

Enumeration of the 1995 Harrison River Chinook Salmon Escapement

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ENUMERATION OF THE 1995 HARRISON RIVER
CHINOOK SALMON ESCAPEMENT

by

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ABSTRACT

M.K. Farwell, R. Diewert, L.W. Kalnin, and R.E. Bailey. 1998. Enumeration of the 1995 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2453: 32 p.

In 1985, the Pacific Salmon Treaty committed the Canadian Department of Fisheries and Oceans to halt the decline in abundance of chinook salmon (*Oncorhynchus tshawytscha*) stocks. The Harrison River was designated a chinook indicator stock, and escapement has been monitored annually since 1984. In 1995, record low numbers of marks were applied and recovered, a result of observed high water levels and apparent low chinook abundance. Statistical biases in the recovery sample, a result of the small male sample size, did not permit the Harrison River chinook escapement to be estimated using the Petersen mark-recapture method. A total escapement estimate of unknown accuracy of 28,616 was derived by application of the average males per female in the 1984-94 escapement estimates to the 1995 female data. The unknown accuracy of the escapement estimate did not permit revision of previous conclusions about stock status. The age composition of the recovery sample was 32.0% age 3₁, 41.2% age 4₁, and 26.8% age 5₁. The sex composition of the mark application sample was 48.7% female and 51.3% male.

Key Words: Chinook salmon, Harrison River, indicator stock, escapement, Pacific Salmon Treaty.

RÉSUMÉ

M.K. Farwell, R. Diewert, L.W. Kalnin and R.E. Bailey. 1998. Enumeration of the 1995 Harrison River chinook salmon escapement. Can. Manuscr. Rep. Fish. Aquat. Sci. 2453: 32 p.

En signant le Traité concernant le saumon du Pacifique en 1985, le ministère des Pêches et des Océans du Canada s'engageait à intervenir pour contrer le déclin de l'abondance des stocks de saumon quinnat (*Oncorhynchus tshawytscha*). Les saumons de la rivière Harrison ont été désignés comme stock indicateur, et l'échappée est surveillée chaque année depuis 1984. En 1995, le nombre de marques apposées et récupérées a été le plus bas jamais connu, ce qui est dû aux hautes eaux observées et à la faible abondance apparente des quinnats. Des biais statistiques dans l'échantillon de poissons récupérés, dus à la petite taille de cet échantillon, ont rendu impossible l'évaluation de l'échappée de quinnats de la Harrison par la méthode de marquage-recapture de Petersen. On a estimé à 28 616 l'effectif total de l'échappée, sans toutefois connaître le degré d'exactitude de ce chiffre, en appliquant la moyenne du nombre de mâles par femelle dans les estimations des échappées de 1984-1994 aux données de 1995 sur les femelles. Faute de connaître le degré d'exactitude de l'estimation, nous n'avons pas pu réviser les conclusions antérieures sur l'état du stock. Dans l'échantillon de poissons récupérés, la composition par âge était de 32,0 % d'âge 3₁, de 41,2 % d'âge 4₁ et de 26,8 % d'âge 5₁. La composition par sexe de l'échantillon était de 48,7 % de femelles et de 51,3 % de mâles.

Mots clés: Saumon quinnat, rivière Harrison, stock indicateur, échappée, Traité concernant le saumon du Pacifique.

INTRODUCTION

The 1985 Pacific Salmon Treaty committed management agencies in Canada and the United States of America to halt the decline in chinook salmon (*Oncorhynchus tshawytscha*) spawning escapements and to attain, by 1998, escapement goals established by each nation (Anon. 1985). To evaluate rebuilding progress, the Department of Fisheries and Oceans monitors a group of key stocks selected to represent all British Columbia chinook stocks. The status and response to management actions of these stocks is evaluated by measuring, with known precision, either annual trends in escapement (escapement indicator stocks) or in escapement and total harvest (exploitation rate indicator stocks).

The Harrison River was designated an escapement indicator stock in 1984 because it comprised almost one-third of the Fraser River system chinook escapement in the 1970s (Farwell *et al.* 1987) and, as a white-fleshed, fall spawning stock with juveniles which migrate to sea immediately following emergence (Fraser *et al.* 1982), it is unique in the Fraser River system. Individual monitoring, therefore, was warranted. Previous reports documented the 1984-1994 Harrison River chinook enumeration studies (Staley 1990; Farwell *et al.* 1990, 1991, 1992, 1996; Schubert *et al.* 1993, 1994). The current report documents the 1995 field methods, analytic techniques, and study results.

Included are estimates of adult age, length, sex, adipose fin clip (AFC) incidence, coded wire tag (CWT) recoveries, and escapement by sex and age. The report concludes with a discussion of data limitations and stock status.

STUDY AREA

The Harrison River is part of a complex system which drains a mountainous coastal watershed in southern British Columbia (Fig. 1).

The river originates at Harrison Lake and flows southwest for 16.5 km, entering the Fraser River 116 km upstream from the Strait of Georgia. Between 1951 and 1994, the river had an annual mean daily discharge of $440 \text{ m}^3 \cdot \text{s}^{-1}$, with an annual mean daily maximum of $1269 \text{ m}^3 \cdot \text{s}^{-1}$ and minimum of $121 \text{ m}^3 \cdot \text{s}^{-1}$ measured at the

outlet of Harrison Lake (unpublished data, pers. comm. Lynne Campo, Environment Canada). Flow extremes are moderated by Lillooet and Harrison lakes. The study area was divided into eight reaches based on homogeneity of physical characteristics (Fig. 2):

Reach 1 (Harrison Lake to km 9.5), from the lake to Morris Creek, has a wide, low gradient channel with a depth of 10 m and a sand substrate;

Reach 2 (km 9.5 to 7.7) extends to Billy Harris Slough on the northwest shore and to the top of Reach 5 on the southeast shore. The channel is similar to Reach 1 except the depth is 3.0 m and the substrate is gravel;

Reach 3 (km 7.7 to 7.1) extends to a shear boom on the northwest shore. It has a higher gradient than reaches 1 and 2 and has a cobble/gravel substrate;

Reach 4 (km 7.1 to 6.3) is similar to Reach 3 except there are several side channels on the northwest shore separated from the main channel by gravel bars. The channel substrate is gravel;

Reach 5 (km 7.7 to 6.3) is a large side channel with a low gradient, a depth of 1.5 m and a sand substrate. An island at the mid-point divides the reach into two sections;

Reach 6 (km 6.3 to 4.5) extends to a rock bluff on the southeast shore, 2 km above the Highway 7 bridge, and includes the main channel and the upper Chehalis River flood plain. The channel depth is 3 m and the substrate is bedrock/gravel;

Reach 7 (km 4.5 to 3.0) extends to the Highway 7 bridge, and includes the main channel and the lower Chehalis River flood plain. The gradient is lower than Reach 6 and the substrate is mud;

Reach 8 (km 3.0 to 0) extends to the Fraser River and includes Harrison Bay. The river is deep (up to 4 m) and slow, flowing over a sand and gravel substrate. Harrison Bay is shallow with a mud substrate. There are several mid-river entrainment structures designed to divert the flow away from Harrison Bay. The bay

dewaters at low Harrison River discharges, and chinook tend to avoid the area.

FIELD METHODS

TAG APPLICATION

Chinook adults were captured in reaches 2 and 4 from October 17 to November 14, 1995 using a 67 m x 6 m x 9 cm-mesh seine net. The net was set by power boat in a downstream crescent and withdrawn from the river to enclose a small area of water along the river bank. Cap-tured chinook were held in the net until removed for tagging and release. Spaghetti tags were applied in a submerged wooden tray constructed with a flexible plastic bottom and a meter stick recessed in one side. After tagging, the adults were released over a submerged section of the net; at no time were they removed from the water. Precocious males (jacks), defined as a male with a nose-fork (NF) length of 50 cm or less, were released untagged.

The spaghetti tags consisted of a 50 cm long, 2 mm diameter hollow plastic tube numbered with a unique code. The tag was inserted with a 13 cm long stainless steel needle through the musculature and pterygiophore bones 2 cm below the anterior portion of the dorsal fin. It was tied tightly over the dorsal surface with a square knot. Each tagged fish received a secondary mark to allow the assessment of tag loss. One or two 7 mm diameter holes were punched through the right operculum of males and females, respectively, using a single hole punch. Care was taken to avoid gill damage. Date and location (reach) of capture, tag number, sex, NF length (± 0.5 cm) and adipose fin status were recorded for each chinook released with a tag. Release condition was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation).

SPAWNING GROUND SURVEYS

The spawning grounds were surveyed from October 24 to December 14, 1995. Complete surveys were conducted weekly by two-person crews, with two to four crews required depending on carcass abundance. The shore was surveyed on foot while deep water areas,

including the mid-river entrainment structures, were surveyed by boat. Carcasses were recorded by date, reach, recovery type (shore or deep water), sex (confirmed by abdominal incision), and mark type (spaghetti tag, secondary mark or AFC). Each marked carcass and every twentieth unmarked carcass was sampled. All were cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included postorbital-hypural plate (POH) length (± 0.1 cm), sex, female spawning success (0%, 50%, or 100% spawned), adipose fin condition, and scales. For AFC chinook, the head was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped or as complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact but soft), or rotten (skin and bones), and the absence of one or both eyes was noted.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

Period

Temporal bias was assessed using a chi-square test (Sokal and Rohlf 1981). Application bias was examined by comparing among periods the mark incidence in the recovery sample, where mark incidence was the proportion of the chinook adults marked with either a spaghetti tag or a secondary mark. Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered.

Location

Spatial bias was similarly assessed in the application sample by comparing among sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered.

Fish Size

Size related bias was assessed using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). Application bias was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing the NF length frequency distributions of each.

Fish Sex

Sex related bias was assessed using chi-square tests. Application bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and nonrecovered components and comparing the sex composition in each.

Other Tests

Bias resulting from tagging stress was also assessed using chi-square tests. The application sample was partitioned into two groups, those which required ventilation at release and those which did not, and recovery rates were examined in each group. As well, differential spawning success was examined in marked and unmarked spawning ground recoveries.

Statistical bias in the mark-recapture estimation method was deemed to be present when there were fewer than 4 recaptures in a class (Ricker 1975).

ESTIMATION OF SPAWNER POPULATION

Total Escapement

Due to unusually high flows and low numbers of spawners, the 1995 escapement estimate was not calculated in the same manner as previous years (i.e. Farwell et al. 1996). The 1995 escapement of Harrison River chinook adults was estimated by calculating a mark-recapture estimate for females using the Petersen formula (Chapman modification)

(Ricker 1975), and inferring the male escapement by using the average male:female sex ratio for 1984-1994. Total escapement was the sum of escapement by sex:

- 1) Estimated Harrison River chinook escapement (N_t):

$$N_t = N_m + N_f$$

where:

N_f = adult female escapement estimate;

$$= \frac{(M_f + 1)(C_f + 1)}{(R_f + 1)}$$

N_m = adult male escapement estimate

$$= (N_t)(\text{male:female}_{1984-94})$$

where:

M_f = number of adult female chinook spaghetti tagged and secondary marked and released ;

C_f = number of adult female carcasses examined for spaghetti tags;

R_f = number of spaghetti tagged or secondary marked adult females recovered; and

$\text{male:female}_{1984-94}$

= male:female ratio for 1984-1994.

- 2) We were unable to generate 95% confidence limits of N_t because of the inability to generate a mark-recapture estimate for males. The 95% confidence limits of N_f

$$N_f \pm 1.96 \sqrt{V_f}$$

where:

V_f = variance of the adult female escapement estimate;

$$= \frac{(N_f^2)(C_f - R_f)}{(C_f + 1)(R_f + 2)}$$

Adipose Fin Clipped Escapement

The estimated AFC escapement was the product of the AFC incidence in the recovery sample, the largest of the two available samples, and the mark-recapture escapement estimate. Confidence limits and escapement by CWT code were not estimated because CWT sample sizes were not sufficient to permit stratification by age.

RESULTS

SPAGHETTI TAG APPLICATION

Spaghetti tags and secondary marks were applied to 265 chinook adults in the Harrison River from October 17 to November 14, 1995 (Appendix 1; Table 1). One fish (0.4%) had an AFC. Five fish (1.9%) required ventilation at release (Table 2). None of this group were recovered; however this was not significantly different ($p > 0.05$; chi-square) from the recovery rate of the remaining fish (5.0%). Consequently, they were left within the application sample. None of the fish were misidentified by sex at the time of tagging (Appendix 2). Therefore, there was no need to correct the application sample for sex identification error and 136 (51.3%) males and 129 (48.7%) females were released with a spaghetti tag and secondary mark (Table 1). Most (87%) were released in Reach 2, with 35 (13%) released in Reach 4.

Mean NF length of males and females was 81.8 cm and 85.7 cm, respectively. The release group was not sampled for age.

In 1995, 39 previously tagged fish were recaptured in subsequent beach seine sets (Appendix 1). All recaptures occurred on the same day as initial marking. None of the recaptured fish were subsequently recovered on the spawning grounds; however, this was not significantly lower than the recovery rate (5.6%) shown by the remainder of the marked population ($p > 0.05$; chi-square).

SPAWNING GROUND RECOVERY

In 1995, 1,990 chinook adults and 39 jacks were recovered on the spawning grounds from October 24 to December 14 (Table 1; Appendix 3). There were 850 (42.7%) adult male and 1,140 (57.3%) adult female carcass recoveries.

Of those adults, 10 (0.5%) had an AFC and 13 (0.6%) had a spaghetti tag and secondary mark. None showed spaghetti tag loss and none were recovered without a secondary mark. Most of the adults were recovered in reaches 4 and 6 (37% each), 8 (14%), and 7 (9%).

Age, Length and Sex

The age, length, and sex of the 1995 Harrison River spawning ground recoveries are reported in Appendix 4. Most males (43.6%) were age 3₁ while most females (45.9%) were age 4₁. There was no significant difference in the age composition of males or females with and without an AFC ($p > 0.05$; chi-square). The mean POH length of males and females was 66.1 cm and 72.0 cm, respectively. Females comprised 57.4% of the sampled fish; All sampled fish had white flesh.

Coded Wire Tag Recoveries

Three adult males and 7 females had an AFC (jacks were not examined for an AFC), an incidence of 0.35% and 0.61% respectively (Appendix 5). There was no significant difference ($p > 0.05$; chi-square) in AFC incidence by sex. Two AFC carcasses were headless. There was no significant difference ($p > 0.05$; chi-square) in AFC incidence in either sex when the sample was stratified spatially. There was no significant difference ($p > 0.05$) in AFC incidence in males when the sample was stratified temporally; however, females showed a significant difference with a higher AFC incidence in the late period.

CWTs were recovered from 4 heads (2 male and 2 female), of which 1 (25%) was from a 1991-brood Chehalis River Hatchery release, and 3 (75%) were from a 1992-brood, Chehalis River Hatchery release. CWT loss averaged 42.9% (Appendix 5). There was no significant difference ($p > 0.05$; chi-square) in CWT loss in carcasses with eyes versus those missing one

or both eyes (Appendix 6), indicating that predators did not influence measured CWT loss.

There was also no significant difference ($p > 0.05$; chi-square) in CWT loss between fresh and decomposed carcasses. A significant difference in CWT loss was noted between carcasses with AFCs (0%) and those with fungus obscuring the area (75%) ($p < 0.05$; chi-square).

Scale ageing accuracy was evaluated in the samples for which both ageable scales and CWTs were available. None of the three CWT fish was aged incorrectly.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in four recovery periods (Table 3). Mark incidences in both sexes were lowest (0.0%) in the latest period and highest (males 0.5% and females 1.4%) in the early period. The differences were not significantly different than that expected ($p > 0.05$; chi-square). To increase sample size, data for both sexes were combined; however, no significant difference was noted.

Recovery bias was examined by comparing the proportions recovered from four application periods (Table 4). The proportions ranged from 0% to 2.9% in males and 0% to 10.8% in females, but the differences were not significant ($p > 0.05$) in either sex. No significant difference was observed when data for both sexes were combined to increase sample size.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in three recovery sections (Table 5). Mark incidence ranged from 0% in the upper section to 1.4% in the lower section. The differences were not significant ($p < 0.05$; chi-square) in either sex. To increase sample size, data for both sexes were combined; however, no significant difference was apparent.

Recovery bias was examined by stratifying the application sample into two reaches and

comparing proportions recovered from each (Table 6). The proportions ranged from 0.0% to 9.6%; however, the differences were not significant in either sex ($p > 0.05$) or when both sexes were combined to increase sample size.

Fish Size

Size related bias in the application sample was examined by comparing the POH length frequency distributions of marked and unmarked spawning ground recoveries. No significant difference ($p > 0.05$; Kolmogorov-Smirnov two sample test) was noted in either sex or when both sexes were combined to increase sample size. When the recovery sample was stratified into 10 cm POH length increments, the proportion marked was highest in average sized fish (Table 7).

Recovery 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 ($p > 0.05$) in either sex. To increase sample size data from both sexes were combined; however, no significant difference was apparent.

Fish Sex

There was no significant difference ($p > 0.05$; chi-square) in the sex ratio of the marked and unmarked spawning ground recoveries (Table 8). The application sample, therefore, was relatively unbiased with respect to sex.

There was a significant difference ($p < 0.05$; chi-square) in the sex ratio of the recovered and nonrecovered components of the application sample (Table 8) indicating a biased recovery sample. In addition, there was a significant difference noted in the proportion of males (1.5%) and females (8.5%) released with spaghetti tags and recovered on the spawning grounds ($p < 0.05$; chi-square)(Table 1).

Recovery Method

High water levels during the recovery period precluded boat surveys for carcass recovery from deep water in 1995.

Spawning Success

Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 72.2% (Appendix 7). The spawning success of marked (68.2%) and unmarked (72.7%) females was not significantly different ($p > 0.05$; chi-square).

ESTIMATION OF SPAWNER POPULATION

While serious spatial and temporal biases were not identified in this study, there were significant sex related biases identified (Table 9; see Discussion). Therefore it was necessary to calculate the escapement by sex. The 1995 escapement of Harrison River chinook females, calculated using the Petersen estimator, was 12,361 (Table 10), with lower and upper 95% confidence limits of 5,677 and 19,045. Based on the age composition of the female recovery sample, the escapement contained 3,153 age 3₁, 5,676 age 4₁, and 3,532 age 5₁ female chinook adults. The escapement of male chinook adults was not estimated by the Petersen estimator because of the statistical bias inherent in a recovery of only two marks. A male estimate of 16,255 was derived by applying the average number of males per female (1.32:1.00) in the 1984-1994 escapement estimates to the 1995 female estimate. Based on the age composition of the male recovery sample, the escapement contained 7,093 age 3₁, 5,320 age 4₁, and 3,842 age 5₁ male chinook adults.

In 1995, there were record low numbers of marks applied (12% of average), marks recovered (7% of average), and carcasses recovered (23% of average) (Table 11). Also during the 1995 study period (October 15 to December 31), there was a record high mean Harrison River flow (203% of average). Greater deviations from daily average flows also occurred during the 1995 recovery period (Figure 3), compared to previous studies. Daily discharge markedly increased as a result of a prolonged period of heavy rains.

Based on the recovery sample adult AFC incidence of 0.5% for both sexes combined (Appendix 5), the 1995 escapement estimate contained 143 AFC chinook adults.

Escapement by CWT code was not estimated because sample size was insufficient to warrant stratification of the AFC sample by age and sex.

DISCUSSION

SAMPLING SELECTIVITY

Population estimates derived from mark-recapture studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce emigration of tagged fish from the population, affect subsequent behaviour, or alter recapture vulnerability; and nonrepresentative tag application or recovery resulting from samples which are too small, or are selective by fish size, sex, or spatial and temporal run component.

Tag loss was anticipated and accounted for by applying a secondary mark to all spaghetti tagged fish. Physiological stress during marking was minimized by using a low stress handling technique described by Staley (1990). Stress induced emigration was assessed by observing the recaptures of spaghetti tagged fish during subsequent tagging efforts. In 1995, all recaptures occurred on the same day as initial release and none of the recaptured fish were subsequently recovered in the spawning ground recovery sample. The lack of recovery was not significantly different than that expected; however, the lack of recaptures past the day of initial tagging has not been previously recorded (Farwell *et al.* 1996). We concluded that, while emigration of marked fish may have occurred, we have no evidence to indicate that the rate of emigration shown by marked fish was different than that of unmarked fish.

To evaluate the effect of handling stress on subsequent spawning behaviour, we compared spawning success in spaghetti tagged and untagged females. No significant difference was noted. These results are consistent with those in past studies (Farwell *et al.* 1991, 1992, 1996; Schubert *et al.* 1993, 1994). We concluded, therefore, that capture and marking did not significantly influence subsequent behaviour and that the assumption concerning

recapture vulnerability was not seriously violated.

It was not possible to definitively test the representativeness of the application and recovery samples because the true population parameters were not known. Instead, we examined the samples for five biases: statistical, temporal, spatial, fish size and fish sex, as indicators of weakness in the study.

No significant bias was noted in the application sample (Table 9). A bias to females was identified in the recovery sample, necessitating the calculation of escapement estimates by sex. Without evidence of significant bias, we concluded that the female escapement estimate was unlikely to be biased.

The bias of the recovery sample away from males combined with the statistical bias, resulting from the recovery of only two male chinook, was considered serious. Ricker (1975) indicated that statistical bias cannot be ignored when fewer than four marks are recovered. We concluded that the statistical bias would not permit the calculation of a statistically valid adult male chinook escapement estimate. It followed that an accurate total escapement estimate could not be derived from the 1995 mark recapture data.

In the absence of a statistically valid method of estimating male escapement, we selected a calculation method based on the average male:female ratio observed during the 1984-94 study period. This method, although resulting in an estimate of unknown accuracy, was selected as the best available among a variety of subjective methods.

STOCK STATUS

Stock status has been assessed through estimates derived from the current mark recapture study which was implemented in 1984. Farwell *et al.* (1996) reported that, for the years 1984 to 1994, estimated escapements had been trendless. Escapements had declined sharply in the initial years of the study, increased to a peak of 177,375 in 1990, and, until 1995, remained in the 90,000 to 130,000 range. The probable inaccuracy of the 1995 escapement estimate precludes placing

confidence in a revision of past assessments of the escapement trend; however, the following may offer some hint about stock status.

The record low numbers of marks applied, marks recovered, and carcasses recovered combined to produce a record low female escapement estimate. No significant biases were associated with this estimate. We concluded that the unbiased nature of a record low female estimate may indicate that the male and total escapements may also have been low.

A factor which may have contributed to the record low numbers observed in the 1995 study was an atypical water flow pattern in the Harrison River (Figure 3). During the mark application period, river flows were near average, application effort was not affected, and biases were not identified. During the recovery period, abnormally high flows affected recovery effort and contributed to low recovery numbers; however, significant spatial or temporal biases were not observed in the data. Therefore, we concluded that a small total population size was the major contributor to the record low numbers of marks applied as well as to the record low number of mark and carcass recoveries.

We consider the 1995 total escapement to be well below average and presume that it may have been below the previous record low estimate of 35,116 adult chinook. We see no evidence that would require a change to the conclusion of the Chinook Technical Committee (Anon. 1994) that the Harrison River chinook will not rebuild to the escapement goal of 241,700 by 1998.

SUMMARY

1. The Harrison River chinook stock is one of a group of British Columbia chinook stocks being monitored to evaluate escapement responses to management actions implemented under the Pacific Salmon Treaty.
2. Adult spawners were enumerated by a mark-recapture study from October 17 to December 14, 1995. Chinook adults were captured using a beach seine and marked with spaghetti tags and opercular punches.

The escapement was censused by the recovery of carcasses following spawning.

3. The 1995 chinook adult escapement was estimated from a spaghetti tag application sample of 265 adults, a recovery sample of 1,990 adults, and a recovery of 13 carcasses with spaghetti tags or secondary marks. The total escapement could not be estimated with known accuracy because of a serious statistical bias in the male data. Female escapement was estimated at a record low 12,361 adults. A male estimate of 16,255, and of unknown accuracy was derived by application of average sex ratio data.
4. The dominant age class was age 3₁ (43.6%) in males and age 4₁ (45.9%) in females. POH length averaged 66.1 cm for males and 72.0 for females.
5. No biases were identified in the application sample. A sex bias was detected in the recovery sample. In addition, a statistical bias was present in the male data. The basic assumptions underlying the Petersen mark-recapture technique were seriously violated for males but not for females. The 1995 escapement estimate could not be accurately quantified. Based on assumptions about the data a below average total escapement was indicated.
6. Harrison River escapement has been trendless over the 1984-1994 study period. The lack of a accurate 1995 estimate does not change this conclusion and the opinion of the Canada/U.S. Chinook Technical Committee that this stock is exploited at a level which is higher than the long term sustainable level is still valid. The stock is unlikely to rebuild by 1998.

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Table 1. Spaghetti tag application, carcass examination and mark recovery, by sex, of Harrison River chinook adults, 1995.

Sex	Spaghetti tags applied	Carcasses examined	Marks recovered				Percent recovered
			Spaghetti tag and secondary mark	Secondary mark only	Spaghetti tag only	Total	
Male	136	850	2	0	0	2	1.5%
Female	129	1,140	11	0	0	11	8.5%
Total	265	1,990	13	0	0	13	4.9%

Table 2. Spaghetti tag application and recovery, by release condition and sex, of Harrison River chinook adults, 1995.

Release condition	Spaghetti tags applied			Spaghetti tags recovered			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Swam away without assistance	132	128	260	2	11	13	1.5%	8.6%	5.0%
Required ventilation	4	1	5	0	0	0	0.0%	0.0%	0.0%

Table 3. Incidence of spaghetti tags or secondary marks in chinook adults recovered on the Harrison River spawning grounds, by recovery period and sex, 1995.

Recovery period	Recovered with spaghetti tags or secondary marks a			Chinook adult carcasses examined a			Mark incidence		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
23-Oct to 29-Oct	1	3	4	198	214	412	0.5%	1.4%	1.0%
30-Oct to 05-Nov	1	4	5	244	477	721	0.4%	0.8%	0.7%
06-Nov to 12-Nov	0	4	4	323	363	686	0.0%	1.1%	0.6%
13-Nov to 17-Dec	0	0	0	85	86	171	0.0%	0.0%	0.0%

Table 4. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application period and sex, 1995.

Application period	Spaghetti tags and secondary mark applied			Carcasses recovered with spaghetti tags			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
16-Oct to 22-Oct	79	83	162	1	9	10	1.3%	10.8%	6.2%
23-Oct to 29-Oct	34	24	58	1	2	3	2.9%	8.3%	5.2%
30-Oct to 05-Nov	20	18	38	0	0	0	0.0%	0.0%	0.0%
06-Nov to 12-Nov	-	-	-	-	-	-	-	-	-
13-Nov to 26-Nov	3	4	7	0	0	0	0.0%	0.0%	0.0%

Table 5. Proportion of the Harrison River chinook adult spawning ground recovery sample marked with spaghetti tags or secondary marks, by recovery location and sex, 1995.

Recovery section a	Carcasses recovered with spaghetti tags or secondary marks			Chinook adult carcasses examined			Mark incidence		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Upper	0	0	0	24	13	37	0.0%	0.0%	0.0%
Middle	1	2	3	281	469	750	0.4%	0.4%	0.4%
Lower	1	9	10	545	658	1,203	0.2%	1.4%	0.8%

a. Section definitions: Upper - reaches 1 and 2; Middle - reaches 3,4 and 5; and Lower - reaches 6,7 and 8.

Table 6. Proportion of the spaghetti tag application sample recovered on the Harrison River spawning grounds, by application reach and sex, 1995.

Application reach	Spaghetti tags and secondary marks applied			Carcasses recovered with spaghetti tags			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Reach 2	116	114	230	2	11	13	1.7%	9.6%	5.7%
Reach 4	20	15	35	0	0	0	0.0%	0.0%	0.0%

Table 7. Proportion of the Harrison River chinook adult spaghetti tag application sample recovered on the spawning grounds, by 10 cm increments of postorbital-hypural length and sex, 1995.

Postorbital -hypural length (cm)	Carcasses recovered			Carcasses recovered with spaghetti tags or secondary marks ^a	
	Male	Female	Total	Male	Female
40-49.9	14	0	14	0	0
50-59.9	7	2	9	0	0
60-69.9	22	39	61	1	5
70-79.9	24	57	81	1	5
80-89.9	12	12	24	0	0
90-99.9	1	0	1	0	0

a. Excludes 1 female for which POH length not recorded.

Table 8. Sex composition of Harrison River chinook adults in the spaghetti tag application and spawning ground recovery samples, 1995.

Sex	Application sample, by recovery status				Recovery sample, by mark status			
	Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
Male	136	15.4%	53.2%	51.3%	850	15.4%	42.9%	42.7%
Female	129	84.6%	46.8%	48.7%	1,140	84.6%	57.1%	57.3%

Table 9. Results of the statistical tests for bias in the 1995 Harrison River chinook adult escapement estimation study. a

Bias type	Application sample	Recovery sample
Statistical b	-	Bias in Males
Period	No bias	No bias
Location	No bias	No bias
Fish size	No bias	No bias
Fish sex	No bias	Bias to females
Recovery method	-	-

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

b. Bias present when recoveries total 4 or less.

Table 10. Annual escapement estimates and 95% confidence limits, by sex and age, for Harrison River chinook adults, 1984-1995. a

Sex	Year	Escapement at age							95% confidence limits of total escapement	
		3/1	4/1	4/2	5/1	5/2	6/1	Total	Lower	Upper
Male	1984	38,688	30,764	0	2,797	0	0	72,249	55,457	89,042
	1985	47,771	59,236	0	7,643	0	0	114,650	78,343	150,957
	1986	4,907	76,407	0	3,505	0	0	84,819	64,336	105,302
	1987	10,910	24,374	0	5,803	0	0	41,088	33,166	49,011
	1988	1,828	14,473	0	1,524	0	0	17,825	13,533	22,117
	1989	34,566	11,522	0	4,389	0	0	50,478	36,652	64,304
	1990	3,832	98,361	0	2,555	0	0	104,748	72,116	137,380
	1991	21,761	17,921	0	8,320	0	0	48,002	33,818	62,186
	1992	25,820	50,164	0	1,107	0	0	77,090	58,585	95,595
	1993	26,693	21,354	0	3,003	0	0	51,050	39,372	62,727
	1994	2,965	49,740	0	2,306	0	329	55,340	41,683	68,997
	1995	7,093	5,320	0	3,842	0	0	16,255 b	n/a	n/a
Female	1984	11,062	32,754	0	4,772	0	0	48,588	37,881	59,296
	1985	12,248	43,426	557	3,897	0	0	60,128	46,951	73,304
	1986	759	73,224	0	3,794	0	0	77,777	65,683	89,872
	1987	782	26,115	0	11,052	0	0	37,950	33,560	42,341
	1988	418	14,990	70	1,743	0	70	17,291	14,222	20,361
	1989	13,364	7,565	252	3,026	0	0	24,207	16,638	32,907
	1990	1,391	69,844	0	1,391	0	0	72,627	60,273	84,981
	1991	8,066	23,046	0	11,523	0	0	42,636	28,641	56,631
	1992	4,963	46,165	0	2,193	0	0	53,321	43,041	63,601
	1993	18,552	44,033	224	5,141	0	0	67,949	55,024	80,873
	1994	765	40,997	0	956	96	191	43,004	37,101	48,907
	1995	3,153	5,676	0	3,532	0	0	12,361	5,677	19,045
Total	1984	49,751	63,518	0	7,569	0	0	120,837	100,921	140,752
	1985	60,019	102,662	557	11,541	0	0	174,778	136,153	213,402
	1986	5,666	149,631	0	7,299	0	0	162,596	138,811	186,385
	1987	11,693	50,489	0	16,856	0	0	79,038	69,981	88,096
	1988	2,247	29,463	70	3,267	0	70	35,116	29,839	40,392
	1989	47,931	19,087	252	7,415	0	0	74,685	58,737	90,663
	1990	5,224	168,205	0	3,946	0	0	177,375	142,483	212,268
	1991	29,827	40,967	0	19,844	0	0	90,638	70,712	110,564
	1992	30,782	96,329	0	3,299	0	0	130,411	109,242	151,580
	1993	45,244	65,387	224	8,144	0	0	118,998	101,580	136,417
	1994	3,729	90,738	0	3,261	96	521	98,344	83,466	113,223
	1995	10,246	10,996	0	7,374	0	0	28,616	n/a	n/a

a. Rounding errors may be present.

b. Estimate derived by application of 1984-94 average number of males per female to 1995 female estimate.

Table 11. Annual chinook mark application, mark and carcass recovery, and average flow in the Harrison River, 1984-1995.

Year	Marks			Carcasses recovered	Average flow ^a (Oct 15 -Dec 31)
	Applied	Recovered	Percent recovered		
1984	1,805	144	8.0%	9,908	369.9
1985	1,662	113	6.8%	10,894	234.1
1986	2,534	217	8.6%	13,369	237.7
1987	3,444	367	10.7%	7,899	202.5
1988	1,159	178	15.4%	5,507	326.8
1989	1,614	81	5.0%	4,003	388.8
1990	3,606	164	4.5%	7,080	586.4
1991	1,870	74	4.0%	3,700	255.2
1992	1,469	164	11.2%	14,207	282.1
1993	2,379	172	7.2%	8,691	195.3
1994	2,396	255	10.6%	9,371	229.1
1984-1994 average	2,176	175	8.1%	8,603	300.7
1995	265	13	4.9%	1,990	612.6

a. Average cubic metres per second at Station 08MG13 (near Harrison Hot Springs) during October 15 - December 31 period.

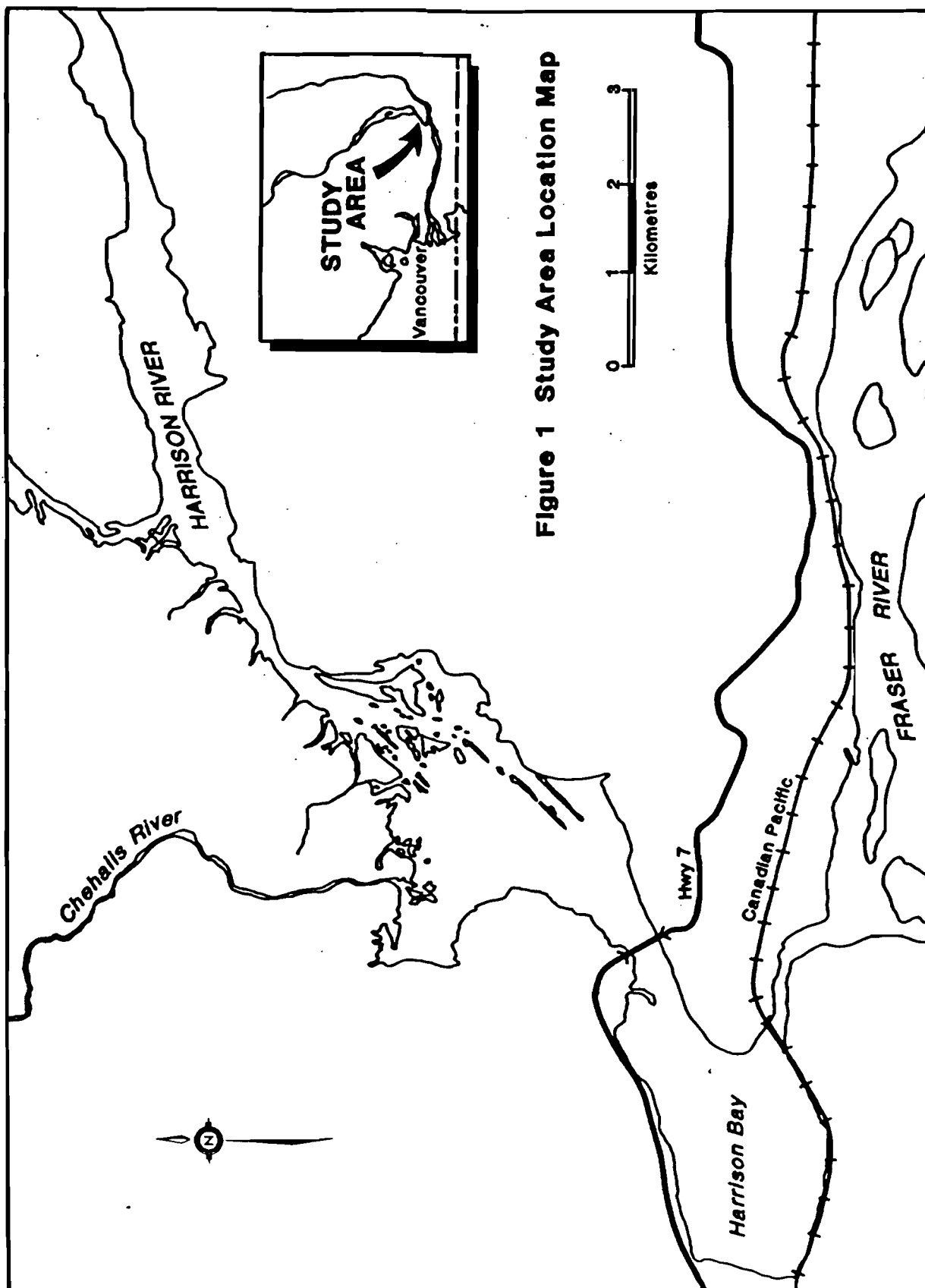


Fig. 1. Study area location map.

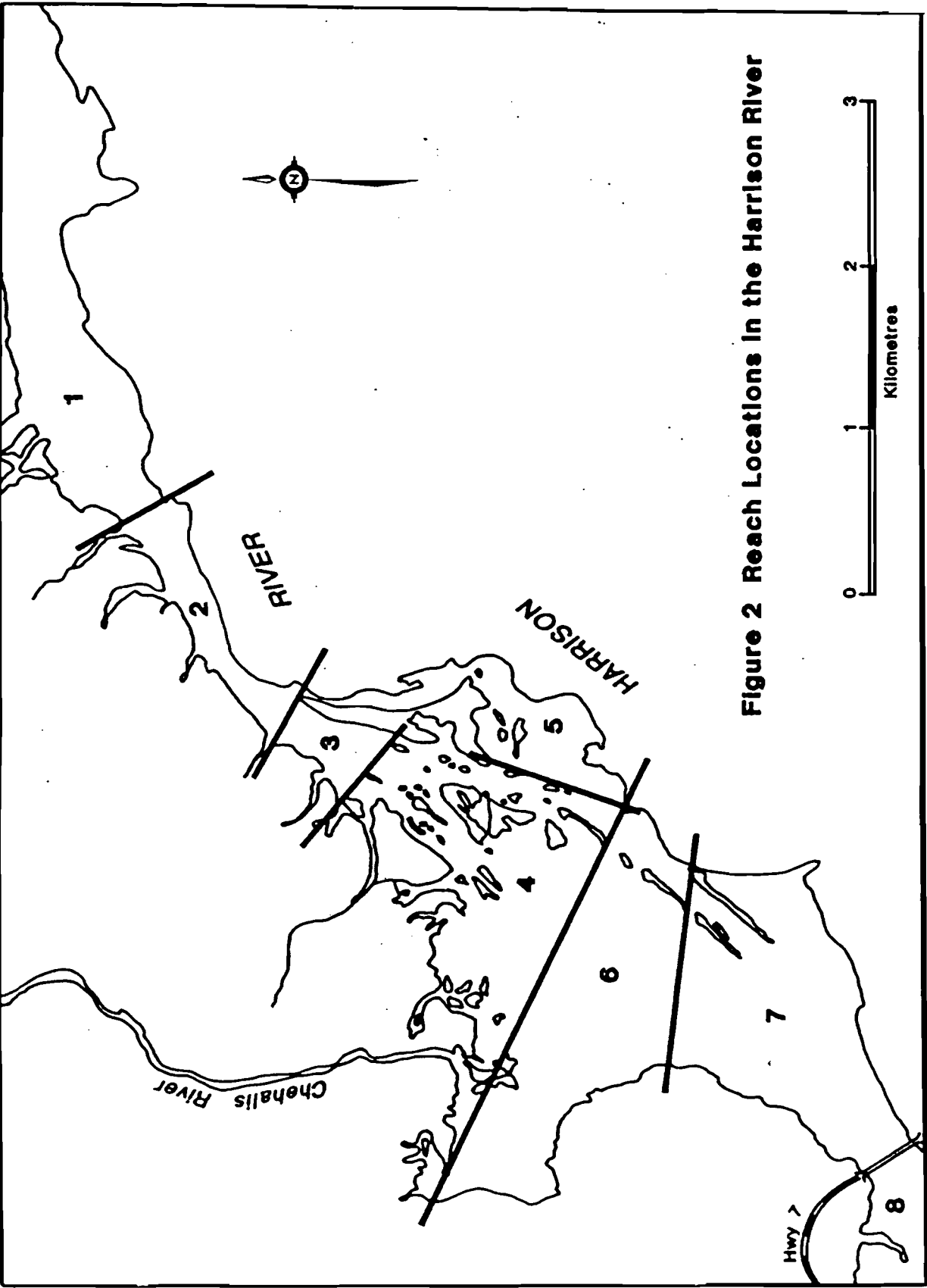


Figure 2 Reach Locations in the Harrison River

Fig. 2. Reach locations in the Harrison River.

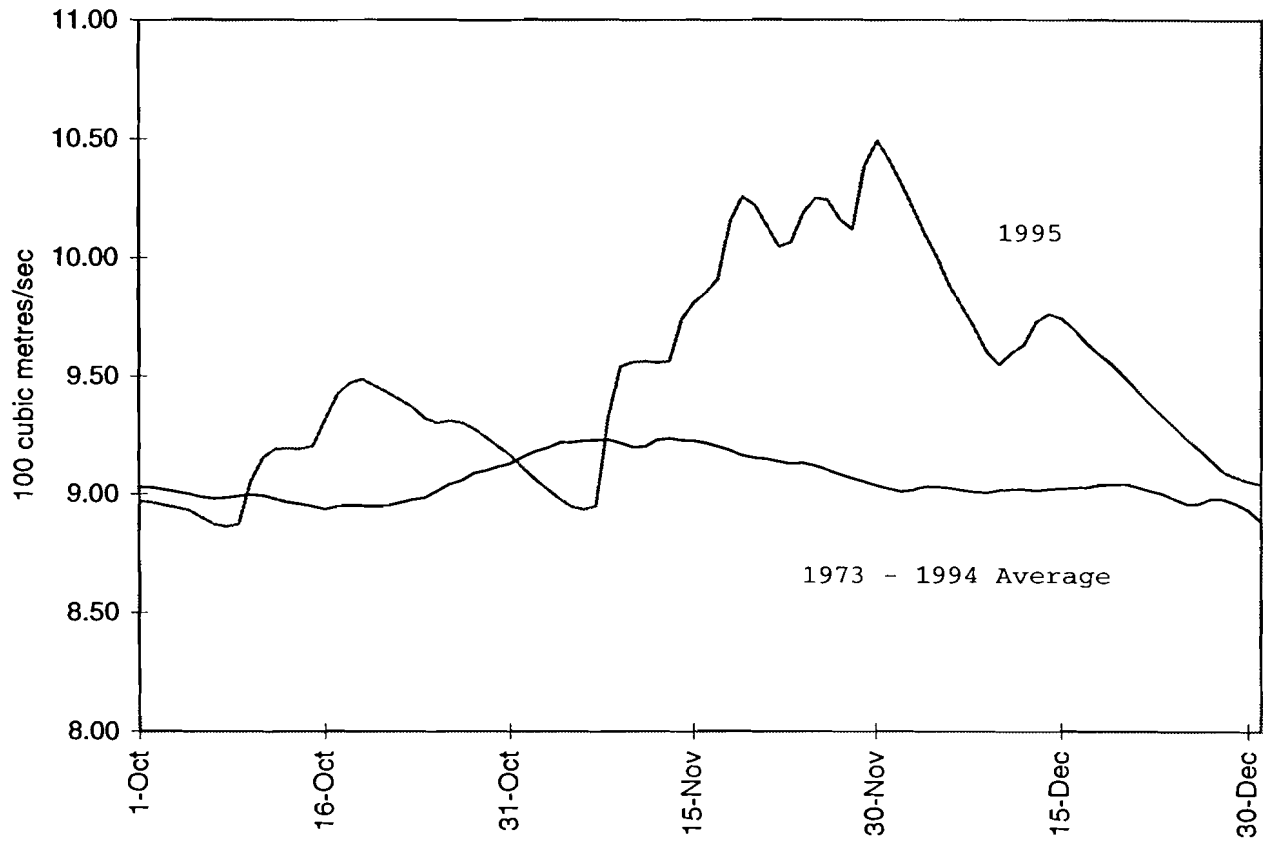


Fig. 3. Water flow in the Harrison River near Harrison Hot Springs, October - December, 1995 and 1973-1994 average.

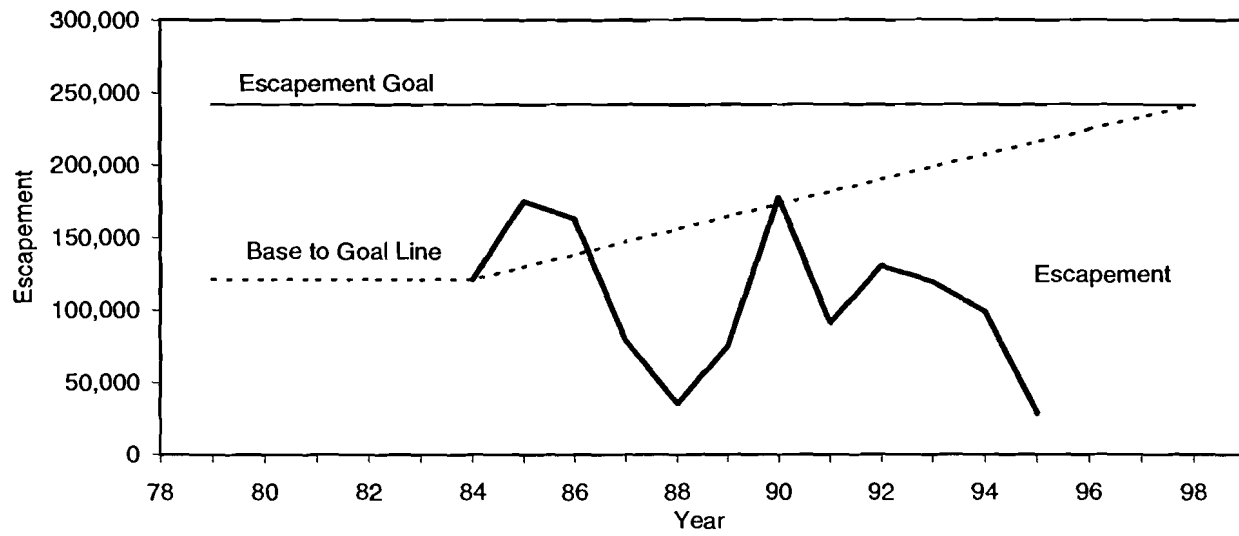


Fig. 4. Harrison River chinook annual escapement relative to the escapement goal and the base to goal linear rebuilding approximation.

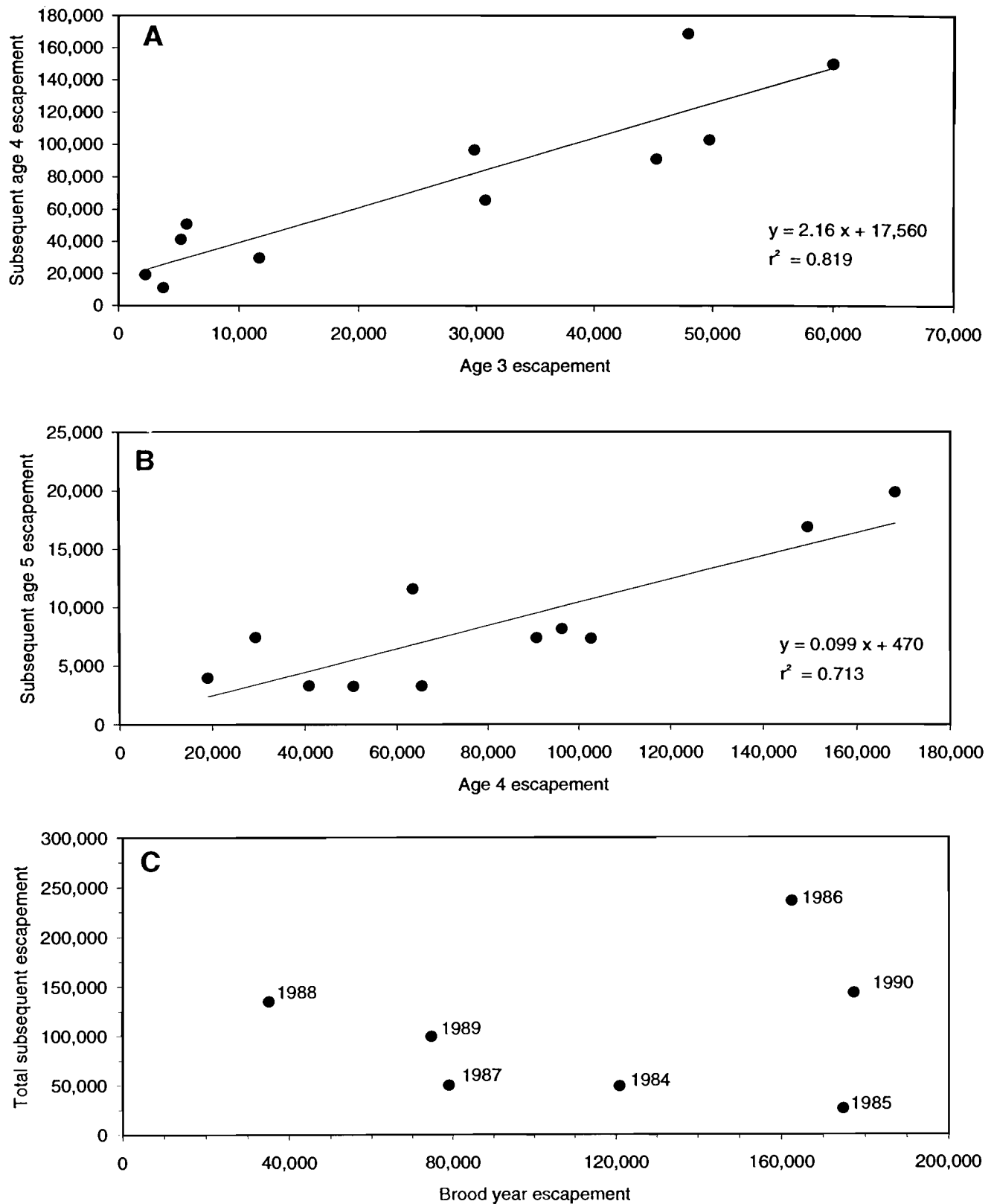


Fig. 5. Harrison River chinook escapement patterns: A) escapement at age 3 versus escapement at age 4 one year later; B) escapement at age 4 versus escapement at age 5 one year later; and C) parental escapement versus total subsequent escapement for that brood year.

Appendix 1. Daily application of spaghetti tags and secondary marks, by reach, adipose fin status and sex, to chinook adults in the Harrison River, 1995. a

Spaghetti tags applied													
Date	Reach	Adipose present			Adipose absent			Total			Recaptures		
		Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Jack b
17-Oct	2	22 c	24	46	0	0	0	22	24	46	10	7	4
18-Oct	2	29	24	53	0	0	0	29	24	53	1	0	0
19-Oct	2	15	23	38	0	0	0	15	23	38	1	4	4
20-Oct	2	13	12	25	0	0	0	13	12	25	2	3	2
23-Oct	2	21 c	17 c	38	1	0	1	22	17	39	2	5	2
24-Oct	2	2	5	7	0	0	0	2	5	7	0	0	2
27-Oct	2	10	2	12	0	0	0	10	2	12	0	0	1
30-Oct	2	1	3	4	0	0	0	1	3	4	0	0	0
31-Oct	2	0	1	1	0	0	0	0	1	1	0	0	0
31-Oct	4	17 d	11	28	0	0	0	17	11	28	2	1	1
02-Nov	2	0	1	1	0	0	0	0	1	1	0	0	0
03-Nov	2	2	2	4	0	0	0	2	2	4	1	0	0
14-Nov	4	3	4	7	0	0	0	3	4	7	0	0	0
Total	2	115	114	229	1	0	1	116	114	230	17	19	15
	4	20	15	35	0	0	0	20	15	35	2	1	1
Total	-	135	129	264	1	0	1	136	129	265	19	20	16

a. Not corrected for sex identification errors.

b. Jacks were released untagged.

c. Includes 1 which required ventilation.

d. Includes 2 which required ventilation.

Appendix 2. Spaghetti tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status, tag number and age, of chinook adults recovered in the Harrison River, 1995.

Application sample						Recovery sample					Days out
Date	Reach	NF length (cm)	Sex	Adipose fin	Spaghetti tag number	Date	Reach	POH length (cm)	Sex	Age	
17-Oct	2	97.0	F	P	M00004	06-Nov	6	79.2	F	5/1	20
17-Oct	2	74.0	F	P	M00025	26-Oct	7	63.0	F	3/1	9
17-Oct	2	81.0	F	P	M00043	27-Oct	5	65.8	F	3/1	10
18-Oct	2	90.0	F	P	M00051	01-Nov	4	77.5	F	4/1	14
18-Oct	2	80.0	F	P	M00056	06-Nov	6	64.8	F	3/1	19
18-Oct	2	91.0	F	P	M00068	25-Oct	6	77.8	F	5/1	7
19-Oct	2	84.0	F	P	M00128	01-Nov	4	68.9	F	5/1	13
19-Oct	2	93.0	F	P	M00134	06-Nov	7	76.0	F	5/1	18
20-Oct	2	83.0	M	P	M00156	25-Oct	4	70.0	M	4/1	5
20-Oct	2	80.0	F	P	M00162	03-Nov	6	63.5	F	3/1	14
23-Oct	2	91.0	F	P	M00170	06-Nov	6	73.9	F	4/1	14
23-Oct	2	78.0	M	P	M00196	03-Nov	6	65.0	M	3/1	11
23-Oct	2	83.0	F	P	M00200	03-Nov	6	-	F	4/1	11
Females initially identified as males:				0	0.0%					Mean days out:	12.7
Males initially identified as females:				0	0.0%					Max. days out:	20.0
										Min. days out:	5.0
POH and NF Regressions:		Females	POH =		0.85 NF - 2.02, ($r^2 = 0.91$)						
			NF =		1.08 POH + 9.67						
		Males	not applicable; only two data points								

Appendix 3. Daily chinook carcass recoveries, by reach, mark status and sex, in the Harrison River, 1995.

Date	Reach	Unmarked		Spagetti tag and secondary mark		Secondary mark only		Spagetti tag only		Total			Adipose fin absent	
		Male	Female	Male	Female	Male	Female	Male	Femal	Male	Female	Jack a	Male	Female
24-Oct	2	0	1	0	0	0	0	0	0	0	1	0	0	0
	3	2	1	0	0	0	0	0	0	2	1	0	0	0
25-Oct	3	5	2	0	0	0	0	0	0	5	2	0	0	0
	4	81	115	1	0	0	0	0	0	82	115	0	0	0
	6	22	34	0	1	0	0	0	0	22	35	1	0	0
26-Oct	7	38	34	0	1	0	0	0	0	38	35	3	0	1
	8	41	17	0	0	0	0	0	0	41	17	3	2	0
27-Oct	5	1	1	0	1	0	0	0	0	1	2	0	0	0
	8	7	6	0	0	0	0	0	0	7	6	0	0	0
01-Nov	4	86	168	0	2	0	0	0	0	86	170	2	0	1
02-Nov	2	19	12	0	0	0	0	0	0	19	12	0	0	0
	4	36	102	0	0	0	0	0	0	36	102	3	0	1
03-Nov	6	102	191	1	2	0	0	0	0	103	193	4	1	0
06-Nov	6	116	221	0	3	0	0	0	0	116	224	3	0	0
	7	37	21	0	1	0	0	0	0	37	22	4	0	1
	8	21	9	0	0	0	0	0	0	21	9	8	0	0
07-Nov	4	39	45	0	0	0	0	0	0	39	45	1	0	0
	8	87	37	0	0	0	0	0	0	87	37	6	0	0
10-Nov	4	17	22	0	0	0	0	0	0	17	22	0	0	0
	7	4	3	0	0	0	0	0	0	4	3	0	0	0
	8	2	1	0	0	0	0	0	0	2	1	0	0	0
15-Nov	2	3	0	0	0	0	0	0	0	3	0	0	0	0
	6	12	21	0	0	0	0	0	0	12	21	0	0	0
	7	11	7	0	0	0	0	0	0	11	7	0	0	0
16-Nov	4	11	7	0	0	0	0	0	0	11	7	0	0	1
	7	1	4	0	0	0	0	0	0	1	4	0	0	0
	8	26	19	0	0	0	0	0	0	26	19	1	0	0
17-Nov	2	1	0	0	0	0	0	0	0	1	0	0	0	0
20-Nov	7	8	7	0	0	0	0	0	0	8	7	0	0	1
21-Nov	7	1	0	0	0	0	0	0	0	1	0	0	0	0
	8	1	1	0	0	0	0	0	0	1	1	0	0	0
22-Nov	5	2	2	0	0	0	0	0	0	2	2	0	0	0
05-Dec	6	1	5	0	0	0	0	0	0	1	5	0	0	0
	8	2	2	0	0	0	0	0	0	2	2	0	0	0
07-Dec	8	0	1	0	0	0	0	0	0	0	1	0	0	0
12-Dec	7	3	2	0	0	0	0	0	0	3	2	0	0	0
	8	0	7	0	0	0	0	0	0	0	7	0	0	1
14-Dec	2	1	0	0	0	0	0	0	0	1	0	0	0	0
	4	0	1	0	0	0	0	0	0	0	1	0	0	0
	6	1	0	0	0	0	0	0	0	1	0	0	0	0
Total	2	24	13	0	0	0	0	0	0	24	13	0	0	0
	3	7	3	0	0	0	0	0	0	7	3	0	0	0
	4	270	460	1	2	0	0	0	0	271	462	6	0	3
	5	3	3	0	1	0	0	0	0	3	4	0	0	0
	6	254	472	1	6	0	0	0	0	255	478	8	1	0
	7	103	78	0	2	0	0	0	0	103	80	7	0	3
	8	187	100	0	0	0	0	0	0	187	100	18	2	1
Total		848	1,129	2	11	0	0	0	0	850	1,140	39	3	7

a. Adipose status not recorded for jacks.

Appendix 4. Proportion at age and mean length at age, by AFC status and sex, of chinook carcasses recovered on the Harrison River spawning grounds, 1995.

Adipose fin status	Age a	Female			Male		
		Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Unmarked	5/1	26	28.8%	75.8	13	24.5%	8.2
	4/1	43	47.3%	72.5	18	34.0%	7.4
	3/1	22	24.2%	65.5	22	41.5%	6.3
	Sub-1	91	100.0%	71.8	53	100.0%	65.2
	Sub-2	0	0.0%	-	0	0.0%	-
	Total	102	62.2%	72.1	62	37.8%	66.0
	Flesh colour						
	Red	0	0.0%	-	0	0.0%	-
	White	105	100.0%	72.0	65	100.0%	66.0
Adipose fin clip	5/1	2	28.8%	77.2	0	0.0%	-
	4/1	2	28.8%	71.8	0	0.0%	-
	3/1	3	42.9%	66.8	2	100.0%	69.6
	Sub-1	7	100.0%	71.1	2	100.0%	69.6
	Sub-2	0	0.0%	-	0	0.0%	-
	Total	7	50.0%	71.1	7	50.0%	68.4
	Flesh colour						
	Red	0	0.0%	-	0	0.0%	-
	White	7	100.0%	71.11	3	100.0%	68.4
Total	5/1	28	28.8%	75.9	13	23.6%	81.6
	4/1	45	45.9%	72.5	18	32.7%	74.5
	3/1	25	25.5%	65.9	24	43.6%	63.9
	Sub-1	98	100.0%	71.8	55	100.0%	65.3
	Sub-2	0	0.0%	-	0	0.0%	-
	Total	109	61.2%	72.0	69	36.8%	66.1
	Flesh colour						
	Red	0	0.0%	-	0	0.0%	-
	White	112	100.0%	72.0	68	100.0%	66.1

a. Totals include unusable samples.

Appendix 5. AFC and CWT sampling of chinook adults recovered on the Harrison River spawning grounds, 1995

			Sampling results		
			Male	Female	Total
Sample size			850	1,140	1,990
Number with AFCs			3	7	10
AFC but no head			0	2	2
CWT lost during processing			0	1	1
AFC but no CWT			1	2	3
CWT recovered:					
Code	Brood	Release site			
18 08 43	1992	Chehalis Hatchery	2	1	3
18 03 36	1991	Chehalis Hatchery	0	1	1
Total			2	2	4
AFC incidence (%)			0.35%	0.61%	0.50%
CWT loss (%)			33.33%	50.00%	42.86%
Spatial pattern in AFC incidence:					
Upper Section (reaches 1,2)			0.00%	0.00%	0.00%
Middle Section (reaches 3,4,5)			0.00%	0.64%	0.40%
Lower Section (reaches 6,7,8)			0.55%	0.61%	0.58%
Temporal pattern in AFC incidence:					
Early Period (24-Oct to 10-Nov)			0.39%	0.38%	0.38%
Late Period (11-Nov to 14-Dec)			0.00%	3.49%	1.75%

Appendix 6. Incidence of CWT loss, by carcass condition, eye status, and AFC condition, in AFC chinook adult carcasses recovered on the Harrison River spawning grounds, 1995.

Observation	Condition	Number a	CWT absent b	CWT loss (%)
Carcass condition	Fresh	0	0	-
	Moderately fresh	5	2	40.0%
	Moderately rotten	2	1	50.0%
	Rotten	1	0	0.0%
Eyes present	None	2	0	0.0%
	One	3	2	66.7%
	Two	3	1	33.3%
Adipose fin clip	Complete	4	0	0.0%
	Partial	4	3	75.0%
	Questionable	0	0	-

a. Excludes two AFC carcasses with no heads.

b. Includes one CWT lost during processing.

Appendix 7. Spawning success, by mark status, in female chinook carcasses recovered on the Harrison River spawning grounds, 1995.

		Percent spawned			Weighted mean
Mark status		0%	50%	100%	
Spaghetti tag or secondary mark	Number	3	1	7	68.2%
	Percent	27.3%	9.1%	63.6%	
Unmarked	Number	22	9	66	72.7%
	Percent	22.7%	9.3%	68.0%	
Total	Number	25	10	73	72.2%
	Percent	23.1%	9.3%	67.6%	