Fishery Data Series No. 94-46

Chilkat River Chinook Salmon Studies, 1993

by

Robert E. Johnson

November 1994

Alaska Department of Fish and Game

Division of Sport Fish

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ABSTRACT

A mark-recapture experiment was used in 1993 to estimate abundance of chinook salmon (*Oncorhynchus tshawytscha*) age 1.3 and older returning to the Chilkat River, near Haines, Alaska.

One hundred sixty-one (161) large (age 1.3 and older) chinook salmon were captured in gill nets between June 1 and July 22, 1993. The mean date of the immigration was July 3. One hundred fifty-nine (159) of these fish were tagged with solid-core spaghetti tags.

Between 29 July and 4 September, 614 large chinook salmon spawning in the Chilkat River drainage—mostly on the Kelsall and Tahini rivers—were inspected for tags to estimate abundance. A modified Petersen model (n_1 = 159, n_2 = 614, m_2 = 21) was used to estimate that 4,472 (SE = 851) chinook salmon age 1.3 and older returned to the Chilkat River drainage in 1993. An unknown number of these fish died of natural causes or were caught in a subsistence fishery prior to spawning.

The population estimate is not significantly different from the estimate for large chinook salmon in 1991 (5,897 ± 1,005) and 1992 (5,204 ± 935).

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, Chilkat River, escapement, mark-recapture, immigration, age composition, Kelsall River, Nataga Creek, Tahini River, Klehini River, Big Boulder Creek, Haines, Alaska.

INTRODUCTION

The Chilkat River is a large, glacial system that originates in British Columbia, 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 were made from aerial survey counts of chinook salmon *Oncorhynchus tshawytscha* in Stonehouse and Big Boulder creeks (Figure 1) by Alaska Department of Fish and Game (ADF&G) staff. 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 escapements in Southeast Alaska (Pahlke 1992).

In 1984 and 1985, eggs were collected from the Tahini River chinook salmon population. These eggs were incubated and hatched at Crystal Lake hatchery, and the fry were coded wire tagged and released back into the Tahini River. Following these releases, research on the Chilkat River grew to include sampling Tahini River escapements for coded wire tags (CWT's), and identifying migratory routes, timing, and contributions of chinook salmon to fisheries in Southeast Alaska (Pahlke et al. 1990, Pahlke 1991). These studies found that tagged fish from the Tahini River were recovered mostly in the inside waters of northern Southeast Alaska and did not contribute heavily to the overall chinook harvest. Harvest data for the 1984 and 1985 brood years are summarized in Johnson et al. (1993); contributions to sport and commercial fisheries were estimated at 360 (1984 brood year) and 530 (1985 brood year). A summary of CWT'd chinook salmon released into the Chilkat River system and years of 1.3 and 1.4 age-class return by brood year is presented in Appendix A1. Specific chinook salmon CWT tagging and release data for the period 1985-1992 is presented in Appendix A2.

In 1991, the Division of Sport Fish initiated research to estimate the spawning distributions and total escapement of large chinook salmon to the Chilkat River 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 or imprecise indices of spawning escapement for the drainage.

During 1991, radio telemetry (in conjunction with a mark-recapture experiment) was used to estimate an immigration of 5,897 (SE = 1,005) large chinook salmon, of which 54% (SE = 6.2%) 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 et al. 1992). The experiment was repeated in 1992 and estimated an immigration of 5,204 (SE = 935), of which 73% (SE = 5.5%) spawned in the Kelsall River system, 20% (SE = 4.9%) in the Tahini River, 5% (SE = 6.2%) in the Klehini River system, 1% (SE = 1.4%) in the mainstem Chilkat River, and 1% (SE = 1.4%) in Assignation Creek (Johnson et al. 1993). An unknown number of these fish died of natural causes, or were caught in a subsistence fishery, before spawning.

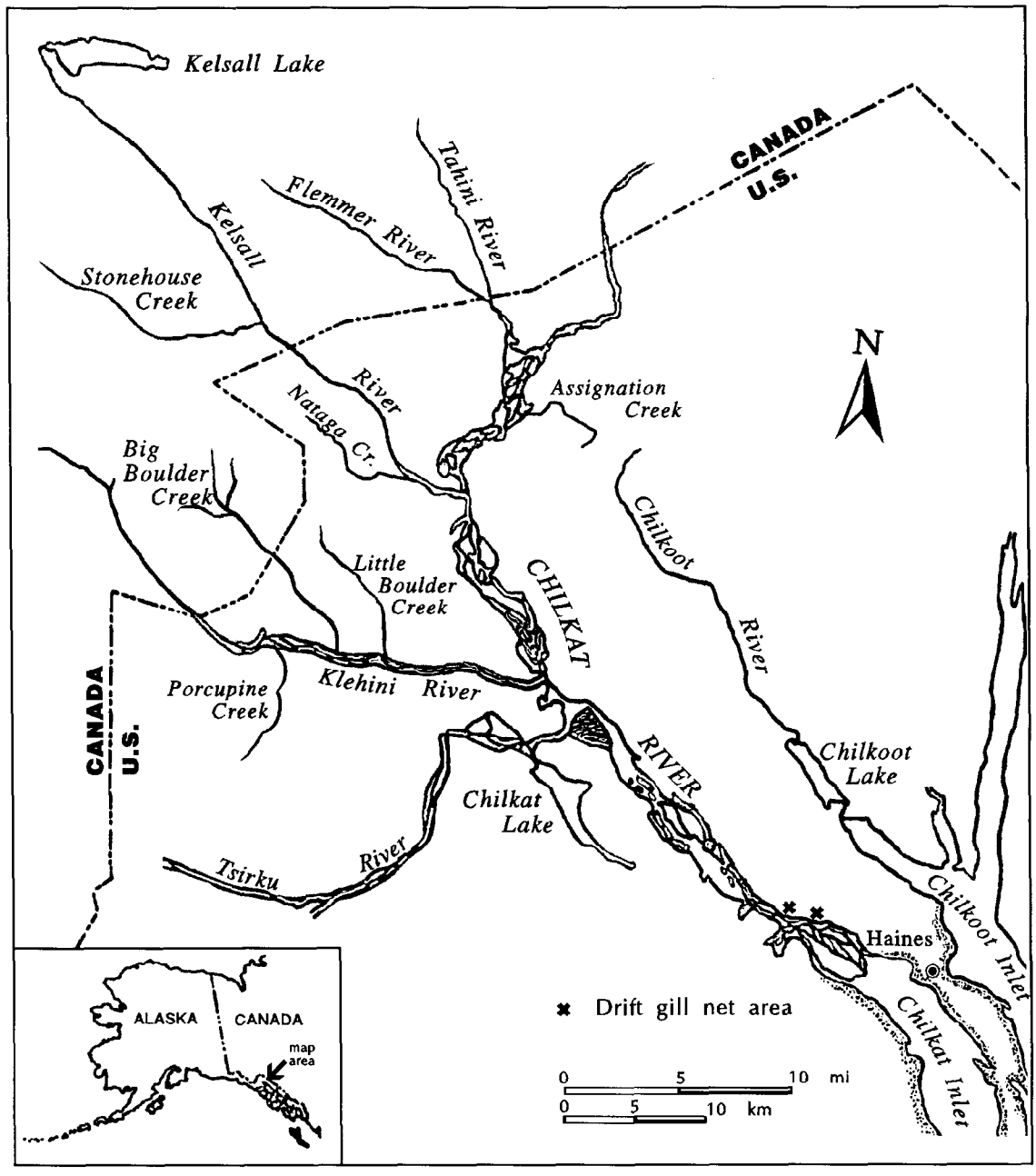

Figure 1. Main features of the Chilkat River drainage, northern Southeast Alaska and northwestern British Columbia.

The research objective in 1993 was to estimate the immigration of large chinook salmon into the Chilkat River. A second study to estimate harvest and catch distribution of Chilkat River chinook salmon (via coded wire tagging) was abandoned when program review determined that the project would not improve current estimates of harvest and distribution.

METHODS

Gill nets 70 feet long and 10 feet deep with a 7.5-inch stretched mesh were drifted between Chilkat River miles 7 and 8, from 15 June through 22 July 1993. 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).

Every day, except 17 June, two technicians made 43 drifts between 0600 and 1400 hours. Daily fishing effort (43 drifts) was selected a priori, intended to yield a desired total catch of 225 chinook salmon. Fishing was conducted from an 18-foot boat in three adjoining 0.3-mile-long areas, which were marked along a 0.9-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 if the net became entangled or drifted into shallow water, the terminated drift was subsequently completed before a new drift was started. 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 et al. 1992). Captured fish were initially classified as "large" or "small," depending on their mid-eye-to-fork length (MEF): fish ≥660 mm MEF were designated large, and fish <660 mm MEF were designated small. Healthy chinook salmon were tagged with a uniquely numbered spaghetti tag threaded over a solid plastic core, and a one-quarter-inch hole was punched into the upper edge of the left operculum as a secondary mark.

Age of each fish was determined from scale pattern analysis (Olsen 1992). Then each fish was reclassified as large or small, using age, rather than length, as criteria; fish 1.3 years or older 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. A mark-recapture experiment was used to estimate the number of large chinook salmon returning to the Chilkat River in 1993. Marks were applied to fish captured near river mile 7.5 between 15 June and 22 July, as explained above.

Escapements in the Kelsall and Tahini rivers (Figure 1), which comprised about 90% of the large chinook salmon spawning in the Chilkat River in 1991 and 1992 (Johnson et al. 1992, 1993), 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 22 July through 11 August. Thereafter, fish were sampled by this crew near spawning areas (20 August through 1 September). Spawning grounds in the Kelsall River and Nataga Creek were sampled from 9 August to 5 September. Chinook salmon were captured with gill nets, 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 released alive, and slashing the

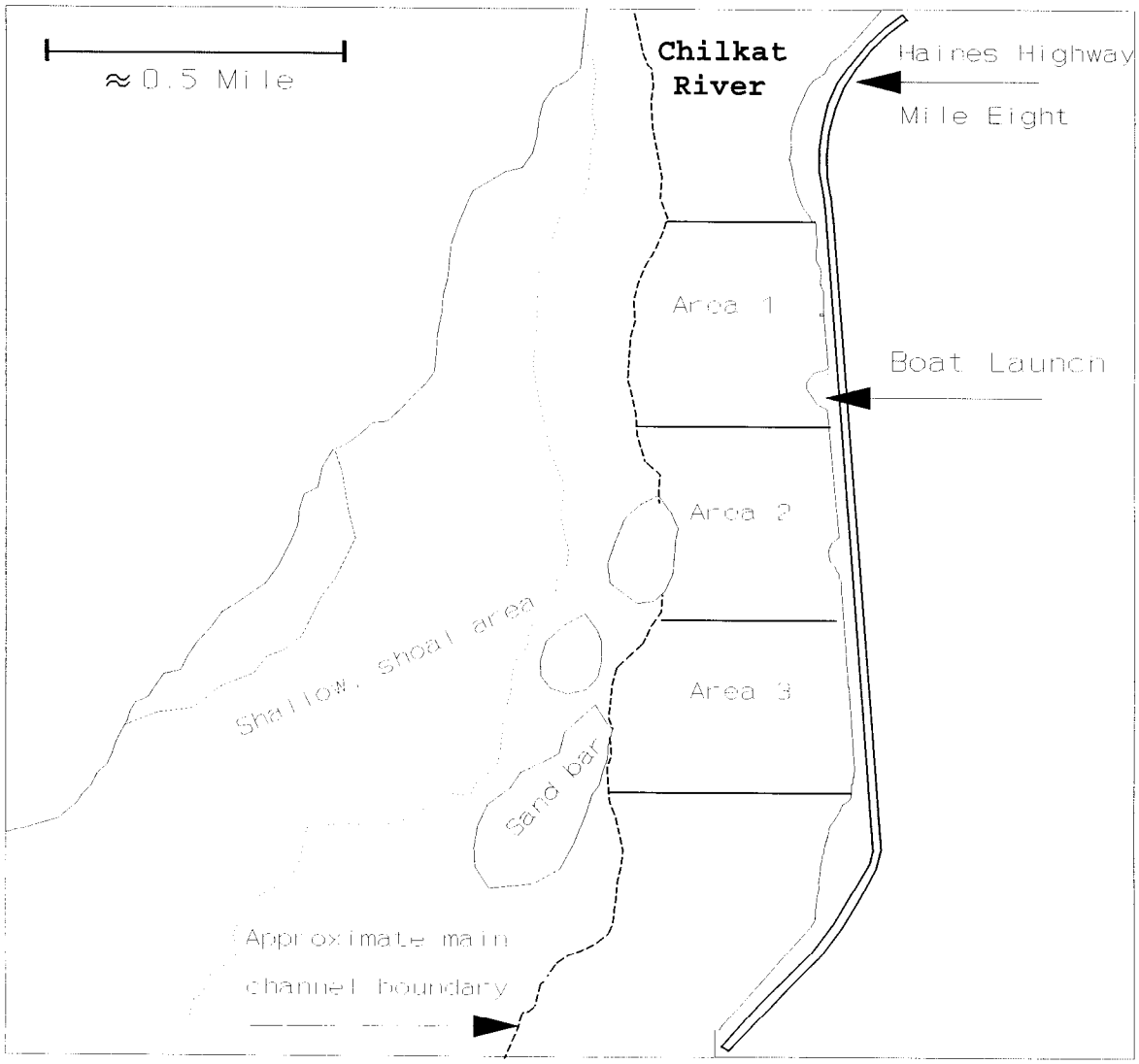

Figure 2. Chilkat River drift gill net fishing areas near the Haines Highway, 1993. Distances are approximate.

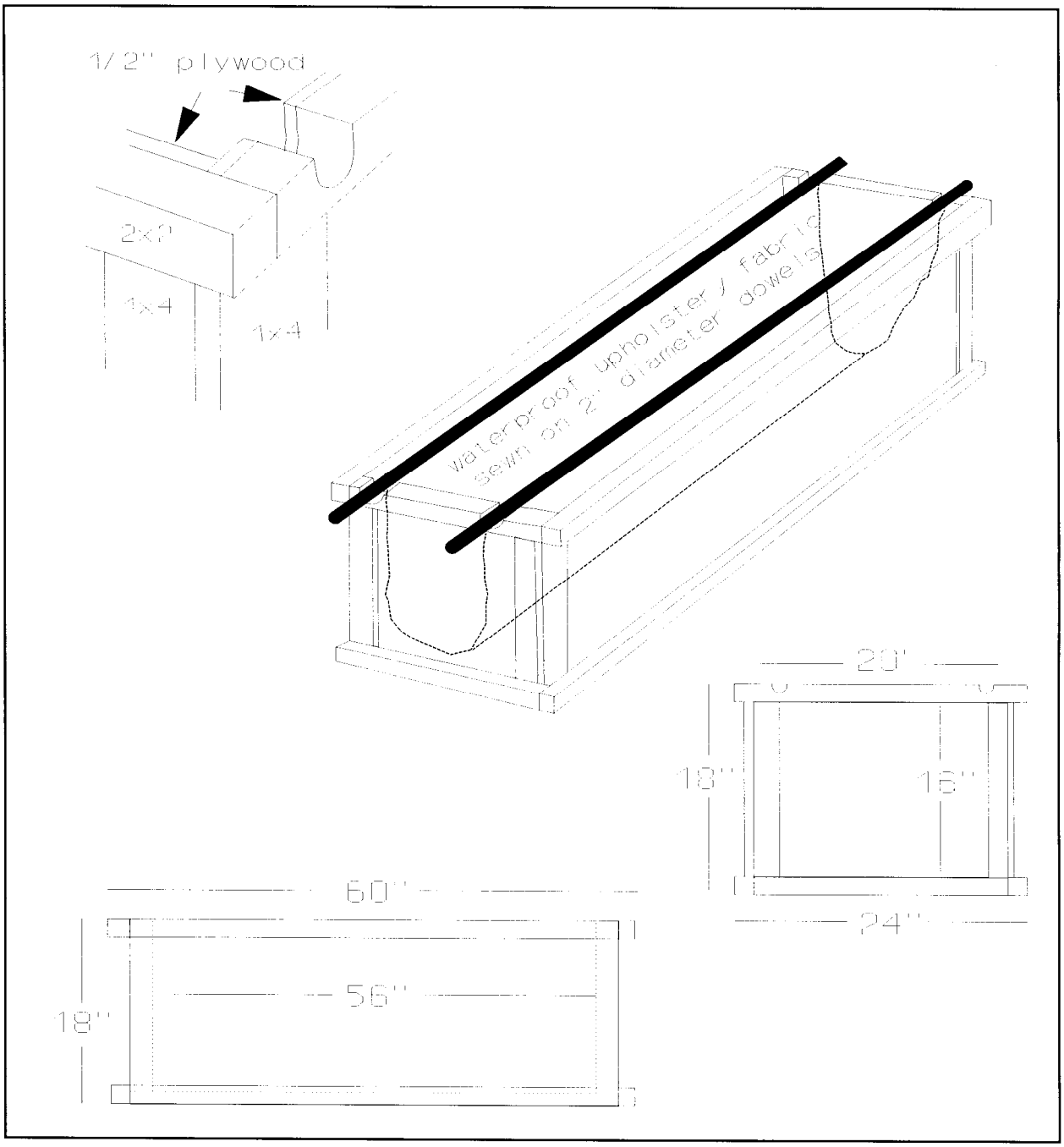

Figure 3. Tagging box used for attaching spaghetti tags to chinook salmon, 1993.

sampled carcasses. Chinook salmon were sampled in Big Boulder Creek from 4 August through 10 August with assistance of staff from the ADF&G Fisheries Management, Enhancement, and Development Division.

Abundance (numbers immigrating) was estimated using the Petersen model for a closed population (Seber 1982), as developed in previous investigations (Johnson et al. 1992, 1993). Finally, to provide evidence that the assumption for random sampling was met, a 2x2 contingency table was used to test the hypothesis ($\alpha = 0.05$) that marking fractions were equal in the two spatially separated sampling areas (Kelsall-Nataga and Tahini rivers). A discussion of these and other assumptions is included below.

RESULTS

One hundred sixty-one (161) large (age 1.3 and older) and 11 small chinook salmon were captured in the lower Chilkat River between 15 June through 22 July, 1993 (Appendices A3 and A4). Of the 161 large chinook salmon captured, 159 were given an external spaghetti tag (Table 1). Ten small fish were tagged with a spaghetti tag. Two of the large chinook salmon were sampled for coded wire tags and not tagged. Capture rates peaked on 29 June (Figures 4, 5). The mean date of the migratory timing (Mundy 1984) at river mile 7.5 was 3 July. A peak in water temperature during the immigration coincided with increased catches in the gill net (Figure 4, Appendix A5).

Sex ratios of large fish captured during tagging at mile 7.5 were 48% male and 52% female chinook salmon (Table 2). Sex ratios in large fish from Kelsall/ Nataga spawning ground (carcass) surveys were 41% male and 59% female. Seven hundred forty-five (745) unique chinook salmon were captured during the spawning ground sampling (Table 3). Large female chinook were captured more frequently than large male chinook (337 female, 277 male). Few chinook were observed in Nataga Creek during 1993. Twenty-one (21) large tagged fish were recovered when inspecting fish for marks.

The probability of capturing a marked chinook salmon in the Tahini ($p = 0.039$) and Kelsall ($p = 0.035$) rivers was not significantly different ($\chi^2 = 0.046$, $df = 1$, $P = 0.83$). Although not estimated in 1993, run timing for chinook salmon bound for the Tahini and Kelsall rivers appeared to be similar during 1991 and 1992. Therefore, recovery data for the mark-recapture experiment was combined across areas again during 1993, and Chapman's modified Petersen estimator ($n_1 = 159$, $n_2 = 614$, $m_2 = 21$) was used to estimate the immigration of large chinook salmon. The estimate of 4,472 (SE = 851) 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.

DISCUSSION

The 1993 immigration of 4,472 ± 851 was not significantly different from immigration in 1991 (5,897 ± 1,005) and 1992 (5,204 ± 935). Nevertheless, declining point estimates for those three years and observations by field personnel suggest fewer spawners in 1993 than in 1991 or 1992. This could be attributed to the relative strength of the 1986 brood year in those years. In 1991, the 1986 brood year contributed an estimated 3,211 (as age 1.3 fish) to the

Table 1. Numbers of chinook salmon caught in gill nets and marked with a spaghetti tag near Chilkat River mile 7.5 in 1993, by age and time period. (For detailed daily catch data, see Appendix A2.)

Time period	Age ≥ 1.3	Age ≤ 1.2	
	Number tagged	Number tagged	Total
6/15-6/19	7	0	7
6/20-6/24	11	0	11
6/25-6/29	45	0	45
6/30-7/04	39	5	44
7/05-7/09	21	1	22
7/10-7/14	27	3	30
7/15-7/19	8	0	8
7/20-7/22	1	1	2
Total	159	10	169

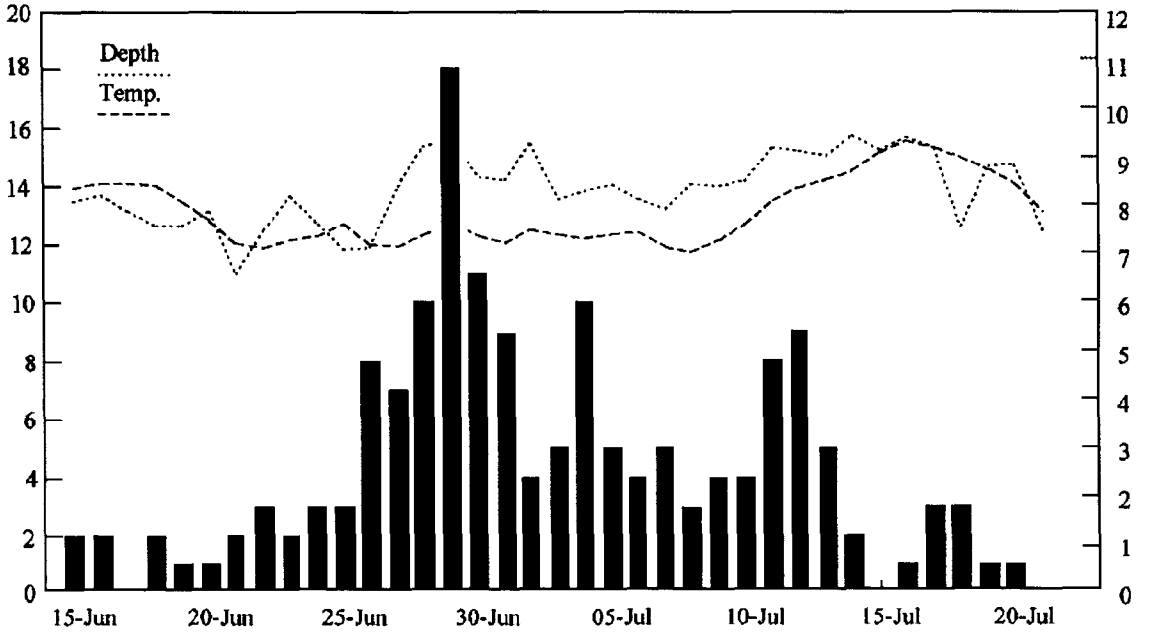

Figure 4. Depth (cm/19), temperature (°C), and large chinook salmon caught in drift gill net near mile 7.5 Chilkat River, 1993.

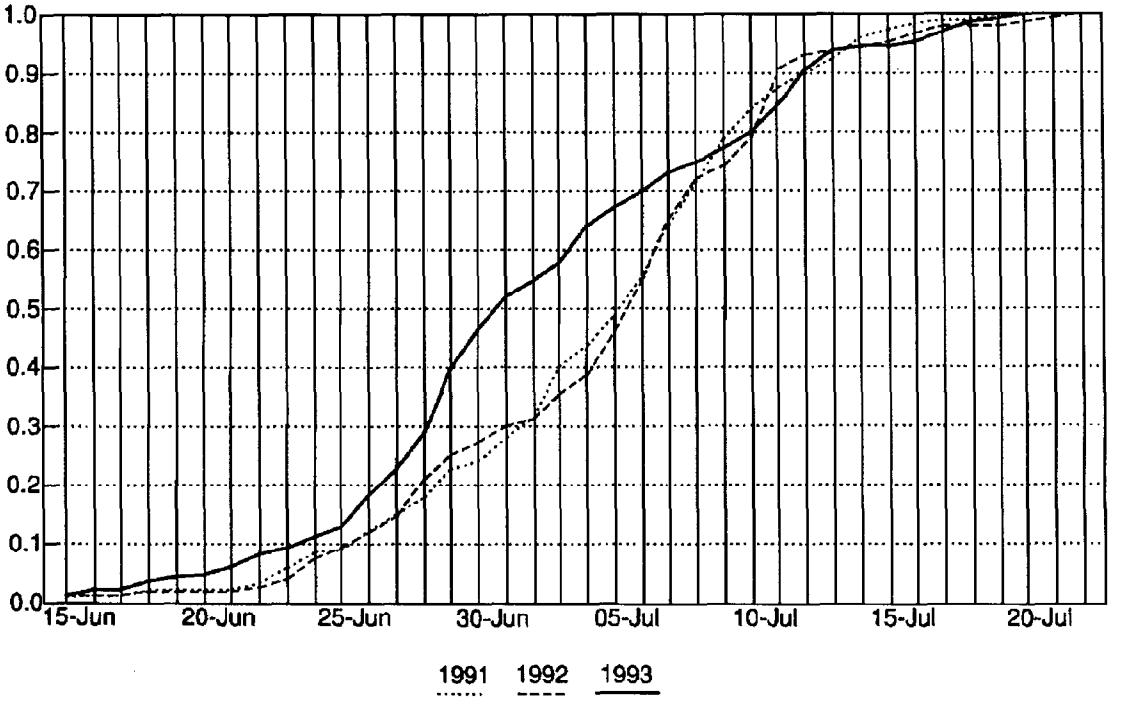

Figure 5. Cumulative proportions of large chinook salmon caught in drift gill net near mile 7.5 Chilkat River, 1991-1993.

Table 2. Age composition of chinook salmon sampled during tagging and recovery surveys on the Chilkat River, 1993, listed by gear type.

	Brood year and age class					
	1990	1989	1988	1987	1986	
	2.0	1.2	1.3	1.4	1.5	Total
Tagging: gill net, river mile 7.5						
Male						
Sample size	0	9	33	22	2	66
Percent	0.0	7.0	25.8	17.2	1.6	51.6
SD	0.0	2.2	3.8	3.3	1.1	4.4
Female						
Sample size	0	0	26	36	0	62
Percent	0.0	0.0	20.3	28.1	0.0	48.4
SD	0.0	0.0	3.5	3.9	0.0	4.4
All fish						
Sample size	0	9	59	58	2	128
Percent	0.0	7.0	46.1	45.3	1.6	100.0
SD	0.0	2.2	4.4	4.4	1.1	
Recovery survey: Tahini River gill net						
Male						
Sample size	0	53	39	10	0	102
Percent	0.0	42.1	31.0	7.9	0.0	81.0
SD	0.0	4.4	4.1	2.4	0.0	3.5
Female						
Sample size	0	0	7	17	0	24
Percent	0.0	0.0	5.6	13.5	0.0	19.0
SD	0.0	0.0	2.0	3.0	0.0	3.5
All fish						
Sample size	0	53	46	27	0	126
Percent	0.0	42.1	36.5	21.4	0.0	100.0
SD	0.0	4.4	4.3	3.7	0.0	0.0

-continued-

Table 2. (Page 2 of 3).

	Brood year and age class					
	1990	1989	1988	1987	1986	
	2.0	1.2	1.3	1.4	1.5	Total
Recovery survey: Tahini River spawning grounds						
Male						
Sample size	0	1	7	1	1	10
Percent	0.0	4.3	30.4	4.3	4.3	43.5
SD	0.0	4.3	9.8	4.3	4.3	10.6
Female						
Sample size	0	0	3	9	1	13
Percent	0.0	0.0	13.0	39.1	4.3	56.5
SD	0.0	0.0	7.2	10.4	4.3	10.6
All fish						
Sample size	0	0	10	10	2	23
Percent	0.0	0.0	43.5	43.5	8.7	100.0
SD	0.0	0.0	10.6	10.6	6.0	
Recovery survey: Big Boulder Creek spawning grounds						
Male						
Sample size	0	5	20	0	0	25
Percent	0.0	13.2	52.6	0.0	0.0	68.5
SD	0.0	5.6	8.2	0.0	0.0	7.8
Female						
Sample size	0	1	4	6	2	13
Percent	0.0	2.6	10.5	15.8	5.3	34.2
SD	0.0	2.6	5.0	6.0	3.7	7.8
All fish						
Sample size	0	6	24	6	2	38
Percent	0.0	15.8	63.2	15.8	5.3	100.0
SD	0.0	6.0	7.9	6.0	3.7	

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Table 2. (Page 3 of 3).

	Brood year and age class					
	1990	1989	1988	1987	1986	
	2.0	1.2	1.3	1.4	1.5	Total
Recovery survey: Kelsall River and Nataga Creek spawning grounds						
Male						
Sample size	1	43	91	49	1	185
Percent	0.3	11.1	23.5	12.6	0.3	47.7
SD	0.3	1.6	2.1	1.7	0.3	2.5
Female						
Sample size	0	1	94	100	8	203
Percent	0.0	0.3	24.2	25.8	2.1	52.3
SD	0.0	0.3	2.2	2.2	0.7	2.5
All fish						
Sample size	1	44	185	149	9	388
Percent	0.3	11.3	47.7	38.4	2.3	100.0
SD	0.3	1.6	2.5	2.4	0.8	

Table 3. Numbers of fish inspected for marks and numbers of marked fish found during tag recovery surveys, by size, sex, system and sampling dates, Chilkat River, 1993.

System/sampling	Date	Captures				Recaptures[c]			
		Large[a]		Small[b]		Large		Small	
		M	F	M	F	M	F	M	F
Kelsall River	8/9 - 9/5	179	253	56	1	5	10	0	0
Nataga Creek	8/9 - 9/5	5	8	3	0	0	0	0	0
Tahini (gill net)	7/22 - 8/11	60	30	61	0	2	2	2	0
Tahini (carcasses)	8/20 - 9/1	11	32	3	0	1	0	0	0
Big Boulder Creek	8/4 - 8/10	22	14	7	0	1	0	0	0
Total		277	337	130	1	9	12	2	0

[a] Fish aged 1.3 and older.

[b] Fish aged 1.2 and younger.

[c] Also included under captures.

escapement, and in 1992 contributed 3,595 (as age 1.4 fish) to the escapement (Appendix A.6). However, in 1993, the 1987 brood year (as age 1.3 fish) and the 1988 brood year (as age 1.4 fish) contributed only 2,141 and 2,105, respectively. The strength of the 1986 brood year may have been due to high rates of natural survival. Marine survival for wild and hatchery stocks from the 1986 brood of Unuk and Chickamin fish in southern Southeast Alaska (McPherson and Carlile *In prep.*) was higher than in adjacent brood years.

Several assumptions are implicit in the use of the Petersen model (Seber 1982). 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) that fish did not lose marks. In respect to assumption (a), considerable efforts were made to catch and mark fish in proportion to their abundance during the immigration. Also, sampling was spread fairly uniformly across the escapement, and tagging ratios on the Tahini ($p = 0.039:1$) and Kelsall-Nataga ($p = 0.035:1$) rivers were similar. To achieve a random sample during the second sampling event, carcass sampling must not be size selective. Size selective sampling for fish marked in event one was not apparent in event two (KS test, $d_{max} = 0.18$, $P = 0.59$). Also, since 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, assumption (a) appears fairly robust for this experiment. Assumption (b) is reasonable since tagging continued until only about one fish a day was being caught. We have no direct evidence to disprove assumption (c). Tag loss was observed in 1 of 23 total tagged fish recovered during the experiment, and that missing tag was easily noted by the opercular-punch secondary mark. Other potential biases in this experiment were discussed in Johnson et al. (1993), and appear to be small.

Although there could be fewer large chinook salmon immigrating in 1993 relative to 1991 or 1992, the population is most certainly viable and capable of sustaining current levels of harvest in subsistence, sport and commercial fisheries. Since a conservation concern in not apparent for Chilkat chinook salmon at these levels of escapement, a program that measures escapement with less accuracy (than a mark-recapture experiment) would be sufficient for these fisheries. Escapement can be calculated from an unbiased sample or index of number of spawners. Such an index should be a consistent proportion of the total escapement, should be an unbiased sample, and be large a large enough proportion of the total as to reduce the error associated with annual variations. Three potential indices, developed from past years' investigations, are presented in Table 4 and discussed below. None currently have utility because the data are insufficient to judge accuracy and precision of the indices.

1. An index of abundance based on the CPUE of chinook salmon in drift gill nets fished at the 7.5-mile site seems to have the most promise. Because catches from this site should be proportional to the total escapement, it is more accurate than other methods. Drawbacks of this index are high cost, limited sample size, and the possibility that the Chilkat River could change channels, causing annual fishing effort to be incomparable.

2. A second method would count the number of dead of dying chinook salmon in the Kelsall River delta. Chinook are continuously swept out of the river

Table 4. Comparison of three methods for indexing chinook salmon abundance in Chilkat River. "Deviation from estimate" is the difference between the escapement estimated from the index and the escapement estimated from a mark recapture experiment.

	1991	1992	1993
Estimated Escapement[a]	5,897	5,204	4,472
Mainstem Gillnet CPUE[b]	ND	0.0674	0.0528
Escapement estimated from index			4,077
Deviation from estimate			-9%
Tahini River Gillnet CPUE (all sexes)[c]	1.493	0.859	0.656
Escapement estimated from index	9,535	4,145	3,096
Deviation from estimate	62%	-20%	-31%
Kelsall R. Carcass Count ($p_{escapement}$)[d]	ND	0.090	0.094
Escapement estimated from index			5,435
Deviation from estimate			22%

[a] Johnson et al 1992, Johnson et al 1993, this paper.
[b] Catch of large chinook per foot of net fished per day, summed.
[c] Catch of large chinook per net hour per day, summed.
[d] Proportion of Kelsall count to estimated abundance.
ND = no data or not sampled in a manner comparable with other years.

and into the delta where they remain and can be counted. Counts of chinook salmon in the Kelsall River delta made up 9.0% and 9.4%, respectively, of the total escapement during 1992 and 1993.

3. Catch data from set gill nets on the Tahini River: A set gill net has been operated on the Tahini River for all but one year since 1984, producing the longest running data base on the Chilkat River system, except for counts in Big Boulder and Stonehouse creeks. This sampling program was initially developed to capture brood stock for enhancement programs, and, unfortunately, sampling gear was not always fished consistently. Additionally, catches are heavily biased for small male chinook, perhaps due to the smaller gill net mesh size, gill net construction, temporal stratification by sex, or set versus drift gill net configuration. This tributary index is less robust because the Tahini River accounts for about 30% of all spawners in the drainage.

4. Big Boulder and Stonehouse creeks: escapement counts from these two tributaries were the basis of the historical basinwide escapement index. This method is highly inaccurate because the proportion of fish spawning in there is small (about 5%) relative to the total escapement (Johnson et al. 1992, 1993). Consequently, small changes in counts caused by random processes or poor survey conditions produced large variations in the basinwide estimate.

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APPENDIX A

Appendix A1. CWT Chinook salmon released into the Chilkat River system, and years of 1.3 and 1.4 return, by brood year.

System	Brood year	Number of fish released	Years when age 1.3 & 1.4 return
Tahini River	1984	42,360[a]	1989-1990
Tahini River	1985	44,120[a]	1991-1992
Chilkat River	1987	4,553[b]	1992-1993
Chilkat River	1988	32,048[c]	1993-1994
Tahini River	1988	5,293[d]	1993-1994
Total		37,341	1993-1994
Chilkat River	1989	12,390[e]	1994-1995
Tahini River	1989	31,369[f]	1994-1995
Total		43,759	1994-1995
Tahini River	1990	35,520[g]	1995-1996
Tahini River	1991	60,555[h]	1996-1997
Big Boulder Creek	1991	43,018[i]	1996-1997
Total		103,573	1996-1997

[a] Tahini stock zero-check fingerlings back-planted into Tahini River from Crystal Lake hatchery following May egg take.

[b] Wild fingerlings captured, tagged and released in October 1988.

[c] Includes 29,857 wild fingerlings captured, tagged, and released in Sept/Oct 1989 in the Kelsall and Chilkat River and 2,191 smolt captured, tagged, and released in April 1990 in Chilkat River.

[d] Wild fingerlings tagged in August 1989.

[e] Wild fingerlings tagged in Sept/Oct 1990 in Kelsall and Chilkat Rivers.

[f] Includes 1,403 wild fingerlings tagged in Sept/Oct 1990 in Tahini and 29,966 Tahini River stock backplanted into Tahini River from J. Meyers PNP hatchery, May 14, 1990.

[g] Backplanted Tahini River stock into Tahini River by J. Meyers PNP hatchery May 24, 1991.

[h] Backplanted Tahini River stock into Tahini River by J. Meyers PNP hatchery May 20, 1992.

[i] Backplanted Big Boulder stock into Big Boulder Creek by Gastineau PNP hatchery May 22, 1992.

Appendix A2. Chinook salmon coded wire tag releases in the Chilkat River, 1985-1992.

Tag code	Assoc. hatchery	Release site	Brood year	Last released	Released/ #tagged	Marked& tagged	Shed marked	PSC un- marked	Total fish released	Stock name
B41114	CRYSTAL LK	TAHINI R	84	20-May-85	1.014	42360	601	0	42961	TAHINI R[a]
B30612	CRYSTAL LK	TAHINI R	85	12-May-86	1.053	11383	376	232	11991	TAHINI R[a]
B30613	CRYSTAL LK	TAHINI R	85	12-May-86	1.054	11779	389	242	12410	TAHINI R[a]
B30610	CRYSTAL LK	TAHINI R	85	12-May-86	1.053	10419	344	212	10975	TAHINI R[a]
B30611	CRYSTAL LK	TAHINI R	85	12-May-86	1.053	10539	348	215	11102	TAHINI R[a]
42717	WILD	KELSALL R	87	28-Oct-88	1.000	4553	0	0	4553	KELSALL R
42837	WILD	TAHINI R	88	24-Aug-89	1.000	5293	0	0	5293	TAHINI R
43337	WILD	CHILKAT R	88	26-Apr-90	1.013	2191	29	0	2220	CHILKAT R
42710	WILD	CHILKAT R	88	08-Nov-89	1.012	9778	119	0	9897	CHILKAT R
42714	WILD	KELSALL R	88	11-Oct-89	1.003	10470	32	0	10502	KELSALL R
42715	WILD	KELSALL R	88	16-Oct-89	1.012	4152	50	0	4202	KELSALL R
42843	WILD	KELSALL R	88	30-Sep-89	1.006	5457	38	0	5495	KELSALL R
43338	WILD	TAHINI R	89	08-Oct-90	1.000	1403	0	0	1403	TAHINI R
43339	WILD	CHILKAT R	89	27-Oct-90	1.000	2230	0	0	2230	CHILKAT R
43347	WILD	KELSALL R	89	15-Oct-90	1.008	10160	82	0	10242	KELSALL R
401011008	J MYERS	TAHINI R	89	14-May-90	1.006	12155	73	0	12228	TAHINI R[a]
401011009	J MYERS	TAHINI R	89	14-May-90	1.006	10955	66	0	11021	TAHINI R[a]
401011010	J MYERS	TAHINI R	89	14-May-90	1.005	6856	41	0	6897	TAHINI R[a]
401011014	J MYERS	TAHINI R	90	24-May-91	1.000	24948	0	0	24948	TAHINI R[a]
401010913	J MYERS	TAHINI R	90	24-May-91	1.075	10572	796	0	11368	TAHINI R[a]
401020603	GASTINEAU	TAHINI R	91	20-May-92	1.035	27204	957	0	28161	TAHINI R[a]
401020602	GASTINEAU	TAHINI R	91	20-May-92	1.031	33351	1067	0	34418	TAHINI R[a]

[a] Backplanted from hatchery.

Appendix A3. Number of gill net drifts and catch of large chinook salmon by date and area, and cumulative catch and proportion for the drift gill nets fished near Chilkat River mile 7, 1993.

	Drifts by area			Catch by area			Total daily drifts	Total daily catch	Cumulative catch	Cumulative proportion
	1	2	3	1	2	3				
15-Jun	15	14	14	1	1	0	43	2	2	0.012
16-Jun	14	15	14	2	0	0	43	2	4	0.025
17-Jun	2	1	1	0	0	0	4	0	4	0.025
18-Jun	15	14	14	0	0	2	43	2	6	0.037
19-Jun	15	14	14	1	0	0	43	1	7	0.043
20-Jun	15	14	14	0	1	0	43	1	8	0.050
21-Jun	15	14	14	1	0	1	43	2	10	0.062
22-Jun	15	14	14	2	0	1	43	3	13	0.081
23-Jun	15	14	14	1	0	1	43	2	15	0.093
24-Jun	15	14	14	1	0	2	43	3	18	0.112
25-Jun	15	14	14	1	2	0	43	3	21	0.130
26-Jun	14	15	14	2	4	2	43	8	29	0.180
27-Jun	15	14	14	2	4	1	43	7	36	0.224
28-Jun	15	14	14	2	5	3	43	10	46	0.286
29-Jun	15	14	14	7	10	1	43	18	64	0.398
30-Jun	15	14	14	2	6	3	43	11	75	0.466
01-Jul	15	14	14	7	2	0	43	9	84	0.522
02-Jul	15	14	14	1	2	1	43	4	88	0.547
03-Jul	15	14	14	2	2	1	43	5	93	0.578
04-Jul	15	14	14	3	3	4	43	10	103	0.640
05-Jul	15	14	14	0	3	2	43	5	108	0.671
06-Jul	15	14	14	2	0	2	43	4	112	0.696
07-Jul	15	14	14	2	1	2	43	5	117	0.727
08-Jul	15	14	14	0	1	2	43	3	120	0.745
09-Jul	15	14	14	1	2	1	43	4	124	0.770
10-Jul	15	14	14	0	0	4	43	4	128	0.795
11-Jul	15	14	14	1	4	3	43	8	136	0.845
12-Jul	15	14	14	2	3	4	43	9	145	0.901
13-Jul	15	14	14	2	2	1	43	5	150	0.932
14-Jul	15	14	14	0	0	2	43	2	152	0.944
15-Jul	15	14	14	0	0	0	43	0	152	0.944
16-Jul	15	14	14	0	0	1	43	1	153	0.950
17-Jul	14	14	15	1	0	2	43	3	156	0.969
18-Jul	14	15	14	1	0	2	43	3	159	0.988
19-Jul	15	14	14	0	0	1	43	1	160	0.994
20-Jul	15	14	14	0	1	0	43	1	161	1.000
21-Jul	15	14	14	0	0	0	43	0	161	1.000

Appendix A4. Fish number, sex, length (MEF), age, and tag number for tagging on the Chilkat River by date, 1993.

Date tagged	Fish no.	Sex	Age[a]	Length	Tag number	Date tagged	Fish no.	Sex	Age	Length	Tag number
15-Jun	1	F	N/A[b]	980	GY00586	29-Jun	48	M	1.3	860	B00618
15-Jun	2	M	1.3	690	GY00587	29-Jun	49	F	1.4	915	B00620
16-Jun	3	F	N/A	800	GY00588	29-Jun	50	M	N/A	730	B00621
16-Jun	4	F	1.4	905	GY00589	29-Jun	51	M	N/A	770	CWT
18-Jun	5	M	1.3	710	GY00590	29-Jun	52	F	N/A	860	B00622
18-Jun	6	M	1.4	920	GY00591	29-Jun	53	M	1.4	860	B00623
19-Jun	7	M	1.4	820	GY00592	29-Jun	54	M	1.3	670	B00624
20-Jun	8	F	1.3	805	GY00593	29-Jun	55	F	1.4	920	B00625
21-Jun	9	M	1.3	780	GY00594	29-Jun	56	F	1.4	940	B00626
21-Jun	10	F	1.4	980	GY00595	29-Jun	57	M	1.3	755	B00627
22-Jun	11	M	1.4	960	R00061	29-Jun	58	M	1.4	910	B00628
22-Jun	12	F	1.3	670	R00062	29-Jun	59	M	1.3	830	B00629
22-Jun	13	M	1.4	860	R00063	29-Jun	60	F	1.4	845	B00630
23-Jun	14	M	1.4	950	R00064	29-Jun	61	F	1.3	800	B00631
23-Jun	15	F	1.4	885	R00065	29-Jun	62	M	1.4	920	B00632
24-Jun	16	F	1.3	840	R00066	29-Jun	63	M	1.4	885	B00633
24-Jun	17	M	1.4	830	R00067	29-Jun	64	F	1.4	895	B00634
24-Jun	18	F	1.4	940	R00068	30-Jun	65	M	N/A	660	B00635
25-Jun	19	F	1.4	875	R00069	30-Jun	66	M	1.4	905	B00636
25-Jun	20	M	1.3	690	R00070	30-Jun	67	F	1.3	835	B00637
25-Jun	21	F	1.4	880	R00071	30-Jun	68	F	N/A	770	B00638
26-Jun	22	F	N/A	820	R00072	30-Jun	69	M	N/A	710	B00639
26-Jun	23	F	N/A	820	R00073	30-Jun	70	F	N/A	880	B00640
26-Jun	24	M	N/A	800	R00074	30-Jun	71	M	1.2	610	B00641
26-Jun	25	M	1.5	990	R00075	30-Jun	72	F	1.3	820	B00642
26-Jun	26	M	1.4	905	R00076	30-Jun	73	M	N/A	750	B00643
26-Jun	27	M	1.3	855	R00077	30-Jun	74	M	N/A	670	B00644
26-Jun	28	F	N/A	840	R00078	30-Jun	75	F	1.3	860	B00645
26-Jun	29	F	N/A	890	R00079	30-Jun	76	M	1.3	760	B00646
27-Jun	30	M	1.3	750	R00080	01-Jul	77	F	1.4	865	B00647
27-Jun	31	F	1.3	700	B00601	01-Jul	78	M	N/A	900	B00648
27-Jun	32	M	1.4	780	B00602	01-Jul	79	M	1.3	745	B00649
27-Jun	33	M	N/A	695	B00603	01-Jul	80	M	1.2	640	B00650
27-Jun	34	M	1.3	760	B00604	01-Jul	81	M	1.3	780	B00651
27-Jun	35	F	N/A	900	B00605	01-Jul	82	F	N/A	840	B00652
27-Jun	36	F	1.4	920	B00606	01-Jul	83	F	1.3	850	B00653
28-Jun	37	M	N/A	800	B00607	01-Jul	84	F	1.3	750	B00654
28-Jun	38	F	N/A	700	B00608	01-Jul	85	M	1.4	870	B00655
28-Jun	39	M	1.4	980	B00609	01-Jul	86	M	1.4	660	B00656
28-Jun	40	F	1.4	880	B00610	02-Jul	87	M	1.3	830	B00657
28-Jun	41	F	1.3	755	B00611	02-Jul	88	F	N/A	900	B00658
28-Jun	42	F	N/A	910	B00612	02-Jul	89	M	1.2	655	B00659
28-Jun	43	F	1.3	850	B00613	02-Jul	90	F	1.3	815	B00660
28-Jun	44	F	1.4	945	B00614	02-Jul	91	F	1.4	865	B00661
28-Jun	45	F	N/A	875	B00615	03-Jul	92	M	1.2	630	B00662
28-Jun	46	F	1.4	875	B00616	03-Jul	93	F	N/A	755	B00663
29-Jun	47	M	1.3	760	B00617	03-Jul	94	F	N/A	790	B00664

-continued-

Appendix A4. (Page 2 of 2).

Date tagged	Fish no.	Sex	Age[a]	Length	Tag number	Date tagged	Fish no.	Sex	Age	Length	Tag number
03-Jul	95	M	1.5	920	B00665	10-Jul	134	M	N/A	690	P00703
03-Jul	96	F	1.3	780	B00666	10-Jul	135	F	N/A	885	P00704
03-Jul	97	M	1.4	915	B00667	11-Jul	136	F	N/A	770	P00705
03-Jul	98	M	1.2	660	CWT	11-Jul	137	F	1.4	860	P00706
04-Jul	99	M	1.4	800	B00668	11-Jul	138	M	1.3	750	P00707
04-Jul	100	F	1.4	900	B00669	11-Jul	139	F	1.4	850	P00708
04-Jul	101	M	N/A	800	B00670	11-Jul	140	F	1.4	910	P00709
04-Jul	102	M	N/A	790	B00671	11-Jul	141	M	N/A	800	P00710
04-Jul	103	F	N/A	890	B00672	11-Jul	142	M	1.2	600	P00711
04-Jul	104	M	1.2	680	B00673	11-Jul	143	F	1.3	750	P00712
04-Jul	105	F	1.4	720	B00674	11-Jul	144	F	N/A	795	P00713
04-Jul	106	M	N/A	685	B00675	12-Jul	145	F	1.3	770	P00714
04-Jul	107	M	1.4	925	B00676	12-Jul	146	M	1.3	750	P00715
04-Jul	108	M	N/A	750	B00677	12-Jul	147	F	1.3	770	P00716
04-Jul	109	F	1.3	800	B00678	12-Jul	148	F	1.3	750	P00717
05-Jul	110	M	N/A	970	B00679	12-Jul	149	F	1.4	855	P00718
05-Jul	111	M	1.3	585	B00680	12-Jul	150	M	1.4	900	P00719
05-Jul	112	F	1.4	910	B00681	12-Jul	151	M	1.3	850	P00720
05-Jul	113	F	1.3	800	B00682	12-Jul	152	M	1.3	665	P00721
05-Jul	114	M	1.3	715	B00683	12-Jul	153	M	1.3	770	P00722
06-Jul	115	M	1.3	855	B00684	13-Jul	154	M	1.2	570	P00723
06-Jul	116	M	1.3	770	B00685	13-Jul	155	M	1.2	630	P00724
06-Jul	117	M	1.4	930	B00686	13-Jul	156	M	1.3	690	P00725
06-Jul	118	F	1.4	925	B00687	13-Jul	157	M	N/A	740	P00726
07-Jul	119	F	1.4	840	B00688	13-Jul	158	F	1.4	840	P00727
07-Jul	120	F	1.4	920	B00689	13-Jul	159	M	1.3	820	P00728
07-Jul	121	M	N/A	950	B00690	13-Jul	160	M	1.3	700	P00729
07-Jul	122	M	1.3	735	B00691	14-Jul	161	F	1.4	860	P00730
07-Jul	123	F	1.4	980	B00692	14-Jul	162	M	1.3	670	CWT
08-Jul	124	F	1.4	830	B00693	16-Jul	163	F	1.4	930	P00731
08-Jul	125	M	1.3	870	B00694	17-Jul	164	M	1.4	990	P00732
08-Jul	126	M	N/A	590	B00695	17-Jul	165	F	1.4	915	P00733
08-Jul	127	F	1.4	880	B00696	17-Jul	166	F	1.3	800	P00734
09-Jul	128	M	1.3	725	B00697	18-Jul	167	F	1.3	800	P00736
09-Jul	129	F	1.4	850	B00698	18-Jul	168	M	N/A	760	P00737
09-Jul	130	F	1.4	890	B00699	18-Jul	169	M	1.3	790	P00738
09-Jul	131	F	1.3	690	B00700	19-Jul	170	F	1.3	785	P00739
10-Jul	132	F	1.3	785	P00701	20-Jul	171	F	1.3	760	P00740
10-Jul	133	M	N/A	790	P00702	21-Jul	172	M	N/A	605	P00741

[a] European notation; see text.

[b] N/A = Not aged due to annulus reabsorption, etc.

Appendix A5. Average daily 1993 water temperature and depth of Chilkat River near the drift gill net site at river mile 7.5.

Date	Temp (°C)	Depth (cm)	Date	Temp. (°C)	Depth (cm)
15-Jun	8.1	159.0	04-Jul	8.3	139.5
16-Jun	8.3	161.0	05-Jul	8.5	141.0
17-Jun	7.9	161.0	06-Jul	8.2	141.5
18-Jun	7.6	160.5	07-Jul	7.9	136.0
19-Jun	7.6	154.0	08-Jul	8.4	134.0
20-Jun	7.9	146.5	09-Jul	8.4	138.5
21-Jun	6.6	137.5	10-Jul	8.5	144.5
22-Jun	7.5	135.5	11-Jul	9.2	154.0
23-Jun	8.2	139.0	12-Jul	9.2	159.0
24-Jun	7.6	140.0	13-Jul	9.1	162.0
25-Jun	7.1	145.5	14-Jul	9.5	165.5
26-Jun	7.2	137.0	15-Jul	9.2	173.0
27-Jun	8.4	136.5	16-Jul	9.4	177.5
28-Jun	9.3	141.0	17-Jul	9.2	175.0
29-Jun	9.4	145.0	18-Jul	7.5	171.0
30-Jun	8.6	140.0	19-Jul	8.8	166.0
01-Jul	8.6	137.5	20-Jul	8.8	160.5
02-Jul	9.3	142.5	21-Jul	7.4	149.5
03-Jul	8.2	141.0			

Appendix A6. Annual age compositions[a] and brood year returns of large chinook salmon immigrating into Chilkat River, 1991-1993.

Return year		Age class 1.3	1.4	1.5	Total
1993[b]	n	59	58	2	119
	%	49.6	48.7	1.7	100.0
	N	2,218	2,178	76	4,472
1992[c]	n	39	83	0	122
	%	32.0	68.0	0	100.0
	N	1,689	3,595	0	5,284
1991[d]	n	104	83	4	191
	%	54.5	43.5	2.0	100.0
	N	3,211	2,563	123	5,897
Average	%	45.4	53.4	3.0	
	N	2,373	2,779	100	5,252

Brood year returns

Brood year	Age class 1.3	1.4	1.5	Total
1984	N/A	N/A	123	N/A
1985	N/A	2,563	0	N/A
1986	3,211	3,595	76	6,882
1987	1,689	2,178	N/A	3,867
1988	2,218	N/A	N/A	N/A
Average	2,372	2,778	100	5,374

[a] Based on sampling at Chilkat River mile 7.5 with drift gill nets (n) and expanded upward for immigration (N).

[b] Estimated from this investigation.

[c] Estimated from Johnson et al. (1993).

[d] Estimated from Johnson et al. (1992).

Appendix A7. List of computer data files for Chilkat River chinook salmon studies, 1993.

Data File	Description
93drdata.wk1	LOTUS file of daily drift net catch, river temperature, and depth.
93drift.wk1	LOTUS file of individual chinook sampled during drift gill net sampling, including date, time, sex, age, length, tag #, and comments.
93n2mstr.wk1	LOTUS file of individual chinook sampled on the spawning grounds of the Chilkat River system, including date, system, sex, length, age, initial capture/recapture status, and comments