Adult Chinook Escapement Assessment Conducted on the Nanaimo River During 2010

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by

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ABSTRACT

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In 2010, Fisheries and Oceans Canada in co-operation with Snuneymuxw First Nation and Nanaimo River Hatchery continued an escapement study of chinook salmon (*Oncorhynchus tshawytscha*) in the Nanaimo River. Areas of concentration for this study included:

i) Calculating Petersen population estimates through carcass mark-recapture surveys for fall run chinook;
ii) Generating an area-under-the-curve population estimate by conducting swim surveys in the lower Nanaimo River for fall run chinook;
iii) Enumerating summer run chinook by snorkel surveys;
iv) Enumerating the chinook food fish catch by Snuneymuxw First Nation; and
v) Collecting and analyzing biological data, including sex, age, length, adipose clip, coded-wire tag (CWT) data and thermal mark otolith data.

In 2010, the estimated total return of fall run adult chinook to the Nanaimo River was the AUC estimate of 2,201 fish of which 1,989 spawned naturally and 162 were used removed for broodstock. The Petersen mark-recapture estimate for the fall run was biased low; therefore the AUC estimate was used for the final estimate. No Petersen mark-recapture study was performed in the upper river on the First Lake summer run chinook. Hatchery broodstock collection and snorkel surveys estimated the naturally spawning population of this stock to be 561 adults and the total return to be 675 adults (including 114 spawned broodstock). In addition, an estimated 50 adults were harvested by the Snuneymuxw for food fish from the lower Nanaimo River between the Cedar Bridge and the Estuary. Total return of all adult chinook to the Nanaimo River system in 2010 was 2,876 fish.

RÉSUMÉ

Watson, N.M. 2013. Adult chinook escapement assessment conducted on the Nanaimo River during 2010. Can. Manuscr. Rep. Fish. Aquat. Sci. 3011: ix + 43 p.

En 2010, Pêches et Océans Canada, en collaboration avec la Première Nation Snuneymuxw et l'écloserie de la rivière Nanaimo, a poursuivi son étude sur les échappées de saumon quinnat (*Oncorhynchus tshawytscha*) dans la rivière Nanaimo. Cette étude visait surtout à :

- i) Estimer la population selon la méthode de Petersen à partir de relevés de marquage-recapture de carcasses lors de la remonte d'automne du saumon quinnat.
- ii) Réaliser une estimation de la population avec la méthode de la surface sous la courbe à partir de relevés à la nage effectués dans le cours inférieur de la rivière Nanaimo lors de la remonte d'automne du saumon quinnat.
- iii) Dénombrer les saumons quinnat lors de la remonte d'été au moyen de relevés au tuba;
- iv) Quantifier les prises de saumon quinnat comme poisson de consommation par la Première Nation Snuneymuxw;
- v) Recueillir et analyser des donnes biologiques, notamment les données concernant le sexe, l'âge, la taille, l'ablation de la nageoire adipeuse, la micromarque magnétisée codée (MMC) et le marquage thermique de l'otolithe.

En 2010, les montaisons totales estimatives de saumon quinnat adulte lors de la remonte d'automne dans la rivière Nanaimo correspondaient à une estimation de la surface sous la courbe de 2 201 poissons dont 1 989 se reproduisant de manière naturelle et 162 retirés pour le stock de reproduction. Étant donné que l'estimation selon la méthode de Petersen par marquage-recapture pour la remonte d'automne est une estimation à la baisse, on a eu recours à l'estimation de la surface sous la courbe pour l'estimation définitive. La remonte d'été de First Lake du saumon quinnat dans le cours supérieur du fleuve n'a fait l'objet d'aucune étude de marquage-recapture selon la méthode de Petersen. La collecte de géniteurs d'écloserie et les relevés au tuba ont permis d'estimer la population de poissons reproducteurs naturels de ce stock à 561 adultes et les montaisons totales à 675 adultes (y compris un stock de géniteurs de 114 poissons). De plus, on estime que 50 adultes du cours inférieur de la rivière Nanaimo, entre Cedar Bridge et l'estuaire, ont été pêchés par la Première Nation Snuneymuxw comme poissons de consommation. Les montaisons totales de saumon quinnat dans le réseau hydrographique de la rivière Nanaimo s'élevaient à 2 876 poissons en 2010.

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, 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 discontinued as an exploitation rate indicator in 2002 and the enumeration fence was discontinued the following season in 2003. However, the Nanaimo River system remains an important escapement indicator for lower Strait of Georgia chinook with the unique distinction of monitoring one fall and two earlier runs (spring and summer).

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 early chinook stocks and one fall run stock returning to the Nanaimo River (Figure 1).

The two early run stocks enter the river between March and August and hold in First Lake (summer run), Second Lake (spring run) 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, in October (Hardie 2002). The majority of fry are stream-type which rear for up to one year before out-migrating to the estuary (Healey 1980, Blackman 1981, Nagtegaal and Carter 2000).

The First Lake summer run spawns within the first two kilometers downstream of the First Lake outlet to the Wolf Creek junction pool (Healey and Jordan 1982, Hardie 2002). The peak of spawning is typically during the first two weeks of October (Nagtegaal and Carter 2000, Brahniuk et al., 1993). Chinook fry produced from the summer 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 out-migrate upon emergence. Once in the estuary, First Lake fry exhibit greater agonistic behaviour 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/September 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, out-migrating to sea to rear in the estuary upon emergence (Healey and Jordan 1982).

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 char (*Salvelinus malma*).

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 fall run chinook fry were released. Over the years fry production has increased, and the release target from 2010 brood year was 405,000 fall run fed fry and 225,000 summer run fed fry. In May 2011, a total of 436,769 fall run chinook fry and 226,193 First Lake summer run chinook fry from the 2010 brood year were released into the Nanaimo River and First Lake, respectively. There is no hatchery enhancement for the upper Nanaimo River spring run chinook stock.

Coded-wire tagging of chinook began with 1979 broodyear fish and by 2004 broodyear, 75.6% of fall run chinook fry carried coded-wire tags (CWT). In 2004 the Cowichan River lost all its brood stock due to heavy snowfall resulting in a power and pump failure. Therefore no fry were available to be coded-wire tagged from Cowichan. As an alternative, it was decided by DFO to tag the Nanaimo River fry and the river was used as the surrogate indicator for that brood year. No coded-wire tagged chinook fry have been released in the Nanaimo River since 2005 (2004 brood year). Also no chinook fry have been adipose clipped since 2005 brood year.

Over the past several years, the system has been comprehensively assessed using alternative escapement methods (i.e. Area Under the Curve and Petersen mark-recapture) to estimate the chinook population returning to the watershed. In 2010, DFO, Science Branch, in conjunction with Snuneymuxw First Nation and the Nanaimo River Hatchery continued to operate carcass mark-recapture and swim survey programs to collect chinook escapement, coded-wire tag information and otolith thermal mark data.

Thermal marking of Nanaimo River summer run and fall run chinook otoliths began with 2005 brood year fish and this method replaced coded-wire tagging. The 2005 brood year fish were released in 2006 as fed fry with thermal marks. Otolith marking has been done each year since 2005 on all hatchery fry prior to release. Recoveries of marked fish in the hatchery broodstock and carcass recovery samples can be used to show the proportion of thermally marked hatchery fish in the escapement, as well as identify strays in the escapement from other hatcheries that thermally mark fish. Chinook fry released from these hatcheries have been exposed to varying temperatures and as a result, have a specific banding pattern on their otoliths (Hoyseth and Hargreaves 1995). For more information on the thermal marking of Pacific Salmon in Canada see O'Brien *et al*., 2012.

In consultation with various user groups, the B.C. Ministry of Environment, Lands and Parks initiated a Nanaimo River Water Management Plan in June of 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).

The objectives of the 2010 chinook escapement study included:

1. Providing fall run and First Lake summer run chinook salmon estimates for the Nanaimo River watershed,
2. Estimating the Snuneymuxw First Nation food fishery catch,
3. Recording hatchery broodstock removals of fall and summer run chinook,

4. Implementing a carcass mark-recapture study for fall run chinook,
5. Collecting biological data, recovering CWT's, and otoliths from both fall and summer run chinook,
6. Generating an area-under-the-curve (AUC) estimate through swim surveys in the lower Nanaimo River for fall run chinook, and
7. Calculating a peak live plus dead estimate through swim surveys in the upper Nanaimo River.

This report presents the results of the escapement study completed during 2010. Analysis of biological data collected through carcass sampling and hatchery broodstock sampling are presented for both fall and summer run chinook populations.

METHODS

The methods employed to estimate fall and summer run chinook spawning escapement in the Nanaimo River include carcass mark-recapture techniques, swim survey counts, AUC analysis of swim surveys and aerial surveys. The pooled Petersen mark-recapture calculation and the AUC estimate were used to generate a chinook population estimate for lower river fall stock only. The enumeration of the summer run chinook was limited to swim counts providing a peak live plus dead estimate. Biological data including length, sex, scales, presence/absence of an adipose fin, otolith marks and coded-wire tagged heads were collected from carcasses during mark-recapture and broodstock collection programs for both fall and summer run chinook.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

Escapement estimates were generated from mark-recapture data using the pooled Petersen model (Chapman modification; Ricker 1975) for fall run adult and jack chinook. The mark-recapture also provided information on length frequencies, age compositions, and sex composition. In the past, CWT data were also collected for use in calculating enhanced (hatchery) contribution in the Nanaimo River watershed, but CWT's have not been applied on Nanaimo stocks since 2005 brood year. CWT data are still used to identify marked fish entering and spawning in the Nanaimo River that originated from other hatcheries. Otoliths were also collected to determine the mark rate of sampled fish and the hatchery of origin based on the specific thermal mark.

The carcass mark-recapture estimate is based on recoveries of chinook carcasses tagged on the lower Nanaimo River spawning grounds. This method of population estimation is implemented for several reasons. First, the handling and tagging of live chinook causes stress and could delay the upstream migration. Second, the carcasses provide the primary source of CWT and otolith recoveries and biological information. For these reasons the tagging of chinook carcasses is preferred because it provides an independent estimate of population while minimizing the physical contact to spawning chinook salmon.

The carcass mark-recapture operation involved a crew of three people in an inflatable boat searching the river daily for spawned-out chinook carcasses. Each carcass was tagged with a numbered Ketchum[1] aluminum sheep ear tag on the left operculum and released into the river. Fish were also hole-punched in the left operculum in case the aluminum tag was lost. For all recaptures, tag number and location were recorded. Once recaptured, the carcass was removed from the river to avoid multiple recaptures.

Biological information such as post orbital-hypural (POH) length, sex, capture location, and the presence or absence of an adipose fin were recorded. If the adipose fin was missing the head was catalogued and taken for CWT analysis at the laboratory. Five scale samples were taken from the preferred area to be analyzed for age composition (Shaw 1994). Otoliths were also collected from chinook for examination for thermal marking to assess the possibility of strays from large scale hatcheries from the US and Canada as well as to calculate enhanced (hatchery) contribution.

Recovery effort was concentrated on the lower portion of the Nanaimo River sampling fall run chinook, which generally spawn between the Island Highway Bridge and the Cedar Bridge (Figure 2). Biological sampling was conducted on the upper portion of the Nanaimo River targeting First Lake summer run chinook, which spawn in a two-kilometer stretch of river between the outlet of First Lake and the Wolf Creek confluence. No Petersen mark-recapture was completed on this stock and once sampled, carcasses were removed from the river to prevent recaptures.

Biological information similar to that recorded for the carcass mark-recapture was provided by Nanaimo River Hatchery staff from chinook collected for purposes of broodstock. This included both fall run chinook and First Lake summer run chinook. The hatchery staff only requires a portion of the fish used for broodstock to be sampled, especially when broodstock numbers are high.

The field designations of male and jack chinook during the broodstock collection were based on POH length and any male chinook collected that were less than 50 cm were provisionally called a jack. Following age analysis of these samples, all chinook showing only one marine annulus were jacks and all fish with more than one marine annulus were males.

Mark-recapture estimates were calculated using a pooled Petersen estimator. Since the true population size was unknown, 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 mark-recapture was used to attain both samples thus limiting the ability to assess sample bias.

Finding sampling bias 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

[1] Ketchum Manufacturing Ltd., Ottawa, Canada

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; however 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.

SWIM SURVEYS

Nanaimo River Hatchery staff coordinated and conducted swim surveys to provide an independent estimate of spawning chinook and to assess spawning distribution throughout select portions of the lower Nanaimo River. Swim surveys were carried out using three or four swimmers who stay abreast of each other while moving downstream. Swimmers combined individual counts, which were recorded by pre-defined localities in the river (Figure 2).

Swim survey counts were used to calculate an AUC estimate for fall run chinook (English et al. 1992; Irvine et al. 1993). In this portion of the river, swim counts were combined from three segments and each count was expanded for observer efficiency and the estimated percent population observed by the swimmers.

Two metrics required in calculating an AUC estimate are survey life and observer efficiency (OE). Generally through a tagging process, a survey life statistic is generated. In the fall of 2007 the tagging was carried out, but soon after a major rain event caused highly turbid water in the system for a number of days. Swims were postponed, and by the time they commenced, there were few tagged chinook remaining in the target reaches; therefore, no survey life was generated for 2007. In 2008, though water conditions were good for observing, there were issues with fish distribution. Fish were not holding in large numbers in the typically accessed pools and consequently too few fish were available for capture and tagging for calculating an updated survey life statistic. For these reasons, AUC calculations still use the 2006 survey life of 11.5 days. The important factor of observer efficiency accounts for fish missed by observers during the swim survey, due to visibility, light levels, water turbidity, precipitation and flow conditions. Observer efficiency can also account for areas where fish can hide, such as deep pools or log jams.

Percent population (PP) can also be used in the AUC estimate to account for portions of the habitat that were unsurveyed during the swim survey compared to the amount of habitat available. If the entire habitat was covered during the swim survey, PP is 100% and there are no further expansions. In some cases, the full extent of the habitat is not surveyed (PP <100%) and the swim count is expanded for the proportion missed.

AERIAL SURVEYS

Aerial surveys were conducted throughout the Nanaimo River watershed, which were focused on enumerating chinook and chum salmon. The helicopter, an Aerospatiale A-star 350B, was flown at low altitude, approximately 300 feet (~91.4 m), to aid in visibility and identification of salmon species. Counts were made by river pool or river section and combined to obtain a final estimate. One to three observers were employed for each survey and observer counts are compared following the survey.

FIRST NATIONS FOOD FISHERY

An in-river rod and gillnet fishery for chinook takes place in late August through October to provide food, social, and ceremonial fish for the Snuneymuxw First Nation (SFN). This fishery is held in a one-kilometer area downstream from the Cedar Bridge to the estuary and is monitored by the SFN Fisheries Guardians who assist in producing a total First Nations catch estimate. The survey staff were directed to traverse the section of the river where fishing takes place and perform effort counts as well as interview fishers and record their catch and fishing times.

WATER MANAGEMENT PLAN

Low flows and water levels likely result in delayed fish movement and resulting higher water temperatures may potentially increase levels of disease and parasites. This is particularly true for the parasite Ich (*Ichthyophthirius, sp.*), 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.

Two man-made reservoirs in the Nanaimo River system have been utilized 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 (NRWMP) was initiated by the B.C. Ministry of Environment (BCMOE) in June of 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 ten-kilometer 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.

The Nanaimo River Water Management Plan also incorporates the ramping (a gradual increase and/or decrease) of water levels to minimize effects of sudden changes in river dynamics. Possible effects include the stranding of fish, alteration of river hydrology, and erosion of riverbanks. The recommended minimum duration of a water release is 48 hours, with the optimum release time being three to four days. The recommended minimum discharge for a water release is 14.87 m^3/s (525 ft^3/s), to be released from Fourth Lake (Hop Wo *et al.* 2005).

2010 RESULTS

CARCASS MARK-RECAPTURE

In 2010, the carcass mark-recapture program was completed on the lower Nanaimo River only. Due to limited crew availability there were no mark recapture data collected for the upper Nanaimo River summer run. A DFO crew accessed the upper river to perform biological data collection on three days; 19 and 28 October and 9 November. These data were used to determine the range and average lengths of chinook on the spawning grounds, as well as the age structure, mark rate and otolith analysis of the summer run chinook from First Lake to Wolf Creek.

Lower Nanaimo River

The lower Nanaimo River carcass mark-recapture commenced on 18 October, consisted of 24 sampling days, and was completed 19 November (Table 2). Daily Nanaimo River discharge for the duration of the carcass mark-recapture and a timeline of swim surveys and mark recapture program for the fall run stock are presented in Table 1 and Figure 3, respectively.

During the sampling period, 49 male, 103 female, 62 jack and 3 unknown adult chinook were tagged and released in the lower Nanaimo River (Table 2). Tagged carcasses recaptured included 13 (19.7%) males, 31 (47.0%) females, 18 (27.3%) jacks and 4 (6.1%) unknown adults. Using the Petersen estimator, the total adult lower Nanaimo River fall run chinook population estimate was 670 adults (95% CL: 500 – 840) and 269 jack (95% CL: 166 – 372), resulting in a total population estimate of 924 chinook (95% CL: 732 – 1116; Table 3).

Male chinook observed on the carcass mark-recapture were provisionally designated as an adult (Age 3_1+ Gilbert Rich age[2]) or jack (Age 2_1) based on size (<450 mm POH length designated as jack). The ability to divide males based on age was utilized once the scales were read. Age information provided from scale data determined that 16 adults were found to be incorrectly identified as jacks. There was no differentiation made for female chinook regardless of scale age data but females ranged in Gilbert Rich ages of 2_1, 3_1, 4_1 or 5_1 (Table 7A).

Potential Biases

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

1. Temporal Bias: Temporal recovery bias was assessed by stratifying application data into five discrete periods and comparing recovered and unrecovered tags to total tags applied. With a total of 24 sampling days, which cannot be evenly stratified into five equal periods; the second last period has one less day than the other four (Table 9). This will also help offset the fewer tags in the system at the beginning of the study. A Chi-square test was performed on males,

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[2]Gilbert Rich age, where the first number indicates the total age and the second number subscript indicates the number of years spent in freshwater

females, jacks, adults combined and all combined. Males and jacks were both limited to relatively small sample sizes (13 and 18 recoveries, respectively, over the 24-day period) and were therefore assessed combined as well. A moderately significant temporal bias was found with females (Chi-Square = 9.56; $p<0.05$) and a significant bias was found when adults were pooled (Chi-Square = 15.47; $p<0.01$). No significant temporal bias was found in the recovery of males (Chi-Square = 2.08), jacks (Chi-Square = 5.45), males and jacks combined (Chi-Square = 3.69) or pooled sexes (Chi-Square = 7.86).

Temporal application bias was assessed by stratifying recovery data into five discrete periods and comparing tagged and untagged recoveries to total recoveries. The same time periods were used in these calculations. A Chi-square test was performed on males, females, combined adults, jacks, males and jacks combined and all combined. No significant temporal bias was found with adult males (Chi-square = 3.54) or males and jacks combined (Chi-square = 7.06), however, females (Chi-square = 19.13; $p<0.01$), jacks (Chi-square = 17.44; $p<0.005$), adults combined (Chi-square = 12.13; $p<0.05$) and all combined (Chi-square = 13.03; $p<0.05$) were found to be significantly biased.

2. Fish Sex Bias: Sex related bias was examined by comparing the sex ratios of the application samples and recovery samples for adult males, females and jacks. No sex related bias was evident when comparing male, female or jack populations between the application and recovery samples (Chi-square = 0.11 and Chi-square = 0.21, respectively).

3. Size Bias: Size related bias was examined by comparing the mean POH lengths of marked and recovered chinook by sex. No significant size bias was evident in the recovery samples of adult male, female, or jack chinook (Students t-test: $t = 0.76$; $p<0.50$, $t = 0.24$; $p<0.90$, and $t = 0.49$; $p<0.70$ for males, females, and jacks, respectively).

SWIM SURVEYS

In 2010, a total of ten swim surveys were conducted. Eight swim surveys were focused in the lower portion of the Nanaimo River to determine fall chinook abundance and distribution (Table 4). Swims in the lower river began on 30 August and ended on 19 October. Most of these swims started at the Island Highway Bridge pool and ended at Raines Rock pool within tidal influence and targeted fall run chinook (Figure 2). The final swim ended at the Firehall Pool due to high numbers of chum and few chinook downstream of this pool area. Two swims were conducted in the upper Nanaimo River to determine First Lake summer run abundance and distribution. The first swim was on 26 July and included only spot checks in pools. The second swim on 13 October was past the peak of the run and many fish were already spawned out and dead (Table 4).

Swim surveys conducted in lower portions of the Nanaimo River Watershed between 7 September and 19 October were used to calculate an AUC estimate for fall run chinook. These swims were differentiated into three segments which contained multiple adjacent pools and riffle sections, specifically; Segment 1, Bridge Pool to Haslam Creek Junction; Segment 2, Haslam Creek Junction to Cedar Bridge; Segment 3, Cedar Bridge to Estuary (Figure 2). Observer efficiency varied slightly between swims, but remained adequate throughout the survey period as water levels stayed low to moderate and visibility was good in generally clear water. Percent population dropped over time because the swimmers did not swim past the extent of the chinook range due to the migration of chum into the lower river. Daily Nanaimo River discharge during the course of the swim surveys is presented in Figure 3 and includes swim survey start and end dates.

AREA UNDER THE CURVE

In 2006, the process was completed to establish the survey life of Nanaimo River chinook. Two reconnaissance swims were conducted prior to the tagging day and on 28 September, 145 chinook, comprised of 45 adult males, 50 females and 50 jacks were tagged with fluorescent spaghetti tags and released in the San Salvador area. A follow up swim was conducted on 29 September to count the number of tagged fish in the system. Subsequent swims were conducted weekly to estimate the overall number of chinook in the lower river as well as count the remaining tagged chinook. Through this process a survey life statistic of 11.5 days was generated.

In 2007 and 2008 survey life estimates were unable to be completed. In 2007 tagging was completed, but due to a storm event delaying swims, an accurate survey life could not be derived. In 2008 insufficient fish were available for capture in the typical holding pools appropriate for seining and as a result no tagging was completed. No tagging studies for estimating survey life have been attempted since 2008.

A start date of 27 August was chosen as a time just before fall run chinook entered the survey area (approximately ten days before the first complete swim). The last of the fall run chinook were estimated to have entered the river 12 days after the last swim, yielding an end date of 31 October.

Observer Efficiency was variable during swims in 2010, ranging from 69% - 95%, and PP ranged from 40% during spot checks up to 100% for a complete swim survey (Table 4 and Figure 5). Observer Efficiency was low on 28 September and 12 October (69% and 70% respectively) due to low visibility in deep pools and high water levels. Percent Population was 40% for the spot checks done on 26 July because the crew only checked the deep pools where fish were holding and much of the habitat was unsurveyed. During the second half of the survey period PP decreased to 70% because the swim crew were unable to survey the whole habitat extent for chinook.

The calculated AUC estimate for fall run adult chinook in the lower Nanaimo River in 2010 using a survey life of 11.5 days is 2,201 fish. An AUC estimate was also generated for fall run jack chinook within the lower Nanaimo River using the same survey life but with no expansions (no OE or PP expansions). This methodology yielded an estimate of 1,040 jack chinook. It is important to note both of these AUC estimates are for total returns and have not been adjusted for broodstock removals or FSC catch. No AUC estimate was calculated for the summer run chinook as there were not sufficient swim data collected targeting this group.

AERIAL SURVEY

One aerial survey was conducted in 2010 primarily to enumerate chum salmon in the lower Nanaimo River; no aerial surveys were directed at chinook escapement enumeration in 2010. The single overflight took place in early November and although some chinook were observed, the flight did not observe a complete count of fall run chinook in the lower river; therefore, there is not a population estimate to report based on this flight. The flight revealed very few observations of chinook and took place past the peak of the run.

FIRST NATION FOOD FISHERY

In 2010, two Snuneymuxw First Nation Fishery Guardians attempted to conduct effort counts and interview SFN fishers in the river during the FSC fishery. However, insufficient data were provided to calculate a catch estimate. The Fishery Guardians conducted post-season phone interviews. The result of these interviews included a total of 50 chinook removed from the river by FSC fishers (46 chinook caught by gill net and four caught by rod). This is considered a minimum estimate of chinook catch by the FSC fishery with low reliability due to potential recall biases from post-fishery phone interviews. Due to the lack of in-river interviews, the guardians were also unable to attain biological samples from chinook and coho caught in this fishery in 2010 and as a result, comparing size, age and mark rates as was done in previous years, could not be completed.

BROODSTOCK REMOVALS

From 22 September to 20 October, Nanaimo River Hatchery's field records show 90 male, 97 female, and 63 jack fall run chinook were collected for broodstock purposes from lower portions of the Nanaimo River during six collection days (Table 5). Of these fish, 59 males, 93 females and 31 jack were spawned for broodstock and the remaining fish were either mortalities (six males, four females and 12 jack) or released (25 males and 20 jack) back into the lower river on 30 October. On 5 and 6 October, 77 male, 63 female and three jack First Lake summer run broodstock chinook were collected from First Lake. Of these fish, 58 males, 56 females and two jacks were spawned for broodstock and the remaining fish were released back into First Lake on 12 October (19 males, seven females and one jack). No upper Nanaimo River spring run chinook were removed for hatchery broodstock.

BIOLOGICAL DATA

During the lower Nanaimo River spawning ground carcass mark-recapture, 49 male, 103 female, three unknown adults and 62 jack fall run chinook carcasses were biologically sampled and measured for POH length (Table 2). The lengths of adult male chinook ranged from 45 cm to 78 cm and averaged 62.5 cm (Table 6A). Adult females ranged from 52 cm to 84 cm and averaged 67.5 cm. Jack chinook ranged in length from 35 cm to 64 cm and averaged 43.3 cm. One jack chinook included in the samples was much larger than the remaining jacks (64 cm) but age results indicate that this fish was a 2-year old. Excluding this fish from the samples, the maximum length of jacks was 50 cm with an average of 43.0 cm. Of all the fish sampled during the carcass mark recapture, only one female was missing an adipose fin, resulting in a female mark rate of 1.0% (Table 6A).

Age analysis (Gilbert Rich age) of fall male chinook revealed that 60.7% were 2_1, 24.7% were 3_1, 12.4% were 4_1, 1.1% were 5_1 and 1.1% were 5_2 (Table 7A). Analysis of fall female chinook scales indicated that 1.4% were 2_1, 50.0% were 3_1, 47.1% were 4_1 and 1.4% were 5_1. Only one male fish had scales exhibiting over-wintering in freshwater (age 5_2).

During the upper Nanaimo River spawning ground carcass biological sampling, 24 male, 50 female, and 13 jack summer run chinook carcasses were biologically sampled and measured for POH length. The lengths of adult male chinook ranged from 50 cm to 75 cm and averaged 60.2 cm, females ranged from 55 cm to 77 cm and averaged 67.7 cm, and jacks ranged from 34 cm to 52 cm and averaged 43.1 cm (Table 6B). None of the fish sampled in the upper river were missing adipose fins.

Age analysis of male chinook revealed that 28.6% were 2_1, 54.3% were 3_1, 8.6% were 3_2 and 8.6% were 4_1 (Table 7B). Analysis of female chinook scales yielded that 71.4% were 3_1, 2.4% were 3_2, 21.4% were 4_1, 2.4% were 4_2 and 2.4% were 5_1. Five of the upper river chinook (three males and two females) were found to exhibit over-wintering in freshwater (one age 4_2 female and the remaining four fish were age 3_2).

Of fish sampled during the carcass biological sampling operations, there were no significant differences between the mean lengths of lower and upper river male chinook (Students t-test: t = 1.34; p<0.20), female chinook (Students t-test: t = 0.19; p<0.90) or jack chinook (Students t-test: t = 0.18; p<0.90). Average length at age was calculated for both fall run and summer run chinook sampled on the spawning grounds and these data are presented in Table 8.

Following age analysis and biological sampling of the fall run hatchery broodstock, 25 fish that were formerly designated as adult males were corrected to be jacks (age 2) and 8 fish that were recorded as females were actually adult males. The Nanaimo Hatchery staff also included some broodstock morts in their biosampling that were not spawned. From the biological sampling data, a total of 44 adult male, 85 female, and 56 jack fall run chinook were sampled from hatchery broodstock, measured for POH length, age samples and examined for adipose-clipped fins. Adult male chinook ranged from 49 cm to 80 cm and averaged 64.9 cm. Female chinook lengths ranged from 54 cm to 81 cm and averaged 68.2 cm, jack chinook ranged from 36 cm to 53 cm and averaged 47.0 cm (Table 10A).

Four females were found to be missing adipose fins resulting in a mark rate of 4.7%; no other fish sampled were missing adipose fins (Table 10A). Ages of fish identified as male chinook were 66.7% 2_1, 21.9% 3_1, 9.0% 4_1 and 2.6% 5_1. Female chinook were 44.3% 3_1, 54.3% 4_1 and 1.4% 5_1 (Table 11A). All fall run chinook were found to be ocean-type chinook as no scales exhibited over-wintering in freshwater.

The Nanaimo River Hatchery staff sampled 25 males, 25 females and 1 jack during the broodstock sampling of summer run chinook. Males ranged from 50 cm to 71 cm and averaged 61.4 cm, females ranged from 59 cm to 79 cm and averaged 68.8 cm and the jack was 28.0 cm (Table 10B). Age analysis results showed that males were 92.9% 3_1 and 7.1% 4_1 and females were 68.8% 3_1, 25.0% $4_{1.}$ One female was 4_2 (6.3% of females) exhibited over-wintering in freshwater (Table 11B).

When comparing mean lengths of fall run jack chinook recovered from the lower Nanaimo River spawning grounds to jack hatchery broodstock samples, it was found that the broodstock fish were significantly larger than fish from the Petersen mark-recapture study (Student's t-test: t = 4.96; p<0.0001). T-test comparisons between mean length of male chinook sampled at the hatchery and those recovered in the lower mark-recapture programs revealed no significant difference in mean length (Student's t-test: t = 1.48; p<0.15). Similarly, there was no significant statistical difference between the mean lengths of fall run females sampled at the hatchery and those from the lower Nanaimo River mark-recapture program (Student's t-test: t = 0.72; p<0.50).

Comparisons between mean lengths of summer run male chinook recovered on the spawning grounds and chinook sampled from hatchery broodstock yielded no significant difference (Student's t-test: $t = 0.68$; $p<0.50$). Similarly lengths of summer run female fish sampled at the hatchery were not significantly different in size from fish sampled on the spawning grounds (Student's t-test: $t = 0.73$; $p<0.50$). Summer run jacks could not be compared since only one jack was sampled at the hatchery. When all male and jack lengths were pooled together, there was a significant difference between the hatchery broodstock and fish recovered from the spawning grounds (Student's t-test: $t = 1.38$; $p<0.05$) inferring broodstock sampled fish were significantly larger.

A highly significant difference was found between the mean lengths of female and male summer run broodstock sampled at the Nanaimo River hatchery (Student's t-test: $t = 4.53$; $p<0.0001$) where females were found to be significantly larger. Similarly there was a significant difference in mean lengths of female and male fall run broodstock (Student's t-test: $t = 2.65$; $p<0.01$) where females were significantly larger. Average length at age was calculated for both fall run and summer run chinook and these data are presented in Table 12.

One female fall run chinook carcass recovered on the spawning grounds was missing an adipose fin but this fish was not found to contain a CWT. None of the fish sampled in the summer run carcass sampling were adipose clipped.

The Nanaimo River Hatchery found four chinook collected for fall run broodstock to be missing adipose fins, denoting the possible presence of a CWT. No summer run broodstock fish were found to be marked. All four of the fall run chinook heads sent in for analysis were found to contain CWT's. Of these four fish (all female), one was released from the Chemainus River from the 2006 brood year. The remaining three fish were from Cowichan River, one from 2006 brood and two from 2007 brood (Table 13). For a list of Nanaimo River Hatchery fry releases, brood years 1997 – 2010, see Table 14. For fry releases to the Chemainus River and Cowichan River Watershed, brood years 2002 – 2010, see Table 15.

A Chi-square comparison between female chinook mark rates obtained from lower Nanaimo River carcass mark-recapture and fall run broodstock collection was calculated. Only five females were found to have adipose clips in these samples (four from the fall broodstock and one from the fall mark-recapture program). No other fish collected during the broodstock or carcass recovery programs had adipose clips. When comparing the females obtained from fall run chinook collected in the carcass mark-recapture and broodstock, there was no statistically significant difference found (Chi-square = 2.51).

Otoliths were collected from 197 chinook carcasses (47 male, 90 female, 60 jack) from the lower river and 83 (24 male, 46 female, 13 jack) from the upper river. Results from the lower fall run indicate that 77.7% were marked (16.0% of males, 34.0% of females and 27.7% of jacks; seven were destroyed and two had no sample). One fish had an adipose clip but the otolith was destroyed from this sample and therefore had no result. Results from the upper summer run carcass samples indicate that 37.5% were marked (7.5% of males, 22.5% of females and 7.5% of jacks; three were destroyed). All otolith marks were determined to be from the Nanaimo River Hatchery.

Nanaimo River Hatchery staff collected 185 otoliths from fall broodstock (44 male, 85 female and 56 jack) and 51 otoliths from summer broodstock (25 male, 25 female and 1 jack). Results from the fall run broodstock indicate that 85.5% were marked (14.8% of males, 40.2% of females and 30.2% of jacks; 10 were destroyed, one had no sample and one was unreadable). Of these samples, four females had adipose clips and CWT's. The CWT results for three of the four fish matched the otolith marks from the Cowichan River brood years 2006 and 2007. The CWT and otolith results from the fourth fish indicated the fish was thermally marked at Nitinat Hatchery and released in the Chemainus River (Table 13). All other thermally marked otoliths were from the Nanaimo River Hatchery.

Results from the summer run broodstock indicate that 54.2% were marked (29.2% of males and 25.0% of females; three were destroyed and the single jack was not marked). All summer run fish that had marked otoliths were marked from Nanaimo Hatchery and none were strays from other hatcheries.

WATER MANAGEMENT PLAN

In 2010, there were no scheduled water releases to assist in migration of the chinook stocks in the Nanaimo River. Water levels were low (less than the recommended flow of $15m^3/s$) until 25 September. Following this date, there was sufficient rainfall which kept river levels elevated for the remainder of October and through November, therefore, water releases were not required. The average daily flow for the month of October was 35.5 m^3/s; well above the target release rate for migrating salmon of ~$15m^3/s$. Daily Nanaimo River discharge is presented in Table 1 and Figure 3. A summary of mean monthly Nanaimo River discharge (including minimum and maximum) and historical monthly mean is presented in Figure 4.

POPULATION ESTIMATE

The estimated total return of chinook to the Nanaimo River Watershed for summer and fall run stocks combined is 2,876 adult and 1149 jack. The number of naturally spawning fall run adult chinook in the Nanaimo River during 2010 was determined to be the AUC swim survey estimate (2,201 fish) minus the net fall run broodstock removals (152 spawned and 10 morts) and the 50 chinook caught in the FSC fishery. Unspawned broodstock removals that were returned to the river included 25 male adults and 20 jacks and these fish were released on 30 October. Following this methodology, the total number of adult fall run chinook spawning naturally in the Nanaimo River was estimated to be 1,989 fish (Table 16A).

The Petersen mark-recapture calculation was also employed to estimate the fall run population. Through this methodology, the estimate was 670 adults (95% CI 500-840) and 269 jacks (95% CI 166-372), equalling a total return of 924 natural spawners (95% CI 732-1116; Table 3). The total return estimate would include the addition of broodstock removals (162 adults and 43 jack) and FSC catch (50 fish) to give a total of 882 adults and 312 jack, equalling 1194 fish.

Using the peak swim count as the only escapement estimate, the number of returning summer run fish was estimated to be 561 adult (including 135 dead adults) and 107 jack (including six dead jack; peak live plus dead count on 13 October; Table 4) plus the broodstock capture of 114 adult and two jack (Table 5). This yields a total summer run return of 675 adult and 109 jack chinook (Table 16).

The total return for all jack chinook to the Nanaimo River was estimated to be the total fall run jack chinook (1040 AUC estimate), plus total First Lake summer run jack chinook (109 peak live plus dead estimate), yielding 1,149 fish (Table 16B). The AUC estimate of 1040 includes 43 jacks removed for broodstock (31 spawned and 12 morts) and 20 jacks that were released back into the river. The peak live plus dead estimate of summer run jack chinook includes three fish that were removed for broodstock (two spawned and one released back into the river prior to the swim survey; Table 5).

No escapement estimate for the spring run stock was completed in 2010. No swim surveys were conducted above the outlet of First Lake and any spring run chinook would likely have been past this point in the system prior to the first swim survey spot check on 26 July.

In the past, enhanced (hatchery) contribution was calculated by expanding the mark rate (proportion of adipose clipped fish) observed in the carcass mark-recapture program (deadpitch) with the ratio of marked to unmarked hatchery releases. With the discontinuation of coded-wire tagging and adipose clipping, and the advent of thermal marking, the procedure to calculate enhanced contribution has been changed. Hatchery broodstock are not used in the calculation because the capture method is much less random than deadpitch and introduces bias into the enhanced estimate. Total fall run chinook (adults and jacks) enhanced contribution was determined to be 77.7% in 2010 based on otolith mark data from the deadpitch samples. Otolith mark results and calculated hatchery contribution for year previous to 2010 and up to 2011 will be presented in the 2011 Nanaimo River report.

2010 DISCUSSION

CARCASS MARK-RECAPTURE

Variable water conditions existed through most of the mark-recapture program, which commenced on 18 October and ended on 19 November. Water levels were relatively low at the beginning of the program, rose sharply at the beginning of the second week on 25 October and remained average to high until the final day. Water levels during the first three days of the third week were very high as well and during these high water days, carcass recovery was minimal. The average discharge during the entire survey was 53.4m^3/s, with the first peak of 139.0 m^3/s on 26 October and the highest peak of 168.0 m^3/s on 2 November. After this high water event, levels dropped on 4 November and remained at an average of 42.8 m^3/s for the remainder of the program. The high flows during the study period facilitate the mixing of carcasses. If the carcasses do not properly mix they are easily recaptured later on in the study resulting in a low Petersen estimate. Potential biases in the data collection may explain the large difference in population estimates between the AUC and Petersen methods. Without proper mixing and closed containment of the population, it is easy for live or dead fish to enter and leave the sampling area biasing results.

It appears that this year’s data are consistent with past year’s data. A much higher adult escapement estimate was determined from the AUC than the mark-recapture; in 2009, it was not possible to compare these estimates as there were insufficient data to produce a mark-recapture estimate (Figure 7). The raw swim count on 5 October proves that the mark-recapture estimate is biased low since the unexpanded adult chinook count exceeds the total adults estimated from the mark-recapture calculation (Table 3 and 4). For this reasons, the AUC estimate was adopted as the final escapement estimate for the 2010 lower river fall run chinook population.

Lower Nanaimo River

Mark rates were very low for both hatchery broodstock samples and the carcass recovery on the fall run spawning grounds and only females were found to have clipped adipose fins (4.7% and 1.0%, respectively). When comparing mark rates between hatchery samples to the lower river carcass mark-recapture program, a Chi-square analysis was performed. The result indicates no significant difference between the fall hatchery mark rates to that of the lower river carcass recovery program (Chi-square = 2.51). The low mark rates can be attributed to the fact that there has been no CWT tagging or adipose clipping on Nanaimo River hatchery released fish since 2005 (2004 brood year); instead, fish have been thermally marked.

Significant temporal bias was found for recovery samples for females only. This bias however is not entirely unexpected as through the study period more and more fish are available for recapture as more fish are marked over time. The expected bias leans towards a higher rate of recovery later in the study, which was not the case in 2010, except for the last period where recovery did increase (Table 9 and Figure 6). The low recovery rate in the second and third weeks could have been due to extreme rain events that caused the river to rise, making carcasses inaccessible or washed downstream below the survey area. A sharp decline in recoveries is not unusual at the very end of the survey as fewer fish are left in the system to both be tagged and recaptured. In 2010, the river level was higher during the mark-recapture program than in past years, making it more difficult to mark and recapture carcasses. Also, with relatively small sample sizes (as few as zero recoveries in a period) used in these calculations, only a few fish may make a significant difference. There was no significant application bias for adult males or males and jacks combined, however a significant application bias was found for females, jacks, adults combined and pooled sexes. Again these biases are not uncommon being an open site where fewer fish are available for tagging late in the study.

Water discharge can play an important role in the success of the mark-recapture program and with very large fluctuations in water discharge over the sample period, mixing may be variable and access can be difficult. Also, there can be problems with predators (bears) that may remove the tagged carcasses from the sample area, especially during the beginning of the study. As noted in previous years' studies, bears will become satiated after some time and remove fewer carcasses, further biasing the results.

There are also other problems associated with the use of a Petersen mark-recapture study in a river application like the one used. One of the fundamental necessities for a mark-recapture program is the population must be contained or closed. This is not the case as live fish can enter into the sampling area, leave the sampling area, as well as carcasses can leave and enter the area especially during higher flows caused by heavy rains. The water levels during the survey were variable with two extreme high flow events, lasting a few days each. Very few carcasses were captured during these high flow events and fewer carcasses were tagged and recovered each week (Table 2). The final week showed a slight increase in carcasses captured per day compared to the previous week (Figure 6).

No sex related bias was evident in the application or recovery samples when adult male, female and jack chinook were compared. This suggests gender 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 between application and recovery samples.

SWIM SURVEYS

Swim surveys conducted in the lower portion of the Nanaimo River provided the primary information for generating a population estimate and a spawning distribution of fall run chinook. The last date, 31 October, used in AUC calculations, assumes that no more chinook were available to be counted on or after this date. Any chinook entering the system after this date would not be included in the AUC estimate. A tagging study in 2006 conducted to obtain the survey life statistic for lower Nanaimo River chinook, generated an estimate of 11.5 days.

The fall run jack chinook estimate generated by AUC calculations was not expanded for observer efficiency or percent population as was applied to adult chinook. As jack chinook are physically smaller than most adults, jacks may be harder to see in the river and would therefore have lower observer efficiency, resulting in increased expansions to the estimates. Similarly, the survey life statistic of 11.5 days was intended for adult chinook, and therefore assumes that adults and jacks are both available to be counted for the same amount of time. Since the observer efficiencies recorded were for enumeration of adult chinook and there has been no survey life assessment on jack chinook in the Nanaimo River, the counts were not expanded and the final jack estimate may be lower than the actual jack escapement.

Swim surveys in the upper Nanaimo River occurred in 2010 in a two km portion of the spawning area during the migration and spawning period. The results from these swims were solely used to estimate the population of the summer run stock.

AERIAL SURVEY

One aerial survey was conducted on the lower Nanaimo River in 2010 at the end of the chinook spawning timing. Consequently, the aerial survey was not able to provide an independent estimate of fall run chinook as well as spawning distribution. During swims for fall run chinook in the lower Nanaimo River, some misidentification is possible as chum salmon are the most abundant species in the latter part of in-migration in that area. In comparison to swim surveys, aerial surveys are less reliable and due to the late timing, the aerial survey was not used in the population estimate for the chinook stocks in 2010.

FIRST NATIONS FOOD FISHERY

Catch estimation procedures developed by DFO were implemented and conducted by Snuneymuxw First Nation Fishery Guardians in 2010. There was insufficient catch per unit effort and catch data to complete an estimate of FSC catch for 2010. A post-season phone survey was conducted by SFN Fishery Guardians, which yielded a minimum number of 50 chinook caught and removed from the lower river by SFN fishers in 2010. For the purpose of total river returns, this estimate is considered a minimum catch with low reliability as there were likely other fishers that removed chinook from the river and were not contacted by the Fishery Guardians during the phone survey. SFN catch estimates are difficult to compare year to year as methods for determining these results often change annually. In the future, DFO in conjunction with the SFN intend to continue to develop a sampling strategy that will better collect effort and catch information, allowing a more defensible estimate. SFN Fishery Guardians noted that the FSC chinook catch in 2010 was minimal due to the high allocations of food fish (Fraser sockeye) to the Snuneymuxw people and a decreased need to fish for Nanaimo chinook in-river as a food fish.

BIOLOGICAL DATA

Both mark-recapture samples and broodstock samples collected from fall run chinook were expected to have negligible variation in lengths, as they were retrieved from the same population. Jack fall run broodstock were found to be significantly larger than the fish sampled on the spawning grounds, and the same significant difference was found when pooling adult males and jacks. Conversely, there was no statistical difference between fall run adult males or fall run adult females when comparing broodstock and fish sampled on the spawning grounds. It is possible that the hatchery staff were selective in the male and jack fish that were collected and sampled for broodstock. Hatchery staff released 25 adult males and 20 jacks back into the river on 30 October following their broodstock sampling and these fish could have been smaller, on average, than the fish that were used in the broodstock samples. This may have biased the hatchery broodstock samples resulting in this significant difference.

Similarly, the same significant differences in size were found when comparing hatchery broodstock to fish sampled on the spawning grounds between jack summer run fish and pooled adult male and jack summer run. These differences could have been due to the same size selectivity bias of fish used for broodstock. Fish released following the broodstock sampling included 19 males, seven females and one jack of which were not measured for length.

There was also a significant difference between the mean lengths of male and female adults from the hatchery samples in both summer run and fall run samples. This is consistent with most years where female fall run chinook were significantly larger than fall run males when comparing hatchery samples. This is partially due to the slightly older makeup of the female population, which contained many more age 4_1 fish than were sampled out of the male population.

Only five female fish sampled form the fall run broodstock and mark-recapture operations were adipose fin clipped. The very low clip rates found in both sample types were due to the fact that the Nanaimo River hatchery has not fin clipped their chinook fry releases since brood year 2004. Where comparing the mark rates of these fish, there was no statistical significant difference between fall run adult chinook obtained from mark-recapture and broodstock collection.

The five heads from adipose-clipped females were sent for CWT recovery sampling. One, from the mark-recapture collection, was missing the CWT tag. Of the four CWT's decoded from the hatchery broodstock collection, one was from the 2006 Chemainus broodstock, one was from the 2006 Cowichan broodstock and the remaining two were from the 2007 Cowichan broodstock (Table 13). Nanaimo releases have not been tagged with CWT's since the 2004 brood year and with fewer releases of fish containing CWT's from other hatcheries over the last few brood years, comparing stray rates cannot be done over years. However it is interesting to note that over the past five years, only strays from the Chemainus River and Cowichan River have been detected, while in 2008 additional strays from the Puntledge and Big Qualicum Rivers were detected.

Thermal otolith marking results indicated that the fall run fish had a higher mark rate than the summer run fish from both broodstock and carcass samples. Most marks were from the Nanaimo River Hatchery, including all summer run fish. Of the fall run fish sampled, one was marked with a Nitinat Hatchery mark at the egg stage (pre-hatch) but the CWT result from this fish indicated that it was tagged and released in Chemainus River, after being reared at Nanaimo River Hatchery (Table 13). The Nitinat Hatchery thermal mark was the mark that is used for eggs that are supplied to other hatcheries for release in Sooke and Esquimalt, but the CWT and otolith results from this fish indicate that eggs were supplied to Chemainus in 2006. The remaining fall run fish that were sampled for thermal marks indicated that three were strays from the Cowichan Hatchery and the remaining marks were from the Nanaimo River Hatchery.

WATER MANAGEMENT PLAN

Previous successes with water releases suggest that they are beneficial in aiding and encouraging chinook migration (Hop Wo et al. 2005), however, flow levels were sufficient during the run timing in 2010. As a result, water releases were not necessary to aid in chinook migration as natural flows for October were above the target flows outlined in the WMP of 14.87 m^3/s. During the swim surveys in the lower river, fish were observed to have spread out over the spawning area. In previous years (1995 – 2003), water release successes were evaluated by monitoring movement of chinook past the enumeration fence, however, since there is no longer a fence program, and there were no water releases in 2010, this was not possible.

POPULATION ESTIMATE

The 2010 Nanaimo River fall run chinook population estimate was based on the AUC swim survey calculation that produced estimates of 2,201 adults and 1,040 jacks. One of the goals of this study was to have two independent and analytical methods of estimating the population of fall run chinook. The carcass mark-recapture program provided data to calculate a Petersen estimate, but this calculation produced much lower estimates of fall run adult and jack escapements due to biases in the marking and recapturing of the carcasses, placing low confidence on the Petersen estimate. Therefore, the fall run chinook population was estimated by both the AUC and the Petersen calculations, but the AUC estimate was adopted as the final 2010 escapement.

Through the Petersen methodology the estimate was 670 adults (95% CI 500-840) and 269 jacks (95% CI 166-372). As mentioned, changing river conditions can affect mark and recapture rates; also redistribution of carcasses in the system may have been insufficient. As a result, the number recaptured may be biased high, which would lead to a low estimate. This likely explains the large difference between the AUC and Petersen estimates. For example, the peak counts of adult and jack chinook on 5 October estimated 731 unexpanded adults and 447 jack in the survey reach (Table 4). These swim counts are higher than the adult and jack chinook Petersen estimate for the entire season. This confirms that the Petersen estimate is biased low for both the adult and jack escapement.

The natural spawning estimate of fall run adult chinook (1,989) is approximately 34% higher than the 2000-2009 average of 1,487 fish. However, given that there have been several methods used to estimate the total return, it is difficult to make true comparisons. Annual fall run adult chinook estimates by type (fence, Petersen mark-recapture, and AUC) are presented in Tables 16A, 16B, and Figure 7.

The First Lake summer run chinook estimate is ideally obtained by numerous swim surveys. Only one full survey was completed during the 2010 spawning season, and one incomplete spot check early in the season. Additionally, the Petersen mark-recapture estimate was not completed in 2010 as too few personnel were available to complete adequate surveys. The naturally spawning estimate for summer run adult chinook of 561 fish is 62% higher than the 2000–2009 average of 347. Annual adult chinook escapements are presented in Tables 16A, 16B, and Figure 8.

The 2010 total estimate of 675 adult summer run chinook was well above the 2005 – 2009 5-year average of 503 fish. The total jack population for the summer stock is estimated at 109 fish, which is also an increase from the previous 5-year average of 87 fish. It is important to note that this summer run estimate is a minimum run size, as it was determined from one snorkel survey and brood captures. It is possible that the actual run size may be significantly greater than the estimate provided; especially since the peak swim count was past the peak spawn timing and many dead chinook were observed during the swim. Ideally a number of swims would have taken place, as in the lower river, and an AUC calculated for the summer stock.

The fall run natural spawning estimate of 997 jacks is slightly lower than the 2000-2009 average of 1,054 fish. The Petersen estimate of 269 is only about one fourth of this ten-year average. The estimate of 107 summer run jack chinook for 2010 can only be compared to the past five-year average, from 2005-2009 with an average of 63 jacks, which is a 69% increase.

The total adult return for both summer and fall run fish including natural spawners, hatchery broodstock and SFN FSC catch is 2,876 fish, which is almost a small increase from the past ten-year average of 2,525 adult chinook. The 2010 escapement is 65% of the highest return on record (2008), but total escapements over the past 10 years have been encouraging news for this unique East Coast Vancouver Island watershed (Table 16 and Figure 8).

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TABLES

Table 1. Nanaimo River daily discharge[1] (m^3/s), 2010

	Month											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	30.7	31.8	69.9	60.5	35.5	53.6	8.3	5.1	4.3	23.9	138.0	58.7
2	72.0	31.9	53.9	65.1	31.1	71.0	7.8	5.3	4.3	21.0	168.0	50.3
3	76.3	31.0	46.9	100.0	43.5	85.7	7.2	5.3	4.3	18.8	103.0	41.4
4	72.2	29.6	38.4	77.1	48.6	64.6	6.8	5.4	4.3	17.4	62.1	34.2
5	71.2	32.0	32.6	59.2	42.6	46.8	6.6	5.5	4.2	15.5	45.8	29.0
6	59.4	36.5	27.8	49.2	35.2	37.6	6.2	5.4	4.3	12.7	39.1	25.7
7	48.4	36.1	24.7	43.5	29.8	31.9	6.1	5.4	4.5	12.0	51.2	64.2
8	44.9	33.0	22.5	76.2	26.2	28.2	6.5	5.5	4.5	12.2	51.8	320.0
9	112.0	29.2	20.4	77.5	24.4	26.8	6.9	5.6	4.5	20.1	47.6	333.0
10	176.0	26.0	19.3	57.7	22.8[2]	25.5	7.2	5.6	4.5	54.6	46.4	207.0
11	487.0	28.0	20.2	44.5	21.7	24.1	7.0	5.5	4.5	54.3	38.5	122.0
12	557.0	77.8	21.4	36.5	22.2	22.3	6.8	5.6	4.4	45.9	38.3	220.0
13	275.0	134.0	22.4	31.7	22.0	22.0	5.9	5.6	5.4	38.0	35.8	244.0
14	195.0	238.0	23.0	29.7	21.3	21.4	5.3	5.6	5.8	29.9	36.1	191.0
15	502.0	167.0	28.7	30.4	23.5	19.9	5.0	5.0	5.6	21.5	35.6	141.0
16	331.0	119.0	38.4	33.4	25.4	17.8	5.2	4.1	5.4	18.2	35.4	95.1
17	163.0	95.4	83.9	41.7	26.1	16.3	5.5	4.0	5.2	15.9	39.2	66.0
18	169.0	69.0	77.9	70.2	28.7	15.5	5.5	4.0	5.6	14.1	44.9	47.9
19	172.0	50.8	55.5	75.6	31.3	14.4	5.5	3.9	7.1	12.2	37.6	41.0
20	116.0	40.4	42.9	89.8	49.9	14.4	5.5	3.9	8.5	11.1	32.8	35.7
21	79.3	33.1	39.9	85.3	53.9	14.5	5.4	3.9	9.4	10.4	28.0	33.7
22	56.8	27.9	49.9	64.9	45.0	14.1	5.2	3.9	8.9	13.0	24.9	41.1
23	44.7	25.0	48.3	49.6	36.9	13.2	5.0	4.1	8.1	15.8	22.3	70.0
24	37.4	24.0	40.8	41.6	30.3	13.1	4.9	3.9	11.0	52.7	20.1	353.0
25	53.6	28.7	36.3	38.2	29.4	12.4	4.8	4.0	23.6	109.0	18.8	483.0
26	88.6	51.2	36.1	34.5	38.1	12.0	4.7	4.1	67.7	139.0	21.4	309.0
27	76.3	92.6	34.1	46.3	52.1	11.6	4.6	4.1	60.0	89.9	24.8	176.0
28	56.6	91.3	37.8	60.9	57.3	11.0	4.4	4.1	46.3	57.8	24.4	116.0
29	44.8		96.7	52.9	59.8	10.2	4.5	4.1	35.8	49.1	24.2	77.3
30	38.4		116.0	42.4	51.6	9.0	4.8	4.1	28.4	42.4	51.2	51.3
31	34.6		86.5		50.8		5.0	4.2		51.5		40.6
Total	4341.2	1710.3	1393.1	1666.1	1117.0	780.9	180.0	145.8	400.2	1099.9	1387.3	4118.2
Mean	140.0	61.1	44.9	55.5	36.0	26.0	5.8	4.7	13.3	35.5	46.2	133.0
Max	557.0	238.0	116.0	100.0	59.8	85.7	8.3	5.6	67.7	139.0	168.0	483.0
Min	30.7	24.0	19.3	29.7	21.3	9.0	4.4	3.9	4.2	10.4	18.8	25.7

[1]Data recorded at Water Survey Canada Station 08HB034 which is located upstream of the "Bungy Zone" in Cassidy, B.C.

[2]Partial day only

Discharge data are preliminary and subject to revision.

Table 2. Daily summary of fall run chinook sampled during the carcass mark-recapture program, lower Nanaimo River, 2010

	Carcasses Examined				Tags Applied				Recaptured Carcasses			
Date	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown	Male	Female	Jack	Unknown
18-Oct	8	9	8	0	8	9	8	0	0	0	0	0
19-Oct	4	0	6	0	4	0	5	0	0	0	1	0
20-Oct	6	6	10	0	5	3	8	0	1	3	2	0
21-Oct	5	8	11	0	2	5	8	0	3	3	3	0
22-Oct	10	7	17	0	8	6	10	0	2	1	7	0
25-Oct	2	4	0	0	1	3	0	0	1	1	0	0
26-Oct	2	4	0	1	2	4	0	0	0	0	0	1
27-Oct	5	4	3	0	3	4	3	0	2	0	0	0
28-Oct	3	13	5	0	3	11	5	0	0	2	0	0
29-Oct	4	8	8	0	2	8	6	0	2	0	2	0
1-Nov	1	2	0	0	1	1	0	0	0	1	0	0
2-Nov	0	2	0	0	0	2	0	0	0	0	0	0
3-Nov	1	7	2	0	0	7	2	0	1	0	0	0
4-Nov	2	10	4	0	2	9	3	0	0	1	1	0
5-Nov	2	8	0	0	2	5	0	0	0	3	0	0
8-Nov	0	8	1	0	0	4	1	0	0	4	0	0
9-Nov	0	1	2	0	0	1	2	0	0	0	0	0
10-Nov	2	3	0	1	2	2	0	0	0	1	0	1
12-Nov	1	3	0	3	1	2	0	3	0	1	0	0
15-Nov	0	10	2	1	0	7	1	0	0	3	1	1
16-Nov	0	6	0	1	0	5	0	0	0	1	0	1
17-Nov	1	7	1	0	1	5	0	0	0	2	1	0
18-Nov	1	1	0	0	0	0	0	0	1	1	0	0
19-Nov	2	3	0	0	2	0	0	0	0	3	0	0
Total	62	134	80	7	49	103	62	3	13	31	18	4

Table 3. Petersen fall run chinook escapement estimates by sex, lower Nanaimo River, 2010

	Population	95% Confidence Limits	
Sex	Estimate	Lower	Upper
Adult Male [1]	225	125	325
Female	439	308	570
Total Adult [2]	**670**	**500**	**840**
Jack	269	166	372
Total Population	**924**	**732**	**1116**

[1] Jacks not included.

[2] Population estimate includes 4 unknown sex adults in calculation and is calculated based on 155 marked and 44 recaptured adults

Table 4. Swim survey counts for adult chinook with observer efficiency and system estimates, conducted on the Nanaimo River, 2010

Swim Date	Observer Efficiency	Chinook Counts: Live Adults	Live Jacks	Dead	Estimated Chinook: Live Adults	Live Jacks	Dead	Adult Expansion for Percent Population	In-River Chinook Estimate (L+D): Expanded Adults plus Dead	Jacks	Comments
26-Jul	90%	172	125	1	192	125	1	40%	481	125	A
30-Aug	88%	38	37	0	43	37	0	-	43	37	B
7-Sep	80%	76	233	0	95	233	0	100%	95	233	C
14-Sep	83%	59	107	0	71	107	0	100%	71	107	C
21-Sep	94%	191	134	0	204	134	0	90%	227	134	C
28-Sep	69%	385	174	0	557	174	0	70%	796	174	C
5-Oct	90%	731	447	0	812	447	0	70%	1160	447	C
12-Oct	70%	204	155	0	292	155	0	70%	417	155	C
13-Oct	90%	268	101	141	298	101	141	70%	567	101	D
19-Oct	95%	412	290	0	434	290	0	70%	620	290	E

Comments

A Upper portion of the river only, from First Lake to Wolf Creek, Spot Checks only
B Lower portion of the river only, from Bridge Pool to Raines Road, Spot Checks only (no Percent Population estimate)
C Lower portion of the river only, from Bridge Pool to Raines Road
D Upper portion of the river only, from First Lake to Wolf Creek
E Lower portion of the river only, from Bridge Pool to Firehall Pool

Table 5. 2010 Nanaimo River Hatchery broodstock collection summary for fall and summer run chinook

Number of Fish	Fall Chinook: Female	Male	Jack	Summer Chinook: Female	Male	Jack
Captured	97	90	63	63	77	3
Spawned	93	59	31	56	58	2
Mort	4	6	12	0	0	0
Released	0	25	20	7	19	1
Kelt	0	0	0	0	0	0

* male & jack numbers vary due to staff judgement

Table 6A. Length-frequency of fall run chinook sampled during carcass mark-recapture, lower Nanaimo River, 2010

Length (cm)	Males	Females[1]	Jacks
34	0	0	0
35	0	0	**1**
36	0	0	**1**
37	0	0	**3**
38	0	0	**3**
39	0	0	**3**
40	0	0	**4**
41	0	0	**5**
42	0	0	**6**
43	0	0	**4**
44	0	0	**11**
45	**2**	0	**7**
46	0	0	**2**
47	**2**	0	**4**
48	0	0	**2**
49	0	0	**2**
50	0	0	**3**
51	0	0	0
52	0	**1**	0
53	0	**1**	0
54	0	0	0
55	0	**1**	0
56	**1**	0	0
57	**2**	**1**	0
58	**4**	**2**	0
59	**2**	**4**	0
60	**5**	**2**	0
61	**4**	**3**	0
62	**3**	**4**	0
63	**2**	**11**	0
64	**1**	**7**	**1**
65	**3**	**9**	0
66	**4**	**6**	0
67	**3**	**5**	0
68	**1**	**2**	0
69	**5**	**5**	0
70	**1**	**5**	0
71	**1**	**4**	0
72	0	**4**	0
73	**1**	**5**	0
74	0	**6**	0
75	0	**3**	0
76	0	**2**	0
77	0	**1**	0
78	**2**	**4**	0
79	0	**2**	0
80	0	**1**	0
81	0	0	0
82	0	**1**	0
83	0	0	0
84	0	**1**	0
Total	**49**	**103**	**62**
Mean Length	62.5	67.5	43.3
Standard Deviation	7.1	6.5	4.5

[1] One female was adipose clipped, resulting in a mark rate of 1.0% for females

Table 6B. Length-frequency of summer run chinook sampled during carcass deadpitch sampling, upper Nanaimo River, 2010

Length (cm)	Males	Females	Jacks
34	0	0	**1**
35	0	0	**1**
36	0	0	0
37	0	0	0
38	0	0	**1**
39	0	0	**1**
40	0	0	**2**
41	0	0	0
42	0	0	**1**
43	0	0	**1**
44	0	0	0
45	0	0	**1**
46	0	0	0
47	0	0	0
48	0	0	0
49	0	0	0
50	**1**	0	**1**
51	0	0	**1**
52	0	0	**2**
53	**1**	0	0
54	0	0	0
55	**3**	**1**	0
56	**3**	0	0
57	**1**	**1**	0
58	**3**	**2**	0
59	**1**	**2**	0
60	**2**	**2**	0
61	0	**2**	0
62	**3**	**1**	0
63	**2**	**2**	0
64	0	**2**	0
65	0	**2**	0
66	0	0	0
67	**1**	**4**	0
68	0	**3**	0
69	0	**4**	0
70	0	**2**	0
71	**1**	**3**	0
72	0	**5**	0
73	0	**3**	0
74	**1**	**5**	0
75	**1**	**1**	0
76	0	**2**	0
77	0	**1**	0
78	0	0	0
79	0	0	0
80	0	0	0
81	0	0	0
82	0	0	0
83	0	0	0
84	0	0	0
Total	**24**	**50**	**13**
Mean Length	60.2	67.7	43.1
Standard Deviation	6.3	5.7	6.2

Table 7A. Summary of age data from fall run chinook sampled during the carcass mark-recapture program, lower Nanaimo River, 2010

Gilbert Rich Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
2_1	2008	2	54	60.7%	1	1.4%	55	34.6%
3_1	2007	3	22	24.7%	35	50.0%	57	35.8%
4_1	2006	4	11	12.4%	33	47.1%	44	27.7%
5_1	2005	5	1	1.1%	1	1.4%	2	1.3%
5_2	2005	5	1	1.1%	0	0.0%	1	0.6%
Total			89	100%	70	100%	159	100%

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater
Total number of unreadable scales: 25

Table 7B. Summary of age data from summer run chinook sampled during the carcass deadpitch sampling, upper Nanaimo River, 2010

Gilbert Rich Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
2_1	2008	2	10	28.6%	0	0.0%	10	13.0%
3_1	2007	3	19	54.3%	30	71.4%	49	63.6%
3_2	2007	3	3	8.6%	1	2.4%	4	5.2%
4_1	2006	4	3	8.6%	9	21.4%	12	15.6%
4_2	2006	4	0	0.0%	1	2.4%	1	1.3%
5_1	2005	5	0	0.0%	1	2.4%	1	1.3%
Total			35	100%	42	100%	77	100%

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater
Total number of unreadable scales: 6

Table 8. Average length (cm) at age for fall and summer run chinook sampled during the mark-recapture biological data collection, Nanaimo River, 2010

	Fall Chinook			Summer Chinook		
Gilbert Rich Age[1]	Male	Female	Total	Male	Female	Total
2_1	43.7	52.2	43.9	42.2		42.2
3_1	61.0	63.5	62.5	58.5	66.1	63.2
3_2				45.9	66.7	51.1
4_1	67.1	71.0	70.1	65.7	71.6	70.1
4_2					75.5	75.5
5_1	78.0	67.6	72.8		72.4	72.4
5_2	73.1		73.1			
Total	51.6	66.9	58.4	53.4	67.7	61.2

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater

Table 9. Percentage of the tag application sample recovered on the spawning grounds, by application period and sex, lower Nanaimo River, 2010

Application Period	Days of Application	Tag Recovery Male	Tag Recovery Female	Tag Recovery Total	Tag Application Male	Tag Application Female	Tag Application Total	Tag Recovery (%) Male	Tag Recovery (%) Female	Tag Recovery (%) Total
Oct 18 - 22	5	6	7	13	27	23	50	18%	23%	21%
Oct 25 - 29	5	5	3	8	11	30	41	31%	9%	16%
Nov 1 - 5	5	1	5	6	5	24	29	17%	17%	17%
Nov 8 - 12	4	0	6	6	3	9	12	0%	40%	33%
Nov 15 - 19	5	1	10	11	3	17	20	25%	37%	35%
Total	24	13	31	44	49	103	152	21%	23%	22%

excluding jacks (adults only)

Table 10A. Length-frequency of fall run chinook sampled from hatchery broodstock, lower Nanaimo River, 2010

Length (cm)	Males	Females	Jacks
36	0	0	**1**
37	0	0	0
38	0	0	0
39	0	0	0
40	0	0	**1**
41	0	0	0
42	0	0	**3**
43	0	0	**4**
44	0	0	0
45	0	0	**7**
46	0	0	**8**
47	0	0	**7**
48	0	0	**6**
49	**1**	0	**7**
50	**1**	0	**3**
51	**1**	0	**3**
52	**1**	0	**3**
53	0	0	**3**
54	0	**1**	0
55	**1**	0	0
56	**2**	**2**	0
57	**2**	0	0
58	**1**	**2**	0
59	**1**	**2**	0
60	**3**	**3**	0
61	**2**	**1**	0
62	**2**	**2**	0
63	0	**5**	0
64	**3**	**5**	0
65	**2**	**4**	0
66	**1**	**6**	0
67	**1**	**6**	0
68	**2**	**8**	0
69	**3**	**5**	0
70	**4**	**3**	0
71	**2**	**5**	0
72	**1**	**3**	0
73	**1**	**3**	0
74	**1**	**6**	0
75	0	**2**	0
76	0	**3**	0
77	**2**	**1**	0
78	**1**	**3**	0
79	**1**	**1**	0
80	**1**	**1**	0
81	0	**2**	0
Total	**44**	**85**	**56**
Mean Length	64.9	68.2	47.0
Standard Deviation	8.0	6.1	3.4

[1] Four females were adipose clipped, resulting in a mark rate of 4.7% for females; see table 13

Table 10B. Length-frequency of summer run chinook sampled from hatchery broodstock, upper Nanaimo River, 2010

Length (cm)	Males	Females	Jacks
28	0	0	**1**
29	0	0	0
30	0	0	0
31	0	0	0
32	0	0	0
33	0	0	0
34	0	0	0
35	0	0	0
36	0	0	0
37	0	0	0
38	0	0	0
39	0	0	0
40	0	0	0
41	0	0	0
42	0	0	0
43	0	0	0
44	0	0	0
45	0	0	0
46	0	0	0
47	0	0	0
48	0	0	0
49	0	0	0
50	**2**	0	0
51	0	0	0
52	0	0	0
53	0	0	0
54	**1**	0	0
55	0	0	0
56	**3**	0	0
57	0	0	0
58	0	0	0
59	**2**	**1**	0
60	**1**	**3**	0
61	**1**	0	0
62	**4**	**1**	0
63	**1**	0	0
64	**2**	**3**	0
65	**2**	**1**	0
66	**2**	**1**	0
67	**2**	0	0
68	0	0	0
69	0	**1**	0
70	**1**	**1**	0
71	**1**	0	0
72	0	**6**	0
73	0	**2**	0
74	0	**1**	0
75	0	**1**	0
76	0	**1**	0
77	0	0	0
78	0	**1**	0
79	0	**1**	0
Total	**25**	**25**	**1**
Mean Length	61.4	68.8	28.0
Standard Deviation	5.5	6.0	-

Table 11A. Summary of age data from fall run chinook broodstock collection, lower Nanaimo River, 2010

Gilbert Rich Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
2_1	2008	2	52	66.7%	0	0.0%	52	35.1%
3_1	2007	3	17	21.8%	31	44.3%	48	32.4%
4_1	2006	4	7	9.0%	38	54.3%	45	30.4%
5_1	2005	5	2	2.6%	1	1.4%	3	2.0%
Total			78	100%	70	100%	148	100%

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater

Total number of unreadable scales: 37

Table 11B. Summary of age data from First Lake summer run chinook broodstock collection, upper Nanaimo River, 2010

Gilbert Rich Age[1]	Brood Year	Total Age	Males #	Males %	Females #	Females %	Total #	Total %
3_1	2007	3	13	92.9%	11	68.8%	24	80.0%
4_1	2006	4	1	7.1%	4	25.0%	5	16.7%
4_2	2006	4	0	0.0%	1	6.3%	1	3.3%
Total			14	100%	16	100%	30	100%

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater

Total number of unreadable scales: 21

Table 12. Average length (cm) at age for fall and summer run chinook sampled during the broodstock collection, Nanaimo River, 2010

Gilbert Rich Age[1]	Fall Chinook Male	Fall Chinook Female	Fall Chinook Total	Summer Chinook Male	Summer Chinook Female	Summer Chinook Total
2_1	47.0		47.0			
3_1	61.7	63.8	63.1	61.3	69.0	64.8
4_1	70.2	71.4	71.2	67.0	73.6	72.3
4_2					70.0	70.0
5_1	78.3	74.6	77.0			
Total	53.1	68.1	60.2	61.7	70.2	66.2

[1] The first number indicates the total age and the second number indicates the number of years spent in freshwater
See table 11 for sample size

Table 13. Coded-wire tag data from fall run chinook sampled at the Nanaimo River Hatchery during brood stock collection, 2010

Recovery Data				Release Data					Otolith Data		
Date	**Sex (MFJ)**	**POH (mm)**	**E-Label**	**CWT Code**	**Brood Year**	**Hatchery**	**Release Start Date**	**Release End Date**	**Hatchery**	**Thermal Mark**	**Brood Year**
9-Oct-10	F	755	372072E	185261	2006	Chemainus	15-May-07	15-May-07	Nitinat River	4H	2006
13-Oct-10	F	647	372073E	185358	2007	Cowichan	29-May-07	29-May-07	Cowichan River	4-1H	2007
18-Oct-10	F	580	372074E	186220	2007	Cowichan	25-Apr-08	25-Apr-08	Cowichan River	4-1H	2007
29-Oct-10	F	644	372075E	186042	2006	Cowichan	9-May-07	9-May-07	Cowichan River	1,3,1H	2006

Table 14. Nanaimo River Hatchery chinook release data for brood years 1997 - 2010

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Release Start Date	Release End Date	Release Site	Run Type
183220	1997	25240	70000	36.06	6.67	1998/05/07	1998/05/07	First Lake	Summer
183221	1997	25173	99098	25.4	6	1998/05/15	1998/05/15	First Lake	Summer
183223	1997	28252	43881	64.38	6.01	1998/05/26	1998/05/26	Nanaimo R	Fall
182408	1997	10050	15610	64.38	6.01	1998/05/26	1998/05/26	Nanaimo R	Fall
183222	1997	24824	24824	100	15.5	1998/07/23	1998/07/23	Jack Point	Fall
-	1998	0	442830	0	5.1	1999/05/12	1999/05/13	Nanaimo R	Fall
-	1998	0	165595	0	5.61	1999/05/28	1999/05/28	First Lake	Summer
-	1998	0	50411	0	11	1999/06/02	1999/07/08	Jack Point	Fall
184330	1999	25185	257394	9.78	4.03	2000/05/17	2000/05/17	First Lake	Summer
184332	1999	25071	25071	100	5.1	2000/05/18	2000/05/18	Nanaimo R	Fall
184331	1999	25185	25185	100	5.1	2000/05/18	2000/05/18	Nanaimo R	Fall
184333	1999	25165	25165	100	5.1	2000/05/18	2000/05/18	Nanaimo R	Fall
184334	1999	25231	25231	100	5.1	2000/05/18	2000/05/18	Nanaimo R	Fall
-	1999	0	99238	0	4.8	2000/05/18	2000/05/18	Nanaimo R	Fall
184335	1999	25300	126422	20.01	5	2000/05/05	2000/05/23	Nanaimo R	Fall
184336	1999	25115	125497	20.01	5	2000/05/05	2000/05/23	Nanaimo R	Fall
184329	1999	25175	57625	43.69	10.34	2000/06/23	2000/06/23	Jack Point	Fall
184363	2000	24739	207955	11.9	6.56	2001/05/23	2001/05/24	First Lake	Summer
184552	2000	50060	105512	47.44	4.9	2001/04/28	2001/05/29	Nanaimo R	Fall
184553	2000	50254	105920	47.45	4.9	2001/04/28	2001/05/29	Nanaimo R	Fall
184554	2000	50259	105931	47.45	4.9	2001/04/28	2001/05/29	Nanaimo R	Fall
184362	2000	25091	51070	49.13	8.67	2001/06/06	2001/06/06	Jack Point	Fall
184717	2001	25119	102917	24.41	4.68	2002/05/09	2002/05/09	Nanaimo R	Fall
184718	2001	25355	103883	24.41	4.68	2002/05/09	2002/05/09	Nanaimo R	Fall
183205	2001	25182	25182	100	5.61	2002/05/14	2002/05/14	Nanaimo R	Fall
183206	2001	25237	25237	100	5.61	2002/05/14	2002/05/14	Nanaimo R	Fall
184337	2001	25102	186187	13.48	5.7	2002/05/16	2002/05/16	First Lake	Summer
184715	2001	25307	25307	100	3.78	2002/05/16	2002/05/16	Nanaimo R	Fall
184716	2001	25131	25131	100	3.78	2002/05/16	2002/05/16	Nanaimo R	Fall
184628	2001	25119	51508	48.77	6.62	2002/05/17	2002/05/17	Jack Point	Fall
185527	2002	39650	39650	100	20	2003/07/31	2003/07/31	Nanaimo R	Fall
185528	2002	40226	40226	100	10	2003/05/31	2003/05/31	Nanaimo R	Fall
-	2002	0	173081	0	7.3	2003/05/06	2003/05/19	First Lake	Summer
-	2002	0	324204	0	6	2003/05/08	2003/05/21	Nanaimo R	Fall
-	2003	0	187214	0	7.42	2004/05/06	2004/05/18	First Lake	Summer
-	2003	0	120199	0	4.86	2004/05/19	2004/05/19	Nanaimo R	Fall
185713	2004	29538	38922	75.89	5	2005/05/19	2005/06/15	Nanaimo R	Fall
185714	2004	29559	39146	75.51	5	2005/05/16	2005/06/15	Nanaimo R	Fall
185715	2004	29392	38729	75.89	5	2005/05/19	2005/06/15	Nanaimo R	Fall
185716	2004	29293	38792	75.51	5	2005/05/19	2005/06/15	Nanaimo R	Fall
185717	2004	29124	38763	75.13	5	2005/05/19	2005/06/15	Nanaimo R	Fall
185802	2004	27774	36782	75.51	5	2005/05/19	2005/06/15	Nanaimo R	Fall
185803	2004	24568	32535	75.51	5	2005/05/19	2005/06/15	Nanaimo R	Fall
-	2004	0	154922	0	8	2005/05/18	2005/05/18	First Lake	Summer
-	2005	0	204874	0	7.16	2006/05/14	2006/05/24	First Lake	Summer
-	2005	0	345494	0	4.8	2006/05/22	2006/05/24	Nanaimo R	Fall
-	2006	0	650	0	0.3	2007/02/07	2007/02/07	Nanaimo R	Fall
-	2006	0	223745	0	5.3	2007/05/17	2007/05/17	First Lake	Summer
-	2006	0	420817	0	4.8	2007/05/23	2007/05/29	Nanaimo R	Fall
-	2007	0	229551	0	5.1	2008/05/16	2008/05/16	First Lake	Summer
-	2007	0	134552	0	5.1	2008/05/16	2008/05/16	Nanaimo R	Fall
-	2008	0	232496	0	4.9	2009/05/11	2009/05/11	First Lake	Summer
-	2008	0	418068	0	5.3	2009/05/14	2009/05/14	Nanaimo R	Fall
-	2009	0	350722	0	5.85	2010/04	2010/05	Nanaimo R	Fall
-	2009	0	221184	0	7.81	2010/04	2010/05	First Lake	Summer
-	2010	0	436769	0	5.1	2011/05/05	2011/05/06	Nanaimo R	Fall
-	2010	0	226193	0	7.4	2011/05/20	2011/05/20	First Lake	Summer

Table 15. Chemainus River and Cowichan River chinook release data for brood years 2002 – 2010

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Release Start Date	Release End Date	Release Site	Run Type
185129	2002	25191	55331	45.53	10	2003/05/15	2003/05/16	Chemainus R	Fall
185130	2002	25253	55394	45.59	10	2003/05/15	2003/05/16	Chemainus R	Fall
185131	2002	25167	40850	61.61	7	2003/05/15	2003/05/16	Chemainus R	Fall
185132	2002	25282	40966	61.71	7	2003/05/15	2003/05/16	Chemainus R	Fall
185530	2003	49960	79417	62.91	11.4	2004/05/07	2004/05/17	Chemainus R	Fall
185531	2003	50283	79775	63.03	5.44	2004/05/17	2004/05/18	Chemainus R	Fall
-	2004	0	22164	0	9.5	2005/05/17	2005/05/17	Chemainus R	Fall
184421	2005	17514	17514	100	9.84	2006/05/15	2006/05/15	Chemainus R	Fall
185209	2005	29608	29608	100	9.84	2006/05/15	2006/05/15	Chemainus R	Fall
185210	2005	28339	28339	100	9.84	2006/05/15	2006/05/15	Chemainus R	Fall
185059	2006	27134	39227	69.17	9.54	2007/05/16	2007/05/16	Chemainus R	Fall
185261	2006	27813	39288	70.79	4.6	2007/05/15	2007/05/15	Chemainus R	Fall
185601	2006	28085	39673	70.79	4.6	2007/05/15	2007/05/15	Chemainus R	Fall
185718	2006	29873	42882	69.66	9.17	2007/05/16	2007/05/16	Chemainus R	Fall
-	2007	0	22818	0	10.84	2008/05/15	2008/05/15	Chemainus R	Fall
-	2008	0	47000	0	10.6	2009/05/14	2009/05/14	Chemainus R	Fall
185902	2009	7083	7083	100	0	2011/05	2011/05	Chemainus R	Fall
186046	2009	26087	26087	100	0	2010/05	2010/05	Chemainus R	Fall
186047	2009	28847	28992	99.5	0	2010/05	2010/05	Chemainus R	Fall
186334	2010	9845	9945	98.99	7.1	2011/05/18	2011/05/18	Chemainus R	Fall
184918	2002	50091	383156	13.07	4.5	2003/04/11	2003/04/11	Cowichan R Up	Fall
184919	2002	50186	383877	13.07	4.5	2003/04/11	2003/04/11	Cowichan R Up	Fall
185013	2002	24712	257226	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Up	Fall
185014	2002	25128	261555	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Up	Fall
185015	2002	25102	261282	9.61	5.74	2003/05/26	2003/05/26	Cowichan R Up	Fall
185016	2002	25197	288668	8.73	6	2003/05/27	2003/05/27	Cowichan R Low	Fall
185052	2002	25134	99918	25.15	7.36	2003/05/28	2003/05/28	Cowichan Est	Fall
185412	2003	25144	99887	25.17	6.54	2004/05/26	2004/05/26	Cowichan Est	Fall
185660	2003	25111	197202	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Up	Fall
185661	2003	25110	197194	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Up	Fall
185662	2003	25124	197304	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Up	Fall
185663	2003	25051	196731	12.73	3.85	2004/04/05	2004/04/05	Cowichan R Up	Fall
185701	2003	25168	219733	11.45	5.3	2004/05/20	2004/05/20	Cowichan R Up	Fall
185702	2003	24863	219261	11.34	5.3	2004/05/20	2004/05/20	Cowichan R Up	Fall
185703	2003	24987	219252	11.4	5.3	2004/05/20	2004/05/20	Cowichan R Up	Fall
185704	2003	25029	98411	25.43	6.65	2004/05/11	2004/05/11	Cowichan R	Fall
-	2003	0	116307	0	2.41	2004/11/08	2004/11/19	Cowichan Lk Tribs	Fall
184422	2005	14825	127435	11.63	3.4	2006/04/25	2006/04/25	Cowichan R Up	Fall
185818	2005	29556	254061	11.63	3.4	2006/04/25	2006/04/25	Cowichan R Up	Fall
185819	2005	29313	251973	11.63	3.4	2006/04/25	2006/04/25	Cowichan R Up	Fall
185820	2005	26426	228299	11.58	3.4	2006/04/25	2006/04/25	Cowichan R Up	Fall
184836	2005	14589	125598	11.62	6.1	2006/05/15	2006/05/15	Cowichan R Up	Fall
185810	2005	29646	255225	11.62	6.1	2006/05/15	2006/05/15	Cowichan R Up	Fall
185811	2005	29364	252798	11.62	6.1	2006/05/15	2006/05/15	Cowichan R Up	Fall
185812	2005	26464	227831	11.62	6.1	2006/05/15	2006/05/15	Cowichan R Up	Fall
185214	2005	25188	99087	25.42	6.1	2006/05/30	2006/05/30	Cowichan Est	Fall
186042	2006	25018	149964	16.68	4.1	2007/05/09	2007/05/09	Cowichan R Low	Fall
185832	2006	25040	71335	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
185833	2006	24989	71190	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
185834	2006	24923	71002	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
186035	2006	25078	71444	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
186036	2006	25222	71854	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
186037	2006	25005	71235	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
186039	2006	25015	71264	35.1	5.8	2007/05/23	2007/05/23	Cowichan R Up	Fall
186038	2006	25030	99913	25.05	6	2007/05/24	2007/05/24	Cowichan Est	Fall
185606	2006	25060	70637	35.48	10.76	2007/06/18	2007/06/18	Cowichan Est	Fall
186040	2006	24965	70369	35.48	10.76	2007/06/18	2007/06/18	Cowichan Est	Fall
186041	2006	12424	49764	24.97	10.32	2007/06/18	2007/06/18	Cowichan Est	Fall

Table 15 continued

Tagcode	Brood Year	Number Tagged	Number Released	CWT % Marked	Weight (g)	Release Start Date	Release End Date	Release Site	Run Type
185339	2007	40783	40783	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
185355	2007	41037	41037	100	6.03	2008/04/25	2008/04/25	Cowichan R	Fall
185356	2007	40850	40850	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
186015	2007	10816	10816	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
186016	2007	10822	10822	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
186219	2007	29848	29848	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
186220	2007	29978	29978	100	6.03	2008/04/25	2008/04/25	Cowichan R Up	Fall
80346	2007	5188	5201	99.75	8.34	2008/05/29	2008/05/29	Cowichan Est	Fall
185357	2007	35061	35061	100	7.54	2008/05/29	2008/05/29	Cowichan R Up	Fall
185358	2007	41095	41198	99.75	7.54	2008/05/29	2008/05/29	Cowichan R Up	Fall
185359	2007	41715	41715	100	7.54	2008/05/29	2008/05/29	Cowichan R Up	Fall
185739	2007	10174	10199	99.75	8.34	2008/05/29	2008/05/29	Cowichan Est	Fall
185858	2007	10008	10033	99.75	8.34	2008/05/29	2008/05/29	Cowichan Est	Fall
186225	2007	29833	29833	100	7.54	2008/05/29	2008/05/29	Cowichan R	Fall
186226	2007	29594	29743	99.5	7.54	2008/05/29	2008/05/29	Cowichan R	Fall
186227	2007	27417	27417	100	7.54	2008/05/29	2008/05/29	Cowichan R	Fall
182211	2007	10249	10249	100	14.93	2008/07/02	2008/07/02	Cowichan Est	Fall
183532	2007	10341	10341	100	14.93	2008/07/02	2008/07/02	Cowichan Est	Fall
186006	2007	4717	4717	100	14.93	2008/07/02	2008/07/02	Cowichan Est	Fall
180469	2008	46703	64865	72	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
180470	2008	46321	64218	72.13	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
180471	2008	46306	64197	72.13	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
180472	2008	46868	64976	72.13	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
180473	2008	46362	64626	71.74	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
186137	2008	17180	23818	72.13	5.22	2009/05/04	2009/05/04	Cowichan R	Fall
180377	2008	29448	85868	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
180395	2008	34963	101950	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
180396	2008	32490	94739	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
185344	2008	29149	85143	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
185345	2008	28165	82127	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
185705	2008	29340	85701	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186311	2008	29006	84579	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186312	2008	29190	85263	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186313	2008	29788	86860	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186314	2008	29012	84743	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186315	2008	29830	86982	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186316	2008	27894	81478	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186317	2008	29354	85594	34.29	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
186318	2008	29211	85324	34.24	5.6	2009/05/19	2009/05/19	Cowichan R	Fall
180378	2008	25219	100094	25.2	7.53	2009/05/28	2009/05/28	Cowichan Est	Fall
180379	2008	25179	100200	25.13	13.35	2009/06/22	2009/06/22	Cowichan Est	Fall
180492	2009	59984	60407	99.3	7.3	2010/05/14	2010/05/14	Cowichan R	Fall
180493	2009	58349	58349	100	7.3	2010/05/14	2010/05/14	Cowichan R	Fall
180678	2009	29092	29092	100	7.3	2010/05/14	2010/05/14	Cowichan R	Fall
180967	2009	58118	58235	99.8	7.3	2010/05/14	2010/05/14	Cowichan R	Fall
180888	2009	29131	29131	100	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
180889	2009	28763	28763	100	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
180890	2009	28513	28513	100	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
180968	2009	58029	58029	100	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
186307	2009	27596	27735	99.5	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
186308	2009	19694	19694	100	7.55	2010/05/21	2010/05/21	Cowichan R	Fall
186045	2009	23381	23381	100	43.5	2010/09/30	2010/10/05	Cowichan R	Fall
181394	2010	58369	58369	100	5.97	2011/04/28	2011/04/30	Cowichan R	Fall
181395	2010	58365	58481	99.8	5.97	2011/04/28	2011/04/30	Cowichan R	Fall
186228	2010	28954	28954	100	5.97	2011/04/28	2011/04/30	Cowichan R	Fall
181396	2010	57828	57828	100	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
181397	2010	57333	57478	99.75	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
181398	2010	57770	58207	99.25	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
181399	2010	57680	57680	100	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
186110	2010	5740	5740	100	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
186309	2010	28766	28766	100	7.09	2011/05/17	2011/05/20	Cowichan R	Fall
186310	2010	27038	27038	100	7.09	2011/05/17	2011/05/20	Cowichan R	Fall

Table 16A. Total adult chinook returns to the Nanaimo River, 1975-2010

	Natural Spawners		Hatchery Broodstock		First Nations	Total
Year	Fall	Summer	Fall	Summer[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	-	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 [3]
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]
2003	1378 [7]	393	82 [8]	131 [8]	50	2034 [3]
2004	1891 [9]	200	119 [10]	106	220	2549 [11]
2005	1239 [9]	201	186	122	950	2705 [11]
2006	1723 [9]	672	220	168	580	3363 [11]
2007	2222 [9]	220 [9]	100	126	225	2893 [11]
2008	2281	506	200	189	720	3896 [11]
2009	1319 [9]	148	151	163	449	2230 [11]
2010	1989 [9]	561	162	114	50	2876 [11]

[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 Nation food fish catch and summer run
[4] Mark recapture Petersen estimate.
[5] Mark recapture estimate plus fall broodstock removal, First Nation food fish catch and summer run estimate.
[6] Adjusted fence count minus broodstock removal above the fence.
[7] Extrapolated fence count, plus adult/jack adjustment, minus broodstock removals above the fence.
[8] Does not include fish released during high water.
[9] AUC estimate minus broodstock removals.
[10] 107 fish from Nanaimo River Mainstem and 12 from Napoleon Creek.
[11] AUC estimate plus summer estimates plus broodstock removals plus First Nation food fish catch.

Table 16B. Total jack Chinook returns to the Nanaimo River, 1995-2010

Year	Natural Spawners: Fall [1]	Natural Spawners: Summer [2]	Hatchery Broodstock: Fall	Hatchery Broodstock: Summer[1]	First Nations Food Fish Catch	Total Returns [3]
1995	3236	200	88	N/A	-	3524
1996	891	-	72	28	-	991
1997	173	-	24	12	-	209
1998	599	-	30	6	-	635
1999	280 [4]	-	3	21	-	304 [5]
2000	992	-	10	6	-	1008
2001	1385 [6]	-	19	27	-	1431
2002	644 [6]	-	15	15	-	674
2003	772 [7]	-	48	8	-	828
2004	190 [8]	-	30	17	-	255
2005	487 [8]	16	58	91	-	654
2006	2716 [8]	120 [9]	66	8	-	2910
2007	1931 [8]	12	44	12	62	2061
2008	843 [8]	133	52	5	-	1033
2009	580 [8]	36	50	2	-	668
2010	997 [8]	107 [9]	43	2	-	1149

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

[2] First Lake summer run only.

[3] Natural

[4] Mark recapture Petersen estimate.

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

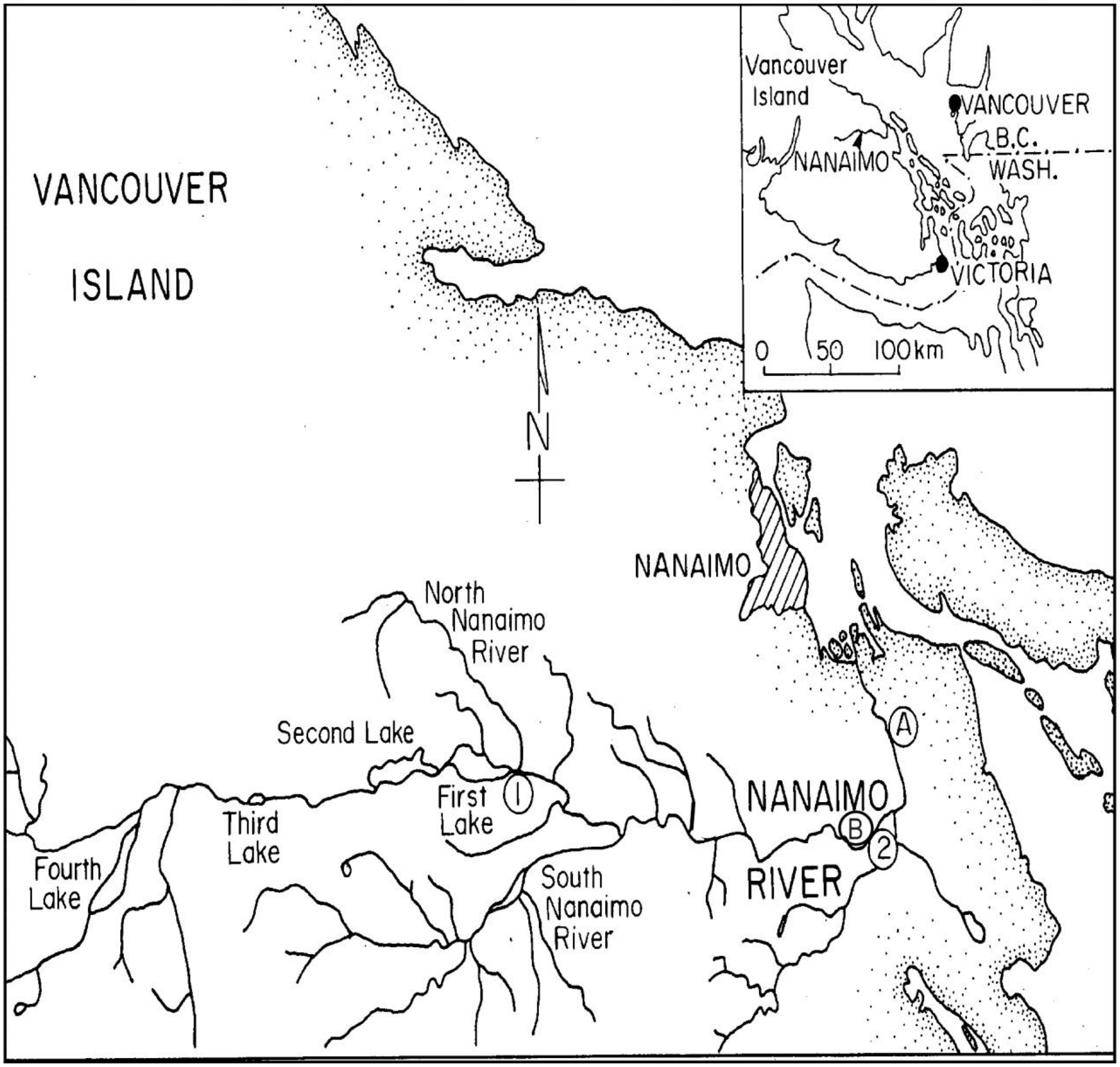
[6] Adjusted fence count minus broodstock removal above the fence.

[7] Extrapolated fence count, plus adult/jack adjustment, minus broodstock removals above the fence.

[8] AUC estimate minus broodstock removals.

[9] Swim Survey Estimate

FIGURES



LEGEND:

1 Hatchery Release Site for summer run (First Lake) chinook
2 Hatchery Release Site for fall run chinook
A Enumeration Fence Site (removed 2003)
B Downstream Fry Trapping Site (discontinued)

Figure 1. Nanaimo River study area

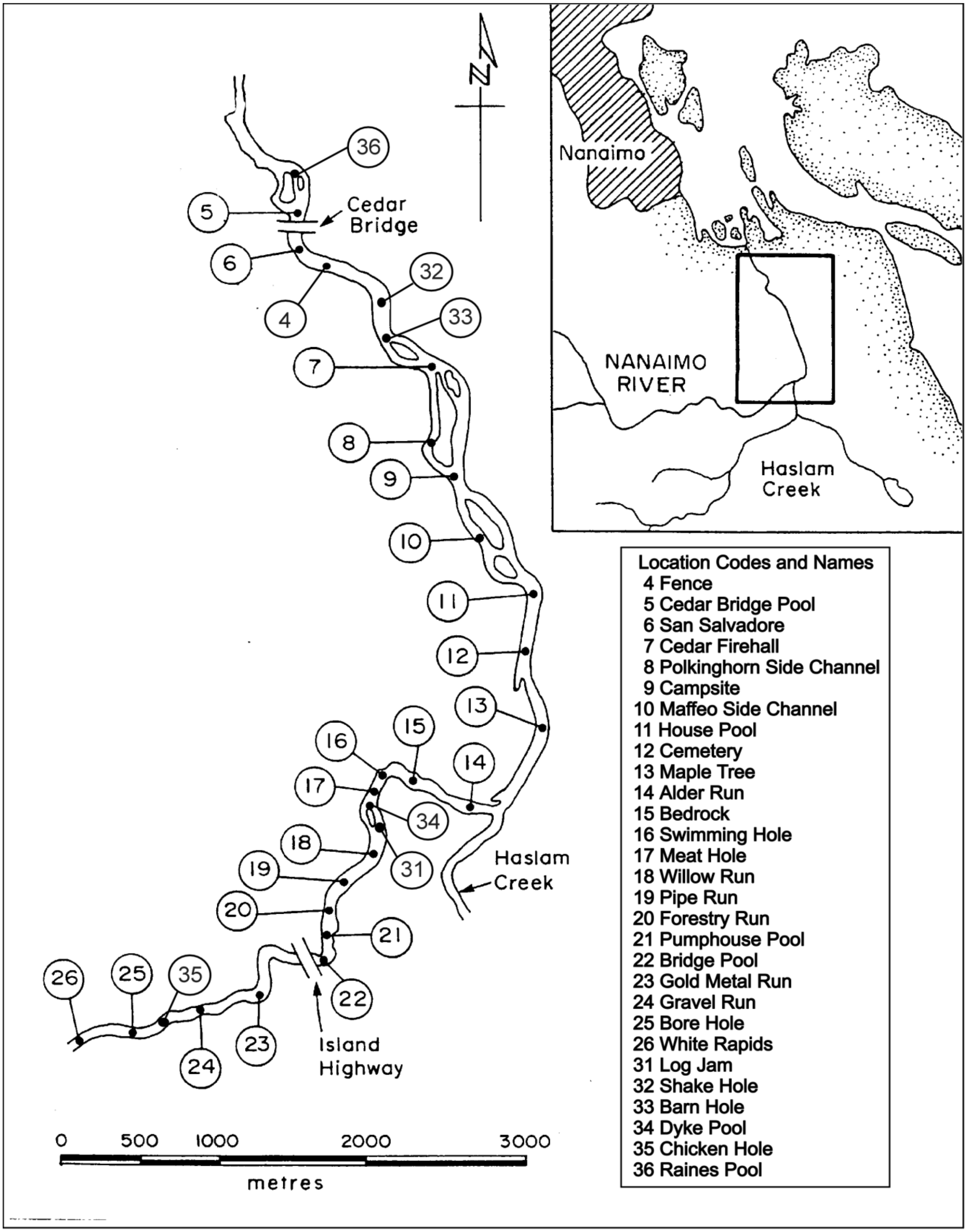


Figure 2. Mark-recapture sites and swim survey area on the lower Nanaimo River

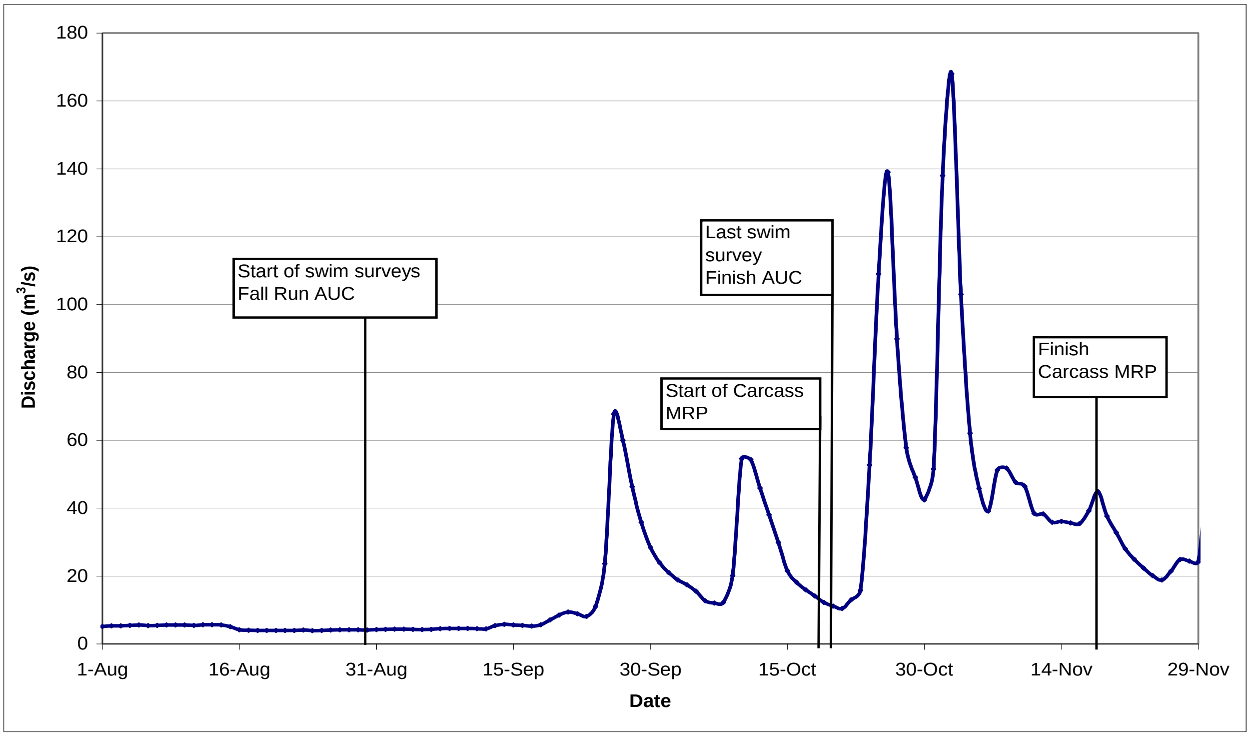


Figure 3. Daily Nanaimo River Discharge (m^3/s) during the fall run chinook season 2010. Discharge data are preliminary and subject to revision

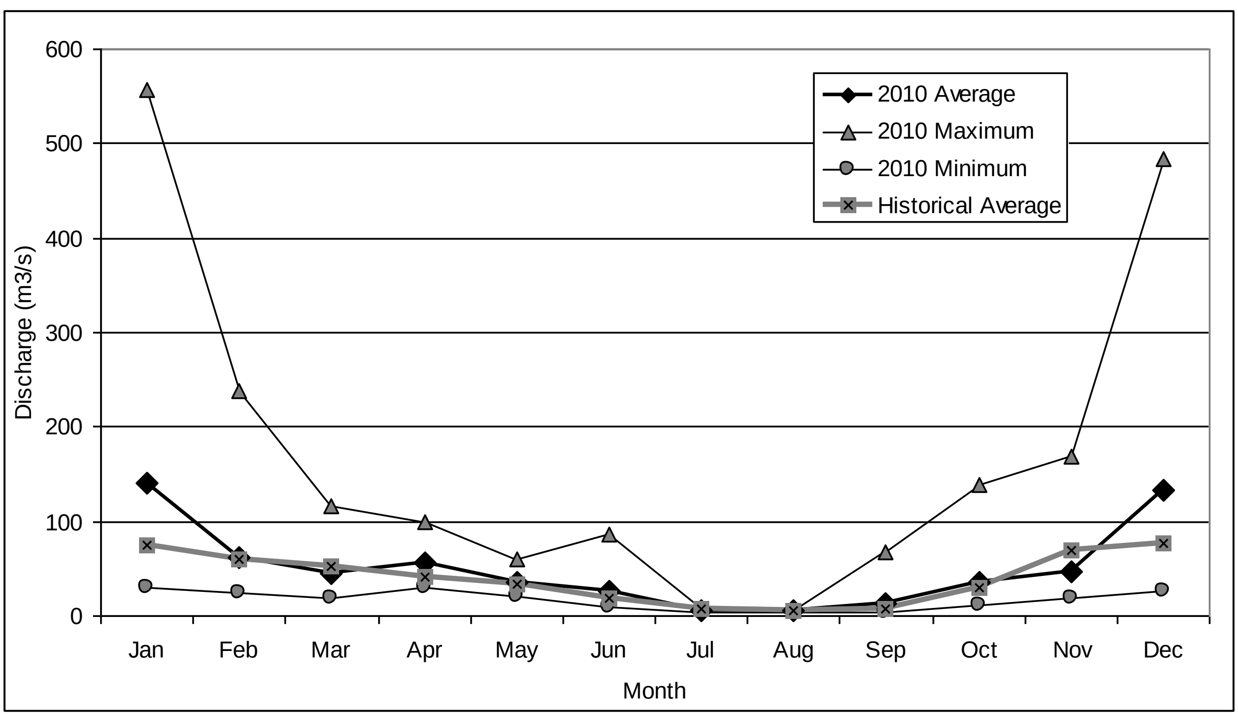


Figure 4. Monthly Nanaimo River discharge (m^3/s) in 2008 along with historic (1965-2010) monthly mean

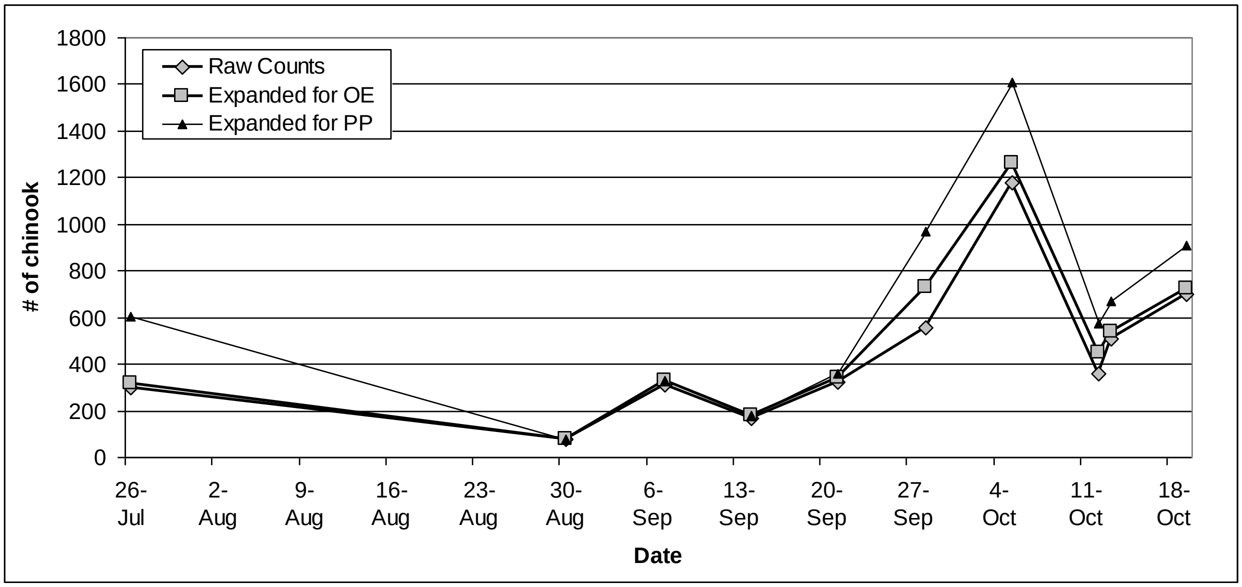


Figure 5. Raw swim survey counts and expanded (for observer efficiency, OE and percent population, PP) counts of chinook on the upper and lower Nanaimo River in summer/fall 2010

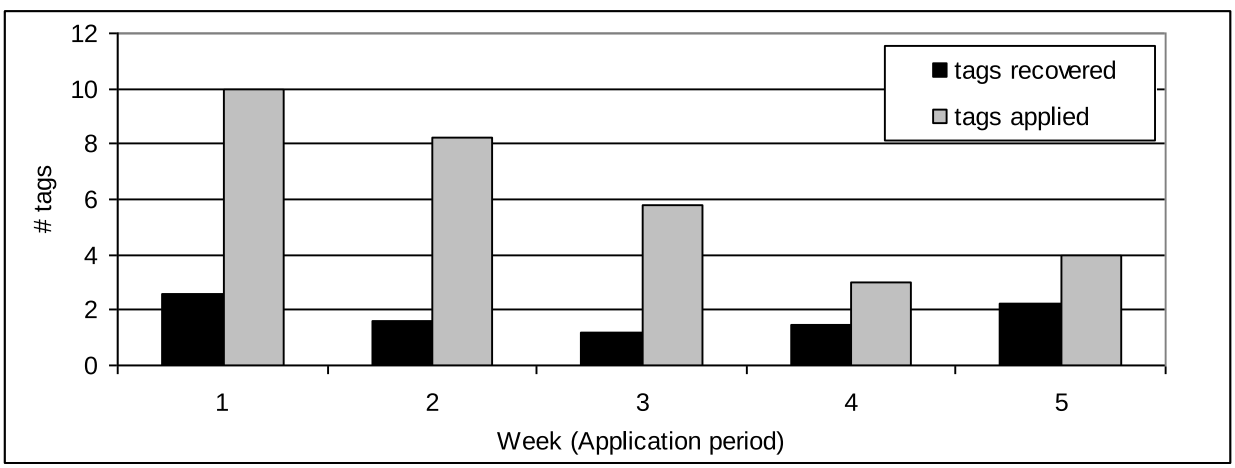


Figure 6. Number of tags applied and recovered during each week (application period) or the mark-recapture program, lower Nanaimo River, 2010

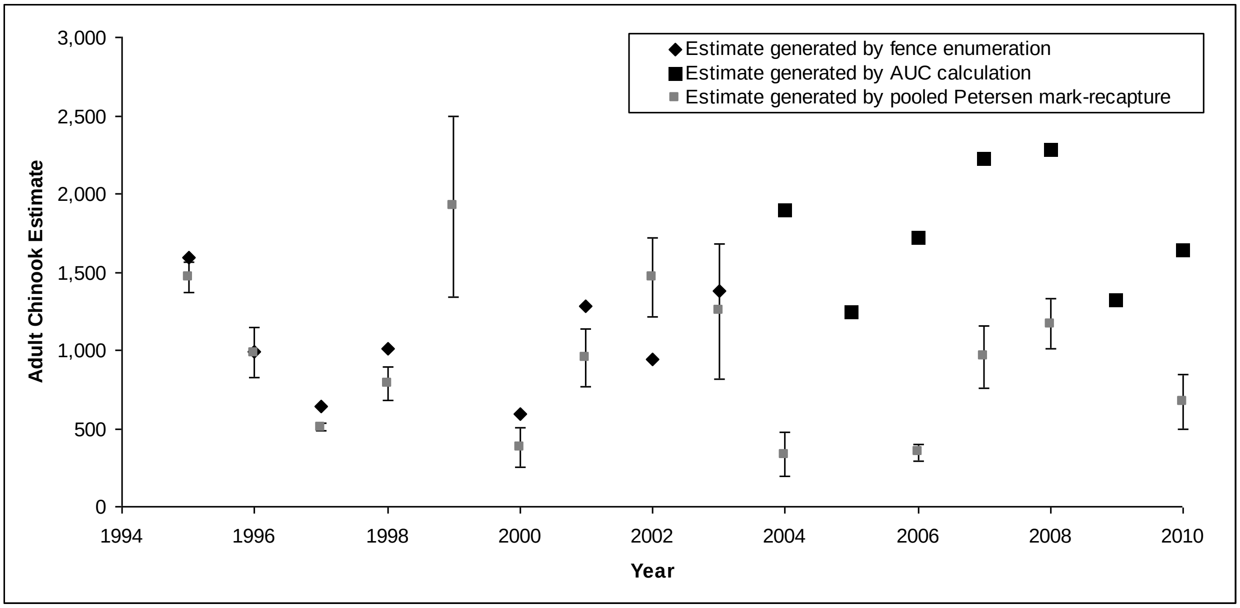


Figure 7. Annual comparisons of naturally spawning fall run adult chinook population estimates generated by fence information, AUC, and mark-recapture pooled Petersen calculations (with 95% confidence intervals), lower Nanaimo River, 1995-2010.

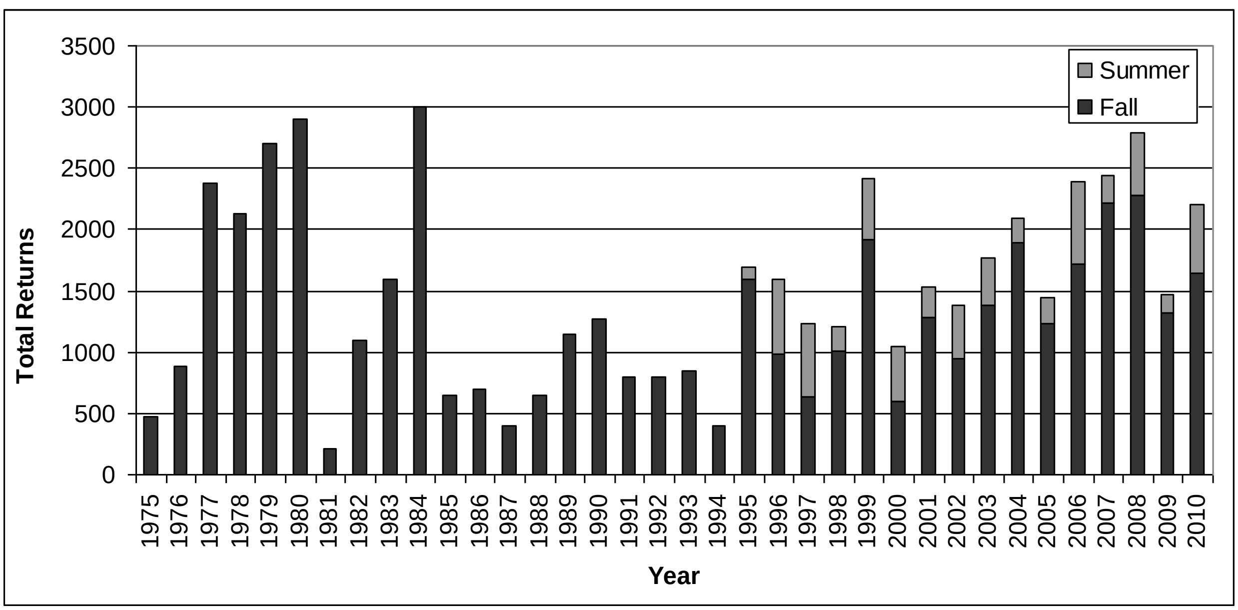


Figure 8. Annual adult fall and summer run chinook escapements in the Nanaimo River 1975-2010