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# Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of Campbell and Quinsam Rivers, 1991

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March 1993

## Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2199

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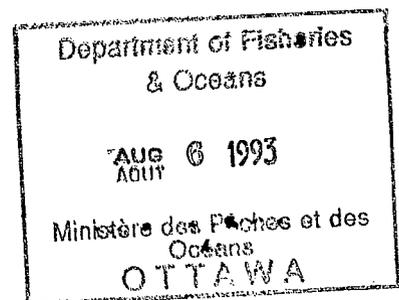
ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG  
RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF  
CAMPBELL AND QUINSAM RIVERS, 1991

by

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## ABSTRACT

Frith, H. R., B. L. Nass and T. C. Nelson. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1991. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2199 : viii + 57 p.

Estimates of escapement were derived for the Campbell/Quinsam rivers system for 1991 using carcass tagging as part of the chinook key stream program. The Petersen estimate of chinook escapement was 8012 in 1991. Both males and females were predominantly age 4 and 5 but the specific age structure varied between the Campbell River, Quinsam River and Quinsam Hatchery. Escapement estimates are presented by river, sex, and age.

Escapement of adipose-clipped chinook to the entire system was 278 in 1991. 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 1991 the hatchery contribution was 71.1% and 66.7% 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 66.1% for males and 63.6% for females in 1991.

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

## RÉSUMÉ

Frith, H. R., B. L. Nass and T. C. Nelson. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1991. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2199 : viii + 57 p.

Les saumons quinnats marqués morts ont servi à établir le nombre d'échappées dans le bassin de la Campbell-Quinsam en 1991, dans le cadre du programme d'étude des rivières clés pour le quinnat; on est arrivé au chiffre de 8012, en utilisant l'estimation de Petersen. Les mâles comme les femelles avaient surtout 4 ou 5 ans, mais la pyramide des âges varie entre la rivière Campbell, la rivière Quinsam et la pisciculture de Quinsam. Les résultats sont présentés par rivière, âge et sexe.

L'échappée de quinnats marqués à la nageoire adipeuse se monte à 278 pour tout le bassin versant en 1991. Ce résultat a été stratifié par âge, sexe et code de marquage. La contribution totale de la pisciculture à l'échappée (poissons marqués ou non) a été calculée à partir du nombre de marques observées et du taux de marquage au lâcher. En 1991, la part de la pisciculture a été de 71,1 % pour les mâles et de 66,7 % pour les femelles. La part calculée de cette façon a été comparée à celle établie avec la méthode du Programme de marquage et de recapture (Kuhn, 1988) utilisant des fils codés, qui donne 66,1 % pour les mâles et 63,6 % pour les femelles en 1991.

Mots clés : Campbell, Quinsam, quinnat, cours d'eau clé, échappée, fils codés, marquage, poissons marqués morts.

## 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*).

This manuscript report is the fifth 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), and the 1989-90 results are described in Bocking (1991*b*).

The 1991 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. The results are then discussed with respect to other studies and recommendations are made regarding future 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<sup>2</sup> and for the Quinsam River system is 265 km<sup>2</sup> (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<sup>3</sup>s<sup>-1</sup> to 826.0 m<sup>3</sup>s<sup>-1</sup> (mean=96.0 m<sup>3</sup>s<sup>-1</sup>). Flows on the Quinsam River are not controlled and vary from 0.9 m<sup>3</sup>s<sup>-1</sup> to 21.6 m<sup>3</sup>s<sup>-1</sup> (mean=9.0 m<sup>3</sup>s<sup>-1</sup>) (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 in October. Peak spawning occurs from mid-October to mid-November (Andrew et al. 1988, Van

Tine, pers. comm.<sup>2</sup>). 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 mid-October to late November 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:

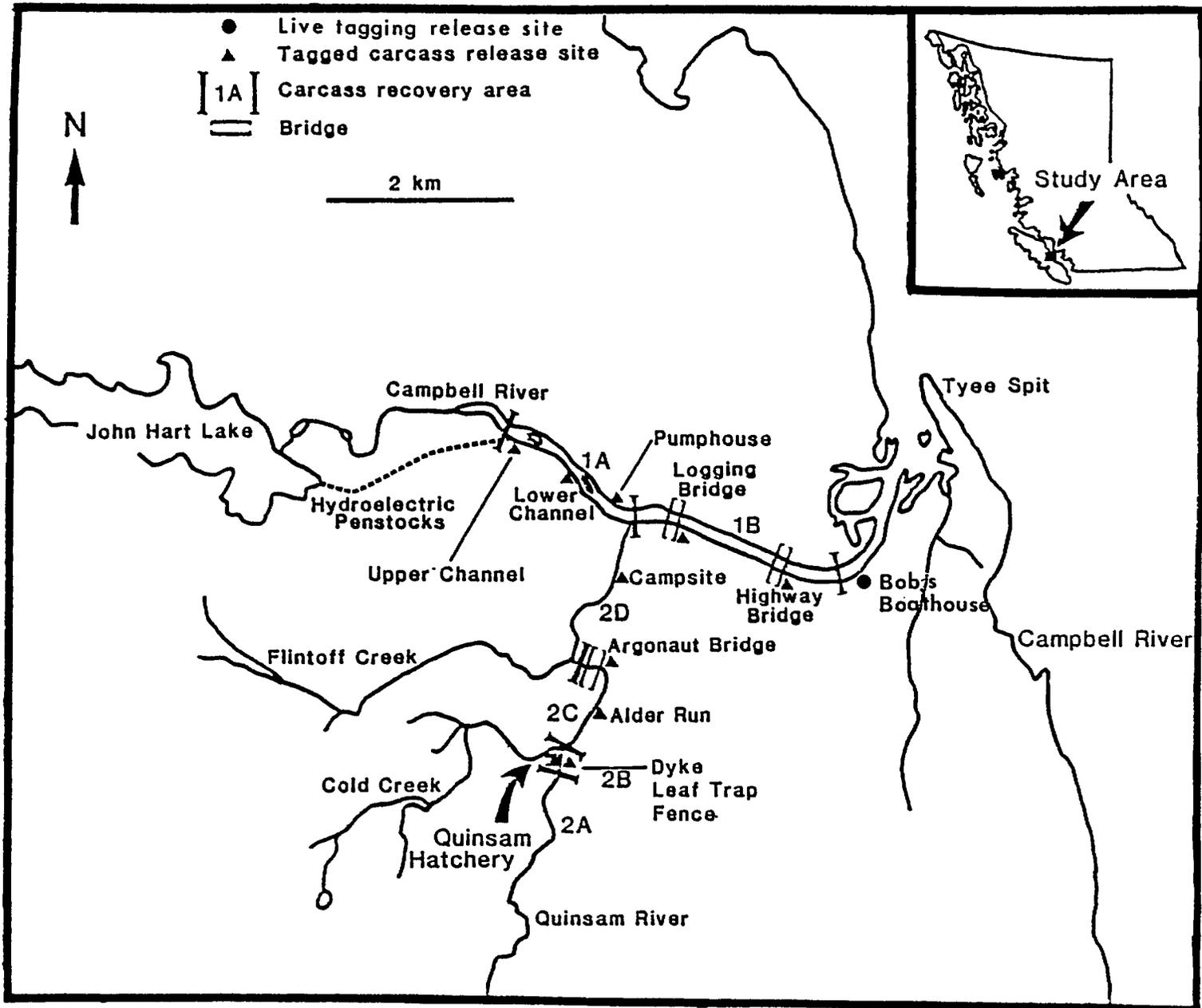
There are four main ways of stratifying the carcass tagging and recovery data to produce a Petersen estimate of escapement:

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

---

<sup>2</sup>Manager of Quinsam Hatchery, P.O. Box 467, Campbell River, B.C. V9W5C1

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



#### 4. sexes pooled with rivers separate.

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) and Bocking (1991b) and are repeated in this paper for the benefit of those only reading this manuscript.

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 1991, 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 1991, 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 rivers-separate escapement estimates 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 1991 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 1991, 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 on 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 tag non-reporting incidence.

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 in the dead recovery with the rate at carcass weirs if such data were available.

### Calculations

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

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

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

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

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

where  $n$  is the total number of sex strata (2) and  $m$  is the total number of river strata (2).

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 1991.

### 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:

$$\text{tag rate} = R / C \quad (3)$$

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

$$\text{tag recovery rate} = R / M \quad (4)$$

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 55-57% of the carcasses (marked and unmarked fish) recovered in the Campbell River, 18-24% of the carcasses recovered in the Quinsam River, and 17% 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 rivers-separate Petersen estimates. 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 1985 - 1989 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:

$$EAD_{i,r} = \frac{OAD_{i,r} \cdot P_{i,r}}{C_{i,r}} \quad (5)$$

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:

$$EAD_{i,r,tc} = \frac{EAD_{i,r} \cdot NDT_{i,r,tc}}{\sum NDT_{i,r}} \quad (6)$$

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 (1991b).

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

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

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:

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

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. This method is currently used by DFO to estimate hatchery contributions in commercial and sport chinook catches.

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

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

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

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 (1991b).

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

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

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:

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

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 1991, 372 chinook carcasses were tagged and released (returned to the river) continuously throughout the spawning period from October 16 to November 15 in the Campbell River and 482 carcasses were tagged and released from October 17 to November 21 in the Quinsam River (Table 3; Appendix 1 and 2).

## RECOVERY

Surveys to recover carcasses in 1991 began on October 22 in the Campbell River and on October 21 in the Quinsam River and continued until November 15 (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 1991 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. Subsequent references in this report to the number of carcasses recovered are for the number of recoveries used in the Petersen estimate.

In 1991, a total of 796 chinook carcasses were examined in the Campbell River (317 males, 468 females, and 11 jacks; Table 3). This number included 214 tag recoveries (71 males, 143 females and 0 jacks). In the Quinsam River, a total of 2035 chinook carcasses were examined (691 males, 1302 females, and 42 jacks; Table 3). This included 287 tag recoveries (96 males, 191 females, and 0 jacks). In both rivers, more females than males were recovered, and fewer jacks were retrieved than either males or females.

The carcass tag recovery rates in the Campbell River (57.5%) and Quinsam River (59.5%) in 1991 were within 2% and were not significantly different ( $P > 0.5$ ,  $\chi^2$ ; Zar, 1984). The tag recovery rate was higher for females (62% and 66% in Campbell and Quinsam Rivers respectively) but the difference between sexes was only significant for the Quinsam River ( $P < 0.001$ ,  $\chi^2$ ).

## 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 1991 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 1382 and 3352 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 1991, including hatchery rack recoveries and fish counted above the Quinsam River fence, was estimated to be 8012 adults with 95% confidence limits of 7263 to 8906 fish.

The proportion of fish between the two rivers and the Quinsam Hatchery was 17.3; 41.8; 40.9 (Campbell; Quinsam; hatchery). These proportions are very similar to the numbers of chinook returning to the Campbell River system since 1987 (Bocking, 1991*b*). The total returns show a 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 5 years (both sexes) (Table 5). In the Quinsam River and hatchery, the dominant age classes was 4 years for males and 5 years for females in 1991 (Table 6).

Summaries of mean lengths by age are presented in Tables 5 through 7. In 1991, male and female chinook from Campbell River had larger mean lengths (postorbital-hypural) than male and female chinook from the Quinsam River (Campbell: male = 792 mm, female = 821 mm; Quinsam: male = 736 mm, female = 785 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 1991 are shown in Table 8.

The population escapement, stratified by age class and sex, is shown in Table 8 for Campbell/Quinsam river system chinook in 1991. The sex ratio of males (not including jacks)/females was 0.82 in the Campbell River, 0.70 in the Quinsam River, and 1.04 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 1985 to 1988 brood years were captured in the dead recovery programs in 1991 (Appendix 7 and 8). There were no recoveries of adipose-clipped chinook jacks (1989 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 1991, there were 19 adipose-clipped chinook recovered in the Campbell River dead pitch, 98 in the Quinsam River dead pitch and 159 at the hatchery rack (Table 10). The adipose clip mark rate was highest in the hatchery returns (6.2%) and lowest in the Campbell River returns (2.4%). The total estimated adipose clips to Campbell River, Quinsam River, and Quinsam Hatchery were 33, 163, and 196, 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 significantly different ( $\chi^2$ ,  $P < 0.02$ ).

### 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 (four strays from the Puntledge to the Campbell in 1991). A total of 260 CWT heads from adipose-clipped fish recovered in the 1991 dead recovery were successfully decoded.

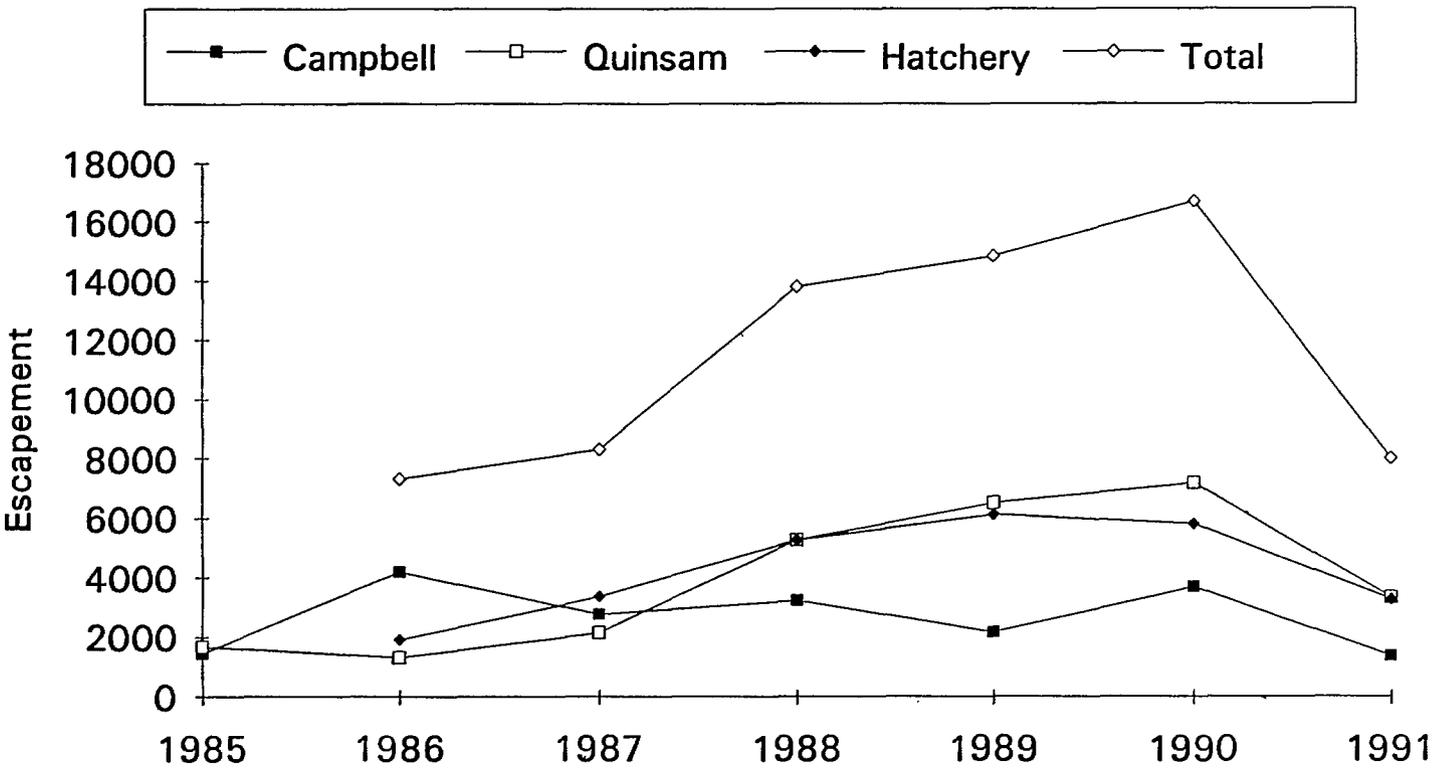


Figure 2. Chinook escapement estimates, stratified by river location, 1985 (Andrew et al. 1988), 1986-88 (Bocking et al. 1990), 1989-90 (Bocking, 1991b) and 1991 (this study).

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 1991 escapement of chinook to the Campbell River, Quinsam River and Quinsam Hatchery were 465, 2097, and 2871, respectively (Table 13).

The hatchery contributions to the total escapement of chinook in 1991, by age class is presented in Table 14. The hatchery contribution to the Campbell River population of chinook was estimated to be 26.8% for males and 39.3% for females in 1991. Contributions to the in-river Quinsam chinook escapement were 68.4% for males and 58.5% for females. This increased to 90.5% for males and 90.5% for females in the returns to the hatchery. Strays contributed as much as 1.1% of the total CWT returns to the Campbell River and 2.0% to the Quinsam River in 1991.

#### 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 1991 escapement of chinook to the Campbell River, Quinsam River and Quinsam Hatchery using Method B were 468, 1896, and 2753, respectively (Table 17).

The hatchery contribution to the total escapement of chinook in 1991, by age class, is presented in Table 18. The 1991 hatchery contribution to the Campbell River population of chinook was estimated to be 26.0% for males and 40.4% for females. Contributions to the in-river Quinsam chinook escapement were 55.7% for males and 57.2% for females. These were lower than the 90.4% for males and 83.0% for females in the returns to the hatchery. Strays contributed as much as 1.1% of the total CWT returns to the Campbell River and 2.0% to the Quinsam River in 1991.

## DISCUSSION AND CONCLUSIONS

### POPULATION ESTIMATION

Several potentially important sources of bias in Petersen estimates were circumvented by stratifying the populations of each river by sex. In this study, there were factors that affected sexes differentially, as indicated by differences in the sex ratios obtained in hatchery seining 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). Hence, it is important to continue to stratify escapement estimates on the Quinsam/Campbell by sex.

Potentially important sources of bias in Petersen estimates were also circumvented by stratifying the estimates by river. Results indicated that there was very little straying between major river strata or between tagging and recovery 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 0.82 in 1991. The ratio of males to females in the Quinsam River was 0.70 in 1991. The sex ratio of hatchery returns was 1.04 in 1991.

### 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 2.4% - 6.2% in 1991.

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 (26.8% to 90.5% in 1991; Table 14) to Method B (26.0% to 90.4%; 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 19 to 161 adipose clips enumerated for each river stratum (jacks not included). The 95% confidence limits for 19 recoveries (based on a Poisson frequency distribution) would be approximately  $\pm 46\%$  and significantly smaller at 15% for 161 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 1991. 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, 1991b).

## SUMMARY

1. Total escapement estimates for chinook salmon in the Campbell/Quinsam rivers system using carcass tagging were 8012 in 1991. 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 5.
3. Females were more abundant in the river populations while males were generally more 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 392 in 1991.
6. The total estimated hatchery contribution to the chinook escapement, based on adipose clips (Method A), was 5433 (68.7%) in 1991. The contribution estimate derived using the adjusted CWTs recovered (Method B) was lower: 5119 (64.7%).

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Table 1. Summary of methods for the Campbell and Quinsam rivers chinook salmon enumeration programs, 1991.

| Item                              | Method and Materials  |
|-----------------------------------|---|
|                                   | 1991  |
| Dead recovery population estimate | Petersen estimate, sum of separate estimates for sexes and rivers   |
| Dead 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, 1991.

| River    | No. of<br>person days |
|----------|-----------------------|
| Campbell | 59                    |
| Quinsam  | 52                    |

Table 3. Summary of in situ carcass tagging and dead recovery of chinook salmon in Campbell and Quinsam rivers, 1991.

| Category                | Campbell (a) | Quinsam (b) | Total |
|-------------------------|--------------|-------------|-------|
| <u>Carcass tagging:</u> |              |             |       |
| Males                   | 140          | 193         | 333   |
| Females                 | 232          | 289         | 521   |
| Jacks                   | 0            | 0           | 0     |
| Total                   | 372          | 482         | 854   |
| <u>Dead recovery:</u>   |              |             |       |
| Males                   | 317          | 691         | 1008  |
| Females                 | 468          | 1302        | 1770  |
| Jacks                   | 11           | 42          | 53    |
| Total                   | 796          | 2035        | 2831  |
| Tagged males (c)        | 71           | 96          | 167   |
| Tagged females (c)      | 143          | 191         | 334   |
| Tagged jacks (c)        | 0            | 0           | 0     |
| Total tagged (c)        | 214          | 287         | 501   |
| Tag rate (%)            | 26.9         | 14.1        | 17.7  |
| Tag recovery rate (%)   | 57.5         | 59.5        | 58.7  |
| Tag loss (%)            | 2.3          | 3.1         | 2.7   |

(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, 1991. Confidence limits are from fiducial 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    |
|---------------------------------------|------|--------|----------|----------|
| <u>Campbell River (a)</u>             |      |        |          |          |
| Number tags applied (d)               | 140  | 232    | 0        | 372      |
| Number recovered (e)                  | 317  | 468    | 11       | 796      |
| Number of tagged recoveries (f)       | 71   | 143    | 0        | 214      |
| Petersen estimate                     | 623  | 759    | NA       | 1382 (i) |
| Lower 95% CL                          | 495  | 645    | NA       | 1140 (i) |
| Upper 95% CL                          | 783  | 893    | NA       | 1676 (i) |
| <u>Quinsam River (b, below fence)</u> |      |        |          |          |
| Number tags applied (d)               | 193  | 289    | 0        | 482      |
| Number recovered (e)                  | 691  | 1302   | 42       | 2035     |
| Number of tagged recoveries (f)       | 96   | 191    | 0        | 287      |
| Petersen estimate                     | 1384 | 1968   | NA       | 3352 (i) |
| Lower 95% CL                          | 1136 | 1709   | NA       | 2845 (i) |
| Upper 95% CL                          | 1686 | 2266   | NA       | 3952 (i) |
| <u>Quinsam River (c, above fence)</u> |      |        |          |          |
| Number of fish (g)                    | 192  | 388    | 32       | 612      |
| <u>Quinsam Hatchery</u>               |      |        |          |          |
| Number of fish (g)                    | 1423 | 1169   | 74       | 2666     |
| <u>Total system</u>                   |      |        |          |          |
| Escapement estimate                   | 3622 | 4284   | NA       | 8012 (i) |
| Lower 95% CL                          | 3054 | 3523   | NA       | 7263 (i) |
| Upper 95% CL                          | 3892 | 4328   | NA       | 8906 (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) Escapement to Quinsam River above the fence. Includes 369 unknowns apportioned to males, females and jacks using the sex ratio observed in the dead pitch

(d) Total tagged and punched

(e) Total tagged and untagged recoveries

(f) Total recoveries possessing an operculum punch (secondary mark)

(g) Confidence limits not applicable

(h) Due to the lack of tagged recoveries, Peterson estimates were not calculated for jacks

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

Table 5. Age composition of Campbell River chinook salmon, 1991 (determined from dead recovery).

| Sex and age      | Unmarked | AD/CWT | Total | Percent | Postorbital-hypural length (mm) |           |          |        |       |  |
|------------------|----------|--------|-------|---------|---------------------------------|-----------|----------|--------|-------|--|
|                  |          |        |       |         | N                               | Mean (mm) | SD       | 95% CL |       |  |
|                  |          |        |       |         |                                 |           |          | Lower  | Upper |  |
| <b>Males (a)</b> |          |        |       |         |                                 |           |          |        |       |  |
| 3.1              | 8        | 0      | 8     | 8.1     | 8                               | 649       | 84       | 643    | 655   |  |
| 4.1              | 34       | 4      | 38    | 38.4    | 37                              | 751       | 53       | 749    | 753   |  |
| 5.1              | 49       | 3      | 52    | 52.5    | 52                              | 843       | 47       | 842    | 844   |  |
| 6.1              | 1        | 0      | 1     | 1.0     | 1                               | 840       | 0        | 840    | 840   |  |
| Total aged       | 92       | 7      | 99    | 100.0   | 98                              | 792.4     | 53.0 (b) | 782    | 803   |  |
| Unknown age      |          |        | 82    |         | 82                              | 791       | 91       | 771    | 811   |  |
| Total            |          |        | 181   |         |                                 |           |          |        |       |  |
| <b>Females</b>   |          |        |       |         |                                 |           |          |        |       |  |
| 4.1              | 16       | 6      | 22    | 20.0    | 22                              | 763       | 63       | 760    | 766   |  |
| 5.1              | 79       | 4      | 83    | 75.5    | 83                              | 834       | 44       | 833    | 835   |  |
| 6.1              | 3        | 2      | 5     | 4.5     | 5                               | 862       | 25       | 857    | 867   |  |
| Total aged       | 98       | 12     | 110   | 100.0   | 110                             | 821.1     | 47.8 (b) | 812    | 830   |  |
| Unknown age      |          |        | 168   |         | 168                             | 824       | 50       | 816    | 832   |  |
| Total            |          |        | 278   |         |                                 |           |          |        |       |  |

(a) No jacks were identified in the ageing analysis

(b) Pooled standard deviation (Zar 1984)

Table 6. Age composition of Quinsam River chinook salmon, 1991 (determined from dead recovery).

| Sex and age      | Unmarked | AD/CWT | Total | Percent | Postorbital-hypural length (mm) |           |          |        |       |  |
|------------------|----------|--------|-------|---------|---------------------------------|-----------|----------|--------|-------|--|
|                  |          |        |       |         | N                               | Mean (mm) | SD       | 95% CL |       |  |
|                  |          |        |       |         |                                 |           |          | Lower  | Upper |  |
| <b>Males (a)</b> |          |        |       |         |                                 |           |          |        |       |  |
| 3.1              | 19       | 9      | 28    | 23.7    | 28                              | 625       | 61       | 602    | 648   |  |
| 4.1              | 52       | 15     | 67    | 56.8    | 67                              | 748       | 52       | 736    | 760   |  |
| 5.1              | 19       | 3      | 22    | 18.6    | 21                              | 833       | 49       | 812    | 854   |  |
| 6.1              | 1        | 0      | 1     | 0.9     | 1                               | 940       | 0        | 940    | 940   |  |
| Total aged       | 91       | 27     | 118   | 100.0   | 117                             | 735.5     | 53.6 (b) | 726    | 745   |  |
| Unknown age      |          |        | 48    |         | 48                              | 741       | 83       | 718    | 764   |  |
| Total            |          |        | 166   |         |                                 |           |          |        |       |  |
| <b>Females</b>   |          |        |       |         |                                 |           |          |        |       |  |
| 3.1              | 1        | 0      | 1     | 0.7     | 1                               | 540       | 0        | 540    | 540   |  |
| 4.1              | 29       | 32     | 61    | 39.6    | 61                              | 747       | 31       | 739    | 755   |  |
| 5.1              | 64       | 26     | 90    | 58.4    | 90                              | 813       | 45       | 804    | 822   |  |
| 6.1              | 1        | 1      | 2     | 1.3     | 2                               | 805       | 64       | 230    | 1380  |  |
| Total aged       | 95       | 59     | 154   | 100.0   | 154                             | 785.0     | 35.2 (b) | 484    | 495   |  |
| Unknown age      |          |        | 75    |         | 75                              | 794       | 46       | 784    | 804   |  |
| Total            |          |        | 229   |         |                                 |           |          |        |       |  |

(a) No jacks were identified in the ageing analysis

(b) Pooled standard deviation (Zar 1984)

Table 7. Age composition of Quinsam Hatchery chinook salmon, 1991 (determined from rack recovery).

| Sex and age      | Unmarked | AD/CWT | Total | Percent | Postorbital-hypural length (mm) |           |          |        |       |
|------------------|----------|--------|-------|---------|---------------------------------|-----------|----------|--------|-------|
|                  |          |        |       |         | N                               | Mean (mm) | SD       | 95% CL |       |
|                  |          |        |       |         |                                 |           |          | Lower  | Upper |
| <b>Males (a)</b> |          |        |       |         |                                 |           |          |        |       |
| 3.1              | 7        | 26     | 33    | 17.5    | 33                              | 617       | 71       | 593    | 641   |
| 4.1              | 62       | 56     | 118   | 62.8    | 118                             | 735       | 50       | 726    | 744   |
| 5.1              | 26       | 11     | 37    | 19.7    | 37                              | 784       | 55       | 766    | 802   |
| Total aged       | 95       | 93     | 188   | 100     | 188                             | 723.9     | 55.2 (b) | 716    | 732   |
| Unknown age      |          |        | 80    |         | 80                              | 744       | 62       | 730    | 758   |
| Total            |          |        | 268   |         |                                 |           |          |        |       |
| <b>Females</b>   |          |        |       |         |                                 |           |          |        |       |
| 3.1              | 2        | 0      | 2     | 1.0     | 2                               | 696       | 74       | 581    | 811   |
| 4.1              | 47       | 33     | 80    | 38.0    | 80                              | 754       | 38       | 746    | 762   |
| 5.1              | 96       | 28     | 124   | 59.0    | 124                             | 806       | 47       | 798    | 814   |
| 5.2              | 1        | 1      | 2     | 1.0     | 2                               | 814       | 21       | 784    | 844   |
| 6.1              | 2        | 0      | 2     | 1.0     | 2                               | 827       | 44       | 766    | 888   |
| Total aged       | 148      | 62     | 210   | 100.0   | 210                             | 777.7     | 43.9 (b) | 772    | 784   |
| Unknown age      |          |        | 48    |         | 48                              | 786       | 53       | 771    | 801   |
| Total            |          |        | 258   |         |                                 |           |          |        |       |

(a) No jacks were identified in the ageing analysis

(b) Pooled standard deviation (Zar 1984)

Table 8. Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1991.

| Location              | Length class (mm) | Age       |       |       |       |       |          |         |     |       |       |       |       |          |        |
|-----------------------|-------------------|-----------|-------|-------|-------|-------|----------|---------|-----|-------|-------|-------|-------|----------|--------|
|                       |                   | Males (a) |       |       |       |       |          | Females |     |       |       |       |       |          |        |
|                       |                   | 2         | 3     | 4     | 5     | 6     | Total(b) | unk(c)  | 2   | 3     | 4     | 5     | 6     | Total(b) | unk(c) |
| <u>Campbell River</u> |                   |           |       |       |       |       |          |         |     |       |       |       |       |          |        |
|                       | 250-299           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 300-349           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 350-399           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 400-449           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 450-499           | 0         | 0     | 0     | 0     | 0     | 0        | 1       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 500-549           | 0         | 1     | 0     | 0     | 0     | 1        | 1       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 550-599           | 0         | 0     | 0     | 0     | 0     | 0        | 1       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 600-649           | 0         | 2     | 0     | 0     | 0     | 2        | 2       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 650-699           | 0         | 1     | 3     | 0     | 0     | 4        | 1       | 0   | 0     | 2     | 0     | 0     | 2        | 1      |
|                       | 700-749           | 0         | 3     | 7     | 1     | 0     | 11       | 12      | 0   | 0     | 6     | 0     | 0     | 6        | 6      |
|                       | 750-799           | 0         | 1     | 13    | 2     | 0     | 16       | 8       | 0   | 0     | 3     | 8     | 0     | 11       | 15     |
|                       | 800-849           | 0         | 0     | 11    | 17    | 0     | 28       | 24      | 0   | 0     | 6     | 30    | 1     | 37       | 66     |
|                       | 850-899           | 0         | 0     | 3     | 19    | 1     | 23       | 22      | 0   | 0     | 5     | 33    | 2     | 40       | 56     |
|                       | 900-949           | 0         | 0     | 0     | 12    | 0     | 12       | 8       | 0   | 0     | 0     | 9     | 2     | 11       | 20     |
|                       | 950-999           | 0         | 0     | 0     | 1     | 0     | 1        | 2       | 0   | 0     | 0     | 3     | 0     | 3        | 3      |
|                       | 1000-1049         | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 1      |
|                       | Mean (e)          | 0.0       | 649.0 | 751.0 | 843.0 | 840.0 | 792.4    | 791.0   | 0.0 | 0.0   | 763.0 | 834.0 | 862.0 | 821.1    | 824.0  |
|                       | SD (e)            | 0.0       | 84.0  | 53.0  | 47.0  | 0.0   | 53.0     | 91.0    | 0.0 | 0.0   | 63.0  | 44.0  | 25.0  | 47.8     | 50.0   |
|                       | N                 | 0         | 8     | 37    | 52    | 1     | 98       | 82      | 0   | 0     | 22    | 83    | 5     | 110      | 168    |
| <u>Quinsam River</u>  |                   |           |       |       |       |       |          |         |     |       |       |       |       |          |        |
|                       | 250-299           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 300-349           | 0         | 0     | 0     | 0     | 0     | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 350-399           | 0         | 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         | 1     | 0     | 0     | 0     | 1        | 0       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 550-599           | 0         | 4     | 0     | 0     | 0     | 4        | 0       | 0   | 1     | 0     | 0     | 0     | 1        | 0      |
|                       | 600-649           | 0         | 11    | 2     | 0     | 0     | 13       | 6       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 650-699           | 0         | 5     | 3     | 0     | 0     | 8        | 5       | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                       | 700-749           | 0         | 5     | 16    | 0     | 0     | 21       | 9       | 0   | 0     | 18    | 5     | 0     | 23       | 4      |
|                       | 750-799           | 0         | 2     | 28    | 2     | 0     | 32       | 11      | 0   | 0     | 31    | 12    | 1     | 44       | 22     |
|                       | 800-849           | 0         | 0     | 14    | 9     | 0     | 23       | 10      | 0   | 0     | 12    | 35    | 0     | 47       | 29     |
|                       | 850-899           | 0         | 0     | 4     | 5     | 0     | 9        | 4       | 0   | 0     | 0     | 34    | 1     | 35       | 16     |
|                       | 900-949           | 0         | 0     | 0     | 4     | 0     | 4        | 3       | 0   | 0     | 0     | 4     | 0     | 4        | 4      |
|                       | 950-999           | 0         | 0     | 0     | 1     | 1     | 2        | 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 (e)          | 0.0       | 625.0 | 748.0 | 833.0 | 940.0 | 735.5    | 74.1    | 0.0 | 540.0 | 747.0 | 813.0 | 805.0 | 785.0    | 794.0  |
|                       | SD (e)            | 0.0       | 61.0  | 52.0  | 49.0  | 0.0   | 53.6     | 8.3     | 0.0 | 0.0   | 31.0  | 45.0  | 64.0  | 40.2     | 46.0   |
|                       | N                 | 0         | 28    | 67    | 21    | 1     | 117      | 48      | 0   | 1     | 61    | 90    | 2     | 154      | 75     |

Table 8 (cont). Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1991.

| River                   | Length class (mm) | Age       |       |       |       |     |          |         |     |       |       |       |       |          |        |
|-------------------------|-------------------|-----------|-------|-------|-------|-----|----------|---------|-----|-------|-------|-------|-------|----------|--------|
|                         |                   | Males (a) |       |       |       |     |          | Females |     |       |       |       |       |          |        |
|                         |                   | 2         | 3     | 4     | 5     | 6   | Total(b) | unk(c)  | 2   | 3     | 4     | 5     | 6     | Total(b) | unk(c) |
| <b>Quinsam Hatchery</b> |                   |           |       |       |       |     |          |         |     |       |       |       |       |          |        |
|                         | 250-299           | 0         | 0     | 0     | 0     | 0   | 0        | 1(d)    | 0   | 0     | 0     | 0     | 0     | 0        | 0      |
|                         | 300-349           | 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        |        |
|                         | 400-449           | 0         | 0     | 0     | 0     | 0   | 0        | 0       | 0   | 0     | 0     | 0     | 0     | 0        |        |
|                         | 450-499           | 0         | 1     | 0     | 0     | 0   | 1        | 0       | 0   | 0     | 0     | 0     | 0     | 0        |        |
|                         | 500-549           | 0         | 2     | 0     | 0     | 0   | 2        | 0       | 0   | 0     | 0     | 1     | 0     | 1        |        |
|                         | 550-599           | 0         | 5     | 1     | 0     | 0   | 6        | 2       | 0   | 0     | 0     | 0     | 0     | 0        |        |
|                         | 600-649           | 0         | 11    | 1     | 0     | 0   | 12       | 2       | 0   | 0     | 0     | 0     | 0     | 0        |        |
|                         | 650-699           | 0         | 6     | 12    | 0     | 0   | 18       | 6       | 0   | 1     | 1     | 1     | 0     | 3        |        |
|                         | 700-749           | 0         | 7     | 35    | 6     | 0   | 48       | 15      | 0   | 0     | 21    | 2     | 0     | 23       |        |
|                         | 750-799           | 0         | 0     | 43    | 13    | 0   | 56       | 32      | 0   | 1     | 33    | 21    | 0     | 55       |        |
|                         | 800-849           | 0         | 1     | 23    | 11    | 0   | 35       | 16      | 0   | 0     | 23    | 62    | 1     | 86       |        |
|                         | 850-899           | 0         | 0     | 3     | 5     | 0   | 8        | 6       | 0   | 0     | 2     | 34    | 1     | 37       |        |
|                         | 900-949           | 0         | 0     | 0     | 2     | 0   | 2        | 1       | 0   | 0     | 0     | 5     | 0     | 5        |        |
|                         | 950-999           | 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        |        |
|                         | Mean (e)          | 0.0       | 617.0 | 735.0 | 784.0 | 0.0 | 723.9    | 744.0   | 0.0 | 696.0 | 754.0 | 806.0 | 827.0 | 785.3    | 786.0  |
|                         | SD (e)            | 0.0       | 71.0  | 50.0  | 55.0  | 0.0 | 55.2     | 62.0    | 0.0 | 74.0  | 38.0  | 47.0  | 44.0  | 44.1     | 53.0   |
|                         | N                 | 0         | 33    | 118   | 37    | 0   | 188      | 80      | 0   | 2     | 80    | 126   | 2     | 210      | 48     |

(a) No jacks were identified in the ageing analysis

(b) Poled standard deviation

(c) Unk = age unknown

(d) This chinook was 18 cm and aged as 1.1 by CWT analysis

(e) Values for postorbital-hypural length

Table 9. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River Quinsam Hatchery, 1991.

| Location                    | Age       | Males (a) |         | Females  |         |
|-----------------------------|-----------|-----------|---------|----------|---------|
|                             |           | Number    | Percent | Number   | Percent |
| <u>Campbell River</u>       |           |           |         |          |         |
|                             | 3.1       | 50        | 8.1     | 0        | 0.0     |
|                             | 4.1       | 239       | 38.4    | 152      | 20.0    |
|                             | 5.1       | 327       | 52.5    | 573      | 75.5    |
|                             | 6.1       | 6         | 1.0     | 34       | 4.5     |
|                             | Total (c) | 623 (d)   | 100.0   | 759      | 100.0   |
| <u>Quinsam River</u>        |           |           |         |          |         |
|                             | 3.1       | 328       | 23.7    | 14       | 0.7     |
|                             | 4.1       | 786       | 56.8    | 779      | 39.6    |
|                             | 5.1       | 257       | 18.6    | 1149     | 58.4    |
|                             | 6.1       | 12        | 0.9     | 26       | 1.3     |
|                             | Total (c) | 1384      | 100.0   | 1968     | 100.0   |
| <u>Quinsam Hatchery (b)</u> |           |           |         |          |         |
|                             | 3.1       | 283       | 17.5    | 16       | 1.0     |
|                             | 4.1       | 1014      | 62.8    | 592      | 38.0    |
|                             | 5.1       | 318       | 19.7    | 919      | 59.0    |
|                             | 5.2       | 0         | 0.0     | 16       | 1.0     |
|                             | 6.1       | 0         | 0.0     | 16       | 1.0     |
|                             | Total (c) | 1615      | 100.0   | 1557 (d) | 100.0   |

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

(b) Includes chinook enumerated above the fence on the Quinsam River

(c) Petersen estimates from Table 4

(d) Rounding error prohibits correct summation

Table 10. Estimates of the total escapement of adipose clipped chinook salmon to the Campbell River, Quinsam River and the Quinsam Hatchery, 1991. The Petersen estimates were derived using the in situ carcass-tagging method (Method A).

| Location                           | Sex      | Sample size (a)<br>A | Observed adipose clips (a)<br>B | Mark rate (%)<br>$C = (B/A) \times 100$ | Population estimate (b)<br>D | Percentage of population sampled<br>$E = (A/D) \times 100$ | Total estimated adipose clips<br>$F = (B/A) \times D$ |
|------------------------------------|----------|----------------------|---------------------------------|---|------------------------------|--|---|
| <u>Campbell River</u>              |          |                      |                                 |   |                              |  |   |
|                                    | Male (d) | 323                  | 7                               | 2.2                                     | 623                          | 51.8   | 14  |
|                                    | Female   | 469                  | 12                              | 2.6                                     | 759                          | 61.8   | 19  |
|                                    | Total    | 792                  | 19                              | 2.4                                     | 1382                         | 57.3   | 33  |
| <u>Quinsam River (below fence)</u> |          |                      |                                 |   |                              |  |   |
|                                    | Male (d) | 706                  | 37                              | 5.2                                     | 1384                         | 51.0   | 73  |
|                                    | Female   | 1328                 | 61                              | 4.6                                     | 1968                         | 67.5   | 90  |
|                                    | Total    | 2034                 | 98                              | 4.8                                     | 3352                         | 60.7   | 163   |
| <u>Quinsam Hatchery (c)</u>        |          |                      |                                 |   |                              |  |   |
|                                    | Male (d) | 1423                 | 96                              | 6.7                                     | 1615                         | 88.1   | 109   |
|                                    | Female   | 1169                 | 65                              | 5.6                                     | 1557                         | 75.1   | 87  |
|                                    | Total    | 2592                 | 161                             | 6.2                                     | 3172                         | 81.7   | 196   |

(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) Population estimate includes chinook enumerated above the fence on the Quinsam River

(d) 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, 1991. The source of tags for the Petersen estimates was from in situ carcass tagging. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method A).

| Brood year | CWT code | Campbell River (a)     |   |                         |     | 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 |      |
|            |          | M (b)                  | F | M                       | F   | M                      | F  | M                       | F    | M                      | F  | M                       | F    | M                      | F  | M                       | F    |
| 1988       | 25526    | 0                      | 0 | 0.0                     | 0.0 | 3                      | 0  | 7.3                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 5                      | 0  | 9.7                     | 0.0  |
|            | 25527    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 1                      | 0  | 1.2                     | 0.0  | 2                      | 0  | 3.6                     | 0.0  |
|            | 25814    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 3                      | 0  | 4.8                     | 0.0  |
|            | 25815    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 3                      | 0  | 4.8                     | 0.0  |
|            | 25816    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 3                      | 0  | 4.8                     | 0.0  |
|            | 25817    | 0                      | 0 | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  |
|            | 25818    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 4                      | 0  | 4.7                     | 0.0  | 5                      | 0  | 7.1                     | 0.0  |
|            | 25819    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 3                      | 0  | 3.5                     | 0.0  | 4                      | 0  | 6.0                     | 0.0  |
|            | 25820    | 0                      | 0 | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0  | 3                      | 0  | 3.5                     | 0.0  | 3                      | 0  | 3.5                     | 0.0  |
|            | 25821    | 0                      | 0 | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0  | 3                      | 0  | 3.5                     | 0.0  | 3                      | 0  | 3.5                     | 0.0  |
|            | 25822    | 0                      | 0 | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  | 2                      | 0  | 2.4                     | 0.0  |
|            | Subtotal | 0                      | 0 | 0.0                     | 0.0 | 9                      | 0  | 21.9                    | 0.0  | 26                     | 0  | 30.6                    | 0.0  | 35                     | 0  | 52.5                    | 0.0  |
| 1987       | 24419    | 0                      | 0 | 0.0                     | 0.0 | 0                      | 2  | 0.0                     | 3.1  | 7                      | 3  | 8.2                     | 4.3  | 7                      | 5  | 8.2                     | 7.3  |
|            | 24420    | 0                      | 1 | 0.0                     | 1.6 | 0                      | 2  | 0.0                     | 3.1  | 2                      | 1  | 2.4                     | 1.4  | 2                      | 4  | 2.4                     | 6.1  |
|            | 24421    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 0  | 2.4                     | 0.0  | 5                      | 3  | 5.9                     | 4.3  | 6                      | 3  | 8.3                     | 4.3  |
|            | 24736    | 0                      | 0 | 0.0                     | 0.0 | 2                      | 4  | 4.9                     | 6.1  | 2                      | 2  | 2.4                     | 2.9  | 4                      | 6  | 7.2                     | 9.0  |
|            | 24737    | 0                      | 2 | 0.0                     | 3.2 | 1                      | 6  | 2.4                     | 9.2  | 1                      | 3  | 1.2                     | 4.3  | 2                      | 11 | 3.6                     | 16.6 |
|            | 24956    | 0                      | 1 | 0.0                     | 1.6 | 1                      | 1  | 2.4                     | 1.5  | 7                      | 5  | 8.2                     | 7.1  | 8                      | 7  | 10.7                    | 10.2 |
|            | 25358    | 1                      | 0 | 2.0                     | 0.0 | 0                      | 3  | 0.0                     | 4.6  | 6                      | 2  | 7.1                     | 2.9  | 7                      | 5  | 9.1                     | 7.4  |
|            | 25359    | 1                      | 0 | 2.0                     | 0.0 | 2                      | 2  | 4.9                     | 3.1  | 6                      | 4  | 7.1                     | 5.7  | 9                      | 6  | 13.9                    | 8.8  |
|            | 25360    | 0                      | 0 | 0.0                     | 0.0 | 1                      | 4  | 2.4                     | 6.1  | 5                      | 1  | 5.9                     | 1.4  | 6                      | 5  | 8.3                     | 7.5  |
|            | 25361    | 1                      | 0 | 2.0                     | 0.0 | 2                      | 0  | 4.9                     | 0.0  | 4                      | 1  | 4.7                     | 1.4  | 7                      | 1  | 11.6                    | 1.4  |
|            | 25362    | 0                      | 0 | 0.0                     | 0.0 | 2                      | 3  | 4.9                     | 4.6  | 6                      | 4  | 7.1                     | 5.7  | 8                      | 7  | 11.9                    | 10.3 |
|            | 25363    | 1                      | 1 | 2.0                     | 1.6 | 3                      | 4  | 7.3                     | 6.1  | 3                      | 2  | 3.5                     | 2.9  | 7                      | 7  | 12.8                    | 10.5 |
|            | Subtotal | 4                      | 5 | 8.0                     | 7.9 | 15                     | 31 | 36.5                    | 47.3 | 54                     | 31 | 63.5                    | 44.2 | 73                     | 67 | 108.0                   | 99.4 |

(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 1991. The source of tags for the Petersen estimates was from in situ carcass tagging. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method A).

| Brood year         | CWT code | Campbell River (a)     |    |                         |      | 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 |       |
|                    |          | M (b)                  | F  | M                       | F    | M                      | F  | M                       | F    | M                      | F  | M                       | F    | M                      | F   | M                       | F     |
| 1986               | 24152    | 0                      | 0  | 0.0                     | 0.0  | 0                      | 5  | 0.0                     | 7.6  | 0                      | 2  | 0.0                     | 2.9  | 0                      | 7   | 0.0                     | 10.5  |
|                    | 24153    | 1                      | 0  | 2.0                     | 0.0  | 0                      | 1  | 0.0                     | 1.5  | 1                      | 4  | 1.2                     | 5.7  | 2                      | 5   | 3.2                     | 7.2   |
|                    | 24154    | 0                      | 0  | 0.0                     | 0.0  | 0                      | 1  | 0.0                     | 1.5  | 1                      | 1  | 1.2                     | 1.4  | 1                      | 2   | 1.2                     | 3.0   |
|                    | 24155    | 0                      | 1  | 0.0                     | 1.6  | 0                      | 2  | 0.0                     | 3.1  | 1                      | 4  | 1.2                     | 5.7  | 1                      | 7   | 1.2                     | 10.3  |
|                    | 24156    | 1                      | 1  | 2.0                     | 1.6  | 3                      | 3  | 7.3                     | 4.6  | 2                      | 4  | 2.4                     | 5.7  | 6                      | 8   | 11.7                    | 11.9  |
|                    | 24157    | 0                      | 1  | 0.0                     | 1.6  | 3                      | 3  | 7.3                     | 4.6  | 1                      | 5  | 1.2                     | 7.1  | 4                      | 9   | 8.5                     | 13.3  |
|                    | 24158    | 0                      | 0  | 0.0                     | 0.0  | 0                      | 2  | 0.0                     | 3.1  | 3                      | 2  | 3.5                     | 2.9  | 3                      | 4   | 3.5                     | 5.9   |
|                    | 24159    | 0                      | 1  | 0.0                     | 1.6  | 0                      | 6  | 0.0                     | 9.2  | 0                      | 5  | 0.0                     | 7.1  | 0                      | 12  | 0.0                     | 17.9  |
|                    | 24160    | 0                      | 0  | 0.0                     | 0.0  | 0                      | 2  | 0.0                     | 3.1  | 2                      | 3  | 2.4                     | 4.3  | 2                      | 5   | 2.4                     | 7.3   |
|                    | Subtotal | 2                      | 4  | 4.0                     | 6.3  | 6                      | 25 | 14.6                    | 38.1 | 11                     | 30 | 12.9                    | 42.8 | 19                     | 59  | 31.5                    | 87.3  |
| 1985               | 23645    | 0                      | 0  | 0.0                     | 0.0  | 0                      | 1  | 0.0                     | 1.5  | 0                      | 0  | 0.0                     | 0.0  | 0                      | 1   | 0.0                     | 1.5   |
|                    | 24140    | 0                      | 2  | 0.0                     | 3.2  | 0                      | 0  | 0.0                     | 0.0  | 0                      | 0  | 0.0                     | 0.0  | 0                      | 2   | 0.0                     | 3.2   |
|                    | Subtotal | 0                      | 2  | 0.0                     | 3.2  | 0                      | 1  | 0.0                     | 1.5  | 0                      | 0  | 0.0                     | 0.0  | 0                      | 3   | 0.0                     | 4.7   |
| Total hatchery (c) |          | 6                      | 11 | 12.0                    | 17.4 | 30                     | 57 | 73.0                    | 86.9 | 91                     | 61 | 107.0                   | 87.0 | 127                    | 129 | 192.0                   | 191.4 |

(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 1991. The source of tags for the Petersen estimates was from in situ carcass tagging. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method A).

| Brood year         | CWT code | Campbell River (a)     |    |                         |     | 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 |     |
|                    |          | M (b)                  | F  | M                       | F   | M                      | F  | M                       | F   | M                      | F  | M                       | F   | M                      | F   | M                       | F   |
| <b>Strays: (d)</b> |          |                        |    |                         |     |                        |    |                         |     |                        |    |                         |     |                        |     |                         |     |
| 1987               | 24958    | 0                      | 0  | 0.0                     | 0.0 | 0                      | 1  | 0.0                     | 1.5 | 0                      | 0  | 0.0                     | 0.0 | 0                      | 1   | 0.0                     | 1.5 |
| 1986               | 24716    | 0                      | 0  | 0.0                     | 0.0 | 0                      | 1  | 0.0                     | 1.5 | 0                      | 0  | 0.0                     | 0.0 | 0                      | 1   | 0.0                     | 1.5 |
| 1986               | 24718    | 1                      | 0  | 2.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0 | 1                      | 0   | 2.0                     | 0.0 |
| 1985               | 23730    | 0                      | 1  | 0.0                     | 1.6 | 0                      | 0  | 0.0                     | 0.0 | 0                      | 0  | 0.0                     | 0.0 | 0                      | 1   | 0.0                     | 1.6 |
| Total strays       |          | 1                      | 1  | 2.0                     | 1.6 | 0                      | 2  | 0.0                     | 3.1 | 0                      | 0  | 0.0                     | 0.0 | 1                      | 3   | 2.0                     | 4.6 |
| Total CWT          |          | 7                      | 12 | 14                      | 19  | 30                     | 59 | 73                      | 90  | 91                     | 61 | 107                     | 87  | 128                    | 132 | 194                     | 196 |
| No data (5000)     |          | 0                      | 0  |                         |     | 0                      | 0  |                         |     | 1                      | 0  |                         |     | 1                      | 0   |                         |     |
| No pin (8000)      |          | 0                      | 0  |                         |     | 7                      | 2  |                         |     | 3                      | 3  |                         |     | 10                     | 5   |                         |     |
| Lost pin (9000)    |          | 0                      | 0  |                         |     | 0                      | 0  |                         |     | 1                      | 1  |                         |     | 1                      | 1   |                         |     |
| Observed adipose   |          | 7                      | 12 |                         |     | 37                     | 61 |                         |     | 96                     | 65 |                         |     | 140                    | 138 |                         |     |

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

(b) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(c) Estimated total hatchery 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, 1991.

| Brood year         | CWT code | Release numbers |          | CWT loss (%) | Days held | Adipose release status |            |
|--------------------|----------|-----------------|----------|--------------|-----------|------------------------|------------|
|                    |          | CWT             | Untagged |              |           | Clipped                | Uncolipped |
| 1988               | 25526    | 24624           | 182558   | 1.4          | 7         | 24974                  | 182208     |
|                    | 25527    | 23937           | 244318   | 2.8          | 7         | 24627                  | 243628     |
|                    | 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      |
| 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               |          | 24152           | 19947    | 276591       | 0.0       | 0                      | 19947      |
|                    | 24153    | 19935           | 276591   | 0.0          | 0         | 19935                  | 276591     |
|                    | 24154    | 19990           | 276591   | 0.0          | 0         | 19990                  | 276591     |
|                    | 24155    | 18978           | 467555   | 0.0          | 0         | 18978                  | 467555     |
|                    | 24156    | 20006           | 467555   | 0.0          | 0         | 20006                  | 467555     |
|                    | 24157    | 19982           | 467555   | 0.0          | 0         | 19982                  | 467555     |
|                    | 24158    | 19980           | 299513   | 0.0          | 0         | 19980                  | 299513     |
|                    | 24159    | 19899           | 299513   | 0.0          | 0         | 19899                  | 299513     |
|                    | 24160    | 19979           | 299513   | 0.0          | 0         | 19979                  | 299513     |
|                    | 1985     | 23645           | 24843    | 98507        | 0.0       | 0                      | 24843      |
| 24140              |          | 14532           | 409583   | 0.1          | 10        | 14547                  | 409568     |
| Total hatchery     |          | 775863          | 10035846 |              |           | 784341                 | 10027368   |
| <u>Strays: (a)</u> |          |                 |          |              |           |                        |            |
| 1987               | 24958    | 25913           | 898585   | 0.1          | 3         | 25939                  | 898559     |
| 1986               | 24716    | 26341           | 199822   | 0.2          | 1         | 26394                  | 199769     |
| 1986               | 24718    | 26800           | 150662   | 0.2          | 1         | 26854                  | 150608     |
| 1985               | 23730    | 75240           | 33970    | 1.0          | 1         | 76000                  | 33210      |

(a) Strays came from Nicola River, Puntledge River (hybrids), and 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, 1991 (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      |        |
| 1988       | 25526             | 24974               | 182208    | 8.30             | 0.0                                 | 0.0  | 60.6          | 0.0   | 19.5             | 0.0   | 80.1  | 0.0    |        |
|            | 25527             | 24627               | 243628    | 10.89            | 0.0                                 | 0.0  | 26.5          | 0.0   | 12.8             | 0.0   | 39.3  | 0.0    |        |
|            | 25814             | 25604               | 289063    | 12.29            | 0.0                                 | 0.0  | 29.9          | 0.0   | 28.9             | 0.0   | 58.8  | 0.0    |        |
|            | 25815             | 25855               | 292479    | 12.31            | 0.0                                 | 0.0  | 30.0          | 0.0   | 29.0             | 0.0   | 58.9  | 0.0    |        |
|            | 25816             | 22570               | 255833    | 12.34            | 0.0                                 | 0.0  | 30.0          | 0.0   | 29.0             | 0.0   | 59.0  | 0.0    |        |
|            | 25817             | 25029               | 268880    | 11.74            | 0.0                                 | 0.0  | 0.0           | 0.0   | 27.6             | 0.0   | 27.6  | 0.0    |        |
|            | 25818             | 25096               | 269867    | 11.75            | 0.0                                 | 0.0  | 28.6          | 0.0   | 55.3             | 0.0   | 83.9  | 0.0    |        |
|            | 25819             | 25037               | 270958    | 11.82            | 0.0                                 | 0.0  | 28.8          | 0.0   | 41.7             | 0.0   | 70.5  | 0.0    |        |
|            | 25820             | 25162               | 406284    | 17.15            | 0.0                                 | 0.0  | 0.0           | 0.0   | 60.5             | 0.0   | 60.5  | 0.0    |        |
|            | 25821             | 24958               | 402992    | 17.15            | 0.0                                 | 0.0  | 0.0           | 0.0   | 60.5             | 0.0   | 60.5  | 0.0    |        |
|            | 25822             | 25237               | 407497    | 17.15            | 0.0                                 | 0.0  | 0.0           | 0.0   | 40.3             | 0.0   | 40.3  | 0.0    |        |
|            |                   | Subtotal            | 274150    | 3289688          |                                     | 0.0  | 0.0           | 234.3 | 0.0              | 405.1 | 0.0   | 639.4  | 0.0    |
|            | 1987              | 24419               | 24931     | 333010           | 14.36                               | 0.0  | 0.0           | 0.0   | 43.8             | 118.2 | 61.4  | 118.2  | 105.2  |
|            |                   | 24420               | 24858     | 332048           | 14.36                               | 0.0  | 22.7          | 0.0   | 43.8             | 33.8  | 20.5  | 33.8   | 87.0   |
| 24421      |                   | 24960               | 333409    | 14.36            | 0.0                                 | 0.0  | 34.9          | 0.0   | 84.4             | 61.4  | 119.3 | 61.4   |        |
| 24736      |                   | 21006               | 65112     | 4.10             | 0.0                                 | 0.0  | 20.0          | 25.0  | 9.6              | 11.7  | 29.6  | 36.7   |        |
| 24737      |                   | 21006               | 65112     | 4.10             | 0.0                                 | 13.0 | 10.0          | 37.5  | 4.8              | 17.5  | 14.8  | 68.0   |        |
| 24956      |                   | 25118               | 330180    | 14.15            | 0.0                                 | 22.4 | 34.4          | 21.6  | 116.4            | 100.9 | 150.8 | 144.8  |        |
| 25358      |                   | 25078               | 309963    | 13.36            | 26.7                                | 0.0  | 0.0           | 61.1  | 94.3             | 95.3  | 121.0 | 156.4  |        |
| 25359      |                   | 25206               | 310514    | 13.32            | 26.6                                | 0.0  | 64.8          | 40.6  | 94.0             | 76.0  | 185.4 | 116.6  |        |
| 25360      |                   | 25315               | 311859    | 13.32            | 0.0                                 | 0.0  | 32.4          | 81.3  | 78.3             | 19.0  | 110.7 | 100.3  |        |
| 25361      |                   | 24979               | 328344    | 14.15            | 28.3                                | 0.0  | 68.8          | 0.0   | 66.5             | 20.2  | 163.7 | 20.2   |        |
| 25362      |                   | 24957               | 328062    | 14.14            | 0.0                                 | 0.0  | 68.8          | 64.7  | 99.8             | 80.7  | 168.6 | 145.4  |        |
| 25363      |                   | 24691               | 51015     | 3.07             | 6.1                                 | 4.9  | 22.4          | 18.7  | 10.8             | 8.7   | 39.3  | 32.3   |        |
|            |                   | Subtotal            | 292106    | 3098627          |                                     | 87.8 | 63.0          | 356.6 | 438.2            | 810.9 | 573.3 | 1255.2 | 1074.5 |

(continued)

Table 13 (cont.). Estimates of total escapement of hatchery-reared chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag co 1991 (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) |       |               |        |                  |        |        |        |  |
|------------|--------------------|---------------------|-----------|------------------|-------------------------------------|-------|---------------|--------|------------------|--------|--------|--------|--|
|            |                    | Clipped             | Unclipped |                  | Campbell River                      |       | Quinsam River |        | Quinsam Hatchery |        | Total  |        |  |
|            |                    |                     |           |                  | M (b)                               | F     | M             | F      | M                | F      | M      | F      |  |
| 1986       | 24152              | 19947               | 276591    | 14.87            | 0.0                                 | 0.0   | 0.0           | 113.4  | 0.0              | 42.4   | 113.4  | 42.4   |  |
|            | 24153              | 19935               | 276591    | 14.87            | 29.7                                | 0.0   | 0.0           | 22.7   | 17.5             | 84.9   | 69.9   | 84.9   |  |
|            | 24154              | 19990               | 276591    | 14.84            | 0.0                                 | 0.0   | 0.0           | 22.6   | 17.4             | 21.2   | 40.1   | 21.2   |  |
|            | 24155              | 18978               | 467555    | 25.64            | 0.0                                 | 40.6  | 0.0           | 78.2   | 30.1             | 146.3  | 108.4  | 186.8  |  |
|            | 24156              | 20006               | 467555    | 24.37            | 48.7                                | 38.6  | 177.9         | 111.5  | 57.3             | 139.0  | 217.6  | 355.5  |  |
|            | 24157              | 19982               | 467555    | 24.40            | 0.0                                 | 38.6  | 178.1         | 111.7  | 28.7             | 174.0  | 140.3  | 390.7  |  |
|            | 24158              | 19980               | 299513    | 15.99            | 0.0                                 | 0.0   | 0.0           | 48.8   | 56.4             | 45.6   | 105.2  | 45.6   |  |
|            | 24159              | 19899               | 299513    | 16.05            | 0.0                                 | 25.4  | 0.0           | 146.9  | 0.0              | 114.5  | 146.9  | 139.9  |  |
|            | 24160              | 19979               | 299513    | 15.99            | 0.0                                 | 0.0   | 0.0           | 48.8   | 37.6             | 68.4   | 86.4   | 68.4   |  |
|            | Subtotal           | 178696              | 3130977   |                  | 78.5                                | 143.2 | 356.0         | 704.6  | 245.1            | 836.2  | 1028.2 | 1335.4 |  |
| 1985       | 23645              | 24843               | 98507     | 4.97             | 0.0                                 | 0.0   | 0.0           | 7.6    | 0.0              | 0.0    | 0.0    | 7.6    |  |
|            | 24140              | 14547               | 409568    | 29.16            | 0.0                                 | 92.3  | 0.0           | 0.0    | 0.0              | 0.0    | 0.0    | 92.3   |  |
|            | Subtotal           | 39390               | 508075    |                  | 0.0                                 | 92.3  | 0.0           | 7.6    | 0.0              | 0.0    | 0.0    | 99.9   |  |
|            | Total hatchery     |                     |           |                  | 166.3                               | 298.5 | 946.9         | 1150.4 | 1461.1           | 1409.5 | 2922.8 | 2509.8 |  |
|            | <u>Strays: (d)</u> |                     |           |                  |                                     |       |               |        |                  |        |        |        |  |
| 1987       | 24958              | 25939               | 898559    | 35.64            | 0.0                                 | 0.0   | 0.0           | 54.4   | 0.0              | 0.0    | 0.0    | 54.4   |  |
| 1986       | 24716              | 26394               | 199769    | 8.57             | 0.0                                 | 0.0   | 0.0           | 13.1   | 0.0              | 0.0    | 0.0    | 13.1   |  |
| 1986       | 24718              | 26854               | 150608    | 6.61             | 13.2                                | 0.0   | 0.0           | 0.0    | 0.0              | 0.0    | 13.2   | 0.0    |  |
| 1985       | 23730              | 76000               | 33210     | 1.44             | 0.0                                 | 2.3   | 0.0           | 0.0    | 0.0              | 0.0    | 0.0    | 2.3    |  |
|            | Total strays       |                     |           |                  | 13.2                                | 2.3   | 0.0           | 67.4   | 0.0              | 0.0    | 13.2   | 69.7   |  |

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

(b) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(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, 1991. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 13).

| Location                    | Age   | Estimated escapement (a) |          | Hatchery contribution (b) |         |        |         | Stray contribution (b) |     |        |     |
|-----------------------------|-------|--------------------------|----------|---------------------------|---------|--------|---------|------------------------|-----|--------|-----|
|                             |       |                          |          | Male (c)                  |         | Female |         | Male (c)               |     | Female |     |
|                             |       | Male (c)                 | Female   | Number                    | %       | Number | %       | Number                 | %   | Number | %   |
| <u>Campbell River</u>       |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 50                       | 0        | 0                         | 0.0     | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 239                      | 152      | 88                        | 36.8    | 63     | 41.4    | 0                      | 0.0 | 0      | 0.0 |
|                             | 5.1   | 327                      | 573      | 79                        | 24.2    | 143    | 25.0    | 13                     | 4.0 | 0      | 0.0 |
|                             | 6.1   | 6                        | 34       | 0                         | 0.0     | 92     | 100 (e) | 0                      | 0.0 | 2      | 5.9 |
|                             | Total | 623                      | 759      | 167                       | 26.8    | 298    | 39.3    | 13                     | 2.1 | 2      | 0.3 |
| <u>Quinsam River</u>        |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 328                      | 14       | 234                       | 71.3    | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 786                      | 779      | 357                       | 45.4    | 438    | 56.2    | 0                      | 0.0 | 54     | 6.9 |
|                             | 5.1   | 257                      | 1149     | 356                       | 100 (e) | 705    | 61.4    | 0                      | 0.0 | 13     | 1.1 |
|                             | 6.1   | 12                       | 26       | 0                         | 0.0     | 8      | 30.8    | 0                      | 0.0 | 0      | 0.0 |
|                             | Total | 1384                     | 1968     | 947                       | 68.4    | 1151   | 58.5    | 0                      | 0.0 | 67     | 3.4 |
| <u>Quinsam Hatchery (d)</u> |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 283                      | 16       | 405                       | 100 (e) | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 1014                     | 592      | 811                       | 80.0    | 573    | 96.8    | 0                      | 0.0 | 0      | 0.0 |
|                             | 5.1   | 318                      | 935      | 245                       | 77.0    | 836    | 89.4    | 0                      | 0.0 | 0      | 0.0 |
|                             | 6.1   | 0                        | 16       | 0                         | 0.0     | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | Total | 1615                     | 1557 (f) | 1461                      | 90.5    | 1409   | 90.5    | 0                      | 0.0 | 0      | 0.0 |

(a) From Table 9

(b) From Table 13

(c) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(d) Population estimate includes chinook enumerated above the fence on the Quinsam River

(e) Estimated hatchery contribution greater than 100%

(f) Rounding error prohibits correct summation

Table 15. Estimates of the adjusted number of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1991. 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    |
| 1988       | 25526    | 0                  | 0 | 0.0           | 0.0 | 3             | 0  | 3.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 5             | 0  | 5.0           | 0.0  |
|            | 25527    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 1                | 0  | 1.0           | 0.0  | 2             | 0  | 2.0           | 0.0  |
|            | 25814    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 3             | 0  | 3.0           | 0.0  |
|            | 25815    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 3             | 0  | 3.0           | 0.0  |
|            | 25816    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 3             | 0  | 3.0           | 0.0  |
|            | 25817    | 0                  | 0 | 0.0           | 0.0 | 0             | 0  | 0.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 2             | 0  | 2.0           | 0.0  |
|            | 25818    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 4                | 0  | 4.1           | 0.0  | 5             | 0  | 5.1           | 0.0  |
|            | 25819    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 3                | 0  | 3.1           | 0.0  | 4             | 0  | 4.1           | 0.0  |
|            | 25820    | 0                  | 0 | 0.0           | 0.0 | 0             | 0  | 0.0           | 0.0  | 3                | 0  | 3.1           | 0.0  | 3             | 0  | 3.1           | 0.0  |
|            | 25821    | 0                  | 0 | 0.0           | 0.0 | 0             | 0  | 0.0           | 0.0  | 3                | 0  | 3.1           | 0.0  | 3             | 0  | 3.1           | 0.0  |
|            | 25822    | 0                  | 0 | 0.0           | 0.0 | 0             | 0  | 0.0           | 0.0  | 2                | 0  | 2.0           | 0.0  | 2             | 0  | 2.0           | 0.0  |
|            | Subtotal | 0                  | 0 | 0.0           | 0.0 | 9             | 0  | 9.0           | 0.0  | 26               | 0  | 26.6          | 0.0  | 35            | 0  | 35.6          | 0.0  |
| 1987       | 24419    | 0                  | 0 | 0.0           | 0.0 | 0             | 2  | 0.0           | 2.0  | 7                | 3  | 7.2           | 3.0  | 7             | 5  | 7.2           | 5.0  |
|            | 24420    | 0                  | 1 | 0.0           | 1.0 | 0             | 2  | 0.0           | 2.0  | 2                | 1  | 2.0           | 1.0  | 2             | 4  | 2.0           | 4.0  |
|            | 24421    | 0                  | 0 | 0.0           | 0.0 | 1             | 0  | 1.0           | 0.0  | 5                | 3  | 5.1           | 3.0  | 6             | 3  | 6.1           | 3.0  |
|            | 24736    | 0                  | 0 | 0.0           | 0.0 | 2             | 4  | 2.0           | 4.0  | 2                | 2  | 2.0           | 2.0  | 4             | 6  | 4.0           | 6.0  |
|            | 24737    | 0                  | 2 | 0.0           | 2.0 | 1             | 6  | 1.0           | 6.0  | 1                | 3  | 1.0           | 3.0  | 2             | 11 | 2.0           | 11.0 |
|            | 24956    | 0                  | 1 | 0.0           | 1.0 | 1             | 1  | 1.0           | 1.0  | 7                | 5  | 7.2           | 5.1  | 8             | 7  | 8.2           | 7.1  |
|            | 25358    | 1                  | 0 | 1.0           | 0.0 | 0             | 3  | 0.0           | 3.0  | 6                | 2  | 6.1           | 2.0  | 7             | 5  | 7.1           | 5.0  |
|            | 25359    | 1                  | 0 | 1.0           | 0.0 | 2             | 2  | 2.0           | 2.0  | 6                | 4  | 6.1           | 4.1  | 9             | 6  | 9.1           | 6.1  |
|            | 25360    | 0                  | 0 | 0.0           | 0.0 | 1             | 4  | 1.0           | 4.0  | 5                | 1  | 5.1           | 1.0  | 6             | 5  | 6.1           | 5.0  |
|            | 25361    | 1                  | 0 | 1.0           | 0.0 | 2             | 0  | 2.0           | 0.0  | 4                | 1  | 4.1           | 1.0  | 7             | 1  | 7.1           | 1.0  |
|            | 25362    | 0                  | 0 | 0.0           | 0.0 | 2             | 3  | 2.0           | 3.0  | 6                | 4  | 6.1           | 4.1  | 8             | 7  | 8.1           | 7.1  |
|            | 25363    | 1                  | 1 | 1.0           | 1.0 | 3             | 4  | 3.0           | 4.0  | 3                | 2  | 3.1           | 2.0  | 7             | 7  | 7.1           | 7.0  |
|            |          | Subtotal           | 4 | 5             | 4.0 | 5.0           | 15 | 31            | 15.0 | 31.0             | 54 | 31            | 55.2 | 31.5          | 73 | 67            | 74.2 |
| 1986       | 24152    | 0                  | 0 | 0.0           | 0.0 | 0             | 5  | 0.0           | 5.0  | 0                | 2  | 0.0           | 2.0  | 0             | 7  | 0.0           | 7.0  |
|            | 24153    | 1                  | 0 | 1.0           | 0.0 | 0             | 1  | 0.0           | 1.0  | 1                | 4  | 1.0           | 4.1  | 2             | 5  | 2.0           | 5.1  |
|            | 24154    | 0                  | 0 | 0.0           | 0.0 | 0             | 1  | 0.0           | 1.0  | 1                | 1  | 1.0           | 1.0  | 1             | 2  | 1.0           | 2.0  |
|            | 24155    | 0                  | 1 | 0.0           | 1.0 | 0             | 2  | 0.0           | 2.0  | 1                | 4  | 1.0           | 4.1  | 1             | 7  | 1.0           | 7.1  |
|            | 24156    | 1                  | 1 | 1.0           | 1.0 | 3             | 3  | 3.0           | 3.0  | 2                | 4  | 2.0           | 4.1  | 6             | 8  | 6.0           | 8.1  |

(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, 1991. 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     |
|                    | 24157            | 0                  | 1  | 0.0           | 1.0  | 3             | 3  | 3.0           | 3.0  | 1                | 5  | 1.0           | 5.1  | 4             | 9   | 4.0           | 9.1   |
|                    | 24158            | 0                  | 0  | 0.0           | 0.0  | 0             | 2  | 0.0           | 2.0  | 3                | 2  | 3.1           | 2.0  | 3             | 4   | 3.1           | 4.0   |
|                    | 24159            | 0                  | 1  | 0.0           | 1.0  | 0             | 6  | 0.0           | 6.0  | 0                | 5  | 0.0           | 5.1  | 0             | 12  | 0.0           | 12.1  |
|                    | 24160            | 0                  | 0  | 0.0           | 0.0  | 0             | 2  | 0.0           | 2.0  | 2                | 3  | 2.0           | 3.0  | 2             | 5   | 2.0           | 5.0   |
|                    | Subtotal         | 2                  | 4  | 2.0           | 4.0  | 6             | 25 | 6.0           | 25.0 | 11               | 30 | 11.2          | 30.5 | 19            | 59  | 19.2          | 59.5  |
| 1985               | 23645            | 0                  | 0  | 0.0           | 0.0  | 0             | 1  | 0.0           | 1.0  | 0                | 0  | 0.0           | 0.0  | 0             | 1   | 0.0           | 1.0   |
|                    | 24140            | 0                  | 2  | 0.0           | 2.0  | 0             | 0  | 0.0           | 0.0  | 0                | 0  | 0.0           | 0.0  | 0             | 2   | 0.0           | 2.0   |
|                    | Subtotal         | 0                  | 2  | 0.0           | 2.0  | 0             | 1  | 0.0           | 1.0  | 0                | 0  | 0.0           | 0.0  | 0             | 3   | 0.0           | 3.0   |
|                    | Total hatchery   | 6                  | 11 | 6.0           | 11.0 | 30            | 57 | 30.0          | 57.0 | 91               | 61 | 93.0          | 62.0 | 127           | 129 | 129.0         | 130.0 |
| <u>Strays: (c)</u> |                  |                    |    |               |      |               |    |               |      |                  |    |               |      |               |     |               |       |
| 1987               | 24958            | 0                  | 0  | 0.0           | 0.0  | 0             | 1  | 0.0           | 1.0  | 0                | 0  | 0.0           | 0.0  | 0             | 1   | 0.0           | 1.0   |
| 1986               | 24716            | 0                  | 0  | 0.0           | 0.0  | 0             | 1  | 0.0           | 1.0  | 0                | 0  | 0.0           | 0.0  | 0             | 1   | 0.0           | 1.0   |
| 1986               | 24718            | 1                  | 0  | 1.0           | 0.0  | 0             | 0  | 0.0           | 0.0  | 0                | 0  | 0.0           | 0.0  | 1             | 0   | 1.0           | 0.0   |
| 1985               | 23730            | 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                  | 1  | 1.0           | 1.0  | 0             | 2  | 0.0           | 2.0  | 0                | 0  | 0.0           | 0.0  | 1             | 3   | 1.0           | 3.0   |
|                    | Total CWT        | 7                  | 12 | 7             | 12   | 30            | 59 | 30            | 59   | 91               | 61 | 93            | 62   | 128           | 132 | 130           | 133   |
|                    | No data (5000)   | 0                  | 0  |               |      | 0             | 0  |               |      | 1                | 0  |               |      | 1             | 0   |               |       |
|                    | No pin (8000)    | 0                  | 0  |               |      | 7             | 2  |               |      | 3                | 3  |               |      | 10            | 5   |               |       |
|                    | Lost pin (9000)  | 0                  | 0  |               |      | 0             | 0  |               |      | 1                | 1  |               |      | 1             | 1   |               |       |
|                    | Observed adipose | 7                  | 12 |               |      | 37            | 61 |               |      | 96               | 65 |               |      | 140           | 138 |               |       |

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

(b) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

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

(d) Estimated total hatchery from Table 10

Table 16. Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1991. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method B).

| Brood year | CWT code | Campbell River (a) |     |                |     | Quinsam River |      |                |      | Quinsam Hatchery |      |                |      | Total         |      |                |      |
|------------|----------|--------------------|-----|----------------|-----|---------------|------|----------------|------|------------------|------|----------------|------|---------------|------|----------------|------|
|            |          | Adjusted CWTs      |     | Estimated CWTs |     | Adjusted CWTs |      | Estimated CWTs |      | Adjusted CWTs    |      | Estimated CWTs |      | Adjusted CWTs |      | Estimated CWTs |      |
|            |          | M (b)              | F   | M              | F   | M             | F    | M              | F    | M                | F    | M              | F    | M             | F    | M              | F    |
| 1988       | 25526    | 0.0                | 0.0 | 0.0            | 0.0 | 3.0           | 0.0  | 5.9            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 5.0           | 0.0  | 8.2            | 0.0  |
|            | 25527    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 1.0              | 0.0  | 1.2            | 0.0  | 2.0           | 0.0  | 3.1            | 0.0  |
|            | 25814    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 3.0           | 0.0  | 4.3            | 0.0  |
|            | 25815    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 3.0           | 0.0  | 4.3            | 0.0  |
|            | 25816    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 3.0           | 0.0  | 4.3            | 0.0  |
|            | 25817    | 0.0                | 0.0 | 0.0            | 0.0 | 0.0           | 0.0  | 0.0            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 2.0           | 0.0  | 2.3            | 0.0  |
|            | 25818    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 4.1              | 0.0  | 4.6            | 0.0  | 5.1           | 0.0  | 6.6            | 0.0  |
|            | 25819    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 3.1              | 0.0  | 3.5            | 0.0  | 4.1           | 0.0  | 5.4            | 0.0  |
|            | 25820    | 0.0                | 0.0 | 0.0            | 0.0 | 0.0           | 0.0  | 0.0            | 0.0  | 3.1              | 0.0  | 3.5            | 0.0  | 3.1           | 0.0  | 3.5            | 0.0  |
|            | 25821    | 0.0                | 0.0 | 0.0            | 0.0 | 0.0           | 0.0  | 0.0            | 0.0  | 3.1              | 0.0  | 3.5            | 0.0  | 3.1           | 0.0  | 3.5            | 0.0  |
|            | 25822    | 0.0                | 0.0 | 0.0            | 0.0 | 0.0           | 0.0  | 0.0            | 0.0  | 2.0              | 0.0  | 2.3            | 0.0  | 2.0           | 0.0  | 2.3            | 0.0  |
|            | Subtotal | 0.0                | 0.0 | 0.0            | 0.0 | 9.0           | 0.0  | 17.6           | 0.0  | 26.6             | 0.0  | 30.1           | 0.0  | 35.6          | 0.0  | 47.8           | 0.0  |
| 1987       | 24419    | 0.0                | 0.0 | 0.0            | 0.0 | 0.0           | 2.0  | 0.0            | 3.0  | 7.2              | 3.0  | 8.1            | 4.1  | 7.2           | 5.0  | 8.1            | 7.0  |
|            | 24420    | 0.0                | 1.0 | 0.0            | 1.6 | 0.0           | 2.0  | 0.0            | 3.0  | 2.0              | 1.0  | 2.3            | 1.4  | 2.0           | 4.0  | 2.3            | 5.9  |
|            | 24421    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 0.0  | 2.0            | 0.0  | 5.1              | 3.0  | 5.8            | 4.1  | 6.1           | 3.0  | 7.8            | 4.1  |
|            | 24736    | 0.0                | 0.0 | 0.0            | 0.0 | 2.0           | 4.0  | 3.9            | 5.9  | 2.0              | 2.0  | 2.3            | 2.7  | 4.0           | 6.0  | 6.2            | 8.6  |
|            | 24737    | 0.0                | 2.0 | 0.0            | 3.2 | 1.0           | 6.0  | 2.0            | 8.9  | 1.0              | 3.0  | 1.2            | 4.1  | 2.0           | 11.0 | 3.1            | 16.2 |
|            | 24956    | 0.0                | 1.0 | 0.0            | 1.6 | 1.0           | 1.0  | 2.0            | 1.5  | 7.2              | 5.1  | 8.1            | 6.8  | 8.2           | 7.1  | 10.1           | 9.9  |
|            | 25358    | 1.0                | 0.0 | 1.9            | 0.0 | 0.0           | 3.0  | 0.0            | 4.4  | 6.1              | 2.0  | 7.0            | 2.7  | 7.1           | 5.0  | 8.9            | 7.2  |
|            | 25359    | 1.0                | 0.0 | 1.9            | 0.0 | 2.0           | 2.0  | 3.9            | 3.0  | 6.1              | 4.1  | 7.0            | 5.4  | 9.1           | 6.1  | 12.8           | 8.4  |
|            | 25360    | 0.0                | 0.0 | 0.0            | 0.0 | 1.0           | 4.0  | 2.0            | 5.9  | 5.1              | 1.0  | 5.8            | 1.4  | 6.1           | 5.0  | 7.8            | 7.3  |
|            | 25361    | 1.0                | 0.0 | 1.9            | 0.0 | 2.0           | 0.0  | 3.9            | 0.0  | 4.1              | 1.0  | 4.6            | 1.4  | 7.1           | 1.0  | 10.5           | 1.4  |
|            | 25362    | 0.0                | 0.0 | 0.0            | 0.0 | 2.0           | 3.0  | 3.9            | 4.4  | 6.1              | 4.1  | 7.0            | 5.4  | 8.1           | 7.1  | 10.9           | 9.9  |
|            | 25363    | 1.0                | 1.0 | 1.9            | 1.6 | 3.0           | 4.0  | 5.9            | 5.9  | 3.1              | 2.0  | 3.5            | 2.7  | 7.1           | 7.0  | 11.3           | 10.3 |
|            |          | Subtotal           | 4.0 | 5.0            | 7.7 | 8.1           | 15.0 | 31.0           | 29.4 | 45.9             | 55.2 | 31.5           | 62.6 | 42.0          | 74.2 | 67.5           | 99.7 |

(continued)

Table 16 (cont.). Estimates of total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1991. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 13 (Method B).

| Brood year         | CWT code          | Campbell River (a) |      |                |      | Quinsam River |      |                |      | Quinsam Hatchery |      |                |      | Total         |       |                |       |
|--------------------|-------------------|--------------------|------|----------------|------|---------------|------|----------------|------|------------------|------|----------------|------|---------------|-------|----------------|-------|
|                    |                   | Adjusted CWTs      |      | Estimated CWTs |      | Adjusted CWTs |      | Estimated CWTs |      | Adjusted CWTs    |      | Estimated CWTs |      | Adjusted CWTs |       | Estimated CWTs |       |
|                    |                   | M (b)              | F    | M              | F    | M             | F    | M              | F    | M                | F    | M              | F    | M             | F     | M              | F     |
| 1986               | 24152             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 5.0  | 0.0            | 7.4  | 0.0              | 2.0  | 0.0            | 2.7  | 0.0           | 7.0   | 0.0            | 10.1  |
|                    | 24153             | 1.0                | 0.0  | 1.9            | 0.0  | 0.0           | 1.0  | 0.0            | 1.5  | 1.0              | 4.1  | 1.2            | 5.4  | 2.0           | 5.1   | 3.1            | 6.9   |
|                    | 24154             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 1.0  | 0.0            | 1.5  | 1.0              | 1.0  | 1.2            | 1.4  | 1.0           | 2.0   | 1.2            | 2.8   |
|                    | 24155             | 0.0                | 1.0  | 0.0            | 1.6  | 0.0           | 2.0  | 0.0            | 3.0  | 1.0              | 4.1  | 1.2            | 5.4  | 1.0           | 7.1   | 1.2            | 10.0  |
|                    | 24156             | 1.0                | 1.0  | 1.9            | 1.6  | 3.0           | 3.0  | 5.9            | 4.4  | 2.0              | 4.1  | 2.3            | 5.4  | 6.0           | 8.1   | 10.1           | 11.5  |
|                    | 24157             | 0.0                | 1.0  | 0.0            | 1.6  | 3.0           | 3.0  | 5.9            | 4.4  | 1.0              | 5.1  | 1.2            | 6.8  | 4.0           | 9.1   | 7.0            | 12.8  |
|                    | 24158             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 2.0  | 0.0            | 3.0  | 3.1              | 2.0  | 3.5            | 2.7  | 3.1           | 4.0   | 3.5            | 5.7   |
|                    | 24159             | 0.0                | 1.0  | 0.0            | 1.6  | 0.0           | 6.0  | 0.0            | 8.9  | 0.0              | 5.1  | 0.0            | 6.8  | 0.0           | 12.1  | 0.0            | 17.3  |
|                    | 24160             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 2.0  | 0.0            | 3.0  | 2.0              | 3.0  | 2.3            | 4.1  | 2.0           | 5.0   | 2.3            | 7.0   |
|                    | Subtotal          | 2.0                | 4.0  | 3.9            | 6.5  | 6.0           | 25.0 | 11.8           | 37.0 | 11.2             | 30.5 | 12.8           | 40.6 | 19.2          | 59.5  | 28.4           | 84.1  |
| 1985               | 23645             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 1.0  | 0.0            | 1.5  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 1.0   | 0.0            | 1.5   |
|                    | 24140             | 0.0                | 2.0  | 0.0            | 3.2  | 0.0           | 0.0  | 0.0            | 0.0  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 2.0   | 0.0            | 3.2   |
|                    | Subtotal          | 0.0                | 2.0  | 0.0            | 3.2  | 0.0           | 1.0  | 0.0            | 1.5  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 3.0   | 0.0            | 4.7   |
|                    | Total hatchery    | 6.0                | 11.0 | 11.6           | 17.8 | 30.0          | 57.0 | 58.8           | 84.5 | 93.0             | 62.0 | 105.5          | 82.6 | 129.0         | 130.0 | 175.9          | 184.8 |
| <u>Strays: (c)</u> |                   |                    |      |                |      |               |      |                |      |                  |      |                |      |               |       |                |       |
| 1987               | 24958             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 1.0  | 0.0            | 1.5  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 1.0   | 0.0            | 1.5   |
| 1986               | 24716             | 0.0                | 0.0  | 0.0            | 0.0  | 0.0           | 1.0  | 0.0            | 1.5  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 1.0   | 0.0            | 1.5   |
| 1986               | 24718             | 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            | 0.0   |
| 1985               | 23730             | 0.0                | 1.0  | 0.0            | 1.6  | 0.0           | 0.0  | 0.0            | 0.0  | 0.0              | 0.0  | 0.0            | 0.0  | 0.0           | 1.0   | 0.0            | 1.6   |
|                    | Total strays      | 1.0                | 1.0  | 1.9            | 1.6  | 0.0           | 2.0  | 0.0            | 3.0  | 0.0              | 0.0  | 0.0            | 0.0  | 1.0           | 3.0   | 1.9            | 4.6   |
|                    | Petersen est. (d) | 623                | 759  |                |      | 1384          | 1968 |                |      | 1615             | 1557 |                |      |               |       |                |       |
|                    | Sample size (d)   | 323                | 469  |                |      | 706           | 1328 |                |      | 1423             | 1169 |                |      |               |       |                |       |

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

(b) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(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, 1991 (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) |      |               |       |                  |       |        |       |
|------------|-------------------|---------------------|--------------|------------------|-------------------------------------|------|---------------|-------|------------------|-------|--------|-------|
|            |                   | CWT                 | Untagged (d) |                  | Campbell River                      |      | Quinsam River |       | Quinsam Hatchery |       | Total  |       |
|            |                   |                     |              |                  | M (b)                               | F    | M             | F     | M                | F     | M      | F     |
| 1988       | 25526             | 24624               | 182558       | 8.4              | 0.0                                 | 0.0  | 49.5          | 0.0   | 19.5             | 0.0   | 69.0   | 0.0   |
|            | 25527             | 23937               | 244318       | 11.2             | 0.0                                 | 0.0  | 22.0          | 0.0   | 13.0             | 0.0   | 35.0   | 0.0   |
|            | 25814             | 25246               | 289421       | 12.5             | 0.0                                 | 0.0  | 24.4          | 0.0   | 28.9             | 0.0   | 53.3   | 0.0   |
|            | 25815             | 25545               | 292789       | 12.5             | 0.0                                 | 0.0  | 24.4          | 0.0   | 28.9             | 0.0   | 53.3   | 0.0   |
|            | 25816             | 22344               | 256059       | 12.5             | 0.0                                 | 0.0  | 24.4          | 0.0   | 28.9             | 0.0   | 53.3   | 0.0   |
|            | 25817             | 25029               | 268880       | 11.7             | 0.0                                 | 0.0  | 0.0           | 0.0   | 27.2             | 0.0   | 27.2   | 0.0   |
|            | 25818             | 25096               | 269867       | 11.8             | 0.0                                 | 0.0  | 23.0          | 0.0   | 54.5             | 0.0   | 77.6   | 0.0   |
|            | 25819             | 25037               | 270958       | 11.8             | 0.0                                 | 0.0  | 23.2          | 0.0   | 41.1             | 0.0   | 64.3   | 0.0   |
|            | 25820             | 24810               | 406636       | 17.4             | 0.0                                 | 0.0  | 0.0           | 0.0   | 60.5             | 0.0   | 60.5   | 0.0   |
|            | 25821             | 24609               | 403341       | 17.4             | 0.0                                 | 0.0  | 0.0           | 0.0   | 60.5             | 0.0   | 60.5   | 0.0   |
|            | 25822             | 24884               | 407850       | 17.4             | 0.0                                 | 0.0  | 0.0           | 0.0   | 40.3             | 0.0   | 40.3   | 0.0   |
|            | Subtotal          | 271161              | 3292677      |                  | 0.0                                 | 0.0  | 191.0         | 0.0   | 403.4            | 0.0   | 594.3  | 0.0   |
| 1987       | 24419             | 24457               | 333484       | 14.6             | 0.0                                 | 0.0  | 0.0           | 43.4  | 118.8            | 59.4  | 118.8  | 102.8 |
|            | 24420             | 24386               | 332520       | 14.6             | 0.0                                 | 23.7 | 0.0           | 43.4  | 33.9             | 19.8  | 33.9   | 86.9  |
|            | 24421             | 24486               | 333883       | 14.6             | 0.0                                 | 0.0  | 28.7          | 0.0   | 84.8             | 59.4  | 113.5  | 59.4  |
|            | 24736             | 20607               | 65511        | 4.2              | 0.0                                 | 0.0  | 16.4          | 24.8  | 9.7              | 11.3  | 26.1   | 36.1  |
|            | 24737             | 20607               | 65511        | 4.2              | 0.0                                 | 13.5 | 8.2           | 37.2  | 4.8              | 17.0  | 13.0   | 67.7  |
|            | 24956             | 24641               | 330657       | 14.4             | 0.0                                 | 23.3 | 28.3          | 21.4  | 117.0            | 97.6  | 145.3  | 142.3 |
|            | 25358             | 24677               | 310364       | 13.6             | 26.2                                | 0.0  | 0.0           | 60.4  | 94.5             | 36.8  | 120.6  | 97.1  |
|            | 25359             | 24727               | 310993       | 13.6             | 26.2                                | 0.0  | 53.2          | 40.2  | 94.5             | 73.5  | 173.9  | 113.8 |
|            | 25360             | 24834               | 312340       | 13.6             | 0.0                                 | 0.0  | 26.6          | 80.5  | 78.7             | 18.4  | 105.3  | 98.9  |
|            | 25361             | 24504               | 328819       | 14.4             | 27.8                                | 0.0  | 56.5          | 0.0   | 66.9             | 19.5  | 151.2  | 19.5  |
|            | 25362             | 24483               | 328536       | 14.4             | 0.0                                 | 0.0  | 56.5          | 64.1  | 100.3            | 78.1  | 156.8  | 142.2 |
|            | 25363             | 24222               | 51484        | 3.1              | 6.0                                 | 5.1  | 18.4          | 18.5  | 10.9             | 8.5   | 35.3   | 32.0  |
|            | Subtotal          | 286631              | 3104102      |                  | 86.2                                | 65.6 | 292.8         | 433.8 | 814.8            | 499.3 | 1193.9 | 998.7 |

(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, 1991 (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.

$$\text{Expansion factor} = (\text{CWT releases} + \text{untagged releases}) / \text{CWT releases}$$

| Brood year         | CWT release group | Release numbers (c) |              | Expansion factor | Expanded hatchery contributions (a) |       |               |        |                  |        |        |        |
|--------------------|-------------------|---------------------|--------------|------------------|-------------------------------------|-------|---------------|--------|------------------|--------|--------|--------|
|                    |                   | CWT                 | Untagged (d) |                  | Campbell River                      |       | Quinsam River |        | Quinsam Hatchery |        | Total  |        |
|                    |                   |                     |              |                  | M (b)                               | F     | M             | F      | M                | F      | M      | F      |
| 1986               | 24152             | 19947               | 276591       | 14.9             | 0.0                                 | 0.0   | 0.0           | 110.2  | 0.0              | 40.3   | 0.0    | 150.4  |
|                    | 24153             | 19935               | 276591       | 14.9             | 28.7                                | 0.0   | 0.0           | 22.0   | 17.2             | 80.5   | 45.9   | 102.6  |
|                    | 24154             | 19990               | 276591       | 14.8             | 0.0                                 | 0.0   | 0.0           | 22.0   | 17.2             | 20.1   | 17.2   | 42.1   |
|                    | 24155             | 18978               | 467555       | 25.6             | 0.0                                 | 41.5  | 0.0           | 76.0   | 29.7             | 138.8  | 29.7   | 256.3  |
|                    | 24156             | 20006               | 467555       | 24.4             | 47.0                                | 39.4  | 143.3         | 108.3  | 56.5             | 132.0  | 246.8  | 279.8  |
|                    | 24157             | 19982               | 467555       | 24.4             | 0.0                                 | 39.5  | 143.5         | 108.5  | 28.3             | 165.1  | 171.8  | 313.1  |
|                    | 24158             | 19980               | 299513       | 16.0             | 0.0                                 | 0.0   | 0.0           | 47.4   | 55.6             | 43.3   | 55.6   | 90.7   |
|                    | 24159             | 19899               | 299513       | 16.1             | 0.0                                 | 26.0  | 0.0           | 142.7  | 0.0              | 108.6  | 0.0    | 277.4  |
|                    | 24160             | 19979               | 299513       | 16.0             | 0.0                                 | 0.0   | 0.0           | 47.4   | 37.1             | 64.9   | 37.1   | 112.3  |
|                    | Subtotal          | 178696              | 3130977      |                  | 75.7                                | 146.4 | 286.8         | 684.5  | 241.7            | 793.7  | 604.2  | 1624.6 |
| 1985               | 23645             | 24843               | 98507        | 5.0              | 0.0                                 | 0.0   | 0.0           | 7.4    | 0.0              | 0.0    | 0.0    | 7.4    |
|                    | 24140             | 14532               | 409583       | 29.2             | 0.0                                 | 94.5  | 0.0           | 0.0    | 0.0              | 0.0    | 0.0    | 94.5   |
|                    | Subtotal          | 39375               | 508090       |                  | 0.0                                 | 94.5  | 0.0           | 7.4    | 0.0              | 0.0    | 0.0    | 101.8  |
| Total hatchery     |                   |                     |              |                  | 161.9                               | 306.5 | 770.6         | 1125.6 | 1459.9           | 1293.0 | 2392.4 | 2725.1 |
| <u>Strays: (e)</u> |                   |                     |              |                  |                                     |       |               |        |                  |        |        |        |
| 1987               | 24958             | 25913               | 898585       | 35.7             | 0.0                                 | 0.0   | 0.0           | 52.9   | 0.0              | 0.0    | 0.0    | 52.9   |
| 1986               | 24716             | 26341               | 199822       | 8.6              | 0.0                                 | 0.0   | 0.0           | 12.7   | 0.0              | 0.0    | 0.0    | 12.7   |
| 1986               | 24718             | 26800               | 150662       | 6.6              | 12.8                                | 0.0   | 0.0           | 0.0    | 0.0              | 0.0    | 12.8   | 0.0    |
| 1985               | 23730             | 75240               | 33970        | 1.5              | 0.0                                 | 2.3   | 0.0           | 0.0    | 0.0              | 0.0    | 0.0    | 2.3    |
| Total strays       |                   |                     |              |                  | 12.8                                | 2.3   | 0.0           | 65.6   | 0.0              | 0.0    | 12.8   | 67.9   |

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

(b) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(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, 1991. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 17).

| Location                    | Age   | Estimated escapement (a) |          | Hatchery contribution (b) |         |        |         | Stray contribution (b) |     |        |     |
|-----------------------------|-------|--------------------------|----------|---------------------------|---------|--------|---------|------------------------|-----|--------|-----|
|                             |       |                          |          | Male (c)                  |         | Female |         | Male (c)               |     | Female |     |
|                             |       |                          |          | Number                    | %       | Number | %       | Number                 | %   | Number | %   |
| <u>Campbell River</u>       |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 50                       | 0        | 0                         | 0.0     | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 239                      | 152      | 86                        | 36.0    | 66     | 43.4    | 0                      | 0.0 | 0      | 0.0 |
|                             | 5.1   | 327                      | 573      | 76                        | 23.2    | 146    | 25.5    | 13                     | 4.0 | 0      | 0.0 |
|                             | 6.1   | 6                        | 34       | 0                         | 0.0     | 95     | 100 (e) | 0                      | 0.0 | 2      | 7.1 |
|                             | Total | 623                      | 759      | 162                       | 26.0    | 307    | 40.4    | 13                     | 2.1 | 2      | 0.3 |
| <u>Quinsam River</u>        |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 328                      | 14       | 191                       | 58.2    | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 786                      | 779      | 293                       | 37.3    | 434    | 55.7    | 0                      | 0.0 | 53     | 6.8 |
|                             | 5.1   | 257                      | 1149     | 287                       | 100 (e) | 685    | 59.6    | 0                      | 0.0 | 13     | 1.1 |
|                             | 6.1   | 12                       | 26       | 0                         | 0.0     | 7      | 26.9    | 0                      | 0.0 | 0      | 0.0 |
|                             | Total | 1384                     | 1968     | 771                       | 55.7    | 1126   | 57.2    | 0                      | 0.0 | 66     | 3.4 |
| <u>Quinsam Hatchery (d)</u> |       |                          |          |                           |         |        |         |                        |     |        |     |
|                             | 3.1   | 283                      | 16       | 403                       | 100 (e) | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | 4.1   | 1014                     | 592      | 815                       | 80.4    | 499    | 84.3    | 0                      | 0.0 | 0      | 0.0 |
|                             | 5.1   | 318                      | 935      | 242                       | 76.1    | 794    | 84.9    | 0                      | 0.0 | 0      | 0.0 |
|                             | 6.1   | 0                        | 16       | 0                         | 0.0     | 0      | 0.0     | 0                      | 0.0 | 0      | 0.0 |
|                             | Total | 1615                     | 1557 (f) | 1460                      | 90.4    | 1293   | 83.0    | 0                      | 0.0 | 0      | 0.0 |

(a) From Table 9

(b) From Table 17

(c) Does not include jacks; no estimates of jack abundance were available, no jacks were identified in the ageing analysis and no adipose-clipped jacks were observed

(d) Population estimate includes chinook enumerated above the fence on the Quinsam River

(e) Estimated hatchery contribution greater than 100%

(f) Rounding error prohibits correct summation

**APPENDICES**

Appendix 1. Staple tagging of chinook salmon carcasses in Campbell River, 1991.

| Date          | Capture area (a) | Tagged     |            |          | Total      |
|---------------|------------------|------------|------------|----------|------------|
|               |                  | Male       | Female     | Jack     |            |
| Oct-16        | 1A               | 1          | 3          | 0        | 4          |
|               | 1B               | 1          | 30         | 0        | 31         |
| Oct-18        | 1A               | 0          | 2          | 0        | 2          |
|               | 1B               | 1          | 28         | 0        | 29         |
| Oct-22        | 1A               | 0          | 16         | 0        | 16         |
|               | 1B               | 8          | 11         | 0        | 19         |
| Oct-23        | 1A               | 5          | 4          | 0        | 9          |
|               | 1B               | 4          | 17         | 0        | 21         |
| Oct-25        | 1A               | 0          | 2          | 0        | 2          |
|               | 1B               | 9          | 19         | 0        | 28         |
| Oct-29        | 1A               | 0          | 11         | 0        | 11         |
|               | 1B               | 10         | 1          | 0        | 11         |
| Oct-30        | 1A               | 14         | 1          | 0        | 15         |
|               | 1B               | 3          | 5          | 0        | 8          |
| Nov-01        | 1A               | 2          | 0          | 0        | 2          |
|               | 1B               | 22         | 1          | 0        | 23         |
| Nov-05        | 1A               | 3          | 0          | 0        | 3          |
|               | 1B               | 11         | 0          | 0        | 11         |
| Nov-06        | 1A               | 11         | 1          | 0        | 12         |
|               | 1B               | 5          | 4          | 0        | 9          |
| Nov-08        | 1A               | 0          | 10         | 0        | 10         |
|               | 1B               | 11         | 1          | 0        | 12         |
| Nov-12        | 1A               | 0          | 1          | 0        | 1          |
|               | 1B               | 7          | 10         | 0        | 17         |
| Nov-13        | 1A               | 5          | 6          | 0        | 11         |
|               | 1B               | 2          | 16         | 0        | 18         |
| Nov-15        | 1A               | 0          | 21         | 0        | 21         |
|               | 1B               | 5          | 11         | 0        | 16         |
| <b>Totals</b> |                  | <b>140</b> | <b>232</b> | <b>0</b> | <b>372</b> |

(a) See Figure 1 for location of capture areas

Appendix 2. Staple tagging of chinook salmon carcasses in Quinsam River, 1991.

| Date          | Capture area (a) | Tagged     |            |          | Total      |
|---------------|------------------|------------|------------|----------|------------|
|               |                  | Male       | Female     | Jack     |            |
| Oct-17        | 2B               | 2          | 0          | 0        | 2          |
|               | 2C               | 1          | 5          | 0        | 6          |
|               | 2D               | 1          | 2          | 0        | 3          |
| Oct-21        | 2B               | 1          | 5          | 0        | 6          |
|               | 2C               | 6          | 8          | 0        | 14         |
|               | 2D               | 2          | 2          | 0        | 4          |
| Oct-24        | 2B               | 6          | 7          | 0        | 13         |
|               | 2C               | 5          | 15         | 0        | 20         |
|               | 2D               | 2          | 3          | 0        | 5          |
| Oct-28        | 2B               | 3          | 14         | 0        | 17         |
|               | 2C               | 14         | 23         | 0        | 37         |
|               | 2D               | 0          | 8          | 0        | 8          |
| Oct-31        | 2B               | 3          | 13         | 0        | 16         |
|               | 2C               | 11         | 18         | 0        | 29         |
|               | 2D               | 3          | 6          | 0        | 9          |
| Nov-04        | 2B               | 7          | 11         | 0        | 18         |
|               | 2C               | 21         | 27         | 0        | 48         |
|               | 2D               | 5          | 2          | 0        | 7          |
| Nov-07        | 2B               | 8          | 11         | 0        | 19         |
|               | 2C               | 18         | 15         | 0        | 33         |
|               | 2D               | 8          | 2          | 0        | 10         |
| Nov-11        | 2B               | 7          | 16         | 0        | 23         |
|               | 2C               | 27         | 32         | 0        | 59         |
|               | 2D               | 1          | 2          | 0        | 3          |
| Nov-12        | 2B               | 0          | 0          | 0        | 0          |
|               | 2C               | 0          | 0          | 0        | 0          |
|               | 2D               | 6          | 3          | 0        | 9          |
| Nov-14        | 2B               | 5          | 5          | 0        | 10         |
|               | 2C               | 15         | 18         | 0        | 33         |
|               | 2D               | 4          | 8          | 0        | 12         |
| Nov-18        | 2B               | 0          | 3          | 0        | 3          |
|               | 2C               | 0          | 4          | 0        | 4          |
|               | 2D               | 0          | 0          | 0        | 0          |
| Nov-21        | 2B               | 0          | 0          | 0        | 0          |
|               | 2C               | 1          | 0          | 0        | 1          |
|               | 2D               | 0          | 1          | 0        | 1          |
| <b>Totals</b> |                  | <b>193</b> | <b>289</b> | <b>0</b> | <b>482</b> |

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

Appendix 3. Dead recovery of tagged chinook salmon carcasses in Campbell River, 1991.

| Date         | Recovery<br>area (a) | Recovered |            |          | Total      |
|--------------|----------------------|-----------|------------|----------|------------|
|              |                      | Male      | Female     | Jack     |            |
| Oct-22       | 1A                   | 0         | 0          | 0        | 0          |
|              | 1B                   | 1         | 1          | 0        | 2          |
| Oct-23       | 1A                   | 0         | 1          | 0        | 1          |
|              | 1B                   | 1         | 1          | 0        | 2          |
| Oct-25       | 1A                   | 0         | 1          | 0        | 1          |
|              | 1B                   | 2         | 1          | 0        | 3          |
| Oct-29       | 1A                   | 0         | 0          | 0        | 0          |
|              | 1B                   | 5         | 7          | 0        | 12         |
| Oct-30       | 1A                   | 4         | 9          | 0        | 13         |
|              | 1B                   | 2         | 5          | 0        | 7          |
| Nov-01       | 1A                   | 0         | 0          | 0        | 0          |
|              | 1B                   | 9         | 13         | 0        | 22         |
| Nov-05       | 1A                   | 1         | 4          | 0        | 5          |
|              | 1B                   | 11        | 17         | 0        | 28         |
| Nov-06       | 1A                   | 8         | 15         | 0        | 23         |
|              | 1B                   | 2         | 8          | 0        | 10         |
| Nov-08       | 1A                   | 2         | 1          | 0        | 3          |
|              | 1B                   | 4         | 22         | 0        | 26         |
| Nov-12       | 1A                   | 0         | 3          | 0        | 3          |
|              | 1B                   | 7         | 13         | 0        | 20         |
| Nov-13       | 1A                   | 9         | 8          | 0        | 17         |
|              | 1B                   | 1         | 3          | 0        | 4          |
| Nov-15       | 1A                   | 0         | 2          | 0        | 2          |
|              | 1B                   | 2         | 8          | 0        | 10         |
| <b>Total</b> |                      | <b>71</b> | <b>143</b> | <b>0</b> | <b>214</b> |

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

Appendix 4. Dead recovery of tagged chinook salmon carcasses in Quinsam River, 1991.

| Date   | Capture area (a) | Recovered |        |      | Total |
|--------|------------------|-----------|--------|------|-------|
|        |                  | Male      | Female | Jack |       |
| Oct-21 | 2B               | 0         | 1      | 0    | 1     |
|        | 2C               | 1         | 0      | 0    | 1     |
|        | 2D               | 1         | 1      | 0    | 2     |
| Oct-24 | 2B               | 0         | 1      | 0    | 1     |
|        | 2C               | 2         | 9      | 0    | 11    |
|        | 2D               | 3         | 1      | 0    | 4     |
| Oct-28 | 2B               | 4         | 5      | 0    | 9     |
|        | 2C               | 4         | 9      | 0    | 13    |
|        | 2D               | 1         | 3      | 0    | 4     |
| Oct-31 | 2B               | 3         | 13     | 0    | 16    |
|        | 2C               | 8         | 19     | 0    | 27    |
|        | 2D               | 1         | 8      | 0    | 9     |
| Nov-04 | 2B               | 2         | 10     | 0    | 12    |
|        | 2C               | 6         | 17     | 0    | 23    |
|        | 2D               | 1         | 4      | 0    | 5     |
| Nov-07 | 2B               | 3         | 6      | 0    | 9     |
|        | 2C               | 9         | 19     | 0    | 28    |
|        | 2D               | 4         | 0      | 0    | 4     |
| Nov-11 | 2B               | 3         | 10     | 0    | 13    |
|        | 2C               | 12        | 14     | 0    | 26    |
|        | 2D               | 2         | 0      | 0    | 2     |
| Nov-12 | 2B               | 0         | 0      | 0    | 0     |
|        | 2C               | 0         | 0      | 0    | 0     |
|        | 2D               | 3         | 6      | 0    | 9     |
| Nov-14 | 2B               | 2         | 3      | 0    | 5     |
|        | 2C               | 15        | 22     | 0    | 37    |
|        | 2D               | 3         | 8      | 0    | 11    |
| Nov-18 | 2B               | 1         | 1      | 0    | 2     |
|        | 2C               | 2         | 1      | 0    | 3     |
|        | 2D               | 0         | 0      | 0    | 0     |
| Total  |                  | 96        | 191    | 0    | 287   |

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

Appendix 5. Sequential mark-recapture data for chinook salmon carcasses in Campbell River, 1991. Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).

| Date             | Male         |                  |                    | Female       |                  |                    | Jack         |                  |                    | Total        |                  |                    |
|------------------|--------------|------------------|--------------------|--------------|------------------|--------------------|--------------|------------------|--------------------|--------------|------------------|--------------------|
|                  | No. examined | No. tags applied | No. tags recovered | No. examined | No. tags applied | No. tags recovered | No. examined | No. tags applied | No. tags recovered | No. examined | No. tags applied | No. tags recovered |
| Oct-16           | 6            | 2                | 0                  | 1            | 1                | 0                  | 0            | 0                | 0                  | 7            | 3                | 0                  |
| Oct-18           | 2            | 1                | 0                  | 0            | 0                | 0                  | 0            | 0                | 0                  | 2            | 1                | 0                  |
| Oct-22           | 13           | 8                | 1                  | 15           | 5                | 1                  | 0            | 0                | 0                  | 28           | 13               | 2                  |
| Oct-23           | 19           | 9                | 1                  | 25           | 11               | 2                  | 1            | 0                | 0                  | 45           | 20               | 3                  |
| Oct-25           | 28           | 9                | 2                  | 24           | 11               | 2                  | 0            | 0                | 0                  | 52           | 20               | 4                  |
| Oct-29           | 31           | 10               | 5                  | 39           | 22               | 7                  | 0            | 0                | 0                  | 70           | 32               | 12                 |
| Oct-30           | 39           | 17               | 6                  | 62           | 32               | 14                 | 0            | 0                | 0                  | 101          | 49               | 20                 |
| Nov-01           | 52           | 24               | 9                  | 63           | 33               | 13                 | 3            | 0                | 0                  | 118          | 57               | 22                 |
| Nov-05           | 34           | 14               | 12                 | 55           | 30               | 21                 | 0            | 0                | 0                  | 89           | 44               | 33                 |
| Nov-06           | 26           | 16               | 10                 | 55           | 27               | 23                 | 5            | 0                | 0                  | 86           | 43               | 33                 |
| Nov-08           | 28           | 11               | 6                  | 50           | 21               | 23                 | 0            | 0                | 0                  | 78           | 32               | 29                 |
| Nov-12           | 18           | 7                | 7                  | 40           | 21               | 16                 | 2            | 0                | 0                  | 60           | 28               | 23                 |
| Nov-13           | 18           | 7                | 10                 | 26           | 12               | 11                 | 0            | 0                | 0                  | 44           | 19               | 21                 |
| Nov-15           | 9            | 5                | 2                  | 14           | 6                | 10                 | 0            | 0                | 0                  | 23           | 11               | 12                 |
| Total            | 323          | 140              | 71                 | 469          | 232              | 143                | 11           | 0                | 0                  | 803          | 372              | 214                |
| Totals for MR(a) | 317          | 140              | 71                 | 468          | 232              | 143                | 11           | 0                | 0                  | 796          | 372              | 214                |

(a) To be used in the Peterson population estimation procedure for the carcass tagging and recovery method

Appendix 6. Sequential mark-recapture data for chinook salmon carcasses in Quinsam River, 1991. 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-17                  | 15           | 4                | 0                  | 26           | 7                | 0                  | 0            | 0                | 0                  | 41           | 11               | 0                  |
| Oct-21                  | 40           | 9                | 2                  | 67           | 15               | 2                  | 0            | 0                | 0                  | 107          | 24               | 4                  |
| Oct-24                  | 49           | 13               | 5                  | 110          | 25               | 11                 | 6            | 0                | 0                  | 165          | 38               | 16                 |
| Oct-28                  | 77           | 17               | 9                  | 183          | 45               | 17                 | 4            | 0                | 0                  | 264          | 62               | 26                 |
| Oct-31                  | 73           | 17               | 12                 | 152          | 37               | 40                 | 4            | 0                | 0                  | 229          | 54               | 52                 |
| Nov-04                  | 97           | 33               | 9                  | 207          | 40               | 31                 | 4            | 0                | 0                  | 308          | 73               | 40                 |
| Nov-07                  | 84           | 34               | 16                 | 173          | 28               | 25                 | 8            | 0                | 0                  | 265          | 62               | 41                 |
| Nov-11                  | 123          | 35               | 17                 | 234          | 50               | 24                 | 7            | 0                | 0                  | 364          | 85               | 41                 |
| Nov-12                  | 28           | 6                | 3                  | 19           | 3                | 6                  | 4            | 0                | 0                  | 51           | 9                | 9                  |
| Nov-14                  | 102          | 24               | 20                 | 131          | 31               | 33                 | 5            | 0                | 0                  | 238          | 55               | 53                 |
| Nov-18                  | 14           | 0                | 3                  | 22           | 7                | 2                  | 0            | 0                | 0                  | 36           | 7                | 5                  |
| Nov-21                  | 4            | 1                | 0                  | 4            | 1                | 0                  | 0            | 0                | 0                  | 8            | 2                | 0                  |
| <b>Total</b>            | <b>706</b>   | <b>193</b>       | <b>96</b>          | <b>1328</b>  | <b>289</b>       | <b>191</b>         | <b>42</b>    | <b>0</b>         | <b>0</b>           | <b>2076</b>  | <b>482</b>       | <b>287</b>         |
| <b>Totals for MR(a)</b> | <b>691</b>   | <b>193</b>       | <b>96</b>          | <b>1302</b>  | <b>289</b>       | <b>191</b>         | <b>42</b>    | <b>0</b>         | <b>0</b>           | <b>2035</b>  | <b>482</b>       | <b>287</b>         |

(a) To be used in the Peterson population estimation procedure for the carcass tagging and recovery method

Appendix 7. Total dead recovery and adipose clip recovery of chinook salmon in Campbell River, 1991 (a).

| Date         | Area 1A             |            |          |            |                           |          |          |          | Area 1B             |            |          |            |                           |          |          |           |
|--------------|---------------------|------------|----------|------------|---------------------------|----------|----------|----------|---------------------|------------|----------|------------|---------------------------|----------|----------|-----------|
|              | Total recovered (b) |            |          |            | Adipose clipped recovered |          |          |          | Total recovered (b) |            |          |            | Adipose clipped recovered |          |          |           |
|              | M                   | F          | J        | T          | M                         | F        | J        | T        | M                   | F          | J        | T          | M                         | F        | J        | T         |
| Oct-16       | 2                   | 2          | 0        | 4          | 0                         | 0        | 0        | 0        | 4                   | 1          | 0        | 5          | 0                         | 0        | 0        | 0         |
| Oct-18       | 0                   | 0          | 0        | 0          | 0                         | 0        | 0        | 0        | 2                   | 0          | 0        | 2          | 0                         | 0        | 0        | 0         |
| Oct-22       | 0                   | 0          | 0        | 0          | 0                         | 0        | 0        | 0        | 13                  | 13         | 0        | 26         | 0                         | 0        | 0        | 0         |
| Oct-23       | 13                  | 21         | 1        | 35         | 0                         | 1        | 0        | 1        | 6                   | 4          | 0        | 10         | 0                         | 0        | 0        | 0         |
| Oct-25       | 1                   | 1          | 0        | 2          | 0                         | 0        | 0        | 0        | 27                  | 23         | 0        | 50         | 1                         | 0        | 0        | 1         |
| Oct-29       | 4                   | 8          | 0        | 12         | 0                         | 0        | 0        | 0        | 27                  | 31         | 0        | 58         | 2                         | 1        | 0        | 3         |
| Oct-30       | 26                  | 48         | 0        | 74         | 0                         | 0        | 0        | 0        | 13                  | 14         | 0        | 27         | 0                         | 0        | 0        | 0         |
| Nov-01       | 7                   | 4          | 0        | 11         | 1                         | 1        | 0        | 2        | 45                  | 59         | 3        | 107        | 0                         | 2        | 0        | 2         |
| Nov-05       | 5                   | 5          | 0        | 10         | 0                         | 0        | 0        | 0        | 29                  | 50         | 0        | 79         | 0                         | 1        | 0        | 1         |
| Nov-06       | 20                  | 35         | 1        | 56         | 0                         | 0        | 0        | 0        | 6                   | 20         | 4        | 30         | 0                         | 0        | 0        | 0         |
| Nov-08       | 0                   | 9          | 0        | 9          | 0                         | 0        | 0        | 0        | 28                  | 41         | 0        | 69         | 1                         | 2        | 0        | 3         |
| Nov-12       | 0                   | 4          | 0        | 4          | 0                         | 0        | 0        | 0        | 18                  | 36         | 2        | 56         | 0                         | 2        | 0        | 2         |
| Nov-13       | 11                  | 24         | 0        | 35         | 1                         | 2        | 0        | 3        | 7                   | 2          | 0        | 9          | 1                         | 0        | 0        | 1         |
| Nov-15       | 0                   | 3          | 0        | 3          | 0                         | 0        | 0        | 0        | 9                   | 11         | 0        | 20         | 0                         | 0        | 0        | 0         |
| <b>Total</b> | <b>89</b>           | <b>164</b> | <b>2</b> | <b>255</b> | <b>2</b>                  | <b>4</b> | <b>0</b> | <b>6</b> | <b>234</b>          | <b>305</b> | <b>9</b> | <b>548</b> | <b>5</b>                  | <b>8</b> | <b>0</b> | <b>13</b> |

(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, 1991 (a).

| Date         | Area 2B             |            |          |            |                           |           |          |           | Area 2C             |            |           |             |                           |           |          |           | Area 2D             |            |           |            |                           |          |          |           |
|--------------|---------------------|------------|----------|------------|---------------------------|-----------|----------|-----------|---------------------|------------|-----------|-------------|---------------------------|-----------|----------|-----------|---------------------|------------|-----------|------------|---------------------------|----------|----------|-----------|
|              | Total recovered (b) |            |          |            | Adipose clipped recovered |           |          |           | Total recovered (b) |            |           |             | Adipose clipped recovered |           |          |           | Total recovered (b) |            |           |            | Adipose clipped recovered |          |          |           |
|              | 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-17       | 3                   | 7          | 0        | 10         | 0                         | 0         | 0        | 0         | 7                   | 15         | 0         | 22          | 1                         | 1         | 0        | 2         | 5                   | 4          | 0         | 9          | 0                         | 0        | 0        | 0         |
| Oct-21       | 8                   | 20         | 0        | 28         | 3                         | 0         | 0        | 3         | 20                  | 41         | 0         | 61          | 2                         | 3         | 0        | 5         | 12                  | 6          | 0         | 18         | 1                         | 0        | 0        | 1         |
| Oct-24       | 15                  | 41         | 3        | 59         | 1                         | 2         | 0        | 3         | 25                  | 60         | 1         | 86          | 1                         | 5         | 0        | 6         | 9                   | 9          | 2         | 20         | 1                         | 0        | 0        | 1         |
| Oct-28       | 11                  | 62         | 1        | 74         | 0                         | 5         | 0        | 5         | 56                  | 99         | 3         | 158         | 3                         | 5         | 0        | 8         | 10                  | 22         | 0         | 32         | 0                         | 1        | 0        | 1         |
| Oct-31       | 11                  | 56         | 0        | 67         | 2                         | 2         | 0        | 4         | 42                  | 79         | 3         | 124         | 3                         | 3         | 0        | 6         | 20                  | 17         | 1         | 38         | 1                         | 0        | 0        | 1         |
| Nov-04       | 12                  | 60         | 0        | 72         | 0                         | 0         | 0        | 0         | 69                  | 134        | 1         | 204         | 3                         | 6         | 0        | 9         | 16                  | 13         | 3         | 32         | 0                         | 2        | 0        | 2         |
| Nov-07       | 22                  | 51         | 3        | 76         | 0                         | 1         | 0        | 1         | 42                  | 101        | 4         | 147         | 2                         | 5         | 0        | 7         | 20                  | 21         | 1         | 42         | 0                         | 3        | 0        | 3         |
| Nov-11       | 31                  | 67         | 2        | 100        | 1                         | 3         | 0        | 4         | 85                  | 160        | 5         | 250         | 6                         | 5         | 0        | 11        | 7                   | 7          | 0         | 14         | 1                         | 2        | 0        | 3         |
| Nov-12       | 0                   | 0          | 0        | 0          | 0                         | 0         | 0        | 0         | 0                   | 0          | 0         | 0           | 0                         | 0         | 0        | 0         | 28                  | 19         | 4         | 51         | 0                         | 0        | 0        | 0         |
| Nov-14       | 20                  | 22         | 0        | 42         | 0                         | 0         | 0        | 0         | 58                  | 84         | 2         | 144         | 3                         | 5         | 0        | 8         | 24                  | 25         | 3         | 52         | 0                         | 1        | 0        | 1         |
| Nov-18       | 2                   | 14         | 0        | 16         | 1                         | 1         | 0        | 2         | 9                   | 8          | 0         | 17          | 0                         | 0         | 0        | 0         | 3                   | 0          | 0         | 3          | 1                         | 0        | 0        | 1         |
| Nov-21       | 0                   | 1          | 0        | 1          | 0                         | 0         | 0        | 0         | 3                   | 0          | 0         | 3           | 0                         | 0         | 0        | 0         | 1                   | 3          | 0         | 4          | 0                         | 0        | 0        | 0         |
| <b>Total</b> | <b>135</b>          | <b>401</b> | <b>9</b> | <b>545</b> | <b>8</b>                  | <b>14</b> | <b>0</b> | <b>22</b> | <b>416</b>          | <b>781</b> | <b>19</b> | <b>1216</b> | <b>24</b>                 | <b>38</b> | <b>0</b> | <b>62</b> | <b>155</b>          | <b>146</b> | <b>14</b> | <b>315</b> | <b>5</b>                  | <b>9</b> | <b>0</b> | <b>14</b> |

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

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

