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ADULT CHINOOK ESCAPEMENT ASSESSMENT CONDUCTED ON THE NANAIMO RIVER DURING 1999 AND 2000

by

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ABSTRACT

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In 1999 and 2000, 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. We also examined the effects of a water management plan implemented in 1989 to aid the upstream movement of fall chinook.

In 1999, no fence enumeration was available and the carcass mark-recapture Petersen estimate was used in calculating escapement values. The Petersen estimate of 1,920 adult chinook combined with hatchery broodstock removals and First Nations catch yielded a total fall run adult chinook estimate of 2,232 fish. The First Lake spring run adult chinook estimate of 679 fish was estimated using swim surveys conducted in the First Lake area with the addition of hatchery broodstock removals. The total run size of Nanaimo River adult chinook during 1999 was 2,911 fish.

In 2000, fence enumeration began on 06 September and finished on 18 October and a complete Nanaimo River chinook enumeration was attained. The estimated total return of fall run adult chinook to the Nanaimo River was 906 fish of which 596 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 to be 612 adult fish. The 2000 total return of both fall run and spring run adult chinook to the Nanaimo River was 1,518 fish.

RÉSUMÉ

Carter, E.W., D.A. Nagtegaal, N.K. Hop Wo, and K.E. Jones. 2003. Adult chinook escapement assessment conducted on the Nanaimo River during 1999 and 2000. Can. Manuscr. Rep. Fish. Aquat. Sci. 2653: 58 p.

En 1999 et en 2000, Pêches et Océans Canada, en collaboration avec la Première nation de Snuneymuxw, a poursuivi une étude sur la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) de la rivière Nanaimo. L'étude a surtout consisté à: i) dénombrer les saumons en remonte; ii) recueillir des données biologiques et des données de marquage-recapture (micromarques magnétisées codées); iii) estimer la remonte par dénombrement des carcasses marquées, en guise de comparaison. Nous avons également étudié les effets d'un plan de gestion de l'eau mis en œuvre en 1989 pour faciliter la montaison du saumon quinnat d'automne.

Comme aucune donnée de dénombrement à une barrière n'était disponible pour 1999, nous avons utilisé l'estimation de marquage-recapture de Petersen appliquée aux carcasses pour calculer les valeurs d'échappée. L'estimation de Petersen (1 920 saumons quinnats adultes) ajoutée au nombre de géniteurs prélevés pour des écloseries et aux prises faites par les Autochtones a donné une remonte automnale totale estimée à 2 232 poissons adultes. La remonte printanière du saumon quinnat du lac First a été estimée à 679 adultes, d'après les résultats de relevés effectués à la nage, auxquels on a ajouté le nombre de géniteurs prélevés pour des écloseries. En 1999, la remonte totale dans la rivière Nanaimo s'est donc chiffrée à 2 911 saumons adultes.

En 2000, un dénombrement complet du saumon quinnat de la rivière Nanaimo a été réalisé à une barrière du 6 septembre au 18 octobre. La remonte d'automne d'adultes dans cette rivière a été estimée à 906 saumons, dont 596 ont frayé naturellement. À partir d'observations faites au lac First et de données compilées lors du prélèvement de géniteurs, nous avons estimé la remonte printanière totale du saumon quinnat du lac à 612 adultes. Ainsi, la remonte totale (d'automne et de printemps) d'adultes dans la rivière Nanaimo en 2000 s'est chiffrée à 1 518 poissons.

INTRODUCTION

Part 1 of this report deals with the results and discussion associated with the 1999 Nanaimo River adult chinook escapement. Part 2 of this report documents the results and discussion from the 2000 Nanaimo River adult chinook escapement. A combined introduction and methods section precedes both years and is presented with notes pertaining to specific years. Joint acknowledgements and references sections are provided following the 2000 results and discussion sections.

BACKGROUND

Since 1988, considerable interest has been focused on the status of chinook salmon (*Oncorhynchus tshawytscha*) stocks in the lower Strait of Georgia. Along with the Cowichan River, the Nanaimo River is one of the lower Strait of Georgia exploitation and escapement indicator rivers where chinook spawning escapement information is intensively collected. Escapement information is used to evaluate rebuilding strategies and harvest management policies for lower Strait of Georgia chinook (Farlinger et al. 1990). In 1999 and 2000, 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.

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 or Second Lakes 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 and 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 portion 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 2000 about 410,196 fall run and 257,394 First Lake spring run chinook fry were released. Coded-wire tagging (CWT) of chinook began in 1979 and by 2000, 43.0% of fall run chinook fry and 9.8% of spring run chinook fry were coded-wire tagged (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 1999 and 2000. 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,
4. implementing a carcass mark-recapture study for both 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 through 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 1999 and 2000 is 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 km to a site known as San Salvadore at the Nanaimo River campground (Figure 1, Figure 2). During 1999 the fence was washed away after two weeks of enumeration due to improper anchoring. 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 enabled us to estimate the sex composition and enhanced (hatchery) contribution in the population using the 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 valuable 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; 1998; 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

[1] Ketchum Manufacturing Ltd., Ottawa, Canada

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.

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 the Island highway bridge and the Forks were conducted to estimate the number of fall chinook as well as to observe their distribution. Visual surveys in the vicinity of First and Second Lakes were conducted during broodstock collection and were used to estimate the number of First Lake spring run chinook.

WATER MANAGEMENT PLAN

Low river flows and water levels likely result in delayed fish movement and higher water temperatures 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 Environment, 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 10-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.

Part 1:

1999

RESULTS

ENUMERATION FENCE

In 1999, due to improper anchoring of the rail that secures the panels, the fence was washed out after only two weeks of monitoring. As a result, no complete fence count of chinook is available for that year.

SWIM SURVEYS

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. Four swim surveys were conducted in the lower Nanaimo River between 20 September and 07 October, 1999 (Table 3, Figure 2).

In addition, visual surveys conducted in the vicinity of First and Second Lakes were used to estimate the First Lake spring run chinook. The naturally spawning estimate for First Lake spring run chinook in 1999 was 500 adults (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.).

HATCHERY COMPONENT

Between 05 October and 22 October, the Nanaimo River Hatchery staff collected 116 male, 126 female and three jack fall run chinook upstream of the enumeration fence (Table 5). In addition, 105 male, 74 female and 21 jack First Lake spring run chinook were collected upstream of the fence (Table 5). No Upper Nanaimo River spring run chinook were collected for hatchery broodstock.

NATIVE 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 1999, the catch included 70 adult chinook.

CARCASS MARK-RECAPTURE

During the 1999 carcass mark-recapture study morphological characteristics were not used to differentiate between adult male and jack chinook. In order to identify the jack and adult male ratios of chinook recovered from the spawning grounds an analysis of length and age distributions was conducted. With the exception of three fish, two year old male chinook have POH lengths of 510 mm or less, while male chinook older than three years old have lengths greater than 510 mm (Figure 3). During the 1999 carcass mark-recapture results and analysis, jack and adult male chinook were differentiated by POH length. A jack chinook is defined as having a POH length of 510mm or less while an adult male chinook has a POH length greater than 510 mm.

The carcass mark-recapture program began on 25 October and was discontinued on 08 November, 1999. River discharge rates during the mark-recapture study period are presented in Figure 4. During this period 145 male, 100 female, 31 jack and one unknown chinook carcasses were tagged and released in the Nanaimo River (Table 7). Of the 41 carcasses recaptured with tags, 22 (53.7%) were male, 13 (31.7%) were female, three (7.3%) were jack and three (7.3%) were unknown chinook. Using the pooled Petersen estimator, the total adult fall run chinook population estimate was 1920 fish (95% CI: 1342 - 2498), while the jack fall run chinook population estimate was 280 fish (95% CI: 49 - 511) (Table 9).

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 11). There was no detectable temporal bias for male or female chinook when stratified into identical recovery periods (Chi-square = 9.33; $p<0.01$ and Chi-square = 6.98; $p<0.01$).

Temporal bias in the recovery sample was analysed by stratifying the recovery rates into four application periods (Table 13). A statistical difference in the recovery sample male chinook was observed (Chi-square = 12.09; $p<0.01$). Conversely, no statistical difference was found in female chinook (Chi-square = 8.58; $p<0.01$).

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 = 0.23; $p<0.01$ and Chi-square = 0.16; $p<0.01$, application sample and recovery sample, respectively) (Table 15). When jack chinook were included into the application and recovery samples no significant bias was apparent (Chi-square = 0.73; $p<0.01$, and Chi-square = 0.54; $p<0.01$, application sample and recovery sample, respectively) (Table 17).

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: $t = 0.790$; $p<0.01$, $t = 1.387$; $p<0.01$, and $t = 1.498$; $p<0.01$, for males, females and jacks respectively).

BIOLOGICAL DATA

During the spawning ground carcass recovery 176 male and 100 female chinook carcasses were recovered and measured for post orbital-hypural length (Table 19). The lengths of male chinook carcasses ranged from 32.5 cm to 82.0 cm and averaged 61.0 cm, while adult female carcasses ranged from 41.0 cm to 83.0 cm and averaged 66.0 cm. A total of 16 male and 12 female chinook were missing adipose fins (9.1% and 13.5%, respectively) (Table 19). Age analysis revealed 71.3% of fish classified as adult male chinook were three years old, 44.4% of female chinook were three years old, and 95.8 % of carcasses identified as jack chinook were two years old (Table 20).

A total of 41 male and 75 female fall run chinook were randomly collected from hatchery broodstock, measured for POH lengths and monitored for adipose-clipped fins (Table 22). Adult male chinook ranged from 52.3 cm to 77.5 cm and averaged 64.4 cm while female chinook lengths ranged from 52.9 cm to 83.0 cm and averaged 66.5 cm. Two males (4.9%) and three females (4.0%) were found to be missing adipose fins (Table 22). Age analysis revealed adult male and female chinook were predominately 3 years old (80.0% and 67.2%, respectively) (Table 23).

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 adult male or female chinook chinook (Student's t-test: $t = 1.130$; $p<0.01$ and $t = 0.402$; $p<0.01$). No statistical comparison could be made for jack chinook due to no samples being obtained from hatchery broodstock.

A total of six male and 52 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 25). Male chinook ranged from 47.8 cm to 58.5 cm and averaged 54.5 cm while female chinook ranged from 50.3 cm to 76.7 cm and averaged 61.2 cm. One male chinook and nine female chinook were adipose clipped representing 16.7% and 17.3%, respectively (Table 25). Age analysis revealed 100.0% of male chinook were three years old and 73.7% of female chinook were also three years old (Table 26).

Coded-wire tags were recovered from 24 chinook carcasses sampled on the spawning grounds. Most chinook identified as having a CWT were released from the Nanaimo River Hatchery (83.3%) with 18 fish released in the Nanaimo River, one fish released at Jack Point and one fish released at First Lake (Table 28). A summary of the Nanaimo River Hatchery CWT and fry release data for 1994 to 1999 brood years is presented in Table 30.

WATER MANAGEMENT PLAN

A single water release occurred between 01 October and 04 October and was important in increasing river levels and encouraging fish to migrate upstream during this time. Flows from the reservoirs increased to 520 ft^3/s (~14.7 m^3/s) during the four day release. A summary of monthly Nanaimo River discharge and ten year average is presented in Figure 5.

POPULATION ESTIMATE

Escapement and total return estimates for 1999 were determined using the carcass mark-recapture Petersen estimate since fence enumeration data were not available. Morphological features were not used to differentiate between adult male and jack chinook during the carcass recovery. As a result, length and age comparisons were utilised to determine whether a recovered male chinook carcass was a jack or an adult.

The number of natural spawning fall run adult chinook in the Nanaimo River during 1999 was determined to be 1,920 fish (Table 31). The total return of adult fall run chinook to the Nanaimo River was determined to be the sum of the mark-recapture Petersen calculation with the addition of broodstock removals and the First Nation's fishery catch, yielding 2,232 fish. The natural spawning population of First Lake spring run chinook estimated from swim surveys was 500 adult chinook and with the addition of broodstock removals yields 679 fish. No Upper Nanaimo River spring run population estimate was calculated 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 2,911 fish (Table 31).

DISCUSSION

ENUMERATION FENCE

In previous years enumeration fence counts have provided fall run chinook estimates. Due to the fence becoming washed out after only two weeks of enumeration, no fence data were used in the 1999 Nanaimo River chinook escapement estimates.

SWIM SURVEYS

The four swim surveys conducted in the lower Nanaimo River provide supplemental information to the fence enumeration data. Swim surveys in the upper portion of the Nanaimo River and First Lake area provided population estimates for the First Lake spring chinook stock.

NATIVE 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 1999 estimate of 70 adult chinook was an increase over previous years

(Table 31). Since no observers were employed during 1999, SFN catch estimates could not be independently verified.

CARCASS MARK-RECAPTURE

The 510 mm length division separating jack chinook and adult male chinook carcasses recovered from the spawning grounds was necessary because no distinction was made between the two age classes during the mark-recapture study. This differentiation was especially important because no fence counting data were available during this year and the mark-recapture Petersen calculation provided the sole source of fall run chinook estimation.

The assessment of sampling selectivity revealed several biases in the mark-recapture study. There was no statistically significant temporal bias for male or female chinook in the recovery sample as well as female chinook in the application sample. Conversely, a statistical difference was found in male chinook from the application sample. Typically recoveries should increase as the study progresses since tagging and recovery were concurrent activities. As a result, there are less 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 usually increases. The lack of detectable differences in recovery rates suggests tagged carcasses may be swept downstream and out of the surveyed area. This would result in an over-estimation of the actual population by the Petersen estimate.

No sex related bias was evident in the application or recovery samples when male, female, or jack 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 size, 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

There was no statistical difference in mean POH lengths of chinook sampled on the spawning grounds and those sampled from hatchery broodstock. This may be due to the relatively non-selective collection methods used in both the carcass recovery and the hatchery broodstock collection. Furthermore, because both samples were collected from the fall run chinook stock, negligible variation in lengths was to be expected.

Coded-wire tag recoveries were primarily from 1997 (45.8%) and 1996 (50.0%) brood year which would be two and three-year old chinook, respectively. The one CWT fish released from First Lake suggests some spring run chinook may be spawning below First Lake. The recovery of spring run chinook in the mark-recapture study would result in an overestimation of the fall run stock population with the Petersen estimator.

WATER MANAGEMENT PLAN

The scheduled water release usually results in peaked abundance of chinook migration upstream. No fence count was available this year to verify peak migration periods.

POPULATION ESTIMATE

The 1999 Nanaimo River fall run chinook population estimate was based on the carcass mark-recapture Petersen estimate. The fall run chinook natural spawning estimate of 1,920 fish is above the 1975 to 1999 average of 1,247 fish. The 1999 estimate of 500 natural spawning First Lake spring run adult chinook is 25% above the 1995 to 1999 average of 400 adult chinook. The 1999 total return estimate for both fall run and spring run chinook of 2,911 fish almost doubles the 1975 to 1999 period average of 1,609 fish.

Part 2:

2000

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 06 September until 18 October, 2000. Water conditions were clear for most of the study with nine 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 and all counts were deemed to be reliable. A total of 886 adult chinook, 715 jack chinook, 103 adult coho, 1,248 jack coho, and 4,141 chum were enumerated. In addition, four fish were unable to be accurately identified and were recorded as unknown. Since there were no breaches in the fence during the course study it was assumed all fish migrating past the fence were enumerated.

In the new fence location, the fish swam through the trap box voluntarily allowing an opportunity to observe preferred times of natural movement. The period between 1600 h and 1700 h showed the highest percentage of movement of both adult and jack chinook with 9.5% and 13.6%, respectively (Table 2).

Environmental data collected at the enumeration fence included water temperature and river depth (Table 1). Water temperature fluctuated during the course of the study. Temperature over this period ranged from a high of 19°C to a low of 10°C with an average of 13.5°C (Figure 6). Water depth was relatively low for a majority of the study with a low of 14 cm to a high of 110 cm and an average of 26.9 cm (Figure 6).

SWIM SURVEYS

Since the counting fence was put into place on 06 September, the intention was to enumerate the fall run of 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. Three swim surveys were conducted in the lower Nanaimo River on 14 September, 29 September and 04 October, 2000 (Table 4, Figure 2).

In addition, visual surveys conducted in the vicinity of First and Second Lakes were used to estimate the First Lake spring run chinook. According to these observations, the escapement estimate for the total return of the First Lake spring run chinook in 2000 was about 450 adults (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.).

HATCHERY COMPONENT

Between 03 October and 16 October, the Nanaimo River Hatchery staff collected 88 male, 83 female and ten jack fall run chinook downstream of the enumeration fence. In addition, eight male and five female fall run chinook were collected on 10 October and 15 October upstream of the fence. Between 03 October and 06 October, 99 male, 63 female and six jack spring run chinook were captured in the First Lake area. A summary of all hatchery broodstock collected is presented in Table 6.

NATIVE FOOD FISHERY

Historically, an in-river chum gillnet fishery has taken place, usually in October, to provide food fish for the Snuneymuxw First Nation. 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 2000, the catch included 126 adult chinook.

CARCASS MARK-RECAPTURE

The carcass mark-recapture program began on 30 October and was discontinued on 22 November, 2000. During this period 47 male, 41 female, 36 jack and 12 unknown chinook carcasses were tagged and released in the Nanaimo River (Table 8). Of the 39 carcasses recaptured with tags, 13 (33.3%) were male, 13 (33.3%) were female, nine (23.1%) were jack and four (10.3%) were unknown chinook. Using the Petersen estimator, the total adult fall run chinook population estimate was 379 fish (95% CI: 256 - 502), while the jack fall run chinook population estimate was 170 fish (95% CI: 81 - 260) (Table 10).

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 12). There was a significant temporal bias in the application sample for female adult chinook when the data were stratified into four equal recovery periods (Chi-square = 22.79; $p<0.01$). There was no detectable temporal bias for male chinook when stratified into identical recovery periods (Chi-square = 9.02; $p<0.01$).

Temporal bias in the recovery sample was analysed by stratifying the recovery rates into four application periods (Table 14). A statistical difference in the recovery sample for both male and female adult chinook was observed (Chi-square = 20.35; $p<0.01$ and Chi-square = 215.50; $p<0.01$, males and females, respectively).

2. Fish Sex: Sex related bias was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries by application sample and by recovery sample. No sex related bias was evident when comparing male and female chinook populations (Chi-square = 0.17; p<0.01 and Chi-square = 0.12; p<0.01, application sample and recovery sample, respectively) (Table 16). When jack chinook were included into the application and recovery samples no significant bias was apparent (Chi-square = 0.44; p<0.01, and Chi-square = 0.26; p<0.01, application sample and recovery sample, respectively) (Table 18).

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 = 0.227; p<0.01, t = 0.351; p<0.01, and t = 0.718; p<0.01, for males, females and jacks respectively).

BIOLOGICAL DATA

During the spawning ground carcass recovery 46 male, 41 female and 36 jack chinook carcasses were recovered and measured for POH length (Table 19). The lengths of adult male chinook carcasses ranged from 45.0 cm to 79.0 cm and averaged 58.4 cm, while adult female carcasses ranged from 43.0 cm to 82.0 cm and averaged 64.0 cm. Jack chinook carcasses ranged in lengths from 32.5 cm to 44.0 cm and averaged 40.1 cm. A total of seven male, 11 female and two jack chinook were missing adipose fins (15.2%, 26.8% and 5.6%, respectively) (Table 19). Age analysis reveals 47.6% of fish classified as adult male chinook were three years old, 37.5% of female chinook were three years old, and 95.8% of carcasses identified as jack chinook were two years old (Table 21).

A total of 63 male, 85 female and two jack fall run chinook were randomly collected from hatchery broodstock, measured for POH lengths and monitored for adipose clipped fins (Table 22). Adult male chinook ranged from 35.6 cm to 71.2 cm and averaged 55.7 cm while female chinook lengths ranged from 40.4 cm to 89.0 cm and averaged 69.0 cm. The two jack chinook lengths were 42.4 cm and 52.8 cm. Eight males (12.7%) and 15 females (17.6%) were found to be missing adipose fins (Table 22). Adult male chinook were predominately 3 years old (54.5%), while 60.6% of female chinook were 4 year olds (Table 24).

When comparing the mean lengths of fall run chinook recovered from the spawning grounds and those collected from hatchery broodstock, no statistical difference was apparent for adult male chinook (Student's t-test: t = 1.511; p<0.01). Alternatively, there was a difference between POH lengths in fall run female chinook collected from the spawning grounds and those sampled from hatchery broodstock (Student's t-test: t = 3.179; p<0.01). The sample size of jack chinook sampled from hatchery broodstock was too small for a statistical comparison.

A total of 51 female and six jack (no adult males were selected) 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 25). Female chinook ranged from 52.4 cm to 76.4 cm and averaged 65.0 cm while jack chinook ranged from 33.1 cm to 48.5 cm and averaged

43.1 cm. Eight female chinook were adipose clipped representing 15.7% and no jack chinook were missing adipose fins (Table 25). Age analysis revealed 63.6% female chinook were three years old and 50.0% of jack chinook were 2 years old (Table 27).

Coded-wire tags were recovered from 16 chinook carcasses sample on the spawning grounds. Most chinook identified as having a CWT were released from the Nanaimo River Hatchery (93.8%) with 93.8% CWT chinook from the 1997 brood year (Table 29). A summary of the Nanaimo River Hatchery CWT and fry release data for 1994 to 1999 brood years is presented in Table 30.

WATER MANAGEMENT PLAN

Nanaimo River water releases occurred between 25 September and 02 October, 2000. The initial water release occurred at Fourth Lake at a discharge rate of 525 ft^3/s (~14.9 m^3/s) on 25 September and continually decreased to 375 ft^3/s (~10.6 m^3/s) on 27 September, 250 ft^3/s (~7.1 m^3/s) on 28 September and 100 ft^3/s (~2.8 m^3/s) on 29 September. Between 29 September and 02 October, water was released from Jump Lake at a constant 50 ft^3/s (~1.4 m^3/s). The water release in 2000 was important in encouraging about 400 fish to pass through the fence during this time (Figure 7). This proved to be the peak movement of the fall chinook migration in 2000. A summary of monthly Nanaimo River discharge and ten year average is presented in Figure 5.

POPULATION ESTIMATE

Escapement and total return estimates for 2000 were determined using fence count data since these are 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 8). 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 2-year old jack chinook with lengths greater then 450 mm (32.6%) and the proportion of 3-year old or greater adult chinook with lengths of 450 mm or less (1.7%). The fence count data were then adjusted by these proportions yielding total chinook fence counts of 609 adults and 992 jacks.

The number of naturally spawning fall run adult chinook in the Nanaimo River during 2000 was determined to be the adjusted fence count minus any fall run chinook 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 596 fish (Table 31). 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 Nation's fishery catch, yielding 906 fish. Swim surveys provided a naturally spawning First Lake spring run chinook estimate of 450 adult chinook and with the addition of First Lake chinook broodstock removals, a total estimate of 612 adult fish was reached. No Upper Nanaimo River spring run population estimate was calculated 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 1,518 fish (Table 31).

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 fence.

The possibility of 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. However, chum passing through the fence still outnumbered all other species (Table 1).

Water levels along with river discharge influenced fish movement past the counting fence (Figure 7). This is particularly evident between 27 September and 01 October during a scheduled water release resulting in peak chinook migration. During this period, the peak of chinook migration occurred on 28 September with an one day increase of 386 adult chinook after a rise in water levels.

SWIM SURVEYS

The three swim surveys conducted in the lower Nanaimo River provide supplemental information to fence enumeration data. Swim surveys in the upper portion of the Nanaimo River and First Lake area provided population estimates for the First Lake spring chinook stock.

NATIVE 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 2000 estimate of 126 adult chinook was an increase from the previous year (Table 31). Since no observers were employed during 2000, SFN catch estimates could not be independently verified.

CARCASS MARK-RECAPTURE

The carcass mark/recapture program began on 30 October and was discontinued on 22 November, 2000. Heavy rains resulted in an increase in water flows and suspended debris which created problems when attempting to recapture carcasses in the river. Commonly, carcasses were swept off the spawning grounds and into deep pools or back eddies where recovery can be quite difficult. This is particularly true for the lighter male carcasses resulting in a lower recovery and possible overestimate of males in the population. Given these conditions, an estimated 11% of total chinook that were enumerated at the counting fence were sampled in the mark-recapture portion of this study.

The assessment of sampling selectivity revealed several biases in the mark-recapture study. A significant temporal bias for female chinook in the recovery sample as well as male and female chinook in the application sample was 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. The Chi-square analysis of the recovery and application samples highlighted the inability to find unmarked carcasses in the last half of the mark-recapture study. This would result in a smaller sample size and decreased accuracy of the Petersen estimate.

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 recovering 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 size, of tagged carcasses that were redistributed back into the river after tagging. Testing revealed that there was no size biases for male, female, or jack chinook.

BIOLOGICAL DATA

Analysis revealed that fall type female chinook sampled from the hatchery broodstock had a greater POH length when compared to those sampled on the spawning grounds. This may be due to broodstock collection methods which can involve selecting fish from a larger group of chinook in the river. A possible tendency to inadvertently choose larger fish could explain the larger POH lengths observed.

Coded-wire tag recoveries were mostly 1997 brood year (93.8%) which would be three years old chinook returning to spawn. Total fall run chinook hatchery releases for 1997 brood year were 84,315 fry with 63,126 carrying CWT's (Table 30). The lack of 1998 brood year recoveries is due to no CWT chinook fry being released from the Nanaimo River Hatchery for that particular year.

WATER MANAGEMENT PLAN

The scheduled water release provide optimal conditions for upstream migration of salmon past the enumeration fence and as a result peak fence counts were obtained (Figure 7). The water release was decreased gradually to minimise impact on fish and other Nanaimo River wildlife associated with an abrupt decrease in river discharge.

POPULATION ESTIMATE

The 2000 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 596 was higher than the 256 - 502, 95% confidence interval obtained from the mark-recapture Petersen estimate. An underestimation by the Petersen estimate may be due to the mark-recapture study area which concentrates on the main spawning channel and does not include chinook that spawn outside of the surveyed area. The First Lake spring run population estimate was based on information acquired through swim surveys and hatchery broodstock collection conducted in the First Lake area. The 2000 estimate of 450 naturally spawning First Lake spring run adult chinook is consistent with the 1995 – 2000 average of 408 adult chinook. The 2000 total return estimate for both fall run and spring run chinook of 1,518 is slightly below the period average of 1,605 adult fish.

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Table 1. Daily counts at the Nanaimo River enumeration fence, 2000.

Date	Visibility[1]	Depth (cm)	Temp (°C)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unknown
6-Sep	-	-	-	0	0	0	0	0	0
7-Sep	1-2	21	15	0	0	0	0	0	0
8-Sep	1-2	21	15	1	0	0	0	0	0
9-Sep	1-2	26	15	3	0	0	0	0	0
10-Sep	1	25	14	3	0	0	0	0	0
11-Sep	1-2	27	14	0	0	0	0	0	0
12-Sep	1-2	26	15	0	1	0	0	0	0
13-Sep	1	25	15	2	4	0	2	0	0
14-Sep	1	23	16	3	4	0	0	0	0
15-Sep	1	26	17	19	14	0	3	1	0
16-Sep	1	22	17	6	5	3	0	8	0
17-Sep	1-2	20	17	1	5	0	0	0	0
18-Sep	1	15	17	0	2	0	0	0	0
19-Sep	1	15	18	0	2	0	0	0	0
20-Sep	1	15	16	6	11	0	1	0	0
21-Sep	1	15	17	11	10	0	0	0	0
22-Sep	1	16	15	2	15	1	1	0	0
23-Sep	1	18	14	8	11	2	1	0	0
24-Sep	1	18	13	0	7	1	0	0	0
25-Sep	1	18	13	0	9	0	0	0	0
26-Sep	1	17	13	9	14	0	0	0	0
27-Sep	1	22	12	48	100	0	2	0	0
28-Sep	1	39	15	386	347	26	31	0	1
29-Sep	1	37	15	18	28	0	0	0	0
30-Sep	1	45	14	16	18	1	2	1	0
1-Oct	1	35	15	1	1	0	0	0	0
2-Oct	1	33	13	6	7	0	0	1	1
3-Oct	1	29	13	14	25	0	2	0	2
4-Oct	1	27	12	3	5	0	0	0	0
5-Oct	1	25	12	2	6	0	0	0	0
6-Oct	1	25	11	1	2	0	0	0	0
7-Oct	1	23	10	1	0	0	1	0	0
8-Oct	1-2	27	10	0	3	0	0	0	0
9-Oct	1	26	11	8	0	2	0	12	0
10-Oct	1	22	12	19	14	4	2	0	0
11-Oct	1	21	12	89	9	4	6	269	0
12-Oct	1	19	11	58	25	1	3	434	0

Table 1. (continued)

Date	Visibility[1]	Depth (cm)	Temp (°C)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unknown
13-Oct	1	18	10	39	4	2	0	153	0
14-Oct	1-2	30	11	29	5	0	0	13	0
15-Oct	1	28	10	51	1	2	0	23	0
16-Oct	1	26	10	9	0	0	7	318	0
17-Oct	1-2	54	10	14	1	54	1184	2907	0
18-Oct[2]	2	110	-	0	0	0	0	1	0
Total				886	715	103	1248	4141	4

[1] Visibily Code: 1 = clear; 2 = cloudy.
[2] Partial enumeration from 0000-0800 hours.

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

Time Period	Chinook Adult Count	Chinook Adult %	Chinook Jack Count	Chinook Jack %	Coho Adult Count	Coho Adult %	Coho Jack Count	Coho Jack %	Chum Count	Chum %
0000 - 0100	59	6.7	29	4.1	4	3.9	1	0.1	115	2.8
0100 - 0200	29	3.3	45	6.3	6	5.8	1	0.1	148	3.6
0200 - 0300	39	4.4	28	3.9	9	8.7	3	0.2	137	3.3
0300 - 0400	37	4.2	41	5.7	10	9.7	3	0.2	91	2.2
0400 - 0500	31	3.5	37	5.2	10	9.7	2	0.2	47	1.1
0500 - 0600	18	2.0	6	0.8	3	2.9	0	0.0	76	1.8
0600 - 0700	11	1.2	10	1.4	0	0.0	0	0.0	10	0.2
0700 - 0800	5	0.6	13	1.8	4	3.9	3	0.2	50	1.2
0800 - 0900	12	1.4	8	1.1	2	1.9	31	2.5	266	6.4
0900 - 1000	15	1.7	10	1.4	2	1.9	23	1.8	448	10.8
1000 - 1100	27	3.0	28	3.9	7	6.8	4	0.3	71	1.7
1100 - 1200	27	3.0	26	3.6	2	1.9	213	17.1	460	11.1
1200 - 1300	27	3.0	35	4.9	0	0.0	202	16.2	395	9.5
1300 - 1400	57	6.4	50	7.0	1	1.0	239	19.2	418	10.1
1400 - 1500	61	6.9	41	5.7	2	1.9	229	18.3	373	9.0
1500 - 1600	26	2.9	33	4.6	0	0.0	272	21.8	399	9.6
1600 - 1700	84	9.5	97	13.6	31	30.1	5	0.4	122	2.9
1700 - 1800	44	5.0	43	6.0	2	1.9	4	0.3	43	1.0
1800 - 1900	23	2.6	16	2.2	0	0.0	0	0.0	48	1.2
1900 - 2000	45	5.1	16	2.2	2	1.9	0	0.0	74	1.8
2000 - 2100	63	7.1	22	3.1	2	1.9	5	0.4	135	3.3
2100 - 2200	46	5.2	19	2.7	1	1.0	2	0.2	105	2.5
2200 - 2300	53	6.0	23	3.2	2	1.9	0	0.0	57	1.4
2300 - 2400	47	5.3	39	5.5	1	1.0	6	0.5	53	1.3
Total	886	100.0	715	100.0	103	100.0	1248	100.0	4141	100.0

Table 3. Swim surveys conducted on the Nanaimo River, 1999.

Fall Run Chinook

Date	Area [1]	Adult Chinook
20-Sep	Cemetery to Raines Pool	242
05-Oct	Bridge Pool	20
06-Oct	Dyke Pool to Cemetery	133
07-Oct	Bridge Pool to Log Jam	63 [2]

[1] See Figure 2.
[2] Includes adult and jack chinook.

Table 4. Swim surveys conducted on the Nanaimo River, 2000.

Fall Run Chinook

Date	Area [1]	Adult Chinook
14-Sep	Bridge Pool to Raines Pool	190
29-Sep	Bridge Pool to Pumphouse	191
04-Oct	Bridge Pool to Swim Hole	80

[1] See Figure 2.

Table 5. Summary, by day and location, of chinook collected for Nanaimo River Hatchery broodstock, 1999.

Fall Run Chinook

Date	Location Code[1]	Below Fence			Above Fence		
		Male	Jack	Female	Male	Jack	Female
05-Oct	22	-	-	-	17	0	3
06-Oct	34	-	-	-	12	2	17
07-Oct	22	-	-	-	0	0	9
07-Oct	21	-	-	-	2	0	2
07-Oct	31	-	-	-	2	0	6
08-Oct	34	-	-	-	22	0	33
12-Oct	22	-	-	-	2	0	4
12-Oct	19	-	-	-	13	0	5
12-Oct	34	-	-	-	6	0	21
15-Oct	22	-	-	-	3	1	11
19-Oct	19	-	-	-	20	0	0
20-Oct	19	-	-	-	9	0	5
22-Oct	19	-	-	-	8	0	10
Total		0	0	0	116	3	126

First Lake Spring Run Chinook

Date	Location	Below Fence			Above Fence		
		Male	Jack	Female	Male	Jack	Female
04-Oct	First Lake	-	-	-	91	12	17
06-Oct	First Lake	-	-	-	8	9	16
08-Oct	First Lake	-	-	-	6	0	15
12-Oct	First Lake	-	-	-	0	0	15
14-Oct	First Lake	-	-	-	0	0	11
Total		-	-	-	105	21	74

[1] See Figure 2.

Table 6. Summary, by day and location, of chinook collected for Nanaimo River Hatchery broodstock, 2000.

Fall Run Chinook

Date	Location Code[1]	Below Fence Male	Below Fence Jack	Below Fence Female	Above Fence Male	Above Fence Jack	Above Fence Female
03-Oct	6	27	10	25	-	-	-
05-Oct	6	11	0	6	-	-	-
10-Oct	6	11	0	11	-	-	-
10-Oct	31	-	-	-	4	0	2
12-Oct	6	1	0	5			
15-Oct	22	-	-	-	4	0	3
16-Oct	6	38	0	36	-	-	-
Total		88	10	83	8	0	5

First Lake Spring Run Chinook

Date	Location	Below Fence Male	Below Fence Jack	Below Fence Female	Above Fence Male	Above Fence Jack	Above Fence Female
03-Oct	First Lake	-	-	-	71	6	22
05-Oct	First Lake	-	-	-	28	0	29
06-Oct	First Lake	-	-	-	0	0	12
Total		-	-	-	99	6	63

[1] See Figure 2.

Table 7. Daily summary of chinook sampled during the carcass mark-recapture program, Nanaimo River, 1999.

	Carcasses Examined				Tags Applied				Carcasses Recaptured			
Date	Male	Female	Jack	Unkn	Male	Female	Jack	Unkn	Male	Female	Jack	Unkn
25-Oct	2	3	0	0	2	3	0	0	0	0	0	0
26-Oct	19	13	4	1	18	13	4	1	0	0	0	0
27-Oct	17	7	6	0	16	7	6	0	1	0	0	0
28-Oct	4	6	2	0	4	6	2	0	0	0	0	0
29-Oct	10	7	0	0	10	7	0	0	0	0	0	0
01-Nov	25	17	4	0	25	16	4	0	0	1	0	0
02-Nov	6	8	3	0	2	1	2	0	4	7	1	0
03-Nov	30	25	2	2	24	22	2	0	6	3	0	2
04-Nov	35	13	9	1	29	13	7	0	6	0	2	1
05-Nov	19	12	4	0	14	10	4	0	5	2	0	0
08-Nov	1	2	0	0	1	2	0	0	0	0	0	0
Total	168	113	34	4	145	100	31	1	22	13	3	3

Table 8. Daily summary of chinook sampled during the carcass mark-recapture program, Nanaimo River, 2000.

	Carcasses Examined				Tags Applied				Carcasses Recaptured			
Date	Male	Female	Jack	Unkn	Male	Female	Jack	Unkn	Male	Female	Jack	Unkn
30-Oct	4	7	1	0	4	7	1	0	0	0	0	0
31-Oct	11	11	4	1	11	10	4	1	0	1	0	0
06-Nov	16	7	6	1	13	7	6	1	3	0	0	0
07-Nov	10	11	8	7	8	9	6	7	2	2	2	0
09-Nov	1	2	4	1	1	2	4	1	0	0	0	0
10-Nov	3	6	0	0	2	4	0	0	1	2	0	0
14-Nov	8	5	4	3	5	1	3	2	2	4	1	1
16-Nov	4	3	10	3	1	0	7	0	3	3	3	3
20-Nov	3	2	3	0	2	1	2	0	1	1	1	0
22-Nov	1	0	5	0	0	0	3	0	1	0	2	0
Total	61	54	45	16	47	41	36	12	13	13	9	4

Table 9. Petersen chinook escapement estimates by sex, Nanaimo River, 1999.

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Male [1]	1066	670	1463
Female	822	432	1213
Total Adult	**1920**	**1342**	**2498**
Jack	280	49	511
Total Population	2111	1523	2700

[1] Adult males only, jacks not included.

Table 10. Petersen chinook escapement estimates by sex, Nanaimo River, 2000.

Sex	Population Estimate	95% Confidence Limits	
		Lower	Upper
Male [1]	209	116	303
Female	165	92	238
Total Adult	**379**	**256**	**502**
Jack	170	81	260
Total Population	603	440	765

[1] Adult males only, jacks not included.

Table 11. Incidence of tagged adult chinook carcasses recovered on the spawning grounds by recovery period and sex, Nanaimo River, 1999.

Recovery Period	Days of Recovery	Tagged Recoveries Male	Female	Total	Total Recoveries Male	Female	Total	Tag Incidence (%) Male	Female	Total
Oct 25 - Oct 27	3	1	0	1	38	23	61	2.63	0.00	1.64
Oct 28 - Oct 31	4	0	0	0	14	13	27	0.00	0.00	0.00
Nov 01 - Nov 04	4	16	11	27	96	63	159	16.67	17.46	16.98
Nov 05 - Nov 08	4	5	2	7	20	14	34	25.00	14.29	20.59
Total	15	22	13	35	168	113	281	13.10	11.50	12.46
Chi-Square Test Result:								9.33	6.98	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 12. Incidence of tagged adult chinook carcasses recovered on the spawning grounds by recovery period and sex, Nanaimo River, 2000.

Recovery Period	Days of Recovery	Tagged Recoveries Male	Female	Total	Total Recoveries Male	Female	Total	Tag Incidence (%) Male	Female	Total
Oct 30 - Nov 04	6	0	1	1	15	18	33	0.00	5.56	3.03
Nov 05 - Nov 10	6	6	4	10	30	26	56	20.00	15.38	17.86
Nov 11 - Nov 16	6	5	7	12	12	8	20	41.67	87.50	60.00
Nov 17 - Nov 22	6	2	1	3	4	2	6	50.00	50.00	50.00
Total	24	13	13	26	61	54	115	21.31	24.07	22.61
Chi-Square Test Result:								9.02	22.79	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 13. Percentage of the tag application sample recovered on the spawning grounds, by application period and sex, Nanaimo River, 1999.

Application Period	Days of Application	Tags Applied Male	Tags Applied Female	Tags Applied Total	Tagged Recoveries Male	Tagged Recoveries Female	Tagged Recoveries Total	Percent Recovered Male	Percent Recovered Female	Percent Recovered Total
Oct 25 - Oct 27	3	36	23	59	1	0	1	2.78	0.00	1.69
Oct 28 - Oct 31	4	14	13	27	0	0	0	0.00	0.00	0.00
Nov 01 - Nov 04	4	80	52	132	16	11	27	20.00	21.15	20.45
Nov 05 - Nov 08	4	15	12	27	5	2	7	33.33	16.67	25.93
Total		145	100	245	22	13	35	15.17	13.00	14.29
Chi-Square test result:								12.09	8.58	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 14. Percentage of the tag application sample recovered on the spawning grounds, by application period and sex, Nanaimo River, 2000.

Application Period	Days of Application	Tags Applied Male	Tags Applied Female	Tags Applied Total	Tagged Recoveries Male	Tagged Recoveries Female	Tagged Recoveries Total	Percent Recovered Male	Percent Recovered Female	Percent Recovered Total
Oct 30 - Nov 04	6	15	17	32	0	1	1	0.00	5.88	3.13
Nov 05 - Nov 10	6	24	22	46	6	4	10	25.00	18.18	21.74
Nov 11 - Nov 16	6	6	1	7	5	7	12	83.33	700.00	171.43
Nov 17 - Nov 22	6	2	1	3	2	1	3	100.00	100.00	100.00
Total		47	41	88	13	13	26	27.66	31.71	29.55
Chi-Square test result:								20.35	215.50	
Critical Chi-Square (df = 3; alpha = 0.01)								11.35	11.35	

Table 15. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 1999.

Sex	Application sample by recovery status: Sample Size	Recovered	Not Recovered	Total	Recovery sample by mark status: Sample Size	Marked	Not Marked	Total
Male	145	62.9%	58.6%	59.2%	168	62.9%	59.3%	59.8%
Female	100	37.1%	41.4%	40.8%	113	37.1%	40.7%	40.2%
Chi-Square test result:				0.23				0.16
Critical Chi-Square (df = 1; alpha = 0.01)				6.64				6.64

Table 16. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 2000.

Sex	Application sample by recovery status: Sample Size	Recovered	Not Recovered	Total	Recovery sample by mark status: Sample Size	Marked	Not Marked	Total
Male	47	50.0%	54.8%	53.4%	61	50.0%	52.8%	53.0%
Female	41	50.0%	45.2%	46.6%	54	50.0%	46.1%	47.0%
Chi-Square test result:				0.17				0.12
Critical Chi-Square (df = 1; alpha = 0.01)				6.64				6.64

Table 17. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 1999 (jacks included).

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	145	57.9%	51.7%	52.5%	168	57.9%	52.7%	53.3%
Female	100	34.2%	36.6%	36.2%	113	34.2%	36.1%	35.9%
Jack	31	7.9%	11.8%	11.2%	34	7.9%	11.2%	10.8%
Chi-Square test result:				0.73				0.54
Critical Chi-Square (df = 2; alpha = 0.01)				9.21				9.21

Table 18. Sex composition of chinook in the tag application and recovery samples, Nanaimo River, 2000 (jacks included).

	Application sample by recovery status				Recovery sample by mark status			
Sex	Sample Size	Recovered	Not Recovered	Total	Sample Size	Marked	Not Marked	Total
Male	47	37.1%	38.2%	37.9%	61	37.1%	38.4%	38.1%
Female	41	37.1%	31.5%	33.1%	54	37.1%	32.8%	33.8%
Jack	36	25.7%	30.3%	29.0%	45	25.7%	28.8%	28.1%
Chi-Square test result:				0.44				0.26
Critical Chi-Square (df = 2; alpha = 0.01)				9.21				9.21

Table 19. Length-frequency of chinook sampled during the carcass mark-recapture program, Nanaimo River, 1999 and 2000.

	1999		2000		
Length (cm)	Males [1]	Females	Males	Jacks	Females
32	1	0	0	2	0
33	5	0	0	0	0
34	0	0	0	0	0
35	1	0	0	1	0
36	2	0	0	2	0
37	3	0	0	0	0
38	2	0	0	5	0
39	1	0	0	4	0
40	2	0	0	4	0
41	1	1	0	5	0
42	1	0	0	6	0
43	1	0	0	5	1
44	3	0	0	2	1
45	2	1	7	0	0
46	2	1	1	0	1
47	1	0	4	0	0
48	1	1	2	0	0
49	1	1	0	0	0
50	0	0	1	0	0
51	2	0	0	0	0
52	1	1	0	0	0
53	3	0	0	0	1
54	2	0	2	0	0
55	3	0	2	0	2
56	1	1	2	0	1
57	3	5	2	0	1
58	2	3	2	0	1
59	9	6	0	0	1
60	4	6	1	0	1
61	11	4	1	0	5
62	10	6	2	0	1
63	6	3	3	0	3
64	13	7	1	0	1
65	13	4	1	0	3
66	5	4	0	0	2
67	5	2	4	0	1
68	9	4	0	0	1

Table 19. (continued)

Length (cm)	1999 Males [1]	1999 Females	2000 Males	2000 Jacks	2000 Females
69	9	1	1	0	2
70	3	10	0	0	1
71	2	1	0	0	3
72	5	4	3	0	3
73	7	2	1	0	1
74	1	5	1	0	0
75	6	4	0	0	0
76	4	1	0	0	1
77	2	5	0	0	0
78	2	2	1	0	0
79	1	0	1	0	0
80	0	1	0	0	1
81	1	1	0	0	0
82	1	1	0	0	1
83	0	1	0	0	0
Total	176	100	46	36	41
Mean Length cm)	61.0	66.0	58.4	40.1	64.0
Std. Deviation	11.9	8.3	10.2	2.86	8.63
Adipose Clips	16	12	7	2	11
Mark Rate	9.1%	13.5%	15.2%	5.6%	26.8%

[1] Includes both adult male and jack chinook

Table 20. Summary of age data from fall run chinook carcass mark-recapture, Nanaimo River, 1999.

European Age [1]	Brood Year	Total Age	Males [2] #	Males [2] %	Females #	Females %	Total #	Total %	Jacks [3] #	Jacks [3] %
0.1	1997	2	2	2.1	6	9.5	8	5.1	23	95.8
0.2	1996	3	67	71.3	28	44.4	95	60.5	0	0.0
1.1	1996	3	0	0.0	0	0.0	0	0.0	1	4.2
0.3	1995	4	23	24.5	23	36.5	46	29.3	0	0.0
0.4	1994	5	2	2.1	6	9.5	8	5.1	0	0.0
Total			94	100.0	63	100.0	157	100.0	24	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).
[2] A male is classified as greater than 510 mm.
[3] A jack is classified as less than or equal to 510 mm.

Total number of unreadable scales: 64

Table 21. Summary of age data from fall run chinook carcass mark-recapture, Nanaimo River, 2000.

European Age [1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %	Jacks #	Jacks %
0.1	1998	2	15	35.7	1	3.1	16	21.6	23	95.8
0.2	1997	3	20	47.6	12	37.5	32	43.2		0.0
1.1	1997	3		0.0	2	6.3	2	2.7	1	4.2
0.3	1996	4	5	11.9	11	34.4	16	21.6		0.0
1.2	1996	4	2	4.8	1	3.1	3	4.1		0.0
0.4	1995	5		0.0	3	9.4	3	4.1		0.0
1.3	1995	5		0.0	1	3.1	1	1.4		0.0
0.5	1994	6		0.0	1	3.1	1	1.4		0.0
Total			42	100.0	32	100.0	74	100.0	24	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: 13

Table 22. Length-frequency of fall run chinook sampled during broodstock collection, Nanaimo River, 1999 and 2000.

	1999		2000		
Length (cm)	Males [1]	Females	Males	Jacks	Females
36	0	0	1	0	0
37	0	0	1	0	0
38	0	0	0	0	0
39	0	0	0	0	0
40	0	0	1	0	1
41	0	0	0	0	0
42	0	0	1	1	0
43	0	0	0	0	1
44	0	0	1	0	0
45	0	0	1	0	0
46	0	0	2	0	1
47	0	0	1	0	0
48	0	0	3	0	0
49	0	0	1	0	0
50	0	0	4	0	0
51	0	0	2	0	0
52	2	0	5	0	0
53	0	1	0	1	0
54	1	0	4	0	0
55	0	0	6	0	0
56	0	1	1	0	0
57	0	1	3	0	0
58	3	3	2	0	1
59	2	5	1	0	2
60	3	1	2	0	3
61	3	4	2	0	2
62	1	4	3	0	4
63	3	4	3	0	1
64	3	3	2	0	7
65	4	8	1	0	4
66	4	5	2	0	1
67	2	4	2	0	4
68	1	6	3	0	5
69	2	4	1	0	6
70	0	5	0	0	4
71	0	2	1	0	6
72	1	3	0	0	6

Table 22. (continued)

Length (cm)	1999 Males [1]	1999 Females	2000 Males	2000 Jacks	2000 Females
73	3	1	0	0	3
74	0	4	0	0	3
75	2	1	0	0	8
76	0	1	0	0	2
77	1	2	0	0	0
78	0	0	0	0	2
79	0	1	0	0	2
80	0	0	0	0	1
81	0	0	0	0	2
82	0	0	0	0	0
83	0	1	0	0	0
84	0	0	0	0	1
85	0	0	0	0	0
86	0	0	0	0	1
87	0	0	0	0	0
88	0	0	0	0	0
89	0	0	0	0	1
Total	41	75	63	2	85
Mean Length (cm)	64.4	66.5	55.7	47.6	69.0
Std. Deviation	6.0	5.8	8.2	7.4	8.1
Adipose Clips	2	3	8	0	15
Mark Rate	4.9%	4.0%	12.7%	0.0%	17.6%

[1] Adult males only, no jack chinook were randomly collected.

Table 23. Summary of age data from fall run chinook broodstock collection, Nanaimo River, 1999.

European Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %	Jacks #	Jacks %
0.2	1996	3	28	80.0	41	67.2	69	71.9	0	0.0
1.1	1996	3	1	2.9	0	0.0	1	1.0	0	0.0
0.3	1995	4	6	17.1	20	32.8	26	27.1	0	0.0
Total			35	100.0	61	100.0	96	100.0	0	0.0

[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: 11

Table 24. Summary of age data from fall run chinook broodstock collection, Nanaimo River, 2000.

European Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %	Jacks #	Jacks %
0.1	1998	2	21	38.2	3	4.2	24	19.0	1	50.0
0.2	1997	3	30	54.5	19	26.8	49	38.9	0	0.0
0.3	1996	4	4	7.3	43	60.6	47	37.3	1	50.0
1.2	1996	4	0	0.0	4	5.6	4	3.2	0	0.0
0.4	1995	5	0	0.0	2	2.8	2	1.6	0	0.0
Total			55	100.0	71	100.0	126	100.0	2	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: 14

Table 25. Length-frequency of First Lake spring run chinook sampled during broodstock collection, Nanaimo River, 1999 and 2000.

Length (cm)	1999 Males [1]	1999 Females	2000 Males	2000 Jacks	2000 Females
33	0	0	0	1	0
34	0	0	0	0	0
35	0	0	0	0	0
36	0	0	0	0	0
37	0	0	0	0	0
38	0	0	0	0	0
39	0	0	0	0	0
40	0	0	0	1	0
41	0	0	0	0	0
42	0	0	0	1	0
43	0	0	0	0	0
44	0	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	0	0	0	1	0
48	1	0	0	2	0
49	0	0	0	0	0
50	1	1	0	0	0
51	0	1	0	0	0
52	0	2	0	0	1
53	0	4	0	0	0
54	1	3	0	0	1
55	0	1	0	0	1
56	0	3	0	0	0
57	0	2	0	0	1
58	3	5	0	0	1
59	0	4	0	0	3
60	0	4	0	0	4
61	0	2	0	0	2
62	0	2	0	0	3
63	0	3	0	0	7
64	0	4	0	0	5
65	0	0	0	0	0
66	0	1	0	0	1
67	0	0	0	0	2
68	0	0	0	0	2
69	0	0	0	0	4

Table 25. (continued)

Length (cm)	1999 Males [1]	1999 Females	2000 Males	2000 Jacks	2000 Females
70	0	2	0	0	5
71	0	1	0	0	2
72	0	2	0	0	2
73	0	3	0	0	0
74	0	0	0	0	0
75	0	1	0	0	2
76	0	1	0	0	2
77	0	1	0	0	0
Total	6	52	0	6	51
Mean Length (cm)	54.5	61.2	-	43.1	65.0
Std. Deviation	4.5	7.2	-	6.0	5.7
Adipose Clips	1	9	-	0	8
Mark Rate	16.7%	17.3%	-	0.0%	15.7%

[1] No biological data was obtained from randomly collected jack chinook.

Table 26. Summary of age data from First Lake spring run chinook broodstock collection, Nanaimo River, 1999.

European Age [1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %	Jacks #	Jacks %
0.1	1997	2	0	0.0		0.0	0	0.0	17	89.5
0.2	1996	3	6	100.0	28	73.7	34	77.3	1	5.3
1.1	1996	3	0	0.0		0.0	0	0.0	1	5.3
0.3	1995	4	0	0.0	9	23.7	9	20.5	0	0.0
1.2	1995	4	0	0.0	1	2.6	1	2.3	0	0.0
Total			6	100.0	38	100.0	44	100.0	19	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: 11

Table 27. Summary of age data from First Lake spring run chinook broodstock collection, Nanaimo River, 2000.

European Age [1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %	Jacks #	Jacks %
0.1	1998	2	0	0.0	0	0.0	0	0.0	3	50.0
0.2	1997	3	0	0.0	28	63.6	28	63.6	2	33.3
1.1	1997	3	0	0.0	1	2.3	1	2.3	1	16.7
0.3	1996	4	0	0.0	12	27.3	12	27.3	0	0.0
1.2	1996	4	0	0.0	3	6.8	3	6.8	0	0.0
Total			0	0.0	44	100.0	44	100.0	6	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: 5

Table 28. Coded-wire tag code data from chinook sampled on the spawning grounds, Nanaimo River, 1999.

Recovery Data				Release Data			
Date (dd/mm/yy)	Location	POH Length (mm)	Sex	Brood Year	Tag Code	Location	Date (dd/mm/yy)
25/10/99	32	600	M	1996	18-34-54	First Lake	20/05/97
26/10/99	21	765	Unkn		No Data		
26/10/99	20	445	M	1997	18-32-23	Nanaimo R.	26/05/98
26/10/99	21	590	F	1996	18-27-46	Nanaimo R.	21/05/97
26/10/99	22	645	F	1996	18-27-46	Nanaimo R.	21/05/97
27/10/99	20	385	M	1997	18-32-22	Jack Point	23/07/98
27/10/99	20	440	M	1997	18-32-31	Sooke R.	28/05/98
27/10/99	20	520	M	1996	18-27-47	Nanaimo R.	05/05/97
27/10/99	19	680	M	1996	18-27-46	Nanaimo R.	21/05/97
28/10/99	33	525	F	1997	18-34-23	Big Qualicum R.	01/06/98
29/10/99	18	640	F	1996	18-27-46	Nanaimo R.	21/05/97
01/11/99	12	620	F	1996	18-27-46	Nanaimo R.	21/05/97
01/11/99	11	650	M	1996	18-27-46	Nanaimo R.	21/05/97
01/11/99	11	370	M	1997	18-27-63	Cowichan R.	09/04/98
01/11/99	10	680	F	1996	18-27-46	Nanaimo R.	21/05/97
01/11/99	10	580	M	1996	18-23-07	Robertson Cr.	14/05/98
03/11/99	17	585	F		No Pin		
03/11/99	17	600	F		No Pin		
03/11/99	17	410	F	1997	18-32-23	Nanaimo R.	26/05/98
03/11/99	16	745	F		No Pin		
03/11/99	16	720	M	1995	18-03-58	Nanaimo R.	02/05/96
04/11/99	16	695	M	1996	18-27-46	Nanaimo R.	21/05/97
04/11/99	15	655	F	1996	18-27-47	Nanaimo R.	05/05/97
04/11/99	14	460	M	1997	18-32-23	Nanaimo R.	26/05/98
04/11/99	14	470	M	1997	18-32-23	Nanaimo R.	26/05/98
04/11/99	14	450	F	1997	18-32-23	Nanaimo R.	26/05/98
04/11/99	14	465	M	1997	18-32-23	Nanaimo R.	26/05/98
05/11/99	20	405	M	1997	18-32-23	Nanaimo R.	26/05/98
05/11/99	18	675	M		No Data		

Table 29. Coded-wire tag code data from chinook sampled on the spawning grounds, Nanaimo River, 2000.

Recovery Data				Release Data			
Date (dd/mm/yy)	Location	POH Length (mm)	Sex	Brood Year	Tag Code	Location	Date (dd/mm/yy)
30/10/00	27	580	1	1997	18-32-20	First Lake	07/05/98
30/10/00	27	580	2	1997	18-32-20	First Lake	07/05/98
30/10/00	20	615	2	1997	18-32-22	Jack Point	23/07/98
30/10/00	20	665	2	1997	18-25-63	Chemainus R.	21/05/98
31/10/00	18	610	1	1997	18-32-22	Jack Point	23/07/98
31/10/00	18	575	2	1997	18-24-08	Nanaimo R.	26/05/98
31/10/00	18	610	2	1997	18-32-22	Jack Point	23/07/98
31/10/00	15	670	1	1997	18-32-23	Nanaimo R.	26/05/98
31/10/00	14	635	1		No Data		
06/11/00	20	805	2	1996	18-27-46	Nanaimo R.	21/05/97
06/11/00	20	790	1	1997	18-32-23	Nanaimo R.	26/05/98
06/11/00	14	650	1	1997	18-32-23	Nanaimo R.	26/05/98
06/11/00	14	390	3		No Pin		
06/11/00	14	635	1	1997	18-32-22	Jack Point	23/07/98
06/11/00	13	735	2		No Pin		
06/11/00	13	590	2	1997	18-32-23	Nanaimo R.	26/05/98
07/11/00	19	610	2	1997	18-24-08	Nanaimo R.	26/05/98
07/11/00	11	560	2	1997	18-32-23	Nanaimo R.	26/05/98
09/11/00	8	380	3		No Pin		
10/11/00	18	675	2	1997	18-32-22	Jack Point	23/07/98

Table 30. Nanaimo River Hatchery chinook release data for the brood years 1994 - 1999.

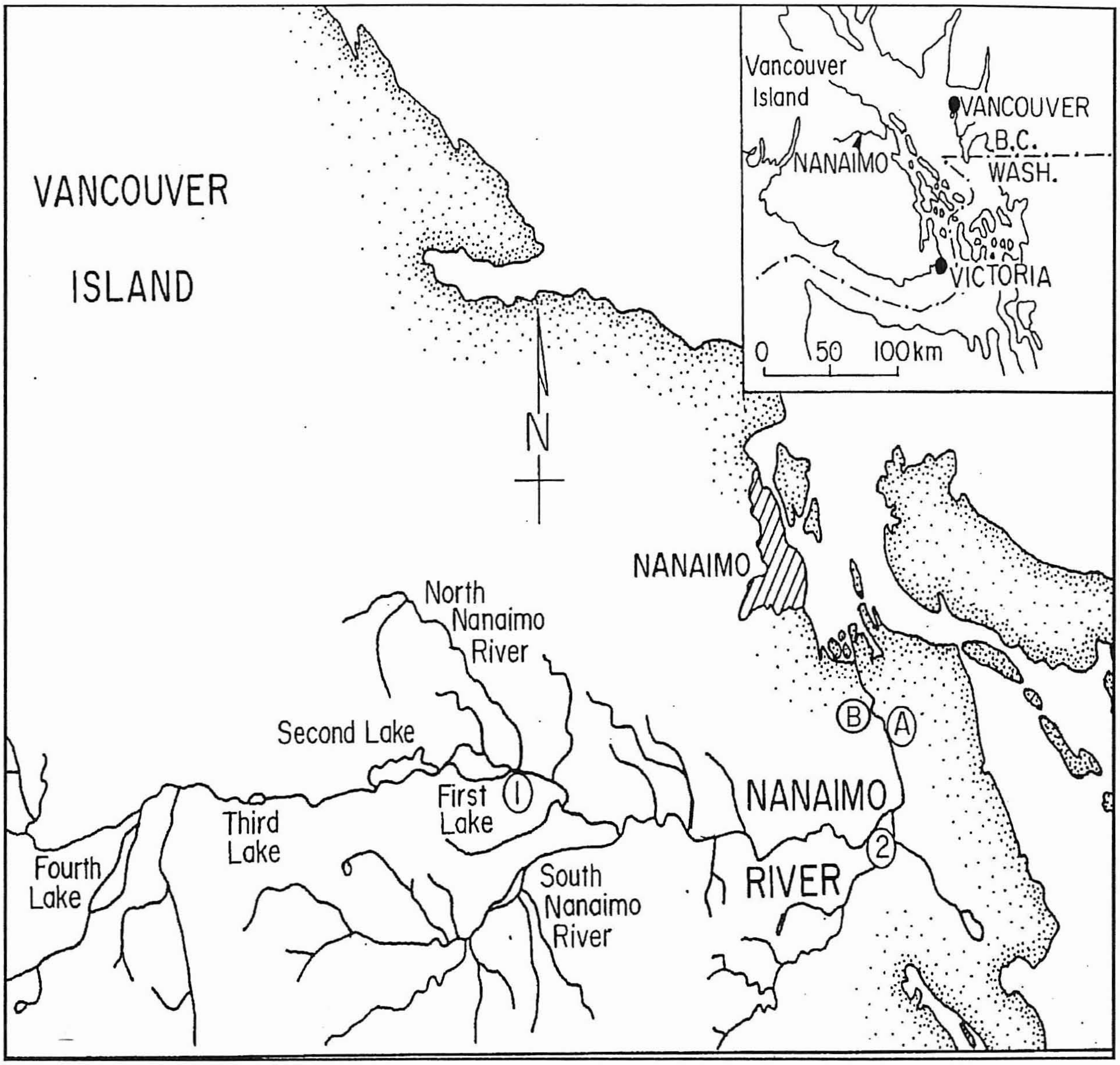
Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Start Release Date	End Release Date	Release Site	Run Type
181323	1994	25286	96450	26.22	6.6	24/05/95	25/05/95	Nanaimo R.	Fall
181324	1994	25147	95919	26.22	6.6	24/05/95	25/05/95	Nanaimo R.	Fall
182159	1994	25347	111844	22.66	5.49	04/05/95	04/05/95	Nanaimo R.	Fall
180355	1995	24978	38928	64.16	6.26	09/05/96	09/05/96	First Lake	Spring[1]
180358	1995	25086	216293	11.6	5.7	01/05/96	02/05/96	Nanaimo R.	Fall
180357	1995	25137	310220	8.1	7	29/05/96	30/05/96	Nanaimo R.	Fall
180356	1995	25003	38967	64.16	6.26	09/05/96	09/05/96	First Lake	Spring[1]
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

[1] First Lake spring run chinook only.

Table 31. Total adult chinook returns to the Nanaimo River, 1975-2000.

	Natural Spawners		Hatchery Broodstock		Native Food	Total
Year	Fall	Spring [1]	Fall	Spring [1]	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		10	752
1995	1592 [2]	100	311	75	50	2128 [3]
1996	990 [2]	600	257	167	335	2349 [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]

[1] First Lake spring run chinook only.
[2] Count at enumeration fence minus fall broodstock removal above the fence.
[3] Fall natural spawners plus fall broodstock removal below the fence, Native food fish catch and spring run estimate.
[4] Mark recapture Peterson estimate.
[5] Mark recapture estimate plus fall broodstock removal, Native food fish catch and spring run estimate.
[6] Adjusted fence count minus fall 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.

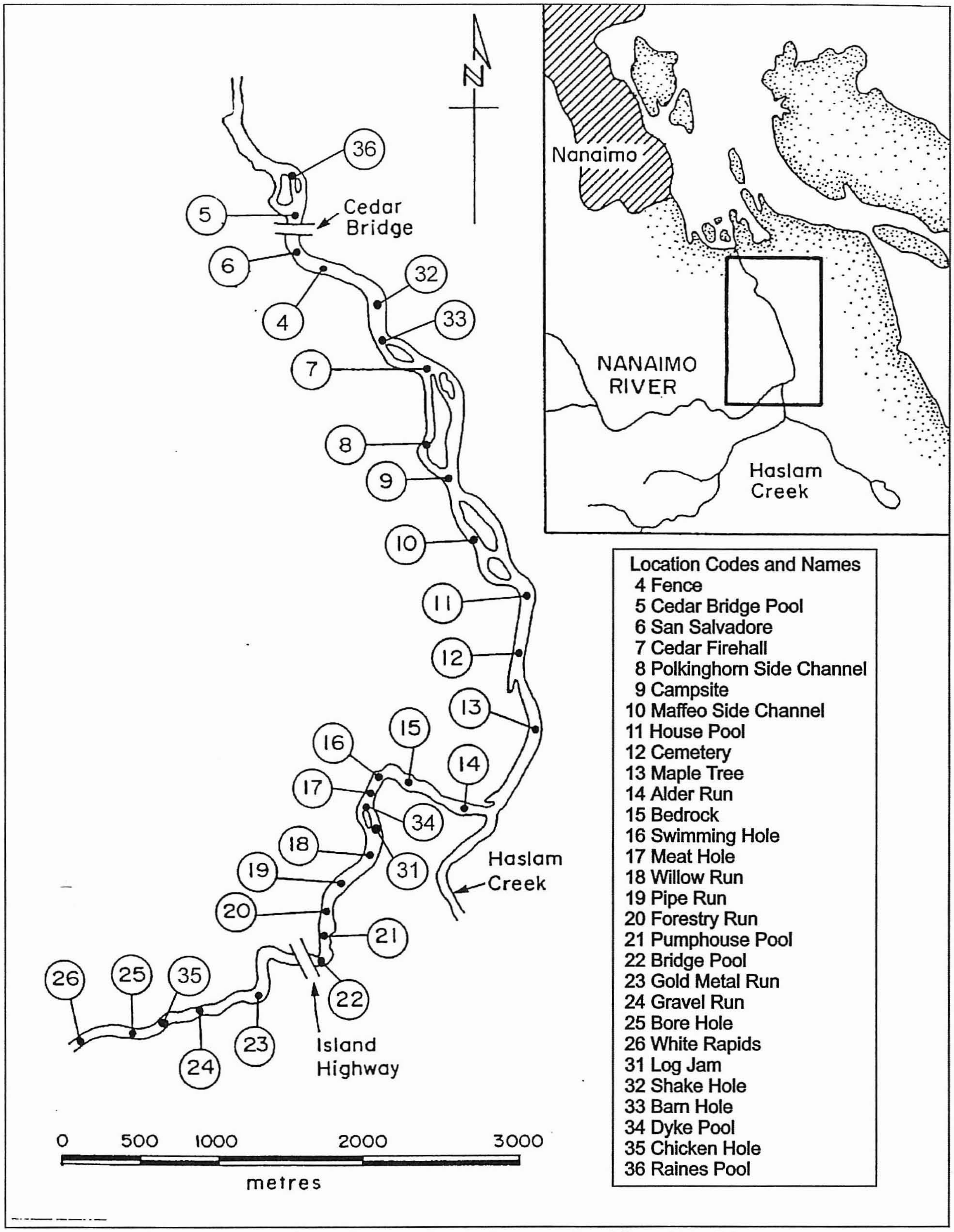


Figure 2. Swim survey and mark-recapture sites on the Nanaimo River.

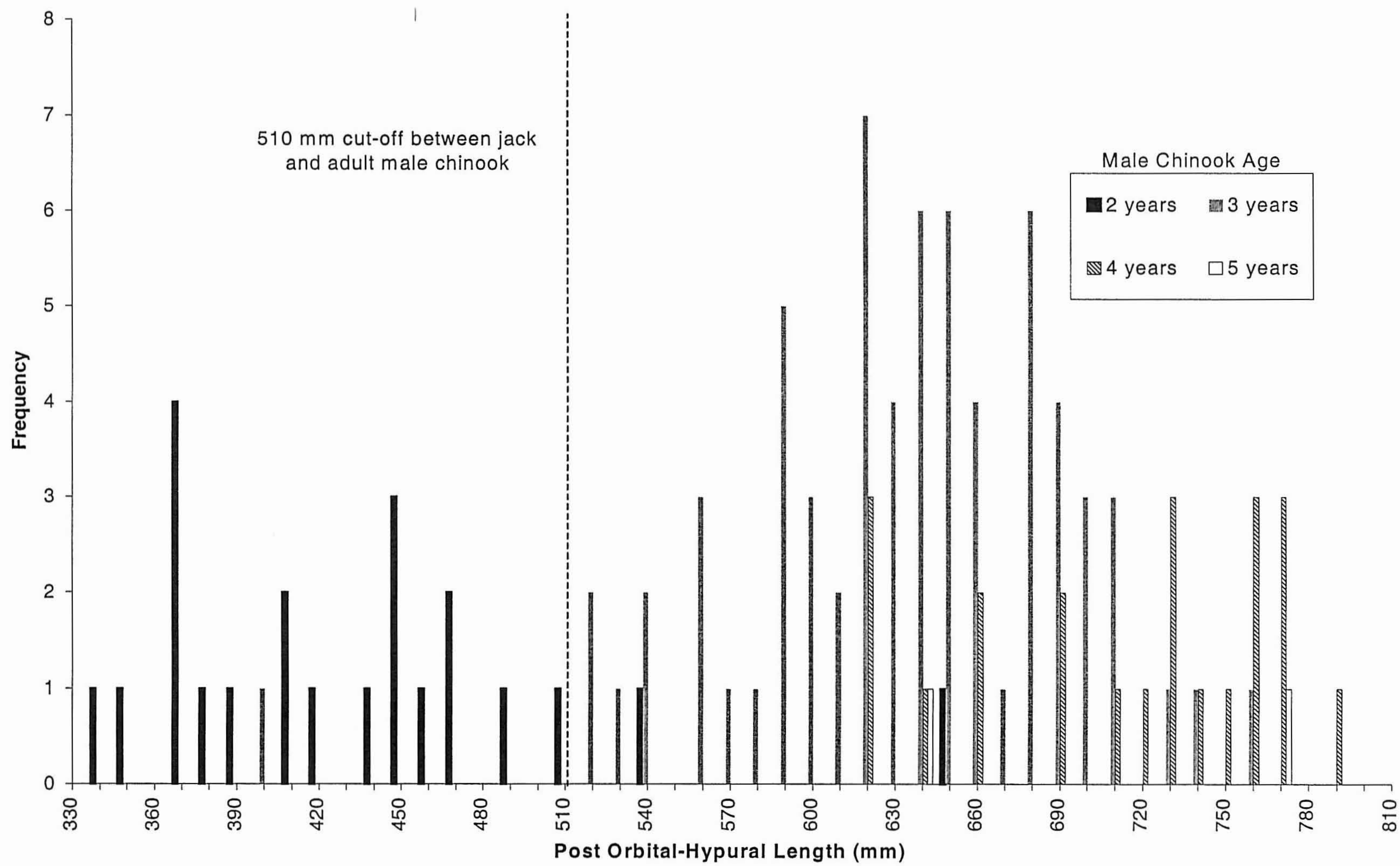


Figure 3. Jack and adult male chinook length-frequencies, stratified by age, collected from the Nanaimo River spawning grounds, 1999.

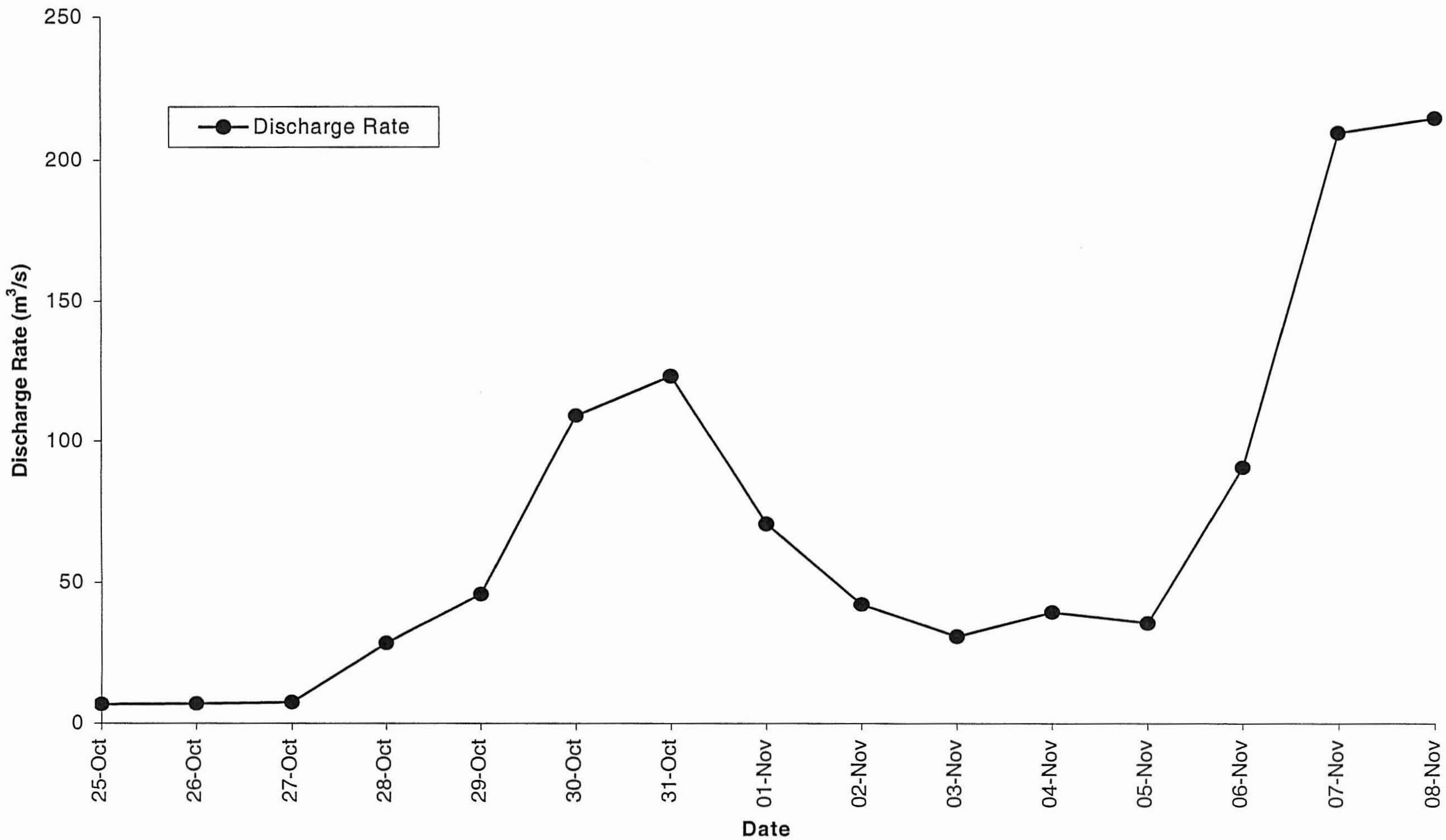


Figure 4. Daily discharge rate during the carcass mark-recapture study, Nanaimo River, 1999.

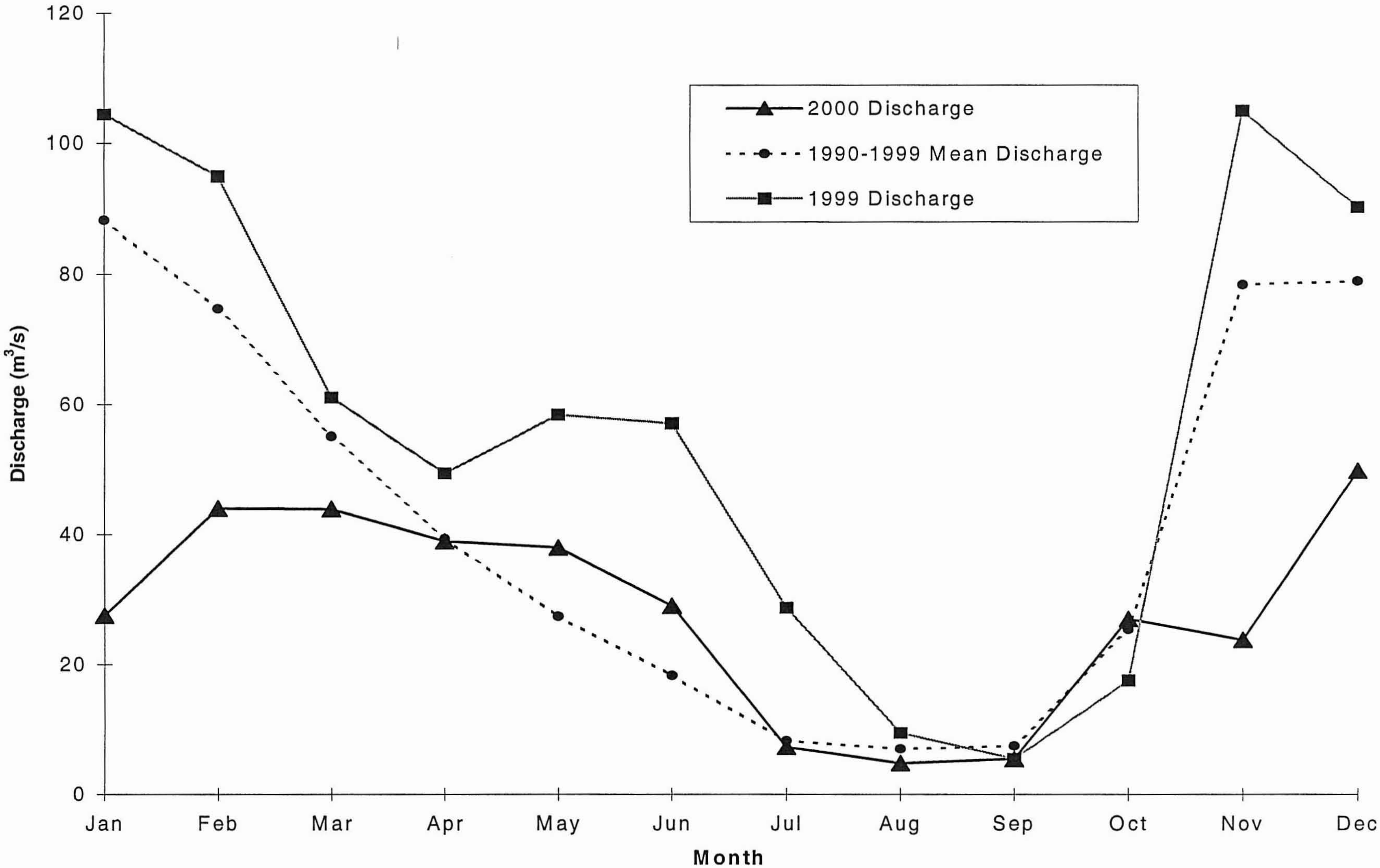


Figure 5. Monthly Nanaimo River discharge (m^3/s) in 1999 and 2000 with historical values.

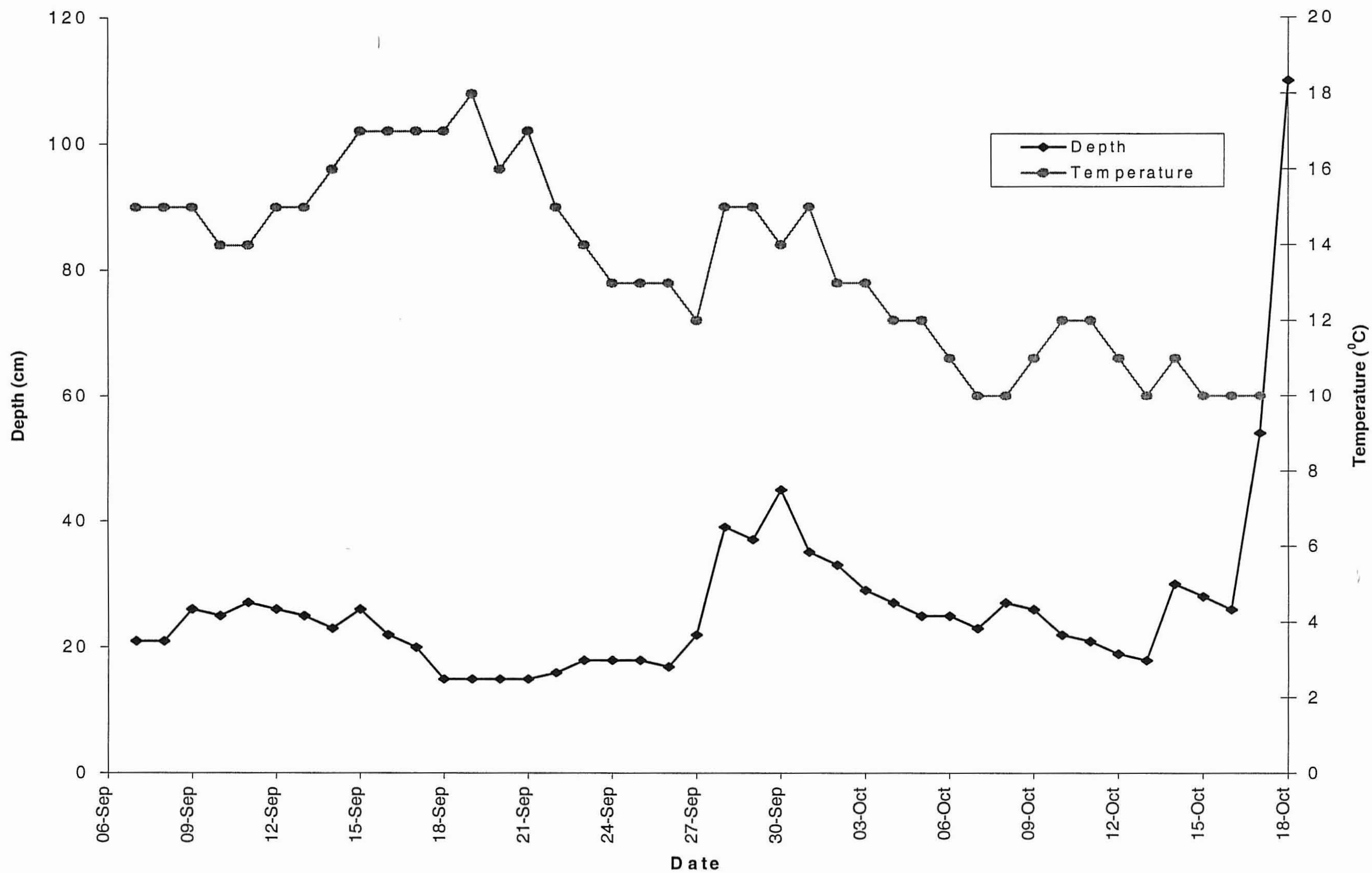


Figure 6. Average depth and water temperature at the Nanaimo River enumeration fence, 2000.

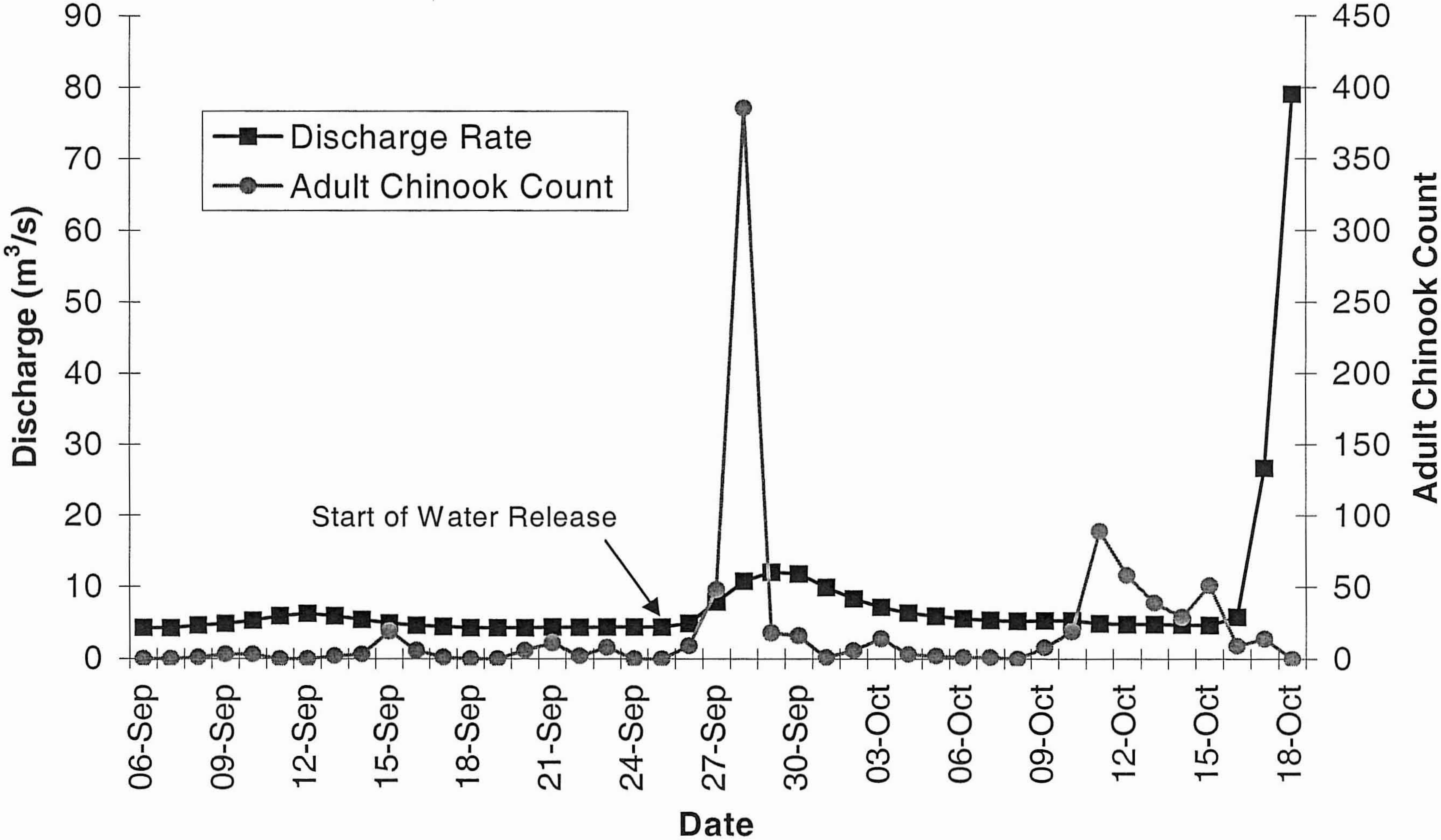


Figure 7. Daily discharge and adult chinook count, Nanaimo River, 2000.

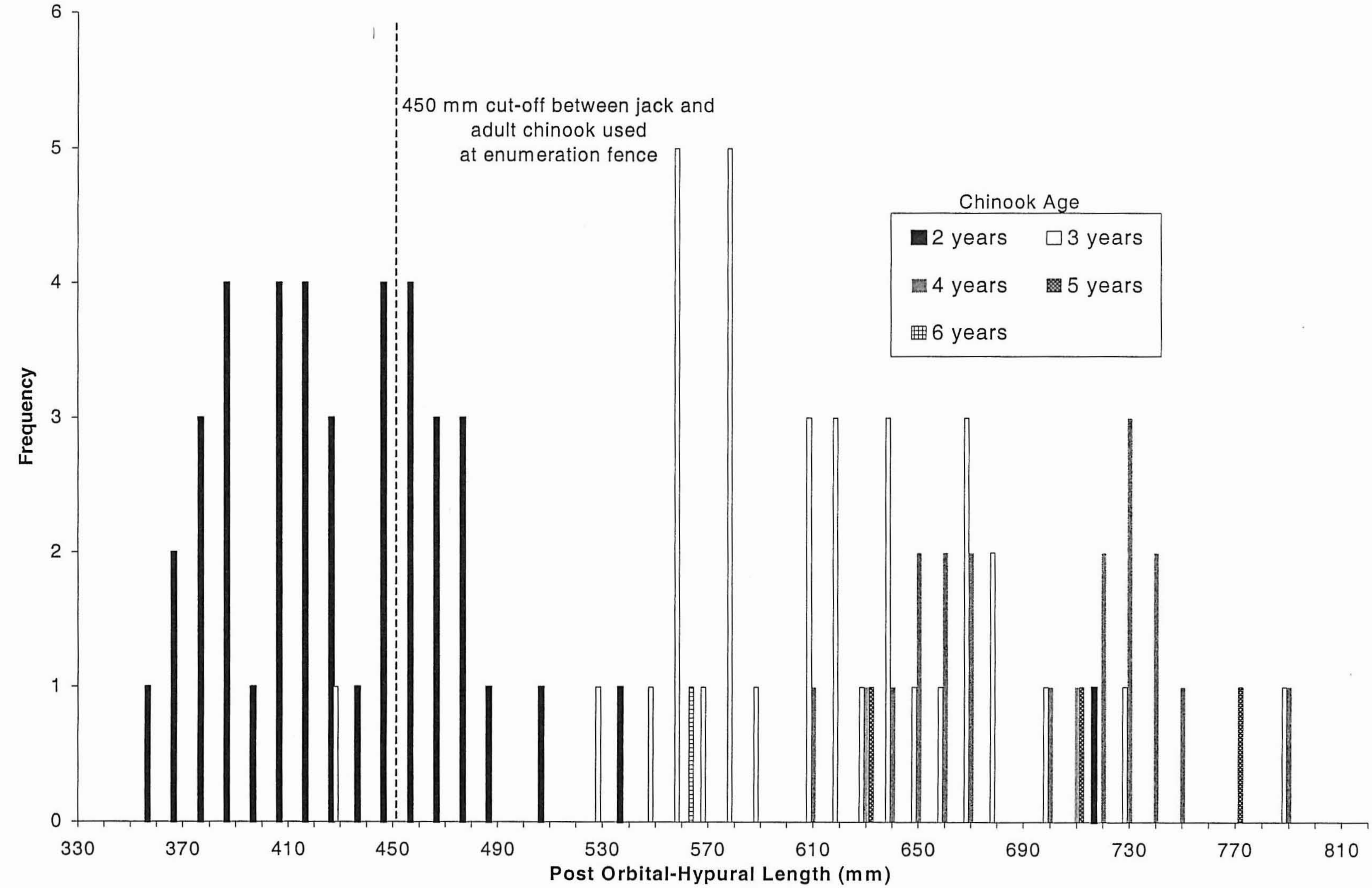


Figure 8. Jack and adult chinook length-frequencies, stratified by age, collected from the Nanaimo River spawning grounds, 2000.