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ABSTRACT

Radio telemetry and a mark-recapture experiment were used to estimate spawning distribution and number of chinook salmon (*Oncorhynchus tshawytscha*) age 1.3 and older immigrating to the Chilkat River near Haines, Alaska, in 1992.

One hundred forty-eight large (age 1.3 and older) chinook salmon were captured with gill nets between Chilkat River miles 7 and 8 between June 1 and July 22, 1992. Seventy-four of these fish were implanted with radio transmitters, and 73 were tagged with solid-core spaghetti tags; 66 of the fish with transmitters were tracked to areas of the drainage where it was assumed they spawned.

The mean date of the immigration of large chinook salmon sampled was July 6. An estimated 72.7% (SE = 5.5%) of the immigration spawned in the Kelsall River system, 19.7% (SE = 4.9%) in the Tahini River, 4.6% (SE = 2.6%) in the Klehini River system, 1.5% (SE = 1.5%) in the mainstem Chilkat River, and 1.5% (SE = 1.5%) in Assignation Creek.

Between July 29 and September 4, 1992, 905 large chinook salmon spawning in the Chilkat River drainage, mostly on the Kelsall and Tahini rivers, were inspected for tags in order to estimate abundance. A modified Petersen model (n_1 = 139, n_2 = 905, m_2 = 23) was used to estimate that 5,284 (SE = 949) chinook salmon age 1.3 and older immigrated to the Chilkat River.

These results are similar to those in 1991. The estimated immigration to the Chilkat River system was much greater than the historical expansion estimator would have indicated, and the historic index areas, Big Boulder and Stonehouse Creeks, again were not major spawning locations.

A complete analysis of the coded wire tag recovery database for the 1984 and 1985 brood year releases into the Tahini River is also presented. The contribution to sport and commercial fisheries from Tahini River fish was estimated at 310 fish (1984 brood year) and 530 fish (1985 brood year). Estimated harvests were 372 fish (commercial troll), 264 fish (commercial drift gill net), and 204 fish (sport fishery).

KEY WORDS: Radio telemetry, chinook salmon, *Oncorhynchus tshawytscha*, Chilkat River, escapement, spawning distribution, mark-recapture, abundance, coded wire tags, contribution estimates, age composition, Kelsall River, Nataga Creek, Tahini River, Klehini River, Big Boulder Creek, Assignation Creek, Haines, Alaska.

INTRODUCTION

The Chilkat River is a large, glacial system that originates in Yukon, Canada, and has its terminus near Haines, Alaska (Figure 1). The mainstem and major tributaries (Tsirku, Klehini, Kelsall, and Tahini rivers) comprise approximately 220 miles of river channel in a watershed covering about 1,000 square miles. The river system originates from many glaciers and flows through rugged, dissected mountainous terrain, converging to a silty, braided river system (Bugliosi 1988).

Beginning in 1981, indices of abundance for large (age 1.3 and older)[1] chinook salmon were made from aerial survey counts in Stonehouse and Big Boulder Creeks (Figure 1). These areas were selected because they were the only clear-water sections with spawning chinook salmon that could be effectively surveyed. Prior to 1992 the indices were used in a program to monitor trends in chinook salmon escapement in Southeast Alaska (Pahlke 1992).

In 1991, the Division of Sport Fish tagged chinook salmon entering the Chilkat River with radio transmitters and numbered plastic tags to estimate the spawning distribution and immigration to the drainage. This research was motivated by concern that Chilkat River chinook salmon were severely depleted and/or that the peak survey counts in Stonehouse and Big Boulder Creeks were providing inaccurate and/or imprecise indices of spawning escapement for the drainage.

During 1991, 54% (SE = 6.2%) of the sampled immigration to the Chilkat River drainage spawned in the Kelsall River system, 33% (SE = 6.0%) in the Tahini River, 8% (SE = 3.7%) in the Klehini River system, 4% (SE = 1.4%) in the mainstem Chilkat River, and 1% (SE = 0.8%) in Assignation Creek (Johnson, Marshall, and Elliott, 1992). Chapman's modified Petersen estimator was used to estimate that 5,897 (SE = 1,005) chinook salmon age 1.3 and older immigrated to the Chilkat River in 1991.

Chinook salmon eggs were collected on the Tahini River in 1984 and 1985, incubated and hatched at Crystal Lake hatchery. The fry were coded-wire tagged and released back into the Tahini River. Following these releases, escapement to Tahini River was sampled for coded-wire tags (CWT's) to identify migratory routes, timing, and contribution of chinook salmon to fisheries in Southeast Alaska (Pahlke, Mecum, and Marshall 1990, Pahlke 1991). These studies reported that tagged fish from the Tahini River were being recovered mostly in the inside waters of northern Southeast Alaska and did not contribute heavily to the overall chinook harvest.

Experiments to estimate the number of chinook salmon immigrating to the Chilkat River and the distribution of spawning were repeated in 1992 to determine the consistency of the 1991 findings. This paper presents those results, and an analysis of the entire CWT recovery database for the 1984 and 1985 brood year releases into the Tahini River; contributions to sport and commercial fisheries from the 1984 and 1985 brood years are now complete.

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[1] Traditionally, chinook salmon over 660 mm (mid-eye to fork of tail) have been considered large (3, 4, and 5 ocean) fish, aged 1.3 and above (numerals preceding the decimal refer to number of freshwater annuli, numerals following the decimal are the number of marine annuli, and total age is the sum of these numbers plus one).

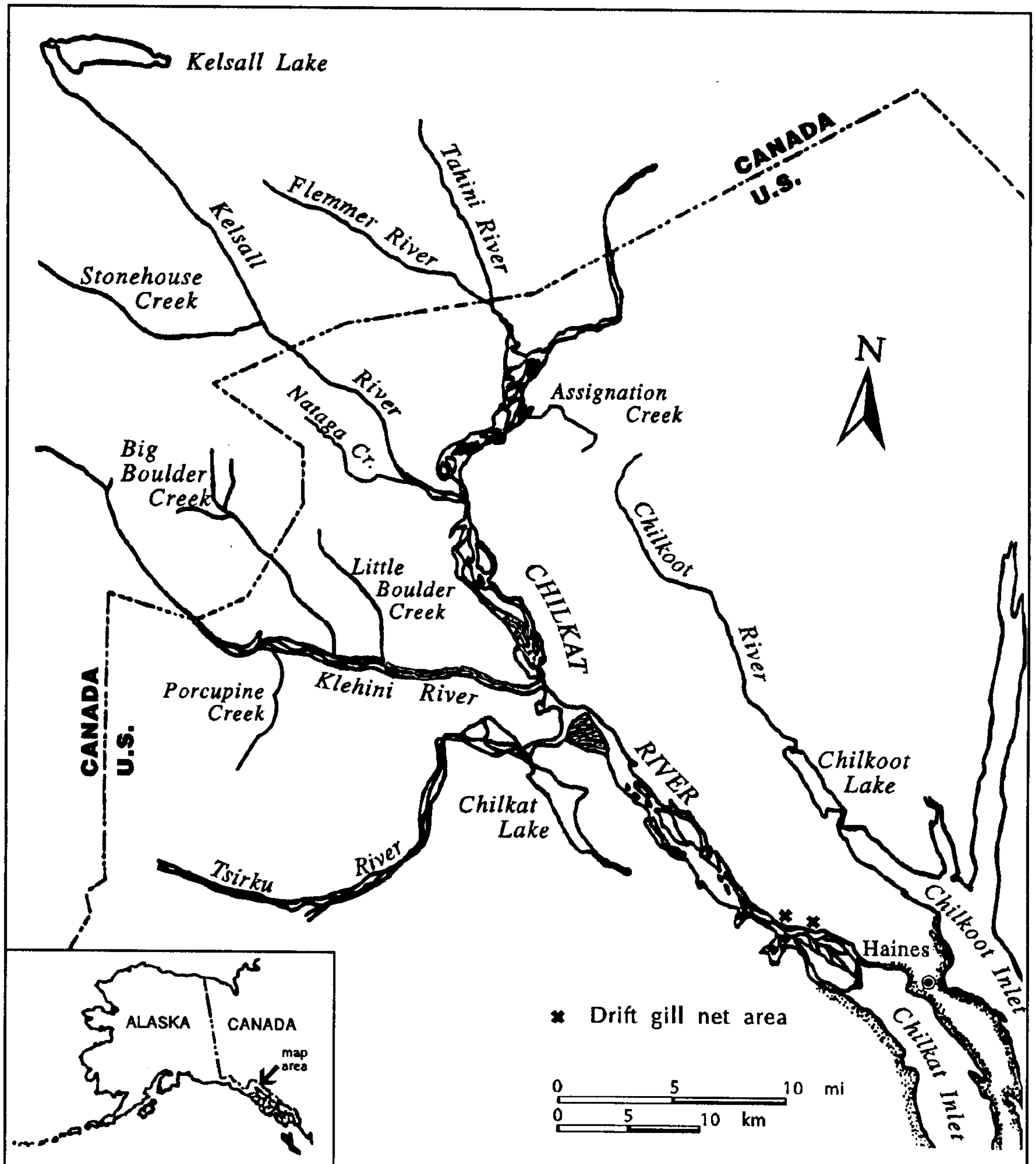

Figure 1. Main features of the Chilkat River drainage.

METHODS

Gill nets 50 feet long and 10 feet deep, with a 7.5-inch stretched mesh were drifted between Chilkat River miles 7 and 8, from June 1 through July 22, 1992. The drifts occurred where the main channel of the river was constrained to an area approximately 300 feet wide and 5 to 8 feet deep (Figure 2).

Each day except June 6 and 7, two technicians made 43 drifts between 0600 and 1400 hours. Daily fishing effort (43 drifts) was selected a priori to yield a desired total catch of 225 chinook salmon. Fishing was conducted from an 18-foot boat in four adjoining 0.3-mile-long areas, which were marked along a 1.2 mile long stretch of river (Figure 2). The 43 drifts took about 6 hours to complete when fish were not captured. Fishing continued from area 1 to area 2 and then to area 3 if fish were not being captured. If a (0.3 mile) drift was prematurely terminated because a fish was caught, or the net became entangled or drifted into shallow water, the terminated drift was subsequently completed before a new drift was started. Area 4 was usually avoided because of snags and other physical hazards and reserved for days when high winds hampered fishing in other areas (area 1 was most exposed to the wind). Water depth (cm), and temperature (°C) were recorded daily at 0700 and 1330 hours at river mile 8.

Captured chinook salmon were placed in a box filled with water (Figure 3), quickly untangled or cut from the net, tagged, scale sampled, and "sexed" during a visual examination. Sex was estimated with significant uncertainty early in the season (Johnson, Marshall, and Elliott 1992). Captured fish were initially classified as "large" or "small," depending on their mid-eye to fork length (MEF): fish ≥660 mm MEF were called large, and fish <660 mm MEF were called small. Every other large healthy chinook was esophageally implanted with an 30-31 Mhz Advanced Telemetry Systems[2] (ATS) radio transmitter (Eiler 1989), had a uniquely numbered spaghetti tag attached beneath the dorsal fin, and was released. All healthy chinook salmon not implanted with a transmitter were tagged with a uniquely numbered spaghetti tag threaded over a solid plastic core, and half of the adipose fin was removed as a secondary mark on all tagged fish.

Age of each fish was determined from scale pattern analysis (Olsen 1992). Then, each fish was reclassified large or small using age, rather than length, as criteria; fish 1.3 years or older were classified large, while younger fish were classified small. Any fish whose scales could not be aged were classified small or large using the 660 mm MEF cut-point criteria.

Distribution of Spawning

Beginning June 13, an attempt was made to locate each radio transmitter once a week. Radio-tracking was conducted from the roadside, boats, and aircraft, using ATS receivers. Transmitters were located from the road system when possible, then from a river-boat or Cessna 182 aircraft as the size of the search area increased. Search paths for aerial surveys covered the mainstem and tributaries reasonably accessible to immigrating chinook salmon. The highway milepost, river mile, or (LORAN) air mile from the Haines Airport was recorded for each frequency located. Tracking data was later rounded to the nearest 0.5 mile of the Chilkat River or tributary where the transmitter was located.

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[2] Reference to trade names does not imply endorsement by ADF&G.

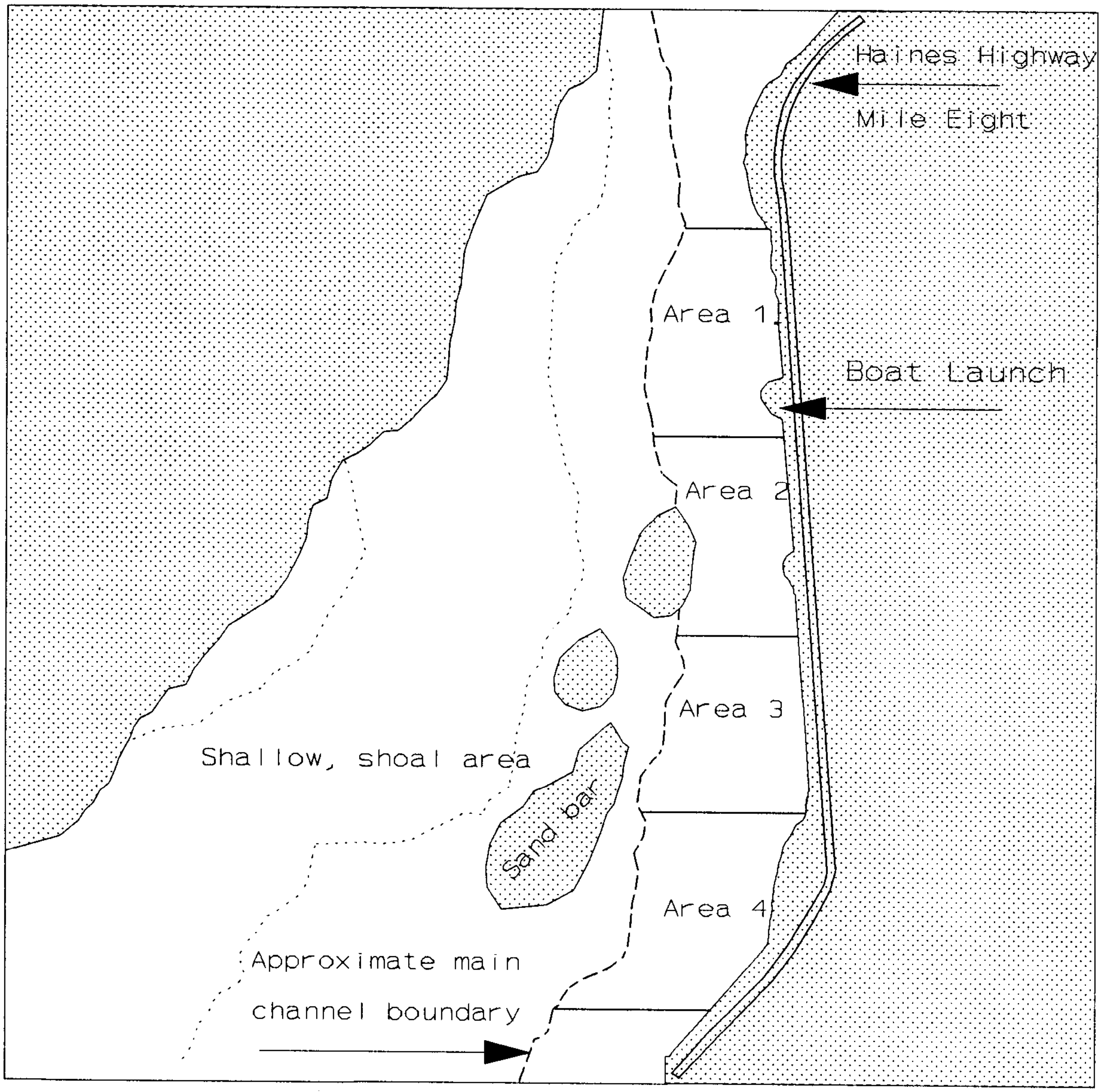

Figure 2. Chilkat River drift gill net fishing areas near the Haines Highway, 1992. Distances are approximate.

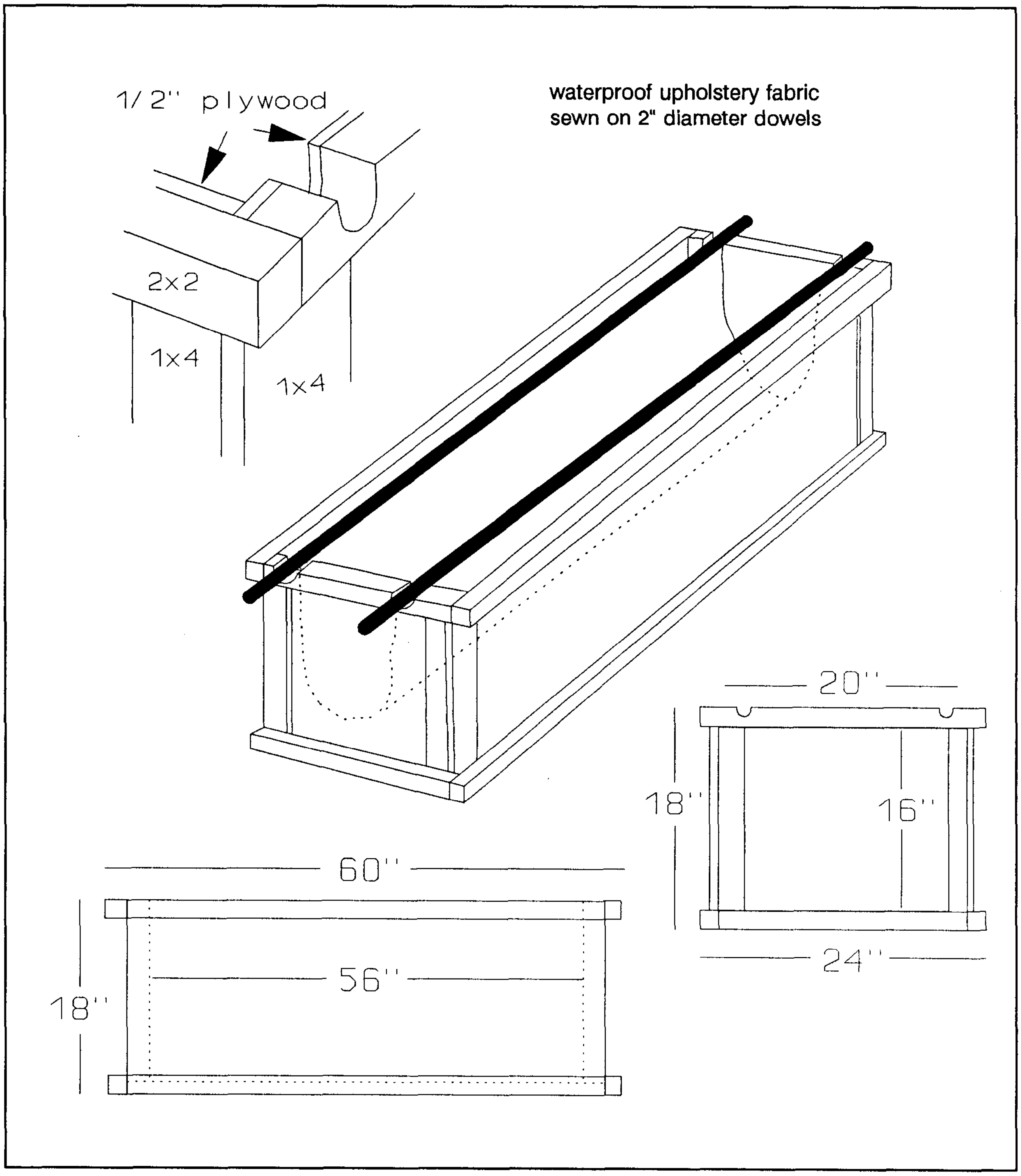

Figure 3. Tagging box used for inserting radio transmitters and attaching spaghetti tags in/on large chinook salmon, 1992.

Airplane searches were conducted 800 feet above ground at 85-100 knots. Antennae attached to each wing strut of the aircraft were connected to two receivers, and monitored by two people. Up to 50 frequencies were programmed into each receiver before an air search started. About half-way through a flight (after most of the radio transmitters had been located) the remaining frequencies were usually added to the receivers. Most aerial surveys also covered one new (but unlikely) area where "missing" transmitters might be located, e.g., above the falls of the mainstem Chilkat River.

When field operations were concluded, chinook salmon implanted with radio transmitters were assigned one of five possible fates (Table 1). Although the criteria were designed to provide unambiguous assignments, it is possible that a fish could be assigned a code that does not represent its true fate, thus biasing subsequent estimates. However, since most chinook salmon were located weekly, we believe it unlikely that a significant number of fish were incorrectly assigned a code for spawning in a tributary. Because most fish appear to spawn in tributaries, and are relocated several times over several weeks, we believe that the assignments are largely unbiased.

The proportion of large (aged 1.3 and older) chinook salmon spawning in each area was estimated

$$P_a = \frac{r_a}{\sum_{a=1}^{5} r_a} \qquad (1)$$

where r_a = the number of large fish tagged with radios that were tracked to and assumed to spawn in area a (a was equal to 5 in 1992). The standard error of P_a was estimated using the standard formula for a proportion (Cochran 1977).

Abundance

The number of large (aged ≥ 1.3 years) chinook salmon immigrating to the Chilkat River was estimated from mark-recapture data. Marks (spaghetti tags and radios) were applied to fish captured near river mile 7.5 between June 1 and July 22, as explained above.

Escapements in the Kelsall and Tahini Rivers (Figure 1), which received an estimated 87% of the large chinook salmon spawning in the Chilkat River in 1991 (Johnson, Marshall, and Elliott 1992), were subsequently sampled for marks by two teams of two people. A gill net set across the Tahini River was used to capture immigrating chinook salmon from July 16 through August 17, and fish were sampled near spawning areas from August 14 through August 31. Spawning grounds in the Kelsall River and Nataga Creek were sampled from July 29 to September 4. Chinook salmon were captured with gill nets, dip nets, bare hands, and spears. Double sampling was prevented by punching a hole in the operculum of all captured fish released alive, and slashing sampled carcasses. Chinook salmon were sampled in Big Boulder Creek from July 31 through August 15 with assistance of staff from the Alaska Department of Fish and Game (ADF&G) Fisheries Rehabilitation, Enhancement, and Development Division.

A 2x2 contingency table (chi-square statistic) was used to test the hypotheses (α = 0.05) that recovery rates for the two types of tags was equal; if so, all recoveries could be pooled to estimate abundance.

Table 1. Criteria developed to assign fates to radio transmitters implanted in chinook salmon.

Fate code	Fate and criteria
1	Probable spawning in a tributary: a chinook salmon whose radio transmitter was tracked into a tributary, and remained in or was tracked downstream from that location. When a transmitter was tracked to more than one tributary, the last tributary was assumed to be the spawning location.
2	Mortality or regurgitation: a chinook salmon whose radio transmitter either did not advance upstream after tagging or stopped in the mainstem Chilkat River and broadcast in the mortality mode (perhaps intermittently) over at least 4 weeks, and never tracked to a lower location in the river.
3	Probable spawning in the mainstem: a chinook salmon whose radio transmitter was tracked upstream (first observation, if the highest observed, was not in the mortality mode), observed in a mode other than the mortality mode near its highest location, then observed in a downstream location.
4	Captured: a chinook salmon whose radio transmitter was returned from a fishery.
5	Unknown: a chinook salmon whose radio transmitter was rarely located (one or two weeks, never in a tributary), and/or does not fit into any of the other four categories. These tracking histories were typically uninformative, or suggestive of more than one possible fate.

To provide evidence that random marking or sampling assumptions for a Petersen estimator were met (Seber 1982), two additional hypothesis tests ($\alpha = 0.05$) were conducted. In one test a 2x2 contingency table was used to test the hypotheses that recovery rates were equal in the two spatially separated sampling areas (Kelsall-Nataga and Tahini Rivers). Second, an odds ratio (Agresti 1984) was used to test the hypothesis that run timing for fish bound to the Kelsall-Nataga and Tahini River is equal:

$$\Phi = \frac{\left(\frac{N_{e,t}}{N_{e,k}}\right)}{\left(\frac{N_{l,t}}{N_{l,k}}\right)} \tag{2}$$

where N represents the number of radio-transmitters implanted during the first (e) or second (l) half of the sampled immigration, which were tracked to the Tahini (t) or Kelsall rivers (k). The estimated odds ratio was compared to 95% confidence limits for $\Phi = 1$ to complete the test. Failure to accept the hypothesis of equal recovery rates would suggest a Darroch-type estimator was appropriate. The second hypothesis test was made to help understand the data and determine if problems related to fish behavior might exist.

Contributions to Fisheries

An estimated 42,360 hatchery-reared fry from brood year 1984 were given adipose clips and CWT's (code B41114) and released to the Tahini River in May 1985, and 44,120 similarly marked fry (codes B30610-B30613) from brood year 1985 were released in May 1986 (Pahlke, Mecum, and Marshall 1990). Tagged smolts emigrated from the river in 1986 and 1987, respectively, and remained at sea from one to six years before returning to spawn. Each summer between 1989 and 1992, carcass surveys and a gillnet were used to sample chinook salmon escaping into the Tahini River. All captured fish were inspected for missing adipose fins and had scales removed for age analysis (Olsen 1992). Heads were removed from dead and nearly dead fish missing their adipose fins, marked with a numbered cinch strap, and sent to the ADF&G Tag Lab in Juneau to have the CWT removed and decoded. The fraction θ for each brood b (1984 or 1985) in the Tahini River marked with a tag and a missing adipose fin was estimated from the sampling data (Table 2)

$$\theta_b = \sum_{i=1989}^{1992} t_{b,i} \Big/ \sum_{i=1989}^{1992} n_{b,i} \tag{3}$$

where

$t_{b,i}$ = number of fish in year i that are successfully aged and from brood year b and missing an adipose fin; and

$n_{b,i}$ = number of fish in year i that are successfully aged and from brood year b.

While at sea, maturing and adult chinook salmon from these tagged cohorts were intercepted by various sport and commercial fisheries. Heads from harvested fish missing adipose fins were returned to the ADF&G Juneau Tag Lab through designed (random) sampling programs and via select and voluntary pathways. All (1984-1985

Table 2. Number of chinook salmon with and without adipose fins in samples from escapements on the Tahini River from 1989 through 1992 that were aged to the 1984 and 1985 brood years.

	Brood year 1984			Brood year 1985		
Year of survey	Fish age	Number without fins	Number sampled	Fish age	Number without fins	Number sampled
1989[1]	1.3	16	70	1.2	11	55
1990[2]	1.4	8	42	1.3	12	85
1991[3]	1.5	0	18	1.4	8	56
1992[3]	1.6	0	0	1.5	0	0
Sum		24	130		31	196
Theta			0.185			0.158

[1] Pahlke, Mecum, and Marshall 1990.

[2] Pahlke 1991.

[3] This study.

brood Tahini River) CWT's returned to ADF&G from random sampling programs were used to estimate contributions.

The contribution n_1 of a release group or stock of interest to a fishery is

$$\hat{n}_1 = \frac{m_1}{m_2}\frac{a_1}{a_2}\frac{H}{n_2}\frac{m_c}{\theta} \qquad (4)$$

where H = total harvest in the fishery, n_2 = number of fish inspected (the sample), a_1 = number of fish which are missing an adipose fin, a_2 = number of heads that arrive at the lab, m_1 = number of heads with CWT's detected, m_2 = number of CWT's that are dissected from heads and decoded, m_c = number of CWT's with code(s) of interest, and θ = fraction of the cohort tagged with code(s) of interest. When H and θ are known without error, an unbiased estimate of the variance of (4) can be calculated as shown by Clark and Bernard (1987). However, H is estimated with error in most sport fisheries, and θ is estimated with error when wild stocks are tagged. When these situations occur, unbiased estimates of the variance of $\hat{n}_1$ must be obtained by other methods.

Bernard (1992) noted that statistics to estimate n_1 in these cases come from three sampling programs: angler surveys to estimate H, catch sampling to estimate $M = (m_1/m_2)(a_1/a_2)(m_c/n_2)$, and escapement sampling (for wild stocks) to estimate θ. In these cases, the model (4) for CWT data (Bernard 1992) can be written

$$\hat{n}_1 = \frac{H\,M}{\hat{\theta}} \qquad (5)$$

where M corresponds to the statistics obtained in the catch sampling program. When H is known (from fish tickets for example) and θ is estimated with error, the variance of (5) can be estimated (Bernard 1992)

$$V[\hat{n}_1] = \theta^{-2}\left(V[\bar{M}]\,\hat{H}^2 + V[\hat{H}]\,M^2 - V[\bar{M}]\,V[\hat{H}]\right) \qquad (6)$$

and if H and θ are both estimated with error the variance can be estimated

$$\begin{aligned} V[\hat{n}_1] = {} & V[\hat{H}]\,M^2\,\hat{\theta}^{-2} + V[\bar{M}]\,\hat{H}^2\,\hat{\theta}^{-2} + V[\hat{\theta}^{-1}]\hat{H}^2\,M^2 \\ & - V[\hat{H}]\,V[\bar{M}]\,\hat{\theta}^{-2} - V[\bar{M}]V[\hat{\theta}^{-1}]\,\hat{H}^2 - V[\hat{H}]V[\hat{\theta}^{-1}]\,M^2 \\ & + V[\hat{H}]\,V[\bar{M}]\,V[\hat{\theta}^{-1}] \end{aligned} \qquad (7)$$

where V[H] can be estimated from the angler surveys, $V[\hat{\theta}^{-1}]$ can be estimated from a Monte Carlo simulation (e.g., Geiger 1990), and $V[\bar{M}]$ can be estimated using the bootstrap technique (Efron 1982). In this study, equation (6) was used when CWT's were recovered in commercial fishery strata, and (7) was used when CWT's were recovered in sport fishery strata.

A Monte Carlo simulation was used to estimate $V[\hat{\theta}^{-1}]$. We assumed sampling for tags in escapements from 1984 or 1985 brood years followed a binomial process: fish of the correct age either had, or did not have a tag. Five thousand values of t^* from the binomial distribution $B(t;n,\hat{\theta})$ given $n = \sum n_{b,i}$, and $\hat{\theta}$ (equation 3) were drawn. Each value of t^* was used to calculate a new value θ^*. The value $V[\hat{\theta}^{-1}]$ was then estimated from distribution of 5,000 values of $1/\theta^*$.

A bootstrap estimate of $V[\bar{M}]$ was generated by resampling data from the catch sampling program organized into six categories as described by Bernard (1992). The categories describe fish whose: 1) adipose fins were present and heads were not retained; 2) adipose fins were missing and heads were retained but lost; 3) heads arrived at the lab, but contained no CWT; 4) CWT's were removed but not decoded; 5) CWT's were decoded, but not of interest; and 6) CWT's were decoded to a code of interest. The relative frequency of fates in each category describes a multinomial empirical density distribution with probabilities

$$\left(\frac{n_2 - a_1}{n_2}\right) \left(\frac{a_1 - a_2}{n_2}\right) \left(\frac{a_2 - m_1}{n_2}\right) \left(\frac{m_1 - m_2}{n_2}\right) \left(\frac{m_2 - m_c}{n_2}\right) \left(\frac{m_c}{n_2}\right) \tag{8}$$

In each bootstrap, a sample of size n_2 was drawn with replacement from this distribution, and the statistics used to generate a new value (M^*) of M. The mean and variance of 2,000 such bootstrap values were drawn to estimate $V[\bar{M}]$ and $\bar{M}$ (which is used instead of M in equation 5).

Commercial catch data for the analysis were summarized by ADF&G statistical week and district (for gill net fisheries), or by (troll) period and quadrant (for troll fisheries (e.g. see, Clark, Van Alen, and Marshall 1985).

Sport fish coded wire tag recovery data were obtained from Juneau Tag Lab reports and summarized by biweek and fishery (e.g., biweek 16 during the Juneau Marine Creel Survey). Harvest estimates were obtained from ADF&G reports (Suchanek and Bingham 1989, 1990, 1991) and ADF&G computer summaries. In most cases, CWT's of interest were recovered in only a few of the sampling strata (e.g., low/high use harbors, morning/evening periods, derby strata, charter/lodge contributions) which defined the fishery-biweek. Assuming that the harvests of fish with CWT's of interest are independent of sampling strata within fishery-biweeks, harvests and sampling information were totaled over the fishery-biweek to estimate contributions. This procedure allows comparisons between published biweekly harvests (N) and the CWT data, and minimizes biases that can result if estimates are derived from data obtained in minor strata where sampling rates are unusual.

RESULTS

One hundred and forty eight (148) large (age 1.3 and older) and 3 small chinook salmon were captured in the lower Chilkat River between June 15 through July 23, 1992 (Appendices A1 and A2). One of the large chinook salmon was wounded and not tagged. Capture rates peaked on July 12 (Figure 4). The mean date of the migratory timing (Mundy 1984) at river mile 7.5 was July 6 (Figure 5). A peak in water temperature and depth during the immigration coincided with relatively low catches in the gill net (Figure 4).

Of the 148 large chinook salmon captured, 74 were implanted with a radio transmitter and given an external spaghetti tag, and 73 were given only a spaghetti tag (Table 3). Three small fish were tagged with a spaghetti tag.

The data on sex (Table 4) suggests fewer large male (37%) than large female (63%) chinook salmon were captured during tagging. Sex ratios in *large* fish from spawning ground (carcass) surveys shows the same pattern (37% male, 63% female).

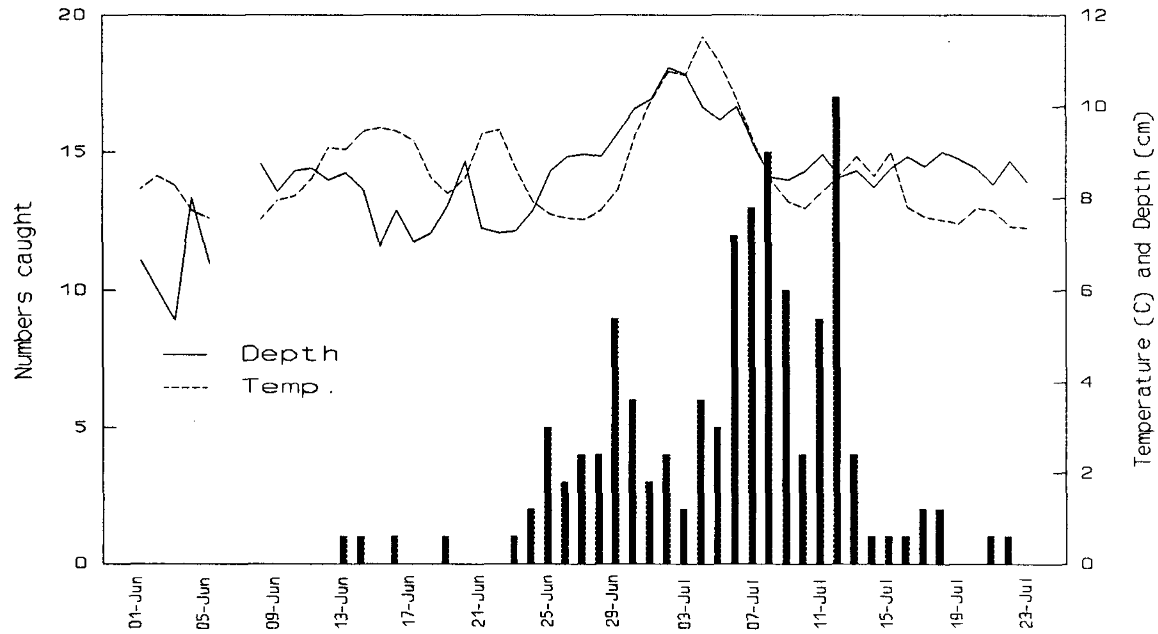

Figure 4. Water depth (cm/19), relative temperature (C°), and large chinook captured, Chilkat River mile 7.5, 1992.

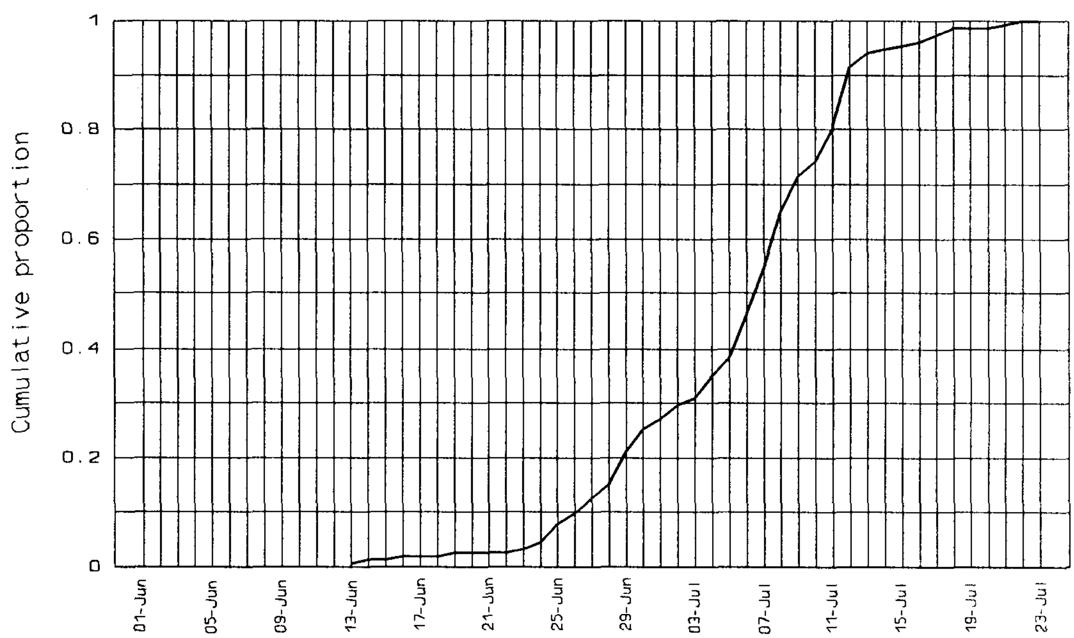

Figure 5. Cumulative proportion of large chinook salmon caught in the gill net, Chilkat River mile 7.5, 1992.

Table 3. Number of chinook salmon captured in gill nets and marked with spaghetti tags or radio transmitters near Chilkat River mile 7.5 in 1992, by age class and time period[a].

	Age ≥ 1.3		Age ≤ 1.2		
Time Period	Spag[b]	Radio[c]	Spag	Radio	Total
6/01-6/14	1	1	0	0	2
6/15-6/19	1	1	0	0	2
6/20-6/24	1	2	0	0	3
6/25-6/29	13	12	0	0	25
6/30-7/04	10	11	0	0	21
7/05-7/09	27	27	1	0	55
7/10-7/14	16	16	2	0	34
7/15-7/19	3	3	0	0	6
7/20-7/23	1	1	0	0	2
Total	73	74	3	0	150

[a] Detailed daily catch data appear in Appendix A2.

[b] Modified spaghetti tag.

[c] Radio transmitter.

Table 4. Age composition of chinook salmon sampled during tagging and recovery surveys on the Chilkat River, 1992, listed by gear type.

	Brood Year and Age Class							
	1990	1989	1988		1987	1986	1985	
	0.1	1.1	1.2	2.1	1.3	1.4	1.5	Total
Tagging: gill net, river mile 7								
Male								
Sample size	0	0	1	0	13	32	0	46
Percent	0.0	0.0	0.8	0.0	10.5	25.8	0.0	37.1
Std. dev.	0.0	0.0	0.8	0.0	2.8	3.9	0.0	4.4
Female								
Sample size	0	0	1	0	26	51	0	78
Percent	0.0	0.0	0.8	0.0	21.0	41.1	0.0	62.9
Std. dev.	0.0	0.0	0.8	0.0	3.7	4.4	0.0	4.4
All fish								
Sample size	0	0	2	0	39	83	0	124
Percent	0.0	0.0	1.6	0.0	31.5	66.9	0.0	100
Std. dev.	0.0	0.0	1.1	0.0	4.2	4.2	0.0	0
Recovery survey: Tahini River gill net								
Male								
Sample size	0	0	22	1	46	33	0	102
Percent	0.0	0.0	14.7	0.7	30.7	22.0	0.0	68.0
Std. dev.	0.0	0.0	2.9	0.7	3.8	3.4	0.0	3.8
Female								
Sample size	0	0	16	0	32	0	0	48
Percent	0.0	0.0	10.7	0.0	21.3	0.0	0.0	32.0
Std. dev.	0.0	0.0	7.7	0.0	3.4	0.0	0.0	3.8
All fish								
Sample size	0	0	38	1	78	33	0	150
Percent	0.0	0.0	25.3	0.7	52.0	22.0	0.0	100
Std. dev.	0.0	0.0	3.6	0.7	4.1	1.2	0.0	0
Recovery survey: Tahini River spawning grounds								
Male								
Sample size	0	3	20	0	25	25	0	73
Percent	0.0	0.2	13.2	0.0	16.6	16.6	0.0	48.3
Std. dev.	0.0	0.4	2.8	0.0	3.0	3.0	0.0	4.1
Female								
Sample size	0	1	0	0	24	53	0	78
Percent	0.0	0.7	0.0	0.0	15.9	35.1	0.0	51.7
Std. dev.	0.0	0.7	0.0	0.0	3.0	3.4	0.0	4.1
All fish								
Sample size	0	4	20	0	49	78	0	151
Percent	0.0	2.6	13.2	0.0	32.5	51.7	0.0	100
Std. dev.	0.0	1.3	2.8	0.0	3.8	4.1	0.0	0

-continued-

Table 4. (Page 2 of 2).

	Brood Year and Age Class							
	1990	1989	1988		1987	1986	1985	
	0.1	1.1	1.2	2.1	1.3	1.4	1.5	Total
Recovery survey: Kelsall River and Nataga Creek spawning grounds								
Male								
Sample size	0	10	35	1	74	85	0	206[a]
Percent	0.0	2.0	7.1	0.2	15.0	17.2	0.0	41.5
Std. dev.	0.0	0.8	1.5	0.3	2.1	2.2	0.0	2.9
Female								
Sample size	1	1	5	0	71	207	2	287
Percent	0.2	0.2	1.0	0.0	14.4	42.0	0.4	58.2
Std. dev.	0.3	0.3	0.6	0.0	2.1	2.9	0.1	2.9
All Fish								
Sample size	1	11	40	1	145	292	2	493[a]
Percent	0.2	2.2	8.1	0.2	29.4	59.2	0.4	100
Std. dev.	0.3	0.9	1.6	0.3	9.1	2.9	0.4	0

[a] Includes one age 1.6 male (1984 brood) sampled.

Distribution of Spawning

Sixty-six (66) of the 74 large chinook salmon given radio transmitters were successfully tracked to a spawning area (Table 5). Four other transmitters were thought to be regurgitated, lost because a fish died before spawning, or tracked in a way that defied assignment of a fate (Table 6). One radio transmitter was returned from the commercial drift gill net fishery in Lynn Canal, and two were returned from the subsistence fishery at Klukwan. One transmitter was never located. A detailed summary of the radio-tracking data is Appendix A3.

The proportions of large chinook salmon spawning in 5 areas upstream of Chilkat River mile 7.5 were: 72.7% (SE = 5.5%) in the Kelsall River system, 19.7% (SE = 4.9%) in the Tahini River, 4.6% (SE = 2.6%) in the Klehini River system, 1.5% (SE = 1.5%) in Assignation Creek, and 1.5% (SE = 1.5%) in the mainstem Chilkat River.

Abundance

One thousand twenty-seven (1,027) unique chinook salmon were captured during the spawning ground sampling (Table 7). Large female chinook were captured more frequently than large male chinook (526 female, 379 male). No chinook were observed in Nataga Creek during 1992, much in contrast with observations in 1991. Twenty three large tagged fish were recovered when inspecting fish for marks (Table 7).

The probability of recapturing spaghetti and radio-transmitter-tagged chinook salmon was not significantly different ($\chi^2 \leq 0.001$, df = 1, P = 0.97), so numbers of both types of tags were pooled to estimate abundance. The probability of capturing a marked chinook salmon in the Tahini (p = 0.016) and Kelsall rivers (p = 0.033) was not significantly different ($\chi^2 = 2.3$, df = 1, P = 0.13). Run timing for chinook salmon bound for the Tahini and Kelsall rivers also appeared to be similar, since $\Phi = 1.02$ was well within the bounds of a 95% confidence interval for $\Phi = 1$ (0.31 to 3.36). Thus, recovery data was combined across areas and we used Chapman's modified Petersen estimator ($n_1 = 139$, $n_2 = 905$, $m_2 = 23$) to estimate the number of large chinook salmon immigrating to the Chilkat drainage in 1992 (8 lost radio tags [Table 5] were not included in n_1). The estimate of 5,284 (SE = 949) is germane to the time of tagging near river mile 7.5, since an unknown component of mortality occurs (due to natural causes and a subsistence fishery) between the two sampling events.

Contributions to Fisheries

Three hundred twenty six (326) large adult chinook salmon in the Tahini River from the 1984 and 1985 brood years were inspected for missing adipose fins (Table 2). An estimated 18.5% percent of adults from the 1984 brood year and 15.8% percent from the 1985 brood year were missing their adipose fins (Table 2). All of the 24 CWT's decoded from fish sampled in the Tahini River between 1989 and 1991 (when fish with missing adipose fins were found) were from the Tahini River stocking in 1984 and 1985. Although some straying into the Chilkat River by fish released in Lutak Inlet in 1988 is occurring, these fish were unambiguously distinguished from 1984 and 1985 brood Tahini River fish based on age. Also, none of the 5,684 tagged smolt released in Taiya Inlet (near Skagway) in 1985 were recovered in the Tahini River from 1989 through 1992.

Table 5. Summary of fates assigned to radio transmitters placed on large (age 1.3 and older) chinook salmon, and estimated percentage by area of large chinook salmon spawning in the Chilkat River drainage, 1992.

Fate	Tag implants	Spawning % dist.[a]
Spawning area:		
Kelsall River system[b]	48	72.7
Tahini River	13	19.7
Klehini River system[c]	3	4.6
Mainstem Chilkat	1	1.5
Assignation Creek	1	1.5
		100.0
Tag returns from fisheries	3	
Mortality/regurgitation[d]	4	
Unknown[e]	1	
Total	74	

[a] Percentage of the total of 66 fish tracked to spawning locations.

[b] Includes mainstem Kelsall River, Nataga Creek, and Stonehouse Creek; no transmitters were tracked into Nataga Creek, and one transmitter was tracked into Stonehouse Creek.

[c] Includes mainstem Klehini River and Big Boulder Creek.

[d] Data consistent with hypothesis fish lost transmitter or died before spawning.

[e] Transmitter never located after tagging.

Table 6. Radio tracking data (Chilkat River mile) for large chinook salmon assigned a fate code 2 (mortality/transmitter regurgitation), or fate code 5 (unknown), Chilkat River, 1992.

		Survey period									
Fish #	Date tagged	6/22-6/28	6/29-7/05	7/06-7/12	7/13-7/19	7/20-7/26	7/27-8/02	8/03-8/09	8/10-8/16	8/17-8/23	8/24-8/30
		Mortality or tag regurgitation (fate code = 2)									
7	6/24		6.5	6.5	**7.0**[a]	7.5	7.5	**7.5**[a]	7.0	**7.0**[a]	**7.0**[a]
33	6/30						4.8			5.0	5.0
77	7/07			5.5	19.5	24.5	24.5	**24.5**[a]	**24.5**[a]	**24.5**[a]	**24.5**[a]
103	7/09			7.5	7.0	8.0	8.0		**7.0**[a]	**7.0**[a]	**7.0**[a]
		Unknown (fate code = 5)									
71	7/07					26.0					

[a] Observation of a mortality pulse in survey period.

Table 7. Number of fish inspected for marks and number of marked fish found during tag recovery surveys by size, sex, system, and sampling dates, Chilkat River, 1992.

System/sampling	Date	Captures				Recaptures[c]		
		Large[a]		Small[b]		Large		Small
		M	F	M	F	Spa[d]	Rad[e]	Spa
Kelsall River	7/29 - 9/4	212	359	48	7	9	9	1
Tahini (gill net)	7/16 - 8/17	99	59	26	0	2	2	1
Tahini (carcasses)	8/14 - 8/31	61	95	31	1	0	1	0
Big Boulder Creek	7/31 - 8/15	7	13	9	0	0	0	0
Total		379	526	114	8	11	12	2

[a] Fish aged 1.3 and older.

[b] Fish aged 1.2 and younger.

[c] Also included under Captures.

[d] Spaghetti tag recovered during random sampling.

[e] Radio transmitters recovered during random sampling.

Fifty-three CWT's were recovered in random sampling programs from 1988 through 1991 (Appendix A4) and another 20 tags were obtained in a non-random (select or voluntary) fashion. The distributions of recoveries from random and non-random sources (Table 8) were similar in several respects. Most recoveries came from or were reported from ADF&G Districts 115 (Lynn Canal, 37%-50%), 114 (Icy Straits, 20%-39%), and District 111 (Stephens Passage, 12%-20%), while fewer recoveries (2% to 8%) were from Districts 109 and 112 (Chatham Straits), 110 (Frederick Sound), and 113 (outside waters).

Detailed random sampling data were collapsed by appropriate fishery strata and expanded by the appropriate fishery marking and sampling fractions to estimate contributions of the 1984 and 1985 brood chinook (Table 9). An estimated total of 310 (SE = 65) 1984 brood year and 530 (SE = 127) 1985 brood year Tahini River chinook salmon were harvested in the randomly sampled fisheries.

For both brood years combined, the sport fisheries took about 24% of the harvest (Table 10), the drift gill net fishery took 32% (30% in District 115), and the troll fishery took 44% (36% in the NW Quadrant). All but 1 recovery (District 113) was from the inside waters of Southeast Alaska (Tables 8 and 9).

Of the harvest of these two brood years, 65% were taken before age 1.3 (Table 11, upper panel). Forty five percent of these (244 fish) were taken in drift gill net fisheries. Chinook salmon aged 1.3 and 1.4 were harvested mostly (64% overall) by the troll, and to a lesser extent by the sport fisheries. Landings by the drift gill net fishery (Table 11, lower panel) had the highest proportion (84%) of age 1.2 Tahini River fish, compared to 58% for sport harvests and 49% for troll harvests.

Time of harvest (Figure 6) of Tahini River chinook salmon also differed among these fisheries. In the Haines sport fishery, chinook were caught in late May through June, were ages 1.3 and 1.4, and were mostly mature fish returning to spawn. In the Juneau sport fishery, fish were caught in August as feeders at ages 1.2 and 1.3. The drift gill net fishery tended to harvest the fish through out the season, from statistical weeks 26 through 38 with the peak harvest occurring in statistical week 31 (about 24 July to 5 August). The troll fishery tended to harvest Tahini River chinook salmon early in the year, statistical weeks 23 through 29 and after statistical week 38.

These contributions must be used with certain cautions: contributions to unsampled fisheries or fishery strata are not estimated, and other unsampled sources of chinook salmon mortality due to fishing exist.

DISCUSSION

Results from tagging programs conducted in 1992 are similar to results obtained in 1991 (Johnson, Marshall, and Elliott 1992). In 1992, immigration to the river was estimated as 5,284 large fish, compared to 5,897 in 1991. Also, an estimated 92.4% of spawning occurred in the Kelsall and Tahini Rivers in 1992, compared to 87.1% in 1991. The proportion of large chinook salmon spawning in the Kelsall River varied from about 54% in 1991, to 73% in 1992. Likewise, the proportion of large chinook spawning in the Tahini River varied from about 33% in 1991 to 20% in 1992.

Table 8. Number of coded wire tags from 1984 and 1985 brood year Tahini River chinook salmon recovered in random and non-random sampling programs, by reported fishing district, 1988 through 1991.

ADFG Fishing District	Random Sampling Programs					Non-Random Sampling Programs				
	Gill Net	Troll[1]	Sport	Total	Percent	Gill Net	Troll[1]	Sport	Total	Percent
Dist. 109	-	4	-	4	8%	-	1	-	1	5%
Dist. 110	-	1	-	1	2%	-	-	-	-	-
Dist. 112	-	1	-	1	2%	-	-	-	-	-
Dist. 113	-	-	-	-	-	-	1	-	1	5%
Dist. 111	2	-	4	6	12%	-	-	4	4	20%
Dist. 114	-	20	-	20	39%	-	3	1	4	20%
Dist. 115	14	-	5	19	37%	3	-	7	10	50%
Total[2]	16	26	9	51	100%	3	5	12	20	100%

[1] Troll returns by district can be misleading since harvests can occur in multiple districts prior to a landing.

[2] One tag from mixed district 111+115 sample excluded from summary.

Table 9. Fishery contributions (nl) and standard errors (SE) from releases of 1984 and 1985 brood year chinook salmon reared in a hatchery, marked with coded-wire tags, and released into the Tahini River[1]. Estimated harvest (N) and its variance (V[N]), sample size (n_2), and sampling parameters (a_1, a_2, m_1, m_2, m_c) are shown for tags recovered during random sampling by brood year (BrYr), recovery year (Rec), type of fishery (Type), and by ADF&G commercial fishery statistical week (StWk) and district (Dist), sport fishery biweek (Biwk), and commercial troll fishery period (Per) and quadrant (Quad).

Type	Rec	Age	StWk	Biwk	Per	Quad	Dist	N	V[N]	n2	a1	a2	m1	m2	mc	n1	SE
1984 BrYr RECOVERIES																	
SPORT-JNO	1988	1.2	37	18		NE	111	175	1,568	61	22	22	20	20	1	16	16
GILLN	1988	1.2	27			NE	111+115	384		287	14	14	14	14	1	7	7
GILLN	1988	1.2	29			NE	115	145		71	8	8	7	7	1	11	11
GILLN	1988	1.2	30			NE	115	59		28	6	6	5	5	1	11	11
GILLN	1988	1.2	31			NE	115	318		133	5	5	5	5	1	13	13
GILLN	1988	1.2	32			NE	115	246		98	10	10	8	8	2	27	19
GILLN	1988	1.2	35			NE	111	118		102	16	16	13	13	2	13	9
TROLL	1988	1.2	28		3	NW	114	103,646		39,687	1,279	1,225	1,107	1,104	1	15	14
TROLL	1988	1.2	29		3	NE		21,924		14,074	1,441	1,383	1,244	1,240	1	9	9
TROLL	1988	1.2	42		7	NW	114	7,860		2,680	186	184	170	170	2	32	23
SPORT-HNS	1989	1.3	23	12		NE	115	127	1,559	36	2	2	2	2	1	19	18
GILLN	1989	1.3	27			NE	115	240		131	14	14	14	14	1	10	10
TROLL	1989	1.3	23		2	NW	114	4,015		2,328	170	163	147	147	2	19	14
TROLL	1989	1.3	25		4	NE	109	6,514		3,183	323	321	294	293	1	11	11
TROLL	1989	1.3	27		6	NE	109	12,000		6,123	562	554	500	498	1	11	11
TROLL	1989	1.3	27		6	NW	114	120,325		37,055	1,208	1,199	1,099	1,097	2	36	26
TROLL	1989	1.3	41		9	NE	109	7,793		6,465	736	731	680	680	1	7	7
TROLL	1989	1.3	41		9	NW	114	5,121		2,068	120	118	111	111	1	14	14
SPORT-HNS	1990	1.4	22	11		NE	115	147	2,392	43	2	2	1	1	1	19	19
GILLN	1990	1.4	26			NE	115	75		39	4	4	3	3	1	10	10
Total								291,232		114,692						310	65

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Table 9. (Page 2 of 2).

Type	Rec	Age	StWk	Biwk	Per	Quad	Dist	N	V[N]	n2	a1	a2	m1	m2	mc	n1	SE
1985 BrYr RECOVERIES																	
GILLN	1988	1.1	29			NE	115	145		71	8	8	7	7	1	13	13
GILLN	1988	1.1	33			NE	115	87		55	5	5	5	5	1	10	10
SPORT-HNS	1989	1.2	24	12		NE	115	127	1,559	36	2	2	2	2	1	22	22
SPORT-JNO	1989	1.2	32	16		NE	111	1,005	49,055	443	59	57	51	51	2	30	22
SPORT-JNO	1989	1.2	36	18		NE	111	488	4,526	62	7	7	7	7	1	50	49
GILLN	1989	1.2	30			NE	115	97		20	6	6	6	6	1	31	30
GILLN	1989	1.2	31			NE	115	235		19	2	2	2	2	1	78	78
GILLN	1989	1.2	33			NE	115	227		80	9	9	7	7	1	18	18
GILLN	1989	1.2	35			NE	115	37		37	8	8	8	8	1	6	6
GILLN	1989	1.2	38			NE	115	9		9	1	1	1	1	1	6	6
TROLL	1989	1.2	40		9	NW	114	5,121		2,068	120	118	111	111	7	111	46
TROLL	1989	1.2	43		9	NE	110	7,793		6,465	736	731	680	680	2	15	11
SPORT-HNS	1990	1.3	23	12		NE	115	95	917	25	2	2	2	2	2	48	35
TROLL	1990	1.3	23		2	NW	114	1,625		874	58	58	53	53	1	12	12
TROLL	1990	1.3	26		4	NW	114	8,933		2,660	175	175	163	163	2	42	30
TROLL	1990	1.3	34		7	NE	112	2,351		1,096	173	171	165	165	1	14	13
TROLL	1991	1.4	23		3	NW	114	6,582		3,418	293	292	271	271	2	24	17
Total								34,957		17,438						530	127

1 Harvest and sampling estimates for sport fishery strata are for the entire biweek and marine boat sport fishery in which the random recovery occurred.

Table 10. Estimated harvest of 1984 and 1985 brood year Tahini River chinook salmon in Southeast Alaska fisheries by age class and year caught.

		1984 Brood Year				1985 Brood Year				Total		
FISHERY	Fish Age	Year Caught	Estimated Harvest	SE	Percent	Year Caught	Estimated Harvest	SE	Percent	Estimated Harvest	SE	Percent
Haines Sport												
	Age 1.2	1988				1989	22	22		22	222	
	Age 1.3	1989	19	18		1990	48	35		67	39	
	Age 1.4	1990	19	19		1991				19	19	
	Subtotal		38	26	12%		70	41	13%	108	49	13%
Juneau Sport												
	Age 1.2	1988	16	16		1989	80	54		96	56	
	Age 1.3	1989				1990						
	Subtotal		16	16	5%		80	54	15%	96	56	11%
Drift Gill Net (District 115)												
	Age 1.1	1987				1988	23	16		23	16	
	Age 1.2	1988	69[1]	29		1989	139	86		208	91	
	Age 1.3	1989	10	10		1990				10	10	
	Age 1.4	1990	10	10		1991				10	10	
	Subtotal		89	32	29%		162	87	31%	251	93	30%

-continued-

Table 10. (Page 2 of 2).

		1984 Brood Year				1985 Brood Year				Total		
FISHERY	Fish Age	Year Caught	Estimated Harvest	SE	Percent	Year Caught	Estimated Harvest	SE	Percent	Estimated Harvest	SE	Percent
Drift Gill Net (District 111)												
	Age 1.2	1988	13	9		1989				13	9	
	Subtotal		13	9	4%					13	9	2%
Troll (NE Quad)												
	Age 1.2	1988	9	9		1989	15	11		24	14	
	Age 1.3	1989	29	17		1990	14	13		43	21	
	Age 1.4	1990				1991						
	Subtotal		38	19	12%		29	17	5%	67	26	8%
Troll (NW Quad)												
	Age 1.2	1988	47	27		1989	111	46		158	53	
	Age 1.3	1989	69	33		1990	54	32		123	46	
	Age 1.4	1990				1991	24	17		24	17	
	Subtotal		116	42	37%		189	59	36%	305	72	36%
Total			310	65	100%		530	127	100%	840	142	100%

[1] May include a small contribution (≤7 fish) from district 111.

Table 11. Estimated harvests by age of 1984 and 1985 brood year Tahini River chinook salmon in Southeast Alaska fisheries, 1988 through 1991, by type of fishery. Percentages of total harvests-at-age are computed by type of fishery (top panel), and percentages of harvest-by-fishery, by age (lower panel) are shown.

	Sport		Gill Net		Troll		Total	
Age	Estimated Harvest	Percent	Estimated Harvest	Percent	Estimated Harvest	Percent	Estimated Harvest	Percent of Total
Percentages of total harvests-at-age, by type of fishery								
1.1			23	100%			23	3%
1.2	118	23%	221	42%	182	35%	521	62%
1.3	67	28%	10	4%	166	68%	243	29%
1.4	19	36%	10	19%	24	45%	53	6%
Total	204		264		372		840	100%
Percentages of harvest-by-fishery, by age								
1.1			23	9%			23	3%
1.2	118	58%	221	84%	182	49%	521	62%
1.3	67	33%	10	4%	166	45%	243	29%
1.4	19	9%	10	4%	24	6%	53	6%
Total	204	100%	264	100%[1]	372	100%	840	100%

[1] Percentages do not add to 100% because of rounding error.

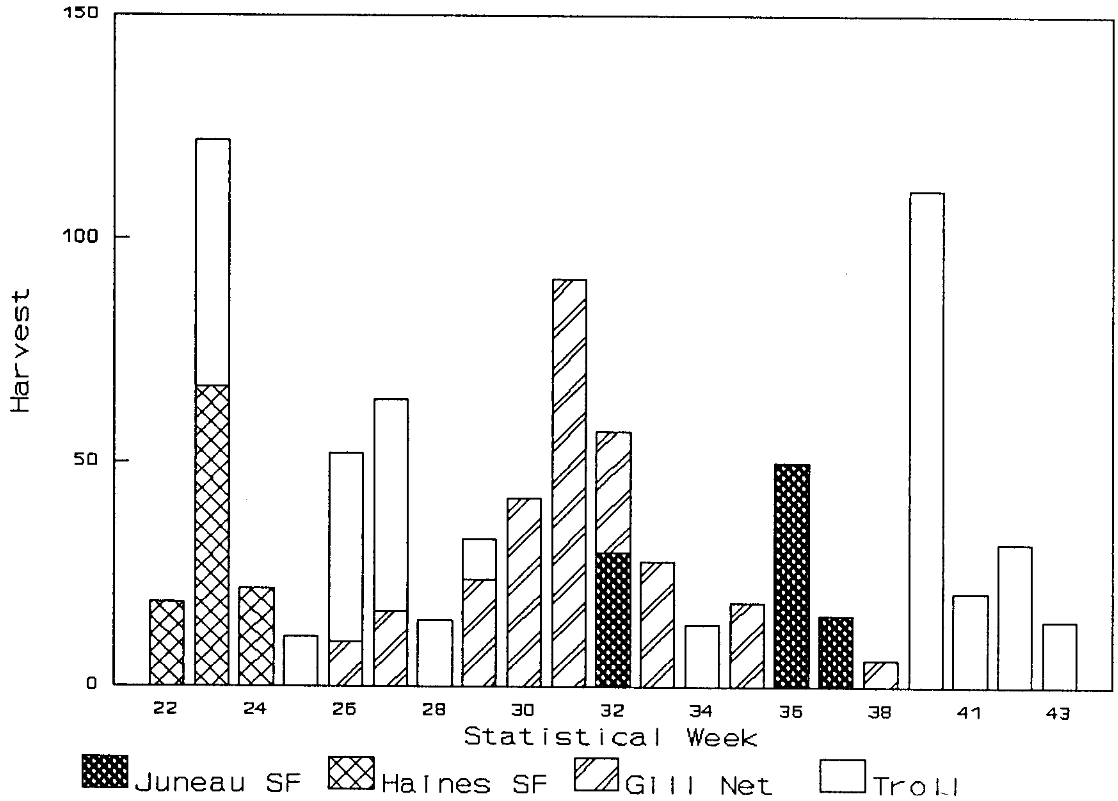

Figure 6. Harvest of 1984 and 1985 brood year Tahini River chinook salmon by fishery and statistical week. Note that tag recoveries did not occcur in statistical week 39.

As in 1991, the estimated immigration to the Chilkat River system was much greater than the historical expansion estimator (third lowest count since the index counts were established) would have indicated. Only 2 radio implanted chinook were tracked to Stonehouse Creek; none were tracked to Big Boulder Creek during 1992. Thus, the historic index areas, Big Boulder and Stonehouse Creeks, were again not major spawning locations during the 1992 season. These results demonstrate the futility of trying to gauge the abundance of spawning chinook stocks in the Chilkat River system by expansion of visually observed escapement in these historic indicator streams.

A high proportion of the chinook salmon sampled on the spawning grounds in 1992 were age 1.4 (Table 4). Initially, we wondered if the sampling was biased toward larger (older) fish. As a result, the mark-recapture data was used to estimate immigration of fish aged 1.3 and 1.4, to the river. The analysis suggested the immigration contained roughly 1.7 times as many fish aged 1.4 as fish aged 1.3. Also, samples from the Juneau marine boat sport fishery during April and May, 1992 (Paul Suchanek, ADF&G, personal communication) contained twice as many fish aged 1.4 as fish aged 1.3. We conclude that high survival of the 1986 brood year, and/or low survival of the 1987 brood, was responsible for the strong showing of age-1.4 chinook salmon on the Chilkat River in 1992.

In estimating the distribution of spawning escapement we assumed: a) catch of large chinook salmon during the tagging event was in proportion to their numbers immigrating over time; b) tagging did not change the spawning destination of a fish; and c) fates of tagged fish were accurately determined.

Since fishing effort was relatively constant, a failure of assumption a) would be related to time-dependent changes in catchability. Migratory timing was similar for the two major spawning areas (using the odds ratio), and age-compositions for fish aged 1.2, 1.3, and 1.4 years in the two major spawning areas (in carcass surveys) appears similar (χ^2 = 4.8 df = 2, P=0.09), so gear selectivity (for fish of different size) was not an obvious problem in 1992. However, environmental conditions did fluctuate notably during the experiment (Figure 4, Appendix A5), and the estimated proportions tagged in the Tahini (p = 0.016:1) and Kelsall-Nataga (p = 0.033:1) spawning areas can be taken as weak evidence for non-proportional tagging (with only 23 recaptures, these estimates are not significantly different). At any rate, the relative proportions observed in 1991 in the Tahini (p = 0.06) and Kelsall (0.03) Rivers were not similar to those in 1992, so there is no suggestion of a systematic bias from year to year (also note that the proportions in 1991 are incorrectly switched in discussions in Johnson, Marshall, and Elliott 1992, p.14 and p.19). We did not test for effects of the tagging on fish behavior, but think assumption b) probably valid in this experiment. With respect to assumption c), assigned fates of some radio-tracked fish could be in error (Johnson, Marshall, and Elliott 1992). For example, motion and mortality sensor signals can lead to ambiguous, inconsistent conclusions about a fate of a tracked fish (Bendock and Alexandersdottir 1992, Johnson, Marshall, and Elliott 1992). However, since only a small number (4) of fish with ambiguous tracking histories were *not* assigned to a spawning area, potential errors in these and other assignments are unlikely to substantially influence the estimated proportions for spawning in each area.

In estimating abundance we assumed: d) 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; e) untagged fish did not recruit to the population between sampling events; f) tagged and untagged fish suffered similar mortality rates between sampling events; and g) that fish did not lose marks.

Although sample sizes (and thus statistical power) was low, tests to determine if immigrants were tagged in proportion to their abundance (above) do not demonstrate a failure of assumption d). In addition, sampling effort for tags on the Kelsall and Tahini Rivers, where an estimated 93% of spawning occurred, was fairly constant across the time of most spawning and emigration (death). Some fish immigrating to river early (June) may have died prior to escapement sampling (which began mid- to late-July), and some fish remained in the river when we stopped sampling. However, the number of fish captured at the start (≈2 fish/day) and end (≈12 fish/day) of the second sampling event was relatively small. Size-selective sampling for fish marked in event one was not apparent in event two (KS test, $d_{max} = 0.06$, $P = 0.79$), and depensatory sampling (over-loading samplers) was not pronounced during the peak of event two (peak sample was 50/fish day). We thus concluded (the complex) assumption d) was reasonable.

Assumption e) seems reasonable since tagging continued until few fish were being caught. We also have no test of assumption f). We believe 4 of 74 radio transmitters (5%) tracked on large chinook salmon were regurgitated *or* associated with fish which died prematurely during the experiment. Some of these fish (and 1 fish with an unknown fate) certainly may have died due to the tagging procedure. However, others just as certainly died due to other causes, and we cannot separate these fates. Given the indicated low-percentage of *potential* mortality of fish marked with radio-transmitters, assumption f) is reasonable. If this assumption was not substantially true our closed-population estimator would be biased (high if marked fish died more frequently than unmarked fish). The loss of primary tags (assumption g) was significant during the experiment, but secondary marks (clipped adipose fins) were available to indicate fish that had been previously marked. On the Kelsall-Nataga system, two spaghetti tags were compromised; one when the numbered tubing slipped off the tag core, and the other when a radio implanted chinook was captured missing its spaghetti tag. On the Tahini River there were three cases of missing spaghetti tags; these were observed on chinook that had been subject to multiple recaptures where the tags were in place during the initial recapture.

Failures of assumptions discussed above could result in a biased estimate of immigration. In 1991, we compared immigration estimates from Peterson and Darroch estimators to see if unequal marked to unmarked ratios in the two sampled spawning areas could led to significant bias, and found none (Johnson, Marshall, and Elliott 1992). Other potential biases in estimating immigration might be estimated through simulation, if departures in the assumptions were or could be estimated. For example, 5% of the fish with radio-transmitters may have died due to tagging stress, so we might guess that 5% (or 4) of the 73 fish with spaghetti tags also died between sampling events. If this were true, then the estimated immigration of 5,284 is biased high by 3%. Other simulations would provide interesting extensions of this experiment, and could lead to an improved estimator. Simulations to evaluate bias due to departures in assumptions d) and e) might be most interesting. In addition, immigration is obviously a biased estimator of spawning escapement, if some fish die before spawning. However, bias in estimating spawning escapement could be equally difficult to assess.

The coded wire tag data has provided important insights about migratory patterns and exploitation by sport and commercial fisheries. The fish are harvested in the inside waters of Southeast Alaska (72 of 73 recoveries). Gillnet fisheries tend to harvest the immature fish throughout the season (statistical weeks 26-38), and Juneau area sport fisheries catch the fish around August. Troll fisheries tended to harvest the mature fish early (statistical weeks 23-29) and to harvest immature fish late (statistical weeks 39-43) in the year. Mature fish are also caught by the Haines sport fishery as they returned to spawn. Sixty four percent of estimated contributions are from the NE quadrant (Districts 109-112 and 115) and over 90% are reported from Districts 115, 114, and 111 (Table 9). Sixty five percent of the two Tahini River chinook salmon brood years harvested were taken by age 1.2 (Table 11). Forty five percent of the fish were taken in drift gill net fisheries.

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APPENDIX A

Appendix A1. Number of gill net drifts and catch by date and area, and cumulative catch and proportion for the drift gill nets fished near Chilkat River mile 7, 1992.

	Drifts by area				Catch by area				Total daily drifts	Total daily catch	Cumu-lative catch	Cumulative proportion
	1	2	3	4	1	2	3	4				
01-Jun	14	14	15	0	0	0	0	0	43	0	0	0.000
02-Jun	15	14	14	0	0	0	0	0	43	0	0	0.000
03-Jun	14	14	15	0	0	0	0	0	43	0	0	0.000
04-Jun	14	14	15	0	0	0	0	0	43	0	0	0.000
05-Jun	15	14	14	0	0	0	0	0	43	0	0	0.000
06-Jun	0	0	0	0	0	0	0	0	0	0	0	0.000
07-Jun	0	0	0	0	0	0	0	0	0	0	0	0.000
08-Jun	14	14	15	0	0	0	0	0	43	0	0	0.000
09-Jun	15	14	14	0	0	0	0	0	43	0	0	0.000
10-Jun	14	14	15	0	0	0	0	0	43	0	0	0.000
11-Jun	14	12	17	0	0	0	0	0	43	0	0	0.000
12-Jun	15	14	14	0	0	0	0	0	43	0	0	0.000
13-Jun	15	12	16	0	1	0	0	0	43	1	1	0.007
14-Jun	16	11	16	0	1	0	0	0	43	1	2	0.013
15-Jun	15	14	14	0	0	0	0	0	43	0	2	0.013
16-Jun	16	14	13	0	0	1	0	0	43	1	3	0.020
17-Jun	15	14	14	0	0	0	0	0	43	0	3	0.020
18-Jun	15	12	16	0	0	0	0	0	43	0	3	0.020
19-Jun	15	12	8	8	1	0	0	0	43	1	4	0.026
20-Jun	14	11	13	5	0	0	0	0	43	0	4	0.026
21-Jun	1	17	17	8	0	0	0	0	43	0	4	0.026
22-Jun	10	14	10	9	0	0	0	0	43	0	4	0.026
23-Jun	14	13	13	3	0	0	1	0	43	1	5	0.033
24-Jun	15	14	14	0	0	0	2	0	43	2	7	0.046
25-Jun	13	13	17	0	1	4	0	0	43	5	12	0.079
26-Jun	14	14	14	1	2	0	1	0	43	3	15	0.099
27-Jun	17	15	11	0	2	2	0	0	43	4	19	0.126
28-Jun	14	14	15	0	2	1	1	0	43	4	23	0.152
29-Jun	14	14	15	0	4	2	3	0	43	9	32	0.212
30-Jun	15	14	14	0	1	2	3	0	43	6	38	0.252
01-Jul	15	14	14	0	1	1	1	0	43	3	41	0.272
02-Jul	15	14	14	0	2	2	0	0	43	4	45	0.298
03-Jul	14	15	14	0	1	1	0	0	43	2	47	0.311
04-Jul	15	14	14	0	2	4	0	0	43	6	53	0.351
05-Jul	15	14	14	0	1	2	2	0	43	5	58	0.384
06-Jul	14	14	15	0	4	6	2	0	43	12	70	0.464
07-Jul	15	14	14	0	4	5	4	0	43	13	83	0.550
08-Jul	15	14	14	0	5	7	3	0	43	15	98	0.649
09-Jul	15	14	14	0	4	5	1	0	43	10	108	0.715
10-Jul	14	14	15	0	0	2	1	0	43	3	112	0.742
11-Jul	15	14	14	0	5	2	2	0	43	9	121	0.801
12-Jul	15	14	14	0	3	7	7	0	43	17	138	0.914
13-Jul	15	14	14	0	3	1	0	0	43	4	142	0.940
14-Jul	15	14	14	0	0	1	0	0	43	1	143	0.947
15-Jul	15	14	14	0	0	0	1	0	43	1	144	0.954
16-Jul	15	14	14	0	1	0	0	0	43	1	145	0.960
17-Jul	15	14	14	0	1	1	0	0	43	2	147	0.974
18-Jul	15	14	14	0	1	1	0	0	43	2	149	0.987
19-Jul	15	14	14	0	0	0	0	0	43	0	149	0.987
20-Jul	15	14	14	0	0	0	0	0	43	0	149	0.987
21-Jul	15	14	14	0	0	0	1	0	43	1	150	0.993
22-Jul	15	14	14	0	0	0	1	0	43	1	151	1.000
23-Jul	15	14	14	0	0	0	0	0	43	0	151	1.000
Total	734	703	722	34	54	60	37	0	2,193	151		

Appendix A2. Fish number, sex, length (MEF), age, and tag type for tagging on the Chilkat River, by date, 1992.

Date tagged	Fish no.	Sex	MEF (mm)	Age[a]	Tag type
13-Jun	1	F	900	1.4	radio
14-Jun	2	F	825	1.4	spag.[b]
16-Jun	3	F	810	1.3	radio
19-Jun	4	M	920	1.4	spag.
23-Jun	5	F	835	N/A[c]	radio
24-Jun	6	F	865	1.4	spag.
24-Jun	7	F	860	1.4	radio
25-Jun	8	F	860	N/A	spag.
25-Jun	9	F	760	1.3	radio
25-Jun	10	M	910	1.4	spag.
25-Jun	11	F	860	1.3	radio
25-Jun	12	M	910	1.4	spag.
26-Jun	13	F	950	1.4	radio
26-Jun	14	F	900	1.4	spag.
26-Jun	15	F	930	1.4	radio
27-Jun	16	F	915	1.4	spag.
27-Jun	17	F	840	1.4	radio
27-Jun	18	F	925	N/A	spag.
27-Jun	19	M	800	1.4	radio
28-Jun	20	F	910	1.4	spag.
28-Jun	21	F	960	N/A	radio
28-Jun	22	F	950	1.4	spag.
28-Jun	23	M	810	1.3	radio
29-Jun	24	F	905	1.4	spag.
29-Jun	25	F	930	1.4	radio
29-Jun	26	F	890	N/A	spag.
29-Jun	27	F	885	1.4	radio
29-Jun	28	M	1000	1.4	spag.
29-Jun	29	M	880	N/A	radio
29-Jun	30	M	790	1.4	spag.
29-Jun	31	M	975	1.4	spag.
29-Jun	32	M	1020	1.4	radio
30-Jun	33	M	1010	1.3	radio
30-Jun	34	M	745	1.3	spag.
30-Jun	35	F	890	1.4	radio
30-Jun	36	F	910	1.4	spag.
30-Jun	37	F	875	N/A	radio
30-Jun	38	F	825	1.3	spag.
01-Jul	39	M	850	1.4	radio
01-Jul	40	F	760	1.3	spag.
01-Jul	41	M	870	1.3	radio
02-Jul	42	F	770	1.3	spag.
02-Jul	43	F	920	1.4	spag.
02-Jul	44	F	870	1.4	radio
02-Jul	45	M	920	1.4	radio
03-Jul	46	F	820	1.3	spag.
03-Jul	47	M	910	1.4	radio
04-Jul	48	F	780	N/A	spag.
04-Jul	49	F	870	1.4	radio
04-Jul	50	F	840	1.3	spag.
04-Jul	51	F	815	1.4	radio
04-Jul	52	M	660	1.3	spag.
04-Jul	53	F	880	1.4	radio
05-Jul	54	F	880	1.4	spag.
05-Jul	55	M	1060	1.4	radio
05-Jul	56	M	1005	1.4	spag.
05-Jul	57	F	870	1.4	spag.
05-Jul	58	F	855	1.4	radio
06-Jul	59	F	875	1.4	radio
06-Jul	60	F	800	N/A	spag.
06-Jul	61	F	675	1.3	radio
06-Jul	62	F	830	N/A	spag.
06-Jul	63	F	915	N/A	radio
06-Jul	64	M	710	1.3	spag.
06-Jul	65	F	860	1.4	radio
06-Jul	66	F	770	N/A	spag.
06-Jul	67	F	940	1.4	radio
06-Jul	68	F	870	1.4	radio
06-Jul	69	F	780	1.4	spag.
06-Jul	70	M	540	N/A	spag.
07-Jul	71	F	840	1.4	radio
07-Jul	72	M	600	1.3	spag.
07-Jul	73	F	825	1.4	radio
07-Jul	74	M	660	N/A	spag.
07-Jul	75	F	780	1.3	spag.
07-Jul	76	M	920	N/A	radio
07-Jul	77	M	840	1.4	radio
07-Jul	78	M	920	N/A	spag.
07-Jul	79	F	870	1.4	radio
07-Jul	80	F	885	1.4	spag.
07-Jul	81	F	820	N/A	spag.
07-Jul	82	M	910	1.4	radio
07-Jul	83	F	775	1.3	radio
08-Jul	84	M	1090	1.4	spag.
08-Jul	85	F	780	1.3	radio
08-Jul	86	F	675	1.3	spag.
08-Jul	87	F	820	1.4	spag.
08-Jul	88	F	840	1.3	radio
08-Jul	89	M	895	1.4	radio
08-Jul	90	F	840	1.3	spag.
08-Jul	91	M	880	1.4	radio
08-Jul	92	M	970	1.3	spag.
08-Jul	93	M	780	1.4	radio
08-Jul	94	F	900	N/A	spag.
08-Jul	95	M	850	1.4	radio
08-Jul	96	F	820	1.3	spag.
08-Jul	97	F	870	1.4	radio
08-Jul	98	M	770	1.3	spag.
09-Jul	99	M	880	1.4	radio
09-Jul	100	M	1000	1.4	spag.
09-Jul	101	F	780	1.3	radio
09-Jul	102	F	800	1.4	spag.
09-Jul	103	M	970	1.4	radio
09-Jul	104	F	880	N/A	spag.
09-Jul	105	F	870	1.4	radio
09-Jul	106	F	875	1.4	spag.
09-Jul	107	F	890	1.4	radio
09-Jul	108	M	910	1.4	spag.
10-Jul	109	F	840	1.3	radio
10-Jul	110	M	870	1.4	spag.
10-Jul	None	M	960	1.4	None
10-Jul	111	F	780	1.3	radio
11-Jul	112	M	910	1.4	spag.
11-Jul	113	F	650	1.2	spag.
11-Jul	114	F	860	1.4	radio
11-Jul	115	M	650	1.2	spag.
11-Jul	116	F	950	1.4	spag.
11-Jul	117	F	860	1.3	radio
11-Jul	118	M	850	1.4	spag.
11-Jul	119	M	870	1.3	radio

-continued-

Appendix A2. (Page 2 of 2).

Date tagged	Fish no.	Sex	MEF (mm)	Age	Tag type	
11-Jul	120	M	740	1.3	spag.	
12-Jul	121	F	920	N/A	radio	
12-Jul	122	F	870	1.4	spag.	
12-Jul	123	F	940	1.4	radio	
12-Jul	124	F	890	1.4	spag.	
12-Jul	125	F	800	1.4	radio	
12-Jul	126	F	830	1.4	spag.	
12-Jul	127	F	870	1.3	radio	
12-Jul	128	F	820	1.3	spag.	
12-Jul	129	F	860	N/A	radio	
12-Jul	130	M	1000	1.4	spag.	
12-Jul	131	M	980	1.3	radio	
12-Jul	132	M	630	1.3	spag.	
12-Jul	133	M	825	1.4	radio	
12-Jul	134	F	800	1.4	spag.	
12-Jul	135	F	880	1.4	radio	
12-Jul	136	M	1010	1.4	spag.	
12-Jul	137	F	865	1.4	radio	
13-Jul	138	M	880	N/A	spag.	
13-Jul	139	F	820	1.4	radio	
13-Jul	140	F	860	1.3	spag.	
13-Jul	141	M	820	N/A	spag.	
14-Jul	142	F	810	1.3	radio	
15-Jul	143	M	840	N/A	radio	
16-Jul	144	F	890	N/A	spag.	
17-Jul	145	F	840	1.4	radio	
17-Jul	146	F	860	1.3	spag.	
18-Jul	147	F	850	N/A	radio	
18-Jul	148	F	830	1.3	spag.	
21-Jul	149	M	840	1.4	spag.	
22-Jul	150	F	850	N/A	radio	

[a] European notation; see text.

[b] spag.= modified spaghetti tag

[c] N/A = Not aged due to annulus reabsorbtion, scale lost, etc.

Appendix A3. Locations of radio transmitters implanted in large chinook salmon in 1992, listed by radio frequency, date tagged, river mile/tributary where located (see system code), and survey period.

			Survey period											
Radio freq.	Fish no.	Date tagged	6/22-6/28	6/29-7/5	7/6-7/12	7/13-7/19	7/20-7/26	7/27-8/02	8/3-8/09	8/10-8/16	8/17-8/23	8/24-8/30	Fate code[a]	Sys. code[b]
30.021	1	13-Jun	8.0	24.0	29.0	34.0	0.0T	1.5T	3.0T		2.5TM	2.5T	1	1
30.042	3	16-Jun	6.0	18.0	23.0		5.5K	6.5K	5.0K	6.0KM	6.0KM	5.0KM	1	2
30.060	5	23-Jun	9.5	21.0	21.5	32.0	1.0K	6.0K	2.0K	2.0K	1.5K	1.5K	1	2
30.080	7	24-Jun		6.5	6.5	7.0M	7.5	7.5	7.5M	7.0	7.0M	7.0M	2	
30.100	9	25-Jun		6.5	19.0	24.0	0.3K	2.0K	2.0K	2.0K	0.5KM	0.5KM	1	2
30.120	11	25-Jun		9.0	14.5M[c]	21.5M	30.0M	32.0M	3.0T	3.0T	2.5T	2.5T	1	1
30.140	13	26-Jun		18.5	24.0	26.0	2.0T	3.0T	2.0T	2.0T	2.0TM	2.0TM	1	1
30.160	15	26-Jun		6.0M	10.0	19.0	25.0	1.5T	1.5T	2.0T	2.0T	1.5TM	1	1
30.180	17	27-Jun			21.5		2.0K	2.0K	2.0K	2.0K	1.5K	1.5K	1	2
30.200	19	27-Jun		18.5									4	
30.220	21	28-Jun		9.5	16.0	2.0KI		7.5KI	8.0KI				1	3
30.240	23	28-Jun		9.0	16.5	16.5	31.0	3.0K	2.0K	2.0K	2.0K	1.0KM	1	2
30.260	25	29-Jun		9.5	16.5M	19.0	4.0K	7.0K	2.5K	6.0K	5.0KM	5.5KM	1	2
30.280	27	29-Jun		9.0	13.5		4.0K	7.5K	7.5K	7.0K	6.0K	6.5KM	1	2
30.300	29	29-Jun		9.0	20.0	21.0	4.5KIM	10.0KIM	10.0KIM	10.0KIM	10.0KIM	10.0KIM	1	3
30.332	32	29-Jun			14.0	19.0	29.0M	29.0M	31.0	2.0T	1.5TM	2.0TM	1	1
30.352	33	30-Jun						4.8			5.0	5.0	2	
30.372	35	30-Jun		6.0	12.0		1.0K	5.5K	5.0K	5.0K	5.0K	1.0K	1	2
30.392	37	30-Jun		6.0	6.0		26.0			2.0K			1	2
30.412	39	01-Jul		6.0	10.0		29.0	30.0	2.0K	1.5K	0.5K	2.0K	1	2
30.432	41	01-Jul		5.0	13.5		31.0	3.0T	2.0T	1.5T	29.00	29.0M	1	1
30.452	44	02-Jul			18.5	19.0	3.0K	5.5K	7.0K	6.0K			1	2
30.475	45	02-Jul			12.0	18.0	28.0	2.0K	3.0K	2.0K	1.0K	1.5KM	1	2
30.492	47	03-Jul			15.0	18.5	3.5K	11.0K		9.0K	9.5K	7.0K	1	2
30.522	49	04-Jul			12.5	23.0		1.0K	3.0K	1.5K	2.0KM	2.0KM	1	2
30.542	51	04-Jul			16.0		2.0K	1.5K	2.0K	1.0K	1.5K	2.0KM	1	2
30.562	53	04-Jul			13.5	15.5	32.0	1.0K	2.0K	1.0K	1.5K	29.5M	1	2
30.579	55	05-Jul			13.5		4.0K	7.5K	1.0SH	1.0SH	1.0SH	9.5KM	1	4
30.602	58	05-Jul			15.5	18.5	1.0KM	1.0KM	1.0K	1.0KM	1.0KM	2.0KM	1	2
30.661	59	06-Jul			14.5	17.0	3.0K	0.0K	1.0K	1.0K	1.0KM	1.0K	1	2
30.682	61	06-Jul			13.5M	14.5M	28.5	3.0K	1.0K	1.0K	31.0		1	2
30.703	63	06-Jul			7.0	19.0	28.0	0.5T	2.0T	1.0T	2.0T	2.0TM	1	1
30.722	65	06-Jul			14.0	21.5		3.0K	1.0K	1.0K	2.0K	1.0KM	1	2
30.742	67	06-Jul			8.0	7.5	0.5K	4.5K	6.0K	4.0K	5.5K	5.5K	1	2
30.762	68	06-Jul				9.0	20.0						4	
30.782	71	07-Jul					26.0						5	
30.802	73	07-Jul			7.0	14.5	28.5	2.0K	1.0K	1.0K	0.5K	31.0	1	2
30.821	76	07-Jul			7.0	20.0	24.0	28.5	3.0K	1.0K	0.5K	2.0K	1	2
30.862	77	07-Jul			5.5	19.5	24.5	24.5	24.5M	24.5M	24.5M	24.5M	2	
30.882	79	07-Jul			7.5	17.0	28.0	25.0	3.5KI	5.0KI	8.0KI	8.0KIM	1	3
30.912	82	07-Jul			12.0	24.0		0.0K	2.0K	1.0K	2.5K	1.0KM	1	2
30.930	83	07-Jul			8.0	20.0		27.5	8.5K	2.0K	2.0K	1.5K	1	2
30.952	85	08-Jul				13.5	28.0	29.0	1.0K	1.0K	2.0K	1.5K	1	2
30.970	88	08-Jul				14.0	2.0K	2.0K	2.0K	2.0K	2.0K	1.0K	1	2
30.992	89	08-Jul				20.0		30.0		1.0K	1.5K	1.0K	1	2
31.012	91	08-Jul			4.5		3.5K	4.0K	1.0K	2.5K	1.5K	29.5M	1	2
31.032	93	08-Jul				19.0	31.0	2.0K	1.5K	2.5K	2.0K	29.5M	1	2
31.042	95	08-Jul				23.0		3.0K	5.0K	4.5K	6.0K	2.5KM	1	2
31.052	97	08-Jul				20.0		31.0	2.0K	4.5K	5.0K	4.5K	1	2
31.092	99	09-Jul				16.5	3.5K	8.0K	8.0K	6.5K	6.0K	5.5KM	1	2
31.112	101	09-Jul			8.0	20.5	29.0	2.0T	2.0T	3.0T	2.0TM		1	1
31.122	103	09-Jul			7.5	7.0	8.0	8.0		7.0M	7.0M	7.0M	2	
31.132	105	09-Jul				18.0	27.0	3.5K	7.5K	6.5K	6.05KM		1	2
31.152	107	09-Jul				20.0	29.0	5.0K	6.5K	4.5K	6.0K	5.5KM	1	2
31.162	109	10-Jul				23.0		29.0	0.0A	1.0A	1.0A		1	5
31.172	111	10-Jul											4[d]	
31.192	114	11-Jul				20.5		30.0	3.5K	4.0K	7.0K	1.0KM	1	2
31.202	117	11-Jul				11.0	20.0M	30.0M	3.0K	3.0K	2.0K	2.0K	1	2
31.232	119	11-Jul				11.0	24.0	30.0	4.0K	1.0K	2.0K	2.0K	1	2
31.242	121	12-Jul				23.0		0.0K	1.0K	1.0K	1.0KM	1.0KM	1	2
31.252	123	12-Jul				16.5	25.0	27.0	32.0	2.0T	2.0T	2.0TM	1	1
31.262	125	12-Jul				19.0		3.0K	5.0K	5.0K	6.5K	4.5KM	1	2
31.292	127	12-Jul				15.0M	19.0		30.0	4.5K	7.0K	7.5K	1	2

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			Survey period											
Radio freq.	Fish no.	Date tagged	6/22–6/28	6/29–7/5	7/6–7/12	7/13–7/19	7/20–7/26	7/27–8/02	8/3–8/09	8/10–8/16	8/17–8/23	8/24–8/30	Fate code[a]	Sys. code[b]
31.312	129	12-Jul				13.5	24.5	27.0	26.0	2.5K	1.5K	1.5K	1	2
31.322	131	12-Jul				16.0	26.0	29.0	33.0	2.0T	2.0T	1.5T	1	1
31.332	133	12-Jul				7.5	25.0	29.0	5.0K	5.0K	6.0K	7.0K	1	2
31.352	135	12-Jul				19.0	26.0	30.0	31.0	0.0A	2.0T	2.0T	1	1
31.362	137	12-Jul				15.5	30.0	32.0	1.0K	0.5K	1.0K	0.5K	1	2
31.382	139	13-Jul					24.5	26.0	32.0	2.0T	2.0T	2.0TM	1	1
31.392	142	14-Jul					25.0	29.0	32.0	2.0T	2.0T	2.0T	1	1
31.411	143	15-Jul				19.0	24.0	28.0	3.5K	5.0K	5.0K	7.0K	1	2
31.432	145	17-Jul					20.0	28.0	18.0	18.0M	18.0M	18.0M	3	
31.452	147	18-Jul				10.0	17.5	26.0	29.0		3.0K	3.0K	1	2
31.472	150	22-Jul					18.0	20.0	25.0	2.0K	6.0K	0.5K	1	2

[a] Fate codes:
1 = Probable successful tributary spawning.
2 = Probable mortality or regurgitation.
3 = Probable mainstem spawner.
4 = Captured and returned.
5 = Unknown fate.

[b] System codes:
1 = Tahini River (T)
2 = Kelsall River (K)
3 = Klehini River (KI)
4 = Stonehouse Creek (SH)
5 = Assignation Creek (A)

[c] M = radio transmitter was operating in the mortality mode when located.

[d] Fish captured in the Lynn Canal commercial gill net fishery on July 27.

Appendix A4. Random sampling data for coded-wire tags from 1984 and 1985 brood year chinook salmon reared in a hatchery and released into the Tahini River during 1985 and 1986, respectively[1]. Estimated harvest (N) and its variance (V[N]), sample size (n_2), and sampling parameters (a_1, a_2, m_1, m_2, m_c) are shown for tags recovered during random sampling by fish-head number (Head), brood year (BrYr), tag-code (Code), recovery year (Rec), type of fishery (Type), and by ADF&G commercial fishery statistical week (StWk) and district (Dist), sport fishery biweek (Biwk), and commercial troll fishery period (Per) and quadrant (Quad).

Head	BrYr	Code	Rec	Type	StWk	Biwk	Per	Quad	Dist	N	V[N]	n2	a1	a2	m1	m2	mc	Comments[1]
1984 BrYr RECOVERIES																		
2430	84	B41114	88	SPORT-JNO	37	18		NE	111	31	0	31	12	12	11	11	1	One of several strata
4214	84	B41114	88	GILLN	27			NE	111+115	384		287	14	14	14	14	1	Mixed district sample
7837	84	B41114	88	GILLN	29			NE	115	145		71	8	8	7	7	1	
23421	84	B41114	88	GILLN	30			NE	115	59		28	6	6	5	5	1	
97725	84	B41114	88	GILLN	31			NE	115	318		133	5	5	5	5	1	
97184	84	B41114	88	GILLN	32			NE	115	246		98	10	10	8	8	1	
97182	84	B41114	88	GILLN	32			NE	115	246		98	10	10	8	8	1	
2683	84	B41114	88	GILLN	35			NE	111	118		102	16	16	13	13	1	
97441	84	B41114	88	GILLN	35			NE	111	118		102	16	16	13	13	1	
3026	84	B41114	88	TROLL	28		3	NW	114	103,646		39,687	1,279	1,225	1,107	1,104	1	
15749	84	B41114	88	TROLL	29		3	NE		21,924		14,074	1,441	1,383	1,244	1,240	1	
3803	84	B41114	88	TROLL	42		7	NW	114	7,860		2,680	186	184	170	170	1	
3813	84	B41114	88	TROLL	42		7	NW	114	7,860		2,680	186	184	170	170	1	
26029	84	B41114	89	SPORT-HNS	23	12		NE	115	40	681	7	1	1	1	1	1	One of several strata, SBI
65826	84	B41114	89	GILLN	27			NE	115	240		131	14	14	14	14	1	
39539	84	B41114	89	TROLL	23		2	NW	114	4,015		2,328	170	163	147	147	1	
39525	84	B41114	89	TROLL	23		2	NW	114	4,015		2,328	170	163	147	147	1	
69060	84	B41114	89	TROLL	25		4	NE	109	6,514		3,183	323	321	294	293	1	
67090	84	B41114	89	TROLL	27		6	NE	109	12,000		6,123	562	554	500	498	1	
51651	84	B41114	89	TROLL	27		6	NW	114	120,325		37,055	1,208	1,199	1,099	1,097	1	
39658	84	B41114	89	TROLL	27		6	NW	114	120,325		37,055	1,208	1,199	1,099	1,097	1	
74155	84	B41114	89	TROLL	41		9	NE	109	7,793		6,465	736	731	680	680	1	
74177	84	B41114	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
53370	84	B41114	90	SPORT-HNS	22	11		NE	115	55	342	22	1	1	1	1	1	One of several strata, SBI
11257	84	B41114	90	GILLN	26			NE	115	75		39	4	4	3	3	1	

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Head	BrYr	Code	Rec	Type	StWk	Biwk	Per	Quad	Dist	N	V[N]	n2	a1	a2	m1	m2	mc	Comments[1]
1985 BrYr RECOVERIES																		
28265	85	B30613	88	GILLN	29			NE	115	145		71	8	8	7	7	1	
23601	85	B30612	88	GILLN	33			NE	115	87		55	5	5	5	5	1	
26030	85	B30611	89	SPORT-HNS	24	12		NE	115	18	83	8	1	1	1	1	1	One of several strata, SBI
26703	85	B30612	89	SPORT-JNO	31	16		NE	111	412	0	388	52	51	46	46	1	One of several strata, SBI
18674	85	B30612	89	SPORT-JNO	32	16		NE	111	412	0	388	52	51	46	46	1	One of several strata, SBI
46190	85	B30612	89	SPORT-JNO	36	18		NE	111	224	2,022	33	3	3	3	3	1	One of several strata, SBI
64534	85	B30612	89	GILLN	30			NE	115	97		20	6	6	6	6	1	
64721	85	B30612	89	GILLN	31			NE	115	235		19	2	2	2	2	1	
68764	85	B30610	89	GILLN	33			NE	115	227		80	9	9	7	7	1	
81845	85	B30613	89	GILLN	35			NE	115	37		37	8	8	8	8	1	N=34, set to n2=37
83940	85	B30613	89	GILLN	38			NE	115	9		9	1	1	1	1	1	N=8, set to n2=9
79676	85	B30610	89	TROLL	40		9	NW	114	5,121		2,068	120	118	111	111	1	
79686	85	B30612	89	TROLL	40		9	NW	114	5,121		2,068	120	118	111	111	1	
74178	85	B30610	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
86172	85	B30610	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
86169	85	B30611	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
74175	85	B30612	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
74181	85	B30613	89	TROLL	41		9	NW	114	5,121		2,068	120	118	111	111	1	
83239	85	B30613	89	TROLL	43		9	NE	110	7,793		6,465	736	731	680	680	1	
84472	85	B30610	89	TROLL	44		9	NE	109	7,793		6,465	736	731	680	680	1	
53364	85	B30612	90	SPORT-HNS	23	12		NE	115	57	779	10	1	1	1	1	1	One of several strata, SBI
53365	85	B30612	90	SPORT-HNS	24	12		NE	115	32	116	14	1	1	1	1	1	One of several strata, SBI
2805	85	B30612	90	TROLL	23		2	NW	114	1,625		874	58	58	53	53	1	
4035	85	B30612	90	TROLL	26		4	NW	114	8,933		2,660	175	175	163	163	1	
4036	85	B30612	90	TROLL	26		4	NW	114	8,933		2,660	175	175	163	163	1	
33466	85	B30613	90	TROLL	34		7	NE	112	2,351		1,096	173	171	165	165	1	
52159	85	B30613	91	TROLL	23		3	NW	114	6,582		3,418	293	292	271	271	1	
27820	85	B30613	91	TROLL	23		3	NW	114	6,582		3,418	293	292	271	271	1	

1 Based on the ADF&G CFMD Tag Lab database. SBI = harvest N reported in "Sport.Bas" report is below the total harvest for the fishery and biweek estimated in FDS reports. Variances for sport fish harvests are from unpublished summaries (Paul Suchanek, ADF&G Juneau, personal communication).

Appendix A5. Average daily water temperature and relative depth measurements on the Chilkat River, 1992[1].

Date	Temp. (°C)	Depth (cm)	Date	Temp. (°C)	Depth (cm)
01-Jun	6.7	156.0	28-Jun	8.9	147.0
02-Jun	6.0	161.0	29-Jun	9.4	155.5
03-Jun	5.4	157.5	30-Jun	10.0	178.0
04-Jun	8.0	147.0	01-Jul	10.2	192.5
05-Jun	6.6	144.0	02-Jul	10.9	204.5
06-Jun	-	-	03-Jul	10.7	203.0
07-Jun	-	-	04-Jul	10.0	219.0
08-Jun	8.8	143.5	05-Jul	9.7	208.5
09-Jun	8.2	151.0	06-Jul	10.0	193.0
10-Jun	8.6	153.0	07-Jul	9.1	174.0
11-Jun	8.7	160.0	08-Jul	8.5	159.5
12-Jun	8.4	173.0	09-Jul	8.4	150.5
13-Jun	8.6	172.0	10-Jul	8.6	148.0
14-Jun	8.2	179.5	11-Jul	9.0	155.0
15-Jun	7.0	181.0	12-Jul	8.5	161.5
16-Jun	7.8	179.5	13-Jul	8.6	169.0
17-Jun	7.1	175.5	14-Jul	8.3	161.0
18-Jun	7.3	160.5	15-Jul	8.7	171.0
19-Jun	7.9	154.0	16-Jul	8.9	148.5
20-Jun	8.8	160.5	17-Jul	8.7	144.5
21-Jun	7.4	178.5	18-Jul	9.0	143.0
22-Jun	7.3	180.0	19-Jul	8.9	141.5
23-Jun	7.3	164.0	20-Jul	8.7	148.0
24-Jun	7.8	150.5	21-Jul	8.3	147.0
25-Jun	8.6	145.5	22-Jul	8.8	140.5
26-Jun	8.9	144.0	23-Jul	8.4	140.0
27-Jun	9.0	143.5			

1 Temperature was measured at the boat launch (about river mile 7.5) and a staff gage was located near river mile 8.