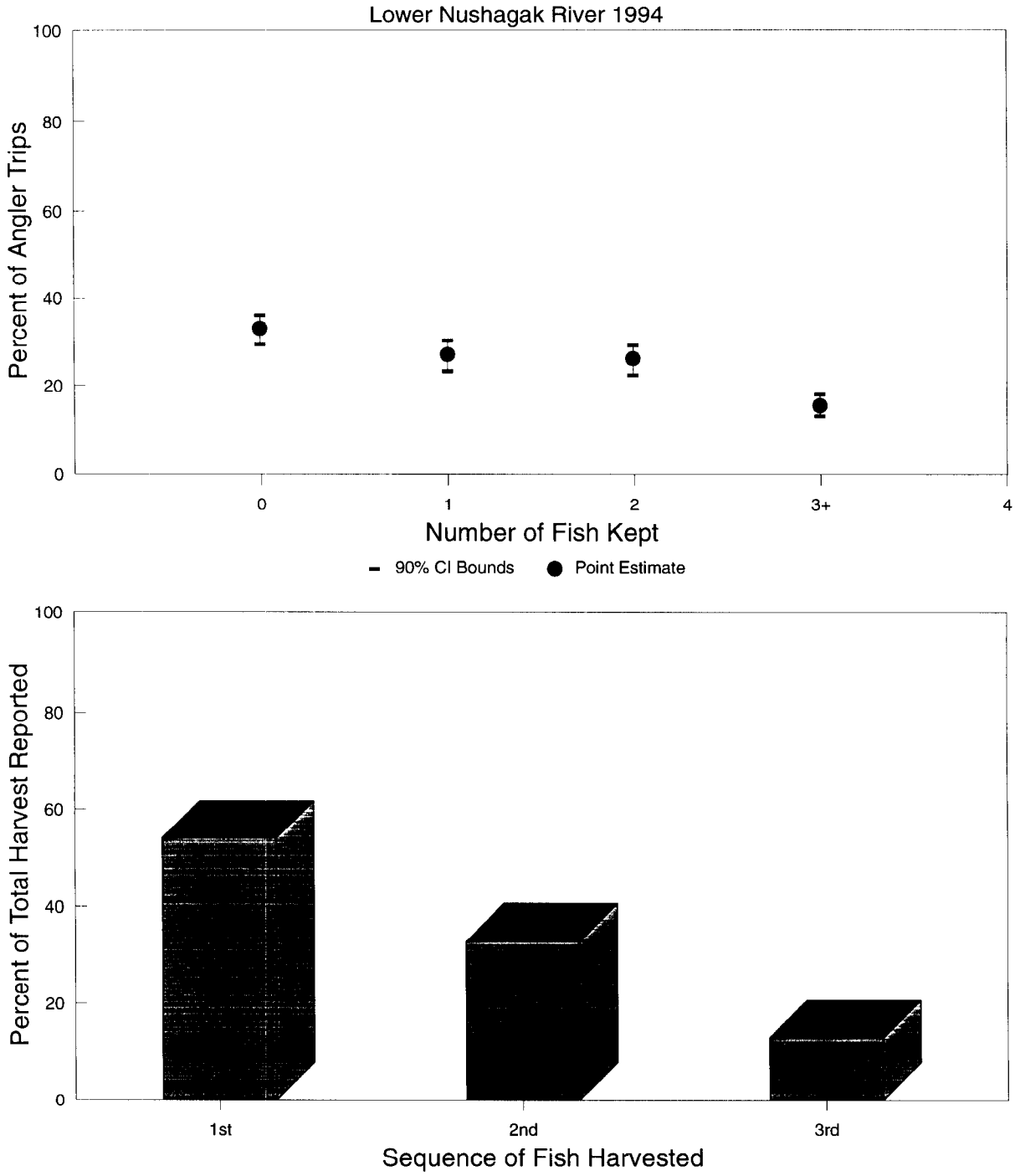

Figure 5.-Percent of angler trips by number of fish kept and percent of total harvest represented by the first, second or third fish taken among all anglers in the lower Nushagak River chinook salmon fishery, 20 June through 15 July 1994.

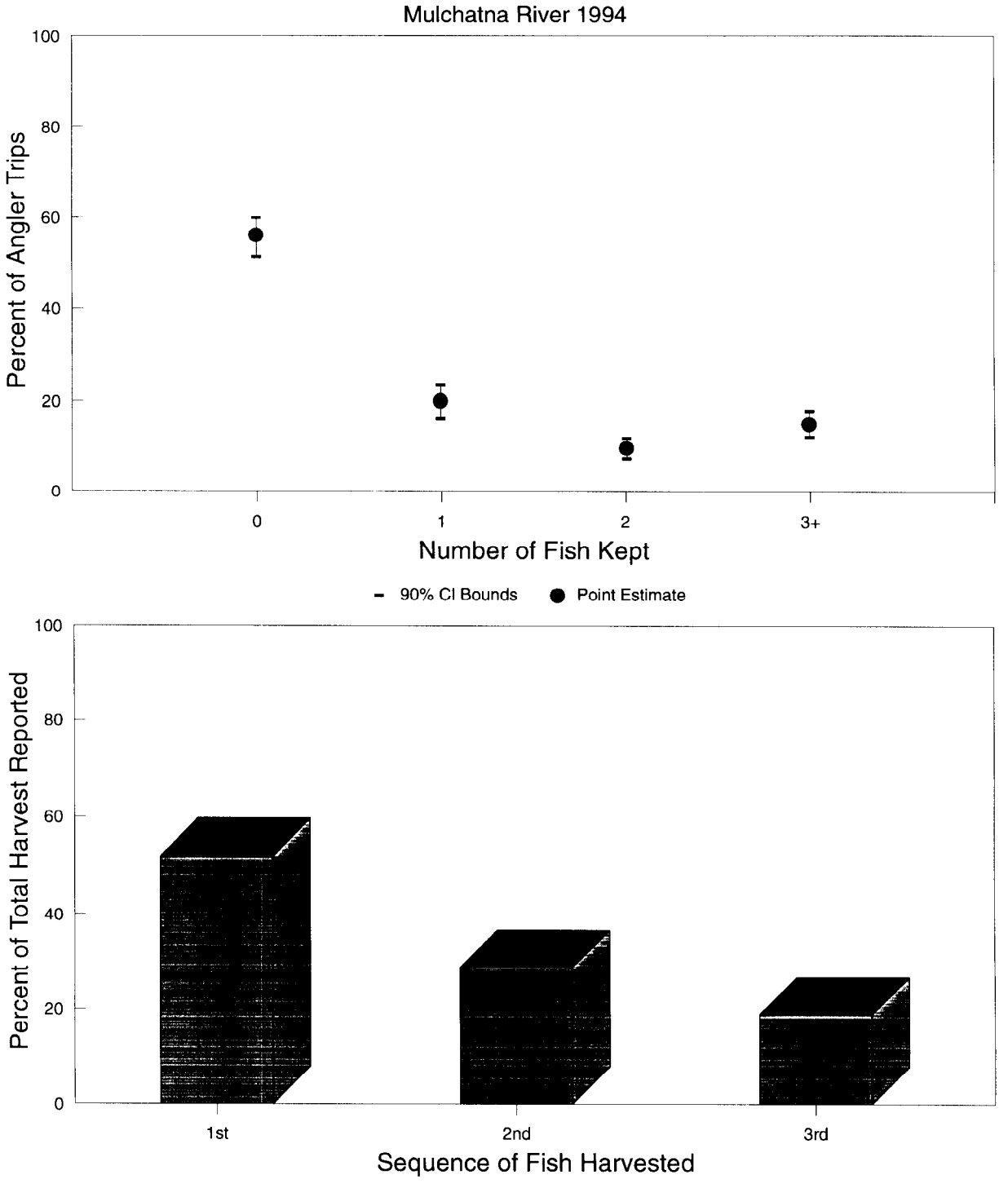

Figure 6.-Percent of angler trips by number of fish kept and percent of total harvest represented by the first, second or third fish taken among all anglers in the Mulchatna River chinook salmon fishery, 25 June through 25 July 1994.

Percentages of Angler Trips by Angler Type and Gear Type

Lower Nushagak River

Of the 1,325 interviews conducted in the lower Nushagak River study, 77.4% (SE = 1.1%) of the anglers were guided, 88% (SE = 0.9%) were not Alaska Residents and 7.4% (SE = 0.7%) were residents of another country (Table 9). Guided anglers were defined as having all the benefits of a full service guide: food and lodging, air and boat field transportation, with all fishing equipment provided.

Among the 22.5% (SE = 1.1%) unguided anglers, subcategories of anglers were identified (Table 9). Outfitted anglers rented some or all major equipment to conduct the trip such as camping, boating, or fishing gear. Chartered, unguided anglers used the services of an air taxi or boat operator for transportation to their fishing site.

The majority of lower Nushagak River anglers used spinning gear (40.9%, SE = 1.4%) or a combination of spinning gear with bait (55.2%, SE = 1.4%) (Table 9).

Mulchatna River

Nearly equal portions of the 728 anglers interviewed along the Mulchatna River were guided or unguided (48.2% guided, SE = 1.9%; 51.6% unguided, SE = 1.9%) (Table 10). Only 17 anglers or 2.3% (SE = 0.6%) were Alaskan residents and none of those were from nearby communities (Table 10). Nearly half (49.2%, SE = 1.9%) of the anglers were visitors from countries other than the United States (Table 10). Despite the large contingent of unguided, non-Alaskan resident anglers, only 16.3% (SE = 1.4%) reported using outfitting services and 18.1% (SE = 1.4%) chartered an air taxi or boat to get to this remote fishing area.

The regulation that limits anglers to single-hook artificial lures is reflected in the narrow selection of only spinning gear (89.1%, SE = 1.2%) or fly fishing gear (10.7%, SE = 1.1%) in the Mulchatna River study site (Table 10).

Age, Length At Age, and Sex Composition of the Sport Harvest

Lower Nushagak River

While collecting angler interviews, the survey technicians also obtained samples from 231 chinook salmon harvested in the lower Nushagak River sport fishery (Table 11). The chinook salmon sport fishery harvested mainly age 1.2 (12.0%, SE = 2.22), age 1.3 (31.0%, SE = 3.15), and age 1.4 (52.8%, 3.40) fish (Table 11). Males composed 63.0% (SE = 3.29) of the harvest while 34.3% (SE = 3.24) were females. The overall average length was 772 mm (30 in) (SE = 10.63), and the mean weight was 8.9 kg (19.6 lb) (SE = 0.3). The longest fish measured was 1,003 mm (39.5 in) and weighed 15.3 kg (33.7 lb), while the heaviest fish was 994 mm (39.1 in) in length and weighed 18.5 kg (40.7 lb).

Mulchatna River

Two hundred seventy-two chinook salmon were sampled in the Mulchatna River chinook salmon fishery (Table 12). Nearly 22% (SE = 2.64) were age 1.2, 46.6% (SE = 3.18) were age 1.3, and 25.1% (SE = 2.76) were age 1.4 (Table 12). Males made up nearly 78.9% (SE = 2.60) of the harvest and females constituted 21.1% (SE = 2.60) of the fish kept. The mean length of the sampled harvest was 698 mm (27 in) (SE = 8.83) and the mean weight was 6.2 kg (13.6 lb) (SE = 0.2) (Table 12). The biggest fish measured during the survey period was 900 mm (35.4 in) in length and weighed 17.5 kg (38.5 lb).

Coho Salmon Fisheries

Lower Nushagak River

The survey of the lower Nushagak River coho salmon sport fishery began as scheduled on 29 July. However, escapement of coho salmon as indicated by the department's sonar counter was very poor. Angling success was very

Table 9.-Number and percent of angler-trips by gear type and angler type during the lower Nushagak River chinook salmon sport fishery, 20 June through 15 July 1994.

Characteristic	Angler Trips	Percent	SE (%)
ANGLER TYPE			
Guided (assumes all services provided)	1,026	77.4	1.1
Unguided (all)	298	22.5	1.1
Unguided, Outfitted	77	5.8	0.6
Unguided Chartered (boat or air taxi)	21	1.6	0.3
Alaskan Residents	158	11.9	0.9
Local Alaska Residents	77	5.8	0.6
Nonlocal Alaska Residents	81	6.1	0.7
Non Alaskan Residents	1,167	88.0	0.9
U. S. Residents	1,043	92.6	0.7
Non- U. S. Residents	83	7.4	0.7
TACKLE TYPE			
Spin	542	40.9	1.4
Spin and Bait	732	55.2	1.4
Spin and Fly	9	6.8	0.7
Spin, Fly, and Bait	12	9.0	0.8
Bait	1	0.1	0.8
Fly	19	14.3	1.0
TOTAL ANGLER TRIPS	1,325		

Table 10.-Number and percent of angler-trips by gear type and angler type during the Mulchatna River chinook salmon sport fishery, 25 June through 25 July 1994.

Characteristic	Angler Trips	Percent	SE (%)
ANGLER TYPE			
Guided (assumes all services provided)	351	48.2	1.9
Unguided (all)	376	51.6	1.9
Unguided, Outfitted	119	16.3	1.4
Unguided Chartered (boat or air taxi)	132	18.1	1.4
Alaskan Residents	17	2.3	0.5
Local Alaska Residents	0	0	0
Nonlocal Alaska Residents	17	2.3	0.6
Non Alaskan Residents	711	97.7	0.6
U. S. Residents	351	48.2	1.9
Non- U. S. Residents	358	49.2	1.9
TACKLE TYPE			
Spin	649	89.1	1.2
Fly	78	10.7	1.1
TOTAL ANGLER TRIPS	728		

Table 11.-Mean lengths (mm) and weights (kg) of chinook salmon, by sex and age group, from samples collected from the sport harvest on the lower Nushagak River, 20 June to 16 July 1994.

	Age Group					
	UNKNOWN	1.2	1.3	1.4	1.5	TOTAL
Sex Unknown						
Percent			0.5	2.3		2.8
SE			0.46	1.03		1.12
Sample Size			1	5		6
Mean Length	578			852		806
SE				38.67		55.55
Sample Size	1		0	5		6
Mean Weight	3.2			10.6		9.4
SE				1.4		1.7
Sample Size	1		0	5		6
Females						
Percent		0.5	6.5	26.9	0.5	34.3
SE		0.46	1.68	3.02	0.46	3.24
Sample Size		1	14	58	1	74
Mean Length	865	590	753	865	903	843
SE	13.66		25.28	7.48		8.90
Sample Size	8	1	14	58	1	82
Mean Weight	11.3	3.2	7.6	11.1	12.8	10.4
SE	0.5		0.6	0.3		0.3
Sample Size	8	1	14	58	1	82
Males						
Percent		11.6	24.1	23.6	3.7	63.0
SE		2.18	2.92	2.90	1.29	3.29
Sample Size		25	52	51	8	136
Mean Length	691	484	682	874	921	729
SE	75.86	16.95	17.94	12.54	12.26	15.20
Sample Size	8	25	52	51	8	144
Mean Weight	7.5	2.6	6.2	11.8	12.9	8.0
SE	2.1	0.5	0.5	0.5	0.6	0.4
Sample Size	8	25	52	51	7	143
All Samples						
Percent		12.0	31.0	52.8	4.2	100
SE		2.22	3.15	3.40	1.36	
Sample Size		26	67	114	9	216
Mean Length	766	488	697	869	919	772
SE	42.48	16.78	15.46	6.94	11.00	10.63
Sample Size	17	26	66	114	9	232
Mean Weight	9.0	2.6	6.5	11.4	12.8	8.9
SE	1.1	0.5	0.4	0.3	0.5	0.3
Sample Size	17	26	66	114	8	231

Table 12.-Mean lengths (mm) and weights (kg) of chinook salmon, by sex and age group, from samples collected from the sport harvest on the Mulchatna River, 25 June to 25 July 1994.

	Age Group						
	UNKNOWN	1.1	1.2	1.3	1.4	1.5	TOTAL
FEMALES							
Percent			0.8	5.3	14.6	0.4	21.1
SE			0.57	1.42	2.25	0.40	2.60
Sample Size			2	13	36	1	52
Mean Length	854		700	802	868	923	847
SE	35.70		57.00	29.51	8.25		10.44
Sample Size	4		2	13	36	1	56
Mean Weight	10.2		5.4	8.1	10.7	13.5	9.9
SE	1.0		0.4	0.9	0.3		0.4
Sample Size	4		2	13	36	1	56
MALES							
Percent		4.5	21.1	41.3	10.5	1.6	78.9
SE		1.32	2.60	3.14	1.96	0.80	2.60
Sample Size		11	52	102	26	4	195
Mean Length	624	390	552	698	830	906	660
SE	26.49	8.85	6.65	8.34	13.01	55.96	9.12
Sample Size	21	11	52	102	26	4	216
Mean Weight	4.2	1.1	2.8	5.7	9.9	12.6	5.2
SE	0.6	0.1	0.1	0.2	0.6	2.3	0.2
Sample Size	21	11	52	102	26	4	216
ALL SAMPLES							
Percent		4.5	21.9	46.6	25.1	2.0	100
SE		1.32	2.64	3.18	2.76	0.90	
Sample Size		11	54	115	62	5	247
Mean Length	661	390	558	710	852	909	698
SE	28.48	8.85	7.62	8.62	7.59	43.48	8.83
Sample Size	25	11	54	115	62	5	272
Mean Weight	5.2	1.1	2.8	6.0	10.3	12.8	6.2
SE	0.7	0.1	0.1	0.2	0.3	1.8	0.2
Sample Size	25	11	54	115	62	5	272

poor as well, and few anglers came to fish. The escapement level became so alarmingly low that the sport fishery was closed 8 August and the survey was terminated. By 12 August the coho salmon escapement had improved to levels sufficient to reopen the sport fishery albeit with a 2 fish per day bag limit. The dismantled survey was not resumed.

For the abbreviated survey at the lower Nushagak River coho salmon fishery a total of 66 anglers were interviewed. Thirty-two of the interviews were completed-trip interviews, 29 through voluntary report cards and 3 onsite (Table 13). The small number of interviews did not warrant a full analysis and can be summarized briefly. Anglers reported

Table 13.-Summary of angler interviews, by type, collected from the lower Nushagak River coho salmon sport fishery, 29 July through 8 August 1994.

		Interview		Hours	Coho Salmon			
Date	Week	Number	Type[a]	Fished	Caught[b]	Catch/hour	Kept	Released
7/29/94	30	10	CARD	51.42	27	0.53	15	12
7/30/94	31	2	CARD	16.5	2	0.12	2	0
7/31/94	31	5	CARD	34.17	7	0.20	6	1
8/1/94	31	2	CARD	6	0	0.00	0	0
8/2/94	31	2	CARD	13	13	1.00	7	6
8/6/94	32	3	ONSITE	6.99	0	0.00	0	0
8/7/94	32	1	CARD	1.75	0	0.00	0	0
8/8/94	32	7	CARD	22.75	14	0.62	7	7
Total		3	ONSITE	6.99	0	0.00	0	0
Total		29	CARD	145.59	63	0.43	37	26
Overall Total		32	ALL	152.58	63	0.41	37	26

[a] Type = ONSITE interviews were collected from anglers who had completed their daily fishing before being interviewed. CARD interviews are the result of incomplete interviews later completed with data from returned voluntary angler report cards.

[b] Catch = fish kept + fish released.

catching 63 coho salmon and harvesting 37 (Table 13). Sixty-two of the anglers were guided, non-Alaskan residents. Spin tackle was the choice of 53 anglers while 11 anglers used fly fishing gear.

Mulchatna River

The Mulchatna River coho salmon survey had just been set up when the closure of the sport fishery was announced. The survey was canceled for the season. No anglers were interviewed.

Computer programs and data files used for this report are in Appendix B1.

DISCUSSION

The 1994 chinook salmon fisheries on the Nushagak and Mulchatna rivers were quite good. The escapement was estimated by the department sonar counter to be 95,954 fish; 20,000 more fish than the 75,000 inriver escapement goal of the Nushagak and Mulchatna Chinook Salmon Management Plan. Chinook salmon angling success in the lower Nushagak River appears to have been much better in 1994 compared to 1991 when a similar survey found 40% (SE = 7.4) of the angler trips catching no fish and 60% (SE = 5.0) of the trips producing catches of one or more salmon (Dunaway and Bingham 1992, p. 17). Trips resulting in harvests also differed between the two surveys with nearly 64% (SE = 7.3) of the 1991 trips taking no chinook salmon versus the 33% of 1994 (Table 4) (Dunaway and Bingham 1992, p. 17). The percentage of anglers ending their angling day with a given harvest varied somewhat between the two surveys: in 1991

56% took 0, 20% took 1, 16% took 2, and 8% took 3 chinook salmon (Dunaway and Bingham 1992, p. 23). Not surprisingly, the contributions to the total harvest of the first, second, or third fish among all anglers' bags were similar for both surveys. The fishery continues to have a very high component of guided anglers and spin tackle retains a level of popularity similar to 1991. When making comparisons between the 1991 and 1994 surveys, one should bear in mind that the 1991 survey was 17 days long (21 June through 7 July), and may have missed an important portion of the 1991 fishery. The 1994 survey sought to encompass more of the fishing season and to be less vulnerable to run timing variation and consequent shifts in the fishery's peak.

Comparisons between the 1991 and 1994 Mulchatna River chinook salmon fisheries are less clear because the 1991 study split the fishery into two parts. Each part was surveyed with a different technique and the results were not combined. As with the 1991 lower Nushagak River survey, the 1991 Mulchatna River surveys only ran from 1 June through 15 July. However being much closer to the spawning areas, the Mulchatna River fishery may be less affected by run timing than the lower Nushagak River. Another problem obscuring the 1994 results for the Mulchatna survey site was the difficulty the numerous foreign anglers may have had understanding and completing the volunteer report cards. Although most were very eager to participate, their cards were often difficult to interpret. Still, comparisons between the 1991 and 1994 Mulchatna River surveys is worthwhile, since the Alaska Board of Fisheries restricted gear in the study area to single-hook artificial lures in January 1992.

It appears that the percent of Mulchatna River angler trips with no fish caught increased from 1991 (5%, SE = 3.9 and 29%, SE = 2.7) to 44% (SE = 2.4) in 1994 (Table 6) (Dunaway and Bingham 1992, pp. 19, 21). Trips with catches of chinook salmon showed changes proportional to the observations of zero catch from the two studies. The change could be an artifact of the new gear restrictions for the site but this is only speculation, as no comparable information was collected in 1991. In addition, there may have been more unguided foreign anglers in the area in 1994. A technician who participated in both studies remarked that there seemed to be more foreign anglers in 1994 and that the new gear restrictions seemed to especially hamper their ability to catch fish.

Angler trips where harvests occurred are not as obviously different from 1991 to 1994. In fact, the 1994 distribution of harvest success for 0, 1+, and 2+ fish is quite similar to that observed in 1991 in sublocation 001 (within 100 meters of the mouth of the Stuyahok River) (Dunaway and Bingham 1992). The two surveys diverge at the 3+ fish category with 14.9% of the 1994 angler trips recorded versus only 1.7% (SE = 1.3) of the 1991 sublocation 001 angler trips (Dunaway and Bingham 1992, p. 19). Comparing the 1994 distribution of harvest success to 1991 at site 002 indicates a distinctly higher percentage of 1991 anglers harvesting chinook salmon (0 fish, 21.8%, SE = 7.9; 1+ fish, 78.2%, SE = 9.8; 2+ fish 52.8%, SE = 9.5) except in the 3+ fish category (20%, SE = 5.4). Whether the 1994 survey, by including both 1991 sites in a single study essentially "averaged" the results from the 1991 sites is unclear, but remains a possibility.

The percentage of angler trips resulting in a total daily bag of a given number of fish may be slightly different from 1991 to 1994 at sublocation 001 (0 fish 60%, 1 fish 23%, 2 fish 15%, 3 fish 2%) and very much different from sublocation 002 (0 fish, 14%, 1 fish

28%, 2 fish 32%, 3 fish 26%) (Dunaway and Bingham 1992, pp. 25, 26). As with the distributions of angling success comparisons, the significance, if any, of the differences is unclear. It is possible that the changes are a result of changing angler habits.

The nearly 52% unguided anglers contacted during the 1994 survey of the Mulchatna River may reflect the establishment in the area of several semi-permanent tent camps belonging to European fishing clubs. The camps provide lodging and gear to their visitors but no official guides.

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LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). 1992. Review of the Nushagak watershed coho salmon fisheries and stock status. Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries Central Region. Regional Information Report No. 1D91-10. Anchorage.

Bernard, D. R., A. E. Bingham, and M. Alexandersdottir. *In prep.* The mechanics of conducting onsite creel surveys in Alaska. Alaska Department of Fish and Game, Special Publication, Anchorage.

Clutter, R. I. and L. E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin IX of the International Pacific Salmon Fisheries Commission, New Westminster, British Columbia, Canada.

Cochran, W. G. 1977. Sampling techniques, third edition. John Wiley and Sons, New York.

Dunaway, D. O. and A. E. Bingham. 1992. Creel surveys on the chinook salmon sport fishery on the lower Nushagak River and mid-Mulchatna River, Alaska, 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-16, Anchorage.

Dunaway, D. O., A. E. Bingham, and R. E. Minard. 1991. Effort, catch, and harvest statistics for the chinook salmon sport fishery in the middle Mulchatna River, Alaska, during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-40, Anchorage.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Society of Industrial and Applied Mathematics, Philadelphia.

Francisco, R. K., C. Anderson, C. Burkey Jr., M. Fogarty, D. B. Molyneaux, C. Utermole, and K. Vaught. 1995. Annual management report for the subsistence and commercial fisheries of the Kuskokwim area, 1994. Alaska Department of Fish and Game, CFMD, Regional Information Report No. 3A95-15, Anchorage.

Lipchak, R. *Unpublished.* Middle Mulchatna River creel and public use surveys, 1986. Alaska Department of Fish and Game, Sport Fish Division files, Dillingham. Information from this study may be available from the Bristol Bay Coastal Resource Service Area office in Dillingham.

Lux, F. E. 1971. Age determination of fishes (revised). National Marine Fisheries Service. Fishery Leaflet 637. Seattle, Washington.

Mills, M. J. 1979. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1978-1979, Project F-9-11, 20 (SW-1), Juneau.

Mills, M. J. 1980. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1979-1980, Project F-9-12, 21 (SW-1), Juneau.

LITERATURE CITED (Continued)

Mills, M. J. 1981*a*. Alaska statewide sport fish harvest studies (1979). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A), Juneau.

Mills, M. J. 1981*b*. Alaska statewide sport fish harvest studies (1980). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22 (SW-I-A), Juneau.

Mills, M. J. 1982. Alaska statewide sport fish harvest studies (1981). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23 (SW-1), Juneau.

Mills, M. J. 1983. Alaska statewide sport fish harvest studies (1982). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24 (SW-1), Juneau.

Mills, M. J. 1984. Alaska statewide sport fish harvest studies (1983). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984. Project F-9-16, 25 (SW-1-A), Juneau.

Mills, M. J. 1985. Alaska statewide sport fish harvest studies (1984). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, 26 (SW-1-A), Juneau.

Mills, M. J. 1986. Alaska statewide sport fish harvest studies (1985). Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1985-1986, Project F-10-1, 27 (RT-2), Juneau.

Mills, M. J. 1987. Alaska statewide sport fisheries harvest report 1986. Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau.

Mills, M. J. 1988. Alaska statewide sport fisheries harvest report 1987. Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau.

Mills, M. J. 1989. Alaska statewide sport fisheries harvest report 1988. Alaska Department of Fish and Game, Fishery Data Series No. 122, Juneau.

Mills, M. J. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage.

Mills, M. J. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage.

Mills, M. J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage.

Mills, M. J. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage.

Mills, M. J. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Minard, R. E. 1987. Effort and catch statistics for the chinook salmon (*O. tshawytscha*) sport fishery in the lower Nashagak [sic] River, Alaska during 1986. Alaska Department of Fish and Game. Fishery Data Series No. 15, Juneau.

Minard, R. E. and T. E. Brookover, III. 1988. Effort and catch statistics for the sport fishery for chinook salmon in the lower Nushagak River, 1987. Alaska Department of Fish and Game, Fishery Data Series No. 43, Juneau.

Minard, R. E. and D. O. Dunaway. 1995. 1994 area management report for the recreational fisheries of the Southwest Alaska sport fish management area. Alaska Department of Fish and Game, Fishery Management Report No. 95-2, Anchorage.

Minard, R. E. and S. P. Morstad. 1985. Nushagak River chinook salmon (*O. tshawytscha*) sport fish monitoring program, 1982 and 1984. Alaska Department of Fish and Game, Bristol Bay Data Report No. 85-7, Juneau.

Scarnecchia, D. L. 1979. Variation of scale characteristics of coho salmon with sampling location on the body. Progressive Fish Culturist 41(3):132-135.

Sokal, R. R. and F. J. Rohlf. 1981. Biometry, second edition. W. H. Freeman and Company, New York.

Welander, A. D. 1940. A study of the development of the scale of the chinook salmon (*Oncorhynchus tshawytscha*). Master's thesis, University of Washington, Seattle.

APPENDIX A. EVALUATION OF INTERVIEW DATA

Appendix A1.-Procedures used to compare and combine data from completed onsite interviews and returned voluntary report cards.

Completed-trip data were available from two sources: anglers who had completed their fishing prior to being interviewed onsite, and anglers who had not completed their fishing prior to being interviewed but were issued voluntary report cards and returned them. This appendix compares the two data sets and describes how data from the two sources were pooled to estimate angler success parameters and harvest analysis parameters.

Chi-square tests of independence were used to determine whether the number of fish caught/harvested was independent of type of angler (ONSITE: fishing completed prior to time of interview versus CARD: fishing not completed at time of interview and angler filled out and returned a card). The analysis was performed by site (lower Nushagak River, Mulchatna River) and by week, although weeks 29 and 30 on the Mulchatna River were pooled for lack of data. Catch was classified into four categories; 0, 1-3, 3-6, and >6 fish; except for weeks 26 and 29/30 on the Mulchatna River, for which catch was pooled into two categories, 0 and $\geq$1 fish. Harvest was classified into four categories; 0, 1, 2, or $\geq$3 fish; again except for weeks 26 and 29/30 on the Mulchatna River, for which harvest was pooled into two categories, 0 and $\geq$1 fish.

Catch distribution differed by type of angler during all weeks at the lower Nushagak River, with ONSITE anglers catching fewer fish than CARD anglers (Appendix A2, all $P < 0.05$). On the Mulchatna River, catch distribution did not differ during weeks 26 and 27 ($P > 0.05$), but did differ during weeks 28 (χ^2=11.1, df=3, P=0.011), and 29/30 (χ^2=13.3, df=1, P<0.001; Appendix A2). As at the lower Nushagak River, during weeks 28-30 Mulchatna River ONSITE anglers caught fewer fish than CARD anglers.

Harvest distribution differed by type of angler for weeks 26 (χ^2=12.5, df=3, P=0.006) and 27 (χ^2=15.5, df=3, P=0.001) at the lower Nushagak River, during which time ONSITE anglers harvested *more* fish than CARD anglers (Appendix A2). There was no significant difference (P>0.05) in harvest distribution during weeks 25 and 28 at the lower Nushagak River. On the Mulchatna River, harvest differed by type of angler during weeks 29/30 (χ^2=7.6, df=1, P=0.006), with ONSITE anglers harvesting fewer fish than CARD anglers; however, there were only 17 complete-trip interviews on the Mulchatna River during those weeks (Appendix A2). There was no significant difference in harvest distribution during weeks 26, 27, and 28 on the Mulchatna River.

Effort (hours fished per day) differed between types of anglers (ONSITE vs. CARD), more so at the lower Nushagak River (F=237.4, df=1,577, P<0.0001) than at the Mulchatna River (F=4.18, df=1,343, P=0.042). In both cases CARD anglers fished longer than ONSITE anglers (Appendix A3).

ONSITE anglers clearly differed from CARD anglers. The noted differences between angler-types had two possible origins: (1) anglers who completed fishing before being interviewed were more or less successful than anglers who had not finished fishing, and/or (2) anglers who returned their cards were more or less successful than anglers who did not. If the latter case was true, any estimates from the existing data would have an unknown bias, since there are no means to estimate the completed-trip fishing success of anglers who didn't return their cards.

Therefore, as an indirect way to investigate the likelihood of case (2), we tested, by week, whether success differed *at time of interview* between those anglers who eventually returned their cards (CARD anglers) and those anglers who were issued cards but did not return them. Out of 16 tests (harvest and catch at two locations for 4 weeks), there were only two significant ($P<0.05$) differences (harvest, lower Nushagak River, week 25, $\chi^2=14.7$, df=2, $P=0.001$; catch, Mulchatna River, week 27, $\chi^2=12.4$, df=3, $P=0.006$). We concluded that the noted differences in angler success were probably due mostly to scenario (1) above (success of anglers who had completed fishing before being interviewed differed from the success of those who had not).

Valid estimates of success can therefore be obtained from the data, with one complication. Survey data were self-weighted (by design) over time, however they were not self-weighted with respect to type of angler interview (ONSITE vs. CARD), because not all cards were returned. That is, the interview data were more or less a census of all anglers finishing early (probably few escaped being interviewed), while the card data represent only a sample of all the anglers encountered by the creel technicians who had not completed fishing for the day.

Since there were differences in angler success between angler types, the incomplete return of cards was taken into account when pooling the data by applying a greater weight to the CARD anglers than what they represent in the raw data. Card data were weighted by the number of cards issued (representing the number of anglers still fishing when interviewed) rather than by the number of returned cards (only a sample of the former). The process was carried out by week, since the card return rate (and therefore the weighting factor for the card data) appeared to decline over time (Appendix A4).

Angler Success

We estimated the proportions of anglers achieving certain levels of catch and harvest as follows. Let m be the number of anglers interviewed all season. Of the m_i anglers interviewed during week i, let

m_{1i} = the number of anglers who had already completed fishing,

m_{2i} = the number of anglers who had not completed fishing and were issued a card, and eventually completed and returned it, and

m_{3i} = the number of anglers who had not completed fishing and were issued a card, but either did not complete it correctly or did not return it.

Also, let

m_{1ij} = the number of anglers who had already completed fishing during week i and caught j or more chinook salmon,

m_{2ij} = the number of anglers who had not completed fishing during week i, were issued a card, eventually completed and returned it, and caught j or more chinook salmon, and

m_{3ij} = the number of anglers who had not completed fishing during week i, were issued a card, either did not complete it correctly or did not return it, and caught j or more chinook salmon.

Note that we had no information on the completed-trip success of the third category of anglers, i.e., the m_{3ij} are unknown. The proportion of anglers catching j or more fish during the entire season (all weeks) was estimated as

$$\hat{p}_j = \sum_i \left[w_{1i} \frac{m_{1ij}}{m_{1i}} + w_{2i} \frac{m_{2ij}}{m_{2i}} \right] \tag{A1.1}$$

where w_{1i} and w_{2i} are the weights applied to the data from onsite completed-trip interviews and returned cards, respectively. The weights, which summed to one over the season, were calculated as

$$w_{1i} = \frac{m_{1i}}{m}, \text{ and} \tag{A1.2}$$

$$w_{2i} = \frac{m_{2i} + m_{3i}}{m}. \tag{A1.3}$$

Note that the data from the returned cards were weighted to reflect the number of cards issued rather than the number of cards returned. The proportion of anglers harvesting j or more chinook salmon was estimated in the same manner. The proportion of anglers catching or harvesting exactly j chinook salmon was also estimated in the same manner, after redefining the m_{1ij} and m_{2ij} appropriately.

The variances of these estimated proportions were estimated as follows:

$$\hat{Var}(\hat{p}_j) = \sum_i \left[w_{1i}^2 \frac{\frac{m_{1ij}}{m_{1i}}\left(1 - \frac{m_{1ij}}{m_{1i}}\right)}{m_{1i} - 1} + w_{2i}^2 \frac{\frac{m_{2ij}}{m_{2i}}\left(1 - \frac{m_{2ij}}{m_{2i}}\right)}{m_{2i} - 1} \right]. \tag{A1.4}$$

Harvest Analysis

The proportion of fish occupying the k^{th} position in the creel was estimated as

$$\hat{p}_k = \frac{\hat{p}_j \cdot m}{\sum_{j=1}^{jmax} \left(\hat{p}_j \cdot m\right)} \tag{A1.5}$$

where j equals k, $\hat{p}_j$ is the proportion of anglers harvesting j or more chinook, m is the total number of anglers interviewed, and jmax is the maximum number of fish harvested by any one angler. The denominator of (A1.5) is the estimated total number of fish harvested by all anglers contacted during the survey.

The variance of $\hat{p}_k$ was estimated using the resampling techniques of Efron (1982). Each survey produced data $\{h_{1i}\}$ and $\{h_{2i}\}$, in which each h_{1i} is the harvest of an angler who had already finished fishing at the time of being interviewed during week i, and each h_{2i} is the harvest of an angler who was issued a card during week i and returned it. There were m_{1i} and m_{2i} of such data

points (angler-trips), respectively, for each week i. In addition, there were m_{3i} angler-trips in which the completed-trip harvest was unknown because the angler did not return his card. The total number of angler-trips for each week was $m_i = m_{1i} + m_{2i} + m_{3i}$. One thousand bootstrap samples were drawn by resampling these original m_i angler-trips with replacement. For each bootstrap sample, for each week i , m_{1i} angler-trips were randomly chosen with replacement from the m_{1i} angler-trips for which the data came from onsite interviews, and $m_{2i} + m_{3i}$ angler-trips were randomly chosen with replacement from the $m_{2i} + m_{3i}$ angler-trips which came from issued cards. Therefore the number of angler-trips m'_{3i} for which the harvest was unknown varied with each bootstrap sample, and usually differed from the corresponding number m_{3i} in the original data. The numbers m'_{1ij} of angler-trips from onsite interviews in which j chinook were harvested were tallied from each bootstrap sample, as were the numbers m'_{2ij} of angler-trips from returned cards in which j chinook were harvested. The proportions p'_j of anglers harvesting exactly j chinook and the proportions p'_k of chinook occupying the k^{th} position in the creel were calculated for each bootstrap sample using (A1.1) and (A1.5) above, after substituting m'_{3i} for m_{3i}, m'_{1ij} for m_{1ij}, and m'_{2ij} for m_{2ij}. Finally, the variance of $\hat{p}_k$ was estimated by calculating the sample variance of the 1000 bootstrap values of p'_k.

Appendix A2.-Comparisons of the number of chinook salmon kept or caught from card completed-trip interviews versus onsite completed-trip interviews on the lower Nushagak and Mulchatna rivers, 1994.

Lower Nushagak River

Kept categories: 0,1,2, or ≥ 3 fish kept; df = 3.

Catch categories: 0, 1-3, 3-6, >6 fish caught; df = 3.

	Completed-trip Interviews		Chinook Salmon		Fish Kept		Fish Caught	
Week	Card	Onsite	Kept	Caught	$\chi 2$	P	$\chi 2$	P
25	75	46	108	713	4.077	0.253	12.926	0.005
26	182	92	404	1,762	12.532	0.006	13.008	0.005
27	153	73	276	1,232	15.493	0.001	8.456	0.037
28	55	32	128	399	4.644	0.200	15.937	0.001
Total	465	243	916	4,106				

Mulchatna River

For kept in weeks 26 and 29/30 (pooled), categories were: 0, ≥ 1 fish kept; df = 1.

For kept in weeks 27 & 28, categories were: 0, 1, 2, ≥3 fish kept; df = 3.

For catch in weeks 26 and 29/30 (pooled), categories were: 0 , ≥ 1 fish caught; df = 1.

For catch in weeks 27 & 28, categories were: 0, 1-3, 3-6, and >6 fish caught); df = 3.

	Completed-trip Interviews		Chinook Salmon		Fish Kept		Fish Caught	
Week	Card	Onsite	Kept	Caught	$\chi 2$	P	$\chi 2$	P
26	27	12	24	37	0.611	0.434	2.411	0.121
27	160	23	208	485	1.802	0.614	4.615	0.202
28	105	30	104	265	0.757	0.860	11.090	0.011
29 & 30	67	17	38	171	7.563	0.006	13.326	0.000
Total	359	82	374	958				

Appendix A3.-Mean effort (hours fished) of completed-trip anglers returning cards versus completed-trip anglers interviewed onsite on the lower Nushagak and Mulchatna rivers, 1994.

	Week				
	25	26	27	28	29
Lower Nushagak River					
Completed-trip anglers returning cards	13.07	13.87	11.31	13.31	
Completed-trip anglers interviewed onsite	5.30	6.39	5.84	6.15	
Mulchatna River					
Completed-trip anglers returning cards		5.12	9.97	7.06	3.81
Completed-trip anglers interviewed onsite		4.33	5.50	4.64	1.44

Appendix A4.-Return rate of angler-interview cards during the chinook salmon sport fisheries on the lower Nushagak and Mulchatna rivers in 1994.

	Week					
	25	26	27	28	29	Total
Lower Nushagak River						
Cards returned	75	182	153	55		465
Cards not returned	88	212	210	107		617
Total	163	394	363	162		1082
Proportion returned	0.46	0.46	0.42	0.34		0.43
	$c^2 = 7.76$, P = 0.053					
Mulchatna River						
Cards returned		48	139	105	67	359
Cards not returned		22	107	77	80	286
Total		70	246	182	147	645
Proportion returned		0.69	0.57	0.58	0.46	0.56
	$c^2 = 11.16$, P = 0.011					

APPENDIX B. LIST OF DATA FILES AND PROGRAMS USED

Appendix B1.-Data files and computer programs used to produce this report.

	Data Files
Interview data:	
T003AIA4.DTA	Nushagak chinook salmon onsite interviews 6/20/94 to 6/24/94.
T004AIB4.DTA	Nushagak chinook salmon onsite interviews 6/25/94 to 7/15/94.
T003AIK4.CRD	Nushagak chinook card interviews.
T003AIK4.MRG	Nushagak chinook onsite and card interviews merged. These data were used for angler success analysis.
T003AIC4.DTA	Nushagak coho salmon angler interviews 7/29/94 to 8/8/94.
T007BIA4.DTA	Mulchatna chinook salmon onsite interviews 6/25/94 to 6/30/94.
T007BIB4.DTA	Mulchatna chinook salmon onsite interviews 7/1/94 to 7/25/94.
T007BIK4.CRD	Mulchatna chinook card interviews.
T007BIK4.MRG	Mulchatna chinook onsite and card interviews merged. There data were used for angler success analysis.
Biological data:	
T003ABA4.DTA	Nushagak sport harvested chinook salmon.
T007BBA4.DTA	Mulchatna sport harvested chinook salmon.
	Analysis Programs:
CC91	A series of programs which sort raw data from files and produce frequency reports and assist in locating some data errors.
BBXPEXE	A series of programs that uses biological data files to produce tables of mean lengths, and weights by sex and age group.
DATAENTER.PRG	The program arranges the information in standard Angler Interview Mark-Sense format and permits the data to be used to test assumptions, and compare between and within incompleted and completed-trip interviews, to determine whether data from the two sources could be validly combined for parameter estimation.
CARDENTR.PRG	Dbase® program to enter data from voluntary report cards.
DOINT90	A set of Dbase® programs that reformat standard angler interview data files into a single row of data for each interview.
MERGE.PRG	Dbase® program used to merge the original onsite interview data files with the products of CARDENTR.PRG