Adult Chinook Escapement Assessment Conducted on the Cowichan River During 2005, 2006, and 2007

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ADULT CHINOOK ESCAPEMENT ASSESSMENT CONDUCTED ON THE COWICHAN RIVER DURING 2005, 2006, and 2007

by

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ABSTRACT

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In 2005, 2006, and 2007, the South Coast Area Stock Assessment group of Fisheries & Oceans Canada 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 in 2005 and 2006 since this was considered to be the most accurate enumeration method. A carcass mark-recapture study was conducted on the spawning grounds in 2007 to augment the collection of biological data and was used in place of the fence count to estimate population.

The total return of adult Chinook to the Cowichan River was estimated to be 3059 in 2005, 2126 in 2006, and 2424 in 2007. The number of naturally spawning adult Chinook in 2005, 2006, and 2007 were 1512, 1069, and 1860, respectively. The number of adult Chinook collected for broodstock was 940, 671, and 320, respectively, and the number of adult Chinook captured in the First Nations food fishery was 607, 390, and 238, respectively.

RESUME

Baillie, S.J., Matthews, I.M., Elliott, D., and McColl, B.D. 2015. Adult Chinook escapement assessment conducted on the Cowichan River during 2005, 2006, and 2007. Can. Manuscr. Rep. Fish. Aquat. Sci. 3079: ix + 80 p.

En 2005, 2006 et 2007, le groupe d'évaluation des stocks du secteur de la côte Sud de Pêches et Océans Canada a poursuivi une étude sur la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) dans la rivière Cowichan. Ce projet d'évaluation approfondie des échappées est en place depuis 1988. Les principales composantes de cette étude comprenaient :

i) le dénombrement de reproducteurs et des montaisons totales,
ii) l'estimation des prises des Premières Nations à des fins alimentaires;
iii) la consignation des prélèvements de stocks de géniteurs de l'écloserie, et
iv) la collecte de données biologiques, environnementales et sur les micromarques magnétisées codées.

Les estimations de la population de saumons quinnats adultes et des grisles ont été déterminées en fonction du dénombrement à la barrière en 2005 et en 2006, puisqu'il a été convenu qu'il s'agit de la méthode la plus précise de dénombrement. Une étude de marquage-recapture de carcasses a été effectuée dans les frayères en 2007 pour accroître la collecte de données biologiques et a été utilisée à la place de la barrière de dénombrement pour estimer la population.

Le nombre total de montaisons de saumons quinnats adultes dans la rivière Cowichan a été estimé à 3 059 en 2005, 2 126 en 2006 et 2 424 en 2007. Le nombre de saumons quinnats adultes se reproduisant naturellement a été de 1 512 en 2005, 1 069 en 2006 et 1 860 en 2007. Le nombre de saumons quinnats adultes recueillis pour les stocks de géniteurs a été de 940, 671 et 320, respectivement, et le nombre de saumons quinnats adultes capturés dans le cadre de la pêche à des fins alimentaires des Premières Nations a été de 607, 390 et 238, respectivement.

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 (Pacific Salmon Commission 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 1979 (Cross *et al.* 1991). Chinook fry releases have ranged from a low of 30,373 (BY 1981) to 3,228,287 (BY 2001), averaging 1.4 million (BY 1979 – 2007). Coded-wire tag (CWT) releases also began with the 1979 brood and by 2007 approximately 31.0% of the Chinook released carried coded-wire tags.

Initially there were no plans to conduct a downstream Chinook fry enumeration project in 2005. During the previous winter, a severe winter snow storm had caused a power outage to the Cowichan Hatchery, resulting in a near complete loss of the 2004 brood Chinook production. As a result, there was no coded-wire tagged Chinook group available for release. To address this potential loss of fisheries information, the decision was made to run the downstream project using the available hatchery staff, and retain the Chinook fry catch from the trap. This group was to be tagged and released.

This report presents the results of the study completed during 2005, 2006, and 2007. The objectives included:

1. enumerating Chinook, coho and chum adult salmon migrating past the counting fence,
2. enumerating Chinook fry downstream (2005),
3. estimating First Nations food fishery catch,
4. recording hatchery broodstock removals,
5. collecting biological data and sampling coded-wire tag recoveries,
6. monitoring results of the Cowichan River Water Management Plan.

METHODOLOGY

A detailed description of the methodology is presented in Nagtegaal *et al.* (1994). A summary of methods is presented below along with any changes that were incorporated during the 2005, 2006, or 2007 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 0.4 – 374.2 m^3/s and averages 53.8 m^3/s[1]. The target for water release from the Cowichan Lake weir during the summer is 7.0 m^3/s. Approximately 25 tributaries drain into the Cowichan River. 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*), Brook Trout (*Salvelinus fontinalis*), Brown Bullhead (*Ameiurus nebulosis*), and Pumpkinseed Sunfish (*Lepomis gibbosus*) (Perrin *et al.* 1988). Recently Peamouth Chub (*Mylocheilus caurinua*) has been noted in the lower 3 kilometers. 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.

The Cowichan Chinook stock has been supplemented by hatchery releases since 1979 (Table 1) and have been caught in fisheries throughout the Pacific coastal areas from Alaska to Oregon. The highest incidence of catch has been Georgia Strait Sport North (43%), Georgia Strait Troll (12%) and Georgia Strait Sport South (12%).

Chinook fry enumeration

A rotary screw trap (RST) 2.4 m in diameter was used in 2005 to trap juveniles migrating downstream to the Cowichan Estuary. Fish passing through the cone are caught in a live box. The trap was in operation from February 14th to May 20th, and was held in place by a galvanized steel cable which secured the trap at the pump house site. The trap was set for fishing and then sampled on alternating days. The trap was set at approximately 1900 h and fished continuously until 0700 h the following morning at which time the trapped fish were removed and sampled. The trap was then set again on the following evening after sampling had occurred. During efficiency test, trapping occurred continuously over 24-hour periods and the trap was checked at both 0700 h and 1900 h to monitor the day and night movement.

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[1] Water Survey of Canada historical data recorded at Cowichan Lake, 1988-2007

For each trapping session (12 hour overnight fishing time) the number of Chinook fry caught was increased by 25% to expand to the full 24 hour diurnal period. This expansion is based on previous Cowichan Chinook fry work (see Nagtegaal *et al.* 1996). On days when the trap was not in operation, the missing data was interpolated by averaging the catch from the previous and the following trapping session.

All captured fish were enumerated by species and recorded by time period and capture date. Coho were recorded as either fry or one year old smolts. Biophysical conditions (water temperature, flow rates, water clarity, and weather conditions) were also noted.

Trap efficiency information, using the mark-recapture of Bismark Brown stained juvenile Chinook (Ward and Verhoeven 1963), was used to expand the trap catch to estimate total numbers migrating past the trap site. Chinook fry were stained and then released approximately 500 m upstream from the trap site. The number of stained fish recaptured from continuous trapping over the next three to four days was recorded.

Chinook adult enumeration

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. There was no broodstock collection at the counting fence during this study period.

An underwater video camera was installed at the fence site in order obtain an independent estimate of Chinook mark rate and to provide a visual check on species identification. In 2005 the camera was upgraded to a digital video recording system[2] to improve image quality and allow field staff to immediately review images without interrupting the recording process. The camera was positioned in the trap box to record images down a Plexiglas tunnel in the fence fishway with a light on 24 hours a day to ensure visibility. Mirrors along the side of the tunnel allowed a full side view of fish. The video was recorded by a digital video recorder (DVR) located in the counting tower and tapes were reviewed at a later date.

Identification of jack Chinook (2 year old males) at the counting fence was determined by approximate fork length. A measured length of 45 cm was marked on the flashboard within the counting raceway for comparison purposes and any Chinook passing through the fence that appeared to be shorter than this length was noted as a jack.

With this report we have noted 2 year old females (‘Jills’) as a separate group. Although Groot and Margolis (1991) consider these as ‘virtually unknown’, they do cite some studies that provide evidence for maturing rates of two year old females at 0-3% for some Chinook stocks.

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[2] Elmo CCD TV camera; DVMS recording unit by Honeywell International Inc.

Chinook carcass biosampling

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. Starting in 2007, up to 400 otoliths were sampled each from hatchery broodstock and from carcasses recovered on the spawning grounds. All Chinook sampled from the spawning grounds or hatchery broodstock were examined for the presence of a coded-wire tag (CWT) using either a Northwest Marine Technology[3] Handheld Wand Detector or a Northwest Marine Technology[3] R9500 Tunnel Detector. All adipose fin clipped Chinook and fish suspected of having a CWT had heads removed for decoding of coded-wire tags as well as scales obtained for age analysis. All Chinook recovered on the spawning grounds in each year were sampled and spawning condition was noted. Hatchery staff collected biological data from a sample of Chinook broodstock during the study period in each year.

Thermal marks

A thermal mark is a pattern of circuli that is caused to be laid down in the otolith bone of hatchery fish, using an alternating pattern of relatively cold and warm temperatures (Brothers 1990). The range of temperatures used is within the tolerance range of the specific fish and is generated with either two difference sources of water (e.g., well water and surface water) or water that has been cooled, alternating with the ambient temperature water.

A thermal mark of 4-1H was assigned to the Cowichan River Hatchery Chinook stock. The coding stands for a series of four marks, separated by a larger gap, then a final mark prior to hatching. This mark was first applied to the 2006 brood, and for every brood in subsequent years. Although the first of these marked Chinook would not be returning until 2008, the carcasses collected in 2007 were sampled for thermal marks for the purpose of crew training.

Swim surveys

A single swim survey was conducted in 2006 and 2007 on the day the fence was removed from the river to estimate the number of Chinook downstream from the fence site. The purpose of the swim surveys were to ascertain how many spawners were downstream from the counting fence, therefore the swim counts were not expanded to the total system and remain independent of fence counts.

Mark and recapture

No mark and recapture was conducted in 2005. A mark and recapture study was attempted in 2006 but due to high water levels very few carcasses were recovered and the data was not sufficient to produce a reasonable population estimate.

In 2007 the counting fence was dismantled early due to high water levels so a mark and recapture was conducted to compliment the fence data. Adult and jack Chinook carcasses were sampled in the upper section of the Cowichan River, from Cowichan Lake to Three

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[3] Northwest Marine Technology Inc., Shaw Island, Washington, U.S.A.

Firs, on week days from October 22nd to November 30th. The majority of Chinook spawning activity has historically occurred in this area. Crews surveyed the spawning grounds in an inflatable boat and recovered all carcasses encountered with a gaff hook attached to the end of a pole. Each newly recovered carcass was tagged with a Ketchum[4] aluminium sheep ear tag and released. Tag number, spawning condition, POH length, sex, and adipose fin status were recorded for each carcass, and otoliths and scales were collected for origin and age determination. Tag number and recapture location were recorded for all previously tagged carcasses recovered each day, and the recaptured carcasses were then removed from the system.

Mark-recapture estimates for adult and jack Chinook were generated using the Petersen model (Chapman modification). The sex of some adult Chinook carcasses was not recorded for all samples by one field crew so the male/female ratio of Chinook collected by the second field crew was applied to the total adult count to produce estimates for male and female Chinook.

To determine the validity of the mark-recapture estimate, potential biases were assessed to test for violations of the assumptions associated with the Petersen mark-recapture method (Ricker 1975; Seber 1982; Krebs 1989). Temporal bias in application samples was examined by stratifying sampling dates into three periods and comparing the incidence of tag application and tag recovery over time. Sex-related bias in the recovery sample was assessed by comparing the sex ratio of recovered samples with unrecovered samples.

First Nations food fishery

The summary of First Nations catches from 1979 to 2007 is summarised in Table 2. In 1990, a systematic approach was developed by the Cowichan Tribes Aboriginal Fisheries Management (CTAF) program to monitor the fishery more closely and to better estimate the First Nations food fish catch (Paige 1992, 1997). This 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 2005.

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

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. In 2005 DFO hired an observer to conduct this work which would allow the CTAF estimate to be independently verified. No independent observer was hired in 2006 or 2007; catch and effort data were collected by Cowichan Tribes Guardians and submitted to DFO for analysis.

[4] Ketchum Manufacturing Ltd., Ottawa, Canada

Water management plan

Low flow and low water levels are likely to result in delayed fish movement and higher water temperatures, potentially increasing 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 Norske Canada, DFO, Land and Water British Columbia, Cowichan River Hatchery, Cowichan Tribes, and other user groups lead to a water management plan for the Cowichan River. The plan proposes to raise the level of the Cowichan Weir to compensate for a high sediment rise downstream of the weir that interferes with water control. Raising the weir would allow more water storage during the spring and summer that would be available for release during low water levels in the summer. The recommendations of the Water Management Plan are being reviewed by the North Cowichan Regional District.

Appendix 1 summarizes the Cowichan Lake weir water discharge levels proposed by the Water Use Round Table, comprised of Catalyst Paper, DFO, BC Ministry of Environment. Under normal circumstances the summer flow is regulated to be 7 m^3/s however due to a large scale restoration project at the Stoltz Slide in 2006, water flows were held at 4.5 m^3/s through the summer until the fall storms.

Population estimate of natural spawners

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. This method was used in 2005 and 2006. Due to early removal of the counting fence in 2007, the mark-recapture data and Petersen estimate was used as the final population estimate in place of the fence data.

RESULTS

Environmental information

Water temperature, visibility, depth, and weather data were collected at the fence site; however, water level data collected from the Water Survey of Canada was used for all three years and water temperature data was used for 2005 in place of the fence data.

Average water temperature during the study period in 2005, 2006, and 2007 was 17.0^oC, 13.9^oC, and 16.2^oC, respectively. In all three years the temperature declined steadily over the study period, ranging from about 14.0 and 20.3^oC in September and about 11.0 to 17.1^oC in October across all three years (Figures 3, 4, and 5).

Water depth during the study period varied in each year, with an average of 0.413 m in 2005, 0.206 m in 2006, and 0.791 m in 2007 according to the Water Survey of Canada. Average river discharge, also recorded by Water Survey of Canada, averaged 9.04 m^3/s during the 2005 study period, 3.42 m^3/s in 2006, and 39.08 m^3/s in 2007. Water levels in 2005 were close to the historical mean, whereas water levels in 2006 were lower and in 2007 were much higher than the historical mean (Figures 6, 7, and 8). River discharge during the study period ranged from 5.18 to 23.5m^3/s in 2005, from 2.58 to 5.53m^3/s in

2006, and from 5.84 to 22.63m^3/s in 2007 (Tables 3, 4, and 5). High water levels in early October of 2007 lead to early removal of the counting fence.

Fry enumeration (2005)

The Chinook fry enumeration project was scheduled to run from mid-February through to late May; however there was damage inflicted to the trap deliberately by members of the public, preventing operation of the trap during most of April. During this period, the same methodology was used to interpolate and fill in the missing information.

A total of 2081 Chinook fry were captured in the RST. Of these, 1009 were retained and transported to the Cowichan Hatchery for a possible coded-wire tag release. As this number was too small to be effective as a tag group, these fry were released back to the river in June, 2005. As an alternative, a group of 200,000 Chinook from the Nanaimo River hatchery were coded-wire tagged and released in that river.

There were two trap efficiency tests, on March 4 and March 21. The first test used chum fry due to the low numbers of available Chinook. From the first release of 300 chum fry there were 11 recaptures, showing a trap efficiency of 3.7%. This proportion was used to expand the daily estimate from 14 February through 14 March, at which time the trap had to be moved to a new location. From the second release of 225 Chinook fry there was only 3 recaptures, indicating a trap efficiency of 1.3%. This proportion was used from 15 March through to the end of the project in June, 2005.

Table 6 shows the complete data set, with interpolations. The enumeration estimate was 283,000 Chinook fry. There was a broad mode of migration during mid to late February, and a narrow mode during late March. The 50 percentile date was 20 March.

Adult enumeration fence

The enumeration fence was installed at the traditional location upstream of Duncan (Figure 1) in all three years. In 2005 and 2006 it was operational from September 6 to October 26. In 2007, it was set up on September 4 and removed on October 5 due to high water levels that allowed fish to swim over the fence and severely reduced visibility from the counting tower. Weather was mostly clear to mildly cloudy, with only 10 days of rain reported in 2005, 9 days in 2006, and 3 days in 2007. Water visibility was mostly clear, with low visibility on 3 days in 2005, no days in 2006, and 1 day in 2007 (Tables 7, 8 and 9).

In 2005 and 2006, conditions were favourable for accurately counting fish migrating past the fence and all observers were experienced in the identification of salmon species so the counts were deemed reliable. In 2005, 1277 adult Chinook, 996 jack Chinook, 2054 adult coho, 805 jack coho, 334 chum, and 22 fish of unidentifiable species were enumerated at the fence. In 2006, 179 adult Chinook, 125 jack Chinook, 19 adult coho, 4 jack coho, 8 chum, and 1 fish of unidentifiable species were enumerated at the fence. In 2007 conditions were less favourable and the counts were not used to determine population size. A total of 350 adult Chinook, 269 jack Chinook, 31 adult coho, 8 jack coho, and 1 chum were counted before the fence was removed. There were no fence breaches in 2005 or 2006, so it was assumed that all fish migrating past the fence during the study period were enumerated (Tables 7, 8 and 9).

In all three years, Chinook jack migration closely mirrored adult temporal migration with the highest migration rates occurring during the middle of the run around the last week of September (Figures 3, 4, and 5).

The pattern of daily migration past the fence was examined by summarizing hourly counts of fish through the fence. In 2005, the migration was fairly steady throughout the day, with 3-5% of migration occurring each hour. The highest migration rate occurred between 16:00 and 18:00, with 16.1% of all fish passing through the fence during this time period (Table 10). In 2006 and 2007 the migration pattern was weighted towards the late night and early morning hours. In 2006, 63.9% of fish moved past the fence between 00:00 and 08:00, and 21.8% between 20:00 and 24:00 (Table 11). In 2007, 38.7% of fish moved past the fence between 00:00 and 06:00, and 32.1% between 18:00 and 24:00 (Table 12).

Video enumeration data for marked and unmarked Chinook was not available for 2005 and 2006. Though the fence video was operational in both of these years, adipose status was not identifiable due to turbid water and poor images. In 2007, several video recordings from September 19 to October 4 were used to obtain an estimate of Chinook mark rate (Table 13). A total of 326 adult Chinook and 26 jack Chinook were counted moving past the video recorder. Of these, 8 adults (2.5%) were marked and another 8 (2.5%) were recorded as having an unknown adipose status. None of the jack Chinook were marked, but 3 (11.5%) were recorded as having an unknown adipose status. Forty-two Chinook recorded moving past the video were of unknown sex and unknown adipose fin status.

Hatchery broodstock collection and sampling

2005

The Cowichan River Hatchery collected 940 adult and 80 jack Chinook for brood stock. The adipose fin clipped Chinook (52) were sampled and comprised of 11 male, 27 female, 13 jacks and 1 unknown sex (Table 15). No unclipped Chinook were sampled. The majority of adults were age 3_1 (91% of males, 60% of females). Post-orbital hypural lengths of males ranged from 53.5 to 68.5 cms and averaged 59.3 cm. Lengths of females ranged from 48.0 to 72.0 cms and averaged 61.2 cm. Lengths of jacks ranged from 34.8 to 47.5 cms and averaged 43.2 cm.

Fifty-two heads suspected of containing CWTs were collected from hatchery broodstock, and 49 yielded CWT information while 3 had no tags. Most Chinook (46) identified as having a CWT were released by the Cowichan River hatchery. 1 male and 10 females were from brood year 2001, 8 males and 15 females were brood year 2002 and 12 males were from brood year 2003. Three Chinook were identified as having originated from the Chemainus River hatchery: two from the 2002 brood year and one from the 2003 brood year (Table 23).

2006

The Cowichan River Hatchery collected 354 males, 475 females and 38 jack Chinook for brood stock, of which 80 males and 78 females were released back to the river, above the fence site. This release was imposed by a limit of broodstock collection to 33% of the spawning population. This left 274 males, 397 females and 38 jacks for brood. 1 male and 3 females were collected from above the fence site.

237 Chinook from the broodstock collection were sampled consisting of 108 male, 112 female and 17 jack Chinook. Post-orbital hypural lengths of males ranged from 30.9 to 78.8 cm and averaged 59.6 cm. Lengths of female Chinook ranged from 38.1 to 79.0 cm and averaged 62.5 cm, and jack length ranged from 38.2 to 50.3 cm and averaged 41.4 cm (Table 16). A total of 20 male, 32 female and 1 jack Chinook were missing adipose fins (19.4%, 28.6%, and 5.9%, respectively) (Table 16).

30 of the scale samples were unreadable. The majority of both males and females were aged as 3_1 (85% and 74%, respectively) (Table 19).

Fifty-five Chinook heads suspected to contain a CWT were collected from hatchery broodstock. Fifty yielded CWT information while 5 contained no tags. Four of the CWTs were found to have originated from the Chemainus River hatchery, brood year 2003, and one from the Nanaimo River hatchery, brood year 2004. The remaining 45 Cowichan origin samples consisted of 93% from brood year 2003 and 7% from brood year 2002. (Table 24). There were no CWTs released from brood year 2004.

2007

The Cowichan River Hatchery collected 159 males, 161 females, and 48 jack Chinook collected for the broodstock and sampled. Post-orbital hypural length of males ranged from 46.0 to 79.0 cm and averaged 61.4 cm. Length of females ranged from 52.0 to 81.0 cm and averaged 66.6 cm, and jack length ranged from 34.0 to 51.0 cm and averaged 44.5 cm (Table 17). A total of 1 jack, 3 males and 6 females had clipped adipose fins (2.4% and 3.7%, respectively) (Table 20).

Ten heads were collected from hatchery broodstock in 2007 and all were found to contain a CWT (Table 23). Of the Chinook collected, 70% were from the 2003 brood year and released in 2004, and 80% were released from the Cowichan River hatchery. Two of the CWTs recovered were found to have originated from the Nanaimo River hatchery, brood year 2004 (Table 23).

In 2007, 295 otoliths were collected from the hatchery broodstock sample. From this sample one otolith was thermally marked, from Nanaimo Fall Chinook, brood year 2005. No Cowichan marked Chinook were expected.

Chinook spawner biosampling

2005

In 2005, a total of 359 carcasses were recovered on the spawning grounds, consisting of 70 males, 190 females, 95 jacks and 4 jills. Post-orbital hypural length of male carcasses ranged from 36.5 to 80.0 cm and averaged 64.7 cm, while females ranged from 52.8 to 81.2 cm and averaged 66.2 cm. Jack Chinook carcasses ranged in length from 28.9 to 48.7 cm, and averaged 46.6 cm. Jill Chinook carcasses ranged from 32.58 to 46.0 cm and averaged 40.7 cm. (Table 26). Of the carcasses sampled, 1 male, 4 females, and 3 jacks had clipped adipose fins (Table 26). The majority of adult Chinook were aged as 4_1, with 66.0% of males and 71.1% of females in this age category (Table 29).

A total of 8 carcasses sampled from the spawning grounds and one carcass examined from the FSC fishery were missing an adipose fin but were not submitted for analysis for the presence of a CWT.

2006

In 2006, a total of 69 carcasses were recovered from the spawning grounds, consisting of 6 males, 22 females, 38 jacks, 1 jill and 1 fish of unknown sex. Post-orbital hypural length of male carcasses ranged from 55.3 to 79.0 cm and averaged 66.2 cm, while females ranged from 52.0 cm to 77.4 cm and averaged 62.3 cm. Jack Chinook length ranged from 32.5 to 55.3 cm and averaged 40.4 cm (Table 27). The jill Chinook was 56.5 cm. Out of the carcasses sampled, 2 males and 2 females had clipped adipose fins. The majority of adult Chinook were aged as 3_1 (66.6% of males and 68.8% of females) (Table 27).

4 Chinook carcasses were adipose clipped, indicating the presence of a coded-wire tag. Although the heads were not submitted, the two females were aged 3_1 and 4_1, and the two males were aged 3_1 and unknown.

There was no statistically significant difference between the lengths of male, female, and jack carcasses collected on the spawning grounds and those collected from hatchery broodstock (Student's t-test: $t = 0.93$, $p = 0.393$ for males, $t = -0.13$, $p = 0.898$ for females, and $t = -0.48$, $p = 0.633$ for jacks).

2007

In 2007, a total of 471 carcasses were recovered on the spawning grounds as a mark-recapture study and were aged and measured for post-orbital hypural length. The carcass sample consisted of 65 males, 180 females, 149 jacks, 12 jills (female jacks) and 65 fish of unknown sex. The length of adult male carcasses ranged from 43.0 to 85.1cm and averaged 60.8 cm, while females ranged from 37.0 to 90.3 cm and averaged 63.8 cm. The POH length of both male and female jacks ranged from 35.0 to 58.0 cm and averaged 44.5 cm (Table 28). Of the carcasses sampled, 1 male, 4 females, 17 jacks, and 1 fish of unknown sex had clipped adipose fins (Table 28). The majority of adult Chinook were aged as 3 years old (78.8% of males and 60.2% of females) (Table 31).

There was no statistically significant difference between the lengths of male and jack Chinook recovered on the spawning grounds and those sampled for hatchery broodstock (Students t-test: $t = -0.6$, $p = 0.55$ for males, $t = -0.12$, $p = 0.901$ for jacks). There was, however, a statistically significant difference between the lengths of female Chinook collected on the spawning grounds and those collected for hatchery broodstock ($t = -3.88$, $p = 0.000$).

A total of 22 carcasses collected from the spawning grounds had clipped adipose fins and were subsequently analyzed for the presence of a CWT. Eighteen of the heads yielded CWT information, while 4 contained no pins (Table 32). Three of these samples were from jack Chinook, and it is likely that the amount of physical material collected from the carcass was insufficient and that the tag was missed. The fourth no-tag was from an adult Chinook and the entire head had been collected, thus it was a true NOPIN. Most Chinook identified as having a CWT were released from the Cowichan Hatchery (88.8%) with a majority of fish from the 2005 brood year and released in 2006 (83.3%) (Table 32). One Chinook was found to have been released from the Nanaimo hatchery, brood year 2004, and one from the Chemainus hatchery, brood year 2005.

A total of 398 otoliths were collected from carcasses on the spawning grounds during the mark and recapture study in 2007. Two otoliths were found to have originated from Englishman River (Big Qualicum River stock) and two were of unknown origin. These would likely have originated from hatcheries in Washington State. No Cowichan Chinook marks were expected.

Swim surveys

Five segments between the DIDSON site and the pump house were counted in the swim survey conducted on October 5, 2007 by four DFO swimmers. A total of 29 Chinook, 2 coho, 1 chum, and 24 large trout were counted. Visibility in the system was low due to cloud cover and fog, and swimmers could only see up to a distance of about 1 meter. Many fish were also expected to be residing in deep pools where they could not be counted, so observer efficiency was estimated at 30%. As a result, swim survey counts were not expanded and were not included in the evaluation of population size.

Mark and recapture

No carcass mark-recapture survey was done in 2005, and though one was attempted in 2006, very few carcasses were recovered.

In 2007 a total of 65 males, 169 females, 153 jacks, and 64 carcasses of unknown sex were tagged and released on the spawning grounds in the Upper Cowichan River (Tables 33 and 34). Of these, 59 carcasses were recaptured, including 9 males (15.3%), 20 females (33.9%), 16 jacks (27.1%), and 14 unknown Chinook (23.7%) (Table 36 and 37). All unknown fish were considered adults. An additional 15 recaptures were added to the total number of adult recaptures and 5 were added to the total number of jack recaptures to compensate for a low recovery rate during the end of the study period. These recapture estimates were analyzed using the Petersen estimator to return a population estimate of 1,860 adults (95% CI: 1,429 to 2,291) and 1,267 jacks (95% CI: 782 to 1,752) (Table 35).

Bias testing

The deadpitch sample selectivity has several potential biases that were tested for to see if the assumptions of the Peterson mark recapture estimate have been met.

1. Temporal bias: Temporal bias was examined by stratifying the data into three periods and examining whether there was a tendency for either application of tags or recovery of tags over time. For tag application there was no bias between time periods for either the adult sample (Chi-square = 1.18, df = 2 and alpha = 0.01) or the jack sample (Chi-square = 0.44, df = 2 and alpha = 0.01).

   For tag recovery there was a bias in both the adult (Chi-square = 17.53, df = 2 and alpha = 0.01) and jack samples (Chi-square = 9.57, df = 2 and alpha = 0.01). The data shows that there were very few recoveries of tags in the third time period despite quite a few tags applied to carcasses.

2. Fish sex bias: Sex related bias was tested by comparing the sex ratio in the marked and unmarked recoveries by application sample and recovery sample. Adult males and females were examined first, then adult males, females and jacks were examined. In all cases there was no bias found.

The temporal bias in the tag recovery is due to a low recovery rate of tagged carcasses during the third time period. This bias would have the effect of overestimating the population. To compensate for this mark recovery bias in the third time period we used the recovery rate during the first two time periods as a guide to estimate the number of marks that should have been recaptured had there been no bias. As a result we added 15 and 5, respectively, to the adult and jack mark recovery data.

First Nations food fishery

Historical estimates of the number of Chinook captured in the in-river First Nations food fishery are presented in Table 2 and Figure 9. In 2005, the First Nations food fishery catch estimate was 607 adults and 110 jacks. Catch information was collected during September and October by both DFO and Cowichan Tribes Guardians. The Cowichan Tribes data was more complete and was used for the overall estimate.

In 2006 and 2007, observed catch data was collected by Cowichan Tribes and submitted to DFO for analysis and expansion. The final catch estimate was 390 adults and 130 jacks in 2006 and 238 adults and 132 jacks in 2007.

Water management plan

The water release strategy implemented in 2004 was continued in 2005 with pulse releases throughout the fence operation period to encourage fish migration. It was determined that the most beneficial time to release water from the weir is between September 17 and October 11, during night-time high tides in the estuary, as this is when fish are likely to be in the lower reaches of the river. The counting fence can be safely operated up to a river discharge of approximately 22 m^3/s (Nagtegaal *et al.* 2006).

The first pulse release in 2005 commenced September 26, where water output from the weir was increased from 7 m^3/s to 16 m^3/s over a period of time between 7:00am and 1:00pm. The 16 m^3/s water level was maintained until 1:00pm on September 27, at which time the water output at the weir was decreased until the level returned to 7 m^3/s at 8:00pm. Another release with the exact same timeline and water level increase was initiated on October 3 and finished on October 4. It was found that the first pulse release did not result in the expected increase of fish movement, so another pulse release was conducted on October 9 at 7:00 where the water level was increased from 7 m^3/s to 13 m^3/s by 1:00pm. The 13 m^3/s water level was held until October 11 at 7:00am, at which time water discharge from the weir was decreased to reach 7 m^3/s by 7:00pm that day. Again, concerns that Chinook migration did not increase to an expected degree lead to a final pulse release beginning on October 15, when the water level was raised to 16 m^3/s and held for 48 hours, then decreased to a level of 14 m^3/s which was sustained until removal of the fence on October 27. Peak adult and jack Chinook migration occurred on September 29, 2 days after the first pulse release, with 159 adults (12.4%) and 246 jacks (24.8%) migrating past the fence that day (Table 3). Increases in migration did correspond with other pulse releases but were not high enough to alleviate concerns (Figure 6).

No pulse releases were scheduled in 2006 as, due to low water levels in the river and in Cowichan Lake, no water was available for release.

In 2007, the first pulse release was initiated at 8 am on September 16 where water level was increased from 7 m^3/s to 18 m^3/s over a 6 hour period. The 18 m^3/s water level was held for 36 hours then decreased over a 6 hour period to return to a base flow of 10 m^3/s. This base flow level was sustained between pulse releases throughout the rest of the season. Identical pulse releases were conducted on September 24, October 1, and October 8th of

2007. Peak Chinook migration occurred on October 1, with 60 adults (17.1%) and 38 jacks (14.1%) moving past the fence this day.

Population estimate

Escapement and total return estimates in 2005 and 2006 were determined using fence count data, as this is considered to be the most accurate enumeration method. In 2007, the estimates were determined using mark and recapture data due to the lack of a complete fence count. Tables 38 and 39 show the adult and jack estimates to 2007.

2005

1277 adult and 996 jack Chinook were enumerated at the fence. Normally the fence results would be expanded by a factor based on the percent proportion of the population arriving before the day the fence was taken down. In 2005 a 'Trap and Truck' project was enacted toward the end of the enumeration period which resulted in 235 adults and 53 jacks which were transported from below the fence to the spawning areas upstream. These totals were added to the fence enumeration in lieu of a post-fence expansion for an estimate of natural spawners of 1512 adults and 1049 jacks. The Cowichan River Hatchery collected 940 adults and 80 jacks for broodstock, and an estimated 607 adults and 110 jacks were taken in the Food, Social and Ceremonial fishery. Summed together there were 3059 adults and 1239 jacks that returned to the Cowichan River.

2006

179 adult and 125 jack Chinook were enumerated at the fence. Normally the fence results would be expanded by a factor based on the percent proportion of the population arriving before the day the fence was taken down. A swim count was conducted on the day the fence was removed and 116 adult Chinook were enumerated downstream. A 'Trap and Truck' project was enacted toward the end of the enumeration period resulted in 616 adults and 616 jacks which were transported from below the fence to the spawning areas upstream. In addition, the hatchery released 158 adults from their brood capture to comply with OHEB collection rules. These totals were added to the fence enumeration in lieu of a post-fence expansion for an estimate of natural spawners of 1069 adults and 741 jacks. The Cowichan River Hatchery collected 671 adults and 38 jacks, after releases and correction based on age designation; however 4 of the adults were collected from above the enumeration fence so the summation will reflect this. The estimated catch from the Cowichan Tribes' Food, Social and Ceremonial fishery was 390 adults and 130 jacks. Summed together there were 2126 adults and 909 jacks that returned to the Cowichan River.

2007

In previous years the estimate of natural spawners is based on enumeration results at the counting fence, expanded for run timing for periods when the fence was not operating. Using this method the count of 350 adult Chinook at the end of 4 October would represent 45.2% of the average cumulative fence count to date. Expanding the count to 100% produces an estimate of 774 adults. The standard error bounds on this estimate are 475-2096 which is based on annual variation around the run timing data.

When the fence enumeration was finished the field crew initiated the carcass deadpitch mark recapture and biosampling project. As this task proceeded it became apparent that the fence run timing estimate was too low to be consistent with the numbers of observed Chinook spawners. The deadpitch crew sampled 471 Chinook adults and jacks which is usually a small proportion of the spawning abundance. In addition, anecdotal reports received from the public suggested that there were more Chinook in the river than the fence estimate.

As a result of the limited fence coverage the estimate of natural spawners was based on the carcass mark recapture estimate. The count of adults (350) and jacks (269) at the fence can be considered to be the minimum estimate of natural spawners, minus 43 adults and 26 jacks that were collected for brood above the fence.

The mark recapture task was conducted between 22 October and 30 November in the preferred spawning areas above Skutz Falls. Spawning activity below Skutz Falls has been associated with low water conditions however in 2007 the water level was adequate for Chinook to pass through the fishway at the falls. There was some spawning activity below the falls however this was assumed to be insignificant.

For the purpose of the mark recapture estimate, any carcasses sampled on the first day were not included as part of the recapture, and similarly, any marks applied on the final day were not included as part of the mark component.

There were a large number of carcasses of unknown sex recorded by one of the two field crews. Any that were aged as 2_1 were deemed to be jacks and included with the jack mark recapture estimate. All others were deemed to be adults.

298 adult carcasses were marked, 366 were subsequently examined with 58 recaptures. This results in an estimate of 1860 adults (+/- 431).

153 jack carcasses were marked, 180 were subsequently examined with 21 recaptures. This results in an estimate of 1267 jacks (+/- 485).

Wild/Hatchery Origin

Tables 38, 39 and 40 show the calculations required to estimate the hatchery component of the Chinook return for 2005, 2006 and 2007, respectively. Each table is stratified to brood year (Age) and return component (Hatchery Broodstock, Natural Spawners or Native Fishery). The data within the table shows the estimated number of coded-wire tags by tag code, and the expanded number of associated hatchery releases.

DISCUSSION

Fry enumeration

The 2005 Fry Enumeration project was challenged with equipment issues, specifically damage caused by vandalism. This damage occurred during early April and required removal of the trap from the river in order to repair. As a result the data from 2-Apr to 9-May is largely missing, and required interpolation over that period. Although the results are presented here, they are highly uncertain.

Chinook adult and jack enumeration

The fence was successful in 2005 and 2006 in providing estimates of spawning populations of adult and jack Chinook. It is assumed that all fish passing through the fence were enumerated, as gaps between fence panels were closed with sandbags and an observer was on duty 24 hours a day. While the fence was intended to be self-cleaning, field staff were regularly required to remove leafy debris from fence panels during periods of high water flow. The trap gate was closed during these times so no fish could have passed through unobserved.

The counting fence cannot be operated safely above a river discharge level of about 22 cms. When high flows are reached, fish are able to pass over the fence without being counted. High flows resulted in the removal of the fence on October 26 in 2005 and, coincidentally, in 2006 as well. No adjustment for late migrating Chinook was done based on the Trap and Truck procedure that was conducted in both years after the fence was removed. In 2007, a high water level (23 cms) was reached on October 5 and continued over the following days, necessitating early removal of the counting fence. When the fence is removed at this stage of the Chinook migration, to use a run timing model to estimate the whole abundance would be highly uncertain. About 45.3% of fish migration occurs before this day, so the fence data was not sufficient enough to provide a population estimate in 2007. Instead, a carcass mark-recapture estimate was used to provide an estimate of the natural spawner abundance.

Several of the past fence enumeration studies have shown that there is often a difference between the jack to adult ratio of fish counted through the fence of the carcasses collected from the spawning grounds (Nagtegaal and Carter 1998, 2000). To an observer in a counting tower at the fence, discrimination between jacks and adults is based mainly on the length of the fish as it appears from above. This would likely result in some longer jacks being counted as adults, and some shorter adults being counted as jacks. Therefore, the jack to adult ratio recorded at the fence is not considered to be reflective of the true population ratio. In order to correct for this, the fence counts were adjusted in 2005 and 2006 based on the proportion of jacks carcasses recovered on the spawning grounds that were longer than 450mm and the proportion of adults shorter than 450mm. This is the established jack cut-off length that has been used in past years. However many jacks in the carcass recovery sample in both 2005 and 2006 were longer than 450mm so the cut-off may be too low to accurately determine the jack to adult ratio. This would result in an overestimate of the number of adults and an underestimate of the number of jacks in the spawning population.

An estimate of Chinook mark rate could not be determined from the fence video in 2005 and 2006 because of low visibility that resulted in poor quality images. The mark rate obtained from the fence video in 2007 was similar to the mark rate of Chinook carcasses collected on the spawning grounds and from hatchery broodstock and statistical analysis revealed no significant difference. Sex cannot be accurately differentiated from the video recordings so all adult Chinook were combined in the analysis. The numbers of jack Chinook counted by the video and the number collected for hatchery broodstock are low compared to the number of jacks collected on the spawning grounds, so a low mark rate is expected in each of these samples. Video analysis is thought to be the most accurate method of determining mark rate because it eliminates location and selection biases associated with collection of carcasses or broodstock.

Chinook carcass biosampling

Average lengths of males, females, and jacks was consistent throughout all three years. There was no statistically significant difference between the mean POH lengths of Chinook recovered on the spawning grounds and those collected for hatchery broodstock. There was a significant difference between the mean lengths of females collected in 2007 from the spawning grounds and for broodstock. This difference might be a result of the different collection methods for the two samples; during the mark and recapture study carcasses are collected from the spawning grounds, while Chinook are collected for broodstock with tangle-nets and beach seines (Nagtegaal *et al.* 2006), which might lead to capture selectivity.

There was no statistically significant difference between the adipose clip rates of carcasses collected on the spawning grounds and those collected for hatchery broodstock in 2006 or 2007. Broodstock collection is highly biased towards adults, so the clip rate of jack Chinook in the broodstock sample is likely not an accurate representation of the clip rate in the total population.

Otoliths were collected in 2007 as a baseline for collection in future years, but marked otoliths from the Cowichan River hatchery are not expected to appear until 2008 in jack Chinook. The otolith marking study was implemented to provide an alternate estimate of hatchery contribution in future years. Before 2006, only some of the Chinook released from the Cowichan River hatchery were given CWTs. Now, in addition to coded-wire tagging, all hatchery stock are given a thermal mark so the number of hatchery returns can be determined with a smaller sample size.

Swim surveys

The swim survey conducted on 5 October 2007 found 29 adult Chinook located downstream of the fence site, indicating that the migration of the Chinook was ongoing.

Mark and 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 and undue stress to the fish, this practice was abandoned. 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 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.

There was a temporal bias found in the recovery sample of the mark and recapture study done in 2007. A significantly lower number of tagged carcasses were recaptured in the earliest two periods of the study than in the third time period, despite the fact that there was no difference in the number of tags applied. In past years, bias assessments have shown that there is often a higher number of recoveries in the later stages of the study, due to the fact that there are more tagged carcasses available (Nagtegaal *et al.* 2006).

Some of the usual assumptions associated with mark and recapture studies do not apply when carcasses rather than live fish are the object of the study. For example, marks cannot affect individuals, increase vulnerability to predation or recapture, or affect distribution of captured individuals throughout the population. Therefore, the mark and recapture study conducted on the spawning grounds in 2007 can be considered a fairly reliable method for estimating population. Some marked carcasses must inevitably disappear due to scavenging, but assuming that marks do not influence predators’ selection and both marked and unmarked carcasses are taken in equal proportion, predation will not affect the population estimate. It is also likely that some marked carcasses could have fallen into deep pools or become trapped in an area that prevented recovery.

First Nations food fishery

The 2005 adult Chinook catch estimate was about average compared to historical estimates. Adult estimates in 2006 and 2007 were somewhat lower than the historical average, though overall counts were low in these years. Jack catch estimates for all three years were consistent with recent historical data. Estimates may have been higher if non-catch mortalities had been taken into consideration (Nagtegaal *et al.* 2004). Non-catch mortalities include Chinook that escape capture by fisheries but suffer injuries or high stress induced by fisheries and die before spawning.

Water management Plan

Water level is important during salmon run season as it determines the ease with which fish can migrate to the traditional spawning grounds. During periods of low water levels salmon are more likely to be susceptible to poaching and predation, as well as increased stress (Hop Wo *et al.* 2005). The ability to control flow levels through the Cowichan Lake Weir has been beneficial to fish migration in past years. Pulse releases from the weir imitate natural storm events that encourage fish movement upstream and allow fish to reach the spawning grounds with minimal stress.

Fence operation is also dependent on flow; in high flows the fence will become submerged, allowing fish to pass over it. Large floating debris may also cause damage to the fence panels and counting tower. If water storage in the Cowichan Lake is kept at a level below the weir, then water level in the river can be controlled. If heavy rainfall raises water level in the lake above the maximum capacity, water will spill over the weir and river discharge can no longer be controlled. For this reason, pulse releases during the fall can also be necessary for proper fence operation (Nagtegaal *et al.* 2004).

In 2005, increases in daily Chinook migration generally coincided with pulse releases (Figure 6). The highest peak in migration occurred 2 days after the first pulse releases, and several smaller peaks throughout the run occurred just after other releases. It takes about 12 hours for a water release to reach the fence from the weir, and about another hour for it to reach the estuary, so it is natural for fish migration to increase after the release.

In 2006, the water level in Cowichan Lake was too low for water to be released from the weir. Chinook migration past the fence followed a fluctuating pattern, with the highest daily count being 11 adults and 12 jacks on September 27 (Figure 7). The counting fence is traditionally installed about 10-12 km upstream of the estuary. Field crews have observed spawning Chinook in the vicinity of the fence in some years so it is possible that some fish spawned below the fence in this year, resulting in an underestimation of escapement.

A slightly different water management strategy was employed in 2007; pulse releases were maintained for a longer period of time (36 hours) and after the first release, a base flow of 10 m^3/s rather than 7 m^3/s as in previous years was maintained throughout the fence operation period. This was done out of a concern that fish movement was lower than in past years. Holding in the lower river is generally stressful to salmon, so a continuous flow is preferable, when possible, to encourage upstream movement (Nagtegaal *et al.* 2004). The major migration peak in 2007 did coincide with the pulse release on October 1, but a series of small peaks in the early part of the run make it difficult to say whether the first pulse releases were beneficial (Figure 8).

Marine Seal Predation

In the Manuscript reports for Cowichan Chinook returns for the years prior to 2004, 300 adult Chinook were added to the in-river abundance estimate to account for Chinooks lost to pinniped predation in Cowichan Bay. This figure was based on information from Olesiuk *et al.* (1990). The purpose of this adjustment was to include the impact of local predators on the returning number of Chinook that are specific to the Cowichan population so that the resulting abundance estimate can be used as an indicator for the Lower Georgia Strait Management Unit.

There is no annual adjustment to the figure based on changes in predator abundance, Chinook abundance, abundance of other prey items, or water levels within the Cowichan River.

The authors of this paper have decided to leave this adjustment out. Although there is a pinniped presence in Cowichan Bay that specifically target returning Cowichan Chinook, this is not the only location that seals, sea lions and killer whales prey upon Chinook. As an indicator, to include with the return the estimated loss to local predators assumes that there is no predation elsewhere in the Management Unit that this indicator represents.

There are many sources of mortality throughout the life cycle and to include this specific one, without annual inputs such as predator or prey population size, accessibility of freshwater refuge, etc. limits the usefulness of this statistic.

Population estimate

In 2005 and 2006 the population estimate could be determined using expanded fence counts. In past years this has been the preferred estimate even when a mark and recapture study was done as well. In 2007 the mark and recapture study was the main source of data for the population estimate and was used in place of the fence data to estimate escapement.

A Mark-Recapture method provides an uncertainty estimate through the formulae and is straightforward to calculate. The uncertainty of the expanded fence estimate is based on an exact count, which is then expanded using data from years when the fence had been operated to the end of October and later. Since Chinook run timing varies with rainfall events there is some refinement of the run timing model based on the date of an increase in discharge from the summer low flow.

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Tables

Table 1. Cowichan River Hatchery Chinook release[1] data for brood years 2005-2007

Tag Code	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site
184422	2005	14825	127435	11.63	3.4	25/04/2006	25/04/2006	COWICHAN R UP
184836	2005	14589	125598	11.62	6.1	15/05/2006	15/05/2006	COWICHAN R UP
185810	2005	29646	255225	11.62	6.1	15/05/2006	15/05/2006	COWICHAN R UP
185811	2005	29364	252798	11.62	6.1	15/05/2006	15/05/2006	COWICHAN R UP
185812	2005	26464	227831	11.62	6.1	15/05/2006	15/05/2006	COWICHAN R UP
185818	2005	29556	254061	11.63	3.4	25/04/2006	25/04/2006	COWICHAN R UP
185819	2005	29313	251973	11.63	3.4	25/04/2006	25/04/2006	COWICHAN R UP
185820	2005	26426	228299	11.58	3.4	25/04/2006	25/04/2006	COWICHAN R UP
185214	2005	25188	99087	25.42	6.1	30/05/2006	30/05/2006	COWICHAN BAY
185832	2006	25040	71335	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
185833	2006	24989	71190	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
185834	2006	24923	71002	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
186035	2006	25078	71444	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
186036	2006	25222	71854	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
186037	2006	25005	71235	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
186039	2006	25015	71264	35.10	5.8	23/05/2007	23/05/2007	COWICHAN R UP
186042	2006	25018	149964	16.68	4.1	09/05/2007	09/05/2007	COWICHAN R LOW
185606	2006	25060	70637	35.48	10.76	18/06/2007	18/06/2007	COWICHAN R
186038	2006	25030	99913	25.05	6	24/05/2007	24/05/2007	COWICHAN R
186040	2006	24965	70369	35.48	10.76	18/06/2007	18/06/2007	COWICHAN R
185355	2007	41037	41037	100	6.0	25/04/2008	25/04/2008	COWICHAN R
185356	2007	40850	40850	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
185339	2007	40783	40783	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
186016	2007	10822	10822	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
186015	2007	10816	10816	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
186220	2007	29978	29978	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
186219	2007	29848	29848	100	6.0	25/04/2008	25/04/2008	COWICHAN R UP
080346	2007	5188	5201	99.75	8.3	29/05/2008	29/05/2008	COWICHAN EST
185858	2007	10008	10033	99.75	8.3	29/05/2008	29/05/2008	COWICHAN EST
185739	2007	10174	1019	99.75	8.3	29/05/2008	29/05/2008	COWICHAN EST
186225	2007	29833	29833	100	7.5	29/05/2008	29/05/2008	COWICHAN R
186227	2007	27417	27417	100	7.5	29/05/2008	29/05/2008	COWICHAN R
186226	2007	29594	29743	99.5	7.5	29/05/2008	29/05/2008	COWICHAN R
185358	2007	41095	41198	99.75	7.5	29/05/2008	29/05/2008	COWICHAN R UP
185359	2007	41715	41715	100	7.5	29/05/2008	29/05/2008	COWICHAN R UP
185357	2007	35061	35061	100	7.5	29/05/2008	29/05/2008	COWICHAN R UP
182211	2007	10249	10249	100	14.9	02/07/2008	02/07/2008	COWICHAN EST
183532	2007	10341	10341	100	14.9	02/07/2008	02/07/2008	COWICHAN EST
186006	2007	4717	4717	100	14.9	02/07/2008	02/07/2008	COWICHAN EST

[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 2. Annual adult and jack Chinook catch estimates from the Cowichan River First Nations Food Fishery[1], 1981-2007

	Chinook Catch	
Year[2]	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
2004	320	4
2005	607	110
2006	390	130
2007	238	132

[1] Includes Chinook caught in both the spear fishery and the in-river gillnet fishery.

[2] Since 1988, data have 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 3. Daily Cowichan River discharge[1] measured in cubic meters per second, 2005

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	66.10	137.00	39.10	78.20	40.60	40.40	8.27	5.68	5.26	6.07	99.70	50.20
2	62.30	130.00	39.60	97.30	38.70	36.50	7.77	5.70	5.02	5.89	103.00	47.90
3	59.00	123.00	38.30	103.00	36.70	33.90	7.46	5.58	5.19	7.91	104.00	45.90
4	55.80	118.00	37.40	103.00	33.10	30.90	6.82	5.38	5.41	13.30	109.00	44.00
5	53.00	111.00	33.50	102.00	31.00	28.80	6.83	5.22	5.41	6.03	112.00	42.60
6	50.90	109.00	28.50	119.00	28.70	24.20	7.78	5.10	5.48	5.81	114.00	41.00
7	49.50	105.00	29.40	116.00	26.40	22.20	7.79	5.01	5.34	6.22	108.00	39.60
8	47.40	99.40	29.50	112.00	23.90	21.50	8.85	5.09	5.52	6.02	103.00	38.00
9	45.00	94.50	30.40	105.00	22.20	19.50	10.60	4.96	5.28	7.38	99.70	36.50
10	42.90	88.60	29.50	98.70	20.40	18.40	10.90	5.16	5.33	11.20	105.00	35.40
11	40.90	83.60	27.80	103.00	19.50	17.60	11.10	5.52	5.32	10.10	115.00	34.30
12	39.50	79.90	26.00	100.00	18.20	16.60	11.60	5.55	5.41	6.50	116.00	32.90
13	37.40	75.90	24.50	95.80	16.50	16.00	11.90	5.30	5.27	8.95	117.00	32.00
14	35.40	71.20	23.80	90.40	15.60	16.10	11.80	5.28	5.24	7.86	111.00	31.00
15	33.70	66.60	22.90	87.50	16.30	15.00	11.30	5.37	5.18	10.10	104.00	30.10
16	33.50	63.50	22.00	123.00	16.60	13.70	11.50	5.32	5.42	16.40	98.70	28.90
17	63.20	60.60	20.50	129.00	15.90	15.00	10.30	5.69	5.46	18.10	93.80	27.90
18	148.00	57.60	19.00	122.00	17.00	14.50	9.79	5.47	6.57	16.60	89.20	26.80
19	262.00	55.40	19.50	114.00	23.40	13.60	9.30	5.54	5.57	16.00	85.30	26.40
20	277.00	52.60	27.30	105.00	36.20	13.30	8.78	5.37	5.73	16.10	81.20	43.90
21	242.00	49.50	29.90	97.50	41.60	14.00	8.30	5.22	5.49	15.80	77.20	73.90
22	299.00	47.00	26.60	92.20	50.70	13.80	7.84	5.18	5.34	16.60	73.30	92.40
23	321.00	44.90	24.70	86.60	78.40	11.90	7.93	5.23	5.41	17.70	69.60	103.00
24	267.00	43.20	23.70	80.90	83.90	10.50	7.20	5.29	5.39	17.20	66.10	135.00
25	237.00	41.70	22.80	74.50	79.90	10.30	6.93	5.43	5.39	17.30	64.90	147.00
26	214.00	39.80	40.80	68.30	73.90	9.61	6.58	5.29	7.64	23.50	62.10	151.00
27	196.00	38.30	47.40	62.20	67.90	9.43	6.40	5.24	13.30	42.90	58.70	161.00
28	180.00	37.00	40.70	55.10	61.40	8.85	6.19	5.08	6.60	53.90	55.80	170.00
29	164.00		39.10	48.80	56.70	8.58	6.04	5.30	7.17	33.30	54.70	169.00
30	150.00		41.80	44.80	50.20	8.17	5.81	5.17	6.56	44.60	52.40	171.00
31	144.00		46.60		44.20		5.80	5.26		90.90		187.00
Total	3916.5	2123.8	952.6	2814.8	1185.7	532.8	265.5	165.0	176.7	576.2	2703.4	2295.6
Mean	126.3	75.9	30.7	93.8	38.2	17.8	8.6	5.3	5.9	18.6	90.1	74.1
Max	321.0	137.0	47.4	129.0	83.9	40.4	11.9	5.7	13.3	90.9	117.0	187.0
Min	33.5	37.0	19.0	44.8	15.6	8.2	5.8	5.0	5.0	5.8	52.4	26.4

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

Table 4. Daily Cowichan River discharge[1] measured in cubic meters per second, 2006

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1	186.00	188.00	50.20	66.10	31.40	21.10	5.73	5.12	3.43	3.19	5.23	142.00
2	203.00	194.00	50.10	65.10	30.30	23.90	5.45	5.01	3.44	3.30	5.95	133.00
3	183.00	180.00	48.70	63.70	29.60	25.20	5.27	5.36	3.38	3.34	13.00	123.00
4	174.00	236.00	46.80	63.20	29.00	24.90	5.15	5.22	3.29	3.23	28.40	118.00
5	213.00	216.00	45.30	61.30	30.30	24.50	5.31	4.86	3.12	3.06	41.20	113.00
6	250.00	188.00	45.90	59.50	29.90	22.80	5.40	4.86	2.94	3.05	169.00	110.00
7	222.00	170.00	54.10	57.40	30.10	22.00	5.24	4.87	2.75	3.08	186.00	105.00
8	205.00	157.00	60.40	56.00	30.00	21.10	5.07	5.05	2.79	3.14	167.00	104.00
9	249.00	144.00	68.30	56.10	28.60	22.10	4.95	5.03	2.87	3.12	154.00	104.00
10	262.00	134.00	62.30	56.10	27.90	21.80	4.77	5.06	2.76	3.11	156.00	106.00
11	252.00	126.00	58.70	54.50	27.90	23.30	4.27	5.02	2.67	3.13	157.00	169.00
12	240.00	117.00	55.40	53.10	28.00	26.50	4.05	4.78	2.61	3.16	175.00	217.00
13	297.00	110.00	52.50	51.00	28.30	28.70	3.46	4.46	2.58	3.08	202.00	276.00
14	269.00	103.00	50.00	52.20	28.10	30.40	3.46	4.51	2.66	3.21	176.00	243.00
15	236.00	97.50	49.10	52.80	28.40	28.90	3.11	4.61	2.70	3.50	280.00	265.00
16	224.00	91.60	50.50	50.50	28.50	26.80	3.38	4.46	2.64	3.46	313.00	223.00
17	283.00	85.30	50.40	47.20	26.70	23.80	3.36	4.28	2.76	3.81	319.00	201.00
18	255.00	79.70	48.70	40.20	25.40	21.10	3.35	4.12	3.00	5.07	333.00	187.00
19	223.00	74.80	46.60	34.30	23.70	18.60	3.48	3.99	3.20	5.30	304.00	187.00
20	209.00	70.30	45.00	32.30	23.80	16.50	3.93	3.81	3.17	5.19	304.00	188.00
21	189.00	66.00	43.20	33.10	22.90	13.60	4.27	3.47	3.12	5.00	311.00	226.00
22	175.00	62.40	47.10	32.30	23.90	11.00	4.04	3.43	3.05	5.00	299.00	215.00
23	163.00	59.60	55.40	30.90	23.60	8.84	4.07	3.59	2.99	5.26	278.00	207.00
24	152.00	56.00	64.40	30.70	24.00	7.75	3.97	3.45	2.98	5.29	260.00	204.00
25	140.00	52.60	69.60	31.70	24.80	6.77	4.38	3.29	2.96	5.29	236.00	231.00
26	139.00	51.40	69.50	31.60	25.80	6.59	4.47	3.27	2.95	5.53	217.00	218.00
27	139.00	54.20	69.20	30.80	26.60	6.18	4.54	3.33	3.00	5.78	199.00	195.00
28	144.00	52.60	67.40	31.10	25.20	6.02	4.99	3.46	3.09	5.55	180.00	181.00
29	148.00		65.60	32.80	23.80	5.87	4.95	3.34	3.20	5.59	165.00	170.00
30	182.00		63.70	31.30	22.20	5.75	4.92	3.34	3.23	5.26	154.00	160.00
31	159.00		63.30		20.80		5.16	3.34		5.36		149.00
Total	6365.0	3217.0	1717.4	1388.9	829.5	552.4	138.0	131.8	89.3	129.4	5787.8	5470.0
Mean	205.3	114.9	55.4	46.3	26.8	18.4	4.5	4.3	3.0	4.2	192.9	176.5
Max	297.0	236.0	69.6	66.1	31.4	30.4	5.7	5.4	3.4	5.8	333.0	276.0
Min	139.0	51.4	43.2	30.7	20.8	5.8	3.1	3.3	2.6	3.1	5.2	104.0

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

Table 5. Daily Cowichan River discharge[1] measured in cubic meters per second, 2007

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	152.19	88.91	78.95	107.43	68.92	24.54	6.34	8.80	5.77	24.24	72.27	65.95
2	303.57	82.85	75.68	100.10	64.44	23.84	6.15	8.72	5.90	23.33	67.21	64.14
3	284.14	78.82	72.87	92.52	61.34	23.01	6.10	8.54	6.18	23.46	65.31	216.54
4	245.28	75.56	69.54	87.37	55.09	21.73	6.12	8.45	6.50	23.39	63.33	374.18
5	238.33	72.66	67.97	81.45	48.51	20.77	6.01	8.68	6.14	22.63	60.50	305.74
6	267.01	69.37	67.75	75.98	39.66	20.08	5.95	8.66	6.01	23.95	58.38	264.90
7	302.38	69.69	74.83	72.47	32.81	19.17	5.93	8.47	6.12	48.92	56.01	241.41
8	271.16	72.52	84.36	71.36	27.82	18.17	5.86	8.64	6.14	66.44	54.47	217.90
9	256.39	71.65	109.44	73.75	28.47	18.06	5.88	8.55	6.00	66.62	57.51	201.71
10	248.26	72.35	115.57	71.78	30.30	17.41	5.85	8.73	5.84	71.47	69.54	180.91
11	225.26	72.35	209.05	68.34	29.84	15.51	5.75	8.76	6.10	71.75	74.84	164.11
12	204.37	73.59	277.94	65.35	29.46	15.10	5.88	8.72	6.06	69.82	132.80	151.33
13	189.18	74.23	216.62	66.78	29.84	14.79	6.08	8.68	5.88	67.21	134.77	139.51
14	172.70	73.98	193.29	74.39	29.92	14.59	5.95	8.40	5.98	64.61	121.89	133.23
15	155.42	80.23	178.25	72.72	29.94	14.10	5.71	7.46	6.11	63.28	122.25	136.34
16	141.32	85.14	169.47	72.06	30.00	13.53	5.64	7.04	6.10	62.69	152.60	138.92
17	134.38	84.40	164.07	71.79	30.39	12.67	5.69	6.44	14.36	60.67	146.33	140.34
18	126.41	91.04	159.87	69.57	29.70	11.91	5.94	6.10	17.02	69.39	140.93	133.45
19	124.14	92.80	156.39	68.34	29.98	11.10	6.12	5.98	9.22	87.58	129.34	136.49
20	116.50	107.10	160.29	64.95	32.56	10.04	6.32	5.90	8.54	99.23	125.94	136.98
21	110.23	106.69	151.49	62.14	32.23	9.08	6.79	5.85	8.56	96.85	118.48	125.96
22	115.97	102.42	143.95	61.00	30.94	8.23	7.96	5.84	8.57	110.47	110.86	126.39
23	145.16	97.88	145.85	57.53	30.28	7.56	8.04	5.78	8.51	117.05	102.01	125.31
24	148.54	95.20	159.50	56.49	26.13	6.86	8.09	5.84	17.08	114.65	95.89	124.80
25	139.66	95.19	166.25	55.79	25.81	6.63	8.22	5.81	19.27	108.81	89.54	116.74
26	130.06	92.09	157.60	55.99	25.89	6.52	8.80	5.93	11.22	101.87	84.23	110.66
27	121.22	88.78	147.31	66.82	25.07	6.51	9.10	5.92	8.75	96.36	80.13	104.26
28	114.86	84.04	137.09	78.22	25.25	6.62	8.65	5.89	11.43	91.00	76.16	100.51
29	107.94		128.15	76.12	25.40	7.04	8.37	5.82	12.07	86.14	74.65	95.41
30	100.60		121.37	73.56	25.48	6.55	8.04	5.72	19.77	81.14	69.91	91.87
31	95.08		113.73		24.97		8.37	5.65		76.49		86.26
Total	5487.71	2351.53	4274.50	2172.16	1056.44	411.73	209.66	223.77	271.18	2191.48	2808.08	4752.25
Mean	177.02	83.98	137.89	72.41	34.08	13.72	6.76	7.22	9.04	70.69	93.60	153.30
Max	303.57	107.10	277.94	107.43	68.92	24.54	9.10	8.80	19.77	117.05	152.60	374.18
Min	95.08	69.37	67.75	55.79	24.97	6.51	5.64	5.65	5.77	22.63	54.47	64.14

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

Note: Data is preliminary and subject to changes

Table 6. Daily enumeration of chum and Chinook fry, with expanded estimates, Cowichan River, 2005.

Date	Observed Chum Fry	Observed Chinook fry	Interpolated data	24 hour estimate	Expanded estimate	Total to date	Removed to hatchery
14-Feb-05							
15-Feb-05	6	42		42	1145	1145	
16-Feb-05	5	172		172	4691	5836	
17-Feb-05			193	217	5922	11758	
18-Feb-05	2	214		268	7295	19053	100
19-Feb-05			181	226	6153	25207	
20-Feb-05			181	226	6153	31360	
21-Feb-05	3	147		184	5011	36372	
22-Feb-05			190	238	6477	42849	
23-Feb-05	3	233		291	7943	50792	200
24-Feb-05			171	213	5813	56605	
25-Feb-05	128	108		135	3682	60286	
26-Feb-05			122	152	4142	64428	
27-Feb-05			122	152	4142	68570	
28-Feb-05	200	135		169	4602	73173	
01-Mar-05			93	116	3153	76326	
02-Mar-05	493	50		63	1705	78031	50
03-Mar-05			48	60	1636	79667	
04-Mar-05	778	46		58	1568	81235	
05-Mar-05			51	63	1722	82957	
06-Mar-05			51	63	1722	84678	
07-Mar-05	1268	55		69	1875	86553	55
08-Mar-05			60	74	2028	88582	
09-Mar-05	1835	64		80	2182	90764	64
10-Mar-05	2175	84		84	2291	93055	84
11-Mar-05	2324	39		39	1064	94118	39
12-Mar-05			37	46	1244	95363	
13-Mar-05			37	46	1244	96607	
14-Mar-05	2130	34		43	1159	97766	34
15-Mar-05			24	30	2250	100016	
16-Mar-05	1160	14		18	1313	101328	14
17-Mar-05			25	31	2344	103672	
18-Mar-05	2490	36		45	3375	107047	36
19-Mar-05			194	243	18188	125235	
20-Mar-05			194	243	18188	143422	
21-Mar-05	4847	352		440	33000	176422	127
22-Mar-05			198	247	18516	194938	
23-Mar-05	7222	43		54	4031	198969	43
24-Mar-05	6605	48		48	3600	202569	48
25-Mar-05	1686	9		9	675	203244	9
26-Mar-05			24	29	2203	205447	
27-Mar-05			24	29	2203	207650	
28-Mar-05	7050	38		48	3563	211213	38
29-Mar-05			33	41	3094	214307	
30-Mar-05	10225	28		35	2625	216932	28
31-Mar-05			34	43	3188	220119	
01-Apr-05	1877	40		50	3750	223869	40
02-Apr-05			39	48	3615	227484	
03-Apr-05			37	46	3479	230963	
04-Apr-05			36	45	3344	234307	
05-Apr-05			34	43	3208	237515	
06-Apr-05			33	41	3073	240588	

Table 6 (cont.)

Date	Observed Chum Fry	Observed Chinook fry	Interpolated data	24 hour estimate	Expanded estimate	Total to date	Removed to hatchery
07-Apr-05			31	39	2938	243525	
08-Apr-05			30	37	2802	246327	
09-Apr-05			28	36	2667	248994	
10-Apr-05			27	34	2531	251525	
11-Apr-05			26	32	2396	253921	
12-Apr-05			24	30	2260	256182	
13-Apr-05			23	28	2125	258307	
14-Apr-05			21	27	1990	260296	
15-Apr-05			20	25	1854	262150	
16-Apr-05			18	23	1719	263869	
17-Apr-05			17	21	1583	265452	
18-Apr-05			15	19	1448	266900	
19-Apr-05			14	18	1313	268213	
20-Apr-05			13	16	1177	269390	
21-Apr-05			11	14	1042	270432	
22-Apr-05			10	12	906	271338	
23-Apr-05			8	10	771	272109	
24-Apr-05			7	8	635	272744	
25-Apr-05			5	7	500	273244	
26-Apr-05			4	5	365	273609	
27-Apr-05			2	3	229	273838	
28-Apr-05	738	1		1	94	273932	
29-Apr-05			2	2	141	274072	
30-Apr-05			2	3	188	274260	
01-May-05			3	3	234	274494	
02-May-05			3	4	281	274775	
03-May-05			4	4	328	275103	
04-May-05			4	5	375	275478	
05-May-05			5	6	422	275900	
06-May-05			5	6	469	276369	
07-May-05			6	7	516	276885	
08-May-05			6	8	563	277447	
09-May-05			7	8	609	278057	
10-May-05		7		7	525	278582	
11-May-05		1		1	75	278657	
12-May-05		3		3	225	278882	
13-May-05		8		8	600	279482	
14-May-05			6	6	450	279932	
15-May-05			4	4	300	280232	
16-May-05		2		2	150	280382	
17-May-05		9		9	675	281057	
18-May-05		4		4	300	281357	
19-May-05		10		10	750	282107	
20-May-05		5		5	375	282482	
21-May-05			4	4	300	282782	
22-May-05			3	3	225	283007	
23-May-05			1	1	75	283082	
24-May-05			0	0	0	283082	

Table 7. Daily fence counts at the Cowichan River fence site, 2005

			Temp	Depth	Chinook		Coho			
Date	Weather[1]	Visibility[2]	(°C)	(cm)	Adult	Jack	Adult	Jack	Chum	Unkn
06-Sep	1	1			0	0	0	0	0	0
07-Sep	1	1		52.0	7	3	0	0	0	0
08-Sep	1	1	17.0	52.0	3	4	0	0	0	0
09-Sep	1-2	1	16.3	51.2	3	2	0	0	0	0
10-Sep	1-2	1	18.0	52.7	1	5	0	0	0	0
11-Sep	1	1	16.7	52.7	4	5	0	0	0	0
12-Sep	1-2	1	17.7	54.0	5	8	0	0	0	0
13-Sep	1-2	1	10.5	54.0	6	11	0	0	0	0
14-Sep	2	1-2	10.3	54.0	3	9	0	0	0	0
15-Sep	2-3	1	15.0	53.0	2	1	0	0	0	0
16-Sep	2-3	1	12.0	54.0	4	0	0	0	0	0
17-Sep	1-2	1	12.3	53.0	1	2	0	0	0	0
18-Sep	1	1	16.0	54.0	6	6	0	0	0	0
19-Sep	1-2	1	16.0	53.3	4	6	0	0	0	0
20-Sep	1	1	16.0	54.0	6	10	0	0	0	0
21-Sep	1	1	13.7	54.0	3	2	0	0	0	0
22-Sep	1	1	15.5	53.7	1	3	0	0	0	0
23-Sep	1	1	16.0	53.0	3	7	0	0	0	0
24-Sep	1	1	13.7	53.7	0	2	0	0	0	0
25-Sep	1	1	14.3	54.0	4	6	0	0	0	0
26-Sep	1	1	15.5	53.0	1	3	0	0	0	0
27-Sep	1-2	1-2	16.0	68.3	62	66	69	91	5	1
28-Sep	1-3	1-2	15.5	58.3	1	6	1	0	0	0
29-Sep	2-3	1	16.3	57.0	159	246	2	1	0	3
30-Sep	1-2	1	17.0	57.0	24	32	11	2	0	0
01-Oct	1	1	15.3	54.7	16	2	2	0	0	0
02-Oct	1-2	1	13.0	54.0	10	3	0	0	0	0
03-Oct	2-3	1	13.7	54.0	34	17	0	1	0	2
04-Oct	1-2	1-2	13.7	68.0	58	17	4	5	0	1
05-Oct	3	1	15.3	56.3	13	3	3	1	0	1
06-Oct	2-3	1	14.3	54.3	13	10	0	0	0	1
07-Oct	2	1	14.7	54.0	11	1	3	2	0	0
08-Oct	2	1	14.7	54.7	6	4	0	0	0	0
09-Oct	1-2	1	13.7	54.3	7	6	0	0	0	1
10-Oct	2-3	1	14.3	61.7	54	39	18	6	0	1
11-Oct	1-2	1	14.7	64.7	44	26	19	11	1	0
12-Oct	1-3	1	14.0	56.0	19	16	4	3	0	0
13-Oct	2	1-2	14.0	60.3	107	117	18	10	0	0
14-Oct	2-3	1-2	14.0	58.7	28	15	6	6	1	0
15-Oct	1-2	1-2	12.7	57.0	8	3	13	10	0	0
16-Oct	2	2	13.0	71.3	54	16	67	19	3	1
17-Oct	2	2	14.3	73.7	117	57	188	87	3	4
18-Oct	2	1-2	14.7	71.7	110	38	119	41	1	0
19-Oct	2	1	14.3	70.7	15	16	51	22	1	6
20-Oct	1-2	1	13.7	71.7	36	19	203	67	5	0
21-Oct	1-2	1	10.7	70.7	8	1	26	18	8	0
22-Oct	1-2	1	14.0	70.5	29	19	108	53	4	0
23-Oct	2-3	1	14.0	72.0	35	26	147	94	15	0
24-Oct	1-2	1	14.0	72.0	4	4	27	17	2	0
25-Oct	1-2	1-2	13.7	72.3	13	6	15	13	6	0
26-Oct	1	2	13.0	77.3	115	70	930	225	279	0
Totals					1277	996	2054	805	334	22

Table 8. Daily fence counts at the Cowichan River fence site, 2006

Date	Weather[1]	Visibility[2]	Temp (°C)	Depth (cm)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unkn
06-Sep	1	1			0	0	0	0	0	0
07-Sep	1	1			2	1	0	0	0	0
08-Sep	1	1			2	4	0	0	0	0
09-Sep	1-3	1			0	0	0	0	0	1
10-Sep	1	1	11.5		3	0	0	0	0	0
11-Sep	1	1	17.0	390.0	4	0	0	0	0	0
12-Sep	1	1	16.7	390.0	3	2	0	0	0	0
13-Sep	1-2	1	17.7	390.0	4	4	0	0	0	0
14-Sep	1-2	1	15.3	218.7	4	3	0	0	0	0
15-Sep	1-3	1-2	15.0	299.7	3	1	0	0	0	0
16-Sep	1-2	1	14.0	380.0	2	1	0	0	0	0
17-Sep	1-3	1	15.3	386.7	0	1	0	0	0	0
18-Sep	1-3	1-2	14.3	400.0	3	1	0	0	0	0
19-Sep	1-3	1-2	15.3	406.7	6	3	0	0	0	0
20-Sep	1-3	1-2	15.3	406.7	9	4	0	0	0	0
21-Sep	1-2	1	14.0	406.7	4	2	0	0	0	0
22-Sep	1	1	14.0	405.0	3	7	0	0	0	0
23-Sep	1	1	14.7	390.0	4	3	0	0	0	0
24-Sep	1	1	14.7	396.7	3	7	1	0	0	0
25-Sep	1	1	14.3	390.0	6	6	0	1	0	0
26-Sep	1	1	16.3	303.3	4	2	0	0	0	0
27-Sep	1	1	15.0	383.3	11	12	0	0	0	0
28-Sep	1	1	15.0	272.7	6	7	0	0	0	0
29-Sep	1	1	15.0	400.0	11	9	0	0	0	0
30-Sep	1-2	1	15.5	403.3	2	1	0	0	0	0
01-Oct	1	1	16.3	396.7	5	0	1	0	0	0
02-Oct	1	1	15.5	345.0	4	6	0	0	0	0
03-Oct	1	1	14.0	403.3	1	0	0	0	0	0
04-Oct	1	1	13.3	400.0	3	0	0	0	0	0
05-Oct	1	1	13.7	393.3	1	2	0	0	0	0
06-Oct	1-2	1	14.3	393.3	0	0	1	0	0	0
07-Oct	1-2	1-2	14.0	390.0	4	0	1	0	0	0
08-Oct	2	1-2	13.3	400.0	0	0	0	0	0	0
09-Oct	1	1	13.0	390.0	0	0	2	0	0	0
10-Oct	1	1	8.0	393.3	4	0	0	0	0	0
11-Oct	1	1	12.7	393.3	3	1	0	0	0	0
12-Oct	1	1	14.0	400.0	1	4	1	1	0	0
13-Oct	1	1	12.0	390.0	0	4	0	0	0	0
14-Oct	1	1	12.5	400.0	0	0	0	0	0	0
15-Oct	1-3	1-2	13.0	400.0	8	4	0	0	0	0
16-Oct	1-3	1-2	13.0	403.3	6	3	1	0	0	0
17-Oct	1	1	12.5	390.0	3	0	0	1	0	0
18-Oct	1-3	1-2	13.0	436.7	4	2	0	0	0	0
19-Oct	2	1-2	14.0	466.7	6	9	3	0	0	0
20-Oct	1	1	13.0	456.7	9	5	0	1	1	0
21-Oct	1	1	12.7	450.0	5	0	4	0	1	0
22-Oct	1	1	11.7	450.0	0	0	0	0	1	0
23-Oct	1	1	12.3	460.0	3	3	0	0	4	0
24-Oct	1	1	11.3	460.0	2	0	3	0	0	0
25-Oct	1-2	1-2	11.7	460.0	6	1	0	0	1	0
26-Oct	2	N/A	12.0	460.0	2	0	1	0	0	0
Totals					179	125	19	4	8	1

Table 9. Daily fence counts at the Cowichan River fence site, 2007

			Temp	Depth	Chinook		Coho			
Date	Weather[1]	Visibility[2]	(°C)	(m)	Adult	Jack	Adult	Jack	Chum	Unknown
04-Sep	N/A	N/A	N/A	N/A	0	0	0	0	0	0
05-Sep	1	1	N/A	51.0	0	0	0	0	0	0
06-Sep	1	1	19.0	51.0	1	0	0	0	0	0
07-Sep	1	1	18.7	40.0	1	1	0	0	0	0
08-Sep	1	1	15.3	40.0	1	0	0	0	0	0
09-Sep	1	1	15.0	40.0	1	2	0	0	0	0
10-Sep	1	1	18.0	54.0	4	3	0	0	0	0
11-Sep	1	1	18.0	50.0	3	3	0	0	0	0
12-Sep	1	1	19.0	50.0	4	1	0	0	0	0
13-Sep	1	1	18.7	54.3	3	3	0	0	0	0
14-Sep	1	1	18.3	54.0	1	6	0	0	0	0
15-Sep	1-2	1	18.7	54.0	7	18	0	0	0	0
16-Sep	1-2	1	18.0	54.7	0	2	0	0	0	0
17-Sep	1	1-2	17.3	64.7	16	15	1	0	0	0
18-Sep	1-2	1-2	16.7	71.0	19	15	0	0	0	0
19-Sep	1	1	15.7	62.3	15	6	0	0	0	0
20-Sep	1-2	1-2	15.5	59.0	7	7	0	0	0	0
21-Sep	1-2	1	16.3	58.7	8	13	0	0	0	0
22-Sep	1	1	15.5	58.0	11	9	13	1	0	0
23-Sep	1	1	15.3	58.0	2	7	0	0	0	0
24-Sep	1	1-2	15.3	72.3	13	12	0	0	0	0
25-Sep	1-2	1	17.0	74.3	14	18	0	0	0	0
26-Sep	1-2	1	16.5	60.5	12	7	0	0	0	0
27-Sep	1-2	1	16.0	58.0	19	22	0	0	0	0
28-Sep	1	1	16.0	62.0	22	8	0	0	0	0
29-Sep	1-3	1	14.0	58.0	17	14	0	0	0	0
30-Sep	2-3	1-2	14.3	71.0	60	38	6	7	1	0
01-Oct	1-2	2	13.7	80.0	47	23	6	0	0	0
02-Oct	1-2	1	14.7	78.3	19	5	2	0	0	0
03-Oct	1-3	1-2	14.0	77.3	10	5	1	0	0	0
04-Oct	1-2	1-2	13.7	77.0	12	5	2	0	0	0
05-Oct	1	1	13.0	77.0	1	1	0	0	0	0
Total					350	269	31	8	1	0

[1]Weather Code: 1 - Clear
2 - Cloudy
3 - Raining

[2]Visibility Code: 1 - Clear
2 - Cloudy

Table 10. Counts, by time interval, at the Cowichan River fence site, 2005

	Chinook				Coho				Chum	
	Adult		Jack		Adult		Jack			
Time period	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	46	3.6	57	5.8	55	2.7	13	1.6	2	0.6
0100 - 0200	61	4.8	40	4.0	58	2.8	20	2.5	3	0.9
0200 - 0300	57	4.5	49	4.9	44	2.1	43	5.3	3	0.9
0300 - 0400	51	4.0	50	5.0	57	2.8	58	7.2	0	0.0
0400 - 0500	63	4.9	32	3.2	45	2.2	34	4.2	0	0.0
0500 - 0600	55	4.3	29	2.9	62	3.0	29	3.6	10	3.0
0600 - 0700	50	3.9	47	4.7	64	3.1	26	3.2	4	1.2
0700 - 0800	75	5.9	65	6.6	62	3.0	28	3.5	4	1.2
0800 - 0900	52	4.1	18	1.8	50	2.4	41	5.1	5	1.5
0900 - 1000	77	6.0	27	2.7	95	4.6	51	6.3	35	10.5
1000 - 1100	13	1.0	4	0.4	131	6.4	39	4.8	29	8.7
1100 - 1200	41	3.2	0	0.0	199	9.7	23	2.9	51	15.4
1200 - 1300	53	4.1	9	0.9	191	9.3	32	4.0	29	8.7
1300 - 1400	37	2.9	13	1.3	172	8.3	51	6.3	26	7.8
1400 - 1500	14	1.1	7	0.7	68	3.3	13	1.6	18	5.4
1500 - 1600	8	0.6	20	2.0	165	8.0	28	3.5	21	6.3
1600 - 1700	73	5.7	64	6.5	210	10.2	80	9.9	24	7.2
1700 - 1800	86	6.7	91	9.2	137	6.6	77	9.6	39	11.7
1800 - 1900	67	5.2	48	4.8	39	1.9	32	4.0	22	6.6
1900 - 2000	54	4.2	89	9.0	25	1.2	12	1.5	2	0.6
2000 - 2100	88	6.9	85	8.6	29	1.4	19	2.4	1	0.3
2100 - 2200	72	5.6	81	8.2	37	1.8	30	3.7	4	1.2
2200 - 2300	46	3.6	42	4.2	33	1.6	12	1.5	0	0.0
2300 - 2400	40	3.1	24	2.4	33	1.6	14	1.7	0	0.0
Total	1279	100	991	100	2061	100	805	100	332	100

Table 11. Counts, by time interval, at the Cowichan River fence site, 2006

	Chinook				Coho				Chum	
	Adult		Jack		Adult		Jack			
Time period	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	11	6.1	11	8.8	2	10.5	2	50.0	0	0
0100 - 0200	19	10.6	16	12.8	0	0.0	0	0.0	1	12.5
0200 - 0300	13	7.3	8	6.4	0	0.0	1	25.0	0	0
0300 - 0400	17	9.5	10	8	2	10.5	1	25.0	0	0
0400 - 0500	15	8.4	14	11.2	4	21.1	0	0.0	2	25
0500 - 0600	12	6.7	11	8.8	2	10.5	0	0.0	1	12.5
0600 - 0700	12	6.7	12	9.6	3	15.8	0	0.0	0	0
0700 - 0800	9	5.0	3	2.4	0	0.0	0	0.0	0	0
0800 - 0900	3	1.7	0	0	0	0.0	0	0.0	0	0
0900 - 1000	2	1.1	1	0.8	0	0.0	0	0.0	0	0
1000 - 1100	1	0.6	2	1.6	0	0.0	0	0.0	0	0
1100 - 1200	0	0.0	3	2.4	0	0.0	0	0.0	0	0
1200 - 1300	1	0.6	0	0	0	0.0	0	0.0	0	0
1300 - 1400	1	0.6	1	0.8	0	0.0	0	0.0	0	0
1400 - 1500	2	1.1	0	0	0	0.0	0	0.0	0	0
1500 - 1600	4	2.2	1	0.8	0	0.0	0	0.0	3	37.5
1600 - 1700	1	0.6	1	0.8	0	0.0	0	0.0	0	0
1700 - 1800	6	3.4	2	1.6	1	5.3	0	0.0	0	0
1800 - 1900	3	1.7	2	1.6	0	0.0	0	0.0	0	0
1900 - 2000	3	1.7	4	3.2	0	0.0	0	0.0	0	0
2000 - 2100	11	6.1	8	6.4	2	10.5	0	0.0	0	0
2100 - 2200	7	3.9	3	2.4	0	0.0	0	0.0	1	12.5
2200 - 2300	15	8.4	6	4.8	2	10.5	0	0.0	0	0
2300 - 2400	11	6.1	6	4.8	1	5.3	0	0.0	0	0
Total	179	100	125	100	19	100	4	100	8	100

Table 12. Counts, by time interval, at the Cowichan River fence site, 2007

	Chinook				Coho				Chum	
	Adult		Jack		Adult		Jack			
Time Period	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	17	4.8	13	4.9	0	0.0	0	0.0	0	0.0
0100 - 0200	33	9.4	16	6.0	0	0.0	0	0.0	0	0.0
0200 - 0300	21	6.0	19	7.1	1	3.1	0	0.0	0	0.0
0300 - 0400	22	6.3	21	7.9	2	6.3	1	11.1	0	0.0
0400 - 0500	25	7.1	12	4.5	5	15.6	0	0.0	0	0.0
0500 - 0600	23	6.6	13	4.9	10	31.3	1	11.1	0	0.0
0600 - 0700	11	3.1	13	4.9	3	9.4	0	0.0	0	0.0
0700 - 0800	11	3.1	12	4.5	0	0.0	0	0.0	0	0.0
0800 - 0900	10	2.8	5	1.9	1	3.1	0	0.0	0	0.0
0900 - 1000	23	6.6	11	4.1	1	3.1	0	0.0	0	0.0
1000 - 1100	6	1.7	10	3.7	0	0.0	0	0.0	0	0.0
1100 - 1200	9	2.6	8	3.0	1	3.1	1	11.1	0	0.0
1200 - 1300	11	3.1	3	1.1	0	0.0	0	0.0	0	0.0
1300 - 1400	2	0.6	1	0.4	0	0.0	0	0.0	0	0.0
1400 - 1500	4	1.1	1	0.4	2	6.3	0	0.0	0	0.0
1500 - 1600	5	1.4	3	1.1	0	0.0	0	0.0	0	0.0
1600 - 1700	7	2.0	5	1.9	0	0.0	0	0.0	0	0.0
1700 - 1800	8	2.3	4	1.5	1	3.1	0	0.0	0	0.0
1800 - 1900	38	10.8	35	13.1	3	9.4	1	11.1	0	0.0
1900 - 2000	11	3.1	16	6.0	0	0.0	0	0.0	1	100.0
2000 - 2100	8	2.3	6	2.2	0	0.0	0	0.0	0	0.0
2100 - 2200	16	4.6	11	4.1	1	3.1	1	11.1	0	0.0
2200 - 2300	20	5.7	15	5.6	0	0.0	1	11.1	0	0.0
2300 - 2400	10	2.8	14	5.2	1	3.1	3	33.3	0	0.0
Total	351	100	267	100	32	100	9	100	1	100

Table 13. Chinook mark rate from enumeration fence video, Cowichan River, 2007

		Unmarked Chinook		Marked Chinook		Unknown Chinook		
Date	Time	Adult	Jack	Adult	Jack	Adult	Jack	Unknown
Sep-19	20:58 - 22:58	3	0	0	0	0	0	0
Sep-20	00:08 - 21:06	21	1	1	0	0	0	2
Sep-21	00:42 - 22:49	9	1	0	0	0	0	1
Sep-22	02:16 - 19:42	11	1	2	0	7	0	0
Sep-23	00:25 - 23:43	10	0	0	0	0	0	0
Sep-24	01:06 - 21:44	24	2	0	0	0	0	0
Sep-25	00:12 - 23:46	14	1	0	0	1	0	0
Sep-26	00:44 - 23:45	5	0	0	0	0	0	2
Sep-27	00:03 - 23:42	15	2	1	0	0	0	0
Sep-28	00:14 - 20:48	24	1	0	0	0	0	0
Sep-29	00:56 - 20:59	25	1	0	0	0	0	1
Sep-30	05:29 - 23:41	86	7	1	0	0	1	18
Oct-01	01:36 - 16:06	31	2	2	0	0	2	17
Oct-02	03:18 - 23:57	16	3	0	0	0	0	0
Oct-03	01:49 - 23:58	9	1	0	0	0	0	1
Oct-04	01:19 - 21:22	7	0	1	0	0	0	0
Total		310	23	8	0	8	3	42
Mark rate				2.5%	0.0%			

Table 14. Annual Cowichan River Hatchery broodstock collection of adult and jack Chinook, 1981-2007

	Chinook Broodstock Collection	
Year	Adult	Jack[1]
1981	282	
1982	534	
1983	242	
1984	278	
1985	175	
1986	315	
1987	582	
1988	678	30
1989	535	96
1990	327	1
1991[2]	1755	347
1992	1850	77
1993	2200	228
1994	1357	145
1995	2149	512
1996	1615	258
1997	125	79
1998	1485	201
1999	1659	1
2000	1529	14
2001	1732	0
2002	1480	0
2003[3]	862	14
2004	575	20
2005	940	80
2006	671	38
2007	320	48

[1]Barry Cordocedo (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 later but returned to the river.

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

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Table 15. Length-frequency of Chinook broodstock collected by the Cowichan River Hatchery, 2005

(this sample is adipose fin clipped only)

Length (cm)	Male	Female	Jack
34			1
35			
36			
37			
38			1
39			
40			2
41			1
42			
43			1
44			1
45			1
46			3
47			2
48		1	
49			
50			
51			
52			
53	2		
54	1		
55	1	3	
56		1	
57		3	
58	1	2	
59	1	2	
60	1	2	
61		1	
62			
63	2	1	
64	1	2	
65		1	
66		1	
67		1	
68	1	1	
69			
70		1	
71		3	
72		1	
Total	11	27	13
Mean length (cm)	59.3	62.0	432
St. Dev. (cm)	5.04	6.22	4.01

Table 16. Length-frequency of Chinook broodstock collected by the Cowichan River Hatchery, 2006

Length (cm)	Male	Female	Jack
31	1		
32			
33			
34			
35			
36			
37			
38		2	2
39		1	
40	3		5
41	2		6
42			2
43			
44	2		
45			
46	3		
47	1		1
48	1		
49			
50	4	1	1
51	8	3	
52			
53		2	
54		1	
55		2	
56	1	3	
57	2	3	
58	1	4	
59	8	3	
60	22	10	
61	13	11	
62	3	8	
63	4	10	
64	1	9	
65	5	8	
66	3	6	
67	3	3	
68		4	
69	2	3	
70	4	3	
71	2	2	
72		3	
73	1	1	
74	2	2	
75	1		
76		1	
77	1		
78	2	2	
79	2	1	
Total	108	112	17
Mean length (cm)	59.6	62.5	41.4
St. Dev (cm)	9.12	6.96	2.99
Fin clips	21	32	1
Rate	19.4	28.6	5.9%

Table 17. Length-frequency of Chinook broodstock collected by the Cowichan River Hatchery, 2007

Length (cm)	Male	Female	Jack
34			1
35			
36			
37			
38			1
39			2
40			4
41			
42			5
43			2
44			3
45			4
46	1		5
47	1		5
48	3		2
49	2		4
50	4		2
51	5		1
52	4	1	
53	3		
54	2		
55	6	1	
56	3	3	
57	8	2	
58	8	4	
59	7	2	
60	12	6	
61	10	15	
62	14	16	
63	5	7	
64	10	7	
65	13	8	
66	5	10	
67	3	8	
68	12	13	
69	9	9	
70	5	5	
71		7	
72	3	6	
73	3	2	
74	2	11	
75		7	
76		5	
77		2	
78		3	
79	1		
80			
81		1	
Total	164	161	41
Mean length (cm)	61.4	66.6	44.5
St. Dev. (cm)	6.51	5.80	3.82
Adipose fin clips	3	6	1
Fin clip rate	1.8%	3.7%	2.4%

Table 18. Summary of age by sex of Cowichan River Chinook collected for hatchery broodstock, 2005

	Male		Female		Total Adult		Jack		Total	
Gilbert-Rich Age	#	%	#	%	#	%	#	%	#	%
Adipose Clips only										
2_1	0	0%	0	0%	0	0%	13	100%	13	27%
3_1	10	91%	15	60%	25	69%	0	0%	25	51%
4_1	1	9%	10	40%	11	31%	0	0%	11	22%
5_1	0	0%	0	0%	0	0%	0	0%	0	0%
Total	11	100%	25	100%	36	100%	13	100%	49	100%
All broodstock										
2_1					0	0%	28	100%	28	16%
3_1					52	35%	0	0%	52	30%
4_1					87	60%	0	0%	87	50%
5_1					7	5%	0	0%	7	4%
Total					146	100%	28	100%	174	100%

Total number of unreadable scales: 23

Table 19. Summary of age by sex of Cowichan River Chinook collected for hatchery broodstock, 2006

Gilbert-Rich	Male		Female		Total Adult		Jack		Total	
Age	#	%	#	%	#	%	#	%	#	%
2_1	0	0%	0	0%	0	0%	15	100%	15	7%
3_1	82	85%	71	74%	153	80%	0	0%	153	74%
4_1	13	14%	21	22%	34	18%	0	0%	34	16%
5_1	1	1%	4	4%	5	3%	0	0%	5	2%
Total	96	100%	96	100%	192	100%	29	100%	207	100%

Total number of unreadable scales: 30

Table 20. Summary of age by sex of Cowichan River Chinook collected for hatchery broodstock, 2007

	Total	
Gilbert-Rich age	#	%
2_1	48	13.0%
3_1	222	60.3%
4_1	97	26.4%
5_1	1	0.3%
Total	315	100%

Total number of unreadable scales: 43

Table 21. Daily summary of Chinook broodstock collected by the Cowichan River Hatchery, 2006

	Below Fence			Above Fence		
Date	Male	Female	Jack	Male	Female	Jack
02-Oct-06	36	66	0	0	0	0
06-Oct-06	25	45	0	0	0	0
10-Oct-06	62	86	2	0	0	0
11-Oct-06	24	22	0	0	1	0
13-Oct-06	20	23	0	0	0	0
16-Oct-06	13	32	1	3	0	0
17-Oct-06	55	69	0	0	0	0
18-Oct-06	27	31	45	0	0	0
24-Oct-06	0	0	1	0	0	0
02-Nov-06	0	1	0	0	0	0
06-Nov-06	0	0	1	0	0	0
07-Nov-06	0	1	3	0	0	0
08-Nov-06	0	2	2	0	0	0

Note: This data has not been corrected for age.

Table 22. Daily summary of Chinook broodstock collected by the Cowichan River Hatchery, 2007

	Below Fence			Above fence		
Date	Male	Female	Jack	Male	Female	Jack
20-Sep-07	1	1	0	0	0	0
26-Sep-07	11	8	3	0	0	0
27-Sep-07	31	39	0	0	0	0
28-Sep-07	8	5	1	0	0	0
29-Sep-07	1	54	0	0	0	0
30-Sep-07	13	17	0	0	0	0
03-Oct-07	35	41	0	0	0	0
04-Oct-07	40	36	0	0	0	0
05-Oct-07	1	1	1	0	0	0
06-Oct-07	0	0	0	0	0	0
15-Oct-07	0	0	2	0	0	0
17-Oct-07	0	0	0	1	0	1
18-Oct-07	0	0	0	5	1	0
19-Oct-07	0	0	0	1	1	3
22-Oct-07	0	0	0	1	3	13
23-Oct-07	0	0	0	3	3	5
24-Oct-07	0	0	0	5	7	0
25-Oct-07	0	0	0	1	1	0
26-Oct-07	0	0	0	1	2	0
29-Oct-07	0	0	0	2	1	4
30-Oct-07	0	0	0	1	1	0
1-Nov-07	0	0	0	0	1	0
2-Nov-07	0	0	0	0	0	0
5-Nov-07	0	0	0	0	1	0
6-Nov-07	0	0	0	0	0	0
7-Nov-07	0	0	0	0	0	0
14-Nov-07	0	0	6	0	0	0

Note: This data has not been corrected for age.

Table 23. Release and recovery data for coded-wire tags recovered from hatchery broodstock collected from the Cowichan River, 2005

Recovery Date	Adipose Clipped	POH Length (mm)	Sex	Brood Year	Tag Code	Release Location	Release Date
4-Nov-05	A	640	F	2002	185052	Cowichan	28/05/2003
4-Nov-05	A	580	M	2002	185132	Chemainus	15/05/2003
4-Nov-05	A	475	J	2003	185704	Cowichan	11/05/2004
4-Nov-05	A	630	M	2002	184919	Cowichan	11/04/2003
4-Nov-05	A	475	J	2003	185412	Cowichan	26/05/2004
4-Nov-05	A	540	M	2002	184918	Cowichan	11/04/2003
4-Nov-05	A	600	M	2002	184918	Cowichan	11/04/2003
4-Nov-05	A	460	J	2003	185701	Cowichan	20/05/2004
4-Nov-05	A	400	J	2003	185704	Cowichan	11/05/2004
4-Nov-05	A	410	J	2003	185703	Cowichan	20/05/2004
7-Nov-05	A	432	J	2003	185661	Cowichan	05/04/2005
7-Nov-05	A	459	J	2003	185701	Cowichan	20/05/2004
7-Nov-05	A	685	M	2001	184645	Cowichan	30/04/2002
7-Nov-05	A	640	M	2002	184918	Cowichan	11/04/2003
8-Nov-05	A	348	J	2003	185704	Cowichan	11/05/2004
9-Nov-05	A	465	J	2003	185531	Chemainus	17/05/2004
9-Nov-05	A	550	J	2002	185129	Chemainus	15/05/2003
9-Nov-05	A	405	J	2003	185702	Cowichan	20/05/2004
9-Nov-05	A	575	F	2002	185014	Cowichan	26/05/2003
9-Nov-05	A	635	M	2002	184918	Cowichan	11/04/2003
9-Nov-05	A	590	M	2002	184919	Cowichan	11/04/2003
9-Nov-05	A	380	J	2003	185660	Cowichan	05/04/2004
9-Nov-05	A	600	F	2002	185052	Cowichan	28/05/2003
24-Oct-05	A	557	F	2002	185016	Cowichan	27/05/2003
24-Oct-05	A	663	F	2001	184643	Cowichan	15/05/2002
26-Oct-05	A	595	F	2002	184918	Cowichan	11/04/2003
26-Oct-05	A	670	F	2001	184640	Cowichan	11/04/2002
26-Oct-05	A	650	F	2001	184643	Cowichan	15/05/2002
26-Oct-05	A	720	F	2001	184642	Cowichan	11/04/2002
26-Oct-05	A	585	F	2002	185013	Cowichan	26/05/2003
26-Oct-05	A	615	F	2002	185015	Cowichan	26/05/2003
26-Oct-05	A	700	F	2001	184642	Cowichan	11/04/2002
26-Oct-05	A	565	F	2002	185014	Cowichan	26/05/2003
26-Oct-05	A	630	F	2002	184918	Cowichan	11/04/2003
26-Oct-05	A	710	F	2001	184643	Cowichan	15/05/2002
31-Oct-05	A	600	F	2002	185014	Cowichan	26/05/2003
31-Oct-05	A	535	J	2002	184918	Cowichan	11/04/2003
31-Oct-05	A	460	J	2003	185661	Cowichan	05/04/2004
31-Oct-05	A	535	J	2002	185052	Cowichan	28/05/2003
4-Nov-05	A	445	J	2003	185704	Cowichan	11/05/2004
4-Nov-05	A	590	F	2002	185016	Cowichan	27/05/2003
4-Nov-05	A	715	F		No pin		
4-Nov-05	A	480	F		No pin		
4-Nov-05	A	715	F	2001	184640	Cowichan	11/04/2002
4-Nov-05	A	685	F	2001	184639	Cowichan	11/04/2002
4-Nov-05	A	570	F	2002	185013	Cowichan	26/05/2003
20-Oct-05	A	577	F	2002	185015	Cowichan	26/05/2003
26-Oct-05	A	550	F		No pin		
26-Oct-05	A	550	F	2002	185015	Cowichan	26/05/2003
26-Oct-05	A	640	F	2001	184644	Cowichan	15/05/2002
27-Oct-05	A	585	F	2002	185052	Cowichan	28/05/2003
N/A	A	N/A	N/A	2001	184644	Cowichan	15/05/2002

Table 24. Release and recovery data for coded-wire tags recovered from hatchery broodstock collected from the Cowichan River, 2006

Recovery Date	Adipose Clipped	POH length (mm)	Sex	Brood Year	Tag Code	Release Location	Release Date
23-Oct-06	a	595	M	2003	185531	Chemainus	
30-Oct-06	a	595	F		No Pin		
30-Oct-06	a	605	F	2003	185704	Cowichan	11/05/2004
30-Oct-06	a	608	F	2003	185662	Cowichan	05/04/2004
30-Oct-06	a	614	F	2003	185661	Cowichan	05/04/2004
30-Oct-06	a	642	F	2003	185530	Chemainus	
30-Oct-06	a	651	F	2003	185660	Cowichan	05/04/2004
31-Oct-06	a	513	F		No Pin		
31-Oct-06	a	551	F	2003	185702	Cowichan	20/05/2004
31-Oct-06	a	552	F	2003	185702	Cowichan	20/05/2004
31-Oct-06	a	563	F	2003	185704	Cowichan	11/05/2004
31-Oct-06	a	589	F	2003	185704	Cowichan	11/05/2004
31-Oct-06	a	616	F	2003	185660	Cowichan	05/04/2004
31-Oct-06	a	641	F	2003	185530	Chemainus	07/05/2004
31-Oct-06	a	646	F	2003	185702	Cowichan	20/05/2004
31-Oct-06	a	670	F	2003	185663	Cowichan	05/04/2004
31-Oct-06	a	700	F		No Pin		
31-Oct-06	a	710	F	2002	185014	Cowichan	26/05/2003
01-Nov-06	a	654	M	2003	185660	Cowichan	05/04/2004
02-Nov-06	a	602	M		No Pin		
03-Nov-06	a	580	F	2003	185701	Cowichan	20/05/2004
03-Nov-06	a	640	F	2003	185662	Cowichan	05/04/2004
03-Nov-06	a	645	F	2003	185704	Cowichan	11/05/2004
03-Nov-06	a	655	F	2003	185703	Cowichan	20/05/2004
08-Nov-06	a	410	J	2004	185717	Nanaimo	19/05/2005
08-Nov-06	a	510	M	2003	185412	Cowichan	26/05/2004
08-Nov-06	a	700	M	2002	185014	Cowichan	26/05/2004
09-Nov-06	a	480	M	2003	185701	Cowichan	20/05/2004
09-Nov-06	a	600	F	2003	185412	Cowichan	26/05/2004
09-Nov-06	a	600	M	2003	185702	Cowichan	20/05/2004
09-Nov-06	a	600	F	2003	185702	Cowichan	20/05/2004
09-Nov-06	a	610	F	2003	185704	Cowichan	11/05/2004
09-Nov-06	a	620	M	2003	185412	Cowichan	26/05/2004
09-Nov-06	a	620	F	2003	185704	Cowichan	11/05/2004
09-Nov-06	a	630	M		No Pin		
09-Nov-06	a	640	F	2003	185704	Cowichan	11/05/2004
09-Nov-06	a	650	M	2003	185412	Cowichan	26/05/2004
07-Nov-06	a	573	M	2003	185703	Cowichan	20/05/2004
07-Nov-06	a	665	M	2002	185013	Cowichan	26/05/2003
14-Nov-06	a	520	F	2003	185412	Cowichan	26/05/2004
14-Nov-06	a	570	F	2003	185701	Cowichan	20/05/2004
14-Nov-06	a	570	F	2003	185704	Cowichan	11/05/2004
14-Nov-06	a	588	M	2003	185704	Cowichan	11/05/2004
15-Nov-06	a	590	M	2003	185704	Cowichan	11/05/2004
16-Nov-06	a	591	M	2003	185660	Cowichan	05/04/2004
17-Nov-06	a	600	F	2003	185702	Cowichan	20/05/2004
18-Nov-06	a	630	M	2003	185701	Cowichan	20/05/2004
19-Nov-06	a	632	M	2003	185702	Cowichan	20/05/2004
20-Nov-06	a	650	F	2003	185704	Cowichan	11/05/2004
21-Nov-06	a	665	M	2003	185704	Cowichan	11/05/2004
22-Nov-06	a	670	M	2003	185702	Cowichan	20/05/2004
23-Nov-06	a	680	F	2003	185412	Cowichan	26/05/2004
24-Nov-06	a	680	M	2003	185663	Cowichan	05/04/2004

25-Nov-06	a	775	M	2003	185531	Chemainus	17/05/2004
?		?	?	2003	185704	Cowichan	11/05/2004

Table 25. Release and recovery data for coded-wire tags recovered from hatchery broodstock collected from the Cowichan River, 2007

Recovery Date	Adipose Clipped	POH Length (mm)	Sex	Brood Year	Tag Code	Release Location	Release Date
10-Oct-07	A	740	M	2003	185661	Cowichan	05/04/2004
19-Oct-07	A	755	M	2004	185714	Nanaimo	16/05/2005
24-Oct-07	A	600	M	2003	185701	Cowichan	20/05/2004
29-Oct-07	A	740	F	2003	185662	Cowichan	05/04/2004
29-Oct-07	A	650	F	2003	185704	Cowichan	11/05/2004
29-Oct-07	A	580	F	2004	185717	Nanaimo	19/05/2005
1-Nov-07	A	650	F	2003	185704	Cowichan	11/05/2004
1-Nov-07	A	630	F	2003	185702	Cowichan	20/05/2004
1-Nov-07	A	680	F	2003	185702	Cowichan	20/05/2004
1-Nov-07	A	460	J	2005	185812	Cowichan	15/05/2006

Table 26. Length-frequency of Chinook sampled on the Cowichan River spawning grounds, 2005

Length (mm)	Male	Female	Jack	Jill
29			2	
30			2	
31			5	
32			1	
33			3	1
34			7	
35			3	
36			3	
37	1		8	
38			9	
39			11	
40			4	
41			7	
42			8	2
43			4	
44			6	
45			5	
46	1		3	1
47	1		2	
48			1	
49	1		1	
50				
51	1			
52				
53	1	5		
54	1	2		
55		3		
56	1	4		
57	3	8		
58		4		
59	1	4		
60	3	8		
61	4	8		
62	3	7		
63	4	5		
64	5	8		
65	3	13		
66	5	10		
67	1	14		
68	7	16		
69	3	6		
70	5	16		
71	5	11		
72	3	9		
73	2	8		
74		5		
75	1	6		
76	2	3		
77		3		
78	1	1		

79	1			
80	1	1		
81		2		
Total	70	190	95	4
Mean Length	647	662	388	407
St. Dev.	78.7	62.0	46.6	55.9
Adipose Fin Clips	1	4	3	0
Fin Clip Rate	1.4%	2.1%	3.2%	0.0%

Table 27. Length-frequency of Chinook sampled on the Cowichan River spawning grounds, 2006

Length (cm)	Male	Female	Jack	Jill
33			1	
34			1	
35			1	
36			1	
37			2	
38			5	
39			5	
40			7	
41			4	
42			4	
43			3	
44				
45				
46			1	
47			1	
48			1	
49				
50				
51				
52		1		
53		1		
54		1		
55	1		1	
56	1	2		
57				1
58		2		
59				
60		5		
61				
62				
63		2		
64		2		
65	1			
66		1		
67	1	1		
68		1		
69				
70	1		1	
71	1			
72				
73				
74		1		
75				
76				
77		2		
78				
79	1			

Total	7	22	38	1
Mean Length	662	623	404	56.5
St. Dev.	83.7	71.9	40.4	
Adipose Fin Clips	2	2	0	0
Fin Clip Rate	28.6%	9.1%	0.0%	0.0%

Table 28. Length-frequency of Chinook sampled in the Cowichan River spawning grounds, 2007

Length (cm)	Male	Female	Jack	Jill	unknown
35			1	1	
36			2		
37		1	3		
38			8		
39			5		
40			7	1	
41		1	9	5	
42			9	1	
43	1	2	11		
44		1	15	1	
45	1		17		
46	1	1	14	1	
47	1		13	2	
48			8		
49	2	3	9		
50	1	2	6		1
51	2		6		
52		2	3		2
53					1
54		1			
55	3	1	1		2
56	3	7	1		2
57	1	6			3
58	6	4	1		1
59	4	8			5
60	4	9			5
61	5	17			2
62	6	11			1
63	3	7			5
64	2	9			3
65	3	13			2
66	4	5			4
67	1	8			1
68	2	7			1
69	3	10			4
70		9			3
71	2	8			2
72		6			2
73	2	4			1
74	1	4			
75		2			1
76		3			1
77		3			2
78		1			3
79					
80					
81					1
82					

83					1
84					
85	1				
86					
87					
88					
89					
90		1			
91					
92					
93					1
Total	65	180	149	12	65
Mean Length	608	636	446	428	
St. Dev.	74.7	72.5	42.3	40.0	
Adipose Fin Clips	1	4	17	0	1
Fin Clip Rate	1.5%	2.3%	11.4%	0.0%	

Table 29. Summary of age by sex for Cowichan River Chinook collected from the spawning grounds during 2005

Gilbert-Rich	Male		Female		Total Adult		Jack		Jill		Total	
Age	#	%	#	%	#	%	#	%			#	%
2_1	0	0%	0	0%	0	0%	82	100%	4	100%	86	33%
3_1	16	33%	29	23%	45	26%	0	0%	0	0%	45	17%
4_1	31	65%	91	71%	122	70%	0	0%	0	0%	122	47%
5_1	1	2%	8	6%	9	5%	0	0%	0	0%	9	3%
Total	48	100%	128	100%	176	101%	82	100%	4	100%	262	100%

Total number of unreadable scales: 97

Table 30. Summary of age by sex for Cowichan River Chinook collected from the spawning grounds, 2006

Gilbert-Rich	Male		Female		Total Adult		Jack		Jill		Total	
Age	#	%	#	%	#	%	#	%			#	%
2_1	0	0%	0	0%	0	0%	38	100%	1	100%	39	62%
3_1	5	71%	11	69%	16	70%	0	0%	0	0%	16	26%
4_1	2	29%	4	25%	6	26%	0	0%	0	0%	6	10%
5_1	0	0%	1	6%	1	4%	0	0%	0	0%	1	2%
Total	7	100%	16	100%	23	100%	36	100%	1	100%	61	100%

Total number of unreadable scales: 11

Table 31. Summary of age by sex for Cowichan River Chinook collected from the spawning grounds, 2007

Gilbert-Rich	Male		Female		Total Adult		Jack		Jill		Unknown Sex		Total	
Age	#	%	#	%	#	%	#	%			#	%	#	%
2_1	0	0%	0	0%	0	0%	149	100%	12	100%	0	0%	156	32%
3_1	41	79%	74	60%	115	66%	0	0%	0	0%	26	57%	141	43%
4_1	11	21%	49	40%	60	34%	0	0%	0	0%	20	43%	80	24%
5_1	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Total	52	100%	123	100%	175	100%	149	100%	7	100%	46	100%	377	100%

Total number of unreadable scales: 144
The known sex sample was biased

Table 32. Release and recovery data for coded-wire tags recovered from Cowichan River Chinook sampled on the spawning grounds, 2007

Date Recovered	Location Recovered	Adipose Clipped	POH length (mm)	Sex	Brood Year	Tag Code	Release Location	Date Released
2-Nov-07	12	A	423	J	2005	185812	Cowichan	15/05/2006
5-Nov-07	14	A	640	F	2003	185661	Cowichan	05/04/2004
5-Nov-07	25	A	851	M	adult	No pin		
5-Nov-07	14	A	412	J	2005	185810	Cowichan	15/05/2006
5-Nov-07	14	A	490	J	2005	185811	Cowichan	15/05/2006
5-Nov-07	22	A	425	J	2005	185819	Cowichan	25/04/2006
5-Nov-07	28	A	467	J	2005	185819	Cowichan	25/04/2006
5-Nov-07	25	A	455	J	2005	185812	Cowichan	15/05/2006
6-Nov-07	16	A	458	J	2005	184421	Chemainus	
6-Nov-07	13	A	445	J	2005	No pin		
6-Nov-07	24	A	416	J	2005	No pin		
8-Nov-07	4	A	523	F	2005	No pin		
8-Nov-07		A	503	J	2005	185811	Cowichan	15/05/2006
9-Nov-07	14	A	450	J	2005	184836	Cowichan	15/05/2006
13-Nov-07	14	A	471	J	2005	185812	Cowichan	15/05/2006
16-Nov-07	13	A	464	J	2005	185811	Cowichan	15/05/2006
19-Nov-07	13	A	466	J	2005	184836	Cowichan	15/05/2006
22-Nov-07	5	A	677	F	2003	185663	Cowichan	05/04/2004
22-Nov-07	33	A	487	J	2005	185818	Cowichan	24/04/2006
30-Nov-07	12	A	460	J	2005	185819	Cowichan	24/04/2006
30-Nov-07	12	A	443	J	2005	185810	Cowichan	15/05/2006
30-Nov-07	13	A	691	F	2004	185805	Nanaimo	

Table 33. Daily summary of carcasses examined, tags applied and tagged recoveries, by sex, for Chinook in the upper Cowichan River, 2007

	Carcasses Examined				Tags Applied				Tagged Carcasses Recovered			
Date	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown
22-Oct	0	0	0	1	0	0	0	0	0	0	0	0
23-Oct	0	1	0	0	0	1	0	0	0	0	0	0
24-Oct	0	3	1	0	0	1	0	0	0	0	0	0
25-Oct	1	1	1	1	1	1	1	1	0	0	0	0
26-Oct	1	2	0	0	1	0	0	0	0	0	0	0
29-Oct	1	5	0	3	1	5	0	3	0	0	0	0
30-Oct	2	11	0	0	2	11	0	0	0	0	0	0
31-Oct	3	15	0	0	3	15	0	0	0	4	0	0
01-Nov	3	1	2	3	3	1	2	3	0	1	0	0
02-Nov	1	5	9	3	1	5	9	3	0	2	0	1
05-Nov	10	15	27	9	10	15	26	9	2	3	1	1
06-Nov	4	3	12	9	4	3	11	9	1	2	6	1
07-Nov	15	6	19	13	15	6	18	13	0	3	1	3
08-Nov	2	12	19	5	2	12	19	5	3	0	0	0
09-Nov	3	7	5	0	3	7	5	0	0	0	0	0
13-Nov	3	8	16	2	3	8	16	2	1	0	1	2
14-Nov	4	15	3	4	4	15	3	4	0	3	2	3
15-Nov	0	5	2	1	0	5	2	1	0	0	1	0
16-Nov	1	1	5	4	1	1	5	4	0	1	0	0
19-Nov	2	11	4	4	2	11	4	4	0	3	2	1
20-Nov	1	12	2	1	1	12	2	1	0	1	0	0
21-Nov	2	11	2	1	2	11	2	1	0	1	0	0
22-Nov	2	11	6	1	2	11	6	1	2	0	0	2
26-Nov	1	3	4	0	1	3	4	0	0	0	0	0
27-Nov	0	3	2	0	0	3	2	0	0	0	0	0
28-Nov	3	16	2	0	3	15	2	0	0	1	0	1
29-Nov	0	3	2	0	0	3	2	0	0	0	0	0
30-Nov	0	6	4	0	0	6	4	0	0	0	0	0
Total	65	192	149	65	65	187	145	64	9	25	14	15

Table 34. Tags applied, carcasses examined and marks recovered, by sex, for Chinook in the Cowichan River, 2007

Sex	Tags Applied	Carcasses Examined	Marks Recovered	Percent Recovered
Male	65	73	9	13.8%
Female	169	200	20	11.8%
Unknown	64	78	14	21.9%
Total Adult	298	351	43	47.6%
Jack	153	175	16	10.5%
Total Population	451	526	59	58.0%

Note: These totals are different than those in the 'M-R summary'

Table 35. Petersen mark-recapture estimates, stratified by sex, for Cowichan River Chinook, 2007

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Adults	1860	1429	2291
Jacks	1267	782	1752
Total Population	3986	2632	5340

Table 36. Incidence of tagged adult Chinook carcasses recovered on the spawning grounds by recovery period and sex, Cowichan River, 2007

Recovery Period	Days of Recovery	Tagged Recoveries			Total Recoveries			Tag Incidence (%)		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Oct 22 - Oct 26	5	0	0	0	0	0	0	N/A	N/A	N/A
Oct 29 - Nov 2	5	0	7	7	10	44	54	0.0%	15.9%	13.0%
Nov 5 - Nov 9	5	6	8	14	40	51	91	15.0%	15.7%	15.4%
Nov 13 - Nov 16	4	1	4	5	3	13	16	33.3%	30.8%	31.3%
Nov 19 - Nov 22	4	2	5	7	7	42	49	28.6%	11.9%	14.3%
Nov 26 – 30	5	0	1	1	4	32	36	0.0%	3.1%	2.8%
Total	28	9	25	34	64	182	246	14.1%	13.7%	13.8%

Table 37. Proportion of the tag application sample recovered on the spawning grounds by application period and sex, Cowichan River, 2007

Application	Days of	Tags Applied			Tagged Recoveries			Percent Recovered		
Period	Application	Male	Female	Total	Male	Female	Total	Male	Female	Total
Oct 22 - Oct 26	5	2	3	5	0	0	0	0.0%	0.0%	0.0%
Oct 29 – Nov 2	5	10	37	47	0	7	7	0.0%	18.9%	14.9%
Nov 5 – Nov 9	5	35	43	78	6	8	14	17.1%	18.6%	17.9%
Nov 13 – Nov 16	4	2	9	11	1	4	5	50.0%	44.4%	45.5%
Nov 19 – Nov 22	4	5	37	42	2	5	7	40.0%	13.5%	16.7%
Nov 26 – 30	5	4	30	34	0	1	1	0.0%	3.3%	2.9%
Total	28	58	159	217	9	25	34	15.5%	15.7%	15.7%

Table 38. Estimate of hatchery origin Chinook, 2005 return

Brood Year	Tag code	Hatchery Broodstock		Natural Spawners		Native Fishery	
		Estimated #	Expanded #	Estimated #	Expanded #	Estimated #	Expanded #
2001 (Age 4)	184639	1.1	10.7	0.6	6.2	0.4	4.3
	184640	2.2	21.4	1.2	12.4	0.9	8.7
	184642	2.2	21.4	1.2	12.4	0.9	8.7
	184643	3.2	101.5	2.5	78.2	1.8	54.9
	184644	2.2	67.7	1.2	39.1	0.9	27.5
	184645	1.0	11.1	1.0	10.8	0.4	4.9
	Sum		233.8		159.0		109.0
							501.7
2002 (Age 3)	184918	7.2	49.8	6.9	52.7	3.5	26.7
	184919	2.0	15.3	2.0	14.9	0.9	6.7
	185013	2.2	22.4	1.2	13.0	0.9	9.1
	185014	3.2	33.6	1.9	19.4	1.3	13.7
	185015	3.2	33.6	1.9	19.4	1.3	13.7
	185016	2.2	24.7	1.2	14.3	0.9	10.0
	185052	4.2	14.2	4.9	19.3	3.1	12.1
	Sum		193.7		153.0		91.9
							438.6
2003 (Age 2)	185412	1.0	1.4	1.8	7.0	0.9	3.4
	185660	1.0	2.8	1.8	13.8	0.9	6.8
	185661	2.0	5.5	3.5	27.6	1.7	13.6
	185701	2.0	6.2	3.5	30.7	1.7	15.1
	185702	1.0	3.1	3.5	31.0	1.7	15.3
	185703	1.0	3.1	1.8	15.4	0.9	7.6
	185704	4.0	5.5	8.8	34.5	4.3	17.0
	Sum		27.6		159.8		78.9
							266.3

Table 39. Estimate of hatchery origin Chinook, 2006 return

Brood Year	Tag code	Hatchery Broodstock Estimated #	Hatchery Broodstock Expanded #	Natural Spawners Estimated #	Natural Spawners Expanded #	Native Fishery Estimated #	Native Fishery Expanded #
2002 (Age 4)	185013	0.8	8.3	1.3	13.5	0.5	4.7
	185014	1.6	17.0	2.5	25.9	0.9	9.4
	Sum		25.3		39.4		14.1
							78.8
2003 (Age 3)	185412	4.9	19.4	7.5	29.6	2.7	10.8
	185660	3.3	25.6	5.0	39.1	1.8	14.2
	185661	0.8	6.6	1.2	9.3	0.5	3.5
	185662	1.7	13.1	2.4	18.6	0.9	7.1
	185663	1.6	12.8	2.5	19.5	0.9	7.1
	185701	3.3	28.5	5.0	43.4	1.8	15.8
	185702	6.6	57.9	9.8	86.7	3.6	31.9
	185703	1.6	14.3	2.5	21.8	0.9	7.9
	185704	10.7	42.2	15.8	61.9	5.9	23.1
	Sum		220.4		330.0		121.3
							671.6

Table 40. Estimate of hatchery origin Chinook, 2007 return

Brood Year	Tag code	Hatchery Broodstock Estimated #	Hatchery Broodstock Expanded #	Natural Spawners Estimated #	Natural Spawners Expanded #	Native Fishery Estimated #	Native Fishery Expanded #
2003 (Age 4)	185661	1.0	7.9	4.3	33.5	0.8	6.5
	185662	1.0	7.9	2.7	21.4	0.4	3.3
	185663	0.0	0.0	2.7	21.4	0.4	3.3
	185701	1.0	8.7	1.5	13.4	0.4	3.6
	185702	2.0	17.6	5.5	48.1	0.8	7.3
	185704	2.0	7.9	5.5	21.5	0.8	3.3
	Sum		49.9		159.3		27.2
							236.4
2005 (Age 2)	184836	0.0	0.0	13.6	117.4	1.4	12.2
	185810	0.0	0.0	13.6	117.4	1.4	12.2
	185811	0.0	0.0	20.5	176.1	2.1	18.4
	185812	1.0	8.6	27.3	234.9	2.8	24.5
	185818	0.0	0.0	6.8	58.6	0.7	6.1
	185819	0.0	0.0	20.5	175.9	2.1	18.3
	Sum		8.6		880.4		91.7
							980.7

Table 41. Total adult Chinook returns to the Cowichan River for the years 1975-2007

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	5001 [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]
2004	2146 [6]	575	320	3341 [4]
2005	1527 [8]	940	607	3074
2006	1069 [8]	671	390	2165
2007	1860 [8]	326	238	2424

[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 2002, 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 an adjustment using the jack/adult ratios obtained from the spawning grounds.

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

[8] Estimates from 2005 to present are made from expanding the Fence count to estimate the number of Chinook that return prior to and after the fence is installed.

Table 42. Total jack Chinook returns to the Cowichan River for the years 1982-2007

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	195 [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
2004	1503	20	4	1527
2005	1045	80	110	1235
2006	752	38	130	885
2007	1267	48	132	1441

[1] The number of natural spawners was calculated as the number of adults recorded at the fence minus the adults removed for broodstock above of 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 was based on visual counts

[4] For 1988-2007 estimate was 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

Figures

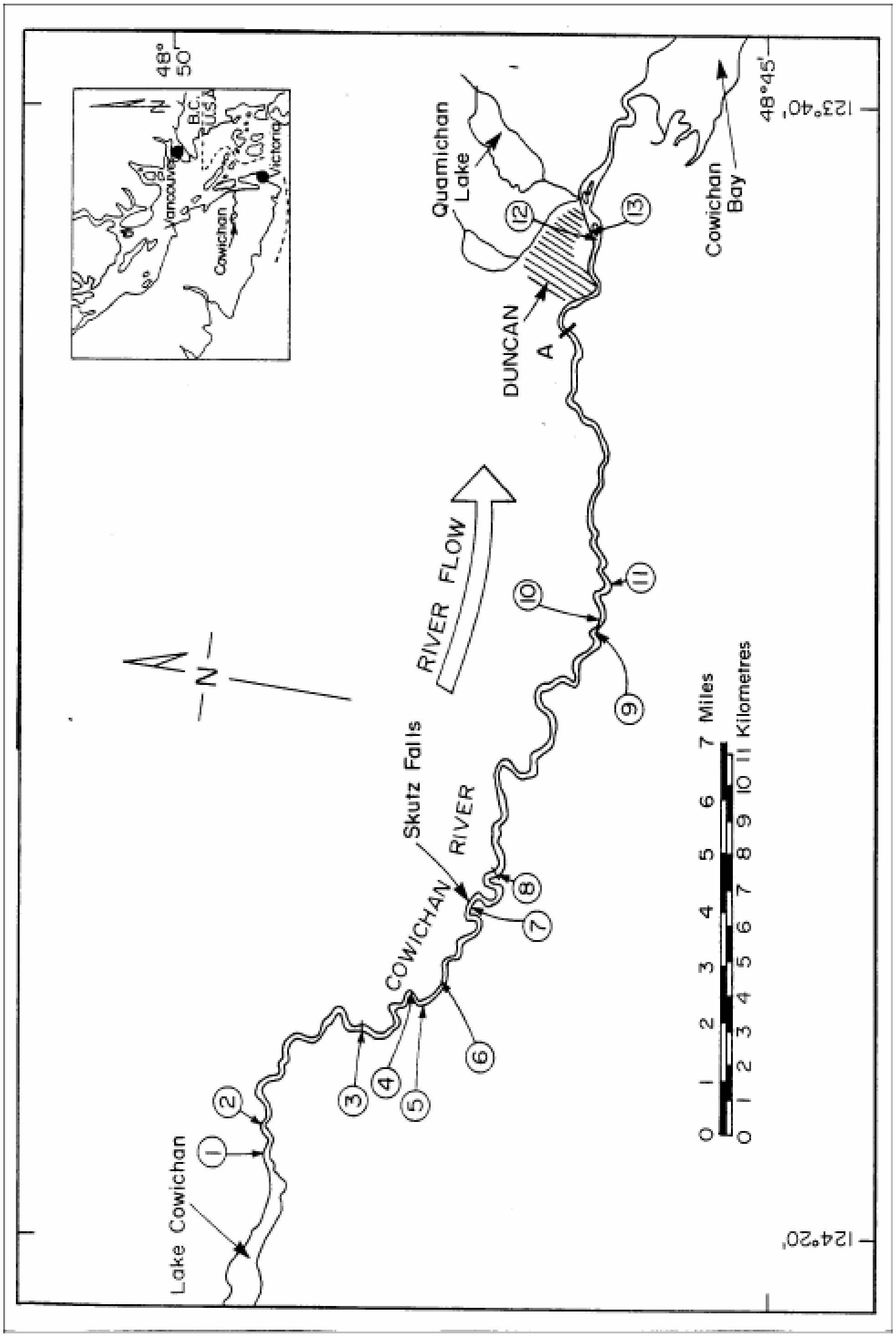

Figure 1. Cowichan River survey areas

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.

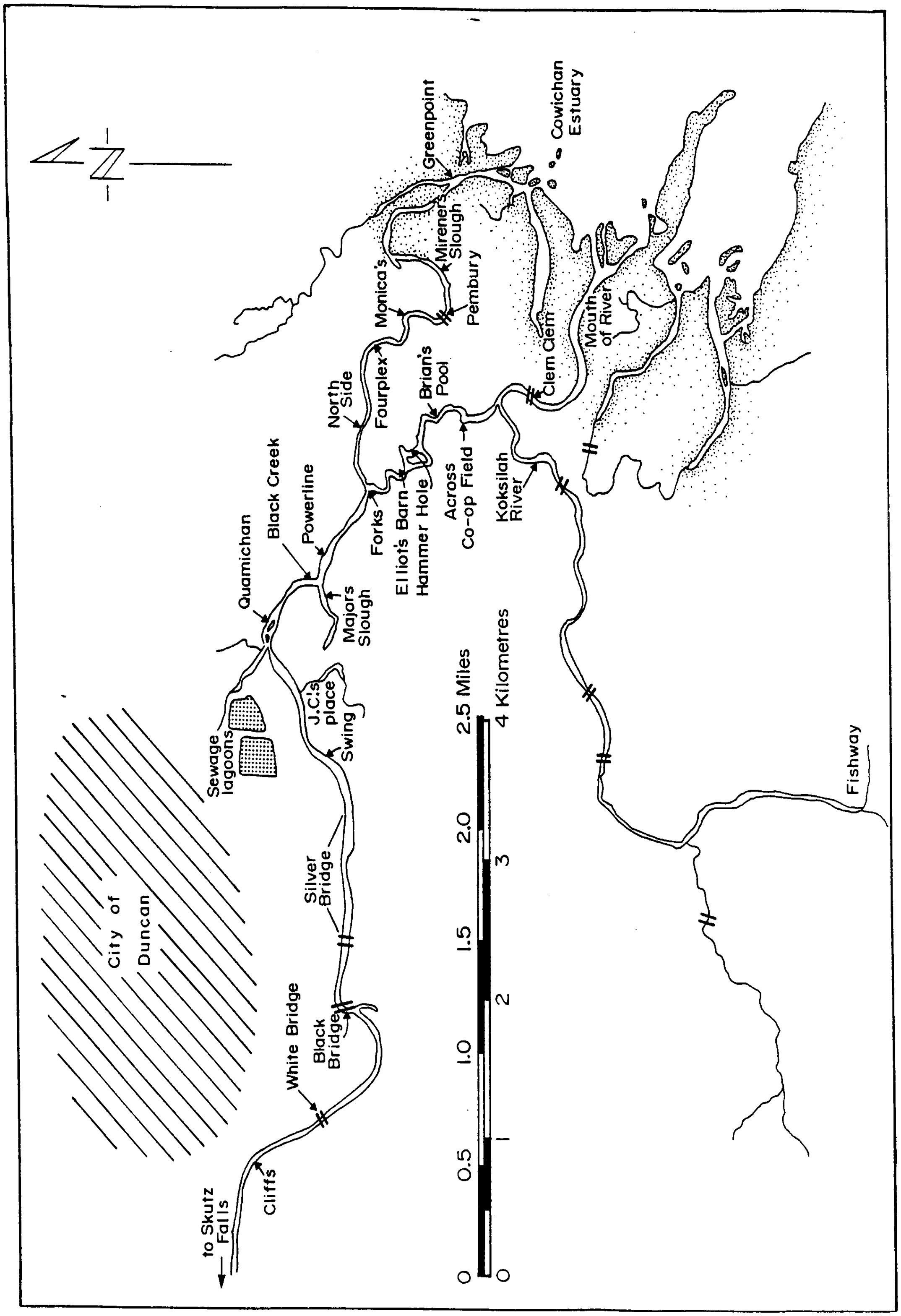

Figure 2. River management zones for the First Nations food fishery

River Management Zones Key

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

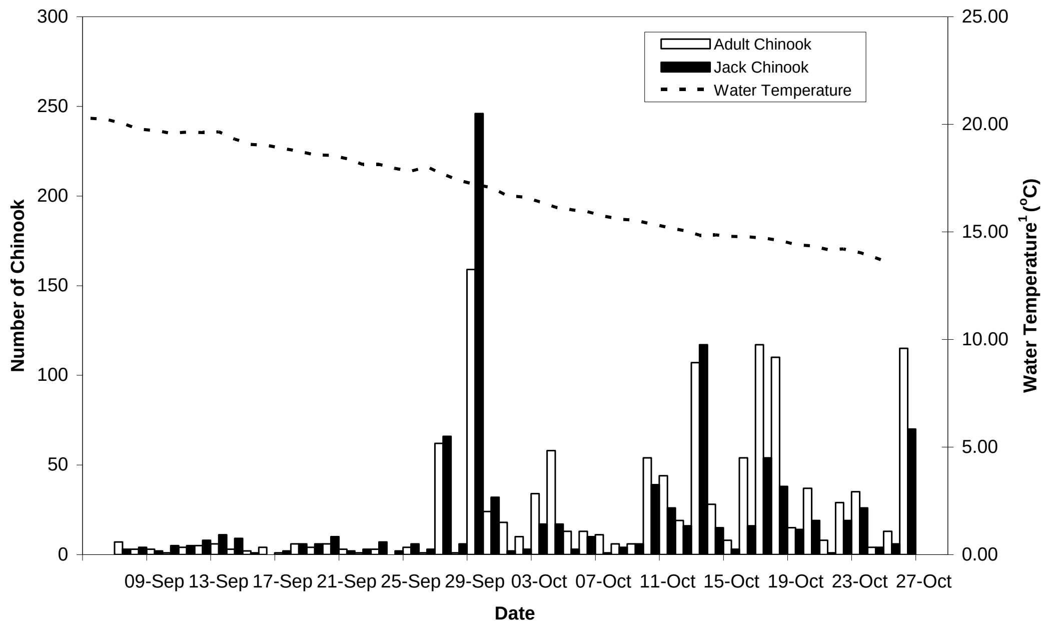

Figure 3. Daily fence counts of adult and jack Chinook and water temperature, Cowichan River, 2005

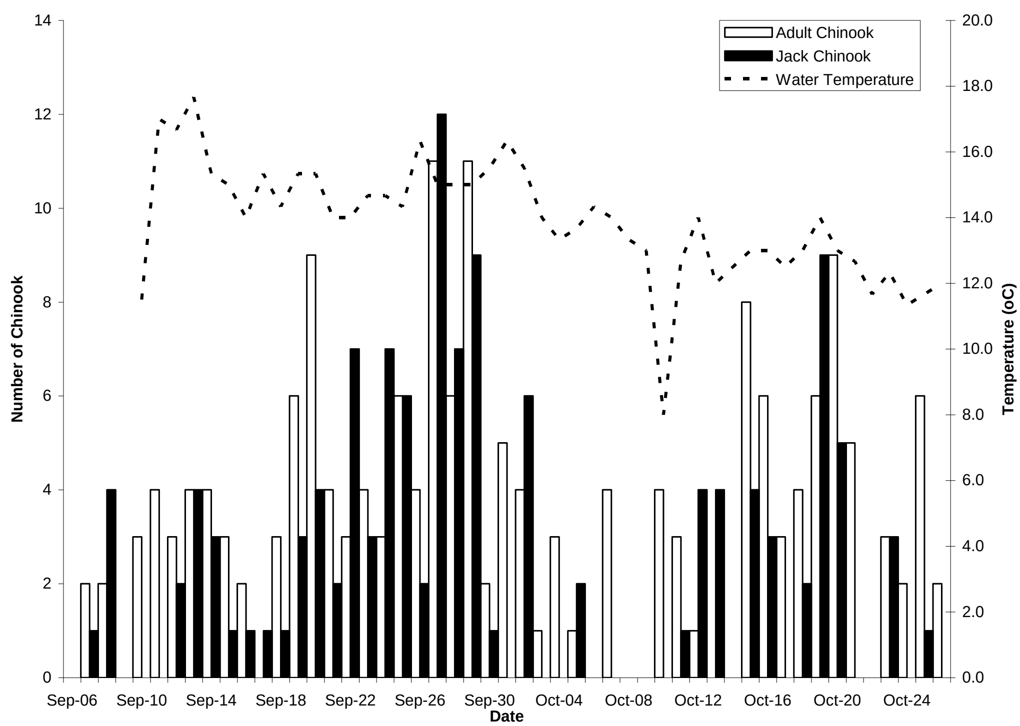

Figure 4. Daily fence counts of adult and jack Chinook and water temperature, Cowichan River, 2006

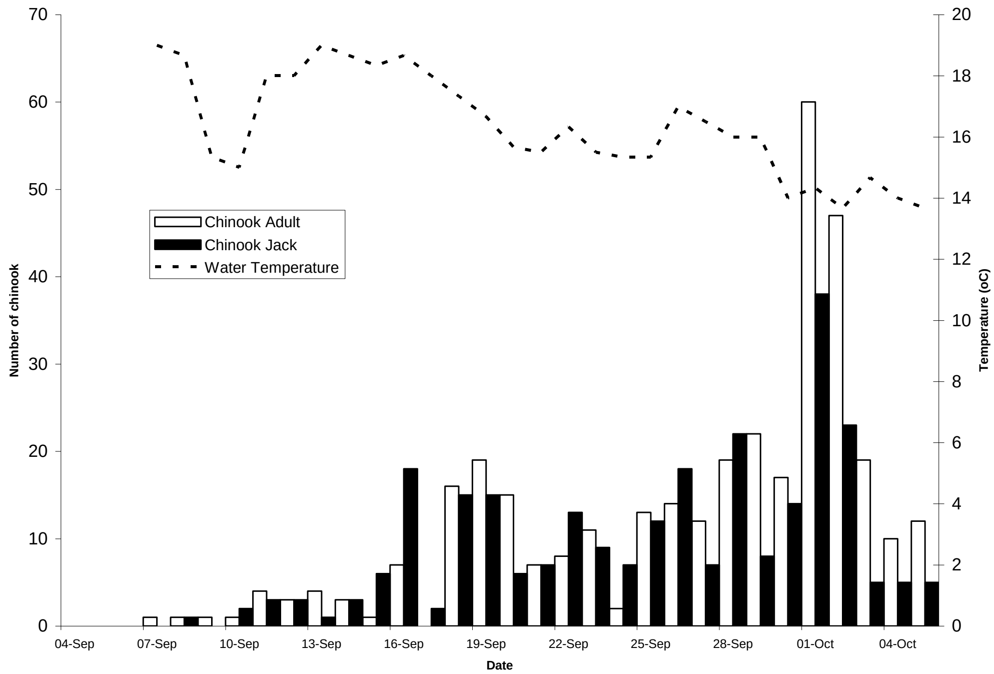

Figure 5. Daily fence counts o adult and jack Chinook and water temperature at the fence site, Cowichan River, 2007

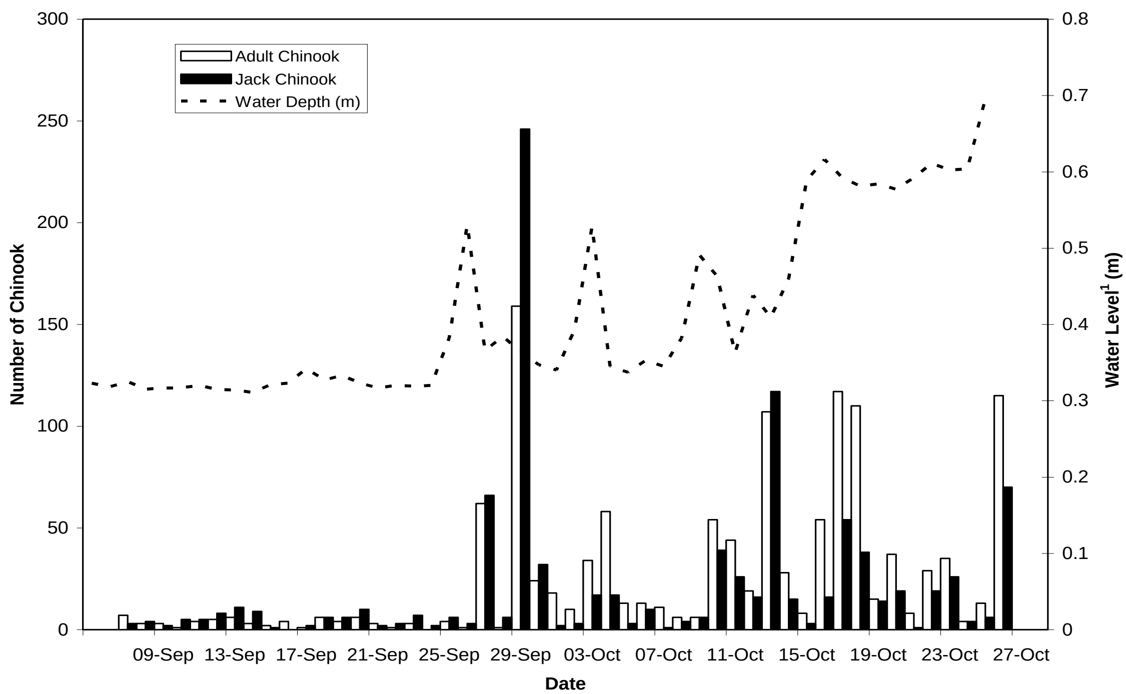

Figure 6. Daily fence counts of adult and jack Chinook and water level, Cowichan River, 2005

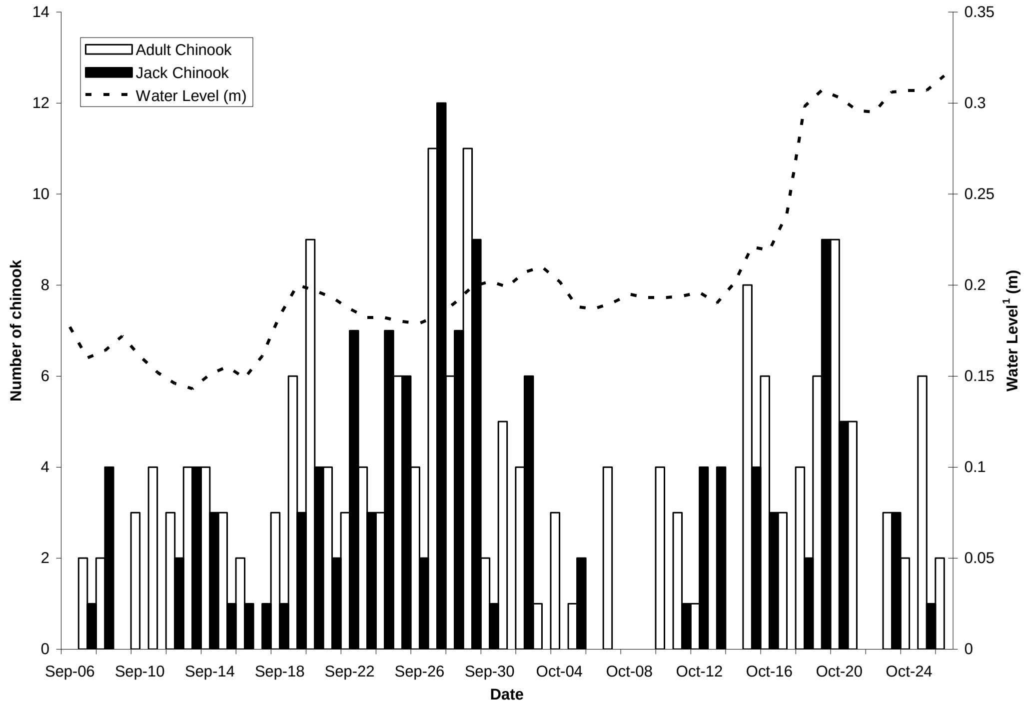

Figure 7. Daily fence counts of adult and jack Chinook and water level, Cowichan River, 2006

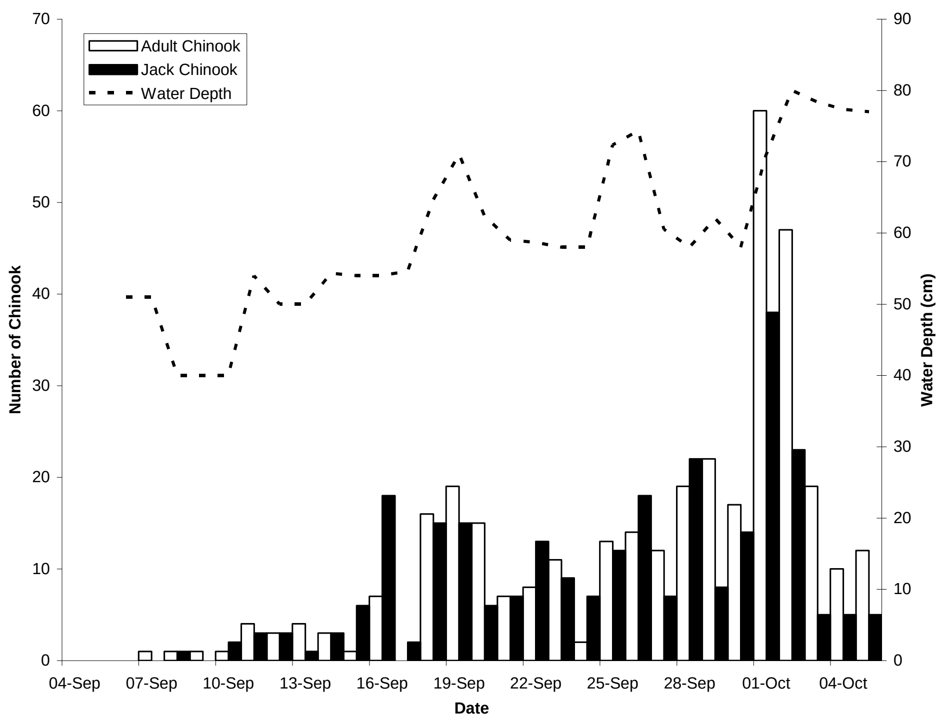

Figure 8. Daily fence counts from adult and jack Chinook and water depth at the Cowichan River fence site, 2007

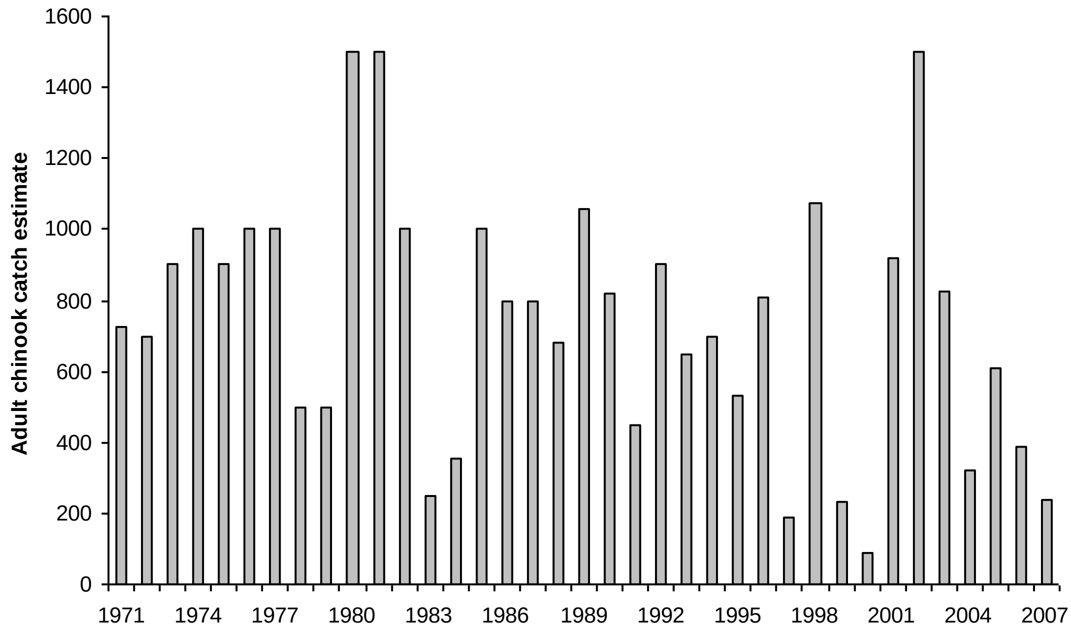

Figure 9. Adult Chinook catch from the First Nations' food fishery, 1971-2007

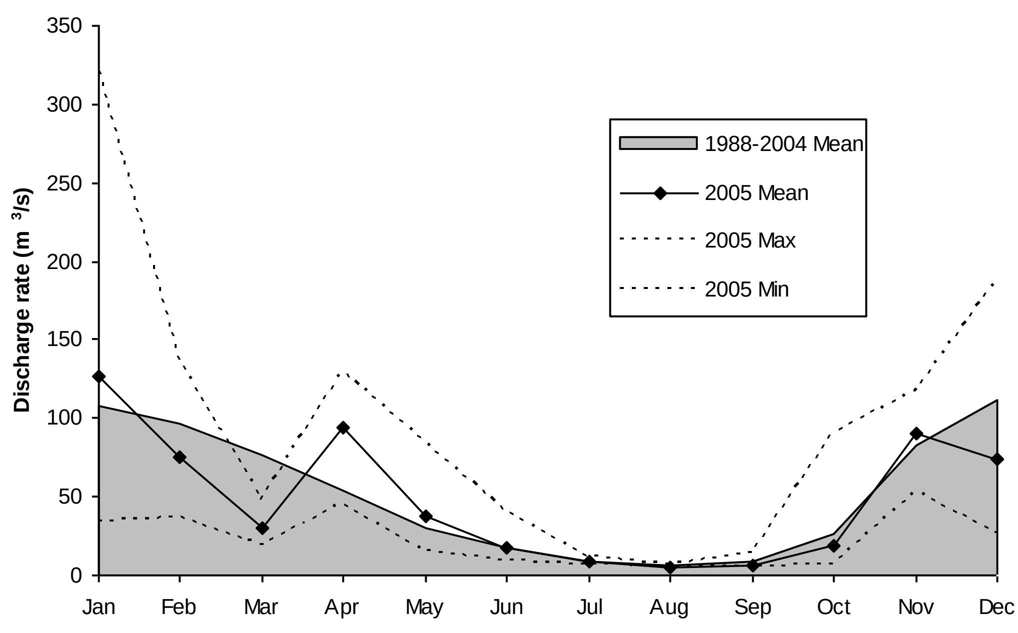

Figure 10. 2005 Cowichan River monthly discharge, with historic values

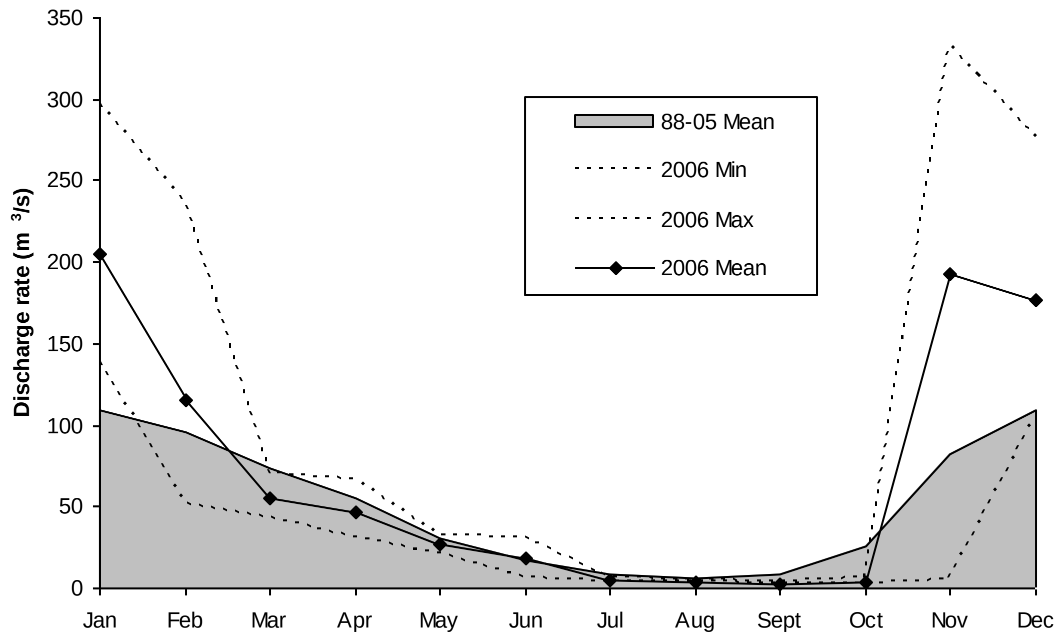

Figure 11. 2006 Cowichan River monthly discharge, with historic values

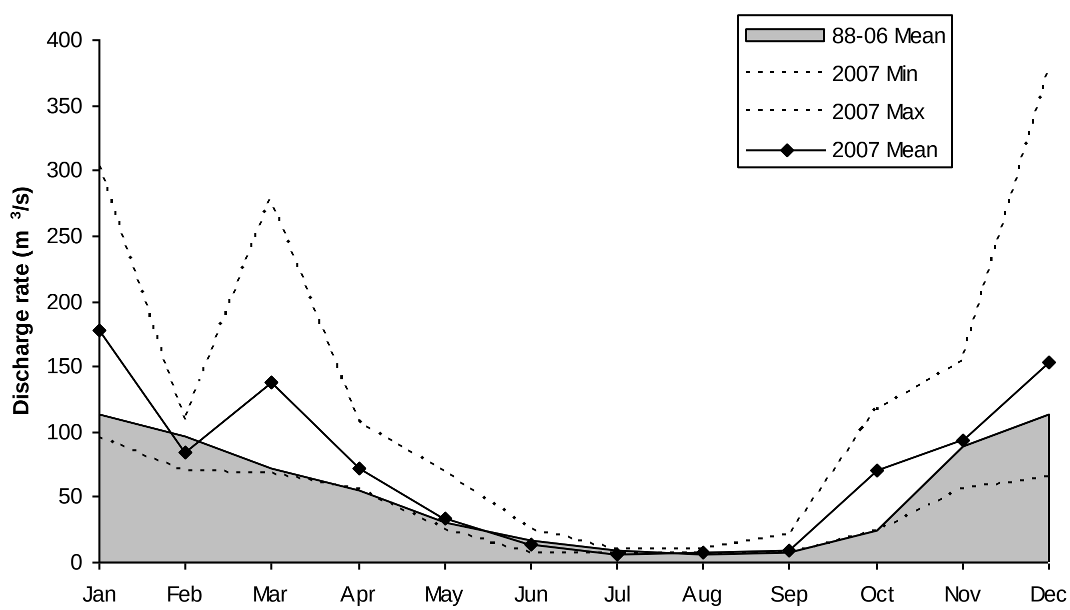

Figure 12. 2007 Cowichan River monthly discharge, with historic values

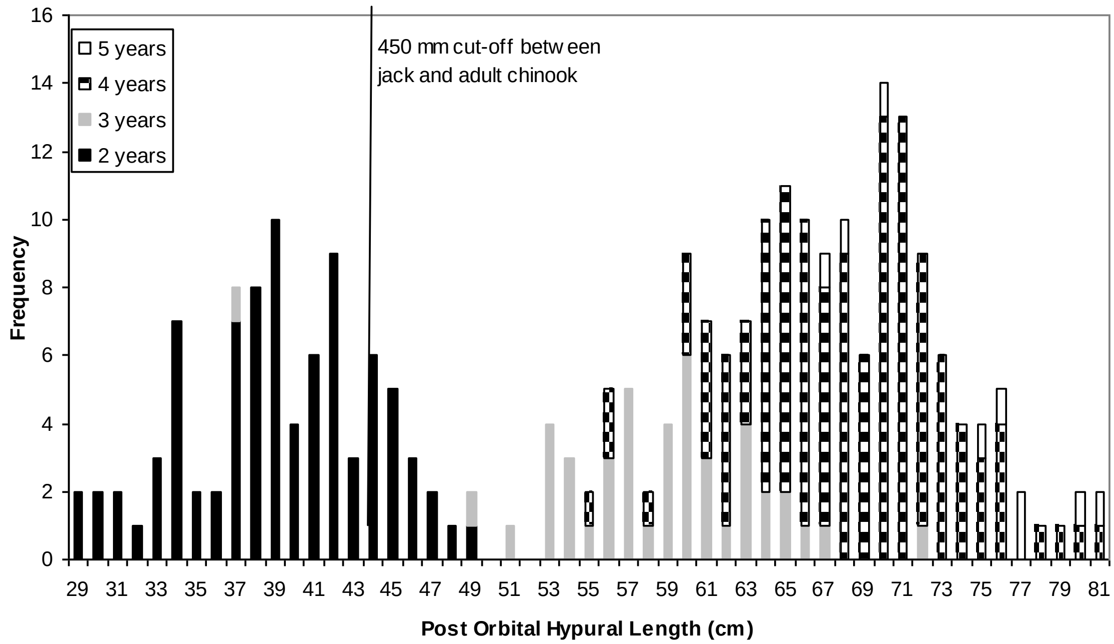

Figure 13. Length frequency of adult and jack Chinook collected from the Cowichan River spawning grounds, 2005

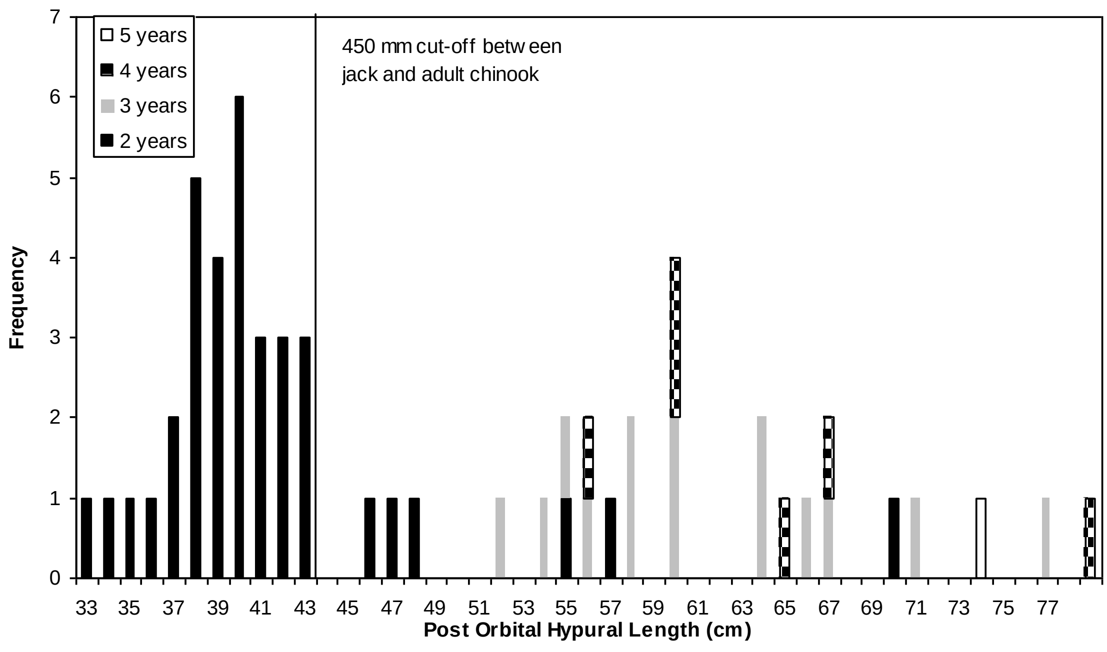

Figure 14. Length frequency of adult and jack Chinook collected on the Cowichan River spawning grounds, 2006

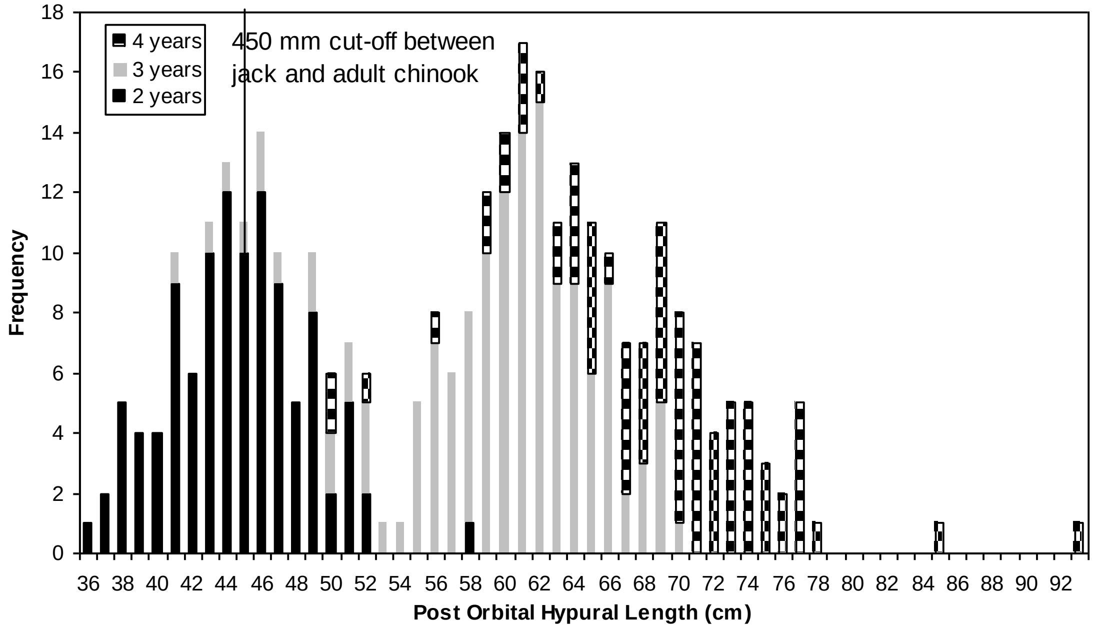

Figure 15. Length frequency of adult and jack Chinook collected on the Cowichan River spawning grounds, 2007

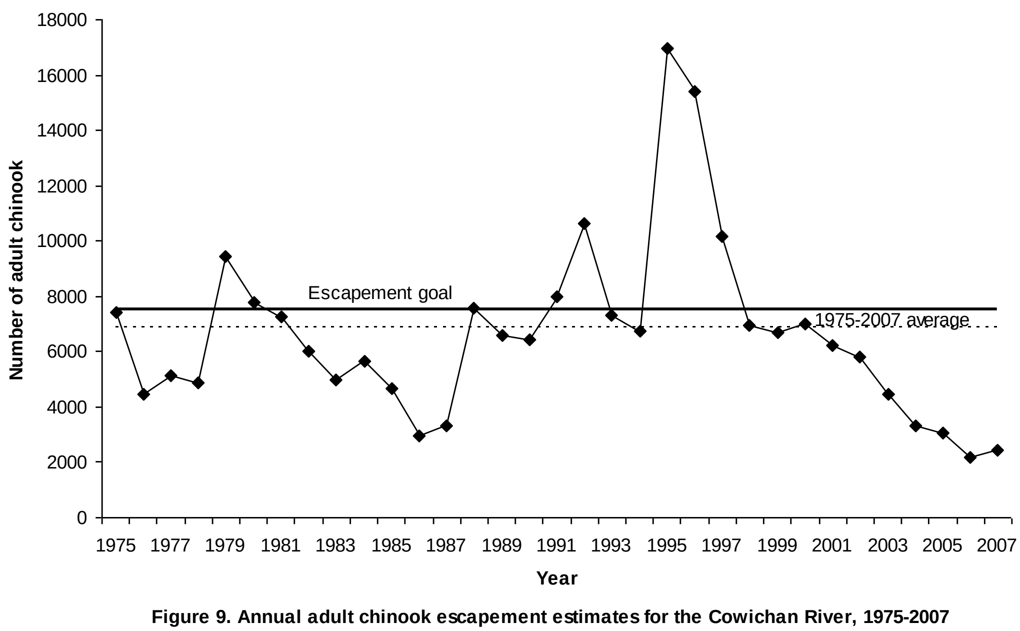

Figure 16. Annual adult Chinook escapement estimates for the Cowichan River, 1975 - 2007

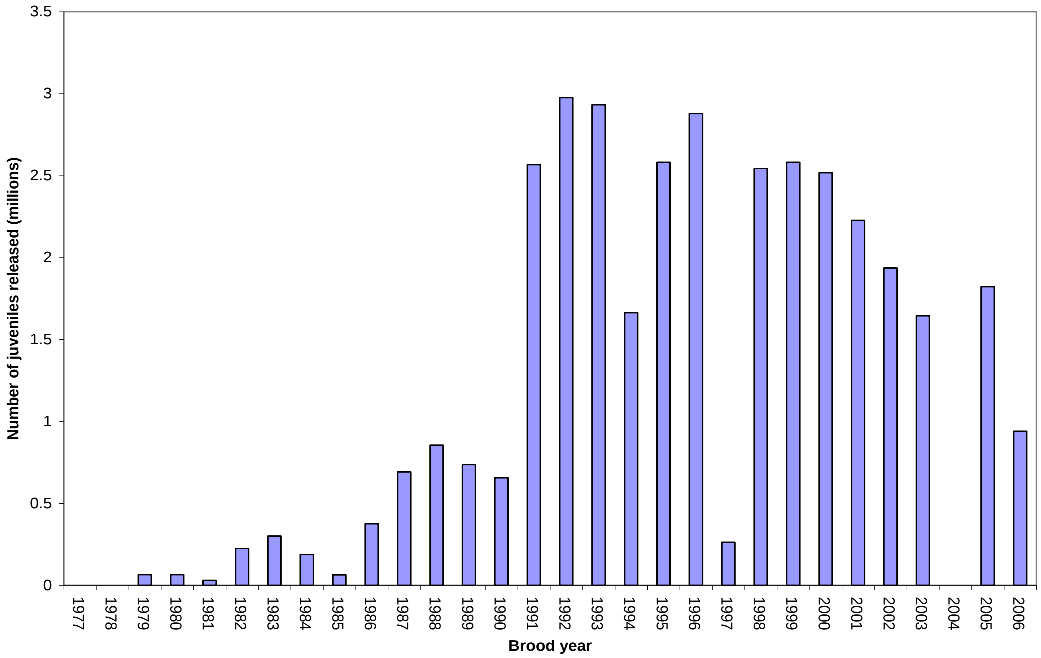

Figure 17. Annual release of hatchery Chinook into the Cowichan River as fry (3g) and as pre-smolts (6g), brood years 1979 – 2006)

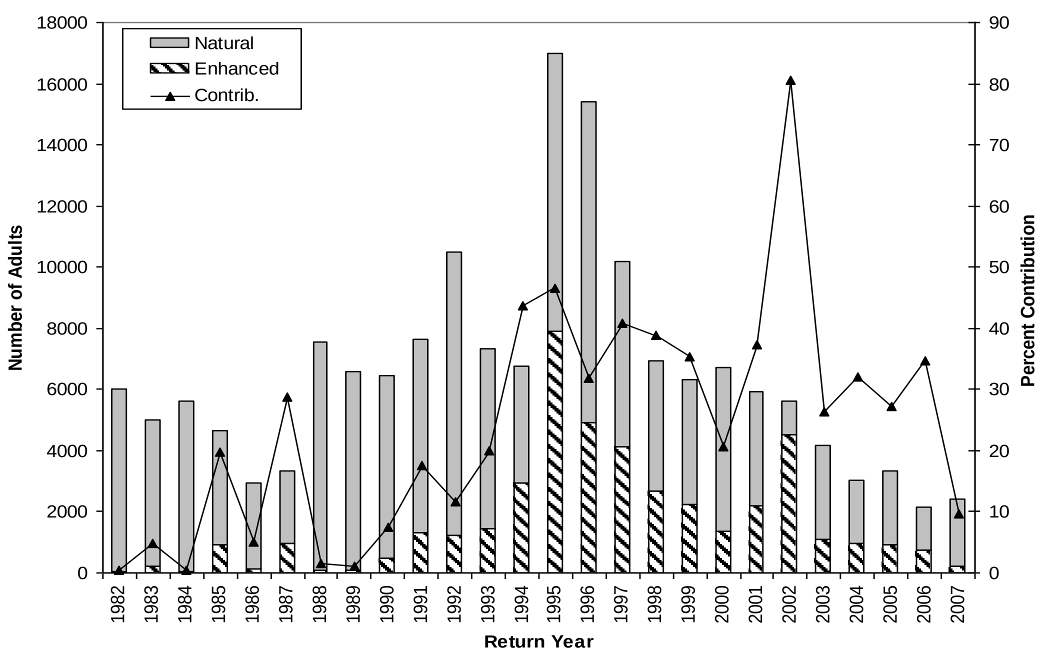

Figure 18. Annual natural and enhanced contributions to adult Chinook escapement, Cowichan River, 1982 – 2007.

APPENDIX

Summary of Cowichan Weir Start-up, operation and seasonal protocols

(accessed 2-Mar-09
www.catalystpaper.com/communities/communities_crofton_results_waterlevel.xml)

Goals:

1. Maintain full storage behind the weir until July 9th if possible
2. Maintain an optimum 25 cms prior to May 1 if conditions allow
3. Maintain a minimum 15 cms in Cowichan River prior to June 15
4. Maintain a minimum 7 cms from June 15 to end of weir control period typically around Nov 1

Note: There may be provisions for possible spring and fall pulse flows for fish conservation.

A) Weir Startup Considerations:

1. Do not start-up weir earlier than Feb 28th due to the risk of a "rain on snow" flood event.

2. Schedule initial spring meeting to discuss/determine weir startup at 162.6 m GSC declining lake level which allows about 10 days before crest of weir is reached – avoid going below the crest.

3. Avoid lake level dropping below crest of weir in a year with below normal snowpack by April 15

4. Review snowpack level (currently measured at Jump Cr. – Nanaimo watershed) and assess prediction of snow water inflows to Cowichan (not currently available)
    a. Note: Estimated that about 10 to 20% of total inflow to the lake from April to June 30 is contributed by snowmelt runoff, the remainder is precipitation

5. Review likelihood of precipitation
    a. Early spring vs. late spring – likelihood of late spring rainfall vs. risk/cost of early start-up (cost to man and operate weir, risk of impact to fish resource of less than 15 cms flows)
    b. Weather forecast and long range precipitation/inflow trends

B) Weir Start-up Triggers:

Start up weir if either of the two triggers below are met.

Trigger #1: There is low snowpack, the lake level is at the crest of weir at 162.37 GSC m, and it is past Feb 28th

OR:

Trigger #2: There is average snowpack and the lake level is 17 cm below the weir crest (162.20 GSC m).

Note: Trigger #2 is based on a rule curve of 25 cms to May 1, 15 cms to June 15, then 7 cms to season end – ie. a rule curve that improves the ability to rebuild and sustain storage to July 9th and recapture of occasional summer season precipitation inflows.

C) *Weir Start-up Ramp-down Protocol (Run of river to 25 cms)*

* Catalyst Paper will issue one press release for the entire weir operating season, and carry out pulse(s) in-season as directed by MOE.

* River flows will be measured using the Catalyst Paper static gauge and can be cross checked with Water Survey of Canada on-line automated Cowichan Lake river gauge.

Assessment Notice: Starting in 2006, an examination of the two tier spring river minimum flow (25 cms and 15 cms) will be done with the view that in drought situations, one tier 15 cms may be used to conserve storage. Significant fish conservation and sport fishery impacts may or may not occur based on the study's findings.

Weir Start-up Protocol:

1) Close boat lock over the course of half a day. (This will drop river flow typically from run of river 48 cms to 45cms over 48 hours, however, river flow will recover to run of river flow again as velocity of flow through the 4 spill gates increases to compensate for the Boat Lock closure).

2) Make no adjustments to spill gates for 2 days after the Boat Lock is closed.

3) Natural uncontrolled river flows >30cms need to be ramped down slowly as would occur when a high pressure system prevails – reduce the river flows no more than 3 cms/day and gradually adjust flows down to maintain 25 cms until May 1.

D) *First Spring Ramp-down Protocol: (25 cms to 15 cms)*

On April 28 (3 days ahead of the May 1 rule curve minimum target of 15 cms to allow for a gradual decline), start reducing the river flow from 25 cms to 15 cms by gradually closing the spill gates to achieve a river flow reduction rate of no greater than 2 cms/day.

E) Second Spring Ramp-down Protocol: (15 cms to 7 cms)

This is the most sensitive fisheries period when flow ramping must be gradual due to side-channel stranding of salmonid fry, juveniles and alevins still in the river gravels.

1. An acceptable ramp down rate if conservation of storage need is urgent: June 13 to June 17, reduced by 2 cms per day.
2. An ideal ramp down rate is over a longer period from June 11 to June 19, with a reduction of flow by 1 cms per day.
3. In ideal conditions, ramp down only at dusk or at night to minimize stranding risk of newly emerged fry.

F) Spring Spilling Protocol (if required): Prior to July 9

If, after going on control, but before June 15 (the beginning of the summer river rule curve flow of 7 cms), the lake level begins to approach Full Storage Level (FSL) due to increasing inflows, open the spillgates to spill water and maintain the lake level as close to FSL as possible, without going more than 15cm above FSL.

As the lake level approaches FSL, begin increasing the river flow gradually by up to 5 cms/day, as required to meet the target FSL of 162.38 GSC m (maximum 162.53 GSC m). Continue operating the spillgates to achieve inflow = outflow and a target FSL lake level until June 15. This will be a balancing act as inflows into the lake (snowmelt and precipitation) vary depending upon the weather.

G) Summer Maintenance Flows June 15 – Fall (7 cms)

Maintain 7 cms throughout the summer period

H) Falls pulse flows: (7 cms to 18 cms) Sept 17 to Oct 11

Pulse flows released at the weir in the fall are a conservation measure used to stimulate Chinook upstream migration from the estuary.

1. Trigger for a pulse flow is based on available storage and lake level. If lake level is below the rule curve, a decision may be made not to initiate a pulse flow, or it may be initiated based on an acceptable probability of rainfall.

2. Optimum pulse flow conditions
    a. Fishery is closed.
    b. Timing window set by fisheries management committee
    c. Pulse window: Sept 17 to Oct 11

d. Optimum flow pulse is 18 cms (maximum for counting fence is 22 cms, maximum for Somenos backwatering/agricultural constraints is 24 cms
e. Ramp-up from 7 to 18 cms over 6 hours, hold for 30 hours, ramp down from 18 cms to 7 cms over 12 hours)

3. Backwatering affect into Somenos sub-basin does not begin until flow exceeds 24 cms – therefore this is not a constraint to pulse flows.

4. Process for obtaining a pulse flow(s):
   a. The fisheries management committee will discuss and agree on pulse size and release timing.
   b. One week in advance of pulse, a request is to be co-ordinated by a DFO stock assessment staff member to Catalyst Paper, and then reviewed/approved by MOE's Water Stewardship Division based on criteria above,

5. Using the Water Survey Canada online river flow measurement at Lake Cowichan and at the Silver Bridge in Duncan shows that a pulse at the weir in Lake Cowichan takes about 12 hours to reach the estuary.

I) End of Year Weir Shutdown

1. Target the shut down of weir operation for on/about Oct 31st, providing the lake level remains below the crest of the weir. The weir's operation in the fall assists the Canada/US International salmon counting fence with a target river flow of 20cms. These flows also assist Somenos Basin agriculturists. Weir shutdown and flow ramp-up to be co-ordinated so that the counting fence is removed from the river in advance of opening the weir's gates.

2. If lake level has not reached the crest of the weir, maintain weir operation into November until fall rains begin to rebuild storage.

When going off control, the ramp-up flow rate will depend on the current flow, as it is the difference between current flow and "run of river" that will determine the ramp-up rate strategy. If the current flow is low (ie. 20 cms as the weir has been maintained in support of the fish counting fence operation and agricultural constraints in Somenos), then ramp up will be longer (over 5 days). If the current flow is high (~40 cms) ramp-up can proceed faster (approx 2 days) to run of river at which time the weir can be shut down for the season.

At an approximate flow about about 57 cms, it has been noted that the weir's spillgates do not dictate river flow but rather it is the pinch point downstream of the weir which controls the flowrate in the river.

Catalyst Paper Cowichan Lake level and Cowichan River flow data, Jump Creek snow pack and Duncan weather forecast available at:

http://www.catalystpaper.com/communities/communities_crofton_results_waterlevel.xml

On-Line Water Survey of Canada (Cowichan River at Lake Cowichan (discharge and temp.)

http://scitech.pyr.ec.gc.ca/waterweb/formnav.asp?lang=0

J) Other information

River kayaking is negatively impacted at flows below 7 cms. At around 6 cms it is still navigable but bumpy. At 5 cms or lower, it is very bumpy and tours may be cancelled at these kind of low flow rates.

The District of North Cowichan operated “Joint Utility Board” sewage lagoons in Duncan require a 40:1 dilution ratio, which equates to a minimum Cowichan River flow requirement of 5.1 cms (downstream of the Silver Bridge).

Broodstock collection typically occurs starting September 1 until the end of October. The fishing crews can safely handle a maximum flow of 18 cms.

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Also, with input from Craig Sutherland, UMA Engineering

L) Revision History

Revision Date	Change	Acknowledgements
May 12, 2008	Addition of spring spilling protocol	Michelle Vessey
Oct 17, 2008	Broodstock max flow restrictions	Michelle Vessey
Oct 21, 2008	Infor re: downstream pinch point at 57 cms added	Michelle Vessey
Nov 2009	Sorted tables	Charles Thirkill