Enumeration of the 1996 Nicola River Chinook Salmon Escapement

M.K. Farwell, R.E. Bailey, and J.S. Baxter

Fisheries and Oceans Canada
Science Branch, Pacific Region
1278 Dalhousie Drive
Kamloops, British Columbia
V2C 6G3

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ENUMERATION OF THE 1996 NICOLA RIVER CHINOOK SALMON ESCAPEMENT

by

M.K. Farwell[1], R.E. Bailey, and J.S. Baxter

Fisheries and Oceans Canada

Science Branch, Pacific Region

1278 Dalhousie Drive

Kamloops, British Columbia

V2C 6G3

[1]C.17, Cottonwood Site
Rural Route No. 1
Lone Butte, British Columbia
V0K 1X0

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ABSTRACT

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The Nicola River spring-run chinook salmon stock was chosen to compare aerial escapement counting methods currently employed to estimate chinook salmon escapements to many Fraser River tributaries, with mark-recapture type estimates. In 1996, 799 marks were applied and 361 were recovered in a recovery sample of 7,938 chinook. Spatial and temporal biases were detected in both the application or recovery samples; however, the Petersen estimate was deemed acceptable. The escapement estimates, derived by sex, were 7,573 males (lower 95% CI=6,498, upper 95% CI=8,647) and 10,204 females (lower 95% CI=8,740, upper 95% CI=11,669). The adipose fin clipped component of the escapement (357) was the lowest on record as a result of an outbreak of bacterial kidney disease in the hatchery. The total adult escapement estimate of 17,777 fish (lower 95% CI=15,961, upper 95% CI=19,594) was the highest on record. Aerial estimates, based on expanded counts from two flights nearest the peak of spawning were 13,368 and 16,885.

Key Words: Chinook salmon, Nicola River, indicator stock, escapement, mark-recapture, aerial counts.

RÉSUMÉ

Farwell, M.K., R.E. Bailey, and J.S. Baxter. 2000. Enumeration of the 1996 Nicola River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2525: 44 p.

Nous avons choisi le stock de quinnat à remonte printanière de la Nicola pour comparer des méthodes de dénombrement aérien des échappées, couramment employées pour estimer les échappées de quinnat vers de nombreux affluents du Fraser, aux méthodes d'estimation par marquage-recapture. En 1996, 799 marques ont été implantées, et 361 ont été récupérées sur un échantillon de 7 938 quinnats capturés. Nous avons détecté des biais spatiaux et temporels tant dans l'application que dans la récupération des marques; toutefois, l'estimation obtenue par la méthode Petersen a été jugée acceptable. Les estimations de l'échappée, calculées par sexe, étaient de 7 573 mâles (IC inférieur, 95 % = 6 498, IC supérieur, 95 % = 8 647) et 10 204 femelles (IC inférieur, 95 % = 8 740, IC supérieur, 95 % = 11 669). La portion des poissons marqués par ablation de la nageoire adipeuse (357) était la plus basse jamais enregistrée, suite à une épidémie de maladie bactérienne du rein à l'écloserie. L'estimation de l'échappée totale d'adultes, soit 17 777 poissons (IC inférieur, 95 % = 15 961, IC supérieur, 95 % = 19 594) était la plus élevée jamais observée. Les estimations aériennes, fondées sur les dénombrements effectués lors des deux vols les plus rapprochés du pic de fraye, étaient de 13 368 et 16 885.

Mots clés: Saumon quinnat, rivière Nicola, marquage-recapture, stock indicateur, échappée, dénombrements aériens.

INTRODUCTION

Escapements of Fraser River spring- and summer-run chinook salmon (*Oncorhynchus tshawytscha*) populations are estimated annually using aerial and mark-recapture census methods. In many tributary areas, aerial census methods are used because of the ability to fly geographically widespread areas in a relatively short period of time, the difficulty of accessing many of the systems by land, and because the water conditions are appropriate for counting fish from the air. Escapement estimates are typically derived from two or three overflights, with the assumption that at the peak of spawning, and under ideal conditions, surveyors would observe 65% of the total run.

Escapements to other tributary areas have been estimated by the Petersen mark-recapture method. This estimation technique has the advantage of having the capacity to assign confidence limits around the population estimate. In British Columbia, mark-recapture methods have been employed to estimate chinook escapements to the Harrison River from 1984 on (Farwell et al. 1998), and to the Lower Shuswap River in 1984. The Nicola river escapement was first estimated by the mark-recapture method in 1995 (Farwell et al. 1999).

To date, we have little information on the repeatability of aerial counts, the impact of flight timing, and few comparisons against estimates with well defined statistical properties (fences or mark-recapture studies). The 1995 Nicola River comparison indicated that the aerial estimate was 39% below that of the mark-recapture estimate.

The 1996 study of chinook escapement in the Nicola River watershed was designed to allow the comparison of the aerial escapement estimate with the mark-recapture estimate of known precision. The 1996 Nicola River study also provides precise estimates of both the age and sex composition of the spawning population, and of the contribution of hatchery-origin salmon to total spawning escapement.

STUDY AREA

The upper Nicola River originates between the Nicola Plateau and the Douglas Plateau, approximately 70 km east of the community of Merritt. It flows in a northerly direction for 97 km before entering Nicola Lake near the mid-point of the south-eastern shoreline of the lake. The Nicola River drains Nicola Lake at a flow control structure, and flows in a south-westerly direction for 12 km to its confluence with the Coldwater River in Merritt. From this point, the Nicola River flows in a north-north-westerly direction for 20 km until its confluence with Spius Creek. Below its confluence with Spius Creek, the Nicola flows north-westerly for 52 km, entering the Thompson River at Spences Bridge (Fig. 1).

Many other smaller tributaries enter the Nicola River below Nicola Lake. Tributaries that provide spawning habitat for salmon include Clapperton and Guichon creeks. Clapperton Creek flows into the Nicola River approximately 0.5 km below the outlet of Nicola Lake, and Guichon Creek enters the Nicola River about 5 km downstream of the Nicola - Coldwater confluence. Other tributaries flowing into the Nicola below the Spius confluence include Shakan, Skuhun, and Nooaitch creeks.

The Nicola and Coldwater rivers are heavily impacted by agricultural practices. Bank erosion, channel widening and destabilization, and siltation are all common features of the Nicola drainage, associated with the removal of riparian vegetation to increase grazing land. Other associated agricultural impacts include de-watering due to irrigation and nutrient additions from livestock (Millar et al. 1997).

Rood and Hamilton (1995) documented the hydrology of the Nicola basin. They reported mean annual daily flows of 22.7 $m^3 \cdot sec^{-1}$, mean August flows of 15.9 $m^3 \cdot sec^{-1}$. Maximum flows approach 350 $m^3 \cdot sec^{-1}$. Peak flows occur typically during May or June, but also may occur during "rain on snow" events when heavy rain and sudden warming cause rapid snowmelt in late fall or early spring. Minimum flows often occur in late August or early September, or in winter. Water temperatures range from 0°C with ice cover in mid winter to as high as 29°C when extreme heat waves are combined with low flows (Walthers and Nener 1997).

Salmonid fish species other than chinook salmon inhabiting the Nicola River include coho salmon (*O. kisutch*), pink salmon (*O gorbuscha*), steelhead and rainbow trout (*O. mykiss*), and bull trout (*Salvelinus confluentus*). Non-salmonid fish include suckers (*Catastomus columbianus*), sculpins (*Cottus* spp.), and northern pikeminnow (*Ptychocheilus oregonensis*) (Sebastion 1982).

For the purposes of the analyses required for this study, the river and its major tributaries (Coldwater River and Spius Creek) were divided into eight sampling strata as described in Table 1.

Table 1. River segments and associated stratum designations.

River segment	Stratum	Length
Upper Nicola R. (above Nicola Lake)	1	9.5 km
Nicola outlet to Coldwater River confluence	2	24.5 km
Lower 5 km Coldwater River	3	6.0 km
Coldwater River confluence to Gavelin Bridge	4	13.5 km
Gavelin Bridge to Spius Creek confluence	5	8.0 km
Spius Creek below Little Box Canyon	6	6.5 km
Nicola River from Spius Creek confluence to lower Dot trestle	7	18.0 km
Nicola River from lower Dot trestle to "14 Mile Canyon"	8	8.5 km

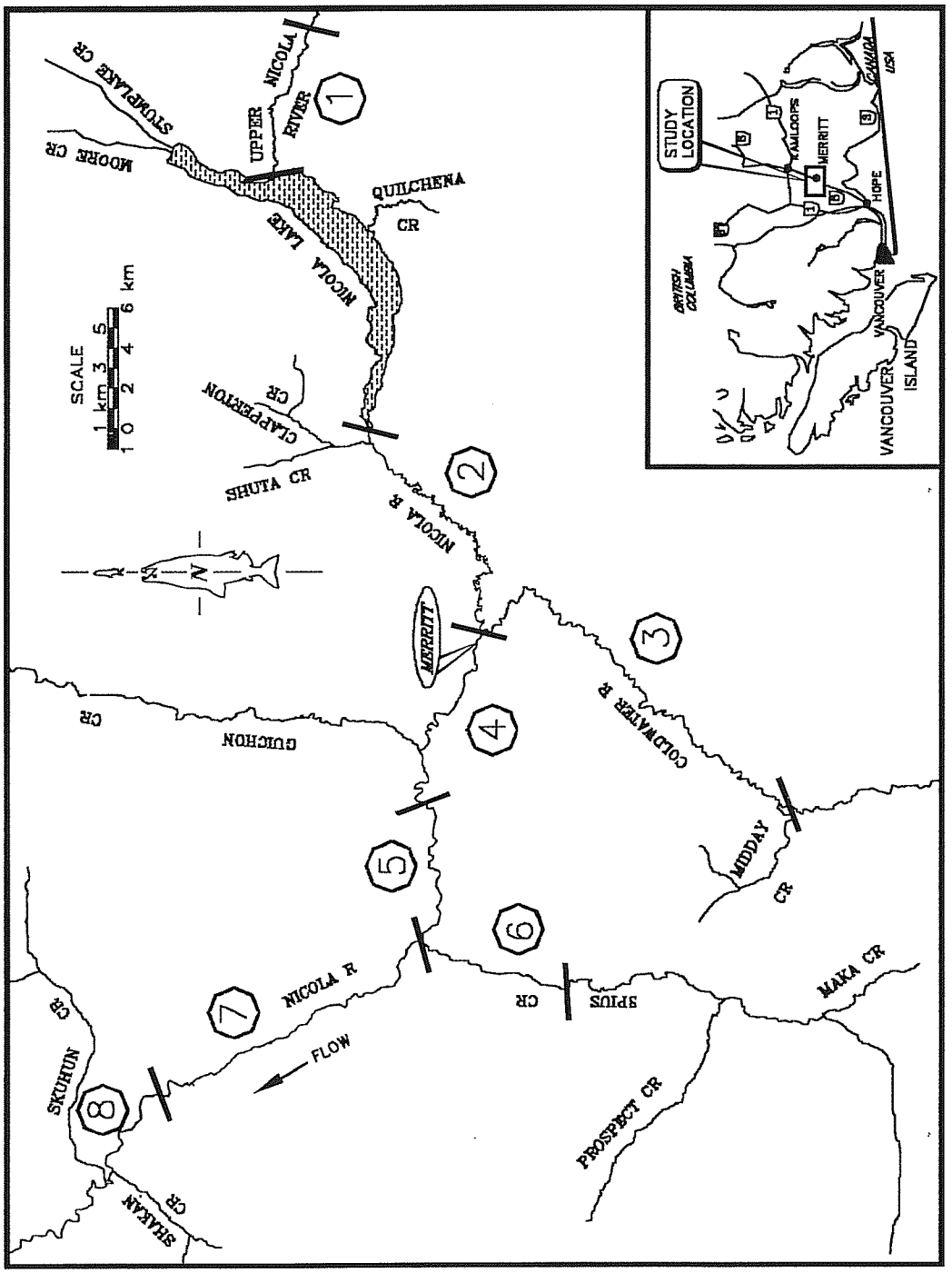

Figure 1. Study area map and stratum locations in the Nicola and Coldwater rivers and Spius Creek.

FIELD METHODS

TAG APPLICATION

Chinook were captured by angling between 10 August and 25 August. Capture and marking was attempted in all river segments except stratum 1, 3, and 6.

Anglers used single barbless hooks (Eagle Claw L183F, size 1) baited with salmon eggs treated with borax. Chinook were landed and either processed immediately, or held individually for up to 15 min. in 1.25 m x 0.3 m diameter vinyl flow-through holding tubes, anchored instream in a manner to achieve suitable water flow prior to processing. Anglers recorded the relative amount of bleeding from the area of the hook as none, slight, moderate or heavy and also noted where the fish was hooked. The hooking location was later categorized as either critical (roof of mouth, gills, tongue, or eye) or non-critical.

For tag application, each fish was placed in a canvas cradle, the fork length measured (+/- 1 cm), and the sex and adipose fin clip (AFC) status recorded. Fish were tagged with Petersen disk tags. Sex specific operculum punches (0.7 cm hole) were applied to the left operculum as a secondary mark prior to release of the fish. The release condition of the fish, categorized as 1 (swam away rapidly), 2 (swam away slowly), or 3 (required ventilation), was also recorded.

Petersen disk tags consisted of two 2.2 cm diameter laminated dark green cellulose acetate disks (one uniquely numbered), and a 0.7 cm diameter transparent plastic buffer disk threaded through centrally punched holes onto a 7.7 cm long nickel pin. The pin was inserted through the musculature and pterygiophore bones approximately 1.5 cm below the insertion of the dorsal fin, with the disks arranged one on each side of the fish, and the buffer disk on the pin head side. Disks were held in place by twisting the pin into a double knot, thereby securing both disks snugly against the fish.

CARCASS RECOVERY

Sampling of chinook carcasses commenced on Sept. 6 and continued until Oct. 10 at which time no further carcasses were found. Strata 2-7 were surveyed in their entirety at least once every five days during the period of the recovery. Stratum 1 (above Nicola Lake) was not surveyed; however, the Upper Nicola Indian Band ran a counting fence in stratum 1, and only counted 16 adult chinook through the fence, none of which were marked. Crews consisted of two to five people, and all surveys were conducted in a downstream direction.

All carcasses were recorded by date, stratum, sex (confirmed by incision), tag type (Petersen disk, operculum tag), adipose fin clip, post-orbital to hypural plate (POH) length (+/- 1 cm), and secondary mark status. Once sampled, all carcasses were cut in two and returned to the river. Heads were collected from every adipose fin clipped chinook for coded wire tag (CWT) recovery and decoding. Scale samples were taken from each secondary marked fish, each fish sampled for CWT recovery, and every tenth unmarked fish not sampled for CWT recovery. Fish were aged according to the Gilbert-Rich coding system. The condition of the adipose fin clip was recorded as either complete (flush with dorsal surface), partial (nub present), or questionable (appeared to be clipped but fungus or decomposition obscured the area).

Spawning success was estimated for all intact female carcasses. Success was categorized as either 0% (pre-spawning mortality), 50% (partially spent), or 99% (virtually no eggs remaining). The condition of the carcass was recorded for all carcasses as either fresh (gills red or mottled), moderately fresh (gills white but flesh still firm), moderately rotten (body intact but soft), and rotten (only skin and bones remaining). The number of eyes remaining in the carcass was also recorded.

AERIAL ENUMERATION

Aerial counts were performed during low level (10-30 m) flights in a Bell 206B helicopter, at speeds between 10 and 40 $km \cdot h^{-1}$, proceeding in a downstream direction. Two observers, seated on the opposite side of the aircraft to the pilot, counted all chinook salmon observed, and recorded them as either live or dead (carcasses) by stratum. Where deceased fish had been cut in two by the carcass recovery crew, only the posterior sections including tails were counted as a carcass.

At the end of each stratum count, the observers recorded their individual tallies, discussed their observations, and determined a "best" estimate for the stratum. Frequently, but not exclusively, the best estimate was the higher number of the two observers' counts.

Five flight dates were scheduled. The flight days were to occur prior to, during, and after the expected peak of spawning activity. On the two flight dates nearest the peak, replicate enumeration flights were undertaken. For replicate flights, the two crews of experienced counters commenced counting at the same time and counted the entire system, however their respective counts began in different strata, typically at least two strata apart.

In 1996, aerial surveys were expanded based on observations gathered during the 1995 study (Farwell et al. 1999). Counts on the Coldwater River (stratum 3) were extended upstream to the confluence of Midday Creek, and counts on the Nicola River were expanded downstream to "14 Mile Canyon" from the lower Dot Trestle, thus creating stratum 8.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

With the exception of tests for sex-related biases and tagging stress (which uses data from female fish alone), all tests for sampling selectivity were performed on samples that were stratified by sex.

Period

Temporal bias was assessed for both the marking and recovery samples. Recovery bias was examined by comparing the mark incidence from each application period in the recovery samples. Marking bias was examined by comparing the mark occurrence in each of the recovery periods. Differences among periods were compared using the G-test (Sokal and Rohlf 1981).

Location

Spatial bias was assessed, using G-tests, in a manner similar to the assessment of temporal bias. Recovery bias was assessed by stratifying the application sample by stratum and comparing the proportions recovered from each stratum. Application bias was assessed by comparing the differences in mark incidence among recovery strata.

Fish Size

Size related bias was assessed using the Kolmogorov-Smirnov two sample test (Sokal and Rohlf 1981). Application bias was assessed by comparing POH length frequency distributions in marked and unmarked fish in the recovery sample. Recovery bias was assessed by comparing fork length frequency distributions in the recovered and not-recovered portions of the tag application sample.

Fish Sex

Sex related bias was assessed using G-tests. Recovery bias was assessed by stratifying the application sample into recovered and non-recovered components and comparing the male and female proportions in each. Application bias was assessed by comparing the sex ratio in the marked and unmarked carcasses in the recovery sample. In addition, sex specific differences in mark recovery and tag loss were assessed.

Tagging Stress

Mark application stress was assessed by comparing the categorical spawn retention data for the marked and unmarked females in the carcass recovery sample using G-tests. Tagging stress was also assessed by comparing the rates of mark-recovery from the three release condition categories. Angling stress was assessed by comparing the recovery rates in fish in the four different bleeding categories and in fish hooked in critical and non-critical areas.

ESTIMATION OF SPAWNER POPULATION

Mark-Recapture Escapement

The adult chinook salmon population within the Nicola River study area was estimated using the Chapman modification of the Petersen estimator (Ricker 1975). In anticipation of significant sex related differences in the data and in order to facilitate comparison with similar studies, the escapement was calculated by sex. The escapement to the river (N_t) was the sum of the male (N_m) and female (N_f) escapements. Male escapement was estimated by:

$$N_m = \frac{(M_m + 1)(n_m + 1)}{(m_m + 1)} - 1$$

where:

M_m = number of males released with primary and secondary marks corrected for sex identification errors;

m_m = number of primary and/or secondary marked male carcasses recovered; and

n_m = number of male carcasses examined for marks.

Standard error (square root of the variance) of the male escapement estimate was calculated as:

$$SE_m = \sqrt{\frac{(N_m^2)(n_m - m_m)}{(n_m + 1)(m_m + 2)}}$$

and the 95% upper and lower confidence limits on the male estimate were calculated as:

$$N_m \pm 1.96\ SE_m$$

The female escapement (N_f) along with its standard error (SE_f) and confidence limits were calculated in an analogous manner. Confidence limits on the total escapement were calculated from the square root of the summed male and female variances.

Sex Identification Correction

Identification errors occurred because sexually dimorphic traits were not fully developed at the time of marking and internal examinations were not possible until the carcass survey. Tag application data were corrected for sex identification error using the method described by Staley (1990).

The corrected number of males released with primary and secondary marks (M_m) was estimated as:

$$M_m = \frac{M_m^* - ((M_t)(m_{m,f}))/m_f}{1 - (m_{m,f}/m_f) - (m_{f,m}/m_m)}$$

where:

M_m^* = number released with primary and secondary marks identified as male at mark application;

M_t = total number released with primary and secondary marks;

m_m = males recovered with primary or secondary marks;

m_f = females recovered with primary or secondary marks;

$m_{m,f}$ = females identified as male at mark application; and

$m_{f,m}$ = males identified as female at mark application.

The corrected number of females (M_f) was calculated by subtraction ($M_t - M_m$).

Adipose Fin Clipped Escapement

The AFC escapement was calculated from the AFC incidence in the carcass recovery sample. This sample was the largest of the two samples and reflected the incidence of AFC fish in the population after removal of hatchery brood stock. The AFC incidence in the recovery sample was tested for statistically significant differences (G-test) related to clip condition. If differences were noted, questionable clips were removed from further analysis. AFC escapement was the product of the sex specific AFC incidence and the sex specific Petersen population estimate. Differences in AFC incidence by sex were also tested for significance.

Escapement by Age Group

Escapement by age group was calculated by applying the age composition in the recovery sample to the Petersen population estimate. As sex specific Petersen estimates were calculated, age data were also stratified by sex. The difference in age composition between the sexes was assessed by the G-test. In addition, the age composition in carcasses with and without AFCs was compared and if a significant difference was noted the escapement at age was also stratified by AFC status.

Coded Wire Tagged Escapement

Escapement by CWT code group was calculated by applying the sex specific CWT code composition in the carcass recovery sample to the age and sex stratified AFC escapement estimate. Age and sex grouped CWT codes were apportioned by code within the appropriate age and sex specific AFC escapement estimate. Confidence intervals on the CWT escapements were not calculated. Long-term CWT loss was calculated from the proportion of AFC carcasses recovered without a CWT in the total AFC carcass sample. Apparent CWT loss resulting from carcass decomposition or predator activity was assessed (G-test). If significant differences were noted, the atypical category within the sample was deleted from the analysis of tag loss.

Aerial Escapement

When counting conditions were optimal, estimates of escapement were derived by summing stratum counts of total fish observed to obtain a total daily count, then dividing the total daily count by 0.65 to yield an estimate of escapement.

RESULTS

FISH CAPTURE AND MARK APPLICATION

Eight hundred and forty-one individual chinook salmon were captured by angling between August 10 and August 25. Of those, 23 were radio tagged and released and nine died during the capture and handling process or within one hour after mark application. All of the immediate mortalities were hooked in the gill arch or tongue area and bleeding heavily. Two marked chinook were removed from the system and used for hatchery brood purposes, and one escaped during handling leaving 806 for inclusion in mark-recapture analyses. At marking, 329 chinook were judged to be male and 477 were identified as female (Table 2). Twenty-six identification errors were noted, the predominant error being characterizing a fish as female when it was a male. Following correction for sex identification errors, we estimate that a total of 390 males and 416 females were tagged and released. Within that release there were 26 bearing an AFC.

Table 2. Marks applied, by sex and adipose fin status, and sex identity errors in Nicola River chinook salmon, 1996.

	At mark application			Corrected for identity error	
Sex	Total	Adipose fin absent [a]	Error rate	Total	Adipose fin absent [a]
Male	329	8	5%	390	9
Female	477	18	21%	416	17
Total	806	26		806	26

a. Included in total.

Tag application was attempted in five of the eight river segments (Appendix 1). No fish capture was attempted in stratum 1 as it was a headwater area, nor in strata 3 and 6 as they were tributary areas. Within the remaining 5 strata, most (60%) tags were applied in the furthest downstream strata (strata 7 and 8).

Capture and Release Conditions

Of the 806 fish with primary and secondary marks, the majority (89.7%) swam away rapidly at the time of release (Table 3). Only 1.2% required gill ventilation or swimming assistance after mark application. There was no significant difference in either sex in percentage recovery among the three release condition categories ($p>0.05$; G-test).

Table 3. Marks applied and recovered, by release condition after tag application, by sex, of Nicola River chinook salmon, 1996.

	Applied [a]		Recovered		Percent recovered	
Release condition	Male	Female	Male	Female	Male	Female
Swam rapidly	354	369	139	143	39.3%	38.8%
Swam sluggishly	33	40	17	15	51.6%	37.4%
Required assistance	3	7	1	3	29.6%	45.3%
Total	390	416	157	161	40.2%	38.7%

a. Corrected for sex identification errors; rounding errors may be present.

Of the 806 fish with primary and secondary marks, the majority (82.6%) were not bleeding from the angling hook location (Table 4). A slight or moderate amount of bleeding was observed in 16.5% of the angled fish, while 0.9% exhibited heavy bleeding. There were lower mark-recovery rates in fish which bled; however, the differences were not statistically significant ($p>0.05$; G-test). In view of the low recovery rate in the heavy bleeders and the observation that all of the immediate

mortalities were bleeding heavily, we decided to remove the 7 fish which exhibited heavy bleeding from the mark-recapture analyses.

Table 4. Marks applied and recovered, by relative amount of bleeding after being angled, by sex, of Nicola River chinook salmon, 1996.

	Applied [a]		Recovered		Percent recovered	
Bleeding condition	Male	Female	Male	Female	Male	Female
Heavy	1	6	0	1	0.0%	16.3%
Moderate	9	5	1	1	11.7%	18.2%
Slight	58	61	23	22	39.5%	36.2%
None	323	343	133	137	41.2%	39.9%
Total	390	416	157	161	40.2%	38.7%

a. Corrected for sex identification errors; rounding errors may be present.

Of the 799 chinook with primary and secondary marks that were not bleeding heavily, a small portion (9.6%) were hooked in a location which could result in a potentially critical injury (gills, tongue, roof of mouth, and eye) (Table 5). The mark recovery rate in fish which were hooked in critical areas was not significantly different ($p>0.05$; G-test) from that in fish hooked in non-critical areas.

Table 5. Marks applied and recovered, by location of hook after being angled, by sex, of Nicola River chinook salmon, 1996.

	Applied [a]		Recovered		Percent recovered	
Location of Hook [b]	Male	Female	Male	Female	Male	Female
Critical area	46	31	18	11	39.0%	35.7%
Non-critical area	343	379	139	149	40.5%	39.3%
Total	389	410	157	160	40.3%	39.1%

a. Corrected for sex identification errors; rounding errors may be present.
b. Critical areas are roof of mouth, gills, tongue, and eye; all other areas are non-critical.

Size and Age at Release

Within the mark application sample, males averaged 762 mm fork length (median 763 mm, range 520 to 990 mm) while females averaged 711 mm (median 710 mm, range 500 to 880 mm). Length-frequency distributions by sex were significantly different ($p<0.05$; Kolmogorov-Smirnov test). Ageing structures were not removed at the time of mark application; however, scales from recovered marked fish indicated that 0.3% were age 3, 95.1% were age 4, and 4.6% were age 5. Yearling freshwater age (sub2) fish were dominant at 98.3%, with the remainder (1.7%) showing an under-yearling (sub1) freshwater age.

Recaptures

Following release, 32 marked fish were recaptured during subsequent mark application periods (Appendix 2). Two of those fish were taken for hatchery use and removed from the mark-recapture data analyses. Of the remaining 30, eleven (36.7%) were recovered in the carcass sample. This recovery rate was not significantly different than that observed in fish which had not been recaptured (45.5%) ($p>0.05$; chi-square test). Elapsed time between mark application and subsequent recapture averaged 2 days (mode 2 days, range 0 to 10 days).

CARCASS RECOVERY

Three crews carried out carcass recovery daily from Sept. 6 to Oct. 10. A total of 7,945 carcasses were examined during the recovery period of which 7,938 were suitable for inclusion in the mark-recapture study. The excluded fish were comprised of 6 which bore radio tags, and 1 which was bleeding heavily at mark application. Of the 7,938 carcasses, there were 361 chinook that were either primary or secondary marked, and 7,577 unmarked fish (Table 6) (Appendices 4 and 5). Of the carcasses that could be assigned to sex, there were 179 and 177 marked males and females, and 3,313 and 4,245 unmarked males and females, respectively. Five marked and 19 unmarked carcasses could not be sexed due to their condition at recovery. A total of 176 carcasses bore an AFC.

Table 6. Carcass recovery and marked carcasses by sex and adipose fin status in the Nicola River, 1996.

		Primary mark			Adipose fin		
Sex	Total carcasses	Petersen disc	Secondary mark only	Total	Absent	Present	Unknown
Male	3,492	157	22	179	61	3,429	2
Female	4,422	160	17	177	115	4,306	1
Unknown	24	5	0	5	0	24	0
Total	7,938	322	39	361	176	7,759	3

Recovery efforts were concentrated in strata 2 through 7 (Appendix 5). Stratum 1 was not surveyed while other strata were surveyed 5 to 18 days each. Stratum 8 data were included with that of stratum 7. The greatest number of carcass recoveries were from strata 4 (50.0%) and 5 (20.5%) while the lowest were from strata 6 (1.0%) and 7 (4.6%). AFC carcass distribution was significantly different from that observed in the non-AFC carcasses ($p<0.05$, chi-square test). AFC carcasses were mainly recovered in strata 2 (33.3%) and 4 (23.0%).

Hatchery and Miscellaneous Recoveries

Between Aug. 13 and 23, the Spius Creek Hatchery removed 198 chinook from the watershed (Appendix 3). Two primary marked chinook were removed from the study area during the mark application period and used for hatchery brood stock. These fish were excluded from the mark-recapture data analyses. No other miscellaneous recoveries were recorded.

Sex, Size, and Age

Of the carcasses which could have their sex confirmed, 44.1% (3,492) were male and 55.9% (4,422) were female. Average POH lengths derived from 3,447 of the male and 4,289 of the female carcasses were 585 mm and 562 mm, respectively. In all age classes, males were larger than females (Appendix 6).

The age composition of AFC carcasses was significantly different from that in carcasses which bore an adipose fin ($p<0.05$; G-test). In aged AFC carcasses, 32.6% had an under-yearling freshwater growth period (sub1) while only 1.6% of the carcasses with the adipose fin present showed a sub1 growth pattern (Appendix 6). There was no significant difference between the age compositions of male and female carcasses in either AFC or non-AFC samples ($p>0.05$; G-test). Age composition of

AFC carcasses was 2.3% age 3, 88.6% age 4, and 9.1% age 5 while that in carcasses with the adipose fin present was 0.4% age 3, 92.3% age 4, and 7.3% age 5.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in eleven recovery periods, each of 2 to 5 days duration (Table 7). Pooling of days was done to decrease statistical bias resulting from small sample sizes. The greatest amount of pooling (5 days) was done in the early and late periods when sample sizes were smallest. Mark incidence in males averaged 5.1% (range 1.8 to 7.3%) while female mark incidence averaged 4.0% (range 2.5 to 10.3%). A higher mark incidence was noted in the earlier periods in both sexes; however, a significant difference was only detected in females ($p<0.05$; G-test).

Table 7. Incidence of primary or secondary marks in Nicola River chinook salmon, by recovery period and sex, 1996.

	Marked			Total			Mark incidence		
Recovery period	Male	Female	Unknown	Male	Female	Unknown	Male	Female	Unknown
06-10 Sep	1	3	1	21	29	1	4.8%	10.3%	100.0%
11-15 Sep	4	2	0	55	66	0	7.3%	3.0%	-
16-17 Sep	25	10	0	378	271	1	6.6%	3.7%	0.0%
18-19 Sep	40	30	0	562	503	1	7.1%	6.0%	0.0%
20-21 Sep	22	29	0	474	549	0	4.6%	5.3%	-
22-23 Sep	16	16	0	339	428	16	4.7%	3.7%	0.0%
24-25 Sep	32	27	1	678	1,035	1	4.7%	2.6%	100.0%
26-27 Sep	23	37	0	509	789	1	4.5%	4.7%	0.0%
28-30 Sep	9	10	0	215	349	0	4.2%	2.9%	-
01-05 Oct	3	7	2	165	275	2	1.8%	2.5%	100.0%
06-10 Oct	4	6	1	96	128	4	4.2%	4.7%	100.0%
Total	179	177	5	3,492	4,422	24	5.1%	4.0%	20.8%

Recovery bias was examined by comparing the proportions recovered from each two day period of mark application (Table 8). Data were pooled into 2 day periods to increase sample size. In males the average percentage recovered was 40.3% (range 24.2 to 85.3%) while in females the average was 39.1% (range 22.8 to 62.1%). Both males and females showed significant differences ($p>0.05$; G-test).

Table 8. Primary marks applied and recovered in the Nicola River, by application date and sex, 1996.

	Applied a		Recovered		Percent recovered	
Application date	Male	Female	Male	Female	Male	Female
10-11 Aug	20	45	17	12	85.3%	26.6%
12-13 Aug	46	92	18	21	39.1%	22.8%
14-15 Aug	39	49	12	19	31.0%	38.5%
16-17 Aug	33	38	8	14	24.2%	36.9%
18-19 Aug	104	59	41	32	39.5%	54.1%
20-21 Aug	86	86	35	38	40.8%	44.0%
22-23 Aug	45	26	17	16	37.6%	62.1%
24-25 Aug	17	14	9	8	53.5%	56.5%
Total	389	410	157	160	40.3%	39.1%

a. Corrected for sex identification errors; rounding error may be present.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in the six river segments in which there were recovery efforts. In males, mark incidence ranged from 2.9% to 8.8% with the highest mark incidence in stratum 6 while in females the incidence of marks ranged from 2.7% to 8.3% with the highest incidence in stratum 7 (Table 9). In both sexes, the observed distribution of marks was significantly different from that expected ($p<0.05$; G-test).

Table 9. Incidence of primary or secondary marks in Nicola River chinook salmon, by recovery section and sex, 1996.

	Marked			Total			Mark incidence		
Stratum	Male	Female	Unknown	Male	Female	Unknown	Male	Female	Unknown
2	13	24	1	369	683	16	3.5%	3.5%	6.3%
3	10	13	0	347	486	1	2.9%	2.7%	0.0%
4	96	64	2	1,940	2,026	4	4.9%	3.2%	50.0%
5	50	57	2	655	968	3	7.6%	5.9%	66.7%
6	3	1	0	34	43	0	8.8%	2.3%	-
7	7	18	0	147	216	0	4.8%	8.3%	-
Total	179	177	5	3,492	4,422	24	5.1%	4.0%	20.8%

Spatial recovery bias was assessed by examining the percentage recovery from each of the 5 mark application strata (Table 10). There were no marks applied in strata 1, 3, and 6. In males, the percentage recovered ranged from 37.0% from marks applied in stratum 4 to 60.4% for stratum 2 while in females the range was 29.4% from marks applied in stratum 7 to 78.0% for stratum 2. The difference observed in males was not significant; however, females showed a significant difference ($p<0.05$; G-test).

Table 10. Primary marks applied and recovered in the Nicola River, by application stratum and sex, 1996.

	Applied a		Recovered		Percentage recovered	
Stratum	Male	Female	Male	Female	Male	Female
2	3	8	2	6	60.4%	78.0%
4	98	59	37	38	37.9%	63.9%
5	67	79	35	36	52.1%	45.7%
7	178	242	66	71	37.0%	29.4%
8	43	22	17	9	39.6%	40.8%
Total	389	410	157	160	40.3%	39.1%

a. Corrected for sex identification errors; rounding error may be present.

Fish Size

Size related bias in the application sample was examined by comparing the POH length frequency distributions of marked and unmarked carcasses. No significant differences ($p>0.05$; Kolmogorov-Smirnov two sample test) were detected in males or females (Table 11).

Table 11. Percent marked and frequency distribution of marked and unmarked chinook in the recovery sample, by sex and 100 mm increments in POH length, in the Nicola River, 1996.

POH length	Marked		Unmarked		Percent marked	
interval (mm)	Male	Female	Male	Female	Male	Female
201-300	0	0	0	0	-	-
301-400	0	0	14	8	0.0%	0.0%
401-500	4	7	81	155	4.7%	4.3%
501-600	105	139	1,898	3,275	5.2%	4.1%
601-700	66	25	1,212	667	5.2%	3.6%
701-800	4	0	64	6	1.5%	0.0%
Total	176	171	3,269	4,111	5.1%	4.0%

Recovery sample bias was examined by partitioning the application sample into recovered and non-recovered components and comparing NF length frequency distributions. There was no significant difference ($p>0.05$; Kolmogorov-Smirnov test) in either of the sex groups (Table 12).

Table 12. Percent recovered and frequency distribution of primary marked chinook in the application and recovery samples, by sex and 100 mm increments in fork length, in the Nicola River, 1996.

Fork length	Application sample [a]		Recovery sample		Percent recovered	
interval (mm)	Male	Female	Male	Female	Male	Female
401-500	0	0	0	0	-	-
501-600	3	8	2	2	69.5%	24.6%
601-700	29	153	17	44	58.4%	28.8%
701-800	229	277	107	109	46.7%	39.4%
801-900	96	6	30	5	32.2%	87.1%
901-1000	4	0	1	0	28.0%	0.0%
Total	358	443	157	160	43.8%	36.1%

a. Uncorrected for sex identification error due to lack of sufficient length stratified sex error data.

Fish Sex

Application bias was assessed by comparing the sex ratio in the marked and unmarked spawning ground recoveries (Table 13). There was a significant difference ($p<0.05$; G-test). Recovery bias, assessed by comparing the sex ratio of the recovered and non-recovered components of the application sample, was not detected ($p>0.05$; G-test). In addition, there was no significant difference between the recovery rates of males (46.0%) and females (43.2%) ($p>0.05$; chi-square test) (Table 15).

Table 13. Sex composition of Nicola River chinook salmon in mark application and carcass recovery samples, 1996.

	Application sample [a]			Recovery sample		
Sex	Total	Recovered	Not recovered	Sample size	Marked	Unmarked
Male	389	50.3%	47.5%	3,492	50.3%	43.8%
Female	410	49.7%	52.5%	4,422	49.7%	56.2%
Total	799	100.0%	100.0%	7,914	100.0%	100.0%

a. Corrected for sex identification errors; rounding errors may be present.

Spawning Success

Apparent spawning success, derived from the internal examination of female spawning ground recoveries, was estimated at 97.4% (Appendix 7). The spawning success of marked females (94.4%) was significantly lower than that in unmarked females (97.5%) ($p<0.05$; G-test).

AERIAL ENUMERATION

Seven aerial enumeration flights, each with two observers, were undertaken in 1996 (Appendix 8). Single daily flights took place on September 5, 9, and 23 while on September 12 and 18 two consecutive flights with different crews were done. The best count from the second flight on September 12 was 20.8% (2,286 fish) lower than the best estimate from the first flight. On September 18, the second flight's best count was 8.2% (611 fish) lower than the best estimate from the first flight.

The peak abundance occurred during the September 12 flight with a count of 10,975 chinook (93.8% actively spawning, 5.3% holding and 0.9% dead). Four days earlier (September 9) 29.2% of the chinook were holding while 6 days later (September 18) 49.2% of the chinook observed were dead.

ESTIMATION OF SPAWNER POPULATION

Mark-Recapture Escapement

The mark-recovery data used to calculate spawning population size was comprised of the number of marks released and available for recovery (corrected for sex identification errors), the number of carcasses examined within the study area, and the number of marks recovered within the study. A significant bias to females was identified in the application sample (Table 14); therefore, the data were stratified by sex. Other biases were observed in one or both of the sexes.

Table 14. Results of statistical tests for bias in the 1996 Nicola River chinook salmon escapement estimation study. [a]

Bias type	Application sample	Recovery sample
Statistical [b]	n/a	No bias
Period	Bias to early period in females	Bias to late periods in both sexes
Location	Bias to lower strata in both sexes	Bias to upper strata in both sexes
Fish size	No bias	No bias
Fish sex	Bias to females	No bias

a. No bias indicates that bias was not detected; undetected bias may be present.

b. Bias present when recoveries total 4 or less.

The 1996 escapement of 17,777 Nicola River chinook salmon was calculated by summing the sex specific Petersen population estimates. Lower and upper 95% confidence limits on this estimate were 15,961 and 19,594, respectively (Table 15). The male escapement was estimated to be 7,573 while the female estimate was 10,204. To assist in determining the potential magnitude and direction of the observed biases, other estimates were derived from the SPAS program (Arnason et al. 1996). The temporal Schaefer estimate was 17,777 while the least squares estimate was 18,037. The spatial Schaefer estimate was 17,528 and the least squares estimate was 18,651. Within the least squares estimates, the Darroch method only produced one estimate, that for temporally stratified females (Table 15). The female data did not pass the pooling tests suggesting that the Petersen estimate may be biased. The male data passed the pooling tests indicating that the Petersen estimate was probably acceptable.

The AFC fish in the recovery sample did not show any significant differences in CWT absence by carcass condition category or loss of eyes to predators but did show a significant difference in carcasses with partial or questionable clips (Appendix 9). Therefore only those carcasses with complete AFCs were used to assess AFC incidence and CWT loss. AFC incidence and CWT loss in males (1.5% and 2.3%, respectively) was significantly lower than that observed in female carcasses (2.4% and 20.4%) ($p < 0.05$, G-test) (Appendix 10). Application of sex specific AFC data to the male and female escapements apportioned the total escapement into 357 AFC chinook and 17,420 chinook bearing adipose fins. There were significant differences in the spatial and temporal distribution of AFC chinook (Appendix 10). There was a significantly high proportion of AFC chinook observed in Spius Creek (stratum 6), the site of the chinook enhancement facility that releases the AFC juveniles. In the first week of recovery there was a significantly high proportion of AFC chinook observed.

Table 15. Escapement estimates derived from mark-recovery data for Nicola River chinook salmon, by sex, 1996.

	Sex			
	Male	Female	Unknown	Total
Carcasses sampled	3,492	4,422	24	7,938
Marks applied [a]	389	410	0	799
Marks recovered	179	177	5	361
Percentage recovered	46.0%	43.2%		45.2%
Population size	7,573	10,204	-	17,777
Lower 95% Confidence Limit	6,498	8,740	-	15,961
Upper 95% Confidence Limit	8,647	11,669	-	19,594
Temporally Stratified Estimates [b]				
Least Square [c]	7,979	10,058	-	18,037
Schaefer	7,610	10,167	-	17,777
Pooling Tests	Pass	Fail	-	-
Spatially Stratified Estimates [b]				
Least Square	9,937	8,714	-	18,651
Schaefer	7,570	9,958	-	17,528
Pooling Tests	Pass	Fail	-	-
AFC Incidence	1.5%	2.4%	-	2.0%
AFC Population size	115	242	-	357

a. Corrected for sex identification errors.
b. Derived from SPAS (Arnason et al. 1996).
c. Darroch method produced temporal female estimate but failed to produce other estimates.

Age composition of the AFC and adipose fin present carcasses was significantly different (Appendix 6); therefore, the calculations of escapement by age group were stratified by sex and AFC status (Table 16). Based on the age composition of the aged portion of the recovery sample, the escapement was comprised of 0.4% age 3, 92.3% age 4, and 7.3% age 5 chinook. The escapement of AFC fish with a CWT present totaled 282 chinook. Escapement by CWT code is presented in Table 16.

Table 16. Estimated escapement by age and CWT group of Nicola River chinook salmon, 1996.

Adipose status		Group	Male	Female	Total
Present	Age	3	63	0	63
		4	6,804	9,284	16,088
		5	590	679	1269
Absent	Age	3	2	6	8
		4	97	221	318
		5	14	17	31
	CWT	180850	0	3	3
		180851	11	20	31
		180852	46	79	125
		180853	23	62	85
		181226	7	7	14
		181227	9	8	17
		181754	2	0	2
		181642	0	5	5
		lost	16	59	75

Aerial Escapement

Expanded aerial estimates of escapement were 16,885 and 13,368 fish for the two flights that took place September 12. Based on the observed abundance of fish that were holding (<6%) and the portion of the total count that were dead (<1%) the September 12 flights appear to have occurred near the peak of spawning. During the September 9 flight 29% of the fish appeared to be holding (categorized as those residing in deeper pools, and not actively spawning or in the vicinity of spawning gravels) while during the two flights on September 18 an average of 44% of the fish were dead.

The observers indicated that the relatively clear water and normal flow conditions assisted their observation accuracy during the flights that occurred near the peak of spawning. The two best estimates from the duplicate flights on September 12 were significantly different as were the two estimates from the two flights on September 18 ($p<0.05$; chi-square).

DISCUSSION

The estimation of population size for spring and summer run chinook salmon present in the tributaries to the Fraser and Thompson rivers has traditionally been done using visual counts from helicopter overflights. Initially, only one flight per year was undertaken on each tributary; however, the current program attempts to count escapement on two or three separate days near the peak of spawning for each system. The overflight program was initiated in the early 1970's and expanded to provide two or three flights per system in 1989 and 1990.

Visual estimates tend to be inaccurate, and have been reported to frequently underestimate population size (Tschaplinski and Hyatt 1991). The accuracy of aerial estimates, and other visual methods in general, are influenced by the physical conditions at the time of counting. Light penetration, turbidity, fish behaviour and weather all influence fish visibility (Bevan 1961). Reflection of the sun also has a marked effect on the ability of observers to count fish at certain times. Other factors influencing aerial estimates include the experience of the pilot and observers, flight scheduling, and frequency of counts (Bevan 1961; Neilson and Geen 1981).

For this study, flights were scheduled to occur between 1000h and 1400h. This ensured that the sun was at its highest point in the sky, thus minimizing glare and maximizing light penetration. While all observers wore polarized glasses, glare was still a factor at certain locations, and counting was difficult when flying from brightly illuminated areas into shade. Water turbidity was a minor factor influencing counts in 1996; however, wind riffling was not thought to be significant.

Salmon are counted most easily when dispersed into shallow spawning grounds at the peak of spawning (Cousens et al. 1982). Therefore, it is important to schedule flights to coincide with the peak of spawning. In 1996, observers on the first two flights noted significant numbers of fish holding in pools while on the last two flights there were significant numbers of carcasses and vacated redds; an indication that the peak of spawning had occurred between these two time periods. Spawning likely peaked on or about the date of the September 12 flight.

The 1995 Nicola River project determined a significant negative bias (39%) in the visual estimation of that spring and summer run chinook salmon escapement (Farwell et al. 1999). In 1996, the higher of the two best estimates derived nearest the peak of spawning was 5% lower than the Petersen estimate while the lower best estimate was 25% less than the Petersen estimate.

The mark-recapture method requires that the capture and tagging process does not significantly influence subsequent fish behaviour (Ricker 1975). We assessed this possible source of bias by comparing the recovery rates from fish that were categorized by apparently different amounts of stress at the time of release back into the population. We assumed that these categories were indicative of differing amounts of stress. The recovery rates did not differ significantly whether the fish swam away rapidly, was sluggish, or required ventilation or swimming assistance. Further, the

recovery rate of fish that were recaptured and released during subsequent mark application periods was not significantly different from that of fish that were only subjected to one capture experience. Another method used to assess the influence of marking on subsequent fish behaviour was testing the data on the apparent spawning success in female chinook. These data showed that tagged females had a significantly lower apparent spawning success. This is similar to that observed in 1995 but is in contrast to other studies (Farwell et al. 1998).

A second important aspect to the mark-recapture method is that the mark application and carcass recovery samples should be representative of the population (Ricker 1975). It is preferable for both samples to be taken in a random manner; however, if only one of the samples is random, the results are not seriously biased (Robson 1969). In the present study we assessed the representativeness of the sampling process by looking for bias in the temporal and spatial patterns of the two samples. We observed significant biases; however, the biases were in opposite directions. Fish size distributions and sex compositions in the two samples were tested for significant differences, and a bias toward females was detected in the application sample. In order to indicate if the magnitude of the biases was significant we utilized the SPAS program. This program concluded that there was some indication that the Chapman modified Petersen population estimate for females derived from the pooled data may have been significantly biased. As the stratified estimates fell within the 95% confidence limits of the Petersen method we deemed the Petersen estimate to have sufficient accuracy and precision for the purposes of this study.

POPULATION SIZE

The population size estimated by the mark-recovery data was 17,777 chinook, while the estimates derived from the aerial enumeration data nearest the peak were 16,885 and 13,368.

Within the population there were few adipose fin clipped, hatchery origin, chinook. This was in contrast to the high incidence observed in 1995. This change in hatchery contribution is a result of significant mortalities from an outbreak of bacterial kidney disease in pre-smolt juvenile chinook of the 1992 brood-year at Spius Creek Hatchery in early 1994.

Similar to the observations in 1995, the distribution of the hatchery chinook was nonrandom. There was a concentration of clipped chinook in Spius Creek (stratum 6), the site of the hatchery and the highest percentage of clipped carcasses were observed in the first week of carcass recovery. The spatial pattern follows logically from the fact that the juveniles were reared in the Spius Creek hatchery. The nonrandom distribution over the recovery period may be the result of the pattern of removal of clipped fish during the hatchery brood collection or it may be related to a significantly different

temporal migration pattern of hatchery fish. Another influence may be the different freshwater age pattern exhibited in hatchery fish. These patterns should be monitored in future studies.

SUMMARY

In an attempt to improve upon the available information, the population of Nicola River chinook salmon was assessed by a mark-recovery program. The results of this assessment were compared with the results of the traditional aerial escapement enumeration program.

Primary and secondary marks were applied to chinook salmon following their capture by angling. During the period 10 to 25 August, 841 individual chinook were captured and 799 were marked, released, and remained available for inclusion in the study.

After correction for sex identification errors the application sample was comprised of 389 males and 410 females. The males averaged 762 mm fork length while females averaged 711 mm. Age composition of marked fish in the recovery sample was 0.3% age 3, 95.1% age 4, and 4.6% age 5. Yearling freshwater growth pattern (sub2) was dominant (98.3%).

Carcass recovery occurred during 6 September to 10 October. The recovery sample was comprised of 7,938 chinook, of which 361 bore primary or secondary marks.

The recovery sample was comprised of 3,492 males, 4,422 females and 24 fish that could not be sexed. Average size of the males was 585 mm POH length while females averaged 562 mm. Age composition of chinook with the adipose fin present was 0.4% age 3, 92.3% age 4, and 7.3% age 5. AFC chinook were 2.3% age 3, 88.6% age 4, and 9.1% age 5. Under-yearling (sub1) freshwater age was more common in AFC chinook (32.6%) than in those with the adipose fin present (1.6%).

Sampling selectivity related to temporal and spatial patterns, fish size and sex was assessed in both mark and recovery samples. Spatial and temporal biases were detected but the magnitude of the biases was not deemed to be significant. To facilitate comparison with other reports, the data were stratified by sex.

Enumeration flights were undertaken on 5, 9, 12, 18, and 23 September. Duplicate flights were done on 12 and 18 September. The counts on the two flights nearest the peak (12 September) were 10,975 (99% live) and 8,689 (99% live), respectively.

Spawning population size estimated from the mark-recovery data was 17,777 chinook (7,573 male and 10,204 female chinook). Within that population there were 357 AFC fish. Peak population size estimates from the September 12 aerial enumeration flight data were 16,885 and 13,368 chinook.

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Appendix 1. Daily mark application, by sex, reach, and adipose fin status, to Nicola River chinook, 1996.

		Total Marks Applied [a]			AFC Chinook [b]		
Date	Reach	Male	Female	Total	Male	Female	Total
10-Aug	4	3	11	14	0	0	0
10-Aug	5	1	4	5	0	0	0
11-Aug	5	14	32	46	0	0	0
12-Aug	7	17	57	74	1	2	3
13-Aug	7	24	45 [e]	69	1	1	2
14-Aug	5	8	16	24	0	1	1
14-Aug	7	9	18	27	2	4	6
15-Aug	4	8	8	16	0	0	0
15-Aug	7	8	12	20	0	0	0
15-Aug	8	0	1	1	0	1	1
16-Aug	7	12	27	39	0	1	1
16-Aug	8	1	1	2	0	0	0
17-Aug	5	4 [f]	5	9	0	0	0
17-Aug	7	4	7	11	0	0	0
17-Aug	8	8	3	12 [c]	0	0	0
18-Aug	4	27	20	47	0	0	0
18-Aug	7	13	11	24	0	0	0
18-Aug	8	0	2	2	0	0	0
19-Aug	5	29 [f]	29	58	0	0	0
19-Aug	7	8	4	12	0	0	0
19-Aug	8	9	12	21	0	0	0
20-Aug	2	3	8	11	0	3	3
20-Aug	4	16	13	29	1	0	1
20-Aug	7	30 [d]	37	67	0	1	1
21-Aug	7	17	33	50	2	2	4
21-Aug	8	7	9	16	0	1	1
22-Aug	4	26	25	51	1	1	2
23-Aug	7	1	2	3	0	0	0
23-Aug	8	10	7	17	0	0	0
24-Aug	5	3	4 [d]	7	0	0	0
24-Aug	7	8	9	17	0	0	0
25-Aug	7	3	5	8	0	0	0
Total	2	3	8	11	0	3	3
	4	80	77	157	2	1	3
	5	59	90	149	0	1	1
	7	154	267	421	6	11	17
	8	35	35	71 [c]	0	2	2
	Grand total	331	477	809 [c]	8	18	26

a. Excludes 9 fish which died at mark application and 23 fish released with radiotags.

b. AFC chinook included in total marks applied.

c. Includes one of unknown sex released without a secondary mark and no length recorded.

d. Includes one which exhibited heavy bleeding at capture.

e. Includes 5 which exhibited heavy bleeding at capture.

f. Includes 1 which was subsequently recaptured and used for hatchery purposes (Appendix 2).

Appendix 2. Recaptures of previously marked chinook salmon, by application and recovery dates and locations, and sex, in the Nicola River, 1996.

Application				Primary Tag		Recapture			
Date	Reach	Sex	Adipose fin status	Series	Number	Date	Reach	Result [a]	Days out
11-Aug	5	F	P	-	000023	11-Aug	5	R	0
11-Aug	5	F	P	-	000025 [b]	14-Aug	5	R	3
12-Aug	7	F	P	-	000127	21-Aug	7	R	9
12-Aug	7	F	A	-	000115	12-Aug	7	R	0
12-Aug	7	M	A	-	000103 [b]	12-Aug	7	R	0
12-Aug	7	F	P	-	000090 [b]	13-Aug	7	R	1
13-Aug	7	M	P	-	000213	20-Aug	7	R	7
13-Aug	7	M	P	-	000198	20-Aug	7	R	7
13-Aug	7	M	P	-	000151	13-Aug	7	R	0
13-Aug	7	M	P	-	000159 [b]	15-Aug	7	R	2
14-Aug	7	M	P	-	000223	14-Aug	7	R	0
14-Aug	7	F	P	-	000244 [b]	24-Aug	5	R	10
15-Aug	4	M	P	-	000337 [b]	19-Aug	5	R	4
15-Aug	4	M	P	-	000327	21-Aug	4	R	6
15-Aug	7	M	P	-	000257	15-Aug	7	R	0
15-Aug	7	F	P	-	000262 [b]	15-Aug	7	R	0
17-Aug	5	M	P	-	000426	20-Aug	5	B	3
17-Aug	8	M	P	-	000413	23-Aug	8	R	6
18-Aug	4	M	P	-	000354	18-Aug	4	R	0
18-Aug	4	M	P	-	000387	20-Aug	4	R	2
18-Aug	4	F	P	-	000372	20-Aug	4	R	2
18-Aug	7	M	P	-	000434	19-Aug	7	R	1
19-Aug	5	M	P	-	000535	21-Aug	5	B	2
19-Aug	5	M	P	-	000510 [b]	21-Aug	4	R	2
19-Aug	5	F	P	-	000530	21-Aug	4	R	2
19-Aug	5	M	P	-	000502	19-Aug	5	R	0
20-Aug	4	F	P	-	000587 [b]	22-Aug	4	R	2
20-Aug	7	F	P	-	000624 [b]	20-Aug	7	R	0
21-Aug	7	F	P	-	000675	21-Aug	7	R	0
22-Aug	4	M	P	-	000733	22-Aug	4	R	0
22-Aug	4	F	P	-	000716 [b]	22-Aug	4	R	0
23-Aug	8	F	P	-	000750	23-Aug	8	R	0
									Days out
								Average	2
								Mode	0
								Maximum	10
								Minimum	0

a. Result codes: R - returned to the river; B - taken for hatchery brood stock.

b. Recovered during carcass sampling.

Appendix 3. Chinook salmon removed from the Nicola River for Spius Hatchery brood stock purposes, 1996.

		Total [a]			Adipose Fin Absent		
Date	Reach	Male	Female	Total	Male	Female	Total
13-Aug	4	3	4	7	0	0	0
15-Aug	7	1	3	4	0	0	0
16-Aug	4	19	10	29	1	0	1
16-Aug	7	3	3	6	0	0	0
19-Aug	2	19	13	32	3	1	4
20-Aug	4	12	7	19	1	0	1
20-Aug	5	9 [b]	11	20	1	1	2
20-Aug	7	0	5	5	0	1	1
21-Aug	4	8	2	10	0	0	0
21-Aug	5	15 [b]	18	33	0	0	0
21-Aug	7	2	3	5	1	0	1
22-Aug	7	10	16	26	1	0	1
23-Aug	2	0	2	2	0	0	0
Total	2	19	15	34	3	1	4
	4	42	23	65	2	0	2
	5	24	29	53	1	1	2
	7	16	30	46	2	1	3
	Grand Total	101	97	198	8	3	11

a. Includes AFC chinook

b. Includes one Petersen disc marked chinook.

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
10-Aug	5	800	F	P	0	000003	26-Sep	5L	570	F	-	47
10-Aug	4	840	M	P	0	000007	08-Oct	4L	620	M	42	59
10-Aug	4	750	F	P	0	000008	18-Sep	4U	555	F	42	39
10-Aug	4	750	F a	P	0	000010	19-Sep	4U	550	M	42	40
10-Aug	4	790	F a	P	0	000012	24-Sep	4U	630	M	-	45
10-Aug	4	700	F	P	0	000014	20-Sep	4L	540	F	42	41
10-Aug	4	690	F a	P	0	000016	17-Sep	4U	500	M	42	38
10-Aug	4	710	F a	P	0	000017	17-Sep	4U	560	M	42	38
10-Aug	4	720	M	P	0	000018	19-Sep	4L	570	M	42	40
11-Aug	5	740	F	P	0	000051	19-Sep	4L	590	F	41	39
11-Aug	5	710	M	P	0	000058	17-Sep	4L	535	M	42	37
11-Aug	5	760	F a	P	0	000059	18-Sep	4U	590	M	-	38
11-Aug	5	680	F	P	0	000060	18-Sep	5U	510	F	42	38
11-Aug	5	670	F	P	0	000061	25-Sep	5U	540	F	42	45
11-Aug	5	690	F a	P	0	000062	30-Sep	4L	545	M	42	50
11-Aug	5	780	F	P	0	000047	25-Sep	5L	590	F	42	45
11-Aug	5	720	F	P	0	000065	25-Sep	5U	560	F	42	45
11-Aug	5	860	M	P	0	000045	18-Sep	4U	680	M	-	38
11-Aug	5	680	F	P	0	000064	22-Sep	4L	540	F	42	42
11-Aug	5	730	F	P	0	000025	18-Sep	5U	555	F	42	38
11-Aug	5	670	M	P	0	000049	23-Sep	4U	530	M	42	43
11-Aug	5	710	F	P	0	000022	22-Sep	4U	580	F	42	42
11-Aug	5	780	M	P	0	000027	24-Sep	5L	590	M	42	44
11-Aug	5	720	F a	P	0	000029	09-Oct	5L	-	NK	-	59
11-Aug	5	700	F a	P	0	000032	26-Sep	3L	640	M	-	46
11-Aug	5	780	M	P	0	000035	17-Sep	4L	615	M	42	37
11-Aug	5	810	F a	P	0	000038	18-Sep	4U	610	M	-	38
11-Aug	5	740	F	P	0	000040	25-Sep	5U	-	F	42	45
11-Aug	5	770	M	P	0	000041	23-Sep	4L	565	M	42	43
11-Aug	5	740	M	P	0	000043	18-Sep	4U	560	M	42	38
12-Aug	7	740	M	P	0	000073	18-Sep	4U	580	M	42	37
12-Aug	7	750	F a	P	0	000114	26-Sep	7U	600	M	42	45
12-Aug	7	780	M	P	0	000136	28-Sep	2L	610	M	42	47
12-Aug	7	790	F a	P	0	000134	01-Oct	4U	590	M	-	50
12-Aug	7	780	M	P	0	000130	18-Sep	4U	610	M	42	37
12-Aug	7	770	M	P	0	000128	21-Sep	4L	590	M	42	40
12-Aug	7	810	F a	P	0	000124	25-Sep	5L	610	M	42	44
12-Aug	7	670	F	P	0	000122	18-Sep	5U	510	F	42	37
12-Aug	7	690	F	P	0	000137	27-Sep	CC	560	F	42	46
12-Aug	7	691	F a	P	0	000110	27-Sep	3L	565	M	-	46
12-Aug	7	730	M a	A	0	000103	27-Sep	5L	570	F	41	46
12-Aug	7	750	F	P	0	000093	20-Sep	7L	590	F	42	39
12-Aug	7	760	F	P	0	000090	01-Oct	5L	545	F	-	50
12-Aug	7	740	F	P	0	000088	07-Oct	3L	580	F	42	56
12-Aug	7	750	M	P	0	000086	26-Sep	7U	580	M	42	45
12-Aug	7	740	F	P	0	000076	26-Sep	5L	580	F	-	45
12-Aug	7	670	F	P	0	000113	18-Sep	4U	530	F	42	37
12-Aug	7	720	F	P	0	000082	27-Sep	2U	540	F	42	46
13-Aug	7	760	M	P	0	000217	27-Sep	4L	670	M	42	45
13-Aug	7	730	M	P	0	000189	26-Sep	7U	575	M	-	44
13-Aug	7	800	F a	P	0	000192	20-Sep	7L	580	M	52	38
13-Aug	7	600	F	P	0	000194	20-Sep	4L	485	F	42	38
13-Aug	7	710	F	P	0	000196	20-Sep	4L	570	F	42	38
13-Aug	7	670	F	P	0	000197	30-Sep	5L	540	F	-	48
13-Aug	7	680	F	P	0	000200	25-Sep	5L	540	F	42	43
13-Aug	7	740	M	P	0	000209	28-Sep	2L	550	M	-	46
13-Aug	7	820	M	P	0	000168	19-Sep	5U	670	M	42	37
13-Aug	7	620	M a	P	0	000186	26-Sep	7U	580	F	42	44
13-Aug	7	770	M	P	0	000205	20-Sep	4U	590	M	42	38
13-Aug	7	720	F	P	0	000167	30-Sep	5L	560	F	-	48

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
13-Aug	7	720	F	P	0	000155	19-Sep	5U	580	F	42	37
13-Aug	7	690	F	P	0	000185	19-Sep	4U	570	F	-	37
13-Aug	7	710	F	P	0	000163	30-Sep	5L	550	F	-	48
13-Aug	7	620	F	P	0	000173	28-Sep	2L	470	F	42	46
13-Aug	7	820	F	P	0	000169	17-Sep	4L	665	F	52	35
13-Aug	7	740	M	P	0	000175	08-Oct	4U	560	M	-	56
13-Aug	7	690	F	P	0	000177	08-Oct	4L	540	F	42	56
13-Aug	7	720	F	P	0	000180	20-Sep	4U	570	F	42	38
13-Aug	7	720	F a	P	0	000182	25-Sep	5L	520	M	42	43
13-Aug	7	750	M	P	0	000159	22-Sep	4L	580	M	42	40
14-Aug	5	750	F	P	0	000320	24-Sep	2L	560	F	42	41
14-Aug	5	810	M	P	0	000314	26-Sep	5L	590	M	42	43
14-Aug	5	720	F	P	0	000306	18-Sep	4U	600	F	42	35
14-Aug	5	750	M	P	0	000324	16-Sep	3M	580	M	42	33
14-Aug	5	710	F	P	0	000301	19-Sep	4U	560	F	42	36
14-Aug	5	680	F	P	0	000307	24-Sep	5L	530	F	42	41
14-Aug	5	780	M	P	0	000310	19-Sep	4L	750	M	42	36
14-Aug	5	740	F	P	0	000313	23-Sep	4U	575	F	42	40
14-Aug	5	620	F	P	0	000315	26-Sep	5L	450	F	42	43
14-Aug	5	740	F	P	0	000316	26-Sep	3L	630	F	-	43
14-Aug	5	740	M a	P	0	000312	22-Sep	4L	550	F	-	39
14-Aug	7	770	M	P	0	000243	18-Sep	4U	630	M	42	35
14-Aug	5	790	M	P	0	000322	18-Sep	4U	605	M	42	35
14-Aug	7	650	F	P	0	000218	22-Sep	4L	510	F	-	39
14-Aug	7	750	F	P	0	000219	25-Sep	5L	550	F	-	42
14-Aug	7	785	M	P	0	000224	18-Sep	4U	600	M	42	35
14-Aug	7	690	F	P	0	000230	06-Sep	7U	-	F	42	23
14-Aug	7	750	F a	P	0	000234	20-Sep	4U	600	M	42	37
14-Aug	5	680	F a	P	0	000321	20-Sep	4U	570	M	42	37
14-Aug	7	720	F a	P	0	000244	17-Sep	4L	570	M	42	34
14-Aug	7	660	F	P	0	000233	23-Sep	4U	500	F	42	40
15-Aug	4	810	M	P	0	000330	19-Sep	4U	600	M	42	35
15-Aug	4	680	F a	P	0	000335	24-Sep	5U	560	M	42	40
15-Aug	4	720	F	P	0	000336	21-Sep	4L	570	F	42	37
15-Aug	7	730	F	P	0	000255	27-Sep	7U	600	F	42	43
15-Aug	4	770	M	P	0	000337	14-Sep	3L	615	M	42	30
15-Aug	4	660	F	P	0	000339	19-Sep	5U	530	F	-	35
15-Aug	4	650	F	P	0	000340	21-Sep	4U	520	F	42	37
15-Aug	7	780	F	P	0	000251	27-Sep	2U	630	F	52	43
15-Aug	7	720	F	P	0	000262	23-Sep	4L	560	F	42	39
15-Aug	7	700	F	P	0	000252	26-Sep	7L	550	F	42	42
16-Aug	7	590	F	P	0	000342	27-Sep	5L	450	F	42	42
16-Aug	7	750	F	P	0	000341	20-Sep	4L	595	F	42	35
16-Aug	7	680	M	P	0	000290	30-Sep	5L	520	M	-	45
16-Aug	7	670	F	P	0	000288	26-Sep	5L	-	F	-	41
16-Aug	7	840	F	P	0	000285	16-Sep	3M	665	F	52	31
16-Aug	7	720	F	P	0	000284	25-Sep	5L	580	F	-	40
16-Aug	7	730	F	P	0	000280	20-Sep	7L	590	F	42	35
16-Aug	7	740	F	P	0	000277	18-Sep	4U	575	F	42	33
16-Aug	7	700	F	P	0	000274	21-Sep	4L	570	F	42	36
16-Aug	8	710	F	P	0	000269	27-Sep	3L	585	F	42	42
16-Aug	8	741	M	P	0	000270	25-Sep	5U	605	M	-	40
17-Aug	5	700	F	P	0	000433	24-Sep	2L	585	F	42	38
17-Aug	5	740	F	P	0	000428	18-Sep	4U	600	F	42	32
17-Aug	7	740	F a	P	0	000423	08-Oct	4L	590	M	42	52
17-Aug	7	780	F	P	0	000422	20-Sep	7L	640	F	42	34
17-Aug	7	690	F	P	0	000419	23-Sep	4L	540	F	-	37
17-Aug	8	690	M	P	0	000411	30-Sep	5L	480	M	-	44
17-Aug	5	770	M	P	0	000430	18-Sep	4U	620	M	42	32
17-Aug	7	720	M	P	0	000350	17-Sep	4U	560	M	42	31

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
17-Aug	7	580	F a	P	0	000348	25-Sep	5L	550	M	42	39
17-Aug	8	680	F	P	0	000347	25-Sep	5L	540	F	42	39
17-Aug	8	750	M	P	0	000406	17-Sep	6	570	M	-	31
18-Aug	8	740	F a	P	0	000443	24-Sep	5U	615	M	42	37
18-Aug	7	740	M	P	0	000436	27-Sep	4L	590	M	-	40
18-Aug	7	730	M	P	0	000439	26-Sep	7L	560	M	42	39
18-Aug	7	790	M	P	0	000441	19-Sep	4L	585	M	42	32
18-Aug	4	700	F	P	0	000396	30-Sep	4U	550	F	-	43
18-Aug	8	700	F	P	0	000444	01-Oct	5L	-	F	-	44
18-Aug	7	780	F	P	0	000446	22-Sep	4U	620	F	52	35
18-Aug	7	780	M	P	0	000450	25-Sep	5L	570	M	42	38
18-Aug	7	790	M	P	0	000451	18-Sep	5U	620	M	42	31
18-Aug	7	800	M	P	0	000453	17-Sep	4U	610	M	42	30
18-Aug	7	700	M	P	0	000440	19-Sep	5U	565	M	42	32
18-Aug	4	670	F	P	0	000369	16-Sep	4U	530	F	-	29
18-Aug	4	760	F	P	0	000353	21-Sep	4U	610	F	42	34
18-Aug	4	770	M	P	0	000355	17-Sep	4U	610	M	42	30
18-Aug	4	690	F	P	0	000360	25-Sep	3L	560	F	-	38
18-Aug	4	610	F	P	0	000398	21-Sep	4U	480	F	42	34
18-Aug	4	710	M	P	0	000368	17-Sep	4U	560	M	-	30
18-Aug	4	700	M	P	0	000397	25-Sep	4U	540	M	42	38
18-Aug	4	730	F	P	0	000370	26-Sep	3L	600	F	42	39
18-Aug	4	660	F	P	0	000375	21-Sep	4L	550	F	42	34
18-Aug	4	690	F	P	0	000376	08-Oct	4L	535	F	42	51
18-Aug	4	760	M	P	0	000395	13-Sep	2U	585	M	42	26
18-Aug	4	720	F	P	0	000379	07-Oct	3L	580	F	42	50
18-Aug	4	680	F	P	0	000385	22-Sep	4U	540	F	42	35
18-Aug	4	700	F	P	0	000388	22-Sep	4U	550	F	42	35
18-Aug	4	780	M	P	0	000390	20-Sep	2U	600	M	-	33
18-Aug	4	680	M	P	0	000391	24-Sep	5L	490	M	-	37
18-Aug	4	740	F	P	0	000393	16-Sep	4U	600	F	42	29
18-Aug	4	760	F	P	0	000394	16-Sep	4U	600	F	42	29
18-Aug	4	700	F	P	0	000378	28-Sep	2L	560	F	-	41
18-Aug	4	770	M	P	0	000367	21-Sep	4L	610	M	-	34
19-Aug	7	730	M	P	0	000483	16-Sep	4U	580	M	42	28
19-Aug	8	690	F a	P	0	000473	25-Sep	4U	550	M	-	37
19-Aug	8	710	F	P	0	000471	25-Sep	5U	590	F	42	37
19-Aug	8	740	M	P	0	000468	25-Sep	5U	610	M	42	37
19-Aug	8	650	M	P	0	000466	23-Sep	4U	605	M	42	35
19-Aug	7	580	M	P	0	000482	27-Sep	5L	-	M	-	39
19-Aug	8	660	F	P	0	000461	26-Sep	2U	530	F	42	38
19-Aug	5	820	F a	P	0	000540	23-Sep	4U	655	M	52	35
19-Aug	5	780	M	P	0	000523	17-Sep	4L	580	M	42	29
19-Aug	5	700	M	P	0	000525	25-Sep	5U	510	M	42	37
19-Aug	5	790	M	P	0	000526	26-Sep	5L	570	M	-	38
19-Aug	5	810	M	P	0	000531	18-Sep	5U	600	M	42	30
19-Aug	5	800	M	P	0	000533	09-Sep	4U	600	M	42	21
19-Aug	5	700	F	P	0	000534	24-Sep	5U	545	F	42	36
19-Aug	5	770	M	P	0	000522	23-Sep	4L	575	M	42	35
19-Aug	5	790	F	P	0	000538	18-Sep	5U	600	F	52	30
19-Aug	5	760	F	P	0	000541	18-Sep	4U	595	F	42	30
19-Aug	5	810	M a	P	0	000543	20-Sep	4L	650	F	52	32
19-Aug	5	820	M	P	0	000547	21-Sep	4L	600	M	-	33
19-Aug	5	820	M	P	0	000550	24-Sep	5L	610	M	42	36
19-Aug	5	770	M a	P	0	000552	01-Oct	4U	-	NK	-	43
19-Aug	5	800	F	P	0	000553	25-Sep	5U	620	F	52	37
19-Aug	5	750	M	P	0	000554	01-Oct	4U	540	M	42	43
19-Aug	5	780	F	P	0	000555	28-Sep	2L	600	F	-	40
19-Aug	5	660	F a	P	0	000557	19-Sep	4L	575	M	42	31
19-Aug	5	780	F	P	0	000558	24-Sep	5U	595	F	52	36

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
19-Aug	5	760	F a	P	0	000536	18-Sep	5U	580	M	42	30
19-Aug	8	810	F a	P	0	000479	30-Sep	5L	525	M	52	42
19-Aug	7	700	F	P	0	000489	26-Sep	3M	-	F	42	38
19-Aug	5	710	F	P	0	000544	18-Sep	5U	550	F	42	30
19-Aug	7	740	M	P	0	000484	27-Sep	5L	580	M	42	39
19-Aug	5	740	F	P	0	000521	22-Sep	4L	580	F	42	34
19-Aug	7	730	F a	P	0	000486	23-Sep	4L	565	M	42	35
19-Aug	7	750	M	P	0	000491	21-Sep	4L	590	M	42	33
19-Aug	7	680	M	P	0	000485	19-Sep	4U	540	M	42	31
19-Aug	5	850	M	P	0	000501	19-Sep	4L	650	M	42	31
19-Aug	5	700	F	P	0	000504	20-Sep	4L	550	F	-	32
19-Aug	5	760	F	P	0	000505	18-Sep	5U	600	F	42	30
19-Aug	5	750	M	P	0	000506	24-Sep	5L	550	M	42	36
19-Aug	5	770	M	P	0	000510	20-Sep	4L	585	M	-	32
19-Aug	5	740	M	P	0	000512	18-Sep	5U	550	M	42	30
19-Aug	5	650	F	P	0	000515	18-Sep	4U	505	F	42	30
19-Aug	5	710	F	P	0	000520	16-Sep	4U	560	F	42	28
19-Aug	7	770	F a	P	0	000492	01-Oct	5L	-	NK	-	43
20-Aug	7	750	F	P	0	000623	17-Sep	4L	600	F	42	28
20-Aug	7	750	M	P	0	000612	19-Sep	5U	570	M	42	30
20-Aug	7	870	M	P	0	000617	20-Sep	7L	670	M	42	31
20-Aug	7	740	F	P	0	000624	25-Sep	2L	560	F	-	36
20-Aug	7	740	M	P	0	000615	26-Sep	3L	570	M	-	37
20-Aug	7	670	M	P	0	000625	02-Oct	6	505	M	42	43
20-Aug	7	680	F	P	0	000608	26-Sep	5L	500	F	42	37
20-Aug	7	620	M	P	0	000606	19-Sep	5U	490	M	42	30
20-Aug	7	700	F	P	0	000605	17-Sep	4L	560	F	42	28
20-Aug	7	710	F	P	0	000604	20-Sep	7L	575	F	42	31
20-Aug	7	800	M	P	0	000603	26-Sep	5L	610	M	42	37
20-Aug	7	690	F	P	0	000611	25-Sep	5L	550	F	42	36
20-Aug	7	780	M	P	0	000632	23-Sep	4L	580	M	42	34
20-Aug	7	740	M	P	0	000635	18-Sep	4U	560	M	42	29
20-Aug	7	700	F	P	0	000636	01-Oct	4U	545	F	42	42
20-Aug	7	650	F	P	0	000638	25-Sep	2L	510	F	42	36
20-Aug	7	700	F	P	0	000646	18-Sep	5U	555	F	-	29
20-Aug	7	750	F	P	0	000657	22-Sep	4U	590	F	42	33
20-Aug	7	720	M	P	0	000668	19-Sep	4U	560	M	42	30
20-Aug	7	710	F	P	0	000666	26-Sep	5L	560	F	42	37
20-Aug	7	740	F	P	0	000602	18-Sep	5U	610	F	-	29
20-Aug	7	700	F	P	0	000664	26-Sep	5L	540	F	42	37
20-Aug	7	780	M	P	0	000654	25-Sep	5L	610	M	42	36
20-Aug	7	840	M a	P	0	000660	09-Sep	4U	-	NK	-	20
20-Aug	7	710	F	P	0	000652	26-Sep	7U	570	F	42	37
20-Aug	7	700	M a	P	0	000659	26-Sep	2U	520	F	42	37
20-Aug	4	740	M	P	0	000598	21-Sep	4U	580	M	-	32
20-Aug	2	710	F	P	0	000493	10-Oct	2U	560	F	-	51
20-Aug	2	800	M	P	0	000494	20-Sep	2U	630	M	42	31
20-Aug	2	750	M	P	0	000498	25-Sep	2U	460	M	42	36
20-Aug	2	720	F	P	0	000559	19-Sep	5U	580	F	-	30
20-Aug	2	720	F	P	0	000561	03-Oct	CC	590	F	42	44
20-Aug	2	700	F	P	0	000563	24-Sep	2U	550	F	-	35
20-Aug	2	790	M a	P	0	000564	25-Sep	2U	-	NK	-	36
20-Aug	2	770	F	A	0	000565	13-Sep	2U	640	F	-	24
20-Aug	4	680	M a	P	0	000568	18-Sep	4U	510	F	42	29
20-Aug	4	680	F	P	0	000569	04-Oct	2U	525	F	42	45
20-Aug	4	750	M	P	0	000594	30-Sep	4U	560	M	42	41
20-Aug	2	670	F	P	0	000500	20-Sep	2U	560	F	42	31
20-Aug	4	760	F	P	0	000595	20-Sep	2U	560	F	42	31
20-Aug	4	750	M	P	0	000570	25-Sep	2U	600	M	42	36
20-Aug	4	800	M	P	0	000593	16-Sep	4U	580	M	42	27

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
20-Aug	4	720	F	P	0	000588	21-Sep	4L	580	F	42	32
20-Aug	4	700	F	P	0	000587	19-Sep	4U	520	F	42	30
20-Aug	4	750	M	P	0	000586	26-Sep	3L	580	M	-	37
20-Aug	4	820	M	P	0	000585	20-Sep	4U	620	M	42	31
20-Aug	4	730	M	P	0	000578	24-Sep	2U	550	M	-	35
20-Aug	4	750	M	P	0	000577	23-Sep	2L	560	M	31	34
20-Aug	4	800	M	P	0	000574	23-Sep	2L	610	M	42	34
21-Aug	7	740	F	P	0	000805	18-Sep	4U	590	F	42	28
21-Aug	8	770	M	P	0	000820	24-Sep	5U	640	M	42	34
21-Aug	7	760	F	P	0	000819	26-Sep	7U	635	F	42	36
21-Aug	7	800	M	P	0	000818	16-Sep	4U	590	M	42	26
21-Aug	7	850	M	A	0	000817	13-Sep	2U	675	M	41	23
21-Aug	7	730	F	P	0	000816	06-Sep	7U	565	F	42	16
21-Aug	7	790	M	P	0	000814	24-Sep	5U	615	M	42	34
21-Aug	7	670	F	P	0	000801	23-Sep	4L	510	F	42	33
21-Aug	7	740	F	P	0	000806	24-Sep	4U	550	F	-	34
21-Aug	7	720	M a	P	0	000677	17-Sep	4L	565	F	42	27
21-Aug	7	830	M	P	0	000802	18-Sep	5U	600	M	42	28
21-Aug	8	650	F	P	0	000821	26-Sep	7U	515	F	42	36
21-Aug	7	850	M	P	0	000811	25-Sep	4U	600	M	42	35
21-Aug	7	680	M	P	0	000678	23-Sep	4L	595	M	42	33
21-Aug	8	760	M	P	0	000835	18-Sep	5U	580	M	42	28
21-Aug	7	750	M	P	0	000673	24-Sep	5U	620	M	42	34
21-Aug	7	700	F	P	0	000680	24-Sep	5L	550	F	42	34
21-Aug	7	740	F	P	0	000674	25-Sep	5U	590	F	-	35
21-Aug	8	730	F a	A	0	000828	19-Sep	4L	560	M	42	29
21-Aug	7	780	M	P	0	000683	24-Sep	5L	580	M	42	34
21-Aug	7	680	F	P	0	000688	19-Sep	4U	520	F	42	29
21-Aug	7	730	M	P	0	000691	22-Sep	4L	555	M	42	32
21-Aug	7	670	F	P	0	000696	26-Sep	7U	530	F	42	36
21-Aug	7	990	M	A	0	000697	24-Sep	5L	690	M	51	34
21-Aug	8	800	M	P	0	000834	24-Sep	5U	-	M	-	34
21-Aug	8	750	F	P	0	000832	18-Sep	5U	570	F	42	28
22-Aug	4	760	M	P	0	000741	07-Oct	3L	580	M	-	46
22-Aug	4	760	M	P	0	000745	18-Sep	4U	580	M	42	27
22-Aug	4	760	M	P	0	000744	30-Sep	4U	610	M	-	39
22-Aug	4	750	F	A	0	000742	20-Sep	2U	625	F	41	29
22-Aug	4	720	M	P	0	000721	21-Sep	4U	520	M	42	30
22-Aug	4	700	F a	P	0	000702	21-Sep	4U	560	M	42	30
22-Aug	4	750	F	P	0	000720	24-Sep	2U	580	F	42	33
22-Aug	4	760	F	P	0	000718	23-Sep	2L	620	F	42	32
22-Aug	4	810	M	P	0	000717	20-Sep	4U	620	M	42	29
22-Aug	4	720	F	P	0	000723	27-Sep	3L	590	F	42	36
22-Aug	4	740	F	P	0	000716	18-Sep	5U	570	F	-	27
22-Aug	4	700	M	P	0	000740	19-Sep	4U	540	M	42	28
22-Aug	4	770	M	P	0	000715	21-Sep	4L	580	M	-	30
22-Aug	4	760	F	P	0	000710	28-Sep	3L	570	F	-	37
22-Aug	4	690	M	P	0	000709	17-Sep	4U	510	M	42	26
22-Aug	4	750	M	P	0	000707	30-Sep	4U	550	M	-	39
22-Aug	4	740	F	P	0	000706	20-Sep	2U	580	F	-	29
22-Aug	4	730	M	P	0	000722	24-Sep	2L	535	M	42	33
22-Aug	4	750	F	P	0	000704	13-Sep	2L	570	F	42	22
22-Aug	4	680	F	P	0	000701	16-Sep	4U	540	F	42	25
22-Aug	4	720	F	P	0	000700	19-Sep	4U	570	F	42	28
22-Aug	4	760	M	A	0	000726	16-Sep	4U	590	M	42	25
22-Aug	4	700	F	P	0	000735	01-Oct	4U	570	F	-	40
22-Aug	4	710	F	P	0	000736	27-Sep	3L	580	F	42	36
22-Aug	4	680	F	P	0	000737	20-Sep	4L	550	F	42	29
22-Aug	4	720	F	P	0	000705	27-Sep	3L	560	F	42	36
23-Aug	8	740	M	P	0	000763	19-Sep	4U	560	M	42	27

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
23-Aug	8	740	F a	P	0	000758	16-Sep	4U	570	M	-	24
23-Aug	8	720	F	P	0	000757	23-Sep	4L	575	F	42	31
23-Aug	8	790	M	P	0	000754	23-Sep	4L	620	M	42	31
23-Aug	8	710	F	P	0	000752	27-Sep	7U	550	F	42	35
23-Aug	8	770	F a	P	0	000751	26-Sep	3M	-	M	42	34
23-Aug	8	840	M	P	0	000749	27-Sep	5L	620	M	42	35
24-Aug	5	630	F	P	0	000789	06-Sep	7U	515	F	52	13
24-Aug	7	720	M	P	0	000780	26-Sep	5L	570	M	42	33
24-Aug	7	770	M	P	0	000771	16-Sep	4U	580	M	-	23
24-Aug	7	710	F	P	0	000772	19-Sep	4U	560	F	42	26
24-Aug	7	750	M	P	0	000775	23-Sep	4U	560	M	42	30
24-Aug	7	700	F a	P	0	000776	24-Sep	4U	555	M	-	31
24-Aug	5	770	M	P	0	000792	19-Sep	4L	590	M	42	26
24-Aug	7	710	M	P	0	000778	17-Sep	4U	540	M	42	24
24-Aug	7	720	F	P	0	000781	30-Sep	5L	560	F	52	37
24-Aug	5	750	M	P	0	000787	20-Sep	4L	575	M	42	27
24-Aug	5	740	F	P	0	000788	30-Sep	4U	570	F	42	37
24-Aug	5	730	F	P	0	000790	26-Sep	5L	560	F	42	33
24-Aug	7	730	F	P	0	000777	20-Sep	4U	560	F	42	27
25-Aug	7	700	M	P	0	000799	23-Sep	4L	535	M	42	29
25-Aug	7	800	F a	P	0	000796	21-Sep	4L	590	M	-	27
25-Aug	7	520	M a	P	0	000797	20-Sep	7L	410	F	42	26
25-Aug	7	830	F	P	0	000798	20-Sep	4U	650	F	52	26
-	-	-	-	-	Lost	-	13-Sep	2U	590	M	42	-
-	-	-	-	-	Lost	-	16-Sep	4U	590	M	42	-
-	-	-	-	-	Lost	-	16-Sep	4U	580	M	42	-
-	-	-	-	-	Lost	-	16-Sep	3L	620	M	-	-
-	-	-	-	-	Lost	-	16-Sep	3L	640	M	42	-
-	-	-	-	-	Lost	-	17-Sep	6	650	M	-	-
-	-	-	-	-	Lost	-	17-Sep	6	560	F	42	-
-	-	-	-	-	Lost	-	17-Sep	4U	610	M	-	-
-	-	-	-	-	Lost	-	17-Sep	4L	550	M	42	-
-	-	-	-	-	Lost	-	18-Sep	5U	610	M	42	-
-	-	-	-	-	Lost	-	18-Sep	5U	560	F	42	-
-	-	-	-	-	Lost	-	18-Sep	5U	600	M	-	-
-	-	-	-	-	Lost	-	19-Sep	4U	600	M	42	-
-	-	-	-	-	Lost	-	19-Sep	4L	555	M	42	-
-	-	-	-	-	Lost	-	19-Sep	4U	680	M	42	-
-	-	-	-	-	Lost	-	20-Sep	7L	515	M	42	-
-	-	-	-	-	Lost	-	20-Sep	4L	610	M	42	-
-	-	-	-	-	Lost	-	20-Sep	4L	560	F	-	-
-	-	-	-	-	Lost	-	20-Sep	7L	560	F	42	-
-	-	-	-	-	Lost	-	21-Sep	4L	560	F	42	-
-	-	-	-	-	Lost	-	21-Sep	4U	480	F	42	-
-	-	-	-	-	Lost	-	22-Sep	4U	630	M	41	-
-	-	-	-	-	Lost	-	24-Sep	5U	550	F	42	-
-	-	-	-	-	Lost	-	24-Sep	4U	510	M	-	-
-	-	-	-	-	Lost	-	25-Sep	5L	560	F	42	-
-	-	-	-	-	Lost	-	25-Sep	5U	610	M	42	-
-	-	-	-	-	Lost	-	25-Sep	5U	545	F	42	-
-	-	-	-	-	Lost	-	25-Sep	4U	560	M	42	-
-	-	-	-	-	Lost	-	26-Sep	3M	-	F	42	-
-	-	-	-	-	Lost	-	26-Sep	7U	610	F	-	-
-	-	-	-	-	Lost	-	26-Sep	5L	520	F	42	-
-	-	-	-	-	Lost	-	26-Sep	5L	580	M	42	-
-	-	-	-	-	Lost	-	26-Sep	5L	640	M	42	-
-	-	-	-	-	Lost	-	26-Sep	5L	580	M	-	-
-	-	-	-	-	Lost	-	26-Sep	5L	540	F	-	-
-	-	-	-	-	Lost	-	26-Sep	5L	610	M	42	-

Appendix 4. Mark recoveries, by application and recovery date and location, size, sex, adipose fin status, and age, of chinook salm recovered in the Nicola River, 1996.

Application							Recovery					
		Fork length		Adipose	Primary Tag				POH length			Days
Date	Reach	(mm)	Sex	fin	Series	Number	Date	Reach	(mm)	Sex	Age	out
-	-	-	-	-	Lost	-	27-Sep	5L	560	F	42	-
-	-	-	-	-	Lost	-	27-Sep	5L	630	M	-	-
-	-	-	-	-	Lost	-	27-Sep	5L	480	F	42	-
-	-	-	-	-	Lost	-	27-Sep	5L	520	F	42	-
-	-	-	-	-	Lost	-	01-Oct	5U	545	F	-	-
-	-	-	-	-	Lost	-	08-Oct	4L	560	F	-	-

			Mean days out	36
Percent sex identification error[a]	Male	21.0%	Maximum	59
	Female	5.0%	Minimum	13

Length regressions:

Male	POH = 0.6883x + 65.722	r^2= 0.60	
	NF = 0.8738x + 241.5		
Female	POH = 0.7636x + 16.683	r^2= 0.78	
	NF = 1.0267x + 137.2		

a. Sex identification error.

Appendix 5. Daily chinook salmon carcass recoveries, by reach, mark status, and sex, in the Nicola River, 1996. [a]

		Unmarked			Primary and Secondary Marked			Secondary Mark Only			Primary Mark Only			Total		
Date	Reach	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex
06/09/96	7	2	6	0	0	2	0	0	0	0	0	1	0	2	9	0
07/09/96	4	7	4	0	0	0	0	0	0	0	0	0	0	7	4	0
09/09/96	4	1	2	0	1 [c]	0	0	0	0	0	0	0	1	2	2	1
"	5	2	4	0	0	0	0	0	0	0	0	0	0	2	4	0
"	6	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10/09/96	2	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0
"	3	7	7	0	0	0	0	0	0	0	0	0	0	7	7	0
13/09/96	2	4	15	0	2 [b]	2 [b]	0	1	0	0	0	0	0	7	17	0
14/09/96	3	47	49	0	1	0	0	0	0	0	0	0	0	48	49	0
16/09/96	3	96	38	1	1	1	0	2	0	0	0	0	0	99	39	1
"	4	64	51	0	6 [b]	5	0	0	0	0	0	0	0	75	56	0
17/09/96	2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
"	4	176	156	0	11	2 [c,d]	0	2	0	0	1	1	0	185	159	0
"	6	16	16	0	0	0	0	1	1	0	1	0	0	18	17	0
18/09/96	4	235	193	1	12	9	0	0	0	0	0	0	0	247	202	1
"	5	76	76	0	6	10	0	2	1	0	0	0	0	84	87	0
19/09/96	4	178	161	0	13	7	0	3	0	0	0	0	0	194	168	0
"	5	33	43	0	4	3	0	0	0	0	0	0	0	37	46	0
20/09/96	2	25	61	0	2	4 [b]	0	0	0	0	0	0	0	27	65	0
"	4	152	184	0	7	10	0	1	1	0	0	0	0	160	195	0
"	7	41	33	0	2	5	0	1	1	0	0	0	0	44	39	0
21/09/96	4	234	242	0	8	6	0	0	1	0	1	1	0	243	250	0
22/09/96	4	190	180	0	2	9	0	1	0	0	0	0	0	193	189	0
23/09/96	2	12	21	15	2	1	0	0	0	0	0	0	0	14	22	15
"	4	121	211	1	11	6	0	0	0	0	0	0	0	132	217	1
24/09/96	2	108	193	0	2	4	0	0	0	0	0	0	0	110	197	0
"	3	9	30	0	0	0	0	0	0	0	0	0	0	9	30	0

Appendix 5. Daily chinook salmon carcass recoveries, by reach, mark status, and sex, in the Nicola River, 1996. [a]

		Unmarked			Primary and Secondary Marked			Secondary Mark Only			Primary Mark Only			Total		
Date	Reach	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex
24/09/96	4	99	97	0	2	1	0	1	0	0	0	0	0	102	98	0
"	5	83	201	0	12 [b]	4	0	0	1	0	0	0	0	95	206	0
25/09/96	2	72	98	0	2	2	0	0	0	0	0	0	1	74	100	1
"	3	26	77	0	0	1	0	0	0	0	0	0	0	26	78	0
"	4	69	70	0	3	0	0	1	0	0	0	0	0	73	70	0
"	5	177	222	0	7	11	0	1	2	0	1	1	0	186	236	0
"	7	3	20	0	0	0	0	0	0	0	0	0	0	3	20	0
26/09/96	2	30	41	0	0	2	0	0	0	0	0	0	0	30	43	0
"	3	48	104	0	4	3	0	0	1	0	0	0	0	52	108	0
"	5	77	104	1	4	8	0	4	2	0	0	0	0	85	114	1
"	7	72	97	0	4	6 [b]	0	0	1	0	0	0	0	76	104	0
27/09/96	2	34	97	0	0	3	0	0	0	0	0	0	0	34	100	0
"	3	56	88	0	1	4	0	0	0	0	0	0	0	57	92	0
"	4	84	82	0	2	0	0	0	0	0	0	0	0	86	82	0
"	5	70	101	0	3	2 [b]	0	1	3	0	0	0	0	74	106	0
"	6	1	3	0	0	0	0	0	0	0	0	0	0	1	3	0
"	7	14	35	0	0	2	0	0	0	0	0	0	0	14	37	0
28/09/96	2	28	61	0	2	3	0	0	0	0	0	0	0	30	64	0
"	3	32	53	0	0	1	0	0	0	0	0	0	0	32	54	0
"	6	10	17	0	0	0	0	0	0	0	0	0	0	10	17	0
30/09/96	4	102	136	0	4	2	0	0	0	0	0	0	0	106	138	0
"	5	34	72	0	5	6	0	0	0	0	0	0	0	39	78	0
01/10/96	4	63	104	0	0	0	0	0	0	0	0	0	1	63	104	1
"	5	25 [c]	51	0	0	2	0	0	1	0	0	0	1	25	54	1
02/10/96	4	17	31	0	0	0	0	0	0	0	0	0	0	17	31	0
"	5	13	15	0	0	0	0	0	0	0	0	0	0	13	15	0
"	6	3	6	0	1	0	0	0	0	0	0	0	0	4	6	0

Appendix 5. Daily chinook salmon carcass recoveries, by reach, mark status, and sex, in the Nicola River, 1996. a

		Unmarked			Primary and Secondary Marked			Secondary Mark Only			Primary Mark Only			Total		
Date	Reach	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex	Male	Female	Unknown sex
03/10/96	2	19	27	0	0	1	0	0	0	0	0	0	0	19	28	0
"	7	8	7	0	0	0	0	0	0	0	0	0	0	8	7	0
04/10/96	2	14	27	0	0	1	0	0	0	0	0	0	0	14	28	0
07/10/96	3	16	27	0	1	2	0	0	0	0	0	0	0	17	29	0
08/10/96	4	52	54	0	3	2	0	0	1	0	0	0	0	55	57	0
09/10/96	4	0	4	0	0	0	0	0	0	0	0	0	0	0	4	0
"	5	15	22	0	0	0	0	0	0	0	0	0	1	15	22	1
10/10/96	2	9	15	0	0	1	0	0	0	0	0	0	0	9	16	0
Total	2	356	659	15	12	24	0	1	0	0	0	0	1	369	683	16
	3	337	473	1	8	12	0	2	1	0	0	0	0	347	486	1
	4	1,844	1,962	2	85	59	0	9	3	0	2	2	2	1,940	2,026	4
	5	605	911	1	41	46	0	8	10	0	1	1	2	655	968	3
	6	31	42	0	1	0	0	1	1	0	1	0	0	34	43	0
	7	140	198	0	6	15	0	1	2	0	0	1	0	147	216	0
Grand total		3,313	4,245	19	153	156	0	22	17	0	4	4	5	3,492	4,422	24

a. Excludes 6 carcasses bearing radiotags.

b. Includes one with adipose fin missing

c. Includes one of unknown adipose fin status.

d. Excludes one which exhibited heavy bleeding at release.

Appendix 6. Percentage at age and mean length at age, by AFC status and sex, of chinook carcasses recovered in the Nicola River, 1996.

			Female			Male		
Adipose fin status	Age		Sample size	Percent	Mean POH length (mm)	Sample size	Percent	Mean POH length (mm)
Absent [a]	3 1		2	2.3%	605	0	0.0%	-
	3 2		0	0.0%	-	1	2.2%	410
	4 1		29	33.7%	605	11	23.9%	651
	4 2		49	57.0%	555	28	60.9%	583
	5 1		0	0.0%	-	1	2.2%	690
	5 2		6	7.0%	637	5	10.9%	658
	6 2		0	0.0%	-	0	0.0%	-
	Total	Sub 1	31	36.0%	605	12	26.1%	655
		Sub 2	55	64.0%	564	34	73.9%	589
		Total [c]	115	-	576	59	-	608
Present [b]	3 1		0	0.0%	-	3	0.8%	608
	4 1		5	1.3%	620	4	1.1%	696
	4 2		364	91.9%	558	319	90.1%	580
	5 2		27	6.8%	617	28	7.9%	654
	6 2		0	0.0%	-	0	0.0%	-
	Total	Sub 1	5	1.3%	620	7	2.0%	659
		Sub 2	391	98.7%	562	347	98.0%	586
		Total [c]	4,170	-	561	3,386	-	585
Total	3 1		2	0.4%	605	3	0.7%	608
	3 2		0	0.0%	-	1	0.2%	410
	4 1		34	7.1%	607	15	3.7%	663
	4 2		413	85.7%	558	348	86.8%	581
	5 1		0	0.0%	-	1	0.2%	690
	5 2		33	6.8%	621	33	8.2%	655
	6 2		0	0.0%	-	0	0.0%	-
	Total	Sub 1	36	7.5%	607	19	4.7%	656
		Sub 2	446	92.5%	562	382	95.3%	587
		Total [c]	4,289	-	562	3,447	-	585

a. Excludes unreadable scale samples.
b. Excludes unreadable scale samples.
c. Includes all measured carcasses.

Appendix 7. Spawning success, by mark status, in female chinook salmon carcasses recovered in the Nicola River, 1996.

Mark status		Percent spawned 0%	50%	100%	Weighted mean
Petersen disk present	Number	7	5	149	
	Percent	4.3%	3.1%	92.5%	94.1%
Secondary mark only	Number	0	1	16	
	Percent	0.0%	5.9%	94.1%	97.1%
Total marks	Number	7	6	165	
	Percent	3.9%	3.4%	92.7%	94.4%
Unmarked	Number	74	62	4,071	
	Percent	1.8%	1.5%	96.8%	97.5%
Total	Number	81	67	4,220	
	Percent	1.9%	1.5%	96.6%	97.4%

Appendix 8. Number of live and dead chinook observed during aerial enumeration flights over the Nicola River, 1996.

		Reach																		
		1		2		3		4		5		6		7		8		Total		
Flight Date		Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead	Total
05/09/96	Observer 1	-	-	105	2	305	1	1,036	3	377	3	34	0	1,015	8	102	1	2,974	18	2,992
	Observer 2	-	-	87	2	302	1	941	3	289	3	33	0	1,071	8	76	1	2,799	18	2,817
	Best Estimate	-	-	105	2	305	1	1,036	3	377	3	34	0	1,071	8	102	1	3,030	18	3,048
	% Dead		-		2%		0%		0%		1%		0%		1%		1%		1%	
09/09/96	Observer 1	-	-	1,388	3	906	1	3,681	3	1,139	0	102	2	1,178	6	203	2	8,597	17	8,614
	Observer 2	-	-	1,092	3	800	1	3,270	3	1,152	0	104	2	1,078	6	235	2	7,731	17	7,748
	Best Estimate	-	-	1,388	3	906	1	3,681	3	1,152	0	104	2	1,178	6	235	2	8,597	17	8,614
	% Dead		-		0%		0%		0%		0%		2%		1%		1%		0%	
12/09/96	Observer 1	-	-	2,112	10	1,280	29	4,252	21	1,782	18	83	2	832	8	311	2	10,877	90	10,967
	Observer 2	-	-	2,023	9	1,184	28	4,475	26	1,568	16	85	2	822	10	280	3	10,437	94	10,531
	Best Estimate	-	-	2,112	10	1,280	29	4,475	26	1,782	18	85	2	832	10	311	3	10,877	98	10,975
	% Dead		-		0%		2%		1%		1%		2%		1%		1%		1%	
12/09/96	Observer 3	-	-	1,760	10	1,202	21	2,950	22	1,506	11	134	6	811	12	241	1	8,604	83	8,687
	Observer 4	-	-	1,675	10	1,133	17	2,896	21	1,424	9	121	5	698	13	204	2	8,151	77	8,228
	Best Estimate	-	-	1,760	10	1,202	21	2,950	22	1,506	11	134	6	811	13	241	2	8,604	85	8,689
	% Dead		-		1%		2%		1%		1%		4%		2%		1%		1%	
18/09/96	Observer 1	-	-	654	350	399	361	1,637	2,000	596	800	23	18	235	92	253	50	3,797	3,671	7,468
	Observer 2	-	-	447	201	301	126	1,062	367	398	512	22	18	190	22	199	27	2,619	1,273	3,892
	Best Estimate	-	-	654	350	399	361	1,637	2,000	596	800	23	18	235	92	253	50	3,797	3,671	7,468
	% Dead		-		35%		48%		55%		57%		44%		28%		17%		49%	
18/09/96	Observer 3	-	-	607	396	366	363	1,597	1,345	929	420	46	13	434	96	108	20	4,087	2,653	6,740
	Observer 4	-	-	584	347	451	346	1,514	1,014	847	352	43	19	441	96	120	27	4,000	2,201	6,201
	Best Estimate	-	-	607	396	451	363	1,597	1,345	929	420	46	19	441	96	120	27	4,191	2,666	6,857
	% Dead		-		39%		45%		46%		31%		29%		18%		18%		39%	
23/09/96	Observer 1	-	-	203	333	63	286	352	700	206	276	5	15	187	99	68	21	1,084	1,730	2,814
	Observer 2	-	-	198	220	64	269	344	820	201	205	5	3	192	59	68	21	1,072	1,597	2,669
	Best Estimate	-	-	203	333	64	286	352	820	206	276	5	15	192	99	68	21	1,090	1,850	2,940
	% Dead		-		62%		82%		70%		57%		75%		34%		24%		63%	

Appendix 9. Incidence of CWT absence, by carcass condition, eye status, and AFC condition, in AFC chinook carcasses recovered in the Nicola River, 1996.

Observation	Condition	Number	CWT absent	Percentage loss
Carcass condition	Fresh	10	1	10.0%
	Moderately fresh	49	7	14.3%
	Moderately rotten	97	16	16.5%
	Rotten	20	4	20.0%
Eyes present	None	17	2	11.8%
	One	27	5	18.5%
	Two	130	21	16.2%
Adipose fin clip	Complete	158	20	12.7%
	Partial	13	7	53.8%
	Questionable	1	1	100.0%

Appendix 10. AFC and CWT sampling of chinook salmon carcasses recovered in the Nicola River, 1996.

			Male	Female	Unknown sex	Total
Sample size			3,492	4,422	0	7,914
Number with AFCs			53	105	0	158
AFC carcass without a head			3	3	0	6
CWT lost during processing			1	1	0	2
AFC carcass without a CWT			1	19	0	20
CWTs recovered from AFC carcasses:						
Code	Brood	Release site				
180850	temp	temp	0	1	0	1
180851	temp	temp	5	8	0	13
180852	temp	temp	20	32	0	52
180853	temp	temp	10	25	0	35
181226	temp	temp	3	3	0	6
181227	temp	temp	4	3	0	7
181642	temp	temp	1	0	0	1
181754	temp	temp	0	2	0	2
Total			43	74	0	117
AFC incidence (%)			1.5%	2.4%	-	2.0%
CWT loss (%)			2.3%	20.4%	-	19.3%
Spatial pattern in AFC incidence:		Reach				
		1	-	-	-	-
		2	4.1%	5.6%	-	5.0%
		3	1.7%	4.1%	-	3.1%
		4	0.8%	0.9%	-	0.9%
		5	1.4%	1.5%	-	1.5%
		6	5.9%	16.3%	-	11.7%
		7	3.4%	3.2%	-	3.3%
Temporal pattern in AFC incidenc		Period				
		Sep 14 - 15	3.9%	7.4%	-	5.8%
		Sep 16 - 17	1.6%	3.3%	-	2.3%
		Sep 18 - 19	0.7%	1.6%	-	1.1%
		Sep 20 - 21	2.1%	2.2%	-	2.2%
		Sep 22 - 23	0.3%	0.0%	-	0.1%
		Sep 25 - 26	2.5%	2.5%	-	2.5%
		Sep 27 - 29	1.8%	3.5%	-	2.9%
		Oct 02 - 05	1.1%	2.0%	-	1.6%