Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of the Harrison River, 1984-1988

M.J. Staley

Department of Fisheries and Oceans
Fisheries Branch
#416, Suite 400-555 West Hastings Street
Vancouver, British Columbia V6B 5G3

April 1990

Canadian Manuscript Report of
Fisheries and Aquatic Sciences
No. 2066

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.

Paul Starr

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2066

April 1990

ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF THE HARRISON RIVER, 1984 - 1988

by

M. J. Staley[1]

Department of Fisheries and Oceans
Fisheries Branch
#416, Suite 400 - 555 West Hastings Street
Vancouver, British Columbia
V6B 5G3

[1]#219 811 Beach Avenue
Vancouver, British Columbia
V6Z 2B5

Cat. No. Fs 97-4/2066E ISSN 0706-6473

Correct citation for this publication:

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.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

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.

This report summarizes mark recapture and biological studies carried out on the chinook salmon (Oncorhynchus tshawytscha) of the Harrison River from 1984 to 1988. Peterson estimates from the studies were 120,836 174,777 162,598 79,039 and 35,116 for 1984 through 1988 respectively. Confidence levels on the estimates ranged between +/- 11.5% to +/- 22.1%.

Data on sex, length, age, area of release, handling, release condition and pre-spawn mortality were analyzed. Large errors in sex identification required the development of a correction factor for sex at time of tagging.

Coded wire tags from the Chehalis (Harrison R.) and Chilliwack (Chilliwack R.) hatcheries were recovered in the Harrison River in these studies. Escapement estimates for coded wire tags were 195, 562, 195, 350 and 300 for the five years. Low incidence of these tags and the error in the total population estimates generated 95% confidence intervals for CWT escapements of a factor of approximately 2.

Key Words: Harrison, chinook, key stream, escapement, coded wire tags, live tagging

RÉSUMÉ

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.

Le présent rapport résume les résultats d'études de marquage-recapture et d'études biologiques du saumon quinnat (Oncorhynchus tshawytscha) de la rivière Harrison réalisées de 1984 à 1988. Les effectifs estimés par la méthode Petersen ont été, pour la période 1984-1988, respectivement de 120 836, 174 777, 162 598, 79 039 et 35 116. Les niveaux de confiance des estimations variaient de ± 11,5% à ± 22,1%.

Les données sur la sexe, la longuer, l'âge, le lieu de remise à l'eau, la manutention, les conditions de remise à l'eau et la mortalité d'avant le frai ont fait l'objet d'analyses. L'existence d'importantes erreurs touchant la détermination du sexe a nécessité l'élaboration d'un facteur de correction pour le sexe au moment du marquage.

Des fils codés implantés aux pisciculturés de Chehalis (riv. Harrison) et de Chilliwack (riv. Chilliwack) ont été récupérés dans la rivière Harrison. Pour ces cinq années, les estimations des remontées de poissons marqués ont été, respectivement, de 195, 562, 195, 350 et 300. La faible incidence de ces marqueurs et l'erreur liée aux estimations des effectifs totaux de la population se sont traduites par des intervalles de confiance de 95% des échappées de poissons marqués par fil codés atteignant un facteur de 2 environ.

Mots clés: Harrison, quinnat, cours d'eau clé, échappée, marqueur en fil codé, maquage à l'état vivant.

INTRODUCTION

The 1985 Canada - United States Pacific Salmon Treaty improved cooperation in salmon management, research and enhancement in the northeast Pacific. One of the main focuses of the treaty was a management regime aimed at rebuilding depressed chinook (Oncorhynchus tshawytscha) stocks.

To assess the progress and success of the management changes, "key streams" or stocks were selected as indicators of the response of chinook stocks in general to changes in harvest patterns following the implementation of the treaty. In British Columbia nine key streams were initially selected, representing a wide range of life histories and geographical areas. Four streams were in the Fraser River watershed. These included: the Bowron River in the upper Fraser, the Eagle and Shuswap rivers in the South Thompson drainage, and the Harrison River in the Lower Fraser (Fig. 1).

The purpose of the key stream program was twofold. One purpose was to measure the spawning escapement of the stocks to detect any changes. The second purpose of the key steams program was to measure changes in overall harvest rates on the stocks through analysis of coded wire tagging (CWT) data. The Harrison River study was primarily aimed at estimating escapement.

This report gives the results of the 1984-88 spawner enumeration and biological sampling projects on the Harrison River chinook stocks. The results include escapement population estimates, sex age and size compositions, recoveries of CWT's, and results of various tests of study bias.

The first section describes the study area. The next section discusses the methods used for tagging and recovering fish and carcasses, biological sampling and data analysis. Results are then presented including annual spawning escapement estimates, sex and age structure and estimated escapement of CWT chinook.

STUDY AREA

The Harrison River is the largest tributary in the Fraser River Drainage below Hope. Originating from Harrison Lake, the river flows southwest for approximately 18 km to join the north bank of the Fraser River 116 km from the sea. The Harrison River drains an area of 8,000 km^2 and has a mean annual discharge of 449 m^3s^{-1}. Extreme flows ranged from 66.3 m^3s^{-1} to 1,930 m^3s^{-1} over the period 1951 to 1982. Annual mean monthly flows ranged from 202 m^3s^{-1} in March to 947 m^3s^{-1} in June.

The study area was divided into eight reaches according to homogeneous physical characteristics (Fig. 2).

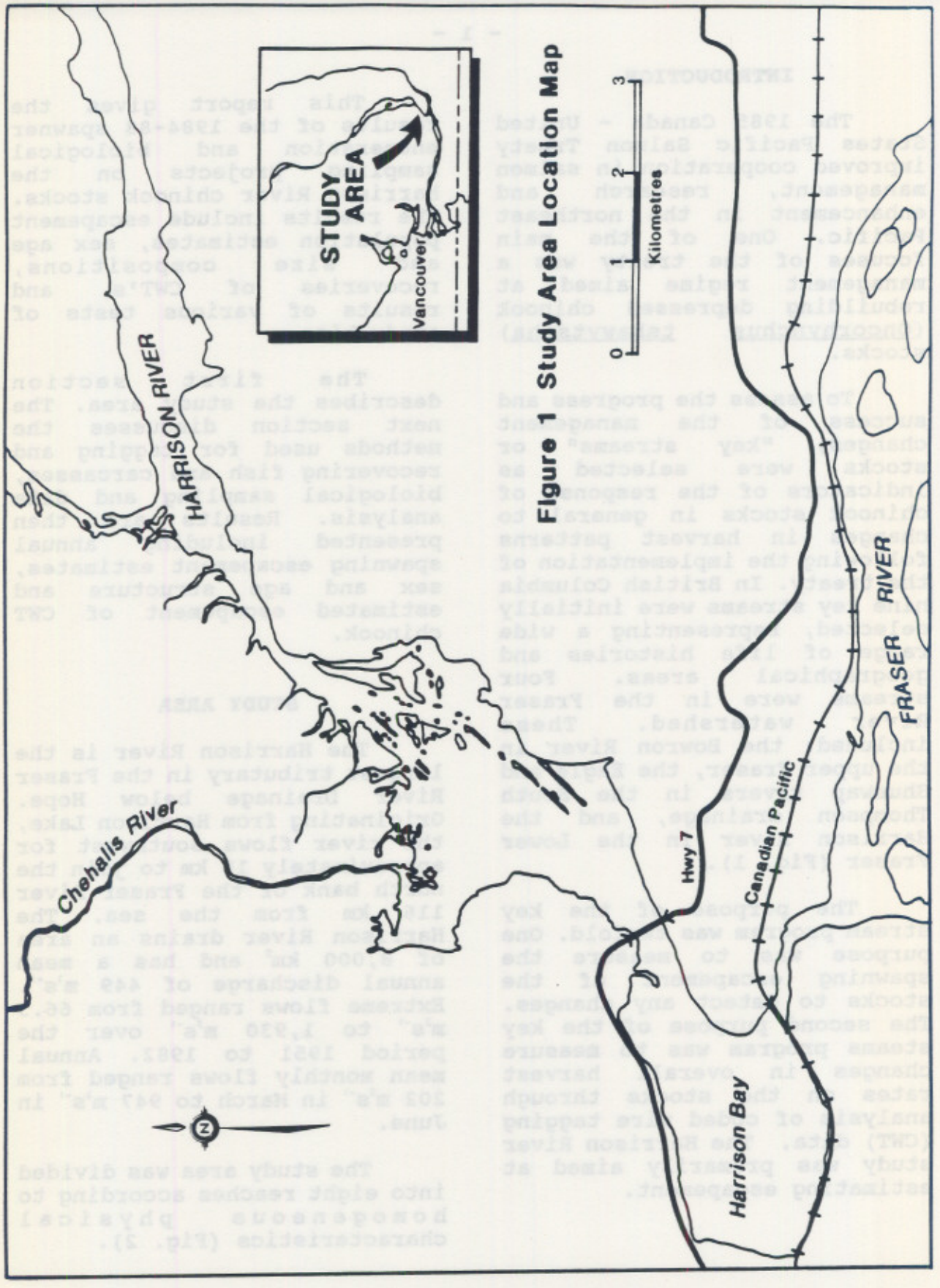

FIGURE 1. Study area location map for chinook salmon spawner enumeration, Harrison River, 1984 - 88.

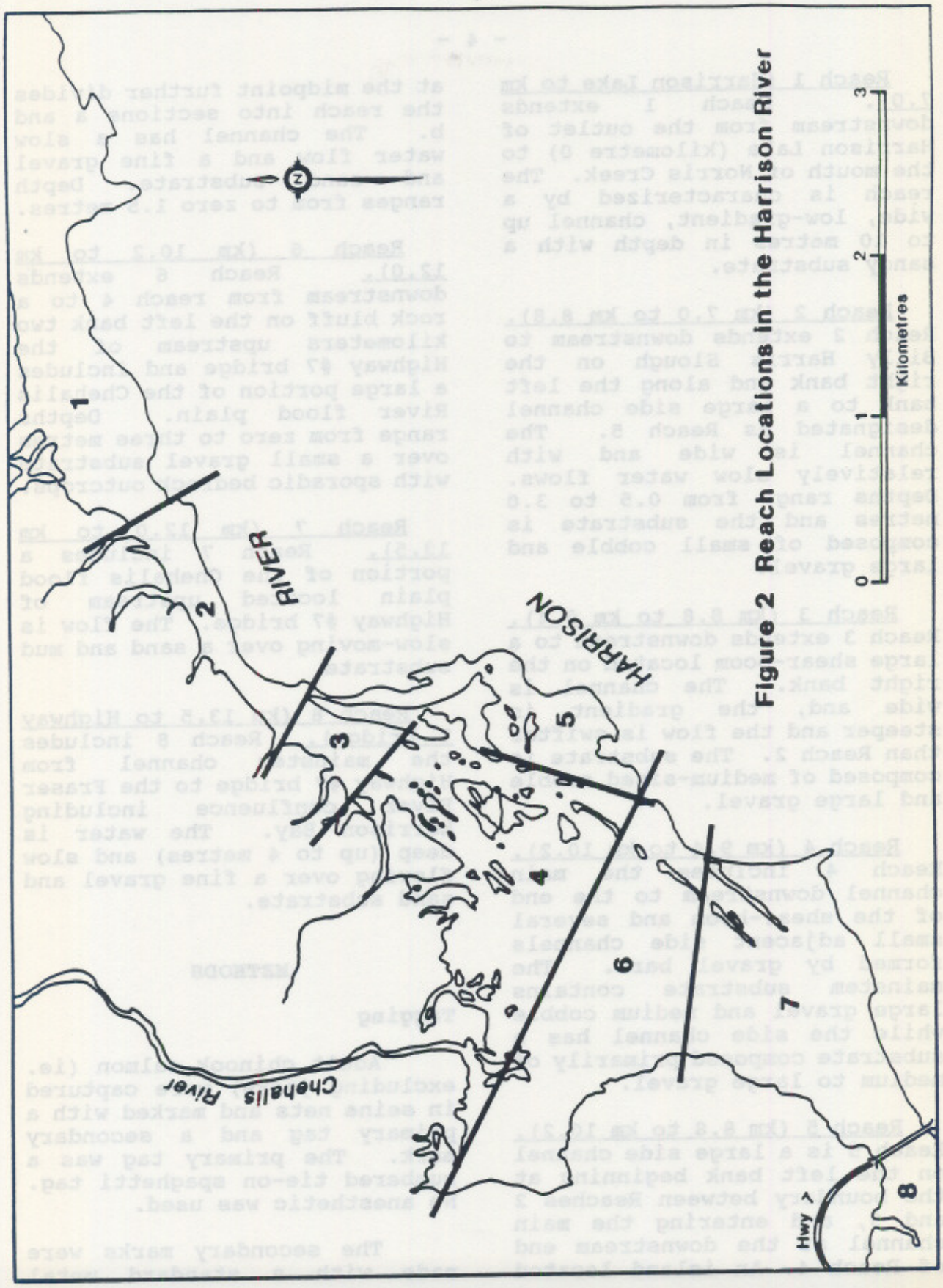

FIGURE 2. Reach locations for the chinook salmon spawner enumeration study, Harrison River, 1984 - 88.

Reach 1 (Harrison Lake to km 7.0). Reach 1 extends downstream from the outlet of Harrison Lake (kilometre 0) to the mouth of Norris Creek. The reach is characterized by a wide, low-gradient, channel up to 10 metres in depth with a sandy substrate.

Reach 2 (km 7.0 to km 8.8). Reach 2 extends downstream to Billy Harris Slough on the right bank and along the left bank to a large side channel designated as Reach 5. The channel is wide and with relatively slow water flows. Depths range from 0.5 to 3.0 metres and the substrate is composed of small cobble and large gravel.

Reach 3 (km 8.8 to km 9.4). Reach 3 extends downstream to a large shear-boom located on the right bank. The channel is wide and, the gradient is steeper and the flow is swifter than Reach 2. The substrate is composed of medium-sized cobble and large gravel.

Reach 4 (km 9.4 to km 10.2). Reach 4 includes the main channel downstream to the end of the shear-boom and several small adjacent side channels formed by gravel bars. The mainstem substrate contains large gravel and medium cobble while the side channel has a substrate composed primarily of medium to large gravel.

Reach 5 (km 8.8 to km 10.2). Reach 5 is a large side channel on the left bank beginning at the boundary between Reaches 2 and 3, and entering the main channel at the downstream end of Reach 4. An island located at the midpoint further divides the reach into sections a and b. The channel has a slow water flow and a fine gravel and sand substrate. Depth ranges from to zero 1.5 metres.

Reach 6 (km 10.2 to km 12.0). Reach 6 extends downstream from reach 4 to a rock bluff on the left bank two kilometers upstream of the Highway #7 bridge and includes a large portion of the Chehalis River flood plain. Depths range from zero to three metres over a small gravel substrate with sporadic bedrock outcrops.

Reach 7 (km 12.0 to km 13.5). Reach 7 includes a portion of the Chehalis flood plain located upstream of Highway #7 bridge. The flow is slow-moving over a sand and mud substrate.

Reach 8 (km 13.5 to Highway 7 bridge). Reach 8 includes the mainstem channel from Highway #7 bridge to the Fraser River confluence including Harrison Bay. The water is deep (up to 4 metres) and slow flowing over a fine gravel and sand substrate.

METHODS

Tagging

Adult chinook salmon (ie. excluding jacks) were captured in seine nets and marked with a primary tag and a secondary mark. The primary tag was a numbered tie-on spaghetti tag. No anesthetic was used.

The secondary marks were made with a standard metal

single-hole paper punch. A 6 mm hole was punched through the right or left operculum. The side or sides used for the secondary mark varied from year to year depending upon the associated studies.

In 1984 and 1985, chinook were captured in a 61 x 5 m seine net with 9 cm stretch mesh. In 1986, 1987 and 1988, adult chinook were captured in a 67 x 6.1 m seine net with 9 cm mesh. The nets were set from the stern of a jet boat in a crescent shape downstream and back to shore.

In 1986 and 1987, some chinook adults were captured by angling, tagged and released.

In 1986 and 1987, handling stress was assessed by alternate use of high and low stress methods. With the high stress method chinook adults were removed from the net by hand and place on a wooden tray equipped with a flexible plastic bottom and a measuring stick in one side. The tray was mounted on a one-metre high stand to facilitate fish tagging. Following tagging the fish were removed from the tray by hand and released into the river.

In the low stress method, fish were not lifted out of the water but slid gently into the open end of a tagging tray. Once tagged the fish were gently slid out of the tray and assisted past the net without removing them from the water. All angled fish were tagged using the low stress method.

To assess differential tag loss and mortality among the tagging methods, a unique secondary mark was applied to each group. The low and high stress fish were given one or two operculum punches on the right side respectively. Angled fish carried a single punched hole on the left side.

The high stress method was used in 1984 and 1985. In 1988 only the low stress method was used.

The tagging schedule by year and by reach is summarized in Table 1. Tagging was started in mid October and was completed by the end of November in all years except 1985 when tagging continued until December 24 and 1988 when tagging was finished by the 10'th of November. Recovery started approximately a week after tagging started and continued until sometime in December or early January.

The following data were recorded for each tagged fish: date and location of tagging, tag number, nose to fork length (+/- 0.5 cm), sex, presence or absence of adipose fin, capture method, handling method (high or low stress), type of secondary mark and, the condition of the fish when released (1 - swims away vigorously, 2 - swims away sluggishly or, 3 -requires ventilation). Any bleeding from the gills or abdomen was also recorded.

Census Procedure

Chinook carcasses were

TABLE 1. Summary of chinook live tagging and carcass recovery dates and locations, Harrison River 1984-88.

Year	Activity	Dates	Reach
1984			
	Tagging	October 19 to November 30	2 3 4 5 and 7.
	Recovery	November 9 to December 20	2 3 4 5 6 and 7.
1985			
	Tagging	October 16 to December 24	2 4 and 7.
	Recovery	October 21 to January 2 (1986)	2 3 4 5 6 7 and 8.
1986			
	Tagging	October 14 to November 28	2 3 4 6 and 7.
	Recovery	October 21 to January 5 (1987)	2 3 4 5 6 7 and 8.
1987			
	Tagging	October 13 to December 1	2 3 4 6 and 7.
	Recovery	October 22 to December 10	1 2 3 4 6 7 and 8.
1988			
	Tagging	October 13 to November 9	2 3 4 and 6.
	Recovery	October 19 to December 5	1 2 3 4 5 6 7 and 8.

recovered on and downstream of the spawning areas by boat and foot surveys. All recovered carcasses were cut in two to avoid recounting during subsequent surveys.

In 1986 and 1987, a carcass weir was placed on the right bank of sub-reach 4F. It extended 6 metres downstream from a log shear-boom at an angle 45 degrees to the shore. The same data were recorded for carcasses caught in the weir as those observed in the foot and boat surveys. Subsequent analyses did not distinguish between the two methods.

All recovered carcasses were examined first for a secondary mark, then for the primary tag. This procedure was used to reduce the bias introduced by examining tagged fish more carefully than untagged fish for secondary marks. If a primary tag was present it was removed and the type of secondary mark recorded. The sex of all recovered carcasses was determined by incising the abdominal cavity and examining the reproductive organs.

Biological Sampling

Biological samples were taken from all tagged carcasses and from every tenth to twentieth unmarked carcass.

All sampled carcasses were measured for post orbital - hypural plate length (POHL). Scales were taken from both preferred regions on each side of the fish. In 1986 scales were placed in individually marked envelopes and later mounted, pressed and aged by the Department of Fisheries and Oceans scale aging laboratory in Vancouver. In 1984, 1985, 1987 and 1988 scales were placed in numbered scale books in the field then later pressed and aged by the scale laboratory. Spawning success of each sampled female was recorded as 0% (unspawned), 50% (partially spawned) or 99% (spawned out).

All carcasses were examined for an adipose fin clip (AFC), indicating the presence of a coded wire tag (CWT). The condition of the clip was recorded as: 1 - complete clip, flush with back; 2 - partial clip, nub present but well healed or; 3 - questionable, appears clipped but too much fungus and decay to be certain. The presence or absence of eyes was recorded to assist in determining the level of CWT loss which occurred after death as a result of decomposition and scavenging. Carcasses condition was also recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body in tact but flesh soft) or extremely rotten (skin and bones). For all adipose clipped fish the head was removed uniquely numbered and sent to the head recovery laboratory for CWT removal and decoding.

All recovery data was recorded by reach.

Calculations of Spawning Escapement

The population size of adult males and females was

determined separately and summed to obtain the total adult escapement population. The Chapman modification of the Peterson method was used to calculate population sizes (Ricker, 1975; p. 78). The formula used in the calculation (subscripts for males and females are omitted) was:

$$N = \frac{(M + 1)(C + 1)}{(R + 1)}$$

Where:

N = estimate of total number of adult males or females.

M = number of primary tags and secondary marks applied to males and females during the live tagging operation (adjusted for sex misidentification at tagging and discussed later under sex identification correction).

C = number of males or females examined for primary tags and secondary marks (tag loss during the carcass recovery operation.

R = number of male or female tag and tag loss (secondary marks only) recaptured during the carcass recovery (census) sampling.

For both the total population estimates and the estimates by sex the total number of fish recovered with primary tags and secondary marks were used.

Confidence intervals for the total population and population by sex were calculated by two methods. The first method used the standard procedure from Ricker (1975; p. 78). The variance (V(N)) of the population estimate for each sex and for the total (unstratified by sex) was approximated using the following formula:

$$V(N) = \frac{N^2 (C - R)}{(C + 1)(R + 2)}$$

The 95% confidence limits for the population estimate by sex and the total unstratified by sex were calculated by adding and subtracting 1.96 times the square root of V(N). The variance of the estimate of total population from the sum of the sexes was approximated by summing the variance of the estimates for each sex.

A second approach involved calculating the confidence intervals of the recoveries (R_s) using the normal approximation to the hyper-geometric distribution of R_s/C_s (Zar 1984, p. 377). The hyper-geometric distribution is more appropriate for this study because the sample (C) was large relative to the finite population (N) and was taken without replacement.

$$p' = R_s/C_s$$

$$Var(p') = (1 - C_s/N_s)p'(1 - p')/(C_s - 1)$$

These confidence intervals were then substituted into the Chapman equation above to estimate the confidence

intervals for the population estimates.

Unfortunately, it is very difficult to calculate the confidence intervals of the total population estimate from the sum of the sexes separately using this second method. Therefore, the standard method (first above) was used to estimate the confidence interval used in this report.

Sex Identification Correction

The population estimates by sex required an accurate assessment of the number of fish tagged and recovered for each sex. Unfortunately, sex identification of live fish at tag application was not accurate enough to use the original data for population estimates (results section). To address this problem a sex correction factor was developed.

It was assumed that sex identification was done accurately at the time of carcass recovery and that identification errors were made at the time of tagging. This assumption was a reasonable one as some of the fish had not developed sexual characteristics when they were tagged, and all carcasses were incised and examined during recovery.

The correction factor was derived as follows:

Let r_m be the actual recovery rate for males.

$r_m = R_m/M_m$

Where:

R_m = is the total recovery of males with primary tags.

M_m = is the actual number of males tagged.

$r_f = R_f/(M_T - M_m)$

Where:

R_f = the total recovery of females with primary tags.

M_T = is the total number of fish tagged.

$M_m = M'_m - M_{m,f} + M_{f,m}$

Where:

M'_m = the reported number of males tagged.

$M_{m,f}$ = the number of fish tagged as males that were actually females.

$M_{f,m}$ = the number of fish tagged as females that were actually males.

$M_{m,f}$ and $M_{f,m}$ can be estimated from the number of fish recovered that were incorrectly identified when tagged and the respective recovery rates:

$M_{m,f} = R_{m,f}/r_f$

$M_{f,m} = R_{f,m}/r_m$

Where:

$R_{m,f}$ = the number of females recovered that were identified as males when tagged.

$R_{f,m}$ = the number of males recovered that were identified as females when tagged.

By substitution and rearrangement of terms an estimate for the actual number of males tagged was:

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

The estimate for the actual number of females tagged was obtained by subtraction.

These estimates introduce error into the calculations and include those from sampling as well as potential ones due to correlations between sex identification errors and primary tag loss. For the purpose of this report none of these errors have been included in the calculation of confidence intervals.

Tests for Bias by Sex

The sex of spaghetti tagged fish released and carcasses recovered were examined for evidence of bias. Two approaches were used.

The first method examined the statistical difference between the ratio of tagged fish recovered to the number of tag fish released. A Chi-Square test of these ratios, or recovery rates, by sex to the recovery rate of the total number of tags applied and recovered was done for each year. In addition the data from all the years was combined to examine overall bias. The years were combined by calculating a the ratio of a weighted average tag recoveries to the total tags applied over all years. The tag recoveries were weighted by the number of carcasses examined in each year.

Tests were conducted for a weighted average of the total tag recoveries and for the sum of the weighed averages by sex.

A second approach compared the ratio of tag recoveries to number of carcasses examined by sex (a different recovery rate) to the total recoveries. Chi-Square tests were applied to each year separately in addition to a combined test using average tag recoveries weighted by the number released.

Tests for Bias By Size

Potential biases due to the size of the fish was examined by testing for significant differences between the size distribution (fork-length; measured at time of tagging) of all tagged fish released and the size distribution (measured at time of tagging) of the tagged fish recovered. In addition size distributions (post-orbital hpurnal length; measured at recovery) for the total population of carcasses recovered to the sub-population of carcasses with tags were compared.

The Kolomogorov - Smirnof test as described in Zar (1984; pp. 53 - 58) was used to test for significance.

Tests for Bias by Age

Potential difference in the age structure of carcasses recovered with tags to the age structure of a representative

sample of all carcasses examined was conducted. Chi-Square tests were carried out on the age structure data for each year. In addition, the data from all years was combined by simply summing the data for each year and comparing the age structures from these two samples from the total population consisting of all carcasses from all five years.

Tests for Bias from other Sources

Potential bias in recovery rates due to location of tagging, tagging stress, release condition and spawning success were examined using Chi-Square tests.

Calculations of Escapement of CWT's.

The proportion of spawners with the adipose fin missing was estimated from the ratio of missing fins to the total number of carcasses examined. Confidence intervals around these proportions were estimated as described in Cochran (1977; pp. 57 - 59):

p +/- 1.96 (square-root of V(p) + finite population correction (fpc))

Where:

p - proportion of fish with adipose missing.
V(p) = (1 - f)p(1-p)/(n-1)
fpc = 1/2n
n = number of carcasses examined.
f = n/N
N = total population estimate.

RESULTS

Tagging and Carcass Recovery

The results of the live-tagging and spawning ground carcass recovery operations for the years 1984 through 1988 are summarized in Table 2 and in more detail (day, reach, sex, adipose clipped recoveries and presence or absence of secondary marks) in Appendices 1 through 5 for live-tagging and 6 through 10 for dead recovery. The number of fish tagged, marked and identified by sex and the recovery of primary tagged and secondary marked and unmarked carcasses are shown. In addition the number of sex identification errors are also presented.

In 1984, several carcasses were recovered with a primary tag and no secondary mark. It is believed that a secondary mark was not applied on some of the releases.

Estimates of Spawning Escapement

Adult chinook escapement estimates for sexes separate and stratified (sum of sexes separate) and unstratified totals are summarized in Table 3 along with the 95% confidence limits for each estimate for years 1984-88, inclusive. Total adult escapement (stratified) peaked in 1985 at 174,777 fish and continuously declined thereafter to a low of 35,694 fish in 1988.

TABLE 2. Summary of live adult chinook spaghetti tagging and spawning ground carcass recovery sampling, Harrison River, 1984-88.

Item	Year				
	1984	1985	1986	1987	1988
Tag application					
Males (uncorrected)	1,148	961	1,067	1,357	598
Males (corrected)[a]	1,129	915	1,125	1,324	608
Females (uncorrected)	657	701	1,467	2,087	561
Females (corrected)[a]	676	747	1,409	2,120	551
Unknown sex	5	1			
Total	1,810	1,663	2,534	3,444	1,159
Percent males[b]	63	58	42	39	52
Percent females[b]	36	42	58	61	48
Carcass recovery adults					
Males	4,399	4,625	4,820	3,069	1,843
Females	5,509	6,269	8,549	4,830	3,664
Total	9,908	10,894	13,369	7,899	5,507
Percent males	44	42	36	39	33
Percent females	56	58	64	61	67
Tag and secondary mark recoveries					
Males, spaghetti tag and secondary mark	44	33	42	80	47
Males, spaghetti tag only	8	0	1	1	0
Males, secondary mark only	16	3	20	17	15
Total marked males	68	36	63	98	62
Females, spaghetti tag and secondary mark	57	75	133	258	115
Females, spaghetti tag only	7	0	3	1	0
Females, secondary mark only	12	2	18	10	1
Total marked females	76	77	154	269	116
Total, spaghetti tag and secondary mark	101	108	175	338	162
Total, spaghetti tag only	15	0	4	2	0
Total, secondary mark only	28	5	38	27	16
Total marked	144	113	217	367	178
Tagged females recovered that were tagged as males $R_{m,f}$	8	13	7	12	6
as a percent of recovered females	11	17	5	4	5
Tagged males recovered that were tagged as females $R_{f,m}$	3	3	5	4	3
as a percent of recovered males	4	8	8	4	5

[a] - Spaghetti tag and secondary marks corrected for sex identification error at live tagging. See sex identification correction procedure in methods section.

[b] - Based on corrected numbers of males and females. See footnote "a".

TABLE 3. Estimates of spawning escapements of adult chinook salmon, their variances and 95% confidence limits using the Pearson formula and the hypergeometric formula, Harrison River, 1985 - 88.

Year and sex	M[a]	C	R	N[b]	V(N)[c]	95% CL of N Upper	95% CL of N Lower	As +/- % of N using V(N)	As +/- % of N using Hyper.[d]
1984									
Males	1,132	4,399	68	72,249	7.3E+07	89,042	55,457	23.2%	29.1%
Females	678	5,509	76	48,588	3.0E+07	59,296	37,881	22.0%	26.2%
Stratified total	-	-	-	120,836	1.0E+08	140,752	100,921	16.5%	-
Unstratified total	1,810	9,908	144	123,760	1.0E+08	143,688	103,832	16.1%	18.3%
Percent difference[e]			-2.4%						
1985									
Males	916	4,625	36	114,650	3.4E+08	150,957	78,343	31.7%	45.0%
Females	747	6,269	77	60,128	4.5E+07	73,304	46,951	21.9%	26.2%
Stratified total	-	-	-	174,777	3.9E+08	213,402	136,153	22.1%	-
Unstratified total	1,663	10,894	113	159,029	2.2E+08	187,942	130,115	18.2%	21.3%
Percent difference[e]			9.9%						
1986									
Males	1,125	4,820	63	84,819	1.1E+08	105,302	64,336	24.1%	30.6%
Females	1,409	8,549	154	77,777	3.8E+07	89,872	65,683	15.5%	17.2%
Stratified total	-	-	-	162,598	1.5E+08	186,385	138,811	14.6%	-
Unstratified total	2,534	13,369	217	155,472	1.1E+08	175,895	135,049	13.1%	14.4%
Percent difference[e]			4.6%						
1987									
Males	1,324	3,069	98	41,088	1.6E+07	49,011	33,166	19.3%	22.8%
Females	2,120	4,830	269	37,950	5.0E+06	42,341	33,560	11.6%	12.1%
Stratified total	-	-	-	79,039	2.1E+07	88,096	69,981	11.5%	-
Unstratified total	3,444	7,899	367	73,955	1.4E+07	81,323	66,587	10.0%	10.4%
Percent difference[e]			6.9%						
1988									
Males	608	1,843	62	17,825	4.8E+06	22,117	13,533	24.1%	29.5%
Females	551	3,664	116	17,291	2.5E+06	20,361	14,222	17.8%	18.7%
Stratified total	-	-	-	35,116	7.2E+06	40,392	29,839	15.0%	-
Unstratified total	1,159	5,507	178	35,694	6.8E+06	40,823	30,565	14.4%	15.2%
Percent difference			-1.6%						

[a] - Values for M have been corrected for sex identification errors at live tagging. See Table 2 for raw data and methods section for sex identification correction procedure. Tags applied to fish of unknown sex were divided into males and females in proportion to those estimated after sex identification correction.

[b] - $N = (M + 1)(C + 1)/(R + 1)$

[c] - $V(N) = N^2(C - R)/(C + 1)(R + 2)$

[d] - Percent difference from N using $\pm$ 1.96 SQRT(V(R/C)) where $V(R/C) = (1 - C/N)(R/C)(1 - R/C)/(C - 1)$; see methods section

[e] - Percentage difference is the percent that the stratified total estimate of N is less than (-) or greater than (+) the unstratified estimate computed as : (Stratified total estimate of N - Unstratified total estimate of N) divided by the Unstratified estimate of N minus 100.

Stratified estimates of total adult escapement varied from unstratified estimates for corresponding years by -2.4%, +9.9%, +4.6%, +6.9% and -1.6% in 1984 through 1988, respectively.

Sex identification error ranged from 4% to 17% (Table 2). A method of estimating the actual number of males and females tagged (described earlier) was used to estimate the population by sex. Table 2 presents the corrected number of males and females tagged. These numbers are used to estimate the populations in Table 3.

Confidence intervals for population estimates are presented in Table 3. The standard method calculates the 95% confidence intervals on the summed stratified population estimates were between 11.5% in 1988 and 22.1% in 1985.

The unstratified confidence intervals range from 10.0% to 18.2% for the standard method and 10.4% to 21.3% for the method using the hyper-geometric distribution. In all cases the standard method generated a smaller estimate of error than the other method.

Bias by Sex

Mark recovery rates or the proportion of marks (primary tags and secondary marks) recovered of males and females were significantly different ($p < 0.01$) from the total recovery rates in all years individually and combined (Table 4). Females were always recovered at a higher rate or in a larger proportion (10.3% to 21.1%) than males.

The proportion of male and female carcasses with tags to the those with and without tags was compared to the ratio of tags to carcasses. These analyses indicated a significant difference by sex to the .05 level in all years other than 1984 and 1988 ($p > .05$). 1987, 1985 and 1986 showed significant differences to the .01, .025 and .05 level respectively (Table 5). The analysis of all years combined generated a significant difference over all to the .01 level.

Bias by Size

Comparisons of the NF length data from the tagged and recovered sample of the total tagged population indicates significant differences to the .05 level in all years except 1987 (Table 6). The mean NF length in the recovered sample was longer than the mean of the total tagged population for all years. This result suggests that the survival and/or recovery of tagged fish is biased towards longer fish.

Comparisons of POH length data from the total carcasses and the marked carcasses sampled showed a significant difference to the .05 level in 1984 and 1985. The other years showed no significant differences in the length distributions (Table 7). The mean POH lengths of the marked and tagged carcasses were always shorter than the total sample of carcasses. This result suggests a possible bias

TABLE 4. Carcass tag recovery rates and sex bias for chinook salmon from live tagging application samples, Harrison River, 1984-88.

Sex and year	Spaghetti tag application sample: Number recovered[b]	Number released[a]	Recovery rate	Chi-Square	
1984					
Male	68	1,129	6.02%		
Female	76	676	11.24%	Chi-Square =	15.69
Total	144	1,805	7.98%	(p > .05)	
1985					
Male	36	915	3.9%		
Female	77	747	10.3%	Chi-Square =	26.36
Total	113	1,662	6.8%	(p < .01)	
1986					
Male	63	1,125	5.6%		
Female	154	1,409	10.9%	Chi-Square =	22.69
Total	217	2,534	8.6%	(p < .01)	
1987					
Male	98	1,324	7.4%		
Female	269	2,120	12.7%	Chi-Square =	23.93
Total	367	3,444	10.7%	(p < .01)	
1988					
Male	62	608	10.2%		
Female	116	551	21.1%	Chi-Square =	26.20
Total	178	1,159	15.4%	(p < .01)	
All years combined[c]					
Male	63	5,101	1.2%		
Female	137	5,503	2.5%	Chi-Square =	22.46
Total	198	10,604	1.9%	(p < .01)	
Total weighted by sex	200	10,604	1.9%	Chi-Square = (p < .01)	22.28

[a] - Corrected for sex identification error.
[b] - Includes all fish with spaghetti tags and secondary marks.
[c] - Tag recoveries are weighted by number of carcasses examined (Note: the weighted total is different than the total of the weighted sexes).

TABLE 5. Carcass tag recovery rates and sex bias for chinook salmon in spawning ground recovery samples (originating from live tagging), Harrison River, 1984-88.

Sex and year	Spawning ground recovery sample: Number of spaghetti and secondary tags recovered[a]	Number of carcasses recovered	Recovery rate	Chi-Square
1984				
Male	68	4,399	1.55%	
Female	76	5,509	1.38%	Chi-Square = 0.47
Total	144	9,908	1.45%	(p > .05)
1985				
Male	36	4,625	0.8%	
Female	77	6,269	1.2%	Chi-Square = 5.25
Total	113	10,894	1.0%	(.01 < p < .025)
1986				
Male	63	4,820	1.3%	
Female	154	8,549	1.8%	Chi-Square = 4.72
Total	217	13,369	1.6%	(.01 < p < .05)
1987				
Male	91	3,069	3.0%	
Female	269	4,830	5.6%	Chi-Square = 29.26
Total	360	7,899	4.6%	(p < .01)
1988				
Male	62	1,843	3.4%	
Female	116	3,664	3.2%	Chi-Square = 0.15
Total	178	5,507	3.2%	(p > .05)
All years combined[b]				
Male	66	18,756	0.4%	
Female	174	28,821	0.6%	Chi-Square = 15.35
Total	230	47,577	0.5%	(p < .01)
Total of weighted sexes	240	47,577	0.5%	Chi-Square = 14.30 (p < .01)

[a] - Includes all fish with spaghetti tags and secondary marks.
[b] - Tag recoveries are weighted by number of tags released (Note: the weighted total is different than the total of the weighted sexes).

TABLE 6. Mean nose-fork length of spaghetti tag application samples (total and tagged recoveries) and Kolmogorov - Smirnov test statistics for adult chinook salmon, Harrison River, 1984 - 88.

	Nose-fork length (cm)								
	Total tagged			Tagged recoveries			Kolmogorov - Smirnov		
Year	Mean	SD	n[a]	Mean	SD	n[a]	D_{max}	N	Significance
1984	81.6	10.5	1791	81.9	9.5	114	.135	114	(.02 < p < .05)
1985	78.3	12.1	1683	81.0	8.2	108	.177	108	(p < .01)
1986	88.5	9.1	2534	89.6	6.9	179	.127	179	(p < .01)
1987	91.0	9.3	3441	91.4	8.8	340	.061	340	(p > .05)
1988	89.2	10.7	1158	91.1	7.6	155	.117	155	(.02 < p < .05)

[a] - Not all sampled fish were measured.

TABLE 7. Mean post-orbital hypural length of spawning ground carcass recovery samples (total and tagged recoveries) and Kolmogorov - Smirnov test statistics for adult chinook salmon, Harrison River, 1984 - 88.

	Post-orbital hypural length (cm)								
	Total carcass			Tagged recoveries			Kolmogorov - Smirnov		
Year	Mean	SD	n[a]	Mean	SD	n[a]	D_{max}	N	Significance
1984	67.4	7.7	421	65.4	7.9	114	.131	114	(.01 < p < .02)
1985	69.4	6.8	231	67.1	7.0	110	.145	110	(.01 < p < .02)
1986	72.1	6.3	647	71.7	5.3	206	.068	206	(.05 < p)
1987	73.2	7.5	690	73.1	6.6	360	.039	360	(.05 < p)
1988	73.3	6.5	505	73.0	5.9	174	.049	174	(.05 < p)

[a] - Not all sampled fish were measured.

TABLE 8. Summary of average nose fork length in the spaghetti tagged population and post orbital hypural length from the carcasses. For adult chinook salmon, Harrison River, 1984-88.

Year	Nose-fork length (cm) $\bar{X}$	SD	Post-orbital hypural length (cm) $\bar{Y}$	SD	n[a]	Regression[b] equations	S_y[c]
1984	81.3	11.0	68.4	7.3	114	Y = 2.4 + 0.76X	2.8
1985	78.3	15.0	71.4	5.9	112	Y = 8.6 + 0.69X	7.3
1986	88.5	9.1	72.3	6.7	170	Y = 28.6 + 0.48X	6.9
1987	90.7	9.4	73.3	8.4	341	Y = 14.4 + 0.64X	7.7
1988	91.2	7.8	72.7	5.7	158	Y = 15.4 + 0.62X	5.4

[a] - The number of paired samples.
[b] - Y = post-orbital hypural length (cm); X = nose fork length.
[c] - S_y = Standard error of $\hat{Y}$, an estimated value of Y for a give value of X.

towards smaller fish in the tagging process.

A third method, involving the estimation of the NF length, at the time of tagging, of carcasses that were not tagged but were in the recovery sample, was attempted. The method tried to compare the NF distribution in tagged sample and the total recovered sample. A regression equation was calculated for each year relating the POHL to the NF length in the tagged and recovered population. Unfortunately, the error introduced by the regression equation made it impossible to detect differences in the length frequencies. Table 8 presents the regression equations along with the means and standard deviations in NF and POH lengths.

Bias by Age

The recovery sample age structure is presented in Table 9. Differences in age structure in the tagged and untagged samples were Chi-Square tested for each year. Only 1985 data showed significant differences ($p < 0.01$) in the tagged populations of carcasses (age 4 fish were not as well represented in the tagged sample). The combined data for all years shows a mixed result, being significant to the .05 level but not at .01.

There may be some error entering into the age analysis through errors in ageing the fish. Comparison of the ageing results of CWT fish with the known age from the coded tags indicated that at least 4 fish out of 116 were aged incorrectly (Appendix 11).

Effect of Tagging Location on Recovery Rates

The effect of tagging location on recovery rates provided mixed results. Table

TABLE 9. Age structure and recovery bias of spawning ground carcass recovery samples of Harrison River, chinook salmon, 1984 - 88.

Year	Age	Number of untagged recoveries	Number of tagged recoveries[a]	Total Number	Total Percent	
1984	2$_1$	2	2	4	1.0	Chi-Square = 4.36
	3$_1$	91	43	134	35.0	(.05 < p)
	4$_1$	153	64	217	56.7	
	5$_1$	24	4	28	7.3	
	Total	270	113	383		
1985	3$_1$	18	29	47	23.9	Chi-Square = 12.11
	4$_1$	90	48	138	70.1	(p < .01)
	4$_2$	1	0	1	0.5	
	5$_1$	8	3	11	5.6	
	Total	117	80	197		
1986	2$_1$	5	0	5	0.9	Chi-Square = 2.86
	3$_1$	8	3	11	2.1	(.05 < p)
	4$_1$	353	142	495	92.4	
	5$_1$	20	5	25	4.7	
	Total	386	150	536		
1987	2$_1$	1	0	1	0.2	Chi-Square = 5.76
	3$_1$	27	28	55	9.7	(.05 < p)
	4$_1$	185	187	372	65.7	
	5$_1$	54	84	138	24.4	
	Total	267	299	566		
1988	2$_1$	2	0	2	0.5	Chi-Square = 4.30
	3$_1$	14	12	26	6.5	(.05 < p)
	4$_1$	225	104	329	82.3	
	4$_2$	1	0	1	0.3	
	5$_1$	27	14	41	10.3	
	6$_1$	1	0	1	0.0	
	Total	270	130	400		
All years combined						
	2$_1$	8	2	10	0.6	Chi-Square = 18.46
	3$_1$	144	103	247	14.7	(.01 < p < .05)
	4$_1$	781	441	1222	72.7	
	4$_2$	1	0	1	0.1	
	5$_1$	106	96	202	12.0	
	Total	1040	642	1682		

[a] - Includes secondary marks.

TABLE 10. Summary of spaghetti tag recovery rates (primary tags only) by tagging reach for chinook salmon that were live tagged and recaptured in the spawning ground dead recovery, Harrison River 1984 - 88.

Reach number and year	Number		Recovery rate (%)	Chi-Square
	Tagged	Recovered		
1984				
2	960	69	7.2	
3	166	8	4.8	
4	436	24	5.5	
5	226	14	6.2	
7	22	1	4.5	
Total	1810	16	6.4	2.41 ($p > .05$)
1985				
2	606	70	11.3	
4	1042	36	3.5	
7	15	2	13.5	
Total	1663	108	6.5	42.53 ($p < .01$)
1986				
2	1035	89	8.6	
3	413	37	9.0	
4	396	23	5.8	
6	396	29	4.3	
7	9	1	11.1	
Total	2534	179	7.1	15.31 ($p < .01$)
1987				
2	1413	140	10.0	
3	654	82	12.5	
4	935	82	8.2	
6	376	29	7.7	
7	66	7	10.6	
Total	3444	340	9.9	8.5 ($p > .05$)
1988				
2	43	2	4.7	
3	403	64	15.9	
4	704	93	13.2	
6	9	3	33.3	
Total	1159	162	14.0	7.5 ($p > .05$)

10 presents the recovery rates by reach and year and the corresponding Chi-Square values. Tagging location appears to have had a significant effect ($p < .01$) on recovery rates in 1985 and 1986. However, no significant effect was detected in 1984, 1987 and 1988 ($p > .05$).

Effect of Tagging Stress on Recovery Rates

In 1986 and 1987 fish were tagged using high and low stress methods. The results of these experiments are presented in Table 11. Differences in the recovery rates between high and low stress treatments were analyzed by applying Chi-Square tests to the data (excluding angling). The 1987 data showed no significant difference ($p > .05$) between the recovery rates for high and low stressed fish. In 1986 there was a significant difference ($p < .05$) with a higher recovery rate of high stressed fish.

Effect of Release Condition on Recovery Rates

Table 12 presents tagging and recovery rates for fish released in three different conditions and subsequently recovered. Chi-Square tests were performed on the recovery rates to detect significant differences due to release condition.

In 1984 and 1985, no significant difference ($p > .05$) was detected among the three release conditions. In 1986 a significant difference ($p < .05$) was detected. This difference was less pronounced in 1987 and 1988. Release condition 3 was significantly different from the other ($p < .05$).

Female Spawning Success

The proportion of female carcasses that were not completely spawned (0 and 50 percent) and those that were completely spawned (99 percent) were compared between marked (spaghetti tagged and secondary marked) and unmarked carcasses (Table 13). No significant difference was found in 1984, likely due to the small incidence of incomplete spawning. In 1985 through 1988 incomplete spawning was significantly higher in the unmarked population than among marked (spaghetti tagged and secondary marked) carcasses ($p < .01$).

Recovery of Coded Wire Tags

In the five years of this study (1984-88), a total of 149 adipose clipped chinook salmon were recovered during the spawning ground dead pitch. Annual numbers of adipose clipped recoveries ranged from a low of 16 fish in 1984 and 1986 to a high of 47 fish in 1988. Appendix 11 summarizes dead pitch mark (adipose clipped) recovery information and CWT decoding for all years and presents further details on hatchery rearing, release location and the stock employed for each CWT code that was encountered. Appendices 1 through 5 summarize the same information (excepting CWT codes) on a year by year basis for all adiposed clipped dead

TABLE 11. Comparison of tagging stress treatments for chinook salmon, Harrison River 1986 and 1987.

Tagging treatment and year	Number of tags applied[a]	Number of primary tags recovered and rate (%)	Number of secondary marks only recovered and rate	Total
1986[b]				
High stress	1239	100 (8.1)	21 (1.7)	120 (9.7)
Low stress	1251	76 (6.1)	14 (1.4)	94 (7.5)
Angled	44	3 (6.8)	0 (0.0)	3 (6.8)
Total	2534	179 (7.1)	38 (1.5)	217 (8.6)
1987[c]				
High stress	1620	139 (8.6)	13 (0.8)	152 (9.4)
Low stress	1609	163 (10.1)	12 (0.7)	175 (10.9)
Angled	214	37 (17.3)	2 (0.9)	39 (18.2)
Total	3443[d]	338[d] (9.8)	27 (0.8)	366[d] (10.6)

[a] - All but one fish was released with an accompanying secondary mark.
[b] - Chi-Square without angling: 3.86 ($0.01 < p < 0.05$).
[c] - Chi-Square without angling: 2.15 ($p > 0.05$).
[d] - Tagging stress data was missing for one tagged fish.

TABLE 12. Summary of recovery rates of spaghetti tagged chinook salmon with respect to release condition. Harrison River 1984 - 88.

Condition at release and year	Number tagged	Number of primary tags recovered	Recovery rate %	Chi-Square
1984				
Vigorous	1171	70	6.0	0.01[a] (p > .05)
Sluggish	576	35	6.1	
Ventilated	59	8	13.6	5.55[b] (p > .05)
Total	1806[c]	113[c]	6.3	
1985				
Vigorous	1004	58	5.8	2.21[a] (p > .05)
Sluggish	614	47	7.6	
Ventilated	45	3	6.7	2.21[b] (p > .05)
Total	1663	108	6.5	
1986				
Vigorous	1111	62	5.6	4.67[a]
Sluggish	1349	105	7.8	(.01 < p < .05)
Ventilated	74	12	16.2	14.23[b] (p < .01)
Total	2534	179	7.1	
1987				
Vigorous	2333	212	9.1	3.68[a] (p > .05)
Sluggish	1049	118	11.3	
Ventilated	62	10	16.1	6.39[b]
Total	3444	340	9.9	(.01 < p < .05)
1988				
Vigorous	915	122	13.3	0.65[a] (p > .05)
Sluggish	233	35	15.0	
Ventilated	10	4	40.0	6.18[b]
Total	1158[c]	161[c]	13.9	(.01 < p < .05)

[a] - Vigourous and sluggish only.
[b] - All three condition types.
[c] - Not all fish released had their condition recorded.

TABLE 13. Spawning status of spaghetti tagged (or secondary mark) and untagged female chinook salmon from spawning ground carcass recoveries, Harrison River, 1984 - 88.

Tagged or untagged and year	Incomplete spawning	Fully spawned	Total[a]	Percent incomplete spawning	Chi-Square	
1984						
Tagged	1	74	75	1.3%		
Untagged	3	163	166	1.8%	Chi-Square =	0.07
Total	4	237	241	1.7%	(p > .05)	
1985						
Tagged	3	74	77	3.9%		
Untagged	13	73	86	15.1%	Chi-Square =	5.78
Total	16	147	163	9.8%	(.01 p < .025)	
1986						
Tagged	14	132	146	9.6%		
Untagged	63	251	314	20.1%	Chi-Square =	7.85
Total	77	383	460	16.7%	(p < .01)	
1987						
Tagged	42	222	264	15.9%		
Untagged	55	124	179	30.7%	Chi-Square =	13.69
Total	97	346	443	21.9%	(p < .01)	
1988						
Tagged	3	104	107	2.8%		
Untagged	25	195	220	11.4%	Chi-Square =	6.74
Total	28	299	327	8.6%	(p < .01)	

[a] - Only fish with a record of spawning condition were included in these analyses.

pitch recoveries, by day and river reach. Of the 149 heads from the adipose clipped fish recovered (all years), only 116 CWT's were extracted and decoded.

During the live-tagging for Petersen population estimates in 1984-86 a total of 56 adipose clipped chinook salmon were observed (8, 19, 9, 7 and 13 in the respective years; Appendices 6 through 10). None of these fish were subsequently recovered in the carcass recovery phase.

There was good agreement in most years between CWT age (known-age) and scale age. Only 4 (3.4%) of the total 116 CWT's that were decoded over the five years of study had scale ages that differed from known-aged fish from CWT release, recovery and decoding (Appendix 12). Scale reading error ranged from a low of 3.4% in 1985 to a high of 13.3% in 1984.

Escapement of Adipose Clipped Fish

Table 14 presents the estimates of missing adipose fin/CWT escapements in the Harrison River. The point estimates are 195, 562, 195, 350 and 300 for the years 1984 through 1988 respectively. Three estimates of the confidence intervals are presented. One set of confidence intervals involves the adipose mark sampling error applied to the mean point estimate of total escapement. The second set calculate the bounds on the upper 95% limit on the total escapement estimate generated from the error in the adipose mark rate. The third set is the corresponding lower bounds. The maximum of these bounds range from 77 to 348, 285 to 924, 78 to 341, 204 to 524 and 183 to 442 for the years 1984 to 1988 respectively.

In the adipose clipped recoveries in these studies that had CWT's that were decoded, 24 (20.7%) of the 116 tags decoded over the five years belonged to fish released in the Chilliwack River (Table 15). These data suggest that there may be a significant amount of straying in the spawning migration of these fish. It is not surprising that Chilliwack hatchery fish might migrate to the Harrison because of it's proximity and because Harrison River stock has been used for broodstock in the Chilliwack hatchery.

DISCUSSION

Population Estimation

Accuracy or the lack of bias in the population estimates for mark recapture studies depend on many factors. The most important factors are that the process of either marking or sampling for marks is representative of the total population and that the probability of observing a fish in the recovery sample is independent of the presence or absence of marks. Unfortunately, it is not possible to definitively test whether either tagging or recovery are representative of the population because no

TABLE 14. Escapement estimates of marked (missing adipose fin/CWT) chinook salmon in the Harrison River, 1984 -88.

Item	Year 1984	1985	1986	1987	1988
Total escapement[a] estimate:					
A. Point Estimate	120,836	174,777	162,598	79,039	35,116
B. Upper 95% CL	140,752	213,402	186,385	88,096	40,392
C. Lower 95% CL	100,921	136,153	138,811	69,981	29,839
Total adipose clips recovered[b]	16	35	16	35	47
Carcasses sampled	9,908	10,894	13,369	7,899	5,507
Adipose mark rate %					
D. Point Estimate	0.16%	0.32%	0.12%	0.44%	0.85%
Standard error	0.04%	0.05%	0.03%	0.07%	0.11%
finite correction factor	0.01%	0.00%	0.00%	0.01%	0.01%
E. Upper 95% CL	0.25%	0.43%	0.18%	0.59%	1.09%
F. Lower 95% CL	0.08%	0.21%	0.06%	0.29%	0.61%
Adipose clipped escapement					
A x D	195	562	195	350	300
A x E	299	757	298	470	384
A x F	92	366	91	231	215
B x D	227	686	223	390	345
B x E	348	924	341	524	442
B x F	107	447	105	257	247
C x D	163	437	166	310	255
C x E	249	590	254	416	327
C x F	77	285	78	204	183

[a] - From Table 3; sum of sexes separate.
[b] - From Appendices 1 through 5.

TABLE 15. Straying of returning adult chinook salmon to Harrison River, from adipose clipped/CWT juveniles released in Chilliwack River, 1984 - 88.

Year	Strays[a]	Non-strays	Total
1984	1 (6.7)	14	15
1986	7 (24.1)	22	29
1987	2 (14.3)	12	14
1988	9 (23.7)	29	38
Total	24 (20.7)	92	116

[a] - All strays were from Chilliwack River; figures in parenthesis are percentages of the total adipose clipped fish with CWT's that were decoded successfully.

independent measure of the population is available. In addition it is not possible to know with certainty that the recoveries are representative with respect to the presence or absence of marks.

Potential Biases

Differences in tag recovery rates for males and females were detected and separate population estimates calculated for each sex. This procedure reduced much of the error expected from this source of bias. Unfortunately, the sex correction method presented in this report provides only an estimate of the tagged population by sex. Sampling errors associated with the small number of recoveries of mis-identified fish were not included in these calculations. Methods for including these sampling errors in the confidence interval calculations could be developed.

The sex correction factor was developed from primary tags only. It would be useful in future studies to apply a different secondary mark for each sex so that fish that have lost their primary tag can be used to estimate the sex correction factor.

The differences in the length frequencies between the recovered fish and the total tagged population indicate that the recovery process does not produce a representative sample of the tagged population. It may be possible to calculate a factor to correct the recovery sample for this bias. Such a process would increase the size of the confidence intervals on the population estimates.

The significant difference in pre-spawn mortality between marked and unmarked carcasses suggests that the tagging process may be bias or that the presence of a tag on the fish changes it's spawning behaviour. The exact cause of the problem is not known, however, this result suggests that the recovery sample of

tags is not representative of the spawning population.

ACKNOWLEDGEMENTS

I would like to thank Neil Schubert and Lanny Kalnin for their contributions in the field work and project management as well as ideas and suggestions in the preparation of these analyses. Early work by C.R. Gosselin, N.D. Schubert, L.W. Kalnin and K. Wilson pointed the direction for much of the analyses reported here. I would like to thank Rick Semple for his support and understanding in the inevitable delays that I experienced.

REFERENCES

Cochran, W.G. 1977. Sampling Techniques. 3rd. ed. John Wiley, Now York. 428 pp.

Freund, J.E. 1971, Mathematical Statistics. Prentice Hall, Inc. Englewood Cliffs N.J. 463 p.

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

Zar, J.H. 1984, Biostatistical Analysis. Prentice Hall, Inc. Englewood Cliffs N.J. 718 p.

APPENDICES

APPENDIX 1. Summary of dead chinook spawning ground recoveries by date and reach, Harrison River 1984.

Date or reach	Total recoveries			Adipose clipped recoveries			Secondary mark absent						Secondary mark present					
							Primary absent			Primary present			Spaghetti absent			Spaghetti present		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
09-Nov	78	95	173	0	1	1	77	95	172	0	0	0	0	0	0	1	0	1
13-Nov	158	100	258	0	0	0	154	100	254	0	0	0	0	0	0	4	0	4
14-Nov	227	189	416	1	1	2	223	188	411	1	0	1	2	0	2	1	1	2
15-Nov	147	197	344	0	0	0	144	193	337	0	0	0	1	2	3	2	2	4
16-Nov	168	114	282	0	0	0	166	114	280	0	0	0	0	0	0	2	0	2
19-Nov	65	67	132	0	0	0	64	66	130	0	0	0	0	0	0	1	1	2
20-Nov	37	54	91	0	0	0	35	54	89	0	0	0	1	0	1	1	0	1
21-Nov	69	51	120	0	1	1	68	51	119	0	0	0	0	0	0	1	0	1
22-Nov	227	341	568	0	2	2	227	339	566	0	0	0	0	0	0	0	2	2
23-Nov	266	460	726	3	0	3	264	459	723	1	0	1	0	0	0	1	1	2
26-Nov	482	384	866	0	3	3	473	378	851	0	0	0	2	1	3	7	5	12
27-Nov	48	47	95	0	0	0	48	47	95	0	0	0	0	0	0	0	0	0
28-Nov	359	361	720	1	1	2	357	352	709	0	1	1	0	0	0	2	8	10
29-Nov	374	449	823	1	0	1	373	441	814	0	0	0	0	0	0	1	8	9
30-Nov	165	367	532	0	0	0	164	365	529	0	1	1	0	0	0	1	1	2
03-Dec	243	333	576	0	1	1	234	327	561	1	0	1	3	1	4	5	5	10
04-Dec	101	227	328	0	0	0	99	225	324	1	0	1	0	0	0	1	2	3
05-Dec	164	209	373	0	0	0	161	206	367	2	0	2	0	2	2	1	1	2
06-Dec	175	225	400	0	0	0	173	219	392	0	2	2	0	1	1	2	3	5
07-Dec	278	369	647	0	0	0	275	362	637	0	1	1	1	0	1	2	6	8
09-Dec	40	67	107	0	0	0	39	65	104	0	0	0	1	2	3	0	0	0
11-Dec	51	139	190	0	0	0	50	137	187	0	0	0	0	0	0	1	2	3
12-Dec	257	352	609	0	0	0	250	350	600	2	0	2	4	2	6	1	0	1
13-Dec	88	167	255	0	0	0	85	162	247	0	2	2	1	0	1	2	3	5
14-Dec	46	42	88	0	0	0	45	42	87	0	0	0	0	0	0	1	0	1
17-Dec	58	39	97	0	0	0	56	33	89	0	0	0	0	0	0	2	6	8
18-Dec	5	7	12	0	0	0	5	7	12	0	0	0	0	0	0	0	0	0
19-Dec	19	26	45	0	0	0	18	26	44	0	0	0	0	0	0	1	0	1
20-Dec	4	31	35	0	0	0	4	30	34	0	0	0	0	1	1	0	0	0
Reach																		
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	14	15	29	0	0	0	14	15	29	0	0	0	0	0	0	0	0	0
3	281	561	842	0	1	1	278	557	835	0	1	1	0	0	0	3	3	6
4	1,560	2,346	3,906	4	3	7	1,542	2,323	3,865	4	2	6	6	2	8	8	19	27
5	690	732	1,422	1	3	4	680	717	1,397	0	1	1	3	5	8	7	9	16
6	517	600	1,117	1	1	2	509	591	1,100	2	0	2	3	3	6	3	6	9
7	1,337	1,255	2,592	0	2	2	1,308	1,230	2,538	2	3	5	4	2	6	23	20	43
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4,399	5,509	9,908	6	10	16	4,331	5,433	9,764	8	7	15	16	12	28	44	57	101

APPENDIX 2. Summary of dead chinook spawning ground recoveries by date and reach, Harrison River 1985.

Date or reach	Total recoveries			Adipose clipped recoveries			Secondary mark absent						Secondary mark present					
							Primary absent			Primary present			Spaghetti absent			Spaghetti present		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
21-Oct	31	32	63	0	0	0	31	32	63	0	0	0	0	0	0	0	0	0
22-Oct	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
23-Oct	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
24-Oct	1	3	4	0	0	0	1	3	4	0	0	0	0	0	0	0	0	0
25-Oct	6	4	10	0	0	0	6	4	10	0	0	0	0	0	0	0	0	0
28-Oct	135	160	295	1	2	3	135	160	295	0	0	0	0	0	0	0	0	0
01-Nov	240	311	551	0	4	4	238	306	544	0	0	0	0	1	1	2	4	6
06-Nov	227	273	500	3	4	7	221	257	478	0	0	0	1	0	1	5	16	21
07-Nov	438	547	985	0	5	5	436	544	980	0	0	0	0	0	0	2	3	5
08-Nov	631	695	1326	0	0	0	631	695	1326	0	0	0	0	0	0	0	0	0
13-Nov	1	4	5	0	0	0	0	0	0	0	0	0	0	0	0	1	4	5
14-Nov	253	401	654	0	0	0	252	395	647	0	0	0	0	0	0	1	6	7
15-Nov	455	780	1235	0	2	2	453	780	1233	0	0	0	0	0	0	2	0	2
20-Nov	430	621	1051	0	0	0	428	613	1041	0	0	0	0	0	0	2	8	10
26-Nov	173	186	359	0	0	0	171	180	351	0	0	0	0	0	0	2	6	8
04-Dec	56	95	151	1	5	6	54	93	147	0	0	0	1	0	1	1	2	3
05-Dec	330	309	639	1	0	1	327	298	625	0	0	0	0	0	0	3	11	14
10-Dec	333	537	870	0	0	0	333	537	870	0	0	0	0	0	0	0	0	0
13-Dec	3	0	3	0	0	0	3	0	3	0	0	0	0	0	0	0	0	0
16-Dec	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
17-Dec	114	153	267	0	0	0	114	153	267	0	0	0	0	0	0	0	0	0
19-Dec	153	283	436	1	5	6	147	278	425	0	0	0	0	0	0	6	5	11
20-Dec	50	53	103	0	0	0	49	53	102	0	0	0	0	0	0	1	0	1
24-Dec	145	213	358	0	0	0	141	210	351	0	0	0	1	0	1	3	3	6
27-Dec	61	106	167	0	0	0	61	106	167	0	0	0	0	0	0	0	0	0
30-Dec	210	221	431	0	0	0	208	214	422	0	0	0	0	1	1	2	6	8
31-Dec	116	242	358	0	1	1	116	241	357	0	0	0	0	0	0	0	1	1
02-Jan	33	37	70	0	0	0	33	37	70	0	0	0	0	0	0	0	0	0
REACH																		
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	83	113	196	0	2	2	79	98	177	0	0	0	0	1	1	4	14	18
3	359	691	1,050	1	4	5	356	682	1,038	0	0	0	0	0	0	3	9	12
4	1,940	2,849	4,789	4	13	17	1,929	2,826	4,755	0	0	0	1	0	1	10	23	33
5	925	1,233	2,158	1	6	7	921	1,225	2,146	0	0	0	0	0	0	4	8	12
6	782	875	1,657	1	3	4	772	865	1,637	0	0	0	2	0	2	8	10	18
7	335	366	701	0	0	0	334	358	692	0	0	0	0	0	0	1	8	9
8	201	142	343	0	0	0	198	138	336	0	0	0	0	1	1	3	3	6
Total	4,625	6,269	10,894	7	28	35	4,589	6,192	10,781	0	0	0	3	2	5	33	75	108

APPENDIX 3. Summary of dead chinook spawning ground recoveries by date and reach, Harrison River 1986.

Date or reach[a]	Total recoveries			Adipose clipped recoveries			Secondary mark absent						Secondary mark present					
							Primary absent			Primary present			Spaghetti absent			Spaghetti present		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
21-Oct	17	69	86	0	0	0	16	69	85	0	0	0	1	0	1	0	0	0
22-Oct	9	26	35	0	0	0	9	24	33	0	0	0	0	1	1	0	1	1
23-Oct	46	66	112	0	0	0	45	63	108	0	1	1	0	1	1	1	1	2
28-Oct	65	121	186	0	0	0	65	121	186	0	0	0	0	0	0	0	0	0
29-Oct	53	106	159	0	0	0	53	104	157	0	0	0	0	0	0	0	2	2
30-Oct	82	103	185	0	1	1	80	100	180	0	0	0	1	0	1	1	3	4
31-Oct	118	178	296	0	0	0	118	177	295	0	0	0	0	0	0	0	1	1
03-Nov	10	27	37	0	0	0	10	27	37	0	0	0	0	0	0	0	0	0
04-Nov	132	321	453	0	2	2	131	314	445	0	1	1	0	0	0	1	6	7
05-Nov	206	399	605	0	1	1	205	396	601	0	0	0	0	0	0	1	3	4
06-Nov	217	439	656	0	0	0	215	433	648	0	0	0	0	0	0	2	6	8
07-Nov	485	674	1159	1	3	4	481	660	1141	0	0	0	1	2	3	3	12	15
10-Nov	161	405	566	0	0	0	161	402	563	0	0	0	0	0	0	0	3	3
11-Nov	61	37	98	0	0	0	61	37	98	0	0	0	0	0	0	0	0	0
12-Nov	413	897	1310	0	0	0	409	884	1293	0	0	0	0	3	3	4	10	14
13-Nov	432	926	1358	0	0	0	426	907	1333	0	0	0	1	3	4	5	16	21
14-Nov	33	74	107	0	0	0	33	72	105	0	0	0	0	0	0	0	2	2
17-Nov	244	378	622	1	1	2	242	370	612	0	0	0	2	1	3	0	7	7
18-Nov	255	488	743	0	0	0	253	478	731	0	0	0	1	1	2	1	9	10
19-Nov	288	438	726	0	1	1	284	432	716	0	0	0	3	1	4	1	5	6
20-Nov	74	94	168	0	1	1	70	91	161	0	0	0	1	0	1	3	3	6
21-Nov	41	79	120	0	0	0	41	78	119	0	0	0	0	0	0	0	1	1
24-Nov	52	83	135	0	0	0	51	79	130	0	0	0	0	1	1	1	3	4
25-Nov	54	129	183	0	0	0	53	128	181	0	0	0	0	0	0	1	1	2
26-Nov	15	17	32	1	0	1	15	17	32	0	0	0	0	0	0	0	0	0
27-Nov	92	180	272	0	0	0	91	180	271	1	0	1	0	0	0	0	0	0
28-Nov	66	102	168	0	0	0	65	101	166	0	0	0	1	0	1	0	1	1
01-Dec	83	232	315	0	1	1	83	226	309	0	0	0	0	0	0	0	6	6
02-Dec	149	184	333	0	0	0	142	180	322	0	0	0	2	0	2	5	4	9
03-Dec	121	212	333	1	0	1	119	208	327	0	0	0	1	1	2	1	3	4
04-Dec	20	68	88	0	0	0	18	63	81	0	0	0	0	0	0	2	5	7
05-Dec	154	153	307	0	0	0	152	148	300	0	0	0	2	1	3	0	4	4
08-Dec	74	83	157	0	1	1	74	77	151	0	1	1	0	1	1	0	4	4
09-Dec	118	134	252	0	0	0	118	134	252	0	0	0	0	0	0	0	0	0
10-Dec	57	130	187	0	0	0	57	129	186	0	0	0	0	1	1	0	0	0
11-Dec	47	67	114	0	0	0	43	66	109	0	0	0	0	0	0	4	1	5
12-Dec	13	34	47	0	0	0	12	32	44	0	0	0	1	0	1	0	2	2
15-Dec	31	70	101	0	0	0	27	67	94	0	0	0	0	0	0	4	3	7
16-Dec	34	48	82	0	0	0	34	48	82	0	0	0	0	0	0	0	0	0
17-Dec	33	42	75	0	0	0	32	41	73	0	0	0	0	0	0	1	1	2
18-Dec	43	54	97	0	0	0	43	54	97	0	0	0	0	0	0	0	0	0
19-Dec	76	102	178	0	0	0	75	100	175	0	0	0	1	0	1	0	2	2
22-Dec	27	61	88	0	0	0	26	59	85	0	0	0	1	0	1	0	2	2
23-Dec	8	6	14	0	0	0	8	6	14	0	0	0	0	0	0	0	0	0
29-Dec	1	2	3	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0
30-Dec	3	5	8	0	0	0	3	5	8	0	0	0	0	0	0	0	0	0
05-Jan	7	6	13	0	0	0	7	6	13	0	0	0	0	0	0	0	0	0
Total	4,820	8,549	13,369	4	12	16	4,757	8,395	13,152	1	3	4	20	18	38	42	133	175

[a] - Reach data for 1986 not available to author at time of printing.

APPENDIX 4. Summary of dead chinook spawning ground recoveries by date and reach, Harrison River 1987.

Date or reach	Total recoveries			Adipose clipped recoveries			Secondary mark absent						Secondary mark present					
							Primary absent			Primary present			Spaghetti absent			Spaghetti present		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
22-Oct	32	33	65	0	1	1	32	33	65	0	0	0	0	0	0	0	0	0
23-Oct	70	71	141	0	0	0	70	71	141	0	0	0	0	0	0	0	0	0
26-Oct	147	173	320	1	0	1	147	172	319	0	0	0	0	0	0	0	1	1
27-Oct	141	216	357	0	0	0	139	211	350	0	0	0	0	0	0	2	5	7
28-Oct	42	90	132	0	0	0	42	89	131	0	0	0	0	0	0	0	1	1
29-Oct	93	119	212	0	0	0	92	118	210	0	0	0	0	0	0	1	1	2
30-Oct	102	124	226	0	0	0	102	119	221	0	0	0	0	0	0	0	5	5
02-Nov	87	150	237	0	0	0	86	144	230	0	0	0	0	0	0	1	6	7
03-Nov	99	161	260	1	0	1	98	150	248	0	0	0	0	0	0	1	11	12
04-Nov	113	256	369	0	1	1	108	245	353	0	0	0	1	0	1	4	11	15
05-Nov	176	403	579	1	3	4	172	390	562	0	0	0	0	0	0	4	13	17
06-Nov	107	121	228	0	0	0	101	114	215	0	0	0	1	0	1	5	7	12
09-Nov	179	139	318	1	0	1	176	133	309	0	0	0	0	0	0	3	6	9
10-Nov	105	105	210	0	1	1	101	98	199	0	0	0	0	0	0	4	7	11
12-Nov	120	194	314	0	2	2	117	184	301	0	0	0	0	0	0	3	10	13
13-Nov	258	350	608	2	1	3	257	325	582	0	0	0	0	0	0	1	25	26
16-Nov	135	332	467	1	1	2	132	311	443	0	0	0	0	0	0	3	21	24
17-Nov	61	216	277	0	0	0	60	198	258	0	0	0	0	1	1	1	17	18
18-Nov	217	291	508	3	1	4	203	257	460	0	1	1	6	3	9	8	30	38
19-Nov	119	109	228	1	2	3	114	100	214	0	0	0	0	1	1	5	8	13
20-Nov	96	124	220	0	1	1	90	114	204	0	0	0	0	1	1	6	9	15
23-Nov	59	201	260	1	2	3	56	186	242	0	0	0	0	1	1	3	14	17
24-Nov	123	116	239	1	0	1	116	105	221	1	0	1	3	2	5	3	9	12
25-Nov	118	167	285	1	0	1	112	158	270	0	0	0	2	0	2	4	9	13
26-Nov	27	78	105	1	2	3	25	73	98	0	0	0	0	0	0	2	5	7
27-Nov	53	126	179	0	0	0	51	119	170	0	0	0	0	0	0	2	7	9
30-Nov	38	148	186	0	0	0	31	136	167	0	0	0	1	1	2	6	11	17
01-Dec	48	55	103	0	0	0	48	53	101	0	0	0	0	0	0	0	2	2
02-Dec	17	59	76	0	1	1	17	57	74	0	0	0	0	0	0	0	2	2
03-Dec	0	10	10	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0
04-Dec	56	53	109	0	0	0	47	49	96	0	0	0	3	0	3	6	4	10
08-Dec	19	23	42	1	0	1	17	22	39	0	0	0	0	0	0	2	1	3
09-Dec	11	17	28	0	0	0	11	17	28	0	0	0	0	0	0	0	0	0
10-Dec	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Reach																		
1	7	1	8	0	0	0	7	1	8	0	0	0	0	0	0	0	0	0
2	86	146	232	1	0	1	83	144	227	0	0	0	2	0	2	1	2	3
3	107	229	336	0	0	0	106	214	320	0	0	0	0	3	3	1	12	13
4	244	650	894	3	5	8	234	608	842	0	1	1	1	2	3	9	39	48
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	378	956	1,334	2	3	5	365	901	1,266	0	0	0	3	1	4	10	54	64
7	770	1,201	1,971	4	2	6	755	1,137	1,892	0	0	0	1	1	2	14	63	77
8	1,477	1,647	3,124	6	9	15	1,421	1,556	2,977	1	0	1	10	3	13	45	88	133
Total	3,069	4,830	7,899	16	19	35	2,971	4,561	7,532	1	1	2	17	10	27	80	258	338

APPENDIX 5. Summary of dead chinook spawning ground recoveries by date and reach, Harrison River 1988.

Date or reach	Total recoveries			Adipose clipped recoveries			Secondary mark absent						Secondary mark present					
							Primary absent			Primary present			Spaghetti absent			Spaghetti present		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
19-Oct	24	17	41	1	0	1	24	17	41	0	0	0	0	0	0	0	0	0
20-Oct	43	96	139	1	0	1	43	95	138	0	0	0	0	0	0	0	1	1
21-Oct	17	25	42	1	0	1	17	25	42	0	0	0	0	0	0	0	0	0
24-Oct	104	168	272	0	0	0	104	164	268	0	0	0	0	0	0	0	4	4
25-Oct	129	152	281	0	1	1	129	148	277	0	0	0	0	0	0	0	4	4
26-Oct	18	42	60	0	0	0	18	41	59	0	0	0	0	0	0	0	1	1
27-Oct	34	37	71	0	1	1	34	37	71	0	0	0	0	0	0	0	0	0
28-Oct	28	48	76	0	0	0	27	47	74	0	0	0	0	0	0	1	1	2
31-Oct	78	93	171	0	0	0	77	92	169	0	0	0	0	0	0	1	1	2
01-Nov	107	167	274	2	1	3	102	162	264	0	0	0	2	0	2	3	5	8
02-Nov	185	173	358	0	3	3	178	166	344	0	0	0	3	0	3	4	7	11
03-Nov	110	221	331	0	2	2	104	212	316	0	0	0	2	0	2	4	9	13
04-Nov	71	201	272	1	2	3	67	197	264	0	0	0	0	0	0	4	4	8
07-Nov	21	26	47	1	0	1	21	26	47	0	0	0	0	0	0	0	0	0
09-Nov	0	2	2	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
10-Nov	79	157	236	1	2	3	76	151	227	0	0	0	1	0	1	2	6	8
14-Nov	74	262	336	0	5	5	70	247	317	0	0	0	1	0	1	3	15	18
15-Nov	138	436	574	1	6	7	132	426	558	0	0	0	1	1	2	5	9	14
16-Nov	58	54	112	0	0	0	56	53	109	0	0	0	0	0	0	2	1	3
17-Nov	82	108	190	1	2	3	71	99	170	0	0	0	1	0	1	10	9	19
18-Nov	127	417	544	0	3	3	126	396	522	0	0	0	0	0	0	1	21	22
21-Nov	83	225	308	0	5	5	82	223	305	0	0	0	1	0	1	0	2	2
22-Nov	21	54	75	0	0	0	20	52	72	0	0	0	0	0	0	1	2	3
23-Nov	24	32	56	0	0	0	22	31	53	0	0	0	1	0	1	1	1	2
24-Nov	26	77	103	1	0	1	25	74	99	0	0	0	0	0	0	1	3	4
25-Nov	13	19	32	0	0	0	13	18	31	0	0	0	0	0	0	0	1	1
28-Nov	34	110	144	0	3	3	32	110	142	0	0	0	0	0	0	2	0	2
29-Nov	44	85	129	0	0	0	41	83	124	0	0	0	1	0	1	2	2	4
30-Nov	6	23	29	0	0	0	6	23	29	0	0	0	0	0	0	0	0	0
01-Dec	31	62	93	0	0	0	30	58	88	0	0	0	1	0	1	0	4	4
04-Dec	9	36	45	0	0	0	9	35	44	0	0	0	0	0	0	0	1	1
05-Dec	25	39	64	0	0	0	25	38	63	0	0	0	0	0	0	0	1	1
Reach																		
1	2	0	2	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0
2	1	4	5	0	0	0	1	4	5	0	0	0	0	0	0	0	0	0
3	45	101	146	2	0	2	45	99	144	0	0	0	0	0	0	0	2	2
4	498	1,352	1,850	3	20	23	481	1,318	1,799	0	0	0	3	0	3	14	34	48
5	115	226	341	0	0	0	114	222	336	0	0	0	0	0	0	1	4	5
6	279	678	957	0	2	2	276	655	931	0	0	0	1	0	1	2	23	25
7	704	1,090	1,794	5	13	18	670	1,040	1,710	0	0	0	9	1	10	25	49	74
8	199	213	412	1	1	2	192	210	402	0	0	0	2	0	2	5	3	8
Total	1,843	3,664	5,507	11	36	47	1,781	3,548	5,329	0	0	0	15	1	16	47	115	162

APPENDIX 6. Summary of chinook live (spaghetti) tagging by date and reach, Harrison River 1984.

Date or reach	Adipose fin present				Adipose fin absent				Total			
	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total
19/10/84	11	0	0	11	0	0	0	0	11	0	0	11
22/10/84	28	6	0	34	0	0	0	0	28	6	0	34
23/10/84	111	14	0	125	0	1	0	1	111	15	0	126
24/10/84	91	17	1	109	0	1	0	1	91	18	1	110
25/10/84	63	22	3	88	0	0	0	0	63	22	3	88
26/10/84	100	8	0	108	0	0	0	0	100	8	0	108
29/10/84	112	26	0	138	0	0	0	0	112	26	0	138
30/10/84	39	36	0	75	0	0	0	0	39	36	0	75
31/10/84	5	3	0	8	0	0	0	0	5	3	0	8
02/11/84	25	18	0	43	2	0	0	2	27	18	0	45
05/11/84	63	51	0	114	0	1	0	1	63	52	0	115
06/11/84	102	88	1	191	0	2	0	2	102	90	1	193
07/11/84	57	57	0	114	0	1	0	1	57	58	0	115
08/11/84	126	91	0	217	0	0	0	0	126	91	0	217
09/11/84	32	35	0	67	0	0	0	0	32	35	0	67
13/11/84	50	49	0	99	0	0	0	0	50	49	0	99
14/11/84	58	47	0	105	0	0	0	0	58	47	0	105
15/11/84	12	13	0	25	0	0	0	0	12	13	0	25
19/11/84	31	43	0	74	0	0	0	0	31	43	0	74
20/11/84	20	21	0	41	0	0	0	0	20	21	0	41
21/11/84	4	0	0	4	0	0	0	0	4	0	0	4
30/11/84	6	6	0	12	0	0	0	0	6	6	0	12
Reach												
2	691	262	5	958	0	2	0	2	691	264	5	960
3	72	91	0	163	0	3	0	3	72	94	0	166
4	262	171	0	433	2	1	0	3	264	172	0	436
5	105	121	0	226	0	0	0	0	105	121	0	226
7	16	6	0	22	0	0	0	0	16	6	0	22
Total	1146	651	5	1802	2	6	0	8	1148	657	5	1810

APPENDIX 7. Summary of chinook live (spaghetti) tagging by date and reach, Harrison River 1985.

Date or reach	Adipose fin present				Adipose fin absent				Total			
	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total
16/10/85	12	13	0	25	0	0	0	0	12	13	0	25
17/10/85	19	25	0	44	0	0	0	0	19	25	0	44
18/10/85	51	23	0	74	0	0	0	0	51	23	0	74
22/10/85	5	5	0	10	0	0	0	0	5	5	0	10
23/10/85	54	37	0	91	0	1	0	1	54	38	0	92
24/10/85	91	74	0	165	0	0	0	0	91	74	0	165
25/10/85	112	81	0	193	1	0	0	1	113	81	0	194
29/10/85	85	26	0	111	0	0	0	0	85	26	0	111
30/10/85	75	51	0	126	4	1	0	5	79	52	0	131
31/10/85	58	103	0	161	1	0	0	1	59	103	0	162
04/11/85	80	55	0	135	3	1	0	4	83	56	0	139
05/11/85	76	34	0	110	0	0	0	0	76	34	0	110
12/11/85	47	24	0	71	0	0	0	0	47	24	0	71
13/11/85	49	66	1	116	2	1	0	3	51	67	1	119
18/11/85	28	17	0	45	0	1	0	1	28	18	0	46
19/11/85	31	28	0	59	0	0	0	0	31	28	0	59
11/12/85	13	9	0	22	0	1	0	1	13	10	0	23
12/12/85	9	6	0	15	0	0	0	0	9	6	0	15
13/12/85	10	8	0	18	1	1	0	2	11	9	0	20
16/12/85	14	3	0	17	0	0	0	0	14	3	0	17
18/12/85	17	3	0	20	0	0	0	0	17	3	0	20
20/12/85	7	1	0	8	0	0	0	0	7	1	0	8
24/12/85	6	2	0	8	0	0	0	0	6	2	0	8
Reach												
2	331	263	0	594	9	3	0	12	340	266	0	606
4	609	425	1	1035	3	4	0	7	612	429	1	1042
7	9	6	0	15	0	0	0	0	9	6	0	15
Total	949	694	1	1644	12	7	0	19	961	701	1	1663

APPENDIX 8. Summary of chinook live (spaghetti) tagging by date and reach, Harrison River 1986.

Date or reach	Adipose fin present				Adipose fin absent				Total			
	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total
14/10/86	11	6	0	17	0	0	0	0	11	6	0	17
15/10/86	45	25	0	70	0	0	0	0	45	25	0	70
16/10/86	37	28	0	65	0	2	0	2	37	30	0	67
17/10/86	66	57	0	123	0	0	0	0	66	57	0	123
18/10/86	2	0	0	2	0	0	0	0	2	0	0	2
20/10/86	82	105	0	187	0	0	0	0	82	105	0	187
21/10/86	31	36	0	67	0	0	0	0	31	36	0	67
22/10/86	44	43	0	87	0	0	0	0	44	43	0	87
23/10/86	11	12	0	23	0	0	0	0	11	12	0	23
24/10/86	116	94	0	210	0	0	0	0	116	94	0	210
25/10/86	25	18	0	43	0	0	0	0	25	18	0	43
27/10/86	61	102	0	163	0	0	0	0	61	102	0	163
28/10/86	43	111	0	154	0	2	0	2	43	113	0	156
29/10/86	48	104	0	152	0	1	0	1	48	105	0	153
30/10/86	28	123	0	151	0	0	0	0	28	123	0	151
02/11/86	15	24	0	39	0	0	0	0	15	24	0	39
03/11/86	52	58	0	110	0	0	0	0	52	58	0	110
04/11/86	31	68	0	99	0	1	0	1	31	69	0	100
05/11/86	48	70	0	118	0	0	0	0	48	70	0	118
06/11/86	52	90	0	142	1	0	0	1	53	90	0	143
10/11/86	13	16	0	29	0	0	0	0	13	16	0	29
13/11/86	8	23	0	31	0	0	0	0	8	23	0	31
14/11/86	14	29	0	43	0	0	0	0	14	29	0	43
17/11/86	46	57	0	103	0	0	0	0	46	57	0	103
18/11/86	62	75	0	137	0	1	0	1	62	76	0	138
19/11/86	25	29	0	54	1	0	0	1	26	29	0	55
20/11/86	6	9	0	15	0	0	0	0	6	9	0	15
21/11/86	16	16	0	32	0	0	0	0	16	16	0	32
24/11/86	10	11	0	21	0	0	0	0	10	11	0	21
25/11/86	6	13	0	19	0	0	0	0	6	13	0	19
27/11/86	10	7	0	17	0	0	0	0	10	7	0	17
28/11/86	1	1	0	2	0	0	0	0	1	1	0	2
Reach												
2	347	683	0	1030	1	4	0	5	348	687	0	1035
3	190	222	0	412	0	1	0	1	190	223	0	413
4	194	202	0	396	0	0	0	0	194	202	0	396
6	330	348	0	678	1	2	0	3	331	350	0	681
7	4	5	0	9	0	0	0	0	4	5	0	9
Total	1065	1460	0	2525	2	7	0	9	1067	1467	0	2534

APPENDIX 9. Summary of chinook live (spaghetti) tagging by date and reach, Harrison River 1987.

Date or reach	Adipose fin present				Adipose fin absent				Total			
	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total
13/10/87	6	11	0	17	0	0	0	0	6	11	0	17
14/10/87	20	22	0	42	0	0	0	0	20	22	0	42
15/10/87	27	9	0	36	0	0	0	0	27	9	0	36
16/10/87	28	37	0	65	0	0	0	0	28	37	0	65
19/10/87	74	46	0	120	1	0	0	1	75	46	0	121
20/10/87	51	39	0	90	0	0	0	0	51	39	0	90
21/10/87	53	87	0	140	0	0	0	0	53	87	0	140
22/10/87	46	148	0	194	0	0	0	0	46	148	0	194
23/10/87	53	110	0	163	0	0	0	0	53	110	0	163
24/10/87	13	16	0	29	1	0	0	1	14	16	0	30
25/10/87	12	9	0	21	0	0	0	0	12	9	0	21
26/10/87	56	61	0	117	0	0	0	0	56	61	0	117
27/10/87	34	53	0	87	0	0	0	0	34	53	0	87
28/10/87	82	258	0	340	0	1	0	1	82	259	0	341
29/10/87	96	263	0	359	0	0	0	0	96	263	0	359
30/10/87	26	124	0	150	0	0	0	0	26	124	0	150
31/10/87	19	22	0	41	0	0	0	0	19	22	0	41
01/11/87	13	11	0	24	0	0	0	0	13	11	0	24
02/11/87	54	91	0	145	0	0	0	0	54	91	0	145
03/11/87	91	101	0	192	0	0	0	0	91	101	0	192
04/11/87	40	38	0	78	0	1	0	1	40	39	0	79
06/11/87	42	49	0	91	0	0	0	0	42	49	0	91
07/11/87	22	33	0	55	1	0	0	1	23	33	0	56
08/11/87	11	17	0	28	0	0	0	0	11	17	0	28
09/11/87	32	35	0	67	0	0	0	0	32	35	0	67
10/11/87	108	94	0	202	0	0	0	0	108	94	0	202
12/11/87	92	113	0	205	1	1	0	2	93	114	0	207
13/11/87	29	37	0	66	0	0	0	0	29	37	0	66
14/11/87	7	7	0	14	0	0	0	0	7	7	0	14
16/11/87	20	23	0	43	0	0	0	0	20	23	0	43
17/11/87	24	31	0	55	0	0	0	0	24	31	0	55
19/11/87	21	21	0	42	0	0	0	0	21	21	0	42
20/11/87	31	37	0	68	0	0	0	0	31	37	0	68
23/11/87	10	14	0	24	0	0	0	0	10	14	0	24
26/11/87	3	2	0	5	0	0	0	0	3	2	0	5
27/11/87	6	11	0	17	0	0	0	0	6	11	0	17
01/12/87	1	4	0	5	0	0	0	0	1	4	0	5
Reach												
2	384	1028	0	1412	0	1	0	1	384	1029	0	1413
3	314	336	0	650	3	1	0	4	317	337	0	654
4	446	488	0	934	0	1	0	1	446	489	0	935
6	161	214	0	375	1	0	0	1	162	214	0	376
7	48	18	0	66	0	0	0	0	48	18	0	66
Total	1353	2084	0	3437	4	3	0	7	1357	2087	0	3444

APPENDIX 10. Summary of chinook live (spaghetti) tagging by date and reach, Harrison River 1988.

Date or reach	Adipose fin present				Adipose fin absent				Total			
	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total	Male	Female	Unknown sex	Total
13/10/88	0	1	0	1	0	0	0	0	0	1	0	1
14/10/88	11	4	0	15	0	0	0	0	11	4	0	15
17/10/88	41	48	0	89	1	0	0	1	42	48	0	90
18/10/88	35	47	0	82	0	0	0	0	35	47	0	82
19/10/88	5	1	0	6	0	0	0	0	5	1	0	6
20/10/88	12	5	0	17	0	0	0	0	12	5	0	17
21/10/88	39	46	0	85	0	1	0	1	39	47	0	86
24/10/88	24	43	0	67	1	2	0	3	25	45	0	70
25/10/88	14	13	0	27	0	0	0	0	14	13	0	27
26/10/88	47	59	0	106	0	0	0	0	47	59	0	106
27/10/88	44	39	0	83	0	0	0	0	44	39	0	83
28/10/88	78	59	0	137	1	0	0	1	79	59	0	138
31/10/88	73	48	0	121	1	0	0	1	74	48	0	122
01/11/88	55	32	0	87	3	0	0	3	58	32	0	90
02/11/88	38	38	0	76	2	0	0	2	40	38	0	78
03/11/88	28	34	0	62	0	0	0	0	28	34	0	62
04/11/88	27	27	0	54	0	0	0	0	27	27	0	54
07/11/88	6	4	0	10	0	1	0	1	6	5	0	11
09/11/88	12	9	0	21	0	0	0	0	12	9	0	21
Reach												
2	30	13	0	43	0	0	0	0	30	13	0	43
3	222	172	0	394	7	2	0	9	229	174	0	403
4	330	370	0	700	2	2	0	4	332	372	0	704
6	7	2	0	9	0	0	0	0	7	2	0	9
Total	589	557	0	1146	9	4	0	13	598	561	0	1159

APPENDIX 11. Coded wire tag codes recovered in the Harrison River (1984 - 88) from chinook salmon during spawning ground carcass surveys and related hatchery rearing stock and release information.

Brood year	Tag code	Hatchery rearing	Stock	Release site	Observed CWT recoveries by year 1984	1985	1986	1987	1988	Total
1980	022109	Chehalis	Harrison	Harrison	1					1
1981	022163	Chilliwack	Harrison	Chilliwack	1	7	1			9
1981	022205	Chehalis	Harrison	Harrison	13	22	1			36
1982	022422	Chilliwack	Harrison	Chilliwack			1	1		2
1982	022520	Chehalis	Harrison	Harrison			2	1		3
1982	022521	Chehalis	Harrison	Harrison			2			2
1982	022523	Chehalis	Harrison	Harrison			4			4
1982	022525	Chehalis	Harrison	Harrison			3			3
1983	022655	Chehalis	Harrison	Harrison					1	1
1983	022659	Chilliwack	Harrison	Chilliwack				1		1
1983	022660	Chilliwack	Harrison	Chilliwack				1	1	2
1983	022725	Chehalis	Harrison	Harrison				5	1	6
1983	022759	Chehalis	Harrison	Harrison				4		4
1983	022760	Chehalis	Harrison	Harrison				1		1
1983	022761	Chehalis	Harrison	Harrison				2		2
1984	022819	Chehalis	Harrison	Harrison					2	2
1984	023041	Chehalis	Harrison	Harrison					2	2
1984	023042	Chehalis	Harrison	Harrison					2	2
1984	023043	Chehalis	Harrison	Harrison					2	2
1984	023128	Chehalis	Harrison	Harrison				1	10	11
1984	023414	Chilliwack	Chilliwack	Chilliwack					1	1
1984	023416	Chilliwack	Chilliwack	Chilliwack					1	1
1984	023417	Chilliwack	Chilliwack	Chilliwack					3	3
1984	023418	Chilliwack	Chilliwack	Chilliwack				1	1	2
1984	023419	Chilliwack	Chilliwack	Chilliwack				1	2	3
1985	023755	Chehalis	Harr. x Chehal.[a]	Harrison					1	1
1985	023756	Chehalis	Harr. x Chehal.	Harrison					3	3
1985	023758	Chehalis	Harr. x Chehal.	Harrison					1	1
1985	023759	Chehalis	Harr. x Chehal.	Harrison				1	1	2
1985	023761	Chehalis	Harr. x Chehal.	Harrison					1	1
1986	024052	Chehalis	Harr. x Chehal.	Harrison					1	1
1986	024406	Chehalis	Harr. x Chehal.	Harrison					1	1
Subtotal (decoded CWT's)					15	29	14	20	38	116
Lost or no pin					1	6	2	15	9	33
Total					16	35	16	35	47	149

[a] - Harrison River x Chehalis River cross.

APPENDIX 12. Agreement between total ages of adipose clipped chinook salmon aged by extraction and decoding of CWT's and scale reading, Harrison River dead recovery, 1984-88.

Recovery year and CWT code	Scale age[a] 2.1	3.1	4.1	4.2	5.1	Unknown	Total
1984							
02/21/09						1	1
02/21/63			1				1
02/22/05		10	2[b]			1	13
Total		10	3			2	15
1985							
02/21/63			5		1[b]	1	7
02/22/05			19			3	22
Total			24		1	4	29
1986							
02/21/63						1	1
02/22/05					1		1
02/24/22			1				1
02/25/20			1			1	2
02/25/21			1			1	2
02/25/23			2		1[b]	1	4
02/25/25			3				3
Total			8		2	4	14
1987							
02/24/22						1	1
02/25/20					1		1
02/26/59						1	1
02/26/60			1				1
02/27/25			5				5
02/27/59			3			1	4
02/27/60			1				1
02/27/61			1			1	2
02/31/28		1					1
02/34/18		1					1
02/34/19		1					1
02/37/59	1						1
Total	1	3	11	0	1	4	20

[a] - Age interpretation eg. 4.1 means the fish has a total age of 4 years (i.e. is in its fourth year of life and decimal 1 is the year of life the fish left freshwater and entered the ocean; disagreements between scale age and known (CWT) age fish are flagged with a footnote letter where applicable.

[b] - Incorrect age; scale age different than known (CWT) age.

APPENDIX 12 (cont'd). Agreement between total ages of adipose clipped chinook salmon aged by extraction and decoding of CWT's and scale reading, Harrison River dead recovery, 1984-88.

Recovery year and CWT code	Scale age[a]						
	2.1	3.1	4.1	4.2	5.1	Unknown	Total
1988							
02/26/55					1		1
02/26/60					1		1
02/27/25					1		1
02/28/19			2				2
02/30/41						2	2
02/30/42			1			1	2
02/30/43			1			1	2
02/31/28		2		1		7	10
02/34/14			1				1
02/34/16			1				1
02/34/17			3				3
02/34/18			1				1
02/34/19			1			1	2
02/37/55		1					1
02/37/56		3					3
02/37/58						1	1
02/37/59		1					1
02/37/61						1	1
02/40/52		1					1
02/44/06	1						1
Total	1	8	11	1	3	14	38

[a] - Age interpretation eg. 4.1 means the fish has a total age of 4 years (i.e. is in its fourth year of life and decimal 1 is the year of life the fish left freshwater and entered the ocean; disagreements between scale age and known (CWT) age fish are flagged with a footnote letter where applicable.

[b] - Incorrect age; scale age different than known (CWT) age.