Abundance, Age, Size, Sex and Coded-Wire Tag Recoveries for Chinook Salmon Escapements of Campbell and Quinsam Rivers, 1997

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ABUNDANCE, AGE, SIZE, SEX AND CODED-WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF CAMPBELL AND QUINSAM RIVERS, 1997

by

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ABSTRACT

Sturhahn, J. C., D. A. Nagtegaal, and M. Trenholme. 1999. Abundance, age, sex and coded-wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2477: 49 p.

Chinook salmon (Oncorhynchus tshawytscha) escapement estimates were derived for the Campbell/Quinsam River system for 1997 utilizing carcass tag and recovery methods as part of the chinook key stream program. The Petersen estimate of chinook escapement was 2,862 with 95 % confidence limits of 2,566 to 3,158 fish. This estimate includes hatchery removals (sales, broodstock, mortalities) and chinook which were permitted to move above the hatchery fence Four-year old (0.3; 0 freshwater, 3 ocean) males and females dominated returns to the Quinsam River and hatchery while four-year old (0.3) males and five-year old (0.4) females predominated returns to the Campbell River. Total returns of coded-wire tagged chinook to the Campbell/Quinsam system were 212 in 1997. For the purposes of this study, escapement estimates are stratified by river, sex, and tag code. The hatchery contribution to the escapement was derived by expanding the actual number of coded-wire tag returns for each of the brood years and for each tag code. In 1997, the total hatchery contribution was 1,089 (66.4 %) for males and 669 (54.6 %) for females.

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

RESUME

Sturhahn, J. C., D. A. Nagtegaal, and M. Trenholme. 1999. Abundance, age, sex and coded-wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2477: 49 p.

Les estimations de l'échappée de quinnats (*Oncorhynchus tshawytscha*) ont été calculées pour le réseau de la Campbell et de la Quinsam en 1997 au moyen de marquage des carcasses et de la récupération des marques dans le cadre du programme des cours d'eau clés pour le quinnat. Selon l'estimation de Petersen, l'échappée de quinnats s'établissait à 2 862 avec une limite de confiance à 95 % comprise entre 2 566 et 3 158 poissons. Cette estimation comprend les prélèvements à l'écloserie (ventes, cheptel reproducteur, mortalités) et les quinnats qu'on a laissé remonter en amont de la barrière de l'écloserie. Des mâles et des femelles de quatre ans (0.3 ; 0 en eau douce, 3 en mer) dominaient dans les retours dans la Campbell et à l'écloserie tandis que des mâles de quatre ans (0.3) et des femelles de cinq ans (0.4) prédominaient dans la remonte de la Campbell. En 1997, le nombre total de quinnats portant une micromarque codée qui sont revenus dans le réseau de la Campbell et de la Quinsam s'élevait à 212. Aux fins de la présente étude, les estimations de l'échappée sont stratifiées selon la rivière, le sexe et le code inscrit sur la marque. La contribution de l'écloserie à l'échappée a été calculée en élargissant le nombre réel de retours des poissons porteurs de micromarques codées pour chacune des années d'éclosion et pour chaque code inscrit sur la marque. En 1997, la contribution totale de l'écloserie était de 1 089 (66,4 %) pour les mâles et de 669 (54,6 %) pour les femelles.

Mots-clés : Campbell, Quinsam, quinnat, cours d'eau clés, échappée, micromarques codées, marquage des poissons vivants, marquage des carcasses.

INTRODUCTION

One of the primary goals of Fisheries and Oceans Canada (DFO) long term management plans is the restoration of Pacific chinook salmon stocks to historical levels. The Campbell and Quinsam River systems were chosen for study as important "key streams" which represent the overall status of chinook bearing streams along the British Columbia coast. These selected streams provide ongoing information to fisheries managers in response to artificial (hatchery), and natural production, and harvest management strategies. This "key stream" program began in 1984, in accordance with 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 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). The Quinsam Hatchery, built in 1972 approximately 3.7 kilometers up from the confluence with the Campbell River, enhances salmon and anadromous trout of the Quinsam and neighbouring streams. Chinook escapements to the Quinsam River were negligible prior to establishment of the Quinsam Hatchery, but increased to 1,500 and 1,800 in 1985 and 1986, respectively. The returns further increased to 5,300 in 1988 and 5,412 in 1990. Total system escapement peaked in 1990 with an estimated 15,538 returning chinook (Frith et al. 1993). The following year it dropped to 3,200. More recently, chinook escapement dropped to 2,982 in 1994 (Frith and Nelson 1995).

The objectives of this document are to provide a chinook salmon escapement estimate to the Campbell/Quinsam River system based upon carcass tag recovery using the Petersen method as well as returns of coded-wire tagged (CWT) adults. The escapement of coded-wire tagged adults is also used to estimate the Quinsam Hatchery contribution.

In the 1994 manuscript, Frith and Nelson discuss possible biases in the Petersen method, carcass tagging methodology, and stratification method. Frith and Nelson (1995) describe the assumptions necessary for the methods and tests for biases caused by violations of these assumptions. This information has been repeated for the readers benefit. The methods section describes the snorkel surveys, the tag and recovery effort, biological and physical sampling, and calculations. The results section presents the swim survey observations, tag and recovery results, population estimates, age, length, and sex composition, and the results of the coded-wire tag returns.

For the purposes of this report, tagging means to attach a staple tag to the operculum of a deceased, spawned out chinook salmon. Marked fish refer to those returning adults lacking an adipose fin and presumably carrying a coded-wire tag applied during their juvenile stage prior to release from the hatchery.

STUDY AREA

The physical attributes of the Quinsam/Campbell drainage area have been described in detail by Andrew et al. (1988) and are depicted in Figure 1. The Campbell River originates east of the Vancouver Island Ranges and drains some 1,465 km^2 of land. The river flows in an easterly direction for approximately 9 km where it empties into Discovery Passage at a point slightly north of the City of Campbell River, British Columbia. One of the major tributaries of Campbell River is the Quinsam River which drains a watershed of 265 km^2 and enters the Campbell River 3.5 km from the estuary. The Quinsam River flows for over 30 km through a series of small lakes and is fed by numerous tributaries to the south of the Campbell River watershed including Cold Creek, Flintoff Creek, and the Iron River (Andrew et al. 1988).

Water flow on the Quinsam River has been regulated since 1956 by an hydroelectric dam situated above Middle Quinsam Lake approx. 5.5 km upstream of the mouth. This dam allows flow control and enables maintenance of minimum flow rates during dry periods. Flow rates have ranged from 0.9 to 21.6 m^3s^{-1} with a mean of 9.2 m^3s^{-1} (Bell and Thompson, 1977), since 1973. Flows in the Campbell River are controlled by the John Hart Generating Station and vary from 1.2 m^3s^{-1} to 826.0 m^3s^{-1} with a mean of 96.0 m^3s^{-1} (Marshall et al. 1977).

The upper watersheds of the Campbell and Quinsam Rivers are impacted by logging and mining industries while logging roads provide access for extensive recreational use. Commercial activity in the Campbell River estuary includes log booming, sawmill operations, shake mills, floatplane facilities, and recreational boat moorages (Andrew et al. 1988). Man-made islands have been constructed in the estuary in an effort to improve fish habitat (Levings et al. 1986).

Numerous species of Pacific salmon are found in the Campbell/Quinsam system including pink (*Oncoryhnchus gorbuscha*), chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and sockeye (*O. nerka*) in order of abundance. Steelhead trout (*O. mykiss*) and Cutthroat trout (*O. clarki*) are also found in this system.

Although 27 km of the Quinsam River is accessible to natural spawning, the majority of chinook spawning occurs in the lower 4 km of the river. A portion of chinook is permitted to pass through the counting fence at the Quinsam Hatchery and to spawn in the upper reaches of the lower Quinsam River. Mature chinook begin returning to the Campbell River in late August with the migration peaking in October. Spawning occurs over several weeks from mid October to mid November. Quinsam River chinook enter the system slightly later and spawn into early December. Coho salmon have been observed spawning in the lower Quinsam River, but not in the

Campbell River itself. Chum and pink salmon spawn in the lower reaches of both the Campbell and Quinsam Rivers.

METHODS

POPULATION ESTIMATION

The 1997 chinook salmon escapement estimates were determined using the adjusted Petersen method (Ricker 1975). Escapement estimates were calculated for each river and sex using carcass tagging and recovery techniques. These estimates were then combined with the Quinsam Hatchery returns plus those adults counted above the hatchery fence to produce an estimate of escapement for the entire Campbell and Quinsam River system.

Population Stratification

Carcass Tagging:

Petersen estimates were stratified by sex and river and then summed to obtain an estimate of the whole population. By segregating the data into separate population strata, potential biases due to differential rates of tag application, recovery of carcasses, and tag loss were minimized (Andrew et al. 1988). Petersen estimates were generated for the Campbell River and the Quinsam River (below the fence).

Potential Biases

Carcass Tagging:

Within a stratum, Petersen estimates using carcass tagging are subject to bias depending on the extent to which these assumptions are violated (Andrew et al. 1988; Bocking et al. 1990).

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

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

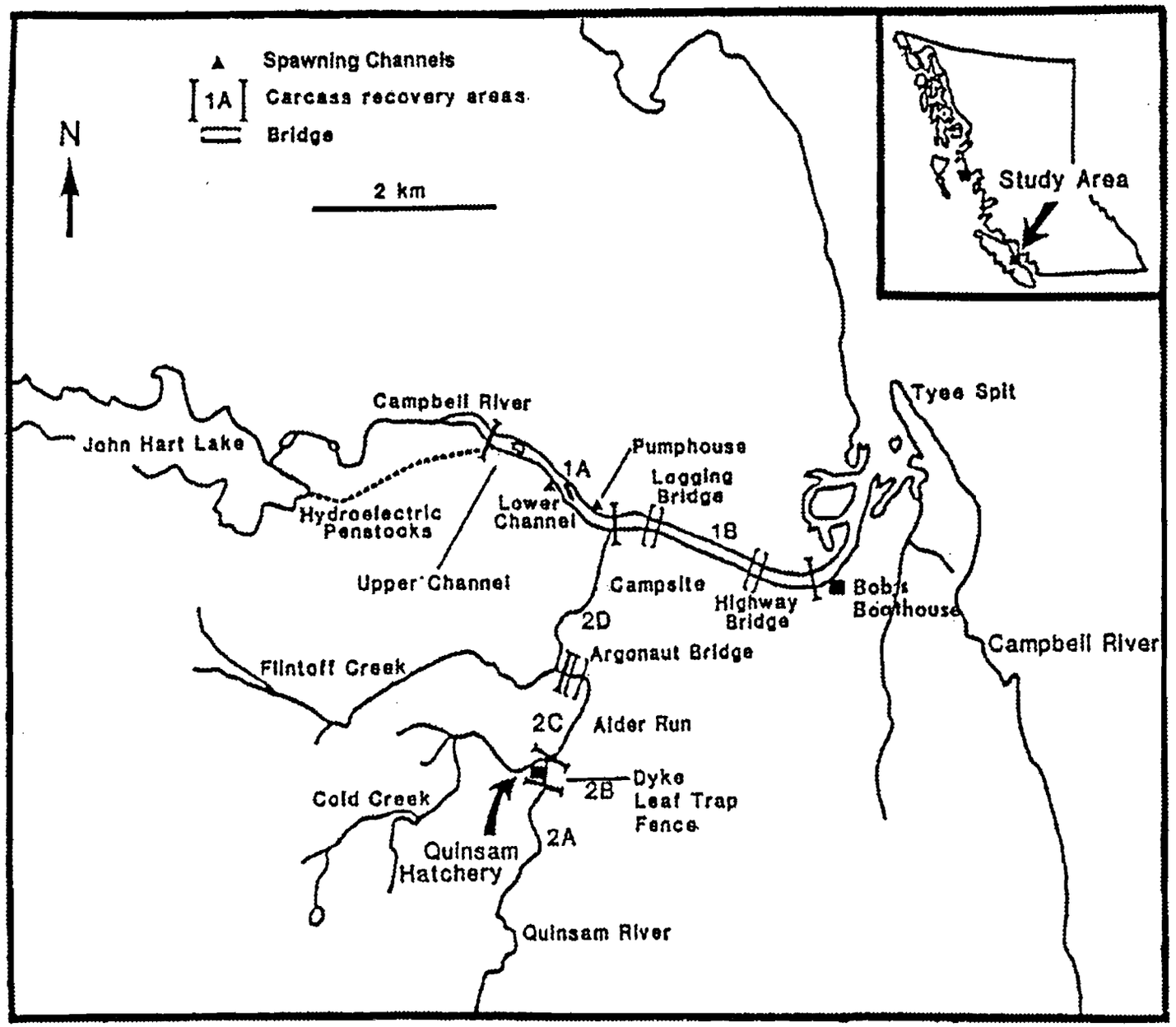

Figure 1. Map of the Campbell and Quinsam rivers study area.

To obtain an accurate Petersen estimate, tags must be applied and recovered in proportion to the available population. In 1997, carcasses were tagged *in situ* during examination. Hatchery workers attempted to tag a consistent proportion of the number of fish examined during each recovery survey by tagging four of every ten carcasses in 1997. A higher tag rate was applied when the number of carcasses examined in a day was low. The percentage of fish tagged ranged from about 33-100% over the study period (Appendices 5 and 6).

A related problem associated with escapement estimates for separate rivers is that tagged carcasses may stray (washout) between rivers. Apart from passive movement due to water flow, tagged carcasses are not subject to movement or straying in the same way as live fish. In 1997 no strays were reported in the Quinsam or Campbell rivers.

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

An addition of new carcasses following tagging could cause the Petersen calculations to overestimate or underestimate the true population depending on how they mixed with tagged fish. In 1997, tagging continued *in situ* in the rivers every 1 to 6 days during the spawning and die-off period. Tagging and recovery continued through to November 27.

Assumption 3. There is no tag loss.

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

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

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

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

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

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

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

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

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

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

Calculations

The adjusted Petersen estimate of each river stratum and sex was calculated as follows (Chapman's formula; Ricker 1975):

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

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

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

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

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

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

Population estimates were not calculated for jack or stray chinook.

TAGGING

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

RECOVERY

Sampling crews that conducted the dead recovery were composed of two to six workers each day. Recovery crews were instructed to dead pitch and count all available carcasses and record and keep all operculum tags. Crews attempted to distribute recovery effort evenly throughout the study period. Dead chinook were surveyed for recoveries from the Campbell and Quinsam rivers by three methods:

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

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

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

Chinook were also recovered at the Quinsam Hatchery rack and from a floating fence operated in area 2D of the Quinsam River (Figure 1). The floating fence used for adult capture was installed at the beginning of Oct. and was removed on Oct. 29, 1997. This fence caught most carcasses which drifted downstream in the current. Carcasses that were found on the fence were placed back onto the fence after being staple tagged and sampled. Due to high water and

siltation, few chinook were observed in the water and the majority of carcass tagging and recovery occurred on the banks of the rivers.

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

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

Other calculations relating to the dead recovery were as follows:

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

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

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

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

BIOLOGICAL AND PHYSICAL SAMPLING

Biological sampling was conducted during the tagging procedure. Data collected include sex, presence of secondary marks, and postorbital-hypural lengths. Length was recorded for 79% of the carcasses (marked and unmarked fish) recovered in the Campbell River, 66% of the carcasses recovered in the Quinsam River, and 14% of the chinook recovered alive at the hatchery rack.

Scale samples were taken in conjunction with length measurements. In addition, a portion of adipose-clipped fish (CWT) was sampled for age (CWT decoding) and length. 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. Ageing of scales was conducted at the DFO 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 Nanaimo.

Ageing data were accepted on the premise that the scales contained a portion of the previous annulus and were not regenerated. Scales were rejected at the ageing lab if they were mounted upside down, if they were resorbed, or if they had regenerate centers. Ages were recorded for fish where at least two scales could be read for both marine and freshwater ages. The ageing system in this report follows the method originally described by Gilbert and Rich (1927). For the purposes of this report only the total age was reported.

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 mean lengths of known and unknown age males and females. The dead recovery sample was used to determine the age and length composition of the population. Because of problems in distinguishing jacks from adult males, age and length information for jacks was grouped with males.

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

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

CODED-WIRE TAGGING AND RECOVERY

Juvenile chinook from the 1991-1995 brood years were marked at Quinsam Hatchery with binary CWT's described by Jefferts et al. (1963) using standard methods (Armstrong and Argue 1977). Adipose fins of coded-wire tagged juveniles were clipped prior to the release of these fish.

Estimates of the contribution of hatchery-reared chinook to the total escapement were calculated by expanding the percentage of CWT tags in escapement counts by tag code. The number of successfully decoded CWT chinook in the escapement was estimated and stratified by river and sex using the methods described for the Mark Recovery Program (Kuhn 1988). 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:

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

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

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

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 CWT's 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 this method are discussed in Bocking (1991).

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:

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

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

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:

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

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

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

RESULTS

TAGGING

Carcass Tagging

In 1997, 74 chinook carcasses were tagged and released (returned to the river) between October 24 and November 18 in the Campbell River, and 191 carcasses were tagged and released from October 24 to November 24 in the Quinsam River (Table 3; Appendices 1 and 2).

RECOVERY

Surveys totalling 92.8 person days to recover carcasses in 1997 began on October 28 in the Campbell River and on October 27 in the Quinsam River and continued on until November 21 and November 27, respectively (Table 2; Figure 1; Appendices 3 and 4). On some days, some reaches in each river were surveyed more frequently than others.

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 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 were not included.

In 1997, 98 chinook carcasses were examined in the Campbell River (Table 3; Appendix 3), including 26 tag recoveries. In the Quinsam River, 331 chinook carcasses were examined (Table 3; Appendix 4) including 95 tag recoveries.

The carcass tag recovery rates in the Campbell River (35.1%) and Quinsam River (49.2%) in 1997 were significantly different by 14.1% ($P < 0.05$, χ^2; Zar 1984). The tag rates were similar for males (29.0%) and females (39.5%) in Campbell River and for males (53.8%) and females (43.0%) in Quinsam River ($P < 0.05$, χ^2; Zar 1984).

POPULATION ESTIMATES

Carcass Tagging

Petersen escapement estimates were stratified by river and sex (Table 4). In 1997, chinook escapement to the Campbell River and Quinsam River was estimated at 275 and 684 adults respectively (Table 4). Sex-specific estimates and 95% confidence limits for both rivers were also calculated (Table 4). The total escapement to the Campbell/Quinsam River system in 1997, including hatchery rack recoveries, was estimated at 2,862 adults with 95% confidence limits of 2,566 and 3,158.

In 1997, the relative percentage of fish between the Campbell River, Quinsam River, and Quinsam Hatchery sampling locations was 9.2%, 23.1%, and 67.7% respectively. The percentages were 29.8%, 41.4%, and 28.8% in 1996 (Nagtegaal and Graf 1998) and 11.7%, 42.6%, and 45.7% in 1995 (Frith and Nelson, 1995), respectively. The total estimated return in 1997 is slightly less than returns in 1996 (3063), and slightly more than the estimated return of 2445 in 1995 (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). Ages of all Campbell and Quinsam River chinook returns ranged from 1 to 6 years (Tables 5-8). The dominant age-group in the Campbell River was age-4 for males and age-5 for females, in the Quinsam River was age-4 for both sexes, and at the hatchery was age-4 for both sexes. Chinook returning to the Quinsam hatchery were primarily age-4 ranging from 50.0% of males to 64.7% of females. The Quinsam River return showed similar results with an age-4 dominance ranging from 50.5 % of males and 63.0 % of females. Males returning to the Campbell River were primarily age-4 yielding 40.6% while females were primarily age-5 yielding 52.3%. The age-4 category represented > 40% for both males and females in all locations. Males in the age-3 group were most abundant in the Quinsam River composing 40.54 % of the return while males in this age group were less abundant in the Campbell River and Quinsam Hatchery ranging from 18.75% to 35.26%, respectively.

Male and female chinook from Campbell River had larger mean lengths than male and female chinook from the Quinsam River (Campbell: male = 773 mm, female = 813 mm; Quinsam : male = 686 mm, female = 775 mm; Tables 5-8). T-tests were conducted to compare the mean lengths among sexes and among rivers. Male chinook carcasses were significantly smaller than female carcasses in Quinsam River ($P < 0.001$) and Quinsam Hatchery ($P < 0.001$) but not in the

Campbell River ($P > 0.05$). Female and male carcasses in Campbell River were significantly larger than those recovered in the Quinsam River ($P < 0.002$) and the Quinsam Hatchery ($P < 0.002$). There was no significant difference between mean lengths of unaged and aged (all ages) chinook for any combination of sex and river stratum (t-test, $P > 0.05$).

The male/female sex ratio was found to be 0.87 for the Campbell River in 1997. The male/female sex ratios for the Quinsam River and Quinsam Hatchery were 1.21 and 1.72 respectively (Table 9).

CODED-WIRE TAGGING AND RECOVERY

Adipose-clipped (CWT) juvenile chinook releases into the Campbell and Quinsam Rivers from the 1992 to 1994 brood years were captured as adults in the dead recovery program in 1997 (Appendices 7,8, and 9). There were 23 adult CWT recoveries in Quinsam River, 189 adult CWT recoveries at the Quinsam hatchery, and three adult CWT recoveries in Campbell River. A total of 16 jack CWT recoveries were also identified from the 1995 and 1996 brood years, 15 from the Quinsam Hatchery rack and one from the Quinsam River.

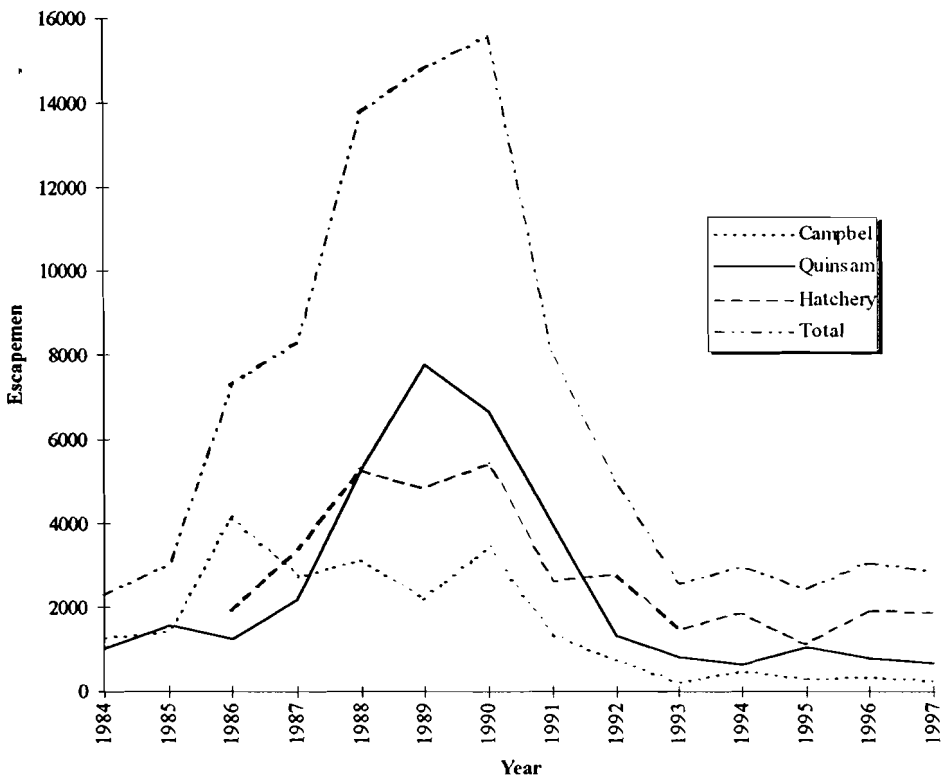

Figure 2. Chinook escapement estimates, stratified by river location, for 1985-1997 (Andrew et al. 1988; Bocking et al. 1990; Bocking 1991; Frith et al. 1993; Frith 1993; Frith and Nelson 1994; Frith and Nelson 1995; Nagtegaal and Graf 1998, and this study).

Hatchery release information was determined for recovered tag codes as well as hatchery contribution to escapements by tag code (Tables 10, to 13). Also, the estimated hatchery contribution to the escapement by age class can be found in Table 14.

In 1997, there were three adipose-clipped chinook recovered in the Campbell River dead pitch, 25 in the Quinsam River dead pitch and 190 at the hatchery rack not including jacks (Table 11). The adipose-clip mark rate was highest in hatchery returns (10.0%) and lowest in the Campbell River returns (3.1%). The mark rate for the Quinsam River was 7.6%.

Hatchery Contribution

For the purposes of this study, the actual number of CWT's present in the escapement was used to estimate the total hatchery contribution. (The allocations of the total escapement of CWT's to tag codes recovered in each portion of the river are shown in Tables 11-13). The estimated hatchery contributions to the 1997 escapement of chinook (both males and females) to the Campbell River, Quinsam River, and Quinsam Hatchery were 67, 352, and 1337, respectively (Table 13).

The 1997 hatchery contribution to the Campbell River population of chinook was estimated to be 46.1 % for males and 5.4 % for females (Table 14). Contribution to the in-river Quinsam chinook escapement were >100.0 % for males as well as for females. Hatchery returns contributed 70.8 % of males and 69.5 % of females in the returns to the Quinsam Hatchery. No strays were reported in 1997.

DISCUSSION AND CONCLUSIONS

POPULATION ESTIMATION

Errors may arise as a result of differences in the abundance of chinook between sexes or river locations. Escapement estimates must be stratified in order to reduce these errors. In this study, sex ratio differences occurred in hatchery broodstock, dead recovery, and Petersen estimates. A greater number of females than males were recovered in the dead pitch surveys for the Quinsam River and Campbell River whereas the number of males was greater in the Quinsam Hatchery. Andrew et al. (1988) found greater numbers of females than males in live and dead pitch recoveries in the Quinsam/Campbell system in 1986, as did Shardlow et al. (1986) in 1984-85. In years since 1986, females have dominated in Campbell and Quinsam rivers but males have dominated in Quinsam Hatchery (Bocking 1991; Frith et al. 1993). This discrepancy between recovery rates of male/female chinook spawners also occurs in other species. Higher numbers of females than males have been observed in spawning ground dead pitches for sockeye salmon

(Petersen 1954), pink salmon (Ward 1959), and coho salmon (Eames and Hino 1981; Eames et al. 1981). The number of chinook in the Quinsam Hatchery was much greater than Quinsam and Campbell River returns (Bocking 1991; Frith et al 1993). The stratification of escapement estimates by sex and river location avoids a known source of error in the Quinsam/Campbell system and this practice should be continued for future population estimates.

It is unknown as to how completely tagged carcasses mixed with the rest of the carcass population. Incomplete mixing may have occurred in situations where tagged carcasses settled in deep pools preventing further movement. This potential bias arising from incomplete mixing is usually addressed by conducting tagging and recovery effort in proportion to the distribution of fish, by frequently moving to different tagging and recovery sites throughout both operations, and by snorkelling or SCUBA diving in deeper areas. These techniques rely on good water clarity for success.

AGE, LENGTH AND SEX COMPOSITION

In 1997, chinook escapements to the Campbell and Quinsam Rivers were composed mainly of age-4 and age-5 fish with females being slightly older. A similar age structure has been observed in recent years (Bocking 1991; Frith et al 1993; Frith and Nelson 1994; 1995). The ratio of adult males to females, as determined from the Petersen estimates, was 0.87 in Campbell River and 1.21 in Quinsam River in 1997. The adult male to female ratio of returns to the Quinsam Hatchery was 1.72 in 1997. No consistent pattern of sex ratios between river locations has been observed in recent years (Frith et al 1993; Frith and Nelson 1994; 1995). The mean length of chinook in the three river locations have remained similar over the past four years (Frith et al 1993; Frith and Nelson 1994; 1995).

CODED-WIRE TAGGING AND RECOVERY

There were 10 recoveries in Quinsam Hatchery and one recovery in Quinsam River of adipose-clipped chinook jacks (1996 brood). There were also five recoveries in Quinsam Hatchery of adipose-clipped jacks (1995 brood). In 1997, the rate of recovery ranged from 3.1 % to 10.0 %. No strays were reported in 1997.

In this study, the actual number of CWT's present in the escapement was used to estimate the total hatchery contribution. Hatchery contributions ranged from 5.4 % for Campbell River females to 70.8 % for Quinsam Hatchery males.

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

1. Low number of recoveries of and decoded CWT's may reduce the precision of the estimates; and

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

SUMMARY

1. The total escapement for chinook salmon in the Campbell/Quinsam River system using carcass tagging and hatchery returns was estimated at 2,862 in 1997 with 95 % confidence limits of 2,566 and 3,158. Estimates were stratified by river and sex.

2. Chinook returning to the Campbell River, Quinsam River, and Quinsam Hatchery ranged in age from one to six years. All fish entered salt water in their first year of life. The dominant age-group for both male and female chinook retuning to the Quinsam River and Quinsam Hatchery was age-4. Males returning to the Campbell River were primarily age-4 while females were primarily age-5.

3. Based on the Petersen estimates and Quinsam Hatchery rack recoveries, female chinook were more abundant than males in both the Campbell and Quinsam Rivers while male chinook outnumbered females in the Quinsam Hatchery returns.

4. Chinook from the Campbell River yielded the largest mean length while chinook from the Quinsam Hatchery yielded the smallest mean length. Females were significantly larger than males in the Campbell River, Quinsam River, and Quinsam Hatchery.

5. The number of actual CWT's present in the escapement to the Campbell/Quinsam system totalled 212. The total estimated return of coded-wire tagged chinook was 238.

6. The total hatchery contribution to the chinook escapement, based on CWT returns was estimated at 1,758 (61.4 %) in 1997.

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TABLES

Table 1. Summary of methods for the Campbell and Quinsam River chinook salmon enumeration programs, 1997.

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

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

Table 2. Summary of tagging and recovery effort (person days) for chinook salmon carcasses in the Campbell and Quinsam Rivers, 1997.

	Person Days		
River	Stream walk	Diver	Total
Campbell	32.7	12	44.7
Quinsam	48.1	-	48.1
			92.8

Table 3. Summary of in situ carcass tagging and dead recovery of chinook salmon carcasses in Campbell and Quinsam rivers, 1997.

Category	Campbell(a)	Quinsam(b)	Total
Carcasses tagged:			
Males	31	104	135
Females	43	86	129
Jacks	0	1	1
Total	74	191	265
Carcasses			
Males	39	164	203
Females	59	165	224
Jacks	0	2	2
Total	98	331	429
Tags recovered (c):			
Males	9	56	65
Females	17	37	54
Jacks	0	1	1
Total	26	94	120
Tag summary:			
Observed tag rate (%)	26.5	28.4	28.0
Tag return rate (%)	35.1	49.2	45.3
Tag loss (%)			

(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. Peterson 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, 1997. (Confidence limits are determined Assuming R is Poisson distributed (Ricker 1975, p. 343).)

River and Item	Male	Female	Jack (h)	Total	
Campbell River					
Number tags applied (d)	31	43	0	74	
Number recovered (e)	39	59	0	98	
Number of tagged recoveries (f)	9	17	0	26	
Petersen estimate	128	147	NA	275	(i)
Lower 95% CL	59	90	NA	149	(i)
Upper 95% CL	197	204	NA	401	(i)
Quinsam River (b, below fence)					
Number tags applied (d)	104	86	1	191	
Number recovered (e)	164	165	2	331	
Number of tagged recoveries (f)	56	37	1	94	
Petersen estimate	304	380	NA	684	(i)
Lower 95% CL	240	274	NA	514	(i)
Upper 95% CL	368	486	NA	854	(i)
Quinsam Hatchery (c)					
Number of fish (g)	1204	699	109	2012	
Total system					
Escapement	1636	1226	NA	2862	(i)
Lower 95% CL (j)	1503	1063	NA	2566	(i)
Upper 95% CL	1769	1389	NA	3158	(i)

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

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

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

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

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

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

(g) Confidence limits not applicable

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

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

(j) Confidence limits for the total system are proportions of a combined Petersen estimate for (a) and (b)

Table 5. Age composition of Campbell River chinook salmon, 1997 (determined from dead recovery).

Sex and age		Unmarked	AD/CWT	Total	Percent	N	Mean length(mm)	SD	95% CL Lower	95% CL Upper
Males (a)										
3		6	0	6	18.75	6	595	51	554	636
4		13	0	13	40.62	13	776	84	730	822
5		11	1	12	37.50	12	846	50	818	874
6		1	0	1	3.13	1	930	0	-	-
	Total aged	31	1	32	100.00	32	773	114	733	813
Females										
4		20	1	21	47.73	21	783	49	789	831
5		23	0	23	52.27	23	839	36	825	854
	Total aged	43	1	44	100.00	44	813	50	798	828

(a) no jacks were observed in Campbell River in 1997.

Table 6. Age composition of Quinsam River chinook salmon, 1997.

Sex and age		Unmarked	AD/CWT	Total	Percent(b)		N	Mean Length(mm)	SD	95% CL Lower	95% CL Upper
Males (a)											
1		0	1	1	0.90		1	200	0	-	-
2		0	0	0	0.00		0	-	-	-	-
3		35	10	45	40.54	(40.90)	45	626	81	603	649
4		53	3	56	50.45	(50.90)	56	723	70	705	741
5		9	0	9	8.11	(8.20)	9	806	63	765	847
	Total aged	97	14	111	100.00		111	686	104	666	705
Females											
3		1	0	1	1.09		1	700	0	-	-
4		50	8	58	63.04		58	744	36	735	753
5		29	2	31	33.70		31	830	42	815	845
6		2	0	2	2.17		2	838	4	833	843
	Total aged	82	10	92	100.00		92	775	57	763	787

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

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

Table 7. Age composition of Quinsam Hatchery chinook salmon, 1997.

Sex and age		Unmarked	AD/CWT	Total	Percent(b)		N	Mean Length(mm)	SD	95% CL Lower	95% CL Upper
Males (a)											
1		0	10	10	5.26		10	199	18	188	210
2		0	5	5	2.63		5	389	33	360	418
3		26	41	67	35.27	(37.59)	67	595	56	582	608
4		62	33	95	50.00	(54.91)	95	745	55	734	756
5		10	2	12	6.32	(6.93)	12	845	47	818	872
6		1	0	1	0.52	(0.57)	1	756	0	-	-
	Total aged	99	91	190	100.00	(100.00)	190	661	152	639	682
Females											
3		6	3	9	4.48		9	644	46	614	674
4		92	38	130	64.67		130	742	43	735	749
5		48	13	61	30.35		61	823	45	812	834
6		0	1	1	0.50		1	812	0	-	-
	Total aged	146	55	201	100.00		201	763	63	754	772

(a) Jacks are included with males (10 age 1, 5 age 2, 2 age 3)

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

Table 8. Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1997.

Location	Length class (mm)	Age												
		Males							Females					
		1	2	3	4	5	6	Total	2	3	4	5	6	Total
Campbell River														
	250-299	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
	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	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	1	0	0	0	1	0	0	0	0	0	0
	550-599	0	0	3	1	0	0	4	0	0	0	0	0	0
	600-649	0	0	1	0	0	0	1	0	0	0	0	0	0
	650-699	0	0	1	1	0	0	2	0	0	0	0	0	0
	700-749	0	0	0	3	1	0	4	0	0	7	0	0	7
	750-799	0	0	0	2	1	0	3	0	0	5	3	0	8
	800-849	0	0	0	5	3	0	8	0	0	7	11	0	18
	850-899	0	0	0	0	5	0	5	0	0	2	7	0	9
	900-949	0	0	0	1	2	1	4	0	0	0	2	0	2
	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	0	0	595	776	846	930	773	0	0	783	839	0	813
	SD	0	0	51	84	50	0	114	0	0	49	36	0	50
	N	0	0	6	13	12	1	32	0	0	21	23	0	44
Quinsam River														
	250-299	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
	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	0	0	0	0	0	0	0	0	0	0	0	0
	500-549	0	0	8	0	0	0	8	0	0	0	0	0	0
	550-599	0	0	11	4	0	0	15	0	0	0	0	0	0
	600-649	0	0	12	4	0	0	16	0	0	0	0	0	0
	650-699	0	0	5	10	0	0	15	0	0	7	0	0	7
	700-749	0	0	4	17	2	0	23	0	1	24	1	0	26
	750-799	0	0	4	14	2	0	20	0	0	21	6	0	27
	800-849	0	0	1	6	2	0	9	0	0	6	14	2	22
	850-899	0	0	0	0	2	0	2	0	0	0	8	0	8
	900-949	0	0	0	1	1	0	2	0	0	0	2	0	2
	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	200	0	626	723	806	0	686	0	700	744	830	838	775
	SD	0	0	81	70	63	0	104	0	0	36	42	4	57
	N	1	0	45	56	9	0	111	0	1	58	31	2	92

Table 8 (cont'd). Age-length distribution of Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon, 1997.

Length class (mm)	Males 1	2	3	4	5	6	Total	Females 2	3	4	5	6	Total
Quinsam Hatchery													
150-199	5	0	0	0	0	0	0	0	0	0	0	0	0
200-249	5	0	0	0	0	0	0	0	0	0	0	0	0
250-299	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
350-399	0	4	0	0	0	0	4	0	0	0	0	0	0
400-449	0	1	1	0	0	0	2	0	0	0	0	0	0
450-499	0	0	3	0	0	0	3	0	0	0	0	0	0
500-549	0	0	9	0	0	0	9	0	0	0	0	0	0
550-599	0	0	21	1	0	0	22	0	2	0	0	0	2
600-649	0	0	24	3	0	0	27	0	2	3	0	0	5
650-699	0	0	6	15	0	0	21	0	3	17	0	0	20
700-749	0	0	3	31	0	0	34	0	2	53	4	0	59
750-799	0	0	0	28	2	1	31	0	0	48	14	0	62
800-849	0	0	0	14	4	0	18	0	0	8	25	1	34
850-899	0	0	0	3	5	0	8	0	0	1	15	0	16
900-949	0	0	0	0	1	0	1	0	0	0	3	0	3
950-999	0	0	0	0	0	0	0	0	0	0	0	0	0
1000-	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	199	389	595	745	845	756	661	0	644	742	823	812	763
SD	18	33	56	55	47	0	152	0	46	43	45	0	63
N	10	5	67	95	12	1	190	0	9	130	61	1	201

Table 9. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River, and Quinsam Hatchery, 1997.

Age	Males (a)		Females	
	Number (b)	Percent (c)	Number (b)	Percent (c)
Campbell River				
3	24	18.75	0	0.00
4	52	40.62	70	47.73
5	48	37.50	77	52.27
6	4	3.13	0	0.00
Total	128 (d)	100.00	147 (d)	100.00
Quinsam River				
3	124	40.90	4	1.09
4	155	50.90	240	63.04
5	25	8.20	128	33.70
6	0	0.00	8	2.17
Total	304 (d)	100.00	380 (d)	100.00
Quinsam Hatchery				
3	453	37.59	31	4.48
4	661	54.91	452	64.67
5	83	6.93	212	30.35
6	7	0.57	4	0.50
Total	1204 (d)	100.00	699 (d)	100.00

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

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

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

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

Table 10. CWT release data for hatchery-reared chinook salmon returning to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1997.

Brood Year	CWT Code	Release Numbers CWT	Release Numbers Untagged	CWT loss(%)	CWT mark(%)	Days held
1994	20960	24880	204284	0	10.9	24
	20961	24769	204881	0.4	10.8	22
	20962	24997	203420	0	10.9	20
	20963	26086	224406	0.4	10.4	17
	181644	25528	85223	4.6	23	34
	181645	25946	80280	2.6	24.4	32
	181646	26471	193017	0.6	12.1	29
	181647	26470	189087	0.6	12.3	25
	181648	26529	184863	0.7	12.5	23
	181649	26438	192831	0.4	12.1	21
	181650	26397	126362	0.7	17.3	28
	181651	26375	267688	0.6	9	26
1993	180628	25362	205743	0.6	11	9
	180629	26632	115968	0.6	18.7	15
	180630	263221	162885	0.2	9.1	13
	180631	26719	259036	0	9.4	12
	181356	26204	63724	1	29.1	19
	181357	26140	78365	2	25	16
	181358	26574	81724	1.2	24.5	14
	181359	25147	174609	0.1	12.6	10
	181360	25631	180326	0.3	12.4	9
	181361	26115	177005	0.2	12.9	11
	181362	26370	188110	0.2	12.3	10
1992	181148	23730	207121	0.2	10.3	20
	181152	24932	264600	1.1	8.6	6
	181153	24450	263991	2.7	8.5	13
	181154	23689	242773	5.8	8.9	21
	181156	24228	420934	4.3	5.4	21
	181157	24101	190170	4.8	11.2	20
	181158	23382	194822	7.4	10.7	21
	Total	1003513	5628248			

Table 11. Estimates of the adjusted number of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1997.

Brood year	CWT code	Campbell River (a,b) Observed CWT's M	Campbell River (a,b) Observed CWT's F	Campbell River (a,b) Adjusted CWT's M	Campbell River (a,b) Adjusted CWT's F	Quinsam River (a,b) Observed CWT's M	Quinsam River (a,b) Observed CWT's F	Quinsam River (a,b) Adjusted CWT's M	Quinsam River (a,b) Adjusted CWT's F	Quinsam Hatchery (a,b) Observed CWT's M	Quinsam Hatchery (a,b) Observed CWT's F	Quinsam Hatchery (a,b) Adjusted CWT's M	Quinsam Hatchery (a,b) Adjusted CWT's F	Total (a,b) Observed CWT's M	Total (a,b) Observed CWT's F	Total (a,b) Adjusted (c) CWT's M	Total (a,b) Adjusted (c) CWT's F
1994	20960	0	0	0.00	0.00	1	0	1.00	0.00	6	0	6.00	0.00	7	0	7.00	0.00
	20961	0	0	0.00	0.00	0	0	0.00	0.00	1	0	1.00	0.00	1	0	1.00	0.00
	20962	0	0	0.00	0.00	0	0	0.00	0.00	1	0	1.00	0.00	1	0	1.00	0.00
	20963	0	0	0.00	0.00	0	0	0.00	0.00	3	1	3.00	1.00	3	1	3.00	1.00
	181644	0	0	0.00	0.00	0	0	0.00	0.00	13	0	13.00	0.00	13	0	13.00	0.00
	181645	0	0	0.00	0.00	0	0	0.00	0.00	10	1	10.00	1.00	10	1	10.00	1.00
	181646	0	0	0.00	0.00	1	0	1.00	0.00	8	0	8.00	0.00	9	0	9.00	0.00
	181647	0	0	0.00	0.00	0	0	0.00	0.00	13	0	13.00	0.00	13	0	13.00	0.00
	181648	0	0	0.00	0.00	0	0	0.00	0.00	3	0	3.00	0.00	3	0	3.00	0.00
	181649	0	0	0.00	0.00	1	0	1.00	0.00	9	1	9.00	1.00	10	1	10.00	1.00
	181650	0	0	0.00	0.00	0	0	0.00	0.00	2	0	2.00	0.00	2	0	2.00	0.00
	181651	0	0	0.00	0.00	0	0	0.00	0.00	6	0	6.00	0.00	6	0	6.00	0.00
	Subtotal	0	0	0.00	0.00	3	0	3.00	0.00	75	3	75.00	3.00	78	3	78	3.00
1993	180628	0	0	0.00	0.00	1	1	1.00	1.00	3	0	3.00	0.00	4	1	4.00	1.00
	180629	0	0	0.00	0.00	0	1	0.00	1.00	6	3	6.00	3.00	6	4	6.00	4.00
	180630	0	0	0.00	0.00	2	0	2.00	0.00	2	4	2.00	4.00	4	4	4.00	4.00
	180631	0	0	0.00	0.00	1	0	1.00	0.00	2	2	2.00	2.00	3	2	3.00	2.00
	181356	0	1	0.00	1.00	2	1	2.00	1.00	4	5	4.00	5.00	6	6	6.00	6.00
	181357	0	0	0.00	0.00	1	1	1.00	1.00	7	8	7.00	8.00	8	9	8.00	9.00
	181358	0	0	0.00	0.00	1	0	1.00	0.00	11	8	11.00	8.00	12	8	12.00	8.00
	181359	0	0	0.00	0.00	0	2	0.00	2.00	4	7	4.00	7.00	4	9	4.00	9.00
	181360	0	0	0.00	0.00	1	0	1.00	0.00	2	3	2.00	3.00	3	3	3.00	3.00
	181361	0	0	0.00	0.00	1	2	1.00	2.00	2	5	2.00	5.00	3	7	3.00	7.00
	181362	0	0	0.00	0.00	0	0	0.00	0.00	2	2	2.00	2.00	2	2	2.00	2.00
	Subtotal	0	1	0.00	1.00	10	8	10.00	8.00	45	47	45.00	47.00	55	56	55.00	56.00

Table 11 (cont'd). Estimates of the adjusted number of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1997.

		Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Observed CWT's		Adjusted CWT's		Observed CWT's		Adjusted CWT's		Observed CWT's		Adjusted CWT's		Observed CWT's		Adjusted (c) CWT's	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1992	181148	0	0	0.00	0.00	0	0	0.00	0.00	0	1	0.00	1.00	0	1	0.00	1.00
	181149	1	0	1.00	0.00	0	0	0.00	0.00	0	0	0.00	0.00	1	0	1.00	0.00
	181152	0	0	0.00	0.00	0	0	0.00	0.00	2	2	2.00	2.00	2	2	2.00	2.00
	181153	0	0	0.00	0.00	0	0	0.00	0.00	1	0	1.00	0.00	1	0	1.00	0.00
	181154	0	0	0.00	0.00	0	2	0.00	2.00	0	4	0.00	4.00	0	6	0.00	6.00
	181156	0	0	0.00	0.00	0	0	0.00	0.00	0	2	0.00	2.00	0	2	0.00	2.00
	181157	0	0	0.00	0.00	0	0	0.00	0.00	0	3	0.00	3.00	0	3	0.00	3.00
	181158	0	0	0.00	0.00	0	0	0.00	0.00	0	1	0.00	1.00	0	1	0.00	1.00
	Subtotal	1	0	1.00	0.00	0	2	0.00	2.00	3	13	3.00	13.00	4	15	4.00	15.00
1991	180416	0	0	0.00	0.00	0	0	0.00	0.00	0	1	0.00	1.00	0	1	0.00	2.00
	Subtotal	0	0	0.00	0.00	0	0	0.00	0.00	0	1	0.00	1.00	0	1	0.00	2.00
Total Hatchery		1	1	1.00	1.00	13	10	13.00	10.00	123	64	123.00	64.00	137	75	137.0	75.0
Total CWT		1	1	1.00	1.00	13	10	13.00	10.00	123	64	123.00	64.00	137	75	137.0	75.0
No data (5000)		0	0			0	0			0	0			0	0		
No pin (8000)		0	1			2	0			3	0			5	1		
Lost pin (9000)		0	0			0	0			0	0			0	0		
Observed adipose		1	2			15	10			126	64			142	76		

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) Two decimal places are carried for the adjusted CWT's in order to calculate the expanded hatchery contribution in Table 13

Table 12. Estimates of the total escapement of CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1997.

		Campbell River (a,b)				Quinsam River (a,b)				Quinsam Hatchery (a,b)				Total (a,b)			
		Adjusted(e) CWT's		Estimated CWT's		Adjusted (e) CWT's		Estimated CWT's		Adjusted (e) CWT's		Estimated CWT's		Adjusted (e) CWT's		Estimated CWT's	
Broodd year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1994	20960	0.00	0.00	0.00	0.00	1.00	0.00	1.88	0.00	6.00	0.00	6.00	0.00	7.00	0.00	7.88	0.00
	20961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
	20962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
	20963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	1.00	3.00	1.00	3.00	1.00	3.00	1.00
	181644	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00	0.00	13.00	0.00	13.00	0.00	13.00	0.00
	181645	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	1.00	10.00	1.00	10.00	1.00	10.00	1.00
	181646	0.00	0.00	0.00	0.00	1.00	0.00	1.88	0.00	8.00	0.00	8.00	0.00	9.00	0.00	9.88	0.00
	181647	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.00	0.00	13.00	0.00	13.00	0.00	13.00	0.00
	181648	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00
	181649	0.00	0.00	0.00	0.00	1.00	0.00	1.88	0.00	9.00	1.00	9.00	1.00	10.00	1.00	10.88	1.00
	181650	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00
	181651	0.00	0.00	0.00	0.00	0.00.	0.00	0.00	0.00	6.00	0.00	6.00	0.00	6.00	0.00	6.00	0.00
	Subtotal	0.00	0.00	0.00	0.00	3.00	0.00	5.64	0.00	75.00	3.00	75.00	3.00	78.00	3.00	80.64	3.00
1993	180628	0.00	0.00	0.00	0.00	1.00	1.00	1.88	2.30	3.00	0.00	3.00	0.00	4.00	1.00	4.88	2.30
	180629	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.30	6.00	3.00	6.00	3.00	6.00	4.00	6.00	5.30
	180630	0.00	0.00	0.00	0.00	2.00	0.00	3.77	0.00	2.00	4.00	2.00	4.00	4.00	4.00	5.77	4.00
	180631	0.00	0.00	0.00	0.00	1.00	0.00	1.88	0.00	2.00	2.00	2.00	2.00	3.00	2.00	3.88	2.00
	181356	0.00	1.00	0.00	2.49	2.00	1.00	3.77	2.30	4.00	5.00	4.00	5.00	6.00	6.00	7.77	9.79
	181357	0.00	0.00	0.00	0.00	1.00	1.00	1.88	2.30	7.00	8.00	7.00	8.00	8.00	9.00	8.88	10.30
	181358	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	11.00	8.00	11.00	8.00	12.00	8.00	11.00	8.00
	181359	0.00	0.00	0.00	0.00	0.00	2.00	0.00	4.61	4.00	7.00	4.00	7.00	4.00	9.00	4.00	11.61
	181360	0.00	0.00	0.00	0.00	1.00	0.00	1.88.0	0.00	2.00	3.00	2.00	3.00	3.00	3.00	3.88	3.00
	181361	0.00	0.00	0.00	0.00	1.00	2.00	1.88	4.61	2.00	5.00	2.00	5.00	3.00	7.00	3.88	9.61
	181362	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	Subtotal	0.00	1.00	0.00	2.49	10.00	8.00	16.90	18.42	45.00	47.00	45.00	47.00	55.00	56.0	61.94	67.91

Table 12 (cont'd).

Brood year	CWT code	Campbell River (a,b) Adjusted(e) CWT's M	Campbell River (a,b) Adjusted(e) CWT's F	Campbell River (a,b) Estimated CWT's M	Campbell River (a,b) Estimated CWT's F	Quinsam River (a,b) Adjusted(e) CWT's M	Quinsam River (a,b) Adjusted(e) CWT's F	Quinsam River (a,b) Estimated CWT's M	Quinsam River (a,b) Estimated CWT's F	Quinsam Hatchery (a,b) Adjusted(e) CWT's M	Quinsam Hatchery (a,b) Adjusted(e) CWT's F	Quinsam Hatchery (a,b) Estimated CWT's M	Quinsam Hatchery (a,b) Estimated CWT's F	Total (a,b) Adjusted(e) CWT's M	Total (a,b) Adjusted(e) CWT's F	Total (a,b) Estimated CWT's M	Total (a,b) Estimated CWT's F
1992	181148	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
	181149	1.00.	0.00	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	3.28	0.00
	181152	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	181153	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
	181154	0.00	0.00	0.00	0.00	0.00	2.00	0.00	4.61	0.00	4.00	0.00	4.00	0.00	6.00	0.00	8.61
	181156	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	2.00	0.00	2.00	0.00	2.00
	181157	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	3.00	0.00	3.00	0.00	3.00
	181158	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
	Subtotal	1.00	0.00	3.28	0.00	0.00	2.00	0.00	4.61	3.00	13.00	3.00	13.00	4.00	15.0	6.28	17.61
1991	180416	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
	Subtotal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	2.00	0.00	1.00
Total Hatchery		1.00	1.00	3.28	2.49	13.00	10.00	22.54	23.03	123.00	64.00	123.00	64.00	137.00	75.0	148.86	89.52
Petersen est. (c)		128	147			304	380			1204	699						
Sample size (d)		37	59			165	165			1204	699						

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) From Table 9
(d) Campbell River data from Appendix 7; Quinsam River data from Appendix 8; Quinsam Hatchery data from unsummarized recovery data base
(e) Two decimal places are carried for the adjusted CWT's in order to calculate the expanded hatchery contribution in Table 13

Table 13. Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam Hatchery, by tag code, 1997.

Brood year	CWT release group	Release Numbers (c)		Expansion Factor (c)	Campbell River		Quinsam River		Quinsam hatchery		Total	
		CWT	Untagged (d)		M	F	M	F	M	F	M	F
1994	20960	24880	204284	9.2	0.00	0.00	17.30	0.00	55.20	0.00	72.50	0.00
	20961	24769	204881	9.3	0.00	0.00	0.00	0.00	9.30	0.00	9.30	0.00
	20962	24997	203420	9.1	0.00	0.00	0.00	0.00	9.10	0.00	9.10	0.00
	20963	26086	224406	9.6	0.00	0.00	0.00	0.00	28.80	9.60	28.80	9.60
	181644	25528	85223	4.3	0.00	0.00	0.00	0.00	55.90	0.00	55.90	0.00
	181645	25946	80280	4.1	0.00	0.00	0.00	0.00	41.00	4.10	41.00	4.10
	181646	26471	193017	8.3	0.00	0.00	15.60	0.00	66.40	0.00	82.00	0.00
	181647	26470	189087	8.1	0.00	0.00	0.00	0.00	105.30	0.00	105.30	0.00
	181648	26529	184863	8.0	0.00	0.00	0.00	0.00	24.00	0.00	24.00	0.00
	181649	26438	192831	8.3	0.00	0.00	15.60	0.00	74.70	8.30	90.30	8.30
	181650	26397	126362	5.8	0.00	0.00	0.00	0.00	11.60	0.00	11.60	0.00
	181651	26375	267688	11.1	0.00	0.00	0.00	0.00	66.60	0.00	66.60	0.00
	Subtotal	310886	2156342		0.00	0.00	48.50	0.00	547.90	22.00	596.40	22.00
1993	180628	25362	205743	9.1	0.00	0.00	17.11	20.93	27.30	0.00	44.41	20.93
	180629	26632	115968	5.4	0.00	0.00	0.00	12.42	32.40	16.20	32.40	28.62
	180630	26322	262885	11.0	0.00	0.00	41.47	0.00	22.00	44.00	63.47	44.00
	180631	26719	259036	10.7	0.00	0.00	20.12	0.00	21.40	21.40	41.52	21.40
	181356	26204	63724	3.4	0.00	8.47	12.82	7.82	13.60	17.00	26.42	33.29
	181357	26140	78365	4.0	0.00	0.00	7.52	9.20	28.00	32.00	35.52	41.20
	181358	26574	81724	4.1	0.00	0.00	0.00	0.00	45.10	32.80	45.10	32.80
	181359	25147	174609	7.9	0.00	0.00	0.00	36.42	31.60	55.30	31.60	91.72
	181360	25631	180326	8.0	0.00	0.00	15.04	0.00	16.00	24.00	31.04	24.00
	181361	26115	177005	7.8	0.00	0.00	14.66	35.96	15.60	39.00	30.26	74.96
	181362	26370	188110	8.1	0.00	0.00	0.00	0.00	16.20	16.20	16.20	16.20
	Subtotal	287216	1787495		0.00	8.47	128.74	122.75	269.20	297.90	397.94	429.12

Table 13 (cont'd). Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River, and Quinsam by tag code, 1997.

Brood year	CWT release group	Release Numbers		Expansion Factor (c)	Expanded hatchery contributions (a,b)							
					Campbell River		Quinsam River		Quinsam Hatchery		Total	
		CWT	Untagged		M	F	M	F	M	F	M	F
1992	181148	23730	207121	9.7	0.00	0.00	0.00	0.00	0.00	9.70	0.00	9.70
	181149	24128	407685	17.9	58.71	0.00	0.00	0.00	0.00	0.00	58.71	0.00
	181152	24932	264600	11.6	0.00	0.00	0.00	0.00	23.20	23.20	23.20	23.20
	181153	24450	263991	11.8	0.00	0.00	0.00	0.00	11.80	0.00	11.80	0.00
	181154	23689	242773	11.2	0.00	0.00	0.00	51.63	0.00	44.80	0.00	96.43
	181156	24228	420934	18.4	0.00	0.00	0.00	0.00	0.00	36.80	0.00	36.80
	181157	24101	190170	8.9	0.00	0.00	0.00	0.00	0.00	26.70	0.00	26.70
	181158	23382	194822	9.3	0.00	0.00	0.00	0.00	0.00	9.30	0.00	9.30
	Subtotal	192640	2192096		58.71	0.00	0.00	51.63	35.00	150.50	93.71	202.1
1991	180416	23951	327065	14.7	0.00	0.00	0.00	0.00	0.00	14.70	0.00	14.70
	Subtotal	23951	327065		0.00	0.00	0.00	0.00	0.00	14.70	0.00	14.70
	Total Hatchery				58.71	8.47	177.24	174.38	852.10	485.10	1088.05	667.9

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) The expansion factor is used to expand the estimated number of CWT chinook in the escapement to account for unmarked hatchery releases and, hence, derive hatchery contributions to escapement ; Expansion factor = (CWT releases + untagged releases)/CWT releases
(d) Untagged = AD only (ie. tag lost) + unmarked (ie. no CWT/AFC applied)

Table 14. Estimated hatchery and stray contributions to Campbell River, Quinsam River, and Quinsam Hatchery chinook salmon escapement, 1997.

				Hatchery contribution (b)				Stray contribution (b)			
		Estimated escapement (a)		Male (c)		Female		Male (c)		Female	
	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number	%
Campbell River											
	3	24	0	0	0.0	0	0.0	0	0.00	0	0.00
	4	52	70	0	0.0	8	11.4	0	0.00	0	0.00
	5	48	77	59	100 (d)	0	0.0	0	0.00	0	0.00
	6	4	0	0	0.0	0	0.0	0	0.00	0	0.00
	Total	128	147	59	46.1	8	5.4	0	0.00	0	0.00
Quinsam River											
	3	124	4	49	38.9	0	0.0	0	0.00	0	0.00
	4	155	240	129	81.6	123	51.3	0	0.00	0	0.00
	5	25	128	0	0.0	52	40.6	0	0.00	0	0.00
	6	0	8	0	0.0	0	0.0	0	0.00	0	0.00
	Total	304	380	178	57.6	175	46.0	0	0.00	0	0.00
Quinsam Hatchery											
	3	453	31	548	100 (d)	22	71.0	0	0.00	0	0.00
	4	661	452	269	40.7	298	65.9	0	0.00	0	0.00
	5	83	212	35	42.2	151	71.2	0	0.00	0	0.00
	6	7	4	0	0.0	15	100 (d)	0	0.00	0	0.00
	Total	1204	699	852	70.8	486	69.5	0	0.00	0	0.00

(a) From Table 9
(b) Contributions were calculated using CWT expansion for the estimated number of CWT's (Table 13)
(c) Does not include jacks
(d) Estimated hatchery contribution greater than 100%

APPENDICES

Appendix 1. Staple tagging of chinook salmon carcasses in Campbell River, 1997.[1]

Date	Capture area [1]	Tagged			
		Male	Female	Jack	Total
24-Oct	CHA	0	2	0	2
24-Oct	CHB	3	1	0	4
24-Oct	CHC	2	5	0	7
28-Oct	1C	4	11	0	15
28-Oct	CHB	4	0	0	4
28-Oct	1B	1	1	0	2
28-Oct	CHC	0	1	0	1
28-Oct	1A	0	2	0	2
30-Oct	2B	1	0	0	1
30-Oct	2C	0	1	0	1
31-Oct	1B	10	7	0	17
04-Nov	1B	1	2	0	3
05-Nov	1A	0	1	0	1
07-Nov	1B	1	2	0	3
11-Nov	1B	0	2	0	2
11-Nov	1A	0	1	0	1
14-Nov	1B	2	3	0	5
18-Nov	1B	2	1	0	3
Total		31	43	0	74

[1] The spawning channel was divided into three sections. CH A is the top 1/3, CH B is the middle 1/3, and CH C is the bottom 1/3 of the channel. See Figure 1 for location of capture areas.

Appendix 2. Staple tagging of chinook salmon carcasses in Quinsam River, 1997.

Date	Capture Area[1]	Tagged			
		Male	Female	Jack	Total
24-Oct	2B	3	2	0	5
24-Oct	2C	0	2	0	2
24-Oct	2D	4	5	0	9
27-Oct	2B	2	4	0	6
27-Oct	2C	7	11	0	18
27-Oct	2D	21	6	0	27
28-Oct	2A	2	2	0	4
28-Oct	2D	2	1	0	3
29-Oct	2A	0	1	0	1
29-Oct	2B	1	0	0	1
29-Oct	2C	5	8	0	13
29-Oct	2D	13	10	0	23
30-Oct	2D	3	2	0	5
01-Nov	2A	1	0	0	1
03-Nov	2A	1	0	0	1
03-Nov	2B	1	2	0	3
03-Nov	2C	0	3	0	3
03-Nov	2D	0	2	0	2
04-Nov	2A	0	1	0	1
06-Nov	2C	2	0	0	2
06-Nov	2D	0	4	0	4
10-Nov	2A	1	0	0	1
10-Nov	2B	2	3	0	5
10-Nov	2C	4	1	0	5
10-Nov	2D	12	4	0	16
13-Nov	2B	3	1	0	4
13-Nov	2C	0	1	0	1
13-Nov	2D	8	2	0	10
17-Nov	2B	0	2	0	2
17-Nov	2D	1	2	0	3
20-Nov	2B	1	1	0	2
20-Nov	2C	1	2	0	3
20-Nov	2D	0	1	0	1
24-Nov	2C	3	0	0	3
Total		104	86	0	190

[1] See Figure 1 for location of capture areas.

Appendix 3. Recovery of tagged chinook salmon carcasses in Campbell River, 1997 .

Date	Recovery area (a)	Recovered (a)			
		Male	Female	Jack	Total
28-Oct	CHA	0	1	0	1
28-Oct	CHB	2	0	0	2
28-Oct	CHC	0	4	0	4
30-Oct	1A	0	2	0	2
30-Oct	CHB	3	1	0	4
30-Oct	CHC	0	1	0	1
31-Oct	1B	1	0	0	1
04-Nov	1B	0	1	0	1
11-Nov	1A	0	1	0	1
11-Nov	1B	1	0	0	1
14-Nov	1B	0	3	0	3
18-Nov	1B	1	3	0	4
21-Nov	1B	1	0	0	1
Total		9	17	0	26

(a) See Figure 1 for location of recovery areas

Appendix 4. Recovery of tagged chinook salmon carcasses in Quinsam River, 1997.

Date	Recovery area (a)	Recovered (a)			
		Male	Female	Jack	Total
27-Oct	2B	1	2	0	3
27-Oct	2D	2	4	0	6
29-Oct	2B	2	1	0	3
29-Oct	2D	15	4	0	19
29-Oct	2C	2	2	0	4
30-Oct	2D	3	1	0	4
31-Oct	1B	1	0	0	1
03-Nov	2B	1	0	0	1
03-Nov	2C	1	0	0	1
03-Nov	2D	0	2	0	2
04-Nov	1B	0	1	0	1
04-Nov	2A	1	0	0	1
06-Nov	2D	0	1	0	1
10-Nov	2D	2	4	0	6
13-Nov	2B	1	3	0	4
13-Nov	2C	2	2	0	4
13-Nov	2D	11	1	1	13
17-Nov	2B	1	1	0	2
17-Nov	2D	1	3	0	4
20-Nov	2B	1	1	0	2
20-Nov	2D	5	4	0	9
20-Nov	2C	1	0	0	1
24-Nov	2D	1	0	0	1
27-Nov	2C	2	0	0	2
Total		57	37	1	95

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

Appendix 5. Sequential mark-recapture data for chinook salmon carcasses in Campbell River, 1997. (Carcasses examined on or before the first date of tagging are not included for the mark-recapture estimate (MR).)

	Male			Female			Jack			Total		
Date	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered
24-Oct	6	5	0	12	8	0	0	0	0	18	13	0
28-Oct	9	9	2	16	15	5	0	0	0	25	24	7
30-Oct	1	1	3	2	1	4	0	0	0	3	2	7
31-Oct	9	9	1	8	7	0	0	0	0	17	16	1
04-Nov	1	1	0	2	2	1	0	0	0	3	3	1
05-Nov	1	0	0	2	1	0	0	0	0	3	1	0
07-Nov	2	1	0	3	2	0	0	0	0	5	3	0
11-Nov	1	1	1	3	3	1	0	0	0	4	4	2
14-Nov	6	2	0	8	3	3	0	0	0	14	5	3
18-Nov	2	2	1	3	1	3	0	0	0	5	3	4
21-Nov	0	0	1	0	0	0	0	0	0	0	3	1
Total	38	31	9	59	43	17	0	0	0	97	77	26
Total for MR(a)	32	26	9	47	35	17	0	0	0	79	64	26

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

Appendix 6. Sequential mark-recapture data for chinook salmon carcasses in Quinsam River, 1997. (Carcasses examined on or before the first date of tagging are not included for mark-recapture estimate (MR).)

	Male			Female			Jack			Total		
Date	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered	No. examined	No. tags applied	No. tags recovered
13-Oct	1	0	0	0	0	0	0	0	0	1	0	0
24-Oct	11	7	0	20	9	0	0	0	0	31	16	0
27-Oct	38	30	3	34	21	6	0	0	0	72	51	9
28-Oct	4	4	0	6	3	0	1	0	0	11	7	0
29-Oct	24	19	19	27	19	7	0	0	0	51	38	26
30-Oct	4	3	3	4	2	1	0	0	0	8	5	4
01-Nov	1	1	0	0	0	0	0	0	0	1	1	0
03-Nov	8	2	2	11	7	2	0	0	0	19	9	4
04-Nov	0	0	1	1	1	1	0	0	0	1	1	2
06-Nov	4	2	0	6	4	1	0	0	0	10	6	1
10-Nov	30	19	2	18	8	4	1	1	0	49	28	6
13-Nov	18	11	14	14	4	6	0	0	1	32	15	21
17-Nov	9	1	2	11	4	4	0	0	0	20	5	6
20-Nov	4	2	7	10	4	5	0	0	0	14	6	12
24-Nov	6	3	1	1	0	0	0	0	0	7	3	1
25-Nov	3	0	0	0	0	0	0	0	0	3	0	0
27-Nov	0	0	2	2	0	0	0	0	0	2	0	2
Total	165	104	56	165	86	37	2	1	1	331	191	94
Total for MR(a)	154	97	56	145	77	37	2	1	1	300	175	94

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

Appendix 7. Total dead recovery and adipose clip recovery of chinook salmon in Campbell River, 1997.

	Area 1A (a)								Area 1B (a)								Area 1C (a)							
	Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
24-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28-Oct	0	2	0	2	0	0	0	0	1	1	0	2	0	0	0	0	4	12	0	16	0	0	0	0
30-Oct	0	1	0	1	0	1	0	1	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
31-Oct	0	0	0	0	0	0	0	0	9	8	0	17	0	1	0	1	0	0	0	0	0	0	0	0
04-Nov	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0
05-Nov	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-Nov	0	0	0	0	0	0	0	0	1	3	0	5	1	0	0	1	0	0	0	0	0	0	0	0
11-Nov	0	1	0	1	0	0	0	0	1	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0
14-Nov	2	2	0	4	0	0	0	0	3	5	0	8	0	0	0	0	0	0	0	0	0	0	0	0
18-Nov	0	2	0	2	0	0	0	0	2	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	10	0	13	0	1	0	1	19	22	0	42	1	1	0	2	4	13	0	17	0	0	0	0

(a) See Figure 1 for location of recovery areas

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

Appendix 8. Total dead recovery and adipose-clip recovery of chinook salmon in Campbell River spawning channel, 1997.

	Channel A (a)								Channel B (a)								Channel C (a)							
	Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
24-Oct	1	4	0	5	0	0	0	0	3	3	0	6	0	0	0	0	2	6	0	8	0	0	0	0
28-Oct	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
30-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14-Nov	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
18-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	5	0	6	0	0	0	0	8	3	0	11	0	0	0	0	2	6	0	8	0	0	0	0

(a) See Figure 1 for location of recovery areas (The spawning channel was divided into three sections ; channel A is the top 1/3, channel B is the middle 1/3, and channel C is the bottom 1/3 of the channel length)

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

Appendix 9. Total dead recovery and adipose clip recovery of chinook salmon in Quinsam River, 1997.

	Area 2A (a)								Area 2B (a)							
	Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
13-Oct	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
24-Oct	0	0	0	0	0	0	0	0	5	11	0	16	0	0	0	0
27-Oct	0	0	0	0	0	0	0	0	5	14	0	19	0	1	0	1
28-Oct	2	3	0	5	0	0	0	0	0	0	0	0	0	0	0	0
29-Oct	1	2	0	3	0	0	0	0	4	5	0	9	0	0	0	0
30-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
01-Nov	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
03-Nov	1	0	0	1	0	0	0	0	5	4	0	9	1	0	0	1
04-Nov	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
06-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10-Nov	3	2	0	5	0	0	0	0	5	4	0	9	0	0	0	0
13-Nov	0	0	0	0	0	0	0	0	5	3	0	8	0	1	0	1
17-Nov	1	0	0	1	0	0	0	0	3	3	0	6	0	0	0	0
20-Nov	0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0
24-Nov	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0
25-Nov	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
27-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	13	8	0	21	0	0	0	0	35	46	0	81	1	2	0	3

(a) See Figure 1 for location of recovery areas

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

Appendix 9 (cont'd). Total dead recovery and adipose clip recovery of chinook salmon in Quinsam River, 1997 .

	Area 2C (a)								Area 2D (a)							
	Total examined (b)				Adipose clipped recoveries				Total examined (b)				Adipose clipped recoveries			
Date	M	F	J	T	M	F	J	T	M	F	J	T	M	F	J	T
13-Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24-Oct	0	3	0	3	0	1	0	1	6	6	0	12	2	0	0	2
27-Oct	9	12	0	21	2	1	0	3	24	8	0	32	1	2	0	3
28-Oct	0	0	0	0	0	0	0	0	2	3	0	6	0	0	1	1
29-Oct	5	10	0	15	0	0	0	0	14	10	0	24	1	0	0	1
30-Oct	0	0	0	0	0	0	0	0	4	4	0	8	1	0	0	1
01-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
03-Nov	1	5	0	6	0	0	0	0	1	2	0	3	1	0	0	1
04-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06-Nov	4	1	0	5	1	0	0	1	0	5	0	5	0	1	0	1
10-Nov	6	5	0	11	0	0	0	0	16	7	0	23	1	0	0	1
13-Nov	2	6	0	8	0	2	0	2	11	5	0	16	1	1	0	2
17-Nov	3	5	0	8	1	1	0	2	2	3	0	5	0	0	0	0
20-Nov	1	2	0	3	0	0	0	0	2	6	0	8	1	0	0	1
24-Nov	4	1	0	5	1	0	0	1	0	0	0	0	0	0	0	0
25-Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Nov	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0
Total	35	50	0	85	5	5	0	10	82	61	0	144	9	4	1	14

(a) See Figure 1 for location of recovery areas

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