Resource Protection & Conservation • Benefits for Canadians
tection et conservation des ressources • Bénéfices aux Canadiens

Stamp Falls Fishway Counts, Adipose Clip/ CWT Recovery and Biological Sampling of Chinook Salmon Escapements in Stamp River and Robertson Creek Hatchery, 1990

R.C. Bocking

Department of Fisheries and Oceans
Fisheries Branch
#416, Suite 400-555 West Hastings Street
Vancouver, British Columbia V6B 5G3

August 1991

Canadian Technical Report of
Fisheries and Aquatic Sciences No. 1815

heries
d Oceans
Pêches
et Océans

Canada

Canadian Technical Report of
Fisheries and Aquatic Sciences 1815

July 1991

STAMP FALLS FISHWAY COUNTS, ADIPOSE CLIP/CWT RECOVERY AND BIOLOGICAL SAMPLING OF CHINOOK SALMON ESCAPEMENTS IN STAMP RIVER AND ROBERTSON CREEK HATCHERY, 1990

by

R.C. Bocking[1]

for

Department of Fisheries and Oceans
Fisheries Branch
#416, Suite 400 - 555 West Hastings Street
Vancouver, B.C.
V6B 5G3

[1]**LGL Limited, environmental research associates, 9768 Second Street, Sidney, B.C. V8L 3Y8**

Cat. No. Fs 97-6/1815E ISSN 0706/6457

Correct citation for this publication:

Bocking, R.C. 1991. Stamp Falls Fishway counts, adipose clip/CWT recovery and biological sampling of chinook salmon escapements in Stamp River and Robertson Creek Hatchery, 1990. Can. Tech. Rep. Fish. Aquat. Sci. 1815: x + 92 p.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF FIGURES

LIST OF FIGURES (cont'd)

LIST OF APPENDICES

ABSTRACT

Bocking, R.C. 1991. Stamp Falls Fishway counts, adipose clip/CWT recovery and biological sampling of chinook salmon escapements in Stamp River and Robertson Creek Hatchery, 1990. Can. Tech. Rep. Fish. Aquat. Sci. 1815: x + 92 p.

Estimates of salmon escapement were derived for the Stamp River for 1990 using visual counts at the Stamp Falls Fishway. After adjusting for observer error and missing data due to flooding, the total escapement of chinook salmon to the Stamp river was estimated at 135,254 $\pm$ 4125. Escapement estimates for coho salmon are also presented as well as partial estimates for sockeye.

The age, size, sex, and hatchery contributions for chinook salmon in the Stamp River are also described using data from carcass recovery and live returns to Robertson Creek Hatchery. The dominant age for chinook salmon spawning in the river was 4 years while male fish returning to the hatchery were predominantly age 3. Female chinook (all ages) were of similar size among the river spawners and hatchery spawners and tended to be larger than their male counterparts. Age structure analyses revealed substantial errors in the visual identification of jack chinook.

Escapement of adipose clipped chinook to the whole Stamp River system was 5450 and represented 4.0 % of the entire population. The total hatchery contribution (marked and unmarked) to the escapement was estimated by expanding the number of observed adipose clips by the adipose mark rate at release. In 1990, Robertson Creek Hatchery contributed approximately 81.8 % of the chinook escapement to Stamp River. The hatchery contribution estimated in this manner was compared with that estimated using the Mark Recovery Program (Kuhn, 1988) method of coded wire tag expansions (72.1%). Hatchery strays from Quesnel River and Capilano River contributed an additional 0.2% to the total excapement. The reasons for the differences in hatchery contribution estimates using the two methods are discussed.

Key words: Stamp River, chinook, keystream, escapement, fishway, coded wire tags, hatchery contribution

RÉSUMÉ

Bocking, R. C. 1991. Stamp Falls Fishway counts, adipose clip/CWT recovery and biological sampling of chinook salmon escapements in Stamp River and Robertson Creek Hatchery, 1990. Can. Tech. Rep. Fish Aquat. Sci. 1815: x + 92 p.

On a évalué la remontée du saumon dans la rivière Stamp en 1990 à partir d'observations visuelles faites à la passe migratoire de cette rivière. En tenant compte de l'erreur due à l'observateur et des données manquantes dues aux crues, on a évalué la remontée à 135 254 ± 4125 individus. On présente également des chiffres de remontée pour le coho et des chiffres partiels pour le saumon rouge.

On établit également l'âge, la taille et le sexe des quinnats dans la Stamp, ainsi que la contribution des piscicultures, à partir des poissons morts récupérés et des poissons retournés vivants à la pisciculture de Robertson Creek. L'âge le plus fréquent était 4 ans dans le cas des quinnats reproducteurs et de 3 dans celui des mâles qui retournaient à la pisciculture. Les quinnats femelles (tous âges confondus) étaient de même taille parmi les reproducteurs de rivière et ceux de pisciculture, mais généralement plus gros que les mâles. L'analyse de la pyramide des âges a révélé de graves erreurs dans l'identification visuelle des quinnats mâles.

La remontée de quinnats à nageoire adipeuse rognée a totalisé 5450 poissons représentant 4.0 % de tout l'effectif. La contribution totale de la pisciculture à la montaison a été établie par le taux de marquage et recapture. En 1990, la pisciculture de Robertson Creek a fourni environ 81.8 % de la remontée de quinnat dans la Stamp. Ce chiffre a été comparé au taux obtenu par de la méthode du programme de récupération des fils codés (Kuhn, 1988), soit 72.1 %. Les poissons provenant des pisciculture de la Quesnel et de la Capilano ont fourni 0.2 % de la remontée. On explique les différences entre les résultats des deux méthodes d'évaluation des contributions des piscicultures.

Mots clés: Rivière Stamp, saumon quinnat, cours d'eau clé, montaison passe migratoire, fils codés, contribution de pisciculture

INTRODUCTION

The chinook salmon of the Somass River system was selected as one of the indicator stocks for assessing the response of Pacific chinook salmon stocks to a new harvest management regime. The goal of the new management regime is to rebuild chinook stocks to historical levels. This "key stream" program began in 1984 in response to objectives set out in the Canada - U.S. Salmon treaty.

The major objectives of the key stream program are:

1. to accurately estimate chinook escapement on key streams;

2. to estimate harvest rates and contributions to fisheries and escapement based on coded wire tagged/adipose clip returns, including estimates of the total escapement of coded wire tags to the key streams system; and

3. to estimate the contribution of hatchery and natural production to the escapement.

This report deals with the determination of spawning escapement to the Stamp River and related biological information. The objectives of the study were:

1. to estimate the total chinook escapement to the Stamp River;

2. to determine the age and sex composition of the in-river population and hatchery returns to the system; and

3. to estimate the total escapement of coded wire tagged chinook to the system, thereby assessing the hatchery contribution to the total escapement.

Part I of this report addressed the first objective and Part II of the report addresses objectives 2 and 3. Escapement estimates for the Stamp River for 1990 were derived using visual counts at the Stamp Falls Fishway and manual counts at Robertson Creek Hatchery. Coded wire and adipose clip returns and hatchery contributions were estimated using dead recoveries of chinook throughout the Stamp River and live returns of chinook to Robertson Creek Hatchery.

PART I: STAMP FALLS FISHWAY COUNTS

INTRODUCTION

The chinook salmon of the Somass River system (including Robertson Creek Hatchery production) are the most abundant stock of this species on Vancouver Island and make important contributions to troll, net and sport fisheries in U.S. and Canadian waters. Coded wire tag returns for chinook released from Robertson Creek Hatchery have been used to estimate the contribution of hatchery production to coastal fisheries (Sibert and Schnute 1982; English and Griffiths 1984); however, these analyses were incomplete due to the lack of reliable data on escapement, Indian fishery catches, and terminal sport fishery harvests. In 1984, the Department of Fisheries and Oceans initiated several investigations for Somass River chinook, including:

1. escapement estimation using a combination of mark-recapture techniques, counts of fish passing through the Stamp Falls Fishway, deadpitch surveys and hatchery returns (Lightly et al. 1988);

2. catch estimates for the Indian food fishery from field surveys; and

3. catch estimates for the Alberni Inlet and Somass River sport fisheries derived from creel surveys.

In 1985, the responsibility for providing reliable escapement and terminal catch estimates for Somass River chinook was allocated to the Key Stream Program as part of a coast-wide attempt to monitor the effect of new management action on chinook stock status. The poor precision and potential for biases in the 1984 and 1985 escapement estimation procedures prompted DFO staff to investigate the potential for using a video camera system to obtain more reliable counts of each species passing through the Stamp Falls Fishway. A video camera installed in the fishway on 19 September 1986, was successfully used to record the passage of most of the chinook migrating past Stamp Falls in that year. While the video camera provided a 24 hour a day record of the fish passing through the fishway, problems associated with species identification and "fall-back" (multiple passage of the same fish through the counting area) still affected the resulting escapement estimates. In 1987, a video camera system was again used to monitor the fish passing through the fishway in conjunction with procedures to validate camera counts and a tagging program to address the "fall-back" problem. The 1988 run was monitored using a combination of video recordings and visual counts of fish passing through the Stamp Falls Fishway. This procedure also encountered problems, mainly with quantifying errors associated with accuracy of fish counts and species determination, and with obtaining estimates of fish passing upstream during periods of extreme high water. Difficulties in reliably identifying species, sexes and discriminating jacks from video tape stop-frame images and the inordinate amount of time required to process the video recordings led to the dropping of the video camera technique.

In 1989, the salmon run was monitored by visual counting (in real time) only. Some of the problems encountered included: 1) large build-ups of fish below the counting chute (pers. comm. D.

Lawseth, manager, Robertson Creek Hatchery, Nanaimo); 2) fish passed undetected during times when the counting chute was adjusted for water levels; and 3) difficulties calibrating observer counts for discrimination of species and size.

Much has been learned about estimating the escapement of chinook salmon to the Stamp River from the previous 6 years of study. The first lesson is that attempts to collect extensive data on CWT mark rates (from adipose clips), sex ratios, and other biological characteristics from chinook salmon at the fishway have, for the most part, interfered with the counting operations and passage of fish through the fishway and have only resulted in limited information. Secondly, counts from the fishway are not necessarily an estimate of the total escapement to the Somass system and it is very difficult to accurately estimate the total escapement of fish to the system. Aside from the inherent problems with counting fish as they pass through the Stamp Falls Fishway, counts at the fishway ignore the presence of chinook spawners below the fishway, those chinook which migrate up the falls, and chinook spawners in the Sproat River. Mark-recapture can provide an estimate for the entire Somass drainage but such estimates are costly and are often biased due to violations of one or more of the basic assumptions associated with the estimation technique. Despite these problems in accurately estimating the escapement of chinook to the Somass River system, it is still possible to develop an index of escapement using visual counts of chinook at Stamp Falls Fishway. Reliable indices of abundance can serve one of the purposes of the Key Stream Program which is to monitor relative changes in chinook stocks. Considerably more effort and money would have to be expended to generate reliable escapement estimates which could be used for hatchery contribution estimates and stock recruitment analyses.

Under this more modest objective of using the fishway counts as an index of abundance, we developed a method of accurately counting and interpreting counts of chinook and other salmonid species at Stamp Falls. If consistency of method is maintained each year and the following assumptions hold, then a reliable index of abundance for Somass River chinook can be obtained and changes in abundance can be monitored. The necessary assumptions for this are:

1. A constant proportion of the total chinook escapement to the Somass River system passes through the Stamp Falls Fishway;

2. The fraction of chinook which bypass the Stamp Falls Fishway does not vary with run size or with flow conditions in the river; and

3. The actual counts of chinook passing through the fishway are accurate and precise (within 10%).

In this year's study we developed a simple technique that ensured that assumption 3 was met for 1990 and which could be easily employed in subsequent years. Assumptions 1 and 2 have not yet been evaluated but should be in future studies. Our specific objectives in the 1990 study were to:

1. Count all chinook, coho, sockeye, steelhead, and other salmonids passing through the Stamp Falls Fishway between 11 September and 20 November, 1990;

2. Quantify the random error associated with species identification and mis-counting of fish migrating through the fishway; and

3. Estimate the number of fish migrating through the fishway during periods when reliable counting could not be conducted.

To achieve these objectives, we modified previous designs of the counting apparatus to provide satisfactory rates of fish passage as well as accurate counts of each species. The design employed was very similar to that used by Lightly et al. (1988).

STUDY AREA

The Somass River system is one of the largest on Vancouver Island and includes the Stamp and Sproat Rivers near Port Alberni (Fig. 1). The Stamp River drains Great Central Lake and flows northeast and southeast into the Somass River. The Sproat River drains Sproat Lake and flows eastward into the Stamp River.

The Somass River system supports sockeye, chinook, coho, chum and pink salmon, as well as steelhead and cutthroat trout. It supports the largest chinook salmon stock on the west coast of Vancouver Island. The Somass River chinook stocks are comprised of wild populations spawning in the Sproat and Stamp Rivers and hatchery production from Robertson Creek Hatchery (Fig. 1). Since 1984, when rigorous counting techniques were first employed on the Somass system, chinook escapements have ranged from 45,000 to 82,000 (Wright, 1990). Escapement estimates prior to 1984 are of questionable accuracy since they are from DFO spawning files and the techniques employed are not well documented. Since 1986, only those chinook returning to the upper Stamp River (above the fishway) have been enumerated, although aerial surveys of spawners in the lower portion of the river have occasionally been conducted. Table 1 shows the total estimates of chinook returning to various portions of the Somass River system and the methods used since 1984.

Somass River chinook generally have a fall run timing with the majority of the population returning in September and October. The majority of the chinook return as four year olds, although ages range from 2 to 7 years. Coho salmon appear to have a similar run timing (Wright 1990).

Sockeye returning to the Somass River system are from Sproat and Great Central Lake and tributaries. Only a fraction of the sockeye returning to Great Central Lake are enumerated at Stamp Falls Fishway since the majority of the run (> 85%) has usually passed prior to 1 September. Sockeye have not been rigorously counted at Stamp Falls since the counting systems employed have usually allowed small adults and jacks (< 45 cm) to pass through the counting bars, undetected. Coho, pink, chum salmon and steelhead have also been enumerated at Stamp Falls Fishway with varying levels of rigor and success in recent years.

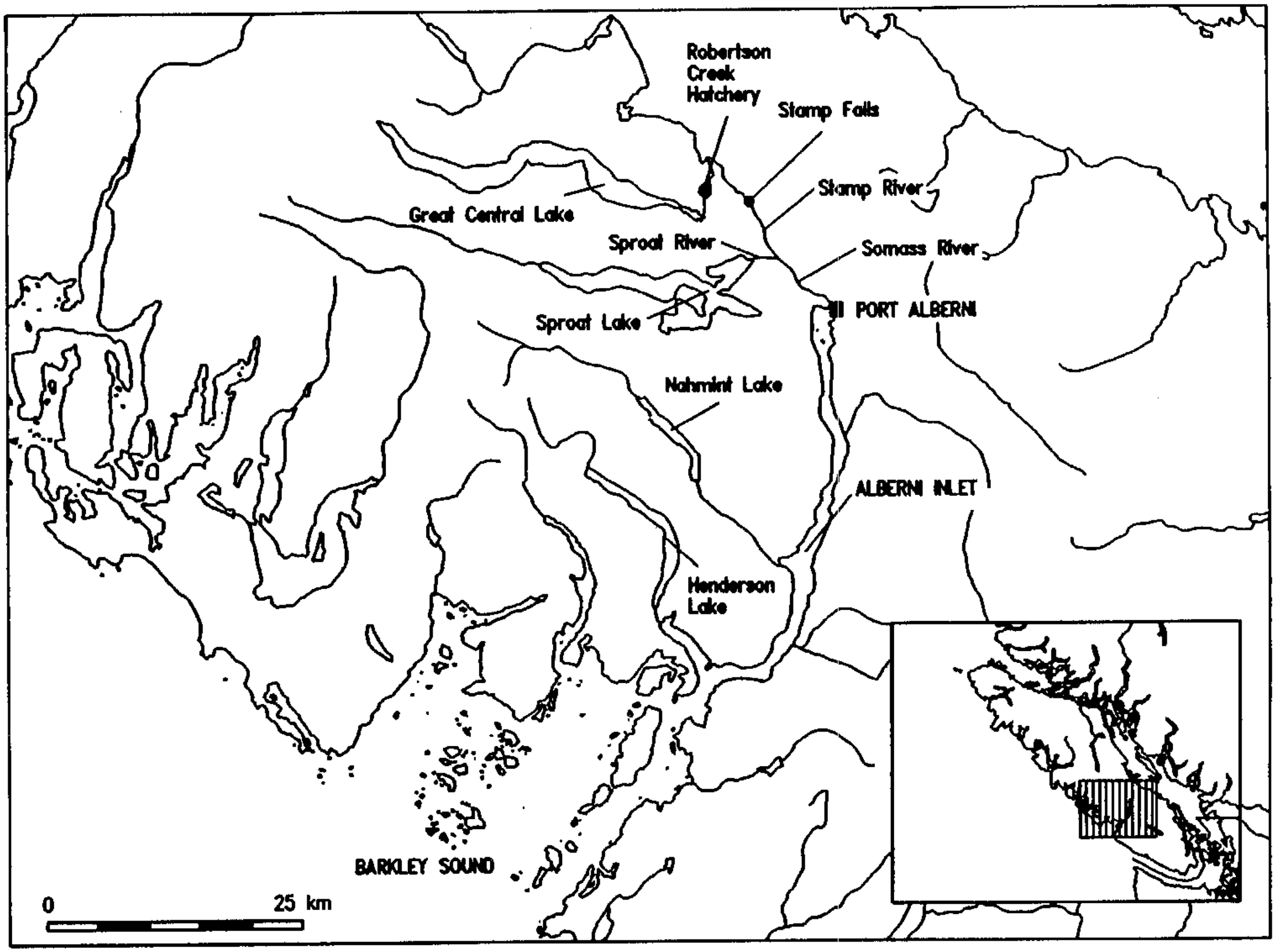


Figure 1. Map of Somass River system and Stamp Falls.

Table 1. Estimates of the number of chinook salmon returning to various portions of the Somass River system and the methods of enumeration, 1984-1989.

Year	Location	Method	Estimate (d)	Reference
1984	Sproat River and lower Stamp		36443 (a) (3443)	Lightly et al. 1988
	Upper Stamp (above fishway)	fishway visual count (a)	63776 (a) (52744)	Lightly et al. 1988
	Hatchery (b)	manual count	11001	Lawseth, pers. comm.
	Total Somass system	mark recapture(b)	100219 (c) (67219)	Lightly et al. 1988
1985	Sproat River and lower Stamp			
	Upper Stamp (above fishway)			
	Hatchery (b)	manual count	19108	Lawseth, pers. comm.
	Total Somass system	mark recapture		
1986	Sproat River and lower Stamp			
	Upper Stamp (above fishway)	fishway video count	35121	Heizer , 1991
	Hatchery (b)	manual count	13953	Lawseth, pers. comm.
	Total Somass system			
1987	Sproat River and lower Stamp			
	Upper Stamp (above fishway)	fishway video count	53216	Heizer, 1991
	Hatchery (b)	manual count	38698	Lawseth, pers. comm.
	Total Somass system			
1988	Sproat River and lower Stamp			
	Upper Stamp (above fishway)	fishway visual count	76320	J.C. Lee and Assoc.
	Hatchery (b)	manual count	14663	Lawseth, pers. comm.
	Total Somass system			
1989	Sproat River and lower Stamp			
	Upper Stamp (above fishway)	fishway visual count	82366 (e)	M.C. Wright and Assoc. 1990
	Hatchery (b)	manual count	28934	Lawseth, pers. comm.
	Total Somass system			

(a) The Petersen live mark and dead recapture estimate is adjusted for all sources of fishing predation subsequent to tagging. The adjusted figures are shown in parentheses.

(b) Don Lawseth, pers. comm, manager, Robertson Creek Hatchery, P.O. Box 1100, Port Alberni, B.C. , V9Y 7L9.

(c) The Petersen live mark and dead recapture estimate gives total escapement before commercial and sportfishing losses. Tagging mortality and tag loss estimates were made to adjust marked release numbers and tag recoveries upwards (10%) for tag non-detection and tag non-reporting in the Petersen equation.

(d) Includes jacks

(e) Includes 3141 chinook mortalities in the area immediately below Stamp Falls.

METHODS

Biophysical Observations

Water temperatures were recorded daily at the fishway, usually between the hours of 0800 and 1000 am using a max-min thermometer. Water levels were also recorded daily using a staff gauge positioned on the upstream corner of the fishway in the exit pool. Levels were recorded to the nearest 0.5 cm. Weather conditions were also monitored in terms of percent sun, cloud, and precipitation.

Fishway Counts

Visual counts of salmonids passing through the Stamp Falls Fishway were made between 11 September and 8 November, 1990. A counting station was installed at the upstream end of the fishway and is shown diagrammatically in Figure 2. Aluminum panels, 2.4 m x 1 m, with bars spaced 5.1 cm apart, were placed in the fishway. The panels were stacked one on top of the other as needed for the top of the panels to be at least .3 m above the water line. The panels were constructed of 7.6 cm channel aluminum frame with 2.54 cm (od) aluminum conduit. A white vexar fence (mesh size = 2 in), strung on an aluminum frame was placed on the upstream side of the panel (Fig. 3) to effectively close the gap between the bars and prevent small salmonids (i.e. sockeye and coho < 45 cm) from escaping between the panel bars. The panels were set into channel aluminum tracks which were attached to the inside of the fishway. Large aluminum gates, situated immediately downstream of the panels were positioned in a VEE formation to funnel fish through an opening at the bottom of the lower most panel.

Fish then passed over a 2 m x 2.4 m wide aluminum flashboard. The opening was 0.3 m high and 1.3 m wide, and was designed to prevent multi-layered schools of fish from entering. A gate could be closed to prevent passage when the counting station was unmanned. To improve visibility a 1 m x 1 m viewing window was floated on the surface over the flashboard (Fig. 4). Observers sat on top of the fishway and counted the fish as they passed under the viewing window. A thin film of water was placed on top of the viewing window to enhance the image of the fish below. To prevent glare, tarps were placed over the fishway at the counting site.

Counts were made daily between dawn and dusk (usually from 0800 to 1700) and the panel gate was closed during the night. Two observers manned the station during counting hours and alternated counting every 1 hour. The counting system described above worked well under most flow conditions. However, when the counting depth became greater than 1 m or the turbidity of the water increased, the following modifications were made. The aluminum panel with the gate was raised to 0.5 m off the bottom off the fishway and a solid aluminum panel was placed underneath. A counting chute (0.5m x 0.5m x 1.0m) was attached to the upstream side of the gate opening. This chute had a white flashboard and plexiglass sides. The viewing window was again floated on the water surface above the chute. This system was only used for a few days just prior to and after a flood event, when the water depth in the fishway was greater than 1 m.

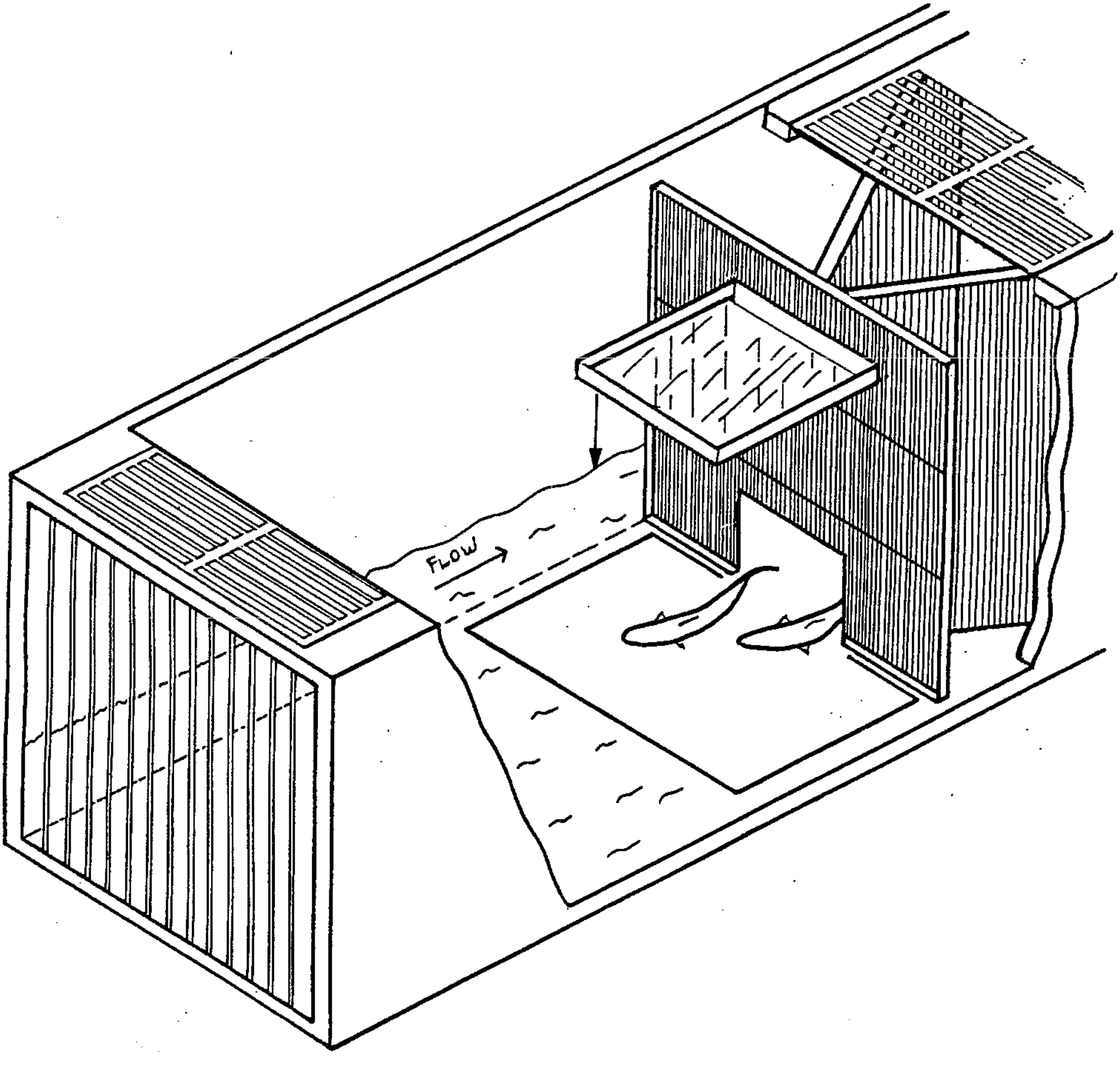


Figure 2. Diagram of the fish counting facility installed at the upstream end of Stamp Falls fishery, 11 Sept - 8 Nov, 1991.

Figure 3. Photograph of downstream end of the fish counting facility showing Vee gate, panels and vexar screening.

Figure 4. Photograph of counting facility showing aluminum flashboard and viewing window.

Total counts of adult and jack chinook, adult and jack coho, sockeye, pink, chum, and steelhead were recorded hourly. The aluminum flashboard was marked at 34 cm and 59 cm to allow size range estimates of coho and chinook jacks, respectively. These total length size categories are based on age-length data from Robertson Creek Hatchery. Daily summaries presenting totals for each of the salmonid species (chinook adults, chinook jacks, coho adults, coho jacks, sockeye and steelhead) counted at Stamp Falls Fishway were phoned into Robertson Creek Hatchery twice weekly and used for inseason management at the hatchery.

Precision of Counts

Estimates of counting and species identification errors were derived from a program of sub-sampling. For approximately one hour each day, the exit from the fishway was blocked using aluminum panels covered with vexar mesh (2 cm) so that fish could be counted, trapped and examined for species verification (Fig. 5). Fish were counted through the gate and over the flashboard as normal but were contained in a 2 m x 2.4 m area. Between 10 and 100 fish of varying species composition were usually counted for each test. The captured fish were then dipnetted from the containment area and carefully checked for species. The tests were conducted at various times of the day and under varying light and water conditions. Tests were conducted daily from September 18 to October 23. No tests were conducted after this date because of high water and low numbers of fish.

Hourly visual counts and species identification were adjusted in proportion to the difference between the observed visual counts and the true or verified counts. These differences were calculated in terms of the mean proportional error (PE) for each sampling interval (generally 1 week):

$$PE_k=\frac{\sum_{j=1}^{n}\frac{VerC_j}{VCj}}{n} \qquad (1)$$

where $VerC_j$ is the true number of fish determined from each test *(j)*, VC_j is the number of fish observed during the test, PE_k is the mean proportional error of the visual counts for sample period *k* (usually 1 week), and *n* is the number of tests conducted in each sampling interval.

The hourly counts of each species could then be adjusted using the following equation:

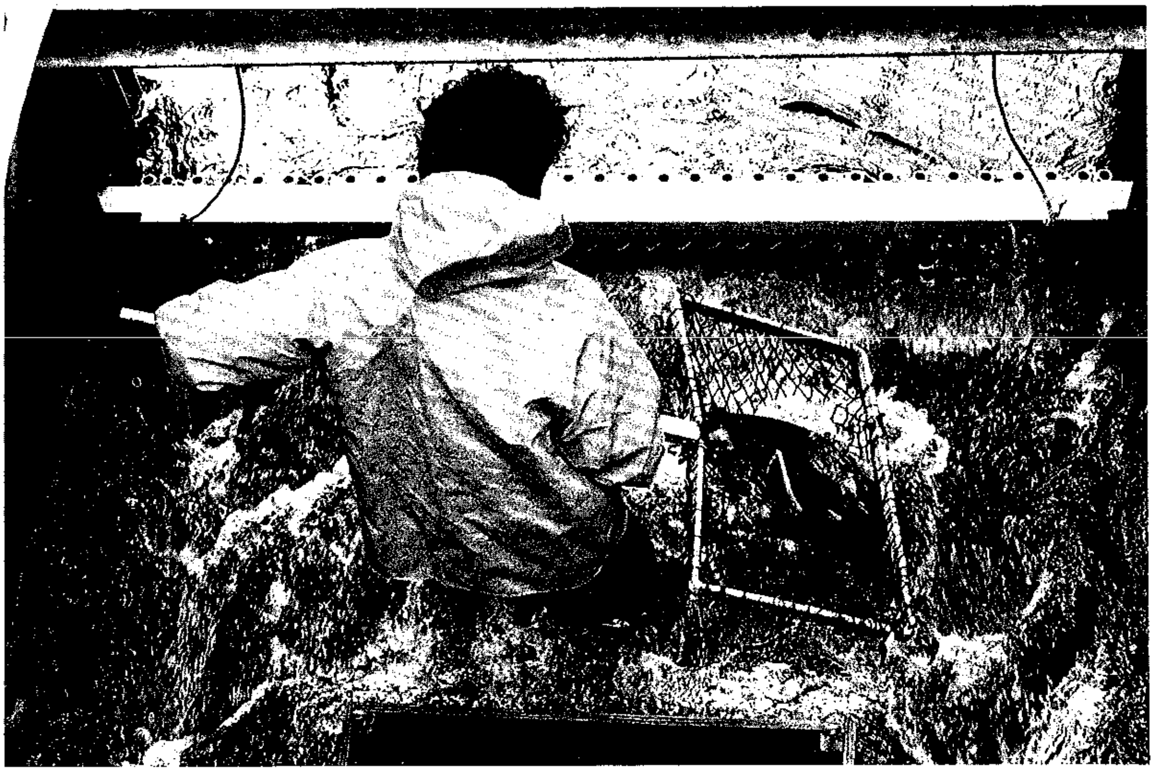


Figure 5. Photograph of worker dipnetting fish from containment area during verification test.

$$VCadj_{k,j,i}=Visualcount_{k,j,i} \cdot PE_k \tag{2}$$

where $VC_{k,j,i}$ is the actual count of fish in hour i, on day j and in sample period k; $VC'_{k,j,i}$ is the corresponding adjusted count; and PE_k is the mean proportional error for sample period k.

The variance can be calculated for the total number of fish estimated in each week using the following equation:

$$Var(VCadj_{k,j,i})=\sum_{i=1}^{m}(VC_{k,j,i})^2 \cdot Var(PE_k) \tag{3}$$

where VC_k is the total weekly count, VC'_k is the adjusted weekly count and $Var(PE_k)$ is the variance estimated from each sample period series of comparisons of trap counts with visual counts (from equation 1).

The adjusted hourly counts for each species were summed to give daily estimates of the number of fish moving through the fishway and further summed to provide a total population estimate. The weekly variance estimates were summed to produce a single variance estimate and 95% confidence intervals for the escapement of each species counted through the Stamp Falls Fishway. The standard error estimate was obtained by dividing the square root of the above variance by the total number of verification tests (n=36).

Data from the verification tests were examined for density dependent effects to confirm that the above method of adjusting the visual counts and estimating variance was valid. In addition, the verification tests were used to compare the counting accuracy of each of the three observers used in the study.

Interpolation of Missing Counts

During periods of high or turbid water when visual counts could not be made, estimates of the number of chinook and coho passing through the fishway were estimated using the relationship between 1990 fishway counts and 1990 hatchery returns for periods when the fishway counts were available. The number of sockeye migrating during periods when counting was not possible was estimated using linear interpolation.

RESULTS

Accuracy and Precision of Counts

Two factors were considered in assessing the accuracy and precision of the fishway counts. The first involved observer error in enumerating the fish and in species identification. The second involved a comparison of 'between observer' error. To assess these sources of error, verification tests were conducted for approximately 1 hour each day. We attempted to conduct the tests at various times of the day to account for varying light conditions and diel migration patterns of the fish. Figure 6 shows the hourly distribution of tests conducted for each of three timing periods. Comparing this distribution of tests to the diel migration pattern of salmonids at the fishway (see Figs. 15,16,17) indicates that there was no serious discrepancy between the tests and fish movement, with the exception of a large number of tests conducted at 1400 hours.

Species Identification and Enumeration Error

Species identification error was determined by comparing the visual counts made during the verification tests with the true number and species composition of fish captured during the tests (Table 2). Scattergrams of the daily visual counts and the verified counts were plotted for each of chinook adults, chinook jacks, coho adults, coho jacks, and sockeye (Fig. 7). Not enough data was collected to permit an evaluation of counting error for steelhead, pink or chum. Standard regression analyses were performed on the data in these plots to test for the form (linear or nonlinear) of the relationship between the actual visual counts and the true number of fish. In all cases, standard residual analyses did not allow the rejection of linearity in the relations for each species. Also, each of the y-intercepts approximated zero. We, therefore, used simple ratio estimators to derive weekly correction factors and variance estimates for our counts of each species (Table 2).

The verification tests reveal several interesting results. The amount of bias in the visual counts, depending on the species, was between -29% and -17% during the first week of tests (second week of counting). The amount of error fluctuated between 0% and ±23% for the next 2 weeks and by the second week of October the error was only between 0% and ±13%, depending on the species. Counts of adult and jack chinook were the most accurate, followed by sockeye. Counts of adult and jack coho were the least accurate. The precision of the visual counts was also poor during the first 3 weeks of counting ($0.07 < SD < 0.58$) but precision improved substantially thereafter, particularly for chinook. From the first week of October onwards, the standard deviation on adult counts of chinook was between 0.06 and 0.12. The precision of coho adult and jack counts was poorest. These differences in the precision of the counts for each species is graphically portrayed in Figure 7.

Between Observer Error

The average observer error was calculated for each of the three observers using the data from the verification tests. No significant differences were found between observers for any of the species

Table 2. Results of Stamp Falls verification tests, 1990. O = observed count, V=verified count.

Week	Date	Time	Observer	Gauge height	Chinook adults			Chinook jacks			Coho adults			Coho jacks			Sockeye		
					O	V	V/O	O	V	V/O	O	V	V/O	O	V	V/O	O	V	V/O
2	18/9/90	1530	mike	1.16	2.00	0.00	0.00	1.00	0.00	0.00	5.00	3.00	0.60	4.00	3.00	0.75	18.00	12.00	0.67
2	19/9/90	1400	rob	1.15	3.00	3.00	1.00	0.00	0.00	1.00	9.00	9.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00
2	20/9/90	1100	mike	1.16	1.00	1.00	1.00	0.00	0.00	1.00	3.00	2.00	0.67	1.00	1.00	1.00	13.00	14.00	1.08
2	21/9/90	1010	rob	1.17	1.00	1.00	1.00	0.00	0.00	1.00	5.00	3.00	0.60	1.00	1.00	1.00	15.00	17.00	1.13
2	22/9/90	1700	ken	1.17	1.00	1.00	1.00	1.00	1.00	1.00	9.00	7.00	0.78	5.00	1.00	0.20	9.00	7.00	0.78
2	23/9/90	1400	mike	1.17	5.00	5.00	1.00	5.00	5.00	1.00	9.00	9.00	1.00	3.00	1.00	0.33	1.00	1.00	1.00
			Mean				**0.83**			**0.83**			**0.77**			**0.71**			**0.94**
			SD				**0.41**			**0.41**			**0.19**			**0.36**			**0.18**
3	24/9/90	1600	ken	1.17	3.00	6.00	2.00	3.00	2.00	0.67	9.00	6.00	0.67	1.00	1.00	1.00	3.00	3.00	1.00
3	25/9/90	1000	mike	1.16	1.00	2.00	2.00	3.00	3.00	1.00	7.00	6.00	0.86	0.00	0.00	1.00	13.00	13.00	1.00
3	26/9/90	1400	ken	1.16	2.00	1.00	0.50	0.00	0.00	1.00	6.00	7.00	1.17	3.00	3.00	1.00	11.00	10.00	0.91
3	27/9/90	1300	rob	1.17	0.00	0.00	1.00	3.00	3.00	1.00	12.00	11.00	0.92	0.00	0.00	1.00	35.00	32.00	0.91
3	28/9/90	1400	ken	1.23	3.00	3.00	1.00	3.00	4.00	1.33	4.00	5.00	1.25	1.00	1.00	1.00	12.00	10.00	0.83
3	29/9/90	1000	rob	1.19	7.00	7.00	1.00	0.00	0.00	1.00	4.00	4.00	1.00	1.00	0.00	0.00	32.00	29.00	0.91
3	30/9/90	1000	mike	1.16	6.00	5.00	0.83	0.00	0.00	1.00	2.00	3.00	1.50	0.00	0.00	1.00	20.00	17.00	0.85
			Mean				**1.19**			**1.00**			**1.05**			**0.86**			**0.92**
			SD				**0.58**			**0.19**			**0.28**			**0.38**			**0.07**
4	1/10/90	1400	rob	1.16	9.00	9.00	1.00	1.00	1.00	1.00	9.00	9.00	1.00	0.00	0.00	1.00	6.00	6.00	1.00
4	2/10/90	1300	mike	1.16	22.00	22.00	1.00	0.00	0.00	1.00	4.00	4.00	1.00	3.00	2.00	0.67	1.00	1.00	1.00
4	3/10/90	1100	rob	1.11	29.00	30.00	1.03	2.00	1.00	0.50	2.00	3.00	1.50	1.00	2.00	2.00	6.00	5.00	0.83
4	4/10/90	1100	mike	1.24	13.00	11.00	0.85	2.00	2.00	1.00	2.00	4.00	2.00	2.00	2.00	1.00	11.00	13.00	1.18
4	5/10/90	1400	ken	1.23	14.00	14.00	1.00	1.00	0.00	0.00	10.00	11.00	1.10	0.00	0.00	1.00	23.00	25.00	1.09
4	6/10/90	1200	mike	1.2	13.00	13.00	1.00	1.00	1.00	1.00	8.00	8.00	1.00	0.00	0.00	1.00	52.00	56.00	1.08
4	7/10/90	1300	ken	1.19	8.00	8.00	1.00	1.00	1.00	1.00	11.00	11.00	1.00	3.00	3.00	1.00	38.00	40.00	1.05
			Mean				**0.98**			**0.79**			**1.23**			**1.10**			**1.03**
			SD				**0.06**			**0.39**			**0.39**			**0.42**			**0.11**

Table 2. Results of Stamp Falls verification tests, 1990. O = observed count, V=verified count.

Week	Date	Time	Observer	Gauge height	Chinook adults O	Chinook adults V	Chinook adults V/O	Chinook jacks O	Chinook jacks V	Chinook jacks V/O	Coho adults O	Coho adults V	Coho adults V/O	Coho jacks O	Coho jacks V	Coho jacks V/O	Sockeye O	Sockeye V	Sockeye V/O
5	8/10/90	1200	rob	1.7	9.00	9.00	1.00	0.00	0.00	1.00	11.00	11.00	1.00	2.00	2.00	1.00	67.00	69.00	1.03
5	9/10/90	1500	ken	1.15	20.00	18.00	0.90	1.00	1.00	1.00	1.00	2.00	2.00	3.00	0.00	0.00	41.00	35.00	0.85
5	10/10/90	1200	rob	1.2	8.00	8.00	1.00	2.00	2.00	1.00	12.00	12.00	1.00	2.00	2.00	1.00	33.00	33.00	1.00
5	11/10/90	1100	ken	1.07	12.00	14.00	1.17	1.00	1.00	1.00	14.00	13.00	0.93	3.00	2.00	0.67	29.00	26.00	0.90
5	12/10/90	900	rob	1.21	2.00	2.00	1.00	0.00	0.00	1.00	8.00	8.00	1.00	3.00	3.00	1.00	61.00	57.00	0.93
5	13/10/90	1000	mike	1.15	11.00	11.00	1.00	0.00	0.00	1.00	8.00	8.00	1.00	0.00	0.00	1.00	13.00	13.00	1.00
5	14/10/90	1400	rob	1.15	10.00	10.00	1.00	4.00	4.00	1.00	3.00	3.00	1.00	1.00	2.00	2.00	12.00	11.00	0.92
			Mean				**1.01**			**1.00**			**1.13**			**0.95**			**0.95**
			SD				**0.08**			**0.00**			**0.38**			**0.59**			**0.06**
6	15/10/90	1400	mike	1.15	8.00	8.00	1.00	3.00	3.00	1.00	6.00	6.00	1.00	0.00	0.00	1.00	8.00	8.00	1.00
6	16/10/90	1400	ken	1.13	19.00	18.00	0.95	1.00	1.00	1.00	4.00	5.00	1.25	0.00	0.00	1.00	7.00	5.00	0.71
6	17/10/90	1400	mike	1.12	21.00	21.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	11.00	6.00	0.55
6	18/10/90	1600	ken	1.23	17.00	22.00	1.29	0.00	0.00	1.00	10.00	6.00	0.60	0.00	0.00	1.00	6.00	7.00	1.17
6	19/10/1990	1200	mike	1.25	16.00	16.00	1.00	0.00	0.00	1.00	8.00	8.00	1.00	1.00	1.00	1.00	12.00	10.00	0.83
6	20/10/90	1100	rob	1.25	13.00	13.00	1.00	1.00	1.00	1.00	6.00	6.00	1.00	1.00	0.00	1.00	15.00	14.00	0.93
6	21/10/90	1600	ken	1.36	10.00	10.00	1.00	0.00	0.00	1.00	4.00	3.00	0.75	1.00	1.00	1.00	15.00	13.00	0.87
			Mean				**1.03**			**1.00**			**0.94**			**1.00**			**0.87**
			SD				**0.12**			**0.00**			**0.21**			**0.00**			**0.20**
7	22/10/90	1200	rob	1.38	13.00	13.00	1.00	0.00	0.00	1.00	11.00	11.00	1.00	0.00	0.00	1.00	4.00	4.00	1.00
7	23/10/90	1300	ken	1.39	9.00	10.00	1.11	0.00	1.00	1.00	9.00	7.00	0.78	2.00	2.00	1.00	11.00	12.00	1.09
			Mean				**1.06**			**1.00**			**0.89**			**1.00**			**1.05**
			SD				**0.08**			**0.00**			**0.16**			**0.00**			**0.06**

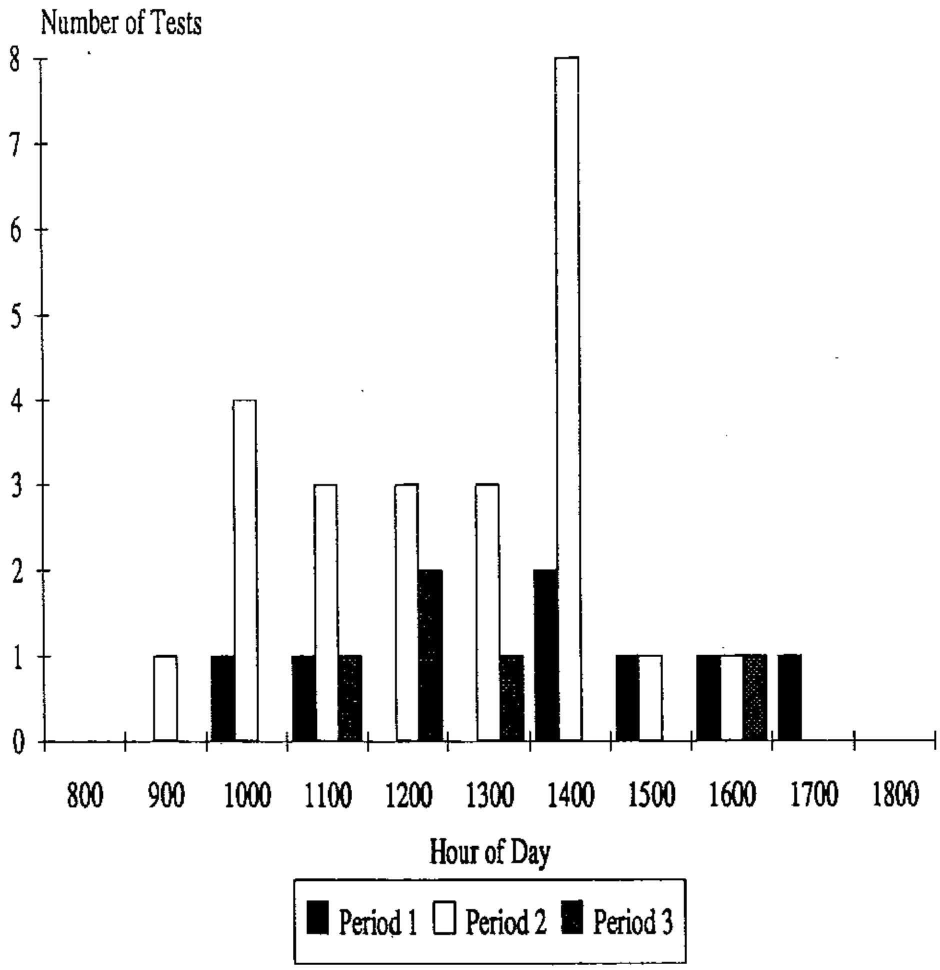


Figure 6. Frequency distribution of verification tests conducted at Stamp Falls. Period 1 = 11 Sept to 24 Sept, Period 2 = 25 Sept to 18 Oct, and Period 3 = 19 Oct to 23 Oct.

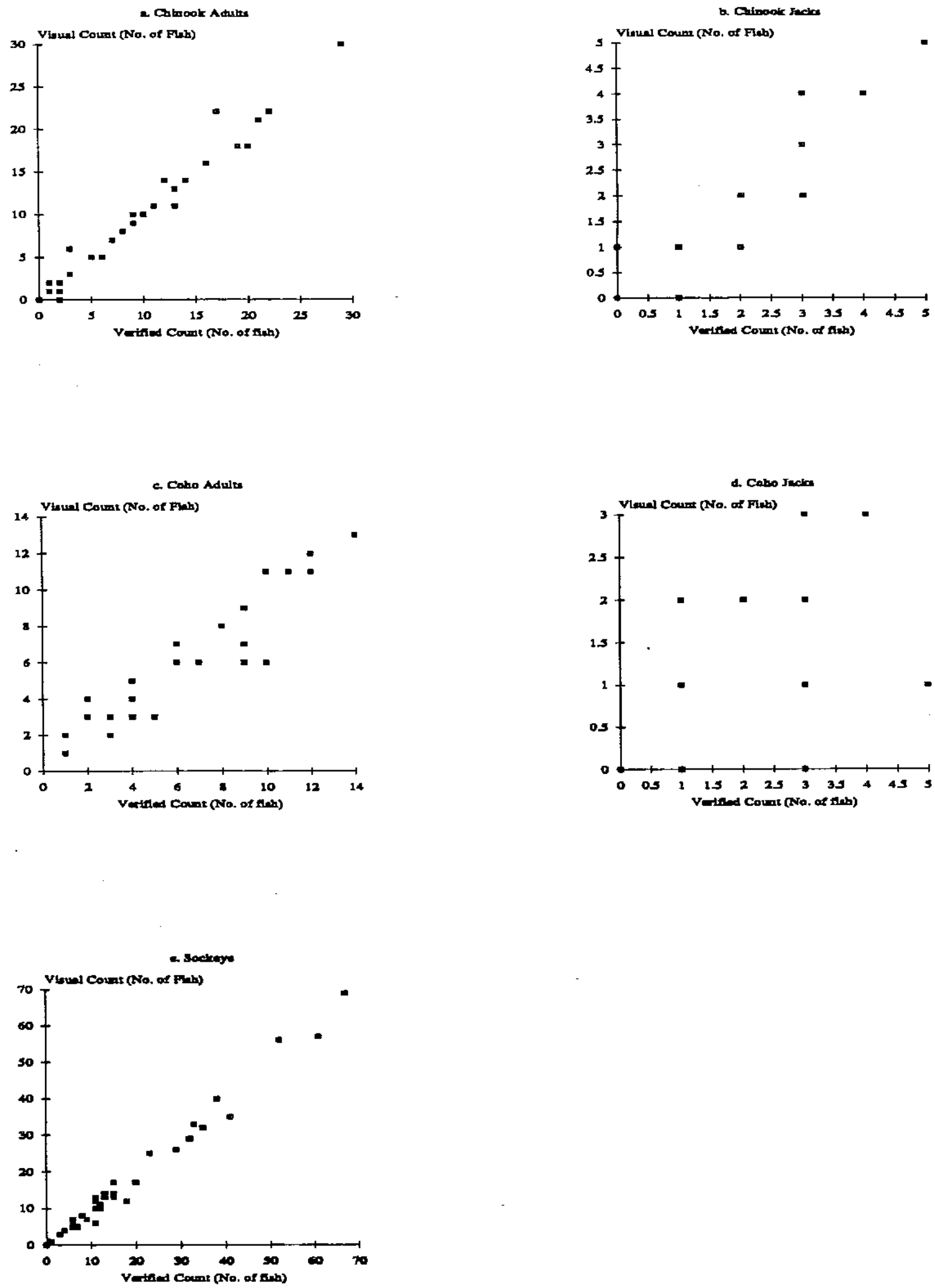


Figure 7. Scattergrams of visual counts versus verified counts from all verification tests conducted at Stamp Falls.

(Table 3) (ANOVA, $p > 0.05$). However, observer 3 tended to have more precise counts during the verification tests.

Incomplete Counts

During the counting program, there were periods when fish could pass through the fishway without being counted. The first of these periods was between 24 October and 1 November inclusive, when flood conditions caused water levels in the fishway to rise by nearly 2 m. The high water and turbidity reduced visibility to near zero. Flood conditions again caused the stoppage of counting on 9 November as water levels rose over 2 metres and breached the top of the fishway. Flood conditions persisted for over 1 week and counting was not resumed. Accordingly, the fishway counts for 1990 are only for the period of 11 September to 8 November. In addition, on one occasion, observers arrived at the fishway to find the gate open and fish moving through. Apparently, fish had prodded the door enough to open it just wide enough to allow passage. No correction was attempted to account for this.

Counts of chinook and coho passing through the fishway during the flood period of 24 October to 1 November were estimated using an adjustment factor derived by comparing fishway counts prior to 24 October and returns to Robertson Creek Hatchery during the same period. First the cumulative count of chinook adults (male and female) at the fishway was compared to the cumulative count of adult male chinook returning to the hatchery (Fig. 8a). Note that female chinook were not used in the hatchery count because of sampling biases at the hatchery. Next, the cumulative count at Stamp Falls was plotted against the cumulative count at Robertson Creek Hatchery (Fig. 8b). It was evident from this figure that the relationship of the cumulative fishway and hatchery counts for chinook adults over the entire migration period was not a simple linear relation. However, there were distinct periods during the migration period when the movement of chinook adults through the fishway appeared to parallel the movement of chinook adult males into the hatchery. For adult chinook these periods were September 29 - October 19, October 18 - October 23 and October 24 - November 5. The divisions between these periods are characterized by the steps in Figure 8b. Therefore, for the purposes of estimating the numbers of chinook adults moving through the fishway during the flood, we assumed that the pattern of movement of chinook adults between 14 October and 23 October continued during the flood. Accordingly, we used the linear regression equation of the cumulative fishway counts versus the cumulative hatchery returns for this latter period to estimate the fishway counts during this period (Fig. 8c).

This procedure for estimating the movement of chinook adults through the fishway during the flood between 24 October and 1 November was repeated for chinook jacks, coho adults, and coho jacks (Fig. 9,10,11). In all cases, significant relationships were found between the cumulative fishway counts and the cumulative hatchery returns between 14 October and 23 October. We also tested for significant relationships between the cumulative fishway counts, lagged by one to 5 days, and the cumulative hatchery returns. Lagging the fishway counts did not improve the relationship.

Since no secondary counts were available for sockeye during the flood period (the Great Central Lake counting system had been dismantled), the number of sockeye salmon moving up the fishway between 24 October and 1 November was estimated using linear interpolation. No

Table 3. Comparison of observer error from verification tests.

Observer	Number of tests	Chinook Adults		Chinook Jacks		Coho Adults		Coho Jacks		Sockeye	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	12	1.08	0.35	0.92	0.32	1.02	0.38	0.82	0.35	0.94	0.14
2	12	0.97	0.43	0.92	0.29	1.05	0.37	0.90	0.21	0.94	0.18
3	12	1.00	0.01	0.96	0.14	1.00	0.19	1.08	0.51	0.97	0.08

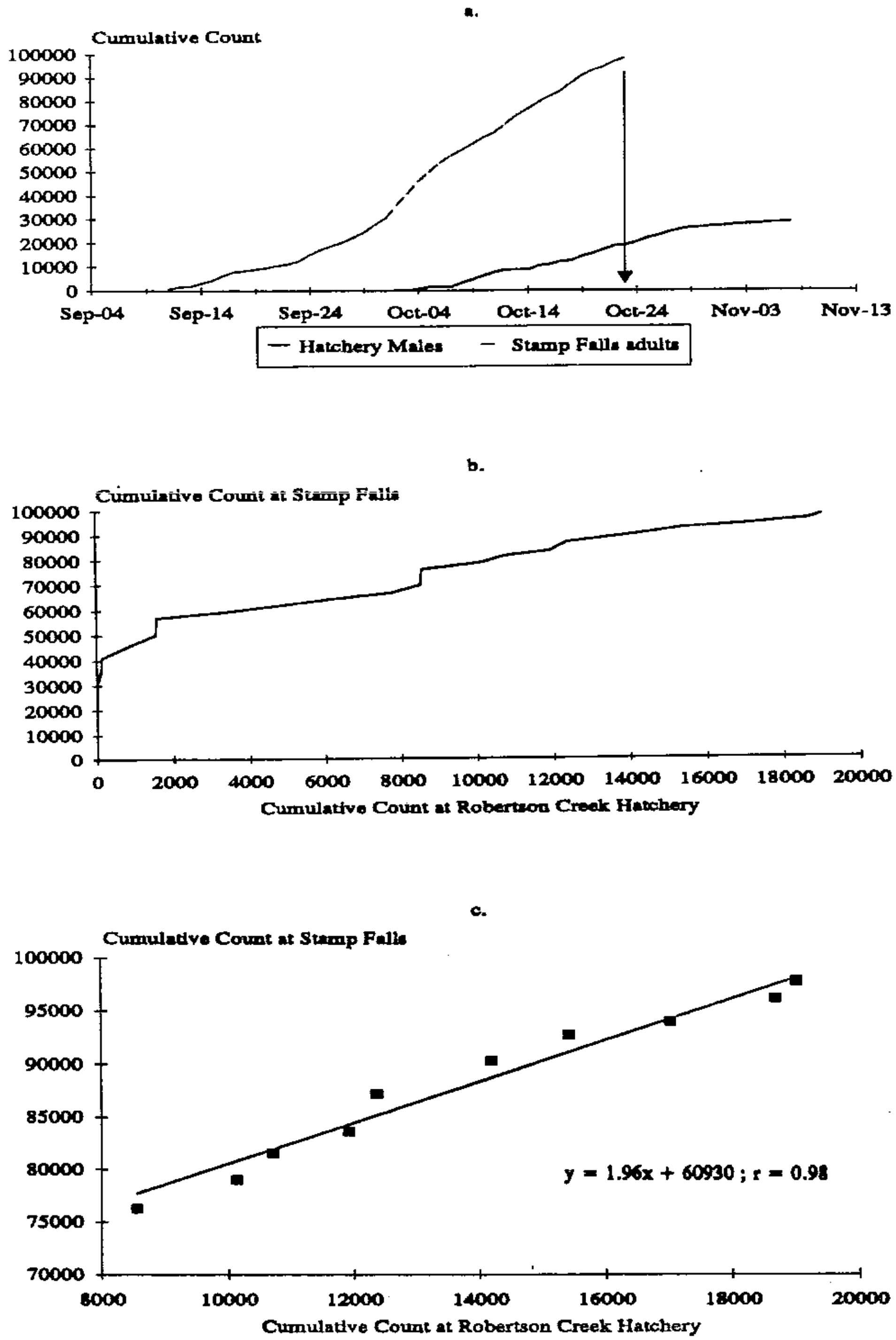


Figure 8. The relationship between counts of adult male chinook at Robertson Creek Hatchery and counts of all adults at Stamp Falls. Figure b is the relationship between the cumulative count of adult males at the hatchery and the cumulative count of adults at Stamp Falls from 11 September to 23 October, inclusive (n=43). Figure c is the same relationship plus the linear regression for 14 October to 23 October, inclusive (n=10).

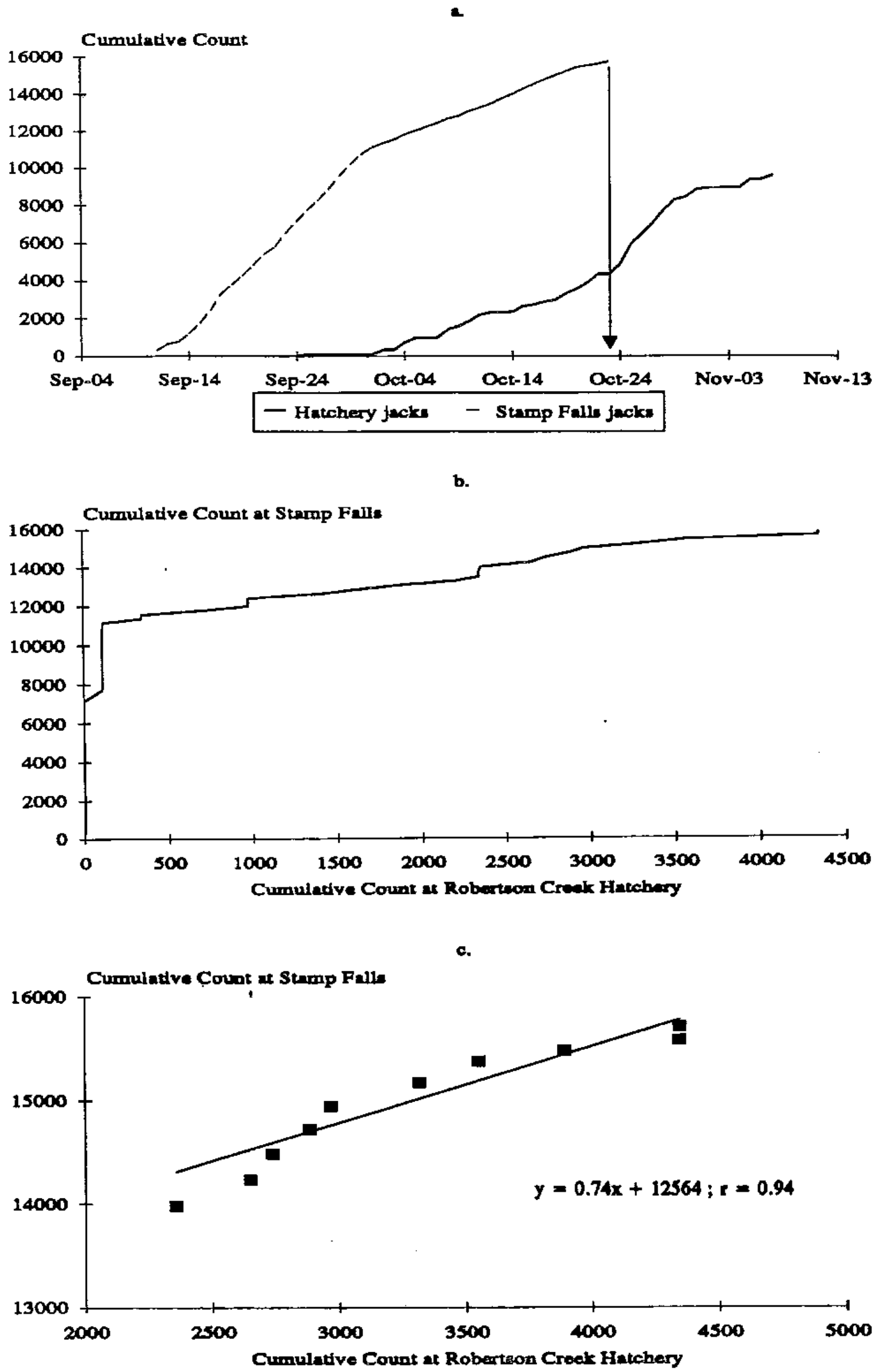


Figure 9. The relationship between counts of jack chinook at Robertson Creek Hatchery and counts of jacks at Stamp Falls. Figure b is the relationship between the cumulative count of jacks at the hatchery and the cumulative count of jacks at Stamp Falls from 11 September to 23 october, inclusive (n=43). Figure c is the same relationship plus the linear regression for 14 October to 23 October, inclusive (n=10).

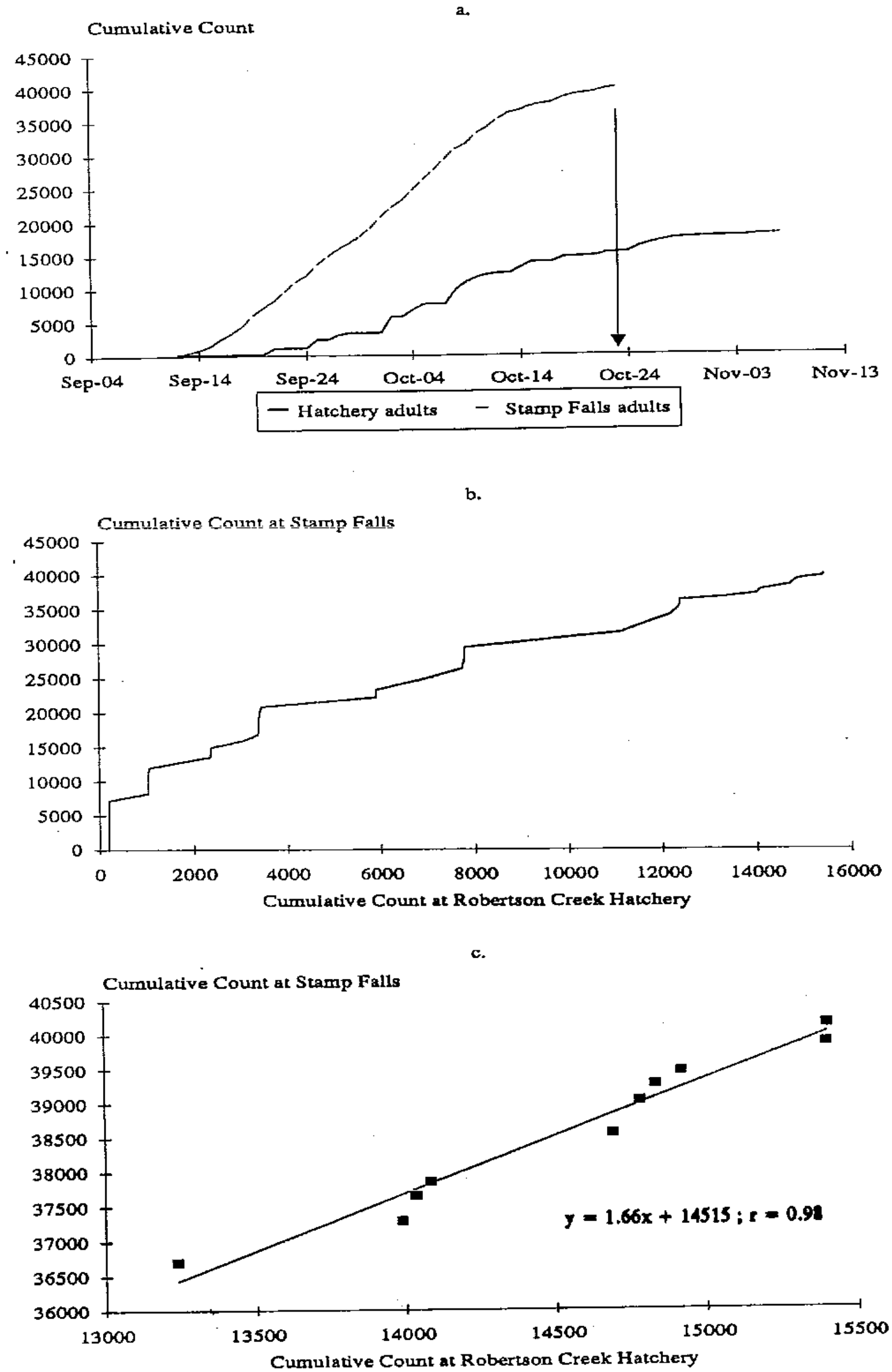


Figure 10. The relationship between counts of adult coho at Robertson Creek Hatchery and counts of adults at Stamp Falls. Figure b is the rleationship between the cumulative count of adult coho at the hathcery and the cumulative count of adults at Stamp Falls from 12 September to 23 October, inclusive (n=42). Figure c is the same relationship plus the linear regression for 14 October to 23 October, inclusive (n=10).

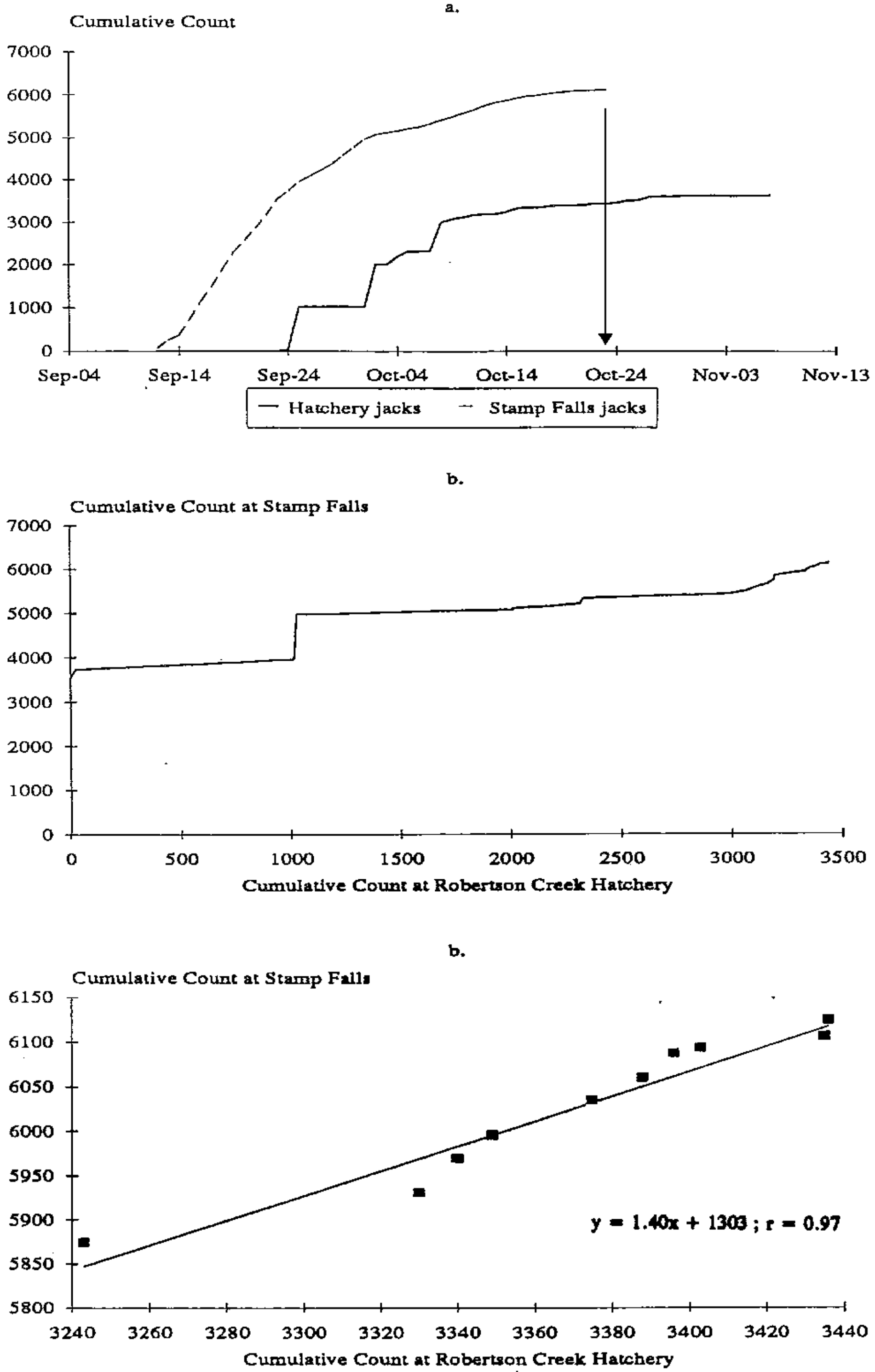


Figure 11. The relationship between counts of jack coho at Robertson Creek Hatchery and counts of jacks at Stamp Falls. Figure b is the relationship between the cumulative count of jack coho at the hatchery and the cumulative count of jacks at Stamp Falls from 12 September to 23 October, inclusive (n=42). Figure c is the same relationship plus the linear regression fro 14 October to 23 October, inclusive (n=10).

adjustments were made for pink, chum or steelhead movement during the flood. As well, no attempt was made to estimate the number of salmon migrating through the fishway after 8 November.

Variance estimates for the interpolated counts for each species were estimated using the variance estimates derived from verification tests conducted during the preceding sample period (week 6, Table 2).

Adjusted Counts and Population Estimates

The daily fishway counts for each species, adjusted for observer error and incomplete counts are shown in Table 4. The unadjusted hourly counts are provided in Appendix 1-1 to 1-5. The total estimated number of adult chinook passing through the fishway between 11 September and 8 November was 117107 ± 3401. The estimate of jack chinook was 18147 ± 723. Adult coho numbered 45440 ± 1891 while jack coho numbered 5332 ± 378. We estimated a total of 70941 ± 2497 sockeye passed through the fishway during the counting period.

Migration Timing

<u>Seasonal Migration</u>

Figure 12 shows the adjusted daily counts of chinook adults and jacks at the Stamp Falls Fishway along with temperature and water levels. The migration of chinook adults peaked at 5382 fish on 2 October with a second smaller peak estimated during the first flood on 25 October. The adjusted counts of chinook jacks peaked several times, on 18 September, 29 September, and 25 October. Aside from the high counts of fish estimated for 25 October, the migration of chinook seemed to be irrespective of water levels. Figure 12 also indicates that the counting period from 11 September to 9 November covered most of the migration of chinook with some of the front end of the migration missed. Over 500 adult chinook were counted on the first day of counting and as many as 2000 to 5000 chinook may have passed through the fishway prior to this date. By 8 November, counts of adult chinook were less than 100 per day and the run of chinook was all but over.

Coho adults followed a similar migration pattern as for adult chinook (Fig. 13) with peak numbers of 2000 occurring on 1 October. As for chinook jacks, the adjusted counts of jack coho peaked earlier than for adults on 16 September. The counting period of 11 September to 8 November appeared to have covered most of the adult coho run through the fishway but some of the early run (prior to 11 September) coho jacks were missed. Coho migration also appeared to be independent of water levels.

Counts of sockeye salmon at Stamp Falls had a very narrow distribution with a maximum daily count of 6633 on 7 October and extremely long tails to the run before and after the peak (Fig. 14). The reason for this distribution for sockeye migration during the counting period is probably related to water conditions in the river. Prior to 10 September, extreme low water in the Stamp and Somass rivers prevented sockeye from moving into the rivers from Alberni Inlet. Between 10 September and 15, water flows were increased and sockeye began moving through the fishway in

Table 4. Total daily counts of salmonids passing through Stamp Falls fishway, September 11 to November 8, 1990. These counts are adjusted for species verification (Table 2). Numbers in italics (Oct. 24 - Nov. 1) are estimated using the relationship between counts at Stamp Falls and counts at Robertson Creek Hatchery (Figs 3,4,5 and 6). Daily totals for sockeye from October 24 to November 1, inclusive, are from linear interpolation. SE is the standard error for the total count, derived from verification tests.

	Chinook		Coho						
Date	Adults	Jacks	Adults	Jacks	Sockeye	Pink	Chum	Steelhead	Unknown
Sep-11	635	250	120	86	2448	0	0	0	2
Sep-12	787	280	167	45	2669	0	0	1	10
Sep-13	173	98	220	133	1460	0	0	0	3
Sep-14	1018	374	278	83	1623	0	0	1	2
Sep-15	1046	460	455	259	1527	0	0	20	0
Sep-16	1574	561	809	293	1762	0	0	6	4
Sep-17	1213	721	691	256	1759	0	0	16	5
Sep-18	479	397	788	280	1512	0	0	2	1
Sep-19	548	416	1297	276	1020	0	0	8	0
Sep-20	501	453	809	195	1014	0	0	7	0
Sep-21	704	471	802	204	876	0	0	11	0
Sep-22	585	322	1082	216	651	0	0	19	0
Sep-23	1005	588	1165	280	614	0	0	19	1
Sep-24	3093	643	883	160	552	0	0	16	2
Sep-25	2410	593	1722	191	1481	0	0	15	0
Sep-26	1899	555	1423	114	1564	0	0	3	0
Sep-27	1806	598	1096	121	1640	0	0	2	0
Sep-28	2537	706	944	125	1308	0	0	7	0
Sep-29	2535	636	1024	171	826	0	0	13	0
Sep-30	3871	536	1456	169	720	0	0	9	0
Oct-01	2872	292	2015	216	986	0	0	7	0
Oct-02	5382	171	1689	109	548	0	0	9	0
Oct-03	4721	150	1353	44	937	0	0	4	0
Oct-04	4996	202	1822	47	2340	0	0	3	0
Oct-05	4025	159	1920	57	2904	0	0	3	0
Oct-06	3768	166	1763	46	5385	0	0	0	0
Oct-07	2809	159	2009	84	6633	0	0	3	0
Oct-08	2639	228	1690	86	5717	0	0	4	0
Oct-09	2434	170	845	68	5428	0	0	4	0
Oct-10	2734	248	1827	86	3277	0	0	8	0
Oct-11	2117	206	972	74	1632	0	1	7	2
Oct-12	3462	214	1389	95	1734	0	0	16	1
Oct-13	3525	258	1059	71	952	0	0	17	0
Oct-14	2725	247	377	46	708	0	0	5	1
Oct-15	2861	254	554	57	666	0	0	12	0
Oct-16	2619	254	342	39	491	0	0	10	0
Oct-17	2169	237	186	26	387	0	0	16	1
Oct-18	3624	224	658	39	520	0	0	8	0
Oct-19	3264	229	446	25	319	0	3	7	0
Oct-20	2487	207	227	28	270	0	2	10	0

Table 4. Total daily counts of salmonids passing through Stamp Falls fishway, September 11 to November 8,1990. These counts are adjusted for species verification (Table 2). Numbers in italics (Oct. 24 - Nov. 1) are estimated using the relationship between counts at Stamp Falls and counts at Robertson Creek Hatchery (Figs 3,4,5 and 6). Daily totals for sockeye from October 24 to November 1, inclusive, are from linear interpolation. SE is the standard error for the total count, derived from verification tests.

	Chinook		Coho						
Date	Adults	Jacks	Adults	Jacks	Sockeye	Pink	Chum	Steelhead	Unknown
Oct-21	1360	101	172	6	164	0	4	9	0
Oct-22	2293	103	368	13	169	0	6	14	0
Oct-23	1719	130	242	18	185	0	8	4	0
Oct-24	*2688*	*463*	*53*	*22*	*171*				
Oct-25	*3567*	*806*	*1202*	*78*	*157*				
Oct-26	*2029*	*398*	*617*	*15*	*142*				
Oct-27	*2701*	*433*	*557*	*101*	*128*				
Oct-28	*2295*	*514*	*464*	*17*	*114*				
Oct-29	*1423*	*393*	*293*	*7*	*100*				
Oct-30	*349*	*110*	*15*	*4*	*86*				
Oct-31	*955*	*287*	*94*	*1*	*71*			0	18
Nov-01	*233*	*67*	*128*	*17*	*57*			1	484
Nov-02	365	66	351	12	43	0	0	10	23
Nov-03	395	76	153	3	33	0	0	7	12
Nov-04	389	115	169	8	129	0	0	11	62
Nov-05	259	63	115	3	107	0	0	5	43
Nov-06	194	33	46	2	87	0	0	4	21
Nov-07	174	43	24	4	81	0	0	9	18
Nov-08	66	15	4	0	57	0	1	6	5
Total	**117107**	**18147**	**45440**	**5332**	**70941**	**0**	**25**	**408**	**721**
SE	1684	358	936	187	1236				
Upper 95% CL	120508	18870	47331	5710	73438				
Lower 95% CL	113705	17424	43549	4954	68444				

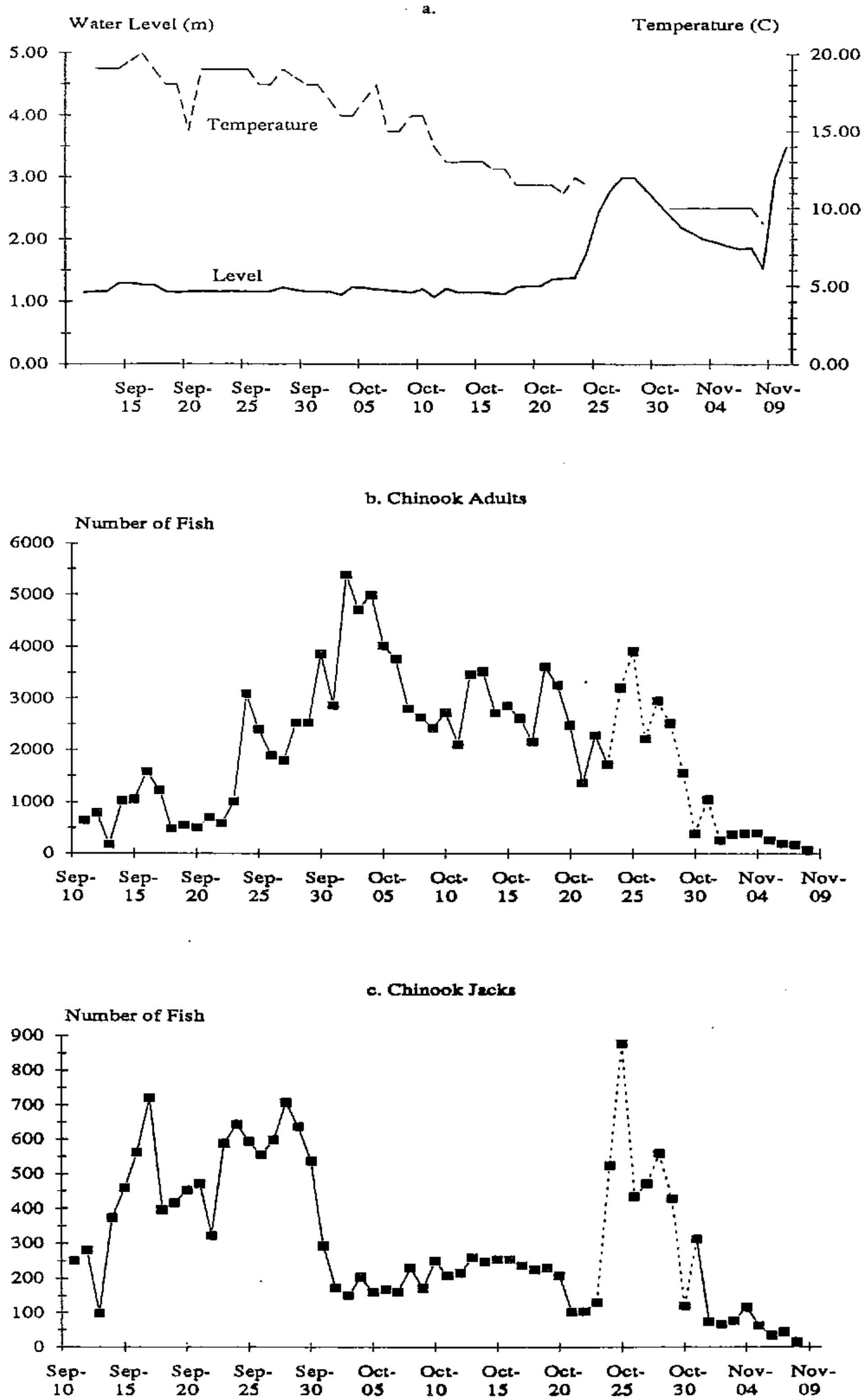


Figure 12. Daily water levels and temperatures at Stamp Falls (a). Adjusted daily counts of adult and jack chinook at Stamp Falls (b and c). Dashed portion of each curve indicates interpolated data based on relationship in Figures 3c and 4c.

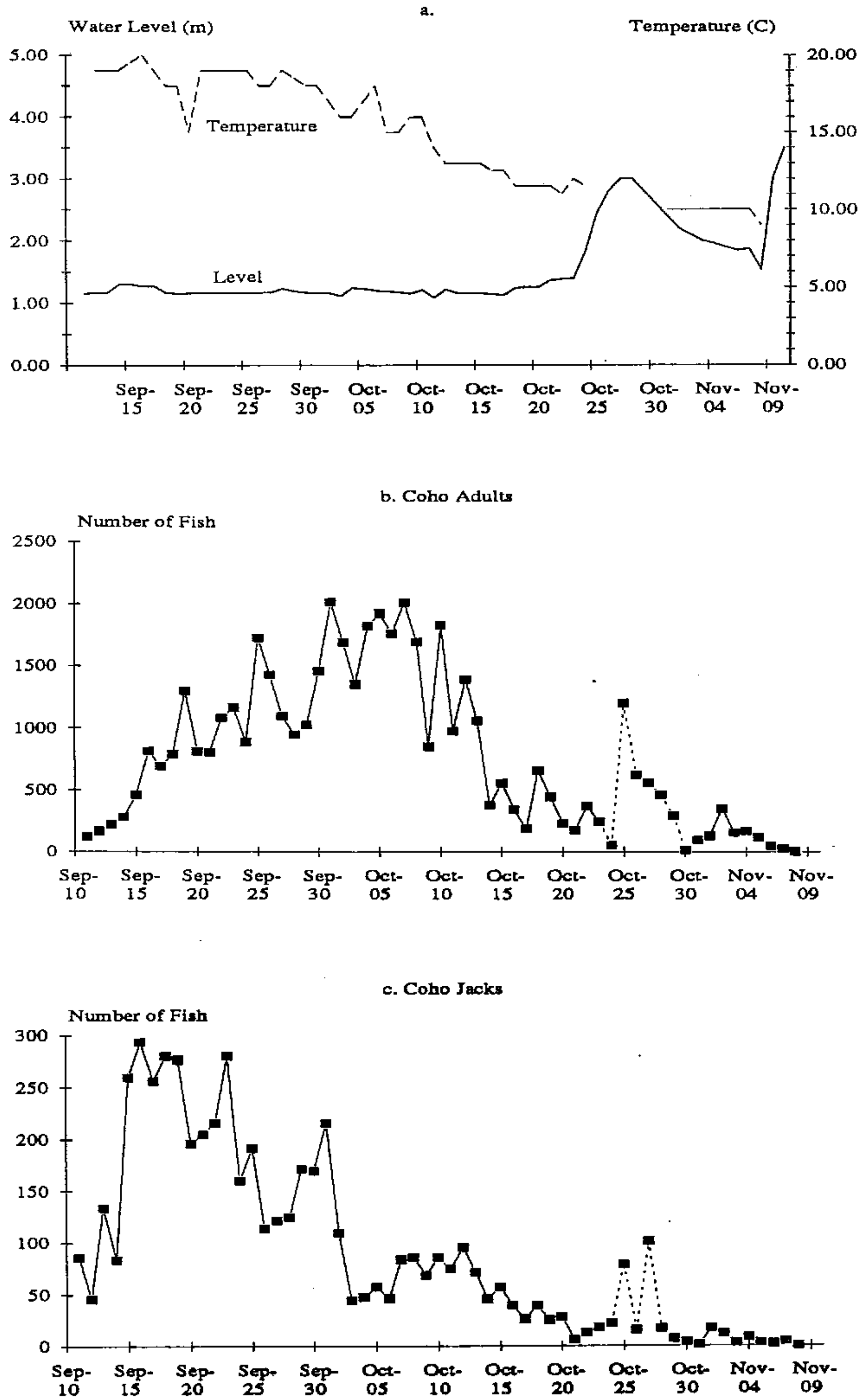
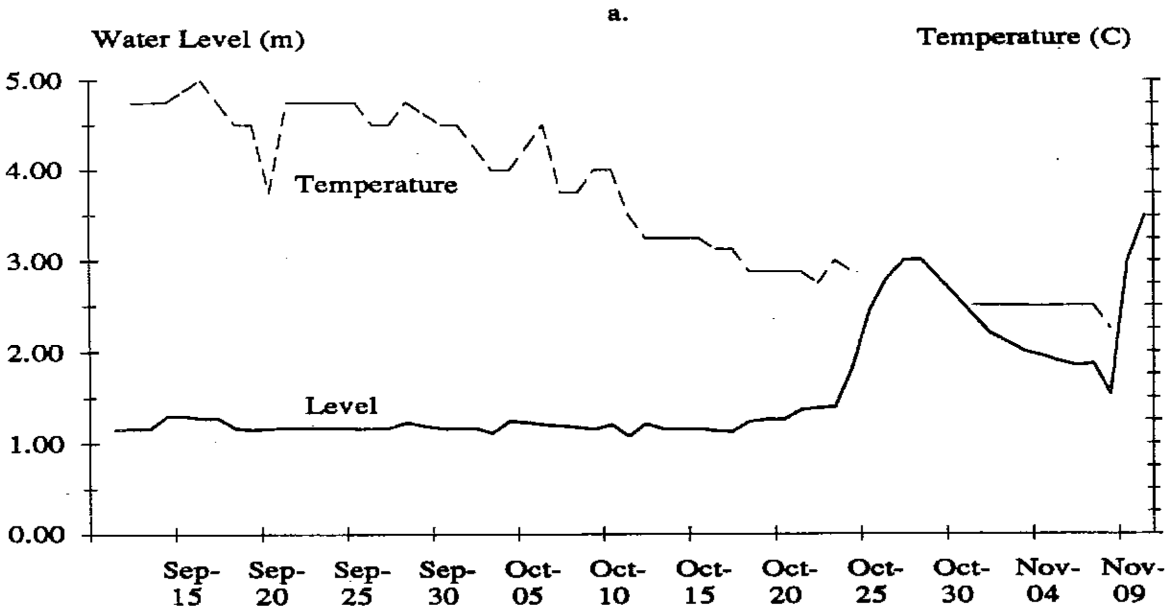


Figure 13. Daily water levels and temperatures at Stamp Falls (a). Adjusted daily counts of adult and jack coho at Stamp Falls (b and c). Dashed portion of each curve indicates interpolated data based on relationship in Figures 5c and 6c.



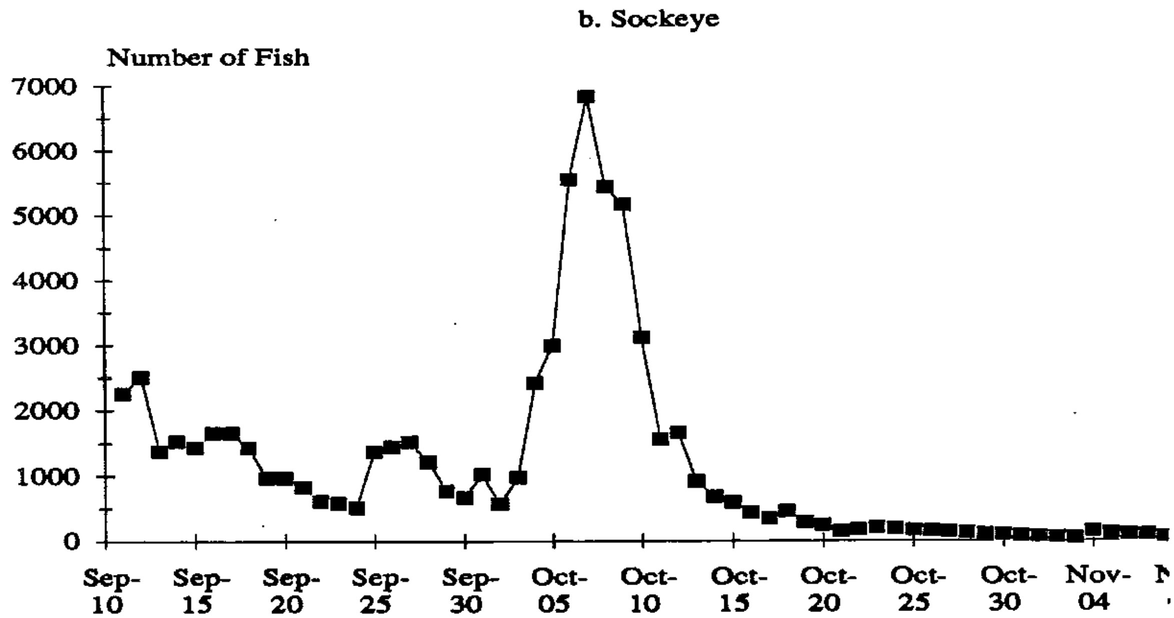


Figure 14. Daily water levels and temperatures at Stamp Falls (a). Adjusted daily counts of adult and jack sockeye at Stamp Falls (b).

large numbers (1000 - 2000 per day). It would appear that either the majority of the sockeye took approximately 4 weeks to respond to the increased flows and/or took 4 weeks to reach the fishway from Alberni Inlet. Thus the peak counts of sockeye on 7 October were likely a result of a delayed response to increased water levels in early September.

It should be noted that the counts of sockeye at Stamp Falls Fishway in no way represent the total escapement of sockeye to Great Central Lake since the majority of sockeye migrated prior to when counting began. However, counts at the fishway can be used as a check against sockeye counts at the outlet to Great Central Lake from 11 September to 9 November.

Diel Migration

To ensure complete counts of salmonids passing through the fishway, the gate to the counting facility was closed and fish migration was blocked from 1800 to 0800 hours. Hourly counts of each species were made during daylight hours. The mean hourly count of each species for four different counting periods were calculated and plotted in Figures 15, 16, and 17. Hourly counts during times when verification tests were conducted were excluded from the analysis.

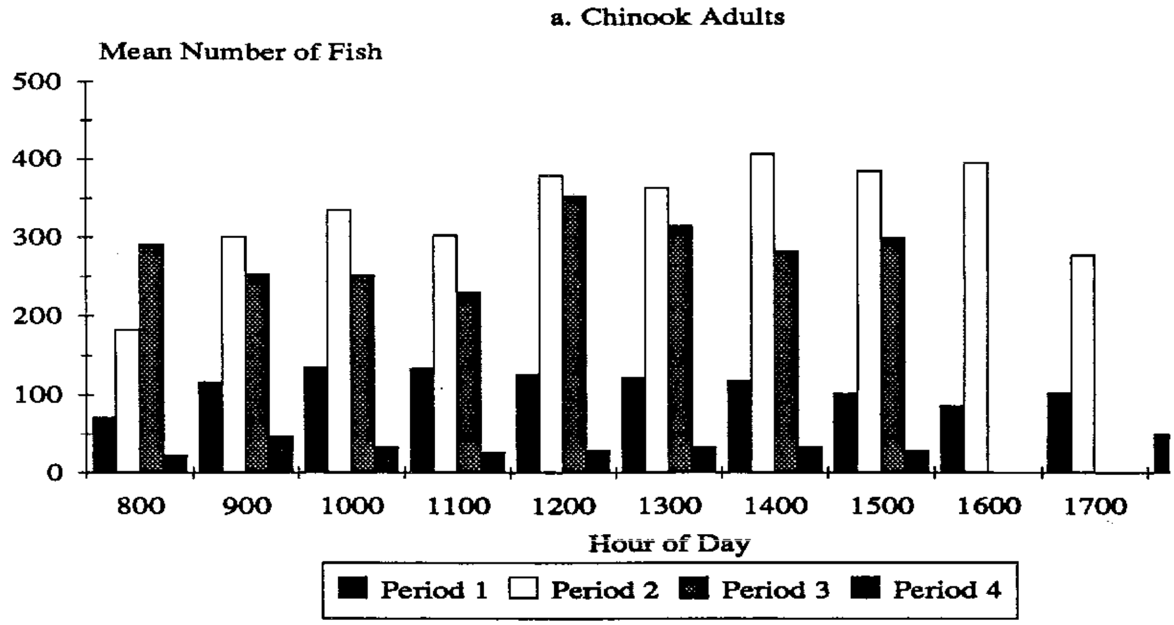
There was no obvious pattern of diel migration for any of the species examined. It would appear, however, that the movement of fish through the fishway tended to start out slowly for the first hour after the gate was opened in the morning and decrease again during the last hour of counting. The time of peak hourly migration varied substantially among timing periods and species but typically there was a peak movement mid-morning and mid-afternoon.

DISCUSSION

Salmonids migrating through the Stamp Falls Fishway were visually enumerated at the upstream end of the fishway. The objectives of the program were to: 1) obtain highly accurate counts of all species of fish passing through the fishway with an emphasis on the number of chinook adults and jacks; and 2) quantify the errors associated with counting, speciation, and the ability of observers to discriminate between jacks and adults. Using daily verification tests, we were able to successfully quantify observer error. We were also able to partially correct for incomplete counts by estimating the number of salmonids passing through the fishway during periods of flooding. No adjustments were made for missed early migrating fish. All these sources of error are discussed below. As well, we discuss our total fishway counts in the context of total escapement and indices of abundance.

Observer Error

There are a number of possible sources of error in the counts of salmonids passing through the Stamp Falls Fishway and the counting apparatus and counting techniques employed were designed to mitigate as many of these sources of error as possible. The primary sources of error include



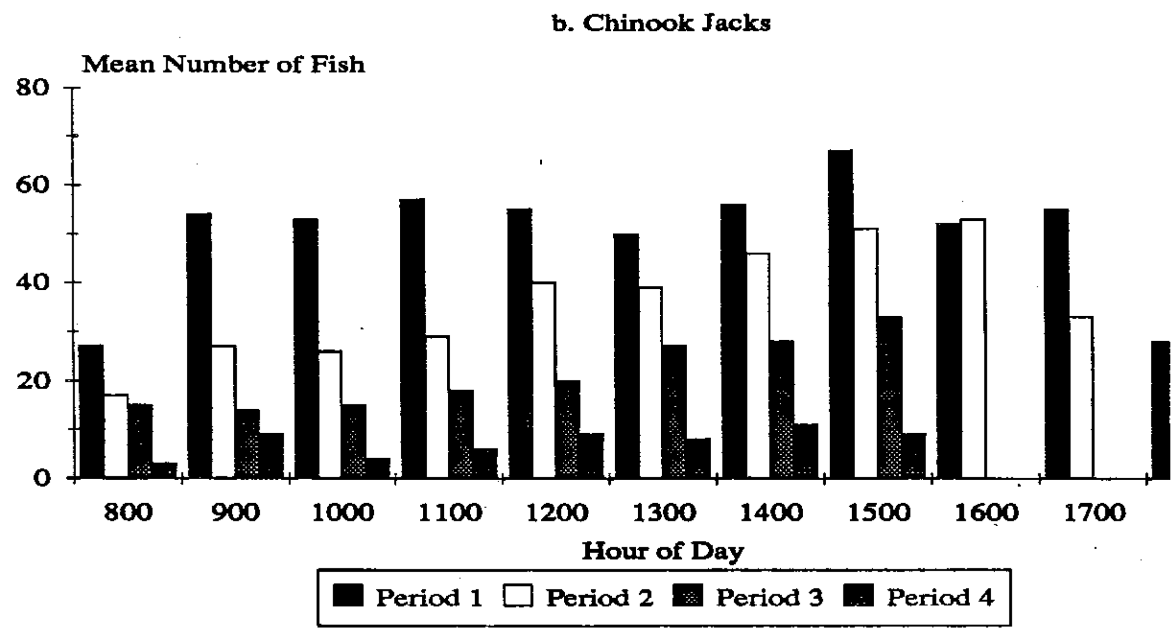


Figure 15. Hourly migration pattern for adult and jack chinook at Stamp Falls. Period 1 = 11 Sept to 24 Sept, Period 2 = 25 Sept to 18 Oct, Period 3 = 19 Oct to 23 Oct, and Period 4 = 2 Nov to 8 Nov.

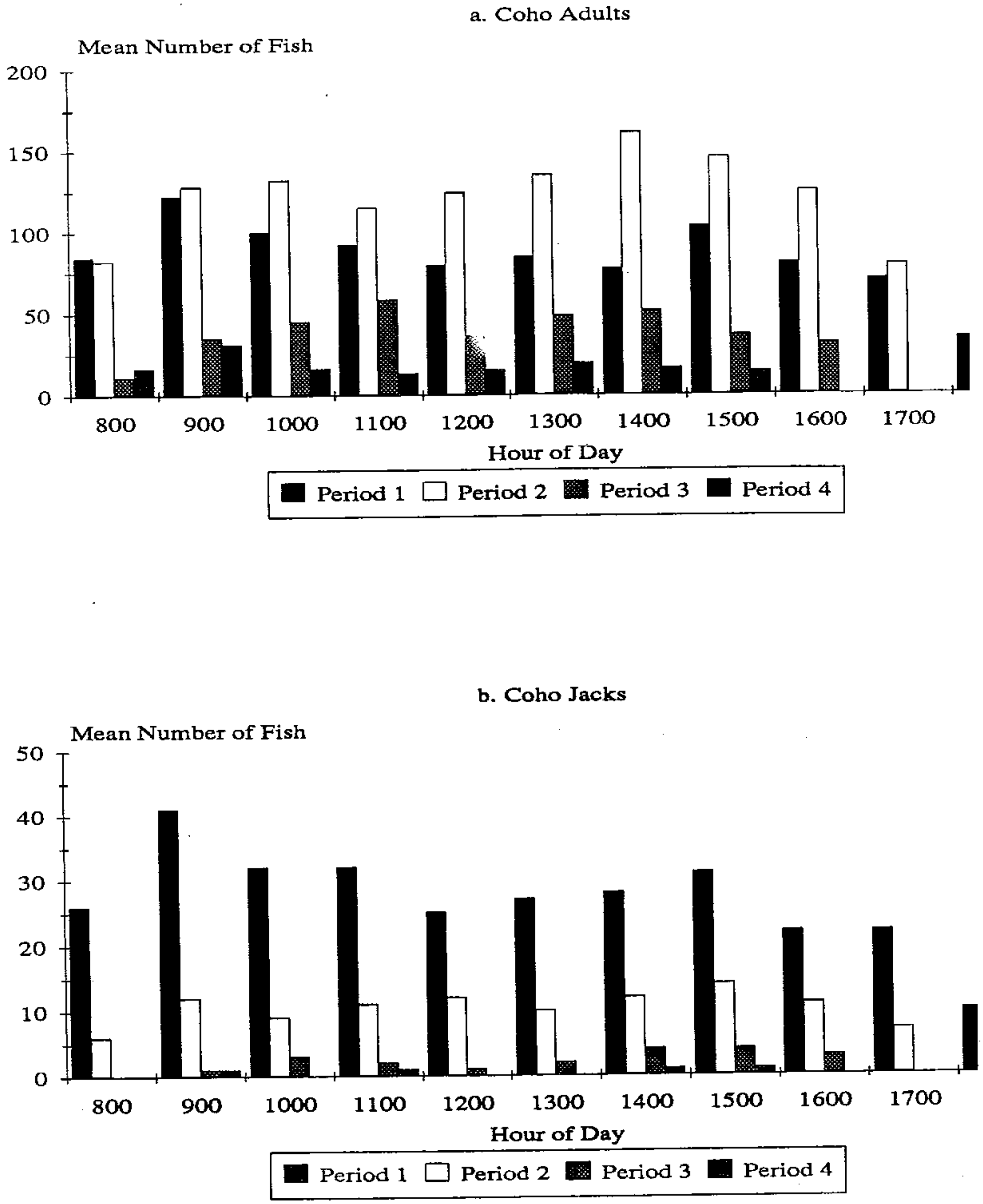


Figure 16. Hourly migration pattern for adult and jack coho salmon at Stamp Falls. Period 1 = 11 Sept to 24 Sept, Period 2 = 25 Sept to 18 Oct, Period 3 = 19 Oct to 23 Oct, and Period 4 = 2 Nov to 8 Nov.

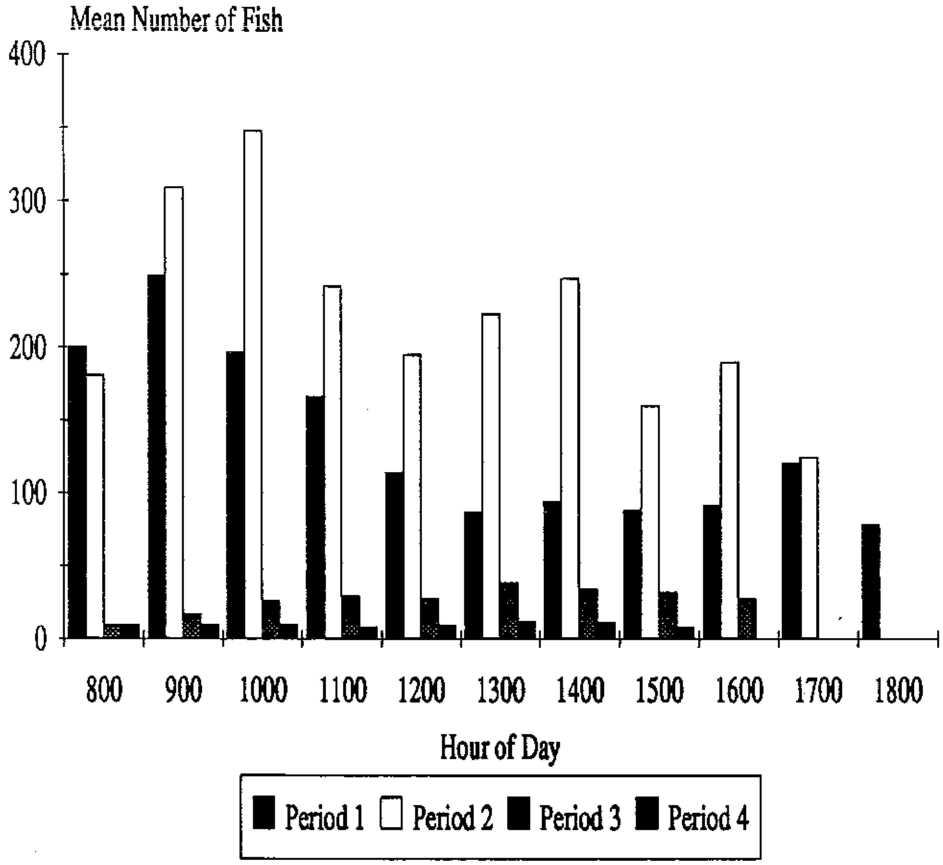


Figure 17. Hourly migration pattern for adult and jack sockeye at Stamp Falls. Period 1 = 11 Sept to 24 Sept, Period 2 = 25 Sept to 18 Oct, Period 3 = 19 Oct to 23 Oct, and Period 4 = 2 Nov to 8 Nov.

observer error (species identification and miscounts) and multiple passage of fish (layering of fish and fall-back within the fishway).

Multiple passage of fish was mitigated in the design of the counting apparatus. The opening in the panels was purposely kept small to prevent too many fish from passing over the flashboard at one time. Fall-back was minimized by setting the main fishway gates in a Vee formation to funnel the fish through the opening. This system worked well to minimize fall-back and once fish nosed through the panel opening, they moved quickly over the flashboard and out of the fishway.

Errors in species identification and enumeration (observer error), as determined from the verification tests at Stamp Falls, ranged between 71% and 123% of the true number depending on the sample period and fish species. Counts of chinook adults were the most precise and errors ranged from 83% to 119% over the migration period. However, after adjusting for counting error, the total counts for each species had 95% confidence intervals of between ± 3.5% for sockeye and ± 7.1% for coho jacks. The confidence intervals for the population estimate for chinook adults was ± 2.9%. These confidence intervals accurately reflect the observers ability to count each species of salmon. Sockeye were easily distinguished from the other species because of their distinct spawning colours and the presence of scarring on the body or fins. Coho jacks were more difficult to enumerate because small jacks (<30 cm) were still able to escape from the containment area during the verification tests, and during normal counting operations, even with vexar screening (2 cm) covering the aluminum panels. This difficulty was manifested in a highly variable efficiency of counting for jack coho and wider confidence intervals on the final population estimate. Chinook adults were easy to identify because of their large size and body shape. However, some of the adult coho returning to the Stamp River are also very large and were sometimes confused with small adult or jack chinook. Observers relied on differences between body colour (coho tend to be darker) and spotting on the posterior side of the fish (larger and wider spaced spots on chinook). Difficulties in distinguishing between large coho and small adult or jack chinook were particularly pronounced when fish swam quickly through the viewing area. Steelhead were easily identified from the other salmonids based on colour, the shape of the caudal peduncle, and fin ray coloration. We have no estimate, however, on the accuracy and precision of our counts for steelhead, pink, and chum salmon.

Incomplete Counts

During this study there were four possible causes of incomplete counts at the fishway. The first cause was flooding which prevented counting in the fishway but still allowed fish to move through the fishway. Flooding resulted in 2 periods of missed counting opportunities. The first was a 9 day period between 22 October and 1 November and the second was a 10 day period from 9 November to 19 November. We used two separate techniques to estimate counts of salmonids moving through the fishway during the first flood period. For sockeye, because we did not have independent counts from elsewhere in the river system, we used linear interpolation. It is difficult to say how well linear interpolation resulted in accurate estimates of the number of sockeye passing during the flood, but it likely underestimated the true number to some extent. We used the relationship between cumulative fishway counts and cumulative hatchery counts to estimate the number of chinook and coho moving through the fishway during the flood. Although there is still uncertainty with this technique, it probably more accurately reflects the movement of fish during the flood than linear interpolation. The results suggest that the majority of fish moving in the 9 day period between 24 October and 9 November did so during the first 5 days of the flood. Lagging the fishway counts to account for the time of migration from the fishway to the hatchery did not improve the relationship. We conclude that the reason for this is because fish returning to the hatchery gather in the lagoon just outside the hatchery for varying periods of time and movement of fish into the hatchery is driven primarily by the density of fish in the lagoon. This can best be described as a "treadmill" effect, whereby fish move into the hatchery in approximately the same proportion to fish moving into the lagoon from downstream areas.

The second source of incomplete counts is from migration through the fishway before and after operation of the counting facility. Our results suggest that a number of fish (of all species), including between 2000 and 5000 chinook may have passed through the fishway prior to 11 September. The results suggest that by 8 November, very few fish were moving through the fishway, although some probably did pass through when the second flood began on 9 November. We have no way of correcting for this source of error in our counts. However, we do recommend that the fishway be operated from 1 September to 15 November in 1991.

The third potential source for incomplete counts was the escape of small fish through the panel bars and this was minimized by using vexar screening (mesh size 5 cm). However, fish < 30 cm) could still pass through the vexar. This included coho jacks, and very small adult coho or sockeye. No attempt was made to correct for these missed fish.

Lastly, fish bypassing the fishway and successfully negotiating Stamp Falls is a fourth potential source of incomplete fishway counts. Throughout the counting period, fish of all species were observed attempting to jump the falls. Many succeeded in reaching back eddies or small pools in the mid sections of the falls. We were unable to confirm that any fish did or did not successfully negotiate the falls. Some attempts should be made in the future to quantify the number of fish bypassing the fishway. This can be done by tagging fish as they leave the fishway and comparing mark rates of fish at the hatchery with mark rates at the fishway. If there is no significant difference between mark to unmarked ratios then it can be concluded that the number of fish bypassing the fishway is insignificant.

Fishway Counts as Indices of Abundance

Accurate estimates of chinook and other salmonid escapement to the Somass River system is very difficult. Attempts at mark recapture in 1984 (Lightly et al. 1988) and 1985 (pers. comm. D. Lightly, consultant, Gabriola Island, B.C.) produced unreliable results. However, the fishway counts can be used as an index of abundance if a constant proportion of the target species migrates through the fishway each year. If some attempt is made to estimate the number of fish spawning below the fishway in the lower Stamp River, the Somass and the Sproat River, then the total escapement to the system can be approximated. It is our recommendation that attempts be made to estimate the number of chinook (and perhaps coho) that spawn below the Stamp Falls Fishway. Aerial surveys might provide a rough approximation but, if budgets allow, a more rigorous survey should be conducted each year (either carcass mark-recapture or instream surveys).

Migration Timing

The timing of migration of chinook salmon in 1990 was approximately 2 weeks earlier than for 1989 (Wright 1990) and for 1972 and 1973 (DFO, unpublished data) and similar to 1984 (Lightly et al. 1988). Peak numbers of chinook passing through the fishway occurred on 2 October. In both 1989 and 1990, the migration of chinook was mostly complete by mid November. The same was true for 1984. This degree of variability in run timing is not unusual and the timing of counting operations at Stamp Falls should consider this. We recommend that counting in 1991 begin on 1 September and continue until 15 November.

The analysis of diel migration at Stamp Falls Fishway illustrates that there is some variability in the diel migration of all species of salmonids. The reason for this variability is unknown.

PART II: AGE, SIZE AND SEX ANALYSIS AND CODED WIRE TAG RECOVERIES

INTRODUCTION

This section of the report deals with the population characteristics (age, length and sex) of Stamp River chinook and the hatchery contributions to the total escapement. I stratified the population into two main areas: those chinook spawning in the upper Stamp River between Stamp Falls and Robertson Creek Hatchery (the "in-river" population) and those chinook returning to Robertson Creek Hatchery. The reason for this level of stratification was to compare differences in age, length and sex attributes of these two components of the total escapement as well as different hatchery contributions. It was hypothesized that there would be significant differences in age structure, length and sex between the in-river population and the hatchery population. As well, I hypothesized that the percentage of hatchery origin fish would be significantly higher in the hatchery than in the river.

I also examined two approaches to estimating the hatchery contribution to the Stamp River. The first of these methods (Method A) has been used in other documents for chinook keystreams (Andrews et al. 1988, Bocking et al. 1990, Carolsfeld et al. 1991) and uses the recovery rate of adipose clipped chinook to expand tag code specific recoveries. The second method I used (Method B) was described by Kuhn et al. 1988 and uses the recovery of CWTs (not necessarily adipose clipped) in the escapement to estimate the hatchery contribution.

In this report "tagging" refers to the tagging of chinook juveniles with coded wire tags and marking with clipped adipose fins.

METHODS

Dead Recovery

Dead recovery in the Stamp River was conducted between 5 October and 31 October, 1990. The river was divided into 3 areas: upstream of the carcass weir (A), the carcass weir (B) and downstream of the carcass weir (C) (Fig. 18). The carcass weir was located at the upstream end of Stamp Lagoon, and consisted of a 150' x8' net strung across a 250' wide part of the river. The net, made of polyweb with 5" mesh, was suspended between two 3/8" cables running the full width of the river and anchored to trees on each shore. The bottom cable was held to the river bottom by rebar hooks driven into the gravel. The top cable was connected to a winch on each shore to facilitate a total release of the top end in situations such as high water.

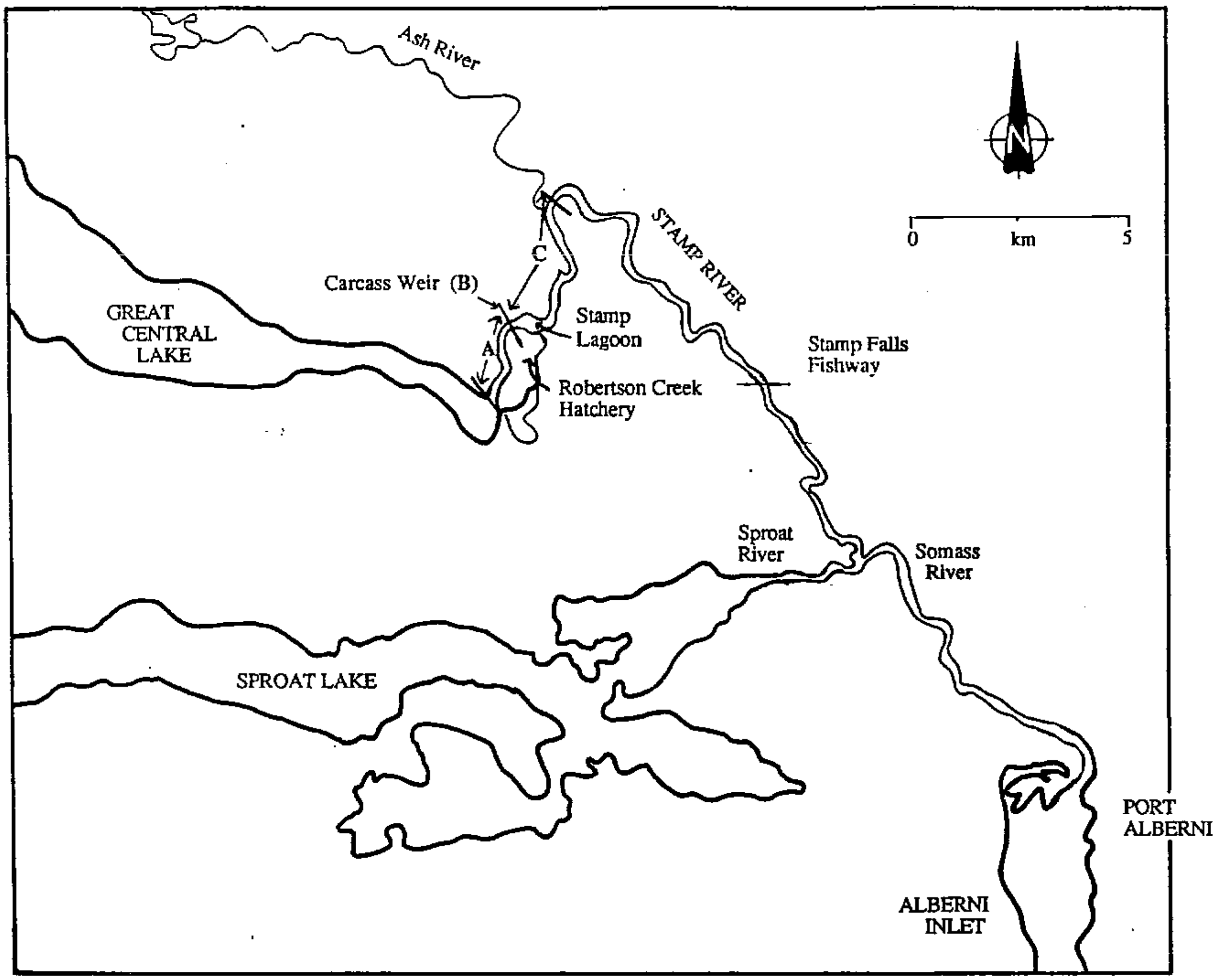


Figure 18. Map of Stamp River and Robertson Creek showing carcass recovery areas.

The reach between the Ash River confluence and Stamp Falls was not surveyed since the habitat there is unsuitable for spawning and few adults use that section. Dead fish were recovered by walking the stream bank and shallow water between Stamp Lagoon and the Ash River confluence, but primarily by gaffing from a boat.

Carcasses recovered were measured (postorbital-hypural length) and examined for sex and missing adipose fins. A portion of the recovered carcasses were also sampled for scales and all chinook with missing adipose fins had their heads removed for coded wire tag analysis. All carcasses were cut in half to prevent double counting.

Hatchery Returns

The staff at Robertson Creek enumerated all chinook returning between 12 September and 30 November, 1990. Daily records included the number of males, females and jacks, missing adipose fins, some scales sampling and length measurements. Heads from all adipose clipped chinook were removed and analysed for coded wire tags.

Population Estimates

The total population of chinook returning to the Robertson Creek Hatchery was determined from brailer counts and stratified by males, females and jacks. The in-river population of adult chinook (above Stamp Falls) was determined by subtracting the total number of adult returns to the hatchery from the fishway count (see Part I). This estimate for adult chinook was then apportioned between males and females using the ratio of males to females as determined from the in-river dead recovery sample. The in-river population of jacks was determined by subtracting the number of jack returns to the hatchery from the fishway count of jack chinook.

Age, Length and Sex Analyses

Biological sampling during dead recovery and at the hatchery included scales for age determination, length, sex, and presence of an adipose clip. Males were considered to be jacks when their length was less than 59 cm. Some adipose clipped fish (CWT) were also sampled for age and length. Five scales were taken from each side of the fish from the preferred area and were placed on gum cards.

Scales were read at the DFO scale lab in Vancouver. Ages were only read when a portion of the previous annulus was present and scales were not regenerated. Scales were classified as unreadable if the scales had regenerate centres, were resorbed, or if they were mounted upside down. Ages were recorded for fish for which there were at least two scales that could be read for both marine and freshwater ages. In this report, the first numeral of the age recorded indicates the year of total life and the decimal point and following numeral indicates the year of life in which the fish migrated to the ocean. The aging system follows that described by Gilbert and Rich (1972).

The age composition determined with the available samples is valid only if age sampling was random and there was no bias in the readability of scales with age. Ages of older fish are usually more difficult to read than those of young fish because scales of older fish undergo more resorption and regeneration. The data were examined for this potential bias by comparing mean lengths of known and unknown (scales unreadable or not sampled) aged males and females.

The age specific population estimates were then determined by allocating portions of the population estimate to age classes according to the age composition determined from scale samples. Sex ratios were determined for the in-river population and the hatchery.

Hatchery Contributions

Heads from adipose clipped chinook were removed and transported to the DFO tag recovery laboratory in North Vancouver for dissection and tag decoding.

The estimation of the contribution of hatchery reared chinook to the total escapement utilizes the adipose or coded wire tag mark rate in the escapement. We used two different approaches (Method A and Method B) to determine the contribution of hatchery released chinook, by tag code, to the escapement. In the first approach, we used the dead recovery samples to estimate the total number of adipose clipped fish in the escapement, stratified by river location (in-river versus hatchery) and sex. We call this Method A. It should be noted that CWT expansions by the Mark Recovery Program for commercial and sport fisheries use Method B and therefore CWT expansions for escapements using Method A are not directly comparable.

Method A

To determine the hatchery contribution using adipose clip mark rates we used the following 3 step process (Bocking et al. 1990, Andrews et al. 1988):

1. determine the appropriate samples and population strata to use for estimating the overall adipose clip rate (using either the mark rate at hatchery release or that found in the escapement or some combination of the two based on what is the most representative sample);

2. determine the proportion of the population examined to produce the observed number of adipose clips. This is then used to calculate the total number of adipose clips estimated to be in the escapement; and

3. allocate the total number of adipose clips estimated to be in the escapement among the tag codes in proportion to those successfully decoded.

Adipose clipped fish were enumerated separately for males and females in the Stamp River and at the Robertson Creek Hatchery. The recovery of jack chinook was included with the adult male recoveries in this analysis. The first step was to estimate the number of adipose clipped fish in each stratum (river versus hatchery) from the observed number of adipose clips:

$$EAD_{i,r}=\frac{OAD_{i,r}\cdot P_{i,r}}{C_{i,r}} \tag{4}$$

where *EAD* is the estimated number of adipose clips, *OAD* is the number of adipose clips observed, *C* is the number of fish examined, *P* is the population estimate, and *i* and *r* are subscripts denoting sex and river location (stratum). The sex specific population estimates used here were from the age-structure analysis.

Given an estimate of the total number of adipose clips for each sex escaping to each portion of the system, the number of adipose clips for each tag code can be estimated by the allocation of adipose clips to tag code groups based on their relative frequency in the sample of decoded tags:

$$EAD_{i,r,tc}=\frac{EAD_{i,r}\cdot NDT_{i,r,tc}}{SumNDT_{i,r}} \tag{5}$$

where *tc* is a subscript denoted tag code and *NDT* is the number of successfully decoded tags for each tag code, strata and sex.

This approach of first estimating adipose clipped fish and then allocating these among the successfully decoded CWTs assumes that any adipose clipped fish not decoded (i.e. no pins) were once marked but lost their coded wire tag for some reason. If this assumption is incorrect, the calculation of the number of hatchery origin fish using this method would be positively biased. It is possible, especially in the dead pitch, that some fish identified as hatchery releases by missing adipose fins may be fish that have naturally lost their adipose fins through some other means, e.g. carcass decomposition, or were mis-identified. If decomposition of adipose fins is occurring, then the adipose clip rate among hatchery fish recovered in the dead pitch should be higher than that observed at release.

Other potential sources of bias in the hatchery contribution estimate derived using Method A include: negative bias due to possible lower survival rates for marked fish, negative bias due to possible regeneration of adipose fins, and an unknown bias due to possible unequal tag loss among tag code or ages. The combined effect of all these potential sources of bias is not known but could result in a hatchery contribution estimate that is slightly less than the true value. This is because, with the exception of natural occurrences of missing adipose fins, all of the above mentioned factors will negatively bias the final estimate. The extent of this bias will, of course, depend on the relative effect of each factor.

The hatchery contribution to each year's escapement, stratified by river location and sex, was calculated by expanding the estimated number of adipose clips from each tag code group in proportion to the percentage of juvenile fish having an adipose clip at time of release:

$$EHC_{i,r,tc}=\frac{EAD_{i,r,tc}\cdot(RC_{tc}+RUC_{tc})}{RC_{tc}} \tag{6}$$

where *EHC* is the estimated hatchery contribution, *RC* is the number of chinook released with adipose fin clips associated with tag code *tc*, and *RUC* is the number of chinook released without adipose fin clips associated with tag code *tc*.

These estimates of hatchery contribution, stratified by brood year (t), river location (r), sex (i) and tag code (tc) are summed to give the hatchery contribution of all tag codes to the entire escapement (*EHC*):

$$EHC=\sum_{t=1}^{j}\sum_{r=1}^{k}\sum_{i=1}^{m}\sum_{tc=1}^{n} EHC_{t,r,i,tc} \tag{7}$$

where n is the number of tag codes for a given brood year t.

Due to the potentially different ages at maturity of males and females, it is important that allocation of adipose clipped fish to tag codes be carried out separately by sex whenever possible. In this study, the sex of all fish sampled for CWTs was recorded so that it was possible to estimate the total escapement of tag codes by sex (males included jacks). Final hatchery contribution estimates were made separately for fish of Robertson Creek origin and for hatchery stays from other rivers.

Method B

In the second approach used to estimate the hatchery contribution, we estimated the number of successfully decoded CWT chinook in the escapement, stratified by river and sex using the methods described for the Mark Recovery Program (Kuhn et al. 1988). The primary difference between this method and Method A is that Method B uses the number of actual CWTs present in the escapement from which to derive the hatchery contribution, whereas Method A uses the number of adipose clips present in the escapement.

Estimating the total number of CWT returns from each of the brood years, and for each tag code is also three step process:

1. determining the appropriate samples and population strata to use for estimating the overall CWT rate (using either the mark rate at hatchery release or that found in the escapement or some combination of the two based on what is the most representative sample);

2. determining the proportion of the population examined to produce the observed number of CWT returns. This is then used to calculate the total number of CWT returns estimated to be in the escapement; and

3. allocating the total number of CWT returns estimated to be in the escapement among the tag codes in proportion to those successfully decoded.

The first step using this approach is to adjust the observed number of CWT recoveries accounting for "no tag" recoveries:

$$ADJ_{i,r,tc} = OBS_{i,r,tc} \cdot [1 + \frac{LP}{K} + \frac{ND \cdot (K+LP)}{K \cdot (K+LP+NP)}] \tag{8}$$

where *ADJ* is the adjusted number of observed CWT fish, *OBS* is the observed number of CWT fish, *K* is the sum of all successfully decoded tags for all tag codes recovered, *LP* is the number of lost pin recoveries, *ND* is the number of no data recoveries, *NP* is the number of no pin recoveries, and *i, r,* and *tc* are subscripts denoting, sex, river location, and tag code.

This adjusted number of CWT recoveries is then used to estimate the total number of CWT returns for each tag code:

$$EST_{i,r,tc} = \frac{ADJ_{i,r,tc} \cdot P_{i,r}}{C_{i,r}} \tag{9}$$

where *EST* is the estimated number of CWT recoveries for a single tag code, *C* is the number of fish examined, *P* is the population estimate, and *i, r,* and *tc* are subscripts denoting sex, river, and tag code.

This approach of estimating the number of CWT chinook in the escapement assumes that any adipose clipped chinook found without CWTs were never marked. This assumption is only valid if chinook tagged with a particular tag code did not lose the CWT after release from the hatchery (i.e. after accounting for tag loss during a retention test). Since it has been demonstrated that CWT fish lose 90% of their tags within 4 weeks of tagging (Blankenship 1990), any fish that have been released within this 4 week period are likely to continue to have some tag loss prior to being recovered in the fishery or escapement. Violation of the assumption of no tag loss will result in a negative bias in the hatchery contribution estimates.

Other potential sources of bias in the hatchery contribute estimates derived using Method B include: negative bias due to possible lower survival rate for marked fish and negative bias due to regeneration of adipose fins. Since all of the factors have the potential to cause negative bias in the final contribution estimate, Method B will always produce a lower estimate than Method A. This point is discussed later in the context of the results from this study.

The hatchery contribution to each year's escapement, stratified by river location and sex, was calculated by expanding the estimated number of CWT fish from each tag code group in proportion to the percentage of juvenile fish having a CWT at time of release:

$$EHC_{i,r,tc} = \frac{EAD_{i,r,tc} \cdot (RM_{tc} + RUM_{tc})}{RM_{tc}} \tag{10}$$

where *EHC* is the estimated hatchery contribution, *RM* is the number of chinook released with CWTs in brood year *t*, and *RUM* is the number of chinook released without CWTs in brood year *t*.

As for Method A, these estimates of hatchery contribution by tag code were then summed to give the hatchery contribution of all tag codes to the entire escapement, stratified by river, sex and brood year:

$$EHC=\sum_{t=1}^{j}\sum_{r=1}^{k}\sum_{i=1}^{m}\sum_{tc=1}^{n} EHC_{t,r,i,tc} \tag{11}$$

where *n* is the number of tag codes for a given brood year *t*.

Percent hatchery contributions by sex and age were then calculated using the population estimates derived from the age structure analysis. Final hatchery contribution estimates were made separately for fish of Robertson Creek origin and for hatchery strays from other rivers.

RESULTS

Age, Length and Sex Composition

All of the fish sampled in the Stamp River and Robertson Creek were ocean-reared; i.e. they left the river to rear in the ocean during their first year of life and are termed sub-ones in this report (Table 5). Total ages of Stamp River chinook ranged from 2 to 6 years. The dominant age-group in the in-river population (Stamp River dead recovery) was age 4 years (both sexes). In the Robertson Creek Hatchery, the dominant male age group was 3 year olds. Females throughout the system were predominantly age 4.

Summaries of mean lengths by age are presented in Table 5. In this table, the total mean length (all ages) is weighted according to the number of fish sampled. Stamp River males (mean postorbital-hypural length = 67.0 cm) were larger than Robertson Creek Hatchery male returns (mean postorbital-hypural length = 59.9 cm). This is because 3-year-old chinook constituted a larger proportion of the male population in the hatchery (62.8%) than in the river (34.2%). When stratified by age, the mean length of Stamp River makes was the same as for hatchery males. The mean length of females was the same for in-river fish and hatchery returns (length = 74.0 cm). The age length relations for the in-river population and the hatchery are shown graphically in Figure 19. There was no significant difference (t-test, $p > 0.2$) between the mean length of chinook that were not aged and the weighted (all ages) mean length of aged chinook (Table 5).

The population estimates, stratified by river location, sex and age class, are shown in Table 6. The sex ratio of adult males to females in the hatchery, as determined from brailer counts was 13.0 % females, 64.3% adult males and 22.8% jack males (Table 7). However, the age structure analysis

Table 5. Age-length (postorbital-hypural) distribution of chinook salmon carcasses recovered in the Stamp River and chinook salmon live returns to Robertson Creek Hatchery, 1990.

River	Length class (cm)	Age													
		Males (a)							Females						
		2.1	3.1	4.1	5.1	6.1	Total	Unk(b)	2.1	3.1	4.1	5.1	6.1	Total	Unk
Stamp River dead recovery															
	25-29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30-34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	35-39	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	40-44	4	0	0	0	0	0	1	0	0	0	0	0	0	0
	45-49	1	1	0	0	0	0	2	0	0	0	0	0	0	0
	50-54	1	7	1	0	0	0	0	0	0	0	0	0	0	0
	55-59	0	19	2	0	0	0	1	0	0	2	0	0	0	0
	60-64	0	46	5	1	0	0	2	0	2	1	0	0	0	0
	65-69	0	22	22	0	0	0	4	0	9	10	1	0	0	0
	70-74	0	2	71	0	0	0	3	0	3	85	1	0	0	4
	75-79	0	2	60	3	0	0	6	0	0	92	17	0	0	6
	80-84	0	1	13	5	0	0	0	0	0	17	29	0	0	10
	85-89	0	0	3	0	0	0	0	0	0	3	11	0	0	1
	90-94	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	95-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	100-104	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	42.0	60.0	72.0	76.0	0.0	67.0 (c)	64.0	0.0	65.0	73.0	79.0	0.0	4.0 (c	77.0
	SD	3.0	5.0	5.0	7.0	0.0	5.0	11.0	0.0	3.0	4.0	4.0	0.0	4.0	5.0
	Total	6	100	177	9	0	292	19	0	14	210	60	0	284	21
	Percent	2.1	34.2	60.6	3.1	0.0	100		0.0	4.9	73.9	21.1	0.0	100	
Robertson Creek Hatchery (d)															
	25-29	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	30-34	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	35-39	3	0	0	0	0	3	0	0	0	0	0	0	0	0
	40-44	13	0	1	0	0	14	0	0	0	0	0	0	0	0
	45-49	15	0	0	0	0	15	0	0	0	0	0	0	0	0
	50-54	1	5	0	0	0	6	0	0	0	1	0	0	1	0
	55-59	0	38	1	0	0	39	0	0	3	0	0	0	3	0
	60-64	0	84	5	0	0	89	7	0	11	1	0	0	12	2
	65-69	0	21	14	0	0	35	1	0	19	7	0	0	26	2
	70-74	0	6	21	0	0	27	2	0	1	82	0	0	83	5
	75-79	0	0	12	1	0	13	0	0	2	116	14	0	132	6
	80-84	0	1	3	1	0	5	0	0	1	29	32	0	62	6
	85-89	0	0	1	0	0	1	0	0	0	4	12	1	17	0
	90-94	0	0	0	0	0	0	0	0	0	1	3	0	4	0
	95-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	100-104	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mean	42.3	59.9	69.1	76.0	0.0	59.9 (c)	63.0	0.0	64.0	73.9	80.0	86.0	3.9 (c	73.0
	SD	3.0	4.0	6.6	4.0	0.0	4.6	5.0	0.0	4.3	3.9	4.1	0.0	3.6	6.0
	N	32	155	58	2	0	247	10	0	37	241	61	1	340	21
	Percent	13.0	62.8	23.5	0.8	0.0	100.0		0.0	10.9	70.9	17.9	0.3	100.0	

(a) Includes jacks
(b) Unk = age unknown (scale unreadable)
(c) Weighted mean and standard deviation
(d) Weighted averages of marked and unmarked chinook

Table 6. Escapement estimates, by age, of chinook salmon escapement to upper Stamp River (above Stamp Falls, excluding hatchery) and Robertson Creek Hatchery, 1990.

		Males (a)		Females	
River	Age	Number	Percent	Number	Percent
Stamp River					
	2.1	1063	2.1	0	0.0
	3.1	17312	34.2	2040	5.0
	4.1	30675	60.6	30146	73.9
	5.1	1569	3.1	8607	21.1
	6.1	0	0.0	0	0.0
	Total (b)	50619	100.0	40793	100.0
Robertson Creek Hatchery					
	2.1	4961	13.0	0	0.0
	3.1	23928	62.7	619	10.9
	4.1	8968	23.5	4026	70.9
	5.1	305	0.8	1017	17.9
	6.1	0	0.0	17	0.3
	Total (c)	38163	100.0	5679	100.0

(a) Includes jacks

(b) Adult fishway count minus adult hatchery returns, apportioned by sex ratios derived from dead recovery. Note: the total number of males includes 51% of the adult in river population plus 100% of the jack population.

(c) total hatchery returns

Table 7. Sex composition of chinook recovered in the river and at the Robertson Creek Hatchery, 1990.

Location	Type of sampling	Females		Males		Jacks		Total	
		Number	%	Number	%	Number	%	Number	%
Hatchery	Braile	5679	13.0	28176	64.3	9987	22.8	43842	100.0
Hatchery	Age-comp	5679	13.0	33202	75.7	4961	11.3	43842	100.0
Upper Stamp	Fishway	40793	44.6	42459	46.4	8160	8.9	91412	100.0
Upper Stamp	Age-comp	40793	44.6	49556	54.2	1063	1.2	91412	100.0

produced a ratio of 13.0:75.7:11.3 (F:M:J) suggesting that as many as 5000 adult males were misclassified as jacks during the hatchery counting of returns. The sex ratio for the upper Stamp in-river population of chinook as determined from fishway counts minus the hatchery returns was 44.6:46.4:8.9. As for the hatchery returns, the age structure sex ratios of 44.6:54.2:1.2 suggest that as many as 12000 adult males were misidentified as jacks at the fishway counting operation (18471 - 5150 - 1063). Table 7 lists the final, sex-specific, population estimates using the observed counts and all age composition data.

Hatchery Contributions

The results of coded wire tag returns are presented below for the upper Stamp River and Robertson Creek Hatchery. Information includes the following:

1. the raw data and mark rates for the calculations;

2. estimates of the total escapement of adipose clips (Method A) and/or CWTs (Method B);

3. the observed and estimated escapement of adipose clips (Method A) or CWTs (Method B) by tag code, and the hatchery contribution to the escapement for each tag code; and

4. the estimated hatchery contribution to the escapement by age class.

In the upper Stamp River there were 252 adipose clipped chinooks recovered in the dead pitch (Appendix 1-2: mark rate = 4.0%) and 1791 at the Robertson Creek Hatchery (Appendix 1-2: mark rate = 4.1%). Table 8 shows the total estimated number of adipose clips in the in-river population and the hatchery returns. These mark rates represent the number of adipose clipped chinook as a percentage of the total number of chinook in each population (wild + hatchery stock). Using just the number of hatchery fish (as estimated from the hatchery contribution estimates using Method A) the hatchery stock mark rates were 5.1% for the in-river population and 4.6% for the hatchery populations. These adipose clip mark rates at return were close to the total adipose clip mark rate at release for all tag codes recovered in the escapement (4.7%). Only Stamp River males had a higher mark rate.

Hatchery Contributions - Method A

Results from the decoding of adipose clipped fish from the upper Stamp River dead pitch and returns to Robertson Creek Hatchery are shown in Table 9. Any CWT fish recovered in the Stamp River which were released from another river were included in the analysis (1 from Capilano River and 1 from Chilcotin River). These strays amounted to less than 1% of the total return. A total of 214 CWT heads from adipose clipped fish recovered in the dead recovery were successfully decoded. A total of 1533 CWT heads recovered at the hatchery were successfully decoded. Age 2 males (jacks) were included with all other adult males for this analysis.

The allocations of the total escapement of adipose clips to tag codes recovered in each portion of the river (in-river versus hatchery) are shown in Tables 9 and 11. Table 10 lists the number of

Table 8. Estimates of the total escapement of adipose clipped fish to the upper Stamp River (above falls) and to the Robertson Creek Hatchery, 1990. The escapement estimates to the upper Stamp River are calculated as the fishway counts minus the returns to the hatchery.

River and sex	Sample size (a) A	Observed adipose clips (b) B	Mark rate (%) C=(B/A)x10	Escapement estimate (c) D	Percentage of population sampled E=(A/D)x100	Total estimated adipose clips F=(B/A)xD
Upper Stamp River						
Male (d)	3382	141	4.2	50619	6.7	2110
Female	2926	110	3.8	40793	7.2	1534
Total	6308	251	4.0	91412	6.9	3644
Robertson Creek Hatchery						
Male (d)	38163	1574	4.1	38163	100.0	1574
Female	5679	217	3.8	5679	100.0	217
Total	43842	1791	4.1	43842	100.0	1791

(a) From Appendix 2-1 for upper Stamp River and Appendix 2-2 for Robertson Creek Hatchery.

(b) From Appendix 2-1 for upper Stamp River and Appendix 2-2 for Robertson Creek Hatchery.

(c) Estimates are stratified among sexes according to hatchery braile and fishway counts (Table 7).

(d) Note that the sample size and number of adipose clips observed is 1 fish less than reported in the Appendices due to the misidentification of 1 male coho. Includes jacks.

Table 9. Estimates of total escapement of adipose clipped chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 11 (Method A).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Decoded adipose clips		Estimated adipose clips		Decoded adipose clips		Estimated adipose clips	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
1988	25014	0	0	0.0	0.0	33	0	37.6	0.0
	25630	0	0	0.0	0.0	6	0	6.8	0.0
	25640	0	0	0.0	0.0	6	0	6.8	0.0
	25643	0	0	0.0	0.0	4	0	4.6	0.0
	25645	0	0	0.0	0.0	7	0	8.0	0.0
	25646	0	0	0.0	0.0	4	0	4.6	0.0
	25648	0	0	0.0	0.0	3	0	3.4	0.0
	25651	0	0	0.0	0.0	6	0	6.8	0.0
	25653	0	0	0.0	0.0	4	0	4.6	0.0
	25654	0	0	0.0	0.0	7	0	8.0	0.0
	25657	0	0	0.0	0.0	9	0	10.2	0.0
	25658	0	0	0.0	0.0	6	0	6.8	0.0
	25660	0	0	0.0	0.0	6	0	6.8	0.0
	25663	0	0	0.0	0.0	8	0	9.1	0.0
	25701	0	0	0.0	0.0	3	0	3.4	0.0
	25702	0	0	0.0	0.0	2	0	2.3	0.0
	25703	0	0	0.0	0.0	2	0	2.3	0.0
	25704	0	0	0.0	0.0	6	0	6.8	0.0
	25705	0	0	0.0	0.0	3	0	3.4	0.0
	25836	0	0	0.0	0.0	36	0	41.0	0.0
	25837	0	0	0.0	0.0	37	0	42.1	0.0
	25838	0	0	0.0	0.0	22	0	25.0	0.0
	25839	0	0	0.0	0.0	17	0	19.3	0.0
	26055	0	0	0.0	0.0	6	0	6.8	0.0
	26056	0	0	0.0	0.0	21	0	23.9	0.0
	26057	1	0	17.7	0.0	33	0	37.6	0.0
	Total	1	0	17.7	0.0	297	0	338.0	0.0
1987	24311	3	0	53.2	0.0	32	1	36.4	1.4
	24802	0	0	0.0	0.0	39	0	44.4	0.0
	24803	0	0	0.0	0.0	51	1	58.0	1.4
	24804	1	0	17.7	0.0	37	0	42.1	0.0
	24805	4	0	70.9	0.0	25	2	28.5	2.9
	24806	2	0	35.5	0.0	36	2	41.0	2.9
	24809	2	0	35.5	0.0	52	1	59.2	1.4
	24810	1	1	17.7	15.8	39	1	44.4	1.4
	24937	5	0	88.7	0.0	12	1	13.7	1.4
	24948	2	1	35.5	15.8	11	2	12.5	2.9

Table 9. Estimates of total escapement of adipose clipped chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 11 (Method A).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Decoded adipose clips		Estimated adipose clips		Decoded adipose clips		Estimated adipose clips	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
	24949	0	1	0.0	15.8	20	0	22.8	0.0
	24950	2	0	35.5	0.0	21	1	23.9	1.4
	24951	3	0	53.2	0.0	33	0	37.6	0.0
	24952	6	0	106.4	0.0	34	0	38.7	0.0
	24958	2	0	35.5	0.0	39	2	44.4	2.9
	24959	1	0	17.7	0.0	48	2	54.6	2.9
	24960	3	0	53.2	0.0	50	1	56.9	1.4
	24961	1	0	17.7	0.0	40	1	45.5	1.4
	25326	1	0	17.7	0.0	58	1	66.0	1.4
	25327	1	0	17.7	0.0	64	5	72.8	7.2
	25328	1	0	17.7	0.0	61	4	69.4	5.8
	25329	4	0	70.9	0.0	50	2	56.9	2.9
	Subtotal	45	3	797.9	47.4	852	30	969.7	43.4
1986	24256	5	4	88.7	63.3	17	6	19.3	8.7
	24257	4	7	70.9	110.7	21	11	23.9	15.9
	24361	7	5	124.1	79.1	25	5	28.5	7.2
	24362	6	13	106.4	205.6	15	12	17.1	17.4
	24363	2	1	35.5	15.8	23	5	26.2	7.2
	24401	4	8	70.9	126.5	20	10	22.8	14.5
	24514	11	10	195.0	158.1	7	2	8.0	2.9
	24515	7	3	124.1	47.4	13	7	14.8	10.1
	24516	3	8	53.2	126.5	9	5	10.2	7.2
	24517	0	0	0.0	0.0	13	3	14.8	4.3
	24518	3	4	53.2	63.3	11	8	12.5	11.6
	24519	2	4	35.5	63.3	7	6	8.0	8.7
	24520	2	2	35.5	31.6	7	4	8.0	5.8
	24644	0	5	0.0	79.1	6	2	6.8	2.9
	24645	3	2	53.2	31.6	10	2	11.4	2.9
	24646	3	0	53.2	0.0	6	5	6.8	7.2
	24647	4	0	70.9	0.0	6	0	6.8	0.0
	24648	5	3	88.7	47.4	12	2	13.7	2.9
	Subtotal	71	79	1258.9	1249.3	228	95	259.5	137.4
1985	23734	0	4	0.0	63.3	1	3	1.1	4.3
	23735	0	1	0.0	15.8	0	3	0.0	4.3
	23736	0	0	0.0	0.0	1	4	1.1	5.8
	23737	0	5	0.0	79.1	1	7	1.1	10.1

Table 9. Estimates of total escapement of adipose clipped chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated adipose clips for calculating the expanded hatchery contribution in Table 11 (Method A).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Decoded adipose clips		Estimated adipose clips		Decoded adipose clips		Estimated adipose clips	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
	23738	0	3	0.0	47.4	1	1	1.1	1.4
	23739	0	1	0.0	15.8	1	1	1.1	1.4
	23740	0	1	0.0	15.8	1	0	1.1	0.0
	23741	0	0	0.0	0.0	0	5	0.0	7.2
	Subtotal	0	15	0	237.2	6	24	6.8	34.7
1984	23206	0	0	0.0	0.0	0	1	0.0	1.4
	Subtotal	0	0	0.0	0.0	0	1	0	1.4
Total hatchery		117	97	2074.5	1534.0	1383	150	1574.0	217.0
Strays: (c)									
	24749	1	0	17.7	0.0	0	0	0.0	0.0
	24559	1	0	17.7	0.0	0	0	0.0	0.0
Total strays		2	0	35.5	0.0	0	0	0.0	0.0
Total CWT		119	97	2110	1534	1383	150	1574	217
No head taken		4	4			92	36		
No data (5000)		1	1			6	0		
No pin (8000)		14	8			90	30		
Lost pin (9000)		3	0			3	1		
Observed adipose		262	207			1574	217		

(a) abbreviations are M = male, F= female

(b) includes jacks

(c) Adipose clipped fish that have strayed to Stamp River from other enhancement facilities

Table 10. CWT and adipose clip release data for hatchery reared chinook salmon returning to the Somass River system a Robertson Creek Hatchery, by tag code, 1990.

Brood year	CWT release group	Release Numbers CWT	Untagged	CWT loss (%)	Days held	Adipose release status Clipped	Unclipped
1988	25014	25393	627708	0.1	3	25418	627683
	25630	10385	9	0.1	3	10394	0
	25640	9780	9	0.1	3	9789	0
	25643	9704	8	0.1	3	9712	0
	25645	9645	8	0.1	3	9653	0
	25646	9723	8	0.1	3	9731	0
	25648	9805	9	0.1	3	9814	0
	25651	9783	9	0.1	3	9792	0
	25653	9805	9	0.1	3	9814	0
	25654	10091	9	0.1	3	10100	0
	25657	9875	9	0.1	3	9884	0
	25658	9882	9	0.1	3	9891	0
	25660	10258	9	0.1	3	10267	0
	25663	9902	9	0.1	3	9911	0
	25701	9893	9	0.1	3	9902	0
	25702	9878	9	0.1	3	9887	0
	25703	9864	9	0.1	3	9873	0
	25704	9730	8	0.1	3	9738	0
	25705	9888	9	0.1	3	9897	0
	25836	25389	1489437	0.1	3	25414	1489412
	25837	25026	1075504	0.1	3	25051	1075479
	25838	24734	1414607	0.1	3	24759	1414582
	25839	25298	936521	0.1	3	25323	936496
	26055	25330	676910	0.1	3	25355	676885
	26056	25079	1765174	0.1	3	25104	1765149
	26057	24939	901048	0.1	3	24964	901023
1987	24311	31137	322939	0.0	3	31137	322939
	24802	29450	305443	0.0	3	29450	305443
	24803	31791	0	0.0	3	31791	0
	24804	28912	0	0.0	3	28912	0
	24805	29111	0	0.0	3	29111	0
	24806	32201	0	0.0	3	32201	0
	24809	29554	306662	0.5	3	29703	306513
	24810	29060	301535	0.5	3	29206	301389
	24937	27033	413	1.5	3	27445	1
	24948	24137	369	1.5	3	24505	1
	24949	24691	0	0.0	3	24691	0
	24950	26264	0	0.0	3	26264	0
	24951	27071	530793	0.0	3	27071	530793
	24952	24270	475872	0.0	3	24270	475872
	24958	25913	898585	0.1	3	25939	898559
	24959	26354	904241	0.0	3	26354	904241
	24960	24425	838738	0.0	3	24425	838738

Table 10. CWT and adipose clip release data for hatchery reared chinook salmon returning to the Somass River system a Robertson Creek Hatchery, by tag code, 1990.

Brood year	CWT release group	Release Numbers CWT	Release Numbers Untagged	CWT loss (%)	Days held	Adipose release status Clipped	Adipose release status Unclipped
	24961	25921	890976	0.0	3	25921	890976
	25326	26695	497358	0.7	3	26883	497170
	25327	23657	412459	0.5	3	23776	412340
	25328	25640	484187	0.7	3	25821	484006
	25329	25951	496221	0.8	3	26160	496012
1986	24256	24175	1186784	4.2	3	25235	1185724
	24257	22396	112833	5.0	3	23575	111654
	24361	23973	1243529	0.8	3	24166	1243336
	24362	26805	1388942	1.0	3	27076	1388671
	24363	24283	1351824	0.7	3	24454	1351653
	24401	25922	1444366	0.7	3	26105	1444183
	24514	20615	164	0.8	3	20779	0
	24515	19981	160	0.8	3	20141	0
	24516	19089	153	0.8	3	19242	0
	24517	19187	0	0.0	3	19187	0
	24518	20878	0	0.0	3	20878	0
	24519	20065	0	0.0	3	20065	0
	24520	18814	96	0.5	3	18909	1
	24644	19990	102	0.5	3	20090	2
	24645	20790	107	0.5	3	20894	3
	24646	21154	242	1.1	3	21389	7
	24647	16952	194	1.1	3	17141	5
	24648	20840	238	1.1	3	21072	6
1985	23734	25263	975803	0.5	3	25390	975676
	23735	26746	989535	0.0	3	26746	989535
	23736	26320	662585	0	3	26320	662585
	23737	25915	659653	0	3	25915	659653
	23738	25274	1136087	0.5	3	25401	1135960
	23739	26998	1211439	0.5	3	27134	1211303
	23740	26215	1186721	0.5	3	26347	1186589
	23741	25976	1173343	0.5	3	26107	1173212
1984	23206	21625	950185	2.7	3	22225	949585
	Total hatchery	1594558	32228943			1602454	32221047
Strays:							
1986	24559	25148	179449	6.7	6	26954	177643
1987	24749	25187	137516	0.0	1	25187	137516

Table 11. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and estimated Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of adipose clipped chinook in the escapement (from Table 9) to account for unclipped hatchery releases and hence to derive hatchery contributions to escapement. Expansion factor = (adipose clipped + unclipped releases) / adipose clipped releases.

Brood	CWT release	Release Numbers (c)		Expansion	Expanded hatchery contribution (a)			
					Upper Stamp River		Robertson Creek Hatcher	
year	group	Clipped	Unclipped	Factor	M(b)	F	M (b)	F
1988	25014	25418	627683	25.69	0	0	965	0
	25630	10394	0	1.00	0	0	7	0
	25640	9789	0	1.00	0	0	7	0
	25643	9712	0	1.00	0	0	5	0
	25645	9653	0	1.00	0	0	8	0
	25646	9731	0	1.00	0	0	5	0
	25648	9814	0	1.00	0	0	3	0
	25651	9792	0	1.00	0	0	7	0
	25653	9814	0	1.00	0	0	5	0
	25654	10100	0	1.00	0	0	8	0
	25657	9884	0	1.00	0	0	10	0
	25658	9891	0	1.00	0	0	7	0
	25660	10267	0	1.00	0	0	7	0
	25663	9911	0	1.00	0	0	9	0
	25701	9902	0	1.00	0	0	3	0
	25702	9887	0	1.00	0	0	2	0
	25703	9873	0	1.00	0	0	2	0
	25704	9738	0	1.00	0	0	7	0
	25705	9897	0	1.00	0	0	3	0
	25836	25414	1489412	59.60	0	0	2442	0
	25837	25051	1075479	43.93	0	0	1850	0
	25838	24759	1414582	58.13	0	0	1456	0
	25839	25323	936496	37.98	0	0	735	0
	26055	25355	676885	27.70	0	0	189	0
	26056	25104	1765149	71.31	0	0	1704	0
	26057	24964	901023	37.09	658	0	1393	0
	Subtotal				658	0	10839	0
1987	24311	31137	322939	11.37	605	0	414	16
	24802	29450	305443	11.37	0	0	505	0
	24803	31791	0	1.00	0	0	58	1
	24804	28912	0	1.00	18	0	42	0
	24805	29111	0	1.00	71	0	28	3
	24806	32201	0	1.00	35	0	41	3
	24809	29703	306513	11.32	401	0	670	16
	24810	29206	301389	11.32	201	179	502	16
	24937	27445	1	1.00	89	0	14	1

Table 11. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and estimated Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of adipose clipped chinook in the escapement (from Table 9) to account for unclipped hatchery releases and hence to derive hatchery contributions to escapement. Expansion factor = (adipose clipped + unclipped releases) / adipose clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion Factor	Expanded hatchery contribution (a)			
					Upper Stamp River		Robertson Creek Hatcher	
		Clipped	Unclipped		M(b)	F	M (b)	F
	24948	24505	1	1.00	35	16	13	3
	24949	24691	0	1.00	0	16	23	0
	24950	26264	0	1.00	35	0	24	1
	24951	27071	530793	20.61	1096	0	774	0
	24952	24270	475872	20.61	2192	0	797	0
	24958	25939	898559	35.64	1264	0	1582	103
	24959	26354	904241	35.31	626	0	1929	102
	24960	24425	838738	35.34	1880	0	2011	51
	24961	25921	890976	35.37	627	0	1610	51
	25326	26883	497170	19.49	346	0	1287	28
	25327	23776	412340	18.34	325	0	1336	133
	25328	25821	484006	19.74	350	0	1371	114
	25329	26160	496012	19.96	1416	0	1136	58
	Subtotal				11613	211	16167	703
1986	24256	25235	1185724	47.99	4254	3036	928	417
	24257	23575	111654	5.74	407	635	137	91
	24361	24166	1243336	52.45	6510	4147	1492	379
	24362	27076	1388671	52.29	5563	10750	893	908
	24363	24454	1351653	56.27	1996	890	1473	407
	24401	26105	1444183	56.32	3995	7126	1282	815
	24514	20779	0	1.00	195	158	8	3
	24515	20141	0	1.00	124	47	15	10
	24516	19242	0	1.00	53	127	10	7
	24517	19187	0	1.00	0	0	15	4
	24518	20878	0	1.00	53	63	13	12
	24519	20065	0	1.00	35	63	8	9
	24520	18909	1	1.00	35	32	8	6
	24644	20090	2	1.00	0	79	7	3
	24645	20894	3	1.00	53	32	11	3
	24646	21389	7	1.00	53	0	7	7
	24647	17141	5	1.00	71	0	7	0
	24648	21072	6	1.00	89	47	14	3
	Subtotal				23487	27232	6327	3083
1985	23734	25390	975676	39.43	0	2494	45	171
	23735	26746	989535	38.00	0	601	0	165

Table 11. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and estimated Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of adipose clipped chinook in the escapement (from Table 9) to account for unclipped hatchery releases and hence to derive hatchery contributions to escapement. Expansion factor = (adipose clipped + unclipped releases) / adipose clipped releases.

Brood year	CWT release group	Release Numbers (c)		Expansion Factor	Expanded hatchery contribution (a)			
					Upper Stamp River		Robertson Creek Hatcher	
		Clipped	Unclipped		M(b)	F	M (b)	F
	23736	26320	662585	26.17	0	0	30	151
	23737	25915	659653	26.45	0	2092	30	268
	23738	25401	1135960	45.72	0	2169	52	66
	23739	27134	1211303	45.64	0	722	52	66
	23740	26347	1186589	46.04	0	728	52	0
	23741	26107	1173212	45.94	0	0	0	332
	Subtotal				0	8806	261	1220
1984	23206	22225	949585	43.73	0	0	0	63
	Subtotal				0	0	0	63
Total hatchery					35757	36248	33594	5069
Strays: (d)								
1986	24559	26954	177643	7.59	135	0	0	0
1987	24749	25187	137516	6.46	115	0	0	0
Total strays					249	0	0	0

(a) abbreviations are M = male and F = female

(b) includes jacks

(c) from Table 10

(d) Adipose clipped fish that have strayed to Stamp River from other enhancement facilities

CWT fish and adipose clipped fish released for each tag code (data from MRP database) . The estimated hatchery contributions to the 1990 escapement of chinook to the upper Stamp River and Robertson Creek Hatchery were 72005 and 38663, respectively (Table 11). The hatchery contribution to the total escapement of chinook each year, by age class is presented in Table 12. The hatchery contribution to the in-river population of Robertson Creek chinook was estimated to be 70.6% for males and 88.9% for females. This increased to 88.0% for males and 89.3% for females in the returns to the hatchery. Hatchery strays from the Capilano and Chilcotin rivers accounted for 0.5% of the in-river male population.

Hatchery Contributions - Method B

Results from the decoding of CWTs from the upper Stamp River dead pitch and returns to Robertson Creek Hatchery are shown in Table 13. This table shows the number of observed CWT fish in the escapement and the adjusted number of CWTs for each tag code (Equation 11). As mentioned above, any CWT fish recovered in the Stamp River which were released from another river were excluded from the analysis (1%). The allocations of the total escapement of CWT fish to tag codes recovered in each portion of the river (in-river versus hatchery) are shown in Tables 14 and 15. The estimated hatchery contributions to the 1990 escapement of chinook to the Stamp River and Robertson Creek Hatchery using Method B (MRP method) were 64119 and 33449, respectively (Table 15). The hatchery contribution to the total escapement of chinook each year, by age class is presented in Table 16. The hatchery contribution to the in-river population of Robertson Creek chinook was estimated to be 62.2% for males and 80.0% for females. This increased to 78.3% for males and decreased to 62.7% for females in the returns to the hatchery.

DISCUSSION

Age, Length and Sex Composition

The age-length composition obtained from sampling river carcasses was very similar to the age structure obtained from hatchery returns. The only apparent bias was for males where the mean size was considerably smaller in the hatchery returns than in the dead recovery. This is, in part, because smaller fish, particularly jacks tend to be washed out of the system before they can be recovered as carcasses (Lightly et al. 1988). This bias was also evident in the age structure for each of the populations. The percentage of jacks was much higher in the hatchery (13.0 %) than in the river (2.1%). The age structure for females was virtually the same for the dead pitch and hatchery returns. One curious discrepancy between the age structure of the in-river population and the hatchery returns was the percentage of 3 and 4 year old males. Age 4 males dominated the population sampled in the dead pitch while age 3 males dominated the hatchery population. The reason for this difference is not clear but could possibly be attributed to a greater propensity for young males to return to the hatchery.

The lower proportion of females observed in the hatchery returns (13.0%) compared to the in-river dead recovery (44.6%) has been observed in other hatchery populations (Bocking et al. 1990,

Table 12. Estimated hatchery contribution to the upper Stamp River and Robertson Creek Hatchery chinook salmon escapement, 1990. Contributions were calculated using expansion Method A for the estimated number of adipose clips (Table 11).

		Estimated escapement (a)		Hatchery contribution (b)				Stray contribution (b)			
				Male		Female		Male		Female	
Area	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number	%
Upper Stamp River											
	2.1	1063	0	657	61.8	0	0.0	0	0.0	0	0.0
	3.1	17312	2040	11613	67.1	211	10.3	115	0.7	0	0.0
	4.1	30675	30146	23487	76.6	27232	90.3	135	0.4	0	0.0
	5.1	1569	8607	0	0.0	8806	102.3	0	0.0	0	0.0
	6.1	0	0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	50619	40793	35757	70.6	36249	88.9	250	0.5	0	0.0
Robertson Creek Hatchery											
	2.1	4961	0	10839	218.5	0	0.0	0	0.0	0	0.0
	3.1	23928	619	16167	67.6	703	113.5	0	0.0	0	0.0
	4.1	8968	4026	6327	70.6	3083	76.6	0	0.0	0	0.0
	5.1	305	1017	261	85.6	1220	120.0	0	0.0	0	0.0
	6.1	0	17	0	0.0	63	370.6	0	0.0	0	0.0
	Total	38162	5679	33594	88.0	5069	89.3	0	0.0	0	0.0

(a) from Table 6
(b) from Table 15
(c) Includes jacks

Table 13. Adjusted number of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 14 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
1988	25014	0	0	0.0	0.0	33	0	35.3	0.0
	25630	0	0	0.0	0.0	6	0	6.4	0.0
	25640	0	0	0.0	0.0	6	0	6.4	0.0
	25643	0	0	0.0	0.0	4	0	4.3	0.0
	25645	0	0	0.0	0.0	7	0	7.5	0.0
	25646	0	0	0.0	0.0	4	0	4.3	0.0
	25648	0	0	0.0	0.0	3	0	3.2	0.0
	25651	0	0	0.0	0.0	6	0	6.4	0.0
	25653	0	0	0.0	0.0	4	0	4.3	0.0
	25654	0	0	0.0	0.0	7	0	7.5	0.0
	25657	0	0	0.0	0.0	9	0	9.6	0.0
	25658	0	0	0.0	0.0	6	0	6.4	0.0
	25660	0	0	0.0	0.0	6	0	6.4	0.0
	25663	0	0	0.0	0.0	8	0	8.5	0.0
	25701	0	0	0.0	0.0	3	0	3.2	0.0
	25702	0	0	0.0	0.0	2	0	2.1	0.0
	25703	0	0	0.0	0.0	2	0	2.1	0.0
	25704	0	0	0.0	0.0	6	0	6.4	0.0
	25705	0	0	0.0	0.0	3	0	3.2	0.0
	25836	0	0	0.0	0.0	36	0	38.5	0.0
	25837	0	0	0.0	0.0	37	0	39.5	0.0
	25838	0	0	0.0	0.0	22	0	23.5	0.0
	25839	0	0	0.0	0.0	17	0	18.2	0.0
	26055	0	0	0.0	0.0	6	0	6.4	0.0
	26056	0	0	0.0	0.0	21	0	22.4	0.0
	26057	1	0	1.1	0.0	33	0	35.3	0.0
	Total	1	0	1.1	0.0	297	0	317.4	0.0
1987	24311	3	0	3.2	0.0	32	1	34.2	1.2
	24802	0	0	0.0	0.0	39	0	41.7	0.0
	24803	0	0	0.0	0.0	51	1	54.5	1.2
	24804	1	0	1.1	0.0	37	0	39.5	0.0
	24805	4	0	4.3	0.0	25	2	26.7	2.4
	24806	2	0	2.1	0.0	36	2	38.5	2.4
	24809	2	0	2.1	0.0	52	1	55.6	1.2
	24810	1	1	1.1	1.0	39	1	41.7	1.2
	24937	5	0	5.3	0.0	12	1	12.8	1.2
	24948	2	1	2.1	1.0	11	2	11.8	2.4

Table 13. Adjusted number of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 14 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
	24949	0	1	0.0	1.0	20	0	21.4	0.0
	24950	2	0	2.1	0.0	21	1	22.4	1.2
	24951	3	0	3.2	0.0	33	0	35.3	0.0
	24952	6	0	6.4	0.0	34	0	36.3	0.0
	24958	2	0	2.1	0.0	39	2	41.7	2.4
	24959	1	0	1.1	0.0	48	2	51.3	2.4
	24960	3	0	3.2	0.0	50	1	53.4	1.2
	24961	1	0	1.1	0.0	40	1	42.7	1.2
	25326	1	0	1.1	0.0	58	1	62.0	1.2
	25327	1	0	1.1	0.0	64	5	68.4	6.0
	25328	1	0	1.1	0.0	61	4	65.2	4.8
	25329	4	0	4.3	0.0	50	2	53.4	2.4
	Subtotal	45	3	47.8	3.1	852	30	910.5	36.2
1986	24256	5	4	5.3	4.2	17	6	18.2	7.2
	24257	4	7	4.3	7.3	21	11	22.4	13.3
	24361	7	5	7.4	5.2	25	5	26.7	6.0
	24362	6	13	6.4	13.6	15	12	16.0	14.5
	24363	2	1	2.1	1.0	23	5	24.6	6.0
	24401	4	8	4.3	8.4	20	10	21.4	12.1
	24514	11	10	11.7	10.5	7	2	7.5	2.4
	24515	7	3	7.4	3.1	13	7	13.9	8.4
	24516	3	8	3.2	8.4	9	5	9.6	6.0
	24517	0	0	0.0	0.0	13	3	13.9	3.6
	24518	3	4	3.2	4.2	11	8	11.8	9.7
	24519	2	4	2.1	4.2	7	6	7.5	7.2
	24520	2	2	2.1	2.1	7	4	7.5	4.8
	24644	0	5	0.0	5.2	6	2	6.4	2.4
	24645	3	2	3.2	2.1	10	2	10.7	2.4
	24646	3	0	3.2	0.0	6	5	6.4	6.0
	24647	4	0	4.3	0.0	6	0	6.4	0.0
	24648	5	3	5.3	3.1	12	2	12.8	2.4
	Subtotal	71	79	75.5	82.8	228	95	243.7	114.7
1985	23734	0	4	0.0	4.2	1	3	1.1	3.6
	23735	0	1	0.0	1.0	0	3	0.0	3.6
	23736	0	0	0.0	0.0	1	4	1.1	4.8
	23737	0	5	0.0	5.2	1	7	1.1	8.4

Table 13. Adjusted number of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the adjusted CWTs for estimating the total number of CWTs in Table 14 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Observed CWTs		Adjusted CWTs		Observed CWTs		Adjusted CWTs	
Brood year	CWT code	M (b)	F	M	F	M	F	M	F
	23738	0	3	0.0	3.1	1	1	1.1	1.2
	23739	0	1	0.0	1.0	1	1	1.1	1.2
	23740	0	1	0.0	1.0	1	0	1.1	0.0
	23741	0	0	0.0	0.0	0	5	0.0	6.0
	Subtotal	0	15	0.0	15.7	6	24	6.4	29.0
1984	23206	0	0	0.0	0.0	0	1	0.0	1.2
	Subtotal	0	0	0.0	0.0	0	1	0.0	1.2
Total hatchery		117	97	124.4	101.6	1383	150	1478.0	181.0
Strays: (c)									
	24749	1	0	1.1	0.0	0	0	0.0	0.0
	24559	1	0	1.1	0.0	0	0	0.0	0.0
	Total strays	2	0	2.1	0.0	0	0	0.0	0.0
	Total CWT	119	97	126.5	101.6	1383	150	1478.0	181.0
No head taken		4	4			92	36		
No data (5000)		1	1			6	0		
No pin (8000)		14	8			90	30		
Lost pin (9000)		3	0			3	1		
Observed adipose		141	110			1574	217		

(a) abbreviations are M=male and F=female

(b) includes jacks

(c) CWT fish that have strayed to Stamp River from other enhancement facilities

Table 14. Estimates of total escapement of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 15 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood year	CWT code	M (b)	F	M	F	M (b)	F	M	F
1988	25014	0.0	0.0	0.0	0.0	35.3	0.0	35.3	0.0
	25630	0.0	0.0	0.0	0.0	6.1	0.0	6.1	0.0
	25640	0.0	0.0	0.0	0.0	6.4	0.0	6.4	0.0
	25643	0.0	0.0	0.0	0.0	4.0	0.0	4.0	0.0
	25645	0.0	0.0	0.0	0.0	7.0	0.0	7.0	0.0
	25646	0.0	0.0	0.0	0.0	8.3	0.0	8.3	0.0
	25648	0.0	0.0	0.0	0.0	3.0	0.0	3.0	0.0
	25651	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0
	25653	0.0	0.0	0.0	0.0	4.0	0.0	4.0	0.0
	25654	0.0	0.0	0.0	0.0	7.0	0.0	7.0	0.0
	25657	0.0	0.0	0.0	0.0	9.1	0.0	9.1	0.0
	25658	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0
	25660	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0
	25663	0.0	0.0	0.0	0.0	8.0	0.0	8.0	0.0
	25701	0.0	0.0	0.0	0.0	3.0	0.0	3.0	0.0
	25702	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0
	25703	0.0	0.0	0.0	0.0	2.0	0.0	2.0	0.0
	25704	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0
	25705	0.0	0.0	0.0	0.0	3.0	0.0	3.0	0.0
	25836	0.0	0.0	0.0	0.0	36.2	0.0	36.2	0.0
	25837	0.0	0.0	0.0	0.0	37.2	0.0	37.2	0.0
	25838	0.0	0.0	0.0	0.0	22.1	0.0	22.1	0.0
	25839	0.0	0.0	0.0	0.0	17.1	0.0	17.1	0.0
	26055	0.0	0.0	0.0	0.0	6.0	0.0	6.0	0.0
	26056	0.0	0.0	0.0	0.0	21.1	0.0	21.1	0.0
	26057	1.0	0.0	15.5	0.0	33.2	0.0	33.2	0.0
	Subtotal	1.0	0.0	15.5	0.0	305.6	0.0	305.6	0.0
1987	24311	3.1	0.0	46.4	0.0	32.2	1.0	32.2	1.0
	24802	0.0	0.0	0.0	0.0	39.2	0.0	39.2	0.0
	24803	0.0	0.0	0.0	0.0	51.3	1.0	51.3	1.0
	24804	1.0	0.0	15.5	0.0	37.2	0.0	37.2	0.0
	24805	4.1	0.0	61.8	0.0	25.2	2.0	25.2	2.0
	24806	2.1	0.0	30.9	0.0	36.2	2.0	36.2	2.0
	24809	2.1	0.0	30.9	0.0	52.3	1.0	52.3	1.0
	24810	1.0	1.0	15.5	14.1	39.2	1.0	39.2	1.0
	24937	5.2	0.0	77.3	0.0	12.1	1.0	12.1	1.0
	24948	2.1	1.0	30.9	14.1	11.1	2.0	11.1	2.0

Table 14. Estimates of total escapement of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 15 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood year	CWT code	M (b)	F	M	F	M (b)	F	M	F
	24949	0.0	1.0	0.0	14.1	20.1	0.0	20.1	0.0
	24950	2.1	0.0	30.9	0.0	21.1	1.0	21.1	1.0
	24951	3.1	0.0	46.4	0.0	33.2	0.0	33.2	0.0
	24952	6.2	0.0	92.7	0.0	34.2	0.0	34.2	0.0
	24958	2.1	0.0	30.9	0.0	39.2	2.0	39.2	2.0
	24959	1.0	0.0	15.5	0.0	48.3	2.0	48.3	2.0
	24960	3.1	0.0	46.4	0.0	50.3	1.0	50.3	1.0
	24961	1.0	0.0	15.5	0.0	40.2	1.0	40.2	1.0
	25326	1.0	0.0	15.5	0.0	58.4	1.0	58.4	1.0
	25327	1.0	0.0	15.5	0.0	64.4	5.0	64.4	5.0
	25328	1.0	0.0	15.5	0.0	61.4	4.0	61.4	4.0
	25329	4.1	0.0	61.8	0.0	50.3	2.0	50.3	2.0
	Subtotal	46.5	3.0	695.4	42.2	857.3	30.2	857.3	30.2
1986	24256	5.2	4.0	77.3	56.3	17.1	6.0	17.1	6.0
	24257	4.1	7.1	61.8	98.5	21.1	11.1	21.1	11.1
	24361	7.2	5.0	108.2	70.4	25.2	5.0	25.2	5.0
	24362	6	13	92.7	183.0	15.1	12.1	15.1	12.1
	24363	2.1	1.0	30.9	14.1	23.1	5.0	23.1	5.0
	24401	4.1	8.1	61.8	112.6	20.1	10.1	20.1	10.1
	24514	11.4	10.1	170.0	140.7	7.0	2.0	7.0	2.0
	24515	7.2	3.0	108.2	42.2	13.1	7.0	13.1	7.0
	24516	3.1	8.1	46.4	112.6	9.1	5.0	9.1	5.0
	24517	0.0	0.0	0.0	0.0	13.1	3.0	13.1	3.0
	24518	3.1	4.0	46.4	56.3	11.1	8.1	11.1	8.1
	24519	2.1	4.0	30.9	56.3	7.0	6.0	7.0	6.0
	24520	2.1	2.0	30.9	28.1	7.0	4.0	7.0	4.0
	24644	0.0	5.0	0.0	70.4	6.0	2.0	6.0	2.0
	24645	3.1	2.0	46.4	28.1	10.1	2.0	10.1	2.0
	24646	3.1	0.0	46.4	0.0	6.0	5.0	6.0	5.0
	24647	4.1	0.0	61.8	0.0	6.0	0.0	6.0	0.0
	24648	5.2	3.0	77.3	42.2	12.1	2.0	12.1	2.0
	Subtotal	73.3	79.8	1097.2	1111.9	229.4	95.6	229.4	95.6
1985	23734	0.0	4.0	0.0	56.3	1.0	3.0	1.0	3.0
	23735	0.0	1.0	0.0	14.1	0.0	3.0	0.0	3.0
	23736	0.0	0.0	0.0	0.0	1.0	4.0	1.0	4.0
	23737	0.0	5.0	0.0	70.4	1.0	7.0	1.0	7.0

Table 14. Estimates of total escapement of CWT chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. One decimal place is carried for the estimated CWTs for calculating the expanded hatchery contribution in Table 15 (Method B).

		Upper Stamp River (a)				Robertson Creek Hatchery			
		Adjusted CWTs		Estimated CWTs		Adjusted CWTs		Estimated CWTs	
Brood year	CWT code	M (b)	F	M	F	M (b)	F	M	F
	23738	0.0	3.0	0.0	42.2	1.0	1.0	1.0	1.0
	23739	0.0	1.0	0.0	14.1	1.0	1.0	1.0	1.0
	23740	0.0	1.0	0.0	14.1	1.0	0.0	1.0	0.0
	23741	0.0	0.0	0.0	0.0	0.0	5.0	0.0	5.0
	Subtotal	0.0	15.1	0.0	211.1	6.0	24.2	6.0	24.2
1984	23206	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Subtotal	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
	Total hatchery	113.9	91.9	1808.0	1365.2	1398.4	151.0	1398.4	151.0
Strays:(c)									
	24749	1.1	0	15.9	0.0	0	0	0.0	0.0
	24559	1.1	0	15.9	0.0	0	0	0.0	0.0
	Total strays	3.2	0	31.8	0.0	0	0	0.0	0.0
Escapement estimate		50619	40793			38163	5679		
Sample Size		3382	2926			38163	5679		

(a) abbreviations are M=male and F=female

(b) includes jacks

(c) CWT fish that have strayed to Stamp River from other enhancement facilities

Table 15. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 14) to account for untagged hatchery releases and hence to derive hatchery contributions to escapement.
Expansion factor = (CWT + untagged releases) / CWT releases.

Brood year	CWT release group	Release Numbers CWT	Release Numbers Untagged (c)	Expansion Factor	Expanded hatchery contribution (a) Upper Stamp River M(b)	Upper Stamp River F	Robertson Creek Hatchery M	Robertson Creek Hatchery F
1988	25014	25393	627708	25.72	0	0	907	0
	25630	10385	9	1.00	0	0	6	0
	25640	9780	9	1.00	0	0	6	0
	25643	9704	8	1.00	0	0	4	0
	25645	9645	8	1.00	0	0	7	0
	25646	9723	8	1.00	0	0	8	0
	25648	9805	9	1.00	0	0	3	0
	25651	9783	9	1.00	0	0	6	0
	25653	9805	9	1.00	0	0	4	0
	25654	10091	9	1.00	0	0	7	0
	25657	9875	9	1.00	0	0	9	0
	25658	9882	9	1.00	0	0	6	0
	25660	10258	9	1.00	0	0	6	0
	25663	9902	9	1.00	0	0	8	0
	25701	9893	9	1.00	0	0	3	0
	25702	9878	9	1.00	0	0	2	0
	25703	9864	9	1.00	0	0	2	0
	25704	9730	8	1.00	0	0	6	0
	25705	9888	9	1.00	0	0	3	0
	25836	25389	1489437	59.66	0	0	2161	0
	25837	25026	1075504	43.98	0	0	1637	0
	25838	24734	1414607	58.19	0	0	1288	0
	25839	25298	936521	38.02	0	0	650	0
	26055	25330	676910	27.72	0	0	167	0
	26056	25079	1765174	71.38	0	0	1508	0
	26057	24939	901048	37.13	574	0	1233	0
	Subtotal				574	0	9650	0
1987	24311	31137	322939	11.37	527	0	366	11
	24802	29450	305443	11.37	0	0	446	0
	24803	31791	0	1.00	0	0	51	1
	24804	28912	0	1.00	15	0	37	0
	24805	29111	0	1.00	62	0	25	2
	24806	32201	0	1.00	31	0	36	2
	24809	29554	306662	11.38	352	0	595	11
	24810	29060	301535	11.38	176	160	446	11
	24937	27033	413	1.02	78	0	12	1

Table 15. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 14) to account for untagged hatchery releases and hence to derive hatchery contributions to escapement.

Expansion factor = (CWT + untagged releases) / CWT releases.

Brood year	CWT release group	Release Numbers CWT	Release Numbers Untagged (c)	Expansion Factor	Expanded hatchery contribution (a) Upper Stamp River M(b)	Upper Stamp River F	Robertson Creek Hatchery M	Robertson Creek Hatchery F
	24948	24137	369	1.02	31	14	11	2
	24949	24691	0	1.00	0	14	20	0
	24950	26264	0	1.00	31	0	21	1
	24951	27071	530793	20.61	955	0	684	0
	24952	24270	475872	20.61	1911	0	705	0
	24958	25913	898585	35.68	1103	0	1400	72
	24959	26354	904241	35.31	546	0	1706	71
	24960	24425	838738	35.34	1638	0	1778	36
	24961	25921	890976	35.37	547	0	1424	36
	25326	26695	497358	19.63	303	0	1146	20
	25327	23657	412459	18.43	285	0	1187	93
	25328	25640	484187	19.88	307	0	1220	80
	25329	25951	496221	20.12	1244	0	1012	41
	Subtotal				10142	188	14331	491
1986	24256	24175	1186784	50.09	3870	2820	857	303
	24257	22396	112833	6.04	373	595	128	67
	24361	23973	1243529	52.87	5719	3721	1330	266
	24362	26805	1388942	52.82	4897	9664	797	638
	24363	24283	1351824	56.67	1751	798	1312	285
	24401	25922	1444366	56.72	3506	6386	1141	571
	24514	20615	164	1.01	171	142	7	2
	24515	19981	160	1.01	109	43	13	7
	24516	19089	153	1.01	47	113	9	5
	24517	19187	0	1.00	0	0	13	3
	24518	20878	0	1.00	46	56	11	8
	24519	20065	0	1.00	31	56	7	6
	24520	18814	96	1.01	31	28	7	4
	24644	19990	102	1.01	0	71	6	2
	24645	20790	107	1.01	47	28	10	2
	24646	21154	242	1.01	47	0	6	5
	24647	16952	194	1.01	63	0	6	0
	24648	20840	238	1.01	78	43	12	2
	Subtotal				20787	24564	5673	2176
1985	23734	25263	975803	39.63	0	2231	40	120
	23735	26746	989535	38.00	0	535	0	115

Table 15. Estimates of total escapement of hatchery reared chinook salmon to the upper Stamp River and Robertson Creek Hatchery, by tag code, 1990. The expansion factor is used to expand the estimated number of CWT chinook in the escapement (from Table 14) to account for untagged hatchery releases and hence to derive hatchery contributions to escapement.

Expansion factor = (CWT + untagged releases) / CWT releases.

	CWT				Expanded hatchery contribution (a)			
Brood	release	Release Numbers		Expansion	Upper Stamp River		Robertson Creek Hatchery	
year	group	CWT	Untagged (c)	Factor	M(b)	F	M	F
	23736	26320	662585	26.17	0	0	26	105
	23737	25915	659653	26.45	0	1862	27	186
	23738	25274	1136087	45.95	0	1940	46	46
	23739	26998	1211439	45.87	0	646	46	46
	23740	26215	1186721	46.27	0	651	47	0
	23741	25976	1173343	46.17	0	0	0	232
	Subtotal				0	7864	232	851
1984	23206	21625	950185	44.94	0	0	0	45
	Subtotal				0	0	0	45
Total hatchery					31503	32616	29886	3563
Strays: (d)								
1986	24559	25148	179449	8.14	129	0	0	0
1987	24749	25187	137516	6.46	103	0	0	0
Total strays					232	0	0	0

(a) abbreviations are M=male and F=female

(b) includes jacks

(c) Untagged = AD only (i.e. tag lost) + unmarked (i.e. no CWT/AFC applied)

(d) CWT fish that have strayed to Stamp River from other enhancement facilities

Table 16. Estimated hatchery contribution to the upper Stamp River and Robertson Creek Hatchery chinook salmon escapement, 1990. Contributions were calculated using expansion Method B for the estimated number of CWTs (Table 15).

		Estimated escapement (a)		Hatchery contribution (b)				Stray contribution (b)			
				Male		Female		Male		Female	
Area	Age	Male (c)	Female	Number	%	Number	%	Number	%	Number	%
Upper Stamp River											
	2.1	1063	0	574	54.0	0	0.0	0	0.0	0	0.0
	3.1	17312	2040	10142	58.6	188	9.2	103	0.6	0	0.0
	4.1	30675	30146	20787	67.8	24564	81.5	129	0.4	0	0.0
	5.1	1569	8607	0	0.0	7864	91.4	0	0.0	0	0.0
	6.1	0	0	0	0.0	0	0.0	0	0.0	0	0.0
	Total	50619	40793	31503	62.2	32616	80.0	232	0.5	0	0.0
Robertson Creek Hatchery											
	2.1	4961	0	9650	194.5	0	0.0	0	0.0	0	0.0
	3.1	23928	619	14331	59.9	491	79.3	0	0.0	0	0.0
	4.1	8968	4026	5673	63.3	2176	54.0	0	0.0	0	0.0
	5.1	305	1017	232	76.1	851	83.7	0	0.0	0	0.0
	6.1	0	17	0	0.0	45	264.7	0	0.0	0	0.0
	Total	38162	5679	29886	78.3	3563	62.7	0	0.0	0	0.0

(a) from Table 6
(b) from Table 15
(c) Includes jacks

Lightly et al. 1988, Sibert and Schnute 1982). However, the extremely low proportion of this year's females in the hatchery return is considerably lower than reported by Lightly et al. (1988) for the Stamp River in 1984 (30.4%). It has been postulated that the lower proportion of females in hatchery returns is due to a greater reluctance by females to use the fishway into the hatchery (Lightly et al. 1988). While the hatchery returns of females may be negatively biased, the proportion of females in the dead recovery may be positively biased because females tend to remain near their redds in shallow water and are more readily available as carcasses than males. Despite this problem, the dead recovery data is probably less biased than the hatchery data and, second to live recovery data in the river, provides the best estimate of sex ratios for this population.

Finally, the jack to adult male ratios determined from the age structure analysis revealed a serious bias in the discrimination of jack and adult males during field observations. Visual counts of chinook at the Stamp Falls Fishway (see Part I) and brailer counts of chinook returning to the hatchery overestimated the number of jack chinook in the population by over 50%. The age structure plots (Fig. 19) indicate that the size cutoff for jacks and adults used at the fishway (59 cm total length, approx. 50-54 cm postorbital-hypural) was appropriate. Therefore, errors in the identification of jack chinook can be attributed to observer error. If these visual count data are used inseason to assist fishery management, then errors of this magnitude can be serious. In this report I used the age structure data to generate age specific population estimates and hatchery contribution estimates.

Hatchery Contributions

The mark rates (number of adipose clips) for hatchery stock observed in the dead recovery and the hatchery returns (4.0% and 4.1%, respectively) was lower than the overall mark rate at the time of release (4.7%). This is to be expected because of the presence of wild (unclipped) stock in the returning escapement and naturally missing adipose fins. The fact that the mark rates at return are similar for the river population and the hatchery may, at first glance, suggest that the dilution by wild stock fish is equal for river spawners and returns to the hatchery. However, if we estimate the average mark rate at release for only the tag groups that are observed in the return (we call this the adjusted mark rate at release calculated by dividing the number of adipose clips, from Table 8, by the hatchery contribution estimate, from Table 12), it is evident that there is a greater proportion of wild fish among the river spawners than hatchery returns. The adjusted mark rate at release for the river population was 5.1% while the adjusted mark rate at release for fish returning to the hatchery was 4.6%. If hatchery fish, from all tag codes, were returning in equal proportion as river spawners and hatchery returns, these mark rates should be the same. The number of wild fish in each population was the following: 19156 wild chinook in the upper Stamp River (21.0% of the river spawners) and 5178 wild chinook returning to the hatchery (11.8% of the total hatchery returns).

Estimates of the total hatchery contribution to the in-river population and the hatchery returns were different using Method A (adipose clip rate) versus Method B (CWT rate). Method A produced higher hatchery contribution estimates (70.6% for in-river males to 89.3% for hatchery females) than Method B (62.2% for in-river males to 80.0% for in-river females). The biggest differences (stratified by location and sex) occurred where tag loss at return was substantially different from tag loss at release (Table 17). The largest differences between contribution estimates using Method A and B were for in-river males and hatchery females. These results emphasize one of the basic differences between the two methods. Method B assumes that no tag loss occurs after release, while

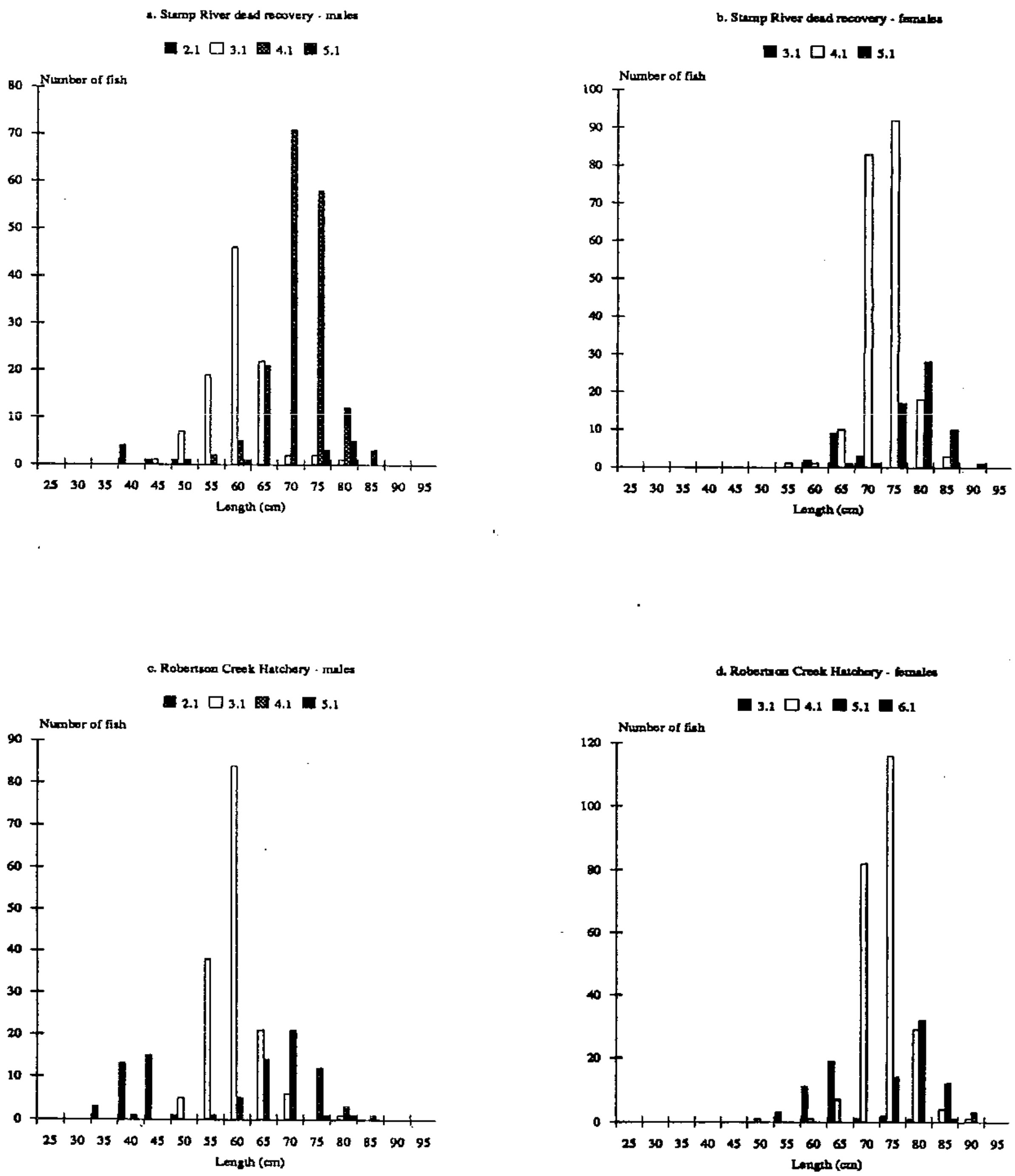


Figure 19. Age-length (postorbital-hypural) relations for chinook salmon sampled from dead recovery in the Stamp River and from returns to Robertson Creek Hatchery, 1990.

Table 17. Comparison of tag loss at release with tag loss at recovery.

Location	Sex	CWT loss (%)	
		At release (a)	At recovery (b)
Upper Stamp River	Male (c)	0.56	10.3
	Female	0.56	6.2
Hatchery	Male	0.56	6.1
	Female	0.56	16.6

(a) tag loss is the weighted average tag loss rate from retention tests for all tag codes (Table 10)
(b) tag loss is the number of no pins divided by the total number of heads examined for tags (Table 9)
(c) includes jacks

Method A assumes that there is no naturally occurring adipose fin losses. While I did not directly evaluate these two assumptions, the consistency of mark rate (number of adipose clips at return) between the dead recovery and the hatchery returns suggests that erosion of adipose fins due to decomposition, resulting in misidentification, could not account for the differences in the contribution estimates. On the other hand, since Robertson Creek Hatchery only held juvenile fish for 3 days before release, additional tag loss after release seems likely (Blankenship 1990). Therefore, the results from Method A more likely approximate the true hatchery contribution estimates.

However, if we used Method B instead of Method A, these mark rates were higher (5.7% for dead recovery and 5.4% for hatchery). This is further evidence that Method A may be the better method for calculating hatchery contributions. The following table summarizes the potential source of bias and their subsequent affect on the hatchery contribution estimates derived using each method.

Factor	Direction of Bias	
	Method A	Method B
1. Lower survival of marked fish	negative	negative
2. Regeneration of adipose clips	negative	negative
3. natural loss of adipose fin	positive	nil
4. Loss of CWT	nil	negative
5. Differing tag loss among ages	unknown	nil

From this table it can be seen that Method B should always produce hatchery contribution estimates which are negatively biased and lower than estimates using Method A. This is confirmed by the results of this study.

SUMMARY

Fishway Counts

Counts of adult salmon returning to spawn in the Stamp River were conducted at Stamp Falls Fishway using visual observations from September 11 to November 8. Raw counts of salmon passing through the fishway were adjusted for observer error by comparing fish counts with verified counts of fish. By week three, counting errors ranged between 0% and ± 13% depending on species and was normally less accurate in earlier weeks (range = 0% to ± 23%). A relationship was derived between counts of chinook and coho at the Stamp Falls Fishway and live returns to Robertson Creek Hatchery. This relationship was used to interpolate fish numbers for a ten day flood period between October 23 and November 2, when counts were not obtained at the fishway. After correcting for observer error and missing data due to flooding, the final estimate of chinook salmon was 135,254 ± 6,452. An estimated 50,772 ± 3,870 coho passed through the fishway and 70,941 ± 2,039 sockeye were counted.

Age, Length and Sex Composition

The age, length and sex composition of 1990 Stamp River chinook salmon were determined from carcass recovery and sampling of live returns to Robertson Creek Hatchery. The in-river population of spawners and the hatchery returns were analysed separately. Both male and female chinook in the in-river population were predominantly 4 years old. Female returns to Robertson Creek Hatchery were also predominantly 4 year olds but male returns to the hatchery were mostly 3 year olds. This difference in age structure for males in the river and at the hatchery accounts for a significant difference in the mean length of males in each of these populations. There was a much larger proportion of females among river spawners (44.6%) than among hatchery returns (13.0%). The results of this study revealed that there was considerable error (> 50%) in the identification of jack chinook by field crews. Aging by scales and coded wire tags indicated that counts at the fishway and the hatchery overestimated the number of jack chinook by over 50%.

Hatchery Contribution Estimates

Adipose clip mark rates for the in-river carcass recovery sample and the hatchery returns were 4.0% and 4.1%, respectively. Two methods were described and used to estimate hatchery contributions to the escapement. Using Method A, which expands the number of observed adipose clipped chinook, the hatchery contribution for the total Stamp River escapement was estimated at 81.8%. Using Method B, which expands the number of CWTs (excluding those with adipose clips only), the hatchery contribution was estimated at 72.1%. Both estimates varied among sexes and river versus hatchery spawners. The reasons for the differences between these two estimates were discussed in the context of the assumptions. Comparisons were made between the mark rate at release (4.7%) and the mark rate at recovery (hatchery fish only) using each of these methods. Method A produced hatchery stock mark rates at recovery which were similar to the mark rate at release (in-river, 5.1%; hatchery, 4.6%). Method B, on the other hand, produced hatchery stock mark rates which were higher (in-river, 5.7%; hatchery, 5.4%). These results indicate that Method B may underestimate the hatchery contribution of chinook more so than Method A. The most likely reason for this is the additional loss of coded wire tags after release from the hatchery. This was confirmed by comparing tag loss at release (0.56%) with tag loss at recovery (6.1 - 16.6%). The various assumptions and potential biases of these two methods needs to be explored rigorously in future studies.

ACKNOWLEDGMENTS

Much of the success of this program was due to the innovative and diligent work of our three field crew members: Ken Lund, Mike Burwash and Rob Anderson. The author sincerely thanks Rick Semple, Paul Starr and Don Lawseth (all with DFO) and Karl English and Shirley Brown of LGL Limited for reviewing this manuscript. I also thank the Robertson Creek Hatchery field crews who collected data for this study, and Karl English and Bryan Nass who assisted with the design of the fishway counting apparatus and analysis. Lisa Clark helped prepare the final manuscript. This work was conducted by LGL Limited, environmental research associates, under contract to the Department of Fisheries and Oceans (No. XSB90-00089-(003)/A).

REFERENCES

Andrews, J. H., M. Lightly, and T. M. Webb. 1988. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1985. Can. MS Rep. Fish. Aquat. Sci. 2007: 46 p.

Blankenship, H. L. 1990. Effects of time and fish size on coded wire tag loss from chinook and coho salmon. American Fisheries Society Symposium 7: 237-243.

Bocking, R.C., K.K. English and T. M. Webb. 1990. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam rivers, 1986-1988. Can. MS Rep. Fish. Aquat. Sci. 2065: 126 p.

Carolsfeld, J., K. K. English, P. Frank and T. M. Webb. 1990. Abundance, age, size, sex and coded wire tag recoveries for chinook salmon escapements of Kitsumkalum River, 1987-1988. Can. MS Rep. Fish. Aquat. Sci. 2074:54 p.

English, K. K. and W. B. Griffiths. 1984. Robertson Creek Hatchery: History, data and evaluation of production. Unpubl. Report by LGL Ltd. for Department of Fisheries and Oceans. 95 p. + Appendices.

Gilbert, C. H. and W. H. Rich. 1927. Investigations concerning the red salmon runs to the Karluk River, Alaska. Bull. U.S. Bus. Fish. 43(2): 1-69 (Doc. No. 991).

Heizer, S. 1991. Escapement enumeration of salmon passing through Stamp Falls Fishway on the Somass River system, 1986 through 1989. Can. MS Rep. Fish Aquat. Sci. 2067: 55 p.

Lee, J. C. N. B. F. Cousens and V. Walker. 1989. Salmonid studies at Stamp Falls Fishway - Somass River, 1988. Unpubl. Report by J.C. Lee and Associates Ltd. for Department of Fisheries and Oceans. (Contract FP501-8-0261). 66 p.

Kuhn, B. R. 1988. The MRP-Reporter Program: A data extraction and reporting tool for the Mark Recovery Program Database. Can Tech. Rep. Fish. Aquat. Sci. 1625: 145 p.

Lightly, D.T., T. F. Shardlow and A. Y. Fedorenko. 1988. Determination of the 1984 salmon escapement to Somass River system. Can. MS Rep. Fish. Aquat. Sci. 1982: 104 p.

Sibert, J. and J. Schnute. 1982. Analysis of the Alberni Inlet chinook salmon production system. Can. Tech. Rep. Fish. Aquat. Sci. 1131: 149 p.

Wright, M.C. 1990. Migration patterns and abundance of chinook (Oncorhynchus tshawytsha) and coho (Oncorhynchus kisutch) salmon entering the Stamp River system in 1989. Unpubl. Report by M.C. Wright and Associates for Department of Fisheries and Oceans. (Contract FP501-9-0201). 15 p. + appendices.

APPENDICES

Appendix 1-1. Actual counts of adult chinook salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

Date	Hour of Day 800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Sep-11	12	72	135	111	83	108	88	22	14	46	57	14	762
Sep-12	30	100	83	122	121	127	113	98	66	84	4		948
Sep-13	1	39	40	18	11	15	14	13	18	36	4		209
Sep-14	70	125	131	193	209	181	124	46	53	73	22		1227
Sep-15	56	138	215	176	195	112	132	140	96				1260
Sep-16	176	146	129	213	217	178	269	219	152	197			1896
Sep-17	27	117	142	148	167	157	177	140	107	137	143		1462
Sep-18	43	59	100	51	8	94	52	104	**4**		62		577
Sep-19	18	71	60	75	92	62	**3**	75	136	68			660
Sep-20	24	63	71	**1**	52	62	65	69	43	107	47		604
Sep-21	76	108	**1**	83	114		52	142	113	97	62		848
Sep-22	65	114	103	72	91	64	61	69	60	**1**	5		705
Sep-23	109	146	136	112	108	144	**5**	75	164	126	86		1211
Sep-24	280	329	411	349	302	264	258	200	**3**	154	49		2599
Sep-25	148	289	**1**	300	240	224	210	197	220	196			2025
Sep-26	104	148	164	222	247	213	**2**	207	159	130			1596
Sep-27	141	189	207	227	212	**0**	170	226	110	36			1518
Sep-28	112	223	237	308	290	251	**3**	217	303	188			2132
Sep-29	171	238	**7**	278	334	232	232	224	195	219			2130
Sep-30	246	322	**6**	396	446	404	434	367	402	230			3253
Oct-01	160	228	319	304	370	448	**9**	313	398	382			2931
Oct-02	274	481	574	623	662	**425**	687	607	590	569			5492
Oct-03	146	568	610	**29**	705	544	635	649	502	429			4817
Oct-04	429	413	646	**13**	640	632	498	646	577	604			5098
Oct-05	402	485	584	496	521	458	**14**	**8**	567	572			4107
Oct-06	225	424	381	367	**13**	402	563	501	488	481			3845
Oct-07	221	242	319	339	380	**8**	371	391	422	173			2866
Oct-08	182	225	294	228	**9**	410	299	404	390	172			2613
Oct-09	77	255	223	226	259	364	446	**20**	323	217			2410
Oct-10		305	344	380	**22**	370	364	319	459	144			2707
Oct-11	42	244	246	**12**	347	306	313	260	326				2096
Oct-12	126	**126**	352	363	436	373	440	454	459	299			3428
Oct-13	181	302	**83**	417	324	433	399	481	416	454			3490
Oct-14	174	225	153	287	301	346	**144**	408	513	147			2698
Oct-15	171	246	264	239	363	297	**118**	421	413	246			2778
Oct-16	146	270	239	258	270	294	**90**	411	386	179			2543
Oct-17	137	217	209	190	225	259	**21**	351	483	14			2106
Oct-18	165	394	358	373	388	385	454	440	**240**	321			3518
Oct-19	184	360	318	373	**194**	476	418	408	438				3169
Oct-20	157	286	228	**110**	314	293	330	350	347				2415
Oct-21		236	172	171	167	166	191	207	**10**				1320
Oct-22		351	331	253	**13**	476	313	199	227				2163
Oct-23		222	215	209	209	**9**	324	245	189				1622

Appendix 1-1. Actual counts of adult chinook salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Oct-24													
Oct-25													
Oct-26													
Oct-27													
Oct-28	HIGH WATER PREVENTED COUNTING												
Oct-29													
Oct-30													
Oct-31													
Nov-01													
Nov-02	9	77	37	37	42	38	50	54					344
Nov-03	66	91	32	22	40	49	35	38					373
Nov-04	19	49	61	40	46	51	70	31					367
Nov-05	14	58	34	25	29	23	32	29					244
Nov-06	21	22	40	26	15	22	18	19					183
Nov-07	12	22	12	26	20	33	21	18					164
Nov-08	11	4	18	9	4	6	5	5					62

Appendix 1-2. **Actual counts of jack chinook salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.**

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Sep-11	6	14	62	36	36	48	30	8	3	32	19	7	301
Sep-12	10	59	33	52	37	36	23	33	26	28	0		337
Sep-13	0	5	14	10	0	9	9	11	21	38	1		118
Sep-14	19	27	37	75	71	71	48	25	31	30	16		450
Sep-15	17	57	53	102	71	42	81	94	37				554
Sep-16	20	61	36	104	96	72	88	95	66	38			676
Sep-17	9	37	77	54	98	75	117	103	87	116	96		869
Sep-18	54	79	82	63	4	50	42	65	**1**		38		478
Sep-19	36	74	42	47	69	32	**0**	68	102	31			501
Sep-20	29	66	49	**0**	27	57	65	78	25	111	39		546
Sep-21	43	70	**0**	45	54		38	141	72	74	30		567
Sep-22	29	56	31	30	45	37	44	61	50	**1**	4		388
Sep-23	75	90	98	42	74	63	**5**	53	100	65	43		708
Sep-24	27	60	81	86	81	52	92	97	**3**	41	23		643
Sep-25	42	54	**3**	67	48	62	62	84	88	83			593
Sep-26	22	47	33	72	70	81	**0**	95	86	49			555
Sep-27	43	69	67	52	84	**3**	77	117	51	35			598
Sep-28	25	48	57	93	89	79	**3**	104	121	87			706
Sep-29	36	73	**0**	58	89	78	101	70	78	53			636
Sep-30	32	26	**0**	56	57	79	67	79	92	48			536
Oct-01	20	21	43	36	37	65	**1**	40	70	37			370
Oct-02	9	13	24	25	36	**12**	45	18	16	18			216
Oct-03	5	19	17	**2**	28	15	32	22	28	22			190
Oct-04	27	17	24	**2**	20	26	33	38	46	23			256
Oct-05	19	19	27	13	33	17	**1**	**0**	38	34			201
Oct-06	10	19	11	12	**1**	21	47	31	33	25			210
Oct-07	10	11	20	17	25	**1**	28	36	39	14			201
Oct-08	14	23	22	11	**0**	35	29	39	44	11			228
Oct-09	4	13	16	18	18	28	27	**1**	21	24			170
Oct-10		21	21	28	**2**	38	49	40	37	12			248
Oct-11	7	27	27	**1**	25	26	35	26	32				206
Oct-12	3	**5**	20	19	30	19	22	27	41	28			214
Oct-13	16	12	**6**	28	21	25	42	22	44	42			258
Oct-14	12	7	11	23	26	35	**18**	41	54	20			247
Oct-15	7	19	19	14	35	21	**20**	61	44	14			254
Oct-16	13	19	18	21	18	17	**9**	56	69	14			254
Oct-17	10	22	14	10	19	34	**2**	48	57	21			237
Oct-18	13	15	21	18	25	23	34	31	**10**	34			224
Oct-19	4	12	14	21	**8**	31	33	48	58				229
Oct-20	7	20	16	**6**	28	14	43	35	38				207
Oct-21		15	13	10	12	16	18	17	**0**				101
Oct-22		16	12	11	**0**	18	17	10	19				103
Oct-23		14	14	16	13	**0**	24	31	18				130

Appendix 1-2. **Actual counts of jack chinook salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.**

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Oct-24													
Oct-25													
Oct-26													
Oct-27													
Oct-28	HIGH WATER PREVENTED COUNTING												
Oct-29													
Oct-30													
Oct-31													
Nov-01													
Nov-02	0	8	4	6	9	4	17	18					66
Nov-03	7	10	6	5	9	12	17	10					76
Nov-04	6	21	8	6	20	14	25	15					115
Nov-05	5	7	5	12	10	8	8	8					63
Nov-06	2	8	0	7	4	6	1	5					33
Nov-07	2	8	1	5	9	8	7	3					43
Nov-08	0	2	1	2	2	6	1	1					15

Appendix 1-3. Actual counts of adult coho salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

Date	Hour of Day												Total
	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
Sep-11	12	18	28	32	6	15	4	10	1	9	3	2	140
Sep-12	6	2	6	4	15	9	42	48	40	42	3		217
Sep-13	14	28	54	45	24	27	19	16	17	28	14		286
Sep-14	37	57	34	48	37	52	49	18	13	10	6		361
Sep-15	46	102	78	73	50	48	57	65	72				591
Sep-16	54	125	68	120	114	109	108	155	97	100			1050
Sep-17	34	126	99	73	79	80	83	120	70	72	62		898
Sep-18	112	125	156	78	25	135	95	197	**10**		90		1023
Sep-19	100	244	229	192	213	131	**9**	249	173	144			1684
Sep-20	122	208	110	**3**	117	82	117	76	76	83	56		1050
Sep-21	133	106	**5**	129	91		159	174	132	67	45		1041
Sep-22	227	227	179	166	153	148	78	93	112	**7**	15		1405
Sep-23	225	223	152	146	109	138	**9**	120	157	169	65		1513
Sep-24	56	122	102	94	72	115	115	94	**9**	46	16		841
Sep-25	161	133	**7**	151	158	253	294	207	188	88			1640
Sep-26	100	147	162	133	112	168	**6**	239	174	114			1355
Sep-27	178	155	127	73	121	**12**	130	127	80	41			1044
Sep-28	135	165	90	74	95	103	**4**	92	96	45			899
Sep-29	125	115	**4**	129	114	135	116	120	68	49			975
Sep-30	169	129	**2**	156	128	173	213	174	135	108			1387
Oct-01	189	151	149	134	147	219	**9**	214	219	207			1638
Oct-02	132	187	152	140	138	**105**	154	163	112	90			1373
Oct-03	27	104	96	**2**	120	111	157	201	161	121			1100
Oct-04	85	251	181	**2**	236	131	163	123	183	126			1481
Oct-05	154	184	323	293	224	140	**10**	**4**	138	91			1561
Oct-06	41	165	133	149	**8**	187	230	192	198	130			1433
Oct-07	105	152	169	205	231	**11**	277	241	173	69			1633
Oct-08	54	134	175	187	**11**	317	144	261	154	59			1496
Oct-09	29	95	102	127	101	94	77	**1**	81	41			748
Oct-10		188	185	267	**29**	253	216	171	242	66			1617
Oct-11	15	106	145	**14**	208	120	105	79	68				860
Oct-12	38	**72**	135	132	133	114	134	184	147	140			1229
Oct-13	47	86	**50**	122	100	111	103	132	96	90			937
Oct-14	17	68	27	45	38	33	**17**	39	32	18			334
Oct-15	13	47	75	60	69	62	**41**	101	74	47			589
Oct-16	21	41	50	40	39	52	**15**	41	42	23			364
Oct-17	9	42	36	29	15	9	**1**	34	12	11			198
Oct-18	39	100	119	93	69	56	56	78	**50**	40			700
Oct-19	15	87	70	96	**31**	48	47	44	36	0			474
Oct-20	7	22	32	**19**	46	28	31	33	23				241
Oct-21		8	37	11	31	29	32	31	**4**				183
Oct-22		36	63	76	**11**	88	62	42	36				414
Oct-23		20	24	48	31	**9**	82	30	28				272

Appendix 1-3. **Actual counts of adult coho salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.**

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Oct-24													
Oct-25													
Oct-26													
Oct-27													
Oct-28	HIGH WATER PREVENTED COUNTING												
Oct-29													
Oct-30													
Oct-31													
Nov-01													
Nov-02	34	88	46	30	43	78	41	34					394
Nov-03	41	35	19	8	15	14	21	19					172
Nov-04	19	39	16	22	16	26	25	27					190
Nov-05	9	38	17	16	18	7	14	10					129
Nov-06	8	10	8	9	5	2	4	6					52
Nov-07	2	5	3	2	5	4	3	3					27
Nov-08	0	1	2	1	0	0	1	0					5

Appendix 1-4. Actual counts of jack coho salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Sep-11	20	34	6	14	3	1	5	2	8	3	5	2	103
Sep-12	4	4	1	3	4	3	14	16	5	9	1		64
Sep-13	9	18	34	33	22	14	15	13	12	12	6		188
Sep-14	13	14	7	15	20	18	11	9	8	1	1		117
Sep-15	13	46	45	46	34	43	51	46	41				365
Sep-16	13	48	33	47	38	45	44	51	40	54			413
Sep-17	13	43	52	30	40	33	49	23	21	36	20		360
Sep-18	34	76	49	43	12	45	57	43	**5**		30		394
Sep-19	39	58	48	56	48	33	**1**	51	29	26			389
Sep-20	35	52	39	**1**	15	16	23	30	16	32	16		275
Sep-21	39	46	**1**	41	33		22	51	21	23	11		288
Sep-22	58	40	28	16	26	38	28	32	30	**5**	3		304
Sep-23	56	62	52	40	38	29	**1**	43	29	30	14		394
Sep-24	12	32	17	26	15	27	14	24	**1**	17	1		186
Sep-25	23	26	**0**	41	22	21	32	19	18	20			222
Sep-26	8	14	5	18	20	17	**3**	20	17	10			132
Sep-27	10	19	18	15	30	**0**	15	13	12	9			141
Sep-28	8	17	20	15	11	14	**1**	30	17	12			145
Sep-29	17	36	**0**	33	20	19	14	26	23	11			199
Sep-30	19	21	**0**	38	19	23	18	28	15	16			197
Oct-01	14	15	18	35	17	28	**0**	37	25	7			196
Oct-02	3	9	12	8	13	**10**	8	8	14	14			99
Oct-03	3	9	2	**1**	9	2	2	4	6	2			40
Oct-04	1	6	6	**2**	6	6	7	3	6	0			43
Oct-05	1	4	4	4	9	8	**0**	**0**	14	8			52
Oct-06	1	3	6	1	**0**	4	12	3	10	2			42
Oct-07	3		8	4	9	**3**	11	24	6	8			76
Oct-08	5	6	7	4	**2**	5	23	15	12	11			90
Oct-09	1	10	13	7	10	4	13	**3**	7	4			72
Oct-10		11	10	8	**4**	16	13	16	8	4			90
Oct-11	1	14	8	**3**	18	9	4	13	8				78
Oct-12	2	**12**	14	7	12	15	6	20	7	5			100
Oct-13	2	13	**3**	5	7	7	10	4	13	11			75
Oct-14	3	7	4	5	7	2	**5**	7	4	4			48
Oct-15	3	7	7	7	6	6	**3**	10	5	3			57
Oct-16	2	5	5	2	4	4	**2**	8	2	5			39
Oct-17	0	11	5	3	2	1	**0**	1	3	0			26
Oct-18	0	4	8	4	6	3	6	4	**2**	2			39
Oct-19	0	4	4	2	**2**	1	5	2	5				25
Oct-20	0	3	5	**2**	3	3	2	9	1				28
Oct-21		0	0	0	0	0	2	3	**1**				6
Oct-22		0	1	1	**0**	3	3	3	2				13
Oct-23		0	3	3	1	**2**	6	1	2				18

Appendix 1-4. Actual counts of jack coho salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

	Hour of Day												
Date	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	Total
Oct-24													
Oct-25													
Oct-26													
Oct-27													
Oct-28	HIGH WATER PREVENTED COUNTING												
Oct-29													
Oct-30													
Oct-31													
Nov-01													
Nov-02	1	5	0	1	1	0	3	1					12
Nov-03	0	0	1	0	0	0	2	0					3
Nov-04	0	1	1	1	0	2	0	3					8
Nov-05	1	0	1	1	0	0	0	0					3
Nov-06	0	1	0	0	0	0	0	1					2
Nov-07	0	0	0	1	1	1	1	0					4
Nov-08	0	0	0	0	0	0	0	0					0

Appendix 1-5. Actual counts of sockeye salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

Date	Hour of Day												Total
	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
Sep-11	290	429	332	269	156	108	99	83	144	239	233	66	2448
Sep-12	392	380	288	278	286	219	194	174	204	194	60		2669
Sep-13	204	263	194	146	81	60	41	83	117	177	94		1460
Sep-14	182	299	246	272	133	138	72	98	62	87	34		1623
Sep-15	196	299	294	221	195	86	92	91	53				1527
Sep-16	156	237	179	165	162	118	274	157	163	151			1762
Sep-17	180	282	261	198	150	117	97	110	111	128	125		1759
Sep-18	319	264	226	139	90	79	88	156	**42**		109		1512
Sep-19	173	216	114	122	76	53	**0**	100	85	81			1020
Sep-20	202	216	142	**13**	87	39	50	39	43	105	78		1014
Sep-21	174	218	**15**	178	34		53	41	51	63	49		876
Sep-22	135	161	123	58	39	40	12	25	21	**9**	28		651
Sep-23	129	139	86	43	43	30	**1**	30	40	38	35		614
Sep-24	66	77	70	67	66	41	51	47	**3**	52	12		552
Sep-25	213	250	**13**	261	147	114	132	89	125	137			1481
Sep-26	234	308	181	156	126	95	**11**	145	153	155			1564
Sep-27	263	305	226	209	155	**35**	120	159	86	82			1640
Sep-28	186	265	180	175	134	117	**12**	106	75	58			1308
Sep-29	130	149	**32**	145	92	57	46	48	61	66			826
Sep-30	117	93	**20**	128	51	53	54	55	88	61			720
Oct-01	179	155	144	103	85	75	**6**	88	77	74			986
Oct-02	66	101	96	60	52	**29**	36	35	41	32			548
Oct-03	50	88	83	**6**	155	74	77	139	138	127			937
Oct-04	194	209	218	**11**	420	212	246	257	277	296			2340
Oct-05	260	325	467	345	360	252	**23**	**71**	445	356			2904
Oct-06	409	699	731	637	**52**	914	625	423	492	403			5385
Oct-07	560	763	909	856	807	**38**	1045	590	804	261			6633
Oct-08	581	887	951	682	**67**	1072	420	435	446	176			5717
Oct-09	275	819	885	952	768	579	544	**41**	379	186			5428
Oct-10		648	683	458	**96**	477	283	289	249	94			3277
Oct-11	103	359	381	**29**	271	157	100	130	102				1632
Oct-12	105	**333**	373	228	179	124	107	131	73	81			1734
Oct-13	79	198	**114**	139	76	63	65	80	59	79			952
Oct-14	56	174	114	98	47	59	**41**	41	56	22			708
Oct-15	43	125	115	62	51	52	**42**	86	48	42			666
Oct-16	25	75	82	50	34	41	**30**	83	47	24			491
Oct-17	19	70	62	32	29	36	**11**	60	48	20			387
Oct-18	15	41	78	66	59	66	47	61	**57**	30			520
Oct-19	9	34	53	42	**34**	48	31	34	34	0			319
Oct-20	9	34	40	**30**	35	29	31	34	28				270
Oct-21		2	9	24	23	27	32	32	**15**				164
Oct-22		7	13	20	**4**	46	23	40	16				169
Oct-23		7	14	30	24	**11**	51	20	28				185

Appendix 1-5. Actual counts of sockeye salmon at Stamp Falls Fishway, 1990. Bold numbers that are underlined indicate when verification tests were conducted.

Date	Hour of Day												Total
	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
Oct-24													
Oct-25													
Oct-26													
Oct-27													
Oct-28	HIGH WATER PREVENTED COUNTING												
Oct-29													
Oct-30													
Oct-31													
Nov-01													
Nov-02	4	7	6	5	5	5	7	4					43
Nov-03	8	4	3	2	4	4	4	4					33
Nov-04	12	9	14	14	12	29	20	19					129
Nov-05	15	12	14	12	17	15	12	10					107
Nov-06	11	13	11	10	10	12	9	11					87
Nov-07	7	12	11	8	12	10	15	6					81
Nov-08	7	15	9	4	2	10	8	2					57

APPENDIX 2

Appendix 2-1. Dead recovery and adipose clip recovery of chinook salmon in the Stamp River, 1990.

	Carcass Weir (a)						Above carcass weir						Below carcass weir						Total					
	(b) Total recovered			Adipose clipped recovered			Total recovered			Adipose clipped recovered			Total recovered			Adipose clipped recovered			Total recovered			Adipose clipped recovered		
Date	M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	M	F	J	M	F	J
Oct-05	7	3	0	0	0	0	1	3	0	0	0	0	30	30	2	1	1	0	38	36	2	1	1	0
Oct-06	3	4	0	0	0	0	3	0	0	0	0	0	6	7	0	0	1	0	12	11	0	0	1	0
Oct-07	7	1	0	0	0	0	4	2	0	0	0	0	8	5	0	0	1	0	19	8	0	0	1	0
Oct-08	1	3	0	0	0	0	6	1	0	1	0	0	26	9	0	1	0	0	33	13	0	2	0	0
Oct-09	5	3	0	0	0	0	12	12	2	2	1	0	10	13	0	0	0	0	27	28	2	2	1	0
Oct-10	6	2	1	0	0	0	5	19	3	0	0	0	52	47	6	0	1	0	63	68	10	0	1	0
Oct-11	5	8	0	0	0	0	7	10	2	0	1	0	38	28	2	6	1	0	50	46	4	6	2	0
Oct-12	15	9	0	1	0	0	43	56	2	1	0	0	37	46	4	3	0	0	95	111	6	5	0	0
Oct-13	16	12	2	2	0	0	40	40	0	4	3	0	21	36	0	0	3	0	77	88	2	6	6	0
Oct-14	4	3	1	2	0	0	63	51	1	1	1	0	35	33	2	0	0	0	102	87	4	3	1	0
Oct-15	48	19	0	4	1	0	106	58	3	7	1	1	61	70	4	0	4	0	215	147	7	11	6	1
Oct-16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-17	56	41	3	1	1	0	74	66	8	4	2	0	48	87	3	4	2	0	178	194	14	9	5	0
Oct-18	78	48	3	1	0	1	113	128	5	2	6	0	117	103	7	1	1	0	308	279	15	4	7	1
Oct-19	71	68	8	2	1	1	95	60	9	4	2	0	28	21	5	1	1	0	194	149	22	7	4	1
Oct-20	93	62	3	5	5	0	30	29	1	4	0	0	0	0	0	0	0	0	123	91	4	9	5	0
Oct-21	47	39	2	3	2	0	0	0	0	0	0	0	48	46	2	3	2	0	95	85	4	6	4	0
Oct-22	129	87	5	10	6	0	0	0	0	0	0	0	54	60	1	1	3	1	183	147	6	11	9	1
Oct-23	147	99	13	8	4	2	0	0	0	0	0	0	106	79	14	5	6	1	253	178	27	13	10	3
Oct-24	60	32	9	1	0	0	59	46	13	1	5	2	60	59	9	3	3	0	179	137	31	5	8	2
Oct-25	0	0	0	0	0	0	94	92	29	4	8	1	31	34	6	3	0	1	125	126	35	7	8	2
Oct-26	0	0	0	0	0	0	107	112	21	4	3	2	0	0	0	0	0	0	107	112	21	4	3	2
Oct-27	0	0	0	0	0	0	24	22	4	0	0	0	0	0	0	0	0	0	24	22	4	0	0	0
Oct-28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct-29	0	0	0	0	0	0	138	173	17	1	5	0	79	52	27	3	2	1	217	225	44	4	7	1
Oct-30	0	0	0	0	0	0	201	307	37	8	8	0	0	0	0	0	0	0	201	307	37	8	8	0
Oct-31	0	0	0	0	0	0	65	145	15	2	8	0	66	86	18	3	4	0	131	231	33	5	12	0
Total	798	543	50	40	20	4	1290	1432	172	50	54	6	961	951	112	38	36	4	3049	2926	334	128	110	14

(a) See Figure 18 for area locations.
(b) M=male, F=female, J=jack.

Appendix 2-2. Live recovery and adipose clip recovery of chinook salmon at Robertson Creek Hatchery, 1990.

Date	Total recovered			Adipose clipped recovered		
	M	F	J	M	F	J
Sep-12	0	1	0	0	1	0
Sep-21	1	0	1	0	0	0
Sep-25	19	4	108	0	0	5
Sep-27	0	0	0	0	0	0
Sep-28	0	1	0	0	0	0
Oct-01	0	3	2	0	0	0
Oct-02	107	1	230	5	1	3
Oct-03	1	27	0	1	3	0
Oct-04	749	95	383	34	10	8
Oct-05	682	205	256	28	1	9
Oct-06	5	114	0	1	2	0
Oct-07	5	106	0	0	0	0
Oct-08	1814	6	439	70	6	12
Oct-09	1361	267	188	54	3	7
Oct-10	1469	239	266	50	6	14
Oct-11	1518	332	328	74	9	7
Oct-12	787	329	141	33	2	8
Oct-13	1	97	0	0	0	0
Oct-14	35	4	14	2	4	0
Oct-15	1587	168	296	58	21	9
Oct-16	577	57	88	27	8	4
Oct-17	1209	175	146	58	10	3
Oct-18	441	132	84	19	2	4
Oct-19	1811	27	349	79	14	19
Oct-20	1241	440	235	50	8	10
Oct-21	1612	293	342	53	9	20
Oct-22	1649	280	451	69	3	16
Oct-23	317	153	2	13	0	0
Oct-24	1212	16	534	43	8	19
Oct-25	1820	260	1089	98	17	118
Oct-26	1035	438	538	40	7	20
Oct-27	1378	247	585	64	8	19
Oct-28	1171	173	694	34	17	33
Oct-29	726	414	531	28	5	14
Oct-30	178	193	148	4	1	3
Oct-31	487	68	388	18	8	5
Nov-01	119	91	91	3	1	2
Nov-02	1	11	0	0	0	0
Nov-03	20	2	9	1	1	2
Nov-04	16	8	0	0	8	0
Nov-05	437	14	459	14	9	9
Nov-06	38	83	15	1	0	1
Nov-07	224	8	201	11	2	1
Nov-08	26	37	8	0	0	0
Nov-09	97	10	95	17	0	3
Nov-10	0	12	0	0	0	0
Nov-11	0	0	0	0	0	0
Nov-12	15	0	3	0	0	0
Nov-13	62	14	76	1	0	1
Nov-14	2	1	0	1	0	0
Nov-15	12	0	9	1	0	0
Nov-16	12	1	12	2	0	1
Nov-17	7	7	12	0	0	0
Nov-18	10	1	7	1	0	0
Nov-19	11	1	16	1	0	0

Appendix 2-2. Live recovery and adipose clip recovery of chinook salmon at Robertson Creek Hatchery, 1990.

Date	Total recovered			Adipose clipped recovered		
	M	F	J	M	F	J
Nov-20	13	3	11	0	0	0
Nov-21	14	2	16	0	1	1
Nov-22	0	1	11	0	0	1
Nov-23	6	0	1	0	0	0
Nov-24	0	0	0	0	0	0
Nov-25	0	0	0	0	0	0
Nov-26	0	0	0	0	0	0
Nov-27	26	0	54	1	0	0
Nov-28	0	6	1	0	0	0
Nov-29	3	0	5	0	0	0
Nov-30	0	1	19	0	1	1
Total	28176	5679	9987	1162	217	412