Fishery Data Series No. 96-48

Sport Fishing Effort, Catch, and Harvest, Fishery Contributions, and Inriver Abundance of Chilkat River Chinook Salmon, in 1995

by

Randolph P. Ericksen

December 1996

Alaska Department of Fish and Game **Division of Sport Fish**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

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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Randolph P. Ericksen
Division of Sport Fish, Haines

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

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Randolph P. Ericksen
Alaska Department of Fish and Game, Division of Sport Fish
P.O. Box 330
Haines, AK 99827-0330, USA

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ABSTRACT

We estimated the 1995 marine sport harvest and escapement of chinook salmon returning to the Chilkat River near Haines, Alaska. A creel survey was used during the Haines marine boat fishery in the spring of 1995 to estimate angler effort for, and harvest of, wild mature chinook salmon assumed to be bound for the Chilkat River. Harvest of large (>28 inches in total length) chinook salmon and chartered angler effort and harvest were also estimated. Harvests of 1988 and 1989 brood year Chilkat River chinook salmon were estimated through random recoveries of coded wire tagged fish in sampled fisheries. A mark-recapture experiment was used to estimate the in-river abundance of spawning chinook salmon in the Chilkat River.

An estimated 9,457 angler-hours (SE = 501) of effort (8,606 targeted salmon hours, SE = 483) were expended for a harvest of 228 (SE = 41) large chinook salmon, of which 193 (SE = 35) were wild, mature fish. Chartered anglers accounted for 19% and 22% of estimated targeted salmon effort and harvest of large chinook salmon, respectively.

Harvests of the 1988 and 1989 brood year Chilkat River chinook salmon were estimated at 1,648 (SE = 403) and 698 (SE = 152), respectively. Reasons why these estimates are considered as minimum harvests are discussed.

One hundred eighty-six (186) large (age 1.3 and older) chinook salmon were captured in the lower Chilkat River between June 13 and August 8, 1995 in drift gillnets and two fish wheels. One hundred eighty (180) of these fish were tagged with solid-core spaghetti tags (121 in drift gillnets and 59 in the fish wheels). Of a total 376 large chinook salmon examined on spawning tributaries to the Chilkat River, 17 were carrying tags. On the basis of these data, it was estimated that 3,790 (SE = 805) large chinook salmon ($n_1 = 180$, $n_2 = 376$, $m_2 = 17$) immigrated into the Chilkat River during 1995.

Key words: Mark-recapture, creel survey, angler effort and harvest, boat sport fishery, hatchery, escapement, coded wire tag, age composition, length-at-age estimation, chinook salmon, *Oncorhynchus tshawytscha*, Chilkat River, Kelsall River, Tahini River, Big Boulder Creek, Nataga Creek, Haines, Southeast Alaska.

INTRODUCTION

A spring marine boat sport fishery occurs annually in Chilkat Inlet (Figures 1 and 2), near Haines, Southeast Alaska, and targets mature chinook salmon *Oncorhynchus tshawytscha* returning to the Chilkat River. A creel survey has been used to monitor harvest in this fishery since 1984. The harvest in this fishery peaked at over 1,600 chinook salmon in 1985 and 1986 (Neimark 1985; Mecum and Suchanek 1986, 1987; Bingham et al. 1988; Suchanek and Bingham 1989, 1990, 1991; Ericksen 1994).

Beginning in 1981, the Alaska Department of Fish and Game (ADF&G) began a program to index chinook salmon abundance in the Chilkat River using aerial survey counts in Stonehouse and Big Boulder creeks (Figure 1; Pahlke 1992). These areas were selected because they were the only clearwater spawning areas that could be effectively surveyed. The indices were used in a regionwide program to monitor chinook salmon escapements in Southeast Alaska (Pahlke 1992). In 1983, annual enhancement of the Chilkat River chinook salmon began by collecting gametes in a tributary to the Chilkat River (the Tahini River) for incubation in the Crystal Lake Hatchery.

Concern about Chilkat River chinook salmon developed when the indices of adult abundance declined in 1985 and 1986. This decline coincided with high harvests of chinook in the commercial troll, commercial drift gillnet, and marine sport fisheries in the area. In 1987, the Department began to restrict sport, subsistence and commercial fisheries in upper Lynn Canal, and recreational fisheries were closed entirely in 1991 and 1992. The Haines King Salmon Derby was closed beginning in 1988.

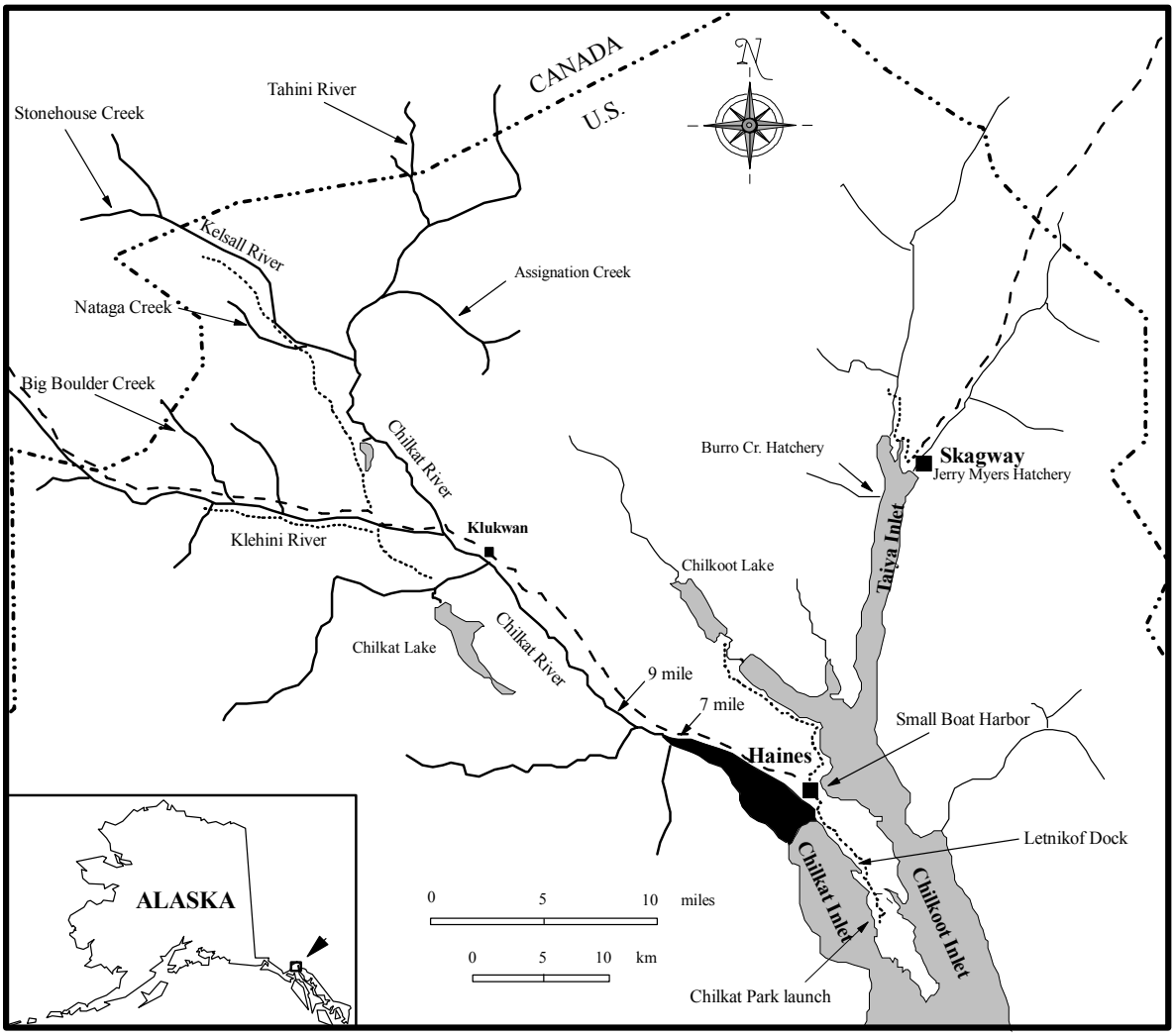

Figure 1.-Location of sampling sites and release sites of coded wire tagged chinook salmon near Haines and Skagway, Southeast Alaska, 1995.

As a result of these concerns, the Division of Sport Fish initiated a program to tag wild juvenile chinook salmon in 1988 with coded wire tags (CWTs) to better determine migratory patterns and contributions to sport and commercial fisheries. Also, radio telemetry and mark-recapture experiments were conducted in 1991 and 1992 to estimate spawning distribution and abundance of large (age 1.3 years and older) chinook salmon in the river. Results of this research indicated that most of the chinook spawn in two major tributaries of the Chilkat River—the Kelsall and Tahini rivers, and immature fish are harvested as they rear in inside waters of Southeast Alaska (Johnson et al. 1992, 1993).

Mark-recapture experiments were maintained as a means to estimate the escapement of large chinook salmon after 1992. Estimates have ranged between 4,472 (SE = 851) and 6,795 (SE = 1,005) fish (Johnson et al. 1992, 1993; Johnson 1994; Ericksen 1995). Because abundance has appeared relatively high and stable, a

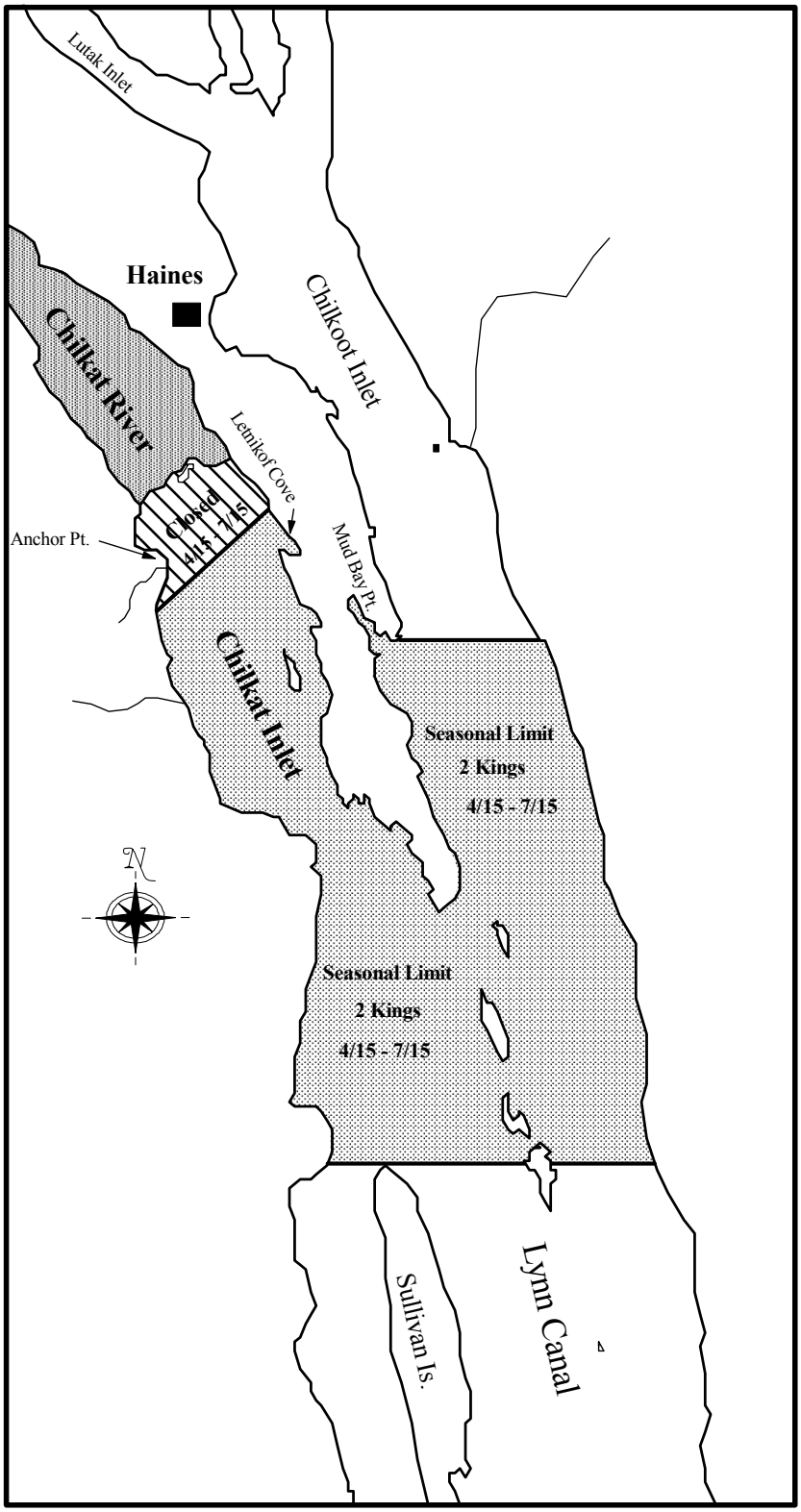

Figure 2.-Location of the 1995 Haines marine chinook salmon sport fishing regulatory area.

king salmon derby was held in Haines during 1995, for the first time in 8 years.

Estimating harvest and escapement is the continuing goal of the Chilkat River chinook salmon research program. Research objectives in 1995 were:

1. to estimate the 1995 immigration of large (age 1.3) chinook salmon into the Chilkat River;
2. to estimate the harvest of wild mature chinook salmon in the Haines spring marine boat sport fishery from May 8 to July 2, 1995; and
3. to estimate the harvest of 1988 and 1989 brood year Chilkat River chinook salmon in randomly sampled fisheries.

STUDY AREA

The Chilkat River is a large glacial system that originates in British Columbia, Canada, flows through rugged dissected mountainous terrain, and terminates in Chilkat Inlet near Haines Alaska (Figure 1). The mainstem and major tributaries comprise approximately 350 km of river channel in a watershed covering about 1,600 square km (Bugliosi 1988).

The third largest population of chinook salmon in Southeast Alaska is found in the Chilkat River (Pahlke 1993). Previous studies suggest Chilkat River chinook salmon rear in the inside waters of Southeast Alaska (Pahlke 1991, Johnson et al. 1993). Electrophoretic analysis indicates that this population is genetically related to southern British Columbia and Washington stocks more than to other Southeast Alaskan populations (Gharett et al. 1987).

The spring marine boat fishery in Haines has been popular with local and non-local anglers alike; an estimated 61% of the anglers who fished in 1985 were not from Haines (Bethers 1986). In 1988, an estimated $1.1 million was spent by anglers fishing in Haines and Skagway for chinook salmon (Jones and Stokes Associates, Inc. 1991). The Haines King Salmon Derby, which began in the mid 1950s, was directed primarily at returning Chilkat River chinook salmon.

The current Chilkat River escapement goal of 2,000 chinook salmon was established in the late 1970s and is currently under review. Current harvest regulations prevent sport fishing for chinook salmon near the mouth of the Chilkat River and establish a regulatory area in Chilkat Inlet and upper Lynn Canal where a seasonal limit of two chinook salmon is in effect between April 15 and July 15 (see Figure 2). Commercial fishing regulations are structured to reduce incidental harvests of mature chinook salmon in the Lynn Canal gillnet fishery.

METHODS

ABUNDANCE

A mark-recapture experiment was used to estimate the number of large chinook salmon returning to the Chilkat River in 1995, as in previous years (Ericksen 1995). Fish were captured from June 13 through August 9 with drift gillnets and fish wheels in the lower Chilkat River between the area adjacent to Haines Highway miles 7 and 9. Large chinook salmon were marked with a solid-core spaghetti tag and a hole punch in the upper left operculum prior to release. Water depth (cm), and temperature (°C) were recorded daily at 0700 and 1330 hours near highway mile 8. Fish were examined for marks on three spawning tributaries of the Chilkat River between August 4 and September 5. Expected relative precision (95% C.I.) for the experiment was about ±30%.

LOWER RIVER MARKING

Gillnets 21.3 m long and 3.0 m deep (70 ft x 10 ft) with an 18.5-cm (7.25-in.) stretched

mesh were drifted from June 13 through July 21, 1995. Each day the crew tried to complete 43 drifts between 0600 and 1400 hours. The crew fished from an 18-foot boat in three adjoining 0.5-km-long areas, which were marked along the same 1.5-km-long stretch of river used in 1993 and 1994 (see Figure 2 in Johnson 1994). This section of the river was approximately 100 m wide and 2–3 m deep. The 43 drifts took about 6 hours to complete when fish were not captured.

Fishing continued uninterrupted from area 1 to area 2, and then to area 3 if fish were not captured. If a (0.5-km) drift was prematurely suspended because a fish was caught, or if the net became entangled or drifted into shallow water, the drift was resumed and completed before a new drift was started. If 43 drifts could not be completed during the day, additional drifts were added to the next day's total to make up the balance.

Two four-basket fish wheels were installed by ADF&G Commercial Fisheries Management and Development Division (CFMADD) personnel early in the season to monitor escapement of sockeye salmon *O. nerka* to the Chilkat River. The Division of Sport Fish provided funding for one technician to work on the fish wheels in exchange for CFMADD's tagging of captured chinook. One fish wheel was operated adjacent to the Haines Highway mile 8 from June 20 through September 19, and another adjacent to mile 9 from June 15 through September 19. The wheels were located along the east bank of the river, where the main flow was constrained to one side of the floodplain. Fish wheels were operated continuously except for maintenance.

Captured chinook salmon were placed in a water-filled tagging box (see Figure 3 in Johnson 1994), inspected for missing adipose fins, and measured to the nearest 5 mm, mid-eye-to-fork length (MEF). Fish were initially classified as "large" or "small," depending on their length: fish ≥660 mm MEF were designated large, and fish <660 mm MEF were designated small.

Healthy large (and small) chinook salmon were scale sampled, visually "sexed," marked with a uniquely numbered spaghetti tag threaded over a solid plastic core, and given a ¼-inch hole punch in the upper edge of the left operculum as a secondary mark. Age of each fish was determined at the end of the season from scale pattern analysis (Olsen 1992).

Then each fish was reclassified as large or small, using ocean age rather than length as criteria; fish with three or more ocean years of residence were classified as large, and younger fish were classified as small. Any fish whose scales could not be aged was classified small or large by using the 660-mm-MEF cut-point criteria.

SPAWNING GROUND RECOVERY

Escapements in the Kelsall and Tahini rivers (Figure 1), which constituted about 90% of the large chinook salmon spawning in the Chilkat River in 1991 and 1992 (Johnson et al. 1992, 1993), were sampled for marks by two teams of two people. Spawning grounds in the Kelsall River (including Nataga Creek) were sampled from August 6 to September 4. Spawning grounds in the Tahini River were sampled from August 7 to September 4. Chinook salmon were also sampled in Big Boulder Creek from August 4 through September 5 with assistance from CFMADD staff. Chinook salmon were captured with gillnets, dip nets, bare hands, and spears. Double sampling was prevented by punching a hole in the lower edge of the left operculum of all captured fish.

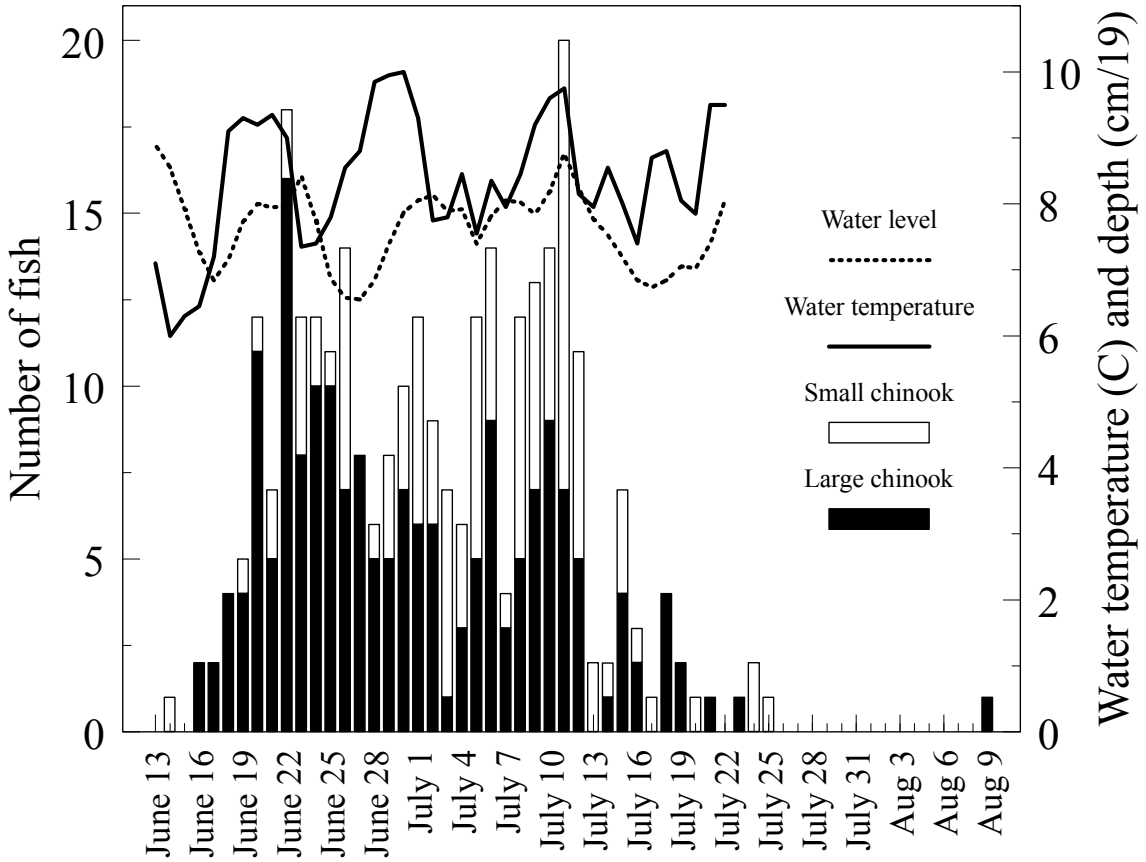

Figure 3.-Daily water depth (cm/19), temperature (^{0}C), and catch of small (<age 1.3) and large (≥ age 1.3) chinook salmon catch in drift gill nets and fish wheels operating in the lower Chilkat River, June 13 through August 9, 1995.

Abundance (numbers immigrating) was estimated using Chapman's modified Petersen estimator for a closed population (Seber 1982):

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)} - 1 \quad (1)$$

$$V[\hat{N}] = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)} \quad (2)$$

where

n_1 = number of large chinook salmon marked in the lower river,

n_2 = number of large chinook salmon examined on the spawning grounds, and

m_2 = number of marked fish recaptured on the spawning grounds.

Age composition, mean length-at-age of the immigration, and associated variances were calculated using standard normal statistics.

HARVEST

1995 Haines spring marine boat sport fishery

A stratified multi-stage direct expansion creel survey was used to estimate the harvest of chinook salmon in the Haines marine boat sport fishery. Temporal stratification included 7-day (weekly) periods at one high-use site and 14-day (biweekly) periods at two low-use sites. A separate temporal stratum

existed during the Haines Derby (May 27, 28, and 29) at both high- and low-use sites.

The three access locations were the Letnikof Dock (the high-use site), the Chilkat State Park boat launch (low-use), and the small boat harbor (low-use) (see Figure 1). Prior surveys indicate that anglers landing their catch at the Letnikof Dock account for 62–93% of the harvest of chinook salmon.

Each fishing day was defined as starting at 0800 hr and ending at civil twilight. The survey at Letnikof Dock also contained morning/ evening stratification, with relatively longer evening strata (see below), and weekend/weekday stratification of the evening strata during the peak of the season. Sampling densities with two technicians were expected to yield an overall relative precision (95% C.I.) of about ±35%. Sampling at each location had days as primary sampling units and boat-parties as secondary units.

Sampling at Letnikof Dock occurred from May 8 to July 2, 1995. Morning sampling strata lasted from 0800 hr to 2 hours before mid-day, and evening sampling strata lasted from 2 hours before mid-day to civil twilight. Thus, evening strata were 4 hours longer than morning strata. This stratification scheme was designed to increase the precision of the estimates by maximizing sampling during hours when most of the anglers exited the fishery. Random selections determined primary units to sample in each strata. Two morning and three evening strata were sampled each week, except as noted below.

During the peak of the fishery (May 15 through June 11) the evening strata at Letnikof Dock was further divided into weekday and weekend/holiday stratification defined by Saturdays, Sundays, and May 22 (Victoria Day). During this peak season, two morning, two weekday evening, and two weekend/holiday evening periods were sampled each week. Nineteen unique strata were sampled at Letnikof Dock in 1995.

Sampling was initiated at the small boat harbor and Chilkat State Park boat launch on May 8 and May 22, respectively, and continued through July 2. There was no type of day stratification at the low-use sites, so each bi-weekly sampling period was divided into 14 morning and 14 evening periods of equal length. Random selections determined primary units to sample in each morning and evening stratum. To accommodate the impossibility of sampling three sites simultaneously with only 2 technicians, 14 changes were made to the randomized sampling schedule at low-use sites. Sixteen unique strata were sampled at the low-use harbors during 1995.

During each sampled period, all sport fishing boats returning to the harbor were counted. Boat-parties returning to the dock were interviewed to determine the number of rods fished, hours fished, type of trip (charter or noncharter), target species (chinook salmon, Pacific halibut *Hippoglossus stenolepis*), and number of fish kept and/or released by species. Interviewing boat-parties also included sampling all harvests of chinook salmon for maturity and missing adipose fins. Maturity was determined (Ericksen 1994, Appendix A) so that the harvest of wild, mature fish assumed to be returning to the Chilkat River could be estimated. In rare cases, some parties were not interviewed, or maturity status could not be determined. When one or more boat-parties could not be interviewed, total effort and catch for the strata were estimated by expanding by the total number of parties returning to the dock during that period. Similarly, when a boat-party had fish of unknown maturity, all interview information for that boat-party was ignored and expansions (by sample period) were made from harvests of remaining boat-

parties and the total number of boat-parties counted.

The harvest in each stratum ($\hat{H}_h$) was estimated (Cochran 1977):

$$\hat{H}_h = D_h \overline{H}_h \tag{3}$$

$$\overline{H}_h = \frac{\sum_{i=1}^{d_h} \hat{H}_{hi}}{d_h} \tag{4}$$

$$\hat{H}_{hi} = M_{hi} \frac{\sum_{j=1}^{m_{hi}} h_{hij}}{m_{hi}} \tag{5}$$

where:

h_{hij} = harvest on boat j in sampling day (period) i, of stratum h,

m_{hi} = number of boat parties interviewed in day i,

M_{hi} = number of boat-parties counted in day i,

d_h = number of days (morning or evening periods) sampled in stratum h, and

D_h = number of days in stratum h.

The variance of the harvest by stratum was estimated:

$$V\left[\hat{H}_h\right] = (1 - f_{1h}) D_h{}^2 \frac{\sum_{i=1}^{d_h} (\hat{H}_{hi} - \overline{H}_h)^2}{d_h (d_h - 1)} + \tag{6}$$

$$D_h \sum_{i=1}^{d_h} M_{hi}{}^2 (1 - f_{2hi}) \frac{\sum_{j=1}^{m_{hi}} (h_{hij} - \overline{h}_{hi})^2}{d_h m_{hi} (m_{hi} - 1)}$$

where f_{1h} is the sampling fraction for periods and f_{2hi} is the sampling fraction for boat-parties. Catch and effort were estimated similarly, substituting C and E for H in equation 3 through equation 6. Total harvests for the season were the sums across strata ΣH_h and $\Sigma V[H_h]$.

Chinook salmon sampled in the angler harvest were measured to the nearest 5 mm in fork length. Five scales were removed from the left side of each sampled fish (right side if left side scales were regenerated), along a line two scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin. A triacetate impression of the scales (30 seconds at 7,000 kg/sq^2, at a temperature of 97°C) was used for age determination. Scales were aged using procedures in Olsen (1992).

Information recorded for each chinook salmon sampled included sex, fork length (mm), maturity, and the presence or absence of adipose fin. Heads from chinook salmon missing adipose fins were retained, and a locking plastic strap with a unique number was inserted through the jaw of the head. Heads and CWT recovery data were sent to the ADF&G CWT Processing Laboratory in Juneau, where any tags present were removed and decoded, and corresponding information was entered into the tag lab data base.

Age composition and mean length-at-age of chinook salmon in the sport fishery harvest, and associated variances were estimated using standard normal statistics.

Contribution of 1989 and 1990 brood years to sampled fisheries

Wild juvenile chinook salmon from the 1988 and 1989 broods were captured, coded wire tagged, and released into the Chilkat River drainage during 1989 and 1990 (Table 1) (Pahlke et al. 1990, Pahlke 1991). In addition, eggs were collected from adult chinook salmon in the Tahini River in 1989 and incubated at the Jerry Myers hatchery in Skagway. The resulting fry were CWTd and released back in the Tahini River the following spring (Table 1).

Harvest of brood year 1989 and 1990 chinook salmon from the Chilkat River was estimated from fish sampled from catches in commercial and sport fisheries in Southeast Alaska from 1992 through 1995, and from escapement samples collected in the lower Chilkat River. Because several fisheries

Table 1.-Releases of 1988 and 1989 brood year coded wire tagged chinook salmon into the Chilkat River drainage by tag code, 1989–1990 (Pahlke et al. 1990, Pahlke 1991).

Tag code	Wild/ hatchery	Release site/stock	Brood year	Date released	Marked & tagged	Shed mark	Total released
42837	wild	Tahini R.	88	8/24/89	5,293	0	5,293
43337	wild	Chilkat R.	88	4/26/90	2,191	29	2,220
42710	wild	Chilkat R.	88	11/8/89	9,778	119	9,897
42714	wild	Kelsall R.	88	10/11/89	10,470	32	10,502
42715	wild	Kelsall R.	88	10/16/89	4,152	50	4,202
42714	wild	Kelsall R.	88	9/30/89	5,457	38	5,495
43338	wild	Tahini R.	89	10/8/90	1,403	0	1,403
43339	wild	Chilkat R.	89	10/27/90	2,230	0	2,230
43347	wild	Kelsall R.	89	10/15/90	10,160	82	10,160
401011008	J Myers	Tahini R.	89	5/14/90	12,155	73	12,228
401011009	J Myers	Tahini R.	89	5/14/90	10,955	66	11,021
401011010	J Myers	Tahini R.	89	5/14/90	6,856	41	6,897

exploited chinook salmon over many months and years, the harvest of chinook salmon from the Chilkat River was estimated over several strata, each a combination of time, area, and type of fishery.

Statistics from the commercial troll fishery were stratified by fishing period and by fishing quadrant. Statistics from drift gillnet and seine, and cost recovery (private nonprofit [PNP]) fisheries were stratified by week and by fishing district. Statistics from sport fisheries (Haines and Juneau) were stratified by biweek and by fishing district. An estimate of the harvest $\hat{n}_{l\,1}$ was calculated for each stratum, then summed across strata and across fisheries to obtain an estimate of the total harvest:

$$\hat{N}_c = \sum_{h=1}^{L} \hat{n}_{l\,h} \qquad (7)$$

$$V[\hat{N}_c] = \sum_{h=1}^{L} V[\hat{n}_{l\,h}]$$

where L is the number of strata. The variance of the sum of the estimates was calculated as the sum of the variances across strata, because sampling was independent across strata and across fisheries.

Sampled chinook salmon were counted and inspected for missing adipose fins. Heads of all recaptured salmon were retrieved, marked, and sent to Juneau for dissection. Heads that arrived in Juneau were passed through a magnetometer to detect a CWT and were dissected if the presence of metal was indicated. If a CWT was found and the tag was undamaged, its code was read under a microscope. Oliver (1990) and Hubartt et al. (1995) present details of sampling commercial and sport fisheries, respectively. Clark and Bernard (1987), Geiger (1990), and Bernard and Clark (*In press*) describe CWT estimation. The fraction of each brood year returning to the Chilkat River with CWTs was estimated from chinook salmon captured in drift gillnets and fish wheels in the lower Chilkat River between 1991 and 1995. The proportions in each brood year with CWTs were estimated:

$$\hat{\theta}_b = \frac{y_b}{t_b}$$

Error! Switch argument not spe

cifi ed.(8)

where y_b **Error! Switch argument not specified.** is the number of fish in the sample that are determined to be from brood year b, and are missing their adipose fin; and, t_b **Error! Switch argument not specified.** is the number of fish in the sample that are determined to be from brood year b.

The harvest in a stratum was calculated as

$$\hat{n}_1 = \frac{m_1}{m_2}\frac{a_1}{a_2}\frac{H}{n_2}\frac{m_c}{\hat{\theta}} = H\,\hat{\theta}^{-1}\hat{M} \qquad (9)$$

where:

$\hat{M}$ 2 the final statistic obtained through = sampling harvests,

n2 = total number of chinook sampled in the stratum,

a1 = total number of adipose clips sampled in n2,

a2 = total number of heads in a1 received at tag lab,

m1 = number of tags detected in a2,

m2 = total number of tags decoded in m1, and

mc = number of CWTs in m2 with given tag code.

The bootstrap of Efron (1982) as modified by Buckland and Garthwaite (1991) was used to estimate M and its variance. A multinomial, empirical density distribution with six cells was created with the data from the catch sampling program. The probabilities of drawing a single sample from this distribution were calculated from the original data as follows:

$$\frac{n_2 - a_1}{n_2} \quad \frac{a_1 - a_2}{n_2} \quad \frac{a_2 - m_1}{n_2} \quad \frac{m_1 - m_2}{n_2} \quad \frac{m_2 - m_c}{n_2} \quad \frac{m_c}{n_2}\ 4$$

The bootstrap began with drawing a sample of size n2 with replacement from the empirical distribution according to the probabilities based on the original data. One thousand such samples were drawn, and the results of each (say the bth sample) were tallied to obtain a new set of statistics $\left\{a_1^*, a_2^*, m_1^*, m_2^*, m_c^*\right\}_b$ and a value of M_b. The mean of M_b $(\overline{M})$ 3 and its variance $V[\overline{M}]$ 4were calculated for each stratum as:

$$V[\overline{M}] = \frac{\sum_{b=1}^{B}\left(M_b - \overline{M}\right)^2}{B - 1} \qquad (10)$$

$$\text{with } \overline{M} = \frac{\sum_{b=1}^{B} M_b}{B}$$

where B is the number of bootstrap samples drawn (=1000).

In the case of wild stocks harvested in sport fisheries where both H and θ are estimated with error, the variance of the estimated harvest was calculated according to the procedures of Goodman (1960):

$$\begin{aligned} V\left[\hat{n}_1\right] = {} & V[\hat{H}]M^2\hat{\theta}^{-2} + V[\overline{M}]\hat{H}^2\hat{\theta}^{-2} \\ & + V[\hat{\theta}^{-1}]\hat{H}^2M^2 - V[\hat{H}]V[\overline{M}]\hat{\theta}^{-2} \\ & - V[\overline{M}]V[\hat{\theta}^{-1}]\hat{H}^2 - V[\hat{H}]V[\theta^{-1}]M^2 \\ & + V[\hat{H}]V[\overline{M}]V[\hat{\theta}^{-1}] \end{aligned} \qquad (11)$$

where $V\left[\hat{H}\right]$ was estimated from the angler surveys, and $V\left[\hat{\theta}^{-1}\right]$was estimated as described below.

In the case of wild stocks harvested in commercial fisheries where H is known and θ is estimated with error, the variance of the estimated harvest was again calculated according to the procedures of Goodman (1960):

$$V\left[\hat{n}_1\right] = H^2\left(V\left[\overline{M}\right]\hat{\theta}^{-2} + V\left[\hat{\theta}^{-1}\right]\hat{M}^2 - V\left[\overline{M}\right]V\left[\hat{\theta}^{-1}\right]\right) \qquad (12)$$

Note that $\hat{M}$5 and not $\overline{M}$6 was used in equations (11) and (12), even though $V[\overline{M}]$7 was used as an approximation to $V[\hat{M}]$8.

The statistic $V[\hat{\theta}^{-1}]$9 was estimated from a Monte Carlo simulation (see Geiger 1990) where the binomial probability distribution was employed as a model for the recovery of tagged fish. A large set of simulated statistics $\{\theta_1^*, \theta_2^*, \ldots \theta_B^*10\}$ was drawn from binom $(\hat{\theta}, n_e)$11 from which

$$\left\{\frac{1}{\theta_1^*}, \frac{1}{\theta_1^*}, \ldots \frac{1}{\theta_B^*}\right\} = \left\{y_1^*, y_2^*, \ldots y_B^*\right\} \quad (13)$$

$$V\left[\theta^{-1}\right] = \frac{\sum_{b=1}^{B}\left(y_b^* - \bar{y}^*\right)^2}{B-1}$$

where each θ was the subset of n_e in the simulation that had no adipose fins (and Chilkat River tags) divided by n_e.

Because planted hatchery fish might exhibit different behaviors (migration timing, distribution in fisheries, etc.) than wild fish, an odds ratio (Agresti 1984) was used to test the hypothesis that run timing of wild and hatchery fish was equal. Recoveries of 1989 brood year CWTd fish were pooled over years and divided into early (through statistical week 26) or late season (later than statistical week 26). The odds ratio was calculated as

$$\Phi = \frac{\left(\frac{N_{e,w}}{N_{e,h}}\right)}{\left(\frac{N_{l,w}}{N_{l,w}}\right)} \quad (14)$$

where N represents the number of CWTd fish recovered during the early (e) or late (l) season, which are of wild (w) or hatchery (h) origin. The estimated odds ratio was compared to 90% confidence limits for $\Phi = 1$ to complete the test.

Contribution of 1989 and 1990 brood years to subsistence fisheries

The harvest of Chilkat River chinook salmon from the 1989 and 1990 brood years (H_b) in the 1995 Haines subsistence fishery was estimated:

$$\hat{H}_b = H_T \hat{p}_b \quad (15)$$

$$V[\hat{H}_b] = H_T^2 \frac{p_b(1-p_b)}{(n-1)}$$

where H_T is the harvest of chinook salmon reported in ADF&G subsistence reports (CFMADD files), $\hat{p}_b = \frac{n_b}{n}$ is the estimated proportion of chinook salmon immigrating to the Chilkat River of a given brood year, n is the total number of chinook salmon sampled in the drift gillnet and successfully aged in a given year, and n_b is the number of those aged that were of a given brood year.

RESULTS

ABUNDANCE

One hundred eighty six (186) large (age 1.3 and older) and 108 small chinook salmon were captured with drift gillnets and fish wheels in the lower Chilkat River between June 13 and August 8, 1995 (Table 2, Figure 3). Capture rates of large chinook salmon peaked on June 22. The mean date of migratory timing (when 50% of the immigration has occurred, Mundy 1984) in the lower river was June 26 (Figure 4). Fish captured in the gillnet were predominantly (63.1%) age 1.4 and evenly split between males and females (Table 3). In contrast, age 1.2 was dominant (34.7%) in fish wheels, and fish were mostly males (78.4%, Table 3). Large (≥ age 1.3) chinook salmon captured in gillnets and fish wheels did not differ significantly different in size (K-S test, $d_{max} = 0.176$, $P = 0.157$), but a significantly higher proportion in the gillnets appeared to

be males (χ^2 = 4.63, df = 1, P = 0.031). Of the 186 large fish captured, 180 were given an external spaghetti tag. One fish captured in the fish wheels was previously marked in the drift gillnet; two fish captured in the drift gillnet and three captured in the fish wheels

Table 2.-Numbers of large and small chinook salmon caught in the lower Chilkat River by time period, gear type, and size, June 13 through August 14, 1995. Size was based on ocean age: "large" are fish with ≥ 3 years ocean residence, or it not aged, fish ≥ 660 mm MEF.

	Drift Gill Net		Fish Wheels		Total		
Date	Large	Small	Large	Small	Large	Small	Total
6/14-6/18	8	1	0	0	8	1	9
6/19-6/23	33	5	11	5	44	10	54
6/24-6/28	30	3	10	8	40	11	51
6/29-7/03	20	10	5	11	25	21	46
7/04-7/08	17	9	8	14	25	23	48
7/09-7/13	7	4	21	28	28	32	60
7/14-7/18	6	0	5	6	11	6	17
7/19-7/23	2	0	2	1	4	1	5
7/24-7/28			0	3	0	3	3
7/29-8/07			0	0	0	0	0
8/08-8/14			1	0	0	0	1
8/15-9/19			0	0	0	0	0
Total	123	32	63	76	186	108	294

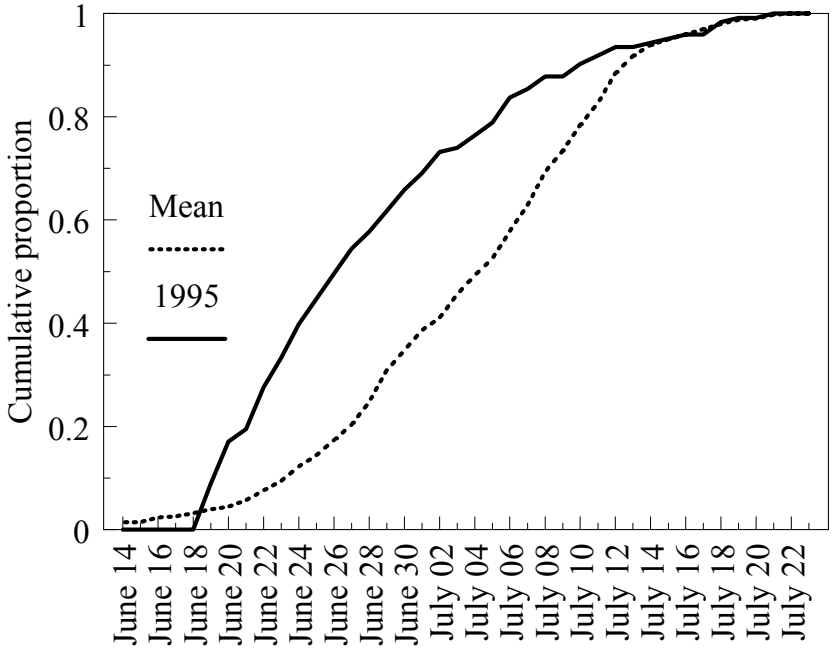

Figure 4.-Cumulative proportion of large (≥ age 1.3) chinook salmon captured with drift gill nets in the lower Chilkat River in 1995 compared with the mean cumulative proportion, 1991-1994.

Table 3.-Age composition of chinook salmon sampled during tagging and recovery surveys on the Chilkat River drainage, by gear type, 1995.

	Brood year and age class						Total aged	Total sampled[a]
	1992	1991	1990	1989	1988	1988		
	1.1	1.2	1.3	1.4	1.5	2.4		
TAGGING: GILLNET, MILE 7.5								
Male								
Sample size	0	24	8	27	3	0	62	75
Percent		38.7	12.9	43.5	4.8			48.1
SD		6.2	4.3	6.3	2.7			4.0
Mean length		610	733	911	957			
SD		49	43	72	50			
Female								
Sample size	0	5	4	55	4	0	68	81
Percent		7.4	5.9	80.9	5.9			51.9
SD		3.2	2.9	4.8	2.9			4.0
Mean length		577	673	869	890			
SD		85	83	47	10			
All fish								
Sample size	0	29	12	82	7	0	130	156
Percent		22.3	9.2	63.1	5.4			
SD		3.7	2.5	4.2	2.0			
Mean length		605	713	883	925			
SD		56	63	60	46			
TAGGING: FISH WHEELS, MILE 8 AND 9[b]								
Male								
Sample size	35	39	7	19	0	0	100	109
Percent	35	39.0	7.0	19.0				78.4
SD	4.8	4.9	2.6	3.9				3.5
Mean length	339	572	620	781				
SD	37	66	89	137				
Female								
Sample size	0	2	1	15	0	0	18	30
Percent		11.1	5.6	83.3				21.6
SD		7.4	5.4	8.8				3.5
Mean length		645	670	889				
SD		21		53				
All fish								
Sample size	35	41	8	34	0	0	118	139
Percent	29.7	34.7	6.8	28.8				
SD	4.2	4.4	2.3	4.2				
Mean length	339	576	687	914				
SD	37	67	89	61				
RECOVERY SURVEY: TAHINI RIVER SPAWNING GROUNDS								
Male								
Sample size	1	39	5	11	1	0	57	63
Percent	1.8	68.4	8.8	19.3	1.8			57.8
SD	1.7	6.2	3.7	5.2	1.7			4.7
Mean length	330	576	688	910	935			
SD		55	92	36				
Female								
Sample size	0	1	3	35	2	0	41	46
Percent		2.4	7.3	85.4	4.9			42.2
SD		2.4	4.1	5.5	3.4			4.7
Mean length		635	752	871	875			
SD			21	56				
All fish								
Sample size	1	40	8	46	3	0	98	109
Percent	1.0	40.8	8.2	46.9	3.1			
SD	1.0	5.0	2.8	5.0	1.7			
Mean length	330	578	713	881	895			
SD		55	77	54	49			

-continued-

Table 3.-Page 2 of 2.

	Brood year and age class						Total aged	Total sampled[a]
	1992	1991	1990	1989	1988	1988		
	1.1	1.2	1.3	1.4	1.5	2.4		
RECOVERY SURVEY: BIG BOULDER CREEK SPAWNING GROUNDS								
Male								
Sample size	0	12	3	16	0	0	31	33
Percent		38.7	9.7	51.6				45.8
SD		8.7	5.3	9.0				5.9
Mean length		609	715	863				
SD		69	48	72				
Female								
Sample size	0	1	1	30	1	0	33	39
Percent		3.0	3.0	91.0	3.0			54.2
SD		3.0	3.0	5.0	3.0			5.9
Mean length		640	765	856	895			
SD				40				
All fish								
Sample size	0	13	4	46	1	0	64	72
Percent		20.3	6.3	71.9	1.6			
SD		5.0	3.0	5.6	1.6			
Mean length		612	728	859	895			
SD		66	46	53				
RECOVERY SURVEY: KELSALL RIVER/NATAGA CREEK SPAWNING GROUNDS								
Male								
Sample size	3	48	12	46	2	0	111	130
Percent	2.7	43.2	10.8	41.4	1.8			48.0
SD	1.5	4.7	2.9	4.7	1.3			3.0
Mean Length	362	558	695	903	950			
SD	18	65	77	71	28			
Female								
Sample size	0	0	5	110	9	1	125	141
Percent			4.0	88.0	7.2	0.8		52.0
SD			1.8	2.9	2.3	0.8		3.0
Mean length			773	852	902	870		
SD			34	40	31			
All fish								
Sample size	3	48	17	156	11	1	236	271
Percent	1.3	20.3	7.2	66.1	4.7	0.4		
SD	0.7	2.6	1.7	3.1	1.4	0.4		
Mean length	362	558	718	865	911	870		
SD	18	65	76	58	35			

[a] Includes fish that were not assigned an age. Not all fish examined for marks were scale sampled (i.e., carcass decayed, part of body missing, etc.).

[b] Small chinook salmon (<660 mm FL) were sampled only for length at the fish wheels. Fish <440 mm were assumed to be age 1.1. Fish ≥440 and <660 mm were assumed to be age 1.2.

were < 660 mm MEF and were not tagged (though they were later aged as 1.3).

Three hundred seventy-six (376) large and 130 small chinook salmon were examined on the spawning grounds for marks, and 17 large and one small marked fish were recovered (Table 4). Three of the 17 marked fish were missing their tags but were identified by the opercular punch. Females were dominant in samples from Big Boulder Creek (54.2%) and the Kelsall (52.0%) River. In contrast, males were dominant (57.8%) in samples from the Tahini River (Table 3). This is due to a higher proportion of younger aged fish (largely precocious males) sampled in this tributary, which may have been a result of enhancement efforts. The probability of capturing a marked chinook salmon was not significantly different among spawning areas ($\chi^2 = 0.415$, df = 2, P = 0.813), thus data from all spawning areas were combined.

The cumulative distribution function (CDF) of lengths of large chinook salmon marked in the lower Chilkat River did not differ significantly from the CDF of large tagged chinook salmon recaptured on the spawning grounds (K-S test, $d_{max} = 0.152$, P = 0.865) (Figure 5, top). This result suggests the second sampling event was not size selective. Unfortunately, the test was not very powerful owing to the small number of recoveries (17), and the CDF suggests the spawning ground sample may have been somewhat enriched in larger (perhaps female) fish, as is sometimes observed (Pahlke et al. 1996). Still, the K-S test and the CDF are not unusual, and an estimated 3,790 (SE = 805) large chinook salmon immigrated into the Chilkat River in 1995 under the Petersen model ($n_1 = 180$, $n_2 = 376$, $m_2 = 17$). This estimate is germane to the time of tagging in the lower river, since an unquantified removal occurs (due to natural mortality and subsistence fishery harvest) between the two sampling events.

The CDF of lengths of marked fish differed significantly from the CDF of large chinook salmon examined for marks on the spawning grounds (K-S test, $d_{max} = 0.155$, P = 0.0059) (Figure 5, bottom). In conjunction with the prior K-S test result, this suggests the marking event was size selective, and fish

Table 4.-Number of chinook salmon inspected for marks and number of marked fish recaptured during tag recovery surveys in the Chilkat River drainage, by location, size, and sex , 1995.

		Number inspected						Number marked[a]			
		Large[c]			Small[c]			Large		Small	
Location	**Dates**	M	F	U[b]	M	F	U[b]	M	F	M	F
Kelsall	8/06-9/04	74	145	2	57	2	1	3	7	1	0
Nataga	8/09-8/25	5	8	0	6	0	0	0	1	0	0
Tahini	8/07-9/04	30	49	4	48	1	2	1	3	0	0
Big Boulder	8/04-9/05	21	38	0	12	1	0	0	2	0	0
Total		130	240	6	123	4	3	4	13	1	0

[a] Also included under number of fish inspected.

[b] Fish sampled with no sex information.

[c] Size was based on ocean age where "large" are fish with $\geq$ 3 yrs ocean residence, or if not aged, fish that are $\geq$660mm MEF.

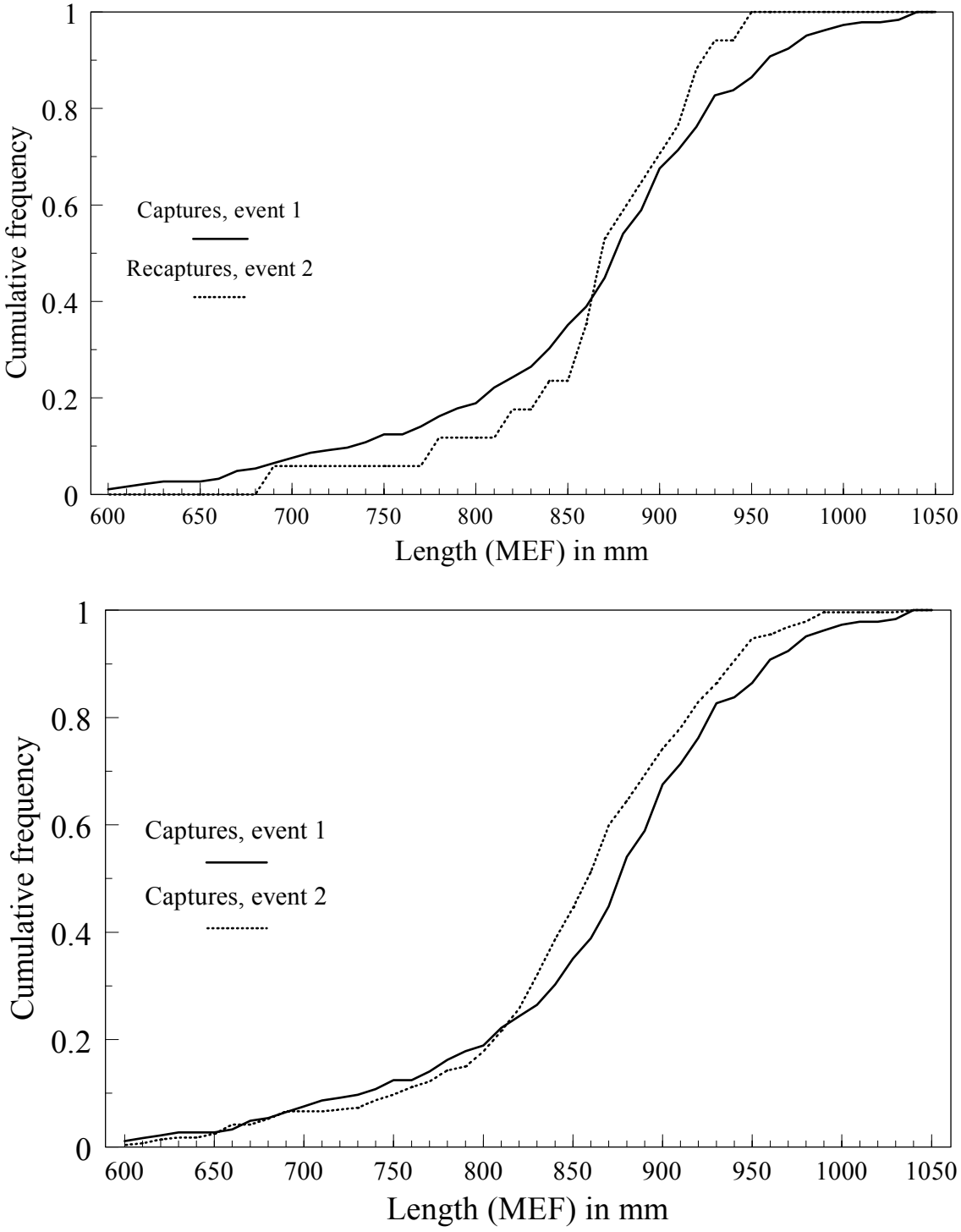

Figure 5.-The cumulative distribution function (CDF) of lengths (MEF) of large (≥ age 1.3) chinook salmon marked in the lower Chilkat River versus lengths of marked fish recaptured on the spawning grounds (top) and versus lengths of large fish examined for marks on the spawning grounds (bottom), 1995.

from the first sampling event should not be used to estimate size and length composition of the escapement (Bernard and Hansen 1992). However, the second K-S test was a powerful test which detected relatively small differences in length compositions. Since it is possible, and perhaps even likely, that the second sampling event was actually as selective (or moreso) than the first, both samples were combined to estimate length and size composition.

HARVEST

1995 Haines Spring Marine Boat Sport Fishery

An estimated total of 9,457 (SE = 501) angler-hours of effort were expended in the Haines marine boat fishery between May 8 and July 2, 1995 to catch 255 (SE = 42) and harvest 228 (SE = 41) large chinook salmon (Table 5). This estimate was based on a sample of 425 boat-parties who fished 4,013 angler-hours (3,833 salmon-hours) and harvested 92 large (≥28 inches total length) and two small chinook salmon (Appendix A1 through A3). An estimated 193 (SE = 34) of the chinook salmon harvested in this fishery were wild, mature fish assumed to be returning to the Chilkat River (Table 5). Approximately 91% (8,606 salmon-hours, SE = 483) of the angler effort targeted chinook salmon. The remainder was directed toward other species, primarily Pacific halibut. An estimated 512 (SE = 69) small (sublegal, <28 inches total length) chinook salmon were caught, and 14 (SE = 13) were harvested (illegally). Seventy-seven percent (77%) of the estimated salmon effort and 88% of the estimated harvest of chinook salmon occurred between May 22 and June 18 (Table 5). Angling pressure for chinook salmon was relatively light during the first and last two weeks, so our coverage of the fishery for mature chinook salmon was essentially complete. Estimates by site are shown in Appendices A1 through A3. Charter boat anglers accounted for about 19% of the salmon effort (1,651 salmon-hours, SE = 243) and 22% of the harvest (50, SE = 12) of chinook salmon in this fishery.

Anglers returning to the Letnikof Dock were responsible for 75% of the estimated salmon effort (6,442 salmon-hours, SE = 273) and 72% of the estimated harvest (165, SE = 31) of large chinook salmon (Appendix A1). Anglers returning to the Chilkat State Park boat launch and the small boat harbor accounted for an estimated 811 (SE = 261) and 1,353 (SE = 301) salmon-hours of effort, respectively, and harvests of 42 (SE = 24) and 21 (SE = 9) large chinook salmon (Appendices A2 and A3), respectively.

Age and Length of Harvest

Technicians sampled a total of 94 chinook salmon for age and length during the study; 79 were assigned an age. Chinook salmon sampled at the small boat harbor (in Chilkoot Inlet) were significantly younger (χ^2 = 16.6, df = 1, P <0.001) than those sampled at the other harbors (in Chilkat Inlet), so these samples were analyzed separately. Fish landed at the small boat harbor are more likely to be from hatchery releases in Taiya Inlet (Figure 1), so this is a sensible result.

Of a total 88 chinook salmon sampled for age and length at the Chilkat Inlet harbors (Letnikof Dock and Chilkat State Park boat launch), 75 were assigned an age (Table 6). About half of the chinook harvested (51.1%, SE = 3.9%) were male. The predominant age class was age -1.4 (52.0%, SE = 4.5%).

Four of the six fish sampled at the small boat harbor were female. All four of the successfully aged fish were aged 1.2.

Table 5.-Total estimated effort, catch, and harvest of chinook salmon, with estimates of precision, in the Haines marine boat sport fishery, by biweek, May 8 through July 2, 1995.

	Non-derby		Derby			
	May 08–21	May 22–Jun 04	May 27–29	Jun 05–18	Jun 19–Jul 02	Total
Angler-hours						
Estimate	1,201	1,262	2,194	3,281	1,519	9,457
Variance	60,072	65,448	7,762	80,752	37,404	251,438
Precision [a]	0.40	0.40	0.08	0.17	0.25	0.10
Salmon-hours						
Estimate	1,162	1,262	2,194	3,136	852	8,606
Variance	62,754	65,448	7,762	83,277	14,237	233,478
Precision	0.42	0.40	0.08	0.18	0.27	0.11
Large chinook catch						
Estimate	23	56	26	145	5	255
Variance	43	546	4	1,160	12	1,765
Precision	0.56	0.82	0.15	0.46	1.36	0.32
Large chinook kept						
Estimate	22	51	23	127	5	228
Variance	43	571	4	1,019	12	1,649
Precision	0.58	0.92	0.17	0.49	1.36	0.35
Wild mature chinook kept (excludes hatchery and immature fish)						
Estimate	17	44	19	108	5	193
Variance	26	445	1	723	12	1,207
Precision	0.59	0.94	0.10	0.49	1.36	0.35
Small chinook catch						
Estimate	41	50	137	260	24	512
Variance	642	147	514	4,606	80	5,989
Precision	1.21	0.48	0.32	0.51	0.73	0.30
Small chinook kept						
Estimate	0	0	0	14	0	14
Variance				168		168
Precision				1.81		1.81

[a] Relative precision = 1.96 SE/estimate.

Table 6.-Estimated age composition and mean length-at-age of chinook salmon harvested at Chilkat Inlet harbors in the Haines marine boat sport fishery, May 8 through July 2, 1995.

	Brood year and age class				Total aged	Total sampled[a]
	1991	1990	1989	1988		
	1.2	1.3	1.4	1.5		
Male						
Sample size	11	11	15	1	38	45
Percent	28.9	28.9	39.5	2.6		51.1
SE	5.8	5.8	6.3	2.1		3.9
Mean length [b]	732	834	981	1,065		
SE	6	14	7			
Female						
Sample size	1	12	24	0	37	43
Percent	2.7	32.4	64.9			48.9
SE	2.1	6.0	6.2			3.9
Mean length	775	851	957			
SE		8	6			
All						
Sample size	12	23	39	1	75	88
Percent	16.0	30.7	52.0	1.3		
SE	3.3	4.2	4.5	1.0		
Mean length	735	843	966	1,065		
SE	4	8	5			

[a] Includes fish that were not assigned an age.

[b] Length measured in mm from snout to fork of tail.

Contribution to Commercial and Recreational Fisheries

Fraction of 1989 and 1990 Broods Tagged

Of the 877 chinook salmon from the 1988 brood year sampled in the Chilkat River drainage between 1991 and 1995, 59 had adipose clips from the wild-stock tagging program (Tables 1 and 7). The tagging fraction of fish sampled with gillnet and fish wheel in the lower river (n = 435) was significantly lower than that sampled on the spawning grounds (n = 442, χ^2 = 13.0, df = 1, P = 0.0003). Since sampling on the lower river was designed to be representative of the escapement over time, and it was not possible to tag wild fish in proportion to their abundance across the drainage, only the samples from the lower river sampling were used to estimate the tagging fraction of the entire drainage The estimated tagging fraction (θ) was thus 0.036782 (SE = 0.00904) for the 1988 brood year (Table 7).

Of 808 chinook salmon from the 1989 brood year sampled in the Chilkat River drainage between 1991 and 1995, 71 had adipose clips from the wild-stock and hatchery tagging programs (Tables 1 and 7). Tagging fractions of those sampled on the spawning grounds (n = 544) and in the lower river (n = 264) were not significantly different (χ^2 = 2.36, df = 1, P = 0.124). However, tagging fractions for fish sampled on the principal tagging and sampling areas, the Tahini and Kelsall rivers, were signi-ficantly different (χ^2 = 40.5, df = 1, P <0.001), and since hatchery back-planted brood year 1989 chinook salmon were not expected to be randomly distributed, only samples from the lower river were used to estimate the tagging fraction. The estimated tagging fraction (θ) was thus 0.109848 (SE = 0.0193) for the 1989 brood year (Table 7).

Table 7.-Number of 1988 and 1989 brood year chinook salmon sampled for adipose fin clips in the Chilkat River drainage by year and gear type/spawning tributary, 1991–1995.

		1988 brood year			1989 brood year		
Year	Gear/ tributary	Fish sampled	Fish with adclips	Marked/ unmarked	Fish sampled	Fish with adclips	Marked/ unmarked
LOWER RIVER RECOVERIES [a]							
1991	fish wheels	166	4	0.024	2	0	0.000
1992	gillnet	4	1	0.250			
1993	gillnet	79	3	0.038	12	0	0.000
1994	gillnet	135	5	0.037	76	9	0.118
1994	fish wheels	43	3	0.070	33	9	0.273
1995	gillnet	8	0	0.000	99	7	0.071
1995	fish wheels				42	4	0.095
Lower river total		435	16	0.036782	264	29	0.109848
SE				0.009035			0.019282
V(1/θ)				80.50029			3.16191
SPAWNING GROUND RECOVERIES							
1994	Big Boulder	26	1	0.038	17	0	0.000
1994	Tahini	113	20	0.177	71	18	0.254
1994	Kelsall	284	20	0.070	174	6	0.034
1995	Big Boulder	1	0	0.000	52	0	0.000
1995	Tahini	3	0	0.000	51	10	0.196
1995	Kelsall	15	2	0.133	179	8	0.045
Spawning ground total		442	43	0.0973	544	42	0.0772

[a] Only lower river recoveries were used to estimate the tagging fraction (θ) for contribution estimates.

The temporal recovery of wild and hatchery back-planted chinook salmon with CWTs from the 1989 brood year in random sampling programs did not differ significantly (odds ratio test, $\Phi = 0.27$ was within a 95% C.I. for $\Phi = 1$ of 0.07 to 1.12). Thus, recoveries of both wild and hatchery back-planted fish were used in estimating contributions.

Haines Sport Fishery

Wild and hatchery-reared chinook salmon released into the Chilkat River (1989–90 broods), fish with CWTs from upper Lynn Canal (89–91 broods), and fish from Kasnyku Bay in Chatham Strait (1990 brood) and Bear Cove near Sitka (1989 brood) were recovered in the 1995 Haines marine creel survey. Eighty-eight (88) chinook salmon (42% of estimated harvest) were sampled at Chilkat Inlet harbors (Letnikof Dock and Chilkat State Park) between May 8 and July 2, and 12 fish were missing fins. An estimated 140 (SE = 86) chinook were of hatchery origin and 84 (SE =69) were from the wild stock tagging program on the Chilkat River (Table 8). This total exceeds the estimated harvest of 207 fish from the on-site creel survey, largely because of the large estimated contribution (43 age 1.3 and 74 age 1.4, 117 total) that resulted from two recoveries of Northern Southeast Regional Aquaculture Association (NSRAA) hatchery fish. The estimate of 117 NSRAA fish is certainly biased high, a result of catching "rare" tagged fish. Most of the chinook harvested in this fishery are certainly wild Chilkat River fish. For comparison, the on-site survey estimated that only 70 age 1.3 fish

Table 8.-Contribution estimates of hatchery produced and wild coded wire tagged chinook salmon to the Haines marine sport fishery, with statistics used for computing estimates by biweek, 1995.

Hatchery	Release site	Tag code	Brood year	Biweek	Catch N	Var[N]	Sample n2	Aclp a1	Heads a2	Detect m1	Decode m2	Tags mc	Contribution n1	Boot-est	SE
CHILKAT INLET HARBOR RECOVERIES															
Hidden Falls	Taiya Inlet	04-40-57,59	91	Derby[a]	23	4	21	4	4	3	3	2	2	2	1
		04-40-57	91	6/05-6/18	120	977	49	6	6	6	6	1	2	2	2
		04-36-55	90	6/05-6/18	120	977	49	6	6	6	6	1	2	2	2
		Release site contribution:											6		3
Hidden Falls	Kasnyku Bay	04-36-42	90	6/05-6/18	120	977	49	6	6	6	6	1	43	44	43
		Release site contribution:											43		43
Medvejie	Bear Cove	04-36-29	89	6/05-6/18	120	977	49	6	6	6	6	1	74	75	74
		Release site contribution:											74		74
Jerry Myers	Pullen Creek	04-34-47	89	6/05-6/18	120	977	49	6	6	6	6	1	2	2	2
		Release site contribution:											2		2
Jerry Myers	Tahini River	04-01-011014	90	Derby	23	4	21	4	4	3	3	1	1	1	1
		Release site contribution:											1		1
Gastineau	Tahini River	04-01-020602	91	6/05-6/18	120	977	49	6	6	6	6	1	2	2	2
		Release site contribution:											2		2
Wild stock	Kelsall River	04-33-47	89	non-derby 5/22-6/04	51	571	11	2	1	1	1	1	84	69	69
		Release site contribution:											84		69
SMALL BOAT HARBOR RECOVERIES															
Hidden Falls	Taiya Inlet	04-40-56	91	5/08-5/21	14	34	3	1	1	1	1	1	5	5	4
		Release site contribution:											5		4
Burro Creek	Burro Creek	04-40-47	91	6/05-6/18	21	210	3	1	1	1	1	1	7	7	6
		Release site contribution:											7		6

[a] Derby was May 27 to May 29, 1995

(30.7%) and 133 age 1.4 fish (52.0%) were caught in the sport harvest (Table 6).

Six chinook salmon were sampled at the small boat harbor (two fish <28 inches in length), and two (large) fish were missing their adipose fins. An estimated 12 hatchery fish (SE = 7) were landed at this harbor between May 8 and July 2, very nearly the estimated total of 14 fish from the on-site creel survey.

Southeast Alaska Fisheries

Seventy-one (71) chinook salmon with CWTs released into the Chilkat River from brood years 1988 and 1989 were recovered (random, select, and volunteer recoveries) in various fisheries between 1992 and 1995 (Table 9; Appendix A4). All of these fish were recovered in the inside waters of Southeast Alaska (districts 111–115) north of Hidden Falls (Chatham Strait), excepting three recoveries in Yakutat and four recoveries in southcentral Alaska (Table 9, Figure 6).

CWTs from 24 brood year 1988 and 27 brood year 1989 Chilkat River chinook salmon were recovered in randomly sampled fisheries (Table 9) in Alaska. These recoveries were used to estimate a harvest of 1,629 (SE = 403) and 656 (SE = 152) brood year 1988 and 1989 Chilkat River fish, respectively, in the sampled sport and commercial fisheries in Alaska (Table 10). In addition, 97 chinook salmon were reported in the Chilkat Inlet and Chilkat River subsistence fisheries between 1992 and 1995. An estimated 19 (SE = 1) and 42 (SE = 2) fish were from the 1988 and 1989 brood years, respectively (Table 11). Thus, the total estimated harvests of Chilkat River chinook salmon are estimated at 1,648 (SE = 403) for brood year 1988 and 698 (SE = 152) for brood year 1989 (Table 11).

Table 9.-Number of random and non-random recoveries of 1988 and 1989 brood year Chilkat River coded wire tagged chinook salmon, by brood year, reported fishing district, and gear type, 1992 through 1995.

District	Random recoveries								Non-rand		
	Gillnet	Troll	Sport	PNP	Seine	Escape-ment	Total	%	Gillnet	Troll	Spor
						1988 BROOD YEAR					
111	2						2	2.6			
112			1	1	1		3	3.9			
114		5					5	6.6		1	
115	7		6			52	65	85.5	3		3
183											
225	1						1	1.3			
Subtotal	10	5	7	1	1	52	76	100.0	3	1	3
						1989 BROOD YEAR					
111	2		3				5	7.4			1
112											3
114		2					2	2.9			
115	9		7			41	57	83.8	3		4
183	2						2	2.9			
212	1						1	1.5			
221				1			1	1.5			
241											1
Subtotal	14	2	10	1	0	41	68	100.0	3	0	9
Total	24	7	17	2	1	93	144		6	1	12

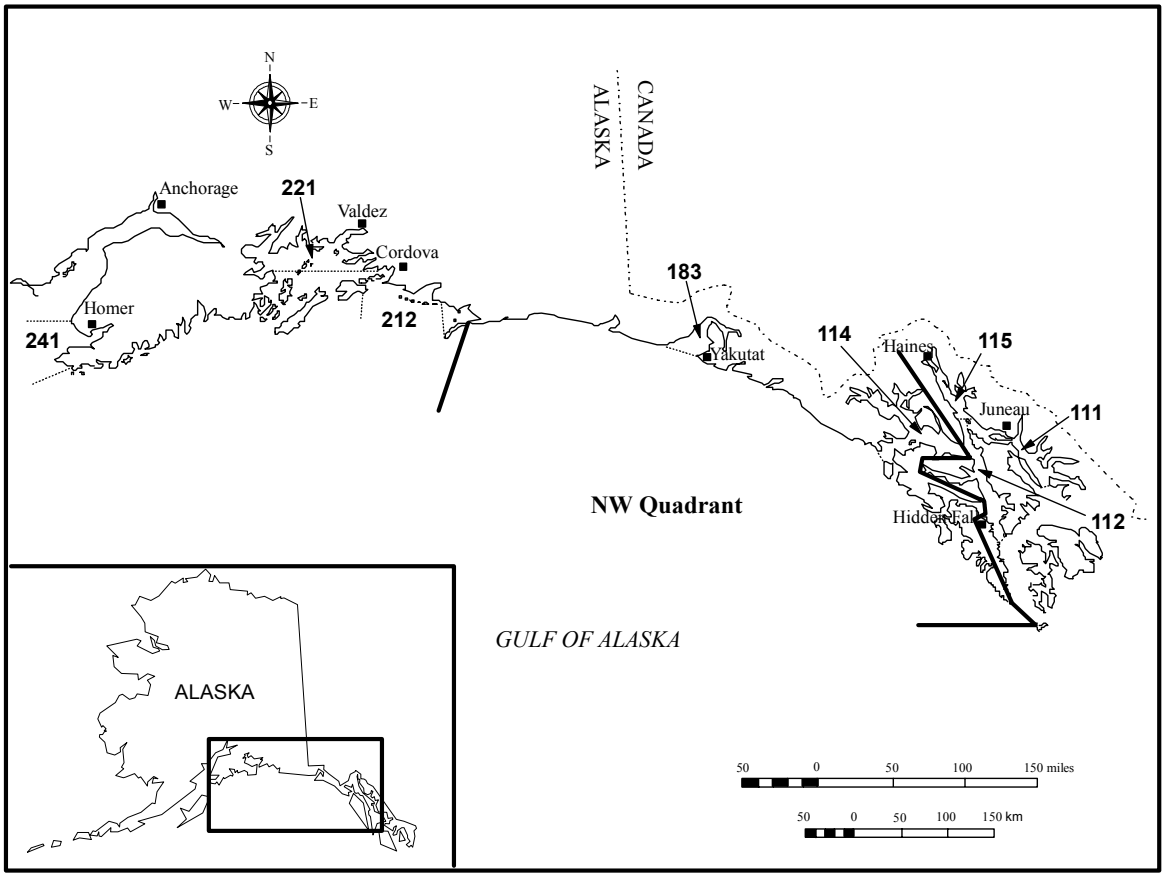

Figure 6.-Commercial fishing districts along the coast of Alaska where coded wire tagged Chilkat River chinook salmon were recovered.

The distribution of the harvest between gear groups was similar between the two brood years (Table 11). The Haines and Juneau sport fisheries combined for an average of 48.5% of the estimated harvest. Commercial gillnet fisheries averaged 30.7% of the harvest. The troll fishery averaged 14.7% of the estimated harvest but ranged between 22.5% and 7.0% of the harvest for the two brood years. The remainder of the harvest was split between the Chilkat subsistence, the district 112 seine, and cost recovery (PNP) fisheries at Hidden Falls and Valdez (Table 11, Figure 6).

The distribution of the estimated harvest by age class for the two brood years was slightly different (Table 12). The estimated harvest of 1988 brood chinook was relatively evenly distributed between ages 1.2 (27.9%), 1.3 (35.1%) and 1.4 (36.9%). In contrast, most brood year 1989 fish were harvested at age 1.3 (57.6%); harvests of age 1.2 fish (21.4%) and 1.4 fish (21.1%) were nearly equal. Most (51.2% and 75.2%) of the estimated harvest of age 1.2 fish was taken in the commercial gillnet fisheries for both brood years. Fish aged 1.3 from the 1988 brood year were evenly split between sport (37.3%), commercial gillnet (25.6%), and commercial troll (35.8%) fisheries. Age 1.3 fish from the 1989 brood year were harvested mostly (63%) in sport fisheries.

A list of computer data files used in this analysis is in Appendix A5.

Table 10.-Fishery contributions (n_1) and standard errors (SE) of 1988 and 1989 brood year Chilkat River chinook salmon. Estimated harvest (N) and its variance (Var[N]), sample size (n_2), and sampling parameters (a_1, a_2, m_1, m_2, mc) are shown for tags recovered during random sampling by recovery year, fishery, and time period.

	Stat.				Harvest		Sample	Aclp	Heads	Detect	Decode	Tags	Contribution		
Fishery	week	Biweek	Pd	Dist	N	Var[N]	(n_2)	(a_1)	(a_2)	(m_1)	(m_2)	(mc)	n_1	Boot-Est	SE
1988 BROOD YEAR															
1992 Recoveries-age 1.2															
Taku gillnet	39			111	8	0	6	3	3	3	3	1	36	35	33
Lynn Canal gillnet	26			115	200	0	98	32	32	31	31	2	111	111	80
Lynn Canal gillnet[a]	27/28			115	270	0	217	55	55	55	55	1	34	35	34
PWS gillnet	28			225	22	0	11	1	1	1	1	1	54	55	53
Chatham seine	31			112	44	0	36	5	5	5	5	1	33	34	33
NW quad troll	42/45		8	114	15,625	0	5,237	270	269	247	247	2	163	157	119
Hidden Falls PNP	26			112	245 [b]	0	245	74	73	67	67	1	28	28	28
1993 Recoveries-age 1.3															
Taku gillnet	26			111	1,992	0	825	58	58	56	56	1	66	64	67
Lynn Canal gillnet	27			115	161	0	123	45	45	43	43	1	36	34	35
Lynn Canal gillnet	28			115	140	0	83	13	13	13	13	1	46	45	45
NW quad troll	28		3	114	41,618	0	16,423	665	654	616	616	2	140	139	104
NW quad troll	35		5	114	20,354	0	8,444	365	357	333	333	1	67	68	68
Haines sport	24/25	12		115	127	1,273	48	5	5	4	4	3	216	215	142
1994 Recoveries-age 1.4															
Lynn Canal gillnet	26			115	196	0	99	17	17	15	15	1	54	55	52
Lynn Canal gillnet	28			115	136	0	89	13	13	12	12	1	42	41	41
Juneau sport	24	12		111	1,102	28,843	143	22	19	17	17	1	243	241	247
Haines sport	22	11		115	46	82	21	4	4	3	3	1	60	59	58
Haines sport	24/25	12		115	199	1,511	54	7	7	6	6	2	200	197	150
Total brood year 1988					82,485		32,202					24	1,629		403
1989 BROOD YEAR															
1993 Recoveries-age 1.2															
Taku gillnet	39			111	5	0	3	1	1	1	1	1	15	15	12
Lynn Canal gillnet	27			115	161	0	123	45	45	43	43	6	71	72	31
Lynn Canal gillnet	28			115	129	0	97	39	39	36	36	1	12	13	13
Cordova gillnet	28			212	27	0	18	1	1	1	1	1	14	14	14
Haines sport	26	13		115	83	1,159	21	1	1	1	1	1	36	35	34

- continued -

Table 10.-Page 2 of 2.

Fishery	Stat. week	Biweek	Pd	Dist	Harvest N	Harvest Var[N]	Sample (n_2)	Aclp (a_1)	Heads (a_2)	Detect (m_1)	Decode (m_2)	Tags (mc)	Contribution n_1	Contribution Boot-Est	Contribution SE
1989 BROOD YEAR (continued)															
1994 Recoveries-age 1.3															
Taku gillnet	39			111	8	0	6	3	3	3	3	1	36	35	33
Taku gillnet	26			111	1,119	0	730	57	57	51	51	1	14	14	14
Lynn Canal gillnet	27			115	182	0	50	19	19	19	19	1	33	34	32
Lynn Canal gillnet	30			115	97	0	78	27	27	26	26	1	11	11	11
Yakutat gillnet	25			183	37	0	10	1	1	1	1	1	34	32	32
Yakutat gillnet	27			183	53	0	23	1	1	1	1	1	21	20	20
NW quad troll	28		3	114	66,679	0	27,336	1,278	1,268	1,181	1,180	1	22	22	22
Valdez PNP	26			221	24 [b]	0	24	1	1	1	1	1	9	9	9
Juneau sport	24	12		111	1,102	28,843	143	22	19	17	17	1	81	79	77
Juneau sport derby	34			111	551	0	551	70	69	64	64	2	18	18	13
Haines sport	23	11		115	46	82	21	4	4	3	3	1	20	20	19
Haines sport	24/25	12		115	199	1,511	54	7	7	6	6	4	134	134	72
1995 Recoveries-age 1.4															
NW quad troll	14		1	114	4,740	0	1,605	116	116	104	104	1	27	26	27
Haines sport	22	12		115	51	571	11	2	1	1	1	1	84	69	69
Total brood year 1989					75,285		30,894					27	656		152

[a] Two strata were combined because more fish were sampled than were reported in the harvest.

[b] More chinook were sampled than reported in the harvest in these strata. The harvest was increased to equal the number of chinook sampled.

Table 11.-Estimated harvest of 1988 and 1989 brood year Chilkat River chinook salmon by fishery, age class, and year harvested.

		1988 Brood Year				1989 Brood Year				
Fishery	**Age**	Year harvested	Estimated harvest	SE	%	Year harvested	Estimated harvest	SE	%	**Average %**
SUBSISTENCE FISHERIES										
Chilkat Inlet	1.3	1993	1	0.1		1994	4	0.4		
	1.4	1994	6	0.4		1995	23	1.6		
	1.5	1995	2	0.7						
	Subtotal		9	1	0.6		27	2	3.9	2.2
Chilkat River[a]	1.2					1993	1	0.3		
	1.3	1993	6	0.6		1994	1	0.1		
	1.4	1994	2	0.1		1995	13	0.8		
	1.5	1995	1	0.4						
	Subtotal		9	0.7	0.6		15	0.9	2.1	1.3
	Total subsistence		19	1	1.1		42	2	6.0	3.5
RECREATIONAL FISHERIES										
Haines sport	1.2	1992				1993	36	34		
	1.3	1993	216	142		1994	154	74		
	1.4	1994	260	161		1995	84	69		
	Subtotal		476	215	28.9		274	107	39.3	34.1
Juneau sport	1.3	1993				1994	99	78		
	1.4	1994	243	247		1995				
	Subtotal		243	247	14.7		99	78	14.2	14.5
	Total recreational		719	327	43.6		373	133	53.4	48.5
GILLNET FISHERIES										
District 115 drift gillnet	1.2	1992	145	87		1993	83	34		
	1.3	1993	82	57		1994	44	34		
	1.4	1994	96	66		1995				
	Subtotal		323	123	19.6		127	48	18.2	18.9
District 111 drift gillnet	1.2	1992	36	33		1993	15	12		
	1.3	1993	66	67		1994	14	14		
	Subtotal		102	75	6.2		29	18	4.2	5.2
District 183 gillnet	1.3					1994	55	38		
	Subtotal						55	38	7.9	3.9
District 212 gillnet	1.2					1993	14	14		
	Subtotal						14	14	2.0	1.0
District 225 gillnet	1.2	1992	54	53						
	Subtotal		54	53	3.3					1.6
	Total gillnet		479	154	29.1		225	65	32.3	30.7
TROLL FISHERIES										
NW quadrant troll	1.2	1992	163	119		1993				
	1.3	1993	207	124		1994	22	22		
	1.4	1994				1995	27	27		
	Subtotal		370	172	22.5		49	35	7.0	14.7
	Total troll		370	172	22.5		49	35	7.0	14.7
MISCELLANEOUS FISHERIES										
District 112 seine	1.2	1992	33	33						
	Subtotal		33	33	2.0					1.0
Hidden Falls PNP	1.2	1992	28	28						
	Subtotal		28	28	1.7					0.8
Valdez PNP	1.3					1994	9	9		
	Subtotal						9	9	1.3	0.6
	Total miscellaneous		61	43	3.7		9	9	1.3	1.9
TOTAL ALL FISHERIES			1,648	403	100.0		698	152	100.0	

[a] The Chilkat River subsistence fishery harvest is included in the inriver abundance estimates for that year.

Table 12.-Estimated harvest of 1988 and 1989 brood year Chilkat River chinook salmon by age class and fishery type.

		1988 Brood Year			1989 Brood Year			
Age	**Fishery**	Estimated Harvest	SE	%	Estimated Harvest	SE	%	**Average %**
1.2	Subsistence				1	0.3	0.7	0.3
	Recreational				36	34	24.2	12.1
	Gillnet	235	107	51.2	112	38	75.2	63.2
	Troll	163	119	35.5				17.8
	Seine	33	33	7.2				3.6
	Cost recovery	28		6.1				3.1
	Subtotal	459	163	27.9	149	51	21.4	24.6
1.3	Subsistence	7	0.6	1.3	5	0.4	1.1	1.2
	Recreational	216	142	37.3	253	108	63.0	50.2
	Gillnet	148	88	25.6	113	53	28.1	26.9
	Troll	207	124	35.8	22	22	5.5	20.6
	Cost recovery				9	9	2.2	1.1
	Subtotal	578	208	35.1	402	122	57.6	46.3
1.4	Subsistence	8	0.4	1.3	36	1.8	24.5	12.9
	Recreational	503	295	82.8	84	69	57.2	70.0
	Gillnet	96	66	15.8				7.9
	Troll				27	27	18.4	9.2
	Subtotal	607	302	36.9	147	74	21.1	29.0
1.5	Subsistence	3	1	100.0				
	Subtotal	3	1	0.2				0.1
Total		1,648	403		698	152		

DISCUSSION

In estimating abundance we assumed: (a) tagging of large chinook salmon was in proportion to their numbers immigrating over time, or that immigration timing of the stocks was similar and sampling for marks on fish spawning in the areas sampled was random; (b) untagged fish did not recruit to the population between sampling events; (c) tagged and untagged fish suffered similar mortality rates between sampling events; and (d) fish did not lose marks. Considerable efforts were made to catch and mark fish in proportion to their abundance (assumption a) during the immigration by sampling uniformly across the escapement. Sampling effort for tags on the Kelsall and Tahini rivers (where >90% of spawning occurred in 1991 and 1992) was fairly constant across the time when spawning fish die and are available for sampling. Previous research on the Chilkat River (Johnson et al. 1992, 1993) suggests immigration timing is similar for Tahini and Kelsall river stocks. We also failed to reject the hypothesis that tagging ratios on the Tahini ($p = 0.048:1$) and Kelsall-Nataga ($p = 0.047:1$) rivers were different.

To achieve a random sample during the second sampling event, carcass sampling must not be size-selective. Carcass surveys are known to be selective for females in some situations (Pahlke et al. 1996*)*, but, while some selection may have occurred in this study, size selectivity did not appear to be significant. Conversely, sex composition of large chinook salmon sampled was significantly different between the marking and recovery events ($\chi^2 = 5.825$, df = 1, $P = 0.016$), which suggests that the estimate should have been stratified by sex. However, estimation of sex during the marking event is known to be biased (Ericksen 1995 and discussion below), and the small number of male recaptures (4) could yield a significant statistical bias (Seber 1982). Thus, we did not stratify by sex.

Assumption (b) is reasonable since tagging continued until only about one fish a day was being caught.

Recapture rates of fish tagged in the gillnet (0.057) and the fish wheels (0.111) suggest a failure of assumption (c), but we accept the hypothesis that the two recovery rates are equal ($\chi^2 = 1.8$, df = 1, $P = 0.185$).

Three of the marked fish that were recaptured were missing tags. However, these fish were still identified as marked fish by the secondary mark (opercular-punch). Thus, assumption (d) appears to be robust.

The 1995 immigration of 3,790 fish (SE = 805) appears to be the lowest since abundance estimates were initiated in 1991 (Table 13), although the estimate is not significantly different from other years. Other indicators (subsistence reports and field observations) concur that abundance was lower in 1995. This could be attributed to the very low relative strength of the 1990 brood year in 1995 (Table 14). Similarly, the low relative abundance estimated during 1993 was thought to be a result of the low relative strength of the 1987 brood year (Table 14, and Johnson 1993).

Sex was estimated with significant uncertainty early in the season: 4 out of 17 tagged fish that were recaptured on the spawning grounds were sexed incorrectly during the marking event, as judged by sex determination on the spawning ground (where sexual dimorphism is more evident). In past years, the proportion of females was overestimated during the marking event (Ericksen 1995). In contrast, this year 40% of the recaptured fish were sexed as male during the marking event, compared to 27% when the same fish were recaptured on the

Table 13.-Parameters used to estimate abundance of large (≥ age 1.3) chinook salmon to the Chilkat River, 1991–1995.

	1991[a]	1992[b]
Drift gillnet	(5/22–7/19)	(6/01–7/2
Number of fish marked	80	148
Fish wheels	(5/05–7/19)	
Number of fish marked	145	n/a
		SPAWNING GROU
Kelsall/Nataga	(8/06–9/05)	(7/29–9/0
Captures	507	571
Recoveries	15	18
Tahini gillnet	(7/22–8/09)	(7/16–8/1
Captures	155	158
Recoveries	9	4
Tahini carcass[e]	(8/11–9/03)	(8/14–8/3
Captures	39	156
Recoveries	2	1
Big Boulder	(8/05–9/12)	(7/31–8/1
Captures	30	20
Recoveries	0	0
All recovery areas		
Captures	733[f]	905
Recoveries	27[f]	23
Abundance	5,897	5,284
SE	1,005	949
Rel. precision[g]	0.33	0.35

[a] Taken from Johnson et al. (1992).

[b] Taken from Johnson et al. (1993).

[c] Taken from Johnson (1994).

[d] Taken from Ericksen (1995).

[e] Sampling was not consistent within or between years.

[f] Includes capture data from other systems.

[g] Relative precision = 1.96 SE/estimate.

Table 14.-Estimated annual age compositions for 1991–1995 returns and brood year returns (1984–1990) of large (≥ age 1.3) chinook salmon immigrating into the Chilkat River. Annual age compositions are estimated as the age composition in the the drift gillnet multiplied by the estimated abundance.

Return year	Age class 1.3	1.4	1.5	Total
1995				
Abundance	450	3,077	263	3,790
SE	93.2	653.1	53.2	805
1994[a]				
Abundance	2,405	4,276	114	6,795
SE	445	708	67	1,057
1993[b]				
Abundance	2,218	2,178	76	4,472
SE	468	461	54	851
1992[b]				
Abundance	1,689	3,595	0	5,284
SE	375	682		949
1991[b]				
Abundance	3,211	2,563	123	5,897
SE	586	484	64	1,005
Average				
Percent	42.8	55.8	1.4	
Abundance	2,381	3,153	78	5,612

BROOD YEAR RETURNS

Brood year	Age class 1.3	1.4	1.5	Total	SE
1984			123		
1985		2,563	0		
1986	3,211	3,595	76	6,882	901
1987	1,689	2,178	114	3,981	598
1988	2,218	4,276	263	6,757	851
1989	2,405	3,077		5,482	790
1990	450				
Average	1,995	3,138	115	5,776	

[a] Taken from Ericksen (1995).

[b] Taken from Johnson (1994).

spawning grounds. Sex composition during the marking event should be viewed with great caution.

Sport fishing effort and harvest patterns observed during 1995 were similar to those observed in recent years. During 1995, 75% of the estimated salmon effort and 72% of the estimated harvest of chinook salmon originated from the Letnikof Dock. The 1995 estimated harvest of large chinook salmon is similar to the harvest during the last 5 years the fishery was open (1988, 1989, 1990, 1993 and 1994) (Table 15, Figure 7). Sport fishing effort was also similar to that observed in 1989, 1990 and 1993. Catch of large chinook salmon per salmon hour of effort (CPUE) in 1995 was similar to that observed in recent years, but was lower than that observed during the mid-1980s (Table 15) when anglers were allowed to fish to the mouth of the river. The 1995 effort and harvest did not approach the levels that prompted fishery restrictions in 1987.

The harvest pattern of 1988 and 1989 brood Chilkat River chinook salmon in this study is similar to that observed in prior studies (Pahlke 1991, Johnson et al. 1993). First, these fish are harvested primarily in the inside waters of Southeast Alaska. Over 80% of the estimated harvest occurred in districts 111, 112, and 115, with the Haines area (district 115) harvest exceeding 40%. Second, the Haines sport fishery harvests mature fish as they return to spawn. All of the harvest in this fishery occurred early in the season (Figure 8), between statistical week 22 and 25. Finally, other fisheries tend to harvest these fish later in the season as immature fish. One notable exception to this is the Juneau sport fishery, where most of the Chilkat River chinook salmon harvest took place earlier in the year, (Figure 8) probably mature fish.

The estimates of harvest produced in this study do not consider all potentially important sources of fishing mortality. The largest potential for undocumented harvest involves incidental mortalities in the district 115 gillnet fishery. For example, studies of the commercial drift gillnet fisheries in Taku Inlet (Joe Muir, Commercial Fisheries Management and Development Division, Douglas, Alaska, personal communication) and Lynn Canal (Ericksen and Marshall, *In prep*.) indicate that the catch of chinook salmon in these fisheries may be ten times the reported harvest. Although some of these fish are released, many of these fish are retained for personal use, and incidental mortality of released fish is probably very high. Assuming that the true mortality of chinook salmon caught in these gillnet fisheries is ten times the reported catch, our harvest estimates derived through CWT recoveries may be biased low by as much as 330%. Also, some sport fisheries in northern Southeast Alaska that are not sampled for CWTs (e.g., Skagway, Hoonah, Gustavus, Tenakee, Elfin Cove) surely harvest a small number of Chilkat River fish, and it is likely that some chinook salmon incidentally harvested in the subsistence fishery are not reported.

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Table 15.-Estimated angler effort, and large (≥ 28 in) chinook salmon catch and harvest in the Haines marine boat sport fishery for similar sample periods, 1984–1995.

Year	Survey dates	Effort				Large (≥28") Chinook Salmon				
		Total angler hours	SE	Salmon-hours	SE	Catch	SE	Harvest	SE	CPUE[a]
1984[b]	5/06-6/30	10,253	[c]	9,855	[c]	1,072	[c]	1,072	[c]	0.109
1985[d]	4/15-7/15	21,598	[c]	20,582	[c]	1,705	[c]	1,696	[c]	0.083
1986[e]	4/14-7/13	33,857	[c]	32,533	[c]	1,659	[c]	1,638	[c]	0.051
1987[f]	4/20-7/12	26,621	2,557	22,848	2,191	1,094	189	1,094	189	0.048
1988[g]	4/11-7/10	36,222	3,553	32,723	3,476	505	103	481	101	0.015
1989[h]	4/24-6/25	10,526	999	9,363	922	237	42	235	42	0.025
1990[i]	4/23-6/21	[i]	[i]	11,972	1,169	248	60	241	57	0.021
1993[j]	4/26-7/18	11,919	1,559	9,069	1,479	349	63	314	55	0.038
1994[k]	5/09-7/03	9,726	723	7,682	597	269	41	220	32	0.035
1995	5/08-7/02	9,457	501	8,606	483	255	42	228	41	0.030
84-86 average		21,903		20,990		1,479		1,469		0.070
89-95 average		10,407		9,338		272		248		0.030

[a] Catch of large chinook salmon per salmon hour of effort.

[b] From Neimark (1985).

[c] Estimates of variance were not provided until 1987.

[d] From Mecum and Suchanek (1986).

[e] From Mecum and Suchanek (1987).

[f] From Bingham et al. (1988).

[g] From Suchanek and Bingham (1989).

[h] From Suchanek and Bingham (1990).

[i] From Suchanek and Bingham (1991), no estimate of the total angler effort and harvest was provided.

[j] From Ericksen (1994).

[k] From Ericksen (1995).

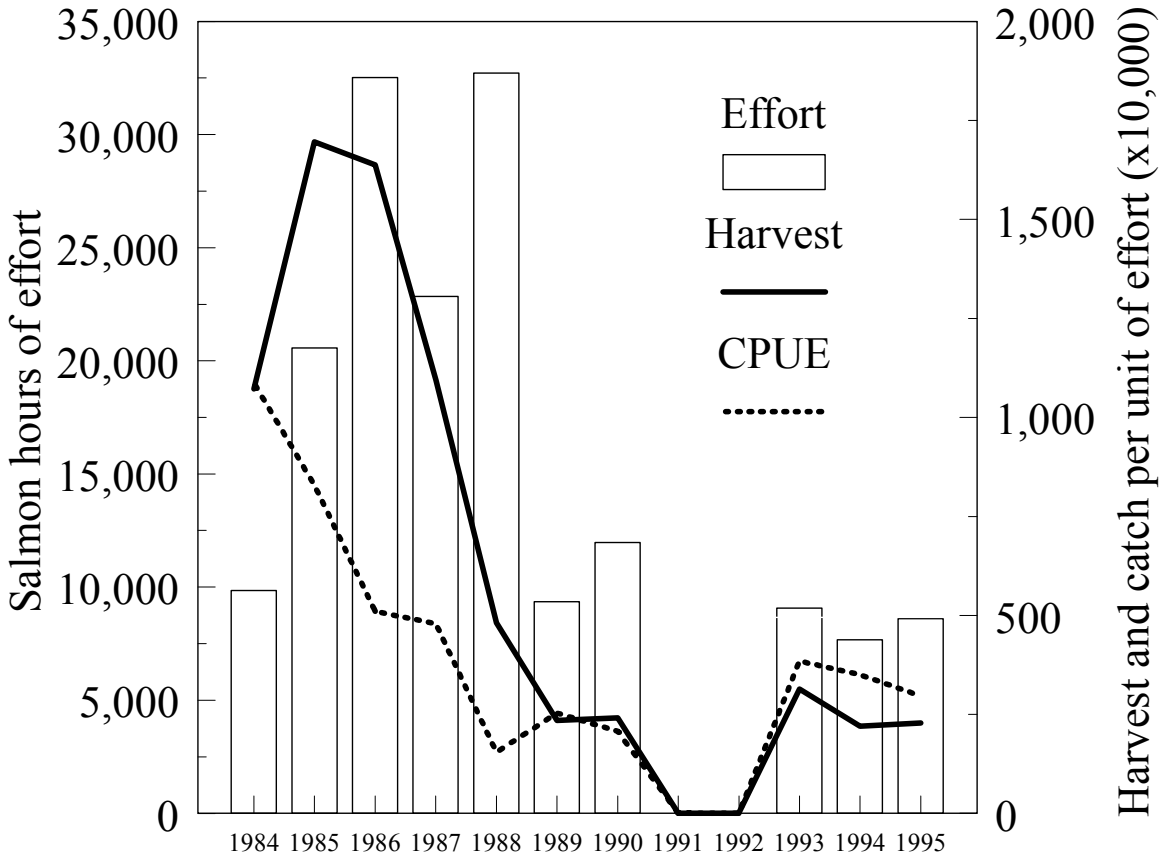

Figure 7.-Estimated angler effort for, and harvest and catch per unit of effort of large (≥ 28 in) chinook salmon in the Haines spring marine boat sport fishery, 1984-1995. Data taken from Table 15 (fishery was closed in 1991 and 1992).

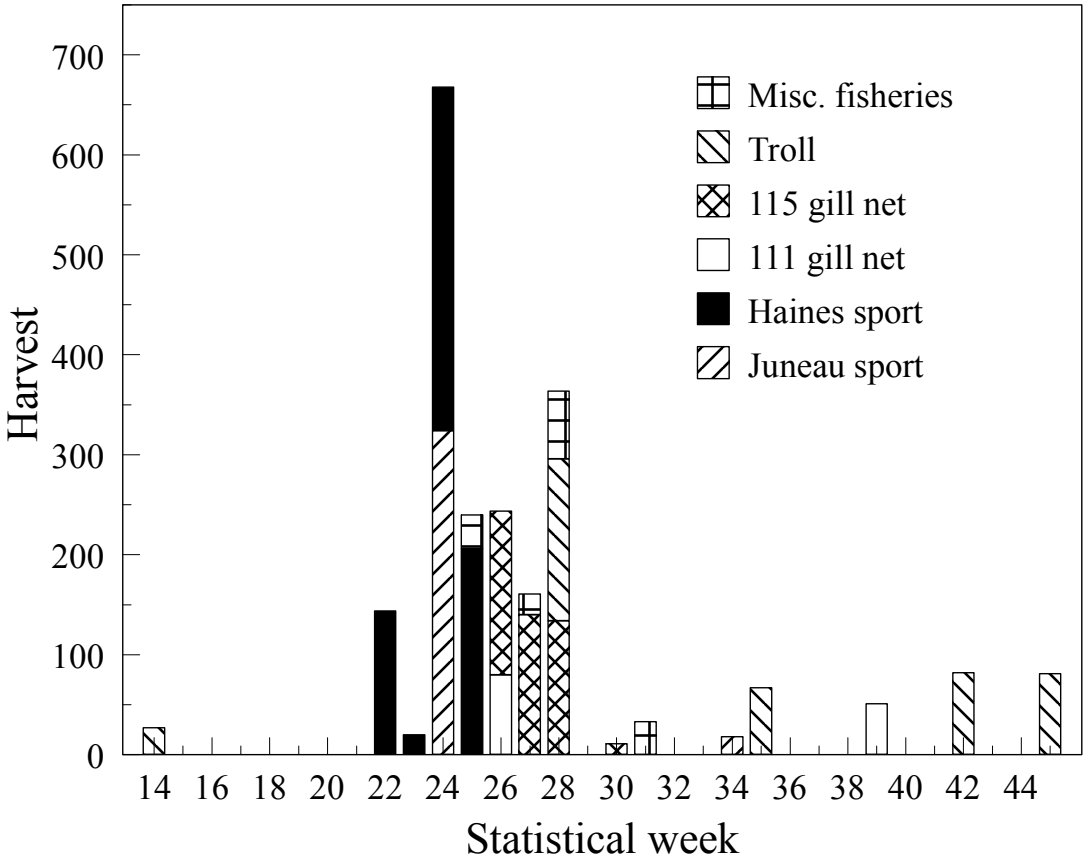

Figure 8.-Harvest of 1988 and 1989 brood year (combined) Chilkat River chinook salmon by fishery and statistical week, 1992 - 1985.

from adipose fin clipped chinook salmon to remove and read coded wire tags. Special thanks to Sam Bertoni and Anna Sharp at the tag lab, for providing timely CWT data summaries and answering my many requests for information. Donna Buchholz and Gail Heineman of the Research and Technical Services (RTS) Unit of the Division of Sport Fish processed mark sense forms and provided data control. Bob Marshall with RTS in Douglas provided biometric support in the study design, and analysis. Finally, Bob Marshall, Steve Elliott, Scott McPherson, and Sandy Sonnichsen provided critical review of this report.

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APPENDIX A

Appendix A1.-Sampling statistics, estimated effort, catch, and harvest of chinook salmon at the Letnikof Dock by week, May 8 through July 2, 1995.

			Non-derby	Derby					
	May 08	May 15	May 22	May 27	June 05	June 12	June 19	June 26	
	May 14	May 21	June 04	May 29	June 11	June 18	June 25	July 02	Total
Boats Counted	1	39	31	101	103	44	17	12	348
Angler-hs. Sampled	1	295	305	1,311	920	347	169	148	3,496
Salmon-hs. Sampled	1	291	305	1,311	879	347	166	120	3,420
Large Chinook Sampled	0	5	6	21	35	13	2	0	82
Small Chinook Sampled	0	0	0	0	0	0	0	0	0
Angler Hours									
Estimate	2	331	831	1,967	1,743	893	464	344	6,575
Variance	1	1,427	2,941	5,096	30,795	17,511	13,322	1,200	72,293
Salmon-hours									
Estimate	2	327	831	1,967	1,686	893	457	279	6,442
Variance	1	1,427	2,941	5,096	34,339	17,511	12,967	192	74,474
Large Chinook Catch									
Estimate	0	9	21	26	85	46	5	0	192
Variance		9	0	4	969	107	12		1,101
Large Chinook Kept									
Estimate	0	8	16	23	77	36	5	0	165
Variance		9	25	4	853	82	12		985
Wild Mature Chinook Kept									
Estimate	0	8	16	19	71	30	5	0	149
Variance		9	25	1	643	38	12		728
Small Chinook Catch									
Estimate	0	8	43	122	174	37	14	2	400
Variance		9	105	508	3,189	535	28	3	4,377

Appendix A2.-Sampling statistics, estimated effort, catch, and harvest of chinook salmon at the Chilkat State Park boat launch, by bi-week, May 22 through July 2, 1995.

	Non-derby	Derby			
	May 22	May 27	June 05	June 19	
	June 04	May 29	June 18	July 02	Total
Boats Counted	5	7	6	3	21
Angler-hs. Sampled	43	68	43	10	164
Salmon-hs. Sampled	43	68	43	1	155
Large Chinook Sampled	5	0	1	0	6
Small Chinook Sampled	0	0	0	0	0
Angler-hours					
Estimate	301	203	277	75	856
Variance	59,010	2,282	6,563	3,991	71,846
Salmon-hours					
Estimate	301	203	277	30	811
Variance	59,010	2,282	6,563	481	68,336
Large Chinook Catch					
Estimate	35	0	7	0	42
Variance	546		42		588
Large Chinook Kept					
Estimate	35	0	7	0	42
Variance	546		42		588
Wild Mature Chinook Kept					
Estimate	28	0	7	0	35
Variance	420		42		462
Small Chinook Catch					
Estimate	7	15	7	0	29
Variance	42	6	42		90

Appendix A3.-Sampling statistics, estimated effort, catch, and harvest of chinook salmon at the Small Boat Harbor, by bi-week, May 8 through July 2, 1995.

		Non-derby	Derby			
	May 08	May 22	May 27	June 05	June 19	
	May 21	June 04	May 29	June 18	July 02	Total
Boats Counted	31	4	1	9	11	56
Angler-hs. Sampled	187	19	8	53	86	353
Salmon-hs. Sampled	179	19	8	40	12	258
Large Chinook Sampled	3	0	0	1	0	4
Small Chinook Sampled	0	0	0	2	0	2
Angler-hours						
Estimate	868	130	24	368	636	2,026
Variance	58,644	3,497	384	25,883	18,891	107,299
Salmon-hours						
Estimate	833	130	24	280	86	1,353
Variance	61,326	3,497	384	24,864	597	90,668
Large Chinook Catch						
Estimate	14	0	0	7	0	21
Variance	34			42		76
Large Chinook Kept						
Estimate	14	0	0	7	0	21
Variance	34			42		76
Wild Mature Chinook Kept						
Estimate	9	0	0	0	0	9
Variance	17					17
Small Chinook Catch						
Estimate	33	0	0	42	8	83
Variance	633			840	49	1,522
Small Chinook Kept						
Estimate	0	0	0	14	0	14
Variance				168		168

Appendix A4.-Random, select, and volunteer recoveries of 1988 and 1989 coded wire tagged Chilkat River chinook salmon.

Tag Code	Head Number	Recovery Date	Stat. Wk	Gear	Dist.	Sub dist.	H[b]	n2	a1	a2	m1	m2
Brood year 1988 random recoveries												
42710	24915	6/23/92	26	GILLNET	115		200	98	32	32	31	31
42714	24916	6/23/92	26	GILLNET	115		200	98	32	32	31	31
42710	3515	6/25/92	26	PNP FISH	112	22	245[a]	245	74	73	67	67
42710	75746	7/7/92	28	GILLNET	225		22	11	1	1	1	1
42837	23804	7/9/92	27&28	GILLNET	115		270	217	55	55	55	55
42714	50268	7/28/92	31	SEINE	112		44	36	5	5	5	5
42715	37986	8/23/92	35	ESCAPEMENT	115	32						
42710	37988	8/30/92	36	ESCAPEMENT	115	32						
42714	17825	9/22/92	39	GILLNET	111		8	6	3	3	3	3
42837	53023	10/15/92	42	TROLL	114	70	15,625	5,237	270	269	247	247
42837	52960	11/2/92	45	TROLL	114	70	15,625	5,237	270	269	247	247
43337	94053	6/11/93	24	SPORT	115	32	109	48	5	5	4	4
42714	93957	6/12/93	24	SPORT	115	32	109	48	5	5	4	4
42837	94055	6/16/93	25	SPORT	115	32	109	48	5	5	4	4
42837	21749	6/22/93	26	GILLNET	111	32	1,992	825	58	58	56	56
42710	94010	6/29/93	27	ESCAPEMENT	115	32						
43337	11107	6/30/93	27	GILLNET	115		161	123	45	45	43	43
42837	94011	7/3/93	27	ESCAPEMENT	115	32						
42714	2038	7/6/93	28	TROLL	114	70	41,618	16,423	665	654	616	616
42710	2040	7/6/93	28	TROLL	114	70	41,618	16,423	665	654	616	616
42837	94013	7/14/93	29	ESCAPEMENT	115	32						
43337	11155	7/15/93	29	GILLNET	115		140	83	13	13	13	13
42710	94061	7/24/93	30	ESCAPEMENT	115	32						
42710	94015	8/4/93	32	ESCAPEMENT	115	32						
42710	94016	8/4/93	32	ESCAPEMENT	115	32						
42710	94017	8/4/93	32	ESCAPEMENT	115	32						
42843	94020	8/13/93	33	ESCAPEMENT	115	32						
42710	2528	8/22/93	35	TROLL	114	25	20,354	8,444	365	357	333	333
42837	94037	8/24/93	35	ESCAPEMENT	115	32						
43337	3451	5/24/94	22	SPORT		32	36	20	4	4	3	3
42710	3453	6/6/94	24	SPORT	115	32	139	50	7	7	6	6
43337	2311	6/7/94	24	SPORT	112	15	1,102	143	22	19	17	17
43337	3474	6/15/94	25	SPORT	115	32	139	50	7	7	6	6
42714	20240	6/21/94	26	GILLNET	115		196	99	17	17	15	15
42715	30145	7/5/94	28	GILLNET	115		136	89	13	13	12	12
42714	3476	8/10/94	33	ESCAPEMENT	115	32						
43337	3477	8/11/94	33	ESCAPEMENT	115	32						
42843	3478	8/14/94	34	ESCAPEMENT	115	32						
43337	3479	8/16/94	34	ESCAPEMENT	115	32						
42715	3480	8/18/94	34	ESCAPEMENT	115	32						
42715	3481	8/18/94	34	ESCAPEMENT	115	32						
42837	3515	8/18/94	34	ESCAPEMENT	115	32						
43337	3482	8/19/94	34	ESCAPEMENT	115	32						
42715	3483	8/19/94	34	ESCAPEMENT	115	32						
42710	3558	8/19/94	34	ESCAPEMENT	115	32						
42710	3485	8/20/94	34	ESCAPEMENT	115	32						
42714	3519	8/20/94	34	ESCAPEMENT	115	32						
42714	3486	8/21/94	34	ESCAPEMENT	115	32						
42715	3523	8/21/94	34	ESCAPEMENT	115	32						
42837	3525	8/21/94	34	ESCAPEMENT	115	32						
43337	3526	8/21/94	34	ESCAPEMENT	115	32						

-continued-

Appendix A4.-Page 2 of 4.

Tag Code	Head Number	Recovery Date	Stat. Wk	Gear	Dist.	Sub dist.	H	n2	a1	a2	m1	m2
42837	3527	8/22/94	35	ESCAPEMENT	115	32						
42710	3487	8/23/94	35	ESCAPEMENT	115	32						
42837	3529	8/23/94	35	ESCAPEMENT	115	32						
42837	3530	8/23/94	35	ESCAPEMENT	115	32						
42714	3488	8/24/94	35	ESCAPEMENT	115	32						
42837	3533	8/24/94	35	ESCAPEMENT	115	32						
42715	3491	8/25/94	35	ESCAPEMENT	115	32						
42710	3492	8/25/94	35	ESCAPEMENT	115	32						
42837	3537	8/25/94	35	ESCAPEMENT	115	32						
42837	3538	8/25/94	35	ESCAPEMENT	115	32						
42837	3539	8/25/94	35	ESCAPEMENT	115	32						
42837	3540	8/25/94	35	ESCAPEMENT	115	32						
42837	3541	8/25/94	35	ESCAPEMENT	115	32						
42710	3494	8/26/94	35	ESCAPEMENT	115	32						
42710	3495	8/27/94	35	ESCAPEMENT	115	32						
42710	3496	8/27/94	35	ESCAPEMENT	115	32						
42837	3542	8/27/94	35	ESCAPEMENT	115	32						
42837	3544	8/27/94	35	ESCAPEMENT	115	32						
42710	3497	8/30/94	36	ESCAPEMENT	115	32						
42837	3546	9/1/94	36	ESCAPEMENT	115	32						
42837	3547	9/1/94	36	ESCAPEMENT	115	32						
42843	3500	9/2/94	36	ESCAPEMENT	115	32						
42715	3639	9/2/94	36	ESCAPEMENT	115	32						
42714	99375	8/11/95	32	ESCAPEMENT	115	32						
42843	99379	8/18/95	33	ESCAPEMENT	115	32						
Brood year 1988 select recoveries												
43337	13003	6/22/92	26	GILLNET	115	10						
42710	13023	8/5/92	32	GILLNET	115	31						
42714	13026	8/12/92	33	GILLNET	115	31						
42837	33638	11/6/92	45	TROLL	114	70						
42710	34002	5/15/94	21	SUBSISTENCE	183	10						
42710	3501	5/23/94	22	SPORT	115	32						
42843	3503	6/6/94	24	SPORT	115	32						
42837	3504	6/6/94	24	SPORT	115	32						
Brood year 1989 random recoveries												
401011008	93959	6/22/93	26	SPORT	115	32	68	21	1	1	1	1
43338	21801	6/29/93	27	GILLNET	115		161	123	45	45	43	43
401011010	21986	6/29/93	27	GILLNET	115		161	123	45	45	43	43
401011008	21989	6/29/93	27	GILLNET	115		161	123	45	45	43	43
401011008	21997	6/29/93	27	GILLNET	115		161	123	45	45	43	43
43347	84250	6/29/93	27	GILLNET	115		161	123	45	45	43	43
43347	11102	6/30/93	27	GILLNET	115		161	123	45	45	43	43
43347	84754	7/6/93	28	GILLNET	115		129	97	39	39	36	36
401011009	50938	7/6/93	28	GILLNET	212		27	18	1	1	1	1
401011008	94059	7/23/93	30	ESCAPEMENT	115	32						
401011009	94060	7/24/93	30	ESCAPEMENT	115	32						
401011008	94062	7/25/93	31	ESCAPEMENT	115	32						
401011009	94063	7/26/93	31	ESCAPEMENT	115	32						
401011010	94064	7/26/93	31	ESCAPEMENT	115	32						
43347	94021	8/14/93	33	ESCAPEMENT	115	32						
401011010	94074	8/20/93	34	ESCAPEMENT	115	32						
401011008	14384	9/22/93	39	GILLNET	111	32	5	3	1	1	1	1
43338	3471	6/1/94	23	SPORT	115	32	36	20	4	4	3	3

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Tag Code	Head Number	Recovery Date	Stat. Wk	Gear	Dist.	Sub dist.	H	n2	a1	a2	m1	m2
43339	3454	6/6/94	24	SPORT	115	32	139	50	7	7	6	6
43347	2156	6/8/94	24	SPORT	111	50	1,102	143	22	19	17	17
43338	3455	6/9/94	24	SPORT	115	32	139	50	7	7	6	6
43347	3456	6/11/94	24	SPORT	115	32	139	50	7	7	6	6
43347	34101	6/13/94	25	GILLNET	183	10	37	10	1	1	1	1
401011009	3475	6/15/94	25	SPORT	115	32	139	50	7	7	6	6
401011010	3505	6/19/94	26	ESCAPEMENT	115	32						
401011010	3506	6/21/94	26	ESCAPEMENT	115	32						
43338	20616	6/22/94	26	GILLNET	111		1,119	730	57	57	51	51
43338	81172	6/23/94	26	PNP FISH	221	61	24[a]	24	1	1	1	1
43347	30153	6/27/94	27	GILLNET	115		182	50	19	19	19	19
401011008	34055	6/28/94	27	GILLNET	183	10	53	23	1	1	1	1
401011009	87014	7/5/94	28	TROLL	114	30	66,679	27,336	1,278	1,268	1,181	1,180
43347	30578	7/19/94	30	GILLNET	115		97	78	27	27	26	26
401011008	3507	8/10/94	33	ESCAPEMENT	115	32						
401011008	3509	8/14/94	34	ESCAPEMENT	115	32						
43347	6601	8/19/94	34	SPORT	111		551	551	70	69	64	64
401011008	3517	8/19/94	34	ESCAPEMENT	115	32						
43347	35522	8/20/94	34	SPORT	111		551	551	70	69	64	64
43347	3484	8/20/94	34	ESCAPEMENT	115	32						
43338	3518	8/20/94	34	ESCAPEMENT	115	32						
401011009	3522	8/20/94	34	ESCAPEMENT	115	32						
401011010	3524	8/21/94	34	ESCAPEMENT	115	32						
401011008	3528	8/22/94	35	ESCAPEMENT	115	32						
401011009	3531	8/23/94	35	ESCAPEMENT	115	32						
401011009	3532	8/23/94	35	ESCAPEMENT	115	32						
43347	3489	8/24/94	35	ESCAPEMENT	115	32						
401011009	3534	8/24/94	35	ESCAPEMENT	115	32						
401011010	3536	8/25/94	35	ESCAPEMENT	115	32						
43347	3493	8/26/94	35	ESCAPEMENT	115	32						
43338	3545	8/28/94	36	ESCAPEMENT	115	32						
43347	3498	8/31/94	36	ESCAPEMENT	115	32						
43347	3499	8/31/94	36	ESCAPEMENT	115	32						
43347	99254	4/7/95	14	TROLL	114	21	4,740	1,605	116	116	104	104
43347	99306	6/3/95	22	SPORT	115	32						
401011008	99324	8/8/95	32	ESCAPEMENT	115	32						
401011008	99326	8/13/95	33	ESCAPEMENT	115	32						
401011009	99327	8/14/95	33	ESCAPEMENT	115	32						
401011008	99348	8/14/95	33	ESCAPEMENT	115	32						
43347	99376	8/14/95	33	ESCAPEMENT	115	32						
43347	99349	8/15/95	33	ESCAPEMENT	115	32						
401011008	99350	8/15/95	33	ESCAPEMENT	115	32						
43347	99353	8/17/95	33	ESCAPEMENT	115	32						
43347	99378	8/17/95	33	ESCAPEMENT	115	32						
43339	99380	8/19/95	33	ESCAPEMENT	115	32						
401011009	99354	8/21/95	34	ESCAPEMENT	115	32						
43339	99381	8/22/95	34	ESCAPEMENT	115	32						
43347	99356	8/23/95	34	ESCAPEMENT	115	32						
43347	99383	8/25/95	34	ESCAPEMENT	115	32						
43347	99384	8/25/95	34	ESCAPEMENT	115	32						
Brood year 1989 select recoveries												
401011009	94052	5/28/93	22	SPORT	115	32						
401011008	2406	6/3/94	23	SPORT	111	31						

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Tag Code	Head Number	Recovery Date	Stat. Wk	Gear	Dist.	Sub dist.	H	n2	a1	a2	m1	m2
401011008	2110	6/6/94	24	SPORT	112	16						
401011009	168	6/12/94	25	SPORT	112	15						
401011009	3561	6/21/94	26	GILLNET	115	31						
401011009	3458	7/4/94	28	GILLNET	115	10						
401011009	3603	8/1/94	32	GILLNET	115							
401011009	99229	5/12/95	19	SPORT	112	16						
43338	99304	5/26/95	21	SPORT	115	32						
401011009	99313	6/13/95	24	SPORT	115	32						
Brood year 1989 volunteer recoveries												
401011009	31	8/14/94	34	SPORT	115	34						
43347	26701	8/25/94	35	SPORT	241	09						

[a] The reported harvest in these strata was less than the number of chinook salmon sampled. Thus, the harvest was adjusted to equal the number sampled.

[b] Sampling statistic: harvest (N), sample size (n_2), number in sample with missing fins (a_1), number of heads arriving at lab (a_2), number of heads with cwts detected (m_1), and number of cwts found and decoded (m_2).

Appendix A5.-Computer data files used in the analysis of this report.

File name	Description
F0810MA5.DTA	Mark-sense ASCII file containing angler interview data from the Haines marine sport fishery in 1995.
1OVERTC.EXE	Program to estimate the variance of θ^{-1}.
CWT4.EXE	Program to estimate harvests from CWT recovery data.
HAINE.PRG	Dbase program to generate SAS data file from mark-sense file.
HAINESCT.PRN	Count file (text) used in HAMC95.SAS to expand for missing interview data.
HAMC95.SAS	SAS program to estimate effort and harvest in the Haines marine sport fishery using HAINESCT.PRN and output from HAINE.PRG.
95AWL.XLS	Excel workbook containing all age-length data from the Haines sport fishery, and tagging and recovery efforts in the Chilkat River drainage during 1995.
95ODDRAT.XLS	Excel workbook used to test whether the random recoveries of BY89 wild and hatchery backplanted CWT'ed were significantly different over time.
95POPEST.XLS	Excel workbook used to estimate 1995 abundance of Chilkat River chinook.
95SPAWN.XLS	Excel workbook containing raw data from chinook sampled on the Chilkat River spawning tributaries during 1995.
95TAGS.XLS	Excel workbook containing raw data from chinook captured in the lower Chilkat River during 1995.
CONT8889.XLS	Excel workbook containing all recoveries of BY88 and BY89 CWT'ed Chilkat chinook by year, 1992-1995.
THETAKAT.XLS	Excel workbook used to estimate θ for BY88 and BY89 Chilkat chinook.