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A Coded Wire Tag Assessment of Salmon River (Langley) Coho Salmon: 1991 Tag Application and 1992-1993 Spawner Enumeration

N.D. Schubert, M.K. Farwell and L.W. Kalnin

Department of Fisheries and Oceans
Operations Branch
610 Derwent Way, Annacis Island
New Westminster, British Columbia V3M 5P8

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A CODED WIRE TAG ASSESSMENT OF SALMON RIVER (LANGLEY) COHO SALMON: 1991 TAG APPLICATION AND 1992-1993 SPAWNER ENUMERATION

by

N.D. Schubert, M.K. Farwell[1] and L.W. Kalnin

Department of Fisheries and Oceans
Operations Branch
610 Derwent Way, Annacis Island
New Westminster, B.C. V3M 5P8

[1]C.17, Cottonwood Site
Rural Route No. 1
Lone Butte, B.C. V0K 1X0

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ABSTRACT

Schubert, N.D., M.K. Farwell, and L.W. Kalnin. 1994. A coded wire tag assessment of Salmon River (Langley) coho salmon: 1991 tag application and 1992-1993 spawner enumeration. Can. Manuscr. Rep. Fish. Aquat. Sci. 2208: 39 p.

In 1986, the Department of Fisheries and Oceans implemented a plan to improve the assessment data for coho salmon (*Oncorhynchus kisutch*) through the long term evaluation of key stocks. The Salmon River (Langley) was selected for the evaluation, with known precision, of annual escapement, marine survival, harvest distribution and exploitation rate. An estimated 29,435 (corrected for long term tag loss) coho smolts were released with coded wire tags in the spring of 1991 at an average size of 96.0 mm and 8.9 g. The adult escapement was estimated in fall and winter of 1992-1993 using the simple Petersen mark-recapture method. Escapement was estimated at 2,604 coho adults of which 730 had coded wire tags and 39 (5.1%) had lost the coded wire tag. Smolt to adult survival and exploitation rate totalled 8.9% and 72.3%, respectively.

Escapement progressively declined over the 1984-1989 brood years, from 11,947 in 1987 to 2,604 in 1992. At the same time, smolt to adult survival declined by 2.0 percentage points per year, exploitation rate remained above 70% and smolt production declined. All of these factors point to a conservation concern for this and other similar stocks.

Key Words: Coho salmon, Salmon River (Langley), key stream, coded wire tag, escapement, survival, exploitation rate.

RÉSUMÉ

Schubert, N.D., M.K. Farwell, and L.W. Kalnin. 1994. A coded wire tag assessment of Salmon River (Langley) coho salmon: 1991 tag application and 1992-1993 spawner enumeration. Can. Manuscr. Rep. Fish. Aquat. Sci. 2208: 39 p.

En 1986, le ministère des Pêches et Océans a entrepris une évaluation à long terme des stocks clés pour améliorer la base de données sur le saumon coho (*Oncorhynchus kisutch*). Il a choisi de faire cette évaluation dans la rivière Salmon (Langley) et d'établir des données précises sur l'échappée annuelle, la survie, la répartition des captures et le taux d'exploitation. Au printemps de 1991, environ 29 435 (chiffre ajusté pour tenir compte des pertes à long terme de micromarques magnétisées codées) jeunes saumons mesurant en moyenne 96,0 mm, pesant en moyenne 8,9 g, et pourvus d'une micromarque magnétisée codée ont été relâchés. L'échappée des adultes a été estimée à l'automne et au printemps de 1992-1993 au moyen de la technique Petersen de marquage-recapture. L'échappée a été estimée à 2 604 poissons, dont 730 avaient encore leur micromarque et 39 (5.1%) l'avaient perdue. Le taux de survie des jeunes saumons atteignant l'état adulte et le taux d'exploitation étaient de 8.9% et 72.3% respectivement.

L'échappé a subit une baisse progressive de 1984 à 1989, de 11 947 poissons en 1987 à 2 604 poissons en 1992. En même temps, le taux de survie des jeunes saumons atteignant l'état adulte a subit une baisse de 2% par année, le taux d'exploitation a de meuré au dessus 70%, et la production des jeunes saumons a baissé. Tous ces facteurs mettent en evidence les besoins de conservation pour le stock de la riviére Salmon ainsi que pour des stocks similaires.

Mots clés: Saumon coho, rivière Salmon (Langley), cours d'eau important, micromarque magnétisée codée, échappée, survie, le taux d'exploitation.

INTRODUCTION

In 1986, the Department of Fisheries and Oceans implemented a plan to improve coho salmon (*Oncorhynchus kisutch*) assessment data through the long term evaluation of key stocks. The Salmon River was selected for the evaluation, with known precision, of annual escapement, marine survival, harvest distribution, and exploitation rate. This stock was selected for three reasons. First, because recent escapements comprised 4% of the Fraser River total (Farwell *et al.* 1987), the status of Salmon River coho was an important measure of the status of the Fraser River coho resource. Second, 1976-1978 brood year studies (Schubert 1982; Schubert and Fleming 1989) provided a time series of comparable escapement, survival and exploitation rate data. Third, manageable logistics limited project costs.

This report documents, for the 1989 brood, the 1991 smolt coded wire tag (CWT) application and the 1992-1993 adult escapement estimation studies. Previous reports documented the evaluation of the 1984-1988 brood years (Schubert and Kalnin 1990; Farwell *et al.* 1991, 1992a, 1992b; Kalnin and Schubert 1991). This report describes the field methods, analytic techniques and study results, including smolt timing, age and size as well as adult age, length, sex, adipose fin clip (AFC) incidence, escapement estimates and long term CWT loss. The study did not estimate the escapement of precocious males (jacks). The report includes a discussion of data limitations and a synthesis of study results for the 1984-1989 brood years.

STUDY AREA

The Salmon River flows northwest for 33 km, entering the Fraser River west of Fort Langley, B.C. (Fig. 1). Coghlan Creek, the principal tributary, joins the mainstem 14 km upstream from the Fraser River. The system, with an average annual discharge of 1.41 $m^3 \cdot s^{-1}$ (Environment Canada 1980), drains 85 km^2 of agricultural and residential land. During the Fraser River spring freshet, the Salmon River flows through a pumphouse located at the river mouth. Because no provisions were made for fish passage, up to 31% of the coho smolts are killed as they pass through the pumps (Russell MS 1981). The study area was divided into ten reaches, five in the Salmon River and five in Coghlan Creek (Fig. 1). Reaches were established to accommodate statistical tests for bias rather than on the basis of homogeneity of physical characteristics. In most study reaches, the river flows across low gradient terrain in a shaded, meandering channel with a gravel substrate. The only exceptions are reaches C5 and S5 where the river is marshy and summer flows are low.

FIELD METHODS

SMOLT CAPTURE

Fence traps similar to those described by Schubert (1982) operated in the Salmon River (30 m above the Coghlan Creek confluence) and in Coghlan Creek (30 m above the Salmon River confluence) from April 22 to May 30, 1991. Captured fish were enumerated at least once daily. Coho smolts were transferred to holding boxes or to the tagging site for tagging and sampling. Coho fry were not enumerated because the 6 mm fence mesh did not fully restrict their passage. The remaining catch was identified to species and released below the fence. Steelhead (*O. mykiss*) and cutthroat (*O. clarki*) trout were recorded as smolt or presmolt. Trout smolts had a silver coloration and nose-fork (NF) length greater than 110 mm. Presmolts had distinct parr marks and a length of less than 110 mm.

CODED WIRE TAG APPLICATION

The CWT equipment and methods were described by Armstrong and Argue (1977). Coded wire tagging occurred from April 23 to May 22, 1991 at intervals of one to four days. On each day, smolts were sorted by size (NF length greater or less than 100 mm) and separate nose moulds and implant depths were used for each group. Implant depth was checked by bisecting the skull of a tagged smolt along the medial plane. If the CWT was not in the preferred position in the cartilaginous wedge of the skull, the implant depth was adjusted and the procedure repeated until CWT placement was correct. The nose mould was then marked to ensure correct placement following nose mould changes. The smolts were anaesthetized with Tricaine Methane Sulfonate (TMS), marked by adipose fin removal, coded wire tagged and passed through a quality control device to ensure the CWT was present. Any diseased, damaged or undersize (NF length less than 55 mm) smolts were released untagg-

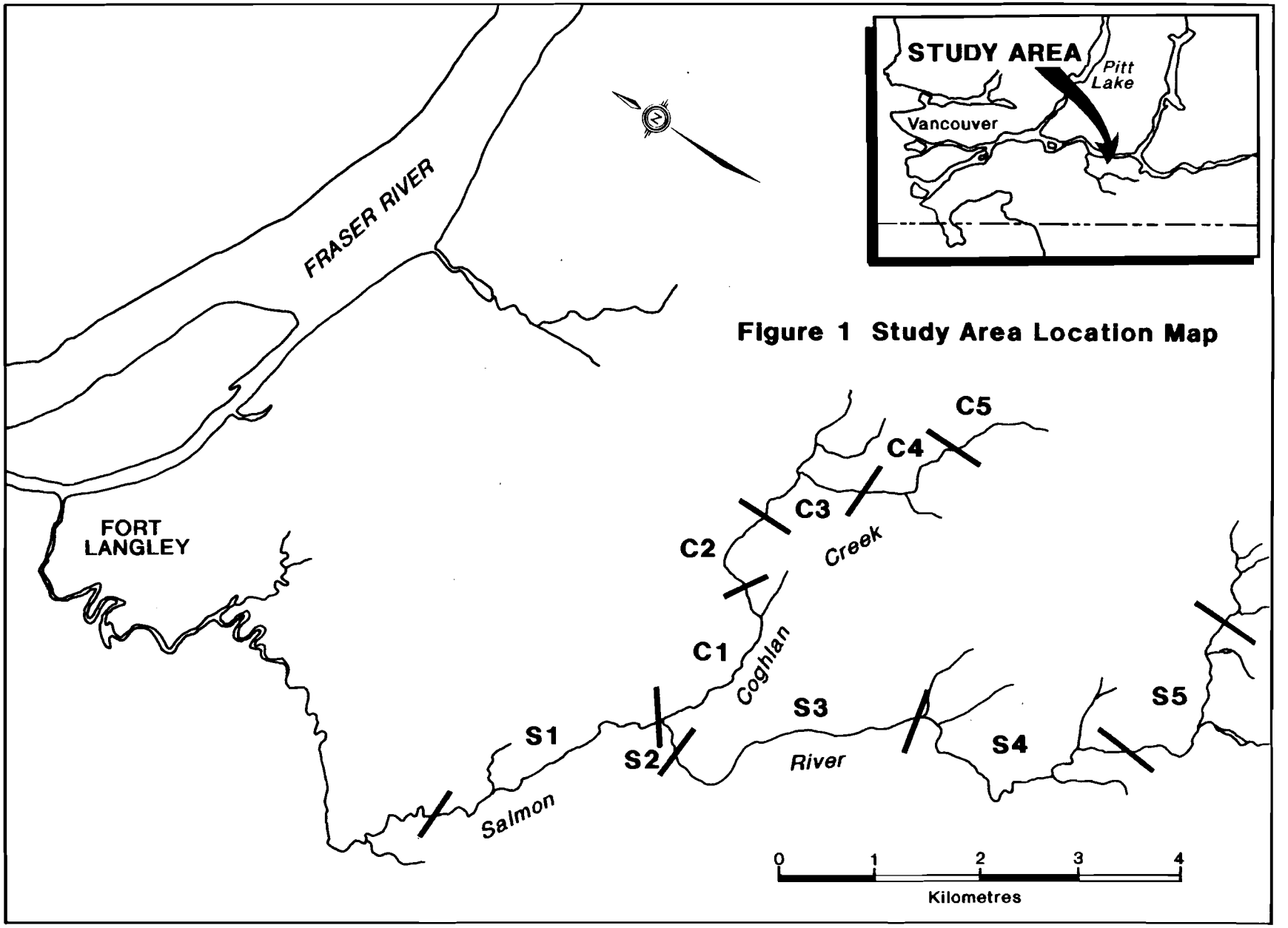

Figure 1 Study Area Location Map

ed. A sample of approximately 200 smolts was removed from the recovery bucket and retained for 24 hours to assess AFC quality, delayed mortality and CWT loss. Any coho without a CWT or with a poor AFC was retagged or reclipped.

SMOLT TRANSPORT

To avoid pump mortality, the coho smolts were transported to and released at the river mouth, either immediately after tagging or in the morning when water temperatures were lower. The smolts were transported in a 180 litre plastic container supplied with air from a 12 volt air pump. Transport required less than 15 minutes.

SMOLT SAMPLING

Fifty coho smolts per site were sampled twice weekly for scales, length and weight. The smolts were anaesthetized with TMS, a scale smear was removed with a scalpel from each side of the fish, NF length was measured to the nearest millimetre, and mean wet weight (±0.1 g) was determined in aggregate using a triple beam balance.

ADULT CAPTURE

Coho adults were captured in reaches S1 to S5 and C1 to C5 (Fig. 1) from November 4, 1992 to January 6, 1993. Coho were attracted from log jams and cut banks with a Smith Root Model 12® 24 volt direct current electroshocker. Voltage, amperage, pulse width and frequency were adjusted daily to minimize visible damage (body bruising) while providing sufficient torpor to permit capture. Shocked coho adults (NF length greater than 30 cm) were captured in a dip net, permitted to recover in a 60 litre container of water, marked and released.

Coho adults were marked with Petersen disk tags in a wooden tray (10 cm x 10 cm x 100 cm) constructed with a flexible plastic bottom and a metre stick recessed in one side. The tags consisted of two 22 mm diameter laminated cellulose acetate disks and one 7 mm diameter transparent plastic buffer disk threaded through centrally punched holes onto a 77 mm long nickel pin. The pin was inserted with pliers through the musculature and pterygiophore bones approximately 12 mm below the anterior portion of the dorsal fin insertion. The disk tags, arranged with one on each side of the fish and with a buffer disk on the pin head side, were secured by twisting the pin into a double knot. One disk per pair was numbered with a unique code. Green tags were used to reduce colour contrast, thereby minimizing recovery and predation biases. Each tagged fish received a secondary mark, a 7 mm diameter hole punched through the right operculum using a single hole paper punch, to allow the estimation of tag loss. Males and females received one and two punches, respectively, to permit the estimation of sex identification error. Care was taken to avoid gill tissue damage. Date and location (reach) of capture, disk tag number, NF length (±0.5 cm), sex and adipose fin status were recorded for each fish released with a disk tag. Activity at release was recorded as 1 (swam away vigorously), 2 (swam away sluggishly) or 3 (required ventilation). Electroshocker bruising to the body was recorded as 0 (none), 1 (faint bruise), 2 (bruise up to 25 mm in diameter), 3 (bruise over 25 mm in diameter). Recovered disk tagged carcasses were enumerated and sampled (described below) to assess handling mortality.

SPAWNING GROUND SURVEYS

The spawning grounds were surveyed weekly from November 18, 1992 to February 5, 1993. Complete surveys, conducted by a two to four person crew walking upstream, required up to two days. Live adults were counted and carcasses were recorded by date, reach, sex (confirmed by abdominal incision) and mark type (disk tag, secondary mark or AFC). Each marked carcass and every tenth unmarked carcass was sampled. All carcasses were then cut in two with a machete and returned to the river. Sample data, recorded by date and reach, included post-orbital-hypural plate (POH) length (to the nearest 0.1 cm), sex, female spawning success (0%, 50% or 100% spawned), adipose fin and carcass condition, and scale samples. For AFC coho, the head was removed posterior to the eye orbit for later CWT identification. Adipose fin condition was recorded as unclipped, complete (flush with dorsal surface), partial (nub present) or questionable (appeared clipped but fungus or decomposition obscured the area). The condition of AFC carcasses was recorded as fresh (gills red or mottled), moderately fresh (gills white, body firm), moderately rotten (body intact, flesh soft) or rotten (skin and bones), and the absence of one or both eyes was noted.

ANALYTIC PROCEDURES

TESTS FOR SAMPLING SELECTIVITY

Period

Temporal bias was assessed using a chi-square test (Sokal and Rohlf 1981). Application bias was examined by comparing between periods the mark incidence in the recovery sample, where mark incidence was the proportion of the coho adults marked with either a disk tag or a secondary mark. Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered.

Location

Spatial bias was similarly assessed in the application sample by comparing between sections the mark incidence in the recovery sample. Recovery bias was examined by stratifying the application sample by section and comparing the proportions recovered.

Fish Size

Size related bias was assessed using the Kolmogorov-Smirnov two-sample test (Sokal and Rohlf 1981). Application bias was examined by comparing the POH length-frequency distributions of marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the NF length-frequency distributions of each.

Fish Sex

Sex related bias was assessed using chi-square tests. Application bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries. Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex composition in each.

Other Tests

Bias resulting from tagging stress was also assessed using chi-square tests as above. The application sample was partitioned into two groups, those which required ventilation at release and those which did not, and recovery rates were examined in each group. As well, differential spawning success was examined in marked and unmarked spawning ground recoveries.

ESTIMATION OF SPAWNER POPULATION

Total Escapement

The 1992-1993 escapement of Salmon River coho adults was calculated from the mark-recapture data using the Petersen formula (Chapman modification) (Ricker 1975). Total escapement was the sum of escapement by sex:

1) Estimated Salmon River system coho escapement (N_t):

$$N_t = N_m + N_f$$

where:

N_m = estimated escapement of adult males;

$$= \frac{(M_m + 1)(C_m + 1)}{(R_m + 1)}$$

N_f = estimated escapement of females, analogous to above.

2) Ninety-five percent confidence limits of N_t:

$$N_t \pm 1.96 \sqrt{V_t}$$

where:

N_t = total escapement estimate;

V_t = variance of the escapement estimate;

$= V_m + V_f$

V_m = variance of the adult male escapement estimate;

$$= \frac{(N_m^2)(C_m - R_m)}{(C_m + 1)(R_m + 2)}$$

N_m = adult male escapement estimate;

C_m = number of adult male carcasses examined for disk tags;

R_m = number of disk tagged or secondary marked males recovered;

V_f = variance of female escapement estimate, analogous to above.

Sex Identification Correction

The tag application data were corrected for sex identification error. Error occurred because the development of sexually dimorphic traits was often not advanced and internal examinations could not be made. The correction of the recovery data was unnecessary because all carcasses were incised and examined internally. Sex identification error was corrected as described by Staley (1990):

3) Estimated true number of males released with disk tags and secondary marks (M_m):

$$M_m = \frac{M^*_m - (M_t R_{m,f})/R_f}{1 - (R_{m,f}/R_f) - (R_{f,m}/R_m)}$$

where:

M^*_m = field estimate of the number of males released with disk tags and secondary marks;
M_t = total number of coho adults released with disk tags and secondary marks;
$R_{m,f}$ = number of females recovered with disk tags which were released as males;
$R_{f,m}$ = number of males recovered with disk tags which were released as females;
R_f = number of females recovered with disk tags;
R_m = number of males recovered with disk tags.

4) Estimated true number of females released with disk tags and secondary marks (M_f):

$$M_f = M_t - M_m$$

Adipose Fin Clipped Escapement

We estimated the AFC escapement from the AFC incidence in the carcass recovery sample, the largest of the two available samples. The AFC incidences in the Salmon River and Coghlan Creek were first tested for significant differences using a chi-square test. If no difference was noted, the AFC escapement was the product of the pooled AFC incidence and the mark-recapture escapement estimate. Ninety-five percent confidence limits were calculated from the respective upper and lower confidence limits of the AFC incidence and the escapement estimate. For example, the upper 95% confidence limit of the AFC escapement estimate was the product of the upper limit of the AFC incidence and the upper limit of the total mark-recapture estimate. The mathematical relationships are reported below (Cochran 1977):

5) Estimated AFC escapement (N_a):

$$N_a = p\,(N_t)$$

6) Ninety-five percent confidence limits for p:

$$p \pm 1.96\,(se + fpc)$$

where:

p = sample proportion with an AFC;
se = standard error;
$= (1 - f)pq/(n - 1)$
fpc = finite population correction;
$= \frac{1}{2n}$
n = sample size;
q = 1 - p
$f = \frac{n}{N_t}$

If the Salmon River and Coghlan Creek AFC incidences differed, then the AFC escapement estimate was the product of the stream-specific total escapement, the stream-specific AFC incidence, and the pooled CWT retention level. Total escapement by stream was calculated by applying the ratio of the stream-specific Schaefer estimates to the simple Petersen estimate. Confidence limits, therefore could not be reported for the AFC escapement using this method.

Coded Wire Tagged Escapement

Escapement by CWT code and long term CWT loss were calculated by applying the CWT composition in the carcass recovery sample to the estimated escapement of AFC adults. Apparent CWT loss was adjusted for post-mortality loss resulting from carcass decomposition and predator activity, where appropriate.

HARVEST SAMPLING

This report provides estimates of harvest by CWT code for the 1988-1989 brood years. Harvest data, summarized by catch region, gear and month, were obtained from the regional mark recovery program data base (Kuhn *et al.* 1988). These data were then corrected for two sampling problems, when appropriate. First, observed recoveries were not expanded for time-area strata where the proportion of the catch sampled was too small to provide reliable estimates. Because rigorous statistical tests were unavailable, we arbitrarily rejected strata where the sampled proportion was less than 0.10 if the sample totalled less than 10,000 coho and five recoveries of the CWT group of interest. Second, some troll fishery recoveries could not be isolated to a single catch region. In these cases, we combined the sample and harvest data for those regions in that week to compute a new sample proportion for that recovery. Salmon River coho were also vulnerable to the sport and native fisheries in the lower Fraser River. Harvest could not be estimated because these fisheries were not sampled for AFCs and, in the latter, voluntary head returns were unavailable.

RESULTS

SMOLT CAPTURE

Catch of coho smolts totalled 35,013 in 1991, 24,346 in Salmon River and 10,667 in Coghlan Creek (Appendix 1). The 50% migration and the peak daily catch occurred on May 10 and May 7, respectively, in the Salmon River and on May 11 and May 6, respectively, in Coghlan Creek. High discharges rendered the traps inoperable for one day (May 9) in the Salmon River and two days (May 9-10) in Coghlan Creek. The reported timing of the 1991 smolt migration, therefore, may be somewhat biased.

CODED WIRE TAG APPLICATION

AFC and CWT releases totalled 31,378 coho smolts in 1991 (Appendix 2). When adjusted for long term CWT loss (5.1%) (Appendices 9 and 10) and short term (24-hour) post tagging mortality (Appendix 2), the number released with CWTs and identifiable AFCs was 29,435. Short term CWT loss averaged 0.4% (range 0.0% to 3.8%) (Appendix 2). The incidence of disease, damage, or structural anomalies averaged 13.2% (Appendix 3). The most prevalent condition was 'fog eye' (12.8%), a reversible condition associated with capture stress. No naturally missing adipose fins were observed.

COHO SMOLT AGE AND SIZE

Coho emigrated from the Salmon River system entirely as yearling (age 1+) smolts. Smolt size averaged 96.5 mm and 9.1 g in the Salmon River and 94.3 mm and 8.3 g in Coghlan Creek (Appendix 4). Weighted mean smolt size was 96.0 mm and 8.9 g. Smolt size declined through the migration in Coghlan Creek, while in the Salmon River the trend was less distinct.

DISK TAG APPLICATION

Disk tags and secondary marks were applied to 281 coho adults in the Salmon River system from November 4, 1992 to January 6, 1993 (Appendix 5); 72 (25.6%) had an AFC. Two hundred and ten tags (74.7%) were applied in the Salmon River and 71 (25.3%) in Coghlan Creek; most were released in reaches S1 (38%), S2 (17%), S4 (15%) and C1 (14%).

Forty-three fish (15.3%) required ventilation at release; however, the proportion of this group recovered (11.6%) was not significantly different ($p > 0.05$; chi-square) from the remaining fish (9.3%) (Table 2). Electrochocker bruising was noted in 129 fish (45.9%) (Table 2). The proportion of this group recovered (1.6%) was significantly lower ($p < 0.05$; chi-square) than in the unbruised group (16.4%). These fish were removed from the application sample, therefore, reducing the total release to 152 fish (Table 1).

An estimated 13.3% of the males and none of the females were misidentified at the time of tagging (Appendix 6). When adjusted for this error, an estimated 98 (64.5%) males and 54 (35.5%) females were released, unbruised, with disk tags and secondary marks (Table 1). Most were released in reaches S1 (34%), C1 (18%), S2 (14%) and S4 (14%).

Mean NF length of males and females was 50.8 cm and 54.3 cm, respectively. Females were significantly larger than males ($p < 0.05$; ANOVA); however, no difference was noted between those with and without an AFC.

Table 1. Disk tag application, carcass examination and mark recovery, by sex, of Salmon River system coho adults, 1992-1993.

Sex	Disk tags applied a	Carcasses examined b	Marks recovered: Disk tag and secondary mark b	Marks recovered: Secondary mark only	Marks recovered: Disk tag only	Marks recovered: Total	Percent recovered
Male	98	240	14	0	0	14	14.3%
Female	54	220	11	0	0	11	20.4%
Total	152	460	25	0	0	25	16.4%

a. Corrected for sex identification error; excludes 129 with electroshocker bruising at release.

b. Adults only; excludes 1 male and 1 female with electroshocker bruising at release.

SPAWNING GROUND RECOVERY

Excluding 2 bruised adults, 460 adults and 36 jacks were recovered on the spawning grounds from November 18, 1992 to February 5, 1993 (Table 1; Appendix 7). Of the adults, 240 (52.2%) were male and 220 (47.8%) were female, 124 (27.0%) had an AFC, 25 (5.4%) had a disk tag and secondary mark, and none had lost a disk tag or secondary mark. Three (8.3%) jacks had an AFC. The proportion of disk tagged fish with AFCs which was recovered (12.1%) was not significantly different ($p > 0.05$; chi-square) than that of fish without an AFC (17.6%).

The distribution of recoveries was 223 adults (48.5%) in the Salmon River and 237 (51.5%) in Coghlan Creek. Most were recovered in reaches C1 (24%), S3 (14%), C2 (14%) and S4 (14%).

Age, Length and Sex

The age and length of the 1992-1993 spawning ground recoveries are reported in Appendix 8. All of the adult males and 95.1% of the females were age 3_2. No difference in age composition was noted between streams or by AFC status ($p > 0.05$; chi-square). The mean POH length of males and females was 41.2 cm and 44.0 cm, respectively. Females were significantly larger than males ($p < 0.05$; ANOVA); however, no difference was noted between those with and without an AFC.

Coded Wire Tag Recoveries

Sixty-six adult males, 58 females and 3 jacks were recovered with an AFC, an incidence of 27.4%, 26.2% and 8.3%, respectively. The AFC incidence was significantly higher ($p < 0.05$; chi-square) in the Salmon River in both males and females (Appendix 9). CWTs were recovered from 58 adult males, 44 adult females and 1 jack; all were of Salmon River system origin. There was a significant difference ($p < 0.05$; chi-square) in the spatial distribution of CWT recoveries. Recoveries in the Salmon River were largely (85.7%) of Salmon River origin, while Coghlan Creek recoveries were largely (81.3%) of Coghlan Creek origin (Appendix 9). There was no significant difference ($p > 0.05$; chi-square) in the temporal pattern of recoveries between CWT codes.

CWT loss averaged 12.6% and 50.0% in adults and jacks, respectively, with no difference ($p > 0.05$; chi-square) noted between the Salmon River and Coghlan Creek (Appendix 9). No difference in CWT loss was noted in carcasses with eyes versus those missing one or both eyes ($p > 0.05$; chi-square) (Appendix 10), indicating that predators did not influence measured CWT loss. A significant difference was noted, however, between fresh and decomposed carcasses ($p < 0.05$; chi-square) (Appendix 10). When the latter were removed from the sample, the adjusted long term CWT loss rate was 5.1%.

Table 2. Disk tag application and recovery of Salmon River system coho adults, by release condition, 1992-1993.

Category	Release condition	Disk tags applied	Disk tags recovered	Percent recovered
Swimming performance a	Normal	236	22	9.3%
	Required ventilation	43	5	11.6%
Body bruising	None visible	152	25	16.4%
	Present	129	2	1.6%

a. Excludes 2 for which condition was not recorded at release.

Table 3. Incidence of disk tags or secondary marks in coho adults recovered on the Salmon River system spawning grounds, by recovery period and sex, 1992-1993.

	Recovered with disk tag or secondary mark			Total recovery a			Mark incidence		
Recovery period	Male	Female	Total	Male	Female	Total	Male	Female	Total
18-Nov to 05-Dec	2	2	4	23	21	44	8.7%	9.5%	9.1%
06-Dec to 19-Dec b	3	4	7	99	97	196	3.0%	4.1%	3.6%
20-Dec to 31-Dec	6	3	9	75	66	141	8.0%	4.5%	6.4%
01-Jan to 05-Feb	3	2	5	43	36	79	7.0%	5.6%	6.3%

a. Adults only.

b. Excludes 1 male and 1 female with electroshocker bruising at release.

Table 4. Proportion of the disk tag application sample recovered on the Salmon River system spawning grounds, by application period and sex, 1992-1993.

	Disk tags and secondary mark applied a			Carcasses recovered with disk tags b			Percent recovered		
Application period	Male	Female	Total	Male	Female	Total	Male	Female	Total
04-Nov to 19-Nov	20	16	36	1	5	6	5.0%	31.3%	16.7%
20-Nov to 08-Dec	37	13	50	2	4	6	5.4%	30.8%	12.0%
09-Dec to 06-Jan	42	24	66	9	4	13	21.4%	16.7%	19.7%

a. Corrected for sex identification error; excludes 129 with electroshocker bruising at release.

b. Excludes 1 male and 1 female with electroshocker bruising at release.

Table 5. Proportion of the Salmon River system coho adult spawning ground recovery sample marked with disk tags or secondary marks, by recovery section and sex, 1992-1993.

Location	Recovery section a	Carcasses recovered with disk tags or secondary marks			Coho adult carcasses examined b			Mark incidence		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Salmon River	Lower c	5	4	9	27	38	65	18.5%	10.5%	13.8%
	Middle	2	2	4	48	16	64	4.2%	12.5%	6.3%
	Upper c	0	0	0	37	57	94	0.0%	0.0%	0.0%
Coghlan Creek	Lower	6	3	9	55	54	109	10.9%	5.6%	8.3%
	Upper	1	2	3	73	55	128	1.4%	3.6%	2.3%

a. Salmon River: lower - S1, S2; middle - S3; upper - S4, S5.
Coghlan Creek: lower - C1; upper - C2, C3, C4, C5.

b. Adults only.

c. Excludes 1 with electroshocker bruising at release.

Table 6. Proportion of the disk tag application sample recovered on the Salmon River system spawning grounds, by application section and sex, 1992-1993.

Location	Application section	Disk tags applied a			Carcasses recovered with disk tags or secondary marks b			Percent recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Salmon River	Lower	32	40	72	2	4	6	6.3%	10.0%	8.3%
	Middle	1	3	4	1	0	1	100.0%	0.0%	25.0%
	Upper	18	6	24	3	3	6	16.7%	50.0%	25.0%
Coghlan Creek	Lower	19	8	27	4	2	6	21.1%	25.0%	22.2%
	Upper	15	10	25	2	4	6	13.3%	40.0%	24.0%

a. Excludes 129 with electroshocker bruising at release.

b. Excludes 2 with electroshocker bruising at release.

SAMPLING SELECTIVITY

Period

Temporal bias in the application sample was examined by comparing mark incidences in four recovery periods (Table 3). Mark incidences ranged from 3.0% to 9.5%, but were not significantly different ($p > 0.05$; chi-square) in either males or females.

Recovery bias was examined by comparing the proportions recovered from three application periods (Table 4). The proportions ranged from 5.0% to 31.3%, but were not significantly different ($p > 0.05$) in either males or females.

Location

Spatial bias in the application sample was examined by comparing the mark incidences in five recovery sections (Table 5). Mark incidence ranged from 0.0% to 18.5%, but the differences were significant ($p < 0.05$; chi-square) only in males. Mark incidences were highest in the lower sections of Salmon River and Coghlan Creek.

Table 7. Proportion of the Salmon River system coho adult disk tag application sample recovered on the spawning grounds, by 10 cm increments of nose-fork length and sex, 1992-1993.

Nose-fork length (cm)	Disk tags applied a			Carcasses recovered with disk tags or secondary marks b			Percent recovered		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
30-39.9	9	0	9	0	0	0	0.0%	-	0.0%
40-49.9	32	8	40	5	2	7	15.6%	25.0%	17.5%
50-59.9	47	43	90	7	11	18	14.9%	25.6%	20.0%
60-69.9	8	4	12	0	0	0	0.0%	0.0%	0.0%
70-79.9	1	0	1	0	0	0	0.0%	-	0.0%

a. Corrected for sex identification error; excludes 129 with electroshocker bruising at release.

b. Excludes 2 with electroshocker bruising at release.

Table 8. Sex composition of Salmon River system coho adults in the disk tag application and spawning ground recovery samples, 1992-1993.

	Application sample sex ratio, by recovery status a				Recovery sample sex ratio, by mark status b			
Sex	Sample size	Recovered	Not recovered	Total	Sample size	Marked	Unmarked	Total
Male	98	56.0%	66.1%	64.5%	240	56.0%	52.0%	52.2%
Female	54	44.0%	33.9%	35.5%	220	44.0%	48.0%	47.8%

a. Corrected for sex identification error; excludes 129 with electroshocker bruising at release.

b. Adults only; excludes 2 with electroshocker bruising at release.

Table 9. Results of the statistical tests for bias in the 1992-1993 Salmon River system coho adult escapement estimation study. a

Bias type	Application sample	Recovery sample
Statistical	-	No bias
Period	No bias	No bias
Location	Males biased to lower sections	No bias
Fish size	No bias	No bias
Fish sex	No bias	No bias

a. A "no bias" test result indicates that bias was not detected; undetected biases may be present.

Table 10. Escapement estimates and 95% confidence limits, by sex and age, for Salmon River system coho adults, 1992-1993.

Group	Escapement by age			95% confidence limits on escapement estimate	
	3/2	4/3	Total	Lower	Upper
Male	1,591	0	1,591	836	2,345
Female	964	49	1,013	477	1,548
Total	2,555	49	2,604	1,678	3,529

Recovery bias was examined by stratifying the application sample into five sections and comparing the proportions recovered (Table 6). Excluding the middle section of the Salmon River, where few tags were applied, the proportions ranged from 6.3% to 50.0%; however, the differences were not significant ($p > 0.05$) in either males or females.

Fish Size

Size related bias in the application sample was examined by comparing POH length-frequency distributions of marked and unmarked spawning ground recoveries. No significant difference ($p > 0.05$; Kolmogorov-Smirnov two-sample test) was noted in males or females.

Recovery bias was examined by partitioning the application sample into recovered and non-recovered components and comparing NF length-frequency distributions of each. No significant difference ($p > 0.05$) was noted (Table 7).

Fish Sex

No significant difference ($p > 0.05$; chi-square) was noted in the sex ratio of marked and unmarked spawning ground recoveries (Table 8). The application sample, therefore, was relatively unbiased with respect to sex.

No significant difference ($p > 0.05$) was noted in the sex ratio of the recovered and non-recovered components of the application sample (Table 8). Furthermore, no difference was noted in the proportion of males (14.3%) and females (20.4%) released with disk tags and recovered on the spawning grounds (Table 1). We concluded, therefore, that the recovery sample was relatively unbiased with respect to sex.

Spawning Success

Spawning success, estimated from the internal examination of female spawning ground recoveries, was estimated at 98.6% (Appendix 11). Spawning success of marked (95.5%) and unmarked (99.0%) females was significantly different ($p < 0.05$; difference in proportions test).

ESTIMATION OF SPAWNER POPULATION

Total Escapement

Because serious spatial and temporal biases were not identified in this study (Table 9; see Discussion), escapement was calculated by sex using the simple Petersen estimator. The 1992-1993 escapement of Salmon River coho adults was 2,604 (Table 10), with lower and upper 95% confidence limits of 1,678 and 3,529, respectively. The escapement of male and female coho adults was 1,591 and 1,013, respectively. Age 3_2 fish dominated the adult escapement (98.1%); only 1.9% were age 4_3.

The total escapement was allocated between the Salmon River and Coghlan Creek by applying proportions calculated using Schaefer's estimator (Ricker 1975) to the above estimates. The Salmon River accounted for 63.1% (1,642) of the total escapement, 57.0% (906) of the adult male escapement and 72.8% (738) of the female escapement.

Table 11. Smolt releases, adult escapement and survival to adult escapement, by location and CWT code, of 1989 brood Salmon River system coho salmon.

Location		CWT code 02 08 49	CWT code 02 08 50	CWT code 02 08 51	Adult escapement with an AFC but without a CWT
Salmon River	Number of smolts released a	10,188	0	9,943	-
	Spawning ground recoveries				
	Number	26	10	34	-
	Percent by code	37.1%	14.3%	48.6%	-
	Escapement b	211	81	276	31
Coghlan Creek	Number of smolts released a	0	9,305	0	-
	Spawning ground recoveries				
	Number	0	26	6	-
	Percent by code	0.0%	81.3%	18.8%	-
	Escapement c	0	131	30	9
Total	Escapement	211	213	306	39
	Survival to escapement	2.1%	2.3%	3.1%	-

a. Adjusted for long term CWT loss (0.051).

b. Product of the Salmon River escapement (1,642), AFC incidence (0.364), CWT retention (0.949) and proportion by code.

c. Product of the Coghlan Creek escapement (962), AFC incidence (0.177), CWT loss (0.949) and proportion by code.

Adipose Fin Clips and Coded Wire Tags

The AFC incidences in the Salmon River (0.364) and Coghlan Creek (0.177) were significantly different ($p < 0.05$; chi-square). The AFC escapement, therefore, was the sum of the AFC estimates calculated for each stream. The AFC escapement was the product of the stream-specific total escapement, the stream-specific AFC incidence and the pooled CWT retention level. Escapement by stream was the product of the simple Petersen estimate for the entire system and the ratio of the stream-specific Schaefer estimates. The estimated coho adult AFC escapement was 769, of which 598 returned to the Salmon River and 171 to Coghlan Creek (Table 11). Of that total, 211 returned with code 02 08 49, 213 with code 02 08 50, 306 with code 02 08 51, and 39 (5.1%) had lost the CWT. Survival from smolt release to adult escapement averaged 2.5%. There was a significant difference ($p < 0.5$; chi-square) in survival between the Salmon River (2.6%) and Coghlan Creek (2.3%) codes, and the difference between the early (2.1%) and late (3.1%) Salmon River releases was highly significant ($p < 0.005$; chi-square).

BROOD YEAR EXPLOITATION AND SURVIVAL

Harvest estimates compiled from CWT recoveries for the 1988 brood year are presented in Appendix 12. An estimated 1,077 coded wire tagged coho (Table 12) were harvested in the Fraser River (excluding the river sport and Indian fisheries) and in the ocean fisheries of southern British Columbia and Washington; all were taken in 1991. The 1988 brood harvest distribution was highly atypical in that most harvest occurred in outside or approach waters and very little occurred inside the Strait of Georgia. For example, 73% of the harvest occurred in the troll fishery off the west coast of Vancouver Island, and a further 12% was harvested in the Juan de Fuca net fishery and 9% in the U.S. fisheries. Only 4% of the catch was harvested in inside waters, i.e. in the Strait of Georgia and the Fraser River; however, the harvest rate in two Fraser River gill net fisheries was relatively high at 6.5%. In contrast to the 1988 brood, the 1976-1978 (Schubert and Zallen 1990) and 1984-1987 (Farwell *et al.* 1992b) broods were harvested primarily in inside waters. An average of 59% of the harvest of those broods occurred in the Strait of Georgia

the proportion tagged (5.8%) was below the long term average (8.7%). The proportion of the escapement censused (17.7%) and of the marks recovered (16.4%) were below the study average of 19.5% and 20.2%, respectively (Farwell *et al.* 1992b), reflecting a series of freshets during the study. The result of the reduced effectiveness in both the application and recovery samples was reduced precision of the escapement estimate.

MARK-RECAPTURE STUDY

Population estimates derived from mark-recapture studies are susceptible to bias from a number of sources, including: tag loss; physiological stress which can induce the emigration of tagged fish from the population or alter recapture vulnerability; and nonrepresentative tag application or recovery resulting from samples which are selective by fish size, sex or spatial and temporal run component. We evaluated the effect of capture and tagging on subsequent catchability and concluded that this assumption was seriously violated in 1992. The application of excessive current by the electroshocker clearly influenced subsequent catchability or survival because the recovery rate of bruised fish was significantly reduced. This bias was addressed by removing bruised fish from the analysis; however, there were indications that the application of electric current, even at non-damaging levels, can also introduce bias. As in previous years, a small but significant difference in the spawning success of marked and unmarked females suggested that exposure to electric current at levels which did not cause external bruising could influence subsequent behaviour. Such longer term impacts were unexpected because others (e.g Schreck *et al.* 1976) reported that fish physiology returned to preshock conditions within 48 hours. We were unable to determine if a change in behaviour associated with the reduced spawning success also occurred and influenced subsequent catchability; however, given the small difference in 1992, any bias in the population estimate would have been minor.

Electroshocker bruising in 1992 resulted from the use of new equipment which required a protracted learning period to determine the appropriate settings. Although bruising was not recorded in previous studies, we believe that the high incidence in 1992 resulted solely from the new equipment and was unique to the present study. Undetected bias in previous estimates was considered unlikely. Given the potential impact on study results, however, future studies must record the incidence of bruising and take immediate measures to minimize its occurrence.

It was not possible to definitively test the representativeness of the application and recovery samples because the true population parameters were not known. Instead, we examined the samples for four biases, temporal, spatial, fish size and fish sex, as indicators of weakness in the study design. The only bias identified was a spatial bias in the tag application (Table 9). Robson (1969) found that, when nonrepresentative sampling occurs, accurate results may still be achieved if one sample is representative. Because the assumption of representativeness of the recovery sample was not seriously violated, we concluded that the impact of application sample bias on the population estimate would have been minor. This conclusion was supported by the spatially stratified Schaefer estimate, which differed from the simple Petersen by only 3.7%.

STOCK STATUS

The currebt status of the Salmon River system coho salmon stock can be inferred from trends in adult escapement, exploitation rate, smolt to adult survival (Fig. 2) and smolt production (Table 12):

- Escapement declined in each successive year of the study (from 11,947 in 1987 to 2,604 in 1992) at an average annual rate of 13.8% or 1,848 spawners per year. The six year study duration was not sufficient to permit the use of nonparametric trend tests such as described by Cox and Stuart (1955); however, the magnitude and progressive nature of the trend suggests an extreme event not inconsistent with an escapement collapse.

- Smolt to adult survival declined (from an unweighted average of 18.1% in the 1984-1985 brood years to 8.0% in the 1988-1989 broods) at an average annual rate of 10.2% or 2.0 percentage points per year. An almost identical trend occurred in cultured Vedder-Chilliwack River coho (C. Cross, SEP Assessment Biologist, pers. comm.), a nearby stock with a similar marine harvest distribution (Schubert and Zallen 1990).

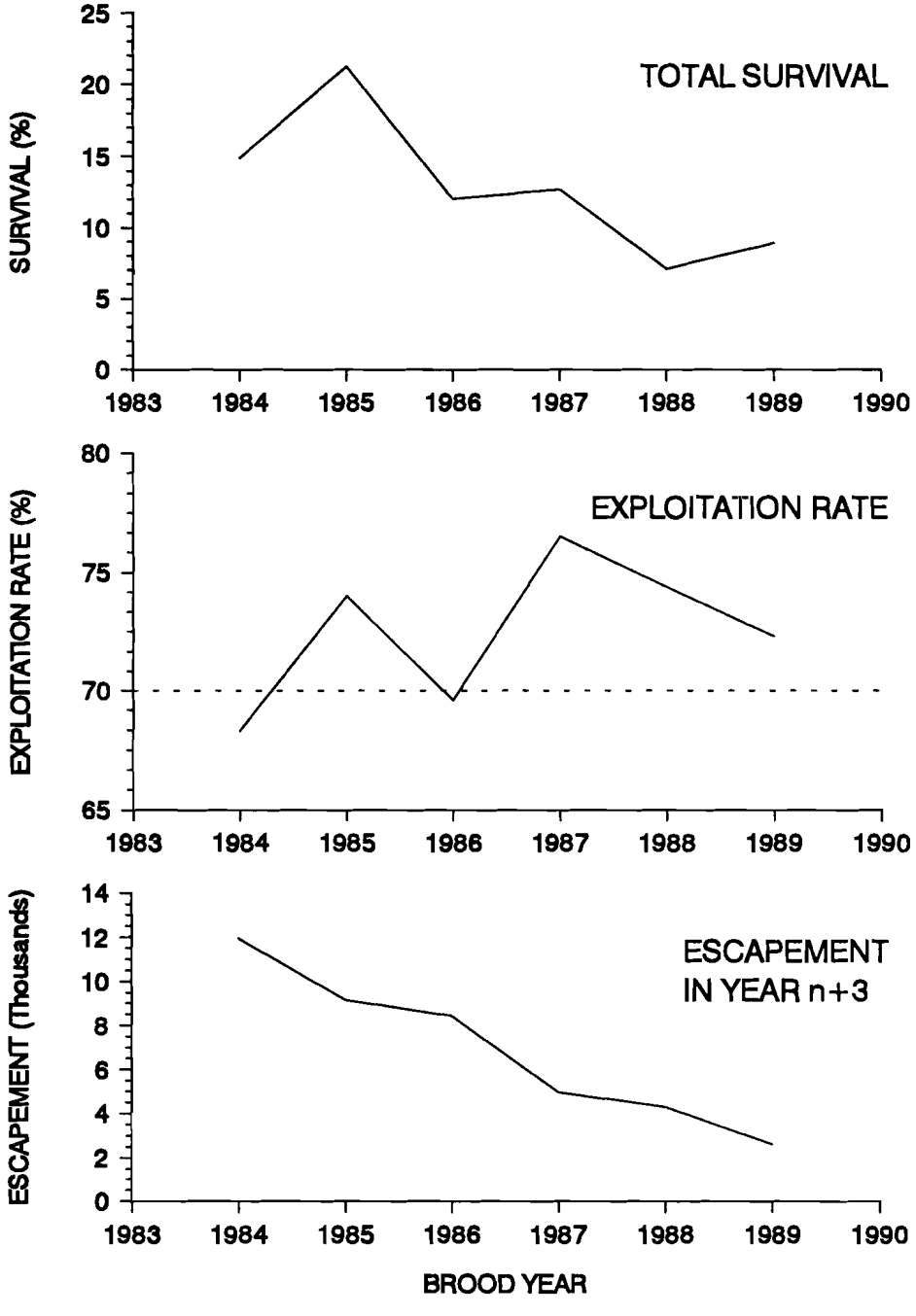

Figure 2. Trends in total survival, exploitation rate and adult escapement in 1984 - 1989 brood Salmon River coho salmon. The dashed line on the exploitation rate plot represents the upper limit of the range of sustainable exploitation.

- Exploitation rates (ERs) increased at an average annual rate of 1.2% or 0.8 percentage points per year. ERs were more variable than either escapement or survival; however, they remained above 70% in four of the six study brood years. This is important because 70% is felt to be the upper limit of exploitation sustainable by coastal coho stocks (Anon. 1990), and because ERs may have been under estimated (e.g. because the CWT catch in the river Indian and sport fisheries was unknown, CWTs in undersampled marine fishery strata were not expanded, and mark-recapture estimate tend to overestimate escapement and underestimate ER). Study period ERs, therefore, may have been considerably higher than the sustainable level.

- Smolt production, as indicated by the smolt production index (SPI), declined by an average of 8.3% per year. The SPI for the most recent brood year (1989) was the lowest recorded during the study. We believe that, because of annual differences in the differential survival between coded wire tagged and untagged fish, the SPI is a relatively insensitive index of smolt production; however, the negative trend and the poor 1989 brood index suggests that there has been an erosion of the smolt production from this system during the six year study.

In summary, a collapse of Salmon River system coho escapements was coincident with sharp declines in smolt to adult survival and reduced smolt production. At the same time, the exploitation rate was above, and perhaps substantially above, the sustainable level. These findings were consistent with stock status information presented by the Department of Fisheries and Oceans in support of a planning process to rebuild wild coho stocks in southern British Columbia (Anon. 1990).

The causal factors for the observed trends are uncertain. Walters (1993) and others (e.g. R.J. Beamish, pers. comm.) have proposed a number of hypotheses to explain the recent 50% decline in the catch of wild coho salmon in the Strait of Georgia. Four will be considered here: overexploitation; freshwater habitat loss; intraspecific competition with hatchery smolts; and ocean changes which have reduced the survival of both enhanced and wild fish.

When overexploition occurs, it causes declining escapements and, consequently, reduced smolt production. Walters rejected overexploitation as a cause of reduced catch because there was no detectable recruitment reduction. In the current study, however, there is evidence of reduced smolt production and adult recruitment. Consequently, we were unable to reject overexploitation as a cause of the observed trends.

Walters also rejected freshwater habitat loss because, while acknowledging that degradation had occurred, the losses had been insufficient to account for the 50% reduction in catch. Over the course of our study, we did not note gross habitat changes which impacted directly on or near the stream course. If smolt production declined, therefore, there is little evidence of habitat loss as a direct causal factor.

We also considered the hypothesis that declining wild survivals resulted from direct competition between wild and hatchery fish in the estuarine or marine environment. If such an interaction occurred, we would expect the decline in smolt to adult survivals to be more pronounced in wild than in hatchery fish. To test this assumption, we selected the Vedder-Chilliwack River hatchery stock for comparison because its marine harvest distribution was similar to the study stock (Schubert and Zallen 1990). This permitted us to eliminate at least one extraneous variable. Because these stocks experienced nearly identical declines in survival over the same period, we concluded that wild-hatchery interactions played at most a minor causal role in the observed trends.

The relationship between climate, ocean conditions and fish production is attracting increased attention in the literature (e.g. Beamish 1993; Beamish and Bouillon 1993). The sharp decline in smolt to adult survival may reflect large scale oceanographic changes resulting from climate change; however, it was beyond the scope of our study to evaluate the role of these factors as causal agents for the observed survival trends.

In conclusion, although we could not identify the cause of the trends in the stock status indicators presented above, our data do not support enhancement impacts or habitat degradation as causal factors. We note, however, that these are difficult factors to quantify and deserve further

study. The most probable causal factors were overexploitation and changes in ocean conditions. Ultimately, the reason for the decline or collapse in escapement, whether poor survival or overexploitation, is irrelevant to our recommendation for the management of this stock and the stocks which it represents. Exploitation rates must be reduced for this stock to rebuild.

SUMMARY

1. The Salmon River (Langley) supports one of a group of B.C. coho stocks being monitored for responses to management actions by measuring annual escapement, marine survival, harvest distribution and exploitation rate. This report documents the 1989 brood year results.

2. Coded wire tags (CWTs) and adipose fin clips (AFCs) were applied to emigrant smolts at fence traps in Salmon River and Coghlan Creek, the principal tributary, from April 23 to May 22, 1991. Tagged smolts were transported and released below a pumphouse at the river mouth.

3. A total of 29,435 coho smolts were released with CWTs and AFCs. Size averaged 96.0 mm nose-fork length and 8.9 g wet weight.

4. Adult spawners were enumerated by a mark-recapture study from November 4, 1992 to February 5, 1993. Coho adults were captured using an electroshocker and marked with disk tags and opercular punches. Escapement was censused by the recovery of carcasses following spawning.

5. The 1992-1993 coho adult escapement was estimated from a tag application sample of 152, a recovery sample of 460, and a recovery of 25 tags or secondary marks. Fish with electroshocker bruising were excluded from the simple Petersen population estimate. The estimate was 2,604 adults, of which 1,591 were male, 1,013 were female and 769 had AFCs. Long term CWT loss was 5.1%.

6. The proportion of the smolt release recovered on the spawning grounds was 2.5%. The proportion was higher in Salmon River versus Coghlan Creek and in the late versus early time periods.

7. Most (98.1%) of the adult escapement was age 3_2. Adult POH length averaged 41.2 cm for males and 44.0 cm for females.

8. A spatial bias in the application sample was the only bias identified during this study, and was considered unlikely to have influenced the reliability of the escapement estimate.

9. Trends in escapement, survival, smolt production and exploitation rate were evaluated for the 1984-1989 brood years. The collapse of Salmon River system coho escapements was coincident with sharply declining survivals and reduced smolt production. At the same time, exploitation rates were above the sustainable level. All of these findings indicate a conservation concern for this and similar coho stocks.

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APPENDICES

Appendix 1a. Daily enumeration of downstream migrants, by species, at the Salmon River fence trap, 1991.

Date	Water temp. (C) a	Water level (m) a	Coho smolt	Cutthroat trout		Rainbow trout		Lamprey	Sculpin	Stickle-back	Cray-fish	Sucker
				Smolt	Parr	Smolt	Parr					
22-Apr	10.0	0.10	70	9	0	24	0	4	0	2	2	0
23-Apr	9.0	0.11	181	5	1	169	0	1	5	0	1	0
24-Apr	11.0	0.13	278	28	2	72	1	2	5	0	0	0
25-Apr	8.0	0.17	628	32	9	122	5	0	2	0	2	0
26-Apr	8.0	0.19	270	8	0	24	2	2	2	0	1	0
27-Apr	7.0	0.14	477	3	1	76	0	2	2	0	0	0
28-Apr	8.5	0.12	154	5	0	1	0	0	0	0	0	0
29-Apr	7.0	0.14	352	18	0	17	0	0	0	0	0	0
30-Apr	8.0	0.13	473	1	0	19	0	0	0	0	0	0
01-May	9.0	0.12	921	50	1	104	1	0	0	0	0	0
02-May	9.0	0.11	534	9	1	3	1	0	0	0	0	0
03-May	10.0	0.10	1,175	35	4	43	1	1	1	0	0	0
04-May	10.5	0.10	1,114	53	1	37	0	0	0	0	1	0
05-May	10.0	0.10	863	14	1	56	8	1	0	0	1	0
06-May	10.0	0.13	1,595	183	7	243	8	5	0	0	0	0
07-May	10.0	0.19	2,108	66	14	55	7	2	6	0	1	0
08-May	9.5	0.29	874	41	10	66	13	0	5	0	3	0
09-May b	9.0	0.30	-	-	-	-	-	-	-	-	-	-
10-May	9.5	0.20	280	8	2	7	0	0	1	0	0	0
11-May	10.0	0.18	237	12	2	2	0	0	0	1	0	0
12-May	-	0.15	688	6	1	4	3	1	3	0	0	0
13-May	10.0	0.14	611	3	0	1	0	0	0	0	0	0
14-May	10.0	0.13	1,109	14	4	10	1	0	0	0	0	0
15-May	10.0	0.12	753	3	2	4	2	1	1	0	0	0
16-May	11.0	0.11	1,142	9	2	4	0	0	0	0	1	0
17-May	11.0	0.11	1,132	6	0	2	2	1	0	0	2	0
18-May	11.0	0.14	1,664	49	20	91	17	1	1	0	1	0
19-May	11.0	0.14	1,376	34	3	12	7	0	1	0	1	0
20-May	11.5	0.13	564	14	1	6	2	0	0	0	0	0
21-May	11.0	0.12	301	12	1	1	0	0	0	0	0	0
22-May	10.0	0.11	417	3	0	2	0	1	1	0	1	0
23-May	9.0	0.11	419	14	5	2	0	1	0	0	2	0
24-May	10.0	0.12	250	84	0	1	0	1	0	0	0	0
25-May	10.0	0.19	264	88	0	5	0	1	0	0	1	0
26-May	10.0	0.17	739	103	4	33	5	1	2	0	0	0
27-May	10.0	0.14	127	4	1	2	0	0	2	0	4	0
28-May	10.0	0.12	75	7	0	0	0	2	0	0	1	0
29-May	10.5	0.12	51	8	0	0	0	0	0	0	1	0
30-May	10.5	0.12	80	25	0	6	0	0	0	0	0	0
Total	-	-	24,346	1,066	100	1,326	86	31	40	3	27	0

a. Recorded at approximately 0800 hrs.

b. Trap out due to high water.

Appendix 1b. Daily enumeration of downstream migrants, by species, at the Coghlan Creek fence trap, 1991.

Date	Water temp. (C) a	Water level (m) a	Coho smolt	Cutthroat trout		Rainbow trout		Lamprey	Sculpin	Stickle-back	Cray-fish	Sucker
				Smolt	Parr	Smolt	Parr					
22-Apr	9.5	0.18	50	14	0	46	0	0	0	0	0	0
23-Apr	9.0	0.17	79	8	11	29	0	0	0	0	0	0
24-Apr	11.0	0.19	49	21	7	26	1	0	0	0	0	0
25-Apr	8.0	0.22	204	75	10	59	4	0	0	0	1	0
26-Apr	8.0	0.19	130	12	1	8	4	1	1	0	0	0
27-Apr	7.0	0.18	128	12	1	8	0	0	0	0	0	0
28-Apr	8.0	0.18	127	17	2	5	1	0	0	0	0	0
29-Apr	7.0	0.19	103	9	4	4	1	2	0	0	0	0
30-Apr	8.0	0.18	336	35	3	9	0	1	0	0	0	0
01-May	8.5	0.17	273	39	3	26	2	2	0	0	1	0
02-May	9.0	0.17	424	35	10	18	8	0	0	0	0	0
03-May	9.0	0.16	332	70	10	13	8	0	3	0	1	0
04-May	10.0	0.18	509	71	5	17	1	0	0	0	1	0
05-May	10.0	0.17	631	38	8	22	7	0	0	0	2	0
06-May	10.0	0.21	1,036	203	19	149	7	0	2	1	0	0
07-May	10.0	0.25	678	183	13	29	4	0	1	2	3	0
08-May	9.0	0.34	190	12	0	1	0	0	5	0	0	0
09-May b	9.0	0.35	-	-	-	-	-	-	-	-	-	-
10-May b	10.0	0.24	-	-	-	-	-	-	-	-	-	-
11-May	9.5	0.21	184	44	4	1	0	1	0	0	0	0
12-May		0.20	403	66	10	4	6	1	3	0	1	0
13-May	9.5	0.19	491	56	7	8	4	1	0	0	1	0
14-May	9.0	0.18	611	55	5	2	1	0	0	0	0	0
15-May	9.0	0.18	324	55	5	4	3	0	0	0	0	0
16-May	10.0	0.18	759	48	7	1	10	0	0	0	1	0
17-May	11.0	0.17	491	100	9	7	8	0	0	0	0	0
18-May	10.0	0.19	422	162	14	7	8	2	0	1	1	0
19-May	10.0	0.20	441	73	2	0	4	0	1	0	0	0
20-May	10.0	0.18	283	41	2	1	3	0	0	0	0	0
21-May	10.0	0.17	130	48	6	3	0	0	0	0	0	0
22-May	10.0	0.17	114	51	6	2	2	0	1	0	0	0
23-May	8.0	0.17	125	41	2	0	0	0	0	0	1	0
24-May	10.0	0.17	129	30	2	1	2	0	0	0	0	0
25-May	9.0	0.22	109	75	9	1	0	0	1	0	1	0
26-May	9.0	0.19	179	72	0	0	0	0	1	0	0	0
27-May	9.5	0.18	66	35	0	2	0	1	2	0	1	0
28-May	9.0	0.18	70	28	0	0	0	0	0	0	1	0
29-May	10.0	0.18	24	19	4	2	1	0	0	0	1	0
30-May	10.0	0.18	33	16	1	0	0	0	0	0	0	0
Total	-	-	10,667	1,969	202	515	100	12	21	4	18	0

a. Recorded at approximately 0800 hrs.

b. Trap out due to high water.

Appendix 2a. Application of coded wire tags, by code and date, to Salmon River coho salmon smolts, 1991.

CWT code	Tagging date	Maximum holding time (days)	Pre-tagging mort-ality	Total number marked	24 hour CWT rejection		Post tagging mortality		Total released with CWTs c
					N a	(%)	Immediate	24-hour b	
02 08 49	23-Apr	1	0	241	199	0.5	2	1	225
	25-Apr	1	0	900	241	3.8	10	15	795
	26-Apr	0	0	261	139	0.7	0	2	244
	29-Apr	0	0	986	218	0.0	0	0	936
	30-Apr	0	0	473	253	0.8	0	0	445
	01-May	0	0	921	273	1.1	4	0	860
	02-May	0	0	534	272	0.0	1	0	506
	03-May	0	5	1,166	139	0.0	0	0	1,107
	06-May	3	4	3,545	244	0.0	50	0	3,314
	07-May	0	0	1,067	235	2.0	0	0	992
	08-May	0	0	826	307	0.7	0	13	766
Total (mean)		(0.5)	9	10,920	2,520	(0.6)	67	31	10,188
02 08 51	08-May	0	0	1,014	307	0.7	0	16	940
	10-May	0	0	279	279	0.0	0	0	265
	13-May	2	0	611	243	0.0	7	0	573
	14-May	0	0	1,532	238	0.0	2	0	1,451
	15-May	0	0	753	271	0.4	0	0	712
	16-May	0	0	1,143	263	0.4	1	0	1,079
	17-May	0	1	1,132	224	0.0	0	0	1,074
	20-May	2	0	3,594	245	0.0	35	0	3,376
	21-May	0	0	301	301	0.0	0	0	286
	22-May	0	0	201	201	1.5	0	0	188
	Total (mean)	(0.4)	1	10,560	2,572	(0.3)	45	16	9,943
Total (mean)		(0.5)	10	21,480	5,092	(0.5)	112	47	20,130

a. Sample size held to assess tag loss.

b. Based on mortality rate observed in QCD subsample expanded to entire tag lot.

c. Adjusted for long term CWT loss (see text).

Appendix 2b. Application of coded wire tags, by code and date, to Coghlan Creek coho salmon smolts, 1991.

CWT code	Tagging date	Maximum holding time (days)	Pre-tagging mort-ality	Total number marked	24 hour CWT rejection		Post tagging mortality		Total released with CWTs c
					N a	(%)	Immediate	24-hour b	
02 08 50	23-Apr	3	0	139	137	0.0	2	2	128
	25-Apr	1	1	251	235	1.2	13	6	217
	26-Apr	0	0	130	115	0.9	0	1	121
	29-Apr	2	0	302	218	3.7	1	0	273
	30-Apr	0	0	336	242	2.5	0	0	310
	01-May	0	0	273	159	0.0	1	0	258
	02-May	0	0	424	188	0.0	2	0	400
	03-May	0	0	332	294	0.3	0	0	314
	06-May	4	38	2,788	312	0.0	17	0	2,630
	07-May	0	0	190	190	0.0	0	0	180
	12-May	2	1	1,087	319	0.3	1	0	1,027
	13-May	0	0	610	299	0.3	2	0	575
	14-May	0	0	323	323	0.0	0	2	305
	15-May	0	0	759	233	0.0	0	0	720
	16-May	0	0	491	253	0.0	7	0	459
	20-May	4	0	1,279	261	0.0	1	0	1,213
	21-May	0	0	114	112	0.0	0	2	106
	22-May	0	0	70	70	0.0	0	0	66
	Total	(Mean)	40	9,898	3,960	(0.21)	47	13	9,305

a. Sample size held to assess tag loss.

b. Based on mortality rate observed in QCD subsample expanded to entire tag lot.

c. Adjusted for long term CWT loss (see text).

Appendix 3. Anomalies encountered while coded wire tagging wild Salmon River system coho salmon smolts, 1991.

Location	Number inspected	Fog eye	Neascus	Scoliosis	General damage	Naturally missing adipose fin
Salmon River	21,356	3,032	80	2	11	0
		14.2%	0.4%	0.0%	0.1%	0.0%
Coghlan Creek	9,902	959	30	9	5	0
		9.7%	0.3%	0.1%	0.1%	0.0%
Total	31,258	3,991	110	11	16	0
		12.8%	0.4%	0.0%	0.1%	0.0%

Appendix 4. Mean length and weight, by location and date, of coho salmon smolts in the Salmon River system, 1991.

Location	Sample date	Sample size	Nose-Fork length (mm) Mean	Nose-Fork length (mm) Standard deviation	Mean wet weight (g)
Salmon River	22-Apr	50	104.7	18.5	11.3
	26-Apr	50	97.8	15.7	9.6
	30-Apr	50	91.9	10.8	7.5
	03-May	50	98.2	13.1	9.4
	10-May	50	101.7	10.7	10.6
	14-May	50	98.9	9.6	10.2
	17-May	50	90.8	10.0	7.3
	21-May	50	90.7	10.8	7.6
	24-May	50	98.0	10.8	9.3
	29-May	50	94.1	7.4	8.5
	Total	500	96.5 a	-	9.1 a
Coghlan Creek	23-Apr	50	107.1	14.0	12.5
	26-Apr	50	106.9	13.4	12.3
	30-Apr	50	104.1	14.6	11.8
	03-May	50	98.1	9.9	9.6
	14-May	50	92.2	6.1	7.7
	17-May	50	92.9	8.5	8.1
	21-May	50	91.3	7.2	5.8
	24-May	50	95.1	7.2	9.5
	29-May	50	91.6	6.7	7.8
	Total	450	94.3 a	-	8.3 a
Total	-	950	96.0 a	-	8.9 a

a. Weighted by proportion of smolt migration in time periods.

Appendix 5a. Daily application of disk tags and secondary marks, by reach, release condition, adipose fin status and sex, to coho adults in the Salmon River, 1992-1993. a

		Released unbruised			Released with electroshocker bruising			Total			Adipose absent c	
Date	Reach b	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
04-Nov	S1	7	2	9	2	4	6	9	6	15	3	1
	S2	0	0	0	0	1	1	0	1	1	0	1
06-Nov	S1	2	6	8	2	2	4	4	8	12	2	4
	S2	2	1	3	1	1	2	3	2	5	1	1
09-Nov	S1	0	1	1	1	0	1	1	1	2	0	1
	S2	0	2	2	1	1	2	1	3	4	0	1
	S3	0	1	1	2	1	3	2	2	4	0	1
13-Nov	S1	0	0	0	2	1	3	2	1	3	0	0
16-Nov	S2	1	1	2	1	1	2	2	2	4	0	2
	S4	3	3	6	1	1	2	4	4	8	3	0
	S5	0	0	0	1	1	2	1	1	2	0	0
20-Nov	S1	2	2	4	3	3	6	5	5	10	0	1
	S2	2	0	2	3	2	5	5	2	7	2	0
23-Nov	S1	4	7	11	6	12	18	10	19	29	0	5
	S2	0	0	0	3	2	5	3	2	5	1	1
	S4	1	1	2	3	3	6	4	4	8	1	2
25-Nov	S1	1	0	1	2	1	3	3	1	4	1	0
	S2	1	0	1	1	1	2	2	1	3	1	0
02-Dec	S1	0	0	0	2	2	4	2	2	4	1	1
	S2	1	2	3	1	2	3	2	4	6	1	3
	S4	4	0	4	4	1	5	8	1	9	3	1
	S5	2	0	2	0	0	0	2	0	2	0	0
07-Dec	S1	1	2	3	1	0	1	2	2	4	1	1
09-Dec	S1	3	5	8	4	2	6	7	7	14	3	1
	S2	0	0	0	0	1	1	0	1	1	0	0
	S3	1	2	3	3	0	3	4	2	6	0	0
16-Dec	S1	0	0	0	3	0	3	3	0	3	2	0
	S2	0	1	1	0	1	1	0	2	2	0	1
18-Dec	S2	3	3	6	1	1	2	4	4	8	0	1
	S4	8	2	10	3	3	6	11	5	16	2	1
21-Dec	S1	0	1	1	0	0	0	0	1	1	0	0
	S2	0	1	1	1	1	2	1	2	3	0	0
06-Jan	S1	2	3	5	0	0	0	2	3	5	0	1
Total	S1	22	29	51	28	27	55	50	56	106	13	16
	S2	10	11	21	13	15	28	23	26	49	6	11
	S3	1	3	4	5	1	6	6	4	10	0	1
	S4	16	6	22	11	8	19	27	14	41	9	4
	S5	2	0	2	1	1	2	3	1	4	0	0
Total	-	51	49	100	58	52	110	109	101	210	28	32

a. Not corrected for sex identification errors.

b. Salmon River reaches: S1 - below Coghlan Creek. S4 - 56 Ave. to 248 St.
S2 - Coghlan Creek to 64 Ave. S5 - 248 St. to 256 St.
S3 - 64 Ave. to 56 Ave.

c. Included in 'Total' column.

Appendix 5b. Daily application of disk tags and secondary marks, by reach, release condition, adipose fin status and sex, to coho adults in Coghlan Creek, 1992-1993. a

		Released unbruised			Released with electroshocker bruising			Total			Adipose absent c	
Date	Reach b	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
13-Nov	C3	1	1	2	0	1	1	1	2	3	1	0
	C5	1	1	2	0	0	0	1	1	2	1	0
25-Nov	C1	5	0	5	1	1	2	6	1	7	0	0
	C2	7	2	9	3	1	4	10	3	13	4	2
	C3	1	1	2	0	0	0	1	1	2	1	1
07-Dec	C1	0	1	1	1	0	1	1	1	2	0	0
11-Dec	C1	14	7	21	7	2	9	21	9	30	0	1
	C2	3	1	4	0	0	0	3	1	4	1	0
	C4	1	3	4	0	1	1	1	4	5	0	0
	C5	1	1	2	0	0	0	1	1	2	0	0
21-Dec	C1	0	0	0	0	1	1	0	1	1	0	0
Total	C1	19	8	27	9	4	13	28	12	40	0	1
	C2	10	3	13	3	1	4	13	4	17	5	2
	C3	2	2	4	0	1	1	2	3	5	2	1
	C4	1	3	4	0	1	1	1	4	5	0	0
	C5	2	2	4	0	0	0	2	2	4	1	0
	Total	34	18	52	12	7	19	46	25	71	8	4

a. Not corrected for sex identification error.

b. Coghlan Creek reaches: C1 - Salmon River to Hwy. 1. C4 - 64 Ave. to 256 St.
C2 - Hwy. 1 to 248 St. C5 - Above 256 St.
C3 - 248 St. to 64 Ave.

c. Included in 'Total' column.

Appendix 6. Disk tag and secondary mark recoveries, by application and recovery date and location, size, sex, adipose fin status and disk tag number, of coho salmon adults released in the Salmon River system, 1992-1993.

Application sample						Recovery sample				
Date	Reach	NF length (cm)	Sex	Adipose fin	Disk tag number	Date	Reach	POH length (cm)	Sex	Days out
4-Nov	S1	54.0	F	P	20008	7-Dec	S1	42.8	F c	33
6-Nov	S1	57.5	M	P	20016	7-Dec	S1	42.5	M	31
6-Nov	S1	52.5	F	P	20025	18-Nov	S1	40.4	M a,b	12
6-Nov	S2	59.0	F	P	20023	7-Dec	S1	47.6	F b	31
13-Nov	C3	59.5	F	P	20046	21-Dec	C1	46.5	F	38
16-Nov	S4	60.0	M	A	20056	16-Dec	S4	45.5	M c	30
16-Nov	S4	52.0	F	P	20059	4-Dec	S3	44.8	F	18
16-Nov	S4	56.5	F	P	20060	4-Dec	S3	46.0	F b	18
23-Nov	S1	54.5	F	P	20099	7-Dec	S1	46.1	F	14
23-Nov	S1	57.0	F	P	20105	28-Dec	S1	46.5	F	35
25-Nov	C1	43.1	M	P	20131	21-Dec	C1	34.0	M	26
25-Nov	C2	56.5	F	A	20134	7-Dec	C3	47.5	F	12
25-Nov	C2	59.0	F	P	20140	5-Feb	C2	46.2	F b	72
2-Dec	S4	45.5	M	P	20156	4-Dec	S3	36.3	M	2
9-Dec	S3	54.0	M	P	20201	15-Dec	S1	42.5	M	6
11-Dec	C1	45.5	F	P	20225	5-Jan	C1	36.8	M a	25
11-Dec	C1	43.5	F	P	20226	21-Dec	C1	37.5	F b	10
11-Dec	C1	45.0	M	P	20227	12-Dec	C1	37.9	M	1
11-Dec	C1	57.5	M	P	20223	5-Jan	C1	44.5	M	25
11-Dec	C1	49.5	M	P	20241	29-Dec	C1	41.0	M	18
11-Dec	C2	47.0	M	A	20204	21-Dec	C1	39.0	M	10
11-Dec	C4	53.5	F	P	20210	15-Dec	C5	43.8	F	4
11-Dec	C5	52.5	M	P	20213	6-Jan	C3	41.5	M	26
18-Dec	S2	54.0	M	P	20250	28-Dec	S1	41.5	M	10
18-Dec	S4	55.5	M	P	20260	28-Dec	S3	44.3	M	10
18-Dec	S4	51.0	F	A	20265	4-Feb	S1	39.8	F	48
18-Dec	S4	58.5	M	A	20272	28-Dec	S2	47.5	M	10

			Mean days out:	21.3
Females initially identified as males:	0	0.0%	Max. days out:	72.0
Males initially identified as females:	2	13.3%	Min. days out:	1.0

POH and NF regressions:

Males:
POH length = 0.63 NF length + 8.17
NF length = 1.41 POH length - 6.1

Females:
POH length = 0.63 NF length + 9.91
NF length = 1.28 POH length - 2.59

a. Incorrect sex identification during disk tag application
b. Required ventilation at release.
c. Bruised at release.
d. See Appendix 5 for reach descriptions.

Appendix 7a. Daily coho carcass recoveries, by reach, mark status and sex, in the Salmon River, 1992-1993.

		Unmarked			Disk tag and secondary mark		Secondary mark only		Total			Adipose absent a		
Date	Reach	Male	Female	Jack	Male	Female	Male	Female	Male	Female	Jack	Male	Female	Jacks
18-Nov	S1	0	2	0	1	0	0	0	1	2	0	0	0	0
	S2	0	0	0	0	0	0	0	0	0	0	0	0	0
20-Nov	S3	2	0	0	0	0	0	0	2	0	0	0	0	0
27-Nov	S1	0	0	0	0	0	0	0	0	0	0	0	1	0
	S3	0	3	0	0	0	0	0	0	3	0	0	2	0
04-Dec	S2	3	1	1	0	0	0	0	3	1	1	1	0	0
	S3	5	0	1	1	2	0	0	6	2	1	3	0	0
	S4	3	4	0	0	0	0	0	3	4	0	2	4	0
	S5	5	1	0	0	0	0	0	5	1	0	2	0	0
07-Dec	S1	3	11	3	1	3 b	0	0	4	14 b	3	1	4	0
15-Dec	S1	1	2	0	1	0	0	0	2	2	0	0	1	0
	S2	2	1	0	0	0	0	0	2	1	0	1	0	0
	S3	23	5	2	0	0	0	0	23	5	2	10	0	0
16-Dec	S4	11	26	3	1 b	0	0	0	12 b	26	3	6	11	0
	S5	7	9	2	0	0	0	0	7	9	2	3	3	0
21-Dec	S1	1	3	1	0	0	0	0	1	3	1	1	0	0
22-Dec	S4	5	9	0	0	0	0	0	5	9	0	1	2	0
	S5	2	4	0	0	0	0	0	2	4	0	0	3	0
28-Dec	S1	3	7	0	1	1	0	0	4	8	0	3	1	0
	S2	3	2	0	1	0	0	0	4	2	0	1	1	0
	S3	16	6	0	1	0	0	0	17	6	0	8	0	0
29-Dec	S4	2	3	2	0	0	0	0	2	3	2	0	2	0
05-Jan	S1	0	2	0	0	0	0	0	0	2	0	0	1	0
06-Jan	S4	0	0	0	0	0	0	0	0	0	0	0	0	0
	S5	2	0	0	0	0	0	0	2	0	0	1	0	0
07-Jan	S2	0	0	0	0	0	0	0	0	0	0	0	0	0
	S3	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Feb	S1	6	3	1	0	1	0	0	6	4	1	1	1	0
	S2	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Feb	S3	0	0	0	0	0	0	0	0	0	0	0	0	0
	S5	0	1	0	0	0	0	0	0	1	0	0	0	0
Total	S1	14	30	5	4	5 b	0	0	18	35 b	5	6	8	0
	S2	8	4	1	1	0	0	0	9	4	1	3	2	0
	S3	46	14	3	2	2	0	0	48	16	3	21	2	0
	S4	21	42	5	1 b	0	0	0	22 b	42	5	9	19	0
	S5	16	15	2	0	0	0	0	16	15	2	6	6	0
	Total	105	105	16	8	7	0	0	113 b	112 b	16	45	37	0

a. Included in 'Total' column.
b. One bruised at release.

Appendix 7b. Daily coho carcass recoveries, by reach, mark status and sex, in the Coghlan Creek, 1992-1993.

		Unmarked			Disk tag and secondary mark		Secondary mark only		Total			Adipose absent a		
Date	Reach	Male	Female	Jack	Male	Female	Male	Female	Male	Female	Jack	Male	Female	Jacks
18-Nov	C3	0	0	0	0	0	0	0	0	0	0	0	0	0
	C4	0	0	0	0	0	0	0	0	0	0	0	0	0
	C5	0	3	0	0	0	0	0	0	3	0	0	3	0
20-Nov	C1	2	1	1	0	0	0	0	2	1	1	0	0	0
	C2	0	0	0	0	0	0	0	0	0	0	0	0	0
27-Nov	C1	0	0	0	0	0	0	0	0	0	0	0	0	0
	C2	1	0	0	0	0	0	0	1	0	0	0	0	0
04-Dec	C3	0	0	1	0	0	0	0	0	0	1	0	0	1
	C5	0	4	1	0	0	0	0	0	4	1	0	2	0
05-Dec	C4	0	0	0	0	0	0	0	0	0	0	0	0	0
07-Dec	C1	6	10	0	0	1	0	0	6	11	0	0	3	0
	C2	12	6	3	0	0	0	0	12	6	3	1	0	1
12-Dec	C1	6	9	1	1	0	0	0	7	9	1	0	2	0
	C2	5	6	0	0	0	0	0	5	6	0	1	1	0
15-Dec	C3	10	4	0	0	0	0	0	10	4	0	3	1	0
	C4	10	3	0	0	0	0	0	10	3	0	2	2	0
	C5	0	1	0	0	1	0	0	0	2	0	0	1	0
21-Dec	C1	10	11	2	2	2	0	0	12	13	2	1	1	0
	C2	8	3	3	0	0	0	0	8	3	3	2	0	0
22-Dec	C3	2	0	0	0	0	0	0	2	0	0	1	0	0
	C4	1	0	0	0	0	0	0	1	0	0	0	0	0
28-Dec	C3	2	4	0	0	0	0	0	2	4	0	0	2	0
	C4	3	1	0	0	0	0	0	3	1	0	1	1	0
29-Dec	C1	7	8	2	1	0	0	0	8	8	2	2	1	0
	C2	2	0	0	0	0	0	0	2	0	0	0	0	0
	C5	2	2	0	0	0	0	0	2	2	0	2	0	0
05-Jan	C1	2	1	0	2	0	0	0	4	1	0	0	0	1
	C2	1	0	1	0	0	0	0	1	0	1	0	0	0
06-Jan	C3	2	0	0	1	0	0	0	3	0	0	0	0	0
	C4	1	0	0	0	0	0	0	1	0	0	0	0	0
07-Jan	C5	0	0	0	0	0	0	0	0	0	0	0	0	0
04-Feb	C1	16	11	2	0	0	0	0	16	11	2	3	0	0
	C5	0	0	0	0	0	0	0	0	0	0	0	0	0
05-Feb	C2	7	11	2	0	1	0	0	7	12	2	1	1	0
	C3	2	3	0	0	0	0	0	2	3	0	0	0	0
	C4	1	2	1	0	0	0	0	1	2	1	1	0	0
Total	C1	49	51	8	6	3	0	0	55	54	8	6	7	1
	C2	36	26	9	0	1	0	0	36	27	9	5	2	1
	C3	18	11	1	1	0	0	0	19	11	1	4	3	1
	C4	16	6	1	0	0	0	0	16	6	1	4	3	0
	C5	2	10	1	0	1	0	0	2	11	1	2	6	0
	Total	121	104	20	7	5	0	0	128	109	20	21	21	3

a. Included in 'Total' column.

Appendix 8. Proportion at age and mean length at age, by location, AFC status and sex, of coho carcasses recovered on the Salmon River system spawning grounds, 1992-1993.

			Female			Male		
	Mark status	Age a	Sample size	Percent	Mean POH length (cm)	Sample size	Percent	Mean POH length (cm)
Salmon River	Unmarked	4/3	0	0.0%	-	0	0.0%	-
		3/2	7	100.0%	46.8	7	87.5%	43.1
		2/2	0	0.0%	-	1	12.5%	27.5
		Total	10	47.6%	46.2	11	52.4%	41.2
	Adipose fin clip	4/3	1	6.7%	48.0	0	0.0%	-
		3/2	14	93.3%	45.1	23	100.0%	43.0
		2/2	0	0.0%	-	0	0.0%	-
		Total	37	45.1%	44.3	45	54.9%	43.0
	Total	4/3	1	4.5%	46.6	0	0.0%	-
		3/2	21	95.5%	44.5	30	96.8%	41.8
		2/2	0	0.0%	-	1	3.2%	27.9
		Total	47	45.6%	44.0	56	54.4%	41.2
Coghlan Creek	Unmarked	4/3	0	0.0%	-	0	0.0%	-
		3/2	8	100.0%	41.4	10	90.9%	41.4
		2/2	0	0.0%	-	1	9.1%	28.8
		Total	10	41.7%	41.1	14	58.3%	40.5
	Adipose fin clip	4/3	1	9.1%	45.2	0	0.0%	-
		3/2	10	90.9%	44.2	14	100.0%	39.5
		2/2	0	0.0%	-	0	0.0%	-
		Total	21	46.7%	43.9	24	53.3%	38.0
	Total	4/3	1	5.3%	45.2	0	0.0%	-
		3/2	18	94.7%	42.9	24	96.0%	40.3
		2/2	0	0.0%	-	1	4.0%	28.8
		Total	31	44.9%	43.0	38	55.1%	39.0
Total	Unmarked	4/3	0	0.0%	-	0	0.0%	-
		3/2	15	100.0%	43.9	17	89.5%	42.1
		2/2	0	0.0%	-	2	10.5%	28.1
		Total	20	44.4%	43.7	25	55.6%	40.8
	Adipose fin clip	4/3	2	7.7%	46.6	0	0.0%	-
		3/2	24	92.3%	44.7	38	97.4%	41.6
		2/2	0	0.0%	-	1	2.6%	27.5
		Total	58	45.3%	44.2	70	54.7%	41.3
	Total	4/3	2	4.9%	46.6	0	0.0%	-
		3/2	39	95.1%	44.4	55	94.8%	41.8
		2/2	0	0.0%	-	3	5.2%	27.9
		Total	78	45.1%	44.0	95	54.9%	41.2

a. Totals include unageable samples.

Appendix 9. AFC and CWT sampling of coho salmon recovered on the Salmon River system spawning grounds, 1992-1993.

			Recovered in Salmon River				Recovered in Coghlan Creek				Total	
			Adult male	Adult female	Adult total	Jack	Adult male	Adult female	Adult total	Jack	Adult total	Jack
Sample size			113	112	225	16	128	109	237	20	462	36
Number with AFC's			45	37	82	0	21	21	42	3	124	3
- AFC but no head			1	2	3	0	1	1	2	1	5	1
- CWT lost during processing			1	0	1	0	0	1	1	0	2	0
- AFC but no CWT present			3	5	8	0	2	5	7	1	15	1
- CWT recovered:												
Code	*Brood*	*Release site*										
02 09 19	1990	Coghlan Creek	0	0	0	0	0	0	0	1	0	1
02 08 50	1989	Coghlan Creek	3	7	10	0	15	11	26	0	36	0
02 08 49	1989	Salmon River	16	10	26	0	0	0	0	0	26	0
02 08 51	1989	Salmon River	21	13	34	0	3	3	6	0	40	0
Total			40	30	70	0	18	14	32	1	102	1
AFC incidence (%)			39.8%	33.0%	36.4%	0.0%	16.4%	19.3%	17.7%	15.0%	26.8%	8.3%
CWT loss (%)			6.8%	14.3%	10.1%	-	10.0%	25.0%	17.5%	50.0%	12.6%	50.0%

Appendix 10. Incidence of CWT loss, by carcass condition, eye status, and AFC condition, in coho carcasses recovered on the Salmon River system spawning grounds, 1992-1993.

Observation	Condition	Number	Status unknown a	CWT absent	CWT loss (%)
Carcass condtion	Fresh	32	0	3	9.4%
	Moderately fresh	46	0	1	2.2%
	Moderately rotten	42	2	11	27.5%
	Rotten	3	1	1	50.0%
	Not recorded	4	4	0	-
Eyes	Present	91	1	11	12.2%
	Absent	29	1	5	17.9%
	Not recorded	7	5	0	-
Adipose fin clip	Complete	99	2	7	7.2%
	Partial	14	0	7	50.0%
	Questionable	9	1	1	12.5%
	Not recorded	5	4	1	-

a. Either a carcass with no head or the head was lost during processing.

Appendix 11. Spawning success in female coho carcasses recovered on the Salmon River system spawning grounds, 1992-1993

Mark status		Percent spawned			
		0%	50%	100%	Weighted mean
Disk tag or secondary mark	Number	0	1	10	11
	Percent	0.0%	9.1%	90.9%	95.5%
Unmarked	Number	1	0	99	100
	Percent	1.0%	0.0%	99.0%	99.0%
Total	Number	1	1	109	111
	Percent	0.9%	0.9%	98.2%	98.6%

a. Excludes one bruised at release.

Appendix 12a. Observed and estimated recoveries of 1988 brood Salmon River system coho salmon (code 02 08 34). a

			1991 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Strait of	Obs:	-	-	-	-	-	1	-	-	1	-	-	-	2
	Georgia	Est:	-	-	-	-	-	2	-	-	8	-	-	-	10
	Juan de Fuca	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
		Est:	-	-	-	-	-	-	5	-	-	-	-	-	5
	Washington/	Obs:	-	-	-	-	-	-	1	1	-	-	-	-	2
	Oregon b	Est:	-	-	-	-	-	-	2	9	-	-	-	-	11
Troll	West Vancouver	Obs:	-	-	-	-	-	1	70	24	6	-	-	-	101
	Island	Est:	-	-	-	-	-	2	283	114	21	-	-	-	420
	Strait of	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
	Georgia	Est:	-	-	-	-	-	-	5	-	-	-	-	-	5
	Washington/	Obs:	-	-	-	-	-	-	1	1	1	-	-	-	3
	Oregon b	Est:	-	-	-	-	-	-	3	2	3	-	-	-	8
Net	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	1	1	-	2
		Est:	-	-	-	-	-	-	-	-	-	3	3	-	6
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	14	3	-	-	-	17
		Est:	-	-	-	-	-	-	-	62	11	-	-	-	73
	Puget Sound b	Obs:	-	-	-	-	-	-	2	5	2	2	-	-	11
		Est:	-	-	-	-	-	-	3	13	13	7	-	-	36
Total		Obs:	0	0	0	0	0	2	76	45	13	3	1	0	140
		Est:	0	0	0	0	0	4	301	200	56	10	3	0	574

a. Department of Fisheries and Oceans database.
b. Pacific States Marine Fisheries Commission database.

Appendix 12b. Observed and estimated recoveries of 1988 brood Salmon River system coho salmon (code 02 08 35). a

			1991 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Juan de Fuca	Obs:	-	-	-	-	-	-	-	2	-	-	-	-	2
		Est:	-	-	-	-	-	-	-	5	-	-	-	-	5
	Puget Sound b	Obs:	-	-	-	-	-	-	-	-	2	-	-	-	2
		Est:	-	-	-	-	-	-	-	-	16	-	-	-	16
	Washington/	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
	Oregon b	Est:	-	-	-	-	-	-	2	-	-	-	-	-	2
Troll	South Central	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
		Est:	-	-	-	-	-	-	1	-	-	-	-	-	1
	West Vancouver	Obs:	-	-	-	-	-	1	59	11	5	-	-	-	76
	Island	Est:	-	-	-	-	-	1	240	51	22	-	-	-	314
	Strait of	Obs:	-	-	-	-	-	-	2	-	-	-	-	-	2
	Georgia	Est:	-	-	-	-	-	-	9	-	-	-	-	-	9
	Washington/	Obs:	-	-	-	-	-	-	-	1	1	-	-	-	2
	Oregon b	Est:	-	-	-	-	-	-	-	3	1	-	-	-	4
Net	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	3	1	-	4
		Est:	-	-	-	-	-	-	-	-	-	9	3	-	12
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	8	1	-	-	-	9
		Est:	-	-	-	-	-	-	-	38	4	-	-	-	42
	Puget Sound b	Obs:	-	-	-	-	-	-	1	1	5	2	-	-	9
		Est:	-	-	-	-	-	-	1	1	13	5	-	-	20
Total		Obs:	0	0	0	0	0	1	64	23	14	5	1	0	108
		Est:	0	0	0	0	0	1	253	98	56	14	3	0	425

a. Department of Fisheries and Oceans database.
b. Pacific States Marine Fisheries Commission database.

Appendix 12c. Observed and estimated recoveries of 1988 brood Salmon River system coho salmon (code 02 08 36). a

			1991 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Washington/	Obs:	-	-	-	-	-	1	-	1	-	-	-	-	2
	Oregon b	Est:	-	-	-	-	-	2	-	1	-	-	-	-	3
Troll	West Vancouver	Obs:	-	-	-	-	-	-	4	6	1	-	-	-	11
	Island	Est:	-	-	-	-	-	-	18	23	14	-	-	-	55
Net	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	2	-	-	2
		Est:	-	-	-	-	-	-	-	-	-	6	-	-	6
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	3	-	-	-	-	3
		Est:	-	-	-	-	-	-	-	13	-	-	-	-	13
	Puget Sound b	Obs:	-	-	-	-	-	-	-	1	-	-	-	-	1
		Est:	-	-	-	-	-	-	-	1	-	-	-	-	1
Total		Obs:	0	0	0	0	0	1	4	11	1	2	0	0	19
		Est:	0	0	0	0	0	2	18	38	14	6	0	0	78

a. Department of Fisheries and Oceans database.
b. Pacific States Marine Fisheries Commission database.

Appendix 13a. Observed and estimated recoveries of 1989 brood Salmon River system coho salmon (code 02 08 49). a

			1992 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Central	Obs:	-	-	-	-	-	-	-	2	-	-	-	-	2
		Est:	-	-	-	-	-	-	-	8	-	-	-	-	8
	Strait of	Obs:	-	-	-	1	7	16	8	-	1	-	-	-	33
	Georgia, north	Est:	-	-	-	7	30	52	54	-	7	-	-	-	150
	Strait of	Obs:	-	-	1	1	3	1	2	-	-	-	-	-	8 b
	Georgia, south	Est:	-	-	1	1	24	7	2	-	-	-	-	-	35
	Puget Sound	Obs:	-	-	-	-	-	1	1	1	-	-	-	-	3
		Est:	-	-	-	-	-	1	1	1	-	-	-	-	3
	Juan de Fuca	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
		Est:	-	-	-	-	-	-	8	-	-	-	-	-	8
	Washington/	Obs:	-	-	-	-	-	1	1	2	-	-	-	-	4
	Oregon ocean	Est:	-	-	-	-	-	4	5	5	-	-	-	-	14
Troll	Central	Obs:	-	-	-	-	-	-	3	-	-	-	-	-	3
		Est:	-	-	-	-	-	-	9	-	-	-	-	-	9
	West Vancouver	Obs:	-	-	-	-	-	-	16	8	6	-	-	-	30
	Island	Est:	-	-	-	-	-	-	74	33	32	-	-	-	139
	Strait of	Obs:	-	-	-	-	-	-	23	-	3	-	-	-	26 b
	Georgia	Est:	-	-	-	-	-	-	70	-	16	-	-	-	86
Net	Alaska Seine	Obs:	-	-	-	-	-	-	-	1	-	-	-	-	1
		Est:	-	-	-	-	-	-	-	3	-	-	-	-	3
	Johnstone Strait	Obs:	-	-	-	-	-	-	-	1	-	1	-	-	2
		Est:	-	-	-	-	-	-	-	4	-	2	-	-	6
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	-	3	-	-	-	3
		Est:	-	-	-	-	-	-	-	-	8	-	-	-	8
	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	12	-	-	12
		Est:	-	-	-	-	-	-	-	-	-	18	-	-	18
	Misc. Canadian	Obs:	-	-	-	-	-	-	-	1	-	1	-	-	2
		Est:	-	-	-	-	-	-	-	4	-	1	-	-	5
Total (1992 catch)		Obs:	0	0	1	2	10	19	55	16	13	14	0	0	130
		Est:	0	0	1	8	54	64	223	58	63	21	0	0	492

a. Department of Fisheries and Oceans database.

b. Some observed recoveries were not expanded due to a failure to meet the sampling criteria.

Appendix 13b. Observed and estimated recoveries of 1989 brood Salmon River system coho salmon (code 02 08 50). a

			1992 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Strait of Georgia, north	Obs:	-	-	-	1	6	10	6	-	1	-	-	-	24
		Est:	-	-	-	7	25	32	41	-	7	-	-	-	112
	Strait of Georgia, south	Obs:	-	-	-	1	2	-	-	-	-	1	-	-	4
		Est:	-	-	-	1	16	-	-	-	-	2	-	-	19 c
	Puget Sound	Obs:	-	-	-	-	-	-	-	1	-	-	-	-	1
		Est:	-	-	-	-	-	-	-	1	-	-	-	-	1
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	1	1	1	-	-	3
		Est:	-	-	-	-	-	-	-	6	5	5	-	-	16
	Washington/ Oregon ocean	Obs:	-	-	-	-	-	-	-	3	-	-	-	-	3
		Est:	-	-	-	-	-	-	-	16	-	-	-	-	16
Troll	Central	Obs:	-	-	-	-	-	-	2	-	-	-	-	-	2
		Est:	-	-	-	-	-	-	21	-	-	-	-	-	21
	West Vancouver Island	Obs:	-	-	-	-	-	-	35	16	6	-	-	-	57
		Est:	-	-	-	-	-	-	156	59	17	-	-	-	232
	Strait of Georgia	Obs:	-	-	-	-	-	-	27	1	-	-	-	-	28
		Est:	-	-	-	-	-	-	91	6	-	-	-	-	97
	Washington/ Oregon ocean	Obs:	-	-	-	-	-	-	2	-	-	-	-	-	2
		Est:	-	-	-	-	-	-	3	-	-	-	-	-	3
Net	Johnstone Strait	Obs:	-	-	-	-	-	-	-	-	-	1	-	-	1
		Est:	-	-	-	-	-	-	-	-	-	2	-	-	2
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	3	-	-	-	-	3
		Est:	-	-	-	-	-	-	-	7	-	-	-	-	7
	Puget Sound b	Obs:	-	-	-	-	-	-	-	-	-	2	-	-	2
		Est:	-	-	-	-	-	-	-	-	-	5	-	-	5
	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	9	-	-	9
		Est:	-	-	-	-	-	-	-	-	-	14	-	-	14
Total		Obs:	0	0	0	2	8	10	72	25	8	14	0	0	139
		Est:	0	0	0	8	41	32	312	95	29	28	0	0	545

a. Department of Fisheries and Oceans database.

b. Pacific States Marine Fisheries Commission database.

c. Some observed recoveries were not expanded due to a failure to meet the sampling criteria.

Appendix 13c. Observed and estimated recoveries of 1989 brood Salmon River system coho salmon (code 02 08 51). a

			1992 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Sport	Central	Obs:	-	-	-	-	-	-	1	-	1	-	-	-	2
		Est:	-	-	-	-	-	-	4	-	4	-	-	-	8
	Strait of	Obs:	-	-	-	2	5	26	8	2	2	-	-	-	45
	Georgia, north	Est:	-	-	-	14	21	84	54	11	14	-	-	-	198
	Strait of	Obs:	-	-	-	1	8	3	-	-	1	-	-	-	13 c
	Georgia, south	Est:	-	-	-	1	64	21	-	-	4	-	-	-	90
	Puget Sound	Obs:	-	-	-	-	-	-	-	-	1	-	-	-	1
		Est:	-	-	-	-	-	-	1	-	1	-	-	-	2
	Juan de Fuca	Obs:	-	-	-	-	-	-	3	1	1	-	-	-	5
		Est:	-	-	-	-	-	-	23	6	5	-	-	-	34
	Washington/	Obs:	-	-	-	-	-	-	1	1	-	-	-	-	2
	Oregon ocean	Est:	-	-	-	-	-	-	8	1	-	-	-	-	9
Troll	Central	Obs:	-	-	-	-	-	-	8	-	-	-	-	-	8
		Est:	-	-	-	-	-	-	41	-	-	-	-	-	41
	West Vancouver	Obs:	-	-	-	-	-	-	39	14	8	-	-	-	61
	Island	Est:	-	-	-	-	-	-	175	57	28	-	-	-	260
	Strait of	Obs:	-	-	-	-	-	-	38	5	3	-	-	-	46 c
	Georgia	Est:	-	-	-	-	-	-	125	43	3	-	-	-	171
Net	Johnstone Strait	Obs:	-	-	-	-	-	-	-	-	1	-	-	-	1
		Est:	-	-	-	-	-	-	-	-	2	-	-	-	2
	Juan de Fuca	Obs:	-	-	-	-	-	-	-	9	-	-	-	-	9
		Est:	-	-	-	-	-	-	-	23	-	-	-	-	23
	Puget Sound b	Obs:	-	-	-	-	-	-	-	-	-	1	-	-	1
		Est:	-	-	-	-	-	-	-	-	-	3	-	-	3
	Fraser River	Obs:	-	-	-	-	-	-	-	-	-	12	-	-	12
		Est:	-	-	-	-	-	-	-	-	-	18	-	-	18
	Misc. Canadian	Obs:	-	-	-	-	-	-	-	-	-	1	-	-	1
		Est:	-	-	-	-	-	-	-	-	-	3	-	-	3
Total (1992 catch)		Obs:	0	0	0	3	13	29	98	32	18	14	0	0	207
		Est:	0	0	0	15	85	105	431	141	61	24	0	0	862

a. Department of Fisheries and Oceans database.

b. Pacific States Marine Fisheries Commission database.

c. Some observed recoveries were not expanded due to a failure to meet the sampling criteria.

Continued

Appendix 13c. Observed and estimated recoveries of 1989 brood Salmon River system coho salmon (code 02 08 51) continued. a

			1993 Catch by month												
Fishery	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Troll	West Vancouver Island	Obs:	-	-	-	-	-	-	1	-	-	-	-	-	1
		Est:	-	-	-	-	-	-	4	-	-	-	-	-	4

a. Department of Fisheries and Oceans database.