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Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of Campbell and Quinsam Rivers, 1992

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ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF CAMPBELL AND QUINSAM RIVERS, 1992

by

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ABSTRACT

Frith, H. R. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2207 : viii + 56 p.

Estimates of escapement were derived for the Campbell/Quinsam river system for 1992 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 4782 in 1992. Both males and females were predominantly age 4 and 5 but the specific age structure varied between the Campbell River, and the Quinsam River and hatchery. Escapement estimates are presented by river, sex, and age.

Escapement of adipose-clipped chinook to the entire system was 318 in 1992. 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 1992 the hatchery contribution was 86.0% and 77.0% 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 hatchery contribution was 83.6% for males and 74.0% for females in 1992.

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

RÉSUMÉ

Frith, H. R. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2207 : viii + 56 p.

Les échappées des rivières Campbell et Quinsam de 1992 ont été estimées à partir des carcasses marquées dans le cadre du programme des cours d'eau clés pour le saumon quinnat. L'échappée de quinnats estimée par la méthode Petersen a été de 4 782 poissons en 1992. L'échappée était surtout constituée de poissons d'âges 4 ou 5, tant des mâles que des femelles, mais la structure des âges des poissons provenant de la rivière Campbell, de la rivière Quinsam et de la pisciculture n'était pas le même. Les échappées estimées sont présentées par rivière, sexe et âge.

Dans l'ensemble du bassin versant, l'échappée des quinnats à adipeuse rognée s'est élevée à 318 poissons en 1992. Cette valeur a été stratifiée en fonction de l'âge, du sexe et du code de marquage. L'apport total des poissons d'élevage (marqués et non marqués) à l'échappée a été estimé par extrapolation du nombre de poissons à adipeuse rognée à l'aide du rapport entre les poissons marqués et non marqués au moment de la remise à l'eau. En 1992, l'apport des poissons d'élevage a été de 86,0 % et 77,0 % pour, respectivement, les quinnats mâles et femelles formant l'échappée. Ces valeurs ont été comparées à celles du programme de marquage et de recapture (Kuhn, 1988) qui fait appel au marquage par fils codés. Selon cette méthode, l'apport total des poissons d'élevage a été de 83,6 % de mâles et de 74,0 % de femelles en 1992.

Mots clés: Campbell, Quinsam, quinnat, cours d'eau clé, échappée, fil codé, poissons marqués, carcasses marquées.

INTRODUCTION

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

The major objectives of the key stream program are:

1. to accurately estimate chinook escapement on key streams;

2. to estimate harvest rates and contributions to fisheries and escapement based on coded wire tagged/adipose clip returns, including estimates of the total escapement of coded wire tags to the key streams system; and

3. to estimate the contribution of hatchery and natural production to the escapement.

Chinook escapements to the Campbell River have ranged from 750 to 8,000 since 1947 (Shardlow et al. 1986). Chinook escapement to the Quinsam River was negligible prior to the opening of Quinsam Hatchery in 1972, but has increased from 1,500 in 1985 to 5,300 in 1988 (Andrew et al. 1988, Bocking et al. 1990). Chinook returns to the Quinsam Hatchery have also increased from 1,800 in 1986 to 15,538 in 1990 (Bocking, 1991*b*). Lower returns of 3400 in Quinsam River and 3200 in Quinsam hatchery were observed in 1991.

This manuscript report is the sixth in a series describing the escapement monitoring and biological sampling of chinook salmon in the Campbell/Quinsam system. The 1984 study results are presented in Shardlow et al. (1986), 1985 results are in Andrew et al. (1988), the 1986-88 study results are described by Bocking et al. (1990), the 1989-90 results are described in Bocking (1991*b*), and the 1991 results are in Frith et al. (1993).

The 1992 escapements of chinook salmon were calculated using the adjusted Petersen method (Ricker 1975) by tagging carcasses to produce separate estimates for sexes and rivers and summing these 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 estimates to produce a final escapement figure for the entire Quinsam/Campbell system.

In this report, potential biases in the Petersen method, carcass tagging method and method of stratification are discussed. Assumptions for the methods used and the tests for biases caused by violations of assumptions are also described in the methods section. The results section presents the population estimates, tests for bias in tagging and recovery, population composition (age, length, and sex), and the results of coded wire tagging studies.

To avoid confusion in terminology relating to tagging and marking, the word "tagging" in this report refers to operculum tagging of live or 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 are accessible to natural spawning but chinook spawning takes place primarily in the lower 4 km of the river (Shardlow et al. 1986). Chinook access to the upper Quinsam River above the counting fence near Quinsam Hatchery was improved in 1988.

Flows in the Campbell River are controlled by the John Hart Generating Station, located 5.5 km upstream of the mouth (Marshall et al. 1977) and vary from 1.2 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 moorage (Andrew et al. 1988). Man-made islands have been constructed in the estuary in an effort to improve fish habitat (Levings 1986). The lower reaches of the Campbell River have been modified due to expansion of the Campbell River community (population approximately 18,000) which surrounds the lower 2 km of the river. Access to the Campbell River is primarily by municipal roads and by Campbell River Road, which runs along the south bank of the river.

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

The Campbell/Quinsam river system supports five species of Pacific salmon as well as steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*). The salmonids, in order of abundance, are pink, chinook, chum and coho 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

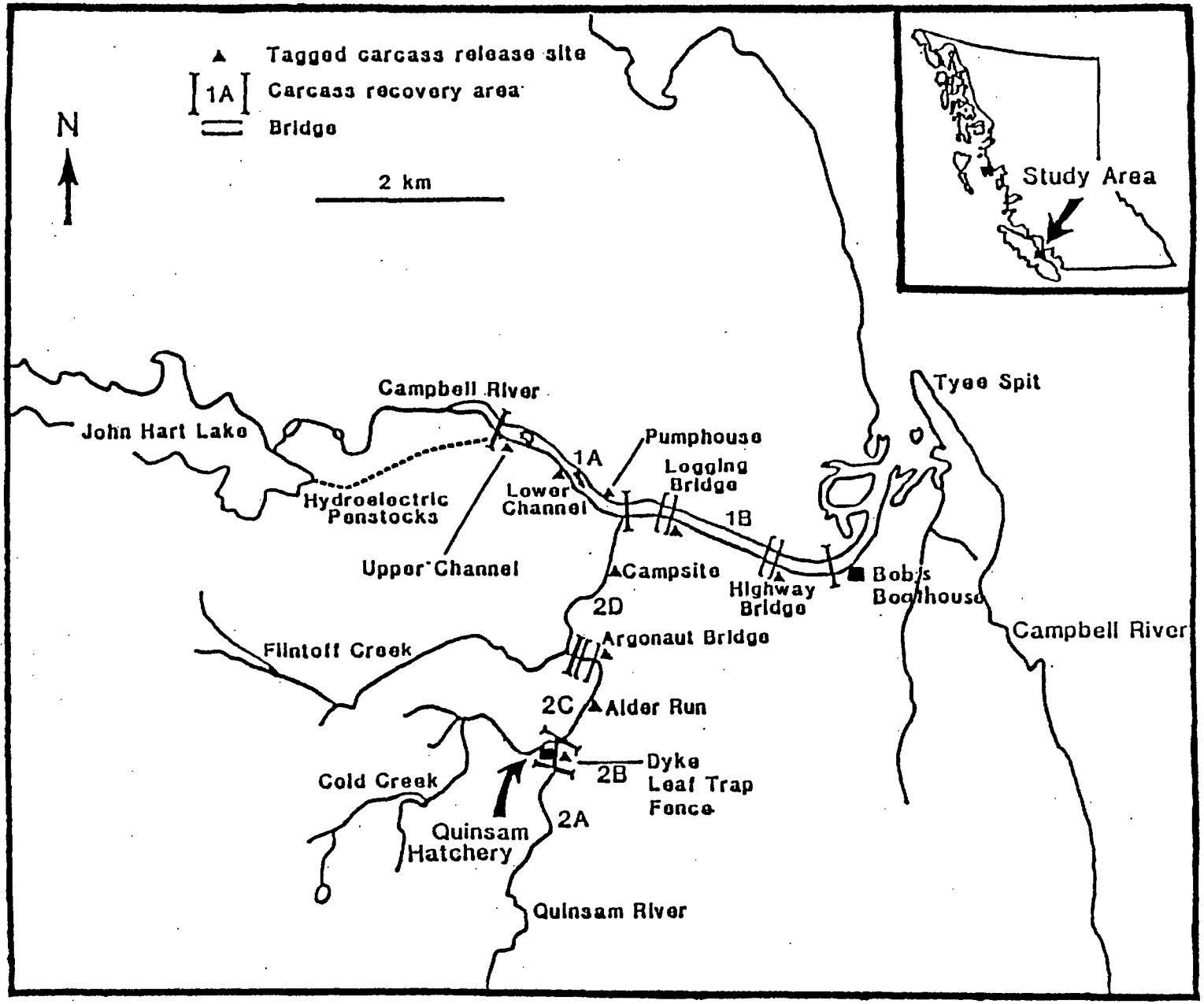


Figure 1. Map of the Campbell and Quinsam rivers study area.

in October. Peak spawning occurs from mid-October to mid-November (Andrew et al. 1988, VanTine, pers. comm.[2]). Migration of chinook into the Quinsam River occurs later from late September to late November and is strongly influenced by rainfall. Spawning is usually completed by late November or early December.

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

METHODS

Carcass tagging and recovery was conducted from October 19 to November 19 by Quinsam Hatchery workers. A summary of methods for this study is presented in Table 1 and is described below.

POPULATION ESTIMATION

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

Population Stratification

Carcass Tagging:

There are four main ways of stratifying the carcass tagging and recovery data to produce a Petersen estimate of escapement:

1. sexes and rivers pooled;
2. sexes separate with rivers pooled;
3. sexes separate and rivers separate; and
4. sexes pooled with rivers separate.

---

[2]Manager of Quinsam Hatchery, P.O. Box 467, Campbell River, B.C. V9W5C1

Separate Petersen estimates may be calculated for each stratum and then summed to obtain an estimate of the whole population. By segregating the data into separate population strata, potential biases created by factors which affect the strata at different rates may be avoided. The main factors of concern are rates of tag application, recovery of carcasses, and tag loss. If carcasses in the Campbell and Quinsam rivers do not mix following release of tagged carcasses in each river, forming two distinct groups for the purpose of enumeration, then there is a potential for substantial bias in unstratified estimates if tagging or dead recovery rates and effort are not identical. Similarly if the two sexes (and jacks) have different rates of tag application, recovery rates, or tag loss, then a single population estimate may be biased.

Due to the likelihood of factors affecting sexes and rivers at different rates, as documented by Andrew et al. (1988), Petersen estimates were stratified by sex and river in this study. 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 potentially biased by violation of a number of assumptions. Seven of these assumptions were discussed in Andrew et al. 1988, Bocking et al. (1990), Bocking (1991*b*) and Frith et al. (1993) and are repeated in this paper for the benefit of the reader.

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

1. Tags are consistently applied in proportion to the available population and/or the distribution of recovery effort is proportional to the number of fish present in different river reaches and/or tagged fish become randomly mixed with untagged fish.

To obtain an accurate Petersen estimate, it is important to apply and/or recover tags in proportion to the available population. In 1992, carcasses were tagged sequentially and *in situ* during recovery. Hatchery workers attempted to tag a consistent proportion of the number of fish examined during each recovery survey by tagging every fifth carcass in 1992, although this proportion still tended to vary considerably (usually 20 - 60%) between days depending on the number of tagged carcasses recovered.

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 1992 there was no straying between rivers of tagged carcasses.

2. There is a negligible influx of spawners after the conclusion of tagging.

An influx of spawners following tagging could cause the Petersen calculations to overestimate or underestimate the true population depending on how they mixed with tagged fish. In 1992, tagging continued *in situ* in the rivers almost daily throughout the spawning and die-off period.

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.

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

In this study, no duplicate pitches were conducted to reexamine deadpitch carcasses for missed tags and secondary marks, therefore it was not possible to evaluate the incidence of missing tags.

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

Dead recovery from a population other than the tagged population will cause Petersen calculations to overestimate the true population. Indications that tagging and recovery were conducted on different populations would be different age frequency and length frequency distributions among the two samples. Since tagging occurred concurrently with recovery, this is not likely a problem.

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

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

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

Buoyancy and decomposition may be important factors causing differential behaviour of tagged and untagged carcasses especially if tagged carcasses become bloated with air during handling. Differences in tag visibility could cause preferential sampling of tagged carcasses, and result in an underestimate of the population. An attempt was made to circumvent this problem by using neutral

colours to prevent increased visibility of tagged carcasses. It is not possible to test the assumption of similar visibility between tagged and untagged carcasses with the data from this study. The assumption of similar buoyancy and decomposition of tagged and untagged carcasses could be tested by comparing the tag recovery rate during dead recovery with the recovery rate at carcass weirs if such data were available.

Calculations

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

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

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:

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

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

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

Population estimates were not calculated for jack chinook because none were marked.

Strays

There were no carcass strays between rivers in 1992.

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 keep recovery effort as complete and consistent as possible throughout the study period. Dead chinook were recovered from the Campbell and Quinsam rivers by two methods:

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

2. a SCUBA diver recovered carcasses from deep pools in the lower reaches of the Campbell and Quinsam rivers.

Chinook were also recovered live at the Quinsam Hatchery rack.

Each carcass was examined for the presence of a staple tag, opercular punch hole(s) and missing adipose fin. Heads were removed from adipose-clipped fish for sampling of coded wire tags (CWT). Data collected from the carcasses is 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 the purposes of the 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 one day was necessary to allow sufficient mixing between tagged and untagged carcasses.

Other calculations relating to the dead recovery were as follows:

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

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

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

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

BIOLOGICAL AND PHYSICAL SAMPLING

Biological sampling during dead recovery included scales for age determination, length, sex, presence of secondary marks (hole punches in operculum) and presence of an adipose clip. Postorbital-hypural length was recorded from 69-70% of the carcasses (marked and unmarked fish) recovered in the Campbell River, 55-59% of the carcasses recovered in the Quinsam River, and 19-20% of the chinook recovered alive at the hatchery rack. No jacks were identified in the ageing process.

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 regenerate centres, they were resorbed, or if they 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, the first numeral of the age recorded indicates the year of total life and the decimal point and following numeral indicates the year of life in which the fish migrated to the ocean. 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.

The sex ratio was determined for each river by sexes and Petersen estimates for separate rivers. This method provides a valid sex ratio. The test for potential differences in tag loss was 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 1986 - 1990 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 release of the fish.

The estimation of the contribution of hatchery-reared chinook to the total escapement utilizes two different 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 for the hatchery. Estimates of the number of adipose clips for jack chinook were not possible because there was no population estimate.

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. However,

if decomposition of adipose fins is occurring then the adipose mark rate (based on hatchery contributions only) in the dead pitch should be higher than the mark rate at release. 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 having 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 included jacks). Final hatchery contribution estimates were made separately for fish of Quinsam hatchery origin and for strays from other rivers.

Method B

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

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

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

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

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:

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

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:

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

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 1992, 140 chinook carcasses were tagged and released (returned to the river) continuously throughout the spawning period from October 20 to November 13 in the Campbell River and 163 carcasses were tagged and released from October 19 to November 19 in the Quinsam River (Table 3; Appendix 1 and 2).

RECOVERY

Surveys to recover carcasses in 1992 began on October 21 in the Campbell River and on October 22 in the Quinsam River and continued until November 13 and 19 respectively (Appendix 3 and 4; Fig. 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 1992 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 1992, a total of 344 chinook carcasses were examined in the Campbell River (133 males, 211 females, and 0 jacks; Table 3). This number included 63 tag recoveries (20 males, 43 females and 0 jacks). In the Quinsam River, a total of 743 chinook carcasses were examined (247 males, 488 females, and 0 jacks; Table 3). This included 90 tag recoveries (21 males, 69 females, and 0 jacks). In both rivers, more females than males were recovered and no jacks.

The carcass tag recovery rates in the Campbell River (45.0%) and Quinsam River (55.2%) in 1992 differed by 10.2% but were not significantly different ($P > 0.05$, χ^2; Zar, 1984). The tag recovery rate was higher for females (50% and 58% in Campbell and Quinsam Rivers respectively) but the difference between sexes was not significant for the either river ($P > 0.05$ for both, χ^2).

POPULATION ESTIMATES

Carcass Tagging

The parameter values used in the derivation of the Petersen escapement estimate, stratified by river and sex are given in Table 4. The 1992 chinook escapement to the Campbell River and Quinsam River, as estimated using a simple Petersen estimate from *in situ* carcass tagging and recovery, was estimated at 770 and 1334 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 1992, including hatchery rack recoveries, was estimated to be 4782 adults with 95% confidence limits of 4218 to 5648 fish.

The proportion of fish between the two rivers and the Quinsam Hatchery was 16.1; 27.9; 56.0 (Campbell; Quinsam; hatchery). These proportions are a departure from previous years averaging 17.9: 42.2: 39.9 for 1989-1991 (Bocking 1991*b*, Frith et al. 1993) where the maximum range for any one system was 9.3%. In 1992, the Quinsam River representation was down 14.3% and the Quinsam hatchery was up by 16.1% compared to the previous 3 year average. The total returns show a continued decrease from the high in 1990 for the Campbell River, Quinsam River and hatchery (Figure 2).

AGE, LENGTH AND SEX COMPOSITION

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) (Tables 5 to 7). Total ages of Campbell and Quinsam river chinook ranged from 3 to 6 years. The dominant age-group in the Campbell River was age 4 and 5 years for males and age 5 for females (Table 5). In the Quinsam River and hatchery, the dominant age class was 4 years for both sexes in 1992 (Table 6).

Summaries of mean lengths by age are presented in Tables 5 through 7. In 1992, male and female chinook from Campbell River had larger mean lengths (postorbital-hypural) than male and female chinook from the Quinsam River (Campbell: male = 793 mm, female = 805 mm; Quinsam:

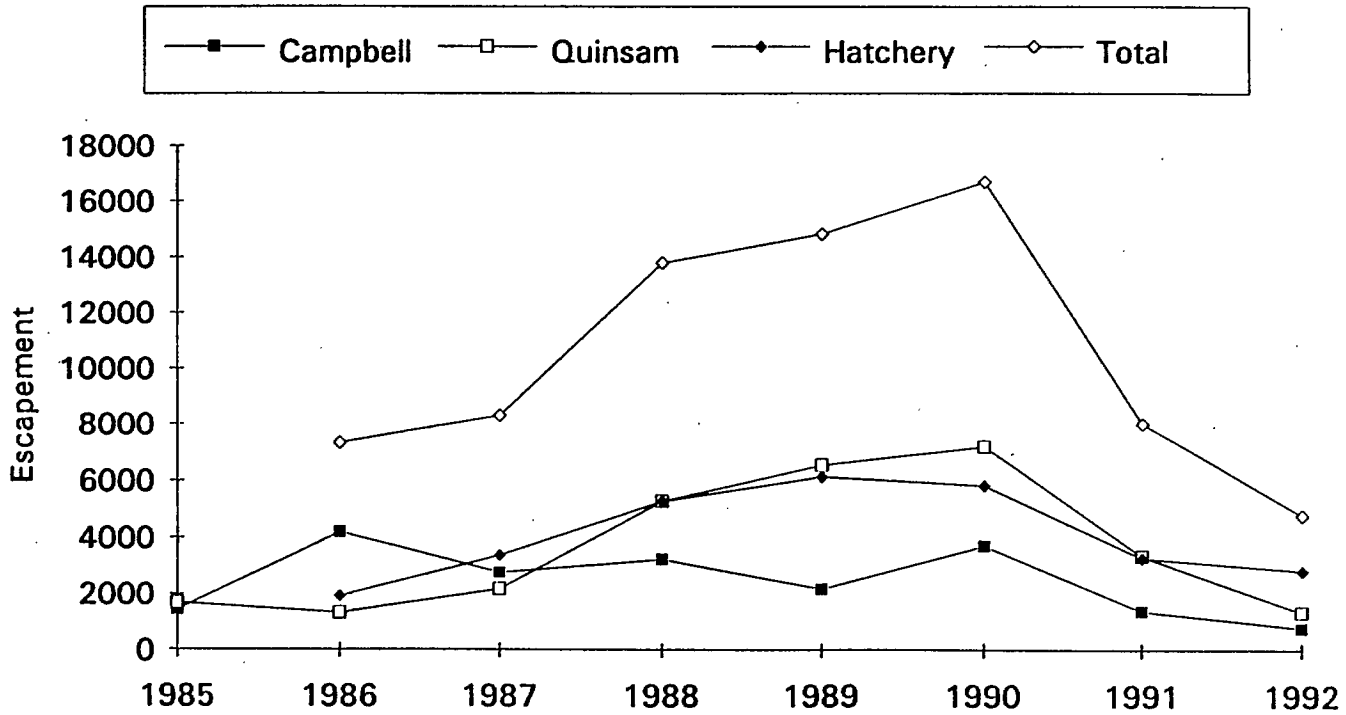


Figure 2. Chinook escapement estimates, stratified by river location, 1985 (Andrew et al. 1988), 1986-88 (Bocking et al. 1990), 1989-90 (Bocking, 1991*b*), 1992 (Frith et al. 1993) and 1992 (this study).

male = 744 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 ($P < 0.001$). Carcasses recovered in the Campbell River were significantly larger than those recovered in the Quinsam River ($P < 0.001$). Carcasses recovered in the Quinsam River were also significantly larger than chinook recovered at the hatchery (males and females, $P < 0.001$).

There was no significant difference between the mean length of chinook that were not aged and the mean length (all ages) of aged 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 1992 are shown in Table 8.

The population escapement, stratified by age class and sex, is shown in Table 9 for Campbell/Quinsam river system chinook in 1992. The sex ratio of males (not including jacks)/females was 0.84 in the Campbell River, 0.59 in the Quinsam River, and 0.99 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 1986 to 1989 brood years were captured in the dead recovery programs in 1992 (Appendix 7 and 8). There were no recoveries of adipose-clipped chinook jacks (1990 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 calculations; (Appendices 7 and 8)

2. estimates of the total escapement of adipose clips; (Table 10)

3. the observed and estimated escapement of adipose clips by tag codes, and the hatchery contribution to the escapement for each tag code; (Tables 11 to 13 and Tables 15 to 17)

4. the estimated hatchery contribution to the escapement by age class. (Tables 14 and 18)

In 1992, there were 17 adipose-clipped chinook recovered in the Campbell River dead pitch, 47 in the Quinsam River dead pitch and 199 at the hatchery rack (Table 10). The adipose clip mark rate was highest in the hatchery returns (7.4%) and lowest in the Campbell River returns (4.7%). The total estimated adipose clips to Campbell River, Quinsam River, and Quinsam Hatchery were 35, 84, and 199, 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, $P > 0.10$).

Hatchery Contributions - Method A

Results from the decoding of adipose-clipped fish from the Campbell and Quinsam river dead pitch and returns to Quinsam Hatchery are shown in Table 11. Any CWT fish recovered in the system which were released from another enhancement facility were included in the analysis (five strays from other systems to the Campbell in 1992). A total of 263 fish were recovered in 1992 and of these 252 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 1992 escapement of chinook to the Campbell River, Quinsam River and Quinsam Hatchery were 225, 1085, and 2568, respectively (Table 13).

The hatchery contributions to the total escapement of chinook in 1992, by age class is presented in Table 14. The hatchery contribution to the Campbell River population of chinook was estimated to be 12.3% for males and 43.4% for females in 1992. Contributions to the in-river Quinsam chinook escapement were 84.3% for males and 79.6% for females. This increased to 100% for males and 85.9% for females in the returns to the hatchery. Strays contributed as much as 38.7% of the total CWT returns to the Campbell River and 0% to the Quinsam River in 1992.

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 1992 escapement of chinook to the Campbell River, Quinsam River and Quinsam Hatchery using Method B were 203, 1010, and 2539, respectively (Table 17).

The hatchery contribution to the total escapement of chinook in 1992, by age class, is presented in Table 18. The 1992 hatchery contribution to the Campbell River population of chinook was estimated to be 8.5% for males and 41.2% for females. Contributions to the in-river Quinsam chinook escapement were 81:0% for males and 72.3% for females. These were lower than the 100% for males and 85.2% for females in the returns to the hatchery. The estimated stray contribution was greater than 100% of the escapement estimate in Campbell River, whereas no strays were reported for Quinsam River or hatchery. A very large expansion factor (44.0) for one of the stray CWT release groups (Table 17) caused the large expanded hatchery contribution for strays and is subject to larger error.

DISCUSSION AND CONCLUSIONS

POPULATION ESTIMATION

The separation of Petersen estimates by sex provides a more accurate estimate of the total population size. In this study, sex ratio differences occured in hatchery seines, for broodstock, dead recovery, and Petersen estimates. A higher proportion of females were recovered in the dead pitch surveys than males. Andrew et al. (1988) found similar differences in the sex ratios between dead pitch recoveries in both rivers in 1986, as did Shardlow et al. (1986) in 1984-85. Higher proportions of females than males have also been observed in spawning ground dead pitches for sockeye (Petersen 1954), pinks (Ward 1959), and coho (Eames and Hino 1981, and Eames et al. 1981). The stratification of escapement estimates by sex on the Quinsam/Campbell system should be continued to minimise error in population estimates.

Petersen estimates were also improved by stratifying estimates by river. No straying was observed between river strata or between tagging strata within each river. There was also no significant difference between the tag recovery rates in the Campbell and Quinsam rivers.

Straying between rivers by live-tagged fish was circumvented by tagging carcasses instead. However, one factor which could have produced a serious bias in the carcass tagging Petersen estimate is the incomplete mixing of tagged carcasses with the rest of the carcass population, particularly in deep pools, where many carcasses may have been immobilized. Bias due to incomplete mixing was reduced by conducting tagging and recovery effort in proportion to the distribution of fish.

AGE, LENGTH AND SEX COMPOSITION

The Campbell and Quinsam rivers chinook escapements are composed mainly of age 4 and 5 fish. The ratio of males to females, as determined from the Petersen estimates, in the Campbell River was 0.84 in 1992. The ratio of males to females in the Quinsam River was 0.59 in 1992. The sex ratio of hatchery returns was 0.99 in 1992.

CODED WIRE TAGGING AND RECOVERY

In this study, we used the adipose clip rate in the dead recovery of chinook in the rivers and at the hatchery rack to estimate the number of adipose clips in the escapement (Method A). Sampling for adipose clipped fish was random at each of these locations. The rate of recovery was 4.7% - 7.4% in 1992.

Estimates of the total hatchery contribution to the Quinsam Campbell River system were different using Method A (AFC rate) and Method B (CWT rate). Method A produced similar hatchery contribution estimates (12.3% to 100% in 1992; Table 14) to Method B (8.5% to 100%; Table 18).

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. The low number of recoveries of adipose clips and decoded CWTs (less than 20 CWTs in some brood years) may make the precision of the estimates so low as to be of relatively little use in those brood years; and

2. The sample of heads obtained for the decoding of CWTs may not be a random sample from the population and might contain a bias due to size selectivity or other factors.

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 17 to 199 adipose clips enumerated for each river stratum (jacks not included). The 95% confidence limits for 17 recoveries (based on a Poisson frequency distribution) would be approximately ± 46% and significantly smaller at 15% for 199 recoveries. These estimates of precision are conservative because the expansion factors used to estimate the total number of adipose clips/marks in the escapement are also estimated with error.

There were differences between the hatchery contribution to each of the Campbell River, the Quinsam River, and the Quinsam Hatchery within 1992. In general, there was a higher proportion of hatchery-reared fish in the Quinsam River and at the hatchery than in the Campbell River. This pattern has been observed in previous years (Bocking et al. 1990; Bocking, 1991*b*; Frith et al. 1993).

SUMMARY

1. Total escapement estimates for chinook salmon in the Campbell/Quinsam rivers system using carcass tagging were 4782 in 1992. Estimates were stratified by river and sex.

2. The age composition of chinook varied between the Campbell and Quinsam rivers and the Quinsam Hatchery. Male chinook were predominantly age 4 while females were predominantly age 4 and 5.

3. Females were more abundant in the river populations while males and females were equally abundant in the hatchery returns.

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 rivers system was 318 in 1992.

6. The total estimated hatchery contribution to the chinook escapement, based on adipose clips (Method A), was 3878 (81.1%) in 1992. The contribution estimate derived using the adjusted CWTs recovered (Method B) was lower: 3750 (78.4%).

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Table 1. Summary of methods for the Campbell and Quinsam rivers chinook salmon enumeration programs, 1992.

Item	Method and Materials 1991
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
the tags used (Size No. 3, 1 1/8 " x 1/4") are recommended for sheep and swine

Table 2. Summary of tagging and recovery effort for chinook salmon carcasses in the Campbell and Quinsam rivers, 1992.

River	No. of person days
Campbell	36
Quinsam	33

Table 3. Summary of in situ carcass tagging and dead recovery of chinook salmon in Campbell and Quinsam rivers, 1992.

Category	Campbell (a)	Quinsam (b)	Total
Carcass tagging:			
Males	54	43	97
Females	86	119	205
Jacks	0	1	1
Total	140	163	303
Dead recovery:			
Males	133	247	380
Females	211	488	699
Jacks	0	8	8
Total	344	743	1087
Tagged males (c)	20	21	41
Tagged females (c)	43	69	112
Tagged jacks (c)	0	0	0
Total tagged (c)	63	90	153
Tag rate (%)	18.3	12.1	14.1
Tag recovery rate (%)	45.0	55.2	50.5
Tag loss (%)	0.0	5.6	2.8

(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, 1992. Confidence limits are from fudicial limits for the Poisson distribution using Pearson's formulae when R is greater than 50 (Ricker 1975, p. 343).

River and Item	Male	Female	Jack (h)	Total
Campbell River (a)				
Number tags applied (d)	54	86	0	140
Number recovered (e)	133	211	0	344
Number of tagged recoveries (f)	20	43	0	63
Petersen estimate	351	419	NA	770 (i)
Lower 95% CL	232	313	NA	545 (i)
Upper 95% CL	558	575	NA	1133 (i)
Quinsam River (b, below fence)				
Number tags applied (d)	43	119	1	163
Number recovered (e)	247	488	8	743
Number of tagged recoveries (f)	21	69	0	90
Petersen estimate	496	838	NA	1334 (i)
Lower 95% CL	331	665	NA	995 (i)
Upper 95% CL	779	1057	NA	1837 (i)
Quinsam Hatchery (c)				
Number of fish (g)	1334 (j)	1344	143	2821
Total system				
Escapement estimate	2181	2601	NA	4782 (i)
Lower 95% CL	1896	2322	NA	4218 (i)
Upper 95% CL	2672	2976	NA	5648 (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 not including 1 unknown
(d) Total tagged and punched
(e) Total tagged and untagged recoveries less number observed on first day of taggging
(f) Total recoveries possessing an operculum punch (secondary mark)
(g) Confidence limits not applicable
(h) Peterson estimates were not calculated for jacks
(i) Totals not including jacks (see (h))
(j) Includes 2 males transferred above fence

Table 5. Age composition of Campbell River chinook salmon, 1992 (Determined from dead recovery).

Sex and age	Unmarked	(b) AD/CWT	Total	Percent	Postorbital-hypural length (mm) N	Mean (mm)	SD	95% CL Lower	95% CL Upper
Males (a)									
3	3	0	3	3.6	3	590	8	581	599
4	38	2	40	47.6	40	744	77	720	768
5	38	0	38	45.2	38	825	51	808	842
6	3	0	3	3.6	3	875	64	801	949
Total aged	82	2	84	100.0	84	793	94	772	813
Unknown age			9		9	748	92	686	810
Total			93						
Females									
4	29	7	36	32.2	37 (c)	751	47	736	766
5	61	6	67	59.8	67	823	38	814	832
6	9	0	9	8.0	9	885	33	863	907
Total aged	99	13	112	100.0	113	805	58	794	815
Unknown age			33		33	813	60	792	834
Total			145						

(a) No jacks were identified in the ageing analysis
(b) Including strays
(c) Includes one fish measured but not aged

Table 6. Age composition of Quinsam River chinook salmon, 1992 (Determined from dead recovery).

Sex and age	Unmarked	AD/CWT	Total	Percent	Postorbital-hypural length (mm)				
								95% CL	
					N	Mean (mm)	SD	Lower	Upper
Males (a)									
3	8	1	9	7.8	9	597	30	578	618
4	74	13	87	75.7	87	742	66	728	756
5	16	3	19	16.5	19	819	49	797	841
Total aged	98	17	115	100.0	115	744	80	729	758
Unknown age			21		21	717	86	680	754
Total			136						
Females									
4	52	10	62	49.6	62	752	44	741	763
5	44	14	58	46.4	58	820	54	806	834
6	3	2	5	4.0	5	847	27	823	871
Total aged	99	26	125	100.0	125	787	60	777	799
Unknown age			161		161	783	47	776	791
Total			286						

(a) Not including jacks

Table 7. Age composition of Quinsam Hatchery chinook salmon, 1992 (Determined from rack 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	4	8	12	5.9	12	585	52	555	615
4	82	78	160	79.2	160	726	60	717	736
5	15	15	30	14.9	30	796	57	775	817
Total aged	101	101	202	100.0	202	728	73 (b)	718	739
Unknown age			47		47	753	67	734	773
Total			249						
Females									
4	88	46	134	55.1	134	745	43	738	752
5	62	47	109	44.9	109	803	49	794	812
Total aged	150	93	243	100.0	243	771	54 (b)	764	777
Unknown age			32		32	782	56	762	802
Total			275						

(a) No jacks were identified in the ageing analysis

Table 8. Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1992.

Location	Length class (mm)	Age													
		Males (a)							Females						
		2	3	4	5	6	Total	unk(b)	2	3	4	5	6	Total	unk(b)
Campbell River															
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	1	0	0	1	1	0	0	0	0	0	0	0
	550-599	0	2	1	0	0	3	0	0	0	0	0	0	0	0
	600-649	0	1	1	0	0	2	0	0	0	0	0	0	0	0
	650-699	0	0	8	0	0	8	1	0	0	5	0	0	5	2
	700-749	0	0	6	0	0	6	2	0	0	13	2	0	15	2
	750-799	0	0	11	5	1	17	2	0	0	13	15	0	28	9
	800-849	0	0	10	14	0	24	2	0	0	4	33	1	38	11
	850-899	0	0	2	7	1	10	1	0	0	1	16	5	22	6
	900-949	0	0	0	12	1	13	0	0	0	0	1	3	4	3
	950-999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	590	744	853	875	793	748	0	0	751	823	885	805	813
	SD	0	8	77	51	64	94	98	0	0	47	38	33	58	61
	N	0	3	40	38	3	84	9	0	0	36	67	9	112	33
Quinsam River															
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	550-599	0	3	2	0	0	5	0	0	0	0	0	0	0	0
	600-649	0	6	5	0	0	11	5	0	0	1	0	0	1	0
	650-699	0	0	13	0	0	13	3	0	0	7	1	0	8	4
	700-749	0	0	19	1	0	20	6	0	0	17	1	0	18	33
	750-799	0	0	30	4	0	34	2	0	0	31	16	0	47	67
	800-849	0	0	15	10	0	25	4	0	0	6	27	1	34	40
	850-899	0	0	2	4	0	6	0	0	0	0	7	4	11	15
	900-949	0	0	1	0	0	1	1	0	0	0	5	0	5	2
	950-999	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
	Mean	0	597	742	819	0	744	717	0	0	752	820	847	787	783
	SD	0	30	66	49	0	80	86	0	0	44	54	27	60	47
	N	0	9	87	19	0	115	21	0	0	62	58	5	125	161

(a) No jacks were identified in the ageing analysis
(b) Unk = age unknown

Table 8 (cont). Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1992.

River	Length class (mm)	Age													
		Males (a)							Females						
		2	3	4	5	6	Total	unk(b)	2	3	4	5	6	Total	unk(b)
Quinsam Hatchery															
	250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	4	0	0	0	4	0	0	0	0	0	0	0	0
	550-599	0	2	1	0	0	3	0	0	0	0	0	0	0	0
	600-649	0	5	16	0	0	21	4	0	0	1	0	0	1	0
	650-699	0	1	37	1	0	39	4	0	0	18	1	0	19	2
	700-749	0	0	45	4	0	49	16	0	0	54	14	0	68	8
	750-799	0	0	38	10	0	48	13	0	0	48	39	0	87	11
	800-849	0	0	22	7	0	29	5	0	0	11	35	0	46	6
	850-899	0	0	1	8	0	9	5	0	0	1	15	0	16	5
	900-949	0	0	0	0	0	0	0	0	0	0	5	0	5	0
	950-999	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	0	585	726	796	0	728	753	0	0	745	803	0	771	782
	SD	0	52	60	57	0	73	67	0	0	43	49	0	54	56
	N	0	12	160	30	0	202	47	0	0	134	109	0	243	32

(a) Not including jacks
(b) Unk = age unknown

Table 9. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River, Quinsam Hatchery, 1992.

Location	Age	Males (a) Number	Males (a) Percent (c)	Females Number (b)	Females Percent (c)
Campbell River					
	3	13	3.6	0	0.0
	4	167	47.6	135	32.2
	5	159	45.2	251	59.8
	6	13	3.6	34	8.0
	Total	351 (d)	100.0	419 (d)	100.0
Quinsam River					
	3	39	7.8	0	0.0
	4	375	75.7	416	49.6
	5	82	16.5	389	46.4
	6	0	0.0	34	4.0
	Total	496 (d)	100.0	838 (d)	100.0
Quinsam Hatchery					
	3	79	5.9	0	0.0
	4	1057	79.2	741	55.1
	5	199	14.9	603	44.9
	Total	1334 (d)	100.0	1344 (d)	100.0

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

(b) Number of fish by age are calculated using the Total and percent age composition. Values are rounded to the nearest whole number

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

(d) Petersen estimates from Table 4

Table 10. Estimates of the total escapement of adipose clipped chinook salmon to the Campbell River, Quinsam River and the Quinsam Hatchery, 1992. 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)	144	3	2.1	351	41.0	7
	Female	215	14	6.5	419	51.3	27
	Total	359	17	4.7	770	46.6	35
Quinsam River (below fence)							
	Male (c)	253	18	7.1	496	51.0	35
	Female	496	29	5.8	838	59.2	49
	Total	749	47	6.3	1334	56.1	84
Quinsam Hatchery							
	Male (c)	1334	104	7.8	1334	100.0	104
	Female	1344	95	7.1	1344	100.0	95
	Total	2678	199	7.4	2678	100.0	199

(a) Campbell River data from Appendix 7; Quinsam River data from Appendix 8; Quinsam Hatchery data from unsummarized rack recovery data base, no adipose-clipped jacks were observed

(b) From Table 4

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

Table 11. Estimates of total escapement of adipose-clipped chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992. 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)				Quinsam River				Quinsam Hatchery				Total			
		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 (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1989	20354	0	0	0.0	0.0	0	0	0.0	0.0	5	0	5.1	0.0	5	0	5.1	0.0
	20355	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	20356	0	0	0.0	0.0	1	0	2.1	0.0	0	0	0.0	0.0	1	0	2.1	0.0
	20359	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	20360	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	0	0	0.0	0.0	1	0	2.1	0.0	8	0	8.2	0.0	9	0	10.3	0.0
1988	25526	0	0	0.0	0.0	4	0	8.2	0.0	4	7	4.1	7.2	8	7	12.4	7.2
	25527	0	1	0.0	2.1	0	3	0.0	5.7	1	0	1.0	0.0	1	4	1.0	7.7
	25528	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	25814	0	1	0.0	2.1	2	0	4.1	0.0	4	5	4.1	5.1	6	6	8.2	7.2
	25815	0	0	0.0	0.0	3	0	6.2	0.0	3	4	3.1	4.1	6	4	9.3	4.1
	25816	1	0	3.5	0.0	1	0	2.1	0.0	7	3	7.2	3.1	9	3	12.8	3.1
	25817	0	0	0.0	0.0	1	0	2.1	0.0	4	4	4.1	4.1	5	4	6.2	4.1
	25818	0	0	0.0	0.0	2	0	4.1	0.0	11	6	11.3	6.1	13	6	15.4	6.1
	25819	0	1	0.0	2.1	0	1	0.0	1.9	9	6	9.3	6.1	9	8	9.3	10.1
	25820	0	0	0.0	0.0	0	2	0.0	3.8	18	6	18.5	6.1	18	8	18.5	9.9
	25821	0	0	0.0	0.0	2	0	4.1	0.0	7	3	7.2	3.1	9	3	11.3	3.1
	25822	0	0	0.0	0.0	0	2	0.0	3.8	9	2	9.3	2.0	9	4	9.3	5.8
	Subtotal	1	3	3.5	6.2	15	8	30.9	15.1	78	46	80.3	47.0	94	57	114.7	68.3

(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 1992. 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)				Quinsam River				Quinsam Hatchery				Total			
		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 (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1987	24419	0	1	0.0	2.1	0	0	0.0	0.0	1	2	1.0	2.0	1	3	1.0	4.1
	24420	0	0	0.0	0.0	0	3	0.0	5.7	0	3	0.0	3.1	0	6	0.0	8.7
	24421	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	2.0	1	2	1.0	2.0
	24736	0	0	0.0	0.0	0	1	0.0	1.9	1	1	1.0	1.0	1	2	1.0	2.9
	24737	0	2	0.0	4.2	0	0	0.0	0.0	0	5	0.0	5.1	0	7	0.0	9.3
	24956	0	0	0.0	0.0	1	0	2.1	0.0	3	5	3.1	5.1	4	5	5.1	5.1
	25358	0	1	0.0	2.1	0	3	0.0	5.7	2	6	2.1	6.1	2	10	2.1	13.9
	25359	0	0	0.0	0.0	0	1	0.0	1.9	0	7	0.0	7.2	0	8	0.0	9.0
	25360	0	1	0.0	2.1	0	1	0.0	1.9	1	5	1.0	5.1	1	7	1.0	9.1
	25361	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.1	1.0	2	1	2.1	1.0
	25362	0	0	0.0	0.0	0	6	0.0	11.3	4	6	4.1	6.1	4	12	4.1	17.4
	25363	0	1	0.0	2.1	0	1	0.0	1.9	0	4	0.0	4.1	0	6	0.0	8.0
	Subtotal	0	6	0.0	12.5	1	16	2.1	30.2	15	47	15.4	48.0	16	69	17.5	90.6
1986	24153	0	0	0.0	0.0	0	1	0.0	1.9	0	0	0.0	0.0	0	1	0.0	1.9
	24156	0	0	0.0	0.0	0	1	0.0	1.9	0	0	0.0	0.0	0	1	0.0	1.9
	Subtotal	0	0	0.0	0.0	0	2	0.0	3.8	0	0	0.0	0.0	0	2	0.0	3.8
Total hatchery		1	9	3.5	18.7	17	26	35.0	49.0	101	93	104.0	95.0	119	128	142.5	162.7

(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 1992. 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)				Quinsam River				Quinsam Hatchery				Total			
		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 (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Strays: (d)																	
1988	25701	0	1	0.0	2.1	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	2.1
	25703	0	1	0.0	2.1	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	2.1
	25705	0	1	0.0	2.1	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	2.1
	25837	1	0	3.5	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	3.5	0.0
	26056	0	1	0.0	1.9	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.9
Total strays		1	4	3.5	8.2	0	0	0.0	0.0	0	0	0.0	0.0	1	4	3.5	8.2
Total CWT (c)		2	13	7.0	27.0	17	26	35.0	49.0	101	93	104.0	95.0	120	132	147.0	176.0
No data (5000)		0	0			0	0			0	0			0	0		
No pin (8000)		1	1			1	3			3	2			5	6		
Lost pin (9000)		0	0			0	0			0	0			0	0		
Observed adipose		3	14			18	29			104	95			125	138		

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

Table 12. CWT release data for hatchery-reared chinook salmon returning to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992.

Brood year	CWT code	Release numbers		CWT loss (%)	Days held	Adipose release status	
		CWT	Untagged			Clipped	Unclipped
1989	20354	23306	174330	1.9	12	23757	173879
	20355	22574	263949	0.8	11	22756	263767
	20356	23041	259539	1.0	10	23274	259306
	20359	24396	300109	2.7	10	25073	299432
	20360	24499	291972	1.9	10	24973	291498
1988	25526	24624	182558	1.4	7	24974	182208
	25527	23937	244318	2.8	7	24627	243628
	25528	24329	255180	1.4	7	24674	254835
	25814	25246	289421	1.4	7	25604	289063
	25815	25545	292789	1.2	7	25855	292479
	25816	22344	256059	1.0	7	22570	255833
	25817	25029	268880	0.0	7	25029	268880
	25818	25096	269867	0.0	7	25096	269867
	25819	25037	270958	0.0	7	25037	270958
	25820	24810	406636	1.4	7	25162	406284
	25821	24609	403341	1.4	7	24958	402992
	25822	24884	407850	1.4	7	25237	407497
1987	24419	24457	333484	1.9	unk	24931	333010
	24420	24386	332520	1.9	unk	24858	332048
	24421	24486	333883	1.9	unk	24960	333409
	24736	20607	65511	1.9	unk	21006	65112
	24737	20607	65511	1.9	unk	21006	65112
	24956	24641	330657	1.9	10	25118	330180
	25358	24677	310364	1.6	10	25078	309963
	25359	24727	310993	1.9	10	25206	310514
	25360	24834	312340	1.9	10	25315	311859
	25361	24504	328819	1.9	10	24979	328344
	25362	24483	328536	1.9	10	24957	328062
	25363	24222	51484	1.9	10	24691	51015
1986	24153	19935	276591	0.0	0	19935	276591
	24156	20006	467555	0.0	0	20006	467555
	Total hatchery	739878	8686004			750704	8675178
Strays: (a)							
1988	25701	9893	9	0.1	3	9902	0
1988	25703	9864	9	0.1	3	9873	0
1988	25705	9888	9	0.1	3	9897	0
1988	25837	25026	1075504	0.1	3	25051	1075479
1988	26056	25079	1765174	0.1	3	25104	1765149

(a) Strays came from Robertson Creek

Table 13. Estimates of total escapement of hatchery-reared chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992 (Method A). The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 11) to account for unclipped hatchery releases and, hence, derive hatchery contributions to escapement.
Expansion factor = (adipose clipped + unclipped releases)/adipose-clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion factor	Expanded hatchery contributions (a)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		Clipped	Unclipped		M (b)	F	M	F	M	F	M	F
1989	20354	23757	173879	8.3	0.0	0.0	0.0	0.0	42.8	0.0	42.8	0.0
	20355	22756	263767	12.6	0.0	0.0	0.0	0.0	13.0	0.0	13.0	0.0
	20356	23274	259306	12.1	0.0	0.0	25.0	0.0	0.0	0.0	25.0	0.0
	20359	25073	299432	12.9	0.0	0.0	0.0	0.0	13.3	0.0	13.3	0.0
	20360	24973	291498	12.7	0.0	0.0	0.0	0.0	13.0	0.0	13.0	0.0
	Subtotal	119834	1287881		0.0	0.0	25.0	0.0	82.2	0.0	107.2	0.0
1988	25526	24974	182208	8.3	0.0	0.0	68.3	0.0	34.2	59.3	102.5	59.3
	25527	24627	243628	10.9	0.0	22.6	0.0	61.6	11.2	0.0	11.2	84.2
	25528	24674	254835	11.3	0.0	0.0	0.0	0.0	11.7	0.0	11.7	0.0
	25814	25604	289063	12.3	0.0	25.5	50.6	0.0	50.6	62.8	101.2	88.3
	25815	25855	292479	12.3	0.0	0.0	76.0	0.0	38.0	50.3	114.1	50.3
	25816	22570	255833	12.3	43.2	0.0	25.4	0.0	88.9	37.8	157.5	37.8
	25817	25029	268880	11.7	0.0	0.0	24.2	0.0	48.4	48.0	72.5	48.0
	25818	25096	269867	11.8	0.0	0.0	48.4	0.0	133.1	72.0	181.5	72.0
	25819	25037	270958	11.8	0.0	24.6	0.0	22.3	109.6	72.5	109.6	119.3
	25820	25162	406284	17.1	0.0	0.0	0.0	64.6	317.8	105.1	317.8	169.7
	25821	24958	402992	17.1	0.0	0.0	70.6	0.0	123.6	52.5	194.2	52.5
	25822	25237	407497	17.1	0.0	0.0	0.0	64.6	158.9	35.0	158.9	99.7
	Subtotal	298824	3544523		43.2	72.7	363.5	213.1	1126.0	595.3	1532.7	881.2
1987	24419	24931	333010	14.4	0.0	29.8	0.0	0.0	14.8	29.3	14.8	59.2
	24420	24858	332048	14.4	0.0	0.0	0.0	81.2	0.0	44.0	0.0	125.2
	24421	24960	333409	14.4	0.0	0.0	0.0	0.0	14.8	29.3	14.8	29.3
	24736	21006	65112	4.1	0.0	0.0	0.0	7.7	4.2	4.2	4.2	11.9
	24737	21006	65112	4.1	0.0	17.0	0.0	0.0	0.0	20.9	0.0	38.0
	24956	25118	330180	14.1	0.0	0.0	29.1	0.0	43.7	72.2	72.8	72.2

(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 1992 (Method A). The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 11) to account for unclipped hatchery releases and, hence, derive hatchery contributions to escapement.
Expansion factor = (adipose clipped + unclipped releases)/adipose-clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion Factor	Expanded hatchery contributions (a)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		Clipped	Unclipped		M (b)	F	M	F	M	F	M	F
	25358	25078	309963	13.4	0.0	27.7	0.0	75.5	27.5	81.9	27.5	185.2
	25359	25206	310514	13.3	0.0	0.0	0.0	25.1	0.0	95.2	0.0	120.3
	25360	25315	311859	13.3	0.0	27.7	0.0	25.1	13.7	68.0	13.7	120.8
	25361	24979	328344	14.1	0.0	0.0	0.0	0.0	29.1	14.4	29.1	14.4
	25362	24957	328062	14.1	0.0	0.0	0.0	159.9	58.3	86.7	58.3	246.6
	25363	24691	51015	3.1	0.0	6.4	0.0	5.8	0.0	12.5	0.0	24.7
	Subtotal	292106	3098627		0.0	108.6	29.1	380.4	206.1	558.9	235.2	1047.9
1986	24153	19935	276591	14.9	0.0	0.0	0.0	28.0	0.0	0.0	0.0	28.0
	24156	20006	467555	24.4	0.0	0.0	0.0	45.9	0.0	0.0	0.0	45.9
	Subtotal	39941	744146		0.0	0.0	0.0	74.0	0.0	0.0	0.0	74.0
Total hatchery					43.2	181.3	417.7	667.5	1414.2	1154.2	1875.1	2003.0
Strays (d)												
1988	25701	9902	0	1.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.1
1988	25703	9873	0	1.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.1
1988	25705	9897	0	1.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	2.1
1988	25837	25051	1075479	43.9	153.8	0.0	0.0	0.0	0.0	0.0	153.8	0.0
1988	26056	25104	1765149	71.3	0.0	137.5	0.0	0.0	0.0	0.0	0.0	137.5

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

Table 14. Estimated hatchery contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1992. 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	13	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	167	135	43	25.7	73	54.1	0	0.0	0	0.0
	5	159	251	0	0.0	109	43.4	154	96.9	144	57.4
	6	13	34	0	0.0	0	0.0	0	0.0	0	0.0
	Total	351	419	43	12.3	182	43.4	154	43.9	144	34.4
Quinsam River											
	3	39	0	25	64.1	0	0.0	0	0.0	0	0.0
	4	375	416	364	97.1	213	51.2	0	0.0	0	0.0
	5	82	389	29	35.4	380	97.7	0	0.0	0	0.0
	6	0	34	0	0.0	74	100 (e)	0	0.0	0	0.0
	Total	496	838	418	84.3	667	79.6	0	0.0	0	0.0
Quinsam Hatchery (d)											
	3	79	0	82	100 (e)	0	0.0	0	0.0	0	0.0
	4	1057	741	1126	100 (e)	595	80.3	0	0.0	0	0.0
	5	199	603	206	100 (e)	559	92.7	0	0.0	0	0.0
	Total	1334	1344	1414	100 (e)	1154	85.9	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, 1992. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 17 (Method B).

Brood year	CWT code	Campbell River (a)				Quinsam River				Quinsam Hatchery				Total			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
		M (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1989	20354	0	0	0.0	0.0	0	0	0.0	0.0	5	0	5.0	0.0	5	0	5.0	0.0
	20355	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	20356	0	0	0.0	0.0	1	0	1.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0
	20359	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	20360	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	0	0	0.0	0.0	1	0	1.0	0.0	8	0	8.0	0.0	9	0	9.0	0.0
1988	25526	0	0	0.0	0.0	4	0	4.0	0.0	4	7	4.0	7.0	8	7	8.0	7.0
	25527	0	1	0.0	1.0	0	3	0.0	3.0	1	0	1.0	0.0	1	4	1.0	4.0
	25528	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.0
	25814	0	1	0.0	1.0	2	0	2.0	0.0	4	5	4.0	5.0	6	6	6.0	6.0
	25815	0	0	0.0	0.0	3	0	3.0	0.0	3	4	3.0	4.0	6	4	6.0	4.0
	25816	1	0	1.0	0.0	1	0	1.0	0.0	7	3	7.0	3.0	9	3	9.0	3.0
	25817	0	0	0.0	0.0	1	0	1.0	0.0	4	4	4.0	4.0	5	4	5.0	4.0
	25818	0	0	0.0	0.0	2	0	2.0	0.0	11	6	11.0	6.0	13	6	13.0	6.0
	25819	0	1	0.0	1.0	0	1	0.0	1.0	9	6	9.0	6.0	9	8	9.0	8.0
	25820	0	0	0.0	0.0	0	2	0.0	2.0	18	6	18.0	6.0	18	8	18.0	8.0
	25821	0	0	0.0	0.0	2	0	2.0	0.0	7	3	7.0	3.0	9	3	9.0	3.0
	25822	0	0	0.0	0.0	0	2	0.0	2.0	9	2	9.0	2.0	9	4	9.0	4.0
	Subtotal	1	3	1.0	3.0	15	8	15.0	8.0	78	46	78.0	46.0	94	57	94.0	57.0
1987	24419	0	1	0.0	1.0	0	0	0.0	0.0	1	2	1.0	2.0	1	3	1.0	3.0
	24420	0	0	0.0	0.0	0	3	0.0	3.0	0	3	0.0	3.0	0	6	0.0	6.0
	24421	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	2.0	1	2	1.0	2.0
	24736	0	0	0.0	0.0	0	1	0.0	1.0	1	1	1.0	1.0	1	2	1.0	2.0
	24737	0	2	0.0	2.0	0	0	0.0	0.0	0	5	0.0	5.0	0	7	0.0	7.0
	24956	0	0	0.0	0.0	1	0	1.0	0.0	3	5	3.0	5.0	4	5	4.0	5.0
	25358	0	1	0.0	1.0	0	3	0.0	3.0	2	6	2.0	6.0	2	10	2.0	10.0
	25359	0	0	0.0	0.0	0	1	0.0	1.0	0	7	0.0	7.0	0	8	0.0	8.0
	25360	0	1	0.0	1.0	0	1	0.0	1.0	1	5	1.0	5.0	1	7	1.0	7.0

(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, 1992. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 17 (Method B).

		Campbell River (a)				Quinsam River				Quinsam Hatchery				Total			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	25361	0	0	0.0	0.0	0	0	0.0	0.0	2	1	2.0	1.0	2	1	2.0	1.0
	25362	0	0	0.0	0.0	0	6	0.0	6.0	4	6	4.0	6.0	4	12	4.0	12.0
	25363	0	1	0.0	1.0	0	1	0.0	1.0	0	4	0.0	4.0	0	6	0.0	6.0
	Subtotal	0	6	0.0	6.0	1	16	1.0	16.0	15	47	15.0	47.0	16	69	16.0	69.0
1986	24153	0	0	0.0	0.0	0	1	0.0	1.0	0	0	0.0	0.0	0	1	0.0	1.0
	24156	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	2	0.0	2.0	0	0	0.0	0.0	0	2	0.0	2.0
	Total hatchery	1	9	1.0	9.0	17	26	17.0	26.0	101	93	101.0	93.0	119	128	119.0	128.0
Strays: (c)																	
1988	25701	0	1	0.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0
	25703	0	1	0.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0
	25705	0	1	0.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0
	25837	1	0	1.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0
	26056	0	1	0.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0
	Total strays	1	4	1.0	4.0	0	0	0.0	0.0	0	0	0.0	0.0	1	4	1.0	4.0
	Total CWT	2	13	2.0	13.0	17	26	17.0	26.0	101	93	101.0	93.0	120	132	120.0	132.0
No data (5000)		0	0			0	0			0	0			0	0		
No pin (8000)		1	1			1	3			3	2			5	6		
Lost pin (9000)		0	0			0	0			0	0			0	0		
Observed adipose		3	14			18	29			104	95			125	138		

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

(b) Does not include jacks

(c) Adipose-clipped fish that have strayed from other systems

Table 16. Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method B).

		Campbell River (a)				Quinsam River				Quinsam Hatchery				Total			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1989	20354	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0	5.0	0.0
	20355	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
	20356	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0
	20359	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
	20360	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	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	8.0	0.0	8.0	0.0	9.0	0.0	10.0	0.0
1988	25526	0.0	0.0	0.0	0.0	4.0	0.0	7.8	0.0	4.0	7.0	4.0	7.0	8.0	7.0	11.8	7.0
	25527	0.0	1.0	0.0	1.9	0.0	3.0	0.0	5.1	1.0	0.0	1.0	0.0	1.0	4.0	1.0	7.0
	25528	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
	25814	0.0	1.0	0.0	1.9	2.0	0.0	3.9	0.0	4.0	5.0	4.0	5.0	6.0	6.0	7.9	6.9
	25815	0.0	0.0	0.0	0.0	3.0	0.0	5.9	0.0	3.0	4.0	3.0	4.0	6.0	4.0	8.9	4.0
	25816	1.0	0.0	2.4	0.0	1.0	0.0	2.0	0.0	7.0	3.0	7.0	3.0	9.0	3.0	11.4	3.0
	25817	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	4.0	4.0	4.0	4.0	5.0	4.0	6.0	4.0
	25818	0.0	0.0	0.0	0.0	2.0	0.0	3.9	0.0	11.0	6.0	11.0	6.0	13.0	6.0	14.9	6.0
	25819	0.0	1.0	0.0	1.9	0.0	1.0	0.0	1.7	9.0	6.0	9.0	6.0	9.0	8.0	9.0	9.6
	25820	0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.4	18.0	6.0	18.0	6.0	18.0	8.0	18.0	9.4
	25821	0.0	0.0	0.0	0.0	2.0	0.0	3.9	0.0	7.0	3.0	7.0	3.0	9.0	3.0	10.9	3.0
	25822	0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.4	9.0	2.0	9.0	2.0	9.0	4.0	9.0	5.4
	Subtotal	1.0	3.0	2.4	5.8	15.0	8.0	29.4	13.5	78.0	46.0	78.0	46.0	94.0	57.0	109.8	65.4
1987	24419	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	1.0	2.0	1.0	2.0	1.0	3.0	1.0	3.9
	24420	0.0	0.0	0.0	0.0	0.0	3.0	0.0	5.1	0.0	3.0	0.0	3.0	0.0	6.0	0.0	8.1
	24421	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
	24736	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.7
	24737	0.0	2.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	5.0	0.0	5.0	0.0	7.0	0.0	8.9
	24956	0.0	0.0	0.0	0.0	1.0	0.0	2.0	0.0	3.0	5.0	3.0	5.0	4.0	5.0	5.0	5.0
	25358	0.0	1.0	0.0	1.9	0.0	3.0	0.0	5.1	2.0	6.0	2.0	6.0	2.0	10.0	2.0	13.0
	25359	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7	0.0	7.0	0.0	7.0	0.0	8.0	0.0	8.7

(continued)

Table 16 (cont.). Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method B).

		Campbell River (a)				Quinsam River				Quinsam Hatchery				Total			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
	25360	0.0	1.0	0.0	1.9	0.0	1.0	0.0	1.7	1.0	5.0	1.0	5.0	1.0	7.0	1.0	8.6
	25361	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
	25362	0.0	0.0	0.0	0.0	0.0	6.0	0.0	10.1	4.0	6.0	4.0	6.0	4.0	12.0	4.0	16.1
	25363	0.0	1.0	0.0	1.9	0.0	1.0	0.0	1.7	0.0	4.0	0.0	4.0	0.0	6.0	0.0	7.6
	Subtotal	0.0	6.0	0.0	11.7	1.0	16.0	2.0	27.0	15.0	47.0	15.0	47.0	16.0	69.0	17.0	85.7
1986	24153	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7
	24156	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.7
	Subtotal	0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	2.0	0.0	3.4
Total hatchery		1.0	9.0	2.4	17.5	17.0	26.0	33.3	43.9	101.0	93.0	101.0	93.0	119.0	128.0	136.8	154.5
Strays: (c)																	
1988	25701	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.9
	25703	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
	25705	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.9
	25837	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26056	1.0	4.0	2.4	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	2.4	7.8
Total strays		2.0	6.0	4.9	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.0	4.9	11.7
Petersen est. (d)		351	419			496	838			1334	1344						
Sample size (d)		144	215			253	496			1334	1344						

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

Table 17. Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1992 (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)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		CWT	Untagged (d)		M (b)	F	M	F	M	F	M	F
1989	20354	23306	174330	8.5	0.0	0.0	0.0	0.0	42.4	0.0	42.4	0.0
	20355	22574	263949	12.7	0.0	0.0	0.0	0.0	12.7	0.0	12.7	0.0
	20356	23041	259539	12.3	0.0	0.0	24.0	0.0	0.0	0.0	24.0	0.0
	20359	24396	300109	13.3	0.0	0.0	0.0	0.0	13.3	0.0	13.3	0.0
	20360	24499	291972	12.9	0.0	0.0	0.0	0.0	12.9	0.0	12.9	0.0
	Subtotal	117816	1289899		0.0	0.0	24.0	0.0	81.3	0.0	105.4	0.0
1988	25526	24624	182558	8.4	0.0	0.0	66.0	0.0	33.7	58.9	99.6	58.9
	25527	23937	244318	11.2	0.0	21.8	0.0	56.8	11.2	0.0	11.2	78.6
	25528	24329	255180	11.5	0.0	0.0	0.0	0.0	11.5	0.0	11.5	0.0
	25814	25246	289421	12.5	0.0	24.3	48.9	0.0	49.9	62.3	98.7	86.6
	25815	25545	292789	12.5	0.0	0.0	73.3	0.0	37.4	49.8	110.7	49.8
	25816	22344	256059	12.5	30.4	0.0	24.4	0.0	87.2	37.4	142.0	37.4
	25817	25029	268880	11.7	0.0	0.0	23.0	0.0	47.0	47.0	70.0	47.0
	25818	25096	269867	11.8	0.0	0.0	46.1	0.0	129.3	70.5	175.4	70.5
	25819	25037	270958	11.8	0.0	23.0	0.0	20.0	106.4	70.9	106.4	113.9
	25820	24810	406636	17.4	0.0	0.0	0.0	58.8	313.0	104.3	313.0	163.1
	25821	24609	403341	17.4	0.0	0.0	68.2	0.0	121.7	52.2	189.9	52.2
	25822	24884	407850	17.4	0.0	0.0	0.0	58.8	156.5	34.8	156.5	93.5
	Subtotal	295490	3547857		30.4	69.2	349.9	194.3	1104.7	588.2	1485.0	851.6
1987	24419	24457	333484	14.6	0.0	28.5	0.0	0.0	14.6	29.3	14.6	57.8
	24420	24386	332520	14.6	0.0	0.0	0.0	74.2	0.0	43.9	0.0	118.1
	24421	24486	333883	14.6	0.0	0.0	0.0	0.0	14.6	29.3	14.6	29.3

(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, 1992 (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)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		CWT	Untagged (d)		M (b)	F	M	F	M	F	M	F
	24736	20607	65511	4.2	0.0	0.0	0.0	7.1	4.2	4.2	4.2	11.2
	24737	20607	65511	4.2	0.0	16.3	0.0	0.0	0.0	20.9	0.0	37.2
	24956	24641	330657	14.4	0.0	0.0	28.3	0.0	43.3	72.1	71.5	72.1
	25358	24677	310364	13.6	0.0	26.5	0.0	68.8	27.2	81.5	27.2	176.7
	25359	24727	310993	13.6	0.0	0.0	0.0	22.9	0.0	95.0	0.0	118.0
	25360	24834	312340	13.6	0.0	26.5	0.0	22.9	13.6	67.9	13.6	117.3
	25361	24504	328819	14.4	0.0	0.0	0.0	0.0	28.8	14.4	28.8	14.4
	25362	24483	328536	14.4	0.0	0.0	0.0	146.2	57.7	86.5	57.7	232.7
	25363	24222	51484	3.1	0.0	6.1	0.0	5.3	0.0	12.5	0.0	23.9
	Subtotal	286631	3104102		0.0	103.8	28.3	347.4	204.0	557.4	232.2	1008.6
1986	24153	19935	276591	14.9	0.0	0.0	0.0	25.1	0.0	0.0	0.0	25.1
	24156	20006	467555	24.4	0.0	0.0	0.0	41.2	0.0	0.0	0.0	41.2
	Subtotal	39941	744146		0.0	0.0	0.0	66.3	0.0	0.0	0.0	66.3
Total hatchery					30.4	173.0	402.2	608.0	1390.0	1145.6	1822.5	1926.6

(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, 1992 (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)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		CWT	Untagged (d)		M (b)	F	M	F	M	F	M	F
Strays: (e)												
1988	25701	9893	9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25703	9864	9	1.0	2.4	7.8	0.0	0.0	0.0	0.0	2.4	7.8
	25705	9888	9	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25837	25026	1075504	44.0	214.4	514.2	0.0	0.0	0.0	0.0	214.4	514.2
	26056	25079	1765174	71.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total strays					216.8	522.0	0.0	0.0	0.0	0.0	216.8	522.0

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) From Table 12
(d) Untagged = AD only (ie. tag lost) + unmarked (ie. no CWT/AFC applied)
(e) CWT chinook that have strayed from other systems

Table 18. Estimated hatchery and stray contribution to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1992. 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	13	0	0	0.0	0	0.0	0	0.0	0	0.0
	4	167	135	30	18.0	69	51.1	217	100 (d)	522	100 (d)
	5	159	251	0	0.0	104	41.4	0	0.0	0	0.0
	6	13	34	0	0.0	0	0.0	0	0.0	0	0.0
	Total	352	419	30	8.5	173	41.3	217	61.6	522	100 (d)
Quinsam River											
	3	39	0	24	61.5	0	0.0	0	0.0	0	0.0
	4	375	416	350	93.3	194	46.6	0	0.0	0	0.0
	5	82	389	28	34.1	347	89.2	0	0.0	0	0.0
	6	0	34	0	0.0	66	100 (d)	0	0.0	0	0.0
	Total	496	838	402	81.0	607	72.4	0	0.0	0	0.0
Quinsam Hatchery											
	3	79	0	82	0.0	0	0.0	0	0.0	0	0.0
	4	1057	741	1107	100 (d)	588	79.4	0	0.0	0	0.0
	5	199	603	204	100 (d)	557	92.4	0	0.0	0	0.0
	Total	1334	1344	1393	100 (d)	1145	85.2	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. Staple tagging of chinook salmon carcasses in Campbell River, 1992.

Date	Capture area (a)	Tagged			
		Male	Female	Jack	Total
Oct-20	1A	3	1	0	4
	1B	1	1	0	2
Oct-21	1A	0	1	0	1
	1B	6	4	0	10
Oct-27	1A	0	1	0	1
	1B	7	18	0	25
Oct-28	1A	3	6	0	9
	1B	4	1	0	5
Oct-30	1A	0	3	0	3
	1B	9	8	0	17
Nov-03	1A	1	1	0	2
	1B	7	16	0	23
Nov-04	1A	4	5	0	9
	1B	3	5	0	8
Nov-06	1A	0	1	0	1
	1B	4	4	0	8
Nov-10	1A	0	1	0	1
	1B	2	2	0	4
Nov-11	1A	0	4	0	4
	1B	0	0	0	0
Nov-13	1A	0	0	0	0
	1B	0	3	0	3
Totals		54	86	0	140

(a) See Figure 1 for location of capture areas

Appendix 2. Staple tagging of chinook salmon carcasses in Quinsam River, 1992.

Date	Capture area (a)	Tagged			
		Male	Female	Jack	Total
Oct-19	2B	1	0	0	1
	2C	0	1	0	1
	2D	1	2	0	3
Oct-22	2B	0	1	0	1
	2C	0	1	0	1
	2D	0	3	0	3
Oct-26	2B	1	3	0	4
	2C	3	4	0	7
	2D	1	5	0	6
Oct-29	2B	1	7	0	8
	2C	6	7	0	13
	2D	2	10	0	12
Nov-02	2B	2	8	0	10
	2C	4	9	0	13
	2D	3	9	0	12
Nov-05	2B	0	2	0	2
	2C	2	6	0	8
	2D	2	6	0	8
Nov-09	2B	1	2	0	3
	2C	1	5	0	6
	2D	2	5	0	7
Nov-12	2B	2	4	0	6
	2C	1	4	0	5
	2D	2	6	1	9
Nov-16	2B	0	5	0	5
	2C	3	3	0	6
	2D	2	1	0	3
Nov-19	2B	0	0	0	0
	2C	0	0	0	0
	2D	0	0	0	0
Totals		43	119	1	163

(a) See Fig.1 for location of capture areas

Appendix 3. Dead recovery of tagged chinook salmon carcasses in Campbell River, 1992.

Date	Recovery area (a)	Recovered			
		Male	Female	Jack	Total
Oct-21	1B	1	0	0	1
Oct-27	1B	1	2	0	3
Oct-28	1A	0	1	0	1
	1B	0	1	0	1
Oct-30	1B	0	10	0	10
Nov-03	1A	0	2	0	2
	1B	7	7	0	14
Nov-04	1A	1	3	0	4
	1B	2	1	0	3
Nov-06	1A	1	1	0	2
	1B	2	5	0	7
Nov-10	1B	0	5	0	5
Nov-11	1A	1	1	0	2
Nov-13	1A	0	1	0	1
	1B	4	3	0	7
	Total	20	43	0	63

(a) See Fig.1 for location of recovery areas

Appendix 4. Dead recovery of tagged chinook salmon carcasses in Quinsam River, 1992.

Date	Capture area (a)	Recovered			
		Male	Female	Jack	Total
Oct-22	2D	0	1	0	1
Oct-26	2C	1	1	0	2
	2D	0	1	0	1
Oct-29	2B	0	2	0	2
	2C	2	2	0	4
	2D	0	2	0	2
Nov-02	2B	0	2	0	2
	2C	1	6	0	7
	2D	1	3	0	4
Nov-05	2B	2	2	0	4
	2C	1	5	0	6
	2D	1	9	0	10
Nov-09	2B	0	0	0	0
	2C	0	4	0	4
	2D	3	4	0	7
Nov-12	2B	0	3	0	3
	2C	2	3	0	5
	2D	2	4	0	6
Nov-16	2B	1	2	0	3
	2C	0	4	0	4
	2D	1	3	0	4
Nov-19	2B	0	1	0	1
	2C	2	5	0	7
	2D	1	0	0	1
	Total	21	69	0	90

(a) See Fig.1 for location of capture areas

Appendix 5. Sequential mark-recapture data for chinook salmon carcasses in Campbell River, 1992. 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
Oct-20	11	4	0	4	2	0	0	0	0	15	6	0
Oct-21	12	6	1	12	5	0	0	0	0	24	11	1
Oct-27	24	7	1	48	19	2	0	0	0	72	26	3
Oct-28	18	7	0	16	7	2	0	0	0	34	14	2
Oct-30	22	9	0	22	11	10	0	0	0	44	20	10
Nov-03	21	8	7	34	17	9	0	0	0	55	25	16
Nov-04	13	7	3	30	10	4	0	0	0	43	17	7
Nov-06	8	4	3	19	5	6	0	0	0	27	9	9
Nov-10	7	2	0	7	3	5	0	0	0	14	5	5
Nov-11	1	0	1	9	4	1	0	0	0	10	4	2
Nov-13	7	0	4	14	3	4	0	0	0	21	3	8
Total	144	54	20	215	86	43	0	0	0	359	140	63
Totals for MR(a)	133	54	20	211	86	43	0	0	0	344	134	63

(a) To be used in the Peterson 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, 1992. Carcasses examined on or before the first date of tagging are not included in the number examined for the mark-recapture estimate (MR).

Date	Male			Female			Jack			Total		
	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered
Oct-19	6	2	0	8	3	0	0	0	0	14	5	0
Oct-22	2	0	0	17	5	1	0	0	0	19	5	1
Oct-26	21	5	1	41	12	2	3	0	0	65	17	3
Oct-29	56	9	2	96	24	6	2	0	0	154	33	8
Nov-02	64	9	2	121	26	11	0	0	0	185	35	13
Nov-05	22	4	4	58	14	16	0	0	0	80	18	20
Nov-09	26	4	3	43	12	8	1	0	0	70	16	11
Nov-12	30	5	4	56	14	10	1	1	0	87	20	14
Nov-16	19	5	2	42	9	9	0	0	0	61	14	11
Nov-19	7	0	3	14	0	6	1	0	0	22	0	9
Total	253	43	21	496	119	69	8	1	0	757	163	90
Totals for MR(a)	247	43	21	488	119	69	8	1	0	743	163	90

(a) To be used in the Peterson 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, 1992 (a).

	Area 1A								Area 1B							
	Total recovered (b)				Adipose clipped recovered				Total recovered (b)				Adipose clipped recovered			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
Oct-20	8	2	0	10	1	0	0	1	3	2	0	5	0	0	0	0
Oct-21	1	2	0	3	0	0	0	0	11	10	0	21	0	1	0	1
Oct-27	0	3	0	3	0	1	0	1	24	45	0	69	0	2	0	2
Oct-28	11	13	0	24	0	1	0	1	7	3	0	10	0	1	0	1
Oct-30	3	5	0	8	0	0	0	0	19	17	0	36	1	0	0	1
Nov-03	2	4	0	6	0	1	0	1	19	30	0	49	1	0	0	1
Nov-04	5	16	0	21	0	3	0	3	8	14	0	22	0	2	0	2
Nov-06	0	1	0	1	0	0	0	0	8	18	0	26	0	0	0	0
Nov-10	0	1	0	1	0	0	0	0	7	6	0	13	0	1	0	1
Nov-11	1	8	0	9	0	1	0	1	0	1	0	1	0	0	0	0
Nov-13	0	1	0	1	0	0	0	0	7	13	0	20	0	0	0	0
Total	31	56	0	87	1	7	0	8	113	159	0	272	2	7	0	9

(a) See Fig. 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, 1992 (a).

	Area 2B								Area 2C								Area 2D							
	Total recovered (b)				Adipose clipped recovered				Total recovered (b)				Adipose clipped recovered				Total recovered (b)				Adipose clipped recovered			
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
Oct-19	1	1	0	2	0	0	0	0	1	4	0	5	0	0	0	0	4	3	0	7	0	0	0	0
Oct-22	0	4	0	4	0	0	0	0	0	6	0	6	0	1	0	1	2	7	0	9	0	0	0	0
Oct-26	4	10	1	15	0	0	0	0	11	16	2	29	0	3	0	3	6	15	0	21	1	1	0	2
Oct-29	11	23	0	34	0	0	0	0	26	42	1	69	1	5	0	6	19	31	1	51	2	1	0	3
Nov-02	15	39	0	54	2	3	0	5	23	42	0	65	1	3	0	4	26	40	0	66	1	0	0	1
Nov-05	1	8	0	9	0	0	0	0	11	25	0	36	2	2	0	4	10	25	0	35	3	1	0	4
Nov-09	4	7	0	11	0	0	0	0	7	19	1	27	0	1	0	1	15	17	0	32	0	0	0	0
Nov-12 (c)	5	13	0	18	0	0	0	0	13	21	0	34	1	1	0	2	12	22	1	35	2	0	0	2
Nov-16	4	17	0	21	1	1	0	2	10	16	0	26	1	1	0	2	5	9	0	14	0	3	0	3
Nov-19	2	6	0	8	0	1	0	1	4	4	1	9	0	1	0	1	1	4	0	5	0	0	0	0
Total	47	128	1	176	3	5	0	8	106	195	5	306	6	18	0	24	100	173	2	275	9	6	0	15

(a) See Fig. 1 for location of recovery areas

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

(c) One fish not recorded for Nov 12 due to no known recovery area