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ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF CAMPBELL AND QUINSAM RIVERS, 1995

by

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TABLE OF CONTENTS

TABLE OF CONTENTS - Cont'd

LIST OF TABLES

LIST OF TABLES - Cont'd

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Frith, H. R. and T.C. Nelson. 1997. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2411: ix + 59.

Estimates of escapement were derived for the Campbell/Quinsam River system for 1995 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 2,445 in 1995 and includes hatchery removals (sales, broodstock, mortalities) and chinook passed over the hatchery fence. Chinook were predominantly age-5 for males and females in Campbell River with 53% age-5 for males and 63% age-5 for females. In the Quinsam River and at the hatchery, males were mostly age-4. Females were mostly age-5 in the Quinsam River and although females were mostly age-4 at the hatchery, the proportion that were age-5 was greater than for males. Males were 65% age-4 in Quinsam River and 66% age-4 at the hatchery, whereas females were 52% age-5 in Quinsam River and 50% age-5 and 46% age-4 at the hatchery. Females were more abundant than males at all river locations. Chinook were largest in the Campbell River and smallest at the Quinsam Hatchery. The average length of females was larger than males at all river locations.

Estimated escapement of adipose-clipped chinook to the entire system was 157 in 1995. 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 1995, the hatchery contribution was 75.8% and 80.5% 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 1995 hatchery contribution was 67.6% for males and 64.5% 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. 1997. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1995, Can. Manuscr. Rep. Fish. Aquat. Sci. 2411: ix + 59.

On a établi pour 1995 des estimations des échappées dans le système Campbell/Quinsam reposant sur le marquage des carcasses, dans le cadre du programme des cours d'eau clés pour le quinnat. L'estimation par la méthode Petersen des échappées de quinnats était de 2445 pour 1995 et incluait les prélèvements à l'écloserie (vente, cheptel reproducteur, mortalités) et les quinnats qui avaient franchi la clôture de l'écloserie. Dans la Campbell, les quinnats mâles et femelles étaient majoritairement d'âge 5 (53 % pour les mâles et 65 % pour les femelles). Dans la Quinsam et à l'écloserie, les mâles étaient surtout d'âge 4; les femelles de la Quinsam étaient surtout d'âge 5 et, même si celles de l'écloserie étaient majoritairement d'âge 4, la proportion de spécimens d'âge 5 était plus élevée chez elles que chez les mâles. Le pourcentage de mâles d'âge 4 était de 65 % dans la Quinsam et de 66 % à l'écloserie; pour ce qui est des femelles, dans la Quinsam, 52 % étaient d'âge 5 et, à l'écloserie, on trouvait 50 % de spécimens d'âge 4 et 46 % d'âge 5. À tous les sites des cours d'eau, les femelles étaient plus abondantes que les mâles. C'est dans la Campbell que les quinnats avaient la plus grande taille et à l'écloserie qu'ils avaient la plus petite. La longueur moyenne des femelles était supérieure à celle des mâles pour tous les sites des cours d'eau.

L'estimation des échappées de quinnats micromarqués était de 157 pour 1995. On a ensuite ventilé cette estimation par âge, par sexe et par code de marque. On a estimé la contribution totale de l'écloserie (individus marqués et non marqués) à l'échappée en appliquant au nombre de marques observées une extension du taux de marquage au lâcher. En 1995, la contribution de l'écloserie aux échappées de quinnats mâles et femelles était respectivement de 75,8 % et de 80,5 %. Ces estimations de la contribution de l'écloserie ont été comparées à celles calculées par la méthode d'extension des micromarques codées du Programme de récupération des marques (Kuhn, 1988). Selon cette dernière méthode, la contribution totale de l'écloserie en 1995 était de 67,6 % pour les mâles et de 64,5 % pour les femelles.

Mots clés: Campbell, Quinsam, quinnat, cours d'eau clés, échappées, micromarques codées, marquage des vifs, marquage des carcasses.

INTRODUCTION

The chinook salmon of the Campbell/Quinsam River system was selected as one of the indicator stocks (key streams) for assessing the status of Pacific chinook salmon. The goal of the Department of Fisheries and Oceans (DFO) management plan for chinook the is to rebuild chinook stocks to historic levels. The 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 to key streams;

2. to estimate harvest rates 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 total 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 ninth 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; Frith 1993; Frith and Nelson 1994; 1995).

As in previous years, the 1995 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 tests for biases caused by violations of assumptions are described in the methods section. The results section presents the carcass tagging and recovery data, population estimates, age, length, and sex composition, and hatchery contribution estimates from coded wire tag and adipose clip recovery data. the results of coded wire tagging studies.

To avoid confusion over the definition of the terms 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 km^2 and for the Quinsam River system is 265 km^2 (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. Spawning channels were constructed in the Lower Channel of the Campbell River in 1995 prior to the spawning season (Figure 1).

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 m^3s^{-1} to 826.0 m^3s^{-1} (mean=96.0 m^3s^{-1}). Flows on the Quinsam River are not controlled and vary from 0.9 m^3s^{-1} to 21.6 m^3s^{-1} (mean=9.0 m^3s^{-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 from logging roads. Access to upper reaches can be more difficult.

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 for broodstock collection is located immediately upstream of the hatchery (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 20 to November 15 by Quinsam Hatchery workers. A summary of methods for this study is presented in Table 1 and is described below.

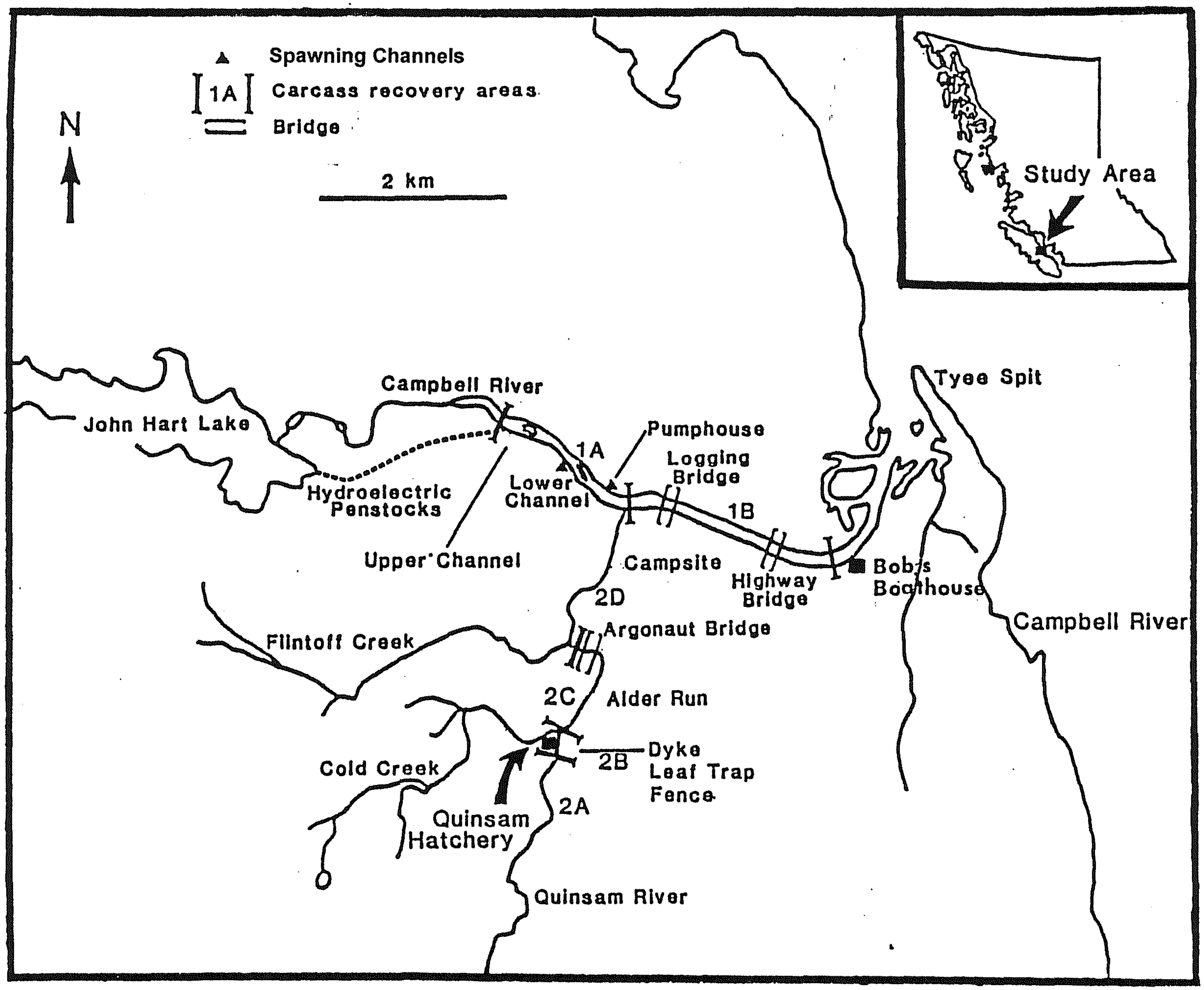

Figure 1. Map of the Campbell and Quinsam rivers study area.

POPULATION ESTIMATION

Chinook salmon were enumerated using the adjusted Petersen method (Ricker 1975, p. 78) by tagging spawned-out chinook carcasses and recovering tagged carcasses on subsequent survey days.

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 1995, 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 1995. 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 22-100% over the study period (Appendix 4 and 5).

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 1995 no strays were reported in the Quinsam or Campbell rivers.

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 1995, tagging continued *in situ* in the rivers every 1 to 6 days during the spawning and die-off period but was terminated on November 15 due to high water. In previous years tagging and recovery continued until the first week of December.

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. Indicators that tagging and recovery were conducted on different populations include 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, the number of recoveries required to achieve a 25% accuracy with 95% confidence for populations (10^2 to 10^9) ranges from 25 to 75 (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. The assumption of mixing can not be tested with the data available 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):

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

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:

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

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 or stray chinook because no marked jacks or strays were recovered.

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 surveyed for recoveries from the Campbell and Quinsam rivers by three methods:

1. recovery crews searched the banks and shallow reaches of the rivers on foot and from a boat;

2. a SCUBA diver searched for carcasses in deep pools of lower reaches of the Campbell and Quinsam rivers;

3. recovery crew snorkel surveyed one of the new spawning channels (Second Island) in the Campbell River.

Chinook were also recovered at the Quinsam Hatchery rack and from a floating fence operated in 2D of the Quinsam River. Due to high water and siltation, few chinook were observed in the water and the majority of carcass tagging and recovery occurred on the banks or the rivers.

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:

$$tag\ rate = R\ /\ C \tag{3}$$

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

$$tag\ recovery\ rate = R\ /\ M \tag{4}$$

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 75% of the carcasses (marked and unmarked fish) recovered in the Campbell River, 68% of the carcasses recovered in the Quinsam River, and 34% 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 1989 - 1993 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:

$$EAD_{i,r} = \frac{OAD_{i,r} \cdot P_{i,r}}{C_{i,r}} \tag{5}$$

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:

$$EAD_{i,r,tc} = \frac{EAD_{i,r} \cdot NDT_{i,r,tc}}{\sum NDT_{i,r}} \tag{6}$$

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 (1991*b*).

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:

$$EHC_{i,r,tc} = \frac{EAD_{i,r,tc} \cdot (RC_{tc} + RUC_{tc})}{RC_{tc}} \tag{7}$$

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:

$$EHC = \sum_{t=1}^{j} \sum_{r=1}^{k} \sum_{i=1}^{m} \sum_{tc=1}^{n} EHC_{t,r,i,tc} \tag{8}$$

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.

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:

$$ADJ_{i,r,tc} = OBS_{i,r,tc} \cdot [1 + \frac{LP}{K} + \frac{ND \cdot (K+LP)}{K \cdot (K+LP+NP)}] \quad (9)$$

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:

$$EST_{i,r,tc} = \frac{ADJ_{i,r,tc} \cdot P_{i,r}}{C_{i,r}} \quad (10)$$

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 (1991*b*).

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:

$$EHC_{i,r,tc} = \frac{EST_{i,r,tc} \cdot (RM_{tc} + RUM_{tc})}{RM_{tc}} \tag{11}$$

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:

$$EHC_{i,r,t} = \sum_{t=1}^{j} \sum_{r=1}^{k} \sum_{i=1}^{m} \sum_{tc=1}^{n} EHC_{t,r,i,tc} \tag{12}$$

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 1995, 97 chinook carcasses were tagged and released (returned to the river) between October 24 to November 10 in the Campbell River, and 231 carcasses were tagged and released from October 20 to November 15 in the Quinsam River (Table 3; Appendices 1 and 2).

RECOVERY

Surveys to recover carcasses in 1995 began on October 31 in the Campbell River and on October 25 in the Quinsam River and continued until November 10 and November 15, 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 1995 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 1995, a total of 139 chinook carcasses were examined in the Campbell River (51 males, 88 females, and zero jacks; Table 3). This number included 45 tag recoveries (14 males, 31 females and zero jacks). In the Quinsam River, a total of 378 chinook carcasses were examined (138 males, 237 females, and three jacks; Table 3). This included 80 tag recoveries (30 males, 50 females, and zero jacks).

The carcass tag recovery rates in the Campbell River (46.4%) and Quinsam River (34.6%) in 1995 were significantly different by 11.8% ($P < 0.05$, χ^2; Zar 1984). The tag rates were similar for males (70.6%) and females (69.3%) in Campbell River and for males (69.6%) and females (56.1%) 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 1995, chinook escapement to the Campbell River and Quinsam River was estimated at 290 and 1055 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 1995, including hatchery rack recoveries, was estimated at 2,445 adults with 95% confidence limits of 2,075 to 3,023 fish.

The proportion of fish amongst sampling location strata was 11.9: 43.1: 46.3 (Campbell:Quinsam:hatchery). These proportions are different from the 15.8: 20.9: 63.3 observed in 1994 and are more similar 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 estimated in

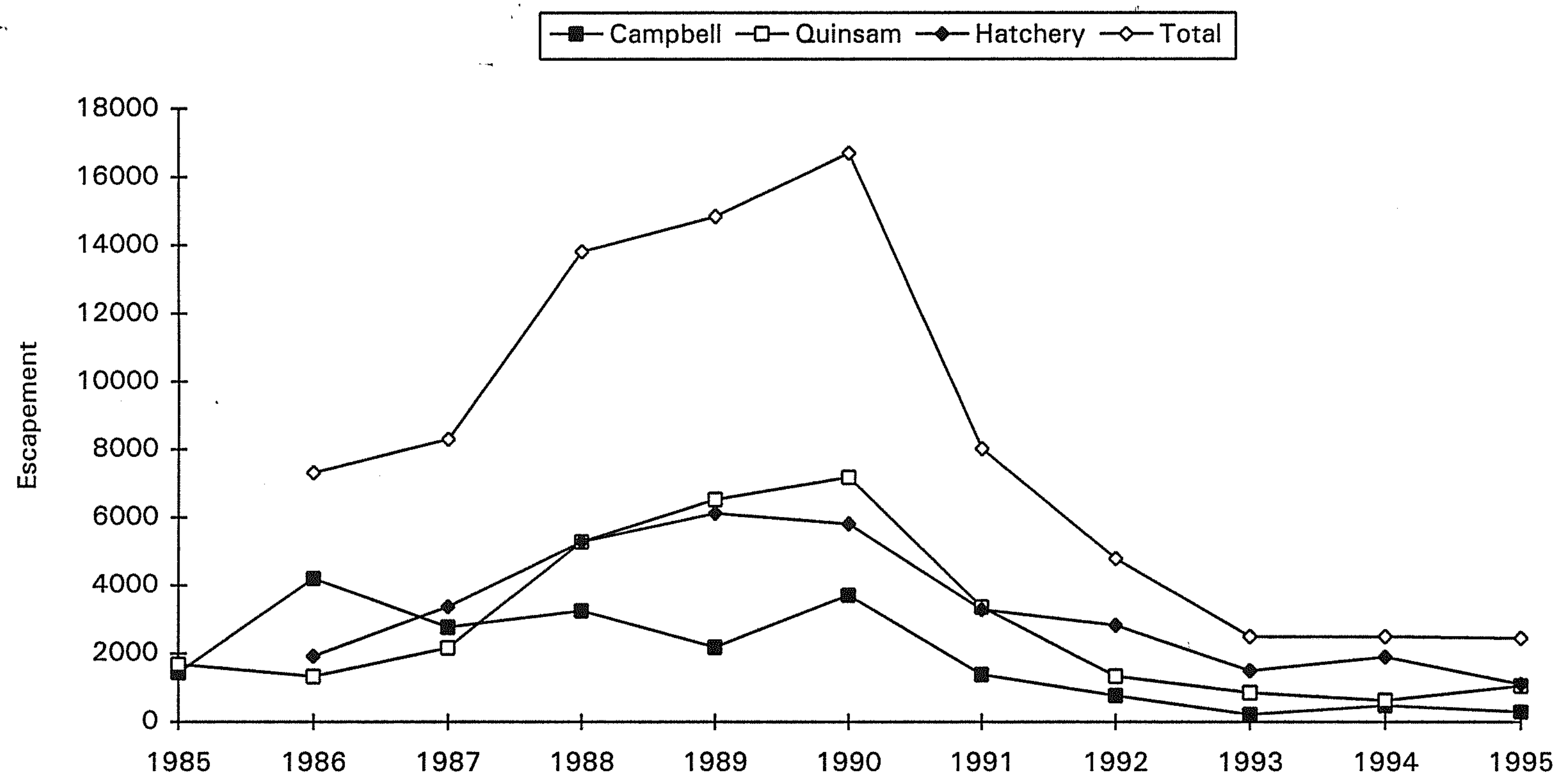

Figure 2. Chinook escapement estimates, stratified by river location, for 1985 (Andrew et al. 1988), 1986-88 (Bocking et al. 1990), 1989-90 (Bocking 1991), 1991 (Frith et al. 1993), 1992 (Frith 1993), 1993 (Frith and Nelson 1994), 1994 (Frith and Nelson 1995) and this study.

1995 is slightly less than returns in 1994, and is significantly less than the high of 16,698 chinook estimated 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 in the Campbell River was age-5 for both sexes, in the Quinsam River was age-4 for males and age-5 for females, and at the hatchery was age-4 for both sexes. The proportions of sexes in the age-4 group ranged from 31.7 to 50.0% for females and from 36.1 to 63.5% 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 River and hatchery males where age-5 fish made up less than 20% and age-3 fish were more abundant (Table 9). Age-3 fish represented greater than 20% for males in Quinsam River but not at the hatchery.

Male and female chinook from Campbell River had larger mean lengths (postorbital-hypural) than male and female chinook from the Quinsam River (Campbell: male = 783 mm, female = 810 mm; Quinsam: male = 700 mm, female = 787 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 Quinsam River ($P < 0.001$) and Quinsam Hatchery ($P < 0.001$) but not in Campbell River ($P > 0.05$). 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 only significant for females ($P > 0.05$).

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 1995 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 0.74 in the Campbell River, 0.70 in the Quinsam River, and 0.95 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 1989 to 1992 brood years were captured in the dead recovery programs in 1995 (Appendix 7 and 8 and Table 11). There were two recoveries in Quinsam River and nine 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 1995, there were four adipose-clipped chinook recovered in the Campbell River dead pitch, 23 in the Quinsam River dead pitch and 85 at the hatchery rack not including jacks (Table 10). The adipose-clip mark rate was highest in the hatchery returns (7.7%) and lowest in the Campbell River returns (2.9%). The total estimated adipose clips to Campbell River, Quinsam River, and Quinsam Hatchery were 9, 63, and 85, 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 would be included in the analysis (but no strays were recovered in 1995). A total of 112 adipose-clipped fish were recovered in 1995 and of these 101 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 1995 escapement of chinook to the Campbell River, Quinsam River, and Quinsam Hatchery were 121, 735, and 1061, respectively (Table 13).

The hatchery contributions to the total escapement of chinook in 1995, by age class is presented in Table 14. The hatchery contribution to the Campbell River population of chinook was estimated to be 72.4% for males and 19.0% for females. Contributions to the in-river Quinsam chinook escapement were 40.5% for males and 90.2% for females and to the Quinsam Hatchery were >100.0% for males and 88.2% for females.

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 74, 471, and 1066, respectively (Table 17).

The hatchery contribution to the total escapement of chinook in 1995, by age class, is presented in Table 18. The 1995 hatchery contribution to the Campbell River population of chinook was estimated to be 35.0% for males and 17.9% for females. Contributions to the in-river Quinsam chinook escapement were 33.3% for males and 52.9% for females. Hatchery returns were composed of >100.0% for males and 91.3% for females in the returns to the hatchery. No strays were reported in 1995.

DISCUSSION AND CONCLUSIONS

POPULATION ESTIMATION

Differences in the abundance of chinook between sexes or river locations can cause errors in the total estimate of chinook for a river system if estimates are not stratified. 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.

The degree of mixing of tagged carcasses with the rest of the carcass population may have been incomplete, particularly in deep pools where carcasses may have settled without further movement. Bias due to incomplete mixing is usually 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. However, the concentration of silt in the Campbell and Quinsam rivers in 1995 was unusually high and visibility was very poor. Dead pitch recovery and tagging was restricted mainly to the river banks although SCUBA surveys and snorkel surveys did successfully recover chinook in some locations. In addition, tagging and recovery effort was terminated one to three weeks early. Due to less complete sampling than in most years, incomplete mixing in 1995 would have caused some bias in chinook population estimates in 1995.

AGE, LENGTH AND SEX COMPOSITION

In 1995, chinook escapements to the Campbell and Quinsam rivers were composed mainly of age-4 and age-5 year old fish with females being slightly older. A similar age structure has been observed in recent years (Bocking 1991; Frith, Nass and Nelson 1993; Frith and Nelson 1994; 1995). The ratio of adult males to females, as determined from the Petersen estimates, was 0.74 in Campbell River and 0.70 in Quinsam River in 1995. The adult male to female ratio of returns to the Quinsam Hatchery was 1.95 in 1995. No consistent pattern of sex ratios between river locations has been observed in recent years (Frith, Nass and Nelson 1993; Frith and Nelson 1994; 1995). 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; 1995).

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 2.9% - 7.7% in 1995.

Estimates of the total hatchery contribution to the Quinsam/Campbell River system for adult males and females in 1995 were either approximately the same (within 5%) or higher (6.7% to 107.0%) using Method A (AFC rate) compared to Method B (CWT rate). Method A produced hatchery contribution estimates ranging from 17.9% to >100.0% (Table 14) and were similar in range to the 19.0% to >100.0% 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%; Frith and Nelson 1995) and 1995 can be explained by the low number of adipose clip returns recovered and the greater error associated with smaller sample sizes.

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. 12 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 two to 47 adipose clips enumerated for each river stratum (jacks not included) in 1995. The lower and upper 95% confidence limits for two recoveries (based on a Poisson frequency distribution) would be 0.24 and 3.57 or -176% and +357% respectively. For 47 recoveries the lower and upper 95% confidence interval are 34.5 and 61.4 which represents a much smaller percentage of the number of recoveries at -27% and +31% respectively. 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 1995. In general, there was a higher proportion of hatchery-reared fish in the Quinsam Hatchery than at the two river locations. In previous years the hatchery contribution to the Quinsam River has been higher than in the Campbell River but this difference was less in 1995 (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 2445 in 1995. 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 or age-5 returns. Age-3, Age-4 or Age-5 were ranked second in numbers for some combinations of sex and river location. Male chinook were predominantly age-4 with the exception of Campbell River males where the number of age-5 was greatest. Female chinook were predominantly age-5 with the exception of Quinsam Hatchery where the number of age-4 was greatest by a small amount.

3. Based on the Petersen estimates and Quinsam Hatchery rack recoveries, females were more abundant in all river locations.

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 157 fish in 1995.

6. The total estimated hatchery contribution to the chinook escapement, based on adipose clips (Method A), was 1,918 (78.4%) in 1995. The contribution estimate derived using the adjusted CWTs recovered (Method B) was slightly lower at 1,612 (65.9%).

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TABLES

Table 1. Summary of methods for the Campbell and Quinsam rivers chinook salmon enumeration programs, 1995.

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, 1995.

River	Stream walk	Diver	Total person days
Campbell	26.5	2	28.5
Quinsam	24	0	24

Table 3. Summary of in situ carcass tagging and dead recovery of chinook salmon in Campbell and Quinsam rivers, 1995.

Category	Campbell (a)	Quinsam (b)	Total
Carcasses tagged:			
Males	36	96	132
Females	61	133	194
Jacks	0	2	2
Total	97	231	328
Carcasses examined:			
Males	51	138	189
Females	88	237	325
Jacks	0	3	3
Total	139	378	517
Tags recovered (c):			
Males	14	30	44
Females	31	50	81
Jacks	0	0	0
Total	45	80	125
Tag summary:			
Observed tag rate (%)	32.4	21.2	24.2
Tag return rate (%)	46.4	34.6	38.1
Tag loss (%)	2.0	8.8	5.4

(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)

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 carcass tagging and recovery of carcasses, 1995. Confidence limits are determined assuming R is Poisson distributed (Ricker 1975, p. 343).

River and Item	Male	Female	Jack (h)	Total	
Campbell River (a)					
Number tags applied (d)	36	61	0	97	
Number recovered (e)	49	85	0	134	
Number of tagged recoveries (f)	14	31	0	45	
Petersen estimate	123	167	NA	290	(i)
Lower 95% CL	76	118	NA	194	(i)
Upper 95% CL	213	242	NA	455	(i)
Quinsam River (b, below fence)					
Number tags applied (d)	96	133	2	231	
Number recovered (e)	138	235	3	376	
Number of tagged recoveries (f)	30	50	0	80	
Petersen estimate	435	620	NA	1055	(i)
Lower 95% CL	308	473	NA	781	(i)
Upper 95% CL	636	832	NA	1468	(i)
Quinsam Hatchery (c)					
Number of fish (g)	539	561	31	1131	
Total system					
Escapement estimate	1097	1348	NA	2445	(i)
Lower 95% CL	922	1152	NA	2075	(i)
Upper 95% CL	1388	1636	NA	3023	(i)

(a) Appendix 5 for no. of carcasses recovered, no. of carcasses tagged, and no. of tagged recoveries, by date in Campbell River
(b) Appendix 6 for no. of carcasses recovered, no. of carcasses tagged, and no. of tagged 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 recoveries possessing an operculum punch (secondary mark)
(g) Confidence limits not applicable
(h) Peterson estimates were not calculated for jacks due to low sample size
(i) Totals not including jacks (see (h))

Table 5. Age composition of Campbell River chinook salmon, 1995 (determined from dead recovery).

Sex and age	Unmarked	AD/CWT	Total	Percent	Postorbital-hypural length (mm) N	Mean (mm)	SD	95% CL Lower	95% CL Upper
Males (a)									
3	3	1	4	11.1	4	553	58	495	611
4	13	0	13	36.1	13	729	88	680	778
5	19	0	19	52.8	19	868	89	827	909
Total aged	35	1	36	100.0	36	783	135	738	828
Unknown age	0	1	1		1	830	0	-	-
Total			37						
Females									
3	2	0	2	3.3	2	818	177	568	1068
4	19	0	19	31.7	19	757	46	736	778
5	36	2	38	63.3	38	833	50	817	849
6	1	0	1	1.7	1	965	0	-	-
Total aged	58	2	60	100.0	60	810	62	798	822
Unknown age	4	0	4		4	820	90	730	910
Total			64						

(a) no jacks were observed in Campbell River in 1995.

Table 6. Age composition of Quinsam River chinook salmon, 1995 (determined from dead recovery).

Sex and age		Unmarked	AD/CWT	Total	Percent (b)		Postorbital-hypural length (mm) N	Mean (mm)	SD	95% CL Lower	95% CL Upper
Males (a)											
2		2	0	2	2.1		2	375	35	325	425
3		23	0	23	24.0	(24.5)	23	610	66	583	637
4		58	3	61	63.5	(64.9)	61	727	66	710	744
5		9	1	10	10.4	(10.6)	10	806	42	779	832
	Total aged	92	4	96	100.0	(100.0)	96	700	99	680	720
	Unknown age	6	1	7			7	729	42	697	760
	Total			103							
Females											
3		1	0	1	0.7		1	595	0	-	-
4		60	2	62	44.3		62	768	39	758	777
5		66	7	73	52.1		73	803	41	794	813
6		3	1	4	2.9		4	831	34	798	865
	Total aged	130	10	140	100.0		140	787	47	779	795
	Unknown age	3	8	11			11	761	55	727	794
	Total			151							

(a) Jacks are included with males (two 2 yr old fish)
(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, 1995 (determined from rack recovery).

Sex and age		Unmarked	AD/CWT	Total	Percent (b)		Postorbital-hypural length (mm)				
										95% CL	
							N	Mean (mm)	SD	Lower	Upper
Males (a)											
1		0	4	4	2.7		4	219	24	-	-
2		2	3	5	3.4	(0.7)	5	388	33	359	418
3		16	10	26	17.8	(18.8)	26	616	59	593	639
4		62	29	91	62.3	(65.9)	91	721	62	708	734
5		11	8	19	13.0	(13.9)	19	761	65	731	790
6		1	0	1	0.7	(0.7)	1	928	0	-	-
	Total aged	92	54	146	100.0	(100.0)	146	684	124	663	704
	Unknown age	26		26			26	677	173	609	745
	Total			172							
Females											
3		6	1	7	3.8		7	646	61	601	692
4		72	20	92	50.0		92	747	51	736	757
5		67	17	84	45.7		84	784	51	773	796
6		1	0	1	0.5		1	811	0	-	-
	Total aged	146	38	184	100.0		184	760	59	752	769
	Unknown age	31		31			31	746	51	727	764
	Total			215							

(a) Jacks are included with males (4 age 1, 4 age 2, and 3 of unknown age).
(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, 1995.

Location	Length class (mm)	Males 1	Males 2	Males 3	Males 4	Males 5	Males 6	Males Total	Males unk(a)	Females 2	Females 3	Females 4	Females 5	Females 6	Females Total	Females unk(a)
Campbell River																
	250-299	0	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	0
	350-399	0	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	0
	450-499	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
	500-549	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0
	550-599	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
	600-649	0	0	1	1	1	0	3	0	0	0	0	0	0	0	0
	650-699	0	0	0	2	0	0	2	0	0	0	2	0	0	2	0
	700-749	0	0	0	2	0	0	2	0	0	0	3	0	0	3	1
	750-799	0	0	0	4	2	0	6	0	0	0	11	11	0	22	1
	800-849	0	0	0	3	2	0	5	1	0	2	3	11	0	16	1
	850-899	0	0	0	0	4	0	4	0	0	0	0	12	0	12	1
	900-949	0	0	0	0	7	0	7	0	0	0	0	3	0	3	0
	950-999	0	0	0	0	3	0	3	0	0	0	0	1	1	2	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	0	553	729	868	0	783	830	0	818	757	833	965	810	820
	SD	0	0	58	88	89	0	135	0	0	177	46	50	0	62	90
	N	0	0	4	13	19	0	36	1	0	2	19	38	1	60	4
Quinsam River																
	250-299	0	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	0
	350-399	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	400-449	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0
	550-599	0	0	6	3	0	0	9	0	0	0	0	0	0	0	0
	600-649	0	0	7	3	0	0	10	1	0	1	0	0	0	1	0
	650-699	0	0	3	9	0	0	12	0	0	0	0	0	0	0	0
	700-749	0	0	2	24	1	0	27	3	0	0	17	5	0	22	6
	750-799	0	0	1	8	3	0	12	3	0	0	29	20	1	50	2
	800-849	0	0	0	12	3	0	15	0	0	0	13	38	2	53	2
	850-899	0	0	0	2	3	0	5	0	0	0	3	8	1	12	1
	900-949	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
	950-999	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	375	610	727	806	0	700	729	0	595	768	803	831	787	761
	SD	0	35	66	66	42	0	99	42	0	0	39	41	34	47	55
	N	0	2	23	61	10	0	96	7	0	1	62	73	4	140	11

(a) Unk = age unknown

Table 8 (cont). Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1995.

River	Length class (mm)	Age														
		Males								Females						
		1	2	3	4	5	6	Total	unk(a)	2	3	4	5	6	Total	unk(a)
Quinsam Hatchery																
	150-199	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
	200-249	3	0	0	0	0	0	3	1	0	0	0	0	0	0	0
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
	350-399	0	2	0	0	0	0	2	1	0	0	0	0	0	0	0
	400-449	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0
	550-599	0	0	7	4	1	0	12	2	0	1	1	0	0	2	0
	600-649	0	0	7	5	0	0	12	1	0	3	1	1	0	5	1
	650-699	0	0	5	25	2	0	32	3	0	2	11	3	0	16	5
	700-749	0	0	3	30	4	0	37	8	0	0	36	14	0	50	9
	750-799	0	0	0	18	9	0	27	5	0	1	31	34	0	66	11
	800-849	0	0	0	6	1	0	7	3	0	0	9	26	1	36	4
	850-899	0	0	0	3	2	0	5	1	0	0	2	5	0	7	1
	900-949	0	0	0	0	0	1	1	0	0	0	1	1	0	2	0
	950-999	0	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	0
	Mean	219	388	616	721	761	928	684	677	0	646	747	784	811	760	746
	SD	24	33	59	62	65	0	124	173	0	61	51	51	0	59	51
	N	4	5	26	91	19	1	146	26	0	7	92	84	1	184	31

(a) Unk = age unknown

Table 9. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River, Quinsam Hatchery, 1995.

		Males (a)		Females	
Location	Age	Number (b)	Percent (c)	Number (b)	Percent (c)
Campbell River					
	3	14	11.1	6	3.3
	4	44	36.1	53	31.7
	5	65	52.8	106	63.3
	6	0	0.0	3	1.7
	Total	123 (d)	100.0	167 (d)	100.0
Quinsam River					
	3	107	24.5	4	0.7
	4	282	64.9	275	44.3
	5	46	10.6	323	52.1
	6	0	0.0	18	2.9
	Total	435 (d)	100.0	620 (d)	100.0
Quinsam Hatchery					
	2	4	0.7	0	0.0
	3	101	18.8	21	3.8
	4	355	65.9	281	50.0
	5	75	13.9	256	45.7
	6	4	0.7	3	0.5
	Total	539 (d)	100.0	561 (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, 1995. 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)x100	Population estimate (b) D	Percentage of population sampled E=(A/D)x100	Total estimated adipose clips F=(B/A)xD
Campbell River							
	Male (c)	51	2	3.9	123	41.5	5
	Female	88	2	2.3	167	52.7	4
	Total	139	4	2.9	290	47.9	9
Quinsam River (below fence)							
	Male (c)	138	5	3.6	435	31.7	16
	Female	237	18	7.6	620	38.2	47
	Total	375	23	6.1	1055	35.5	63
Quinsam Hatchery							
	Male (c)	539	47	8.7	539	100.0	47
	Female	561	38	6.8	561	100.0	38
	Total	1100	85	7.7	1100	100.0	85

(a) Campbell River data from Appendix 7; Quinsam River data from Appendix 8; Quinsam Hatchery data from unsummarized rack recovery data base, seven 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, 1995. 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).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1992	180209	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	181148	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181149	1	0	5.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	5.0	0.0
	181151	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181152	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181153	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181155	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.2	0.0	4	0	4.2	0.0
	181157	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181158	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	Subtotal	1	0	5.0	0.0	0	0	0.0	0.0	10	1	10.4	1.0	11	1	15.4	1.0
1991	21328	0	0	0.0	0.0	0	0	0.0	0.0	5	1	5.2	1.0	5	1	5.2	1.0
	21329	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	1.9	1	2	1.0	1.9
	21331	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.1	1.0	2	1	2.1	1.0
	180415	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.1	1.0	2	1	2.1	1.0
	180416	0	0	0.0	0.0	1	1	4.0	4.7	1	1	1.0	1.0	2	2	5.0	5.7
	180417	0	0	0.0	0.0	0	0	0.0	0.0	0	2	0.0	1.9	0	2	0.0	1.9
	180418	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.2	0.0	4	0	4.2	0.0
	180419	0	0	0.0	0.0	0	1	0.0	4.7	0	7	0.0	6.8	0	8	0.0	11.5
	180420	0	0	0.0	0.0	0	0	0.0	0.0	1	4	1.0	3.9	1	4	1.0	3.9
	180421	0	0	0.0	0.0	2	0	8.0	0.0	6	0	6.3	0.0	8	0	14.3	0.0
	180422	0	0	0.0	0.0	0	0	0.0	0.0	6	1	6.3	1.0	6	1	6.3	1.0
	Subtotal	0	0	0.0	0.0	3	2	12.0	9.4	28	20	29.2	19.5	31	22	41.2	28.9
1990	20956	0	2	0.0	4.0	0	2	0.0	9.4	0	0	0.0	0.0	0	4	0.0	13.4
	20957	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	1.9	1	2	1.0	1.9
	20958	0	0	0.0	0.0	0	0	0.0	0.0	2	6	2.1	5.8	2	6	2.1	5.8
	20959	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.1	0.0	2	0	2.1	0.0
	21448	0	0	0.0	0.0	0	1	0.0	4.7	0	1	0.0	1.0	0	2	0.0	5.7
	21449	0	0	0.0	0.0	0	1	0.0	4.7	1	1	1.0	1.0	1	2	1.0	5.7

(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, 1995. 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).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	21450	0	0	0.0	0.0	1	1	4.0	4.7	1	1	1.0	1.0	2	2	5.0	5.7
	21451	0	0	0.0	0.0	0	2	0.0	9.4	0	3	0.0	2.9	0	5	0.0	12.3
	26016	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	26017	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	26019	0	0	0.0	0.0	0	0	0.0	0.0	0	2	0.0	1.9	0	2	0.0	1.9
	Subtotal	0	2	0.0	4.0	1	7	4.0	32.9	8	17	8.3	16.6	9	26	12.3	53.5
1989	26062	0	0	0.0	0.0	0	1	0.0	4.7	0	0	0.0	0.0	0	1	0.0	4.7
	Subtotal	0	0	0.0	0.0	0	1	0.0	4.7	0	0	0.0	0.0	0	1	0.0	4.7
	Total CWT (c)	1	2	5.0	4.0	4	10	16.0	47.0	46	38	48.0	37.0	51	50	69.0	88.0
No data (5000)		0	0			0	0			0	0			0	0		
No pin (8000)		1	0			1	8			1	0			3	8		
Lost pin (9000)		0	0			0	0			0	0			0	0		
Observed adipose		2	2			5	18			47	38			54	58		

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) Total estimated adipose clips from Table 10
(d) There were no strays 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, 1995.

Brood year	CWT code	Release numbers CWT	Release numbers Untagged	CWT loss (%)	Days held	Adipose release status Clipped	Adipose release status Unclipped
1992	180209	24770	322229	0.5	i	24894	322105
	181148	23730	207121	0.2	20	23778	207073
	181149	24128	407685	0.4	17	24225	407588
	181151	24731	465315	1.7	16	25159	464887
	181152	24932	264600	1.1	6	25209	264323
	181153	24450	263991	2.7	13	25128	263313
	181155	24123	198815	4.8	17	25339	197599
	181157	24101	190170	4.8	20	25316	188955
	181158	23382	194822	7.4	21	25251	192953
1991	21328	24770	291356	0.5	12	24894	291232
	21329	24661	598989	0.5	21	24785	598865
	21331	24593	526740	1.4	21	24942	526391
	180415	180415	473762	1.1	20	182422	471755
	180416	23951	303114	4.4	15	25053	302012
	180417	24967	317856	1.1	15	25245	317578
	180418	24864	313407	1.3	13	25191	313080
	180419	24709	185742	1.5	15	25085	185366
	180420	24952	435566	0.8	16	25153	435365
	180421	23760	196364	5.4	14	25116	195008
	180422	24936	226054	0.7	13	25112	225878
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
	26019	26817	502724	0.7	10	27006	502535
1989	26062	24929	291542	0.1	10	24954	194589
	Total hatchery	962023	10560893			976453	10449535

(a) no strays were observed in 1995.

Table 13. Estimates of total escapement of hatchery-reared chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1995 (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) Clipped	Release Numbers (c) Unclipped	Expansion factor	Expanded hatchery contributions (a,b) Campbell River M	Campbell River F	Quinsam River M	Quinsam River F	Quinsam Hatchery M	Quinsam Hatchery F	Total M	Total F
1992	180209	24894	322105	13.9	0.0	0.0	0.0	0.0	0.0	13.6	0.0	13.6
	181148	23778	207073	9.7	0.0	0.0	0.0	0.0	10.1	0.0	10.1	0.0
	181149	24225	407588	17.8	89.1	0.0	0.0	0.0	0.0	0.0	89.1	0.0
	181151	25159	464887	19.5	0.0	0.0	0.0	0.0	20.3	0.0	20.3	0.0
	181152	25209	264323	11.5	0.0	0.0	0.0	0.0	12.0	0.0	12.0	0.0
	181153	25128	263313	11.5	0.0	0.0	0.0	0.0	12.0	0.0	12.0	0.0
	181155	25339	197599	8.8	0.0	0.0	0.0	0.0	36.7	0.0	36.7	0.0
	181157	25316	188955	8.5	0.0	0.0	0.0	0.0	8.8	0.0	8.8	0.0
	181158	25251	192953	8.6	0.0	0.0	0.0	0.0	9.0	0.0	9.0	0.0
	Subtotal	224299	2508796		89.1	0.0	0.0	0.0	109.0	13.6	198.1	13.6
1991	21328	24894	291232	12.7	0.0	0.0	0.0	0.0	66.3	12.4	66.3	12.4
	21329	24785	598865	25.2	0.0	0.0	0.0	0.0	26.3	49.0	26.3	49.0
	21331	24942	526391	22.1	0.0	0.0	0.0	0.0	46.1	21.5	46.1	21.5
	180415	182422	471755	3.6	0.0	0.0	0.0	0.0	7.5	3.5	7.5	3.5
	180416	25053	302012	13.1	0.0	0.0	52.2	61.4	13.6	12.7	65.8	74.1
	180417	25245	317578	13.6	0.0	0.0	0.0	0.0	0.0	26.4	0.0	26.4
	180418	25191	313080	13.4	0.0	0.0	0.0	0.0	56.0	0.0	56.0	0.0
	180419	25085	185366	8.4	0.0	0.0	0.0	39.4	0.0	57.2	0.0	96.6
	180420	25153	435365	18.3	0.0	0.0	0.0	0.0	19.1	71.3	19.1	71.3
	180421	25116	195008	8.8	0.0	0.0	70.1	0.0	54.9	0.0	125.0	0.0
	180422	25112	225878	10.0	0.0	0.0	0.0	0.0	62.6	9.7	62.6	9.7
	Subtotal	432999	3862529		0.0	0.0	122.3	100.8	352.3	263.8	474.7	364.5
1990	20956	27007	189100	8.0	0.0	32.0	0.0	75.2	0.0	0.0	0.0	107.2
	20957	26913	430017	17.0	0.0	0.0	0.0	0.0	17.7	33.1	17.7	33.1
	20958	26738	205715	8.7	0.0	0.0	0.0	0.0	18.1	50.8	18.1	50.8
	20959	26026	203364	8.8	0.0	0.0	0.0	0.0	18.4	0.0	18.4	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, 1995 (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) Clipped	Release Numbers (c) Unclipped	Expansion Factor	Expanded hatchery contributions (a,b): Campbell River M	Campbell River F	Quinsam River M	Quinsam River F	Quinsam Hatchery M	Quinsam Hatchery F	Total M	Total F
	21448	26696	496763	19.6	0.0	0.0	0.0	92.2	0.0	19.1	0.0	111.3
	21449	26817	332412	13.4	0.0	0.0	0.0	63.0	14.0	13.0	14.0	76.0
	21450	26384	331055	13.5	0.0	0.0	54.2	63.7	14.1	13.2	68.3	76.9
	21451	26635	320364	13.0	0.0	0.0	0.0	122.5	0.0	38.1	0.0	160.5
	26016	27348	588755	22.5	0.0	0.0	0.0	0.0	23.5	0.0	23.5	0.0
	26017	26630	283542	11.6	0.0	0.0	0.0	0.0	0.0	11.3	0.0	11.3
	26019	27006	502535	19.6	0.0	0.0	0.0	0.0	0.0	38.2	0.0	38.2
	Subtotal	294200	3883622		0.0	32.0	54.2	416.5	105.9	216.8	160.1	665.2
1989	26062	24954	194589	8.8	0.0	0.0	0.0	41.4	0.0	0.0	0.0	41.4
	Subtotal	24954	194589		0.0	0.0	0.0	41.4	0.0	0.0	0.0	41.4
Total hatchery					89.1	32.0	176.5	558.6	567.2	494.1	832.9	1084.7

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) From Table 12

Table 14. Estimated hatchery contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1995. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 13).

				Hatchery contribution (b)				Stray contribution (b)			
		Estimated escapement (a)		Male (c)		Female		Male (c)		Female	
Location	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number	%
Campbell River											
	3	14	6	89	100(e)	0	0.0	0	0.0	0	0.0
	4	44	53	0	0.0	0	0.0	0	0.0	0	0.0
	5	65	106	0	0.0	32	30.2	0	0.0	0	0.0
	6	0	3	0	0.0	0	0.0	0	0.0	0	0.0
	Total	123	168	89	72.4	32	19.0	0	0.0	0	0.0
Quinsam River											
	3	107	4	0	0.0	0	0.0	0	0.0	0	0.0
	4	282	275	122	43.3	101	36.7	0	0.0	0	0.0
	5	46	323	54	100(e)	417	100(e)	0	0.0	0	0.0
	6	0	18	0	0.0	41	100(e)	0	0.0	0	0.0
	Total	435	620	176	40.5	559	90.2	0	0.0	0	0.0
Quinsam Hatchery (d)											
	2	4	0	0	0.0	0	0.0	0	0.0	0	0.0
	3	101	21	109	100(e)	14	66.7	0	0.0	0	0.0
	4	355	281	352	99.2	264	94.0	0	0.0	0	0.0
	5	75	256	106	100(e)	217	84.8	0	0.0	0	0.0
	6	4	3	0	0.0	0	0.0	0	0.0	0	0.0
	Total	539	561	567	100(e)	495	88.2	0	0.0	0	0.0

(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, 1995. One decimal place is carried for the adjusted CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1992	180209	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	181148	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181149	1	0	1.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0
	181151	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181152	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181153	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181155	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.0	0.0	4	0	4.0	0.0
	181157	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	181158	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	Subtotal	1	0	1.0	0.0	0	0	0.0	0.0	10	1	10.0	1.0	11	1	11.0	1.0
1991	21328	0	0	0.0	0.0	0	0	0.0	0.0	5	1	5.0	1.0	5	1	5.0	1.0
	21329	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	2.0	1	2	1.0	2.0
	21331	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.0	1.0	2	1	2.0	1.0
	180415	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.0	1.0	2	1	2.0	1.0
	180416	0	0	0.0	0.0	1	1	1.0	1.0	1	1	1.0	1.0	2	2	2.0	2.0
	180417	0	0	0.0	0.0	0	0	0.0	0.0	0	2	0.0	2.0	0	2	0.0	2.0
	180418	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.0	0.0	4	0	4.0	0.0
	180419	0	0	0.0	0.0	0	1	0.0	1.0	0	7	0.0	7.0	0	8	0.0	8.0
	180420	0	0	0.0	0.0	0	0	0.0	0.0	1	4	1.0	4.0	1	4	1.0	4.0
	180421	0	0	0.0	0.0	2	0	2.0	0.0	6	0	6.0	0.0	8	0	8.0	0.0
	180422	0	0	0.0	0.0	0	0	0.0	0.0	6	1	6.0	1.0	6	1	6.0	1.0
	Subtotal	0	0	0.0	0.0	3	2	3.0	2.0	28	20	28.0	20.0	31	22	31.0	22.0
1990	20956	0	2	0.0	2.0	0	2	0.0	2.0	0	0	0.0	0.0	0	4	0.0	4.0
	20957	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	2.0	1	2	1.0	2.0
	20958	0	0	0.0	0.0	0	0	0.0	0.0	2	6	2.0	6.0	2	6	2.0	6.0
	20959	0	0	0.0	0.0	0	0	0.0	0.0	2	0	2.0	0.0	2	0	2.0	0.0
	21448	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0	0	2	0.0	2.0
	21449	0	0	0.0	0.0	0	1	0.0	1.0	1	1	1.0	1.0	1	2	1.0	2.0

(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, 1995. One decimal place is carried for the adjusted CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	21450	0	0	0.0	0.0	1	1	1.0	1.0	1	1	1.0	1.0	2	2	2.0	2.0
	21451	0	0	0.0	0.0	0	2	0.0	2.0	0	3	0.0	3.0	0	5	0.0	5.0
	26016	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	26017	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.0
	26019	0	0	0.0	0.0	0	0	0.0	0.0	0	2	0.0	2.0	0	2	0.0	2.0
	Subtotal	0	2	0.0	2.0	1	7	1.0	7.0	8	17	8.0	17.0	9	26	9.0	26.0
1989	26062	0	0	0.0	0.0	0	1	0.0	1.0	0	0	0.0	0.0	0	1	0.0	1.0
	Subtotal	0	0	0.0	0.0	0	1	0.0	1.0	0	0	0.0	0.0	0	1	0.0	1.0
	Total hatchery	1	2	1.0	2.0	4	10	4.0	10.0	46	38	46.0	38.0	51	50	51.0	50.0
	Total CWT	1	2	1.0	2.0	4	10	4.0	10.0	46	38	46.0	38.0	51	50	51.0	50.0
No data (5000)		0	0			0	0			0	0			0	0		
No pin (8000)		1	0			1	8			1	0			3	8		
Lost pin (9000)		0	0			0	0			0	0			0	0		
Observed adipose		2	2			5	18			47	38			54	58		

(a) Abbreviations are M = male, F = female
(b) Does not include jacks

Table 16. Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1995. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1992	180209	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
	181148	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
	181149	1.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.4	0.0
	181151	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
	181152	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
	181153	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
	181155	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	0.0
	181157	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
	181158	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
	Subtotal	1.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	10.0	1.0	10.0	1.0	11.0	1.0	12.4	1.0
1991	21328	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1.0	5.0	1.0	5.0	1.0	5.0	1.0
	21329	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0
	21331	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
	180415	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
	180416	0.0	0.0	0.0	0.0	1.0	1.0	3.2	2.6	1.0	1.0	1.0	1.0	2.0	2.0	4.2	3.6
	180417	0.0	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
	180418	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	0.0
	180419	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6	0.0	7.0	0.0	7.0	0.0	8.0	0.0	9.6
	180420	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	1.0	4.0	1.0	4.0	1.0	4.0
	180421	0.0	0.0	0.0	0.0	2.0	0.0	6.3	0.0	6.0	0.0	6.0	0.0	8.0	0.0	12.3	0.0
	180422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	1.0	6.0	1.0	6.0	1.0	6.0	1.0
	Subtotal	0.0	0.0	0.0	0.0	3.0	2.0	9.5	5.3	28.0	20.0	28.0	20.0	31.0	22.0	37.5	25.3
1990	20956	0.0	2.0	0.0	3.8	0.0	2.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	4.0	0.0	9.1
	20957	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0
	20958	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.0	2.0	6.0	2.0	6.0	2.0	6.0

(continued)

Table 16 (cont.). Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1995. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 17 (Method B).

		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	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	20959	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
	21448	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6	0.0	1.0	0.0	1.0	0.0	2.0	0.0	3.6
	21449	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6	1.0	1.0	1.0	1.0	1.0	2.0	1.0	3.6
	21450	0.0	0.0	0.0	0.0	1.0	1.0	3.2	2.6	1.0	1.0	1.0	1.0	2.0	2.0	4.2	3.6
	21451	0.0	0.0	0.0	0.0	0.0	2.0	0.0	5.3	0.0	3.0	0.0	3.0	0.0	5.0	0.0	8.3
	26016	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
	26017	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
	26019	0.0	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
	Subtotal	0.0	2.0	0.0	3.8	1.0	7.0	3.2	18.5	8.0	17.0	8.0	17.0	9.0	26.0	11.2	39.3
1989	26062	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6
	Subtotal	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.6
Total hatchery		1.0	2.0	2.4	3.8	4.0	10.0	12.6	26.4	46.0	38.0	46.0	38.0	51.0	50.0	61.0	68.2
Petersen est. (c)		123	167			435	625			539	561						
Sample size (c)		51	88			138	237			539	561						

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) 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, 1995 (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) CWT	Release Numbers (c) Untagged (d)	Expansion factor	Expanded hatchery contributions (a,b) Campbell River M	Campbell River F	Quinsam River M	Quinsam River F	Quinsam Hatchery M	Quinsam Hatchery F	Total M	Total F
1992	180209	24770	322229	14.0	0.0	0.0	0.0	0.0	0.0	14.0	0.0	14.0
	181148	23730	207121	9.7	0.0	0.0	0.0	0.0	9.7	0.0	9.7	0.0
	181149	24128	407685	17.9	43.2	0.0	0.0	0.0	0.0	0.0	43.2	0.0
	181151	24731	465315	19.8	0.0	0.0	0.0	0.0	19.8	0.0	19.8	0.0
	181152	24932	264600	11.6	0.0	0.0	0.0	0.0	11.6	0.0	11.6	0.0
	181153	24450	263991	11.8	0.0	0.0	0.0	0.0	11.8	0.0	11.8	0.0
	181155	24123	198815	9.2	0.0	0.0	0.0	0.0	37.0	0.0	37.0	0.0
	181157	24101	190170	8.9	0.0	0.0	0.0	0.0	8.9	0.0	8.9	0.0
	181158	23382	194822	9.3	0.0	0.0	0.0	0.0	9.3	0.0	9.3	0.0
	Subtotal	218347	2514748		43.2	0.0	0.0	0.0	108.1	14.0	151.3	14.0
1991	21328	24770	291356	12.8	0.0	0.0	0.0	0.0	63.8	12.8	63.8	12.8
	21329	24661	598989	25.3	0.0	0.0	0.0	0.0	25.3	50.6	25.3	50.6
	21331	24593	526740	22.4	0.0	0.0	0.0	0.0	44.8	22.4	44.8	22.4
	180415	180415	473762	3.6	0.0	0.0	0.0	0.0	7.3	3.6	7.3	3.6
	180416	23951	303114	13.7	0.0	0.0	43.0	36.0	13.7	13.7	56.7	49.7
	180417	24967	317856	13.7	0.0	0.0	0.0	0.0	0.0	27.5	0.0	27.5
	180418	24864	313407	13.6	0.0	0.0	0.0	0.0	54.4	0.0	54.4	0.0
	180419	24709	185742	8.5	0.0	0.0	0.0	22.5	0.0	59.6	0.0	82.1
	180420	24952	435566	18.5	0.0	0.0	0.0	0.0	18.5	73.8	18.5	73.8
	180421	23760	196364	9.3	0.0	0.0	58.4	0.0	55.6	0.0	114.0	0.0
	180422	24936	226054	10.1	0.0	0.0	0.0	0.0	60.4	10.1	60.4	10.1
	Subtotal	426578	3868950		0.0	0.0	101.5	58.5	343.7	274.0	445.2	332.5
1990	20956	26953	189154	8.0	0.0	30.4	0.0	42.3	0.0	0.0	0.0	72.7
	20957	26752	430178	17.1	0.0	0.0	0.0	0.0	17.1	34.2	17.1	34.2
	20958	26658	205795	8.7	0.0	0.0	0.0	0.0	17.4	52.3	17.4	52.3

(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, 1995 (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)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		CWT	Untagged (d)		M	F	M	F	M	F	M	F
	20959	25870	203520	8.9	0.0	0.0	0.0	0.0	17.7	0.0	17.7	0.0
	21448	26509	496950	19.7	0.0	0.0	0.0	52.1	0.0	19.7	0.0	71.8
	21449	26602	332627	13.5	0.0	0.0	0.0	35.6	13.5	13.5	13.5	49.1
	21450	26384	331055	13.5	0.0	0.0	42.7	35.7	13.5	13.5	56.3	49.3
	21451	26502	320497	13.1	0.0	0.0	0.0	69.1	0.0	39.3	0.0	108.3
	26016	27211	588892	22.6	0.0	0.0	0.0	0.0	22.6	0.0	22.6	0.0
	26017	25911	284261	12.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	12.0
	26019	26817	502724	19.7	0.0	0.0	0.0	0.0	0.0	39.5	0.0	39.5
	Subtotal	292169	3885653		0.0	30.4	42.7	234.8	101.9	224.0	144.7	489.2
1989	26062	24929	291542	12.7	0.0	0.0	0.0	33.5	0.0	0.0	0.0	33.5
	Subtotal	24929	291542		0.0	0.0	0.0	33.5	0.0	0.0	0.0	33.5
Total hatchery					43.2	30.4	144.2	326.7	553.8	512.0	741.1	869.2

(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)

Table 18. Estimated hatchery and stray contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1995. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 17).

				Hatchery contribution (b)				Stray contribution (b)			
		Estimated escapement (a)		Male (c)		Female		Male (c)		Female	
Location	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number	%
Campbell River											
	3	14	6	43	100 (d)	0	0.0	0	0.0	0	0.0
	4	44	53	0	0.0	0	0.0	0	0.0	0	0.0
	5	65	106	0	0.0	30	28.3	0	0.0	0	0.0
	6	0	3	0	0.0	0	0.0	0	0.0	0	0.0
	Total	123	168	43	35.0	30	17.9	0	0.0	0	0.0
Quinsam River											
	3	107	4	0	0.0	0	0.0	0	0.0	0	0.0
	4	282	275	102	36.2	59	21.5	0	0.0	0	0.0
	5	46	323	43	93.5	235	100 (d)	0	0.0	0	0.0
	6	0	18	0	0.0	34	101 (d)	0	0.0	0	0.0
	Total	435	620	145	33.3	328	52.9	0	0.0	0	0.0
Quinsam Hatchery											
	2	4	0	0	0.0	0	0.0	0	0.0	0	0.0
	3	101	21	108	100 (d)	14	66.7	0	0.0	0	0.0
	4	355	281	344	96.9	274	97.5	0	0.0	0	0.0
	5	75	256	102	100 (d)	224	87.5	0	0.0	0	0.0
	6	4	3	0	0.0	0	0.0	0	0.0	0	0.0
	Total	539	561	554	100 (d)	512	91.3	0	0.0	0	0.0

(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, 1995.

Date	Capture area (a)	Tagged			
		Male	Female	Jack	Total
24-Oct	1A	2	1	0	3
24-Oct	1B	0	1	0	1
24-Oct	CH	0	0	0	0
26-Oct	1A	1	1	0	2
26-Oct	1B	0	0	0	0
26-Oct	CH	3	1	0	4
27-Oct	1A	0	0	0	0
27-Oct	1B	1	2	0	3
27-Oct	CH	0	0	0	0
31-Oct	1A	4	8	0	12
31-Oct	1B	7	6	0	13
31-Oct	CH	0	0	0	0
1-Nov	1A	0	0	0	0
1-Nov	1B	0	0	0	0
1-Nov	CH	0	8	0	8
2-Nov	1A	0	0	0	0
2-Nov	1B	0	0	0	0
2-Nov	CH	6	10	0	16
3-Nov	1A	2	10	0	12
3-Nov	1B	1	2	0	3
3-Nov	CH	0	0	0	0
7-Nov	1A	0	3	0	3
7-Nov	1B	2	3	0	5
7-Nov	CH	0	0	0	0
8-Nov	1A	0	0	0	0
8-Nov	1B	0	0	0	0
8-Nov	CH	7	4	0	11
10-Nov	1A	0	1	0	1
10-Nov	1B	0	0	0	0
10-Nov	CH	0	0	0	0
Total		36	61	0	97

(a) CH refers to a spawning channel off of Recovery area 1A.

Appendix 2. Operculum tagging of chinook salmon carcasses in Quinsam River, 1995.

Date	Capture area	Tagged			
		Male	Female	Jack	Total
20-Oct	2B	0	1	0	1
20-Oct	2C	0	0	0	0
20-Oct	2D	0	0	0	0
23-Oct	2B	1	1	0	2
23-Oct	2C	2	2	0	4
23-Oct	2D	10	5	0	15
25-Oct	2B	0	4	0	4
25-Oct	2C	3	5	0	8
25-Oct	2D	4	3	0	7
26-Oct	2B	0	0	0	0
26-Oct	2C	0	0	0	0
26-Oct	2D	8	4	0	12
30-Oct	2B	1	9	0	10
30-Oct	2C	7	9	0	16
30-Oct	2D	7	16	0	23
1-Nov	2B	3	2	0	5
1-Nov	2C	5	17	0	22
1-Nov	2D	12	6	2	20
2-Nov	2B	0	0	0	0
2-Nov	2C	0	0	0	0
2-Nov	2D	5	10	0	15
6-Nov	2B	1	6	0	7
6-Nov	2C	4	16	0	20
6-Nov	2D	6	8	0	14
7-Nov	2B	0	0	0	0
7-Nov	2C	0	0	0	0
7-Nov	2D	9	4	0	13
13-Nov	2B	0	0	0	0
13-Nov	2C	3	2	0	5
13-Nov	2D	4	1	0	5
15-Nov	2B	0	2	0	2
15-Nov	2C	0	0	0	0
15-Nov	2D	1	0	0	1
Total		96	133	2	231

Appendix 3. recovery of tagged chinook salmon carcasses in Campbell River, 1995.

Date	Recovery area (a)	Recovered (a)			
		Male	Female	Jack	Total
31-Oct	1A	0	1	0	1
31-Oct	1B	0	1	0	1
31-Oct	CH	0	0	0	0
2-Nov	1A	0	0	0	0
2-Nov	1B	0	0	0	0
2-Nov	CH	2	0	0	2
3-Nov	1A	3	7	0	10
3-Nov	1B	2	2	0	4
3-Nov	CH	0	0	0	0
7-Nov	1A	2	2	0	4
7-Nov	1B	0	1	0	1
7-Nov	CH	0	0	0	0
8-Nov	1A	2	3	0	5
8-Nov	1B	0	0	0	0
8-Nov	CH	1	12	0	13
10-Nov	1A	1	2	0	3
10-Nov	1B	0	0	0	0
10-Nov	CH	1	0	0	1
Total		14	31	0	45

(a) CH refers to a spawning channel off of Recovery area 1A.

Appendix 4. Recovery of tagged chinook salmon carcasses in Quinsam River, 1995.

Date	Capture area	Tagged			
		Male	Female	Jack	Total
25-Oct	2B	0	0	0	0
25-Oct	2C	0	0	0	0
25-Oct	2D	0	2	0	2
26-Oct	2B	0	0	0	0
26-Oct	2C	0	0	0	0
26-Oct	2D	2	1	0	3
30-Oct	2B	0	0	0	0
30-Oct	2C	0	1	0	1
30-Oct	2D	0	0	0	0
1-Nov	2B	0	1	0	1
1-Nov	2C	2	2	0	4
1-Nov	2D	4	9	0	13
2-Nov	2B	0	0	0	0
2-Nov	2C	0	0	0	0
2-Nov	2D	10	8	0	18
6-Nov	2B	0	5	0	5
6-Nov	2C	3	8	0	11
6-Nov	2D	0	3	0	3
7-Nov	2B	0	0	0	0
7-Nov	2C	0	0	0	0
7-Nov	2D	5	1	0	6
13-Nov	2B	0	5	0	5
13-Nov	2C	1	2	0	3
13-Nov	2D	2	2	0	4
15-Nov	2B	0	0	0	0
15-Nov	2C	1	0	0	1
15-Nov	2D	0	0	0	0
Total		30	50	0	80

Appendix 5. Sequential mark-recapture data for chinook salmon carcasses in Campbell River, 1995. Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).

	Male			Female			Jack			Total		
Date	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
24-Oct	2	2	0	3	2	0	0	0	0	5	4	0
26-Oct	4	4	0	2	2	0	0	0	0	6	6	0
27-Oct	1	1	0	2	2	0	0	0	0	3	3	0
31-Oct	14	11	0	16	14	2	0	0	0	30	25	2
1-Nov	0	0	0	12	8	0	0	0	0	12	8	0
2-Nov	10	6	2	17	10	0	0	0	0	27	16	2
3-Nov	8	3	5	18	12	9	0	0	0	26	15	14
7-Nov	2	2	2	6	6	3	0	0	0	8	8	5
8-Nov	10	7	3	11	4	15	0	0	0	21	11	18
10-Nov	0	0	2	1	1	2	0	0	0	1	1	4
Total	51	36	14	88	61	31	0	0	0	139	97	45
Total for MR(a)	49	36	14	85	61	31	0	0	0	134	97	45

(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 6. Sequential mark-recapture data for chinook salmon carcasses in Quinsam River, 1995. Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).

	Male			Female			Jack			Total		
Date	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
20-Oct	0	0	0	2	1	0	0	0	0	2	1	0
23-Oct	17	13	0	10	8	0	0	0	0	27	21	0
25-Oct	12	7	0	20	12	2	0	0	0	32	19	2
26-Oct	8	8	2	9	4	1	0	0	0	17	12	3
30-Oct	21	15	0	45	34	1	0	0	0	66	49	1
1-Nov	25	20	6	36	25	12	3	2	0	64	47	18
2-Nov	6	5	10	13	10	8	0	0	0	19	15	18
6-Nov	22	11	3	62	30	16	0	0	0	84	41	19
7-Nov	11	9	5	5	4	1	0	0	0	16	13	6
13-Nov	14	7	3	31	3	9	0	0	0	45	10	12
15-Nov	2	1	1	4	2	0	0	0	0	6	3	1
Total	138	96	30	237	133	50	3	2	0	378	231	80
Total for MR(a)	138	96	30	235	133	50	3	2	0	376	231	80

(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, 1995 (a).

	Area 1A								Area 1B								Spawning Channel (CH)							
	Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
24-Oct	2	1	0	3	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
26-Oct	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	4	0	0	0	0
27-Oct	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0
31-Oct	5	9	0	14	0	0	0	0	9	7	0	16	0	0	0	0	0	0	0	0	0	0	0	0
1-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	12	0	2	0	2
2-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	17	0	27	1	0	0	1
3-Nov	4	13	0	17	0	0	0	0	4	5	0	9	1	0	0	1	0	0	0	0	0	0	0	0
7-Nov	0	3	0	3	0	0	0	0	2	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0
8-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	11	0	21	0	0	0	0
10-Nov	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12	28	0	40	0	0	0	0	16	19	0	35	1	0	0	1	23	41	0	64	1	2	0	3

(a) See Figure 1 for location of recovery areas
(b) Abbreviations are M = male, F = female, J = jack, T = total

Appendix 8. Total dead recovery and adipose clip recovery of chinook salmon in Quinsam River, 1995 (a).

	Area 2B								Area 2C								Area 2D							
	Total recovered (b)				Adipose clipped recoveries				Total recovered (b)				Adipose clipped recoveries				Total recovered (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
20-Oct	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
23-Oct	2	2	0	4	0	0	0	0	2	2	0	4	0	0	0	0	13	6	0	19	0	0	0	0
25-Oct	2	12	0	14	0	2	0	2	6	5	0	11	0	0	0	0	4	3	0	7	0	0	0	0
26-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	9	0	17	0	2	0	2
30-Oct	4	12	0	16	0	0	0	0	9	15	0	24	1	3	0	4	8	18	0	26	0	2	0	2
1-Nov	4	6	0	10	0	3	0	3	6	22	1	29	0	0	0	0	15	8	2	25	1	1	0	2
2-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	13	0	19	0	0	0	0
6-Nov	7	23	0	30	0	0	0	0	6	26	0	32	1	2	0	3	9	13	0	22	2	2	0	4
7-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	5	0	16	0	0	0	0
13-Nov	4	14	0	18	0	0	0	0	4	11	0	15	0	0	0	0	6	6	0	12	0	0	0	0
15-Nov	1	3	0	4	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0
Total	24	73	0	97	0	5	0	5	33	83	1	117	2	6	0	8	81	81	2	164	3	7	0	10

(a) See Figure 1 for location of recovery areas
(b) Abbreviations are M = male, F = female, J = jack, T = total