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# Enumeration of the 1990 Harrison River Chinook Salmon Escapement

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# ENUMERATION OF THE 1990 HARRISON RIVER CHINOOK SALMON ESCAPEMENT

by

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Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1991. Enumeration of the 1990 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2111: 26 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 1990, the Harrison River chinook escapement was estimated, using the Petersen mark-recapture method, at 177,375 adults. The sex composition of the escapement was 41% female and 59% male. The age composition of the recovery sample was 0.3% age $2_1$, 2.3% age $3_1$, 95.3% age $4_1$, and 2.0% 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. 1991. Enumeration of the 1990 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2111: 26 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 1990, l'échappée du quinnat dans la rivière Harrison a été évaluée à 177 375 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 de l'échantillon de récupération était la suivante: 0,3% d'âge $2_1$, 2,3% d'âge $3_1$, 95,3% d'âge $4_1$, et 2,0% 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.

Previous reports have documented the 1984-89 Harrison River chinook enumeration studies (Staley 1990, Farwell **et al.** 1990). The current report documents the 1990 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.

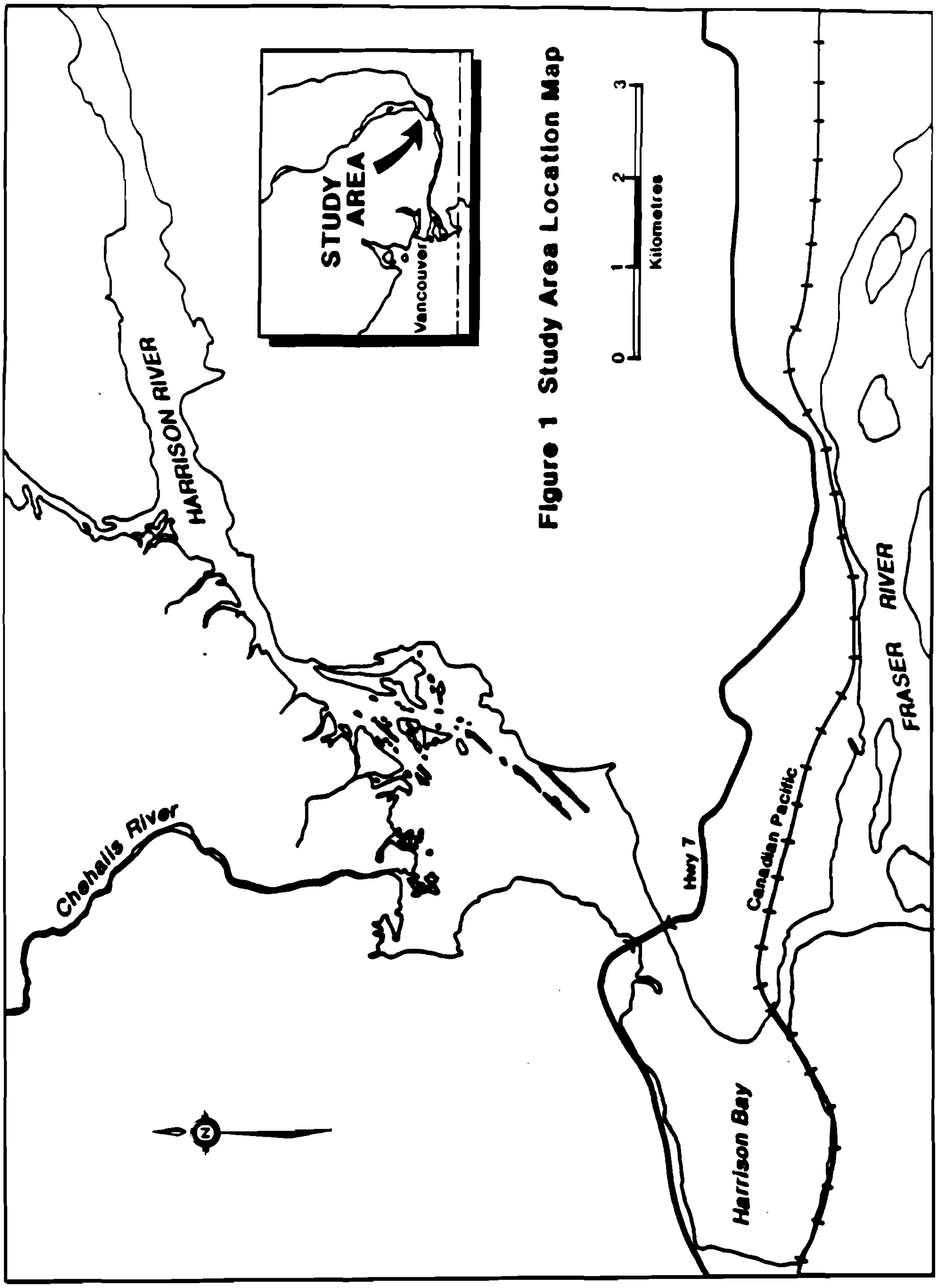


Figure 1 Study Area Location Map

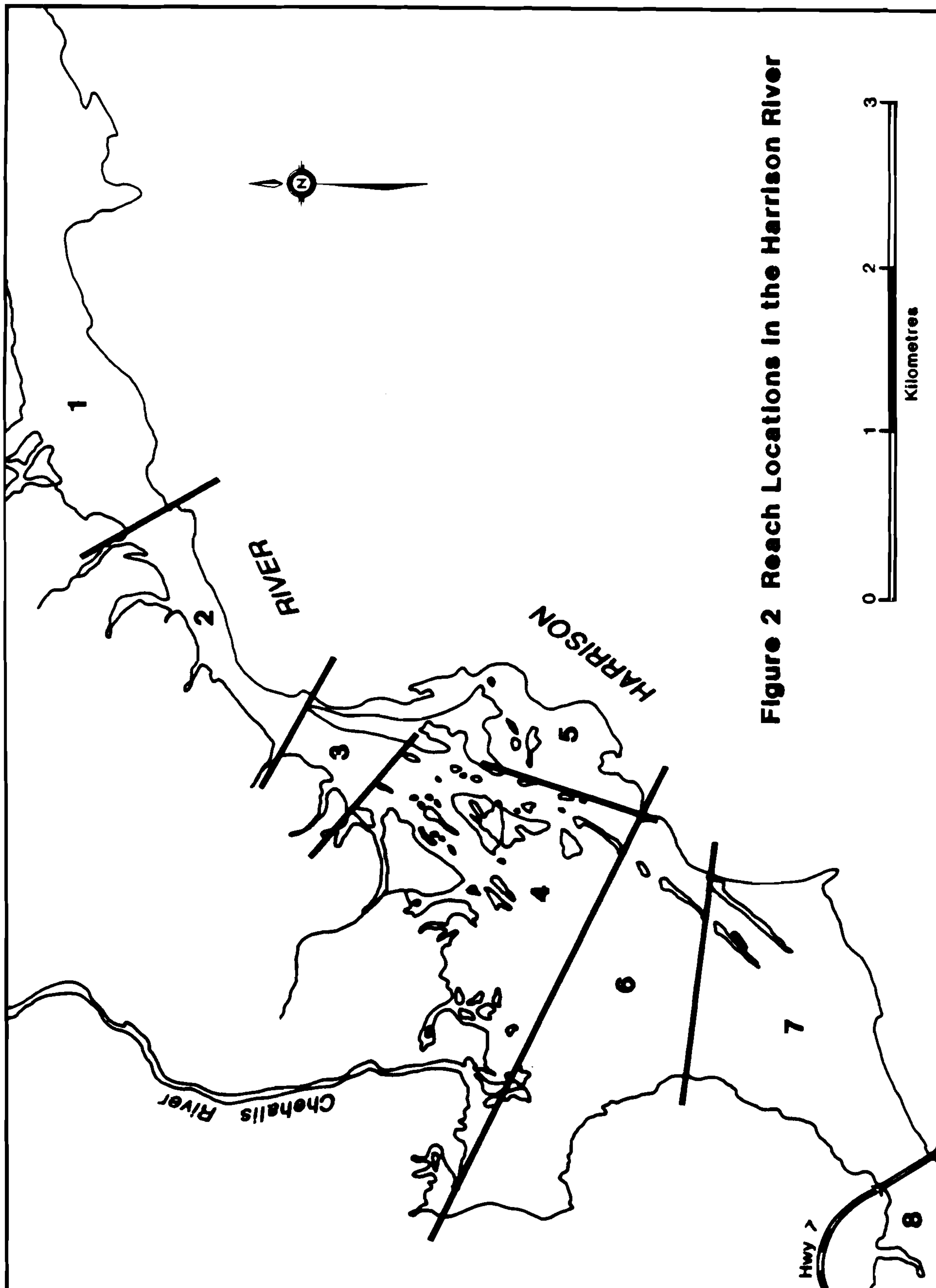


Figure 2 Reach Locations in the Harrison River

Reach 5 (km 7.7 to 6.3) is a 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 divides the reach into two sections.

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, 3, and 4 from October 15 to November 8, 1990 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 removed for tagging and release.

### 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 in 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 14, 1990. 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 1990 escapement of Harrison River chinook adults was calculated from the markrecapture 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 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 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 ($M_m$):

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

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 as males;
- $R_{f,m}$ = 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 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

Three thousand six hundred ten chinook adults were released with spaghetti tags and secondary marks from October 15 to November 8, 1990 (Appendix 1). Release condition was good, with only four (0.1%) requiring ventilation (Table 2). The recovery of this group (25.0%) was significantly higher ($p < 0.05$; chi-square) than that of the remaining fish (3.7%). Consequently, these fish were removed from the application and recovery samples (Table 1).

An estimated 35.7% of the males and 0.8% of the females were misidentified at the time of tagging (Appendix 2). After adjustments for release condition and sex identification error, an estimated 1,543 (42.8%) males and 2,063 (57.2%) females were released with spaghetti tags and secondary marks (Table 1).

#### Spawning Ground Recovery

After adjustment for release condition, 7,080 chinook adults were recovered on the spawning grounds from October 18 to December 14, 1990 (Table 1; Appendix 3). Of that total, 2,577 (36.4%) were male, 4,503 (63.6%) were female, 54 (0.8%) had AFCs, 134 (1.9%) had spaghetti tags and secondary marks, and 30 (0.4%) had secondary marks only. Males (62.2%) lost tags at a significantly higher rate than females (5.5%) ($p < 0.05$; chi-square).

### SAMPLING SELECTIVITY

#### Period

Temporal bias in the application sample was examined by comparing

Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1990.

| Sex | Spaghetti tags applied[a] | Carcasses examined[b] | Marks recovered[b]: Spaghetti tag and secondary mark | Marks recovered[b]: Secondary mark only | Marks recovered[b]: Spaghetti tag only | Marks recovered[b]: Total | Percent recovered |
|---|---|---|---|---|---|---|---|
| Male | 1,543 | 2,577 | 14 | 23 | 0 | 37 | 2.4% |
| Female | 2,063 | 4,503 | 120 | 7 | 0 | 127 | 6.2% |
| Total | 3,606 | 7,080 | 134 | 30 | 0 | 164 | 4.5% |

[a] Adjusted for sex identification error. Excludes 4 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, 1990.

| Release condition | Spaghetti tags applied | Spaghetti tags recovered | Percent recovered |
|---|---|---|---|
| Fish swam away without assistance | 3,606 | 134 | 3.7% |
| Fish required ventilation | 4 | 1 | 25.0% |
| Total | 3,610 | 135 | 3.7% |

between periods the mark incidence in the recovery sample (Table 3), where mark incidence was defined as the incidence of chinook adults marked with either a spaghetti tag or secondary mark. Mark incidence was significantly different than expected ($p < 0.05$; chi-square), with a higher incidence (3.9%) in the week of November 19-25.

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 4). No significant 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 1.9% to 3.4%, was not different from that expected ($p > 0.05$; chi-square).

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). The proportion female was significantly higher in the recovered group ($p < 0.05$; 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 (6.2%) than males (2.4%) (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 (2.2%) and in deep water (2.7%) (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 (93.4%) and unmarked (94.4%) females (Appendix 4). No significant difference was noted ($p > 0.05$; chi-square).

## ESTIMATION OF SPAWNER POPULATION

**Total Escapement**

The 1990 escapement of Harrison River chinook adults, calculated from

Table 3. Incidence of spaghetti tags or secondary marks in chinook salmon recovered on the spawning grounds, by period, in the Harrison River, 1990.

| Recovery period | Recovered with spaghetti tag or secondary mark | | Total recovery | | Mark incidence (%) |
|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | |
| 22 Oct to 28 Oct | 6 | 3.6% | 445 | 6.3% | 1.3% |
| 29 Oct to 04 Nov | 19 | 11.5% | 1,104 | 15.6% | 1.7% |
| 05 Nov to 11 Nov | 34 | 20.6% | 1,819 | 25.7% | 1.9% |
| 12 Nov to 18 Nov a | 0 | 0.0% | 0 | 0.0% | - |
| 19 Nov to 25 Nov | 53 | 32.1% | 1,366 | 19.3% | 3.9% |
| 26 Nov to 02 Dec | 22 | 13.3% | 845 | 11.9% | 2.6% |
| 03 Dec to 09 Dec | 15 | 9.1% | 633 | 8.9% | 2.4% |
| 10 Dec to 16 Dec | 16 | 9.7% | 869 | 12.3% | 1.8% |
| Total | 165 | - | 7,081 | - | 2.3% |

a. Flood conditions, no recovery effort.

Table 4. Proportion of the spaghetti tag application sample recovered on the spawning grounds, by period, in the Harrison River, 1990.

| Application period | Spaghetti tags applied[a] | Spaghetti tags recovered[b] | Percent recovered |
|---|---|---|---|
| 15 Oct to 21 Oct | 816 | 33 | 4.0% |
| 22 Oct to 28 Oct | 1,081 | 39 | 3.6% |
| 29 Oct to 04 Nov | 1,066 | 43 | 4.0% |
| 05 Nov to 11 Nov | 643 | 19 | 3.0% |
| Total | 3,606 | 134 | 3.7% |

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release, and 30 with a secondary mark only.

Table 5. Incidence of spaghetti tags and secondary marks, by reach and section, in the Harrison River spawning ground recovery sample, 1990.

| 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 | 155 | 2.2% | 4 | 2.4% | 2.6% |
| | Total | 155 | 2.2% | 4 | 2.4% | 2.6% |
| Middle | Reach 3 | 638 | 9.0% | 15 | 9.1% | 2.4% |
| | Reach 4 | 1,933 | 27.3% | 41 | 25.0% | 2.1% |
| | Reach 5 | 553 | 7.8% | 19 | 11.6% | 3.4% |
| | Total | 3,124 | 44.1% | 75 | 45.7% | 2.4% |
| Lower | Reach 6 | 2,250 | 31.8% | 42 | 25.6% | 1.9% |
| | Reach 7 | 1,032 | 14.6% | 29 | 17.7% | 2.8% |
| | Reach 8 | 519 | 7.3% | 14 | 8.5% | 2.7% |
| | Total | 3,801 | 53.7% | 85 | 51.8% | 2.2% |
| Total | - | 7,080 | - | 164 | - | 2.3% |

[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, 1990.

| Reach | Tags applied[a] | Tags recovered[b] | Percent recovered |
|---|---|---|---|
| Reach 2 | 3,542 | 134 | 3.8% |
| Reach 3 | 42 | 0 | 0.0% |
| Reach 4 | 22 | 0 | 0.0% |
| Total | 3,606 | 134 | 3.7% |

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 30 with a secondary mark only.

Table 7. Spaghetti tag application and recovery of Harrison River chinook adults, by nose-fork length, 1990.

| Nose-fork length (cm) | Spaghetti tags applied[a] | Carcasses recovered with spaghetti tags[b] | Percent recovered |
|---|---|---|---|
| 60-69 | 80 | 1 | 1.3% |
| 70-79 | 268 | 6 | 2.2% |
| 80-89 | 1,553 | 65 | 4.2% |
| 90-99 | 1,403 | 54 | 3.9% |
| 100-109 | 287 | 8 | 2.8% |
| 110-119 | 15 | 0 | 0.0% |
| Total | 3,606 | 134 | 3.7% |

[a] Excludes 4 which required ventilation at release.
[b] Excludes 1 which required ventilation at release and 30 with a secondary mark only.

Table 8. Sex composition of application and recovery samples of Harrison River chinook adults, 1990.

| Sex | | Application sample[a] | | | Recovery sample[b] | | |
|---|---|---|---|---|---|---|---|
| | | Recovered[b] | Not recovered | Total | Marked | Unmarked | Total |
| Male | Percent | 22.6 | 38.3 | 37.5 | 22.6 | 36.7 | 36.4 |
| | Number | 37 | 1,317 | 1,354 | 37 | 2,540 | 2,577 |
| Female | Percent | 77.4 | 61.7 | 62.5 | 77.4 | 63.3 | 63.6 |
| | Number | 127 | 2,125 | 2,252 | 127 | 4,376 | 4,503 |
| Total | Number | 164 | 3,442 | 3,606 | 164 | 6,916 | 7,080 |

[a] Excludes 4 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, 1990.

| Method | Number recovered[a] | Recovered with tags or secondary marks[a] | Mark incidence (%) |
|---|---|---|---|
| Shore recovery | 5,588 | 124 | 2.2% |
| Deep water recovery | 1,492 | 40 | 2.7% |
| Total | 7,080 | 164 | 2.3% |

[a] Excludes 1 which required ventilation at release.

Table 10. Escapement estimates, by sex, for Harrison River chinook adults, 1990.

| Sex | Escapement estimate | 95% confidence limit | |
|---|---|---|---|
| | | Lower | Upper |
| Male | 104,748 | 72,116 | 137,380 |
| Female | 72,627 | 60,273 | 84,981 |
| Total | 177,375 | 142,483 | 212,268 |
| AFC Adult | 1,353 | - | - |

the mark-recapture data, was 177,375, with lower and upper 95% confidence limits of 142,483 and 212,268 (Table 10). The escapement of male and female chinook adults was 104,748 and 72,627, respectively.

### Adipose Fin Clipped Escapement

Based on the chinook adult AFC incidence in the recovery sample (0.8%) (Appendix 3), the 1990 escapement of AFC adults was 1353 chinook (Table 10). CWT escapement estimates were not determined because total 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 ($p > 0.05$; chi square); however, the CWT absence (100%) in carcasses with questionable clips was significantly higher than that in carcasses with complete (13%) or partial clips (50%) ($p < 0.05$) (Appendix 6).

## AGE, LENGTH AND SEX

The age composition of 299 chinook adults recovered without AFCs was 2.0% age $3_1$, 96.3% age $4_1$ and 1.7% age $5_1$ (Table 11). The age composition of 45 carcasses with AFCs was 2.2% age $2_1$, 4.4% age $3_1$, 88.9% age $4_1$ and 4.4% 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 90.9 cm and 87.7 cm, respectively (Appendix 7). Mean POH lengths of males and females in the recovery sample were 73.5 cm and 72.0 cm, respectively (Appendix 7).

Females comprised 62.5% of the application sample, 63.6% of the recovery sample (Table 8) and 40.9% 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 not high 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. Because there was no significant difference in spawning success, we concluded that capture and marking did not influence subsequent behaviour.

## 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 (temporal bias and bias to females) and recovery (bias to females) samples (Table 12).

Table 11. Age composition of chinook carcasses recovered on the spawning grounds, by adipose fin and CWT status, in the Harrison River, 1990.

| Age | Adipose fin present | | Adipose fin absent | | Coded wire tag present | |
|---|---|---|---|---|---|---|
| | no. | % | no. | % | no. | % |
| $2_1$ | 0 | 0.0% | 1 | 2.2% | 1 | 2.9% |
| $3_1$ | 6 | 2.0% | 2 | 4.4% | 2 | 5.7% |
| $4_1$ | 288 | 96.3% | 40 | 88.9% | 30 | 85.7% |
| $5_1$ | 5 | 1.7% | 2 | 4.4% | 2 | 5.7% |
| Total | 299 | - | 45 | - | 35 | - |

Table 12. Summary of results of statistical tests for bias in the 1990 Harrison River escapement estimation study.

| Test | Application sample | Recovery sample |
|---|---|---|
| Period | Bias to 19 Nov to 25 Nov | No bias |
| Location | No bias | No bias |
| Fish size | No bias | No bias |
| Fish sex | Bias toward females | Bias toward females |
| Recovery method | - | No bias |

Neither bias, however, was likely to have introduced bias in the escapement estimate. The temporal 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 1990 Harrison River chinook escapement estimate.

**ESCAPEMENT TRENDS**

The Harrison River mark-recapture study was implemented in 1984 to monitor the rebuilding expected from management actions implemented after the signing of the Pacific Salmon Treaty. From 1984 to 1988, Harrison chinook escapements showed a strong negative trend. Escapement peaked at 174,800 in 1985 and declined for three successive years to 35,100 in 1988 (Staley 1990). Escapement increased to 74,685 in 1989 (Farwell et al 1990). The 1990 escapement estimate of 177,375 is the highest since this mark-recapture study was implemented; however, the stock is still below 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 15 to December 14, 1990. 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 1990 chinook adult escapement was estimated from a spaghetti tag application sample of 3,606, a recovery sample of 7,080, and a recovery of 164 carcasses with spaghetti tags or secondary marks. The estimated escapement was 177,375 chinook adults, of which 72,627 were female and 104,748 were male, and 1,353 had adipose fin clips.

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

| | $2_1$ | $3_1$ | $4_1$ | $5_1$ |
|---|---|---|---|---|
| Female | 0% | 2% | 96% | 2% |
| Male | 1% | 4% | 93% | 2% |

POH length averaged 72.0 cm for females and 73.5 for males.

5. Biases were identified in both the application and recovery samples; however, there was no indication that the 1990 escapement estimate was biased.



**ACKNOWLEDGEMENTS**

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## REFERENCES

Anon. 1985. An agreement between the Government of Canada and the Government of the United States of America concerning Pacific salmon. 36p.

Farwell, M.K., N.D. Schubert, K.H. Wilson, and C.R. Harrison. 1987. Salmon escapements to streams entering statistical areas 28 and 29, 1951 to 1985. Can. Data Rep. Fish. Aquat. Sci. 601: 166p.

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.

Fraser, F.J., P.J. Starr, and A.Y. Fedorenko. 1982. A review of the chinook and coho salmon of the Fraser River. Can. Tech. Rep. Fish. Aquat. Sci. 1126: 130 p.

Ricker, W.E. 1975. Computations and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382p.

Robson, D.S. 1969. Mark-recapture methods of population estimation. In New Developments in Survey Sampling. N.C. Johnson and H. Smith, Jr. (eds.). Wiley-Interscience, Wiley and Sons. New York.

Staley, M.J. 1990. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of the Harrison River, 1984-1988. Can. MS Rep. Fish. Aquat. Sci. 2066: vii + 42p.

# APPENDICES

Appendix 1. Chinook adult spaghetti tag application, by adipose fin status and sex, in the Harrison River, 1990. a

| | | Adipose present | | | Adipose absent | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| 15-Oct | 2 | 43 b | 64 | 107 | 0 | 0 | 0 | 43 | 64 | 107 |
| 16-Oct | 2 | 74 | 70 | 144 | 2 | 1 | 3 | 76 | 71 | 147 |
| 17-Oct | 2 | 43 | 84 | 127 | 1 | 0 | 1 | 44 | 84 | 128 |
| 18-Oct | 2 | 51 | 129 | 180 | 1 | 3 | 4 | 52 | 132 | 184 |
| 19-Oct | 2 | 109 | 140 | 249 | 1 | 1 | 2 | 110 | 141 | 251 |
| 22-Oct | 2 | 104 | 145 c | 249 | 1 | 0 | 1 | 105 | 145 | 250 |
| 23-Oct | 2 | 99 | 139 | 238 | 1 | 3 | 4 | 100 | 142 | 242 |
| 24-Oct | 2 | 27 | 105 | 132 | 2 | 0 | 2 | 29 | 105 | 134 |
| | 4 | 12 | 9 | 21 | 0 | 1 | 1 | 12 | 10 | 22 |
| 25-Oct | 2 | 126 | 170 | 296 | 0 | 4 | 4 | 126 | 174 | 300 |
| 26-Oct | 2 | 37 | 57 | 94 | 0 | 0 | 0 | 37 | 57 | 94 |
| | 3 | 24 | 18 | 42 | 0 | 0 | 0 | 24 | 18 | 42 |
| 29-Oct | 2 | 83 | 194 | 277 | 0 | 0 | 0 | 83 | 194 | 277 |
| 30-Oct | 2 | 101 | 198 | 299 | 0 | 1 | 1 | 101 | 199 | 300 |
| 31-Oct | 2 | 68 | 143 | 211 | 0 | 2 | 2 | 68 | 145 | 213 |
| 01-Nov | 2 | 100 | 173 | 273 | 2 | 1 | 3 | 102 | 174 | 276 |
| 05-Nov | 2 | 76 | 136 | 212 | 0 | 1 | 1 | 76 | 137 | 213 |
| 06-Nov | 2 | 91 | 130 | 221 | 1 | 0 | 1 | 92 | 130 | 222 |
| 08-Nov | 2 | 75 | 131 | 206 | 0 | 2 | 2 | 75 | 133 | 208 |
| Total | 2 | 1,307 | 2,208 | 3,515 | 12 | 19 | 31 | 1,319 | 2,227 | 3,546 |
| | 3 | 24 | 18 | 42 | 0 | 0 | 0 | 24 | 18 | 42 |
| | 4 | 12 | 9 | 21 | 0 | 1 | 1 | 12 | 10 | 22 |
| Total | - | 1,343 | 2,235 | 3,578 | 12 | 20 | 32 | 1,355 | 2,255 | 3,610 |

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

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

| Application sample | | | | | Recovery sample | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | NF length (cm) | Sex | Adipose fin | Date | Reach | POH length (cm) | Sex | Days out |
| 15-Oct | 2 | 97.0 | F | P | 05-Nov | 5 | 76.4 | F | 21 |
| 15-Oct | 2 | 90.0 | F | P | 25-Oct | 4 | 72.3 | F a | 10 |
| 15-Oct | 2 | 88.0 | F | P | 06-Nov | 7 | 70.1 | F | 22 |
| 15-Oct | 2 | 100.0 | F | P | 01-Nov | 3 | 81.4 | F | 17 |
| 15-Oct | 2 | 88.0 | F | P | 27-Nov | 4 | 66.4 | F | 43 |
| 15-Oct | 2 | 83.0 | F | P | 25-Oct | 2 | 66.3 | F | 10 |
| 16-Oct | 2 | 91.0 | F | P | 07-Nov | 3 | 73.5 | F | 22 |
| 16-Oct | 2 | 96.0 | F | P | 08-Nov | 4 | 77.0 | F | 23 |
| 16-Oct | 2 | 87.5 | F | P | 28-Nov | 4 | 68.6 | F | 43 |
| 16-Oct | 2 | 89.0 | F | P | 01-Nov | 3 | 71.7 | F | 16 |
| 16-Oct | 2 | 97.0 | F | P | 08-Nov | 4 | 80.5 | F | 23 |
| 16-Oct | 2 | 91.0 | F | P | 02-Nov | 5 | 77.0 | F | 17 |
| 16-Oct | 2 | 87.0 | F | P | 11-Dec | 5 | 65.3 | F | 56 |
| 17-Oct | 2 | 82.0 | F | P | 29-Nov | 5 | 59.7 | F | 43 |
| 17-Oct | 2 | 89.0 | F | P | 05-Nov | 6 | 70.2 | F | 19 |
| 17-Oct | 2 | 82.0 | F | P | 07-Nov | 4 | 69.0 | F | 21 |
| 18-Oct | 2 | 89.0 | F | P | 07-Nov | 3 | 71.0 | F | 20 |
| 18-Oct | 2 | 97.5 | F | P | 05-Nov | 6 | 78.8 | F | 18 |
| 18-Oct | 2 | 86.0 | F | P | 25-Oct | 5 | 69.5 | F | 7 |
| 18-Oct | 2 | 92.0 | F | P | 02-Nov | 6 | 75.2 | F | 15 |
| 18-Oct | 2 | 84.0 | F | P | 04-Dec | 4 | 67.8 | F | 47 |
| 18-Oct | 2 | 98.0 | F | P | 06-Nov | 7 | 81.5 | F | 19 |
| 18-Oct | 2 | 94.0 | F | P | 05-Nov | 6 | 75.1 | F | 18 |
| 19-Oct | 2 | 83.0 | F | P | 08-Nov | 4 | 68.1 | F | 20 |
| 19-Oct | 2 | 84.0 | F | P | 19-Nov | 8 | 69.0 | M | 31 |
| 19-Oct | 2 | 84.0 | F | P | 07-Nov | 3 | 68.8 | F | 19 |
| 19-Oct | 2 | 86.0 | F | P | 26-Oct | 6 | 69.0 | F | 7 |
| 19-Oct | 2 | 94.5 | F | P | 30-Oct | 5 | 75.4 | F a | 11 |
| 19-Oct | 2 | 84.0 | M | P | 01-Nov | 5 | 71.4 | F | 13 |
| 19-Oct | 2 | 91.0 | F | P | 20-Nov | 7 | 72.8 | F | 32 |
| 19-Oct | 2 | 93.0 | F | P | 30-Oct | 4 | 75.2 | F | 11 |
| 19-Oct | 2 | 92.0 | F | P | 01-Nov | 3 | 76.1 | F | 13 |
| 19-Oct | 2 | 78.0 | F | P | 05-Nov | 6 | 65.6 | F a | 17 |
| 22-Oct | 2 | 90.0 | F | P | 04-Dec | 4 | 71.1 | F | 43 |
| 22-Oct | 2 | 96.0 | F | P | 06-Nov | 7 | 78.8 | F b | 15 |
| 22-Oct | 2 | 85.0 | F | P | 25-Oct | 2 | 69.6 | F | 3 |
| 22-Oct | 2 | 80.0 | F | P | 05-Nov | 6 | 66.4 | F a | 14 |
| 22-Oct | 2 | 90.0 | F | P | 20-Nov | 7 | 73.2 | F | 29 |
| 22-Oct | 2 | 78.5 | F | P | 20-Nov | 7 | 60.5 | F | 29 |
| 22-Oct | 2 | 96.0 | F | P | 02-Nov | 7 | 78.5 | F | 11 |
| 22-Oct | 2 | 100.0 | M | P | 23-Oct | 7 | 78.6 | M | 1 |
| 22-Oct | 2 | 89.0 | F | P | 01-Nov | 5 | 72.3 | F | 10 |
| 23-Oct | 2 | 92.0 | F | P | 06-Nov | 7 | 73.0 | F | 14 |
| 23-Oct | 2 | 83.0 | F | P | 01-Nov | 3 | 67.7 | F | 9 |
| 23-Oct | 2 | 84.5 | F | P | 06-Nov | 7 | 68.8 | F | 14 |
| 23-Oct | 2 | 87.0 | F | P | 21-Nov | 6 | 72.4 | F | 29 |
| 23-Oct | 2 | 84.0 | F | P | 07-Nov | 5 | 68.0 | F | 15 |

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

| Application sample | | | | | Recovery sample | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | NF length (cm) | Sex | Adipose fin | Date | Reach | POH length (cm) | Sex | Days out |
| 23-Oct | 2 | 81.0 | F | P | 02-Nov | 5 | 66.8 | F | 10 |
| 23-Oct | 2 | 98.0 | F | P | 07-Nov | 3 | 79.7 | F | 15 |
| 23-Oct | 2 | 78.0 | F | P | 06-Nov | 7 | 64.9 | F | 14 |
| 23-Oct | 2 | 87.0 | F | P | 29-Nov | 4 | 68.2 | F | 37 |
| 24-Oct | 2 | 81.0 | F | P | 22-Nov | 5 | 65.5 | F | 29 |
| 24-Oct | 2 | 83.0 | F | P | 02-Nov | 6 | 68.0 | F | 9 |
| 24-Oct | 2 | 91.0 | F | P | 03-Dec | 4 | 72.3 | F | 40 |
| 24-Oct | 2 | 95.0 | F | P | 07-Nov | 3 | 77.0 | F | 14 |
| 24-Oct | 2 | 88.0 | F | P | 07-Nov | 3 | 71.0 | F | 14 |
| 24-Oct | 2 | 87.0 | F | P | 05-Dec | 6 | 69.5 | F | 42 |
| 24-Oct | 2 | 103.0 | F | P | 06-Nov | 7 | 84.0 | F | 13 |
| 24-Oct | 2 | 92.0 | F | P | 29-Nov | 5 | 74.7 | F | 36 |
| 25-Oct | 2 | 88.0 | M | P | 20-Nov | 7 | 74.5 | M | 26 |
| 25-Oct | 2 | 87.0 | F | P | 11-Dec | 4 | 68.1 | F | 47 |
| 25-Oct | 2 | 87.0 | F | P | 13-Dec | 5 | 70.4 | F | 49 |
| 25-Oct | 2 | 90.0 | F | P | 30-Nov | 7 | 72.8 | F | 36 |
| 25-Oct | 2 | 88.0 | F | P | 19-Nov | 8 | 71.0 | F | 25 |
| 25-Oct | 2 | 92.5 | F | P | 02-Nov | 6 | 73.5 | F | 8 |
| 25-Oct | 2 | 84.0 | F | P | 22-Nov | 5 | 66.5 | F | 28 |
| 25-Oct | 2 | 96.2 | F | P | 20-Nov | 7 | 74.0 | F | 26 |
| 25-Oct | 2 | 61.0 | M | P | 02-Nov | 5 | 47.6 | M | 8 |
| 25-Oct | 2 | 94.5 | F | P | 28-Nov | 4 | 75.1 | F | 34 |
| 26-Oct | 2 | 79.0 | F | P | 21-Nov | 6 | 65.1 | F | 26 |
| 26-Oct | 2 | 92.0 | F | P | 05-Nov | 6 | 75.3 | F | 10 |
| 26-Oct | 2 | 102.0 | M | P | 28-Nov | 4 | 75.4 | M | 33 |
| 26-Oct | 2 | 92.5 | F | P | 19-Nov | 8 | 75.0 | F | 24 |
| 29-Oct | 2 | 86.5 | F | P | 22-Nov | 6 | 69.5 | F | 24 |
| 29-Oct | 2 | 88.0 | F | P | 03-Dec | 6 | 72.0 | F | 35 |
| 29-Oct | 2 | 82.0 | F | P | 04-Dec | 4 | 61.6 | F | 36 |
| 29-Oct | 2 | 97.0 | F | P | 20-Nov | 7 | 77.6 | F | 22 |
| 29-Oct | 2 | 82.0 | F | P | 22-Nov | 6 | 65.1 | F | 24 |
| 29-Oct | 2 | 87.0 | F | P | 11-Dec | 4 | 68.4 | F | 43 |
| 29-Oct | 2 | 93.0 | F | P | 21-Nov | 5 | 77.8 | F | 23 |
| 29-Oct | 2 | 97.0 | F | P | 19-Nov | 8 | 80.2 | F | 21 |
| 29-Oct | 2 | 88.0 | F | P | 20-Nov | 5 | 72.5 | F | 22 |
| 29-Oct | 2 | 89.0 | F | P | 03-Dec | 5 | 68.7 | F | 35 |
| 29-Oct | 2 | 81.0 | F | P | 05-Nov | 6 | 65.2 | F | 7 |
| 29-Oct | 2 | 89.0 | F | P | 22-Nov | 4 | 59.9 | F | 24 |
| 30-Oct | 2 | 87.0 | F | P | 12-Dec | 4 | 71.8 | F | 43 |
| 30-Oct | 2 | 94.0 | M | P | 05-Nov | 6 | 73.7 | M | 6 |
| 30-Oct | 2 | 89.0 | F | P | 28-Nov | 4 | 76.8 | M | 29 |
| 30-Oct | 2 | 84.0 | F | P | 03-Dec | 6 | 69.5 | F | 34 |
| 30-Oct | 2 | 84.0 | F | P | 29-Nov | 4 | 65.2 | F | 30 |
| 30-Oct | 2 | 96.0 | F | P | 22-Nov | 4 | 75.0 | F | 23 |
| 30-Oct | 2 | 91.0 | F | P | 20-Nov | 5 | 74.5 | F | 21 |
| 30-Oct | 2 | 85.0 | F | P | 22-Nov | 6 | 69.2 | F | 23 |
| 30-Oct | 2 | 91.0 | F | P | 21-Nov | 6 | 74.5 | F | 22 |

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

| Application sample | | | | | Recovery sample | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | NF length (cm) | Sex | Adipose fin | Date | Reach | POH length (cm) | Sex | Days out |
| 31-Oct | 2 | 90.0 | F | P | 19-Nov | 8 | 71.0 | M | 19 |
| 31-Oct | 2 | 89.0 | F | P | 04-Dec | 4 | 70.4 | M | 34 |
| 31-Oct | 2 | 85.0 | F | P | 11-Dec | 4 | 67.6 | F | 41 |
| 31-Oct | 2 | 87.0 | F | P | 22-Nov | 5 | 70.1 | F | 22 |
| 31-Oct | 2 | 87.0 | F | P | 19-Nov | 8 | 68.5 | F | 19 |
| 31-Oct | 2 | 93.0 | F | P | 02-Nov | 5 | 76.5 | F | 2 |
| 01-Nov | 2 | 95.5 | F | P | 22-Nov | 4 | 71.5 | F | 21 |
| 01-Nov | 2 | 79.0 | F | P | 22-Nov | 5 | 64.0 | F | 21 |
| 01-Nov | 2 | 87.0 | F | P | 21-Nov | 6 | 69.9 | F | 20 |
| 01-Nov | 2 | 82.0 | F | P | 29-Nov | 5 | 66.5 | F | 28 |
| 01-Nov | 2 | 87.0 | M | P | 22-Nov | 6 | 68.8 | M | 21 |
| 01-Nov | 2 | 92.0 | F | P | 07-Nov | 3 | 75.1 | F | 6 |
| 01-Nov | 2 | 93.0 | F | P | 29-Nov | 4 | 77.5 | F | 28 |
| 01-Nov | 2 | 78.0 | F | P | 07-Nov | 3 | 65.7 | F | 6 |
| 01-Nov | 2 | 90.0 | F | P | 20-Nov | 7 | 74.0 | F | 19 |
| 01-Nov | 2 | 94.0 | F | P | 07-Nov | 3 | 78.4 | F | 6 |
| 01-Nov | 2 | 88.0 | F | P | 20-Nov | 7 | 72.0 | F | 19 |
| 01-Nov | 2 | 82.0 | F | P | 19-Nov | 8 | 67.5 | F | 18 |
| 01-Nov | 2 | 89.5 | F | P | 06-Nov | 7 | 73.5 | F | 5 |
| 01-Nov | 2 | 82.0 | F | P | 22-Nov | 6 | 69.6 | F | 21 |
| 01-Nov | 2 | 100.0 | F | P | 20-Nov | 7 | 79.5 | F | 19 |
| 01-Nov | 2 | 84.0 | F | P | 03-Dec | 6 | 67.6 | F | 32 |
| 05-Nov | 2 | 89.0 | F | P | 19-Nov | 8 | 73.6 | F | 14 |
| 05-Nov | 2 | 103.0 | M | P | 14-Dec | 8 | 83.3 | M | 39 |
| 05-Nov | 2 | 95.0 | F | P | 11-Dec | 4 | 73.6 | F a | 36 |
| 05-Nov | 2 | 98.0 | F | P | 22-Nov | 4 | 77.2 | F a | 17 |
| 06-Nov | 2 | 82.0 | F | P | 22-Nov | 4 | 65.5 | F | 16 |
| 06-Nov | 2 | 94.0 | F | P | 29-Nov | 5 | 75.5 | F | 23 |
| 06-Nov | 2 | 101.0 | F | P | 11-Dec | 4 | 78.8 | F | 35 |
| 06-Nov | 2 | 85.0 | F | P | 29-Nov | 5 | 67.3 | F | 23 |
| 06-Nov | 2 | 90.5 | F | P | 03-Dec | 6 | 71.5 | F | 27 |
| 06-Nov | 2 | 92.0 | F | P | 08-Nov | 4 | 79.8 | M | 2 |
| 08-Nov | 2 | 98.0 | M | P | 30-Nov | 8 | 75.9 | M | 22 |
| 08-Nov | 2 | 92.5 | F | P | 21-Nov | 6 | 75.0 | F | 13 |
| 08-Nov | 2 | 88.0 | F | P | 13-Dec | 4 | 72.2 | F | 35 |
| 08-Nov | 2 | 103.0 | M | P | 14-Dec | 8 | 81.2 | M | 36 |
| 08-Nov | 2 | 85.0 | F | P | 30-Nov | 7 | 69.5 | F | 22 |
| 08-Nov | 2 | 92.0 | F | P | 11-Dec | 4 | 72.6 | F | 33 |
| 08-Nov | 2 | 90.0 | F | P | 22-Nov | 6 | 73.9 | F | 14 |
| 08-Nov | 2 | 93.0 | F | P | 11-Dec | 4 | 71.7 | F | 33 |
| 08-Nov | 2 | 92.0 | F | P | 05-Dec | 6 | 75.5 | F | 27 |

Continued

Appendix 2. Spaghetti tag recoveries in the Harrison River, by application and recovery date and location, 1990.

| Application sample | | | | | Recovery sample | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | NF length (cm) | Sex | Adipose fin | Date | Reach | POH length (cm) | Sex | Days out |

Females initially identified as males: 1 0.8%

Males initially identified as females: 5 35.7%

Mean days out: 22.6

Maximum days out: 56

Minimum days out: 1

POH and NF Regressions:

| | | |
|---|---|---|
| Males | POH = | 0.74 NF + 5.84 |
| | NF = | 1.16 POH + 6.25 |
| Females | POH = | 0.77 NF + 2.80 |
| | NF = | 1.03 POH + 14.82 |

a. Incorrect sex identification during disk tag application.

b. Required ventilation assistance at release.

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1990.

| | | Unmarked | | Secondary mark only | | Spaghetti tag and secondary mark | | Total | | Adipose absent | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Reach | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| 18-Oct | 4 | 4 | 4 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 |
| | 6 | 5 | 7 | 0 | 0 | 0 | 0 | 5 | 7 | 0 | 0 |
| | 7 | 4 | 5 | 0 | 0 | 0 | 0 | 4 | 5 | 0 | 0 |
| | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 23-Oct | 4 | 15 | 16 | 0 | 0 | 0 | 0 | 15 | 16 | 0 | 0 |
| | 6 | 30 | 24 | 0 | 0 | 0 | 0 | 30 | 24 | 0 | 0 |
| | 7 | 15 | 19 | 0 | 0 | 1 | 0 | 16 | 19 | 0 | 0 |
| 24-Oct | 7 | 33 | 33 | 0 | 0 | 0 | 0 | 33 | 33 | 0 | 0 |
| | 8 | 4 | 6 | 0 | 0 | 0 | 0 | 4 | 6 | 0 | 0 |
| 25-Oct | 2 | 9 | 16 | 0 | 0 | 0 | 3 a | 9 | 19 a | 0 | 0 |
| | 3 | 8 | 4 | 0 | 0 | 0 | 0 | 8 | 4 | 0 | 0 |
| | 4 | 27 | 63 | 0 | 0 | 0 | 1 | 27 | 64 | 0 | 0 |
| 26-Oct | 4 | 3 | 4 | 0 | 0 | 0 | 0 | 3 | 4 | 0 | 0 |
| | 6 | 34 | 30 | 0 | 0 | 0 | 1 | 34 | 31 | 0 | 1 |
| | 7 | 8 | 8 | 0 | 0 | 0 | 0 | 8 | 8 | 0 | 1 |
| 30-Oct | 4 | 40 | 93 | 0 | 0 | 0 | 1 | 40 | 94 | 0 | 0 |
| | 5 | 18 | 40 | 0 | 0 | 0 | 1 | 18 | 41 | 0 | 0 |
| 01-Nov | 2 | 18 | 38 | 0 | 1 | 0 | 0 | 18 | 39 | 0 | 0 |
| | 3 | 35 | 66 | 1 | 0 | 0 | 4 | 36 | 70 | 0 | 0 |
| | 5 | 12 | 6 | 0 | 0 | 0 | 2 | 12 | 8 | 0 | 0 |
| 02-Nov | 5 | 40 | 85 | 1 | 0 | 1 | 1 | 42 | 86 | 0 | 0 |
| | 6 | 154 | 312 | 0 | 0 | 0 | 5 | 154 | 317 | 1 | 1 |
| | 7 | 23 | 29 | 0 | 0 | 0 | 1 | 23 | 30 | 0 | 1 |
| | 8 | 48 | 28 | 0 | 0 | 0 | 0 | 48 | 28 | 0 | 0 |
| 05-Nov | 6 | 197 | 398 | 2 | 0 | 1 | 8 | 200 | 406 | 2 | 1 |
| | 7 | 67 | 117 | 0 | 0 | 0 | 3 | 67 | 120 | 0 | 0 |
| 06-Nov | 7 | 78 | 103 | 0 | 0 | 0 | 5 | 78 | 108 | 0 | 1 |
| 07-Nov | 2 | 31 | 38 | 0 | 0 | 0 | 1 | 31 | 39 | 0 | 0 |
| | 3 | 138 | 280 | 0 | 0 | 0 | 9 | 138 | 289 | 1 | 2 |
| | 4 | 10 | 48 | 0 | 0 | 0 | 1 | 10 | 49 | 0 | 0 |
| 08-Nov | 4 | 95 | 185 | 0 | 0 | 1 | 3 | 96 | 188 | 3 | 2 |
| 19-Nov | 8 | 98 | 126 | 0 | 0 | 2 | 7 | 100 | 133 | 1 | 3 |
| 20-Nov | 7 | 168 | 188 | 3 | 1 | 1 | 10 | 172 | 199 | 1 | 2 |
| | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 21-Nov | 6 | 95 | 197 | 2 | 0 | 0 | 6 | 97 | 203 | 2 | 3 b |
| | 7 | 2 | 8 | 1 | 0 | 0 | 0 | 3 | 8 | 0 | 0 |
| 22-Nov | 4 | 99 | 19 | 0 | 0 | 0 | 5 | 99 | 24 | 1 | 1 |
| | 5 | 52 | 46 | 3 | 1 | 0 | 3 | 55 | 50 | 0 | 0 |
| | 6 | 41 | 173 | 1 | 0 | 1 | 6 | 43 | 179 | 0 | 2 |
| 27-Nov | 4 | 88 | 111 | 0 | 0 | 0 | 1 | 88 | 112 | 1 | 0 |
| | 6 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 8 | 14 | 19 | 0 | 0 | 0 | 0 | 14 | 19 | 0 | 0 |
| 28-Nov | 4 | 53 | 116 | 2 | 1 | 2 | 2 | 57 | 119 | 1 | 0 |
| 29-Nov | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| | 4 | 11 | 17 | 0 | 0 | 0 | 3 | 11 | 20 | 0 | 0 |
| | 5 | 60 | 112 | 1 | 0 | 0 | 5 | 61 | 117 | 1 | 1 |
| 30-Nov | 5 | 6 | 6 | 0 | 0 | 0 | 0 | 6 | 6 | 0 | 0 |

Appendix 3. Chinook carcass recoveries, by mark status and sex, in the Harrison River, 1990.

| Date | Reach | Unmarked | | Secondary mark only | | Spaghetti tag and secondary mark | | Total | | Adipose absent | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Male | Female | Male | Female | Male | Female | Male | Female |
| | 6 | 24 | 29 | 0 | 0 | 0 | 0 | 24 | 29 | 2 | 0 |
| | 7 | 36 | 47 | 1 | 0 | 0 | 2 | 37 | 49 | 0 | 1 c |
| | 8 | 35 | 34 | 1 | 0 | 1 | 0 | 37 | 34 | 2 | 0 |
| 03-Dec | 4 | 9 | 14 | 1 | 0 | 0 | 1 | 10 | 15 | 0 | 0 |
| | 6 | 93 | 169 | 0 | 1 | 0 | 5 | 93 | 175 | 1 | 0 |
| 04-Dec | 4 | 80 | 169 | 1 | 0 | 1 | 2 | 82 | 171 | 0 | 2 |
| 05-Dec | 6 | 32 | 34 | 0 | 1 | 0 | 2 | 32 | 37 | 0 | 1 |
| | 7 | 8 | 3 | 0 | 0 | 0 | 0 | 8 | 3 | 0 | 0 |
| | 8 | 3 | 4 | 0 | 0 | 0 | 0 | 3 | 4 | 0 | 1 |
| 10-Dec | 5 | 9 | 42 | 0 | 0 | 0 | 0 | 9 | 42 | 0 | 0 |
| | 6 | 32 | 95 | 0 | 0 | 0 | 0 | 32 | 95 | 0 | 1 |
| 11-Dec | 4 | 59 | 179 | 1 | 1 | 0 | 8 | 60 | 188 | 0 | 2 |
| 12-Dec | 4 | 35 | 86 | 0 | 0 | 0 | 1 | 35 | 87 | 0 | 0 |
| 13-Dec | 3 | 23 | 69 | 0 | 0 | 0 | 1 | 23 | 70 | 0 | 1 |
| | 4 | 41 | 99 | 0 | 0 | 0 | 1 | 41 | 100 | 0 | 0 |
| 14-Dec | 8 | 30 | 54 | 1 | 0 | 2 | 0 | 33 | 54 | 1 | 1 |
| Total | 2 | 58 | 93 | 0 | 1 | 0 | 4 | 58 | 98 | 0 | 0 |
| | 3 | 204 | 419 | 1 | 0 | 0 | 14 | 205 | 433 | 1 | 3 |
| | 4 | 669 | 1223 | 5 | 2 | 4 | 30 | 678 | 1255 | 6 | 7 |
| | 5 | 197 | 337 | 5 | 1 | 1 | 12 | 203 | 350 | 1 | 1 |
| | 6 | 737 | 1471 | 5 | 2 | 2 | 33 | 744 | 1506 | 8 | 10 |
| | 7 | 442 | 561 | 5 | 1 | 2 | 21 | 449 | 583 | 1 | 6 |
| | 8 | 233 | 272 | 2 | 0 | 5 | 7 | 240 | 279 | 5 | 5 |
| | Total | 2540 | 4376 | 23 | 7 | 14 | 121 | 2577 | 4504 | 22 | 32 |

a. One required ventilation at release.

b. Includes 2 with questionable AFCs.

c. Questionable AFC.

Appendix 4. Spawning success of female chinook spawning ground recoveries, by mark status, in the Harrison River, 1990.

| | | Percent spawned | | | |
|---|---|---|---|---|---|
| | | 0% | 50% | 100% | Weighted mean |
| Spaghetti tag or | Number | 8 | 0 | 114 | |
| secondary mark | Percent | 6.6% | 0.0% | 93.4% | 93.4% |
| Unmarked | Number | 9 | 0 | 151 | |
| | Percent | 5.6% | 0.0% | 94.4% | 94.4% |
| Total | Number | 17 | 0 | 265 | |
| | Percent | 6.0% | 0.0% | 94.0% | 94.0% |

Appendix 5. CWT spawning ground recoveries in the Harrison River, 1990.

| CWT code | Release site | Brood year | CWTs Recovered Male | Female | Total |
|---|---|---|---|---|---|
| 2-37-54 | Chehalis R. | 1985 | 1 | 0 | 1 |
| 2-37-57 | Chehalis R. | 1985 | 1 | 0 | 1 |
| 2-40-52 | Chehalis R. | 1985 | 0 | 1 | 1 |
| 2-44-02 | Chehalis R. | 1986 | 2 | 1 | 3 |
| 2-44-03 | Chehalis R. | 1986 | 1 | 1 | 2 |
| 2-44-04 | Chehalis R. | 1986 | 4 | 3 | 7 |
| 2-44-05 | Chehalis R. | 1986 | 3 | 1 | 4 |
| 2-44-06 | Chehalis R. | 1986 | 6 | 3 | 9 |
| 2-44-07 | Chehalis R. | 1986 | 2 | 1 | 3 |
| 2-44-08 | Chehalis R. | 1986 | 0 | 2 | 2 |
| 2-44-09 | Chehalis R. | 1986 | 1 | 3 | 4 |
| 2-45-47 | Chilliwack R | 1986 | 1 | 1 | 2 |
| 2-47-38 | Chehalis R. | 1987 | 0 | 1 | 1 |
| 2-47-39 | Chehalis R. | 1987 | 1 | 0 | 1 |
| 2-57-47 | Chilliwack R | 1988 | 0 | 1 | 1 |
| Total CWT carcasses | | | 23 | 19 | 42 |
| AFC carcasses with no CWT a | | | 9 | 0 | 9 |
| Total AFC carcasses | | | 32 | 19 | 51 |

a. Excludes 3 with questionable AFCs.

Appendix 6. Incidence of CWT loss by carcass condition, eye status, and AFC condition in AFC chinook adult carcasses in the Harrison River, 1990.

| Category | Condition | Number | CWT absent | CWT loss (%) |
|---|---|---|---|---|
| Carcass condition | Fresh | 6 | 3 | 50.0% |
| | Moderately fresh | 13 | 1 | 7.7% |
| | Moderately rotten | 27 | 6 | 22.2% |
| | Rotten | 8 | 2 | 25.0% |
| Eyes a | Present | 5 | 2 | 40.0% |
| | Absent | 45 | 10 | 22.2% |
| Adipose fin clip | Complete | 45 | 6 | 13.3% |
| | Partial | 6 | 3 | 50.0% |
| | Questionable | 3 | 3 | 100.0% |

a. E[illegible]tion not recorded on 4 carcasses

Append[illegible] Mean lengths by age and sex for Harrison River chinook salmon, 1990.

| Sample | Age | Sex | Sample Size | Percent | Length (cm) Mean | Standard deviation | Range |
|---|---|---|---|---|---|---|---|
| Application a,b | - | Male | 1,355 | 37.5% | 90.9 | 10.3 | 60.0 - 114.0 |
| | | Female | 2,255 | 62.5% | 87.7 | 5.7 | 61.0 - 108.0 |
| | | Total | 3,610 | - | 88.9 | 7.9 | 60.0 - 114.0 |
| Recovery c | 2/1 | Male | 1 | 0.3% | 50.4 | - | - |
| | | Female | 0 | 0.0% | - | - | - |
| | 3/1 | Male | 3 | 0.9% | 62.4 | 12.8 | 47.6 - 69.8 |
| | | Female | 5 | 1.5% | 69.1 | 5.4 | 62.5 - 75.2 |
| | 4/1 | Male | 77 | 22.4% | 74.0 | 5.5 | 61.0 - 88.9 |
| | | Female | 251 | 73.0% | 71.9 | 4.6 | 59.7 - 84.5 |
| | 5/1 | Male | 2 | 0.6% | 83.5 | 4.5 | 80.3 - 86.7 |
| | | Female | 5 | 1.5% | 79.6 | 8.5 | 64.8 - 86.2 |
| | Total | Male | 83 | 24.1% | 73.5 | 6.7 | 47.6 - 88.9 |
| | | Female | 261 | 75.9% | 72.0 | 4.8 | 59.7 - 86.2 |
| | | Total | 344 | - | 72.3 | 5.4 | 47.6 - 88.9 |

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