Abundance, Age, Size, Sex and Coded Wire Tag Recoveries For Chinook Salmon Escapement of Kitsumkalum River, 1996

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ABUNDANCE, AGE, SIZE, SEX AND CODED WIRE TAG RECOVERIES FOR CHINOOK SALMON ESCAPEMENT OF KITSUMKALUM RIVER, 1996

by

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Estimates of escapement were derived for the summer/fall run of chinook salmon (*Oncorhynchus tshawytscha*) of the Kitsumkalum River for 1996 using live-tagging and carcass-recovery operations. This study is part of the Chinook Key Stream Program. The Petersen estimate of the total escapement of summer/fall-run adult male and female chinook to the Kitsumkalum River was 12,403. In this report, total escapement estimates are the summation of individual estimates generated by sex and river section (upper and lower). An inadequate recovery of tagged male chinook (n=1) in the upper river section precluded the calculation of a population estimate for this segment of the total population. Age-6 female chinook comprised the largest proportion of the escapement 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 278 fish (2.2% 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 304 fish or 2.5% of the total adult male and female escapement estimate (approximately 1.2% for both males and females). These hatchery contribution estimates were compared with those estimated using the Mark Recovery Program approach (Method B), wherein the coded wire tag (CWT) rate at release is applied to the estimated escapement of chinook possessing a CWT. Using Method B, the total hatchery contribution was 186 fish or 1.5% of the total adult male and female escapement estimate (0.6% for adult males and 0.9% for females).

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

RÉSUMÉ

Blakley, A. C. and T. C. Nelson. 1998. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapement of Kitsumkalum River, 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2446: *viii* + 54 p.

Nous avons estimé l'effectif de l'échappée de la remonte estivale/automnale de quinnat (*Oncorhynchus tshawytscha*) de la rivière Kitsumkalum en 1996 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 12403. 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). Le nombre insuffisant de saumons mâles étiquetés qui a été récupéré (1 saumon) dans le cours supérieur de la rivière ne permet pas de faire une estimation adéquate de l'effectif pour ce segment de la population. Dans les deux tronçons, les quinnats femelles d'âge 6 composaient la plus grande partie des échappées.

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 278 poissons (2,2 % 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 304 poissons, soit 2,5 % de l'échappée totale d'adultes mâles et femelles (1,2 % des deux sexes). 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 186 poissons, soit 1,5 % de l'échappée totale estimée des adultes mâles et femelles (0,6 % pour les mâles adultes et 0,9 % pour les femelles).

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 binary coded wire tags (CWTs) 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 that describes 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), the 1994 results are presented in Nelson (1995), and the 1995 results are presented in Nelson (1997).

The 1996 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 CWT 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 CWTs 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 3-km 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*) is commonly the most abundant species, followed by chinook, coho, sockeye, and chum salmon (*O. tshawytscha*, *O. kisutch*, *O. nerka*, and *O. keta*, respectively). Deep Creek Hatchery, located approximately 6 km from the confluence with the Skeena River, contributes to chinook enhancement.

There are two spawning stocks of chinook in the Kitsumkalum system: 1) an early run (not considered in this report) that spawns upstream of Kitsumkalum Lake in late July to early August (Alexander and English 1996); and 2) a late run (or summer/fall run) that starts migrating into the river in early August. Spawning of the summer/fall run is usually completed by late September. Chinook spawners are usually more abundant in the lower river section than in the upper river section. For the years 1984 through 1995, total summer/fall-run chinook escapements to the 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; 12,629, and 7221 respectively[1] (Andrew and Webb 1988, Carolsfeld et al. 1990, Nass and Bocking 1992, Nelson 1993a, Nelson 1993b, Nelson 1994, Nelson 1995, and Nelson 1997, respectively).

Kitsumkalum chinook are harvested in sport, commercial, and native food fisheries. 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. Kitsumkalum River adult chinook are among the heaviest on the Pacific Coast; fish in excess of 34 kg (75 lbs) are usually taken each year in the in-river sport fishery.

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[1] The escapement estimates for 1991-95 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).

METHODS

A summary of study methods used in 1996 is presented in Table 1. Live-tagging and carcass-recovery sampling periods and effort are presented in Table 2. The live-tagging and dead-recovery crews both consisted of four-person teams, and in most cases were the same individuals. 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 live-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.

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) within 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 1996, individuals tagged in the lower river received a right opercular punch and those tagged in the upper river received a left opercular punch (in previous years of study, individuals tagged in the lower river received a left opercular punch and a right opercular punch was designated for the upper river individuals).

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. 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:

$$ES_{i,\, u\,to\,l} = TS_{i,\, u\,to\,l} \cdot (M_{i,\,l} \,/\, R_{i,\,l}) \tag{3}$$

where ES_i is the expanded number of in-river strays, TS_i is the number of tagged in-river strays, M_i is the number of secondary marks applied and R_i is the number of secondary marks recovered, by sex (i).

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:

$$M'_{i,\,l} = M_{i,\,l} + ES_{i,\,u\,to\,l} - ES_{i,\,l\,to\,u} \tag{4a}$$

where M'_i is the adjusted number of marks applied, by sex (i).

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:

$$M'_{i,\,u} = M_{i,\,u} + ES_{i,\,l\,to\,u} - ES_{i,\,u\,to\,l} \tag{4b}$$

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.

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 noted, and sex was determined visually. Males less than 50 cm (postorbital-hypural) were classified as jacks.

Recovery

Recovery crews were instructed to deadpitch 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 deadpitches.

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 CWT 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 1990 - 1994 brood years were marked at the Deep Creek Hatchery with CWTs using standard methods (Armstrong and Argue 1977). Adipose fins of juvenile chinook tagged with CWTs were removed (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 1996. 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:

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

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 carcass-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:

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

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 CWT 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 deadpitch, 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 deadpitch 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:

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

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

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

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

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

Due to the potentially different ages at maturity of males and females, it is important that the allocation of adipose-clipped fish to tag codes be carried out separately by sex whenever possible. In this study, the sex of all fish sampled for CWTs was recorded so that it was possible to estimate the total escapement of tag codes by sex. Final hatchery contribution estimates were made separately for fish of Kitsumkalum origin only as there were no strays (from CWTs decoded) from other rivers in 1996.

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-tagging and dead-recovery sample size. Instead, the live and dead 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:

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

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 1996 occurred between 19 August and 19 September (Table 2). Numbers of chinook captured, tagged, and released during the 1996 tagging operations in the upper and lower Kitsumkalum River, by date, are presented in Appendix A.

A total of 941 chinook (495 males, 438 females, and eight jacks) were tagged, operculum punched, and released (Table 3). Of these, 321 were tagged in the upper river (185 males, 130 females, and six jacks) and 620 were tagged in the lower river (310 males, 271 females, and two jacks).

Recovery

Carcass-recovery operations in 1996 occurred between 03 September and 04 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 748 chinook carcasses (150 males, 596 females, and two jacks) were examined during carcass-recovery operations in 1996 (Table 3). Of the 131 carcasses recovered in the upper river (21 males, 108 females, and two jacks) there were 25 total tag and/or punch recoveries (one male and 24 females). Of the 617 carcasses recovered in the lower river (129 males and 488 females), there were 36 total tag and/or punched recoveries (9 males and 27 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 1996, six male chinook 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 19.1% and 4.9% was achieved for the upper and lower Kitsumkalum, respectively (Table 4). Total tag recovery was 7.8% for the upper river and 4.8% for the lower river. There was no total tag loss for either the upper or lower river.

Population Estimates

Mark-recapture data, Petersen population estimates, and 95% confidence levels for chinook escapement to the Kitsumkalum River in 1996 are presented in Table 5. The number of chinook carcasses recovered includes 14 carcasses with no sex designation (one in the upper river and 13 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 female to the upper river, and three males and 10 females to the lower river). The recovery of only one tagged male chinook from the upper river precluded an estimate of that portion of the total chinook population; the adjusted Petersen method requires a minimum of three tag (or punch) recoveries to be valid (Ricker 1975, p. 79). Similarly, because no tagged/punched jack chinook were recovered in either the upper or lower river in 1996, jacks were omitted from the analysis.

The 1996 estimated total escapement of adult chinook to the total Kitsumkalum system (both sections of river) was 12,403. The lower and upper 95% confidence limits were 7704 and 21,778, respectively. The estimated total escapement included 571 adult chinook (female only) to the upper Kitsumkalum River and 11,831 adult chinook (male and female) to the lower Kitsumkalum River.

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 1996 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. Marine/freshwater age composition, calculated from scale samples only, is presented in Table 7.

In 1996, age-4 to age-7 adult chinook were represented in the deadpitch with age-6 chinook comprising approximately 62.8% of the aged samples (Table 6). Age-4, age-5, and age-7 chinook represented another 2.6%, 29.5%, and 5.1% of the samples, respectively. In 1996, 97% of the scale-aged chinook had a freshwater age of 2 (Table 7). Petersen population estimates, stratified by age and sex, were used to calculate the age composition of the escapement based on the age composition observed in the deadpitch (Table 8). However, due to the small number of male age samples (n = 4), and the lack of age-6 samples, the estimated male escapements by age are most likely not representative of the actual male population. Age-6 females were estimated to comprise 69.3% of the total female escapement; the remaining female escapement consisted of fish that were age 4 (0.3%), age 5 (27.6%), and age 7 (2.8%; Table 8).

The mean lengths (postorbital-hypural) of all (aged and unaged) adult male and female chinook, sampled from the deadpitch in 1996 (presented in Table 6), were compared within river sections (upper and lower) and between river sections, and produced the following results:

1) *Within river sections*

   a) in the upper river, males (mean = 840 mm) had a larger mean length than adult females (mean = 833 mm), though the difference was not significant (t-test, $P>0.5$); and

   b) in the lower river, females (mean = 846 mm) had a larger mean length than adult males (mean = 843 mm), though the difference was not significant (t-test, $P>0.5$).

2) *Between river sections*

   a) the difference in size between upper and lower river males was not significant (t-test, $P>0.5$); while

   b) female chinook from the upper river had a significantly smaller mean length than females from the lower river (t-test, $P<0.005$).

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

2) *Lower river*

aged males vs. unaged males	not significant ($P > 0.2$)
aged females vs. unaged females	not significant ($P > 0.1$)

Sex ratios were calculated using the Petersen population estimates for 1996 (Table 5). Calculations for males did not include jacks. The ratio of adult males:females was 1.19 for the lower river and 1.08 for the total river; a male:female sex ratio was not calculated for the upper river due to the lack of a population estimate for males. A statistical comparison of the number (from Petersen estimates) of adult males (n = 6435) and females (n = 5968) 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 estimate 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) lower river adult males and lower river females; and

2) upper river females and lower river females.

Coded Wire Tagging and Recovery

Decoded CWTs, retrieved from the heads of adipose-clipped fish collected during carcass-recovery operations, indicated that only hatchery fish from the 1990, 1991, and 1992 brood years were present. However, because the total number of decoded tags was relatively small (n = 11), other hatchery brood years could also have been present (but not sampled). All of the CWT chinook decoded in 1996 were of Kitsumkalum River origin (Deep Creek Hatchery); thus, the estimated contribution of chinook from other hatcheries (between-river strays) was not included in these analyses.

The results of 1996 CWT 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 (sum of upper and lower) 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, 1996 (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 1996 live-tagging operations, a total of nine adipose-clipped chinook were observed in the upper river and 15 were observed in the lower river (Table 9). During the carcass-recovery operations, five adipose-clipped chinook were observed in the upper river and a total of 13 adipose-clipped chinook were observed in the lower river. The combined (live tagging and carcass recovery) adipose-clip mark rates were 3.1% for the upper river and 2.2% for the lower river; these mark rates were not significantly different (χ^2, $P>0.05$). The total estimated number of adipose-clipped adult male and female chinook (weighted average for live and dead) to the total river was 278 (14 to the upper river and 265 to the lower river); this estimate comprised 2.2% of the total escapement estimate.

<u>Hatchery Contributions - Method A</u>

The estimated total escapements of each CWT group decoded in 1996 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. A total of 11 CWT heads from adipose-clipped chinook recovered in 1996 were successfully decoded (Table 10).

Using Method A, the 1996 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 304 fish (152 adult males and 152 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 1996 was estimated at 2.5%; the total hatchery contribution was made up of approximately equal numbers of male and female chinook.

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 1996 estimated hatchery contribution to escapement for chinook salmon to the total Kitsumkalum River was 186 fish (77 adult males and 108 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 1996 was estimated to be 1.5% (0.6% for adult males and 0.9% 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 1996 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, 1996 population estimates of adult male and female chinook can be compared with population estimates from past studies.

The Petersen estimate of the total escapement of summer/fall-run adult male and female chinook to the Kitsumkalum River was 12,403, which is a 42% increase from the 1995 adult male and female population estimate (7221; Nelson 1997) and a 1% decrease from the 1994 estimate (12,629; Nelson 1995). Figure 2 illustrates the estimated escapements of adult chinook with upper and lower 95% confidence limits, for the total Kitsumkalum River from 1984-1996. The total population estimate is the sum of the individual estimates for the upper and lower sections of the Kitsumkalum River, except in 1984, when the population estimate was derived from pooled data due to a lack of recaptures in the upper river (Andrew and Webb 1988).

For 1996, the estimated number of adult female chinook to the upper Kitsumkalum River (n = 571) represented 4.6% of the total escapement. Unfortunately, due to the recovery of only one tagged male from the upper river in 1996, an adjusted Petersen estimate could not be calculated for that segment of the population; this problem is further complicated by the high number of tagged/punched males from the upper river that were recovered in the lower river (strays). Figures 3 and 4 present the estimated escapements of adult chinook, with upper and lower 95% confidence limits, for the upper and lower Kitsumkalum River, respectively, from 1985-1996. In 1993, chinook escapement to the upper Kitsumkalum River represented 34% of the total escapement; in 1994, the upper river escapement represented 15% of the total escapement, and in 1995 represented 12.6% of the total escapement.

In 1996, the number of observed in-river strays from the upper to the lower river was six males; there was not a significant difference in the number of male and female in-river strays from the upper to the lower river (χ^2, P>0.005). This difference 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 1996.

Confidence intervals for the Petersen estimates varied by sex and river section. The lower and upper confidence limits for the total adult male and female population estimate of chinook (12,403) were 38% less and 76% greater, respectively, than for the population estimate. These proportions are higher than the 25% accuracy recommended for salmon management purposes (Ricker 1975), and are primarily a result of the low number of tagged recoveries.

Age, Length, and Sex Composition

Age-6 chinook represented the largest percentage (69.3%) of the female escapement to the total Kitsumkalum River in 1996; age-5 chinook represented the next largest contribution of the female escapement (27.6%). Due to the small number of male samples aged, no reliable estimate of the age composition of the male population was possible. In general, the 1996 female age composition was similar to those reported in previous years (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; Nelson 1993b; Nelson 1994; Nelson 1995).

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 1996, a significant difference was found between the lengths of the upper and lower females ($P<0.005$).

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

Stratified mean lengths of aged and unaged adult male and female chinook in the upper Kitsumkalum River in 1996 varied more than 50 mm in some cases from respective 1995 mean lengths, but the sample size for aged lengths in 1996 was much smaller (n = 78) in comparison to that of 1995 (n = 110). Given the low number of successfully aged samples, sampling crews should be instructed to increase the frequency of scale and, if necessary, fin collection during the carcass-recovery operation from every fifth carcass to every third carcass.

Adult males (51.9%) represented a larger proportion of the total escapement compared to females (48.1%) in 1996. Because the population estimate for males does not include males from the upper river (and jacks from both the upper and lower river), a larger 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 2.41% in 1996.

Estimates of percent hatchery contribution to total Kitsumkalum River chinook escapement in 1996 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 (2.5%) than Method B (1.5%). Possible reasons for the differences in the estimates are discussed in Bocking (1991b).

A comparison of percent hatchery contributions for 1989-96, by year and estimation method (Method A and Method B) is provided below:

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%
1996	2.5%	1.5%

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 estimated CWT escapement very poor; 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 escapement estimate. In 1996, a net total of 41 adipose clips and 11 decoded CWTs were recorded from the live-tagging and carcass-recovery operations.

In 1996, crews examined 7.8% of the estimated population of adult male and female chinook for adipose clips during live-tagging operations and 6.0% of the estimated population during carcass-recovery operations. The examination levels are considerably lower than those in 1995 (13.0% and 11.4%, respectively).

SUMMARY

1. The 1996 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 12,403. This estimate is the summation of individual Petersen estimates stratified by river section (upper and lower) and sex. Upper river males and jack chinook were not included in the total population estimate as an

inadequate number of tagged/punched recoveries precluded a Petersen population estimate for that segment of the total population. The 1996 escapement estimate (12,403) is a 42% increase from the 1995 population estimate (n = 7221; Nelson 1997) and 1% decrease from the 1994 estimate (n = 12,629; Nelson 1995).

2. The 1996 escapement of adult male and female chinook was represented by age-4 to age-7 fish. Age-6 female chinook comprised the largest portion of the total female escapement (69.3%), followed by age-5 (27.6%), age-7 (2.8%) and age-4 (0.3%) females. Proportional contribution estimates, by age, for the male population could not be reliably estimated.

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 1996, a significant difference was found between the lengths of the upper and lower females. Significant differences were not found between aged and unaged specimens (both sexes in both sections of the river), which would indicate that lengths from the aged samples were representative of these populations.

4. Adult males (n = 6435) significantly outnumbered adult females (n = 5968) in 1996. The difference between the numbers of males and females in the total chinook population was likely even greater, in that the male population estimate did not include adult males from the upper river or jack chinook from the total river.

5. The total estimated escapement of adipose-clipped adult male and female chinook to the total Kitsumkalum River in 1996 was 278 (2.2% 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 304 fish (2.5% 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 186 fish (1.5% of the total escapement estimate).

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TABLES

Table 1. Summary of methods for the Kitsumkalum River chinook salmon enumeration program, 1996.

Item	Method and materials 1996
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, 1996.

Location	Tagging period	Effort (days) (c)	Carcass recovery period	Effort (days) (c)
Upper river (a)	Aug 21 - Sep 19	11	Sep 04 - Sep 27	10
Lower river (b)	Aug 19 - Sep 17	16	Sep 03 - Oct 04	11

(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, 1996.

Category	Upper river	Lower river	Total
Live tagging (a)			
Males examined	187	312	499
Females examined	143	330	473
Jacks examined	6	2	8
Total examined	336	644	980
Males tagged/punched	185	310	495
Females tagged/punched	130	308	438
Jacks tagged/punched	6	2	8
Total tagged/punched	321	620	941
Dead recovery (b, c)			
Males examined	21	129	150
Females examined	108	488	596
Jacks examined	2	0	2
Total examined	131	617	748
Punched-only males (d)	0	0	0
Punched-only females (d)	0	0	0
Punched-only jacks (d)	0	0	0
Total punched only (d)	0	0	0
Tagged/punched males (e)	1	9	10
Tagged/punched females (e)	24	27	51
Tagged/punched jacks (e)	0	0	0
Total tagged/punched (e)	25	36	61
Strays (f)			
Stray males	0	6	6
Stray females	0	0	0
Stray jacks	0	0	0
Total strays	0	6	6

(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 with no tag ("No. TL" from Appendix B)

(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, 1996.

Category	Upper river	Lower river	Total
Tag rate (a)			
Male tag rate (%)	4.8	2.3	2.7
Female tag rate (%)	22.2	5.5	8.6
Jack tag rate (%)	0.0	0.0	0.0
Total tag rate (%)	19.1	4.9	7.4
Tag recovery rate (b)			
Male tag recovery rate (%)	0.5	1.0	0.8
Female tag recovery rate (%)	18.5	8.8	11.6
Jack tag recovery rate (%)	0.0	0.0	0.0
Total tag recovery rate (%)	7.8	4.8	5.8
Tag loss rate (c)			
Male tag loss rate (%)	0.0	0.0	0.0
Female tag loss rate (%)	0.0	0.0	0.0
Jack tag loss rate (%)	0.0	0.0	0.0
Total tag loss rate (%)	0.0	0.0	0.0

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, 1996. Confidence limits are from fudicial limits for the Poisson distribution using Ricker (1975, p. 343).

Location	Male	Female	Jack	Total
Upper river				
Number tagged (a)	185	130	6	321
Number recovered (b)(c)	21	108	2	131
Number of tagged fish recovered (d)	1	24	0	25
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)	N/A	130	6	136
Petersen estimate (h)	N/A	571	N/A	571 (i)
Lower 95% CL	N/A	390	N/A	390 (i)
Upper 95% CL	N/A	871	N/A	871 (i)
Lower river				
Number tagged (a)	310	308	2	620
Number recovered (b)(c)	129	488	0	617
Number of tagged fish recovered (d)	9	27	0	36
Number of tagged strays from upper river (e)	6	0	0	6
Expanded No. of tagged strays from upper river (f)	184	0	0	184
Number of tagged fish for Petersen estimate (g)	494	308	2	804
Petersen estimate (h)	6435	5396	N/A	11831 (i)
Lower 95% CL	3555	3759	N/A	7314 (i)
Upper 95% CL	12870	8037	N/A	20907 (i)
Total river				
Petersen estimate	6435	5968	N/A	12403 (i)
Lower 95% CL	3555	4149	N/A	7704 (i)
Upper 95% CL	12870	8908	N/A	21778 (i)

(a) Total live tagged/punched (Appendix A, "No. tagged")
(b) Total dead recoveries (Appendix B, "No. revd")
(c) Includes recoveries with no sex designation (one in the upper river and 13 in the lower river); sex ratios from the upper and lower river carcass recoverywere used to attribute sex designations (one female to the upper river; three males and 10 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), except for upper river males; because the calculated No. of "expanded strays" to the lower river was greater than the number tagged in the upper river (an impossible occurrence), the maximum possible No. of strays was used instead, i.e. No. tagged in the upper river - No. recovered in the upper river
(g) No. of tagged fish for Petersen estimate = No. tagged + expanded No. of tagged strays - expanded No. of tagged strays from other section, except for upper river males, for which this number could not be calculated (N/A)
(h) Because no marked jacks were recovered in the upper or lower river, no population estimates could be calculated for these groups (N/A); because only one tagged male was recovered in the upper river, no population estimate could be calculated for this group (N/A)
(i) These totals do not include jacks (see footnote h) or upper-river adult males

Table 6. Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1996. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (c)	Total age (years) (a)													
	Male (b)							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														
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	0	0	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	0	0	0	0	2	2	0	1	0	0	1	5	6
750-799	0	1	0	0	1	1	2	1	3	0	0	4	10	14
800-849	0	0	0	0	0	3	3	0	5	11	0	16	18	34
850-899	0	0	0	0	0	3	3	0	0	9	0	9	24	33
900-949	0	0	0	0	0	6	6	0	0	4	1	5	4	9
950-999	0	0	0	0	0	1	1	0	0	0	0	0	1	1
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	1	0	0	1	19	20	1	9	24	1	35	62	97
Percent (aged)	0.0	100.0	0.0	0.0	100.0			2.9	25.7	68.6	2.9	100.0		
Mean (c)	0	790	0	0	790	843	840	760	790	851	940	835	831	833
SD (c)	0	0	0	0	0	111	109	0	33	33	0	47	50	48

Table 6. (cont.) Age-length distribution of deadpitch Kitsumkalum River chinook salmon, 1996. Data for calculations are from scale analysis and CWT age samples.

Length class (mm) (c)	Total age (years) (a) Male (b) 4	5	6	7	Total aged	Total unaged	Total aged + unaged	Female 4	5	6	7	Total aged	Total unaged	Total aged + unaged
Lower river														
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	0	0	0	0	0	0	0	0	0
600-649	1	0	0	0	1	0	1	0	0	0	0	0	0	0
650-699	0	0	0	0	0	1	1	0	0	0	0	0	0	0
700-749	0	1	0	0	1	5	6	0	0	0	0	0	2	2
750-799	0	0	0	0	0	12	12	0	3	3	0	6	37	43
800-849	0	2	0	0	2	13	15	0	6	7	0	13	113	126
850-899	0	0	0	0	0	11	11	0	0	14	1	15	125	140
900-949	0	0	0	1	1	28	29	0	1	1	0	2	46	48
950-999	0	0	0	0	0	2	2	0	0	0	0	0	1	1
1000-1049	0	0	0	1	1	1	2	0	0	0	0	0	1	1
1050-1099	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	3	0	2	6	74	80	0	10	25	1	36	325	361
Percent (aged)	16.7	50.0	0.0	33.3	100.0			0.0	27.8	69.4	2.8	100.0		
Mean (c)	620	780	0	960	813	846	844	0	809	845	890	836	847	846
SD (c)	0	35	0	57	137	82	86	0	40	36	0	41	50	48

(a) Total age is the sum of the freshwater and marine ages (see Table 7, footnote c)

(b) Does not include jacks

(c) Postorbital-hypural length

Table 7. Age composition of chinook salmon sampled during carcass-recovery operations in the Kitsumkalum River, 1996. (a)

Location	Age (c)	Male (b) N	Male (b) Percent	Female N	Female Percent
Upper river					
	41	0	N/A	0	0.0
	42	0	N/A	1	2.9
	51	0	N/A	1	2.9
	52	0	N/A	7	20.6
	61	0	N/A	0	0.0
	62	0	N/A	24	70.6
	71	0	N/A	0	0.0
	72	0	N/A	1	2.9
	Total	0	N/A	34	100.0
Lower river					
	41	0	0.0	0	0.0
	42	0	0.0	0	0.0
	51	0	0.0	1	3.3
	52	2	50.0	7	23.3
	61	0	0.0	0	0.0
	62	0	0.0	21	70.0
	71	0	0.0	0	0.0
	72	2	50.0	1	3.3
	Total	4	100.0	30	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. Estimated chinook salmon escapement to the Kitsumkalum River, 1996, by total age.

	Total age	Male (a)		Female	
		Number (b)	Percent	Number (b)	Percent
Upper river					
	4	N/A	0.0	17	2.9
	5	N/A	100.0	147	25.7
	6	N/A	0.0	391	68.6
	7	N/A	0.0	17	2.9
	Total	N/A (d)	100.0 (c)	571 (d)(e)	100.1 (c)
Lower river					
	4	1075	16.7	0	0.0
	5	3218	50.0	1500	27.8
	6	0	0.0	3745	69.4
	7	2143	33.3	151	2.8
	Total	6435 (d)(e)	100.0 (c)	5396 (d)	100.0 (c)

(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) Represents summation of unrounded numbers

Table 9. Estimates of escapement, and weighted estimate, of adipose-clipped chinook salmon to the upper, lower, and total Kitsumkalum River, 1996.

Location and sex	Live tagging: Sample size (a) A	Live tagging: Observed adipose clips (b) B	Live tagging: Mark rate (%) C=B/A*100	Dead recovery: Sample size (c) D	Dead recovery: Observed adipose clips (d) E	Dead recovery: Mark rate (%) F=E/D*100	Petersen population estimate (e) G	Total estimated adipose clips: Live tagging H=C/100*G	Total estimated adipose clips: Dead recovery I=F/100*G	Weighted estimate of adipose clips J (f)
Upper river										
Male (g)	187	5	2.67	21	3	14.29	N/A	N/A	N/A	N/A (h)
Female	143	4	2.80	108	2	1.85	571	16	11	14
Subtotal	330	9	2.73	129	5	3.88	571	16	11	14
Lower river										
Male (g)	312	6	1.92	129	4	3.10	6435	124	200	146
Female	330	9	2.73	488	9	1.84	5396	147	100	119
Subtotal	642	15	2.34	617	13	2.11	11831	271	299	265
Total river										
Male (g)	499	11	2.20	150	7	4.67	6435	124	200	146
Female	473	13	2.75	596	11	1.85	5967.6	163	110	132
Total	972	24	2.47	746	18	2.41	12403	287	310	278

(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)
(h) Weighted estimate of adipose clip was not available (N/A) for upper river males because a Petersen population estimate for this segment of the population could not be calculated (see Table 5)

Table 10. Estimates of total escapement of adipose-clipped chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1996. 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 (b)		Decoded adipose clips		Estimated adipose clips	
Brood year	CWT code	M (c)	F	M (c)	F	M (c)	F	M (c)	F
Kitsumkalum River (Deep Creek Hatchery)									
1992	181049	0	0	N/A	0.0	1	0	73.0	0.0
	Subtotal	0	0	N/A	0.0	1	0	73.0	0.0
1991	021010	1	0	N/A	0.0	1	0	73.0	0.0
	023116	0	1	N/A	14.0	0	3	0.0	51.0
	Subtotal	1	1	N/A	14.0	1	3	73.0	51.0
1990	021135	0	0	N/A	0.0	0	1	0.0	17.0
	021136	0	0	N/A	0.0	0	1	0.0	17.0
	021137	0	0	N/A	0.0	0	1	0.0	17.0
	021139	0	0	N/A	0.0	0	1	0.0	17.0
	Subtotal	0	0	N/A	0.0	0	4	0.0	68.0
	Total CWT	1	1	N/A (d)	14.0 (d)	2	7	146.0 (d)	119.0 (d)
No data (5000) (e)		5	4			6	8		
No pin (8000)		2	1			2	2		
Lost pin (9000)		0	0			0	0		
Observed adipose clips		8	6			10	17		

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

(b) Estimated adipose clips not available (N/A) for upper river males (see Table 9)

(c) Does not include jacks

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

(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 1996, one operculum-tagged and adipose-clipped chinook captured during live tagging was subsequently recovered as a carcass in the lower river (one decoded CWT female); the deletion of this fish from the 24 "No data" entries for adipose clips from the live-tagging operation assured that individual adipose clips were 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, 1996.

Brood year	CWT release group	CWT release numbers: CWT (A)	CWT release numbers: Untagged (B)	CWT loss (%) (C)	Days held (D)	Adipose release status: Clipped (E) = A/(1-C/100)	Adipose release status: Unclipped (F) = A+B-E
Kitsumkalum River (Deep Creek Hatchery)							
1992	181049	26134	622	1.0	1	26398	358
1991	021010	25634	2391	2.0	1	26157	1868
	023116	156630	11760	0.3	1	157101	11289
1990	021135	26736	5545	0.0	1	26736	5545
	021136	26783	5545	0.0	1	26783	5545
	021137	26599	5544	0.0	1	26599	5544
	021139	26624	5545	0.0	1	26624	5545
	Total hatchery	315140	36952			316398	35694

Table 12. Estimates of total escapement of hatchery-reared chinook salmon (Method A) to the upper and lower Kitsumkalum River, by tag code, 1996. 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.

	CWT				Expanded hatchery contribution (a)(f)			
Brood	release	Adipose release status (b)		Expansion	Upper river		Lower river	
year	group	Clipped	Unclipped	factor (c)	M (d)	F	M (e)	F
1992	181049	26398	358	1.01	N/A	0.0	74.0	0.0
	Subtotal				N/A	0.0	74.0	0.0
1991	021010	26157	1868	1.07	N/A	0.0	78.2	0.0
	023116	157101	11289	1.07	N/A	15.0	0.0	54.7
	Subtotal				N/A	15.0	78.2	54.7
1990	021135	26736	5545	1.21	N/A	0.0	0.0	20.5
	021136	26783	5545	1.21	N/A	0.0	0.0	20.5
	021137	26599	5544	1.21	N/A	0.0	0.0	20.5
	021139	26624	5545	1.21	N/A	0.0	0.0	20.5
	Subtotal				N/A	0.0	0.0	82.1
	Total hatchery				N/A	15.0	152.2	136.8

(a) Abbreviations are M = male, F = female
(b) From Table 11
(c) Expansion factor = (adipose-clipped + unclipped releases) / adipose-clipped releases
(d) Expanded hatchery contribution not available (N/A) for upper river males (see Table 10)
(e) Does not include jacks
(f) 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, 1996. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 12).

	Estimated escapement (b)		Hatchery contribution (a)			
			Male(c)(d)		Female	
Total age	Male (c)	Female	Number	Percent	Number	Percent
Upper river						
4	N/A	16	N/A	N/A	0.0	0.0
5	N/A	146	N/A	N/A	15.0	10.3
6	N/A	392	N/A	N/A	0.0	0.0
7	N/A	16	N/A	N/A	0.0	0.0
Subtotal	N/A	571 (e)	N/A	N/A	15.0	2.6
Lower river						
4	1075	0	74.0	6.9	0.0	0.0
5	3218	1500	78.2	2.4	54.7	3.6
6	0	3745	0.0	0.0	82.1	2.2
7	2143	151	0.0	0.0	0.0	0.0
Subtotal	6435 (e)	5396	152.2	2.4	136.8	2.5
Total river						
4	1075	16	74.0	6.9	0.0	0.0
5	3218	1646	78.2	2.4	69.7	4.2
6	0	4137	0.0	0.0	82.1	2.0
7	2143	167	0.0	0.0	0.0	0.0
Total	6435	5967	152.2	2.4	151.8	2.5

(a) Subtotals of expanded hatchery contribution from Table 12
(b) From Table 8
(c) Does not include jacks
(d) Hatchery contribution is not available (N/A) for upper river males (see Table 12)
(e) Represents summation of unrounded numbers

Table 14. Adjusted number of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1996. 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
1992	181049	0	0	0.0	0.0	1	0	2.5	0.0
	Subtotal	0	0	0.0	0.0	1	0	2.5	0.0
1991	021010	1	0	2.7	0.0	1	0	2.5	0.0
	023116	0	1	0.0	3.0	0	3	0.0	5.7
	Subtotal	1	1	2.7	3.0	1	3	2.5	5.7
1990	021135	0	0	0.0	0.0	0	1	0.0	1.9
	021136	0	0	0.0	0.0	0	1	0.0	1.9
	021137	0	0	0.0	0.0	0	1	0.0	1.9
	021139	0	0	0.0	0.0	0	1	0.0	1.9
	Subtotal	0	0	0.0	0.0	0	4	0.0	7.6
	Total CWT	1	1	2.7	3.0	2	7	5.0	13.2
No data (5000) (d)		5	4			6	8		
No pin (8000)		2	1			2	2		
Lost pin (9000)		0	0			0	0		
Observed adipose		8	6			10	17		

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

(b) From Table 10

(c) Does not include jacks

(d) See footnote (e), Table 10

Table 15. Estimates of total escapement of CWT chinook salmon to the upper and lower Kitsumkalum River, by tag code, 1996. 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 (d)	F	M (c)	F	M (c)	F
1992	181049	0.0	0.0	N/A	0.0	2.5	0.0	36.5	0.0
	Subtotal	0.0	0.0	N/A	0.0	2.5	0.0	36.5	0.0
1991	021010	2.7	0.0	N/A	0.0	2.5	0.0	36.5	0.0
	023116	0.0	3.0	N/A	6.8	0.0	5.7	0.0	37.4
	Subtotal	2.7	3.0	N/A	6.8	2.5	5.7	36.5	37.4
1990	021135	0.0	0.0	N/A	0.0	0.0	1.9	0.0	12.5
	021136	0.0	0.0	N/A	0.0	0.0	1.9	0.0	12.5
	021137	0.0	0.0	N/A	0.0	0.0	1.9	0.0	12.5
	021139	0.0	0.0	N/A	0.0	0.0	1.9	0.0	12.5
	Subtotal	0.0	0.0	N/A	0.0	0.0	7.6	0.0	50.1
	Total CWT	2.7	3.0	N/A	6.8	5.0	13.3	73.0	87.5
Escapement est. (e)		N/A	571			6435	5396		
Sample size (f)		208	251			441	818		

(a) Abbreviations are M = male, F = female
(b) From Table 14
(c) Does not include jacks
(d) Estimated CWTs not avialable (N/A) for upper river males (see Table 5)
(e) Petersen estimate from Table 5
(f) 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, 1996. 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.

	CWT				Expanded hatchery contribution (a)(f)			
Brood	release	Release numbers (b)		Expansion	Upper river		Lower river	
year	group	CWT	Untagged	factor (c)	M (d)	F	M (e)	F
1992	181049	26134	622	1.02	N/A	0.0	37.3	0.0
	Subtotal				N/A	0.0	37.3 (g)	0.0
1991	021010	25634	2391	1.09	N/A	0.0	39.9	0.0
	023116	156630	11760	1.08	N/A	7.3	0.0	40.2
	Subtotal				N/A	7.3 (g)	39.9 (g)	40.2 (g)
1990	021135	26736	5545	1.21	N/A	0.0	0.0	15.1
	021136	26783	5545	1.21	N/A	0.0	0.0	15.1
	021137	26599	5544	1.21	N/A	0.0	0.0	15.1
	021139	26624	5545	1.21	N/A	0.0	0.0	15.1
	Subtotal				N/A	0.0	0.0	60.6 (g)
	Total CWT				N/A	7.3	77.2	100.8

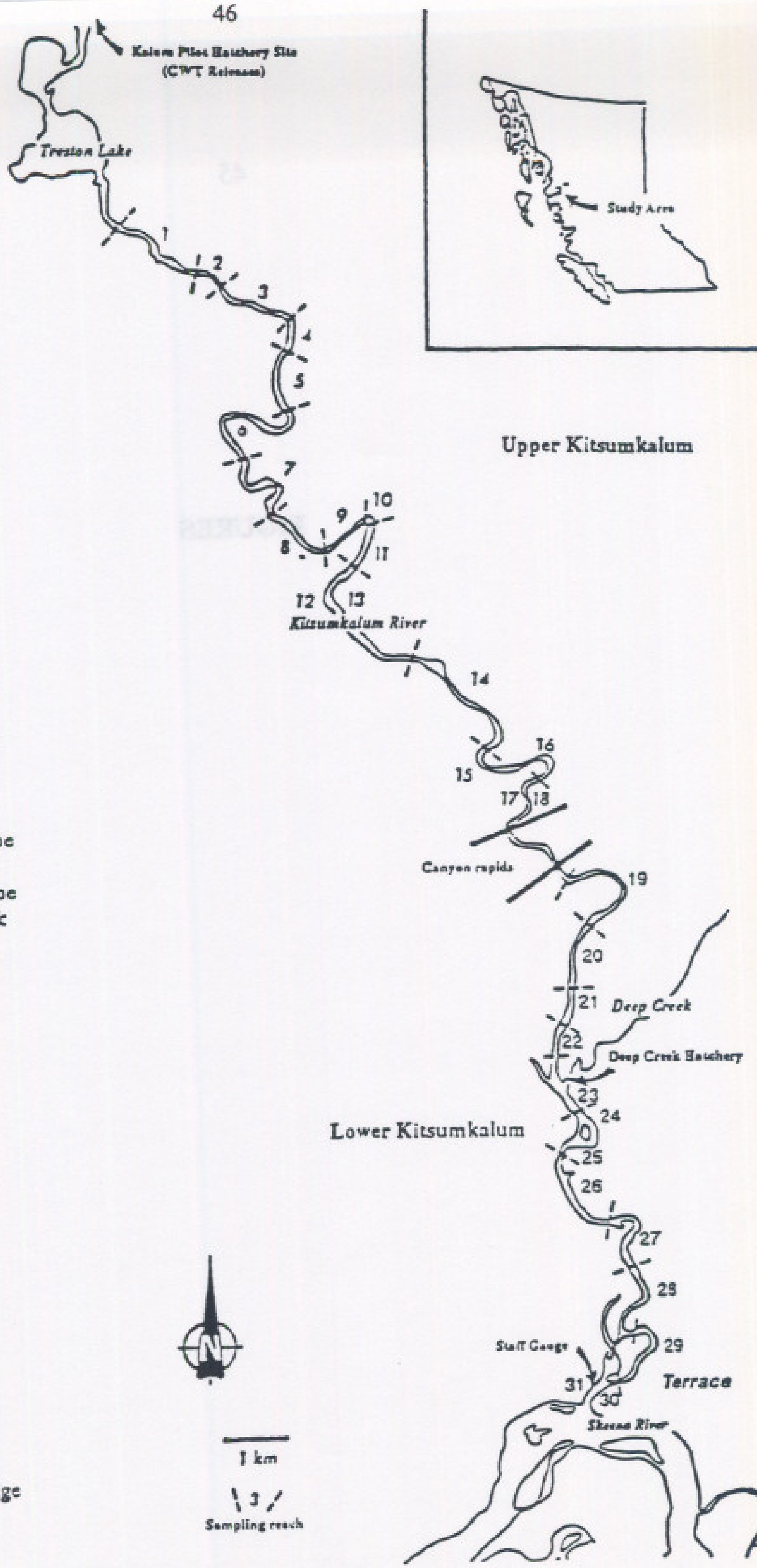
(a) Abbreviations are M = male, F = female
(b) From Table 11
(c) Expansion factor = (CWT releases + untagged releases) / CWT releases
(d) Expanded hatchery contribution not avialable (N/A) for upper river males (see Table 15)
(e) Does not include jacks
(f) Calculated from estimated CWTs in Table 15
(g) Represents summation of unrounded numbers

Table 17. Estimated hatchery contribution of chinook salmon, by age, to the upper, lower, and total Kitsumkalum River, 1996. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 16).

	Estimated escapement (c)		Hatchery contribution (a)(b)			
			Male (d)(e)		Female	
Total age	Male (d)	Female	Number	Percent	Number	Percent
Upper river						
4	N/A	16	N/A	N/A	0.0	0.0
5	N/A	146	N/A	N/A	7.3	5.0
6	N/A	392	N/A	N/A	0.0	0.0
7	N/A	16	N/A	N/A	0.0	0.0
Subtotal	N/A	571 (f)	N/A	N/A	7.3	1.3
Lower river						
4	1075	0	37.3	3.5	0.0	0.0
5	3218	1500	39.9	1.2	40.2	2.7
6	0	3745	0.0	0.0	60.6	1.6
7	2143	151	0.0	0.0	0.0	0.0
Subtotal	6435 (f)	5396	77.2	1.2	100.8	1.9
Total river						
4	1075	16	37.3	3.5	0.0	0.0
5	3218	1646	39.9	1.2	47.5	2.9
6	0	4137	0.0	0.0	60.6	1.5
7	2143	167	0.0	0.0	0.0	0.0
Total	6435	5966	77.2	1.2	108.1	1.8

(a) Kitsumkalum River (Deep Creek Hatchery)
(b) Subtotals of expanded hatchery contribution from Table 16
(c) From Table 8
(d) Does not include jacks
(e) Hatchery contribution is not available (N/A) for upper river males (see Table 16)
(f) Represents summation of unrounded numbers

FIGURES



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

Total Kitsumkalum River
Adult Chinook Escapements 1984 - 1996

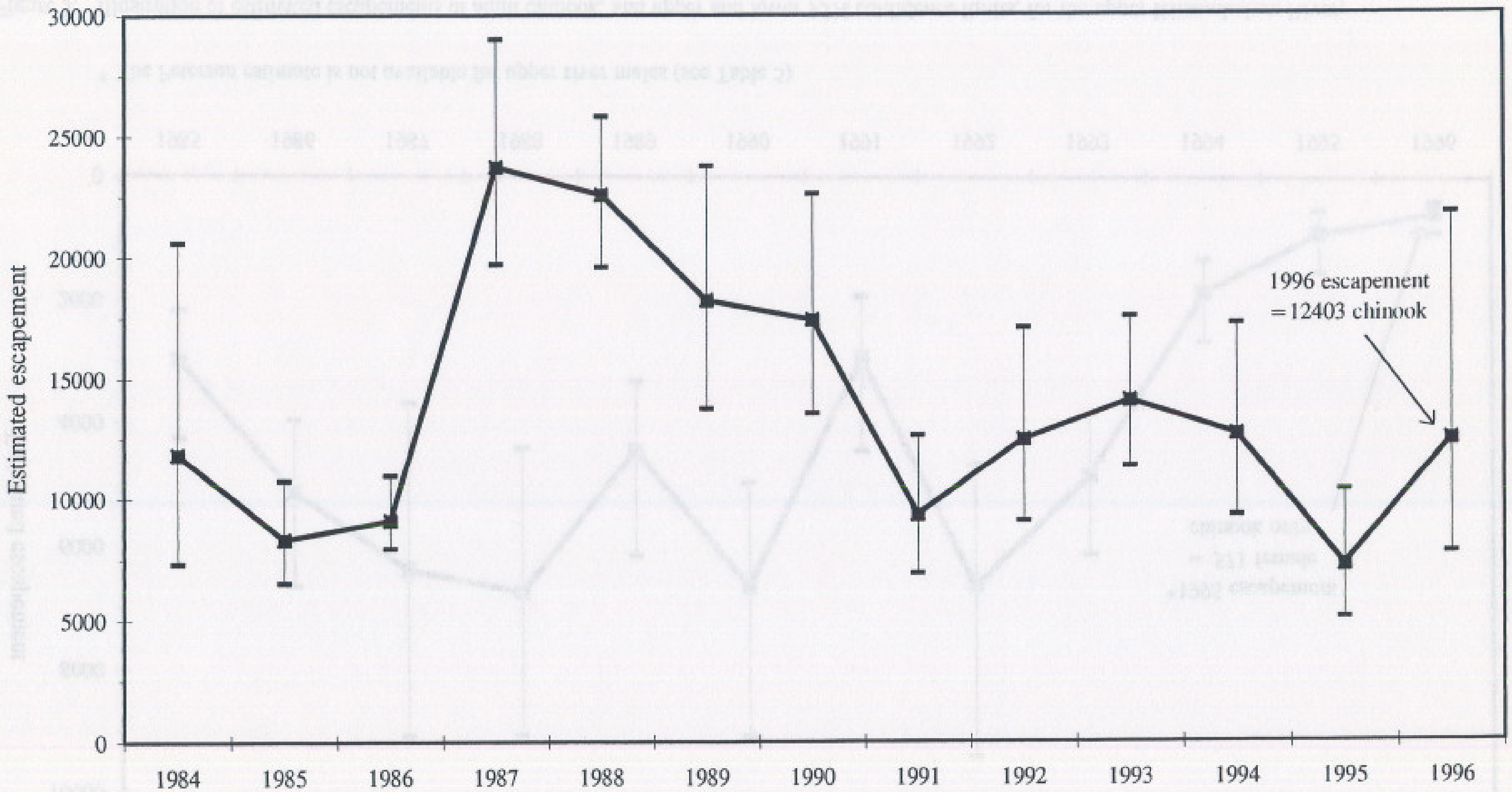
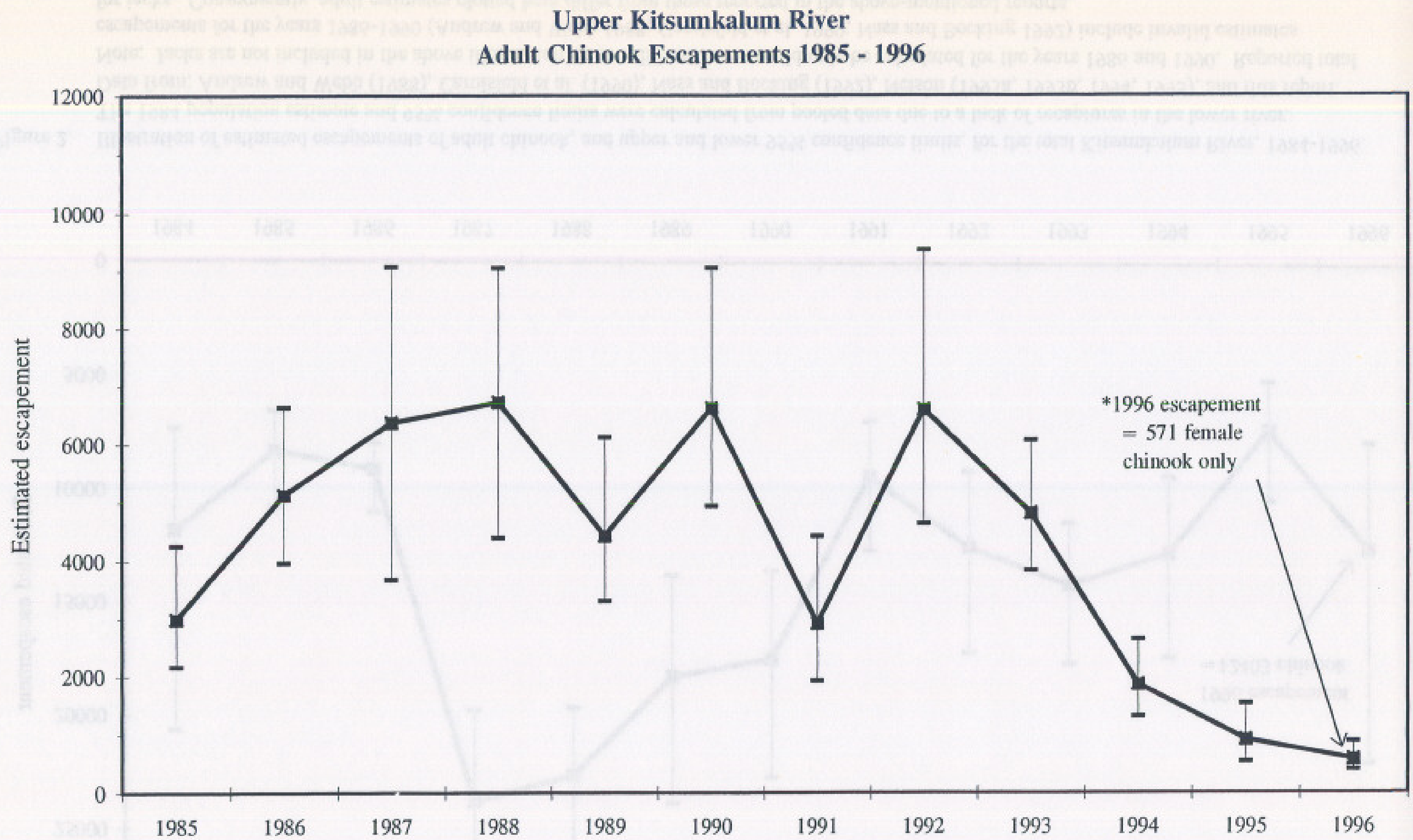


Figure 2. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the total Kitsumkalum River, 1984-1996. The 1984 population estimate and 95% confidence limits were calculated from pooled data due to a lack of recaptures in the lower river. Data from: Andrew and Webb (1988), Carolsfeld et al. (1990), Nass and Bocking (1992), Nelson (1993a, 1993b, 1994, 1995), and this report. Note: Jacks are not included in the above illustration since valid estimates could only be calculated for the years 1986 and 1990. Reported total escapements for the years 1986-1990 (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992) include invalid estimates for jacks. Consequently, adult estimates plotted here differ from those reported in the above-mentioned reports.



* The Petersen estimate is not available for upper river males (see Table 5)

Figure 3. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the upper Kitsumkalum River, 1985-1996. 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. Note: Jacks not included in the above illustration; see Figure 2 for explanation.

Lower Kitsumkalum River
Adult Chinook Escapements 1985 - 1996

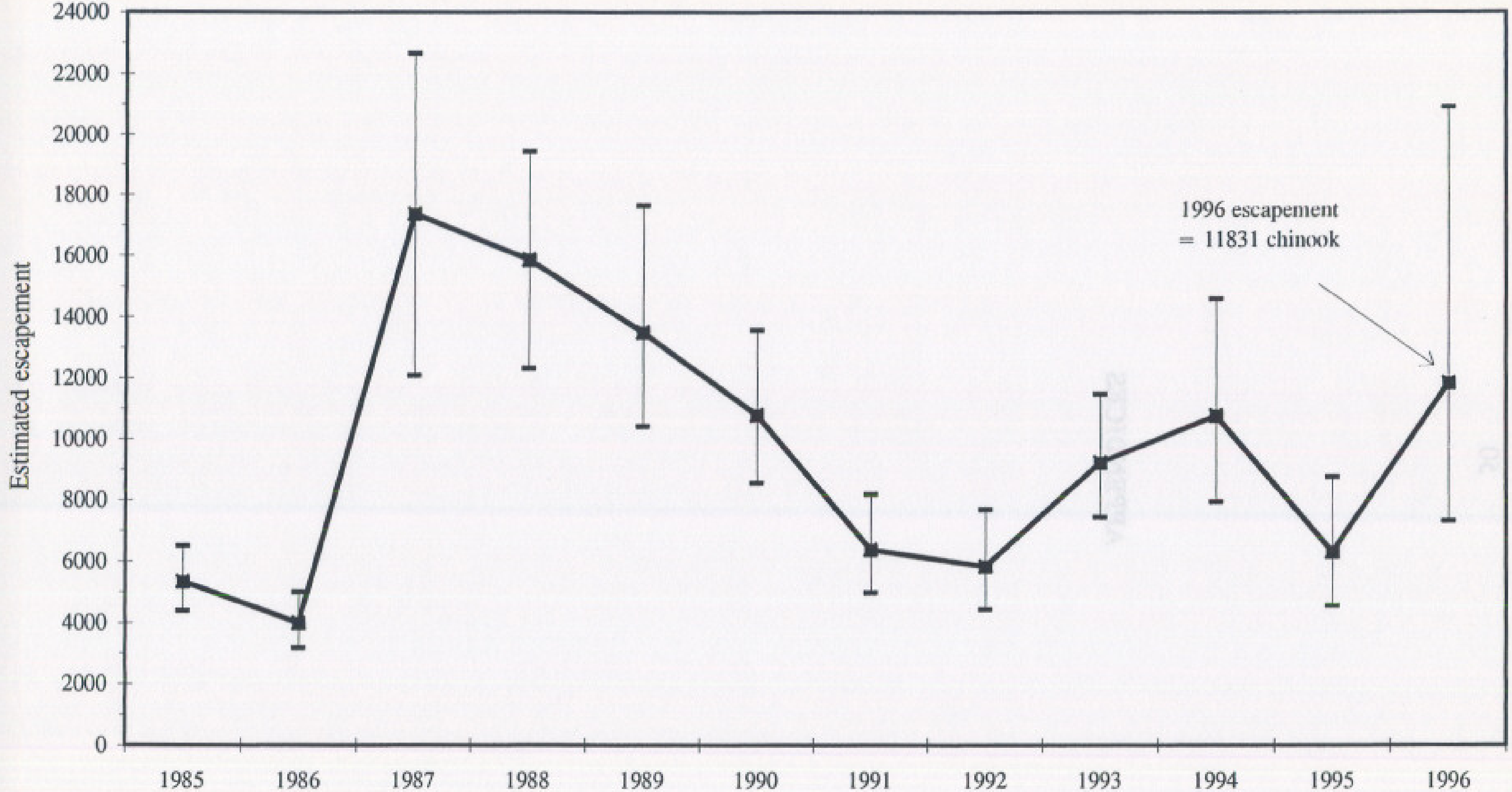


Figure 4. Illustration of estimated escapements of adult chinook, and upper and lower 95% confidence limits, for the lower Kitsumkalum River, 1985-1996. In 1984, a population estimate for the lower river was not produced; an estimate for the total river is available (see Figure 4). Data from: Andrew and Webb (1988), Carolsfeld et al. (1990), Nass and Bocking (1992), Nelson (1993a, 1993b, 1994, 1995), and this report. Note: Jacks are not included in the above illustration; see Figure 2 for explanation.

APPENDICES

Appendix A. Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1996.

		No	Male				Female				Jack			
		effort	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Location	Date	(NE)	captured	sacs (a)	tagged	ad clip	captured	sacs (a)	tagged	ad clip	captured	sacs (a)	tagged	ad clip
Upper river (b)														
	21-Aug		2	0	2	0	1	0	1	0	0	0	0	0
	22-Aug	NE												
	23-Aug	NE												
	24-Aug	NE												
	25-Aug	NE												
	26-Aug	NE												
	27-Aug		17	0	16	0	13	0	13	1	0	0	0	0
	28-Aug	NE												
	29-Aug	NE												
	30-Aug		20	0	20	0	15	0	15	0	1	0	1	0
	31-Aug	NE												
	01-Sep	NE												
	02-Sep		28	0	28	0	20	0	20	0	2	0	2	0
	03-Sep	NE												
	04-Sep		19	0	18	2	12	2	10	1	0	0	0	0
	05-Sep	NE												
	06-Sep		27	0	27	1	20	5	15	1	0	0	0	0
	07-Sep		32	0	32	1	17	0	17	1	0	0	0	0
	08-Sep	NE												
	09-Sep	NE												
	10-Sep	NE												
	11-Sep		17	0	17	1	21	3	18	0	2	0	2	0
	12-Sep	NE												
	13-Sep	NE												
	14-Sep	NE												
	15-Sep	NE												
	16-Sep		21	0	21	0	18	3	15	0	1	0	1	0
	17-Sep	NE												
	18-Sep		3	0	3	0	5	0	5	0	0	0	0	0
	19-Sep		1	0	1	0	1	0	1	0	0	0	0	0
		Totals	187	0	185	5	143	13	130	4	6	0	6	0

Appendix A. (cont.) Numbers of chinook salmon captured, sacrificed, tagged, and adipose clipped, by date, in the upper and lower Kitsumkalum River, 1996.

			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														
	19-Aug		8	0	8	0	12	0	12	0	0	0	0	0
	20-Aug		19	0	19	1	18	0	18	1	0	0	0	0
	21-Aug		32	0	32	0	20	0	20	0	0	0	0	0
	22-Aug		23	0	23	1	27	0	27	0	1	0	1	0
	23-Aug		10	0	10	0	9	0	9	0	0	0	0	0
	24-Aug	NE												
	25-Aug	NE												
	26-Aug		22	0	22	0	22	0	22	0	0	0	0	0
	27-Aug	NE												
	28-Aug		19	0	19	0	15	0	15	1	0	0	0	0
	29-Aug		26	0	26	2	21	0	21	3	1	0	1	0
	30-Aug	NE												
	31-Aug		19	0	19	0	21	0	21	1	0	0	0	0
	01-Sep	NE												
	02-Sep	NE												
	03-Sep		22	0	22	0	21	2	19	0	0	0	0	0
	05-Sep		23	2	21	0	27	10	17	1	0	0	0	0
	06-Sep	NE												
	07-Sep	NE												
	08-Sep	NE												
	09-Sep		17	0	17	0	35	5	30	1	0	0	0	0
	10-Sep		31	0	31	0	34	3	31	0	0	0	0	0
	11-Sep	NE												
	12-Sep		20	0	20	1	21	2	19	0	0	0	0	0
	13-Sep		17	0	17	1	24	0	24	1	0	0	0	0
	14-Sep	NE												
	15-Sep	NE												
	16-Sep	NE												
	17-Sep		4	0	4	0	3	0	3	0	0	0	0	0
		Totals	312	2	310	6	330	22	308	9	2	0	2	0

(a) Sacrificed for broodstock or died during tagging operation and GSI (Genetic Sampling Identification) samples; nine GSI samples were taken on 05 Sep of which two were designated males and seven were designated females

(b) Includes 25 fish tagged in the upper river on 30 August with no sex designation; a designation of 14 males, 10 females, and one jack was attributed to these tag releases 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, 1996.

Date	No effort (NE)	Male No. rcvd (a)	Male No. tag (b)	Male No. TL (c)	Male No. ad (d)	Male No. strays (e)	Female No. rcvd (a)	Female No. tag (b)	Female No. TL (c)	Female No. ad (d)	Female No. strays (e)	Jack No. rcvd (a)	Jack No. tag (b)	Jack No. TL (c)	Jack No. ad (d)	Jack No. strays (e)
Upper river																
03-Sep	NE															
04-Sep		0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
05-Sep	NE															
06-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
07-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
08-Sep	NE															
09-Sep	NE															
10-Sep	NE															
11-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-Sep	NE															
13-Sep	NE															
14-Sep	NE															
15-Sep	NE															
16-Sep		1	0	0	0	0	35	9	0	1	0	1	0	0	0	0
17-Sep	NE															
18-Sep		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19-Sep		9	1	0	2	0	31	8	0	1	0	0	0	0	0	0
20-Sep	NE															
21-Sep	NE															
22-Sep	NE															
23-Sep		4	0	0	1	0	22	3	0	0	0	0	0	0	0	0
24-Sep	NE															
25-Sep		7	0	0	0	0	15	3	0	0	0	1	0	0	0	0
26-Sep	NE															
27-Sep		0	0	0	0	0	2	1	0	0	0	0	0	0	0	0
28-Sep	NE															
29-Sep	NE															
30-Sep	NE															
01-Oct	NE															
02-Oct	NE															
03-Oct	NE															
04-Oct	NE															
		21	1	0	3	0	108	24	0	2	0	2	0	0	0	0

Appendix B. Chinook salmon carcass-recovery data, by date, for the upper and lower Kitsumkalum River, 1996. (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																
03-Sep		0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
04-Sep	NE															
05-Sep	NE															
06-Sep	NE															
07-Sep		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
08-Sep	NE															
09-Sep		6	0	0	0	0	13	1	0	1	0	0	0	0	0	0
10-Sep		2	0	0	0	0	8	0	0	1	0	0	0	0	0	0
11-Sep	NE															
12-Sep	NE															
13-Sep		2	0	0	0	0	15	0	0	0	0	0	0	0	0	0
14-Sep	NE															
15-Sep	NE															
16-Sep		3	0	0	0	0	27	4	0	2	0	0	0	0	0	0
17-Sep		8	1	0	2	0	64	7	0	4	0	0	0	0	0	0
18-Sep		25	3	0	1	2	96	5	0	1	0	0	0	0	0	0
19-Sep	NE															
20-Sep	NE															
21-Sep	NE															
22-Sep	NE															
23-Sep	NE															
24-Sep		21	2	0	0	1	108	6	0	0	0	0	0	0	0	0
25-Sep	NE															
26-Sep		24	1	0	0	1	92	3	0	0	0	0	0	0	0	0
27-Sep	NE															
28-Sep	NE															
29-Sep	NE															
30-Sep	NE															
01-Oct	NE															
02-Oct	NE															
03-Oct	NE															
04-Oct		38	2	0	1	2	61	1	0	0	0	0	0	0	0	0
		129	9	0	4	6	488	27	0	9	0	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 (one in the upper river and 13 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 (presented in Tables 3 and 5) include one additional female (upper river), and three additional males and 10 additional females (lower river)