A Comparison of the Catch Distribution, Harvest Rate and Survival of Wild and Cultured Salwein Creek Coho Salmon

N.D. Schubert and D.B. Lister

Field Services Branch
Department of Fisheries and Oceans
80–6th Street
New Westminster, British Columbia V3L 5B3

August 1986

Canadian Technical Report of
Fisheries and Aquatic Sciences
No. 1425

Canadian Technical Report of
Fisheries and Aquatic Sciences 1425

August 1986

A COMPARISON OF THE CATCH DISTRIBUTION, HARVEST RATE AND SURVIVAL OF WILD AND CULTURED SALWEIN CREEK COHO SALMON

by

N.D. Schubert and D.B. Lister[1]

Department of Fisheries and Oceans
Field Services Branch
80 - 6th Street
New Westminster, B.C.
V3L 5B3

[1] D.B. Lister and Associates Ltd.
P.O. Box 2156
Clearbrook, B.C.
V2T 3X8

Cat. No. Fs 97-6/1425E ISSN 0706-6457

Correct citation for this publication:

Schubert, N.D. and D.B. Lister. 1986. A comparison of the catch distribution, harvest rate and survival of wild and cultured Salwein Creek coho salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1425: 37p.

CONTENTS

	Page
LIST OF FIGURES	v
LIST OF TABLES	vi
LIST OF APPENDICES	vii
ABSTRACT/RÉSUMÉ	viii
INTRODUCTION	1
STUDY AREA DESCRIPTION	1
STUDY DESIGN	4
METHODS	5
CATCH SAMPLING	5
ESCAPEMENT ESTIMATION	5
Salwein Creek	5
Precocious Males (1982-83)	5
Adults (1983-84)	5
Chilliwack River Hatchery	7
Other Tributaries	7
STATISTICAL ANALYSES	7
RESULTS	8
CATCH DISTRIBUTION	8
ESCAPEMENT	14
Salwein Creek	14
Estimation Bias	14
Chilliwack River Hatchery	14
Estimation Bias	14
Other Tributaries	14
SURVIVAL	16
SIZE	17
DISCUSSION	17
ESCAPEMENT ESTIMATION BIAS	17
CATCH DISTRIBUTION	19

CONTENTS

	Page
SIZE	19
SURVIVAL	20
HARVEST RATE	20
STRAYING	21
MANAGEMENT IMPLICATIONS	22
SUMMARY	23
ACKNOWLEDGEMENTS	24
LITERATURE CITED	24
APPENDICES	27

LIST OF FIGURES

Figure		Page
1.	Vedder-Chilliwack River system location map	2
2.	Salwein Creek study area location map	3
3.	Map of major British Columbia commercial catch regions	6
4.	Distribution of the catch of wild and combined cultured groups among the major fisheries. Percentages are based on the estimated total number of CWT's taken in each fishery	11
5.	Seasonal distribution of the catch of wild and combined cultured groups in the Georgia Strait and freshwater sport fisheries. Monthly percentages are based on the estimated numbers of CWT's taken in each fishery	13

LIST OF TABLES

Table		Page
1.	Summary of release information for wild and cultured Salwein Creek coho salmon smolts	4
2.	Annual precentage fishery contribution of cultured and wild Salwein Creek coho salmon	9
3.	Estimated tag recoveries of cultured and wild Salwein Creek coho salmon in major British Columbia and Washington state fisheries	10
4.	Percentage distribution of cultured and wild Salwein Creek coho salmon among the major British Columbia hook and line fisheries and among the northern and southern approach net fisheries	12
5.	Seasonal distribution of CWT recoveries from age 3 cultured and wild Salwein Creek coho salmon in commercial troll and net fisheries	12
6.	Summary of escapement by CWT group of Salwein Creek coho salmon, 1982-83 and 1983-84	15
7.	Estimated survivals, fishery contributions and harvest rates of cultured and wild Salwein Creek coho salmon	16
8.	Fork length of cultured and wild Salwein Creek coho salmon in the west coast of Vancouver Island troll fishery, July 1983	17
9.	Postorbital-hypural plate length of cultured and wild Salwein Creek coho adults on the spawning grounds	18
10.	Effect of potential escapement estimation error on the estimated survival and harvest rate of cultured and wild Salwein Creek coho salmon	18
11.	Observed percentages of precocious male and adult Salwein Creek coho salmon straying from the site of smolt release	22

LIST OF APPENDICES

Appendix	Page
1a. Observed and estimated recoveries of hatchery release Salwein Creek coho salmon (Code 02 22 31)	28
1b. Observed and estimated recoveries of spot release Salwein Creek coho salmon (Code 02 21 14)	30
1c. Observed and estimated recoveries of 24 h release Salwein Creek coho salmon (Code 02 22 46)	32
1d. Observed and estimated recoveries of wild release Salwein Creek coho salmon (Code 02 21 15)	34
2. Projected survival of Salwein Creek coho salmon at different levels of escapement estimation error	36
3. Projected harvest rates of Salwein Creek coho at different levels of escapement estimation error	37

ABSTRACT

Schubert, N.D. and D.B. Lister. 1986. A comparison of the catch distribution, harvest rate and survival of wild and cultured Salwein Creek coho salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1425: 37 p.

Wild and cultured groups of 1980 brood Salwein Creek coho salmon (**Oncorhynchus kisutch**) were coded wire tagged and released as smolts in spring, 1982. Subsequent catches and escapements were examined to assess between-group differences in catch distribution, survival, harvest rate and fish size. No difference was noted in catch distribution or in fish size in the catch or the escapement. The wild group survived at a significantly higher rate (16.3% vs 12.4%) and contributed to the fisheries at a slightly higher rate (11.6% vs 9.8%). The wild group recruited to the commercial and sport fisheries earlier, while cultured groups were harvested at a higher average rate (81.5% vs 72.6%); however, the latter difference may in part reflect escapement estimation biases.

Key words: Salwein Creek coho, wild and cultured comparison, fish size, harvest distribution, survival, harvest rate, recruitment timing.

RÉSUMÉ

Schubert, N.D. and D.B. Lister. 1986. A comparison of the catch distribution, harvest rate and survival of wild and cultured Salwein Creek coho salmon. Can. Tech. Rep. Fish. Aquat. Sci. 1425: 37 p.

Des groupes de saumon coho sauvage et d'élevage de 1980 du ruisseau Salwein ont été étiquetés avec des fils codés puis libérés au stade de saumoneau au printemps de 1982. On a examiné les prises subséquentes et les remontes afin d'évaluer les différences entre les groupes pour ce qui est de la distribution des prises, de la survie, du taux d'exploitation et de la taille du poisson. On n'a noté aucune différence dans la distribution des prises ni dans la taille du poisson pris ou du poisson de remonte. Le taux de survie du groupe de saumon sauvage était beaucoup plus élevé que celui du saumon d'élevage (16.3% comparativement à 12.4%). Le saumon sauvage représentait aussi une partie légèrement plus grande des prises (11.6% comparativement à 9.8%). Ce groupe a été recruté plus tôt dans le cas de la pêche sportive; cependant, le taux d'exploitation du groupe de saumon d'élevage a été beaucoup plus élevé (81.5% comparativement à 72.6%). Il se peut toutefois que cette différence résulte en partie d'erreurs dans les estimations des remontes.

Mots-clés: coho du ruisseau Salwein, comparaison entre groupes sauvages et groupes d'élevage, taille du poisson, distribution des prises, survie, taux d'exploitation, temps du recrutement.

INTRODUCTION

The management of coho salmon (**Oncorhynchus kisutch**) in British Columbia is largely passive, with harvest management plans established in the absence of harvest rate or escapement goals. The development of more sophisticated approaches has been inhibited by the quality of existing coho stock assessment information. Coho salmon have long been recognized as among the most difficult salmon species to study, due both to the mixed stock nature of their marine distribution and to spawner characteristics which make escapement estimation difficult (Anon. 1969, 1984). As a result, improved stock assessment information, an important prerequisite for active management, is required in order to define current stock status and to evaluate future management actions.

The survival, harvest rate and catch distribution of Fraser River coho salmon have been evaluated through a number of coded wire tagging (CWT) studies (Schubert 1982, Fedorenko and Cook 1982, Hutton **et al.** MS 1983, Schubert and Fedorenko 1985, Schubert **et al.** 1985); however, the usefulness of these data has been limited by high costs which have restricted study to a few stocks over short time periods. The advent of large scale coho enhancement in the Fraser River system in 1980 provided an opportunity to obtain such data at a substantially reduced cost. Because CWT's are applied to a segment of all hatchery production, these data could be useful to wild stock management if the catch distribution, survival and harvest rate of wild and cultured stocks were similar. The purpose of this study, therefore, was to assess these parameters in the wild and cultured components of a single stock in a preliminary investigation of the feasibility of managing wild stocks on the basis of hatchery production assessment information.

This report summarizes the study design and juvenile treatments, presented in more detail by Schubert (1984), and describes harvest and escapement estimation techniques and the observed catch distribution, survival and harvest rate of the cultured and wild CWT groups. The report concludes with a discussion of the implications of the study results to coho salmon management.

STUDY AREA DESCRIPTION

The study area is located in the Vedder-Chilliwack River system, a major salmon and steelhead trout system which originates in the Cascade Mountains of Washington State and flows in a westerly direction for approximately 94 km before entering the Fraser River near Chilliwack, B.C. (Fedorenko and Cook 1982) (Fig. 1). Annual discharge in the Vedder-Chilliwack River averaged 68 m^3/sec during the period 1911 to 1984 (Environment Canada 1985). The main study site was Salwein Creek, a small lowland tributary which enters the Vedder portion of the Vedder-Chilliwack River approximately 7 km upstream from the Fraser River (Fig. 2). The creek, which has a total length of approximately 3.2 km, flows in a number of branches through farmland drainage ditches. A portion of the creek located 0.8 km upstream from the creek mouth was excavated by the Department of National Defence to form a large pond. A semi-permanent enumeration trap, constructed in a fishway at the pond outflow, was used for escapement enumeration during this study.

The cultured coho smolts used in this study were reared at Chilliwack River Hatchery, a Department of Fisheries and Oceans (DFO) enhancement facility which became operational in 1980. The hatchery is located on the Chilliwack River at the confluence of Slesse Creek, approximately 34 km upstream from the Fraser River. Other areas within the Vedder-Chilliwack system which were assessed during this study are detailed in Fig. 1.

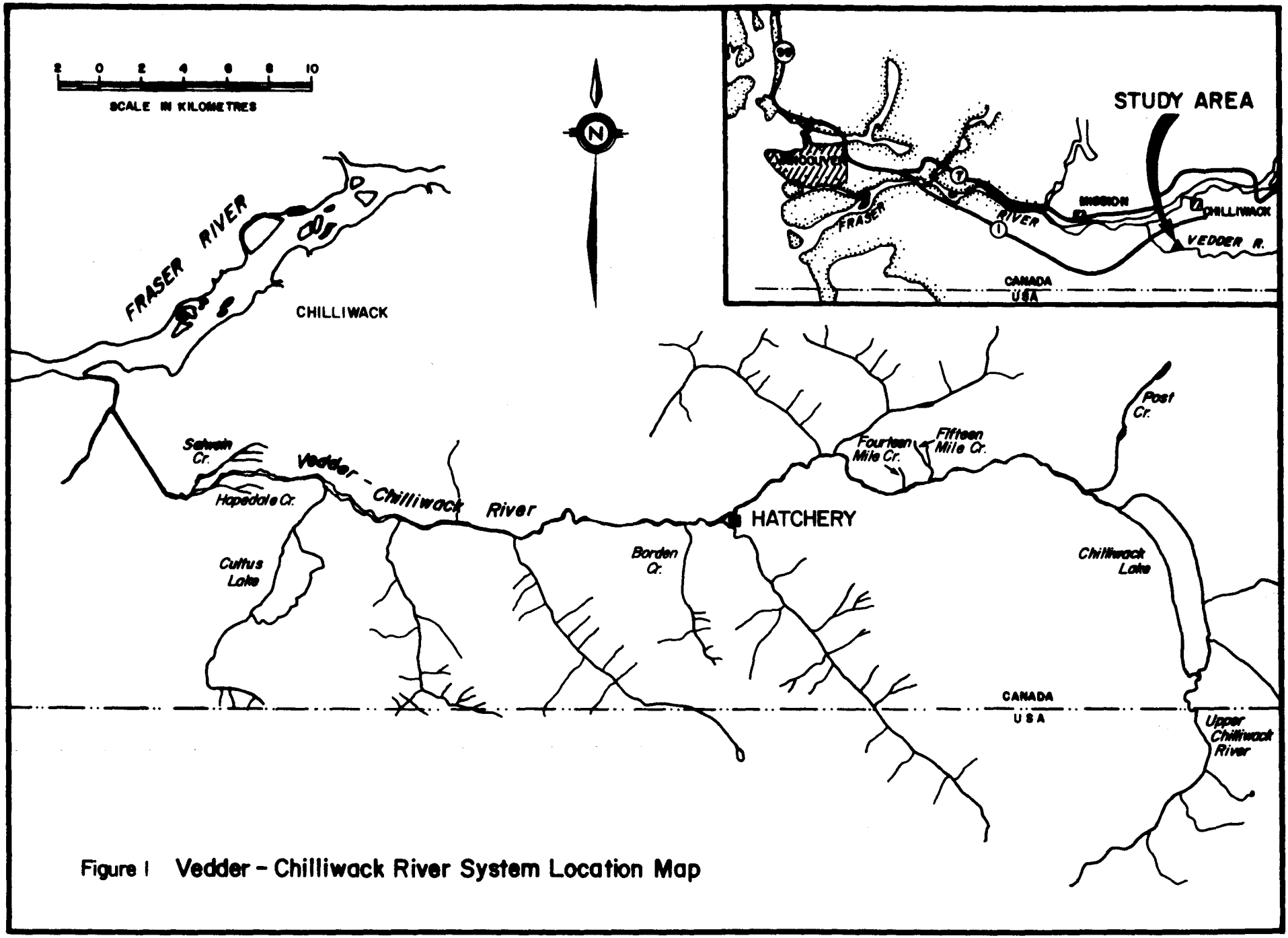
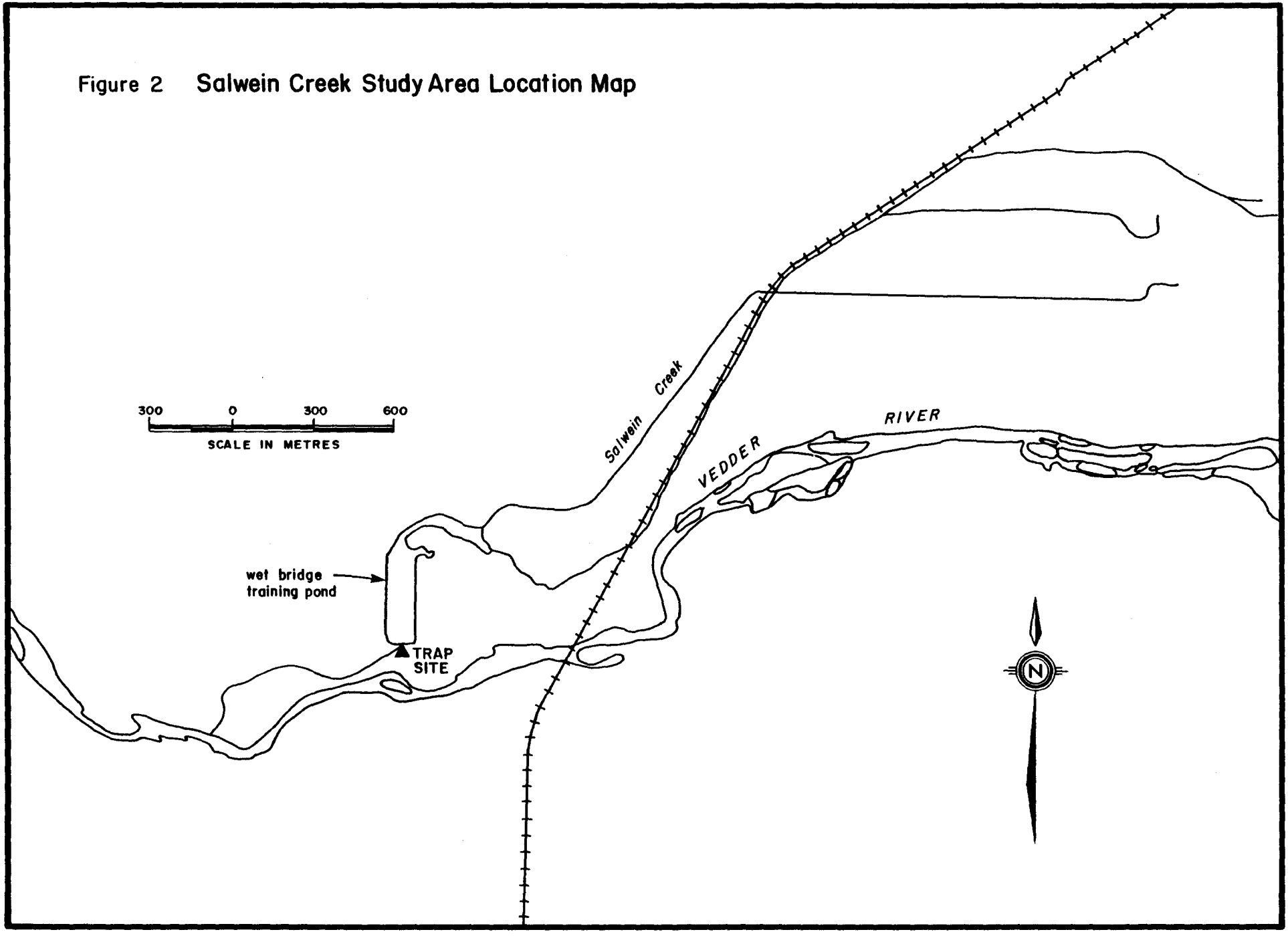


Figure 1 Vedder - Chilliwack River System Location Map

Figure 2 Salwein Creek Study Area Location Map



STUDY DESIGN

The study was designed to determine the effects of hatchery culture on total contribution to fisheries and on the distribution of that contribution among marine commercial and sport fisheries by comparing CWT groups of cultured and wild coho from the same stock. The numbers of tagged smolts released were intended to enable detection of a 25% difference between groups in survival to catch in four major fisheries: the Georgia Strait commercial troll fishery, the Georgia Strait sport fishery, the west coast of Vancouver Island troll fishery, and the combined Puget Sound sport and commercial fisheries. The actual distribution and number of CWT recoveries permitted an analysis more detailed than originally planned.

Coho brood stock for hatchery culture was obtained from the trap in Salwein Creek. Brood stock was collected throughout the run, from December 14, 1980 to February 6, 1981, to obtain a representative sample of the Salwein stock. Fifty-one females were crossed with 34 males to produce approximately 118,000 fertilized eggs. The female coho taken for the study comprised a significant proportion of the observed Salwein Creek escapement in the winter of 1980-81; however, the actual proportion taken was unknown because total escapement was not adequately assessed. Egg incubation and juvenile rearing to the smolt stage were carried out at Chilliwack River Hatchery. Survival from egg collection to release of one year old smolts approximated 74%. All release groups were subjected to the same water supplies, facilities and rearing conditions.

The cultured smolts were tagged at Chilliwack River Hatchery and released in three groups as part of a separate study to assess the effects of release strategies on straying of returning adults within the Chilliwack River system. The cultured groups were released (1) at Chilliwack River Hatchery, (2) directly into lower Salwein Creek, and (3) into lower Salwein Creek after holding in pens within the creek. They are referred to in subsequent sections as the "hatchery release", "spot release" and "24 h release" respectively. The latter group was to be held in the creek for 15 days before release to determine the effect of additional imprinting on adult homing. Poor conditions in the pens necessitated release of this group into Salwein Creek after approximately 24 h. Size and time of release of each group are presented in Table 1.

Wild coho smolts were tagged as they emigrated through an enumeration fence on lower Salwein Creek. A minor portion (4.7%) of the tagged wild group was captured in minnow traps set in the

Table 1. Summary of release information for wild and cultured Salwein Creek coho salmon smolts.

Group	*Number released	Release date	Mean weight at release (g)
Hatchery release	19,354	May 10	22.8
Spot release	19,359	May 17	23.8
24 h release	19,982	May 6	21.0
Wild	11,776	Apr 23-Jun 18	10.5

* Adjusted for long term CWT loss (see Fleming and Schubert MS 1986).

creek downstream of the fence. Coho smolts emigrated primarily between early May and mid June, with the 10%, 50% and 90% migrations occurring on May 9, May 22 and June 8 respectively. Size at release is presented in Table 1.

METHODS

CATCH SAMPLING

A coast-wide catch sampling program, supported by government management agencies in British Columbia and the Pacific Coast states of Alaska, Washington, Oregon and California, was conducted throughout the fishing season to enable estimation of fishery contributions of particular marked salmonid groups.

In British Columbia, commercial catch statistics were compiled by the Department of Fisheries and Oceans for 32 statistical areas and 14 catch regions (statistical area aggregates). Salmon landings by the commercial fishery were sampled with the objective of examining 20% of the catch by gear type, week and statistical area (J.E. Sager & Associates 1985). The 20% catch sampling level has been adopted by all agencies participating in the coast-wide mark recovery program. The fishery contribution of each marked group was estimated, by area and time, from the number of actual recoveries and the estimated proportion of the catch examined for marks. For purposes of this study, estimates of marked fish contributions were developed by major catch region (Fig. 3) and gear. Size data (fork length to nearest mm) and scale samples were also obtained from a random sample of the commercial catch in each area and time period.

Tag recoveries in the British Columbia marine and freshwater sport fisheries were obtained on a voluntary basis from fishermen who return the heads of adipose clipped fish to a network of 195 head depots distributed throughout the province. Voluntary returns represent only a portion of the total number of sport caught tagged fish. The tag reporting rate, also termed the "awareness factor", can vary significantly between areas and time periods (Kimura 1976; Palermo MS 1985). In Georgia Strait, the reporting rate was determined from the estimated catch of adipose clipped coho reported by a year round creel census program (Shardlow **et al.** 1985). In the Fraser River system, the reporting rate was estimated in a similar way from a creel census program conducted during the fall and winter of 1984 (DPA MS 1985).

Although Salwein Creek coho were also vulnerable in the native subsistance fishery on the Fraser River, contributions could not be estimated because the fishery was not sampled and voluntary head returns were unavailable.

ESCAPEMENT ESTIMATION

Salwein Creek

Precocious Males (1982-83): The escapement of adipose clipped precocious males to Salwein Creek was monitored at the trap from December 3, 1982 to March 3, 1983. Catch was removed daily and enumerated by species, sex and adipose status. Adipose clipped precocious males were killed to determine the CWT code and all other fish were either retained for use in hatchery culture or released above the trap. The trap was inoperative from December 23 to January 3 and on January 10 due to inadequate staffing and high flows respectively, and after January 23 trap monitoring was sporadic and daily records were not maintained. As a result, escapement records were incomplete. An independent estimate was not made.

Adults (1983-84): The escapement of adipose clipped coho adults was monitored at the trap from November 25, 1983 to February 10, 1984; however, the trap was inoperative from December 21 to 28 and January 4 to 7 due to ice formation and high flows respectively. Since the trap could not provide a reliable es-

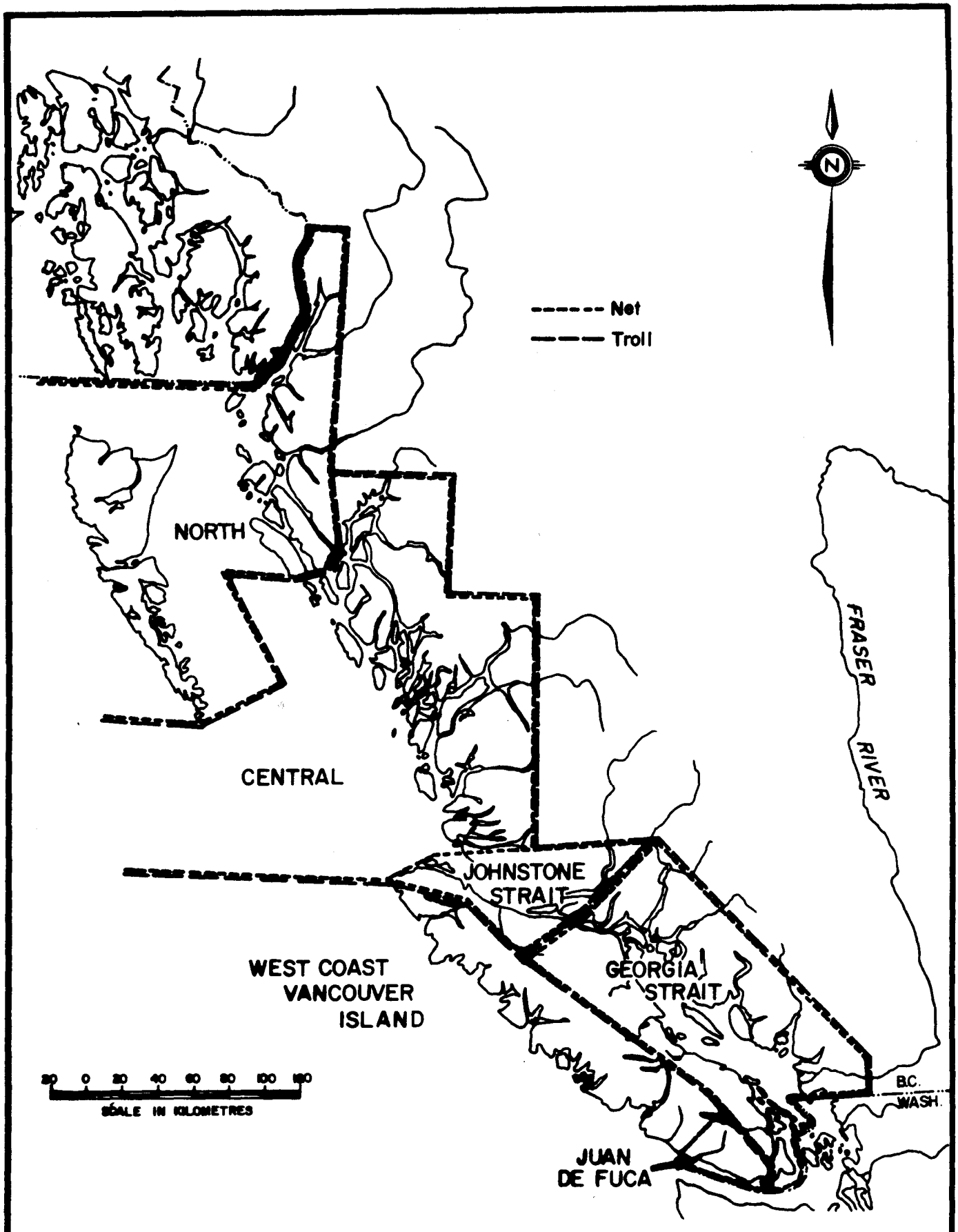


Figure 3 Map of Major British Columbia Catch Regions

capement estimate, a mark-recapture program was implemented on January 10. After that date, approximately 80% of the adult catch was marked with a disk tag and secondary mark prior to release above the trap. Adult coho were also dip netted from holding pools near the spawning grounds on January 11 in order to similarly mark that portion of the population which had migrated into the creek before that date.

The spawning grounds were surveyed on foot three times per week between January 13 and February 16, 1984. Live adults were enumerated visually and all carcasses were sampled, cut in two with a machete to avoid recounting on subsequent surveys and returned to the stream. Each carcass was first examined for a secondary mark and then for a disk tag to reduce the bias from examining disk tagged fish more closely for secondary marks than untagged fish. Size (postorbital-hypural plate length to nearest 0.5 cm), sex and adipose condition data and scale samples were obtained from all carcasses and, for adipose clipped individuals, the head was removed for later CWT recovery and decoding.

The escapement of adult coho salmon to Salwein Creek was calculated from the disk tagging data using the adjusted Petersen formula (Chapman modification) (Ricker 1975). Confidence limits ($p < 0.05$) were calculated using Pearson's formula. The return of adipose clipped coho adults was estimated by applying the observed proportion of adipose clipped adults in the carcass recovery sample to the population estimate. Confidence limits ($p < 0.05$) were calculated by applying the 95% confidence limits of the proportion to the upper and lower limits of the population estimate. Population estimation procedures are described in detail by Fleming and Schubert (MS 1986).

Chilliwack River Hatchery

Coho salmon returns were monitored at a trap located at the hatchery outflow from September 1, 1982 to January 19, 1983 and August 25, 1983 to March 2, 1984. The daily catch was enumerated by species, sex and adipose status. All adipose clipped precocious males were killed for CWT recovery. Adult coho returning in 1983-84 were sorted by time period and sex into one of six channels (early - August 25 to October 30; middle - October 31 to November 15; late - November 16 to March 2) where they were held until mature. After spawning, a sample of heads from each group was removed for CWT recovery and decoding.

Other Tributaries

Straying of Salwein Creek coho to other tributaries in the Vedder-Chilliwack system was assessed during DFO activities independent of this study. Marked fish were enumerated at fence traps in Post Creek from November 5 to December 23, 1982 and November 4, 1983 to January 4, 1984, and in the upper Chilliwack River from September 29 to October 15, 1982 and September 30 to November 3, 1983. CWT's were recovered from all adipose clipped precocious males and from adipose clipped adults removed as hatchery brood stock.

Foot surveys were conducted during 1983-84 in Borden Creek on February 6, Hopedale Creek on February 16, Fourteen Mile Creek on January 10 and Fifteen Mile Creek on January 10 and February 6, 1984. Coho carcasses were enumerated and heads were removed from adipose clipped carcasses for CWT recovery and decoding. No surveys were conducted in 1982-83.

STATISTICAL ANALYSES

Catch distributions of the four tagged groups in the principal marine fisheries, the commercial troll and the Georgia Strait sport fishery, were analysed by chi-square tests of independence with correction for continuity (Sokal and Rohlf 1981). These tests employed the actual number of tag recoveries in each geographic area, not the estimated

number which was based on expansion factors of varying magnitude. Catch data by area were grouped to provide a minimum of 15 recoveries from any one geographic area being tested. Statistical comparisons were made first among the three cultured groups and, if no significant differences were found, between the combined cultured groups and the wild group.

Seasonal distribution of CWT recoveries in the commercial troll and net fisheries was also examined by chi-square in the same manner as the geographic distribution. Though observed numbers of recoveries in October, the last month of the fishing season, were relatively low (4 to 15 recoveries per group), all expected values in the chi-square analysis exceeded the recommended minimum of five. The seasonal distribution of cultured (combined) and wild group CWT recoveries in the Georgia Strait sport fishery was analysed by a more sensitive statistical test, the Lee-Desu test (Lee and Desu 1972), which has previously been applied in the analysis of survival curves. This test generates a D statistic which is distributed as chi-square with g-1 degrees of freedom, where g equals the number of groups being compared.

There were generally insufficient fish length samples from a given sampling stratum, i.e. by gear, catch region and month, to support statistical analysis. As a result, only the stratum with the largest sample size, the west coast of Vancouver Island in July, 1983, was subjected to analysis. One-way analysis of variance (ANOVA) (Sokal and Rohlf 1981) was employed to test for length differences between the four tagged groups. Spawning ground length samples, which were treated as a single sampling stratum, were similarly tested using one-way ANOVA.

The survival rate of the wild group was compared with the mean survival rate of the three cultured groups by a Student's t-test in which one of the two samples, the wild group, was represented by a single variate which did not contribute to either degrees of freedom or the estimate of within-group variance (Sokal and Rohlf 1981). The variance in cultured group survival rates was taken as the variance estimate for purposes of this test. Degrees of freedom were n-1 where n equals the number of groups (3). The test determined the likelihood that the single wild group had come from a population with the same mean as the cultured groups. Both the rates of contribution to fisheries and total survival to catch and escapement were compared in this manner. Harvest rates, defined as the ratio of catch during the second ocean year to the sum of that catch plus adult (age 3_2) escapement, were examined by the same procedure. More sensitive tests, such as the G-test (Sokal and Rohlf 1981), were avoided in order to minimize the possibility of a Type I error.

Because escapements of precocious males (age 2_2) were considered to be minimum estimates, only the more reliable data for age 3_2 fish were used in the analysis of harvest rates. This procedure is more meaningful in a biological context since the egg potential of the escapement is almost entirely dependent on females maturing at age 3_2, and in a fishery management context since the major marine fisheries primarily harvest maturing adults.

RESULTS

CATCH DISTRIBUTION

Contribution to the fisheries was estimated as 7,090, including 5,727 from the three cultured groups and 1,363 from the wild group. Monthly CWT recovery data and estimated recoveries by fishery and month are shown for each tagged group in Appendix 1.

Salwein coho contributed to fisheries primarily in the second ocean year (1983) and as mature fish on the spawning run in that year. A small sport

fishery contribution occurred in 1984; however, this reflected a freshwater catch during the early months of 1983-84 and, in Georgia Strait, a possible delay in the voluntary return of fish actually captured in 1983. Annual percentage contributions of cultured and wild groups to fisheries are compared in Table 2. The marine catch was taken over a broad geographic range. CWT's were recovered in the troll fisheries in Alaska and Oregon; however, most marine exploitation, 86% of cultured and 89% of wild catch, occurred in southern British Columbia waters, i.e. Georgia, Johnstone and Juan de Fuca straits and the west coast of Vancouver Island.

The cultured and wild groups were similarly distributed among the eight major fisheries in British Columbia and along the Washington coast (Fig. 4 and Table 3). The Georgia Strait sport fishery was the largest single source of exploitation, accounting for over 40% in both wild and cultured groups.

Catches in the hook and line fisheries were considered to best represent ocean distributions. The distribution of cultured and wild groups between three major British Columbia troll and sport fishing areas, North and Central coast, west coast of Vancouver Island and Georgia Strait, is shown in Table 4. No significant differences in distribution were evident among cultured groups (chi-square; $p > 0.4$) or between the wild group and the combined cultured groups ($p > 0.5$).

Distributions were further analyzed by comparing catches in the net fisheries at the north and south approaches to Georgia Strait (Table 4). No significant differences were evident among cultured groups (chi-square; $p > 0.3$) or between the wild group and combined cultured groups ($p > 0.5$). This indicates that wild and cultured Salwein Creek coho reared in similar proportions in outside waters and returned to the river by similar routes.

Wild fish tended to contribute to marine commercial fisheries slightly earlier in the season than cultured fish (Table 5). Differences in monthly catch distribution among cultured groups were small and not statistically significant (chi-square; $p > 0.7$). The more pronounced difference in monthly catch distribution of the wild group and the combined cultured groups did approach statistical significance (chi-square; $p < 0.1$).

Salwein coho were caught in the Georgia Strait sport fishery throughout the year. As with the commercial fisheries, the wild group tended to contribute to the sport fishery earlier than the cultured groups (Fig. 5). Comparison of cumulative monthly catches indicated that timing differences between the wild and combined cultured groups were significant (Lee-Desu test; $p < 0.05$).

Table 2. Annual percentage fishery contribution of cultured and wild Salwein Creek coho salmon.

Group	1982	1983	1984
Cultured	1.6%	97.9%	0.5%
Wild	1.4%	98.4%	0.2%

Table 3. Estimated tag recoveries of cultured and wild Salwein Creek coho salmon in major British Columbia and Washington state fisheries.

Fishery*	Cultured groups				Wild group
	Hatchery release	Spot release	24 h release	Cultured total	
North and central coast troll	185 (9.5%)	127 (6.4%)	140 (7.8%)	452 (7.9%)	105 (7.7%)
West coast Vancouver Island troll	337 (17.3%)	407 (20.6%)	394 (21.9%)	1,138 (19.9%)	291 (21.4%)
Georgia Strait troll	224 (11.5%)	221 (11.2%)	126 (7.0%)	571 (10.0%)	138 (10.1%)
Georgia Strait sport	753 (38.6%)	804 (40.7%)	766 (42.5%)	2,323 (40.6%)	621 (45.6%)
Washington sport and troll	27 (1.4%)	43 (2.2%)	36 (2.0%)	106 (1.9%)	24 (1.8%)
Freshwater sport	133 (6.8%)	118 (6.0%)	149 (8.3%)	400 (7.0%)	73 (5.4%)
British Columbia net	235 (12.1%)	197 (10.0%)	134 (7.4%)	566 (9.9%)	86 (6.3%)
Washington net	40 (2.1%)	52 (2.6%)	54 (3.0%)	146 (2.6%)	21 (1.5%)
Miscellaneous sport and troll	15 (0.8%)	7 (0.4%)	3 (0.2%)	25 (0.4%)	4 (0.3%)
Totals	1,949	1,976	1,802	5,727	1,363

* All fisheries are in British Columbia coastal waters unless otherwise indicated.

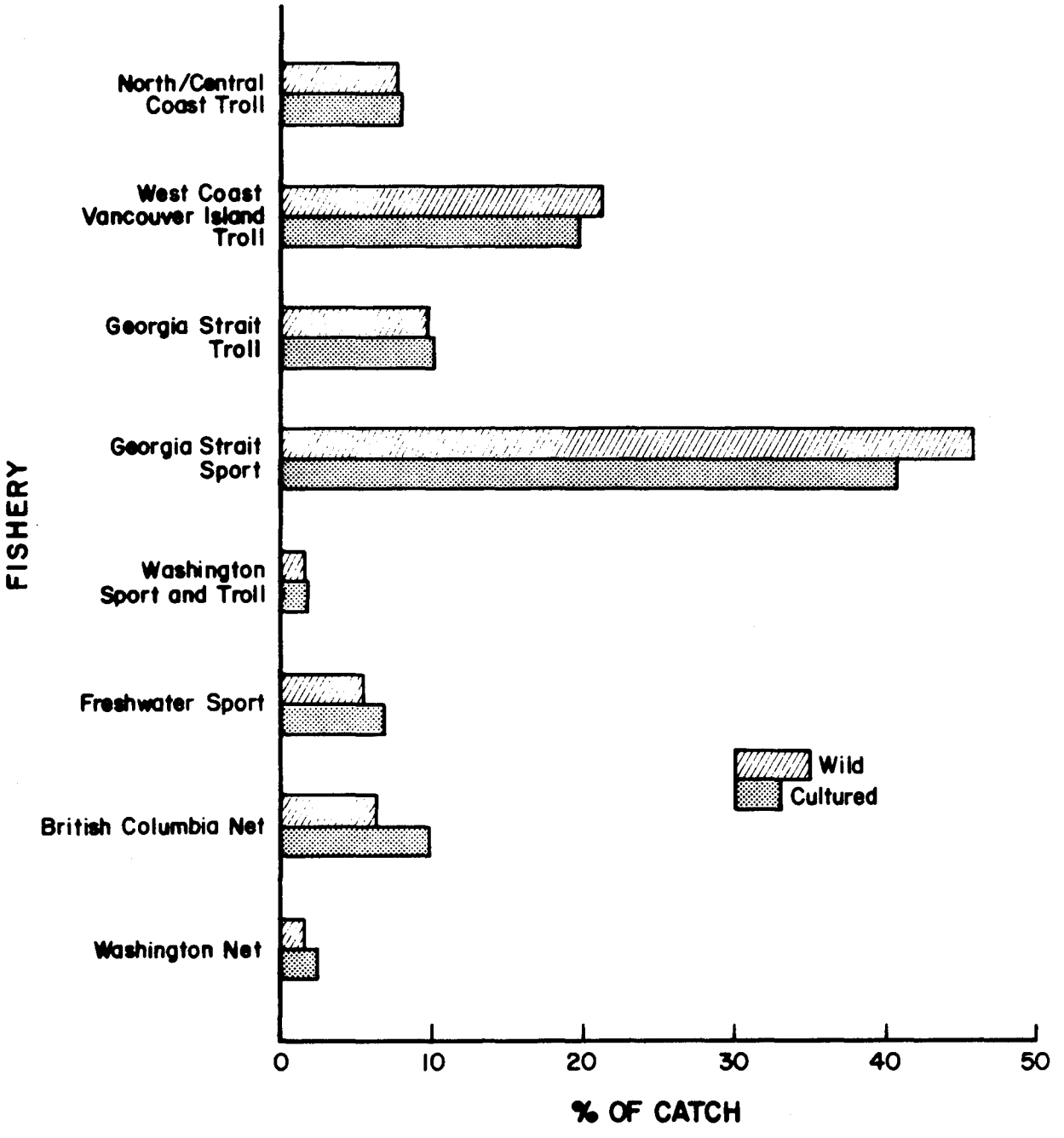


Figure 4 Distribution of the catch of wild and combined cultured groups among the major fisheries. Percentages are based on the estimated total number of CWT s taken in each fishery.

Table 4. Percentage distribution of cultured and wild Salwein Creek coho salmon among the major British Columbia hook and line fisheries and among the northern and southern approach net fisheries.*

Fishery	Cultured groups: Hatchery release	Spot release	24 h release	Cultured total	Wild group
Hook and line fisheries					
North and central coast troll	8.4% (28)	5.4% (19)	6.1% (20)	6.6% (67)	5.8% (15)
West coast Vancouver Island troll	14.1% (47)	15.2% (53)	17.0% (56)	15.4% (156)	14.8% (38)
Georgia Strait sport and troll	77.5% (258)	79.4% (277)	76.9% (253)	77.9% (788)	79.4% (204)
Net fisheries					
Johnstone Strait net	68.9% (42)	56.1% (37)	56.4% (22)	60.8% (101)	53.6% (15)
Juan de Fuca Strait and Puget Sound net	31.1% (19)	43.9% (29)	43.6% (17)	39.2% (65)	46.4% (13)

* Percentages based on numbers of tag recoveries shown in brackets.

Table 5. Seasonal distribution of CWT recoveries from age 3 cultured and wild Salwein Creek coho salmon in commercial troll and net fisheries.

Group	July	August	September	October	Total number of recoveries
Hatchery release	35.1% (59)	30.4% (51)	25.6% (43)	8.9% (15)	168
Spot release	42.2% (70)	31.3% (52)	18.7% (31)	7.8% (13)	166
24 h release	36.9% (48)	34.6% (45)	21.5% (28)	6.9% (9)	130
Cultured total	38.2% (177)	31.9% (148)	22.0% (102)	8.0% (37)	464
Wild release	48.9% (46)	33.0% (31)	13.8% (13)	4.3% (4)	94

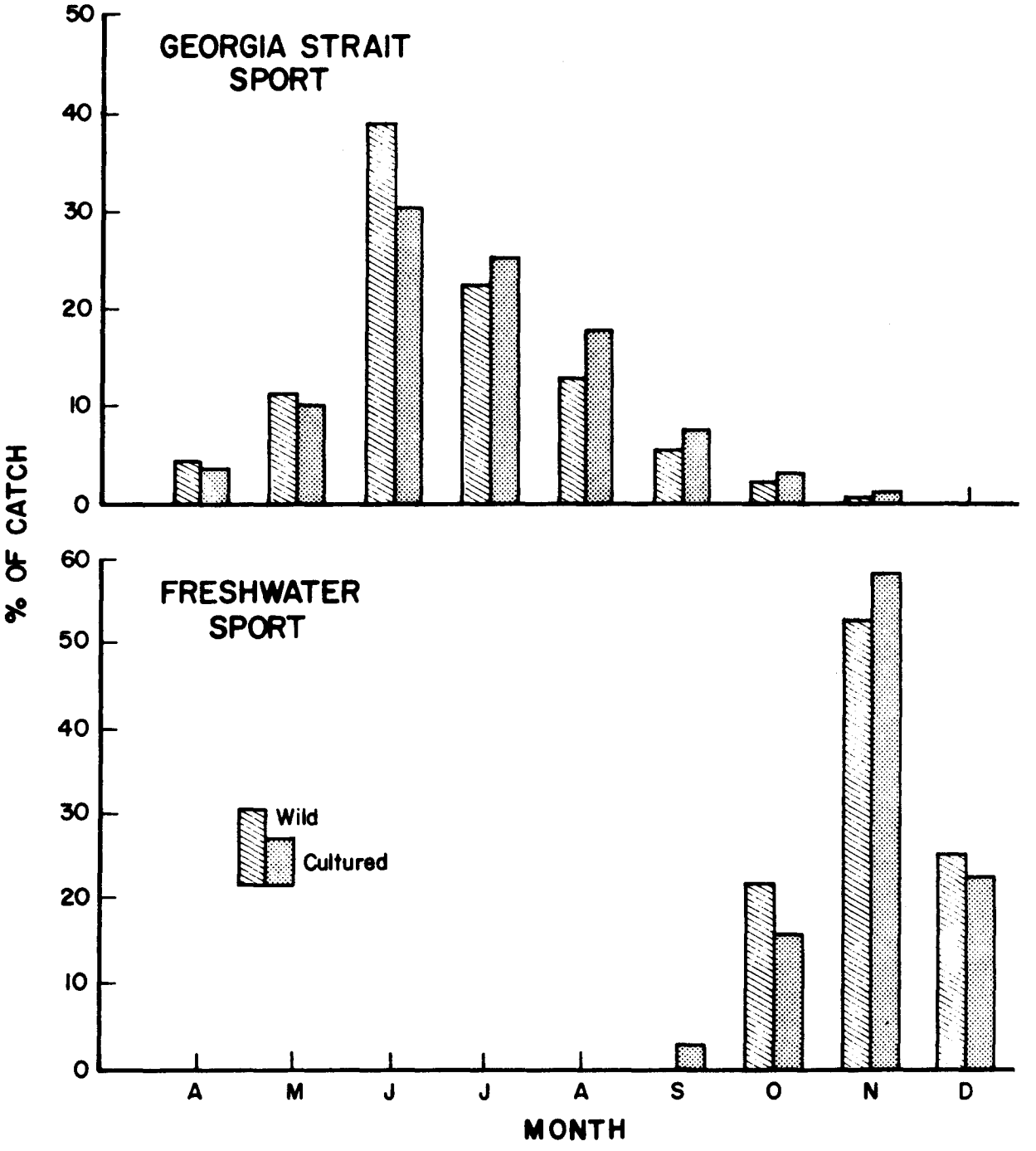


Figure 5 Seasonal distribution of the catch of wild and combined cultured groups in the Georgia Strait and freshwater sport fisheries. Monthly percentages are based on the estimated numbers of CWTs taken in each fishery.

ESCAPEMENT

The escapement of coded wire tagged precocious male and adult Salwein Creek coho salmon was estimated at 2,100, including 1,549 from the three cultured groups and 551 from the wild group. The escapement of tagged adult coho was estimated at 1,281 and 507 for the three cultured groups and the wild group respectively. Individual escapements to Salwein Creek, Chilliwack River Hatchery and other Vedder-Chilliwack tributaries are reported by CWT group in Table 6.

Salwein Creek

The escapement of precocious male coho to Salwein Creek in 1982-83, based on incomplete counts at the trap, was 306, including 297 which were marked with adipose clips. The escapement by CWT group is presented in Table 6. Since the trap did not operate through the entire migration period, these estimates represent minimum escapement levels for precocious males.

The escapement of adult coho to Salwein Creek in 1983-84 was estimated as 1,000, with 95% confidence limits of 1,360 and 734. The escapement of adipose clipped adult coho was estimated as 859, with 95% confidence limits of 1,211 and 612. The escapement by CWT group, estimated from a sample of 330 adipose clipped coho recovered on the spawning grounds, is presented in Table 6.

Estimation Bias: Fleming and Schubert (MS 1986) examined the mark-recapture data for biases related to fish size, sex, timing, tag loss and handling stress. Stress-related mortality was the only potentially serious problem noted. Thirty-two disk tagged fish, which remained torpid in the quiescent water above the fence until recovery, apparently suffered from handling stress and were eliminated from the tag application and recovery data. We speculate that similarly affected individuals may have passed through the fishway into the pond immediately above the trap. Since recovery efforts were ineffective in this area, and a correlation between condition at release and subsequent mortality was not noted, it was not possible to correct for this potential bias. As a result, the number of marked fish available for recovery may have been overestimated, producing a Type A error (Ricker 1975) and an overestimate of escapement. For example, if a number of tags equivalent to that recovered at the trap had been lost in the pond, the estimated escapement would be reduced from 1,000 to 754.

Chilliwack River Hatchery

The 1982-83 hatchery escapement of adipose clipped precocious male coho from all hatchery releases was 1,050. The escapement of Salwein Creek coho, estimated from a sample of 924, is presented in Table 6.

The escapement of adipose clipped adult coho in 1983-84 was 2,700. The escapement of Salwein Creek coho, estimated from samples of 482, 635 and 1,092 from the early, middle and late timing groups respectively, is presented in Table 6.

Estimation Bias: The enumeration trap at the Chilliwack River Hatchery was installed before the onset of migration of Salwein coho and removed after its completion. The trap operated without interruption through the entire coho migration period in both 1982-83 and 1983-84; however, a bias may have resulted if fish were hesitant to approach the trap and subsequently strayed to other areas.

Other Tributaries

No precocious males of Salwein Creek origin were recovered at traps in Post Creek or the upper Chilliwack River in 1982-83. In 1983-84, only three tagged adult coho of Salwein Creek origin were recovered in other spawning areas. The estimated escapement by CWT group was four from the 24 h release and

Table 6. Summary of escapement by CWT group of Salwein Creek coho salmon, 1982-83 and 1983-84.

Location	Estimated escapement				
	Hatchery release	Spot release	24 h release	Cultured total	Wild group
Precocious Males (1982-83)					
Salwein Creek	4	64	171	239	44
Chilliwack Hatchery	4	10	15	29	0
Misc.	0	0	0	0	0
Total	8	74	186	268	44
Adults (1983-84)					
Salwein Creek	3	150	170	323	505
Chilliwack Hatchery	377	272	305	954	0
Misc.	0	0	4	4	2
Total	380	422	479	1,281	507
Grand Total	388	496	665	1,549	551

Table 7. Estimated survivals, fishery contributions and harvest rates of cultured and wild Salwein Creek coho salmon.

	Cultured groups				
	Hatchery release	Spot release	24 h release	Cultured total	Wild group
Number of smolts released	19,354	19,359	19,982	58,695	11,776
Fishery contributions					
First ocean year	6	23	65	94	19
Second ocean year	1,943	1,953	1,737	5,633	1,344
Total	1,949	1,976	1,802	5,727	1,363
% of smolt release	10.1%	10.2%	9.0%	9.8%	11.6%
Escapement					
Precocious male[a]	8	74	186	268	44
Adult	380	422	479	1,281	507
Total	388	496	665	1,549	551
Survival to catch and escapement					
Total	2,337	2,472	2,467	7,276	1,914
% of smolt release	12.1%	12.8%	12.4%	12.4%	16.3%
Harvest rate[b]	83.6%	82.2%	78.4%	81.5%	72.6%

[a] Considered to be a minimum estimate of precocious male escapement (see Methods).
[b] Harvest rates calculated on the basis of catch during the second ocean year and adult (age 3) escapement.

two from the wild release returning to Borden and Post creeks respectively.

Straying was not monitored in a number of small tributaries located within 10 km of either Salwein Creek or the hatchery; however, coho escapements to those tributaries totalled only 270 and 250 in 1982-83 and 1983-84 respectively (Farwell **et al.** MS 1986). Inadequate assessment in those areas, therefore, was not expected to significantly bias study results.

SURVIVAL

The three cultured groups contributed at similar rates to the fishery and exhibited comparable total survival (Table 7). With respect to total survival, the highest group rate of 12.8% (spot release) exceeded the lowest (hatchery release) by only 0.7 percentage points. Survival of wild smolts was greater than that of cultured smolts on the average, in terms of both fishery contributions (11.6% versus 9.8%) and

total survival (16.3% versus 12.4%). Statistically, the difference in total survival was significant (t-test; $p < 0.02$) whereas the difference in fishery contribution was not ($p > 0.10$).

The cultured groups contributed relatively more to fisheries and less to escapement than the wild group. Harvest rates of cultured groups (78.4% to 83.6%) were higher than that of the wild group (72.6%); however, the difference was not statistically significant (t-test; $p > 0.2$).

SIZE

Sample sizes in the commercial fisheries were inadequate for the statistical analysis of length data in all but one sampling stratum, the west coast of Vancouver Island in July, 1983. Mean lengths of each tagged group in that fishery are shown in Table 8. Between-group differences in length were not statistically significant (ANOVA; $p > 0.3$).

Mean lengths of cultured and wild Salwein Creek coho adults sampled on the spawning grounds in 1983-84 are shown in Table 9. Between group differences in length were not detected (ANOVA; $p > 0.05$). Lengths were not recorded for precocious males in 1982-83.

DISCUSSION

ESCAPEMENT ESTIMATION BIAS

Escapements of Salwein Creek coho to the two main return sites, Salwein Creek and the hatchery, were assessed using techniques with inherently different estimation biases. The mark-recapture technique used in the creek tends to overestimate escapement if the underlying assumptions are not met (Cousens **et al.** 1982, Simpson 1984). In this study, underestimation of handling mortality may have produced a substantial but unquantified positive bias in the Salwein Creek escapement estimate. Escapement to the hatchery, on the other hand, was assessed using a technique which underestimates escapement when the underlying assumptions are not met. A negative bias in the hatchery escapement estimate may have occurred due to trap avoidance by returning Salwein Creek coho; however, a failure to detect significant straying of Salwein coho to other tributaries suggested that, if present, this bias was minor.

Table 8. Fork length of cultured and wild Salwein Creek coho salmon in the west coast of Vancouver Island troll fishery, July 1983.

Group	n	Fork length (mm) Mean	s	Range
Hatchery release	15	493	36	412-574
Spot release	30	486	40	407-598
24 h release	25	504	44	407-620
Wild release	26	491	30	433-556
Combined	96	493	38	407-620

Table 9. Postorbital-hypural plate length of cultured and wild Salwein Creek coho adults on the spawning grounds.

Group	MALE n	MALE Mean (mm)	MALE s	FEMALE n	FEMALE Mean (mm)	FEMALE s	TOTAL n	TOTAL Mean (mm)	TOTAL s
Wild Coho									
Unmarked	27	431	44.5	22	429	37.4	50	429	48.1
Marked	83	431	39.8	81	427	36.1	164	429	37.9
TOTAL	110	431	41.0	103	427	36.4	214	429	40.5
Cultured Coho									
Hatchery release	0	-	-	1	463	-	1	463	-
Spot release	17	412	42.0	34	413	27.9	51	413	32.7
24 h release	14	442	57.9	37	432	36.1	51	435	43.0
TOTAL	31	426	49.8	72	423	32.4	103	424	38.2

Table 10. Effect of potential escapement estimation error on the estimated survival and harvest rate of cultured and wild Salwein Creek coho salmon.

Escapement estimate[1]	Cultured groups	Wild group
	Total Survival (%)	
Original estimate	12.4	16.3
Adjusted estimate [2]	12.4	15.2
	Adult Harvest Rate (%)	
Original estimate	81.5	72.6
Adjusted estimate [2]	81.3	77.9

[1] Except where noted, escapement by site is as listed in Table 6.
[2] Estimated escapement to Salwein Creek and Chilliwack River Hatchery decreased by 25% and increased by 10% respectively.

Since the proportions of the cultured and wild groups which returned to each site differed, the impact of site-specific escapement estimation errors on the survival and harvest rate estimates would differ between groups (Appendices 2 and 3). Table 10 lists survivals and harvest rates associated with levels of escapement estimation error thought to be reasonable maxima for each technique. Cultured group survival and harvest rate estimates were relatively insensitive to escapement estimation error at either site. Survival was unchanged and the harvest rate changed by only 0.2%. Wild group survivals and harvest rates were not sensitive to estimation errors at the hatchery, of course, because none returned to the hatchery; however, they were quite sensitive to escapement estimation errors in Salwein Creek. For example, a 25% overestimate of escapement to the creek would decrease estimated survival by 1.1% while the harvest rate estimate would increase by 5.3%. The implications of these results are discussed in a later section; however, the sensitivity of the wild group harvest rate estimate to escapement estimation error emphasizes the importance of addressing all potential escapement estimation biases when studying heavily exploited stocks.

CATCH DISTRIBUTION

No differences were observed in the distribution of the four tagged groups among the various fisheries. Evidently, exposure to hatchery culture and consequent release at a larger size than wild smolts did not measurably affect the ocean distribution of the cultured group. Experiments conducted at Quinsam River and Rosewall Creek hatcheries on the Vancouver Island east coast have shown that release timing does affect the distribution of catch by ocean fisheries (Bilton 1980; Bilton **et al.** 1984). Coho from late releases were less widely distributed in the fisheries than those from early releases. Though there was some evidence that small smolts tended to contribute proportionately more to local Georgia Strait fisheries than large smolts (Bilton **et al.** 1984; Table 11), the authors concluded that "differences in distribution associated with size are generally not large and are of questionable significance".

Wild Salwein Creek coho contributed as adults to commercial fisheries and the Georgia Strait sport fishery earlier in the season than the cultured coho. This difference in catch timing may reflect faster growth of wild fish during early marine residency and consequently earlier recruitment to the minimum size limits of these fisheries. It may also reflect a different maturity schedule among wild and cultured fish, with the wild fish starting their return migration to the river earlier than cultured fish. Timing of sexual maturation in salmon is considered to be mainly under genetic control (Ricker 1972). A difference in maturity schedules of the wild and cultured groups could therefore reflect differences in genetic background. This could result from brood stock selection bias or alternately, the progeny of coho spawning in Salwein Creek could have been exposed to selective pressures not present in the hatchery, and those pressures could have favoured fish with an earlier maturity schedule. The opportunity for genetic selection of this nature is certainly much greater in the wild, where mortality from spawning to smolt emigration would approximate 98-99% (Fraser **et al.** 1983) compared to 26% for the groups cultured at Chilliwack River Hatchery (Schubert 1984).

SIZE

No size differences between tagged groups were evident in either the commercial troll catch or the escapement of age 3 fish. The size advantage of cultured smolts at the time of seaward migration was not carried through to the adult stage. Other studies of cultured coho have shown that larger smolts within a single release group produce larger age 2 (precocious male) and age 3

(adult) coho in the escapement (Hager and Noble 1976; Bilton 1980); however, in another experiment, Bilton **et al.** (1984) found that this smolt size-adult size relationship held for precocious male but not adult returns.

SURVIVAL

Fishery contribution rates and total returns to catch and escapement indicate that wild Salwein Creek coho survived at a higher rate than any of the three cultured groups. Since wild and cultured adults were identical in size in the troll fishery and the escapement, the difference in survival may reflect reduced fitness in the cultured fish at some time prior to recruitment to the fisheries. As noted previously, earlier recruitment of wild fish may reflect faster growth of the initially smaller wild fish during the period of early marine residency. We speculate, therefore, that the cultured group may have suffered high early ocean mortality relative to the wild group during a period of adaptation to natural feeding regimes and predators.

The observed survivals of wild and cultured Salwein Creek coho may be biased to some extent by study techniques. For example, the tagging procedures were likely to have placed wild smolts at a disadvantage relative to cultured smolts. Wild smolts migrating from Salwein Creek were tagged at a stage when stamina is known to be reduced (Flagg and Smith 1981) and the fish are especially sensitive to handling stresses (Strange **et al.** 1977). Such stresses were minimized in the cultured smolts by tagging during February, approximately three months before release. Although the two cultured groups released in Salwein Creek may have been exposed to similar stresses during transport, there is no evidence of any impact on survival relative to the hatchery release group (Table 7).

The added effects of tagging smolts at the time of seaward migration, relative to tagging them at the hatchery before smoltification, were assessed at Minter Creek, Washington (L. Blankenship, Washington Department of Fisheries, Olympia, pers. comm.). One group of cultured pre-smolt coho yearlings was adipose clipped, planted in Minter Creek upstream of an enumeration fence, and subsequently tagged as advanced smolts migrating from the stream. A second lot of the same cultured group, which had been tagged at the hatchery well before smoltification, was released at the smolt stage downstream of the fence. Adult return data from two release years indicate that groups tagged at the time of smolt migration survived at rates 15% and 18% lower than hatchery-tagged groups. The Minter Creek smolts may have been more sensitive to handling and tagging than wild Salwein smolts, as they were tagged nearer to saltwater and possibly in a more advanced stage of smoltification. However, it seems likely that, in this study, the wild Salwein group suffered some tagging mortality additional to that experienced by cultured smolts.

A second potential bias involves overestimation of cultured group release totals. The tagged cultured groups were vulnerable to predation for three months prior to release from the hatchery. Although predation control measures were likely to have limited losses, predation impacts were not evaluated. It is not possible, therefore, to estimate the overall impact of tagging mortality and predation on the relative survival of the wild and cultured groups.

HARVEST RATE

The wild group was harvested at a lower rate than the cultured groups. As noted earlier, the estimate of harvest rate for the wild group was quite sensitive to positive bias in the mark-recapture estimate of escapement to Salwein Creek. If the escapement overestimate amounted to 25%, for example, the difference in estimated harvest rates for the wild and cultured groups would be

reduced by approximately 50%, from 8.9 to 4.5 percentage points (Appendix 3). It seems unlikely, however, that escapement estimation error was the only factor involved. The disparity in harvest rates of cultured and wild fish may also be related to differences in their availability to marine fisheries. As wild fish contributed to sport and commercial fisheries somewhat earlier than cultured fish, they may have started their return migration to the river earlier and may therefore have been exposed to fisheries, particularly hook and line fisheries, for a shorter time during the period of highest vulnerability to harvest (Argue **et al.** 1983). The existence of differences in maturity schedules could also have affected the relative vulnerability of cultured and wild groups to sport and commercial troll fisheries. For example, decreases in susceptibility of adult coho to hook and line gear in Juan de Fuca Strait during August-September have been attributed to sexual maturation (Argue 1970). Earlier maturation could therefore have reduced the late-season vulnerability of the wild Salwein group to hook and line fisheries, which accounted for 92% of total exploitation on the group.

Harvest rates of the cultured Salwein groups were inversely related to the escapement of precocious males in each group (Table 7). The proportion of a particular group maturing at age 2 could have influenced harvest rate if the males remaining in the ocean at age 3 tended to be more vulnerable to the fishery than females. In that case, a larger proportion of males maturing at age 3 would result in a higher contribution rate to ocean fisheries.

In summary, it appears that harvest rate estimates for wild Salwein coho could have been negatively influenced by earlier maturation and lower vulnerability to ocean fisheries, as well as by any overestimate of escapement to Salwein Creek. Harvest rate estimates for the cultured groups were more likely to have been positively biased by underestimates of escapement, due mainly to adult straying within the home river. It is considered probable, however, that any possible biases in the escapement estimates did not account for more than 50% of the observed difference in harvest rates of cultured and wild groups.

STRAYING

The discussion in this section refers to documented straying of returning adult and precocious male coho within the Vedder-Chilliwack River system. Straying is defined as the recovery of a tagged coho at a site, i.e. either a stream or the Chilliwack River Hatchery, other than the site of smolt release.

The coho salmon enhancement strategy employed in the Vedder-Chilliwack system involved egg collection from selected tributary spawning populations, culture of the resultant juveniles to the smolt stage at a centrally located hatchery, and stocking of the smolts back into their native stream. One of the objectives was to augment natural production by ensuring that returning adults spawn in their native stream and contribute fully to natural production. Adults produced from cultured smolts were therefore expected to return to the area of smolt release.

Wild Salwein coho strayed at rates of 0% and 0.4% for precocious males and adults respectively. Rates of straying for the cultured groups were higher and varied considerably between groups and between precocious males and adults (Table 11). Adult returns from the hatchery release strayed at a low rate as adults and a relatively high rate as precocious males. The latter result is not particularly meaningful, however, as there were only eight precocious males recovered. Adults returning from Salwein Creek releases, i.e. the spot and 24 h releases, strayed at a high rate, whereas the precocious males from these releases showed a relatively low degree of straying. Salwein Creek cultured release groups accounted for 98.5% of

Table 11. Observed percentages of precocious male and adult Salwein Creek coho salmon straying from the site of smolt release[1].

	Hatchery release	Spot release	24 h release	Wild release
Precocious males (1982-83)	50.0% (8)	13.5% (74)	8.1% (186)	0.0% (44)
Adults (1983-84)	0.8% (380)	64.4% (422)	64.5% (479)	0.4% (507)

[1] Data from Table 6. Total number of tag recoveries from each release is shown in brackets.

all straying documented in this study. Virtually all (99.3%) of that straying was back to the Chilliwack River Hatchery.

Similar results were obtained from two groups (1962 and 1975 broods) of cultured coho smolts in a tributary of the Green River, Washington. Smolts cultured at Green River Hatchery on Soos Creek were marked and released in Newaukum Creek, a tributary entering Green River 8 km upstream of Soos Creek. Adult coho returns from these releases strayed back to Green River Hatchery at observed rates of 100% (Hager and Senn MS 1965) and 37% (T. Flint, Washington Department of Fisheries, Olympia, pers. comm.) respectively.

Adult returns from the two cultured smolt releases in Salwein Creek strayed substantially more than the precocious male returns. Cultured chinook salmon (**Oncorhynchus tshawytscha**) returns to the Cowlitz River, Washington, showed a similar pattern, with precocious male (age 2_2) returns straying at only 10-20% of the rate observed in age 3_2-5_2 adults (Quinn and Fresh 1984).

Although most of the straying documented in this study was to the Chilliwack River Hatchery, straying to other spawning areas could have been greater than that observed, as survey coverage of most tributary and mainstem spawning areas was limited. A continued high level of straying by cultured coho could result in interbreeding between stocks, possibly reducing genetic divergence and, ultimately, the genetic fitness of the stocks concerned (Hartle 1980). The present information base is quite inadequate for assessing the likelihood of that development.

MANAGEMENT IMPLICATIONS

If the wild and cultured components of a salmon stock have similar marine catch distributions and harvest rates, then CWT data from the cultured group can be used to develop and assess harvest strategies for wild fish of that stock or other similar stocks. However, one must be confident that changes in the estimated parameters reflect the impact of natural variability or management actions rather than annual variations in fish culture practices, size and time at release or, indeed, cumulative genetic change which may occur over successive generations under even the most careful fish culture regimes. Results from the present preliminary study suggest that, although the approach merits further investigation, it should not yet be considered for broad application in regional coho management. Although no difference was noted in the catch distribution of wild

and first generation cultured Salwein Creek coho, differences in survival, recruitment timing and possibly harvest rate suggest that the measurement of these parameters in cultured groups may not provide adequate indicators of the same parameters in wild fish. Because this study involved only one stock for a single year, many of the above questions cannot be answered. However, the results suggest that CWT harvest rate data for cultured stocks should be interpreted with caution and, until these questions can be answered with confidence, the assessment of coho management actions should include studies involving wild stocks.

SUMMARY

1. Wild and cultured components of a single coho stock were coded wire tagged in a study of between-group differences in survival, catch distribution and harvest rate. Eggs taken from brood stock obtained from Salwein Creek, a small lowland tributary of the Vedder-Chilliwack River, were incubated and reared to smolt stage at the Chilliwack River Hatchery. An estimated 58,695 cultured smolts were released in three groups, one from the hatchery and two in Salwein Creek, during May 1982. A further 11,776 wild coho smolts were tagged as they emigrated from Salwein Creek between April 23 and June 18, 1982. The cultured and wild smolts averaged 22.5 g and 10.5 g at release respectively.

2. CWT recoveries in the commercial fisheries of Oregon, Washington, British Columbia and Alaska were determined through the coast-wide catch sampling program. Recoveries in the sport fisheries of Washington and British Columbia were determined through various creel census programs. The escapement of each group was estimated at fence traps in Salwein Creek and at the hatchery, and at fence traps and by visual surveys in a number of other Vedder-Chilliwack system tributaries. The 1983-84 Salwein Creek escapement was estimated from a mark-recapture study.

3. CWT recoveries in the fisheries were estimated at 7,090, including 5,727 from the cultured groups and 1,363 from the wild group. Recoveries were distributed from Oregon to Alaska; however, 86% and 89% of the cultured and wild catch respectively occurred in southern British Columbia waters. The Georgia Strait sport fishery was the largest harvester of the stock.

4. CWT recoveries in the escapement were estimated at 2,100, including 1,549 from the cultured groups and 551 from the wild group. The estimated escapement to the creek and the hatchery may have had positive and negative biases respectively.

5. Cultured groups released in Salwein Creek strayed from the release site at a low rate as precocious males (8% to 14%) but at a high rate as adults (64%), with virtually all recorded straying (99.3%) back to the hatchery site. Wild and hatchery release groups both strayed from the respective release sites at low rates as adults (0.4% and 0.8% respectively). Precocious males of the wild group exhibited no recorded straying.

6. No significant difference was noted in the distribution of the cultured and wild groups among the eight commercial and sport fisheries of Washington and British Columbia.

7. No significant size differences between the wild and cultured groups were evident in either the troll catch or the escapement of age 3 fish, despite the initial size advantage of cultured smolts at the time of seaward migration.

8. Wild fish recruited to the commercial and sport fisheries earlier than cultured fish, significantly earlier in the case of the sport fishery.

9. Wild Salwein Creek coho survived at a higher rate (16.3%) than any of the three cultured groups (12.1% to 12.8%).

10. The wild group was harvested at a lower rate (73%) than the three cultured groups (78% to 84%). Although a positive bias in the Salwein Creek escapement may account for much of the difference, other factors associated with differential vulnerability to harvest may also be involved.

11. It was concluded that the development and assessment of harvest strategies for wild coho on the basis of CWT data from cultured coho stocks entails significant risk and that, until further studies are completed, the evaluation of management actions should include wild stock data.

ACKNOWLEDGEMENTS

M. Milko, L. Kalnin, G. Buxton, D. Buxton and Chilliwack River Hatchery staff carried out all field activities reported in this study. L. Schubert supplied hatchery assessment information. Dr. J. Yensen of Vancouver Community College provided advice on statistical analyses. V. Palermo and N. Williscroft provided advice concerning the use of ocean fishery CWT recovery information. Review comments received from A.W. Argue, M. Farwell, R. Harrison, E. Perry, W. Saito, P. Starr and K. Wilson are gratefully acknowledged. L. Blakenship, Washington Department of Fisheries, and J. Ritter, DFO Halifax, provided unpublished data. Y. Yole provided age analyses. The manuscript was typed by R. Reimer.

LITERATURE CITED

Anon. 1969. Reports by the United States and Canada on the status, ocean migrations and exploitation of northeast Pacific stocks of chinook and coho salmon, to 1964. Volume II. Report by the Canadian Section. Informal Committee on Chinook and Coho. 111 p.

Anon. 1984. Preliminary report of the Canada/U.S. technical committee on coho salmon. Prepared for the advisors to the U.S./Canada negotiations on the limitations of salmon interceptions. 99 p.

Argue, A.W. 1970. A study of factors affecting exploitation of Pacific salmon in the Canadian gantlet fishery of Juan de Fuca Strait. Canada Dept. of Fisheries and Forestry, Fisheries Service Tech. Rep. 1970-11: 259 p.

Argue, A.W., R. Hilborn, R.M. Peterman, M.J. Staley and C.J. Walters. 1983. The Strait of Georgia chinook and coho fishery. Can. Bull. Fish. Aquat. Sci. 221: 97 p.

Bilton, H.T. 1980. Returns of adult coho salmon in relation to mean size and time at release of juveniles to the catch and the escapement. Can. Tech. Rep. Fish. Aquat. Sci. 941: 41 p.

Bilton, H.T., R.B. Morley, A.S. Coburn and J. Van Tyne. 1984. The influence of time and size at release of juvenile coho salmon on returns at maturity; results of releases from Quinsam River Hatchery, B.C. in 1980. Can. Tech. Rep. Fish. Aquat. Sci. 1306: 98 p.

Cousens, N.B.F., G.A. Thomas, C.G. Swann and M.C. Healey. 1982. A review of salmon escapement estimation techniques. Can. Tech. Rep. Fish. Aquat. Sci. 1108: 122 p.

DPA. MS 1985. The Fraser River bar sport fishery design study. Prepared for the Department of Fisheries and Oceans, New Westminster, B.C. 81 p.

Environment Canada. 1985. Historic streamflow summary, British Columbia, to 1984. Inland Waters Directorate, Water Resources Branch, Ottawa. 996 p.

Farwell, M.K., N.D. Schubert, K.H. Wilson and C.R. Harrison. MS 1986. Salmon escapements to streams entering statistical areas 28 and 29, 1951 to 1985. Dept. Fish. Oceans, New Westminster. 126 p.

Fedorenko, A.Y. and R.J. Cook. 1982. Trapping and coded wire tagging of wild coho juveniles in the Vedder-Chilliwack River, 1976 to 1979. Can. MS Rep. Fish. Aquat. Sci. 1678: 79 p.

Flagg, T.A. and L.S. Smith. 1982. Changes in swimming behavior and stamina during smolting of coho salmon. p. 191-195. **In** E.L. Brannon and E.O. Salo (eds.), Salmon and Trout Migratory Behavior Symposium, Univ. of Washington, Seattle.

Fleming, J.O. and N.D. Schubert. MS 1986. A coded wire tag assessment of selected lower Fraser River coho stocks. Can. MS Rep. Fish. Aquat. Sci. In prep.

Fraser, F.J., E.A. Perry and D.T. Lightly. 1983. Big Qualicum River salmon development project, Volume 1: A biological assessment, 1959-1972. Can. Tech. Rep. Fish. Aquat. Sci. 1189: 198 p.

Hager, R. and H.G. Senn. MS 1965. Study results in off-station liberations of yearling hatchery reared coho. Unpublished manuscript. Washington Dept. of Fisheries, Olympia. 2 p.

Hager, R.C. and R.E. Noble. 1976. Relation of size at release of hatchery-reared coho salmon to age, size, and sex composition of returning adults. Prog. Fish Cult. 38: 144-147

Hartl, D.L. 1980. Principles of population genetics. Sinauer Associates, Inc., Sunderland, Massachusetts. 488 p.

Hutton, R., C. Manson, M. Lauder and P. Fee. MS 1983. 1982 coho studies North Thompson River system. Dept. Fish. Oceans, New Westminster, B.C. 147 p.

J.E. Sager & Associates. 1985. Salmonid tag recovery program in British Columbia - 1984 operations summary. Prepared for Department of Fisheries & Oceans, Vancouver, B.C. 130 p.

Kimura, D.K. 1976. Estimating the total number of marked fish present in a catch. Trans. Am. Fish. Soc. 105: 664-668

Lee, E. and M. Desu. 1972. A computer program for comparing K samples with right-censored data. Computer Programs in Biomedicine 2: 315-321

Palermo, R.V. MS 1985. Awareness factor variability in the Strait of Georgia sport fishery. Unpublished manuscript. Dept. of Fisheries & Oceans, Vancouver, B.C. 72 p.

Quinn, T.P. and K. Fresh. 1984. Homing and straying in chinook salmon from Cowlitz River Hatchery, Washington. Can. J. Fish. Aquat. Sci. 41: 1078-1082

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations. p. 19-160. **In** R.C. Simon and P.A. Larkin (eds.), The stock concept in Pacific Salmon. H.R. MacMillan

Lectures in Fisheries, Univ. of British Columbia, Vancouver.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

Schubert, N.D. 1982. Trapping and coded wire tagging of wild coho salmon smolts in the Salmon River (Langley), 1978 to 1980. Can. MS Rep. Fish. Aquat. Sci. 1672: 68 p.

Schubert, N.D. 1984. A comparison of wild and cultured Salwein Creek coho salmon: 1982 tagging summary. Can. MS Rep. Fish. Aquat. Sci. 1739: 22 p.

Schubert, N.D. and A.Y. Fedorenko. 1985. Trapping and coded wire tagging of wild coho salmon juveniles in the upper Pitt River system, 1979 and 1980. Can. MS Rep. Fish. Aquat. Sci. 1815: 78 p.

Schubert, N.D., G.E. Rosberg, R.J. Cook and G.M.W. Cronkite. 1985. A coded wire tag assessment of Birkenhead River coho salmon: 1982 tag application and 1984 spawner enumeration. Can. MS Rep. Fish. Aquat. Sci. 1816: 55 p.

Shardlow, T.F., T. Hoyt and K.K. English. 1985. Strait of Georgia Creel survey sport fishery statistics, 1983. Can. MS Rep. Fish. Aquat. Sci. 1872: In prep.

Simpson, K. 1984. The accuracy of mark-recapture estimates of escapements. **In** Proceedings of the workshop on stream indexing for salmon escapement estimation, West Vancouver, B.C., 2-3 February 1984. P.E.K. Symons and M. Waldichuk (eds.). Can. Tech. Rep. Fish. Aquat. Sci. 1326: xv + 258 p.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry, the principles and practices of statistics in biological research, 2nd edition. W.H. Freeman and Co., New York. 859 p.

Strange, R.J., C.B. Schreck and J.T. Golden. 1977. Corticoid stress responses to handling and temperature in salmonids. Trans. Am. Fish. Soc. 106: 213-218

APPENDICES

APPENDIX 1a. OBSERVED AND ESTIMATED RECOVERIES OF HATCHERY RELEASE SALWEIN CREEK COHO SALMON (CODE 02 22 31).

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
						1982 CATCH								
SPORT														
GEORGIA STRAIT SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	0	2	0	2
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	2	0	2
FRESHWATER SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	1	1
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	4	4
						1983 CATCH								
TROLL														
ALASKAN TROLL	OBSERVED	0	0	0	0	0	0	1	0	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	2	0	0	0	0	0	2
NORTHERN TROLL	OBSERVED	0	0	0	0	0	0	2	0	0	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	18	0	0	0	0	0	18
NORTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	1	0	1	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	2	0	2	0	0	0	4
SOUTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	12	4	8	0	0	0	24
	ESTIMATED	0	0	0	0	0	0	84	41	38	0	0	0	163
NORTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	3	5	0	0	0	0	8
	ESTIMATED	0	0	0	0	0	0	17	41	0	0	0	0	58
SOUTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	12	12	13	2	0	0	39
	ESTIMATED	0	0	0	0	0	0	121	89	60	9	0	0	279
WASHINGTON TROLL	OBSERVED	0	0	0	0	0	0	0	2	1	0	0	0	3
	ESTIMATED	0	0	0	0	0	0	0	4	2	0	0	0	6
OREGON TROLL	OBSERVED	0	0	0	0	0	0	1	0	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	3	0	0	0	0	0	3
GEORGIA STRAIT TROLL	OBSERVED	0	0	0	0	0	0	9	0	1	1	0	0	11
	ESTIMATED	0	0	0	0	0	0	182	0	32	10	0	0	224
MISC. TROLL	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	1	0	0	0	0	1
NET														
CENTRAL NET	OBSERVED	0	0	0	0	0	0	1	0	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	5	0	0	0	0	0	5
JOHNSTONE STRAIT NET	OBSERVED	0	0	0	0	0	0	15	16	11	0	0	0	42
	ESTIMATED	0	0	0	0	0	0	38	78	65	0	0	0	181
JUAN DE FUCA NET	OBSERVED	0	0	0	0	0	0	0	0	2	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	0	4	0	0	0	4
PUGET SOUND NET	OBSERVED	0	0	0	0	0	0	2	7	2	6	0	0	17
	ESTIMATED	0	0	0	0	0	0	2	17	6	15	0	0	40
GEORGIA STRAIT NET	OBSERVED	0	0	0	0	0	0	0	3	0	6	0	0	9
	ESTIMATED	0	0	0	0	0	0	0	9	0	18	0	0	27
FRASER GILL NET	OBSERVED	0	0	0	0	0	0	0	1	4	0	0	0	5
	ESTIMATED	0	0	0	0	0	0	0	4	14	0	0	0	18

CONTINUED

APPENDIX 1a. HATCHERY RELEASE CONTINUED.

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SPORT														
CENTRAL SPORT	OBSERVED	0	0	0	0	0	0	0	3	0	0	0	0	3
	ESTIMATED	0	0	0	0	0	0	0	9	0	0	0	0	9
GEORGIA STRAIT	OBSERVED	0	2	0	17	20	58	79	45	17	5	4	0	247
SPORT	ESTIMATED	0	2	0	46	69	231	182	140	54	17	4	0	746
PUGET SOUND	OBSERVED	1	0	0	0	0	0	0	0	1	0	0	0	2
SPORT	ESTIMATED	4	0	0	0	0	0	0	0	6	0	0	0	10
WASHINGTON	OBSERVED	0	0	0	0	0	0	1	4	0	0	0	0	5
OCEAN SPORT	ESTIMATED	0	0	0	0	0	0	2	9	0	0	0	0	11
FRESH WATER	OBSERVED	1	0	0	0	0	0	0	1	1	5	33	23	64
SPORT	ESTIMATED	2	0	0	0	0	0	0	2	2	10	63	44	123
1984 CATCH														
SPORT														
GEORGIA STRAIT	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
SPORT	ESTIMATED	0	0	0	0	0	0	0	5	0	0	0	0	5
FRESH WATER	OBSERVED	2	1	0	0	0	0	0	0	0	0	0	0	3
SPORT	ESTIMATED	4	2	0	0	0	0	0	0	0	0	0	0	6
SUMMARY														
TROLL	OBSERVED	0	0	0	0	0	0	41	24	24	3	0	0	92
	ESTIMATED	0	0	0	0	0	0	429	176	134	19	0	0	758
NET	OBSERVED	0	0	0	0	0	0	18	27	19	12	0	0	76
	ESTIMATED	0	0	0	0	0	0	45	108	89	33	0	0	275
SPORT	OBSERVED	4	3	0	17	20	58	80	54	19	10	39	24	328
	ESTIMATED	10	4	0	46	69	231	184	165	62	27	69	48	916
TOTAL	OBSERVED	4	3	0	17	20	58	139	105	62	25	39	24	496
	ESTIMATED	10	4	0	46	69	231	658	449	285	79	69	48	1949

APPENDIX 1b. OBSERVED AND ESTIMATED RECOVERIES OF SPOT RELEASE SALWEIN CREEK COHO SALMON (CODE 02 21 14).

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
						1982 CATCH								
SPORT														
GEORGIA STRAIT SPORT	OBSERVED	0	0	0	0	0	0	0	0	1	3	5	0	9
	ESTIMATED	0	0	0	0	0	0	0	0	2	5	5	0	12
FRESHWATER SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	1	3	2	6
	ESTIMATED	0	0	0	0	0	0	0	0	0	2	6	4	11
						1983 CATCH								
TROLL														
NORTHERN TROLL	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
NORTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	1	2	0	0	0	0	3
	ESTIMATED	0	0	0	0	0	0	2	11	0	0	0	0	13
SOUTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	6	4	6	0	0	0	16
	ESTIMATED	0	0	0	0	0	0	45	37	32	0	0	0	114
NORTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	3	1	1	0	0	0	5
	ESTIMATED	0	0	0	0	0	0	15	7	3	0	0	0	25
SOUTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	27	9	9	3	0	0	48
	ESTIMATED	0	0	0	0	0	0	262	67	39	14	0	0	382
WASHINGTON TROLL	OBSERVED	0	0	0	0	0	0	0	2	0	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	4	0	0	0	0	4
GEORGIA STRAIT TROLL	OBSERVED	0	0	0	0	0	0	11	0	0	1	0	0	12
	ESTIMATED	0	0	0	0	0	0	211	0	0	10	0	0	221
MISC. B.C. TROLL	OBSERVED	0	0	0	0	0	0	3	0	1	0	0	0	4
	ESTIMATED	0	0	0	0	0	0	3	0	1	0	0	0	4
NET														
CENTRAL NET	OBSERVED	0	0	0	0	0	0	1	0	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	5	0	0	0	0	0	5
JOHNSTONE STRAIT NET	OBSERVED	0	0	0	0	0	0	10	17	10	0	0	0	37
	ESTIMATED	0	0	0	0	0	0	29	79	47	0	0	0	155
JUAN DE FUCA NET	OBSERVED	0	0	0	0	0	0	0	0	2	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	0	4	0	0	0	4
PUGET SOUND NET	OBSERVED	0	0	0	0	0	0	8	15	0	4	0	0	27
	ESTIMATED	0	0	0	0	0	0	11	30	0	11	0	0	52
GEORGIA STRAIT NET	OBSERVED	0	0	0	0	0	0	0	2	0	5	0	0	7
	ESTIMATED	0	0	0	0	0	0	0	7	0	18	0	0	25
FRASER GILL NET	OBSERVED	0	0	0	0	0	0	0	0	2	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	0	8	0	0	0	8

CONTINUED

APPENDIX 1b. SPOT RELEASE CONTINUED.

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SPORT														
CENTRAL SPORT	OBSERVED	0	0	0	0	0	0	0	0	1	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	0	3	0	0	0	3
GEORGIA STRAIT	OBSERVED	1	0	2	8	16	60	97	51	16	7	7	0	265
SPORT	ESTIMATED	1	0	4	22	55	239	224	159	51	24	7	0	786
PUGET SOUND	OBSERVED	0	0	0	0	0	0	2	1	1	1	0	0	5
SPORT	ESTIMATED	0	0	0	0	0	0	11	6	5	4	0	0	26
WASHINGTON	OBSERVED	0	0	0	0	0	0	0	5	0	0	0	0	5
OCEAN SPORT	ESTIMATED	0	0	0	0	0	0	0	13	0	0	0	0	13
FRESH WATER	OBSERVED	0	0	0	0	0	0	0	0	3	8	34	9	54
SPORT	ESTIMATED	0	0	0	0	0	0	0	0	6	15	65	17	103
1984 CATCH														
SPORT														
GEORGIA STRAIT	OBSERVED	0	0	0	0	1	0	1	0	0	0	0	0	2
SPORT	ESTIMATED	0	0	0	0	3	0	3	0	0	0	0	0	6
FRESH WATER	OBSERVED	2	0	0	0	0	0	0	0	0	0	0	0	2
SPORT	ESTIMATED	4	0	0	0	0	0	0	0	0	0	0	0	4
SUMMARY														
TROLL	OBSERVED	0	0	0	0	0	0	51	18	17	4	0	0	90
	ESTIMATED	0	0	0	0	0	0	538	126	75	24	0	0	763
NET	OBSERVED	0	0	0	0	0	0	19	34	14	9	0	0	76
	ESTIMATED	0	0	0	0	0	0	45	116	59	29	0	0	249
SPORT	OBSERVED	3	0	2	8	17	60	100	57	22	20	49	11	349
	ESTIMATED	5	0	4	22	58	239	238	178	67	50	83	21	964
TOTAL	OBSERVED	3	0	2	8	17	60	170	109	53	33	49	11	515
	ESTIMATED	5	0	4	22	58	239	821	420	201	103	83	21	1976

APPENDIX 1c. OBSERVED AND ESTIMATED RECOVERIES OF 24 h RELEASE SALWEIN CREEK COHO SALMON (02 22 46).

FISHERY		STATISTICAL MONTH												TOTAL
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
						1982 CATCH								
NET														
PUGET SOUND NET	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	4	0	0	0	0	4
SPORT														
GEORGIA STRAIT SPORT	OBSERVED	0	0	0	0	0	0	0	0	2	8	8	0	18
	ESTIMATED	0	0	0	0	0	0	0	0	5	12	8	0	25
FRESHWATER SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	0	8	1	9
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	32	4	36
						1983 CATCH								
TROLL														
NORTHERN TROLL	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
NORTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	2	1	0	0	0	0	3
	ESTIMATED	0	0	0	0	0	0	7	10	0	0	0	0	17
SOUTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	7	6	4	0	0	0	17
	ESTIMATED	0	0	0	0	0	0	52	53	18	0	0	0	123
NORTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	6	1	1	0	0	0	8
	ESTIMATED	0	0	0	0	0	0	34	10	3	0	0	0	47
SOUTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	18	16	9	5	0	0	48
	ESTIMATED	0	0	0	0	0	0	166	117	41	23	0	0	347
WASHINGTON TROLL	OBSERVED	0	0	0	0	0	0	0	0	1	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	0	2	0	0	0	2
GEORGIA STRAIT TROLL	OBSERVED	0	0	0	0	0	0	5	0	0	0	0	0	5
	ESTIMATED	0	0	0	0	0	0	126	0	0	0	0	0	126
MISC. TROLL	OBSERVED	0	0	0	0	0	0	2	1	0	0	0	0	3
	ESTIMATED	0	0	0	0	0	0	2	1	0	0	0	0	3
NET														
CENTRAL NET	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	3	0	0	0	0	3
JOHNSTONE STRAIT NET	OBSERVED	0	0	0	0	0	0	6	7	9	0	0	0	22
	ESTIMATED	0	0	0	0	0	0	29	34	47	0	0	0	110
JUAN DE FUCA NET	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
PUGET SOUND NET	OBSERVED	0	0	0	0	0	0	2	9	4	2	0	0	17
	ESTIMATED	0	0	0	0	0	0	2	19	18	11	0	0	50
GEORGIA STRAIT NET	OBSERVED	0	0	0	0	0	0	0	1	0	2	0	0	3
	ESTIMATED	0	0	0	0	0	0	0	6	0	9	0	0	15
FRASER GILL NET	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0

CONTINUED

APPENDIX Ic. 24 h RELEASE CONTINUED.

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SPORT														
CENTRAL SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
GEORGIA STRAIT	OBSERVED	0	1	1	12	21	57	81	40	22	5	8	0	248
SPORT	ESTIMATED	0	1	2	33	72	227	187	124	70	17	8	0	741
PUGET SOUND	OBSERVED	0	0	0	0	1	0	4	0	0	0	0	0	5
SPORT	ESTIMATED	0	0	0	0	4	0	22	0	0	0	0	0	26
WASHINGTON	OBSERVED	0	0	0	0	0	0	1	3	0	0	0	0	4
OCEAN SPORT	ESTIMATED	0	0	0	0	0	0	2	6	0	0	0	0	8
FRESH WATER	OBSERVED	1	0	0	0	0	0	0	0	1	14	35	7	58
SPORT	ESTIMATED	2	0	0	0	0	0	0	0	2	27	67	13	111
1984 CATCH														
SPORT														
GEORGIA STRAIT	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
SPORT	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
FRESH WATER	OBSERVED	0	0	0	0	0	0	0	0	0	1	0	0	1
SPORT	ESTIMATED	0	0	0	0	0	0	0	0	0	2	0	0	2
NET														
JOHNSTONE STRAIT	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
NET	ESTIMATED	0	0	0	0	0	0	0	6	0	0	0	0	6
SUMMARY														
TROLL	OBSERVED	0	0	0	0	0	0	40	25	15	5	0	0	85
	ESTIMATED	0	0	0	0	0	0	387	191	64	23	0	0	665
NET	OBSERVED	0	0	0	0	0	0	8	20	13	4	0	0	45
	ESTIMATED	0	0	0	0	0	0	31	72	65	20	0	0	188
SPORT	OBSERVED	1	1	1	12	22	57	86	43	25	28	59	8	343
	ESTIMATED	2	1	2	33	76	227	211	130	77	58	115	17	949
TOTAL	OBSERVED	1	1	1	12	22	57	134	88	53	37	59	8	473
	ESTIMATED	2	1	2	33	76	227	629	393	206	101	115	17	1802

APPENDIX 1d. OBSERVED AND ESTIMATED RECOVERIES OF WILD RELEASE SALMEIN CREEK COHO SALMON (02 21 15).

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
						1982 CATCH								
SPORT														
GEORGIA STRAIT SPORT	OBSERVED	0	0	0	0	0	0	0	0	1	2	2	0	5
	ESTIMATED	0	0	0	0	0	0	0	0	2	3	2	0	7
FRESHWATER SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	1	2	0	3
	ESTIMATED	0	0	0	0	0	0	0	0	0	4	8	0	12
						1983 CATCH								
TROLL														
NORTHERN TROLL	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
NORTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	1	0	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	2	0	0	0	0	0	2
SOUTH-CENTRAL TROLL	OBSERVED	0	0	0	0	0	0	6	6	1	1	0	0	14
	ESTIMATED	0	0	0	0	0	0	49	45	3	6	0	0	103
NORTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	6	1	0	0	0	0	7
	ESTIMATED	0	0	0	0	0	0	33	7	0	0	0	0	40
SOUTH-WEST TROLL	OBSERVED	0	0	0	0	0	0	20	5	6	0	0	0	31
	ESTIMATED	0	0	0	0	0	0	190	34	27	0	0	0	251
WASHINGTON TROLL	OBSERVED	0	0	0	0	0	0	0	2	0	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	4	0	0	0	0	4
GEORGIA STRAIT TROLL	OBSERVED	0	0	0	0	0	0	7	0	0	0	0	0	7
	ESTIMATED	0	0	0	0	0	0	138	0	0	0	0	0	138
MISC. TROLL	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
NET														
CENTRAL NET	OBSERVED	0	0	0	0	0	0	0	1	0	0	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	3	0	0	0	0	3
JOHNSTONE STRAIT NET	OBSERVED	0	0	0	0	0	0	3	9	3	0	0	0	15
	ESTIMATED	0	0	0	0	0	0	11	41	14	0	0	0	66
JUAN DE FUCA NET	OBSERVED	0	0	0	0	0	0	0	0	2	0	0	0	2
	ESTIMATED	0	0	0	0	0	0	0	0	4	0	0	0	4
PUGET SOUND NET	OBSERVED	0	0	0	0	0	0	3	6	1	1	0	0	11
	ESTIMATED	0	0	0	0	0	0	6	12	2	1	0	0	21
GEORGIA STRAIT NET	OBSERVED	0	0	0	0	0	0	0	1	0	2	0	0	3
	ESTIMATED	0	0	0	0	0	0	0	4	0	9	0	0	13
FRASER GILL NET	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0

CONTINUED

APPENDIX 1d. WILD RELEASE CONTINUED.

FISHERY		STATISTICAL MONTH JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SPORT														
CENTRAL SPORT	OBSERVED	0	0	0	0	0	0	0	0	0	1	0	0	1
	ESTIMATED	0	0	0	0	0	0	0	0	0	4	0	0	4
GEORGIA STRAIT	OBSERVED	1	0	1	11	17	61	62	26	11	4	2	1	197
SPORT	ESTIMATED	1	0	2	30	59	243	143	81	35	14	2	1	611
PUGET SOUND	OBSERVED	0	0	0	0	0	1	1	1	0	0	0	0	3
SPORT	ESTIMATED	0	0	0	0	0	4	5	7	0	0	0	0	16
WASHINGTON	OBSERVED	0	0	0	0	0	1	0	0	1	0	0	0	2
OCEAN SPORT	ESTIMATED	0	0	0	0	0	1	0	0	3	0	0	0	4
FRESH WATER	OBSERVED	0	0	0	0	0	0	0	0	0	7	17	8	32
SPORT	ESTIMATED	0	0	0	0	0	0	0	0	0	13	33	15	61
1984 CATCH														
SPORT														
GEORGIA STRAIT	OBSERVED	0	0	0	0	0	1	0	0	0	0	0	0	1
SPORT	ESTIMATED	0	0	0	0	0	3	0	0	0	0	0	0	3
FRESH WATER	OBSERVED	0	0	0	0	0	0	0	0	0	0	0	0	0
SPORT	ESTIMATED	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMMARY														
TROLL	OBSERVED	0	0	0	0	0	0	40	14	7	1	0	0	62
	ESTIMATED	0	0	0	0	0	0	412	90	30	6	0	0	538
NET	OBSERVED	0	0	0	0	0	0	6	17	6	3	0	0	32
	ESTIMATED	0	0	0	0	0	0	17	60	20	10	0	0	107
SPORT	OBSERVED	1	0	1	11	17	64	63	27	13	15	23	9	244
	ESTIMATED	1	0	2	30	59	251	148	88	40	38	45	16	718
TOTAL	OBSERVED	1	0	1	11	17	64	109	58	26	19	23	9	338
	ESTIMATED	1	0	2	30	59	251	577	238	90	54	45	16	1363

APPENDIX 2. PROJECTED SURVIVAL OF SALWEIN CREEK COHO SALMON AT DIFFERENT LEVELS OF ESCAPEMENT ESTIMATION ERROR.

a. CULTURED GROUPS

HATCHERY ESCAPEMENT ESTIMATE (1.00 = FENCE COUNT)	SALWEIN CREEK ESCAPEMENT ESTIMATE (1.00 = MARK-RECAPTURE ESTIMATE)					
	1.00	0.95	0.90	0.85	0.80	0.75
1.00	12.40	12.37	12.34	12.31	12.29	12.26
1.05	12.48	12.45	12.42	12.40	12.37	12.34
1.10	12.56	12.53	12.50	12.48	12.45	12.42
1.15	12.64	12.61	12.59	12.56	12.53	12.50
1.20	12.72	12.69	12.67	12.64	12.61	12.58
1.25	12.80	12.78	12.75	12.72	12.69	12.67

b. WILD GROUP

HATCHERY ESCAPEMENT ESTIMATE (1.00 = FENCE COUNT)	SALWEIN CREEK ESCAPEMENT ESTIMATE (1.00 = MARK-RECAPTURE ESTIMATE)					
	1.00	0.95	0.90	0.85	0.80	0.75
1.00	16.25	16.04	15.82	15.61	15.40	15.18
1.05	16.25	16.04	15.82	15.61	15.40	15.18
1.10	16.25	16.04	15.82	15.61	15.40	15.18
1.15	16.25	16.04	15.82	15.61	15.40	15.18
1.20	16.25	16.04	15.82	15.61	15.40	15.18
1.25	16.25	16.04	15.82	15.61	15.40	15.18

APPENDIX 3. PROJECTED HARVEST RATES OF SALWEIN CREEK COHO AT DIFFERENT LEVELS OF ESCAPEMENT ESTIMATION ERROR.

a. CULTURED GROUPS

HATCHERY ESCAPEMENT ESTIMATE (1.00 = FENCE COUNT)	SALWEIN CREEK ESCAPEMENT ESTIMATE (1.00 = MARK-RECAPTURE ESTIMATE)					
	1.00	0.95	0.90	0.85	0.80	0.75
1.00	81.47	81.66	81.85	82.05	82.24	82.44
1.05	80.91	81.10	81.29	81.48	81.67	81.86
1.10	80.36	80.55	80.74	80.92	81.11	81.30
1.15	79.82	80.00	80.19	80.37	80.56	80.74
1.20	79.28	79.47	79.65	79.83	80.01	80.20
1.25	78.76	78.93	79.11	79.29	79.47	79.65

b. WILD GROUP

HATCHERY ESCAPEMENT ESTIMATE (1.00 = FENCE COUNT)	SALWEIN CREEK ESCAPEMENT ESTIMATE (1.00 = MARK-RECAPTURE ESTIMATE)					
	1.00	0.95	0.90	0.85	0.80	0.75
1.00	72.61	73.61	74.65	75.71	76.80	77.92
1.05	72.61	73.61	74.65	75.71	76.80	77.92
1.10	72.61	73.61	74.65	75.71	76.80	77.92
1.15	72.61	73.61	74.65	75.71	76.80	77.92
1.20	72.61	73.61	74.65	75.71	76.80	77.92
1.25	72.61	73.61	74.65	75.71	76.80	77.92