Enumeration of the 1996 Harrison River Chinook Salmon Escapement

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ENUMERATION OF THE 1996 HARRISON RIVER CHINOOK SALMON ESCAPEMENT

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In 1985, the Pacific Salmon Treaty committed the Canadian Department of Fisheries and Oceans to halt the decline in abundance of chinook salmon (*Oncorhynchus tshawytscha*) stocks. The Harrison River was designated a chinook indicator stock, and escapement has been monitored annually since 1984. In 1996, 1,894 marks were applied and 160 were recovered in a recovery sample of 4,916 chinook. Sex based biases were observed in the application and recovery samples. No other significant biases were detected. The escapement estimates derived by sex were 19,214 adult males, 18,180 adult females, and 39,840 precocious males. The total adult escapement estimate (37,394) was the third lowest since monitoring began in 1984. Revisions of sampling technique to reduce handling stress associated with recaptures and to improve identification of adult and precocious males are suggested. Although no bias was detected, the age composition of the escapement estimate may be biased as a result of the theft of scale samples.

Key Words: Chinook salmon, Harrison River, indicator stock, escapement, Pacific Salmon Treaty.

RÉSUMÉ

Farwell, M.K., R.E. Bailey, and J. Tadey. 1999. Enumeration of the 1996 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2478: 30 p.

En 1985, le traité sur le saumon du Pacifique faisait obligation au ministère des Pêches et des Océans du Canada à enrayer le déclin de l'abondance des stocks de quinnat (*Oncorhynchus tshawytscha*). Le stock de la Harrison a été désigné comme stock indicateur, et son échappée est surveillée chaque année depuis 1984. En 1996, 1 894 marques ont été appliquées, dont 160 ont été récupérées dans un échantillon de 4 916 quinnats prélevés à cette fin. Des biais liés au sexe ont été observés dans les échantillons des opérations de marquage et de récupération, mais aucun autre biais important n'a été noté. Les estimations de l'échappée, calculées selon le sexe, étaient de 19 214 mâles adultes, 18 180 femelles adultes 39 840 mâles précoces. L'estimation de l'échappée totale d'adultes (37 394) était la troisième parmi les plus basses depuis le début de la surveillance en 1984. Nous proposons des modifications à la technique d'échantillonnage pour réduire le stress de la manutention à la recapture et pour améliorer l'identification des mâles adultes et précoces. Bien qu'aucun biais n'ait été détecté, la composition par âge de l'estimation de l'échappée pourrait être biaisée suite au vol d'échantillons d'écailles.

Mots clés : quinnat, Harrison, stock indicateur, échappée, Traité sur le saumon du Pacifique.

INTRODUCTION

The 1985 Pacific Salmon Treaty committed management agencies in Canada and the United States of America to halt the decline in chinook salmon (*Oncorhynchus tshawytscha*) spawning escapements and to attain, by 1998, escapement goals established by each nation (Anon. 1985). To evaluate rebuilding progress, the Department of Fisheries and Oceans has monitored a group of key stocks selected to represent all British Columbia chinook stocks. The status and response to management actions of these stocks are evaluated by measuring, with known precision, either annual trends in escapement (escapement indicator stocks) or in escapement and total harvest (exploitation rate indicator stocks).

The Harrison River was designated an escapement indicator stock in 1984 because it comprised almost one-third of the Fraser River system chinook escapement in the 1970s (Farwell *et al.* 1987) and, as a white-fleshed, fall spawning stock with juveniles which migrate to sea immediately following emergence (Fraser *et al.* 1982), it is unique in the Fraser River system. Individual monitoring, therefore, was warranted. Previous reports documented the 1984-1995 Harrison River chinook enumeration studies (Staley 1990; Farwell *et al.* 1990, 1991, 1992, 1996, 1998; Schubert *et al.* 1993, 1994). The current report documents the 1996 field methods, analytic techniques, and study results. Included are estimates of age, length, sex, adipose fin clip (AFC) incidence, coded wire tag (CWT) recoveries, and escapement by sex and age. The report concludes with a discussion of data limitations and stock status.

STUDY AREA

The Harrison River is part of a complex system which drains a mountainous coastal watershed in southern British Columbia (Fig. 1). The river originates at Harrison Lake and flows south-west for 16.5 km, entering the Fraser River 116 km upstream from the Strait of Georgia. Between 1951 and 1994, the river had an annual mean daily discharge of 440 $m^3 \times s^{-1}$, with an annual mean daily maximum of 1269 $m^3 \times$ s-1 and minimum of 121 $m^3 \times$ s-1 measured at the outlet of Harrison Lake (unpublished data, pers. comm. Lynne Campo, Environment Canada). Flow extremes are moderated by Lillooet and Harrison lakes. The study area was divided into eight reaches based on homogeneity of physical characteristics (Fig. 2):

Reach 1 (Harrison Lake to km 9.5), from the lake to Morris Creek, has a wide, low gradient channel with a depth of 10 m and a sand substrate;

Reach 2 (km 9.5 to 7.7) extends to Billy Harris Slough on the north-west shore and to the top of Reach 5 on the south-east shore. The channel is similar to Reach 1 except the depth is 3.0 m and the substrate is gravel;

Reach 3 (km 7.7 to 7.1) extends to a shear boom on the north-west shore. It has a higher gradient and a cobble/gravel substrate;

Reach 4 (km 7.1 to 6.3) is similar to Reach 3 except there are several side channels on the north-west shore separated from the main channel by gravel bars. The channel substrate is gravel;

Reach 5 (km 7.7 to 6.3) is a large side channel with a low gradient, a depth of 1.5 m and a sand substrate. An island at the mid-point divides the reach into two sections;

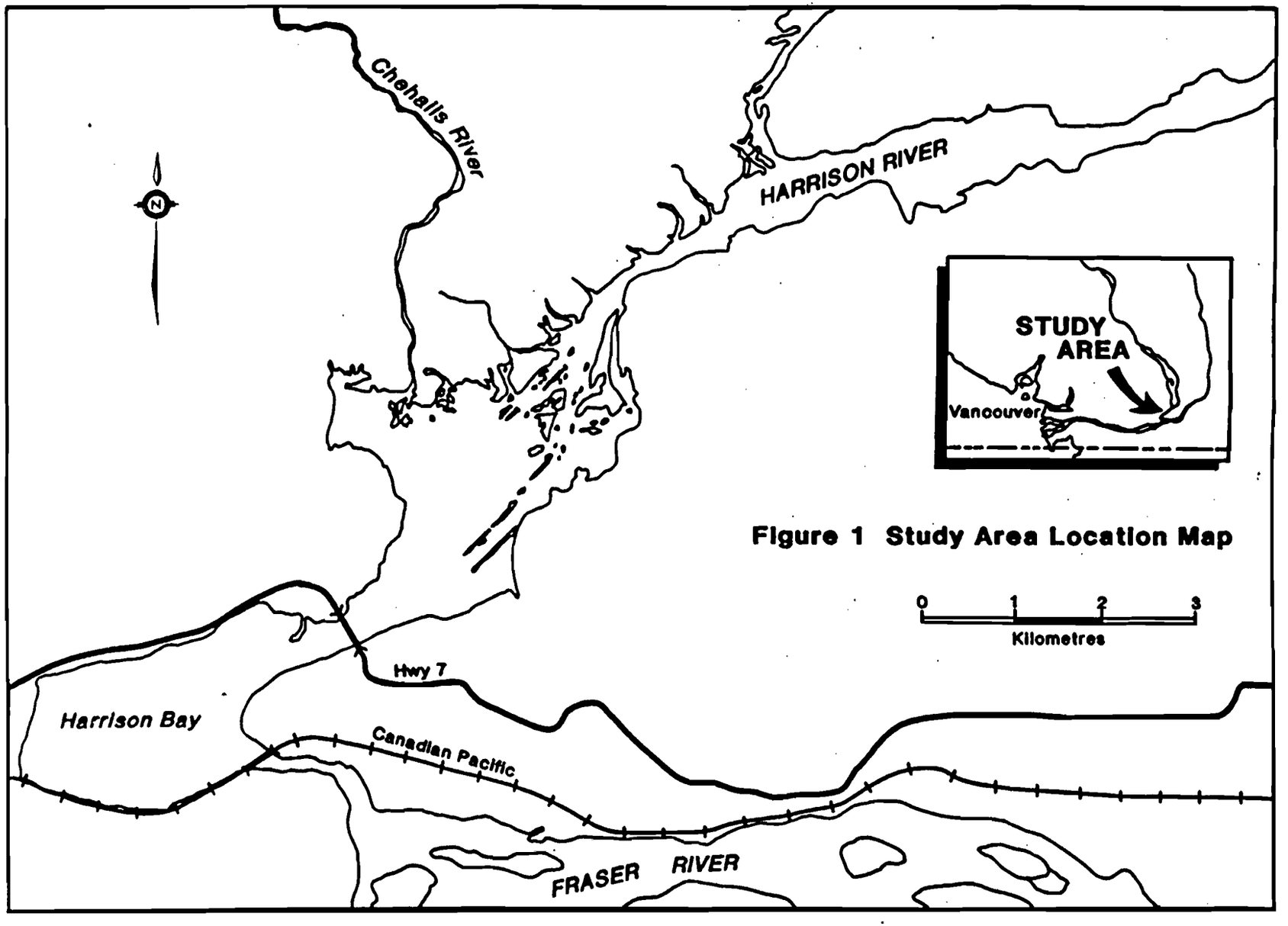

Fig. 1. Study area location map.

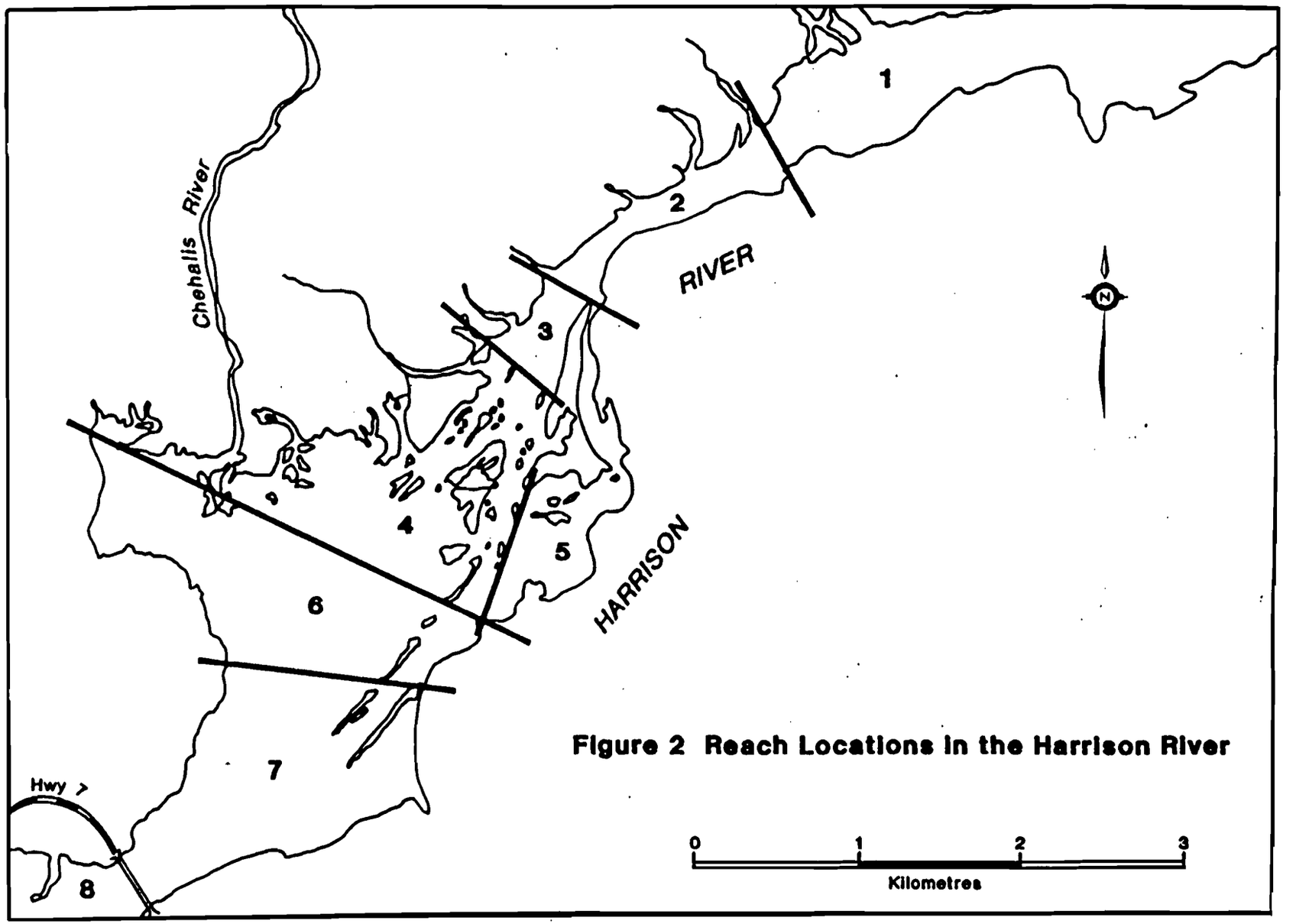

Fig. 2. Reach locations in the Harrison River.

Reach 6 (km 6.3 to 4.5) extends to a rock bluff on the south-east shore, 2 km above the Highway 7 bridge, and includes the main channel and the upper Chehalis River flood plain. The channel depth is 3 m and the substrate is bedrock/gravel;

Reach 7 (km 4.5 to 3.0) extends to the Highway 7 bridge, and includes the main channel and the lower Chehalis River flood plain. The gradient is lower than Reach 6 and the substrate is mud;

Reach 8 (km 3.0 to 0) extends to the Fraser River and includes Harrison Bay. The river is deep (up to 4 m) and slow, flowing over a sand and gravel substrate. Harrison Bay is shallow with a mud substrate. There are several mid-river entrainment structures designed to divert the flow away from Harrison Bay. The bay dewaters at low Harrison River discharges, and chinook tend to avoid the area.

FIELD METHODS

TAG APPLICATION

Chinook salmon were captured in reaches 2 through 4 and reach 6 from October 15 to November 18, 1996 using a 67 m x 6 m x 9 cm-mesh seine net. The net was set by power boat in a downstream crescent and withdrawn from the river to enclose a small area of water along the river bank. Captured chinook were held in the net until removed for tagging and release. Spaghetti tags were applied in a submerged wooden tray constructed with a flexible plastic bottom and a meter stick recessed in one side. After tagging, the fish were released over a submerged section of the net; at no time were they removed from the water. During tag application, any previously tagged fish which were recaptured were released without removal from the water. Date, reach, and tag number were recorded for recaptured fish.

The spaghetti tags consisted of a 50 cm long, 2 mm diameter hollow plastic tube numbered with a unique code. The tag was inserted with a 13 cm long stainless steel needle through the musculature and pterygiophore bones 2 cm below the anterior portion of the dorsal fin. It was tied tightly over the dorsal surface with a square knot. Each tagged fish received a secondary mark to allow the assessment of tag loss. One 7 mm diameter hole was punched through the right operculum of males and jacks using a single hole punch. Female right opercula were punctured twice. Care was taken to avoid gill damage. Field estimates of sex were based on developing secondary sexual characteristics. The distinction between adult and precocious males was based on nose-fork (NF) length with jacks having a NF of less than 65 cm. Date and location (reach) of capture, tag number, sex, NF length (±0.5 cm) and adipose fin status were recorded for each chinook released with a tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation).

SPAWNING GROUND SURVEYS

The spawning grounds were surveyed from October 18 to December 6, 1996. Complete surveys were conducted weekly by two-person crews, with two to four crews required depending on carcass abundance. The shore was surveyed on foot while deep water areas, including the mid-river entrainment structures, were surveyed by boat. Carcasses were recorded by date, reach, recovery type (shore or deep water), sex (confirmed by abdomen incision), and mark type (spaghetti tag, secondary mark or AFC). Carcasses identified as male were classed as jack chinook if the POH length was less than 50 cm. Each marked carcass and every twentieth unmarked carcass was sampled. All were cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included postorbital-hypural plate (POH) length (±0.1 cm), sex, female spawning success (0%, 50%, or 100% spawned), adipose fin condition, flesh colour, and scales. For AFC chinook, the head was removed posterior to the

eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped or as complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact but soft), or rotten (skin and bones), and the absence of one or both eyes was noted.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

Period

Temporal bias was assessed using a chi-square test (Sokal and Rohlf 1981). Application bias was examined by comparing among periods the mark incidence in the recovery sample, where mark incidence was the proportion of the chinook adults marked with either a spaghetti tag or a secondary mark. Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered.

Location

Spatial bias was assessed using a chi-square test. Application bias was examined by comparing among river sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered.

Fish Size

Size related bias was assessed using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). Application bias was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the NF length frequency distributions of each.

Fish Sex

Sex related bias was assessed using chi-square tests. Application bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each.

Other Tests

Bias resulting from tagging stress was also assessed using chi-square tests. The application sample was partitioned by the three categories of release condition and recovery rates were examined between groups. Bias associated with the stress of recapture and release of previously tagged fish was

assessed. The recaptures were stratified by number of recaptures and recovery rates among groups were compared using a chi-square test. As well, differential spawning success was examined in marked and unmarked spawning ground recoveries.

Statistical bias in the mark-recapture estimation method was deemed to be present when there were fewer than 4 recaptures in a class (Ricker 1975).

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1996 escapement of Harrison River chinook adults was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). Total escapement was the sum of escapement by sex as calculated by the following formulae:

1) Estimated Harrison River chinook escapement (N_t):

$$N_t = N_m + N_f + N_{jk}$$

where:

N_m = adult male escapement estimate;

$$= \{(M_m + 1)(C_m + 1)\} / (R_m + 1)$$

N_f = female escapement estimate, analogous to above.

N_{jk} = jack escapement estimate, analogous to above.

2) Ninety-five percent confidence limits of Nt:

$$N_t \pm 1.96(V_t^{0.5})$$

where:

N_t = total escapement estimate;

V_t = variance of the escapement estimate;

$= V_m + V_f + V_{jk}$

V_m = variance of the adult male escapement estimate;

$$= \{(N_m^2)(C_m - R_m)\} / \{(C_m + 1)(R_m + 2)\}$$

N_m = adult male escapement estimate;

C_m = number of adult male carcasses examined for spaghetti tags;

R_m = number of spaghetti tagged or secondary marked adult males recovered;

V_f = variance of female escapement estimate, analogous to above.

V_{jk} = variance of jack escapement estimate, analogous to above.

Escapement by Age

The estimated escapement of an age group was the product of the sex specific escapement estimate and the proportion of an age group in the total of the aged fish, stratified by sex. Confidence limits were not estimated.

Adipose Fin Clipped Escapement

The estimated AFC escapement was the product of the AFC incidence in the recovery sample, the largest of the two available samples, and the mark-recapture escapement estimate stratified by sex. If no significant difference between AFC incidence in the sex groups was detected then a pooled estimate of AFC incidence was utilized. Confidence limits and escapement by CWT code were not estimated.

RESULTS

SPAGHETTI TAG APPLICATION

Spaghetti tags and secondary marks were applied to 1,908 chinook salmon in the Harrison River from October 15 to November 18, 1996. Two of the marked chinook, one male and one jack, were subsequently recovered in a native fishery in the mainstem of the Fraser River and were their associated data were removed from the application sample. Of the remaining marked fish, 641 were identified as male, 628 were female, and 637 were jacks. Forty-one of the fish (2.1%) had an AFC (Appendix 1).

Table 1. Spaghetti tag application, carcass examination, and mark recovery, by sex, of Harrison River chinook salmon, 1996.

			Marks recovered				
Sex	Spaghetti tags applied	Carcasses examined	Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	Percent recovered
Male	641	1,675	32	22	1	55	8.6%
Female [a]	616	2,533	76	3	6	85	13.8%
Jack	637	561	6	2	0	8	1.3%
Unknown Sex	-	147	1	0	11	12	-
Total	1,894	4,916	115	27	18	160	8.4%

[a] Excludes 12 fish recaptured and released more than four times during application period.

None of the fish were misidentified by sex at the time of tagging (Appendix 2). Therefore, there was no need to correct the application sample for sex identification error. Three hundred and forty-six previously tagged fish were recaptured during subsequent tag application periods (Table 2). Within that total, individual fish were recaptured up to seven times with females showing a significantly higher incidence of recapture (23.2%) than males (20.0%) or jacks (11.1%) . The differences in recovery rates

by number of recaptures was examined and a significant difference in recovery rates was observed in females between those fish recaptured five or more times and those with one to four recaptures episodes ($p < 0.05$, chi-square). There was no significant difference in the recovery rates of females which had never been recovered and those which had been recovered less than five times. Therefore the 12 females which were recovered more than four times were removed from the application sample. Within the recaptured fish group, the incidence of recapture episodes numbering greater than four was significantly higher in females (8.2%) than in males (1.6%) or jacks (1.4%).

Table 2. Spaghetti tag application and recovery, by number of recaptures during tag application, by sex, of Harrison River chinook salmon, 1996.

	Spaghetti tags applied			Spaghetti tags recovered				Percent recovered		
Number of times recaptured	Male	Female	Jack	Male	Female	Jack		Male	Female	Jack
0	512	482	566	24	58	6	[a]	4.7%	12.0%	1.1%
1	95	78	60	7	15	0	[b]	7.4%	19.2%	0.0%
2	23	29	8	2	4	0		8.7%	13.8%	0.0%
3	7	18	2	0	3	0		0.0%	16.7%	0.0%
4	2	9	0	0	2	0		0.0%	22.2%	-
5	1	7	0	0	4	0		0.0%	57.1%	-
6	1	4	1	0	1	0		0.0%	25.0%	0.0%
7	0	1	0	0	0	0		-	0.0%	-
Total	641	628	637	33	87	6		5.1%	13.9%	0.9%

a. Includes 11 fish of unknown sex at recovery

b. Includes 1 fish of unknown sex at recovery.

Of the 1,895 fish for which release condition was recorded, 2 fish (0.1%) required ventilation at release while 331 swam away sluggishly after tag application (17.5%) (Table 3). The recovery rates, by sex, of these two groups were not significantly different ($p > 0.05$; chi-square) from the recovery rate of the remaining fish. Consequently, they were left within the application sample.

Table 3. Spaghetti tag application and recovery, by release condition during tag application, by sex, of Harrison River chinook salmon, 1996.

	Spaghetti tags applied			Spaghetti tags recovered			Percent recovered		
Release condition	Male [a]	Female [b]	Jack [c]	Male	Female	Jack	Male	Female	Jack
Swam rapidly	512	476	574	25	57	5	4.9%	12.0%	0.9%
Swam sluggishly	124	147	60	8	25	1	6.5%	17.0%	1.7%
Required assistance	0	1	1	0	0	0	-	0.0%	0.0%
Total	636	624	635	33	82	6	5.2%	14.7%	0.9%

a. Excludes 5 for which release condition was not recorded.

b. Excludes 4 for which release condition was not recorded.

c. Excludes 2 for which release condition was not recorded.

Most (79.5%) of the marked chinook were released in Reach 3; an additional 20.0% were released in Reach 2 and the remaining 0.5% were released in reaches 4 and 6. Of the recaptured chinook, 98.4% were recaptured in Reach 3.

Mean and range of NF lengths of males, females, and jacks were 83.4 cm (65.5 to 116.0 cm), 84.8 cm (65.5 to 105 cm) , and 51.1 (33.5 to 67.5 cm), respectively. Although no sex identificiation errors were observed there was a 2.0 cm overlap in jack and adult lenths. To minimize handling time and associated stress, the release group was not sampled for age.

SPAWNING GROUND RECOVERY

In 1996, a total of 4,916 chinook salmon were recovered on the spawning grounds from October 18 to December 6 (Table 1; Appendix 3). There were 1,675 (34.1%) adult males, 2,533 (51.5%) adult females and 561 (11.4%) jack carcass recoveries. In addition, 147 (3.0%) of the carcasses were unable to have their sex determined. Of the total, 53 (1.1%) had an AFC and 115 (2.3%) had a spaghetti tag and secondary mark. Twenty-seven fish showed spaghetti tag loss. Tag loss was significantly higher in males and jacks (average 38.1%) than in females (3.5%) ($p < 0.05$, chi-square). Tag loss between males (40.0%) and jacks (25.0%) was not significantly different. Of the 18 tags which were recovered without a secondary mark, only 2 were recovered from carcasses with complete opercula. Most (71.6%)of the chinook carcasses were recovered in the lower section (reaches 6 to 8) (Appendix 3).

Age, Length and Sex

The age, length, and sex of the 1996 Harrison River spawning ground recoveries are reported in Appendix 4. Age samples were taken throughout the period October 18 to December 6; however, after a theft of various project items, the only samples available for ageing were from the period November 27 to December 6. Unlike the scale samples, POH lengths were available for the entire spawning ground recovery period. A comparison of the POH frequency distributions in the fish sampled before and after the theft did not show a significant difference ($p > 0.05$, Kolmogorov-Smirnov two-sample test).

During the entire recovery period, the mean POH length of female, male, and jack chinook was 69.8 cm, 69.1 cm, and 40.8 cm, respectively. Fish identified in the field as jacks ranged in size from 29 to 51 cm POH while the smallest fish field-identified as a male was 51.5 cm and the smallest female was 52 cm. Of the aged samples, most females (76.9%) were age 4_1 while the age 3_1 and 4_1 males each represented 48.3% of the aged males. One fish identified in the field as a 49 cm POH jack was aged as an age 3_1 male indicating a 1.5 cm overlap in POH lengths. No fish identified in the field as adult males were aged as jacks. The age composition of AFC and unmarked carcasses was compared. A significant difference was observed only in females ($p < 0.05$; chi-square). Four (0.5%) of the 837 carcasses examined for flesh colour had red flesh.

Coded Wire Tag Recoveries

Fifty-three chinook had an AFC (Appendix 5). Three carcasses had questionable AFCs and one carcass had no head. CWTs were recovered from 44 heads (21 male, 17 female, and 6 jacks), of which 10 (23%) were from 1992-brood, 28 were from 1993-brood, and 4 were from 1994-brood Chehalis River Hatchery releases. Two jack CWTs were from a 1994-brood release at the Stave River. A single CWT was lost during processing and 7 (13.2%) heads did not contain a CWT. There was no significant difference ($p > 0.05$; chi-square) in CWT loss in carcasses with eyes versus those missing one or both eyes (Appendix 6) and no significant difference ($p > 0.05$; chi-square) in CWT loss between fresh and rotten carcasses. A significantly high absence of CWTs (66.7%) was observed in carcasses with questionable AFCs ($p < 0.05$; chi-square). Therefore three carcasses with fungus obscuring the AFC area were removed from calculations of CWT loss and AFC incidence.

There was no significant difference ($p > 0.05$; chi-square) in AFC incidence by sex. There was no significant difference ($p > 0.05$) in AFC incidence when the individual sex samples were stratified spatially. There was a significant difference ($p > 0.05$) in AFC incidence in males and females when their samples were stratified temporally. Both sexes showed the highest AFC incidence in the late time period Scale ageing accuracy was evaluated in the 7 samples for which both aged scales and CWTs were available. No ageing errors were noted.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in three recovery periods (Table 4). Mark incidences in males and jacks were highest in the latest period while female mark incidence was highest in the earliest period. The differences were not significantly different than that expected ($p > 0.05$; chi-square).

Table 4. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the Harrison River spawning grounds, by recovery period and sex, 1996.

		Recovery Period		
		18-Oct to 09-Nov	10-Nov to 23-Nov	24-Nov to 06-Dec
Recovered with spaghetti tags or secondary marks	Male	19	19	17
	Female	44 [b]	26	15
	Jack	6	0	2
	Unknown [a]	1	2	1
Carcasses examined	Male	751	543	381
	Female	1,085 [b]	877	571
	Jack	359	153	49
	Unknown	70	27	42
Mark Incidence	Male	2.5%	3.5%	4.5%
	Female	4.1%	3.0%	2.6%
	Jack	1.7%	0.0%	4.1%
	Unknown	1.4%	7.4%	2.4%

[a] Excludes 8 recoveries without a recovery date recorded.

[b] Excludes 5 which were recaptured more than 4 times after tagging.

Recovery bias was examined by comparing the proportions recovered from three application periods (Table 5). The percentages ranged from 0% to 16.4%, with the highest values in females lowest in jacks. Within each sex group, the differences among time periods were not significant ($p > 0.05$, chi-square).

Table 5. Percentage of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1996.

		Application Period		
		15-Oct to 22-Oct	23-Oct to 31-Oct	01-Nov to 18-Nov
Spagetti tags applied	Male	144	298	199
	Female [a]	213	232	171
	Jack	174	301	162
Spaghetti tags recovered	Male	8	14	11
	Female	25	38	19
	Jack	4	2	0
Percent recovered	Male	5.6%	4.7%	5.5%
	Female	11.7%	16.4%	11.1%
	Jack	2.3%	0.7%	0.0%

[a] Excludes 12 fish recaptured more than four times after initial tagging.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in three recovery sections (Table 6). In males and jacks, the highest mark incidence (3.7% and 1.5%, respectively) was in the lower section; while the highest mark incidence in female carcasses (5.0%) was in the upper section. The observed differences were not significant ($p > 0.05$; chi-square).

Table 6. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the Harrison River spawning grounds, by recovery section and sex, 1996.

		Recovery Section [a]		
		Upper	Middle	Lower
Recovered with spaghetti tags or secondary marks	Male	0	7	48
	Female [b]	1	23	61
	Jack	0	1	7
	Unknown [c]	0	1	3
Carcasses examined	Male	11	380	1,284
	Female [b]	20	865	1,648
	Jack	2	81	478
	Unknown [c]	5	32	102
Mark Incidence	Male	0.0%	1.8%	3.7%
	Female	5.0%	2.7%	3.7%
	Jack	0.0%	1.2%	1.5%
	Unknown	0.0%	3.1%	2.9%

[a] Section definitions: Upper - reaches 1 and 2; Middle - reaches 3,4, and 5; and Lower - reaches 6,7, and 8.

[b] Excludes 5 which were recaptured more than 4 times after tagging.

[c] Excludes 8 recoveries without a recovery reach recorded.

Recovery bias was examined by stratifying the application sample into three reaches and comparing proportions recovered from each (Table 7). The percentages ranged from 0.0% to 14.1%; however, the differences observed in each of the sexes were not significant ($p > 0.05$).

Table 7. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application reach and sex, 1996.

		Application reach		
		Reach 2	Reach 3	Reaches 4 - 6
Spaghetti tags applied	Male	88	550	3
	Female [a]	188	426	2
	Jack	102	530	5
Spaghetti tags recovered	Male	4	29	0
	Female	22	60	0
	Jack	2	4	0
Percent recovered	Male	4.5%	5.3%	0.0%
	Female	11.7%	14.1%	0.0%
	Jack	2.0%	0.8%	0.0%

[a] Excludes 12 fish recaptured more than four times after initial tagging.

Fish Size

Size related bias in the application sample was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant differences ($p > 0.05$; Kolmogorov-Smirnov two sample test) were detected in females or jacks; while males showed a significant bias toward the smaller sizes (Table 8). To determine whether misidentification of males and jacks may have influenced the size bias, the jack and male portions of the recovery sample were grouped. In the combined male sample, there was no significant difference between the marked and unmarked length frequency distributions.

Recovery sample bias was examined by partitioning the application sample into recovered and non-recovered components and comparing NF length frequency distributions. There was no significant difference ($p > 0.05$, Kolmogorov-Smirnov two sample test) in any of the sex groups (Table 9).

Table 8. Incidence of spaghetti tags or secondary marks in Harrison River chinook carcass sample recovered on the spawning grounds, by 10 cm increments of post-orbital-hypural length and sex, 1996.

POH	Carcasses sampled			Carcass with spaghetti tag or secondary mark			Mark incidence		
Length (cm)	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
20-29.9	0	0	1	0	0	0	-	-	0.0%
30-39.9	0	0	42	0	0	4	-	-	9.5%
40-49.9	1	0	87	0	0	2	-	-	2.3%
50-59.9	33	16	7	6	0	0	18.2%	0.0%	0.0%
60-69.9	114	243	0	15	41	0	13.2%	16.9%	-
70-79.9	127	251	0	11	38	0	8.7%	15.1%	-
80-89.9	36	37	0	1	7	0	2.8%	18.9%	-
90-99.9	0	0	0	0	0	0	-	-	-

Table 9. Proportion of the Harrison River chinook salmon spaghetti tag application sample recovered on the spawning grounds, by 10 cm increments of nose-fork length and sex, 1996.

Nose-fork	Spaghetti tags applied			Recovered with spaghetti tag			Percentage recovered		
length (cm)	Male	Female	Jack	Male	Female	Jack	Male	Female	Jack
30-39.9	0	0	15	0	0	1	-	-	6.7%
40-49.9	0	0	253	0	0	4	-	-	1.6%
50-59.9	0	0	312	0	0	2	-	-	0.6%
60-69.9	50	3	57	0	0	0	0.0%	0.0%	0.0%
70-79.9	194	152	0	13	18	0	6.7%	11.8%	-
80-89.9	225	314	0	15	41	0	6.7%	13.1%	-
90-99.9	127	146	0	10	30	0	7.9%	20.5%	-
100-109.9	42	13	0	1	3	0	2.4%	23.1%	-
110-119.9	2	0	0	0	0	0	0.0%	-	-

Fish Sex

There was no significant difference ($p > 0.05$; chi-square) in the sex ratio of the marked and unmarked spawning ground recoveries (Table 10). The application sample, therefore, was not significantly biased. There was a significant difference ($p < 0.05$; chi-square) in the sex ratio of the recovered and non-recovered components of the application sample (Table 10) indicating that the recovery sample was biased to females. In addition, there were significant differences noted among the recovery rates of males (8.6%), females (13.8%), and jacks (1.3%) ($p < 0.05$; chi-square) (Table 1).

Table 10. Sex composition of Harrison River chinook salmon in the spaghetti tag application and spawning ground recovery samples, 1996.[a]

	Application sample [b]			Recovery sample [c]		
Sex	Sample size	Recovered	Not recovered	Sample size	Marked	Unmarke
Male	641	37.2%	33.6%	1675	37.2%	35.0
Female	616	57.4%	30.4%	2,533	57.4%	53.0
Jack	637	5.4%	36.0%	561	5.4%	12.0

a. Excludes 12 fish recaptured and released more than four times during application period.
b. Excludes 12 fish of unknown sex at recovery
c. Excludes 147 fish of unknown sex at recovery

Recovery Method

Bias in mark recovery resulting from method of recovery was assessed by comparing the mark incidence in the deep water and shallow water recovery areas (Table 11). There was no apparent significant difference between the incidence of marks in the shallow and deep samples in any of the sex groups. The low mark incidence (0.1%) in the carcasses recovered from unknown water depth is the result of a selective sampling procedure Only marked fish and those fish sampled for length, sex, age and other factors (24.9%) had the depth of recovery reported.

Table 11. Incidence of spaghetti tags and secondary marks in chinook salmon carcasses, by depth of water in the recovery area, recovered on the Harrison River spawning grounds, 1996.

		Depth of water		
		Shallow [a]	Deep	Unknown
Recovered with spaghetti tags or secondary marks	Male	42	13	1
	Female	68	16	1
	Unknown sex	3	1	8
	Jack	6	1	2
Carcasses recovered	Male	311	77	1288
	Female	563	101	1869
	Unknown sex	10	2	135
	Jack	131	28	403
Mark Incidence	Male	13.5%	16.9%	0.1%
	Female	12.1%	15.8%	0.1%
	Unknown sex	30.0%	50.0%	5.9%
	Jack	4.6%	3.6%	0.5%

[a] Excludes 5 females recaptured more than four times during application period.

To assess size bias resulting from different recovery methods the POH length frequency distributions of carcasses from the deep and shallow water recovery methods were compared. No signficant differences were noted in any of the sexes ($p > 0.05$, Kolmogorov-Smirnov two sample test) (Table 12).

Table 12. Length frequency distribution in the Harrison River chinook carcass sample recovered in shallow and deep water areas of the spawning grounds, by 10 cm increments of post-orbital-hypural length and sex, 1996.

POH	Shallow water carcasses			Deep water carcasses		
length (cm)	Male	Female	Jack	Male	Female	Jack
20-29.9	0	0	1	0	0	0
30-39.9	0	0	39	0	0	3
40-49.9	1	0	74	0	0	12
50-59.9	28	15	6	5	1	0
60-69.9	92	217	0	21	25	0
70-79.9	108	224	0	19	27	0
80-89.9	31	30	0	5	6	0
90-99.9	0	0	0	0	0	0

Spawning Success

Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 98.0% (Appendix 7). The spawning success of marked (98.2%) and unmarked (98.0%) females was not significantly different ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

While serious spatial and temporal biases were not identified in this study, there were significant sex related biases identified (Table 13; see Discussion). Therefore it was necessary to calculate the escapement by sex.

Table 13. Results of the statistical tests for bias in the 1996 Harrison River chinook salmon escapement estimation study.[a]

Bias type	Application sample	Recovery sample
Statistical [b]	n/a	No bias
Period	No bias	No bias
Location	No bias	No bias
Fish size	Bias to smaller males	No bias
Fish sex	No bias	Bias toward females and away from jacks
Recovery method	n/a	Bias away from jacks

a. No bias indicates that bias was not detected; undetected bias may be present.

b. Bias present when recoveries total 4 or less.

The 1996 escapement of Harrison River chinook salmon, calculated as the sum of the Petersen estimators for each sex, was estimated at 77,234 (Table 14), with lower and upper 95% confidence limits of 51,973 and 102,495. The adult male and female escapement was estimated to total 37,394 ± 6,176 while the estimated jack population was 39,840 ± 24,495. Based on the age composition of the aged portion of the recovery sample, the escapement contained 39,840 age 2_1 jacks, and 12,979 age 3_1, 23,268 age 4_1, and 1,147 age 5_1 chinook adults. Based on the pooled AFC incidence (1.0%) in the recovery sample, adjusted for the CWT loss in carcasses with questionable AFCs (Appendices 5 and 6), the 1996 escapement estimate included 373 AFC adults and 398 AFC jacks. Escapement by CWT code was not estimated because sample size was insufficient to warrant stratification of the AFC sample by age and sex.

Table 14. Annual escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook salmon, 1984-1996.[a]

		Escapement at Age								95% confidence limit on total escapement	
Sex	Year	2/1	3/1	4/1	4/2	5/1	5/2	6/1	Total	Lower	Upper
Male	1984	n/a	38,688	30,764	0	2,797	0	0	72,249	55,457	89,042
	1985	n/a	47,771	59,236	0	7,643	0	0	114,650	78,343	150,957
	1986	n/a	4,907	76,407	0	3,505	0	0	84,819	64,336	105,302
	1987	n/a	10,910	24,374	0	5,803	0	0	41,088	33,166	49,011
	1988	n/a	1,828	14,473	0	1,524	0	0	17,825	13,533	22,117
	1989	n/a	34,566	11,522	0	4,389	0	0	50,478	36,652	64,304
	1990	n/a	3,832	98,361	0	2,555	0	0	104,748	72,116	137,380
	1991	n/a	21,761	17,921	0	8,320	0	0	48,002	33,818	62,186
	1992	n/a	25,820	50,164	0	1,107	0	0	77,090	58,585	95,595
	1993	n/a	26,693	21,354	0	3,003	0	0	51,050	39,372	62,727
	1994	n/a	2,965	49,740	0	2,306	0	329	55,340	41,683	68,997
	1995	n/a	7,093	5,320	0	3,842	0	0	16,255 [b]	n/a	n/a
	1996	n/a	9,283	9,283	0	648	0	0	19,214	14,310	24,118
Female	1984	0	11,062	32,754	0	4,772	0	0	48,588	37,881	59,296
	1985	0	12,248	43,426	557	3,897	0	0	60,128	46,951	73,304
	1986	0	759	73,224	0	3,794	0	0	77,777	65,683	89,872
	1987	0	782	26,115	0	11,052	0	0	37,950	33,560	42,341
	1988	0	418	14,990	70	1,743	0	70	17,291	14,222	20,361
	1989	0	13,364	7,565	252	3,026	0	0	24,207	16,638	32,907
	1990	0	1,391	69,844	0	1,391	0	0	72,627	60,273	84,981
	1991	0	8,066	23,046	0	11,523	0	0	42,636	28,641	56,631
	1992	0	4,963	46,165	0	2,193	0	0	53,321	43,041	63,601
	1993	0	18,552	44,033	224	5,141	0	0	67,949	55,024	80,873
	1994	0	765	40,997	0	956	96	191	43,004	37,101	48,907
	1995	0	3,153	5,676	0	3,532	0	0	12,361	5,677	19,045
	1996	0	3,696	13,985	0	499	0	0	18,180	14,425	21,935
Adult Total	1984	n/a	49,751	63,518	0	7,569	0	0	120,837	100,921	140,752
	1985	n/a	60,019	102,662	557	11,541	0	0	174,778	136,153	213,402
	1986	n/a	5,666	149,631	0	7,299	0	0	162,596	138,811	186,385
	1987	n/a	11,693	50,489	0	16,856	0	0	79,038	69,981	88,096
	1988	n/a	2,247	29,463	70	3,267	0	70	35,116	29,839	40,392
	1989	n/a	47,931	19,087	252	7,415	0	0	74,685	58,737	90,663
	1990	n/a	5,224	168,205	0	3,946	0	0	177,375	142,483	212,268
	1991	n/a	29,827	40,967	0	19,844	0	0	90,638	70,712	110,564
	1992	n/a	30,782	96,329	0	3,299	0	0	130,411	109,242	151,580
	1993	n/a	45,244	65,387	224	8,144	0	0	118,998	101,580	136,417
	1994	n/a	3,729	90,738	0	3,261	96	521	98,344	83,466	113,223
	1995	n/a	10,246	10,996	0	7,374	0	0	28,616	n/a	n/a
	1996	n/a	12,979	23,268	0	1,147	0	0	37,394	31,218	43,571
Jacks	1996	39,840	0	0	0	0	0	0	39,840	15,345	64,334

a. Rounding errors may be present.

b. Derived by application of average male:female ratio to female estimate (Farwell et al. 1998).

DISCUSSION

SAMPLING SELECTIVITY

Population estimates derived from mark-recapture studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce emigration of tagged fish from the population, affect subsequent behaviour, or alter recapture vulnerability; and non-representative tag application or recovery resulting from samples which are too small, or are selective by fish size, sex, or spatial and temporal run component.

Tag loss was anticipated and accounted for by applying a secondary mark to all spaghetti tagged fish. Physiological stress during marking was minimised by using a low stress handling technique described by Staley (1990); however, this method still results in stress on the fish. The cumulative effect of this stress was evident in those fish which underwent multiple recapture episodes. There was a significantly high mark recovery rate in females which were recaptured more than four times and those fish were removed from subsequent data analyses. Males, with a behavioural tendency to roam further than females (Faulkner, 1993) showed significantly lower incidences of recapture and no significant indication of influence on subsequent mark recovery. In 1996, stress induced emigration, as indicated by observing the recaptures of spaghetti tagged fish during subsequent tagging efforts, was low. The only direct evidence of emigration was two marked chinook recovered in a native fishery on the mainstem of the Fraser River. We conclude that emigration of marked fish may have occurred but we have no evidence to indicate that the rate of emigration of marked fish was different than that of unmarked fish.

To evaluate the effect of handling stress on subsequent spawning behaviour, we compared spawning success in spaghetti tagged and untagged females. No significant difference was noted. These results are consistent with those in past studies (Farwell *et al.* 1991, 1992, 1996, 1998; Schubert *et al.* 1993, 1994). We concluded, therefore, that capture and marking did not significantly influence subsequent behaviour and that the assumption concerning recapture vulnerability was not seriously violated.

It was not possible to definitively test the representativeness of the application and recovery samples because the true population parameters were not known. Instead, we examined the two samples for five biases: statistical, temporal, spatial, fish size and fish sex, as indicators of weakness in the study (Table 13).

A bias indicating a tendency to marking smaller males was noted in the application sample. This bias was not observed when adult and precocious males were grouped. We conclude that a portion of this apparent bias results from the overlapping sizes of these two classes of males. Increased accuracy of identification of jacks may remove this source of bias in future projects. A significant bias to females was identified in the recovery sample, necessitating the calculation of escapement estimates by sex. An additional bias noted in the recovery sample was a bias away from precocious males. This bias occurred in both the shallow and deep water recovery areas. A portion of this bias may be an artifact of the overlapping sizes of adult and precocious males; however, we suggest that field methods may be contributing significantly to this bias. During the chinook carcass recovery period, the Harrison River has abundant carcasses of other species which are of a size range similar to precocious male chinook. To remove this anti-jack bias field methods may have to be altered. Without evidence of significant bias occurring in both samples, we concluded that the 1996 adult escapement estimate was unlikely to be biased. The biases associated with jacks may be significant and the 1996 jack escapement estimate may be biased. Theft of most of the scale samples from the recovery sample may have introduced a bias in the age composition of the escapement; however, evidence of such a bias was not detected. Analyses of past year's age composition patterns within the recovery period may help in assessing this potential source of bias.

SUMMARY

1. The Harrison River chinook stock is one of a group of British Columbia chinook stocks being monitored to evaluate escapement responses to management actions implemented under the Pacific Salmon Treaty.

2. Spawners were enumerated by a mark-recapture study from October 15 to December 6, 1996. Chinook adults and precocious males were captured using a beach seine and marked with spaghetti tags and opercular punches. The escapement was censused by the recovery of carcasses following spawning.

3. The 1996 chinook escapement was estimated from a spaghetti tag application sample of 1,257 adults and 637 jacks, a recovery sample of 4,355 adults and 561 jacks, and a recovery of 152 adult and 8 jack carcasses with spaghetti tags or secondary marks. The escapement estimate was 37,394 adults and 39,840 jacks. This is the first year jack chinook were included in the project.

4. All scale samples collected prior to November 27 were stolen and not available for age analysis. Within the remaining samples, the dominant age class was age 4_1 (76.9%) in the females while age 3_1 and 4_1 fish were equally represented (48.3% each) in males. POH length over the complete recovery period averaged 69.1 cm for males and 69.8 cm for females and 40.8 cm for jacks. A bias related to the missing scales was not detected.

5. A size related bias within the males was identified in the application sample. A sex bias was detected in the recovery sample. In addition, a size related bias was present in the recovery method data. The basic assumptions underlying the Petersen mark-recapture technique were not seriously violated and the adult estimates are not significantly biased. The overlapping sizes of adult and precocious males can lead to inaccuracy of identification of jack chinook. This along with the bias away from jacks in the recovery sample leads us to conclude that the jack estimate may be significantly biased.

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APPENDICES

Appendix 1. Daily application of spaghetti tags and secondary marks, by reach, adipose fin status, and sex to chinook salmon; and daily recaptures of previously marked chinook salmon, by sex, captured and released during subsequent mark application in the Harrison River, 1996. [a]

		Adipose present				Adipose absent				Total				Recaptures [g]			
Date	Reach	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total	Male	Female	Jack	Total
15-Oct	2	22	12	44	78	0	1	0	1	22	13	44	79	0	0	1	1
16-Oct	2	1	2	3	6	0	0	0	0	1	2	3	6	0	0	0	0
	3	1	1	8	10	0	0	0	0	1	1	8	10	0	0	0	0
17-Oct	2	9	25 [d]	25	59	0	0	0	0	9	25	25	59	0	0	0	0
18-Oct	2	0	1	3	4	0	0	0	0	0	1	3	4	0	0	0	0
	3	15	9	33	57	0	0	2	2	15	9	35	59	0	1	1	2
21-Oct	2	42	121 [c]	18	181	2	3	0	5	44	124	18	186	0	0	0	0
22-Oct	2	6	9 [d]	3	18	0	0	0	0	6	9	3	18	1	1	0	2
	3	43	30 [i]	34 [c]	107	3	1	1	5	46	31	35	112	2	3	0	5
24-Oct	3	72	60 [b,d,h]	68	200	2	1	1	4	74	61	69	204	21	42	14	77
25-Oct	2	0	0	4	4	0	0	0	0	0	0	4	4	0	1	0	1
	3	27 [d]	25	52 [d]	104	0	1	0	1	27	26	52	105	22	25	8	55
28-Oct	2	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0
	3	62	51 [j]	45 [k]	158	0	2	0	2	62	53	45	160	11	11	11	33
	4	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
29-Oct	3	34	20 [i]	28	82	2	0	1	3	36	20	29	85	17	16	4	37
30-Oct	3	63 [d]	54 [j]	52	169	2	0	1	3	65	54	53	172	18	34	8	60
31-Oct	3	26	26 [h]	42	94	5	0	1	6	31	26	43	100	11	21	6	38
	4	1	1	2	4	0	0	0	0	1	1	2	4	0	0	0	0
	6	1	1	3	5	0	0	0	0	1	1	3	5	0	0	1	1
01-Nov	2	4 [e]	11	1	16	0	0	0	0	4	11	1	16	1	1	0	2
	3	17	22	33	72	2	0	0	2	19	22	33	74	18	34	9	61
04-Nov	3	64 [k]	44	58	166	0	1	0	1	64	45	58	167	23	45	12	80
05-Nov	2	2	3	0	5	0	0	0	0	2	3	0	5	0	2	0	2
	3	31 [d]	30 [d]	22 [d]	83	3 [d]	1	1	5	34	31	23	88	18	26	11	55
12-Nov	3	58	46	40	144	0	1	0	1	58	47	40	145	11	9	1	21
15-Nov	3	16 [d]	11	7	34	0	0	0	0	16	11	7	34	6	18	1	25
18-Nov	3	2	1	0	3	0	0	0	0	2	1	0	3	0	1	0	1
Total	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	86	184	102	372	2	4	0	6	88	188	102	378	2	5	1	8
	3	531	430	522	1,483	19	8	8	35	550	438	530	1,518	179 [f]	287 [f]	86	552
	4	2	1	2	5	0	0	0	0	2	1	2	5	0	0	0	0
	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	6	1	1	3	5	0	0	0	0	1	1	3	5	0	0	1	1
	Total	620	616	629	1,865	21	12	8	41	641	628	637	1,906	181	292	88	561

a. Not corrected for sex identification errors.
b. Includes 2 for which secondary mark was not recorded.
c. Includes 1 which required ventilation at release.
d. Includes 1 for which release condition was not recorded
e. Includes 1 for which nose-fork length was not recorded
f. Includes 1 for which recapture date was unknown.
g. Includes multiple recaptures of individual fish
h. Includes 1 female recaptured more than four times
i. Includes 2 females recaptured more than four times
j. Includes 3 females recaptured more than four times
k. Excludes 1 fish recovered in mainstem Fraser River Native fishery.

Appendix 2a. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults not recaptured during tag application and recovered in the Harrison River, 1996.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
15-Oct	2	86.0	F	P	279	05-Nov	8	69.5	F	-	21
15-Oct	2	77.0	M	P	409	-	-	-	-	-	-
15-Oct	2	86.0	F	P	412	15-Nov	4	68.0	F	-	31
15-Oct	2	70.0	M	P	414	26-Nov	6	56.0	M	-	42
16-Oct	2	98.5	F	P	461	26-Nov	7	76.0	F	-	41
17-Oct	2	78.0	F	P	476	26-Nov	7	63.5	F	4/1	40
17-Oct	2	80.0	F	P	481	07-Nov	6	65.5	F	-	21
17-Oct	2	49.0	J	P	491	06-Nov	6	39.0	J	-	20
17-Oct	2	80.0	F	P	497	14-Nov	7	64.0	F	-	28
17-Oct	2	40.0	J	P	512	06-Nov	6	33.0	J	-	20
18-Oct	3	83.0	M	P	582	04-Nov	8	65.0	M	-	17
18-Oct	3	85.5	F	P	588	25-Oct	4	70.0	F	-	7
18-Oct	3	48.0	J	P	594	06-Nov	7	38.0	J	-	19
21-Oct	2	90.0	F	P	601	05-Nov	6	71.0	F	-	15
21-Oct	2	94.0	F	P	651	07-Nov	6	75.0	F	-	17
21-Oct	2	99.0	F	P	659	08-Nov	6	80.0	F	-	18
21-Oct	2	81.5	F	P	685	-	-	-	-	-	-
21-Oct	2	83.0	F	P	693	15-Nov	4	66.5	F	-	25
21-Oct	2	86.5	F	P	696	07-Nov	6	70.0	F	-	17
21-Oct	2	85.0	F	P	699	05-Nov	3	69.0	F	-	15
21-Oct	2	77.0	F	P	714	06-Nov	7	63.0	F	-	16
21-Oct	2	72.0	M	P	715	07-Nov	7	57.0	M	-	17
21-Oct	2	104.0	M	P	745	07-Nov	6	81.0	M	-	17
21-Oct	2	92.0	F	P	760	06-Nov	6	73.0	F	-	16
21-Oct	2	82.0	F	P	762	02-Dec	5	64.5	F	-	42
21-Oct	2	79.0	F	P	765	15-Nov	6	65.5	F	-	25
21-Oct	2	74.0	F	P	769	07-Nov	6	61.5	F	-	17
21-Oct	2	87.0	F	P	782	13-Nov	2	69.0	F	-	23
22-Oct	2	92.0	F	P	794	08-Nov	6	72.5	F	-	17
22-Oct	3	104.5	F	P	821	29-Oct	4	83.5	F	-	7
22-Oct	3	78.5	M	P	824	24-Oct	6	61.0	M	-	2
22-Oct	3	91.5	F	P	825	15-Nov	4	-	-	-	24
22-Oct	3	90.0	F	P	861	06-Nov	6	68.0	F	-	15
22-Oct	3	85.0	M	P	862	29-Oct	4	66.0	M	-	7
22-Oct	3	78.0	F	P	863	05-Nov	8	62.5	F	-	14
22-Oct	3	92.0	F	P	866	-	-	-	-	-	-
22-Oct	3	78.0	M	P	871	07-Nov	6	-	-	-	16
22-Oct	3	54.0	J	P	914	08-Nov	6	43.5	J	-	17
24-Oct	3	80.0	F	P	931	07-Nov	6	66.0	F	-	14
24-Oct	3	87.0	F	P	935	07-Nov	6	72.5	F	-	14
24-Oct	3	89.5	F	P	1000	06-Nov	7	73.0	F	-	13
24-Oct	3	76.0	F	P	1010	07-Nov	6	63.5	F	-	14
24-Oct	3	88.0	M	P	1023	14-Nov	6	70.5	M	-	21
24-Oct	3	98.0	F	P	1071	06-Nov	6	79.5	F	-	13
24-Oct	3	94.0	F	P	1072	20-Nov	8	76.0	F	-	27
24-Oct	3	98.0	F	P	1073	05-Nov	7	80.0	F	-	12
24-Oct	3	90.5	M	P	1079	07-Nov	6	74.0	M	-	14
24-Oct	3	84.0	F	P	1091	08-Nov	4	66.5	F	-	15
24-Oct	3	79.0	M	P	1103	05-Nov	8	62.0	M	-	12

Appendix 2a. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults not recaptured during tag application and recovered in the Harrison River, 1996.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
25-Oct	3	77.5	F	A	1128	02-Dec	5	63.0	F	3/1	38
25-Oct	3	91.5	F	P	1177	06-Nov	7	75.5	F	-	12
28-Oct	3	79.0	F	A	1269	13-Nov	8	63.0	F	-	16
28-Oct	3	79.5	F	P	1288	06-Nov	6	66.0	F	-	9
28-Oct	3	94.0	F	P	1302	04-Nov	3	69.0	F	-	7
28-Oct	3	78.0	F	P	1311	06-Nov	6	67.0	F	-	9
28-Oct	3	81.0	F	P	1332	07-Nov	6	67.0	F	-	10
28-Oct	3	77.0	F	P	1344	26-Nov	8	63.5	F	-	29
28-Oct	3	96.0	F	P	1349	22-Nov	6	75.5	F	-	25
28-Oct	3	82.0	F	P	1365	05-Nov	6	66.0	F	-	8
28-Oct	3	51.0	J	P	1371	06-Nov	6	41.0	J	-	9
29-Oct	3	81.0	F	P	1401	29-Nov	4	64.0	F	-	31
29-Oct	3	87.0	F	P	1407	21-Nov	4	71.5	F	-	23
29-Oct	3	84.0	M	A	1417	25-Nov	8	67.0	M	-	27
29-Oct	3	81.0	M	P	1429	13-Nov	8	65.5	M	-	15
29-Oct	3	91.0	M	P	1452	07-Nov	6	71.5	M	-	9
29-Oct	3	96.0	F	P	1461	13-Nov	8	75.0	F	-	15
29-Oct	3	49.0	J	P	1478	25-Nov	8	39.0	J	-	27
30-Oct	3	88.0	F	P	1504	-	-	-	-	-	-
30-Oct	3	76.5	F	P	1512	14-Nov	7	64.0	F	-	15
30-Oct	3	80.0	F	P	1514	13-Nov	8	62.5	F	-	14
30-Oct	3	82.0	F	P	1520	20-Nov	7	68.0	F	-	21
30-Oct	3	96.5	M	P	1527	18-Nov	8	77.0	M	-	19
30-Oct	3	85.0	M	P	1541	20-Nov	8	66.0	M	-	21
30-Oct	3	76.5	M	P	1603	20-Nov	6	61.5	M	-	21
31-Oct	3	82.5	F	P	1670	-	-	-	-	-	-
31-Oct	3	81.5	M	P	1693	05-Nov	8	64.0	M	-	5
31-Oct	3	78.0	M	P	1703	25-Nov	8	-	-	-	25
01-Nov	3	79.5	F	P	1767	25-Nov	8	65.0	F	-	24
01-Nov	3	83.5	F	P	1818	08-Nov	6	69.0	F	-	7
01-Nov	2	92.0	F	P	1844	13-Nov	8	73.5	F	-	12
01-Nov	2	86.0	M	P	1855	13-Nov	8	66.0	M	-	12
04-Nov	3	85.0	F	P	1898	15-Nov	4	70.5	F	-	11
04-Nov	3	94.0	F	P	1903	14-Nov	6	76.0	F	-	10
04-Nov	3	85.5	M	P	1934	27-Nov	7	67.0	M	-	23
04-Nov	3	83.0	M	P	1977	13-Nov	7	67.0	M	-	9
04-Nov	3	73.0	M	P	2001	26-Nov	7	59.0	M	-	22
05-Nov	3	86.5	F	P	2038	15-Nov	4	71.0	F	-	10
05-Nov	3	94.5	F	P	2061	26-Nov	8	78.0	F	-	21
05-Nov	3	86.0	M	P	2073	26-Nov	7	67.5	M	-	21
05-Nov	3	75.0	M	P	2091	19-Nov	7	59.5	M	-	14
05-Nov	3	76.0	F	P	2107	07-Nov	6	63.0	F	-	2
12-Nov	3	97.0	M	P	2145	15-Nov	6	76.0	M	-	3
12-Nov	3	87.0	F	P	2161	26-Nov	8	72.0	F	-	14
12-Nov	3	92.0	M	P	2187	-	-	-	-	-	-
12-Nov	3	94.0	M	P	2202	27-Nov	7	76.0	M	4/1	15
12-Nov	3	36.0	J	P	2230	-	-	-	-	-	-
12-Nov	3	86.0	F	P	2260	18-Nov	7	73.0	F	-	6
12-Nov	3	79.0	M	P	2265	27-Nov	7	63.0	M	3/1	15

Appendix 2a. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults not recaptured during tag application and recovered in the Harrison River, 1996.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
15-Nov	3	76.0	F	P	2284	02-Dec	5	-	F	-	17
15-Nov	3	90.0	M	P	2296	22-Nov	4	74.5	M	-	7
15-Nov	3	93.0	F	P	2319	03-Dec	8	80.0	F	4/1	18
	Primary tag lost; application data unknown					04-Nov	3	78.0	M	-	-
	Primary tag lost; application data unknown					06-Nov	8	71.0	M	-	-
	Primary tag lost; application data unknown					07-Nov	7	59.0	M	-	-
	Primary tag lost; application data unknown					07-Nov	7	-	J	-	-
	Primary tag lost; application data unknown					07-Nov	6	67.0	M	-	-
	Primary tag lost; application data unknown					07-Nov	6	80.0	F	-	-
	Primary tag lost; application data unknown					07-Nov	6	68.0	M	-	-
	Primary tag lost; application data unknown					07-Nov	7	67.0	M	-	-
	Primary tag lost; application data unknown					14-Nov	7	-	F	-	-
	Primary tag lost; application data unknown					15-Nov	6	68.5	M	-	-
	Primary tag lost; application data unknown					18-Nov	8	63.5	M	-	-
	Primary tag lost; application data unknown					18-Nov	8	75.5	M	-	-
	Primary tag lost; application data unknown					18-Nov	8	69.5	M	-	-
	Primary tag lost; application data unknown					21-Nov	4	80.5	M	-	-
	Primary tag lost; application data unknown					21-Nov	5	67.0	M	-	-
	Primary tag lost; application data unknown					22-Nov	4	76.5	M	-	-
	Primary tag lost; application data unknown					25-Nov	8	70.0	M	-	-
	Primary tag lost; application data unknown					25-Nov	8	66.0	M	-	-
	Primary tag lost; application data unknown					25-Nov	8	65.5	M	-	-
	Primary tag lost; application data unknown					26-Nov	6	71.5	M	-	-
	Primary tag lost; application data unknown					26-Nov	6	56.0	M	-	-
	Primary tag lost; application data unknown					26-Nov	7	72.5	M	-	-
	Primary tag lost; application data unknown					26-Nov	8	60.0	M	-	-
	Primary tag lost; application data unknown					27-Nov	7	76.0	M	-	-
	Primary tag lost; application data unknown					29-Nov	4	72.0	F	-	-
	Primary tag lost; application data unknown					29-Nov	5	66.5	M	-	-
	Primary tag lost; application data unknown					29-Nov	5	42.0	J	-	-

Females initially identified as males:	0	0.0%	Mean days out:	17.3
Males initially identified as females:	0	0.0%	Max. days out:	42.0
Jacks initially identifed as male:	0	0.0%	Min. days out:	2.0

POH and NF Regressions:			
	Females	POH =	0.71 NF + 8.55, (r^2 = 0.96)
		NF =	1.25 POH - 0.73
	Males	POH =	0.78 NF + 0.94, (r^2 = 0.96)
		NF =	1.23 POH + 1.97
	Jacks	POH =	0.74 NF + 2.93, (r^2 = 0.98)
		NF =	1.33 POH - 3.16

Appendix 2b. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recaptured during tag application and recovered in the Harrison River, 1996.

Application sample							Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Number of times recaptured and released	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
18-Oct	3	89.0	M	P	2	586	08-Nov	6	66.5	M	-	21
22-Oct	2	86.5	F	P	1	797	05-Nov	8	70.5	F	-	14
22-Oct	3	78.0	F	P	4	830	06-Nov	6	62.0	F	-	15
22-Oct	3	85.5	F	P	6	864	30-Oct	5	69.0	F	-	8
22-Oct	3	72.0	M	P	1	872	08-Nov	6	56.0	M	-	17
22-Oct	3	95.0	F	P	5	896	07-Nov	6	79.0	F	-	16
24-Oct	3	84.0	M	P	1	918	20-Nov	8	65.0	-	-	27
24-Oct	3	90.5	F	P	3	919	07-Nov	7	73.5	F	-	14
24-Oct	3	93.0	F	P	3	923	29-Oct	4	78.0	F	-	5
24-Oct	3	99.0	F	P	2	932	07-Nov	7	81.0	F	-	14
24-Oct	3	84.0	F	P	1	953	06-Nov	6	66.0	F	-	13
24-Oct	3	75.0	M	P	1	1015	20-Nov	8	56.5	M	-	27
24-Oct	3	90.5	M	P	1	1100	05-Nov	6	71.0	M	-	12
28-Oct	3	89.0	M	P	1	1233	07-Nov	6	70.0	M	-	10
28-Oct	3	96.0	M	P	2	1281	22-Nov	7	75.0	M	-	25
28-Oct	3	85.5	F	P	3	1306	06-Nov	6	71.0	F	-	9
28-Oct	3	89.0	F	P	5	1338	07-Nov	6	71.5	F	-	10
28-Oct	3	88.0	F	P	1	1361	08-Nov	4	71.5	F	-	11
29-Oct	3	93.0	F	P	5	1403	04-Nov	3	65.0	F	-	6
29-Oct	3	100.0	F	P	2	1408	08-Nov	6	84.0	F	-	10
30-Oct	3	84.0	F	P	1	1495	22-Nov	6	67.5	F	-	23
30-Oct	3	91.0	F	P	4	1497	20-Nov	6	74.5	F	-	21
30-Oct	3	89.0	F	P	2	1525	06-Nov	6	72.5	F	-	7
30-Oct	3	92.0	F	P	1	1539	27-Nov	7	72.0	F	5/1	28
30-Oct	3	94.5	F	P	5	1600	08-Nov	4	74.5	F	-	9
30-Oct	3	86.0	F	P	2	1633	07-Nov	6	70.5	F	-	8
31-Oct	3	105.0	F	P	1	1674	08-Nov	4	84.5	F	-	8
31-Oct	3	85.0	F	P	1	1695	08-Nov	4	72.0	F	-	8
01-Nov	2	76.0	F	P	1	1849	13-Nov	8	62.0	F	-	12
04-Nov	3	98.0	M	P	1	1886	26-Nov	8	78.0	M	-	22
04-Nov	3	81.0	F	P	1	1930	14-Nov	7	65.0	F	-	10
04-Nov	3	86.5	F	P	1	1989	14-Nov	7	71.0	F	-	10
12-Nov	3	81.0	M	P	1	2167	-	-	-	-	-	-
12-Nov	3	90.0	F	P	1	2237	20-Nov	6	75.0	F	-	8
12-Nov	3	91.0	F	P	1	2244	27-Nov	7	78.0	F	-	15
12-Nov	3	79.0	F	P	1	2252	29-Nov	4	66.0	F	3/1	17
12-Nov	3	81.0	F	P	1	2261	20-Nov	6	66.5	F	-	8

Females initially identified as males:	0	0.0%	Mean days out:	13.8
Males initially identified as females:	0	0.0%	Max. days out:	28.0
Jacks initially identified as male	0	0.0%	Min. days out:	5.0

POH and NF Regressions:

Females	POH =	0.80 NF + 1.34, (r^2 = 0.66)
	NF =	1.01 POH + 15.84
Males	POH =	0.85 NF - 6.47, (r^2 = 0.97)
	NF =	1.14 POH + 9.73

Appendix 3. Daily chinook salmon carcass recoveries, by reach, mark status and sex, in the Harrison River, 1996.

		Unmarked				spaghetti tag and secondary mark				Secondary mark only			spaghetti tag only				Total				Adipose fin absent		
Date	Reach	Male	Female	Unknown sex	Jack	Male	Female	Unknown sex	Jack	Male	Female	Jack	Male	Female	Unknown sex	Jack	Male	Female	Unknown sex	Jack	Male	Female	Jack
18-Oct	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
21-Oct	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
22-Oct	6	14	27	0	5	0	0	0	0	0	0	0	0	0	0	0	14	27	0	5	0	0	0
23-Oct	7	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	1	4	0	1	0	0	0
23-Oct	8	4	2	0	3	0	0	0	0	0	0	0	0	0	0	0	4	2	0	3	0	0	0
24-Oct	6	14	29	0	5	0	0	0	0	0	0	0	1	0	0	0	15	29	0	5	1	0	0
24-Oct	7	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
25-Oct	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
25-Oct	4	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
25-Oct	6	21	33	1	7	0	0	0	0	0	0	0	0	0	0	0	21	33	1	7	0	0	1
29-Oct	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
29-Oct	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
29-Oct	3	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0
29-Oct	4	37	65	3	7	1	2	0	0	0	0	0	0	0	0	0	38	67	3	7	1	0	0
30-Oct	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
30-Oct	4	3	10	0	0	0	0	0	0	0	0	0	0	0	0	0	3	10	0	0	0	0	0
30-Oct	5	5	8	0	2	0	1 a	0	0	0	0	0	0	0	0	0	5	9	0	2	0	0	0
31-Oct	4	5	6	1	0	0	0	0	0	0	0	0	0	0	0	0	5	6	1	0	0	0	0
31-Oct	5	5	8	0	4	0	0	0	0	0	0	0	0	0	0	0	5	8	0	4	0	0	0
01-Nov	8	7	4	0	8	0	0	0	0	0	0	0	0	0	0	0	7	4	0	8	0	0	0
04-Nov	3	13	26	0	4	0	2 a	0	0	1	0	0	0	0	0	0	14	28	0	4	0	1	0
04-Nov	8	14	13	0	20	1	0	0	0	0	0	0	0	0	0	0	15	13	0	20	0	0	0
05-Nov	3	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0
05-Nov	6	33	50	0	18	1	2	0	0	0	0	0	0	0	0	0	34	52	0	18	0	0	0
05-Nov	7	19	10	1	19	0	1	0	0	0	0	0	0	0	0	0	19	11	1	19	0	0	1
05-Nov	8	50	16	2	47	2	2	0	0	0	0	0	0	1	0	0	52	19	2	47	0	0	0
06-Nov	6	84	145	0	39	0	9	0	3	0	0	0	0	0	0	0	84	154	0	42	1	0	0
06-Nov	7	44	54	1	33	0	3	0	1	0	0	0	0	0	0	0	44	57	1	34	0	1	0
06-Nov	8	4	6	0	12	0	0	0	0	1	0	0	0	0	0	0	5	6	0	12	0	0	0
07-Nov	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
07-Nov	6	182	245	51	45	4	11 b	0	0	2	1	0	0	1	1	0	188	258	52	45	0	1	0
07-Nov	7	37	26	1	27	1	2	0	0	2	0	1	0	0	0	0	40	28	1	28	0	0	0
08-Nov	4	92	154	2	30	0	5 a	0	0	0	0	0	0	0	0	0	92	159	2	30	1	0	0
08-Nov	6	33	86	6	14	2	4	0	1	0	0	0	0	0	0	0	35	90	6	15	0	0	0
12-Nov	3	15	30	0	0	0	0	0	0	0	0	0	0	0	0	0	15	30	0	0	0	0	0
13-Nov	2	5	9	4	0	0	1	0	0	0	0	0	0	0	0	0	5	10	4	0	0	0	0
13-Nov	3	8	10	0	2	0	0	0	0	0	0	0	0	0	0	0	8	10	0	2	0	0	0
13-Nov	5	6	12	4	0	0	0	0	0	0	0	0	0	0	0	0	6	12	4	0	0	0	0
13-Nov	7	12	6	0	1	1	0	0	0	0	0	0	0	0	0	0	13	6	0	1	0	0	0
13-Nov	8	47	54	1	15	2	5	0	0	0	0	0	0	0	0	0	49	59	1	15	1	5	0
14-Nov	6	55	94	0	6	1	1	0	0	0	0	0	0	0	0	0	56	95	0	6	1	1	0
14-Nov	7	74	84	2	26	0	4	0	0	0	1	0	0	0	0	0	74	89	2	26	1	1	0
15-Nov	4	19	86	1	1	0	3	1	0	0	0	0	0	1	0	0	19	90	2	1	0	0	0
15-Nov	6	50	94	2	15	1	0	0	0	1	0	0	0	1	0	0	52	95	2	15	3	0	1
18-Nov	7	16	21	0	7	0	1	0	0	0	0	0	0	0	0	0	16	22	0	7	0	1	0
18-Nov	8	43	30	1	22	1	0	0	0	3	0	0	0	0	0	0	47	30	1	22	2	2	0
19-Nov	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
19-Nov	7	19	12	0	2	1	0	0	0	0	0	0	0	0	0	0	20	12	0	2	0	0	1
20-Nov	4	2	9	0	2	0	0	0	0	0	0	0	0	0	0	0	2	9	0	2	0	0	0

Appendix 3. Daily chinook salmon carcass recoveries, by reach, mark status and sex, in the Harrison River, 1996.

		Unmarked				spaghetti tag and secondary mark				Secondary mark only			spaghetti tag only				Total				Adipose fin absent		
Date	Reach	Male	Female	Unknown sex	Jack	Male	Female	Unknown sex	Jack	Male	Female	Jack	Male	Female	Unknown sex	Jack	Male	Female	Unknown sex	Jack	Male	Female	Jack
20-Nov	6	24	67	2	4	1	3	0	0	0	0	0	0	0	0	0	25	70	2	4	0	1	0
20-Nov	7	8	9	1	1	0	1	0	0	0	0	0	0	0	0	0	8	10	1	1	1	0	0
20-Nov	8	20	17	1	20	2	0	0	0	0	0	0	0	1	1	0	22	18	2	20	1	0	1
21-Nov	3	5	9	1	0	0	0	0	0	0	0	0	0	0	0	0	5	9	1	0	0	0	0
21-Nov	4	33	101	2	4	0	1	0	0	1	0	0	0	0	0	0	34	102	2	4	0	1	0
21-Nov	5	17	22	1	9	0	0	0	0	1	0	0	0	0	0	0	18	22	1	9	0	1	0
22-Nov	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0
22-Nov	4	11	28	0	2	1	0	0	0	1	0	0	0	0	0	0	13	28	0	2	0	1	0
22-Nov	6	7	11	1	1	0	1	0	0	0	0	0	0	1	0	0	7	13	1	1	0	0	1
22-Nov	7	10	8	0	0	1	0	0	0	0	0	0	0	0	0	0	11	8	0	0	0	0	0
22-Nov	8	17	23	1	13	0	0	0	0	0	0	0	0	0	0	0	17	23	1	13	0	0	0
25-Nov	8	51	41	4	16	1	1	0	1	3	0	0	0	0	1	0	55	42	5	17	4	1	0
26-Nov	6	54	69	12	7	1	0	0	0	2	0	0	0	0	0	0	57	69	12	7	0	1	0
26-Nov	7	22	45	2	2	2	2	0	0	1	0	0	0	0	0	0	25	47	2	2	0	0	0
26-Nov	8	43	40	0	3	1	3	0	0	1	0	0	0	0	0	0	45	43	0	3	1	0	0
27-Nov	3	7	19	0	0	0	0	0	0	0	0	0	0	0	0	0	7	19	0	0	0	1	0
27-Nov	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
27-Nov	7	48	73	5	4	3	2	0	0	1	0	0	0	0	0	0	52	75	5	4	2	2	0
28-Nov	2	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0
28-Nov	3	6	21	0	0	0	0	0	0	0	0	0	0	0	0	0	6	21	0	0	0	0	0
28-Nov	4	3	19	0	2	0	0	0	0	0	0	0	0	0	0	0	3	19	0	2	0	0	0
28-Nov	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
29-Nov	4	37	89	9	5	0	2	0	0	0	1	0	0	0	0	0	37	92	9	5	0	0	0
29-Nov	5	17	37	2	4	0	0	0	0	1	0	1	0	0	0	0	18	37	2	5	0	2	0
02-Dec	5	13	30	3	0	0	3	0	0	0	0	0	0	0	0	0	13	33	3	0	0	1	0
02-Dec	6	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
03-Dec	7	11 e	7	0	2	0	0	0	0	0	0	0	0	0	0	0	11	7	0	2	1 d	0	0
03-Dec	8	26	20	0	0	0	1	0	0	0	0	0	0	0	0	0	26	21	0	0	0	0	0
04-Dec	4	4	14	1	1	0	0	0	0	0	0	0	0	0	0	0	4	14	1	1	0	0	0
05-Dec	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
05-Dec	5	6	10	0	0	0	0	0	0	0	0	0	0	0	0	0	6	10	0	0	0	0	0
05-Dec	6	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0
05-Dec	7	12	3	0	1	0	0	0	0	0	0	0	0	0	0	0	12	3	0	1	0	0	0
06-Dec	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
06-Dec	3	1	5	1	0	0	0	0	0	0	0	0	0	0	0	0	1	5	1	0	0	0	0
Total	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
	2	11	18	5	1	0	1	0	0	0	0	0	0	0	0	0	11	19	5	1	0	0	0
	3	58	132	2	7	0	3	0	0	1	0	0	0	0	0	0	59	135	2	7	0	2	0
	4	246	584	19	54	2	14	1	0	2	1	0	0	1	0	0	250	600	20	54	2	2	0
	5	69	129	10	19	0	4	0	0	2	0	1	0	0	0	0	71	133	10	20	0	4	0
	6	572	956	76	166	11	31	0	4	5	1	0	1	3	1	0	589	991	77	170	6	4	3
	7	338	362	13	126	9	16	0	1	4	1	1	0	0	0	0	351	379	13	128	5	5	2
	8	326	266	10	179	10	12	0	1	8	0	0	0	2	2	0	344	280	12	180	9	8	1
	Total	1,620	2,448	135	553	32	81	1	6	22	3	2	1	6	11 c	0	1,675	2,538	147	561	22	25	6

a. Includes 1 which was recaptured more than four times.

b. Includes 2 which were recaptured more than four times.

c. Includes 8 of unknown recovery date and reach.

d. Includes 1 with field identification as a jack.

Appendix 4. Percentage at age and mean length at age, by AFC status and sex, of chinook carcasses recovered on the Harrison River spawning grounds, 1996

		Female			Male			Jack		
Adipose fin status	Age a	size	Sample Percent	Mean POH length (cm)	size	Sample Percent	Mean POH length (cm)	size	Sample Percent	Mean POH length (cm)
Unmarked	5/1	3	1.8%	80.5	3	3.6%	81.8	0	0.0%	0.0
	4/1	135	79.9%	71.1	41	48.8%	74.6	0	0.0%	0.0
	3/1	31	18.3%	65.8	40	47.6%	62.4	0	0.0%	0.0
	2/1	0	0.0%	0.0	0	0.0%	0.0	12	100.0%	37.4
	Sub-1	169	100.0%	70.3	84	100.0%	69.0	12	100.0%	37.4
	Sub-2	0	0.0%	-	0	0.0%	-	0	0.0%	-
	Total	450	54.4%	70.0	254	30.7%	69.4	123	14.9%	40.6
	Flesh colour									
	Red	1	0.2%	55.5	1	0.4%	58.5	2	1.9%	45.5
	White	425	99.8%	70.1	241	99.6%	69.5	106	98.1%	40.8
Adipose fin clip	5/1	0	0.0%	0.0	0	0.0%	0.0	0	-	0.0
	4/1	1	25.0%	71.0	1	33.3%	73.5	0	-	0.0
	3/1	3	75.0%	62.2	2	66.7%	57.5 b	0	-	0.0
	2/1	0	0.0%	0.0	0	0.0%	0.0	0	-	0.0
	Sub-1	4	100.0%	64.4	3	100.0%	62.0	0	-	0.0
	Sub-2	0	0.0%	-	0	0.0%	-	0	-	-
	Total	24	52.2%	65.9	22	47.8%	65.3	6	13.0%	42.7
	Flesh colour									
	Red	0	0.0%	-	0	0.0%	-	0	0.0%	-
	White	24	100.0%	65.9	21	100.0%	65.2	6	100.0%	42.7
Total	5/1	5	2.7%	76.5	3	3.4%	81.8	0	0.0%	0.0
	4/1	140	76.9%	71.1	43	48.3%	74.7	0	0.0%	0.0
	3/1	37	20.3%	65.3	43	48.3%	62.2	0	0.0%	0.0
	2/1	0	0.0%	0.0	0	0.0%	0.0	14	100.0%	38.3
	Sub-1	182	100.0%	70.1	89	100.0%	68.9	14	100.0%	38.3
	Sub-2	0	0.0%	-	0	0.0%	-	0	0.0%	-
	Total	485	54.2%	69.8	278	31.1%	69.1	132	14.7%	40.8
	Flesh colour									
	Red	1	0.2%	55.5	1	0.4%	58.5	2	1.7%	45.5
	White	459	99.8%	69.8	263	99.6%	69.2	115	98.3%	41.0

a. Totals include unageable samples and samples of unknown adipose status or flesh colour but exclude carcasses with no POH length record.
b. Includes one carcass (49 cm POH length) identified in the field as a jack

Appendix 5. AFC and CWT sampling of chinook salmon recovered on the Harrison River spawning grounds, 1996

			Male	Female	Unknown sex	Jack	Total
Sample size			1,676	2,538	147	562	4,923
Number with AFCs			22	25	0	6	53
Questionable AFCs			0	3	0	0	3
AFC carcass without a head			0	1	0	0	1
CWT lost during processing			0	1	0	0	1
AFC carcass without a CWT			1	6	0	0	7
AFC carcass wtih questionable clip and without a CWT			0	2	0	0	2
CWTs recovered:							
Code	Brood	Release site					
18-02-13	1994	Stave River	0	0	0	2	2
18-08-42	1992	Chehalis Hatchery	0	2	0	0	2
18-08-43	1992	Chehalis Hatchery	3	2	0	0	5
18-08-44	1992	Chehalis Hatchery	1	2	0	0	3
18-12-31	1993	Chehalis Hatchery	6	3	0	0	9
18-12-32	1993	Chehalis Hatchery	6	3	0	0	9
18-12-33	1993	Chehalis Hatchery	5 b	5	0	0	10
18-19-45	1994	Chehalis Hatchery	0	0	0	2	2
18-19-46	1994	Chehalis Hatchery	0	0	0	2	2
Total			21	17	0	6	44
AFC incidence (%) a			1.3%	0.9%	0.0%	1.1%	1.0%
CWT loss (%) a			4.5%	19.0%	-	0.0%	10.2%
Spatial pattern in AFC incidence: a							
Upper Section (reaches 1,2)			0.0%	0.0%	0.0%	0.0%	0.0%
Middle Section (reaches 3,4,5)			0.5%	0.9%	0.0%	0.0%	0.8%
Lower Section (reaches 6,7,8)			1.5%	0.9%	0.0%	1.3%	1.1%
Temporal pattern in AFC incidence: a							
Early Period (18-Oct to 08-Nov)			0.5%	0.3%	0.0%	0.6%	0.4%
Middle Period (9-Nov to 22 Nov)			1.8%	1.3%	0.0%	2.6%	1.5%
Late Period (23-Nov to 06-Dec)			2.1%	1.4%	0.0%	0.0%	1.7%

a. Excludes carcasses with questionable AFCs (Appendix 6).

b. Includes one fish identified in the field as a jack

Appendix 6. Incidence of CWT loss, by carcass condition, eye status, and AFC condition, in AFC chinook salmon carcasses recovered on the Harrison River spawning grounds, 1996

Observation	Condition	Number a	CWT absent b	CWT loss (%)
Carcass condition	Fresh	9	0	0.0%
	Moderately fresh	18	4	22.2%
	Moderately rotten	22	2	9.1%
	Rotten	3	1	33.3%
Eyes present	None	24	3	12.5%
	One	11	2	18.2%
	Two	17	3	17.6%
Adipose fin clip c	Complete	38	4	10.5%
	Partial	5	2	40.0%
	Questionable	3	2	66.7%

a. Excludes 1 AFC carcass with head not recovered.
b. Includes one CWT lost during processing.
c. Excludes 6 AFC carcasses with clip condition not reported.

Appendix 7. Spawning success, by mark status, in female chinook carcasses recovered on the Harrison River spawning grounds, 1996.

Mark status		Percent spawned			
		0%	50%	100%	Weighted mean
Spaghetti tag or secondary mark	Number	1	1	82	
	Percent	1.2%	1.2%	97.6%	98.2%
Unmarked	Number	27	33	2096	
	Percent	1.3%	1.5%	97.2%	98.0%
Total	Number	28	34	2178	
	Percent	1.3%	1.5%	97.2%	98.0%