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Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of Campbell and Quinsam Rivers, 1994

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**Canadian Manuscript Report of
Fisheries and Aquatic Sciences No. 2325**

**ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG
RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF
CAMPBELL AND QUINSAM RIVERS, 1994**

by

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for

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ABSTRACT

Frith, H. R. and T.C. Nelson. 1995. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1994. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2325 : ix + 61 p.

Estimates of escapement were derived for the Campbell/Quinsam River system for 1994 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 2,982 in 1994 and includes hatchery removals (sales, broodstock, mortalities) and chinook passed over the hatchery fence. Males and females were mostly age 4, except in Campbell River where females were mostly age 5. Males and females were variable in age distribution. Females ranged from 37.8% age 4 in Campbell River to 68.6% age 4 in Quinsam Hatchery. Males ranged from 46.4% age 4 in Quinsam River to 71.4% age 4 in Campbell River.

Estimated escapement of adipose-clipped chinook to the entire system was 182 in 1994. This estimate was further stratified by age, sex, and tag code. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose-clip mark rate at release. In 1994, the hatchery contribution was 69.8% and 85.3% for male and female chinook escapements, respectively. These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program (Kuhn 1988) method of coded wire tag expansions. Using the MRP method, the total 1994 hatchery contribution was 64.0% for males and 83.2% for females.

Key words: Campbell, Quinsam, chinook, key stream, escapement, coded wire tags, live tagging, carcass tagging

RÉSUMÉ

Frith, H. R. and T. C. Nelson. 1995. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1994, Can. Manuscr. Rep. Fish. Aquat. Sci. 2325 : ix + 61 p.

Les taux d'échappées dans le réseau des rivières Campbell et Quinsam en 1994 ont été établis au moyen des micromarques de carcasses utilisées dans le cadre du programme concernant les principaux cours d'eau fréquentés par le saumon quinnat. Selon Petersen, le taux d'échappées en 1994 s'élève à 2 982, ce qui comprend les retraits de l'écloserie (ventes, stocks reproducteurs, décès) ainsi que les saumons qui sont passés par-dessus la clôture de l'écloserie. En général, les mâles et les femelles sont âgés de quatre ans, sauf dans la rivière Campbell où les femelles avaient pour la plupart cinq ans. Le taux d'échappées des mâles et des femelles variait selon l'âge. Pour les saumons femelles de quatre ans, le taux d'échappées allait de 37,8 p. 100 (rivière Campbell) à 68,6 p. 100 (écloserie de Quinsam). Pour les saumons mâles de quatre ans, le taux allait de 46,4 p.100 (rivière Quinsam) à 71, 4 p. 100 (rivière Campbell).

Dans l'ensemble du réseau, le taux d'échappées du saumon quinnat dont la nageoire adipeuse a été coupée était de 182 en 1994. Ce taux a été ventilé par âge, sexe et codes des micromarques. On a déterminé le nombre total de poissons (marqués et non marqués) provenant de l'écloserie en faisant une extrapolation à partir des remontées observées de saumons à nageoire adipeuse coupée et du nombre de saumons à nageoire adipeuse coupée qui avaient été relâchés. En 1994, 69,8 p. 100 (mâles) et 85,3 p. 100 (femelles) des poissons d'échappées provenaient d'écloseries. Ces pourcentages ont été comparés aux taux obtenus au moyen de la méthode du Programme de reprise des poissons étiquetés, qui repose sur un facteur d'extrapolation du nombre portant des micromarques magnétisées codées (Kuhn et al. 1988). Pour ce qui est des échappées de 1994 calculées selon cette méthode, 64,0 p. 100 des saumons quinnats mâles et 83,2 p. 100 des saumons quinnats femelles au total provenaient de l'écloserie du ruisseau Robertson.

Key words : Campbell, Quinsam, quinnat, cours d'eau clé, échappée, fil codé, poissons marqués, carcasses marquées

INTRODUCTION

The chinook salmon of the Campbell/Quinsam River system was selected as one of the indicator stocks for assessing the response of Pacific chinook salmon stocks to a new harvest management regime. The goal of the new management regime is to rebuild chinook stocks to historical levels. This "key stream" program began in 1984 in response to objectives set out in the Canada - U.S. Salmon treaty.

The major objectives of the key stream program are:

1. to accurately estimate chinook escapement on key streams;
2. to estimate harvest rates and contributions to fisheries and escapement based on coded wire tagged/adipose clip returns, including estimates of the total escapement of coded wire tags to the key streams system; and
3. to estimate the contribution of hatchery and natural production to the escapement.

Chinook escapements to the Campbell River have ranged from 750 to 8,000 since 1947 (Shardlow et al. 1986). Chinook escapement to the Quinsam River was negligible prior to the opening of Quinsam Hatchery in 1972, but has increased to 1,500 in 1985 and 5,311 in 1988 (Andrew et al. 1988, Bocking et al. 1990). Chinook returns to the Quinsam Hatchery have also increased from 1,885 in 1986 to 5,412 in 1990 (Bocking 1991*b*). In recent years, total system adult escapement has declined from a high of 15,538 in 1990 to 2,486 in 1993 (Frith et al. 1992; Frith 1993).

This manuscript report is the eighth in a series describing the escapement monitoring and biological sampling of chinook salmon in the Campbell/Quinsam River system (Shardlow et al. 1986; Andrew et al. 1988; Bocking et al. 1990; Bocking 1991*b*; Frith et al. 1993; in Frith 1993; Frith and Nelson 1994).

As in previous years, the 1994 escapements of chinook salmon were calculated using the adjusted Petersen method (Ricker 1975). Carcasses were tagged to produce escapement estimates for each sex and river and summed to form a total estimate for the in-river escapement of chinook. The total recovery of chinook salmon at the Quinsam Hatchery was then added to the in-river escapement estimates to produce an escapement figure for the Quinsam/Campbell River system.

Potential biases in the Petersen method, carcass tagging method, and method of stratification are discussed in Frith and Nelson (1994). Assumptions for the methods used and the tests for biases caused by violations of assumptions are described in the methods section. The results section presents the population estimates, tests for bias in tagging and

recovery, population composition (age, length, and sex), and the results of coded wire tagging studies.

To avoid confusion in terminology relating to tagging and marking, the word "tagging" in this report refers to operculum tagging of dead mature chinook in the river and "marking" refers to marking of chinook juveniles with coded wire tags (CWT) and adipose fin clips (AFC).

STUDY AREA

The physical attributes of the Quinsam/Campbell drainage area have been described in detail by Andrew et al. (1988). The Campbell River originates east of the Vancouver Island Ranges and flows in an easterly direction for 9 km into Discovery Passage immediately north of the city of Campbell River, British Columbia (Figure 1). The Quinsam River, a major tributary of Campbell River, flows for over 30 km in a northerly direction through a series of small lakes before joining Campbell River approximately 3.8 km upstream from its mouth.

The drainage area for the Campbell River system is 1,460 km² and for the Quinsam River system is 265 km² (Andrew et al. 1988). Fish passage in Campbell River is blocked by natural falls and a hydroelectric dam 5.5 km upstream of the mouth. Approximately 27 km of the Quinsam River is accessible to natural spawning but chinook spawning takes place primarily in the lower 4 km of the river (Shardlow et al. 1986). Chinook access to the upper Quinsam River above the counting fence near Quinsam Hatchery was improved in 1988.

Flows in the Campbell River are controlled by the John Hart Generating Station, located 5.5 km upstream of the mouth (Marshall et al. 1977) and vary from 1.2 m³s⁻¹ to 826.0 m³s⁻¹ (mean=96.0 m³s⁻¹). Flows on the Quinsam River are not controlled and vary from 0.9 m³s⁻¹ to 21.6 m³s⁻¹ (mean=9.0 m³s⁻¹) (Shardlow et al. 1986).

Commercial activity in the Campbell River estuary includes log booming, sawmill operations, shake mills, a seaplane base at Tyee Spit, and recreational boat moorages (Andrew et al. 1988). Man-made islands have been constructed in the estuary in an effort to improve fish habitat (Levings 1986). The lower reaches of the Campbell River have been modified due to expansion of the Campbell River community (population approximately 18,000) which surrounds the lower 2 km of the river. Access to the Campbell River is primarily by municipal roads and by Campbell River Road, which runs along the south bank of the river.

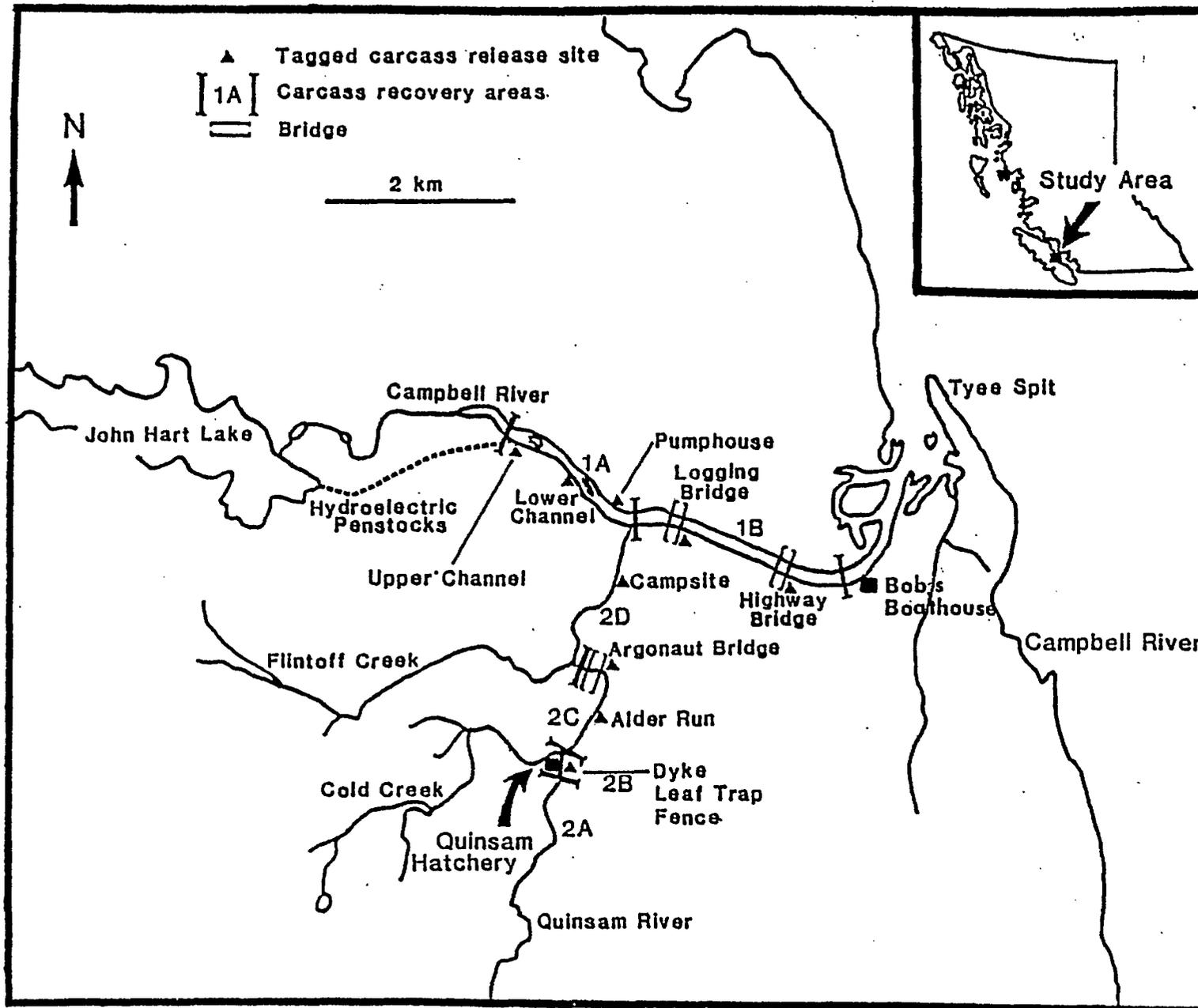
Mining for coal is conducted in the headwaters of the Quinsam River, and forest harvesting is conducted throughout the watershed (Andrew et al. 1988). The lower reaches of the Quinsam River are easily accessed via logging roads, whereas access is more difficult in upper reaches above the hatchery.

The Campbell/Quinsam river system supports five species of Pacific salmon as well as steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*). The salmonids, in order of abundance, are pink, chinook, chum, coho and sockeye salmon (*O. gorbuscha*, *O. tshawytscha*, *O. keta*, *O. kisutch*, and *O. nerka*, respectively). Chinook spawn in Campbell River upstream of the confluence with the Quinsam River, and in the Quinsam River from the mouth to the counting fence (Andrew et al. 1988). Each year some chinook salmon swim through the counting fence to spawn in the upper Quinsam River or are passed over the fence by hatchery staff. Coho spawn in the Quinsam River, but not in the Campbell River, and chum and pink salmon that previously spawned in the lower reaches of the Campbell River now utilize the lower reaches of Quinsam River as well. Chinook begin migration into the Campbell River in late August and the majority of chinook enter the system in October. Peak spawning in Campbell River occurs from mid-October to mid-November (Andrew et al. 1988; Frith and Nelson 1994). Migration of chinook into the Quinsam River occurs later from late September to late November and is strongly influenced by rainfall. Spawning is usually completed by late November or early December.

The Quinsam Hatchery is located approximately 3.7 km upstream of the Quinsam River confluence with the Campbell River. A fence is located immediately upstream of the hatchery for broodstock collection (Figure 1). Fish distribution and smolt production, as well as river flows and water quality in the watershed were studied by Blackmun et al. (1985).

METHODS

Carcass tagging and recovery was conducted from October 18 to December 5 by Quinsam Hatchery workers. A summary of methods for this study is presented in Table 1 and is described below.



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Figure 1. Map of the Campbell and Quinsam rivers study area.

POPULATION ESTIMATION

Chinook salmon were enumerated using the adjusted Petersen method (Ricker 1975, p. 78) by tagging spawned-out chinook carcasses and recovering tags from the carcasses. Carcasses were tagged and recovered *in situ*.

Population Stratification

Carcass Tagging:

Petersen estimates were stratified by sex and river and then summed to obtain an estimate of the whole population. By segregating the data into separate population strata, potential biases due to differential rates of tag application, recovery of carcasses, and tag loss were avoided (Andrew et al. 1988). Petersen estimates were generated for the Campbell River and the Quinsam River (below the fence). Additional counts of chinook salmon returning to the hatchery rack and those fish passing upstream through the Quinsam River fence were added to the two Petersen estimates to give a total system escapement.

Potential Biases

Carcass Tagging:

Within a stratum, Petersen estimates using carcass tagging are subject to bias if a number of assumptions are violated (Andrew et al. 1988; Bocking et al. 1990).

Tests used to evaluate bias of the Petersen estimate in this study are also presented and discussed below. Certain biases caused by methods of tagging, recovery, and age determination are discussed in subsequent sections.

Assumption 1. Tags are applied in proportion to the available population, the distribution of recovery effort is proportional to the number of fish present in each river reach, and tagged fish mix randomly with untagged fish.

To obtain an accurate Petersen estimate, tags must be applied and recovered in proportion to the available population. In 1994, carcasses were tagged *in situ* during examination. Hatchery workers attempted to tag a consistent proportion of the number of fish examined during each recovery survey by tagging four of every ten carcasses in 1994. A higher tag rate was applied when the number of carcasses examined in a day was low. The proportion of fish tagged ranged from about 40-100% over the study period.

A related problem associated with escapement estimates for separate rivers is that tagged carcasses may stray (washout) between rivers. Apart from passive movement due to water flow, tagged carcasses are not subject to movement or straying in the same way as live fish. In 1994 there were five strays from Quinsam River recovered in the Campbell River.

Assumption 2. There are no or minimal additional die-offs of spawners after the conclusion of tagging.

An addition of new carcasses following tagging could cause the Petersen calculations to overestimate or underestimate the true population depending on how they mixed with tagged fish. In 1994, tagging continued *in situ* in the rivers every 1 to 5 days throughout the spawning and die-off period.

Assumption 3. There is no tag loss.

A high incidence of tag loss will cause Petersen calculations to overestimate the true population. Tag loss was determined by a hole punch in the operculum of all tagged carcasses. A different number of opercular holes was used to distinguish carcasses tagged in the Campbell River from carcasses tagged in the Quinsam River. All secondary marks (opercular punches) were included in the tag recovery data and Petersen estimates.

Assumption 4. All tags are recognized and reported during recovery after the conclusion of tagging.

In this study, no duplicate pitches were conducted to re-examine carcasses for missed tags and secondary marks. Therefore, it was not possible to evaluate the validity of this assumption.

Assumption 5. Recovery efforts are made on the same population that was tagged.

Dead recovery from a population other than the tagged population will cause Petersen calculations to overestimate the true population. Indications that tagging and recovery were conducted on different populations would be different age frequency and length frequency distributions among the two samples. Since tagging occurred concurrently with recovery, this is an unlikely source of error.

Assumption 6. There is adequate sampling to provide an accurate and precise population estimate.

A small number of tag recoveries in a stratum will cause Petersen estimates to have low precision. Petersen estimates are generally more reliable if a high proportion of tagged fish are recovered in each stratum. In the absence of other sources of bias, approximately 25 to 75 recaptures will produce population estimates with 25% accuracy, and 95% confidence, for population sizes of 10^2 to 10^9 (Ricker 1975).

Assumption 7. Tagged carcasses are representative of the population and behave in a similar manner to untagged carcasses with respect to buoyancy, visibility, and decomposition.

Tagged carcass recoveries will not be representative of the population if tagged carcasses do not mix completely with untagged carcasses (see assumption 1), in which case the Petersen method may overestimate or underestimate the population. The thoroughness of mixing depends on whether tagged carcasses behave in a similar manner to untagged carcasses. It is not possible to statistically test the assumption of mixing with the data from this study.

Buoyancy and decomposition may be important factors causing differential behaviour of tagged and untagged carcasses especially if tagged carcasses become bloated with air during handling. Differences in tag visibility could cause preferential sampling of tagged carcasses, and result in an underestimate of the population. An attempt was made to circumvent this problem by using neutral colours to prevent increased visibility of tagged carcasses. It is not possible to test the assumption of similar visibility between tagged and untagged carcasses with the data from this study. The assumption of similar buoyancy and decomposition of tagged and untagged carcasses could be tested by comparing the tag recovery rate during dead recovery with the recovery rate at carcass weirs if such data were available.

Calculations

The adjusted Petersen estimate of each river stratum and sex was calculated as follows (Chapman's formula, cited in Ricker 1975, p. 78):

$$P_{i,r} = \frac{(C_{i,r} + 1) (M_{i,r} + 1)}{(R_{i,r} + 1)} \quad (1)$$

where P is the population estimate, C is the total number of fish recovered, M is the total number of fish tagged, and R is the number of tagged fish recovered and includes fish with missing tags (secondary marks only). The subscript i is the sex stratum and the subscript r is the river stratum.

Population estimates for sex and river (carcass tagging only) strata were summed to obtain a total in-river population estimate:

$$P_t = \sum_{i=1}^n \sum_{r=1}^m P_{i,r} \quad (2)$$

where n is the total number of sex strata and m is the total number of river strata.

Confidence limits for each stratum population estimate were obtained using fiducial limits for the Poisson distribution as described by Ricker (1975, p79). The 95% confidence limits for the total escapement was then determined by assigning equal weights to all strata and summing the lower and upper confidence limits across strata.

Population estimates were not calculated for jack chinook because no marked jacks were recovered.

Strays

In this study, tagged carcasses released in one river and recovered in the other river were considered to be strays. For the purpose of the Petersen population estimate calculations, the total number of strays from the Quinsam River (Q) to the Campbell River (C) was estimated by expanding the observed number of tagged strays as follows:

$$ES_{Q \text{ to } C} = TS_{Q \text{ to } C} \times (M_{Campbell} / R_{Campbell}) \quad (3)$$

where ES is the expanded number of strays, TS is the number of tagged strays, M is the number of secondary marks applied and R is the number of secondary marks recovered.

No straying occurred from the Campbell River to the Quinsam River. The expanded number of tagged strays from the Quinsam to the Campbell was then used to estimate the number of tagged fish available in the Campbell River:

$$M'_{Campbell} = M_{Campbell} + ES_{Q \text{ to } C} - ES_{C \text{ to } Q} \quad (4)$$

where M' is the adjusted number of marks applied.

Equation 4 provides the adjusted estimate for the number of tagged fish available for recapture ($M_{i,r}$) used in equation 1. Tagged fish available for recaptures in Quinsam River is then:

$$M_{Quinsam}^I = M_{Quinsam} + ES_{C \text{ to } Q} - ES_{Q \text{ to } C} \quad (5)$$

TAGGING

Tagging was conducted in tandem with the dead recovery effort. This enabled the tagging effort to be spread evenly throughout the recovery period (Appendix 1 and 2).

RECOVERY

Sampling crews that conducted the dead recovery were composed of two to six workers each day. Table 2 shows the number of person-days spent in dead recovery effort in each river. Recovery crews were instructed to dead pitch and count all available carcasses and record and keep all operculum tags. Crews attempted to distribute recovery effort evenly throughout the study period. Dead chinook were recovered from the Campbell and Quinsam rivers by two methods:

1. recovery crews searched the banks and shallow reaches of the rivers on foot and from a boat; and
2. a SCUBA diver recovered carcasses from deep pools in the lower reaches of the Campbell and Quinsam rivers.

Chinook were also recovered at the Quinsam Hatchery rack.

Each carcass was examined for the presence of an opercular tag and opercular punch hole(s), and the absence of an adipose fin. Heads were removed from adipose-clipped fish for sampling of coded wire tags (CWT). Data collected from carcasses are described in the biological and physical sampling methods section. All carcasses tagged during the recovery effort were released at the same location as they were tagged. All recaptured tagged carcasses were cut in half to prevent recounting in future dead pitches.

For Petersen mark-recapture estimates, only carcasses recovered after the first day of tagging were included in the values of C and R . It was assumed that 24 hours were required between tagging and recapture for sufficient mixing between tagged and untagged carcasses.

Other calculations relating to the dead recovery were as follows:

$$\text{tag rate} = R / C \quad (6)$$

where *tag rate* is an estimate of the proportion of the population that were tagged.

$$\text{tag recovery rate} = R / M \quad (7)$$

where *tag recovery rate* is an estimate of the proportion of tagged fish that were later recaptured.

BIOLOGICAL AND PHYSICAL SAMPLING

Biological sampling during dead recovery included the collection of scales for age determination, length measurements, sex determination, the recording of the presence of secondary marks (hole punches in the operculum), and presence of an adipose clip. Postorbital-hypural length was recorded for 31-45% of the carcasses (marked and unmarked fish) recovered in the Campbell River, 32-39% of the carcasses recovered in the Quinsam River, and 18-30% of the chinook recovered alive at the hatchery rack.

Scale samples were taken from the same unmarked fish as length samples. Some adipose-clipped fish (CWT) were also sampled for age (from CWT decoding) and lengths. A scraping of scales was placed in a labelled plastic envelope and the individual scales from each fish were mounted in scale books at the hatchery. Scales were aged at the Department of Fisheries and Oceans scale laboratory in Vancouver. Heads were removed from adipose-clipped fish and saved for CWT extraction and decoding at the coded wire tag dissection laboratory in Vancouver.

Ages were read only when a portion of the previous annulus was present and scales were not regenerated. Scales were classified as unreadable if the scales had regenerated centres, were resorbed, or were mounted upside down. Ages were recorded for fish for which there were at least two scales that could be read for both marine and freshwater ages. In this report, only the total age was reported. The aging system follows that described by Gilbert and Rich (1927).

The age composition determined with the available samples is valid only if age sampling was random and there was no bias in readability of scales with age. Ages of older fish are usually more difficult to read than those of young fish because scales of older fish usually undergo more resorption and regeneration. The data were examined for this potential bias using a t-test to compare the mean lengths of known and unknown age males and females. The dead recovery sample was used to determine the age and length composition of the population. Because of problems in distinguishing jacks from adult males, age and length information for jacks was grouped with males.

The population of each age class was then determined by allocating portions of the Petersen estimate to age classes according to the age composition determined from scale samples and CWT decoding. The number of jacks was too small to estimate population size with accuracy and therefore escapement by age was determined for adult males and females only.

A sex ratio was determined from Petersen estimates for each river. The test for potential differences in tag loss is described in the tagging methods section. Tag recognition is not likely to be biased by sex, although it was not possible to test this potential bias with the data in this study.

CODED WIRE TAGGING AND RECOVERY

Juvenile chinook from the 1988 - 1992 brood years were marked at Quinsam Hatchery with binary coded wire tags (CWT) described by Jefferts et al. (1963) using standard methods (Armstrong and Argue 1977). Adipose fins of coded wire tagged juveniles were clipped prior to the release of these fish.

Estimates of the contribution of hatchery-reared chinook to the total escapement were calculated following two approaches. The first approach (Method A) applies the AFC (adipose fin clip) mark rate in recovery (dead pitch) samples to estimate AFC escapement by tag code. The second approach (Method B) follows a similar approach where the percentage of CWT tags in escapement counts by tag code are used for expansion.

Method A

Adipose-clipped fish were enumerated separately for males and females in the Campbell River, Quinsam River, and Quinsam Hatchery. Quinsam Hatchery recoveries included fish examined and released upstream of the counting fence. The recovery of chinook jacks was not included with the adult male recoveries in this analysis. The first step was to estimate the number of adipose-clipped fish in each stratum (river and sex) from the observed number of adipose clips:

$$EAD_{i,r} = \frac{OAD_{i,r} \cdot P_{i,r}}{C_{i,r}} \quad (8)$$

where EAD is the estimated number of adipose clips, OAD is the number of adipose clips observed, C is the number of fish examined, P is the population estimate, and i and r are

subscripts denoting sex and river location (stratum). The sex-specific population estimates used here were from the Petersen population estimates for the Campbell and Quinsam Rivers and from direct counts at the hatchery. Estimates of the number of adipose clips for jack chinook were not possible because there was no population estimate for jacks.

Given an estimate of the total number of adipose clips for each sex escaping to each portion of the system, the number of adipose clips for each tag code can be estimated by the allocation of adipose clips to tag code groups based on their relative frequency in the sample of decoded tags:

$$EAD_{i,r,tc} = \frac{EAD_{i,r} \cdot NDT_{i,r,tc}}{\sum NDT_{i,r}} \quad (9)$$

where tc is a subscript denoted tag code, NDT is the number of successfully decoded tags for each tag code, and $\sum NDT$ is the total number of decoded tags for all tag codes, for each strata and sex.

This approach of first estimating adipose-clipped fish and then allocating these among the successfully decoded CWTs assumes that any adipose-clipped fish not decoded contained a coded wire tag at release. If this assumption is incorrect, the calculation of the number of hatchery-origin fish using this method would be positively biased. It is possible, especially in the dead pitch, that some fish identified as hatchery releases by missing adipose fins may be fish that have naturally lost their adipose fins through some other means, e.g. carcass decomposition, or were misidentified. Other potential sources of bias using Method A are discussed in Bocking (1991b).

The hatchery contribution to each year's escapement, stratified by river and sex, was calculated by expanding the estimated number of adipose clips from each tag code group in proportion to the percentage of juvenile fish possessing an adipose clip at time of release:

$$EHC_{i,r,tc} = \frac{EAD_{i,r,tc} \cdot (RC_{tc} + RUC_{tc})}{RC_{tc}} \quad (10)$$

where EHC is the estimated hatchery contribution, RC is the number of chinook released with an adipose fin clip for each tag code group (tc), and RUC is the number of chinook released without an adipose fin clip for each tag code group (tc).

These estimates of hatchery contributions, stratified by brood year (t), river (r), sex (i) and tag code (tc) can then be summed to give the hatchery contribution of all tag codes to the entire escapement:

$$EHC = \sum_{t=1}^j \sum_{r=1}^k \sum_{i=1}^m \sum_{tc=1}^n EHC_{t,r,i,tc} \quad (11)$$

where n is the number of tag codes for a given brood year t .

Due to the potentially different ages at maturity of males and females, it is important that the allocation of adipose-clipped fish to tag codes be carried out separately by sex whenever possible. In this study, the sex of all fish sampled for CWTs was recorded so that it was possible to estimate the total escapement of tag codes by sex (males do not include jacks). Final hatchery contribution estimates were made separately for fish of Quinsam Hatchery origin and for strays from other rivers.

Method B

In the second approach used to estimate the hatchery contribution, we estimated the number of successfully decoded CWT chinook in the escapement, stratified by river and sex using the methods described for the Mark Recovery Program (Kuhn 1988). The primary difference between this method and Method A is that Method B uses the number of actual CWTs present in the escapement from which to derive the hatchery contribution, whereas Method A uses the number of adipose clips present in the escapement. Method B is currently used by DFO to estimate hatchery contributions in commercial and sport chinook catches.

Estimating the total number of CWT returns from each of the brood years, and for each tag code, was done as follows.

First, the observed number of CWT recoveries was adjusted to account for "no pin" (no tag) recoveries:

$$ADJ_{i,r,tc} = OBS_{i,r,tc} \cdot \left[1 + \frac{LP}{K} + \frac{ND \cdot (K + LP)}{K \cdot (K + LP + NP)} \right] \quad (12)$$

where ADJ is the adjusted number of observed CWT fish, OBS is the observed number of CWT fish, K is the sum of all successfully decoded tags for all tag codes recovered, LP is the number of lost pin recoveries, ND is the number of no data recoveries, NP is the number of no pin recoveries, and i , r , and tc are subscripts denoting sex, river, and tag code.

This adjusted number of CWT recoveries was then used to estimate the total number of CWT returns for each tag code:

$$EST_{i,r,tc} = \frac{ADJ_{i,r,tc} \cdot P_{i,r}}{C_{i,r}} \quad (13)$$

where EST is the estimated number of CWT recoveries for a single tag code, C is the number of fish examined, P is the population estimate, and i , r , and tc are subscripts denoting sex, river, and tag code.

This approach of estimating the number of CWT chinook in the escapement assumes that any adipose-clipped chinook found without CWTs were never marked. This assumption is only valid if chinook tagged with a particular tag code did not lose the CWT after release from the hatchery (i.e. after accounting for tag loss during a retention test). Since 90% of tag loss occurs within four weeks of tagging (Blankenship 1990), any fish released within this four-week period are more susceptible to tag loss prior to being recovered in the fishery or escapement. Violation of the assumption of no tag loss will result in a negative bias in the hatchery contribution estimates. Other potential sources of bias using Method B are discussed in Bocking (1991b).

The hatchery contribution to each year's escapement, stratified by river location and sex, was calculated by expanding the estimated number of CWT fish of each tag code group in proportion to the percentage of juvenile fish having a CWT at time of release:

$$EHC_{i,r,tc} = \frac{EST_{i,r,tc} \cdot (RM_{tc} + RUM_{tc})}{RM_{tc}} \quad (14)$$

where EHC is the estimated hatchery contribution, RM is the number of chinook released with CWTs for each tag code group (tc), and RUM is the number of chinook released without CWTs for each tag code group (tc).

As for Method A, these estimates of hatchery contribution by tag code were then summed to give the hatchery contribution of all tag codes to the entire escapement, stratified by river, sex, and brood year:

$$EHC_{i,r,t} = \sum_{t=1}^j \sum_{r=1}^k \sum_{i=1}^m \sum_{tc=1}^n EHC_{t,r,i,tc} \quad (15)$$

where n is the number of tag codes for a given brood year t .

Percent hatchery contributions by sex and age were then calculated using the Petersen population estimates for adult males and females.

RESULTS

TAGGING

Carcass Tagging

In 1994, 117 chinook carcasses were tagged and released (returned to the river) between October 18 to November 17 in the Campbell River, and 198 carcasses were tagged and released from October 19 to December 1 in the Quinsam River (Table 3; Appendices 1 and 2).

RECOVERY

Surveys to recover carcasses in 1994 began on October 21 in the Campbell River and on October 28 in the Quinsam River and continued until November 22 and December 5, respectively (Appendices 3 and 4; Figure 1). On some days, some reaches in each river were surveyed more frequently than others. The number of carcasses recovered in each area of the rivers for 1994 are summarized in Appendices 3 and 4.

Sequential daily totals of the number of carcasses recovered, the number of tags applied, and the number of tags recovered, stratified by river and sex are presented in Appendices 5 and 6. Note that the total number of fish examined is greater than the number of fish examined (C) in the Petersen formula because recoveries on or before the first day of tagging cannot be included.

In 1994, a total of 213 chinook carcasses were examined in the Campbell River (102 males, 110 females, and one jack; Table 3). This number included 56 tag recoveries (24 males, 32 females and zero jacks). In the Quinsam River, a total of 374 chinook carcasses were examined (189 males, 180 females, and five jacks; Table 3). This included 108 tag recoveries (60 males, 48 females, and zero jacks).

The carcass tag recovery rates in the Campbell River (47.9%) and Quinsam River (54.5%) in 1994 differed by 6.6% but the difference was not significant ($P > 0.05$, χ^2 ; Zar 1984). The tag rates were similar for males (43.6%) and females (52.5%) in Campbell River and for males (63.2%) and females (48.5%) in Quinsam River ($P > 0.05$, χ^2 ; Zar 1984).

POPULATION ESTIMATES

Carcass Tagging

Petersen escapement estimates, stratified by river and sex, are given in Table 4. In 1994, chinook escapement to the Campbell River and Quinsam River was estimated at 476 and 629 adults, respectively (Table 4). Sex-specific estimates and 95% confidence limits for both rivers are also shown in Table 4. The total escapement to the Campbell/Quinsam River system in 1994, including hatchery rack recoveries, was estimated at 2,982 adults with 95% confidence limits of 2,693 to 3,415 fish.

The proportion of fish amongst sampling location strata was 15.8: 20.9: 63.3 (Campbell:Quinsam:Hatchery). These proportions show a continued increase in the proportion of hatchery chinook compared to previous years averaging 17.9: 42.2: 39.9 for 1989-1991 (Bocking 1991*b*; Frith et al. 1993). The total number of returns in 1994 is slightly higher than returns in 1993, but it is significantly less than the high in 1990 for the Campbell/Quinsam river system (Figure 2).

AGE, LENGTH AND SEX COMPOSITION

Age composition and mean lengths of chinook salmon are presented in Tables 5-7. All scale-aged fish in the Campbell and Quinsam rivers left the river to rear in the ocean during their first year of life (termed sub-one in this report). Ages of all Campbell and Quinsam river chinook returns ranged from 1 to 6 years. The dominant age-group for both sexes in the Campbell River, Quinsam River and hatchery was age 4 fish except for Campbell River females where age-5 fish dominated. The proportions of sexes in the age-4 group ranged from 37.8 to 68.6% for females and from 48.1 to 74.1% for males in the same river location. In all locations, the number of age-4 and age-5 fish were each greater than 20% for both sexes, except for Quinsam Hatchery males where age-3 and age-4 fish were dominant (Table 9). Age-3 fish represented greater than 20% for males in Quinsam River also.

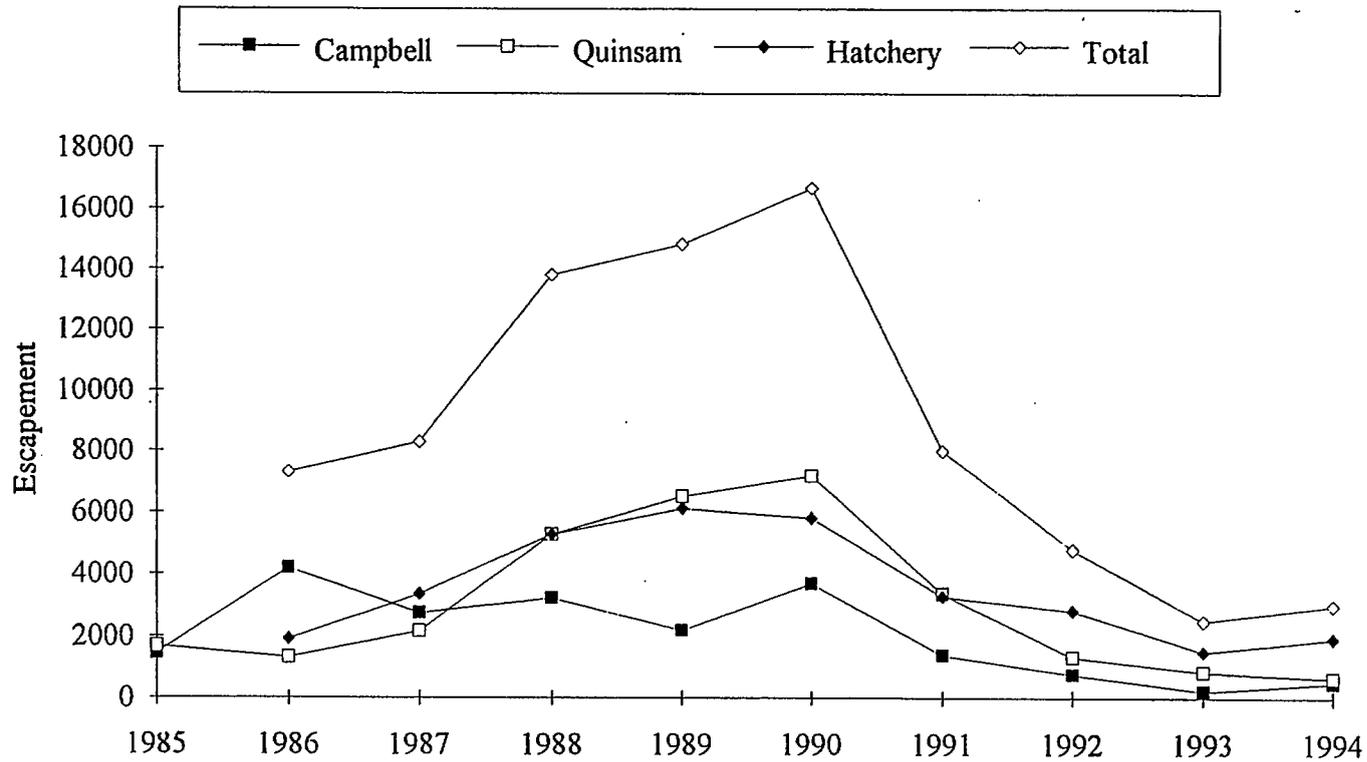


Figure 2. Chinook escapement estimates, stratified by river location, for 1985 (Andrew et al. 1988), 1986-88 (Bocking et al. 1990), 1989-90 (Bocking 1991), 1991 (Frith et al. 1993), 1992 (Frith 1993) and 1993 (this study).

Male and female chinook from Campbell River had larger mean lengths (postorbital-hypural) than male and female chinook from the Quinsam River (Campbell: male = 776 mm, female = 816 mm; Quinsam: male = 698 mm, female = 765 mm). T-tests were conducted to compare the mean lengths among sexes and among rivers. Male chinook carcasses were significantly smaller than female carcasses in Campbell River ($P < 0.05$), Quinsam River ($P < 0.001$) and Quinsam Hatchery ($P < 0.001$). Female and male carcasses recovered in the Campbell River were significantly larger than those recovered in the Quinsam River ($P < 0.002$) and the Quinsam Hatchery ($P < 0.001$). Male and female carcasses recovered in the Quinsam River were larger than chinook recovered at the hatchery but the difference was not significant ($P > 0.05$).

There was no significant difference between the mean length of unaged and aged (all ages) chinook for any combination of sex and river stratum (t-test, $P > 0.05$). Age-length distributions for chinook returning to the Campbell River, Quinsam River, and Quinsam Hatchery in 1994 are shown in Table 8 and escapement stratified by age, class and sex is shown in Table 9. The sex ratio of males (not including jacks)/females was 1.10 in the Campbell River, 0.82 in the Quinsam River, and 1.33 at the Quinsam Hatchery (Table 9).

CODED WIRE TAGGING AND RECOVERY

Coded wire tagged (adipose-clipped) juvenile chinook released into the Campbell and Quinsam rivers from the 1988 to 1991 brood years were captured in the dead recovery programs in 1994 (Appendix 7 and 8). There was one recovery in Quinsam River and three recoveries in Quinsam Hatchery of adipose-clipped chinook jacks (1993 brood).

The results of coded wire tag returns are presented below for the Campbell and Quinsam rivers and the Quinsam Hatchery. Information includes the following:

1. the raw data and mark rates for the Petersen estimates (Appendices 7 and 8);
2. estimates of the total escapement of adipose clips (Table 10);
3. hatchery release information for recovered tag codes (Table 12).
4. the observed and estimated escapement of adipose clips by tag codes, and the hatchery contribution to the escapement for each tag code (Tables 11 and 13 and Tables 15 to 17); and
5. the estimated hatchery contribution to the escapement by age class (Tables 14 and 18).

In 1994, there were nine adipose-clipped chinook recovered in the Campbell River dead pitch, 25 in the Quinsam River dead pitch and 125 at the hatchery rack not including jacks (Table 10). The adipose-clip mark rate was highest in the hatchery returns (6.7%) and lowest in the Campbell River returns (4.2%). The total estimated adipose clips to Campbell River, Quinsam River, and Quinsam Hatchery were 20, 37, and 125, respectively.

These mark rates at return were tested for significant differences between rivers using a chi-square test. The mark rates for the Campbell River, Quinsam River, and Quinsam Hatchery were not significantly different (χ^2 , $P > 0.05$).

Hatchery Contributions - Method A

Results from the decoding of adipose-clipped fish from the Campbell and Quinsam river dead pitch and returns to Quinsam Hatchery are shown in Table 11. Any CWT fish recovered in the system which were released from another enhancement facility were included in the analysis (only two strays were recovered in 1994). A total of 155 fish were recovered in 1994 and of these 143 were successfully decoded.

The allocations of the total escapement of adipose clips to tag codes recovered in each portion of the river are shown in Tables 11 and 13. Table 12 lists the number of CWT fish and adipose-clipped fish released for each tag code (data from MRP database). The estimated hatchery contributions to the 1994 escapement of chinook to the Campbell River, Quinsam River, and Quinsam Hatchery were 191, 493, and 1608, respectively (Table 13).

The hatchery contributions to the total escapement of chinook in 1994, by age class is presented in Table 14. The hatchery contribution to the Campbell River population of chinook was estimated to be 45.4% for males and 34.4% for females. Contributions to the in-river Quinsam chinook escapement were 49.6% for males and >100.0% for females and to the Quinsam Hatchery were 80.7% for males and 92.2% for females. Strays contributed 12.3% and 1.1% of the total CWT returns to the Campbell River and Quinsam Hatchery, respectively.

Hatchery Contributions - Method B

The allocations of the total escapement of CWTs to tag codes recovered in each portion of the river are shown in Tables 15-17. The estimated hatchery contributions to the 1994 escapement of chinook (both males and females) to the Campbell River, Quinsam River, and Quinsam Hatchery using Method B were 117, 430, and 1606, respectively (Table 17).

The hatchery contribution to the total escapement of chinook in 1994, by age class, is presented in Table 18. The 1994 hatchery contribution to the Campbell River population of

chinook was estimated to be 24.9% for males and 24.2% for females. Contributions to the in-river Quinsam chinook escapement were 37.9% for males and 93.6% for females. Hatchery returns were composed of 79.6% for males and 93.3% for females in the returns to the hatchery. The estimated stray contribution was 10.6% and 1.2% of the escapement estimate in Campbell River and Quinsam Hatchery, respectively. No strays were reported for Quinsam River.

DISCUSSION AND CONCLUSIONS

POPULATION ESTIMATION

The calculation of separate Petersen estimates for each sex and river location reduces error when differences in numbers occur. In this study, sex ratio differences occurred in hatchery broodstock, dead recovery, and Petersen estimates. A greater number of females than males were recovered in the dead pitch surveys for the Quinsam River, whereas the number of males was greater in the Campbell River and Quinsam Hatchery. Andrew et al. (1988) found greater numbers of females than males in live and dead pitch recoveries in the Quinsam/Campbell system in 1986, as did Shardlow et al. (1986) in 1984-85. In years since 1986, females have dominated in Campbell and Quinsam rivers but females have dominated in Quinsam Hatchery (Bocking 1991; Frith, Nass and Nelson 1993). Differences in the number of spawning adult salmon between sexes is also common in other species. Higher numbers of females than males have been observed in spawning ground dead pitches for sockeye salmon (Petersen 1954), pink salmon (Ward 1959), and coho salmon (Eames and Hino 1981; Eames et al. 1981). The number of chinook in the Quinsam Hatchery was much greater than Quinsam and Campbell rivers in 1994 and in recent years, Quinsam River returns have greatly exceeded Campbell River returns (Bocking 1991; Frith, Nass and Nelson 1993). The stratification of escapement estimates by sex and river location avoids a known source of error in the Quinsam/Campbell system and this practice should be continued for future population estimates.

Straying of live fish between rivers was not a source of error as the number of strays was estimated using carcass tag returns in adjacent river locations. However, the degree of mixing of tagged carcasses with the rest of the carcass population may not have been complete, particularly in deep pools where carcasses may have settled without further movement. Bias due to incomplete mixing was addressed by conducting tagging and recovery effort in proportion to the distribution of fish, by frequently moving to different tagging and recovery sites throughout both operations, and by snorkelling or SCUBA diving in deeper areas.

AGE, LENGTH AND SEX COMPOSITION

In 1994, chinook escapements to the Campbell and Quinsam rivers were composed mainly of age-4 and age-5 year old fish. A similar age structure has been observed in recent years (Bocking 1991; Frith, Nass and Nelson 1993; Frith and Nelson 1994). The ratio of adult males to females, as determined from the Petersen estimates, was 1.10 in Campbell River and 0.82 in Quinsam River in 1994. The adult male to female ratio of returns to the Quinsam Hatchery was 1.33 in 1994. No consistent pattern of sex ratios between river locations has been observed in recent years (Frith, Nass and Nelson 1993; Frith and Nelson 1994). The mean length of chinook in the three river locations have remained similar over the past four years (Frith, Nass and Nelson 1993; Frith and Nelson 1994).

CODED WIRE TAGGING AND RECOVERY

In this study, we used the adipose clip rate in the dead recovery of chinook in the Quinsam and Campbell rivers and at the hatchery rack to estimate the number of adipose clips in the escapement (Method A). Sampling for adipose-clipped fish was non-selective and assumed random at each of these locations. The rate of recovery was 4.2% - 6.7% in 1994.

Estimates of the total hatchery contribution to the Quinsam/Campbell River system for adult males and females in 1994 were either approximately the same (within 3%) or higher (22.8% to 94.8%) using Method A (AFC rate) compared to Method B (CWT rate). Method A produced hatchery contribution estimates ranging from 34.4% to >100.0% (Table 14) and were similar in range to the 21.6% to 99.7% realized by Method B (Table 18). A comparison of the hatchery contribution estimates for Methods A and B in 1991, 1992 and 1993 returns to the Quinsam/Campbell River system showed smaller differences between the two methods where the maximum differences were 18.5%, 7.2% and 12.7% respectively. The greater maximum difference in total hatchery contribution between the two methods in 1994 (94.8%) can be explained by the low number of adipose clip returns to the Campbell River.

Although we have tried to address as many potential sources of bias as possible in the estimation of the escapement of CWTs described above, we have not explicitly included the following factors:

1. Low number of recoveries of adipose clips and decoded CWTs (e.g. 20 CWTs in the 1989 brood year) may reduce the precision of the estimates; and

2. The sample of heads obtained for the decoding of CWTs may not be a random sample from the population and may be biased (e.g. size selectivity).

We have not formally estimated the level of precision of the estimates of escapement by adipose-clipped fish and individual tag codes, as potential sources of bias can render these misleading. An approximation of the level of precision can be obtained by examining the number of adipose clips/CWT recoveries on which a given estimate is based. There were four to 63 adipose clips enumerated for each river stratum (jacks not included) in 1994. The 95% confidence limits for four recoveries (based on a Poisson frequency distribution) would be approximately $\pm 114\%$ and significantly smaller at 27% for 63 recoveries. These estimates of precision are conservative because the expansion factors used to estimate the total number of adipose clips/marks in the escapement are also estimated with error.

There were differences between the hatchery contributions to each of the Campbell River, the Quinsam River, and the Quinsam Hatchery within 1994. In general, there was a higher proportion of hatchery-reared fish in the Quinsam River and at the hatchery than in the Campbell River. This pattern has been observed in previous years (Bocking et al. 1990; Bocking, 1991*b*; Frith et al. 1993; Frith 1993).

SUMMARY

1. The total escapement for chinook salmon in the Campbell/Quinsam River system using carcass tagging and hatchery returns was estimated at 2982 in 1994. Estimates were stratified by river and sex.
2. The age composition of chinook between the Campbell and Quinsam rivers and the Quinsam Hatchery were similar for males and females with mostly age-4 and secondly age-5. Age-3 were ranked second in numbers for some combinations of sex and river location. Male and female chinook were predominantly age-4 with the exception of Campbell River females where the number of age-5 was greatest.
3. Based on the Petersen estimates and Quinsam Hatchery rack recoveries, females were more abundant in the Quinsam River population, less abundant than males in the rack recoveries and in the Campbell River population.
4. The mean length of chinook salmon was greatest in the Campbell River, and smallest in the Quinsam Hatchery returns. Females tended to be significantly larger than males.

5. The total estimated return of adipose-clipped chinook to the Campbell/Quinsam River system was 182 fish in 1994.
6. The total estimated hatchery contribution to the chinook escapement, based on adipose clips (Method A), was 2,292 (76.9%) in 1994. The contribution estimate derived using the adjusted CWTs recovered (Method B) was slightly lower at 2,152 (72.2%).

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TABLES

Table 1. Summary of methods for the Campbell and Quinsam rivers chinook salmon enumeration programs, 1994.

Item	Method and Materials
Dead recovery population estimate	Petersen estimate, sum of separate estimates for sexes and rivers
Carcass tagging	Cattle ear tags (a) applied in situ to carcasses recovered in river
Secondary marking (dead)	Two-hole opercular punch for Campbell and single hole punch for Quinsam on left operculum
Recovery of fish	Foot, SCUBA surveys, rack
Coded wire tagging (CWT)	Collection of heads from adipose clipped fish in dead recovery and at hatchery rack
Biological and physical sampling	Ages from scales and CWT, sex ratios from sex-specific population estimates for each river and at hatchery rack, postorbital-hypural length

(a) Tags were supplied by:
 Ketchum Manufacturing Sales Ltd., 396 Berkely Ave., Ottawa, Ontario, K2A 2G6
 (Size No. 3, 1 1/8 " x 1/4")

Table 2. Summary of tagging and recovery effort (person-days) for chinook salmon carcasses in the Campbell and Quinsam rivers, 1994.

River	Stream walk	Diver	Total person days
Campbell	36.1	6	42.1
Quinsam	30.5	0	30.5

Table 3. Summary of in situ carcass tagging and dead recovery of chinook salmon in Campbell and Quinsam rivers, 1994.

Category	Campbell (a)	Quinsam (b)	Total
<u>Carcasses tagged:</u>			
Males	55	95	150
Females	61	99	160
Jacks	1	4	5
Total	117	198	315
<u>Carcasses examined:</u>			
Males	102	189	291
Females	110	180	290
Jacks	1	5	6
Total	213	374	587
<u>Tags recovered (c):</u>			
Males	24	60	84
Females	32	48	80
Jacks	0	0	0
Total	56	108	164
<u>Tag summary:</u>			
Observed tag rate (%)	26.3	28.9	27.9
Tag return rate (%)	47.9	54.5	52.1
Tag loss (%)	2.0	6.5	4.2

- (a) See Appendix 5 for number of carcasses recovered, number of carcasses tagged, and number of tagged recoveries, by date in Campbell River
- (b) See Appendix 6 for number of carcasses recovered, number of carcasses tagged, and number of tagged recoveries, by date in Quinsam River
- (c) Tagged recoveries include all carcasses with opercular punch holes (ie. secondary marks), and include five strays from Quinsam River

Table 4. Petersen population estimates, confidence limits and enumeration data for chinook salmon escapement in the Campbell River, Quinsam River, and Quinsam Hatchery based on in situ chinook examination, tagging and tag recovery of carcasses, 1994. Confidence limits are determined assuming R is Poisson distributed (Ricker 1975, p. 343).

River and Item	Male	Female	Jack (i)	Total
Campbell River (a)				
Number of carcasses tagged (d)	55	61	1	117
Number of carcasses examined (e)	101	109	1	211
Number of tagged carcasses recoveries (f)	24	32	0	56
Number of tagged strays from Quinsam River	2	3	0	5
Estimated number of stray tags from Quinsam River	5	6	0	11
Number of tagged fish for Petersen estimate including strays	60	67	NA	127
Petersen estimate (g)	249	227	NA	476 (j)
Lower 95 % CL	170	162	NA	332 (j)
Upper 95 % CL	379	328	NA	707 (j)
Quinsam River (b, below fence)				
Number of carcasses tagged (d)	95	99	4	198
Number of carcasses examined (e)	189	179	5	373
Number of tagged carcasses recoveries (f)	60	48	0	108
Number of tagged strays from Campbell River	0	0	0	0
Estimated number of stray tags from Campbell River	0	0	0	0
Number of tagged fish for Petersen estimate including strays	90	93	NA	183
Petersen estimate	283	345	NA	629 (j)
Lower 95 % CL	221	262	NA	483 (j)
Upper 95 % CL	363	466	NA	829 (j)
Quinsam Hatchery (c)				
Number of fish (h)	1073	805	24	1902
Total system				
Escapement estimate	1605	1377	NA	2982 (j)
Lower 95 % CL	1464	1229	NA	2693 (j)
Upper 95 % CL	1816	1599	NA	3415 (j)

(a) Appendix 5 for no. of carcasses examined, no. of carcasses tagged, and no. of tagged carcass recoveries, by date in Campbell River

(b) Appendix 6 for no. of carcasses examined, no. of carcasses tagged, and no. of tagged carcass recoveries, by date in Quinsam River

(c) Hatchery recoveries plus fish not available for carcass enumeration including brood stock, fish sold, fish released above the fence, and mortalities at the fence trap

(d) Total number of fish tagged and operculum hole punched

(e) Total number of fish examined (tagged and untagged recoveries) less number of fish observed on first day of tagging

(f) Total of carcasses examined possessing an operculum punch (secondary mark)

(g) Including strays from Quinsam River

(h) Confidence limits not applicable

(i) Peterson estimates were not calculated for jacks due to low sample size

(j) Totals not including jacks (see (i))

Table 5. Age composition of Campbell River chinook salmon, 1994 (determined from dead recovery).

Sex and age	Unmarked	AD/CWT.	Total	Percent (b)	Postorbital-hypural length (mm)					
					N	Mean (mm)	SD	95% CL		
								Lower	Upper	
<u>Males (a)</u>										
3	2	0	2	7.2 (3.8)	2	675	106	525	825	
4	20	0	20	71.4 (74.1)	20	752	52	729	775	
5	4	1	5	21.4 (22.1)	5	914	27	890	938	
Total aged	26	1	27	100.0 (100.0)	27	776	86	743	809	
Unknown age	1	3	4		4	775	131	644	906	
Total			31							
<u>Females</u>										
4	17	0	17	37.8	16	760	38	741	779	
5	19	2	21	46.6	21	840	58	814	865	
6	7	0	7	15.6	7	876	36	848	903	
Total aged	43	2	45	100.0	44	816	66	804	828	
Unknown age	1	3	4		4	820	90	730	910	
Total			49							

(a) One 3 yr old jack is included with males

(b) Figures in parentheses are age distributions in percent for adult males only (jacks are excluded)

Table 6. Age composition of Quinsam River chinook salmon, 1994 (determined from dead recovery).

Sex and age	Unmarked	AD/CWT	Total	Percent (b)	Postorbital-hypural length (mm)					
					N	Mean (mm)	SD	95% CL		
								Lower	Upper	
<u>Males (a)</u>										
2	1	0	1	1.8	1	370	0	370	370	
3	14	0	14	25.0 (24.1)	14	594	59	563	626	
4	23	3	26	46.4 (48.1)	25	707	59	683	731	
5	11	3	14	25.0 (25.9)	14	806	74	767	846	
6	1	0	1	1.8 (1.9)	1	760	0	760	760	
Total aged	50	6	56	100.0 (100.0)	55	698	108	669	727	
Unknown age	3	2	5		3	633	57	567	699	
Total			61							
<u>Females</u>										
4	33	5	38	57.6	38	735	47	720	750	
5	16	6	22	33.3	22	801	50	780	822	
6	5	1	6	9.1	6	823	59	775	871	
Total aged	54	12	66	100.0	66	765	60	750	780	
Unknown age	1	2	3		3	760	72	677	843	
Total			69							

(a) Jacks are included with males (one 2 yr old and one 3 yr old)

(b) Figures in parentheses are age distributions in percent for adult males only (jacks are excluded)

Table 7. Age composition of Quinsam Hatchery chinook salmon, 1994 (determined from rack recovery).

Sex and age	Unmarked	AD/CWT	Total	Percent (b)	Postorbital-hypural length (mm)					
					N	Mean (mm)	SD	95% CL		
								Lower	Upper	
<u>Males (a)</u>										
1	0	3	3	1.9	3	197	15	179	214	
3	24	16	40	24.8 (25.3)	40	611	59	593	630	
4	63	40	103	64.0 (65.2)	103	706	52	696	716	
5	8	7	15	9.3 (9.5)	15	801	45	778	824	
Total aged	95	66	161	100 (100.0)	161	682	101	666	698	
Unknown age	36		36		36	695	128	652	738	
Total			197							
<u>Females</u>										
3	4	4	8	3.8	8	696	57	656	736	
4	101	43	144	68.6	144	737	43	730	744	
5	38	12	50	23.8	50	801	44	789	814	
6	5	3	8	3.8	8	861	51	826	897	
Total aged	148	62	210	100.0	210	756	57	748	764	
Unknown age	29		29		29	747	80	717	777	
Total			239							

(a) Jacks (1 yr old fish) are included with males

(b) Figures in parentheses are age distributions in percent for adult males only (jacks are excluded)

Table 8. Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1994.

Location	Length class (mm)	Age													
		Males							Females						
		1	2	3	4	5	6	Total unk(a)	2	3	4	5	6	Total unk(a)	
<u>Campbell River</u>															
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	550-599	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	600-649	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	650-699	0	0	0	3	0	0	3	1	0	0	1	0	0	1
	700-749	0	0	0	5	0	0	5	2	0	0	5	2	0	7
	750-799	0	0	1	7	0	0	8	0	0	0	6	2	0	8
	800-849	0	0	0	5	0	0	5	0	0	0	4	6	1	11
	850-899	0	0	0	0	1	0	1	0	0	0	7	4	11	0
	900-949	0	0	0	0	3	0	3	0	0	0	4	2	6	1
	950-999	0	0	0	0	1	0	1	1	0	0	0	0	0	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	0	675	752	914	0	776	775	0	0	760	840	876	816
	SD	0	0	106	52	27	0	86	131	0	0	38	58	36	66
	N	0	0	2	20	5	0	27	4	0	0	16	21	7	44
<u>Quinsam River</u>															
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	1	0	0	0	0	1	0	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	450-499	0	0	2	0	0	0	2	0	0	0	0	0	0	0
	500-549	0	0	1	0	0	0	1	0	0	0	0	0	0	0
	550-599	0	0	1	1	0	0	2	2	0	0	0	0	0	0
	600-649	0	0	8	3	0	0	11	0	0	0	1	0	0	1
	650-699	0	0	2	6	1	0	9	1	0	0	7	0	0	7
	700-749	0	0	0	7	2	0	9	1	0	0	14	2	0	16
	750-799	0	0	0	7	2	1	10	0	0	0	14	9	1	24
	800-849	0	0	0	1	6	0	7	0	0	0	2	8	2	12
	850-899	0	0	0	0	1	0	1	0	0	0	3	1	4	0
	900-949	0	0	0	0	2	0	2	0	0	0	1	1	2	0
	950-999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	370	594	707	806	760	698	633	0	0	735	801	823	765
	SD	0	0	59	59	74	0	108	57	0	0	47	50	59	60
	N	0	1	14	25	14	1	55	4	0	0	38	22	6	66

(a) Unk = age unknown

Table 8 (cont). Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1994.

River	Length class (mm)	Age													
		Males							Females						
		1	2	3	4	5	6	Total unk(a)	2	3	4	5	6	Total unk(a)	
<u>Quinsam Hatchery</u>															
	150-199	1	0	0	0	0	0	1	0	0	0	0	0	0	0
	200-249	2	0	0	0	0	0	2	0	0	0	0	0	0	0
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	450-499	0	0	2	0	0	0	2	1	0	0	0	0	0	1
	500-549	0	0	1	0	0	0	1	2	0	0	0	0	0	0
	550-599	0	0	13	3	0	0	16	0	0	0	1	0	0	1
	600-649	0	0	11	9	0	0	20	0	0	3	3	0	0	6
	650-699	0	0	10	26	0	0	36	5	0	0	21	2	0	23
	700-749	0	0	3	42	2	0	47	13	0	3	57	3	0	63
	750-799	0	0	0	19	5	0	24	8	0	2	51	13	1	67
	800-849	0	0	0	4	6	0	10	2	0	0	11	25	1	37
	850-899	0	0	0	0	2	0	2	1	0	0	0	7	4	11
	900-949	0	0	0	0	0	0	0	1	0	0	0	0	2	2
	950-999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	197	0	611	706	801	0	682	695	0	696	737	801	861	756
	SD	15	0	59	52	45	0	101	128	0	57	43	44	51	57
	N	3	0	40	103	15	0	161	36	0	8	144	50	8	210

(a) Unk = age unknown

Table 9. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River, Quinsam Hatchery, 1994.

Location	Age	Males (a)		Females	
		Number (b)	Percent (c)	Number (b)	Percent (c)
<u>Campbell River</u>					
	3	9	3.8	0	0.0
	4	185	74.1	86	37.8
	5	55	22.1	106	46.6
	6	0	0.0	35	15.6
	Total	249 (d)	100.0	227 (d)	100.0
<u>Quinsam River</u>					
	3	68	24.1	0	0.0
	4	136	48.1	199	57.6
	5	73	25.9	115	33.3
	6	5	1.9	31	9.1
	Total	283 (d)	100.0	345 (d)	100.0
<u>Quinsam Hatchery</u>					
	3	271	25.3	31	3.8
	4	700	65.2	551	68.6
	5	102	9.5	192	23.8
	6	0	0.0	31	3.8
	Total	1073 (d)	100.0	805 (d)	100.0

(a) Does not include jacks; see table 4, footnote (h)

(b) Number of fish by age are calculated from the product of the percent age (c) and total adult escapement (d)

(c) Percentage age distribution from tables 5, 6 and 7

(d) Petersen estimates or Quinsam Hatchery recoveries from Table 4

Table 10. Estimates of the total escapement of adipose clipped chinook salmon to the Campbell River, Quinsam River and Quinsam Hatchery, 1994. The Petersen estimates were derived using the in situ carcass-tagging method (Method A).

Location	Sex	Sample size (a) A	Observed adipose clips (a) B	Mark rate (%) $C=(B/A) \times 100$	Population estimate (b) D	Percentage of population sampled $E=(A/D) \times 100$	Total estimated adipose clips $F=(B/A) \times D$
<u>Campbell River</u>							
	Male (c)	102	4	3.9	249	41.0	10
	Female	110	5	4.5	227	48.5	10
	Total	212	9	4.2	476	44.5	20
<u>Quinsam River (below fence)</u>							
	Male (c)	189	7	3.7	283	66.8	10
	Female	179	14	7.8	345	51.9	27
	Total	368	21	5.7	628	58.6	37
<u>Quinsam Hatchery</u>							
	Male (c)	1073	63	5.9	1073	100.0	63
	Female	805	62	7.7	805	100.0	62
	Total	1878	125	6.7	1878	100.0	125

(a) Campbell River data from Appendix 7; Quinsam River data from Appendix 8; Quinsam Hatchery data from unsummarized rack recovery data base, three adipose-clipped jacks were observed

(b) From Table 4

(c) Does not include jacks, see Table 4, footnote (i)

Table 11. Estimates of total escapement of adipose-clipped chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994. The source of tags for the Petersen estimates was from in situ carcass tagging. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method A).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1991	21328	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.1	1.0	2	1	2.1	1.0
	21329	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	21331	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	180416	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.1	0.0	1	0	1.1	0.0
	180417	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.2	0.0	4	0	4.2	0.0
	180420	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.1	0.0	1	0	1.1	0.0
	180421	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.1	0.0	1	0	1.1	0.0
	180422	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.2	0.0	3	0	3.2	0.0
	Subtotal	0	0	0.0	0.0	0	0	0.0	0.0	16	1	16.8	1.0	16	1	16.8	1.0
1990	20956	0	0	0.0	0.0	2	0	3.3	0.0	6	5	6.3	5.1	8	5	9.6	5.1
	20957	0	0	0.0	0.0	1	0	1.7	0.0	6	6	6.3	6.1	7	6	8.0	6.1
	20958	0	0	0.0	0.0	0	0	0.0	0.0	3	9	3.2	9.1	3	9	3.2	9.1
	20959	0	0	0.0	0.0	0	1	0.0	2.3	2	4	2.1	4.1	2	5	2.1	6.3
	21448	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	21449	0	0	0.0	0.0	0	0	0.0	0.0	2	3	2.1	3.0	2	3	2.1	3.0
	21450	0	0	0.0	0.0	0	0	0.0	0.0	1	5	1.1	5.1	1	5	1.1	5.1
	21451	0	0	0.0	0.0	0	1	0.0	2.3	9	5	9.5	5.1	9	6	9.5	7.3
	26016	0	0	0.0	0.0	0	2	0.0	4.5	1	3	1.1	3.0	1	5	1.1	7.5
	26017	0	0	0.0	0.0	0	0	0.0	0.0	3	3	3.2	3.0	3	3	3.2	3.0
	26018	0	0	0.0	0.0	0	1	0.0	2.3	0	1	0.0	1.0	0	2	0.0	3.3
	26019	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	Subtotal	0	0	0.0	0.0	3	5	5.0	11.3	37	44	38.9	44.7	40	49	43.9	56.0
1989	20354	0	1	0.0	3.3	0	2	0.0	4.5	0	1	0.0	1.0	0	4	0.0	8.8
	20355	1	0	10.0	0.0	0	0	0.0	0.0	1	1	1.1	1.0	2	1	11.1	1.0
	20357	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	20358	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	20359	0	0	0.0	0.0	0	2	0.0	4.5	0	2	0.0	2.0	0	4	0.0	6.5

(continued)

Table 11 (cont). Estimates of total escapement of adipose-clipped chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code 1994. The source of tags for the Petersen estimates was from in situ carcass tagging. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method A).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips		Observed adipose clips		Estimated adipose clips	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	20360	0	0	0.0	0.0	2	0	3.3	0.0	3	1	3.2	1.0	5	1	6.5	1.0
	26062	0	0	0.0	0.0	0	1	0.0	2.3	0	0	0.0	0.0	0	1	0.0	2.3
	26063	0	0	0.0	0.0	0	0	0.0	0.0	0	4	0.0	4.1	0	4	0.0	4.1
	26101	0	1	0.0	3.3	1	0	1.7	0.0	1	1	1.1	1.0	2	2	2.7	4.3
	26102	0	0	0.0	0.0	0	1	0.0	2.3	0	1	0.0	1.0	0	2	0.0	3.3
	Subtotal	1	2	10.0	6.7	3	6	5.0	13.5	7	12	7.4	12.2	11	20	22.4	32.4
1988	25527	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	25817	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	25819	0	0	0.0	0.0	0	1	0.0	2.3	0	0	0.0	0.0	0	1	0.0	2.3
	25820	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	Subtotal	0	0	0.0	0.0	0	1	0.0	2.3	0	3	0.0	3.0	0	4	0.0	5.3
	Total hatchery	1	2	10.0	6.7	6	12	10.0	27.0	60	60	63.0	61.0	67	74	83.0	94.7
<u>Strays: (d)</u>																	
1990	180311	0	1	0.0	3.3	0	0	0.0	0.0	0	1	0.0	1.0	0	2	0.0	4.3
	Total strays	0	1	0.0	3.3	0	0	0.0	0.0	0	1	0.0	1.0	0	2	0.0	4.3
	Total CWT (c)	1	3	10.0	10.0	6	12	10.0	27.0	60	61	63.0	62.0	67	76	83.0	99.0
	No data (5000)	2	1			0	1			0	0			2	2		
	No pin (8000)	1	1			1	1			2	1			4	3		
	Lost pin (9000)	0	0			0	0			1	0			1	0		
	Observed adipose	4	5			7	14			63	62			74	81		

(a) Abbreviations are M = male, F = female
 (b) Does not include jacks
 (c) Total estimated adipose clips from Table 10
 (d) Adipose-clipped fish that have strayed from other systems

Table 12. CWT release data for hatchery-reared chinook salmon returning to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994.

Brood year	CWT code	Release numbers		CWT loss (%)	Days held	Adipose release status	
		CWT	Untagged			Clipped	Unclipped
1991	21328	24770	291356	7.8	10.6	26866	289260
	21329	24661	598989	4.0	10.8	25689	597961
	21331	24593	526740	4.5	6.3	25752	525581
	180416	23951	303114	7.3	5	25837	301228
	180417	24967	317856	7.3	8.4	26933	315890
	180420	24952	435566	5.4	7.9	26376	434142
	180421	23760	196364	10.8	7.1	26637	193487
	180422	24936	226054	9.9	8.2	27676	223314
1990	20956	26953	189154	0.2	8	27007	189100
	20957	26752	430178	0.6	10	26913	430017
	20958	26658	205795	0.3	6	26738	205715
	20959	25870	203520	0.6	9	26026	203364
	21448	26509	496950	0.7	10	26696	496763
	21449	26602	332627	0.8	8	26817	332412
	21450	26384	331055	0.0	9	26384	331055
	21451	26502	320497	0.5	7	26635	320364
	26016	27211	588892	0.5	14	27348	588755
	26017	25911	284261	2.7	13	26630	283542
	26018	28265	183904	0.0	14	28265	183904
	26019	26817	502724	0.7	10	27006	502535
	1989	20354	23306	174330	1.9	12	23757
20355		22574	263949	0.8	11	22756	263767
20357		23886	441517	1.4	10	24225	441178
20358		24634	449153	1.4	10	24984	448803
20359		24396	300109	2.7	10	25073	299432
20360		24499	291972	1.9	10	24973	291498
26062		24929	291542	0.1	10	24954	194589
26063		24904	291567	0.8	10	25105	196137
26101		25007	291464	0.3	10	25082	417458
26102		24739	291732	1.1	12	25014	190712
1988	25527	23937	244318	2.8	7	24627	243628
	25817	25029	268880	0.0	7	25029	268880
	25819	25037	270958	0.0	7	25037	270958
	25820	24810	406636	1.4	7	25162	406284
Total hatchery		662121	8347684			668244	8174728
Strays: (a)							
1990	180311	29183	271190	9.7	4.8	32318	268055

(a) Stray came from Puntledge River

Table 13. Estimates of total escapement of hatchery-reared chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994 (Method A). The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 11) to account for unclipped hatchery releases and, hence, derive hatchery contributions to escapement.
 Expansion factor = (adipose clipped + unclipped releases)/adipose-clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion factor	Expanded hatchery contributions (a,b)							
		Clipped	Unclipped		Campbell River		Quinsam River		Quinsam Hatchery		Total	
					M	F	M	F	M	F	M	F
1991	21328	26866	289260	11.8	0.0	0.0	0.0	0.0	24.7	12.0	24.7	12.0
	21329	25689	597961	24.3	0.0	0.0	0.0	0.0	51.0	0.0	51.0	0.0
	21331	25752	525581	21.4	0.0	0.0	0.0	0.0	45.0	0.0	45.0	0.0
	180416	25837	301228	12.7	0.0	0.0	0.0	0.0	13.3	0.0	13.3	0.0
	180417	26933	315890	12.7	0.0	0.0	0.0	0.0	53.5	0.0	53.5	0.0
	180420	26376	434142	17.5	0.0	0.0	0.0	0.0	18.3	0.0	18.3	0.0
	180421	26637	193487	8.3	0.0	0.0	0.0	0.0	8.7	0.0	8.7	0.0
	180422	27676	223314	9.1	0.0	0.0	0.0	0.0	28.6	0.0	28.6	0.0
	Subtotal	211765	2880864		0.0	0.0	0.0	0.0	243.0	12.0	243.0	12.0
1990	20956	27007	189100	8.0	0.0	0.0	29.3	0.0	50.4	40.7	79.8	40.7
	20957	26913	430017	17.0	0.0	0.0	31.1	0.0	107.0	103.5	138.1	103.5
	20958	26738	205715	8.7	0.0	0.0	0.0	0.0	27.4	79.5	27.4	79.5
	20959	26026	203364	8.8	0.0	0.0	0.0	21.3	18.5	35.8	18.5	57.1
	21448	26696	496763	19.6	0.0	0.0	0.0	0.0	41.2	0.0	41.2	0.0
	21449	26817	332412	13.4	0.0	0.0	0.0	0.0	28.1	40.8	28.1	40.8
	21450	26384	331055	13.5	0.0	0.0	0.0	0.0	14.2	68.8	14.2	68.8
	21451	26635	320364	13.0	0.0	0.0	0.0	31.5	123.1	66.2	123.1	97.7
	26016	27348	588755	22.5	0.0	0.0	0.0	108.9	23.7	68.7	23.7	177.6
	26017	26630	283542	11.6	0.0	0.0	0.0	0.0	36.7	35.5	36.7	35.5
	26018	28265	183904	7.5	0.0	0.0	0.0	18.1	0.0	7.6	0.0	25.8
	26019	27006	502535	19.6	0.0	0.0	0.0	0.0	41.2	0.0	41.2	0.0
		Subtotal	322465	4067526		0.0	0.0	60.5	179.8	511.4	547.3	571.9
1989	20354	23757	173879	8.3	0.0	25.0	0.0	40.2	0.0	8.5	0.0	73.6
	20355	22756	263767	12.6	113.3	0.0	0.0	0.0	13.2	12.8	126.5	12.8
	20357	24225	441178	19.2	0.0	0.0	0.0	0.0	0.0	19.5	0.0	19.5
	20358	24984	448803	19.0	0.0	0.0	0.0	0.0	39.8	0.0	39.8	0.0

(continued)

Table 13 (cont.). Estimates of total escapement of hatchery-reared chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code 1994 (Method A). The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 11) to account for unclipped hatchery releases and, hence, derive hatchery contributions to escapement.
 Expansion factor = (adipose clipped + unclipped releases)/adipose-clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion Factor	Expanded hatchery contributions (a,b)							
		Clipped	Unclipped		Campbell River		Quinsam River		Quinsam Hatchery		Total	
					M	F	M	F	M	F	M	F
	20359	25073	299432	12.9	0.0	0.0	0.0	62.6	0.0	26.3	0.0	88.9
	20360	24973	291498	12.7	0.0	0.0	46.5	0.0	39.9	12.9	86.4	12.9
	26062	24954	194589	8.8	0.0	0.0	0.0	21.3	0.0	0.0	0.0	21.3
	26063	25105	196137	8.8	0.0	0.0	0.0	0.0	0.0	35.8	0.0	35.8
	26101	25082	417458	17.6	0.0	52.9	32.3	0.0	18.5	17.9	50.9	70.9
	26102	25014	190712	8.6	0.0	0.0	0.0	20.8	0.0	8.8	0.0	29.6
	Subtotal	245924	2917452		113.3	77.9	78.8	144.9	111.5	142.5	303.6	365.2
1988	25527	24627	243628	10.9	0.0	0.0	0.0	0.0	0.0	11.1	0.0	11.1
	25817	25029	268880	11.7	0.0	0.0	0.0	0.0	0.0	11.9	0.0	11.9
	25819	25037	270958	11.8	0.0	0.0	0.0	28.6	0.0	0.0	0.0	28.6
	25820	25162	406284	17.1	0.0	0.0	0.0	0.0	0.0	17.4	0.0	17.4
	Subtotal	99855	1189750		0.0	0.0	0.0	28.6	0.0	40.4	0.0	69.0
	Total hatchery				113.3	77.9	139.3	353.2	865.9	742.2	1118.5	1173.3
<u>Strays (d)</u>												
1990	180311	32318	268055	9.3	0.0	27.9	0.0	0.0	0.0	9.4	0.0	37.3

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(a) Abbreviations are M = male, F = female
 (b) Does not include jacks
 (c) From Table 12
 (d) Adipose-clipped fish that have strayed from other systems

Table 14. Estimated hatchery contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1994.
Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 13).

Location	Age	Estimated escapement (a)		Hatchery contribution (b)				Stray contribution (b)			
				Male (c)		Female		Male (c)		Female	
				Number	%	Number	%	Number	%	Number	%
<u>Campbell River</u>											
	3	9	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	185	86	0	0.0	0	0.0	0	0.0	28	32.6
	5	55	106	113	100(e)	78	73.6	0	0.0	0	0.0
	6	0	35	0	0.0	0	0.0	0	0.0	0	0.0
	Total	249	227	113	45.4	78	34.4	0	0.0	28	12.3
<u>Quinsam River</u>											
	3	68	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	136	199	61	44.9	180	90.5	0	0.0	0	0.0
	5	73	115	79	100(e)	145	100(e)	0	0.0	0	0.0
	6	5	31	0	0.0	29	93.5	0	0.0	0	0.0
	Total	282	345	140	49.6	354	100(e)	0	0.0	0	0.0
<u>Quinsam Hatchery (d)</u>											
	3	271	31	243	89.7	12	38.7	0	0.0	0	0.0
	4	700	551	511	73.0	547	99.3	0	0.0	9	1.6
	5	102	192	112	100(e)	143	74.5	0	0.0	0	0.0
	6	0	31	0	0.0	40	100(e)	0	0.0	0	0.0
	Total	1073	805	866	80.7	742	92.2	0	0.0	9	1.1

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- (a) From Table 9; rounding errors cause apparent discrepancies between numbers at age and totals
(b) From Table 13
(c) Does not include jacks
(d) Population estimate includes chinook enumerated above the fence on the Quinsam River
(e) Estimated hatchery contribution greater than 100%

Table 15. Estimates of the adjusted number of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994. One decimal place is carried for the adjusted CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1991	21328	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.0	1.0	2	1	2.0	1.0
	21329	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	21331	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	180416	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	180417	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.1	0.0	4	0	4.1	0.0
	180420	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	180421	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	180422	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.1	0.0	3	0	3.1	0.0
	Subtotal	0	0	0.0	0.0	0	0	0.0	0.0	16	1	16.3	1.0	16	1	16.3	1.0
1990	20956	0	0	0.0	0.0	2	0	2.0	0.0	6	5	6.1	5.0	8	5	8.1	5.0
	20957	0	0	0.0	0.0	1	0	1.0	0.0	6	6	6.1	6.0	7	6	7.1	6.0
	20958	0	0	0.0	0.0	0	0	0.0	0.0	3	9	3.1	9.0	3	9	3.1	9.0
	20959	0	0	0.0	0.0	0	1	0.0	1.1	2	4	2.0	4.0	2	5	2.0	5.1
	21448	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	21449	0	0	0.0	0.0	0	0	0.0	0.0	2	3	2.0	3.0	2	3	2.0	3.0
	21450	0	0	0.0	0.0	0	0	0.0	0.0	1	5	1.0	5.0	1	5	1.0	5.0
	21451	0	0	0.0	0.0	0	1	0.0	1.1	9	5	9.2	5.0	9	6	9.2	6.1
	26016	0	0	0.0	0.0	0	2	0.0	2.2	1	3	1.0	3.0	1	5	1.0	5.2
	26017	0	0	0.0	0.0	0	0	0.0	0.0	3	3	3.1	3.0	3	3	3.1	3.0
	26018	0	0	0.0	0.0	0	1	0.0	1.1	0	1	0.0	1.0	0	2	0.0	2.1
	26019	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	Subtotal	0	0	0.0	0.0	3	5	3.0	5.4	37	44	37.6	44.0	40	49	40.6	49.4
1989	20354	0	1	0.0	1.3	0	2	0.0	2.2	0	1	0.0	1.0	0	4	0.0	4.4
	20355	1	0	2.0	0.0	0	0	0.0	0.0	1	1	1.0	1.0	2	1	3.0	1.0
	20357	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	20358	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	20359	0	0	0.0	0.0	0	2	0.0	2.2	0	2	0.0	2.0	0	4	0.0	4.2
	20360	0	0	0.0	0.0	2	0	2.0	0.0	3	1	3.1	1.0	5	1	5.1	1.0

(continued)

Table 15 (cont). Estimates of the adjusted number of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994. One decimal place is carried for the adjusted CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	26062	0	0	0.0	0.0	0	1	0.0	1.1	0	0	0.0	0.0	0	1	0.0	1.1
	26063	0	0	0.0	0.0	0	0	0.0	0.0	0	4	0.0	4.0	0	4	0.0	4.0
	26101	0	1	0.0	1.3	1	0	1.0	0.0	1	1	1.0	1.0	2	2	2.0	2.3
	26102	0	0	0.0	0.0	0	1	0.0	1.1	0	1	0.0	1.0	0	2	0.0	2.1
	Subtotal	1	2	2.0	2.5	3	6	3.0	6.5	7	12	7.1	12.0	11	20	12.1	21.0
1988	25527	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	25817	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	25819	0	0	0.0	0.0	0	1	0.0	1.1	0	0	0.0	0.0	0	1	0.0	1.1
	25820	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	Subtotal	0	0	0.0	0.0	0	1	0.0	1.1	0	3	0.0	3.0	0	4	0.0	4.1
	Total hatchery	1	2	2.0	2.5	6	12	6.0	12.9	60	60	44.7	59.0	67	74	52.7	74.4
<u>Strays: (c)</u>																	
1990	180311	0	1	0.0	1.3	0	0	0.0	0.0	0	1	0.0	1.0	0	2	0.0	2.3
	Total strays	0	1	0.0	1.3	0	0	0.0	0.0	0	1	0.0	0.0	0	2	0.0	1.3
	Total CWT	1	3	2.0	3.8	6	12	6.0	12.9	60	61	44.7	59.0	67	76	52.7	75.7
	No data (5000)	2	1			0	1			0	0			2	2		
	No pin (8000)	1	1			1	1			2	1			4	3		
	Lost pin (9000)	0	0			0	0			1	0			1	0		
	Observed adipose	4	5			7	14			63	62			74	81		

(a) Abbreviations are M = male, F = female

(b) Does not include jacks

(c) Fish with CWT that have strayed from other systems

Table 16. Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1991	21328	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0
	21329	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
	21331	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
	180416	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
	180417	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	4.1	0.0	4.1	0.0	4.1	0.0
	180420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
	180421	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
	180422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	0.0	3.1	0.0	3.1	0.0	3.1	0.0
	Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	1.0	16.3	1.0	16.3	1.0	16.3	1.0
1990	20956	0.0	0.0	0.0	0.0	2.0	0.0	3.0	0.0	6.1	5.0	6.1	5.0	8.1	5.0	9.1	5.0
	20957	0.0	0.0	0.0	0.0	1.0	0.0	1.5	0.0	6.1	6.0	6.1	6.0	7.1	6.0	7.6	6.0
	20958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	9.0	3.1	9.0	3.1	9.0	3.1	9.0
	20959	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	2.0	4.0	2.0	4.0	2.0	5.1	2.0	6.1
	21448	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
	21449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0
	21450	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	1.0	5.0	1.0	5.0	1.0	5.0
	21451	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	9.2	5.0	9.2	5.0	9.2	6.1	9.2	7.1
	26016	0.0	0.0	0.0	0.0	0.0	2.2	0.0	4.2	1.0	3.0	1.0	3.0	1.0	5.2	1.0	7.2
	26017	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.0	3.1	3.0	3.1	3.0	3.1	3.0
	26018	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	1.0	0.0	1.0	0.0	2.1	0.0	3.1
	26019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0
	Subtotal	0.0	0.0	0.0	0.0	3.0	5.4	4.5	10.4	37.6	44.0	37.6	44.0	40.6	49.4	42.1	54.4
1989	20354	0.0	1.3	0.0	2.6	0.0	2.2	0.0	4.2	0.0	1.0	0.0	1.0	0.0	4.4	0.0	7.7
	20355	2.0	0.0	4.9	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	3.0	1.0	5.9	1.0
	20357	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
	20358	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0

(continued)

Table 16 (cont.). Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

Brood year	CWT code	Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	20359	0.0	0.0	0.0	0.0	0.0	2.2	0.0	4.2	0.0	2.0	0.0	2.0	0.0	4.2	0.0	6.2
	20360	0.0	0.0	0.0	0.0	2.0	0.0	3.0	0.0	3.1	1.0	3.1	1.0	5.1	1.0	6.0	1.0
	26062	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1
	26063	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.0	0.0	4.0	0.0	4.0
	26101	0.0	1.3	0.0	2.6	1.0	0.0	1.5	0.0	1.0	1.0	1.0	1.0	2.0	2.3	2.5	3.6
	26102	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	1.0	0.0	1.0	0.0	2.1	0.0	3.1
	Subtotal	2.0	2.5	4.9	5.2	3.0	6.5	4.5	12.5	7.1	12.0	7.1	12.0	12.1	21.0	16.5	29.6
1988	25527	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
	25817	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
	25819	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1
	25820	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
	Subtotal	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.1	0.0	3.0	0.0	3.0	0.0	4.1	0.0	5.1
	Total hatchery	2.0	2.5	4.9	5.2	6.0	12.9	9.0	24.9	61.0	60.0	61.0	60.0	69.0	75.4	74.9	90.1
<u>Strays: (c)</u>																	
<u>1989</u>	20949	0.0	1.3	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	2.3	0.0	3.6
	Total strays	0.0	1.3	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	2.3	0.0	3.6
Petersen est. (d)		249	227					283	345					1073	805		
Sample size (d)		102	110					189	179					1073	805		

(a) Abbreviations are M = male, F = female
 (b) Does not include jacks
 (c) CWT chinook that have strayed from other systems
 (d) From Table 10

Table 17. Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994 (Method B). The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 16) to account for unmarked hatchery releases and, hence, derive hatchery contributions to escapement.
Expansion factor = (CWT releases + untagged releases)/CWT releases.

Brood year	CWT release group	Release Numbers (c)		Expansion factor	Expanded hatchery contributions (a,b)							
		CWT	Untagged (d)		Campbell River		Quinsam River		Quinsam Hatchery		Total	
					M	F	M	F	M	F	M	F
1991	21328	24770	291356	12.8	0.0	0.0	0.0	0.0	26.0	12.8	26.0	12.8
	21329	24661	598989	25.3	0.0	0.0	0.0	0.0	51.4	0.0	51.4	0.0
	21331	24593	526740	22.4	0.0	0.0	0.0	0.0	45.6	0.0	45.6	0.0
	180416	23951	303114	13.7	0.0	0.0	0.0	0.0	13.9	0.0	13.9	0.0
	180417	24967	317856	13.7	0.0	0.0	0.0	0.0	55.8	0.0	55.8	0.0
	180420	24952	435566	18.5	0.0	0.0	0.0	0.0	18.8	0.0	18.8	0.0
	180421	23760	196364	9.3	0.0	0.0	0.0	0.0	9.4	0.0	9.4	0.0
	180422	24936	226054	10.1	0.0	0.0	0.0	0.0	30.7	0.0	30.7	0.0
	Subtotal	196590	2896039		0.0	0.0	0.0	0.0	251.6	12.8	251.6	12.8
1990	20956	26953	189154	8.0	0.0	0.0	24.0	0.0	48.9	40.1	72.9	40.1
	20957	26752	430178	17.1	0.0	0.0	25.6	0.0	104.2	102.5	129.8	102.5
	20958	26658	205795	8.7	0.0	0.0	0.0	0.0	26.6	78.5	26.6	78.5
	20959	25870	203520	8.9	0.0	0.0	0.0	18.4	18.0	35.5	18.0	53.9
	21448	26509	496950	19.7	0.0	0.0	0.0	0.0	40.2	0.0	40.2	0.0
	21449	26602	332627	13.5	0.0	0.0	0.0	0.0	27.5	40.5	27.5	40.5
	21450	26384	331055	13.5	0.0	0.0	0.0	0.0	13.8	67.7	13.8	67.7
	21451	26502	320497	13.1	0.0	0.0	0.0	27.2	119.8	65.5	119.8	92.6
	26016	27211	588892	22.6	0.0	0.0	0.0	94.0	23.0	67.9	23.0	161.9
	26017	25911	284261	12.0	0.0	0.0	0.0	0.0	36.5	35.9	36.5	35.9
	26018	28265	183904	7.5	0.0	0.0	0.0	15.6	0.0	7.5	0.0	23.1
	26019	26817	502724	19.7	0.0	0.0	0.0	0.0	40.2	0.0	40.2	0.0
		Subtotal	320434	4069557		0.0	0.0	49.6	155.2	498.6	541.6	548.2
1989	20354	23306	174330	8.5	0.0	21.9	0.0	35.2	0.0	8.5	0.0	65.6
	20355	22574	263949	12.7	62.0	0.0	0.0	0.0	12.9	12.7	74.9	12.7
	20357	23886	441517	19.5	0.0	0.0	0.0	0.0	0.0	19.5	0.0	19.5

(continued)

Table 17 (cont.). Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1994 (Method B). The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 16) to account for unmarked hatchery releases and, hence, derive hatchery contributions to escapement. Expansion factor = (CWT releases + untagged releases)/CWT releases.

Brood year	CWT release group	Release Numbers (c)		Expansion factor	Expanded hatchery contributions (a,b)							
		CWT	Untagged (d)		Campbell River		Quinsam River		Quinsam Hatchery		Total	
					M	F	M	F	M	F	M	F
	20358	24634	449153	19.2	0.0	0.0	0.0	0.0	39.1	0.0	39.1	0.0
	20359	24396	300109	13.3	0.0	0.0	0.0	55.2	0.0	26.6	0.0	81.8
	20360	24499	291972	12.9	0.0	0.0	38.7	0.0	39.4	12.9	78.1	12.9
	26062	24929	291542	12.7	0.0	0.0	0.0	26.3	0.0	0.0	0.0	26.3
	26063	24904	291567	12.7	0.0	0.0	0.0	0.0	0.0	50.8	0.0	50.8
	26101	25007	291464	12.7	0.0	32.6	18.9	0.0	12.9	12.7	31.8	45.3
	26102	24739	291732	12.8	0.0	0.0	0.0	26.6	0.0	12.8	0.0	39.3
	Subtotal	143295	1921030		62.0	54.5	57.6	143.3	104.3	156.5	223.9	354.3
1988	25527	23937	244318	11.2	0.0	0.0	0.0	0.0	0.0	11.2	0.0	11.2
	25817	25029	268880	11.7	0.0	0.0	0.0	0.0	0.0	11.7	0.0	11.7
	25819	25037	270958	11.8	0.0	0.0	0.0	24.5	0.0	0.0	0.0	24.5
	25820	24810	406636	17.4	0.0	0.0	0.0	0.0	0.0	17.4	0.0	17.4
	Subtotal	98813	1190792		0.0	0.0	0.0	24.5	0.0	40.3	0.0	64.9
	Total hatchery				62.0	54.5	107.2	323.0	854.4	751.1	1023.6	1128.7
<u>Strays: (e)</u>												
1990	180311	29183	271190	10.3	0.0	26.6	0.0	0.0	0.0	10.3	0.0	36.8
	Total strays				0.0	26.6	0.0	0.0	0.0	10.3	0.0	36.8

(a) Abbreviations are M = male, F = female

(b) Does not include jacks

(c) From Table 12

(d) Untagged = AD only (ie. tag lost) + unmarked (ie. no CWT/AFC applied)

(e) CWT chinook that have strayed from other systems

Table 18. Estimated hatchery and stray contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1994. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 17).

Location	Age	Estimated escapement (a)		Hatchery contribution (b)				Stray contribution (b)			
				Male (c)		Female		Male (c)		Female	
				Number	%	Number	%	Number	%	Number	%
<u>Campbell River</u>											
	3	9	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	185	86	0	0.0	0	0.0	0	0.0	24	27.9
	5	55	106	62	100 (d)	55	51.9	0	0.0	0	0.0
	6	0	35	0	0.0	0	0.0	0	0.0	0	0.0
	Total	249	227	62	24.9	55	24.2	0	0.0	24	10.6
<u>Quinsam River</u>											
	3	68	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	136	199	50	36.8	155	77.9	0	0.0	0	0.0
	5	73	115	57	78.1	143	100 (d)	0	0.0	0	0.0
	6	5	31	0	0.0	25	80.6	0	0.0	0	0.0
	Total	282	345	107	37.9	323	93.6	0	0.0	0	0.0
<u>Quinsam Hatchery</u>											
	3	271	31	252	93.0	13	41.9	0	0.0	0	0.0
	4	700	551	498	71.1	541	98.2	0	0.0	10	1.8
	5	102	192	104	100 (d)	157	81.8	0	0.0	0	0.0
	6	0	31	0	0.0	40	100 (d)	0	0.0	0	0.0
	Total	1073	805	854	79.6	751	93.3	0	0.0	10	1.2

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(a) From Table 9

(b) From Table 17

(c) Does not include jacks

(d) Estimated hatchery contribution greater than 100%

APPENDICES

Appendix 1. Operculum tagging of chinook salmon carcasses in Campbell River, 1994.

Date	Capture area	Tagged			Total
		Male	Female	Jack	
18-Oct	1A	1	1	0	2
18-Oct	1B	0	0	0	0
21-Oct	1A	2	2	0	4
21-Oct	1B	1	0	0	1
24-Oct	1A	0	1	0	1
24-Oct	1B	0	0	0	0
25-Oct	1A	1	3	0	4
25-Oct	1B	2	3	0	5
26-Oct	1A	2	1	0	3
26-Oct	1B	0	2	0	2
28-Oct	1A	0	0	0	0
28-Oct	1B	0	2	0	2
1-Nov	1A	3	7	0	10
1-Nov	1B	3	8	0	11
3-Nov	1A	0	1	0	1
3-Nov	1B	1	1	0	2
4-Nov	1A	0	0	0	0
4-Nov	1B	3	3	0	6
8-Nov	1A	8	9	0	17
8-Nov	1B	6	6	0	12
10-Nov	1A	1	0	0	1
10-Nov	1B	3	0	0	3
11-Nov	1A	3	0	0	3
11-Nov	1B	7	2	1	10
15-Nov	1A	5	6	0	11
15-Nov	1B	2	1	0	3
17-Nov	1A	1	1	0	2
17-Nov	1B	0	1	0	1
Total		55	61	1	117

Appendix 2. Operculum tagging of chinook salmon carcasses in Quinsam River, 1994.

Date	Capture area	Tagged			Total
		Male	Female	Jack	
19-Oct	2B	0	0	0	0
19-Oct	2C	0	0	0	0
19-Oct	2D	0	1	0	1
24-Oct	2B	0	0	0	0
24-Oct	2C	0	0	0	0
24-Oct	2D	1	1	0	2
27-Oct	2B	1	0	0	1
27-Oct	2C	1	2	0	3
27-Oct	2D	0	0	0	0
28-Oct	2B	0	0	0	0
28-Oct	2C	0	0	0	0
28-Oct	2D	0	1	0	1
31-Oct	2B	0	0	0	0
31-Oct	2C	0	2	0	2
31-Oct	2D	3	1	0	4
2-Nov	2B	0	0	0	0
2-Nov	2C	2	2	0	4
2-Nov	2D	3	4	0	7
7-Nov	2B	13	8	2	23
7-Nov	2C	8	17	0	25
7-Nov	2D	0	1	0	1
8-Nov	2B	0	0	0	0
8-Nov	2C	5	7	0	12
8-Nov	2D	8	9	0	17
9-Nov	2B	0	0	0	0
9-Nov	2C	2	2	0	4
9-Nov	2D	1	2	1	4
14-Nov	2B	2	1	0	3
14-Nov	2C	8	5	0	13
14-Nov	2D	12	10	0	22
16-Nov	2B	0	1	0	1
16-Nov	2C	0	5	1	6
16-Nov	2D	6	3	0	9

(continued)

Appendix 2 (cont.). Operculum tagging of chinook salmon carcasses in Quinsam River, 1994.

Date	Capture area	Tagged			Total
		Male	Female	Jack	
18-Nov	2B	1	0	0	1
18-Nov	2C	2	2	0	4
18-Nov	2D	2	1	0	3
21-Nov	2B	0	2	0	2
21-Nov	2C	3	0	0	3
21-Nov	2D	1	1	0	2
23-Nov	2B	1	2	0	3
23-Nov	2C	1	1	0	2
23-Nov	2D	0	2	0	2
25-Nov	2B	0	0	0	0
25-Nov	2C	1	1	0	2
25-Nov	2D	2	0	0	2
28-Nov	2B	3	0	0	3
28-Nov	2C	1	1	0	2
28-Nov	2D	0	1	0	1
1-Dec	2B	0	0	0	0
1-Dec	2C	0	0	0	0
1-Dec	2D	1	0	0	1
Total		95	99	4	198

Appendix 3. Dead recovery of tagged chinook salmon carcasses in Campbell River, 1994.

Date	Recovery area	Recovered (a)			
		Male	Female	Jack	Total
21-Oct	1A	0	1	0	1
21-Oct	1B	0	0	0	0
26-Oct	1A	0	1	0	1
26-Oct	1B	0	4	0	4
1-Nov	1A	1	1	0	2
1-Nov	1B	0	1	0	1
3-Nov	1A	0	1	0	1
3-Nov	1B	0	0	0	0
4-Nov	1A	0	1	0	1
4-Nov	1B	1	0	0	1
8-Nov	1A	0	2	0	2
8-Nov	1B	0	1	0	1
10-Nov	1A	0	0	0	0
10-Nov	1B	0	4	0	4
11-Nov	1A	5(1)	3	0	8(1)
11-Nov	1B	0	2(1)	0	2(1)
15-Nov	1A	4	2	0	6
15-Nov	1B	9(1)	4(2)	0	13(3)
17-Nov	1A	2	4	0	6
17-Nov	1B	1	0	0	1
22-Nov	1A	0	0	0	0
22-Nov	1B	1	0	0	1
Total		24(2)	32(3)	0	56(5)

(a) Numbers in parentheses indicate numbers of tagged stray recoveries from Campbell River

Appendix 4. Dead recovery of tagged chinook salmon carcasses in Quinsam River, 1994.

Date	Capture area	Tagged			Total
		Male	Female	Jack	
28-Oct	2B	0	0	0	0
28-Oct	2C	0	0	0	0
28-Oct	2D	1	0	0	1
2-Nov	2B	0	0	0	0
2-Nov	2C	0	1	0	1
2-Nov	2D	2	0	0	2
7-Nov	2B	0	0	0	0
7-Nov	2C	0	0	0	0
7-Nov	2D	1	1	0	2
8-Nov	2B	0	0	0	0
8-Nov	2C	1	2	0	3
8-Nov	2D	1	1	0	2
9-Nov	2B	0	0	0	0
9-Nov	2C	2	4	0	6
9-Nov	2D	2	4	0	6
14-Nov	2B	1	2	0	3
14-Nov	2C	4	2	0	6
14-Nov	2D	6	7	0	13
16-Nov	2B	2	0	0	2
16-Nov	2C	3	2	0	5
16-Nov	2D	15	7	0	22
18-Nov	2B	0	0	0	0
18-Nov	2C	2	4	0	6
18-Nov	2D	2	4	0	6
21-Nov	2B	1	0	0	1
21-Nov	2C	0	0	0	0
21-Nov	2D	3	2	0	5
23-Nov	2B	1	0	0	1
23-Nov	2C	3	0	0	3
23-Nov	2D	2	0	0	2
25-Nov	2B	0	2	0	2
25-Nov	2C	1	0	0	1
25-Nov	2D	1	0	0	1

(continued)

Appendix 4 (cont.). Dead recovery of tagged chinook salmon carcasses in Quinsam River, 1994.

Date	Capture area	Tagged			Total
		Male	Female	Jack	
28-Nov	2B	0	0	0	0
28-Nov	2C	0	2	0	2
28-Nov	2D	0	0	0	0
1-Dec	2B	1	0	0	1
1-Dec	2C	1	0	0	1
1-Dec	2D	0	1	0	1
5-Dec	2B	0	0	0	0
5-Dec	2C	0	0	0	0
5-Dec	2D	1	0	0	1
Total		60	48	0	108

Appendix 5. Sequential mark-recapture data for chinook salmon carcasses in Campbell River, 1994. Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).

Date	Male (b)			Female (b)			Jack			Total (b)		
	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered
18-Oct	1	1	0	1	1	0	0	0	0	2	2	0
21-Oct	3	3	0	3	2	1	0	0	0	6	5	1
24-Oct	1	0	0	1	1	0	0	0	0	2	1	0
25-Oct	4	3	0	7	6	0	0	0	0	11	9	0
26-Oct	3	2	0	8	3	5	0	0	0	11	5	5
28-Oct	2	0	0	3	2	0	0	0	0	5	2	0
1-Nov	11	6	1	18	15	2	0	0	0	29	21	3
3-Nov	2	1	0	4	2	1	0	0	0	6	3	1
4-Nov	4	3	1	5	3	1	0	0	0	9	6	2
8-Nov	20	14	0	22	15	3	0	0	0	42	29	3
10-Nov	4	4	0	7	0	4	0	0	0	11	4	4
11-Nov	17(1)	10	5(1)	10(1)	2	5(1)	1	1	0	28(2)	13	10(2)
15-Nov	25(1)	7	13(1)	14(2)	7	6(2)	0	0	0	39(3)	14	19(3)
17-Nov	4	1	3	7	2	4	0	0	0	11	3	7
22-Nov	1	0	1	0	0	0	0	0	0	1	0	1
Total	102(2)	55	24(2)	110(3)	61	32(3)	1	1	0	213(5)	117	56(5)
Total for MR(a)	102(2)	55	24(2)	109(3)	61	32(3)	1	1	0	209(3)	115	56(5)

(a) To be used in the Petersen population estimation procedure for the carcass tagging and recovery method. Number of tags examined on the first day of tagging are not included

(b) The numbers in parentheses indicate the contribution of tagged strays from the Quinsam River to the total number of fish examined or tags recovered

Appendix 6. Sequential mark-recapture data for chinook salmon carcasses in Quinsam River, 1994. Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).

Date	Male			Female			Jack			Total		
	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered
19-Oct	0	0	0	1	1	0	0	0	0	1	1	0
24-Oct	2	1	0	2	1	0	0	0	0	4	2	0
27-Oct	3	2	0	4	2	0	0	0	0	7	4	0
28-Oct	1	0	1	1	1	0	0	0	0	2	1	1
31-Oct	3	3	0	3	3	0	0	0	0	6	6	0
2-Nov	9	5	2	9	6	1	0	0	0	18	11	3
7-Nov	27	21	1	30	26	1	3	2	0	60	49	2
8-Nov	18	13	2	26	16	3	0	0	0	44	29	5
9-Nov	11	3	4	15	4	8	1	1	0	27	8	12
14-Nov	42	22	11	37	16	11	0	0	0	79	38	22
16-Nov	30	6	20	19	9	9	1	1	0	50	16	29
18-Nov	9	5	4	11	3	8	0	0	0	20	8	12
21-Nov	8	4	4	6	3	2	0	0	0	14	7	6
23-Nov	11	2	6	6	5	0	0	0	0	17	7	6
25-Nov	5	3	2	3	1	2	0	0	0	8	4	4
28-Nov	6	4	0	4	2	2	0	0	0	10	6	2
1-Dec	3	1	2	1	0	1	0	0	0	4	1	3
5-Dec	1	0	1	2	0	0	0	0	0	3	0	1
Total	189	95	60	180	99	48	5	4	0	374	198	108
Total for MR(a)	189	95	60	179	99	48	5	4	0	373	197	108

(a) To be used in the Petersen population estimation procedure for the carcass tagging and recovery method. Number of tags examined on the first day of tagging are not included

Appendix 7. Total dead recovery and adipose clip recovery of chinook salmon in Campbell River, 1994 (a).

Date	Area 1A								Area 1B								
	Total examined (b,c)				Adipose clipped recoveries				Total examined (b,c)				Adipose clipped recoveries				
	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	
18-Oct	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
21-Oct	2	3	0	5	0	0	0	0	1	0	0	1	0	0	0	0	0
24-Oct	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Oct	1	4	0	5	0	1	0	0	3	3	0	6	0	0	0	0	0
26-Oct	3	2	0	5	1	0	0	0	0	6	0	6	0	0	0	0	0
28-Oct	0	0	0	0	0	0	0	0	2	3	0	5	0	0	0	0	0
1-Nov	6	8	0	14	0	0	0	0	5	10	0	15	2	1	0	0	0
3-Nov	0	2	0	2	0	0	0	0	2	2	0	4	0	0	0	0	0
4-Nov	0	1	0	0	0	0	0	0	4	4	0	8	0	0	0	0	0
8-Nov	12	13	0	25	1	0	0	0	8	9	0	17	0	2	0	0	0
10-Nov	1	0	0	1	0	0	0	0	3	7	0	10	0	0	0	0	0
11-Nov	10(1)	3	0	13(1)	0	0	0	0	7	7(1)	1	15(1)	0	1	0	0	0
15-Nov	11	8	0	19	0	0	0	0	14(1)	6(2)	0	20(3)	0	0	0	0	0
17-Nov	3	5	0	8	0	0	0	0	1	2	0	3	0	0	0	0	0
22-Nov	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Total	51(1)	51	0	101(1)	2	1	0	0	51(1)	59(3)	1	10(4)	2	4	0	0	0

(a) See Figure 1 for location of recovery areas

(b) Abbreviations are M = male, F = female, J = jack, T = total

(c) Numbers in parentheses indicates the contribution of tagged strays to total recoveries

Appendix 8. Total dead recovery and adipose clip recovery of chinook salmon in Quinsam River, 1994 (a).

Date	Area 2B								Area 2C								Area 2D							
	Total recovered (b)				Adipose clipped recoveries				Total recovered (b)				Adipose clipped recoveries				Total recovered (b)				Adipose clipped recoveries			
	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
19-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	
24-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	4	0	0	0	0
27-Oct	1	0	0	1	0	0	0	0	1	3	0	4	0	1	0	1	1	1	0	2	1	1	0	2
28-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0
31-Oct	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	3	1	0	4	0	0	0	0
2-Nov	1	1	0	2	0	0	0	0	2	3	0	5	0	0	0	0	6	5	0	11	0	1	0	1
7-Nov	16	8	3	27	0	0	1	1	9	20	0	29	1	2	0	3	2	2	0	4	0	0	0	0
8-Nov	0	0	0	0	0	0	0	0	8	10	0	18	2	0	0	2	10	16	0	26	0	5	0	5
9-Nov	0	0	0	0	0	0	0	0	6	7	0	13	0	0	0	0	9	8	1	18	0	0	0	0
14-Nov	7	7	0	14	0	2	0	2	15	10	0	25	0	2	0	2	20	20	0	40	0	0	0	0
16-Nov	2	2	0	4	0	0	0	0	4	7	1	12	0	0	0	0	24	10	0	34	2	0	0	2
18-Nov	1	0	0	1	0	0	0	0	4	6	0	10	0	0	0	0	4	5	0	9	0	0	0	0
21-Nov	1	3	0	4	0	0	0	0	3	0	0	3	0	0	0	0	4	3	0	7	0	0	0	0
23-Nov	3	2	0	5	0	0	0	0	4	2	0	6	0	0	0	0	4	2	0	6	0	0	0	0
25-Nov	0	2	0	2	0	0	0	0	2	1	0	3	0	0	0	0	3	0	0	3	0	0	0	0
28-Nov	4	0	0	4	0	0	0	0	1	3	0	4	0	0	0	0	1	1	0	2	1	0	0	1
1-Dec	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0
5-Dec	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	1	0	0	1	0	0	0	0
Total	37	25	3	65	0	2	1	3	59	76	1	136	3	5	0	8	96	79	1	176	4	7	0	11

(a) See Figure 1 for location of recovery areas

(b) Abbreviations are M = male, F = female, J = jack, T = total

