A Preliminary Report on the Adult Chinook Productivity Study Conducted on the Cowichan River During 1994

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by

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ABSTRACT

Nagtegaal, D. A., E. W. Carter and B. Riddell. 1995. A preliminary report on the adult chinook productivity study conducted on the Cowichan River during 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2331: 62 p.

In 1994, the Biological Sciences Branch, 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, ii) estimation of native food fish catch, iii) recording hatchery broodstock removals, iv) biological sampling and coded-wire tag (CWT) 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 6,638 in 1994. The number of natural spawners was estimated to be 4,936. Cowichan Tribes Aboriginal Fisheries Management estimated the adult chinook escapement to be 5,500. In addition, a water management plan is described which was intended to aid upstream movement of chinook.

RÉSUMÉ

Nagtegaal, D. A., E. W. Carter and B. Riddell. 1995. A preliminary report on the adult chinook productivity study conducted on the Cowichan River during 1994. Can. Manuscr. Rep. Fish. Aquat. Sci. 2331: 62 p.

En 1994, 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 1994, l'effectif de remonte total du saumon quinnat adulte – écloseries et frayères naturelles confondues – dans la rivière Cowichan se chiffrait à 6 638, le nombre de reproducteurs issus de frayères naturelles étant estimé à 4 936. L'organisme de gestion de la pêche autochtone des tribus cowichan a estimé, pour sa part, le taux d'échappée des quinnats adultes à 5 500. 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 Department of Fisheries and Oceans, 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 with additional information collected from the Squamish and Nanaimo River systems. The objectives of this study include: i) quantitatively determining 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) development of guidelines for establishing escapement targets for other B. C. chinook stocks (Nagtegaal et al., 1994a).

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 2.9 million in 1994. Marked releases also began in 1980 and in 1994 approximately 8% of the total number of chinook released were coded-wire tagged (Appendix Table 3).

As an adjunct to this study a water management plan, implemented in 1988 (KPA Engineering Ltd. 1991), was maintained on the Cowichan River by the Fisheries Branch. The rationale behind this plan was to increase water flow for a short period (2-5 days) during the early part of the chinook run. This was intended to aid upstream movement of chinook. These fish may otherwise be obstructed in their upstream migration and suffer pre-spawn mortalities due to typically low water levels in the Fall.

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 1994.

METHODS

Components of escapement enumeration include: i) enumeration of chinook salmon at the counting fence; ii) estimation 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 1994 and are described below.

The counting fence was placed in the same location as in previous years (Fig. 1).

FENCE OPERATION:

Counts were recorded by fifteen 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 four times per day. On a daily basis the fence was cleaned of leaves and other debris. Records of fish collected at the fence by the hatchery staff were also kept.

SWIM SURVEY:

Five swim surveys were conducted in conjunction with Cowichan Tribes Aboriginal Fisheries Management to estimate the spawning population of chinook. The swims were made in the upper section of the river. 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 to derive an escapement estimate. This expansion factor was consistently applied to each swim count with no adjustments made for run timing or the relative distribution of chinook in the river.

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 Aug. 26, Sept. 1, 9, 16, 23, and 27, and Oct. 3 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 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, 1995). 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.

BIOLOGICAL DATA:

Biological data for chinook were collected from three sources: i) hatchery broodstock samples; ii) mark/recapture (spawning ground); and iii) native food fishery. Hatchery staff collected biological data and recorded the incidence of coded-wire tagged fish from the chinook broodstock. On the spawning grounds chinook were sampled for length, sex, scale, and the presence/absence of an adipose clip. The head was removed from all coded-wire tagged fish and frozen for further analysis.

A member of the Cowichan Tribes was hired to collect biological data from the native food fishery. This person monitored both the traditional chinook spear fishery as well as the in-river gillnet fishery. Data for length, sex, age and adipose clip were recorded from the catch by native management zone on a daily basis. The person interviewed as many fishermen as possible and attempted to sample fish from all management zones. Due to concentrated fishing effort in certain zones and lack of cooperation from some fishermen, not all areas were sampled equally.

MARK-RECAPTURE:

A multiple capture-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 operculum and immediately released in the same area as captured. Location of capture and release, tag number, spawning condition, length, sex, and adipose clip

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

information was recorded for each carcass recovered. Tag numbers of previously marked carcasses were recorded and the carcass returned to the river in the same site as captured.

A three man crew in an inflatable boat 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. A second crew collected carcasses from the middle section of the river (Fig. 1). A 4.2 m (14 ft) 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. All coded-wire tagged fish recovered on the the spawning grounds were biosampled and the head removed for future processing.

POPULATION ESTIMATE:

Adult chinook salmon escapement estimates were generated from the carcass capture-recapture data using both Petersen (Chapman modification) (Ricker 1975) and a modified open population Jolly-Seber model (Sykes and Botsford 1986, Schwartz et al. 1993). A comprehensive computer program POPAN-3 (Arnason et. al. 1992) was used to conduct the analysis. The Jolly-Seber model allows estimation of population size at each sampling time as well as survival rates and birth numbers between sampling times.

RESULTS

ENUMERATION FENCE:

In 1994, the counting fence was operated from August 15 through to November 13. From Oct. 30 to Nov. 13 the fence was partially submerged but remained functional and in full operation. Due to excellent conditions we were able to monitor virtually the entire chinook run. Daily counts at the enumeration fence are contained in Table 1, and compared with water depth recorded at the fence (Fig. 3). Total counts recorded during this period were: 5,050 adult chinook; 13,381 jack chinook; 9,599 adult coho; 3,160 jack coho; 7,671 chum and 11 unidentified fish.

During the season, jack chinook tended to enter the river earlier 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. Approximately 45% of adults and 47% 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 134 fish examined, three fish (2.2%) 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 1981-1994 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. Swims in 1994 were conducted in the upper section of the river (Birdhouse to Three Firs pool; Fig. 1) on Aug. 24, Sept. 14, 28, Oct. 13 and 26. The 1994 escapement of adult chinook was determined to be 5500 (Paige 1995) (Fig. 4). All swim surveys were conducted under good conditions (low water and clear visibility) and no major difficulties were encountered.

Table 4 lists the results of the swims conducted in the main pool below the fence. Although there were always fish in the pool below the fence 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 catch estimate of 345 adults and 227 jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group (Paige 1995). According to our observer, the adult chinook catch was quite good this year since optimal fishing conditions prevailed and based on this sampling program an estimated 700 adult chinook were taken in the fishery (J. Coleman, pers. comm.). It was very difficult to assess the quality of the data collected from either of these sources but it was apparent that some discrepancies continue to exist as in previous years.

HATCHERY COMPONENT:

In 1994, 1357 chinook were removed from the river by the Cowichan River hatchery staff, of which 91% were collected below the enumeration fence (Table 6). The hatchery staff (D. Millerd, pers. comm.) indicated they had not met their target of 3.2 million eggs due to difficulties in collecting enough broodstock (Table 7).

Primarily 3 and 4 year old chinook were used for broodstock (Table 8).

BIOLOGICAL DATA:

The majority of the chinook caught in the native food fishery were jack chinook (Tables 9 and 10) with a considerable number of three and four year olds taken as well. This was likely due to the fact that the fishery is most active during the earlier part of the run when relatively more jacks are in the river than adults. Age data from this fishery may not be representative of the actual age composition since there was an unwillingness to have scales taken from adult fish and consequently mostly jack chinook were sampled (J. Coleman, pers. comm.).

The majority of chinook sampled on the spawning grounds were jacks (Table 11) because there was such a large number returning this year. Slightly more adult females were recovered on the spawning grounds than adult males. Adult chinook were comprised of 3 and 4 year olds (Table 12).

Length-frequency summaries of chinook broodstock collected and sampled at the hatchery are listed in Table 13. The hatchery staff randomly sampled approximately 25% of all broodstock collected and then selectively sampled all remaining adipose clipped chinook. The adipose mark rate was 6.7% for males, 9.4% for jack chinook, and 17.1% for females. The mark rate for chinook from hatchery samples was considerably higher than from the spawning grounds.

Coded-wire tag (CWT) recovery information for chinook sampled on the spawning ground is listed in Appendix Table 1 and from the native food fishery in Appendix Table 2. A summary of chinook releases from the Cowichan hatchery by brood year is listed in Appendix Table 3.

WATER RELEASE STUDY:

The release of additional water stored in Lake Cowichan occurred on October 5 and 17 at 8:00 AM. The first pulse of water (20 cu m/sec) and the second pulse (13 cu m/sec) were maintained for a 72 hr period. Water temperature and stage were monitored at the counting fence (Table 14) and total discharge recorded at the Water Survey Canada recording station located below the Island highway in Duncan (Table 15). Note that with the increased flow a corresponding increase in the daily chinook count occurred (Fig. 3). The increase in chinook upstream movement was more dramatic during the first water release.

MARK-RECAPTURE:

Table 16 contains a summary of the carcass capture-recapture data by tagging period. A total of 531 adult and 772 jack chinook carcasses were tagged and released (Table 17). More than 83% of the adult and 90% of the jack carcasses were tagged but never recaptured. Smaller and lighter jack chinook carcasses are more readily swept downstream and often less likely to be recovered than the heavier adult carcasses. This is generally the case during the fall and a potential source of bias, but due to the low flow this year, the usual scenario of carcasses being swept downstream was not a significant problem.

Simple Petersen:

The escapement estimate of adults based on carcass mark-recapture data (Table 18) was 3,470 with lower and upper 95% confidence limits of 2,667 and 4,267, respectively. Approximately 76% 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 19). There were no significant differences in the mark incidence between periods ($P > 0.05$; chi-square; Zar 1984).

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 20). No significant differences were observed ($P > 0.05$; chi-square).

2. Location bias: Spatial bias was examined by comparing the mark incidence between the upper and middle river sections in the recovery sample (Table 16). 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 (17.8%) was much higher than in the middle section (4.9%).

3. Fish size: Size related bias in the application sample was examined by comparing the continuous post orbital/hypural length frequency distributions of marked and unmarked recoveries from the spawning ground (Table 11). No significant differences were observed in males or females ($P >$

0.05; Kolmogorov-Smirnov two sample test). Size related bias in the recovery sample was examined by comparing the continuous post orbital/hypural length frequency distributions of tagged and recaptured carcasses. 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 21). 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. In both cases, no significant differences were found ($P > 0.05$; chi-square).

Jolly-Seber:

Using the modified Jolly-Seber approach we generated estimates for adult chinook only. Summary statistics for the analysis are contained in Table 22. The capture-recapture estimate was calculated to be 3,848 adults +/- 865 (2 SD).

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 information regarding the numbers that may have entered before or after the fence operation. Due to excellent conditions in the fall of 1994, the fence was in operation for what we understood to be essentially the entire run. Even so, the fence count of 5,050 adults and 13,381 jack chinook should be considered an incomplete count of the total run, but the most accurate one available.

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 SURVEY DATA:

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.

Even though lower than average river discharge conditions persisted into late fall again this year (Fig. 5), most chinook spawned in the upper river section. 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. Even so, the final escapement estimate was surprisingly similar to the fence count.

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 1994 catch estimate of 345 adult chinook seemed to be low relative to the fence count, the prevailing fishing conditions and based on our observer sampling information. The biological observer sampled 104 adult chinook and 55 jacks and estimated that he had monitored approximately 20% of the total catch (J. Coleman, pers. comm.). On this basis, the the total food fish catch would be approximately 500 adults, although he suggested that the 1994 fishing season had been good and estimated that at least 700 adults and 450 jack chinook were caught. At best, these two estimates may be considered to be the upper and lower range of the actual food fish catch.

BIOLOGICAL DATA:

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 (5.0%-males; 2.4%-females) was significantly less than the hatchery chinook (6.7%-males; 17.1%-females) broodstock sample ($P < 0.05$, chi-square). No differences, however, 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. No definite conclusions could be made concerning these discrepancies, however, differences have been noted in previous years as well (Nagtegaal et al.,1994c).

WATER RELEASE STUDY:

Weather conditions, water temperature and flow rate all affect the migration timing of spawning salmon. It appears the water release provided considerable opportunity for chinook to move upstream. Approximately 37% of the total escapement of adults and jacks passed by the fence during the first water release period and 7.5% of the adults and 3.2% of jacks during the second water release. The weather had been warm and dry for some time prior to the release. To what extent the weather conditions contributed to the impact of the water release on upstream movement is unknown. The effect on chinook survival of increased water temperatures in the river, due to releasing warmer surface water from the lake, is also unknown.

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. However, conditions for carcass recovery were ideal in 1994, with flows less than 55 cu m/sec and good water clarity. We were able to tag and sample approximately 11% of the total 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 but it was

assumed that these would not 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 32%, and the Jolly-Seber estimate by 26%.

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 seal's diet in Cowichan Bay was comprised of salmon (Bigg et. al. 1990). Based on these data, consumption of chinook salmon could potentially range from 500 to 1000 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.

ESCAPEMENT ESTIMATE:

Escapement estimates for the Cowichan River were primarily based on the fence data since it was assumed that 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 fish taken by the native food fishery. On this basis we calculate the total return to the Cowichan River from Aug. 15 - Nov. 13, 1994 to be 6,638 (Table 23). This should be considered a minimum estimate since these numbers are based on the fence count and assume that no chinook were in the river prior to or after the counting fence was in place. If we include our observer estimate for the native food fish catch and a seal predation estimate of 850, then it is probable that the total return of chinook in 1994 was closer to 7,800 adults. The number of natural spawners was calculated to be 4,936 (Table 23). This was based on the fence count minus the chinook adults removed for broodstock at and above the fence.

Chinook escapements have fluctuated over the past 20 years with a low of 1200 in 1986/87 to a high of 10,000 in 1991 (Fig. 6). For ten out of the past 16 years escapements have ranged between 5000 and 6000 adults with no increasing or decreasing trend evident. Chinook production seems to have remained fairly constant in spite of substantial increases in hatchery production (Fig. 7).

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Table 1. Daily counts at the enumeration fence site, 1994

Date	Chinook		Coho		Chum	Unknown[1]
	Adult	Jack	Adult	Jack		
Aug. 15	0	2	0	0	0	0
16	0	3	0	0	0	0
17	0	3	0	0	0	0
18	2	5	0	0	0	0
19	1	20	0	0	0	0
20	4	7	0	0	0	0
21	1	10	0	0	0	0
22	0	13	0	0	0	0
23	0	16	0	0	0	0
24	2	22	0	0	0	0
25	1	25	0	0	0	0
26	4	37	0	0	0	0
27	2	11	0	0	0	0
28	8	16	0	0	0	0
29	0	5	0	0	0	0
30	0	9	0	0	0	0
31	4	14	0	0	0	0
Sep. 01	4	27	0	0	0	0
02	6	14	0	0	0	0
03	3	28	0	0	0	0
04	9	25	0	0	0	0
05	9	51	0	0	0	0
06	8	57	0	0	0	0
07	1	7	0	0	0	0
08	4	17	0	0	0	0
09	13	54	0	0	0	0
10	57	541	0	0	0	0
11	2	16	0	0	0	0
12	45	122	0	0	0	0
13	45	155	0	0	0	0
14	5	20	0	0	0	0
15	9	12	0	0	0	0
16	23	45	0	0	0	0
17	15	58	0	0	0	0
18	19	52	0	0	0	0
19	137	1117	0	0	0	0
20	196	759	31	10	0	7
21	51	125	17	3	0	1
22	12	64	0	0	0	0
23	14	127	0	1	0	0
24	67	502	71	12	0	0
25	30	299	5	1	0	0
26	28	218	0	1	0	0
27	96	323	0	7	0	0
28	71	119	10	0	0	0
29	31	47	9	1	0	0
30	8	18	1	1	0	0
Oct. 01	3	19	2	5	0	0
02	51	212	4	0	0	0
03	143	268	19	7	0	0
04	21	41	19	25	0	0
05	88	373	186	119	0	0
06	1676	4358	533	436	11	0
07	177	202	34	29	0	0
08	42	65	59	26	0	0

Table 1 (cont.)

Date	Chinook		Coho		Chum	Unknown
	Adult	Jack	Adult	Jack		
Oct. 09	10	6	9	1	0	0
10	9	5	2	0	0	0
11	45	64	6	6	0	0
12	24	45	18	13	0	0
13	21	30	15	8	3	0
14	54	149	19	14	0	1
15	36	43	9	12	2	0
16	83	57	30	1	1	0
17	25	36	10	14	2	0
18	292	330	227	123	14	0
19	62	59	111	57	4	1
20	34	110	103	24	7	0
21	44	138	55	36	5	0
22	17	28	21	29	1	0
23	8	12	19	23	5	0
24	12	72	28	17	2	0
25	35	73	31	27	3	0
26	375	669	870	426	473	0
27	295	305	3206	677	1275	1
28	256	240	1692	325	1339	0
29	16	35	207	101	335	0
30	24	50	389	227	619	0
31	4	17	111	69	341	0
Nov. 01	2	12	92	34	56	0
02	4	7	222	22	83	0
03	5	2	182	54	267	0
04	0	0	79	13	71	0
05	5	4	121	37	202	0
06	0	1	185	38	516	0
07	3	6	127	29	313	0
08	1	0	133	17	618	0
09	0	0	9	0	51	0
10	0	0	4	1	60	0
11	0	1	123	0	604	0
13	1	0	134	1	388	0
Total:	5050	13381	9599	3160	7671	11

[1] Unidentified salmon

Table 2. Daily counts[1] by time interval at the enumeration fence site, 1994

Universal time	Adult No.	Percent	Jack No.	Percent
0000-0100	188	4	538	4
0100-0200	445	9	948	7
0200-0300	374	7	1078	8
0300-0400	373	7	896	7
0400-0500	292	6	761	6
0500-0600	248	5	572	4
0600-0700	260	5	476	4
0700-0800	512	10	1596	12
0800-0900	673	13	2232	17
0900-1000	359	7	955	7
1000-1100	180	4	270	2
1100-1200	35	1	56	0
1200-1300	28	1	76	1
1300-1400	11	0	71	1
1400-1500	35	1	23	0
1500-1600	40	1	37	0
1600-1700	88	2	288	2
1700-1800	121	2	209	2
1800-1900	88	2	198	1
1900-2000	72	1	281	2
2000-2100	136	3	325	2
2100-2200	158	3	461	3
2200-2300	142	3	479	4
2300-2400	192	4	555	4
Totals	5050	100	13381	100

[1]Summary of fence count data

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	

[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, 1994

Date	Area[1]	Chinook Jacks	Chinook Adults	Coho Jacks	Coho Adults
Aug. 26	Fence	33	2		
	First Riffle	6	0		
	Pumphouse Pool	36	0		
Sept. 01	Fence	10	1		
	First Riffle	2	0		
	Pumphouse Pool	28	8		
Sept. 09	Fence	16	7		
	First Riffle	1	6		
	Pumphouse Pool	60	30		
Sept. 16	Fence	45	20		
	First Riffle	28	9		
	Pumphouse Pool	90	70		
Sept. 23	Fence	20	20		
	First Riffle	54	25		
	Pumphouse Pool	350	350		
Sept. 27	Fence	52	38		
	First Riffle	50	17		
	Pumphouse Pool	400	200		
Oct. 3	Fence	40	30		
	First Riffle	60	20		
	Pumphouse Pool	450	250		20

[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)

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

[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[1] by the Cowichan hatchery, 1994.

Date	Below fence			Above fence		
	M	J	F	M	J	F
Oct. 4	161	36	95			
7	6	0	2			
8	11	0	9			
11	169	18	128			
12	75	5	57			
13	51	2	33			
14	165	27	78			
18	4	2	4	9	30	14
19	25	0	57	10	4	10
20	14	0	12	12	0	19
21	24	0	27	6	0	5
24	9	0	11	9	2	4
26	8	19	8	8	0	4
27						1
31						3
Totals:	722	109	521	54	36	60

[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

[1]Barry Cordecedo (Salmon Enhancement Program) provided numbers on broodstock collection from 1981-1987. The brood stock 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], 1994

Age	Males	Females	Total
2	24	0	24
3	155	98	253
4	20	56	76
5	0	1	1
TOTAL:	200	155	355

Total number of regenerate scales read: 51

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

Table 9. Summary of the age data collected for chinook sampled during the native food fishery on the Cowichan River, 1994

Age	Males	Females	Total
2	73	-	73
3	15	16	31
4	7	19	26
5	0	1	1
Total:	95	36	131

Total number of regenerate scales read: 24

Table 10. Length-frequency of chinook sampled from the native food fishery, 1994

Length (cm)	Chinook			
	Males	Jacks	Females	Total
33				
34		1		1
35		0		0
36		1		1
37		1		1
38		5		5
39		3		3
40		12		12
41		10		10
42		11		11
43		11		11
44		2	1	3
45	3		4	7
46	0		4	4
47	1		6	7
48	3		1	4
49	1		3	4
50	0		0	0
51	1		3	4
52	0		1	1
53	0		1	1
54	1		2	3
55	4		3	7
56	2		3	5
57	0		2	2
58	4		3	7
59	2		2	4
60	0		3	3
61	0		0	0
62	0		1	1
63	0		4	4
64	1		1	2
65	2		0	2
66	1		2	3
67	1		1	2
68	0		0	0
69	1		1	2
70	0		0	0
71	0		0	0
72	1		5	6
73	0		0	0
74	1		3	4
75	1		1	2
76	2		2	4
77	0		0	0
78	0		1	1
79	2			2
80	0			0
81	0			0
82	1			1
Total:	35	58	64	157
Adipose Clip:	4	3	5	
Mark Rate (%):	11.4	5.2	7.8	

Table 11. Length-frequency of chinook sampled on the spawning grounds, 1994.

Length (cm)	Males	Jacks	Females	Total
20	0	1	0	1
21	0	1	0	1
22	0	0	0	0
23	0	0	0	0
24	0	1	0	1
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	0	2	0	2
29	0	1	0	1
30	0	3	0	3
31	0	8	0	8
32	0	7	0	7
33	0	23	0	23
34	0	29	0	29
35	0	27	0	27
36	0	42	0	43
37	0	50	0	51
38	0	51	0	51
39	0	57	0	58
40	0	53	0	53
41	0	63	0	63
42	0	62	0	62
43	0	61	0	61
44	0	61	0	61
45	1	55	0	56
46	2	32	1	35
47	2	32	0	34
48	3	27	3	33
49	2	17	0	19
50	10	4	1	15
51	11	3	0	14
52	9	1	0	10
53	6	0	3	9
54	16	1	2	19
55	8	0	1	9
56	13	0	5	18
57	9	0	9	18
58	12	0	10	22
59	20	0	12	32
60	15	0	6	21
61	12	0	11	23
62	9	0	13	22
63	5	0	12	17
64	11	0	11	22
65	10	0	11	21
66	6	0	13	19
67	4	0	19	23
68	4	0	17	21
69	8	0	19	27
70	4	0	21	25
71	7	0	16	23
72	3	0	14	17
73	1	0	14	15
74	3	0	17	20
75	3	0	11	14

Table 11 (cont.)

Length (cm)	Males	Jacks	Females	Total
76	2	0	5	7
77	3	0	2	5
78	1	0	4	5
79	0	0	2	2
80	1	0	0	1
81	1	0	0	1
82	1	0	0	1
83	1	0	0	1
84	0	0	1	1
Total:	239	773	291	1303
Adipose clips:	12	23	7	42
Mark rate:	5.0%	2.9%	2.4%	3.2%

Table 12. Summary of chinook age data collected on the spawning grounds, 1994

Age	Males	Females	Total
2	527	0	527
3	106	78	184
4	23	78	101
5	3	7	10
Total:	659	163	822

Total number of regenerate scales read: 421

Table 13. Length-frequency of chinook broodstock[1] collected for the Cowichan River hatchery, 1994

Length (cm)	Males	Jacks	Females	Total
41	0	1	0	1
42	0	0	0	0
43	1	2	0	3
44	0	1	0	1
45	0	3	0	3
46	0	4	0	4
47	0	2	0	2
48	1	3	0	4
49	0	2	0	2
50	1	4	0	5
51	1	1	0	2
52	1	1	2	4
53	4	2	0	6
54	5	1	1	7
55	17	2	0	19
56	16	1	2	19
57	17	0	3	20
58	9	0	4	13
59	12	1	9	22
60	14	1	6	21
61	16	0	13	29
62	8	0	11	19
63	12	0	10	22
64	4	0	4	8
65	9	0	6	15
66	0	0	3	3
67	0	0	4	4
68	4	0	9	13
69	3	0	9	12
70	3	0	7	10
71	0	0	7	7
72	0	0	4	4
73	2	0	6	8
74	2	0	10	12
75	0	0	4	4
76	1	0	1	2
77	0	0	0	0
78	0	0	1	1
79	0	0	1	1
80	0	0	1	1
81	0	0	1	1
82	0	0	0	0
83	0	0	0	0
84	0	0	0	0
85	0	0	1	1
Total:	163	32	140	335
Adipose clips:	11	3	24	38
Mark rate:	6.7	9.4	17.1	11.3

[1]Summary of random sample of chinook broodstock collected by the Cowichan hatchery.

Table 14. Water temperature and depth at the enumeration fence site, 1994

Date		Depth (cm.)	Temp. (Deg.C)	Date		Depth (cm.)	Temp. (Deg.C)
Aug.	15	190	19	Oct.	01	196	16
	16	190	19		02	193	15
	17	190	18		03	196	13
	18	203	35		04	193	12
	19	200	19		05	196	14
	20	198	20		06	287	14
	21	193	18		07	272	14
	22	193	19		08	263	14
	23	216	18		09	246	14
	24	206	19		10	149	14
	25	206	17		11	145	13
	26	201	18		12	196	12
	27	200	19		13	194	11
	28	200	19		14	200	11
	29	198	19		15	197	11
	30	196	19		16	193	11
	31	196	19		17	192	11
Sept.	01	192	18		18	248	11
	02	195	19		19	291	11
	03	181	17		20	292	11
	04	180	17		21	257	11
	05	186	18		22	225	10
	06	200	18		23	210	11
	07	200	18		24	211	10
	08	201	18		25	226	10
	09	215	18		26	269	10
	10	223	17		27	404	11
	11	213	17		28	480	10
	12	199	17		29	481	10
	13	195	17		30	480	11
	14	200	17		31	581	11
	15	196	17	Nov.	01	648	10
	16	193	18		02	642	9
	17	190	18		03	642	10
	18	196	18		04	658	9
	19	196	18		05	658	10
	20	192	17		06	647	10
	21	192	18		07	681	10
	22	188	19		08	700	10
	23	187	17		09	780	10
	24	191	18		10	820	10
	25	187	18		11	922	10
	26	189	17		13	920	10
	27	193	17				
	28	193	16				
	29	191	17				
	30	191	17				

Table 15. Cowichan River daily discharge[1] in cu.m/sec for 1994.

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	25.1	6.4	10.9	5.0	4.4	4.6	39.0
2	24.3	6.1	9.7	4.9	4.4	4.7	37.8
3	22.4	5.7	8.4	4.9	4.6	4.5	38.2
4	21.5	5.6	8.0	4.8	4.5	4.6	38.0
5	19.7	5.6	8.0	4.6	4.4	6.0	38.7
6	17.5	5.7	7.9	4.8	4.8	11.7	38.8
7	16.4	5.7	7.2	5.1	4.8	11.1	39.5
8	16.1	5.7	7.0	5.2	4.9	10.4	42.0
9	16.2	5.7	6.4	5.1	5.2	5.6	44.0
10	16.1	5.5	6.0	4.9	5.3	4.9	45.3
11	14.4	5.5	5.7	4.8	5.0	4.7	46.2
12	14.5	5.6	5.6	5.1	4.8	4.7	48.5
13	13.9	6.5	5.5	5.1	4.7	4.7	52.0
14	13.7	8.4	5.4	4.9	4.8	5.0	56.0
15	13.7	11.2	5.3	4.8	4.8	4.7	57.0
16	13.8	13.2	4.9	4.8	4.7	6.1	58.3
17	13.5	14.4	4.8	4.7	4.6	9.7	57.0
18	13.4	15.7	4.8	4.6	4.6	11.9	55.4
19	12.9	16.1	4.8	4.7	4.6	9.0	55.8
20	13.1	15.3	4.9	4.2	4.6	7.3	56.4
21	13.2	15.1	5.0	4.2	4.6	7.1	56.1
22	13.1	14.9	5.0	4.4	4.5	7.2	55.6
23	13.1	14.4	4.8	4.8	4.4	7.2	54.1
24	13.3	13.2	4.8	4.6	4.4	7.5	52.5
25	12.7	12.4	4.7	4.6	4.3	8.3	51.0
26	11.5	12.0	4.7	4.5	4.3	10.8	49.0
27	11.0	11.1	4.6	4.4	4.6	16.7	47.6
28	9.8	10.3	4.7	4.3	4.7	21.0	47.0
29	9.3	9.9	4.9	4.4	4.6	20.2	47.0
30	6.9	9.3	5.3	4.5	4.5	24.8	60.3
31	6.5		5.1	4.5		30.0	
Total:	452.5	292.8	186.0	147.2	140.5	296.3	1510
Mean:	14.6	9.7	6.0	4.7	4.6	9.5	50.3

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

Table 16. Summary of adult chinook carcass tag and recovery data for the Cowichan River, 1994.

UPPER RIVER

Date	No. Examined		No. Tagged		No. Recaptured	
	Males	Females	Males	Females	Males	Females
2110	1	0	1	0	0	0
2810	1	3	1	3	1	0
3110	1	3	1	3	0	0
0111	1	6	1	6	0	2
0211	7	7	7	7	1	3
0311	6	7	6	7	0	3
0411	6	4	6	4	2	2
0711	8	18	8	18	2	4
0811	12	22	12	22	1	2
0911	15	8	15	8	3	3
1111	16	19	16	19	4	3
1411	21	23	21	23	5	5
1511	17	22	17	22	1	5
1611	14	15	14	15	1	3
1711	9	12	9	12	3	0
1811	13	18	13	18	2	2
2111	12	9	12	9	2	2
2211	12	20	12	20	2	6
2311	6	7	6	7	0	0
2411	12	9	12	9	1	6
2511	5	7	5	7	0	0
2811	6	15	6	15	0	2
2911	6	6	6	6	0	0
3011	1	2	1	2	0	0
Total:	208	262	208	262	31	53

MIDDLE RIVER

Date	No. Examined		No. Tagged		No. Recaptured	
	Males	Females	Males	Females	Males	Females
1910	1	2	0	2	0	0
2410	5	1	5	1	0	0
2610	0	1	0	1	0	0
2810	1	0	1	0	0	0
3110	1	0	1	0	0	0
0211	7	1	7	1	0	0
0711	9	2	9	2	2	1
0811	3	11	3	11	0	0
0911	1	1	1	1	0	0
1011	2	4	2	4	0	0
1211	2	2	2	2	0	0
1511	1	3	1	3	0	0
1611	0	1	0	1	0	0
Total:	33	29	32	29	2	1

Table 17. Summary of chinook sampled on the spawning grounds, 1994

Date	Male		Female		Jacks	
(dd/mm)	Tagged[1]	Untagged	Tagged	Untagged	Tagged	Untagged
19/10	0	1	2	0	0	0
21/10	1	0	0	0	0	0
24/10	5	0	1	0	2	0
26/10	0	0	1	0	1	0
28/10	2	0	3	0	0	0
31/10	2	0	4	0	0	0
01/11	1	0	6	0	4	0
02/11	16	0	8	0	22	0
03/11	8	0	10	0	15	0
04/11	7	0	5	0	10	0
07/11	18	0	20	0	94	0
08/11	15	0	44	0	64	0
09/11	16	0	9	0	42	0
10/11	2	0	4	0	0	0
11/11	16	0	23	0	66	0
12/11	2	0	2	0	0	0
14/11	23	0	25	0	82	0
15/11	18	0	29	0	64	0
16/11	16	0	19	0	31	0
17/11	11	0	12	0	54	0
18/11	16	0	19	0	60	0
21/11	13	0	10	0	42	0
22/11	13	0	25	0	80	0
23/11	8	0	9	0	23	0
24/11	15	0	9	0	42	0
25/11	6	0	7	0	19	0
28/11	7	0	17	0	39	0
29/11	7	0	6	0	17	0
30/11	1	0	2	0	4	0
Total:	265	1	331	0	877	0

Table 17 (cont.)

Date (dd/mm)	Male Clip[2]	Male Noclip	Female Clip	Female Noclip	Jacks Clip	Jacks Noclip
19/10	0	1	0	2	0	0
21/10	0	1	0	0	0	0
24/10	0	5	0	1	0	2
26/10	0	0	1	0	0	1
28/10	0	2	0	2	0	0
31/10	0	2	1	2	0	0
01/11	0	1	0	6	0	4
02/11	1	13	0	8	2	20
03/11	0	6	0	7	2	9
04/11	1	5	0	4	0	7
07/11	1	16	0	20	3	85
08/11	0	15	1	32	2	53
09/11	2	14	1	8	2	37
10/11	1	1	0	4	0	0
11/11	0	16	1	18	2	54
12/11	0	2	0	2	0	0
14/11	1	20	0	23	0	78
15/11	1	17	0	25	4	51
16/11	0	14	0	16	0	26
17/11	1	8	1	11	3	43
18/11	0	13	0	18	1	49
21/11	2	10	0	9	1	38
22/11	0	12	1	19	1	67
23/11	1	5	0	7	0	19
24/11	0	12	0	9	0	37
25/11	0	5	0	7	0	18
28/11	0	6	0	15	0	36
29/11	0	6	0	6	0	14
30/11	0	1	0	2	0	3
Total:	12	229	7	283	23	751

[1]Chinook carcass tagged with Ketchum aluminum sheep ear tag
[2]Adipose fin clipped chinook

Table 18. Petersen chinook escapement estimates by sex, Cowichan River, 1994.

Carcass mark-recapture:

UPPER RIVER

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	1,365	1,146	1,584
Female	1,281	1,127	1,435
Total	2,646	2,273	3,019

MIDDLE RIVER

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	374	196	552
Female	450	198	702
Total	824	394	1,254

[1] Adult males only, jacks not included

Σ = 3470 MR est.

Table 19. Incidence of tagged adult chinook carcasses recovered[1] on the spawning grounds by recovery period, Cowichan River, 1994

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Nov. 1-5	13	14.9	72	13.5	18.0
Nov. 6-12	25	28.7	163	30.7	15.3
Nov. 13-19	27	31.1	183	34.5	14.7
Nov. 21-26	22	25.3	113	21.3	19.5
Total:	87	100.0	531	100.0	16.4

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

Table 20. Proportion of the tag application sample recovered[1] on the spawning grounds, by period, on the Cowichan River, 1994

Application period	Tags applied	Tags recovered[2]	Recoveries (%)
Nov. 1-5	72	10	13.9
Nov. 6-12	163	15	9.2
Nov. 13-19	183	31	16.9
Nov. 21-26	113	31	27.4
Total:	531	87	16.4

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

Table 21. Sex composition of application and recovery samples of tagged chinook carcasses, Cowichan River, 1994

Sex		Application sample			Recovery sample		
		Recovered	Not Recovered	Total	Marked	Unmarked	Total
Male	Percent	38	47	45	38	47	45
	No.	33	207	240	33	208	241
Female	Percent	62	53	55	62	53	55
	No.	54	237	291	54	237	291
Total:	No.	87	444	531	87	445	532

Table 22. Jolly-Seber carcass capture-recapture statistics[1] for chinook after pooling[2].

Period (i)	n_i	m_i	u_i	R_i	r_i	z_i
1	156	0	156	156	5	0
2	159	2	157	159	12	3
3	95	12	83	95	6	3
4	72	7	65	72	3	2
5	74	5	69	74	0	0

[1] Statistics:

m_i = the number of marked fish captured in the *i*th sample (i=1,...k)
u_i = the number of unmarked fish captured in the *i*th sample (i=1,...k)
n_i = $m_i + u_i$, the total number of fish captured in the *i*th sample (i=1,...k)
R_i = the number of n_i that are released after the *i*th sample (i=1,...k-1). $R_i \leq n_i$ because of losses on capture
r_i = the number of R_i fish released at *i* that are captured again (i=1,...k-1)
z_i = the number of fish captured before *i*, not captured at *i*, and captured again later (i=2,...k-1)

[2] Data collected from Oct. 21 to Nov. 29 (Table 16) was grouped into 5 periods for the purpose of the Jolly-Seber analysis

Table 23. Total adult chinook returns to the Cowichan River, 1975-1994.

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[1]	535[2]	1055	2586
1990	4164	326	604	5094
1991	4086[3]	1755	270	5065
1992	6676	1850	260	8678
1993	5047	1970	295	7312
1994	4936	1357	345	6638

[1]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.
[2]Total broodstock removed.
[3]Includes 2000 adult chinook estimated to have passed by the fence during the period of high water

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.

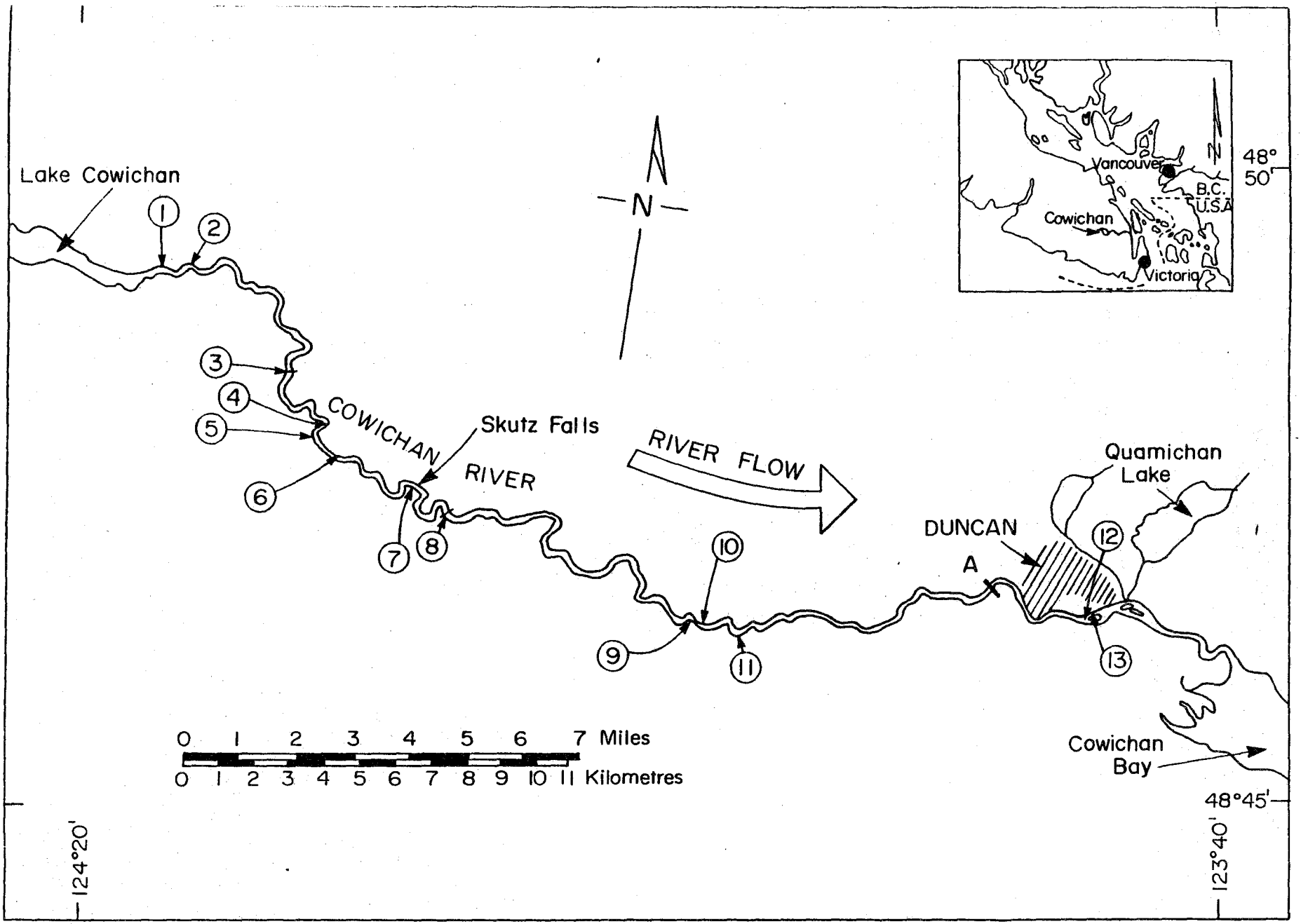

Lake Cowichan
1
2
3
4
5
6
7
8
9
10
11
12
13
COWICHAN RIVER
Skutz Falls
RIVER FLOW
DUNCAN
A
Quamichan Lake
Cowichan Bay
N
Vancouver
B.C.
U.S.A.
Cowichan
Victoria
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres
48° 50'
48°45'
124°20'
123°40'

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

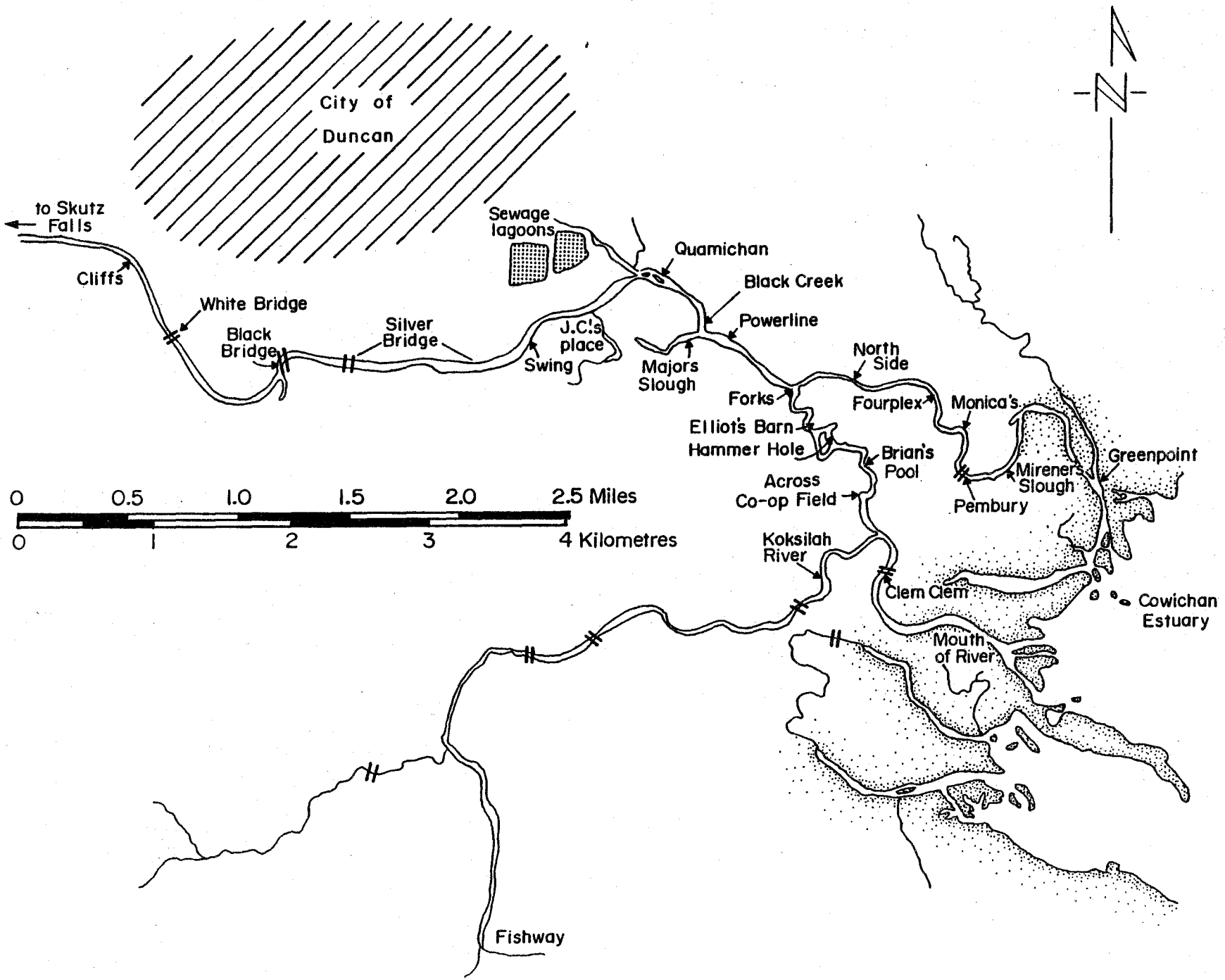
F-Brian's pool to Clem Clem and part of Koksilah

G-Clem Clem to mouth

H-North side to Four plex

I-Four plex to Meriner's slough

J-Meriner's slough to mouth


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

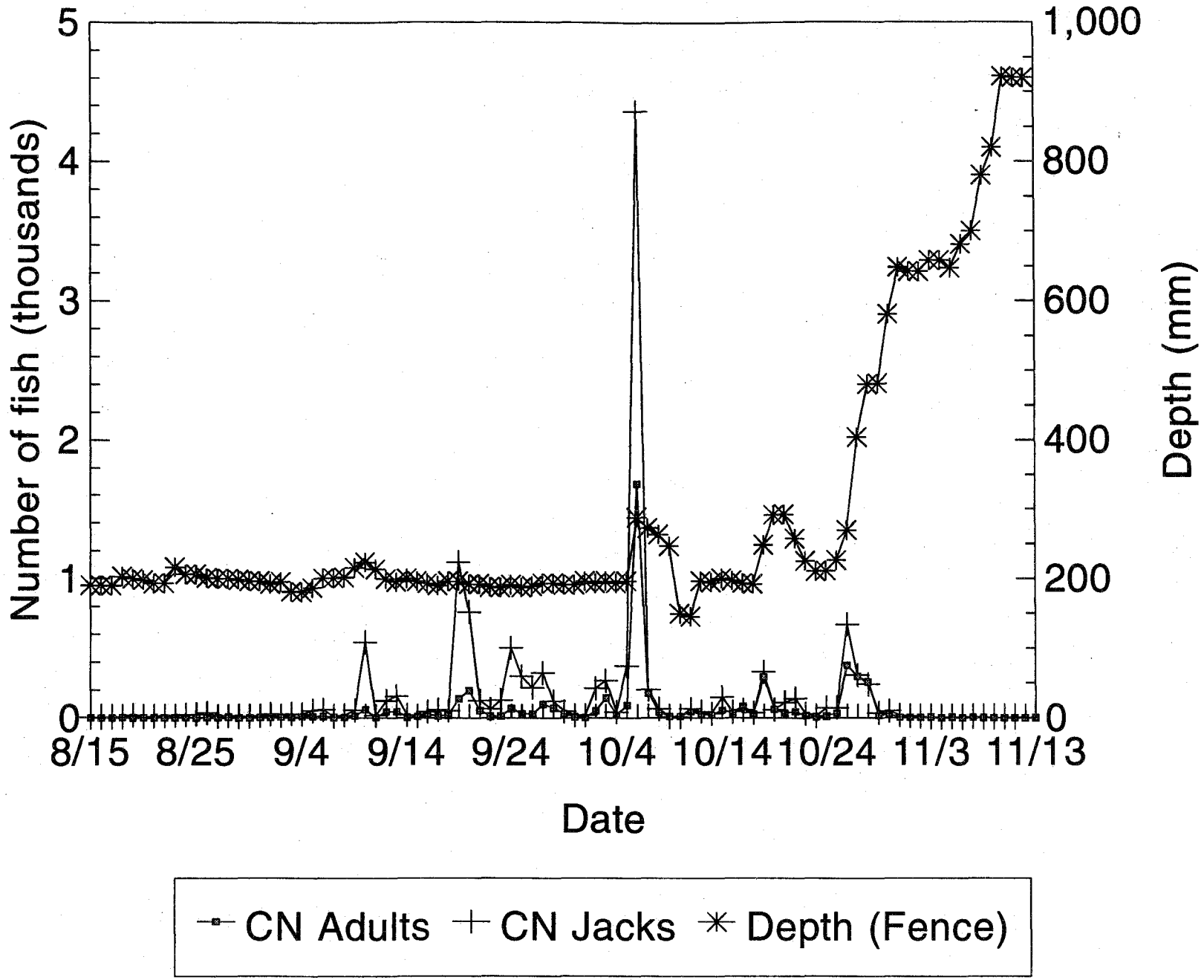


Fig. 3. Daily fence count of chinook and water depth, 1994

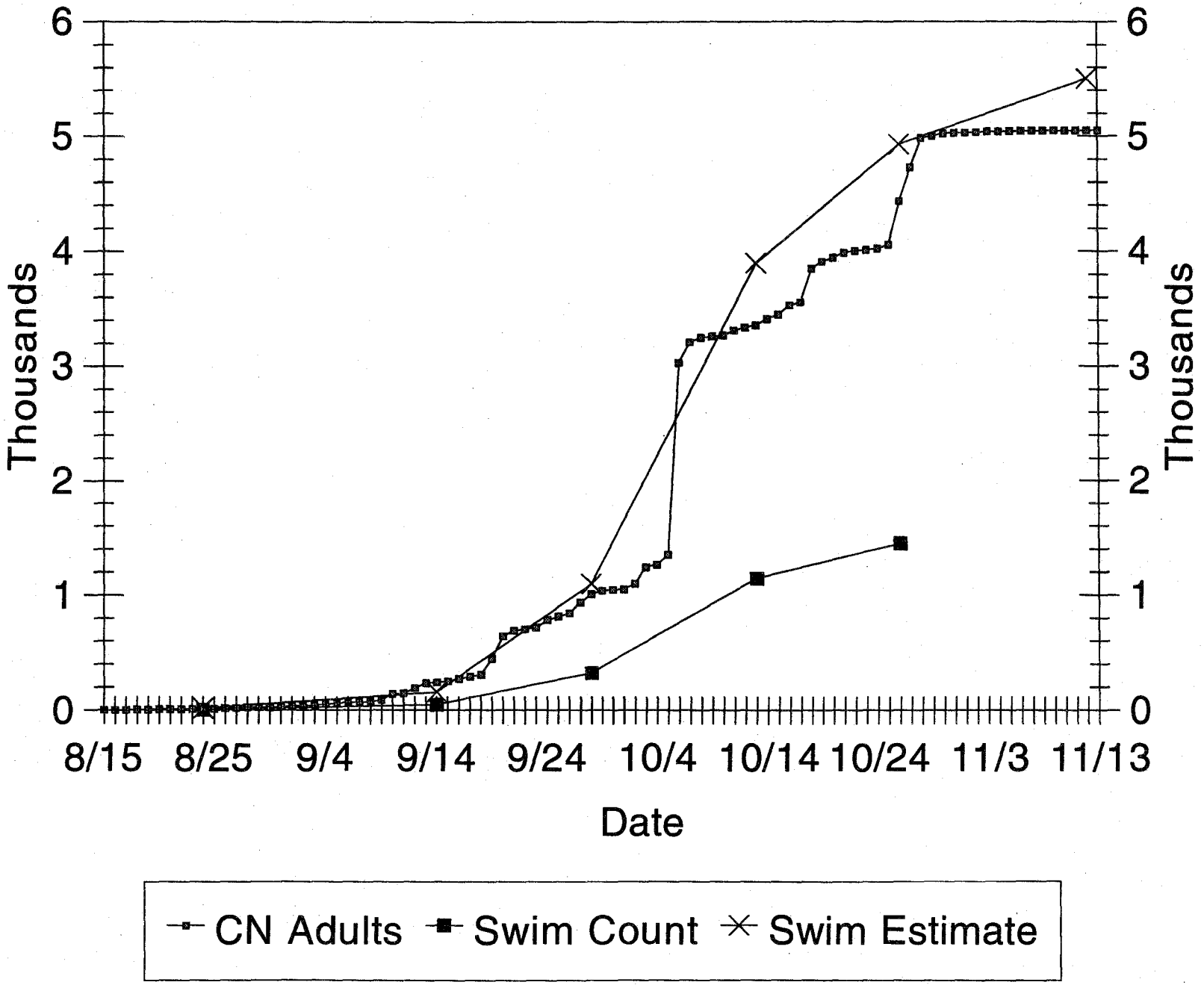


Fig. 4. Adult chinook fence count compared with swim survey data, 1994

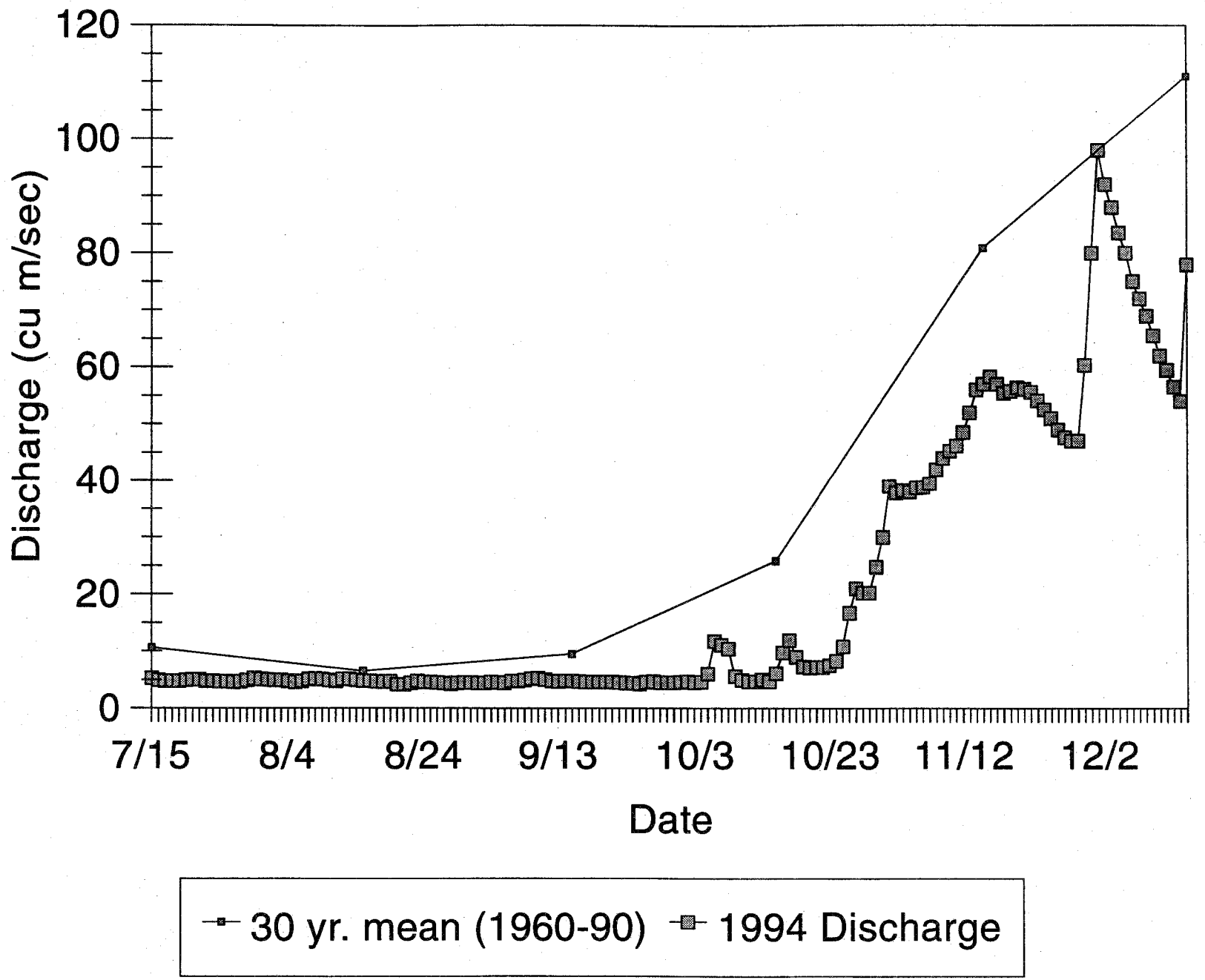


Fig. 5. Cowichan River discharge (cu m/sec).

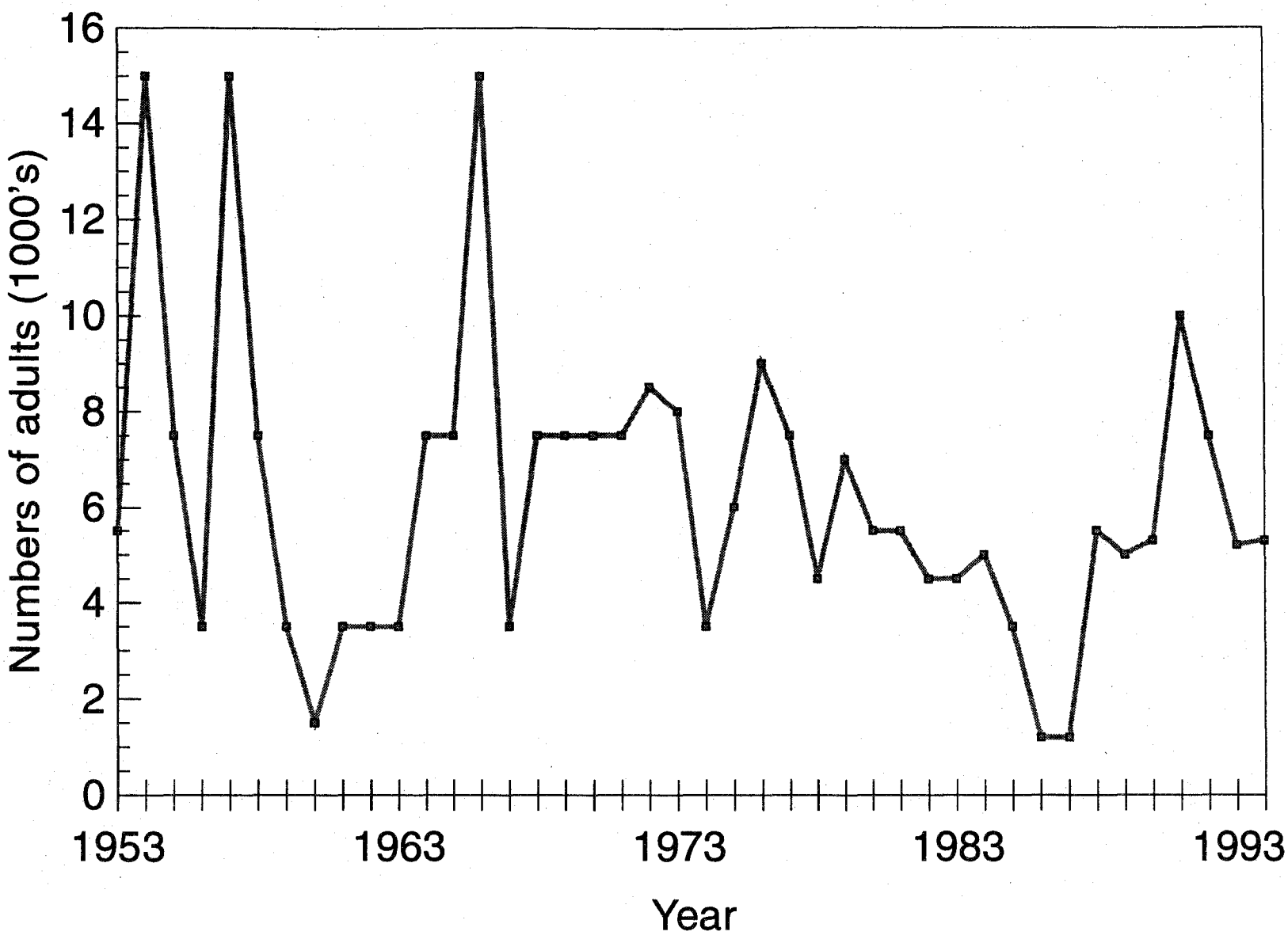


Fig. 6. Adult chinook escapement estimates for the Cowichan River, 1953-1994.
(estimates up to 1988 were based on swim surveys, stream walks, and helicopter flights)
(estimates from 1988 to present were based on fence count and mark-recapture data)

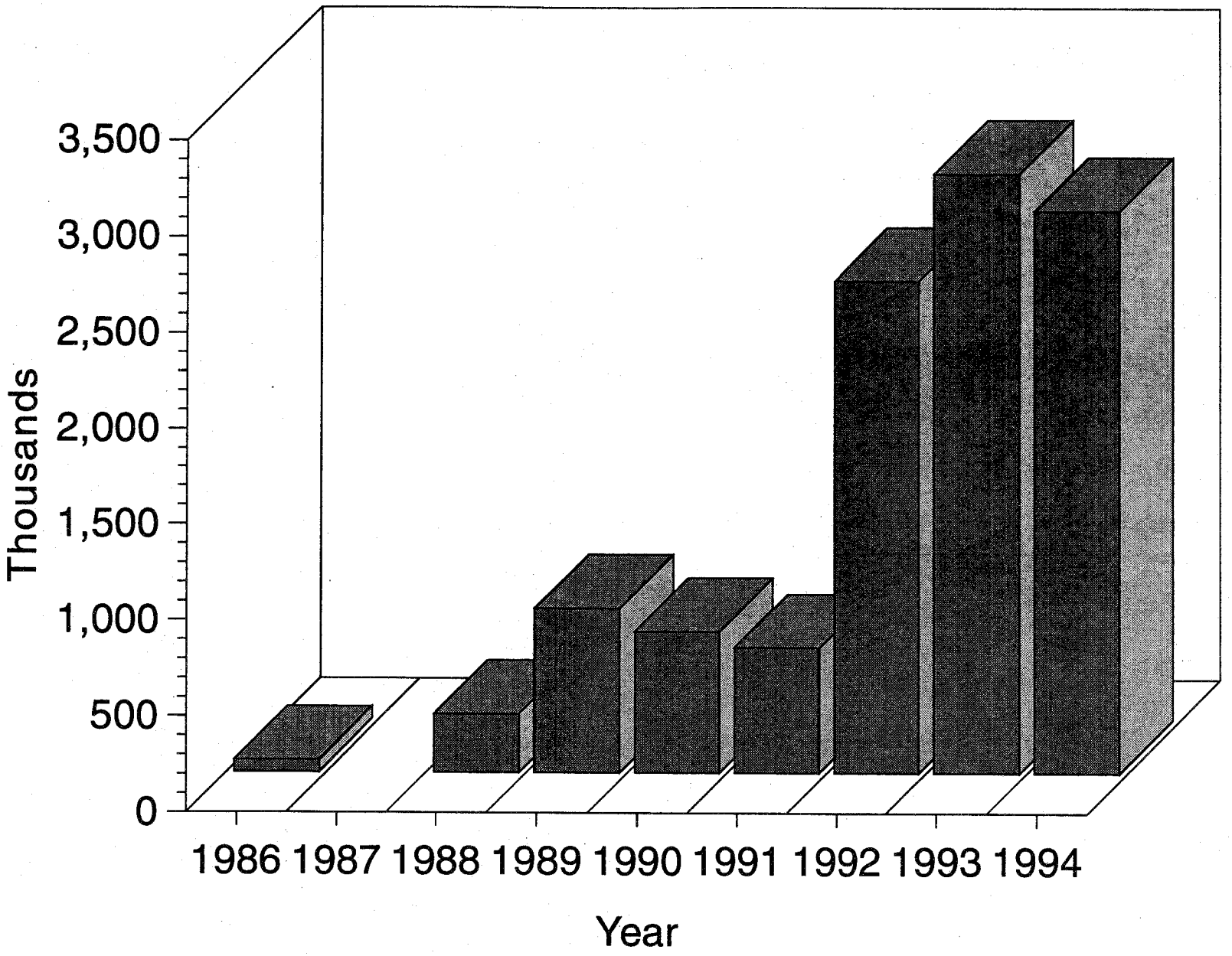


Fig. 7. Hatchery chinook released into the Cowichan system as fry (3 gm) and as pre-smolts (6 gm).

Appendix Table 1. Coded-wire tag code data from chinook sampled on the spawning grounds, 1994

Recovery Date	Length (mm)	Sex	BY[1]	Tagcode[2]	Release[3] location	Recovery[4] location
261094	657	F	90	025310	MIL	Stoltz
281094	835	F	90	020341	LR	"
311094	656	F	90	020339	LR	Trestle
021194	602	M	91	180517	LR	"
021194	438	J		no-pin		
021194	423	J	92	180210	LR	"
031194	419	J	92	180210	LR	"
031194	366	J	92	180210	LR	R. Pool
041194	457	M	92	181044	ER	Trestle
071194	460	M		no-pin		
071194	439	J	92	181043	LP	Three Firs
071194	401	J	92	181043	LP	Trestle
071194	534	M	91	180517	LR	Stoltz
081194	452	M	92	180210	LR	Trestle
081194	615	F	91	180517	LR	Three Firs
081194	332	J		no-pin		
091194	713	F	90	020343	LR	Trestle
091194	691	M	90	020343	LR	Three Firs
091194	431	J	92	180550	LR	"
091194	430	J	92	181044	ER	Trestle
091194	716	M	90	020340	LR	Stoltz
101194	490	M	91	180516	ER	"
111194	464	M	92	181044	ER	Trestle
111194	208	J		no-pin		
111194	702	F	90	020336	ER	R. Pool
141194	740	M	90	020341	LR	Trestle
151194	486	M	92	181044	ER	"
151194	434	J	92	180550	LR	"
151194	439	J	92	180209	SEA	Three Firs
151194	391	J	92	181042	LR	Stoltz
151194	666	M	91	180515	ER	"
171194	475	M	92	181042	LR	R. Pool
171194	405	J	92	181044	ER	Three Firs
171194	642	F	91	180517	LR	"
171194	580	M	91	180521	SEA	"
171194	393	J	92	180209	SEA	"
181194	291	J		no-pin		
181194	415	J		no-pin		
181194	735	F	89	020623	LR	Three Firs
211194	714	M	90	020340	LR	"
211194	765	M	91	180519	ER	Trestle
211194	469	M	92	181043	LP	R. Pool
221194	684	F	91	180517	LR	"
221194	446	J	92	181043	LP	Three Firs
231194	453	M	92	181042	LP	"

[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)
MIL; hatchery release from sea pens in Mill Bay (during June)
[4]Recovery locations; refer to Fig 1.

Appendix Table 2. Coded-wire tag data from chinook sampled in the native food fishery, 1994

Recovery Date	Length (mm)	Sex	BY[1]	Tagcode[2]	Release[3] location	Recovery[4] location
120894	430	J	92	181043	LP	Zone A
220994	473	M	92	180210	LR	Zone H
220994	466	M	92	181043	LP	Zone J
230994	404	J	92	181042	LR	"
230994	547	M	91	180514	LP	"
230994	475	M	92	181042	LR	"
230994	450	M	92	180210	LR	"
230994	600	F	91	180516	ER	"

[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)
MIL; hatchery release from sea pens in Mill Bay (during June)
[4]Recovery locations (Cowichan Aboriginal Fisheries management zones, see Fig 2).

Appendix Table 3. Cowichan hatchery chinook releases by brood year.

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
021846	79	31628	32134	98.4	2.8	:07May80	0118-COWICHAN RIVER
022060	79	32034	32547	98.4	2.8	:07May80	0399-SKUTZ FALLS
022158	80	52519	65000	80.8	2.3	:09Jun81	0118-COWICHAN RIVER
022307	81	30179	30373	99.4	3.1	:12May82	0118-COWICHAN RIVER
022339	82	49135	224944	21.8	2.9	:14May83	0399-SKUTZ FALLS
022831	83	50613	101000	50.1	4.3	:25May84	0355-KOKSILAH RIVER
NOCN8311	83	0	200000	0.0	4.3	:31May84	0118-COWICHAN RIVER
NOCN8411	84	0	187823	0.0	4.8	13May85:14May85	0118-COWICHAN RIVER
023803	85	25365	25804	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
023804	85	25455	25895	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
023911	85	11980	12187	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
NOCN8619	86	0	321172	0.0	4.0	13May87:22May87	0118-COWICHAN RIVER
NOCN8620	86	0	54608	0.0	3.5	:21May87	0355-KOKSILAH RIVER
024334	87	14298	14334	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024729	87	25360	25424	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024730	87	25869	25934	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024731	87	27428	27497	99.7	7.1	18Apr88:18May88	0185-COWICHAN LAKE
024732	87	27271	27339	99.8	7.1	:18May88	0185-COWICHAN LAKE
024733	87	26911	26978	99.8	7.1	:18May88	0185-COWICHAN LAKE
024734	87	23521	23580	99.7	7.1	:18May88	0185-COWICHAN LAKE
024735	87	26719	26786	99.7	3.4	18Apr88:18May88	0118-COWICHAN RIVER
024945	87	26461	26594	99.5	4.9	:25May88	0324-COWICHAN R UPPER
024946	87	26658	26792	99.5	4.9	:25May88	0324-COWICHAN R UPPER
024947	87	26761	26895	99.5	4.9	:25May88	0324-COWICHAN R UPPER
025008	87	26817	26952	99.5	4.9	:25May88	0324-COWICHAN R UPPER
NOCN8731	87	0	387071	0.0	8.2	:26May88	0324-COWICHAN R UPPER
024860	88	25117	25243	99.5	3.7	:28Apr89	0118-COWICHAN RIVER
025012	88	26595	54768	48.6	6.5	:21May89	0118-COWICHAN RIVER
025013	88	25982	54154	48.0	6.5	:21May89	0118-COWICHAN RIVER
025015	88	23058	24894	92.6	3.7	:28Apr89	0118-COWICHAN RIVER
025016	88	26821	26821	100.0	3.7	:28Apr89	0118-COWICHAN RIVER
025017	88	27611	28175	98.0	3.7	:28Apr89	0118-COWICHAN RIVER
025523	88	27531	56123	49.1	6.5	:21May89	0118-COWICHAN RIVER
025524	88	27205	55378	49.1	6.5	:21May89	0118-COWICHAN RIVER
025749	88	26922	133331	20.2	6.1	:15May89	0185-COWICHAN LAKE
025750	88	27036	133446	20.3	6.1	:15May89	0185-COWICHAN LAKE
025751	88	23106	130107	17.8	6.1	:15May89	0185-COWICHAN LAKE
025752	88	26169	132842	19.7	6.1	:15May89	0185-COWICHAN LAKE
020352	89	28287	28573	99.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
020522	89	27072	36800	73.6	6.5	22May90:23May90	0118-COWICHAN RIVER
020622	89	27787	37242	74.6	6.5	22May90:23May90	0118-COWICHAN RIVER
020623	89	28164	37619	74.9	6.5	22May90:23May90	0118-COWICHAN RIVER
020624	89	28331	37786	75.0	6.5	22May90:23May90	0118-COWICHAN RIVER
020938	89	28312	28312	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
020939	89	26218	26218	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
026103	89	27145	27145	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
026255	89	26400	119674	22.1	7.2	:14May90	0185-COWICHAN LAKE
026256	89	25693	119497	21.5	7.2	:14May90	0185-COWICHAN LAKE
026257	89	25790	119325	21.6	7.2	:14May90	0185-COWICHAN LAKE
026258	89	25219	118748	21.2	7.2	:14May90	0185-COWICHAN LAKE
020333	90	25687	94172	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
020334	90	25898	94384	27.4	8.4	15May91:15May91	0185-COWICHAN LAKE
020335	90	25739	94224	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
020336	90	27135	27135	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020337	90	26631	26631	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020338	90	27046	27046	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020339	90	26721	34318	77.9	6.4	21May91:22May91	0118-COWICHAN RIVER
020340	90	26993	34592	78.0	6.4	21May91:22May91	0118-COWICHAN RIVER

Appendix Table 3. (cont.)

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
020341	90	26533	33995	78.0	6.4	21May91:22May91	0118-COWICHAN RIVER
020342	90	25437	92182	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
020343	90	25391	92136	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
NOCN9044	90	0	5086	0.0	5.4	26Jun91:26Jun91	0367-COWICHAN ESTUARY
180513	91	26972	336330	8.0	5.0	17May92:17May92	0185-COWICHAN LAKE
180514	91	25964	335584	7.7	5.0	17May92:17May92	0185-COWICHAN LAKE
180515	91	27694	175107	15.8	4.0	21Apr92:22Apr92	0335-COWICHAN R LOWER
180516	91	27148	174834	15.5	4.0	21Apr92:22Apr92	0335-COWICHAN R LOWER
180517	91	27471	248584	11.1	5.3	20May92:21May92	0324-COWICHAN R UPPER
180518	91	27277	248389	11.0	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	0.0	2.4	25Mar92:25Mar92	0118-COWICHAN RIVER
NOCN9145	91	0	513053	0.0	5.7	19May92:20May92	0324-COWICHAN R UPPER
180209	92	24770	98974	25.0	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	13.0	6.5	25May93:25May93	0118-COWICHAN RIVER
181043	92	54235	901937	6.0	5.6	10May93:10May93	0185-COWICHAN LAKE
181044	92	55027	907719	6.1	3.6	07Apr93:07Apr93	0324-COWICHAN R UPPER
NOCN9231	92	0	437840	0.0	3.7	11May93:11May93	0324-COWICHAN R UPPER
021211	93	24875	103900	23.9	6.2	25May94:25May94	3226-COWICHAN BAY
181319	93	49966	1001002	5.0	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