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Enumeration of the 1989 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 1989, the Harrison River chinook escapement was estimated, using the Petersen mark-recapture method, at 74,685 adults. The sex composition of the escapement was 32% female and 68% male. The age composition of the recovery sample was 1% age 2_1, 64% age 3_1, 24% age 4_1, 1% age 4_2, and 10% age 5_1.

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

RÉSUMÉ

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1990. Enumeration of the 1989 Harrison River chinook salmon escapement. Can. MS Rep. Fish. Aquat. Sci. 2078: 24p.

En 1985, le Traité concernant le saumon du Pacifique a donné comme mission au ministère des Pêches et des Océans du gouvernement canadien de mettre fin à la baisse du saumon quinnat (**Oncorhynchus tshawytscha**). Le stock de la rivière Harrison a été désigné comme stock indicateur de l'état du saumon quinnat et son échappée a fait l'objet d'une surveillance annuelle depuis 1984. En 1989, l'échappée du quinnat dans la rivière Harrison a été évaluée à 74 685 adultes, selon la méthode de marquage et de recapture de Petersen. La composition de la population selon le sexe a été évaluée comme suit: 32 % de femelles et 68% mâles. La composition par âge de l'échantillon de récupération était la suivante: 1% d'âge 2_1, 64% d'âge 3_1, 24% d'âge 4_1, 1% d'âge 4_2, et 10% d'âge 5_1.

Mots cles: Saumon quinnat, rivière Harrison, stock indicateur, échappée, Traité concernant 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 monitors a group of key stocks selected to represent all British Columbia chinook stocks. The status and response to management actions of these stocks is evaluated by measuring, with known precision, either annual trends in escapement (escapement indicator stocks) or in escapement and total harvest (exploitation rate indicator stocks).

Harrison River chinook was designated an escapement indicator stock in 1984 for two reasons. First, the stock comprised almost one-third of the Fraser River system chinook escapement in the 1970's (Farwell **et al.** 1987). The status of this stock, therefore, is an important measure of the status of the Fraser River chinook resource. Second, as a white-fleshed, fall spawning stock with juveniles which migrate to sea immediately following emergence (Fraser **et al.** 1982), Harrison River chinook are unique in the Fraser River system. Individual monitoring, therefore, was warranted.

A previous report documented the 1984-88 Harrison River chinook enumeration studies (Staley 1990). The current report documents the 1989 field methods, analytic techniques and study results. Included are estimates of adult age, length, sex, adipose fin clip (AFC) incidence, coded wire tag (CWT) recoveries and escapement. The report concludes with a discussion of data limitations and recommendations for future studies.

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 southwest for 16.5 km, entering the Fraser River 116 km upstream from the Strait of Georgia. The river has an annual mean daily discharge of 449 m^3/s, with monthly mean daily maximum (947 m^3/s) and minimum (202 m^3/s) flows 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), extending from Harrison Lake downstream to Norris Creek, is characterized by a wide, low gradient channel with a depth of up to 10 m and a sandy substrate.

Reach 2 (km 9.5 to 7.7), extending to Billy Harris Slough and Reach 5 on the northwest and southeast banks, respectively, is similar to Reach 1 except water depth ranges to 3.0 m and the substrate is gravel.

Reach 3 (km 7.7 to 7.1), extending to a shear boom on the northwest bank, is characterized by a gradient higher then Reach 2 and a substrate of cobble and large gravel.

Reach 4 (km 7.1 to 6.3) includes the main channel and several side channels separated from the northwest short by gravel bars. The main channel is similar to Reach 3, with smaller substrate in the side channels.

Reach 5 (km 7.7 to 6.3) is a

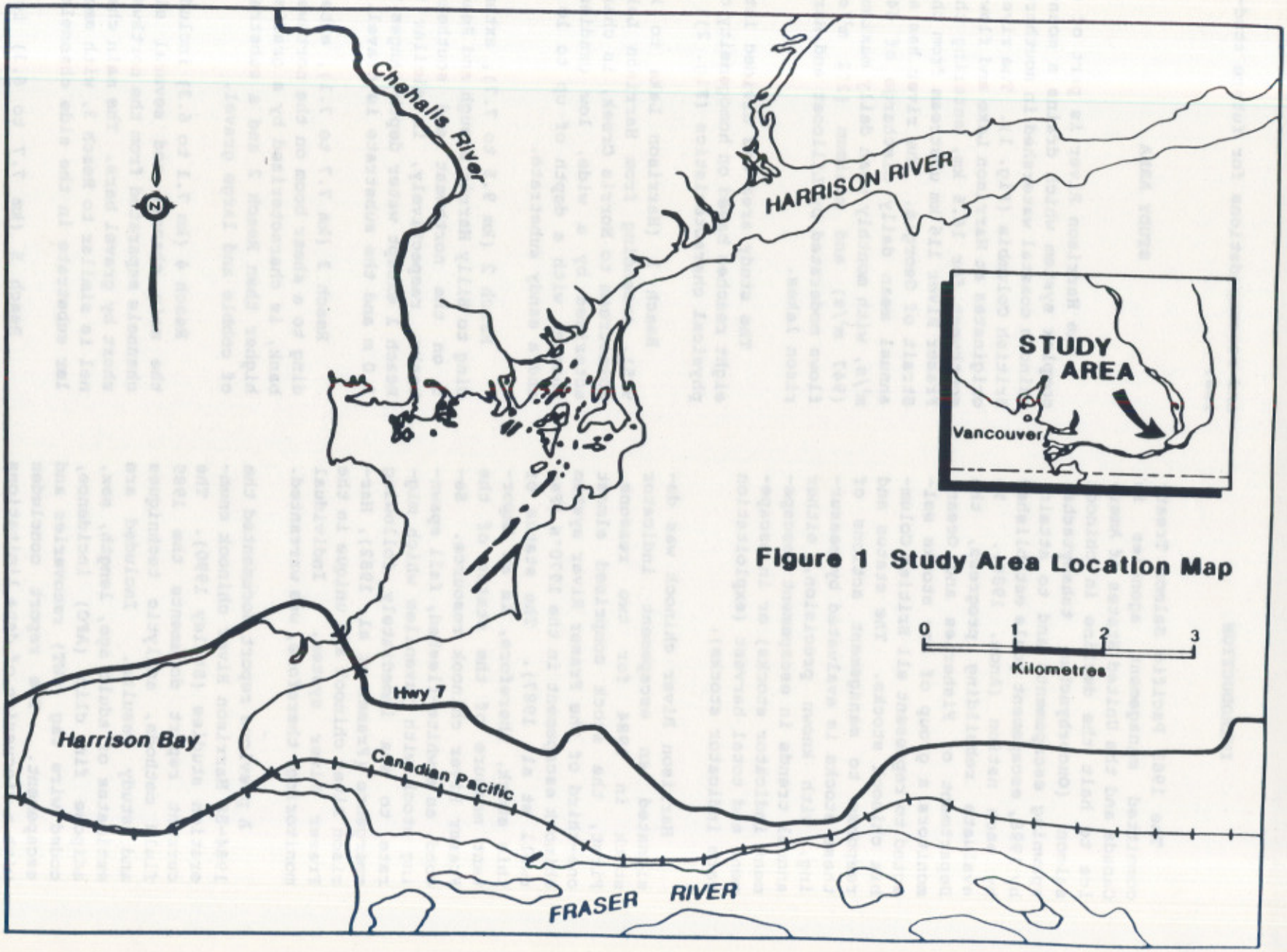

Figure 1 Study Area Location Map

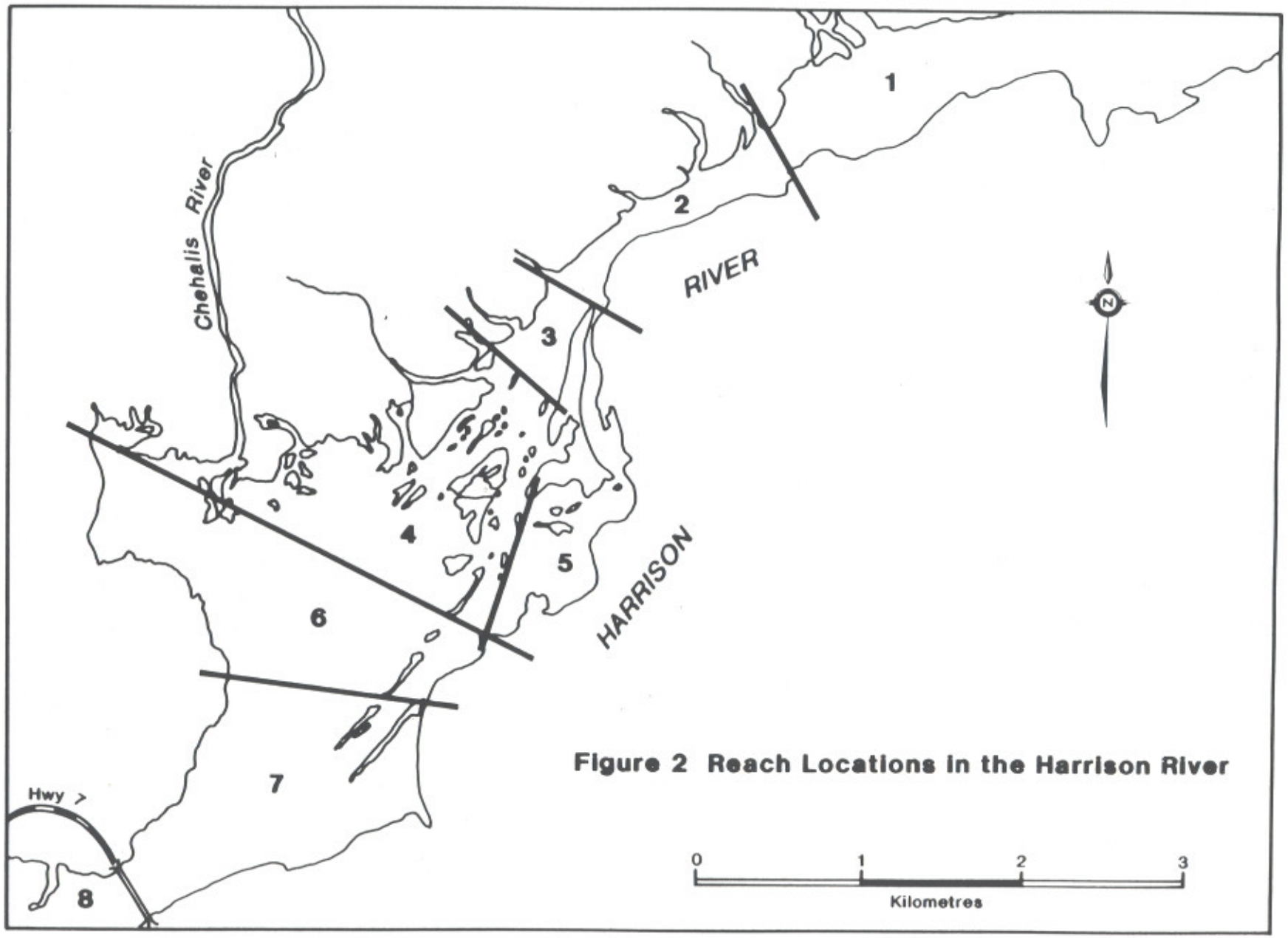

Figure 2 Reach Locations in the Harrison River

large side channel characterized by a low gradient, a depth of up to 1.5 m, and a sand substrate. An island at the midpoint further divides the reach into sections a and b.

Reach 6 (km 6.3 to 4.5), extending to a rock bluff on the southeast short (2 km upstream from the Highway 7 bridge), includes the main channel and part of the Chehalis River flood plain. The channel has a depth of up to 3 m and a substrate of bedrock and gravel.

Reach 7 (km 4.5 to 3.0), extending to the Highway 7 bridge, includes the main channel and part of the Chehalis River flood plain. The channel has a low gradient, a depth of up to 3 m and a mud substrate.

Reach 8 (km 3.0 to 0), which includes the main channel from the Highway 7 bridge to the Fraser River and Harrison Bay, is deep (up to 4 m) and slow flowing over a sand and gravel substrate.

METHODS

FISH CAPTURE

Chinook adults were captured in reaches 2 and 4 from October 16 to November 15, 1989 using a 67 m x 6 m x 9 cm mesh seine net. The net was set by power boat in a downstream crescent, then withdrawn from the river to enclose a small area of water along the river bank. Captured chinook were held in the net until removal for tagging and release.

SPAGHETTI TAG APPLICATION

Spaghetti tags were applied to chinook adults in a wooden tray constructed with a flexible plastic bottom and a meter stick recessed in one side. After tagging, chinook adults were released over a submerged section of the net; at no time were they removed from the water. Precocious males (jacks), defined as chinook less than 50 cm nose-fork (NF) length, were released untagged.

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. The tag 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 or two 7 mm diameter holes were punched through the right operculum of males and females, respectively, using a single hole punch. Care was taken to avoid gill damage.

Date and location (reach) of capture, spaghetti tag number, sex, NF length to the nearest 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

Weekly spawning ground surveys were conducted from October 18 to December 4, 1989. 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 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). Each marked carcass and every twentieth unmarked carcass was sampled. All carcasses 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 to the nearest 0.1 cm, sex, female spawning success (0%, 50%, or 100% spawned), adipose fin condition 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.

ESCAPEMENT ESTIMATION

Total Escapement: The 1989 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:

1) Estimated Harrison River chinook escapement (N_t):

$$N_t = N_m + N_f$$

where:

N_m = estimated escapement of adult males;

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

N_f = estimated escapement of females, analogous to above.

2) Estimated 95% confidence limits of N_t:

$$N_t \pm 1.96 \sqrt{V_t}$$

where:

N_t = total escapement estimate;

V_t = variance of the escapement estimate;

$= V_m + V_f$

V_m = variance of the adult male escapement estimate;

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

N_m = adult male escapement estimate;

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

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

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

Sex Identification Correction: The disk tag application data were corrected for sex identification error. Error occurred because the development of sexually dimorphic traits was often not advanced and internal examinations could not be made. Correction of recovery data was unnecessary because all carcasses were incised and examined internally. Sex identification error was corrected as described by Staley (1990):

3) Estimated true number of males released with disk tags and secondary marks (M_m):

$$M_m = \frac{M^*_m - (M_t R_{m,f})/R_f}{1 - (R_{m,f}/R_f) - (R_{f,m}/R_m)}$$

where:

M^*_m = field estimate of number of males released with disk tags and secondary marks;

M_t = total number of coho adults released with disk tags and secondary marks;

$R_{m,f}$ = number of females recovered with disk tags which were released as males;

$R_{f,m}$ = number of males recovered with disk tags which were released as females;

R_f = number of females recovered with disk tags;

R_m = number of males recovered with disk tags.

4) Estimated true number of females released with disk tags and secondary marks (M_f):

$$M_f = M_t - M_m$$

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. Confidence limits and escapement by CWT code were not estimated because escapement was not stratified by age.

RESULTS

MARK-RECAPTURE

Tag Application

One thousand six hundred seventeen chinook adults were released with spaghetti tags and secondary marks from October 16 to November 15, 1989 (Appendix 1). Release condition was good, with only three (0.2%) requiring ventilation (Table 2). The recovery of this group (33.3%) was significantly higher ($p < 0.05$; chi-square) than that of the remaining fish (4.4%). Consequently, these fish were removed from the application and recovery samples.

An estimated 10.0% of the males and 6.3% of the females were misidentified at the time of tagging (Appendix 2). After adjustments for release condition and sex identification error, an estimated 1,187 (73.5%) males and 427 (26.5%) females were released with spaghetti tags and secondary marks (Table 1).

Spawning Ground Recovery

After adjustment for release condition, 4,003 chinook adults were recovered on the spawning grounds from October 18 to December 4, 1989 (Table 1; Appendix 3). Of that total, 2,081 (52%) were male, 1,922 (48%) were female, 37 (0.9%) had AFCs, 71 (1.8%) had spaghetti tags and secondary marks and 10 (0.2%) had secondary marks only. Males (18.8%) lost tags at a higher rate than females (3.0%) ($p > 0.05$; chi-square).

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing between periods the mark incidence in the recovery sample (Table 3)(mark incidence was defined as the incidence of chinook adults marked with either a spaghetti tag or secondary mark). No significant difference was noted ($p > 0.05$; chi-square).

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 4). No significant

Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1989.

Sex	Spaghetti tags applied[a]	Carcasses examined[b]	Marks recovered[b]				
			Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	Percent recovered
Male	1,187	2,081	39	9	0	48	4.0%
Female	427	1,922	32	1	0	33	7.7%
Total	1,614	4,003	71	10	0	81	5.0%

[a] Adjusted for sex identification error. Excludes 3 which required ventilation at release.

[b] Excludes 1 which required ventilation at release.

Table 2. Spaghetti tag application and recovery of Harrison River chinook salmon, by release condition, 1989.

Release condition	Spaghetti tags applied	Spaghetti tags recovered	Percent recovered
Fish swam away without assistance	1,614	71	4.4%
Fish required ventilation	3	1	33.3%
Total	1,617	72	4.5%

Table 3. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the spawning grounds, by period, in the Harrison River, 1989.

Recovery period	Recovered with spaghetti tag or secondary mark		Total recovery		Mark incidence (%)
	Number	Percent	Number	Percent	
18 Oct to 24 Oct	4	4.9%	212	5.3%	1.9%
25 Oct to 31 Oct	12	14.8%	964	24.1%	1.2%
01 Nov to 07 Nov	18	22.2%	767	19.2%	2.3%
08 Nov to 14 Nov	9	11.1%	491	12.3%	1.8%
15 Nov to 21 Nov	16	19.8%	800	20.0%	2.0%
22 Nov to 28 Nov	11	13.6%	520	13.0%	2.1%
29 Nov to 04 Dec	11	13.6%	249	6.2%	4.4%
Total	81	-	4,003	-	2.0%

Table 4. Proportion of the spaghetti tag application sample recovered on the spawning grounds, by period, in the Harrison River, 1989.

Application period	Spaghetti tags applied[a]	Spaghetti tags recovered[b]	Percent recovered
16 Oct to 22 Oct	515	27	5.2%
23 Oct to 29 Oct	575	22	3.8%
30 Oct to 05 Nov	342	12	3.5%
06 Nov to 12 Nov	169	10	5.9%
13 Nov to 15 Nov	13	0	0.0%
Total	1,614	71	4.4%

[a] Excludes 3 which required ventilation at release.

[b] Excludes 1 which required ventilation at release, and 10 with a secondary mark only.

difference was noted ($p > 0.05$).

Location

Spatial bias in the application sample was examined by comparing between sections the mark incidence in the recovery sample (Table 5). Mark incidence, which ranged from 1.5% to 6.8%, was significantly different from that expected ($p < 0.05$; chi-square). Mark incidence was highest in the upper section.

Recovery bias was examined by stratifying the application sample by section and comparing proportions recovered (Table 6). No significant difference was noted ($p > 0.05$).

Fish Size

Size related bias in the application sample was assessed by comparing the continuous POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant difference was noted in males or females ($p > 0.05$; Kolmogorov-Smirnov two sample test).

Recovery bias was assessed by partitioning the application sample into recovered and non-recovered components and comparing the continuous NF length frequency distributions of each. No significant difference was noted in males or females ($p > 0.05$) (Table 7).

Fish Sex

Sex related bias in the application sample was assessed by comparing the sex ratio of the marked and unmarked spawning ground recoveries (Table 8). No significant difference was noted ($p < 0.05$; chi-square).

Recovery bias was assessed by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each (Table 8). The recovery sample was biased toward females ($p > 0.05$). Furthermore, the proportion of chinook adults released with marks and recovered on the spawning grounds was significantly higher ($p < 0.05$) in females (7.7%) than males (4.0%) (Table 1).

Recovery Method

Differential behaviour related to capture and tagging stress was examined by comparing the mark incidence in carcasses recovered on the shore (1.9%) and in deep water (2.2%) (Table 9). No significant difference ($p > 0.05$; chi-square) was noted.

Spawning Success

Differential behaviour related to capture and tagging stress was examined by comparing the spawning success of marked (93.9%) and unmarked (78.2%) females (Appendix 4). No significant difference was noted ($p < 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1989 escapement of Harrison River chinook adults, calculated from the mark-recapture data, was 74,685, with lower and upper 95% confidence limits of 58,737 and 90,633 (Table 10). The escapement of male and female chinook adults was 50,478 and 24,207, respectively.

Adipose Fin Clipped Escapement

Based on the chinook adult AFC incidence in the recovery sample (0.9%) (Appendix 3), the 1989 escapement of AFC adults was 690 chinook (Table 10). CWT escapement estimates were not determined because total

Table 5. Incidence of spaghetti tags and secondary marks, by reach and section, in the Harrison River spawning ground recovery sample, 1989.

Section	Reach	Carcasses examined		Carcasses recovered with spaghetti tags or secondary marks[a]		Mark incidence (%)
		Number	Percent	Number	Percent	
Upper	Reach 1	0	0.0%	0	0.0%	-
	Reach 2	44	1.1%	3	3.7%	6.8%
	Total	44	1.1%	3	3.7%	6.8%
Middle	Reach 3	66	1.6%	3	3.7%	4.5%
	Reach 4	1,302	32.5%	17	21.0%	1.3%
	Reach 5	61	1.5%	1	1.2%	1.6%
	Total	1,429	35.7%	21	25.9%	1.5%
Lower	Reach 6	1,433	35.8%	23	28.4%	1.6%
	Reach 7	688	17.2%	17	21.0%	2.5%
	Reach 8	409	10.2%	17	21.0%	4.2%
	Total	2,530	63.2%	57	70.4%	2.3%
Total	-	4,003	-	81	-	2.0%

[a] Excludes 1 which required ventilation at release.

Table 6. Proportion of the spaghetti tag application sample recovered on the spawning grounds, by application reach, in the Harrison River, 1989.

Reach	Tags applied[a]	Tags recovered[b]	Percent recovered
Reach 2	1,255	52	4.1%
Reach 4	359	19	5.3%
Total	1,614	71	4.4%

[a] Excludes 3 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 10 with a secondary mark only.

Table 7. Spaghetti tag application and recovery of Harrison River chinook adults, by nose-fork length, 1989.

Nose-fork length (cm)	Spaghetti tags applied[a]	Carcasses recovered with spaghetti tags[b]	Percent recovered
50-59	3	0	0.0%
60-69	154	4	2.6%
70-79	423	17	4.0%
80-89	703	36	5.1%
90-99	265	11	4.2%
100-110	62	3	4.8%
110-120	4	0	0.0%
Total	1,614	71	4.4%

[a] Excludes 3 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 10 with a secondary mark only.

Table 8. Sex composition of application and recovery samples of Harrison River chinook adults, 1989.

Sex		Application sample[a]			Recovery sample[b]		
		Recovered[b]	Not recovered	Total	Marked	Unmarked	Total
Male	Percent	59.3	74.3	73.5	59.3	51.8	52.0
	Number	48	1,139	1,187	48	2,033	2,081
Female	Percent	40.7	25.7	26.5	40.7	48.2	48.0
	Number	33	394	427	33	1,889	1,922
Total	Number	81	1,533	1,614	81	3,922	4,003

[a] Excludes 3 which required ventilation at release.
[b] Excludes 1 which required ventilation at release.

Table 9. Incidence of spaghetti tags and secondary marks in chinook carcasses recovered on the spawning grounds, by recovery method, in the Harrison River, 1989.

Method	Number recovered[a]	Recovered with tags or secondary marks[a]	Mark incidence (%)
Shore recovery	2,702	52	1.9%
Deep water recovery	1,301	29	2.2%
Total	4,003	81	2.0%

[a] Excludes 1 which required ventilation at release.

Table 10. Escapement estimates, by sex, for Harrison River chinook adults, 1989.

Sex	Escapement estimate	95% confidence limit	
		Lower	Upper
Male	50,478	36,652	64,304
Female	24,207	16,258	32,156
Total	74,685	58,737	90,633
AFC Adult	690	-	-

escapement was not stratified by age; however, recoveries are summarized by CWT code and sex in Appendix 5. CWT loss was not influenced by carcass decomposition or predators (Appendix 6).

AGE, LENGTH AND SEX

The age composition of 165 chinook adults recovered without AFCs was 1.2% age 2_1, 63.6% age 3_1, 24.2% age 4_1 and 10.3% age 5_1 (Table 11). The age composition of 27 carcasses with AFCs was 48.1% age 3_1, 40.7% age 4_1 and 11.1% age 5_1 (Table 11). No errors were noted in the aging of chinook with CWT's.

Mean NF length of males and females in the application sample was 81.4 cm and 83.9 cm, respectively (Appendix 7). Mean POH lengths of males and females in the recovery sample were 66.7 cm and 69.1 cm, respectively (Appendix 7).

Females comprised 27% of the application sample, 48% of the recovery sample (Table 8) and 32% of the population estimate.

DISCUSSION

ADULT CAPTURE TECHNIQUE

A basic assumption underlying Petersen mark-recapture studies is that capture and tagging do not influence the subsequent catchability of the fish. We evaluated this factor in two ways. First, we compared the mark incidence in carcasses recovered on the shore and in deep water main channel areas. We assumed that stressed fish would move passively downstream, with the most stressed individuals dying and being differentially recovered in main channel areas. Because no difference was noted, and because mark incidence was less in the lower reaches, we believe differential loss of marked fish was minor. Second, we compared the spawning success in spaghetti tagged and untagged females. A positive bias in spawning success of tagged females was consistent with the results of previous studies (Staley 1990). We concluded, therefore, that capture and marking may influence subsequent behaviour; however, we were unable to determine if this behaviourial change influence catchability.

SAMPLING SELECTIVITY

A second assumption underlying Petersen mark-recapture studies is that the population is sampled in a random or representative manner (Ricker 1975). In studies when non-representative sampling occurs, accurate results may still be achieved if one sample is representative (Robson 1969). In the present study, it was not possible to test for representativeness because the true population parameters were not known. Instead, we examined the samples for four biases, temporal, spatial, fish size and fish sex, as indicators of weaknesses in the study design. Biases were identified in both the tag application (spatial bias) and recovery (bias to females) samples (Table 12). Neither bias, however, was likely to have introduced bias in the escapement estimate. The spatial bias, while present in the application sample, was not noted in the recovery sample. The sex bias was corrected analytically by calculating escapement by sex. We concluded, therefore, that sampling selectivity was unlikely to have introduced significant bias in the 1989 Harrison River chinook escapement estimate.

ESCAPEMENT TRENDS

The Harrison River mark-recap-

Table 11. Age composition of chinook carcasses recovered on the spawning grounds, by adipose fin and CWT status, in the Harrison River, 1989.

	Adipose fin present		Adipose fin absent		Coded wire tag present	
Age	no.	%	no.	%	no.	%
2_1	2	1.2%	0	0.0%	0	0.0%
3_1	105	63.6%	13	48.1%	8	42.1%
4_1	40	24.2%	11	40.7%	8	42.1%
4_2	1	0.6%	0	0.0%	0	0.0%
5_1	17	10.3%	3	11.1%	3	15.8%
6_1	0	0.0%	0	0.0%	0	0.0%
Total	165	-	27	-	19	-

Table 12. Summary of results of statistical tests for bias in the 1989 Harrison River escapement estimation study.

Test	Application sample	Recovery sample
Period	No bias	No bias
Location	Bias toward upper reaches	No bias
Recovery method	-	No bias
Fish size	No bias	No bias
Fish sex	No bias	Bias toward females

ture study was implemented in 1984 to monitor the rebuilding expected from management actions implemented after the signing of the Pacific Salmon Treaty. Since 1984, Harrison chinook escapement have shown a strong negative trend. Escapement peaked 174,800 in 1985 and declined for three successive years to 35,100 in 1988 (Staley 1990). While escapements increased by 39,600 in 1989, the female escapement increased by only 6,900. Overall, the stock has made no apparent progress toward rebuilding to the 1998 escapement goal of 241,700.

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. Adult spawners were enumerated by a mark-recapture study from October 16 to December 4, 1989. Chinook adults 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 1989 chinook adult escapement was estimated from a disk tag application sample of 1,614 a recovery sample of 4,003, and a recovery of 81 carcasses with spaghetti tags or secondary marks. The estimated escapement was 74,685 chinook adults, of which 24,207 were female and 50,478 were male, and 690 had adipose fin clips.

4. The age composition, measured from the recovery sample, was:

	2_1	3_1	4_1	4_2	5_1
Female	0%	55%	31%	1%	13%
Male	2%	68%	22%	0%	8%

POH length averaged 69.1 cm for females and 66.7 for males.

5. Biases were identified in both the application and recovery samples; however, there was no indication that the 1989 escapement estimate was biased.

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APPENDICES

Appendix 1. Chinook adult spaghetti tag application, by adipose fin status and sex, in the Harrison River, 1989. a

		Adipose present			Adipose absent			Total		
Date	Reach	Male	Female	Total	Male	Female	Total	Male	Female	Total
16-Oct	4	22	9	31	0	0	0	22	9	31
17-Oct	2	177	105	282	2	2	4	179	107	286
18-Oct	2	125	59	184	3	0	3	128	59	187
19-Oct	4	9	2	11	0	0	0	9	2	11
23-Oct	4	51 b	20	71	2	0	2	53	20	73
24-Oct	2	75	28	103	2	0	2	77	28	105
25-Oct	2	151	65	216	2	1	3	153	66	219
26-Oct	2	64	20	84	0	2	2	64	22	86
27-Oct	2	61	31	92	0	2	2	61	33	94
30-Oct	2	104	44	148	2	1	3	106	45	151
31-Oct	2	36	20	56	1	0	1	37	20	57
	4	33	6	39	0	0	0	33	6	39
02-Nov	2	33 c	15	48	0	1	1	33	16	49
03-Nov	2	7	0	7	0	0	0	7	0	7
	4	26	13	39	0	0	0	26	13	39
06-Nov	2	3	1	4	0	0	0	3	1	4
	4	25	11	36	1	0	1	26	11	37
07-Nov	2	6	4	10	0	0	0	6	4	10
	4	32	17	49	0	0	0	32	17	49
08-Nov	4	24	7	31	1	0	1	25	7	32
09-Nov	4	27	10	37	1	0	1	28	10	38
14-Nov	4	5	1	6	0	0	0	5	1	6
15-Nov	4	4	3	7	0	0	0	4	3	7
Total	2	842	392	1,234	12	9	21	854	401	1,255
	4	258	99	357	5	0	5	263	99	362
Total	-	1,100	491	1,591	17	9	26	1,117	500	1,617

a. Not corrected for sex identification errors.
b. Two required ventilation.
c. One required ventilation.

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1989.

Application sample					Recovery sample				
Date	Reach	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
16-Oct	4	107.0	M	P	06-Nov	8	81.6	M	21
16-Oct	4	90.0	M	P	01-Nov	6	70.0	M	16
16-Oct	4	104.5	M	P	30-Oct	6	81.0	M	14
17-Oct	2	82.0	F	P	18-Oct	7	67.4	F	1
17-Oct	2	85.0	M	P	25-Oct	8	67.0	M	8
17-Oct	2	79.0	F	P	06-Nov	6	63.2	F	20
17-Oct	2	86.0	M	P	20-Oct	2	69.1	M	3
17-Oct	2	85.0	F	A	25-Oct	7	68.2	F	8
17-Oct	2	86.5	M	P	31-Oct	4	67.7	M	14
17-Oct	2	86.5	M	P	29-Nov	3	62.8	M	43
17-Oct	2	89.0	F	P	21-Nov	6	65.8	M a	35
17-Oct	2	96.0	F	P	24-Oct	3	70.4	F	7
17-Oct	2	82.0	F	P	30-Oct	6	65.0	F	13
17-Oct	2	81.0	M	P	06-Nov	7	60.7	M	20
17-Oct	2	75.0	F	P	25-Oct	7	62.5	F	8
17-Oct	2	71.0	F	P	01-Nov	6	56.1	F	15
17-Oct	2	80.0	M	P	06-Nov	8	62.6	M	20
17-Oct	2	66.0	F	P	16-Nov	8	52.5	M a	30
17-Oct	2	86.0	M	P	01-Nov	4	69.2	M	15
17-Oct	2	81.5	F	P	06-Nov	6	64.4	F	20
17-Oct	2	78.0	F	P	01-Nov	6	62.0	F	15
18-Oct	2	94.0	F	P	25-Oct	8	76.0	F	7
18-Oct	2	98.5	M	P	19-Oct	6	76.2	M	1
18-Oct	2	85.0	F	P	08-Nov	4	66.2	M a	21
18-Oct	2	84.0	M	P	31-Oct	4	69.4	M	13
18-Oct	2	84.0	F	P	01-Nov	4	66.0	F	14
18-Oct	2	77.0	F	P	27-Oct	6	61.3	F	9
23-Oct	4	82.0	M	P	01-Nov	4	64.0	M	9
23-Oct	4	96.5	M	P	25-Oct	7	72.6	M b	2
23-Oct	4	70.0	F	P	25-Oct	7	56.4	F	2
24-Oct	2	85.0	F	P	06-Nov	8	68.3	F	13
24-Oct	2	77.0	M	P	17-Nov	7	53.2	M	24
24-Oct	2	91.0	M	P	17-Nov	4	76.5	M	24
24-Oct	2	81.5	F	P	31-Oct	4	68.2	F	7
24-Oct	2	85.0	F	P	29-Nov	4	64.3	F	36
25-Oct	2	75.0	F	P	31-Oct	4	61.9	F	6
25-Oct	2	81.5	F	P	22-Nov	7	63.8	F	28
25-Oct	2	85.0	M	P	01-Nov	6	66.5	M	7
25-Oct	2	81.0	F	P	21-Nov	5	65.9	F	27
25-Oct	2	95.0	F	P	30-Nov	8	75.3	F	36
25-Oct	2	83.0	M	P	17-Nov	4	71.3	F a	23
26-Oct	2	75.5	F	P	01-Nov	6	60.9	F	6
26-Oct	2	88.0	M	P	24-Nov	7	62.9	M	29
26-Oct	2	74.0	F	P	20-Nov	6	60.3	F	25
26-Oct	2	84.0	M	P	30-Nov	8	68.8	M	35
26-Oct	2	95.5	M	P	27-Nov	6	69.2	M	32
26-Oct	2	89.0	F	P	08-Nov	4	71.8	F	13

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1989.

Application sample					Recovery sample				
Date	Reach	NF length (cm)	Sex	Adipose fin	Date	Reach	POH length (cm)	Sex	Days out
27-Oct	2	77.0	F	P	30-Nov	8	60.8	F	34
27-Oct	2	78.5	M	P	17-Nov	7	60.5	M	21
27-Oct	2	83.0	M	P	24-Nov	7	63.5	M	28
30-Oct	2	85.0	F	P	17-Nov	7	67.0	F	18
30-Oct	2	87.0	M	P	30-Nov	8	67.9	M	31
30-Oct	2	86.0	M	P	08-Nov	4	67.8	M	9
31-Oct	2	80.0	M	P	20-Nov	6	62.3	M	20
31-Oct	2	79.0	M	P	01-Nov	6	65.5	M	1
31-Oct	4	83.0	M	P	06-Nov	6	66.4	M	6
02-Nov	2	60.5	M	P	24-Nov	8	50.7	M	22
02-Nov	2	100.0	F	P	29-Nov	2	77.1	F	27
02-Nov	2	75.0	M	P	22-Nov	8	59.8	F a	20
03-Nov	4	99.0	F	P	08-Nov	6	80.4	F	5
03-Nov	4	65.0	M	P	16-Nov	8	51.4	M	13
03-Nov	4	76.0	F	P	30-Nov	8	61.2	F	27
06-Nov	4	75.0	F	P	08-Nov	6	61.8	M a	2
07-Nov	4	84.0	M	P	24-Nov	7	65.2	M	17
07-Nov	4	92.0	F	P	29-Nov	4	74.5	F	22
07-Nov	4	83.0	M	P	17-Nov	7	53.5	M	10
07-Nov	4	61.5	M	P	27-Nov	6	50.9	M	20
07-Nov	4	86.0	F	P	17-Nov	4	68.0	F	10
08-Nov	4	83.0	M	P	16-Nov	8	66.4	M	8
08-Nov	4	87.0	M	P	22-Nov	8	65.6	M	14
08-Nov	4	78.0	M	P	15-Nov	6	60.3	M	7
09-Nov	4	99.0	M	P	17-Nov	7	74.6	M	8

Females initially identified as males: 2 (6.3%)
Males initially identified as females: 4 (10.0%)

Mean days out: 16.6
Maximum days out: 43
Minimum days out: 1

POH and NF Regressions:

- Males: POH = 0.69 NF + 7.49
  NF = 1.20 POH + 5.56
- Females: POH = 0.72 NF + 6.66
  NF = 1.23 POH - 0.09

a. Incorrect sex identification during disk tag application.
b. Required ventilation at release.

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1989.

		Unmarked		Secondary mark only		Spaghetti tag and secondary mark		Total		Adipose absent	
Date	Reach	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female b
18-Oct	7	6	5	0	0	0	1	6	6	0	1
	8	3	12	0	0	0	0	3	12	0	0
19-Oct	6	16	21	0	0	1	0	17	21	1	1
20-Oct	2	1	1	0	0	1	0	2	1	0	0
	3	5	16	0	0	0	0	5	16	0	0
	4	13	11	0	0	0	0	13	11	0	0
24-Oct	3	1	6	0	0	0	1	1	7	0	0
	4	41	50	0	0	0	0	41	50	0	0
25-Oct	7	56	42	0	0	1 a	3	57	45	0	1
	8	13	8	0	0	1	1	14	9	0	0
26-Oct	7	73	72	0	0	0	0	73	72	1	1
27-Oct	2	3	4	0	0	0	0	3	4	0	0
	6	72	78	0	0	0	1	72	79	1	1
30-Oct	6	124	99	0	0	1	1	125	100	2	0
31-Oct	4	160	148	0	0	2	2	162	150	0	0
01-Nov	4	42	84	0	0	2	1	44	85	0	3
	6	227	177	1	1	3	3	231	181	3	3
06-Nov	6	25	14	0	0	1	2	26	16	0	0
	7	58	21	0	0	1	0	59	21	0	0
	8	85	16	0	0	2	1	87	17	0	0
08-Nov	4	149	137	0	0	2	1	151	138	0	2
	6	87	49	0	0	1	1	88	50	0	1
14-Nov	3	7	4	0	0	0	0	7	4	0	0
	4	19	18	2	0	0	0	21	18	0	1
	5	7	7	0	0	0	0	7	7	0	0
15-Nov	6	31	34	0	0	1	0	32	34	0	1
16-Nov	4	14	33	0	0	0	0	14	33	0	0
	6	25	21	0	0	0	0	25	21	0	0
	7	33	15	1	0	0	0	34	15	0	0
	8	47	17	0	0	3	0	50	17	0	0
17-Nov	4	39	72	0	0	1	2	40	74	2	1
	6	15	52	0	0	0	0	15	52	1	1
	7	43	18	1	0	4	1	48	19	1	1
20-Nov	4	4	0	0	0	0	0	4	0	0	0
	6	27	10	0	0	1	1	28	11	0	0
21-Nov	3	0	4	0	0	0	0	0	4	0	0
	4	20	57	0	0	0	0	20	57	1	0
	5	18	25	0	0	0	1	18	26	0	1
	6	36	44	0	0	1	0	37	44	0	0
	7	14	14	0	0	0	0	14	14	0	0
22-Nov	7	16	31	0	0	0	1	16	32	0	0
	8	33	27	0	0	1	1	34	28	0	1
23-Nov	2	7	3	1	0	0	0	8	3	0	0
	7	1	1	1	0	0	0	2	1	0	0
24-Nov	3	3	5	0	0	0	0	3	5	0	0
	4	3	11	0	0	0	0	3	11	0	1
	6	4	6	0	0	0	0	4	6	0	0
	7	23	16	0	0	3	0	26	16	2	0

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1989.

Date	Reach	Unmarked		Secondary mark only		Spaghetti tag and secondary mark		Total		Adipose absent	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female b
24-Nov	8	27	10	0	0	1	0	28	10	0	0
27-Nov	2	8	3	0	0	0	0	8	3	0	0
	6	21	33	0	0	2	0	23	33	0	0
	7	2	4	0	0	0	0	2	4	0	0
28-Nov	6	30	23	0	0	0	0	30	23	0	0
	7	55	52	0	0	0	0	55	52	0	0
	8	33	18	0	0	0	0	33	18	0	0
29-Nov	2	7	4	0	0	0	1	7	5	0	0
	3	4	8	1	0	1	0	6	8	0	0
	4	67	90	0	0	0	2	67	92	0	0
	6	4	5	0	0	0	0	4	5	0	0
30-Nov	8	22	21	1	0	2	3	25	24	0	0
01-Dec	4	2	1	0	0	0	0	2	1	0	0
04-Dec	5	2	1	0	0	0	0	2	1	0	0
Total	2	26	15	1	0	1	1	28	16	0	0
	3	20	43	1	0	1	1	22	44	0	0
	4	573	712	2	0	7	8	582	720	3	8
	5	27	33	0	0	0	1	27	34	0	1
	6	744	666	1	1	12	9	757	676	8	8
	7	380	291	3	0	9	6	392	297	4	4
	8	263	129	1	0	10	6	274	135	0	1
	Total	2,033	1,889	9	1	40	32	2,082	1,922	15	22

a. One required ventilation at release.
b. Includes two recovered without heads.

Appendix 4. Spawning success of female chinook spawning ground recoveries in the Harrison River, 1989.

		Percent spawned			
		0%	50%	100%	Weighted mean
Spaghetti tag or secondary mark	Number	2	0	31	33
	Percent	6.1%	0.0%	93.9%	93.9%
Unmarked	Number	16	2	60	78
	Percent	20.5%	2.6%	76.9%	78.2%
Total	Number	18	2	91	111
	Percent	16.2%	1.8%	82.0%	82.9%

Appendix 5. CWT spawning ground recoveries in the Harrison River, 1989.

CWT code	Release site	Brood year	CWTs Recovered		
			Male	Female	Total
02 28 19	Chehalis R.	1984	0	1	1
02 30 43	Chehalis R.	1984	1	0	1
02 31 28	Chehalis R.	1984	0	1	1
02 34 16	Chilliwack R.	1984	1	0	1
02 37 55	Chehalis R.	1985	0	1	1
02 37 56	Chehalis R.	1985	1	2	3
02 37 58	Chehalis R.	1985	1	0	1
02 37 59	Chehalis R.	1985	1	2	3
02 37 61	Chehalis R.	1985	0	1	1
02 40 52	Chehalis R.	1985	0	1	1
02 44 02	Chehalis R.	1986	2	1	3
02 44 03	Chehalis R.	1986	0	1	1
02 44 04	Chehalis R.	1986	2	0	2
02 44 05	Chehalis R.	1986	2	0	2
02 44 06	Chehalis R.	1986	0	1	1
02 44 08	Chehalis R.	1986	0	1	1
02 44 09	Chehalis R.	1986	2	0	2
CWT Lost a	-	-	1	2	3
Recovered without a head		-	0	2	2
Total with adipose fin clips:			15	22	37
Total with CWTs:			14	15	29
Total returning without a CWT:			1	5	6

a. CWT present in head but not recovered.

Appendix 6. Incidence of CWT loss by carcass condition and eye status in AFC chinook adult carcasses in the Harrison River, 1989.

Group	Sample size	CWT absent	CWT loss (%)
Carcass fresh	0	0	-
Carcass moderately fresh	11	3	27.3%
Carcass moderately rotten	20	3	15.0%
Carcass rotten	3	0	0.0%
Eyes present	8	1	12.5%
Eyes absent	27	5	18.5%
Complete AFC	29	5	17.2%
Partial AFC	6	1	16.7%

Appendix 7. Mean lengths by age and sex for Harrison River chinook salmon, 1989.

Sample	Age	Sex	Sample size	Percent	Length (cm) Mean	Standard deviation	Range
Application sample a,b	-	Male	1,114	69.0%	81.4	10.2	55.0 - 116.0
		Female	500	31.0%	83.9	7.9	51.0 - 112.0
		Total	1,614	-	82.2	9.6	51.0 - 116.0
Recovery sample c	2/1	Male	2	1.0%	44	10	37.0 - 51.4
		Female	0	0.0%	-	-	-
	3/1	Male	65	33.9%	63.2	6.1	46.3 - 76.0
		Female	53	27.6%	64.6	4.3	53.1 - 75.0
	4/1	Male	21	10.9%	73.7	6.3	63.0 - 87.5
		Female	30	15.6%	72.5	4.5	61.5 - 81.4
	4/2	Male	0	0.0%	-	-	-
		Female	1	0.5%	73.4	-	-
	5/1	Male	8	4.2%	81.5	8.0	66.4 - 94.3
		Female	12	6.3%	79.8	3.6	74.2 - 85.2
	Total	Male	96	50.0%	66.7	9.3	37.4 - 94.3
		Female	96	50.0%	69.1	6.9	53.1 - 85.2
		Total	192	-	67.9	8.7	37.4 - 94.3

a. Not adjusted for sex identification errors.
b. Nose-fork length
c. Postorbital-hypural length