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# Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapement of Kitsumkalum River, 1992

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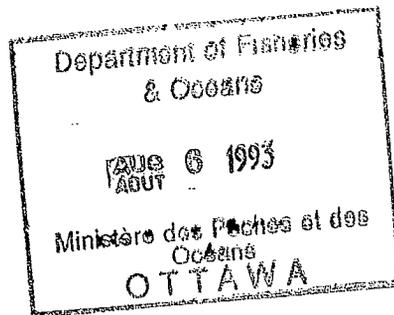
July 1993

ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG  
RECOVERIES FOR CHINOOK SALMON ESCAPEMENT OF  
KITSUMKALUM RIVER, 1992

by

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## ABSTRACT

Nelson, T. C. 1993. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2201: viii + 44 p.

Estimates of escapement were derived for chinook salmon (*Oncorhynchus tshawytscha*) of the Kitsumkalum River for 1992 using live-tagging and carcass-recovery operations. This study is part of the Chinook Key Stream Program. The Petersen estimate of all adult male and female chinook escapement to the total Kitsumkalum River was 12,437. In this report, total escapement estimates are the summation of individual estimates generated by sex and river section (upper and lower). Age-6 chinook comprised the largest proportion of the escapement for both sexes in the upper section of the river and for females in the lower section; males in the lower section were mostly age-5.

The total estimated escapement of adipose-clipped adult male and female chinook to the entire Kitsumkalum River was 407 fish (3.3% of the total estimated escapement). This estimate was further stratified by age, sex and tag code. Proportional hatchery contributions (marked and unmarked) to the escapement were estimated using the Key Stream approach (Method A), wherein the adipose fin clip rate at release and a weighted adipose clip rate at return are applied to the estimated escapement of chinook. Using Method A, the total hatchery contribution was 469 fish or 3.8% of the total adult male and female escapement estimate (3.0% for adult males and 4.5% for females). These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program approach (Method B), wherein the coded wire tag rate at release is applied to the estimated escapement of chinook possessing a CWT. Using Method B, the total hatchery contribution was 454 fish or 3.6% of the total adult male and female escapement estimate (2.9% for adult males and 4.4% for females).

**Key words:** Kitsumkalum, chinook, key stream, escapement, coded wire tags, age composition, hatchery, live tagging.

## RÉSUMÉ

Nelson, T. C. 1993. Abundance, age, size, sex and coded-wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1992. Can. Manusc. Rep. Fish. Aquat. Sci. 2201: viii + 44 p.

On a calculé l'échappée de saumon quinnat (*Oncorhynchus tshawytscha*) de la rivière Kitsumkalum en 1992 à partir du marquage de poissons vivants et de la récupération de poissons morts. Le relevé fait partie du Programme des rivières clés pour le quinnat. L'estimation Peterson de tous les quinnats adultes mâles et femelles échappés dans toute la Kitsumkalum est de 12 437. Dans le rapport, le total des échappées est la somme des estimations générées par sexe et section de rivière (cours supérieur et inférieur). Le plupart des poissons des deux sexes échappés dans le cours supérieur et des femelles échappées dans le cours inférieur avaient 6 ans, et plupart des mâles échappés dans le cours inférieur avaient 5 ans.

Les échappées totales de mâles et de femelles à la nageoire adipeuse encochée s'établit à 407 (3,3 % des échappées totales). L'estimation a été stratifiée part âge, sexe et code d'étiquette. La contribution des piscicultures (poissons marqués et non marqués) a été calculée par la méthode des rivières clés (Méthode A) tandis que le taux de poissons à nageoire encochée au moment du lâcher et un taux pondéré de poissons à nageoire encochée au retour a servi à calculer l'échappée du quinnat. La méthode A donne une contribution totale des pisciculture de 469 poissons ou 3,8 % de la population adulte totale (3,0 % pour les mâles et 4,5 % pour les femelles). Ces résultats ont été mis en regard de ceux obtenus par la méthode du Programme de récupération des poissons marqués (Méthode B), qui compare le taux de poissons portant un fil codé au lâcher au nombre estimé de quinnats échappés portant une fil codé. La méthode B indique une contribution totale de pisciculture des 454 poissons ou 3,6% de la population adulte totale (2,9% des mâles et 4,4 % des femelles).

Mots clés: Kitsumkalum, quinnat, rivière clé, échappée, composition démographique, pisciculture, marquage.

## INTRODUCTION

In 1984, the Kitsumkalum River was selected under the Chinook Key Stream Program as one of the systems used to assess the response of chinook salmon stocks to a new harvest management regime. The goal of the new management regime is to rebuild chinook stocks to historical levels. The Chinook Key Stream Program was initiated in response to objectives set out in the Canada - U.S. Salmon Treaty.

The major objectives of the Chinook Key Stream Program are:

1. to accurately estimate chinook escapement on Key Streams;
2. to estimate harvest rates and contributions to fisheries and escapement based on coded wire tagged/adipose-clip returns, including estimates of the total escapement of coded wire tags to the Key Stream system; and
3. to estimate the contribution of hatchery and natural production to the escapement.

This manuscript report is the fourth in a series describing the escapement monitoring and biological sampling of chinook salmon in the Kitsumkalum River. The 1984-86 results are presented in Andrew and Webb (1988), the 1987-88 results are presented in Carolsfeld et al. (1990), the 1989-90 results are presented in Nass and Bocking (1992), and the 1991 results are presented in Nelson (1993).

The 1992 escapement of chinook salmon was calculated using the adjusted Petersen method (Ricker 1975) by tagging live chinook *in situ* and recovering carcasses. Separate population estimates were calculated for each sex for both the upper and lower sections of the river. A total estimate for the in-river escapement of chinook was calculated by summing the individual estimates.

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

To avoid confusion in terminology relating to tagging and marking, the word "tagging" in this report refers to operculum tagging and punching of live adult and jack chinook in the river; "marking" refers to marking of chinook juveniles with coded wire tags (CWT) and adipose fin clips (AFC).

## STUDY AREA

The physical and geographic aspects of the Kitsumkalum River system have been described in detail by Andrew and Webb (1988). The study area for this project includes the mainstem of the river from its confluence with the Skeena River upstream approximately 20 km to Treston Lake. A three-kilometre section of the river known as Canyon Rapids, located approximately 10 km upstream of the confluence with the Skeena River, divides the study area into two sections - the "upper" and "lower" Kitsumkalum (Figure 1). Although the Canyon Rapids section is generally impassable to boat traffic, it does not constitute a barrier to salmon migration.

The Kitsumkalum River system supports all five species of Pacific salmon as well as steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*) (Hancock et al. 1983). Pink salmon (*O. gorbuscha*) are commonly the most abundant species, followed by chinook, coho, sockeye and chum salmon (*O. tshawytscha*, *O. kisutch*, *O. nerka*, and *O. keta*, respectively). The Deep Creek Hatchery, located approximately six kilometres from the confluence with the Skeena River, contributes to chinook enhancement. There are two spawning stocks of chinook in the Kitsumkalum system. An early run (not considered in this report) spawns upstream of Kitsumkalum Lake in late July to early August. Late-run chinook start migrating into the river in early August. Spawning by these chinook nears completion by early to mid September. Chinook spawners are generally twice as abundant in the lower river section compared to the upper river section. For the years 1984 to 1990, chinook escapements to the Kitsumkalum River have been estimated at 11,825; 8,308; 10,151; 24,508; 22,755; 18,287; 21,039; and 9,288, respectively (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992, and Nelson 1993).

Fisheries on Kitsumkalum chinook include sport, commercial, and native food fishery. The sport fishery occurs throughout the river system, whereas the commercial and native fisheries are limited to areas downstream of the confluence with the Skeena River. In comparison with other stocks, Kitsumkalum River chinook have high average body weights; the genetic strain is arguably one of the heaviest on the Pacific Coast. Fish in excess of 34 kg (75 lbs) are taken each year in the in-river sport fishery.

## METHODS

A summary of methods used for each of the study years is presented in Table 1. Live tagging and carcass recovery sampling periods and effort are presented in Table 2. The tagging and dead recovery crews both consisted of four-person teams. Carcass recovery operations commenced during the last week of the tagging operations.

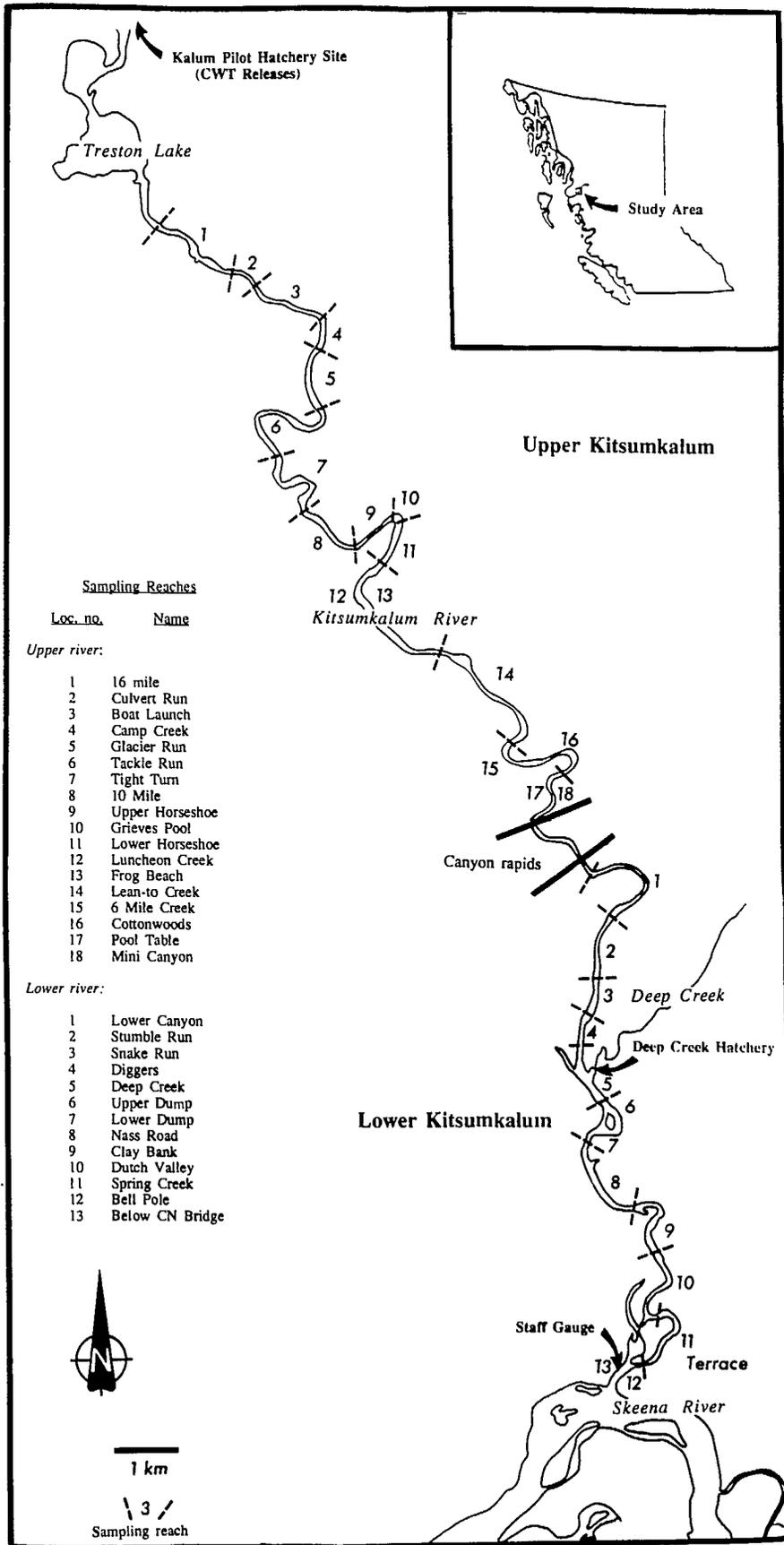


Figure 1. Map of the Kitsumkalum River study area.

Table 1. Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1992.

Item	Method and materials 1992
Population estimate	* Petersen estimate, sum of separate estimates for sexes and river strata
Live tagging (a)	* Cattle ear tags applied <u>in situ</u> to live fish recovered in river
Secondary tagging	* Single-hole opercular punch; Left for lower river Right for upper river
Recovery of fish	* Carcass recovery by foot, boat
Coded wire tagging (CWT)	* Collection of heads from adipose-clipped fish in dead recovery and some during live tagging
Biological and physical sampling	* Ages from scales and CWT * Sex ratios from sex-specific population estimates for strata * Postorbital-hypural length

(a) Tags manufactured by Ketchum Manufacturing Sales Ltd., 396 Berkley Ave., Ottawa, Ontario, Canada, K2A 2G6. The tags used (size no. 3; 1 1/8" x 1/4") are recommended for sheep and swine.

## POPULATION ESTIMATION

Chinook salmon were enumerated using the adjusted Petersen method (Ricker 1975, p. 78) by tagging and operculum punching live adults and jacks throughout the upper and lower sections of the river and then by subsequently examining carcasses for tags and/or operculum punches (tag loss).

### Population Stratification

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

- 1) sexes and river sections pooled;
- 2) sexes separate with river sections pooled;
- 3) sexes separate and river sections separate; and
- 4) sexes pooled with river sections separate.

Separate Petersen estimates may be calculated for each stratum and then summed to obtain an estimate of the whole population. By segregating the data into separate population strata, potential biases (created by factors which affect the strata at different rates) may be avoided. The main factors of concern are rates of tag application, recovery of carcasses, and tag loss. If spawners in the upper and lower river do not mix following release of tagged individuals in each section (thus forming two distinct groups for the purpose of enumeration) then there is a potential for substantial bias in unstratified estimates if tagging or dead recovery rates and effort are not identical. Similarly, if the two sexes have different rates of tag application, recovery, or tag loss, then a single population estimate may be biased. Due to the likelihood of factors affecting sexes and river sections at different rates, as documented by Andrew et al. (1988), Petersen estimates were stratified by sex and river section in this study.

### Potential Biases

Petersen estimates are potentially biased by the violation of a number of assumptions inherent to the model. Seven of these assumptions were discussed in Bocking (1991<sup>a</sup>), Carolsfeld et al. (1990), Bocking et al. (1990), and Andrew and Webb (1988), and are repeated here.

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

To obtain an accurate Petersen estimate, it is important to apply and/or recover tags in proportion to the available population. It is not possible to test whether tagging and dead recovery were conducted on a similar proportion of the population because there is no independent measure of

the numbers of fish available for tagging and dead recovery, nor of the timing of the migration and spawning.

A related problem associated with spatially stratified escapement estimates is that tagged fish may stray (washout or migrate) between the upper and lower sections of the river. Movements of tagged fish are indicated by the location of recovery relative to the location of tagging. Individual tag release and recovery locations were grouped by river section (upper and lower) to facilitate this comparison. In addition, tagged fish may be washed out into the Skeena River where they are not recovered (out of study area). The extent of this latter factor is not addressed in this report. It is not possible to statistically test the extent of mixing of marked and unmarked fish using the data from this study.

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

An influx of spawners following tagging could cause the Petersen calculations to overestimate or underestimate the true population depending on how they mixed with tagged fish. Tagging and recovery periods are established to correspond, as best as possible, with periods of peak spawning and peak die-off.

- 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 the presence of a secondary mark (hole punch) in the operculum of all tagged carcasses. In 1992, individuals tagged in the lower river received a left opercular punch and those tagged in the upper river received a right opercular punch. Petersen estimates calculated in this report were derived using only data from secondary tags (opercular punches).

- 4) All tags are recognized and reported on recovery after the conclusion of tagging.

In this study, no repitches were conducted to re-examine deadpitch carcasses for missed operculum tags and secondary tags, therefore, it was not possible to evaluate tag non-reporting incidence.

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

Dead recovery from a population other than the tagged population will cause Petersen calculations to overestimate the true population. Indications that tagging and recovery were conducted on different populations could be inferred from different age frequency and length frequency distributions among the two samples. This method of inference was tested in this study by comparing the mean length of chinook, stratified by river section and sex, using a t-test.

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

A small number of tag recoveries in a stratum will cause Petersen estimates to have low precision. Petersen estimates are generally more reliable if a high proportion of tagged fish are

recovered in each stratum. In the absence of other sources of bias, approximately 25 to 75 recaptures will produce population estimates with 25% accuracy, and 95% confidence, for populations of  $10^2$  and  $10^9$  (Ricker 1975). Confidence intervals for the escapement estimates were calculated as described later in the calculations sub-section of this chapter.

- 7) Tagged fish suffer the same natural mortality as untagged fish.

Mortality due to tagging procedures could cause Petersen calculations to overestimate the number of effective spawners. Studies conducted during 1987 and 1988 on the Kitsumkalum showed that there was no statistical difference in the spawning success of tagged or untagged chinook females (Carolsfeld et al. 1990) and, therefore, this assumption is probably not violated.

Statistical tests were conducted on particular sets of data in an attempt to determine whether some of the above biases were acting in this study. Certain biases caused by methods of tagging, recovery, age determination, etc. are discussed below.

### Calculations

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

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

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

Population estimates for sex and river section strata were summed to obtain a total in-river population estimate:

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

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

Confidence limits for each stratum population estimate were obtained using fiducial limits for the Poisson distribution as described by Ricker (1975, p. 79; Appendix II, p. 343). The 95% confidence limits for the total escapement was then determined by assigning equal weights to all strata and summing the lower and upper confidence limits across strata.

### Strays

In this study, tagged fish released in one river section and recovered in the other river section were considered to be strays. For the purposes of the Petersen calculations, the total number of strays from the upper Kitsumkalum *u* to the lower Kitsumkalum *l* was estimated by expanding the observed number of tagged strays as follows:

$$ES_{u\ to\ l} = TS_{u\ to\ l} \cdot (M_l / R_l) \quad (3)$$

where *ES* is the expanded number of strays, *TS* is the number of tagged strays, *M* is the number of secondary marks applied and *R* is the number of secondary marks recovered.

This expanded number of tagged strays from the upper to the lower Kitsumkalum was then used to estimate the number of tagged fish available in the lower river:

$$M'_l = M_l + ES_{u\ to\ l} - ES_{l\ to\ u} \quad (4a)$$

where *M'* is the adjusted number of marks applied.

The above equation provides the adjusted estimate for the number of tagged fish available for recapture (*M<sub>i,r</sub>*) used in equation 1.

Straying from the lower river to the upper river was calculated with the reversal of locations in the formula. Tagged fish available for recapture in the upper river are then:

$$M'_u = M_u + ES_{l\ to\ u} - ES_{u\ to\ l} \quad (4b)$$

### TAGGING

Chinook were captured using a 22 x 4 m tangle net with 18 cm mesh. A floating top line and a sinking lead line kept the net perpendicular to the river current until it beached. Chinook were generally tangled by the kype and teeth while smaller species of fish escaped. Nets were fished in prime spawning sections of the river until actual spawning began, at which time the deeper holding pools were more-actively fished.

Upon capture, all chinook were tagged with Ketchum kurl-lock tags on the rim of the operculum and a secondary operculum hole punch was applied. Fish captured in the lower Kitsumkalum were given a hole punch in the left operculum and those captured in the upper river were given a hole punch in the right operculum. The postorbital-hypural length was measured using a cloth tape, the absence or presence of an adipose fin was determined, and sex was determined visually. Males less than 50 cm (postorbital-hypural) were classified as jacks.

## RECOVERY

Recovery crews were instructed to dead pitch all available carcasses and record any operculum tags and punches. Crews attempted to keep recovery effort as complete and consistent as possible throughout the study period. Dead chinook were recovered by searching banks and any areas left dry by decreasing water level and areas where the current slowed such as in back eddies and sloughs. Carcasses were also taken opportunistically while travelling from site to site by boat.

Each carcass was examined for the presence of a Ketchum tag, opercular punch hole, missing adipose fin, sex, and post-spawning condition. Scales were taken randomly for age analysis, and heads were removed from adipose-clipped carcasses for sampling of CWTs. Data collected from the carcasses is described in the biological and physical sampling section of this chapter. All carcasses were cut in half to prevent recounting in future dead pitches.

Using the recovery database, tagging rates and tag recovery rates were calculated as follows:

$$\text{tag rate} = R / C \quad (5)$$

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

$$\text{tag recovery rate} = R / M \quad (6)$$

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

## BIOLOGICAL AND PHYSICAL SAMPLING

Biological sampling during dead recovery included the collection of the following data:

- 1) scales for age determination;
- 2) postorbital-hypural length;
- 3) sex;
- 4) presence of secondary tags (hole punches in operculum); and
- 5) presence of an adipose clip.

Scales were aged at the Department of Fisheries and Oceans scale laboratory in Vancouver. Heads were removed from adipose-clipped fish and saved for CWT extraction and decoding at the coded wire tag dissection laboratory in Vancouver.

Scale ages were read only when a portion of the previous annulus was present and scales were not regenerated. Scales were classified as unreadable if the scales had regenerate centres, they were

resorbed, or if they were mounted upside down. Ages were recorded for fish for which there were at least two scales that could be read for both marine and freshwater ages. The aging system follows that described by Gilbert and Rich (1927).

The age composition determined with the available scale and CWT samples is valid only if age sampling was random and there was no bias in readability of scales with age. Scale ages of older fish are usually more difficult to read than those of younger fish because scales of older fish usually undergo more resorption and regeneration. The data were examined for this potential bias using a t-test to compare the mean lengths of known- and unknown-aged males and females. Because jacks were omitted from the Petersen estimates, a single jack that was successfully aged was not included in the age-length distribution analysis; this same fish was included in the freshwater age analysis.

The population of each age class was determined by allocating portions of the Petersen estimate to age classes according to the age composition determined from scale samples and decoded CWTs. If an age discrepancy occurred for an individual specimen successfully aged by both scale and CWT analysis, the CWT age was used. In addition, if sex or adipose clip discrepancies occurred for the same specimen observed in both the live and dead operations (identified by opercular tag code), data used for that specimen was taken from the dead recovery.

A valid sex ratio was then calculated using the Petersen estimates generated for the upper and lower sections of the river.

## CODED WIRE TAGGING AND RECOVERY

Juvenile chinook from the 1986 - 1990 brood years were marked at the Deep Creek Hatchery with binary coded wire tags (CWT) using standard methods (Armstrong and Argue 1977). Adipose fins of coded wire tagged juveniles were clipped prior to release of the fish.

Two different methods were used to estimate the hatchery contribution, by tag code, to the total escapement. Method A (the Key Stream approach) applies the adipose fin clip rate (AFC) at release and an adipose clip rate (weighted average of adipose clip rates for live and dead recovery) at return to the estimated escapement, stratified by river section and sex, to derive expanded estimated escapements by tag code. In contrast, Method B (the Mark Recovery Program approach) applies the CWT rate at release (assuming no further CWT loss after release) to the estimated escapement of chinook possessing a CWT (combined data from live and dead recovery), stratified by river section and sex, to derive corrected estimated escapements by tag code. Method B uses the number of actual CWTs present in the escapement from which to derive the hatchery contribution, whereas Method A uses the number of adipose clips present in the escapement. The total combined count of adipose clips from both the live and dead operations was adjusted down as a result of the deletion of duplicate counts for the same specimen (identified by opercular tag code). Expansions generated by Method B (used by the Mark Recovery Program for commercial and sport fisheries) are not directly comparable with adipose-clip expansions for escapements using Method A. Details of each methodology are presented below.

**Method A**

Adipose-clipped fish were enumerated by condition (live or dead), sex, and river section stratification. The recovery of jack chinook was not included with the adult male recoveries as no adipose-clipped jacks were captured or recovered in 1991. The first step was to estimate the number of adipose-clipped fish by condition, river section, and sex from the observed number of adipose clips:

$$EAD_{live} = \frac{OAD_{live} \cdot P}{C_{live}} \quad (7)$$

where  $EAD$  is the estimated number of adipose clips,  $OAD$  is the number of adipose clips observed,  $C$  is the number of fish examined,  $P$  is the population estimate, and  $live$  distinguishes between sampling schemes.  $EAD$  for the dead recovery operation is calculated in the same way except with respective substitutions for  $OAD$  and  $C$ . The sex- and stratum-specific population estimates used here are the Petersen population estimates. The live and dead stratified estimates are then combined to calculate a weighted mean number of adipose clips by river section and sex:

$$EAD = \frac{(EAD_{live} \cdot MR_{live}) + (EAD_{dead} \cdot MR_{dead})}{C_{live} + C_{dead}} \quad (8)$$

where  $MR$  is the AFC mark rate at return. We calculated a weighted  $EAD$  for several reasons. First, this procedure remains consistent with the stratification of the data and accounts for differences in sample size. In addition, there are potential differences in adipose detectability between the live and dead sampling. Observation of adipose fin status is potentially misidentified in the live samples due to detection problems associated with live fish handling. On the other hand, naturally occurring fin rot in the dead sampling may cause error during dead recovery operations. Finally, there could be differential biases in the live and dead recovery due to potential migration timing differences between AFC and non-AFC fish.

Using this weighted estimate of the total number of adipose clips for each sex escaping to each section of the river, the number of adipose clips for each tag code can be estimated by the allocation of adipose clips to tag codes based on their relative frequency in the sample of decoded tags:

$$EAD_{i,r,tc} = \frac{EAD_{i,r} \cdot NDT_{i,r,tc}}{SumNDT_{i,r}} \quad (9)$$

where  $NDT$  is the number of successfully decoded tags for each tag code,  $SumNDT$  is the total number of decoded tags for all tag codes, and  $i$ ,  $r$ , and  $tc$  denote sex, river section and tag code, respectively.

This approach of first estimating adipose-clipped fish and then allocating these among the successfully decoded CWTs assumes that any adipose-clipped fish not decoded (i.e. no pins) were once marked but lost their coded wire tag for some reason. If this assumption is incorrect, the calculation of the number of hatchery-origin fish using this method would be positively biased. It is possible, especially in the dead pitch, that some of the fish with missing adipose fins may have lost their adipose fins through some other means (e.g. carcass decomposition) or were misidentified. However, if decomposition of adipose fins is occurring then the adipose mark rate (based on hatchery contributions only) in the dead pitch should be higher than the mark rate at release. Other potential sources of bias using Method A are discussed in Bocking (1991<sup>a</sup>).

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

$$EHC_{i,r,tc} = \frac{EAD_{i,r,tc} \cdot (RC_{tc} + RUC_{tc})}{RC_{tc}} \quad (10)$$

where  $EHC$  is the estimated hatchery contribution,  $RC$  is the number of chinook released with an adipose fin clip for each tag code, and  $RUC$  is the number of chinook released without an adipose fin clip for each tag code.

These estimates of hatchery contributions, stratified by brood year ( $t$ ), river ( $r$ ), sex ( $i$ ) and tag code ( $tc$ ) can then be summed to give the hatchery contribution of all tag codes to the entire escapement:

$$EHC_{i,r,t} = \sum_{i=1}^n EHC_{t,i,r,tc} \quad (11)$$

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

Due to the potentially different ages at maturity of males and females, it is important that the allocation of adipose-clipped fish to tag codes be carried out separately by sex whenever possible. In this study, the sex of all fish sampled for CWTs was recorded so that it was possible to estimate the total escapement of tag codes by sex. Final hatchery contribution estimates were made for fish of Kitsumkalum origin only as there were no strays (from CWTs decoded) from other rivers in 1992.

Method B

In the second approach used to estimate the hatchery contribution, we estimated the number of successfully decoded CWT chinook in the escapement, stratified by river section and sex, using the methods described for the Mark Recovery Program (Kuhn et al. 1988). This method is currently used by DFO to estimate hatchery contributions in commercial and sport chinook catches. In contrast to Method A, the CWT samples were not weighted according to live and dead recovery sample size. Instead, the live and dead recovery data is pooled for the following reasons: 1) low number of CWT recoveries in each sample; 2) there was no reason to believe that tag codes have differing detectability in the live or dead samples; and 3) Method B does not rely on the AFC mark rate and, therefore, detectability of AFC's does not effect the results.

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 CWT) recoveries:

$$ADJ_{i,r,tc} = OBS_{i,r,tc} \cdot \left[ 1 + \frac{LP}{K} + \frac{ND \cdot (K + LP)}{K \cdot (K + LP + NP)} \right] \quad (12)$$

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 (CWT detected, but pin lost prior to reading),  $ND$  is the number of no data recoveries (adipose clip present, but head not taken; head taken and CWT present, but head lost or pin unreadable),  $NP$  is the number of no pin recoveries, and  $i$ ,  $r$ , and  $tc$  are subscripts denoting sex, river section, and tag code, respectively.

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

$$EST_{i,r,tc} = \frac{ADJ_{i,r,tc} \cdot P_{i,r}}{C_{i,r}} \quad (13)$$

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 section, and tag code, respectively.

This approach of estimating the number of CWT chinook in the escapement assumes that any adipose-clipped chinook found without CWTs were never marked. This assumption is only valid if chinook tagged with a particular tag code did not lose the CWT after release from the hatchery (i.e. after accounting for tag loss during a retention test). Since it has been demonstrated that 90% of tag (CWT) losses occur within four weeks of tagging (Blankenship 1990), any fish that have been released within this four-week period are likely to continue to have some tag loss prior to being recovered in the fishery or escapement. Violation of the assumption of no tag loss will result in a

negative bias in the hatchery contribution estimates. Other potential sources of bias using Method B are discussed in Bocking (1991<sup>a</sup>).

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

$$EHC_{i,r,tc} = \frac{EST_{i,r,tc} \cdot (RM_{tc} + RUM_{tc})}{RM_{tc}} \quad (14)$$

where *EHC* is the estimated hatchery contribution, *RM* is the number of chinook released with CWTs for each tag code, and *RUM* is the number of chinook released without CWTs for each tag code.

As for Method A, these estimates of hatchery contribution by tag code were then summed to give the hatchery contribution of all tag codes to the entire escapement, stratified by river section, sex and brood year:

$$EHC_{i,r,t} = \sum_{i=1}^n EHC_{i,i,r,tc} \quad (15)$$

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.

## RESULTS

### TAGGING

Numbers of chinook captured, tagged, and released during the 1992 tagging operations in the upper and lower Kitsumkalum River, by date, are presented in Appendix A.

A total of 1,456 chinook (892 males, 530 females, and 34 jacks) were tagged, operculum punched, and released in 1992 (Table 3). Of these, 669 were tagged in the upper river (390 males, 255 females, and 24 jacks) and 787 were tagged in the lower river (502 males, 275 females, and 10 jacks).

## RECOVERY

A summary of data collected during the carcass recovery operations is presented in Appendix B. The summary includes the total number of carcasses recovered, the number of tagged and/or punched recoveries, the number of carcasses that had lost the tag, and the number of recoveries with an adipose clip, by river section, sex, and date.

A total of 1,451 chinook carcasses (524 males, 918 females, and nine jacks) were examined during carcass recovery operations in 1992 (Table 3). Of the 710 carcasses recovered in the upper river (253 males, 450 females, and seven jacks) there were 59 total tag and/or punch recoveries (30 males, 28 females, and one jack). Of the 741 carcasses recovered in the lower river (271 males, 468 females, and two jacks), there were 99 total tag recoveries (43 males and 56 females).

A total tag rate (incidence) of 7.9% and 12.0% was achieved for the upper and lower Kitsumkalum, respectively (Table 4). Total tag recovery was 8.4% for the upper river and 11.3% for the lower river. In addition, the total tag loss rate was 25.4% for the upper river and 9.1% for the lower river. The high tag loss in the upper river could be a result of improper tag attachment by the upper river crew (for the most part, crews were separate and worked in either the upper or lower river). It is possible that a number of the tag-loss carcasses recovered in the lower river were tagged in the upper river and that the tag loss occurred during transport. A discussion of stray observations and the disproportionate number of males observed in the lower river is presented in the Discussion section of this report.

In this report, fish that were tagged and released in one section of river (upper or lower) and recovered in the other section are referred to as strays. In 1992, three chinook tagged in the lower river were recovered in the upper river. In contrast, 10 chinook (nine males and one female) that were tagged in the upper river were recovered in the lower river (Table 3).

## POPULATION ESTIMATES

Mark-recapture data, Petersen population estimates, and 95% confidence levels for chinook escapement to the Kitsumkalum River in 1992 are presented in Table 5. A single (one) tagged (punched only) jack chinook was recovered from the upper river in 1992. Because the adjusted Petersen method requires a minimum of three tag (or punch) recoveries to be valid (Ricker 1975, p. 79), jacks were omitted from the analysis.

The 1992 estimated total escapement of adult chinook to the total Kitsumkalum system (both sections of river) was 12,437. The lower and upper 95% confidence levels were 9,053 and 17,061, respectively. Total escapement included 6,602 to the upper Kitsumkalum and 5,835 to the lower Kitsumkalum.

## AGE, LENGTH, AND SEX COMPOSITION

Age-length distributions for adult male and female chinook salmon examined during the carcass recovery operations in the upper and lower Kitsumkalum River, 1992, are presented in Table 6. Age data for calculations are from both scale samples and CWT analysis; if an age discrepancy occurred for an individual specimen successfully aged by both scale and CWT analysis, the CWT age was used. Oceanic/freshwater age composition, calculated from scale samples only, is presented in Table 7. Petersen population estimates, stratified by age and sex, are presented in Table 8.

In 1992, age-4 to age-7 chinook were represented in the deadpitch with age-6 chinook comprising approximately 62% of the total run (Table 6). Age-5 and age-4 chinook represented another 37% and 1%, respectively. A single age-7 chinook, a male captured in the lower river, supplied the age-7 representation of 0.3% for the total river. In 1992, 87.7% of the scale-aged chinook had a freshwater age of 2 (Table 7).

Comparisons of the mean lengths (postorbital-hypural) of all (aged and unaged) adult male and female chinook, sampled from the deadpitch in 1992, produced the following results (Table 6):

- 1) in the upper river, adult males (mean = 851) had a smaller mean length than females (mean = 853); and
- 2) in the lower river, adult males (mean = 848) had a smaller mean length than females (mean = 850).

These differences in mean length were not statistically significant in both the upper river and the lower river (t-test,  $P > 0.5$  in both cases). Adult males from the upper river had a larger mean length than adult males from the lower river, but the difference was not significant (t-test,  $P > 0.5$ ). Female chinook from the upper river had a larger mean length than females from the lower river, but the difference was not significant (t-test,  $P > 0.5$ ).

A comparative analysis of the lengths of aged and unaged adult chinook from the upper and lower Kitsumkalum found no significant differences (t-tests) for either sex in either section of river:

- 1) Upper river
  - male ( $P > 0.2$ )
  - female ( $P > 0.2$ )
- 2) Lower river
  - male ( $P > 0.1$ )
  - female ( $P > 0.5$ )

Sex ratios were calculated using the Petersen population estimates for 1992 (Table 5). Calculations for males did not include jacks. The ratio of adult males to females was 0.63 for the upper river, 1.61 for the lower river, and 0.98 for the total river. A statistical comparison of the number (from Petersen estimates) of adult males and females from the total river (pooled population

estimates from both sections of river) found no significant difference from an expected ratio of 50:50 ( $\chi^2$ ,  $P > 0.25$ ). In contrast, significant differences in numbers (from the same expected ratio of 50:50) were found for the following comparisons ( $\chi^2$ ,  $P < 0.001$  in all cases):

- 1) upper river adult males and upper river females;
- 2) lower river adult males and lower river females;
- 3) upper river adult males and lower river adult males; and
- 4) upper river females and lower river females.

### **CODED WIRE TAGGING AND RECOVERY**

Coded wire tagged (adipose-clipped) juvenile chinook from the 1986 to 1991 brood years were sampled as adults in the dead recovery program in 1992. Heads from adipose-clipped chinook carcasses were collected for coded wire tag analysis.

The results of 1992 coded wire tag returns are presented below and include information on the following:

- 1) numbers of chinook captured, sacrificed, tagged (and released), and having an adipose clip, in the upper and lower Kitsumkalum River, by date (Appendix A);
- 2) chinook carcass recovery data, by date, for the upper and lower Kitsumkalum River (Appendix B);
- 3) estimates of the total escapement, and weighted estimate, of adipose-clipped adult male and female chinook to the upper, lower, and total Kitsumkalum River (Table 9);
- 4) the observed, adjusted, and estimated escapement of adipose-clipped adult male and female chinook to the upper and lower Kitsumkalum River, by tag code (Tables 10, 14, and 15);
- 5) CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1992 (Table 11);
- 6) estimates of total escapement of hatchery-reared adult male and female chinook to the upper and lower Kitsumkalum River, by tag code (Tables 12 and 16); and
- 7) the estimated hatchery contribution of adult male and female chinook to the upper, lower, and total Kitsumkalum River, by age (Tables 13 and 17).

During the 1992 live-tagging operations, a total of 26 adipose-clipped chinook were observed in the upper river and 15 were observed in the lower river (Table 9). During the carcass recovery

operations, a total of 30 adipose-clipped chinook were observed in the upper river and 22 were observed in the lower river. The combined (live tagging and carcass recovery) adipose-clip mark rates were 4.09% for the upper river and 2.41% for the lower river; these mark rates were significantly different ( $\chi^2$ ,  $P < 0.025$ ). The total estimated number of adipose-clipped adult male and female chinook (weighted average for live and dead) to the total river was 407 (274 to the upper river and 133 to the lower river); this estimate comprises 3.3% of the total escapement estimate.

#### Hatchery Contributions - Method A

The estimated total escapements of each CWT group decoded in 1992 are shown in Table 10. An adjusted estimate of these escapements (expanded by adipose-clip release data presented in Table 11) is presented in Table 12. All of the CWT chinook decoded in 1992 were of Kitsumkalum origin; thus, the estimated number of strays from other hatcheries were not included in these analyses. A total of 51 CWT heads from adipose-clipped chinook recovered in 1992 were successfully decoded (Table 10).

Using Method A, the 1992 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 469 fish (186 adult males and 283 females) (Table 12).

The proportions of hatchery contributions to the total escapement, by river section, age, and sex, are presented in Table 13. Using Method A, the percentage hatchery contribution to total chinook escapement in 1992 was estimated to be 3.8% (3.0% for adult males and 4.5% for females).

#### Hatchery Contributions - Method B

The adjusted, estimated, and expanded numbers of hatchery-reared chinook, by tag code, river section, and sex, as calculated by Method B, are presented in Tables 14, 15, and 16, respectively. The 1992 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 454 fish (178 adult males and 276 females) (Table 16).

The proportions of hatchery contributions to the total escapement, by river section, age, and sex, are presented in Table 17. Using Method B, the percentage hatchery contribution to total chinook escapement in 1992 was estimated to be 3.6% (2.9% for adult males and 4.4% for females).

## DISCUSSION

### POPULATION ESTIMATION

Previous studies of chinook escapement to the Kitsumkalum River have shown that several factors can bias the population estimates generated from the Petersen model (Andrew and Webb 1988,

Carolsfeld et al. 1990). In particular, these studies illustrated that it is necessary to stratify the data by river section and sex in order to eliminate or minimize the effects of differential tagging and tag recovery between sexes and river sections. This report followed the stratification procedures outlined earlier to generate separate population estimates.

A Petersen estimate for the population of jack chinook in 1992 could not be produced because only one of the 32 tagged and opercular-punched jacks was recovered; the minimum number of tagged recaptures required by the Petersen method is three (for a 95% confidence level; Ricker 1975, p. 79). For comparative purposes, the lack of a population estimate for jacks does not create difficulties because past studies have also stratified population estimates; thus, 1992 population estimates of adult male and female chinook can be compared with population estimates from past studies. The 1992 adult male and female Petersen population estimate of chinook salmon escapement to the total Kitsumkalum River was 12,437, which is a 34% increase over the 1991 adult male and female population estimate (9,288). Adult male and female population estimates for 1989 and 1990 (17,921 and 17,408, respectively) are 31% and 29% (respectively) higher than the 1992 estimate (both estimates from stratified data; Nass and Bocking 1992). The 1987 and 1988 adult male and female population estimates (23,727 and 22,587, respectively) are 48% and 45% (respectively) higher than the 1992 estimate (both estimates from stratified data; Carolsfeld et al. 1990).

In 1992, the number of strays from the upper to the lower river was 10 (nine males and one female); the number of strays from the lower to the upper river was three (two males and one female). The frequency of straying (both sexes) was not significantly different between the two sections of river ( $\chi^2$ ,  $P > 0.5$ ). Although the proportion of the 1992 upper-to-lower strays that were male is high (90%), the difference is not significant ( $\chi^2$ ,  $0.1 > P > 0.05$ ). Similarly, there was no significant difference in the proportions of male to female strays to the upper river ( $\chi^2$ ,  $P > 0.5$ ) or for both sections of river ( $\chi^2$ ,  $0.1 > P > 0.05$ ). The high proportion of strays from the upper to the lower river that are male is similar to the proportions observed in 1987, 1988, and 1991 (72%, 82%, and 85%, respectively; Carolsfeld et al. 1990; Nelson 1993). The high proportion of males that strayed from the upper to the lower river in 1992 is likely the result of behavioral differences between the sexes, in that males tend to return to the main river channel after spawning and are thus more likely to be carried downstream with the current (Andrew and Webb 1988).

Confidence intervals for the Petersen estimates varied by sex and river section. The lower and upper confidence limits for the total adult male and female population estimate of chinook (12,437) were within 27.2% and 37.2%, respectively, of the population estimate. These limits are higher than the 25% accuracy recommended for salmon management purposes (Ricker 1975), which would indicate that increased tagging and recovery efforts are needed.

## AGE, LENGTH, AND SEX COMPOSITION

Age-6 chinook represented the largest percentage (62%) of the escapement to the total Kitsumkalum River in 1992. Age-5 chinook represented the next largest contribution (37%). These findings are consistent with prior investigations (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992, Nelson 1993). The low representation of age-7 chinook (0.3%) in 1992 is consistent only with the 1987 estimate of age-7 escapement (0.0%; Carolsfeld et al., 1990).

Estimates of the proportions of age-7 chinook in the 1988-91 escapements are as follows: 1988, 2.0%; 1989, 2.0%; 1990, 0.9%; 1991, 14.4% (Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993).

Mean postorbital-hypural lengths of adult male and female chinook were compared within and between river sections in order to quantify the likelihood of distinctly separate populations. In 1992, no significant differences (t-tests,  $P > 0.5$  in all cases) in mean lengths were found:

- 1) between sexes in the same section of river (both upper and lower);
- 2) between like sexes in different sections of river (both male and female); and
- 3) between aged and unaged specimens (both sexes in both sections of river).

Therefore, a mean length and standard deviation (in mm), calculated from pooled data from all aged and unaged adult male and female chinook from both the upper and lower river, would provide a valid length representation of the 1992 escapement of adult male and female chinook to the total river ( $n = 1375$ ; mean = 850; SD = 84). A length representation for the total Kitsumkalum River was not calculated in 1989, 1990 and 1991 due to statistically significant differences between various combinations of sex and stratum (Nass and Bocking 1992; Nelson 1993). Stratified mean lengths of aged and unaged adult male and female chinook in the upper and lower Kitsumkalum River in 1992 did not vary more than  $\pm 17$  mm from respective 1991 mean lengths.

Adult males (49.5%) represented a slightly smaller proportion of the total escapement compared to females (50.5%) in 1992. These proportional contributions are very close to 50:50, and there was no significant difference in the actual numbers of all adult males and females (pooled population estimates from both sections of river;  $\chi^2$ ,  $P > 0.25$ ). Previous studies have shown higher variability in sex ratios, both within and between years (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993). The 1992 sex ratios exhibit a higher proportion of adult males to females than in 1989, 1990, and 1991 (1989 adult males 45.1%, females 54.9%; 1990 adult males 42.3% females 57.7%; 1991 adult males 48.3%, females 51.7%).

A between-year comparison of the proportions of all males (jacks included) and females in 1989 and 1990 exhibited high variability (1989 males 46.2%, females 53.89%; 1990 males 52.2%, females 47.8%). These comparisons were possible in 1989 and 1990 because population estimates were calculated for jacks. The estimated number of jacks in 1990 (3631) was a magnitude greater than the estimated number of jacks in 1989 (366). When the highly variant number of jacks is removed from the comparison, annual proportions of adult males and females can be compared to better indicate between-year trends and changes in sex ratios.

#### CODED WIRE TAGGING AND RECOVERY

Two methods (A and B) were employed in this study to estimate hatchery contribution to total chinook escapement. Method A applies the AFC rate at release and a weighted (by numbers observed in live tagging and carcass recovery operations) adipose clip rate at return to the estimated

escapement. Method B applies the CWT rate at release to the estimated escapement of chinook possessing a CWT (combined decoded CWT data from live tagging and carcass recovery operations). Sampling for adipose-clipped fish was random. The total mark rate (incidence) at recovery was 3.6% in 1992.

Estimates of percent hatchery contribution to total Kitsumkalum River chinook escapement in 1992 were similar using Method A (AFC rate) and Method B (CWT rate). Method A produced a slightly higher hatchery contribution estimate for the total river (3.8%) than Method B (3.6%). Potential reasons for the differences in the estimates are discussed in Bocking (1991<sup>b</sup>). Both of the 1992 hatchery contribution estimates (Methods A and B) are higher than any of those estimated for 1989, 1990, and 1991:

Percent hatchery contribution estimates to total Kitsumkalum River chinook escapement

<u>Year</u>	<u>Method A</u>	<u>Method B</u>
1989	3.0%	2.7%
1990	2.3%	2.1%
1991	1.4%	1.2%
1992	3.8%	3.6%

Although we have tried to address as many potential sources of bias as possible in the estimation of the escapement of adipose-clipped and CWTs (decoded) described above, we have not explicitly included the following factors:

- 1) the low number of recoveries of adipose clips and decoded CWTs likely make the precision of the estimates so low as to be of relatively little use for those brood years; and
- 2) the sample of heads obtained for the decoding of CWTs may not be a random sample from the population and might contain a bias due to size selectivity or other factors (Bocking 1991<sup>b</sup>).

We have not formally estimated the level of precision of the estimates of escapement by adipose-clipped fish and individual tag codes; potential sources of bias could cause the estimates to be misleading. An approximation of the level of precision can be obtained by examining the number of adipose clips/CWT recoveries on which a given estimate is based. Based on a Poisson frequency distribution, 65 recoveries would produce upper and lower 95% confidence limits within approximately  $\pm 25\%$  of the population estimate (the maximum recommended bounds for salmon management purposes; Ricker 1975). In 1992, a total of 69 (observed) adipose clips and 51 CWTs (decoded) were observed during the live tagging and carcass recovery operations.

In 1992, crews examined 11.7% of the estimated population of adult male and female chinook for adipose clips during live tagging operations and 11.6% of the estimated population during carcass recovery operations. These examination levels are consistent with those in past years; tagging and recovery effort has remained fairly consistent since 1987.

## SUMMARY

1. The 1992 total Kitsumkalum River escapement estimate of adult male and female chinook salmon, calculated using a combination of live tagging and carcass recovery data, was 12,437. This estimate is the summation of individual Petersen estimates stratified by river section (upper and lower) and sex. Jack chinook were not included in the total population estimate as the low number (one) of tagged/punched recoveries precluded a Petersen population estimate for their segment of the total population.
2. The 1992 escapement of adult male and female chinook was represented by age-4 to age-7 fish. Age-6 chinook comprised the largest portion of the escapement (62%), followed by age-5 (37%), age-4 (1%) and age-7 (0.3%). The proportional representation of age-7 chinook is the lowest since 1987.
3. Mean postorbital-hypural lengths of adult male and female chinook were compared within and between river sections in order to quantify the likelihood of distinctly separate populations. In 1992, no significant differences (t-tests,  $P > 0.5$  in all cases) in mean lengths were found:
  - a) between sexes in the same section of river (both upper and lower);
  - b) between like sexes in different sections of river (both male and female); and
  - c) between aged and unaged specimens (both sexes in both sections of river).

As no statistically significant differences were revealed in the above comparisons, a valid mean length of 850 mm was calculated (from pooled data) for the 1992 total Kitsumkalum River escapement of adult male and female chinook.

4. A statistical comparison of the number (from Petersen estimates) of adult males and females from the total river (pooled population estimates from both sections of river) found no significant difference from an expected ratio of 50:50 ( $\chi^2$ ,  $P > 0.25$ ). In contrast, significant differences in numbers (from the same expected ratio of 50:50) were found for the following comparisons ( $\chi^2$ ,  $P < 0.001$  in all cases):
  - a) upper river adult males and upper river females;
  - b) lower river adult males and lower river females;
  - c) upper river adult males and lower river adult males; and
  - d) upper river females and lower river females.
5. The total estimated escapement of adipose-clipped adult male and female chinook to the total Kitsumkalum River in 1992 was 407 (3.3% of the total escapement estimate).

6. Using the Key Stream approach (Method A), the total estimated hatchery contribution to the total escapement of adult male and female chinook was 469 fish (3.8% of the total escapement estimate). Using the Mark Recovery Program approach (Method B), the total estimated hatchery contribution to the total escapement of adult male and female chinook was 454 fish (3.6% of the total escapement estimate).

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#### REFERENCES

- Andrew, J. H. and T. M. Webb. 1988. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Kitsumkalum River, 1984-1986. *Can. MS Rep. Fish. Aquat. Sci.* 2004: vii + 62 p.
- Andrew, J. H., M. Lightly, and T. M. Webb. 1988. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1985. *Can. Man. Rep. Fish. Aquat. Sci.* 2007: 46 p.
- Armstrong, R. W. and A. W. Argue. 1977. Trapping and coded wire tagging of wild coho and chinook juveniles from the Cowichan River system, 1975. *Fish. Mar. Serv., Tech. Rep. Ser. PAC/T-77-14*: 58 p.
- Blankenship, H. L. 1990. Effects of time and fish size on coded wire tag loss from chinook and coho salmon. *Proceedings of the First International Symposium on Fish Marking Techniques*. Seattle, Washington. June 1988.
- Bocking, R. C. 1991<sup>a</sup>. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1989-1990. *Can. MS. Rep. Fish. Aquat. Sci.* 2124: x + 109 p.

- Bocking, R. C. 1991<sup>b</sup>. Stamp Falls Fishway counts, adipose clip/CWT recovery and biological sampling of chinook salmon escapements in Stamp River and Robertson Creek Hatchery, 1990. Can. Tech. Rep. Fish. Aquat. Sci. 1815: x + 92 p.
- Bocking, R. C., K. K. English, and T. M. Webb. 1990. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1986-1988. Can. MS Rep. Fish. Aquat. Sci. 2065: 126 p.
- Carolsfeld, J., K. K. English, P. Frank, and T. M. Webb. 1990. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Kitsumkalum River, 1987-1988. Can. MS Rep. Fish. Aquat. Sci. 2074: viii + 54 p.
- Gilbert, C. H. and W. H. Rich. 1927. Investigations concerning the red salmon runs to the Karluk River, Alaska. Bull. U.S. Bus. Fish. 43(2): 1-69 (Doc. No 991).
- Hancock, M. J., A. J. Leaney-East, and D. E. Marshall. 1983. Catalogue of salmon streams and spawning escapement of statistical area 4 (lower Skeena River) including coastal streams. Can. Data Rep. Fish. Aquat. Sci. 395. xii + 422 p.
- Kuhn, B. R. 1988. The MRP-Reporter Program: A data extraction and reporting tool for the Mark Recovery Program Database. Can. Tech. Rep. Fish. Aquat. Sci. 1625: 145 p.
- Nass, B. L. and R. C. Bocking. 1992. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements to the Kitsumkalum River, 1989-1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2147: ix + 62 p.
- Nelson, T. C. 1993. Abundance, age, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2182: viii + 43 p.
- Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

Table 2. Summary of live tagging and carcass recovery effort for chinook salmon in the Kitsumkalum River, 1992.

Location	Tagging period	Effort (days)	Carcass recovery period	Effort (days)
Upper river (a)	Aug 24 - Sep 8	11	Aug 24; Sep 8 - Oct 7	18
Lower river (b)	Aug 20 - Sep 8	13	Aug 22 - Oct 8	21

(a) Upper river includes sampling reaches 1 through 18; see Figure 1

(b) Lower river includes sampling reaches 19 through 31; see Figure 1

Table 3. Live tagging and carcass recovery statistics for chinook salmon in the upper and lower Kitsumkalum River, 1992.

Category	Upper river	Lower river	Total
<b>Live tagging (a)</b>			
Males examined	390	502	892
Females examined	276	292	568
Jacks examined	24	10	34
Total examined	690	804	1494
Males tagged/punched	390	502	892
Females tagged/punched	255	275	530
Jacks tagged/punched	24	10	34
Total tagged/punched	669	787	1456
<b>Dead recovery (b)</b>			
Males examined	253	271	524
Females examined	450	468	918
Jacks examined	7	2	9
Total examined	710	741	1451
Punched-only males (c)	8	6	14
Punched-only females (c)	6	3	9
Punched-only jacks (c)	1	0	1
Total punched only (c)	15	9	24
Tagged/punched males (d)	30	43	73
Tagged/punched females (d)	28	56	84
Tagged/punched jacks (d)	1	0	1
Total tagged/punched (d)	59	99	158
<b>Strays (e)</b>			
Stray males	2	9	11
Stray females	1	1	2
Stray jacks	0	0	0
Total strays	3	10	13

(a) See Appendix A for numbers of live chinook captured, tagged, and released, by date

(b) See Appendix B for numbers of chinook carcasses recovered, by date

(c) Operculum-punched carcasses (No. TL from Appendix B); indicates tag loss

(d) Tagged recoveries include all operculum-punched carcasses (No. tag from Appendix B)

(e) For the purpose of this analysis, strays are defined as fish tagged and/or punched in one section of the river (upper or lower) and recovered in the other section

Table 4. Tag rate (incidence), tag recovery rate, and tag loss rate for the live tagging and carcass recovery operations in the upper and lower Kitsumkalum River, 1992.

Category	Upper river	Lower river	Total
<u>Tag rate (a)</u>			
Male tag rate (%)	11.1	12.5	11.8
Female tag rate (%)	6.0	11.8	8.9
Jack tag rate (%)	14.3	0.0	11.1
Total tag rate (%)	7.9	12.0	10.0
<u>Tag recovery rate (b)</u>			
Male tag recovery rate (%)	7.2	6.8	7.0
Female tag recovery rate (%)	10.6	20.0	15.5
Jack tag recovery rate (%)	4.2	0.0	2.9
Total tag recovery rate (%)	8.4	11.3	10.0
<u>Tag loss rate (c)</u>			
Male tag loss rate (%)	26.7	14.0	19.2
Female tag loss rate (%)	21.4	5.4	10.7
Jack tag loss rate (%)	100.0	0.0	100.0
Total tag loss rate (%)	25.4	9.1	15.2

From Table 3:

- (a) Tag rate = ((No. tagged in dead recovery - No. strays in dead recovery) / total No. in dead recovery) \* 100  
 (b) Tag recovery rate = ((No. tagged in dead recovery - No. strays in dead recovery) / No. live tagged) \* 100  
 (c) Tag loss rate = (No. in dead recovery with punch only / No. in dead recovery with punch and tag) \* 100

Table 5. Petersen population estimates, confidence limits, and enumeration data for chinook salmon escapement to the Kitsumkalum River based on *in situ* live chinook tagging and recovery of carcasses, 1992. Confidence limits are from fiducial limits for the Poisson distribution using Pearson's formulae when R is greater than 50 (Ricker 1975, p. 343). Unsexed chinook were omitted from the analysis.

Location	Male	Female	Jack (g)	Total
<b>Upper river</b>				
Number tagged (a)	390	255	24	669
Number recovered (b)	253	450	7	710
Number of tagged fish recovered (c)	30	28	1	59
Number of tagged strays from lower river (d)	2	1	0	3
Expanded No. of tagged strays from lower river (e)	26	9	0	35
Number of tagged fish for Petersen estimate (f)	311	259	24	594
Petersen estimate	2556	4047	N/A	6602 (h)(i)
Lower 95% CL	1808	2829	N/A	4637 (i)
Upper 95% CL	3600	5762	N/A	9362 (i)
<b>Lower river</b>				
Number tagged (a)	502	275	10	787
Number recovered (b)	271	468	2	741
Number of tagged fish recovered (c)	43	56	0	99
Number of tagged strays from upper river (d)	9	1	0	10
Expanded No. of tagged strays from upper river (e)	105	5	0	110
Number of tagged fish for Petersen estimate (f)	581	271	10	862
Petersen estimate	3598	2236	N/A	5835 (h)(i)
Lower 95% CL	2687	1729	N/A	4416 (i)
Upper 95% CL	4809	2889	N/A	7699 (h)(i)
<b>Total river</b>				
Petersen estimate	6154	6283	N/A	12437
Lower 95% CL	4495	4559	N/A	9053 (h)
Upper 95% CL	8410	8651	N/A	17061

(a) Total live tagged/punched (Appendix A)

(b) Total dead recoveries (tagged/punched and untagged/unpunched); Appendix B

(c) Total dead recoveries possessing a tag and/or punch (Appendix B)

(d) Total dead recoveries possessing a tag and/or punch applied in the other section of river

(e) Expanded strays = No. of strays from other section \* (No. tagged/punched in section / No. tagged/punched dead recoveries)

(f) Number of tagged fish for Petersen estimate = No. tagged/punched in section + expanded No. of tagged/punched strays into section - expanded No. of tagged/punched strays out of other section

(g) N/A = not available; due to the low number (1) of tagged/punched jacks recovered, it is not possible to calculate a Petersen estimate for their segment of the population

(h) Summation is a result of rounding

(i) These totals do not include jacks; see footnote (g) above

Table 6. Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1992. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (c)	Total age (years)													
	Male (a)							Female (b)						
	4	5	6	7	Total aged	Total unaged	Total aged + unaged	4	5	6	7	Total aged	Total unaged	Total aged + unaged
<u>Upper river</u>														
400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500-549	0	0	0	0	0	2	2	0	0	0	0	0	0	0
550-599	1	0	0	0	1	2	3	0	0	0	0	0	0	0
600-649	1	1	0	0	2	5	7	0	0	0	0	0	1	1
650-699	0	2	0	0	2	4	6	0	0	1	0	1	0	1
700-749	0	8	0	0	8	8	16	0	2	0	0	2	9	11
750-799	0	5	1	0	6	21	27	0	3	0	0	3	22	25
800-849	0	5	2	0	7	18	25	0	19	11	0	30	82	112
850-899	0	4	8	0	12	32	44	0	11	35	0	46	142	188
900-949	0	2	10	0	12	60	72	0	1	28	0	29	60	89
950-999	0	0	8	0	8	30	38	0	0	2	0	2	2	4
1000-1049	0	0	4	0	4	1	5	0	0	0	0	0	0	0
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	27	33	0	62	183	245	0	36	77	0	113	318	431
Percent (aged)	3.2	43.5	53.2	0.0	100.0			0.0	31.9	68.1	0.0	100.0		
Mean (c)	585	773	933	0	843	858	851	0	824	874	0	858	854	853
SD	49	75	40	0	105	99	114	0	41	41	0	47	46	62

(a) Does not include jacks

(b) Included in this analysis are two CWT-aged females captured during the live tagging operation and sacrificed for broodstock

(c) Postorbital-hypural length

Table 6 (cont.). Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1992. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (c)	Total age (years)													
	Male (a)							Female (b)						
	4	5	6	7	Total aged	Total unaged	Total aged + unaged	4	5	6	7	Total aged	Total unaged	Total aged + unaged
<u>Lower river</u>														
400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500-549	0	0	0	0	0	3	3	0	0	0	0	0	0	0
550-599	1	1	0	0	2	4	6	0	0	0	0	0	0	0
600-649	0	0	0	0	0	7	7	0	0	0	0	0	0	0
650-699	0	1	0	0	1	4	5	0	0	0	0	0	0	0
700-749	0	5	0	0	5	17	22	0	0	0	0	0	9	9
750-799	0	3	0	0	3	29	32	0	8	3	0	11	36	47
800-849	0	8	3	0	11	25	36	0	11	14	0	25	97	122
850-899	0	4	3	0	7	28	35	0	8	35	0	43	144	187
900-949	0	0	8	0	8	53	61	0	0	11	0	11	53	64
950-999	0	0	1	0	1	45	46	0	0	0	0	0	11	11
1000-1049	0	0	0	1	1	5	6	0	0	0	0	0	0	0
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	22	15	1	39	220	259	0	27	63	0	90	350	440
Percent (aged)	2.6	56.4	38.5	2.6	100.0			0.0	30.0	70.0	0.0	100.0		
Mean (c)	580	783	899	1040	829	855	848	0	823	863	0	851	852	850
SD	0	72	47	0	98	109	120	0	37	35	0	40	51	63

(a) Does not include jacks

(b) Included in this analysis are two CWT-aged females captured during the live tagging operation and sacrificed for broodstock

(c) Postorbital-hypural length

Table 7. Freshwater age composition of deadpitch Kitsumkalum River chinook salmon, 1992. (a)

Location	Age (c)	Male (b)		Female	
		N	Percent	N	Percent
<u>Upper river</u>					
	41	0	0.0	0	0.0
	42	2	3.3	0	0.0
	51	11	18.0	12	11.8
	52	15	24.6	14	13.7
	61	0	0.0	0	0.0
	62	33	54.1	76	74.5
	71	0	0.0	0	0.0
	72	0	0.0	0	0.0
	Total	61	100.0	102	100.0
<u>Lower river</u>					
	41	0	0.0	0	0.0
	42	1	2.9	0	0.0
	51	3	8.6	9	10.3
	52	15	42.9	15	17.2
	61	0	0.0	0	0.0
	62	15	42.9	63	72.4
	71	0	0.0	0	0.0
	72	1	2.9	0	0.0
	Total	35	100.0 (d)	87	100.0 (d)

(a) Age composition was calculated using scale samples only

(b) Does not include jacks

(c) Ages are presented in the format of Gilbert and Rich (1927), whereby each digit represents the year of life for total age and freshwater age, respectively; for example, age 41 indicates the fish is in its fourth year of life and left freshwater for ocean rearing during its first year of life

(d) Summation is a result of rounding

Table 8. Petersen estimates, by age, of chinook salmon escapement to the Kitsumkalum River, 1992.

Total age	Male (a)		Female	
	Number (b)	Percent (c)	Number (b)	Percent (c)
<u>Upper river</u>				
4	82	3.2	0	0.0
5	1112	43.5	1291	31.9
6	1360	53.2	2756	68.1
7	0	0.0	0	0.0
Total	2556 (d)	100.0 (d)	4047	100.0
<u>Lower river</u>				
4	94	2.6	0	0.0
5	2029	56.4	671	30.0
6	1385	38.5	1565	70.0
7	94	2.6	0	0.0
Total	3598 (d)	100.0 (d)	2236	100.0

(a) Does not include jacks

(b) Age representation is calculated by applying the respective proportions observed in the deadpitch age-length distribution (Table 6) to the Petersen estimates (Table 5)

(c) From Table 6

(d) Summation is a result of rounding

Table 9. Estimates of the total escapement, and weighted estimate, of adipose-clipped chinook salmon to the upper, lower, and total Kitsumkalum River, 1992.

Location and sex	Live tagging			Dead recovery			Petersen population estimate (c) G	Total estimated adipose clips		Weighted estimate of adipose clips J (d)
	Sample size (a)	Observed adipose clips	Mark rate (%)	Sample size (b)	Observed adipose clips	Mark rate (%)		Live tagging	Dead recovery	
	A	B	C=B/A*100	D	E	F=E/D*100		H=C/100*G	I=F/100*G	
<u>Upper river</u>										
Male (e)	390	13	3.33	253	11	4.35	2556	85	111	95
Female	276	13	4.71	450	19	4.22	4047	191	171	178
Subtotal	666	26	3.90	703	30	4.27	6602	276	282	274
<u>Lower river</u>										
Male (e)	502	7	1.39	271	7	2.58	3598	50	93	65
Female	292	8	2.74	468	15	3.21	2236	61	72	68
Subtotal	794	15	1.89	739	22	2.98	5835	111	165	133
<u>Total river</u>										
Male (e)	892	20	2.24	524	18	3.44	6154	135	204	161
Female	568	21	3.70	918	34	3.70	6283	252	243	246
Total	1460	41	2.81	1442	52	3.61	12437	387	447	407

(a) Sample size for estimating adipose clip rates in the live tagging includes all fish captured minus recaptures (Appendix A)

(b) Sample size for estimating adipose clip rates in the dead recovery includes all fish examined (Appendix B)

(c) From Table 5

(d)  $J = ((A * H) + (D * I)) / (A + D)$

(e) Does not include jacks; see Table 5, footnote (g)

Table 10. Estimates of total escapement of adipose-clipped chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1992. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 12 (Method A).

Brood year	CWT code	Upper river (a)				Lower river (a)			
		Decoded adipose clips		Estimated adipose clips		Decoded adipose clips		Estimated adipose clips	
		M (b)	F	M (b)	F	M (b)	F	M (b)	F
1987	24941	2	3	19.0	26.7	0	0	0.0	0.0
	24942	1	4	9.5	35.6	6	6	55.7	29.1
	24943	0	2	0.0	17.8	0	0	0.0	0.0
	24944	2	4	19.0	35.6	1	5	9.3	24.3
	25060	1	4	9.5	35.6	0	0	0.0	0.0
	25661	4	2	38.0	17.8	0	0	0.0	0.0
	Subtotal	10	19	95.0	169.1	7	11	65.0	53.4
1986	24411	0	1	0.0	8.9	0	1	0.0	4.9
	24412	0	0	0.0	0.0	0	1	0.0	4.9
	24637	0	0	0.0	0.0	0	1	0.0	4.9
	Subtotal	0	1	0.0	8.9	0	3	0.0	14.6
	Total CWT (c)	10	20	95.0	178.0	7	14	65.0	68.0
	No data (5000)	12	12			7	6		
	No pin (8000)	0	0			0	1		
	Lost pin (9000)	0	0			0	0		
	Observed adipose (d)	22	32			14	21		

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

(b) Does not include jacks

(c) Total estimated adipose clips from Table 9 (weighted estimate of adipose clips)

(d) Includes observed adipose clips from live tagging and dead recovery; in 1992, four operculum-tagged and adipose-clipped chinook were observed in the carcass recovery operations (two males from the upper river and two females from the lower river); although these adipose clips were observed twice (see Table 9), they are included only once in this analysis; in addition, two adipose-clipped females, captured during live tagging operations and sacrificed for broodstock, were successfully decoded and included in this analysis

Table 11. CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1992.

Brood year	CWT release group	Release numbers		CWT loss (%)	Days held	Adipose release status	
		CWT	Untagged			Clipped	Unclipped
1987	24941	27021	133	0.5	1	27157	0
	24942	26570	460	1.7	1	27030	0
	24943	25262	8555	0.8	1	25466	8351
	24944	26423	362	1.4	1	26798	0
	25060	27522	14994	0.0	1	27522	14994
	25061	27475	14993	0.0	1	27475	14993
1986	24411	25221	4747	0.7	1	25399	4569
	24412	26784	0	0.0	1	26784	0
	24637	12303	99	0.8	1	12402	0
Total hatchery		224581	44343			226032	42908

Table 12. Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1992. The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 10) to account for unclipped hatchery releases and hence to derive hatchery contributions to escapement.

Brood year	CWT release group	Adipose release (b)		Expansion factor (c)	Expanded hatchery contribution (a)(e)			
		Clipped	Unclipped		Upper river		Lower river	
					M (d)	F	M (d)	F
1987	24941	27157	0	1.00	19.0	26.7	0.0	0.0
	24942	27030	0	1.00	9.5	35.6	55.7	29.1
	24943	25466	8351	1.33	0.0	23.6	0.0	0.0
	24944	26798	0	1.00	19.0	35.6	9.3	24.3
	25060	27522	14994	1.54	14.7	55.0	0.0	0.0
	25061	27475	14993	1.55	58.7	27.5	0.0	0.0
	Subtotal				120.9	204.0	65.0	53.4
1986	24411	25399	4569	1.18	0.0	10.5	0.0	5.7
	24412	26784	0	1.00	0.0	0.0	0.0	4.9
	24637	12402	0	1.00	0.0	0.0	0.0	4.9
	Subtotal				0.0	10.5	0.0	15.4
Total hatchery					120.9	214.5	65.0	68.9

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

(b) From Table 11

(c) Expansion factor = (adipose-clipped + unclipped releases) / adipose-clipped releases

(d) Does not include jacks

(e) Calculated from estimated adipose clips in Table 10

Table 13. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1992. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 12).

Total age	Estimated escapement (b)		Hatchery contribution (a)			
			Male (c)		Female	
	Male (c)	Female	Number	Percent	Number	Percent
<u>Upper river</u>						
4	82	0	0.0	0.0	0.0	0.0
5	1112	1291	120.9	10.9	204.0	15.8
6	1360	2756	0.0	0.0	10.5	0.4
7	0	0	0.0	0.0	0.0	0.0
Subtotal	2556 (d)	4047	120.9	4.7	214.5	5.3
<u>Lower river</u>						
4	94	0	0.0	0.0	0.0	0.0
5	2029	671	65.0	3.2	53.4	8.0
6	1385	1565	0.0	0.0	15.4	1.0
7	94	0	0.0	0.0	0.0	0.0
Subtotal	3598 (d)	2236	65.0	1.8	68.8	3.1
<u>Total river</u>						
4	176	0	0.0	0.0	0.0	0.0
5	3141	1962	185.9	5.9	257.4	13.1
6	2745	4321	0.0	0.0	25.9	0.6
7	94	0	0.0	0.0	0.0	0.0
Total	6154	6283	185.9	3.0	283.3	4.5

(a) From Table 12

(b) From Table 8

(c) Does not include jacks

(d) Summation is a result of rounding

Table 14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1992. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 15 (Method B).

Brood year	CWT code	Upper river (a)				Lower river (a)			
		Decoded adipose clips (b)		Adjusted CWTs		Decoded adipose clips (b)		Adjusted CWTs	
		M (c)	F	M (c)	F	M (c)	F	M (c)	F
1987	24941	2	3	4.4	4.8	0	0	0.0	0.0
	24942	1	4	2.2	6.4	6	6	12.0	8.4
	24943	0	2	0.0	3.2	0	0	0.0	0.0
	24944	2	4	4.4	6.4	1	5	2.0	7.0
	25060	1	4	2.2	6.4	0	0	0.0	0.0
	25661	4	2	8.8	3.2	0	0	0.0	0.0
	Subtotal	10	19	22.0	30.4	7	11	14.0	15.4
1986	24411	0	1	0.0	1.6	0	1	0.0	1.4
	24412	0	0	0.0	0.0	0	1	0.0	1.4
	24637	0	0	0.0	0.0	0	1	0.0	1.4
	Subtotal	0	1	0.0	1.6	0	3	0.0	4.2
Total CWT		10	20	22.0	32.0	7	14	14.0	19.6
No data (5000)		12	12			7	6		
No pin (8000)		0	0			0	1		
Lost pin (9000)		0	0			0	0		
Observed adipose (d)		22	32			14	21		

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

(b) From Table 10

(c) Does not include jacks

(d) Includes observed adipose clips from live tagging and dead recovery; in 1992, four operculum-tagged and adipose-clipped chinook were observed in the carcass recovery operations (two males from the upper river and two females from the lower river); although these adipose clips were observed twice (see Table 9), they are included only once in this analysis; in addition, two adipose-clipped females, captured during live tagging operations and sacrificed for broodstock, were successfully decoded and included in this analysis

Table 15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1992. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 16 (Method B).

Brood year	CWT code	Upper river (a)				Lower river (a)			
		Adjusted CWTs (b)		Estimated CWTs		Adjusted CWTs (b)		Estimated CWTs	
		M (c)	F	M (c)	F	M (c)	F	M (c)	F
1987	24941	4.4	4.8	17.5	26.8	0.0	0.0	0.0	0.0
	24942	2.2	6.4	8.7	35.7	12.0	8.4	55.9	24.7
	24943	0.0	3.2	0.0	17.8	0.0	0.0	0.0	0.0
	24944	4.4	6.4	17.5	35.7	2.0	7.0	9.3	20.6
	25060	2.2	6.4	8.7	35.7	0.0	0.0	0.0	0.0
	25661	8.8	3.2	35.0	17.8	0.0	0.0	0.0	0.0
	Subtotal	22.0	30.4	87.5	169.5	14.0	15.4	65.2	45.3
1986	24411	0.0	1.6	0.0	8.9	0.0	1.4	0.0	4.1
	24412	0.0	0.0	0.0	0.0	0.0	1.4	0.0	4.1
	24637	0.0	0.0	0.0	0.0	0.0	1.4	0.0	4.1
	Subtotal	0.0	1.6	0.0	8.9	0.0	4.2	0.0	12.4
	Total CWT	22.0	32.0	87.5	178.4	14.0	19.6	65.2	57.7
	Escapement est. (d)	2556	4047			3598	2236		
	Sample size (e)	643	726			773	760		

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

(b) From Table 14

(c) Does not include jacks

(d) Petersen estimate from Table 5

(e) Sample size = total live recovery + total dead recovery (from Table 9)

(f) Summation is a result of rounding

Table 16. Estimates of total escapement of hatchery-reared chinook salmon (Method B) to the upper and lower Kitsumkalum River, by tag code, 1992. The expansion factor is used to expand the estimated CWT chinook in the escapement to account for untagged hatchery releases and hence to derive hatchery contributions to escapement.

Brood year	CWT release group	Release numbers (b)		Expansion factor (c)	Expanded hatchery contribution (a)(e)			
		CWT	untagged		Upper river		Lower river	
					M (d)	F	M (d)	F
1987	24941	27021	133	1.00	17.6	26.9	0.0	0.0
	24942	26570	460	1.02	8.9	36.3	56.8	25.1
	24943	25262	8555	1.34	0.0	23.9	0.0	0.0
	24944	26423	362	1.01	17.7	36.2	9.4	20.9
	25060	27522	14994	1.54	13.5	55.1	0.0	0.0
	25061	27475	14993	1.55	54.1	27.6	0.0	0.0
	Subtotal				111.8	205.9	66.3	46.0
1986	24411	25221	4747	1.19	0.0	10.6	0.0	4.9
	24412	26784	0	1.00	0.0	0.0	0.0	4.1
	24637	12303	99	1.01	0.0	0.0	0.0	4.2
	Subtotal				0.0	10.6	0.0	13.2
	Total CWT				111.8	216.5	66.3	59.2

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

(b) From Table 11

(c) Expansion factor = (CWT releases + untagged releases) / CWT releases

(d) Does not include jacks

(e) Calculated from estimated CWTs in Table 15

Table 17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1992. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 16).

Total age	Estimated escapement (b)		Hatchery contribution (a)			
			Male (c)		Female	
	Male (c)	Female	Number	Percent	Number	Percent
<u>Upper river</u>						
4	82	0	0.0	0.0	0.0	0.0
5	1112	1291	111.8	10.1	205.9	15.9
6	1360	2756	0.0	0.0	10.6	0.4
7	0	0	0.0	0.0	0.0	0.0
Subtotal	2556 (d)	4047	111.8	4.4	216.5	5.3
<u>Lower river</u>						
4	94	0	0.0	0.0	0.0	0.0
5	2029	671	66.3	3.3	46.0	6.9
6	1385	1565	0.0	0.0	13.2	0.8
7	94		0.0	0.0	0.0	0.0
Subtotal	3598 (d)	2236	66.3	1.8	59.2	2.6
<u>Total river</u>						
4	176	0	0.0	0.0	0.0	0.0
5	3141	1962	178.1	5.7	251.9	12.8
6	2745	4321	0.0	0.0	23.8	0.6
7	94	0	0.0	0.0	0.0	0.0
Total	6154	6283	178.1	2.9	275.7	4.4

(a) Subtotals of expanded hatchery contributions from Table 16

(b) From Table 8

(c) Does not include jacks

(d) Summation is a result of rounding

Appendix A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1992.

Location	Date	Male				Female				Jack			
		No. captured	No. sacs (a)	No. tagged	No. ad clip	No. captured	No. sacs (a)	No. tagged	No. ad clip	No. captured	No. sacs (a)	No. tagged	No. ad clip
<u>Upper river</u>													
	24-Aug	31	0	31	3	16	0	16	0	0	0	0	0
	25-Aug	55	0	55	1	23	0	23	2	1	0	1	0
	26-Aug	20	0	20	0	11	0	11	0	2	0	2	0
	27-Aug	22	0	22	0	15	0	15	0	2	0	2	0
	28-Aug	25	0	25	0	15	0	15	1	3	0	3	0
	29-Aug	45	0	45	1	20	0	20	2	5	0	5	0
	31-Aug	49	0	49	1	21	0	21	0	1	0	1	0
	1-Sep	28	0	28	1	38	13	25	1	6	0	6	0
	2-Sep	33	0	33	0	34	8	26	0	2	0	2	0
	5-Sep	32	0	32	1	50	0	50	7	2	0	2	0
	8-Sep	50	0	50	5	33	0	33	0	0	0	0	0
	Total	390	0	390	13	276	21	255	13	24	0	24	0
<u>Lower river</u>													
	20-Aug	48	0	48	0	48	0	48	0	1	0	1	0
	21-Aug	34	0	34	1	19	0	19	0	1	0	1	0
	22-Aug	9	0	9	0	13	0	13	2	1	0	1	0
	24-Aug	22	0	22	1	12	0	12	0	0	0	0	0
	26-Aug	24	0	24	1	19	0	19	0	0	0	0	0
	27-Aug	33	0	33	3	11	0	11	0	0	0	0	0
	29-Aug	53	0	53	0	21	0	21	1	2	0	2	0
	30-Aug	19	0	19	0	16	0	16	0	0	0	0	0
	1-Sep	67	0	67	0	24	0	24	1	2	0	2	0
	2-Sep	52	0	52	0	33	0	33	1	0	0	0	0
	3-Sep	82	0	82	1	35	7	28	0	0	0	0	0
	4-Sep	42	0	42	0	31	10	21	1	3	0	3	0
	8-Sep	17	0	17	0	10	0	10	2	0	0	0	0
	Total	502	0	502	7	292	17	275	8	10	0	10	0

(a) Sacrificed for broodstock

Appendix B. Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1992.

Date	Male					Female					Jack				
	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)
<b>Upper river</b>															
24-Aug	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8-Sep	1	1	0	0	0	2	1	0	0	0	1	1	1	0	0
9-Sep	9	1	0	0	0	8	1	0	0	0	0	0	0	0	0
10-Sep	9	1	0	0	0	6	1	0	1	0	0	0	0	0	0
11-Sep	4	2	0	0	0	13	0	0	1	0	0	0	0	0	0
14-Sep	29	5	2	2	1	73	7	2	2	0	1	0	0	0	0
15-Sep	25	4	1	4	0	44	5	0	6	1	0	0	0	0	0
16-Sep	27	0	0	2	0	36	2	1	0	0	2	0	0	0	0
17-Sep	48	6	2	3	1	42	3	2	4	0	0	0	0	0	0
18-Sep	19	5	1	0	0	47	1	0	2	0	1	0	0	0	0
19-Sep	26	1	0	0	0	32	2	0	0	0	2	0	0	0	0
20-Sep	9	0	0	0	0	9	0	0	0	0	0	0	0	0	0
26-Sep	13	2	1	0	0	48	3	1	2	0	0	0	0	0	0
27-Sep	10	1	0	0	0	26	0	0	0	0	0	0	0	0	0
28-Sep	9	0	0	0	0	18	1	0	0	0	0	0	0	0	0
5-Oct	4	0	0	0	0	8	0	0	0	0	0	0	0	0	0
6-Oct	6	0	0	0	0	22	1	0	1	0	0	0	0	0	0
7-Oct	5	1	1	0	0	15	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>253</b>	<b>30</b>	<b>8</b>	<b>11</b>	<b>2</b>	<b>450</b>	<b>28</b>	<b>6</b>	<b>19</b>	<b>1</b>	<b>7</b>	<b>1</b>	<b>1</b>	<b>0</b>	<b>0</b>

(a) Number of carcasses recovered

(b) Number of tagged and/or punched carcasses recovered (tagged fish plus TL fish)

(c) TL = tag loss; these fish had no tag but did have an opercular punch; they are included in the No. Tag column

(d) Number of adipose-clipped carcasses

(e) Strays are defined as fish tagged and/or punched in one section of the river (upper or lower) and recovered in the other section

Appendix B (cont). Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1992.

Date	Male					Female					Jack				
	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)	No. rcvd (a)	No. tag (b)	No. TL (c)	No. ad (d)	No. strays (e)
<u>Lower river</u>															
22-Aug	0	0	0	0	0	2	2	0	2	0	0	0	0	0	0
26-Aug	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
29-Aug	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1-Sep	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
4-Sep	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
8-Sep	14	4	1	0	0	24	7	0	1	1	1	0	0	0	0
9-Sep	16	3	0	0	0	27	7	1	3	0	0	0	0	0	0
10-Sep	13	4	2	3	0	16	4	0	0	0	0	0	0	0	0
14-Sep	50	14	0	0	1	63	10	0	3	0	1	0	0	0	0
15-Sep	39	8	0	1	2	82	15	0	3	0	0	0	0	0	0
16-Sep	17	1	0	3	0	52	5	0	1	0	0	0	0	0	0
17-Sep	26	2	0	0	0	33	1	0	0	0	0	0	0	0	0
21-Sep	26	5	2	0	5	15	0	0	0	0	0	0	0	0	0
23-Sep	2	0	0	0	0	3	0	0	1	0	0	0	0	0	0
24-Sep	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25-Sep	3	0	0	0	0	15	0	0	0	0	0	0	0	0	0
26-Sep	15	1	1	0	1	31	1	0	0	0	0	0	0	0	0
28-Sep	12	1	0	0	0	33	1	0	0	0	0	0	0	0	0
5-Oct	5	0	0	0	0	10	0	0	0	0	0	0	0	0	0
6-Oct	6	0	0	0	0	13	0	0	0	0	0	0	0	0	0
8-Oct	24	0	0	0	0	44	3	2	1	0	0	0	0	0	0
Total	271	43	6	7	9	468	56	3	15	1	2	0	0	0	0

(a) Number of carcasses recovered

(b) Number of tagged and/or punched carcasses recovered (tagged fish plus TL fish)

(c) TL = tag loss; these fish had no tag but did have an opercular punch; they are included in the No. Tag column

(d) Number of adipose-clipped carcasses

(e) Strays are defined as fish tagged and/or punched in one section of the river (upper or lower) and recovered in the other section

