Adult Chinook Escapement Assessment Conducted on the Cowichan River During 1998

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ABSTRACT

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In 1998, 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 7,062 in 1998. The number of natural spawners was estimated to be 4,328. Carcass mark-recapture escapement estimate was determined to be 2,087 (95% CL; 1,956 - 2,218).

RÉSUMÉ

Nagtegaal, D. A. and E. W. Carter. 1999. Adult chinook escapement assessment conducted on the Cowichan River during 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2501: 51 p.

En 1998, 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 1998, l'effectif de remonte total du saumon quinnat adulte - écloseries et frayères naturelles confondues - dans la rivière Cowichan se chiffrait à 4 328, le nombre de reproducteurs issus de frayères naturelles étant estimé à 7 062. 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 262,675 in 1998. Marked releases also began in 1980 and in 1998 approximately 85% 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 1998.

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 1998 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.

NATIVE FOOD FISHERY

In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management (CTAF) program to monitor the fishery more closely and to better estimate the Native food fish catch (Paige 1992, 1997). 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 1998 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 1997).

For some years since 1988, an observer was employed to independently collect catch and biological data from the in-river chinook spear fishery. Due to budget contraints no regular biosampling of the fishery was conducted.

BIOLOGICAL DATA

Biological data for chinook were collected from two sources: i) hatchery broodstock samples; and ii) carcass mark/recapture (spawning grounds). 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. 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

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

carcasses. This section of the river above Skutz Falls represents the area where the majority of chinook spawning typically occurs. On two occasions, one of the crews 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 1998, the counting fence was operated from Sept. 5 through to November 8. Due to high water conditions at the end of the study the fence operation was terminated. 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: 4,328 adult chinook; 3,065 jack chinook; 3,207 adult coho; 1,189 jack coho; 16,800 chum and 11 unidentified fish. During the last days of operation, the combination of heavy rain, increasing flow 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 1900 and 2200. Approximately 55% of adults and 42% 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 150 fish examined, two fish (1.3%) 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 1981-1998 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. Swims in 1998 were conducted in the upper section of the river (Birdhouse to Three Firs pool; Fig. 1) on Sept. 25, Oct. 13, 20 and 26. The 1998 escapement of adult chinook was determined to be 4,284 (Paige 1997) based on the upper river swim counts. Most swim surveys were conducted under good conditions (low water and clear visibility).

NATIVE FOOD FISHERY

Estimates of the Native food fish catch of chinook since 1981 are listed in Table 4. The 1998 catch estimate of 1073 adults and no jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group (Fig. 2). According to our observations, the adult chinook spear fishery was a success this year (Fig. 4) since low water conditions prevailed. Although it was very difficult to assess the quality of the data collected (Paige 1997), it was the highest catch recorded in 20 years.

HATCHERY COMPONENT

In 1998, 1,661 adult chinook were removed from the river by the Cowichan River hatchery staff below the enumeration fence (Table 5). The hatchery staff (D. Millerd, P.O. Box 880, Duncan, B.C., pers. comm.) indicated they had met their target this year (Table 6). Primarily 3 year old chinook were used for broodstock (Table 7).

BIOLOGICAL DATA

Almost the same number of adult male and female chinook were sampled on the spawning grounds (Table 8). Most adults were recovered on the spawning grounds in the upper section and few from the middle section of the river. Mean size of females sampled was 68.1 cm post orbital hypural (POH) length and for males was 61.9 cm (POH). Adult chinook were primarily comprised of 3 and 4 year old fish (Table 9).

Length-frequency summaries of chinook broodstock collected and sampled at the hatchery are listed in Table 10. 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 5.7% for males and 5.8% for females.

The mark rate for chinook from hatchery samples was comparable to the mark rate observed on the spawning grounds.

Coded-wire tag recovery information for chinook sampled on the spawning grounds is listed in Table 11. A summary of chinook releases from the Cowichan hatchery by brood year is listed in Table 12. A cursory look at CWT recoveries on the spawning grounds relative to the total number of fish released (Kuhn 1988) indicated that the majority of recoveries were observed from tag groups released in the upper Cowichan (Road Pool) site.

ENVIRONMENTAL INFORMATION

Water flow and temperature measured at the fence site (Table 1) and discharge information recorded at the Water Survey Canada station below the Island highway bridge in Duncan (Table 13), indicated that river conditions during the fall of 1998 were quite typical (Inland Waters Directorate 1998). Compared to the 30 year mean (1960-90), water flow was near minimum levels for Aug.-Oct. and then exceeded the average recorded river discharge in Nov.-Dec. (Fig. 5). High water levels persisted into the winter months. Particularly heavy rainfall was recorded during this time.

MARK-RECAPTURE

Table 14 contains a summary of the carcass mark-recapture data by tagging period. A total of 389 adult and 512 jack chinook carcasses were tagged and released in the upper river section and only 4 adults and 19 jacks in the middle river section. More than 47% of the adult and 53% 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 2,087 with lower and upper 95% confidence limits of 1,956 and 2,218, respectively (Table 15). This was based on the data from the upper section of the river only since few fish were observed in the middle section. It was assumed that greater than 85% 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 16). 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 17). Significant differences were observed ($P < 0.05$; chi-square). The highest percentage of tags were recovered during the middle week of the study. This occurred even though tags were applied at a consistent rate during the study. Recoveries declined in the last week of the study due to increased water flow which resulted in carcasses being washed downstream more quickly and less available for recovery.

2. Location bias: Spatial bias was not examined between the upper and middle river sections due to insufficient sample size in the middle river section. This may have been due to the cloudy water conditions in this section which made carcass tag and recovery difficult, although few carcasses were found along the sides of the river. Erosion of some clay banks, which exist in this segment of the river, cause the water to be very cloudy and substantially reduce water visibility. Conditions further deteriorate due to high water.

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 18). 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 19). 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. No significant differences were noted between the tag and recovery samples ($P < 0.05$; chi-square). Often in high water conditions, fewer tagged males are recovered than females because the larger-bodied (heavier) females tend to remain in the tag area more readily than the lighter-bodied males that are more readily swept downstream.

This was not the case, however, and it was simply a matter that fewer female carcasses were available to be tagged.

DISCUSSION

ENUMERATION FENCE

The floating fence design adapts well to the considerable changes in flow that occur 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).

In most years, the fence is removed due to high water towards the end of the chinook run and mark-recapture population estimates are used to corroborate the fence data and determine the total return. Enumeration data were collected for the time the fence was in full operation. Although this was the period during which most chinook were presumed to have entered the river, we have no direct count of fish that may have entered before or after the fence was in place and need to rely on swim survey and mark-recapture information. Obviously, the fence count of 4,328 chinook adults and 3,065 jack chinook should be considered an incomplete count of the total run, but the most accurate one available for the time it was in operation. Since the daily count of chinook was minimal when the fence count began, we could assume that the run had just started and few fish had moved upstream past the fence site. Based on information from previous studies (1991-96) for upstream movement after Nov. 8, we estimate that approximately 10% of the run was still to come. If we extrapolate the adult fence on this basis we derive a total count of 4,760 adults. Based on the fence data and calculations of fish movement before and after installation, the estimate of the total chinook run would be somewhat greater than 7,000.

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 (T. Fields, 230

Underwood St., Duncan, B.C. V9R-5K6, pers comm.). 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 lower than average during September/October and was followed by a substantial increase to higher than average discharge conditions in November (Fig. 5). Based on the carcass tagging data most chinook spawned in the upper river section in 1998. 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 (4,284) was comparable to the fence count extrapolation (4,328) and greater than the upper river mark-recapture estimate (2,087). The mark-recapture estimate was low likely due to the increased discharge in November that made tagging and recapture of carcasses difficult.

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 1998 estimate of 1,073 adult chinook was a considerable increase over previous years and the highest catch recorded in 20 years. The prevailing fishing conditions were considered to be very good during September/October based on information provided by CTAF staff. Independent observer estimates of adult chinook catch have been 2 to 3.5 times the amount estimated by the CTAF unit. No independent estimates were made in 1998.

BIOLOGICAL DATA

Significant differences were only noted in the adipose mark rate for females between the random broodstock sample recorded by the hatchery staff and the data collected from the spawning grounds by our field staff. The incidence of adipose-clipped female chinook sampled on the spawning ground was 1.2% and in the hatchery chinook broodstock sample was 5.8%. Significant differences were also noted in the size frequency distribution by sex between hatchery and spawning ground

samples ($D_{obs} < D_{alpha}$; Kolmogorov-Smirnov, Zar 1984). This may in a large part be due to the selection process of choosing numbers of fish by sex and size for hatchery broodstock purposes.

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

Fall rains that often occur during 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 generally good in the upper river but were particularly poor in the middle section, with high flows and cloudy water, making it difficult to tag or recover carcasses. Conditions for tag and recapture deteriorated rapidly during the last weeks of November. We were only able to tag and sample less than 10.0% of the total adult chinook escapement.

Stratification by sex was necessary in order to minimize the effects of differential tagging and recovery between sexes. Some potential biases associated with tagging and recovery of carcasses were examined and it was assumed that these could significantly affect the population estimate. For whatever reason, adult carcasses were much less available for tagging and therefore the estimate for males was considered to be low. If we assume that the fence count extrapolation was the preferred method of estimating escapement, then the stratified Petersen estimates based on carcass mark-recapture underestimated escapement by at least 47%.

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 1998 was estimated to be approximately 500 and likely higher than the past few years due to the low flow conditions in

September and October. DFO charter patrol observations indicated that significant numbers of seals and some sea lions were present in Cowichan Bay.

ESCAPEMENT

Escapement estimates for 1998 were primarily based on 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 and the number of adults removed below the fence by the hatchery for broodstock or in the Native spear fishery. If we also add an estimate for migration before and after the fence was in place then the total return is estimated to be approx. 7,000 (Table 20). If we include a seal predation estimate of 500, then it is probable that the total return of chinook in 1998 was closer to 8,000 adults.

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). In recent years chinook escapement has increased substantially and came close to or exceeded the escapement goal of 12,500 in 1995 and 1996. 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 has increased Fig. 8).

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Table 1. Daily counts at the enumeration fence site, Cowichan River, 1998.

Date (ddmm)	Depth (cm)	Temp. (deg.C)	Chinook		Coho		Chum	Unknown
			Adult	Jack	Adult	Jack		
509	377	18	0	0	0	0	0	0
609	389	19	1	0	0	0	0	0
709	384	18	0	12	0	0	0	1
809	381	18	3	21	0	0	0	0
909	382	18	3	10	0	0	0	0
1009	381	19	5	14	0	0	0	0
1109	377	18	1	2	0	0	0	0
1209	374	18	2	8	0	0	0	0
1309	374	19	5	21	0	0	0	0
1409	376	19	5	9	0	0	0	0
1509	380	18	8	11	0	0	0	0
1609	380	18	1	4	0	0	0	0
1709	380	18	2	4	0	0	0	0
1809	382	18	1	5	0	0	0	0
1909	384	17	17	30	0	0	0	0
2009	377	15	9	27	0	0	0	0
2109	375	17	12	20	0	0	0	0
2209	410	17	35	93	0	0	0	0
2309	410	16	12	34	0	0	0	0
2409	408	17	12	39	0	0	0	0
2509	407	16	9	41	0	0	0	0
2609	405	16	7	13	0	0	0	0
2709	403	17	10	15	0	0	0	0
2809	281	16	12	30	0	0	0	0
2909	280	15	6	27	0	0	0	0
3009	396	15	7	12	0	0	0	0
0110	282	15	16	21	0	0	0	0
0210	409	15	4	4	0	0	0	0
0310	448	14	7	18	0	0	0	0
0410	443	14	9	8	0	0	0	0
0510	430	15	24	23	0	0	0	0
0610	430	14	178	217	6	1	0	1
0710	434	14	36	21	10	4	0	0
0810	444	14	10	13	11	7	0	0
0910	435	14	14	22	5	1	0	0
1010	445	13	30	39	17	15	0	1
1110	452	13	39	34	55	16	0	0
1210	473	13	64	72	0	0	0	1
1310	555	14	783	752	78	53	1	1
1410	577	13	138	99	56	30	3	1
1510	593	13	60	24	59	21	0	2
1610	580	12	63	15	76	32	6	0
1710	585	13	60	78	37	11	12	0
1810	613	12	105	33	80	17	6	0
1910	600	12	51	22	23	11	3	0

Table 1 cont'd

Date (ddmm)	Depth (cm)	Temp. (deg.C)	Chinook		Coho		Chum	Unknown
			Adult	Jack	Adult	Jack		
2010	600	11	18	14	28	4	2	0
2110	600	10	19	9	32	23	11	0
2210	600	12	68	32	53	24	35	1
2310	600	11	84	65	104	59	11	0
2410	600	11	39	29	48	33	23	0
2510	602	12	19	13	34	20	31	0
2610	600	13	21	22	63	28	180	1
2710	613	13	169	61	154	63	416	0
2810	656	12	57	17	39	17	177	0
2910	510	12	28	16	46	36	595	0
3010	563	11	26	26	14	18	238	0
3110	600	12	40	10	51	34	683	0
0111	637	12	56	95	97	72	1215	0
0211	580	12	234	109	159	189	2420	0
0311	596	12	208	75	235	62	1214	0
0411	611	12	306	166	266	94	1513	0
0511	655	12	501	168	258	130	2496	0
0611	645	11	539	74	673	28	1526	0
0711	627	10	16	41	252	32	1952	1
0811	651	10	4	6	88	4	2031	0
Total:			4328	3065	3207	1189	16800	11

Table 2. Daily counts by time interval at the enumeration fence site, 1998.

Time Period	Chinook			
	Adult	Percent	Jack	Percent
0000 - 0100	155	3.6	152	5
0100 - 0200	225	5.2	150	4.9
0200 - 0300	158	3.7	115	3.8
0300 - 0400	180	4.2	149	4.9
0400 - 0500	197	4.6	148	4.8
0500 - 0600	197	4.6	152	5
0600 - 0700	161	3.7	173	5.6
0700 - 0800	378	8.7	215	7
0800 - 0900	309	7.1	172	5.6
0900 - 1000	222	5.1	61	2
1000 - 1100	304	7	50	1.6
1100 - 1200	199	4.6	46	1.5
1200 - 1300	123	2.8	45	1.5
1300 - 1400	163	3.8	25	0.8
1400 - 1500	111	2.6	82	2.7
1500 - 1600	123	2.8	146	4.8
1600 - 1700	116	2.7	136	4.4
1700 - 1800	119	2.7	105	3.4
1800 - 1900	133	3.1	107	3.5
1900 - 2000	104	2.4	100	3.3
2000 - 2100	159	3.7	165	5.4
2100 - 2200	200	4.6	261	8.5
2200 - 2300	157	3.6	177	5.8
2300 - 2400	135	3.1	133	4.3
Total:		100.0		100.0

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'd

			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'd

			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'd

				Chinook				
				Jacks		Adults		
	Method[1]	Date		Count	Estimate	Count	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	
1997	S	Sept.	23	165		358	1217	2-6
	S	Sept.	25	87		404	1373	2-6
	S	Sept.	30	54		509	1730	2-6
	S	Oct.	16	84		289	980	2-6
	S	Oct.	23	1036		1831	6225	2-6
Estimate for Season[5]							6500	
1998	S	Sept.	25	72		37		2-6
	S	Oct.	13	54		53		2-6
	S	Oct.	20	130		857	2913	2-6
	S	Oct.	26	317		1260	4284	2-6
Estimate for Season							4284	

[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. Native food fish catch estimates for the Cowichan River.

Year[2]	Adult Chinook	Jack Chinook[3]
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
1997	191	0
1998	1073	0

[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.
[3] Estimates for jack chinook were not provided in 1997 and 1998.

Table 5. Summary of chinook broodstock collected by the Cowichan hatchery[1], 1998

	Below Fence			At Fence			Above Fence		
Date	Male	Jack	Female	Male	Jack	Female	Male	Jack	Female
22-Sep	35	0	57						
23-Sep	32	0	57						
25-Sep	28	0	34						
28-Sep	40	0	37						
29-Sep	14	0	19						
30-Sep	5	0	5						
01-Oct	17	0	15						
02-Oct	62	0	62						
04-Oct	6	0	11						
05-Oct	110	0	111						
06-Oct	88	0	86						
07-Oct	71	6	82						
08-Oct	36	6	43						
09-Oct	51	0	83						
12-Oct	2	1	4						
13-Oct	49	0	67						
14-Oct	13	0	22						
15-Oct	11	0	9						
16-Oct	56	0	59						
20-Oct	9	0	15						
21-Oct	5	0	11						
22-Oct	2	0	5						
02-Nov	10	0	5						
Total:	762	13	899						

[1] Based on hatchery field records. Hatchery records indicate that 647 males, 201 jacks, and 838 females were used for broodstock.

Table 6. Adult and jack chinook used for hatchery broodstock, Cowichan River.

YEAR	Adult chinook	Jack chinook[1]
1981	282	
1982	534	
1983	242	
1984	278	
1985	175	
1986	315	
1987	582	
1988	678	30
1989	535	96
1990	327	1
1991[2]	1755	347
1992	1850	77
1993	2200	228
1994	1357	145
1995	2149	512
1996	1615	258
1997	125	79
1998	1661	201

[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 7. Summary of chinook broodstock age data[1], 1998.

Age	Males	Females	Total
2	15	0	15
3	70	38	108
4	25	104	129
5		4	4
Total:	110	146	256

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

Table 8. Length-frequency of chinook carcasses sampled on the spawning grounds, Cowichan River, 1998.

Length (cm)	Males	Jacks	Females
24	0	1	0
25	0	2	0
26	0	1	0
27	0	0	0
28	0	1	0
29	0	2	0
30	0	5	0
31	0	7	0
32	0	11	0
33	0	25	1
34	0	27	0
35	0	33	0
36	0	52	0
37	0	46	0
38	0	44	0
39	0	53	0
40	0	52	0
41	0	64	0
42	0	53	0
43	0	34	0
44	0	48	0
45	37	0	0
46	27	0	1
47	18	0	0
48	18	0	0
49	7	0	0
50	9	0	0
51	7	0	1
52	3	0	1
53	2	0	1
54	7	0	3
55	3	0	3
56	2	0	1
57	5	0	10
58	4	0	3
59	5	0	7
60	2	0	3

Table 8 cont'd

Length (cm)	Males	Jacks	Females
61	5	0	8
62	6	0	4
63	1	0	9
64	3	0	6
65	4	0	2
66	1	0	5
67	2	0	7
68	1	0	11
69	0	0	9
70	0	0	4
71	1	0	11
72	2	0	9
73	0	0	11
74	3	0	9
75	4	0	12
76	1	0	7
77	2	0	5
78	0	0	1
79	0	0	1
80	0	0	2
81	1	0	2
82	0	0	0
83	0	0	0
84	0	0	2
85	0	0	0
86	0	0	0
87	0	0	1
TOTAL:	193	561	173
Mean Length:	52.5	38.5	67.5
Adipose clips:	7	22	2
Mark Rate:	3.6 %	3.9 %	1.2 %

Table 9. Summary of chinook age data[1] collected on the spawning grounds, 1998.

Age	Males	Females	Total
2	335		335
3	53	46	99
4	14	86	100
5	1	1	2
Total:	403	133	536

Total number of regenerate scales read: 84

[1] European age designation

Table 10. Length-frequency of chinook broodstock[1] collected by the Cowichan River hatchery, 1998.

Length (cm)	Males	Jacks	Females
44	0	1	0
45	0	1	0
46	0	7	0
47	0	3	0
48	0	1	0
49	0	2	1
50	1	2	0
51	2	2	0
52	3	1	0
53	1	1	0
54	1	1	0
55	2	1	0
56	5	0	4
57	3	0	2
58	2	0	2
59	6	0	1
60	3	0	2
61	4	0	3
62	6	0	5
63	7	0	3
64	1	0	5
65	5	0	6
66	2	0	2
67	1	0	9
68	5	0	3
69	3	0	8
70	1	0	7
71	2	0	10
72	0	0	8
73	0	0	4
74	1	0	6
75	2	0	2
76	1	0	5
77	0	0	2
78	0	0	3
79	0	0	0
80	0	0	0
81	0	0	0
82	0	0	1
Total:	70	23	104
Mean Length:	61.9	48.4	68.1
Adipose Clips:	4	1	6
Mark Rate:	5.7%	4.3%	5.8%

[1] A random sample subset of total broodstock collected.

Table 11. Coded-wire tag code data from chinook sampled on the spawning grounds, 1998.

Recovery Data				Release Data		
Date (ddmmyy)	Location	Length (POH)	Sex	Brood Year	Tag Code	Location
10/29/98	9	640	2	95	18-20-26	Upper Cowichan
10/29/98	15	430	1	97	no-pin	
10/29/98	20	470	1	97	no-pin	
10/29/98	20	430	1	96	18-27-37	Sea Pen
10/29/98	34	440	1	97	no-pin	
10/30/98	21	443	1	96	18-27-39	Lake Pen
10/30/98	14	453	1		lost pin	
11/02/98	9	400	1	96	18-27-40	Upper Cowichan
11/02/98	14	413	1	96	18-27-42	Upper Cowichan
11/03/98	10	416	1	96	18-27-41	Upper Cowichan
11/03/98	11	482	1	96	18-27-41	Upper Cowichan
11/03/98	12	461	1	96	18-27-40	Upper Cowichan
11/03/98	14	442	1	96	18-27-42	Upper Cowichan
11/03/98	14	373	1	97	no-pin	
11/04/98	14	407	1	96	18-27-45	Lower Cowichan
11/05/98			1	96	18-27-38	Lower Cowichan
11/05/98	17	362	1	96	18-27-42	Upper Cowichan
11/05/98	24	463	1	96	18-27-41	Upper Cowichan
11/05/98	26	712	2	94	18-14-38	Upper Cowichan
11/05/98	10	394	1		lost pin	
11/06/98	13	380	1	96	18-27-39	Lake Pen
11/06/98	13	420	1	97	no-pin	
11/06/98	13	375	1	96	18-27-38	Lake Pen
11/09/98	10	582	1	95	18-20-26	Upper Cowichan
11/09/98	55	380	1	95	18-24-44	Big Qualicum
11/09/98	17	423	1	96	18-20-41	Upper Cowichan
11/09/98	10	483	1		lost pin	
11/10/98	10	384	1	96	18-27-38	Lake Pen
11/10/98	12	400	1	96	18-27-38	Lake Pen
11/10/98	14	410	1	96	18-27-43	Upper Cowichan
11/10/98	30	349	1	96	18-27-38	Lake Pen
11/10/98	14	400	1	96	18-27-43	Upper Cowichan

Table 12. Cowichan hatchery chinook releases, 1979-1998.

Tag Code	BY	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	7.5	25May88:26May88	0324-COWICHAN R UPPER
24946	87	26658	123560	21.6	7.5	25May88:26May88	0324-COWICHAN R UPPER
24947	87	26761	123663	21.6	7.5	25May88:26May88	0324-COWICHAN R UPPER
25008	87	26817	123720	21.7	7.5	25May88:26May88	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

Table 12 cont'd

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
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
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	505110	5.4	5.5	19May92:21May92	0324-COWICHAN R UPPER
180518	91	27277	504916	5.4	5.5	19May92:21May92	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
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
182737	96	25235	100196	25.2	6.8	07May97:07May97	3226-COWICHAN BAY
182738	96	25108	318583	7.9	5.4	30Apr97:30Apr97	0185-COWICHAN LAKE
182739	96	25205	319814	7.9	5.4	30Apr97:30Apr97	0185-COWICHAN LAKE
182740	96	25218	448340	5.6	6.3	28Apr97:29Apr97	0324-COWICHAN R UPPER
182741	96	25649	456002	5.6	6.3	28Apr97:29Apr97	0324-COWICHAN R UPPER
182742	96	25457	401644	6.3	3.3	01Apr97:01Apr97	0324-COWICHAN R UPPER
182743	96	25019	394733	6.3	3.3	01Apr97:01Apr97	0324-COWICHAN R UPPER

Table 12 cont'd

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weigh (gm)	Release Date ddmmmyy:ddmmmyy	Release site
182744	96	25154	219780	11.4	5.9	05May97:05May97	0118-COWICHAN RIVER
182745	96	25082	219151	11.4	5.9	05May97:05May97	0118-COWICHAN RIVER
182761	97	25213	25213	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UPPER
182762	97	25206	25206	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UPPER
182763	97	25698	25698	100	3.7	09Apr98:09Apr98	0324-COWICHAN R UPPER
182801	97	24817	28209	88	6.5	13May98:13May98	0324-COWICHAN R UPPER
182802	97	24890	28282	88	6.5	13May98:13May98	0324-COWICHAN R UPPER
182803	97	24923	28316	88	6.5	13May98:13May98	0324-COWICHAN R UPPER
182804	97	24971	24971	100	6.5	21May98:21May98	0118-COWICHAN RIVER
182805	97	25026	25026	100	6.5	21May98:21May98	0118-COWICHAN RIVER
183213	97	24915	51754	48.1	6.3	25May98:25May98	3226-COWICHAN BAY

Table 13. Cowichan River daily discharge[1] in cu. m/sec for 1998.

Day	August	September	October	November	December
1	4.22	4.1	4.37	11.9	185
2	4.32	4.01	4.51	12.9	188
3	4.48	3.99	5.28	13.8	173
4	4.34	4.03	5.56	14.3	155
5	4.32	3.98	5.38	16.1	148
6	4.32	3.98	5.11	15.8	138
7	4.39	4.04	4.96	15.3	143
8	4.3	4.24	5	14.9	142
9	4.2	4.21	5.59	14.7	128
10	4.34	4.15	5.86	14.3	146
11	4.23	4.33	5.73	14.3	145
12	4.23	4.09	7.61	18.4	202
13	4.31	4.02	10.3	50.8	325
14	4.46	4.19	12	57.7	265
15	4.5	4.31	12.4	126	247
16	4.47	4.24	12.3	142	231
17	4.51	4.12	13	132	217
18	4.67	4.22	14.4	121	201
19	4.52	4.25	14.4	115	183
20	4.56	4.13	14.6	163	164
21	4.49	3.96	14.5	206	144
22	4.39	4.04	14.4	208	138
23	4.61	4.11	14	186	133
24	4.59	4.18	13.5	214	126
25	4.43	4.27	13.2	281	123
26	4.42	4.28	12.9	268	125
27	4.28	4.25	12.9	248	127
28	4.11	4.24	12.5	220	145
29	4.23	4.21	11.9	204	188
30	4.23	4.3	11.5	191	184
31	4.06		11.6		167
Total:	135.53	124.47	311.26	3310.20	5326.00
Mean:	4.37	4.15	10.04	110.34	171.81

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

Table 14. Summary of chinook carcass mark-recapture data from the Cowichan River, 1998.

Area: Upper River

Date	No. Examined			No. Tagged			No. Recaptured		
	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks
2710	7	12	17	7	12	17	5	9	8
2910	15	20	20	15	20	20	10	11	14
3010	24	4	19	24	4	19	11	2	8
0211	17	20	36	17	20	36	12	12	24
0311	29	13	69	29	13	69	17	6	31
0411	7	4	17	7	4	17	4	2	9
0511	23	16	48	23	16	48	10	7	25
0611	19	8	44	19	8	44	15	4	29
0911	22	28	54	22	28	54	18	23	31
1011	24	17	74	24	17	74	14	11	36
1111	17	11	65	17	11	65	0	3	18
1211	12	11	40	12	11	40	0	0	3
1811	2	4	5	2	4	5	0	0	1
1911	2	1	4	2	1	4	0	0	0
Total:	220	169	512	220	169	512	116	90	237

Area: Lower River

Date	No. Examined			No. Tagged			No. Recaptured		
	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks
911	1	2	18	1	2	18	0	0	0
1311	0	1	1	0	1	1	0	0	0
Total:	1	3	19	1	3	19	0	0	0

Table 15. Petersen chinook escapement estimates by sex, Cowichan River, 1998.

Carcass mark-recapture:

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male[1]	1,604	1,466	1,742
Female	486	445	527
Total	2,087	1,956	2,218

[1] Adult males only, jacks not included

Table 16. Incidence of tagged adult chinook carcasses recovered[1] on the spawning grounds by recovery period, Cowichan R., 1998.

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 27-Nov. 3	112	25.2	322	35.7	34.7
Nov. 4-10	213	47.9	405	44.9	52.6
Nov. 11-19	119	26.8	174	19.3	68.4
Total:	444	100.0	901	100.0	49.2

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

Table 17. Proportion of the tag application sample recovered[1] on the spawning grounds, by period, Cowichan R., 1998

Application period	Tags applied	Tags recovered[2]	Recoveries (%)
Oct. 27-Nov. 3	322	180	55.9
Nov. 4-10	405	238	58.7
Nov. 11-19	174	25	14.4
Total:	901	443	49.2

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

Table 18. Summary statistics for Kolmogorov-Smirnov length-frequency comparison for tagged and recaptured chinook carcasses, Cowichan River, 1998.

	Cumulative Frequency						Difference		
Length (cm)	Males Tagged	Males Recaps	Females Tagged	Females Recaps	Total Tagged	Total Recaps	Males	Females	Total
25	0	0	0	0	0.002	0.004	0	0	0.002
26	0	0	0	0	0.003	0.007	0	0	0.003
27	0	0	0	0	0.003	0.007	0	0	0.003
28	0	0	0	0	0.004	0.009	0	0	0.004
29	0	0	0	0	0.006	0.013	0	0	0.007
30	0	0	0	0	0.012	0.022	0	0	0.01
31	0	0	0	0	0.019	0.035	0	0	0.016
32	0	0	0	0	0.031	0.048	0	0	0.017
33	0	0	0.006	0	0.059	0.086	0	0.006	0.026
34	0	0	0.006	0	0.088	0.116	0	0.006	0.028
35	0	0	0.006	0	0.124	0.165	0	0.006	0.041
36	0	0	0.006	0	0.18	0.231	0	0.006	0.051
37	0	0	0.006	0	0.23	0.303	0	0.006	0.074
38	0	0	0.006	0	0.277	0.36	0	0.006	0.083
39	0	0	0.006	0	0.334	0.418	0	0.006	0.083
40	0	0	0.006	0	0.391	0.468	0	0.006	0.078
41	0	0	0.006	0	0.46	0.534	0	0.006	0.075
42	0	0	0.006	0	0.517	0.534	0	0.006	0.017
43	0	0.146	0.006	0	0.553	0.576	0.146	0.006	0.022
44	0.199	0.308	0.006	0	0.605	0.622	0.109	0.006	0.017
45	0.353	0.446	0.006	0	0.645	0.662	0.093	0.006	0.016
46	0.465	0.515	0.012	0	0.675	0.681	0.051	0.012	0.006
47	0.539	0.562	0.012	0	0.695	0.695	0.022	0.012	0
48	0.614	0.592	0.012	0	0.714	0.703	0.022	0.012	0.011
49	0.643	0.615	0.012	0	0.722	0.71	0.028	0.012	0.012
50	0.68	0.646	0.012	0	0.731	0.719	0.034	0.012	0.013
51	0.71	0.662	0.017	0.012	0.74	0.725	0.048	0.005	0.015
52	0.722	0.669	0.023	0.024	0.744	0.73	0.053	0.001	0.015
53	0.73	0.677	0.029	0.024	0.748	0.732	0.053	0.005	0.016
54	0.759	0.723	0.046	0.049	0.758	0.749	0.036	0.003	0.009
55	0.772	0.738	0.064	0.073	0.765	0.758	0.033	0.01	0.007
56	0.78	0.754	0.069	0.073	0.768	0.763	0.026	0.004	0.005
57	0.801	0.785	0.127	0.146	0.784	0.785	0.016	0.019	0
58	0.817	0.785	0.145	0.159	0.792	0.787	0.033	0.014	0.005
59	0.838	0.815	0.185	0.171	0.805	0.798	0.023	0.014	0.007
60	0.846	0.831	0.202	0.195	0.81	0.807	0.016	0.007	0.004
61	0.867	0.846	0.249	0.232	0.824	0.818	0.021	0.017	0.007
62	0.892	0.862	0.272	0.244	0.835	0.824	0.031	0.028	0.011
63	0.896	0.862	0.324	0.28	0.846	0.831	0.035	0.043	0.015
64	0.909	0.869	0.358	0.329	0.855	0.842	0.039	0.029	0.014

Table 18 cont'd

Length (cm)	Cumulative Frequency						Difference		
	Males Tagged	Males Recaps	Females Tagged	Females Recaps	Total Tagged	Total Recaps	Males	Females	Total
65	0.925	0.885	0.37	0.329	0.862	0.846	0.041	0.041	0.016
66	0.929	0.892	0.399	0.354	0.868	0.853	0.037	0.045	0.016
67	0.938	0.908	0.439	0.39	0.878	0.864	0.03	0.049	0.014
68	0.942	0.915	0.503	0.463	0.891	0.879	0.027	0.039	0.012
69	0.942	0.915	0.555	0.512	0.901	0.888	0.027	0.043	0.013
70	0.942	0.915	0.578	0.537	0.905	0.892	0.027	0.041	0.013
71	0.946	0.923	0.642	0.634	0.918	0.912	0.023	0.007	0.006
72	0.954	0.938	0.694	0.695	0.93	0.927	0.016	0.001	0.002
73	0.954	0.938	0.757	0.756	0.942	0.938	0.016	0.001	0.003
74	0.967	0.962	0.809	0.805	0.955	0.954	0.005	0.004	0.001
75	0.983	0.977	0.879	0.866	0.972	0.969	0.006	0.013	0.003
76	0.988	0.985	0.919	0.902	0.981	0.978	0.003	0.017	0.003
77	0.996	1	0.948	0.951	0.988	0.991	0.004	0.003	0.003
78	0.996	1	0.954	0.951	0.989	0.991	0.004	0.003	0.002
79	0.996	1	0.96	0.963	0.99	0.993	0.004	0.004	0.003
80	0.996	1	0.971	0.963	0.992	0.993	0.004	0.008	0.001
81	1	1	0.983	0.963	0.996	0.993	0	0.019	0.002
82	1	1	0.983	0.963	0.996	0.993	0	0.019	0.002
83	1	1	0.983	0.963	0.996	0.993	0	0.019	0.002
84	1	1	0.994	0.988	0.998	0.998	0	0.006	0
85	1	1	0.994	0.988	0.998	0.998	0	0.006	0
86	1	1	0.994	0.988	0.998	0.998	0	0.006	0
87	1	1	1	1	0.999	1	0	0	0.001
$D_{.05,62}$ = .169						D_{obs} =	0.146	0.049	0.083

Table 19. Sex composition of application and recovery samples of Cowichan River chinook, 1998.

		Application sample			Recovery sample		
Sex		Recovered	Not Recovered	Total	Marked	Unmarked	Total
Male	Percent	56.3	56.8	56.5	56.3	56.5	56.4
	No.	116	104	220	116	220	336
Female	Percent	43.7	43.2	43.5	43.7	43.4	43.5
	No.	90	79	169	90	169	259
Total:	No.	206	183	389	206	389	595

Table 20. Total adult chinook returns to the Cowichan River, 1975-1998.

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
1995	13452[4]	2149	533	16134[4]
1996	12217[4]	1615	800	14701[4]
1997	7435	125	150	8132
1998	4328	1661	1073	7062

[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
[4] Includes the fence count and an estimate of the numbers of fish that entered the river prior to and after the fence was in place.

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.

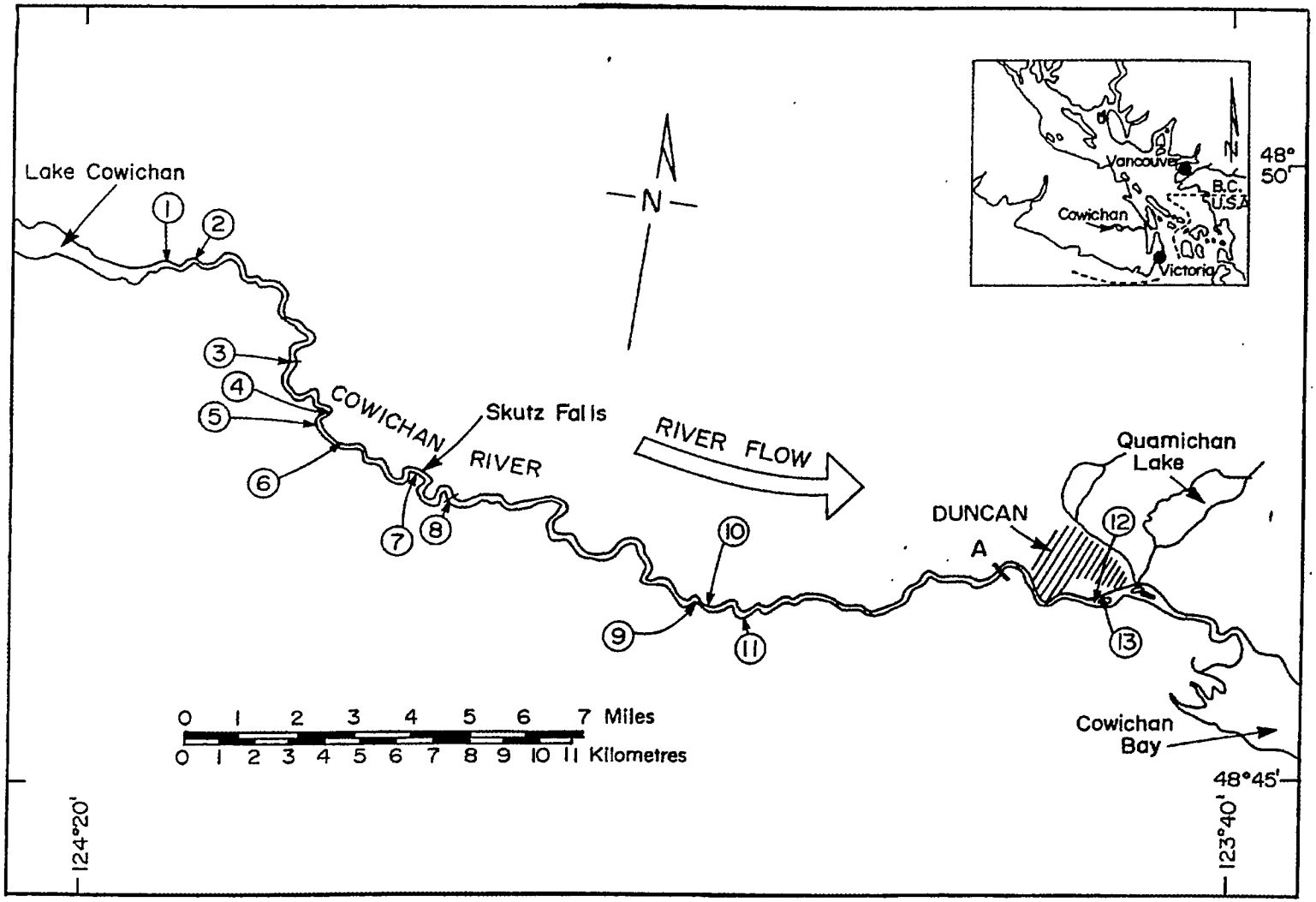

Lake Cowichan
1
2
3
4
5
6
7
8
9
10
11
12
13
COWICHAN
RIVER
Skutz Falls
RIVER FLOW
DUNCAN
A
Quamichan
Lake
Cowichan
Bay
N
Vancouver
B.C.
U.S.A.
Cowichan
Victoria
48°
50'
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres
124°20'
123°40'
48°45'

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

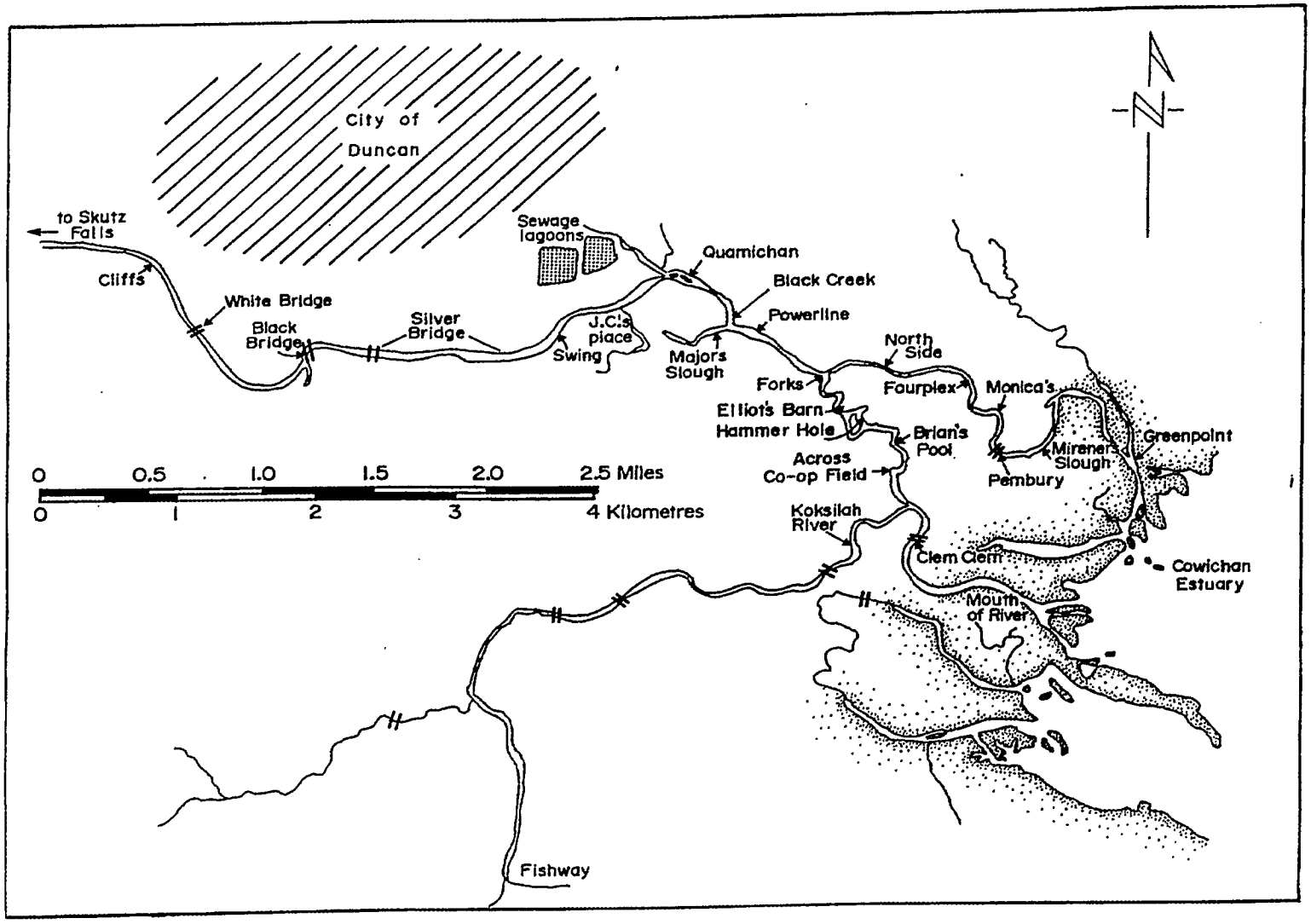
F-Brian's pool to Clem Clem and part of Koksilah

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
J.C.'s
place
Swing
Sewage
lagoons
Quamichan
Black Creek
Powerline
Majors
Slough
North
Side
Forks
Fourplex
Monica's
Elliot's Barn
Hammer Hole
Brian's
Pool
Greenpoint
Miriner's
Slough
Pembury
Across
Co-op Field
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

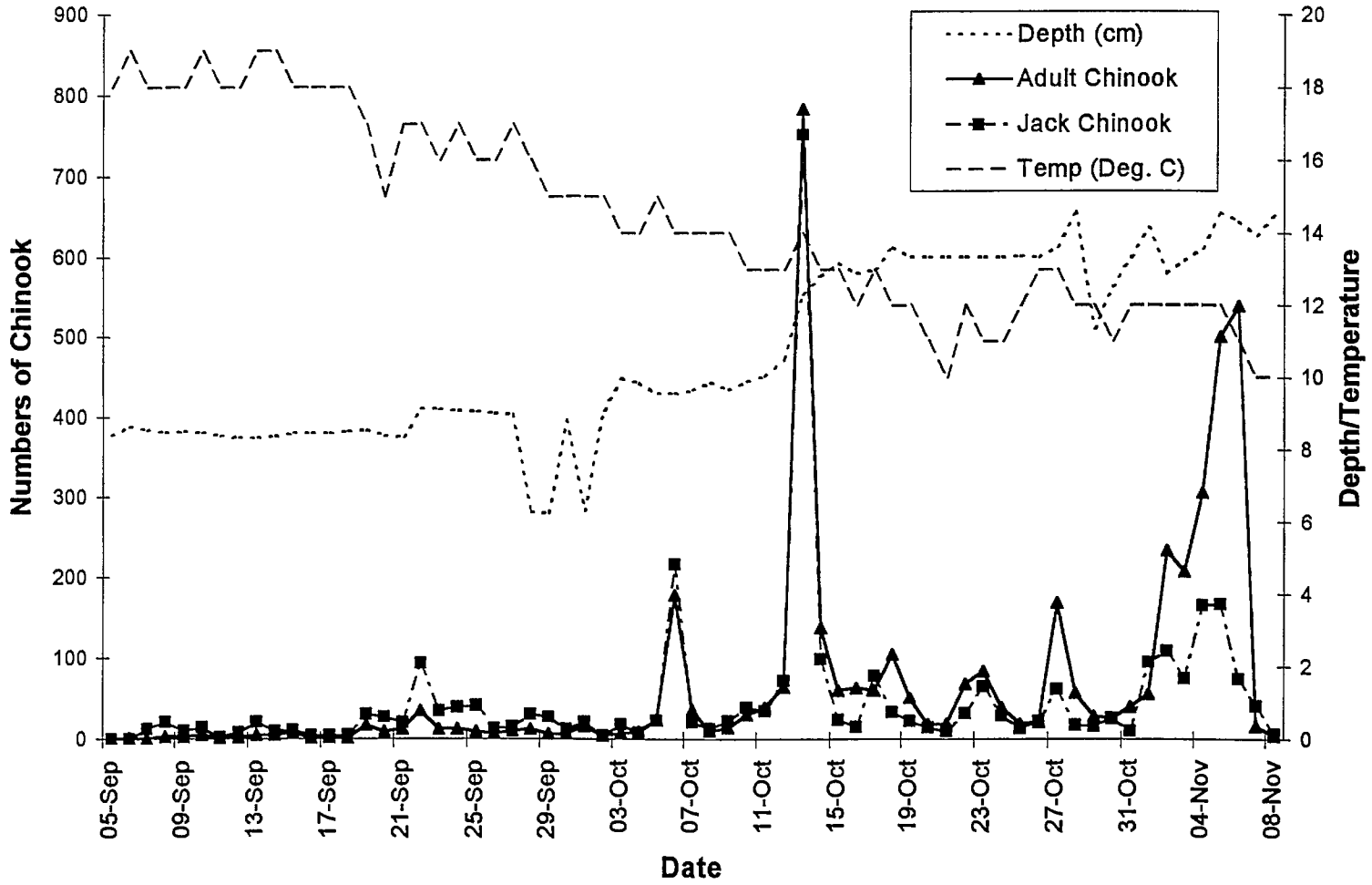


Fig. 3. Daily fence count of adult and jack chinook, water depth and temperature, 1998.

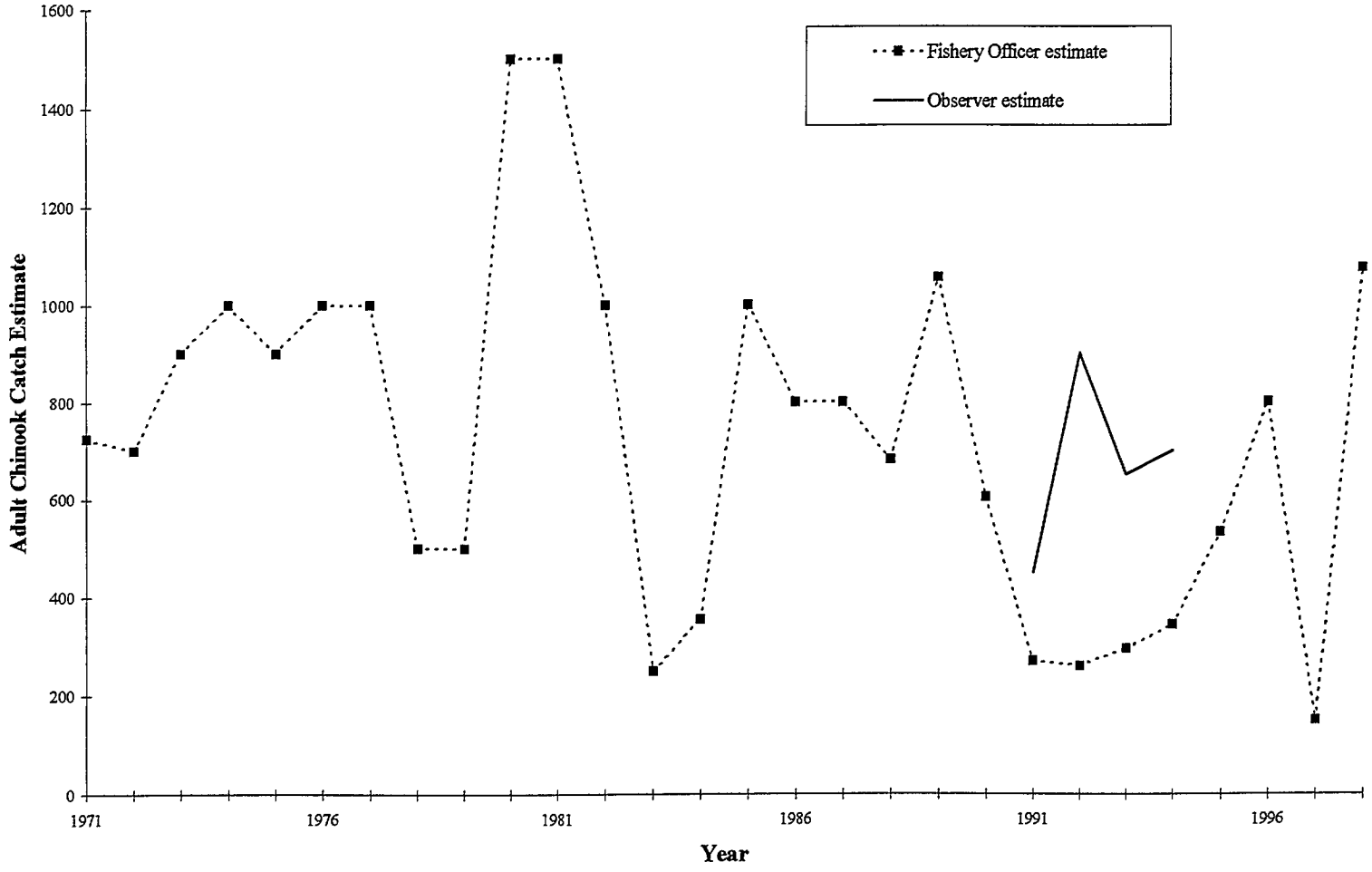


Fig. 4. Native food fishery adult chinook catch data, 1971 ▒ 1998.

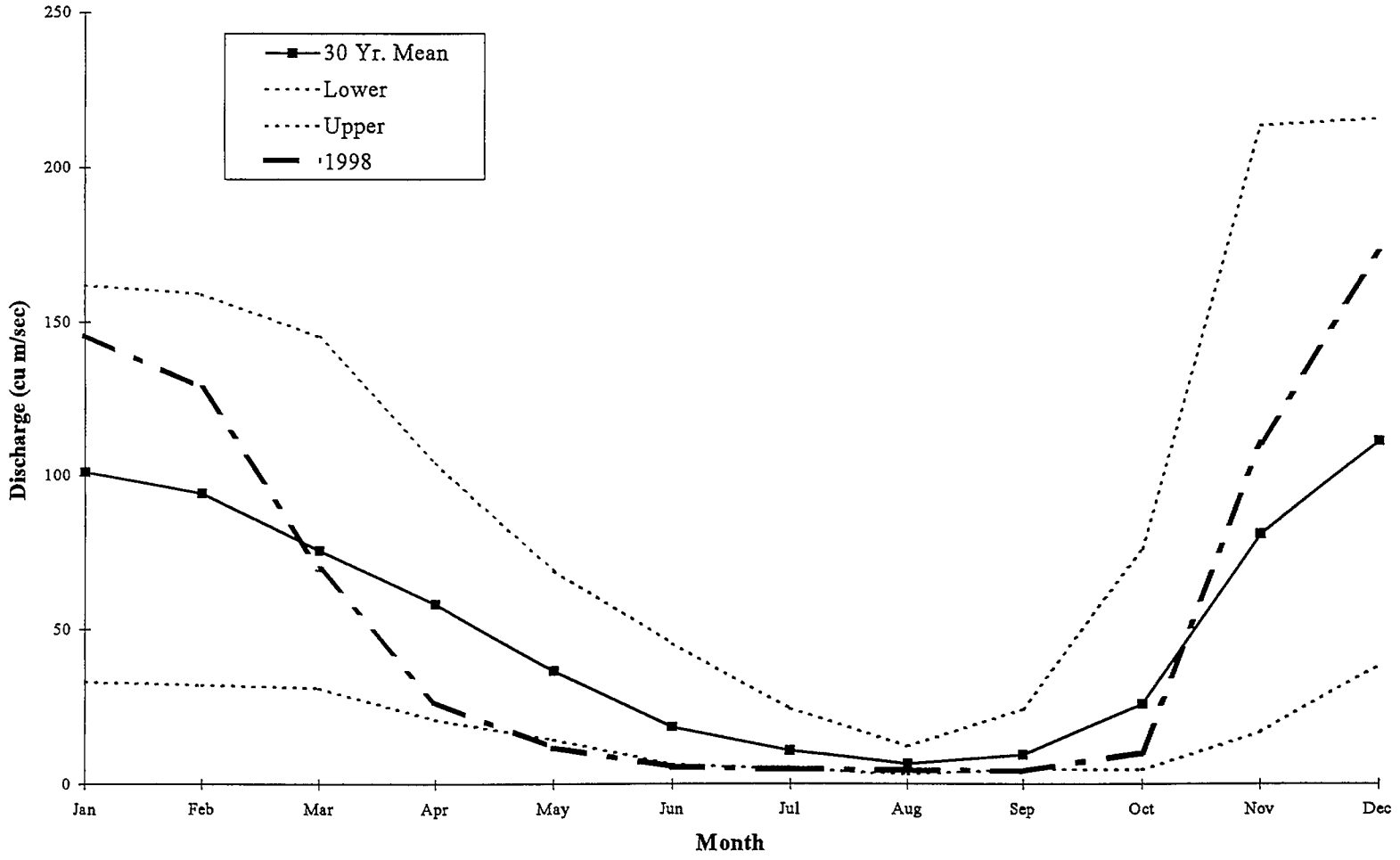


Fig. 5. 1998 Cowichan River discharge (cu. m/sec) compared with historical trends.

Fig. 6. Adult chinook escapement estimates for the Cowichan River, 1953-1998.

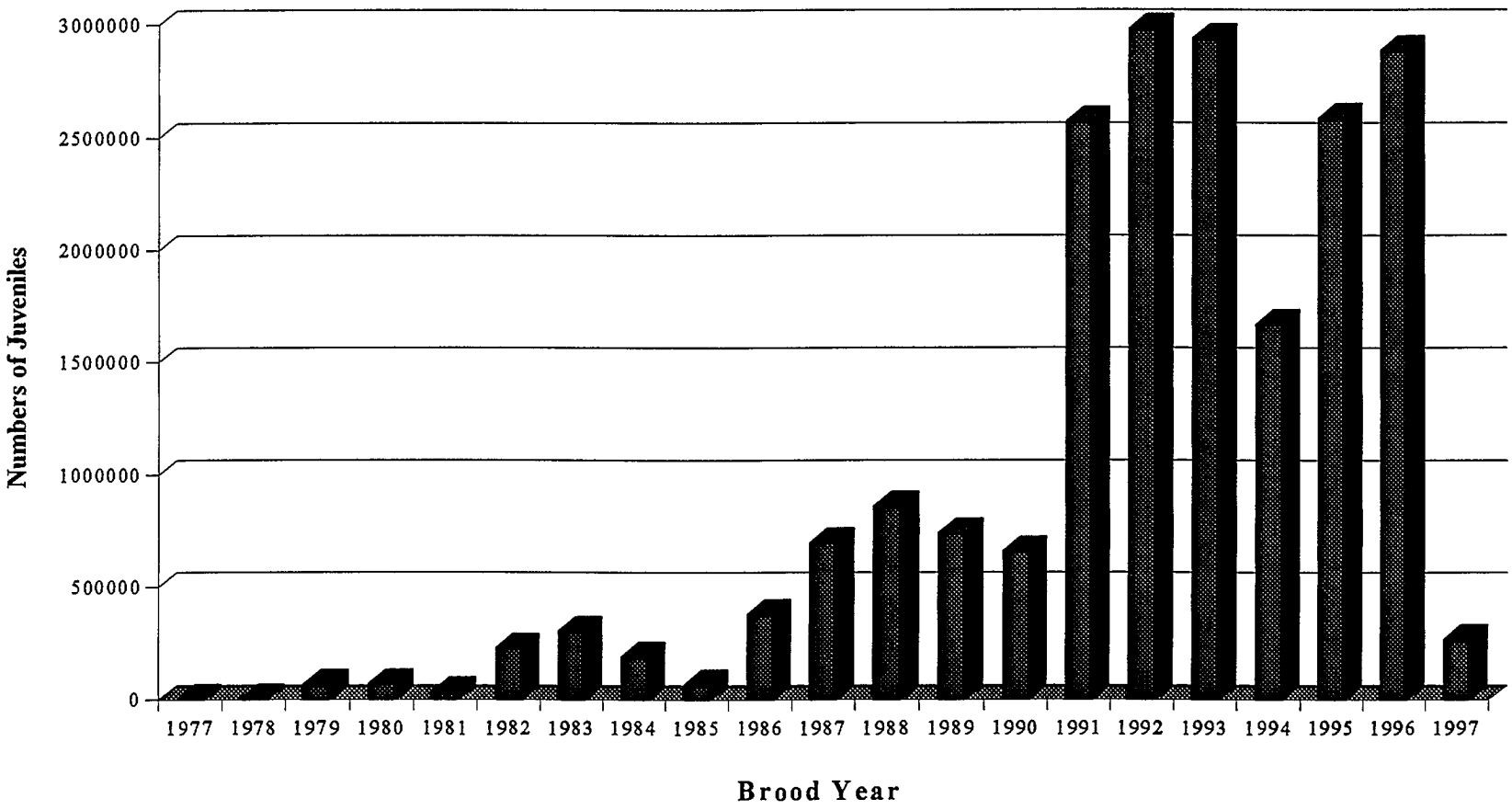


Fig. 7. Hatchery chinook released into the Cowichan River, as fry (3 gm) and as pre-smolts (6 gm).

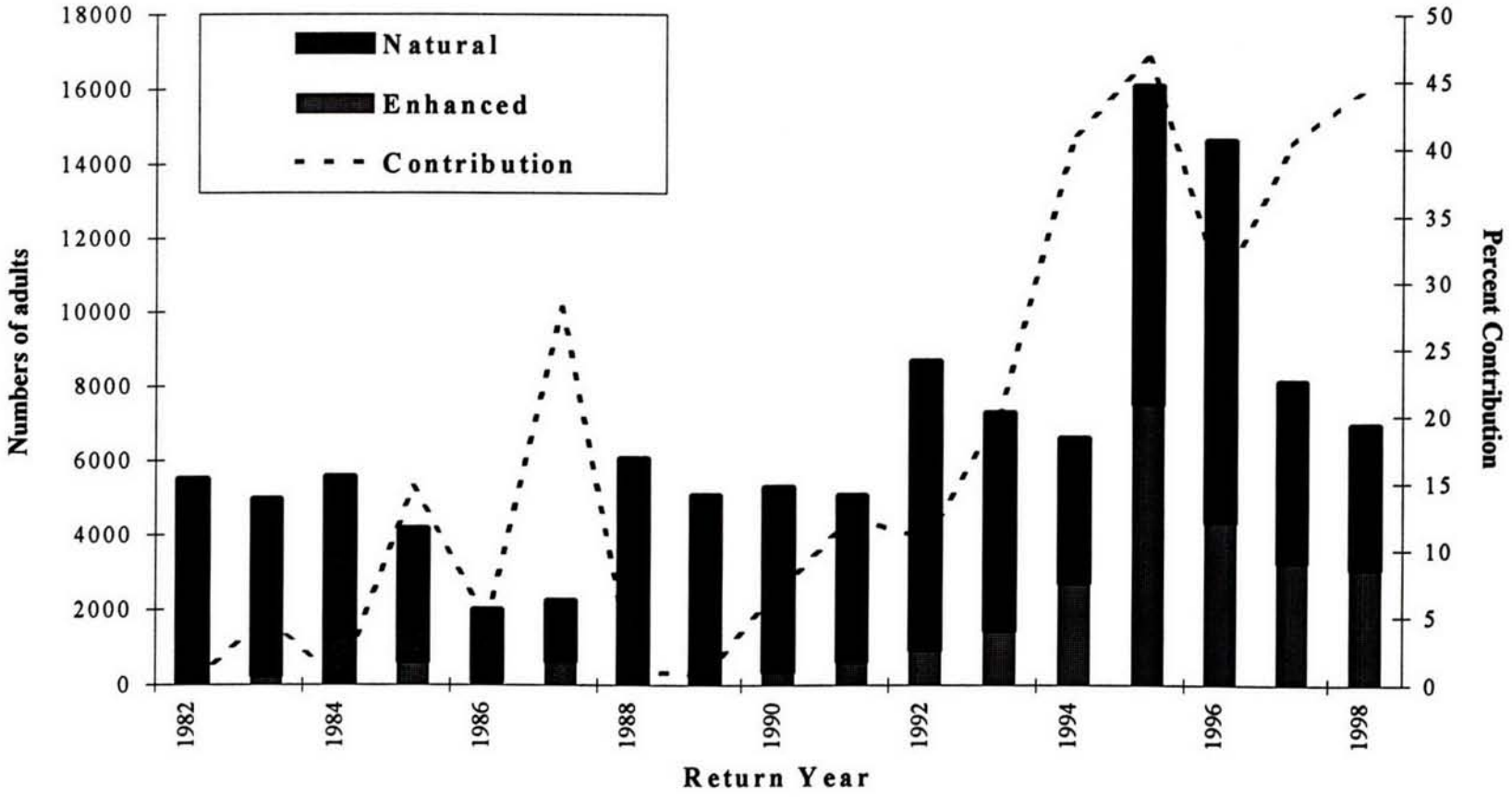


Fig. 8. Natural and enhanced contribution to escapement, Cowichan River, 1982-1998.