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Review of 2000 chinook returns to the West Coast Vancouver Island, forecast of the 2001 return to the Stamp River/Robertson Creek Hatchery Indicator Stock and outlook for other West Coast Vancouver Island chinook stocks

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Abstract

The intensive assessments and resulting abundance forecasts of the Robertson Creek Hatchery (RCH) and Stamp River chinook are undertaken annually for management of ocean and terminal fisheries, and as an indicator of the expected returns to the naturally spawning chinook populations along the west coast of Vancouver Island (WCVI). Forecasts presented in this paper indicate a continued conservation concern for naturally spawning WCVI chinook in 2001.

Review of return of the WCVI chinook in 2000

The 2000, the terminal return of chinook to the Stamp River/RCH indicator stock was estimated to be 6,450 adult (age 3 and older) chinook, plus 2,970 age 2 males (jacks). The adult return represented an 80% decline from the 1999 return level.

Returns to another 22 WCVI streams that were monitored for chinook spawning escapements also declined considerably from 1999 levels. Over all these systems, the decline was approximately 60%. The overall age composition was very similar to that in the Stamp River/RCH terminal run.

Forecast for the 2001 terminal return of the WCVI chinook

The forecasting methods applied have been reviewed and accepted previously by PSARC. For 2001, the forecasted total return of Stamp River/RCH chinook to the terminal area of Barkley Sound and Alberni Inlet is estimated to be 14,200 based on averaging the forecast models. The mean absolute percent error in the average forecast (1985-2000 returns) is 15%. The age structure of the 2001 return is projected to be: 78% Age-3, 9% Age-4, and 13% Age-5; with an expected sex ratio of 20% females. At this time, the forecast only assumes fishing mortality in South East Alaska (SEAK). Harvest rate factors in SEAK were based on the Pacific Salmon Treaty agreements and we initially used a harvest rate scalar of 0.5 in SEAK troll fishery. The remaining cohort is identified as the expected terminal run assuming no fishing mortality on this stock in Canada.

Overall, returns are expected to increase by more than double relative to 2000, due to the expected large age 3 component. However, the number of females, and resulting eggs, will decrease by an expected 25% from the 2000 level. The resulting level of egg deposition to the Stamp River/RCH will be substantially below the base period level (approximately 20% of base). The expected number of eggs would be the lowest on record since 1985 (Appendix Table 3), when the indicator stock program began.

A slightly more conservative terminal run is predicted if the forecast is expressed as a cumulative probability distribution. Based on the annual deviations from forecasts observed between 1988 and 2000, the 50% value of the cumulative distribution is 13,2000 chinook in the terminal run and the 50% confidence interval is 11,600 to 15,100 adult chinook (Appendix Figure 3). However, given that this distribution is based on only 13 years of observations, the authors recommend continuing with past methods and applying the average forecast model that predicts 14,200 adult chinook.

The more serious concern for conservation is the expected run size to the naturally spawning chinook populations along the WCVI. The 2001 outlook in the WCVI indicator streams assumes a 120% increase from 2000 levels and expected 20% female component in the total return. The results show many chinook populations along the WCVI with less than 100 females (Table 9).

Résumé

Chaque année, le saumon quinnat de l'écloserie du ruisseau Robertson et de la rivière Stamp River fait l'objet d'évaluations intensives et de prévisions de l'abondance, utilisées dans la gestion des pêches en mer et en estuaire, mais aussi comme indices des remontes des populations sauvages le long de la côte ouest de l'île de Vancouver (COIV). Les prévisions présentées dans le présent document indiquent que la conservation de ces dernières populations est encore une source de préoccupation en 2001.

Remontes du saumon quinnat sur la COIV en 2000

La remonte de saumon quinnat du stock indicateur de la rivière Stamp/l'écloserie du ruisseau Robertson en 2000 a été estimée à 6 450 adultes (âgés de 3 ans ou plus) et à 2 970 mâles de deux ans (madeleineaux). La remonte des adultes était de 80 % plus faible qu'en 1999.

Les remontes dans 22 autres cours d'eau de la COIV dans lesquels on a surveillé l'échappée du saumon quinnat ont aussi connu une baisse marquée par rapport à 1999, soit d'environ 60 % pour l'ensemble de ces écosystèmes. Globalement, la composition par âge était très semblable à celle de la remonte du stock de la rivière Stamp/l'écloserie du ruisseau Robertson.

Prévision de la remonte du saumon quinnat de la COIV en 2001

Le Comité d'examen des évaluations scientifiques du Pacifique (CEESP) a déjà passé en revue et accepté les méthodes de prévision appliquées. En faisant la moyenne des résultats des modèles de prévision, on prévoit que la remonte de quinnats de la rivière Stamp/l'écloserie du ruisseau Robertson au fond des baies Barkley et Alberni atteindra 14 200 poissons en 2001. L'erreur moyenne absolue en pourcentage de la prévision moyenne (remontes de 1985 à 2000) se chiffre à 15 %. Pour 2001, on prévoit une remonte composée de 78 %, 9 % et 13 % d'individus âgés respectivement de trois, quatre et cinq ans, avec 20 % de femelles. À ce moment, la prévision suppose qu'il n'y a mortalité par pêche que dans le sud-est de l'Alaska. Les taux de capture dans cette région sont fondés sur les ententes conclues dans le cadre du Traité sur le saumon du Pacifique. Nous avons utilisé au départ un taux de capture scalaire de 0,5 pour la pêche à la traîne dans le sud-est de l'Alaska. La cohorte restante est considérée comme la remonte attendue si le stock ne subit aucune mortalité par pêche au Canada.

Globalement, on s'attend à ce que les remontes de 2001 se chiffrent à plus du double des valeurs de 2000, en raison de la forte abondance prévue de la classe d'âge de trois ans. Toutefois, le nombre de femelles et celui des oeufs qu'elles pondront devraient être en baisse de 25 % par rapport à 2000. La ponte du stock de la rivière Stamp/l'écloserie du ruisseau Robertson sera de beaucoup inférieure au niveau de la période de base, soit environ 20 % de ce niveau, ce qui serait la plus faible ponte enregistrée depuis 1985 (tableau 3 en annexe), lorsqu'a débuté le programme des stocks indicateurs.

La remonte prévue est légèrement plus modeste lorsque la prévision est exprimée sous forme d'une distribution de probabilité cumulative. D'après les écarts annuels observés de 1988 à 2000 par rapport aux prévisions, la remonte au niveau de distribution de 50 % se chiffre à 13 200 quinnats, tandis que l'intervalle de confiance à 50 % va de 11 600 à 15 100 quinnats adultes (figure 8). Mais comme cette distribution n'est fondée que sur 13 années d'observations, les auteurs recommandent que l'on continue d'utiliser les méthodes employées jusqu'ici et que l'on applique le modèle de la prévision moyenne, qui prévoit le retour de 14 200 quinnats adultes.

Au plan de la conservation, c'est la taille prévue de la remonte des populations sauvages du saumon quinnat de la COIV qui préoccupe le plus. Les perspectives pour les stocks des cours d’eau indicateurs de la COIV en 2001 supposent une hausse de 120 % par rapport aux niveaux de 2000 et que la remonte totale sera composée à 20 % de femelles. Selon les résultats, bon nombre des populations de saumon quinnat sur la COIV comptent moins de 100 femelles (tableau 9).

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1 Introduction

The Stamp River chinook stock is a key indicator stock for exploitation rate and distribution pattern of WCVI chinook populations. This PSARC document uses methods previously reviewed in Riddell et al (PSARC X96-01) to forecast Stamp River chinook salmon returns to Barkley Sound. This working paper includes a summary of data collection and accounting procedures used in 2000 and a forecast of the 2001 return. Historic data are not repeated but were documented in PSARC X96-01.
Since the development of Robertson Creek Hatchery (RCH) in 1971, the Stamp River system has become one of Canada's major producers of chinook salmon, with large contributions to ocean troll and sport fisheries, and stimulating the development of substantial terminal sport, native, and commercial fisheries.

Analyses of coded-wire tag (CWT) data for this stock indicate that during an average year (prior to 1995) about 50% of the stock was harvested in ocean fisheries, and 50% returned to Barkley Sound. Over half of the ocean harvest occurred in southeast Alaska fisheries (SEAK). In one year of high productivity, production of tagged chinook salmon from RCH alone, including total terminal run plus ocean catch, exceeded 500,000 chinook (1991 return year). This catch is based on expanded CWT data but does not account for incidental mortality in ocean fisheries, or natural production from the Stamp River system. Since 1995, poor marine survival of WCVI chinook, associated with El Nino events, resulted in conservation concerns and restricted ocean exploitation in Canadian fisheries.

The Somass River system is located at the head of Alberni Inlet in Barkley Sound on the west coast Vancouver Island (WCVI). Within this system, the Stamp River, which drains Great Central Lake, and the Sproat River, which drains Sproat Lake, combines to form the Somass River. Roughly half way up the Stamp River are a set of impassable falls, Stamp Falls. A fishway constructed to circumvent the falls are the basis for counting escapement into the upper Stamp River. Historically, naturally spawning chinook were present in the lower Stamp below Stamp Falls, the Sproat River, and the Somass River mainstem. These areas were generally poorly enumerated. However, since the development of RCH on the upper Stamp River, the majority of the spawners are now located in the upper Stamp River.

An interim spawning escapement goal (to guide chinook rebuilding) was established in 1988 based on escapements immediately prior to the 1985 Pacific Salmon Treaty (PST), including:

- 70,000 naturally spawning chinook (or double the estimated 35,000 adult spawners),
- 15,000 chinook for 10 million eggs into RCH, plus a
- 20% increment to account for prespawn mortality.

However, this goal could not be achieved in recent years due to poor marine survival. Consequently, since 1995, the escapement after ocean fisheries was compared to escapement levels immediately prior to the PST, a period of over-exploitation for this stock. This spawner escapement level in this base period was estimated to be:

- 50 million eggs in natural in-river spawn, plus
- 9.3 million eggs for RCH,
- additional 20% increment lost through prespawn mortality

Fishing regimes in Canada have been designed with the goal of staying above this base level escapement.

2 Analytical Framework

The analytical framework for forecasting returns of Stamp River / Robertson Creek Hatchery chinook has been previously reviewed in Riddell et al. (PSARC X96-01). The components of the review are described below.

2.1 Terminal Run Calculation

Assessment and forecasting for the WCVI stock group requires accurate information from the indicator stock at Stamp River / Robertson Creek Hatchery. Sampling of ocean fisheries provides CWT data to determine catch of this stock. Intensive assessment programs, including catch and escapement monitoring and sampling are conducted in the terminal area (DFO Statistical Area 23) of the indicator stock. Results of these monitoring and sampling programs are used to determine the terminal catch and escapement of the indicator stock. This is the “terminal run”. This information becomes the basis for the overall assessment and forecast of WCVI chinook, and is presented in Chapter 3.

2.2 Cohort Analyses

Cohort analysis is conducted using ‘estimated’ CWT recoveries from the catch and escapement to determine survival rates and exploitation patterns for RCH chinook. The incorporation of in-river tag recoveries provides estimates of the true total exploitation rates not possible with most indicator stocks. The cohort model used is documented in Appendix 2 of Starr and Argue (1991) and as modified by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC, TCCHINOOK (99)-2). In determining incidental mortality, only the brood year method was used. The cohort model was modified by the CTC to account for the chinook non-retention fisheries implemented in Canada during 1996. Modifications are documented by the CTC in Appendix G of TCCHINOOK (99)-2.
For each brood year, information used from the cohort analyses include:

- annual distribution of catch and total fishing mortalities;
- survival of CWT groups to age 2 recruitment; and
- ocean (catch or total fishing mortality) and total exploitation rates by fishery and age.

2.3 Forecast Methodology

Forecast Models

Using the results of the cohort analysis, sibling regression models are used to forecast total production from selected tag codes (including total ocean fishing mortality plus total terminal run for brood years used in the cohort analyses). Total production was calculated by multiplying the brood releases (for the selected tag codes) by the estimated total fishing mortality exploitation rates. Tag codes used are listed in Appendix Table 4.

Two combinations of terminal run and total production data have been used in the sibling regression models. Note that the first model developed in 1995 (i.e., Prod1), based on regressing total terminal return at one age class to total terminal return at a subsequent age class is not used since constant ocean fishing mortality rates must be assumed between years.

- Model 2 (Prod2). This regression model uses total terminal return at a younger age class (independent variable) to predict total production (the surviving cohort in the ocean) of a subsequent age or ages from the same brood year. The dependent variable is the total (total ocean fishing mortality plus terminal run) production at a subsequent age or ages.
- Model 3 (Prod3). This regression model uses estimated total production (total fishing mortality plus escapement) of an age class(es) to predict total production of subsequent ages (i.e., the surviving cohort) from the same brood year.

Relationships between all possible age class combinations were examined using these two models. The actual models used for the forecast were based on the highest r^2 values. In the case where more than one age class is used, such as the total terminal run of age 2+3, the total terminal runs at age 2 and age 3 were summed. Estimates of surviving cohort include natural mortality factors and are estimated as the pre-fishery abundance of the youngest age being predicted. All regressions were forced through the origin.

Spreadsheet Model of Fishery Impacts

The level of terminal return depends on the ocean exploitation. In order to predict terminal return and escapement levels, a spreadsheet model was developed to examine effects of changes in ocean harvest rates by fishery and age. Based on forecasted ocean abundance (Chapter 4) and exploitation patterns through the previous year, the model estimates terminal runs expected this year (i) and next year (i + 1), based on projected changes to harvest rates in ocean fisheries.

Due to the multiple age classes in chinook, the forecast can be refined based on observations in the previous year within the same cohort. A ratio is calculated of total terminal return of all hatchery and wild chinook (by age and brood year) divided by the terminal return of hatchery origin chinook (by age and brood year for specified CWT groups). This ratio (or expansion scalar) is used to expand the forecast age 3, 4, and 5 cohort abundance in Table 4 to “total” production of hatchery production not associated with the CWT used in the regression analyses and “natural” production from the Stamp River. This expansion assumes that natural production from the Stamp River exhibits similar behavior and encounters similar fishing pressure as the hatchery stock.

Other components of the spreadsheet include average total mortality exploitation rates by age and fishery, maturity rates and natural mortality rates by age; and matrices of ‘fishery management scalars’. These scalars are used to simulate management actions in the fisheries. Cohorts may be harvested in ocean and terminal fisheries, and/or allowed to become spawners. The surviving immature cohort is passed on to the next age in year i+1. Age 3 cohorts for year i+1 were estimated from average or recent average age 3 survival values (derived from the cohort analysis) times the smolts released in year i-2. These values were then expanded by average brood year scalars to account for natural production.

Forecast Error

A retrospective assessment of the forecasting methodology was presented in PSARC X96-01, for years 1988 through 1995. Including the information through 2000 in this assessment produces an updated estimate of the prediction error. The assessment uses a “leave-one-out” methodology. Each regression model is re-calculated while omitting each data point (one year) once. A terminal return is estimated for each predicted value by the same method as outlined in the spreadsheet. The predicted terminal return is compared to the terminal return actually observed for that year. The error is expressed as a mean absolute percent error (MAPE) for each model or the average of the two models.

In this assessment, the forecast errors (annual deviations) are used to estimate the probability distribution for the predicted terminal run in 2001. The distribution is only based on thirteen data points through 2000 but does present the 2001 forecast within a probabilistic framework. Only the average of the two forecast models is used in developing this distribution.

2.4 WCVI Stock Status based on Escapement Indicators

The Stamp River / Robertson Creek Hatchery stock is the main indicator for the WCVI stock group. Management actions taken to achieve goals for this stock are supposed to have similar effect on other stocks along the WCVI. To monitor changes in spawning levels of other WCVI chinook populations, an extensive survey program assesses spawner levels each year in about 20 escapement indicator stocks. The results are the basis for the overall assessment of status of WCVI chinook stocks. This assessment and status report is presented in Chapter 6.

3 Terminal Run Calculation

The detailed accounting of the terminal return into Barkley Sound (DFO Statistical Area 23) can be found in Appendix Table 1 and is summarized in Table 1a below. The conduct of the monitoring programs and results are described here.

3.1 Sport Fishery Survey

<u>Overview of WCVI creel surveys</u>

A creel survey was conducted along most of the WCVI from mid-June to the end of September. The goal of the survey included, in order of priority: 1) collect catch data, CWT mark incidence, biological sampling for use in the assessment of the chinook indicator stock; 2) determine coho encounters and biological sampling for stock of concern; and 3) determine offshore catch as required by the Pacific Salmon Treaty.

In the terminal run area, 2,307 interviews (15% of the fishing effort) were conducted in Alberni Inlet and approximately 1,419 interviews (6 % of the fishing effort) were conducted in Barkley Sound. Major landing sites in Area 23 (Ucluelet) became inaccessible from August 12 to 26 and interviews were minimal during this time. Fishing effort was surveyed in all sub-areas approximately twice per week or more.

Chinook catch data was collected by size category (less than 45cm, 45-77cm, and 77cm+ fork length) in accordance with size limits in the sport fishery. Most inshore areas were under non-retention to protect WCVI chinook returning to spawn. Chinook encounters in inshore areas of 23 and 24 were monitored by landing site surveys, charter patrol on water interviews, and independent fisher reports.

Effort in Alberni Inlet in August and September was estimated at 1551 boat trips (13% of 1999 effort). In Barkley Sound and offshore Area 23 the effort in August and September was 4518 boat trips (28% of 1999 effort). In area 25 where a portion of the inshore waters was open to chinook the effort was 7820 (42% of 1999 effort).

In areas 20-1, 23, and 24, every chinook and coho observed in the creel survey was visually and electronically sampled for the presence of a coded-wire tag. In areas 25 and 26 chinook and coho were only visually inspected. Due to the implementation of chinook non-retention from inshore areas of 23 and 24 during August and September no CWT or biological data was collected. Otoliths and CWTs were sampled from chinook caught in open inshore areas of 25 and in offshore areas of 123, and 124. Mark incidence and otolith samples were not obtained in Alberni and Barkley Sound in August and September. The total chinook encounters in Alberni Inlet was estimated to be 125 chinook of all origins (19 mortalities at a 15% mortality rate) from approximately 14,197 boat trips (Alberni Inlet includes waters out as far as Pocahontas Point). As a result, the total mortalities of Stamp River chinook in Alberni Inlet are estimated to be 18 fish (see Appendix Table 1).

The terminal run calculation includes all Stamp system chinook caught in the sport fishery in DFO Statistical Areas 123 and 23 (Barkley Sound and Alberni Inlet). Consequently, the mortalities of Stamp River chinook in Barkley Sound must also be determined. During the June through September period the total catch of chinook was estimated to be 2974. During the migration period of Stamp River chinook (the August and September period) the total encounters of chinook in Barkley Sound were 658 from approximately 2505 boat trips. The total mortalities of Stamp River chinook in Barkley Sound were estimated to be 11 chinook. The total mortalities of Stamp River chinook in Area 23 sport fisheries were estimated to be 29 fish.

3.2 Native Fishery Monitoring

Due to concerns over poor chinook returns, Tseshaht and Hupacasath First Nations agreed to forgo in-river fisheries targeting chinook salmon in 2000. There were no chinook reported as incidental catch to earlier sockeye fisheries or later chum fisheries. Coho fisheries were foregone to avoid incidental catch of chinook. There was no reported catch of chinook during August and September by other First Nations in the Barkley Sound and outer Alberni Inlet area.

3.3 Stamp Falls Fishway Observations of Total Escapement

Monitoring of salmonid migration through the Stamp Falls fishway was conducted from September 6 until November 3, 2000. A final observation was made on November 8, 2000 to confirm the absence of a late run of fish migrating through the fishway. A snorkel survey was conducted above Stamp Falls on September 6 to determine the number of chinook already in the system above the counting facility. Observations at Stamp Falls fishway counting facility were conducted for about 14 hours per day from September 6 to 24 from approximately 0.5 hour before sunrise to 0.5 hour after sunset. Observation periods were then reduced periodically until November 8, as the length of daylight hours diminished. No observations were conducted from October 20 to 21 due to very high flow conditions. Counts were interpolated for these days from the previous and following days. Nighttime migration was videotaped from September 6 until October 19 except for September 9/10 and October 12/13 and 17/18 when technical difficulties prevented taping.

The sockeye return to Great Central Lake in 2000 was composed of a strong 1995 brood and poor return of 1996 brood. This age combination along with favourable conditions during the spring/summer resulted in an early migration and very low fall abundance. Coho escapement of approximately 95,000 was the highest on record. Moderate flows and water temperatures during most of the fall of 2000 had no noticeable impact upon the migration of any species through Stamp Falls. The only exception to this was very high flows brought about by a storm event around October 19 to 23 which prevented observation from October 20 to 21. The overall effect of the above conditions was a viewing box that was not too congested and resulted in excellent conditions for the observers.

Components of Chinook Escapement Estimation

Daytime Component

The setup was identical to that used in 1999. A video camera was mounted vertically above the counting tunnel and above the water. A mirror was placed beneath the camera and at a 45° angle behind a sheet of plexiglass which divided the observation box lengthwise. This enabled the fish to be observed from above in half the image and a reflection of the side of the fish in the other half. The viewing box and camera were covered with heavy black plastic to eliminate reflection of light from above. Underwater lights were placed in the box to provide light for the camera and observers. Lines were marked on the side and bottom of the box to aid the observers in determination of jack or adult for each species.

Day time observations were conducted in real time through a 21-inch high-resolution colour monitor. A Super VHS time lapse VCR simultaneously recorded the migration. Observations were entered into a customised MSAccess program on a laptop PC. Time, date, observer, species, direction of migration and life stage (adult or jack) were recorded for each fish as they passed by, along with any comments. Any chinook of 59 cm or less 'total' length were considered to be jacks and were determined by using reference markings on the base and back of the tunnel. The time lapse VCR provided excellent image quality and left a time/date stamp on the image. The images obtained in 2000 were of excellent quality. Synchronised times between the VCR and the Stamp Falls database enabled comparison of the 'real time' observations entered into the database with subsequent verifications.

The daytime component of escapement estimation was derived from a summation of each days net upstream migration through Stamp Falls for each species, adults and jacks separately. These results were subsequently adjusted for observer error using a correction factor obtained through the following verification procedure.

Verification Procedure

Daytime observer error was estimated from verification of 98 randomly chosen hours of tape. An experienced observer from the Stamp Falls fishway crew conducted the verifications. Verifications were entered into the same MSAccess database as for the 'real time' events. Where there were any difficulties in determining either the species or the number of fish passing through the observation box the videotape was slowed, paused or replayed. Results of these verifications were considered to be a true count of the daytime migration.

Linear regression was used to compare verification counts with the 'real time' observations during identical time periods. For adult chinook the correction factor was 1.03 and for jack chinook the correction factor was 0.869. The highly significant relationship for chinook adults was probably due to the experience of the field crew. The chinook jack correlation was 86%, somewhat lower than for adults but a notable improvement over past years. Jacks have always been poorly enumerated due to difficulty in determining their size (compared against reference lines marked on the tunnel) and difficulty in species identification – sometimes being confused with coho. In 2000 jacks were a much greater proportion of the chinook return than in the past few years.

Nighttime Component

A video camera, Super VHS time lapse VCR and lighting operated at night off a bank of batteries and through an inverter. The batteries were re-charged during the day from the generator being used to operate the daytime equipment. Each night's entire migration was recorded by setting the VCR to record up to 12 hours on one videotape. The nighttime component of the estimation was derived from a summation of each calendar days' net upstream migration through Stamp Falls at night. This was done for each species, adults and jacks separately, for all nighttime videotapes reviewed. For nights where the tape was not reviewed the values were interpolated using the following procedure.

Review Procedure

The same experienced observer who conducted the daytime verifications reviewed the nighttime videotapes (approximately 19:30 to 06:30). Where there were difficulties in determining either the species or the number of fish passing through the observation box the videotape was slowed, paused or replayed. The review was therefore considered to be a true representation of the nighttime migration. Initially every second videotape was reviewed and data was entered into the same MSAccess database. Then the tapes for periods which corresponded to the higher daytime counts were all verified. Finally it became evident that there was little relationship between daytime counts and the following nighttime counts. The review process was therefore extended to complete any calendar days (midnight to midnight) which had incomplete nighttime reviews. This permitted a comparison of daytime counts and nighttime counts within a calendar day. Nighttime adult chinook counts varied from 8% to 130% of the daytime counts and jack chinook from 2% to 53% of the daytime counts. Counts for nights that were not reviewed were interpolated from the adjacent nights values.

The observed nighttime migration may not be indicative of natural nighttime migration as it may be influenced by the lighting used in the observation box. However, the low wattage fluorescent bulbs were mounted inside the box so their field of influence was limited and it is unlikely they would have any impact below the first baffle in the fishway.

Early Escapement Component

In some years the number of chinook having migrated past Stamp Falls prior to the start of counting operations can be considerable. In 2000, escapement prior to September 6 was estimated as: i) counts of chinook through the brailer at Robertson Creek Hatchery plus an estimated number in the raceway; and ii) counts of chinook from snorkel surveys from Great Central Lake Dam to Ash River and Ash River to Stamp Falls. Standard snorkel techniques were used by experienced snorkel surveyors. Many of the chinook were observed in large schools (up to several thousand) of mixed species. The majority of fish in the schools were coho and sockeye but included significant numbers of chinook and steelhead. When apportioning large schools into different species components visual estimation was used by observers to determine total numbers and proportions. An observer efficiency (*OE*) is assigned to snorkel surveys to account for inaccessible areas, poor visibility etc. An observer efficiency of 0.5 was applied to chinook counts in this survey.

The general calculations for estimating adult or jack chinook escapement to Stamp River are:

$$CN = \sum_{day} CNday + \sum_{day} CNnight + CNearly$$

$$CNday = \sum_{day} CNobs/cf$$

$$CNnight = \sum_{day} CNnight.obs + \sum_{day} CNnight.in$$

$$CNearly = CNswim.obs / OE + CNhatchery$$

Where:
CN = total escapement of chinook, adults and jacks determined separately
Cnday = daytime counts of chinook adjusted for observer error (adjusted daytime counts)
CNnight = night time counts of chinook
Cnearly = chinook in the system above Stamp Falls prior to commencing the Stamp Falls escapement enumeration program. Estimates are based on counts of fish observed during snorkel surveys and swim-ins to the hatchery or past Great Central Lake Dam.
Cnobs = Daily counts of real time observed chinook from Stamp Falls monitor.
cf = correction factor for observer error. Determined by comparing real time counts to verification counts
Chinook adults *cf* = 1.0300 r^2=0.984, d.f. = 97
Chinook jacks *cf* = 0.869 r^2=0.933, d.f. = 97

CNnight.obs = Daily counts of night observations of chinook from Stamp Falls video
CNnight.in = Interpolated counts for nights where there was no video review due to time and financial constraints.
Cnswim.obs = Counts of chinook observed during a snorkel survey above Stamp Falls prior to the start of counting operations.
OE = Observer error = 0.50. A subjective assessment of the percentage of each species missed during a snorkel survey based on survey conditions (size and speed of river, proportion of river observed, water clarity, etc).
CNhatchery = Count of chinook entering the hatchery prior to the start of counting operations at Stamp Falls fishway.

A minor component of the chinook return can not be accounted for as a result of bypass of the fishway via the falls. Bypass was difficult to quantify. Some coho and chinook were observed part way up Stamp Falls, well above the entrance to the fishway. It was assumed that the majority of fish making it part way up the falls eventually drop back down and enter the fishway.

3.4 Sampling at Robertson Creek Hatchery

In 2000, 2,870 adult chinook and 2,443 jack chinook entered Robertson Creek Hatchery. This included 1,384 females (48% of the adult population). All fish entering the hatchery were counted and recorded by sex. Jacks were distinguished from larger chinook based on a length of 50-cm post orbital hypural (POH) length.

Ripe females were spawned immediately after brailing. Green females were released into a holding pond until mature enough for spawning. All spawned females and pre-spawn mortalities were checked for adipose fin clips (AFCs). All males were also sampled for AFCs after spawning or before sale of the carcasses. AFCs were also checked for six males released back into the Stamp River. Two independent samples for each sex were used to determine the age composition of the total return to the hatchery;

i. ages from CWT chinook with AFC, and
ii. random scale samples from non-adipose clipped fish.

Sample data are summarized in Appendix Table 2. Age composition for each sex was estimated by pooling the number at age in the estimated CWT and scale samples.

Great Central Lake Dam

The pre-season forecast for returns to Stamp River indicated that Robertson Creek Hatchery would have difficulty in reaching it's target of 9.3 million eggs. In an effort to reduce the broodstock shortfall, while at the same time permitting any 'early' wild run to escape into Great Central Lake, the hatchery used a trap at Great Central Lake Dam from October 10 to 20. Adult males (all those captured except 1) and all jacks were released back into the Stamp River above the dam. Ripe females were spawned immediately and green females were transported back to the hatchery for holding. These 35 females contributed about 168,000 eggs (1.7% of total egg collection) to RCH. Biological data (including scales, otoliths, POH lengths and adipose fin clip data) were collected from spawned fish.

Broodstock Collection from Angling

A license was issued to David Murphy's Charter Service to angle for broodstock on a non-profit basis (no clients). Eight female chinook were caught on October 21 and approximately 6 spawned out females were caught on October 22. Angling for broodstock was then terminated. Seven females contributed approximately 32,000 eggs (0.3% of total egg collection) to RCH. Biological data (including scales, otoliths, POH lengths and adipose fin clip data) were collected from spawned fish.

3.5 Sampling on Spawning Grounds

Sampling of carcasses in the Stamp River took place from October 12 through November 9. Objectives included biological sampling (including sex, scales, egg retention level POH lengths, and some fork lengths) of all recovered carcasses. All carcasses were also sampled for AFC's. Any fish with AFC's had their heads removed for subsequent dissection and coded wire tag removal and reading. Otoliths were also sampled from 400 female, 238 male and 71 jacks.

Water levels were low to moderate until a storm event on October 17 to 19 which created subsequent high flow conditions. A jet boat was used to search for and gaff carcasses along river banks and bars. A carcass net was fished above the inlet to the lagoon until high water on October 17 but caught only 7 carcasses. Tails were severed from all sampled fish to prevent subsequent re-sampling.

In 2000, 785 chinook (19% of the river population) were sampled for AFC, with 16 recoveries. Biological samples were taken from 271 adult males, 71 jacks, and 441 females. Sample data are summarized in Appendix Table 2.

Total in-river escapement was determined by subtraction of the hatchery count from the adjusted fishway count. A component was added to account for the releases from the hatchery back into the river. Adult males and jacks are usually underrepresented in the deadpitch sample due to their post spawning behaviour. The in-river sex ratio was therefore estimated as the unweighted average of the hatchery and deadpitch sex ratios.

The in-river population was stratified into males, females, and jacks in the following way:

In-river count = total escapement - total hatchery count
Total river males (TRM) = in-river count x unweighted sex ratio
River females = in-river count - TRM
River jacks = total escapement - total hatchery count
Adult river males = TRM - river jacks

The same criteria were used to determine age composition by sex as for the hatchery samples.

3.6 Total Estimated Terminal Run

The terminal run was defined as catch in DFO Statistical Area 23, including catch of Stamp River/RCH and RCH chinook in native, sport, and commercial fisheries, plus spawning escapement to the RCH and Stamp River. Results from intensive catch monitoring and escapement monitoring programs were used to estimate the terminal run at 9,415 Stamp River/RCH chinook. Approximately one-third of this total run was comprised of age 2 jack chinook. The return by age and fishery is presented in Table 1a. The hatchery component of the terminal run, as estimated by CWT is presented in Table 1b.

Table 1a. Summary of 2000 Terminal Run of Stamp River chinook, including jacks (age2) and adults (age 3-6).

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total Adult	Total
Alberni Inlet Sport[1]	0	3	8	6	1	18	18
Somass Native	0	0	0	0	0	0	0
Barkley Sound Sport[1]	0	2	5	4	0	11	11
Hatchery Returns[2]	2,443	681	1,452	704	69	2,906	5,349
River Escapement[3]	528	303	1,575	1,503	126	3,507	4,035
Total Terminal Run	2,971	989	3,040	2,217	196	6,442	9,413

[1] Calculated at 15% of incidental catch.
[2] Includes captures from Great Central Lake Dam and Sport caught broodstock but excludes hatchery releases.
[3] Stamp River only, includes prespawn mortalities and hatchery releases.

Table 1b. Summary of total return from hatchery production only, based on expanded CWT.

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total Adult	Total
Alberni Inlet Sport[1]	0	0	0	0	0	0	0
Somass Native	0	0	0	0	0	0	0
Barkley Sound Sport[1]	0	0	0	0	0	0	0
Hatchery Returns[2]	2010	173	841	557	47	1,618	3,628
River Escapement[3]	0	0	1256	773	0	2,029	2,029
Total Terminal	2010	173	2097	1330	47	3,647	5,657

[1] No sampling conducted – incidental mortalities only.
[2] Includes captures from Great Central Lake Dam and Sport caught broodstock but excludes hatchery releases.
[3] Stamp River only, includes prespawn mortalities and hatchery releases.

This return deposited approximately 10.1 million eggs into the Stamp River. Approximately 60% of the adult run was females. Prespawn mortality was very low in 2000, with about 10% average mortality across age classes. Based on expanded CWT data, the estimated proportion of hatchery origin chinook was very similar for both swim-in and river spawners at 57%.

4 Cohort Analyses

4.1 CWT based cohort analyses

Cohort analyses for the 1983 through 1998 brood releases from RCH were completed using the total escapement of coded-wire tags to the hatchery and the natural spawning grounds in the upper Stamp River. Note that the returns from the latter 3 broods are incomplete through 2000, so surviving cohorts are estimated using average maturation rates from the completed brood returns.

The cohort analysis provides insight into the annual exploitation and survival of the RCH chinook, including:

- Recoveries from the 1992 brood year are very limited (estimated number of recoveries = 10) and the cohort analysis is not reliable.

- Recoveries for the nine brood years (1983 through 1991) for which total escapement recoveries are available indicate the total exploitation rates (expressed as adult equivalents to account for changes in size limits over time) have averaged:
  ocean total mortality exploitation rates = 44.6% (CV = 13%)
  (ocean implies non-terminal fisheries, outside Barkley Sound), and
  brood total mortality exploitation rates = 65.7% (CV = 6%).

- Returns from the 1993-1995 brood years indicate significant reduction in exploitation rates (estimated average ocean exploitation rate = 33% and total exploitation rate = 52%) as expected due to the conservation actions taken during 1995 through 2000.

- Estimates of marine survival continue to demonstrate highly variable survival and very poor survival for the most recent brood years, 1995, 1996 and 1997 (Table 2). However, returns of Age-2 male chinook in 2000 indicate some improvement in marine survival of the 1998 brood.

- Annual distribution of the total fishing mortality on the Robertson Creek stock has been updated through 2000 CWT recoveries. Conservation actions taken in recent years are again evident in distribution changes (Table 3) and the continued reduction in total fishing mortality. Fishing mortality was the lowest recorded in calendar year 2000. Due to low stock levels, recoveries of CWT were rare. Incidence of thermally marked otoliths provided an independent estimate of total fishing mortality.

Table 2. Estimated survival rates (smolts released to Age 2 cohort) of coded-wire tagged (CWT) groups released from RCH by brood year. Survival to Age-2 cohort include all recoveries, estimated incidental fishing mortality, and annual rates of natural mortality for all ages (Ages 2 through 5). Note the last three broods have incomplete recoveries but are estimated based on observations to date and assuming average maturation rates from completed brood years.

Brood Year	Estimated % Survival Rate for Age-2 cohort CWT groups
1983	0.10%
1984	4.44%
1985	4.32%
1986	12.05%
1987	10.14%
1988	13.12%
1989	9.16%
1990	5.67%
1991	0.99%
1992	0.014%
1993	2.23%
1994	4.86%
1995	0.40%
1996	0.17%
1997	0.028%
1998	1.87%

Table 3. Distribution of total fishing mortality for RCH chinook stock; distributions based on CWT cohort analysis through 2000 and using the brood year method to estimate incidental fishing mortality. Some fisheries with very few recoveries have been combined, e.g. Southern nets and other sport include southern BC and Washington recoveries.

Fishing Mortalities by Major Fishery, as a proportion of Total Fishing Mortalities plus Escapement																	
Catch Year	Alaska Troll	north BC troll	central BC troll	WCVI troll	Alaska Net	NCBC net	south BC net	south US net	Alaska sport	NCBC sport	WCVI sport	Other sport	Term net	Term sport	Total Ocean Fishing Mortality	Total Fishing Mortality	Escape
1985	5.1%	0.0%	1.0%	3.2%	0.0%	0.8%	0.0%	0.0%	0.0%	2.6%	0.0%	21.7%	0.0%	0.9%	34.3%	35.2%	64.8%
1986	13.8%	9.6%	1.9%	6.6%	6.3%	5.2%	1.9%	0.6%	1.5%	1.3%	4.3%	2.9%	0.8%	15.0%	55.8%	71.5%	28.5%
1987	10.5%	8.6%	3.1%	3.1%	3.6%	2.3%	1.0%	0.4%	0.5%	0.6%	0.5%	0.7%	0.3%	19.7%	35.0%	55.0%	45.0%
1988	12.8%	8.9%	1.6%	4.7%	4.4%	1.8%	0.2%	0.3%	1.1%	1.2%	4.5%	0.8%	7.0%	12.8%	42.1%	62.0%	38.0%
1989	14.3%	9.0%	1.4%	3.3%	5.5%	1.0%	1.0%	0.1%	1.3%	1.0%	1.6%	0.8%	15.8%	14.6%	40.5%	70.8%	29.2%
1990	19.5%	8.8%	2.5%	7.6%	4.4%	1.5%	0.6%	0.0%	1.3%	0.9%	1.9%	0.4%	8.2%	7.8%	49.5%	65.5%	34.5%
1991	19.9%	9.5%	2.9%	6.0%	2.6%	0.6%	0.6%	0.0%	2.2%	0.8%	1.1%	0.4%	12.9%	12.1%	46.6%	71.6%	28.4%
1992	17.7%	7.5%	2.9%	18.1%	8.0%	0.8%	0.3%	0.1%	1.3%	1.4%	2.0%	0.2%	0.4%	5.5%	60.3%	66.2%	33.8%
1993	16.5%	7.4%	2.0%	13.7%	2.3%	0.4%	0.8%	0.0%	2.7%	1.4%	2.6%	0.6%	7.0%	13.0%	50.3%	70.3%	29.7%
1994	17.9%	9.1%	1.0%	5.2%	4.6%	1.0%	0.2%	0.0%	3.5%	1.1%	4.3%	0.5%	11.6%	16.7%	48.5%	76.9%	23.1%
1995	17.2%	3.5%	0.4%	1.7%	0.1%	0.4%	0.1%	0.2%	4.4%	1.3%	4.3%	1.4%	6.6%	10.2%	35.1%	51.9%	48.1%
1996	15.0%	2.9%	0.7%	1.7%	1.5%	0.1%	0.0%	0.0%	4.7%	2.3%	1.3%	1.5%	0.1%	1.9%	31.8%	33.8%	66.2%
1997	13.1%	5.2%	1.8%	0.1%	6.7%	0.4%	0.1%	0.0%	4.4%	3.1%	2.0%	0.6%	5.7%	16.8%	37.8%	60.3%	39.7%
1998	17.0%	6.0%	0.1%	0.0%	4.1%	0.0%	0.0%	0.0%	4.5%	2.3%	3.3%	0.6%	3.9%	15.8%	37.9%	57.7%	42.3%
1999	12.9%	4.1%	0.2%	0.0%	0.9%	0.0%	0.0%	0.0%	6.0%	3.2%	3.7%	0.9%	6.7%	20.0%	31.9%	58.6%	41.4%
2000	5.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	3.1%	0.0%	4.4%	0.0%	0.5%	13.0%	13.5%	86.5%
Average																	
1985-94	14.8%	7.8%	2.0%	7.1%	4.2%	1.5%	0.6%	0.1%	1.5%	1.2%	2.3%	2.9%	6.4%	11.8%	46.3%	64.5%	35.5%
1995-00	13.4%	3.6%	0.5%	0.6%	2.2%	0.2%	0.1%	0.0%	4.0%	2.6%	2.4%	1.6%	3.8%	10.9%	31.2%	46.0%	54.0%

4.2 Exploitation Pattern in Canada based on Otolith Thermal Marks

Significant management measures were implemented in 2000 in response to conservation requirements determined in spring 2000. The limited fishing in Canada, along with low numbers of WCVI chinook, resulted in very few CWT recoveries for WCVI stocks. Consequently the exploitation rate in Canada was also examined by analysis of otoliths.

Robertson Creek Hatchery was the first facility in BC to thermally mark salmonids. They have marked all chinook releases since the 1992 brood year. Since then all WCVI major hatcheries have mass marked chinook salmon with the thermal otolith mark. As well, other southern BC hatcheries such as Quinsam River, Chilliwack River, and many Washington State hatcheries apply thermal marks on the otoliths.

The coding system used to represent the thermal mark is called the RBr system. An example code is shown below. In this case the mark is pre-hatch with 3 rings in the first band and 4 rings in the second band.

Eg. 1: 1.3 + 2.4

R B r

where; R = region of the otolith that is marked (1 = pre-hatch, 2 = post-hatch, 3 = both)
B = Band No.
r = the no. of rings in the band

RCH uses a propane fired boiler to raise the temperature of the incubation water by approximately 2^{o}C for a 24 hour period and then drop it back to ambient for 24 hours. This process is repeated for each thermal ring required in the mark. A period of 72 hours of ambient water is required between bands.

Initially marks were varied from year to year to permit brood year identification. However, due to the limited number of marks available an identical mark has been used since the 1999 brood year. Scales will now be required to determine age and brood year of thermally marked releases. The marks relevant to the brood years available, and identified in reading include the following:

Brood Year	1994	1995	1996	1997	1998	1999
RBr Code	1 : 1.4	1 : 1.2 + 2.2	1 : 1.4	1 : 1.2 + 2.2	1 : 1.4 2 : 1.4 + 2.4	1 : 1.3 2 : 1.2 + 2.3

Catch sampling for otoliths was initiated in Langara sport, WCVI sport, northern troll test, and WCVI troll test fisheries. The resulting estimate of impact in the sport fisheries is presented in Appendix Table 5. The cumulative impact of Canadian fisheries was estimated to be approximately 739 Stamp River/RCH chinook of which 372 were age 4 or greater. The latter number represents approximately 6.4% of the total return of age 4+ chinook into Canada. This impact was distributed about 1% in northern sport and 5% in WCVI sport. Impact from First Nations fisheries is not known but assumed to be negligible due to the timing and area of these fisheries relative to the known distribution of WCVI chinook.

5 Forecast

5.1 Regression Statistics for Two Forecast Models

Table 4 summarizes the regression statistics and results of Prod2 and Prod3 regression models. The upper portion of these tables identify each sibling model, the x-value used in the 2001 forecast, the predicted value and its upper and lower 90% confidence bounds, the co-efficient of the regression (intercept is zero), the r-squared value, and sigma (residual standard deviation of the regression).

Regressions 3, 5, and 8 were used in each of the Prod2 and Prod3 regression models to determine the 2001 forecast. These Prod 2 and Prod 3 data points and regressions are plotted in Appendix Figure 1 and 2, respectively. Results of the retrospective assessment of each forecasting equation are also presented in the lower portion of tables.

5.2 Forecast Result

The forecast abundances shown in Table 4 are based on CWT groups listed in Appendix Table 4. These age specific forecasts are expanded to account for hatchery production not associated with the CWT used in the regression analyses and "natural" production from the Stamp River. The expansion factors used in this forecast were 1.48 for Age 2 returns in 2000 (for the age 3+4+5 cohort), 3.87 for Age 3 returns in 2000 (for the age 4+5 cohort), and 1.99 for the Age 4 returns in 2000 (for the age 5+ cohort). Note that the lack of CWT from the 1997 brood year precluded the determination of an expansion scalar for the remaining age 4+5 cohort (1997 brood). Instead the average expansion factor based on 1986 through 1998 brood years, (for age 2+3 within a brood year) was used for the 1997 brood expansion. The total cohort size available to ocean fisheries is presented in Table 5 as "Pre-fishery abundance". Management scalars (i.e., proxy for management actions) may then be applied to average exploitation rates in fisheries to determine catches. In the case of the 2001 forecast, management scalars are only applied to Alaskan fisheries, based on expected catch as outlined in the Pacific Salmon Treaty agreement (harvest rate scalar of 0.5 in SEAK troll). The remaining cohort is identified as the expected terminal run assuming no fisheries in Canada (Table 5) based on recent average maturation rates (0.16 for Age 3, 0.57 for Age 4), or remain at sea as the surviving cohort. At a later stage in the domestic fishery planning process, management scalars are derived for Canadian fisheries to reflect the conservation and allocation requirements for the Stamp River chinook.

Table 4. Regression equations and results for Robertson Creek forecast models.

Part A: Terminal run vs. Total production regressions (Prod2 model, 2001 RCH forecast)

Model # & Desc.	Predictor x-value	Prediction	90% confidence Lower	90% confidence Upper	Slope Para.	r-sq.	sigma
#1,Age 2 vs. Age 3	2710	19267	-562	39095	7.109	0.912	16444
#3, Age 2 vs. Ages (3+4+5)	2710	73325	-15885	162535	27.057	0.898	73450
#5,Age (2+3) vs. Age (4+5)	115	461	-31346	32268	4.009	0.963	26312
#6, Age (2+3+4) vs. Age 5	3106	1407	-8415	11228	0.453	0.953	8124
#7,Age 3 vs. Age (4+5)	115	571	-37342	38483	4.962	0.943	31363
#8,Age (3+4) vs. Age 5	2874	1432	-8607	11471	0.498	0.951	8304

Mean absolute deviations by model:

	Sum of Square error
#1,Age 2 vs. Age 3	0.6782
#3, Age 2 vs. Ages (3+4+5)	0.7179
#5,Age (2+3) vs. Age (4+5)	0.4087
#6, Age (2+3+4) vs. Age 5	0.5655
#7,Age 3 vs. Age (4+5)	0.4546
#8,Age (3+4) vs. Age 5	0.5374

Leave-one-out Assessment (one forecast for each brood year by model type):

	MODEL #1		MODEL #3		MODEL #5		MODEL #6		MODEL #7		MODEL #8	
Brood	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.
1983	1018	4232	3330	16105	1850	3772	326	809	1814	1717	326	594
1984	46586	24507	145793	93772	79366	134789	18753	30968	77303	151873	18753	32414
1985	33358	34869	140433	132274	85660	95913	22257	28610	83212	94363	22257	29038
1986	98183	64555	402754	241715	243657	185979	80700	55038	234780	185706	80700	56400
1987	85760	108549	314988	417290	183383	172314	50660	48402	177810	139712	50660	45789
1988	125080	129741	461386	504238	269045	299272	65770	74700	261810	269495	65770	71991
1989	56980	74880	236411	281953	143545	121345	35860	36329	139600	99441	35860	34767
1990	45660	14084	189060	53521	114720	88047	32000	28893	111200	99666	32000	30905
1991	10460	12442	32038	47384	17262	17154	3200	5908	16910	12549	3200	5628
1992	125	0	446	0	256	501	195	74	235	620	195	82
1993	20740	13055	59553	49769	31050	75016	5000	14704	30500	84166	5000	15266
1994	34270	5205	143897	19801	87701	83809	18830	28383	85630	101026	18830	31054
1995	2960	533	13513	2029	8442	6434	1930	2725	8230	7591	1930	2961
1996	1020	1649	3330	16105	1850	3772	326	809	1814	1717	326	594
1997	520	0	145793	93772	79366	134789	18753	30968	77303	151873	18753	32414

Table 4 Continued

Part B: Total production vs. Total production regressions (Prod3 model, 2001 RCH forecast)

Model # & Desc.	Predictor x-value	Prediction	90% confidence Lower	90% confidence Upper	Slope Para	r-sq.	sigma
#1,Age 2 vs. Age 3	2710	6480	-5439	18399	2.391	0.968	9926
#3, Age 2 vs. Ages (3+4+5)	2710	24802	-28219	77822	9.152	0.964	43838
#5,Age (2+3) vs. Age (4+5)	587	942	-17523	19407	1.605	0.987	15275
#6, Age (2+3+4) vs. Age 5	3645	750	-8451	9952	0.206	0.959	7611
#7,Age 3 vs. Age (4+5)	520	1140	-14737	17017	2.192	0.990	13134
#8,Age (3+4) vs. Age 5	3345	798	-8172	9768	0.238	0.961	7420

Mean absolute deviations by model:

	Sum of Square error
#1,Age 2 vs. Age 3	0.4101
#3, Age 2 vs. Ages (3+4+5)	0.4276
#5,Age (2+3) vs. Age (4+5)	0.2375
#6, Age (2+3+4) vs. Age 5	0.4160
#7,Age 3 vs. Age (4+5)	0.1938
#8,Age (3+4) vs. Age 5	0.3986

Leave-one-out Assessment (one forecast for each brood year by model type):

	MODEL #1		MODEL #3		MODEL #5		MODEL #6		MODEL #7		MODEL #8	
Brood	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.	OBS.	PRED.
1983	1018	2616	3330	10013	1850	3389	326	741	1814	2232	326	598
1984	46586	26070	145793	100329	79366	93019	18753	24109	77303	103458	18753	25328
1985	33358	28172	140433	107571	85660	72181	22257	21840	83212	72867	22257	22500
1986	98183	81090	402754	304837	243657	206070	80700	53261	234780	209616	80700	54298
1987	85760	96255	314988	371959	183383	204632	50660	52183	177810	190132	50660	50799
1988	125080	134696	461386	527594	269045	300365	65770	84130	261810	281339	65770	82665
1989	56980	72657	236411	275563	143545	138486	35860	39529	139600	123726	35860	38575
1990	45660	39888	189060	152083	114720	99494	32000	29004	111200	99541	32000	29650
1991	10460	9113	32038	34893	17262	22917	3200	5766	16910	22948	3200	5770
1992	125	38	446	146	256	226	195	37	235	274	195	39
1993	20740	12881	59553	49379	31050	42037	5000	10671	30500	45622	5000	11073
1994	34270	15292	143897	58451	87701	64885	18830	22237	85630	74840	18830	24299
1995	2960	1578	13513	6040	8442	5809	1930	2042	8230	6489	1930	2209
1996	1020	717	3330	10013	1850	3389	326	741	1814	2232	326	598
1997	520	160	145793	100329	79366	93019	18753	24109	77303	103458	18753	25328

Table 5. Summary of forecasted abundance and terminal run size of Stamp River chinook salmon with no Canadian fisheries. Terminal run after Canadian fisheries to be determined by managers in consultation with stakeholders.

	Pre-Fishery Abundance	Terminal Run with no Canadian Fisheries	Age compositon
1. Model Prod 2 (Terminal vs Total Production)			
1998 brood	108,380	16,480	84%
1997 brood	1,780	880	4%
1996 brood	2,850	2,370	12%
Total	113,010	19,730	
2. Model Prod 3 (Total vs Total Production)			
1998 brood	36,660	5,570	64%
1997 brood	3,640	1,810	21%
1996 brood	1,590	1,320	15%
Total	41,890	8,700	
3. Average of Prod2, Prod3			
1998 brood	72,520	11,020	78%
1997 brood	2,710	1,350	9%
1996 brood	2,220	1,850	13%
Total	77,450	14,220	

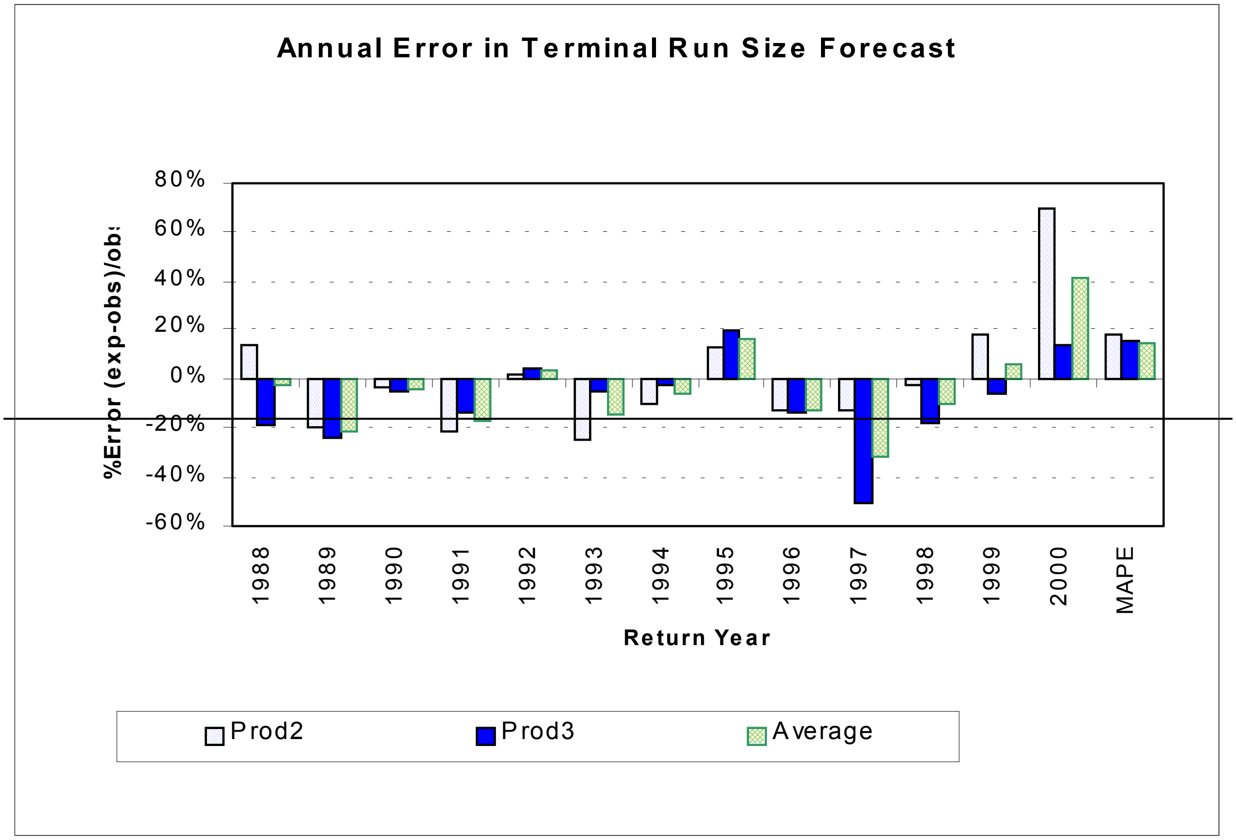
The total terminal run is comprised of approximately 3,000 females (20% of total) with up to 75% run age-3 males.

When the age-specific forecasts are combined to predict the total terminal run to Barkley Sound (i.e. average of Prod2 and Prod3), the forecasting error is, on average, less than for the individual regression models. The mean absolute percent error (MAPE) for the average forecast value is 15% (Figure 1). The low return levels in 2000 resulted in large absolute percent error in the 2000 forecast, including 69% in Prod2, 13% in Prod3, and 40% on the average model forecast. Over the period 1988 to 2000, the MAPE is 17% for Prod 2 and 15% for Prod 3. The error estimates were based on the deviations between forecast and observed returns, where:

- the terminal returns are calculated from the current regression models (i.e., leave one out assessment for the Prod2 and Prod3 models) and the actual preseason assumptions of exploitation rates used in past abundance forecasts.
- The observed total terminal return includes all catch plus escapement of Stamp River chinook in Area 23.

In addition, a cumulative probability distribution for the "average" forecast is shown in Appendix Figure 3. Only 13 data points are available to formulate the cumulative distribution of the forecasts. The forecast at 50% probability of occurrence is approximately a 13,200 return to the Stamp River, and 50% confidence bound on that estimated is 11,600 to 15,100.

Figure 1. Average annual error for Prod2, Prod3, and average forecast models when applied to estimating the terminal run size of Stamp chinook into Barkley Sound, 1988 - 2000. Error is expressed as the percent deviation from the observed terminal run. The mean absolute percent error (MAPE) is also shown.



5.3 2001 Potential Escapement Level into Stamp River

As described in the Introduction, the forecast terminal run is compared relative to a base and the upper rebuilding target. The base reflects the escapement levels immediately prior to the PST implementation in 1985.

Because of changing age and sex compositions between years, the base level was expressed in terms of eggs, including a requirement for hatchery plus natural spawners in the Stamp River (i.e., 50 million eggs from natural spawners plus 9.3 million eggs required for Robertson Creek Hatchery). The escapement required to provide 59 million eggs is determined using Excel solver, given the age composition, fecundity, proportion females, and prespawn mortality parameters outlined in Table 6. The escapement required in 2001 to exceed the base period level of river spawners, given the expected age composition, would be almost 70,000 chinook. This is due to the large proportion of age 3 male chinook expected in the return. In 2001, the forecast terminal return (assuming no fishing in Canada) is approximately 14,220 adult chinook, producing approximately 10 million eggs (Table 7). The historic time series of spawners in the Stamp River is presented in Appendix Table 3. The base level of 50 million eggs in the Stamp River was not achieved in 5 years since 1985. The minimum escapement in the time series occurred in 1996 when less than 9 million eggs were deposited in the Stamp River.

Table 6. Derivation of the number of spawners needed to meet the 50 million eggs for inriver spawning, given forecast age composition, average fecundity, proportions of female by age, and average prespawn mortality.

	Age composition	Fecundity	Proportion Female	Prespawn Mortality	Spawners	Eggs
1998 brood	78%	4000	0.05	.20	54,278	12 million
1997 brood	9%	4400	0.5	.20	6,625	12 million
1996 brood	13%	4800	0.75	.20	9,091	26 million
Total					69,994	50 milion

Table 7. Potential escapement into Stamp River, not including losses to prespawn mortality.

	Prod2 Total Escapement	Prod2 Eggs	Prod3 Total Escapement	Prod3 Eggs	Average Model Total Escapement	Average Model Eggs
1998 brood	16,475	4.61E+06	5,573	1.56E+06	11,024	3.09E+06
1997 brood	884	1.95E+06	1,807	3.98E+06	1,346	2.96E+06
1996 brood	2,371	8.54E+06	1,321	4.76E+06	1,846	6.65E+06
Total return	19,731	15.09E+06	8,701	10.29E+06	14,216	12.69E+06
Expected after 20% prespawn mortality	15,784	12.08E+06	6,961	08.23E+06	11,373	10.15E+06

5.4 Summary and Recommendations for Stamp River chinook

- Intensive monitoring of catch and escapement of Stamp River chinook was successfully completed in 2000.
- The 2000 terminal return of the Stamp River/RCH chinook was approximately 9,500. The age 2 jack chinook were the biggest component (32%) of return at 2971. The age 3 return from the 1997 brood year (988 chinook) was the second lowest on record after the 1992 brood return in 1995. The total age 3 plus age 4 return was lowest return for two consecutive year classes on record since 1985.
- The decline in the Stamp River/RCH chinook is used as an indication of declines in other stocks along the WCVI. Overall, the 2000 return declined 70% from the 1999 return. The decline in adult return (not including age 2 jacks) was almost 80% relative to 1999.
- The 2001 forecast for the Stamp River/RCH chinook is based on the forecasting method used since 1995. The forecast total return of Stamp River/RCH chinook to the terminal area of Barkley Sound and Alberni Inlet is approximately 14,200 based on averaging the Prod2 and Prod3 models. The mean absolute percent error in the average forecast is 15%. The age structure of the return is projected to be: 78% Age-3, 9% Age-4, and 13% Age-5; with an expected sex ratio of 20% females. The forecast return of approximately 3000 female chinook includes almost 800 age 3 females (25%).
- The forecast indicates the 2001 Stamp River/RCH will be more than double the 2000 return. Of this total about 20% will be females. The resulting number of females will actually decrease about 25% relative to 2000 returns of females. This is due to the poor returns of two consecutive age classes, age 4 (1997 brood) and age 5 (1996 brood). However, the decrease would be much larger if not for a good return of age 3 chinook, of which only 5-7% is female.

- The spawner levels will be well below base level in 2001. With no fishing in Canada the expected escapement would provide a potential egg deposition of approximately 10 million eggs, if all fish were allowed to spawn in the river. With removals by RCH for broodstock, this level of egg deposition would be the lowest since the inception of the keystream program.

6 Extensive escapement indicators for WCVI chinook

6.1 Methods

The detailed assessments and forecasts of the Stamp River/Robertson Creek Hatchery chinook are undertaken annually for management plus as an indicator of the expected returns to the naturally spawning chinook populations along the WCVI. Seven populations on north-west Vancouver Island (NWVI), Areas 25 to 27, are in aggregate, used by the Pacific Salmon Commission (PSC) to indicate trends in escapement to naturally spawning chinook along the WCVI. These are termed "PSC extensive" escapement indicators based on the consistent effort and methodology used. Additionally, since 1995, 18 "other extensive" WCVI indicator streams have been surveyed annually (Table 8). Since 1995, the snorkel method has been used to survey escapement to the PSC extensive indicators and the other extensive indicator streams. Surveys are scheduled for every 10 days during September and October, for a minimum of 6 surveys per system. Weather, water condition, and water flows may impact this schedule. Generally, surveyors started surveys from upstream migration barriers or observed upstream limit and snorkeled downstream, 1 to 3 observers per team. Observations were discussed at the end of each habitat type and river section, and recorded on waterproof paper Stream Inspection Logs. The counts from the snorkel surveys are used to estimate escapement by the Area-Under-the-Curve (AUC) method. Age compositions were determined by analysis of scales sampled during broodstock collection, test-fishing and in-river sampling.

6.2 Operational Summary

Through early September to mid October 2000, river levels throughout the WCVI were generally stable and low. There was sufficient water in most systems that in-river migration was not impeded. Water temperatures were suitable for migration (i.e. less than 18°C). Survey conditions were generally favourable with good visibility, good access, etc. As a result of these low water conditions, crews had adequate coverage of all stages of the chinook escapement (pre-spawn, spawn, post-spawn) in most systems. The heavy rains came during the third week in October. During this week high water precluded any surveys from occurring. Surveys were conducted as soon as conditions permitted after this event in the fourth week of October.

Survey coverage on each system is reported in Table 8. The reported survey coverage does not include zero counts either side of the chinook spawning period which are included in the AUC estimation. The timing of zero counts were identified through surveys of 3 systems prior to chinook arrival in the stream. Based on Toquart, Bedwell, and Zeballos Rivers the start of chinook entry was the beginning of September. The chinook spawning was complete by the first week of November.

Surveys in many systems were delayed after the initial survey in September since water levels were low and there was no indication of new fish moving into the system until early October. Once water conditions changed and fish began to move or spawn, survey frequency was shortened and the 10-day survey frequency was again implemented.

Age composition of WCVI chinook escapement was estimated from a cross section of the "extensive" indicators. The samples were collected by hatchery staff during broodstock collection, or by dedicated sampling crews using beach seines in the river, or using test vessel seines in the estuary. As a result of the low chinook escapement, adult sampling was limited to those systems where hatchery broodstock was collected and even with increased effort, there was difficulty in capturing adequate numbers of adults for brood. As an example, the San Juan River (Area 20) collected almost 400 adult chinook during 1999, and was only able to capture 120 adults during 2000.
We used an AUC method to calculate a low, mid, and a high estimate of escapement. The low, mid, and high value estimates were based on a short and a long residence time with the mid-value calculated as the mean of the upper and lower values. In general, 15 and 25 days were used as the short and long residence times, however, when the data suggested that the times were longer or shorter they were adjusted accordingly. As an example, the stream residence time on the Marble River was estimated to be 40 days (short) and 50 days (long). Fish remained in this system for an extended period of time prior to spawning. On the Artlish River, stream residence was estimated to be 10 days (short) and 20 days (long). Fish were observed for a very short period of time in the system. The mid-value estimate was recommended as the escapement estimate on most systems.

Observer efficiencies were used to expand the raw survey counts. These efficiencies relied upon the surveyor's estimate of their efficiency for a particular swim on a particular day and for a particular species. Surveys with efficiencies less than or equal to 50% were removed from the AUC calculation as they represented a low confidence count and the potential for a large inaccuracy in the number of fish as a result of the large expansion.

Table 8. Rivers extensively surveyed (consistent method and effort) to provide quantitative estimates of chinook escapement.

Stream	Stat Area	Survey Method and Frequency in 2000
(PSC)Extensive		
Burman River	25	4 Snorkel
Gold River	25	6 Snorkel
Tahsis River	25	4 Snorkel
Kaouk River	26	8 Snorkel
Artlish River	26	8 Snorkel
Tahsish River	26	5 Snorkel
Marble River	27	4 Snorkel
Hatchery		
Conuma/Canton R	25	6 Snorkel
Nitinat River	22	6 Snorkel

Stream	Stat Area	Survey Method and Frequency in 2000
Other Extensive		
San Juan River	20	Fence/4 Snorkel
Gordon River	20	5 Snorkel
Sarita River	23	5 Snorkel
Toquart River	23	12 Snorkel
Nahmint River	23	6 Snorkel
Bedwell R / Ursus	24	8 Snorkel
Moyeha River	24	6 Snorkel
Megin River	24	6 Snorkel
Sucwoa River	25	4 Snorkel
Deserted Creek	25	4 Snorkel
Tsowwin River	25	4 Snorkel
Leiner River	25	4 Snorkel
Zeballos River	25	7 Snorkel
Tlupana River	25	4 Snorkel
Klaskish River	27	0 Snorkel
Colonial/Cayeghle	27	4 Snorkel

6.3 Stock Status in 2000

Escapement levels in 2000

In 1998 and 1999 the aggregate PSC index exceeded the interim rebuilding goal of 11,500 chinook (double the base period 1979-1982 average escapement). In 2000, the aggregate PSC index declined to 4722 adult chinook, which was below the base level (Figure 2).

Spawner levels in the other extensive indicators are reported in Table 9. The escapement estimates do not include jacks, only adults. Most crews surveying WCVI systems during 2000 noted larger numbers of jack chinook (larger than those observed in 1998 and 1999). On the Sarita and Nahmint Rivers (Area 23), the jack number was estimated as 37% and 52% of the total chinook escapement, respectively. On the Artlish and Tahsish Rivers (Area 26) the jack number was estimated as 15% and 18% of the total escapement, respectively. Jacks contributed 12% to the San Juan escapement, 10% to the Bedwell River, 14% in the Kaouk.

Terminal harvests were not calculated for the other extensive indicators, however, terminal harvests would be negligible except in Nootka Sound (Stat Area 25) where a sport fishery may have impacted local stocks other than Conuma Hatchery returns.

Terminal returns were calculated for Conuma River and Nitinat River using CWT and otolith marks to apportion the terminal catch to these systems. Age and sex composition of the returns were derived from biological sampling in the river, hatchery, and fisheries.

Figure 2. Trend in adult chinook escapement of PSC escapement indicator stocks, 1975 to 2000. The solid line indicates the base period (1979-1982) average escapement. The broken line indicates the PSC rebuilding goal (double the base period average).

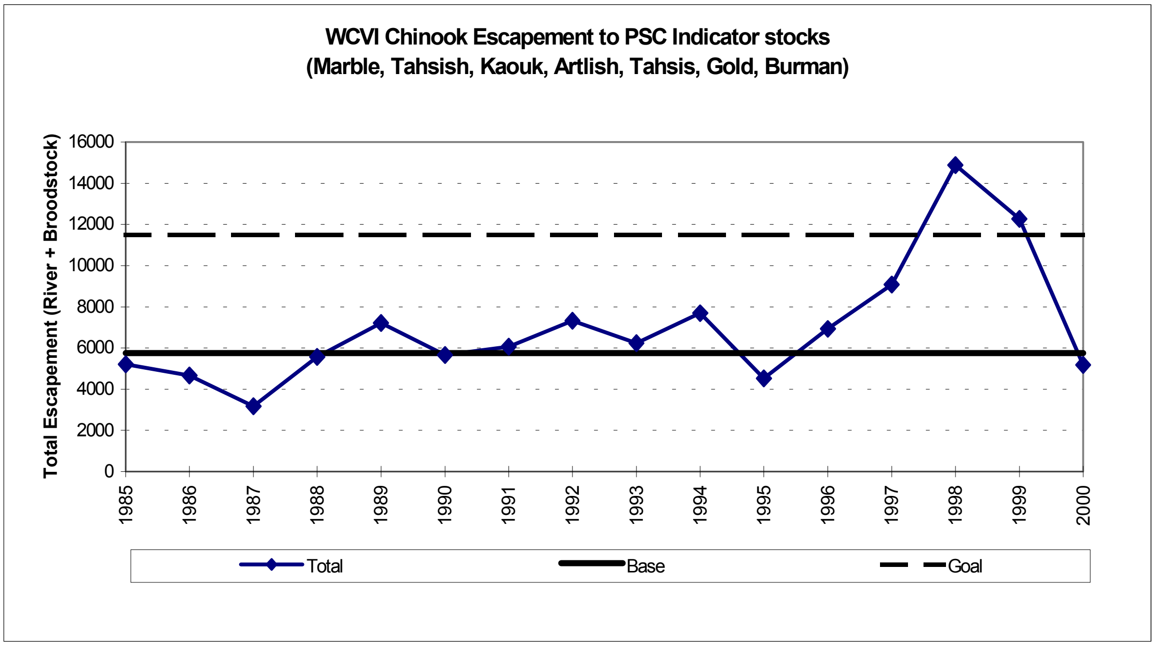


Table 9. 2001 outlook of total escapement and female spawners in selected WCVI indicator streams assuming a 120% increase from 2000 levels and expected 20% female component in the total return.

AREA	RIVER	2000 adults	2001 adults	2001 females
20	San Juan River	370	820	160
21	Gordon River	19	40	10
22	Nitinat River	8663	19,059	3,812
23	Sarita River	301	670	130
23	Nahmint River	68	150	30
23	Toquart River	100	220	40
24	Bedwell River	143	320	60
24	Megin River	160	350	70
24	Moyeha River	94	210	40
25	Burman River	212	470	90
25	Gold River	500	1,110	220
25	Conuma River	9970	22,030	4,410
25	Leiner River	182	400	80
25	Tahsis River	1320	2,920	580
25	Zeballos River	200	440	90
26	Kaouk River	105	230	50
26	Artlish River	75	170	30
26	Tashish River	391	860	170
27	Marble River	2575	5,690	1,140
27	Colonial / Cayeghle	600	1,330	270

The total terminal return of Conuma River chinook was 13,250, including natural spawners, broodstock for the hatchery, and the Area 25 sport fishery (return by age and area is shown in the following table). Catch in the sport fishery was approximately 73% hatchery origin chinook based on presence of thermal marked otoliths. Female spawners in the river totaled approximately 4300 which produced an egg deposition in the river of 19.8 million (assuming fecundities of 4400 at Age 4, 4800 at Age 5 and 5200 at Age 6).

The sex ratio in the Conuma samples was 49.7% male and 50.3% female. The scale samples were collected from the last two brood collection days on the Conuma (of three and a half days total). No test seine in the estuary was done. While the total sample size was smaller than desired (250 random adults, 10% of the total removals and 5% of the total adult escapement) the in-river age composition matched very well with the otolith age composition in the Nootka fishery (i.e. greatest difference was 4% for age-4 fish, other differences were 1.5% or less.

Summary of 2000 terminal run of Conuma River chinook based on expanded scale ages.

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total
Nootka Sport	0	199	1594	753	0	2546
Hatchery Removals	41	100	884	326	15	1366
Natural Escapement	693	654	5768	2125	98	9338
Total Terminal Run	734	954	8246	3204	113	13,250

In the Nitinat River the terminal run into Area 21/22 totaled almost 12,000 chinook, including 7000 natural spawners, 2300 broodstock removals, 1100 First Nations food fishery, and 1400 sport catch. Based on expanded thermal marks, the estimated proportion of hatchery origin chinook in the Area 21 sport fishery was approximately 68%, and about 81% of the chinook escapement into the Nitinat River. Female spawners in the river totaled approximately 4300 which produced an egg deposition in the river of 19.8 million (assuming fecundities of 4000 at Age 3, 4400 at Age 4, 4800 at Age 5 and 5200 at Age 6).

Nitinat River sex ratio was estimated at 34% male and 66% female. The Nitinat sample only includes the escapement scales. The native food scales were classified as low priority and had not been completed to-date.

Summary of 2000 terminal run of Nitinat River chinook based on expanded scale ages.

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total
Sport (A21 & 22)	0	107	758	584	5	1454
Native Food	0	78	553	427	0	1062
Hatchery Removals	37	173	1240	872	7	2309
Natural Escapement	650	466	3285	2615	24	7041
Total Terminal Run	687	825	5835	4498	37	11,866

Change in status relative to 1999

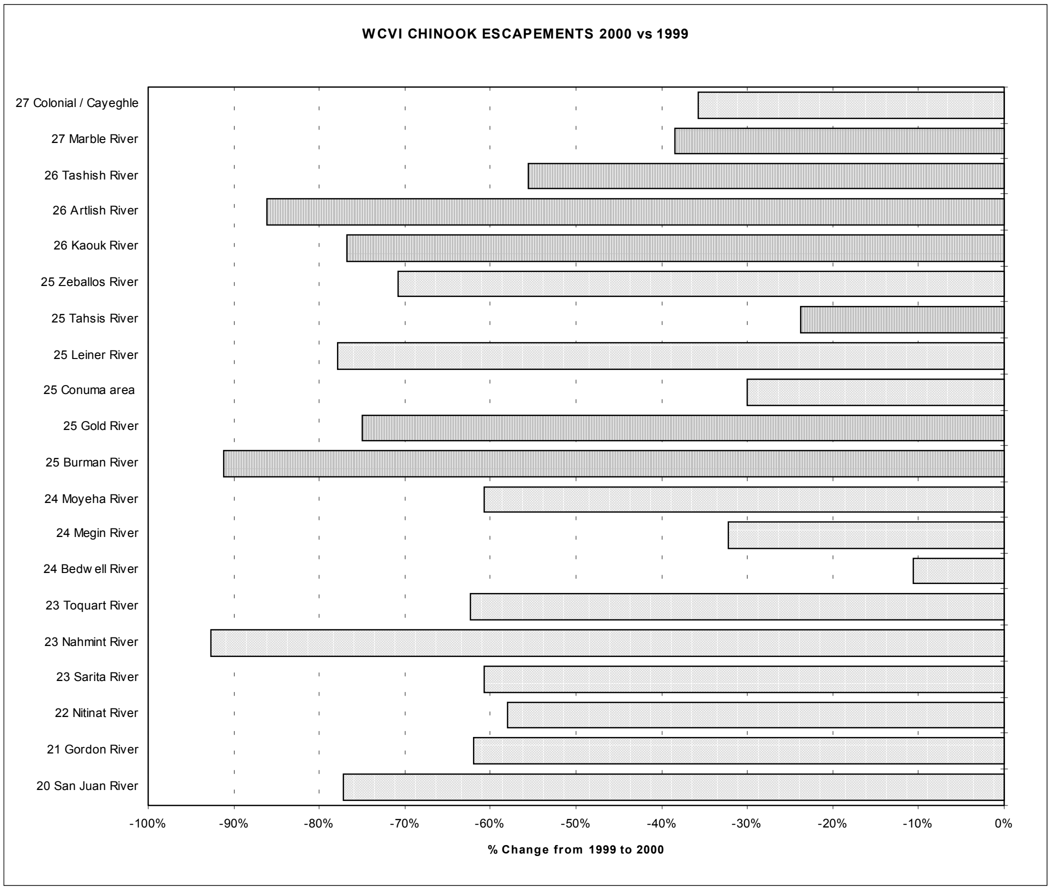
As indicated in the previous chapter, relative change in the Stamp River/RCH indicator stock is used as an indicator of change in chinook escapement to other WCVI systems. The total Stamp River escapement in 2000 declined by 70% from the 1999 return. The decline in adult return (not including age 2 jacks) was almost 80% relative to 1999.

Across all the extensively surveyed systems (excluding the major hatchery systems), the decline in total escapement from 1999 to 2000 was approximately 75%. The change relative to 1999 is presented in Figure 3 for each extensive escapement indicator. The decline occurred in all areas of the WCVI. The PSC aggregate index declined over 60% from 1999 escapements. Within the PSC indicator group, the escapement to both the Burman (Area 25) and Artlish Rivers (Area 26) was 90% lower than 1999. The Tahsis River (Area 25), which did not follow the general pattern in 1998 or 1999 had an escapement 25% lower than 1999. The Area 27 indicator (Marble River) had a 40% decrease in escapement from last year.

The other major hatchery systems along the WCVI did not have the same decrease as in the Stamp. In the Conuma area (including Conuma, Canton, Sucwoa, and Tlupana rivers) the overall decrease was approximately 30% relative to 1999. The area was compared as a whole due to potential straying of Conuma hatchery stock into surrounding rivers. For the Nitinat River the decline was about 50% relative to 1999 levels.

On southwest Vancouver Island (SWVI), eight streams were extensively surveyed for chinook. These systems all had decreased escapements relative to 1999. The 2000 escapement to the San Juan River (Area 20) was the lowest observed since 1989. The Nahmint River (Area 23) also had dramatically decreased escapement, 90% lower than 1999. The three primary indicator stocks in Area 24 (Bedwell, Megin, Moyeha) were all below 1999 escapements with an average decline of approximately 35% (the Moyeha River was 60% lower than 1999).

Figure 3. Relative change in escapement from 1999 to 2000 for WCVI indicator stocks with multiple surveys and quantitative estimates of escapement.



Age composition of 2000 escapements

Available age composition of the escapement to extensive indicators is presented in Table 10. The resulting age data indicate that four year-olds dominated the low returns in most systems. Furthermore, age 3 chinook were at levels equal to or less than those in the Stamp River indicator stock.

6.4 Forecast Returns for extensively surveyed systems along the WCVI

As indicated in the previous chapter, relative change in the Stamp River/RCH indicator stock is used as an indicator of change in chinook escapement to other WCVI systems. In addition, age and sex composition of WCVI stocks is assumed reflected in the Stamp River returns.

The forecast indicates the 2001 Stamp River/RCH will be more than double the 2000 return, with about 20% females. The resulting number of females will be a 25% decrease relative to 2000 returns of females. This is due to the poor returns of two consecutive age classes, age 4 (1997 brood) and age 5 (1996 brood). However, the decrease would be much larger if not for a good return of age 3 chinook, of which about 7% is female.

The age structure of the total adult return is projected to be: 78% Age-3, 9% Age-4, and 13% Age-5. Application of this expected change forms the basis for general outlook of chinook returns along the WCVI, and is presented in Table 9.

Table 10. Age Composition from scale analysis for extensively surveyed systems along the WCVI. Note: Due to low chinook escapement, capture of chinook was limited.

System	Age 3	Age 4	Age 5	Age 6	Sample Size
San Juan R (A20)	5.4%	58.2%	32.7%	3.6%	111
Sarita R (A23)	15.5%	70.9%	10.7%	2.9%	149
Cypre R (A24)	15.2%	75.9%	8.9%	0.0%	79
Marble R (A27)	2.2%	63.9%	32.1%	1.8%	274
Unweighted mean	9.6%	67.2%	21.1%	2.1%	
Standard error about the mean	5.9%	6.7%	11.3%	1.4%	
Nitinat R	7.4%	52.1%	40.2%	0.3%	
Conuma R	7.6%	65.9%	25.6%	0.9%	
Stamp R	15.3%	47.2%	37.4%	0.0%	

6.5 Summary and Recommendations for WCVI Systems Outside the Stamp River

- Confidence in the data is relatively high in 2000. However, lack of quantitative parameter estimates such as stream residence times require attention. Current parameters are based on experience from visual clues on the fish. A marking program should be undertaken to more accurately determine what is an acceptable residence time for chinook adults.
- The total escapement to the PSC indicator stocks fell well below the established goal and the base period average in 2000.
- Escapements across all the PSC indicator stocks declined about 60% from 1999 to 2000. Declines in the extensive escapement indicators generally reflected returns in the Stamp River indicator.
- The 2001 outlook in selected WCVI indicator streams assumes a 120% increase from 2000 levels and expected 20% female component in the total return. The results show many chinook populations along the WCVI with less than 100 females.
- The future recovery in this stock will be highly dependent upon the survival projected for the 1998 brood (the return of age 3 chinook in 2001). Improved survival is forecast based on jack returns to the Stamp/RCH; however, jacks are very difficult to enumerate in natural systems.

7 Literature cited

Pacific Salmon Commission. 1999. 1995 and 1996 Annual Report of the Chinook Technical Committee. TCHINOOK (99)-2. (Pacific Salmon Commission, 600-1155 Robson Street, Vancouver, B.C. V6E 1B5).

PSARC. 1994. PSARC Advisory Document S94-4. *In* Rice et al. 1995. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2318: iv + 404p.

Riddell, B.E., A. Tompkins, W. Luedke and S. Lehmann. 1996. 1996 Abundance forecast, and preliminary outlook for 1997 for Robertson Creek Hatchery and the Stamp River chinook salmon. PSARC Report X96-1. 36p.

Starr, P. and S. Argue. 1991. Evaluation framework for assessing 1989 Strait of Georgia sport fishing regulation changes. Pacific Stock Assessment Review Committee Working Paper S91-3. 59p.

8 Appendices

Appendix Table 1. 2000 Stamp River (Somass) Chinook Terminal Run, Catch and Escapement

FISHERY	DATE	CATCH	Aged	Age 2	3	4	5	6
			AGE COMPOSITION					
ALBERNI INLET FISHERIES								
Alberni Inlet Sport Encounters (released)		125	releases only, apply 15% mortality rate					
			assume 97% Stamp origin based on 1999 info					
Total Alberni Inlet mortalities		**19**						
Total morts of Stamp R chinook in Alberni		**18**		**0**	**3**	**8**	**6**	**1**
Age composition Stamp chinook only					**15.3%**	**47.2%**	**34.4%**	**3.0%**
ESCAPEMENT ABOVE STAMP FALLS								
Hatchery broodstock, morts, surplus		5,350		2,443	681	1,453	704	70
Inriver escapement, potential spawners		4,034		528	303	1,575	1,503	126
ESCAPEMENT TOTAL		**9,384**		**2,971**	**984**	**3,028**	**2,206**	**195**
~~Age composition~~				~~**31.7%**~~	~~**10.5%**~~	~~**32.3%**~~	~~**23.5%**~~	~~**2.1%**~~
Escapement of adults only		6,413						
Escapement hatchery component based on expCWT		3,647						
Total inriver female spawners ni pre-spawn morts		2,436						
prespawn mortality adults		254	4%					
Effective natural spawning females		2,182						
Total inriver eggs		9.8M						
BARKLEY SOUND FISHERIES								
A23B Creel Survey Estimated Total Catch CN		0	= catch during RBT migration only, Aug-Sep only					
23B Release		658	apply 15% mortality rate, assume 11% are Stamp origin based on 50% of 1999 level.					
A123 Creel Survey Estimated Total Catch CN		6,627						
123 Release		623	does not include releases from CP - not available.					
Barkley Sound Mortalities		**99**						
Total morts of Stamp R chinook in Barkley		**11**		**-**	**2**	**5**	**4**	**0**
TOTAL TERMINAL RUN STAMP CHINOOK		**9,413**		**2,971**	**988**	**3,041**	**2,216**	**196**
Age composition Stamp chinook only				**31.6%**	**10.5%**	**32.3%**	**23.5%**	**2.1%**

Appendix Table 2. Total escapement into Stamp River, hatchery and natural spawning.

A. TOTAL COUNT THROUGH STAMP FALLS FISHWAY

	Adults	Jacks	Total Count
Unadjusted Daytime Observations at Stamp Falls:	4,948	2,258	7,206
Adjusted daytime count from tape verification:	4804	2620	7424
Adjusted swim survey count:	117	18	135
Night time count from tape verification:	1492	334	1826
Adjusted jack count after removal of 'jimmies':		2971	
Final adjusted counts (above Stamp Falls):	**6413**	**2971**	**9384**

B. HATCHERY COMPONENT

	Swim in	Sample Size	Released	Marked	unMarked	Sex	C/S
Males (incl jacks):	3,930						
Adjustment factor (M to J):	15						
Females:	1,384	1,321	0	44	2	1,277	F
Jacks:	2,443	2,443		56	0	2,387	J
Adult males:	1,486	1,486	6	19	0	1,467	M
Totals:	**5,313**	**5,250**	**6**	**119**	**2**	**5,131**	

CWT recoveries by sex:

	Expansion	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	Observed	56	3	13	3		75	19
	Estimated	56	3	13	3		75	19
	Expanded	2010	173	309	44		2536	527
Female	Observed			20	21	1	42	42
	Estimated			20	21	1	42	42
	Expanded			531	513	47	1091	1091
Females fr Dam	Observed	-	-	-	-	-	0	0
	Estimated						0	0
	Expanded						0	0
Males fr Dam	Observed						0	0
	Estimated						0	0
	Expanded						0	0
TOTAL (swim-in)	Expanded	2010	173	841	557	47	3628	1618
TOTAL (swim-in+GCL)	Expanded	2010	173	841	557	47	3628	1618

Scale Age composition (from biosample fish only, excluding cwt samples):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	149	254	251	38	2	694	545
Females		3	301	229	25	558	558
Female/ dam			15	14	4	33	33
Male/ dam						0	0

Pooled Age composition (est cwt + scale by age)/(total sample adults only) excluding GCL:

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl Sample
Males		45.6%	46.8%	7.3%	0.4%	100%	564
Females		0.5%	53.5%	41.7%	4.3%	100%	600
Males (GCL Dam only)							0
Females (GCL Dam only)		0.0%	45.5%	42.4%	12.1%	100%	33
Age composition based on Expanded CWT % (including adults):							
Males	79.2%	6.8%	12.2%	1.7%	0.0%	100.0%	
Females	0.0%	0.0%	48.7%	47.0%	4.3%	100.0%	
Female/ dam							

TOTAL RETURN TO HATCHERY BY AGE - including releases (based on pooled samples):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males (swim-in)	2443	677	696	108	5	3929	1486
Females (swim-in)	0	7	740	577	60	1384	1384
Total (swim-in)	2443	684	1436	685	65	5313	2870
Females fr GCL (scales only)		0	16	15	4	35	35
Males from GCL	-	-	-	-	-	0	0
Females from Sport			3	4		7	7
Total (swim-in + GCL)	2443	684	1455	704	69	5349	2906
% hatchery (exp cwt) - swim-ins only	*82%*	*25%*	*59%*	*81%*	*72%*	*68%*	*56%*
% hatchery (otolith)- swim-ins only	100%	100%	100%	100%	100%	100%	100
Otolith sample size	61	92	192	92	7	444	383

NET RETURN TO HATCHERY BY AGE - excluding releases (based on pooled samples):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males (swim-in)	2443	674	693	108	5	3923	1480
Females (swim-in)	0	7	740	577	60	1384	1384
Total (swim-in)	2443	681	1433	685	65	5307	2864
Females from GCL	0	0	16	15	4	36	36
Males from GCL	0	0	3	4	0	7	7
Net swim-in + GCL	2443	681	1452	704	69	5349	2907

0.517 Sex Ratio (Adult Males/Total Adult):
0.623 Ratio of Jacks to Total Males:

Appendix Table 2 cont'd. Total escapement into Stamp River, hatchery and natural spawning.

C. INRIVER POPULATION

INRIVER:

Total spawners:	4,071	=Escapement estimate-hatchery, includes jacks
River Adults:	3,543	=Escapement estimate-hatchery
In-river Jack estimate (a):	528	=Escapement estimate-hatchery
Number of males(incl jacks):	1,592	=total inriver * unweighted pooled sex ratio
Alternate in-river jack est (b):	991	=based on jack/male ratio in hatchery
	0.382	=Sex ratio in sample(Adult males / Total Adult)
	0.449	= Unweighted males (pooled Hatchery & river)

	Total popn.	Sample popn.	No. sampled	Sex	C/S Rate	Marks
Chosen jack est (a):	528	528	75	J	7.04	0
Number of adult males:	1,064	1,064	271	M	3.92	8
Number of females:	2,479	2,479	439	F	7.06	10

CWT composition by sex: (cwt for jacks (age 2) are not used in the estimation of total age composition)

	Expansi	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Total Adults
Males	Observed			4	4		8	8
	Estimated			16	16		31	31
	Expanded			196	342		538	538
Female	Observed			4	4		8	8
	Estimated			28	28		55	55
	Expanded			1060	432		1,493	1,493
Total	Expand	-	-	1256	773		2,029	2,029

Scale Age composition (number at age in sample - jacks applied directly):

						Ttl Jacks	Total Adults
Males	528	72	126	39	2	528	239
Females	0	3	158	207	22	0	390

Pooled Age composition (est cwt + scale by age)/(total sample adults only):

Males	100.0%	26.6%	52.4%	20.2%	0.7%	100.0%
Females	0.0%	0.7%	41.7%	52.7%	4.9%	100.0%

In-River return of 'sample population' by age (based on pooled samples, include jack estimate directly):
This excludes hatchery swim-ins released back to the river.

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	528	283	557	215	8	1592	1064
Females	0	17	1034	1306	122	2479	2479
Total	528	300	1592	1521	130	4071	3543
% hatchery (exp cwt)	*0%*	*0%*	*79%*	*51%*		*50%*	*57%*
% hatchery (otolith)	*98%*	*99%*	*89%*	*86%*	*46%*	*89%*	*88%*
Otolith sample size	*69*	*84*	*324*	*257*	*15*	*750*	*681*

In-River return of 'hatchery releases' by age (based on pooled samples from hatchery):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	0	3	3	0	0	6	6
Females	0	0	0	0	0	0	0
Total	0	3	3	0	0	6	6

GCL Broodstock:

	Total popn	Sample popn.	No. sampled	Sex	C/S Rate
Number of females:	36	36	36	F	1.00

Stamp Sport Rod Brood:

	Total popn	Sample popn.	No. sampled	Sex	C/S Rate
Number of females:	7	7	7	F	1.00

COMPOSITION OF GCL SAMPLES:	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males from GCL	0	0	0	0	0	0	0
% Females from GCL	0%	0%	45%	42%	12%		
Females from GCL	0	0	16	15	4	36	36

IPOSITION OF SPORT ROD SAMPLES:	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males from Sport	0	0	0	0	0	0	0
% Females from Sport	0%	0%	43%	57%	0%		
Females from Sport	0	0	3	4	0	7	7

TOTAL SPAWNING ESCAPEMENT TO STAMP RIVER (in-river return minus river captures, based on pooled scale and CWT ages).

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	528	286	560	216	8	1598	1070
Females	0	17	1015	1287	118	2436	2436
Total	528	303	1575	1503	126	4034	3506
Prespawn Mortality (Females only)	0%	0%	10%	12%	5%		
Effective inriver female spawners	0	17	913	1134	112	2175	2175
Fecundity		4000	4400	4800	5200		
Total Egg Deposition		**66,639**	**4,016,223**	**5,442,442**	**583,427**	**10,108,731**	

Appendix Table 2 cont'd. Total escapement into Stamp River, hatchery and natural spawning.

D. TOTAL ESCAPEMENT RUN TO STAMP RIVER ABOVE STAMP FALLS

(spawning esc. + prespawn morts + hatchery & sport rod removals).

		Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	-	2,971	960	1,253	323	13	5,521	2,550
Females	-	-	24	1,775	1,883	182	3,863	3,863
Total	-	2,971	984	3,028	2,206	195	9,384	6,413
Total expanded CWT		2,010	173	2,097	1,330	47	5,657	3,647
% hatchery (exp cwt)		*68%*	*18%*	*69%*	*60%*	*24%*	*60%*	*57%*
% hatchery (otolith)		99%	99%	93%	90%	63%	93%	92%

notes:

total fishway count includes swim count Sep 6, fishway sep 6 - nov 8

fishway counts were adjusted for observer error

fishway counts were adjusted for night time migration (using night time video)

**total run into hatchery is that killed for broodstock,surplus, etc....all sampled for marks...all others released

assume released chinook are part of river number, but never part of any sample.

note: GCL broodstock. Samples captured and released directly above the dam were not considered as part of the sample.

note: inriver c/s. Hatchery releases excluded as part of sample popn. They are added in lower down.

Appendix Table 3. Total escapement into the Stamp River, including natural spawners, potential eggs, and hatchery removals during the period of the intensive "keystream" surveys, 1985-2000. The 2001 forecast of potential eggs is total eggs for hatchery and inriver spawning and does not make assumptions of any prespawn mortality.

Return Year	**Total Natural Spawners Incl jacks**	**Total Adult Spawners**	**Best Estimate Inriver Egg Deposition**	**Total Hatchery Swimins**	**Total Adults in Hatchery**	**Total Adult Escapement**
1985	74,941	74,279	167,282,000	19,076	18,875	93,154
1986	29,306	29,306	69,225,560	13,935	6,983	36,289
1987	15,454	14,491	9,744,800	38,694	36,156	50,647
1988	62,411	54,305	112,514,000	14,533	12,505	66,810
1989	50,990	44,786	67,998,400	28,929	18,258	63,044
1990	81,840	76,064	107,049,600	45,850	35,998	112,062
1991	96,907	85,843	149,254,400	35,354	30,425	116,268
1992	119,986	117,248	248,124,800	25,126	24,398	141,646
1993	77,644	76,487	176,551,600	20,415	20,043	96,530
1994	47,498	46,605	120,852,800	11,132	11,105	57,710
1995	25,460	23,313	80,042,198	4,990	4,522	27,834
1996	11,121	9,410	8,631,450	18,829	17,920	27,330
1997	13,623	12,785	14,140,245	19,415	19,309	32,095
1998	28,263	28,044	60,617,712	11,876	11,847	39,891
1999	15,375	15,312	47,199,407	2,162	2,137	17,449
2000	4,034	3,506	10,100,000	5,307	2,907	6,413
2001 forecast			12,700,000			14,200

Appendix Table 4. Coded-wire tag groups utilized in the cohort analyses for this analysis. The format of this listing is by Brood Year followed by the 6-digit tag code. Tag codes are selected to represent “production” and “both production and experimental” releases from the facility and are reviewed by Stock Assessment Division and the Salmonid Enhancement Program.

@83 (Brood year)
022662
022663
022708
022753
082247
082248
@84
023131
023132
023133
023134
023135
023136
023142
023143
023144
023145
023151
023203
023204
023206
023208
023304
@85
023734
023735
023736
023737
023738
023739
023740
023741
@86
024256
024257
024361
024362
024363
024401
@87
024311
024802
024809
024810
024951
024952
024958
024959

@87(continued)
024960
024961
025326
025327
025328
025329
@88
025014
025836
025837
025838
025839
026055
026056
026057
@89
020645
020646
020950
020949
020948
020648
020647
020153
020152
020151
@90
021549
021550
021551
021552
021553
021208
021209
@91
180620
180621
180622
180623
180802
180803
180804
180805

@92
180259
180260
180261
180262
180624
180625
180626
180627
@93
181539
181540
181541
181542
181543
181544
181545
181546
@94
181455
181456
181457
181458
181459
181460
182220
182221
182222
182223
182224
182225
@95
182226
182227
182228
182229
182230
182231
182502
182503
182504
182505
182506
182507
182508

@96
182232
182233
182234
182235
182236
182237
182541
182543
182542
182544
182545
182546
182547

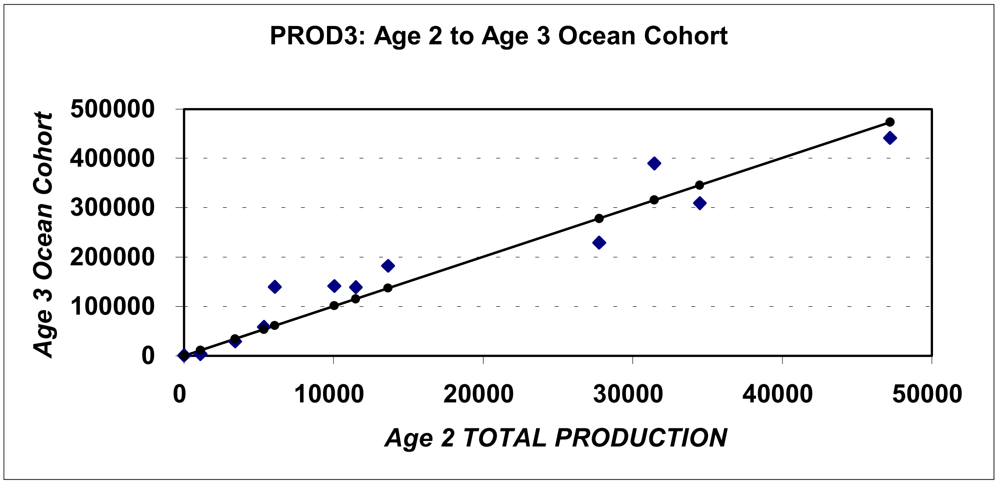
@97
182814
182815
182816
182817
183153
183154
183155
183156
183157
183158

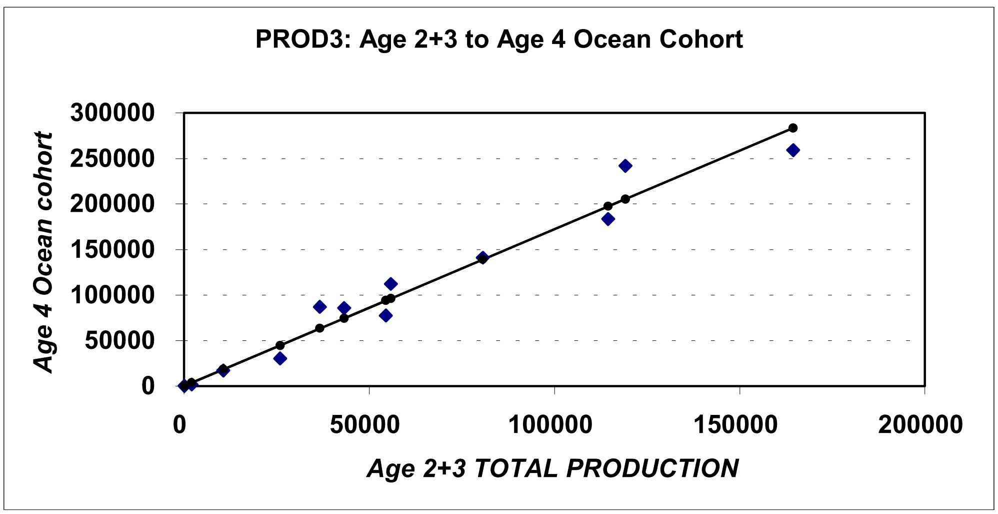
@98
180362
180363
183432
183433
183434
183831

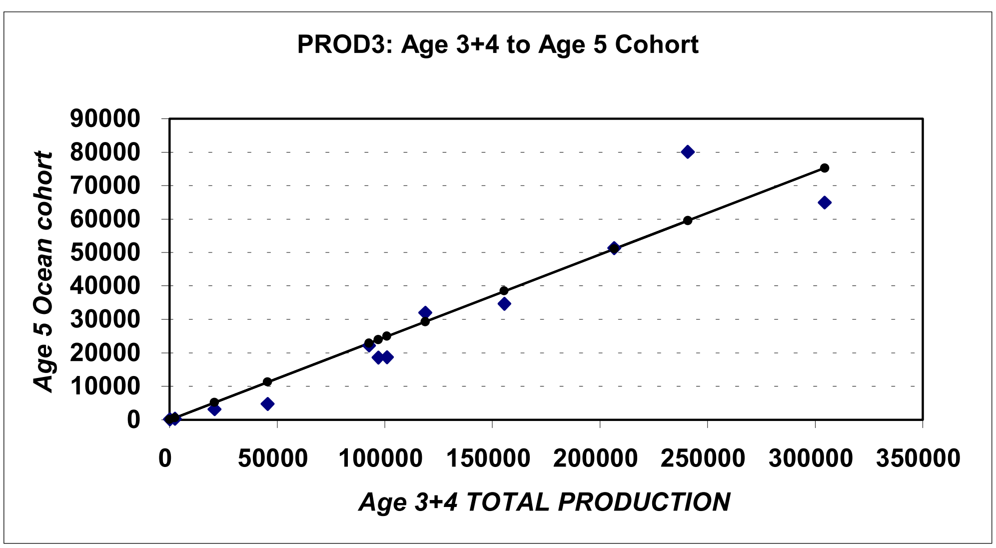
Appendix Table 5. Estimated 2000 impact on Stamp River / RCH chinook in B.C. fisheries based on otolith identification of RCH chinook.

FISHERY AND CATCH IN 2000						ESTIMATED IMPACT IN 2000 FISHERIES					
Area	Month	# CN caught	#CN released	# CN kept, <77cm	# CN caught 77cm+	sample size	%RCH all by	#RCH from total kept, release mort	ER using total RCH	#RCH age 4+	ER using age 4+ only
Langara	6	7,042	8476	3,521	3,521		0.27%	24	0.24%	-	0.00%
Langara	7	7,905	13,667	3,953	3,953	98	1.15%	124	1.22%	41	0.71%
Langara	8	3,060	1,999	1,530	1,530	30	1.15%	42	0.41%	14	0.24%
Langara	9	782	70	391	391	133	1.15%	10	0.10%	3	0.06%
2W	6	1,917	67	959	959		0.27%	6	0.06%	-	0.00%
2W	7	559	-	279	279		1.15%	7	0.07%	2	0.04%
2W	8	583	43	292	292		1.15%	7	0.07%	2	0.04%
2W	9	253	52	126	126		1.15%	3	0.03%	1	0.02%
NTR	9	8,000			8,000	368	0.27%	24	0.23%	-	0.00%
27	6	7		4	3		0.00%	-	0.00%	-	0.00%
27	7	580		348	232		7.4%	43	0.42%	25	0.42%
27	8	420		113	307		14.7%	62	0.61%	36	0.62%
26	6	7		4	3		0.00%	-	0.00%	-	0.00%
26	7	580		348	232		7.4%	43	0.42%	25	0.42%
26	8	420		113	307		14.7%	62	0.61%	36	0.62%
126	6	40		37	3		0.0%	-	0.00%	-	0.00%
126	7	404		376	28		7.4%	30	0.29%	17	0.30%
126	8	360		302	58		14.7%	53	0.52%	31	0.53%
25	7	1,815		468	1,347	19	0.64%	13	0.12%	13	0.22%
25	8	1,653		426	1,227	138	0.64%	11	0.11%	11	0.20%
125	7	8		2	6		0.00%	-	0.00%	-	0.00%
125	8	1					0.64%	0	0.00%	0	0.00%
124	4	4					0.00%	-	0.00%	-	0.00%
124	5	169					0.00%	-	0.00%	-	0.00%
124	6	3,616					0.00%	-	0.00%	-	0.00%
124	7	4,795					0.00%	-	0.00%	-	0.00%
124	8	3,362		1,748	1,613	37	0.26%	9	0.09%	9	0.16%
124	9	266		138	128	61	0.26%	1	0.01%	1	0.01%
123	3	6					0.00%	-	0.00%	-	0.00%
123	4	19					0.00%	-	0.00%	-	0.00%
123	5	438					0.00%	-	0.00%	-	0.00%
123	6	4,637					0.00%	-	0.00%	-	0.00%
123	7	10,306					0.00%	-	0.00%	-	0.00%
123	8	5,255		2,720	2,535	190	0.26%	15	0.15%	15	0.25%
123	9	1,372		900	472	197	0.26%	4	0.04%	4	0.07%
23A	8-9	-	125				100%	19	0.18%	11	0.19%
23B	6	1,159					0.00%	-	0.00%	-	0.00%
23B	7	1,815					0.00%	-	0.00%	-	0.00%
23B	8-9	-	658				11.0%	12	0.12%	7	0.12%
21	7	281			281		0.00%	-	0.00%	-	0.00%
21	8	995			995	31	6.45%	70	0.69%	40	0.69%
21	9	537			537		6.45%	38	0.37%	22	0.37%
WCVI TR	9	2,089			2,089	260	0.38%	9	0.09%	5	0.09%
WCVI FN		-						-	0.00%	-	0.00%
Totals		77,518				1,562		739	7.28%	372	6.38%

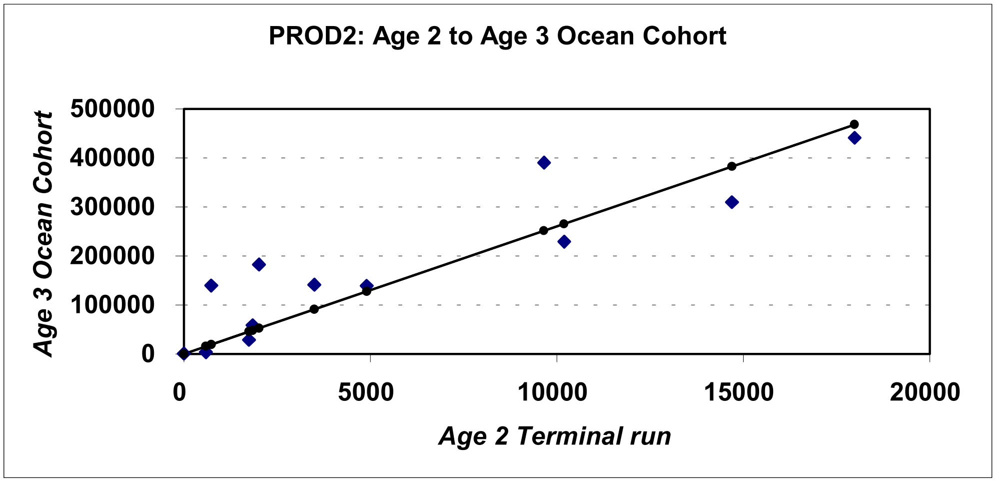
Appendix Figure 1. Model "Prod3" sibling relationships.

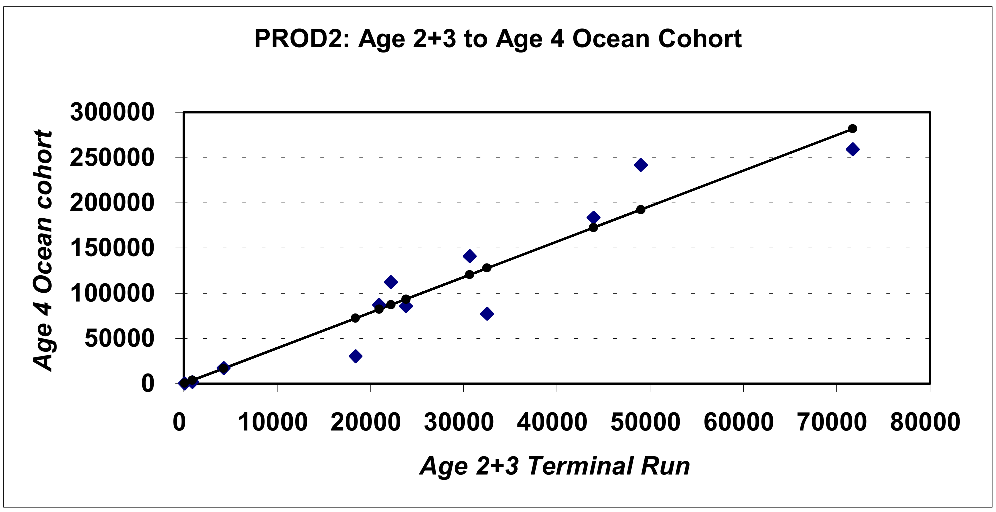


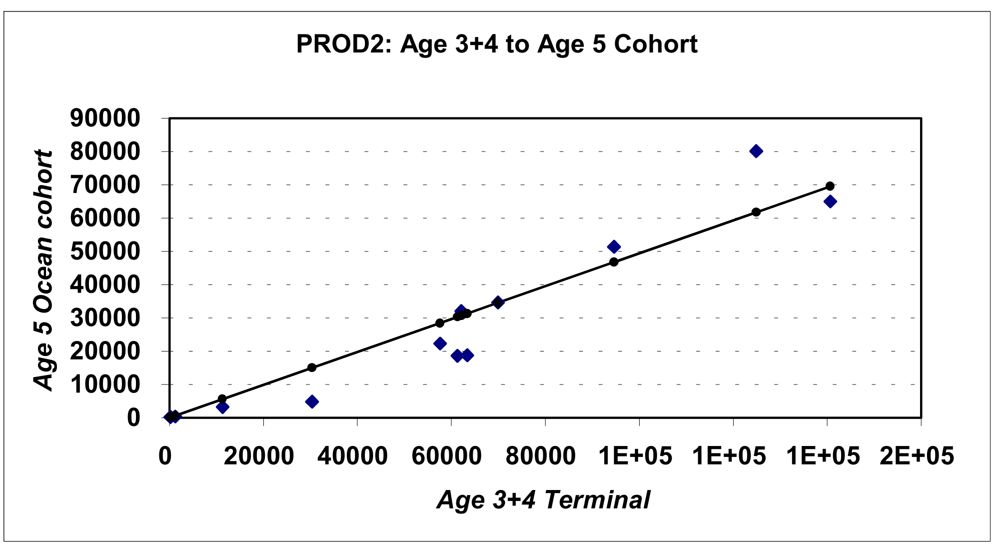




Appendix Figure 2.   Model "Prod2" sibling relationships.







Appendix Figure 3. Cumulative probability distribution of the "average" forecast (average of Prod2 and Prod3) for the year 2001 terminal run to the Stamp River/RCH indicator chinook stock (WCVI). Horizontal dashed lines represent the 25%, 50%, and 75% cumulative probabilities.