Adult Chinook Escapement Assessment Conducted on the Nanaimo River During 2002

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by

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Carter, E.W., Nagtegaal, D.A., and Hop Wo, N.K. 2004. Adult chinook escapement assessment conducted on the Nanaimo River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2691: 41 p.

In 2002, Fisheries and Oceans Canada in co-operation with Snuneymuxw First Nation continued a productivity study of chinook salmon (*Oncorhynchus tshawytscha*) in the Nanaimo River. Areas of concentration for this study included: i) enumeration of returning chinook; ii) collection of biological and coded-wire tag (CWT) data; and iii) estimation of returning chinook using a carcass mark-recapture project as a comparison. The estimated total return of fall run adult chinook to the Nanaimo River was 1,371 of which 946 spawned naturally. We used observations at First Lake and information compiled during broodstock collection to estimate the total return of the First Lake spring chinook stock at 637 adult chinook. Total return of both fall run and spring run adult chinook to the Nanaimo River in 2002 was 2,008. We also examined the effects of a water management plan implemented in 1989 to aid the upstream movement of fall chinook.

RÉSUMÉ

Carter, E.W., Nagtegaal, D.A., and Hop Wo, N.K. 2004. Adult chinook escapement assessment conducted on the Nanaimo River during 2002. Can. Manuscr. Rep. Fish. Aquat. Sci. 2691: 41 p.

En 2002, Pêches et Océans Canada, en coopération avec la Première nation Snuneymuxw, a poursuivi une étude de la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) dans la rivière Nanaimo, dont les principaux éléments étaient les suivants : i) dénombrement des quinnats amontants; ii) collecte de données biologiques et de marques métalliques codées et iii) estimation des remontes de quinnat par le biais d'un projet de récupération des carcasses de saumons étiquetés à titre de comparaison. Selon nos estimations, la remonte totale de quinnats adultes d'automne dans la Nanaimo se chiffrait à 1 371, dont 946 ont frayé dans la rivière. Nous avons utilisé des observations faites dans le lac First et de l'information recueillie lors de la récolte de géniteurs pour estimer la remonte totale de quinnats de printemps dans ce lac, qui se chiffrait à 637 adultes. D'après nos calculs, la remonte totale de quinnats adultes d'automne et de quinnats adultes de printemps dans la rivière Nanaimo en 2002 atteignait 2 008 individus. Nous examinons aussi les effets d'un plan de gestion des eaux mis en œuvre en 1989 en vue de faciliter la montaison du quinnat d'automne.

INTRODUCTION

Since 1988, considerable interest has been focused on the status of chinook salmon (*Oncorhynchus tshawytscha*) stocks in the lower Strait of Georgia. The Nanaimo River along with the Cowichan River and the Squamish River, were chosen to represent the lower Strait of Georgia as exploitation and escapement indicator rivers (PSC 1990). Escapement information is used to evaluate rebuilding strategies and harvest management policies for lower Strait of Georgia chinook (Farlinger et al. 1990). Since then, due to logistical reasons the Squamish River system was dropped as an indicator. The Nanaimo River system was also dropped as an exploitation rate indicator in 2002 but remains an important escapement indicator. In 2002, DFO, Science Branch, in conjunction with the Snuneymuxw First Nation continued to operate a counting fence and collect information on chinook escapements in the Nanaimo River system.

The Nanaimo River chinook exhibit a variety of life history strategies, with at least three genetically distinct runs produced (Carl and Healey 1984). Unique to only a few systems on the east coast of Vancouver Island, there are two distinct spring chinook stocks in additional to a fall run stock returning to the Nanaimo River.

The two spring run stocks enter the river from between December and February and hold in First Lake, Second Lake or deep canyon pools until they spawn during late summer/early fall (Blackman 1981, Brahniuk et al. 1993, Nagtegaal and Carter 2000). The Upper Nanaimo River spring chinook stock spawns upstream of Second Lake to Sadie Creek at the outlet of Fourth Lake (Hardie 2002) during October and the majority of fry are stream-type which rear for up to one year before outmigrating to the estuary (Healey 1980, Blackman 1981, Nagtegaal and Carter 2000).

The First Lake spring run spawns within the first 1.6 kilometers downstream of the First Lake outlet to the Wolfe Creek junction pool (Healey and Jordan 1982, Hardie 2002), with the peak of spawning typically during the first two weeks of October (Nagtegaal and Carter 2000, Brahniuk et al., 1993). Chinook fry produced from the late spring run are mostly ocean-type and rear for 90 days in freshwater before migrating to sea. Stream type fry will be more vulnerable to changes in freshwater productivity and habitat conditions than ocean type fry that outmigrate upon emergence. Once in the estuary, First Lake fry exhibit greater agonistic behavior than fry produced by the lower Nanaimo stocks due to their longer period of territorial stream residence prior to migration into the estuary (Taylor 1990).

The larger fall chinook stock enters the Nanaimo River during August and a large proportion of the run spawns in the lower river downstream of the Borehole/lower canyon area down to the Cedar Road bridge (Healey and Jordan 1982, Hardie 2002). Some of the fall chinook run ascend the falls to spawn in the upper river downstream of First Lake. The majority (99%) of fry incubated in the lower river exhibit ocean-type life history strategy and outmigrate to sea upon emergence to rear in the estuary (Healey and Jordan 1982).

Hatchery production of chinook on the Nanaimo River began in 1979 (Cross et al. 1991). In that first year, eggs were incubated at the Pacific Biological Station and later released into the river. The first year of production at the hatchery facility was 1980 (1979 brood) when 100,000 chinook fry were released. Over the years fry production has increased, and in 2002, a total of 359,165 fall run and 186,187 First Lake spring run chinook fry were released. There is no hatchery enhancement for the Upper Nanaimo River spring run chinook stock. Coded-wire tagging of chinook began in 1979 and by 2002, 49.1% of fall run chinook fry and 13.5% of spring run chinook fry carried coded-wire tags (P. McKay, Nanaimo River Salmonid Enhancement Project Co-Manager, Community Futures Development Corporation of Central Island, 271 Pine Street, Nanaimo, B.C., V9R 2B7. pers. comm.).

In addition to chinook, the Nanaimo River also supports stocks of coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), steelhead trout (*O. mykiss*), cutthroat trout (*O. clarki*), and Dolly Varden (*Salvelinus malma*).

In consultation with various user groups, the B.C. Ministry of Environment, Lands and Parks initiated a Nanaimo River Water Management Plan in June 1989. The primary goal of the plan was to improve salmon escapement by increasing flows during typically low water levels in the fall while at the same time maintaining adequate flows to satisfy industrial and domestic water use (Ministry of Environment, Lands and Parks 1993).

This report presents the results of the study completed during 2002. The objectives included:

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

METHODS

Three methods were employed to estimate chinook spawning escapement in the Nanaimo River. These included fence counts, carcass mark-recapture techniques, and swim surveys. Both fence counts and mark-recapture methods were used to estimate escapement of fall run chinook. Spring run chinook enter the river prior to fence installation, therefore estimates of escapement for this stock were dependent on swims and visual observations at known holding locations and from broodstock capture data at First Lake. Swim surveys were conducted to observe and record spawning distribution of the fall run chinook stock that was enumerated passing the fence. Biological data including length, sex, scales and presence/absence of an adipose fin were collected from carcasses during the mark-recapture program.

Carter and Nagtegaal (1997) have previously described fence construction and data collection methods in detail. A brief description along with modifications made to the project in 2002 are explained below.

FENCE OPERATION

In previous years, attempts to improve the fishway by creating holding pools or diverting water to increase flow and encourage fish movement through the trap box had little success (Carter and Nagtegaal 1998). In 1998, the fence was moved upstream about two kilometers to a site known as San Salvadore, located approximately 200 meters upstream of the Cedar Bridge (Figure 1, Figure 2). In 2000, an excavator operator completed extensive in-river work to properly secure the rail in the substrate and to excavate an approach channel to the trap box and another leading from the trap box upstream. In addition, the rail was further re-enforced by attaching cable and anchors that are buried about two metres into the substrate upstream.

Fish counts were recorded by 15 minute intervals for adult and jack chinook, adult and jack coho, and chum salmon. When identification was in doubt, fish were recorded in the unknown category. Other information including water depth, water temperature, water clarity, and weather was recorded three times daily. Staff were responsible for keeping the fence clear of leaves and other debris as well as general maintenance to ensure optimal operating capability.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

In addition to the fence counts, adult chinook escapement estimates for the fall stock were also generated from the carcass mark-recapture data using a pooled Petersen model (Chapman modification; Ricker 1975). Although the fence counts were considered the most accurate, the mark-recapture data enables estimates of sex composition and enhanced (hatchery) contribution in the population using CWT data.

The carcass mark-recapture estimate is based on recoveries of chinook carcasses tagged on the Nanaimo River spawning grounds. This population estimate compliments the fence enumeration count and is implemented for several reasons. Firstly, the handling and tagging of chinook as they passed through the counting fence would cause additional undue stress and delay migration. Therefore the tagging of chinook carcasses is preferred because it provides an independent estimate of population information while minimizing the physical contact to spawning chinook salmon. Secondly, the carcasses provide the primary source of CWT recoveries and biological information.

The carcass recovery operation involved a two or three-person crew in an inflatable boat searching the river daily for spawned out chinook carcasses. Recovery effort was concentrated on the fall run chinook stock in the area of highest spawning activity between the Island Highway

Bridge and the Cedar Bridge. Each carcass was tagged with a numbered Ketchum[1] aluminum sheep ear tag on the left operculum and released into the river. For all recaptures, the tag number and location were recorded. Once recaptured, the carcass was cut up and removed from the river to avoid multiple recaptures.

In previous years, excursions were made to a two to three km section of river below First Lake to locate spring run chinook carcasses in an attempt to estimate the escapement of this population (Carter and Nagtegaal 1997 – 1999). Due to an inability to recover sufficient numbers of carcasses, this was discontinued in 1998. Population estimates for the First Lake spring stock were based on visual observations in the vicinity of First and Second Lakes.

Biological data were collected primarily from spawned out chinook carcasses which were recovered and tagged during a carcass mark-recapture program on the spawning grounds. Additional biological data were collected from carcasses that washed up onto the fence. Staff at the Nanaimo River Hatchery collected and contributed biological data from the First Lake spring run chinook broodstock. Information and biological samples taken for each chinook carcass included capture location, post orbital-hypural (POH) length, sex, scale sample, and presence or absence of adipose fin. If the adipose fin was absent, indicating a coded-wire tagged fish, the head was removed and placed in a bag with a numbered label. Heads were later catalogued and CWT's were decoded.

Mark-recapture estimates were calculated using a pooled Petersen estimator. Since the true population size was not known, a direct measure of the accuracy of the estimates was not possible. However, an assessment of the underlying assumptions of equal probability of capture, simple random recovery sampling, and complete mixing can usually be made by testing recovery and application samples for temporal, 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 attain both samples thus limiting the ability to assess sample biases.

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

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[1] Ketchum Manufacturing Ltd., Ottawa, Canada

SWIM SURVEYS

Swim surveys were conducted in conjunction with the Nanaimo River Hatchery staff to estimate the number of spawning chinook. To reduce bias, surveys were carried out independently and without knowledge of counts from previous surveys. Swim surveys were normally carried out using three to five swimmers. Swimmers attempted to stay abreast of each other while moving downstream and counts were made independently. Swimmers combined their counts, which were recorded by pre-defined localities in the river (Figure 2).

Swim surveys in the lower river between Chicken Hole and Raines Pool were conducted between 28 August and 25 November to estimate the number of fall chinook as well as to observe their distribution. Visual surveys were also conducted between Green Creek Junction and First Lake in the upper portion of the Nanaimo River Watershed. Nine swim surveys between 26 September and 01 November were carried out to estimate both spring run chinook stocks.

WATER MANAGEMENT PLAN

The low flow and water levels likely result in delayed fish movement and higher water temperatures which may potentially increase levels of disease and parasites. This is particularly true for the parasite Ich (*ichthyophthirius*) which matures more rapidly with higher temperature (Ministry of Environment, Lands and Parks 1993). During particularly low water levels the river flow can be increased with a controlled water release.

Three man-made reservoirs in the Nanaimo River system have been utilised to increase flows during periods of low flow between late summer and early fall. Prior to 1989, water releases were conducted based on an informal arrangement between local Fisheries Officers and Harmac Pacific. Fisheries Officers would request a water release when, in their opinion, fish holding in the lower river became threatened due to low water. These requests would be granted by Harmac dependent upon the availability of water in reserve.

With the increase in population in the Nanaimo area and in an effort to satisfy domestic, industrial, agricultural, fishery, wildlife, and recreational needs; a Nanaimo River Water Management Plan was initiated by the B.C. Ministry of Environment (BCMOE) in June 1989. A team comprised of members from the BCMOE, Greater Nanaimo Water District, MacMillan Bloedel Limited, Snuneymuxw First Nation, and Fisheries and Oceans Canada (DFO) negotiated a water flow management plan (Ministry of Environments, Lands and Parks 1993). The primary water management issue has been to enhance flows to meet fisheries requirements while maintaining flows to satisfy industrial and municipal needs. This is particularly important during periods of lowest flow (September and October) and in the ten km section of river below the Harmac Pulp Operations water intake area. Increases in the fall water releases from the reservoirs since 1989 have encouraged spawning migration.

RESULTS

ENUMERATION FENCE

Since 1998, the enumeration fence has been located at a site known as San Salvadore (Figure 1, Figure 2) and was in operation from 04 September until 28 October, 2002. Water conditions were clear for most of the study with 12 days having moderate visibility and one day with low visibility (Table 1). As a result, conditions were good for enumerating and identifying fish past the fence; therefore, all counts were deemed to be reliable. A total of 1,099 adult chinook, 516 jack chinook, 638 adult coho, 131 jack coho, and 25,892 chum were enumerated. In addition, 96 fish were unable to be accurately identified and were recorded as unknown. Since there were no breaches in the fence during the course of the study it was assumed all fish migrating past the fence were enumerated.

At the fence location, the fish swam through the trap box voluntarily allowing an opportunity to observe preferred times of natural movement. The period between 0800 h and 1100 h showed the highest percentage of chinook movement with 33.6% of adults and 34.3% of jacks travelling through the fence during this time interval (Table 2). During periods of high chum abundance downstream of the fence, staff removed fence panels to encourage large numbers of fish to swim upstream. Fence panels were removed during three periods, from 09 October to 11 October allowing 2,048 chum to be counted, from 16 October to 18 October allowing 7,202 chum to pass through and between 21 October to 23 October where 7,797 chum were enumerated.

Environmental data collected at the enumeration fence included water temperature and river depth (Table 1). Water temperature was highest at the start of the study and decreased steadily until the end of the study. Temperature over this period ranged from a high of 20°C in mid-September to a low of 8°C during three days in October with an average of 13.7°C (Figure 3). Water depth was inconsistent, partially due to tidal influence, with a low of 13.0 cm on 09 September, a high of 51 cm on 17 September and an average of 29.2 cm (Figure 3).

SWIM SURVEYS

Since the counting fence was put into place on 04 September, the intention was to enumerate fall run chinook. Swim surveys are conducted in addition to fence enumeration in order to get an idea of the spawning distribution of chinook as well as fish still holding in the river downstream of the fence. Five swim surveys were conducted in the lower Nanaimo River between 28 August and 25 November (Table 3). The survey showing the highest abundance was conducted on 17 September between the Counting Fence and Raines Pool where 391 adult chinook were enumerated (Table 3, Figure 2).

In addition, nine swim surveys were conducted on the upper portion of the Nanaimo River (Table 3). Three surveys in the First Lake Area on 26 September, 07 October, and 23 October as well as four swims in the Second Lake Area on 26 September, 07 October, 18

October, and 01 November provided an in-river spawning estimate of 432 First Lake spring run adult chinook (H. Bob, Nanaimo River Salmonid Enhancement Project Co-Manager, Community Futures Development Corporation of Central Island, 271 Pine Street, Nanaimo, B.C., V9R 2B7. pers. comm.). Two swim surveys were conducted at the Green Creek Junction on 18 October and 01 November where no chinook were counted and one redd was observed (Table 3). No estimate for the Upper Nanaimo River Spring run chinook was calculated.

HATCHERY COMPONENT

During 01 October to 21 October, the Nanaimo River Hatchery staff collected 98 male, 89 female and 15 jack fall run chinook downstream of the enumeration fence. In addition, 13 male, 12 female, and no jack fall run chinook were collected on 10 October upstream of the fence. Between 01 October and 04 October, 139 male, 66 female and 15 jack First Lake spring run chinook were captured in the First Lake area. No Upper Nanaimo River spring run chinook were removed for hatchery broodstock. A summary of all hatchery broodstock collected is presented in Table 4.

FIRST NATIONS FOOD FISHERY

Historically, an in-river chum gillnet fishery has taken place, usually in October, to provide food fish for the Snuneymuxw First Nation (SFN). This fishery is held in a one km area downstream of the counting fence and monitored by the Snuneymuxw Fisheries Guardians. Catch estimates are acquired through interviews with fishers and provided to the Aboriginal Fisheries Strategy co-ordinator with DFO. In 2002, the catch was determined to be 213 adult chinook.

CARCASS MARK-RECAPTURE

The carcass mark-recapture program began on 22 October and was discontinued on 27 November, 2002. During this period 184 male, 150 female, 89 jack and two unknown chinook carcasses were tagged and released in the Nanaimo River (Table 5). Of the 116 carcasses recaptured with tags, 60 (51.7%) were male, 39 (33.6%) were female, 16 (13.8%) were jack and one (0.9%) was an unknown chinook. Using the Petersen estimator, the total adult fall run chinook population estimate was 1,464 (95% CI: 1,213 – 1,715), while the jack fall run chinook population estimate was 561 (95% CI: 323 - 799) (Table 6).

Potential Biases

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

1. Temporal Bias: Temporal bias in the tagging sample was examined by stratifying the

mark incident rate into four recovery periods (Table 7). There was a significant temporal bias in the application sample for male adult chinook when the data were stratified into four equal recovery periods (Chi-square = 15.19; p<0.01). There was no detectable temporal bias for female chinook when stratified into identical recovery periods (Chi-square = 2.40; p<0.01).

Temporal bias in the recovery sample was analysed by stratifying the recovery rates into four application periods (Table 8). A statistical difference in the recovery sample for adult male chinook was observed (Chi-square = 29.34; p<0.01). Alternatively, there was no statistical bias for female chinook (Chi-square = 4.46; p<0.01).

2. Fish Sex: Sex related bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries by application sample and by recovery sample. No sex related bias was evident when comparing male and female chinook populations (Chi-square = 1.73; p<0.01 and Chi-square = 1.01; p<0.01, application sample and recovery sample, respectively) (Table 9). When jack chinook were included into the application and recovery samples no significant bias was apparent (Chi-square = 6.65; p<0.01, and Chi-square = 3.88; p<0.01, application sample and recovery sample, respectively) (Table 10).

3. Size Bias: Size related bias was examined by comparing the POH mean lengths of unrecovered marked chinook and recaptured chinook by sex. No size bias was evident in the recovery sample of adult male, adult female and jack chinook (Student's t-test: t = 1.904; p<0.05, t = 1.715; p<0.05, and t = 1.317; p<0.05, for males, females and jacks respectively).

BIOLOGICAL DATA

During the spawning ground carcass recovery 185 male, 152 female, and 89 jack chinook carcasses were recovered and measured for post orbital-hypural length (Table 11). The lengths of adult male chinook carcasses ranged from 45.2 cm to 85.9 cm and averaged 60.7 cm, while adult female carcasses ranged from 44.4 cm to 80.1 cm and averaged 64.3 cm. Jack chinook carcasses ranged in lengths from 29.6 cm to 55.2 cm and averaged 39.4 cm. A total of 40 male, 42 female, and 32 jack chinook were missing adipose fins (21.6%, 47.2% and 21.1%, respectively) (Table 11). Age analysis reveals 81.1% of fish classified as adult male chinook were three years old, 58.0% of female chinook were three years old, and 100.0% of carcasses identified as jack chinook were two years old (Table 12)

A total of 58 male, 62 female, and 15 jack fall run chinook were randomly collected from hatchery broodstock, measured for post orbital-hypural lengths, and monitored for adipose-clipped fins (Table 13). Adult male chinook ranged from 30.7 cm to 73.9 cm and averaged 54.9 cm, while female chinook lengths ranged from 55.9 cm to 78.8 cm and averaged 64.6 cm. Jack chinook lengths ranged from 18.4 cm to 23.6 cm and averaged 21.7 cm. Twenty-three males (39.7%), 19 females (30.6%), and eight jacks (53.3%) were found to be missing adipose fins (Table 13). Fish identified as adult male chinook were predominately three years old (47.9%), while 63.6 % of female chinook were three years old, and 100.0% of jack chinook were two years old (Table 14).

When comparing the mean lengths of chinook recovered from the spawning grounds and fall run chinook sampled from hatchery broodstock, no statistical difference was apparent for females (Student's t-test: $t = 0.37$; $p<0.05$). When the same comparison was conducted on male and jack chinook, a statistical difference was found for both (Student's t-test: $t=3.685$; $p<0.05$, and $t=33.524$; $p<0.05$, for males and jacks, respectively). However, if male and jack chinook are categorized by scale age rather than morphology, no statistical difference is found in male chinook (Student's t-test: $t=1.873$; $p<0.05$), but there is still a difference in jack chinook mean length (Student's t-test: $t=2.774$; $p<0.05$).

A total of 32 male and 51 female First Lake spring run chinook were randomly collected from hatchery broodstock to be measured for POH lengths and monitored for the absence of adipose fins (Table 15). Male chinook ranged from 35.6 cm to 73.3 cm and averaged 52.3 cm, while female chinook ranged from 47.2 cm to 79.5 cm and averaged 60.5 cm. There were four male chinook and ten female chinook missing adipose fins representing 12.5% and 19.6%, respectively. Twenty-seven male and 46 female chinook had scales removed for age analysis, 66.7% of males and 89.1% of females were three years old (Table 16).

Coded-wire tags were recovered from 99 chinook carcasses sampled on the spawning grounds. Most chinook (97.0%) identified as having a CWT were reared at the Nanaimo River Hatchery, with 62 chinook (64.6%) released during the 1999 brood year and 34 chinook (35.4%) released during the 2000 brood year (Table 17). Two female chinook were released into the Chemainus River on 30 May, 2000 and one female was released into Cowichan Bay on 17 May, 2000. A summary of the Nanaimo River Hatchery CWT and fry release data for 1996 to 2001 brood years is presented in Table 18.

WATER MANAGEMENT PLAN

Nanaimo River water releases occurred between 30 September and 03 October, 2002. The initial water release occurred at Fourth Lake at a discharge rate of 525 ft^3/s (~14.9 m^3/s) on 30 September and continually decreased to 375 ft^3/s (~10.6 m^3/s) on 02 October and 250 ft^3/s (~7.1 m^3/s) on 03 October. During this period 50 ft^3/s (~1.4 m^3/s) was released from Jump Lake on 02 October. The water release in 2002 was important in encouraging 763 adult chinook to pass through the fence between 02 October and 04 October (Figure 4). A summary of monthly Nanaimo River discharge and ten year average is presented in Figure 5.

POPULATION ESTIMATE

Escapement and total return estimates for 2002 were determined using fence count data since this is considered to be the most accurate enumeration method. However, after reviewing both spawning ground carcass recovery and hatchery broodstock collection data, it became evident that the chinook fence count did not accurately reflect the true jack to adult ratio. Comparing the lengths of jack and adult chinook with the traditionally accepted jack designated length of 450 mm revealed an overlapping of age groups (Figure 6). As a result, the spawning ground carcass recovery data were utilised to apportion the total chinook fence count with a more reflective ratio of jack and adult chinook populations. This was accomplished by comparing age data with length data to calculate the proportion of two year old jack chinook with lengths greater then 450 mm (11.6%) and the proportion of three year old or greater adult chinook with lengths of 450 mm or less (0.0%). The fence count data were then adjusted by these proportions yielding total chinook fence counts of 971 adults and 644 jacks.

The number of naturally spawning fall run adult chinook in the Nanaimo River during 2002 was determined to be the adjusted fence count minus any fall run broodstock removals from areas above the fence. Following this methodology, the total number of adult fall run chinook spawning in the Nanaimo River was estimated to be 946 fish (Table 19). The total return of adult fall run chinook to the Nanaimo River was determined to be the sum of the adjusted fence count, with the addition of broodstock removals below the fence and the First Nations fishery catch, yielding 1,371 fish. The natural spawning population of First Lake spring run chinook estimated from swim surveys was 432 adult chinook and the addition of First Lake broodstock removals yields a total spring run adult estimate of 637. Upper Nanaimo River spring run chinook swim survey counts were zero and no adjustments were made to total spring run chinook estimates. Therefore, the total return of fall run and spring run adult chinook to the Nanaimo River was estimated to be 2,008 fish (Table 19).

DISCUSSION

ENUMERATION FENCE

The floating fence design worked well provided that debris was removed regularly. Water levels were similar to historical data and allowed fish to move through the trap box with little hesitation. Typically, fish hold beneath the fence as they search for a path through.

The possibility of the relocation of the fence inhibiting the upstream movement of chum above the fence has been noted in a previous report (Carter and Nagtegaal 2000). Staff indicated that while chinook and coho made every effort to pass through the fence and continue their migration, many chum were observed spawning below the counting fence. In order to encourage chum to spawn upstream of the enumeration fence, staff would open one or two fence panels during high chum abundance. This encouraged thousands of chum to pass the fence site and continue their migration upstream.

Water levels along with river discharge influenced fish movement past the counting fence (Figure 4). This is particularly evident between 30 September and 03 October, 2002 during a scheduled water release resulting in peak chinook migration. The highest peak of chinook migration occurred on 03 October with an one day increase of 490 adult chinook during the scheduled water release.

SWIM SURVEY

Swim surveys conducted in the lower portion of the Nanaimo River provide supplemental information to the fence enumeration as well as spawning distribution of fall run chinook in the Nanaimo River. During 2002, the natural spawning estimate for First Lake spring run chinook was based on swims surveys conducted in the First Lake and Second Lake Areas. No Upper Nanaimo River spring run chinook estimate was calculated and no adjustments were made to the total Nanaimo River chinook run.

In previous years (Carter and Nagtegaal 1997 – 2000; Carter et al. 2003; Hardie 2002; Hop Wo et al. 2003), the upper distribution of First Lake spring run chinook was assumed to be within the First Lake Area and as well as a portion of the river downstream. The altered spawning distribution may be due to the loss of spawning gravel in the section of Nanaimo River downstream of First Lake (H. Bob, Nanaimo River Salmonid Enhancement Project Co-Manager, Community Futures Development Corporation of Central Island, 271 Pine Street, Nanaimo, B.C., V9R 2B7. pers. comm.). It is assumed that the Upper Nanaimo River spring run chinook presently spawn between Green Creek and T.P. Bridge, and that the two spring run stocks are genetically distinct and therefore do not inter-breed. Genetic testing is required to confirm this hypothesis and a future study is planned to collect DNA samples from chinook captured above Second Lake.

FIRST NATIONS FOOD FISHERY

Catch estimation procedures developed by the Snuneymuxw First Nation have not been assessed by stock assessment staff. As a result, no comments can be made regarding the methodologies used. The 2002 estimate of 213 adult chinook was the second highest catch on record between 1975 to 2002 (Table 19). Since no observers were employed during 2002, SFN catch estimates could not be independently verified.

CARCASS MARK-RECAPTURE

Significant temporal biases for male chinook in the recovery samples and the application samples were evident. This is likely due to the nature of the carcass recovery study, since tagging and recovery were concurrent activities. As a result, there were very few tagged carcasses available for recovery in the early period and as the number of tags in the population accumulated tag incidence in the later periods was higher. Conversely, no temporal bias was detected in female chinook from the recovery samples and from the application samples.

No sex related bias was evident in the application or recovery samples when male and female chinook were compared or when all chinook were compared. This suggests sex was not a contributing factor in the recovery of tagged carcasses.

Size bias testing did not provide an assessment of the size selectivity of the sampling method since both application and recovery samples were attained using the same method. Rather, the size bias assessment provided an evaluation of the recoverability, based on the sizes of tagged carcasses that were redistributed back into the river after tagging. Testing revealed that there were no size biases for male, female, or jack chinook.

BIOLOGICAL DATA

Both mark-recapture samples and broodstock samples were collected from the fall run chinook stock and therefore negligible variation in lengths was expected. A comparison of female mean lengths obtained from the spawning grounds and from the hatchery broodstock revealed no statistical difference and conforms with the expected outcome. However, a comparison between male and jack chinook collected for broodstock and for mark-recapture purposes yielded significant statistical differences in mean lengths. This difference is most likely a combination of two factors: characteristics used in differentiating between male and jack chinook and the method of collection used to obtain chinook. During carcass mark-recapture and broodstock collection the definition of a jack chinook is based on morphological characteristics of which judgement can vary by individual sampler. These characteristics can include, sex, body shape (i.e. slender or fat), and size. When a comparison is based solely on sex and scale age to denote a jack, no significant difference for was found for males (Student's t-test: $t=1.873$; $p<0.05$), but there still remains a difference for jacks (Student's t-test: $t=2.774$; $p<0.05$). This difference may be attributed to varying collection methods with the mark-recapture obtaining dead chinook from river pools and banks, while broodstock collection employs tangle-nets and beach seines.

Coded-wire tag recoveries were mostly 1999 brood year (65.7%) which would be three years old. Total fall run chinook hatchery releases for 1999 brood year were 410,196 with 176,242 carrying CWT's (Table 18). The lack of 1998 brood year recoveries is due to no CWT chinook being released from Nanaimo River Hatchery for that year.

WATER MANAGEMENT PLAN

The scheduled water release during 30 September to 03 October was gradually decreased in order to minimise the effects associated with a sudden drop in river levels. This release resulted in a migration peak as fish holding below the enumeration fence swam upstream during this brief period of increased river discharge.

POPULATION ESTIMATE

The 2002 Nanaimo River fall run chinook population estimate was based on the enumeration fence count. Clear water conditions for most of the study and no breaches in the fence allowed for a complete and accurate fish count. The fall run chinook spawning estimate of

946 is below the 95% confidence interval of 1,213 – 1,715 obtained from the Pooled Petersen calculation. An overestimation with the Petersen estimate is contradictory to the previous seven years where the fence estimate was either within or above the 95% confidence interval generated by mark-recapture data (Carter and Nagtegaal 1997 – 2000; Carter et al. 2003; Hop Wo et al. 2003). The Petersen estimate is generally expected to underestimate the fence estimate due to the nature of the mark-recapture study which only concentrates on the main spawning channel and does not include chinook that spawn outside of the surveyed area. The biased Petersen estimate may be due to periods of high river discharge on 12 November and 13 November (167 m^3/s and 187 m^3/s, respectively) as well as 18 November to 20 November (267 m^3/s, 331 m^3/s, and 199 m^3/s, respectively), which may have resulted in carcasses being washed into the estuary as well as carcasses being left on the shoreline as water levels decreased (Figure 5). The First Lake spring run population estimate was based on three swim surveys and broodstock collection conducted in the First Lake area. The 2002 estimate of 432 naturally spawning spring run adult chinook is above the 1995 – 2001 average of 386 adult chinook. The 2002 total return estimate for both fall run and spring run chinook of 2,008 is above the period average of 1,635 fish.

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Table 1. Daily counts at the Nanaimo River enumeration fence, 2002.

Date	Visibility[1]	Depth (cm)	Temp (°C)	Chinook		Coho		Chum	Unkn
				Adult	Jack	Adult	Jack		
04-Sep[2]	1	-	-	0	0	0	0	0	0
05-Sep	1	-	17.0	0	0	0	0	0	0
06-Sep	1	-	17.5	0	0	0	0	0	0
07-Sep	1	-	17.0	0	1	0	0	0	0
08-Sep	1	33.0	15.7	0	3	0	0	0	0
09-Sep	1-2	22.0	15.7	0	4	0	0	0	0
10-Sep	1	31.7	17.0	1	2	0	0	0	0
11-Sep	1	32.0	17.7	0	2	0	0	0	0
12-Sep	1	30.7	18.0	0	0	0	0	0	0
13-Sep	1	31.7	17.7	1	6	0	0	0	0
14-Sep	1	28.3	18.7	2	1	0	0	0	0
15-Sep	1	35.0	18.0	1	1	0	0	0	0
16-Sep	1-2	33.3	17.7	3	3	0	0	0	0
17-Sep	1	36.0	16.0	0	1	0	0	0	0
18-Sep	1	28.3	15.7	1	3	0	0	0	0
19-Sep	1	31.3	16.0	3	8	1	0	0	0
20-Sep	1	30.0	15.7	0	6	0	0	0	0
21-Sep	1	30.0	16.5	9	1	0	0	0	0
22-Sep	1	29.0	16.0	20	4	6	2	0	2
23-Sep	1	30.3	15.7	4	1	18	0	0	0
24-Sep	1	28.7	16.7	2	9	29	0	0	0
25-Sep	1	29.7	15.7	12	9	11	2	0	4
26-Sep	1-2	29.3	15.3	3	2	0	0	0	0
27-Sep	1	26.0	15.0	0	0	5	1	5	3
28-Sep	1	26.0	15.3	1	9	0	1	1	0
29-Sep	1	24.3	15.3	87	57	155	7	4	59
30-Sep	1-2	25.0	11.5	3	5	4	3	4	0
01-Oct	1	28.0	14.3	1	3	20	13	2	1
02-Oct	1	33.0	13.7	142	63	53	7	26	0
03-Oct	1-2	43.3	13.0	490	201	184	32	42	14
04-Oct	1	43.0	13.3	131	31	42	12	5	0
05-Oct	1	38.7	13.7	6	6	1	1	3	1
06-Oct	1-2	34.0	13.3	7	3	12	5	10	6
07-Oct	1-2	34.3	13.3	2	1	6	5	9	0
08-Oct	1-2	35.7	14.0	2	3	4	1	66	0
09-Oct	1-2	30.3	14.0	7	5	11	0	726	0
10-Oct	1	27.3	12.0	12	3	4	0	1001	0
11-Oct	1	26.7	12.7	3	0	1	5	349	0
12-Oct	1	25.3	11.0	7	5	4	7	66	6
13-Oct	1	27.0	11.0	0	1	2	0	190	0
14-Oct	1	28.0	8.7	5	6	0	0	187	0
15-Oct	1	28.3	9.0	2	1	1	0	752	0
16-Oct	1	24.7	10.0	0	0	1	2	4925	0
17-Oct	1	23.5	-	2	0	1	1	1110	0

Table 1. (continued)

Date	Visibility[1]	Depth (cm)	Temp (°C)	Chinook		Coho		Chum	Unkn
				Adult	Jack	Adult	Jack		
18-Oct	1	28.7	10.0	1	0	5	2	1123	0
19-Oct	1	23.7	10.0	10	1	3	1	1597	0
20-Oct	1	24.7	10.0	2	4	1	3	1832	0
21-Oct	1	24.0	11.0	29	7	4	6	2792	0
22-Oct	1-2	25.7	10.3	14	10	13	3	2646	0
23-Oct	1	24.0	10.0	19	10	14	2	2344	0
24-Oct	1-2	27.7	9.7	28	12	11	6	1683	0
25-Oct	2	25.0	9.3	15	2	5	1	785	0
26-Oct	1-2	23.7	9.7	3	0	2	0	692	0
27-Oct	1	27.0	9.0	4	0	3	0	628	0
28-Oct[3]	1	22.0	8.0	2	0	1	0	287	0
Total				1099	516	638	131	25892	96

[1] Visibility Code: 1 = clear; 2 = cloudy.
[2] Partial enumeration from 1600 – 2400 hours.
[3] Partial enumeration from 0000 – 0800 hours.

Table 2. Total counts by time interval at the Nanaimo River enumeration fence, 2002.

Time Period	Chinook				Coho				Chum	
	Adult		Jack		Adult		Jack			
	Count	%	Count	%	Count	%	Count	%	Count	%
0000 - 0100	10	0.9	13	2.5	5	0.8	4	3.1	557	2.2
0100 - 0200	19	1.7	24	4.7	10	1.6	6	4.6	487	1.9
0200 - 0300	9	0.8	11	2.1	15	2.4	9	6.9	492	1.9
0300 - 0400	15	1.4	15	2.9	5	0.8	5	3.8	369	1.4
0400 - 0500	11	1.0	12	2.3	3	0.5	3	2.3	404	1.6
0500 - 0600	12	1.1	13	2.5	5	0.8	1	0.8	306	1.2
0600 - 0700	6	0.5	9	1.7	5	0.8	1	0.8	354	1.4
0700 - 0800	16	1.5	10	1.9	21	3.3	7	5.3	387	1.5
0800 - 0900	126	11.5	112	21.7	80	12.5	5	3.8	1959	7.6
0900 - 1000	128	11.6	35	6.8	67	10.5	11	8.4	1787	6.9
1000 - 1100	115	10.5	30	5.8	62	9.7	5	3.8	1754	6.8
1100 - 1200	40	3.6	10	1.9	30	4.7	0	0.0	1436	5.5
1200 - 1300	42	3.8	28	5.4	61	9.6	1	0.8	1438	5.6
1300 - 1400	37	3.4	31	6.0	19	3.0	1	0.8	905	3.5
1400 - 1500	39	3.5	18	3.5	56	8.8	11	8.4	921	3.6
1500 - 1600	16	1.5	10	1.9	11	1.7	4	3.1	886	3.4
1600 - 1700	58	5.3	5	1.0	13	2.0	2	1.5	1759	6.8
1700 - 1800	44	4.0	12	2.3	28	4.4	7	5.3	1861	7.2
1800 - 1900	72	6.6	22	4.3	10	1.6	8	6.1	1880	7.3
1900 - 2000	60	5.5	8	1.6	15	2.4	8	6.1	1557	6.0
2000 - 2100	53	4.8	15	2.9	30	4.7	7	5.3	1506	5.8
2100 - 2200	64	5.8	25	4.8	26	4.1	7	5.3	1312	5.1
2200 - 2300	80	7.3	39	7.6	34	5.3	8	6.1	968	3.7
2300 - 2400	27	2.5	9	1.7	27	4.2	10	7.6	607	2.3
Total	1099	100	516	100	638	100	131	100	25892	100

Table 3. Swim surveys conducted on the Nanaimo River, 2002.

Fall Run Chinook

Date	Area [1]	Adult Chinook [3]
28-Aug	Chicken Hole to Raines Pool	86
17-Sep	Counting Fence to Raines Pool	391
01-Oct	San Salvadore	250 [2]
15-Oct	San Salvadore	40
25-Nov	Bridge Pool to Dyke Pool	0

First Lake Spring Run Chinook

Date	Area	Adult Chinook [3]
26-Sep	First Lake Area	123
26-Sep	Second Lake Area	6
07-Oct	First Lake Area	259
07-Oct	Second Lake Area	173
18-Oct	Second Lake Area	118
23-Oct	First Lake Area	65
01-Nov	Second Lake Area	7

Upper Nanaimo River Spring Run Chinook

Date	Area	Adult Chinook [3]
18-Oct	Green Creek Junction	0 [4]
01-Nov	Green Creek Junction	0

[1] See Figure 2.

[2] Includes adult and jack chinook.

[3] Includes live chinook only.

[4] One redd observed.

Table 4. Summary by day and location of chinook collected for Nanaimo River Hatchery broodstock, 2002.

Fall Run Chinook

Date	Location Code[1]	Below Fence			Above Fence		
		Male	Female	Jack	Male	Female	Jack
01-Oct	6	24	22	7	-	-	-
03-Oct	6	12	12	6	-	-	-
08-Oct	6	19	11	0	-	-	-
10-Oct	22	-	-	-	13	12	0
15-Oct	6	19	21	2	-	-	-
18-Oct	6	21	21	0	-	-	-
21-Oct	6	3	2	0	-	-	-
Total		98	89	15	13	12	0

First Lake Spring Run Chinook

Date	Location	Below Fence			Above Fence		
		Male	Jack	Female	Male	Female	Jack
01-Oct	First Lake	-	-	-	34	4	8
02-Oct	First Lake	-	-	-	32	6	4
03-Oct	First Lake	-	-	-	57	31	3
04-Oct	First Lake	-	-	-	16	25	0
Total		-	-	-	139	66	15

[1] See Figure 2.

Table 5. Daily summary of chinook sampled during the carcass mark-recapture program, Nanaimo River, 2002.

	Carcasses Examined				Tags Applied				Recaptured Carcasses			
Date	Unkn	Male	Female	Jack	Unkn	Male	Female	Jack	Unkn	Male	Female	Jack
22-Oct	0	22	18	8	0	22	18	8	0	0	0	0
25-Oct	0	3	5	4	0	3	5	4	0	0	0	0
29-Oct	0	33	25	11	0	27	21	10	0	6	4	1
30-Oct	1	34	21	12	1	30	14	11	0	4	7	1
31-Oct	0	15	14	13	0	14	14	13	0	1	0	0
01-Nov	0	19	13	5	0	18	13	5	0	0	0	0
04-Nov	1	26	37	13	0	15	29	9	0	11	7	4
05-Nov	1	42	16	21	0	16	7	14	1	26	9	7
06-Nov	0	23	15	8	0	19	9	8	0	4	5	0
07-Nov	0	15	8	4	0	12	7	3	0	3	1	1
14-Nov	0	4	9	3	0	2	6	3	0	2	3	0
15-Nov	0	2	0	1	0	2	0	1	0	0	0	0
21-Nov	0	2	5	0	0	2	4	0	0	0	1	0
22-Nov	0	2	3	0	0	1	1	0	0	1	2	0
25-Nov	0	2	1	0	0	1	1	0	0	1	0	0
27-Nov	1	1	1	2	1	0	1	0	0	1	0	2
Total	4	245	191	105	2	184	150	89	1	60	39	16

Table 6. Petersen chinook escapement estimates by sex, Nanaimo River, 2002

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Male [1]	746	585	908
Female	725	527	923
Total Adult	**1464**	**1213**	**1715**
Jack	561	323	799
Total Population	1988	1670	2306

[1] Adult males only, jacks not included.

Table 7. Incidence of tagged adult chinook carcasses recovered on the spawning grounds by recovery period and sex, Nanaimo River, 2002.

Recovery Period	Days of Recovery	Tagged Recoveries			Total Recoveries			Tag Incidence (%)		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Oct 22 - Oct 30	9	10	11	21	92	69	161	10.87	15.94	13.04
Oct 31 - Nov 8	9	45	22	67	140	103	243	32.14	21.36	27.57
Nov 9 - Nov 17	9	2	3	5	6	9	15	33.33	33.33	33.33
Nov 18- Nov 27	10	3	3	6	7	10	17	42.86	30.00	35.29
Total	37	60	39	99	245	191	436	24.49	20.42	22.71
Chi-Square Test Result:								15.19	2.40	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 8. Percentage of the tag application sample recovered on the spawning grounds by application period and sex, Nanaimo River, 2002.

Application Period	Days of Application	Tags Applied			Tagged Recoveries			Percent Recovered		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Oct 22 - Oct 30	9	82	58	140	10	11	21	12.20	18.97	15.00
Oct 31 - Nov 8	9	94	79	173	45	22	67	47.87	27.85	38.73
Nov 9 - Nov 17	9	4	6	10	2	3	5	50.00	50.00	50.00
Nov 18- Nov 27	10	4	7	11	3	3	6	75.00	42.86	54.55
Total		184	150	334	60	39	99	32.61	26.00	29.64
Chi-Square test result:								29.34	4.46	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 9. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 2002.

Sex	Application sample by recovery status				Recovery sample by mark status			
	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	184	60.6%	52.8%	55.1%	244	60.6%	54.9%	56.2%
Female	150	39.4%	47.2%	44.9%	189	39.4%	45.1%	43.8%
Chi-Square test result:				1.73				1.01
Critical Chi-Square (df = 1; alpha = 0.01)				6.64				6.64

Table 10. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 2002 (jacks included).

Sex	Application sample by recovery status				Recovery sample by mark status			
	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	184	52.2%	40.3%	43.5%	245	52.2%	43.4%	45.3%
Female	150	33.9%	36.0%	35.5%	191	33.9%	35.7%	35.3%
Jack	89	13.9%	23.7%	21.0%	105	13.9%	20.9%	19.4%
Chi-Square test result:				6.65				3.88
Critical Chi-Square (df = 2; alpha = 0.01)				9.21				9.21

Table 11. Length-frequency of chinook sampled during the carcass mark-recapture program, Nanaimo River, 2002

Length (cm)	Male	Female	Jack
30	0	0	1
31	0	0	1
32	0	0	1
33	0	0	0
34	0	0	2
35	0	0	6
36	0	0	6
37	0	0	11
38	0	0	8
39	0	0	10
40	0	0	9
41	0	0	5
42	0	0	14
43	0	0	3
44	0	1	5
45	1	0	5
46	4	0	1
47	3	0	0
48	5	0	0
49	0	0	0
50	1	1	0
51	3	0	0
52	2	0	0
53	9	3	0
54	8	2	0
55	5	2	1
56	5	6	0
57	4	5	0
58	17	6	0
59	14	12	0
60	15	10	0
61	10	8	0
62	9	10	0
63	6	11	0
64	11	7	0
65	9	8	0
66	11	7	0
67	9	5	0
68	4	6	0
69	3	5	0
70	4	5	0
71	1	8	0
72	2	2	0

Table 11. (continued)

Length (cm)	Male	Female	Jack
73	1	4	0
74	1	8	0
75	1	4	0
76	3	5	0
77	1	0	0
78	0	0	0
79	1	0	0
80	0	1	0
81	0	0	0
82	1	0	0
83	0	0	0
84	0	0	0
85	0	0	0
86	1	0	0
Total	185	152	89
Mean Length (cm)	60.7	64.3	39.4
Std. Deviation	7.2	6.4	3.8
Adipose Clips	40	42	32
Mark Rate	21.6%	47.2%	21.10%

Table 12. Summary of age data from chinook sampled during the carcass mark-recapture program, Nanaimo River, 2002.

European	Brood	Total	Male		Female		Adult Total		Jack	
Age [1]	Year	Age	#	%	#	%	#	%	#	%
0.1	2000	2	9	6.1	1	0.8	10	3.6	77	100.0
0.2	1999	3	120	81.1	76	58.0	196	70.3	0	0.0
1.1	1999	3	0	0.0	1	0.8	1	0.4	0	0.0
0.3	1998	4	18	12.2	50	38.2	68	24.4	0	0.0
1.2	1998	4	0	0.0	2	1.5	2	0.7	0	0.0
0.4	1997	5	1	0.7	1	0.8	2	0.7	0	0.0
Total			148	100.0	131	100.0	279	100.0	77	100.0

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

Total number of unreadable scales: 41

Table 13. Length-frequency of fall run chinook sampled during broodstock collection, Nanaimo River, 2002

Length (cm)	Male	Female	Jack
18	0	0	1
19	0	0	0
20	0	0	0
21	0	0	6
22	0	0	2
23	0	0	5
24	0	0	1
25	0	0	0
26	0	0	0
27	0	0	0
28	0	0	0
29	0	0	0
30	0	0	0
31	1	0	0
32	0	0	0
33	0	0	0
34	0	0	0
35	2	0	0
36	0	0	0
37	0	0	0
38	2	0	0
39	4	0	0
40	1	0	0
41	0	0	0
42	1	0	0
43	4	0	0
44	1	0	0
45	0	0	0
46	2	0	0
47	1	0	0
48	0	0	0
49	0	0	0
50	0	0	0
51	1	0	0
52	1	0	0
53	0	0	0
54	0	0	0
55	0	0	0
56	1	2	0
57	3	1	0
58	6	5	0
59	2	5	0
60	3	5	0

Table 13. (continued)

Length (cm)	Male	Female	Jack
61	4	2	0
62	5	2	0
63	1	6	0
64	3	5	0
65	0	7	0
66	1	5	0
67	1	2	0
68	1	1	0
69	2	3	0
70	0	1	0
71	1	1	0
72	1	1	0
73	1	1	0
74	1	2	0
75	0	1	0
76	0	1	0
77	0	1	0
78	0	1	0
79	0	1	0
Total	58	62	15
Mean Length (cm)	54.9	64.6	21.7
Std. Deviation	11.3	5.7	1.3
Adipose Clips	23	19	8
Mark Rate	39.7%	30.6%	53.30%

Table 14. Summary of age data from fall run chinook broodstock collection, Nanaimo River, 2002

European Age [1]	Brood Year	Total Age	Male #	Male %	Female #	Female %	Adult Total #	Adult Total %	Jack #	Jack %
0.0	2001	1	0	0.0	0	0.0	0	0.0	9	100.0
0.1	2000	2	17	35.4	0	0.0	17	16.5	0	0.0
0.2	1999	3	23	47.9	35	63.6	58	56.3	0	0.0
0.3	1998	4	6	12.5	18	32.7	24	23.3	0	0.0
1.2	1998	4	2	4.2	1	1.8	3	2.9	0	0.0
0.4	1997	5	0	0.0	1	1.8	1	1.0	0	0.0
Total			48	100.0	55	100.0	103	100.0	9	100.0

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

Total number of unreadable scales: 10

Table 15. Length-frequency of First Lake spring run chinook sampled during broodstock collection, Nanaimo River, 2002

Length (cm)	Male	Female
36	2	0
37	1	0
38	2	0
39	0	0
40	1	0
41	1	0
42	2	0
43	1	0
44	0	0
45	0	0
46	0	0
47	0	1
48	0	0
49	0	0
50	1	0
51	1	0
52	3	2
53	1	1
54	2	5
55	1	3
56	1	2
57	0	9
58	1	3
59	1	2
60	0	1
61	5	0
62	1	2
63	1	4
64	0	3
65	0	2
66	1	2
67	0	1
68	1	0
69	0	3
70	0	1
71	0	1
72	0	0
73	1	0
74	0	2
75	0	0
76	0	0

Table 15. (continued)

Length (cm)	Male	Female
77	0	0
78	0	0
79	0	0
80	0	1
Total	32	51
Mean Length (cm)	52.3	60.5
Std. Deviation	10.4	6.7
Adipose Clips	4	10
Mark Rate	12.5%	19.6%

Table 16. Summary of age data from First Lake spring run chinook broodstock collection, Nanaimo River, 2002

European	Brood	Total	Male		Female		Total	
Age [1]	Year	Age	#	%	#	%	#	%
0.1	2000	2	8	29.6	0	0.0	8	11.0
0.2	1999	3	18	66.7	41	89.1	59	80.8
1.1	1999	3	1	3.7	0	0.0	1	1.4
0.3	1998	4	0	0.0	4	8.7	4	5.5
0.4	1997	5	0	0.0	1	2.2	1	1.4
Total			27	100.0	46	100.0	73	100.0

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

Total number of unreadable scales: 8

Table 17. Coded-wire tag data from chinook sampled on the spawning grounds, Nanaimo River, 2002.

Recovery Data				Release Data			
Date (dd/mm/yy)	Location [1]	POH Length (mm)	Sex	Brood Year	Tag Code	Location	Date (dd/mm/yy)
22-Oct-02	20	554	M	1999	18-43-34	Nanaimo R.	18-May-00
22-Oct-02	19	612	M	1999	18-43-35	Nanaimo R.	23-May-00
22-Oct-02	21	558	F	1999	18-43-29	Jack Point	23-Jun-00
22-Oct-02	19	420	J	2000	18-45-52	Nanaimo R.	29-May-01
22-Oct-02	20	446	J	2000	18-45-52	Nanaimo R.	29-May-01
22-Oct-02	19	358	J	2000	18-45-53	Nanaimo R.	29-May-01
22-Oct-02	19	365	J	2000	18-45-54	Nanaimo R.	29-May-01
22-Oct-02	19	435	J	2000	18-45-54	Nanaimo R.	29-May-01
22-Oct-02	20	296	J	2000	18-45-54	Nanaimo R.	29-May-01
25-Oct-02	20	557	F	1999	18-43-33	Nanaimo R.	18-May-00
25-Oct-02	20	597	F	1999	18-43-34	Nanaimo R.	18-May-00
25-Oct-02	20	423	J	2000	18-45-53	Nanaimo R.	29-May-01
29-Oct-02	19	657	1	1999	18-43-29	Jack Point	23-Jun-00
29-Oct-02	19	563	1	1999	18-43-32	Nanaimo R.	18-May-00
29-Oct-02	19	616	1	1999	18-43-34	Nanaimo R.	18-May-00
29-Oct-02	20	584	1	1999	18-43-34	Nanaimo R.	18-May-00
29-Oct-02	21	656	1	1999	18-43-34	Nanaimo R.	18-May-00
29-Oct-02	19	627	1	1999	18-43-34	Nanaimo R.	18-May-00
29-Oct-02	19	584	1	1999	18-43-35	Nanaimo R.	23-May-00
29-Oct-02	21	568	1	1999	18-43-36	Nanaimo R.	23-May-00
29-Oct-02	19	564	2	1999	18-31-27	Cowichan Bay	17-May-00
29-Oct-02	19	614	2	1999	18-43-31	Nanaimo R.	18-May-00
29-Oct-02	19	602	2	1999	18-43-33	Nanaimo R.	18-May-00
29-Oct-02	19	581	2	1999	18-43-36	Nanaimo R.	23-May-00
29-Oct-02	21	382	3	2000	18-45-52	Nanaimo R.	29-May-01
29-Oct-02	19	432	3	2000	18-45-53	Nanaimo R.	29-May-01
29-Oct-02	19	439	3	2000	18-45-53	Nanaimo R.	29-May-01
29-Oct-02	19	369	3	2000	18-45-54	Nanaimo R.	29-May-01
30-Oct-02	18	579	M	1999	18-43-31	Nanaimo R.	18-May-00
30-Oct-02	17	573	M	1999	18-43-33	Nanaimo R.	18-May-00
30-Oct-02	18	634	M	1999	18-43-33	Nanaimo R.	18-May-00
30-Oct-02	18	788	M	1999	18-43-34	Nanaimo R.	18-May-00
30-Oct-02	19	530	M	1999	18-43-34	Nanaimo R.	18-May-00
30-Oct-02	19	546	M	1999	18-43-36	Nanaimo R.	23-May-00
30-Oct-02	15	653	M	2000	18-45-52	Nanaimo R.	29-May-01
30-Oct-02	19	593	F	1999	18-43-33	Nanaimo R.	18-May-00
30-Oct-02	18	403	J	2000	18-45-53	Nanaimo R.	29-May-01
30-Oct-02	18	449	J	2000	18-45-53	Nanaimo R.	29-May-01
30-Oct-02	18	365	J	2000	18-45-54	Nanaimo R.	29-May-01
30-Oct-02	18	380	J	2000	18-45-54	Nanaimo R.	29-May-01
30-Oct-02	17	365	J		no-pin		
30-Oct-02	18	390	J		no-pin		

Table 17. (continued)

Recovery Data				Release Data			
Date (dd/mm/yy)	Location [1]	POH Length (mm)	Sex	Brood Year	Tag Code	Location	Date (dd/mm/yy)
31-Oct-02	12	674	M	1999	18-43-32	Nanaimo R.	18-May-00
31-Oct-02	13	464	M	1999	18-43-32	Nanaimo R.	18-May-00
31-Oct-02	12	581	M	1999	18-43-33	Nanaimo R.	18-May-00
31-Oct-02	14	603	M	1999	18-43-34	Nanaimo R.	18-May-00
31-Oct-02	12	609	F	1999	18-38-09	Chemainus R.	30-May-00
31-Oct-02	13	530	F	1999	18-43-29	Jack Point	23-Jun-00
31-Oct-02	13	585	F	1999	18-43-31	Nanaimo R.	18-May-00
31-Oct-02	13	619	F	1999	18-43-32	Nanaimo R.	18-May-00
31-Oct-02	12	626	F	1999	18-43-36	Nanaimo R.	23-May-00
31-Oct-02	12	420	J	2000	18-45-53	Nanaimo R.	29-May-01
31-Oct-02	14	373	J	2000	18-45-53	Nanaimo R.	29-May-01
31-Oct-02	14	378	J	2000	18-45-53	Nanaimo R.	29-May-01
31-Oct-02	14	405	J		no-pin		
01-Nov-02	11	523	M	1999	18-43-32	Nanaimo R.	18-May-00
01-Nov-02	10	684	M	1999	18-43-33	Nanaimo R.	18-May-00
01-Nov-02	10	619	M	1999	18-43-35	Nanaimo R.	23-May-00
01-Nov-02	10	619	M	1999	18-43-35	Nanaimo R.	23-May-00
01-Nov-02	10	603	M	1999	18-43-36	Nanaimo R.	23-May-00
01-Nov-02	12	577	M	1999	18-43-36	Nanaimo R.	23-May-00
01-Nov-02	10	645	M		no-pin		
01-Nov-02	11	608	F	1999	18-38-09	Chemainus R.	30-May-00
01-Nov-02	11	616	F	1999	18-43-30	First Lake	17-May-00
01-Nov-02	12	634	F	1999	18-43-31	Nanaimo R.	18-May-00
01-Nov-02	11	606	F	1999	18-43-32	Nanaimo R.	18-May-00
01-Nov-02	10	592	F		no-pin		
01-Nov-02	11	387	J	2000	18-45-52	Nanaimo R.	29-May-01
04-Nov-02	21	562	0	1999	18-43-32	Nanaimo R.	18-May-00
04-Nov-02	21	658	M	1999	18-43-35	Nanaimo R.	23-May-00
04-Nov-02	19	601	F	1999	18-43-31	Nanaimo R.	18-May-00
04-Nov-02	19	569	F	1999	18-43-31	Nanaimo R.	18-May-00
04-Nov-02	21	586	F	1999	18-43-33	Nanaimo R.	18-May-00
04-Nov-02	19	621	F	1999	18-43-34	Nanaimo R.	18-May-00
04-Nov-02	19	593	F	1999	18-43-34	Nanaimo R.	18-May-00
04-Nov-02	19	671	F	1999	18-43-35	Nanaimo R.	23-May-00
04-Nov-02	19	450	J	2000	18-45-52	Nanaimo R.	29-May-01
04-Nov-02	19	436	J	2000	18-45-53	Nanaimo R.	29-May-01
04-Nov-02	19	396	J	2000	18-45-53	Nanaimo R.	29-May-01
04-Nov-02	19	346	J	2000	18-45-54	Nanaimo R.	29-May-01
05-Nov-02	22	640	M	1999	18-43-32	Nanaimo R.	18-May-00
05-Nov-02	17	618	M	1999	18-43-34	Nanaimo R.	18-May-00
05-Nov-02	17	610	M	1999	18-43-36	Nanaimo R.	23-May-00
05-Nov-02	17	584	M		no-pin		

Table 17. (continued)

Recovery Data				Release Data			
Date (dd/mm/yy)	Location [1]	POH Length (mm)	Sex	Brood Year	Tag Code	Location	Date (dd/mm/yy)
05-Nov-02	17	596	F	1999	18-43-36	Nanaimo R.	23-May-00
05-Nov-02	22	572	F	1999	18-43-36	Nanaimo R.	23-May-00
05-Nov-02	17	385	J	2000	18-43-62	Jack Point	06-Jun-01
05-Nov-02	17	417	J	2000	18-45-52	Nanaimo R.	29-May-01
05-Nov-02	17	369	J	2000	18-45-52	Nanaimo R.	29-May-01
05-Nov-02	17	345	J	2000	18-45-53	Nanaimo R.	29-May-01
05-Nov-02	17	462	J	2000	18-45-53	Nanaimo R.	29-May-01
05-Nov-02	17	450	J	2000	18-45-54	Nanaimo R.	29-May-01
05-Nov-02	17	415	J		no-pin		
05-Nov-02	17	392	J		no-pin		
05-Nov-02	17	361	J		no-pin		
05-Nov-02	22	410	J		no-pin		
06-Nov-02	14	633	M	1999	18-43-29	Jack Point	23-Jun-00
06-Nov-02	16	577	M	1999	18-43-29	Jack Point	23-Jun-00
06-Nov-02	12	717	M	1999	18-43-32	Nanaimo R.	18-May-00
06-Nov-02	16	525	M	1999	18-43-33	Nanaimo R.	18-May-00
06-Nov-02	16	636	M	1999	18-43-35	Nanaimo R.	23-May-00
06-Nov-02	13	554	F	1999	18-43-34	Nanaimo R.	18-May-00
06-Nov-02	12	594	F		no-pin		
06-Nov-02	16	540	F		no-pin		
06-Nov-02	13	395	J	2000	18-43-62	Jack Point	06-Jun-01
06-Nov-02	12	423	J	2000	18-45-52	Nanaimo R.	29-May-01
06-Nov-02	13	391	J	2000	18-45-54	Nanaimo R.	29-May-01
06-Nov-02	13	397	J		no-pin		
07-Nov-02	12	556	M	1999	18-43-31	Nanaimo R.	18-May-00
07-Nov-02	7	536	M	1999	18-43-36	Nanaimo R.	23-May-00
07-Nov-02	12	635	F		no-pin		
07-Nov-02	10	421	J	2000	18-45-52	Nanaimo R.	29-May-01
14-Nov-02	15	561	F		no-pin		
21-Nov-02	12	669	F	1999	18-43-36	Nanaimo R.	23-May-00

[1] See Figure 2.

Table 18. Nanaimo River Hatchery chinook release data for brood years 1996 - 2001.

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site	Run Type
182747	1996	28525	115033	24.8	5.44	05/05/97	05/05/97	Nanaimo R.	Fall
182306	1996	9132	36827	24.8	5.44	05/05/97	05/05/97	Nanaimo R.	Fall
183454	1996	10095	42937	23.51	6.22	20/05/97	20/05/97	First Lake	Spring[1]
183453	1996	10077	42861	23.51	6.22	20/05/97	20/05/97	First Lake	Spring[1]
183452	1996	10052	42755	23.51	6.22	20/05/97	20/05/97	First Lake	Spring[1]
183455	1996	10050	42746	23.51	6.22	20/05/97	20/05/97	First Lake	Spring[1]
181716	1996	10025	83484	12.01	4.94	20/05/97	21/05/97	Nanaimo R.	Fall
182746	1996	27690	230592	12.01	4.94	20/05/97	21/05/97	Nanaimo R.	Fall
183220	1997	25240	70000	36.06	6.67	07/05/98	07/05/98	First Lake	Spring[1]
183221	1997	25173	99098	25.4	6	15/05/98	15/05/98	First Lake	Spring[1]
183223	1997	28252	43881	64.38	6.01	26/05/98	26/05/98	Nanaimo R.	Fall
182408	1997	10050	15610	64.38	6.01	26/05/98	26/05/98	Nanaimo R.	Fall
183222	1997	24824	24824	100	15.5	23/07/98	23/07/98	Jack Point	Fall
184330	1999	25185	257394	9.78	4.03	17/05/00	17/05/00	First Lake	Spring[1]
184332	1999	25071	25071	100	5.1	18/05/00	18/05/00	Nanaimo R.	Fall
184331	1999	25185	25185	100	5.1	18/05/00	18/05/00	Nanaimo R.	Fall
184333	1999	25165	25165	100	5.1	18/05/00	18/05/00	Nanaimo R.	Fall
184334	1999	25231	25231	100	5.1	18/05/00	18/05/00	Nanaimo R.	Fall
184335	1999	25300	126422	20.01	5	05/05/00	23/05/00	Nanaimo R.	Fall
184336	1999	25115	125497	20.01	5	05/05/00	23/05/00	Nanaimo R.	Fall
184329	1999	25175	57625	43.69	10.34	23/06/00	23/06/00	Jack Point	Fall
184363	2000	24739	207955	11.9	6.56	23/05/01	24/05/01	First Lake	Spring[1]
184552	2000	50060	105512	47.44	4.9	28/04/01	29/05/01	Nanaimo R.	Fall
184554	2000	50259	105931	47.45	4.9	28/04/01	29/05/01	Nanaimo R.	Fall
184553	2000	50254	105920	47.45	4.9	28/04/01	29/05/01	Nanaimo R.	Fall
184362	2000	25091	51070	49.13	8.67	06/06/01	06/06/01	Jack Point	Fall
184717	2001	25119	102917	24.41	4.68	09/05/02	09/05/02	Nanaimo R.	Fall
184718	2001	25355	103883	24.41	4.68	09/05/02	09/05/02	Nanaimo R.	Fall
183205	2001	25182	25182	100	5.61	14/05/02	14/05/02	Nanaimo R.	Fall
183206	2001	25237	25237	100	5.61	14/05/02	14/05/02	Nanaimo R.	Fall
184337	2001	25102	186187	13.48	5.7	16/05/02	16/05/02	First Lake	Spring[1]
184715	2001	25307	25307	100	3.78	16/05/02	16/05/02	Nanaimo R.	Fall
184716	2001	25131	25131	100	3.78	16/05/02	16/05/02	Nanaimo R.	Fall
184628	2001	25119	51508	48.77	6.62	17/05/02	17/05/02	Jack Point	Fall

[1] First Lake spring run chinook only.

Table 19. Total adult chinook returns to the Nanaimo River, 1975-2002.

	Natural Spawners		Hatchery Broodstock		First Nations	Total
Year	Fall	Spring [1]	Fall	Spring [1]	Food Fish Catch	Returns
1975	475	-	-		15	490
1976	880	-	-		50	930
1977	2380	-	-		60	2420
1978	2125	-	-		40	2165
1979	2700	-	41		23	2764
1980	2900	-	82		200	3182
1981	210	-	15		100	325
1982	1090	-	62		21	1173
1983	1600	-	240		30	1870
1984	3000	-	178		50	3228
1985	650	-	264		185	1099
1986	700	-	258		190	1148
1987	400	-	357		50	807
1988	650	-	429		0	1079
1989	1150	-	402		0	1552
1990	1275	-	122		0	1397
1991	800	-	135		0	935
1992	800	-	377		0	1177
1993	850	-	528		0	1378
1994	400	-	280		0	742
1995	1592 [2]	100	311	75	0	2078 [3]
1996	990 [2]	600	257	167	0	2014 [3]
1997	638 [2]	600	52	129	0	1419 [3]
1998	1011 [2]	200	251	89	0	1551 [3]
1999	1920 [4]	500	242	179	70	2911 [5]
2000	596 [6]	450	184	162	126	1518 [3]
2001	1277 [6]	250	165	169	188	2049 [3]
2002	946 [6]	432	212	205	213	2008 [3]

[1] Ocean type only.

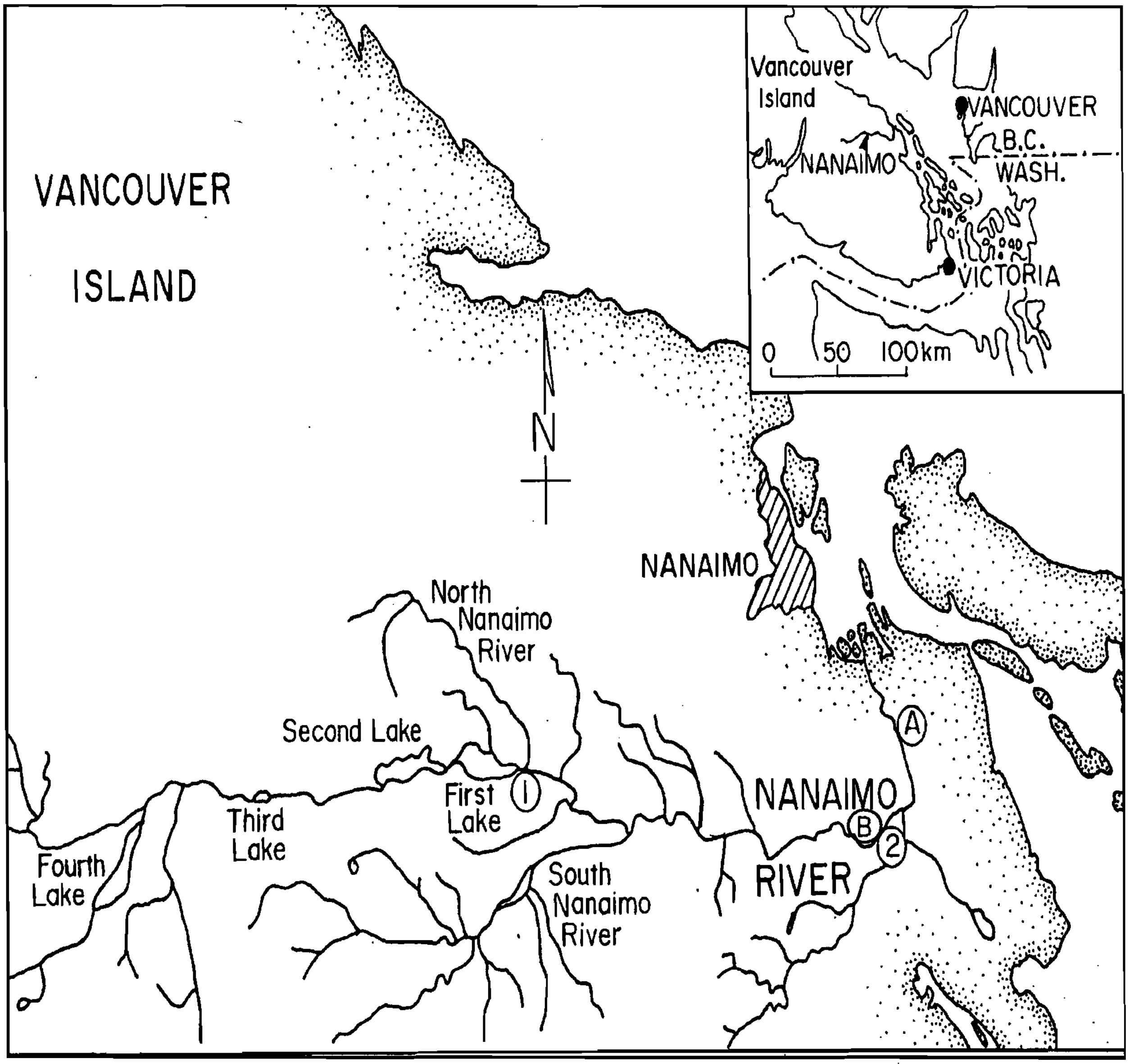
[2] Count at enumeration fence minus broodstock removal above the fence.

[3] Fall natural spawners plus fall broodstock removal below the fence, First Nations food fish catch and spring run estimate.

[4] Mark recapture Peterson estimate.

[5] Mark recapture estimate plus fall broodstock removal, First Nations food fish catch and spring run estimate.

[6] Adjusted fence count minus broodstock removal above the fence.



LEGEND:

1	Hatchery Release Site
2	Hatchery Release Site
A	Enumeration Fence Site
B	Downstream Fry Trapping Site

Figure 1. Nanaimo River study area.

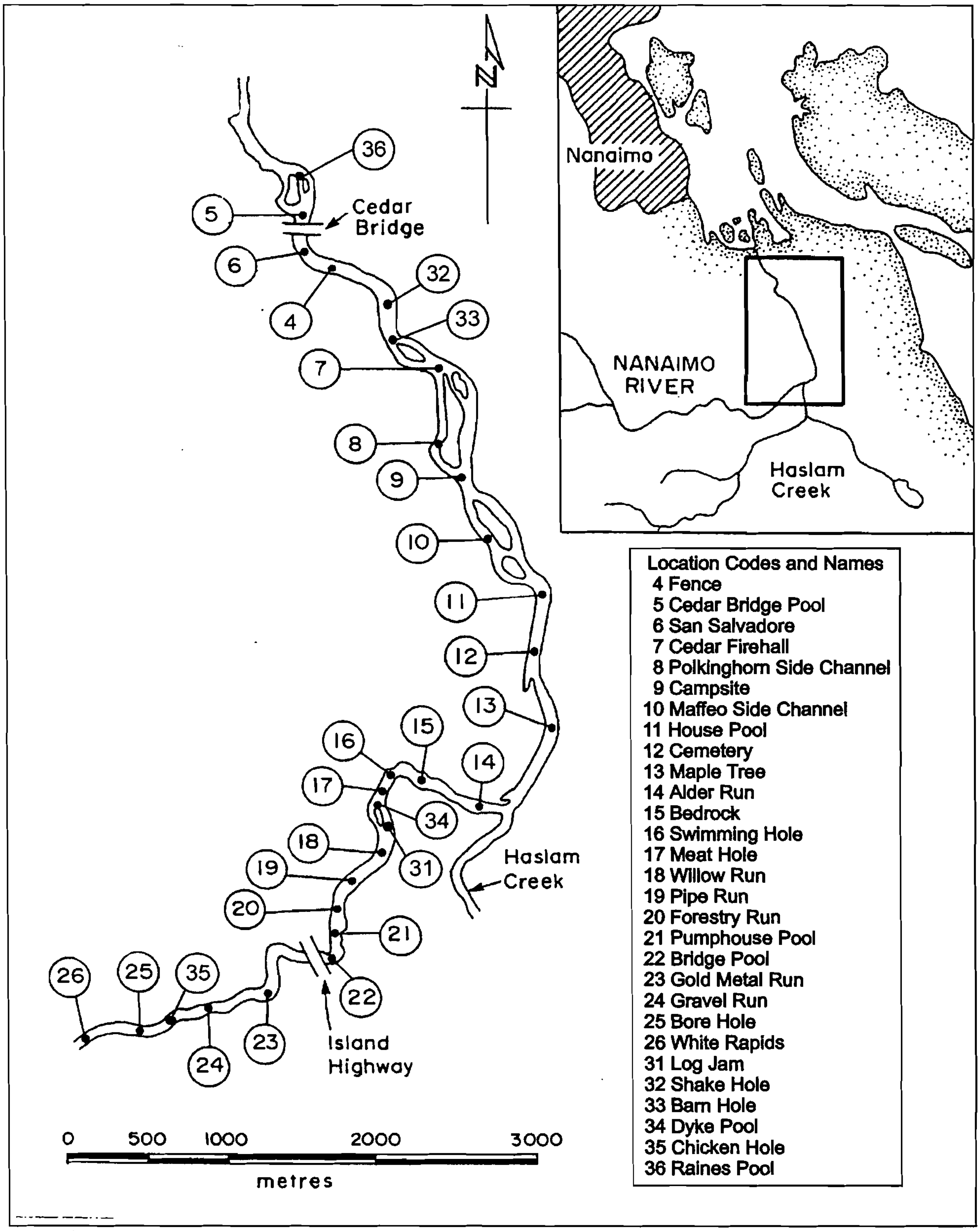


Figure 2. Swim survey and mark-recapture sites on the Nanaimo River.

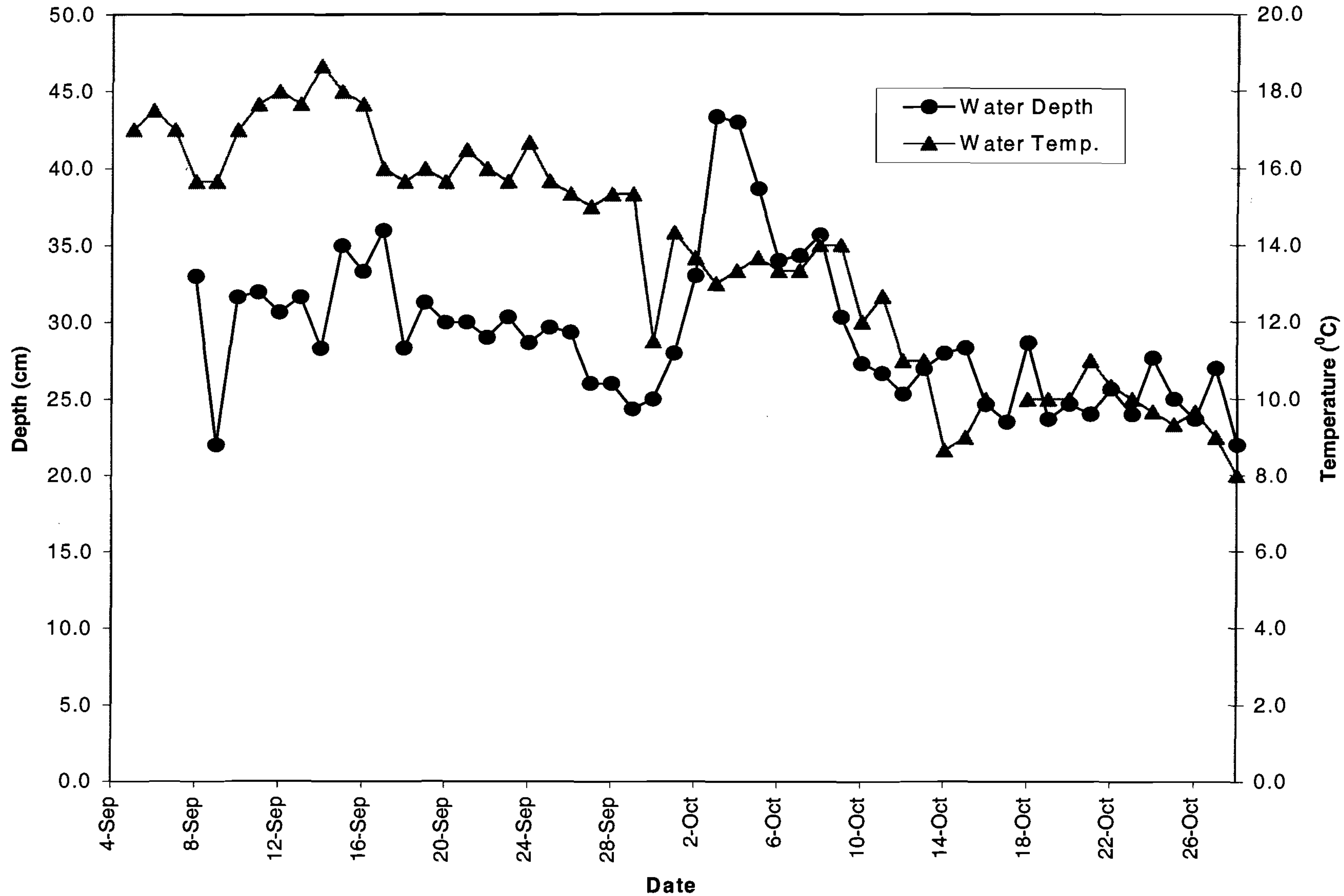


Figure 3. Average water depth and water temperature at the Nanaimo River enumeration fence, 2002.

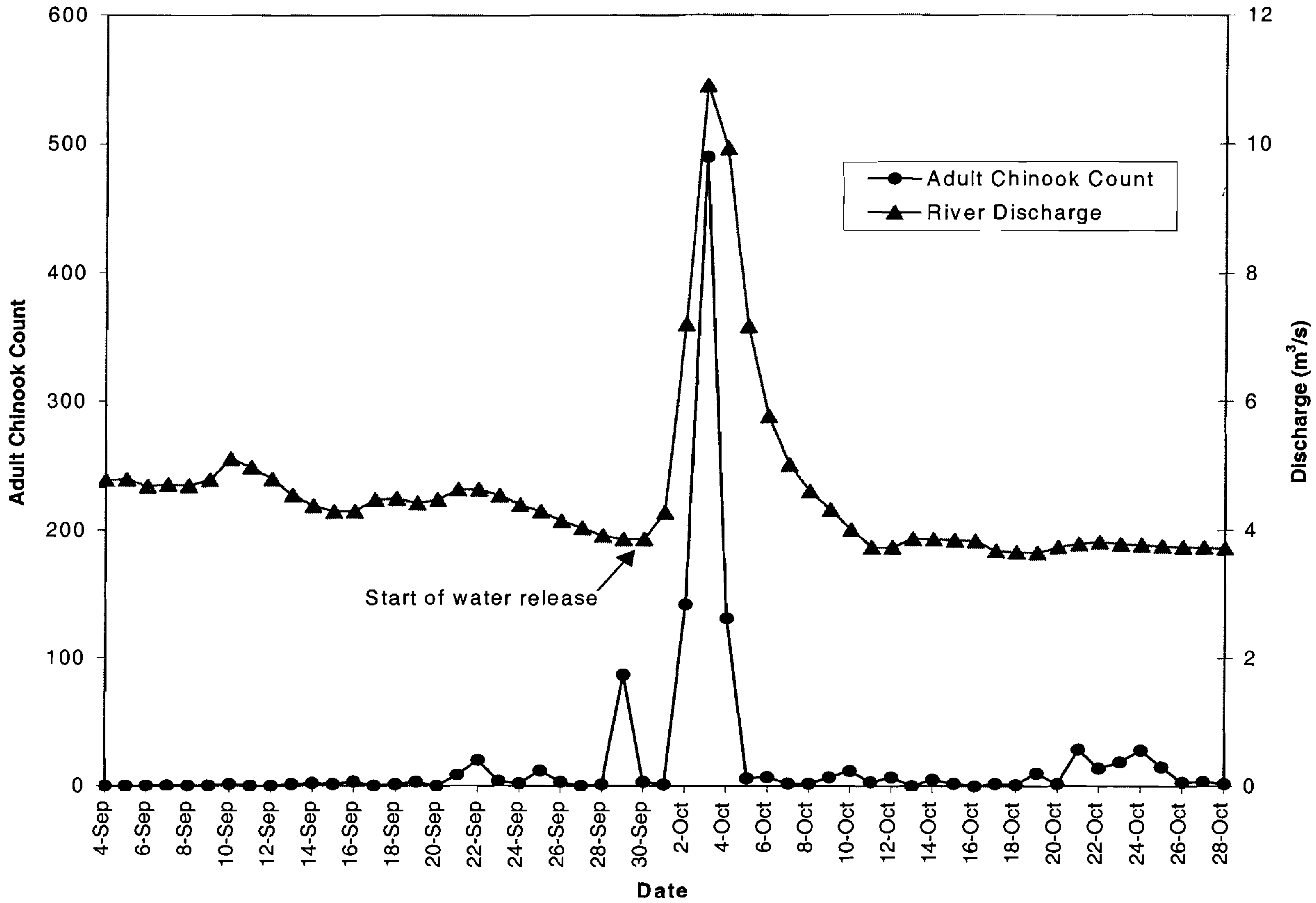


Figure 4. Discharge rate and adult chinook count for the Nanaimo River, 2002.

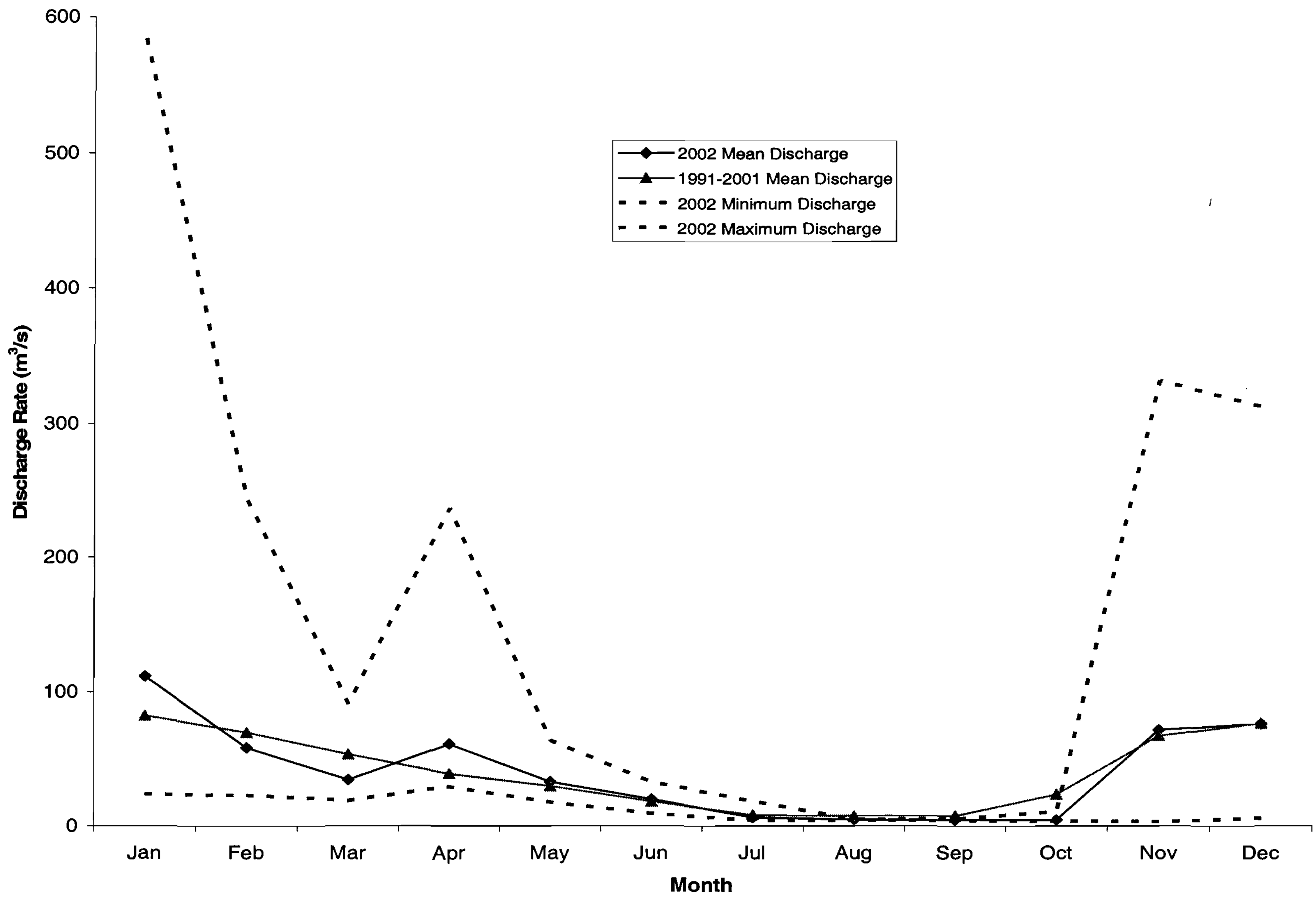


Figure 5. Monthly Nanaimo River discharge (m^3/s) in 2002 along with historical values.

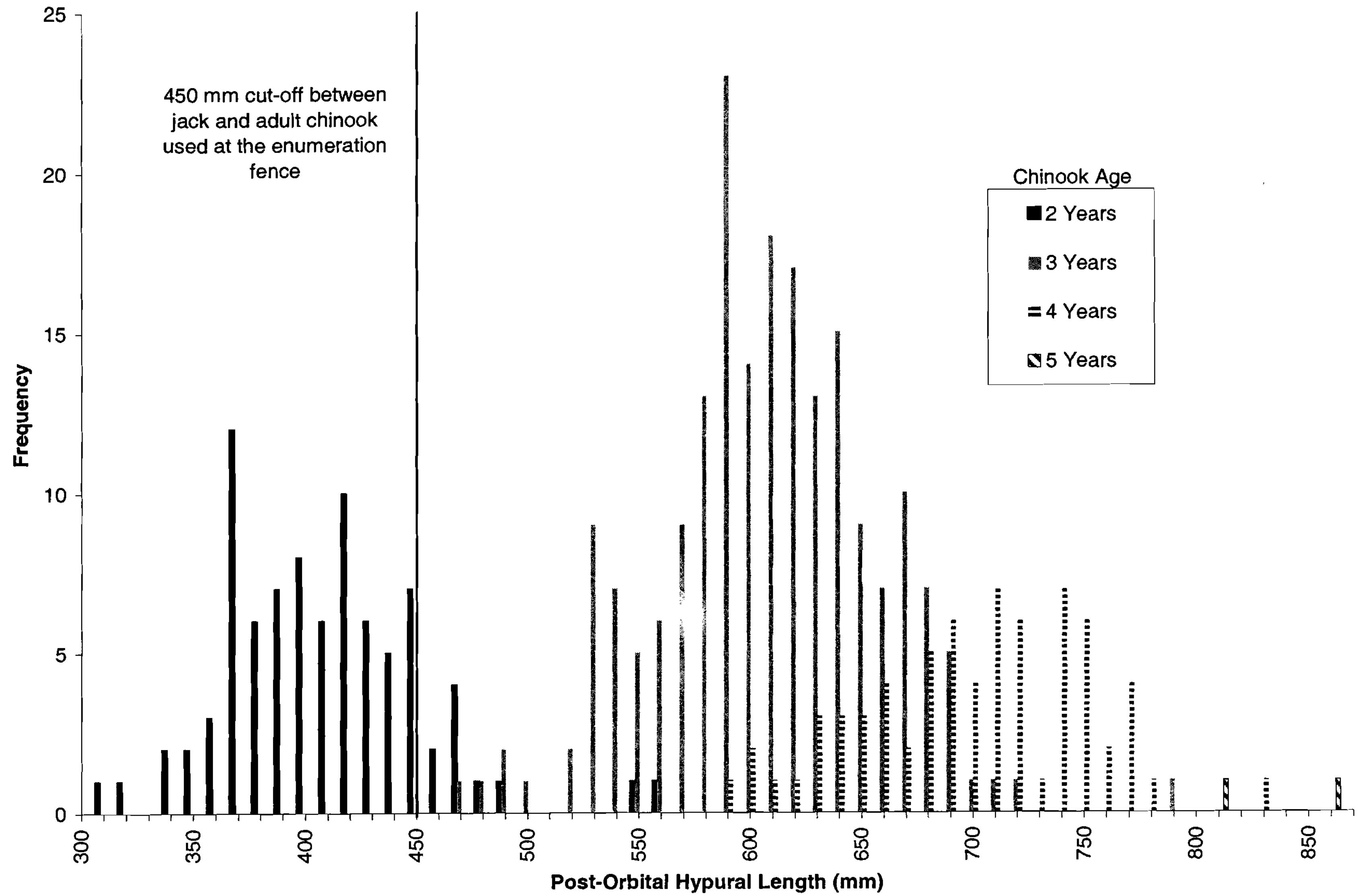


Figure 6. Adult and jack chinook length-frequencies collected from the Nanaimo River spawning grounds, 2002.