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Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapement of Kitsumkalum River, 1995

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**Canadian Manuscript Report of
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1997

ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENT OF KITSUMKALUM RIVER, 1995

by

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for

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Estimates of escapement were derived for the summer/fall run of chinook salmon (*Oncorhynchus tshawytscha*) of the Kitsumkalum River for 1995 using live-tagging and carcass-recovery operations. This study is part of the Chinook Key Stream Program. The Petersen estimate of all summer/fall run adult male and female chinook escapement to the total Kitsumkalum River was 7221. 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 both the upper and lower sections of the river.

The total estimated escapement of adipose-clipped adult male and female chinook to the entire Kitsumkalum River was 101 fish (1.4% 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 116 fish or 1.6% of the total adult male and female escapement estimate (0.6% for adult males and 1.0% 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 80 fish or 1.1% of the total adult male and female escapement estimate (0.4% for adult males and 0.7% for females). Total hatchery contributions were identified for Deep Creek Hatchery (Kitsumkalum River) and other hatcheries. In 1995, Deep Creek Hatchery contributed 82% (Method A) or 72% (Method B) of the total hatchery contribution of chinook salmon escapement of Kitsumkalum River.

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

RÉSUMÉ

Nelson, T. C. 1997. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1995. Can. Manuscr. Rep. Fish. Aquat. Sci. 2405: ix + 57 p.

Nous avons estimé l'effectif de l'échappée de la remonte estivale/automnale de quinnat (*Oncorhynchus tshawytscha*) de la rivière Kitsumkalum en 1995 par des opérations de marquage de poissons vivants et de récupération des carcasses. Cette étude entre dans le cadre du programme des cours d'eau clés pour le quinnat. L'estimation Petersen de l'échappée totale de quinnats adultes mâles et femelles dans la Kitsumkalum était de 7221. Dans ce rapport, les estimations de l'échappée totale correspondent à la somme des estimations par sexe et par tronçon de la rivière (supérieur et inférieur). Dans les deux tronçons, les quinnats d'âge 6 composaient la plus grande partie des échappées des deux sexes.

L'estimation totale des échappées de quinnats adultes mâles et femelles marqués par ablation de la nageoire adipeuse, pour l'ensemble de la Kitsumkalum, était de 101 poissons (1,4 % de l'échappée totale prévue). Cette estimation a été stratifiée par âge, par sexe et par code des micromarques. Pour calculer les contributions proportionnelles des différentes écloseries (poissons marqués et non marqués) aux échappées, on a employé la méthode du cours d'eau clé (méthode A), dans laquelle on applique à l'estimation des échappées de quinnats un facteur correspondant au taux de poissons marqués par ablation de la nageoire adipeuse au moment du lâcher, et un facteur correspondant au taux pondéré de poissons marqués dans la remonte. Avec la méthode A, la contribution totale des écloseries était de 116 poissons, soit 1,6 % de l'échappée totale d'adultes mâles et femelles (0,6 % pour les mâles adultes et 1,0 % pour les femelles). On a comparé la contribution ainsi estimée à celle obtenue avec la méthode du programme de récupération des marques (méthode B), dans laquelle on applique le taux de poissons portant une micromarque codée au moment du lâcher à l'estimation de l'échappée de quinnats portant une telle marque. Avec la méthode B, la contribution totale des écloseries était de 80 poissons, soit 1,1 % de l'échappée totale estimée des adultes mâles et femelles (0,4 % pour les mâles adultes et 0,7 % pour les femelles). On a pu déterminer la contribution totale de l'écloserie de Deep Creek (sur la Kitsumkalum) et d'autres écloseries. En 1995, l'écloserie de Deep Creek représentait 82 % (selon la méthode A) ou 72 % (selon la méthode B) de la contribution totale des écloseries à l'échappée de quinnats de la Kitsumkalum.

Mots clés: Kitsumkalum, quinnat, cours d'eau clé, échappée, micromarques codées, composition par âge, écloserie, marquage des poissons vivants

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 eighth in a series describing the escapement monitoring and biological sampling of the summer/fall run 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), the 1991 results are presented in Nelson (1993a), the 1992 results are presented in Nelson (1993b), the 1993 results are presented in Nelson (1994), and the 1994 results are presented in Nelson (1995).

The 1995 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.

The methods section of this report discusses potential biases in the Petersen method, the live tagging approach, and the methods of stratification. 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, presents the population composition (age, length, and sex), and produces results from coded wire tagging studies. The results are then discussed with respect to previous studies.

To avoid confusion in terminology that relates 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 (Alexander and English 1996). The late-run (or summer/fall run) of chinook start migrating into the river in early August. Spawning by the summer/fall run 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 through 1994, summer/fall run chinook escapements to the total Kitsumkalum River (both upper and lower sections) have been estimated at 11,825; 8308; 10,151; 24,508; 22,755; 18,287; 21,039; 9288; 12,437; 14,059; and 12,629, respectively[1] (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992, Nelson 1993a, Nelson 1993b, Nelson 1994, and Nelson 1995, respectively).

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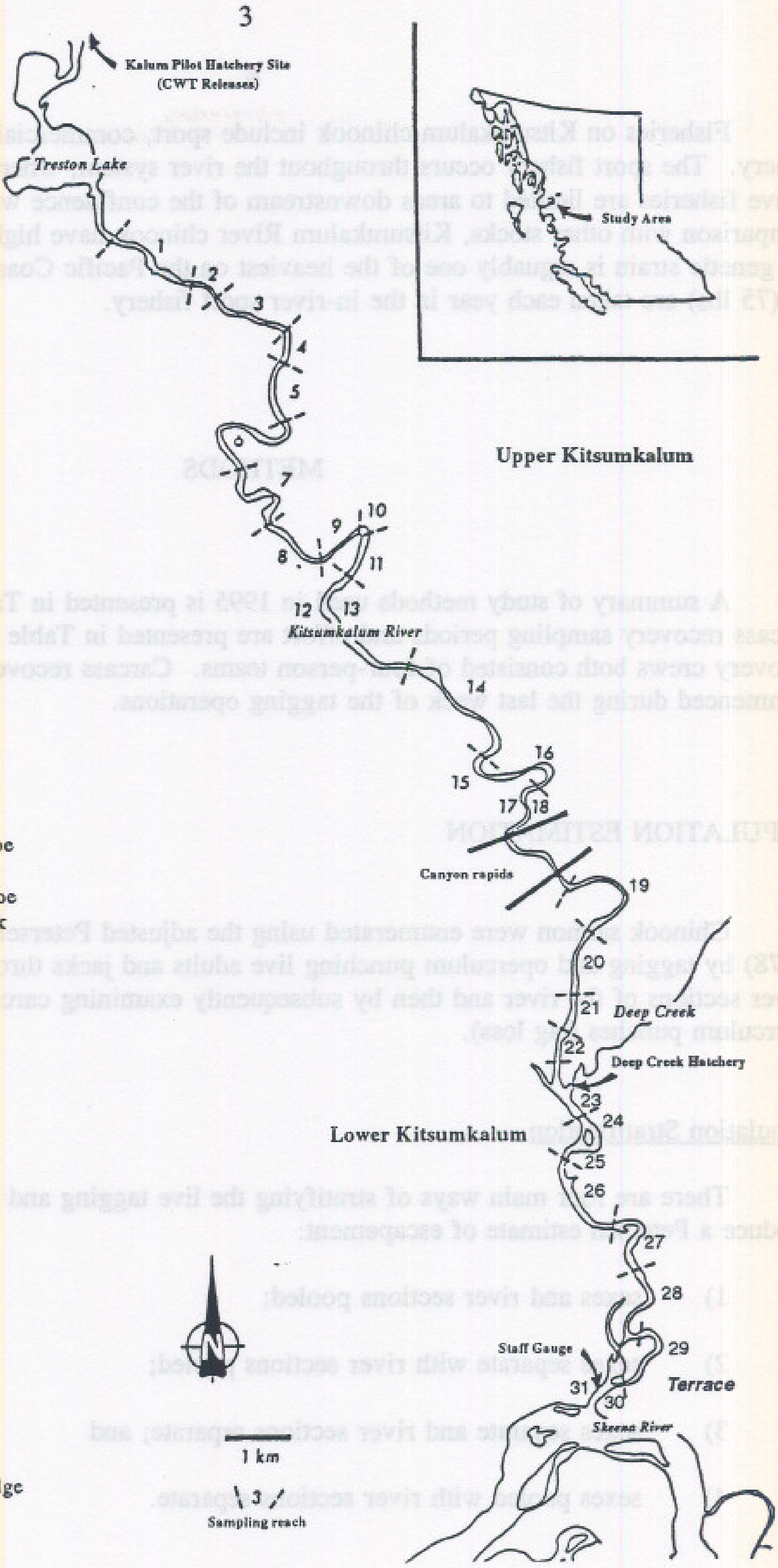
[1] The escapement estimates for 1991 - 1994 are for adult males and females only (population estimates for jacks could not be calculated due to the low number of recoveries of tagged/punched jack carcasses).



Sampling Reaches

No.	Name
Upper River	
1	16 mile
2	Culvert Run
3	Boat Launch
4	Camp Creek
5	Glacier Run
6	Tackle Run
7	Tight Turn
8	10 Mile
9	Upper Horseshoe
10	Grieves Pool
11	Lower Horseshoe
12	Luncheon Creek
13	Frog Beach
14	Lean-to Creek
15	6 Mile Creek
16	Cottonwoods
17	Pool Table
18	Mini Canyon
Lower River	
19	Lower Canyon
20	Stumble Run
21	Snake Run
22	Diggers
23	Deep Creek
24	Upper Dump
25	Lower Dump
26	Nass Road
27	Clay Bank
28	Dutch Valley
29	Spring Creek
30	Bell Pole
31	Below CN Bridge

Figure 1. Map of the Kitsumkalum River Study Area

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 study methods used in 1995 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.

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, carcass recovery, 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 single population estimate may be biased. In view of the likelihood that sexes and river sections could be affected at different rates, as documented by Andrew et al. (1988), Petersen estimates presented in this study were stratified by sex and river section.

<u>Potential Biases</u>

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 (1991a), 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) <u>within</u> the Kitsumkalum River between the upper and lower sections. 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 1995, 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):

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

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:

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

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 in-river strays[2]. For the purposes of the Petersen calculations, the total number of in-river strays from the upper Kitsumkalum u to the lower Kitsumkalum l was estimated by expanding the observed number of tagged in-river 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 in-river strays, TS is the number of tagged in-river strays, M is the number of secondary marks applied and R is the number of secondary marks recovered.

This expanded number of tagged in-river 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 m 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.

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2 Strays from other rivers, identified by decoded CWTs, are referred to in this report as "strays from other hatcheries."

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 operculum tag, operculum 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:

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

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

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

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.

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 1989 - 1993 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 <u>CWTs</u> present in the escapement from which to derive the hatchery contribution, whereas Method A uses the number of <u>adipose clips</u> 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.

<u>Method A</u>

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 1995. 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:

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

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 (1991a).

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:

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

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:

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

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 separately for fish of Kitsumkalum origin and for between-river strays released from other hatcheries[3].

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

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[3] In 1995, single between-river stray (a female collected as a carcass in the upper river) was identified (by decoded CWT), and subsequently confirmed (through re-examination of the CWT) as a 1990 hatchery release from the Squamish River, B.C.

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 AFCs 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:

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

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:

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

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 (1991a).

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:

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

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

Tagging operations in 1995 occurred between 21 August and 20 September (Table 2). Numbers of chinook captured, tagged, and released during the 1995 tagging operations in the upper and lower Kitsumkalum River, by date, are presented in Appendix A.

A total of 876 chinook (507 males, 367 females, and two jacks) were tagged, operculum punched, and released (Table 3). Of these, 272 were tagged in the upper river (174 males, 96 females, and two jacks) and 604 were tagged in the lower river (333 males and 271 females).

RECOVERY

Carcass recovery operations in 1995 occurred between 16 September and 5 October (Table 2). 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 822 chinook carcasses (209 males, 612 females, and one jack) were examined during carcass recovery operations in 1995 (Table 3). Of the 137 carcasses recovered in the upper river (35 males, 101 females, and one jack) there were 22 total tag and/or punch recoveries (eight males and 14 females). Of the 685 carcasses recovered in the lower river (174 males and 511 females), there were 66 total tag and/or punched recoveries (26 males and 40 females). 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 in-river strays. In 1995, nine chinook (seven males and two females) tagged in the upper river were recovered in the lower river (Table 3). No tagged and/or punched in-river strays were recovered in the upper section of the river. A discussion of in-river stray observations is presented in the discussion section of this report.

A total tag rate (incidence) of 16.1% and 8.3% was achieved for the upper and lower Kitsumkalum, respectively (Table 4). Total tag recovery was 8.1% for the upper river and 9.4% for the lower river. In addition, the total tag loss rate was 4.5% for the upper river and 12.1% for the lower river.

POPULATION ESTIMATES

Mark-recapture data, Petersen population estimates, and 95% confidence levels for chinook escapement to the Kitsumkalum River in 1995 are presented in Table 5. The number of chinook carcasses recovered includes 11 carcasses with no sex designation (four in the upper river and seven in the lower river); sex ratios from the upper and lower river carcass recovery were used to attribute sex designations to these recoveries (the result being one male and three females to the upper river, and two males and five females to the lower river). No tagged/punched jack chinook were recovered in either the upper or lower river in 1995; 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 1995 estimated total escapement of adult chinook to the total Kitsumkalum system (both sections of river) was 7221. The lower and upper 95% confidence levels were 5062 and 10,293, respectively. The estimated total escapement included 3087 adult chinook to the upper Kitsumkalum and 4133 adult chinook 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 in 1995 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 1995, age-5 to age-7 adult chinook were represented in the deadpitch with age-6 chinook comprising approximately 80% of the total run (Table 6). Age-5 and age-7 chinook represented another 19% and 1% of the population, respectively. In 1995, 98% of the scale-aged chinook had a freshwater age of 2 (Table 7).

The mean lengths (postorbital-hypural) of all (aged and unaged) adult male and female chinook, sampled from the deadpitch in 1995 (presented in Table 6), were compared within river sections (upper and lower) and between river sections. For all cases, the analyses found no significant differences (t-tests) in lengths, as follows:

1) Within river sections

a) in the upper river, females (mean = 824 mm) had a larger mean length than adult males (mean = 816 mm) and the difference was not significant (t-test, $P>0.5$); and

b) in the lower river, females (mean = 833 mm) had a larger mean length than adult males (mean = 830 mm) and the difference was not significant (t-test, $P>0.5$).

2) Between river sections

a) adult males from the upper river had a smaller mean length than adult males from the lower river, and the difference was not significant (t-test, $P>0.5$); and

b) female chinook from the upper river had a smaller mean length than females from the lower river, and the difference was not significant (t-test, $P>0.05$).

Comparative analyses (t-tests) of the lengths of aged and unaged adult chinook from the upper and lower Kitsumkalum produced the following results:

1) Upper river

aged males vs. unaged males	not significant ($P>0.2$)
aged females vs. unaged females	significant ($P<0.005$)

2) Lower river

aged males vs. unaged males	not significant ($P>0.2$)
aged females vs. unaged females	not significant ($P>0.5$)

Sex ratios were calculated using the Petersen population estimates for 1995 (Table 5). Calculations for males did not include jacks. The ratio of adult males:females was 0.60 for the upper river, 0.77 for the lower river, and 0.75 for the total river. A statistical comparison of the number (from Petersen estimates) of adult males (n = 3087) and females (n = 4133) from the total river (pooled population estimates from both sections of river) found a significant difference from an expected ratio of 50:50 (χ^2, $P<0.001$). Similarly, due to the higher proportion of males throughout the system, significant differences in numbers (from the same expected ratio of 50:50) were found for the following comparisons (χ^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 1988 to 1993 brood years were sampled as in the dead recovery program in 1995, and the heads were collected for coded wire tag analysis. Successfully decoded coded wire tags from the samples provided information only for 1988 and 1990 brood years.

The results of 1995 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, Method A);

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 (Table 10, Method A; Tables 14 and 15, Method B);

5) CWT and adipose-clip release data for hatchery-reared chinook salmon recovered in the Kitsumkalum River, 1995 (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 (Table 12, Method A; Table 16, Method B); and

7) the estimated hatchery contribution of adult male and female chinook to the upper, lower, and total Kitsumkalum River, by age (Table 13, Method A; Table 17, Method B).

During the 1995 live-tagging operations, a total of seven adipose-clipped chinook were observed in the upper river and 10 were observed in the lower river (Table 9). During the carcass recovery operations, no adipose-clipped chinook were observed in the upper river and a total of eight adipose-clipped chinook were observed in the lower river. The combined (live tagging and carcass recovery) adipose-clip mark rates were 1.7% for the upper river and 1.3% for the lower river; these mark rates were not significantly different (χ^2, $P>0.9$). The total estimated number of adipose-clipped adult male and female chinook (weighted average for live and dead) to the total river was 101 (15 to the upper river and 86 to the lower river); this estimate comprised 1.4% of the total escapement estimate.

Hatchery Contributions - Method A

The estimated total escapements of each CWT group decoded in 1995 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 CWT fish recovered in the system that were released from other hatcheries (between-river strays) were included in the analysis. A total of five CWT heads from adipose-clipped chinook recovered in 1995 were successfully decoded (Table 10).

Using Method A, the 1995 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 116 fish (43 adult males and 73 females; Table 12). Of this total hatchery contribution, 82% is attributed to Deep Creek Hatchery (43 males and 52 females) and 18% is attributed to strays from other hatcheries (21 females only); the stray contribution from other hatcheries is based solely on the recovery of one CWT carcass that was released from the Squamish River Hatchery in 1990.

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 1995 was estimated at 1.6% (0.6% for adult males and 1.0% for females). The hatchery contribution from Deep Creek Hatchery was 1.3%, and the hatchery contribution from strays from other hatcheries (Squamish River) was also 0.3%.

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 1995 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 80 fish (32 adult males and 48 females; Table

16). Of this total hatchery contribution, 72% is attributed to Deep Creek Hatchery (32 males and 25 females) and 28% is attributed to strays from other hatcheries (23 females only); the stray contribution from other hatcheries is based solely on the recovery of one CWT carcass that was released from the Squamish River Hatchery in 1990.

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 1995 was estimated to be 1.1% (0.4% for adult males and 0.7% for females). The hatchery contribution from Deep Creek Hatchery was 0.8%, and the hatchery contribution from strays from other hatcheries (Squamish River) was 0.3%.

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 1995 could not be produced because neither of the two tagged and opercular-punched jacks were 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, 1995 population estimates of adult male and female chinook can be compared with population estimates from past studies.

The 1995 total Kitsumkalum River escapement estimate of summer/fall run adult male and female chinook salmon was 7221, which is the lowest escapement estimate for the total river since the inception of the program in 1984. The 1995 escapement estimate is a 43% decrease from the 1994 adult male and female population estimate (12,629; Nelson 1995) and a 49% decrease from the 1993 estimate (14,059; Nelson 1994). Figure 2 presents an illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the total Kitsumkalum River from 1984-1995; in 1984, population estimates were derived from pooled data due to a lack of recaptures in the upper river (Andrew and Webb 1988).

The total population estimate is the sum of individual estimates for the upper and lower sections of the Kitsumkalum River. For 1995, the estimated number of adult male and female chinook to the upper Kitsumkalum River (n = 909) represented 12.6% of the total escapement; this escapement to the upper river, and the proportional representation of the upper river escapement to the total escapement, are also the lowest since the inception of program. Figure 3 presents an illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the upper Kitsumkalum River from 1985-1995. In 1992, chinook escapement to the upper Kitsumkalum River represented 53% of the total escapement; in 1993, the upper river escapement represented 34% of the total escapement, and in 1994 represented 15% of the total escapement. The continuation of this reduction in the proportional representation of escapement for the upper section of the river in 1995 (12.6% of the total escapement) could be an indication that the spawning and/or rearing conditions for chinook in the upper section of the river are degrading at a faster rate than in the lower section. Figure 4 presents an illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the lower Kitsumkalum River from 1985-1995.

In 1995, the number of observed in-river strays from the upper to the lower river was nine (seven males and two females); there was a significant difference in the proportion of male and female in-river strays from the upper to the lower river (χ^2, $P<0.005$). The high proportion of males that strayed from the upper to the lower river in 1995 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). There were no observed in-river strays from the lower river to the upper river in 1995.

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 (7221) were within 42.5% and 29.9%, 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 (80%) of the escapement to the total Kitsumkalum River in 1995. Age-5 chinook represented the next largest contribution (19%).

These findings are consistent with prior investigations (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; Nelson 1993b; Nelson 1994; Nelson 1995). The representation of age-7 chinook (1.0%) in 1995 is lower than the 1994 representation of age-7 chinook (3.0%; Nelson 1995). Estimates of the proportions of age-7 chinook in the 1987-94 escapements are as follows: 1987, 0.0%; 1988, 2.0%; 1989, 2.0%; 1990, 0.9%; 1991, 14.4%; 1992, 0.3%; 1993, 0.3%; and 1994, 3.0% (Carolsfeld et al. 1990, Nass and Bocking 1992, and Nelson 1993a, Nelson 1994, and Nelson 1995, respectively).

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 1995, no significant differences in mean lengths were found in any of the comparisons.

In addition, significant differences were not found between aged and unaged specimens (males only in the upper river; both sexes in the lower river), which would indicate that lengths from the aged samples were representative of these populations. A significant difference ($P<0.005$) was found between the lengths of aged and unaged females sampled in the upper river.

Stratified mean lengths of aged and unaged adult male and female chinook in the upper Kitsumkalum River in 1995 varied more than 50 mm in some cases from respective 1994 mean lengths, but the sample size for aged lengths in 1995 was much smaller (n = 110) in comparison to that of 1994 (n = 203). Given the low number of successfully aged samples, sampling crews should be instructed to increase the frequency of scale data collection during the carcass recovery operation from every fifth carcass to every third carcass.

Adult females (57.3%) represented a larger proportion of the total escapement compared to males (42.7%) in 1995. Because the population estimate for males does not include jacks, a smaller difference in the proportion of all males (adults plus jacks) and females would be expected. There were significant differences (from an expected male:female sex ratio of 50:50) in the actual numbers of all adult males and females (pooled population estimates from both sections of river (χ^2, $P<0.001$), and for all comparisons of like sexes within and between river sections (χ^2, $P<0.001$ in all cases). Previous studies have also shown variability in sex ratios, both within and between years (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; Nelson 1994; Nelson 1995).

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 0.97% in 1995.

Estimates of percent hatchery contribution to total Kitsumkalum River chinook escapement in 1995 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 (1.6%) than Method B (1.1%). Potential reasons for the differences in the estimates are discussed in Bocking (1991b). Both of the 1995 hatchery contribution estimates (Methods A and B) included significant contributions from hatcheries other than Deep Creek (Kitsumkalum River) hatchery. A comparison of percent hatchery contributions for 1989-95, by year and estimation method (Method A and Method B) is provided below:

Percent hatchery contribution estimates to total Kitsumkalum River chinook escapement

Year	Method A	Method B
1989	3.0%	2.7%
1990	2.3%	2.1%
1991	1.4%	1.2%
1992	3.8%	3.6%
1993	1.0%	0.8%
1994	0.5%	0.4%
1995	1.6%	1.1%

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 1991b).

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 ±25% of the population estimate. In 1995, a total of 25 (observed) adipose clips and five CWTs (decoded) were observed during the live tagging and carcass recovery operations.

In 1995, crews examined 13.0% of the estimated population of adult male and female chinook for adipose clips during live tagging operations and 11.4% of the estimated population during carcass recovery operations. The examination levels achieved during the live tagging operation in 1995 was consistent with that in past years; the examination levels achieved during the carcass recovery operation in 1995 was up slightly from the 1994 effort and approximately 3% less than in most years.

SUMMARY

1. The 1995 total Kitsumkalum River escapement estimate of summer/fall run adult male and female chinook salmon, calculated using a combination of live tagging and carcass recovery data, was 7221. 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 lack of tagged/punched recoveries precluded a Petersen population estimate for that segment of the total population. The 1995 escapement estimate (7221) is the lowest escapement estimate for the total river since the inception of the program in 1984, and is a 43% decrease from the 1994 adult male and female population estimate (12,629) and a 49% decrease from the 1993 estimate (14,059).

2. The 1995 escapement of adult male and female chinook was represented by age-5 to age-7 fish. Age-6 chinook comprised the largest portion of the escapement (80%), followed by age-5 (19%), and age-5 (1%).

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 1995, no significant differences in mean lengths were found in any of the comparisons. In addition, significant differences were not found between aged and unaged specimens (males only in the upper river; both sexes in the lower river), which would indicate that lengths from the aged samples were representative of these populations. A significant difference ($P<0.005$) was found between the lengths of aged and unaged females sampled in the upper river.

4. Adult females outnumbered adult males in 1995. 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 a significant difference from an expected ratio of 50:50 (χ^2, $P<0.001$). There were significant differences in the actual numbers of all adult males and females (pooled population estimates from both sections of river (χ^2, $P<0.001$), and for all comparisons of like sexes within and between river sections (χ^2, $P<0.001$ in all cases). Because the population estimate for males does not include jacks, a smaller difference in the proportion of all males (adults plus jacks) and females would be expected.

5. The total estimated escapement of adipose-clipped adult male and female chinook to the total Kitsumkalum River in 1995 was 101 (1.4% 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 116 fish (1.6% of the total escapement estimate); of this total (Method A) hatchery contribution, 82% is attributed to Deep Creek Hatchery and 18% is attributed to strays from other hatcheries. Using the Mark Recovery Program approach (Method B), the total estimated hatchery contribution to the total escapement of adult male and female chinook was 80 fish (1.1% of the total escapement estimate); of this total (Method B) hatchery contribution, 72% is attributed to Deep Creek Hatchery and 28% is attributed to strays from other hatcheries.

7. Using Method A, the hatchery contribution from Deep Creek Hatchery was 1.3%, and the hatchery contribution from strays from other hatcheries (Squamish River) was also 0.3%. Using Method B, the hatchery contribution from Deep Creek Hatchery was 0.8%, and the hatchery contribution from strays from other hatcheries (Squamish River) was 0.3%.

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LITERATURE CITED

Alexander, R. F., and K. K. English. 1996. Distribution, timing and numbers of early-run chinook salmon returning to the Kitsumkalum River watershed in 1995. Report by LGL Limited environmental research associates for Department of Fisheries and Oceans, North Coast Stock Assessment, Prince Rupert, B.C. 81 p.

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. Manuscr. 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. Manuscr. 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[a]. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1989-1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2124: x + 109 p.

Bocking, R. C. 1991[b]. 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. Manuscr. 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. Manuscr. 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. 1995. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2332: viii + 48 p.

Nelson, T. C. 1994. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2249: viii + 47 p.

Nelson, T. C. 1993a. 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 + 43 p.

Nelson, T. C. 1993b. 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.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

TABLES

Table 1. Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1995.

Item	Method and materials 1995
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
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.

Table 2. Summary of live tagging and carcass recovery effort for chinook salmon in the Kitsumkalum River, 1995.

Location	Tagging period	Effort (days) (c)	Carcass recovery period	Effort (days) (c)
Upper river (a)	Aug 28 - Sep 19	9	Sep 18 - Oct 02	6
Lower river (b)	Aug 21 - Sep 20	18	Sep 16 - Oct 05	8

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

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

(c) Derived from the number of individual dates that respective efforts were applied (see Appendices A and B)

Table 3. Live tagging and carcass recovery statistics for chinook salmon in the upper and lower Kitsumkalum River, 1995.

Category	Upper river	Lower river	Total
Live tagging (a)			
Males examined	175	336	511
Females examined	111	319	430
Jacks examined	2	0	2
Total examined	288	655	943
Males tagged/punched	174	333	507
Females tagged/punched	96	271	367
Jacks tagged/punched	2	0	2
Total tagged/punched	272	604	876
Dead recovery (b)			
Males examined	35	174	209
Females examined	101	511	612
Jacks examined	1	0	1
Total examined	137	685	822
Punched-only males (d)	0	5	5
Punched-only females (d)	1	3	4
Punched-only jacks (d)	0	0	0
Total punched only (d)	1	8	9
Tagged/punched males (e)	8	26	34
Tagged/punched females (e)	14	40	54
Tagged/punched jacks (e)	0	0	0
Total tagged/punched (e)	22	66	88
Strays (f)			
Stray males	0	7	7
Stray females	0	2	2
Stray jacks	0	0	0
Total strays	0	9	9

(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) Includes recoveries with no sex designation (four in the upper river and seven in the lower river); sex ratios from the upper and lower river carcass recovery were used to attribute sex designations (one male and three females to the upper river; two males and five females to the lower river)

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

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

(f) 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, 1995.

Category	Upper river	Lower river	Total
Tag rate (a)			
Male tag rate (%)	22.9	10.9	12.9
Female tag rate (%)	13.9	7.4	8.5
Jack tag rate (%)	0.0	0.0	0.0
Total tag rate (%)	16.1	8.3	9.6
Tag recovery rate (b)			
Male tag recovery rate (%)	4.6	5.7	5.3
Female tag recovery rate (%)	14.6	14.0	14.2
Jack tag recovery rate (%)	0.0	0.0	0.0
Total tag recovery rate (%)	8.1	9.4	9.0
Tag loss rate (c)			
Male tag loss rate (%)	0.0	19.2	14.7
Female tag loss rate (%)	7.1	7.5	7.4
Jack tag loss rate (%)	0.0	0.0	0.0
Total tag loss rate (%)	4.5	12.1	10.2

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, 1995. Confidence limits are from fudicial limits for the Poisson distribution using Pearson's formulae when R is greater than 50 (Ricker 1975, p. 343).

Location	Male	Female	Jack (h)	Total
Upper river				
Number tagged (a)	174	96	2	272
Number recovered (b)(c)	35	101	1	137
Number of tagged fish recovered (d)	8	14	0	22
Number of tagged strays from lower river (e)	0	0	0	0
Expanded No. of tagged strays from lower river (f)	0	0	0	0
Number of tagged fish for Petersen estimate (g)	84	82	2	169
Petersen estimate	341	567	N/A	909 (i)
Lower 95% CL	183	347	N/A	530 (i)
Upper 95% CL	610	912	N/A	1522 (i)
Lower river				
Number tagged (a)	333	271	0	604
Number recovered (b)(c)	174	511	0	685
Number of tagged fish recovered (d)	26	40	0	66
Number of tagged strays from upper river (e)	7	2	0	9
Expanded No. of tagged strays from upper river (f)	90	14	0	103
Number of tagged fish for Petersen estimate (g)	423	285	0	707
Petersen estimate	2746	3566	N/A	6312 (i)
Lower 95% CL	1896	2636	N/A	4532 (i)
Upper 95% CL	3957	4814	N/A	8771 (i)
Total river				
Petersen estimate	3087	4133	N/A	7221 (h)
Lower 95% CL	2079	2983	N/A	5062 (h)
Upper 95% CL	4567	5726	N/A	10293 (h)

(a) Total live tagged/punched (Appendix A, "No. tagged")
(b) Total dead recoveries (Appendix B, "No. revd")
(c) Includes recoveries with no sex designation (four in the upper river and seven in the lower river); sex ratios from the upper and lower river carcass recovery were used to attribute sex designations (one male and three females to the upper river; two males and five females to the lower river)
(d) Total dead recoveries possessing a tag and/or punch (Appendix B, "No. tag")
(e) Total dead recoveries possessing a tag and/or punch applied in the other section of river (Appendix B, "No. strays")
(f) Expanded strays = No. of tagged strays * (No. tagged/No. tagged recovered)
(g) Number of tagged fish for Petersen estimate = No. tagged + expanded No. of tagged strays - expanded No. of tagged strays from other section
(h) N/A = not available; due to the lack (0) of tagged/punched jacks recovered, it is not possible to calculate a Petersen estimate for their segment of the population
(i) These totals do not include jacks; see footnote (h) above

Table 6. Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1995. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (b)	Male (a) 4	5	6	7	Total aged	Total unaged	Total aged + unaged	Female 4	5	6	7	Total aged	Total unaged	Total aged + unaged
Upper river														
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	0	0	0	0	0	0	0	0	0
550-599	0	0	0	0	0	1	1	0	0	0	0	0	0	0
600-649	0	0	0	0	0	2	2	0	0	0	0	0	0	0
650-699	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700-749	0	2	0	0	2	1	3	0	0	0	0	0	2	2
750-799	0	1	0	0	1	3	4	0	1	1	0	2	14	16
800-849	0	0	1	0	1	1	2	0	1	5	0	6	25	31
850-899	0	0	1	0	1	7	8	0	0	9	0	9	12	21
900-949	0	0	0	0	0	6	6	0	0	2	0	2	2	4
950-999	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1000-1049	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	3	2	0	5	22	27	0	2	17	0	19	55	74
Percent (aged)	0.0	60.0	40.0	0.0	100.0			0.0	10.5	89.5	0.0	100.0		
Mean (b)	0	737	850	0	782	824	816	0	805	853	0	848	816	824
SD (b)	0	21	42	0	67	105	99	0	35	40	0	40	41	43

Column group header: Total age (years)

Table 6. (cont.) Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1995. Data for calculations are from scale analysis and CWT age samples.

	Total age (years)													
	Male (a)							Female						
Length class (mm) (b)	4	5	6	7	Total aged	Total unaged	Total aged + unaged	4	5	6	7	Total aged	Total unaged	Total aged + unaged
Lower river														
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	0	0	1	0	1	3	4	0	0	0	0	0	0	0
600-649	0	0	1	0	1	3	4	0	0	0	0	0	1	1
650-699	0	0	0	0	0	2	2	0	0	0	0	0	0	0
700-749	0	2	0	0	2	12	14	0	0	1	0	1	4	5
750-799	0	0	0	0	0	13	13	0	8	7	0	15	43	58
800-849	0	1	0	0	1	19	20	0	5	24	0	29	184	213
850-899	0	0	1	1	2	39	41	0	0	30	0	30	107	137
900-949	0	0	1	0	1	22	23	0	0	2	0	2	15	17
950-999	0	0	1	0	1	10	11	0	0	0	0	0	3	3
1000-1049	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	3	5	1	9	126	135	0	13	64	0	77	357	434
Percent (aged)	0.0	33.3	55.6	11.1	100.0			0.0	16.9	83.1	0.0	100.0		
Mean (b)	0	763	788	870	789	833	830	0	797	841	0	834	833	833
SD (b)	0	49	196	0	144	99	102	0	30	34	0	37	40	39

(a) Does not include jacks

(b) Postorbital-hypural length

Table 7. Freshwater age composition of deadpitch Kitsumkalum River chinook salmon, 1995. (a)

Location	Age (c)	Male (b) N	Male (b) Percent	Female N	Female Percent
Upper river					
	41	0	0.0	0	0.0
	42	0	0.0	0	0.0
	51	0	0.0	0	0.0
	52	3	60.0	2	10.5
	61	0	0.0	0	0.0
	62	2	40.0	17	89.5
	71	0	0.0	0	0.0
	72	0	0.0	0	0.0
	Total	5	100.0	19	100.0
Lower river					
	41	0	0.0	0	0.0
	42	0	0.0	0	0.0
	51	0	0.0	3	3.9
	52	2	25.0	10	13.0
	61	0	0.0	0	0.0
	62	5	62.5	64	83.1
	71	0	0.0	0	0.0
	72	1	12.5	0	0.0
	Total	8	100.0	77	100.0

(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 52 indicates the fish is in its fifth year of life and left freshwater for ocean rearing during its second year of life

Table 8. Petersen estimates, by age, of chinook salmon escapement to the Kitsumkalum River, 1995.

	Total age	Male (a)		Female	
		Number (b)	Percent (c)	Number (b)	Percent (c)
Upper river					
	4	0	0.0	0	0.0
	5	205	60.0	60	10.5
	6	137	40.0	508	89.5
	7	0	0.0	0	0.0
	Total	341 (d)(e)	100.0	567 (d)(e)	100.0
Lower river					
	4	0	0.0	0	0.0
	5	915	33.3	602	16.9
	6	1526	55.6	2964	83.1
	7	305	11.1	0	0.0
	Total	2746 (d)	100.0	3566 (d)	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) From Table 5

(e) 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, 1995.

	Live tagging			Dead recovery			Petersen population	Total estimated adipose clips		Weighted estimate of
Location and sex	Sample size (a) A	Observed adipose clips (b) B	Mark rate (%) C=B/A*100	Sample size (c) D	Observed adipose clips (d) E	Mark rate (%) F=E/D*100	estimate (e) G	Live tagging H=C/100*G	Dead recovery I=F/100*G	adipose clips J (f)
Upper river										
Male (g)	175	4	2.29	35	0	0.00	341	8	0	7
Female	111	3	2.70	101	0	0.00	567	15	0	8
Subtotal	286	7	2.45	136	0	0.00	909	23	0	15
Lower river										
Male (g)	336	6	1.79	174	2	1.15	2746	49	32	43
Female	319	4	1.25	511	6	1.17	3566	45	42	43
Subtotal	655	10	1.53	685	8	1.17	6311.8	94	73	86
Total river										
Male (g)	511	10	1.96	209	2	0.96	3087.3	57	32	50
Female	430	7	1.63	612	6	0.98	4133.4	60	42	51
Subtotal										
Total	941	17	1.81	821	8	0.97	7220.6	117	73	101

(a) Sample size for estimating adipose clip rates in the live tagging includes all fish captured minus recaptures (Appendix A)
(b) From Appendix A
(c) Sample size for estimating adipose clip rates in the dead recovery includes all fish examined (Appendix B)
(d) From Appendix B
(e) From Table 5
(f) J=((A * H) + (D * I)) / (A + D)
(g) 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, 1995. 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
Kitsumkalum River (Deep Creek Hatchery)									
1990	021136	0	0	0.0	0.0	0	1	0.0	14.3
	021137	0	0	0.0	0.0	0	1	0.0	14.3
	021138	0	0	0.0	0.0	0	1	0.0	14.3
	Subtotal	0	0	0.0	0.0	0	3	0.0	43.0
1989	020942	0	0	0.0	0.0	1	0	43.0	0.0
	Subtotal	0	0	0.0	0.0	1	0	43.0	0.0
	Total hatchery	0	0	0.0	0.0	1	3	43.0	43.0
Strays from other hatcheries (c)									
1990	021534	0	1	0.0	8.0	0	0	0.0	0.0
	Total strays	0	1	0.0	8.0	0	0	0.0	0.0
	Total CWT (d)	0	1	7.0 (e)	8.0 (e)	1	3	43.0 (e)	43.0 (e)
No data (5000) (f)		4	2			5	3		
No pin (8000)		0	0			0	2		
Lost pin (9000)		0	0			0	0		
Observed adipose clips		4	3			6	8		

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(d) Total CWT = total hatchery + total strays
(e) From Table 9 (weighted estimate of adipose clips)
(f) In addition to "no data" entries from the carcass CWT analysis, included are all adipose clips observed in the live tagging operation minus duplicate counts from the dead recovery (identified by operculum tag or tag loss/operculum punch); in 1995, three operculum tagged and adipose-clipped chinook were recovered as carcasses in the lower river; (one decoded CWT male, one "No data" female, and one "No pin" female); the resultant deletion of three of the 17 "No data" entries for adipose clips from the live tagging operation assures that individual adipose clips are not double counted in the analysis presented in Table 14

Table 11. CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1995.

Brood year	CWT release group	CWT release numbers CWT (A)	Untagged (B)	CWT loss (%) (C)	Days held (D)	Adipose release status Clipped (E) = A/(1-C/100)	Unclipped (F) = A+B-E
Kitsumkalum River (Deep Creek Hatchery)							
1990	021136	26783	5545	0.0	1	26783	5545
	021137	26599	5544	0.0	1	26599	5544
	021138	26722	5545	0.0	1	26722	5545
1989	020942	26908	0	0.0	1	26908	0
	Total hatchery	107012	16634			107012	16634
Strays from other hatcheries (a)							
1990	021534	49183	89499	6.4	42	52546	86136

(a) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs); CWT code 021534 was released from Squamish River Hatchery in 1990

Table 12. Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1995. 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 status (c)		Expansion factor (d)	Expanded hatchery contribution (a)(b)			
					Upper river		Lower river	
		Clipped	Unclipped		M (e)	F	M (e)	F
Kitsumkalum River (Deep Creek Hatchery)								
1990	021136	26783	5545	1.21	0.0	0.0	0.0	17.3
	021137	26599	5544	1.21	0.0	0.0	0.0	17.3
	021138	26722	5545	1.21	0.0	0.0	0.0	17.3
	Subtotal				0.0	0.0	0.0	51.9
1989	020942	26908	0	1.00	0.0	0.0	43.0	0.0
	Subtotal				0.0	0.0	43.0	0.0
	Total hatchery				0.0	0.0	43.0	51.9
Strays from other hatcheries (f)								
1990	021534	52546	86136	2.64	0.0	21.1	0.0	0.0
	Subtotal				0.0	21.1	0.0	0.0
	Total strays				0.0	21.1	0.0	0.0
	Total CWT (g)				0.0	21.1	43.0	51.9

(a) Abbreviations are M = male, F = female
(b) Calculated from estimated adipose clips in Table 10
(c) From Table 11
(d) Expansion factor = (adipose-clipped + unclipped releases) / adipose-clipped releases
(e) Does not include jacks
(f) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(g) Total CWT = total hatchery + total strays

Table 13. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1995. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 12).

			Hatchery contribution (a)							
			Kitsumkalum River (Deep Creek Hatchery)				Strays from other hatcheries (b)			
	Estimated escapement (c)		Male (d)		Female		Male (d)		Female	
Total age	Male (d)	Female	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Upper river										
4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	205	60	0.0	0.0	0.0	0.0	0.0	0.0	21.1	35.3
6	137	508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	341 (e)	567 (e)	0.0	0.0	0.0	0.0	0.0	0.0	21.1	3.7
Lower river										
4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	915	602	0.0	0.0	51.9	8.6	0.0	0.0	0.0	0.0
6	1526	2964	43.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0
7	305	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Subtotal	2746	3566	43.0	1.6	51.9	1.5	0.0	0.0	0.0	0.0
Total river										
4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1120	662	0.0	0.0	51.9	7.8	0.0	0.0	21.1	3.2
6	1662	3472	43.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0
7	305	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3087	4133 (e)	43.0	1.4	51.9	1.3	0.0	0.0	21.1	0.5

(a) Subtotals of expanded hatchery contribution from Table 12
(b) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(c) From Table 8
(d) Does not include jacks
(e) Summation is a result of rounding

Table 14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1995. 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 (b)		Adjusted CWTs		Decoded adipose clips (b)		Adjusted CWTs	
Brood year	CWT code	M (c)	F	M (c)	F	M (c)	F	M (c)	F
Kitsumkalum River (Deep Creek Hatchery)									
1990	021136	0	0	0.0	0.0	0	1	0.0	1.6
	021137	0	0	0.0	0.0	0	1	0.0	1.6
	021138	0	0	0.0	0.0	0	1	0.0	1.6
	Subtotal	0	0	0.0	0.0	0	3	0.0	4.8
1989	020942	0	0	0.0	0.0	1	0	6.0	0.0
	Subtotal	0	0	0.0	0.0	1	0	6.0	0.0
Total hatchery		0	0	0.0	0.0	1	3	6.0	4.8
Strays from other hatcheries (c)									
1990	021534	0	1	0.0	3.0	0	0	0.0	0.0
Total strays		0	1	0.0	3.0	0	0	0.0	0.0
Total CWT (d)		0	1	0.0	3.0	1	3	6.0	4.8
No data (5000) (e)		4	2			5	3		
No pin (8000)		0	0			0	2		
Lost pin (9000)		0	0			0	0		
Observed adipose clips		4	3			6	8		

(a) Abbreviations are M = male, F = female
(b) Does not include jacks
(c) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(d) Total CWT = total hatchery + total strays
(e) In addition to "no data" entries from the carcass CWT analysis, included are all adipose clips observed in the live tagging operation minus duplicate counts from the dead recovery (identified by operculum tag or tag loss/operculum punch); in 1995, three operculum tagged and adipose-clipped chinook were recovered as carcasses in the lower river; (one decoded CWT male, one "No data" female, and one "No pin" female); the resultant deletion of three of the 17 "No data" entries for adipose clips from the live tagging operation assures that individual adipose clips are not double counted in this analysis

Table 15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1995. 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)			
Brood	CWT	Adjusted CWTs (b)		Estimated adipose clips		Adjusted CWTs (b)		Estimated adipose clips	
year	code	M (c)	F	M (c)	F	M (c)	F	M (c)	F
Kitsumkalum River (Deep Creek Hatchery)									
1990	021136	0.0	0.0	0.0	0.0	0.0	1.6	0.0	6.9
	021137	0.0	0.0	0.0	0.0	0.0	1.6	0.0	6.9
	021138	0.0	0.0	0.0	0.0	0.0	1.6	0.0	6.9
	Subtotal	0.0	0.0	0.0	0.0	0.0	4.8	0.0	20.6
1989	020942	0.0	0.0	0.0	0.0	6.0	0.0	32.3	0.0
	Subtotal	0.0	0.0	0.0	0.0	6.0	0.0	32.3	0.0
	Total hatchery	0.0	0.0	0.0	0.0	6.0	4.8	32.3	20.6
Strays from other hatcheries (d)									
1990	021534	0.0	3.0	0.0	8.0	0.0	0.0	0.0	0.0
	Total strays	0.0	3.0	0.0	8.0	0.0	0.0	0.0	0.0
	Total CWT (e)	0.0	3.0	0.0	8.0	6.0	4.8	32.3	20.6
Escapement est. (f)		341	567			2746	3566		
Sample size (g)		210	212			510	830		

(a) Abbreviations are M = male, F = female
(b) From Table 14
(c) Does not include jacks
(d) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(e) Total CWT = total hatchery + total strays
(f) Petersen estimate from Table 5
(g) Sample size = total live recovery + total dead recovery (from Table 9)

Table 16. Estimates of total escapement of hatchery-reared chinook salmon (Method B) to the upper and lower Kitsumkalum River, by tag code, 1995. 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	CWT release numbers (c)		Expansion factor (d)	Expanded hatchery contribution (a)(b)			
					Upper river		Lower river	
		CWT	Untagged		M (e)	F	M (e)	F
Kitsumkalum River (Deep Creek Hatchery)								
1990	021136	26783	5545	1.21	0.0	0.0	0.0	8.3
	021137	26599	5544	1.21	0.0	0.0	0.0	8.3
	021138	26722	5545	1.21	0.0	0.0	0.0	8.3
	Subtotal				0.0	0.0	0.0	24.9
1989	020942	26908	0	1.00	0.0	0.0	32.3	0.0
	Subtotal				0.0	0.0	32.3	0.0
	Total hatchery				0.0	0.0	32.3	24.9
Strays from other hatcheries (f)								
1990	021534	49183	89499	2.82	0.0	22.6	0.0	0.0
	Subtotal				0.0	22.6	0.0	0.0
	Total strays				0.0	22.6	0.0	0.0
	Total CWT (g)				0.0	22.6	32.3	24.9

(a) Abbreviations are M = male, F = female
(b) Calculated from estimated CWTs in Table 15
(c) From Table 11
(d) Expansion factor = (CWT releases + untagged releases) / CWT releases
(e) Does not include jacks
(f) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(g) Total CWT = total hatchery + total strays

Table 17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1995. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 16).

	Total age	Estimated escapement (c)		Hatchery contribution (a)							
				Kitsumkalum River (Deep Creek Hatchery)				Strays from other hatcheries (b)			
				Male (d)		Female		Male (d)		Female	
		Male (d)	Female	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Upper river											
	4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5	205	60	0.0	0.0	0.0	0.0	0.0	0.0	26.6	44.5
	6	137	508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	341 (e)	567 (e)	0.0	0.0	0.0	0.0	0.0	0.0	26.6	4.7
Lower river											
	4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5	915	602	0.0	0.0	24.9	4.1	0.0	0.0	0.0	0.0
	6	1526	2964	32.3	2.1	0.0	0.0	0.0	0.0	0.0	0.0
	7	305	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	2746	3566	32.3	1.2	24.9	0.7	0.0	0.0	0.0	0.0
Total river											
	4	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5	1120	662	0.0	0.0	24.9	3.8	0.0	0.0	26.6	4.0
	6	1662	3472	32.3	1.9	0.0	0.0	0.0	0.0	0.0	0.0
	7	305	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	3087	4133 (e)	32.3	1.0	24.9	0.6	0.0	0.0	26.6	0.6

(a) Subtotals of expanded hatchery contribution from Table 16
(b) Adipose-clipped fish from systems other than the Kitsumkalum (identified by decoded CWTs)
(c) From Table 8
(d) Does not include jacks
(e) Summation is a result of rounding

FIGURES

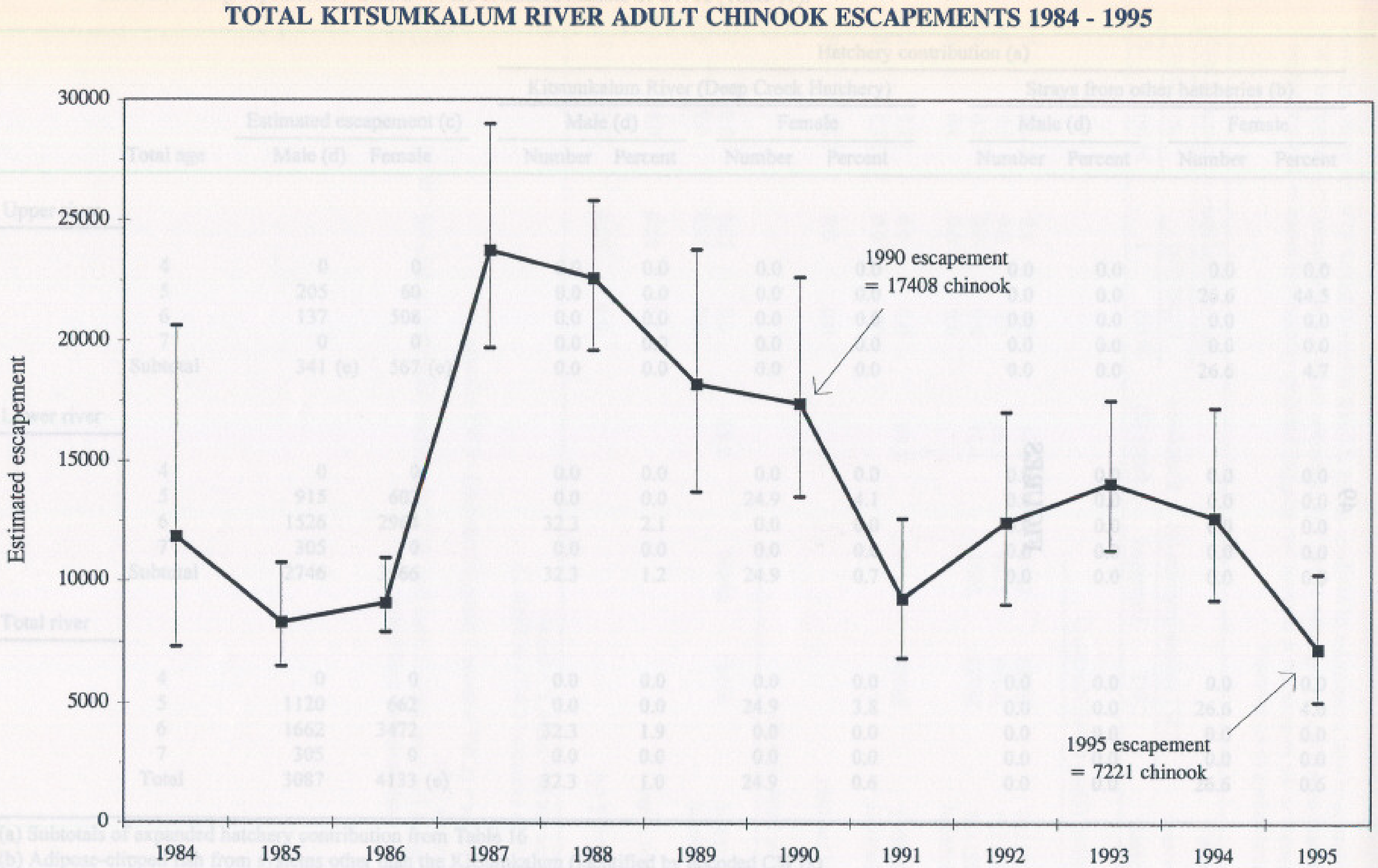

Figure 2. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the total Kitsumkalum River, 1984-1995. The 1984 population estimate and 95% confidence limits were calculated from pooled data due to a lack of recaptures in the lower river. Data from: Andrew and Webb (1988), Carolsfeld et al. (1990), Nass and Bocking (1992), Nelson (1993a, 1993b, 1994, 1995), and this report.

UPPER KITSUMKALUM RIVER ADULT CHINOOK ESCAPEMENTS 1985 - 1995

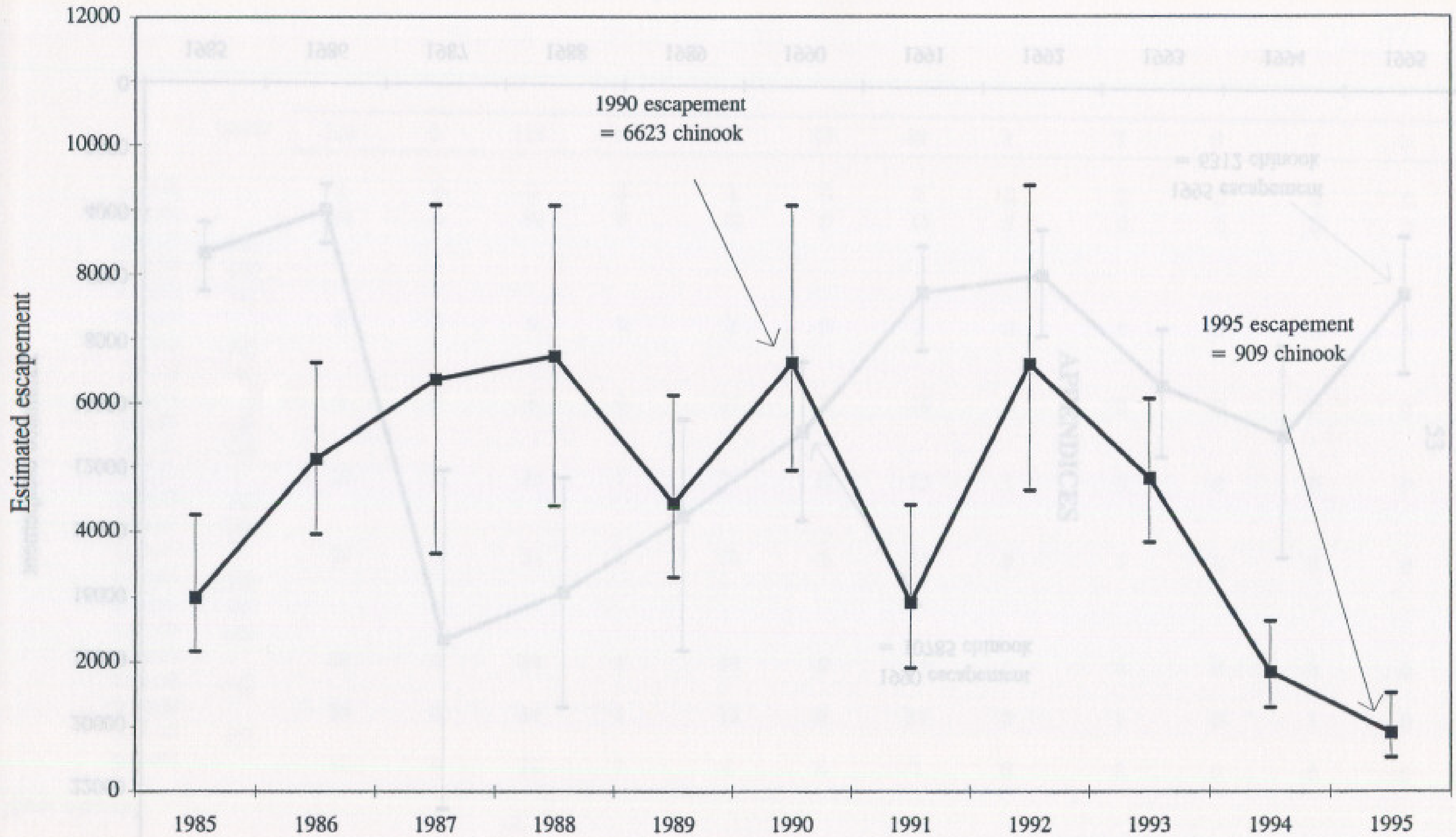

Figure 3. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the upper Kitsumkalum River, 1985-1995. In 1984, a population estimate for the upper river was not produced; an estimate for the total river is available (see Figure 4). Data from: Andrew and Webb (1988), Carolsfeld et al. (1990), Nass and Bocking (1992), Nelson (1993a, 1993b, 1994, 1995), and this report.

LOWER KITSUMKALUM RIVER ADULT CHINOOK ESCAPEMENTS 1985 - 1995

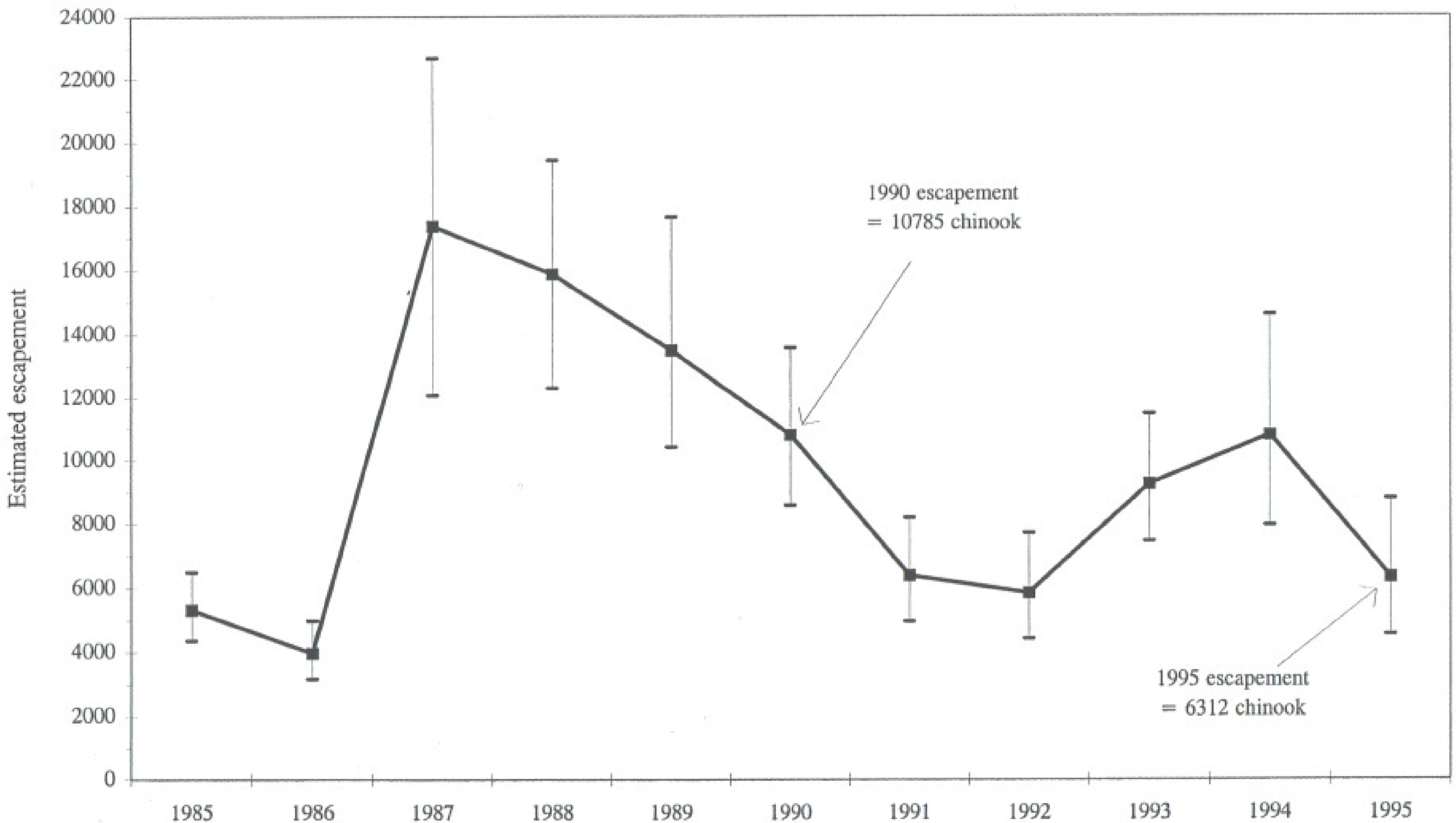

Figure 4. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the lower Kitsumkalum River, 1985-1995. In 1984, a population estimate for the lower river was not produced; an estimate for the total river is available (see Figure 4). Data from: Andrew and Webb (1988), Carolsfeld et al. (1990), Nass and Bocking (1992), Nelson (1993a, 1993b, 1994, 1995), and this report.

APPENDICES

Appendix A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1995.

		No effort	Male				Female				Jack			
Location	Date	(NE)	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
Upper river (b)														
	28-Aug		17	0	17	1	1	0	1	0	0	0	0	0
	29-Aug	NE												
	30-Aug		34	0	34	1	12	0	11	0	1	0	1	0
	31-Aug	NE												
	01-Sep		26	0	26	1	14	0	14	1	0	0	0	0
	02-Sep	NE												
	03-Sep	NE												
	04-Sep	NE												
	05-Sep		28	0	27	0	15	0	14	0	1	0	1	0
	06-Sep	NE												
	07-Sep	NE												
	08-Sep		30	0	30	1	24	11	13	1	0	0	0	0
	09-Sep	NE												
	10-Sep	NE												
	11-Sep		8	0	8	0	21	2	19	0	0	0	0	0
	12-Sep	NE												
	13-Sep	NE												
	14-Sep		8	0	8	0	3	0	3	0	0	0	0	0
	15-Sep	NE												
	16-Sep	NE												
	17-Sep	NE												
	18-Sep		16	0	16	0	12	0	12	1	0	0	0	0
	19-Sep		8	0	8	0	9	0	9	0	0	0	0	0
		Totals	175	0	174	4	111	13	96	3	2	0	2	0

Appendix A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1995. (cont.)

			Male				Female				Jack			
Location	Date	No effort (NE)	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
Lower river														
	21-Aug		11	0	11	0	22	0	22	0	0	0	0	0
	22-Aug		15	0	15	0	16	0	16	1	0	0	0	0
	23-Aug		24	0	23	1	18	0	17	0	0	0	0	0
	24-Aug		18	0	18	0	20	0	20	0	0	0	0	0
	25-Aug		9	0	9	0	11	0	11	1	0	0	0	0
	26-Aug	NE												
	27-Aug	NE												
	28-Aug		2	0	2	0	0	0	0	0	0	0	0	0
	29-Aug		30	0	29	2	16	0	16	0	0	0	0	0
	30-Aug	NE												
	31-Aug		33	0	33	2	27	0	27	0	0	0	0	0
	01-Sep	NE												
	02-Sep		42	0	41	1	31	0	30	1	0	0	0	0
	03-Sep	NE												
	04-Sep	NE												
	05-Sep	NE												
	06-Sep		39	0	39	0	35	22	13	0	0	0	0	0
	07-Sep		19	0	19	0	25	13	12	0	0	0	0	0
	08-Sep	NE												
	09-Sep		23	0	23	0	23	9	14	0	0	0	0	0
	10-Sep	NE												
	11-Sep	NE												
	12-Sep		17	0	17	0	20	2	18	0	0	0	0	0
	13-Sep		17	0	17	0	33	0	33	0	0	0	0	0
	14-Sep		8	0	8	0	4	0	4	0	0	0	0	0
	15-Sep		17	0	17	0	10	0	10	0	0	0	0	0
	16-Sep		8	0	8	0	4	0	4	1	0	0	0	0
	17-Sep	NE												
	18-Sep	NE												
	19-Sep	NE												
	20-Sep		4	0	4	0	4	0	4	0	0	0	0	0
		Totals	336	0	333	6	319	46	271	4	0	0	0	0

(a) Sacrificed for broodstock or died during tagging operation

(b) Includes one fish (male) tagged in the upper river on 30 August with no sex designation; a male designation was attributed to this tag release following an analysis of the male:female sex ratio in the upper river during live tagging operations

Appendix B. Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1995.

		Male					Female					Jack				
Date	No effort (NE)	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)
Upper river																
18-Sep		3	0	0	0	0	13	2	0	0	0	0	0	0	0	0
19-Sep		4	1	0	0	0	8	0	0	0	0	0	0	0	0	0
20-Sep	NE															
21-Sep	NE															
22-Sep		12	3	0	0	0	35	7	0	0	0	0	0	0	0	0
23-Sep	NE															
24-Sep	NE															
25-Sep	NE															
26-Sep		9	3	0	0	0	14	1	0	0	0	0	0	0	0	0
27-Sep	NE															
28-Sep		6	1	0	0	0	24	3	0	0	0	1	0	0	0	0
29-Sep	NE															
30-Sep	NE															
01-Oct	NE															
02-Oct		0	0	0	0	0	4	1	1	0	0	0	0	0	0	0
Unknown (f)		1	0	0	0	0	3	0	0	0	0	0	0	0	0	0
	Totals	35	8	0	0	0	101	14	1	0	0	1	0	0	0	0

Appendix B. Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1995. (cont.)

Date	No effort (NE)	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)
Lower river																
16-Sep		12	1	0	0	0	50	1	0	0	0	0	0	0	0	0
17-Sep	NE															
18-Sep	NE															
19-Sep	NE															
20-Sep		31	5	1	1	2	90	6	0	3	0	0	0	0	0	0
21-Sep		66	6	0	1	3	154	17	2	1	0	0	0	0	0	0
22-Sep	NE															
23-Sep	NE															
24-Sep	NE															
25-Sep		25	5	0	0	0	115	10	1	1	1	0	0	0	0	0
26-Sep	NE															
27-Sep		15	3	1	0	0	47	4	0	1	1	0	0	0	0	0
28-Sep	NE															
29-Sep		12	4	2	0	2	39	1	0	0	0	0	0	0	0	0
30-Sep	NE															
01-Oct	NE															
02-Oct	NE															
03-Oct		10	2	1	0	0	8	1	0	0	0	0	0	0	0	0
04-Oct	NE															
05-Oct		1	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Unknown (f)		2	0	0	0	0	5	0	0	0	0	0	0	0	0	0
	Totals	174	26	5	2	7	511	40	3	6	2	0	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
(f) Includes recoveries (four in the upper river and seven in the lower river) with no sex designation, none of which were tagged, TL, punched, or adipose clipped; respective sex ratios from the upper and lower river carcass recovery operations were applied to these recoveries; total recoveries include one additional male and three additional females (upper river) and two additional males and five additional females (lower river)