Adult Chinook Escapement Assessment Conducted on the Cowichan River During 2000

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ABSTRACT

Diewert, R. E., D. A. Nagtegaal, E.W. Carter, and K. Jones. 2003. Adult chinook escapement assessment conducted on the Cowichan River during 2000. Can. Manuscr. Rep. Fish. Aquat. Sci. 2642: 48p.

In 2000, the Biological Sciences Branch, Pacific Biological Station, continued a study of chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. This in-depth escapement assessment project has been in place since 1988. Major components of this study included: i) enumerating spawners and total return, ii) estimating Native food fish catch, iii) recording hatchery broodstock removals, and iv) collecting biological, environmental and coded-wire tag data.. Population estimates for adult and jack chinook were determined based on the fence count data since this was considered to be the most accurate enumeration method. A carcass mark-recapture study was conducted on the spawning grounds to augment the collection of biological data and to supplement the fence count population estimate. The total return of adult chinook to the Cowichan River was estimated to be 7,027 fish of which 5,109 spawned naturally in the river. A total of 1,529 adult chinook were collected for hatchery broodstock and 89 adults were reported as captured in the Native food fishery.

RÉSUMÉ

Diewert, R. E., D. A. Nagtegaal, E. W. Carter, and K. Jones. 2003. Adult chinook escapement assessment conducted on the Cowichan River during 2000. Can. Manuscr. Rep. Fish. Aquat. Sci. 2642: 48p.

La Direction des sciences biologiques de la Station biologique du Pacifique a poursuivi en 2000 une étude sur la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) dans la rivière Cowichan. Ce projet exhaustif d'évaluation de l'échappée, en cours depuis 1988, comporte les grands volets suivants : i) le dénombrement des reproducteurs et de la remonte totale, ii) l'estimation des prises autochtones à des fins alimentaires, iii) le contrôle des ponctions de reproducteurs d'écloserie et iv) la collecte de données biologiques, environnementales et de micromarque magnétisée codée. On a fait des estimations de la population d'adultes et de quinnats d'un an en mer à partir des données recueillies à la barrière de dénombrement car on considérait cette méthode comme la plus précise. On a aussi recueilli des micromarques sur les carcasses retrouvées dans les frayères afin de bonifier les données biologiques et de renforcer l'estimation de la population reposant sur les données de dénombrement à la barrière. La remonte totale d'adultes dans la rivière Cowichan a été chiffrée à 7 027 quinnats, dont 5 109 ont frayé dans la rivière. Un total de 1 529 adultes ont été prélevés pour combler les besoins d'écloseries et 89 adultes ont été déclarés comme des prises autochtones à des fins alimentaires.

INTRODUCTION

Chinook stocks are invaluable to both commercial and recreational fisheries of the Pacific Northwest (Collicut and Shardlow 1995). In spite of protective measures, chinook salmon abundance has continued to decline. This trend has resulted in the recent addition of chinook to the list of threatened and endangered species in the United States (Waples 1991). The problem of declining stocks is similarly serious on the West Coast of Canada, and has potential ramifications regarding the sustainability of British Columbia's fishing industry (Argue *et al* 1983). Over the past several years, considerable interest has been focused on the chinook stocks of the southern portion of the Strait of Georgia due to the perceived decline in these stocks and their importance to 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 Cowichan River chinook with additional information collected from the Squamish and Nanaimo River stocks. These three stocks were identified as exploitation and escapement indicators and deemed to represent the status of all lower Georgia Strait chinook stocks. Since then, due to logistical reasons the Squamish system was dropped as an indicator.

Major 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 2.58 million in 2000. Coded wire tag releases also began in 1980 and by 2000 approximately 9 % of the chinook released carried coded wire tags.

This report presents the results of the study completed during 2000. The objectives included:

1. enumerating chinook, coho and chum salmon migrating past the counting fence,
2. estimating the Native food fishery catch,
3. recording hatchery broodstock removals,
4. collecting biological data and sampling coded-wire tag (CWT) recoveries, and
5. implementing a carcass mark-recapture study for both adult and jack chinook.

METHODOLOGY

A detailed description of the methodology is presented in Nagtegaal et al. (1994b). A summary of the methods is presented below along with any changes that were incorporated during 2000.

STUDY AREA

The Cowichan River watershed is located on the southeast coast of Vancouver Island and drains an area totalling 826 km^2. The Cowichan River system includes Cowichan, Bear, Mesachie, Somenos, and Quamichan lakes. Cowichan Lake (62 km^2), the largest of the five lakes, is situated approximately 50 km west of the Cowichan Bay estuary. Discharge from a flow control dam situated at the outlet of Cowichan Lake ranges from 7 to 326 $m^3 \cdot s^{-1}$, and averages 44.9 $m^3 \cdot s^{-1}$ (Feilden and Holtby 1987). A total of 26 tributaries drain into the Cowichan River. The largest of these is the Koksilah River, which intersects the mainstem of the Cowichan River approximately 2.5 km upstream of the estuary. The Cowichan River watershed system is a typical Vancouver Island and coastal British Columbia stream in which maximum flows occur during winter months due to heavy rainfall (McDougall 1985).

The Cowichan River supports many salmonid species including chinook (*Oncorhynchus tshawytscha*), coho (*Oncorhynchus kisutch*), chum (*Oncorhynchus keta*), sockeye (*Oncorhynchus nerka*), and pink (*Oncorhynchus gorbuscha*) salmon; as well as cutthroat trout (*Salmo clarkii*), steelhead trout (*Salmo gairdnerii*), kokanee salmon (*Oncorhynchus nerka*), and Dolly Varden char (*Salvelinus malma*). Attempts have been made to introduce several other species including: Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), and speckled char (*Salvelinus fontinalis*) (Perrin *et al.* 1988). The salmonids of the Cowichan River support several vital fisheries, which include a Native food fishery, tidal sport fishery, and a large commercial ocean fishery.

ENUMERATION FENCE

The counting fence was placed upstream of the city of Duncan, in the same location as in previous years (Figure 1). The design incorporated a resistance board weir with a counting raceway (adjustable flashboard) and trap box adjacent to a counting tower equipped with floodlights. Counts were continuously recorded by 15-minute interval for adult and jack chinook, adult and jack coho, and chum salmon. If identification was in doubt fish were recorded as unknown. Water depth, temperature, and clarity, and weather condition were recorded three times per day. The fence was checked daily for any breeches and cleaned of leaves and other debris. Any removals of broodstock at the fence site by hatchery staff were recorded.

SWIM SURVEYS

In an effort to maintain consistency with historical data sets, swim surveys were conducted, in conjunction with Cowichan Tribes Aboriginal Fisheries Management (CTAF), to estimate the spawning population of chinook. Swims were made in the upper section of the river only (Figure 1) with counts extrapolated to the total system. Each survey was conducted by three experienced swimmers while one person in a canoe 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. To maintain consistency in counting procedures the same swim team was used for each survey whenever possible. Based on the historical distribution of spawners, swim counts were expanded by a factor of 3.4 to derive an estimate of total escapement (Nagtegaal *et al.* 1994a). This expansion factor was consistently applied to swim counts with no adjustments made for run timing or changes to spawner distribution. A final escapement estimate was then determined based on consultation with Fishery Officers using the swim counts in conjunction with other anecdotal information.

It was intended that the swim survey estimates remain independent of the fence count. However, even though fence counts were not 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 (Figure 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 catch for 2000.

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

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 Native fishery. Due to budget constraints no observers were employed during 2000 and CTAF catch estimates could not be independently verified.

BIOLOGICAL DATA

Biological data for chinook were collected from hatchery broodstock samples and from carcasses recovered on the spawning grounds. Data collected included sex, post-orbital hypural (POH) length, and adipose fin status (present/absent). Scales were also taken for age analysis and the heads were removed from all adipose fin clipped fish for recovery and decoding of coded-wire tags (CWT). Hatchery staff randomly collected biological data from approximately 25% of the chinook broodstock and from all chinook identified as carrying a CWT. All chinook recovered on the spawning grounds were sampled and spawning condition was noted.

MARK-RECAPTURE

A mark-recapture program involving the tagging and subsequent recovery of chinook jack and adult carcasses was conducted on the spawning grounds. Crews consisting of two or three individuals surveyed the upper section of the river (Figure 1) each day using an inflatable boat. All chinook carcasses encountered 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, POH length, sex, and adipose fin status (present or absent) were recorded for each carcass. Tag number and recovery location were recorded for all previously marked carcasses, which were then returned to the river at the capture site.

The section of the river selected for the mark recapture study is located above Skutz Falls and represents the area where the majority of chinook spawning has typically occurred. A 4.2 m pole with a gaff hook attached to the end was used to recover carcasses. Carcasses that ended up in deep pools were occasionally unable to be retrieved.

POPULATION ESTIMATE

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

To determine the validity of the mark recapture estimate, potential biases were assessed to test for violations of the assumptions inherent in the Petersen mark recapture method (Ricker 1975; Seber 1982; Krebs 1989). Sex related bias in the application sample was examined by comparing the sex ratio of the marked versus the unmarked recoveries. Sex related bias in the recovery sample was assessed by comparing the sex ratio of the recovered versus the unrecovered tag sample. Size bias in the application sample was examined by comparing the lengths of the marked versus the unmarked recoveries. Size bias in the recovery sample was examined by comparing the lengths of the recovered and unrecovered tag sample. Statistical comparisons of the length data were carried out using Student's t-test for two samples. When the data did not meet the requirements for this test then the non-parametric Mann-Whitney U test was employed. Temporal bias in the application sample was assessed by stratifying the recovery sample into approximately equal periods and comparing mark incidence among strata. Stratifying the application sample as above and comparing proportions recovered among strata assessed temporal bias in the recovery sample. Statistical assessments of sex and period bias were carried out using chi-square tests.

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

RESULTS

ENUMERATION FENCE

The enumeration fence was installed upstream from the City of Duncan at the traditional site (Figure 1) and was operational from September 8 to October 24. Water conditions were clear for the majority of the study with only one day noted as cloudy (Table 1). As a result, conditions were ideal for viewing fish migration past the counting tower and all counts are deemed to be reliable. A total of 4,667 chinook adults, 1,391 chinook jacks, 668 coho adults and 132 coho jacks were counted migrating past the enumeration fence. In addition, 148 chum and four unidentified fish were enumerated at the fence site (Table 1). Since there were no breeches of the fence during the project it was assumed that all fish migrating past the fence during the study period were enumerated.

In past years, chinook jacks have been prominent during the early segment of the return migration often out numbering adults. In 2000, the proportion of jacks was high during the early return period but the overall temporal pattern of jack chinook migration past the fence mirrored that of the adult component of the run. (Table 1, Figures 3a, 3b).

The pattern of daily migration past the fence was examined by summarizing hourly counts throughout the program (Table 2). A major peak in migration for both adult and jack chinook occurred between 0700 and 1000 hrs. During this period, 35.9% of adult chinook and 29.8% of jack chinook moved past the fence site. Other smaller migration peaks occurred between 0300 and 0500 hrs, 1700 and 1800 hrs and between 2100 and 2400 hrs (Table 2).

In past years, tower counts and species identification were verified on several occasions throughout the run by capturing all fish migrating past the fence during one counting segment in the upstream trap box. For logistical reasons, this practise was not carried out in 2000.

SWIM SURVEYS

A summary of all visual surveys conducted by DFO Fishery Officers and by the Cowichan Tribes Aboriginal Fisheries Management group from 1981 to 1999 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. In 2000, only 1 swim survey was conducted in the upper section of the river (Figure 1) on September 13. Fence records indicate that very few chinook were in the river by this date. Also, water levels were extremely low making conditions difficult for a comprehensive survey. As a result, no population estimate was made based on the results of swim survey records.

NATIVE FOOD FISHERY

Historical estimates of the number of chinook captured in the in-river Native food fishery are presented in Table 4 and Figure 4. The 2000 catch estimate of 89 adults and zero jacks was determined by the Cowichan Tribes Aboriginal Fisheries Management group (Figure 2). While it is difficult to assess the quality of the data collected, the catch estimate is considered to be low. Observations suggest that the adult chinook spear fishery was more successful than the catch estimate indicates since water conditions were ideal during the fishing season. Also, if non-catch mortality (fish that escapes capture but die before spawning due to fishery induced injuries) were included, the impact of the fishery would likely be much more significant.

HATCHERY COMPONENT

Between September 18 and October 18, Cowichan River hatchery staff collected 723 male, 803 female and 14 jack chinook from the river downstream of the fence. In addition, one male and two female chinook were collected upstream of the fence (Table 5). The total number of chinook removed from the river for hatchery broodstock was within the range required for hatchery production (Table 6). Age analysis of scale samples revealed that the majority of these fish (96.4%) were either three or four years old (Table 7).

BIOLOGICAL DATA

A total of 229 male, 292 female and 589 jack chinook carcasses were recovered on the spawning grounds and measured for post orbital-hypural length (Table 8). Conditions for the recovery of carcasses were ideal with discharge levels below the long-term average during October and November (Figure 5). The length of adult male chinook carcasses ranged from 42.5 to 87.0 cm and averaged 58.8 cm, while female carcasses ranged from 37.5 to 77.0 cm and averaged 64.0 cm. Jack chinook carcasses ranged in length from 23.0 to 61.0 cm and averaged 38.7 cm. A total of 11 male, 10 female and 38 jack chinook carcasses recovered from the spawning grounds were missing an adipose fin indicating the presence of a coded-wire tag (Table 8). These values represent 4.8, 3.4 and 6.5% of the total male, female and jack carcasses, respectively. The majority of adult chinook (89.1%) were three or four years old while most jacks (92.0%) were two years old (Table 9).

A total of 56 male, 142 female and five jack chinook collected for broodstock were randomly selected and measured for post orbital-hypural length (Table 10). The length of male chinook ranged from 45.0 to 78.3 cm and averaged 63.7 cm, while female chinook ranged from 53.8 to 82.5 cm and averaged 68.6 cm. Jack chinook ranged in length from 43.8 to 53.5 cm and averaged 49.6 cm. A total of 5 male, 17 female and 1 jack chinook in the random hatchery sample were missing an adipose fin indicating the presence of a coded wire tag (Table 10). These values represent 8.9, 12.0 and 20.0% of the total male, female and jack samples, respectively.

There was a statistically significant difference between the length of chinook carcasses recovered on the spawning grounds and those in the hatchery broodstock sample for both males and females (Student's t-test: $t = 3.848$; $p<0.001$ and $t=7.589$; $p<0.0001$, for males and females, respectively). In both cases, the broodstock sample was significantly larger than the samples collected on the spawning ground. The jack sample size was too small to be tested.

Analysis revealed that there was a significant difference in the adipose fin clip rate between female chinook carcasses recovered on the spawning grounds and those in the hatchery broodstock sample (Chi-square = 11.963; $p=0.05$). As in past years, the incidence of adipose fin clipped females was higher in the hatchery broodstock sample.

Coded wire tags were recovered from 53 chinook carcasses sampled on the spawning grounds. The majority of these fish (68%) were jacks from the 1998 brood that were released into the Cowichan River while two were jacks released into Cowichan Lake (Table 11). The remaining fish were from the 1997 brood, which were released in 1998 into the Cowichan River. One fish was released into the Chemainus River but was recovered in the upper Cowichan. A summary of all chinook releases from the Cowichan hatchery since 1979 is presented in Table 12.

ENVIRONMENTAL INFORMATION

Environmental data collected at the fence site included water temperature, visibility and river depth (Table 1). Water temperature was generally higher at the start of the study and decreased discontinuously to the end of October. Water temperature over this period ranged from 12.3 to 19.0 ^{0}C and averaged 15.2 ^{0}C. Water depth at the fence site was consistently low until the last week of September, then peaked before dropping again through to mid October. The last two weeks of the project witnessed a second, and higher peak, which lasted until fence removal. Water depth over the study period ranged from 44.7 to 83.7 cm and averaged 54.4 cm. Water clarity was recorded in the form of a visibility code. For the majority of the study, visibility at the fence site was clear. Only six days were recorded as moderately cloudy (code 1-2) and one day as cloudy (Table 1).

River discharge was recorded at the Water Survey Canada station below the Island Highway Bridge in the City of Duncan (Figure 1). River discharge during the fall of 2000 was near the 30-year average for September and October but was well below average in November and December (Figure 6).

CARCASS MARK-RECAPTURE

Between October 30 and November 30 a total of 221 male, 292 female and 587 jack chinook carcasses were tagged and released in the upper Cowichan River (Table 14a, 14b). Of the 244 carcasses recovered with tags, 53 (27.2%) were male, 90 (36.9%) were female, 97 (39.8%) were jacks and 4 (1.6%) could not be identified to sex. Using the Petersen estimator, the adult chinook spawning ground population size was determined to be 2,364 fish (95% CI: 2017 to 2710), while the jack population was estimated to be 4,110 fish (95% CI: 3361 to 4859) (Table 15).

The assessment of sampling selectivity revealed several significant biases in the carcass mark recapture study. First, there was a significant temporal bias in the application sample for both male and female adult chinook when the data were stratified into 4 equal recovery periods (Table 16). There was also a temporal bias in the recovery sample for males; however, the female recovery sample did not show a significant temporal bias (Table 17). No sex related bias was evident in either the application or recovery sample when only the adult segment of the population was examined (Table 18); however, when jacks were included in the assessment both the application and recovery samples showed significant bias (Table 19). No size bias was evident in the recovery sample for adult males or females (Student's t-test: t=0.551 and 0.344, respectively). There was also no size bias evident in the jack recovery sample (Mann-Whitney U test: P=0.083).

POPULATION ESTIMATE

Escapement and total return estimates for 2000 were determined based on the fence count data since this was considered to be the most accurate enumeration method. However, after reviewing both spawning ground carcass recovery and hatchery broodstock collection data, it became evident that the chinook fence count may not accurately reflect the true jack to adult ratio. As a result, the original fence counts were adjusted according to the age composition derived from the carcass biosampling data. The current approach at the fence is to use a 45 cm marker in the trap box to identify adults from jacks. If we examine the size distribution at age from the carcass biosample data, we see some overlap between adults and jacks (Figure 5). We subtracted the percentage of those fish identified as adults that were aged as jacks from the adult fence count. Conversely we subtracted the percentage of those fish identified as jacks that were aged as adults from the jack fence count. This procedure yielded total chinook fence counts of 4,445 adults and 1,612 jacks. Since previous studies have indicated that approximately 15% of the chinook run arrives after late October (Nagtegaal and Carter 1998), the total fence count was expanded by this value and the final estimate of adult chinook migration past the fence site was 5,112 fish.

The number of natural spawning adult chinook in the Cowichan River during 2000 was determined to be the fence count minus any broodstock removals from areas above the fence. Following this methodology, the total number of adult chinook spawning in the Cowichan River was estimated to be 5,109 fish (Table 20).

The total return of adult chinook to the Cowichan River was determined to be the sum of the total fence count plus broodstock removals and the Native fishery catch. A further 300 fish were added to this total to account for chinook lost to seal predation in the Cowichan estuary (see discussion for details). Following this methodology, the total return of adult chinook to the Cowichan River was estimated to be 7,027 fish (Table 20).

DISCUSSION

ENUMERATION FENCE

The floating fence design functioned well in the flow conditions that existed in the lower Cowichan River during the fall of 2000. While the fence was intended to be self-cleaning, field staff were required to regularly remove leafy debris from the fence panels during periods of heavy rain and related high flows. During such periods, fence panels became over burdened and could not remain afloat without the removal of debris. While this difficulty has been observed in other fence studies (Cousens *et al.* 1982, Johnston *et al.* 1986) it is likely that the intensity of the problem varies by year and location.

During many of the past monitoring studies, high flows have caused fence damage or forced early removal resulting in incomplete fence counts. During the current study, the enumeration fence was operational throughout the monitoring period and a complete count of all fish passing the site was attained. However, since the fence was removed on October 24 there was likely a portion of the chinook run that arrived after fence removal. Past studies have indicated that approximately 15% of the chinook run arrives after October 30 (Nagtegaal and Carter 1998). Based on this observation, the adult chinook fence count was expanded by 15% to account for unassessed spawners.

Several of the past fence enumeration studies conducted on the Cowichan River have noted the mis-identification of jack versus adult chinook by observers monitoring the migration of chinook past the fence (Nagtegaal and Carter 1998, 2000). While trap box verifications of observer counts were not carried out in 2000, it became clear from both spawning ground and hatchery broodstock data that the adult to jack ratio recorded at the fence was not reflective of the true population parameters. Since there were a large number of jack chinook at the upper end of the size distribution, it appears as if many of these fish were counted as adults. This seems likely as it would be very difficult to determine the size of a moving fish to within a few centimetres when viewing them from a counting tower well above the river. As a result, the total chinook fence count was apportioned to adult and jack components using the length-frequency at age data from the carcass biosampling data on the spawning grounds.

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. V9L-3X3; 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. The expansion of swim surveys conducted in the upper area alone tends 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.

Since only one swim survey was conducted during a period of extremely low water levels it was not possible to estimate chinook escapement from survey data collected during 2000.

NATIVE FOOD FISHERY

Catch estimation procedures developed by the Cowichan Tribes Aboriginal Fisheries Management unit have not been assessed by stock assessment staff. As a result, no comments can be made regarding the methodologies used. The 2000 estimate of 89 adult chinook was a considerable decrease over past years (Table 4). According to CTAF staff, fishing conditions were considered to be very good during September and October and the spear fishery catch was likely higher than reported. In past years, independent observer estimates of adult chinook catch have been 2 to 3.5 times higher than the CTAF estimate. Since no observers were employed during 2000, CTAF catch estimates could not be independently verified.

BIOLOGICAL DATA

Male and female chinook collected by the hatchery for broodstock were significantly larger than the carcasses recovered on the spawning ground. This suggests that either one or both sampling methods were size selective or that different size components of the returning chinook population were available for sampling at each site. Since deadpitch carcass recovery is generally selective for larger fish (Tschaplinski and Hyatt 1991) and carcass sampling occurred throughout the spawning period, it seems unlikely that selectivity in this sample could explain the result. Also, since broodstock collection occurred over an extended period and beach seines were employed in the capture of fish (a relatively non-selective gear), selectivity seems unlikely. However, since not all chinook captured in each set were taken for broodstock, it may be that the smaller fish were released back into the river. This would result in larger than average fish being included in the broodstock sample while smaller than average fish were returned to the river to contribute to the spawning ground carcass recovery sample. The selective retention of larger broodstock could explain the observed result.

MARK RECAPTURE

The carcass mark-recapture portion of the Cowichan River chinook stock assessment project was implemented many years ago for several reasons. First, since handling fish at the fence site caused significant migration delays this practice was abandoned to ensure chinook reached the spawning grounds without undue stress. As a result, no representative biological samples were available for assessment. While length and age data were collected by hatchery staff during broodstock capture, these data were not consistently representative of the spawning population. The sampling of carcasses from the spawning ground provided an additional source of biological data, which when pooled with the hatchery sample was more representative of the true population. Second, the recovery of coded-wire tags from hatchery broodstock did not provide an adequate sample size for a rigorous assessment. Spawning ground carcass recoveries supplemented the hatchery sample and strengthened the coded-wire tag analysis. Finally, since high flows in past years have caused fence damage that resulted in incomplete enumeration of spawners, an additional method of providing a population estimate was required.

Population estimates for adult and jack chinook were determined using the pooled Petersen estimator. Since the true population size was not known, a direct measure of the accuracy of the estimates was not possible. However, an assessment of the underlying assumptions of equal probability of capture, simple random recovery sampling and complete mixing can usually be made by testing recovery and application samples for temporal, spatial, sex and size related biases (Schubert 2000). To carry out most of the bias assessments, different gear types must be utilized for capturing the tag application and the recovery samples. In the current study, spawning ground carcass recovery was used to attain both samples thus limiting the ability to assess sample biases.

The assessment of sampling selectivity revealed several biases in the carcass mark-recapture study. First, there was a significant temporal bias in the application sample for both male and female chinook. The assessment revealed that tag incidence was very low during the early period and extremely high during the last period. This is likely due to the nature of the carcass recovery study, since tagging and recovery were concurrent activities. As a result, there were very few tagged carcasses available for recovery in the early period and as the number of tags in the population accumulated towards the end of the study, the tag incidence in the later periods was much higher. There was also a temporal bias in the recovery sample for males but not for females. Once again this bias was primarily due to the nature of the study since tags applied in later periods were less likely to be recovered as they were only available for recovery for a short period.

No sex related bias was evident in the application or recovery samples for adult chinook; however, when jacks were included in the assessment both samples showed significant bias. This is likely due to the size difference between adult and jack chinook, which effects the way carcasses behave in the river. Since jack carcasses are much smaller, they are more easily flushed out of the recovery area by small increases in river flow. As a result, they are less likely to be recovered than adult chinook carcasses.

Size bias testing did not provide an assessment of the size selectivity of the sampling method since both application and recovery samples were attained using the same method. Rather, the size bias assessment provided an evaluation of the recoverability, based on size, of tagged carcasses that were redistributed back into the river after tagging. Testing revealed that there was no size bias for male, female or jack chinook. This result suggests that tagged carcasses that were put back into the river were not differentially recovered based on size. While this is somewhat surprising, it should be noted that river discharge levels were well below the 30 year average in October and November (Figure 5). Also, since data were stratified into male, female and jack categories, the size range within each group was relatively restricted (Table 8).

The detection of sampling biases usually results in the use of a stratified estimator; however, Schubert (2000) compared the performance of several mark-recapture population estimators for a sockeye salmon population of known abundance and concluded that the pooled Petersen estimator was less biased and preferred over stratified estimators. In that study, the Schaeffer estimator would not improve accuracy and it was recommended that the method be abandoned for use in population estimation. Also, it was determined that while the maximum likelihood Darroch estimator could potentially improve accuracy there was no obvious way of selecting between accurate and highly biased estimates. Parken and Atagi (2000) found that pooled and stratified estimators of Nass River summer steelhead produced similar escapement estimates but that the pooled estimator was more precise and had less statistical bias than the stratified estimator. These findings indicate the robust nature of the pooled Petersen estimator and suggest that its use to determine population abundance from mark-recapture data is generally appropriate under a wide range of circumstances.

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 migration. While low flow conditions occurred during September and October, 2000, DFO charter patrol observations indicated that fewer seals and sea lions were present in Cowichan Bay. As a result, predation on chinook was estimated to be approximately 300 adults.

POPULATION ESTIMATE

The 2000 Cowichan River chinook population estimate was based on the enumeration fence count. Moderate river flows allowed the fence to remain in place without significant breeches for the duration of the study and it was felt that a near complete census was attained. The estimate of the number of adult chinook migrating past the fence site (expanded for migration after fence removal) was approximately 30% higher than the mark-recapture estimate. This result is consistent with past projects (Nagtegaal and Carter 1998, 2000) and is not an unexpected outcome since the mark-recapture study was conducted in the upper river only (the main spawning area) and did not include any chinook that spawned in other areas of the watershed.

The estimated number of adult spawners was the third lowest since 1975 and well below the period average of 5,797 (Table 20, Figure 7). This result may be partially explained by a dramatic reduction in hatchery releases that occurred in 1997 (Figure 8). A large proportion of this production would have been returning to spawn in 2000 as three year-old fish. The low hatchery contribution to the spawning escapement further supports this finding (Figure 9).

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REFERENCES

Argue, A.L., R. Hilborn, R.M. Peterman, M. J. Staley, and C.J. Walters. 1983. Strait of Georgia chinook and coho fishery. Can. Bull. Fish. Aquat. Sci. 211: 91 p.

Bigg, M.A., G.M. Ellis, P. Cottrell, and L. Milette. 1990. Predation by Harbour seals and Sea lions on adult salmon in Comox Harbour and Cowichan Bay, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1769: 31 p.

Burns, T. An assessment of Chinook salmon enumeration methods in the Cowichan River. Unpublished manuscript.

Collicut, L.D. and T.F. Shardlow. 1995. Strait of Georgia sport fishery creel survey statistics for salmon and groundfish, 1991. Can. Tech. Rep. Fish. Aquatic Sci. 2137: 75 p.

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

Cross, C.L., L. Lapi, and E. A. Perry. 1991. Production of chinook and coho salmon from British Columbia hatcheries, 1971 through 1989. Can. Tech. Rep. Fish. Aquat. Sci. 1816: 48 p.

Farlinger, S., N. Bourne, B. Riddell, D. Chalmers, and A. Tyler (Eds). 1990. Pacific stock assessment review committee (PSARC) annual report for 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2064: 236 p.

Fielden, R.J. and L.B. Holtby. 1987. Standing crop and habitat characteristics of juvenile salmonids at sites in the Cowichan River system. Can. Manuscr. Rep. Fish. Aquat. Sci. 1950: 65 p.

Inland Waters Directorate. Historical stream flow summary, British Columbia, 1999. Water Survey of Canada, Ottawa.

Johnston, N.T., J.R. Irvine, and C.J. Perrin. 1986. A comparative evaluation of fence count, mark-recapture and Bendix sonar estimates of salmon escapements in the Keogh River, a variable -flow coastal B.C. stream. Can. Tech. Rep. Fish. Aquat. Sci. 2111: 44 p.

Krebs, C.J. 1989. Ecological methodology. Harper Collins Publishers, New York. N.Y.

McDougall, R.D. 1985. A habitat management area plan for salmon stocks in the Cowichan watershed. Prepared for Field Services Branch, Dept. Fish. Ocean, Pacific Region.

Nagtegaal, D.A., P. J. Starr, and B. Riddell. 1994a. A preliminary report on the chinook productivity study conducted on the Cowichan River, 1988 and 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2233: 53 p.

Nagtegaal, D.A., J. Candy, and B. Riddell. 1994b. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1990 and 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2265: 71 p.

Nagtegaal, D.A., J. Candy, and B. Riddell. 1994c. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2268: 73 p.

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

Nagtegaal, D.A, and E.W. Carter. 2000. Adult chinook escapement assessment conducted on the Cowichan River during 1999. Can. Manuscr. Rep. Fish. Aquat. Sci. 2544: 59 p.

Olesiuk, P.F., M.A. Bigg, G.M. Ellis, S.J. Crockford, and R.J. Wigen. 1990. An assessment of the feeding habits of Harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis. Can. Tech. Rep. Fish. Aquat. Sci. 1730: 135 p.

Paige, W. 1992. Cowichan River Management Unit: Salmon Catch Statistical Program for 1991/1992. Cowichan Indian Band. Unpublished manuscript.

Paige, W. 1997. Cowichan Tribes Aboriginal Fisheries: Salmon Catch Statistical Program for 1994/1996. Cowichan Indian Band. Unpublished manuscript.

Parken, C.K., and D.Y. Atagi.. 2000. Preliminary estimate of the escapement of summer steelhead to the Nass River, 1998. British Columbia Ministry of Environment, Lands and Parks, Smithers, BC, Skeena Fisheries Report SK-124.

Perrin, C.J., N.T. Johnston, and S.C. Samis. 1988. Effects pf treated sewage effluent on periphyton and zoobenthos in the Cowichan River, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1591: 64 p.

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

Schubert, N.D. 2000. The 1994 Stellako River sockeye (*Oncorhynchus nerka*) escapement: evaluation of pooled Petersen and stratified mark-recapture estimates of a known population. Can. Tech. Rep. Fish. Aquat. Sci. 2303: 56 p.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters, Second edition. Griffin, London.

Tschaplinski, P.J., and K.D. Hyatt. 1991. A comparison of population assessment methods employed to estimate the abundance of sockeye salmon (Oncorhynchus nerka) returning to Henderson Lake, Vancouver Island, during 1989. Can. Tech. Rep. Fish. Aquat. Sci. 1978: 101 p.

Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Can. J. Fish. Aquat. Sci. 48 (Suppl. 1): 124-133.

Table 1. Daily counts at the Cowichan River fence site, 2000.

Date	Visibility	Temp (^{0}C)	Depth (cm)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unknown
08-Sep	1	17.0	46.0	1	0	0	0	0	0
09-Sep	1	17.0	45.0	0	0	0	0	0	0
10-Sep	1	16.0	46.0	0	0	0	0	0	0
11-Sep	1	16.0	45.0	8	2	0	0	0	0
12-Sep	1	16.7	45.0	17	4	0	0	0	0
13-Sep	1	16.3	45.7	7	4	0	0	0	0
14-Sep	1	17.3	45.0	2	7	0	0	0	0
15-Sep	1	18.0	45.0	5	20	0	0	0	0
16-Sep	1	17.7	45.0	6	8	0	0	0	0
17-Sep	1	19.0	45.0	11	10	0	0	0	0
18-Sep	1	18.0	45.3	9	4	0	0	0	1
19-Sep	1	18.3	45.0	119	97	0	0	0	0
20-Sep	1	18.3	45.0	72	49	0	0	0	1
21-Sep	1	17.7	45.0	18	13	0	0	0	0
22-Sep	1	16.3	45.0	35	40	0	0	0	0
23-Sep	1	14.7	44.7	19	8	0	0	0	0
24-Sep	1	15.0	45.0	7	4	0	0	0	0
25-Sep	1	15.0	48.3	5	10	0	0	0	0
26-Sep	1 - 2	15.7	55.7	236	84	0	0	0	0
27-Sep	1	17.0	64.0	811	135	0	0	0	0
28-Sep	1	15.0	63.3	241	77	0	0	0	0
29-Sep	1 - 2	17.0	63.3	354	96	0	0	0	0
30-Sep	1	16.7	64.3	480	116	0	0	0	0
01-Oct	1	16.0	63.3	226	31	0	0	0	0
02-Oct	1	16.0	61.3	207	47	4	0	0	0
03-Oct	1	15.0	55.3	24	7	0	1	0	0
04-Oct	1	14.3	50.7	25	13	0	0	0	0
05-Oct	1	13.7	50.7	34	8	0	0	0	0
06-Oct	1	12.7	53.0	35	36	0	2	1	0
07-Oct	1	12.7	53.7	54	13	0	0	0	0
08-Oct	1	15.0	52.0	6	7	0	0	0	0
09-Oct	1	15.0	50.3	16	18	7	0	0	0
10-Oct	1	15.0	51.0	112	61	2	2	0	0
11-Oct	1	13.3	50.7	17	16	0	0	0	0
12-Oct	1	13.3	50.0	13	6	0	0	0	0
13-Oct	1	14.7	50.3	16	10	0	0	0	0
14-Oct	1	13.7	50.0	10	4	2	0	0	0
15-Oct	1	13.0	50.0	5	1	0	0	0	0
16-Oct	1 - 2	13.3	51.7	26	14	0	0	0	0
17-Oct	1 - 2	13.0	57.3	746	196	195	78	18	0
18-Oct	1 - 2	12.8	63.0	253	48	73	11	5	1
19-Oct	1 - 2	13.0	63.0	60	14	43	4	2	0
20-Oct	2	13.0	83.7	208	30	67	4	43	0
21-Oct	1	12.3	82.7	55	11	113	10	25	0
22-Oct	1	12.3	82.3	32	4	55	5	37	1

Table 1. (continued)

Date	Visibility	Temp (^0C)	Depth (cm)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unknown
23-Oct	1	13.0	81.7	15	4	47	6	9	0
24-Oct	1	13.0	77.5	9	4	60	9	8	0
Total				4667	1391	668	132	148	4

Visibility Code: 1 = clear; 2 = cloudy.

Table 2. Counts, by time interval, at the Cowichan River fence, 2000.

Time Period	Chinook				Coho				Chum	
	Adult		Jack		Adult		Jack			
	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	116	2.5	53	3.8	38	5.7	10	7.6	3	2.0
0100 - 0200	156	3.3	47	3.4	33	4.9	4	3.0	0	0.0
0200 - 0300	248	5.3	94	6.8	37	5.5	2	1.5	5	3.4
0300 - 0400	229	4.9	68	4.9	34	5.1	2	1.5	2	1.4
0400 - 0500	134	2.9	89	6.4	18	2.7	1	0.8	1	0.7
0500 - 0600	173	3.7	74	5.3	16	2.4	3	2.3	3	2.0
0600 - 0700	129	2.8	49	3.5	14	2.1	5	3.8	0	0.0
0700 - 0800	495	10.6	154	11.1	31	4.6	7	5.3	1	0.7
0800 - 0900	697	14.9	161	11.6	46	6.9	7	5.3	17	11.5
0900 - 1000	487	10.4	99	7.1	34	5.1	3	2.3	42	28.4
1000 - 1100	244	5.2	45	3.2	27	4.0	1	0.8	18	12.2
1100 - 1200	187	4.0	24	1.7	77	11.5	15	11.4	4	2.7
1200 - 1300	36	0.8	11	0.8	52	7.8	10	7.6	7	4.7
1300 - 1400	12	0.3	6	0.4	8	1.2	0	0.0	2	1.4
1400 - 1500	23	0.5	8	0.6	31	4.6	15	11.4	0	0.0
1500 - 1600	114	2.4	21	1.5	24	3.6	8	6.1	6	4.1
1600 - 1700	110	2.4	33	2.4	8	1.2	12	9.1	2	1.4
1700 - 1800	228	4.9	44	3.2	42	6.3	5	3.8	2	1.4
1800 - 1900	81	1.7	28	2.0	11	1.6	1	0.8	2	1.4
1900 - 2000	50	1.1	3	0.2	4	0.6	5	3.8	7	4.7
2000 - 2100	71	1.5	33	2.4	21	3.1	5	3.8	9	6.1
2100 - 2200	168	3.6	101	7.3	15	2.2	7	5.3	9	6.1
2200 - 2300	240	5.1	83	6.0	25	3.7	2	1.5	0	0.0
2300 - 2400	239	5.1	63	4.5	22	3.3	2	1.5	6	4.1
Total	4667	100	1391	100	668	100	132	100	148	100

Table 3. Visual survey data collected for the Cowichan River for the years 1981 to 2000.

			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. (continued)

	Method[1]	Date		Chinook Jacks Count	Jacks Estimate	Adults Count	Adults 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. (continued)

			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. (continued)

	Method[1]	Date		Chinook Jacks Count	Jacks Estimate	Adults Count	Adults Estimate	River Segment[2]
1996	S	Sept.	13	45		46	147	2-6
	S		26	166		150	510	2-6
	S	Oct.	2	254		534	1815	2-6
	S		9	579		1157	3933	2-6
	S		15	195		707	2403	2-6
	S		22	557		1699	5776	2-6
Estimate for Season[6]							6500	
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	
1999	S	Sept.	10	88		46	221	2-6
	S	Oct.	13	321		342	1641	2-6
Estimate for Season							4500	
2000	S	Sept.	13	33		25		2-6

[1]S - Swim survey, H - Helicopter survey, F - boat survey
[2]Refer to Figure 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. Estimated catch of chinook adults and jacks in the Cowichan River Native food fishery[1] for the years 1981 to 2000.

Year[2]	Chinook Catch Adult	Jack[3]
1971	725	
1972	700	
1973	900	
1974	1000	
1975	900	
1976	1000	
1977	1000	
1978	500	
1979	500	
1980	1500	
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	820	150
1991	250	70
1992	260	12
1993	295	22
1994	345	227
1995	533	120
1996	810	150
1997	191	na
1998	1073	na
1999	233	89
2000	89	na

[1] Includes chinook caught in both the spear fishery and the in-river gillnet fishery.
[2] Since 1988, data has been collected by the Cowichan Tribes River Management unit. Prior to 1988, data were collected by local Fishery Officers.
[3] Estimates for jack chinook were not provided in 1997, 1998 and 2000.

Table 5. Summary, by day and location, of chinook broodstock collection by Cowichan River hatchery staff during 2000.

Date	Below Fence			Above Fence		
	Male	Jack	Female	Male	Jack	Female
18-Sep	52	0	60	0	0	0
19-Sep	55	0	51	0	0	0
20-Sep	12	0	18	0	0	0
21-Sep	18	0	24	0	0	0
22-Sep	16	0	9	0	0	0
25-Sep	4	0	5	0	0	0
26-Sep	35	0	49	0	0	0
27-Sep	4	0	2	0	0	0
29-Sep	34	0	63	0	0	0
2-Oct	98	0	141	0	0	0
3-Oct	51	14	57	0	0	0
4-Oct	131	0	135	0	0	0
5-Oct	54	0	57	0	0	0
6-Oct	15	0	9	0	0	0
10-Oct	41	0	38	0	0	0
11-Oct	20	0	15	0	0	0
12-Oct	26	0	23	0	0	0
13-Oct	16	0	23	0	0	0
16-Oct	20	0	16	0	0	0
17-Oct	12	0	6	1	0	2
18-Oct	9	0	2	0	0	0
Total	723	14	803	1	0	2

Table 6. Annual hatchery broodstock collection of adult and jack Cowichan River chinook for the years 1981 to 2000.

	Chinook Broodstock Collection	
Year	Adult	Jack[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	1485	201
1999	1659	1
2000	1529	14

[1] Barry Cordecedo (Salmonid Enhancement Program) provided numbers on broodstock collection from 1981 to 1987. The broodstock numbers provided included jacks, but no reliable records were kept. It was estimated that for most years about 10 to 15 jacks were collected. These estimates were subtracted from the broodstock numbers resulting in 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 age, by sex, for Cowichan River chinook collected for hatchery broodstock during 2000.

Age	Male		Female		Total Adult		Jack	
	#	%	#	%	#	%	#	%
2	1	1.4%	0	0.0%	1	0.5%	1	33.3%
3	38	55.1%	18	14.1%	56	28.4%	2	66.7%
4	28	40.6%	106	82.8%	134	68.0%	0	0.0%
5	2	2.9%	4	3.1%	6	3.0%	0	0.0%
Total	69	100%	128	100%	197	100%	3	100%

Table 8. Length-frequency of chinook sampled on the Cowichan River spawning grounds, 2000.

Length (cm)	Males	Jacks	Females
23	0	1	0
24	0	0	0
25	0	0	0
26	0	0	0
27	0	0	0
28	0	1	0
29	0	3	0
30	0	5	0
31	0	10	0
32	0	16	0
33	0	17	0
34	0	20	0
35	0	38	0
36	0	56	0
37	0	44	0
38	0	54	1
39	0	58	0
40	0	59	0
41	0	46	0
42	0	56	0
43	1	40	0
44	0	38	0
45	5	22	1
46	14	1	1
47	5	1	0
48	7	1	0
49	5	0	4
50	9	1	2
51	5	0	3
52	10	0	1
53	8	0	3

Table 8. (continued)

Length (cm)	Males	Jacks	Females
54	5	0	6
55	6	0	5
56	13	0	10
57	7	0	6
58	15	0	9
59	8	0	10
60	10	0	9
61	8	1	17
62	11	0	23
63	9	0	13
64	6	0	21
65	9	0	21
66	1	0	15
67	5	0	19
68	7	0	18
69	5	0	22
70	1	0	13
71	12	0	9
72	4	0	7
73	3	0	7
74	3	0	8
75	0	0	5
76	0	0	2
77	0	0	1
78	2	0	0
79	0	0	0
80	1	0	0
81	2	0	0
82	0	0	0
83	1	0	0
84	0	0	0
85	0	0	0
86	0	0	0
87	1	0	0
Total	229	589	292
Mean Length (cm)	58.8	38.7	64.0
Adipose Fin Clips	11	38	10
Fin Clip Rate	4.8%	6.5%	3.4%

Table 9. Summary of age, by sex, for Cowichan River chinook collected from the spawning grounds during 2000.

	Male		Female		Total Adult		Jack	
Age	#	%	#	%	#	%	#	%
2	13	15.1%	4	3.0%	17	7.7%	207	92.0%
3	46	53.5%	40	29.9%	86	39.1%	12	5.3%
4	24	27.9%	86	64.2%	110	50.0%	5	2.2%
5	3	3.5%	4	3.0%	7	3.2%	1	0.4%
Total	86	100%	134	100%	220	100%	225	100%

Table 10. Length-frequency of chinook hatchery broodstock collected during 2000.

Length (cm)	Males	Jacks	Females
40	0	0	0
41	0	0	0
42	0	0	0
43	0	0	0
44	0	1	0
45	1	0	0
46	0	0	0
47	0	0	0
48	0	0	0
49	0	1	0
50	0	1	0
51	1	1	0
52	1	0	0
53	0	1	0
54	2	0	1
55	1	0	0
56	3	0	1
57	4	0	1
58	3	0	4
59	2	0	5
60	3	0	5
61	1	0	4
62	4	0	2
63	2	0	3
64	2	0	5
65	5	0	3
66	2	0	12
67	1	0	6
68	4	0	17
69	2	0	12
70	1	0	7

Table 10. (continued)

Length (cm)	Males	Jacks	Females
71	1	0	11
72	0	0	8
73	3	0	7
74	2	0	10
75	0	0	2
76	2	0	4
77	1	0	3
78	2	0	4
79	0	0	2
80	0	0	1
81	0	0	0
82	0	0	2
83	0	0	0
Total	56	5	142
Mean Length (cm)	63.7	49.6	68.6
Adipose Fin Clips	5	1	17
Fin Clip Rate	8.9%	20.0%	12.0%

Table 11. Release and recovery data for coded wire tags recovered from Cowichan River chinook sampled on the spawning grounds during 2000.

Recovery Data				Release Data			
Date (dd/mm/yy)	Location	POH Length (mm)	Sex	Brood Year	Tag Code	Location [1]	Date (dd/mm/yy)
30/10/00	6	620	F	97	182740	Cowichan R.	29/04/97
31/10/00	11	659	F	97	182801	Cowichan R.	13/05/98
31/10/00	24	445	J	98	183730	Cowichan R.	10/05/99
31/10/00	24	415	J	98	183733	Cowichan R.	10/05/99
02/11/00	13	595	F	97	182761	Cowichan R.	09/04/98
02/11/00	13	383	J	98	183730	Cowichan R.	10/05/99
03/11/00	22	623	M	97	182563	Chemainus R.	21/05/98
03/11/00	22	643	M	97	182801	Cowichan R.	13/05/98
03/11/00	38	572	F	97	182802	Cowichan R.	13/05/98
03/11/00	29	574	F	97	182803	Cowichan R.	13/05/98
03/11/00	21	605	F	97	182804	Cowichan R.	21/05/98
03/11/00	29	391	J	98	183733	Cowichan R.	10/05/99
06/11/00	6	650	M	97	182563	Cowichan R.	21/05/98
06/11/00	13	550	M	97	182805	Cowichan R.	21/05/98
06/11/00	11	390	J	98	183726	Cowichan Lake	07/05/99
06/11/00	6	505	M	98	183731	Cowichan R.	10/05/99
06/11/00	16	365	J	98	183733	Cowichan R.	10/05/99
06/11/00	10	392	J	98	183734	Cowichan R.	17/05/99

Table 11. (continued).

Recovery Data				Release Data			
Date (dd/mm/yy)	Location	POH Length (mm)	Sex	Brood Year	Tag Code	Location [1]	Date (dd/mm/yy)
08/11/00	13	384	J	98	183730	Cowichan R.	10/05/99
08/11/00	21	428	J	98	183730	Cowichan R.	10/05/99
08/11/00	21	430	J	98	183730	Cowichan R.	10/05/99
09/11/00	24	544	F	97	182763	Cowichan R.	09/04/98
09/11/00	22	564	M	97	183213	Cowichan R.	25/05/98
09/11/00	24	402	J	98	183726	Cowichan Lake	07/05/99
09/11/00	24	368	J	98	183728	Cowichan R.	31/03/99
09/11/00	22	395	J	98	183731	Cowichan R.	10/05/99
09/11/00	23	394	J	98	183732	Cowichan R.	10/05/99
10/11/00	17	376	J	98	183732	Cowichan R.	10/05/99
10/11/00	38	430	J	98	183732	Cowichan R.	10/05/99
10/11/00	29	394	J	98	183734	Cowichan R.	17/05/99
15/11/00	10	362	J	98	183731	Cowichan R.	10/05/99
15/11/00	10	434	J	98	183731	Cowichan R.	10/05/99
15/11/00	10	391	J	98	183734	Cowichan R.	17/05/99
16/11/00	11	425	J	98	183730	Cowichan R.	10/05/99
16/11/00	13	442	J	98	183730	Cowichan R.	10/05/99
16/11/00	12	455	M	98	183731	Cowichan R.	10/05/99
16/11/00	11	385	J	98	183731	Cowichan R.	10/05/99
17/11/00	17	415	J	98	183730	Cowichan R.	10/05/99
17/11/00	17	387	J	98	183731	Cowichan R.	10/05/99
17/11/00	25	410	J	98	183731	Cowichan R.	10/05/99
17/11/00	17	462	M	98	183732	Cowichan R.	10/05/99
17/11/00	25	422	J	98	183732	Cowichan R.	10/05/99
17/11/00	17	479	M	98	183733	Cowichan R.	10/05/99
17/11/00	17	448	J	98	183733	Cowichan R.	10/05/99
17/11/00	25	396	J	98	183733	Cowichan R.	10/05/99
17/11/00	25	409	J	98	183734	Cowichan R.	17/05/99
20/11/00	21	537	F	97	182803	Cowichan R.	13/05/98
20/11/00	23	521	F	97	183213	Cowichan R.	25/05/98
20/11/00	23	441	J	98	183731	Cowichan R.	10/05/99
20/11/00	23	416	J	98	183734	Cowichan R.	17/05/99
22/11/00	10	390	J	98	183734	Cowichan R.	17/05/99
24/11/00	12	681	M	97	182744	Cowichan R.	05/05/97
24/11/00	21	324	J	98	183734	Cowichan R.	17/05/99

[1] Cowichan Hatchery release strategies for chinook:

Upper Cowichan (late): raised to pre-smolt size (5-6 g) prior to release approximately 3 km below the weir in May.

Upper Cowichan (early): raised to fry (3 g) prior to release approximately 3 km below the weir in early April.

Cowichan Lake Pen: raised to pre-smolt size (5-6 g) prior to release just above the weir in May.

Hatchery (late): raised to pre-smolt size (5-6 g) prior to release at the hatchery in May.

Seapen: raised to smolt size (6+ g) prior to release from the netpens in Cowichan Bay in early June.

Table 12. Cowichan River hatchery chinook release[1] data for the years 1979 to 2000.

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
021846	1979	31628	32134	98.4	2.8		1980/05/07	COWICHAN R
022060	1979	32034	32547	98.4	2.8		1980/05/07	SKUTZ FALLS
022158	1980	52519	65000	80.8	2.3		1981/06/09	COWICHAN R
022307	1981	30179	30373	99.4	3.1		1982/05/12	COWICHAN R
022339	1982	49135	224944	21.8	2.9		1983/05/14	SKUTZ FALLS
022831	1983	50613	101000	50.1	4.27		1984/05/25	KOKSILAH R
NOCN8311	1983		200000	0.0	4.27		1984/05/31	COWICHAN R
NOCN8411	1984		187823	0.0	4.8	1985/05/13	1985/05/14	COWICHAN R
023803	1985	25365	25804	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
023804	1985	25455	25895	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
023911	1985	11980	12187	98.3	4.26	1986/05/23	1986/05/24	COWICHAN R
NOCN8619	1986		321172	0.0	4	1987/05/13	1987/05/22	COWICHAN R
NOCN8620	1986		54608	0.0	3.48		1987/05/21	KOKSILAH R
024334	1987	14298	14334	99.7	3.41		1988/04/18	COWICHAN R
024729	1987	25360	25424	99.7	3.4		1988/04/18	COWICHAN R
024730	1987	25869	25934	99.7	3.4		1988/04/18	COWICHAN R
024731	1987	27428	27497	99.7	7.1	1988/04/18	1988/05/18	COWICHAN LK
024732	1987	27271	27339	99.8	7.1		1988/05/18	COWICHAN LK
024733	1987	26911	26978	99.8	7.1		1988/05/18	COWICHAN LK
024734	1987	23521	23580	99.7	7.1		1988/05/18	COWICHAN LK
024735	1987	26719	26786	99.7	3.4	1988/04/18	1988/05/18	COWICHAN R
024945	1987	26461	123361	21.5	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024946	1987	26658	123560	21.6	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024947	1987	26761	123663	21.6	7.49	1988/05/25	1988/05/26	COWICHAN R UP
025008	1987	26817	123720	21.7	7.49	1988/05/25	1988/05/26	COWICHAN R UP
024860	1988	25117	25243	99.5	3.66		1989/04/28	COWICHAN R
025012	1988	26595	54768	48.6	6.49		1989/05/21	COWICHAN R
025013	1988	25982	54154	48.0	6.49		1989/05/21	COWICHAN R
025015	1988	23058	24894	92.6	3.66		1989/04/28	COWICHAN R
025016	1988	26821	26821	100.0	3.66		1989/04/28	COWICHAN R
025017	1988	27611	28175	98.0	3.66		1989/04/28	COWICHAN R
025523	1988	27531	56123	49.1	6.49		1989/05/21	COWICHAN R
025524	1988	27205	55378	49.1	6.49		1989/05/21	COWICHAN R
025749	1988	26922	133331	20.2	6.06		1989/05/15	COWICHAN LK
025750	1988	27036	133446	20.3	6.06		1989/05/15	COWICHAN LK
025751	1988	23106	130107	17.8	6.06		1989/05/15	COWICHAN LK
025752	1988	26169	132842	19.7	6.06		1989/05/15	COWICHAN LK
020352	1989	28287	28573	99.0	3.4	1990/04/12	1990/04/12	COWICHAN R
020522	1989	27072	36800	73.6	6.53	1990/05/22	1990/05/23	COWICHAN R
020622	1989	27787	37242	74.6	6.53	1990/05/22	1990/05/23	COWICHAN R
020623	1989	28164	37619	74.9	6.53	1990/05/22	1990/05/23	COWICHAN R
020624	1989	28331	37786	75.0	6.53	1990/05/22	1990/05/23	COWICHAN R
020938	1989	28312	28312	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R
020939	1989	26218	26218	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R
026103	1989	27145	27145	100.0	3.4	1990/04/12	1990/04/12	COWICHAN R

Table 12 (continued).

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
026255	1989	26400	119674	22.1	7.19		1990/05/14	COWICHAN LK
026256	1989	25693	119497	21.5	7.19		1990/05/14	COWICHAN LK
026257	1989	25790	119325	21.6	7.19		1990/05/14	COWICHAN LK
026258	1989	25219	118748	21.2	7.19		1990/05/14	COWICHAN LK
020333	1990	25687	94172	27.3	8.43	1991/05/15	1991/05/15	COWICHAN LK
020334	1990	25898	94384	27.4	8.43	1991/05/15	1991/05/15	COWICHAN LK
020335	1990	25739	94224	27.3	8.43	1991/05/15	1991/05/15	COWICHAN LK
020336	1990	27135	27135	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020337	1990	26631	26631	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020338	1990	27046	27046	100.0	3.31	1991/04/17	1991/04/17	COWICHAN R
020339	1990	26721	34318	77.9	6.4	1991/05/21	1991/05/22	COWICHAN R
020340	1990	26993	34592	78.0	6.4	1991/05/21	1991/05/22	COWICHAN R
020341	1990	26533	33995	78.0	6.4	1991/05/21	1991/05/22	COWICHAN R
020342	1990	25437	92182	27.6	4.75	1991/06/17	1991/06/18	COWICHAN R
020343	1990	25391	92136	27.6	4.75	1991/06/17	1991/06/18	COWICHAN R
NOCN9044	1990		5086	0.0	5.41	1991/06/26	1991/06/26	COWICHAN ESTUARY
180513	1991	26972	336330	8.0	5.04	1992/05/17	1992/05/17	COWICHAN LK
180514	1991	25964	335584	7.7	5.04	1992/05/17	1992/05/17	COWICHAN LK
180515	1991	27694	254287	10.9	4.01	1992/04/21	1992/04/22	COWICHAN R LOW
180516	1991	27148	254015	10.7	4.01	1992/04/21	1992/04/22	COWICHAN R LOW
180517	1991	27471	505110	5.4	5.47	1992/05/19	1992/05/21	COWICHAN R UP
180518	1991	27277	504916	5.4	5.47	1992/05/19	1992/05/21	COWICHAN R UP
180519	1991	27432	160695	17.1	3.75	1992/04/21	1992/04/22	COWICHAN R LOW
180520	1991	27001	160262	16.8	3.75	1992/04/21	1992/04/22	COWICHAN R LOW
180521	1991	26871	27444	97.9	6.29	1992/05/29	1992/05/29	COWICHAN ESTUARY
180522	1991	26852	27424	97.9	6.29	1992/05/29	1992/05/29	COWICHAN ESTUARY
NOCN9145	1991		513053	0.0	5.69	1992/05/19	1992/05/20	COWICHAN R UP
180209	1992	24770	98974	25.0	6.3	1993/05/25	1993/05/25	COWICHAN ESTUARY
180210	1992	26383	327416	8.1	5.86	1993/05/17	1993/05/19	COWICHAN R UP
180550	1992	25311	326344	7.8	5.86	1993/05/17	1993/05/19	COWICHAN R UP
181042	1992	53620	412953	13.0	6.52	1993/05/25	1993/05/25	COWICHAN R
181043	1992	54235	901937	6.0	5.64	1993/05/10	1993/05/10	COWICHAN LK
181044	1992	55027	907719	6.1	3.56	1993/04/07	1993/04/07	COWICHAN R UP
021211	1993	24875	103900	23.9	6.17	1994/05/25	1994/05/25	COWICHAN BAY
181319	1993	49966	1001002	5.0	6.29	1994/05/05	1994/05/05	COWICHAN LK
181320	1993	50420	684279	7.4	3.79	1994/04/18	1994/04/18	COWICHAN R UP
181321	1993	50045	652354	7.7	6.11	1994/05/18	1994/05/18	COWICHAN R UP
181322	1993	50285	490079	10.3	6.06	1994/05/24	1994/05/24	COWICHAN R
181329	1994	25023	103815	24.1	6.08	1995/05/31	1995/05/31	COWICHAN BAY
181436	1994	50133	100252	50.0	5.44	1995/05/30	1995/05/30	COWICHAN R
181437	1994	49962	418750	11.9	4	1995/05/02	1995/05/02	COWICHAN R UP
181438	1994	49610	939287	5.3	6.32	1995/05/15	1995/05/17	COWICHAN R UP
181439	1994	49846	101763	49.0	6.48	1995/05/25	1995/05/25	COWICHAN LK
182023	1995	25114	109088	23.0	6.76	1996/05/10	1996/05/10	COWICHAN BAY
182024	1995	25653	297360	8.6	6.56	1996/05/06	1996/05/06	COWICHAN LK
182025	1995	24488	283856	8.6	6.56	1996/05/06	1996/05/06	COWICHAN LK
182026	1995	25183	355089	7.1	6.26	1996/05/07	1996/05/07	COWICHAN R UP

Table 12. (continued).

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
182027	1995	25218	355583	7.1	6.26	1996/05/07	1996/05/07	COWICHAN R UP
182028	1995	25052	344597	7.3	3.47	1996/04/02	1996/04/02	COWICHAN R UP
182029	1995	25129	345657	7.3	3.47	1996/04/02	1996/04/02	COWICHAN R UP
182030	1995	25196	245910	10.2	6.37	1996/05/09	1996/05/09	COWICHAN R
182031	1995	25020	244193	10.2	6.37	1996/05/09	1996/05/09	COWICHAN R
182737	1996	25235	100196	25.2	6.79	1997/05/07	1997/05/07	COWICHAN BAY
182738	1996	25108	318583	7.9	5.44	1997/04/30	1997/04/30	COWICHAN LK
182739	1996	25205	319814	7.9	5.44	1997/04/30	1997/04/30	COWICHAN LK
182740	1996	25218	448340	5.6	6.29	1997/04/28	1997/04/29	COWICHAN R UP
182741	1996	25649	456002	5.6	6.29	1997/04/28	1997/04/29	COWICHAN R UP
182742	1996	25457	401644	6.3	3.34	1997/04/01	1997/04/01	COWICHAN R UP
182743	1996	25019	394733	6.3	3.34	1997/04/01	1997/04/01	COWICHAN R UP
182744	1996	25154	219780	11.4	5.89	1997/05/05	1997/05/05	COWICHAN R
182745	1996	25082	219151	11.4	5.89	1997/05/05	1997/05/05	COWICHAN R
182761	1997	25213	25213	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182762	1997	25206	25206	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182763	1997	25698	25698	100.0	3.68	1998/04/09	1998/04/09	COWICHAN R UP
182801	1997	24817	28209	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182802	1997	24890	28282	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182803	1997	24923	28316	88.0	6.47	1998/05/13	1998/05/13	COWICHAN R UP
182804	1997	24971	24971	100.0	6.46	1998/05/21	1998/05/21	COWICHAN R
182805	1997	25026	25026	100.0	6.46	1998/05/21	1998/05/21	COWICHAN R
183213	1997	24915	51754	48.1	6.27	1998/05/25	1998/05/25	COWICHAN BAY
183107	1998	25163	224868	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183108	1998	25201	225208	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183109	1998	24803	132012	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183110	1998	24927	132676	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183111	1998	25163	75629	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183112	1998	24875	74763	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183726	1998	25135	356567	7.0	5.93	1999/05/07	1999/05/07	COWICHAN LK
183727	1998	25136	356568	7.0	5.93	1999/05/07	1999/05/07	COWICHAN LK
183728	1998	25234	225504	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183729	1998	25087	224189	11.2	3.07	1999/03/31	1999/03/31	COWICHAN R UP
183730	1998	24867	132354	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183731	1998	24921	132644	18.8	6.56	1999/05/10	1999/05/10	COWICHAN R UP
183732	1998	24959	75015	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183733	1998	25024	75211	33.3	6.31	1999/05/10	1999/05/10	COWICHAN R
183734	1998	25127	99928	25.1	5.1	1999/05/17	1999/05/17	COWICHAN BAY
183119	1999	24855	270757	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183120	1999	24917	271436	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183121	1999	24933	271609	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183122	1999	25024	272601	9.2	3.19	2000/03/07	2000/03/07	COWICHAN R UP
183123	1999	24776	481197	5.1	6.58	2000/04/27	2000/04/28	COWICHAN R UP
183124	1999	24839	482428	5.1	6.58	2000/04/27	2000/04/28	COWICHAN R UP
183125	1999	25118	215385	11.7	6.99	2000/05/05	2000/05/05	COWICHAN R
183126	1999	25039	215306	11.6	6.99	2000/05/05	2000/05/05	COWICHAN R
183127	1999	25078	99936	25.1	8.66	2000/05/17	2000/05/17	COWICHAN BAY

Table 12. (continued).

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
182811	2000	25175	99829	25.2	7.98	2001/05/23	2001/05/23	COWICHAN BAY
183216	2000	25152	504558	5.0	6.55	2001/05/01	2001/05/01	COWICHAN R UP
183217	2000	24833	503194	4.9	6.55	2001/05/01	2001/05/01	COWICHAN R UP
184539	2000	50166	338640	14.8	6.21	2001/05/03	2001/05/03	COWICHAN R
184546	2000	49972	481337	10.4	3.19	2001/03/19	2001/03/20	COWICHAN R UP
184547	2000	50054	482162	10.4	3.19	2001/03/19	2001/03/20	COWICHAN R UP

[1] Cowichan Hatchery release strategies for chinook:

Upper Cowichan (late): raised to pre-smolt size (5-6 g) prior to release approximately 3 km below the weir in May.

Upper Cowichan (early): raised to fry (3 g) prior to release approximately 3 km below the weir in early April.

Cowichan Lake Pen: raised to pre-smolt size (5-6 g) prior to release just above the weir in May.

Hatchery (late): raised to pre-smolt size (5-6 g) prior to release at the hatchery in May.

Seapen: raised to smolt size (6+ g) prior to release from the netpens in Cowichan Bay in early June.

Table 13. Daily Cowichan River discharge[1] (m^3/s), during 2000.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	67.9	76	59.8	45	49	33.1	13.8	6.64	5.28	16.7	51.3	59.8
2	63.8	82.9	70	46.4	48.3	32.1	12.8	6.35	5.23	15.6	49.9	88.2
3	61.5	72	69.9	47.6	49.6	30.1	12.3	6.26	5.43	11.8	48.1	80.4
4	70.9	67.4	69.7	50.2	49.3	29	11.9	6.12	5.69	9.02	49.6	74.5
5	68.9	63.3	66.3	50.3	52.5	28.6	11	5.94	5.59	9.18	48.7	70.8
6	66.7	60.3	63.1	49.2	54.7	28.4	10.5	5.76	5.5	10.4	47.6	67.3
7	66.1	60	60	46.9	57.4	28.4	10.2	5.55	5.57	11.2	46.5	64
8	74.2	66.3	56.8	44.4	55.9	27.1	9.62	5.43	5.94	10.3	46.6	61
9	76.4	74.6	53.5	43.6	52.5	26	9.39	5.44	5.92	9.31	45.3	58.5
10	73.5	73.8	48.8	42.6	50.7	24.9	8.81	6.07	6	9.7	43.7	56.1
11	70.6	70.6	47.7	42.4	49	25	8.42	5.89	6	9.37	42.5	53.3
12	68.1	68.6	44.3	44.8	47	38.8	8.11	5.71	5.72	9.26	40.9	51.3
13	65.7	65.5	44.3	45.1	44.7	41.9	7.73	5.53	5.61	9.47	39.8	49.1
14	69.4	62.4	50.7	46	42.3	42.4	7.51	5.4	5.68	9.35	38.6	48.4
15	72.7	59.7	47.2	45.9	40.6	42.3	7.31	5.3	6.26	9.36	37.2	46.9
16	70.2	56.4	46.1	44.5	38.7	40.6	7.01	5.65	6.21	10.6	35.7	57.8
17	88.7	54.3	45.6	42.6	37	38.8	6.81	5.62	6.11	14.4	34.4	74.8
18	78.3	52.5	52.2	40.8	34.5	37.3	6.78	5.46	6.04	18.5	32.9	65
19	70.9	50	59.5	38.8	32.5	34.4	6.62	5.72	6	20	31.6	61.7
20	66.8	47.9	58.9	37	32.1	31.5	6.46	5.62	5.97	39.4	30.3	58.2
21	64.7	46.4	56.2	35.9	33.1	29.8	6.35	5.67	6.01	38.9	29.1	56.7
22	61.6	46.4	57.8	37.9	34.6	27.2	6.24	5.51	6.27	38.5	27.7	56.9
23	59.5	47.6	60.3	38.5	33.8	24.6	6.18	5.41	6.24	37.8	28.2	59.8
24	57.9	47	59.2	37.9	31.7	22.8	5.94	5.39	6.12	28.3	28	62.2
25	55.3	47	57.4	37	29	20	5.85	5.33	7.06	13.2	30.1	69.3
26	54	47.9	55.5	38.3	27.4	18.5	5.74	5.38	11.8	16.4	42	70.3
27	51.8	50.1	53.1	38.2	31.4	17.1	6.09	5.69	16.7	30.3	49.7	81.3
28	50.3	50.4	53.6	40.5	35.7	16.4	7.2	5.53	16.7	42	46.5	73.5
29	48.8	56.7	51.2	44.7	36.1	16.5	7.19	5.48	17.5	48.1	45.6	68.6
30	46.9		48.8	46.1	35.8	15	6.83	5.4	17.3	51.2	52.2	64.6
31	47.1		46.9		35		6.71	5.39		53.2		63.9
Total	2009	1724	1714	1289	1282	868.6	253.4	175.6	227.5	660.8	1220	1974
Mean	64.8	59.4	55.3	43.0	41.4	29.0	8.2	5.7	7.6	21.3	40.7	63.7
Max	88.7	82.9	70	50.3	57.4	42.4	13.8	6.64	17.5	53.2	52.2	88.2
Min	46.9	46.4	44.3	35.9	27.4	15	5.74	5.3	5.23	9.02	27.7	46.9

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

Table 14a. Daily summary of carcasses examined, tags applied and tagged recoveries, by sex, for chinook in the upper Cowichan River, 2000.

	Carcasses Examined				Tags Applied				Tagged Carcasses Recovered			
Date	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack
30-Oct	0	1	8	2	0	1	8	2	0	0	0	0
31-Oct	0	19	21	21	0	19	20	21	0	0	1	0
2-Nov	0	18	37	22	0	18	36	22	0	0	1	0
3-Nov	0	21	20	43	0	20	14	37	0	1	6	6
6-Nov	0	22	33	36	0	21	29	35	0	1	4	1
8-Nov	0	27	41	78	0	25	34	71	0	2	7	7
9-Nov	0	19	27	55	0	12	20	52	0	7	7	3
10-Nov	0	16	13	44	0	10	5	39	0	6	8	5
14-Nov	0	21	32	24	0	20	29	24	0	1	3	0
15-Nov	1	21	23	40	0	19	21	36	1	2	2	4
16-Nov	1	17	28	58	1	13	17	53	0	4	11	5
17-Nov	1	28	22	82	0	21	16	74	1	7	6	8
20-Nov	1	6	15	43	0	1	12	37	1	5	3	6
22-Nov	0	8	16	23	0	7	8	20	0	1	8	3
24-Nov	1	13	21	58	0	7	8	27	1	6	13	31
27-Nov	0	4	7	16	0	1	5	14	0	3	2	2
28-Nov	0	8	12	29	0	3	5	15	0	5	7	14
29-Nov	0	3	3	5	0	2	2	3	0	1	1	2
30-Nov	0	2	3	5	0	1	3	5	0	1	0	0
Total	5	274	382	684	1	221	292	587	4	53	90	97

Table 14b. Tags applied, carcasses examined and marks recovered, by sex, for chinook in the upper Cowichan River, 2000.

Sex	Tags Applied	Carcasses Examined	Marks Recovered	Percent Recovered
Male	221	274	53	24.0%
Female	292	382	90	30.8%
Jack	587	684	97	16.5%

Table 15. Petersen mark recaptures estimates, stratified by sex, for Cowichan River chinook, 2000.

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Male	1131	863	1398
Female	1233	1013	1453
Total Adult	**2364**	**2017**	**2710**
Jack	4110	3361	4859
Total Population	6474	5648	7299

Table 16. Incidence of tagged adult chinook in carcasses recovered on the upper Cowichan River spawning grounds, by recovery period and sex.

Recovery Period	Days of Recovery	Tagged Recoveries			Total Recoveries			Tag Incidence (%)		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Oct 30 - Nov 6	8	2	12	14	81	119	200	2.47	10.08	7.00
Nov 7 - 14	8	16	25	41	83	113	196	19.28	22.12	20.92
Nov 15 - 22	8	19	30	49	80	104	184	23.75	28.85	26.63
Nov 23 - 30	8	16	23	39	30	46	76	53.33	50.00	51.32
Total	32	53	90	143	274	382	656	19.34	23.56	21.80
Chi-Square test result:								37.99	31.60	
Critical Chi-Square (df = 3; p = 0.05)								7.82	7.82	

Table 17. Proportion of the tag application sample recovered on the upper Cowichan River spawning grounds, by application period and sex.

Application Period	Days of Application	Tags Applied Male	Tags Applied Female	Tags Applied Total	Tagged Recoveries Male	Tagged Recoveries Female	Tagged Recoveries Total	Percent Recovered Male	Percent Recovered Female	Percent Recovered Total
Oct 30 - Nov 6	8	79	107	186	16	36	52	20.25	33.64	27.96
Nov 7 - 14	8	67	88	155	13	30	43	19.40	34.09	27.74
Nov 15 - 22	8	61	74	135	23	22	45	37.70	29.73	33.33
Nov 23 - 30	8	14	23	37	1	2	3	7.14	8.70	8.11
Total		221	292	513	53	90	143	23.98	30.82	27.88
Chi-Square test result:								9.85	6.16	
Critical Chi-Square (df = 3; p = 0.05)								7.82	7.82	

Table 18. Sex composition of chinook in the tag application and recovery samples on the upper Cowichan River, 2000.

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	221	37.1%	45.4%	43.1%	274	37.1%	43.1%	41.8%
Female	292	62.9%	54.6%	56.9%	382	62.9%	56.9%	58.2%
Chi-Square test result:				2.93				1.67
Critical Chi-Square (df = 1; alpha = 0.05)				3.84				3.84

Table 19. Sex composition of chinook in the tag application and recovery samples on the upper Cowichan River, 2000 (jacks included).

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	221	22.1%	19.5%	20.1%	274	22.1%	20.1%	20.4%
Female	292	37.5%	23.5%	26.5%	382	37.5%	26.5%	28.5%
Jack	587	40.4%	57.0%	53.4%	684	40.4%	53.4%	51.1%
Chi-Square test result:				24.13				15.14
Critical Chi-Square (df = 2; alpha = 0.05)				5.99				5.99

Table 20. Total adult chinook returns to the Cowichan River for the years 1975 to 2000.

Year	Natural Spawners	Broodstock Removal	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	5500	282	1500	7282
1982	4500	534	1000	6034
1983	4500	242	250	4992
1984	5000	278	355	5633
1985	3500	175	1000	4675
1986	1832	315	800	2947
1987	1937	582	800	3319
1988	6200	678	681	7559
1989	5000 [1]	535 [2]	1055	6560
1990	5300	326	820	6446
1991	6000 [3]	1755	250	8005
1992	8500	1850	260	10610
1993	5058	1970	295	7323
1994	5050	1357	345	6752
1995	14300	2149	533	16982
1996	12980	1615	810	15405
1997	9845	125	191	10161
1998	4371	1485	1073	6929
1999	4500	1659	233	6692 [4]
2000	5109	1529	89	7027 [4]

[1] For the years 1989 to the present, the number of natural spawners was calculated as the number of adults recorded at the fence minus the adults removed for broodstock above the fence. In years when fence counts were incomplete, the cumulative run timing curve was used to expand the count.

[2] This number is the total broodstock removed and may include some jacks.

[3] Due to early flooding, estimate is based on expansion of swim surveys and weir counts.

[4] Includes an estimated 300 chinook lost to seal predation in the Cowichan estuary.

Figure 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:

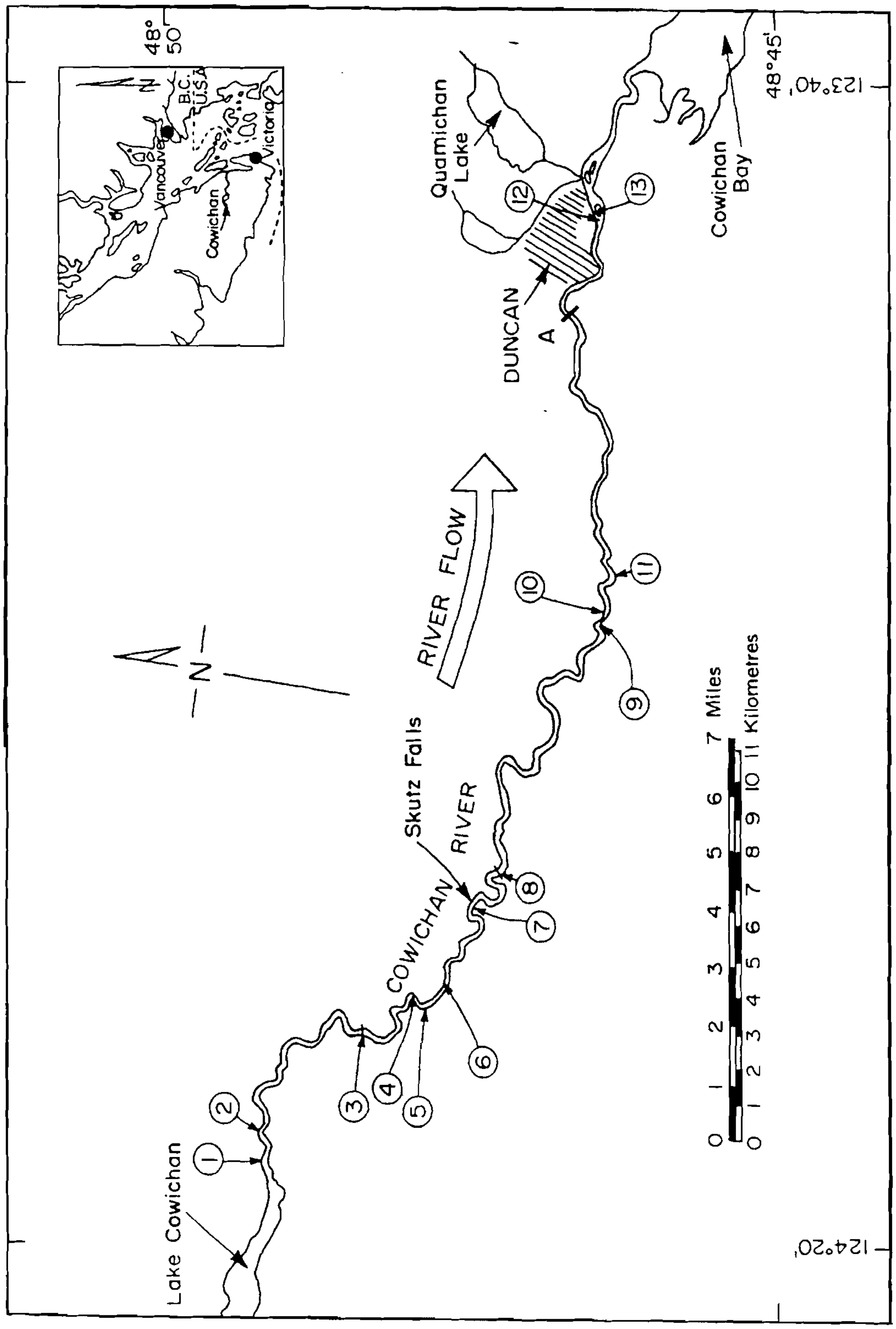
Bird House (1) to Three Firs pool (6) represents the Upper survey section.

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

Figure 2 River Management Zones for Native Food Fishery

A-Cliffs to Silver bridge

B-Silver bridge to JC's place

C-Quamichan to Black creek

D-Powerline to Elliot's barn

E-Elliot's barn to Brian's pool

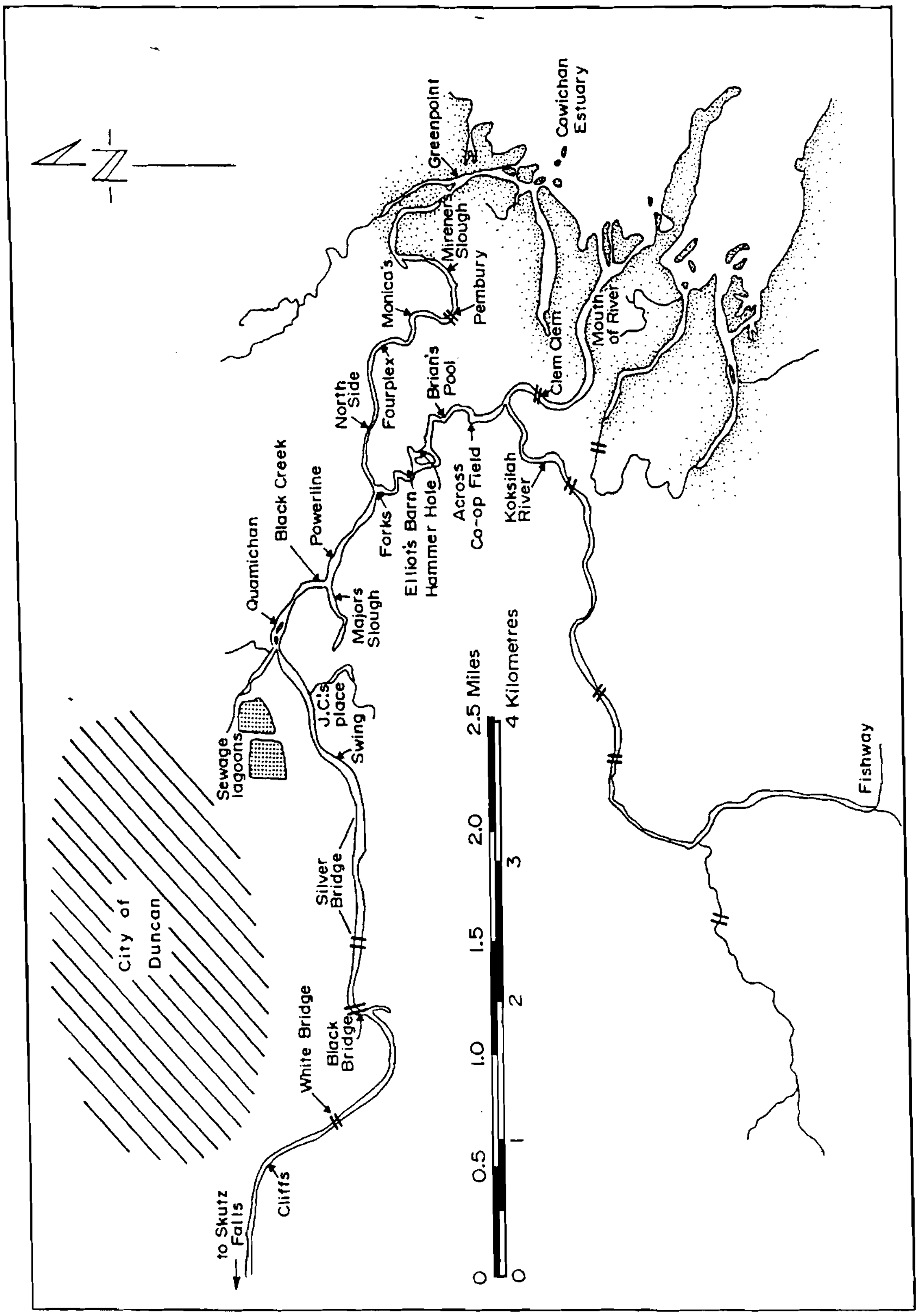
F-Brian's pool to Clem Clem and part of Koksilah

G-Clem Clem to mouth

H-North side to Four plex

I-Four plex to Meriner's slough

J-Meriner's slough to mouth


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

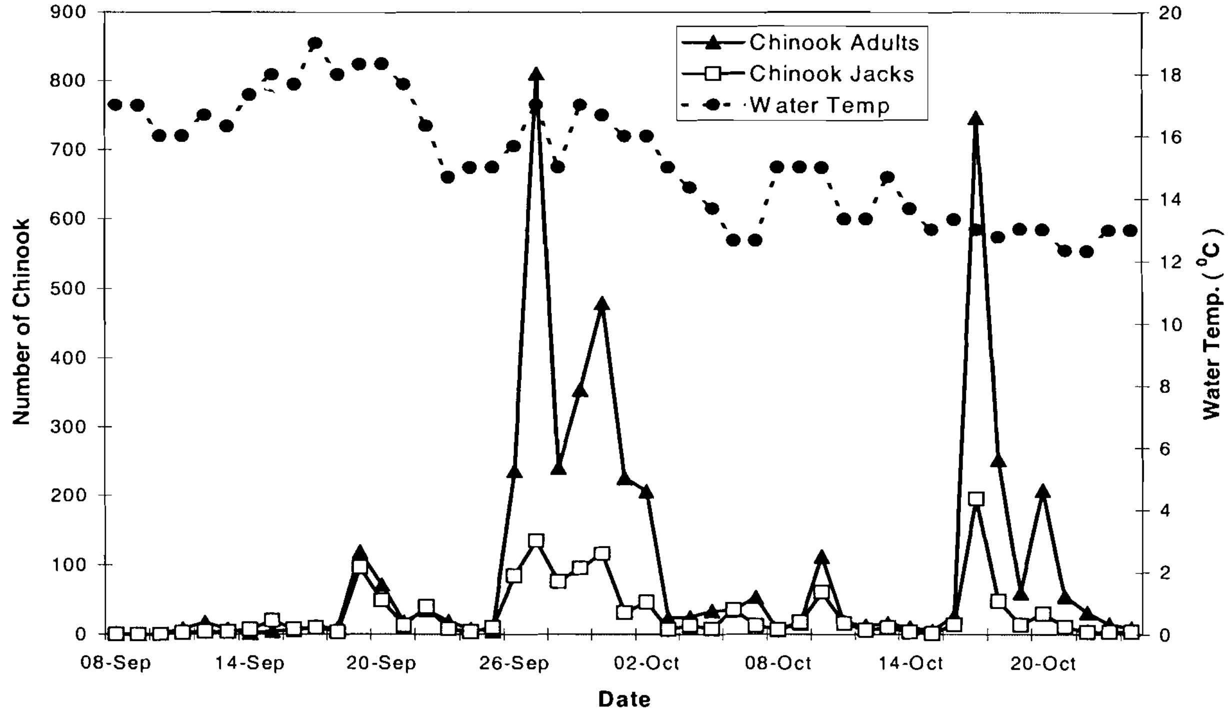


Figure 3a. Daily fence counts of adult and jack chinook and water temperature at the fence site.

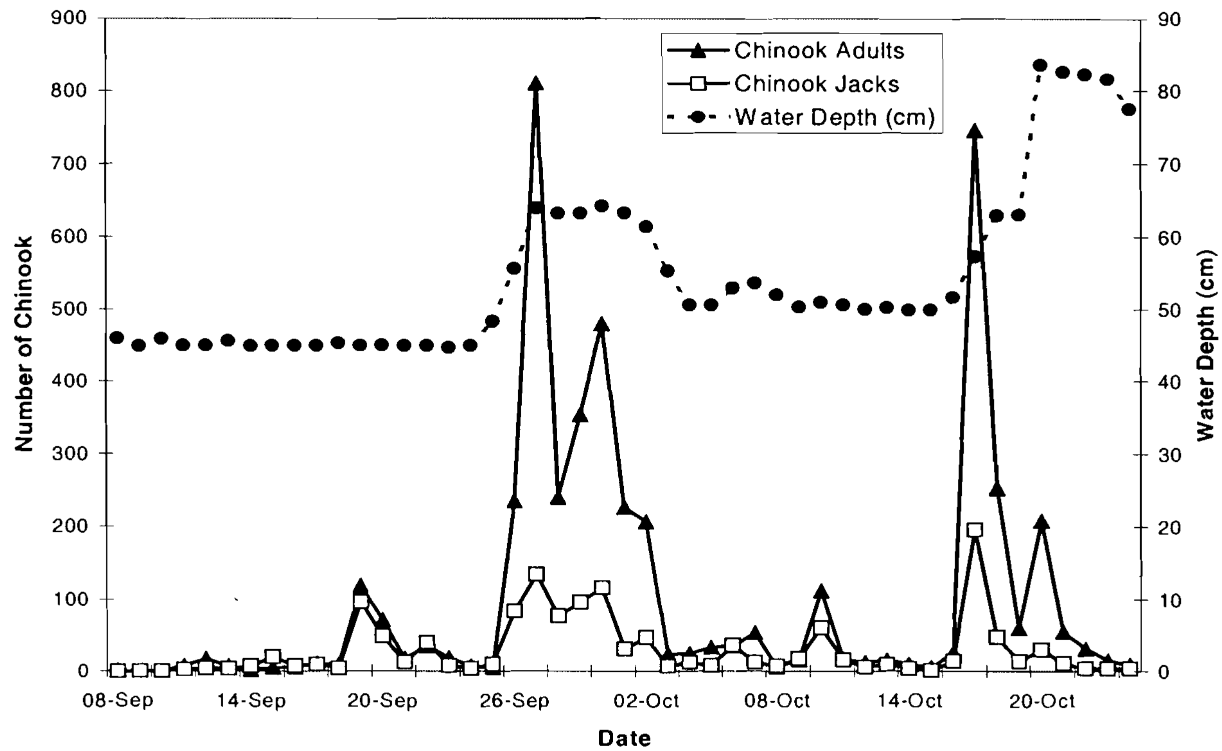


Figure 3b. Daily fences count of adult and jack chinook and water depth at the fence site.

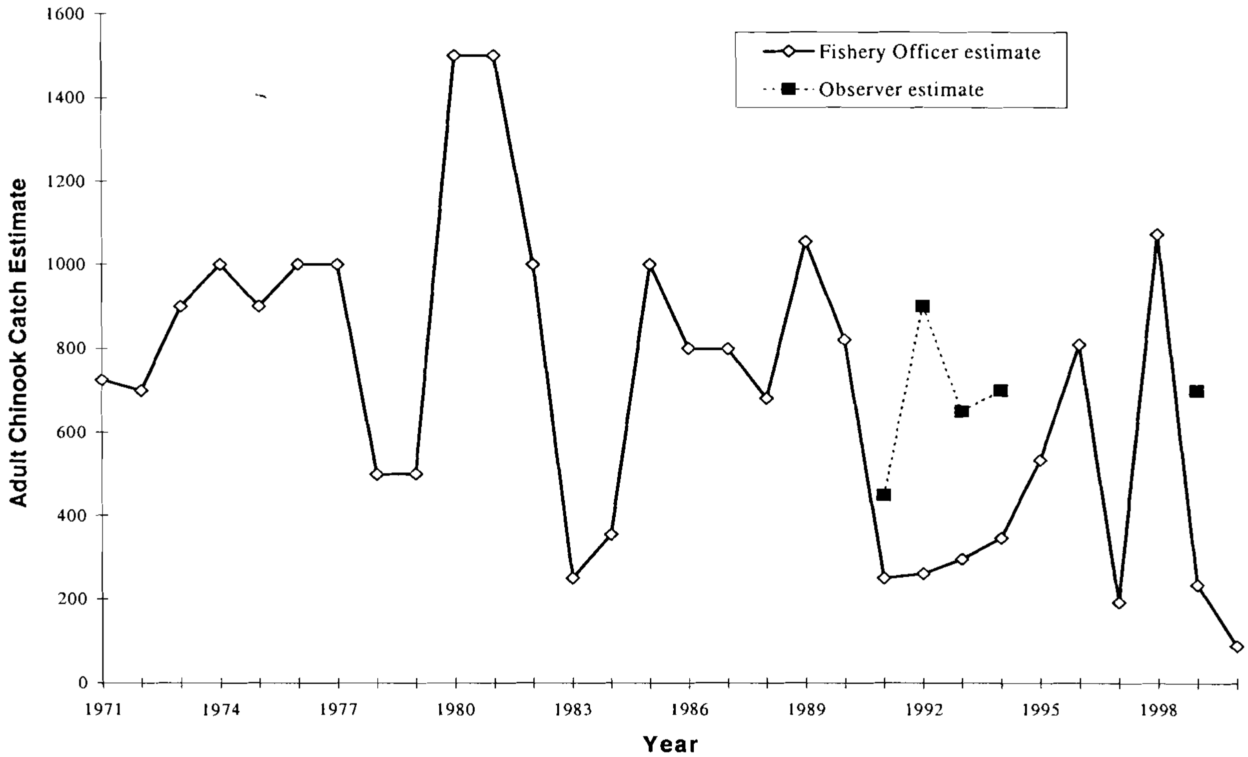


Figure 4. Adult chinook catch in the Cowichan First Nations fishery for the years 1971 to 2000.

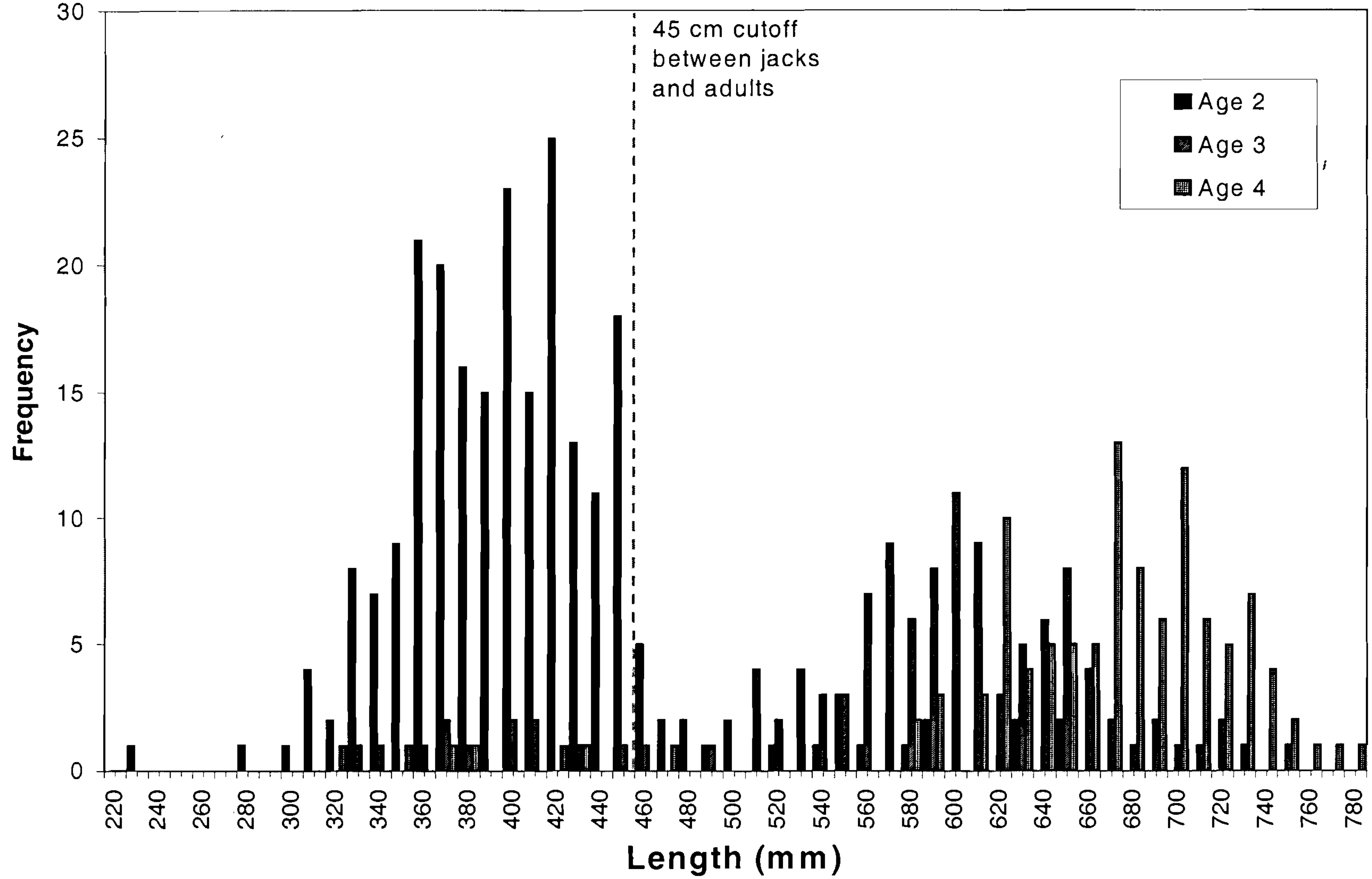


Figure 5. Chinook length at age data from carcass biosampling on the spawning grounds.

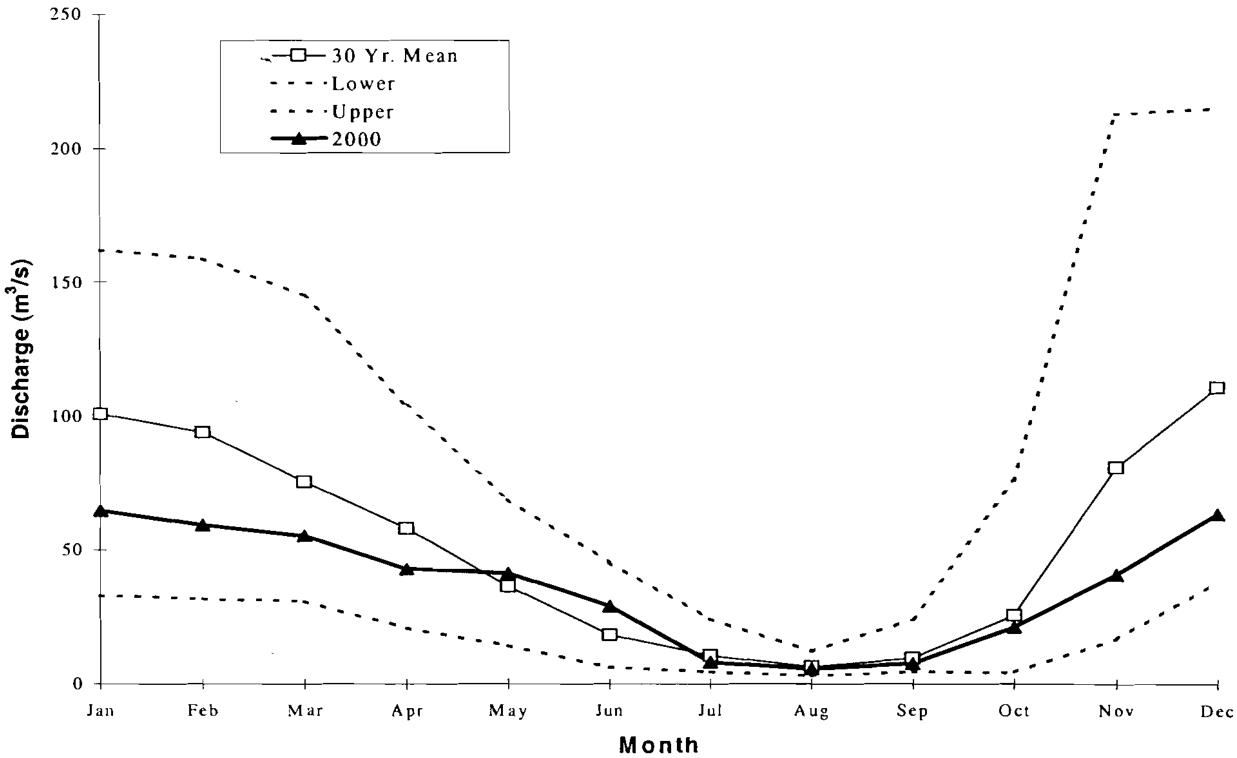


Figure 6. Monthly Cowichan River discharge (m^3/s) in 2000 along with historical values.

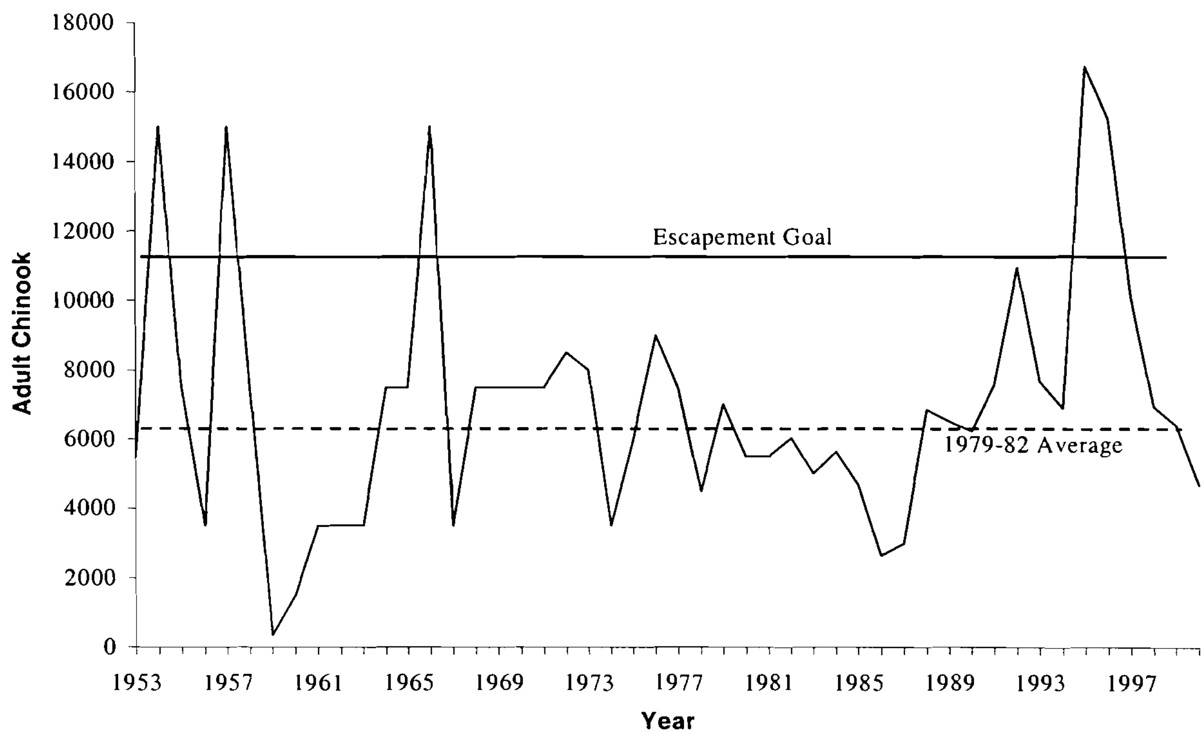


Figure 7. Adult chinook escapement estimates for the Cowichan River for the years 1953 to 2000.

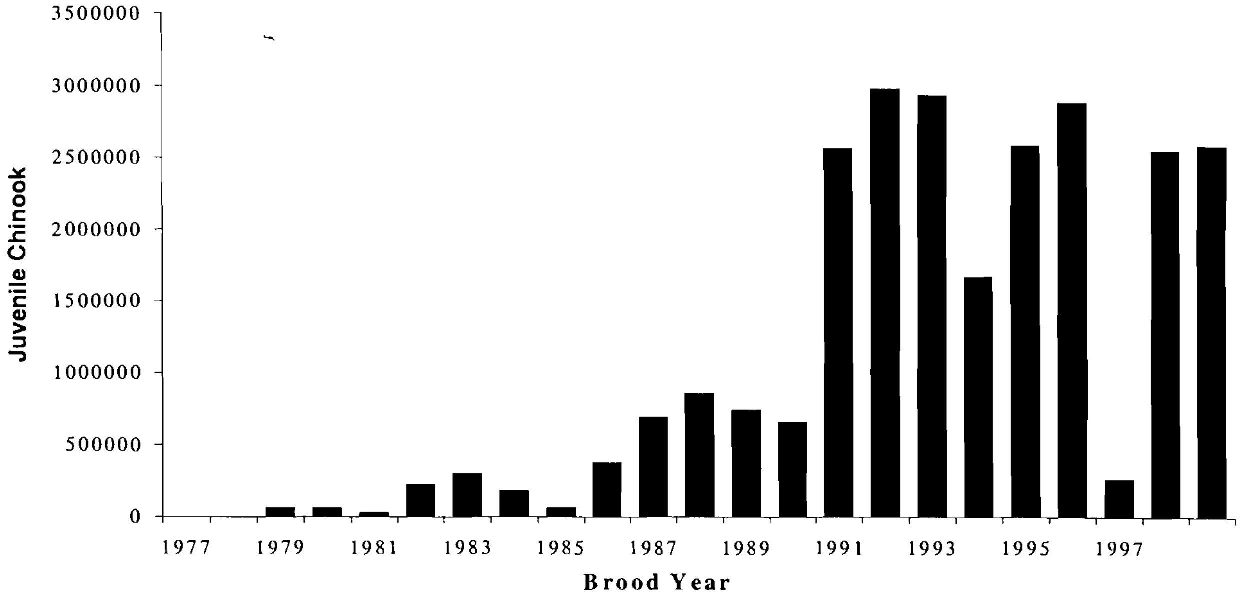


Figure 8. Annual releases of hatchery chinook into the Cowichan River as fry (3 g) and as pre-smolts (6 g) for the years 1977 to 2000.

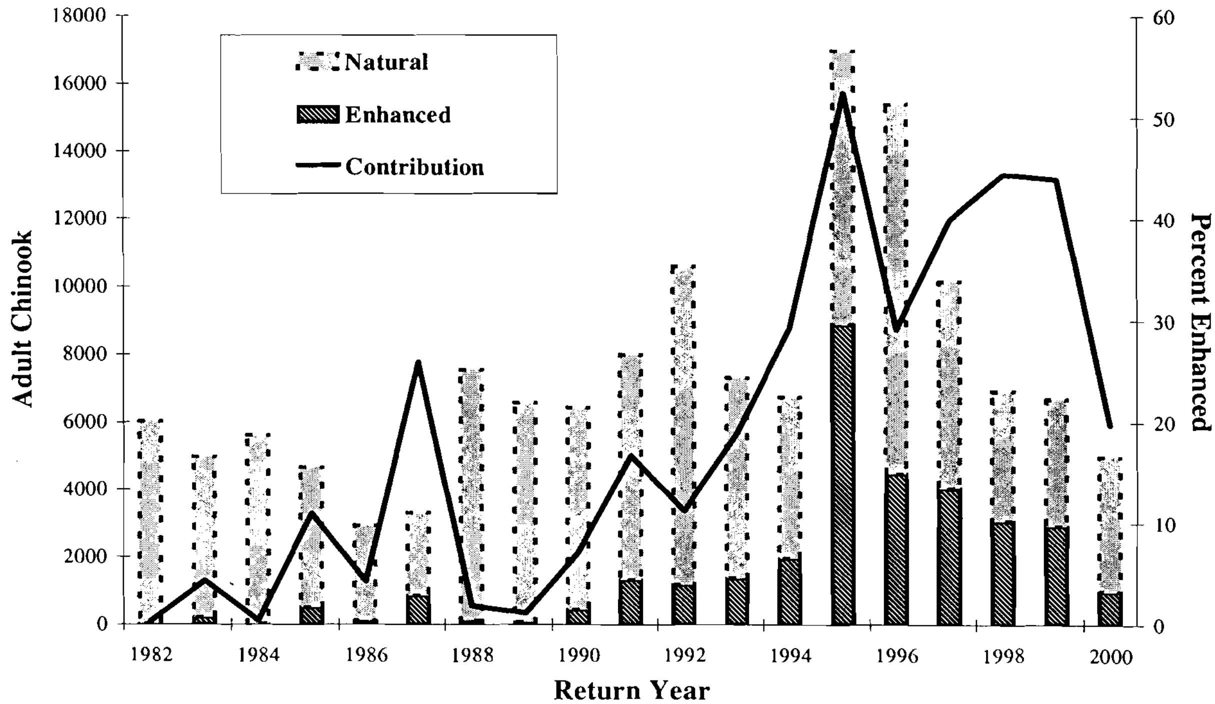


Figure 9. Natural and enhanced contribution to the Cowichan River chinook escapement for the years 1982 to 2000.