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1991 Wannock River Chinook Salmon
Mark-Recapture Experiment

by

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ABSTRACT

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A mark-recapture experiment was conducted on Wannock River chinook salmon (*Onchorynchus tshawytscha*) to improve stock assessment. The Canadian Department of Fisheries and Oceans has comitted to halting the decline of chinook salmon stocks under the Pacific Salmon Treaty of 1985. The Wannock River is the largest component of the Rivers Inlet chinook salmon "escapement indicator stock". The mark-recapture experiment conducted on Wannock River chinook salmon in 1991 estimated female escapement at 3900 to 4000 using Bayesian analysis.

RÉSUMÉ

Winther, I. 1992. 1991 Wannock River chinook salmon mark-recapture experiment. Can. Manuscr. Rep. Fish. Aquat. Sci. 2168: iv + 37 p.

Une expérience de marquage-recapture, destinée à améliorer l'évaluation des stocks, a été menée sur le saumon quinnat (*Onchorynchus tshawytscha*) de la rivèire Wannock. Le ministère des Pêches et des Océans du Canada s'est engagé, dans le cadre du traité de 1985 sur le saumon du Pacificque, à mettre un terme au déclin des stocks de saumon quinnat. Le stock de la Wannock est le principal élément du "stock indicateur des échappées" de saumon quinnat de l'inlet Rivers. L'expérience de marquage-recapture menée in 1991 dans la rivière Wannock a permis d'estimer à 3 900 à 4 000 l'échappée de femelles selon une analyse bayesienne.

TABLE OF CONTENTS

INTRODUCTION

A mark recapture experiment was carried out on the 1991 spawning population of Wannock River chinook salmon to provide information on chinook escapement.

Rivers Inlet was described as an "escapement indicator stock" by the Pacific Salmon Commission Joint Chinook Technical Committee for the purposes of the Pacific Salmon Treaty Chinook Rebuilding Program. The goal for Rivers Inlet was to rebuild chinook spawning populations to a level of 4950 by 1998. This goal represented twice the average spawning escapement for the base period of 1979 to 1982 (Anon. 1991).

The Department of Fisheries and Oceans identifies 11 spawning streams with historical chinook escapements in Rivers Inlet (Statistical Area 9). The Wannock River represents the largest single component of the Rivers Inlet stock accounting for 82% of chinook escapements recorded since 1970. Eight chinook spawning streams, the Amback, Ashlulm, Dallery, Neechanz, Sheemahant, Tzeo and Washwash Rivers, are tributaries of Owikeno Lake accounting for less than 5% of escapements. The Clyak River flowing into Moses Inlet accounts for less than 1%. The Kilbella and Chuckwalla Rivers flow into Kilbella Bay near the head of Rivers Inlet and account for the remaining 12% (Goruk & Winther 1992). Beyond the difference in magnitude exists a difference in the quality of escapement data. Historical chinook escapement information for Owikeno Lake tributaries and the Clyak river consists of visual estimates on the basis of few visits to the streams, often single visits at times other than peak spawning. Thus escapements to the Wannock River drive the escapement trends of Rivers Inlet chinook.

Prior to 1970 visual estimates of chinook escapement to the Wannock River were made. The Wannock River is clouded by glacial silt making visual population estimates inadequate in all but the lowest water conditions. In an attempt to improve population estimates Hilland (1974) conducted mark recapture experiments on Wannock River chinook in 1973 and 1974. Chinook were caught using a beach seine and marked with adipose fin clips. Spawning populations of 4842 and 5446 chinook were found in 1973 and 1974 respectively using simple Petersen estimates. Final escapement figures of 1000 in 1973 and 5500 in 1974 show inconsistent use of the mark recapture information (Goruk & Winther 1992).

Chinook mark recovery and/or carcass enumeration programs were carried out on the Wannock River from 1976 to 1981 and 1984 to 1990 by contractors and guardians of the Fisheries Branch of DFO. The marking programs of 1978 to 1981, 1984, and 1987 to 1990 were conducted during the Industry Inspection of the Owikeno Lake Fall

Survey. These marking programs consisted of a single day of collecting chinook by beach seining and applying Petersen disc tags. Less than 50 chinook were marked annually (Bachen et. al. 1991, Winther et. al. 1990, 1989, Thomson et. al. 1988). No marks were applied in 1976, 1977, and 1985. In 1986, Petersen discs tags were applied to 38 chinook during the Industry Inspection and 82 chinook were marked with spaghetti tags applied by members of the Salmonid Enhancement Program. Final escapement figures from these programs were not derived from mark recapture analytical techniques, rather, combinations of carcass enumeration and visual estimation were incorporated.

In considering historical data it is important to note differences in method of escapement estimation. Escapement estimations for the base period of 1979 to 1982 include carcass enumerations in three of the years but no carcass sampling in 1982. It is not probable that population estimates mark-recapture experiments are comparable with estimates or indices from the base period.

Carcass enumeration on the Wannock River has been conducted by the Department of Fisheries & Oceans (DFO) through funding made available by international commitments under the Pacific Salmon Treaty since 1985. Prior to 1985 chinook carcass enumeration was funded through divisional budgets and through enhancement operations. In 1991 additional Native Co-management funds enabled a larger mark-recovery project. This report presents analyses of data collected jointly by the Oweekeno Band Native Co-management group and a DFO contractor (V. Sampson) to determine the size of the chinook spawning population of the Wannock River in 1991.

Study area description

The Wannock River is located approximately 400 km northwest of Vancouver, British Columbia, at latitude 51° 45' 45" north and longitude 127° 10' 45" west. It is approximately 6 km long, flowing west from Owikeno Lake to Rivers Inlet (Figure 1). The Wannock River drains 3940 km^2 of steep terrain in the Coast Mountains. Glaciers feed most tributaries making the water turbid. The Wannock River is subject to flooding, especially during the study period of October and November. Mean annual flow has been recorded at 326 m^3/s (averaged from 1928 to 1934 and 1961 to 1988). Maximum flow recorded was 2920 m^3/s in January of 1968 but maximum annual flows have occurred during the study period for 16 of the 34 years on record (Anon. 1989). High water conditions can have extremely detrimental effects to program operations by making the capture of chinook for marking difficult and by flushing carcasses from the river, thus reducing the number available for recovery.

The Wannock River valley is less than 2 km wide below the 200 m contour and mountains rise steeply from the valley floor. The river flows along the southern edge of the valley for 2 km then crosses to Kahtit Creek on the north side and empties into Rivers Inlet. The Katit Indian Reserve (Oweekeno Band) occupies most of the valley north of the river and a portion of the south bank near the lake outlet. The valley is heavily wooded. A logging road from Owikeno Lake to Rivers Inlet and an Indian village exist on the north side of the river. There are a few cabins on the south side of the river near the inlet.

At the outlet of Owikeno Lake the Wannock River is broad and slow. The south bank is bedrock rising steeply from the water and the north bank has a gradual gradient of gravel, sand and silt. Approximately 1.5 km downstream of Medowse Creek the river broadens to the north around an islet locally known as "Smokehouse Island". At its narrowest point, approximately 4 km from Rivers Inlet, the Wannock River is 90 meters wide and falls over a short cataract. Immediately downstream the river widens to 200 m and a deep pool exists on the south side, locally referred to as the "spring pool" or "seine hole". The gradient of the south bank decreases and the substrate changes from bedrock to gravel and boulders as the river turns north. A gravel bar exists opposite the spring pool near the center of the river and is exposed at river levels below 2.3 m. (River levels are according to a staff gauge mounted to the outer surface of the water gauging station west of Medowse Creek.) North of the gravel bar the river is shallow and strewn with boulders to 1 m in diameter. The boulder field continues downstream past the tail of the spring pool. Below, the river bed is coarse gravel and boulders with steep banks. The Wannock river runs almost straight from the spring pool to Kahtit Creek where it bends south before entering Rivers Inlet.

Tidal fluctuations are experienced 2.5 km upstream from Rivers Inlet during extreme high tides. A large gravel bar, submerged at high tide, occupies the north part of the Wannock River delta; the Nichnaqueet River shares the southern part. Log dumps and booming grounds exist at the northern and southern edges of the estuary.

METHODS

Applying Marks

Chinook were seined from the spring pool of the Wannock River from October 12 to 31, 1991. Samples were collected daily except on October 17, 18 and 27 when no samples were taken. Setting the seine consisted of towing the net with a jet boat out from the beach in an arc downstream and back to the beach. The net was pursed by closing the arc and drawing the lead line against the beach trapping the fish in a bag of net. Chinook were held in the seine, sampled, marked and released. Sampling consisted of collecting data on date, sex, postorbital-hypural (POH) length and an assessment of condition by noting visible scars or injuries. Marking consisted of punching a 7 mm hole and applying a tag to the left operculum of chinook greater than 35 cm POH length. Chinook less than 35 cm POH length received a 7 mm hole punched through the right operculum. Care was taken not to damage the gills. Tags were individually numbered metal Kurl Lock tags designed for sheep ear tagging by Ketchum Manufacturing Company. Tags were applied with specially modified pliers, even numbered tags for females and odd numbered tags for males.

A sample of precocious male chinook (jacks) less than 55 cm POH were killed for ageing purposes for the Owikeno Salmonid Enhancement Program (OSEP). Initially every seventh jack was killed but later in the program the selection process was stratified in an attempt to provide 10 chinook for each of the following length criteria; 25-30 cm, 30-35 cm, 35-40 cm, 40-45 cm, 45-50 cm, and 50-55 cm POH length. These fish were collected from the tag application sample.

Recovery Sample

Chinook carcasses were sampled daily from October 25 to November 23, on November 27 and 28, and from December 1 to 5, 1991. A 2 man crew ran the entire length of the river by jet boat in search of carcasses. Samples consisted of date, POH length, sex, and marks present. Each fish was checked for opercular punches, tags and fin clips. Chinook were sampled and cut in half before being returned to the river bank. Kurl Lock tags were removed if encountered.

Analysis

1) Population Estimation

Female population size was estimated using a sequential Bayes algorithm as described by Gazey & Staley (1981). This method was selected as the main population estimator because of the small number of marked fish recovered. Calculations of the Bayesian estimation of posterior probability were based on 301 (K = 301) discrete population levels in increments of 50 between 1000 and 16000 female chinook (N_1=1000, N_2=1050,..., N_{301}=16000) for a single time period (T=1). The probability of observing all R_t's given the population size N_i over T sampling intervals given:

M_t = total marked fish at the start of sampling interval t;
C_t = total number of fish sampled during interval t and
R_t = number of recaptures in the sample C_t is:

$$P(N_t \mid R_1, R_2, \ldots R_T) = \frac{\prod_{t=1}^{T}\left(\frac{1}{N_t}\right)^{R_t}\left(1-\frac{M_t}{N_t}\right)^{C_t-R_t}}{\sum_{i=1}^{K}\prod_{t=1}^{T}\left(\frac{1}{N_T}\right)^{R_t}\left(1-\frac{M_t}{N_t}\right)^{C_t-R_t}}$$

The Chapman modification of Petersen mark recapture analysis (Ricker 1975) was presented for comparison. The formula used for the population estimate was:

$$N=\frac{(M+1)\ (C+1)}{(R+1)}$$

where:
N = the population estimate;
M = total fish marked;
C = total fish caught in the recovery sample;
R = the number of marked fish recaptured in sample C.

The Schaefer method of stratified tagging and recovery (Ricker 1975) was performed as a check of variability of conditions during the mark-recovery procedures using the formula:

$$N=\Sigma\left(R_{ij}\frac{M_i C_j}{R_i C_j}\right)$$

The notation was the same as for the Petersen estimate with subscripts i and j referring to the weeks of application and recovery respectively.

2) Bias checks

Tests performed to identify potential sources of bias to the population estimation procedure addressed generally whether the samples met the assumption of equal probability of selection. Sample statistics of sex, time and size were compared with the expectation that random samples of the same population would have the same characteristics. Similarly, the characteristics of marked and unmarked components of the recovery sample were expected to be the same, as were the recovered and not recovered components of the application sample.

Kolmogorov-Smirnov two sample tests (Sokal & Rohlf 1981) were used to compare length frequency distributions of the application and recovery samples, of marked and unmarked components of the recovery sample, and of recovered and unrecovered components of the application samples.

Chi squared contingency tables (Zar 1985) were used to measure differences in sex ratio, to determine sexual bias, and to determine temporal bias between the application and recovery samples.

All tests were made to the 5% level of probability ($p < .05$).

RESULTS

Mark Application

A total of 427 male and 215 female chinook were caught during the mark application sample. All females caught were greater than 55 cm POH length and all received tags and opercular punches. Marks were applied to 359 male chinook. POH length was not recorded for 3 females and 40 males caught on October 12, 1991. Table 1 summarizes marks applied by length criteria. Appendix 1 details the date, sex, POH length, tag number and/or mark type for all marked chinook.

Chinook catch per day is summarized in Table 2. The catch of female chinook was lower early and late in the application sample period. Males were caught in large numbers at the start of the application sample, decreasing later in the sample.

Chinook Removed from the Population

A total of 100 chinook, 50 females and 50 males, were collected for brood stock for the Oweekeno Salmonid Enhancement Project. Fourteen females and 17 males had tags and left opercular punches.

A total of 71 chinook were collected for the OSEP age study. Three marked jacks (with right opercular punches) and 68 unmarked chinook (mostly jacks) were removed from the application sample. Length and age data from the OSEP sample appear in Appendix 2.

Tag Loss

One tag (# 8676) was found at the seining site. Two female chinook were recaptured in the seining process with left hand opercular punches and no tags. No chinook from the recovery sample had evidence of tag loss (opercular punches without Kurl lock tags).

Mark Recovery

Crews examined 148 male and 235 female chinook carcasses for marks. POH lengths were recorded from 137 males and 174 females;

others were too decomposed to measure. A total of 15 marked chinook were recovered, 3 males and 12 females: all had tags and left opercular punches. Data for chinook mark recoveries is summarized in Table 3. Data collected for all chinook recovered included date, sex, POH length, and marks (Appendix 3).

The peak carcass recovery period was mid November. Table 4 compares 1991 carcass recoveries with historical data. Data collected in 1991 were compared with historical mark-recapture and escapement data in Table 5.

Population Estimation

The male chinook population was not estimated because of the bias in the samples and the low number of recoveries.

The mode of the Bayesian population estimate for female chinook in the Wannock River in 1991 was located at 3900 - 4000. The 2.5 and 97.5 % probability quantiles were 2600 and 8500 female chinook respectively. The 95% highest probability density was between 2250 and 7700 female chinook. Figure 2 represented the posterior probability distribution for the Bayesian estimate of the female chinook population.

The population estimate of female chinook using the Chapman modification of the Petersen estimate was 3664. 95% confidence limits of approximately 2167 and 6621 were obtained from tables appropriate to the Poisson distribution and entering R (the number of marked fish in the recovery sample) as 6.2 and 21.

The Schaefer estimate of the female chinook data with the application and recovery samples separated by week was 3207. Data are presented by week of the application and recovery samples in Appendix 4.

Bias Tests

Table 6 charts the process of identifying and isolating bias in the chinook sample data. An indication of bias in the table (YES) reflected a significant difference between samples or statistics being compared.

Differences in length frequency distribution (size bias) and sexual composition were found in the comparison of the application and recovery samples (Table 6A). In Table 6B the statistics of sex, time and size were compared within each of the application and recovery samples respectively. The comparisons were made between recovered and nonrecovered components of the application sample and between marked and unmarked components of the recovery sample. Bias was present in all statistics of the recovery sample compared in Table 6B. Although bias was not measurable in statistics of the application sample, the removal of small (< 55 cm), male chinook from early in the sample for the OSEP age data effectively biased all the statistics of size, sex and time (flagged NO* in Table 6B).

Data were blocked by sex in Table 6C, 6D and 6E to isolate the sexual bias evident in comparisons of the unblocked samples. Length frequency distributions were compared between the application and recovery samples for male and female chinook in Table 6C. Male length frequency distributions were different (Figure 3) and female length frequency distributions were the same (Figure 4). Table 6D and Table 6E, for females and males respectively, compare the statistics of time and size from within the application and recovery samples as in Table 6B. There was no measurable size or time bias in the data for females presented in Table 6D. The results of time bias tests in Table 6E become difficult to interpret because only 3 marked males were recovered. However, there was time bias to the male data from in the application sample (NO*) from the removal of the OSEP age sample and there appears to be bias in the recovery sample. It was not possible to compare the length frequency distributions within application and recovery samples due to the small sample size (UNKNOWN in Table 6E). Data for the bias tests appear in Appendices 5 through 8.

Bias was associated with the male component of the samples. The female data did not appear to be biased.

DISCUSSION

The purpose of this study was to provide an estimate of the 1991 Wannock River chinook spawning population using mark-recapture techniques. As part of the assessment of an "escapement indicator stock" the study provides information for the evaluation of chinook rebuilding as committed under the Pacific Salmon Treaty.

The female chinook population estimate for the Wannock River was 3900 to 4000 chinook using the Bayesian analysis. Bias and low numbers of mark recoveries did not allow for an estimate of the male component of the population.

Assuming all marks were identified and reported, the sum of unique individuals in the application, recovery and brood stock samples was 1079 chinook, 605 males and 474 females.

Basic assumptions of the mark-recapture experiment were:

1) The population was closed and did not change in size through the duration of the experiment.
2) The probability of recovering a marked fish was proportional to the number of marked fish released into the population.
3) Fish did not lose their marks during the experiment.
4) All marks were identified and reported on recovery.

Assumption 1; closure:

Geographically, the experiment was confined to the Wannock River. The boundary at the lake outlet may have violated the assumption of closure to some degree as the extent of spawning in the lake was unknown. With respect to run timing, Wannock River chinook are the last Rivers Inlet stock to spawn. Straying from Kilbella and Chuckwalla Rivers or chinook passing through to streams above Owikeno Lake is therefore unlikely. Owikeno Lake tributary stocks have completed spawning with the last carcasses being observed during sockeye enumerations in September. Kilbella/Chuckwalla stocks have also finished spawning in September (DFO stream survey forms, unpublished).

Temporally, the experiment covered the full duration of spawning and die off. There may have been fish holding in the river when tagging began but spawning had not started. This may have decreased the probability of marking chinook from early in the run. Recoveries in December were due to dropping water levels making deeper carcasses available rather than a continuation of spawning producing more carcasses.

Immigration, emigration and death would only have biased the population estimate if they affected marked and unmarked members differently. Recruitment was not a factor as the mark and recovery periods were sequential.

Assumption 2; equal probability:

Several sampling requirements were implied in the probability assumption:

a) Either the application of marks or the recovery sample were nonselective or the sources of selectivity were independent (Junge, 1963).
b) Marked fish were distributed randomly among the population.
c) Marking did not induce mortality, increasing or decreasing their availability to recovery.
d) Marks do not make carcasses more obvious to samplers than unmarked fish.

a) Nonselective application of marks.

A problem existed in attempting to apply marks relative to chinook timing and/or abundance to obtain a random distribution of marks. A review of carcass recovery data revealed consistent timing of peak carcass recovery through the years, suggesting consistent timing of spawning. However, chinook migration through the Wannock River is not well understood. Anecdotal evidence exists to suggest that chinook migrate up the Wannock River to Owikeno Lake then back into the river to spawn (S.K. Bachen, DFO, pers. comm.). Most visual surveys of Wannock River chinook give accounts of chinook holding at the head of the spring pool (DFO stream survey forms, unpublished). Marks applied to chinook in the spring pool were probably not applied to the stock as it passed the seine hole but rather to holding fish. Multiple migration strategies may exist further confounding the issue of nonselective mark application.

b) Random distribution of marks.

If chinook hold in the lake there may be a significant portion of the population that never becomes available to the application sample by spawning above the spring pool. An accurate population estimate would only be obtained if those chinook tagged in the spring pool distributed themselves randomly through the rest of the population. Testing this would involve stratifying the application and recovery samples spatially. Multiple tagging locations would improve the mixing of marks through the population but capturing chinook for tag application in locations other than the spring pool proved impossible in 1991. Sample selectivity is discussed further below.

c) Mark induced mortality.

A measure of fish condition (not presented) was made after capture but prior to tagging and thus did not relate condition with the stress of tagging. Staley (1990) used fish condition after tagging and female spawning success as measures of marking induced stress and mortality.

d) Mark selection in recovery.

The Kurl Lock tags do not appear to make carcasses more obvious to samplers as carcasses required close inspection in most cases before tags were detected.

Assumption 3; tag loss.

Tag loss was measured by double marking chinook > 55 cm POH with tags and opercular punches. Some tag loss was evident but its magnitude was not large enough to be manifested in the recovery sample. Recaptures in the application sample accounted for the only tag losses observed. The seining process may have caused the losses as tags could have snagged in the net and torn free. At least 2 female chinook lost tags. A tag found on the beach may have represented a third tag lost or be from one of the 2 females mentioned. Tag losses were not removed from the number of females marked in the population calculations as secondary marks (opercular punches) would have been retained.

Assumption 4; mark identification.

Chinook were checked for tags and opercular punches during the recovery sample but no tests were made to determine if marks were missed. Opercular punches could be obscured by fungus or severe decomposition. Crews were changed near the end of the recovery sample and there could have been a difference in mark detection between crews.

Sample Selectivity and Bias

Selectivity of samples could not be measured directly because actual population parameters were unknown. The process of comparing samples and sample statistics was used to identify bias in the samples.

Sexual bias was eliminated by calculating population estimates for each sex separately. The separation of sexes for population estimation is common to mark recapture studies of Pacific salmon (Staley 1990, Bocking 1991, Labelle 1990). Proper identification of sex is required. Staley (1990) describes corrections to sex identification for mark application samples of Harrison River chinook. There was no measurable sexual bias in the application sample of Wannock River chinook but bias was introduced by removing 71 jacks. The recovery sample was biased to females. Sexual bias could be driven by morphological or behavioral differences with the result that males, especially jacks, were flushed from the system and not represented in the carcass recovery sample.

Temporal bias was not significant in either of the application or recovery samples of females. Tests of male temporal bias suffered from the lack of male mark recoveries.

The extreme difference between length frequencies of males in the application and recovery samples suggested selectivity in at least one and possibly both samples. It was evident that the recovery process did not sample small chinook and there was some suggestion that the seining process selected for jacks as experienced by Staley (1990) when marking Harrison River Chinook.

The Kolmogorov-Smirnov two sample test of frequency distributions used to measure differences in length frequencies was only an approximate estimate because the number of lengths recorded for one of the samples is less than 40. Length frequency comparisons of recovered female chinook were only approximations as the sample size was 12. Length frequency comparisons of males within samples was impossible because of the sample size of 3.

Although the bias in sampling and the paucity of mark recoveries for male chinook precludes meaningful analysis, an estimate of females alone is valuable when considering escapement for the purposes of management. The male population could be extrapolated with an unbiased sex ratio. The male : female sex ratio was 2.0:1 in the application sample and was 0.6:1 in the recovery sample but sexual bias is suspected in both.

RECOMMENDATIONS

The intent of this study was to provide information to address a basic question posed by the Chinook Technical Committee: Are Wannock River chinook rebuilding? Unfortunately the study provides little information to answer the question. The changes in methods from the base period to this study preclude comparison. A consistent population estimation or index is required to determine population trends. The results of this study can only be useful in determining trends in the Wannock River chinook population provided mark-recapture studies are carried out in the future and there is consistent use and reporting of mark-recapture information in escapement figures.

Future studies can benefit from the following changes in sampling and data collection:

1) The number of marks applied should be increased (minimum 1000).
2) Samples should remain discrete and complete without the removal of parts of the sample to provide other data (eg. OSEP age sample, brood stock).
3) Data should be kept on all seine sets individually to include the number of fish caught, the time, the date and any recaptures.
4) Fish condition should be recorded after marking upon release.
5) Males and females should be marked differentially with permanent marks (eg. punches) and also receive individually numbered tags.
6) Chinook less than 55 cm POH length should receive smaller Kurl lock tags designed for chick wing tagging to provide an individually numbered mark.
7) The number of recoveries could be improved by installing small temporary obstructions in the river to trap carcasses (eg. chain link and reinforcement rod fences).
8) Data should be kept on where carcasses were recovered.
9) Carcasses should be incised to determine sex.
10) Sex identification in the application sample should be tested and corrected if necessary.
11) Additional samples (repitches) should be made of carcass recoveries to test for missed marks.
12) Basic book keeping should be improved with standardized sample forms and common training for all crews involved.
13) The application sample should be divided spatially, applying marks in different areas of the river.

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Table 1. Marks applied to Wannock River chinook salmon, 1991.

POH Length Criteria	Mark Applied	POH Length Recorded	# Chinook Females	Males
<35 cm	R punch	YES		82
<55 cm	tag and L punch	NO		31
>=35 and <55 cm	L punch	YES		3
>=35 and <55 cm	tag and L punch	YES		108
>=55 cm	tag and L punch	YES	212	126
>=55 cm	tag and L punch	NO	3	9
Total			215	359

Table 2. 1991 Wannock River chinook salmon catch per day of the application sample, recaptures not included.

	CATCH	
Date	Males	Females
12-Oct	40	3
13-Oct	20	2
14-Oct	54	6
15-Oct	55	5
16-Oct	36	5
17-Oct	31	7
18-Oct	no samples	
19-Oct	no samples	
20-Oct	33	25
21-Oct	44	34
22-Oct	33	32
23-Oct	32	31
24-Oct	9	14
25-Oct	2	3
26-Oct	14	14
27-Oct	no samples	
28-Oct	6	10
29-Oct	14	4
30-Oct	0	8
31-Oct	4	12
TOTAL	427	215

Table 3. 1991 Wannock river chinook salmon mark recoveries.

DATE marked	DATE recovered	SEX	TAG #	LENGTH marked (cm)	LENGTH recovered (cm)
20-Oct	03-Dec	F	8360	90	
20-Oct	15-Nov	F	8374	88	87.3
20-Oct	04-Nov	F	8502	81	80.3
21-Oct	21-Nov	F	8538	74	76.5
22-Oct	09-Nov	F	8594	81	81.0
22-Oct	03-Dec	F	8634	84	
22-Oct	22-Nov	F	8638	83	71.0
23-Oct	11-Nov	F	8650	90	90.5
24-Oct	19-Nov	F	8708	73	76.4
26-Oct	17-Nov	F	8736	76	
26-Oct	19-Nov	F	8760	91	91.6
28-Oct	08-Nov	F	8766	83	83.5
15-Oct	15-Nov	M	8725	80	79.2
26-Oct	03-Nov	M	9065	61	60.0
28-Oct	13-Nov	M	9091	83	85.5

Table 4. Wannock River Chinook carcass recoveries by date, 1973 to 1991. No date specific data were available for 1973 and 1977 (0 = samples with no carcasses, blanks = no sample).

	YEAR															
Date	1973	1974	1976	1977	1978	1979	1980	1981	1984	1985	1986	1987	1988	1989	1990	1991
25-Oct									0					0		0
26-Oct					1				0				2	2		0
27-Oct					3		3	1	0		1		1	1		0
28-Oct					4		3	3			4		4	7		2
29-Oct					4	6	2	4	0		2	1	10	5		0
30-Oct					2	4	5	2	0			1	4	11		0
31-Oct					3	9	5	0	2		12	1	11	5	3	0
01-Nov		33			1	2	8	1	0		20	4	30	31	0	5
02-Nov		40			3	11	4	0	0		17	10	20	10	12	3
03-Nov		33			4	8	8	2	2		64	30	14	11	15	7
04-Nov		89			2	39	11	4	2	16	84	10	12	11	21	12
05-Nov		15			19	29	6	12		64	64	48	7	18	25	11
06-Nov		226	16		18	19	6	7	5	97	57	37	20	26	35	11
07-Nov		100	13		8	28	3	0		112	57	9	22	150	88	17
08-Nov		136	11		18	19	14	26	2	64		51	61	38	90	3
09-Nov		165	18		7	68	12	14	3		45	90	18	7	91	11
10-Nov		25	9		3	176	8	13	5			8	42	0	77	21
11-Nov		75	39		40	11	18	11		170	309	4	69	0	50	26
12-Nov		55	8		2	49	19	10	6	229	148	29	30	1	3	13
13-Nov		204	12		25	82	32	11	8	37	90	17	38	6	2	16
14-Nov		148			51	83	48	11	3	37	95	11	19	0	1	16
15-Nov		73	11		42	22	55	23	5	91	42	14		0	12	24
16-Nov		117	7		32	41	27	44	10		63	39	63	0	6	3
17-Nov		31	6		21	21	57	34			88	4	12	0	8	12
18-Nov			3		3	58	39	118	11	108	16		4	0	14	14
19-Nov			11		10	57	18	68	25	45	22	8	13	0	11	20
20-Nov			14		12	0	31	58	25	33	20	4	12	0	2	27
21-Nov		64			32	2	0	17	18	9	33	2	5	0	7	13
22-Nov		88	8		37	8		24	7	18	15		9	5	22	3
23-Nov			4		23	24		87	5				1	0	0	12
24-Nov		23	5		27	22		47	2		14		4	0	0	
25-Nov			5		42	18		9			2		5	0	0	
26-Nov			3		7	11		28	3		7			0	1	
27-Nov			10		6	8		8	4		13	11		0		12
28-Nov			6		2	14		92	4		4	1				7
29-Nov			6			13		3	3		2	3				
30-Nov					9	25		3				1				
01-Dec					1	7		19				1				
02-Dec								6		8						24
03-Dec								7								27
04-Dec								14								7
05-Dec								4								4
TOTAL	724	1740	225	373	524	994	442	845	160	1138	1410	449	562	345	596	383

Table 5. Historical mark-recapture and escapement data for Wannock River chinook salmon, 1973 to 1991.

YEAR	1973	1974	1976	1977	1978	1979	1980	1981	1984	1985	1986	1987	1988	1989	1990	1991
START MARKING	Oct 14	Oct 22			Oct 22	Oct 16	Oct 15	Oct 15	Oct 18	Oct 15	Oct 14	Oct 14	Oct 18	Oct 18	Oct 19	Oct 12
END MARKING	Oct 17	Oct 24														Oct 31
MALES MARKED		26				14		29					29		25	342
FEMALES MARKED		50				17		20					20		15	200
TOTAL MARKED	101	76	120	26	39	31	34	49	48		120	33	49	50	40	542
MALE CARCASSES		829			M:F=2:1	M:F=4:1		M:F=2:1	69	457	562	188		141	247	148
FEMALE CARCASSES		777							91	673	848	261		204	349	235
TOTAL CARCASSES	724	1740	225	373	524	994	442	845	160	1138	1410	449	562	345	596	383
M MARKS RECOVERED		9							0							3
F MARKS RECOVERED		14							0							12
TOTAL RECOVERED	15	23	34	5	14	19	0	0	0		17	0	7	2	5	15
FINAL ESCAPEMENT	1000	5500	1500	1400	2000	2000	2000	3000	750	3000	7000	4500	4000	3000	3500	6500

Final escapements as recorded in Goruk & Winther, 1992.
No data for 1972, 1975, 1982 and 1983, escapement figures of 600, 3000, 750 and 1750 respectively.
No carcass recovery in 1983 but 41 males and 39 females were tagged.

Table 6. Flow chart of bias tests performed on 1991 Wannock River chinook mark recapture data.

6A. Comparison of application and recovery samples of Wannock River chinook.

Size bias	YES
Sexual bias	YES

6B. Identifying bias in application and recovery samples before separating sexes.

Sexes combined	Application sample	Recovery sample
Sexual bias	NO*	YES
Time bias	NO*	YES
Size bias	NO*	YES

6C. Separating sexes to remove sexual bias in the comparison of the application and recovery samples.

	Males	Females
Size bias	YES	NO

6D. Identification of bias in the female component of the application and recovery samples.

FEMALES	Application sample	Recovery sample
Time bias	NO	NO
Size bias	NO	NO

6E. Identification of bias in the male component of the application and recovery samples. Note only 3 male mark recoveries.

MALES	Application sample	Recovery sample
Time bias	NO*	YES
Size bias	UNKNOWN	UNKNOWN

* Bias introduced in sampling but not identified by the statistical test; see text.

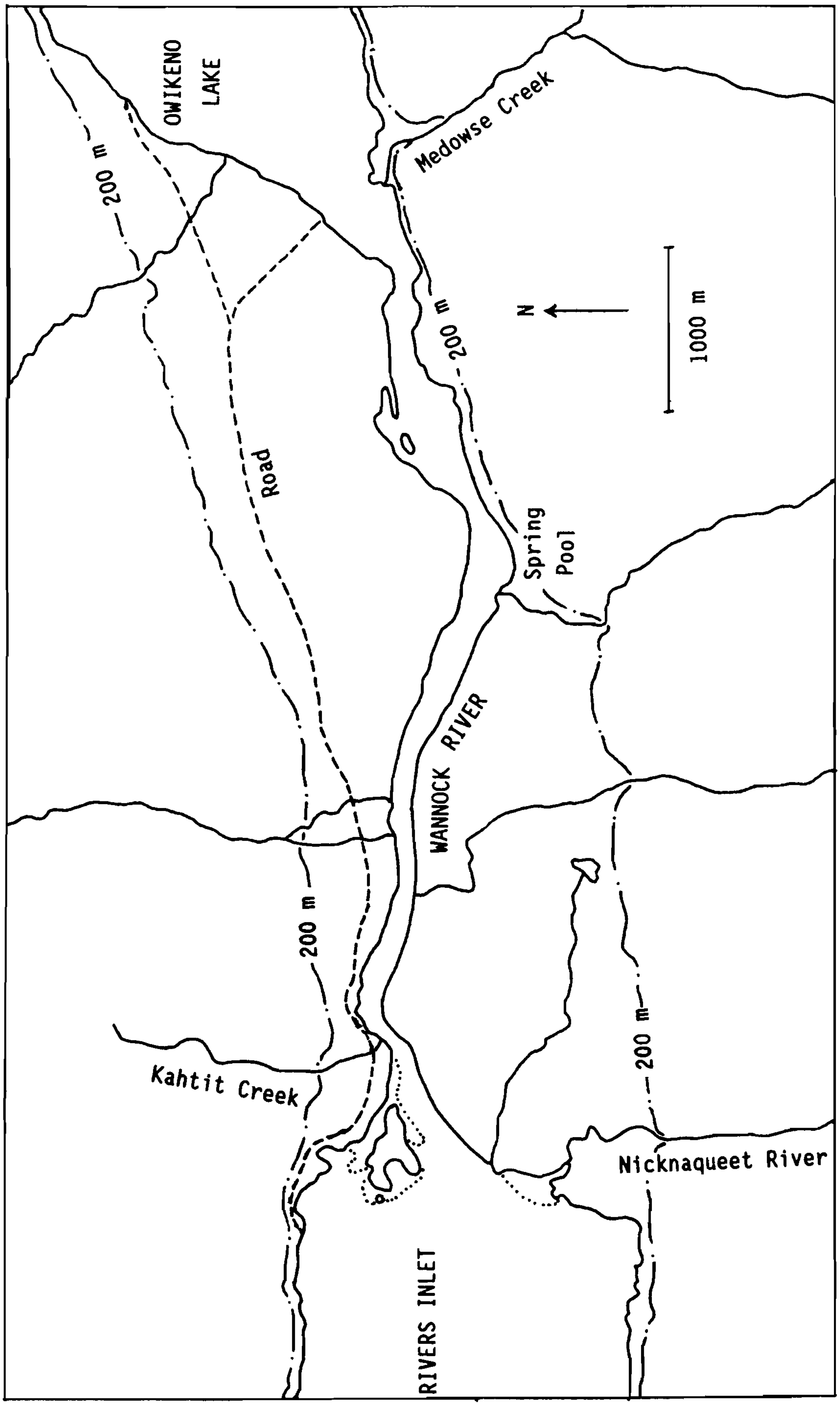


Figure 1. Wannock River, Rivers Inlet, British Columbia.

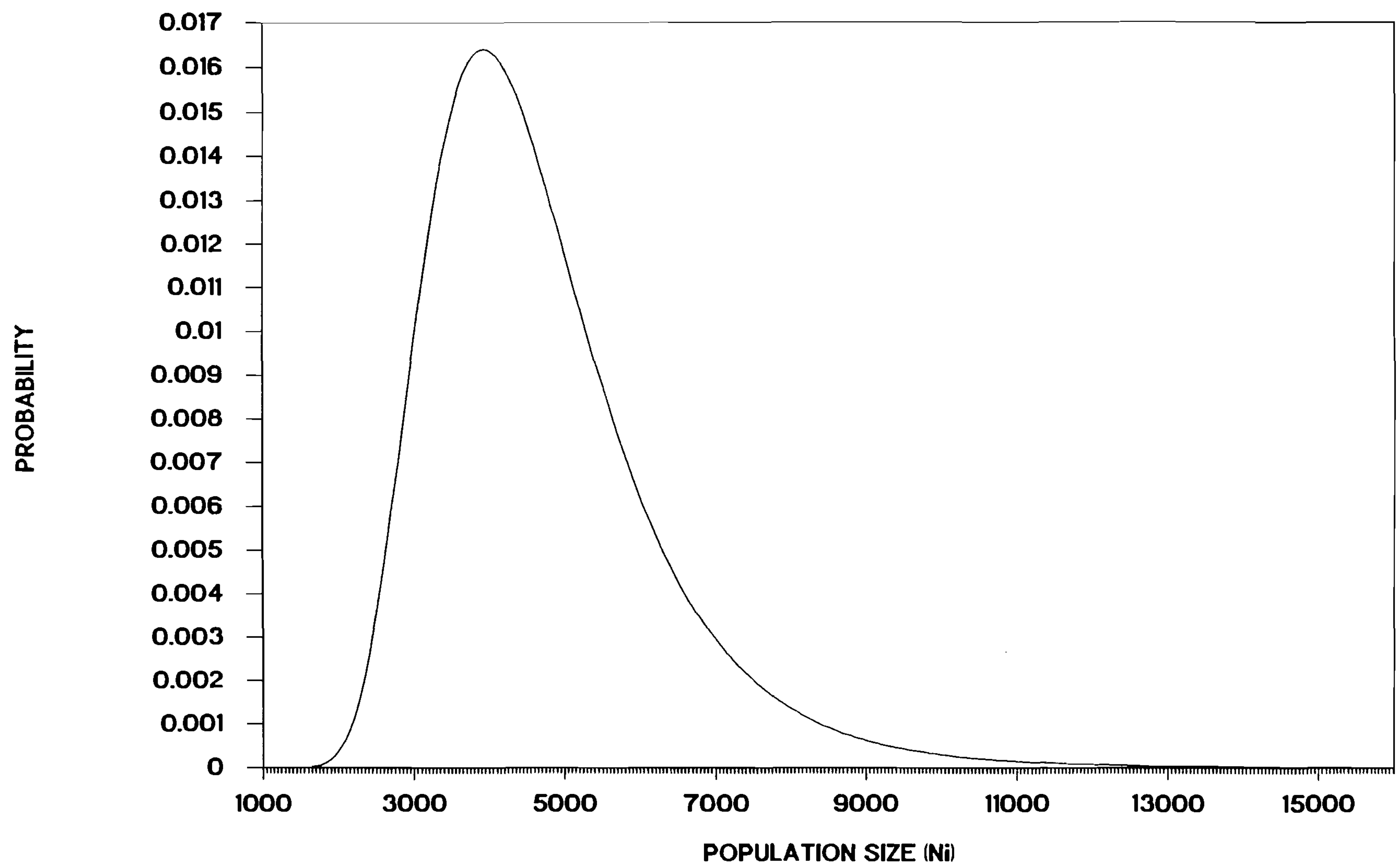
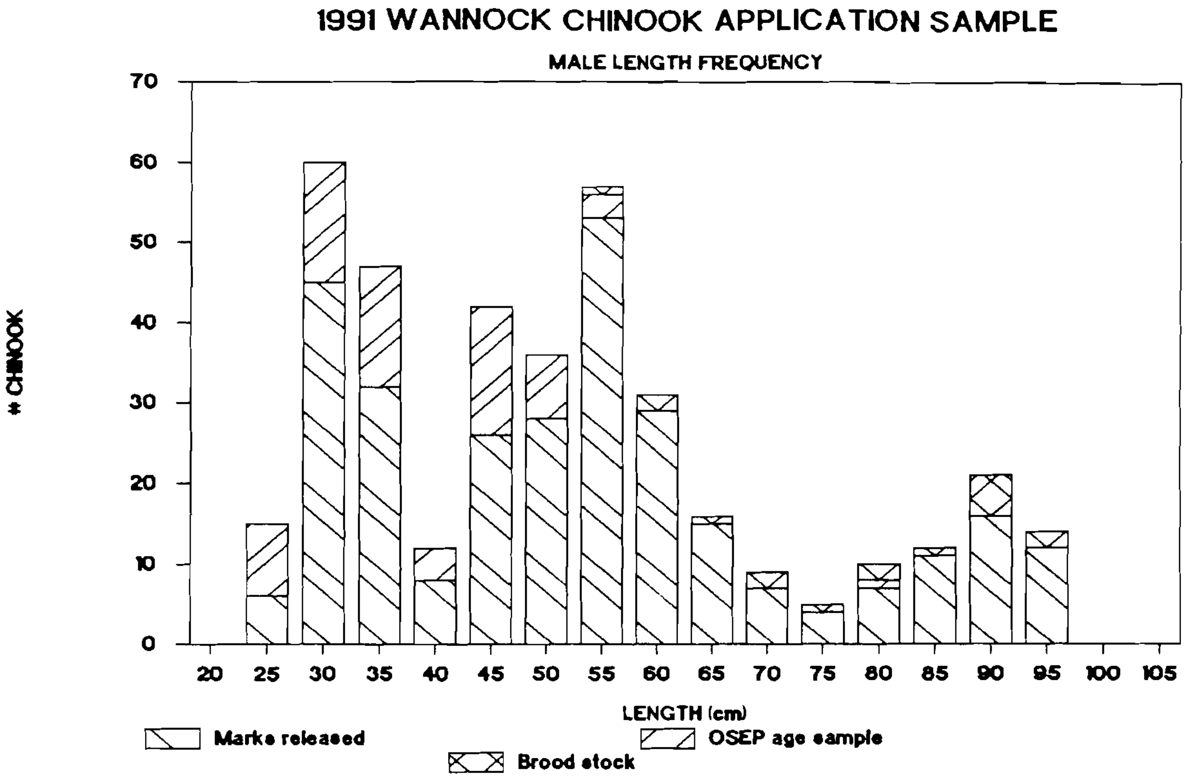


Figure 2. The posterior probability distribution of the population estimate of 1991 Wannock River female chinook salmon obtained using the Bayesian algorithm.



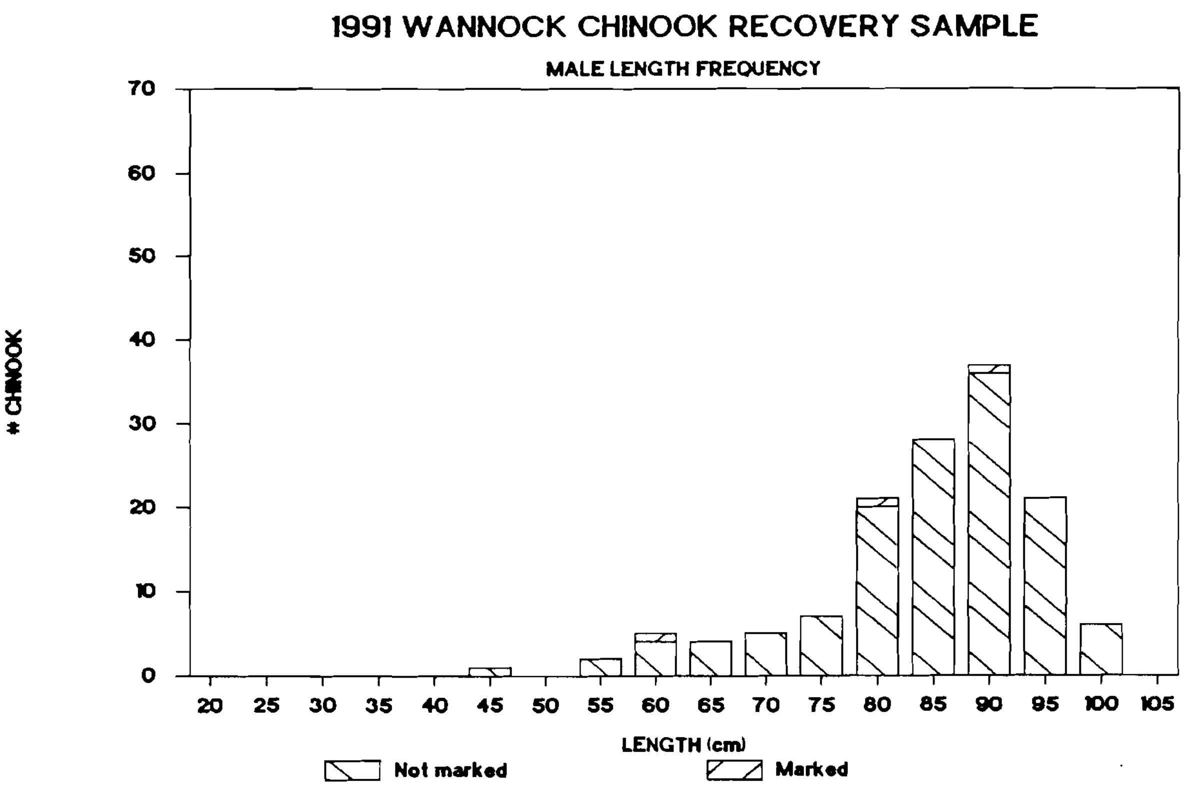
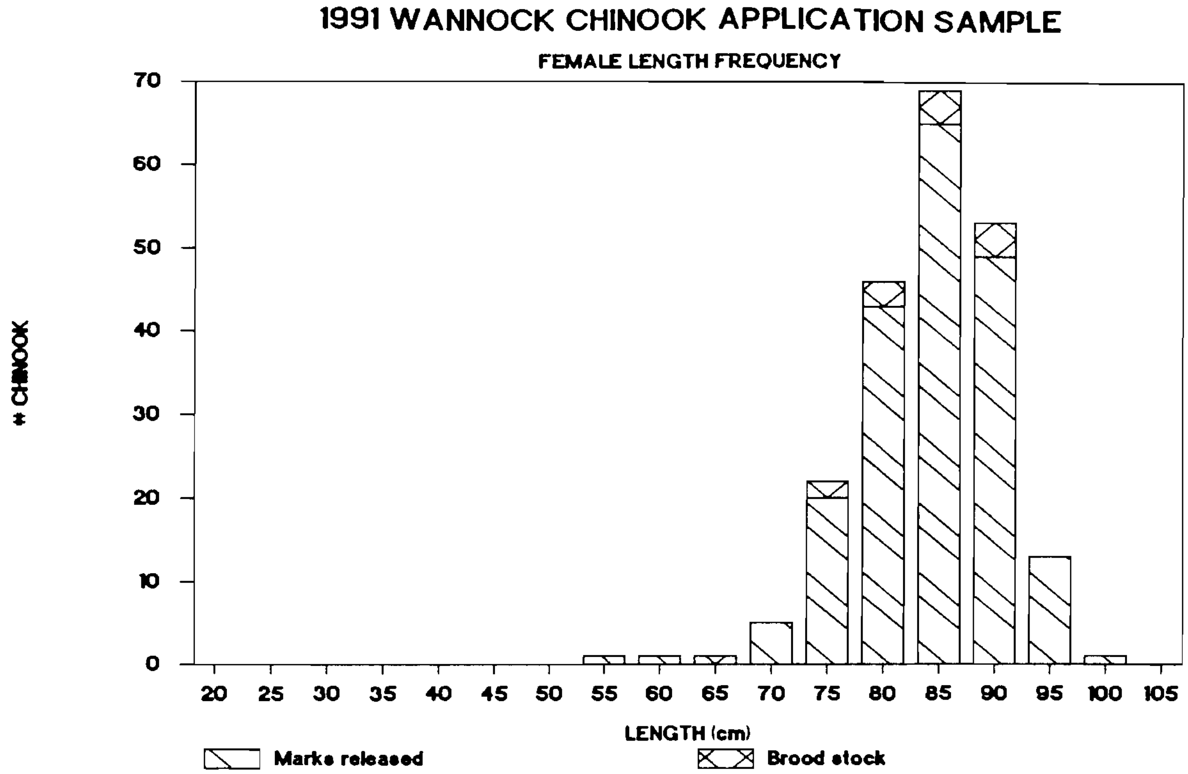


Figure 3. Length frequency histograms of 1991 Wannock River male chinook salmon comparing mark application and recovery samples.



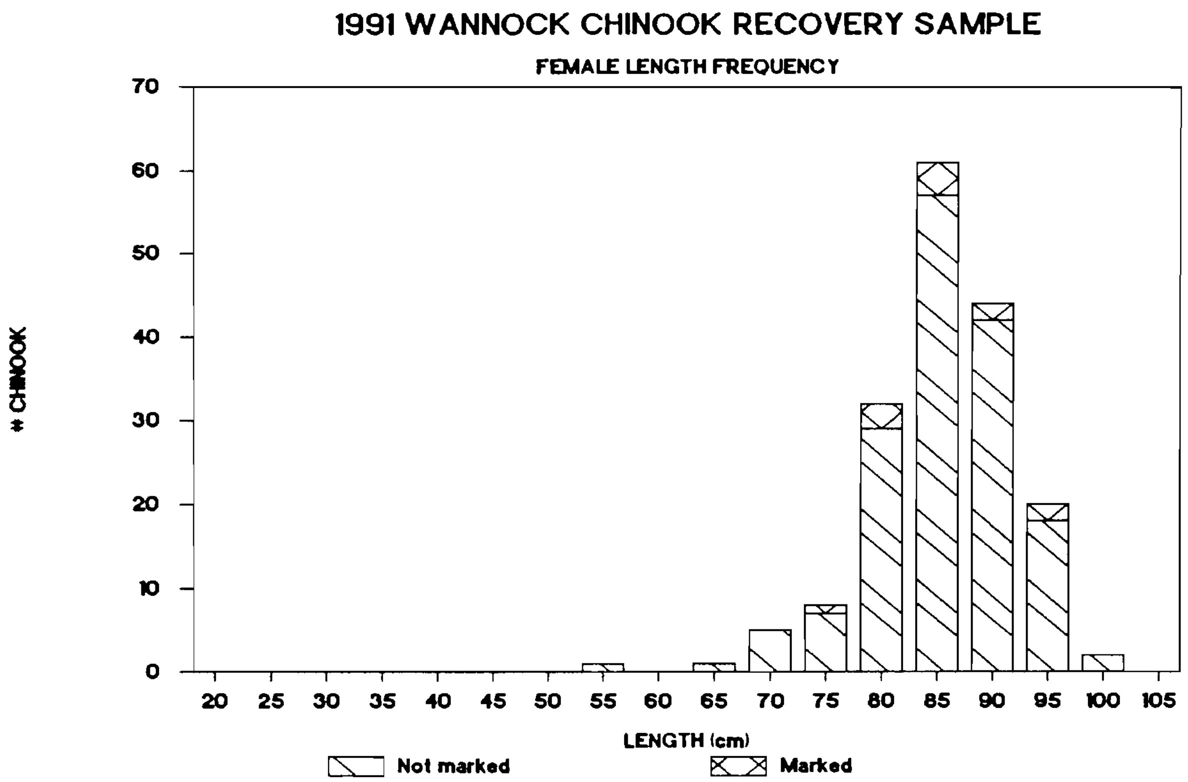


Figure 4. Length frequency histograms of 1991 Wannock River female chinook salmon comparing mark application and recovery samples.

Appendix 1. 1991 Wannock River chinook mark application data. Tag numbers of 0 = opercular punched only. BS = brood stock, DP = recovered, THROWN = tag lost before recovery sample.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
12-Oct	8301	M	>= 55	8301		23-Oct	8975	M	87	8975	
12-Oct	8303	M	<55	8303		23-Oct	8977	M	54	8977	
12-Oct	8305	M	>= 55	8305		23-Oct	8979	M	49	8979	
12-Oct	8307	M	<55	8307		23-Oct	8981	M	52	8981	
12-Oct	8309	M	<55	8309		23-Oct	8983	M	48	8983	
12-Oct	8311	M	<55	8311		23-Oct	8985	M	57	8985	
12-Oct	8313	M	>= 55	8313		23-Oct	8987	M	54	8987	
12-Oct	8315	M	>= 55	8315		23-Oct	8989	M	62	8989	
12-Oct	8317	M	<55	8317		23-Oct	8991	M	58	8991	
12-Oct	8319	M	<55	8319		23-Oct	8993	M	48	8993	
12-Oct	8321	M	<55	8321		23-Oct	8995	M	53	8995	
12-Oct	8323	M	<55	8323		23-Oct	8997	M	37	8997	
12-Oct	8325	M	<55	8325		23-Oct	8999	M	38	8999	
12-Oct	8327	M	<55	8327		23-Oct	9001	M	38	9001	
12-Oct	8329	M	>= 55	8329		23-Oct	9003	M	59	9003	
12-Oct	8331	M	<55	8331		23-Oct	9005	M	52	9005	
12-Oct	8333	M	<55	8333		23-Oct	9007	M	55	9007	
12-Oct	8335	M	>= 55	8335		23-Oct	9009	M	51	9009	
12-Oct	8337	M	<55	8337		23-Oct	9011	M	52	9011	
12-Oct	8339	M	>= 55	8339		23-Oct	9013	M	55	9013	
12-Oct	8341	M	<55	8341		23-Oct	9015	M	35	9015	
12-Oct	8343	M	<55	8343		23-Oct	9017	M	51	9017	
12-Oct	8345	M	>= 55	8345		23-Oct	9019	M	59	9019	
12-Oct	8347	M	<55	8347		23-Oct	9021	M	88	9021	BS
12-Oct	8349	M	<55	8349		23-Oct	9023	M	77	9023	BS
12-Oct	8351	M	<55	8351		23-Oct	9025	M	53	9025	
12-Oct	8353	M	>= 55	8353		23-Oct	9027	M	54	9027	
12-Oct	8355	M	<55	8355		23-Oct	9029	M	42	9029	
12-Oct	8357	M	<55	0		23-Oct	9031	M	42	9031	
12-Oct	8359	M	<55	0		24-Oct	9033	M	89	9033	
12-Oct	8361	M	<55	0		24-Oct	9035	M	51	9035	
12-Oct	8363	M	<55	0		24-Oct	9037	M	46	9037	
12-Oct	8365	M	<55	0		24-Oct	9039	M	49	9039	
12-Oct	8367	M	<55	0		24-Oct	9041	M	47	9041	
12-Oct	8369	M	<55	0		24-Oct	9043	M	54	9043	
12-Oct	8371	M	<55	0		24-Oct	9045	M	47	9045	
12-Oct	8373	M	<55	0		24-Oct	9047	M	57	9047	
12-Oct	8375	M	<55	0		24-Oct	9049	M	56	9049	
12-Oct	8377	M	<55	0		25-Oct	9051	M	94	9051	BS
12-Oct	8379	M	<55	0		25-Oct	9053	M	57	9053	
13-Oct	8381	M	33	0		26-Oct	9055	M	93	9055	BS
13-Oct	8383	M	45	8383		26-Oct	9057	M	94	9057	
13-Oct	8385	M	31	0		26-Oct	9059	M	87	9059	BS
13-Oct	8387	M	29	0		26-Oct	9061	M	83	9061	
13-Oct	8389	M	57	8389		26-Oct	9063	M	85	9063	
13-Oct	8391	M	57	8391		26-Oct	9065	M	61	9065	DP
13-Oct	8393	M	50	8393		26-Oct	9067	M	60	9067	BS
13-Oct	8395	M	61	8395		26-Oct	9069	M	57	9069	

Appendix 1 continued.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
13-Oct	8397	M	91	8397		26-Oct	9071	M	91	9071	
13-Oct	8399	M	46	8399		26-Oct	9073	M	87	9073	
13-Oct	8501	M	29	0		26-Oct	9075	M	57	9075	
13-Oct	8503	M	48	8503		26-Oct	9077	M	59	9077	BS
13-Oct	8505	M	41	8505		26-Oct	9079	M	57	9079	
13-Oct	8507	M	47	8507		26-Oct	9081	M	56	9081	
13-Oct	8509	M	30	0		28-Oct	9083	M	92	9083	
13-Oct	8511	M	35	8511		28-Oct	9085	M	67	9085	BS
13-Oct	8513	M	31	0		28-Oct	9087	M	86	9087	BS
13-Oct	8515	M	29	0		28-Oct	9089	M	93	9089	
13-Oct	8517	M	29	0		28-Oct	9091	M	83	9091	DP
13-Oct	8519	M	30	0		28-Oct	9093	M	60	9093	
14-Oct	8521	M	48	8521		29-Oct		M	26	0	
14-Oct	8523	M	30	0		29-Oct		M	27	0	
14-Oct	8525	M	27	0		29-Oct		M	54	0	
14-Oct	8527	M	30	0		29-Oct		M	30	0	
14-Oct	8529	M	54	8529		29-Oct		M	31	0	
14-Oct	8531	M	28	0		29-Oct		M	51	0	
14-Oct	8533	M	47	8533		29-Oct		M	54	0	
14-Oct	8535	M	52	8535		31-Oct		M	44	0	
14-Oct	8537	M	57	8537		31-Oct		M	28	0	
14-Oct	8539	M	41	8539		31-Oct		M	26	0	
14-Oct	8541	M	49	8541		31-Oct		M	25	0	
14-Oct	8543	M	52	8543							
14-Oct	8545	M	31	0		12-Oct	8302	F	55 OR	8302	
14-Oct	8547	M	52	8547		12-Oct	8304	F	55 OR	8304	
14-Oct	8549	M	43	8549		12-Oct	8306	F	55 OR	8306	
14-Oct	8551	M	50	8551		13-Oct	8308	F	85	8308	
14-Oct	8553	M	31	0		13-Oct	8310	F	82	8310	
14-Oct	8555	M	52	8555		14-Oct	8312	F	74	8312	
14-Oct	8557	M	33	0		14-Oct	8314	F	87	8314	
14-Oct	8559	M	24	0		14-Oct	8316	F	97	8316	
14-Oct	8561	M	30	0		14-Oct	8318	F	57	8318	
14-Oct	8563	M	41	8563		14-Oct	8320	F	77	8320	
14-Oct	8565	M	29	0		14-Oct	8322	F	83	8322	
14-Oct	8567	M	50	8567		15-Oct	8324	F	86	8324	
14-Oct	8569	M	28	0		15-Oct	8326	F	87	8326	
14-Oct	8571	M	29	0		15-Oct	8328	F	70	8328	
14-Oct	8573	M	30	0		15-Oct	8330	F	89	8330	
14-Oct	8575	M	29	0		15-Oct	8332	F	74	8332	
14-Oct	8577	M	30	0		16-Oct	8334	F	87	8334	
14-Oct	8579	M	34	0		16-Oct	8336	F	87	8336	
14-Oct	8581	M	31	0		16-Oct	8338	F	85	8338	BS
14-Oct	8583	M	33	0		16-Oct	8340	F	76	8340	BS
14-Oct	8585	M	40	8585		16-Oct	8342	F	87	8342	
14-Oct	8587	M	28	0		17-Oct	8344	F	79	8344	
14-Oct	8589	M	38	8589		17-Oct	8346	F	88	8346	
14-Oct	8591	M	31	0		17-Oct	8348	F	87	8348	
14-Oct	8593	M	28	0		17-Oct	8350	F	81	8350	
14-Oct	8595	M	27	0		17-Oct	8352	F	65	8352	BS

Appendix 1 continued.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
14-Oct	8597	M	93	8597		17-Oct	8354	F	91	8354	
14-Oct	8599	M	91	8599		17-Oct	8356	F	83	8356	
14-Oct	8601	M	61	8601		20-Oct	8358	F	79	8358	
14-Oct	8603	M	51	8603		20-Oct	8360	F	90	8360	DP
14-Oct	8605	M	59	8605		20-Oct	8362	F	71	8362	
14-Oct	8607	M	70	8607		20-Oct	8364	F	72	8364	
14-Oct	8609	M	39	8609		20-Oct	8366	F	86	8366	
14-Oct	8611	M	55	8611		20-Oct	8368	F	86	8368	
14-Oct	8613	M	26	0		20-Oct	8370	F	81	8370	BS
14-Oct	8615	M	45	8615		20-Oct	8372	F	82	8372	
14-Oct	8617	M	49	8617		20-Oct	8374	F	88	8374	DP
14-Oct	8619	M	52	8619		20-Oct	8376	F	88	8376	
14-Oct	8621	M	32	0		20-Oct	8378	F	84	8378	
14-Oct	8623	M	47	8623		20-Oct	8380	F	82	8380	
14-Oct	8625	M	55	8625		20-Oct	8382	F	84	8382	
14-Oct	8627	M	52	8627		20-Oct	8384	F	77	8384	
15-Oct	8629	M	64	8629		20-Oct	8386	F	83	8386	
15-Oct	8631	M	82	8631		20-Oct	8388	F	84	8388	
15-Oct	8633	M	72	8633		20-Oct	8390	F	82	8390	
15-Oct	8635	M	58	8635		20-Oct	8392	F	83	8392	
15-Oct	8637	M	92	8637		20-Oct	8394	F	72	8394	
15-Oct	8639	M	57	8639		20-Oct	8396	F	87	8396	
15-Oct	8641	M	44	8641		20-Oct	8398	F	79	8398	
15-Oct	8643	M	42	8643		20-Oct	8400	F	77	8400	
15-Oct	8645	M	28	0		20-Oct	8502	F	81	8502	DP
15-Oct	8647	M	37	8647		20-Oct	8504	F	82	8504	
15-Oct	8649	M	30	0		20-Oct	8506	F	84	8506	
15-Oct	8651	M	69	8651		21-Oct	8508	F	83	8508	
15-Oct	8653	M	29	0		21-Oct	8510	F	78	8510	
15-Oct	8655	M	29	0		21-Oct	8512	F	80	8512	
15-Oct	8657	M	36	8657		21-Oct	8514	F	89	8514	
15-Oct	8659	M	29	0		21-Oct	8516	F	83	8516	
15-Oct	8661	M	48	8661		21-Oct	8518	F	67	8518	
15-Oct	8663	M	24	0		21-Oct	8520	F	71	8520	
15-Oct	8665	M	30	0		21-Oct	8522	F	72	8522	
15-Oct	8667	M	30	0		21-Oct	8524	F	88	8524	
15-Oct	8669	M	26	0		21-Oct	8526	F	75	8526	
15-Oct	8671	M	88	8671		21-Oct	8528	F	80	8528	
15-Oct	8673	M	87	8673	BS	21-Oct	8530	F	79	8530	
15-Oct	8675	M	84	8675		21-Oct	8532	F	76	8532	
15-Oct	8677	M	71	8677		21-Oct	8534	F	82	8534	
15-Oct	8679	M	61	8679		21-Oct	8536	F	79	8536	
15-Oct	8681	M	57	8681		21-Oct	8538	F	74	8538	DP
15-Oct	8683	M	71	8683		21-Oct	8540	F	84	8540	
15-Oct	8685	M	64	8685		21-Oct	8542	F	72	8542	
15-Oct	8687	M	56	8687		21-Oct	8544	F	78	8544	
15-Oct	8689	M	48	8689		21-Oct	8546	F	93	8546	
15-Oct	8691	M	32	0		21-Oct	8548	F	80	8548	
15-Oct	8693	M	45	8693		21-Oct	8550	F	87	8550	
15-Oct	8695	M	28	0		21-Oct	8552	F	84	8552	

Appendix 1 continued.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
15-Oct	8697	M	30	0		21-Oct	8554	F	83	8554	
15-Oct	8699	M	33	0		21-Oct	8556	F	77	8556	
15-Oct	8701	M	31	0		21-Oct	8558	F	87	8558	
15-Oct	8703	M	53	8703		21-Oct	8560	F	78	8560	
15-Oct	8705	M	53	8705		21-Oct	8562	F	80	8562	
15-Oct	8707	M	23	0		21-Oct	8564	F	86	8564	
15-Oct	8709	M	32	0		21-Oct	8566	F	84	8566	
15-Oct	8711	M	32	0		21-Oct	8568	F	78	8568	
15-Oct	8713	M	44	8713		21-Oct	8570	F	78	8570	
15-Oct	8715	M	32	0		21-Oct	8572	F	77	8572	
15-Oct	8717	M	31	0		21-Oct	8574	F	76	8574	
15-Oct	8719	M	30	0		22-Oct	8576	F	76	8576	
15-Oct	8721	M	29	0		22-Oct	8578	F	75	8578	
15-Oct	8723	M	88	8723		22-Oct	8580	F	93	8580	
15-Oct	8725	M	80	8725	DP	22-Oct	8582	F	82	8582	
15-Oct	8727	M	86	8727		22-Oct	8584	F	88	8584	
15-Oct	8729	M	55	8729		22-Oct	8586	F	82	8586	
15-Oct	8731	M	35	8731		22-Oct	8588	F	83	8588	
15-Oct	8733	M	30	0		22-Oct	8590	F	89	8590	BS
15-Oct	8735	M	27	0		22-Oct	8592	F	89	8592	
15-Oct	8737	M	25	0		22-Oct	8594	F	81	8594	DP
16-Oct	8739	M	31	0		22-Oct	8596	F	84	8596	
16-Oct	8741	M	43	8741		22-Oct	8598	F	85	8598	
16-Oct	8743	M	45	8743		22-Oct	8600	F	81	8600	
16-Oct	8745	M	33	0		22-Oct	8602	F	80	8602	
16-Oct	8747	M	31	0		22-Oct	8604	F	83	8604	
16-Oct	8749	M	30	0		22-Oct	8606	F	80	8606	
16-Oct	8751	M	49	8751		22-Oct	8608	F	87	8608	
16-Oct	8753	M	31	0		22-Oct	8610	F	89	8610	
16-Oct	8755	M	31	0		22-Oct	8612	F	82	8612	
16-Oct	8757	M	26	0		22-Oct	8614	F	74	8614	
16-Oct	8759	M	35	8759		22-Oct	8616	F	80	8616	
16-Oct	8761	M	28	0		22-Oct	8618	F	86	8618	
16-Oct	8763	M	27	0		22-Oct	8620	F	93	8620	
16-Oct	8765	M	27	0		22-Oct	8622	F	83	8622	
16-Oct	8767	M	27	0		22-Oct	8624	F	83	8624	
16-Oct	8769	M	31	0		22-Oct	8626	F	91	8626	
16-Oct	8771	M	25	0		22-Oct	8628	F	75	8628	BS
16-Oct	8773	M	34	0		22-Oct	8630	F	87	8630	
16-Oct	8775	M	31	0		22-Oct	8632	F	80	8632	
16-Oct	8776.5	M	24	0		22-Oct	8634	F	84	8634	DP
16-Oct	8777	M	92	8777		22-Oct	8636	F	77	8636	
16-Oct	8779	M	54	8779		22-Oct	8638	F	83	8638	DP
16-Oct	8781	M	54	8781		23-Oct	8640	F	77	8640	BS
16-Oct	8783	M	62	8783		23-Oct	8642	F	89	8642	
16-Oct	8785	M	53	8785		23-Oct	8644	F	77	8644	
16-Oct	8787	M	55	8787		23-Oct	8646	F	86	8646	
16-Oct	8789	M	46	8789		23-Oct	8648	F	76	8648	
16-Oct	8791	M	32	0		23-Oct	8650	F	90	8650	DP
16-Oct	8793	M	54	8793		23-Oct	8652	F	74	8652	BS

Appendix 1 continued.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
16-Oct	8795	M	68	8795		23-Oct	8654	F	80	8654	
16-Oct	8797	M	41	8797		23-Oct	8656	F	81	8656	
16-Oct	8799	M	28	0		23-Oct	8658	F	69	8658	
16-Oct	8801	M	45	8801		23-Oct	8660	F	83	8660	
17-Oct	8803	M	52	8803		23-Oct	8662	F	69	8662	
17-Oct	8805	M	86	8805		23-Oct	8664	F	80	8664	
17-Oct	8807	M	77	8807		23-Oct	8666	F	85	8666	
17-Oct	8809	M	95	8809		23-Oct	8668	F	81	8668	
17-Oct	8811	M	47	8811		23-Oct	8670	F	86	8670	
17-Oct	8813	M	45	8813		23-Oct	8672	F	80	8672	
17-Oct	8815	M	54	8815		23-Oct	8674	F	86	8674	
17-Oct	8817	M	46	8817		23-Oct	8676	F	84	8676	THROWN
17-Oct	8819	M	52	8819		23-Oct	8678	F	93	8678	
17-Oct	8821	M	47	8821		23-Oct	8680	F	91	8680	
17-Oct	8823	M	49	8823		23-Oct	8682	F	86	8682	
17-Oct	8825	M	51	8825		23-Oct	8684	F	90	8684	
17-Oct	8827	M	78	8827		23-Oct	8686	F	86	8686	
17-Oct	8829	M	51	8829		23-Oct	8688	F	87	8688	
17-Oct	8831	M	45	8831		23-Oct	8690	F	93	8690	
17-Oct	8833	M	45	8833		23-Oct	8692	F	85	8692	
17-Oct	8835	M	55	8835		23-Oct	8694	F	89	8694	
17-Oct	8837	M	47	8837		23-Oct	8696	F	87	8696	BS
17-Oct	8839	M	62	8839		23-Oct	8698	F	95	8698	
17-Oct	8841	M	52	8841		23-Oct	8700	F	76	8700	
17-Oct	8843	M	44	8843		24-Oct	8702	F	90	8702	BS
17-Oct	8845	M	80	8845		24-Oct	8704	F	76	8704	BS
20-Oct	8847	M	88	8847		24-Oct	8706	F	81	8706	
20-Oct	8849	M	94	8849		24-Oct	8708	F	73	8708	DP
20-Oct	8851	M	79	8851	BS	24-Oct	8710	F	83	8710	
20-Oct	8853	M	35	8853		24-Oct	8712	F	88	8712	
20-Oct	8855	M	90	8855		24-Oct	8714	F	75	8714	
20-Oct	8857	M	68	8857		24-Oct	8716	F	83	8716	
20-Oct	8859	M	81	8859		24-Oct	8718	F	85	8718	BS
20-Oct	8861	M	68	8861		24-Oct	8720	F	84	8720	BS
20-Oct	8863	M	65	8863		24-Oct	8722	F	88	8722	
20-Oct	8865	M	54	8865		24-Oct	8724	F	80	8724	
20-Oct	8867	M	62	8867		24-Oct	8726	F	73	8726	
20-Oct	8869	M	55	8869		24-Oct	8728	F	72	8728	
20-Oct	8871	M	56	8871		25-Oct	8730	F	83	8730	
20-Oct	8873	M	58	8873		25-Oct	8732	F	95	8732	
20-Oct	8875	M	52	8875		25-Oct	8734	F	70	8734	
20-Oct	8877	M	73	8877		26-Oct	8736	F	76	8736	DP
21-Oct	8879	M	63	8879		26-Oct	8738	F	86	8738	
21-Oct	8881	M	64	8881		26-Oct	8740	F	82	8740	
21-Oct	8883	M	83	8883		26-Oct	8742	F	79	8742	
21-Oct	8885	M	55	8885		26-Oct	8744	F	88	8744	
21-Oct	8887	M	57	8887		26-Oct	8746	F	85	8746	
21-Oct	8889	M	77	8889		26-Oct	8748	F	78	8748	
21-Oct	8891	M	58	8891		26-Oct	8750	F	75	8750	
21-Oct	8893	M	54	8893		26-Oct	8752	F	89	8752	

Appendix 1 continued.

DATE	FISH #	SEX	POH (cm)	TAG #	STATUS	DATE	FISH#	SEX	POH (cm)	TAG #	STATUS
21-Oct	8895	M	65	8895		26-Oct	8754	F	86	8754	
21-Oct	8897	M	58	8897		26-Oct	8756	F	81	8756	
21-Oct	8899	M	86	8899		26-Oct	8758	F	86	8758	
21-Oct	8901	M	60	8901		26-Oct	8760	F	91	8760	DP
21-Oct	8903	M	70	8903		26-Oct	8762	F	85	8762	
21-Oct	8905	M	81	8905		28-Oct	8764	F	81	8764	
21-Oct	8907	M	86	8907		28-Oct	8766	F	83	8766	DP
21-Oct	8909	M	61	8909		28-Oct	8768	F	84	8768	
21-Oct	8911	M	45	8911		28-Oct	8770	F	86	8770	BS
21-Oct	8913	M	41	8913		28-Oct	8772	F	71	8772	
22-Oct	8915	M	81	8915		28-Oct	8774	F	87	8774	
22-Oct	8917	M	87	8917		28-Oct	8776	F	55	8776	
22-Oct	8919	M	86	8919		28-Oct	8778	F	91	8778	
22-Oct	8921	M	88	8921		28-Oct	8780	F	82	8780	
22-Oct	8923	M	51	8923		28-Oct	8782	F	76	8782	
22-Oct	8925	M	52	8925		29-Oct	8784	F	83	8784	
22-Oct	8927	M	51	8927		29-Oct	8786	F	78	8786	
22-Oct	8929	M	42	8929		29-Oct	8788	F	82	8788	
22-Oct	8931	M	42	8931		29-Oct	8790	F	81	8790	
22-Oct	8933	M	59	8933		30-Oct	8792	F	81	8792	
22-Oct	8935	M	51	8935		30-Oct	8794	F	86	8794	
22-Oct	8937	M	68	8937		30-Oct	8796	F	83	8796	
22-Oct	8939	M	80	8939		30-Oct	8798	F	89	8798	
22-Oct	8941	M	88	8941	BS	30-Oct	8800	F	81	8800	
22-Oct	8943	M	88	8943		30-Oct	8802	F	78	8802	
22-Oct	8945	M	52	8945		30-Oct	8804	F	82	8804	
22-Oct	8947	M	69	8947	BS	30-Oct	8806	F	77	8806	
22-Oct	8949	M	90	8949		31-Oct	8808	F	79	8808	
22-Oct	8951	M	73	8951	BS	31-Oct	8810	F	84	8810	
22-Oct	8953	M	93	8953		31-Oct	8812	F	83	8812	
22-Oct	8955	M	63	8955	BS	31-Oct	8814	F	83	8814	
22-Oct	8957	M	83	8957		31-Oct	8816	F	80	8816	
22-Oct	8959	M	45	8959		31-Oct	8818	F	75	8818	
22-Oct	8961	M	51	8961	BS	31-Oct	8820	F	81	8820	
22-Oct	8963	M	52	8963		31-Oct	8822	F	87	8822	
22-Oct	8965	M	46	8965		31-Oct	8824	F	90	8824	
22-Oct	8967	M	57	8967		31-Oct	8826	F	89	8826	
22-Oct	8969	M	56	8969		31-Oct	8828	F	74	8828	
23-Oct	8971	M	83	8971	BS	31-Oct	8830	F	91	8830	
23-Oct	8973	M	80	8973							

Appendix 2: Data from fish collected for the OSEP age sample. Data are for chinook unless otherwise indicated. Those marked P had previously received right hand opercular punches and appear in Appendix 1. Chinook ages presented include one freshwater year.

DATE	LENGTH	AGE		DATE	LENGTH	AGE
15-Oct	44	3		20-Oct	45	3
16-Oct	24	2		21-Oct	29	COHO
16-Oct	26	2		21-Oct	29	2
16-Oct	29	2		21-Oct	30	NS
17-Oct	27	COHO		21-Oct	31	2
17-Oct	28	COHO		21-Oct	31	2
17-Oct	28	2	P	21-Oct	31	2
17-Oct	30	2		21-Oct	34	2
17-Oct	32	2		21-Oct	34	3
17-Oct	34	2		21-Oct	35	2
20-Oct	22	2		21-Oct	36	2
20-Oct	23	2		21-Oct	37	2
20-Oct	23	2		21-Oct	37	3
20-Oct	23	2		21-Oct	42	3
20-Oct	24	2		21-Oct	42	3
20-Oct	25	2	P	21-Oct	43	3
20-Oct	25	2		21-Oct	44	3
20-Oct	25	2		21-Oct	45	3
20-Oct	26	2		21-Oct	46	3
20-Oct	26	2	P	21-Oct	46	3
20-Oct	27	2		21-Oct	48	3
20-Oct	28	2		21-Oct	48	3
20-Oct	28	2		21-Oct	48	3
20-Oct	28	2		21-Oct	80	5
20-Oct	31	2		22-Oct	31	2
20-Oct	35	2		22-Oct	31	2
20-Oct	35	3		22-Oct	32	2
20-Oct	36	SOCKEYE		22-Oct	43	3
20-Oct	41	3		23-Oct	49	3
20-Oct	42			23-Oct	52	3
20-Oct	42	3		24-Oct	32	2
20-Oct	42	3		24-Oct	49	3
20-Oct	42	3		24-Oct	50	3
20-Oct	44	3		24-Oct	52	3
20-Oct	44	3		24-Oct	52	3
20-Oct	45	3				

Appendix 3. 1991 Wannock River chinook salmon recovery sample data.

DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #
28-Oct	F	85.8		10-Nov	F	78.5		14-Nov	F	85.0		19-Nov	M	93.4	
28-Oct	F	91.6		10-Nov	F	78.6		14-Nov	F	87.0		20-Nov	F	DC	
01-Nov	F	71.2		10-Nov	F	79.0		14-Nov	F	87.4		20-Nov	F	DC	
01-Nov	M	78.4		10-Nov	F	79.3		14-Nov	F	92.4		20-Nov	F	DC	
01-Nov	M	82.0		10-Nov	F	80.7		14-Nov	F	94.0		20-Nov	F	DC	
01-Nov	M	83.5		10-Nov	F	80.8		14-Nov	M	78.3		20-Nov	F	67.0	
01-Nov	M	87.0		10-Nov	F	81.0		14-Nov	M	84.8		20-Nov	F	75.0	
02-Nov	F	78.2		10-Nov	F	82.5		14-Nov	M	88.2		20-Nov	F	78.2	
02-Nov	F	96.0		10-Nov	F	83.6		14-Nov	M	90.0		20-Nov	F	80.0	
02-Nov	M	81.2		10-Nov	F	83.6		14-Nov	M	96.5		20-Nov	F	81.8	
03-Nov	F	80.0		10-Nov	F	83.7		15-Nov	F	61.0		20-Nov	F	84.0	
03-Nov	F	82.0		10-Nov	F	84.5		15-Nov	F	80.0		20-Nov	F	85.0	
03-Nov	F	83.5		10-Nov	F	85.1		15-Nov	F	82.8		20-Nov	F	86.0	
03-Nov	F	85.0		10-Nov	F	93.6		15-Nov	F	82.9		20-Nov	F	86.0	
03-Nov	M	56.5		10-Nov	M	58.3		15-Nov	F	83.2		20-Nov	F	86.0	
03-Nov	M	60.0	9065	10-Nov	M	82.4		15-Nov	F	84.0		20-Nov	F	89.0	
03-Nov	M	63.7		10-Nov	M	87.4		15-Nov	F	84.3		20-Nov	F	89.8	
04-Nov	F	80.3	8502	10-Nov	M	87.4		15-Nov	F	87.0		20-Nov	M	DC	
04-Nov	F	82.4		10-Nov	M	88.0		15-Nov	F	87.3	8374	20-Nov	M	DC	
04-Nov	F	88.2		10-Nov	M	88.3		15-Nov	F	88.4		20-Nov	M	60.0	
04-Nov	M	68.5		10-Nov	M	95.0		15-Nov	F	89.7		20-Nov	M	70.0	
04-Nov	M	76.4		11-Nov	F	DC		15-Nov	F	90.1		20-Nov	M	75.0	
04-Nov	M	81.6		11-Nov	F	74.7		15-Nov	F	94.0		20-Nov	M	76.8	
04-Nov	M	82.5		11-Nov	F	78.5		15-Nov	M	70.6		20-Nov	M	77.4	
04-Nov	M	85.0		11-Nov	F	83.2		15-Nov	M	74.6		20-Nov	M	88.0	
04-Nov	M	88.0		11-Nov	F	83.4		15-Nov	M	78.6		20-Nov	M	89.4	
04-Nov	M	92.0		11-Nov	F	83.8		15-Nov	M	79.2	8725	20-Nov	M	95.2	
04-Nov	M	94.5		11-Nov	F	84.0		15-Nov	M	80.5		20-Nov	M	97.8	
04-Nov	M	95.0		11-Nov	F	84.2		15-Nov	M	81.2		21-Nov	F	DC	
05-Nov	F	76.7		11-Nov	F	85.0		15-Nov	M	83.7		21-Nov	F	DC	
05-Nov	F	78.0		11-Nov	F	86.3		15-Nov	M	84.2		21-Nov	F	76.5	8538
05-Nov	F	83.0		11-Nov	F	87.0		15-Nov	M	88.5		21-Nov	F	76.8	
05-Nov	M	54.0		11-Nov	F	87.8		15-Nov	M	89.0		21-Nov	F	82.0	
05-Nov	M	65.0		11-Nov	F	90.5	8650	15-Nov	M	91.0		21-Nov	F	82.8	
05-Nov	M	75.2		11-Nov	F	92.0		16-Nov	F	82.2		21-Nov	M	75.5	
05-Nov	M	77.0		11-Nov	F	92.7		16-Nov	F	86.5		21-Nov	M	76.0	
05-Nov	M	85.6		11-Nov	M	65.4		16-Nov	M	95.0		21-Nov	M	80.4	
05-Nov	M	89.4		11-Nov	M	81.5		17-Nov	F	DC	8736	21-Nov	M	88.5	
05-Nov	M	90.0		11-Nov	M	82.0		17-Nov	F	DC		21-Nov	M	90.0	
05-Nov	M	93.0		11-Nov	M	82.7		17-Nov	F	76.6		21-Nov	M	94.8	
06-Nov	F	74.0		11-Nov	M	83.7		17-Nov	F	79.6		21-Nov	M	95.0	
06-Nov	F	85.4		11-Nov	M	88.7		17-Nov	F	83.7		22-Nov	F	71.0	8638
06-Nov	F	86.0		11-Nov	M	90.4		17-Nov	F	84.5		22-Nov	F	74.4	
06-Nov	F	87.0		11-Nov	M	92.0		17-Nov	F	85.0		22-Nov	M	84.7	
06-Nov	F	92.3		11-Nov	M	95.0		17-Nov	F	85.6		23-Nov	F	DC	
06-Nov	M	83.4		11-Nov	M	95.0		17-Nov	F	86.6		23-Nov	F	75.4	
06-Nov	M	87.3		11-Nov	M	96.0		17-Nov	F	96.6		23-Nov	F	81.3	
06-Nov	M	88.8		12-Nov	F	78.0		17-Nov	M	87.0		23-Nov	F	82.0	
06-Nov	M	89.0		12-Nov	F	83.4		17-Nov	M	90.0		23-Nov	F	83.5	
06-Nov	M	89.1		12-Nov	F	83.5		18-Nov	F	69.0		23-Nov	F	85.4	
06-Nov	M	91.0		12-Nov	F	88.0		18-Nov	F	85.4		23-Nov	F	85.8	

Appendix 3 continued.

DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #	DATE	SEX	POH	TAG #
07-Nov	F	77.0		12-Nov	F	90.0		18-Nov	F	86.0		23-Nov	F	87.0	
07-Nov	F	78.3		12-Nov	F	92.4		18-Nov	F	87.8		23-Nov	F	93.6	
07-Nov	F	80.0		12-Nov	M	56.2		18-Nov	M	DC		23-Nov	M	78.4	
07-Nov	F	81.8		12-Nov	M	73.5		18-Nov	M	74.8		23-Nov	M	87.3	
07-Nov	F	85.0		12-Nov	M	80.0		18-Nov	M	76.8		23-Nov	M	88.6	
07-Nov	F	86.0		12-Nov	M	88.2		18-Nov	M	78.8		27-Nov	F	71.0	
07-Nov	F	87.5		12-Nov	M	88.2		18-Nov	M	80.4		27-Nov	F	76.0	
07-Nov	F	91.7		12-Nov	M	91.6		18-Nov	M	80.8		27-Nov	F	77.2	
07-Nov	M	77.0		12-Nov	M	93.2		18-Nov	M	82.0		27-Nov	F	80.0	
07-Nov	M	81.2		13-Nov	F	DC		18-Nov	M	86.7		27-Nov	F	80.0	
07-Nov	M	84.6		13-Nov	F	DC		18-Nov	M	88.0		27-Nov	M	68.0	
07-Nov	M	86.8		13-Nov	F	DC		18-Nov	M	92.4		27-Nov	M	76.0	
07-Nov	M	88.6		13-Nov	F	80.8		19-Nov	F	76.4	8708	27-Nov	M	77.0	
07-Nov	M	88.7		13-Nov	F	84.3		19-Nov	F	77.8		27-Nov	M	80.0	
07-Nov	M	90.0		13-Nov	F	86.2		19-Nov	F	78.6		27-Nov	M	88.0	
07-Nov	M	90.1		13-Nov	F	86.2		19-Nov	F	79.4		27-Nov	M	96.0	
07-Nov	M	92.0		13-Nov	F	87.2		19-Nov	F	79.6		27-Nov	M	100.0	
08-Nov	F	83.5	8766	13-Nov	F	87.4		19-Nov	F	82.0		28-Nov	F	50.6	
08-Nov	F	85.6		13-Nov	F	88.2		19-Nov	F	82.2		28-Nov	F	80.6	
08-Nov	M	83.4		13-Nov	F	88.5		19-Nov	F	85.6		28-Nov	M	40.9	
09-Nov	F	68.5		13-Nov	F	89.0		19-Nov	F	90.4		28-Nov	M	50.7	
09-Nov	F	80.7		13-Nov	F	94.2		19-Nov	F	91.6	8760	28-Nov	M	60.3	
09-Nov	F	81.0	8594	13-Nov	M	81.0		19-Nov	F	92.6		28-Nov	M	60.3	
09-Nov	F	81.3		13-Nov	M	85.5	9091	19-Nov	F	94.0		28-Nov	M	70.2	
09-Nov	F	81.5		13-Nov	M	92.4		19-Nov	F	94.2		02-Dec	F	DC	
09-Nov	F	82.3		14-Nov	F	81.0		19-Nov	M	DC		02-Dec	F	65.4	
09-Nov	F	82.6		14-Nov	F	81.5		19-Nov	M	70.0		02-Dec	F	67.6	
09-Nov	F	84.7		14-Nov	F	82.6		19-Nov	M	72.8		02-Dec	F	71.4	
09-Nov	F	87.5		14-Nov	F	83.0		19-Nov	M	79.5		02-Dec	F	76.0	
09-Nov	F	92.0		14-Nov	F	83.0		19-Nov	M	81.5		02-Dec	F	79.8	
09-Nov	M	86.2		14-Nov	F	84.6		19-Nov	M	81.7		02-Dec	F	87.2	
												02-Dec	M	78.0	

Dec 2 recovered 14 females, 2 males - no lengths
Dec 3 recovered 24 females, 3 males, 2 tags (8634, 8360) - no lengths
Dec 4 recovered 6 females, 1 male - no lengths
Dec 5 recovered 3 females, 1 male - no lengths

Appendix 4. 1991 Wannock River chinook mark application and recovery data stratified by week and separated by sex.

FEMALES		Week of Application 1	2	3	RECOVERIES Marked Fish	Total Fish
	1	-	-	-	0	9
	2	-	2	1	3	45
Week of	3	-	2	1	3	70
Recovery	4	-	3	1	4	50
	5	-	-	-	0	7
	6	-	2	-	2	54
Marks recovered		0	9	3		
Total fish marked		25	129	47		

MALES		Week of Application 1	2	3	RECOVERIES Marked Fish	Total Fish
	1	-	-	-	0	8
	2	1	-	-	1	34
Week of	3	-	-	2	2	47
Recovery	4	-	-	-	0	39
	5	-	-	-	0	12
	6	-	-	-	0	8
Marks recovered		1	0	2		
Total fish marked		220	94	25		

Appendix 5: 1991 Wannock River chinook salmon data for Chi squared tests of sexual bias. "Seine Catch" refers to the entire application sample and "Final Marked Population" has OSEP and broodstock samples removed to represent marked releases available to the recovery sample.

	Seine Catch	Recovery Sample	Total
Male	427	148	575
Female	215	235	450
Total	642	383	1025

Final Marked Population

	Recovered	Not Recovered	Total
Male	3	336	339
Female	12	189	201
Total	15	525	540

Recovery sample

	Marked	Unmarked	Total
Male	3	145	148
Female	12	223	235
Total	15	368	383

Appendix 6. 1991 Wannock River chinook salmon application sample data divided temporally. Time periods are labelled A to C for the weeks of October 12-18, 19-25 and 26-31 respectively.

MALES	PERIOD A	B	C	TOTAL
Recovered	1	0	2	3
Not recovered	219	94	23	336
Total	220	94	25	339

FEMALES	PERIOD A	B	C	TOTAL
Recovered	0	9	3	12
Not recovered	25	121	44	190
Total	25	130	47	202

SEXES COMBINED	PERIOD A	B	C	TOTAL
Recovered	1	9	5	15
Not recovered	244	215	67	526
Total	245	224	72	541

Appendix 7. 1991 Wannock Rivery chinook salmon recovery sample data stratified temporally. Periods A through F represent consecutive weeks of the recovery sample beginning October 28.

	PERIOD						
MALES	A	B	C	D	E	F	TOTAL
Marked	1	0	2	0	0	0	3
Unmarked	7	34	45	39	12	8	145
Total	8	34	47	39	12	8	148

	PERIOD						
FEMALES	A	B	C	D	E	F	TOTAL
Marked	0	3	3	4	0	2	12
Unmarked	9	42	67	46	7	52	223
Total	9	45	70	50	7	54	235

	PERIOD						
SEXES COMBINED	A	B	C	D	E	F	TOTAL
Marked	1	3	5	4	0	2	15
Unmarked	16	76	112	85	19	60	368
Total	17	79	117	89	19	62	383

Appendix 8: 1991 Wannock River chinook salmon mark-recapture length frequency data by sex.

MALES

	FREQUENCY					
LENGTH	SEINE CATCH	OSEP SAMPLE	BROOD STOCK	FINAL MARKED POP'N	RECOVERY SAMPLE	MARK RECOVERIES
25	15	9		6		
30	60	15		45		
35	47	15		32		
40	12	4		8		
45	42	16		26	1	
50	36	8		28		
55	57	3	1	53	2	
60	31		2	29	5	1
65	16		1	15	4	
70	9		2	7	5	
75	5		1	4	7	
80	10	1	2	7	21	1
85	12		1	11	28	
90	21		5	16	37	1
95	14		2	12	21	
100					6	
TOTAL	387	71	17	299	137	3

FEMALES

	FREQUENCY				
LENGTH	SEINE CATCH	BROOD STOCK	FINAL TAGGED POP'N	RECOVERY SAMPLE	MARK RECOVERIES
55	1		1	1	
60	1		1		
65	1	1	0	1	
70	5		5	5	
75	22	2	20	8	1
80	46	3	43	32	3
85	69	4	65	61	4
90	53	4	49	44	2
95	13		13	20	2
100	1		1	2	
TOTAL	212	14	198	174	12