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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Radio telemetry and a mark-recapture experiment were used to estimate spawning distribution and abundance of chinook salmon *Oncorhynchus tshawytscha* age 1.3 and older returning to the Chilkat River, near Haines, Alaska.

Two hundred twenty-five large (age 1.3 and older) chinook salmon were captured in fish wheels and gill nets between May 18 and July 19, 1991. The mean date of the immigration was July 5. One hundred eighteen of these fish were implanted with radio transmitters, and 106 were tagged with solid-core spaghetti tags; 100 of the fish with transmitters were tracked to areas of the drainage where it was assumed they spawned.

An estimated 54% (SE = 6.2%) of the chinook salmon spawning in the Chilkat River drainage in 1991 occurred in the Kelsall River system, 33% (SE = 6.0%) in the Tahini River, 8% in the Klehini River system, 4% in the mainstem Chilkat River, and 1% in Assignation Creek.

Between July 22 and September 12, 733 large chinook salmon spawning in the Chilkat River drainage, mostly on the Kelsall River, Nataga Creek, and Tahini River were randomly inspected for tags. A simple Peterson model (n_1 = 224, n_2 = 733, m_2 = 27) was used to estimate that 5,897 (SE = 1,005) chinook salmon age 1.3 and older returned to the Chilkat River in 1991. An unknown number of these fish died of natural causes, or were caught in a subsistence fishery, prior to spawning.

The two most important findings of this season's research are: a) that estimated escapement to the Chilkat River system was much greater (seven times) than the historical expansion estimator would have indicated; and b) that historic index areas, Big Boulder and Stonehouse creeks, were not major spawning locations during the 1991 season.

KEY WORDS: Radio telemetry, Chinook Salmon, *Oncorhynchus tshawytscha*, Chilkat River, escapement, spawning distribution, mark-recapture, abundance estimate, 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 (Takhin, 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 numerous glaciers and flows through rugged, dissected mountainous terrain, converging to a silty, braided river system (Bugliosi 1988).

In accordance with the U.S./Canada Pacific Salmon Treaty's (PST) program to rebuild stocks of wild chinook salmon, indices of spawner abundance have been obtained annually since 1981 by Alaska Department of Fish and Game (ADF&G) in the only two clear tributaries of the Chilkat River receiving notable chinook salmon escapement: Stonehouse and Big Boulder creeks (Pahlke 1992). These indices of escapement were used to evaluate progress in rebuilding the stock to an expanded index of 2,000 large[1] spawners. However, in 1985 and 1986, these escapement indices declined sharply following rapid growth in the recreational fishery in Chilkat Inlet and increased harvests in the drift gill net fishery in ADF&G District 115 (Table 1). This decline prompted a restriction and closure of the directed chinook salmon sport fishery in Haines, Alaska, from 1987 to the present. Despite this conservative management, the index counts in Stonehouse and Big Boulder creeks have not indicated that Chilkat River chinook salmon stocks have increased.

The research for the present project 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 measures of actual spawning escapement to the Chilkat River drainage. The primary objective of our study was to detect all spawning areas on the Chilkat River which received 7.5% or more of the chinook salmon spawning in 1991. Our experimental method was to attach radio transmitters to large chinook salmon as they immigrated into the lower Chilkat River, and track them upriver. We estimated that the successful tracking of 80 radio transmitters would allow us to meet this objective with 95% confidence, assuming proportional tagging on an expected spawning population of 1,000 large chinook salmon. Large chinook salmon captured but not radio-tagged during this event were tagged with a spaghetti tag.

When radio tagging was completed we began sampling chinook salmon near various spawning grounds, to recover tags and determine the feasibility of sampling for coded wire tags in the future. A large amount of data was collected during this sampling event, which allowed us to estimate abundance of the inriver migration of large chinook salmon.

METHODS

Adult chinook salmon were captured with fishwheels and drift gill nets from May 18 through July 19, 1991. Each fish selected for tagging had a 30-31 Mhz Advanced

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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).

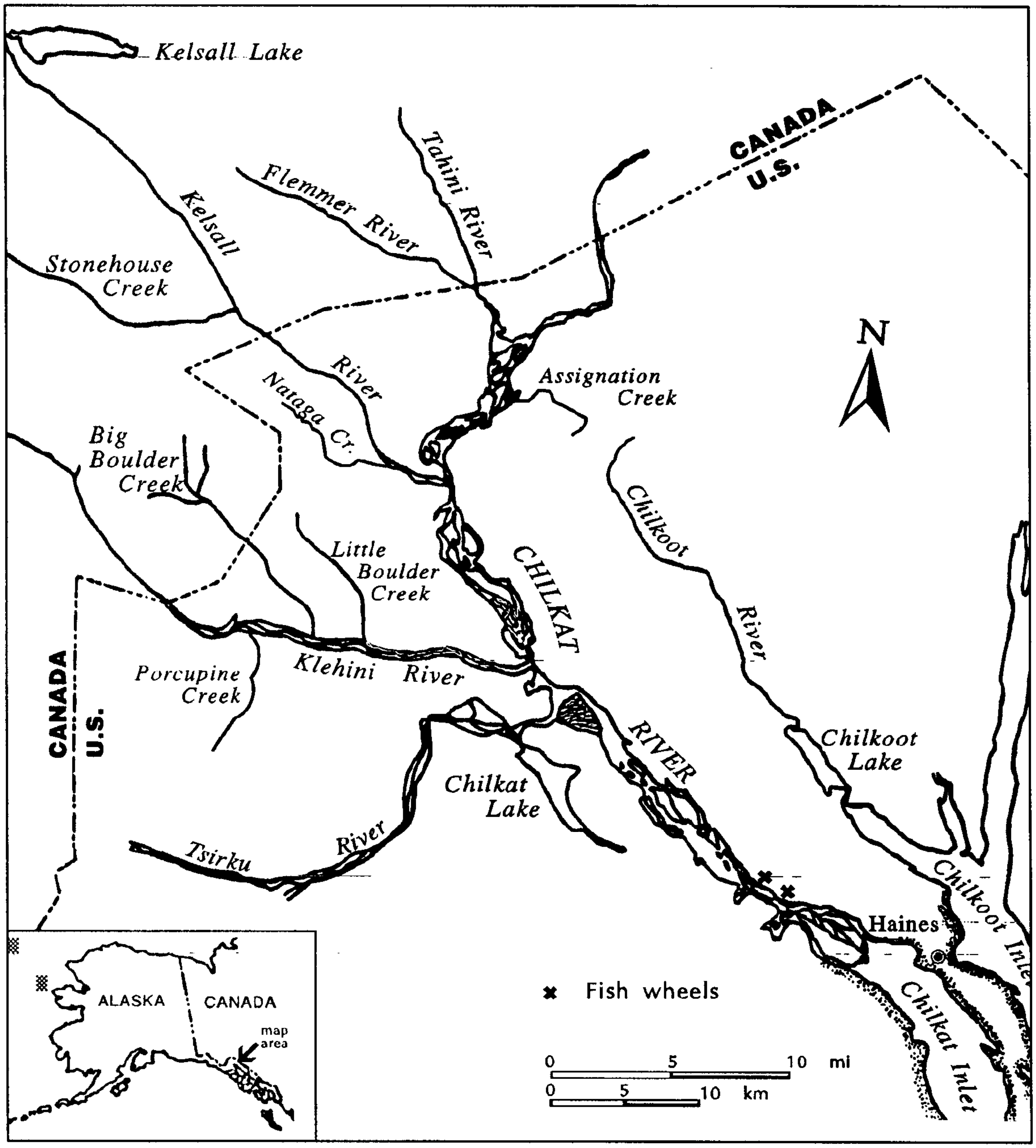

Figure 1. Map of the main features of the Chilkat River drainage.

Table 1. Peak counts of large[a] chinook salmon in Chilkat River index areas, angler effort (angler-hours), and harvest of chinook salmon in Chilkat Inlet marine recreational and District 115 drift gill net fisheries, 1960 to 1991[b,c].

Year	Escapement						Angler effort	Harvest	
	Big Boulder		Stonehouse Creek		Total	Drainage expansion		Sport	115 Gill net
1961	88	(F)	-		88		-	-	683
1962	-		-		-		-	-	806
1963	-		-		-		-	-	276
1964	-		-		-		-	-	771
1965	-		-		-		-	-	1,735
1966	330	(F)	-		330		-	-	868
1967	150	(F)	-		150		-	-	1,171
1968	259	(F)	-		259		-	-	1,489
1969	-		-		-		-	-	1,618
1970	176	(F)	-		176		-	-	1,771
1971	56	(F)	-		56		-	-	2,929
1972	-		-		-		-	-	986
1973	-		-		-		-	-	2,479
1974	0	(F)	-		0		-	-	1,672
1975	21	(F)	-		21	187	-	-	816
1976	25	(F)	-		25	223	-	-	2,142
1977	25	(F)	-		25	223	-	-	1,214
1978	-		-		-	214	-	-	536
1979	-		-		-	214	-	-	3,572
1980	-		-		-	214	-	-	440
1981	187	(H/F)	69	(H)	256	1,143	-	-	1,300
1982	56	(H/F)	123	(H)	179	799	-	-	5,945
1983	121	(H/F)	126	(H)	247	1,103	-	-	2,119
1984	229	(H/F)	104	(H)	333	1,487	10,250	1,070	6,207
1985	70	(H/F)	50	(H)	120	536	21,600	1,615	3,260
1986	20	(F)	9	(H)	29	129	31,540	1,620	2,772
1987	98	(F)	190	(H)	288	1,286	26,590	1,094	3,223
1988	86	(F)	89	(H)	175	781	36,222	481	1,257
1989	74	(F)	231	(H)	305	1,362	10,526	252	1,995
1990	19	(F)	42	(H)	61	272	8,784	210	670
1991[d]	59	(F)	126	(H)	185	805	N/A	N/A	749

[a] Fish >660 mm MEF, determined during surveys.

[b] Data for 1960 through 1990 from Pahlke (1991a), where
(F) = Escapement survey conducted by walking,
(A) = Escapement survey conducted by fixed-wing aircraft,
(H) = Escapement survey conducted by helicopter,
(H/F) = Escapement survey conducted by helicopter and by walking,
- = No survey conducted or data not comparable.

[c] Escapement counts prior to 1975 may not be comparable because of differences in survey dates and counting methods.

[d] Randy Ericksen, ADF&G, Haines, Alaska, personal communication, 1991.

Telemetry Systems[2] (ATS) radio transmitter inserted into its esophagus (Eiler 1989) and released. Radio-tracking was conducted from the roadside (Figure 1) and from boats and aircraft, with ATS receivers.

During tagging operations, captured fish were classified "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." Nearly every healthy "large" fish (and a few "small" fish) were implanted with a radio transmitter at the start of this study. On July 5 we concluded that captures of large fish would greatly exceed our expectations, and the fraction of fish implanted with transmitters was lowered to about 1 in 5. On July 15 the tagging fraction was again changed, to 1 in 3 fish. All but three healthy chinook salmon not implanted with a transmitter during tagging operations were tagged with a colored spaghetti tag threaded over a solid plastic core; the three remaining fish were marked with a floy anchor tag. All spaghetti tags, except 5 green tags used between July 3 and 4 and 19 red tags used between July 8 and 9, were uniquely numbered. All tagged fish had half of their adipose fin removed as a secondary mark.

All chinook salmon captured were sampled for scales and had their sex determined by a visual examination. The sex of a fish was sometimes difficult to determine early in the season; sex composition of these early fish was thus estimated with much uncertainty. Age of a fish was determined from scale pattern analysis (Olsen 1992).

During data analysis, all fish were reclassified "large" or "small" using age, rather than length as criteria: fish 1.3 years or older were designated large, while younger fish are labeled small. Fish whose scales could not be aged were classified "small" or "large" using a 660 mm MEF length cut-point.

Two four-basket fish wheels designed by Jim Dangel (ADF&G, Sitka) were used to capture fish. The catch in the fish wheels was supplemented with fish caught using drift gill nets. One fish wheel operated at Chilkat River mile 8 from May 5 through July 19, and another fish wheel operated at mile 9 from June 9 through July 19. The wheels were located on the east bank of the river at a location where the main channel and flow of the river was constrained to one side of the floodplain. Fish wheels ran 24 hours a day, 7 days per week, except for maintenance.

Gill nets had a 7.5-inch stretched mesh, were 50 feet long, and 10 feet deep. Each day, two technicians conducted ten drifts (0.3 miles each) between 0700 and 0900 hours and ten drifts between 1900 and 2100 hours. These time periods were chosen due to scheduling constraints. Ten drifts took about one hour to complete if no fish were captured. Salmon captured in a gill net were quickly untangled or cut from the net, restrained in a tagging cradle (Hammarstrom et al. 1985), or held in a plastic tote filled with water prior to tagging. The drifts took place along the north shore of the river, where the main channel is constrained. The drift nets were implemented when the lack of catches by the fish wheels caused concern that the wheels were not effective. The use of gill nets continued when catches increased in both gear types, to maintain constant fishing effort during the immigration. Gill nets were fished between river miles 6 and 8, from May 22 through July 19.

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

Chilkat River depth (cm), surface speed (m/sec), and temperature (°C) were recorded at 0800 and 2000 hrs daily at the lower fish wheel. Water speed was measured 1 m below the surface with a Marsh-McBurney current meter. The revolution rate of each fish wheel was also measured each day at 0800 and 2000 hours.

Distribution of Spawning Chinook Salmon

Beginning May 18, an attempt was made to locate each radio transmitter once a week. Transmitters were located from the road system when possible, then from a river boat or Cessna 182 aircraft as size of the search area increased. Search paths for aerial surveys covered mainstem and tributaries reasonably attainable by tagged fish. 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 half-mile of the Chilkat River or of the tributary where the transmitter was located.

Airplane searches were conducted 800 feet above ground at 85 to 100 knots. Antennae were attached to each wing strut of the aircraft and connected to two receivers, and monitored by two people. Up to 50 frequencies were programmed into each receiver before an air search started. Then, usually about halfway through a flight (after most of the radio transmitters had been located), the remaining frequencies were added to both 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 2). Although the criteria were designed to provide unambiguous assignments, it is clear that some fish could have been incorrectly assigned a code that did not represent their true fate. It is unlikely, however, that a significant number of fish tracked to a spawning tributary could be assigned an incorrect fate code or spawning location.

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

$$P_a = \frac{\sum_{t=1}^{3} \left(\frac{N_t}{n_t} \right) r_{a,t}}{\sum_{a=1}^{5} \sum_{t=1}^{3} \left(\frac{N_t}{n_t} \right) r_{a,t}} \qquad (1)$$

where $r_{a,t}$ is the number of large fish tagged with radios in period t that were tracked to and assumed to spawn in area a, N_t is the number of large fish captured in fish wheels and gill nets in period t, and n_t is the number of large fish radio-tagged in period t.

Period (t) refers to distinct spans of time when the tagging fraction was constant; there were three periods in 1991. Note that transmitters assigned to fates not associated with successful spawning (Table 2) are accounted for in computing P_a, such that the sum of the proportions equals one. The standard error of P_a was estimated using the bootstrap (Efron 1982). In each period, n_t new samples were drawn from the assigned fates using the empirical distribution

Table 2. Criteria developed to assign fates to radio transmitter implanted 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 was 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 observed location, then observed in a downstream location.
4	Captured: a chinook salmon whose radio transmitter was returned from the subsistence 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.

of the data, and new values of P_a were estimated. The procedure was repeated 2,000 times and $SE(P_a)$ was computed assuming a normal distribution of the bootstrap estimates.

Abundance of Chinook Salmon Returning to Spawn

Chinook salmon were sampled by two teams of two people at spawning areas throughout the Chilkat River drainage from July 22 to September 4, 1991. One team sampled as many sites as possible but captured large numbers of salmon only on the Kelsall River and at Nataga Creek (Figure 2). This was due in part to the difficulty of capturing fish in areas where the river was high and fast and in part to the inaccessibility of other areas. Chinook salmon were captured with gill nets, dip nets, bare hands, and spears. Double sampling was prevented by punching a hole in the operculum, using a paper punch, of all captured fish released alive and by slashing all sampled carcasses.

The second team sampled chinook salmon immigrating to the Tahini River from July 22 through August 11 with a gill net. Besides sampling for marked fish, brood stock for enhancement was collected with assistance from the ADF&G Fisheries Rehabilitation, Enhancement, and Development Division. Our sampling crew moved to the Kelsall River on August 12 and assisted with sampling there until September 1.

RESULTS

Four hundred fifty-eight chinook salmon were captured in fish wheels and gill nets from May 18 through July 19, 1991 (Table 3). Capture rates peaked on July 7 (Figure 2), nearly one month later than we anticipated on the basis of data from the local recreational marine boat fishery.

Tagging crews captured 225 large (age 1.3 and above) chinook salmon, 43 in the lower fish wheel, 102 in the upper fish wheel, and 80 in the gill net. Similarly, 233 small chinook salmon were captured, 120 in the lower fish wheel, and 113 in the upper fish wheel. No small chinook salmon were captured in the gill net. Sampling with the gill net was necessarily reduced by about 50% from July 3 through July 5 to devote effort to the large number of fish captured in the fish wheels. A detailed, daily summary of the capture data appears in Appendix A.

Most (90%) small chinook salmon captured during tagging were sexed as males, and most (72%) were age 1.1 (Table 4). The sex-data also indicates many fewer large male (75) than large female (151) chinook salmon were captured during tagging. Since sex ratios in samples from spawning areas are close to 1:1, we suggest that sex ratio data collected early in the year (during tagging) is biased, due to the difficulty in determining sex, and should be used with discretion. Age composition of the fish sampled with gill nets and fish wheels was significantly different; gill nets caught no chinook salmon ≤660 mm MEF, while 62% of the chinook salmon caught in fish wheels were ≤660 mm MEF (Table 4).

Of the 225 large chinook salmon captured, 118 were implanted with radio transmitters, 106 were given an external (spaghetti or floy) tag, and all were marked by partial adipose fin clip (Table 5). One large chinook salmon was wounded and not tagged. Of the 233 small chinook salmon captured, 226 were tagged with an external tag, 5 were implanted with transmitters, and all were given a partial adipose fin clip. Two small wounded chinook salmon were not tagged.

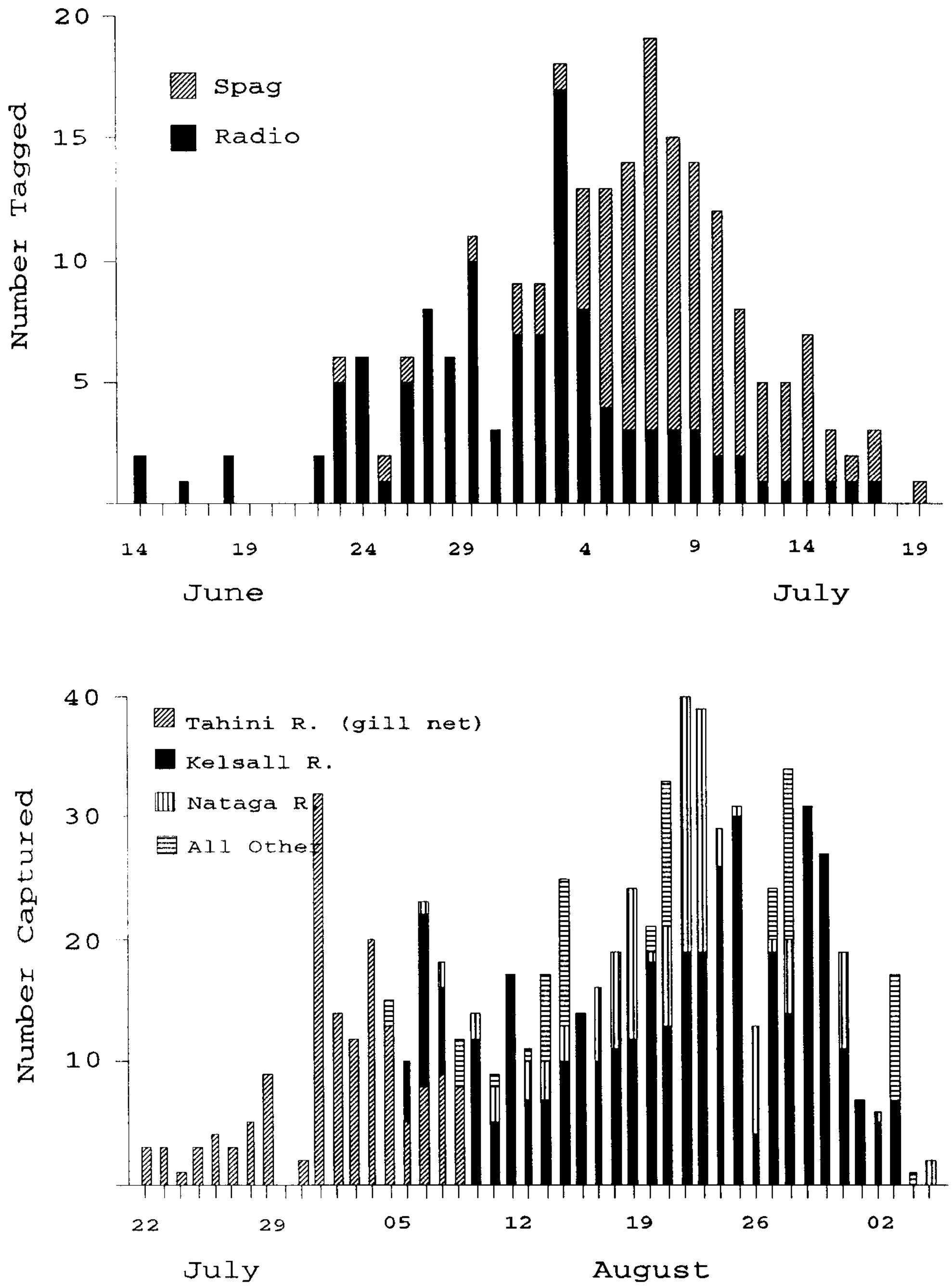

Figure 2. Numbers of chinook salmon age 1.3 and older marked with spaghetti and radio transmitters and released into the lower Chilkat River (top), and numbers of chinook salmon age 1.3 and older sampled in escapement surveys (bottom) charted by date, 1991.

Table 3. Frequency of capturing chinook salmon in fish wheels and gill nets during the tagging experiment in the Chilkat River, 1991, tabulated by size, sex, and time period[a].

Time period	Lower fish wheel[b]				Upper fish wheel[c]				Gill net[d]		Total
	Large[e]		Small[f]		Large		Small		Large		
	M	F	M	F	M	F	M	F	M	F	
5/18-6/09	0	1	2	0	0	0	0	0	0	0	3
6/10-6/14	0	0	0	0	0	0	0	1	1	1	3
6/15-6/19	0	0	3	1	0	1	1	0	0	2	8
6/20-6/24	2	2	5	2	2	1	1	0	4	3	22
6/25-6/29	2	2	17	2	5	8	14	2	4	12	68
6/30-7/04	5	7	21	3	5	19	27	3	4	11	105
7/05-7/09	4	7	34	0	14	29	26	4	8	13	139
7/10-7/14	1	7	25	0	4	11	25	4	6	8	91
7/15-7/19	1	2	4	1	1	2	4	1	1	2	19
Total	15	28	111	9	31	71	98	15	28	52	458

[a] Appendix A details catch by day.

[b] Fished 5/05 to 7/19.

[c] Fished 6/09 to 7/19.

[d] Fished 5/22 to 7/19.

[e] Fish aged 1.3 and older.

[f] Fish aged 1.2 and younger.

Table 4. Age composition of chinook salmon sampled during tagging and recovery surveys on the Chilkat River, 1991, listed by gear type.

	Brood year and age class							
	1989	1988	1987	1987	1986	1985	1984	
	0.1	1.1	1.2	2.1	1.3	1.4	1.5	Total
Tagging: gill nets, river miles 6-8								
Male								
Sample size	0	0	0	0	7	14	1	22
Percent	0.0	0.0	0.0	0.0	10.4	20.9	1.5	32.8
SD	0.0	0.0	0.0	0.0	3.8	5.0	1.5	5.8
Female								
Sample size	0	0	0	0	22	22	1	45
Percent	0.0	0.0	0.0	0.0	32.8	32.8	1.5	67.2
SD	0.0	0.0	0.0	0.0	5.8	5.8	1.5	5.8
All fish								
Sample size	0	0	0	0	29	36	2	67
Percent	0.0	0.0	0.0	0.0	43.3	53.7	3.0	100
SD	0.0	0.0	0.0	0.0	6.1	6.1	2.1	0
Tagging: both fish wheels, river miles 8 and 9								
Male								
Sample size	2	135	29	4	30	11	0	211
Percent	0.6	42.7	9.2	1.3	9.5	3.5	0.0	66.8
SD	0.4	2.8	1.6	0.6	1.7	1.0	0.0	2.7
Female								
Sample size	0	4	16	2	45	36	2	105
Percent	0.0	1.3	5.1	0.6	14.2	11.4	0.6	33.2
SD	0.0	0.6	1.2	0.4	2.0	1.8	0.4	2.7
All fish								
Sample size	2	139	45	6	75	47	2	316
Percent	0.6	44.0	14.2	1.9	23.7	14.9	0.6	100
SD	0.4	2.8	2.0	0.8	2.4	2.0	0.4	0

-continued-

Table 4. (Page 2 of 2).

	Brood year and age class							
	1989	1988	1987	1987	1986	1985	1984	
	0.1	1.1	1.2	2.1	1.3	1.4	1.5	Total
Recovery survey: Tahini River gill net								
Male								
Sample size	0	1	17	0	50	32	6	106
Percent	0.0	0.7	11.3	0.0	33.3	21.3	4.0	70.7
SD	0.0	0.7	2.6	0.0	3.9	3.4	1.6	3.7
Female								
Sample size	0	0	0	0	24	12	8	44
Percent	0.0	0.0	0.0	0.0	16.0	8.0	5.3	29.3
SD	0.0	0.0	0.0	0.0	3.0	2.2	1.8	3.7
All fish								
Sample size	0	1	17	0	74	44	14	150
Percent	0.0	0.7	11.3	0.0	49.3	29.3	9.3	100
SD	0.0	0.7	2.6	0.0	4.1	3.7	2.4	0
Recovery survey: Kelsall River and Nataga Creek								
Male								
Sample size	1	21	66	3	135	96	14	336
Percent	0.2	3.7	11.7	0.5	23.9	17.0	2.5	59.4
SD	0.2	0.8	1.4	0.3	1.8	1.6	0.7	2.1
Female								
Sample size	0	0	1	0	94	124	10	229
Percent	0.0	0.0	0.2	0.0	16.6	21.9	1.8	40.5
SD	0.0	0.0	0.2	0.0	1.6	1.7	0.6	2.1
All fish								
Sample size	1	21	67	3	229	221	24	566
Percent	0.2	3.7	11.8	0.5	40.5	39.0	4.2	100
SD	0.2	0.8	1.4	0.3	2.1	2.1	0.8	0

Table 5. Frequency of tagging chinook salmon in fish wheels and gill nets during the tagging experiment by size, tag type, and time period, Chilkat River, 1991[a].

Time period	Large[b]		Small[c]		Total
	Spa[d]	Rad[e]	Spa	Rad	
5/18-6/09	0	1	2	0	3
6/10-6/14	0	2	1	0	3
6/15-6/19	0	3	5	0	8
6/20-6/24	1	13	8	0	22
6/25-6/29	3	30	29	5	67
6/30-7/04	9	42	54	0	105
7/05-7/09	58	16	64	0	138
7/10-7/14	29	8	54	0	91
7/15-7/19	6	3	9	0	18
Total	106	118	226	5	455

[a] Appendix A details catch by day.

[b] Fish aged 1.3 and older.

[c] Fish aged 1.2 and younger.

[d] Spaghetti or floy tag.

[e] Radio transmitter.

Distribution of Spawning Chinook Salmon

Of the 118 large (age 1.3 and above) chinook salmon given radio transmitters, 100 were tracked to a spawning area (Table 6). Sixteen 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 7). One radio transmitter was returned from the subsistence fishery at Klukwan, and one transmitter was never located. A detailed summary of the radio-tracking data is shown in Appendix B.

Adjusting for differential tagging rates between May 18 and July 19 (Table 6), the proportion of large chinook salmon passing Chilkat River mile 8 and spawning were: 54% (SE = 6.2%) spawned in the Kelsall River system, 33% (SE = 6.0%) spawned in the Tahini River, 8% (SE = 3.7%) spawned in the Klehini River system, 4% (SE = 1.4%) spawned in the mainstem Chilkat River, and 1% (SE = 0.8%) spawned in Assignation Creek.

Movement and Migratory Timing of Radio-Tracked Salmon

The mean date of the migratory timing (Mundy 1984) at river mile 8 was July 5. We detect no difference between mean dates of migratory timing for large (July 5) and small (July 5) chinook salmon captured in fish wheels on the Chilkat River in 1991. Fifty percent of radio-tracked chinook salmon moved upstream immediately after tagging, 45% dropped downstream, and 5% held near the tagging site. Chinook salmon tracked to a spawning area migrated through the mainstem Chilkat River at an average rate of 1.2 miles per day, then up tributaries at an average rate of 0.7 miles per day (Table 8). Overall, fish traveled an average of 1 mile per day. The fastest upstream rate of travel observed was 6.7 miles per day by a 765-mm MEF female chinook salmon tracked 13.5 miles in 2 days.

Abundance of Chinook Salmon Returning to Spawn

Eight hundred sixty-one (861) unique chinook salmon were captured during the spawning ground sampling (Table 9). Almost equal numbers of large male (386) and large female (347) chinook salmon were captured. Age composition of fish sampled in Kelsall River and Nataga Creek was similar (x^2 = 3.5, df = 2, P = 0.18) so age data for these systems was combined (Table 4). Also, the age composition of the 72 fish radio-tracked to the Kelsall-Nataga system and to Tahini River was similar (x^2 = 0.13, df = 1, P = 0.72).

The probability of recapturing spaghetti and radio transmitter tagged chinook salmon was not significantly different (x^2 = 0.03, df = 1, P = 0.88) so recapture data on both types of tags were pooled to estimate spawning abundance. Also, the probability of capturing a marked chinook salmon was not significantly different in the Tahini (P = 0.03) and Kelsall-Nataga Rivers (P = 0.06), indicating data could be combined across these two areas (x^2 = 2.9, df = 1, P = 0.09). The hypothesis that run timing of chinook salmon bound for the Tahini and Kelsall Rivers was equal was tested using an odds ratio (Agresti 1984).

$$\theta = \frac{\left(\dfrac{N_{e,t}}{N_{e,k}}\right)}{\left(\dfrac{N_{1,t}}{N_{1,k}}\right)} \qquad (2)$$

Table 6. Summary of fates assigned to radio transmitters placed on large (age 1.3 and older) chinook salmon by date, and estimated percentage by area of large chinook salmon spawning in the Chilkat River drainage, 1991.

Fate	Implants by tagging period			Expanded by tag fraction	Spawning[a] % Dist.
	May 18-July 04	July 05-July 14	July 15-July 19		
Spawning area:					
Kelsall River system[b]	42	10	2	102.7	53.9
Tahini River	23	7	1	63.4	33.2
Klehini River system[c]	5	2	0	15.1	8.1
Assignation Creek	2	0	0	2.3	1.2
Mainstem Chilkat River	6	0	0	6.9	3.6
				190.7	100.0
Tag Return (Subsistence)	1	0	0		
Mortality/Regurgitation[d]	9	2	0		
Unknown[e]	3	2	0		
	91[f]	23[g]	3[h]		

[a] Percentage of the weighted total of 190.7 fish tracked to spawning locations.

[b] Includes mainstem Kelsall River, Nataga Creek, and Stonehouse Creek; one transmitter was tracked into Nataga Creek, and one radio transmitter was tracked into Stonehouse Creek.

[c] Includes mainstem Klehini River and Big Boulder Creek; 2 transmitters were tracked into Big Boulder Creek.

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

[e] One transmitter never located; data for five transmitters consistent with more than one fate (mortality, regurgitation, mainstem spawning).

[f] Transmitters implanted among 104 fish captured May 18 through July 4, 1991.

[g] Transmitters implanted among 112 fish captured July 5 through July 14, 1991.

[h] Transmitters implanted among 9 fish captured July 15 through July 19, 1991.

Table 7. Chilkat River 1991 radio tracking data (Chilkat River mile) for large chinook salmon assigned a fate code 2 (mortality/transmitter regurgitation), fate code 5 (unknown), or fate code 3 (mainstem spawning). Observations of mortality pulse in survey period highlighted in bold.

			Survey period								
FISH #	DATE TAGGED	CAPTURE METHOD[a]	5/18-6/16	6/24-6/30	7/01-7/07	7/08-7/14	7/15-7/21	7/22-7/28	8/05-8/11	8/19-8/25	9/11
			Mortality or tag regurgitation (fate code = 2)								
3L	6/14	GN	7.0	14.5	12.0		19.0		**19.0**	**18.0**	
17L	6/24	GN		**7.5**	**7.0**	7.0		6.5		**6.0**	
20L	6/25	UW		**9.0**	20.5	21.0	**20.5**	20.5		**19.0**	
29L	6/27	UW		6.0		11.0	**10.5**	10.5		**10.5**	10.5
43L	6/28	GN					**12.5**	13.0		**12.0**	
59L	6/30	GN			18.0	**19.5**	**19.0**	18.0		19.0	
67L	7/01	GN				**19.5**	19.0		**19.0**	**18.5**	
82L	7/03	UW			**5.5**		**4.5**	5.0			5.0
87L	7/03	UW			4.0		**3.5**			**4.5**	
148L	7/08	GN				7.0	4.0	5.5			
188L	7/11	LW				8.0	14.0	**20.0**	**20.0**	19.5	19.5
			Unknown (fate code = 5)								
11L	6/23	GN		**6.5**	9.0	19.0			**29.0**		
68L	7/02	LW				**19.0**	19.0				
91L	7/03	GN						**30.5**	**29.0**		26.5
133L	7/07	LW				14.5					
138L	7/07	UW				11.0		19.0	**20.0**	20.0	
			Mainstem spawning (fate code = 3)								
1L	5/18	LW	26.0	7.0	**1.5**			**1.5**			
7L	6/22	GN		6.0		22.0	30.0	30.0	**5.5**		
25L	6/26	LW		7.5	18.0	21.5	**13.0**	12.0		**12.0**	
46L	6/29	UW						19.0	18.0	**19.0**	**13.0**
73L	7/02	UW			20.0	21.0	30.0	20.0		17.0	17.5
78L	7/03	GN					**13.5**		17.5	**16.0**	

[a] GN = gill net; UW = upper fish wheel; LW = lower fish wheel.

Table 8. Migration rates of chinook salmon implanted with radio transmitters, Chilkat River, 1991[a].

Final spawning system	N	Average days between observations	Average miles between observations	Minimum miles per day	Maximum miles per day	Average miles per day
Lowest observed location in the mainstem to highest mainstem location						
Mainstem	3	23	18.0	0.7	0.9	0.8
Kelsall	46	18	20.0	0.5	2.3	1.2
Tahini	29	18	22.0	0.8	1.8	1.3
Big Boulder	2	9	18.5	1.6	2.7	2.2
Assignation	2	25	28.5	1.1	1.2	1.2
Klehini	3	20	15.0	0.6	1.0	0.8
All areas	85	18.6	20.1	0.5	2.7	1.2
Highest mainstem location to highest tributary location						
Kelsall	45	20	12.6	0.2	1.9	0.6
Tahini	24	18	14.0	0.2	2.1	0.9
Big Boulder	2	26	8.5	0.3	0.4	0.4
Assignation	2	9	6.0	0.5	0.9	0.7
Klehini	4	21	8.5	0.2	0.7	0.5
All areas	77	19.4	12.6	0.7	2.1	0.7
Lowest mainstem location to highest tributary location						
Kelsall	50	35	31.2	0.6	2.7	1.0
Tahini	29	34	35.3	0.8	1.6	1.1
Big Boulder	2	35	27.0	0.8	0.8	0.8
Assignation	2	34	34.5	1.0	1.1	1.1
Klehini	5	39	24.4	0.5	0.7	0.6
All areas	88	34.9	32.1	0.5	2.7	1.0

[a] Compiled for tracking data spanning 7 or more days, and fish successfully tracked to a spawning area.

Table 9. Frequency of capturing tagged and untagged chinook salmon during escapement surveys, tabulated by size, sex, tag type, and system or sampling trip, Chilkat River, 1991.

System/Sampling	Date	Captures				Recaptures[c]			
		Large[a]		Small[b]		Large		Small	
		M	F	M	F	Spa[d]	Rad[e]	Spa	Rad
Kelsall River	8/06-9/03	189	193	64	1	6	5	6	0
Nataga River	8/07-9/05	69	56	33	0	3	1	3	0
Tahini R. (gill net)	7/22-8/09	100	55	18	0	4	5	0	0
" " (carcasses)	8/11-9/03	15	24	8	0	1	1	0	0
Assignation Creek	8/13	0	1	0	0	0	1	0	0
Big Boulder Creek	8/05-9/12	13	17	4	0	0	0	0	0
Porcupine Creek	9/04	0	1	0	0	0	0	0	0
Totals		386	347	127	1	14	13	9	0

[a] Fish aged 1.3 and older.

[b] Fish aged 1.2 and younger.

[c] Also included under captures.

[d] Spaghetti or floy tag recovered during random sampling.

[e] Radio transmitters recovered during random sampling (not included are two non-random recoveries; see notes, Appendix B).

where N represents the number of radio-tags implanted during the first (e) or second (l) half of the sampled immigration and tracked to the Tahini (t) or Kelsall (k) rivers. The hypothesis was accepted, since $\theta = 0.81$ was well within the bounds of a 95% confidence interval for $\theta = 1$ (0.3 to 2.2).

Thus we used Chapman's modified Peterson estimator (Seber 1982, n_1=224, n_2=733, m_2=27) to estimate the immigration of large chinook salmon to the Chilkat drainage. The estimated abundance of 5,897 (SE = 1,005) is germane to the time of tagging near mile 8, since an unknown component of mortality occurred (due to natural causes and a subsistence fishery) between the two sampling events. This estimate is more precise, and not significantly different from, an estimate using a Darroch's estimator (Seber 1982), which does not assume equal probability of recovering marked chinook salmon by recovery area.

DISCUSSION

The two most important findings of this season's research were: (a) estimated escapement to the Chilkat River system was much greater (seven times) than the historical expansion estimator would have indicated, and (b) the historic index areas, Big Boulder and Stonehouse Creeks, were not major spawning locations during the 1991 season.

On the basis of these results, we must seek to determine if this was normal or if it was an extraordinary event. This can be addressed only after similar future studies are concluded. If it was indeed extraordinary, we need to determine the cause.

In estimating the distribution of spawning escapement we assumed: (a) radio-tagging of large chinook salmon 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, departures from proportional sampling (assumption a) would be related to time-dependent changes in catch-ability. Environmental conditions did fluctuate greatly during the experiment (Appendix C), but tagged to untagged ratios from the Tahini (0.03:1) and Kelsall-Nataga (0.06:1) spawning areas provided only weak evidence (P = 0.09) in support of nonproportional tagging. Similarly, we do not think gear selectivity (for size) was an important variable in this experiment; most fish were captured in fish wheels, and we could not demonstrate that age-composition (size) or timing of the stocks in the two major spawning areas was different in 1991. Assumption (b) is probably valid in this experiment, but we did not test for effects of the tagging on fish behavior.

Finally, errors probably exist in assigned fates of some radio-tracked fish, especially fish with fate code 2 (mortality and regurgitation), fate code 3 (mainstem spawning), and fate code 5 (unknown). For example, motion and mortality sensor signals can lead to ambiguous, inconsistent conclusions about a fate of a tracked fish (Bendock and Alexandersdottir 1992). Fates of fish having transmitters located repeatedly in the mainstem between Chilkat River miles 16 and 22 are most uncertain. Also, several transmitters implanted during the later half of the experiment emitted weak signals, potentially contributing to the size of the "unknown" fate category (Table 6). Since most fish with ambiguous tracking histories were not assigned to a spawning area, potential errors in the other assignments are essentially random, we assume, and are unlikely to significantly influence the estimated proportions for spawning in each area.

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 spawning fish 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. Considerable effort to mark immigrating fish in proportion to their abundance was made, and only weak evidence that this did not occur was found (from tag ratios on the Kelsall and Tahini rivers). In addition, sampling effort for tags on the Kelsall and Tahini rivers, where ≈87% of spawning occurred in 1991, was fairly constant across the time of the immigrations, so the complex-assumption (a) is fairly robust for this experiment.

We reason a mechanism for failure of assumption (b) does not exist. We have no direct evidence to disprove assumption (c). We believe 11 of 117 radio transmitters (9%) tracked on large chinook salmon were regurgitated or associated with fish which died prematurely during the experiment. Some of these fish (and some of the five fish with unknown fates) certainly may have died due to the tagging procedure, the subsistence fishery, or to natural causes, and we cannot separate these fates. Similarly, we did not estimate tag loss during the experiment; but on the largest system sampled (Kelsall-Nataga), no tag loss was observed.

It is not known how the size of the escapement of chinook salmon in 1991 was influenced by closures of the recreational and commercial fisheries during the year. The closures were made because the primary age classes returning in 1991 would come from escapements in 1985 and 1986, which were believed at the time to be very small (Table 1).

Research to estimate optimum escapement to the Chilkat River may be desirable. The current escapement goal for the PST rebuilding program is 2,000 age 1.3+ chinook salmon (Pahlke 1992). Prior to 1981, escapements to the Chilkat River were estimated as 1/(0.8 x 0.14) times peak counts from Big Boulder Creek, while from 1981 to present estimates were 1/(0.8 x 0.28) times peak counts from Big Boulder and Stonehouse Creeks (Pahlke 1991b; 0.8 is a survey expansion factor and 0.14 and 0.28 are tributary to drainage expansion factors). The estimate of 2,000 was calculated from the peak estimate of 229 fish for Big Boulder Creek in 1984 (Keith Pahlke, Alaska Department of Fish and Game, Douglas, personal communication). This "best guess" methodology was used because a better, systemic, method was not available. Although optimum escapement is not presently estimable, management escapement goals can be established from the new information provided in this and future studies.

Monitoring to insure escapements to the Chilkat River over the long term is also desirable. As noted in Pahlke (1991a), an index based on standardized CPUE at a setnet site on the Tahini River may provide a practical, cost-effective index of spawner abundance for the Chilkat River drainage. We will continue to evaluate this idea in 1992, using telemetry and mark-recapture experiments on the Chilkat River. However, escapement to the Tahini River may prove to be a relatively variable component of the total escapement to the Chilkat River, and the index may not work if enhancement activities continue on the Tahini River. A better index would be made from surveys on the Kelsall River if sampling there could be standardized. Other methods for indexing escapement to the Chilkat River include operating fish wheels and/or gill nets on the lower Chilkat River, and/or using mark-recapture methods, as in 1991.

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APPENDICES

Appendix A. Fish number, sex, length (MEF), tag type, capture site, and age, for tagging on the Chilkat River, by date, 1991.

Date Tagged	Fish #[a]	Sex	mm	Tag Type	Capture Site[b]	Age[c]
18-May	1L	F	880	RADIO	LW	N/A
25-May	1S	M	595	SPAG	LW	1.2
25-May	2S	M	365	FLOY	LW	N/A
12-Jun	3S	F	560	SPAG	UW	N/A
14-Jun	2L	M	660	RADIO	[d]	N/A
14-Jun	3L	F	1009	RADIO	NET	1.4
15-Jun	4S	F	510	SPAG	LW	1.2
16-Jun	4L	F	1001	RADIO	NET	1.4
16-Jun	5S	M	300	FLOY	LW	N/A
17-Jun	6S	M	370	FLOY	LW	1.1
18-Jun	5L	F	900	RADIO	UW	N/A
18-Jun	6L	F	785	RADIO	NET	1.4
18-Jun	7S	M	350	FLOY	UW	1.1
18-Jun	8S	M	375	FLOY	LW	1.1
21-Jun	9S	M	360	FLOY	LW	1.1
21-Jun	10S	M	355	FLOY	UW	1.1
21-Jun	11S	F	345	FLOY	LW	1.1
22-Jun	7L	M	880	RADIO	LW	N/A
22-Jun	8L	F	850	RADIO	NET	1.4
22-Jun	12S	M	345	FLOY	LW	1.1
23-Jun	9L	F	830	RADIO	LW	1.4
23-Jun	10L	F	780	RADIO	UW	1.3
23-Jun	10Ls	M	510	FLOY	LW	1.3
23-Jun	11L	F	900	RADIO	NET	N/A
23-Jun	12L	M	745	RADIO	UW	1.3
23-Jun	13S	M	348	FLOY	LW	1.1
23-Jun	13L	M	710	RADIO	UW	1.3
23-Jun	14S	M	315	FLOY	LW	1.1
24-Jun	14L	F	885	RADIO	LW	1.4
24-Jun	15S	M	335	FLOY	LW	N/A
24-Jun	15L	F	885	RADIO	NET	1.4
24-Jun	16L	M	960	RADIO	NET	1.4
24-Jun	16S	F	390	FLOY	LW	1.2
24-Jun	17L	M	950	RADIO	NET	1.4
24-Jun	18L	M	785	RADIO	NET	1.4
24-Jun	19L	M	770	RADIO	NET	1.3
25-Jun	17S	M	400	FLOY	LW	1.1
25-Jun	18S	M	350	FLOY	LW	1.1
25-Jun	19S	M	370	FLOY	LW	1.1
25-Jun	20S	M	380	FLOY	LW	N/A
25-Jun	20L	M	805	RADIO	UW	1.3
25-Jun	21S	M	385	FLOY	UW	N/A
25-Jun	22S	F	520	SPAG	LW	1.2
25-Jun	22Ls	M	490	SPAG	LW	1.3
26-Jun	21L	F	870	RADIO	UW	1.4
26-Jun	22L	M	1001	RADIO	NET	1.4
26-Jun	23L	F	730	SPAG	NET	1.3
26-Jun	23S	M	340	FLOY	LW	1.1
26-Jun	24S	M	310	FLOY	LW	1.1
26-Jun	24L	F	860	RADIO	UW	1.4
26-Jun	25S	M	360	FLOY	LW	1.1
26-Jun	25L	F	855	RADIO	NET	1.4
26-Jun	26L	F	735	RADIO	UW	1.3
26-Jun	26S	M	355	FLOY	UW	1.1
27-Jun	27L	F	820	RADIO	NET	1.3
27-Jun	27S	M	320	FLOY	LW	1.1
27-Jun	28S	M	320	FLOY	LW	N/A
27-Jun	28L	M	935	RADIO	UW	1.4
27-Jun	29S	M	360	FLOY	UW	1.1
27-Jun	29L	M	850	RADIO	UW	1.3
27-Jun	30L	F	900	RADIO	NET	1.4
27-Jun	30S	M	610	RADIO	UW	1.2
27-Jun	31S	M	380	FLOY	LW	N/A
27-Jun	31L	F	830	RADIO	NET	1.3
27-Jun	32S	M	370	FLOY	UW	1.1
27-Jun	33L	M	660	RADIO	UW	1.3
27-Jun	33S	M	540	SPAG	UW	1.2
27-Jun	34S	M	420	FLOY	UW	N/A
27-Jun	34L	M	640	RADIO	LW	1.3
27-Jun	35L	F	810	RADIO	LW	N/A
28-Jun	35S	M	350	FLOY	UW	1.1
28-Jun	36S	M	355	FLOY	LW	1.1
28-Jun	37S	F	480	SPAG	UW	1.2
28-Jun	38L	F	820	RADIO	UW	1.3
28-Jun	38S	F	580	RADIO	UW	1.2
28-Jun	39S	M	610	RADIO	LW	N/A
28-Jun	40L	F	800	RADIO	NET	1.3
28-Jun	40S	M	440	WOUND	LW	N/A
28-Jun	41L	F	865	RADIO	NET	1.4
28-Jun	41S	M	500	FLOY	UW	N/A
28-Jun	42L	F	770	RADIO	NET	N/A
28-Jun	42S	F	580	RADIO	LW	1.2
28-Jun	43L	F	890	RADIO	NET	1.4
28-Jun	44L	F	910	RADIO	NET	1.4
29-Jun	43S	M	350	FLOY	UW	1.1
29-Jun	44S	M	340	FLOY	LW	1.1
29-Jun	45L	F	880	RADIO	LW	1.4
29-Jun	45S	M	550	RADIO	LW	1.2
29-Jun	46S	M	230	FLOY	LW	1.1
29-Jun	46L	F	940	RADIO	UW	1.4
29-Jun	47L	F	825	RADIO	UW	N/A
29-Jun	47S	M	370	FLOY	UW	1.1
29-Jun	48L	M	630	RADIO	UW	1.3
29-Jun	48S	M	355	FLOY	UW	1.1
29-Jun	49S	M	370	FLOY	UW	1.1
29-Jun	49L	F	895	RADIO	UW	1.4
29-Jun	50L	M	665	RADIO	NET	1.3
29-Jun	50S	M	370	FLOY	LW	1.1
29-Jun	51S	M	370	FLOY	UW	1.1
29-Jun	51L	F	880	SPAG	NET	1.4
29-Jun	52L	M	845	RADIO	NET	1.4
29-Jun	53L	F	930	RADIO	NET	1.4
29-Jun	54L	M	870	RADIO	NET	N/A
29-Jun	56L	F	901	RADIO	UW	1.5
30-Jun	52S	M	390	FLOY	LW	N/A
30-Jun	53S	M	365	FLOY	UW	N/A
30-Jun	54S	M	340	FLOY	LW	1.1
30-Jun	55S	M	500	SPAG	UW	N/A
30-Jun	56S	M	320	FLOY	UW	1.2
30-Jun	57L	M	690	RADIO	LW	1.3
30-Jun	58L	M	750	RADIO	NET	1.3
30-Jun	59L	F	920	RADIO	NET	1.4
01-Jul	57S	M	365	FLOY	UW	1.1
01-Jul	58S	M	450	FLOY	UW	N/A
01-Jul	59S	F	460	SPAG	LW	2.1
01-Jul	60L	M	885	RADIO	LW	1.4
01-Jul	60S	M	410	FLOY	LW	1.2
01-Jul	61L	F	780	RADIO	UW	1.3
01-Jul	61S	M	345	FLOY	UW	1.1
01-Jul	62S	M	360	FLOY	UW	N/A
01-Jul	62L	M	850	RADIO	NET	1.4
01-Jul	63L	F	765	RADIO	UW	1.3
01-Jul	63S	M	520	SPAG	LW	1.2
01-Jul	64L	M	850	RADIO	UW	1.4

-continued-

Date Tagged	Fish #[a]	Sex	mm	Tag Type	Capture Site[b]	Age[c]	Date Tagged	Fish #	Sex	Tag mm	Capture Type	Site	Age
01-Jul	64S	M	530	SPAG	UW	1.2	04-Jul	94Ls	F	605	SPAG	UW	1.3
01-Jul	65L	F	830	RADIO	UW	1.4	04-Jul	94L	F	820	RADIO	UW	1.3
01-Jul	65Ls	F	580	SPAG	LW	1.3	04-Jul	95L	F	765	RADIO	UW	1.3
01-Jul	65S	M	400	FLOY	LW	1.2	04-Jul	96L	F	835	RADIO	UW	N/A
01-Jul	66L	F	900	SPAG	NET	N/A	04-Jul	97L	F	910	RADIO	UW	N/A
01-Jul	67L	F	860	RADIO	NET	1.4	04-Jul	97S	M	595	SPAG	UW	N/A
02-Jul	66S	F	560	SPAG	LW	1.2	04-Jul	98S	M	340	FLOY	LW	1.1
02-Jul	67S	M	315	FLOY	LW	1.1	04-Jul	98L	F	890	RADIO	UW	N/A
02-Jul	68S	F	610	SPAG	LW	1.2	04-Jul	98Ls	M	650	SPAG	LW	1.3
02-Jul	68L	F	745	RADIO	LW	1.3	04-Jul	99S	M	615	SPAG	UW	1.2
02-Jul	69L	F	725	RADIO	UW	1.3	04-Jul	99L	F	800	RADIO	UW	1.3
02-Jul	69S	M	395	FLOY	LW	1.2	04-Jul	100S	M	320	FLOY	LW	1.1
02-Jul	70S	M	395	FLOY	LW	N/A	04-Jul	100L	F	910	RADIO	NET	1.5
02-Jul	70L	F	960	RADIO	UW	1.4	04-Jul	101S	M	325	FLOY	LW	1.1
02-Jul	71S	M	340	FLOY	UW	1.1	04-Jul	101Ls	M	555	FLOY	LW	1.3
02-Jul	71L	M	895	RADIO	NET	1.4	04-Jul	102S	M	335	FLOY	LW	1.1
02-Jul	72L	F	920	SPAG	LW	1.4	04-Jul	103S	M	520	SPAG	UW	1.2
02-Jul	72S	M	580	SPAG	UW	1.2	04-Jul	104S	F	415	FLOY	UW	2.1
02-Jul	73Ls	F	590	SPAG	UW	1.3	04-Jul	105S	M	340	FLOY	LW	1.1
02-Jul	73L	F	680	RADIO	UW	1.3	05-Jul	101L	F	770	RADIO	LW	N/A
02-Jul	73S	F	535	SPAG	UW	1.2	05-Jul	102L	F	865	RADIO	UW	N/A
02-Jul	74S	M	400	FLOY	LW	1.1	05-Jul	103L	F	830	RADIO	NET	1.3
02-Jul	74L	M	860	RADIO	UW	1.3	05-Jul	105L	M	950	RADIO	NET	1.5
02-Jul	75L	M	910	RADIO	NET	1.4	05-Jul	106S	M	320	FLOY	LW	1.1
02-Jul	75S	M	560	SPAG	LW	1.2	05-Jul	107Ls	M	590	SPAG	UW	1.3
02-Jul	76S	M	340	FLOY	UW	1.1	05-Jul	107S	M	350	FLOY	LW	1.1
02-Jul	77S	M	420	FLOY	LW	1.1	05-Jul	107L	M	770	SPAG	UW	1.4
02-Jul	78S	M	300	FLOY	UW	N/A	05-Jul	108L	M	680	SPAG	UW	1.3
02-Jul	79S	M	325	FLOY	UW	1.1	05-Jul	108S	M	340	FLOY	LW	1.1
02-Jul	80S	M	450	FLOY	UW	1.2	05-Jul	109S	F	470	SPAG	UW	1.2
02-Jul	81S	M	490	SPAG	LW	N/A	05-Jul	109L	F	615	SPAG	UW	1.3
02-Jul	82S	M	335	FLOY	UW	1.1	05-Jul	110S	M	350	FLOY	UW	1.1
02-Jul	83S	M	350	FLOY	UW	N/A	05-Jul	110L	F	960	SPAG	UW	N/A
02-Jul	84S	M	350	FLOY	UW	1.1	05-Jul	111S	M	420	FLOY	UW	2.1
03-Jul	76L	F	810	RADIO	LW	1.3	05-Jul	111L	M	840	SPAG	NET	N/A
03-Jul	77L	F	910	RADIO	UW	1.3	05-Jul	112L	M	635	SPAG	UW	1.3
03-Jul	78L	F	920	RADIO	NET	N/A	05-Jul	112S	M	380	FLOY	LW	1.1
03-Jul	79L	F	830	RADIO	NET	1.4	05-Jul	113S	M	345	FLOY	UW	N/A
03-Jul	80L	F	780	RADIO	NET	1.3	05-Jul	114S	M	300	FLOY	LW	1.1
03-Jul	81L	F	725	RADIO	NET	1.3	05-Jul	115S	M	320	FLOY	UW	1.1
03-Jul	82L	F	860	RADIO	UW	1.3	05-Jul	116Ls	M	620	SPAG	NET	1.3
03-Jul	83L	M	780	RADIO	LW	1.4	05-Jul	116S	M	320	FLOY	LW	1.1
03-Jul	84L	M	760	RADIO	UW	1.3	05-Jul	117S	M	360	FLOY	UW	1.1
03-Jul	85S	M	345	FLOY	UW	N/A	05-Jul	118S	M	620	SPAG	UW	1.2
03-Jul	85L	F	860	RADIO	LW	1.4	05-Jul	119L	F	760	WOUND	UW	1.3
03-Jul	85Ls	M	650	SPAG	UW	1.3	05-Jul	119S	F	575	FLOY	UW	1.2
03-Jul	86S	F	600	SPAG	UW	N/A	05-Jul	120S	M	315	FLOY	LW	1.1
03-Jul	86L	F	680	RADIO	UW	1.3	06-Jul	113L	M	920	RADIO	NET	1.4
03-Jul	87S	M	580	SPAG	UW	1.2	06-Jul	114L	F	685	SPAG	NET	1.3
03-Jul	87L	F	845	RADIO	UW	1.5	06-Jul	116L	F	755	SPAG	UW	1.3
03-Jul	88S	M	330	FLOY	UW	1.1	06-Jul	118L	F	685	RADIO	UW	1.3
03-Jul	88L	F	805	RADIO	UW	1.3	06-Jul	120L	F	880	SPAG	UW	1.4
03-Jul	89S	M	560	SPAG	UW	1.2	06-Jul	121S	M	315	FLOY	UW	N/A
03-Jul	89L	M	725	RADIO	UW	1.3	06-Jul	122L	F	730	SPAG	LW	1.3
03-Jul	90S	M	340	FLOY	LW	1.1	06-Jul	122S	F	360	FLOY	UW	N/A
03-Jul	90L	F	790	RADIO	NET	1.3	06-Jul	123S	M	330	FLOY	UW	1.1
03-Jul	91S	M	450	FLOY	LW	N/A	06-Jul	123L	F	810	RADIO	NET	1.3
03-Jul	91L	F	885	RADIO	NET	N/A	06-Jul	124L	M	915	SPAG	UW	1.4
03-Jul	92S	M	325	FLOY	LW	1.1	06-Jul	124S	M	355	FLOY	UW	1.1
03-Jul	92L	F	810	RADIO	NET	1.4	06-Jul	125L	F	880	SPAG	UW	1.4
03-Jul	93S	M	320	FLOY	LW	1.1	06-Jul	125S	M	375	FLOY	LW	1.1
03-Jul	94S	M	405	FLOY	UW	N/A	06-Jul	126S	M	310	FLOY	UW	1.1
03-Jul	95S	M	630	SPAG	UW	1.2	06-Jul	126L	F	890	SPAG	UW	1.4
03-Jul	96S	M	505	SPAG	UW	1.2	06-Jul	127S	M	350	FLOY	LW	1.1
04-Jul	93Ls	F	640	SPAG	LW	1.4	06-Jul	127L	M	630	SPAG	NET	1.3
04-Jul	93L	F	895	RADIO	LW	1.4	06-Jul	129L	M	840	SPAG	UW	1.3

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Appendix A. (Page 3 of 4).

Date Tagged	Fish #	Sex	mm	Tag Type	Capture Site	Capture Age	Date Tagged	Fish #	Sex	mm	Tag Type	Capture Site	Capture Age
06-Jul	130L	M	1010	SPAG	LW	1.4	09-Jul	158S	M	295	FLOY	LW	1.1
06-Jul	132L	M	700	SPAG	UW	1.3	09-Jul	158L	F	850	RADIO	LW	1.4
07-Jul	128L	F	890	RADIO	UW	1.4	09-Jul	159S	M	285	FLOY	LW	N/A
07-Jul	128S	M	505	SPAG	LW	1.2	09-Jul	160S	M	380	FLOY	LW	1.1
07-Jul	129S	M	365	FLOY	UW	1.1	09-Jul	161S	M	360	FLOY	LW	1.1
07-Jul	130S	M	300	FLOY	UW	1.1	09-Jul	161L	F	730	SPAG	LW	1.3
07-Jul	131S	M	360	FLOY	LW	N/A	09-Jul	162S	M	300	FLOY	LW	1.1
07-Jul	131L	F	915	SPAG	NET	1.4	09-Jul	163S	M	310	FLOY	LW	1.1
07-Jul	132S	M	330	FLOY	LW	1.1	09-Jul	164S	M	325	FLOY	LW	1.1
07-Jul	133L	M	695	RADIO	LW	N/A	09-Jul	165S	M	410	FLOY	UW	1.1
07-Jul	133S	M	320	FLOY	UW	1.1	09-Jul	166S	M	360	FLOY	LW	1.1
07-Jul	134L	F	720	SPAG	NET	1.3	09-Jul	167S	M	400	FLOY	UW	N/A
07-Jul	134S	M	355	FLOY	LW	1.1	09-Jul	168S	M	575	SPAG	UW	1.2
07-Jul	135L	M	770	SPAG	LW	1.3	09-Jul	168L	F	810	RADIO	UW	N/A
07-Jul	135S	M	325	FLOY	UW	1.1	09-Jul	169L	F	725	RADIO	UW	N/A
07-Jul	136L	F	830	SPAG	UW	1.4	09-Jul	169S	M	635	SPAG	UW	1.2
07-Jul	136S	M	390	FLOY	LW	1.1	09-Jul	170L	F	790	SPAG	NET	1.3
07-Jul	137L	F	780	SPAG	UW	1.3	09-Jul	171L	M	665	SPAG	UW	1.3
07-Jul	137S	M	335	FLOY	LW	1.1	09-Jul	172L	F	775	SPAG	NET	1.3
07-Jul	138L	F	830	RADIO	UW	1.3	09-Jul	174L	F	880	SPAG	UW	1.4
07-Jul	138S	M	340	FLOY	LW	1.1	09-Jul	175L	M	850	SPAG	NET	1.4
07-Jul	139L	F	780	SPAG	UW	N/A	09-Jul	176L	F	720	SPAG	UW	1.3
07-Jul	139S	M	285	FLOY	LW	1.1	09-Jul	177L	F	775	SPAG	LW	N/A
07-Jul	140L	M	765	SPAG	UW	1.3	09-Jul	178L	F	770	SPAG	LW	1.3
07-Jul	140S	M	320	FLOY	LW	1.1	09-Jul	180L	F	710	SPAG	UW	1.3
07-Jul	141L	F	735	SPAG	LW	1.3	09-Jul	181L	F	795	SPAG	UW	1.3
07-Jul	143L	M	690	SPAG	UW	N/A	10-Jul	170S	M	330	FLOY	LW	1.1
07-Jul	144L	M	605	SPAG	UW	1.3	10-Jul	171S	M	360	FLOY	LW	1.1
07-Jul	145L	M	805	SPAG	UW	1.3	10-Jul	172S	M	570	SPAG	LW	1.2
07-Jul	147L	M	755	SPAG	NET	N/A	10-Jul	173S	M	360	FLOY	LW	1.1
07-Jul	149L	M	840	SPAG	UW	1.3	10-Jul	173L	F	755	RADIO	LW	N/A
07-Jul	150L	F	880	SPAG	UW	1.4	10-Jul	174S	M	365	FLOY	UW	1.1
07-Jul	151L	M	675	SPAG	UW	1.3	10-Jul	175S	M	390	FLOY	LW	1.1
07-Jul	152L	F	855	SPAG	UW	1.4	10-Jul	176S	M	340	FLOY	UW	1.1
08-Jul	141S	F	390	FLOY	UW	1.1	10-Jul	177S	M	340	FLOY	UW	1.1
08-Jul	142S	M	410	FLOY	LW	N/A	10-Jul	178S	M	365	FLOY	LW	1.1
08-Jul	142L	F	785	RADIO	UW	1.4	10-Jul	179S	M	340	FLOY	UW	1.1
08-Jul	143S	M	320	FLOY	UW	N/A	10-Jul	179L	M	810	RADIO	NET	1.3
08-Jul	144S	M	585	SPAG	UW	1.2	10-Jul	180S	M	640	SPAG	UW	1.2
08-Jul	145S	M	380	FLOY	LW	1.1	10-Jul	181S	M	480	SPAG	UW	N/A
08-Jul	146L	M	885	SPAG	LW	N/A	10-Jul	182S	M	610	SPAG	UW	1.2
08-Jul	146S	M	335	FLOY	UW	1.1	10-Jul	182L	M	790	SPAG	UW	N/A
08-Jul	147S	M	320	FLOY	UW	1.1	10-Jul	183S	M	365	FLOY	LW	1.1
08-Jul	148S	M	345	FLOY	UW	1.1	10-Jul	184L	M	745	SPAG	LW	1.3
08-Jul	148L	F	775	RADIO	NET	1.3	10-Jul	185L	M	660	SPAG	UW	1.3
08-Jul	149S	M	390	FLOY	UW	1.1	10-Jul	186L	M	780	SPAG	NET	N/A
08-Jul	150S	M	325	FLOY	LW	1.1	10-Jul	187L	F	895	SPAG	UW	1.4
08-Jul	151S	M	535	SPAG	LW	1.2	10-Jul	189L	M	790	SPAG	NET	1.3
08-Jul	152S	M	365	FLOY	LW	N/A	10-Jul	190L	F	915	SPAG	LW	1.4
08-Jul	153L	F	725	RADIO	UW	1.3	10-Jul	191L	F	780	SPAG	UW	1.3
08-Jul	154L	F	750	SPAG	NET	1.3	10-Jul	192L	F	910	SPAG	NET	1.4
08-Jul	155L	F	795	SPAG	UW	1.4	10-Jul	195L	F	925	SPAG	NET	N/A
08-Jul	156L	F	780	SPAG	UW	1.3	11-Jul	183L	F	940	RADIO	UW	1.4
08-Jul	159L	M	915	SPAG	NET	1.4	11-Jul	184S	M	380	FLOY	LW	N/A
08-Jul	160L	F	895	SPAG	UW	1.4	11-Jul	185S	M	390	FLOY	UW	1.1
08-Jul	162L	F	805	SPAG	NET	1.3	11-Jul	186S	M	310	FLOY	UW	N/A
08-Jul	163L	F	815	SPAG	UW	1.4	11-Jul	187S	M	430	FLOY	LW	N/A
08-Jul	164L	F	770	SPAG	NET	1.4	11-Jul	188L	F	875	RADIO	LW	N/A
08-Jul	165L	F	795	SPAG	NET	1.3	11-Jul	188S	M	360	FLOY	UW	1.1
08-Jul	166L	F	810	SPAG	UW	1.4	11-Jul	189S	M	320	FLOY	UW	1.1
08-Jul	167L	F	805	SPAG	NET	1.3	11-Jul	190S	M	335	FLOY	UW	1.1
09-Jul	153S	M	385	FLOY	LW	1.1	11-Jul	191S	F	640	SPAG	UW	1.2
09-Jul	154S	M	365	FLOY	UW	1.1	11-Jul	192S	M	640	SPAG	LW	1.2
09-Jul	155S	M	340	FLOY	UW	1.1	11-Jul	193S	M	315	FLOY	LW	N/A
09-Jul	156S	M	290	FLOY	LW	1.1	11-Jul	194S	M	380	FLOY	UW	1.1
09-Jul	157S	M	375	FLOY	LW	1.1	11-Jul	194L	F	835	SPAG	UW	1.3

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Appendix A. (Page 4 of 4).

Date Tagged	Fish #	Sex	mm	Tag Type	Capture Site	Age	Date Tagged	Fish #	Sex	mm	Tag Type	Capture Site	Age
11-Jul	195S	M	375	FLOY	LW	1.1	14-Jul	203L	F	845	RADIO	UW	1.4
11-Jul	196L	F	875	RADIO	LW	1.4	14-Jul	212L	F	825	SPAG	NET	N/A
11-Jul	196S	M	390	FLOY	UW	1.1	14-Jul	213L	F	785	SPAG	UW	1.3
11-Jul	197S	M	310	FLOY	LW	1.1	14-Jul	215S	M	395	FLOY	LW	1.1
11-Jul	197L	F	770	SPAG	UW	1.3	14-Jul	215L	F	825	SPAG	LW	N/A
11-Jul	198S	M	410	FLOY	LW	0.1	14-Jul	216S	M	375	FLOY	LW	1.1
11-Jul	199S	M	410	FLOY	LW	1.1	14-Jul	216L	F	790	SPAG	LW	1.3
11-Jul	199L	M	785	SPAG	UW	1.4	14-Jul	217L	F	755	SPAG	UW	1.3
11-Jul	200L	F	780	SPAG	NET	1.3	14-Jul	217S	M	310	FLOY	UW	1.1
11-Jul	201L	F	795	SPAG	UW	1.3	14-Jul	218L	M	860	SPAG	NET	1.4
11-Jul	206L	M	925	SPAG	NET	1.4	14-Jul	218S	M	360	FLOY	UW	1.1
12-Jul	193L	F	800	RADIO	NET	1.3	14-Jul	219S	M	315	FLOY	UW	1.1
12-Jul	200S	M	330	FLOY	LW	1.1	14-Jul	220S	F	550	SPAG	UW	1.2
12-Jul	201S	M	380	FLOY	UW	2.1	14-Jul	221S	M	370	FLOY	LW	1.1
12-Jul	202S	M	310	FLOY	LW	1.1	14-Jul	222S	F	480	SPAG	UW	1.2
12-Jul	202L	F	770	SPAG	NET	1.3	14-Jul	223S	F	490	SPAG	UW	1.2
12-Jul	203S	M	280	FLOY	LW	1.1	15-Jul	208L	F	700	RADIO	UW	1.3
12-Jul	204L	F	705	SPAG	LW	1.4	15-Jul	219L	F	835	SPAG	NET	1.4
12-Jul	204S	M	290	FLOY	UW	1.1	15-Jul	221L	M	910	SPAG	UW	1.4
12-Jul	205S	M	300	FLOY	UW	N/A	15-Jul	224S	M	315	FLOY	LW	1.1
12-Jul	205L	M	900	SPAG	UW	1.4	16-Jul	211L	M	960	RADIO	NET	1.4
12-Jul	206S	M	410	FLOY	LW	N/A	16-Jul	223L	F	800	SPAG	UW	1.3
13-Jul	198L	F	755	RADIO	UW	1.3	16-Jul	225S	F	560	SPAG	LW	1.2
13-Jul	207L	F	755	SPAG	NET	1.4	16-Jul	226S	M	370	FLOY	LW	1.1
13-Jul	207S	M	365	FLOY	UW	2.1	17-Jul	214L	M	810	RADIO	LW	1.3
13-Jul	208S	M	360	FLOY	UW	1.1	17-Jul	224L	F	600	SPAG	LW	1.4
13-Jul	209L	F	940	SPAG	UW	1.4	17-Jul	225L	F	1025	SPAG	LW	1.4
13-Jul	209S	M	335	FLOY	LW	1.1	17-Jul	227S	F	400	FLOY	UW	1.1
13-Jul	210S	M	385	FLOY	UW	2.1	17-Jul	228S	M	370	FLOY	UW	1.1
13-Jul	210L	M	1020	SPAG	NET	N/A	18-Jul	229S	M	330	FLOY	UW	1.1
13-Jul	211S	M	320	FLOY	UW	1.1	18-Jul	230S	M	375	WOUND	UW	1.1
13-Jul	212S	M	395	FLOY	LW	1.1	18-Jul	231S	M	440	FLOY	LW	0.1
13-Jul	213S	M	340	FLOY	UW	1.1	19-Jul	227L	F	765	SPAG	NET	1.4
13-Jul	214S	M	520	SPAG	LW	N/A	19-Jul	232S	M	355	FLOY	UW	1.1
13-Jul	220L	F	810	SPAG	NET	1.3	19-Jul	233S	M	380	FLOY	LW	1.1

[a] L = large; S = small; Ls = large but initially called small, using length.

[b] LW = lower wheel, Chilkat River mile 8.
UW = upper wheel, Chilkat River mile 9.
Net = drift gill net, between Chilkat River mile 6 and 8.

[c] European notation; see text.

[d] Captured at the Chilkat River mouth, see Fish #2L, Appendix B.

Appendix B. Locations of radio transmitters implanted on large chinook salmon in 1991, listed by radio frequency, date tagged, river mile/ tributary where located (see system code), and survey period.

RADIO FREQ.	FISH #	DATE TAGGED	MILE TAGGED	Survey Period 5/18-6/16	6/24-6/30	7/01-7/07	7/08-7/14	7/15-7/21	7/22-7/28	8/05-8/11	8/19-8/25	9/11	FATE CODE[a]	SYSTEM CODE[b]	NOTE
30.380	1L	5/18	8.0	26.0	7.0	1.5			1.5				3	7	
30.300	2L	6/14	0.0		14.5	20.0	21.0		4.0KS	7.0KS	4.0KS		1	1	c
30.289	3L	6/14	7.0	7.0	14.5	12.0		19.0		19.0	18.0		2		
30.332	4L	6/16	7.0		4.0	5.0	18.5	29.5	32.5	1.5A	0.0A		1	5	
30.342	5L	6/18	9.0		12.0	14.0	19.0	28.0		1.5KS	2.0KS		1	1	
30.349	6L	6/18	7.0		10.0			20.0		2.5KS	1.0KS		1	1	
30.360	7L	6/22	8.0		6.0		22.0	30.0	30.5	5.5			3	7	
30.452	8L	6/22	8.0		6.5	19.0			31.0	2.5KS	2.0KS		1	1	
30.462	9L	6/23	8.0		6.0		30.0	32.0	1.5A	0.5A			1	5	d
30.473	10L	6/23	9.0		7.0	19.0	28.0	31.0	33.0	3.0T	1.0T		1	2	
30.490	11L	6/23	8.0		6.5	9.0	19.0			29.0			5		
30.510	12L	6/23	9.0		9.0		35.0	0.0T		2.0T	2.5T		1	2	
30.522	13L	6/23	9.0		18.5		33.0	1.5T	1.0T	1.5T	1.0KS		1	2	
30.541	14L	6/24	8.0		8.0	19.0	24.0	28.0	1.0T	2.0T	2.0T		1	2	
30.562	15L	6/24	7.0		8.0	16.0	20.5	30.5	1.0T	1.5T	2.5T		1	2	
30.578	16L	6/24	7.0		6.5		21.0	31.0	.5N	3.0KS	1.0KS		1	1	
30.638	17L	6/24	7.0		7.5	7.0	7.0		6.5		6.0		2		
30.618	18L	6/24	7.0		7.0	18.5	24.0	30.5	31.0	2.0KS			1	1	e
30.601	19L	6/24	7.0		4.5		31.0	31.0	33.0	3.0KS	2.0KS		1	1	
30.649	20L	6/25	9.0		9.0	20.5	21.0	20.5	20.5		19.0		2		
30.658	21L	6/26	9.0		8.0	20.0	28.0	28.5	1.0T	2.0T	2.0T		1	2	
30.688	22L	6/26	8.0		12.0	14.0	14.0	19.0	33.0	9.5KS	4.5KS		1	1	
30.400	24L	6/26	6.0			6.5	14.0		29.0	3.0KS	2.0KS		1	1	f
30.422	25L	6/26	7.0		7.5	18.0	21.5	13.0	12.0		12.0		3	7	
30.709	26L	6/26	6.0		6.0	20.5	29.5	1.5T	2.0T	3.0T	3.0T		1	2	
30.752	27L	6/27	7.0		7.0	9.0	19.0	22.0	24.0	9.0KI	8.5KI		1	3	
30.772	28L	6/27	9.0		9.0	18.0	26.0	3.5KS	8.5KS	7.0KS	5.0KS		1	1	
30.791	29L	6/27	9.0		6.0		11.0	10.5	10.5		10.5	10.5	2		
30.820	30L	6/27	7.0		9.0			31.0	33.0	3.0KS	1.0KS		1	1	
30.831	31L	6/27	7.0		10.0	16.0	18.5	20.0	3.0KS	7.5KS	5.0KS		1	1	
30.840	33L	6/27	9.0			19.0	20.0	27.0	1.5T				1	2	g
30.870	34L	6/27	8.0			3.0	3.0	20.0		3.0KS	1.5KS		1	1	
30.900	35L	6/27	8.0			13.0	19.0	2.5KS		3.0KS			1	1	
30.940	38L	6/28	9.0			5.0	21.0	30.5	3.0KS	2.0KS	.5KS		1	1	
30.969	40L	6/28	7.0			5.5		35.5KS	11.0KS	13.5KS	5.5KS		1	1	
31.032	41L	6/28	7.0			18.0	23.0	30.5	1.0T				1	2	
31.010	42L	6/28	7.0			13.0	23.0	34.5KS	5.5KS	7.0KS	5.5KS		1	1	
30.980	43L	6/28	7.0					12.5	13.0		12.0		2		
31.039	44L	6/28	7.0			21.0	31.0	30.5KS	0.5KS		0.5KS		1	1	
31.078	45L	6/29	8.0				20.0	28.0KS	33.0				1	1	h
30.391	46L	6/29	9.0					19.0	18.0	19.0	12.5		3	7	
31.102	47L	6/29	9.0			24.0	27.5	32.5KS	3.0KS	2.0KS	1.0KS		1	1	
31.109	48L	6/29	9.0			22.0	25.0		6.0T	2.0T	28.5		1	2	
31.051	49L	6/29	9.0				10.0		1.0T	6.5KS	5.0KS		1	1	
31.059	50L	6/29	7.0			21.0	24.0	30.5KS	1.0KS	8.5KS	2.0KS		1	1	
31.070	52L	6/29	7.0				20.0	31.0		2.0KS			1	1	i
31.120	53L	6/29	7.0			8.0	18.0		32.5	3.0T	0.5T		1	2	
31.130	54L	6/29	7.0			18.0	21.5		32.5	3.0T	3.0T		1	2	
30.373	56L	6/29	9.0			14.0	19.0		1.5KS				1	1	
31.160	57L	6/30	8.0			6.0	19.5	28.5	1.0T	1.5T	2.0T		1	2	
31.180	58L	6/30	7.0			18.5	25.0			0.5BB			1	4	j
31.201	59L	6/30	7.0			18.0	19.5		18.0		19.0		2		
31.209	60L	7/1	8.0			4.5	18.0		33.0				1	2	k

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Appendix B. (Page 2 of 3).

RADIO FREQ.	FISH #	DATE TAGGED	MILE TAGGED	Survey Period 5/18-6/16	6/24-6/30	7/01-7/07	7/08-7/14	7/15-7/21	7/22-7/28	8/05-8/11	8/19-8/25	9/11	FATE CODE[a]	SYSTEM CODE[b]	NOTE
31.218	61L	7/1	9.0			9.5	15.0			2.0KS	6.0		1	1	l
31.231	62L	7/1	7.0			21.0	1.0KS	4.0KS	8.0KS	6.5KS	6.5KS		1	1	
31.238	63L	7/1	9.0			18.5	20.0	28.0	32.0	3.0T	2.5T		1	2	
31.249	64L	7/1	9.0			19.5	20.5		33.0	3.0KS	3.5T		1	2	
31.260	65L	7/1	9.0			8.5	20.0		4.0KS	8.5KS	7.0KS		1	1	
31.309	67L	7/1	7.0				19.5	19.0		19.0	18.5		2		
31.271	68L	7/2	8.0					19.0	19.0				5		
31.283	69L	7/2	9.0			18.5	19.0	31.5	1.0T				1	2	m
31.292	70L	7/2	9.0			13.0	19.0		3.0KS	1.0T	2.0T		1	2	
31.300	71L	7/2	7.0			18.5	26.0			2.0KS	28.5		1	1	
31.319	73L	7/2	9.0			20.0	21.0	30.0	20.0		17.0	17.5	3	7	
31.319	74L	7/2	9.0			18.0	21.0	5.0KS	8.0KS	7.5KS			1	1	
31.340	75L	7/2	7.0			8.0	19.5	0.5KS		2.0T	2.5T		1	2	
31.250	76L	7/3	8.0				19.5	28.5	33.0	3.0KS	17.0		1	1	
31.339	77L	7/3	9.0			13.0	19.5	0.5KS		2.5KS	1.5KS		1	1	
31.349	78L	7/3	7.0					13.5		17.5	16.0		3	7	
31.351	79L	7/3	7.0				14.5	13.5	2.0KS				1	1	
31.360	80L	7/3	7.0				15.0	20.0	27.5	27.5	0.0SH		1	1	
31.370	81L	7/3	7.0			8.5	19.0		3.0KI	0.5BB			1	4	n
31.411	82L	7/3	8.0			5.5		4.5	5.0			4.5	2		
31.421	83L	7/3	8.0			CAP 22							4		
31.430	84L	7/3	8.0			9.5		20.0		1.0KS	0.0KS		1	1	
31.439	85L	7/3	9.0			8.5		19.0		7.0KS	0.0SH		1	1	
31.449	86L	7/3	9.0			3.5	3.5	20.0	1.0T	6.5KI	8.5KI		1	3	
31.461	87L	7/3	9.0			4.0		3.5			4.5		2		
31.471	88L	7/3	9.0			9.5	13.5	23.0	33.0	7.0KS	0.5SH		1	1	
31.481	89L	7/3	9.0				15.0	33.0	32.0	30.0	0.0KS		1	1	
31.490	90L	7/3	7.0			6.0	6.0	16.0	25.0	9.0KI	9.0KI		1	3	
31.500	91L	7/3	7.0						30.5	29.0		26.5	5		
31.509	92L	7/3	7.0			6.0	6.0	21.0	28.0	2.0KS	1.0KS		1	1	
31.520	93L	7/4	8.0			10.5	17.0	22.0	28.5	4.5KS	1.0KS		1	1	
31.529	94L	7/4	9.0			10.0	13.0	20.0	33.0	7.5KS	5.5KS		1	1	
31.542	95L	7/4	9.0			8.0	13.0	23.0	1.0T	4.0KS	2.0KS		1	1	o
31.549	96L	7/4	9.0			4.5	18.0	19.0	33.0	3.0KS	0.5KS		1	1	
31.560	97L	7/4	9.0				27.0	2.5KS	1.0T	0.0T			1	2	p
31.570	98L	7/4	9.0			22.0	24.0	20.5	31.5	1.5T	1.5T		1	2	
31.580	99L	7/4	9.0				19.0	24.0	33.0	1.5T	2.0T		1	2	
31.588	100L	7/4	7.0				24.0	26.5	32.0	2.0T	2.0T		1	2	
31.598	101L	7/5	8.0				6.0	6.0	17.0	29.5	1.0KS		1	1	
31.609	102L	7/5	9.0			18.0	23.0	2.0KI	4.0KI	5.0KI	4.0KI		1	3	
31.620	103L	7/5	7.0					19.0	25.0	30.5	1.0KS		1	1	
31.630	105L	7/5	6.0				14.5	2.5KS	4.0KS	8.5KS	6.0KS		1	1	
31.640	113L	7/6	6.0				21.0			3.5KS	1.5KS		1	1	
31.649	118L	7/6	9.0				20.0	18.0	1.5KI	8.5KI			1	3	
31.659	123L	7/6	7.0				13.0	20.5	30.5	2.0T	2.5T		1	2	
31.668	128L	7/7	9.0				6.0	17.5	1.0T		5.0KS		1	1	
31.419	133L	7/7	8.0				14.5						5		
31.688	138L	7/7	9.0				11.0		19.0	20.0	20.0		5		
31.679	142L	7/8	9.0				19.0	28.5	31.5	2.0T	2.5T		1	2	q
31.700	148L	7/8	7.0				7.0	4.0	6.0				2		
31.719	153L	7/8	9.0				7.0	18.5	1.0T	2.5KS	1.5KS		1	1	
31.730	158L	7/9	8.0				12.0	20.0	1.5T	2.5T			1	2	
31.752	163L	7/9	9.0				9.0	14.5	25.5	0.0T	2.0T		1	2	
31.761	169L	7/9	9.0				14.0	20.5	32.5	3.0T	1.0T		1	2	
31.770	173L	7/10	8.0				8.0	15.0	24.5	0.5KS	5.5KS		1	1	

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Appendix B. (Page 3 of 3).

RADIO FREQ.	FISH #	DATE TAGGED	MILE TAGGED	Survey Period 5/18-6/16	6/24-6/30	7/01-7/07	7/08-7/14	7/15-7/21	7/22-7/28	8/05-8/11	8/19-8/25	9/11	FATE CODE[a]	SYSTEM CODE[b]	NOTE
31.783	179L	7/10	7.0				7.0	8.0	18.0		1.5KS		1	1	
31.792	183L	7/11	9.0				8.0	15.5	31.0	4.0KS	2.0KS		1	1	
31.801	188L	7/11	9.0				8.0	14.0	20.0	20.0	19.5	19.5	2		
31.831	193L	7/12	7.0				7.0	9.0	24.5	2.5KS	1.5KS		1	1	
31.811	198L	7/13	9.0				8.0	8.0	17.5	1.0T			1	2	r
31.820	203L	7/14	9.0				8.0		1.0T	2.5T	2.5T		1	2	
31.841	208L	7/15	9.0					9.0	16.5	1.5KS			1	1	
31.872	211L	7/16	7.0					15.0	25.0				1	1	
31.882	214L	7/19	7.0					9.0	1.0T	2.5T			1	2	

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

[b] System codes:
1 = Kelsall River (KS)
1 = Stonehouse Creek (SH)
2 = Tahini River (T)
3 = Klehini River (KI)
4 = Big Boulder Creek (BB)
5 = Assignation Creek (A)
7 = Chilkat Mainstem

[c] This chinook salmon was implanted with a radio transmitter in salt water at the mouth of the Chilkat River near Pyramid Island. The fish was at river mile 4 on June 21, and had migrated to river mile 21 by July 10. This was the only chinook salmon tracked from salt water; all other fish were captured between Chilkat River miles 6 and 9.

[d] random recovery, August 13, Assignation Creek.

[e] random recovery, August 20, Kelsall River.

[f] random recovery, August 23, Nataga River.

[g] random recovery, August 03, Tahini River.

[h] random recovery, August 12, Kelsall River.

[i] random recovery, August 16, Kelsall River.

[j] select recovery (ADF&G FRED Division), August 08, Big Boulder Creek.

[k] random recovery, August 01, Tahini River.

[l] random recovery, August 10, Kelsall River.

[m] random recovery, August 03, Tahini River.

[n] select recovery (ADF&G FRED Division), August 08, Big Boulder Creek.

[o] random recovery, August 30, Kelsall River.

[p] random recovery, August 05, Tahini River.

[q] random recovery, August 28, Tahini River.

[r] random recovery, August 07, Tahini River.

Appendix C. Average daily 1991 surface-water speed, water temperature and water depth of Chilkat River at lower fish wheel, and daily revolution rates (RPM) of both fish wheels.

	Speed (ft/sec)	Temp (°C)	Depth (cm)	Fish wheel RPM	
				8-mile wheel	9-mile wheel
05-May	NA	8.30	64.00	2.31	NA
06-May	NA	7.10	68.50	2.45	NA
07-May	NA	5.85	76.00	2.78	NA
08-May	NA	6.95	69.00	2.70	NA
09-May	NA	6.50	70.50	2.60	NA
10-May	NA	6.05	66.50	2.45	NA
11-May	NA	5.70	63.50	2.26	NA
12-May	NA	7.15	60.50	2.45	NA
13-May	NA	7.75	59.50	2.21	NA
14-May	NA	8.15	60.00	2.72	NA
15-May	NA	8.20	65.50	2.88	NA
16-May	NA	8.80	77.50	3.05	NA
17-May	NA	9.20	84.75	3.10	NA
18-May	NA	7.70	92.50	3.03	NA
19-May	NA	7.25	91.50	2.80	NA
20-May	NA	7.95	90.00	2.61	NA
21-May	NA	7.40	85.00	2.56	NA
22-May	NA	9.00	85.00	2.56	NA
23-May	NA	9.75	97.75	2.50	NA
24-May	NA	9.65	106.75	2.57	NA
25-May	NA	9.30	113.00	2.49	NA
26-May	NA	7.85	113.00	2.45	NA
27-May	NA	8.00	106.50	2.42	NA
28-May	NA	7.50	106.25	2.39	NA
29-May	NA	7.80	127.00	2.49	NA
30-May	NA	8.10	128.25	2.40	NA
31-May	NA	7.25	123.50	2.23	NA
01-Jun	NA	7.20	109.50	2.14	NA
02-Jun	NA	7.95	97.00	2.02	NA
03-Jun	NA	9.20	88.75	2.08	NA

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Appendix C. (Page 2 of 3).

	Speed (ft/sec)	Temp (°C)	Depth (cm)	Fish wheel RPM	
				8-mile wheel	9-mile wheel
04-Jun	3.25	9.60	87.00	2.19	NA
05-Jun	3.40	8.85	89.25	2.34	NA
06-Jun	3.50	9.10	93.50	2.67	NA
07-Jun	4.05	8.75	104.50	2.76	NA
08-Jun	3.80	7.85	102.25	2.77	NA
09-Jun	3.55	7.15	91.50	2.57	2.30
10-Jun	3.35	8.90	93.75	2.53	2.37
11-Jun	3.60	10.30	101.00	2.74	2.75
12-Jun	3.70	11.35	106.75	2.71	2.93
13-Jun	3.85	10.90	117.50	2.78	3.08
14-Jun	3.45	11.00	123.50	2.44	3.13
15-Jun	3.30	11.05	133.75	2.31	3.08
16-Jun	3.20	10.40	142.00	2.33	3.27
17-Jun	2.80	9.60	138.00	2.16	3.19
18-Jun	3.00	9.70	138.75	2.10	3.16
19-Jun	3.00	10.80	135.50	2.11	3.20
20-Jun	3.00	11.75	154.50	2.23	3.67
21-Jun	3.05	11.55	165.50	2.40	3.54
22-Jun	3.20	11.20	187.00	2.34	3.59
23-Jun	2.50	11.95	188.50	2.14	3.79
24-Jun	2.80	10.95	185.25	2.05	3.74
25-Jun	2.95	10.70	175.00	1.79	3.63
26-Jun	2.30	10.20	166.00	1.72	3.30
27-Jun	1.95	10.50	157.25	1.53	3.22
28-Jun	1.80	10.35	153.50	1.42	3.44
29-Jun	NA	10.05	168.00	1.68	3.58
30-Jun	NA	8.60	170.00	1.82	3.53
01-Jul	NA	9.50	153.75	1.41	3.12
02-Jul	NA	10.35	151.00	1.41	3.37
03-Jul	NA	10.60	156.00	1.52	3.40
04-Jul	NA	10.05	146.50	1.65	3.27

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Appendix C. (Page 3 of 3).

	Speed (ft/sec)	Temp (°C)	Depth (cm)	Fish wheel RPM	
				8-mile wheel	9-mile wheel
05-Jul	NA	10.70	138.00	1.72	3.16
06-Jul	NA	9.60	136.50	2.12	3.22
07-Jul	NA	9.70	135.50	2.09	3.19
08-Jul	NA	9.50	137.25	2.20	3.11
09-Jul	NA	9.35	135.50	2.02	3.14
10-Jul	NA	9.40	135.00	2.33	3.11
11-Jul	NA	9.15	132.00	2.18	3.04
12-Jul	NA	9.30	137.00	1.44	3.26
13-Jul	NA	10.60	145.50	1.56	3.29
14-Jul	NA	10.20	147.00	1.86	3.25
15-Jul	NA	11.10	146.00	1.81	3.16
16-Jul	NA	9.95	151.50	2.03	3.20
17-Jul	NA	9.30	147.50	1.59	3.13
18-Jul	NA	9.55	151.00	1.88	3.06
19-Jul	NA	8.55	136.50	1.51	3.05
20-Jul	NA	7.70	126.00	0.00	NA