Adult Chinook Escapement Assessment Conducted on the Cowichan River During 2003

D.A. Nagtegaal, E.W. Carter, and N.K. Hop Wo

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

2006

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2761

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des
sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques ques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits a l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2761

2006

ADULT CHINOOK ESCAPEMENT ASSESSMENT CONDUCTED ON THE COWICHAN RIVER DURING 2003

by

D.A. Nagtegaal, E.W. Carter, and N.K. Hop Wo

Fisheries and Oceans Canada

Science Branch, Pacific Region

Pacific Biological Station

Nanaimo, British Columbia

V9T 6N7

Cat. No. Fs 97-4/2761E ISSN 0706-6473

Correct citation for this publication:

Nagtegaal, D.A., Carter, E.W., and Hop Wo, N.K. 2006. Adult chinook escapement assessment conducted on the Cowichan River during 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2761: 51 p.

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

ABSTRACT

Nagtegaal, D.A., Carter, E.W., and Hop Wo, N.K. 2006. Adult chinook escapement assessment conducted on the Cowichan River during 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2761: 51 p.

In 2003, 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 First Nations 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 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 4,481 fish of which 2,494 spawned naturally in the river. A total of 862 adult chinook were collected for hatchery broodstock, 825 adults were estimated as captured in the First Nations food fishery and approximately 300 adults were lost to seal predation.

RÉSUMÉ

Nagtegaal, D.A., Carter, E.W., and Hop Wo, N.K. 2006. Adult chinook escapement assessment conducted on the Cowichan River during 2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2761: 51 p.

En 2003, la Direction des sciences biologiques de la Station biologique du Pacifique a poursuivi dans la rivière Cowichan l'étude sur la productivité du saumon quinnat (Oncorhynchus tshawytscha), un projet d'évaluation approfondie de l'échappée, lancée en 1988. Cette étude comporte les principaux éléments suivants : i) dénombrement des géniteurs et de la remonte totale, ii) estimation du volume des prises autochtones à des fins alimentaires; iii) consignation des prélèvements de géniteurs d'élevage et iv) collecte de données biologiques et environnementales et de données de micromarques magnétisées codées. Les effectifs de quinnats adultes et unibermarins sont estimés à partir des données de barrière de dénombrement étant donné que cette méthode de dénombrement est considérée comme étant la plus précise. Des carcasses de saumons étiquetés sont récupérés dans les frayères de sorte à enrichir les données biologiques et améliorer l'estimation des effectifs fondée sur les données de barrière de dénombrement. La remonte totale de quinnats adultes dans la Cowichan en 2003 a été estimée comme se chiffrant à 4 481 poissons, dont 2 494 ont frayé naturellement dans la rivière. Un total de 862 géniteurs ont été prélevés aux fins d'élevage et, d'après les estimations, 825 adultes ont été capturés dans le cadre de la pêche autochtone à des fins alimentaires et 300 autres ont été la proie des phoques.

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 decline in these stocks and their importance to local fisheries (Hardie et al. 2003; Tompkins et al. 2005). 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 within the framework of the Pacific Salmon Treaty between Canada and the United States were identified as exploitation and escapement indicators and deemed to represent the status of all lower Georgia Strait chinook stocks (PSC 1990). Since then, due to logistical reasons the Squamish River system was dropped as an indicator and in 2002 the Nanaimo River system was dropped as well.

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 1.94 million in 2003. Coded-wire tag (CWT) releases also began in 1980 and by 2003 approximately 11.7% of the chinook released carried coded-wire tags.

This report presents the results of the study completed during 2003. The objectives included:

1. Enumerating chinook, coho and chum salmon migrating past the counting fence,
2. Estimating First Nations food fishery catch,
3. Recording hatchery broodstock removals,
4. Collecting biological data and sampling coded-wire tag recoveries,
5. Implementing a carcass mark-recapture study for both adult and jack chinook, and
6. Monitoring results of the Cowichan River Water Management Plan.

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 the 2003 study.

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/s, and averages 44.9 m^3/s (Fielden 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 (*Oncorhynchus clarki*), steelhead trout (*Oncorhynchus mykiss*), 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 brook trout (*Salvelinus fontinalis*) (Perrin et al. 1988). The salmonids of the Cowichan River support several vital fisheries, which include a First Nations food fishery, tidal sport fishery, and a 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, water clarity, and weather condition were recorded three times per day. The fence was checked regularly for any breaches and cleaned of leaves and other debris. Any removal of broodstock at the fence site by hatchery staff was recorded.

Fence Enumeration Video

An underwater video camera was installed at the fence site in order obtain an independent estimate of chinook mark rate. The camera was positioned in the trap box providing a ¾ view of fish swimming upstream. The video was recorded by a VCR located in the counting tower and tapes were reviewed at a later date. Video data were recorded by species with chinook being differentiated as being either adult or jack. Adipose fin clip status was either recorded as present, absent, or unknown.

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.

FIRST NATIONS FOOD FISHERY

In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management program to monitor the fishery more closely and to better estimate the First Nations food fish catch (Paige 1992, 1997). This new technique replaced the estimation procedure implemented by DFO Fishery Officers who spent time observing the fishery and discussing catch estimates with First Nations personnel. This new approach involved recording catch and effort by management zone within the First Nations 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 2003.

The calculation is as follows;

$$CATCH \equiv \sum_{n}^{w=1} CPUE_{w} \times EFFORT_{d}$$

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 First Nations fishery. No observers were employed in 2003 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, adipose fin status (present/absent), as well as scales obtained for age analysis. All chinook sampled from either the spawning grounds or hatchery broodstock were examined for the presence of a CWT using either a Northwest Marine Technology[1] Handheld Wand Detector or a Northwest Marine Technology[1] R9500 Tunnel Detector. All adipose fin clipped chinook and fish suspected of having a CWT had heads removed for decoding of coded-wire tags. All chinook recovered on the spawning grounds were sampled and spawning condition was noted. Hatchery staff randomly collected biological data from approximately 25% of the chinook broodstock and from all chinook suspected of carrying a CWT.

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 each day using an inflatable boat (Figure 1). All chinook carcasses encountered were individually tagged with a Ketchum[2] 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 removed from the system.

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.

[1] Northwest Marine Technology Inc., Shaw Island, Washington, U.S.A.
[2] Ketchum Manufacturing Ltd., Ottawa, Canada.

Mark-recapture estimates were generated 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 recovered samples with unrecovered samples. Size bias in the application sample was examined by comparing lengths of marked versus unmarked recoveries. Size bias in the recovery sample was examined by comparing lengths of recovered and unrecovered tag samples. Statistical comparisons of length data were carried out using pooled variance Student's t-tests. Temporal bias in application samples was assessed by stratifying sampling dates into approximately equal periods and comparing mark incidence among strata. Similarly, temporal bias in recovery samples was stratified by dates and the ratio of tagged recoveries to tags applied was compared. Statistical assessments of sex and period biases were carried out using Chi-square tests.

WATER MANAGEMENT PLAN

Low flow and low water levels likely result in delayed fish movement and higher water temperatures which may potentially increase levels of diseases and parasites. During particularly low water levels the river flow can be increased with a controlled water release from the Lake Cowichan Weir. Discussions between NorskeCanada, Fisheries and Oceans Canada, Land and Water British Columbia, Cowichan River Hatchery, Cowichan Tribes and other user groups lead to a water management plan for the Cowichan River. This plan was committed to maintaining Cowichan River water levels for fish, First Nations and recreational users.

POPULATION ESTIMATE

Chinook population estimates are based on fence data when enumeration conditions are good and when counts are deemed reliable. Before a final estimate is reached the fence count will be assessed to see if it is representative of a complete chinook run. If necessary, adjustments to account for chinook arriving prior to installation and after fence removal will be made. Data are then adjusted by jack/adult ratios observed from spawning ground chinook recoveries. Total run size is calculated by using adjusted fence count data, First Nations food fishery removals, hatchery broodstock removals and seal predation estimates. The mark-recapture estimate is used in years when fence count data are unreliable.

RESULTS

ENUMERATION FENCE

The enumeration fence was installed upstream from the City of Duncan at the traditional site (Figure 1) and was operational from 08 September to 16 October. Water conditions were clear for most of the study with only two days noted as cloudy and four days as partially 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 1,350 chinook adults, 1,250 chinook jacks, 1,956 coho adults and 6,724 coho jacks were counted migrating past the enumeration fence. In addition, 183 chums, five pinks and 16 unidentified fish were enumerated at the fence site (Table 1). Since there were no breaches of the fence during the project it was assumed that all fish migrating past the fence during the study period were enumerated. Since the fence operation was terminated early (Oct. 16) it was assumed that the total run, however, was not monitored.

In past years, chinook jacks have been prominent during the early segment of the return migration often matching adult chinook counts. In 2003, the proportion of jack chinook mirrored the overall temporal pattern of adult chinook migration past the fence (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 0900 hrs. During this period, 40.4% of adult chinook and 43.7% of jack chinook moved past the fence site.

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. This practise was not carried out in 2003.

Video Enumeration Data

During the 2003 chinook assessment, two fence enumeration videos were chosen to be analysed for chinook mark rates. These two videos were primarily chosen because of the volume of fish expected to be captured on tape. Both tapes were recorded between 2030 hr on 06 October and 0900 hr on 07 October. Of the 1,492 salmon identified by video analysis during this period, 924 were adult chinook, 428 were jack chinook, 93 were adult coho, five were jack coho, two were chum and three were pink salmon. An additional 37 were of unknown salmon species. Twenty-seven adult chinook and three jack chinook were found to be missing adipose fins representing mark rates of 3.76% and 1.50%, respectively. It is also worth noting that over half of the chinook identified as being a jack could not be accurately assessed for their adipose fin status. A summary of chinook mark rates obtained from video analysis is presented in Table 3.

SWIM SURVEYS

Swim survey information was not available for 2003. A summary of all visual surveys conducted by DFO Fishery Officers and by the Cowichan Tribes Aboriginal Fisheries Management group from 1981 to 2003 is presented in Table 4.

FIRST NATIONS FOOD FISHERY

Historical estimates of the number of chinook captured in the in-river First Nations food fishery are presented in Table 5 and Figure 4. The 2003 catch estimates of 825 adults and zero jacks were determined by the Cowichan Tribes Aboriginal Fisheries Management group (Figure 2). Also, if non-catch mortalities (fish that escaped capture but died before spawning due to fishery induced injuries) were included, the impact of the fishery would likely be more significant.

HATCHERY COMPONENT

Between 03 October and 16 October, Cowichan River Hatchery staff collected 451 male, 495 female and 14 jack chinook from the river downstream of the fence. However, 22 male and 86 female chinook were returned to the river below the fence; therefore, the effective broodstock capture from downstream of the fence was 429 male, 409 female and 14 jack chinook. In addition, between 24 October and 03 November, 86 male and 136 female chinook were collected upstream of the fence (Table 6). The total number of chinook removed from the river for hatchery broodstock was within the range required for hatchery production (Table 7). Age analysis of scale samples revealed the majority of chinook used in hatchery broodstock was three or four year olds, 33.3% and 56.3%, respectively (Table 8).

BIOLOGICAL DATA

A total of 205 male, 322 female and 229 jack chinook carcasses were recovered on the spawning grounds and measured for post orbital-hypural length (Table 9). The length of adult male chinook carcasses ranged from 49.3 cm to 81.8 cm and averaged 62.1 cm while female carcasses ranged from 44.9 to 80.9 cm and averaged 65.1 cm. Jack chinook carcasses ranged in length from 20.9 to 54.8 cm and averaged 36.9 cm. A total of nine male, nine female and five jack chinook (representing 4.4%, 2.8% and 2.2%, respectively) recovered from the spawning grounds had clipped adipose fins (Table 9). The majority of adult chinook were three or four years old (40.3% and 56.6%, respectively) while most fish identified as jack chinook (95.6 %) were two years old (Table 10).

A total of 38 male, 109 female and 19 jack chinook were randomly collected from broodstock sampling (Table 11). Post orbital-hypural length measurements of male chinook ranged from 49.0 to 77.0 cm and averaged 57.7 cm while female chinook ranged from 53.5 to

79.0 cm and averaged 67.5 cm. Jack chinook ranged in size from 32.0 cm to 55.5 cm and averaged 40.7cm. Zero male, four female and zero jack chinook were missing adipose fins (0.0%, 3.7% and 0.0%, respectively) (Table 11).

There was a statistically significant difference between the mean lengths of male, female and jack chinook carcasses recovered on the spawning grounds and those samples obtained from hatchery broodstock (Student's t-test: $t = 3.213$; $p<0.05$, $t=3.212$; $p<0.05$ and $t=3.280$; $p<0.05$,for males, females and jacks, respectively).

Analysis revealed no statistically significant difference in the adipose fin clip rate between male, female and jack chinook carcasses recovered on the spawning grounds and those recovered from hatchery broodstock (Chi-square = 1.732; $p<0.01$, Chi-square = 0.213; $p<0.01$ and Chi-square = 0.423; $p<0.01$, for males, females and jacks, respectively). A comparison between adipose fin clip rates obtained from fence video data and fall run hatchery broodstock was also calculated. However, due to the inability to accurately differentiate sex on video, males and females are combined for the analysis. This yielded no statistical differences (Chi-square = 0.381; $p<0.01$ and Chi-square = 0.289; $p<0.01$, for adults and jacks, respectively). Furthermore an adipose clip rate comparison between fence video data and spawning ground chinook also provided no statistical differences (Chi-square = 0.104; $p<0.01$ and Chi-square = 0.272; $p<0.01$, for adults and jacks, respectively).

Twenty-three chinook were missing an adipose fin and heads were subsequently collected from the spawning grounds for CWT analysis. Eighteen of the heads yielded CWT information, while four contained no pins and the information for one head was lost. Most chinook (94.4%) identified as having a CWT were released by the Cowichan River Hatchery, with 35.3% released during the 1999 brood year, 35.3% released during the 2000 brood year and 29.4% released during the 2001 brood year (Table 12). One chinook is found to have been released from the Nanaimo River Hatchery as part of the 2001 brood year strategy. A summary of all chinook releases from the Cowichan River Hatchery since 1979 is presented in Table 13.

ENVIRONMENTAL INFORMATION

Environmental data collected at the fence site included water temperature, visibility and water depth (Table 1). Water temperature was relatively stable in the month of September, with the daily average between 16^{o}C and 19^{o}C. However, there was a very sharp decline in water temperature for 25 September and 26 September; the reasons for this are unclear. During October, there is a steady decline in temperature from 17.0^{o}C on 02 October to 11.0^{o}C on 16 October (Figure 3a). Water depth at the fence site was consistently low with all three peaks associated with water releases (Figure 3b). On 15 October, heavy rainfall increased river levels to a point where water flowed overtop and around the fence. The enumeration project was subsequently discontinued on 16 October. Water clarity was recorded in the form of a visibility code. For the majority of the study, visibility at the fence site was clear with four days recorded as moderately cloudy (code 1-2) and two days 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). Mean monthly river discharge in September

was 3.15 m^3/s, considerably lower than the 1988-2003 mean of 8.41 m^3/s, conversely the mean for October was 130.99 m^3/s, which is higher than the 1988-2003 mean of 28.33 m^3/s (Table 14, Figure 5). The river discharge associated with discontinuing the enumeration project increased from 6.91 m3/s on 15 October to 311 m3/s on 20 October, an increase of 45 fold within five days (Table 14).

CARCASS MARK-RECAPTURE

Between 06 November and 04 December a total of 205 male, 322 female and 229 jack chinook carcasses were tagged and released in the upper Cowichan River (Table 15, 16). Of the 268 carcasses recovered with tags, 77 (28.7%) were male, 144 (53.7%) were female, 44 (16.4%) were jack chinook and three (1.1%) were unknown chinook. Using the Petersen estimator, the adult chinook spawning ground population size was determined to be 1,781 fish (95% CI: 1,585 to 1,978), while the jack chinook population was estimated to be 1,400 fish (95% CI: 1,030 to 1,771) (Table 17).

Potential Biases

The assessment of sampling selectivity had several potential biases in the carcass mark-recapture study.

1. Temporal bias: Temporal bias in the tagging sample was examined by stratifying the mark incident rate into four recovery periods (Table 18). There was a significant temporal bias in the application sample for female chinook when the data were stratified into four equal recovery periods (Chi-square = 15.15; $p<0.01$). Conversely, there was no significant temporal bias in the application sample for male adult chinook (Chi-square = 9.49; $p<0.01$).

Temporal bias in the recovery sample was analysed by stratifying the recovery rates into four application periods (Table 19). A statistical difference in the recovery sample for both male and female adult chinook was observed (Chi-square = 21.52; $p<0.01$ and Chi-square = 44.59; $p<0.01$, males and females, respectively).

2. Fish Sex: Sex related bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries by application sample and by recovery sample. No sex related bias was evident when comparing male and female chinook populations (Chi-square = 2.64; $p<0.01$ and Chi-square = 1.09; $p<0.01$, application and recovery samples, respectively) (Table 20). When jack chinook were included in the application and recovery samples significant bias was apparent in both the application and the recovery samples (Chi-square = 31.02; $p<0.01$, and Chi-square = 19.95; $p<0.01$, application and recovery samples, respectively) (Table 21).

3. Size bias: Size related bias was examined by comparing the POH mean lengths of unrecovered marked chinook and recaptured chinook by sex. No size bias was evident in the recovery sample for adult male, adult female and jack chinook (Student's t-test: $t=0.981$; $p<0.01$, $t=0.038$; $p<0.01$, and $t=0.437$; $p<0.01$, for males, females and jacks respectively).

4. Location bias: Spatial bias was not examined due to insufficient sample size in the middle section of the river.

WATER MANAGEMENT PLAN

In 2003, three water releases occurred. A 24-hour water target release of 11.33 m^3/s occurred on 06 October. The result in river discharge is not available; however, water levels at the fence site increased from 43 cm to 59 cm on 06 October. Weather for 05 October and 06 October was recorded as being sunny as well as cloudy. Peak fish movement occurred on 06 October and 07 October, when 659 adult chinook and 636 jack chinook migrated past the fence site (48.81% and 50.88% of fence enumeration, respectively) (Table 1, Figure 3a, Figure 3b).

The second one-day release occurred on 12 October when 16.99 m^3/s was released from the weir. River discharge, at the Island Highway Bridge, increased from 3.90 m^3/s on 11 October to 13.6 m^3/s on the following day. Water levels at the fence site increased from a daily mean of 45 cm on 11 October to a peak of 80 cm on 12 October. Daily mean water temperatures declined from 15.0^{o}C on 10 October to 13.0^{o}C on 12 October. Rainfall was present before and during the water release. Peak fish movement occurred on 12 October and 13 October when 321 adult chinook and 270 jack chinook migrated past the fence site (23.78% and 21.60% of fence enumeration, respectively) (Table 1, Figure 3a, Figure 3b).

The third water release commenced on 15 October where 14.16 m^3/s was to be released. However, heavy rainfall commenced on 15 October, resulting in river discharge rates increasing from 6.91 m^3/s on 15 October to 52.2 m^3/s on 16 October. By the following day, discharge had tripled to 164 m^3/s and by 20 October discharge had reached 311 m^3/s with the weir gates wide open. The fence enumeration program was discontinued on 16 October due to dangerously high water conditions. Fish movement was starting to increase with 164 adult chinook and 92 jack chinook counted during the first two shifts on 16 October (12.15% and 7.36% of fence enumeration, respectively) (Table 1, Figure 3a, Figure 3b).

POPULATION ESTIMATE

Escapement and total return estimates for 2003 were determined using fence count data since these are considered to be the most accurate enumeration method. Due to the fence project being discontinued early, a total run count was not possible. The 2003 fence enumeration was therefore extrapolated using the combined fence results obtained from 1991 (19 August to 11 November), 1993 (23 August to 22 November), 1994 (15 August to 13 November), 1998 (05 September to 08 November), and 2002 (03 September to 13 November) (Nagtegaal et al. 1994b, Nagtegaal et al. 1995a, Nagtegaal et al. 1995b, Nagtegaal and Carter 1998, Nagtegaal et al. 2004). The 2003 adult chinook enumeration of 1,350 was extrapolated to 2,486 fish while the jack chinook estimate was increased from 1,250 to 1,854 fish.

After reviewing both spawning ground carcass recovery and hatchery broodstock collection data, it became evident that the chinook fence count did not accurately reflect the true jack to adult ratio. Analysing the lengths of jack and adult chinook with the traditionally

accepted jack designated length of 450 mm revealed an overlapping of age groups (Figure 6). As a result, the spawning ground carcass recovery data were utilized to apportion the adjusted chinook fence count with a more reflective ratio of jack and adult chinook within the population. This was accomplished by comparing age data with length data to calculate the proportion of two year old jack chinook with lengths greater then 450 mm (2.3%) and the proportion of three year old or greater adult chinook with lengths of 450 mm or less (4.8%). The extrapolated fence count data were then adjusted by these proportions yielding total chinook fence counts of 2,518 adults and 1,822 jacks.

The number of naturally spawning adult chinook in the Cowichan River during 2003 was determined to be the fence count minus any broodstock removals or First Nations fishery catches from areas above the fence. Following this methodology, the total number of chinook spawning in the Cowichan River was estimated to be 2,494 adults and 1,822 jacks. The total return of adult chinook to the Cowichan River was determined to be the sum of the adjusted fence count with the addition of broodstock removals and the First Nations 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 chinook to the Cowichan River was estimated to be 4,481 adults and 1,836 jacks. Annual summaries of total returns, natural spawners, broodstock removals, and Native catches for adult and jack chinook in the Cowichan River are presented in Table 22 and Table 23, respectively.

DISCUSSION

ENUMERATION FENCE

The floating fence design functioned well in the flow conditions that existed in the lower Cowichan River during the fall of 2003. 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 occasionally 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 extent 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, high flows commencing on 12 October resulted in the project being discontinued as the fence and eventually counting tower were swept downstream. Past studies have indicated that 15% to 24% of the chinook run arrives after October 30 (Nagtegaal and Carter 1998, Nagtegaal et al. 2004) and this proportion is usually incorporated into the final estimate of chinook migration past the fence. In the current study, the adult chinook count was increased by 84.1% and the jack count expanded by 48.3% to adjust for an incomplete run enumeration.

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 2003, 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 number of jack chinook at the upper end of the size distribution, it appears as if some 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 adjusted by the ratio of adult and jack chinook sampled during the spawning ground carcass recovery.

Video Enumeration Data

Video enumeration data provided another means of obtaining chinook mark rates. In past years, mark rates obtained from carcass mark-recapture and broodstock collection were significantly different. An example being 2000, when the mark rates of female chinook obtained from carcass mark-recapture and broodstock collection were found to be statistically different (Chi-Square = 11.963; $p<0.01$) (Diewert et al. 2003). Another example was in 2001, when the mark rates of male chinook obtained from carcass mark-recapture and broodstock collection were found to be statistically different (Chi-Square = 8.788; $p<0.01$) (Hop Wo et al. 2003). In 2003, the chinook mark rate obtained from video analysis is not statistically different than mark rates obtained from carcass mark-recapture or broodstock collection. This suggests that all three methods of obtaining mark rates, employed in 2003, were not biased by the absence or presence of adipose fins.

SWIM SURVEYS

No swim survey information was available in 2003; however, biases typically associated with swim surveys and the extrapolation of actual swim counts to historical estimates warrant 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). 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 (Nagtegaal et al. 1994c). 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.

FIRST NATIONS 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. Discussions involving CTAF and DFO resulted in a final First Nations food fishing estimate of 825 adult chinook. The current food fishing estimate of 825 chinook is a considerable decrease compared to the 2002 estimates (Table 5).

BIOLOGICAL DATA

Male, female and jack chinook collected by the hatchery for broodstock were statistically different in length than the carcasses recovered on the spawning ground. Differences may be attributed to varying collection methods with the mark-recapture obtaining dead chinook from river pools and banks, while broodstock collection employs tangle-nets and beach seines. The length variations in males and jacks may be a combination of two factors: characteristics used in differentiating between male and jack chinook and the method of collection used to obtain chinook. During carcass mark-recapture and broodstock collection the definition of a jack chinook is based on morphological characteristics of which judgement can vary by individual sampler. These characteristics can include, sex, body shape (i.e. slender or fat), and size.

Statistical analysis revealed no difference in the adipose fin clipped rates of both male and female chinook collected from the spawning grounds or those collected for hatchery broodstock. An adipose clip rate comparison between fence video analysis and both hatchery broodstock and spawning grounds sampled chinook also yielded no statistical differences. This suggests adipose fin status did not bias fish collection during the carcass mark-recapture or hatchery broodstock collection.

The 17 CWT's originating from the Cowichan River Watershed were fairly evenly distributed from the 1999, 2000 and 2001 brood years. The one CWT fish originating from the Nanaimo River Hatchery was released directly into the Nanaimo River on 09 May, 2002 along with 25,354 other CWT fish.

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. While length, age and sex 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 yield additional coded-wire tagged fish. 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, the spawning ground carcass recovery was used to obtain both samples thus limiting the ability to assess sample biases.

Significant temporal biases for female chinook in the recovery sample as well as male and female chinook in the application samples were evident. 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 tag incidence in the later periods was higher. Conversely, no temporal bias was detected in male chinook from the recovery sample.

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 affects 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 obtained 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.

Bias associated with location was not tested due to insufficient sample size in the middle section of the river. This may have been due to cloudy water conditions making carcass recoveries difficult, although some carcasses were found along the sides of the river. Erosion of clay banks, which exist in this segment of the river, causes the water to be very cloudy and substantially reduces water visibility. Conditions for recovering carcasses further deteriorate as water flow increases. Although location bias could not be tested, marked fish have been recovered by sports fisherman well downstream of the study area. This suggests some tagged specimens were not available for recapture and were probably flushed out of the study area due to higher than average water flow (Figure 5). A reduction in the ability to recapture tagged carcasses would contribute to an overestimation of the actual chinook population.

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 highlight the robust nature of the pooled Petersen estimator and suggest that its usage in determining population abundance from mark-recapture data is generally appropriate under a wide range of circumstances.

WATER MANAGEMENT PLAN

All three chinook movement peaks occurred in conjunction with water releases. The first water release of the season commenced on 06 October, lasted for 24-hours and occurred during dry and hot weather. This resulted in the largest peak of fish movement with approximately half of the total enumeration for adult and jack chinook migrating upstream within 48 hours of the release. It is worth noting that a complete 2003 total run count was not possible and if peak fish movement was compared to the extrapolated value of 2015 adults, the proportion of chinook migrating during 06 October and 07 October would be 25.96%.

The second water release of the season was also a 24-hour release; however, it was combined with rainfall. When compared with the previous water release, the second release increased the fence depth by an additional 20 cm. This gain in river height did not transfer into higher chinook migration than the first release achieved. The fact that the highest chinook migration peak occurred during the first water release may be attributed to a greater number of fish holding below the fence.

The third water release occurred on 15 October with heavy rainfall. The river discharge increased so suddenly that by the next day water was flowing overtop of the fence and around the fence bulkheads. Due to the fence project being discontinued directly following the release, an assessment of the chinook migration at the fence due to increased water levels was not possible. The partial enumeration on 16 October yielded 164 adult chinook and 92 jack chinook and is considered to be a minimum estimate.

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% (September) to 48% (November) 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 August and September, Fishery Officers observations indicated that seal and sea lion populations have remained constant for the last couple of years in Cowichan Bay. As a result, predation on chinook was estimated to be approximately 300 adults.

POPULATION ESTIMATE

The 2003 Cowichan River chinook population estimate was based on an extrapolated fence count. High river flows resulted in the fence project being discontinued early and the chinook estimate was expanded using a Cowichan River run timing curve derived from previous fence data. The estimated number of natural spawning adult chinook migrating past the fence site of 2,494 was above the 95% confidence limits of the 1,585 – 1,978 adult chinook mark-recapture estimate. This result is consistent with past projects (Nagtegaal and Carter 1998, 2000, Nagtegaal et al. 2004) which recorded fence estimates above mark-recapture estimates. Since the mark-recapture study was conducted in the upper river only (the main spawning area) any chinook that spawned in other areas of the watershed were not included, therefore this estimate would not include all chinook migrating past the fence.

The estimated number of adult spawners was the third lowest since 1975, below the period average of 5,533 and well below the revised escapement goal of 7,400 (Riddell et al. 2000) (Table 22, Figure 7). Hatchery releases of chinook fry were 2.58 million in brood year 1999, 2.41 million in brood year 2000, 3.23 million in brood year 2001, and 1.94 million in brood year 2002 (Figure 8). The enhanced contribution was calculated to be 26.2% of the total adult chinook return. This estimate is thought to be biased high due to the small number of carcasses recovered in the mark-recapture portion of this study coupled with large expansion factors for marked to unmarked fry release ratios. Hatchery and natural contributions for Cowichan River chinook escapement are summarized by year in Figure 9. The total adult chinook estimate of 4,481 was below the period average of 7,137 (Table 22).

ACKNOWLEDGEMENTS

We would like to thank Stefan Deleeuw, James Patterson, Phil Joe, Dave Burton, Frank Sutherland, Shawn Stenhouse, John Paige, Dale Paige, and Alfred Joe for their involvement in the implementation of the enumeration fence, collection of migration and biological data. We thank W. Jansen and E. Teskey, Fisheries and Oceans Canada Fishery Officers stationed in Duncan, for their helpful assistance. We thank the Cowichan Tribes Fisheries Management Unit, in particular Wayne Paige and Wayne Paige Jr. for their cooperation and assistance in acquiring First Nations food fishery data as well as band biologist Guuduniia La Boucan. We thank Don Elliot, manager of the Cowichan River Hatchery, for providing broodstock capture and biosampling data. We thank the conscientious sport fishers who returned the Ketchum tags from the chinook they caught in the Cowichan River. We thank the City of Duncan for allowing us to use their access road to the counting fence site and granting us storage space, power and water from their pumphouse facility. Thanks to Roberta Cook for providing the hatchery contribution data. We thank F. Voysey, from Fisheries and Oceans Canada, W. Van Bruggen, the Regional Water Manager for British Columbia as well as M. Vessey and G. Kissack from NorskeCanada for co-ordinating the water release management plan for the Cowichan River.

REFERENCES

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

Bigg, M.A., Ellis, G.M., Cottrell, P., and Milette, L. 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 Shardlow, T.F. 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., Thomas, G.A., Swann, C.G, and Healey, M.C. 1982. A review of salmon escapement estimation techniques. Can. Tech. Rep. Fish. Aquat. Sci. 1108.

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

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

Fielden, R.J. and Holtby, L.B. 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.

D. C. Hardie, D. A. Nagtegaal, K. Hein and J. Sturhahn. 2003. Strait of Georgia and Northern Vancouver Island sport fishery creel survey statistics for salmon and groundfish, 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2640: 107p.

Hop Wo, N.K., Nagtegaal, D.A., Carter, E.W., and Jones, K.E. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2001. Can. Manuscr. Rep. Fish. Aquat. Sci. 2645: 45 p.

Johnston, N.T., Irvine, J.A., and Perrin, C.J. 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., Starr, P.J., and Riddell, B. 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., Candy, J., and Riddell, B. 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., Candy, J., and Riddell, B. 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., Candy, J., and Riddell, B. 1995a. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2315: 84 p.

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

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

Nagtegaal, D.A., Carter, E.W., Hop Wo, N.K., and Jones, K.E. 2004. Adult chinook escapement assessment conducted on the Cowichan River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2655: 49 p.

Olesiuk, P.F., Bigg, M.A., Ellis, G.M., Crockford, S.J., and Wigen, R.J. 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.

PSC (Pacific Salmon Commission). 1990. Joint Chinook Technical Committee 1989 annual report. TCCHINOOK (90)-3.

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 Atagi, D.Y. 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., Johnston, N.T., and Samis, S.C. 1988. Effects of 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.

Riddell, B., Nagtegaal, D.A., and Chen, D. 2000. A biologically-based escapement goal for Cowichan River fall chinook salmon (*Oncorhynchus tshawytscha*). Draft. Stock Assessment Division, Dept. Fish. Ocean, Pacific Region. 29 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.

Tompkins, A., B. Riddell, and D.A. Nagtegaal. 2005. A Biologically-based Escapement Goal for Cowichan River Fall Chinook Salmon (Oncorhynchus tshawytscha). DFO Can. Sci. Advis. Sec. Res. Doc. 2005/095.

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, 2003.

Date	Visibility[1]	Temp (°C)	Depth (cm)	Chinook		Coho		Chum	Pink	Unkn
				Adult	Jack	Adult	Jack			
8-Sep	1	17.0	45.0	3	6	0	0	0	0	0
9-Sep	1	17.0	45.0	3	2	0	0	0	0	0
10-Sep	1	16.3	44.3	0	1	0	0	0	0	0
11-Sep	1	17.7	45.0	3	5	0	0	0	0	0
12-Sep	1	17.0	44.7	5	6	0	0	0	0	0
13-Sep	1	17.0	44.0	5	4	0	0	0	0	0
14-Sep	1	18.0	43.7	2	7	0	0	0	0	0
15-Sep	1	17.0	43.0	4	20	0	0	0	0	0
16-Sep	1	16.3	43.7	2	8	0	0	0	0	0
17-Sep	1	16.0	43.0	2	3	0	0	0	0	0
18-Sep	1-2	16.0	45.3	3	21	0	0	0	0	0
19-Sep	1	16.0	44.0	4	9	0	0	0	2	0
20-Sep	1	17.3	44.0	3	8	0	0	0	0	0
21-Sep	1	17.0	43.0	8	16	0	0	0	0	0
22-Sep	1	18.0	43.3	1	9	0	0	0	0	0
23-Sep	1	17.7	43.3	10	6	0	0	0	0	0
24-Sep	1	16.7	43.0	2	2	0	0	0	0	0
25-Sep	1	9.7	43.7	1	4	0	0	0	0	0
26-Sep	1	11.7	43.3	4	6	0	0	0	0	0
27-Sep	1	16.3	43.0	10	10	0	0	0	0	0
28-Sep	1	16.7	43.0	5	10	0	0	0	0	0
29-Sep	1	16.7	43.0	7	9	5	1	0	0	0
30-Sep	1	15.7	43.0	4	3	1	1	0	0	0
1-Oct	1	15.3	43.0	9	0	7	3	0	0	0
2-Oct	1	17.0	43.0	16	18	1	0	0	0	0
3-Oct	1-2	15.7	43.0	3	3	2	0	0	1	0
4-Oct	1	16.0	43.0	2	3	1	1	0	0	1
5-Oct	1	15.7	43.0	2	1	3	0	0	0	0
6-Oct	1	15.0	53.7	136	135	35	43	2	0	0
7-Oct	1-2	16.3	52.7	523	501	315	86	2	0	0
8-Oct	1	15.3	44.3	13	2	13	1	0	0	0
9-Oct	1	15.0	45.7	31	26	32	7	0	0	0
10-Oct	1	15.0	45.3	6	3	2	4	0	0	0
11-Oct	1	14.7	45.0	5	8	1	1	0	0	0
12-Oct	2	13.0	75.3	194	165	805	221	11	0	6
13-Oct	1-2	13.0	56.7	127	105	212	131	12	2	0
14-Oct	1	12.0	47.3	3	2	12	1	2	0	1
15-Oct	1	11.3	54.0	25	11	25	12	5	0	0
16-Oct	2	11.0	92.0	164	92	484	211	149	0	8
Totals				1350	1250	1956	724	183	5	16

[1] Visibility Code: 1 = clear; 2 = cloudy.

Table 2. Counts by time interval at the Cowichan River fence, 2003.

Time Period	Chinook				Coho					
	Adult		Jack		Adult		Jack		Chum	
	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	17	1.3	32	2.6	25	1.3	2	0.3	0	0.0
0100 - 0200	40	3.0	37	3.0	40	2.0	16	2.2	2	1.1
0200 - 0300	37	2.7	43	3.4	45	2.3	13	1.8	1	0.5
0300 - 0400	52	3.9	38	3.0	30	1.5	5	0.7	0	0.0
0400 - 0500	70	5.2	75	6.0	29	1.5	18	2.5	2	1.1
0500 - 0600	62	4.6	62	5.0	27	1.4	17	2.3	2	1.1
0600 - 0700	53	3.9	60	4.8	41	2.1	25	3.5	0	0.0
0700 - 0800	263	19.5	255	20.4	197	10.1	83	11.5	5	2.7
0800 - 0900	282	20.9	291	23.3	198	10.1	84	11.6	14	7.7
0900 - 1000	57	4.2	16	1.3	61	3.1	33	4.6	9	4.9
1000 - 1100	31	2.3	12	1.0	32	1.6	18	2.5	3	1.6
1100 - 1200	51	3.8	22	1.8	105	5.4	30	4.1	31	16.9
1200 - 1300	43	3.2	40	3.2	108	5.5	60	8.3	33	18.0
1300 - 1400	33	2.4	13	1.0	179	9.2	45	6.2	34	18.6
1400 - 1500	71	5.3	72	5.8	181	9.3	78	10.8	26	14.2
1500 - 1600	24	1.8	12	1.0	146	7.5	46	6.4	10	5.5
1600 - 1700	5	0.4	18	1.4	56	2.9	16	2.2	0	0.0
1700 - 1800	8	0.6	9	0.7	143	7.3	39	5.4	0	0.0
1800 - 1900	6	0.4	19	1.5	145	7.4	34	4.7	2	1.1
1900 - 2000	26	1.9	8	0.6	61	3.1	10	1.4	4	2.2
2000 - 2100	28	2.1	9	0.7	38	1.9	10	1.4	1	0.5
2100 - 2200	28	2.1	21	1.7	22	1.1	12	1.7	1	0.5
2200 - 2300	38	2.8	39	3.1	27	1.4	12	1.7	3	1.6
2300 - 2400	25	1.9	47	3.8	20	1.0	18	2.5	0	0.0

Total	1350	100	1250	100	1956	100	724	100	183	100

Table 3. Chinook mark rate from enumeration fence video, Cowichan River, 2003.

Start Date	Time	Unmarked Chinook		Marked Chinook		Unknown Chinook	
		Adult	Jack	Adult	Jack	Adult	Jack
6-Oct	0800-0815	452	128	17	3	156	147
7-Oct	0800-0900	239	69	10	0	50	81
Total		691	197	27	3	206	228
Mark Rate				3.91%	1.52%		

Table 4. Visual survey data collected for the Cowichan River, 1981-2003.

			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	
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	

Table 4. (continued)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
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	
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	

Table 4. (continued)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
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	
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	N/A[7]	2-6
Estimate for Season						3069	
	S	Sept. 26	80		230	782	Lower[8]
	S	Oct. 19	439		940	3196	1-6
2001	S	Oct. 23	135		255	867	2-6
Estimate for Season						3282	

Table 4. (continued)

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
2002	S	Oct. 25	111		418	1421	2-3
Estimate for Season						2505	
2003	Not Available.						
Estimate for Season						2494	

[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.
[7]Adult population estimate based on swim survey records was not feasible due to extremely low water conditions during swim survey.
[8]Swim survey took place in the lower Cowichan River from Black Bridge to Green Point (Figure 2).

Table 5. Annual adult and jack chinook catch estimates from the Cowichan River First Nations food fishery[1], 1981-2003.

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	450	70
1992	900	12
1993	650	22
1994	700	227
1995	533	120
1996	810	150
1997	191	N/A
1998	1073	N/A
1999	233	89
2000	89	N/A
2001	918	120
2002	1500	N/A
2003	825	N/A

[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, 2000, 2002 and 2003.

Table 6. Daily summary of chinook broodstock collected by the Cowichan River Hatchery, 2003

	Below Fence			Above Fence		
Date	Male	Female	Jack	Male	Female	Jack
3-Oct	68	89	0	-	-	-
6-Oct	99	94	4	-	-	-
7-Oct	37	22	1	-	-	-
8-Oct	47	45	1	-	-	-
9-Oct	69	105	0	-	-	-
10-Oct	48	43	1	-	-	-
14-Oct	41	49	3	-	-	-
15-Oct	42	46	4	-	-	-
16-Oct	0	2	0	-	-	-
24-Oct	-	-	-	2	1	0
27-Oct	-	-	-	0	3	0
30-Oct	-	-	-	0	12	0
31-Oct	-	-	-	0	6	0
3-Nov	-	-	-	0	0	0
*	-22	-86	0			
Total	429	409	14	2	22	0

* These fish were released below the fence site on an undetermined date.

Table 7. Annual Cowichan River Hatchery broodstock collection of adult and jack chinook, 1981-2003.

Year	Chinook Broodstock Collection	
	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
2001	1732	0
2002	1480	0
2003[3]	862	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.

[3] In Addition, 22 males and 86 females were removed for broodstock but later returned to the river.

Table 8. Summary of age by sex for Cowichan River chinook collected from the hatchery broodstock during 2003.

European Age[1]	Total Age	Male		Female		Total Adult		Jack		Total	
		#	%	#	%	#	%	#	%	#	%
01	2	0	0.0%	0	0.0%	0	0.0%	12	70.6%	12	8.3%
02	3	25	75.8%	18	19.1%	43	33.9%	5	29.4%	48	33.3%
03	4	8	24.2%	73	77.7%	81	63.8%	0	0.0%	81	56.3%
04	5	0	0.0%	3	3.2%	3	2.4%	0	0.0%	3	2.1%
Total		33	100%	94	100%	127	100%	17	100%	144	100%

[1] The first number indicates the number of annuli formed in freshwater, the second number indicates the number of annuli formed in the ocean (Koo 1962).

Total number of unreadable scales: 22

Table 9. Length-frequency of chinook sampled on the Cowichan River spawning grounds, 2003.

Length (cm)	Male	Female	Jack
21	0	0	1
22	0	0	0
23	0	0	0
24	0	0	0
25	0	0	0
26	0	0	0
27	0	0	1
28	0	0	1
29	0	0	4
30	0	0	5
31	0	0	25
32	0	0	7
33	0	0	8
34	0	0	20
35	0	0	17
36	0	0	22
37	0	0	15
38	0	0	9
39	0	0	19
40	0	0	24
41	0	0	20
42	0	0	10
43	0	0	6
44	0	0	4
45	0	1	4

Table 9. (continued).

Length (cm)	Male	Female	Jack
46	0	0	4
47	0	0	0
48	0	0	1
49	1	0	0
50	10	5	0
51	17	22	0
52	1	1	0
53	2	4	1
54	6	0	0
55	13	0	1
56	8	2	0
57	5	2	0
58	8	10	0
59	10	3	0
60	19	32	0
61	8	42	0
62	9	6	0
63	6	4	0
64	8	7	0
65	10	9	0
66	3	9	0
67	4	16	0
68	5	17	0
69	1	19	0
70	12	37	0
71	10	19	0
72	3	10	0
73	4	13	0
74	2	11	0
75	7	5	0
76	5	2	0
77	1	6	0
78	3	2	0
79	0	4	0
80	2	1	0
81	0	1	0
82	2	0	0
Total	205	322	229
Mean Length (cm)	62.1	65.1	36.9
Standard Deviation (cm)	8.1	7.2	4.7
Adipose Fin Clips	9	9	5
Fin Clip Rate	4.4%	2.8%	2.2%

Table 10. Summary of age by sex for Cowichan River chinook collected from the spawning grounds during 2003.

European Age[1]	Total Age	Male		Female		Total Adult		Jack		Total	
		#	%	#	%	#	%	#	%	#	%
01	2	1	0.8%	1	0.6%	2	0.7%	130	95.6%	132	30.6%
02	3	66	55.5%	53	30.1%	119	40.3%	6	4.4%	125	29.0%
03	4	52	43.7%	115	65.3%	167	56.6%	0	0.0%	167	38.7%
04	5	0	0.0%	7	4.0%	7	2.4%	0	0.0%	7	1.6%
Total		119	100%	176	100%	295	100%	136	100%	431	100%

[1] The first number indicates the number of annuli formed in freshwater, the second number indicates the number of annuli formed in the ocean (Koo 1962).

Total number of unreadable scales: 129

Table 11. Length-frequency of chinook broodstock collected by the Cowichan River Hatchery, 2003.

Length (cm)	Male	Female	Jack
32	0	0	1
33	0	0	1
34	0	0	1
35	0	0	1
36	0	0	1
37	0	0	1
38	0	0	4
39	0	0	0
40	0	0	1
41	0	0	0
42	0	0	0
43	0	0	3
44	0	0	1
45	0	0	0
46	0	0	1
47	0	0	0
48	0	0	0
49	1	0	0
50	0	0	0
51	0	0	1
52	2	0	0
53	2	0	0
54	2	1	0
55	4	0	1
56	6	2	0
57	3	2	0

Table 11. (continued)

Length (cm)	Male	Female	Jack
58	5	0	0
59	6	2	0
60	0	4	0
61	2	4	0
62	0	5	0
63	1	3	0
64	0	7	0
65	1	7	0
66	1	5	0
67	0	7	0
68	0	8	0
69	1	9	0
70	0	5	0
71	0	13	0
72	0	7	0
73	0	6	0
74	0	6	0
75	0	0	0
76	0	1	0
77	1	2	0
78	0	2	0
79	0	1	0
Total	38	109	19
Mean Length (cm)	57.7	67.5	40.7
Standard Deviation (cm)	5.1	5.2	7.0
Adipose Fin Clips	0	4	0
Fin Clip Rate	0.0%	3.7%	0.0%

Table 12. Release and recovery data for coded-wire tags recovered from Cowichan River chinook sampled on the spawning grounds during 2003.

Recovery Data					Release Data			
Date (dd/mmm)	Location	Adipose Clipped	POH Length (mm)	Sex	Brood Year	Tag Code	Location [1]	Release Date (dd/mm/yy)
6-Nov	25	A	751	M	1999	183125	Hatchery (late)	05-May-00
6-Nov	7	A	665	F	1999	183127	Seapen	17-May-00
6-Nov	17	A	355	J	2001	184641	Upper Cowichan R (early)	11-Apr-02
6-Nov	10	A	418	J	2001	184718	Nanaimo R	09-May-02
6-Nov	7	A	648	M		No Pin		
10-Nov	17	A	616	F	2000	182811	Seapen	23-May-01
10-Nov	17	A	648	M	2000	184546	Upper Cowichan R (early)	20-Mar-01
10-Nov	19	A	640	M		No Pin		
12-Nov	6	A	708	M		Lost Pin		
13-Nov	10	A	651	F	1999	183124	Upper Cowichan R (late)	28-Apr-00
13-Nov	12	A	552	M	2000	184539	Hatchery (late)	03-May-01
13-Nov	24	A	475	J	2001	184642	Upper Cowichan R (early)	11-Apr-02
17-Nov	14	A	679	F	1999	183126	Hatchery (late)	05-May-00
17-Nov	17	A	415	J	2001	184644	Upper Cowichan R (late)	15-May-02
18-Nov	25	A	504	M	2001	184640	Upper Cowichan R (early)	11-Apr-02
18-Nov	12	A	604	F		No Pin		
19-Nov	29	A	708	F	1999	183125	Hatchery (late)	05-May-00
19-Nov	34	A	412	J	2001	184642	Upper Cowichan R (early)	11-Apr-02
20-Nov	13	A	507	F	2000	182811	Seapen	23-May-01
20-Nov	13	A	702	M		No Pin		
25-Nov	15	A	533	F	2000	183216	Upper Cowichan R (late)	01-May-01
26-Nov	21	A	493	M	2000	182811	Seapen	23-May-01
26-Nov	18	A	688	F	1999	183127	Seapen	17-May-00

1 Cowichan Hatchery release strategies for chinook:

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

Upper Cowichan River (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. Cowichan River Hatchery chinook release[1] data for brood years 1979-2002.

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
026255	1989	26400	119674	22.1	7.19		1990/05/14	COWICHAN LK

Table 13. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
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	SEAPEN
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	SEAPEN
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	SEAPEN
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
182027	1995	25218	355583	7.1	6.26	1996/05/07	1996/05/07	COWICHAN R UP

Table 13. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
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	SEAPEN
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	SEAPEN
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	SEAPEN
182811	2000	25175	99829	25.2	7.98	2001/05/23	2001/05/23	SEAPEN
183216	2000	25152	504558	5.0	6.55	2001/05/01	2001/05/01	COWICHAN R UP

Table 13. (continued)

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
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
184448	2001	25163	96786	26.00	5.68	2002/05/21	2002/05/21	SEAPEN
184639	2001	25140	249911	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184640	2001	25047	248987	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184641	2001	25255	251054	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184642	2001	24957	248092	10.06	3.5	2002/04/11	2002/04/11	COWICHAN R UP
184643	2001	25068	787409	3.18	5.68	2002/05/14	2002/05/15	COWICHAN R UP
184644	2001	25062	787221	3.18	5.68	2002/05/14	2002/05/15	COWICHAN R UP
184645	2001	25019	278423	8.99	5.28	2002/04/28	2002/04/28	COWICHAN R
184646	2001	25197	280404	8.99	5.28	2002/04/28	2002/04/28	COWICHAN R
184918	2002	50091	383156	13.07	4.5	2003/04/11	2003/04/11	COWICHAN R UP
184919	2002	50186	383877	13.07	4.5	2003/04/11	2003/04/11	COWICHAN R UP
185013	2002	24712	257226	9.61	5.74	2003/05/26	2003/05/26	COWICHAN R UP
185014	2002	25128	261555	9.61	5.74	2003/05/26	2003/05/26	COWICHAN R UP
185015	2002	25102	261282	9.61	5.74	2003/05/26	2003/05/26	COWICHAN R UP
185016	2002	25197	288668	8.73	6.0	2003/05/27	2003/05/27	HATCHERY
185052	2002	25134	99918	25.15	7.36	2003/05/28	2003/05/28	SEAPEN

[1] Cowichan River Hatchery release strategies for chinook:

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

Upper Cowichan River (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 14. Daily Cowichan River discharge[1] (m^3/s) during 2003.

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	96.7	181	46.8	118	37	13.9	6.94	5.93	3.66	-	100P	94.2
2	216	172	43.8	113	36.2	13.6	6.91	5.81	3.69	-	91.3	89.4
3	240	156	43.2	106	34.7	13.5	6.74	6.15	3.51	-	83.5P	92.5
4	252	147	43.6	98.5	33.1	14.0	6.52	6.14	3.66	-	77.9P	88.4
5	238P	141	43.7	92.0	30.9	13.5	6.31	6.01	3.54	-	71.2	94.3
6	216	133	43.8	86.1	27.7	13.2	6.2	5.95	2.87	-	65.4	118
7	198	126	43.0	83.3	25.8	13.3	6.23	6.10	3.08	5.59P	60.2	118
8	180	116	42.6	120	24.1	13.1	6.1	6.00	2.97	3.67	55.7	112
9	167	108	44.9	146	22.4	13.1	6.22	5.92	2.86	4.53	52.1	105
10	154	103	48.5	137	21.1	13.3	6.37	5.9	2.93	3.78	49.3	98.6
11	146	99.0	55.7	130	19.9	13	6.16	6.46	3.14	3.9	46.8	93.4
12	140	94.4	76.3	124	19.3	12.6	6.16	5.25	2.99	13.6	43.9	94.9
13	134	89.3	202	120	18.1	11.8	6.44	5.03	3.05	8.76	41.8	94.9
14	129	85.5	218	118	17.1	9.70	7.2	5.05	3.15	4.5	39.9	105
15	124	82.2	199	111	16.6	8.50	6.71	4.95	2.82	6.91	39.7	101
16	119	80.6	188	104	15.9	7.60	6.57	4.98	3.05	52.2	41.6	113
17	110	78.8	179	97.3	15.7	6.61	6.34	5.03	3.1	164	47.5	132
18	107	75.5	170	89.4	15.6	6.59	6.19	4.87	3.34	209	80.9	122
19	102	74.1	167	83.0	15.6	6.50	6.2	4.49	3.37	234	106	112
20	97.9	73.8	168	77.7	15.7	6.45	6.33	4.29	3.04	311	88.1	113
21	96	73.5	170	72.5	15.5	6.83	6.21	4.45	3.01	312	77.6	116
22	106	72.7	229	66.2	15.7	6.68	6.13	4.27	3.03	267	70.9	111
23	154	70.2	213	61.4	16.0	6.55	6.01	4.18	3.00	245	68.3	106
24	154	67.0	190	58.7	16.0	6.49	5.94	4.33	2.94	222	69.8	112
25	149	62.2	175	55.2	16.2	6.66	5.8	4.32	3.11	201	70.0	118
26	209	59.6	164	50.8	14.7	6.52	5.93	4.36	2.98	181	66.2	113
27	194	56.0	151	47.4	14.4	6.32	6.2	4.37	2.96P	162	61.7	107
28	178	51.5	141	43.7	15.2	6.43	6.13	4.39	-	147	114	101
29	170		131	41.3	14.8	6.88	5.98	4.43	-	135	134	94.6
30	165		121	39.1	14.1	7.06	6	3.72	-	121	106	88.2
31	189		120		14.3		6	3.49		110P		83.6
Total	4693	2507	3872	2516	629.4	244	195.2	144.5	78.89	3013	1790	3242
Mean	156.4	100.3	124.9	89.8	20.3	9.76	6.30	4.98	3.15	131.0	68.8	104.6
Max	252	181	229	146	37.0	13.9	7.2	6.46	3.69	312	134	132
Min	96.0	51.5	42.6	39.1	14.1	6.32	5.8	3.49	2.82	3.67	39.7	83.6

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

Table 15. Daily summary of carcasses examined, tags applied and tagged recoveries, by sex, for chinook in the upper Cowichan River, 2003.

Date	Carcasses Examined				Tags Applied				Tagged Carcasses Recovered			
(dd-mmm)	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack	Unkn.	Male	Female	Jack
06-Nov	0	10	14	4	0	10	14	4	0	0	0	0
07-Nov	0	11	13	4	0	11	13	4	0	0	0	0
10-Nov	0	24	40	9	0	20	32	8	0	4	8	1
12-Nov	0	27	29	24	0	20	19	23	0	7	10	1
13-Nov	0	27	36	20	0	21	22	16	0	6	14	4
17-Nov	0	34	47	32	0	25	43	29	0	9	4	3
18-Nov	0	14	28	19	0	10	21	18	0	4	7	1
19-Nov	0	21	22	29	0	15	15	26	0	6	7	3
20-Nov	0	23	36	21	0	14	22	11	0	9	14	10
24-Nov	0	9	32	12	0	7	20	8	0	2	12	4
25-Nov	1	14	30	24	0	9	24	21	1	5	6	3
26-Nov	0	20	31	17	0	14	14	13	0	6	17	4
27-Nov	0	8	28	12	0	5	19	9	0	3	9	3
28-Nov	1	9	18	16	0	6	11	15	1	3	7	1
01-Dec	0	16	27	15	0	10	17	15	0	6	10	0
02-Dec	0	6	15	9	0	4	7	5	0	2	8	4
03-Dec	0	7	15	4	0	4	8	4	0	3	7	0
04-Dec	0	2	5	2	0	0	1	0	0	2	4	2
Total	2	282	466	273	0	205	322	229	2	77	144	44

Table 16. Tags applied, carcasses examined and marks recovered, by sex, for chinook in the upper Cowichan River, 2003.

Sex	Tags Applied	Carcasses Examined	Marks Recovered	Percent Recovered
Male	205	282	77	37.6%
Female	322	466	144	44.7%
Total Adult	527	748	221	41.9%
Jack	229	273	44	19.2%
Total Population	756	1021	265	35.1%

Table 17. Petersen mark-recapture estimates, stratified by sex, for Cowichan River chinook, 2003.

Sex	Population Estimate	95% Confidence Limits Lower	Upper
Male [1]	747	607	888
Female	1040	900	1181
Total Adult	**1781**	**1585**	**1978**
Jack	1400	1030	1771
Total Population	2884	2588	3180

[1] Adult males only, jacks not included.

Table 18. Incidence of tagged adult chinook carcasses recovered on the spawning grounds by recovery period and sex, Cowichan River, 2003.

Recovery Period	Days of Recovery	Tagged Recoveries Male	Female	Total	Total Recoveries Male	Female	Total	Tag Incidence (%) Male	Female	Total
06-Nov to 13-Nov	5	17	32	49	99	132	231	17.17	24.24	21.21
17-Nov to 20-Nov	4	28	32	60	92	133	225	30.43	24.06	26.67
24-Nov to 28-Nov	5	19	51	70	60	139	199	31.67	36.69	35.18
01-Dec to 04-Dec	4	13	29	42	31	62	93	41.94	46.77	45.16
Total	18	77	144	221	282	466	748	27.30	30.90	29.55
Chi-Square test result:								9.49	15.15	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 19. Proportion of the tag application sample recovered on the spawning grounds by application period and sex, Cowichan River, 2003.

Application Period	Days of Application	Tags Applied			Tagged Recoveries			Percent Recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
06-Nov to 13-Nov	5	82	100	182	17	32	49	20.73	32.00	26.92
17-Nov to 20-Nov	4	64	101	165	28	32	60	43.75	31.68	36.36
24-Nov to 28-Nov	5	41	88	129	19	51	70	46.34	57.95	54.26
01-Dec to 04-Dec	4	18	33	51	13	29	42	72.22	87.88	82.35
Total		205	322	527	77	144	221	37.56	44.72	41.94
Chi-Square test result:								21.52	44.59	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 20. Sex composition of chinook in the tag application and recovery samples from the Cowichan River spawning grounds, 2003

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	205	34.8%	41.8%	38.9%	282	34.8%	38.9%	37.7%
Female	322	65.2%	58.2%	61.1%	466	65.2%	61.1%	62.3%
Chi-Square test result:				2.64				1.09
Critical Chi-Square (df = 1; alpha = 0.01)				6.64				6.64

Table 21. Sex composition of chinook in the tag application and recovery samples from the Cowichan River spawning grounds, 2003 (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	205	29.1%	26.1%	27.1%	282	29.1%	27.1%	27.6%
Female	322	54.3%	36.3%	42.6%	466	54.3%	42.6%	45.6%
Jack	229	16.6%	37.7%	30.3%	273	16.6%	30.3%	26.7%
Chi-Square test result:				39.02				19.95
Critical Chi-Square (df = 2; alpha = 0.01)				9.21				9.21

Table 22. Total adult chinook returns to the Cowichan River for the years 1975 to 2003.

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	6590
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 [5]	1529	89	7027 [4]
2001	3282 [5]	1732	918	6232 [4]
2002	2505 [5]	1480	1500	5785 [4]
2003	2494 [6]	862 [7]	825	4481 [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.

[5] For the years 2000 to the present, the adult fence count totals used in calculating natural spawners was adjusted using jack/adult ratios obtained from the spawning grounds.

[6] This estimate was derived by using an extrapolated fence count as well as adjustment using the jack/adult ratios abtained from the spawning grounds.

[7] The 108 adult chinook which were collected and later released downstream of the fence site were not included.

Table 23. Total jack chinook returns to the Cowichan River for the years 1982 to 2003.

Year	Natural Spawners [1]	Broodstock Removal	Native Catch	Total Return
1982	2000 [2]	0	1000	3000
1983 [3]	5460	0	1000	6460
1984	4042	0	700	4742
1985	2200	0	1000	3200
1986	5890	0	800	6690
1987	2085	0	800	2885
1988 [4]	4216	70 [5]	450	4736
1989	995	94 [5]	250	1339
1990	15198	1	150	15349
1991	1341	444 [5]	70	1855
1992	4589	108 [5]	12	4709
1993	5765	196 [5]	22	5983
1994	13345	145	227	13717
1995	10517	564 [5]	120	11201
1996	6483	275 [5]	150	6908
1997	6771	79	0	6850
1998	3065	201	0	3266
1999	1380	1	89	1470
2000 [6]	1879	14	0	1893
2001	1862	0	120	1983
2002	1685	0	0	1685
2003	1822	14	0	1836

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

[2] Estimate based on broodstock sampling

[3] For 1983 - 1987 estimate were based on visual counts

[4] For 1988 - 2004 estimate based on fence counts.

[5] Broodstock information obtained from field records and may differ slightly from official records.

[6] For the years 2000 - 2004, the adult fence count totals used in calculating natural spawners was adjusted using jack/adult ratios obtained from the spawning grounds.

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 – J.C. Pool

Swim survey areas:

Bird House (1) to Three Firs Pool (6) represents the upper survey section.

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

A - Refers to the adult enumeration fence

Tag recovery locations:

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

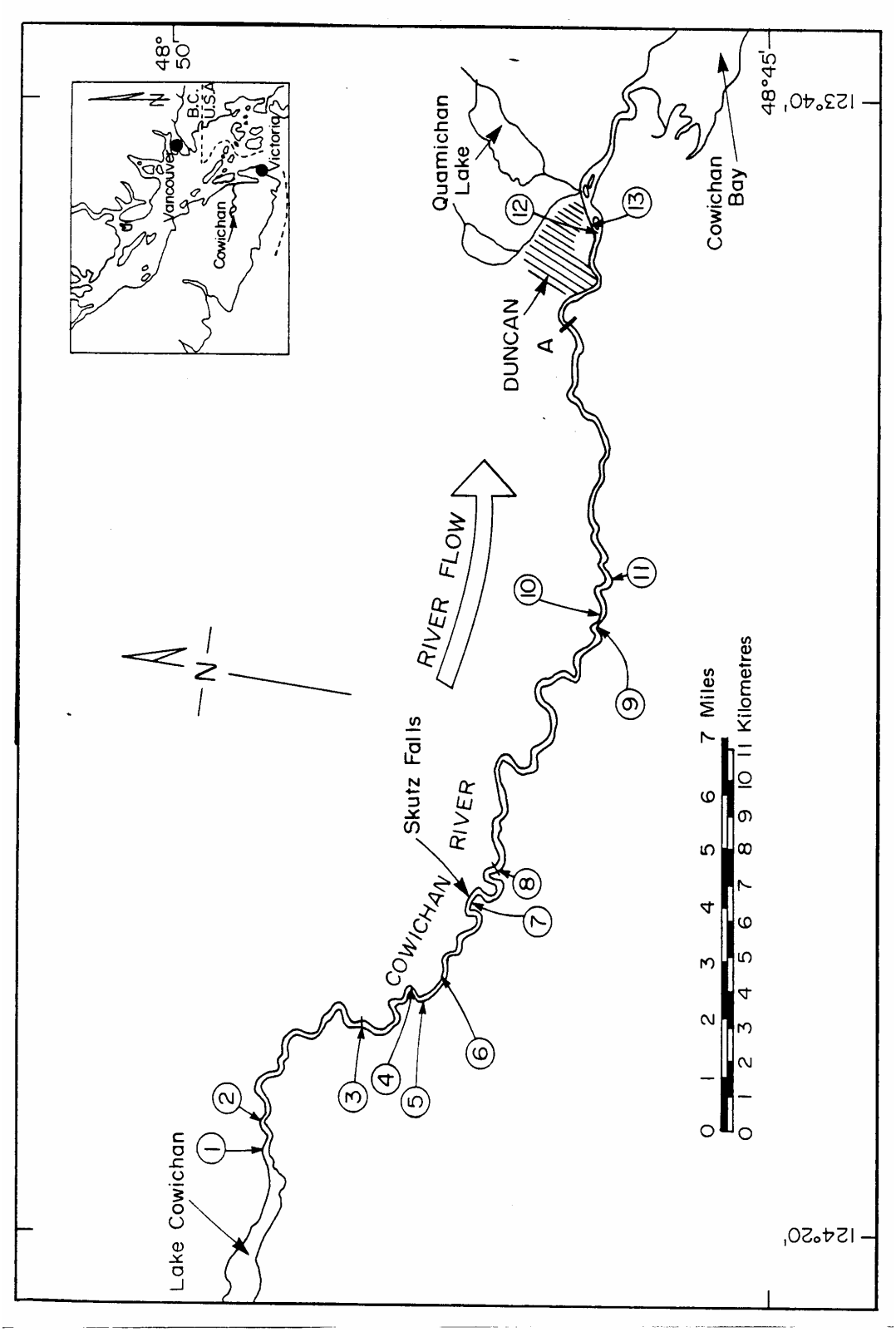

48° 50'
N
B.C.
U.S.A.
Vancouver
Victoria
Cowichan
Quamichan Lake
Cowichan Bay
48°45'
123°40'
DUNCAN
A
RIVER FLOW
N
Skutz Falls
COWICHAN RIVER
Lake Cowichan
124°20'
0 1 2 3 4 5 6 7 Miles
0 1 2 3 4 5 6 7 8 9 10 11 Kilometres
1
2
3
4
5
6
7
8
9
10
11
12
13

Figure 2. River management zones for the First Nations food fishery.

A-Cliffs to Silver Bridge

B-Silver Bridge to J.C.'s Place

C-Quamichan to Black Creek

D-Powerline to Elliot's Barn

E-Elliot's Barn to Brian's Pool

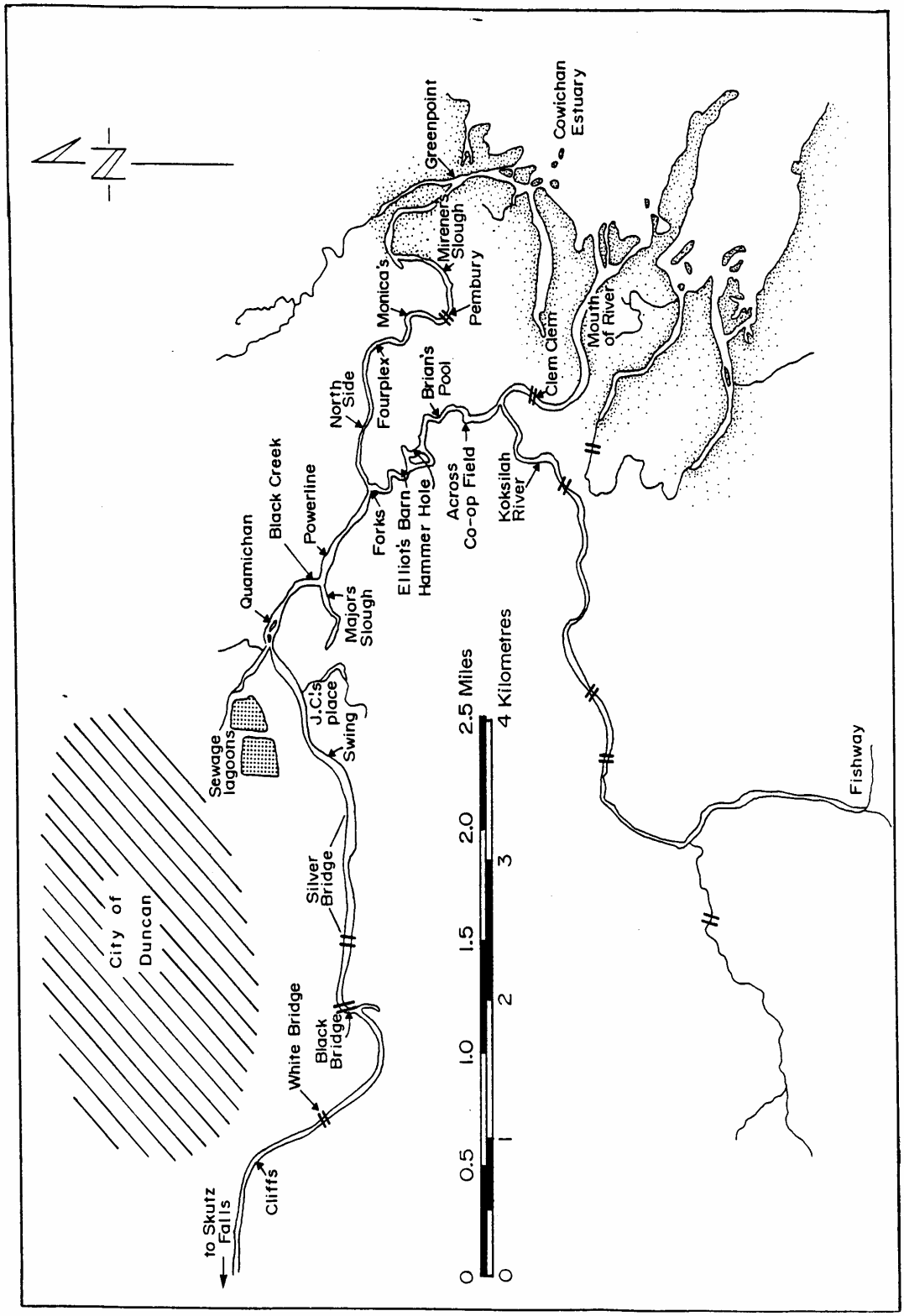
F-Brian's Pool to Clem Clem and part of Koksilah

G-Clem Clem to Mouth of River

H-North Side to Fourplex

I-Fourplex to Meriner's Slough

J-Meriner's Slough to Mouth of River


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

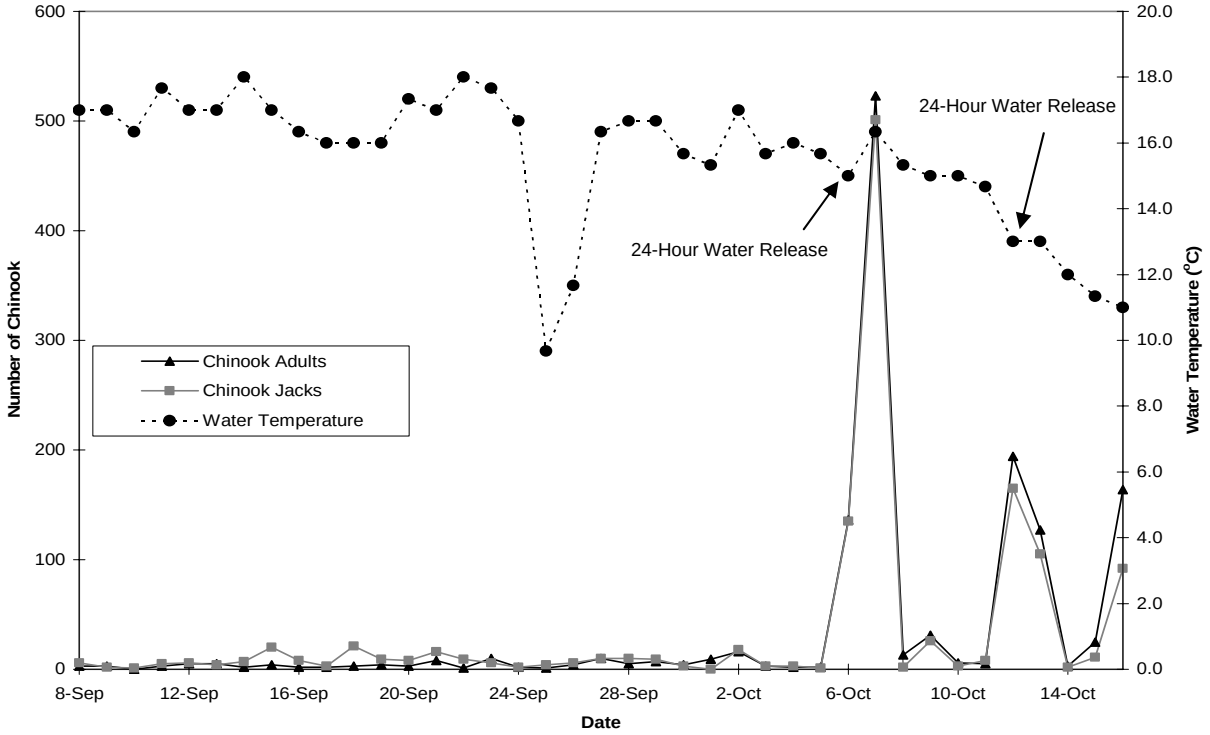


Figure 3a. Daily fence counts of adult and jack chinook and water temperature at the fence site, Cowichan River, 2003.

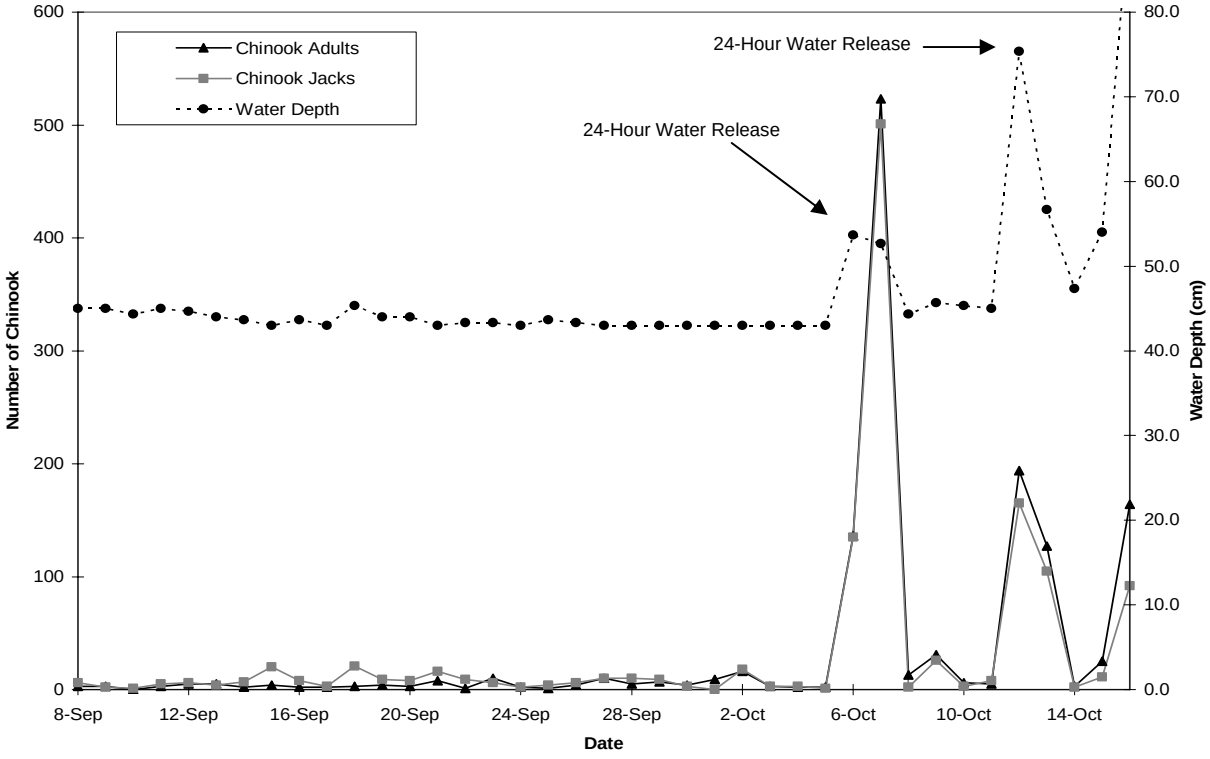


Figure 3b. Daily fence counts of adult and jack chinook and water depth at the fence site, Cowichan River, 2003.

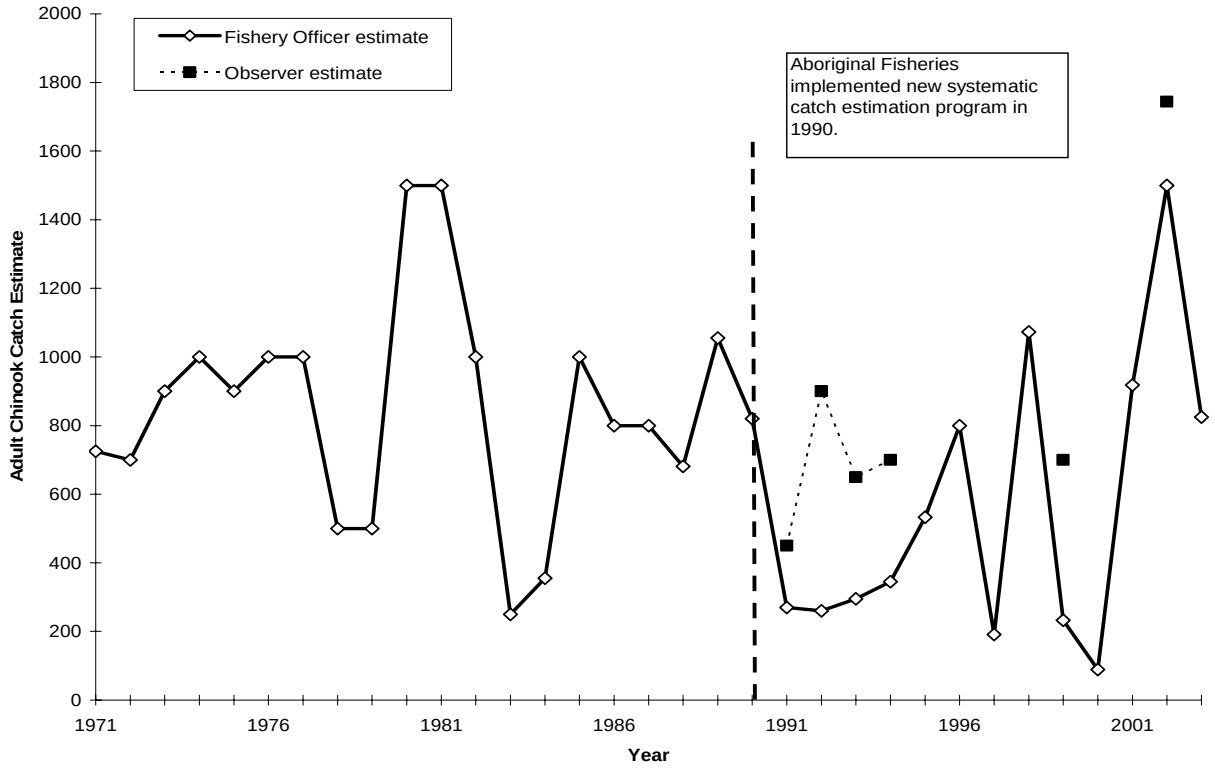


Figure 4. Adult chinook catch from the First Nations food fishery, Cowichan River, 1971-2003.

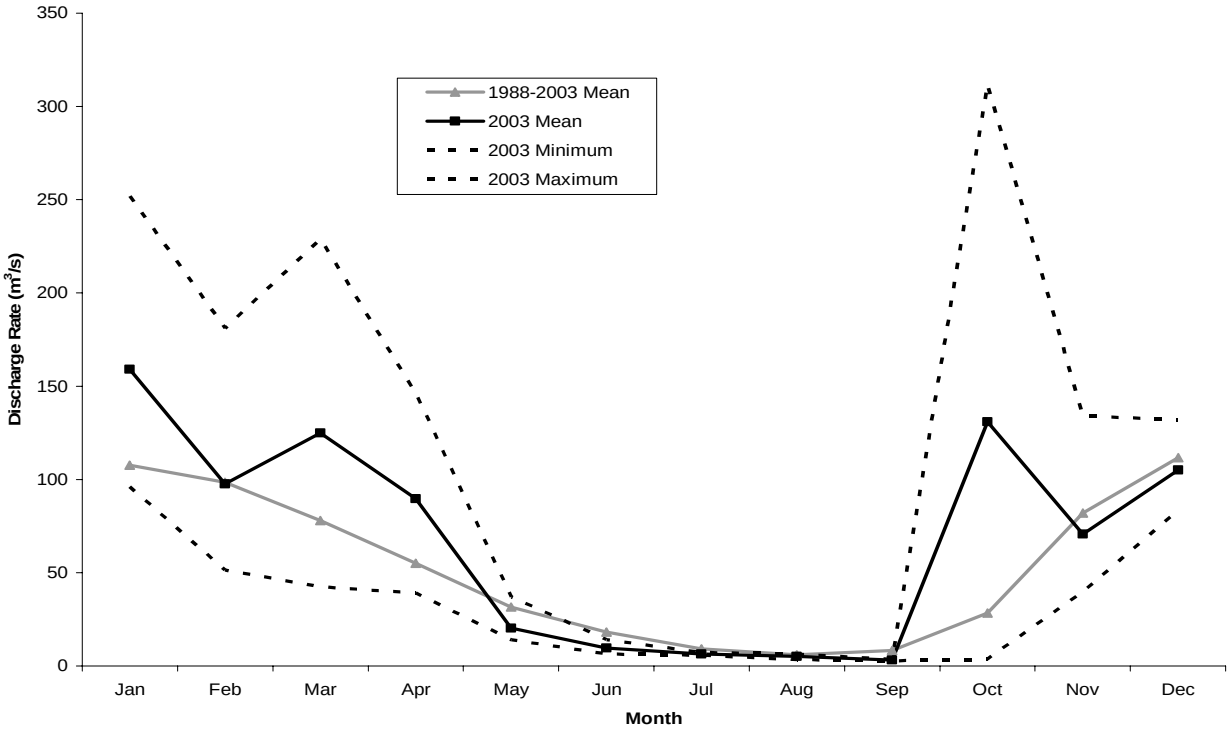


Figure 5. Monthly Cowichan River discharge (m^3/s) in 2003 along with historical values.

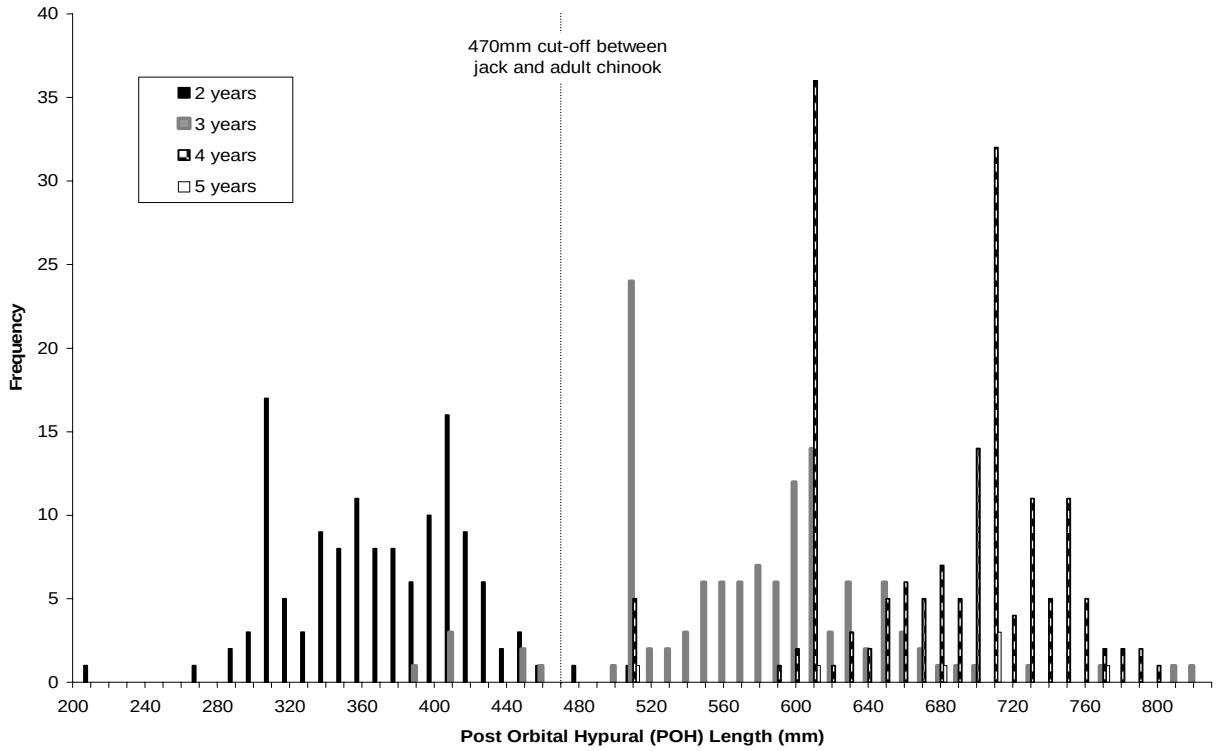


Figure 6. Adult and jack chinook length-frequencies collected from the Cowichan River spawning grounds, 2003.

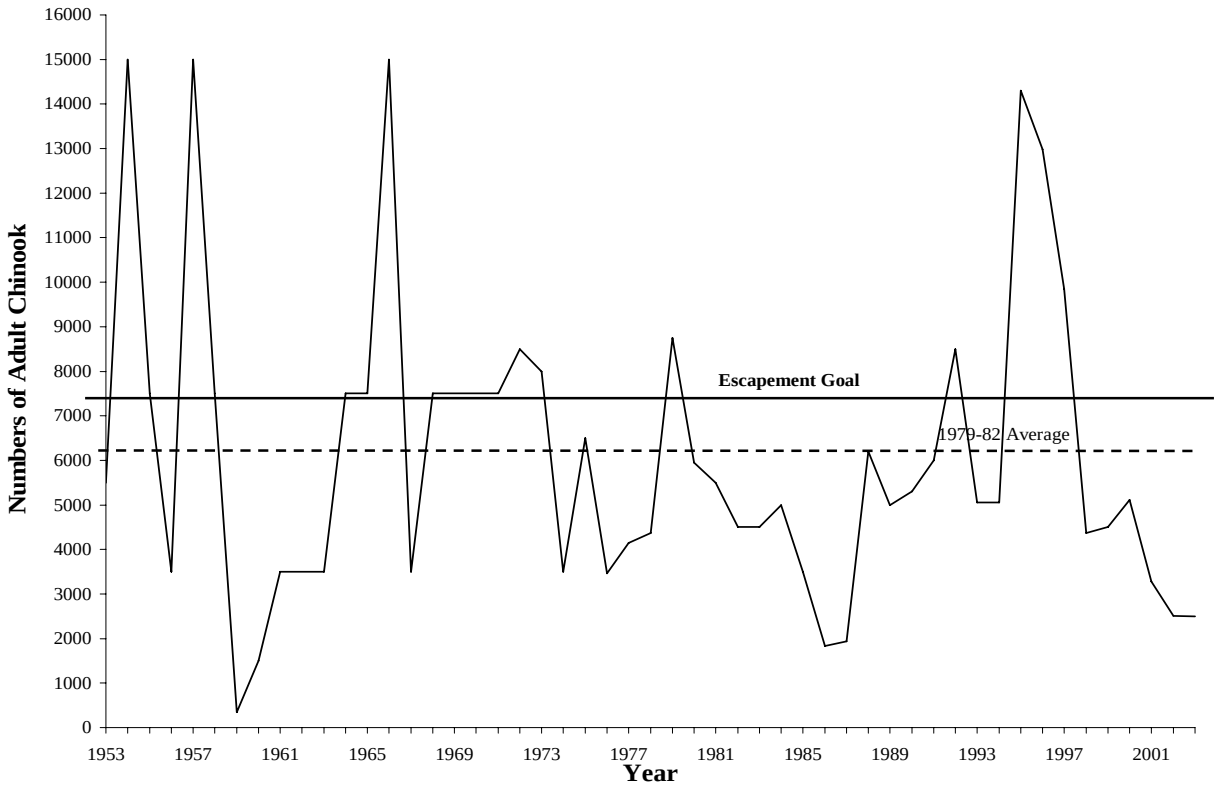


Figure 7. Annual adult chinook escapement estimates for the Cowichan River, 1953-2003.

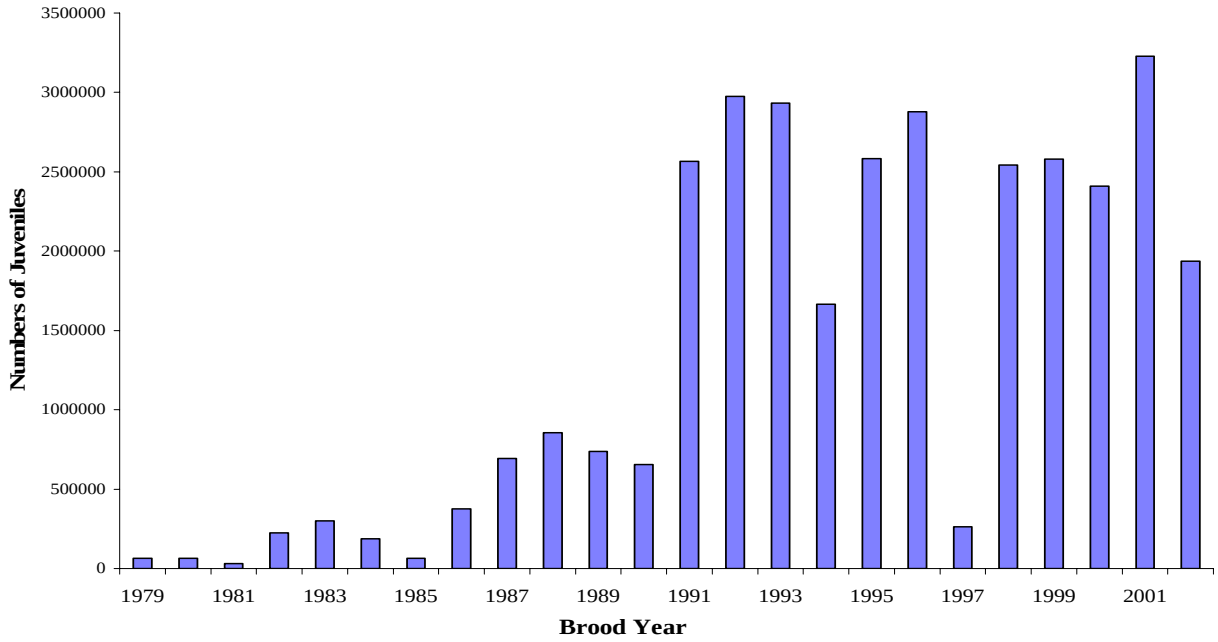


Figure 8. Annual releases of hatchery chinook into the Cowichan River as fry (3 g) and as pre-smolts (6 g), brood year, 1979-2002

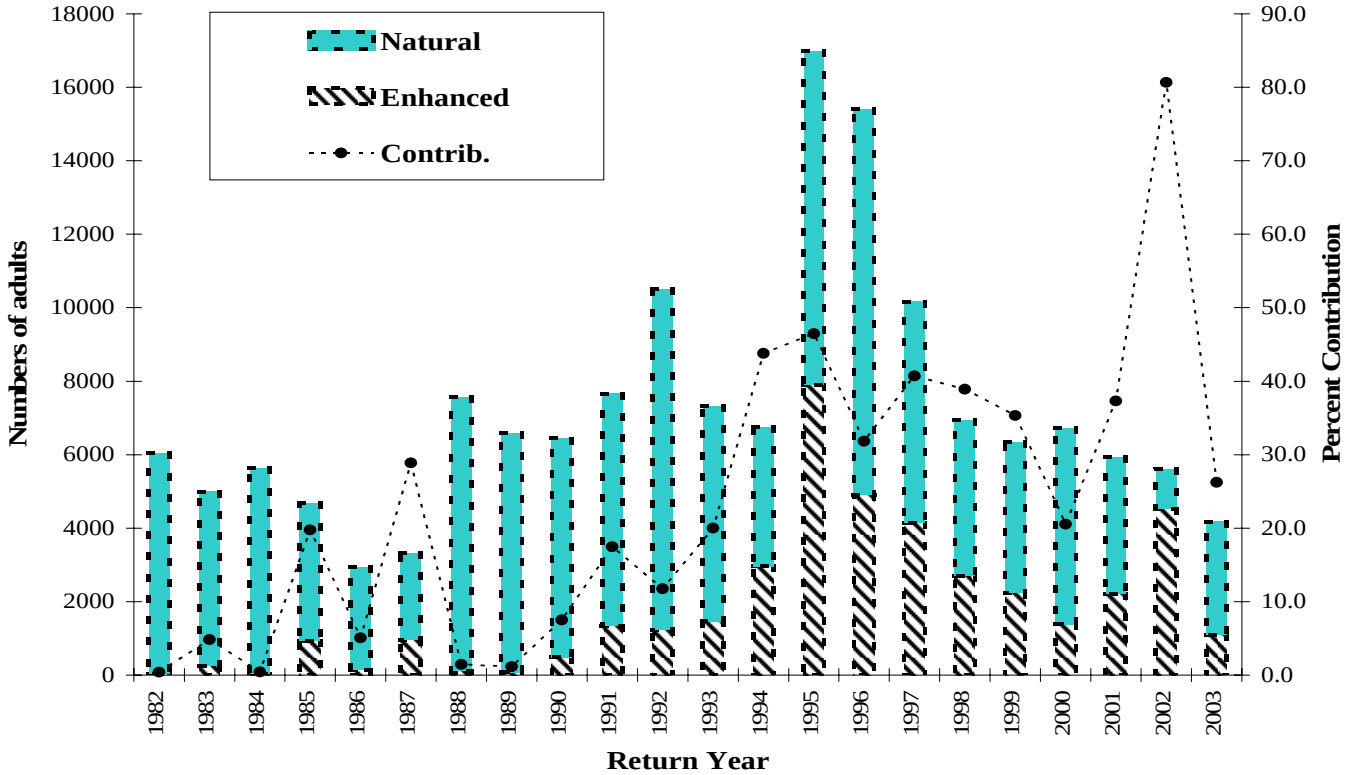


Figure 9. Annual natural and enhanced contributions to adult chinook escapement, Cowichan River, 1982-2003.