Estimation of the 1994 Harrison River Chinook Salmon Escapement

M. K. Farwell, L. W. Kalnin and A. G. Lotto

Fisheries and Oceans Canada
Science Branch, Pacific Region
610 Derwent Way, Annacis Island
New Westminster, British Columbia
V3M 5P8

1996

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2379

Fisheries and Oceans / Pêches et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1–900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901–1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426–1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2379

1996

ESTIMATION OF THE 1994 HARRISON RIVER CHINOOK SALMON ESCAPEMENT

by

M.K. Farwell[1], L.W. Kalnin and A.G. Lotto

Fisheries and Oceans Canada

Science Branch, Pacific Region

610 Derwent Way, Annacis Island

New Westminster, British Columbia

V3M 5P8

[1]C.17, Cottonwood Site
Rural Route No. 1
Lone Butte, British Columbia
V0K 1X0

Cat. No. Fs 97-4/2379E ISSN 0706-6473

Correct citation for this publication:

M.K. Farwell, L.W. Kalnin and A.G. Lotto. 1996. Enumeration of the 1994 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2379: 29 p.

CONTENTS

Page

LIST OF FIGURES v

LIST OF TABLES vi

LIST OF APPENDICES vii

ABSTRACT/RÉSUMÉ viii

INTRODUCTION 1

STUDY AREA 1

FIELD METHODS 4
- TAG APPLICATION 4
- SPAWNING GROUND SURVEYS 4

ANALYTIC PROCEDURES 4
- TESTS FOR SAMPLING SELECTIVITY 4
  - Period 4
  - Location 4
  - Fish Size 5
  - Fish Sex 5
  - Recovery Method 5
  - Other Tests 5
- ESTIMATION OF SPAWNER POPULATION 5
  - Total Escapement 5
  - Sex Identification Correction 5
  - Adipose Fin Clipped Escapement 6

RESULTS 6
- SPAGHETTI TAG APPLICATION 6
- SPAWNING GROUND RECOVERY 7
  - Age, Length and Sex 7
  - Coded Wire Tag Recoveries 7
- SAMPLING SELECTIVITY 8
  - Period 8
  - Location 9
  - Fish Size 9
  - Fish Sex 9
  - Recovery Method 9
  - Spawning Success 9
- ESTIMATION OF SPAWNER POPULATION 9

DISCUSSION 12
- SAMPLING SELECTIVITY 12
- STOCK STATUS 13
- SIBLING REGRESSIONS 14

SUMMARY 14

ACKNOWLEDGEMENTS 16

REFERENCES 16

LIST OF FIGURES

Figure		Page
1.	Study area location map	2
2.	Reach locations in the Harrison River	3
3.	Harrison River chinook annual escapement relative to the escapement goal and the base-to-goal linear rebuilding approximation	13
4.	Harrison River chinook escapement patterns: A) escapement at age 3 versus escapement at age 4 one year later; B) escapement at age 4 versus escapement at age 5 one year later; and C) parental escapement versus total subsequent escapement for that brood year	15

LIST OF TABLES

Table		Page
1.	Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1994	6
2.	Spaghetti tag application and recovery, by release condition and sex, of Harrison River chinook adults, 1994	7
3.	Incidence of spaghetti tags or secondary marks in chinook adults recovered on the Harrison River spawning grounds, by recovery period and sex, 1994	8
4.	Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1994	8
5.	Proportion of the Harrison River chinook adult spawning ground recovery sample marked with spaghetti tags or secondary marks, by recovery location and sex, 1994	10
6.	Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application reach and sex, 1994	10
7.	Proportion of the Harrison River chinook adult spaghetti tag application sample recovered on the spawning grounds, by 10 cm increments of postorbital-hypural length and sex, 1994	10
8.	Sex composition of Harrison River chinook adults in the spaghetti tag application and spawning ground recovery samples, 1994	11
9.	Incidence of spaghetti tags and secondary marks in chinook adult carcasses recovered near shore and in deep water in the Harrison River, 1994	11
10.	Results of the statistical tests for bias in the 1994 Harrison River chinook adult escapement estimation study	11
11.	Annual escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook adults, 1984-1994	12

LIST OF APPENDICES

Appendix		Page
1.	Daily application of spaghetti tags and secondary marks, by reach, adipose fin status and sex, to chinook adults in the Harrison River, 1994	18
2.	Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994	19
3.	Daily chinook carcass recoveries, by reach, mark status and sex, in the Harrison River, 1994	23
4.	Proportion at age and mean length at age, by AFC status and sex, of chinook carcasses recovered on the Harrison River spawning grounds, 1994	25
5.	AFC and CWT sampling of chinook adults recovered on the Harrison River spawning ground, 1994	26
6.	Incidence of CWT loss, by carcass condition, eye status and AFC condition, in AFC chinook adult carcasses recovered on the Harrison River spawning grounds, 1994	27
7.	Spawning success, by mark status, in female chinook carcasses recovered on the Harrison River spawning grounds, 1994	27

ABSTRACT

M.K. Farwell, L.W. Kalnin and A.G. Lotto. 1996. Enumeration of the 1994 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2379: 29 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 1994, the Harrison River chinook escapement was estimated, using the Petersen mark-recapture method, at 98,344 adults. The sex composition of the escapement was 44% female and 56% male. The age composition of the escapement was 3.8% age 3_1, 92.3% age 4_1, 3.3% age 5_1, 0.5% age 6_1 and 0.1% age 5_2.

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

RÉSUMÉ

M.K. Farwell and L.W. Kalnin. 1996. Enumeration of the 1994 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2379: 29 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 1994, l'échappée du quinnat dans la rivière Harrison a été évaluée à 98 344 adultes, selon la méthode de marquage et de recapture de Petersen. La composition de la population selon le sexe a été évaluée comme suit: 44% de femelles et 56% mâles. La composition par âge: 3,8% d'âge 3_1, 92,3% d'âge 4_1, 3,3% d'âge 5_1, 0,5% d'âge 6_1 et 0,1% d'âge 5_2.

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 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 is unique in the Fraser River system. Individual monitoring, therefore, was warranted. Previous reports documented the 1984-1993 Harrison River chinook enumeration studies (Staley 1990; Farwell *et al.* 1990, 1991, 1992; Schubert *et al.* 1993, 1994). The current report documents the 1994 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 of the status of this stock.

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 $m^3 \cdot s^{-1}$, with monthly mean daily maximum (947 $m^3 \cdot s^{-1}$) and minimum (202 $m^3 \cdot s^{-1}$) (Environment Canada 1980) 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 mean depth of 10 m and a predominently 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 chiefly gravel;

Reach 3 (km 7.7 to 7.1) extends to a shear boom on the northwest shore. It has a higher gradient than reaches 1 and 2 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 mean 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 approximately 3 m and the substrate is bedrock/gravel;

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

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

To examine spatial bias in the recovery sample, the study area was considered to be

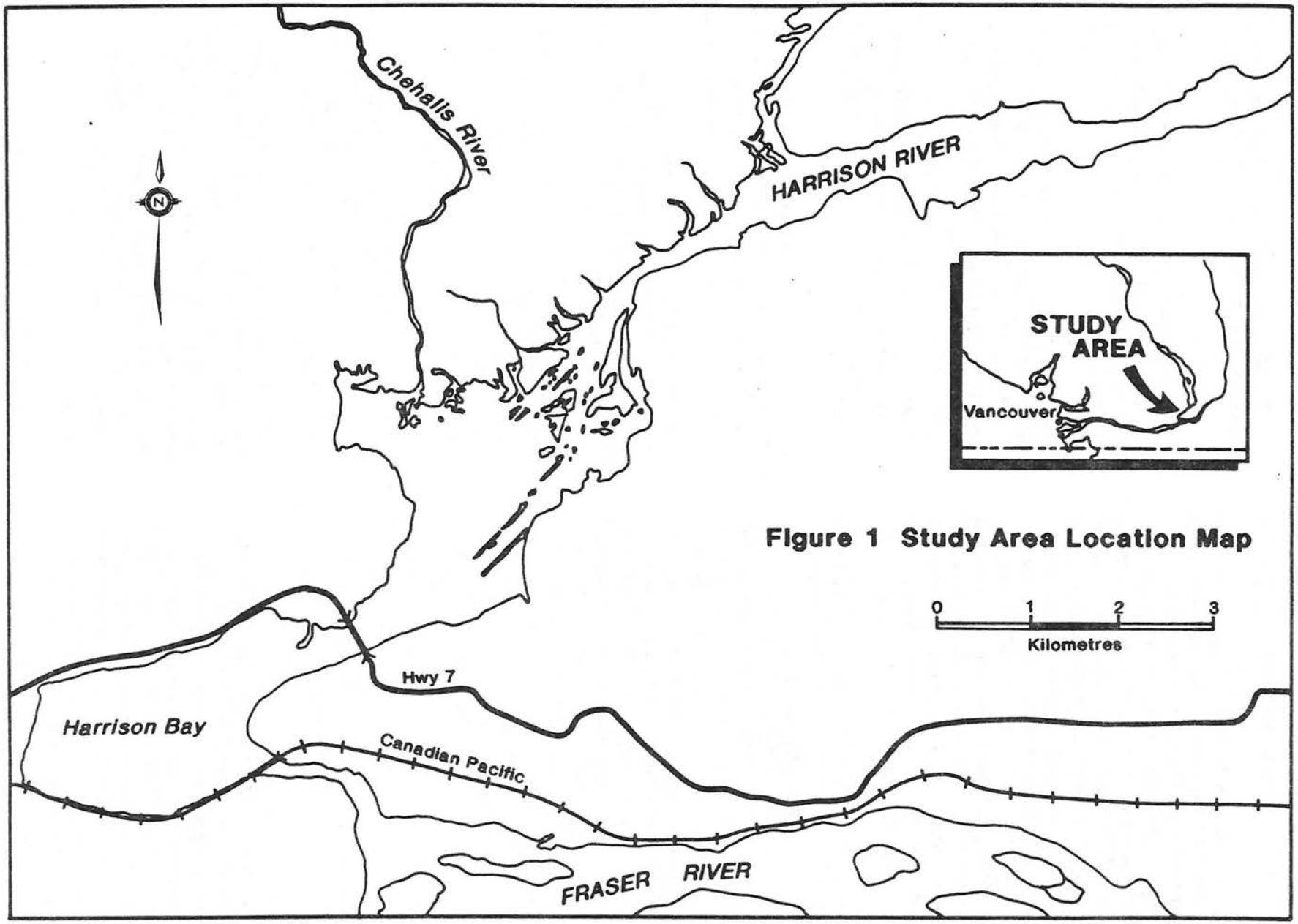

Figure 1 Study Area Location Map

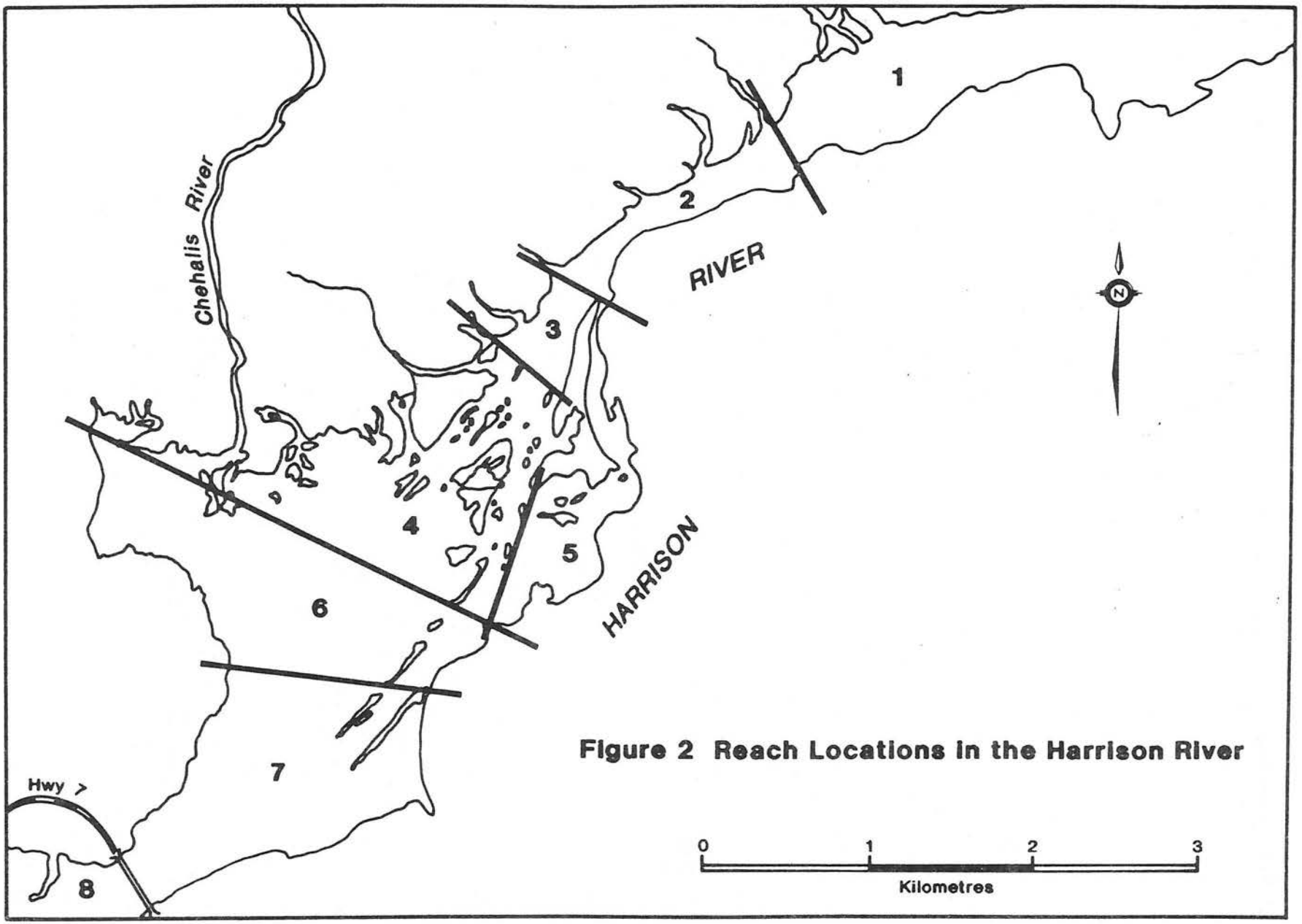

Figure 2 Reach Locations in the Harrison River

comprised of three sections. The upper section comprised reaches 1 and 2, the middle section, reaches 3, 4, and 5, and the lower section, reaches 6, 7, and 8.

FIELD METHODS

TAG APPLICATION

A crew of 6 to 10 individuals were employed in the capture and tagging operation on a five days per week basis. Chinook adults were captured in reaches 2 and 4 from October 18 to November 22, 1994 using a 67 m x 6 m x 9 cm mesh seine net. The net was set by power boat in a downstream crescent and withdrawn from the river to enclose a small area of water along the river bank. From 2 to 6 sets per day were made depending on fish abundance and water conditions. 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 measured and released untagged.

Each spaghetti tag 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 25 to December 15, 1994. 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 among periods the mark incidence in the recovery sample, where mark incidence was the proportion of the chinook adults marked with either a spaghetti tag or a secondary mark. Recovery bias was examined by stratifying the application sample by weekly periods and comparing proportions recovered.

Location

Spatial bias was similarly assessed in the application sample by comparing among sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the

proportions recovered.

Fish Size

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

Fish Sex

Sex related bias was assessed using chi-square tests. Application bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and nonrecovered 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. 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 1994 escapement of Harrison River chinook adults was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). When serious spatial or temporal 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, analogous to above.

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 reco-vered;
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

Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1994.

Sex	Spaghetti tags applied A	Carcasses examined B	Marks recovered: Spaghetti tag and secondary mark B	Marks recovered: Secondary mark only	Marks recovered: Spaghetti tag only	Marks recovered: Total	Percent recovered
Male	943	3,575	47	10	3	60	6.4%
Female	1,453	5,796	182	7	6	195	13.4%
Total	2,396	9,371	229	17	9	255	10.6%

A. Corrected for sex identification error; excludes 16 males and 12 females which required ventilation at release.

B. Excludes 3 males and 4 females which required ventilation at release.

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):

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

where:

- M^*_m = field estimate of the number of males released with spaghetti tags and secondary marks;
- M_t = total number of chinook adults released with spaghetti tags and se-condary marks;
- $R_{m,f}$ = number of females recovered with spaghetti tags which were releas-ed 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 (recovery sample and application sample), 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

SPAGHETTI TAG APPLICATION

Spaghetti tags and secondary marks were applied to 2,424 chinook adults in the Harrison River from October 18 to November 22, 1994 (Appendix 1; Table 1); 17 (0.7%) had an AFC. Twenty eight fish (1.1%) required ventilation at release (Table 2). The percentage of this group recovered (25.1%) was significantly different ($p < 0.05$; chi-square) from the remaining fish (10.0%). This has been consistent in previous studies and it is felt that this group of fish is highly stressed and therefore seeks out slow, shallow, marginal areas to spawn in and

Table 2. Spaghetti tag application and recovery, by release condition and sex, of Harrison River chinook adults, 1994.

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	940	1,449	2,389	50	188	238	5.3%	13.0%	10.0%
Required ventilation	16	12	28	3	4	7	19.0%	33.1%	25.1%

A. Corrected for sex identification errors; excludes 3 males and 4 females for which condition at release was not recorded.

B.. Exludes 17 with secondary mark only.

therefore are subject to an increased chance of recovery after death. Consequently, they were removed from the application sample. An estimated 1.9% of the males and 2.1% of the females were misidentified at the time of tagging (Appendix 2). When adjusted for this error, an estimated 943 (39.4%) males and 1,453 (60.6%) females were released with a spaghetti tag and secondary mark (Table 1). Most (99%) were released in Reach 2, with 25 (1%) released in Reach 4.

Mean NF length of males and females was 92.0 cm and 87.6 cm, respectively. The release group was not sampled for age.

In 1994, 309 previously tagged fish were recaptured in subsequent beach seine sets (Appendix 1). Most (53%) were recaptured within one day of tagging, while 93% were recaptured within one week of tagging. Maximum elapsed time was 20 days.

SPAWNING GROUND RECOVERY

In 1994, 9,378 chinook adults and 260 jacks were recovered on the spawning grounds from October 25 to December 15 (Table 1; Appendix 3). After the removal of 4 tagged males and 3 tagged females which required ventilation at release, there were 3,575 (38.1%) adult male and 5,796 (61.9%) adult female recoveries. Of those adults, 21 (0.2%) had an AFC, 229 (2.4%) had a spaghetti tag and secondary mark, 9 (0.1%) bore a spaghetti tag only, and 17 (0.2%) had a secondary mark only. Spaghetti tag loss in males (16.7%) was significantly higher than in females (3.6%) ($p < 0.05$; chi-square). Recoveries without a secondary mark were from carcasses with missing opercula (Appendix 3). Most of the adults were recovered in reaches 8 (39%), 7 (21%), 6 (15%), and 4 (14%).

Age, Length and Sex

The age, length, and sex of the 1994 Harrison River spawning ground recoveries are reported in Appendix 4. Most males (90%) and females (95%) matured at age 4_1 (Gilbert-Rich age type). There was no significant difference in the age composition of males or females with and without an AFC ($p > 0.05$; chi-square). The mean POH length of males and females was 76.1 cm and 73.4 cm, respectively. Females comprised 71.8% of the sampled fish; 99.9% of the sample had white flesh.

Coded Wire Tag Recoveries

Seven adult males and 14 females had an AFC (jacks were not examined for an AFC), an incidence of 0.2% in either sex (Appendix 5).There was no significant difference ($p > 0.05$; chi-square) in AFC incidence when the male sample was stratified spatially; however, there was a significant difference ($p < 0.05$) in the females, with a higher AFC incidence in the upper section. There was no significant difference ($p > 0.05$) in AFC incidence in either sex when the sample was stratified temporally.

CWTs were recovered from 18 heads (7 male, 11 female), of which 1 (5.6%) was from a

Table 3. Incidence of spaghetti tags or secondary marks in chinook adults recovered on the Harrison River spawning grounds, by recovery period and sex, 1994.

	Recovered with spaghetti tags or secondary marks A			Chinook adult carcasses examined A			Mark incidence		
Recovery period	Male	Female	Total	Male	Female	Total	Male	Female	Total
23-Oct to 29-Oct	2	1	3	151	219	370	1.3%	0.5%	0.8%
30-Oct to 05-Nov	7	9	16	293	390	683	2.4%	2.3%	2.3%
06-Nov to 12-Nov	3	35	38	515	925	1,440	0.6%	3.8%	2.6%
13-Nov to 19-Nov	16	54	70	786	1,340	2,126	2.0%	4.0%	3.3%
20-Nov to 26-Nov	19	61	80	889	1,526	2,415	2.1%	4.0%	3.3%
27-Nov to 03-Dec	7	19	26	606	776	1,382	1.2%	2.4%	1.9%
04-Dec to 10-Dec	3	11	14	217	351	568	1.4%	3.1%	2.5%
11-Dec to 17-Dec	3	5	8	118	269	387	2.5%	1.9%	2.1%

A. Excludes 3 males and 4 females which required ventilation at release.

Table 4. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1994.

	Spaghetti tags and secondary mark applied A			Carcasses recovered with spaghetti tags B			Percent recovered		
Application period	Male	Female	Total	Male	Female	Total	Male	Female	Total
16-Oct to 22-Oct	230	235	465	10	30	40	4.3%	12.8%	8.6%
23-Oct to 29-Oct	486	859	1,345	28	112	140	5.8%	13.0%	10.4%
30-Oct to 05-Nov	127	198	325	3	23	26	2.4%	11.6%	8.0%
06-Nov to 12-Nov	70	125	195	6	16	22	8.6%	12.8%	11.3%
13-Nov to 26-Nov	30	36	66	3	7	10	10.1%	19.3%	15.2%

A. Corrected for sex identification errors; excludes 16 males and 12 females which required ventilation at release.

B. Excludes 10 males and 7 females with secondary marks only; excludes 3 males and 4 females which required ventilation at release.

1989-brood Chilliwack River Hatchery release, and 3 (16.7%), 13 (72.0%) and 1 (5.6%) were from 1989-brood, 1990-brood and 1991-brood Chehalis River Hatchery releases, respectively. CWT loss averaged 14.3% (Appendix 5). There was no significant difference ($p > 0.05$; chi-square) in CWT loss in carcasses with eyes versus those missing one or both eyes (Appendix 6), indicating that predators did not influence measured CWT loss. There was also no significant difference ($p > 0.05$; chi-square) in CWT loss between fresh and decomposed carcasses. A significant difference in CWT loss was noted between carcasses with AFCs (10.5%) and those with fungus obscuring the area (50%) ($p < 0.05$; chi-square).

Scale ageing accuracy was evaluated in 14 samples for which both ageable scales and CWTs were available (Appendix 5). One (7.1%) age 5 fish was aged incorrectly as age 4.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in eight recovery periods (Table 3). Mark incidences in females, lowest (0.5%) in the earliest period and

high (4.0%) in two middle periods, were significantly different than expected ($p < 0.05$; chi-square). No significant difference was noted in males.

Recovery bias was examined by comparing the proportions recovered from five application periods (Table 4). The proportions ranged from 2.4% to 10.1% in males and 11.6% to 19.3% in females, but the differences were not significant ($p > 0.05$) in either sex.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in three recovery sections (Table 5). Mark incidence ranged from 7.7% in the upper section to 1.4% in the middle section. The differences were significant ($p < 0.05$; chi-square) in both sexes.

Recovery bias was examined by stratifying the application sample into two reaches and comparing proportions recovered from each (Table 6). The proportions ranged from 0.0% to 13.0%; however, the differences were not significant in either sex ($p > 0.05$).

Fish Size

Size related bias in the application sample was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. A significant difference ($p < 0.05$; Kolmogorov-Smirnov two sample test) was noted in females only. When the recovery sample was stratified into 10 cm POH length increments, the proportion marked was highest in smaller fish (Table 7).

Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing NF length frequency distributions. There was no significant difference ($p > 0.05$) in either sex.

Fish Sex

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

There was no significant difference ($p > 0.05$) in the sex ratio of the recovered and nonrecovered components of the application sample (Table 8). However, there was a significant difference noted in the proportion of males (6.4%) and females (13.4%) released with spaghetti tags and recovered on the spawning grounds ($p < 0.05$; chi-square) (Table 1).

Recovery Method

There was a significant difference ($p < 0.05$; chi-square) in the mark incidence in carcasses recovered on shore during foot surveys (3.2%) and in deep water during boat surveys (6.9%) (Table 9); however, boat survey data records were only available for the period December 6 to 15.

Spawning Success

Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 92.1% (Appendix 7). The spawning success of marked (94.9%) and unmarked (90.4%) females was not significantly different ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

Although some statistical biases were found, they were not considered significant (Table 10; see Discussion), therefore escapement was calculated by sex using the Petersen estimator. The 1994 escapement of Harrison River chinook adults was 98,344, with lower and upper 95% confidence limits of 83,466 and 113,223 (Table 11). The escapement of male and female chinook adults was 55,340 and 43,004, respectively. Age 4_1 fish dominated the escapement (92.3%), followed by ages 3_1 (3.8%), 5_1 (3.3%), 6_1 (0.5%) and 5_2 (0.1%).

Based on recovery sample chinook adult AFC incidences of 0.2% for males and females (Appendix 5), the 1994 escapement of AFC adults was 212 chinook adults. Escapement by CWT code was not estimated because sample sizes were insufficient to permit the stratification of the AFC sample by age.

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, 1994.

Recovery section A	Carcasses recovered with spaghetti tags or secondary marks B			Chinook adult carcasses examined B			Mark incidence		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Upper	8	20	28	153	261	414	5.2%	7.7%	6.8%
Middle	8	47	55	586	1,390	1,976	1.4%	3.4%	2.8%
Lower	44	128	172	2,836	4,145	6,981	1.6%	3.1%	2.5%

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

B. Excludes 3 males and 4 females which required ventilation at release.

Table 6. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application reach and sex, 1994.

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	933	1,438	2,371	50	187	237	5.4%	13.0%	10.0%
Reach 4	10	15	25	0	1	1	0.0%	6.6%	4.0%

A. Corrected for sex identification error; excludes 16 males and 12 females which required ventilation at release.

B. Exludes 10 males and 7 females with secondary mark only; excludes 3 males and 4 females which required ventilation at release.

Table 7. Proportion of the Harrison River chinook adult spaghetti tag application sample recovered on the spawning grounds, by 10 cm increments of postorbital-hypural length and sex, 1994.

Postorbital -hypural length (cm)	Carcasses recovered A			Carcasses recovered with spaghetti tags or secondary marks A			Percent marked		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
50-59.9	1	0	1	0	0	0	0.0%	-	0.0%
60-69.9	30	102	132	13	48	61	43.3%	47.1%	46.2%
70-79.9	112	358	470	34	129	163	30.4%	36.0%	34.7%
80-89.9	54	42	96	13	15	28	24.1%	35.7%	29.2%
90-99.9	3	0	3	0	0	0	0.0%	-	0.0%

A. Excludes 3 males and 4 females which required ventilation at release and 3 females for which POH length not recorded.

Table 8. Sex composition of Harrison River chinook adults in the spaghetti tag application and spawning ground recovery samples, 1994.

	Application sample, by recovery status A				Recovery sample, by mark status B			
Sex	Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
Male	943	23.5%	41.2%	39.4%	3,575	23.5%	38.6%	38.1%
Female	1,453	76.5%	58.8%	60.6%	5,796	76.5%	61.4%	61.9%

A. Corrected for sex identification error.; excludes 16 males and 12 females which required ventilation at release.

B. Excludes 3 males and 4 females which required ventilation at release.

Table 9. Incidence of spaghetti tags and secondary marks in chinook adult carcasses recovered near shore and in deep water in the Harrison River, 1994.

		Carcasses recovered B			Carcasses recovered with spaghetti tags or secondary marks C			Mark incidence		
Recovery location	A	Male	Female	Total	Male	Female	Total	Male	Female	Total
Shore		2,314	3,961	6,275	42	158	200	1.8%	4.0%	3.2%
Deep water		71	174	245	3	14	17	4.2%	8.0%	6.9%

A. Deep water recovery records began December 6, 1994.

B. Excludes 1193 males and 1665 females recovered prior to Dec. 6; excludes 3 males and 4 females which required ventilation at release.

C. Excludes 15 males and 23 females recovered prior to Dec. 6; excludes 3 males and 4 females which required ventilation at release.

Table 10. Results of the statistical tests for bias in the 1994 Harrison River chinook adult escapement estimation study. A

Bias type	Application sample	Recovery sample
Statistical	-	No bias
Period	No bias	No bias
Location	Bias to upper section in both sexes	No bias
Fish size	Bias to smaller females	No bias
Fish sex	No bias	Bias to females
Recovery method	-	Bias to deep water

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

Table 11. Annual escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook adults, 1984-1994. A

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

A. Rounding errors may be present.

DISCUSSION

SAMPLING SELECTIVITY

Population estimates derived from mark-recapture studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce the emigration of tagged fish from the population and alter recapture vulnerability; and nonrepresentative tag application or recovery resulting from samples which are selective by fish

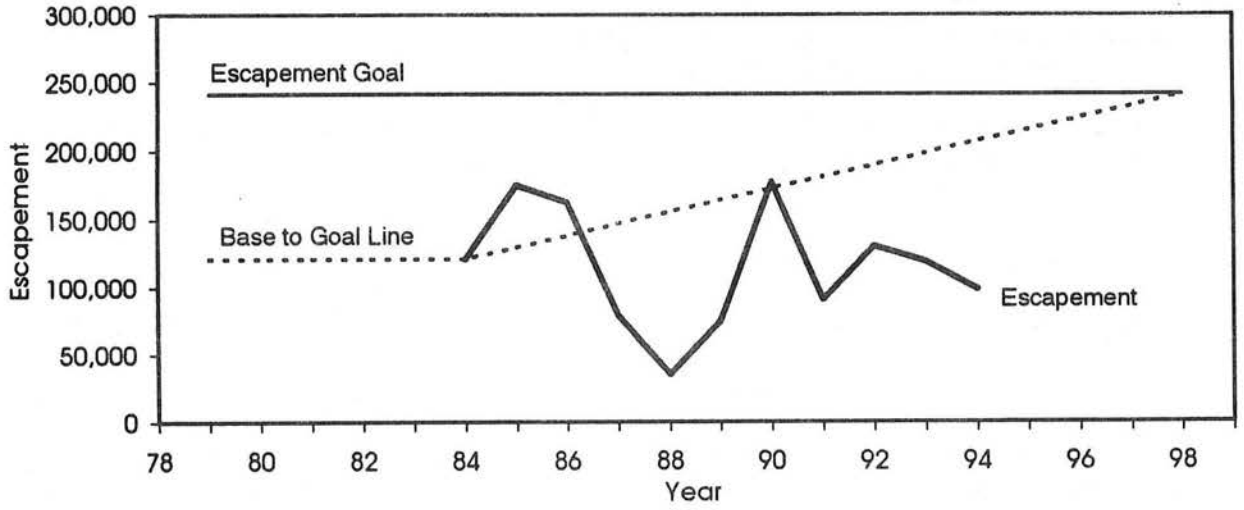

Fig 3. Harrison River chinook annual escapement relative to the escapement goal and the base-to-goal linear rebuilding approximation.

size, sex or spatial and temporal run component. Tag loss was accounted for by applying a secondary mark to all spaghetti tagged fish. The effects of physiological stress, however, were a concern because Harrison chinook are known from previous studies to be sensitive when in a prespawn condition. Staley (1990) reported significant differences in recovery rates between groups tagged using high and low stress procedures; consequently, the low stress procedure was used in the current study. Physiological stress resulting in emigration was not a special concern in 1994 because a large number of spaghetti tagged fish were recaptured during subsequent days of tagging.

We attempted to evaluate the effect of handling stress on subsequent behaviour in two ways. In the first method, incomplete data lead us to reject the significance of the observed difference in mark incidences in carcasses recovered on the shore and those from the deep waters of the main channel. Support for this rejection came from past studies which have not shown significant differences in these incidences (Farwell *et al.* 1991, 1992; Schubert *et al.* 1993, 1994). In the second method, 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 results from the 1990, 1991, 1992, and 1993 studies (Farwell *et al.* 1991, 1992; Schubert *et al.* 1993, 1994).

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.

A spatial bias and a bias to smaller females was noted in the application sample (Table 10). Each of these biases were present in only one of the samples. Junge (1963) noted that, when nonrepre-sentative sampling occurs, accurate results may still be achieved if one sample is representative. We concluded, therefore, that these biases were unlikely to have introduced significant bias in the escapement estimate. A bias to females in the recovery sample was corrected by calculating the escapement by sex.

STOCK STATUS

The 1951-1986 visual escapement estimates are excluded from our evaluation of stock status because Starr and Schubert (1990) con-cluded that they were subjective and, after 1985, were biased by the mark-recapture study. Therefore, stock status was assessed by focusing on estimates from the current study which was implemented in 1984. Figure 3 shows the escapement trend relative to the escapement

goal (241,700) and to a base-to-goal line approximating a rebuilding schedule. Overall, estimated escapements have been trendless. They declined sharply in the initial years of the rebuilding program, then increased to a peak of 177,375 in 1990. Subsequent escapements have been in the range of 90,000 to 130,000. The 1994 escapement estimate of 98,344 was less than the 1984-1993 average escapement of 116,447 and well below the escapement goal and the base-to-goal line.

In its annual evaluation of rebuilding progress, the Chinook Technical Committee (Anon. 1994) placed Harrison River chinook in the *Probably Not Rebuilding* category because: a) the average escapement had not increased from the 1984 base level; and b) the 1993 escape-ment was only 49% of goal and was well below the base-to-goal line. The Committee noted that current exploitation rates on Harrison River chinook probably exceed the level which is sustainable by this stock. The Committee concluded that the Harrison is one of a group of stocks which will not rebuild by 1998. Using the same evaluation criteria with the additional 1994 escapement estimate, we cannot disagree with the Committee's 1994 conclusion.

SIBLING REGRESSIONS

Sibling regressions were calculated for the age 3 escapement and the age 4 escapement one year later (Fig. 4a), and the age 4 escapement and the age 5 escapement one year later (Fig. 4b). In both comparisons, data from the younger class were useful in predicting the older age escapement one year later (r^2 = 0.80 and 0.73, respectively). The maturation schedule of this stock is relatively constant and the impact of annual management variability has been minor. Sibling regressions, therefore, can be useful in the development of preseason escapement forecasts.

While the maturation schedule of Harrison River chinook is relatively constant, there is a high degree of variability in the total survival to escapement among brood years (Fig. 4c). This suggests that brood year survival is determined at a relatively early age class and persists through subsequent older age classes.

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 18 to December 15, 1994. Chinook adults were captured using a beach seine and marked with spaghetti tags and opercular punches. The es-capement was censused by the recovery of carcasses following spawning.

3. The 1994 chinook adult escapement was estimated from a spaghetti tag application sam-ple of 2,396 adults, a recovery sample of 9,371 adults, and a recovery of 255 carcasses with spaghetti tags or secondary marks. The estimated escapement was 98,344 chinook adults, of which 43,004 were female and 55,340 were male, and 212 had an adipose fin clip.

4. The age composition was 95% age 4_1 in males and 90% age 4_1 in females. POH length averaged 76.1 cm for males and 73.4 for females.

5. Spatial and fish size biases were identified in the application sample. A sex bias was detected in the recovery sample. However, the basic assumptions un-derlying the Petersen mark-recapture technique were not seriously violated. We con-cluded, therefore, that the 1994 escapement estimate was not significantly biased.

6. Harrison River escapement has been trend-less over the 1984-1994 study period. The 1994 estimate is consistent with the conclusion of the Canada/U.S. Chinook Technical Committee that this stock is being exploited at a level which is higher than the long term sustainable level and is unlikely to rebuild by 1998 unless further actions are taken to decrease exploitation rates.

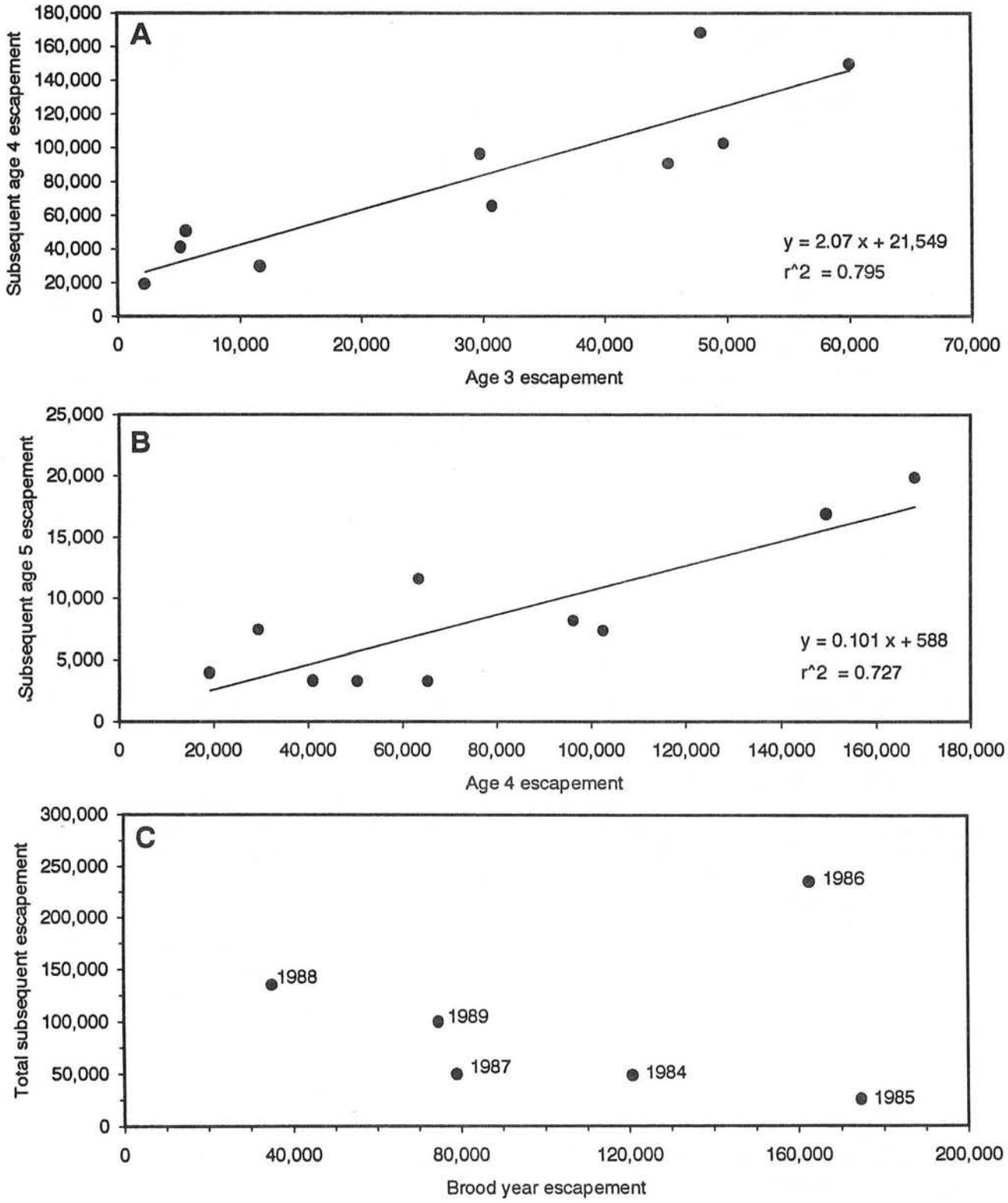

Fig 4. Harrison River chinook escapement patterns: A) escapement at age 3 versus escapement at age 4 one year later; B) escapement at age 4 versus escapement at age 5 one year later; and C) parental escapement versus total subsequent escapement for that brood year.

ACKNOWLEDGEMENTS

Field activities were conducted by: C. Barnard, B. Charlie, D. Classen, J. Delemar, T. Delemar, R. Galbraigh, A. Leon, L. MacDonald, T. Nevin, F. Pointe, I. Redden, and A. Walters.

We wish to thank Neil Schubert for all his contributions to this program in past years, and Jim Irvine for reviewing this document.

REFERENCES

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

Anon. 1994. Pacific Salmon Commission Joint Chinook Technical Committee 1993 annual report. TCCHINOOK (94-)-1: 119 p + appendices.

Darroch, J.N. 1961. The two-sample capture-recapture census when tagging and sampling are stratified. Biometrika 48: 241-260.

Environment Canada. 1980. Historic stream flow summary, British Columbia, to 1979. Inland Waters Directorate, Water Resources Branch, Ottawa. 861 p.

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: 166 p.

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: 24 p.

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.

Farwell, M.K., N.D. Schubert and L.W. Kalnin. 1992. Enumeration of the 1991 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2152: 24 p.

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.

Junge, C.O. 1963. A quantitative evaluation of the bias in population estimates based on selective samples. Int. Comm. North Atl. Fish. Spec. Pub. No. 4: 26-28.

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

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.

Schubert, N.D., M.K. Farwell and L.W. Kalnin. 1994. Enumeration of the 1993 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2242: 27 p.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry, the principles and practices of statistics in biological research. Second edition. W.H. Freeman and Company. San Francisco. 859 p.

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 + 42 p.

Starr, P.J., and N.D. Schubert. 1990. Assessment of Harrison River chinook salmon. Can. MS Rep. Fish. Aquat. Sci. 2085: 47 p.

APPENDICES

Appendix 1. Daily application of spaghetti tags and secondary marks, by reach, adipose fin status and sex, to chinook adults in the Harrison River, 1994. A

		Spaghetti tags applied											
		Adipose present			Adipose absent			Total			Recaptures		
Date	Reach	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Jack B
18-Oct	2	19	14	33	0	0	0	19	14	33	0	0	8
19-Oct	2	89	100	189	1	0	1	90	100	190	2	6	5
20-Oct	2	45 D	26 D	71	0	0	0	45	26	71	1	7	4
21-Oct	2	79	92 D	171	0	1	1	79	93	172	2	0	8
24-Oct	2	99	198	297	1	1	2	100	199	299	1	6	10
25-Oct	2	71	109 D	180	1	1	2	73 C	110	183	10	11	24
26-Oct	2	190 E,H,J	342 D,G,J	532	1	3 F	4	191	345	536	4	11	11
27-Oct	2	102 F	147	249	1	2	3	103	149	252	13	20	18
28-Oct	2	31 G	52	83	0	0	0	31	52	83	1	3	4
31-Oct	2	54 G	49 F	103	0	0	0	54	49	103	6	11	9
01-Nov	2	68 I	111 I	179	1	0	1	69	111	180	32	51	15
04-Nov	2	12	40	52	0	1	1	12	41	53	0	0	1
07-Nov	4	1 F	2 F	3	0	0	0	1	2	3	0	0	0
08-Nov	2	29 G	69 F	98	0	0	0	29	69	98	3	11	1
10-Nov	2	44 F	54	98	1	1	2	45	55	100	20	30	6
14-Nov	2	16	19 G	35	0	0	0	16	19	35	3	25	0
17-Nov	2	4	5	9	0	0	0	4	5	9	0	18	0
22-Nov	4	10	14	24	0	0	0	10	14	24	0	1	0
Total	2	952	1,427	2,379	7	10	17	960	1,437	2,397	98	210	124
	4	11	16	27	0	0	0	11	16	27	0	1	0
Total	-	963	1,443	2,406	7	10	17	971	1,453	2,424	98	211	124

A. Not corrected for sex identification errors.
B. Jacks were released untagged.
C. Includes 1 with no record of adipose status.
D. Includes 1 with no record of release condition.
E. Includes 2 with no record of release condition.
F. Includes 1 which required ventilation.
G. Includes 2 which required ventilation.
H. Includes 3 which required ventilation.
I. Includes 4 which required ventilation.
J. Includes 1 with no record of secondary mark.

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
04-Nov	2	93.0	F	P	H13760	23-Nov	6	76.1	F	41	19
04-Nov	2	92.0	F	P	H13765	05-Dec	8	73.6	F	41	31
08-Nov	2	93.0	M	P	H13777	15-Nov	8	74.3	M	41	7
08-Nov	2	94.0	M	P	H13782	23-Nov	6	76.2	M	-	15
08-Nov	2	81.0	F	P	H13791	29-Nov	7	72.0	F	-	21
08-Nov	2	89.0	F	P	H13792	07-Dec	5	70.4	F	-	29
08-Nov	2	86.0	F	P	H13795	24-Nov	7	71.4	F	41	16
08-Nov	2	87.0	F	P	H13798	23-Nov	7	75.0	F	41	15
08-Nov	2	86.0	F	P	H13803	16-Nov	3	70.6	F	41	8
08-Nov	2	95.0	F	P	H13804	21-Nov	8	81.0	F	41	13
08-Nov	2	82.0	F	P	H13820	21-Nov	8	69.5	F	41	13
08-Nov	2	93.0	F	P	H13822	24-Nov	7	75.5	F	41	16
08-Nov	2	96.0	M	P	H13826	21-Nov	8	74.8	M	-	13
08-Nov	2	91.0	F	P	H13850	15-Nov	2	75.5	F	41	7
08-Nov	2	100.0	M	P	H13858	25-Nov	2	77.5	M	41	17
08-Nov	2	102.0	M	P	H13875	15-Nov	2	78.5	M B	41	7
10-Nov	2	89.0	M	P	H13884	15-Nov	3	70.2	M	41	5
10-Nov	2	84.0	F	P	H13896	24-Nov	7	72.2	F	41	14
10-Nov	2	81.0	F	P	H13897	16-Nov	7	67.0	F	41	6
10-Nov	2	84.0	F	P	H13906	16-Nov	7	70.4	F	41	6
10-Nov	2	89.0	F	P	H13949	25-Nov	2	72.9	F	41	15
10-Nov	2	97.0	F	P	H13951	15-Dec	8	78.4	F	41	35
10-Nov	2	84.0	F	P	H13955	01-Dec	8	71.5	F	31	21
10-Nov	2	84.0	F	P	H13959	28-Nov	8	68.6	F	41	18
10-Nov	2	107.0	M	P	H13974	29-Nov	6	89.5	M	41	19
14-Nov	2	90.0	F	P	H13978	06-Dec	2	74.1	F	41	22
14-Nov	2	87.0	F	P	H13985	01-Dec	6	74.9	F	41	17
14-Nov	2	87.0	M	P	H13986	22-Nov	4	71.8	F A	41	8
14-Nov	2	91.0	M	P	H13987	22-Nov	4	73.7	M	41	8
14-Nov	2	80.0	F	P	H13989	15-Nov	2	65.3	F B	41	1
14-Nov	2	72.0	F	P	H13992	15-Nov	2	65.4	F B	41	1
14-Nov	2	84.0	F	P	H13995	13-Dec	8	72.0	F	41	29
14-Nov	2	93.0	M	P	H13998	28-Nov	8	82.0	M	41	14
14-Nov	2	87.0	F	P	H17702	29-Nov	7	75.0	F	41	15
14-Nov	2	81.0	F	P	H17705	22-Nov	4	70.2	F	41	8
17-Nov	2	92.0	M	P	H17720	25-Nov	2	75.8	M	41	8
22-Nov	4	92.0	F	P	H17731	13-Dec	8	74.5	F	41	21
01-Nov	2	95.0	F	P	H21612	22-Nov	4	77.2	F	41	21
01-Nov	2	84.0	F	P	H21619	09-Nov	6	72.7	F	41	8
01-Nov	2	90.0	F	P	H21623	29-Nov	8	74.2	F	41	28
01-Nov	2	90.0	F	P	H21626	01-Dec	6	70.3	F	41	30
01-Nov	2	86.0	F	P	H21631	28-Nov	8	70.1	F	41	27
01-Nov	2	97.0	F	P	H21634	25-Nov	3	-	F C	41	24
01-Nov	2	84.0	F	P	H21662	24-Nov	8	69.2	F B	41	23
01-Nov	2	90.0	F	P	H21666	14-Nov	4	73.8	F	41	13
01-Nov	2	84.0	F	P	H21679	15-Nov	2	71.0	F	41	14
01-Nov	2	85.0	F	P	H21683	09-Nov	6	72.5	F	41	8

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994 continued.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
04-Nov	2	84.0	F	P	H21696	23-Nov	6	68.2	F	41	19
18-Oct	2	85.0	F	P	H23005	10-Nov	6	69.5	F	41	23
19-Oct	2	90.0	F	P	H23012	22-Nov	4	67.7	F	41	34
19-Oct	2	86.0	F	P	H23040	10-Nov	6	71.2	F	41	22
19-Oct	2	101.0	M	P	H23046	02-Nov	3	81.5	M	41	14
19-Oct	2	90.0	F	P	H23073	03-Nov	8	71.9	F	41	15
19-Oct	2	80.0	F	P	H23080	09-Nov	6	67.3	F	41	21
19-Oct	2	95.0	F	P	H23082	09-Nov	6	78.2	F	41	21
19-Oct	2	99.0	M	P	H23095	08-Nov	7	79.0	M C	-	20
19-Oct	2	92.0	M	P	H23103	09-Nov	4	75.0	M	41	21
19-Oct	2	108.0	M	P	H23104	05-Dec	8	80.0	M C	-	47
19-Oct	2	93.0	F	P	H23117	28-Nov	8	74.0	F	41	40
19-Oct	2	100.0	F	P	H23118	21-Nov	8	84.0	F	41	33
19-Oct	2	92.0	F	P	H23121	02-Nov	3	76.0	F	41	14
19-Oct	2	92.0	M	P	H23125	26-Oct	7	70.9	M	41	7
19-Oct	2	96.0	F	P	H23135	15-Nov	2	81.0	F	-	27
19-Oct	2	79.0	F	P	H23172	08-Nov	7	64.5	F	41	20
19-Oct	2	102.0	M	P	H23176	26-Oct	7	79.7	M	41	7
19-Oct	2	92.0	F	P	H23177	21-Nov	8	67.5	F	-	33
19-Oct	2	77.0	F	P	H23195	29-Nov	8	65.1	F	31	41
20-Oct	2	105.0	M	P	H23199	24-Nov	7	80.8	M	41	35
20-Oct	2	87.0	F	P	H23253	16-Nov	7	70.1	F	-	27
20-Oct	2	76.0	F	P	H23257	21-Nov	8	-	F C	-	32
21-Oct	2	89.0	F	P	H23270	28-Nov	8	77.0	F	41	38
21-Oct	2	88.0	F	P	H23272	09-Nov	4	71.4	F	41	19
21-Oct	2	84.0	F	P	H23275	16-Nov	8	68.8	F	41	26
21-Oct	2	97.0	M	P	H23277	18-Nov	8	76.2	M	41	28
21-Oct	2	85.0	F	P	H23284	15-Nov	2	74.0	F C	41	25
21-Oct	2	108.0	M	P	H23302	18-Nov	8	86.2	M	41	28
21-Oct	2	81.0	F	P	H23316	25-Nov	2	65.7	F	-	35
21-Oct	2	88.0	F	P	H23345	16-Nov	8	72.3	F	41	26
21-Oct	2	87.0	F	P	H23349	18-Nov	7	71.3	F	41	28
21-Oct	2	106.0	M	P	H23356	24-Nov	8	87.0	M	51	34
21-Oct	2	94.0	F	P	H23379	21-Nov	8	-	F	41	31
21-Oct	2	98.0	F	P	H23390	17-Nov	8	78.9	F	41	27
21-Oct	2	84.0	F	P	H23401	15-Nov	3	67.0	F	41	25
21-Oct	2	91.0	F	P	H23402	09-Nov	6	73.4	F	41	19
21-Oct	2	100.0	F	P	H23421	09-Nov	4	81.7	F	41	19
21-Oct	2	92.0	F	P	H23425	27-Oct	6	74.4	F	41	6
24-Oct	2	81.0	F	P	H23445	25-Nov	2	71.5	F	41	32
24-Oct	2	90.0	F	P	H23448	10-Nov	6	74.6	F	41	17
24-Oct	2	90.0	F	P	H23468	12-Dec	6	74.0	F	-	49
24-Oct	2	88.0	F	P	H23484	10-Nov	6	71.7	F	41	17
24-Oct	2	102.0	M	P	H23490	03-Nov	7	83.0	M	41	10
24-Oct	2	88.0	F	P	H23509	24-Nov	7	71.2	F	41	31
24-Oct	2	81.0	F	P	H23521	09-Nov	4	65.5	F	41	16
24-Oct	2	95.0	F	P	H23581	08-Nov	7	76.3	F	41	15

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994 continued.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
24-Oct	2	98.0	F	P	H23582	25-Nov	2	62.3	F	-	32
24-Oct	2	83.0	F	P	H23593	03-Nov	8	76.5	F	41	10
24-Oct	2	88.0	F	P	H23598	16-Nov	8	71.1	F	41	23
24-Oct	2	95.0	F	P	H23600	16-Nov	7	76.4	F	41	23
24-Oct	2	89.0	F	P	H23601	08-Nov	6	74.3	F	-	15
24-Oct	2	89.0	F	P	H23619	16-Nov	3	70.2	F	41	23
24-Oct	2	90.0	F	P	H23630	03-Nov	7	73.3	F	41	10
24-Oct	2	92.0	F	P	H23649	23-Nov	4	76.5	F	41	30
24-Oct	2	82.0	F	P	H23650	08-Nov	7	67.4	F	-	15
24-Oct	2	86.0	F	P	H23654	09-Nov	6	71.2	F	61	16
24-Oct	2	97.0	F	P	H23659	03-Nov	7	68.8	F	41	10
24-Oct	2	89.0	F	P	H23670	09-Nov	4	74.2	F	-	16
24-Oct	2	93.0	F	P	H23681	16-Nov	8	77.9	F	41	23
24-Oct	2	93.0	F	P	H23691	25-Nov	2	74.6	F	41	32
24-Oct	2	90.0	F	P	H23694	14-Nov	4	73.9	F	41	21
24-Oct	2	85.0	F	P	H23707	09-Nov	4	69.2	F	41	16
24-Oct	2	92.0	F	P	H23710	21-Nov	8	73.6	F	41	28
24-Oct	2	91.0	F	P	H23712	16-Nov	3	69.0	F	41	23
24-Oct	2	84.0	F	P	H23725	09-Dec	8	70.0	F	-	46
24-Oct	2	89.0	F	P	H23728	09-Nov	6	73.3	F	41	16
24-Oct	2	88.0	F	P	H23738	24-Nov	6	76.3	F	41	31
25-Oct	2	81.0	F	P	H23760	16-Nov	8	70.6	F	41	22
25-Oct	2	98.0	M	P	H23762	23-Nov	7	79.0	M	41	29
25-Oct	2	82.0	F	P	H23769	23-Nov	4	69.3	F	41	29
25-Oct	2	107.0	M	P	H23777	03-Nov	8	76.4	M	41	9
25-Oct	2	88.0	F	P	H23778	03-Nov	7	72.6	F	41	9
25-Oct	2	80.0	F	P	H23799	24-Nov	7	66.4	F	41	30
25-Oct	2	99.0	M	P	H23800	06-Dec	6	75.0	M C	-	42
25-Oct	2	87.0	F	P	H23802	16-Nov	8	72.3	F	41	22
25-Oct	2	86.0	F	P	H23821	15-Nov	3	68.5	F	41	21
25-Oct	2	84.0	F	P	H23825	08-Nov	7	67.7	F	51	14
25-Oct	2	87.0	F	P	H23833	24-Nov	7	68.7	F	41	30
25-Oct	2	86.0	F	P	H23895	28-Nov	8	68.6	F	41	34
25-Oct	2	84.0	F	P	H23905	24-Nov	8	79.3	F	-	30
25-Oct	2	96.0	F	P	H23907	16-Nov	3	76.6	F	41	22
25-Oct	2	91.0	F	P	H23912	10-Nov	6	74.3	F	41	16
26-Oct	2	85.0	F	P	H23958	29-Nov	6	72.5	F	41	34
26-Oct	2	83.0	F	P	H23963	05-Dec	8	65.0	F	-	40
26-Oct	2	101.0	M	P	H23964	21-Nov	8	78.2	M	41	26
26-Oct	2	87.5	F	P	H23974	15-Nov	2	71.4	F	41	20
26-Oct	2	92.0	F	P	H23982	09-Nov	4	80.0	F	41	14
26-Oct	2	89.0	F	P	H23991	24-Nov	7	73.4	F	41	29
26-Oct	2	77.0	M	P	H24013	03-Nov	7	65.5	M	31	8
26-Oct	2	96.0	F	P	H24026	05-Dec	8	78.0	F C	41	40
26-Oct	2	85.0	F	P	H24039	16-Nov	3	71.5	F	-	21
26-Oct	2	74.0	F	P	H24047	18-Nov	6	61.3	F	41	23
26-Oct	2	87.0	F	P	H24052	18-Nov	8	70.4	F	41	23

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994 continued.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
26-Oct	2	88.0	F	P	H24053	25-Nov	2	70.7	F	41	30
26-Oct	2	95.0	F	P	H24076	23-Nov	4	78.5	F	41	28
26-Oct	2	106.0	M	P	H24082	16-Nov	7	81.6	M	41	21
26-Oct	2	100.0	F	P	H24091	09-Nov	4	83.0	F	41	14
26-Oct	2	92.0	F	P	H24105	28-Nov	8	80.0	F	-	33
26-Oct	2	88.0	F	P	H24112	15-Nov	2	71.5	F	41	20
26-Oct	2	95.0	M	P	H24140	21-Nov	8	71.5	M	41	26
26-Oct	2	87.0	F	P	H24156	16-Nov	7	70.4	F	41	21
26-Oct	2	86.0	M	P	H24169	13-Dec	8	65.5	M	-	48
26-Oct	2	97.0	M	P	H24172	21-Nov	8	74.7	M	41	26
26-Oct	2	88.0	F	P	H24173	18-Nov	7	73.0	F	41	23
26-Oct	2	84.0	F	P	H24186	16-Nov	3	68.2	F	41	21
26-Oct	2	95.0	F	P	H24187	16-Nov	8	78.6	F	41	21
26-Oct	2	95.0	F	P	H24197	18-Nov	6	81.5	F	41	23
26-Oct	2	81.0	M	P	H24204	21-Nov	8	68.0	M	-	26
26-Oct	2	87.0	F	P	H24207	10-Nov	6	71.7	F	41	15
26-Oct	2	82.0	F	P	H24208	21-Nov	8	80.0	F E	41	26
26-Oct	2	90.0	F	P	H24228	09-Nov	4	72.7	F	41	14
26-Oct	2	97.0	M	P	H24236	08-Nov	6	76.0	M	41	13
26-Oct	2	85.0	F	P	H24274	21-Nov	8	69.6	F	41	26
26-Oct	2	88.0	F	P	H24275	23-Nov	6	72.2	F	41	28
26-Oct	2	112.0	M	P	H24292	09-Nov	6	74.6	F A	41	14
26-Oct	2	97.0	F	P	H24301	23-Nov	7	81.0	F	41	28
26-Oct	2	79.0	F	P	H24307	08-Nov	7	65.9	F	41	13
26-Oct	2	101.0	M	P	H24326	13-Dec	8	79.0	M	41	48
26-Oct	2	75.0	M	P	H24348	25-Nov	3	63.0	M	31	30
26-Oct	2	92.0	F	P	H24352	12-Dec	6	69.0	F C	-	47
26-Oct	2	83.0	F	P	H24361	28-Nov	8	70.0	F	41	33
26-Oct	2	87.0	F	P	H24364	08-Nov	6	69.5	F	41	13
26-Oct	2	87.0	F	P	H24381	28-Nov	8	74.5	F	41	33
26-Oct	2	89.0	F	P	H24392	15-Nov	8	72.8	F	41	20
26-Oct	2	97.0	F	P	H24398	24-Nov	7	68.5	F	41	29
26-Oct	2	83.0	F	P	H24399	17-Nov	8	63.8	M A	41	22
26-Oct	2	91.0	F	P	H24401	14-Nov	4	73.5	F	51	19
26-Oct	2	83.0	M	P	H24421	28-Nov	8	68.0	M	41	33
26-Oct	2	96.0	F	P	H24422	29-Nov	8	75.3	F	41	34
26-Oct	2	83.0	F	P	H24448	25-Nov	2	68.0	F	41	30
27-Oct	2	90.0	M	P	H24469	15-Nov	2	75.5	F A	41	19
27-Oct	2	82.0	F	P	H24481	07-Dec	6	65.6	F	-	41
27-Oct	2	93.0	F	P	H24484	17-Nov	8	75.2	F	41	21
27-Oct	2	84.0	F	P	H24493	21-Nov	8	72.0	F	41	25
27-Oct	2	91.0	F	P	H24499	18-Nov	6	74.4	F	61	22
27-Oct	2	87.0	F	P	H24505	18-Nov	6	73.0	F	41	22
27-Oct	2	66.0	M	P	H24528	23-Nov	7	65.0	M E	41	27
27-Oct	2	94.0	M	P	H24533	16-Nov	5	76.0	M	41	20
27-Oct	2	96.0	F	P	H24544	16-Nov	5	81.0	F	41	20
27-Oct	2	86.0	F	A	H24552	18-Nov	7	84.5	F E	51	22

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994 continued.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
27-Oct	2	94.0	F	P	H24554	23-Nov	7	77.5	F	41	27
27-Oct	2	87.0	F	P	H24570	09-Nov	4	72.4	F	31	13
27-Oct	2	87.0	F	P	H24583	23-Nov	6	68.7	F	41	27
27-Oct	2	88.0	F	P	H24589	21-Nov	8	73.5	F	41	25
27-Oct	2	96.0	F	P	H24593	25-Nov	3	83.5	F	-	29
27-Oct	2	84.0	F	P	H24595	03-Nov	8	67.3	F	41	7
27-Oct	2	87.0	F	P	H24599	25-Nov	2	72.9	F	41	29
27-Oct	2	95.0	M	P	H24603	21-Nov	8	75.3	M	41	25
27-Oct	2	87.0	F	P	H24618	21-Nov	8	69.6	F	41	25
27-Oct	2	96.0	F	P	H24629	21-Nov	8	70.5	F	-	25
27-Oct	2	80.0	F	P	H24631	21-Nov	8	67.7	F	41	25
27-Oct	2	71.0	M	P	H24641	08-Dec	7	61.0	M	-	42
27-Oct	2	94.0	F	P	H24651	16-Nov	7	78.9	F	41	20
27-Oct	2	105.0	M	P	H24662	15-Nov	2	81.3	M	41	19
27-Oct	2	76.0	M	P	H24666	02-Nov	2	61.4	M	-	6
27-Oct	2	94.0	M	P	H24671	16-Nov	3	74.4	M	-	20
27-Oct	2	75.0	F	P	H24674	16-Nov	3	63.1	F	-	20
27-Oct	2	100.0	M	P	H24676	15-Nov	8	77.4	M	51	19
27-Oct	2	93.0	F	P	H24679	23-Nov	6	75.3	F	41	27
27-Oct	2	92.0	F	P	H24687	07-Dec	6	71.3	F C	-	41
27-Oct	2	82.0	M	P	H24696	28-Nov	8	65.9	M	-	32
27-Oct	2	89.0	F	P	H24701	16-Nov	8	72.7	F	-	20
27-Oct	2	89.0	F	P	H24703	15-Nov	2	73.0	F	41	19
27-Oct	2	86.0	F	P	H24708	07-Dec	6	71.7	F	-	41
27-Oct	2	90.0	M	P	H24709	24-Nov	7	77.0	M	41	28
27-Oct	2	80.0	F	P	H24710	09-Nov	4	69.0	F	31	13
28-Oct	2	91.0	M	P	H24718	02-Nov	2	72.4	M B	41	5
28-Oct	2	101.0	M	P	H24725	15-Nov	2	73.0	M B	41	18
28-Oct	2	92.0	F	P	H24730	25-Nov	2	75.9	F	41	28
28-Oct	2	100.0	F	P	H24732	25-Nov	4	85.0	F	41	28
28-Oct	2	82.0	F	P	H24734	23-Nov	4	68.5	F	41	26
28-Oct	2	100.0	M	P	H24745	16-Nov	7	77.6	M	-	19
28-Oct	2	101.0	F	P	H24747	09-Nov	6	80.7	F	41	12
28-Oct	2	81.0	F	P	H24754	15-Nov	8	68.2	F	41	18
28-Oct	2	89.0	F	P	H24758	09-Nov	4	73.3	F	41	12
28-Oct	2	85.0	F	P	H24766	16-Nov	8	74.8	F	41	19
28-Oct	2	90.0	F	P	H24774	17-Nov	8	77.0	F	41	20
28-Oct	2	94.0	F	P	H24785	08-Nov	7	74.3	F	41	11
28-Oct	2	89.0	F	P	H24796	25-Nov	3	73.5	F	41	28
31-Oct	2	101.0	M	P	H24799	17-Nov	8	82.0	M	41	17
31-Oct	2	92.0	F	P	H24803	16-Nov	3	72.5	F	41	16
31-Oct	2	96.0	M	P	H24806	12-Dec	6	71.0	M	-	42
31-Oct	2	85.0	F	P	H24808	24-Nov	7	69.0	F	41	24
31-Oct	2	87.0	F	P	H24823	22-Nov	4	70.8	F	41	22
31-Oct	2	84.0	F	P	H24836	16-Nov	5	72.0	F	41	16
31-Oct	2	77.0	M	P	H24858	25-Nov	2	61.0	F A	41	25
31-Oct	2	87.0	F	P	H24872	16-Nov	3	73.0	F	41	16

Continued

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1994 continued.

Application sample						Recovery sample					
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	Days out
31-Oct	2	63.0	M	P	H24889	17-Nov	8	61.2	M E	31	17
31-Oct	2	95.0	F	P	H24896	09-Nov	6	76.3	F	41	9
31-Oct	2	76.0	F	P	H24901	02-Nov	2	64.5	F B	-	2
01-Nov	2	93.0	F	P	H24936	21-Nov	8	70.8	F	41	20
01-Nov	2	85.0	F	P	H24941	25-Nov	2	71.8	F	41	24
01-Nov	2	93.0	F	P	H24962	18-Nov	8	77.5	F	41	17
01-Nov	2	82.0	F	P	H24995	01-Dec	8	70.5	F	41	30
Application data unknown					Tag lost	02-Nov	2	76.8	M	41	n/a
Application data unknown					Tag lost	02-Nov	2	78.2	M	41	n/a
Application data unknown					Tag lost	02-Nov	3	76.5	F	41	n/a
Application data unknown					Tag lost	03-Nov	7	76.5	F	51	n/a
Application data unknown					Tag lost	14-Nov	4	76.0	M	41	n/a
Application data unknown					Tag lost	14-Nov	4	73.3	F	41	n/a
Application data unknown					Tag lost	15-Nov	8	78.5	M	41	n/a
Application data unknown					Tag lost	15-Nov	2	81.0	M	41	n/a
Application data unknown					Tag lost	21-Nov	8	75.5	M	41	n/a
Application data unknown					Tag lost	21-Nov	8	73.3	F	41	n/a
Application data unknown					Tag lost	23-Nov	6	76.0	M	51	n/a
Application data unknown					Tag lost	23-Nov	4	64.8	F	31	n/a
Application data unknown					Tag lost	25-Nov	2	72.4	M	41	n/a
Application data unknown					Tag lost	29-Nov	7	64.2	M	-	n/a
Application data unknown					Tag lost	01-Dec	8	84.5	M	41	n/a
Application data unknown					Tag lost	06-Dec	3	69.8	F	41	n/a
Application data unknown					Tag lost	07-Dec	5	77.0	F	-	n/a

Females initially identified as males: 4 2.1%
Males initially identified as females: 1 1.9%

Mean days out: 22.1
Max. days out: 49.0
Min. days out: 1.0

POH and NF Regressions:
Males: POH = 0.64 NF + 14.90, (r^2 = 0.80)
NF = 1.26 POH + 0.04
Females: POH = 0.56 NF + 22.78, (r^2 = 0.53)
NF = 0.95 POH + 19.62

A. Incorrect sex identification during disk tag application.
B. Required ventilation assistance at release.
C. Unknown secondary mark at recovery.
D. Unknown adipose fin status at recovery.
E. Lengths omitted from regresssions.

Appendix 3. Daily chinook carcass recoveries, by reach, mark status and sex, in the Harrison River, 1993.

		Unmarked		Spagetti tag and secondary mark		Secondary mark only		Spagetti tag only		Total			Adipose fin absent	
Date	Reach	Male	Female	Male	Female	Male	Female	Male	Femal	Male	Female	Jack A	Male	Female
25-Oct	8	54	81	0	0	0	0	0	0	54	81	8	0	0
26-Oct	7	47	85	2	0	0	0	0	0	49	85	11	0	1
27-Oct	4	8	10	0	0	0	0	0	0	8	10	8	0	0
	6	40	42	0	1	0	0	0	0	40	43	5	0	0
31-Oct	7	5	11	0	0	0	0	0	0	5	11	0	0	0
	8	13	22	0	0	0	0	0	0	13	22	2	0	0
02-Nov	2	15	24	2 B	1 B	2	0	0	0	19	25	0	0	0
	3	40	51	1	1	0	1	0	0	41	53	3	0	0
	5	9	16	0	0	0	0	0	0	9	16	0	0	0
03-Nov	7	61	106	2	3	0	1	0	0	63	110	13	0	1
	8	143	151	1	3	0	0	0	0	144	154	38	1	0
08-Nov	6	55	62	1	2	0	0	0	0	56	64	2	0	0
	7	133	194	0	6	0	0	1	0	134	200	13	1	1
09-Nov	4	155	332	1	11	0	0	0	0	156	343	5	0	0
	6	37	103	0	10	0	0	0	0	37	113	9	0	2
10-Nov	6	132	199	0	6	0	0	0	0	132	205	2	0	1
14-Nov	4	46	114	0	3	1	1	0	0	47	118	0	0	0
15-Nov	2	60	115	3 C	9 C	1	0	0	1 D	64	125	4	1	4
	3	35	82	1	2	0	0	0	0	36	84	1	0	0
	8	81	93	2	2	1	0	0	0	84	95	11	0	1
16-Nov	3	62	146	1	9	0	0	0	0	63	155	1	1	0
	5	17	25	1	2	0	0	0	0	18	27	0	0	0
	7	69	151	2	6	0	0	0	0	71	157	1	0	0
	8	117	105	0	9	0	0	0	0	117	114	22	1	0
17-Nov	8	82	95	3	3	0	0	0	0	85	98	14	0	0
18-Nov	6	76	193	0	4	0	0	0	0	76	197	2	0	0
	7	86	130	0	3	0	0	0	0	86	133	6	0	0
	8	39	37	2	2	0	0	0	0	41	39	6	0	0
21-Nov	8	366	418	6	14	1	1	0	1 E	373	434	26	0	1
22-Nov	4	36	94	1	5	0	0	0	0	37	99	3	0	0
23-Nov	4	48	154	0	4	0	1	0	0	48	159	1	1	0
	5	3	3	0	0	0	0	0	0	3	3	0	0	0
	6	23	84	1	5	1	0	0	0	25	89	0	0	0
	7	52	89	2	4	0	0	0	0	54	93	4	0	0
24-Nov	6	18	53	0	1	0	0	0	0	18	54	0	0	0
	7	150	221	2	9	0	0	0	0	152	230	5	0	0
	8	45	62	1	2 B	0	0	0	0	46	64	6	0	0
25-Nov	2	64	95	2	11	1	0	0	0	67	106	0	0	0
	3	43	85	1	2	0	0	0	1 D	44	88	0	0	0
	4	22	107	0	1	0	0	0	0	22	108	0	0	0
28-Nov	8	302	357	4	8	0	0	0	0	306	365	7	0	0
29-Nov	6	16	54	1	1	0	0	0	0	17	55	2	0	0
	7	71	101	0	2	1	0	0	0	72	103	7	0	0
	8	22	26	0	3	0	0	0	0	22	29	2	0	0
30-Nov	2	1	3	0	0	0	0	0	0	1	3	0	0	0
	3	2	3	0	0	0	0	0	0	2	3	0	0	0
	4	2	4	0	0	0	0	0	0	2	4	0	0	0
01-Dec	3	6	11	0	0	0	0	0	0	6	11	0	0	0
	4	5	17	0	0	0	0	0	0	5	17	0	0	0
	6	19	26	0	2	0	0	0	0	19	28	2	0	0

Continued

Appendix 3. Daily chinook carcass recoveries, by reach, mark status and sex, in the Harrison River, 1993 continued.

		Unmarked		Spagetti tag and secondary mark		Secondary mark only		Spagetti tag only		Total			Adipose fin absent	
Date	Reach	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Jack A	Male	Female
01-Dec	8	125	116	0	3	1	0	0	0	126	119	1	1	0
02-Dec	4	2	8	0	0	0	0	0	0	2	8	0	0	0
	6	5	8	0	0	0	0	0	0	5	8	3	0	0
	7	11	7	0	0	0	0	0	0	11	7	0	0	0
	8	10	16	0	0	0	0	0	0	10	16	0	0	0
05-Dec	8	94	110	0	2	0	0	1 D	1 D	95	113	3	0	0
06-Dec	2	5	4	0	1	0	0	0	0	5	5	0	0	0
	3	4	6	0	0	0	1	0	0	4	7	0	0	0
	4	12	40	0	0	0	0	0	0	12	40	1	0	0
	6	15	29	0	0	0	0	1 D	0	16	29	0	0	0
07-Dec	5	9	12	0	1	0	1	0	0	9	14	0	0	0
	6	3	24	0	2	0	0	0	1 D	3	27	0	0	0
08-Dec	7	30	34	1	0	0	0	0	0	31	34	0	0	0
	8	16	30	0	0	0	0	0	0	16	30	0	0	0
09-Dec	8	26	51	0	1	0	0	0	0	26	52	0	0	0
12-Dec	6	21	37	1	1	0	0	0	1 D	22	39	0	0	0
13-Dec	4	3	10	0	0	0	0	0	0	3	10	0	0	0
	6	3	10	0	0	0	0	0	0	3	10	0	0	0
	8	48	106	2	2	0	0	0	0	50	108	0	0	0
14-Dec	7	16	31	0	0	0	0	0	0	16	31	0	0	2
15-Dec	4	9	13	0	0	0	0	0	0	9	13	0	0	0
	8	15	57	0	1	0	0	0	0	15	58	0	0	0
Total	2	145	241	7	22	4	0	0	1	156	264	4	1	4
	3	192	384	4	14	0	2	0	1	196	401	5	1	0
	4	348	903	2	24	1	2	0	0	351	929	18	1	0
	5	38	56	1	3	0	1	0	0	39	60	0	0	0
	6	463	924	4	35	1	0	1	2	469	961	27	0	3
	7	731	1,160	11	33	1	1	1	0	744	1,194	60	1	5
	8	1,598	1,933	21	55	3	1	1	2	1,623	1,991	146	3	2
	Total	3,515	5,601	50	186	10	7	3	6	3,578	5,800	260	7	14

A. Adipose status not recorded for jacks.
B. Includes 1 which required ventilation at release.
C. Includes 2 which required ventilation at release.
D. Recovered from carcass with missing operculum.
E. Recovered from rotten carcass.

Appendix 4. Proportion at age and mean length at age, by AFC status and sex, of chinook carcasses recovered on the Harrison River spawning grounds, 1994.

		Female			Male		
Adipose fin status	Age A	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	6/1	2	0.5%	72.8	1	0.6%	77.8
	5/1	10	2.3%	74.4	7	4.3%	82.3
	4/1	417	95.4%	73.5	148	90.2%	77.3
	3/1	8	1.8%	68.7	8	4.9%	64.0
	Sub-1	437	100.0%	73.5	164	100.0%	76.9
	Sub-2	0	0.0%	-	0	0.0%	-
	Total	490	71.5%	73.4	195	28.5%	76.2
	Flesh colour						
	Red	1	0.2%	67.7	0	0.0%	-
	White	481	99.8%	73.4	187	100.0%	76.1
Adipose fin clip	5/2	1	7.7%	72.7	0	0.0%	-
	4/1	12	92.3%	73.6	3	75.0%	77.3
	3/1	0	0.0%	-	1	25.0%	61.1
	Sub-1	12	92.3%	73.6	4	100.0%	73.2
	Sub-2	1	7.7%	72.7	0	0.0%	-
	Total	14	66.7%	72.9	7	33.3%	75.1
	Flesh colour						
	Red	0	0.0%	-	0	0.0%	-
	White	13	100.0%	73.3	7	100.0%	75.1
Total	6/1	2	0.4%	72.8	1	0.6%	77.8
	5/2	1	0.2%	72.7	0	0.0%	-
	5/1	10	2.2%	74.4	7	4.2%	82.3
	4/1	429	95.3%	73.5	151	89.9%	77.3
	3/1	8	1.8%	68.7	9	5.4%	63.6
	Sub-1	449	99.8%	73.5	168	100.0%	76.8
	Sub-2	1	0.2%	72.7	0	0.0%	-
	Total	504	71.4%	73.4	202	28.6%	76.2
	Flesh colour						
	Red	1	0.2%	67.7	0	0.0%	-
	White	494	99.8%	73.4	194	100.0%	76.1

A. Totals include unageable samples.

Appendix 5. AFC and CWT sampling of chinook adults recovered on the Harrison River spawning grounds, 1994

			Sampling results		
			Male	Female	Total
Sample size			3,578	5,800	9,378
Number with AFCs			7	14	21
AFC but no head			0	0	0
CWT lost during processing			0	0	0
AFC but no CWT			0	3	3
CWT recovered:					
Code	**Brood**	**Release site**			
02 02 42	1989	Chilliwack Hatchery	0	1 B	1
02 06 42	1989	Chehalis Hatchery	1 A	0	1
02 06 44	1989	Chehalis Hatchery	1 A	1	2
02 15 47	1990	Chehalis Hatchery	4 A	5	9
02 15 48	1990	Chehalis Hatchery	0	4 A	4
18 03 35	1991	Chehalis Hatchery	1	0	1
Total			7	11	18
AFC incidence (%)			0.20%	0.24%	0.22%
CWT loss (%)			0.00%	21.43%	14.29%
Spatial pattern in AFC incidence:					
Upper Section (reaches 1,2)			0.65%	0.77%	0.72%
Middle Section (reaches 3,4,5)			0.34%	0.00%	0.10%
Lower Section (reaches 6,7,8)			0.14%	0.22%	0.19%
Temporal pattern in AFC incidence:					
Early Period (23-Oct to 12-Nov)			0.21%	0.39%	0.32%
Middle Period (13-Nov to 26-Nov)			0.24%	0.21%	0.22%
Late Period (27-Nov to 17-Dec)			0.11%	0.14%	0.13%

A. Scale age was unavailable for 1 fish.

B. Includes 1 which was incorrectly scale aged as a 4-year-old.

Appendix 6. Incidence of CWT loss, by carcass condition, eye status, and AFC condition, in AFC chinook adult carcasses recovered on the Harrison River spawning grounds, 1994.

Observation	Condition	Number	CWT absent	CWT loss (%)
Carcass condtion	Fresh	0	0	-
	Moderately fresh	6	0	0.0%
	Moderately rotten	14	3	21.4%
	Rotten	1	0	0.0%
Eyes present A	None	4	0	0.0%
	One	6	1	16.7%
	Two	10	1	10.0%
Adipose fin clip	Complete	18	1	5.6%
	Partial	1	1	100.0%
	Questionable	2	1	50.0%

A. Eye condition was not recorded for 1 AFC carcass.

Appendix 7. Spawning success, by mark status, in female chinook carcassess recovered on the Harrison River spawning grounds, 1994.

		Percent spawned			
Mark status		0%	50%	100%	Weighted mean
Spaghetti tag or secondary mark	Number	9	2	184	
	Percent	4.6%	1.0%	94.4%	94.9%
Unmarked	Number	26	7	273	
	Percent	8.5%	2.3%	89.2%	90.4%
Total	Number	35	9	457	
	Percent	7.0%	1.8%	91.2%	92.1%