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ADULT CHINOOK ESCAPEMENT ASSESSMENT CONDUCTED ON THE COWICHAN RIVER DURING 1996

by

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ABSTRACT

Nagtegaal, D.A., and E.W. Carter. 1998. Adult chinook escapement assessment conducted on the Cowichan River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2449: 65 p.

In 1996, the Stock Assessment Division, Pacific Biological Station, conducted a study of chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. Major components of this ongoing study include: i) enumeration of spawners and total return, ii) estimation of Native food fish catch, iii) recording hatchery broodstock removals, iv) biological sampling and coded-wire tag (CWT) recovery data collection. A carcass mark-recapture study was conducted to augment the fence count. Total return of adult chinook to the Cowichan River was estimated to be 14,701 in 1996. The number of natural spawners was estimated to be 12,217.

RÉSUMÉ

Nagtegaal, D.A., and E.W. Carter. 1998. Adult chinook escapement assessment conducted on the Cowichan River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2449: 65 p.

En 1996, la Direction des sciences biologiques de la Station biologique du Pacifique a entamé une étude sur la productivité du saumon quinnat (Oncorhyncus tshawytscha) dans la rivière Cowichan. Cette étude, qui est toujours en cours, porte principalement sur : i) le recensement des reproducteurs ; ii) le volume de la pêche autochtone de subsistance ; iii) le recensement des spécimens de recrues issus d'écloserie ; iv) l'échantillonnage biologique et l'examen des micromarques magnétisées codées (MMC). Soulignons qu'une étude consistant à étiqueter les carcasses de reproducteurs pour qu'on les remette à l'eau afin de comparer le nombre de carcasses de reproducteurs étiquetées et non étiquetées a permis d'étayer les résultats obtenus aux barrières de comptage. Pour l'année 1996, l'effectif de remonte total du saumon quinnat adulte - écloseries et frayères naturelles confondues - dans la rivière Cowichan se chiffrait à 14 701, le nombre de reproducteurs issus de frayères naturelles étant estimé à 12 217. Enfin, les auteurs décrivent un plan de gestion des eaux destiné à faciliter la remonte du quinnat.

INTRODUCTION

Considerable interest has been focused towards the chinook salmon (*Oncorhynchus tshawytscha*) stocks in the southern portion of the Strait of Georgia over the past several years due to the perceived decline in these stocks and their importance to the local fisheries (Farlinger et. al. 1990). The Stock Assessment Division, Pacific Biological Station, initiated a study of chinook productivity to assess rebuilding strategies and to evaluate the effects of harvest management policies for these stocks. In the fall of 1988, a study was implemented on the Cowichan River chinook stock with additional information collected from the Squamish and Nanaimo River chinook stocks. These three stocks were identified as escapement indicators to represent the status of Lower Georgia Strait chinook stocks.

Hatchery production of chinook on the Cowichan River began in 1980 (Cross et al.,1991). Chinook fry releases have increased from 64,681 in 1980, to 1.6 million in 1996. Marked releases also began in 1980 and in 1996 approximately 11.2% of the total number of chinook released were coded-wire tagged.

The objectives of this study include: i) to quantitatively determine the optimum spawning requirement for chinook salmon in the Cowichan River (this involved investigations of the determinants of juvenile production, interactions between hatchery and wild chinook, and estimation of the spawning escapement and catch attributed to the hatchery and wild components of the total run), and ii) to develop guidelines for establishing escapement targets for other B.C. chinook stocks (Nagtegaal et al.,1994a).

The purpose of this report is to present the results of the adult escapement enumeration component of the chinook productivity study conducted on the Cowichan River during the fall of 1996.

METHODS

Components of escapement enumeration include: i) enumeration of chinook salmon at the counting fence; ii) estimation/biological sampling of Native food fishery catch; iii) recording of hatchery broodstock removals; iv) collection of biological data and sampling of coded-wire tag (CWT) recoveries; and v) carcass mark-recapture studies for both adult and jack chinook.

A detailed description of the methodology used to collect the above information was presented in Nagtegaal et al. (1994b). Some changes were made in 1996 and are described below. The counting fence was placed in the same location as in previous years (Fig. 1).

ENUMERATION FENCE:

A resistance board weir was installed with a counting raceway (adjustable flashboard) and trap box adjacent to the counting tower equipped with floodlights. Counts were continuously recorded for the duration of the operation by 15 minute intervals for adult and jack chinook, adult and jack coho, and chum. If identification was in doubt those fish were recorded as unknown. Water depth, temperature, and clarity, and weather conditions were recorded three times per day. On a daily basis the integrity of the fence was checked and cleaned of leaves and other debris. Records of broodstock collected at the fence by the hatchery staff were also kept.

SWIM SURVEYS:

Swim surveys were conducted, in conjunction with Cowichan Tribes Aboriginal Fisheries Management (CTAF), to estimate the spawning population of chinook. The swims were made in the upper section of the river only (Fig. 1) and extrapolated to the total system. Each survey was conducted by three experienced swimmers and one person in a canoe who recorded the data. Each swimmer (one in the middle and one on each side of the river) counted the fish seen within their range of visibility. The three swimmers attempted to keep abreast as they approached each pool while the person in the canoe lagged behind within hailing distance. Counts were recorded by pool/riffle and then compiled by river section. When possible the same swim team was used for each survey to maintain consistency in counting procedures. Swim counts were expanded by a factor of 3.4, based on historical distribution of spawners, to derive an escapement estimate (Nagtegaal et al. 1994a). This expansion factor was consistently applied to swim counts with no adjustments made for run timing or the changes in the distribution of chinook in the river. A final escapement estimate was then determined in consultation with Fisheries and Oceans Canada Fishery Officers and based on other anecdotal information.

It was intended that the swim survey estimates remain independent of the fence count. Even though no fence count information was passed on to the swim teams during the season, general trends in escapement numbers were known.

During the first weeks of fence operation two swimmers surveyed the large pool immediately below the counting fence. Swims were conducted on Sept. 6, 20, 27, and Oct. 4 to monitor the number of fish holding below the fence. There were some concerns that during low flow conditions, the fence may act as a partial barrier to upstream movement.

NATIVE FOOD FISHERY:

In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management program to monitor the fishery more closely and to better estimate the Native food fish catch (Paige 1992, 1996). This approach involved recording catch and effort by management zone within the Native fishing boundaries (Fig.2). A crew of four observers patrolled the fishery on a daily basis and interviewed fishermen for numbers caught by area and total time spent fishing. In this way, weekly estimates of catch per unit effort (CPUE) were obtained. CPUE was adjusted for daily changes in fishing effort and differences in effort among fishing zones. These data were then extrapolated over time and area to estimate total catch by week and summed over all weeks to estimate the total 1996 catch.

$$CATCH \equiv \sum_{n}^{w=1} CPUE_w \times EFFORT_d$$

where w refers to the time interval for catch (week), and d refers to the time interval for effort (day). No confidence limits were calculated (Paige 1996).

Since 1988, an observer was employed to independently collect catch and biological data from the in-river chinook spear fishery. Due to poor sampling conditions, no regular biosampling of the fishery was conducted and only 44 confiscated chinook salmon were sampled.

BIOLOGICAL DATA:

Biological data for chinook were collected from three sources: i) hatchery broodstock samples; ii) Native food fishery; and iii) carcass mark/recapture (spawning ground). Hatchery staff randomly collected biological data from approximately 25% of the chinook broodstock, recorded the incidence of coded-wire tagged (CWT) fish, and selectively sampled all additional CWT fish. On the spawning grounds chinook were sampled for post-orbital hypural (POH) length, sex, scale, spawning condition and the presence/absence of an adipose clip. All coded-wire tagged fish recovered were biosampled, the head removed and frozen for further analysis.

MARK-RECAPTURE:

A multiple mark-recapture program involving the tagging and subsequent recovery of chinook jack and adult carcasses was conducted on the spawning grounds (Sykes and Botsford 1986). All chinook carcasses were individually tagged with a Ketchum[1] aluminum sheep ear tag on the left operculum and immediately released in the same area as captured.

[1]Ketchum Manufacturing Ltd., Ottawa, Canada.

Location of capture and release, tag number, spawning condition, length, sex, and adipose clip information were recorded for each carcass recovered. Tag numbers and location of previously marked carcasses were recorded and the carcass returned to the river in the same site as captured.

Two or three man crews in inflatable boats daily surveyed the upper section of the river (Fig. 1) and collected all available chinook carcasses. This section of the river above Skutz Falls represents the area where the majority of chinook spawning typically occurs. One of the crews periodically collected carcasses from the middle section of the river (Fig. 1). A 4.2 m pole with a gaff hook attached to the end was used to recover carcasses. Some carcasses were likely missed if they ended up in pools too deep for retrieval.

POPULATION ESTIMATE:

Adult chinook salmon escapement estimates were generated from the carcass mark-recapture data using the Petersen model (Chapman modification) stratified by sex and river section (Ricker 1975). As in past years, it was necessary to stratify the data in order to minimize the effects of differential tagging and tag recovery between sexes and river sections. This study follows the estimation procedure as outlined in previous reports (Nagtegaal et al. 1994a, 1994b, 1994c).

RESULTS

ENUMERATION FENCE:

In 1996, the counting fence was operated from Aug. 30 through to October 24. Due to impending high water conditions the fence was removed on Oct. 25. Daily counts at the enumeration fence are contained in Table 1, and compared with water depth and temperature recorded at the fence (Fig. 3). Total counts recorded during this period were: 10,385 adult chinook; 5,752 jack chinook; 1,537 adult coho; 339 jack coho; 95 chum and 556 unidentified fish. During the last days of operation, the combination of heavy rain and muddy water made identification difficult.

During the early part of the season, more jack chinook entered the river than adult chinook. Daily counts were summarized by one hour intervals (Table 2) and we note that peak movement of adult and jack chinook occurred between 0700 and 0900 and again between 1800 and 1900. Approximately 44% of adults and 32% of jacks migrated past the fence during daylight hours.

During several shifts throughout the migration period an independent count was made at the enumeration fence to determine the

accuracy of the counting procedure and species identification. On several occasions, fish were visually identified by an observer in the counting tower and then captured in the fish trap and identified by a second observer. Of the 167 fish examined, three fish (1.8%) were incorrectly identified. Errors were made in mis-identification of jack or adult fish.

SWIM SURVEYS:

A summary of visual surveys conducted by Fishery Officers and Cowichan Tribes Aboriginal Fisheries Management from 1981-1996 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. Swims in 1996 were conducted in the upper section of the river (Birdhouse to Three Firs pool; Fig. 1) on Sept. 13, 26, Oct. 2, 9, 15, and 22. The 1996 escapement of adult chinook was determined to be 6,500 (Paige 1996) based on the upper river swim counts. Most swim surveys were conducted under good conditions (low water and clear visibility).

Table 4 lists the results of the swims conducted in the main pool below the fence. Although there were always fish in this pool, there was no indication that the fence obstructed the upstream movement of these chinook.

NATIVE FOOD FISHERY:

Estimates of the Native food fish catch of chinook since 1981 are listed in Table 5. The 1996 catch estimate of 810 adults and 150 jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group. According to our observations, the adult chinook catch was quite good this year (Fig. 4) since optimal fishing conditions prevailed. It was very difficult to assess the quality of the data collected from these sources because the entire fishery was not monitored due to unforeseen circumstances (Paige 1996).

HATCHERY COMPONENT:

In 1996, 1,615 adult chinook were removed from the river by the Cowichan River hatchery staff, of which 89% were collected below the enumeration fence (Table 6). The hatchery staff (D. Millerd, P.O. Box 880, Duncan, B.C., pers. comm.) indicated they had met their target this year (Table 7). Primarily 3 and 4 year old chinook were used for broodstock (Table 8).

BIOLOGICAL DATA:

Almost three times as many adult than jack chinook were sampled on the spawning grounds (Tables 9 and 10). Considerably more adults were recovered on the spawning grounds in the upper section than in the middle section of the river. Mean size of females sampled was 69 cm post orbital hypural (POH) length and for males was 61 cm (POH). Adult chinook were primarily comprised of 3 and 4 year old fish (Table 11).

Length-frequency summaries of chinook broodstock collected and sampled at the hatchery are listed in Table 12. The hatchery staff randomly sampled approximately 25% of all broodstock collected and then selectively sampled all remaining adipose-clipped chinook. The adipose mark rate in the random sample was 11.1% for males and 6.8% for females. The mark rate for chinook from hatchery samples was comparable to the mark rate observed on the spawning grounds.

Few fish caught in the Native food fishery were sampled (Table 13). More females were sampled than males and few CWT recoveries were made. Mean size of adult chinook caught was comparable to the chinook sampled on the spawning grounds.

Coded-wire tag recovery information for chinook sampled on the spawning ground is listed in Table 14. A summary of chinook releases from the Cowichan hatchery by brood year is listed in Table 15. A cursory look at CWT recoveries on the spawning grounds relative to the total number of fish released (Kuhn 1988) indicated that proportionately fewer recoveries were observed for the lake pen release group.

ENVIRONMENTAL INFORMATION:

Water temperature (Table 16)and discharge (Table 17) information indicated that the environmental conditions (Inland Waters Directorate 1996) during the fall of 1996 were fairly typical.

MARK-RECAPTURE:

Table 18 contains a summary of the carcass mark-recapture data by tagging period. A total of 1399 adult and 570 jack chinook carcasses were tagged and released in the upper river section and 64 adults and 15 jacks in the middle river section (Table 19). More than 64% of the adult and 83% of the jack carcasses were tagged but never recaptured. Smaller and lighter jack chinook carcasses are often more readily swept downstream and less likely to be recovered than the heavier adult carcasses. This is generally the case during the fall and a potential source of bias. This was especially evident in certain areas in the middle river section where cloudy water, due to riverbank erosion, made it particularly difficult to retrieve both adult and jack carcasses.

Stratified Petersen:

The escapement estimate of adults (excluding jacks) based on carcass mark-recapture data was 9,411 with lower and upper 95% confidence limits of 8,170 and 10,652, respectively (Table 20). Approximately 84% of the total escapement spawned in the upper river section.

Potential biases:

Some of the typical biases associated with mark-recapture experiments (Ricker 1975) are listed below and were examined in some detail for the carcass mark-recapture data. To minimize bias, fish tagging and recovery occurred concurrently and was stratified by sex and river location.

1. Temporal bias:

Temporal bias in the tagging sample was examined by comparing the mark incidence between periods in the recovery sample (Table 21). There were significant differences in the mark incidence between periods ($P < 0.05$; chi-square; Zar 1984). Mark incidence was highest towards the end of the survey.

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 22). Significant differences were observed ($P < 0.05$; chi-square). The highest percentage of tags were recovered during the last week of the study. This was primarily due to the fact that most tags were applied during the last three weeks of the study. Spawner die-off period seemed to be shorter than in previous years and few carcasses were available for tagging in the beginning of the study.

2. Location bias:

Spatial bias was examined by comparing the mark incidence between the upper and middle river sections in the recovery sample (Table 23). There was a significant difference between the upper and middle sections of the river ($P < 0.05$; chi-square). Mark incidence of recoveries in the upper river (25.4%) was much higher than in the middle section (3.0%). This was likely due to the cloudy water conditions which made carcass tag and recovery difficult.

3. Fish size:

Size related bias in the application sample was examined by comparing the continuous POH length frequency distributions of marked and unmarked recoveries from the spawning ground. No significant differences were observed in males or females ($D_{obs} < D_{alpha}$; Kolmogorov-Smirnov two sample test). Size related bias in the recovery sample was examined by comparing the continuous POH length frequency distributions of tagged and recaptured carcasses (Table 24). Again, no significant differences were observed in males or females ($P > 0.05$).

4. Fish sex:

Sex related bias in the application sample was examined by comparing the sex ratio of the marked and unmarked spawning ground

recoveries (Table 25). No significant differences were noted ($P < 0.05$; chi-square). Bias in the recovery sample was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex ratios in each. The recovery sample was biased towards females ($P > 0.05$). In addition, the proportion of chinook adults released with tags and recovered on the spawning grounds was significantly higher ($P < 0.05$) in females (36.9%) than males (29.0%).

DISCUSSION

ENUMERATION FENCE:

Enumeration data could only be collected for the time the fence was in full operation. Although this was the period during which most chinook were presumed to enter the river, we have no count regarding the numbers that may have entered before or after the fence operation. The fence count of 10,385 adults and 5,752 jack chinook should be considered an incomplete count of the total run, but the most accurate one available. Since the daily count of chinook was minimal when the fence count began, we could assume that the run had just started. Based on information from previous studies (1990-94) for upstream movement after Oct. 24, we estimate that approximately 20% of the run was still to come. This was supported by the observations made by the Cowichan Tribes Fisheries Management Unit of good catches in the Native food fishery in the lower river.

The floating fence design adapted well to the considerable changes in flow that occurred during the fall on the Cowichan River. Although it was intended to be self-cleaning, field staff were required to maintain a regular cleaning schedule during times when leafy debris and flooding caused by heavy rains made it difficult for the fence to remain afloat. Due to the considerable number of deciduous trees along the banks of the river, a combination of wind, rain and leaves are the main causes of fence failure. This remains an ongoing problem that is very difficult to overcome (Cousens et. al., 1982; Johnston et. al.,1986).

SWIM SURVEYS:

Among the biases typically associated with swim surveys, the extrapolation of actual swim counts to total estimates warrants some consideration (Burns, unpubl). Assumptions concerning the distribution of chinook in the river at the time of the survey are the basis for expanding these counts to estimate total escapement. In 1991, it became apparent that during high water flow conditions in early fall, expansions based on the swim survey results overestimated total

escapement (Nagtegaal et al. 1994b, 1994c). The results of the 1992 swim surveys support the hypothesis that during low water flow conditions in late fall, expansions based on swim survey results underestimate the number of spawners. Low flow conditions lead to underestimation of spawners because the distribution of fish in the river is affected by flow. Generally, in low water years, not as many fish make it to the traditional spawning areas above Skutz Falls. Expansion of swim surveys conducted in the upper area alone tend to underestimate the number of fish. Conversely, during high water years most of the fish make it above Skutz Falls so the expansion factor tends to overestimate the number of fish.

Flow rate was initially lower than average and was followed by a sudden increase to substantially higher discharge conditions (Fig. 5). Based on the carcass tagging data most chinook spawned in the upper river section in 1996. Since each swim survey count was expanded by the same factor, no consideration was made with regards to the distribution of chinook in the river. The adult escapement estimate for upper river spawners based on the expanded swim count (6500) is somewhat less than the upper river mark-recapture estimate (7905).

NATIVE FOOD FISHERY:

Since we did not have the opportunity to directly assess catch estimation procedures developed by the Cowichan Tribes Aboriginal Fisheries Management unit, no comments could be made regarding the methodologies used. The 1996 estimate of 810 adult chinook was a considerable increase over previous years catch estimates. The prevailing fishing conditions were considered to be good based information provided by Cowichan Tribes Aboriginal Fisheries management. Since 1991, independent observer estimates of adult chinook catch have been 2 to 3.5 times the amount estimated by the CTAF unit (Fig. 4). No independent estimates were made in 1996.

BIOLOGICAL DATA:

No significant differences were noted in the adipose mark rate between the random broodstock sample recorded by the hatchery staff and the data collected by our field staff. The incidence of adipose-clipped fish in the chinook sampled on the spawning ground was 4.4%-males and 4.2%-females, and in the hatchery chinook broodstock sample was 5.4%-males and 6.6%-females. No differences were noted in the size frequency distribution by sex between hatchery and spawning ground samples ($D_{obs} < D_{alpha}$; Kolmogorov-Smirnov, Zar 1984). Typically, the hatchery collects broodstock from various locations in the river and randomly samples 25% to 50% of males, females and jacks at the hatchery after the fish are spawned. In addition, all other adipose-clipped fish collected for broodstock are selectively sampled for production assessment purposes.

MARK-RECAPTURE:

Typically, fall rains that occur during peak spawning cause high flows and turbid water. Carcasses are often trapped in deep pools and cannot be seen or easily recovered due to the turbid conditions. Conditions for carcass recovery were good in the upper river but became particularly poor towards the end of the study in the middle section, with high flows and cloudy water, making it difficult to recover carcasses. We were able to tag and sample approximately 12.0% of the total adult chinook escapement.

Stratification by river section and sex was necessary in order to minimize the effects of differential tagging and recovery between sexes and river sections. Some potential biases associated with tagging and recovery of carcasses were examined and it was assumed that these would significantly affect the population estimate. If we assume that the fence count was the preferred estimate of escapement, then the stratified Petersen estimates based on carcass mark-recapture underestimated escapement by at least 23%.

SEAL PREDATION:

Although seal predation was not directly assessed in this study, it is worthwhile to examine the impact seals have on chinook in Cowichan Bay. In 1988, the number of seals gradually increased from a low of 30 in April to a peak of about 100 in December. According to Olesiuk et al. (1990) harbour seals consume an estimated 9 tonnes of salmon annually in Cowichan Bay. An estimated 23% (Sept.) to 48% (Nov.) of the harbour seals' diet in Cowichan Bay was comprised of salmon (Bigg et. al. 1990). Based on these data, consumption of chinook salmon could potentially range from 100 to 500 adults. These data were collected in 1988 when low flows in the Cowichan River persisted until the end of October. Predation likely increases the longer chinook salmon remain in the estuary waiting for high water to allow upstream movement. Predation on chinook in 1996 was estimated to be approximately 300 and likely lower than the past few years due to the high flow conditions in Sept. and Oct.

ESCAPEMENT:

Escapement estimates for the Cowichan River were primarily based on the fence data since this was the preferred enumeration technique. Total return of adult chinook to the Cowichan River was determined to be equal to the sum of the fence count, the numbers removed for broodstock below the fence, and the number of adults taken by the Native food fishery. If we add the fence count to the estimated migration of fish before and after the fence was in place, the total estimated count past the fence site would be 12,462 adult chinook. On this basis we calculate the total return of adults to the Cowichan River

in 1996 to be 14,701 (Table 26). This should be considered a minimum estimate since these numbers are based on the fence count and some assumptions about the number of fish in the river prior to and after the counting fence was in place. If we include a seal predation estimate of 300, then it is probable that the total return of chinook in 1996 was closer to 15,000 adults. The number of natural spawners was calculated to be 12,217 (Table 26).

Chinook escapements have fluctuated from a low of 1200 in 1986/87 to over 16,000 in 1995, the largest escapement recorded for the past 40 years (Fig. 6). For 10 out of the past 16 years escapements have ranged between 5000 and 6000 adults but in recent years escapement numbers have increased substantially. This escapement trend may in part be due to substantial increases in hatchery production (Fig. 7) and a reduction in commercial and sport fleet effort. Natural production as well as enhanced contribution to the escapement have increased steadily (Fig. 8).

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Table 1. Daily counts at the enumeration fence site, Cowichan R., 1996.

Date	Chinook		Coho		Chum	Unknown
(DDMM)	Adult	Jack	Adult	Jack		
3008	3	7	0	0	0	0
3108	3	9	3	11	0	0
0109	23	20	0	2	0	0
0209	4	3	0	9	0	0
0309	14	3	0	0	0	0
0409	34	133	0	0	0	0
0509	7	15	0	0	0	0
0609	16	8	0	0	0	0
0709	28	41	0	0	0	0
0809	7	17	0	0	0	0
0909	224	191	0	0	0	0
1009	31	25	0	0	0	0
1109	29	24	0	0	0	0
1209	3	10	0	0	0	0
1309	12	20	1	0	0	0
1409	141	155	0	0	0	0
1509	247	233	56	15	0	0
1609	822	376	149	20	0	0
1709	90	34	23	3	0	0
1809	9	7	1	0	0	0
1909	36	29	1	0	0	0
2009	52	16	0	0	0	0
2109	35	15	0	0	0	0
2209	27	16	0	0	0	0
2309	64	40	2	0	0	0
2409	110	23	0	0	0	0
2509	14	8	1	0	0	0
2609	20	9	1	0	0	0
2709	346	469	11	12	1	0
2809	332	109	20	2	2	0
2909	446	261	50	6	0	0
3009	1111	585	45	6	0	0
0110	1208	366	68	7	0	0
0210	211	87	9	2	1	0
0310	898	448	33	19	0	0
0410	769	743	154	41	3	0
0510	345	138	14	8	0	0
0610	58	14	7	2	0	0
0710	228	60	20	5	1	0
0810	115	35	6	2	0	0
0910	53	16	3	0	1	0
1010	35	17	4	0	0	0

Table 1 (cont.)

Date (DDMM)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unknown
1110	145	100	16	1	1	0
1210	140	41	22	3	0	0
1310	549	300	115	13	25	0
1410	481	167	145	17	14	0
1510	479	213	304	81	15	0
1610	40	25	26	16	1	0
1710	48	16	4	0	0	59
1810	88	23	83	10	15	213
1910	39	13	18	1	1	29
2010	17	4	39	7	8	2
2110	14	5	25	7	4	15
2210	15	1	23	1	0	86
2310	67	9	27	10	2	118
2410	3	0	8	0	0	34
TOTAL:	10385	5752	1537	339	95	556

Table 2. Daily counts by time interval at the enumeration fence site, 1996.

Time Period	Chinook			
	Adult	Percent	Jack	Percent
0000 - 0100	373	3.6	291	5.1
0100 - 0200	501	4.8	302	5.3
0200 - 0300	457	4.4	302	5.3
0300 - 0400	458	4.4	209	3.6
0400 - 0500	445	4.3	253	4.4
0500 - 0600	367	3.5	160	2.8
0600 - 0700	637	6.1	314	5.5
0700 - 0800	1203	11.6	547	9.5
0800 - 0900	950	9.1	303	5.3
0900 - 1000	521	5.0	148	2.6
1000 - 1100	285	2.7	81	1.4
1100 - 1200	103	1.0	13	0.2
1200 - 1300	123	1.2	21	0.4
1300 - 1400	77	0.7	25	0.4
1400 - 1500	222	1.2	38	0.7
1500 - 1600	247	2.4	122	2.1
1600 - 1700	347	3.3	173	3.0
1700 - 1800	561	5.4	392	6.8
1800 - 1900	821	7.9	841	14.6
1900 - 2000	456	4.4	412	7.2
2000 - 2100	538	5.4	312	5.2
2100 - 2200	302	2.9	169	2.9
2200 - 2300	200	1.9	125	2.2
2300 - 2400	291	2.8	199	3.5

Table 3. Visual survey data collected for the Cowichan River by Fishery Officers stationed in the Duncan subdistrict.

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1981	S	Sept. 12	175		208	1000	2-4
	S	Oct. 2	103		93	1500	2-4
	S	14	364		1160	4000	2-4
	H	22			2000		1-7
	S	23			3200	5000	2-4
Estimate for Season[3]						5500	
1982	S	Sept. 14	199		131	600	2-4
	S	Oct. 13			153		2-4
	H	19	saw few fish on spawning grounds				1-13
	F	Nov. 8				4000	
Estimate for Season						4500	
1983	S	Sept. 8	38		61	254	2-6
	S	15	62		121	504	2-6
	S	28	190		470	1838	1-2
	S	Oct. 7	207		425	1804	2-6
	S	14	802		997	2836	2-7
	S	25	901		1113	4500	1-6
Estimate for Season						4500	
1984	S	Aug. 28	80		84	400	2-5
	S	Sept. 6	25		72		
	S	13	79		80		3-11
	S	19	35		71		2-6
	S	26	291		434		2-6
	S	Oct. 3	205		283		3-7
	S	"	206		282	2200	8-11
	S	23	525		1300	5000	1-6
	S	Nov. 1	350		1276		1-6
Estimate for Season						5000	
1985	S	Sept. 12	39		46	220	2-6
	S	17	42		10		12-13
	S	18	210		33		2-6
	S	27	245		104	456	2-6
	S	Oct. 3	244		99	360	2-6
	S	10	285		219		2-6
	S	16	293		347		2-6
	S	31	229		934	3500	1-6
Estimate for Season						3500	

Table 3. (cont.)

				Chinook				
				Jacks		Adults		
	Method[1]	Date		Count	Estimate	Count	Estimate	River Segment[2]
1986	S	Sept.	9	295		85	300	2-6
	S		18	46		29	300	3-6
	S		24	161		56	350	12-13
	S	Oct.	7	1310		223	1000	2-6
	S		29	613		473	1200	1-6
	S	Nov.	6	1178		491	1200	
	H		8			515		1-13
Estimate for Season							1200	
1987	S	Sept.	9	30	300	10	50	3-8
	S		17	111		16	75	2-6
	S		25	112		16	75	3-6, 11-12
	S	Oct.	6	196	800	115	400	2-6
	S		15	196		96		1-6
	H		16		saw very few spawners			1-13
	S		28	417		468		1-6
	S	Nov.	6	329		649		1-6
Estimate for Season							1200	
1988	S	Aug.	25	100		50		2-6
	S	Sept.	1	271		149	700	2-6
	S		23	1464		271	1000	2-6
	S	Oct.	3	821	1600	1094	3500	2-6
	S		14	2008		2076	4000	1-6
Estimate for Season							5500	
1989	S	Sept.	11	151		58	300	2-6
	S		21	95		39	350	3-6
	S	Oct.	5	95		48	700	2-3
	S		18	719		350	1200	2-6
	S	Nov.	1	1537		2267		2-6
Estimate for Season							5000	
1990	S	Aug.	29	254		54	250	2-6
	S	Sept.	14	385		89	1000	3-6
	S		27	3169		477	2200	2-3
	S	Oct.	19	4297		2382	5000	2-6
Estimate for Season							5300	

Table 3. (cont.)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
1991	S	Sept. 19			1882	6000	2-6
	S	Oct. 2			2873	7500	2-6
	S	17			2924	8700	2-6
	S	31			3502[4]	9000	2-6
Estimate for Season						10000	
1992	S	Sept. 16	5		8		2-5
	S	Oct. 2	124		46	200	2-6
	S	15	359		291	700	2-6
	S	15	113		162		2-6
	S	27	514		797	2000	1-6
	S	28	591		767		1-6
	S	Nov. 13	506		467		1-6
	S	13	450		640[5]		1-6
Estimate for Season						7500	
1993	S	Sept. 23	23		14	47	2-6
	S	30	81		62	210	2-6
	S	Oct. 14	207		199	676	2-6
	S	28	127		327	1111	2-6
	S	Nov. 4	480		987	3355	
Estimate for Season[6]						5200	
1994	S	Aug. 24	39		3		2-6
	S	Sept. 14	67		46	156	2-6
	S	28	421		323	1098	2-6
	S	Oct. 13	1253		1146	3896	2-6
	S	26	442		1450	4930	2-6
Estimate for Season[6]						5500	
1995	S	Sept. 28	294		267	1170	2-6
	S	Oct. 25	490		1798	6653	2-6
Estimate for Season[6]						15500	

Table 3. (cont.)

	Method[1]	Date	Chinook Jacks Count	Chinook Jacks Estimate	Chinook Adults Count	Chinook Adults Estimate	River Segment[2]
1996	S	Sept. 13	45		46	147	2-6
	S	26	166		150	510	2-6
	S	Oct. 2	254		534	1815	2-6
	S	9	579		1157	3933	2-6
	S	15	195		707	2403	2-6
	S	22	557		1699	5776	2-6
Estimate for Season[6]						6500	

[1]S - Swim survey, H - Helicopter survey, F - boat survey
[2]Refer to Fig. 1
[3]Total escapement estimate for adult chinook
[4]516 chinook carcasses were counted in this total
[5]28 chinook carcasses were counted in this total
[6]swim surveys conducted by Cowichan Tribes River Management Unit, total escapement determined by Fishery Officers.

Table. 4. Cowichan River chinook swim survey data at the fence site, 1996.

Date	Area[1]	Jack Chinook	Adult Chinook	Jack Coho	Adult Coho
Sept. 6	Fence	25	18		
	First Riffle	10	40		
	Pumphouse Pool	140	120		
Sept. 20	Fence	25	45		
	First Riffle	100	300		
	Pumphouse Pool	unk[2]	unk[2]		
Sept. 27	Fence	none	none		
	First Riffle	250	250		
	Pumphouse Pool	300	400		
Oct. 4	Fence	12	35		
	First Riffle	25	50		
	Pumphouse Pool	unk[2]	unk[2]		

[1]Two swimmers counted the number of fish holding under the fence, in the first riffle below the fence, and in the large pool below the fence (Pumphouse pool)
[2]Count unknown due to poor visibility, but >50 adults observed.

Table 5. Native food fish catch estimates for the Cowichan River.[1]

Year[2]	Adult Chinook	Jack Chinook
1981	1500	1500
1982	1000	1000
1983	250	1000
1984	355	700
1985	1000	1000
1986	800	800
1987	800	800
1988	681	450
1989	1055	250
1990	604	214
1991	270	100
1992	260	12
1993	295	22
1994	345	227
1995	533	120
1996	810	150

[1]Includes chinook caught in the Native spear fishery and the in-river gillnet fishery.
[2]Since 1988 data collected by Cowichan Tribes River Management unit. Prior to 1988, data were collected by the local Fishery Officers.

Table 6. Summary of chinook broodstock collected by the Cowichan hatchery[1], 1996.

Date	Below fence			At fence			Above fence		
	M	J	F	M	J	F	M	J	F
Sep. 27	72	43	83						
30	54	13	70						
29	45	11	71						
Oct. 1	35	11	36						
2	17	4	18						
3	16	5	47			4			
4	14	19	37						
6	6		12						
7	15	1	50						
8	61		124						
9	10	5	26						
10	81	8	155				31	3	42
11	48	5	87				5	1	13
15	21	45	61				6	2	5
16	24	6	19				5		10
17								5	3
18	3	28	9				7	6	5
19							1	2	5
21							16	2	23
22							9	1	18
23	3	1	7						
24							12	10	5
25							2	3	1
28	1	27							
29							1		1
Nov. 4	1	8							
5									2
6									6
7									2
8									2
13									6
18									1
Total:	527	240	912			4	95	35	150

[1] Based on hatchery field records

Table 7. Adult chinook escapement used for hatchery broodstock, Cowichan River[1].

Year	No. of fish collected
1981	282
1982	534
1983	242
1984	278
1985	175
1986	315
1987	582
1988	678
1989	535
1990	327
1991[2]	1755
1992	1850
1993	2200
1994	1357
1995	2149
1996	1615

[1]Barry Cordecedo (Salmon Enhancement Program) provided numbers on broodstock collection from 1981-1987. The broodstock numbers provided included jacks, but no reliable records were kept. It was estimated that about 10-15 jacks were collected per year, except in the first few years in the Cowichan River. These estimates were subtacted from the broodstock numbers provided to give an estimate of the number of adult chinook removed from the system.

[2]In addition, 284 males were removed for broodstock but later returned to the river.

Table 8. Summary of chinook broodstock age data[1], 1996.

Age	Males	Females	Total
2	43	0	43
3	62	89	151
4	24	107	131
5	1	1	2
6		1	1
Total:	130	198	328

[1]Data from random biosampling of hatchery chinook broodstock.

Table 9. Length-frequency of chinook carcasses sampled in the upper river section, Cowichan River, 1996.

Length (cm)	Males	Jacks	Females
27	0	1	0
28	0	0	0
29	0	5	0
30	0	3	0
31	0	6	0
32	0	10	0
33	0	10	0
34	0	14	0
35	0	14	0
36	0	20	0
37	0	27	0
38	0	39	0
39	0	41	0
40	0	50	0
41	1	51	0
42	2	52	0
43	6	64	0
44	6	44	1
45	10	42	1
46	21	27	0
47	20	17	0
48	16	10	0
49	12	10	1
50	19	2	3
51	11	1	2
52	9	0	2
53	8	0	3
54	11	0	4
55	13	0	16
56	16	0	12
57	14	0	25
58	19	0	41
59	29	0	27
60	25	0	51
61	20	0	66
62	19	0	65
63	25	0	75
64	19	0	65
65	24	0	69
66	17	0	58
67	16	0	54
68	8	0	42
69	10	0	59
70	10	0	38
71	12	0	36
72	5	0	30
73	10	0	24
74	16	0	24
75	8	0	13
76	6	0	3
77	5	0	7

Table 9 (cont.)

Length (cm)	Males	Jacks	Females
78	1	0	4
79	4	0	3
80	1	0	3
81	0	0	1
82	1	0	1
83	1	0	0
Total:	508	565	931
Adipose-clipped:	12	17	21
Mark rate (%):	2.4	3	2.3

Table 10. Length-frequency of chinook carcasses sampled in the middle river section, Cowichan River, 1996.

Length (cm)	Males	Jacks	Females
33	0	1	0
34	0	1	0
35	0	1	0
36	0	2	0
37	0	0	0
38	0	0	0
39	0	2	0
40	0	1	0
41	0	0	0
42	0	1	0
43	0	1	0
44	0	0	0
45	0	1	0
46	0	0	0
47	0	0	0
48	0	0	0
49	0	0	0
50	0	0	1
51	0	0	0
52	0	0	1
53	0	0	0
54	1	0	0
55	0	0	2
56	1	0	0
57	1	0	0
58	1	0	1
59	1	0	3
60	1	0	1
61	1	0	0
62	0	0	0
63	0	0	3
64	0	0	1
65	2	0	2
66	0	0	2
67	0	0	3
68	0	0	0
69	0	0	3
70	0	0	0
71	0	0	3
72	0	0	1
73	0	0	0
74	0	0	1
75	0	0	0
76	0	0	0

Table 10 (cont.)

Length (cm)	Males	Jacks	Females
77	0	0	0
78	0	0	1
79	0	0	0
80	0	0	0
81	0	0	1
Total:	9	11	30
Adipose-clipped:	1	1	1
Mark rate (%):	11.1	9.1	3.3

Table 11. Summary of chinook age data collected on the spawning grounds, 1996.

Age	Males	Females	Total
2	349	-	349
3	114	168	282
4	65	250	315
5	-	3	3
Total:	528	421	949

Total number of regenerate scales read: 38

Table 12. Length-frequency of chinook broodstock[2] collected for the Cowichan River hatchery, 1996.

Length (cm)	Males	Jacks	Females
30	1	0	0
31	0	0	0
32	0	0	0
33	0	0	0
34	0	0	0
35	0	0	0
36	2	0	0
37	0	0	0
38	2	0	0
39	2	0	0
40	0	0	0
41	4	0	0
42	3	0	0
43	1	0	0
44	2	0	0
45	4	0	0
46	0	0	0
47	1	0	0
48	1	0	0
49	2	0	0
50	1	0	0
51	2	0	0
52	2	0	0
53	1	0	0
54	3	0	0
55	0	0	1
56	5	0	5
57	6	0	6
58	5	0	4
59	3	0	4
60	4	0	9
61	8	0	8
62	5	0	10
63	6	0	15
64	3	0	9
65	4	0	7
66	6	0	14
69	1	0	10
70	0	0	12
71	3	0	10
72	1	0	9
73	2	0	4
74	1	0	2
75	0	0	3

[2] Includes broodstock data from random sample only

Table 12 (cont.)

Length (cm)	Males	Jacks	Females
67	1	0	14
68	1	0	10
76	0	0	2
77	0	0	2
78	0	0	2
79	0	0	1
80	0	0	1
81	0	0	1
82	0	0	0
83	0	0	1
Total:	99	0	176
Adipose-clipped:	11	0	12
Mark rate:	11.1	0	6.8

Table 13. Summary of Native food fishery sampling, Cowichan River, 1996.

LENGTH (cm)	MALES	JACKS	FEMALES
33	0	0	0
34	0	0	0
35	0	0	0
36	0	0	0
37	0	0	0
38	0	0	0
39	0	0	0
40	0	0	0
41	0	0	0
42	0	0	0
43	0	0	0
44	0	0	0
45	0	0	3
46	1	0	0
47	0	0	0
48	0	0	0
49	0	0	0
50	0	0	2
51	0	0	0
52	0	0	0
53	0	0	0
54	1	0	1
55	0	0	0
56	0	0	1
57	0	0	0
58	0	0	0
59	0	0	4
60	1	0	1
61	1	0	3
62	0	0	0
63	2	0	3
64	0	0	0
65	0	0	4
66	0	0	1
67	1	0	1
68	1	0	1
69	1	0	2
70	1	0	0
71	1	0	1
72	0	0	1
73	1	0	2
74	0	0	1
Total:	12	0	32
Adipose-clipped:	1	0	1
Mark rate:	8.3	0	3.1

Table 14. Coded-wire tag code data from chinook sampled on the spawning grounds, 1996.

Recovery date	Length (mm)	Sex	BY[1]	Tagcode[2]	Release location[3]	Recovery location[4]
30-Oct	670	M	91	180526	NAN	Upper
30-Oct	666	M	92	180550	LR	Upper
30-Oct	724	F	92	180550	LR	Upper
30-Oct	631	F	93	181319	LP	Upper
31-Oct	675	M	93	191321	LR	Upper
31-Oct	605	F	93	181321	LR	Upper
31-Oct	661	F	92	181043	LP	Upper
31-Oct	650	F	92	181042	LR	Upper
31-Oct	585	F	93	181320	ER	Upper
31-Oct	563	M	93	181321	LR	Lower
01-Nov	437	M	94	181438	LR	Upper
01-Nov	629	F	93	181319	LP	Upper
04-Nov	533	M	94	181438	LR	Upper
04-Nov	453	M		NO-PIN		Upper
04-Nov	655	M	93	181320	ER	Upper
04-Nov	425	M	94	181438	LR	Upper
08-Nov	438	M	94	181437	ER	Upper
12-Nov	575	F	93	181322	LR	Upper
12-Nov	437	M	94	181437	ER	Upper
12-Nov	689	F	91	180518	LR	Lower
12-Nov	430	M	94	181438	LR	Lower
13-Nov	650	F	92	181043	LP	Upper
14-Nov	442	M	94	181438	LR	Upper
14-Nov	583	F	93	181321	LR	Upper
14-Nov	735	F	92	181043	LP	Upper
14-Nov	634	F	93	181321	LR	Upper
15-Nov	699	F	92	181043	LP	Upper
15-Nov	612	M	93	181322	LR	Upper
15-Nov	599	F		NO-PIN		Upper
16-Nov	452	M	94	181437	ER	Upper
16-Nov	587	F	93	181320	ER	Upper
16-Nov	637	M	93	181320	ER	Upper
18-Nov	476	M	94	181437	ER	Upper
18-Nov	408	M	94	181438	LR	Upper
19-Nov	479	M	94	181438	LR	Upper
19-Nov	473	M	94	181438	LR	Upper
19-Nov	672	F	92	181044	ER	Upper
20-Nov	439	M	94	181437	ER	Upper
21-Nov	467	M	94	181337	LQ	Upper
21-Nov	449	M	94	181329	SEA	Upper
22-Nov	612	F	94	181437	ER	Upper
25-Nov	692	F		NO-PIN		Upper
25-Nov	425	M		NO-DATA		Upper
28-Nov	564	M	94	181437	ER	Upper
29-Nov	600	F	93	181322	LR	Upper
29-Nov	413	M		NO-PIN		Upper
02-Dec	518	M	94	181437	ER	Upper

[1]refers to brood year
[2]no-pin refers to no CWT pin found; lost pin refers to a pin that was lost in the processing procedure
[3]Release locations:
ER; early hatchery release (during April)
LR; late hatchery release (during May)
LP; hatchery release from Cowichan Lake pen sites (during May)
SEA; hatchery release from sea pens in Cowichan Bay (during June)
NAN; hatchery release from Nanaimo R. hatchery
LQ; hatchery release from Little Qualicum R.
[4]Recovery locations; refer to Fig 1.

Table 15. Cowichan hatchery chinook releases[1], 1979-1996.

Tag Code[2]	BY[3]	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
21846	79	31628	32134	98.4	2.8	:07May80	0118-COWICHAN RIVER
22060	79	32034	32547	98.4	2.8	:07May80	0399-SKUTZ FALLS
22158	80	52519	65000	80.8	2.3	:09Jun81	0118-COWICHAN RIVER
22307	81	30179	30373	99.4	3.1	:12May82	0118-COWICHAN RIVER
22339	82	49135	224944	21.8	2.9	:14May83	0399-SKUTZ FALLS
22831	83	50613	101000	50.1	4.3	:25May84	0355-KOKSILAH RIVER
NOCN8311	83	0	200000	0	4.3	:31May84	0118-COWICHAN RIVER
NOCN8411	84	0	187823	0	4.8	13May85:14May85	0118-COWICHAN RIVER
23803	85	25365	25804	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
23804	85	25455	25895	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
23911	85	11980	12187	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
NOCN8619	86	0	321172	0	4	13May87:22May87	0118-COWICHAN RIVER
NOCN8620	86	0	54608	0	3.5	:21May87	0355-KOKSILAH RIVER
24334	87	14298	14334	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
24729	87	25360	25424	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
24730	87	25869	25934	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
24731	87	27428	27497	99.7	7.1	18Apr88:18May88	0185-COWICHAN LAKE
24732	87	27271	27339	99.8	7.1	:18May88	0185-COWICHAN LAKE
24733	87	26911	26978	99.8	7.1	:18May88	0185-COWICHAN LAKE
24734	87	23521	23580	99.7	7.1	:18May88	0185-COWICHAN LAKE
24735	87	26719	26786	99.7	3.4	18Apr88:18May88	0118-COWICHAN RIVER
24945	87	26461	123361	21.5	4.9	:25May88	0324-COWICHAN R UPPER
24946	87	26658	123560	21.6	4.9	:25May88	0324-COWICHAN R UPPER
24947	87	26761	123663	21.6	4.9	:25May88	0324-COWICHAN R UPPER
25008	87	26817	123720	21.7	4.9	:25May88	0324-COWICHAN R UPPER
NOCN8731	87	0	387071	0	8.2	:26May88	0324-COWICHAN R UPPER
24860	88	25117	25243	99.5	3.7	:28Apr89	0118-COWICHAN RIVER
25012	88	26595	54768	48.6	6.5	:21May89	0118-COWICHAN RIVER
25013	88	25982	54154	48	6.5	:21May89	0118-COWICHAN RIVER
25015	88	23058	24894	92.6	3.7	:28Apr89	0118-COWICHAN RIVER
25016	88	26821	26821	100	3.7	:28Apr89	0118-COWICHAN RIVER
25017	88	27611	28175	98	3.7	:28Apr89	0118-COWICHAN RIVER
25523	88	27531	56123	49.1	6.5	:21May89	0118-COWICHAN RIVER
25524	88	27205	55378	49.1	6.5	:21May89	0118-COWICHAN RIVER
25749	88	26922	133331	20.2	6.1	:15May89	0185-COWICHAN LAKE
25750	88	27036	133446	20.3	6.1	:15May89	0185-COWICHAN LAKE
25751	88	23106	130107	17.8	6.1	:15May89	0185-COWICHAN LAKE
25752	88	26169	132842	19.7	6.1	:15May89	0185-COWICHAN LAKE
20352	89	28287	28573	99	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
20522	89	27072	36800	73.6	6.5	22May90:23May90	0118-COWICHAN RIVER
20622	89	27787	37242	74.6	6.5	22May90:23May90	0118-COWICHAN RIVER
20623	89	28164	37619	74.9	6.5	22May90:23May90	0118-COWICHAN RIVER
20624	89	28331	37786	75	6.5	22May90:23May90	0118-COWICHAN RIVER
20938	89	28312	28312	100	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
20939	89	26218	26218	100	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
26103	89	27145	27145	100	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
26255	89	26400	119674	22.1	7.2	:14May90	0185-COWICHAN LAKE
26256	89	25693	119497	21.5	7.2	:14May90	0185-COWICHAN LAKE
26257	89	25790	119325	21.6	7.2	:14May90	0185-COWICHAN LAKE
26258	89	25219	118748	21.2	7.2	:14May90	0185-COWICHAN LAKE
20333	90	25687	94172	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
20334	90	25898	94384	27.4	8.4	15May91:15May91	0185-COWICHAN LAKE
20335	90	25739	94224	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
20336	90	27135	27135	100	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
20337	90	26631	26631	100	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
20338	90	27046	27046	100	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
20339	90	26721	34318	77.9	6.4	21May91:22May91	0118-COWICHAN RIVER

Table 15 (cont.)

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
20340	90	26993	34592	78	6.4	21May91:22May91	0118-COWICHAN RIVER
20341	90	26533	33995	78	6.4	21May91:22May91	0118-COWICHAN RIVER
20342	90	25437	92182	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
20343	90	25391	92136	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
NOCN9044	90	0	5086	0	5.4	26Jun91:26Jun91	0367-COWICHAN ESTUARY
180513	91	26972	336330	8	5	17May92:17May92	0185-COWICHAN LAKE
180514	91	25964	335584	7.7	5	17May92:17May92	0185-COWICHAN LAKE
180515	91	27694	254287	10.9	4	21Apr92:22Apr92	0335-COWICHAN R LOWER
180516	91	27148	254015	10.7	4	21Apr92:22Apr92	0335-COWICHAN R LOWER
180517	91	27471	248584	11.1	5.3	20May92:21May92	0324-COWICHAN R UPPER
180518	91	27277	248389	11	5.3	20May92:21May92	0324-COWICHAN R UPPER
180519	91	27432	160695	17.1	3.8	21Apr92:22Apr92	0335-COWICHAN R LOWER
180520	91	27001	160262	16.8	3.8	21Apr92:22Apr92	0335-COWICHAN R LOWER
180521	91	26871	27444	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUARY
180522	91	26852	27424	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUARY
NOCN9127	91	0	158361	0	2.4	25Mar92:25Mar92	0118-COWICHAN RIVER
NOCN9145	91	0	513053	0	5.7	19May92:20May92	0324-COWICHAN R UPPER
180209	92	24770	98974	25	6.3	25May93:25May93	0367-COWICHAN ESTUARY
180210	92	26383	327416	8.1	5.9	17May93:19May93	0324-COWICHAN R UPPER
180550	92	25311	326344	7.8	5.9	17May93:19May93	0324-COWICHAN R UPPER
181042	92	53620	412953	13	6.5	25May93:25May93	0118-COWICHAN RIVER
181043	92	54235	901937	6	5.6	10May93:10May93	0185-COWICHAN LAKE
181044	92	55027	907719	6.1	3.6	07Apr93:07Apr93	0324-COWICHAN R UPPER
21211	93	24875	103900	23.9	6.2	25May94:25May94	3226-COWICHAN BAY
181319	93	49966	1001002	5	6.3	05May94:05May94	0185-COWICHAN LAKE
181320	93	50420	684279	7.4	3.8	18Apr94:18Apr94	0324-COWICHAN R UPPER
181321	93	50045	652354	7.7	6.1	18May94:18May94	0324-COWICHAN R UPPER
181322	93	50285	490079	10.3	6.1	24May94:24May94	0118-COWICHAN RIVER
181329	94	25023	103815	24.1	6.1	31May95:31May95	3226-COWICHAN BAY
181436	94	50133	100252	50	5.4	30May95:30May95	0118-COWICHAN RIVER
181437	94	49962	418750	11.9	4	02May95:02May95	0324-COWICHAN R UPPER
181438	94	49610	939287	5.3	6.3	15May95:17May95	0324-COWICHAN R UPPER
181439	94	49846	101763	49	6.5	25May95:25May95	0185-COWICHAN LAKE
182023	95	25114	109088	23	6.8	10May96:10May96	3226-COWICHAN BAY
182024	95	25653	297360	8.6	6.6	06May96:06May96	0185-COWICHAN LAKE
182025	95	24488	283856	8.6	6.6	06May96:06May96	0185-COWICHAN LAKE
182026	95	25183	355089	7.1	6.3	07May96:07May96	0324-COWICHAN R UPPER
182027	95	25218	355583	7.1	6.3	07May96:07May96	0324-COWICHAN R UPPER
182028	95	25052	344597	7.3	3.5	02Apr96:02Apr96	0324-COWICHAN R UPPER
182029	95	25129	345657	7.3	3.5	02Apr96:02Apr96	0324-COWICHAN R UPPER
182030	95	25196	245910	10.2	6.4	09May96:09May96	0118-COWICHAN RIVER
182031	95	25020	244193	10.2	6.4	09May96:09May96	0118-COWICHAN RIVER

[1] Data compiled from the Mark Recovery Program (MRP) database (Kuhn 1988).
[2] Tag code: refers to coded-wire tag code (NOCN refers to releases unassociated with a given tag code)
[3] BY: refers to brood year

Table 16. Water temperature and depth recorded at the enumeration fence site, 1996.

Date (DDMM)	Depth (cm.)	Temp. (Deg.C)	Date (DDMM)	Depth (cm.)	Temp. (Deg.C)
3008	490	21	0810	542	14
3108	416	20	0910	526	14
0109	473	19	1010	521	14
0209	443	19	1110	520	15
0309	489	18	1210	514	14
0409	486	18	1310	582	13
0509	480	16	1410	669	13
0609	473	18	1510	669	13
0709	475	17	1610	675	13
0809	486	17	1710	286	12
0909	491	17	1810	100	11
1009	481	17	1910	395	11
1109	476	17	2010	702	11
1209	488	18	2110	1000	13
1309	493	16	2210	1000	13
1409	496	16	2310	1040	12
1509	496	18	2410	1000	11
1609	496	17			
1709	500	16			
1809	496	16			
1909	500	16			
2009	497	15			
2109	500	14			
2209	500	14			
2309	493	13			
2409	490	14			
2509	490	13			
2609	486	14			
2709	485	14			
2809	493	14			
2909	489	14			
3009	490	15			
0110	490	15			
0210	483	14			
0310	496	14			
0410	527	15			
0510	543	14			
0610	539	14			
0710	529	15			

Table 17. Cowichan River daily discharge[1] in cu. m/sec for 1996.

Day	July	August	September	October	November	December
1	6.6	5.3	4.4	3.7	56.4	115
2	6.3	5.4	4.8	3.7	53.8	107
3	6.1	5.3	5	4.1	52.1	101
4	6	5.3	4.7	5.1	50.7	103
5	5.8	4.7	4.6	5.4	48.3	118
6	5.7	4.5	4	5.1	48.5	118
7	5.7	4.6	3.8	5	49.2	123
8	5.5	4.7	4	4.8	67.1	129
9	5.4	4.8	4.1	4.7	72.7	123
10	5.4	5.2	4	4.7	69.5	117
11	5.7	5.3	4	4.9	67.8	119
12	6.1	5.2	4	5.1	69	116
13	5.4	5.1	3.9	6.8	77.7	119
14	5.2	5.3	4.2	8.2	81.7	113
15	5.5	5.4	4	9	79.1	106
16	5.8	5.5	4	8.8	77	100
17	5.6	5.3	4.2	12.3	75.4	94.7
18	5.5	5.1	4.1	33.2	72.5	90.2
19	5.5	5.4	4	29.3	69.5	87
20	5.4	5.4	4.1	26.4	67	85.1
21	5.3	5.7	4	30.1	64.1	85.5
22	5.3	5.2	4	45.9	61.1	83.5
23	5.1	4.4	4	50	57.9	79.4
24	5.2	4	4	62	56.2	75.7
25	5.1	3.9	3.9	61	55.9	72.9
26	5.1	3.8	4.1	58	58.1	69.3
27	5.1	4.2	4.2	56	80.8	66.5
28	5.4	4	3.9	60.7	109	63.5
29	5.4	4	3.9	64.5	88	62.3
30	5.3	4.1	4	61.7	88.9	68.1
31	5.1	4.1		58.9		102
Total:	496	171.6	150.2	123.9	799.1	2025
Mean:	16.00	5.54	5.01	4.00	26.64	65.32

[1] Water Survey of Canada data recorded at the Island Highway bridge in Duncan.

Table 18. Summary of adult carcass tag and recovery data from the Cowichan River, 1996.

Date	Male		Female		Jacks	
(dd/mm)	Tagged	Recovered	Tagged	Recovered	Tagged	Recovered
3010	28	0	32	0	15	0
3110	40	9	28	8	24	2
0111	27	1	25	2	9	1
0411	49	4	49	3	33	2
0811	21	0	61	0	16	0
1211	40	4	42	12	25	1
1311	19	0	44	5	6	0
1411	54	6	90	11	61	2
1511	42	15	94	28	41	8
1611	20	10	33	23	30	5
1811	32	9	79	11	62	5
1911	22	9	55	37	24	7
2011	19	13	62	35	40	11
2111	17	6	14	10	45	9
2211	22	23	78	44	39	13
2511	26	15	61	41	38	14
2611	10	3	8	3	17	4
2711	5	9	27	27	9	3
2811	8	4	11	27	4	4
2911	5	4	5	9	16	1
0212	7	2	28	5	5	0
0312	7	5	17	7	11	3
Total:	520	151	943	348	570	95

Date	Male		Female		Jacks	
(dd/mm)	Clipped	Noclipped	Clipped	Noclipped	Clipped	Noclipped
3010	2	26	2	30	0	15
3110	2	38	4	24	0	24
0111	0	27	1	24	1	8
0411	2	47	0	49	3	30
0811	0	21	0	61	1	15
1211	0	40	2	40	2	23
1311	0	19	2	42	0	6
1411	0	54	3	87	1	60
1511	1	41	2	92	0	41
1611	2	18	1	32	1	29
1811	0	32	0	79	3	59
1911	1	21	1	54	1	23
2011	0	19	0	62	1	39
2111	0	17	0	14	1	44
2211	0	22	1	77	0	39
2511	0	26	1	60	1	37
2611	0	10	0	8	0	17
2711	0	5	0	27	0	9
2811	1	7	1	10	0	4
2911	0	5	0	5	1	15
0212	1	6	0	28	0	5
0312	0	7	0	17	0	11
Total:	12	508	21	922	17	553

Table 19. Summary of chinook carcass mark-recapture data from the Cowichan River, 1996.

Area: **Upper River**

Date	No. Examined		No. Tagged		No. Recaptured	
	Males	Females	Males	Females	Males	Females
3010	28	32	28	32	10	11
3110	32	25	32	25	7	5
0111	27	25	27	25	2	8
0411	37	36	37	36	5	5
0811	21	48	21	48	7	23
1211	39	34	39	34	9	10
1311	18	38	18	38	7	14
1411	54	90	54	90	22	45
1511	42	94	42	94	14	48
1611	20	33	20	33	5	10
1811	32	79	32	79	13	30
1911	22	55	22	55	12	36
2011	19	62	19	62	9	30
2111	17	14	17	14	5	3
2211	22	79	22	79	11	29
2511	26	61	26	61	7	20
2611	10	8	10	8	0	0
2711	5	27	5	27	3	11
2811	8	11	8	11	1	4
2911	5	5	5	5	1	3
0212	7	28	7	28	0	3
0312	7	17	7	17	0	0
Total:	498	901	498	901	150	348

Area: **Middle River**

Date	No. Examined		No. Tagged		No. Recaptured	
	Males	Females	Males	Females	Males	Females
3110	8	3	8	3	0	0
0411	12	13	12	13	1	0
0811	0	13	0	13	0	0
1211	0	8	0	8	0	0
1311	1	6	1	6	0	0
Total:	21	43	21	43	1	0

Table 20. Petersen chinook escapement estimates by sex, Cowichan River, 1996.

Carcass mark-recapture:

UPPER RIVER

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	3,815	3,399	4,231
Female	4,523	4,250	4,796
Total	7,960	7,537	8,383

MIDDLE RIVER

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	253	83	423
Female	990	306	1,674
Total	1,451	633	2,269

[1] Adult males only, jacks not included

Table 21. Incidence of tagged adult chinook carcasses recovered[1] on the spawning grounds by recovery period, in the Cowichan R., 1996.

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 30-Nov. 2	21	4.0	212	10.2	10.0
Nov. 3-9	7	1.4	226	9.5	3.7
Nov. 10-16	114	22.8	607	30.2	19.2
Nov. 17-23	197	39.5	597	30.4	32.9
Nov. 24-30	161	32.3	386	19.7	41.7
Total:	500	100.0	2028	100.0	25.4

[1]includes adult chinook which had lost the tag but had an obvious notch in the operculum or the secondary opercular punch.

Table 22. Percentage of the tag application sample recovered[1] on the spawning grounds, by period, on the Cowichan R., 1996.

Application period	Tags applied	Tags recovered[2]	Recoveries (%)
Oct. 30-Nov. 2	169	43	25.4
Nov. 3-9	142	40	28.2
Nov. 10-16	462	184	39.8
Nov. 17-23	401	178	44.4
Nov. 24-30	225	50	22.2
Total:	1399	495	35.4

[1]includes tag recovery for adult chinook only.
[2]includes only those fish recovered with tag intact

Table 23. Incidence of tagged adult chinook recovered[1] on the spawning grounds by section of river and by period, Cowichan R., 1996.

Upper River

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 30-Nov. 2	20	4.0	200	10.2	10.0
Nov. 3-9	6	1.4	187	9.5	3.7
Nov. 10-16	114	22.8	592	30.2	19.2
Nov. 17-23	197	39.5	597	30.4	32.9
Nov. 24-30	161	32.3	386	19.7	41.7
Total:	498	100.0	1962	100.0	25.4

Middle River

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 30-Nov. 2	1	50.0	12	18.2	8.3
Nov. 3-9	1	50.0	39	59.0	2.6
Nov. 10-16	0	-	15	22.8	-
Nov. 17-23	-	-	-	-	-
Nov. 24-30	-	-	-	-	-
Total:	2	100.0	66	100.0	3.0

[1]includes adult chinook which had lost the tag but had an obvious notch in the operculum or the secondary opercular punch.

Table 23. Summary statistics for Kolmogorov-Smirnov length-frequency comparison for tagged and recaptured chinook carcasses, Cowichan River, 1996.

	Cumulative Frequency						Difference		
Length (cm)	MALES TAGGED	MALES RECAPS	FEMALES TAGGED	FEMALES RECAPS	TOTAL TAGGED	TOTAL RECAPS	MALES	FEMALES	TOTAL
30	0	0	0	0	0.004	0	0	0	0.004
31	0	0	0	0	0.007	0	0	0	0.007
32	0.002	0	0	0	0.012	0.002	0.002	0	0.01
33	0.002	0	0	0	0.017	0.002	0.002	0	0.015
34	0.004	0	0	0	0.024	0.002	0.004	0	0.022
35	0.004	0	0	0	0.031	0.002	0.004	0	0.029
36	0.004	0	0	0	0.041	0.002	0.004	0	0.039
37	0.004	0	0	0	0.055	0.002	0.004	0	0.053
38	0.004	0	0	0	0.074	0.002	0.004	0	0.072
39	0.004	0	0.001	0	0.095	0.002	0.004	0.001	0.093
40	0.004	0	0.001	0	0.12	0.002	0.004	0.001	0.118
41	0.006	0	0.002	0	0.15	0.002	0.006	0.002	0.148
42	0.01	0	0.002	0	0.177	0.002	0.01	0.002	0.175
43	0.022	0.007	0.002	0	0.212	0.004	0.015	0.002	0.208
44	0.034	0.02	0.003	0	0.237	0.008	0.013	0.003	0.229
45	0.053	0.027	0.004	0.003	0.263	0.012	0.026	0.001	0.251
46	0.095	0.054	0.004	0.003	0.287	0.02	0.041	0.001	0.267
47	0.134	0.061	0.004	0.003	0.306	0.022	0.073	0.001	0.284
48	0.166	0.074	0.004	0.003	0.319	0.026	0.091	0.001	0.293
49	0.189	0.088	0.005	0.006	0.33	0.032	0.102	0	0.298
50	0.227	0.122	0.009	0.009	0.342	0.044	0.105	0	0.298
51	0.249	0.128	0.011	0.011	0.349	0.048	0.12	0.001	0.301
52	0.266	0.162	0.013	0.011	0.355	0.058	0.104	0.001	0.296
53	0.28	0.189	0.016	0.014	0.36	0.068	0.091	0.002	0.292
54	0.302	0.223	0.02	0.02	0.368	0.082	0.079	0	0.285
55	0.327	0.25	0.038	0.032	0.382	0.099	0.077	0.006	0.284
56	0.359	0.277	0.05	0.043	0.396	0.115	0.082	0.007	0.282
57	0.387	0.311	0.077	0.066	0.416	0.141	0.076	0.011	0.275
58	0.424	0.345	0.121	0.109	0.446	0.181	0.079	0.012	0.265
59	0.481	0.412	0.15	0.129	0.474	0.215	0.069	0.021	0.259
60	0.531	0.453	0.205	0.175	0.512	0.26	0.078	0.03	0.252
61	0.57	0.493	0.276	0.259	0.555	0.33	0.077	0.017	0.225
62	0.607	0.541	0.346	0.305	0.597	0.376	0.067	0.041	0.221
63	0.657	0.574	0.426	0.405	0.647	0.457	0.082	0.021	0.19
64	0.694	0.601	0.496	0.483	0.689	0.519	0.093	0.013	0.17
65	0.742	0.682	0.57	0.543	0.735	0.586	0.059	0.027	0.15
66	0.775	0.716	0.633	0.592	0.772	0.63	0.059	0.041	0.143
67	0.807	0.743	0.691	0.649	0.807	0.678	0.063	0.041	0.129
68	0.822	0.764	0.736	0.704	0.832	0.722	0.059	0.032	0.11
69	0.842	0.777	0.799	0.776	0.867	0.777	0.065	0.023	0.09
70	0.862	0.804	0.84	0.822	0.891	0.817	0.058	0.018	0.074
71	0.886	0.831	0.879	0.865	0.915	0.855	0.055	0.014	0.06
72	0.895	0.845	0.911	0.899	0.932	0.883	0.051	0.011	0.049
73	0.915	0.851	0.937	0.934	0.949	0.909	0.064	0.003	0.04
74	0.947	0.905	0.962	0.971	0.969	0.952	0.041	0.009	0.017
75	0.963	0.939	0.976	0.989	0.98	0.974	0.023	0.012	0.006

76	0.974	0.966	0.98	0.989	0.984	0.982	0.008	0.009	0.002
77	0.984	0.986	0.987	0.994	0.99	0.992	0.002	0.007	0.002
78	0.986	0.986	0.991	0.994	0.993	0.992	0	0.003	0.001
79	0.994	0.993	0.995	0.997	0.996	0.996	0.001	0.002	0
80	0.996	1	0.998	0.997	0.998	0.998	0.004	0.001	0
81	0.996	1	0.999	0.997	0.999	0.998	0.004	0.002	0.001
82	0.998	1	1	1	1	1	0.002	0	0
83	1	1	1	1	1	1	0	0	0
						D obs =	0.105	0.041	0.301

$D_{.05,53}$ = 0.183

Table 25. Sex composition of application and recovery samples of Cowichan R. chinook, 1996

		Application sample			Recovery sample		
Sex		Recovered	Not Recovered	Total	Marked	Unmarked	Total
Male	Percent	30	38	35	30	35	34
	No.	151	369	520	151	520	671
Female	Percent	70	62	65	70	65	66
	No.	348	595	943	348	943	1296
Total:	No.	499	964	1463	499	1463	1967

Table 26. Total adult chinook returns to the Cowichan River, 1975-1996.

Year	Natural spawner	Brood stock	Native catch	Total return
1975	6500		900	7400
1976	3460		1000	4460
1977	4150		1000	5150
1978	4370		500	4870
1979	8750	195	500	9445
1980	5950	337	1500	7787
1981	6050	282	1500	7832
1982	5450	534	450	6434
1983	4550	242	250	5642
1984	5050	278	355	5683
1985	3550	175	468	4193
1986	1250	315	481	2046
1987	1200	582	455	2237
1988	4712	678	681	6071
1989	996[a]	535[b]	1055	2586
1990	4164	326	604	5094
1991	4086[c]	1755	270	5065
1992	6676	1850	260	8678
1993	5047	1970	295	7312
1994	4936	1357	345	6638
1995	13452[d]	2149	533	16134[d]
1996	12217[d]	1615	800	14701[d]

[a]For 1989 to the present, the number of natural spawners is calculated as the number of adults recorded at the fence minus the adults removed for broodstock above the fence.
[b]Total broodstock removed.
[c]Includes 2000 adult chinook estimated to have passed by the fence during the period of high water
[d] Includes the fence count and an estimate of the numbers of fish that entered the river prior to installation and after removal of the fence.

FIGURES

Fig. 1 Cowichan River Survey Areas:

Swim survey locations were:

1 - Bird House pool
2 - Road pool
3 - Train trestle (mile 70.2)
4 - Old pick-up site
5 - Maple tree
6 - Three Firs pool
7 - Skutz Falls
8 - Marie Canyon
9 - Bible Camp
10 - Cowichan side channel
11 - Sandy pool
12 - Sewer
13 - JC pool

Swim survey areas:

Bird House (1) to Three Firs pool (6) represents the Upper survey section.

Marie Canyon (8) to enumeration fence (A) represents the Middle survey section.

A - refers to the adult enumeration fence

Tag recovery locations:

Locations numbered 1 to 45 are in the upper river section, those numbered 46 to 83 are in the middle river section.

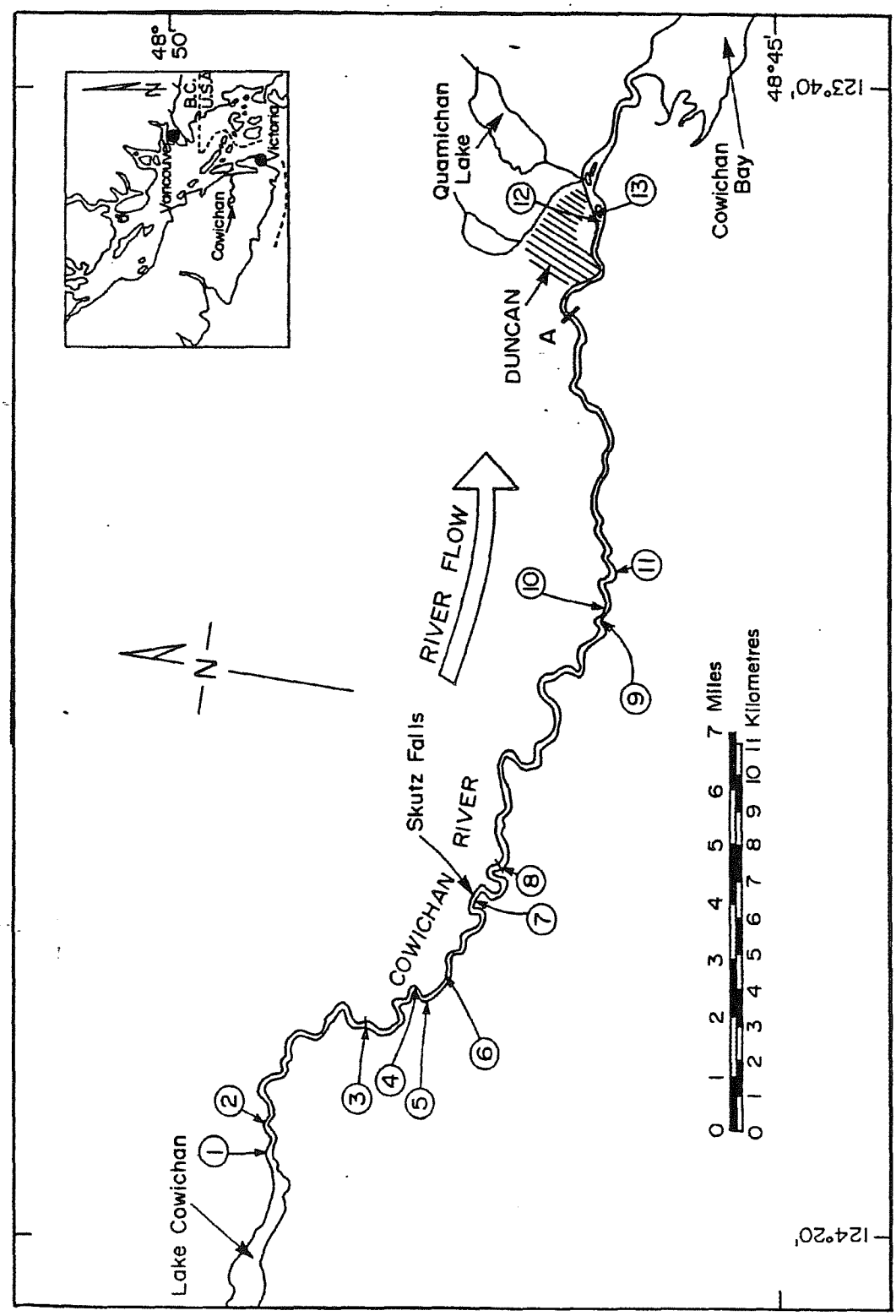

48° 50'
N
B.C.
U.S.A.
Vancouver
Victoria
Cowichan
123°40'
48°45'
Quamichan Lake
Cowichan Bay
DUNCAN
A
RIVER FLOW
N
Skutz Falls
RIVER
COWICHAN
Lake Cowichan
124°20'
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres
1
2
3
4
5
6
7
8
9
10
11
12
13

Fig. 2 River Management Zones for Native Food Fishery

A-Cliffs to Silver bridge

B-Silver bridge to JC's place

C-Quamichan to Black creek

D-Powerline to Elliot's barn

E-Elliot's barn to Brian's pool

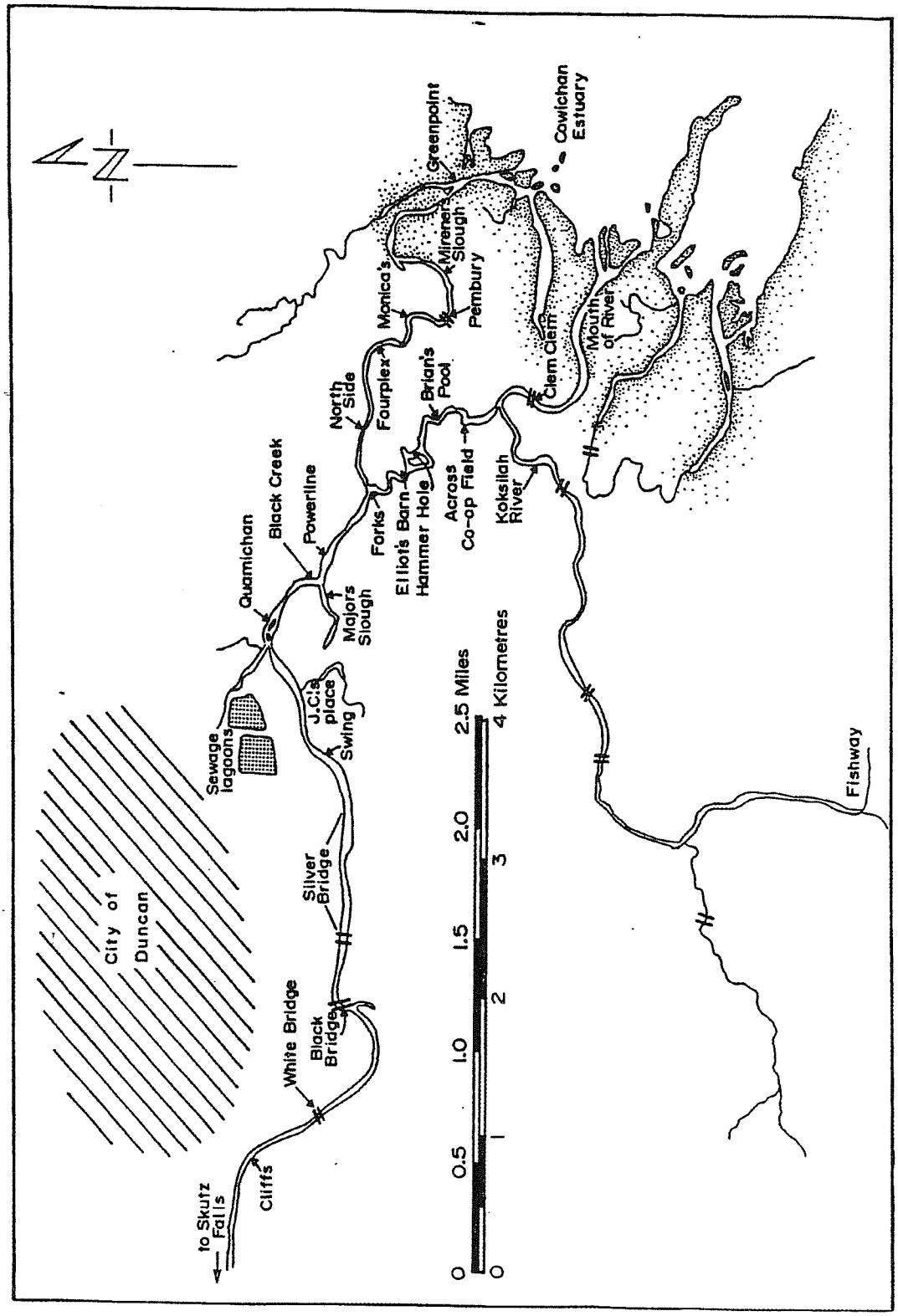
F-Brian's pool to Clem Clem and part of Koksilah

G-Clem Clem to mouth

H-North side to Four plex

I-Four plex to Meriner's slough

J-Meriner's slough to mouth


N
Greenpoint
Cowichan Estuary
Mirener Slough
Monica's
Pembury
Clem Clem
Mouth of River
North Side
Fourplex
Brian's Pool
Across Co-op Field
Koksilah River
Quamichan
Black Creek
Powerline
Forks
Elliot's Barn
Hammer Hole
Majors Slough
J.C.'s place
Swing
Sewage lagoons
Silver Bridge
White Bridge
Black Bridge
City of Duncan
to Skutz Falls
Cliffs
Fishway
0
0.5
1.0
1.5
2.0
2.5 Miles
0
1
2
3
4 Kilometres

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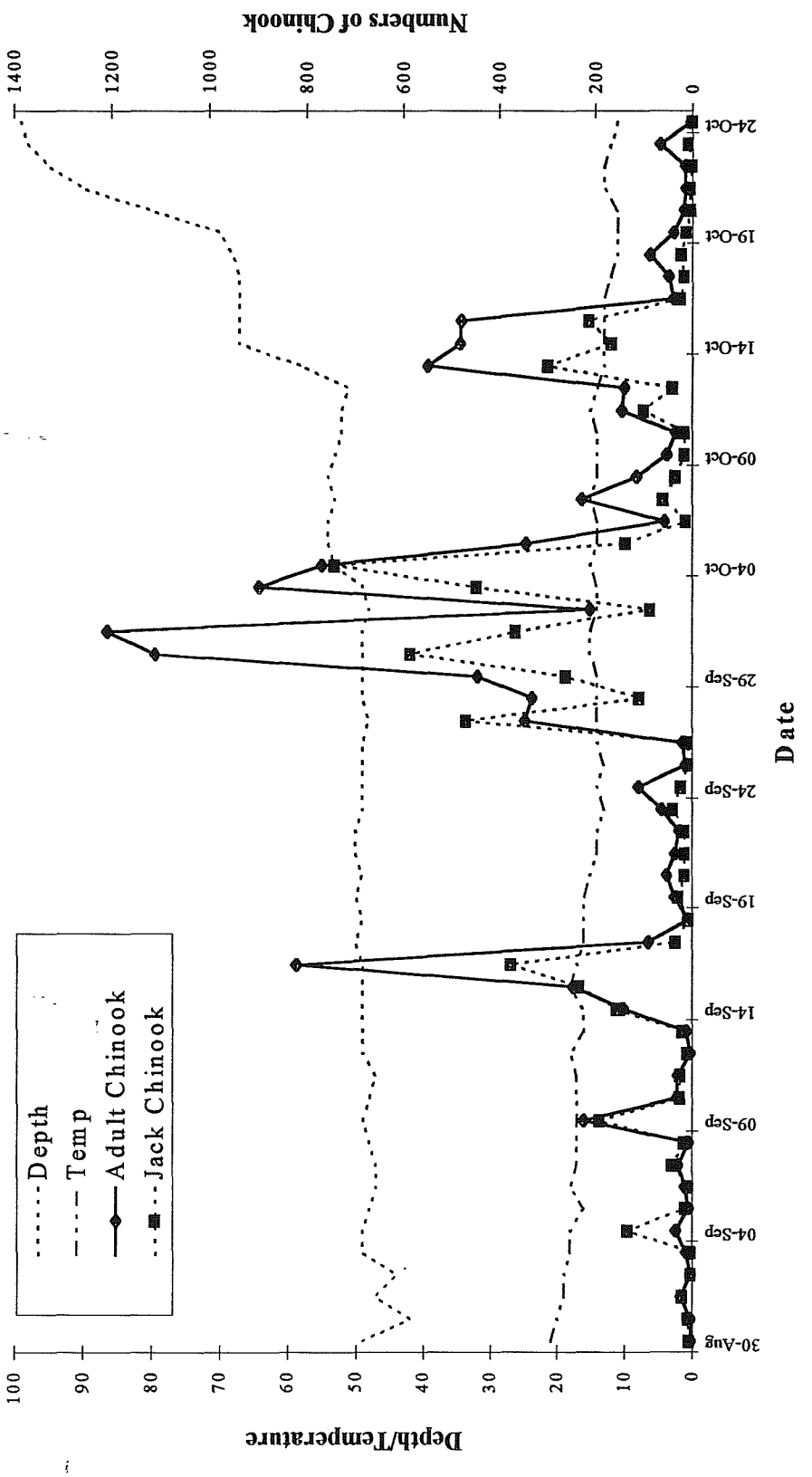

Fig. 3 Daily fence count of chinook, water depth and temperature, 1996.

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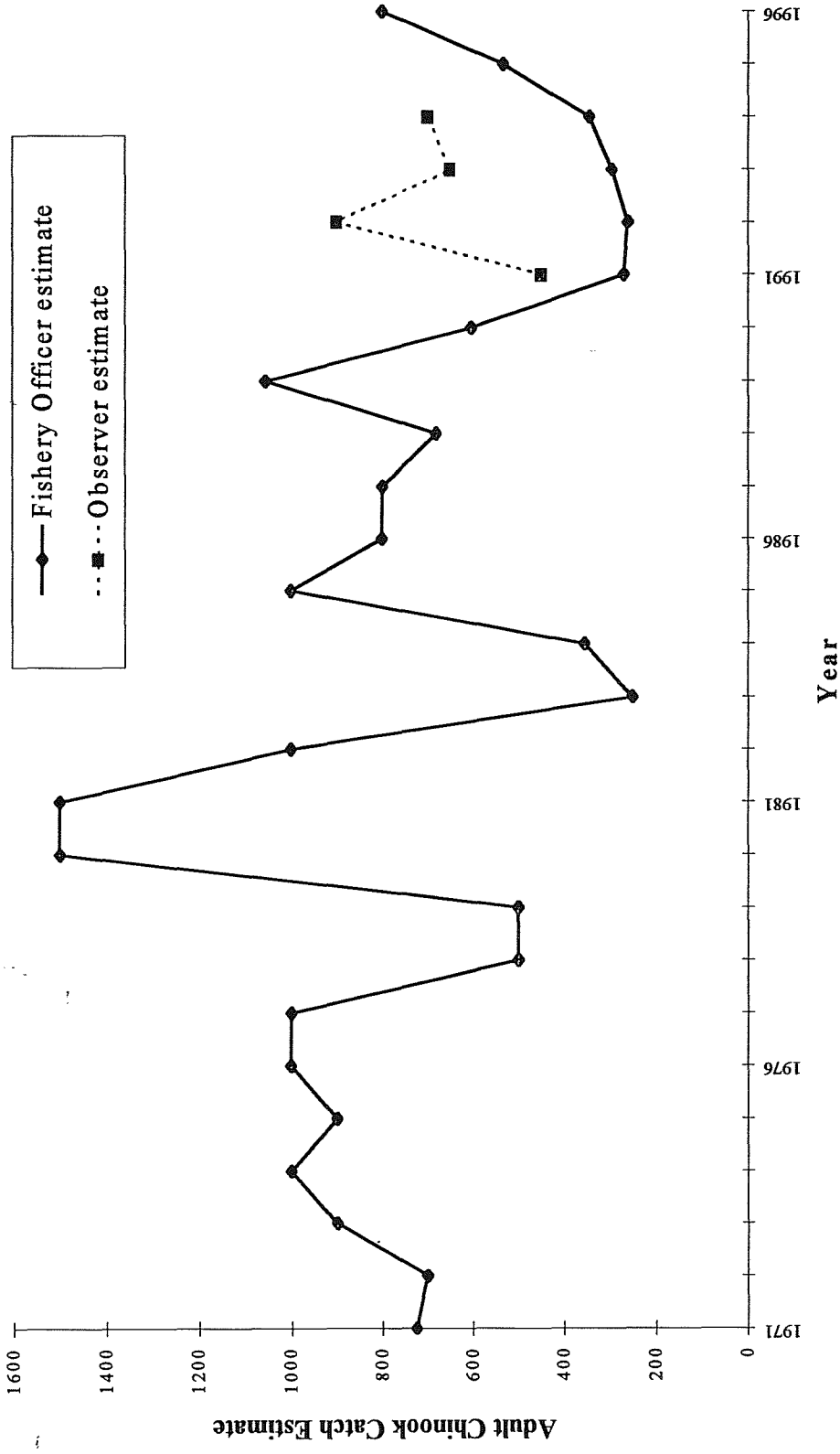

Fig. 4 Native food fishery adult chinook catch data, 1971-96.

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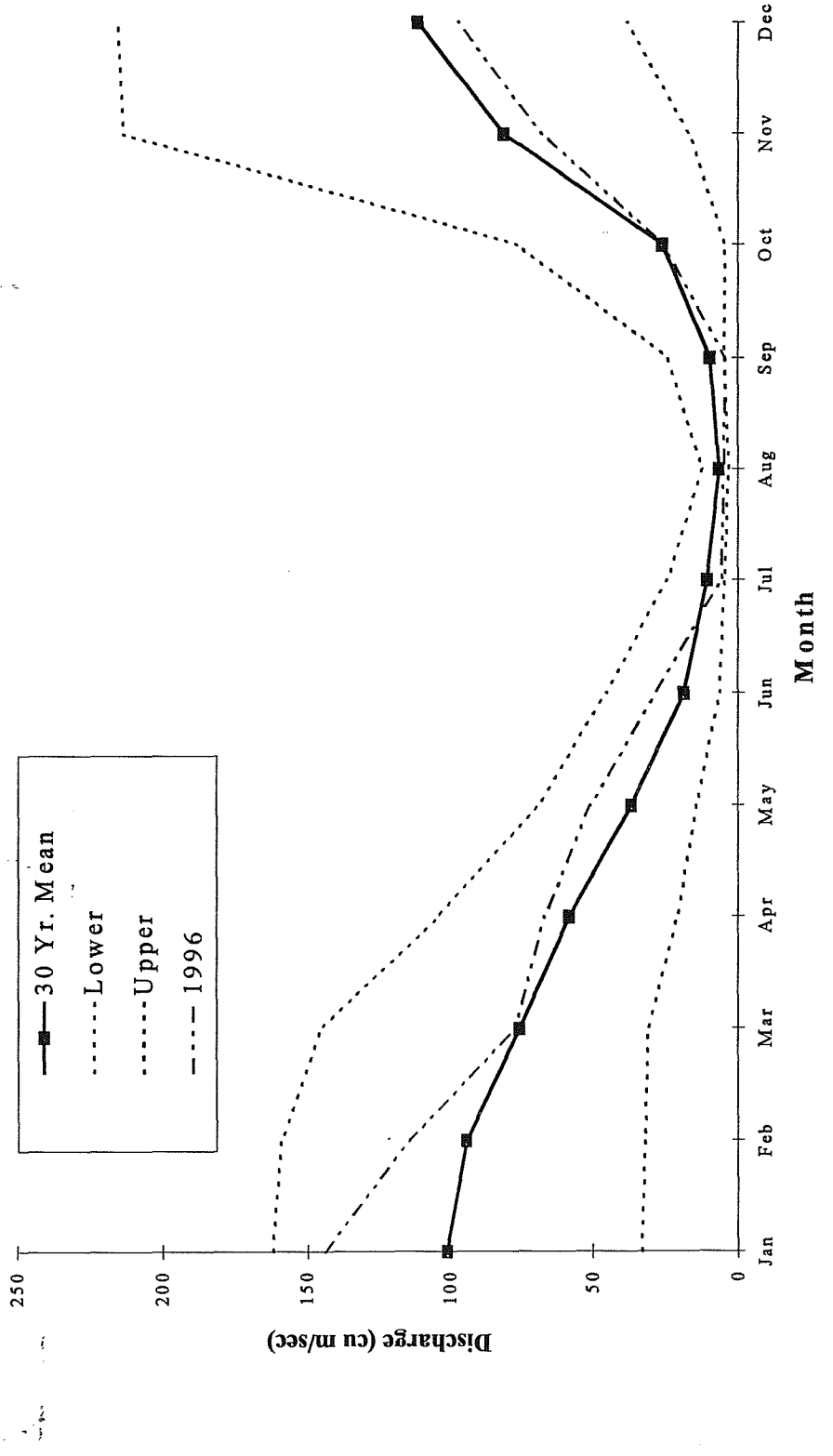

Fig. 5 Cowichan River discharge (cu m/sec)

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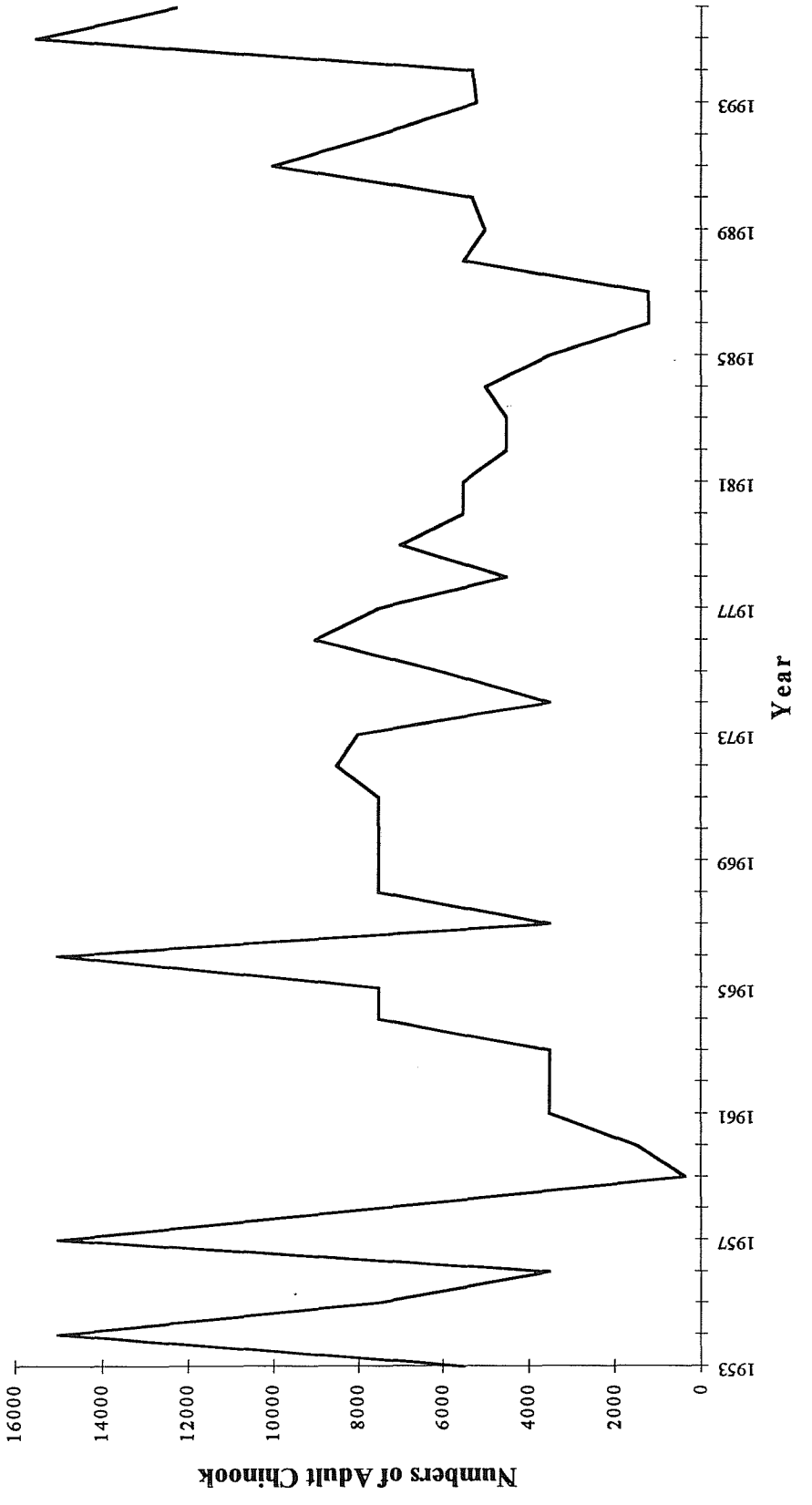

Fig. 6 Adult chinook escapement estimates for the Cowichan River, 1953-1996.

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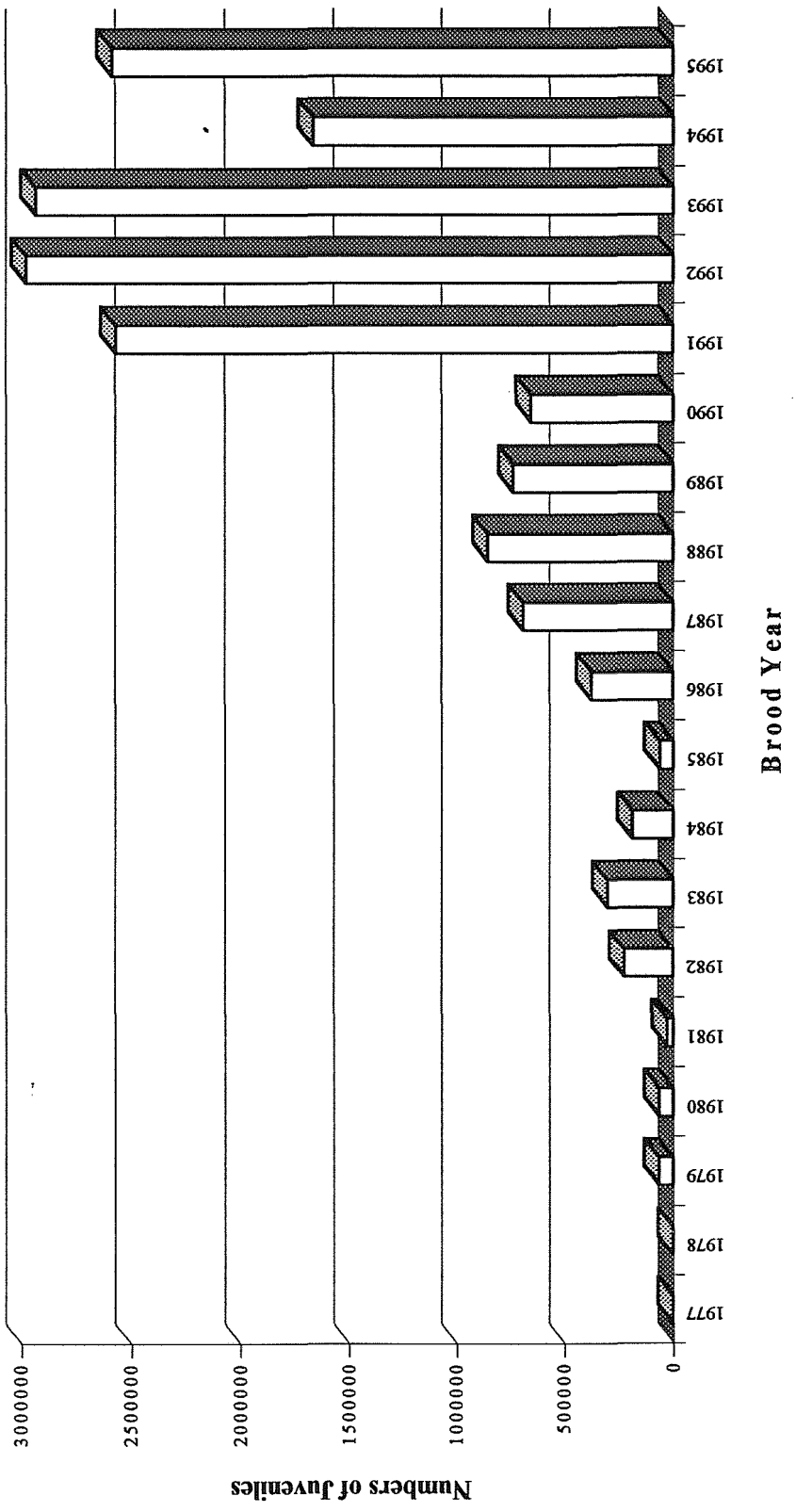

Fig. 7 Hatchery chinook released into the Cowichan River, as fry (3 gm) and as pre-smolts (6 gm).

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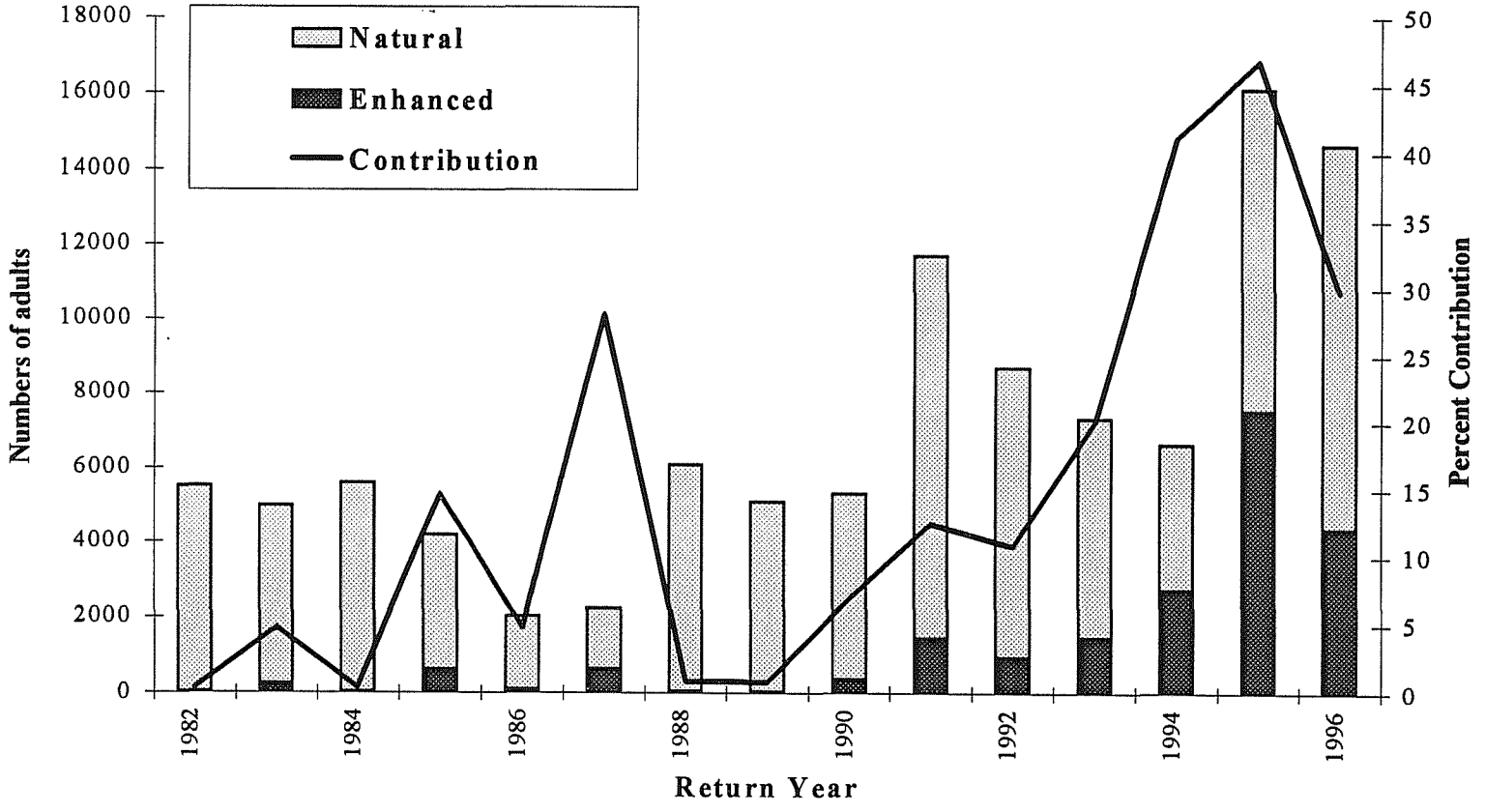

Fig. 8 Natural and enhanced contribution to escapement, Cowichan R., 1982-1996.