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Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of Kitsumkalum River, 1991

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February 1993

ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENT OF KITSUMKALUM RIVER, 1991

by

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Department of Fisheries & Oceans
AUG 6 1993
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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, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2182: viii + 43p.

Estimates of escapement were derived for chinook salmon (*Oncorhynchus tshawytscha*) of the Kitsumkalum River for 1991 using live-tagging and carcass-recovery operations. This study is part of the Chinook Key Stream Program. The Petersen estimate of adult male and female chinook escapement was 9288. 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 both sections of the river.

Estimated escapement of adipose-clipped chinook to the entire system was 110. This estimate was further stratified by age, sex and tag code. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose-clip mark rate at release. The hatchery contribution in 1991 was 2.0% for adult males and 0.9% for females. These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program (MRP) method (Kuhn 1988) of coded wire tag expansions. Using the MRP method, the total hatchery contribution was 1.7% for adult males and 0.8% 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, 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2182: viii + 43p.

La valeur des échappées de saumon quinnat (Oncorhynchus tshawytscha) de la rivière Kitsumkalum en 1991 a été estimée à partir des données de marquage-recapture et de récupération des carcasses. La présente étude a été réalisée dans le contexte du programme des cours d'eau clés pour le quinnat. L'échappée de mâles et de femelles adultes a été estimée à 9 288 poissons par la méthode Petersen. Les estimations totales de l'échappée représentent la somme des estimations obtenues par sexe et segment de cours deau (aval et amont). Les quinnats d'âge 6 constituaient la plus grande proportion des échappés des deux sexes et des deux segments de cours d'eau.

L'échappée des quinnats à nageoire adipeuse rognée a été estimée à 110 poissons pour l'ensemble du bassin. Cette valeur a ensuite été ventilée par âge, sexe et code d'étiquette. L'apport piscicole total (poissons marqués et non marqués) à l'échappée totale a été estimé en extrapolant le nombre de poissons à adipeuse rognée observés à l'aide du taux de marquage à la mise à l'eau. En 1991, l'apport piscicole a été de 2,0% pour les mâles adultes et de 0.9% pour les femelles adultes. La valeur estimée de l'apport piscicole a été comparée à celle obtenue à l'aide de la méthode d'extrapolation par fils codés utilisée pour le programme de marquage-recapture (Kuhn, 1988). Selon cette méthode, l'apport piscicole total était de 1,7% pour les mâles adultes et de 0,8% pour les femelles adultes.

Mots clés: Kitsumkalum, quinnat, cours d'eau clé, échappée, fil codé, composition par âges, 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), and the 1989-90 results are presented in Nass and Bocking (1992).

The 1991 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 (Fig. 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; and 21,039, respectively (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992).

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 two weeks of the tagging operations.

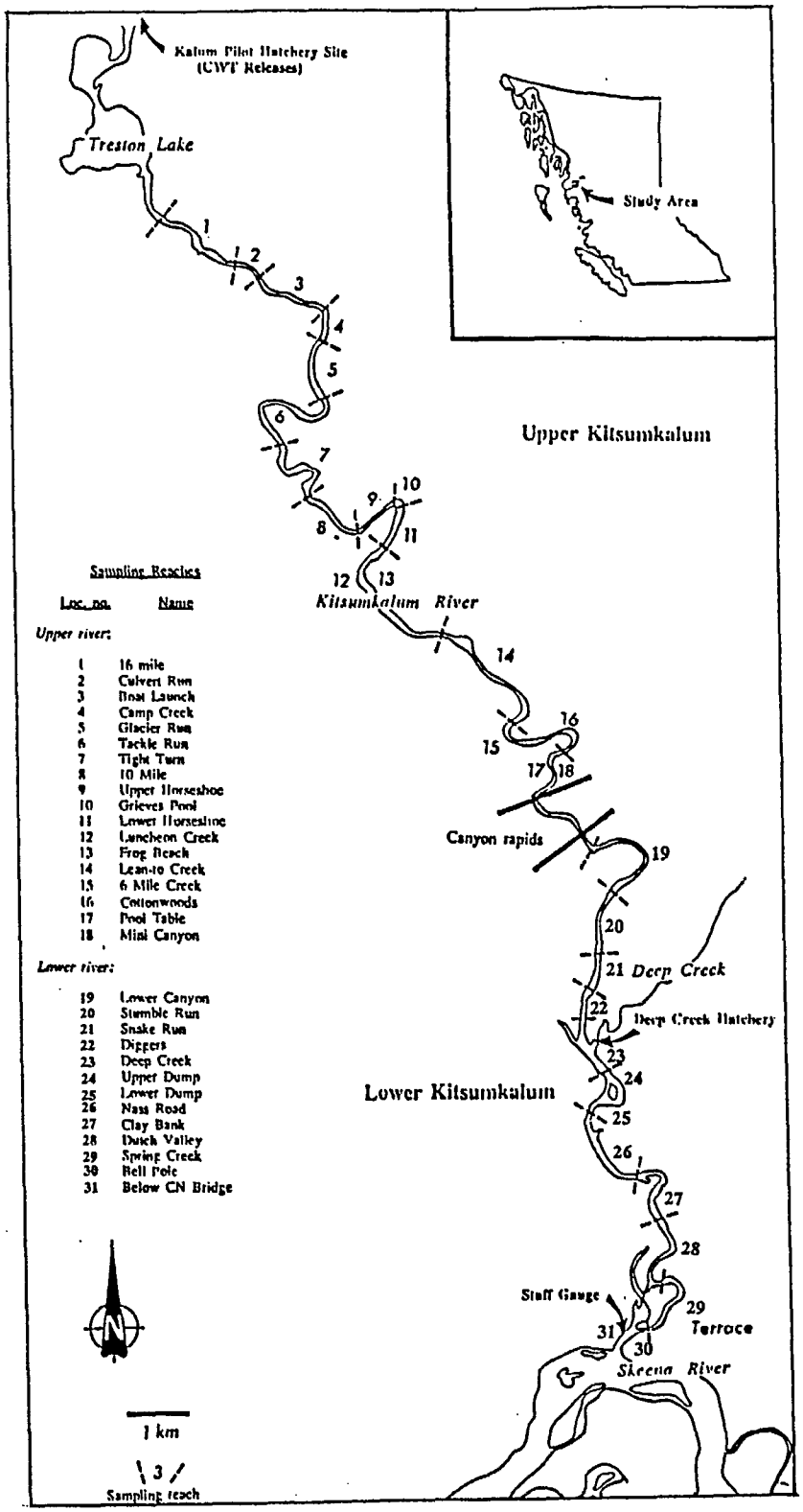

Figure 1. Map of the Kitsumkalum River study area.

Table 1. Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1991.

Item	Method and materials 1991
Population estimate	* Petersen estimate, sum of separate estimates for sexes and river strata
Live tagging (a)	* Cattle ear tags applied in situ 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.

In 1991, no tagged or operculum punched jacks were recovered in either section of the river. Because the Petersen estimate requires tag (or punch) recoveries, jacks were omitted from the analysis.

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[a]), 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 1991, 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):

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

where P is the population estimate, C is the total number of fish recovered, M is the total number of fish tagged, and R is the number of 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:

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

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, p79; Appendix II, p343). 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 ($M_{i,r}$) 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:

$$tag\ rate = R / C \tag{5}$$

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

$$tag\ recovery\ rate = R / M \tag{6}$$

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 1985 - 1989 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. In addition, 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:

$$EAD_{live} = \frac{OAD_{live} \cdot P}{C_{live}} \tag{7}$$

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:

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

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:

$$EAD_{i,r,tc} = \frac{EAD_{i,r} \cdot NDT_{i,r,tc}}{SumNDT_{i,r}} \tag{9}$$

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[a]).

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:

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

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:

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

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 1991.

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:

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

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:

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

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[a]).

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:

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

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:

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

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 1991 tagging operations in the upper and lower Kitsumkalum River, by date, are presented in Appendix A.

A total of 1507 chinook (904 males, 587 females, and 16 jacks) were tagged, operculum punched, and released in 1991 (Table 3). Of these, 711 were tagged in the upper river (451 males, 257 females, and 3 jacks) and 796 were tagged in the lower river (453 males, 330 females, and 13 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 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 1147 chinook carcasses (352 males, 792 females, and 3 jacks) were examined during carcass recovery operations in 1991 (Table 3). Of the 265 carcasses recovered in the upper river (66 males and 199 females) there were 44 total tag recoveries (13 males and 31 females). Of the 882 carcasses recovered in the lower river (286 males, 593 females, and 3 jacks), there were 118 total tag recoveries (56 males and 62 females). None of the 16 tagged and operculum-punched jacks (total for both sections of river) were observed during the carcass recovery operations. A total tag rate (incidence) of 16.2% and 10.3% was achieved for the upper and lower Kitsumkalum, respectively (Table 4). Total tag recovery was 6.0% for the upper river and 11.4% for the lower river. In addition, the total tag loss rate was 0.0% for the upper river and 18.7% for the lower river. The high tag loss in the lower river could be a result of improper tag attachment by the lower river crew (for the most part, crews were separate and worked in either the upper or lower river). Another explanation for the high tag loss in the lower river could be that carcasses in the lower river are subjected to greater turbulence over a longer distance, which could loosen and dislodge opercular tags. Evidence for this later explanation can be found by examining the proportion of lower river carcasses that lost their tags that were males (65%); a similar proportion of the strays from the upper to the lower river were male (85%). It is possible that a number of the tag loss carcasses 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.

Regarding strays in 1991, there was a total of one chinook tagged in the lower river and recovered in the upper river. In contrast, 27 chinook (23 males, 4 females) 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 1991 are presented in Table 5. Jacks were excluded from the population estimates due to a lack of tagged recoveries required by the Petersen method.

The 1991 estimated total escapement of adult chinook to the entire Kitsumkalum system (both sections of river) was 9288. The upper and lower 95% confidence levels were 12,596 and 6,875, respectively. Total escapement included 2,918 to the upper Kitsumkalum and 6,370 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, 1991, 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 1991, age-3 to age-7 chinook were represented in the deadpitch with age-6 chinook comprising approximately 53% of the total run (Table 6). Age-5 chinook represented another 24% while age-4 and age-7 chinook made up 9% and 14%, respectively. A single jack, age-3, length 300 mm, was not included in this analysis. Age structures were similar for the upper and lower sections of the river. In 1991, 96.2% 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 1991, produced the following results:

1) in the upper river, adult males (n = 63, mean = 867, SD = 102) had a larger mean length than the females (n = 195, mean = 837, SD = 63); and

2) in the lower river, adult males (n = 281, mean = 831, SD = 128) had a smaller mean length than the females (n = 566, mean = 856, SD = 51).

These differences in mean length were statistically significant in both the upper river (t-test, $P<0.05$) and the lower river (t-test, $P<0.001$). Adult males from the upper river had a larger mean length than adult males from the lower river, and the difference was significant (t-test, $P<0.05$). Female chinook from the upper river had a smaller mean length than females from the lower river, but the difference was not significant (t-test, $P>0.2$). A comparative analysis of the lengths of aged and unaged adult male and female chinook from the upper and lower Kitsumkalum found a significant differences in the lower river for both adult males (t-test, $P<0.05$) and females (t-test, $P<0.001$); the comparison found no significant differences in the upper river for either sex.

Sex ratios and statistical tests were calculated using the Petersen population estimates for 1991 (Table 5). Calculations for males did not include jacks. The ratio of adult males to females was 0.97 for the upper river, 0.92 for the lower river, and 0.93 for the total system. The number (from Petersen estimates) of adult males in the upper river compared to the number of females in the upper river was not significantly different from 50:50 (χ^2, $P>0.25$), whereas the same comparison in the lower river did result in a significant difference (χ^2, $P<0.001$). Significant differences were also observed for the following population (from Petersen estimates) comparisons:

1. upper river adult males and lower river adult males (χ^2, $P<0.001$);

2. upper river females and lower river females (χ^2, $P<0.001$); and

3. adult males and females from the entire system (pooled population estimates from both sections of river) (χ^2, $P<0.005$).

CODED WIRE TAGGING AND RECOVERY

Coded wire tagged (adipose-clipped) juvenile chinook from the 1984 to 1989 brood years were sampled as adults in the dead recovery program in 1991. Heads from adipose-clipped chinook carcasses were collected for coded wire tag analysis.

The results of 1991 coded wire tag returns are presented below and include information on the following:

1. numbers of chinook captured, tagged, and released in the upper and lower Kitsumkalum River, by date (Appendix A);

2. chinook carcass recovery, by date, for the upper and lower Kitsumkalum River (Appendix B);

3. estimates of the total escapement of adipose-clipped adult male and female chinook to the upper and lower Kitsumkalum River, and weighted estimate (Table 9);

4. the observed 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 (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 entire Kitsumkalum River, by age (Tables 13 and 17).

During the 1991 live-tagging operations, a total of 14 adipose-clipped chinook were observed in the upper river and none were observed in the lower river (Table 9). During the carcass recovery operations, a total of seven adipose-clipped chinook were observed in the upper river and 14 were observed in the lower river. The combined (male and female) adipose-clip mark rates were 2.15% for the upper river and 0.83% for the lower river and were significantly different (χ^2, $P < 0.01$). The total estimated number of adipose-clipped chinook (weighted average for live and dead) to the entire system was 110 (59 to the upper river and 51 to the lower river).

Hatchery Contributions - Method A

The estimated total escapements of each CWT group decoded in 1991 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 1991 were of Kitsumkalum origin; thus, the estimated number of strays from other hatcheries were not included in these analyses. A

total of 17 CWT heads from adipose-clipped chinook recovered in 1991 were successfully decoded (Table 10).

Using Method A, the 1991 estimated hatchery contribution to escapement for chinook salmon in the entire Kitsumkalum River was 132 fish (88 adult males and 44 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 escapement of chinook in the entire Kitsumkalum River in 1991 was estimated to be 1.4% (2.0% for adult males and 0.9% for females).

Hatchery Contributions - Method B

The adjusted, expanded, and total estimated 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 1991 estimated hatchery contribution to escapement for chinook salmon in the entire Kitsumkalum River was 112 fish (75 adult males and 37 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 escapement of chinook in the entire Kitsumkalum River in 1991 was estimated to be 1.2% (1.7% for adult males and 0.8% 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.

Because none of the 16 tagged and opercular-punched jacks were recovered in 1991, a Petersen population estimate could not be produced for that segment of the population. For comparative purposes, the lack of a population estimate for jacks does not create difficulties in that past studies have also stratified population estimates; thus, population estimates of adult males and females from past studies can be compared with 1991 estimates. The adult male and female Petersen population estimate of chinook salmon for the entire Kitsumkalum River in 1991 was 9288, which is just over half the adult male and female population estimates for 1989 and 1990 (17,921 and 17,408,

respectively), and well under half (about 40%) of the 1987 and 1988 adult male and female population estimates (23,727 and 22,587, respectively; both estimates from stratified data) (Nass and Bocking 1992, Carolsfeld et al. 1990).

The substantial number of tagged strays (27) from the upper to the lower river in 1991 is similar to the number of strays from the upper to the lower river in 1987 and 1988 (25 and 17, respectively), although the population estimates in 1987 and 1988 were both more than double that in 1991. A single tagged stray from the lower to the upper river in 1991 is also in line with 1987 and 1988 findings (one and three strays were observed, respectively). In contrast, the 1991 stray observations were greatly dissimilar to those observed in 1989 and 1990, where the number of lower-to-upper strays was higher (four and 11, respectively) and the difference between the number of strays to the upper and lower river was not significant (for either year).

The proportion of the 1991 upper-to-lower strays that were male (85%) is similar to the proportions observed in 1987 and 1988 (72% and 82%, respectively). The high proportion of males observed in 1991 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 upper and lower confidence limits for the total adult male and female population estimate of chinook (9288) were 35.6% and 26.0%, respectively, of the population estimate. These proportions 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 of the escapement to the entire Kitsumkalum River in 1991. Age-5 chinook represented the next largest contribution. These findings are consistent with prior investigations (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992).

The mean postorbital-hypural lengths of adult male and female chinook in the entire Kitsumkalum River in 1991 was smaller than the mean lengths in 1989 and slightly larger than the mean lengths in 1990. Although jacks were not included in the 1991 age-length analysis (which would tend to increase the mean length of males), their inclusion would not have changed the above conclusions, in that only a single jack, age 32, length 300 mm, was excluded from the analysis.

Females (51.7%) represented a larger proportion of the total escapement compared to adult males (48.3%) in 1991. Although these proportional contributions are close to 50:50, the actual numbers of all adult males and females (pooled population estimates from both sections of river) were significantly different (χ^2, $P < 0.005$). Previous reports have shown variability in the sex ratio between years (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992). The 1991 ratios exhibit a higher proportion of adult males to females than in 1989 and 1990 (1989 adult males 45.1%, females 54.9%; 1990 adult males 42.3% females 57.7%).

A comparison of the proportions of all males (jacks included) and females between years 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, the proportions of adult males and females can be compared to indicate annual proportions; we believe this to be a more representative comparison of sex ratios to indicate trends.

CODED WIRE TAGGING AND RECOVERY

In this study, we used the adipose-clip rate in the tagging and dead recovery of chinook in the river to estimate the number of adipose clips in the escapement (Method A). Sampling for adipose-clipped fish was random. The total mark rate (incidence) at recovery was 1.8% in 1991.

Estimates of the total hatchery contribution to the Kitsumkalum River were similar using Method A (AFC rate) and Method B (CWT rate) and suggest a very low contribution of hatchery fish to the 1991 escapement. Method A produced a slightly higher hatchery contribution estimate for the entire river (1.4%) than Method B (1.2%). We have not formally estimated the level of precision of the estimates of escapement by adipose-clipped fish and individual tag codes as potential sources of bias 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. There were between two and 10 adipose clips decoded for each sex (jacks not included; no adipose-clipped jacks were captured or recovered in 1991) and river strata.

Indications of misidentification and/or crew inconsistencies were suggested in 1991; due to the low numbers of observed adipose clips, even minor changes in the data would be reflected in the calculated estimates. For example, the 14 adipose-clipped chinook observed during the live-tagging operations were all males from the upper river. During the carcass recovery operations, adipose-clipped carcasses of both sexes were recovered from both sections of the river; this would indicate misidentification and/or crew inconsistencies during the live tagging operations. Another indication of possible misidentification is the difference in the proportions of observed adipose clips between the live tagging (0.92%) and carcass recovery (1.84%) operations (totals for both sections of river; Table 9). In addition, it is also possible that 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[b]).

In 1991, crews examined 16.5% of the estimated population of adult male and female chinook for adipose clips during live tagging operations and 12.3% 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. Regardless of possible inconsistencies with data collections and potential bias in the estimates, the 1991 results suggest a very low contribution rate of hatchery fish to the total escapement.

SUMMARY

1. The total escapement estimate for adult male and female chinook salmon to the Kitsumkalum River, calculated using a combination of live tagging and carcass recovery data, was 9288 in 1991. This estimate is the summation of individual Petersen estimates stratified by river section and sex. Jacks were not included in the total population estimate because no tagged or opercular-punched jacks were observed during recovery efforts, precluding a Petersen population estimate for their segment of the population.

2. The 1991 chinook escapement was largely represented by age-6 fish.

3. The mean postorbital-hypural lengths of adult male and female chinook varied significantly within the upper (t-test, $P < 0.05$) and lower (t-test, $P < 0.001$) sections of river. The difference in mean lengths of adult males from the upper and lower river was also significant (t-test, $P < 0.05$), whereas the difference in mean lengths for females from the upper and lower river was not significant (t-test, $P > 0.2$).

4. Adult males and females varied in their proportional contribution to river sections. The difference in numbers of adult males and females was not significantly different from 50:50 in the upper river (χ^2, $P > 0.25$). Significant differences in proportional contributions were found for:

    a) adult males and females in the lower river (χ^2, $P < 0.001$);

    b) adult males from the upper river and adult males from the lower river (χ^2, $P < 0.001$);

    c) females from the upper river and females from the lower river (χ^2, $P < 0.001$); and

    d) adult males and females from the entire river (pooled population estimates from both sections of river)(χ^2, $P < 0.005$).

5. The total estimated return of adipose-clipped chinook to the Kitsumkalum River in 1991 was 110 or 1.2% of the escapement.

6. The total estimated hatchery contribution to the chinook escapement in 1991, based on adipose clips (Method A) was 132 (1.4%). The total estimated hatchery contribution to the chinook escapement in 1991 derived using the adjusted CWTs recovered (Method B) was 112 (1.2%).

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Table 2. Summary of live tagging and carcass recovery effort for chinook salmon in the Kitsumkalum River, 1991.

	Tagging period	Effort (days)	Carcass recovery period	Effort (days)
Upper River	Aug 26 - Sep 17	12	Sep 6 - Oct 3	16
Lower River	Aug 19 - Sep 10	19	Aug 30 - Oct 4	25

Table 3. Live tagging and dead recovery statistics for chinook salmon in the upper and lower Kitsumkalum River, 1991.

Category	Upper River	Lower River	Total
Live tagging (a)			
Males examined	451	453	904
Females examined	262	362	624
Jacks examined	3	13	16
Total examined	716	828	1544
Males tagged/punched	451	453	904
Females tagged/punched	257	330	587
Jacks tagged/punched	3	13	16
Total tagged/punched	711	796	1507
Dead recovery (b)			
Males examined	66	286	352
Females examined	199	593	792
Jacks examined	0	3	3
Total examined	265	882	1147
Punched-only males (c)	0	11	11
Punched-only females (c)	0	6	6
Punched-only jacks (c)	0	0	0
Total punched only (c)	0	17	17
Tagged/punched males (d)	13	56	69
Tagged/punched females (d)	31	62	93
Tagged/punched jacks (d)	0	0	0
Total tagged/punched (d)	44	118	162
Strays (e)			
Stray males	1	23	24
Stray females	0	4	4
Stray jacks	0	0	0
Total strays	1	27	28

(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 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 dead recovery operations in the upper and lower Kitsumkalum River, 1991.

Category	Upper River	Lower River	Total
Tag rate (a)			
Male tag rate (%)	18.2	11.5	12.8
Female tag rate (%)	15.6	9.8	11.2
Jack tag rate (%)	0.0	0.0	0.0
Total tag rate (%)	16.2	10.3	11.7
Tag recovery rate (b)			
Male tag recovery rate (%)	2.7	7.3	5.0
Female tag recovery rate (%)	12.1	17.6	15.2
Jack tag recovery rate (%)	0.0	0.0	0.0
Total tag recovery rate (%)	6.0	11.4	8.9
Tag loss rate (c)			
Male tag loss rate (%)	0.0	33.3	24.4
Female tag loss rate (%)	0.0	10.3	6.7
Jack tag loss rate (%)	0.0	0.0	0.0
Total tag loss rate (%)	0.0	18.7	12.7

(a) tag rate = ((no. tagged in dead recovery - no. strays in dead recovery) / total no. in dead recovery) * 100; seeTable 3
(b) tag recovery rate = ((no. tagged in dead recovery - no. strays in dead recovery) / no. live tagged) * 100; seeTable 3
(c) tag loss rate = (no. in dead recovery with punch only / no. in dead recovery with punch and tag) * 100; seeTable 3

Table 5. Petersen population estimates, confidence limits and enumeration data for chinook salmon escapement in the Kitsumkalum River based on in situ live chinook tagging and recovery of carcasses, 1991. Confidence limits are from fudicial 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.

	Male	Female	Jack (g)	Total	
Upper River					
Number tagged (a)	451	257	3	711	
Number examined (b)	66	199	0	265	
Number of tagged fish recovered (c)	13	31	0	44	
Number of tagged strays from lower river (d)	1	0	0	1	
Expanded No. of tagged strays from lower river (e)	35	0	0	35	
Number of tagged fish for Petersen estimate (f)	300	236	3	538	(h)
Petersen estimate	1439	1479	N/A	2918	(i)
Lower 95% CL	866	1052	N/A	1918	(i)
Upper 95% CL	2346	2073	N/A	4419	(i)
Lower River					
Number tagged (a)	453	330	13	796	
Number examined (b)	286	593	3	882	
Number of tagged fish recovered (c)	56	62	0	118	
Number of tagged strays from upper river (d)	23	4	0	27	
Expanded No. of tagged strays from upper river (e)	186	21	0	207	
Number of tagged fish for Petersen estimate (f)	604	351	13	969	(h)
Petersen estimate	3048	3322	N/A	6370	(i)
Lower 95% CL	2357	2600	N/A	4957	(i)
Upper 95% CL	3938	4239	N/A	8177	(i)
Total System					
Escapement estimate	4487	4801	N/A	9288	
Lower 95% CL	3223	3652	N/A	6875	
Upper 95% CL	6284	6313	N/A	12596	

(a) total live tagged/punched (Appendix A)
(b) total dead recoveries (tagged and untagged); Appendix B
(c) total dead recoveries possessing an operculum punch (Appendix B)
(d) total dead recoveries possessing an operculum punch from the other section of the river
(e) expanded strays = (no. of strays from other section) * (no. tagged in section / no. tagged dead recoveries)
(f) number of tagged fish for Petersen estimate = no. tagged in section + expanded no. of tagged strays into section - expanded no. of tagged strays out of other section
(g) N/A = not available; because no tagged or punched jacks were recovered in either section of the river, it is not possible to calculate a Petersen estimate of 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, 1991. Data for calculations are from scale analysis and CWT age samples.

Length class (mm)	Age															
	Male (a)								Female							
	2	3	4	5	6	7	Total	Unk (b)	2	3	4	5	6	7	Total	Unk (b)
Upper River																
250-299	0	0	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	0	0
350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450-499	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500-549	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
550-599	0	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1
600-649	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0
650-699	0	0	1	1	0	0	2	0	0	0	0	1	0	0	1	3
700-749	0	0	0	0	0	0	0	1	0	0	0	4	0	0	4	1
750-799	0	0	0	0	0	0	0	3	0	0	0	7	1	0	8	21
800-849	0	0	0	1	0	0	1	7	0	0	0	9	8	1	18	39
850-899	0	0	2	0	3	0	5	12	0	0	0	3	11	1	15	44
900-949	0	0	0	1	5	1	7	10	0	0	0	0	8	3	11	21
950-999	0	0	0	0	1	1	2	6	0	0	0	1	1	1	3	4
1000-1049	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
1050-1099	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1100-1149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1150-1199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1200-1249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	5	3	9	2	19	44	0	0	0	25	30	6	61	134
Percent	0.0	0.0	26.3	15.8	47.4	10.5	100.0		0.0	0.0	0.0	41.0	49.2	9.8	100.0	
Mean (c)	0	0	710	797	904	945	841	878	0	0	0	797	855	898	836	838
SD	0	0	164	105	25	7	126	89	0	0	0	59	60	47	67	61

(a) does not include jacks; a single jack collected in the lower river, age 32 (see Table 7), length 300 mm, was omitted from this analysis

(b) unknown age

(c) postorbital-hypural length

Table 6 (cont.). Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1991. Data for calculations are from scale analysis and CWT age samples.

Length class (mm)	Age															
	Male (a)								Female							
	2	3	4	5	6	7	Total	Unk (b)	2	3	4	5	6	7	Total	Unk (b)
Lower River																
250-299	0	0	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	0	0
350-399	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
450-499	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
500-549	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
550-599	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
600-649	0	0	2	0	0	0	2	10	0	0	0	0	0	0	0	0
650-699	0	0	2	0	1	0	3	8	0	0	1	0	0	0	1	2
700-749	0	0	1	2	0	0	3	15	0	0	0	2	0	0	2	7
750-799	0	0	0	3	0	0	3	24	0	0	0	8	5	0	13	35
800-849	0	0	0	3	2	0	5	30	0	0	0	6	23	1	30	136
850-899	0	0	0	2	9	0	11	36	0	0	0	1	33	5	39	174
900-949	0	0	0	1	9	4	14	41	0	0	0	2	7	6	15	87
950-999	0	0	0	0	7	4	11	33	0	0	0	0	1	5	6	18
1000-1049	0	0	0	0	1	2	3	8	0	0	0	0	1	0	1	0
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1100-1149	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1150-1199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1200-1249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	6	11	29	10	56	225	0	0	1	19	70	17	107	459
Percent	0.0	0.0	10.7	19.6	51.8	17.9	100.0		0.0	0.0	0.9	17.8	65.4	15.9	100.0	
Mean (c)	0	0	615	807	906	957	864	823	0	0	650	802	858	911	854	856
SD	0	0	101	65	66	42	119	129	0	0	0	51	43	37	57	49

(a) does not include jacks; a single jack collected in the lower river, age 32 (see Table 7), length 300 mm, was omitted from this analysis

(b) unknown age

(c) postorbital-hypural length

Table 7. Freshwater age composition of deadpitch Kitsumkalum River chinook salmon, 1991 (a).

Location	Age (c)	Male (b)		Female	
		N	%	N	%
Upper River					
	41	1	5.9	0	0.0
	42	3	17.6	0	0.0
	51	0	0.0	1	1.7
	52	2	11.8	23	38.3
	61	0	0.0	1	1.7
	62	9	52.9	29	48.3
	72	2	11.8	6	10.0
	Total	17	100	60	100
Lower River					
	32	1	1.8	0	0.0
	41	2	3.6	0	0.0
	42	3	5.5	0	0.0
	52	11	20.0	17	16.3
	61	0	0.0	3	2.9
	62	28	50.9	66	63.5
	72	10	18.2	17	16.3
	73	0	0.0	1	1.0
	Total	55	100	104	100

(a) age composition was calculated using scale samples only

(b) males include a single jack collected in the lower river, age 32

(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

Table 8. Petersen estimates, by age, of chinook salmon escapement to the Kitsumkalum River, 1991.

		Male (a)		Female	
	Age	Number (b)	Percent (c)	Number (b)	Percent (c)
Upper River					
	2	0	0.0	0	0.0
	3	0	0.0	0	0.0
	4	378	26.3	0	0.0
	5	227	15.8	606	41.0
	6	682	47.4	728	49.2
	7	151	10.5	145	9.8
	Total	1439 (d)	100.0	1479	100.0
Lower River					
	2	0	0.0	0	0.0
	3	0	0.0	0	0.0
	4	326	10.7	30	0.9
	5	597	19.6	591	17.8
	6	1579	51.8	2173	65.4
	7	546	17.9	528	15.9
	Total	3048	100.0	3322	100.0

(a) does not include jacks; see Table 5, footnote (g)

(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 of adipose-clipped chinook salmon to the upper and lower Kitsumkalum River and weighted estimate, 1991.

Location and sex	Live tagging			Dead recovery			Petersen population estimate (c)	Total estimated adipose clips		Weighted estimate of adipose clips
	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	G	H=C/100*G	I=F/100*G	J (d)
Upper River										
Male (e)	451	14	3.10	66	5	7.58	1439	45	109	53
Female	262	0	0.00	199	2	1.01	1479	0	15	6
Total	713	14	1.96	265	7	2.64	2918	45	124	59
Lower River										
Male (e)	453	0	0.00	286	4	1.40	3048	0	43	16
Female	362	0	0.00	593	10	1.69	3322	0	56	35
Total	815	0	0.00	879	14	1.59	6370	0	99	51

(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, 1991. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 12 (Method A).

		Upper River (a)				Lower River (a)			
		Decoded adipose clips		Estimated adipose clips		Decoded adipose clips		Estimated adipose clips	
Brood year	CWT code	M (b)	F	M (b)	F	M (b)	F	M (b)	F
1987	24941	0	0	0.0	0.0	2	0	8.0	0.0
	24943	0	0	0.0	0.0	1	0	4.0	0.0
	25060	1	0	13.3	0.0	0	0	0.0	0.0
	25661	1	0	13.3	0.0	0	1	0.0	4.4
	Subtotal	2	0	26.5	0.0	3	1	12.0	4.4
1986	24204	0	1	0.0	6.0	0	0	0.0	0.0
	24411	1	0	13.3	0.0	0	0	0.0	0.0
	24413	0	0	0.0	0.0	0	1	0.0	4.4
	24414	0	0	0.0	0.0	0	1	0.0	4.4
	Subtotal	1	1	13.3	6.0	0	2	0.0	8.8
1985	23704	0	0	0.0	0.0	1	4	4.0	17.5
	23706	1	0	13.3	0.0	0	0	0.0	0.0
	23707	0	0	0.0	0.0	0	1	0.0	4.4
	Subtotal	1	0	13.3	0.0	1	5	4.0	21.9
Total CWT (c)		4	1	53.0	6.0	4	8	16.0	35.0
No data (5000)		14	0			0	1		
No pin (8000)		1	1			0	1		
Observed adipose		19	2			4	10		

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

(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)

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

Table 11. CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1991.

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
	24943	25262	8555	0.8	1	25466	8351
	25060	27522	14994	0.0	1	27522	14994
	25061	27475	14993	0.0	1	27475	14993
1986	24204	20148	461	1.5	1	20455	154
	24411	25221	4747	0.7	1	25399	4569
	24413	26783	108	0.4	1	26891	0
	24414	26581	3134	0.5	1	26715	3000
1985	23704	44183	263	0.4	1	44360	86
	23706	43916	3506	0.4	1	44092	3330
	23707	43892	3679	0.4	1	44068	3503
	Total hatchery	338004	54573			339599	52980

Table 12. Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1991. 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 (c) clipped	Adipose release (c) unclipped	Expansion factor (d)	Expanded hatchery contribution (a) (e) Upper River M (b)	Upper River F	Lower River M (b)	Lower River F
1987	24941	27157	0	1.00	0.0	0.0	8.0	0.0
	24943	25466	8351	1.33	0.0	0.0	5.3	0.0
	25060	27522	14994	1.54	20.5	0.0	0.0	0.0
	25061	27475	14993	1.55	20.5	0.0	0.0	6.8
	Subtotal				40.9	0.0	13.3	6.8
1986	24204	20455	154	1.01	0.0	6.0	0.0	0.0
	24411	25399	4569	1.18	15.6	0.0	0.0	0.0
	24413	26891	0	1.00	0.0	0.0	0.0	4.4
	24414	26715	3000	1.11	0.0	0.0	0.0	4.9
	Subtotal				15.6	6.0	0.0	9.2
1985	23704	44360	86	1.00	0.0	0.0	4.0	17.5
	23706	44092	3330	1.08	14.3	0.0	0.0	0.0
	23707	44068	3503	1.08	0.0	0.0	0.0	4.7
	Subtotal				14.3	0.0	4.0	22.3
	Total hatchery				70.8	6.0	17.3	38.3

(a) abbreviations are M=male, F=female
(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)
(c) from Table 11
(d) expansion factor = (adipose-clipped + unclipped releases) / adipose-clipped releases
(e) calculated from estimated adipose clips in Table 10

Table 13. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and entire Kitsumkalum River, 1991. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 12).

		Estimated escapement (a)		Hatchery contribution (b)			
				Male (c)		Female	
	Age	Male (c)	Female	Number	%	Number	%
Upper River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	378	0	40.9	10.8	0.0	0.0
	5	227	606	15.6	6.9	6.0	1.0
	6	682	728	14.3	2.1	0.0	0.0
	7	151	145	0.0	0.0	0.0	0.0
	Total	1439	1479	70.8	4.9	6.0	0.4
Lower River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	326	30	13.3	4.1	6.8	22.7
	5	597	591	0.0	0.0	9.2	1.6
	6	1579	2173	4.0	0.3	22.3	1.0
	7	546	528	0.0	0.0	0.0	0.0
	Total	3048	3322	17.3	0.6	38.3	1.2
Entire River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	704	30	54.2	7.7	6.8	22.7
	5	824	1197	15.6	1.9	15.2	1.3
	6	2261	2901	18.3	0.8	22.3	0.8
	7	697	673	0.0	0.0	0.0	0.0
	Total	4487	4801	88.1	2.0	44.3	0.9

(a) from Table 8

(b) from Table 12

(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)

Table 14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, 1991, by tag code. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 15 (Method B).

		Upper River (a)				Lower River (a)				
		Decoded adipose clips (c)		Adjusted CWTs		Decoded adipose clips (c)		Adjusted CWTs		
Brood year	CWT code	M (b)	F	M (b)	F	M (b)	F	M (b)	F	
1987	24941	0	0	0.0	0.0	2	0	2.0	0.0	
	24943	0	0	0.0	0.0	1	0	1.0	0.0	
	25060	1	0	3.8	0.0	0	0	0.0	0.0	
	25661	1	0	3.8	0.0	0	1	0.0	1.1	
	Subtotal	2	0	7.6	0.0	3	1	3.0	1.1	
1986	24204	0	1	0.0	1.0	0	0	0.0	0.0	
	24411	1	0	3.8	0.0	0	0	0.0	0.0	
	24413	0	0	0.0	0.0	0	1	0.0	1.1	
	24414	0	0	0.0	0.0	0	1	0.0	1.1	
	Subtotal	1	1	3.8	1.0	0	2	0.0	2.2	
1985	23704	0	0	0.0	0.0	1	4	1.0	4.4	
	23706	1	0	3.8	0.0	0	0	0.0	0.0	
	23707	0	0	0.0	0.0	0	1	0.0	1.1	
	Subtotal	1	0	3.8	0.0	1	5	1.0	5.6	(d)
	Total CWT	4	1	15.2	1.0	4	8	4.0	8.9	
No data (5000) (c)		14	0			0	1			
No pin (8000) (c)		1	1			0	1			
Observed adipose		19	2			4	10			

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

(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)

(c) from Table 10

(d) summation is a result of rounding

Table 15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1991. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 16 (Method B).

		Upper River (a)				Lower River (a)			
		Adjusted		Estimated		Adjusted		Estimated	
Brood	CWT	CWTs (c)		CWTs		CWTs (c)		CWTs	
year	code	M (b)	F	M (b)	F	M (b)	F	M (b)	F
1987	24941	0.0	0.0	0.0	0.0	2.0	0.0	8.2	0.0
	24943	0.0	0.0	0.0	0.0	1.0	0.0	4.1	0.0
	25060	3.8	0.0	10.6	0.0	0.0	0.0	0.0	0.0
	25661	3.8	0.0	10.6	0.0	0.0	1.1	0.0	3.8
	Subtotal	7.6	0.0	21.2	0.0	3.0	1.1	12.4	3.8
1986	24204	0.0	1.0	0.0	3.2	0.0	0.0	0.0	0.0
	24411	3.8	0.0	10.6	0.0	0.0	0.0	0.0	0.0
	24413	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.8
	24414	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.8
	Subtotal	3.8	1.0	10.6	3.2	0.0	2.2	0.0	7.7
1985	23704	0.0	0.0	0.0	0.0	1.0	4.4	4.1	15.3
	23706	3.8	0.0	10.6	0.0	0.0	0.0	0.0	0.0
	23707	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.8
	Subtotal	3.8	0.0	10.6	0.0	1.0	5.6 (f)	4.1	19.1
	Total CWT	15.2	1.0	42.3	3.2	4.0	8.9	16.5	30.6
Escapement est. (d)		1439	1479			3048	3322		
Sample size (e)		517	461			739	955		

(a) abbreviations are M = male, F = female
(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)
(c) from Table 14
(d) Petersen estimate from Table 8
(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, 1991. 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 (c) CWT	Release numbers (c) untagged	Expansion factor (d)	Expanded hatchery contribution (a) (e) Upper River M(b)	Upper River F	Lower River M (b)	Lower River F
1987	24941	27021	133	1.00	0.0	0.0	8.3	0.0
	24943	25262	8555	1.34	0.0	0.0	5.5	0.0
	25060	27522	14994	1.54	16.3	0.0	0.0	0.0
	25061	27475	14993	1.55	16.3	0.0	0.0	5.9
	Subtotal				32.7	0.0	13.8	5.9
1986	24204	20148	461	1.02	0.0	3.3	0.0	0.0
	24411	25221	4747	1.19	12.6	0.0	0.0	0.0
	24413	26783	108	1.00	0.0	0.0	0.0	3.8
	24414	26581	3134	1.12	0.0	0.0	0.0	4.3
	Subtotal				12.6	3.3	0.0	8.1
1985	23704	44183	263	1.01	0.0	0.0	4.1	15.5
	23706	43916	3506	1.08	11.4	0.0	0.0	0.0
	23707	43892	3679	1.08	0.0	0.0	0.0	4.1
	Subtotal				11.4	0.0	4.1	19.6
	Total CWT				56.7	3.3	18.0	33.7

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

(b) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)

(c) from Table 11

(d) expansion factor = (CWT releases + untagged releases) / CWT releases

(e) calculated from estimated CWTs in Table 15

Table 17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and entire Kitsumkalum River, 1991. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 16).

		Estimated escapement (a)		Hatchery contribution (b)			
				Male (c)		Female	
	Age	Male (c)	Female	Number	%	Number	%
Upper River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	378	0	32.7	8.6	0.0	0.0
	5	227	606	12.6	5.5	3.3	0.5
	6	682	728	11.4	1.7	0.0	0.0
	7	151	145	0.0	0.0	0.0	0.0
	Total	1439 (d)	1479	56.7	3.9	3.3	0.2
Lower River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	326	30	13.8	4.2	5.9	19.7
	5	597	591	0.0	0.0	8.1	1.4
	6	1579	2173	4.1	0.3	19.6	0.9
	7	546	528	0.0	0.0	0.0	0.0
	Total	3048	3322	17.9	0.6	33.6	1.0
Entire River							
	2	0	0	0.0	0.0	0.0	0.0
	3	0	0	0.0	0.0	0.0	0.0
	4	705	30	46.5	6.6	5.9	12.7
	5	825	1198	12.6	1.5	11.4	90.5
	6	2261	2900	15.5	0.7	19.6	126.5
	7	697	673	0.0	0.0	0.0	0.0
	Total	4487	4801	74.6	1.7	36.9	0.8

(a) from Table 8

(b) subtotals of expanded hatchery contributions from Table 16

(c) does not include jacks; no adipose-clipped jacks were captured or recovered in 1991 (see Appendices A and B)

Appendix A. Numbers of chinook salmon captured, tagged, and released in the upper and lower Kitsumkalum River, 1991, by date. (a)

		Male				Female				Jack				NA(c)
Location	Date	No. Captured	No. Sacs (b)	No. Tagged	No. Ad Clip	No. Captured	No. Sacs (b)	No. Tagged	No. Ad Clip	No. Captured	No. Sacs (b)	No. Tagged	No. Ad Clip	No. Tagged
Upper River														
	26-Aug	68	0	68	0	13	0	13	0	1	0	1	0	0
	27-Aug	17	0	17	1	8	0	8	0	0	0	0	0	0
	28-Aug	14	0	14	0	1	0	1	0	0	0	0	0	0
	02-Sep	52	0	52	4	16	0	16	0	0	0	0	0	1
	05-Sep	68	0	68	3	32	0	32	0	0	0	0	0	3
	06-Sep	49	0	49	2	11	2	9	0	0	0	0	0	0
	07-Sep	9	0	9	0	10	2	8	0	0	0	0	0	0
	09-Aug	58	0	58	1	58	0	58	0	1	0	1	0	3
	10-Sep	39	0	39	2	31	1	30	0	1	0	1	0	6
	11-Sep	37	0	37	0	43	0	43	0	0	0	0	0	0
	13-Sep	15	0	15	0	24	0	24	0	0	0	0	0	0
	17-Sep	25	0	25	1	15	0	15	0	0	0	0	0	1
	Totals	451	0	451	14	262	5	257	0	3	0	3	0	14
Lower River														
	19-Aug	3	0	3	0	10	0	10	0	0	0	0	0	2
	20-Aug	28	0	28	0	18	0	18	0	0	0	0	0	1
	21-Aug	22	0	22	0	21	0	21	0	0	0	0	0	0
	22-Aug	30	0	30	0	13	0	13	0	0	0	0	0	0
	23-Aug	28	0	28	0	32	0	32	0	0	0	0	0	0
	24-Aug	11	0	11	0	7	0	7	0	0	0	0	0	0
	26-Aug	34	0	34	0	26	0	26	0	2	0	2	0	0
	27-Aug	9	0	9	0	8	0	8	0	0	0	0	0	1
	28-Aug	8	0	8	0	2	0	2	0	1	0	1	0	0
	29-Aug	26	0	26	0	9	0	9	0	0	0	0	0	0
	30-Aug	27	0	27	0	24	1	23	0	0	0	0	0	0
	31-Aug	11	0	11	0	3	0	3	0	0	0	0	0	0
	01-Sep	27	0	27	0	26	0	26	0	1	0	1	0	0
	02-Sep	26	0	26	0	17	0	17	0	1	0	1	0	0
	03-Sep	51	0	51	0	36	3	33	0	2	0	2	0	1
	04-Sep	43	0	43	0	38	6	32	0	3	0	3	0	0
	05-Sep	10	0	10	0	6	1	5	0	0	0	0	0	0
	09-Sep	18	0	18	0	17	4	13	0	1	0	1	0	0
	10-Sep	41	0	41	0	49	17	32	0	2	0	2	0	0
	Totals	453	0	453	0	362	32	330	0	13	0	13	0	5

(a) does not include three tagged-and-released fish that were not assigned location and sex designations
(b) sacrificed for broodstock
(c) these fish were not assigned a sex (M/F/J) designation; none of these were sacs or adipose clipped

Appendix B. Chinook salmon carcass recovery, by date, for the upper and lower Kitsumkalum River, 1991.

		Male				Female				Jack				NA (a)			
Location	Date	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad
Upper River																	
	06-Sep	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	07-Sep	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
	10-Sep	3	1	0	0	3	1	0	0	0	0	0	0	0	0	0	0
	16-Sep	2	1	0	0	7	0	0	0	0	0	0	0	0	0	0	0
	17-Sep	7	2	0	3	6	2	0	1	0	0	0	0	0	0	0	0
	19-Sep	14	3	0	1	21	5	0	0	0	0	0	0	1	0	0	0
	20-Sep	2	1	0	0	12	2	0	0	0	0	0	0	0	0	0	0
	23-Sep	7	0	0	0	28	8	0	0	0	0	0	0	0	0	0	0
	24-Sep	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0
	25-Sep	1	0	0	0	9	3	0	1	0	0	0	0	0	0	0	0
	26-Sep	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0
	27-Sep	0	0	0	0	8	3	0	0	0	0	0	0	0	0	0	0
	30-Sep	4	1	0	1	19	2	0	0	0	0	0	0	3	0	0	0
	01-Oct	8	1	0	0	26	2	0	0	0	0	0	0	0	0	0	0
	02-Oct	9	1	0	0	23	1	0	0	0	0	0	0	0	0	0	0
	03-Oct	7	2	0	0	15	1	0	0	0	0	0	0	0	0	0	0
	Totals	66	13	0	5	199	31	0	2	0	0	0	0	4	0	0	0

(a) these fish were not assigned a sex (M/F/J) designation

(b) No. Tag = number of marked fish recovered (tagged fish plus TL fish)

(c) TL = tag loss; these fish had an opercular punch and are included in the No. Tag column

Appendix B (cont). Chinook salmon carcass recovery, by date, for the upper and lower Kitsumkalum River, 1991.

		Male				Female				Jack				NA (a)			
Location	Date	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad	No. Rcvd	No. Tag (b)	No. TL (c)	No. Ad
Lower River																	
	30-Aug	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	03-Sep	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	04-Sep	3	0	0	0	6	0	0	0	0	0	0	0	1	1	0	0
	05-Sep	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	09-Sep	6	2	0	1	4	2	0	0	0	0	0	0	0	0	0	0
	10-Sep	5	1	0	0	17	1	0	0	0	0	0	0	0	0	0	0
	11-Sep	7	3	0	0	21	2	0	1	0	0	0	0	0	0	0	0
	12-Sep	6	1	0	0	5	0	0	1	0	0	0	0	0	0	0	0
	13-Sep	2	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0
	14-Sep	11	3	0	0	26	5	0	1	0	0	0	0	0	0	0	0
	16-Sep	17	4	0	0	44	6	0	0	0	0	0	0	0	0	0	0
	17-Sep	15	6	1	1	46	3	0	1	0	0	0	0	0	0	0	0
	18-Sep	43	4	0	0	74	7	1	0	2	0	0	0	0	0	0	0
	19-Sep	15	3	0	1	39	6	0	0	0	0	0	0	0	0	0	0
	20-Sep	14	0	0	0	33	4	0	0	0	0	0	0	0	0	0	0
	23-Sep	48	10	3	0	106	9	0	0	0	0	0	0	0	0	0	0
	24-Sep	15	3	0	0	24	4	1	3	0	0	0	0	0	0	0	0
	25-Sep	12	3	1	0	13	0	0	1	0	0	0	0	0	0	0	0
	26-Sep	12	2	1	1	19	1	0	0	0	0	0	0	1	1	0	0
	27-Sep	10	2	0	0	9	1	0	1	1	0	0	0	0	0	0	0
	30-Sep	34	9	5	0	68	7	3	1	0	0	0	0	2	0	0	0
	01-Oct	5	0	0	0	9	1	1	0	0	0	0	0	0	0	0	0
	02-Oct	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
	03-Oct	3	0	0	0	6	0	0	0	0	0	0	0	1	0	0	0
	04-Oct	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0
	Totals	286	56	11	4	593	62	6	10	3	0	0	0	5	2	0	0

(a) these fish were not assigned a sex (M/F/J) designation

(b) No. Tag = number of marked fish recovered (tagged fish plus TL fish)

(c) TL = tag loss; these fish had an opercular punch and are included in the No. Tag column