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Review of 1997 Terminal Run of Somass River Chinook Salmon and Terminal Run Forecast for 1998

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Abstract

Based on returns through 1997 and using methods previously approved by PSARC, the recommended forecast for the total terminal run of Robertson Creek Hatchery and Stamp River chinook (age 3,4, and 5) to Barkley Sound in 1998 is 58,800±20% (based on averaging the Prod2 and Prod3 forecasts). The age structure of the return is projected to be 8% Age 3, 72% Age 4, and 20% Age 5; with an expected sex ratio of 52% females. The number of chinook required to meet the minimum escapement goal is 31,900.

The detailed assessments and forecasts of the RCH/Stamp chinook are undertaken annually for management of that major stock plus as an indicator of the expected returns to the naturally spawning chinook populations along the west coast of Vancouver Island. Terminal run size and spawning escapements to the RCH/Stamp indicator stock have been similar over the past three years and are projected to be similar and relatively weak again in 1998. However, returns to some of the natural systems were better in 1997 than indicated by this stock. This is particularly true for returns to populations along the northern half of the Island (Areas 25 to 27); seven populations in these Areas are, in aggregate, used in the Pacific Salmon Commission (PSC) to indicate trends in escapement to naturally spawning chinook along the WCVI.

While this is positive indication that the conservation actions taken by Canada to protect these populations has been successful, there are two concerns which suggest caution when planning 1998 fisheries. First, the recovery in the northern population is not evident in the more southern naturally spawning populations (e.g., the Area 24 populations and Nahmint River). Secondly, the age structure of the 1997 returns was strongly age-4 chinook. Returns of Age-3 chinook to the natural systems did not appear as strong as the return to the RCH/Stamp indicator stock. Consequently, returns in 1998 may be reduced if survival of the 1994 brood year declined again. The only indication of brood survival for these northern populations is the return to Conuma Hatchery. Age-3 returns in 1997 to Conuma were only about 25% of the Age-4 returns observed in the sport fishery and in the escapement.

While the condition of most naturally-spawning chinook populations along the WCVI have improved during recent years, the above concerns and the relatively weak return forecasted for the RCH/Stamp stock indicate a continued need for conservative management plans in fisheries impacting these stocks during 1998.

Résumé

Suivant les retours observés tout au long de 1997 et les méthodes approuvées par le PSARC, la prévision recommandée pour la remontée terminale dans Barkley Sound du saumon quinnat (3, 4 et 5 ans) des piscicultures de Robertson Creek et de Stamp River est de 58 800 ±20 % pour 1998 (fondée sur la moyenne des prévisions pour les Prod2 et 3). On prévoit un retour composé à 52 % de femelles et comportant 8 %, 72 % et 20 % d'individus âgés respectivement de 3, 4 et 5 ans. Il faut 31 900 individus pour atteindre l'objectif minimal d'échappée du saumon quinnat.

Chaque année, le quinnat de Robertson Creek et de Stamp River fait l'objet d'estimations et de prévisions détaillées, utilisées d'abord dans la gestion de cet important stock, mais aussi comme indices de la remontée des populations sauvages le long de la côte ouest de l'île de Vancouver. La remontée terminale et l'échappée du stock des piscicultures de Robertson Creek et de Stamp River s'est maintenue au même niveau d'abondance au cours des trois dernières années et elle devrait être semblable et faible une fois de plus en 1998. Toutefois, la remontée de certains stocks sauvages a été supérieure en 1997 à celle du stock indicateur. C'est le cas, en particulier, des populations du secteur nord de l'île (zones 25 à 27). En concentration, sept populations de ces zones servent d'ailleurs d'indices à la Pacific Salmon Commission (PSC) pour suivre l'évolution de l'échappée des populations sauvages du saumon quinnat sur la côte ouest de l'île de Vancouver.

Même si ces données indiquent que les mesures de conservation prises par le Canada pour protéger ces populations semblent avoir porté fruit, deux préoccupations incitaient tout de même à la prudence lors de la planification des pêches pour 1998. En premier lieu, le rétablissement observé dans la population au nord ne semble pas s'être reproduit parmi les populations sauvages plus au sud, notamment dans celles de la zone 24 et de la rivière Nahmint. En second lieu, la composition par âge des remontées du quinnat en 1997 était fortement dominée par la classe de 4 ans. Les remontées de la classe de 3 ans dans la population sauvage ont semblé inférieures à celles du stock indicateur de Robertson Creek et de Stamp River. Par conséquent les remontées de 1998 pourraient être plus faibles si la génération de 1994 continuait à décliner. Le seul indice qui permet d'évaluer la survie des populations au nord est la remontée vers la pisciculture de Conuma. Or, en 1997, les remontées de la classe de 3 ans vers Conuma ne représentaient que 25 % environ de l'abondance de celles de la classe de 4 ans observée en pêche sportive et en échappée.

Quoique l'état des populations sauvages de saumon quinnat de la côte ouest de l'île de Vancouver se soit amélioré au cours des dernières années, les préoccupations susmentionnées, de même que les faibles remontées prévues pour les stocks des piscicultures de Robertson Creek et de Stamp River, plaident en faveur de la poursuite en 1998 des plans de gestion comportant des mesures de conservation pour les pêches ayant une influence sur ces stocks.

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1. Introduction

This PSARC document uses methods previously reviewed in Riddell et al (PSARC X96-01) to forecast Somass River chinook salmon returns to Barkley Sound. This working paper includes a summary of data collection and accounting procedures used in 1997 and one forecast of the 1998 return. Historic data are not repeated but documented in PSARC X96-01.

Since the development of Robertson Creek Hatchery (RCH) in 1971, the Somass 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.

CWT analyses for this stock indicate that during an average year (excluding 1995-1997) about 50% of the stock has returned to Barkley Sound, and over half of the ocean harvest has occurred in south east Alaska fisheries (SEAK). Recently, production of chinook salmon from the Somass River system, including total terminal run plus ocean catch of hatchery fish, has ranged as high as 400,000 chinook (1991 return year). This ocean catch is based on expanded coded-wire tag from the hatchery but does not account for incidental mortality in ocean fisheries, or the ocean catch of natural production from the Somass River system.

The Somass River system is located at the head of Alberni Inlet in Barkley Sound on the west coast Vancouver Island. 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. Fishways 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 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.

Extreme conservation concerns due to poor marine survival brought on by an extreme El Nino event in the 1992-1995 period required formulation of a minimum escapement level. This level was based on escapement prior to 1985, and included:

- 50 million egg target for natural spawning,
- 9.3 million egg target for RCH, plus the
- 20% increment to account for prespawn mortality

2. Terminal Run Calculation

The Stamp River is a key indicator for exploitation rates and distribution patterns of WCVI chinook production systems. The accounting of the terminal return into Barkley Sound (DFO Statistical Area 23) is formulated in Appendix Table 1 and summarized in Table 1. The conduct of the monitoring programs and results in 1997 are described herein.

2.1 Sport Fishery Survey

All Somass River chinooks caught in the sport fishery in DFO Statistical Area 23 are included in the terminal run. A creel survey was conducted in Alberni Inlet and Barkley Sound from mid-June to the end of September. During this period 3,709 interviews (14% of the fishing effort) were conducted in Alberni Inlet and 2,489 interviews (9% of the fishing effort) were conducted in Barkley Sound. Approximately 40 effort counts were conducted in each area. Most chinooks observed during the interview process were also sampled for adipose fin clip, scales, and length.

The creel survey results are presented in Appendix Table 1. The total chinook catch in Alberni Inlet was estimated to be 10,900 chinook of all origins, and 15,100 in Barkley Sound (Aug.-Sept.). Effort was approximately 27,000 boat trips in Alberni Inlet, and the same in Barkley Sound.

For the purpose of this accounting, Alberni Inlet includes waters out as far as Pocahontas Point. The total chinook catch in Alberni Inlet, excluding expanded coded wire tag (CWT) recoveries of non-Somass River chinook, is included in the terminal run calculation. The catch of Somass River chinook in Barkley Sound was estimated as the expanded CWT in Barkley Sound / proportion RCH in the Alberni Inlet catch plus escapement (Table 1).

2.2 Native Fishery Monitoring

Under an agreement between DFO and the local First Nations, several Pilot Sales fisheries targeting chinook salmon were conducted in the lower Somass River below Papermill Dam (the tidal limit). Gear is limited to hand set gill nets, mainly using 7-inch mesh size. Fisheries were conducted starting September 2 until September 19. Total catch was estimated by a census of fishers as they landed at designated landing sites and assumed that all fishers were encountered. The total catch observed was 5,726 chinook.

Biological sampling was conducted on a portion of the catch as it was transferred to buyer's totes or as it was unloaded at the plant. In all, 2000 chinook (35% of the total catch) were sampled for mark incidence. Scales, sex, and length were taken from 315 chinook.

The sampled age composition of the native fishery indicates a selection for larger fish, with 64% of the catch being age 4 chinook.

2.3 Stamp Falls Fishway Observations of Total Escapement

Monitoring of salmonid migration through Stamp Falls fishway in 1997 was initiated September 3 and ended November 10. A snorkel survey was conducted above the falls on Sept. 3rd to determine the number of early migrants. Observations at Stamp Falls were conducted daily, except for the period September 30 to October 7, when observation was precluded due to high and turbid water conditions. Full time observation was terminated October 30 due to very low numbers, and spot-checked thereafter until November 10.

Daily observation was generally from 0.5 hour before sunrise to 0.5 hour after sunset. Additional observations were conducted approximately every 10 days, starting 2 hours before sunrise or continuing 2 hours after sunset, to assess migration rates at these times. Very few fish were observed actively migrating during darkness or near darkness.

Observations were conducted using video, from a waterproof camera mounted on a pole approximately 1m from the left side of the counting tunnel. The field of view was approximately 1m (measured at the rear panel of the counting tunnel). In order to reduce error in assessment of length using the video, the tunnel width was reduced to 8.5 inches in width (from 16in. in 1996).

Salmon were identified and recorded by species, including discrimination of adult and jacks. For example, chinook less than 60 cm total length were recorded as jacks, using reference markings on the base and back of the tunnel.

Observations were conducted in real time through a 21inch high-resolution colour monitor. A Super VHS VCR simultaneously recorded the migration. During observation, species (with jack and adult separated) and direction of migration were entered into an Access database and linked to time/date and observer.

Observer error was estimated from verification of 90 randomly chosen hours of tape. Verification personnel were two of the observers at the Stamp Falls fishway. Prior to verification, these observers met with hatchery staff experienced in salmon identification and came to agreement on criteria used to identify species as seen on videotape. Linear regressions, forced through the origin, were formulated using the verified counts (assumed to be true counts) by species as the independent variable and the observed counts as the dependent variable. There were no significant differences in relationships between verified and observed counts by time, observer, or water conditions.

The total observed counts at Stamp Falls were corrected using the following relationships between verified (V) and observed (O) counts:

Chinook adults	Corrected count = V = O / 1.003	r^2=0.9826
Chinook jacks	Corrected count = V = O / .503	r^2=0.2026

Escapement missed during periods of high water was estimated through a mark-recapture survey. Snorkel surveys were conducted in Stamp Lagoon a few days after the completion of the dead pitch sampling program. A ratio of tailed (i.e., not sampled) to tail-less (i.e., sampled) chinook was determined from these observations. This ratio was applied to the dead-pitch sample size to estimate the number of fish 'missed' during sampling. The 'missed' fish plus dead-pitch samples plus hatchery swim-in samples were used as the total escapement.

2.4 Sampling at Robertson Creek Hatchery

In 1997, the hatchery intake was left open, allowing 19,415 chinook to enter Robertson Creek Hatchery, including only 2537 females (13% of the total). All fish entering the hatchery were handled, counted, checked for AFC, and recorded by sex. Jacks were separated from larger chinook based on a length of 50-cm post orbital hypural (POH) length. The age composition of the total return to the hatchery was based on two independent samples for each sex, CWT fish and random scale samples from unmarked fish. Sample data are summarized in Appendix 2. Age composition for each sex was estimated by pooling the number at age in the estimated CWT and scale samples.

2.5 Sampling on Spawning Grounds

Sampling of carcasses in the Stamp River was conducted by 3 people working 5 days per week, from October 1 through November 5, with the exception of a few days when water levels were hazardous to working on the river. The objectives included sampling as many fish as possible for adipose fin clips (AFC), and biological sampling (including scales, otoliths, POH length, sex, egg retention level) of about 500 chinook per sex. Sampling was conducted using a carcass weir when water levels permitted, and searching for carcasses along river banks/bars during high water. Tails were severed from all fish sampled.

In 1997, 5258 chinook were sampled for AFC, with 112 recoveries. Biological sampling was conducted on 807 males and 630 females.

The total in-river escapement was determined by subtraction of the hatchery count from the corrected fishway count. Sample sizes of adult males and jacks in the river are unlikely to be representative of their population sizes due to the post spawning behaviour of males and the absence of small males in the dead pitch. The in-river sex ratio was therefore estimated as the unweighted average of the hatchery sex ratio and the sex ratio for dead pitch sampling in the river.

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

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

Age composition by sex was estimated as in the hatchery samples.

2.6 Total Estimated Terminal Run

The terminal run was defined as catch in DFO Statistical Area 23, including catch of Somass River and RCH chinook in native, sport, and commercial fisheries, plus spawning escapement to the Stamp River.

Table 1a. Summary of 1997 terminal run of Somass River chinook.

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total
Alberni Canal Sport	129	4,288	5,316	309	37	10,081
Somass Native	19	2,044	3,662	0	0	5,726
Barkley Sound Sport	84	1,958	2,438	175	21	4,676
Hatchery Returns	106	15,665	3,631	13	0	19,415
River Spawners	838	5,683	7,061	42	0	13,623
Total Terminal Run	1,175	29,640	22,085	540	59	53,499

Overall, the terminal run was within a few percent of the forecast. However, the age 3 component of the total terminal run was 300% greater than forecast, while the age 4 return was approximately 50% of the forecast. Female escapement into the river totalled approximately 3,300 that produced a deposition in the river of approximately 12 to 13 million eggs, considerably less than the 50 million minimum level. Hatchery requirements were achieved from the 2,537 females that swam into the hatchery. Based on expanded CWT data, the estimated proportion of hatchery fish in the total return was 61% including only 51% of the chinook that spawned in the Stamp River.

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
Alberni Sport	0	1,742	1,709	0	0	3,451
Somass Native	0	1,136	2,921	0	0	4,057
Barkley Sound Sport	0	1,386	2,066	0	0	3,452
Hatchery	72	10,884	3,696	0	0	14,653
River Spawners	551	3,319	3,036	0	0	6,906
Total Terminal Run	623	18,467	13,428	0	0	32,518

3. Analytical Framework

3.1 Cohort Analyses

Cohort analysis is conducted using 'estimated' CWT recoveries to determine survival rates and exploitation patterns for Robertson Creek Hatchery chinook. The incorporation of in-river tag recoveries provides estimates of the true total exploitation rates for this stock. 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 (98)-1). 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 (98)-1.

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.

3.2 Forecasting Models

Sibling regression models have been developed for total production from selected tag codes by age (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 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., Model 1 - 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.

3.3 Spreadsheet Model

A spreadsheet model was developed to examine response in terminal runs to changes in ocean harvest rates by fishery and age. Based on forecasted ocean abundance and average exploitation patterns through the current year (year i), the model estimates terminal runs expected in year i+1 and year i+2 based on changes to harvest rates in ocean fisheries.

Inputs to the spreadsheet include: estimated hatchery production (expanded CWT all tagcodes) in terminal runs by age and year, observed total terminal runs by age and year, and the forecasted age 3, 4, and 5 cohort abundance. Each regression forecast is expanded for total Somass system production to account for hatchery production not associated with the tag codes selected, as well as production from naturally spawning chinook. Expansion scalars are estimated within brood years and by age. These scalars are the ratio of total terminal run (hatchery plus natural) divided by the terminal run of tagged hatchery releases (expanded CWT). This expansion assumes that natural production from the Stamp River exhibits similar behaviour 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' for year i+1 and year i+2. These scalars are used to simulate management actions in the fisheries. Cohorts are 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+2. Age 3 cohorts for year i+2 were estimated from average or recent average age 3 survival values (derived from the cohort analysis) times the smolts released in year i-3. These values were then expanded by average brood year scalars to account for natural production.

3.4 Forecast Error

A retrospective assessment of the forecasting methodology was presented in PSARC S96-01, for years 1988 through 1995. Including the 1996 and 1997 forecasts 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. The omitted data point is then used as the observed value and the predicted value compared to the observed. Average absolute deviations are used as the forecast error expected for each model.

4. Results and Forecast for 1998

4.1 Cohort Analyses

Cohort analyses for the 1983 through 1995 brood releases from Robertson Creek Hatchery were completed using the total escapement of coded-wire tags to the hatchery and the natural spawning grounds in the upper Stamp River. Returns from the latter 3 broods are incomplete through 1997 and are estimated using average maturation rates from the completed brood returns. Recoveries from the 1992 brood year are very limited (estimated number of recoveries = 10) and the cohort analysis is not reliable. However, for the nine brood years (1983 through 1991) for which total escapement recoveries are available, 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 brood year indicate significant reduction in exploitation rates (estimated ocean exploitation rate = 37% and total exploitation rate = 51%) as expected due to the conservation actions taken during 1995 through 1997.

Estimates of marine survival continue to demonstrate highly variable survival and very poor survival for the most recent brood year, 1995 (Table 2).

Annual distribution of the total fishing mortality on the Robertson Creek stock has been up-dated through 1997. Conservation actions taken in recent years are again evident in distribution changes (Table 3).

Table 2. Estimated survival rates (smolts released to Age 2 chinook) of coded-wire tagged (CWT) groups released from Robertson Creek Hatchery by brood years. 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). Survival rates of Age-2 chinook only include recoveries of Age-2 chinook.

Brood Year	Estimated % Survival Rate for CWT groups:	
	Age-2 cohort	Age-2 chinook
1983	0.103	0.012
1984	4.513	0.138
1985	4.358	0.147
1986	12.144	0.418
1987	10.353	0.492
1988	13.156	0.606
1989	9.240	0.413
1990	5.569	0.201
1991	0.994	0.048
1992	0.016	0.0002
1993	2.50*	0.071
1994	4.51*	0.147
1995		0.003

Notes: * these broods have incomplete recoveries but are estimated based on observations to-date and assuming average maturation rates from completed brood years.

4.2 Production-based Forecast Models

Table 4 summarizes the results of Prod2 (terminal run vs. total production) and Prod3 regression models. The upper portion of these tables identify each sibling model, the x-value used in the 1998 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). Asterisks identify regressions used in the 1998 forecast. Results of the retrospective assessment of each forecasting equation are also presented in the lower portion of tables. For each brood year, the observed and predicted values are presented. The mean absolute deviation (estimated prediction error) varied between 42% and 86% of the known data value for the Prod2, and 25% to 50% for the Prod3 model.

Table 3. Distribution of total fishing mortality for Robertson Creek Hatchery chinook stock; distributions based on cohort analysis through 1997 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.

	ALK TROLL	NBC TROLL	CBC TROLL	WCVI TROLL	ALK NET	NCBC NET	SOUTH NETS	ALK SPORT	NCBC SPORT	WCVI SPORT	OTHER SPORT	TERMN SPORT	TERMN NET	FISHING MORTS	SPAWN ESCAPE
1985	3.7%	0.0%	0.0%	3.7%	0.0%	0.0%	0.0%	0.0%	3.7%	0.0%	22.2%	3.7%	0.0%	37.0%	63.0%
1986	13.9%	9.5%	2.2%	7.0%	6.2%	4.8%	2.2%	1.5%	1.5%	4.0%	3.3%	15.4%	0.4%	71.8%	27.8%
1987	10.1%	8.4%	3.2%	3.3%	3.5%	2.2%	1.4%	0.5%	0.6%	0.5%	0.8%	21.3%	0.7%	56.5%	43.5%
1988	12.8%	8.8%	1.6%	4.7%	4.2%	1.8%	0.5%	1.1%	1.1%	4.5%	0.8%	13.4%	7.2%	62.4%	37.6%
1989	14.1%	8.9%	1.4%	3.3%	5.3%	1.0%	1.0%	1.3%	1.0%	1.6%	0.8%	15.3%	15.8%	70.9%	29.0%
1990	19.2%	8.7%	2.5%	7.5%	4.3%	1.4%	0.6%	1.3%	0.9%	1.9%	0.4%	8.5%	8.4%	65.7%	34.3%
1991	19.6%	9.4%	2.8%	5.9%	2.4%	0.6%	0.6%	2.1%	0.8%	1.1%	0.4%	12.5%	12.8%	71.3%	28.7%
1992	17.0%	7.4%	2.8%	17.8%	7.5%	0.8%	0.4%	1.3%	1.4%	2.0%	0.2%	5.8%	0.4%	65.0%	35.0%
1993	16.2%	7.2%	2.0%	13.5%	2.4%	0.3%	0.8%	2.6%	1.4%	2.5%	0.7%	13.2%	6.9%	69.7%	30.2%
1994	18.2%	9.4%	1.1%	5.4%	4.9%	1.0%	0.2%	3.7%	1.2%	7.4%	0.5%	19.3%	3.1%	75.4%	24.5%
1995	16.9%	3.5%	0.4%	1.7%	0.2%	0.4%	0.2%	4.2%	1.2%	4.4%	1.4%	11.2%	6.5%	52.1%	47.8%
1996	7.5%	3.1%	0.5%	1.8%	1.0%	0.0%	0.0%	1.3%	1.6%	24.7%	1.1%	2.2%	0.0%	45.1%	54.8%
1997	12.5%	4.6%	1.9%	0.1%	5.9%	0.4%	0.0%	4.3%	2.0%	2.0%	0.3%	18.9%	3.4%	56.4%	43.6%
1985-94 Average	14.5%	7.8%	2.0%	7.2%	4.1%	1.4%	0.8%	1.5%	1.4%	2.6%	3.0%	12.8%	5.6%	64.6%	35.4%
1995-97 Average	12.3%	3.7%	1.0%	1.2%	2.3%	0.3%	0.0%	3.3%	1.6%	10.4%	0.9%	10.7%	3.3%	51.2%	48.7%

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

PART A: TERMINAL RUN vs. TOTAL PRODUCTION REGRESSIONS (PROD2 MODELS)

Model # and description	Predictor x-value	Prediction	90% confidence interval lower	90% confidence interval upper	para.value (slope)	r-square	sigma
#3, Age 2 vs. Ages(3+4+5)	75	1950.17	-134627.48	138527.83	26.00	0.92	74505.61
#5, Age (2+3) vs. Ages (4+5)	21839	74759.99	37869.59	111650.39	3.42	0.98	19863.29
#6, Ages (2+3+4) vs. Age 5	31092	13512.63	265.10	26760.15	0.43	0.97	7186.83
#7, Age 3 vs. Ages (4+5)	20901	86506.18	38670.86	134341.50	4.14	0.97	25610.54
#8, Ages (3+4) vs. Age 5	29217	14025.54	1368.81	26682.28	0.48	0.97	6863.49

Mean absolute deviations by model:

	Sum of Square error
Age 2 vs. Ages(3+4+5)	0.8631
Age (2+3) vs. Ages (4+5)	0.4407
Ages (2+3+4) vs. Age 5	0.5527
Age 3 vs. Ages (4+5)	0.4292
Ages (3+4) vs. Age 5	0.4402

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

	MODEL #3 OBS.	MODEL #3 PRED.	MODEL #5 OBS.	MODEL #5 PRED.	MODEL #6 OBS.	MODEL #6 PRED.	MODEL #7 OBS.	MODEL #7 PRED.	MODEL #8 OBS.	MODEL #8 PRED.
1983	2604	15737	1300	3286	211	784	1277	1469	211	576
1984	147862	92812	79592	119138	18777	30402	77527	130341	18777	31935
1985	141639	131950	85832	88621	22257	28406	83384	86074	22257	28941
1986	405832	241268	243990	229213	80671	61747	235116	242302	80671	64358
1987	321910	426176	187480	177044	53152	50316	181633	148821	53152	47990
1988	463603	489834	269082	299774	65853	78760	261838	277510	65853	76970
1989	240936	293947	145636	112383	35580	37134	141722	90548	35580	35588
1990	186542	53197	111329	84989	32270	26207	107779	94686	32270	28033
1991	32540	46415	17752	15604	3404	5853	17378	11485	3404	5608
1992	524	0	263	668	195	102	242	807	195	112
1993	2604	15737	1300	3286	211	784	1277	1469	211	576
1994	147862	92812	79592	119138	18777	30402	77527	130341	18777	31935

Table 4 (continued)

PART B: TOTAL PRODUCTION vs. TOTAL PRODUCTION REGRESSIONS (PROD3 MODELS)

Model # and description	Predictor x-value	Prediction	90% confidence interval lower	upper	para.value (slope)	r-square	sigma
#3, Age 2 vs. Ages(3+4+5)	249	2257.57	-73485.16	78000.30	9.07	0.98	41319.01
#5, Age (2+3) vs. Ages (4+5)	40524	63758.75	36953.74	90563.77	1.57	0.99	14484.99
#6, Ages (2+3+4) vs. Age 5	53137	11009.80	-4628.91	26648.51	0.21	0.96	8499.47
#7, Age 3 vs. Ages (4+5)	29826	64081.66	39422.60	88740.73	2.15	0.99	13316.14
#8, Ages (3+4) vs. Age 5	48156	11601.53	-3349.26	26552.31	0.24	0.96	8122.37

Mean absolute deviations by model:

	Sum of square errors
Age 2 vs. Ages(3+4+5)	0.4983
Age (2+3) vs. Ages (4+5)	0.2834
Ages (2+3+4) vs. Age 5	0.4728
Age 3 vs. Ages (4+5)	0.2528
Ages (3+4) vs. Age 5	0.4027

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

	MODEL #3 OBS.	MODEL #3 PRED.	MODEL #5 OBS.	MODEL #5 PRED.	MODEL #6 OBS.	MODEL #6 PRED.	MODEL #7 OBS.	MODEL #7 PRED.	MODEL #8 OBS.	MODEL #8 PRED.
1983	2604	9666	1300	3218	211	645	1277	2103	211	493
1984	147862	101948	79592	94556	18777	24766	77527	105431	18777	26108
1985	141639	108535	85832	72662	22257	22278	83384	73531	22257	23027
1986	405832	302355	243990	205987	80671	54300	235116	211016	80671	55684
1987	321910	368944	187480	202956	53152	52926	181633	189518	53152	51827
1988	463603	524314	269082	298047	65853	86048	261838	280290	65853	85034
1989	240936	279735	145636	139819	35580	41027	141722	125208	35580	40210
1990	186542	153091	111329	100837	32270	28812	107779	101472	32270	29454
1991	32540	36802	17752	22679	3404	5886	17378	22247	3404	5865
1992	524	145	263	332	195	53	242	419	195	58
1993	2604	9666	1300	3218	211	645	1277	2103	211	493
1994	147862	101948	79592	94556	18777	24766	77527	105431	18777	26108

4.3 Spreadsheet Model

The terminal run forecast can vary depending on the model used, the scalars used to expand the hatchery production to total Somass production, and management actions in ocean fisheries. Forecasts of total terminal run to Barkley Sound are presented for both Prod2 and Prod3 models in Table 5. Forecasts for the 1998 terminal run range from 53,400 to 64,100 (average is 58,800), based on that 1998 expected ocean exploitation rates from planned fisheries in Alaska and British Columbia[1] and final estimates of the stock composition in fisheries (Chinook Technical Committee model, calibration 9812)

When the age-specific forecasts are combined to predict the total terminal run to Barkley Sound, the forecasting error is, on average, less than for the individual regression models. Figure 1 compares the annual deviations from observed total terminal runs for the Prod2 and Prod3 models. Over the period 1988 to 1997, the models average 1 to 2% error in the forecast. However, when the forecast error is expressed as the average absolute deviation from annual forecasts, the average error increases to 25% for Prod2 and 20% for Prod3. On an annual basis, the forecasted terminal runs can be expected to vary by ±20 to 25% of the forecast value.

Table 5. Summary of forecasted terminal run size (numbers of chinook) assuming ocean exploitation rates similar to those in 1997.

Terminal Run size by ages:	Prod2 Model Terminal vs. Total	Prod3 Model Total vs. Total	Average Forecast value
Age 3	4457	5117	4787
Age 4	46288	38036	42162
Age 5	13378	10288	11833
Total	64123	53441	58782
Number of females	33489	27092	30290
% Females	52%	51%	51.5%

4.4 Escapement Goal

The escapement goal for 1998 is consistent with the minimum target accepted by PSARC in 1994 (PSARC Advisory Doc. S94-1). Given the expected terminal run size (above, average forecast value assumed) and the allocated terminal catches in sport and Native fisheries (21,900 catch referenced in footnote 1); the minimum escapement goal is achievable. The minimum egg requirement for hatchery and natural spawners in the Stamp River is 31,900 spawning chinook in 1998 (Table 6).

4.5 Recommended Forecast

The recommended forecast for the total terminal run of Robertson Creek Hatchery and Stamp River chinook (age 3,4, and 5) to Barkley Sound in 1998, is 58,800±20% based on averaging the

[1] Documented in June 29, 1998 memo from E. Lochbaum to P. Sprout, internal departmental memo.

Prod2 and Prod3 forecasts. The age structure of the return is projected to be: 8% Age 3, 72% Age 4, and 20% Age 5; with an expected sex ratio of 51.5% females. The number of chinook required to meet the minimum spawning escapement goal is 31,900. This goal is achievable if ocean-fishing mortality is equal to or less than those assumed (footnote 1) and terminal catches do not exceed those allocated.

Table 6. Derivation of the number of spawners needed to meet the minimum egg requirements in the 1998 chinook return.

ESTIMATION PROCEDURE	NUMERICAL VALUES
Minimum egg target for natural spawners	50 Million eggs
Egg requirement for Robertson Creek Hatchery	9.3 Million eggs
% Females expected in terminal run	51.5%
Average Fecundity expected	4500 eggs/female
# of females for Hatchery	2,061
Min. # of females for Natural spawners	11,080
Pre-spawning mortality allowance	20%
Total # females required (including mortality allowance)	16,426
Total number of chinook @ 51% female ratio	31,895

4.6 Other West Coast Vancouver Island chinook systems

The detailed assessments and forecasts of the RCH/Stamp chinook are undertaken annually for management of that major stock plus as an indicator of the expected returns to the naturally spawning chinook populations along the west coast of Vancouver Island. Terminal run size and spawning escapements to the RCH/Stamp indicator stock have been similar over the past three years and are projected to be similar and relatively weak again in 1998. However, returns to some of the natural systems were better in 1997 than indicated by this stock (see Appendix Table 3). This is particularly true for returns to populations along the northern half of the Island (Areas 25 to 27); seven populations in these Areas are, in aggregate, used in the Pacific Salmon Commission (PSC) to indicate trends in escapement to naturally spawning chinook along the WCVI.

While this is positive indication that the conservation actions taken by Canada to protect these populations has been successful, there are two concerns which suggest caution when planning 1998 chinook fisheries. First, the apparent recovery in the northern populations is not evident in the more southern naturally spawning populations (e.g., the Area 24 populations and Nahmint River). Secondly, the age structure of the 1997 returns was strongly age-4 chinook. Returns of Age-3 chinook to the natural systems did not appear as strong as the return to the RCH/Stamp indicator stock. Consequently, returns in 1998 may be reduced if survival of the 1994 brood year declined again. The only indication of brood survival for these northern populations is the return to Conuma Hatchery. Age-3 returns in 1997 to Conuma were only about 25% of the Age-4 returns observed in the sport fishery and in the escapement.

While the condition of most naturally-spawning chinook populations along the WCVI have improved during recent years, the above concerns and the relatively weak return forecasted for the RCH/Stamp stock indicate a continued need for conservative 1998 management plans in fisheries impacting these stocks.

5. Literature cited:

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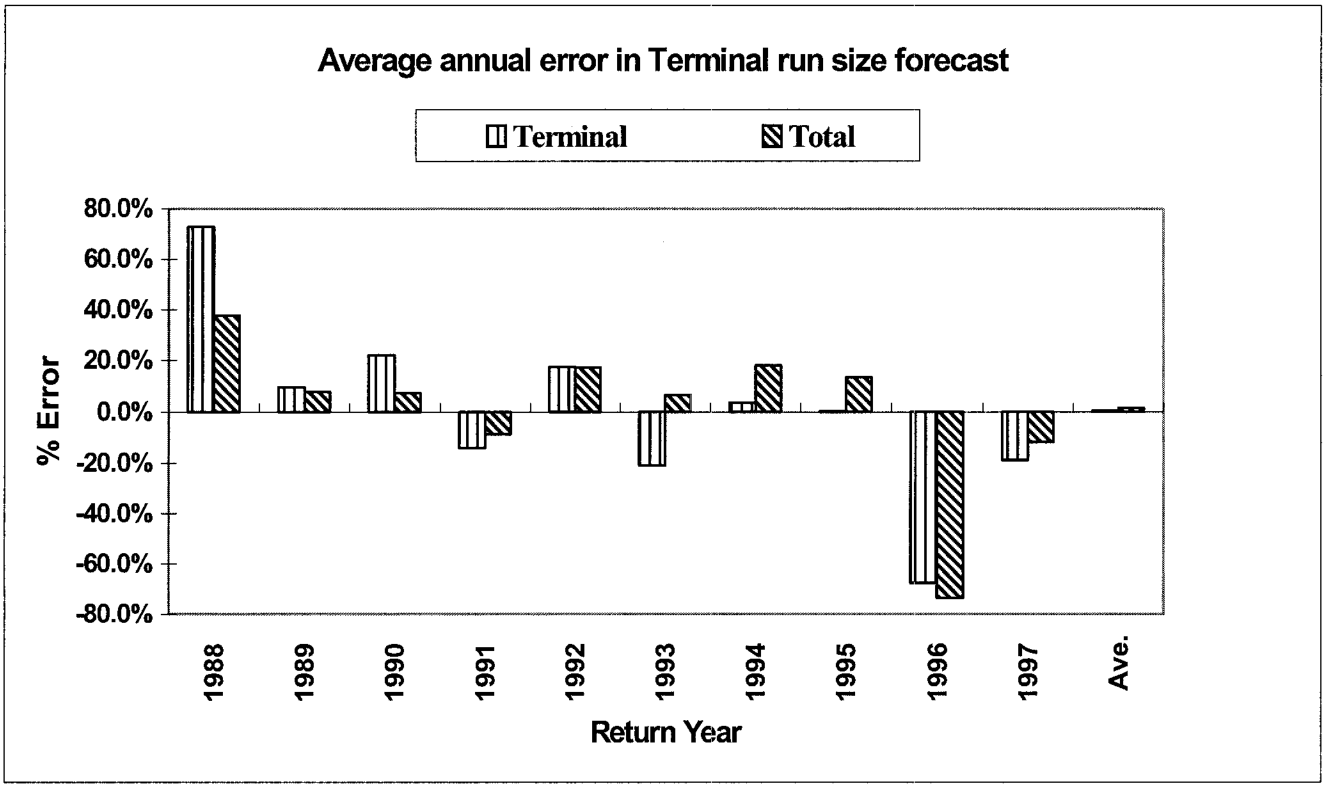
Figure 1. Average annual error for Prod2 and Prod3 forecast models when applied to estimating the terminal run size of Somass chinook into Barkley Sound. Terminal denotes Prod2 model and Total denotes Prod3 model. Error expressed as the deviation from the observed terminal run, 1988 through 1997.



Appendix Table 1. 1997 Somass Chinook Terminal Run, Catch and Escapement

			AGE COMPOSITION							obs
FISHERY	DATE	CATCH	Aged	2	3	4	5	6	Females	MarkInc
TEST FISHERY		no testfishery in 1997								
COMMERCIAL GN		no commercial fisheries in 1997								
ALBERNI SPORT	Aug 1-14	377		1.0%	40.0%	56.0%	3.0%	0.0%		
	Aug 15 - 29	2,531	86	1.0%	40.0%	56.0%	3.0%	0.0%	39%	2.57%
	Aug30-Sep1	3,743	195	0.0%	46.0%	50.0%	3.0%	1.0%	42%	
	Sep 2- 15	3,885	44oto	2.6%	46.2%	48.7%	2.6%	0.0%		
	Sep 16-30	348	40oto	0.0%	54.3%	42.9%	2.9%	0.0%		
TOTAL ALBERNI INLET SPORT		10,884		129	4,867	5,542	309	37		2.57%
				1.2%	44.7%	50.9%	2.8%	0.3%		
AISPT non Somass expCWT		803			579	224				
AISPT SOMASS only		10,081		129	4,288	5,318	309	37		
AISPT RBT exp CWT		3,451		0	1,742	1,709	0	0		
AISPT RBT estimated CWT		207		0	116	61	0	0		
SOMASS NATIVE	2-Sep	781		0.0%	41.8%	58.2%	0.0%	0.0%		
Pilot Sales Project	3-Sep	1,289	213	0.0%	41.8%	58.2%	0.0%	0.0%		3.11%
	4-Sep	354		0.0%	41.8%	58.2%	0.0%	0.0%		
	5-Sep	1,124	19	0.0%	26.3%	73.7%	0.0%	0.0%		3.13%
	10-Sep	242		0.0%	40.5%	59.5%	0.0%	0.0%		
	11-Sep	208		0.0%	40.5%	59.5%	0.0%	0.0%		
	15-Sep	139		0.0%	40.5%	59.5%	0.0%	0.0%		
	18-Sep	455		1.2%	31.3%	67.5%	0.0%	0.0%		
	19-Sep	1,133	83	1.2%	31.3%	67.5%	0.0%	0.0%	44.2%	2.74%
	8-Oct	1		1.2%	31.3%	67.5%	0.0%	0.0%		
TOTAL NATIVE PSP FISHERY		5,726		19	2,044	3,662	0	0		3.05%
				0.3%	35.7%	64.0%	0.0%	0.0%		
Native non Somass expCWT		48		0	0	48	0	0		
NATIVE SOMASS only		5,678		19	2,044	3,614	0	0		
NATIVE RBT from expCWT		4,057		0	1,136	2,921	0	0		
TOTAL INLET CATCH all stocks		16,610		148	6,911	9,204	309	37		
TOTAL INLET CATCH Somass R. only		15,759		148	6,332	8,932	309	37		
				0.9%	40.2%	56.7%	2.0%	0.2%		
TOTAL INLET CATCH rbt expcwt		7,508		0	2,878	4,630	0	0		
TOTAL INLET CATCH natural Somass R only		8,251		148	3,454	4,302	309	37		
ESCAPEMENT TOTAL		33,064		944	21,350	10,715	56	-	5,791	
				2.9%	64.6%	32.4%	0.2%	0.0%		
Total adults after analysis by age and sex		32,121								
Total expanded cwt in escapement		21,620		623	14,203	6,793	-	-		
Total inriver spawners		13,623		838	5,683	7,061	42	-	3,228	
Total inriver eggs		12,240,366								

Determination of total Somass River in Barkley Sound catch using ratio of RCH/total Somass in Alberni Inlet fisheries and escapement.

0.34 =spt only 0.42 =ALT spt only based on total rel/tag for by
0.71 =native 0.48 =total inlet catch
0.65 =esc only 0.60 =inlet catch plus escapement (b)
0.74 = BEST ESTIMATE OF RATIO IN BSND (avg of ratio from total catch / esc and otolith in sport)

A23B Creel Survey Estimated Total Catch CN		15,111	(Aug-Sep only)		Total exp CWT A23B (Aug-Sep)		9,067			
RBT total exp cwt (aug-sep)		3,452		0	1,386	2,066	0	0		
				0.0%	40.2%	59.8%	0.0%	0.0%		
A23B SPORT, SOMASS ORIGIN CATCH		4,676		84	1,958	2,438	175	21		
TOTAL SOMASS CN, AREA 23 SPORT		14,757		212	6,246	7,756	484	59		
TOTAL CATCH A23, EXPCWT RBT		10,960		0	4,264	6,696	0	0		
TOTAL CATCH A23, SOMASS CN		20,435		231	8,290	11,370	484	59		
TOTAL CATCH+ESC A23, EXPCWT RBT		32,580		623	18,467	13,489	0	0		
TOTAL TERMINAL RUN SOMASS ONLY		53,499		1,175	29,640	22,085	540	59		
TOTAL TERMINAL RUN w/o jacks		52,324		2.2%	55.4%	41.3%	1.0%	0.1%		

Appendix 2. Escapement of Somass Chinook, into Robertson Creek Hatchery and Stamp River, 1997

	Adults	Jacks	Total Count
Unadjusted Observed at Stamp Falls:	26,110	638	26,748
Adjusted count from tape verification:	26,103	1,249	27,352
Estimated missed count based on post spawn swims:	6,018		
Total adjusted estimate of chinook escapement to upper Stamp R	32,121	944	33,064

note: jack estimate based on average of observed and adjusted counts

HATCHERY:

	Total	Marked	unMarked	C/S
Males (incl jacks):	16,878	573	16,307	1
Females:	2,537	95	2,442	1
Jacks:	106	5	118	1
Adjustment factor (J to M):	17			
Adult males:	16,772	568	16,189	1
Totals:	**19,415**	668	18,749	1

CWT recoveries by sex:

	Expansion		Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	Observed		2	495	47	0	0	544	542
	Estimated		2	495	47			544	542
	Expanded		72	10790	1341			12203	12131
Female	Observed		0	7	80	0	0	87	87
	Estimated			7	80			87	87
	Expanded			95	2356			2450	2450
Females fr Dam	Observed		0	0	2	0	0	2	2
	Estimated				2			2	2
	Expanded				61			61	61
TOTAL (swim-in)		Expanded	72	10884	3696	0	0	14653	14581
TOTAL (swim-in+GCL)		Expanded	72	10884	3757	0	0	14713	14641

Scale Age composition (from biosample fish only, not including cwt samples):	Age 2	Age 3	Age 4	Age 5	Age 6	Total	
Males	68	465	40	0		573	505
Females	0	57	421	3		481	481
Female/ dam	0	3	21	0		24	24

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		91.7%	8.3%	0.0%	0.0%	100%	1,047
Females		11.3%	88.2%	0.5%	0.0%	100%	594
Age composition based on Expanded CWT %:							
Males	0.6%	88.4%	11.0%	0.0%	0.0%	100.0%	
Females	0.0%	3.9%	96.1%	0.0%	0.0%	100.0%	
Female/ dam	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%	

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

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males (swim-in)	106	15379	1394	0	0	16878	16772
Females (swim-in)	0	286	2238	13	0	2537	2537
Total (swim-in)	106	15665	3631	13	0	19415	19309
Females from GCL	0	3	23	0	0	26	26
Total (swim-in + GCL)	106	15668	3654	13	0	19441	19335
% hatchery (exp cwt) - swim-ins (	*68%*	*69%*	*102%*	*0%*		*75%*	*76%*

0.869 Sex Ratio (Adult Males/Total Adult):

0.006 Ratio of Jacks to Total Males:

Appendix 2 cont'd. Escapement of Somass Chinook, into Robertson Creek Hatchery and Stamp River, 1997

INRIVER POPULATION:

Total inriver spawners:	13649	=Escapement estimate-hatchery, includes jacks
River Adults:	12811	=Escapement estimate-hatchery
In-river Jack estimate (a):	838	=Escapement estimate-hatchery
Number of males(incl jacks):	10,395	=total inriver * unweighted pooled sex ratio
Alternate in-river jack est (b):	65	=based on jack/male ratio in hatchery
	0.655	=Sex ratio in sample(Adult males / Total Adult)
	0.762	= Unweighted males (pooled Hatchery & river)

Chosen jack est (a):	838	sampled=	64	C/S= J	13.09
Number of adult males:	9,558	sampled=	3,400	C/S= M	2.81
Number of females:	3,254	sampled=	1,794	C/S= F	1.81

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

	Expansion	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Total Adults
Males	Observed	1	54	19			74	73
	Estimated	13	152	53			218	205
	Expanded	551	3240	1377			5,168	4,617
Female	Observed	0	4	34			38	38
	Estimated	0	7	62			69	69
	Expanded	0	79	1659			1,738	1,738
Total	Expanded	551	3,319	3,036			6,906	6,355

Scale Age composition (number at age in sample):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total Adults
Males	23	431	374	2		807
Females	0	32	593	5		630

1 female was aged as a 2 year old - due to it's large size it was included as a 3 year old.

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

	Age 2	Age 3	Age 4	Age 5	Age 6	Total
Males	100.0%	57.6%	42.2%	0.2%	0.0%	100.0%
Females	0.0%	5.6%	93.7%	0.7%	0.0%	100.0%

In-River return by age (based on pooled samples, include jack estimate directly):

	Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	838	5503	4036	19	0	10395	9558
Females	0	183	3048	23	0	3254	3254
Total	838	5686	7084	42	0	13649	12811
% hatchery (exp cwt)	*66%*	*58%*	*43%*	*0%*		*51%*	*50%*

GCL Broodstock (females):

Age composition (from scales and cwt's):		Age 2	Age 3	Age 4	Age 5	Age 6	Total	Total Adults
Females		0	3	23	0	0	26	26
CWT composition:	Observed	0	0	2	0	0	2	2
	Estimated	0	0	2	0	0	2	2
	Expanded			61			61	
% hatchery (exp cwt)			0%	263%			233%	

TOTAL NATURAL SPAWNING IN 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	838	5503	4036	19	0	10395	9558
Females	0	180	3025	23	0	3228	3228
Total	838	5683	7061	42	0	13623	12785
Prespawn Mortality	0.00%	8.57%	13.64%	20.00%			
Unspawned Females	0	15	413	5	0		
Fecundity		4,000	4,400	4,800	5,200		
Total Egg Deposition		657.4E+3	11.5E+6	89.4E+3	000.0E+0	12.2E+6	

TOTAL ESCAPEMENT RUN TO STAMP RIVER (spawning escapement + river captures + hatchery removals).

		Age 2	Age 3	Age 4	Age 5	Age 6	Total	Ttl adult
Males	-	944	20,882	5,429	19	-	27,273	26,330
Females	-	-	469	5,286	37	-	5,791	5,791
Total	-	944	21,350	10,715	56	-	33,064	32,121
Total expanded CWT		623	14,203	6,793	-	-	21,620	20,996
% hatchery (exp cwt)		*66%*	*67%*	*63%*	*0%*		*65%*	

Appendix 3. Total Adult Chinook Escapement (river + brood) estimates for selected WCVI systems (no Jack males)
(Table entries 'ni' = stream not investigated in that year, or 'no' = indicates that no chinook were observed in that year)

AREA RIVER	85	86	87	88	89	90	91	92	93	94	95	96	97
A. PSC Indicator stocks.													
25 TAHSIS RIVER	50	60	20	125	500	300	1400	1400	500	380	525	771	722
25 BURMAN RIVER	500	400	100	400	700	1100	2500	2000	1750	2200	594	724	2354
25 GOLD RIVER	1500	1900	600	1000	1000	2000	1000	2500	1700	3600	805	902	1874
26 KAOUK RIVER	300	100	100	65	30	10	20	20	20	150	266	219	558
26 ARTLISH RIVER	400	100	100	70	40	50	20	10	10	100	99	53	402
26 TAHSISH RIVER	1200	1000	500	400	450	200	120	600	250	250	600	288	523
27 MARBLE RIVER	1250	1100	1750	3500	4500	2000	1000	800	2000	1000	1626	3971	2638
% Marble River in Index:	24.0%	23.6%	55.2%	62.9%	62.3%	35.3%	16.5%	10.9%	32.1%	13.0%	36.0%	57.3%	29.1%
B. Other systems: wild or hatchery supplemented. Intensively surveyed since in 1994 or 1995 but less consistently before that time.													
25 LEINER RIVER	100	190	125	336	500	450	300	445	585	300	412	715	516
24 BEDWELL/Ursus	no	10	8	10	70	ni	ni	ni	377	691	291	528	275
24 MOYEHA RIVER	no	ni	no	no	80	ni	ni	ni	250	420	89	243	84
24 MEGIN RIVER	no	30	25	30	26	ni	10	150	436	841	323	164	266
23 NAHMINT RIVER	250	287	400	97	279	596	165	135	158	438	212	246	242

Sums for Sections A & B:

	Spawning Year	85	86	87	88	89	90	91	92	93	94	95	96	97
A.	PSC indicators	5200	4660	3170	5560	7220	5660	6060	7330	6230	7680	4515	6928	9071
B.	Other systems.	350	517	558	473	955	1046	475	730	1806	2690	1327	1896	1383

Systems with major hatcheries

22 NITINAT RIVER	12000	8000	2500	21047	17000	19000	12000	30000	25000	11000	10538	29809	34482
23 SOMASS RIVER	93154	36289	53478	66959	63043	112061	114416	141060	96254	57678	27801	28500	32121
25 CONUMA RIVER	800	210	200	3000	7000	10700	15000	22000	11500	20000	23071	19422	20813

Appendix 4. Coded-wire tag codes utilized in the cohort analyses Appendix 2. Coded-wire tag groups utilized in the cohort analyses Appendix 2. 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 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