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Enumeration of the 1992 Harrison River Chinook Salmon Escapement

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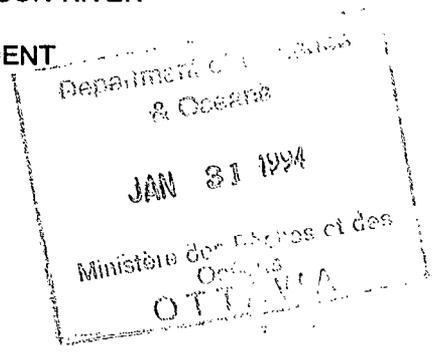
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ENUMERATION OF THE 1992 HARRISON RIVER
CHINOOK SALMON ESCAPEMENT



by

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ABSTRACT

Schubert, N.D., M.K. Farwell and L.W. Kalnin. 1993. Enumeration of the 1992 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2200: 25 p.

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 1992, the Harrison River chinook escapement was estimated, using the Petersen mark-recapture method, at 130,411 adults. The sex composition of the escapement was 41% female and 59% male. The age composition of the escapement was 23.6% age 3₁, 73.9% age 4₁, and 2.5% age 5₁.

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

RÉSUMÉ

Schubert, N.D., M.K. Farwell and L.W. Kalnin. 1993. Enumeration of the 1992 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2200: 25 p.

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 1992, l'échappée du quinnat dans la rivière Harrison a été évaluée à 130 411 adultes, selon la méthode de marquage et de recapture de Petersen. La composition de la population selon le sexe a été évaluée comme suit: 41% de femelles et 59% mâles. La composition par âge: 23,6% d'âge 3₁, 73,9% d'âge 4₁, et 2,5% d'âge 5₁.

Mots clés: 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).

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 was unique in the Fraser River system. Individual monitoring, therefore, was warranted. Previous reports documented the 1984-1991 Harrison River chinook enumeration studies (Staley 1990; Farwell *et al.* 1990, 1991, 1992). The current report documents the 1992 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 by sex and age. The report concludes with a discussion of data limitations and recommendations for the design of 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 $449 \text{ m}^3 \cdot \text{s}^{-1}$, with monthly mean daily maximum ($947 \text{ m}^3 \cdot \text{s}^{-1}$) and minimum ($202 \text{ m}^3 \cdot \text{s}^{-1}$) 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), from the lake to Norris 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 northwest shore and to the top of Reach 5 on the southeast shore. The channel is similar to Reach 1 except the depth is only 3.0 m and the substrate is gravel;

Reach 3 (km 7.7 to 7.1) extends to a shear boom on the northwest 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 northwest 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;

Reach 6 (km 6.3 to 4.5) extends to a rock bluff on the southeast 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 dewateres at low Harrison River discharges, and chinook tend to avoid the area.

FIELD METHODS

TAG APPLICATION

Chinook adults were captured in reaches 2, 3, 4, and 6 from October 19 to November 24, 1992 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

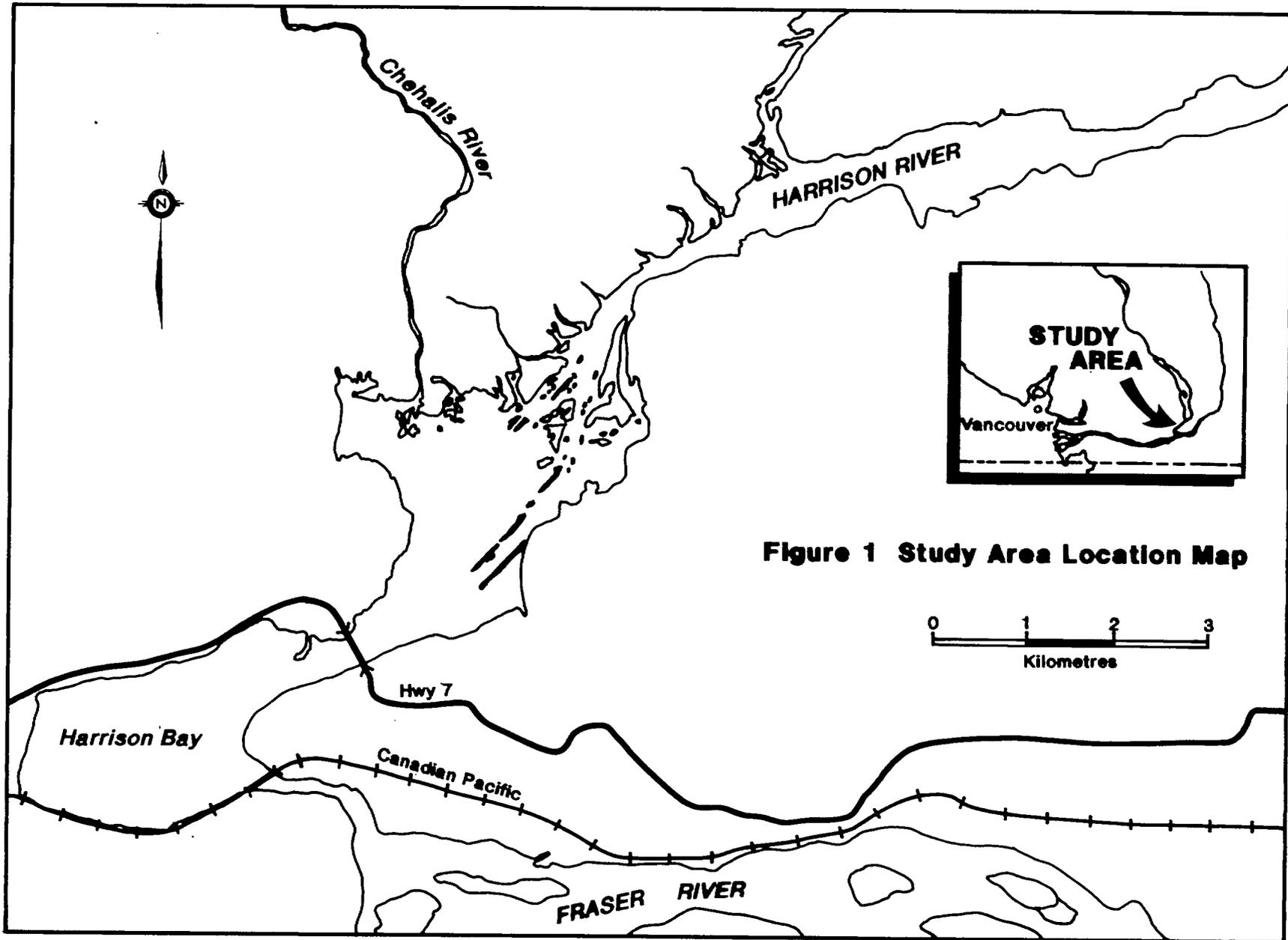


Figure 1 Study Area Location Map

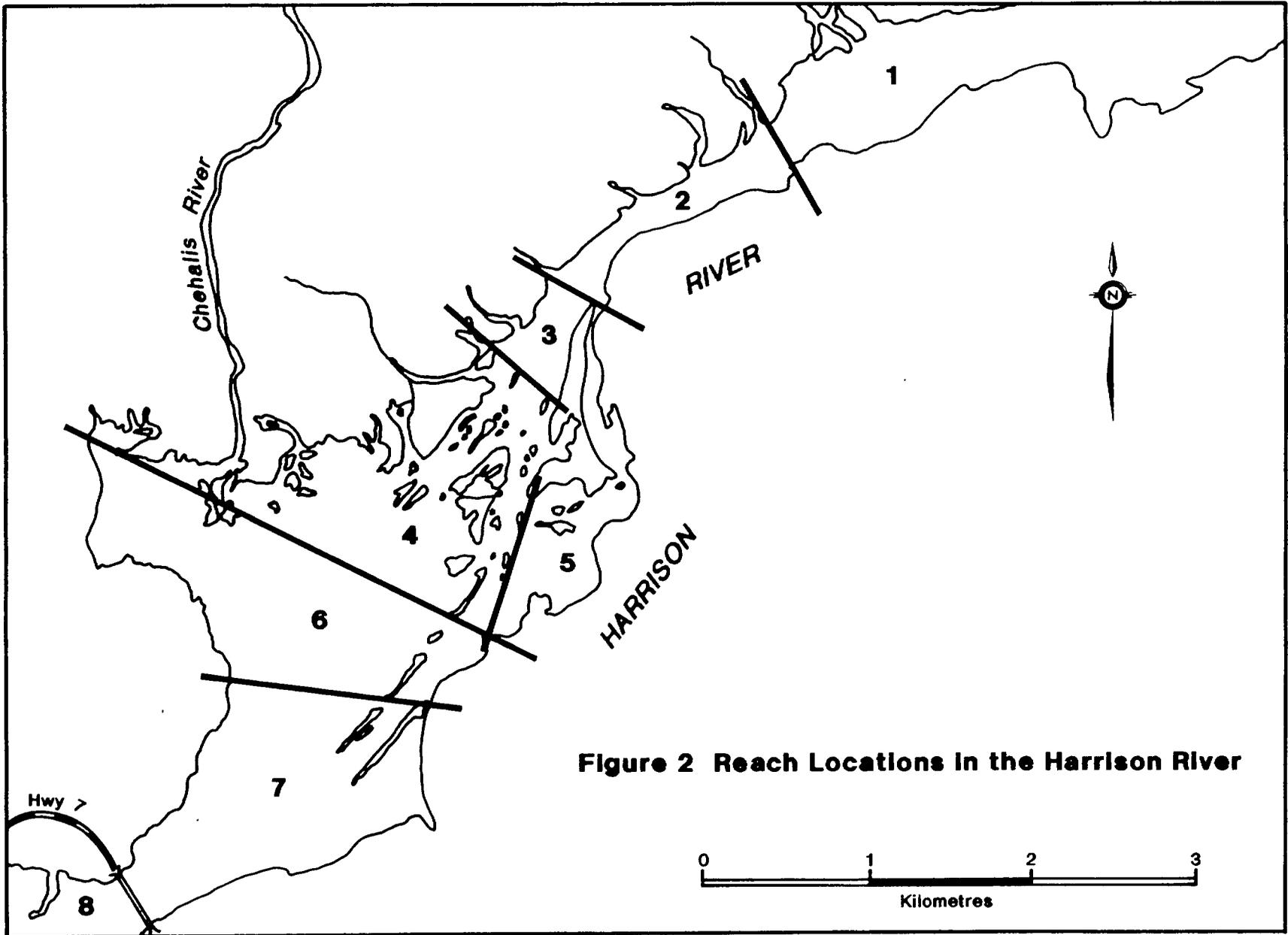


Figure 2 Reach Locations In the Harrison River

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 adults were released over a submerged section of the net; at no time were they removed from the water. Precocious males (jacks), defined as a male with a nose-fork (NF) length of 50 cm or less, 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. 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 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, 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 22 to December 14, 1992. 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). 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, 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 between 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 similarly assessed in the application sample by comparing between 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 through 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 nonrecovered components and comparing the NF length-frequency distributions of each.

Fish Sex

Sex related bias was assessed through 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.

Recovery Method

Chi-square tests were used to compare the mark incidence in carcasses recovered on shore and in deep water. If a serious application stress occurred, marked fish would be prone to being flushed from the system. Mark rates, therefore, would be higher in the deep, main channel areas.

Other Tests

Bias resulting from tagging stress was also assessed using chi-square tests as above. The application sample was partitioned into two groups, those which required ventilation at release and those which did not, and recovery rates were examined in each group. As well, differential spawning success was examined in marked and unmarked spawning ground recoveries.

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1992 escapement of Harrison River chinook adults was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). When biases were identified, stratified estimates were calculated using Schaefer's (Ricker 1975) and Darroch's (1961) estimators. 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 = adult male escapement estimate;

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

N_f = female escapement estimate.

- 2) Ninety-five percent 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 spaghetti tags;

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

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

Sex Identification Correction

The spaghetti 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 the 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 spaghetti tags and secondary marks (M_m):

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

where:

M_m^* = field estimate of number of males released with spaghetti tags and secondary marks;

M_t = total number of chinook adults released with spaghetti tags and secondary marks;

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

Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1992.

Sex	Spaghetti tags applied a	Carcasses examined	Marks recovered				Percent recovered
			Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	
Male	776	6,448	47 b	16	1	64	8.2%
Female	693	7,759	95 b	3	2	100	14.4%
Total	1,469	14,207	142	19	3	164	11.2%

a. Corrected for sex identification error.

b. Includes 1 tag which was unreadable at recovery.

- ed as males;
- $R_{i,m}$ = number of males recovered with spaghetti tags which were released as females;
- R_f = number of females recovered with spaghetti tags;
- R_m = number of males recovered with spaghetti tags.

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

$$M_f = M_t - M_m$$

Adipose FlN 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 CWT sample sizes were not sufficient to permit stratification by age.

RESULTS

TAG APPLICATION

In 1992, 1,469 chinook adults were released with spaghetti tags and secondary marks from October 19 to November 24 (Appendix 1; Table 1). Twenty fish (1.4%) required ventilation (Table

2); however, the proportion of this group recovered (15.0%) was not significantly different ($p > 0.05$; chi-square) from the remaining fish (9.7%). Consequently, they were not removed from the application sample. An estimated 12.8% of the males and 5.3% of the females were misidentified at the time of tagging (Appendix 2). When adjusted for this error, an estimated 776 (52.8%) males and 693 (47.2%) females were released with a spaghetti tag and secondary mark (Table 1). Most (78%) were released in Reach 4, with 228 (16%) released in Reach 2 and 95 (6%) in Reach 3.

SPAWNING GROUND RECOVERY

In 1992, 14,207 chinook adults and 2,260 jacks were recovered from October 22 to December 14 (Table 1; Appendix 3). Of the adults, 6,448 (45.4%) were male, 7,759 (54.6%) were female, 93 (0.7%) had an AFC, 142 (1.0%) had a spaghetti tag and secondary mark, 3 had a spaghetti tag only and 19 (0.1%) had a secondary mark only. Spaghetti tag loss in males (25.0%) was significantly higher than in females (3.0%) ($p < 0.05$; chi-square). Most of the adults were recovered in reaches 6 (34%) and 4 (30%).

Age, Length and Sex

The age, length and sex of the 1992 Harrison River spawning ground recoveries are reported in Appendix 4. Most males matured at ages 3₁ (34%) and 4₁ (65%); females matured almost entirely at age 4₁ (87%). No difference was

noted in the age composition of fish with an AFC ($p > 0.05$; chi-square), and no errors were noted in the ageing of chinook adults with a CWT. The mean NF length of males and females in the application sample was 86.1 cm and 87.6 cm, respectively. The mean POH length of males and females in the recovery sample was 69.2 cm and 72.2 cm, respectively. Females comprised 47.2% of the application sample, 54.6% of the recovery sample and 40.9% of the population.

Coded Wire Tag Recoveries

In 1992, 31 adult males and 62 females were recovered with an AFC (jacks were not examined for an AFC), an incidence of 0.5% and 0.8%, respectively (Appendix 5). CWTs were recovered from 21 males and 45 females. Of those with a CWT, 8 (12.1%) were from 1988-brood Chilliwack River Hatchery releases, and 48 (72.7%) and 10 (15.2%) were from 1988-brood and 1989-brood Chehalis River Hatchery releases, respectively. CWT loss averaged 25% and was not influenced ($p > 0.05$; chi square) by carcass deterioration or predation (as indicated by eye loss) (Appendix 6).

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in seven recovery periods. Mark incidence decreased over time from 2.3% to 0.9% (Table 3); the estimates were significantly different than expected ($p < 0.05$; chi-square).

Recovery bias was examined by comparing the proportions recovered from five application periods (Table 4). The proportions ranged from 6.3% to 12.6%; however, the differences were not significant ($p > 0.05$).

Location

Spatial bias in the application sample was examined by comparing the mark incidences in three recovery sections (Table 5). Mark incidence ranged from 0.0% in the upper section to 1.4% in the lower section; the differences were statistically significant ($p < 0.05$; chi-square).

Recovery bias was examined by stratifying the application sample into four reaches and

comparing proportions recovered from each (Table 6). Excluding Reach 6, where few tags were applied, the proportions ranged from 5.3% to 11.0%; however, the differences were not significant ($p > 0.05$).

Fish Size

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

Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing NF length-frequency distributions of each. No significant difference ($p > 0.05$) was noted in males or females. When the application sample was stratified into 10 cm NF length increments, a higher recovery rate was noted among fish between 70 cm and 110 cm (Table 7); however, this reflected small samples in the larger and smaller size groups rather than a statistically significant difference in recovery rates.

Fish Sex

No difference was noted ($p > 0.05$; chi-square) in the sex ratio of the marked and unmarked spawning ground recoveries (Table 8). The application sample, therefore, was relatively unbiased with respect to sex.

A significant difference was noted ($p < 0.05$) in the sex ratio of the recovered and nonrecovered components of the application sample (Table 8). It was concluded, therefore, that the recovery sample was biased toward females. Further, females marked with spaghetti tags were recovered at a significantly ($p < 0.05$) higher rate (14.4%) than males (8.2%) (Table 1).

Recovery Method

No significant difference ($p > 0.05$; chi-square) was noted in the mark incidence of carcasses recovered on shore (1.1%) during foot surveys and in deep water (1.5%) during boat surveys (Table 9).

Table 2. Spaghetti tag application and recovery of Harrison River chinook adults, by release condition and sex, 1992

Release condition	Spaghetti tags applied a			Spaghetti tags recovered b			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Swam away without assistance	766	682	1,448	45	95	140	5.9%	13.9%	9.7%
Required ventilation	10	10	20	2	1	3	20.0%	10.0%	15.0%

a. Corrected for sex identification error; excludes 1 female for which condition at release was not recorded.

b. Excludes 2 tags (1 male, 1 female) which were unreadable at recovery.

Table 3. Incidence of spaghetti tags or secondary marks in chinook adults recovered on the Harrison River spawning grounds, by recovery period and sex, 1992.

Recovery period	Recovered with spaghetti tag or secondary mark			Total recovery			Mark incidence		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
22-Oct to 30-Oct	2	4	6	106	150	256	1.9%	2.7%	2.3%
31-Oct to 07-Nov	10	10	20	752	876	1,628	1.3%	1.1%	1.2%
08-Nov to 14-Nov	9	15	24	580	624	1,204	1.6%	2.4%	2.0%
15-Nov to 21-Nov	8	16	24	1,291	1,797	3,088	0.6%	0.9%	0.8%
22-Nov to 28-Nov	18	25	43	1,364	1,342	2,706	1.3%	1.9%	1.6%
29-Nov to 05-Dec	9	17	26	1,365	1,673	3,038	0.7%	1.0%	0.9%
06-Dec to 14-Dec	8	13	21	990	1,297	2,287	0.8%	1.0%	0.9%

Table 4. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1992

Application period	Spaghetti tags and secondary mark applied a			Carcasses recovered with spaghetti tags b			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
19-Oct to 23-Oct	178	115	293	9	13	22	5.1%	11.3%	7.5%
24-Oct to 30-Oct	275	239	514	19	36	55	6.9%	15.1%	10.7%
31-Oct to 05-Nov	171	163	334	11	31	42	6.4%	19.0%	12.6%
06-Nov to 12-Nov	89	111	200	4	12	16	4.5%	10.8%	8.0%
13-Nov to 24-Nov	63	65	128	4	4	8	6.3%	6.2%	6.3%

a. Corrected with sex identification error.

b. Excludes 19 with secondary marks only, and 2 tags which were unreadable at recovery.

Table 5. Proportion of the Harrison River chinook adult spawning ground recovery sample marked with spaghetti tags or secondary marks, by recovery location and sex, 1992.

Recovery section	Recovery reach	Chinook adult carcasses examined			Carcasses recovered with spaghetti tags or secondary marks			Mark incidence		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Upper	Reach 1	0	0	0	0	0	0	-	-	-
	Reach 2	42	33	75	0	0	0	0.0%	0.0%	0.0%
	Total	42	33	75	0	0	0	0.0%	0.0%	0.0%
Middle	Reach 3	400	608	1,008	3	4	7	0.8%	0.7%	0.7%
	Reach 4	1,757	2,561	4,318	8	22	30	0.5%	0.9%	0.7%
	Reach 5	299	301	600	3	8	11	1.0%	2.7%	1.8%
	Total	2,456	3,470	5,926	14	34	48	0.6%	1.0%	0.8%
Lower	Reach 6	2,223	2,637	4,860	27	38	65	1.2%	1.4%	1.3%
	Reach 7	884	903	1,787	5	15	20	0.6%	1.7%	1.1%
	Reach 8	843	716	1,559	18	13	31	2.1%	1.8%	2.0%
	Total	3,950	4,256	8,206	50	66	116	1.3%	1.6%	1.4%

Table 6. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application location and sex, 1992.

Application reach	Spaghetti tags and secondary marks applied a			Carcasses recovered with spaghetti tags b			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Reach 2	124	104	228	7	18	25	5.6%	17.3%	11.0%
Reach 3	43	52	95	1	4	5	2.3%	7.7%	5.3%
Reach 4	607	535	1,142	39	74	113	6.4%	13.8%	9.9%
Reach 6	2	2	4	0	0	0	0.0%	0.0%	0.0%

a. Corrected for sex identification error.

b. Excludes 2 tags (1 male, 1 female) which were unreadable at recovery.

Table 7. Proportion of the Harrison River chinook adult spaghetti tag application sample recovered on the spawning grounds, by sex and 10 cm increments of nose-fork length, 1992.

Nose-fork length (cm)	Spaghetti tags applied a			Carcasses recovered with spaghetti tags b			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
50-59.9	11	0	11	0	0	0	0.0%	-	0.0%
60-69.9	61	3	64	1	1	2	1.6%	33.3%	3.1%
70-79.9	141	59	200	9	5	14	6.4%	8.5%	7.0%
80-89.9	237	354	591	16	42	58	6.8%	11.9%	9.8%
90-99.9	228	262	490	14	42	56	6.1%	16.0%	11.4%
100-109.9	96	15	111	7	6	13	7.3%	40.0%	11.7%
110-119.9	2	0	2	0	0	0	0.0%	-	0.0%

a. Corrected for sex identification error.

b. Excludes 2 tags (1 male, 1 female) which were unreadable at recovery.

Table 8. Sex composition of Harrison River chinook adults in the spaghetti tag application and spawning ground recovery samples, 1992.

Sex	Application sample sex ratio, by recovery status a				Recovery sample sex ratio, by mark status			
	Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
Male	776	39.0%	54.6%	52.8%	6,448	39.0%	45.5%	45.4%
Female	693	61.0%	45.4%	47.2%	7,759	61.0%	54.5%	54.6%

a. Corrected for sex identification error.

Table 9. Incidence of spaghetti tags and secondary marks in chinook adult carcasses recovered near shore and in deep water in the Harrison River, 1992. a

Recovery location	Carcasses recovered			Carcasses recovered with spaghetti tags or secondary marks			Mark incidence		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Shore	5,843	7,070	12,913	55	87	142	0.9%	1.2%	1.1%
Deep water	604	688	1,292	8	12	20	1.3%	1.7%	1.5%

a. Location was not recorded for 2 recoveries (1 male and 1 female).

Table 10. Results of the statistical tests for bias in the 1992 Harrison River chinook adult escapement estimation study. a

Bias type	Application sample	Recovery sample
Statistical	-	No bias
Period	Bias to early period	No bias
Location	Bias to lower reaches	No bias
Fish size	No bias	No bias
Fish sex	No bias	Bias to females
Recovery method	-	No bias

a. A "no bias" test result indicates that bias was not detected,; undetected bias may be present.

Table 11. Escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook adults, 1992.

Sex	Escapement at age				95% confidence limits of total escapement	
	3/1	4/1	5/1	Total	Lower	Upper
Male	25,820	50,164	1,107	77,090	58,585	95,595
Female	4,963	46,165	2,193	53,321	43,041	63,601
Total	30,782	96,329	3,299	130,411	109,242	151,580

Spawning Success

Differential behaviour related to capture and tagging stress was examined by comparing the spawning success of marked (99.0%) and unmarked (97.8%) females (Appendix 7). No significant difference was noted ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

Because serious spatial and temporal biases were not identified in this study (Table 10; see Discussion), escapement was calculated by sex using the simple Petersen estimator. The 1992 escapement of Harrison River chinook adults was

130,411, with lower and upper 95% confidence limits of 109,242 and 151,580 (Table 11). The escapement of male and female chinook adults was 77,090 and 53,321, respectively. Age 4, fish dominated the escapement (74%), followed by ages 3₁ (24%) and 5₁ (3%). Females matured almost one year later than males.

Based on recovery sample chinook adult AFC incidences of 0.48% for males and 0.80% for females (Appendix 5), the 1992 escapement of AFC adults was 797 chinook adults. The escapement by CWT code was not estimated because because sample sizes were not sufficient to permit stratification of the AFC sample by age.

DISCUSSION

ADULT CAPTURE TECHNIQUE

An assumption central to the Petersen mark-recapture technique is that capture and tagging will not influence the subsequent catchability of the fish. We evaluated the effect of tagging stress on subsequent behaviour in two ways. First, we compared the mark incidence in carcasses recovered on the shore and in the deep waters of the main channel. We assumed that stressed fish would move passively downstream, and that the most stressed individuals would die and would be recovered at a higher rate in the main channel. No difference in mark incidence was noted, suggesting that any stress induced loss of marked fish from the population was minor. Second, we compared the spawning success in spaghetti tagged and untagged females. No significant difference was noted. We concluded, therefore, that capture and marking did not influence subsequent behaviour and that the assumption concerning recapture vulnerability was not seriously violated. These results are consistent with the 1990 and 1991 study results (Farwell *et al.* 1991, 1992).

SAMPLING SELECTIVITY

A second assumption underlying the Petersen mark-recapture technique is that the population is sampled in a random or representative manner (Ricker 1975). In studies when nonrepresentative sampling occurs, accurate results may still be achieved if one sample is representative (Robson 1969). 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 samples for four biases, temporal, spatial, fish size, and fish sex, as indicators of weakness in the study design. Although biases were identified in both the application (temporal and spatial biases) and recovery (bias to females) samples (Table 10), they were unlikely to have introduced bias in the escapement estimate. The spatial and temporal biases, while present in the application sample, were not noted in the recovery sample. The sex bias, while present in the recovery sample, was not observed in the application sample and was addressed by stratification. We concluded, therefore, that sampling selectivity was unlikely to have introduced significant bias in the

1992 Harrison River chinook escapement estimate.

ESCAPEMENT TRENDS

The Harrison River mark-recapture study was implemented in 1984 to monitor the rebuilding progress expected from management actions implemented after the signing of the Pacific Salmon Treaty. Escapements declined sharply in the initial years of the rebuilding program, from a high of 174,777 in 1985 to only 35,116 in 1988 (Staley 1990). Subsequent escapements increased to a peak of 177,375 in 1990, but decreased to 90,638 in 1991 (Farwell *et al.* 1991, 1992). The 1992 escapement estimate of 130,411 was above the 1984-1991 average escapement of 114,383 but well below the 1998 escapement goal of 241,700. In its annual evaluation of rebuilding progress, the Chinook Technical Committee (Pacific Salmon Commission 1993) concluded that additional management actions will be required to rebuild the Harrison River chinook stock by 1998.

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 19 to December 14, 1992. 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 1992 chinook adult escapement was estimated from a spaghetti tag application sample of 1,469, a recovery sample of 14,207 adults, and a recovery of 164 carcasses with spaghetti tags or secondary marks. The estimated escapement was 130,411 chinook adults, of which 53,321 were female and 77,090 were male, and 797 had an adipose fin clip.
4. The age composition was 34% age 3, 65% age 4, and 1% age 5, in males, and 9% age

3, 87% age 4, and 4% age 5, in females. POH length averaged 72.2 cm for females and 69.2 for males.

5. Biases were identified in both the application and recovery samples; however, the basic assumptions underlying the Petersen mark-recapture technique were not seriously violated. We concluded, therefore, that the 1992 escapement estimate was relatively free of bias.

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APPENDICES

Appendix 1. Daily application of spaghetti tags and secondary marks, by adipose fin status, sex, and reach, to chinook adults in the Harrison River, 1992. a

Date	Reach	Adipose present			Adipose absent			Total		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
19-Oct	4	13	15 b	28	2	0	2	15	15	30
20-Oct	4	58	34	92	0	0	0	58	34	92
21-Oct	4	56	50 c	106	0	1	1	56	51	107
23-Oct	4	34	28	62	1	1	2	35	29	64
26-Oct	4	85	85	170	2	1	3	87	86	173
27-Oct	2	20 c	14 b	34	1	0	1	21	14	35
	4	49	40	89	0	0	0	49	40	89
29-Oct	2	14	15	29	0	0	0	14	15	29
	4	36 b	55	91	0	1	1	36	56	92
30-Oct	4	46	50 b	96	0	0	0	46	50	96
02-Nov	2	8	13	21	0	1	1	8	14	22
	4	73 b	80	153	2	2	4	75	82	157
03-Nov	2	42	43 b	85	0	0	0	42	43	85
	4	8	14	22	0	1	1	8	15	23
05-Nov	2	23	22	45	2	0	2	25	22	47
09-Nov	2	4	6	10	0	0	0	4	6	10
10-Nov	4	27 c	42	69	0	0	0	27	42	69
12-Nov	4	50	69 b	119	1	1	2	51	70	121
17-Nov	3	27 c	38 c	65	0	0	0	27	38	65
19-Nov	3	12 b	16 b	28	1	1	2	13	17	30
	4	11	10 b	21	0	0	0	11	10	21
24-Nov	4	5	3	8	0	0	0	5	3	8
	6	2	2	4	0	0	0	2	2	4
Total	2	111	113	224	3	1	4	114	114	228
	3	39	54	93	1	1	2	40	55	95
	4	551	575	1,126	8	8	16	559	583	1,142
	6	2	2	4	0	0	0	2	2	4
Total	-	703	744	1,447	12	10	22	715	754	1,469

a. Not corrected for sex identification errors.

b. One required ventilation.

c. Two required ventilation.

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex of chinook adults recovered in the Harrison River, 1992.

Application sample						Recovery sample					Days out
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	
19-Oct	4	83.0	F	P	20004	28-Oct	5	67.0	F	4/1	9
20-Oct	4	81.0	M	P	20038	28-Oct	5	63.5	M	4/1	8
20-Oct	4	94.0	F	P	20040	18-Nov	5	72.8	F	5/1	29
20-Oct	4	94.5	F	P	20053	29-Oct	6	78.1	F	4/1	9
20-Oct	4	82.5	F	P	20065	01-Dec	4	70.2	F	r	42
20-Oct	4	96.0	F	P	20067	25-Nov	8	73.5	M a	r	36
20-Oct	4	102.0	F	P	20078	07-Dec	4	80.4	F	4/1	48
20-Oct	4	85.0	F	P	20099	02-Nov	4	70.3	F	4/1	13
20-Oct	4	101.0	M	P	20106	06-Nov	8	79.0	M	4/1	17
20-Oct	4	102.0	F	P	20107	18-Nov	5	80.0	M a	4/1	29
20-Oct	4	78.0	F	P	20121	28-Oct	6	64.1	F	4/1	8
21-Oct	4	79.5	F	P	20137	02-Dec	6	62.8	F	4/1	42
21-Oct	4	100.5	F	P	20151	20-Nov	6	81.0	F	5/1	30
21-Oct	4	96.0	F	P	20164	01-Dec	4	77.0	M a	4/1	41
21-Oct	4	84.0	M	P	20199	02-Nov	4	68.0	F a	4/1	12
21-Oct	4	86.0	F	P	20201	03-Nov	4	68.4	F	4/1	13
21-Oct	4	94.5	F	P	20213	02-Dec	6	73.2	F	4/1	42
21-Oct	4	87.0	F	P	20221	26-Nov	7	64.3	F	4/1	36
23-Oct	4	88.0	M	P	20234	04-Nov	7	68.5	M	4/1	12
23-Oct	4	83.0	M	P	20243	20-Nov	6	64.5	M	3/1	28
23-Oct	4	89.5	M	P	20266	28-Oct	5	69.5	M	4/1	5
23-Oct	4	78.5	M	P	20271	06-Nov	8	62.0	M	4/1	14
26-Oct	4	100.0	M	P	20318	25-Nov	8	78.8	M	4/1	30
26-Oct	4	93.0	F	P	20329	05-Nov	6	69.1	F	4/1	10
26-Oct	4	94.0	F	P	20335	30-Nov	3	76.1	F	4/1	35
26-Oct	4	87.0	F	P	20341	16-Nov	4	69.1	F	5/1	21
26-Oct	4	99.0	M	P	20351	20-Nov	6	78.2	M	4/1	25
26-Oct	4	85.0	F	P	20369	12-Nov	4	71.1	F	4/1	17
26-Oct	4	75.0	M	P	20371	03-Nov	4	59.2	M	3/1	8
26-Oct	4	94.0	M	P	20393	09-Nov	6	72.4	M	3/1	14
26-Oct	4	98.0	M	P	20398	13-Nov	8	72.5	M	4/1	18
26-Oct	4	104.0	F	P	20399	23-Nov	6	85.0	F	4/1	28
26-Oct	4	94.0	F	P	20403	13-Nov	8	77.4	F	4/1	18
26-Oct	4	101.0	F	P	20405	09-Nov	6	82.7	F	4/1	14
26-Oct	4	84.0	F	P	20423	08-Dec	5	69.7	F	r	43
26-Oct	4	92.0	F	P	20439	26-Nov	7	75.5	F	4/1	31
26-Oct	4	88.0	F	P	20465	09-Nov	6	71.7	F	4/1	14
26-Oct	4	92.5	F	P	20468	02-Nov	4	75.7	F	4/1	7
27-Oct	4	91.0	F	P	20476	16-Nov	4	78.6	F	4/1	20
27-Oct	4	94.0	M	P	20492	13-Nov	8	78.0	M b	4/1	17
27-Oct	4	84.0	F	P	20502	10-Dec	6	66.7	F	4/1	44
27-Oct	4	97.0	M	P	20503	03-Dec	6	78.0	M	4/1	37
27-Oct	4	88.5	F	P	20521	18-Nov	5	71.5	F	4/1	22
27-Oct	4	96.0	F	P	20531	04-Nov	6	77.0	F	4/1	8
27-Oct	4	100.5	F	P	20537	13-Nov	8	80.5	F	4/1	17

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex of chinook adults recovered in the Harrison River, 1992 continued.

Application sample						Recovery sample					Days out
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	
27-Oct	4	72.0	M	P	20548	02-Dec	6	55.9	M	3/1	36
27-Oct	4	82.5	F	P	20556	26-Nov	7	69.0	F	4/1	30
27-Oct	4	98.5	F	P	20567	09-Nov	6	79.0	F	4/1	13
27-Oct	4	83.5	F	P	20590	28-Oct	4	56.8	F	4/1	1
29-Oct	4	95.0	F	P	20595	12-Nov	4	76.3	F	4/1	14
29-Oct	4	93.0	F	P	20599	04-Nov	7	76.0	F	4/1	6
29-Oct	4	79.5	M	P	20703	25-Nov	8	66.7	M	4/1	27
29-Oct	4	102.0	M	P	20704	26-Nov	7	81.0	M	-	28
29-Oct	4	88.0	M	P	20710	23-Nov	6	67.3	M	3/1	25
29-Oct	4	88.5	F	P	20711	18-Nov	5	-	-	4/1	20
29-Oct	4	83.0	M	P	20716	02-Dec	6	64.1	M	4/1	34
29-Oct	4	80.0	F	P	20719	07-Dec	4	60.9	F	-	39
29-Oct	4	95.0	F	P	20721	02-Dec	6	74.7	F	4/1	34
29-Oct	4	91.0	F	P	20729	09-Nov	6	72.5	F	4/1	11
29-Oct	4	91.0	F	P	20734	09-Nov	6	74.2	F	4/1	11
29-Oct	4	97.0	F	P	20735	09-Dec	7	76.8	F	4/1	41
29-Oct	4	101.0	F	P	20758	01-Dec	4	81.0	F	4/1	33
29-Oct	4	101.0	M	P	20760	09-Nov	6	79.3	M	4/1	11
29-Oct	4	91.0	F	P	20769	10-Dec	6	69.7	F	4/1	42
29-Oct	4	84.0	M	P	20784	20-Nov	6	66.5	F a	4/1	22
30-Oct	4	90.0	F	P	20813	02-Dec	6	71.3	F	4/1	33
30-Oct	4	85.0	M	P	20815	04-Nov	7	67.8	M	3/1	5
30-Oct	4	77.0	F	P	20818	16-Nov	3	59.9	F	3/1	17
30-Oct	4	76.0	M	P	20820	13-Nov	8	60.0	M	3/1	14
30-Oct	4	65.5	M	P	20823	09-Nov	6	64.9	F a,c	4/1	10
30-Oct	4	80.5	F	P	20824	03-Dec	6	-	M a	4/1	34
30-Oct	4	84.5	F	P	20830	05-Nov	6	67.4	F	4/1	6
30-Oct	4	87.5	F	P	20838	13-Nov	8	72.7	F	4/1	14
30-Oct	4	84.0	M	P	20842	10-Dec	6	64.6	M	3/1	41
30-Oct	4	82.0	F	P	20877	25-Nov	8	65.7	M a	3/1	26
30-Oct	4	95.0	F	P	20887	13-Nov	8	79.2	F	4/1	14
30-Oct	4	90.0	M	P	20901	13-Nov	8	71.0	M	r	14
02-Nov	4	65.0	M	P	20934	25-Nov	8	52.4	M	3/1	23
02-Nov	4	92.0	F	P	20940	20-Nov	6	74.0	F	4/1	18
02-Nov	4	95.0	F	P	20945	26-Nov	7	76.4	F	r	24
02-Nov	4	88.0	F	P	20952	13-Nov	8	72.0	F	4/1	11
02-Nov	4	83.0	F	P	20963	13-Nov	8	63.0	F	3/1	11
02-Nov	4	87.0	M	P	20980	20-Nov	6	68.7	M	4/1	18
02-Nov	4	86.0	F	P	20994	05-Nov	6	71.2	F	4/1	3
02-Nov	4	81.0	F	P	21114	08-Dec	4	65.3	F	4/1	36
02-Nov	4	102.0	M	P	21118	05-Nov	6	78.9	M	4/1	3
02-Nov	4	70.0	F	P	21125	13-Nov	8	57.7	F	4/1	11
02-Nov	4	95.5	F	P	21145	23-Nov	6	78.1	F	4/1	21
02-Nov	4	75.5	M	P	21152	06-Nov	8	60.1	M	3/1	4
02-Nov	4	99.0	F	P	21155	03-Dec	8	77.5	F	4/1	31

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex of chinook adults recovered in the Harrison River, 1992 continued.

Application sample						Recovery sample					Days out
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	
03-Nov	2	77.0	F	P	21002	18-Nov	5	63.8	F	3/1	15
05-Nov	2	89.0	F	P	21019	26-Nov	7	72.5	F	4/1	21
05-Nov	2	92.5	M	P	21024	16-Nov	4	73.3	M	4/1	11
05-Nov	2	90.0	M	A	21033	30-Nov	3	71.3	M d	4/1	25
05-Nov	2	84.5	F	P	21045	30-Nov	3	69.6	F	4/1	25
09-Nov	2	80.0	F	P	21053	08-Dec	7	66.5	F	4/1	29
10-Nov	4	88.0	F	P	21064	25-Nov	8	75.5	F	4/1	15
10-Nov	4	96.0	F	P	21076	02-Dec	6	76.0	F	4/1	22
10-Nov	4	80.0	M	P	21084	25-Nov	8	64.5	M	3/1	15
10-Nov	4	90.0	F	P	21091	23-Nov	6	71.5	F	4/1	13
10-Nov	4	85.0	F	P	21098	23-Nov	6	-	F	4/1	13
02-Nov	4	87.5	F	P	21171	08-Dec	4	66.2	F	4/1	36
02-Nov	4	97.0	F	P	21174	25-Nov	8	77.5	F	4/1	23
02-Nov	4	86.0	F	P	21175	23-Nov	6	69.5	F	4/1	21
03-Nov	4	97.0	F	P	21185	17-Nov	4	78.8	F	4/1	14
03-Nov	4	86.5	F	P	21201	23-Nov	6	70.2	F	4/1	20
03-Nov	2	90.0	F	P	21208	25-Nov	8	77.0	F d	4/1	22
03-Nov	2	86.0	F	P	21210	05-Nov	6	72.0	F b	4/1	2
03-Nov	2	93.0	F	P	21213	03-Dec	6	73.4	F	4/1	30
03-Nov	2	88.0	F	P	21215	02-Dec	6	70.5	F	4/1	29
03-Nov	2	83.5	F	P	21222	18-Nov	5	71.5	F	4/1	15
03-Nov	2	87.0	M	P	21224	16-Nov	3	69.0	M	3/1	13
03-Nov	2	91.0	F	P	21231	08-Dec	4	69.0	F d	4/1	35
03-Nov	2	98.0	M	P	21233	25-Nov	8	79.5	M	4/1	22
03-Nov	2	88.0	F	P	21236	23-Nov	6	69.5	F	4/1	20
03-Nov	2	81.0	M	P	21243	23-Nov	6	66.5	F a	4/1	20
03-Nov	2	94.0	M	P	21244	09-Dec	7	79.0	F a	4/1	36
03-Nov	2	81.5	F	P	21247	07-Dec	4	64.8	M a	3/1	34
03-Nov	2	95.5	M	P	21251	16-Nov	4	73.7	M	4/1	13
03-Nov	2	85.0	F	P	21252	16-Nov	4	74.0	F	4/1	13
03-Nov	2	81.0	F	P	21267	30-Nov	5	68.0	F	4/1	27
03-Nov	2	85.0	F	P	21270	26-Nov	7	68.3	F	5/1	23
03-Nov	2	85.0	M	P	21272	23-Nov	6	66.8	M	r	20
03-Nov	2	90.0	F	P	21280	16-Nov	4	71.2	F	4/1	13
03-Nov	2	95.0	F	P	21299	08-Dec	4	73.5	F	4/1	35
10-Nov	4	85.0	F	P	21301	25-Nov	8	72.5	F	4/1	15
10-Nov	4	72.0	M	P	21305	25-Nov	8	59.3	M	3/1	15
10-Nov	4	92.0	F	P	21315	03-Dec	7	74.7	F	4/1	23
10-Nov	4	90.0	F	P	21316	02-Dec	6	73.0	F	4/1	22
10-Nov	4	93.0	F	P	21318	23-Nov	6	77.0	F	4/1	13
10-Nov	4	103.0	M	P	21327	02-Dec	6	79.3	M b	4/1	22
12-Nov	4	82.0	F	P	21370	26-Nov	7	68.0	F	4/1	14
12-Nov	4	95.0	F	P	21383	20-Nov	6	78.3	F	4/1	8
12-Nov	4	94.0	F	P	21419	26-Nov	7	77.0	F	4/1	14
12-Nov	4	94.0	M	P	21436	09-Dec	7	76.1	M	4/1	27
17-Nov	3	93.0	F	P	21468	25-Nov	8	78.4	F	5/1	8
17-Nov	3	91.0	F	P	21477	07-Dec	4	75.8	F	4/1	20

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, age and sex of chinook adults recovered in the Harrison River, 1992 continued.

Application sample						Recovery sample					Days out
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	
17-Nov	4	87.0	M	P	21500	14-Dec	8	66.5	M	4/1	27
17-Nov	3	95.0	F	P	21505	26-Nov	7	77.4	F	5/1	9
17-Nov	3	73.0	M	P	21520	30-Nov	3	59.2	M	r	13
19-Nov	3	85.5	F	P	21538	03-Dec	6	70.8	F	4/1	14
19-Nov	4	77.0	M	P	21543	08-Dec	4	62.0	M	4/1	19
19-Nov	4	94.0	M	P	21552	08-Dec	4	73.2	M	4/1	19
-	-	-	-	-	unreadable	01-Dec	4	66.0	M	3/1	n/a
-	-	-	-	-	unreadable	26-Nov	7	72.5	F	4/1	n/a
Primary tag lost; application data unknown						09-Nov	6	75.2	M	4/1	n/a
Primary tag lost; application data unknown						16-Nov	3	68.9	F	r	n/a
Primary tag lost; application data unknown						23-Nov	6	71.6	M	4/1	n/a
Primary tag lost; application data unknown						23-Nov	6	59.8	M	3/1	n/a
Primary tag lost; application data unknown						25-Nov	8	64.5	M	3/1	n/a
Primary tag lost; application data unknown						01-Dec	4	79.0	F	4/1	n/a
Primary tag lost; application data unknown						10-Dec	6	69.3	M	r	n/a
Primary tag lost; application data unknown						10-Dec	6	64.2	M	4/1	n/a
Primary tag lost; application data unknown						20-Nov	6	71.0	M	4/1	n/a
Primary tag lost; application data unknown						23-Nov	6	78.6	M	4/1	n/a
Primary tag lost; application data unknown						23-Nov	6	63.5	M	3/1	n/a
Primary tag lost; application data unknown						23-Nov	6	72.0	M	4/1	n/a
Primary tag lost; application data unknown						23-Nov	6	66.5	F	4/1	n/a
Primary tag lost; application data unknown						23-Nov	6	79.0	M	4/1	n/a
Primary tag lost; application data unknown						05-Nov	6	62.0	M	3/1	n/a
Primary tag lost; application data unknown						05-Nov	6	58.5	M	3/1	n/a
Primary tag lost; application data unknown						09-Nov	6	63.0	M	3/1	n/a
Primary tag lost; application data unknown						13-Nov	8	84.0	M	4/1	n/a
Primary tag lost; application data unknown						04-Nov	7	71.0	M	4/1	n/a
Females initially identified as males:				5	5.3%	Mean days out:				20.9	
Males initially identified as females:				6	12.8%	Max. days out:				48.0	
						Min. days out:				1.0	
POH and NF Regressions:		Males	POH =	0.74 NF + 4.20							
			NF =	1.29 POH - 1.57							
		Females	POH =	0.75 NF + 5.44							
			NF =	1.05 POH + 13.80							

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

c. Lengths not included in regressions.
 d. No secondary mark.

Appendix 3. Daily chinook carcass recoveries, by mark status, sex and reach, in the Harrison River, 1992.

Date	Reach	Unmarked		Spaghetti tag and secondary mark		Secondary mark only		Total			Adipose fin absent	
		Male	Female	Male	Female	Male	Female	Male	Female	Jack a	Male	Female
22-Oct	5	3	1	0	0	0	0	3	1	0	0	0
	6	28	30	0	0	0	0	28	30	30	0	1
	7	4	11	0	0	0	0	4	11	7	0	0
28-Oct	4	15	36	0	1	0	0	15	37	10	0	0
	5	17	26	2	1	0	0	19	27	18	0	0
	6	17	27	0	1	0	0	17	28	10	0	1
29-Oct	6	20	15	0	1	0	0	20	16	9	0	0
02-Nov	4	49	100	0	3	0	0	49	103	26	0	0
03-Nov	4	104	135	1	1	0	0	105	136	21	0	0
04-Nov	6	42	38	0	1	0	0	42	39	27	0	0
	7	140	145	2	1	1	0	143	146	93	0	1
05-Nov	6	260	341	1	4 b	2	0	263	345	85	0	0
06-Nov	8	147	107	3	0	0	0	150	107	100	3	2
09-Nov	6	280	307	2	6	2	0	284	313	91	1	3
10-Nov	4	47	75	0	0	0	0	47	75	30	0	1
12-Nov	4	46	72	0	2	0	0	46	74	11	0	0
13-Nov	8	198	155	4 b	7	1	0	203	162	102	6	2
16-Nov	3	123	218	1	1	0	1	124	220	19	3	2
	4	391	635	2	4	0	0	393	639	246	3	9
17-Nov	4	44	49	0	1	0	0	44	50	22	0	1
18-Nov	3	30	53	0	0	0	0	30	53	9	1	0
	5	169	153	1	5	0	0	170	158	53	2	1
	6	30	26	0	0	0	0	30	26	5	0	1
20-Nov	6	496	647	3	4	1	0	500	651	84	3	8
23-Nov	6	433	484	2	9	6	1	441	494	167	0	5
25-Nov	8	348	312	8	5 d	1	0	357	317	167	4	6
26-Nov	7	482	433	1	10	0	0	483	443	174	1	5 c
27-Nov	7	61	68	0	0	0	0	61	68	79	0	1
	8	22	20	0	0	0	0	22	20	22	0	0
30-Nov	3	110	171	2 d	2	0	0	112	173	54	0	2
	5	92	94	0	1	0	0	92	95	49	0	1
01-Dec	4	521	654	2	2	0	1	523	657	83	1	1
02-Dec	4	40	61	0	0	0	0	40	61	6	0	0
	6	324	376	3 b	7	0	0	327	383	77	0	2
03-Dec	2	12	9	0	0	0	0	12	9	1	0	0
	6	150	187	2	2	0	0	152	189	27	0	0
	7	58	63	0	1	0	0	58	64	13	0	0
	8	49	40	0	1	0	0	49	41	2	1	0
04-Dec	8	0	1	0	0	0	0	0	1	0	0	1
07-Dec	2	30	24	0	0	0	0	30	24	0	1	0
	3	134	162	0	0	0	0	134	162	25	0	0
	4	196	302	1	3	0	0	197	305	57	0	4
08-Dec	4	218	286	2	4 d	0	0	220	290	44	0	0
	5	15	19	0	1	0	0	15	20	15	0	0
	6	11	19	0	0	0	0	11	19	6	0	0
	7	60	90	0	1	0	0	60	91	6	0	0
09-Dec	7	74	78	1	2	0	0	75	80	3	1	1
10-Dec	4	69	120	0	0	0	0	69	120	12	0	0
	6	105	102	1	2	2	0	108	104	61	0	0
14-Dec	4	9	14	0	0	0	0	9	14	2	0	0
	8	61	68	1	0	0	0	62	68	0	0	0

Continued

Appendix 3. Daily chinook carcass recoveries, by mark status, sex and reach, in the Harrison River, 1992.

Date	Reach	Unmarked		Spaghetti tag and secondary mark		Secondary mark only		Total			Adipose fin absent	
		Male	Female	Male	Female	Male	Female	Male	Female	Jack a	Male	Female
Total	2	42	33	0	0	0	0	42	33	1	1	0
	3	397	604	3	3	0	1	400	608	107	4	4
	4	1,749	2,539	8	21	0	1	1,757	2,561	570	4	16
	5	296	293	3	8	0	0	299	301	135	2	2
	6	2,196	2,599	14	37	13	1	2,223	2,637	679	4	21
	7	879	888	4	15	1	0	884	903	375	2	8
	8	825	703	16	13	2	0	843	716	393	14	11
	Total	6,384	7,659	48 d	97 e	16	3	6,448	7,759	2,260	31	62

a. AFC status was not recorded for jacks.

b. 1 required ventilation at release.

c. Includes 2 with questionable AFCs.

d. Includes 1 with no secondary mark.

e. Includes 2 with no secondary mark.

Appendix 4. Proportion at age and mean length at age, by sex, of adipose fin clipped and unmarked Harrison River chinook adult spawning ground recoveries, 1992.

Mark status	Age a	Female			Male			
		Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)	
Unmarked	5/1	16	4.0%	78.2	3	1.6%	80.8	
	4/1	347	86.5%	72.7	119	65.4%	75.1	
	3/1	38	9.5%	67.2	60	33.0%	63.8	
	Sub-1	401	100.0%	-	182	100.0%	71.5	
	Sub-2	0	0.0%	-	0	0.0%	-	
	Red	2	0.5%	70.0	0	0.0%	-	
	White	417	99.5%	72.3	201	100.0%	70.7	
	Total	419	67.6%	72.3	201	32.4%	70.7	
	Adipose fin clip	5/1	3	4.9%	70.7	0	0.0%	-
		4/1	53	86.9%	72.5	17	63.0%	74.9
3/1		5	8.2%	68.9	10	37.0%	65.6	
Sub-1		62	100.0%	72.0	31	100.0%	72.0	
Sub-2		0	0.0%	-	0	0.0%	-	
Red		1	1.6%	79.3	0	0.0%	-	
White		61	98.4%	71.9	31	100.0%	72.0	
Total		62	66.7%	72.0	31	33.3%	72.0	
Total		5/1	19	4.1%	77.1	3	1.4%	80.0
		4/1	400	86.6%	72.6	136	65.1%	75.1
	3/1	43	9.3%	67.3	70	33.5%	64.1	
	Sub-1	462	100.0%	72.2	209	100.0%	71.5	
	Sub-2	0	0.0%	-	0	0.0%	-	
	Red	3	0.6%	73.1	0	0.0%	62.0	
	White	478	99.4%	72.2	232	100.0%	69.3	
	Total	481	67.5%	72.2	232	32.5%	69.2	

a. Totals include unageable samples.

Appendix 5. AFC and CWT sampling of chinook adults recovered on the Harrison River spawning grounds, 1992

	Number of CWT's recovered		
	Adult male	Adult female	Total
Sample size	6,448	7,759	14,207
Number with AFCs	31	62	93
- head not taken	2	1	
- AFC but no head	0	2	2
- CWT lost during processing	0	0	0
- AFC but no CWT	8	14	22
- CWT recovered:			
Code	Brood	Release site	
02 57 47	1988	Chilliwack Hatchery	3
02 57 48	1988	Chilliwack Hatchery	5
02 57 61	1988	Chehalis Hatchery	20
02 57 62	1988	Chehalis Hatchery	28
02 06 41	1989	Chehalis Hatchery	4
02 06 42	1989	Chehalis Hatchery	3
02 06 43	1989	Chehalis Hatchery	3
Total			66
AFC incidence (%)	0.48%	0.80%	0.65%
CWT loss (%)	27.59%	23.73%	25.00%

Appendix 6. Incidence of CWT loss by carcass condition, eye status, and AFC condition in AFC chinook adult carcasses in the Harrison River, 1992.

Observation	Condition	Number	CWT absent	CWT loss (%)
Carcass condition	Fresh	6	1	16.7%
	Moderately fresh	28	5	17.9%
	Moderately rotten	46 a	10	21.7%
	Rotten	11	6	54.5%
Eyes b	Present	60 a	14	23.3%
	Absent	13	6	46.2%
Adipose fin clip c	Complete	65 a	11	16.9%
	Partial	12	8	66.7%
	Questionable	2	2	100.0%

a. Excludes 2 with no head.

b. Eye condition was not recorded for 18 carcasses.

c. AFC condition was not recorded for 12 carcasses.

Appendix 7. Spawning success, by mark status, in female chinook carcasses recovered on the Harrison River spawning grounds, 1992.

Mark status		Percent spawned			Weighted mean
		0%	50%	100%	
Spaghetti tag or secondary mark	Number	1	0	99	99.0%
	Percent	1.0%	0.0%	99.0%	
Unmarked	Number	8	0	363	97.8%
	Percent	2.2%	0.0%	97.8%	
Total	Number	9	0	462	97.8%
	Percent	1.9%	0.0%	98.1%	

