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Abundance, Age, Size, Sex and Coded Wire Tag Recoveries for Chinook Salmon Escapements of Kitsumkalum River, 1993

T.C. Nelson

Department of Fisheries and Oceans
Biological Sciences Branch
#416, Suite 400-555 West Hastings Street
Vancouver, British Columbia V6B 5G3

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ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENT OF KITSUMKALUM RIVER, 1993

by

T. C. Nelson[1]

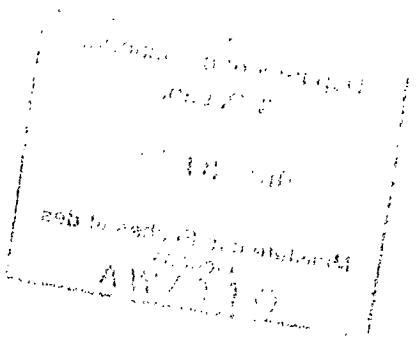
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[1]LGL Limited environmental research associates, 9768 Second Street, Sidney, B.C. V8L 3Y8



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TABLE OF CONTENTS

LIST OF TABLES v

LIST OF FIGURES vi

LIST OF APPENDICES vi

ABSTRACT vii

RÉSUMÉ viii

INTRODUCTION 1
STUDY AREA 2

METHODS 4
POPULATION ESTIMATION 4
Population Stratification 4
Potential Biases 5
Calculations 7
Strays 7
TAGGING 8
RECOVERY 8
BIOLOGICAL AND PHYSICAL SAMPLING 9
CODED WIRE TAGGING AND RECOVERY 10
Method A 11
Method B 13

RESULTS 15
TAGGING 15
RECOVERY 15
POPULATION ESTIMATES 16
AGE, LENGTH, AND SEX COMPOSITION 16
CODED WIRE TAGGING AND RECOVERY 18
Hatchery Contributions - Method A 19
Hatchery Contributions - Method B 20

DISCUSSION 20
POPULATION ESTIMATION 20
AGE, LENGTH, AND SEX COMPOSITION 21
CODED WIRE TAGGING AND RECOVERY 22

TABLE OF CONTENTS - Cont'd

SUMMARY 24

ACKNOWLEDGEMENTS 25

REFERENCES 25

TABLES AND APPENDICES 27-47

LIST OF TABLES

TABLE		Page
1.	Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1993	27
2.	Summary of live tagging and carcass recovery effort for chinook salmon in the Kitsumkalum River, 1993	28
3.	Live tagging and carcass recovery statistics for chinook salmon in the upper and lower Kitsumkalum River, 1993	29
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, 1993	30
5.	Petersen population estimates, confidence limits, and enumeration data for chinook salmon escapement in the Kitsumkalum River based on *in situ* live chinook tagging and recovery of carcasses, 1993	31
6.	Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1993	32
7.	Freshwater age composition of deadpitch Kitsumkalum River chinook salmon, 1993	34
8.	Petersen estimates, by age, of chinook salmon escapement to the Kitsumkalum River, 1993	35
9.	Estimates of the total escapement, and weighted estimate, of adipose-clipped chinook salmon to the upper, lower, and total Kitsumkalum River, 1993	36
10.	Estimates of total escapement of adipose-clipped chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993	37
11.	CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1993	38
12.	Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1993	39

LIST OF TABLES - Cont'd

TABLE Page

13. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1993 40

14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993 41

15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993 42

16. Estimates of total escapement of hatchery-reared chinook salmon (Method B) to the upper and lower Kitsumkalum River, by tag code, 1993 43

17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1993 44

LIST OF FIGURES

FIGURE

1. Map of the Kitsumkalum River study area 3

LIST OF APPENDICES

APPENDIX

A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1993. 45

B. Chinook salmon carcass recovery, by date, for the upper and lower Kitsumkalum River, 1993. 46

ABSTRACT

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.

Estimates of escapement were derived for chinook salmon (*Oncorhynchus tshawytscha*) of the Kitsumkalum River for 1993 using live-tagging and carcass-recovery operations. This study is part of the Chinook Key Stream Program. The Petersen estimate of all adult male and female chinook escapement to the total Kitsumkalum River was 14,059. 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 123 fish (0.9% 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 135 fish or 1.0% of the total adult male and female escapement estimate (1.2% for adult males and 0.8% 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 113 fish or 0.8% of the total adult male and female escapement estimate (1.1% for adult males and 0.6% for females).

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

RÉSUMÉ

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.

Les échappées de saumon quinnat (Oncorhynchus tshawytscha) de la rivière Kitsumkalum en 1993 ont été estimées par marquage et récupération de carcasses. La présente étude a été réalisée dans le cadre du programme des cours d'eau clés du saumon quinnat. L'estimation par méthode Petersen de l'échappée totale de la Kitsumkalum, c'est-à-dire de tous les quinnats mâles et femelles adultes, est de 14 059 poissons. Dans le présent rapport, l'échapée totale estimée représente la somme des échappées déterminées par sexes et parties de la revière (amont et aval). Tant en amont qu'en aval, la plus grande partie de l'échappée était constituée de poissons d'âge 6.

L'échapée totale estimée de mâles et de femelles adultes à adipeuse rognée a été de 123 poissons pour l'ensemble de la Kitsumkalum (0,9 % de l'échappée totale estimée). Cette valeur a ensuite été stratifiée par âges, sexes et codes de marquage. L'apport des poissons d'élevage (marqués et non marqués) à l'échappée a été estimé par la méthode des cours d'eau clés (méthode A) selon laquelle le taux de rognage des adipeuses à la mise à l'eau et un taux pondéré d'adipeuses rognées des poissons revenant au cours d'eau sont appliqués à l'échapée estimée. Selon cette méthode, l'apport total des poissons de pisciculture a été de 135 poissons, ou 1, 0 % de l'estimation totale des mâles et femelles adultes formant l'échappée (1,2 % des mâles et 0,8 % des femelles adultes). Cette valeur a été comparée à celle obtenue par la méthode du Programme de marquage-recapture (méthode B) selon laquelle le taux de marguage par fils codés est appliqué à l'échappée estimée de poissons présentant un fil codé. Cette méthode donne une valeur de 113 poissons, ou 0.8 % de l'échappée totale de mâles et de femelles adultes (1,1 % des mâles et 0.6 % des femelles).

Mots clés: Kitsumkalum, quinnat, cours d'eau clé, échappée, fil codé, compositon par âges, pisciculture, marquage de 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 fourth in a series describing the escapement monitoring and biological sampling of chinook salmon in the Kitsumkalum River. The 1984-86 results are presented in Andrew and Webb (1988), the 1987-88 results are presented in Carolsfeld et al. (1990), the 1989-90 results are presented in Nass and Bocking (1992), the 1991 results are presented in Nelson (1993a), and the 1992 results are presented in Nelson (1993b).

The 1993 escapement of chinook salmon was calculated using the adjusted Petersen method (Ricker 1975) by tagging live chinook *in situ* and recovering carcasses. Separate population estimates were calculated for each sex for both the upper and lower sections of the river. A total estimate for the in-river escapement of chinook was calculated by summing the individual estimates.

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

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

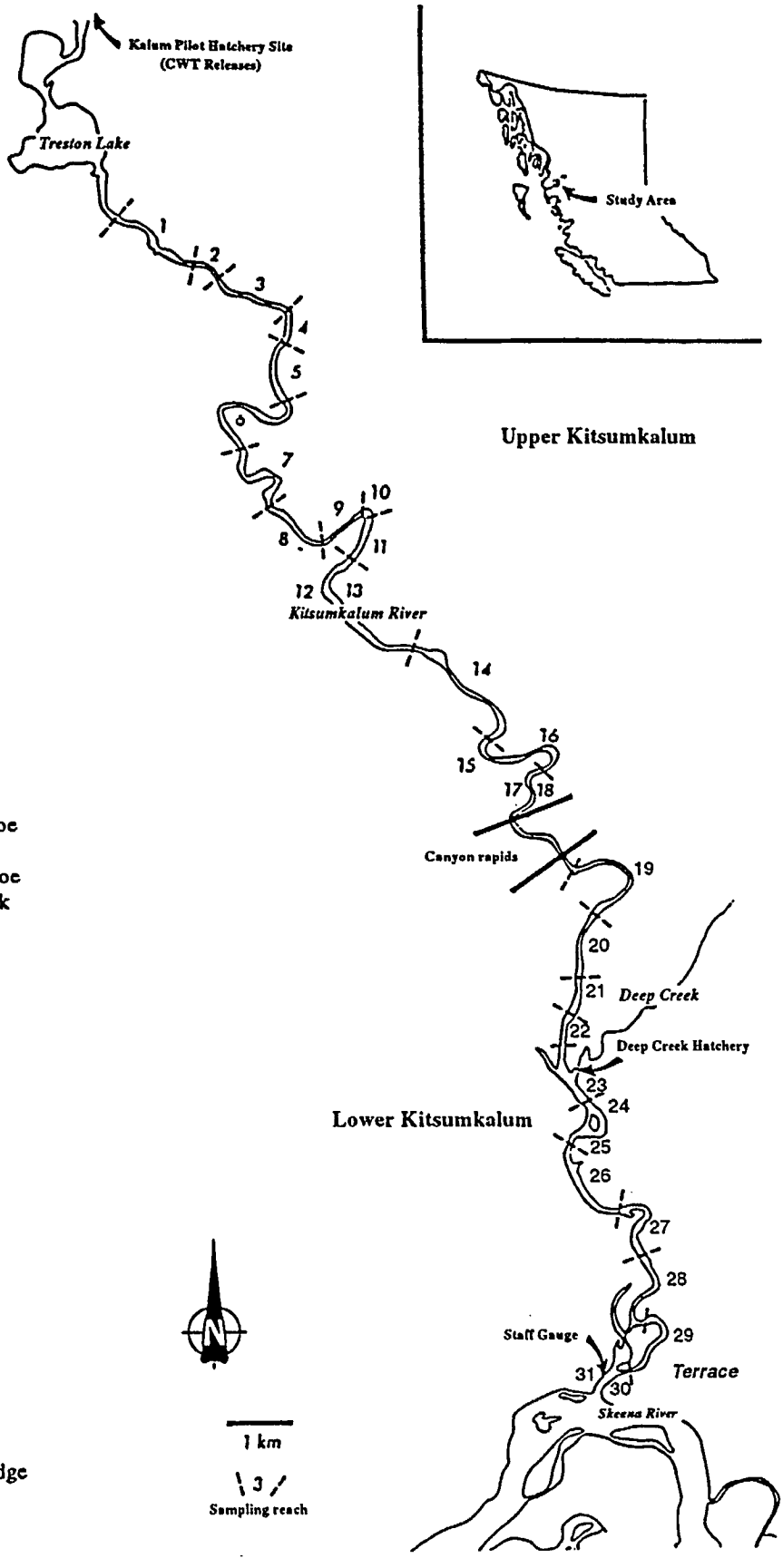
STUDY AREA

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

The Kitsumkalum River system supports all five species of Pacific salmon as well as steelhead trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*) (Hancock et al. 1983). Pink salmon (*O. gorbuscha*) are commonly the most abundant species, followed by chinook, coho, sockeye, and chum salmon (*O. tshawytscha*, *O. kisutch*, *O. nerka*, and *O. keta*, respectively). The Deep Creek Hatchery, located approximately six kilometres from the confluence with the Skeena River, contributes to chinook enhancement. There are two spawning stocks of chinook in the Kitsumkalum system. An early run (not considered in this report) spawns upstream of Kitsumkalum Lake in late July to early August. Late-run chinook start migrating into the river in early August. Spawning by these chinook nears completion by early to mid September. Chinook spawners are generally twice as abundant in the lower river section compared to the upper river section. For the years 1984 through 1992, chinook escapements to the Kitsumkalum River have been estimated at 11,825; 8,308; 10,151; 24,508; 22,755; 18,287; 21,039; 9,288; 12,437 respectively[1] (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992, Nelson 1993a, and Nelson 1993b).

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.

[1] The escapement estimates for 1991 and 1992 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.

METHODS

A summary of study methods used in 1993 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 likelyhood 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.

Potential Biases

Petersen estimates are potentially biased by the violation of a number of assumptions inherent to the model. Seven of these assumptions were discussed in Bocking (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) between the upper and lower sections of the river. Movements of tagged fish are indicated by the location of recovery relative to the location of tagging. Individual tag release and recovery locations were grouped by river section (upper and lower) to facilitate this comparison. In addition, tagged fish may be washed out into the Skeena River where they are not recovered (out of study area). The extent of this latter factor is not addressed in this report. It is not possible to statistically test the extent of mixing of marked and unmarked fish using the data from this study.

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

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

3) There is no tag loss.

A high incidence of tag loss will cause Petersen calculations to overestimate the true population. Tag loss was determined by the presence of a secondary mark (hole punch) in the operculum of all tagged carcasses. In 1993, individuals tagged in the lower river received a left opercular punch and those tagged in the upper river received a right opercular

punch. Petersen estimates calculated in this report were derived using only data from secondary tags (opercular punches).

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

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

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

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

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

A small number of tag recoveries in a stratum will cause Petersen estimates to have low precision. Petersen estimates are generally more reliable if a high proportion of tagged fish are recovered in each stratum. In the absence of other sources of bias, approximately 25 to 75 recaptures will produce population estimates with 25% accuracy, and 95% confidence, for populations of 10^2 and 10^9 (Ricker 1975). Confidence intervals for the escapement estimates were calculated as described later in the calculations sub-section of this chapter.

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

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

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

Calculations

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

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

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

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

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

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

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

Strays

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

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

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

This expanded number of tagged strays from the upper to the lower Kitsumkalum was then

used to estimate the number of tagged fish available in the lower river:

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

where M' is the adjusted number of marks applied.

The above equation provides the adjusted estimate for the number of tagged fish available for recapture ($M_{i,r}$) used in equation 1.

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

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

TAGGING

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

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

RECOVERY

Recovery crews were instructed to dead pitch all available carcasses and record any operculum tags and punches. Crews attempted to keep recovery effort as complete and consistent as possible throughout the study period. Dead chinook were recovered by searching banks and any areas left dry by decreasing water level and areas where the current

slowed such as in back eddies and sloughs. Carcasses were also taken opportunistically while travelling from site to site by boat.

Each carcass was examined for the presence of a 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:

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

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

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

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

BIOLOGICAL AND PHYSICAL SAMPLING

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

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

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

Scale ages were read only when a portion of the previous annulus was present and scales were not regenerated. Scales were classified as unreadable if the scales had regenerate centres, they were resorbed, or if they were mounted upside down. Ages were recorded for fish for which there were at least two scales that could be read for both marine and freshwater ages. The aging system follows that described by Gilbert and Rich (1927).

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

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

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

CODED WIRE TAGGING AND RECOVERY

Juvenile chinook from the 1987 - 1991 brood years were marked at the Deep Creek Hatchery with binary coded wire tags (CWT) using standard methods (Armstrong and Argue 1977). Adipose fins of coded wire tagged juveniles were clipped prior to release of the fish.

Two different methods were used to estimate the hatchery contribution, by tag code, to the total escapement. Method A (the Key Stream approach) applies the adipose fin clip rate (AFC) at release and an adipose clip rate (weighted average of adipose clip rates for live and dead recovery) at return to the estimated escapement, stratified by river section and sex, to derive expanded estimated escapements by tag code. In contrast, Method B (the Mark Recovery Program approach) applies the CWT rate at release (assuming no further CWT loss after release) to the estimated escapement of chinook possessing a CWT (combined data from live and dead recovery), stratified by river section and sex, to derive corrected estimated escapements by tag code. Method B uses the number of actual CWTs present in the escapement from which to derive the hatchery contribution, whereas Method A uses the number of adipose clips present in the escapement. The total combined count of adipose clips from both the live and dead operations was adjusted down as a result of the deletion of duplicate counts for the same specimen (identified by opercular tag code). Expansions generated by Method B (used by the Mark Recovery Program for commercial and sport

fisheries) are not directly comparable with adipose-clip expansions for escapements using Method A. Details of each methodology are presented below.

Method A

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

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

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

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

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

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

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

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:

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

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

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

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

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 for fish of Kitsumkalum origin only as there were no strays (from CWTs decoded) from other rivers in 1993.

Method B

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

Estimating the total number of CWT returns from each of the brood years, and for each tag code, was done as follows. First, the observed number of CWT recoveries was adjusted to account for "no pin" (no CWT) recoveries:

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

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:

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

where *EST* is the estimated number of CWT recoveries for a single tag code, *C* is the number of fish examined, *P* is the population estimate, and *i*, *r*, and *tc* are subscripts denoting sex, river section, and tag code, respectively.

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

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

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

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

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

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

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

RESULTS

TAGGING

Numbers of chinook captured, tagged, and released during the 1993 tagging operations in the upper and lower Kitsumkalum River, by date, are presented in Appendix A.

A total of 1,699 chinook (956 males, 721 females, and 22 jacks) were tagged, operculum punched, and released in 1993 (Table 3). Of these, 776 were tagged in the upper river (464 males, 297 females, and 15 jacks) and 923 were tagged in the lower river (492 males, 424 females, and 17 jacks).

RECOVERY

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

A total of 2,746 chinook carcasses (843 males, 1,891 females, and 12 jacks) were examined during carcass recovery operations in 1993 (Table 3). Of the 1000 carcasses recovered in the upper river (323 males, 666 females, and 11 jacks) there were 142 total tag and/or punch recoveries (67 males and 75 females. Of the 1,746 carcasses recovered in the

lower river (520 males, 1,225 females, and one jack), there were 162 total tag and/or punched recoveries (63 males and 99 females).

A total tag rate (incidence) of 14.0% and 9.2% was achieved for the upper and lower Kitsumkalum, respectively (Table 4). Total tag recovery was 18.0% for the upper river and 17.3% for the lower river. In addition, the total tag loss rate was 13.4% for the upper river and 2.5% for the lower river. The high tag loss in the upper river could be a result of improper tag attachment by the upper river crew (for the most part, crews were separate and worked in either the upper or lower river). It is possible that a number of the tag-loss carcasses recovered in the lower river were tagged in the upper river and that the tag loss occurred during transport. A discussion of stray observations and the disproportionate number of males observed in the lower river is presented in the Discussion section of this report.

In this report, fish that were tagged and released in one section of river (upper or lower) and recovered in the other section are referred to as strays. In 1993, two chinook (one male and one female) tagged in the lower river were recovered in the upper river. Similarly, two chinook (one male and one female) that were tagged in the upper river were recovered in the lower river (Table 3).

POPULATION ESTIMATES

Mark-recapture data, Petersen population estimates, and 95% confidence levels for chinook escapement to the Kitsumkalum River in 1993 are presented in Table 5. No tagged/punched jack chinook were recovered in either the upper or lower river in 1993. 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 1993 estimated total escapement of adult chinook to the total Kitsumkalum system (both sections of river) was 14,059. The lower and upper 95% confidence levels were 11,281 and 17,517, respectively. Total escapement included 4,824 to the upper Kitsumkalum and 9,235 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, 1993, 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 1993, age-4 to age-7 adult chinook were represented in the deadpitch with age-6 chinook comprising approximately 87% of the total run (Table 6). Age-5 and age-4 chinook represented another 12% and 1%, respectively. A single age-7 chinook, a female captured in the upper river, supplied the age-7 representation of 0.3% for the total river. In 1993, 96% 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 1993, were compared within river sections (upper and lower) and between river sections, and produced the following results (Table 6):

1) Within river sections

   a) in the upper river, adult males (mean = 858 mm) had a larger mean length than females (mean = 842 mm) and the difference was significant (t-test, $P<0.002$); and

   b) in the lower river, adult males (mean = 888 mm) had a larger mean length than females (mean = 876 mm) and the difference was significant (t-test, $P<0.002$).

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 significant (t-test, $P<0.02$); and

   b) female chinook from the upper river had a smaller mean length than females from the lower river, and the difference was significant (t-test, $P<0.001$).

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

1) Upper river

male	($P>0.05$)
female	($P>0.2$)

2) Lower river

male	($P > 0.50$)
female	($P > 0.5$)

Sex ratios were calculated using the Petersen population estimates for 1993 (Table 5). Calculations for males did not include jacks. The ratio of adult males to females was 0.85 for the upper river, 0.77 for the lower river, and 0.80 for the total river. A statistical comparison of the number (from Petersen estimates) of adult males and females from the total river (pooled population estimates from both sections of river) found a significant difference from an expected ratio of 50:50 (χ^2, $P < 0.001$). Similarly, 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 1987 to 1992 brood years were sampled as in the dead recovery program in 1993, and the heads were collected for coded wire tag analysis. Successfully decoded coded wire tags from the samples provided information only for 1987 and 1988 brood years.

The results of 1993 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, 1993 (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, Mehtod 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 1993 live-tagging operations, a total of 9 adipose-clipped chinook were observed in the upper river and 10 were observed in the lower river (Table 9). During the carcass recovery operations, a total of 10 adipose-clipped chinook were observed in the upper river and 10 were observed in the lower river. The combined (live tagging and carcass recovery) adipose-clip mark rates were 1.07% for the upper river and 0.75% for the lower river; these mark rates were not significantly different (χ^2, $P > 0.50$). The total estimated number of adipose-clipped adult male and female chinook (weighted average for live and dead) to the total river was 123 (52 to the upper river and 71 to the lower river); this estimate comprised 0.9% of the total escapement estimate.

Hatchery Contributions - Method A

The estimated total escapements of each CWT group decoded in 1993 are shown in Table 10. An adjusted estimate of these escapements (expanded by adipose-clip release data presented in Table 11) is presented in Table 12. All of the CWT chinook decoded in 1993 were of Kitsumkalum origin; thus, the estimated number of strays from other hatcheries were not included in these analyses. A total of 14 CWT heads from adipose-clipped chinook recovered in 1993 were successfully decoded (Table 10).

Using Method A, the 1993 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 135 fish (61 adult males and 74 females; Table 12).

The proportions of hatchery contributions to the total escapement, by river section, age, and sex, are presented in Table 13. Using Method A, the percentage hatchery

contribution to total chinook escapement in 1993 was estimated at 1.0% (1.2% for adult males and 0.8% for females).

Hatchery Contributions - Method B

The adjusted, estimated, and expanded numbers of hatchery-reared chinook, by tag code, river section, and sex, as calculated by Method B, are presented in Tables 14, 15, and 16, respectively. The 1993 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 113 fish (46 adult males and 67 females; Table 16).

The proportions of hatchery contributions to the total escapement, by river section, age, and sex, are presented in Table 17. Using Method B, the percentage hatchery contribution to total chinook escapement in 1993 was estimated to be 0.8% (1.1% for adult males and 0.6% for females).

DISCUSSION

POPULATION ESTIMATION

Previous studies of chinook escapement to the Kitsumkalum River have shown that several factors can bias the population estimates generated from the Petersen model (Andrew and Webb 1988, Carolsfeld et al. 1990). In particular, these studies illustrated that it is necessary to stratify the data by river section and sex in order to eliminate or minimize the effects of differential tagging and tag recovery between sexes and river sections. This report followed the stratification procedures outlined earlier to generate separate population estimates.

A Petersen estimate for the population of jack chinook in 1993 could not be produced because none of the 22 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, 1993 population estimates of adult male and female chinook can be compared with population estimates from past studies. The 1993 adult male and female Petersen population estimate of chinook salmon escapement to the total Kitsumkalum River was 14,059, which is a 13% increase over the 1992 adult male and female population estimate (12,437; Nelson 1993b) and a 51% increase over the 1991 adult male and female population

estimate (9,288; Nelson 1993a). Adult male and female population estimates for 1989 and 1990 (17,921 and 17,408, respectively) are 27% and 24% (respectively) higher than the 1993 estimate (both estimates from stratified data; Nass and Bocking 1992). The 1987 and 1988 adult male and female population estimates (23,727 and 22,587, respectively) are 69% and 61% (respectively) higher than the 1993 estimate (both estimates from stratified data; Carolsfeld et al. 1990).

In 1993, the number of strays from the upper to the lower river was two (one male and one female); the number of strays from the lower to the upper river was also two (one male and one female). The frequency of straying (both sexes) was not significantly different between the two sections of river (χ^2, $P>0.75$). Similarly, there was no significant difference in the proportions of male to female strays to either the upper river (χ^2, $P>0.10$) or the lower river (χ^2, $P>0.50$), or for both sections of river (χ^2, $P>0.10$).

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 (14,059) were within 19.8% and 24.6%, respectively, of the population estimate.

AGE, LENGTH, AND SEX COMPOSITION

Age-6 chinook represented the largest percentage (87%) of the escapement to the total Kitsumkalum River in 1993. Age-5 chinook represented the next largest contribution (12%). These findings are consistent with prior investigations (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; Nelson 1993b). The low representation of age-7 chinook (0.3%) in 1993 is consistent only with the 1992 and 1987 estimate of age-7 escapement (0.3% and 0.0%, respectively; Nelson 1993b and Carolsfeld et al. 1990, respectively). Estimates of the proportions of age-7 chinook in the 1988-91 escapements are as follows: 1988, 2.0%; 1989, 2.0%; 1990, 0.9%; 1991, 14.4% (Carolsfeld et al. 1990, Nass and Bocking 1992, and Nelson 1993a, 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 1993, significant differences in mean lengths were found in the following comparisons:

1) between sexes in the same section of river (both upper and lower); and

2) between like sexes in different sections of river (both male and female).

Significant differences were not found between aged and unaged specimens (both sexes in both sections of river), which would indicate that lengths from the aged samples were representative of the populations.

Stratified mean lengths of aged and unaged adult male and female chinook in the upper Kitsumkalum River in 1993 did not vary more than ± 11 mm from respective 1992 mean lengths, but the mean lengths of aged and unaged adult male and female chinook in the lower river were ± 26 mm and 40 mm greater, respectively, than the respective 1992 mean lengths.

Adult males (44.3%) represented a smaller proportion of the total escapement compared to females (55.7%) in 1993. There was a significant difference in the actual numbers of all adult males and females (pooled population estimates from both sections of river (χ^2, $P<0.001$). Because the population estimate for males does not include jacks, some difference in this comparison would be expected. 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).

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 0.73% in 1993.

Estimates of percent hatchery contribution to total Kitsumkalum River chinook escapement in 1993 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 (1.0%) than Method B (0.8%). Potential reasons for the differences in the estimates are discussed in Bocking (1991b). Both of the 1993 hatchery contribution estimates (Methods A and B) are lower than any of those estimated for 1989, 1990, 1991, and 1992:

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%

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 $\pm 25\%$ of the population estimate. In 1993, a total of 39 (observed) adipose clips and 14 CWTs (decoded) were observed during the live tagging and carcass recovery operations.

In 1993, crews examined 12.3% of the estimated population of adult male and female chinook for adipose clips during live tagging operations and 19.4% of the estimated population during carcass recovery operations. The examination levels achieved during the live tagging operation in 1993 was consistent with that in past years; the examination levels achieved during the carcass recovery operation in 1993 was approximately 7% greater than in past years. This increase in the level of carcass examinations was an important component of the greater accuracy achieved for population estimates in 1993.

SUMMARY

1. The 1993 total Kitsumkalum River escapement estimate of adult male and female chinook salmon, calculated using a combination of live tagging and carcass recovery data, was 14,059. 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.

2. The 1993 escapement of adult male and female chinook was represented by age-4 to age-7 fish. Age-6 chinook comprised the largest portion of the escapement (87%), followed by age-5 (12%), age-4 (1%), and age-7 (0.3%).

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 1993, significant differences in mean lengths were found in the following comparisons:

   a) between sexes in the same section of river (both upper and lower); and

   b) between like sexes in different sections of river (both male and female).

   Significant differences were not found between aged and unaged specimens (both sexes in both sections of river).

4. A statistical comparison of the number (from Petersen estimates) of adult males and females from the total river (pooled population estimates from both sections of river) found a significant difference from an expected ratio of 50:50 (χ^2, $P < 0.001$). Because the population estimate for males does not include jacks, some difference in this comparison would be expected. Similarly, 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):

   a) upper river adult males and upper river females;

   b) lower river adult males and lower river females;

   c) upper river adult males and lower river adult males; and

   d) upper river females and lower river females.

5. The total estimated escapement of adipose-clipped adult male and female chinook to the total Kitsumkalum River in 1993 was 123 (0.9% 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 135 fish (1.0% of the total escapement estimate). Using the Mark Recovery Program approach (Method B), the total estimated hatchery contribution to the total escapement of adult male and female chinook was 113 fish (0.8% of the total escapement estimate). These estimates of hatchery contribution to the total escapement are the lowest since 1989.

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Table 1. Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1993.

Item	Method and materials 1993
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, 1993.

Location	Tagging period	Effort (days)	Carcass recovery period	Effort (days)
Upper river (a)	Aug 20 - Sep 10	22	Aug 31 - Oct 4	19
Lower river (b)	Aug 20 - Sep 11	23	Sep 2 - Oct 4	21

(a) Upper river includes sampling reaches 1 through 18; see Figure 1
(b) Lower river includes sampling reaches 19 through 31; see Figure 1

Table 3. Live tagging and carcass recovery statistics for chinook salmon in the upper and lower Kitsumkalum River, 1993.

Category	Upper river	Lower river	Total
Live tagging (a)			
Males examined	466	492	958
Females examined	328	437	765
Jacks examined	15	7	22
Total examined	809	936	1745
Males tagged/punched	464	492	956
Females tagged/punched	297	424	721
Jacks tagged/punched	15	7	22
Total tagged/punched	776	923	1699
Dead recovery (b)			
Males examined	323	520	843
Females examined	666	1225	1891
Jacks examined	11	1	12
Total examined	1000	1746	2746
Punched-only males (c)	11	4	15
Punched-only females (c)	8	0	8
Punched-only jacks (c)	0	0	0
Total punched only (c)	19	4	23
Tagged/punched males (d)	67	63	130
Tagged/punched females (d)	75	99	174
Tagged/punched jacks (d)	0	0	0
Total tagged/punched (d)	142	162	304
Strays (e)			
Stray males	1	1	2
Stray females	1	1	2
Stray jacks	0	0	0
Total strays	2	2	4

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

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

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

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

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

Table 4. Tag rate (incidence), tag recovery rate, and tag loss rate for the live tagging and carcass recovery operations in the upper and lower Kitsumkalum River, 1993.

Category	Upper river	Lower river	Total
Tag rate (a)			
Male tag rate (%)	20.4	11.9	15.2
Female tag rate (%)	11.1	8.0	9.1
Jack tag rate (%)	0.0	0.0	0.0
Total tag rate (%)	14.0	9.2	10.9
Tag recovery rate (b)			
Male tag recovery rate (%)	14.2	12.6	13.4
Female tag recovery rate (%)	24.9	23.1	23.9
Jack tag recovery rate (%)	0.0	0.0	0.0
Total tag recovery rate (%)	18.0	17.3	17.7
Tag loss rate (c)			
Male tag loss rate (%)	16.4	6.3	11.5
Female tag loss rate (%)	10.7	0.0	4.6
Jack tag loss rate (%)	0.0	0.0	0.0
Total tag loss rate (%)	13.4	2.5	7.6

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, 1993. Confidence limits are from fudicial limits for the Poisson distribution using Pearson's formulae when R is greater than 50 (Ricker 1975, p. 343). Unsexed chinook were omitted from the analysis.

Location	Male	Female	Jack (g)	Total
Upper river				
Number tagged (a)	464	297	15	776
Number recovered (b)	323	666	11	1000
Number of tagged fish recovered (c)	67	75	0	142
Number of tagged strays from lower river (d)	1	1	0	2
Expanded No. of tagged strays from lower river (e)	7	4	0	11
Number of tagged fish for Petersen estimate (f)	463	297	15	775
Petersen estimate	2211	2613	N/A	4824 (h)
Lower 95% CL	1747	2090	N/A	3837 (h)
Upper 95% CL	2797	3264	N/A	6061 (h)
Lower river				
Number tagged (a)	492	424	7	923
Number recovered (b)	520	1225	1	1746
Number of tagged fish recovered (c)	63	99	0	162
Number of tagged strays from upper river (d)	1	1	0	2
Expanded No. of tagged strays from upper river (e)	8	4	0	12
Number of tagged fish for Petersen estimate (f)	493	424	7	924
Petersen estimate	4021	5214	N/A	9235 (h)
Lower 95% CL	3153	4291	N/A	7444 (h)
Upper 95% CL	5122	6334	N/A	11456 (h)
Total river				
Petersen estimate	6232	7827	N/A	14059
Lower 95% CL	4900	6381	N/A	11281
Upper 95% CL	7919	9598	N/A	17517

(a) Total live tagged/punched (Appendix A, "No. tagged")
(b) Total dead recoveries (Appendix B, "No. revd")
(c) Total dead recoveries possessing a tag and/or punch (Appendix B, "No. tag")
(d) Total dead recoveries possessing a tag and/or punch applied in the other section of river (Appendix B, "No. strays")
(e) Expanded strays = No. of tagged strays * (No. tagged/No. tagged recovered)
(f) Number of tagged fish for Petersen estimate = No. tagged + expanded No. of tagged strays - expanded No. of tagged strays from other section
(g) 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
(h) These totals do not include jacks; see footnote (g) above

Table 6. Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1993. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (b)	Total age (years)													
	Male (a)							Female						
	4	5	6	7	Total aged	Total unaged	Total aged + unaged	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	1	0	0	0	1	0	1	0	0	0	0	0	0	0
500-549	2	0	0	0	2	2	4	0	0	0	0	0	0	0
550-599	0	0	1	0	1	1	2	0	0	0	0	0	0	0
600-649	0	1	0	0	1	1	2	0	0	0	0	0	0	0
650-699	0	1	0	0	1	4	5	0	0	0	0	0	1	1
700-749	0	4	1	0	5	10	15	0	0	0	0	0	8	8
750-799	0	3	0	0	3	17	20	0	2	10	0	12	41	53
800-849	0	3	5	0	8	23	31	0	3	24	0	27	211	238
850-899	0	2	15	0	17	74	91	0	1	25	0	26	217	243
900-949	0	0	18	0	18	97	115	0	1	11	0	12	46	58
950-999	0	0	2	0	2	5	7	0	0	0	0	0	2	2
1000-1049	0	0	1	0	1	0	1	0	0	0	1	1	0	1
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1100-1149	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3	14	43	0	60	234	294	0	7	70	1	78	526	604
Percent (aged)	5.0	23.3	71.7	0.0	100.0			0.0	9.0	89.7	1.3	100.0		
Mean (b)	502	770	881	0	837	863	858	0	819	848	1030	848	842	842
SD (b)	23	71	66	0	111	73	82	0	51	39	0	46	40	41

(a) Does not include jacks; two successfully aged jacks (ages 21 and 32, lengths 260 and 310 mm, respectively) were observed in the upper river
(b) Postorbital-hypural length

Table 6. (cont.) Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1993. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (b)	Total age (years)													
	Male (a)							Female						
	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	1	1	0	0	0	0	0	0	0
550-599	0	0	0	0	0	2	2	0	0	0	0	0	0	0
600-649	1	1	1	0	3	9	12	0	0	0	0	0	1	1
650-699	0	0	0	0	0	7	7	0	0	0	0	0	0	0
700-749	1	1	0	0	2	21	23	0	0	0	0	0	1	1
750-799	0	1	4	0	5	34	39	0	3	3	0	6	26	32
800-849	0	0	1	0	1	31	32	0	5	18	0	23	147	170
850-899	0	2	3	0	5	45	50	0	3	73	0	76	366	442
900-949	0	1	9	0	10	102	112	0	2	57	0	59	337	396
950-999	0	0	12	0	12	133	145	0	0	6	0	6	48	54
1000-1049	0	0	5	0	5	31	36	0	0	0	0	0	5	5
1050-1099	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1100-1149	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Total	2	6	35	0	43	418	461	0	13	157	0	170	931	1101
Percent (aged)	4.7	14.0	81.4	0.0	100.0			0.0	7.6	92.4	0.0	100.0		
Mean (b)	670	787	914	0	885	888	888	0	826	879	0	874	877	876
SD (b)	42	99	86	0	107	99	100	0	51	38	0	41	45	44

(a) Does not include jacks; two successfully aged jacks (ages 21 and 32, lengths 260 and 310 mm, respectively) were observed in the upper river
(b) Postorbital-hypural length

Table 7. Freshwater age composition of deadpitch Kitsumkalum River chinook salmon, 1993. (a)

Location	Age (c)	Male (b) N	Male (b) Percent	Female N	Female Percent
Upper river					
	41	0	0.0	0	0.0
	42	3	5.1	0	0.0
	51	2	3.4	1	1.3
	52	12	20.3	6	7.7
	61	0	0.0	2	2.6
	62	42	71.2	68	87.2
	71	0	0.0	0	0.0
	72	0	0.0	1	1.3
	Total	59	100.0	78	100.0 (d)
Lower river					
	41	1	2.3	0	0.0
	42	1	2.3	0	0.0
	51	1	2.3	3	1.8
	52	5	11.6	8	4.8
	61	0	0.0	2	1.2
	62	35	81.4	154	92.2
	71	0	0.0	0	0.0
	72	0	0.0	0	0.0
	Total	43	100.0 (d)	167	100.0

(a) Age composition was calculated using scale samples only

(b) Does not include jacks; two successfully aged jacks (ages 21 and 32) were observed in the upper river

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

(d) Summation is a result of rounding

Table 8. Petersen estimates, by age, of chinook salmon escapement to the Kitsumkalum River, 1993.

	Total age	Male (a) Number (b)	Male (a) Percent (c)	Female Number (b)	Female Percent (c)
Upper river					
	4	111	5.0	0	0.0
	5	515	23.3	235	9.0
	6	1586	71.7	2343	89.7
	7	0	0.0	34	1.3
	Total	2211 (d)(e)	100.0	2613 (d)(e)	100.0
Lower river					
	4	189	4.7	0	0.0
	5	563	14.0	396	7.6
	6	3273	81.4	4818	92.4
	7	0	0.0	0	0.0
	Total	4021 (d)(e)	100.0	5214 (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, 1993.

Location and sex	Live tagging			Dead recovery			Petersen population estimate (c) G	Total estimated adipose clips		Weighted estimate of adipose clips J (d)
	Sample size (a) A	Observed adipose clips B	Mark rate (%) C=B/A*100	Sample size (b) D	Observed adipose clips E	Mark rate (%) F=E/D*100		Live tagging H=C/100*G	Dead recovery I=F/100*G	
Upper river										
Male (e)	466	7	1.50	323	4	1.24	2211	33	27	31
Female	328	2	0.61	666	6	0.90	2613	16	24	21
Subtotal	794	9	1.13	989	10	1.01	4824	49	51	52
Lower river										
Male (e)	492	8	1.63	520	2	0.38	4021	65	15	40
Female	437	2	0.46	1225	8	0.65	5214	24	34	31
Subtotal	929	10	1.08	1745	10	0.57	9235	89	50	71
Total river										
Male (e)	958	15	1.57	843	6	0.71	6232	99	43	71
Female	765	4	0.52	1891	14	0.74	7827	40	58	52
Total	1723	19	1.10	2734	20	0.73	14059	138	100	123

(a) Sample size for estimating adipose clip rates in the live tagging includes all fish captured minus recaptures (Appendix A)
(b) Sample size for estimating adipose clip rates in the dead recovery includes all fish examined (Appendix B)
(c) From Table 5
(d) J=((A * H) + (D * I)) / (A + D)
(e) Does not include jacks; see Table 5, footnote (g)

Table 10. Estimates of total escapement of adipose-clipped chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993. 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
1988	26039	0	0	0.0	0.0	0	2	0.0	8.9
	26040	0	0	0.0	0.0	0	2	0.0	8.9
	26041	0	0	0.0	0.0	1	1	19.9	4.4
	26042	1	0	15.5	0.0	0	0	0.0	0.0
	Subtotal	1	0	15.5	0.0	1	5	19.9	22.1
1987	24941	1	1	15.5	7.0	0	0	0.0	0.0
	24942	0	0	0.0	0.0	0	1	0.0	4.4
	24944	0	0	0.0	0.0	1	1	19.9	4.4
	25060	0	1	0.0	7.0	0	0	0.0	0.0
	25661	0	1	0.0	7.0	0	0	0.0	0.0
	Subtotal	1	3	15.5	21.0	1	2	19.9	8.9
Total CWT		2	3	31.0 (c)	21.0 (c)	2	7	40.0 (c)	31.0 (c)
No data (5000) (d)		8	3			8	1		
No pin (8000)		0	2			0	1		
Lost pin (9000)		0	0			0	0		
Observed adipose		10	8			10	9		

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

(b) Does not include jacks

(c) From Table 9 (weighted estimate of adipose clips)

(d) 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); in 1993, two operculum-tagged and adipose-clipped chinook were observed in the carcass recovery operation (one male from the upper river and one female from the lower river); although these adipose clips were observed twice (see Table 9), they are included only once in this analysis

Table 11. CWT and adipose-clip release data for hatchery-reared chinook salmon returning to the Kitsumkalum River, 1993.

Brood year	CWT release group	Release numbers		CWT loss (%)	Days held	Adipose release status	
		CWT	Untagged			Clipped	Unclipped
1988	26039	27131	2191	1.0	1	27405	1917
	26040	27075	1917	0.0	1	27075	1917
	26041	26543	2184	1.0	1	26811	1916
	26042	24080	2408	2.0	1	24571	1917
1987	24941	27021	133	0.5	1	27157	0
	24942	26570	460	1.7	1	27030	0
	24944	26423	362	1.4	1	26798	0
	25060	27522	14994	0.0	1	27522	14994
	25061	27475	14993	0.0	1	27475	14993
	Total hatchery	239840	39642			241844	37654

Table 12. Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1993. The expansion factor is used to expand the estimated number of adipose-clipped chinook in the escapement (from Table 10) to account for unclipped hatchery releases and hence to derive hatchery contributions to escapement.

Brood year	CWT release group	Adipose release (b)		Expansion factor (c)	Expanded hatchery contribution (a)(e)			
					Upper river		Lower river	
		Clipped	Unclipped		M (d)	F	M (d)	F
1988	26039	27405	1917	1.07	0.0	0.0	0.0	9.5
	26040	27075	1917	1.07	0.0	0.0	0.0	9.5
	26041	26811	1916	1.07	0.0	0.0	21.3	4.7
	26042	24571	1917	1.08	16.7	0.0	0.0	0.0
	Subtotal				16.7	0.0	21.3	23.7
1987	24941	27157	0	1.00	15.5	7.0	0.0	0.0
	24942	27030	0	1.00	0.0	0.0	0.0	4.4
	24944	26798	0	1.00	0.0	0.0	19.9	4.4
	25060	27522	14994	1.54	0.0	10.8	0.0	0.0
	25061	27475	14993	1.55	0.0	10.8	0.0	0.0
	Subtotal				15.5	28.6	19.9	8.9
	Total hatchery				32.2	28.6	41.2	32.6

(a) Abbreviations are M = male, F = female
(b) From Table 11
(c) Expansion factor = (adipose-clipped + unclipped releases) / adipose-clipped releases
(d) Does not include jacks
(e) Calculated from estimated adipose clips in Table 10

Table 13. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1993. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 12).

				Hatchery contribution (a)			
		Estimated escapement (b)		Male (c)		Female	
	Total age	Male (c)	Female	Number	Percent	Number	Percent
Upper river							
	4	111	0	0.0	0.0	0.0	0.0
	5	515	235	16.7	3.2	0.0	0.0
	6	1586	2343	15.5	1.0	28.6	1.2
	7	0	34	0.0	0.0	0.0	0.0
	Subtotal	2211 (d)	2613 (d)	32.2	1.5	28.6	1.1
Lower river							
	4	189	0	0.0	0.0	0.0	0.0
	5	563	396	21.3	3.8	23.7	6.0
	6	3273	4818	19.9	0.6	8.9	0.2
	7	0	0	0.0	0.0	0.0	0.0
	Subtotal	4021 (d)	5214	41.2	1.0	32.6	0.6
Total river							
	4	300	0	0.0	0.0	0.0	0.0
	5	1078	631	38.0	3.5	23.7	3.8
	6	4858	7162	35.4	0.7	37.5	0.5
	7	0	34	0.0	0.0	0.0	0.0
	Total	6232 (d)	7827	73.4	1.2	61.2	0.8

(a) From Table 12
(b) From Table 8
(c) Does not include jacks
(d) Summation is a result of rounding

Table 14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 15 (Method B).

Brood year	CWT code	Upper river (a) Decoded adipose clips (b) M (c)	F	Upper river (a) Adjusted CWTs M (c)	F	Lower river (a) Decoded adipose clips (b) M (c)	F	Lower river (a) Adjusted CWTs M (c)	F
1988	26039	0	0	0.0	0.0	0	2	0.0	2.3
	26040	0	0	0.0	0.0	0	2	0.0	2.3
	26041	0	0	0.0	0.0	1	1	5.0	1.1
	26042	1	0	5.0	0.0	0	0	0.0	0.0
	Subtotal	1	0	5.0	0.0	1	5	5.0	5.6
1987	24941	1	1	5.0	1.6	0	0	0.0	0.0
	24942	0	0	0.0	0.0	0	1	0.0	1.1
	24944	0	0	0.0	0.0	1	1	5.0	1.1
	25060	0	1	0.0	1.6	0	0	0.0	0.0
	25661	0	1	0.0	1.6	0	0	0.0	0.0
	Subtotal	1	3	5.0	4.8	1	2	5.0	2.3
	Total CWT	2	3	10.0	4.8	2	7	10.0	7.9
No data (5000) (d)		8	3			8	1		
No pin (8000)		0	2			0	1		
Lost pin (9000)		0	0			0	0		
Observed adipose		10	8			10	9		

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

(b) From Table 10

(c) Does not include jacks

(d) 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); in 1993, two operculum-tagged and adipose-clipped chinook were observed in the carcass recovery operation (one male from the upper river and one female from the lower river); although these adipose clips were observed twice (see Table 9), they are included only once in this analysis

Table 15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1993. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 16 (Method B).

		Upper river (a)				Lower river (a)			
		Adjusted CWTs (b)		Estimated CWTs		Adjusted CWTs (b)		Estimated CWTs	
Brood year	CWT code	M (c)	F	M (c)	F	M (c)	F	M (c)	F
1988	26039	0.0	0.0	0.0	0.0	0.0	2.3	0.0	7.1
	26040	0.0	0.0	0.0	0.0	0.0	2.3	0.0	7.1
	26041	0.0	0.0	0.0	0.0	5.0	1.1	19.9	3.5
	26042	5.0	0.0	14.0	0.0	0.0	0.0	0.0	0.0
	Subtotal	5.0	0.0	14.0	0.0	5.0	5.6	19.9	17.6
1987	24941	5.0	1.6	14.0	4.2	0.0	0.0	0.0	0.0
	24942	0.0	0.0	0.0	0.0	0.0	1.1	0.0	3.5
	24944	0.0	0.0	0.0	0.0	5.0	1.1	19.9	3.5
	25060	0.0	1.6	0.0	4.2	0.0	0.0	0.0	0.0
	25661	0.0	1.6	0.0	4.2	0.0	0.0	0.0	0.0
	Subtotal	5.0	4.8	14.0	12.6	5.0	2.3	19.9	7.1
	Total CWT	10.0	4.8	28.0	12.6	10.0	7.9	39.7	24.7
Escapement est. (d)		2211	2613			4021	5214		
Sample size (e)		789	994			1012	1662		

(a) Abbreviations are M = male, F = female
(b) From Table 14
(c) Does not include jacks
(d) Petersen estimate from Table 5
(e) Sample size = total live recovery + total dead recovery (from Table 9)

Table 16. Estimates of total escapement of hatchery-reared chinook salmon (Method B) to the upper and lower Kitsumkalum River, by tag code, 1993. The expansion factor is used to expand the estimated CWT chinook in the escapement to account for untagged hatchery releases and hence to derive hatchery contributions to escapement.

Brood year	CWT release group	Release numbers (b)		Expansion factor (c)	Expanded hatchery contribution (a)(e)			
					Upper river		Lower river	
		CWT	untagged		M (d)	F	M (d)	F
1988	26039	27405	1917	1.07	0.0	0.0	0.0	7.6
	26040	27075	1917	1.07	0.0	0.0	0.0	7.6
	26041	26811	1916	1.07	0.0	0.0	21.3	3.8
	26042	24571	1917	1.08	15.1	0.0	0.0	0.0
	Subtotal				15.1	0.0	21.3	18.9
1987	24941	27157	0	1.00	14.0	4.2	0.0	0.0
	24942	27030	0	1.00	0.0	0.0	0.0	3.5
	24944	26798	0	1.00	0.0	0.0	19.9	3.5
	25060	27522	14994	1.54	0.0	6.5	0.0	0.0
	25061	27475	14993	1.55	0.0	6.5	0.0	0.0
	Subtotal				14.0	17.2	19.9	7.1
	Total CWT				29.1	17.2	41.2	26.0

(a) Abbreviations are M = male, F = female
(b) From Table 11
(c) Expansion factor = (CWT releases + untagged releases) / CWT releases
(d) Does not include jacks
(e) Calculated from estimated CWTs in Table 15

Table 17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1993. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 16).

				Hatchery contribution (a)			
		Estimated escapement (b)		Male (c)		Female	
	Total age	Male (c)	Female	Number	Percent	Number	Percent
Upper river							
	4	111	0	0.0	0.0	0.0	0.0
	5	515	235	15.1	2.9	0.0	0.0
	6	1586	2343	14.0	0.9	17.2	0.7
	7	0	34	0.0	0.0	0.0	0.0
	Subtotal	2211 (d)	2613 (d)	29.1	1.3	17.2	0.7
Lower river							
	4	189	0	0.0	0.0	0.0	0.0
	5	563	396	21.3	3.8	18.9	4.8
	6	3273	4818	19.9	0.6	7.1	0.1
	7	0	0	0.0	0.0	0.0	0.0
	Subtotal	4021 (d)	5214	41.2	1.0	26.0	0.5
Total river							
	4	300	0	0.0	0.0	0.0	0.0
	5	1078	631	36.4	3.4	18.9	3.0
	6	4858	7162	33.9	0.7	24.3	0.3
	7	0	34	0.0	0.0	0.0	0.0
	Total	6232 (d)	7827	70.3	1.1	43.2	0.6

(a) Subtotals of expanded hatchery contributions from Table 16
(b) From Table 8
(c) Does not include jacks
(d) Summation is a result of rounding

Appendix A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1993.

		Male				Female				Jack			
Location	Date	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													
	20-Aug	4	0	4	0	2	0	2	0	0	0	0	0
	24-Aug	31	0	29	0	18	0	18	1	1	0	1	0
	25-Aug	32	0	32	0	14	0	14	1	4	0	4	0
	26-Aug	22	0	22	0	11	0	11	0	1	0	1	0
	28-Aug	46	0	46	0	20	0	20	0	3	0	3	0
	30-Aug	41	0	41	0	28	0	28	0	1	0	1	0
	31-Aug	58	0	58	2	44	0	44	0	0	0	0	0
	01-Sep	52	0	52	2	31	2	29	0	1	0	1	0
	02-Sep	32	0	32	1	21	0	21	0	0	0	0	0
	03-Sep	21	0	21	0	34	17	17	0	0	0	0	0
	04-Sep	16	0	16	0	5	1	4	0	1	0	1	0
	07-Sep	34	0	34	0	25	0	25	0	2	0	2	0
	08-Sep	38	0	38	2	31	0	31	0	1	0	1	0
	09-Sep	25	0	25	0	24	0	24	0	0	0	0	0
	10-Sep	14	0	14	0	17	8	9	0	0	0	0	0
	11-Sep	0	0	0	0	3	3	0	0	0	0	0	0
	Total	466	0	464	7	328	31	297	2	15	0	15	0
Lower river (b)													
	20-Aug	15	0	15	0	30	0	30	0	0	0	0	0
	21-Aug	47	0	47	2	58	0	58	0	2	0	2	0
	23-Aug	71	0	71	0	63	0	63	0	2	0	2	0
	24-Aug	26	0	26	0	31	0	31	1	0	0	0	0
	25-Aug	39	0	39	0	28	0	28	0	1	0	1	0
	26-Aug	69	0	69	2	34	0	34	0	1	0	1	0
	27-Aug	50	0	50	2	33	0	33	0	1	0	1	0
	30-Aug	41	0	41	1	29	0	29	0	0	0	0	0
	02-Sep	51	0	51	1	36	0	36	0	0	0	0	0
	03-Sep	32	0	32	0	40	0	40	0	0	0	0	0
	07-Sep	31	0	31	0	36	8	28	0	0	0	0	0
	08-Sep	20	0	20	0	19	5	14	1	0	0	0	0
	Total	492	0	492	8	437	13	424	2	7	0	7	0

(a) Sacrificed for broodstock

(b) Does not include a single capture on 23 August with no sex designation

Appendix B. Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1993.

	Male					Female					Jack				
Date	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															
31-Aug	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
01-Sep	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
08-Sep	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
09-Sep	4	2	0	0	1	18	3	1	0	0	0	0	0	0	0
10-Sep	12	1	0	1	0	19	5	0	0	0	1	0	0	0	0
13-Sep	36	12	1	0	0	146	31	5	1	0	2	0	0	0	0
14-Sep	38	8	1	0	0	62	8	2	0	0	1	0	0	0	0
15-Sep	25	3	0	0	0	53	6	0	2	0	2	0	0	0	0
16-Sep	38	13	1	0	0	56	2	0	2	0	0	0	0	0	0
17-Sep	27	7	3	0	0	32	3	0	0	1	1	0	0	0	0
20-Sep	36	6	1	0	0	53	5	0	0	0	0	0	0	0	0
21-Sep	26	4	2	0	0	60	6	0	0	0	1	0	0	0	0
22-Sep	31	4	1	0	0	31	3	0	1	0	1	0	0	0	0
23-Sep	9	1	0	1	0	18	1	0	0	0	2	0	0	0	0
24-Sep	14	0	0	0	0	23	2	0	0	0	0	0	0	0	0
28-Sep	12	4	0	1	0	24	0	0	0	0	0	0	0	0	0
29-Sep	1	0	0	0	0	20	0	0	0	0	0	0	0	0	0
01-Oct	9	2	1	1	0	33	0	0	0	0	0	0	0	0	0
04-Oct	4	0	0	0	0	14	0	0	0	0	0	0	0	0	0
Total	323	67	11	4	1	666	75	8	6	1	11	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

Appendix B (cont). Chinook salmon carcass recovery data, by date, for the upper and lower Kitsumkalum River, 1993.

	Male					Female					Jack				
Date	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															
02-Sep	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0
03-Sep	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
07-Sep	30	4	0	0	0	55	2	0	0	0	0	0	0	0	0
08-Sep	25	2	0	0	0	56	9	0	0	0	0	0	0	0	0
09-Sep	20	4	1	1	0	64	4	0	2	0	0	0	0	0	0
10-Sep	33	7	0	0	0	110	7	0	0	0	0	0	0	0	0
13-Sep	38	6	0	0	0	106	7	0	0	0	1	0	0	0	0
14-Sep	41	4	0	0	0	137	19	0	3	0	0	0	0	0	0
15-Sep	57	4	0	1	0	120	8	0	1	0	0	0	0	0	0
16-Sep	45	7	0	0	0	65	4	0	0	0	0	0	0	0	0
17-Sep	58	7	0	0	0	92	8	0	1	0	0	0	0	0	0
20-Sep	40	3	0	0	0	76	7	0	0	0	0	0	0	0	0
21-Sep	39	4	1	0	1	104	5	0	1	1	0	0	0	0	0
22-Sep	36	5	0	0	0	85	6	0	0	0	0	0	0	0	0
23-Sep	18	1	0	0	0	60	6	0	0	0	0	0	0	0	0
24-Sep	5	2	1	0	0	21	2	0	0	0	0	0	0	0	0
27-Sep	6	0	0	0	0	10	0	0	0	0	0	0	0	0	0
29-Sep	10	0	0	0	0	28	2	0	0	0	0	0	0	0	0
30-Sep	13	2	0	0	0	27	2	0	0	0	0	0	0	0	0
04-Oct	4	0	0	0	0	7	1	0	0	0	0	0	0	0	0
Total	520	63	4	2	1	1225	99	0	8	1	1	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