

1995 Juvenile Coho Salmon Enumeration Studies at Black Creek, Vancouver Island

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1996

**Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2361**



Canadian Manuscript Report of Fisheries and Aquatic Sciences

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**1995 JUVENILE COHO SALMON
ENUMERATION STUDIES
AT BLACK CREEK, VANCOUVER ISLAND**

by

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for

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1996

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Cat. No. Fs 97-4/2361E ISSN 0706-6473

Correct citation for this publication:

Nelson, T. C. and K. Simpson. 1996. 1995 juvenile coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manusc. Rep. Fish. Aquat. Sci. 2361: ix + 40 p.

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ABSTRACT

Nelson, T. C. and K. Simpson. 1996. 1995 juvenile coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2361: ix + 40 p.

Coho smolts leaving Black Creek between April 21 and June 8, 1995, were trapped at a counting fence, adipose clipped, and tagged (marked) with sequential coded-wire tags. A total of 18,295 smolts were captured and 18,208 of these (99.5%) were marked and released downstream. Smolt mortalities due to tagging were very low (0.01%) in 1995. Results of a mark-recapture trial used to estimate the catch efficiency of the counting fence and trap boxes indicated that the fence and trap were 100% efficient. There were no flood events during the period of fence operation in the spring of 1995 and, due to the extremely low water levels during this period, the likelihood that smolts passed through or around the fence is very low.

An incident in May and June that involved a blockage of the mainstem flow of Black Creek by a stopboard weir resulted in the deployment of two fyke nets to monitor migrating smolt numbers after the removal of the counting fence. From June 10-18, a total of 339 smolts were captured in a fyke net deployed near the fence site; these smolts were not coded-wire tagged. Thus, the minimum known number of migrating smolts that were captured in 1995 is 18,634. It is highly likely that a number of smolts migrated from Black Creek prior to the first day of fence operation.

All smolt data collected at the counting fence were stratified into three predetermined sampling periods. The calculated freshwater age structure of Black Creek coho smolts (from all samples) was 75.1% age 1, 18.6% age 2, and 0.3% age 3. Both the length and weight of migrating age-1 smolts decreased significantly between the first and second sampling periods. In comparison with previous years' studies, the average lengths and weights of smolts sampled in 1995 was high. There was a significant difference between the ratio of male and female smolts (2.0:1) for all sampling periods combined. A low number of coho fry (314) were captured in 1995.

RÉSUMÉ

Nelson, T. C. and K. Simpson. 1996. 1995 juvenile coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2361: ix + 40 p.

Les saumoneaux de coho qui sont sortis du ruisseau Black entre le 21 avril et le 8 juin 1995 ont été capturés à une barrière de dénombrement; on leur a coupé la nageoire adipeuses et implanté une micromarque magnétisée codée. Au total, 18 295 saumoneaux ont été capturés et 18 208 d'entre eux (99,5 %) ont été marqués et relâchés en aval. Le taux de mortalité des saumoneaux due au marquage a été très faible (0,01 %) en 1995. Les résultats d'un essai de marquage-recapture pour évaluer l'efficacité de la barrière de dénombrement et des boîtes à piégeage ont indiqué que ceux-ci étaient entièrement efficaces. Au printemps 1995, il n'y a pas eu de crues pendant la période où la barrière était en place et à cause du niveau extrêmement bas de l'eau pendant cette période, il est peu probable que des saumoneaux aient pu franchir la barrière ou la contourner.

En mai et juin, en raison d'un blocage de l'écoulement du bras principal du ruisseau Black causé par un butoir, on a dû installer deux verveux pour surveiller le nombre de saumoneaux migrateurs une fois que la barrière de dénombrement eût été enlevée. Du 10 au 18 juin, 339 saumoneaux ont été capturés dans un verveux déployé près de la barrière; ces saumoneaux ne portaient pas de micromarques codées. Ainsi, le nombre minimum connu de saumoneaux capturés en 1995 s'élève à 18 634. Il est fort probable qu'un certain nombre de saumoneaux ont quitté le ruisseau Black avant que la première barrière de dénombrement soit installée.

Toutes les données sur les saumoneaux ont été stratifiées en trois périodes d'échantillonnage prédéterminées. La structure par âge en eau douce des saumoneaux de coho (tous les échantillons) a été établie à 75,1 % d'âge 1, 18,6 % d'âge 2 et 0,3 % d'âge 3. La longueur et le poids des saumoneaux d'âge 1 a baissé de façon significative entre la première et la deuxième période d'échantillonnage. En comparaison avec les études des années antérieures, la longueur et le poids des saumoneaux échantillonnés en 1995 étaient élevés. On a noté un écart significatif dans le rapport des saumoneaux mâles et femelles (2,0:1) pour toutes les périodes d'échantillonnage combinées. Un nombre peu élevé (314) d'alevins de coho ont été capturés en 1995.

INTRODUCTION

This report presents results of the coho salmon (*Oncorhynchus kisutch*) smolt enumeration and coded-wire tagging study at Black Creek in 1995. The main objectives of the program were to:

- 1) describe the size and age distribution of the coho smolts leaving Black Creek;
- 2) insert full-length sequential coded-wire tags (CWTs) into coho smolts; and
- 3) obtain results required to examine the relationships between physical environmental factors and smolt and adult migration; smolt migration timing and size and subsequent oceanic harvest distribution; and adult escapement and smolt production.

Achieving these objectives involved the operation of a fence to monitor the downstream migration of juvenile salmonids, counting all migrants, sampling lengths, weights, and ages of coho smolts, and coded-wire tagging of as large a portion of the coho smolts as possible. All smolt data were stratified into the three predetermined sampling periods used in Nelson et al. (1996), Nelson et al. (1995), Nelson et al. (1994a), and Nelson et al. (1994b), the selection of which was based on data provided in Fielden et al. (1989), Bocking et al. (1991), and Nass et al. (1993) to characterize the various phases of seaward migration.

Study Stream

Black Creek is a low-gradient (approximately 0.6%) stream on the east coast of Vancouver Island, B.C. (Figure 1). The system is approximately 26 km long, 5-6 m wide in its middle reaches, and has a catchment area of 72.5 km². For most of its length it meanders through agricultural land, small lakes (including Northy Lake), swampy areas, and beaver ponds. In the lower watershed, there are several tributaries including Millar Creek, a tributary to Northy Lake. Maximum discharges of 50-60 m³·s⁻¹ have been estimated during floods. Black Creek supports populations of coho salmon, cutthroat trout (*O. clarki*), and steelhead trout (*O. mykiss*). Annual escapement estimates for coho are highly variable, ranging from as low as 749 adult spawners in 1987 to 15,000 in earlier years (Hancock and Marshall 1985; Clark and Irvine 1989; Labelle 1990). Coho spawn throughout the watershed, but the best spawning grounds are in Millar Creek, in mainstem areas adjacent to the Sturgess Road Bridge, and in the upper reaches in the vicinity of the Duncan Main logging road (Figure 1). Since 1978, and in those years when it was surveyed, the estimated coho smolt production from Black Creek has varied from a low of 29,776 in 1989 (Bocking et al. 1991) to 119,602 in 1990 (Nass et al. 1993).

The juvenile counting fence was located downstream of the Seaview Road bridge, in Miracle Beach Provincial Park. This location is above tidal influence.

METHODS

Biophysical Monitoring

Weather conditions were monitored daily. Precipitation was ranked on a scale of 0 to 5 with 0 being no precipitation and 5 being heavy precipitation. Percentage cloud cover, wind direction, and wind speed were also noted. Water temperatures and water levels were manually recorded during the periods of fence operation (April 21- June 8), and for an additional period after the removal of the fence from June 11-18. Technicians recorded maximum, minimum, and present water temperatures ($\pm 0.5^\circ \text{C}$) at the counting fence each day between 0800 and 0900 h using a max-min thermometer. Water levels were recorded daily using two staff gauges; one gauge was located beneath the Seaview Road Bridge (adjacent to the fence sites) and the other gauge was located approximately 200 m upstream (at the datalogger station used in previous years¹).

Fence Operations

The Black Creek smolt fence was constructed according to methods described by Conlin and Tutty (1979) using wooden-framed panels screened with 6.4 mm mesh steel hardware cloth. It was installed and operated as per Bocking et al. (1991), and Nass et al. (1993). Plywood holding boxes with Vexar-screened windows to allow water exchange were anchored downstream of the fence to hold sorted fish from the trap boxes. The Black Creek smolt fence and holding facilities were operated from April 21 to June 8, 1995. A broomstick trap was also operated to capture upstream-migrating adult fish. Fry traps to monitor upstream-migrating coho fry were not operated in 1995.

Two fyke nets were installed in Black Creek to monitor smolt migration after the period of fence operation. The fyke nets were operated from June 10-18 and all catches recorded; no coded-wire tagging was performed during the June 10-18 sampling (see **DISCUSSION** section).

¹ The automated datalogger was vandalized in October 1994 and was not functional by the spring sampling period in 1995; thus, water level and temperature data for Black Creek during the period prior to the installation of the fence in 1995 are not available.

Fish Counts

Each morning, all coho captured since the previous day were counted and sorted into groups based on their size. Coho smolts greater than 70 mm fork length were classified as either small (less than 120 mm in length) or large (greater than or equal to 120 mm in length). All coho less than or equal to 70 mm were categorized as fry. Any mortality due to capture, predation, holding, or tagging was recorded.

All non-coho fish migrating downstream were counted and released below the fence. We assumed that adult cutthroat or steelhead caught in the downstream traps were kelts (spawned out). All fin clips observed on non-coho species were recorded.

Trapping Efficiency

A mark-recapture trial was used to estimate the catch efficiency of the counting fence and trap boxes. In 1995, due to the low number of smolts encountered, only one group of smolts ($n = 100$) were anaesthetized using tricaine methane sulphonate (MS-222), given a unique (upper caudal) clip, and released approximately 200 m upstream of the fence. Throughout the entire trapping period, technicians monitored all smolts captured for recaptures from the trapping efficiency test. All recaptures were recorded (recapture date, clip location), anaesthetized, adipose clipped, and coded-wire tagged prior to release downstream of the fence.

Biosampling

Random samples of up to 25 coho smolts were selected from each day's catch (coho fry were not biosampled in 1995). These fish were anaesthetized in MS-222, measured to the nearest mm (fork length), and weighed using an Ohaus C305-S balance (± 0.1 g). Mean lengths and weights were obtained from random samples for all coho juveniles (calculated using combined data) and stratified by age class and sampling period. Sampling periods were the same as in previous years (before May 11, May 11-June 2, and after June 2; Bocking et al. 1991, Nass et al. 1993). Mean lengths and weights between consecutive sampling periods were compared for each age class using t-tests. A mean length and weight for the entire smolt population was calculated from random samples collected across all sampling periods.

Scale sampling procedures followed Ketchen's stratified method (Ricker 1975). An attempt was made to collect scale samples from 10 smolts in each 5 mm size class during each sampling period. Scale samples were not collected from coho fry. Smolts of the required sizes were selected from the catch to supplement the random samples when necessary. The calculated age-length distribution was used to determine the proportional representation of each age class within each sampling

period; a chi-square test was used to detect differences between proportions between periods. Ages of smolts based on scale pattern analysis were reported using the European method of age designation, wherein age-1 smolts had one freshwater annulus, age-2 smolts had two freshwater annuli, etc. Scale samples were interpreted by personnel at the Department of Fisheries and Oceans Fish Ageing Laboratory in Nanaimo, B.C.

A total of 71 coho smolts were dissected to determine sex. Most of these fish were either trap or tag mortalities or fish sacrificed to determine CWT placement. Although the samples used for sex determination were not taken randomly, they were collected throughout the study period to minimize potential biases due to changes in sex ratios over the period of sampling.

Coded-Wire Tagging

Coded-wire tagging was performed by experienced taggers using a Northwest Marine Technology Ltd. (NMT) Mark IV tag injector. An MS-222 bath was used to anaesthetize smolts prior to tagging. The baths were changed regularly and recovery basins were repeatedly flushed with fresh water. All tagged fish were adipose fin clipped.

Since 1988, Black Creek coho smolts have been tagged using different tag codes to differentiate subsequent recoveries by sampling period and size. In 1995, sequential coded-wire tags were used exclusively for smolts to allow the stratification of releases by date. At the beginning and end of each primary tag code (spool) application, tagging technicians collected at least three tags from the spool and taped them in a data book. Later, the wire was decoded to provide unique "start" and "end" sequences for each primary tag code, by date. In addition, smolts greater than or equal to 120 mm (large) and smolts less than 120 mm (small) were tagged with different primary codes (spools). Other data were stratified by sampling period. Most smolts were sorted by hand prior to being anaesthetized, but smolts that were close to 120 mm were sorted (measured) while under anaesthesia. The smolts from one of the size categories were then tagged while the other size category was held in a separate holding pen for tagging later in the day. This latter group of smolts included a small number of smolts that were subjected to two anesthetic baths. No differential mortality was observed between the two size categories over a 24-h holding period.

In total, three different primary tag codes were used (two codes were used for the large size group). Coho fry were not tagged in 1995. Tagging was done every day, except in a few instances when fish were held for two days before tagging. All tagged juveniles were transferred to a holding box and allowed to recover fully from the tagging operation before being released.

Tag Retention

There were four tag retention checks performed on smolts in 1995, three for 24 h and one for 72 h. Approximately 100 fish were used for each 24-h test, and 52 fish were used for the 72-h test.

RESULTS

Biophysical Observations

Daily biophysical measurements are provided in Appendix A. During the period of fence installation in mid-April, water levels were falling from medium-low levels, and continued to fall through the first 12 days of fence operation (Figure 2). A small rise in water levels on May 3 was followed by a second slight rise in water levels on May 12. After May 12, water levels fell to critically low levels through June 2, increased slightly on June 3, dropped through June 8, increased slightly on June 11, and levelled off through June 18. During the period of fence operation, water levels ranged from a maximum of 64.0 cm on May 12 to a minimum of 19.0 cm on June 2. Water temperatures ranged from a minimum of 8.0° C on April 21 to a maximum of 15.0° C in mid-May and early June.

Fish Counts

Coho Smolts

Total daily catches of juvenile coho are provided in Appendix B. A total of 18,295 coho smolts were counted at the Black Creek fence between April 21 and June 8 (Table 1); this is the lowest smolt catch on record for the spring enumeration program at Black Creek since its inception in 1985. During this period, there were 77 pre-tagging mortalities (0.42%) and 8 smolts (0.04%) which either escaped during handling or were released untagged due to injury or poor condition. A total of 311 smolts were captured at the counting fence during the third sampling period (June 3-8).

The smolt migration was roughly unimodal (Figure 3). Daily catches were uniformly low in comparison with previous years' catches, and did not pass the 1000 mark for any single day until May 7. The peak daily catch (1697 smolts on May 12) occurred in conjunction with the second slight increase in water level on May 12. The period of fence operation appeared to cover most of the migration.

Coho Fry

Daily catches of coho fry are given in Appendix B. A total of 314 downstream-migrating coho fry were caught at the fence during the study.

Other Species

Daily catches of non-coho are presented in Appendix C and summarized in Table 2. Cottids were the most numerous non-coho captured, followed (in decreasing order) by hatchery (clipped) cutthroat kelts, wild (no clip) cutthroat kelts, wild steelhead smolts, wild cutthroat smolts, lamprey (*Lampetra* spp.), threespine stickleback (*Gasterosteus aculeatus*), hatchery cutthroat smolts, wild steelhead kelts, and cutthroat parr, respectively. No upstream-migrating fish were captured in the broomstick trap in 1995.

Trapping Efficiency

The trapping efficiency of the fence was tested once (Table 3). On May 5, 100 coho smolts were upper-caudal clipped and released upstream; by May 12, all 100 of these smolts were recaptured (100.0% recovery), which indicates that the fence and traps were fishing effectively and efficiently.

Biosampling

Age

The calculated age-length distribution for wild coho smolts leaving Black Creek is given in Table 4. Age sample data (X) includes non-random samples; the calculated age representation (Y) is based on random sampling. The calculated freshwater age structure of Black Creek smolts (from all samples) was 75.1% age 1, 18.6% age 2, and 0.3% age 3. The age ratio of all age 1:age 2 smolts across all sampling periods was 4:1. When compared between the first two sampling periods, the age ratio of age 1:age 2 changed from 2:1 in period 1, to 21:1 in period 2, and the difference between these age ratios was significant (χ^2 , df = 1, P<0.001).

Length and Weight

The mean fork-length of the Black Creek coho smolt population was 138.0 mm and the mean weight was 29.48g (Table 5). Individual length and weight measurements and the means of these measurements appeared to be normally distributed within sampling periods. Both the length and weight of age-1 smolts decreased significantly between the first and second sampling period (t-tests: length,

$P < 0.001$; weight, $P < 0.001$). The length-frequency distribution of successfully aged smolts is presented in Figure 4.

Sex

A total of 71 Black Creek smolts were dissected to determine sex (Table 6). The proportion of male coho smolts was greater than that of female smolts during sampling period 1 (male:female ratio 1.7:1) and sampling period 2 (male:female ratio 4.0:1), and for all sampling periods combined (male:female ratio 2.0:1). The difference between the number of male and female coho smolts in the total sample was significant ($\chi^2 = 6.82$, $P < 0.01$, $df = 1$).

Coded-Wire Tagging

Coded-Wire Tag Releases

A total of 18,210 coho smolts were coded-wire tagged using three distinct sequential codes (Table 7). Of these tagged smolts, there were two known tagging-related mortalities. A summary of sequential coded-wire tag start and end data, by tag date, is provided in Table 8. Coho fry were not coded-wire tagged in 1995².

Tag Retention

Tag retention tests were performed four times on coho smolts (three 24-h tests and one 72-h test; Table 9). The mean tag retention rate for smolts was 99.7%.

² From 1992-1994, coho fry were coded-wire tagged with half-length tags during spring coho studies at Black Creek.

DISCUSSION

The spring smolt program at Black Creek in 1995 was highlighted by three events: 1) the lowest smolt count at the counting fence since the inception of the program in 1985; 2) critically low water levels throughout most of the second and third sampling periods; and 3) the installation by a private landowner of a flow control weir across the mainstem of Black Creek that blocked water flow and affected fish passage from approximately May 20 to June 1 (see section entitled **1995 Weir Incident**, below).

1995 was the 11th consecutive year that Black Creek coho smolts were counted and coded-wire tagged. Spring smolt counts at the counting fence during this 11-year period have fluctuated from a low of 18,295 in 1995 (this report) to a high of 118,902 in 1990 (Nass et al. 1993; Figure 5).

The shape of the 1995 smolt migration was similar to several previous years' migrations, although there was a vast difference in the total number of smolts observed at the counting fence. Figure 6 illustrates the relative magnitudes and respective migration patterns of coho smolts that migrated during the 1993-1995 spring sampling programs at Black Creek.

It is likely that some smolts migrated from Black Creek prior to the first day of fence operation in 1995; in 1992, over 9% of the total smolt count passed by the counting fence during the second week in April (Nelson et al. 1994a). It was demonstrated that a number of smolts migrated past the fence site during the two-week period following the removal of the fence, but this number was likely less than 1,000 smolts (see **1995 Weir Incident**, below).

Our confidence in the final fence count for 1995 is very high; results of the single trapping efficiency test indicated that the fence and traps were 100% effective in capturing downstream-migrating smolts. In addition, no floods occurred in the spring of 1995, and the low water conditions reduced the chance that smolts passed through or around the fence undetected. Mortalities of smolts due to trapping and predation (0.42%) were low in 1995, as were the number of live smolts (0.04%) that were released untagged due to injury or poor condition.

Coho fry were generally observed infrequently and in low numbers at the counting fence in 1995; however, small coho fry could pass through the 6.4 mm mesh used in the fence panels. The highest catches of coho fry occurred in late May during critically low water levels (almost 70% of the total fry catch occurred from May 25-30). Several species of fish other than coho were observed in 1995; the capture of hatchery (clipped) cutthroat trout was high (375), although high numbers of hatchery cutthroat have been observed in previous years (Nelson et al. 1995).

The majority of age-2 smolts that left Black Creek in 1995 did so during the first sampling period. This observation is consistent with results of previous studies at Black Creek that found the highest proportions of age-2 smolts that migrate do so during the beginning of the first sampling period (Nelson et al. 1995).

The average lengths and weights of age-1 and age-2 coho smolts that migrated in 1995 were high in comparison with respective data from previous years. A likely explanation for this increased growth would be reduced competition for food due to the low smolt numbers in the system in 1994 and 1995.

This is the second consecutive year that a significant difference in sex composition of sampled smolts has been observed. For all smolts sampled, the male:female sex ratio in 1995 was 2.0:1; in 1994, the male:female smolt ratio was 1.5:1.

In 1995, CWT releases of coho smolts totalled 18,208³; this number was 99.5% of the total number of smolts observed at the counting fence (18,295). Mortalities due to tagging (0.01%) were very low in 1995.

Analyses of the marine survival and exploitation rates, and the egg-to-smolt relationships, of Black Creek coho have been conducted (J. Irvine, pers. comm.). Additional analyses should be pursued, and include available information such as annual instream water temperatures and levels (i.e., spawning gravel stability in winter, summer rearing conditions, and smolt vulnerability during spring migrations).

As the primary indicator for wild coho stocks in the Strait of Georgia, data from this study form an integral part of the coho stock assessment process. Our knowledge of the production dynamics of coho increased considerably with the collection of information in 1995.

³ Not corrected for tag loss; total tag loss was 0.279% for smolts in 1995 (see Table 9).

1995 Weir Incident

A flow-control weir, constructed of stopboards, was built for agricultural purposes in September, 1994, on the mainstem of Black Creek at Sturgess Road, 12 km from the mouth (Figure 1). Half the watershed is above this location. The weir was not operated through the winter but the stopboards were evidently installed on or about May 20. The weir likely blocked fish passage and water flow for all or most of the time from May 20 until the stopboards were discovered and progressively removed by DFO personnel on May 31 and June 1. The measured surface flow below the intact weir on May 31 was trivial ($1.6 \times 10^{-4} \text{ m}^3/\text{sec}$) and the surface water above the weir was 20.5° C .

Beach seines and minnow traps were used on May 31 in an effort to sample fish above the intact weir prior to the removal of any stopboards. Sampling effort was applied up to 100 m above the weir. No coho were captured, but they may have been avoiding this ditched area due to the very warm water. On the same day, three isolated pools between the dam and the fence were visited, and schools of smolts were observed in two of them despite poor viewing conditions. The pools were isolated by the low water.

Water levels at the fence accelerated downward between May 21 and May 22, rose slightly a few days later for unknown reasons, and then rose rapidly again when the stored water reached the fence on June 2 (Appendix A). Only 307 smolts were captured at the fence in the 12 days from May 22 to June 2 (Appendix B). With the block removed, another 311 were caught over eight days (June 3-8), 269 of them on June 3.

We have evidence that more smolts left after our fence was removed on June 8. On June 10, we set one fyke net in the mainstem about 250 m above the fence site and another one 30 m below the dismantled Sturgess Road weir. The lower trap caught 339 smolts in six days of fishing up to June 18 (the net did not function on June 14 and 17). Two hundred and seventy-five of them were caught in the first two days. Thirty smolts were captured in the Sturgess Road net, suggesting that smolts were above the weir when it was intact. They were all caught in the first four days.

Neither net was fishing the entire daily run, although we think they were catching most of the smolts. It is likely that the increased catch of coho in the lower fyke net relative to the previous fence catches is due to the increase in water levels after June 8 (Figure 2). The increase in water levels was a result of heavy rain on the June 10 and daily rains through the end of the fyke net sampling period.

The 1995 smolt catch including net catches was 18,634. The net catches were not coded-wire tagged. The run size if the weir blockage had not occurred cannot be accurately estimated but our best estimate is that 1,600 more smolts would

have left on an average run timing. However, the variability seen in previous years could easily mean that the true number is between a few hundred and about 5,000. This conclusion was based on determining the proportion of the run that had occurred by May 20 for each of the 12 previous years (1978, 1979, and 1985-1994) and regressing that on each year's date when the fence count peaked. This was to estimate the proportion of the run that is normally left on May 20, by correcting previous proportions by the inter-annual differences in run timing, as measured by the peak run date. The result was that 15.6% of the run would normally be counted through the fence after May 20 when the peak count was on May 12 like this year. This equates to an estimated total run of 20,242 smolts. That is 1602 more than were captured at the fence and in the nets but the variation around the regression is such that it could be a few hundred to 5000 as stated.

In our opinion there is sufficient uncertainty around this analysis that the 1995 smolt run should be recorded as the number caught (18,634), although the actual run was probably larger. Previous fence counts are probably incomplete since the fence is not operated until the creek is completely dry. However, future analyses, for example of freshwater survivals, should consider that 18,634 may be a larger than average underestimate.

An indication of the proportion of the smolts that left the system before and after the period of fence operation will be the mark rates of returning jacks in 1995 and adults in 1996. Further, an indication that a high number of smolts residualized in the system for another year will be evident in the proportion of age-2 smolts in the spring 1996 age sample. Both of these indicators should be examined. To ensure complete and representative data collections in 1996, the smolt fence should be in place and operational by April 10 to avoid missing the early migration of coho smolts and a high proportion of all age-2 smolts likely to migrate in 1996.

ACKNOWLEDGEMENTS

Much of the success of this project can be attributed to the experience and dedication of our field crew consisting of Jim Amos, Dusty Alix, Don Bolivar, and Rob Fielden. 1995 was a year of managerial transition for the Black Creek coho program, and several Department of Fisheries and Oceans staff lent assistance to the process, including Richard Bailey, Steve Baillie, Ted Carter, Jim Irvine, and Dick Nagtegaal. The Ageing Unit of the Pacific Biological Station was responsible for ageing scale samples. Logistical support for the project was provided by B.C. Parks staff at the Miracle Beach/Strathcona Zone office. Special thanks also to Tom G. Brown and John Lewis (DFO) for their assistance in 1995, and to Bob Bocking and Anita Gurak of LGL Limited for their review of the final manuscript.

This study was funded by the Science Branch of Fisheries and Oceans Canada in support of the International Pacific Salmon Treaty.

LITERATURE CITED

- Bocking, R. C., J. R. Irvine, and R. E. Bailey. 1991. Enumeration and coded wire tagging of coho salmon (*Oncorhynchus kisutch*) smolts leaving Black Creek, French Creek, and the Trent River, on Vancouver Island, 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2115: 103 p.
- Clark, D. G. and J. R. Irvine. 1989. Enumeration and coded-wire tagging of coho salmon (*Oncorhynchus kisutch*) smolts leaving Black Creek, Vancouver Island, during 1978 and 1979, their subsequent distribution in sport and commercial fisheries, and escapement to the creek in 1978-1980. Can. Manuscr. Rep. Fish. Aquat. Sci. 2017: 45 p.
- Conlin, K. and B. D. Tutty. 1979. Juvenile salmonid field trapping manual. Fish. Mar. Serv. Manuscr. Rep. 1530: 136 p.
- Fielden, R. J., G. J. Birch, and J. R. Irvine. 1989. Enumeration and coded-wire tagging of coho salmon (*Oncorhynchus kisutch*) smolts leaving Black Creek, French Creek, and the Trent River, Vancouver Island, during 1988. Can. Manuscr. Rep. Fish. Aquat. Sci. 2018: 85 p.
- Hancock, M. J. and D. E. Marshall. 1985. Catalogue of salmon streams and spawning escapements of Statistical Area 14 Comox-Parksville. Can. Data Rep. Fish. Aquat. Sci. 504: 13 p.
- Labelle, M. 1990. A comparative study of coho stocks of S. E. Vancouver Island, British Columbia. Juvenile outmigration, coded-wire tagging and recovery, escapement enumeration and stock composition at Black Creek, Trent River and French Creek, 1984-1988. Can. Tech. Rep. Fish Aquat. Sci. 1722: 148 p.
- Nass, B. L., J. Carolsfeld, J. R. Irvine, and R. E. Bailey. 1993. Enumeration and coded wire tagging of coho salmon (*Oncorhynchus kisutch*) smolts leaving Black Creek, French Creek, and the Trent River on Vancouver Island during 1990. Can. Manuscr. Rep. Fish. Aquat. Sci. 2206. 82 p.
- Nelson, T. C., J. R. Irvine, and R. E. Bailey. 1996. 1994 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2356 x + 67 p.
- Nelson, T. C., R. E. Bailey, and J. R. Irvine. 1995. 1993 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2291: x + 74 p.

- Nelson, T. C., J. R. Irvine, and R. E. Bailey. 1994a. 1992 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manusc. Rep. Fish. Aquat. Sci. 2290: x + 70 p.
- Nelson, T. C., B. L. Nass, R. E. Bailey, and J. R. Irvine. 1994b. 1991 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manusc. Rep. Fish. Aquat. Sci. 2239: x + 71 p.
- Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can. 191. 382 p.

TABLES

Table 1. Coho smolt catches by sampling period at Black Creek, 1995. Mortalities include smolts killed by trapping and predation.

Sampling period	Total smolt catch ¹			Pre-tagging mortalities	Number released untagged ²	Number available for tagging
	Small (S)	Large (L)	(S + L)			
04/21 - 05/10	938	8134	9072	48	3	9021
05/11 - 06/02	1721	7191	8912	18	5	8889
06/03 - 06/08	67	244	311	11	0	300
Total	2726	15569	18295	77	8	18210

¹small (S) is < 120 mm; large (L) is > = 120 mm

²No. released untagged = known escapees + fish released due to poor condition

Table 2. Total number of non-coho fish caught at the Black Creek smolt counting fence, April - June 1995. All fish were captured moving downstream.

Species	Life stage	Total number caught
Steelhead	smolt (H)	0
	smolt (W)	214
	kelt (W)	10
Cutthroat	fry	0
	parr	1
	smolt (H)	43
	smolt (W)	177
	kelt (H)	375
	kelt (W)	271
Cottids	-	1900
Lamprey	-	159
Stickleback	-	64

H = hatchery (fin clip observed); W = wild (no clips observed)

Table 3. Results of trap efficiency test conducted at Black Creek, 1995.

Date of release	Number smolts released	Fin clip	Number recovered	Date of last recovery	Percent recovered
05/05	100	upper caudal	100	05/12	100.0

Table 4. Age-length distribution of Black Creek coho smolts, by sampling period, 1995. Age representation was determined according to Ketchen's stratified subsampling method (Ricker 1975, p. 67). Age sample "X" includes random and non-random samples; length sample "Y" comprises random samples only.

Sampling period	Size class (mm)	Age sample (X)	Ages in (X)			Length sample (Y)	Calculated ages in (Y)			
			Age 1	Age 2	Age 3		Age 1	Age 2	Age 3	
<u>04/21 - 05/10</u>										
	< 90	0	0	0	0	0	0.0	0.0	0.0	
	90-94	0	0	0	0	0	0.0	0.0	0.0	
	95-99	0	0	0	0	0	0.0	0.0	0.0	
	100-104	0	0	0	0	0	0.0	0.0	0.0	
	105-109	1	1	0	0	1	1.0	0.0	0.0	
	110-114	10	10	0	0	8	8.0	0.0	0.0	
	115-119	11	9	2	0	19	15.5	3.5	0.0	
	120-124	15	15	0	0	66	66.0	0.0	0.0	
	125-129	11	8	3	0	43	31.3	11.7	0.0	
	130-134	14	14	0	0	51	51.0	0.0	0.0	
	135-139	14	13	1	0	48	44.6	3.4	0.0	
	140-144	11	11	0	0	41	41.0	0.0	0.0	
	145-149	8	5	3	0	42	26.3	15.8	0.0	
	150-154	10	8	2	0	27	21.6	5.4	0.0	
	155-159	9	3	6	0	30	10.0	20.0	0.0	
	160-164	6	0	6	0	13	0.0	13.0	0.0	
	165-169	4	0	4	0	18	0.0	18.0	0.0	
	170-174	5	0	4	1	14	0.0	11.2	2.8	
	175-179	9	1	8	0	16	1.8	14.2	0.0	
	180-184	6	0	6	0	15	0.0	15.0	0.0	
	185-189	6	0	6	0	9	0.0	9.0	0.0	
	190-194	5	0	5	0	7	0.0	7.0	0.0	
	195-199	6	0	6	0	4	0.0	4.0	0.0	
	200-204	2	0	2	0	2	0.0	2.0	0.0	
	205-209	2	0	2	0	3	0.0	3.0	0.0	
	210-214	2	0	2	0	1	0.0	1.0	0.0	
	215-219	1	0	1	0	1	0.0	1.0	0.0	
	220-224	0	0	0	0	0	0.0	0.0	0.0	
	225-229	0	0	0	0	1	0.0	0.0	0.0	
	Total	168	98	69	1	480	318	158	3	
							Percent of length sample (Y)	66.3	33.0	0.6

Table 4. Age-length distribution of Black Creek coho smolts, by sampling period, 1995. Age (cont.) representation was determined according to Ketchen's stratified subsampling method (Ricker 1975, p. 67). Age sample "X" includes random and non-random samples; length sample "Y" comprises random samples only.

Sampling period	Size class (mm)	Age sample (X)	Ages in (X)			Length sample (Y)	Calculated ages in (Y)		
			Age 1	Age 2	Age 3		Age 1	Age 2	Age 3
<u>05/11 - 06/02</u>									
	< 90	0	0	0	0	0	0.0	0.0	0.0
	90-94	0	0	0	0	0	0.0	0.0	0.0
	95-99	1	1	0	0	0	0.0	0.0	0.0
	100-104	3	3	0	0	2	2.0	0.0	0.0
	105-109	7	7	0	0	8	8.0	0.0	0.0
	110-114	14	14	0	0	21	21.0	0.0	0.0
	115-119	20	19	1	0	62	58.9	3.1	0.0
	120-124	25	25	0	0	115	115.0	0.0	0.0
	125-129	26	24	2	0	97	89.5	7.5	0.0
	130-134	19	18	1	0	60	56.8	3.2	0.0
	135-139	12	12	0	0	33	33.0	0.0	0.0
	140-144	7	4	3	0	9	5.1	3.9	0.0
	145-149	4	4	0	0	4	4.0	0.0	0.0
	150-154	2	1	1	0	3	1.5	1.5	0.0
	155-159	0	0	0	0	0	0.0	0.0	0.0
	160-164	0	0	0	0	0	0.0	0.0	0.0
	165-169	0	0	0	0	0	0.0	0.0	0.0
	170-174	0	0	0	0	0	0.0	0.0	0.0
	175-179	0	0	0	0	1	0.0	0.0	0.0
	180-184	0	0	0	0	1	0.0	0.0	0.0
	185-189	0	0	0	0	0	0.0	0.0	0.0
	190-194	0	0	0	0	0	0.0	0.0	0.0
	195-199	0	0	0	0	0	0.0	0.0	0.0
	200-204	0	0	0	0	0	0.0	0.0	0.0
	205-209	0	0	0	0	0	0.0	0.0	0.0
	210-214	0	0	0	0	0	0.0	0.0	0.0
	215-219	0	0	0	0	0	0.0	0.0	0.0
	220-224	0	0	0	0	0	0.0	0.0	0.0
	225-229	0	0	0	0	0	0.0	0.0	0.0
	Total	140	132	8	0	416	395	19	0
							94.9	4.6	0.0

Table 4. Age-length distribution of Black Creek coho smolts, by sampling period, 1995. Age (cont.) representation was determined according to Ketchen's stratified subsampling method (Ricker 1975, p. 67). Age sample "X" includes random and non-random samples; length sample "Y" comprises random samples only.

Sampling period	Size class (mm)	Age sample (X)	Ages in (X)			Length sample (Y)	Calculated ages in (Y)		
			Age 1	Age 2	Age 3		Age 1	Age 2	Age 3
<u>06/03 - 06/08</u>									
	< 90	0	0	0	0	0	0.0	0.0	0.0
	90-94	0	0	0	0	0	0.0	0.0	0.0
	95-99	0	0	0	0	1	0.0	0.0	0.0
	100-104	0	0	0	0	0	0.0	0.0	0.0
	105-109	0	0	0	0	0	0.0	0.0	0.0
	110-114	0	0	0	0	4	0.0	0.0	0.0
	115-119	0	0	0	0	7	0.0	0.0	0.0
	120-124	0	0	0	0	8	0.0	0.0	0.0
	125-129	0	0	0	0	11	0.0	0.0	0.0
	130-134	0	0	0	0	11	0.0	0.0	0.0
	135-139	0	0	0	0	7	0.0	0.0	0.0
	140-144	0	0	0	0	5	0.0	0.0	0.0
	145-149	1	1	0	0	1	1.0	0.0	0.0
	150-154	1	1	0	0	1	1.0	0.0	0.0
	155-159	0	0	0	0	0	0.0	0.0	0.0
	160-164	0	0	0	0	0	0.0	0.0	0.0
	165-169	0	0	0	0	0	0.0	0.0	0.0
	170-174	0	0	0	0	0	0.0	0.0	0.0
	175-179	0	0	0	0	0	0.0	0.0	0.0
	180-184	0	0	0	0	0	0.0	0.0	0.0
	185-189	0	0	0	0	0	0.0	0.0	0.0
	190-194	0	0	0	0	0	0.0	0.0	0.0
	195-199	0	0	0	0	0	0.0	0.0	0.0
	200-204	0	0	0	0	0	0.0	0.0	0.0
	205-209	0	0	0	0	0	0.0	0.0	0.0
	210-214	0	0	0	0	0	0.0	0.0	0.0
	215-219	0	0	0	0	0	0.0	0.0	0.0
	220-224	0	0	0	0	0	0.0	0.0	0.0
	225-229	0	0	0	0	0	0.0	0.0	0.0
	Total	2	2	0	0	56	2	0	0
							3.6	0.0	0.0
	Grand total	310	232	77	1	952	715	177	3
							75.1	18.6	0.3

(X) = random and non-random samples

(Y) = random samples only

Table 5. Means and standard deviations for lengths and weights of Black Creek smolts, by age and sampling period, 1995. Data from successfully aged random samples only.

Age	Sampling period	Fork length (mm)			Weight (g)		
		N	Mean	SD	N	Mean	SD
1	04/21 - 05/10	98	131.8	13.68	98	25.01	8.046
	05/11 - 06/02	132	123.8	10.41	127	20.65	5.229
	06/03 - 06/08	2	148.0	2.83	2	30.80	1.697
	Total age-1 ¹	232	127.4	12.64	227	22.62	6.950
2	04/22 - 05/10	69	173.7	22.81	63	54.41	20.929
	05/11 - 06/02	8	134.5	10.65	7	24.33	4.597
	06/03 - 06/08	0	-	-	0	-	-
	Total age-2 ¹	77	169.6	24.91	70	51.40	21.864
3	04/22 - 05/10	1	172.0	0.00	1	51.90	0.000
	05/11 - 06/02	0	-	-	0	-	-
	06/03 - 06/08	0	-	-	0	-	-
	Total age-3 ¹	1	172.0	0.00	1	51.90	0.000
Grand total (all ages) ²		310	138.0	24.68	298	29.48	17.283

¹total means and standard deviations are calculated from pooled data across sampling periods

²total means and standard deviations are calculated from pooled data from all age groups across sampling periods

Table 6. Sex ratios and mean lengths of Black Creek coho smolts, by sampling period, 1995.

Sampling period	Sex	Proportion (%)	Sample size	Mean length (mm)	SD length (mm)
04/21 - 05/10	Male	63.0	29	128	20.8
	Female	37.0	17	116	14.7
05/11 - 06/02	Male	80.0	12	115	7.0
	Female	20.0	3	115	10.0
06/03 - 06/08	Male	60.0	6	119	11.6
	Female	40.0	4	118	5.6
Total ¹	Male	66.2	47	123	18.0
	Female	33.8	24	116	12.9

¹total means and standard deviations are calculated for pooled data across all sampling periods

Table 7. Coded-wire tag release data for Black Creek coho smolts, by size group, 1995.

Size group ¹	Tag code	Tagging dates	No. tagged	Tag morts	No. released tagged ²	No. released untagged ³
Small						
	080811	04/24 - 06/08	2701	1	2700	1
		Subtotal	2701	1	2700	1
Large						
	080810	04/21 - 05/11	9344	0	9344	3
	080812	05/12 - 06/08	6165	1	6164	4
		Subtotal	15509	1	15508	7
Grand total			18210	2	18208	8

Note: all tag codes are for sequential coded-wire tags

¹small is < 120 mm; large is > = 120 mm

²not corrected for tag loss; total tag loss was 0.279% for smolts (see Table 9)

³No. released untagged = known escapees + fish released due to poor condition

Table 8. Sequential coded-wire tag start and end data, by tag date, for coded-wire tags applied to small and large coho smolts at Black Creek, 1995.

Tag date	Small ¹			Large ¹		
	Tag code	Start	End	Tag code	Start	End
04/21				080810	205	387
04/22				080810	393	478
04/23				080810	550	691
04/24	080811	125	129	080810	697	770
04/25				080810	791	904
04/26	080811	151	162	080810	915	1030
04/27	080811	171	183	080810	1042	1283
04/28	080811	196	206	080810	1300	1471
04/29	080811	223	251	080810	1492	1767
04/30	080811	276	310	080810	1789	1995
05/01	080811	326	379	080810	2014	2673
05/02	080811	404	431	080810	2687	2952
05/03	080811	449	573	080810	2965	3853
05/04	080811	588	674	080810	3969	4742
05/05	080811	692	762	080810	4771	5270
05/06	080811	786	940	080810	5521	6391
05/07	080811	953	1084	080810	6413	7487
05/08	080811	1132	1275	080810	7510	8773
05/09	080811	1289	1376	080810	8796	9661
05/10	080811	1423	1646	080810	9681	10909
05/11	080811	1669	1955	080810	10926	12417
05/12	080811	1977	2386	080812	129	1883
05/13	080811	2406	2507	080812	1900	2400
05/14	080811	2524	2657	080812	2425	3370
05/15	080811	2681	2956	080812	3395	4560
05/16	080811	2978	3345	080812	4575	5802
05/17	080811	3366	3539	080812	5828	6282
05/18	080811	3554	3660	080812	6305	6511
05/19	080811	3679	3731	080812	6535	6721
05/20	080811	3750	3789	080812	6737	6813
05/21	080811	3806	3917	080812	6835	7180
05/22	080811	3932	3940	080812	7199	7213
05/23	080811	3959	3989	080812	7239	7341
05/24	080811	4009	4014	080812	7359	7369
05/25	080811	4039	4048	080812	7386	7391
05/26	080811	4065	4077	080812	7405	7418
05/27	080811	4094	4104	080812	7469	7486
05/28	080811	4126	4155	080812	7502	7601
05/30	080811	4173	4183	080812	7615	7667
05/31				080812	7681	7687
06/03	080811	4215	4287	080812	7703	7942
06/04				080812	7962	7971
06/07	080811	4303	4309			
06/08	080811	4323	4333	080812	7984	8025

¹small is < 120 mm; large is > = 120 mm

Table 9. Coded-wire tag retention and loss rates for Black Creek juvenile coho, 1995.

Life stage	Date	Hours held	Sample size	Number tags lost	Tag retention (%)	Tag loss (%)
Smolts						
	04/28	48	52	1	98.1	1.923
	05/05	24	100	0	100.0	0.000
	05/12	24	100	0	100.0	0.000
	05/18	24	107	0	100.0	0.000
		Total	359	1	99.7	0.279

FIGURES

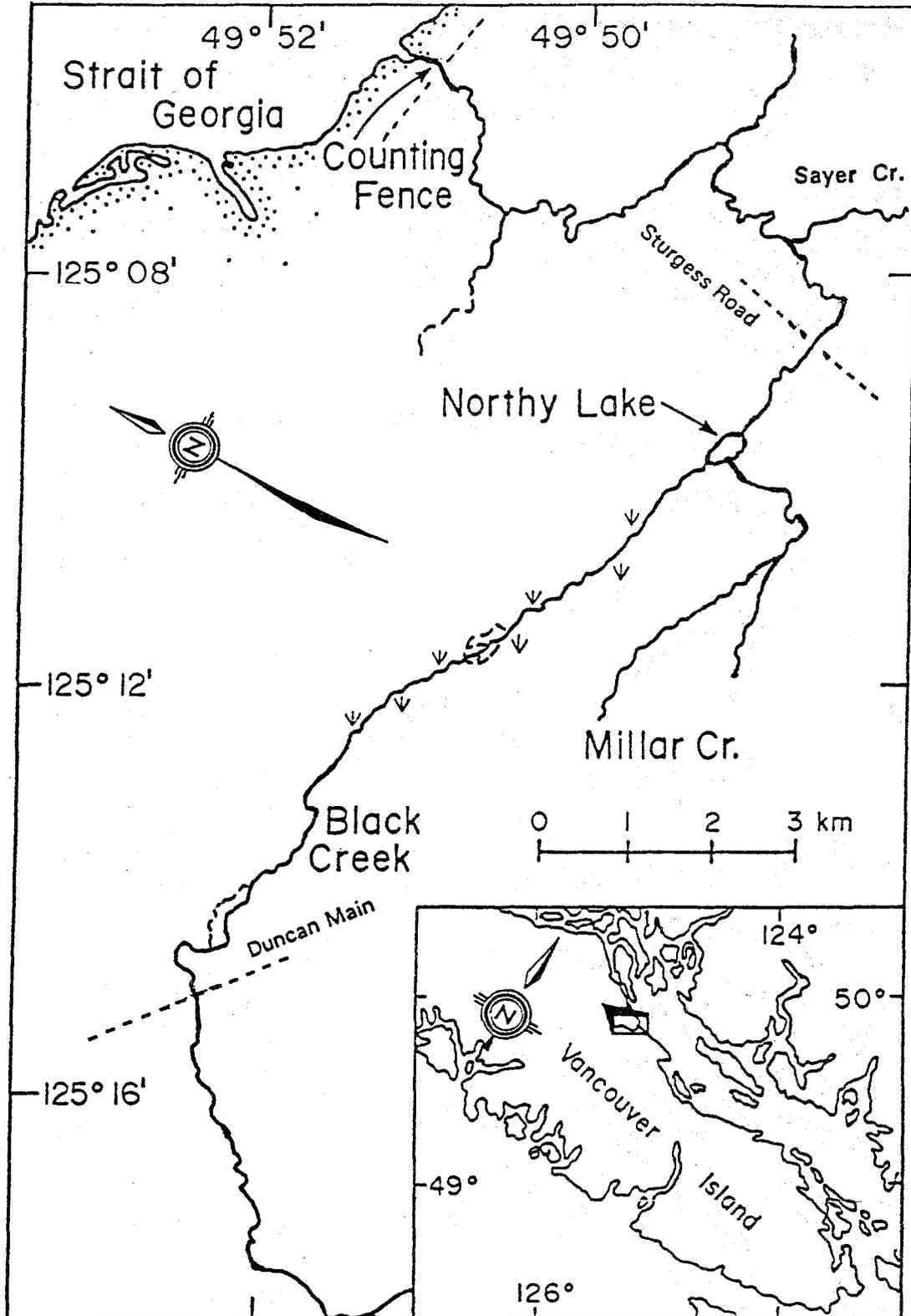


Figure 1. Map of the Black Creek drainage, showing the location of the smolt counting fence.

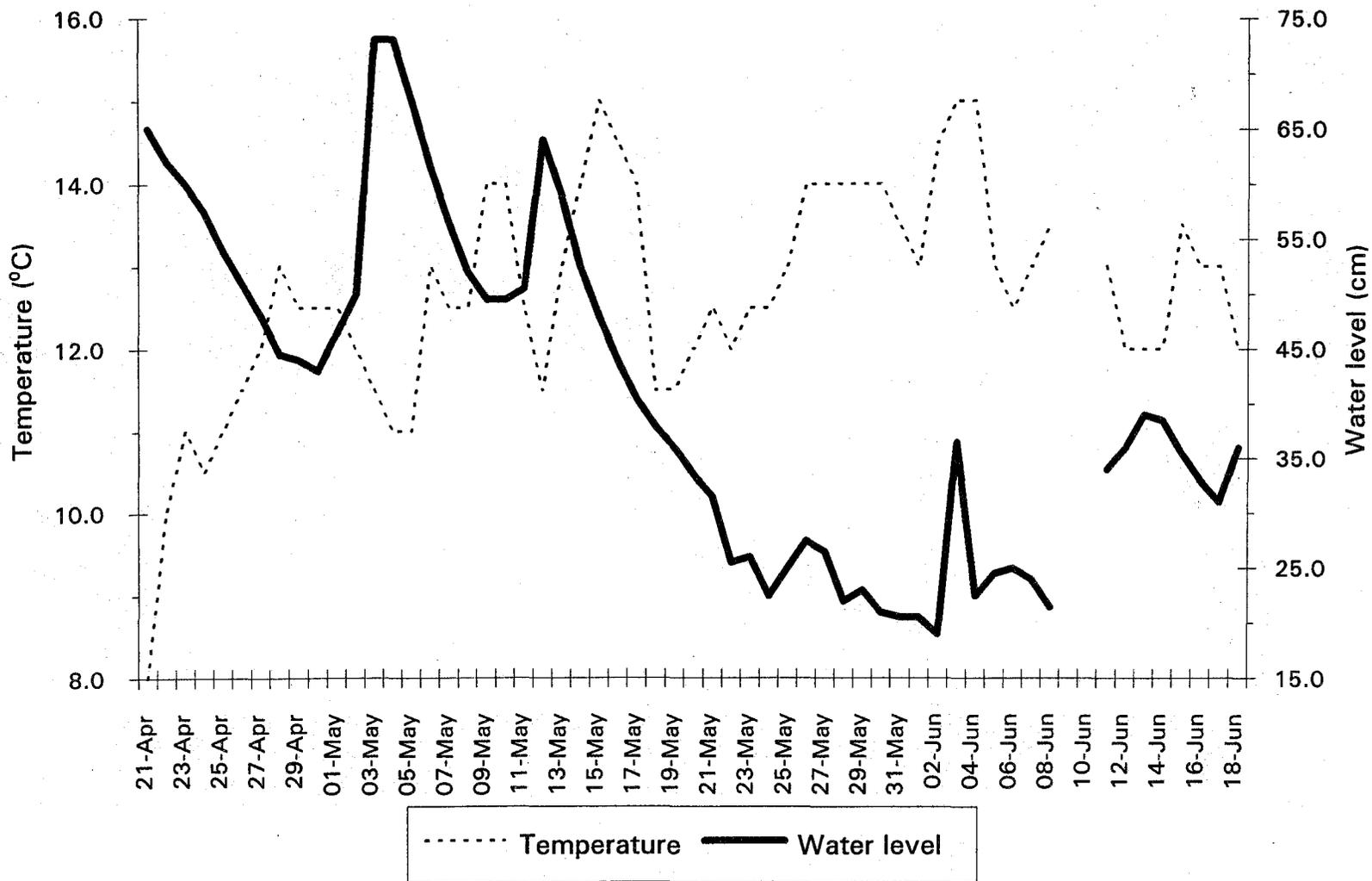


Figure 2. Water temperatures and levels at Black Creek from April 21 - June 18, 1995. Temperature data were recorded at the tagging station; water level data were recorded at the staff gauge located 200 m upstream of the Seaview Road Bridge.

Black Creek Coho Smolts 1995

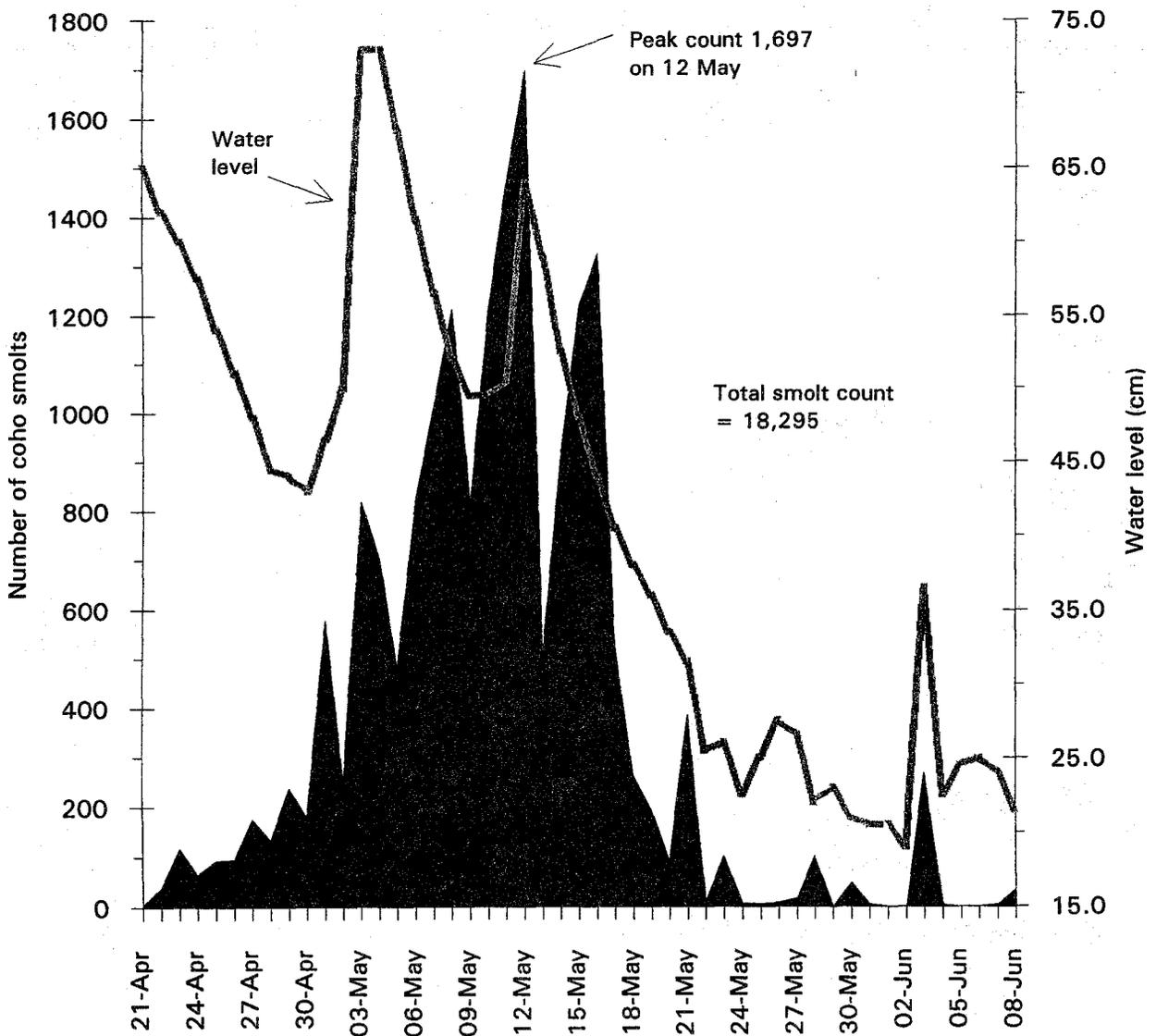


Figure 3. Total daily catches of coho smolts at the counting fence, and associated water levels, by date, at Black Creek, 1995.

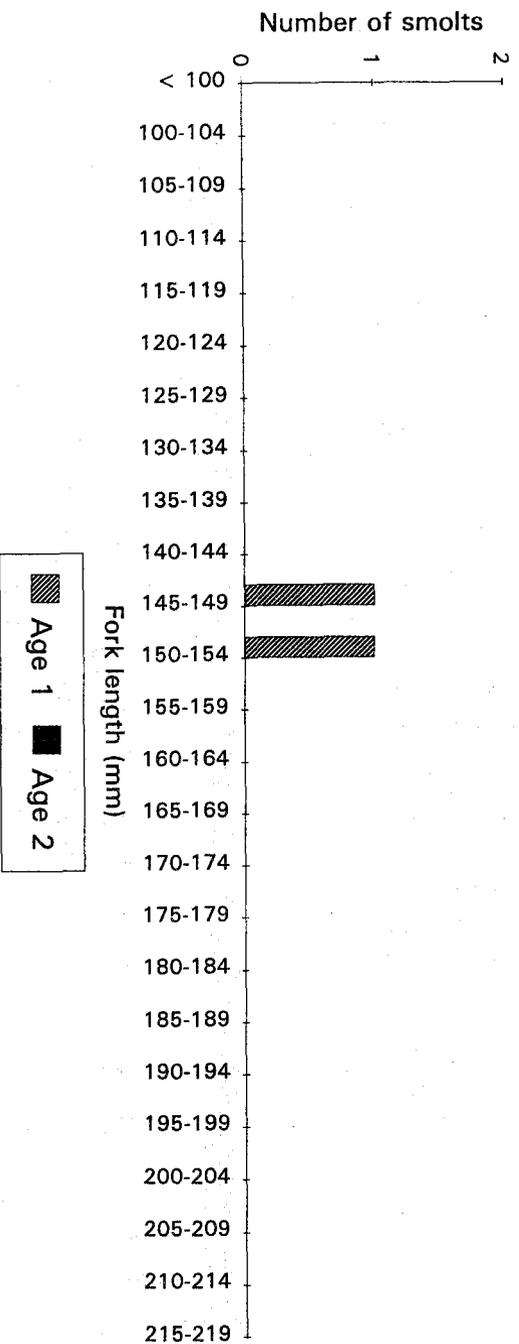
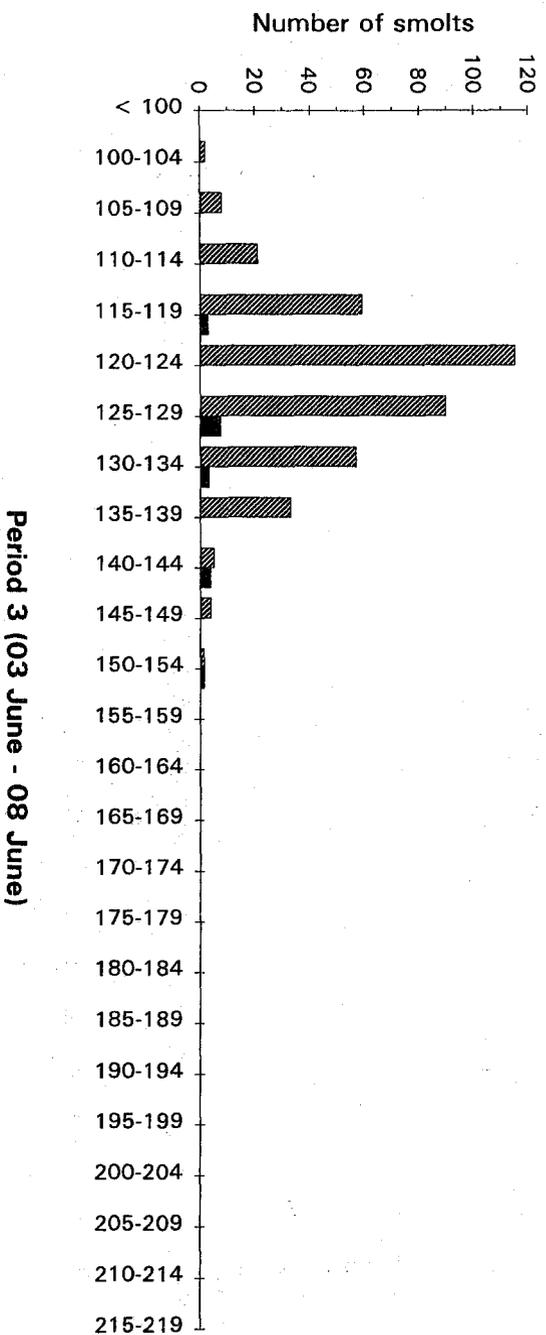
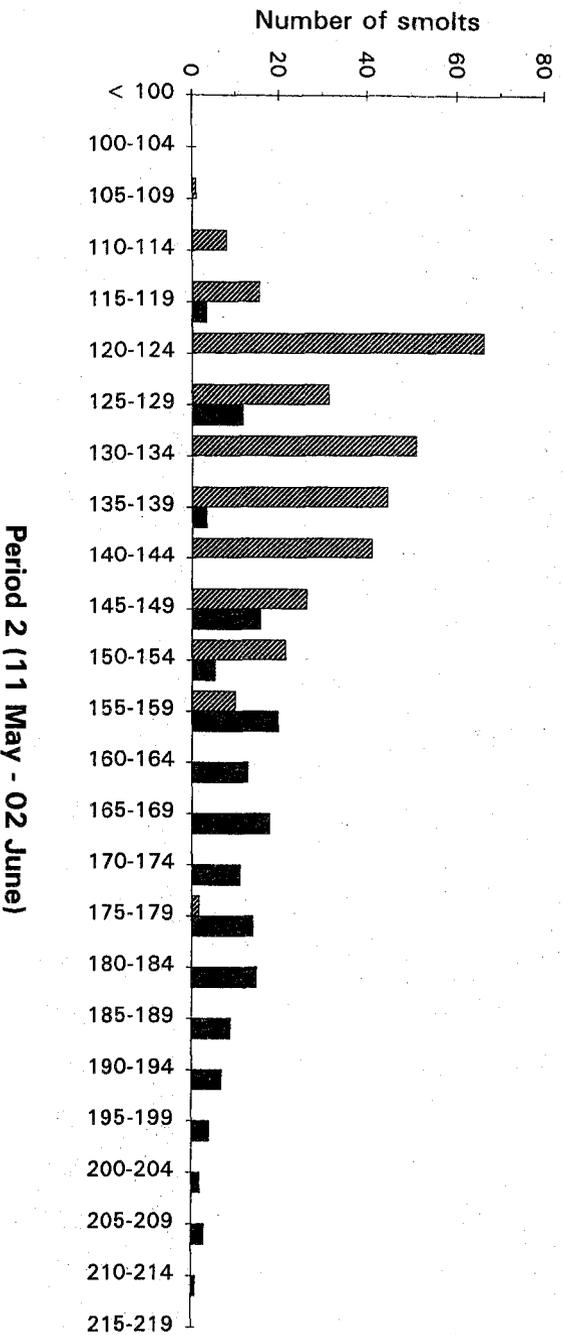


Figure 4. Calculated age-length representation of age-1 and age-2 coho smolts, by sampling period, at Black Creek, 1995. (Data from Table 6.)

Black Creek Coho Smolts 1985 - 1995

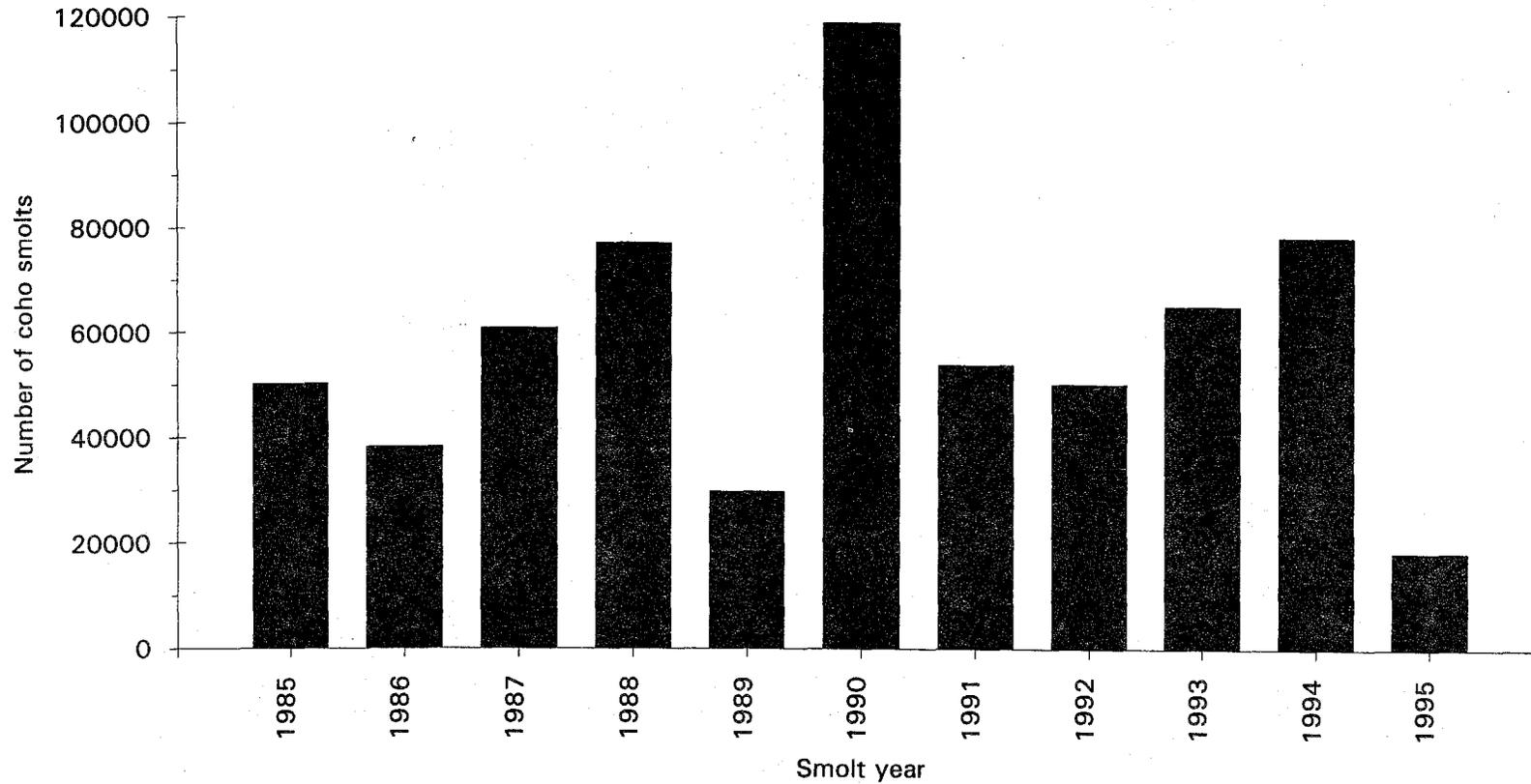


Figure 5. Observed and estimated number of coho smolts that migrated from Black Creek during spring sampling programs, 1985 - 1995. Data from: Labelle (1990), Bocking et al. (1991), Nass et al. (1993), Nelson et al. (1994b), Nelson et al. (1994a), Nelson et al. (1995), Nelson et al. (1996), and this report.

Black Creek Coho Smolt Migrations 1993 - 1995

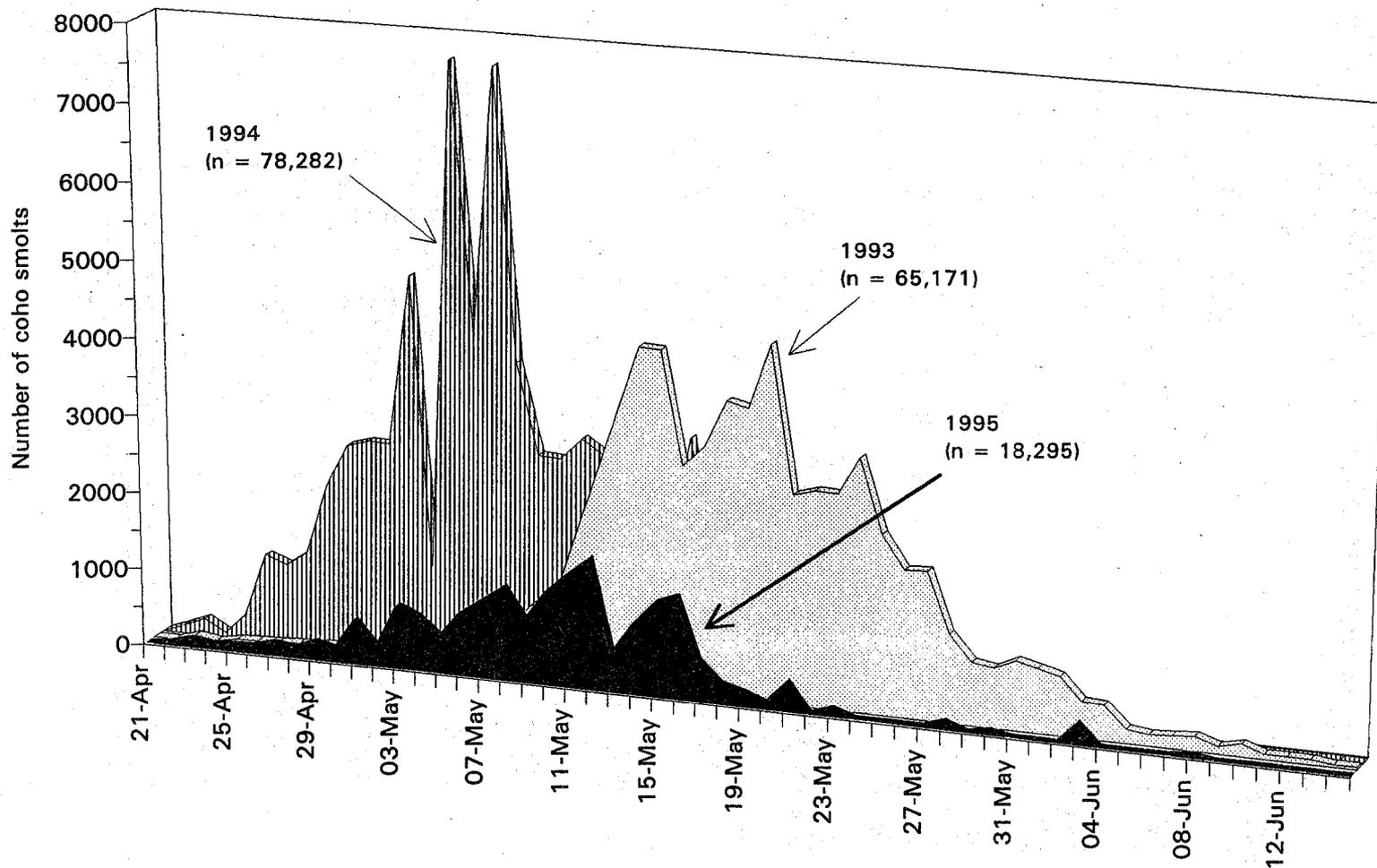


Figure 6. Comparative illustration of the relative magnitudes and respective migration patterns, by like dates between years, of coho smolts that migrated from Black Creek during the 1993, 1994, and 1995 spring sampling seasons.

Appendix A

Biophysical data for Black Creek, April 21-June 18, 1995.

Appendix A. Biophysical data for Black Creek, April 21 - June 18, 1995. Temperature data was recorded at the enumeration fence, and water level data were recorded manually from the staff gauge located 200 m upstream of the Seaview Road Bridge. Time entries indicate the time of day when records for rain, wind direction, wind speed, and cloud cover were recorded.

Date	Time (24 h)	Water Temperature (°C)	Water level (cm)	Rain (0-5)	Wind direction	Wind speed (km/h)	Cloud cover (%)
04/21/95	08:00	8.0	65.0	0		0	5
04/22/95	08:00	10.0	62.0	0		0	5
04/23/95	08:00	11.0	60.0	0		0	5
04/24/95	08:00	10.5	57.5	0	W	7	7
04/25/95	08:00	11.0	54.0	0		0	3
04/26/95	08:00	11.5	51.0	0		0	15
04/27/95	08:00	12.0	48.0	0		0	40
04/28/95	08:00	13.0	44.5	0		0	85
04/29/95	08:00	12.5	44.0	0		0	90
04/30/95	08:00	12.5	43.0	0		0	92
05/01/95	08:00	12.5	46.5	0	NW	5	50
05/02/95	08:00	12.0	50.0	1		0	100
05/03/95	06:30	11.5	73.0	0		0	60
05/04/95	08:00	11.0	73.0	0		0	0
05/05/95	08:00	11.0	67.5	0	NW	10	0
05/06/95	08:00	13.0	61.5	0	NW	10	0
05/07/95	08:00	12.5	56.5	0		0	0
05/08/95	08:00	12.5	52.0	0		0	0
05/09/95	08:00	14.0	49.5	1		0	100
05/10/95	08:00	14.0	49.5	0		0	50
	Mean	11.8	55.4				
	Max	14.0	73.0				
	Min	8.0	43.0				
05/11/95	08:00	12.5	50.5	2		0	100
05/12/95	08:00	11.5	64.0	0		0	40
05/13/95	08:00	13.0	59.0	0	NW	5	0
05/14/95	08:00	14.0	52.5	0		0	95
05/15/95	08:00	15.0	48.0	0	NW	15	5
05/16/95	08:00	14.5	44.0	0		0	0
05/17/95	08:00	14.0	40.5	0		0	90
05/18/95	08:00	11.5	38.0	0	NW	10	0
05/19/95	08:00	11.5	36.0	0	NW	10	0
05/20/95	08:00	12.0	33.5	0	NW	5	0
05/21/95	08:00	12.5	31.5	0		0	0
05/22/95	08:00	12.0	25.5	0		0	5
05/23/95	08:00	12.5	26.0	0	NW	10	0

Appendix A. Biophysical data for Black Creek, April 21 - June 18, 1995. Temperature data was recorded at the enumeration fence, and water level data were recorded manually from the staff gauge located 200 m upstream of the Seaview Road Bridge. Time entries indicate the time of day when records for rain, wind direction, wind speed, and cloud cover were recorded.

Date	Time (24 h)	Water Temperature (°C)	Water level (cm)	Rain (0-5)	Wind direction	Wind speed (km/h)	Cloud cover (%)
05/24/95	08:00	12.5	22.5	0		0	0
05/25/95	08:00	13.0	25.0	0		0	4
05/26/95	08:00	14.0	27.5	0		0	0
05/27/95	08:00	14.0	26.5	0		0	0
05/28/95	08:00	14.0	22.0	0		0	2
05/29/95	08:00	14.0	23.0	0		0	99
05/30/95	08:00	14.0	21.0	0		0	6
05/31/95	08:00	13.5	20.5	0		0	4
06/01/95	08:00	13.0	20.5	0	NW	5	6
06/02/95	08:00	14.5	19.0	0	NW	5	4
	Mean	13.2	33.8				
	Max	15.0	64.0				
	Min	11.5	19.0				
06/03/95	08:00	15.0	36.5	0		0	0
06/04/95	08:00	15.0	22.5	1		0	100
06/05/95	08:00	13.0	24.5	0		0	98
06/06/95	08:00	12.5	25.0	0	NW	10	2
06/07/95	08:00	13.0	24.0	0	NW	5	37
06/08/95	08:00	13.5	21.5	0		0	92
06/09/95							
06/10/95							
06/11/95		13.0	34.0				
06/12/95		12.0	36.0				
06/13/95		12.0	39.0				
06/14/95		12.0	38.5				
06/15/95		13.5	35.5				
06/16/95		13.0	33.0				
06/17/95		13.0	31.0				
06/18/95		12.0	36.0				
	Mean	13.0	31.2				
	Max	15.0	39.0				
	Min	12.0	21.5				

Appendix B

Catches of juvenile coho at the Black Creek counting fence,
by date, 1995.

Appendix B. Catches of juvenile coho at the Black Creek counting fence, by date, 1995.

Capture date	Total fry catch	Total smolt catch ¹	Total pre-tag smolt morts ²	Total No. smolt released untagged ³	Total No. smolts available for tagging ⁴
04/21/95	3	5	0	0	5
04/22/95	0	40	2	0	38
04/23/95	1	117	1	0	116
04/24/95	3	65	3	1	61
04/25/95	6	93	2	0	91
04/26/95	1	95	0	0	95
04/27/95	2	176	0	1	175
04/28/95	0	135	0	0	135
04/29/95	0	239	0	0	239
04/30/95	0	181	0	0	181
05/01/95	2	578	10	0	568
05/02/95	1	252	2	0	250
05/03/95	1	818	4	0	814
05/04/95	0	703	6	0	697
05/05/95	0	483	1	0	482
05/06/95	3	826	2	0	824
05/07/95	0	1019	1	1	1017
05/08/95	1	1213	2	0	1211
05/09/95	5	818	2	0	816
05/10/95	1	1216	10	0	1206
05/11/95	1	1473	0	1	1472
05/12/95	0	1697	0	1	1696
05/13/95	2	514	3	1	510
05/14/95	2	911	2	2	907
05/15/95	0	1220	2	0	1218
05/16/95	0	1326	1	0	1325
05/17/95	1	526	2	0	524
05/18/95	1	264	3	0	261
05/19/95	0	195	0	0	195
05/20/95	0	92	0	0	92
05/21/95	3	387	0	0	387
05/22/95	0	12	0	0	12
05/23/95	7	102	0	0	102
05/24/95	1	6	0	0	6
05/25/95	30	6	0	0	6
05/26/95	103	8	0	0	8
05/27/95	42	17	1	0	16
05/28/95	18	103	3	0	100
05/29/95	6	0	0	0	0
05/30/95	17	48	1	0	47
05/31/95	1	5	0	0	5
06/01/95	2	0	0	0	0
06/02/95	0	0	0	0	0
06/03/95	33	269	10	0	259
06/04/95	4	4	0	0	4
06/05/95	3	0	0	0	0
06/06/95	4	0	0	0	0
06/07/95	0	3	1	0	2
06/08/95	3	35	0	0	35
Total	314	18295	77	8	18210

¹total smolt catch = No. tagged + total pre-tag morts + No. escapees + No. released untagged

²total pre-tag morts = trap and predation mortalities + sacrifices

³total No. released untagged = No. released untagged (due to poor condition) + No. escapees

⁴No. available for tagging = total catch - pre-tag morts - No. released untagged

Appendix C

Catches of fish other than coho at the Black Creek counting fence,
by date, 1995.

Appendix C. Catches of fish other than coho at the Black Creek counting fence, by date, 1995.

Date	Steelhead								Cutthroat								Cottids	Lamprey	Stickle-back
	fry	parr	smolt no ad	smolt no clip	adult no ad	adult no clip	kelt no ad	kelt no clip	fry	parr	smolt no ad	smolt no clip	adult no ad	adult no clip	kelt no ad	kelt no clip			
04/21/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	22	1	2
04/22/95	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	4	56	0	2
04/23/95	0	0	0	1	0	0	0	5	0	0	0	0	0	1	27	73	0	1	
04/24/95	0	0	0	4	0	0	0	0	0	0	0	6	0	0	3	13	110	0	0
04/25/95	0	0	0	6	0	0	0	0	0	0	0	8	0	0	2	12	113	3	2
04/26/95	0	0	0	3	0	0	0	0	0	0	0	9	0	0	0	4	94	2	1
04/27/95	0	0	0	3	0	0	0	0	0	0	0	2	0	0	2	4	68	0	0
04/28/95	0	0	0	3	0	0	0	1	0	0	0	2	0	0	0	0	58	1	1
04/29/95	0	0	0	3	0	0	0	0	0	0	0	1	0	0	1	0	36	1	0
04/30/95	0	0	0	4	0	0	0	0	0	0	1	1	0	0	6	2	32	4	0
05/01/95	0	0	0	3	0	0	0	0	0	0	5	2	0	0	2	1	44	4	1
05/02/95	0	0	0	6	0	0	0	0	0	0	6	3	0	0	3	3	30	3	1
05/03/95	0	0	0	9	0	0	0	3	0	1	7	5	0	0	9	7	15	5	0
05/04/95	0	0	0	28	0	0	0	0	0	0	6	17	0	0	23	27	30	1	2
05/05/95	0	0	0	16	0	0	0	1	0	0	1	8	0	0	14	11	6	1	1
05/06/95	0	0	0	5	0	0	0	0	0	0	0	3	0	0	5	2	24	3	0
05/07/95	0	0	0	15	0	0	0	0	0	0	0	7	0	0	10	15	26	1	0
05/08/95	0	0	0	9	0	0	0	0	0	0	9	12	0	0	23	8	14	1	1
05/09/95	0	0	0	4	0	0	0	0	0	0	2	7	0	0	27	7	33	1	1
05/10/95	0	0	0	6	0	0	0	0	0	0	2	11	0	0	25	12	14	1	0
05/11/95	0	0	0	7	0	0	0	0	0	0	2	18	0	0	20	4	26	1	2
05/12/95	0	0	0	51	0	0	0	0	0	0	0	7	0	0	80	49	4	8	1
05/13/95	0	0	0	17	0	0	0	0	0	0	0	12	0	0	30	27	10	0	0
05/14/95	0	0	0	4	0	0	0	0	0	0	0	11	0	0	22	10	16	0	3
05/15/95	0	0	0	2	0	0	0	0	0	0	0	6	0	0	10	4	11	1	0
05/16/95	0	0	0	0	0	0	0	0	0	0	1	4	0	0	2	9	31	0	0
05/17/95	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	28	1	2
05/18/95	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	12	8	0
05/19/95	0	0	0	1	0	0	0	0	0	0	0	7	0	0	28	2	3	1	0
05/20/95	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	3	0	0
05/21/95	0	0	0	1	0	0	0	0	0	0	1	3	0	0	13	2	5	2	1
05/22/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	4	0
05/23/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	94	21	7
05/24/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	5	1
05/25/95	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	122	7	3

Appendix C. Catches of fish other than coho at the Black Creek counting fence, by date, 1995.

(cont.)

Date	Steelhead								Cutthroat								Cottids	Lamprey	Stickle-back
	fry	parr	smolt no ad	smolt no clip	adult no ad	adult no clip	kelt no ad	kelt no clip	fry	parr	smolt no ad	smolt no clip	adult no ad	adult no clip	kelt no ad	kelt no clip			
05/26/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121	7	7
05/27/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	89	6	1
05/28/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	83	3	3
05/29/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	12	2
05/30/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	3	0
05/31/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	6
06/01/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	3	0
06/02/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06/03/95	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	73	21	5
06/04/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	2	1
06/05/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	1	1
06/06/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	1	1
06/07/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0
06/08/95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Total	0	0	0	214	0	0	0	10	0	1	43	177	0	0	375	271	1900	159	64