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ABUNDANCE, AGE, SIZE, SEX AND CODED-WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENTS OF CAMPBELL AND QUINSAM RIVERS, 1996.

by

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ABSTRACT

Nagtegaal, D., and G.W.F. Graf. 1998. Abundance, age, size, sex, and coded-wire tag recoveries for chinook salmon escapements of Campbell and Quinsam Rivers, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2448: 55 p.

Chinook salmon escapement estimates were derived for the Campbell / Quinsam River system for 1996 utilizing carcass tag and recovery methods as part of the chinook key stream program. The Petersen estimate of chinook escapement was 3,062 with 95 % confidence limits of 2,824 to 3,431 fish. In both the Campbell River and Quinsam River, four year old females dominated, however, in the Quinsam Hatchery, five-year old females dominated. Four-year old males were dominant in the Campbell River and Quinsam Hatchery, but in the Quinsam River , three-year olds were the most prevalent male age group. Returns of coded-wire tagged chinook to the Campbell / Quinsam system totalled 202 in 1996. 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 1996, the total hatchery contribution was 1,126 (87.9 %) for males and 717 (83.1 %) for females.

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

RESUME

Nagtegaal, D., and G.W.F. Graf. 1998. Abundance, age, size, sex, and coded-wire tag recoveries for chinook salmon escapements of Campbell and Quinsam Rivers, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2448: 55 p.

Nous avons effectué des estimations des échappées de saumon quinnat en 1996 pour le système Campbell/Quinsam par des méthodes de marquage-récupération des carcasses dans le cadre du programme des cours d'eau clés pour le quinnat. Selon l'estimation Petersen, l'échappée de quinnat a été de 3 062, avec limites de confiance à 95 % de 2 824 à 3 431 poissons. Dans la Campbell et la Quinsam, les femelles de quatre ans dominaient; à l'écloserie de la Quinsam, c'étaient les femelles de cinq ans qui dominaient. Chez les mâles, ceux de quatre ans dominaient dans la Campbell et à l'écloserie de la Quinsam, mais ceux de trois ans constituaient le principal groupe d'âge dans la Quinsam. On a compté 202 retours de quinnats portant des micromarques dans le système Campbell/Quinsam en 1996. Les estimations des échappées sont stratifiées par rivière, sexe et code de marque. La contribution de l'écloserie à l'échappée a été calculée par développement du nombre réel de retours des micromarques codées pour chaque année de ponte et pour chaque code de marque. En 1996, la contribution totale de l'écloserie était de 1 126 (87,9 %) pour les mâles et de 717 (83,1 %) pour les femelles.

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

INTRODUCTION

The restoration of Pacific chinook salmon stocks to historical levels is one of the primary objectives of Fisheries and Oceans Canada long term management plans. Various "key streams" were chosen for study, including the Campbell and Quinsam River systems, in order to 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. Before this facility was built chinook escapement to the Quinsam River was negligible. Chinook returns to the Quinsam River 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).

This manuscript report is number ten in the series describing the escapement monitoring and biological and physical sampling of chinook salmon in the Campbell and Quinsam River systems. Previous study results are presented in the following reports: Shardlow et al., 1986, and Andrew et al. 1988, for the 1984 and 1985 studies, respectively. The 1986-88 study results are presented in Bocking et al., 1990, and Bocking, 1991 covers 1989 and 1990. Frith et al. 1993; provides the results of the 1991 reporting year, and Frith, 1993, for 1992. Frith and Nelson, 1994, and Frith and Nelson, 1995, present results for 1993 and 1994, respectively.

The objectives of this document are to provide a chinook salmon escapement estimate to the Campbell / Quinsam River system based upon carcass tag and 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.

The 1996 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.

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 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 study area, depicted in Figure 1, comprises the Campbell River and Quinsam River systems of central eastern Vancouver Island. Andrew et al. (1988), described the physical characteristics of the Quinsam / Campbell drainage basin. The Campbell River drains some 1,465 square kilometers of the eastern slopes of the central Vancouver Island Range. It runs in an easterly direction for approximately 9 km to the north side of the City of Campbell River where it flows into Discovery Passage. A waterfall and hydroelectric dam 5.5 km. from the mouth of the Campbell limits fish passage. The Quinsam River drains a watershed of 265 sq. km. It is a major tributary and joins up with the Campbell River 3.5 km. from the estuary. The Quinsam runs for over 30 km through a series of small lakes to the south of the Campbell River watershed and is fed by numerous tributaries, including Cold Creek, Flintoff Creek, and the Iron River.

Water flow on the Quinsam has been regulated since 1956, as there is a diversion dam above Middle Quinsam Lake to provide extra water to the Campbell system for power generation. Flow rates on the lower Quinsam since this dam was built in 1973 ranged from 0.9 to 21.6 m^3/sec with a mean of 9.2 m^3/sec (Bell and Thompson, 1977). The flow control on the upper Quinsam can help maintain minimum flow rates during dry periods but during spring freshets some flooding still happens (Blackmun et al. 1985). Water flow in the Campbell River, controlled by the John Hart Generating Station, varies from 1.2 m^3/sec to 826 m^3/sec with a mean of 96 m^3/sec (Marshall et al. 1977).

The Campbell and Quinsam Rivers are impacted in their upper watersheds by the logging and mining industries. Numerous gravel roads provide access to much of the watershed and there

is considerable recreational use within the Campbell / Quinsam system, although travelling into the upper watershed is more difficult. The lower river runs through residential areas of the City of Campbell River which has grown up around the river. Near the mouth, the Campbell River flows through an area of industrial and commercial enterprises including wood processing, machine shops, commercial and sport fishing activities, and floatplane facilities. In an effort to improve fish habitat, small islands have been constructed in the estuary (Levings et al.1986).

Five species of Pacific salmon are found within the Campbell / Quinsam river system. In order of abundance, these are pink (*Oncoryhnchus gorbuscha*), chinook (*O. tshawytscha*), chum (*O. keta*), coho (*O. kisutch*), and sockeye(*O. nerka*). There are also Steelhead trout (*O. mykiss*), and Cutthroat trout (*O. clarki*).

Chinook salmon have been observed spawning in the Campbell River above the Quinsam River confluence and in the Quinsam River from the confluence with the Campbell to above the hatchery counting fence (Andrew et al. 1988). Some chinook are let through the counting fence at the Quinsam Hatchery to spawn in the higher reaches of the lower Quinsam River. Coho salmon have been observed spawning in the Quinsam River as far as the 12 m waterfall approximately 27 km up from the confluence with the Campbell, but not in the Campbell River itself. Chum and Pink salmon spawn in the lower reaches of both the Campbell and Quinsam Rivers. Mature chinook begin entering the Campbell River in late August with the migration peaking in October. Spawning occurs over several weeks from the middle of October to mid November. Depending upon rainfall to a greater extent than in the Campbell, chinook enter the Quinsam a little later and spawn through November into early December.

METHODS

POPULATION ESTIMATION

The total estimate of the chinook escapement was produced by combining the Petersen estimates from the results of *in situ* chinook carcass tagging and recovery from the Quinsam and Campbell rivers with those fish counted at the Quinsam Hatchery and above the hatchery fence. An estimate of the hatchery contribution to the overall escapement was derived from the returns of coded-wire tagged adult chinook. A summary of methods used in the study is presented in Table 1.

Population Stratification

In this study, carcass tagging and recovery data were stratified to keep the sexes and rivers segregated. This separation of the data was done to minimize the effects of potential biases produced by factors which affect the strata at different rates. These totals are summed to produce an estimate of the entire escapement population.

Potential Biases

Within a sampling category or stratum, Petersen estimates employing carcass tagging are dependent upon a number of assumptions. Population estimates may be biased in either direction by varying amounts depending on the type and extent of violation of these assumptions. Since 1988, Andrew et al., and all of the subsequent studies of this series have presented and discussed seven of these assumptions. These are provided again for the readers benefit. Tests used to determine whether or not these assumptions were violated are presented and discussed with respect to sex and river stratification of the Petersen estimate. Certain biases caused by tag and recovery methods, age determination, etc. are discussed in subsequent sections.

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

To obtain an accurate Petersen estimate, it is important that the rate of tag application and recovery is done in proportion to the available population. In 1996, chinook carcasses were staple tagged *in situ* at the time of examination. Hatchery staff endeavoured to tag a consistent proportion of the number of carcasses examined during each survey. The average tag rate over the study period was approximately 65 % for both rivers. On different days this rate was subject to change depending upon the availability of carcasses.

In determining separate escapement estimates for each river, the problem of tagged carcasses "straying" between rivers is introduced. Unlike live fish, tagged carcasses are subject to passive movement due to water flow. This is particularly important for tagged Quinsam River chinook carcasses drifting down into the Campbell River. Carcasses do not drift from the Campbell into the Quinsam, however, there may be initial confusion as to the origin of carcasses recovered at the confluence of the Campbell and Quinsam where back eddies may cause carcasses to drift into the mouth of the Quinsam. Examination of operculum punches would then identify the origin of the fish. In 1996, there were no tagged strays found in either of the rivers.

Assumption 2. After the conclusion of tagging, there is a negligible number of new spawners entering the study area.

Additional spawned out carcasses entering the study area may cause the Petersen calculations to overestimate or underestimate the actual population depending on how they mixed

with tagged fish. In 1996, carcass tagging was carried out *in situ* every 1-4 days for the duration of the spawning and die-off period.

Assumption 3. There is no tag loss.

A high frequency of lost tags will cause the Petersen calculations to overestimate the true population. The monitoring of tag loss was done with the use of a secondary mark; an operculum hole punch applied to all tagged carcasses. Two operculum holes identified the fish as originating in the Campbell River and one hole meant the fish were tagged in the Quinsam River. The retrieval of any secondary marks was included in the tag recovery data and Petersen estimates.

Assumption 4. All tags are recognized and recorded during recovery after tagging is completed.

In 1996, dead pitches were not duplicated, therefore, it is not possible to investigate the rate of missed tags and secondary marks and evaluate the validity of this assumption.

Assumption 5. Recovery efforts are directed to the same population that was tagged.

If recovery is undertaken on a population other than that which was tagged, then the Petersen estimates will be greater than the true population. Similar populations will have similar age and length frequency distributions. Likewise, dissimilar age and length frequencies between tagged and recovered fish would be an indication that the recovered population is different from the one tagged. Because tagging and recovery took place concurrently, the recovery effort was likely directed at the same population that was tagged.

Assumption 6. The number of fish sampled is large enough to provide an accurate and precise estimate of the population.

The population estimate will have greater reliability and precision if a high proportion of tagged fish are recovered. Discounting other sources of error, approximately 25 to 75 recoveries will produce population estimates with 25 % accuracy, with 95 % confidence, for populations of 10^2 and 10^9 (Ricker 1975).

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

Tagged chinook carcasses must mix completely (refer to Assumption 1) with untagged carcasses in order to be representative of the population. If not, then the estimate of population may be too high or too low. The thoroughness of the mixing depends on where and how tagged carcasses are put back into the river, and whether tagged and untagged carcasses behave similarly. It is not possible to statistically test the assumption of mixing with the data from this study. The process of removing carcasses from the river and handling them may cause differences in

buoyancy and decomposition with untagged carcasses through air entrapment and/or release. Recovery of carcasses could be biased by the increased visibility of tags resulting in an underestimation of the population. The use of neutral coloured tags decreases their visibility thereby reducing preferential recovery sampling. It is not possible to test the assumption of similar visibility between tagged and untagged with the data from this study. The assumption of similar buoyancy and decomposition of tagged and untagged chinook 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 population estimate for each river and sex was calculated using Chapman's formula. from Ricker 1975, p.78.

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

where PE is the population estimate, C is the number of fish tagged, M is the total number of fish recoveries, and R is equal to the number of tagged fish recoveries.
The subscripts s and r denote the sex and river stratums, respectively.

The total in-river population was calculated by summing the total estimates of both sexes in each river:

$$PT = CR_m + CR_f + QR_m + QR_f \qquad (2)$$

where PT is the total in-river population estimate. CR_m and CR_f denote the population estimates for Campbell River males and females, respectively. The symbols QR_m and QR_f represent the respective population estimates for Quinsam River males and females.

Confidence limits (95 %) for the population estimates were determined using fiducial limits for the Poisson distribution as described by Ricker (1975). The confidence limits assign lower and upper population estimates for each river, sex stratified.

Strays

Those chinook carcasses staple tagged in one river and recovered in the other are treated as strays for the purpose of the population estimate. In the event of any strays being found, the estimated total number of strays would be calculated by multiplying the number of tagged strays recovered by the ratio of marked to recovered carcasses.

For carcasses recovered in the Campbell River which were originally tagged in the Quinsam River, the calculation would appear as follows:

$$ETS_{Q\,to\,C} = RTS_{Q\,to\,C} \; x \; (M_{Campbell} / R_{Campbell}) \quad (3)$$

where ETS is the estimated number of tagged strays from the Quinsam River to the Campbell River, RTS is the number of recovered tagged strays, M and R refer to the number of marked and recovered adult chinook from the Campbell River.

In 1996, no stray carcasses were recovered from the Quinsam River or the Campbell River. It is highly improbable that stray carcasses from the Campbell River end up in the Quinsam since the Quinsam flows into the Campbell and the confluence is above tidal influence. In the event of straying, the following equation is necessary to estimate the number of tagged fish available for recapture:

$$AM_{Campbell} = M_{Campbell} + ETS_{Quinsam\ to\ Campbell} \quad (4)$$

where $AM_{Campbell}$ equals the adjusted number of tagged chinook available for recapture in the Campbell River. $M_{Campbell}$ is the number of secondary marks applied, and $ETS_{Quinsam\ to\ Campbell}$ is the estimated number of tagged strays from Quinsam River to Campbell River.

In the unlikely event of tagged carcasses from the Campbell straying into the Quinsam, the equation is the same but the river subscripts are switched:

$$AM_{Quinsam} = M_{Quinsam} + ETS_{Campbell\ to\ Quinsam} \quad (5)$$

The above results provide equation 1 ; ($T_{s,r}$), with the adjusted estimates of tagged chinook available for recapture.

SWIM SURVEYS

Snorkel surveys are done on the Campbell River beginning in early August and continuing approximately once per week until late October. These were qualitative surveys designed to provide a sense of the strength and timing of the run and the position of fish in the river in relation to previous years observations. For the purposes of organizing swim survey data, the Campbell River was divided into eight sections beginning at the canyon pool and ending at the estuary. The following text and Figure 2 describe the swim survey sections of the Campbell River.

Campbell River Section :

1. Begins in the canyon pool and ends at the top of the upper island.
2. The top of the upper island to a point midway between the upper and lower island.

3. Midway between the two islands to a point just upstream of the pumphouse
4. From the pumphouse to the confluence of the Quinsam and Campbell Rivers.
5. From the Campbell/Quinsam confluence to the logging bridge.
6. The logging bridge to the highway bridge.
7. From the highway bridge to the northward sweeping curve of the river
8. Includes the sweeping curve of the river to a point at the top of the estuary.

Swim surveys are not done on the Quinsam River in August due to its small size and low water levels, and lack of fish holding during the summer. The deepest pools of the Quinsam are occasionally surveyed with Scuba gear in the fall to obtain a count of any mature chinook salmon holding in these areas.

TAGGING

Carcass tagging was carried out by Quinsam Hatchery staff on both the Quinsam and Campbell Rivers concurrently with carcass recovery. Adult chinook carcasses were collected at various locations and Ketchum ear tags[2] were attached to the operculum of carcasses plus given a secondary identifier (operculum hole punch) to distinguish the origin of release as being either the Campbell or Quinsam River. Fish tagged on the Campbell River were given two hole punches through their left operculum and those tagged on the Quinsam were given a single hole punch through their left operculum. The carcasses were then released back into the river. The tagged fish were placed back in the same area they were collected. Most carcasses were in good enough condition to be tagged, but some were too deteriorated or damaged to be used in the study.

RECOVERY

Carcass recovery was undertaken the day after tagging and release. Crews were comprised of between two to four people. Recovery crews searched for chinook carcasses by walking both banks and wading in the shallows where possible, and from a boat. To search the deeper pools in the lower reaches of the Campbell and Quinsam, SCUBA was used. Chinook were also recovered at the Quinsam Hatchery rack.

Recovery crews examined and dead pitched all carcasses found, recorded all primary and secondary marks, and kept all operculum tags. Heads were removed from adipose-clipped fish for sampling of coded-wire tags. Data collected from the carcasses is described in biological and physical sampling section. Carcasses tagged during the recovery effort were returned to the same location as they were tagged. Recaptured tagged carcasses were cut in half to prevent counting them again in subsequent dead pitches. Table 2 shows the amount of effort spent in each river for chinook salmon carcass tag and recovery, as well as the tag and recovery rates.

[2] Ketchum Manufacturing Ltd., Ottawa, Canada.

To ensure sufficient mixing between tagged and untagged carcasses, a period of 24 hours elapsed between tagging and recovery. Thus, for the Petersen mark-recapture estimates, only those carcasses recovered after the first day of tagging were included in the values of C (numbers marked) and R (numbers recovered).

An estimate of the proportion of the population that was tagged is provided by the tag rate. The tag rate calculation is as follows :

$$tag\ rate = R / C$$

An estimate of the proportion of tagged fish later recaptured is given by the tag recovery rate. The tag recovery rate calculation is :

$$tag\ recovery\ rate = R / M$$

BIOLOGICAL AND PHYSICAL SAMPLING

A portion of the fish counted were sampled when tagged. Sex, presence of secondary marks, and postorbital-hypural lengths were recorded. Postorbital-hypural lengths were recorded for 68 % of the carcasses (marked and unmarked fish) recovered in the Campbell River, 69 % of the carcasses recovered in the Quinsam River, and 60 % of the chinook recovered alive at the hatchery rack.

Scale samples were taken from the same unmarked fish as the length samples. For accurate ageing, the scales could not be regenerated and the previous annulus had to be at least partially intact. A minimum of two scales from which both aquatic and marine ages could be read were necessary before the scale age was recorded. Scales were rejected at the ageing lab if they were mounted upside down, if they were resorbed, or if they had regenerate centers. In this report scale ages are presented using the method originally described by Gilbert and Rich (1927). The scale ages consist of two numbers, the first numeral represents the total age of the fish and the second the age of the fish when it migrated into the marine environment. Fish too deteriorated for sampling were counted, their condition noted, and then released along with the tagged carcasses to the same location they were collected.

The population of each age class was determined by allocating portions of the Petersen estimate to the age classes according to the age composition determined from scale samples and CWT decoding. The number of jacks was too small to produce a population estimate, thus, the escapement, by age class, was determined for adult males and females only.

Sex ratios for both rivers were determined using the Petersen estimates. Testing for potential differences in tag loss is described in the tagging methods section. Tag recognition is not likely to be sex biased, although it was not possible to test this potential bias with data from this study.

CODED-WIRE TAGGING AND RECOVERY

The Quinsam River Hatchery coded-wire tagged (Jefferts et al. 1963) a portion of the juvenile chinook released during the 1990-1995 brood years. Those fish found lacking their adipose fin were scale sampled, their post-orbital hypural length and sex were recorded and the head was removed for CWT extraction. The hatchery contribution was derived from the actual CWT returns present in the escapement using the methods described for the Mark Recovery Program (Kuhn 1988). CWT returns to the Campbell / Quinsam River system in 1996 are listed in Table 17.

The estimation of the total number of CWT returns from each of the brood years, and for each tag code was done by adjusting the observed number of CWT recoveries to account for adipose clipped recoveries lacking a CWT.

The following formula was used:

$$ADJ_{s,r,tc} = OBS_{s,r,tc} \times \left(1 + \frac{LP}{K} + \frac{ND \times (K+LP)}{K \times (K+LP+NP)} \right) \quad (6)$$

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 the subscripts s, r, and tc denote the sex, river, and tag code.

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

$$EST_{s,r,tc} = \frac{ADJ_{s,r,tc} \times P_{s,r}}{C_{s,r}} \quad (7)$$

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 the subscripts s, r, and tc denote the sex, river, and tag code. This method depends upon the assumption that there is no tag loss after release from the hatchery. Violation of this assumption will cause the hatchery contribution estimate to be lower than the actual contribution. Most tag loss takes place within 4 weeks of tagging, 90% according to Blenkenship 1990. Bocking (1991) discusses other potential sources of bias associated with this method.

The hatchery contribution to each year's escapement, stratified by river and sex, was derived 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 the time of release.

$$EHC_{s,r,tc} = \frac{EST_{s,r,tc} \times (RM_{tc} + RUM_{tc})}{RM_{tc}} \quad (8)$$

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 the hatchery contributions 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. The percent hatchery contributions by sex and age were then calculated using the Petersen population estimates for adult male and female chinook salmon.

RESULTS

SWIM SURVEYS

In 1996, water conditions in the Campbell River were favourable for observing and counting adult chinook. Clear water conditions meant less diver time was necessary, however, safety requirements necessitating a backup-diver increased the costs of this activity. Through flow control, water levels in the Campbell River were reduced during the summer of 1996, in an effort to better reflect the natural low water period during this season. Figure 2 shows the sections of the Campbell River swam.

Section six had the most number of adults observed. Section seven had very few holding fish and in section eight, none were observed. The number of adult chinook observed in each section in 1996 and annually since 1986, are provided in Figure 3. Chinook escapement estimates, from 1985 to 1996, based upon swim surveys and *in situ* carcass tagging and recovery methods, are shown in Figure 4. Swim surveys were not done on the Quinsam River in 1996.

TAGGING

In 1996, from October 3 to November 22, a total of 185 adult chinook carcasses were collected from the Campbell River for examination and tagging. Of these, 121 (65.4 %) were operculum tagged, hole punched, and returned to the Campbell River. Similarly, on the Quinsam River, 149 chinook were examined and 99 carcasses (66.4 %) were tagged and released back into the Quinsam River from October 24 to November 28 (Table 5 and Appendices 1 and 2).

RECOVERY

Chinook carcasses were recovered from the Campbell River beginning on October 25 and ending November 22, and in the Quinsam River from October 30 to November 28. Conditions for carcass recovery on the Campbell were excellent in 1996 with low to medium flows and clear water conditions predominating. A total of 305 person hours were spent in recovery efforts on the Campbell River. Total SCUBA time on the Campbell River deadpitch was 10.2 hours over five days. The Quinsam River had turbid water conditions until November 11. A total of 198 person hours were spent on the Quinsam recovery effort. Overall recovery time was increased over 1995 by five days. This effort resulted in a 54 % recovery rate on the Campbell River and a 30 % recovery rate on the Quinsam. The clarity of the Campbell River below the Quinsam confluence was frequently compromised by silt laden water entering from the Quinsam. A summary of carcass recovery from each area is provided in Table 5 and Appendices 3 and 4.

Of the 185 chinook carcasses examined from the Campbell River, 86 were adult males (46.5 %), 98 were female (53 %) and 2 were jacks (1.1%). The total number that were staple tagged was 121 of which 53 were male (no jacks) and 68 female. There were 66 tag recoveries from this group (54 %) of which 29 were male and 37 female. Tags from a single male and 2 females were lost. Appendices 5 and 6 present mark-recovery data, sex stratified for both river systems.

From the Quinsam River, a total of 149 chinook carcasses were examined, of which 89 were male (including 4 jacks), and 60 were female. Staple tags were attached to 99 of the carcasses comprising 57 males (no jacks) and 42 females. A total of 31 were recovered (31 %) with 17 being male and 13 being female. The rate of tag loss was very low since it was limited to a single female. The difference in tag recovery rates between the Campbell and Quinsam Rivers was 23 % . This was determined to be a significant difference ($P < 0.05$, X^2 ; Zar 1996). In the Campbell system , the tag recovery rate for males was 55 % and for females, 54 %. In the Quinsam system , the tag recovery rate for males was 30 % and for females, 33 %. Neither of these differences were significant ($P > 0.05$, X^2).

POPULATION ESTIMATES

Escapement estimates derived from the Petersen method of carcass tag and recovery are given in Table 6. The estimates are stratified by river and sex and include 95 % confidence limits. In 1996, chinook salmon escapement to the Campbell River was estimated at 157 males and 183 females. Escapement to the Quinsam River below the hatchery was estimated at 285 males and 180 females.

The total 1996 chinook salmon escapement to the Campbell / Quinsam River systems including hatchery rack recoveries, was estimated at 3062 adults with 95 % confidence limits of 2824 to 3431 fish.

In 1996, the relative percentage of fish between the Campbell River, Quinsam River, and Quinsam Hatchery sampling locations was 29.8%, 41.4%, and 28.8%, respectively. Previous proportions were 15.8%, 20.9%, and 63.3% in 1994 (Frith and Nelson 1995), and 17.9%, 42.2%, and 39.9% in 1989-91 (Bocking 1991). The Campbell River return was higher this year than in the previous eight years. The return to the Quinsam River was greater than the previous four years. The increasing number of hatchery returns shows a continued increase in the proportion of hatchery chinook. The total number of returns in 1996 is not significantly different from returns of the previous three years. The 1996 returns remain significantly less than the returns of 1988-90.

AGE, LENGTH, AND SEX COMPOSITION

All scale-aged fish left the river during their first year of life. The total age of all Campbell and Quinsam River chinook ranged from one to six years. The dominant age group in Campbell River for both males and females was four years. In the Quinsam River, the dominant age was four years for females and three years for males. In Quinsam Hatchery, four year old males and five year old females dominated. The order of dominant age groups was four years, followed by five's and three's. The dominant age group of four years in the Campbell River represented between 45 and 50 % of males and females (Tables 7-9).

The mean lengths between the sexes and systems (postorbital-hypural) were as follows: Campbell River: male = 773 mm. , female = 814 mm.; Quinsam River: male = 623 mm.(including jacks), female = 780 mm (Tables 10-12, Figs. 5-7). T-tests were done to compare mean lengths between sexes and rivers. It was found that male chinook carcasses were significantly smaller than female carcasses in Campbell River ($P < 0.05$), Quinsam River ($P < 0.001$), and Quinsam Hatchery ($P < 0.001$). There was no significant difference in mean length between Quinsam River female chinook carcasses and Campbell River males ($P > 0.1$). There was no significant difference between the mean length of unaged and aged (all ages) chinook for any combination of sex and river stratum (t-test, $P > 0.05$).

In 1996, the overall male/female sex ratio was 0.79 for Campbell River. The male/female sex ratio was 0.73 for the dominant age group of four-year olds in the Campbell River. The male/female sex ratio was 1.41 for the Quinsam River, and 1.43 for the Quinsam River Hatchery.

CODED-WIRE TAGGING AND RECOVERY

Adipose-clipped (CWT) juvenile chinook released into the Campbell and Quinsam rivers from the 1990 to 1995 brood years were captured as adults in the carcass recovery programs in 1996 (Table 17). There were five CWT recoveries from the Quinsam River, one of which was a jack from the 1994 brood. The Quinsam Hatchery recovered 187 CWT mature chinook, including ten jacks; six from the 1994 brood, three from 1995, and a stray jack from a Washington State hatchery. There were ten CWT recoveries from the Campbell River, none of which were jacks, in 1996. The highest rate of return of CWT fish was found at the Quinsam Hatchery at 8.3 %, followed by the Campbell River at 2.9 %, and the lowest CWT return rate was to the Quinsam River at 1.1 % (Table 17).

The mark-recovery data for the Petersen estimates of both rivers can be found in Appendices 5 and 6. The observed and adjusted number of CWT chinook salmon returns to the Campbell River, Quinsam River, and Quinsam hatchery by tag code is provided in Table 17. The estimates of the total escapement of CWT chinook salmon, and hatchery-reared CWT fish are shown in Tables 18 and 19.

HATCHERY CONTRIBUTION

In 1996, the contribution to the chinook salmon escapement by the Quinsam River Hatchery was determined using the number of actual CWT's present in the escapement. The 1996 hatchery contribution to the Campbell River chinook population was estimated to be 29.3 % for males and 83.6 % for females. The contribution to the in-river Quinsam chinook escapement was estimated at 42.8 % for males and 19.4 % for females. The contribution to hatchery returns was 87.9 % for males and 83.1 % for females. The estimated stray contribution was 0 % of the escapement estimates for the Campbell River, and the Quinsam River, and hatchery. The hatchery contribution to the total escapement of chinook, in 1996, stratified by age and sex, is presented in Table 20. A single jack stray from Washington state was found in the returns to the Quinsam hatchery.

DISCUSSION

POPULATION ESTIMATION

During swim surveys, adult chinook were observed holding in all sections of the Campbell River except for section eight, in which no chinook were observed (Fig. 1). Section seven also had very few fish. This was in contrast to previous years observations showing sections six, seven and eight holding the majority of adults. In 1996, as in previous years, most fish were observed in section six. Considerably more adult chinook were observed in sections two to five than the

preceding 12 year mean. This may be as a result of the lower water levels which in the past were artificially high during the summer. The water level may have had an influence on visibility and thus, on the number of adults observed. The numbers are not used in the escapement estimate, however, the sum total number of mature chinook observed during the month of October is often close to the derived estimate.

The populations were stratified for each river by sex. This avoids a known source of error. Petersen estimates for each river location and sex were calculated separately, to reduce the amount of error. The number of chinook returning to the Quinsam Hatchery in 1996 and in recent years was much greater than returns to the Quinsam or Campbell rivers. A greater number of females than males were recovered in the dead pitch effort for the Campbell River, whereas the number of males was greater than females in the Quinsam River and hatchery. In 1996, females predominated in the Campbell River, which has been observed since 1986.

AGE, LENGTH, AND SEX COMPOSITION

In 1996, female chinook escapements to the Campbell and Quinsam Rivers were mostly four and five years old. Male chinook escapements were mostly age three, four, then five. Bocking 1991; Frith, Nass, and Nelson 1993; Frith and Nelson 1994 and 1995, have observed similar age structure. The mean length of chinook in the three river locations continues to remain similar to returns of the past several years (Bocking 1991; Frith et al. 1993; Frith and Nelson 1995). The male/female sex ratio was 1.41 in the Quinsam River, 0.79 in the Campbell and 1.43 at the Quinsam Hatchery. In 1994, the male/female sex ratio was 1.33 for the Quinsam Hatchery, 1.1 for the Campbell, and 0.82 in the Quinsam (Frith and Nelson 1994). There does not appear to be a consistent pattern of sex ratios between each river location.

CODED-WIRE TAGGING AND RECOVERY

There were six recoveries in Quinsam Hatchery and one recovery in Quinsam River of adipose-clipped chinook jacks (1994 brood). There were also three recoveries in Quinsam Hatchery of 1995 brood adipose-clipped jacks. There was a single recovery of an adipose-clipped jack stray from a Washington state hatchery. In 1996, the rate of recovery was 1.1 % to 8.3 %.

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 19.4 % to 87.9 %. Similar ranges of hatchery contributions have been seen in the past; 24.2 % to 93.3 % in 1994 (Frith and Nelson 1995).

In the estimation of the escapement of CWTs, the attempt to consider as many potential sources of bias as possible was made, but the following factors were not included:
1) Low numbers of recoveries of decoded CWTs may reduce the precision of the estimates; and

2) The samples for the CWT decoding may not have been selected at random from the population, thus, may be biased.

In 1994, hatchery contributions to the male and female returns to the Quinsam hatchery and of Campbell River females, were high and similar (83% male,88 % female). There were greater differences in the hatchery contributions between the Quinsam River males, females, and Campbell River males. The range of these contributions was 42.8%, 19.4%, and 29.3%, respectively. The higher proportion of hatchery reared fish returning to the hatchery is similar to previous years observations (Bocking et al. 1990, Frith et al. 1993, Frith et al. 1995).

SUMMARY

1. The 1996 total escapement estimate of chinook salmon to the Campbell / Quinsam River system using carcass tag and recovery and hatchery returns was 3,062, with 95 % confidence limits of 2,824 to 3,431 adults. These estimates were stratified by river and sex.

2. The range of age of chinook returns to the Campbell River, Quinsam River, and the Quinsam Hatchery was from one to six years. All fish entered salt water in their first year of life. In the Campbell River, four-year old males and females dominated. In the Quinsam River, four-year old females and three-year old males dominated. Returns to the Quinsam Hatchery were dominated by five-year old females and four-year old males. In descending order, the dominant age groups were four, five, and three.

3. Based on the Petersen estimates and Quinsam Hatchery rack recoveries, female chinook salmon were more abundant than males in the Campbell River population, and less abundant in the Quinsam River population. In the returns to the Quinsam Hatchery females were more abundant than males.

4. The mean length of chinook salmon was greatest in the Campbell River and smallest in the returns to the Quinsam Hatchery. Females tended to be significantly larger than males.

5. The total number of actual CWT returns present in the escapement to the Campbell / Quinsam system was 202. The total estimated return of CWT chinook to the Campbell / Quinsam River system was 2,198 in 1996.

6. The total hatchery contribution to the chinook escapement, based on CWT returns was estimated at 1,843 (83.8 %) in 1996.

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Table 1. Summary of methods and materials for the 1996 chinook salmon enumeration of the Campbell and Quinsam Rivers.

Category	Methods and materials
Primary tagging of expired chinook adults	Operculum tags (cattle ear tag No. 3) applied in situ to dead chinook gathered from the rivers[3]
Secondary tagging	One or two holes were punched through the left operculum to distinguish recovered adults between each river of origin; two holes for the Campbell and one hole for the Quinsam
Biophysical sampling	Scale samples were taken and the Post-hypural orbital lengths and sex recorded to determine sex stratified population estimates for each river
Coded-wire tags (CWT)	At the hatchery and during tag and recovery efforts, CWT adults were sampled and their heads were removed for tag analysis
Recovery of chinook carcasses	Done by walking the rivers edge, by boat, SCUBA, and at the hatchery rack
Population estimate	Petersen estimate stratified by sex for each river combined with the hatchery numbers and those fish spawning above the hatchery fence

[3] Operculum tags supplied by Ketchum Manufacturing Sales Ltd. 396 Berkeley Ave., Ottawa, Ontario K2A 2G6

Table 2. Summary of the effort and the tag and recovery rates of chinook salmon carcasses on the Campbell and Quinsam Rivers in 1996.

	Tag Rate			Overall Tag rate	Recovery Rate			Overall Rec. rate
Campbell R.	Males	Females	Jacks		Males	Females	Jacks	
	53 / 121 43.8%	68 / 121 56.2%	0 / 121 0%	121 / 185 65.4%	29 / 66 46.5%	37 / 66 53.0%	0 / 66 0%	66 / 121 54%
Quinsam R.	57 / 99 57.6%	42 / 99 42.4%	0 / 99 0%	99 / 149 66.4%	17 / 99 17%	13 / 99 13%	0 / 99 0%	31 / 99 31.3%

Campbell R.	SCUBA effort	Total Recovery effort (hours)
Nov.01 96	90 min.	
Nov.05 96	50 min	
Nov.08 96	100 min	
Nov.12 96	110 min	
Nov.15 96	105 min	
Nov.19 96	83 min	
Nov.22 96	75 min	
Total	10.2 hrs.	305

Quinsam R. 198

Table 3. Summary of the 1996 swim surveys of the Campbell River.

Date	Flow (cfs)	Visibility	Weather	River Section[4] 1	2	3	4	5	6	7	8	Total
Aug.08	1250	excel	clear	0	5	12	6	5	30	6	0	64
Aug.21	1000	fair	partly clr		0	0	0	0	50	0	0	50
Aug.29	900	good	clear	0	30	20	5	0	400	20	0	475
Sept.06	900	good	rain	0	100	50	30	200	700	20	0	1100
Sept.12	900	excel	clear		100	120	250	200	750	10	0	1430
Sept.19	1000	excel	clear	50	80	70	120	130	400	20	0	870
Oct.03	4000	excel	rain	20	200	125	100	100	500	50	0	1095
Oct.07		good				3						3
Oct.11	4100	excel	clear	0	125	30	20	300	300	50		825
Oct.24		poor	rain	0	40	30	400	150	450	0	0	1070
Total				70	680	460	931	1085	3580	176	0	6982

[4] See Fig. 2

Table 4. Total numbers of adult chinook salmon observed in each section during swim surveys of the Campbell River from 1985 to 1996 and the 12 year mean.

	River Sections[5]								
Year	1	2	3	4	5	6	7	8	Total
1985	0	0	13	70	580	650	250	0	1563
1986	10	140	130	150	100	700	600	150	1980
1987	0	0	0	20	100	520	1000	500	2140
1988	0	0	500	360	305	1400	175	10	2750
1989	0	5	20	200	400	6000	3000	1000	10625
1990	0	80	20	70	400	2000	1300	800	4670
1991	0	0	0	0	250	3000	1000	1500	5750
1992	200	100	200	40	10	1200	700	500	2950
1993	0	0	50	200	10	600	300	1500	2660
1994	0	200	120	150	700	600	10	0	1780
1995	0	120	55	150	225	1050	250	0	1850
1996	20	200	125	100	100	500	50	0	1095
12 year Mean:	19	70	102	125	265	1518	719	496	3317

[5] See Fig. 1

Table 5. Summary of the 1996 Campbell and Quinsam rivers' in situ chinook carcass tag and recovery program.

Campbell River	Males	Females	Jacks	Total
Total carcasses counted	86	98	2	186
Carcasses examined	58	75	0	133
Carcasses opercular tagged and hole punched	53	69	0	122
Tag rate	61.6%	70.4%	0	65.6%
Primary tag carcass recoveries	28	35	0	63
Secondary mark recoveries (tags lost)	1	2	0	3
Total recoveries	29	37	0	66
Percent recovery	55%	54%	n/a	54%
Percent tag loss	1.9%	2.9%	n/a	2.5%

Quinsam River	Males	Females	Jacks	Total
Total carcasses counted	85	60	4	149
Carcasses examined	64	46	1	111
Carcasses opercular tagged and hole punched	57	42	0	99
Tag rate	67%	70%	0	67.3%
Primary tag carcass recoveries	17	13	0	30
Secondary mark recoveries (tags lost)	0	1	0	1
Total recoveries	17	14	0	31
Percent recovery	30%	33%	n/a	31%
Percent tag loss	0%	2.4%	n/a	1%

Table 6. Total 1996 chinook escapement based on Petersen mark and recapture estimates and the Quinsam Hatchery and spawner contribution above the hatchery.

Campbell River	Males	Females	Jacks	Total
Petersen estimate	157	183	n/a	340
Lower limit @ 95 % confidence	130	145	n/a	275
Upper limit @ 95 % confidence	210	245	n/a	455

Quinsam River	Males	Females	Jacks	Total
Petersen estimate	285	180	13	478
Lower limit @ 95 % confidence	195	97	n/a	292
Upper limit @ 95 % confidence	454	265	n/a	719

Quinsam Hatchery	Males	Females	Jacks	Total
Broodstock	597	749	1	1347
Spawners above hatchery fence	271	8	46	325
Transfers (to Elk Falls channel)	96	100	0	196
Mortalities and fish used for other purposes	316	6	54	376
Total	1280	863	101	2244

Grand Total	1722	1226	114	3062
Lower estimate (P<0.05)	1605	1105	114	2824
Upper estimate (P<0.05)	1944	1373	114	3431

Table 7. Age composition of Campbell River chinook salmon returns in 1996.

Males	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	Upper
Age								
3	15	3	18	30.5	662	89.6	620	703
4	26	1	27	45.8	789	48.1	771	807
5	11	0	11	18.6	864	68	824	904
6	1	0	1	1.7	850			
Unkn age	2	0	2	3.4	843	3.5	837	848
Total aged	53	4	57	96.6	765	100.5	738	791
Total	55	4	59	100	767	99.7	741	792

Females	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	Upper
Age								
4	36	1	37	49.3	794	47.2	779	809
5	28	4	32	42.7	832	37.3	818	845
6	4	0	4	5.3	857	54.2	804	911
Unkn age	1	1	2	2.7	763	3.5	757	768
Total aged	68	5	73	97.3	814	47.8	802	824
Total	69	6	75	100	813	47.9	801	824

Table 8. Age composition of Quinsam River chinook salmon returns in 1996.

Males	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	95 % C.L. Upper
Age								
2	0	1	1	1.5	400			
3	31	2	33	50.8	595	48.5	578	612
4	25	1	26	40	760	79.8	729	792
5	4	0	4	6.2	829	47.8	781	877
Unknown age	1	0	1	1.5	545			
Total aged	60	4	64	98.5	674	113.7	645	702
Total	61	4	65	100	672	113.9	643	700

Females	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	95 % C.L. Upper
Age								
3	1	0	1	2.2	660			
4	27	1	28	60.9	757	51.3	737	777
5	16	0	16	34.7	809	44	787	831
Unknown age	1	0	1	2.2	585			
Total aged	44	1	45	97.8	773	56	757	790
Total	45	1	46	100	769	61.9	751	787

Table 9. Age composition of Quinsam hatchery chinook salmon in 1996.

Males	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	Upper
Age								
1	22	3	25	8.9	187	20.2	179	195
2	19	7	26	9.2	410	38.5	395	425
3	23	86	109	38.6	604	50.1	595	613
4	56	32	88	31.2	744	47.5	734	754
5	20	7	27	9.6	793	50.7	774	812
Unknown age	2	5	7	2.5	594	119.5	505	683
Total aged	140	135	275	98.47	611	176.9	590	633
Total	142	140	282	100	611	175.6	590	632

Females	Unmarked	CWT	Total (N)	Percent	Mean Length (mm)	SD	95 % C.L. Lower	Upper
Age								
3	5	1	6	3	685	79.3	621	748
4	65	23	88	44.7	766	45.9	757	776
5	77	20	97	49.2	802	45	793	811
6	1	0	1	0.5	887			
Unknown age	2	3	5	2.5	787	47.6	744	828
Total aged	148	44	192	97.46	782	52.6	774	790
Total	150	47	197	100	782	53	774	790

Table 10. Age-length distribution of the chinook salmon escapement to the Campbell River in 1996.

	Males Age							Females Age						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
Length (mm)														
500-549	0	0	2	0	0	0	2	0	0	0	0	0	0	0
550-599	0	0	2	0	0	0	2	0	0	0	0	0	0	0
600-649	0	0	3	0	0	0	3	0	0	0	0	0	0	0
650-699	0	0	2	1	0	0	3	0	0	0	0	0	0	0
700-749	0	0	2	4	1	0	7	0	0	0	5	0	0	5
750-799	0	0	3	10	1	0	14	0	0	0	16	4	0	22
800-849	0	0	1	7	1	0	11	0	0	0	9	12	2	23
850-899	0	0	0	4	4	1	9	0	0	0	5	12	1	18
900-949	0	0	0	0	3	0	3	0	0	0	1	0	1	2
950-999	0	0	0	0	1	0	1	0	0	0	0	0	0	0
N	0	0	15	26	11	1	55	0	0	0	36	28	4	70
Mean	0	0	668	789	864	850	772	0	0	0	794	832	858	814
SD	0	0	97	49	68	n/a	99	0	0	0	48	36	54	48

Table 11. Age-length distribution of the chinook salmon escapement to the Quinsam River in 1996.

	Males Age							Females Age						
	1	2	3	4	5	6	Total	1	2	3	4	5	6	Total
Length (mm)														
500-549	0	0	0	0	0	0	0	0	0	0	0	0	0	0
550-599	0	0	5	0	0	0	6	0	0	0	0	0	0	0
600-649	0	0	8	0	0	0	8	0	0	0	1	0	0	2
650-699	0	0	16	3	0	0	19	0	0	0	0	0	0	0
700-749	0	0	1	1	0	0	2	0	0	1	0	0	0	1
750-799	0	0	1	6	0	0	7	0	0	0	10	3	0	13
800-849	0	0	0	6	2	0	8	0	0	0	9	2	0	11
850-899	0	0	0	7	0	0	7	0	0	0	7	9	0	16
	0	0	0	2	2	0	4	0	0	0	0	2	0	2
N														
Mean	0	0	31	25	4	0	61	0	0	1	27	16	0	45
SD	0	0	593	756	829	0	677	0	0	660	758	809	0	774
	0	0	47	78	48	0	108	0	0	n/a	51	44	0	56

Table 12. Age-length distribution of the chinook salmon escapement to the Quinsam Hatchery in 1996.

Length (mm)	Males Age 1	2	3	4	5	6	Total	Females Age 1	2	3	4	5	6	Total
150-199	16	0	0	0	0	0	16	0	0	0	0	0	0	0
200-249	6	0	0	0	0	0	6	0	0	0	0	0	0	0
250-299	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350-399	0	5	0	0	0	0	5	0	0	0	0	0	0	0
400-449	0	11	0	0	0	0	12	0	0	0	0	0	0	0
450-499	0	3	0	0	0	0	3	0	0	0	0	0	0	0
500-549	0	0	0	0	0	0	1	0	0	0	0	0	0	0
550-599	0	0	3	0	0	0	5	0	0	0	0	0	0	0
600-649	0	0	10	3	0	0	14	0	0	2	2	0	0	4
650-699	0	0	7	6	1	0	15	0	0	2	3	2	0	7
700-749	0	0	0	18	3	0	21	0	0	1	14	7	0	23
750-799	0	0	0	21	8	0	30	0	0	0	33	26	0	61
800-849	0	0	0	7	5	0	12	0	0	0	12	32	0	46
850-899	0	0	0	1	3	0	4	0	0	0	0	10	1	11
900-949	0	0	0	0	0	0	0	0	0	0	1	0	0	1
N	22	19	20	56	20	0	144	0	0	5	65	77	1	153
Mean	188	419	622	748	790	0	601	0	0	655	769	802	887	783
SD	21	30	41	49	49	0	217	0	0	33	45	42	n/a	52

Table 13. Petersen estimates, by age, of chinook salmon escapement to the Campbell River, Quinsam River and Quinsam Hatchery, 1996.

Location	Age	Males		Females	
		Number (a)	Percent (b)	Number (a)	Percent (b)
Campbell River					
	3	48	30.5	0	0
	4	72	45.8	90	49.3
	5	29	18.6	78	42.7
	6	3	1.7	10	5.3
	unkn age	5	3.4	5	2.7
	Total	157 (c)	100.0	183 (c)	100
Quinsam River					
	2	4	1.5	0	0
	3	145	50.8	4	2.2
	4	114	40	110	60.9
	5	18	6.2	62	34.7
	unkn age	4	1.5	4	2.2
	Total	285 (c)	100.0	180 (c)	100
Quinsam Hatchery					
	1	114	8.9	0	0
	2	118	9.2	0	0
	3	494	38.6	26	3
	4	399	31.2	386	44.7
	5	123	9.6	425	49.3
	6	32	0	4	0.5
	unkn age		2.5	22	2.5
	Total	1280 (c)	100.0	863 (c)	100

(a) The number of fish by age are calculated from the product of the percent age (b) and the total adult escapement (c).

(b) The percentage age distribution is from tables 7, 8, and 9.

(c) The Petersen estimates and Quinsam Hatchery recoveries are from Table 6.

Table 14. CWT age and length summary of the 1996 chinook salmon escapement to the Campbell River, Quinsam River and Quinsam hatchery.

	Campbell River Deadpitch		Elk Falls Channel		Quinsam River Deadpitch		Quinsam Rack		Combined total		Percent by age
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females	
Age 1	0	0	0	0	0	0	3	0	3	0	2%
Mean Length							182		182		
Age 2	0	0	0	0	1	0	6	0	7	0	4%
Mean Length					400		401		401		
Age 3	3	0	0	0	2	0	86	1	91	1	47%
Mean Length	633				618		599	835	601	835	
Age 4	1	1	0	2	1	1	32	23	34	27	31%
Mean Length	790	780		730	880	740	737	760	743	758	
Age 5	0	4	0	2	0	0	7	18	7	24	16%
Mean Length		829		813			800	795	800	802	
Age 6	0	0	0	0	0	0	0	0	0	0	0%
Total	4	5	0	4	4	1	134	42	142	52	194
Relative % sex stratified	2%	3%	0%	2%	2%	0.50%	69%	22%	73%	27%	100%

Table 15. Combined age-length summary of the 1996 chinook salmon escapement to the Campbell River, Quinsam River, and the Quinsam Hatchery.

	Campbell River Deadpitch		Quinsam River Deadpitch		Quinsam Hatchery Rack		Combined totals		Percent by age
	Males	Females	Males	Females	Males	Females	Males	Females	
Age 1	0	0	0	0	22	0	22	0	4%
Mean Length					188		188		
Age 2	0	0	0	0	19	0	19	0	4%
Mean Length					419		419		
Age 3	15	0	31	1	23	5	69	6	15%
Mean Length	670		590	660	622	655	618	656	
Age 4	26	36	25	27	56	65	107	128	46%
Mean Length	790	790	760	760	748	769	761	773	
Age 5	11	28	4	16	20	77	35	121	30%
Mean Length	860	830	830	810	790	802	817	810	
Age 6	1	4	0	0	0	1	1	5	1%
Mean Length	850	860				887	850	865	
Total	53	68	60	44	140	148	253	260	513
Relative % sex stratified	10%	13%	12%	9%	27%	29%	49%	51%	100%

Table 16. CWT release data for hatchery-reared chinook salmon returning to the Campbell River, Quinsam River and Quinsam Hatchery, by tag code, 1996.

Brood year	CWT code	Release numbers		CWT loss (%)	Days held	Adipose release status		Total
		CWT	Untagged			Clipped	Unclipped	
1995	181659	26,314	209,905	0.28	37	26,388	209,831	236,219
	182016	25,134	105,345	1.6	50	25,543	104,936	130,479
	182018	24,640	109,730	3.7	53	25,587	108,783	134,370
Subtotal		76,089	424,979			77,518	423,550	501,068
1994	181644	24,354	86,397	4.6	34	25,528	85,223	110,751
	181645	25,271	80,955	2.6	32	25,946	80,280	106,226
	181646	26,312	193,176	0.6	29	26,471	193,017	219,488
	181647	26,311	189,246	0.6	25	26,470	189,087	215,557
	181650	26,212	126,547	0.7	28	26,397	126,362	152,759
Subtotal		128,461	676,320			130,812	673,969	804,781
1993	180628	25,210	205,895	0.6	9	25,362	205,743	231,105
	180629	26,472	116,128	0.6	15	26,632	115,968	142,600
	180630	26,269	262,938	0.2	13	26,322	262,885	289,207
	180631	26,719	259,036	0.0	12	26,719	259,036	285,755
	181356	25,942	63,986	1.0	19	26,204	63,724	89,928
	181357	25,617	78,888	2.0	16	26,140	78,365	104,505
	181358	26,255	82,043	1.2	14	26,574	81,724	108,298
	181359	25,122	174,634	0.1	10	25,147	174,609	199,756
	181360	25,554	180,403	0.3	9	25,631	180,326	205,957
	181361	26,063	177,057	0.2	11	26,115	177,005	203,120
	181362	26,317	188,163	0.2	10	26,370	188,110	214,480
Subtotal		285,541	1,789,170			287,216	1,787,495	2074711

Table 17. Estimates of the adjusted number of CWT chinook salmon the the Campbell River, Quinsam River and Quinsam Hatchery, by tag code, 1996[6].

		Campbell River				Quinsam River				Quinsam Hatchery				Total			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
Brood year	CWT code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1995	181659	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	182016	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	182018	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	Subtotal	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.0	0.0	3	0	3.0	0.
1994	181644	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	181645	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	181646	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	181647	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.0	0.0	3	0	3.0	0.
	181650	0	0	0.0	0.0	1	0	1.0	0.0	0	0	0.0	0.0	1	0	1.0	0.
	Subtotal	0	0	0.0	0.0	1	0	1.0	0.0	6	0	6.0	0.0	7	0	7.0	0.
1993	180628	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.0	0.0	3	0	3.0	0.
	180629	0	0	0.0	0.0	0	0	0.0	0.0	12	0	12.1	0.0	12	0	12.1	0.
	180630	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.0	0.0	4	0	4.0	0.
	180631	0	0	0.0	0.0	0	0	0.0	0.0	4	0	4.0	0.0	4	0	4.0	0.
	181356	2	0	2.0	0.0	1	0	1.0	0.0	23	0	23.2	0.0	26	0	26.2	0.
	181357	0	0	0.0	0.0	0	0	0.0	0.0	8	1	8.1	1.0	8	1	8.1	1.
	181358	0	0	0.0	0.0	0	0	0.0	0.0	11	0	11.1	0.0	11	0	11.1	0.
	181359	0	0	0.0	0.0	0	0	0.0	0.0	3	0	3.0	0.0	3	0	3.0	0.
	181360	0	0	0.0	0.0	1	0	1.0	0.0	4	0	4.0	0.0	5	0	5.0	0.
	181361	0	0	0.0	0.0	0	0	0.0	0.0	11	0	11.1	0.0	11	0	11.1	0.
	181362	1	0	1.0	0.0	0	0	0.0	0.0	4	0	4.0	0.0	5	0	5.0	0.
	Subtotal	3	0	3.0	0.0	2	0	2.0	0.0	87	1	87.7	1.0	92	1	92.7	1.

[6] One decimal place is carried for the adjusted CWT's for calculating the expanded hatchery contribution.

Table 17 (cont.)

Brood year	CWT code	Campbell River				Quinsam River				Quinsam Hatchery				Total			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
		M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1992	181147	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.
	181149	0	0	0.0	0.0	0	0	0.0	0.0	2	3	2.0	3.0	2	3	2.0	3.
	181150	0	1	0.0	1.0	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.
	181151	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.
	181152	0	0	0.0	0.0	0	1	0.0	1.0	1	0	1.0	0.0	1	1	1.0	1.
	181153	0	0	0.0	0.0	0	0	0.0	0.0	1	2	1.0	2.0	1	2	1.0	2.
	181154	0	0	0.0	0.0	0	0	0.0	0.0	8	2	8.1	2.0	8	2	8.1	2.
	181155	1	0	1.0	0.0	0	0	0.0	0.0	4	4	4.0	4.0	5	4	5.0	4.
	181156	0	0	0.0	0.0	1	0	1.0	0.0	6	6	6.1	6.0	7	6	7.1	6.
	181157	0	0	0.0	0.0	0	0	0.0	0.0	4	2	4.0	2.0	4	2	4.0	2.
	181158	0	0	0.0	0.0	0	0	0.0	0.0	6	4	6.1	4.0	6	4	6.1	4.
	180209	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.
	Subtotal	1	1	1.0	1.0	1	1	1.0	1.0	32	26	32.26	26.00	34	28	34.26	28.0
1991	21328	0	0	0.0	0.0	0	0	0.0	0.0	0	4	0.0	4.0	0	4	0.0	4.
	21329	0	0	0.0	0.0	0	0	0.0	0.0	1	3	1.0	3.0	1	3	1.0	3.
	21331	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.
	180415	0	0	0.0	0.0	0	0	0.0	0.0	1	0	1.0	0.0	1	0	1.0	0.
	180416	0	1	0.0	1.0	0	1	0.0	1.0	2	3	2.0	3.0	2	5	2.0	5.
	180417	0	0	0.0	0.0	0	0	0.0	0.0	0	2	0.0	2.0	0	2	0.0	2.
	180418	0	0	0.0	0.0	0	0	0.0	0.0	1	4	1.0	4.0	1	4	1.0	4.
	180419	0	0	0.0	0.0	0	0	0.0	0.0	0	1	0.0	1.0	0	1	0.0	1.
	180420	0	2	0.0	2.0	0	2	0.0	2.0	0	1	0.0	1.0	0	5	0.0	5.
	180421	0	0	0.0	0.0	0	0	0.0	0.0	1	1	1.0	1.0	1	1	1.0	1.
	180422	0	1	0.0	1.0	0	1	0.0	1.0	1	0	1.0	0.0	1	2	1.0	2.
	Subtotal	0	4	0.0	4.0	0	4	0.0	4.0	7	20	7.1	20.0	7	28	7.1	28.
Total hatchery		4	5	4	5	4	5	4	5	135	47	136	47	143	57	144	5
Strays *635338		0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.0	0	0	0.0	0.
Total CWT		4	5	4	5	4	5	4	5	135	47	136	47	143	57	144	5
No data		0	0			0	0			0	0			0	0		
No pin		0	0			0	0			6	3			6	3		
Lost pin		0	0			0	0			1	0			1	0		
Observed adipose		4	5			4	5			142	50			150	60		

Table 18. Estimates of the total escapement of CWT chinook salmon to the Campbell River, Quinsam River and Quinsam Hatchery, by tag code, 1996[7].

		Campbell River				Quinsam River				Quinsam hatchery				Total			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood Year	CWT Code	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
1995	181659	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.5	0.0	1.0	0.0	0.5	0.0
	182016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.5	0.0	1.0	0.0	0.5	0.0
	182018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.5	0.0	1.0	0.0	0.5	0.0
	Subtotal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.4	0.0	3.0	0.0	1.4	0.0
1994	181644	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0
	181645	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0
	181646	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0
	181647	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	1.4	0.0	1.4	0.0	1.4	0.0
	181650	0.0	0.0	0.0	0.0	1.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.3	0.0
	Subtotal	0.0	0.0	0.0	0.0	1.0	0.0	3.3	0.0	2.8	0.0	2.8	0.0	3.8	0.0	6.0	0.0
1993	180628	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.2	0.0	3.0	0.0	3.2	0.0
	180629	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	0.0	12.8	0.0	12.1	0.0	12.8	0.0
	180630	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.3	0.0	4.0	0.0	4.3	0.0
	180631	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.3	0.0	4.0	0.0	4.3	0.0
	181356	2.0	0.0	3.7	0.0	1.0	0.0	3.4	0.0	23.2	0.0	24.5	0.0	26.2	0.0	31.5	0.0
	181357	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	1.0	8.5	1.1	8.1	1.0	8.5	1.1
	181358	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	11.7	0.0	11.1	0.0	11.7	0.0
	181359	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.2	0.0	3.0	0.0	3.2	0.0
	181360	0.0	0.0	0.0	0.0	1.0	0.0	3.4	0.0	4.0	0.0	4.3	0.0	5.0	0.0	7.6	0.0
	181361	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	11.7	0.0	11.1	0.0	11.7	0.0
	181362	1.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.3	0.0	5.0	0.0	6.1	0.0
	Subtotal	3.0	0.0	5.5	0.0	2.0	0.0	6.7	0.0	87.7	1.0	92.7	1.1	92.7	1.0	104.9	1.1

[7] One decimal place is carried for the estimated CWT's for calculating the expanded hatchery contribution.

Table 18 (cont.)

Brood Year	CWT Code	Campbell River Adjusted CWTs M	Campbell River Adjusted CWTs F	Campbell River Estimated CWTs M	Campbell River Estimated CWTs F	Quinsam River Adjusted CWTs M	Quinsam River Adjusted CWTs F	Quinsam River Estimated CWTs M	Quinsam River Estimated CWTs F	Quinsam hatchery Adjusted CWTs M	Quinsam hatchery Adjusted CWTs F	Quinsam hatchery Estimated CWTs M	Quinsam hatchery Estimated CWTs F	Total Adjusted CWTs M	Total Adjusted CWTs F	Total Estimated CWTs M	Total Estimated CWTs F
1992	181147	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	0.0	1.1
	181149	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	3.0	2.1	3.2	2.0	3.0	2.1	3.2
	181150	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.9
	181151	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	0.0	1.1
	181152	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.0	1.0	0.0	1.1	0.0	1.0	1.0	1.1	3.0
	181153	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	1.1	2.2	1.0	2.0	1.1	2.2
	181154	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	2.0	8.5	2.2	8.1	2.0	8.5	2.2
	181155	1.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	4.0	4.0	4.3	4.3	5.0	4.0	6.1	4.3
	181156	0.0	0.0	0.0	0.0	1.0	0.0	3.4	0.0	6.1	6.0	6.4	6.5	7.1	6.0	9.8	6.5
	181157	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	2.0	4.3	2.2	4.0	2.0	4.3	2.2
	181158	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	4.0	6.4	4.3	6.1	4.0	6.4	4.3
	180209	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
	Subtotal	1.0	1.0	1.8	1.9	1.0	1.0	3.4	3.0	32.3	26.0	34.1	27.9	34.3	28.0	39.3	32.8
1991	21328	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.3	0.0	4.0	0.0	4.3
	21329	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	1.1	3.2	1.0	3.0	1.1	3.2
	21331	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	0.0	1.1
	180415	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	0.0	1.1	0.0
	180416	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	2.0	3.0	2.1	3.2	2.0	4.0	2.1	5.1
	180417	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.2	0.0	2.0	0.0	2.2
	180418	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	1.1	4.3	1.0	4.0	1.1	4.3
	180419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	0.0	1.1
	180420	0.0	2.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	3.0	0.0	4.8
	180421	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.1	1.1	1.0	1.0	1.1	1.1
	180422	0.0	1.0	0.0	1.9	0.0	0.0	0.0	0.0	1.0	0.0	1.1	0.0	1.0	1.0	1.1	1.9
	Subtotal	0.0	4.0	0.0	7.5	0.0	0.0	0.0	0.0	7.1	20.0	7.5	21.6	7.1	24.0	7.5	29.0
Strays	*635338	(*Wash. state stray)															
Petersen est.		157	183			285	180			1280	863						
Sample size		59	75			65	46			1280	863						

Table 19. Estimates of total escapement of hatchery-reared CWT chinook salmon to the Campbell River, Quinsam River and Quinsam Hatchery, by tag code, 1996[8].

Brood year	CWT release group	Release Numbers CWT	Release Numbers Untagged	Expansion factor	Expanded hatchery contributions: Campbell River M	Campbell River F	Quinsam River M	Quinsam River F	Quinsam Hatchery M	Quinsam Hatchery F	Total M	Total F
1995	181659	26,314	209,905	9.0	0.0	0.0	0.0	0.0	4.1	0.0	4.1	0.0
	182016	25,134	105,345	5.2	0.0	0.0	0.0	0.0	2.4	0.0	2.4	0.0
	182018	24,640	109,730	5.5	0.0	0.0	0.0	0.0	2.5	0.0	2.5	0.0
	Subtotal	76,089	424,979		0.0	0.0	0.0	0.0	9.1	0.0	9.1	0.0
1994	181644	24,354	86,397	4.5	0.0	0.0	0.0	0.0	2.1	0.0	2.1	0.0
	181645	25,271	80,955	4.2	0.0	0.0	0.0	0.0	1.9	0.0	1.9	0.0
	181646	26,312	193,176	8.3	0.0	0.0	0.0	0.0	3.8	0.0	3.8	0.0
	181647	26,311	189,246	8.2	0.0	0.0	0.0	0.0	11.2	0.0	11.2	0.0
	181650	26,212	126,547	5.8	0.0	0.0	18.9	0.0	0.0	0.0	18.9	0.0
	Subtotal	128,461	676,320		0.0	0.0	18.9	0.0	19.1	0.0	37.9	0.0
1993	180628	25,210	205,895	9.2	0.0	0.0	0.0	0.0	29.4	0.0	29.4	0.0
	180629	26,472	116,128	5.4	0.0	0.0	0.0	0.0	69.1	0.0	69.1	0.0
	180630	26,269	262,938	11.0	0.0	0.0	0.0	0.0	46.9	0.0	46.9	0.0
	180631	26,719	259,036	10.7	0.0	0.0	0.0	0.0	45.6	0.0	45.6	0.0
	181356	25,942	63,986	3.5	12.8	0	11.7	0.0	85.8	0.0	110.3	0.0
	181357	25,617	78,888	4.1	0.0	0.0	0.0	0.0	35.0	4.4	35.0	4.4
	181358	26,255	82,043	4.1	0.0	0.0	0.0	0.0	48.1	0.0	48.1	0.0
	181359	25,122	174,634	8.0	0.0	0.0	0.0	0.0	25.6	0.0	25.6	0.0
	181360	25,554	180,403	8.1	0.0	0.0	27.1	0.0	34.5	0.0	61.6	0.0
	181361	26,063	177,057	7.8	0.0	0.0	0.0	0.0	91.5	0.0	91.5	0.0
	181362	26,317	188,163	8.1	14.8	0.0	0.0	0.0	34.5	0.0	49.3	0.0
	Subtotal	285,541	1,789,170		27.6	0.0	38.9	0.0	545.9	4.4	612.4	4.4

[8] The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 18) to account for unmarked hatchery releases and hence, derive hatchery contributions to escapement. Expansion factor = (CWT releases + untagged releases)/Cwt releases.

Table 19 (cont.)

Brood year	CWT release group	Release Numbers CWT	Release Numbers Untagged	Expansion factor	Expanded hatchery contributions: Campbell River M	Campbell River F	Quinsam River M	Quinsam River F	Quinsam Hatchery M	Quinsam Hatchery F	Total M	Total F
1992	181147	24,825	226,001	10.1	0.0	0.0	0.0	0.0	0.0	10.9	0.0	10.9
	181149	24,031	407,782	18.0	0.0	0.0	0.0	0.0	38.3	58.1	38.3	58.1
	181150	24,558	470,483	20.2	0.0	37.8	0.0	0.0	0.0	0.0	0.0	37.8
	181151	24,311	465,735	20.2	0.0	0.0	0.0	0.0	0.0	21.8	0.0	21.8
	181152	24,658	264,874	11.7	0.0	0.0	0.0	35.1	12.5	0.0	12.5	35.1
	181153	23,790	264,651	12.1	0.0	0.0	0.0	0.0	12.9	26.0	12.9	26.0
	181154	22,315	244,147	11.9	0.0	0.0	0.0	0.0	101.5	25.6	101.5	25.6
	181155	22,965	199,973	9.7	17.8	0.0	0.0	0.0	41.3	41.8	59.1	41.8
	181156	23,186	421,976	19.2	0.0	0.0	64.3	0.0	122.9	124.0	187.2	124.0
	181157	22,944	191,327	9.3	0.0	0.0	0.0	0.0	39.6	20.0	39.6	20.0
	181158	21,652	196,552	10.1	0.0	0.0	0.0	0.0	64.6	43.5	64.6	43.5
	180209	24,770	74,204	4.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	4.0
	Subtotal	284,005	3,427,705		17.8	37.8	64.3	35.1	433.8	375.8	515.8	448.7
1991	21328	24,646	291,480	12.8	0.0	0.0	0.0	0.0	0.0	55.2	0.0	55.2
	21329	24,538	599,112	25.4	0.0	0.0	0.0	0.0	27.2	82.0	27.2	82.0
	21331	24,249	527,084	22.7	0.0	0.0	0.0	0.0	0.0	24.5	0.0	24.5
	180415	24,405	529,772	22.7	0.0	0.0	0.0	0.0	24.3	0.0	24.3	0.0
	180416	22,897	304,168	14.3	0.0	26.7	0.0	0.0	30.5	46.2	30.5	72.9
	180417	24,692	318,131	13.9	0.0	0.0	0.0	0.0	0.0	29.9	0.0	29.9
	180418	24,541	313,730	13.8	0.0	0.0	0.0	0.0	14.8	59.5	14.8	59.5
	180419	24,338	186,113	8.6	0.0	0.0	0.0	0.0	0.0	9.3	0.0	9.3
	180420	24,752	435,766	18.6	0.0	69.4	0.0	0.0	0.0	20.1	0.0	89.5
	180421	22,477	197,647	9.8	0.0	0.0	0.0	0.0	10.5	10.6	10.5	10.6
	180422	24,761	226,229	10.1	0.0	18.9	0.0	0.0	10.8	0.0	10.8	18.9
	Subtotal	266,297	3,929,231		0.0	115.0	0.0	0.0	118.0	337.2	118.0	452.2
Total hatchery		1,040,392	10,247,406		45	153	122	35	1,126	717	1,293	905

Strays *635338 (*Wash. state stray)

Table 20. Estimated hatchery and stray contributions to Campbell River, Quinsam River and Quinsam Hatchery chinook salmon escapement, 1996.

				Hatchery contribution (b)				Stray contribution (b)		
		Estimated escapement (a)		Male(c)		Female		Male(c)		Femal
Location	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number
Campbell River										
	3	48	0	28	58.3	0	0.0	0	0.0	0
	4	72	90	18	25.0	38	42.2	0	0.0	0
	5	29	78	0	0.0	115	100(d)	0	0.0	0
	6	3	10	0	0.0	0	0.0	0	0.0	0
	unkn	5	5	0	0.0	0	0.0	0	0.0	0
Total		157	183	46	29.3	153	83.6	0	0.0	0
Quinsam River										
	2	2	0	19	100(d)	0	0.0	0	0.0	0
	3	145	4	39	26.9	0	0.0	0	0.0	0
	4	114	110	64	56.1	35	31.8	0	0.0	0
	5	18	62	0	0.0	0	0.0	0	0.0	0
	6	0	0	0	0.0	0	0.0	0	0.0	0
	unkn	4	4	0	0.0	0	0.0	0	0.0	0
Total		285	180	122	42.8	35	19.4	0	0.0	0
Quinsam Hatchery										
	1	114	0	9	7.9	0	0.0	0	0.0	0
	2	118	0	19	16.1	0	0.0	0	0.0	0
	3	494	26	546	100(d)	4	15.4	0	0.0	0
	4	399	386	434	100(d)	376	97.4	0	0.0	0
	5	123	425	118	95.9	337	79.3	0	0.0	0
	6	32	4	0	0.0	0	0.0	0	0.0	0
	unkn	0	22	0	0.0	0	0.0	0	0.0	0
Total		1280	863	1126	87.9	717	83.1	0	0.0	0

(a) From Table 11
(b) From Table 19
(c) Includes jacks
(d) Estimated hatchery contribution greater than 100 %.

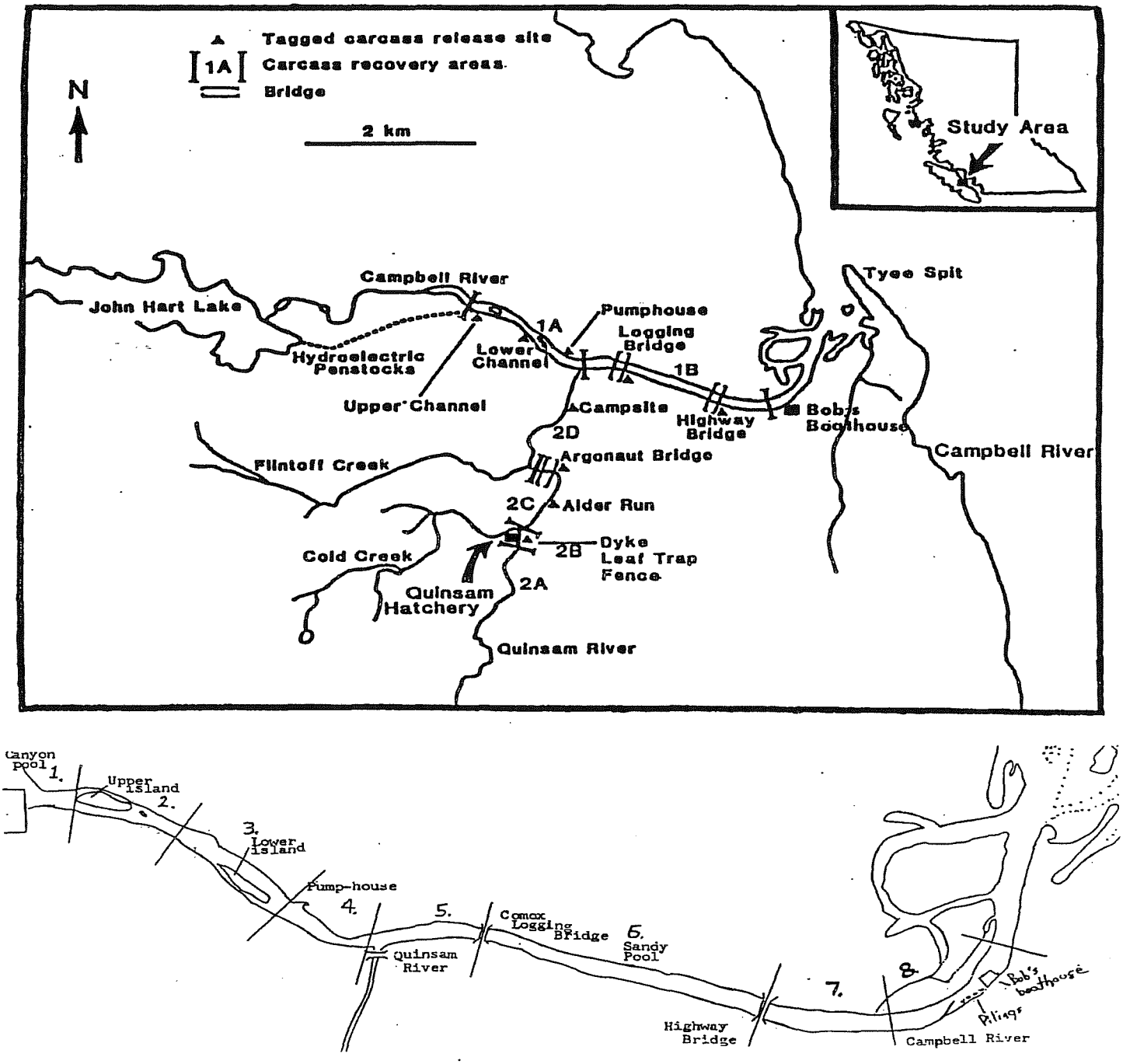

Fig. 1. Study areas (top) and swim survey sections (bottom) of the 1996 Campbell River and Quinsam River chinook enumeration project.

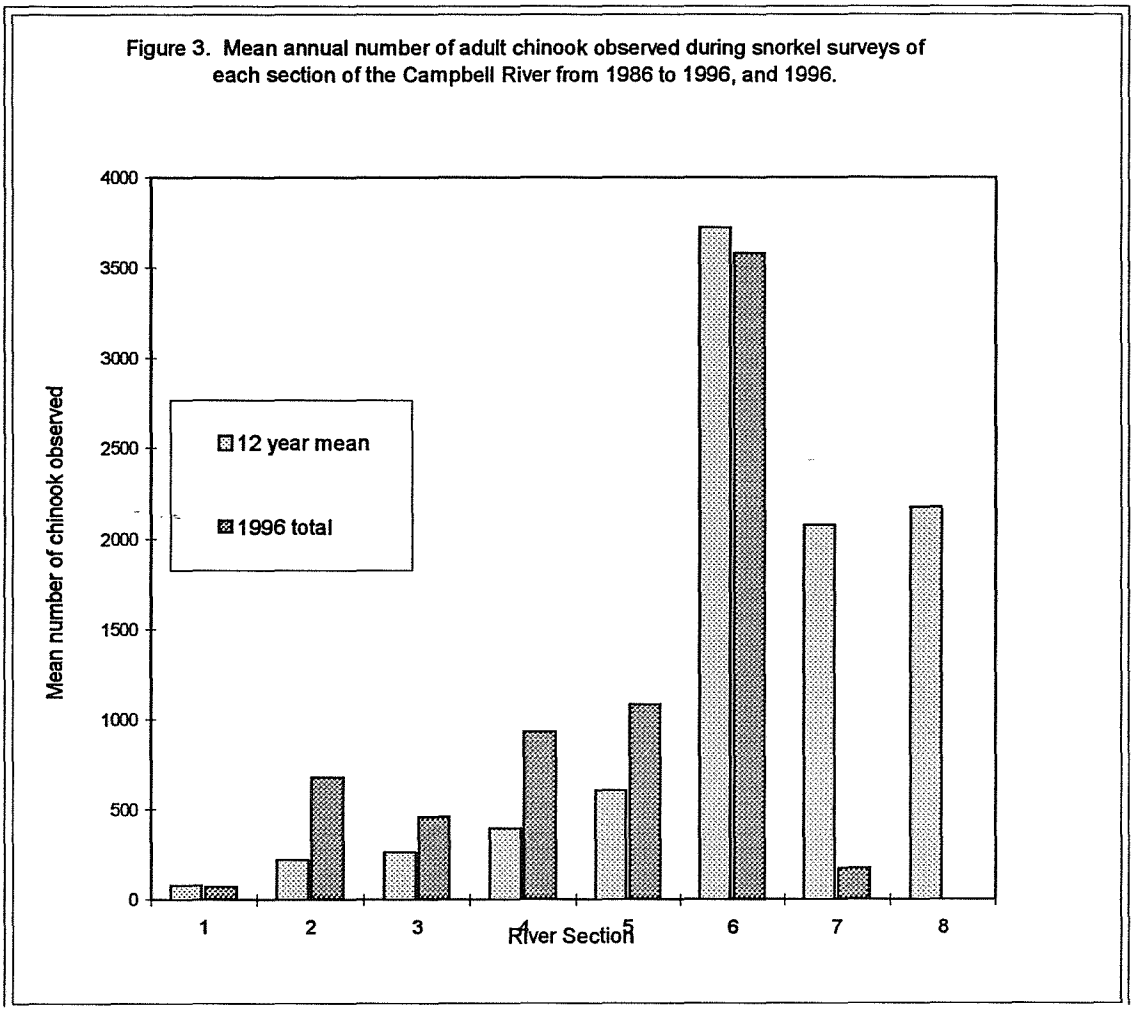

Fig. 2 Mean annual number of adult chinook observed in each section of the Campbell River from 1985 to 1996.

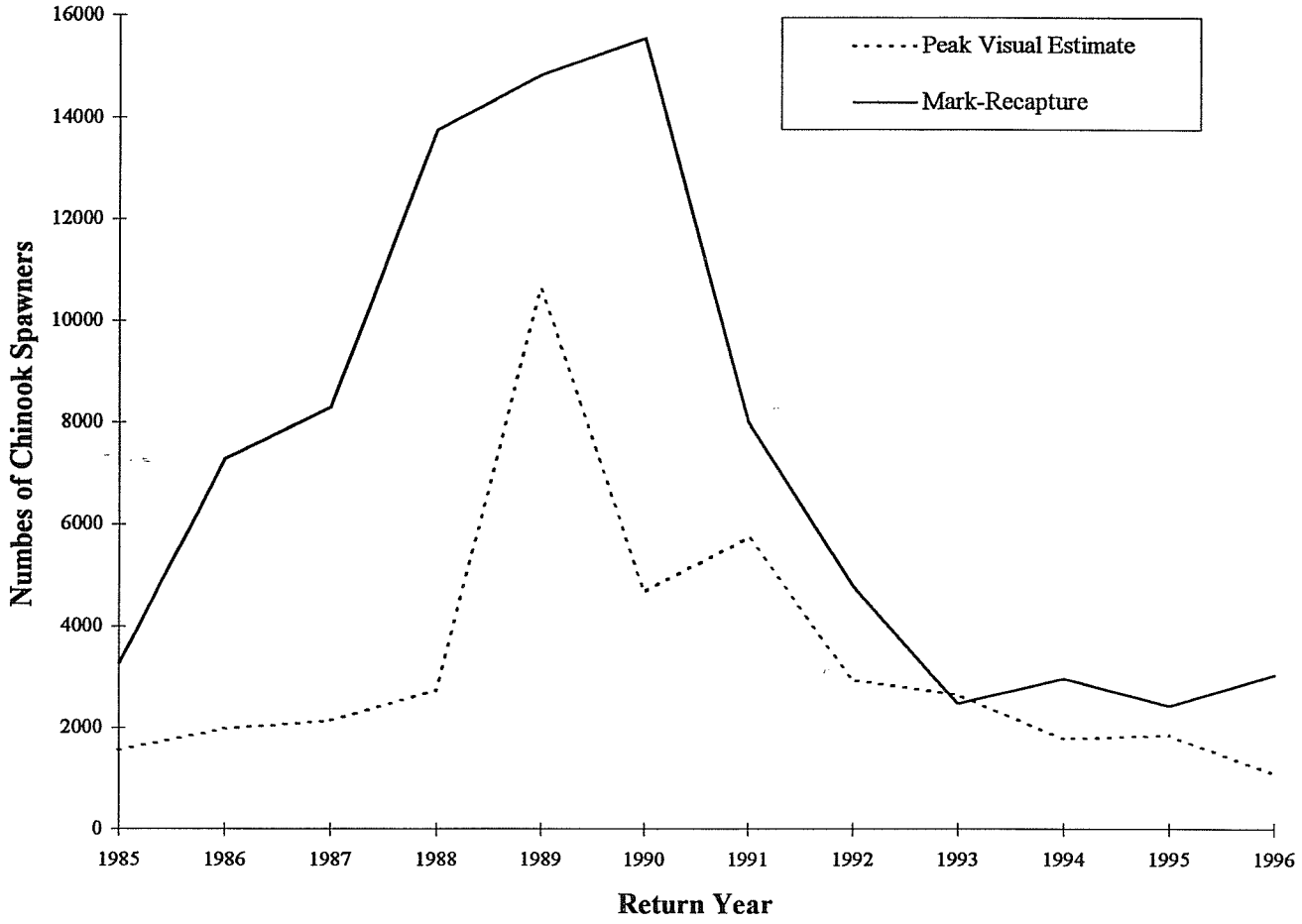

Fig. 3 Chinook salmon escapement estimates to the Campbell River from 1985 to 1996.

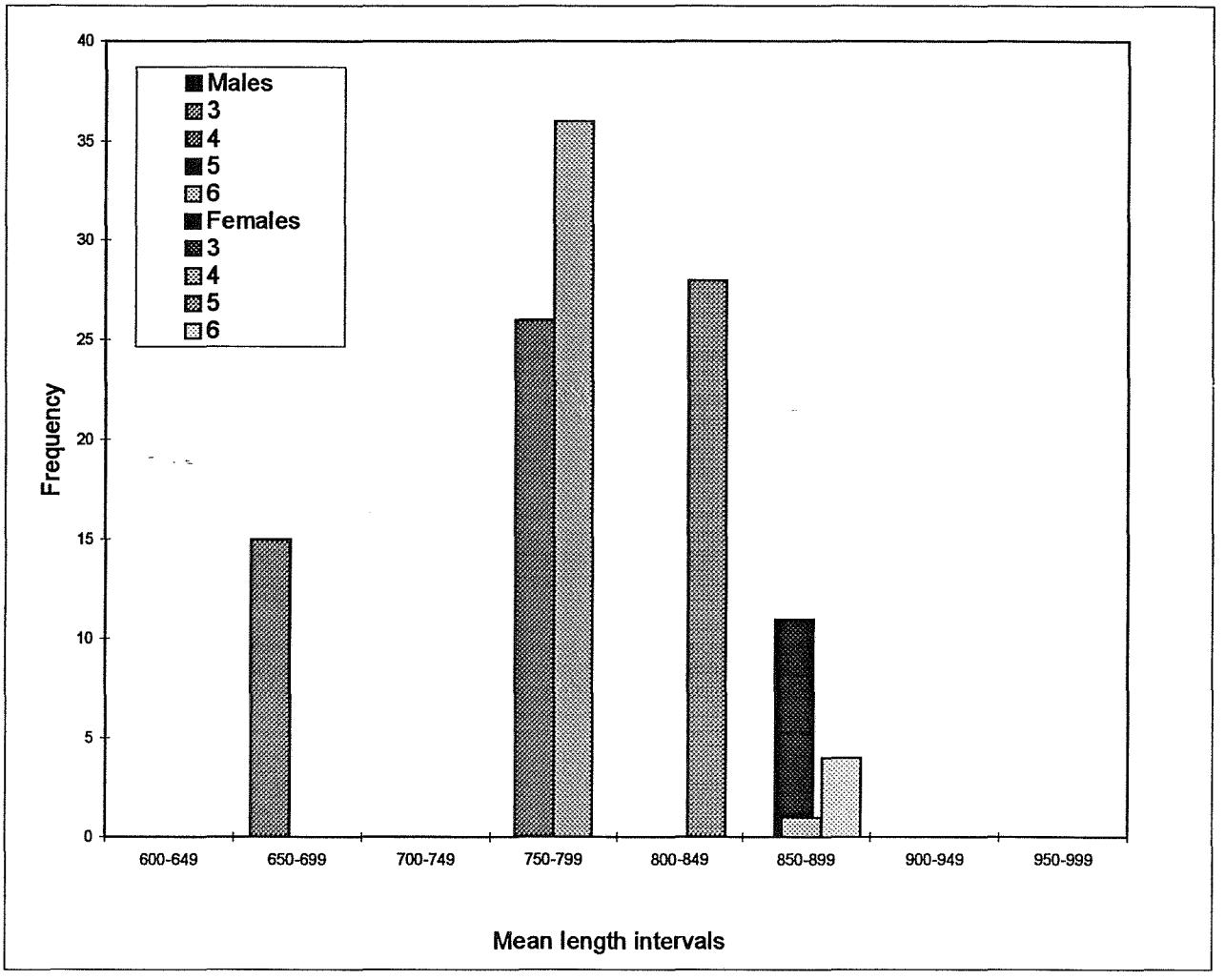

Fig. 4 Age-length frequency histograms, sex stratified, of the Campbell River chinook escapement in 1996.

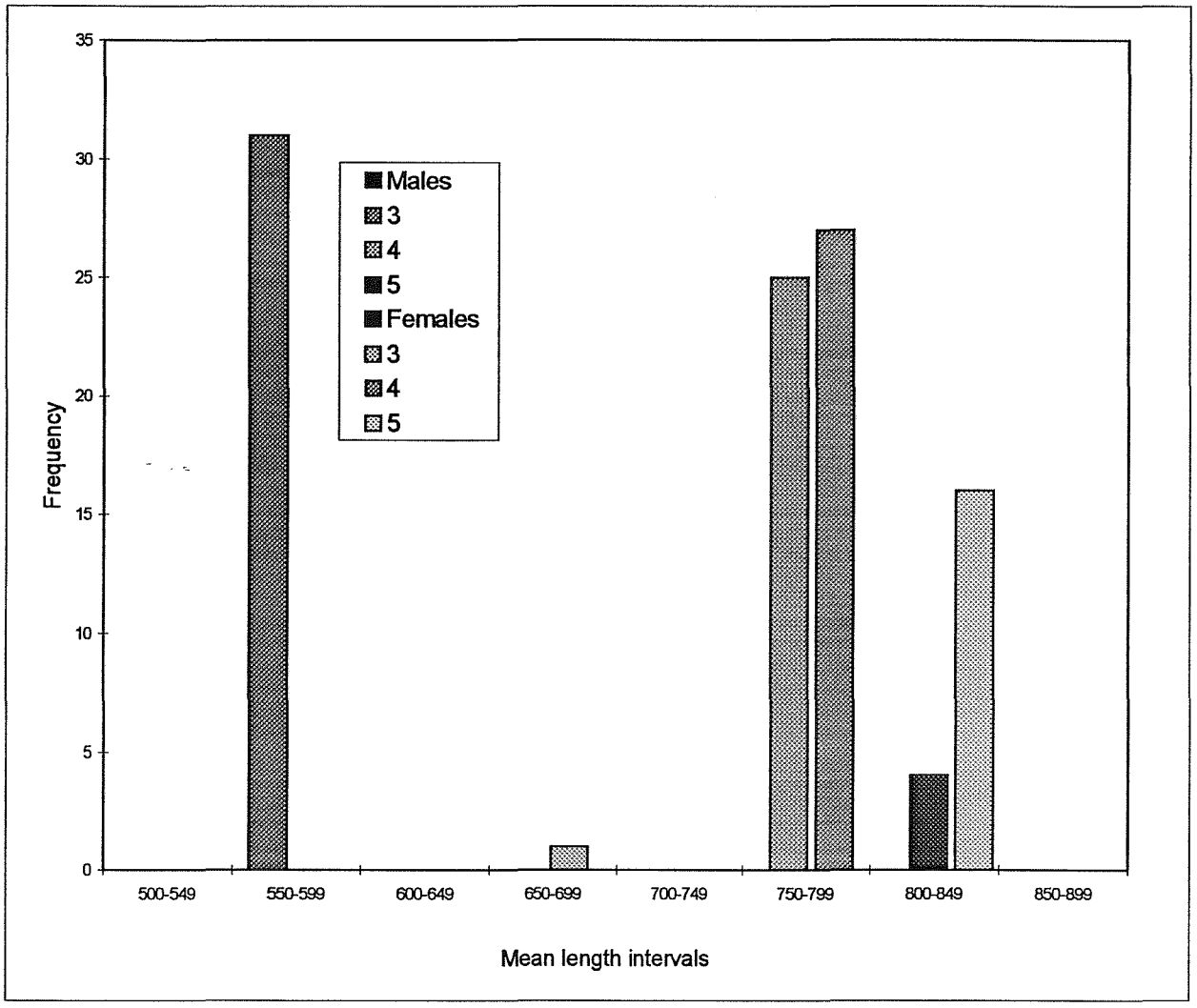

Fig. 5 Age-length frequency histograms, sex stratified, of the Quinsam River chinook escapement in 1996.

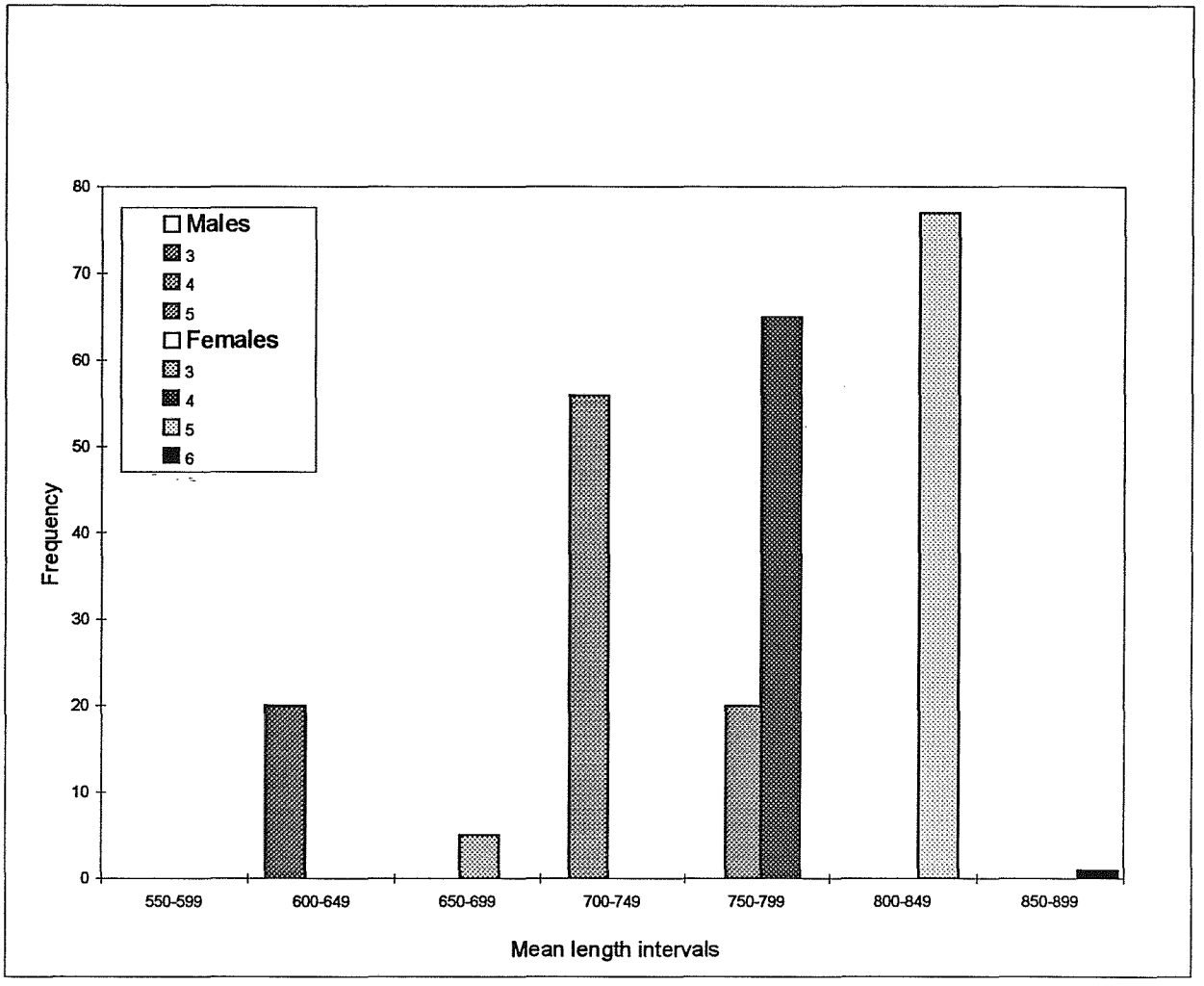

Fig. 6 Age-length frequency histograms, sex stratified, of the Quinsam Hatchery chinook escapement in 1996.

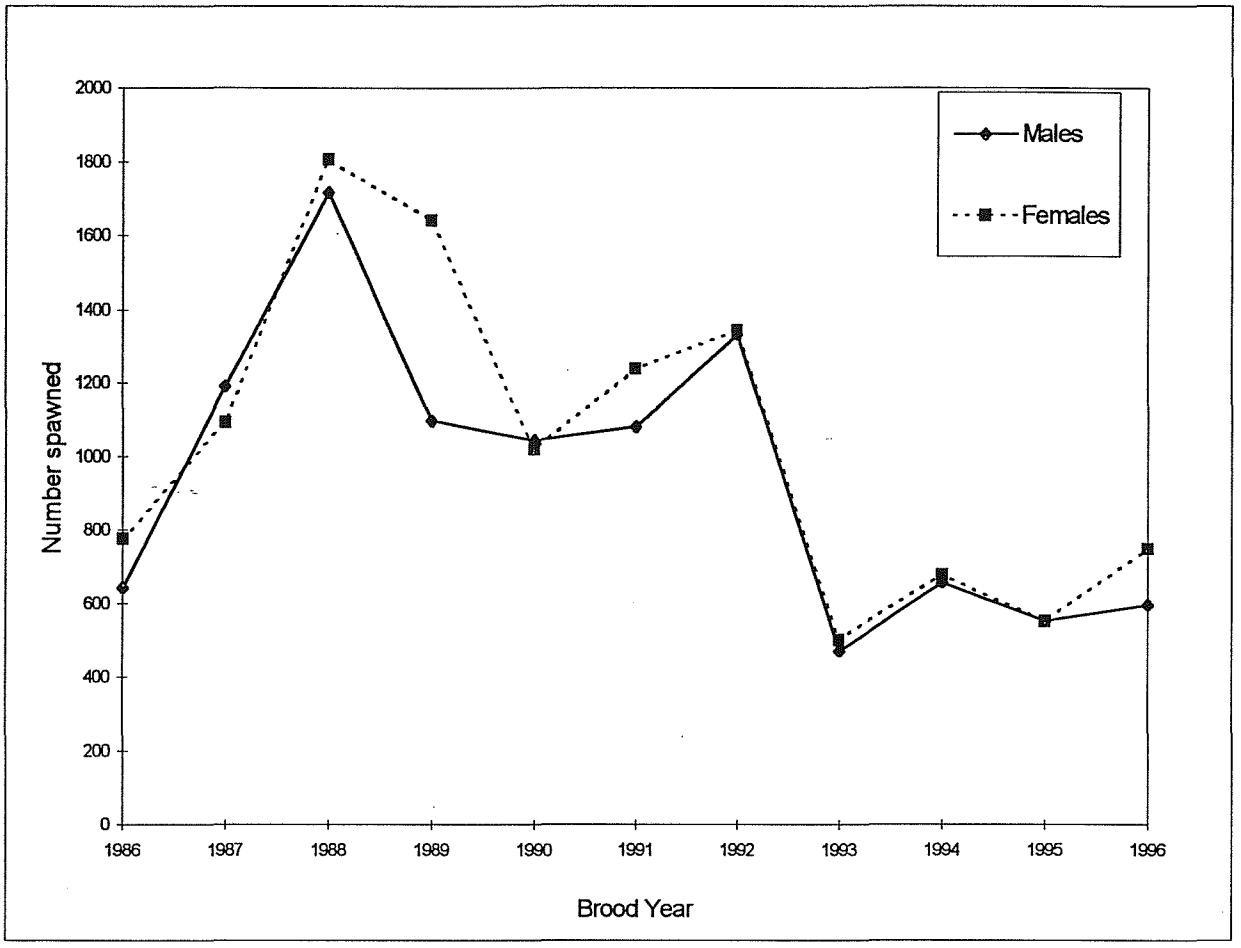

Fig. 7 Quinsam Hatchery spawned broodstock summary, 1986-1996.

Appendix 1. Summary of operculum tagging of chinook salmon carcasses in the Campbell River in 1996.

Date	Capture area	Males	Females	Jacks	Total	Cumulative total
Oct 3 96	CHB	1	0	0	1	1
Oct 25 96	CHB	1	0	0	1	2
Oct 29 96	CHA	0	6	0	6	8
Oct 29 96	CHB	0	2	0	2	10
Oct 29 96	1A	0	3	0	3	13
Oct 29 96	1B	0	2	0	2	15
Oct 30 96	1A	1	0	0	1	16
Oct 30 96	1B	4	5	0	9	25
Nov 01	1A	1	0	0	1	26
Nov 01	1B	5	2	0	7	33
Nov 01	CHB	0	1	0	1	34
Nov 05	1A	1	1	0	2	36
Nov 05	1B	6	9	0	15	51
Nov 05	CHA	2	1	0	3	54
Nov 05	CHB	4	6	0	10	64
Nov 05	CHC	2	2	0	4	68
Nov 06	1A	3	3	0	6	74
Nov 06	1B	3	5	0	8	82
Nov 08	1A	2	0	0	2	84
Nov 08	1B	4	3	0	7	91
Nov 08	CHB	1	1	0	2	93
Nov 12	1A	1	2	0	3	96
Nov 12	1B	5	2	0	7	103
Nov 12	CHB	0	2	0	2	105
Nov 13	1B	3	4	0	7	112
Nov 15	1B	4	3	0	7	119
Nov 15	CHB	1	0	0	1	120
Nov 19	1B	0	2	0	2	122
Total		55	67	0	122	

Total captured from each area:

Area	Males	Females	Jacks	Total
1A	9	9	0	18
1B	34	37	0	71
CHA	2	7	0	9
CHB	8	12	0	20
CHC	2	2	0	4

Appendix 2. Summary of operculum tagging of Quinsam River chinook salmon carcasses in 1996.

Date	Capture area	Males	Females	Jacks	Total	Cumulative Total
Oct 24 96	2C	0	1	0	1	1
Oct 25 96	2D	0	2	0	2	3
Oct 28 96	2D	0	1	0	1	4
Oct 31 96	2C	1	4	0	5	9
Oct 31 96	2D	1	1	0	2	11
Nov 04	2C	1	2	0	3	14
Nov 04	2D	3	1	0	4	18
Nov 07	2C	3	1	0	4	22
Nov 07	2D	2	6	0	8	30
Nov 11	2C	1	0	0	1	31
Nov 11	2D	8	1	0	9	40
Nov 14	2B	1	0	0	1	41
Nov 14	2C	3	1	0	4	45
Nov 14	2D	2	5	0	7	52
Nov 18	2B	3	3	0	6	58
Nov 18	2C	8	1	0	9	67
Nov 18	2D	5	3	0	8	75
Nov 21	2C	4	3	0	7	82
Nov 21	2D	5	2	0	7	89
Nov 25	2B	0	1	0	1	90
Nov 25	2C	4	2	0	6	96
Nov 25	2D	2	1	0	3	99
Nov 28	2C	1	3	0	4	103
Nov 28	2D	3	0	0	3	106
Total		61	45	0	106	

Total captured from each area

Area	Males	Females	Jacks	Total
2B	4	4	0	8
2C	26	18	0	44
2D	31	23	0	54

Appendix 3. Recovery of tagged chinook salmon carcasses on the Campbell River in 1996.

Date	Area	Males Age	Females Age	Jacks	Tag Code
Oct 29 96	CHB	5			4337
Nov 5 96	1A		4		4344
Nov 5 96	1B		5		4347
Nov 5 96	1B	4			27583
Nov 5 96	1B	4			27584
Nov 5 96	1B	5			27587
Nov 5 96	1B	3			27588
Nov 5 96	CHB		5		27586
Nov 6 96	1A		5		4408
Nov 6 96	1B		5		4410
Nov 6 96	1B		5		27581
Nov 8 96	1A	4			27632
Nov 8 96	1B		5		27527
Nov 8 96	1B		4		27528
Nov 8 96	1B	4			27529
Nov 8 96	1B		6		27582
Nov 8 96	1B	4			27641
Nov 8 96	1B		6		27642
Nov 8 96	1B	3			27643
Nov 8 96	1B		5		27644
Nov 8 96	1B		5		27646
Nov 8 96	1B		5		27648
Nov 8 96	1B		5		27649
Nov 8 96	1B		4		27650
Nov 8 96	CHA		5		4345
Nov 8 96	CHA		4		4419
Nov 8 96	CHA	4			4420
Nov 8 96	CHA	4			4421
Nov 8 96	CHA		unkn		NO TAG
Nov 8 96	CHB		5		27599
Nov 8 96	CHB	4			27631
Nov 8 96	CHB		4		27634
Nov 8 96	CHB		unkn		27635
Nov 8 96	CHB		4		27636
Nov 8 96	CHB	5			27637
Nov 8 96	CHC	4			27627
Nov 8 96	CHC		4		27629
Nov 12	1A	5			27550
Nov 12	1A		4		27633
Nov 12	CHB	4			27551
Nov 12	CHB		5		27552

Appendix 3 (cont.)

Date	Area	Males Age	Females Age	Jacks	Tag Code
Nov 13	1B		5		27556
Nov 13	1B	3			27645
Nov 15	1A		4		27568
Nov 15	1B	3			27555
Nov 15	1B		5		27571
Nov 15	1B	4			27573
Nov 15	1B		4		27640
Nov 15	1B		4		27684
Nov 15	1B	4			27686
Nov 15	1B	3			28002
Nov 15	1B	unkn			MISSING
Nov 15	CHC	unkn			27600
Nov 19	1A		4		4409
Nov 19	1A	5			27567
Nov 19	1B		6		27535
Nov 19	1B		unkn		27865
Nov 19	1B		unkn		NO TAG
Nov 19	1B		4		28005
Nov 19	1B	4			28018
Nov 19	1B	3			28019
Nov 19	1B		4		28020
Nov 19	1B	3			28021
Nov 19	1B		unkn		28023
Nov 19	1B	3			28024
Nov 22	1B	5			28032

	No tag	Tagged	Total
Males	1	28	29
Females	2	35	37
Jacks	0	0	0

Area Summary:

	Males	Females
1A	3	5
1B	18	22
CHA	2	3
CHB	4	6
CHC	2	1
Total	29	37

Appendix Table 4. Recovery of Quinsam River chinook salmon carcasses in 1996.

Date	Area	Males Age	Females Age	Jacks	Tag Code
Oct 30	1B		4	0	4338
Nov 07	2D	4		0	4418
Nov 11	2D	4		0	27543
Nov 13	1B		unkn	0	Missing
Nov 14	2C	3		0	27680
Nov 14	2D		5	0	27546
Nov 15	1B		5	0	27547
Nov 15	1B		4	0	27564
Nov 18	2D	4		0	27687
Nov 18	2D	4		0	27561
Nov 18	2D	3		0	28012
Nov 18	2D		5	0	28016
Nov 21	2C	4		0	27692
Nov 21	2C		4	0	27693
Nov 21	2D		4	0	27699
Nov 21	2D	unkn		0	28052
Nov 21	2D	4		0	28053
Nov 21	2D	3		0	28054
Nov 21	2D	4		0	28015
Nov 21	2D	4		0	27700
Nov 25	2C	3		0	28035
Nov 25	2D	4		0	27597
Nov 25	2C	4		0	28037
Nov 25	2C		5	0	28039
Nov 25	2D		4	0	27545
Nov 25	2D		5	0	28045
Nov 28	2B		3	0	27691
Nov 28	2C		5	0	28036
Nov 28	2C	4		0	27604
Nov 28	2C		5	0	28048

	No tag	Tagged	Total
Males	0	17	17
Females	1	13	14
Jacks	0	0	0

Area Summary:

	Males	Females
1B	0	4
2B	0	1
2C	5	4
2D	12	5
Total	17	14

Appendix Table 5. Mark-recapture data for chinook salmon carcasses in Campbell River in 1996.

	Males			Females			Jacks			Total		
Date	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered
Oct.03 96	1	0	0	0	0	0	0	0	0	1	0	0
Oct.25 96	1	1	0	1	0	0	1	0	0	3	1	0
Oct.29 96	3	0	1	14	13	0	0	0	0	17	13	1
Oct.30 96	6	5	0	8	6	0	0	0	0	14	11	0
Nov.01 96	9	6	0	4	3	0	0	0	0	13	9	0
Nov.05 96	17	15	0	29	20	2	0	0	0	46	35	2
Nov.06 96	8	6	0	10	8	0	1	0	0	19	14	0
Nov.08 96	9	6	5	11	6	8	0	0	0	20	12	13
Nov.12 96	11	6	1	7	6	1	0	0	0	18	12	2
Nov.13 96	6	3	0	4	4	0	0	0	0	10	7	0
Nov.15 96	11	7	1	7	3	0	0	0	0	18	10	1
Nov.19 96	3	0	0	2	2	0	0	0	0	5	2	0
Nov.22 96	1	0	0	1	0	0	0	0	0	2	0	0
Total	86	55	8	98	71	11	2	0	0	186	126	19

Appendix Table 6. Mark-recapture data for chinook salmon carcasses on the Quinsam River in 1996.

	Males			Females			Jacks			Total		
Date	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered	No. examined	Tags applied	Tags recovered
Oct.24 96	0	0	0	1	1	0	2	0	0	3	1	0
Oct.25 96	0	0	0	2	2	0	0	0	0	2	2	0
Oct.28 96	1	0	0	1	1	0	0	0	0	2	1	0
Oct.30 96	0	0	0	0	0	1	0	0	0	0	0	1
Oct.31 96	4	2	0	6	5	0	0	0	0	10	7	0
Nov.04 96	10	4	0	5	3	0	0	0	0	15	7	0
Nov.07 96	5	5	1	7	7	0	0	0	0	12	12	1
Nov.11 96	10	9	1	1	1	0	0	0	0	11	10	1
Nov.14 96	9	6	1	9	6	1	0	0	0	18	12	2
Nov.15 96	0	0	0	0	0	2	0	0	0	0	0	2
Nov.18 96	21	18	0	8	7	0	0	0	0	29	25	0
Nov.21 96	13	10	6	9	6	2	1	0	0	23	16	8
Nov.25 96	6	6	3	4	4	3	0	0	0	10	10	6
Nov.28 96	6	0	2	7	0	3	1	0	0	14	0	5
Total	85	60	14	60	43	12	4	0	0	149	103	26