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1991 Juvenile and Adult Coho Salmon Enumeration Studies at Black Creek, Vancouver Island

T. C. Nelson, B. L. Nass, R. E. Bailey, and J. R. Irvine

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Canadian Manuscript Report of Fisheries and Aquatic Sciences 2239

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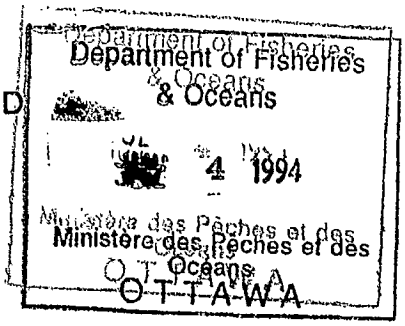
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Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2239

1994

1991 JUVENILE AND ADULT COHO SALMON ENUMERATION STUDIES AT BLACK CREEK, VANCOUVER ISLAND



by

T. C. Nelson[1], B. L. Nass[1], R. E. Bailey, and J. R. Irvine

Biological Sciences Branch

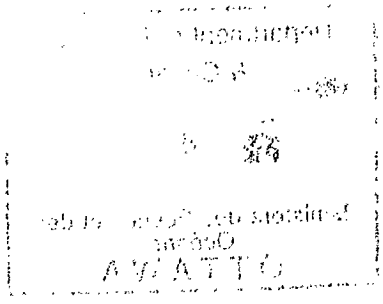
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Cat. No. Fs 97-4/2239E ISSN 0706-6473

Correct citation for this publication:

Nelson, T. C., B. L. Nass, R. E. Bailey, and J. R. Irvine. 1994. 1991 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2239: 71 p.

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ABSTRACT

Nelson, T. C., B. L. Nass, R. E. Bailey, and J. R. Irvine. 1994. 1991 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2239: 71 p.

Coho smolts leaving Black Creek between April 20 and June 24, 1991 were trapped and coded-wire tagged. A total of 53,876 smolts were captured at a counting fence and 53,284 of these (99%) were coded-wire tagged. We estimate that an additional 400 untagged smolts emigrated from Black Creek uncounted. Eighty two emigrant coho fry were also coded-wire tagged with half-length coded-wire tags. Mortalities due to trapping and tagging were low (0.55%). Most smolts were age 1 (92.9%) although the proportion of age-2 smolts increased significantly over the study. Mean stratified lengths and weights did not vary significantly among sampling periods. The ratio of male to female smolts was approximately 1:1.

Coho escapements to Black Creek in 1991 were monitored by an adult counting fence operated between October 15 and November 16, and by conducting upstream mark-recapture and area-under-the-curve (AUC) visual surveys from November 15 to December 17. Escapement estimates for adult and jack coho were derived using four methods: 1) an open simulation model; 2) a Bayesian model; 3) an adjusted Petersen method; and 4) the AUC method. We have most confidence in our estimates of adult and jack coho escapements of 3,568 and 2,373, respectively, derived using an open simulation model. Estimated escapements using the AUC method were 2,033 and 526. Adult and jack coho were predominantly freshwater age 1 (95.0 and 83.3%, respectively). The mean postorbital-hypural lengths of female, adult male, and jack coho were 53.3 cm, 48.3 cm, and 27.5 cm respectively. Female coho were significantly larger than adult male coho. The abundance of male and female coho was similar to 1:1 except when adult males and jacks were combined. Smolt-to-spawner survivals were highest for smolts emigrating during the first tagging period of the out-migrations for both adult and jack returns.

RÉSUMÉ

Nelson, T. C., B. L. Nass, R. E. Bailey, and J. R. Irvine. 1994. 1991 juvenile and adult coho salmon enumeration studies at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2239: 71 p.

Les smolts de cohos quittant le ruisseau Black entre le 20 avril et le 24 juin 1991 ont été capturés pour leur implanter des micro-marques codées. En tout, 53 876 smolts ont été capturés à une clôture de dénombrement; sur ce nombre, 53 284 (99 %) ont reçu des implantations. Nous estimons que 400 smolts non marqués en dévalaison du ruisseau Creek n'ont pu être dénombrés. Quatre-vingt-deux alevins de cohos en dévalaison ont également reçu des implants de micro-marques codées, mais deux fois plus petits que chez les smolts. La mortalité due à la capture et à l'implantation était faible (0,55 %). La plupart des smolts étaient âgés de 1 an (92,9 %), mais, au cours de l'étude, la proportion des smolts âgés de deux ans a augmenté de façon significative. Les strates de longueurs et de poids moyens n'ont pas varié de façon significative d'une période d'échantillonnage à l'autre. Le rapport smolts mâles sur smolts femelles était d'environ 1:1.

Les échappées de cohos vers le ruisseau Black en 1991 ont été évaluées à l'aide d'une clôture de dénombrement des adultes entre le 15 oct. et le 16 nov., et par recapture après marquage en amont et observations visuelles AUC (aire sous la courbe), du 15 nov. au 17 déc. Les estimations pour les cohos, adultes et jacks, ont été obtenues par quatre méthodes : 1) modèle de simulation ouvert; 2) modèle bayesien; 3) méthode de Petersen ajustée; 4) méthode AUC. Nous accordons une grande confiance à nos estimations des échappées de cohos adultes et jacks, soit respectivement 3 568 et 2 373, obtenues par un modèle de simulation ouvert. Les estimations des échappées par la méthode AUC étaient de 2 033 et de 526. Les cohos adultes et jacks avaient de façon prédominante 1 an d'âge en eau douce (respectivement 95 et 83 %). Les longueurs moyennes de la région postorbitale à la section hypurale chez les cohos femelles, adultes mâles et jacks étaient respectivement de 53,3, 48,3 et 27,5 cm. Les cohos femelles étaient significativement plus grandes que les cohos mâles. Le rapport cohos mâles sur cohos femelles était de 1:1, sauf lorqu'on combinait des adultes mâles et des jacks. Les taux de survie smolts/géniteurs étaient maximaux pour les smolts en dévalaison lors de la première période de marquage des individus en dévalaison, aussi bien pour les remontées d'adultes que pour celles de jacks.

INTRODUCTION

This report presents results of the coho salmon (*Oncorhynchus kisutch*) smolt enumeration and coded-wire tagging study, and summarizes the adult coho fence count, upstream mark-recapture, and area-under-the-curve (AUC) escapement studies at Black Creek in 1991. 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 coded-wire tags (CWTs) into coho smolts and half-length CWTs into emigrant coho fry;
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;
4) estimate numbers of returning salmon and to collect coded-wire tagged heads from these fish; and
5) collect data on length, sex, maturity, and age at return.

Achieving these objectives involved the operation of fences to monitor the downstream migration of juvenile salmonids and the upstream movement of maturing salmon, counting all migrants, sampling lengths, weights, and ages of coho, and coded-wire tagging of as large a portion of the coho smolts and emigrant fry as possible. The smolt data were stratified into three pre-determined sampling periods, the selection of which was based on data provided in Fielden et al. (1989), Bocking et al. (1991), and Nass et al. (1993a) to characterize the various phases of seaward migration.

STUDY STREAM

Black Creek (Fig. 1) is a low-gradient stream on the east coast of Vancouver Island, approximately 26 km long, and 5-6 m wide in its middle reaches, and has a watershed area of 72.5 km^2. For most of its length it meanders through agricultural land, small lakes, swampy areas, and beaver ponds. In the lower

watershed, there are several tributaries including Millar Creek. A maximum discharge of 30 $m^3 \cdot s^{-1}$ has been recorded 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 750 adult spawners in 1987 to 15,000 in earlier years (Hancock and Marshall 1985; Clark and Irvine 1989; Labelle 1990a). 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 (Fig. 1). Since 1978, and in those years when it was surveyed, the coho smolt production from Black Creek has varied from a low of 29,476 in 1989 (Bocking et al. 1991) to 119,602 in 1990 (Nass et al. 1993a).

The juvenile and adult fish counting fences were located downstream of the Seaview Road bridge, in Miracle Beach Provincial Park. This location is above tidal influence. For upstream mark-recapture and AUC escapement surveys, the watershed was subdivided into six strata which contained 12 index reaches, each 250 m long (Irvine et al. 1992) (Fig. 1). The locations of stratum boundaries were determined by tributary confluences and/or major transitions in stream gradient or some other habitat characteristic, and the index reaches were selected to be representative of the habitat within their stratum.

SPRING FIELD STUDIES (JUVENILES)

METHODS

Fence Operations

The Black Creek smolt fence was constructed according to methods described by Conlin and Tutty (1979) using wooden-framed panels screened with 1/4" steel hardware cloth. It was installed and operated as per Bocking et al. (1991), and Nass et al. (1993a). 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 continuously from April 20 to June 24, 1991. The fence was maintained at close to 100% efficiency during this period, although there were

intermittent intervals over three days when the fence was partially passable to fish. Fry traps were installed between the fence panels and the stream margins to monitor upstream movements of coho fry.

Biophysical Monitoring

Maximum, minimum, and present water temperatures (± 0.5° C) were recorded daily at the counting fence between 0800 and 0900 h using a max-min thermometer. Water levels were recorded daily using a staff gauge located approximately 200 m upstream from the Seaview Road bridge, outside the influence of the counting fences.

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.

Trapping Efficiency

The trapping efficiency of the fence was tested twice. On April 30, 101 coho smolts were left maxillary clipped and released between 100 and 200 m upstream of the fence, and on May 4, 100 smolts were upper caudal fin clipped and released upstream. Recaptures were carefully monitored throughout the trapping period.

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 (< 120 mm in length) or large (> = 120 mm in length). All coho < = 70 mm were categorized as fry. Emigrant fry and smolts were held in holding boxes until coded-wire tagged and released. 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.

Biosampling

Random samples of up to 25 coho fry and 25 coho smolts were selected from each day's catch. These fish were anaesthetized in tricaine methane sulfonate (MS222), measured to the nearest mm (fork length), and weighed using a Libra 65001 scale (± 0.1 g). Mean lengths and weights were calculated using random samples for all coho juveniles and stratified by age class and sampling period (Bocking et al. 1991; Nass et al. 1993a). Differences in mean lengths and weights between sampling periods were determined 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 samples were collected following Ketchen's stratified method (Ricker 1975). During each sampling period (described below) we attempted to collect scale samples from 10 smolts in each 5 mm size class. 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 squared test was used to detect differences between these proportions. Scale samples were interpreted by personnel at the Department of Fisheries and Oceans ageing laboratory in Nanaimo.

We dissected 149 coho smolts from Black Creek 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. Mark IV tagging machine. An MS222 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 1991, it was intended to apply sequential coded-wire tags and stratify the releases by sequence group; however, due to unforseen circumstances, sequential tags were not applied, and the timing periods were disregarded. Tag codes were changed

only when completely used. Smolts > = 120 mm (large) and smolts < 120 mm (small) were tagged with different codes. Other data were stratified by the sampling periods used in previous years (up to May 10, May 11 - June 02, and June 03 on). Large and small coho were sorted by hand while fish were anaesthetized. 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 was, therefore, subjected to two anaesthetic baths. No differential mortality was observed between the two size categories over a 24-hour holding period. In total, there were six different tag codes used for smolts at Black Creek. Coho fry were tagged with half-length CWTs, and the same tag code was used for fry tagging in all three sampling periods (Table 1). Tagging was done every day, with the exception of 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 seven tag retention checks performed; six after 24 h and one after 72 h. Wherever possible, 100 fish or more were used for each test.

RESULTS

Biophysical Observations

Daily biophysical measurements are provided in Appendix A. Water temperatures at Black Creek ranged from a minimum of 7° C in late April to a maximum of 18° C in June. Water levels declined throughout the study period, except during two small freshets (one in mid-May and another in mid-June) (Fig. 2). Water levels ranged from a maximum of 45 cm in mid-May to a minimum of 21 cm in early June.

Trapping Efficiency

Two trap efficiency tests were conducted during the study, the first in late April and the second in early May (Table 2). All marked smolts released upstream

of the fence were later recovered at the fence, therefore the trap efficiency was assumed to be 100%. However, on April 24 no smolts were captured due to a gap between two of the trap boxes. The problem was repaired but reappeared on April 26 (stress on the linkages between the trap boxes was the likely cause). We estimate that between 10 and 100 smolts passed undetected during this period.

Fish Counts

Coho Smolts

Total daily catches of juvenile coho are provided in Appendix B. A total of 53,876 coho smolts were counted at the Black Creek fence between April 21 and June 24 (Table 3). During this period, there were 295 pre-tagging mortalities (0.55%) and 252 smolts which either escaped during handling, were released due to injury, or were used in the fence efficiency tests (0.47%).

The smolt migration was roughly unimodal (Fig. 3). Significant catches began on May 1 and increased until May 18 when daily catch peaked (5,435). Smolt numbers declined rapidly after that time. Approximately 71% of the smolts were captured between May 1 and May 19. Small coho (<120 mm fork length) comprised 64.3% of the population. The period of fence operation appeared to cover most of the migration, although some smolts were still leaving the system when the fence operation ended.

Coho Fry

Daily catches of coho fry are given in Appendix B. Only 89 downstream migrating coho fry were caught at the fence during the study. Most of those were caught in mid- to late June; only 14 were captured prior to June 3. A total of 170 upstream-migrating coho fry were captured in the fry traps below the fence; a sample of these was measured and all were released above the fence.

Other Species

Daily catches of non-coho are presented in Appendix C and summarized in Table 4. Cottids were the most numerous non-coho captured. Lamprey, steelhead smolts, cutthroat trout smolts, and both wild and hatchery cutthroat trout kelts were also encountered regularly.

Biosampling

Age

The calculated age-length distribution for wild coho smolts leaving Black Creek is given in Table 5. Age sample data (X) include non-random samples. The calculated age representation (Y) is based on random sampling. The calculated freshwater age structure of Black Creek smolts was 92.9% age 1 and 7.1% age 2. When compared over the three sampling periods, the age ratio (age 1:age 2) changed from 35.4:1 in period 1, to 14.3:1 in period 2, and to 7.0:1 in period 3. The differences among the age ratios were significant ($\chi^2 = 28.6$, df = 2, $P<0.001$) indicating that the proportion of age-2 smolts increased over the study. No ageing data are available for fry because scale samples were not taken.

Length and Weight

The mean fork-length of the Black Creek coho smolt population was 119.2 mm and the mean weight was 17.7 g (Table 6). Individual length and weight measurements and the means of these measurements appeared to be normally distributed within sampling periods. Age-1 smolts were significantly smaller (length and weight; t-tests, $P<0.001$) during the third period than in the first. There were no age-3 fish identified in the samples. The length frequency distribution of successfully aged coho smolts is presented in Figure 4.

The mean length and weight of all subsampled fry was 56.9 mm and 2.5 g, respectively. When all subsampled fry were separated into downstream (caught in the smolt trap) and upstream (caught in fry traps downstream of the fence) groups, significant differences were detected between the groups (length and weight; t-tests, $P<0.001$). The upstream-migrating fry were larger in both cases.

Sex

A total of 149 Black Creek smolts were dissected to determine sex. Males and females were observed in similar proportions over the course of the study (Table 7). There were no significant differences between mean lengths for males and females during any of the sampling periods (Neuman-Keuls test, $P>0.05$).

Coded-Wire Tagging

Tag Retention

Tag retention tests were performed seven times on coho smolts (Table 8). Mean tag retention was 98.4%. Most tag loss problems could be attributed to problems with the head mold for small coho smolts (<120 mm) encountered early in the study.

Coded-Wire Tag Releases

A total of 53,284 smolts were coded-wire tagged using six distinct codes, and released. Eighty-two fry were tagged with half-length tags, all of which were the same code. There were 45 known tagging-related mortalities, all of which were smolts (Table 1).

FALL FIELD STUDIES (ADULTS)

METHODS

Biophysical Monitoring

Biophysical conditions were monitored and recorded as described in the earlier section of the report, Spring Field Studies. In addition, discharge was estimated during a major storm event on 18 November. At that time the creek was approximately 2 m deep across the sill at the 16 m wide counting fence, and the estimated water velocity was 1.5 - 2 $m \cdot s^{-1}$.

Coho Population Estimates

Counting Fence Operations

A collapsible adult counting fence was installed (Fig. 1) prior to the first fall rains according to the methods and designs described in Labelle (1990) and Bocking et al. (1992). The fence was composed of a series of wood-frame panels with aluminum tube (2.5 cm diameter) insets spaced 2.5 cm apart. To increase the catch of small adult and jack (precocious male) coho, which were able to squeeze between the aluminum tubing, additional "jack panels" (Bocking et al. 1992) were placed on top of the main fence panels during low-flow and low-debris conditions. The west-side trap box was replaced with an aluminum structure similar to that installed on the east side of the creek in 1990 (Nass et al. 1993b). Both trap boxes were operated when flows permitted.

Salmonids caught in the trap boxes at the counting fence were counted and released upstream. Coho were classified as adult or jack, and the sex of each fish was recorded. All fin and maxillary clips were recorded and degrees of maturity estimated (Bocking et al. 1992; Nass et al. 1993b). Any mortalities at the fence, either naturally occurring or due to handling, were recorded. All coho released upstream were given a uniquely numbered Ketchum No. 1 operculum tag[2]. Operculum tags were applied to fish during transfer to a canvas cradle where fish were sampled for length and scales.

Mark-Recapture

In this report we refer to fish with operculum tags as tagged fish and adipose-clipped fish (fish that had been previously coded-wire tagged) as marked fish. Live coho were recovered upstream throughout the escapement period using electrofishing equipment (Appendix E). Electrofishing surveys were conducted by blocking the downstream end of a recovery area with a small block net and then electrofishing the area. One person operated the block net, one person operated the electrofisher, and one person operated a dip net. The use of block nets greatly reduced the number of escaping coho.

All live untagged coho recovered upstream during surveys were also given a numbered operculum tag. Fish that had been previously operculum tagged but which had since lost their tag were classified as recaptures. All operculum tags

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[2] Ketchum Manufacturing Sales Ltd., 396 Berkley Ave., Ottawa, Ont., Canada, K2A 2G6

applied at the counting fence were classified as primary tags; tags applied to untagged fish upstream were classified as secondary tags. Recovery effort (Table 9) was conducted approximately in proportion to the distribution of coho in the river as determined from the AUC stream walk surveys.

Mark-recapture estimates of the spawning population were generated using three different models; an open population simulation model (Labelle 1990), a sequential Bayesian model (Gazey and Staley 1986), and a Petersen model (Ricker 1975). Bocking et al. (1992) presents the various assumptions required for generating unbiased estimates, and discussed the advantages and disadvantages associated with the use of each estimator.

The open model (Labelle 1990) requires estimates of stream life to simulate the die-off of the stream population; stream life being the number of days a coho spends alive in the stream, where the stream is defined as all areas of the system upstream of the counting fence. Our estimates of stream life do not include time spent holding in the stream below the counting fence. We derived estimates of stream life for adult coho based on recoveries of tagged carcasses. Since each tag was uniquely numbered, dates of passage through the fence were known. Coho carcasses may occasionally remain visible in the stream for many days post-mortem. Therefore, to determine a stream life value, we subjectively estimated the time since death (in days) for each recovery and subtracted that estimate from the total number of days between tagging and carcass recovery.

All coho captured during mark-recapture surveys were examined for operculum tags. Tag loss was recorded when clear evidence of scarring, due to the former presence of an operculum tag, was observed. The scarring usually appeared as a straight slit in the operculum, approximately 0.5 cm in length.

Area-Under-The-Curve (AUC)

AUC escapement estimates were calculated by obtaining periodic fish population estimates, plotting these against time, and then dividing the area under these curves expressed in fish-days by the length of time (days) fish were estimated to be alive in the areas surveyed. To obtain fish population estimates, surveys were conducted at 12 index sites within six strata (Fig. 1). An attempt was made to select index sites that included both good and marginal habitat for fish spawning and holding, and that were representative of the stratum as a whole. Five surveys were conducted from mid-November to mid-December following the methods of Irvine et al. (1992). Fish were counted by two observers walking upstream through each 250 m index site. The observers used wooden poles (2 m in length) to displace coho salmon hiding under cutbanks, rocks, and debris.

Nine observer efficiency tests were conducted in 1991. Each test consisted of verifying the counts of a foot survey crew over a 250 m index reach with a separate electrofishing crew. These data were combined with observer efficiency measurements made at Black Creek during the previous four years. The number of fish observed (dependant variable) was assumed to be a function of the verified number of fish (counted by the electrofishing crew).

Fish population size estimates were determined using the following procedure (Irvine et al. 1993): 1) fish counts at each index site were corrected for observer efficiency; 2) the estimated mean fish density per survey site for each stratum was calculated; 3) the stratified mean density per survey site for the stream was calculated; and 4) the stratified mean density per survey site was expanded to the stream length.

Residence time (survey life) is the average time in days that fish spend alive in the survey area and are available to be counted by the surveyors. Residence time differs from stream life in that the latter includes time spent in other areas of the system where fish may hold but cannot be visually counted (e.g. Northy Lake, Fig. 1). To estimate residence time, two groups of 100 fish were tagged with Petersen disks (as well as operculum tags) at the counting fence and released upstream (green tags applied Nov. 8; orange tags Nov. 12). Coho tagged with Petersen disk tags were subsequently observed and recorded on upstream foot surveys, and those counts were expanded and graphed to produce tag curves and subsequent estimates of residence time (English et al. 1992).

Age, Length, and Sex Composition

All live coho captured at the fence and during upstream surveys were measured for postorbital-hypural length and examined for fin clips, sex (adult males, females and jacks), and maturity. Adult males and jacks were differentiated by a length delimiter of 35 cm (Bocking et al. 1992). Scale samples (Henry 1961) were taken randomly from new captures of coho, either at the fences or upstream. On upstream surveys, only previously untagged coho were sampled for age, length, and sex. Maturities were recorded for both newly captured coho and for recaptured fish. Sex ratios were calculated from the total recovery sample. Average lengths were calculated separately for live fence recoveries and live upstream recoveries, and were stratified by sex and age (adult or jack). We calculated separate average lengths (fence and upstream) because the different recovery methods are potentially size selective (Bocking et al. 1992).

Coded-Wire Tag Recoveries

Adult and jack coho carcasses recovered were counted and the date and location of recovery, operculum tag number (if tagged), length, and any fin clips were recorded. Heads were removed from adipose-clipped carcasses, labelled by location, date, operculum tag number, other fin clips, and length, and individually wrapped and frozen. Once counted, all carcasses were cut in half to prevent resampling during future surveys. Tags were removed and decoded.

To determine the contribution of marked smolts from the 1990 and 1991 smolt emigrations to the 1991 escapement we used the three-step process described in Bocking (1991) and Bocking et al. (1990). Assuming that the survival of unmarked fish was equal to or greater than that of marked fish, this method estimates the minimum contribution of each tag code to the escapement.

Adipose-clipped adult males, adult females, and jacks were counted separately. The population estimates for adults were then apportioned between males and females based on the sex ratio observed in the total live recovery. The live recovery samples were used to estimate the contribution of adipose-clipped coho to the total escapement. This estimate was stratified by adult males, females, and jacks. Sex-specific population estimates for adult males and females were determined from sex ratios at the fence. Given an estimate of the total number of adipose clips for each sex and cohort escaping to the stream, the number of adipose clips for each tag code was estimated by the allocation of adipose clips to tag codes based on their relative frequency in the sample of decoded tags.

RESULTS

Biophysical Monitoring

Daily biophysical measurements are provided in Appendix D. Water temperatures (maximum and minimum) and levels are presented in Figure 5. Daily water temperatures ranged from 12° C in mid-October to 3° C in late November. Water levels increased steadily from October into November and peaked at a flood level of 157 cm on November 18. Peak discharge on November 18 was estimated between 48 and 64 $m^3 \cdot s^{-1}$.

Coho Population Estimates

Counting Fence Operations

The adult counting fence was operated from October 15 through November 16. It was lowered permanently on November 16 due to flooding. Jack panels were removed frequently throughout operations. Due to the high flows and debris accumulations, we were unable to obtain a complete fence count for adult or jack coho.

Between November 4 and November 16, a total of 3,113 adult and 1,873 jack coho were operculum tagged and released above the counting fence (Appendix E). Six adults and 110 jacks died at the fence or were sacrificed for coded-wire tag recovery, and an additional five adults and eight jacks escaped untagged during handling (Table 10). The daily fence capture totals for adult and jack coho are illustrated in Figure 6. Upstream migration peaked on November 11 for both adults and jacks.

Mark-Recapture

Upstream mark-recapture surveys were conducted between November 14 and December 9. A total of 146 live adult coho and 64 live jack coho were examined upstream, of which 130 adults and 53 jacks had been tagged at the fence. Of the live tagged fish recovered upstream, 37 (17.6%; 22 adults and 15 jacks) had lost their operculum tag. Tag loss may have resulted from improper attachment of the tag to the operculum, and tags becoming entangled in root wads and other debris and being torn off by the fish as it freed itself from the debris. Primary tag recaptures, including tag losses, were included in the data used for mark-recapture population estimations.

The various mark-recapture population estimates, derived from the different models, and their respective highest probability density regions or confidence limits, are presented in Table 11. For both adults and jacks, all the mark-recapture estimates were similar. The open simulation model estimated the escapements to be 3,568 adults and 2,373 jacks. The daily numbers of tagged and released coho (used by the open model in generating the escapement estimate) are presented in Appendix E. The Bayesian estimates of escapement were 3,516 adults and 2,313 jacks, and the Petersen estimates were 3,494 adults and 2,256 jacks.

Stream life estimates, stratified by age and sex, are provided in Table 12, and individual stream life values are presented in Appendix F. Stream life ranged from 0-25 d. Average stream life for jacks (23.6 d) was longer than for adult males (14.9 d). Average stream life for females was 16.1 d.

Area-Under-The-Curve

When the untransformed observer efficiency data were examined, there was increasing variability in the proportion of fish seen at higher densities, and the residuals had a heteroscedastic distribution. The natural logarithmic transformation [ln(number of fish + 1)] improved this situation and, therefore, regression parameters calculated on these data (Table 13) were used to expand the visual survey fish count data.

Estimates of residence time ranged between 9.5 and 14.2 days (Table 14). English et al. (1992) found estimates generated using the total tag curve method were more robust than estimates generated using the observed tag curve method. The residence time value used to generate AUC escapement estimates (13.6 d) was the mean of the total residence time estimates generated using with the two tag colours.

Figure 7 illustrates the results of the visual surveys conducted in index sites (adult coho only). The escapement estimates for adult and jack coho were 2,033 and 526 respectively.

Age, Length, and Sex Composition

Figure 8 illustrates the length frequency distribution of the escapement, based on live recoveries. Adult males ranged in size from 35 to 66 cm, ($\bar{x}$ = 48.3 cm). Jacks varied from 20 to 34 cm ($\bar{x}$ = 27.5 cm), and female coho ranged from 24 to 66 cm and averaged 53.3 cm (Table 15). Females were significantly larger than adult males (t-test, $P<0.001$). We calculated mean lengths separately for coho captured at the fence and during upstream recoveries. There were no significant differences in the mean lengths of adult males, adult females, or jacks captured at the fence versus those caught upstream (t-tests: males, $P>0.2$; females, $P>0.05$; jacks, $P>0.05$).

Female coho slightly outnumbered adult males but the difference was not significant (χ^2, $P>0.05$). When adult and jack males were combined, males significantly outnumbered females (χ^2, $P<0.001$) (Table 16).

The freshwater age distributions of the coho escapement are shown in Table 17. There were 200 scale samples aged successfully; however, all scales taken were resorbed to some extent. Most returning adults (95.0%) spent one year in freshwater, as did the majority of the jacks (83.3%).

Coded-Wire Tag Recoveries

We observed 2,701 adipose-clipped adult coho and 1,879 adipose-clipped jacks (Table 18) among the fish that we handled. We estimate that 86.2% of returning adults (3,069) and 93.9% (2,227) of returning jacks were adipose-clipped in 1991. Smolt-to-returning-adult survivals varied among the tagging dates. Smolts of both size class that migrated during the first sampling periods in both 1990 and 1991 had higher survivals (to adult and jack escapement, respectively). No CWTs were recovered from smolts that migrated late in 1990. A very high smolt-to-returning-jack survival rate (14.85%) was observed for large smolts that migrated during the first sampling period in 1991 (Table 19).

DISCUSSION

Coded-wire tagged releases of coho smolts totalled 53,284 in 1991. We estimate that an additional 400 untagged smolts emigrated from Black Creek during the periods before and after the study, and also on those days when a hole in the trap was present. The proportion of adipose-clipped adults and jacks in the escapement suggests that the number of untagged smolts leaving the system may be much higher, or that significant straying is occurring from non-clipped stocks. If we assume that the proportion of returning fish that did not possess an adipose clip (11% in 1991) is representative of the adipose-clip rate in the smolt outmigration, as many as 5,800 smolts may have left the system undetected.

Adult and jack coho captured at the counting fence accounted for 87.6% and 83.9%, respectively, of the open simulation model escapement estimates respectively. We were unable to count the entire run because the counting fence was collapsed due to flooding. These figures indicate that the majority of the returning fish were in the creek by November 16. The contribution of jack coho to the total estimated escapement (open model) was 40%.

Mark-recapture estimates generated from the open, Bayesian, and Petersen models were similar to each other. The similarity of these estimates is a result of our ability to tag a large portion of the population. AUC escapement estimates were less than mark recapture estimates, particularly for jacks. The lower AUC estimates are likely a result of not being able to survey the stream at the peak of the run. We were forced to suspend surveys for 13 d after our survey on

November 15 due to high flows; most of the fish entered the stream during November 11-13 (Fig. 6); many of these fish would not have been in our survey area for our November 14-15 surveys and would have died before our November 26-28 surveys.

AUC escapement estimates for jacks have been low in most previous years (Irvine et al. 1992). We may overestimate the efficiency of observing jacks which would result in an insufficient expansion of the data and produce a consistent low bias in the escapement estimates for jacks. In addition, we have always assumed that the residence time for jacks was the same as for adults, and this is probably not a valid assumption because of the different behaviour of jacks.

We tested for differences in length between adult male and female coho and found females to be significantly larger. This is consistent with previous studies at Black Creek (Bocking et al. 1992; Nass et al. 1993b). We also tested for differences in length between fence- and upstream- (not processed at the fence) captured coho and found no significant difference between like classes.

In 1991, we used a postorbital-hypural length of 35 cm to differentiate between adult male and jack coho in the field. This procedure eliminated observer subjectivity. The 35 cm length was determined by analyzing the lengths of successfully decoded (CWT) returning coho.

We calculated the percentage of outmigrating smolts in 1990 and 1991 which returned to spawn as adults or jacks in 1991, respectively, by dividing the estimated escapement of adipose clips, stratified by sex, by the number of smolts tagged (adipose clipped) and released in the respective outmigrating year. The number of smolts tagged and released in 1990 and 1991 was 118,410 and 53,284, respectively. The estimated adult escapement of adipose clips (open model, n = 3,069) represented 2.6% of the smolts released in 1990. The estimated jack escapement of adipose clips (n = 2,227) represented 4.2% of the smolts released in 1991.

CWT returns of the various groups of smolts to Black Creek suggest that ocean survival of coho smolts varied with timing of migration and the size of smolts. The proportions of smolts returning as adults for various smolt size and timing groups at Black Creek in 1991 suggest that smolts which emigrate near the beginning of the migration have a larger proportional return than do smolts which migrate later. These observations are slightly different from those made in previous studies at Black Creek. Nass et al. (1993b) found that smolts that migrated near the peak of the migration (the middle sampling period) had the highest proportion of return. Data for jacks at Black Creek in 1991 indicate that smolts greater than 120 mm in length were more likely to return as jacks than

were smaller smolts, and this was most pronounced for smolts at the beginning of the migration. This observation is consistent with previous studies at Black Creek.

ACKNOWLEDGEMENTS

We thank our field crew consisting of Jim Amos, Carl Johansen, Vicky McPherson, and Brenda Nass for their enthusiasm and dedication during all phases of the project. We also thank the staffs of the Ageing Unit of the Pacific Biological Station for ageing scale samples, and of J. O. Thomas and Associates for recovering and decoding coded-wire tags from heads recovered during escapement sampling.

This study was funded by the Biological Sciences Branch of the Department of Fisheries and Oceans, Canada, in support of the International Pacific Salmon Treaty.

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Table 1. Coded-wire tag release data for Black Creek coho smolts, by size group, 1991 (not corrected for tag loss).

Size group[1]	Tag code	Tagging dates	No. tagged	Tag morts	No. released tagged	No. released untagged
Small	081002	04/22 - 05/14	9472	28	9444	74
	081004	05/15 - 05/19	10552	0	10552	4
	081005	05/19 - 05/27	10289	0	10289	8
	081006	05/28 - 06/24	4023	1	4022	8
	Total		34336	29	34307	94
Large	081001	04/22 - 05/12	9878	15	9863	143
	081003	05/13 - 06/24	9115	1	9114	15
	Total		18993	16	18977	158
	Grand total		53329	45	53284	252

[1]Small is < 120 mm; Large is ≥ 120 mm

Table 2. Results of trap efficiency tests conducted at Black Creek, 1991.

Date of release	No. released	Fin clip	Number recovered	Date of last recovery	Percent recovered
04/30	101	left maxillary	101	05/21	100.0
05/04	100	upper caudal	100	05/25	100.0

Table 3. Coho smolt catches by sampling period at Black Creek, 1991.

Sampling period	Large	Small	Total	Pre-tagging mortalities[1]	No. released untagged[2]	No. available for tagging
04/21 - 05/10	7546	3614	11160	15	210	10935
05/11 - 06/02	11361	29843	41204	51	38	41115
06/03 - 06/24	322	1190	1512	229	4	1279
Total	19229	34647	53876	295	252	53329

[1]No. released untagged = known escapees + injuries
[2]mortalities include smolts killed by trapping and predation

Table 4. Numbers of non-coho fish caught at the Black Creek smolt enumeration fence, April - June 1991.

Species	Life stage[1]	Total number caught
Steelhead	fry	0
	parr	0
	smolt (H)	0
	smolt (W)	158
	adult (H)	0
	adult (W)	0
	kelt (H)	0
	kelt (W)	3
Cutthroat	fry	0
	parr	7
	smolt (H)	1
	smolt (W)	51
	adult (H)	3
	adult (W)	7
	kelt (H)	50
	kelt (W)	65
Cottids	-	575
Lamprey	-	155
Stickleback	-	48

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

Table 5. Age-length distribution of Black Creek coho smolts, by sampling period, 1991. Age representation was determined according to Ketchen's stratified subsampling method (Ricker 1975, p. 67).

Sampling period	Size class (mm)	Age sample (X)	Age groups in (X) 1	2	Length sample (Y)	Calculated age representation in (Y) 1	2
04/21 - 05/10	< 80	1	1	0	2	2.0	0.0
	80-84	1	1	0	0	0.0	0.0
	85-89	3	3	0	3	3.0	0.0
	90-94	1	1	0	4	4.0	0.0
	95-99	8	8	0	4	4.0	0.0
	100-104	5	5	0	15	15.0	0.0
	105-109	7	7	0	23	23.0	0.0
	110-114	10	9	1	40	36.0	4.0
	115-119	12	12	0	51	51.0	0.0
	120-124	23	23	0	81	81.0	0.0
	125-129	27	26	1	81	78.0	3.0
	130-134	14	14	0	51	51.0	0.0
	135-139	6	5	1	25	20.8	4.2
	140-144	9	9	0	15	15.0	0.0
	145-149	1	1	0	4	4.0	0.0
	150-154	0	0	0	0	0.0	0.0
	155-159	0	0	0	0	0.0	0.0
	160-169	1	1	0	1	1.0	0.0
	> = 165	0	0	0	0	0.0	0.0
	Total	129	126	3	400	389	11
05/11 - 06/02	< 80	0	0	0	0	0.0	0.0
	80-84	0	0	0	0	0.0	0.0
	85-89	1	1	0	1	1.0	0.0
	90-94	7	7	0	6	6.0	0.0
	95-99	8	8	0	39	39.0	0.0
	100-104	8	7	1	85	74.4	10.6
	105-109	8	8	0	118	118.0	0.0
	110-114	8	7	1	93	81.4	11.6
	115-119	6	6	0	55	55.0	0.0
	120-124	5	4	1	44	35.2	8.8
	125-129	20	19	1	37	35.2	1.9
	130-134	7	7	0	22	22.0	0.0
	135-139	11	11	0	10	10.0	0.0
	140-144	8	7	1	9	7.9	1.1
	145-149	2	2	0	2	2.0	0.0
	150-154	0	0	0	0	0.0	0.0
	155-159	0	0	0	0	0.0	0.0
	160-169	0	0	0	0	0.0	0.0
	> = 165	0	0	0	0	0.0	0.0
	Total	99	94	5	521	487	34

Table 5. (cont.) Age-length distribution of Black Creek coho smolts, by sampling period, 1991. Age representation was determined according to Ketchen's stratified subsampling method (Ricker 1975, p. 67).

Sampling period	Size class (mm)	Age sample (X)	Age groups in (X) 1	2	Length sample (Y)	Calculated age representation in (Y) 1	2
06/03 - 06/24	< 80	0	0	0	0	0.0	0.0
	80-84	0	0	0	0	0.0	0.0
	85-89	1	1	0	2	2.0	0.0
	90-94	5	5	0	3	3.0	0.0
	95-99	11	10	1	29	26.4	2.6
	100-104	11	10	1	64	58.2	5.8
	105-109	6	5	1	72	60.0	12.0
	110-114	8	8	0	61	61.0	0.0
	115-119	8	5	3	53	33.1	19.9
	120-124	8	8	0	56	56.0	0.0
	125-129	9	7	2	26	20.2	5.8
	130-134	7	6	1	12	10.3	1.7
	135-139	6	6	0	5	5.0	0.0
	140-144	3	3	0	1	1.0	0.0
	145-149	1	1	0	0	0.0	0.0
	150-154	1	1	0	0	0.0	0.0
	155-159	0	0	0	0	0.0	0.0
	160-169	0	0	0	0	0.0	0.0
	> = 165	0	0	0	0	0.0	0.0
	Total	85	76	9	384	336	48
	Grand total	313	296	17	1305	1212	93

(X) = random and non-random samples
(Y) = random samples only

Table 6. Means and standard deviations for lengths and weights of Black Creek smolts, by age and sampling period, 1991.

Age	Sampling period	Fork length (mm)			Weight (g)		
		N	Mean	SD	N	Mean	SD
1	04/21 - 05/10	119	122.5	13.2	119	19.7	6.0
	05/11 - 06/02	72	119.0	15.0	72	17.3	6.0
	06/03 - 06/24	71	113.6	13.6	71	14.9	5.1
	Total age-1[1]	262	119.1	14.3	262	17.8	6.1
2	04/21 - 05/10	3	125.3	13.9	3	19.7	6.9
	05/11 - 06/02	3	121.7	6.8	3	17.6	2.5
	06/03 - 06/24	7	121.1	7.8	7	16.6	3.3
	Total age-2[1]	13	122.2	8.6	13	17.5	4.0
	Total (age-1 + age-2)[2]	275	119.2	14.0	275	17.7	6.0

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

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

Table 7. Sex ratios and mean lengths of Black Creek coho smolts, by sampling period, 1991.

Sampling period	Sex	Proportion (%)	Sample size	Mean length (mm)	SD
04/21 - 05/10	Male	66.7	32	113.4	15.5
	Female	33.3	16	110.2	7.9
05/11 - 06/02	Male	44.0	22	109.9	11.8
	Female	56.0	28	108.4	10.0
06/03 - 06/24	Male	41.2	21	107.4	9.2
	Female	58.8	30	109.6	9.6
Total[1]	Male	50.6	75	110.7	7.9
	Female	49.4	74	109.3	5.7

[1]weighted means and standard deviations

Table 8. Coded-wire tag retention rates for Black Creek coho smolts, 1991.

Date	Hours held	Sample size	No. tags lost	Percent retention
04/26	24	98	6	93.9
05/01	72	193	10	94.8
05/08	24	211	1	99.5
05/13	24	222	0	100.0
05/20	24	166	1	99.4
05/27	24	146	0	100.0
06/09	24	98	0	100.0
Total		1134	18	98.4

Table 9. Summary of mark-recapture efforts at Black Creek, by date, stratum, and recovery method, 1991.

Date	Stratum [1]	Recovery method [2]	Distance sampled (m)
11/14	D	FS	250
11/14	D	FS / EFS	250
11/14	F	FS	500
11/15	A	FS	250
11/15	C	FS / EFS	500
11/26	F	FS / EFS	500
11/27	C	FS / EFS	250
11/27	C	FS	250
11/27	D	FS	250
11/27	D	FS / EFS	250
11/28	A	FS	500
11/28	B	FS	250
12/03	F	FS	500
12/03	E	FS	500
12/04	A	FS	500
12/04	C	FS / EFS	250
12/04	D	FS / EFS	250
12/09	D	FS / EFS	500
12/09	E	FS	500
12/09	F	FS / EFS	250
12/10	D	FS / EFS	250
12/16	C	FS	500
12/16	D	FS	250
12/16	B	FS	250
12/16	F	FS	250
12/17	A	FS	500

[1] see Figure 1 for stratum locations
[2] FS = foot survey; EFS = electrofishing survey

Table 10. Total number of coho captured and released at the counting fence at Black Creek, 1991.

Age	No. caught	No. sacrificed for sampling	No. released	No. untagged	No. tagged
Adults	3124	6	3118	5	3113
Jacks	1991	110	1881	8	1873

Table 11. Population estimates and associated confidence limits or highest probability density regions (HPD) for adult and jack coho escapements to Black Creek, 1991, generated by: 1) the open model; 2) the Bayesian model; 3) the Petersen model; and 4) area-under-the-curve (AUC).

Estimator	Age class	N	Lower 95%	Upper 95%
Open[1]				
	Adults	3568	3299	3891
	Jacks	2373	1886	2586
Bayesian[1]				
	Adults	3516	2800	4200
	Jacks	2313	1600	3000
Petersen[2]				
	Adults	3494	2947	4143
	Jacks	2256	1732	2934
AUC[3]				
	Adults	2033	N/A	N/A
	Jacks	526	N/A	N/A

N/A = not applicable

[1]upper and lower bounds are the 95% highest probability density regions (HPD)

[2]confidence limits are from fiducial limits for the Poisson distribution using Pearson's formulae when the number of recaptures is greater than 50 (Ricker 1975, p.343)

[3]confidence limits could not be calculated for AUC estimates because of non-random sampling

Table 12. Stream life values for coho salmon at Black Creek, November - December, 1991.

Age	Sex	n	Stream life (days)		
			Range	Mean	SD
Adult	Male	23	2-25	14.9	6.9
	Female	51	2-23	16.1	4.1
	Combined (M+F)	74	0-25	15.7	5.2
Jack	Male	7	0-23	23.6	19.9

Table 13. Parameters for linear and loglinear (ln + 1) regressions between the number of adult or jack coho observed during visual surveys and the number seen or captured during electrofishing surveys conducted at Black Creek from 1987 - 1991.

Cohort	n[1]	Linear			Nonlinear		
		Slope	Constant	r^2	Slope	Constant	r^2
Adults	40	0.888	-0.989	0.92	1.034	-0.341	0.91
Jacks	32	0.552	0.476	0.61	0.878	-0.185	0.71

[1] n = the number of observer efficiency tests performed when at least one fish was seen or captured.

Table 14. Mean annual survey life estimates, in days, for Black Creek coho, 1991.

	Days	
	Green tags	Orange tags
Total curve	13.0	14.2
Observed curve	9.5	12.7

Table 15. Age, sex, and length of live coho salmon recovered in Black Creek, 1991.

	Fence recoveries			Upstream recoveries		
Age and sex	n	Mean (cm)	SD	n	Mean (cm)	SD
Adult males	1472	48.3	7.0	4	51.0	7.6
Females	1542	53.3	4.9	10	50.5	4.6
Jacks	1932	27.5	2.9	11	26.1	2.7

Table 16. Sex ratios and chi-squared results for live coho recovered at Black Creek, 1991.

Adult males only				Adult males and jacks			
No. adult males	No. adult females	Ratio M:F	Chi squared	No. adult males and jacks	No. adult females	Ratio (M+J):F	Chi squared
1513	1627	0.93	2.07	3515	1627	2.16	346.61

Note: critical value of chi squared = 3.84 (df = 1) in all cases

Table 17. Freshwater age distribution of returning adult and jack coho at Black Creek, 1991, as determined from scale pattern analysis.

	Freshwater age						Total aged	Total sampled
	Adults			Jacks				
	1	2	Total	1	2	Total		
Number	133	7	140	50	10	60	200	389
Percent	95.0	5.0		83.3	16.7			

Table 18. Estimates of total escapement of adipose-clipped coho to Black Creek, 1991.

Age/sex	Sample size (A)	Adipose clips (B)	Mark rate (%) (C=B/Ax100)	Population estimate[1] (D)	Percent of population sampled (E=A/Dx100)	Total estimated adipose clips (F=B/AxD)
Male	1513	1302	86.05	1719	88.00	1479
Female	1627	1399	85.99	1849	88.00	1590
Jack	2002	1879	93.86	2373	84.37	2227
Total	5142	4580	89.07	5941	86.55	5292

[1] population estimates are from the open population model (Table 11); male and female estimates are derived using sex ratios of live coho recovered

Table 19. Contribution of 1990 and 1991 coho smolt outmigrations, by tagging period (1990) and tagging dates (1991), to the 1991 escapement to Black Creek.

Smolt year	CWT code	Tagging dates	Size at release (mm)	Observed adipose clips			Estimated adipose clips[1]			No. Smolts		Contribution to escapement			Smolt to returning jack (percent)
				M	F	T	M	F	T	Clipped	Unclipped	M	F	T	
1991	081002	04/22 - 05/14	<120	12	0	12	351.6	0.0	351.6	9444	74	354	0	354	3.72
	081004	05/15 - 05/19	<120	1	0	1	29.3	0.0	29.3	10552	4	29	0	29	0.28
	081005	05/19 - 05/27	<120	1	0	1	29.3	0.0	29.3	10289	8	29	0	29	0.28
	081006	05/28 - 06/24	<120	0	0	0	0.0	0.0	0.0	4022	8	0	0	0	
		Total		14	0	14	410.2	0.0	410.2	34307	94	413	0	413	1.20
	081001	04/22 - 05/12	>=120	50	0	50	1465.1	0.0	1465.1	9863	143	1486	0	1486	14.85
	081003	05/13 - 06/24	>=120	12	0	12	351.6	0.0	351.6	9114	15	352	0	352	3.86
		Total		62	0	62	1816.8	0.0	1816.8	18977	158	1839	0	1839	9.61
		Total decoded		76	0	76	2227	0	2227	53284	252	2252	0	2252	4.21
		Strays		0	0	0									
		No data		1800	0	1800									
		No pin		3	0	3									
		Lost pin		0	0	0									
		Total observed		1879	0	1879									

Table 19. (cont.) Contribution of 1990 and 1991 coho smolt outmigrations, by tagging period (1990) and tagging dates (1991), to the 1991 escapement to Black Creek.

Smolt year	CWT code	Tagging period	Size at release (mm)	Observed adipose clips			Estimated adipose clips[1]			No. Smolts		Contribution to escapement			Smolt to returning adult
				M	F	T[2]	M	F	T[3]	Clipped	Unclipped	M	F	T[4]	(%)[5]
1990	082650, 082653	04/13 - 04/30	<120	1	5	6	70.4	162.2	219.2	3010	6	71	163	220	7.28
	082703, 082721, 082652, 081607	05/01 - 05/10	<120	3	16	22	211.3	519.2	803.8	28209	58	212	520	805	2.85
	082726,025136, 082725	05/11 - 05/15	<120	8	9	21	563.4	292.0	767.3	25570	71	565	293	769	3.00
	081608	05/16 - 05/19	<120	6	8	16	422.6	259.6	584.6	19391	52	424	260	586	3.01
	020841, 082658	05/20 - 06/02	<120	0	0	1	0.0	0.0	36.5	11038	49	0	0	37	0.33
	082709	06/03 - 06/20	<120	1	1	3	70.4	32.4	109.6	3389	11	71	33	110	3.23
		Total		19	39	69	1338.1	1265.5	2521.0	90607	247	1342	1269	2527	2.78
	082708, 082724	04/13 - 04/30	>=120	2	4	8	140.9	129.8	292.3	10743	43	141	130	293	2.72
	082720, 082704	05/01 - 05/10	>=120	0	6	7	0.0	194.7	255.8	12269	31	0	195	256	2.08
	082722	05/11 - 05/15	>=120	0	0	0	0.0	0.0	0.0	2957	8	0	0	0	0.00
	082711	05/16 - 05/19	>=120	0	0	0	0.0	0.0	0.0	777	1	0	0	0	0.00
	082712	05/20 - 06/02	>=120	0	0	0	0.0	0.0	0.0	806	5	0	0	0	0.00
	082654	06/03 - 06/20	>=120	0	0	0	0.0	0.0	0.0	223	3	0	0	0	0.00
		Total		2	10	15	140.9	324.5	548.0	27775	91	141	326	550	1.97
		Total decoded		21	49	84	1479	1590	3069	118382	338	1483	1594	3077	2.59
		Strays		0	0	0									
		No data		1280	1348	2634									
		No pin		1	1	3									
		Lost pin		0	1	1									
		Total observed		1302	1399	2722									

abbreviations are: M = male, F = female

[1]total decoded estimated adipose clips are from Table 18

[2]the total observed adipose clips for the 1990 smolt year group (adults) include 14 decoded CWTs and six observed adipose clips (no data) that did not receive a sex designation (sex unknown)

[3]calculated from observed adipose clips totals

[4]calculated from estimated adipose clips totals

[5]male and female combined

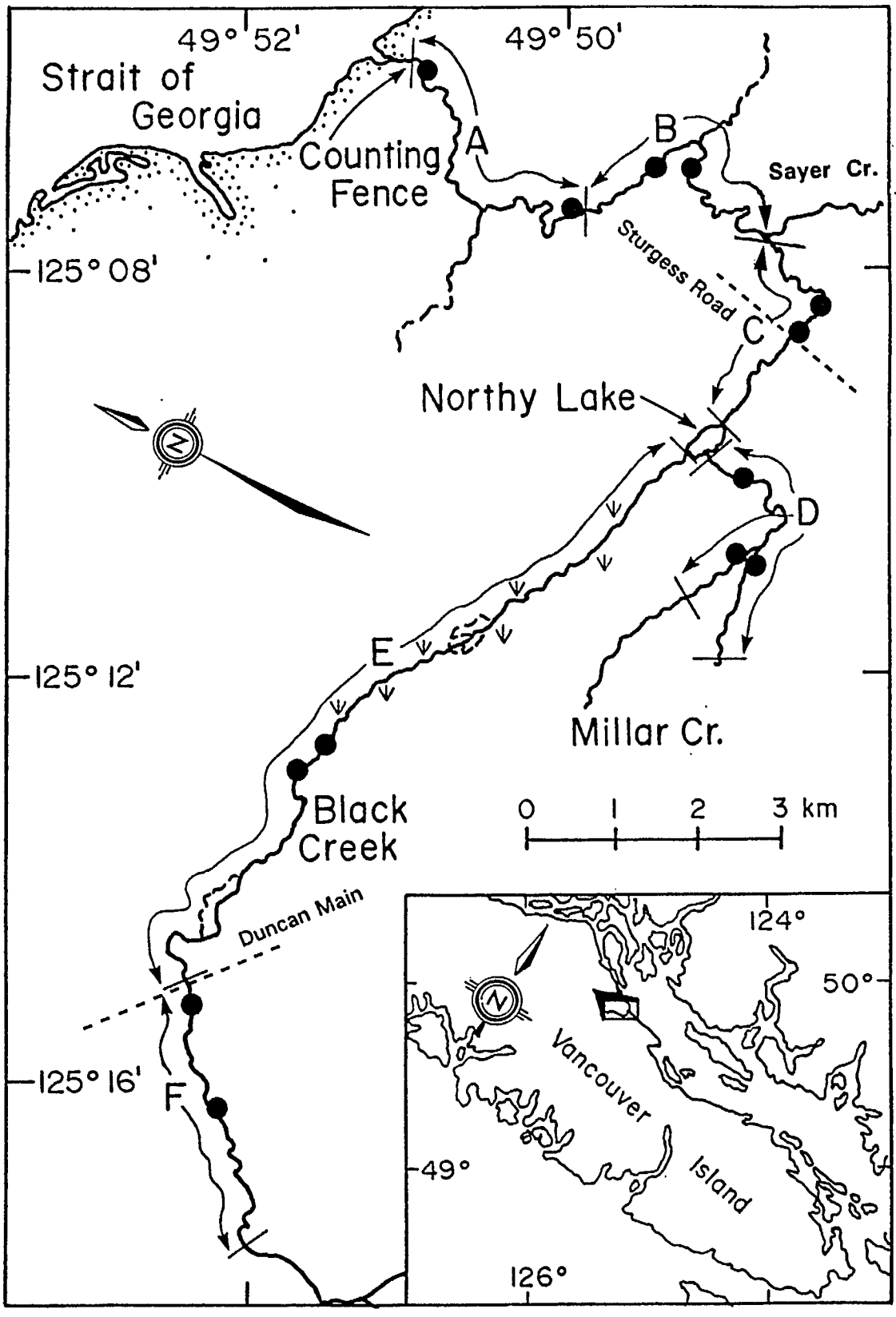


Figure 1. Map of Black Creek study area, showing location of smolt and adult counting fences, upstream recovery strata (A-F), and index reaches (identified by black dots).

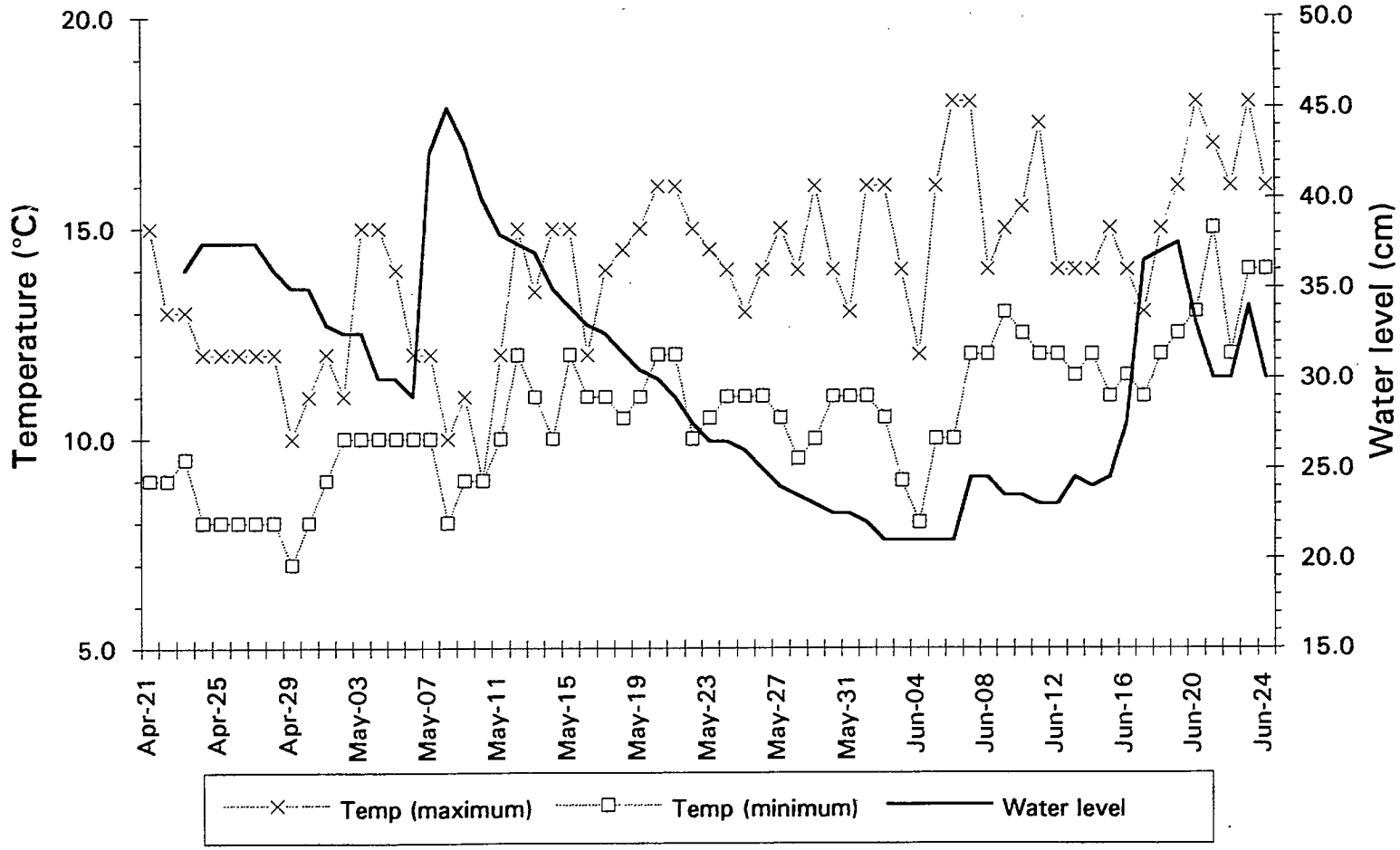


Figure 2. Water temperatures and levels at Black Creek during April, May, and June, 1991.

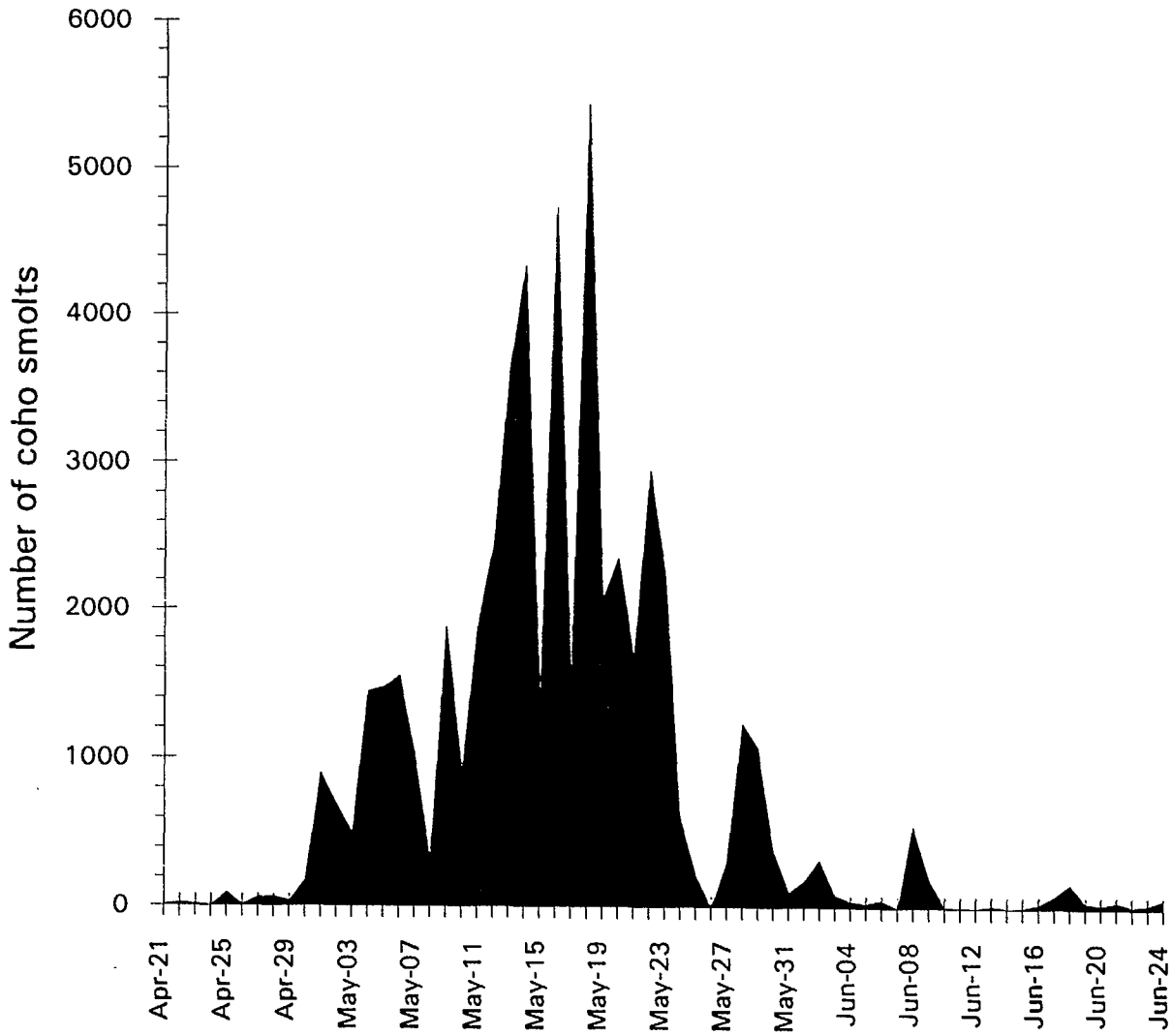


Figure 3. Total daily catches of coho smolts, by date, at Black Creek, 1991.

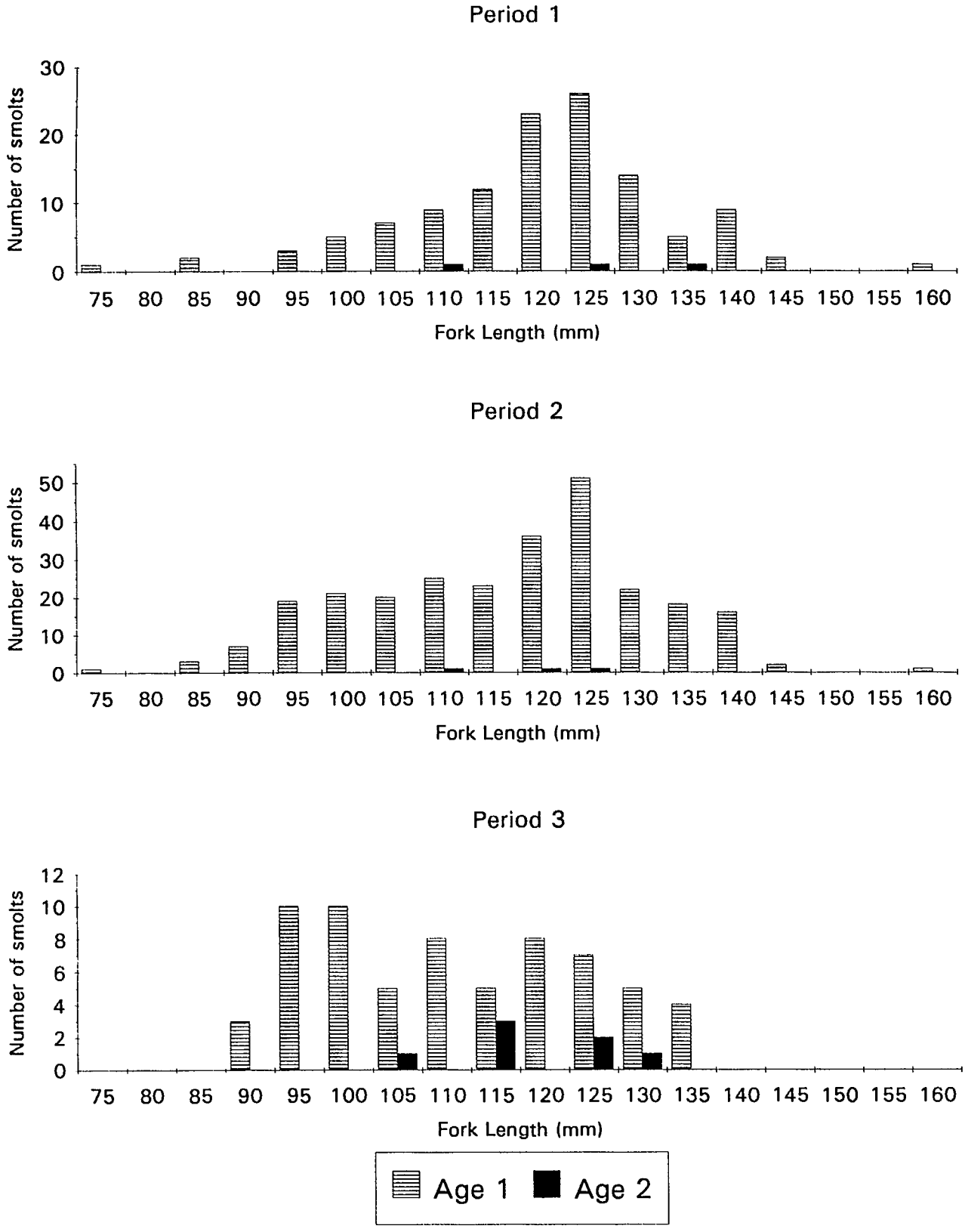


Figure 4. Length-frequency distributions of successfully aged Black Creek coho smolts, by sampling period, 1991. Period 1 (Apr 04-May 10); Period 2 (May 11-Jun 02); Period 3 (Jun 03-24).

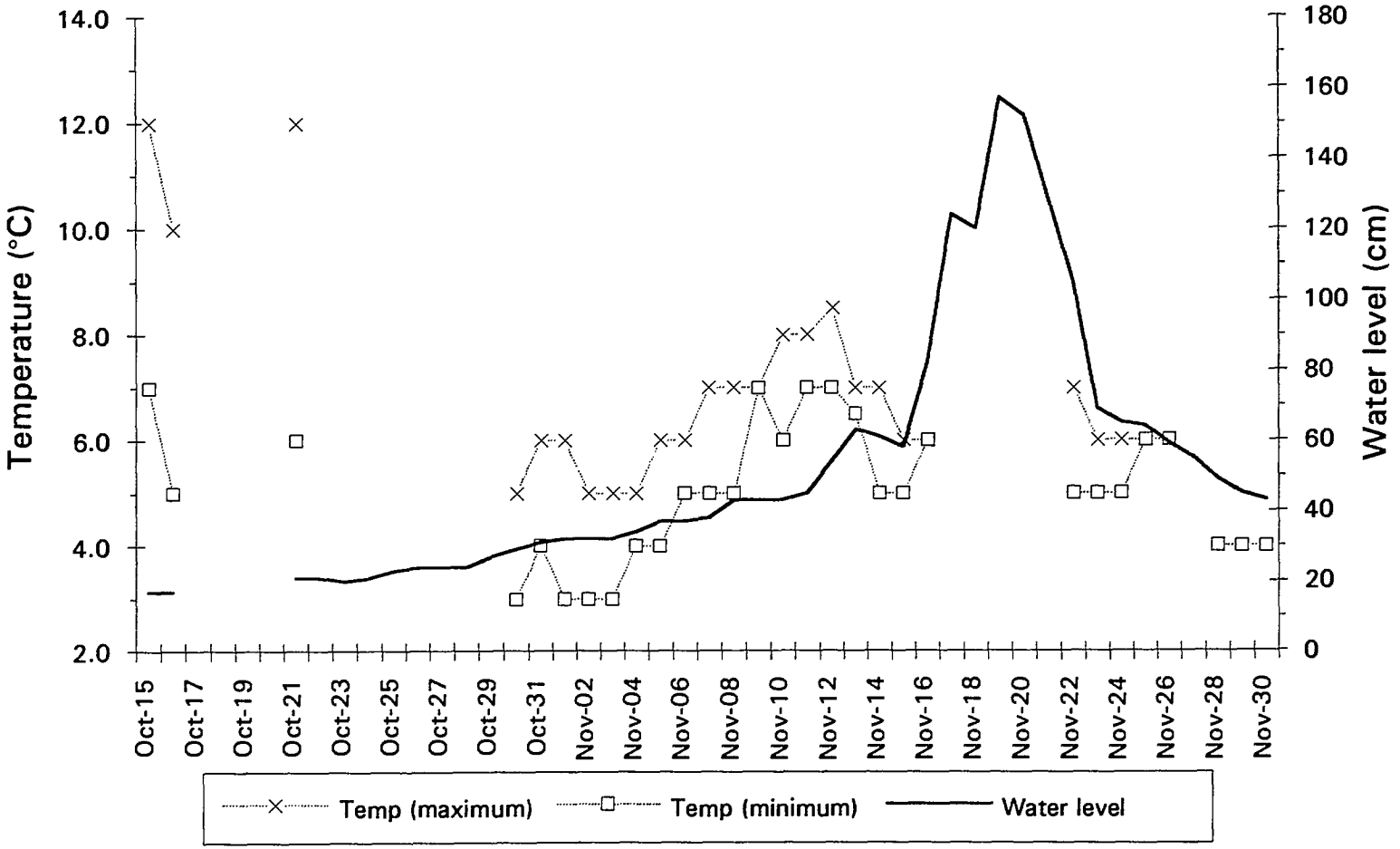


Figure 5. Water temperatures and levels at Black Creek during October and November, 1991.

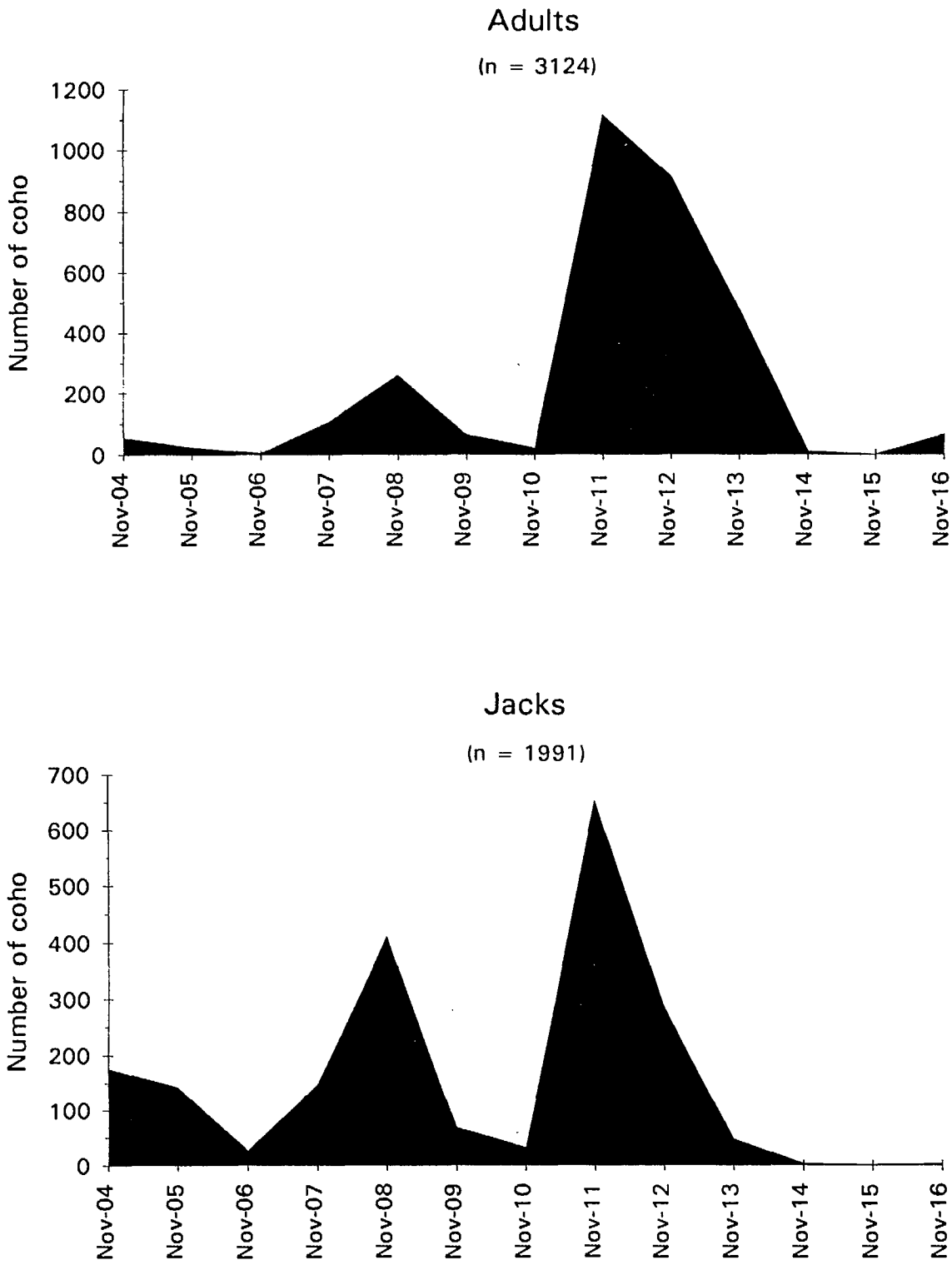


Figure 6. Daily fence counts of adult and jack coho salmon at Black Creek, November, 1991.

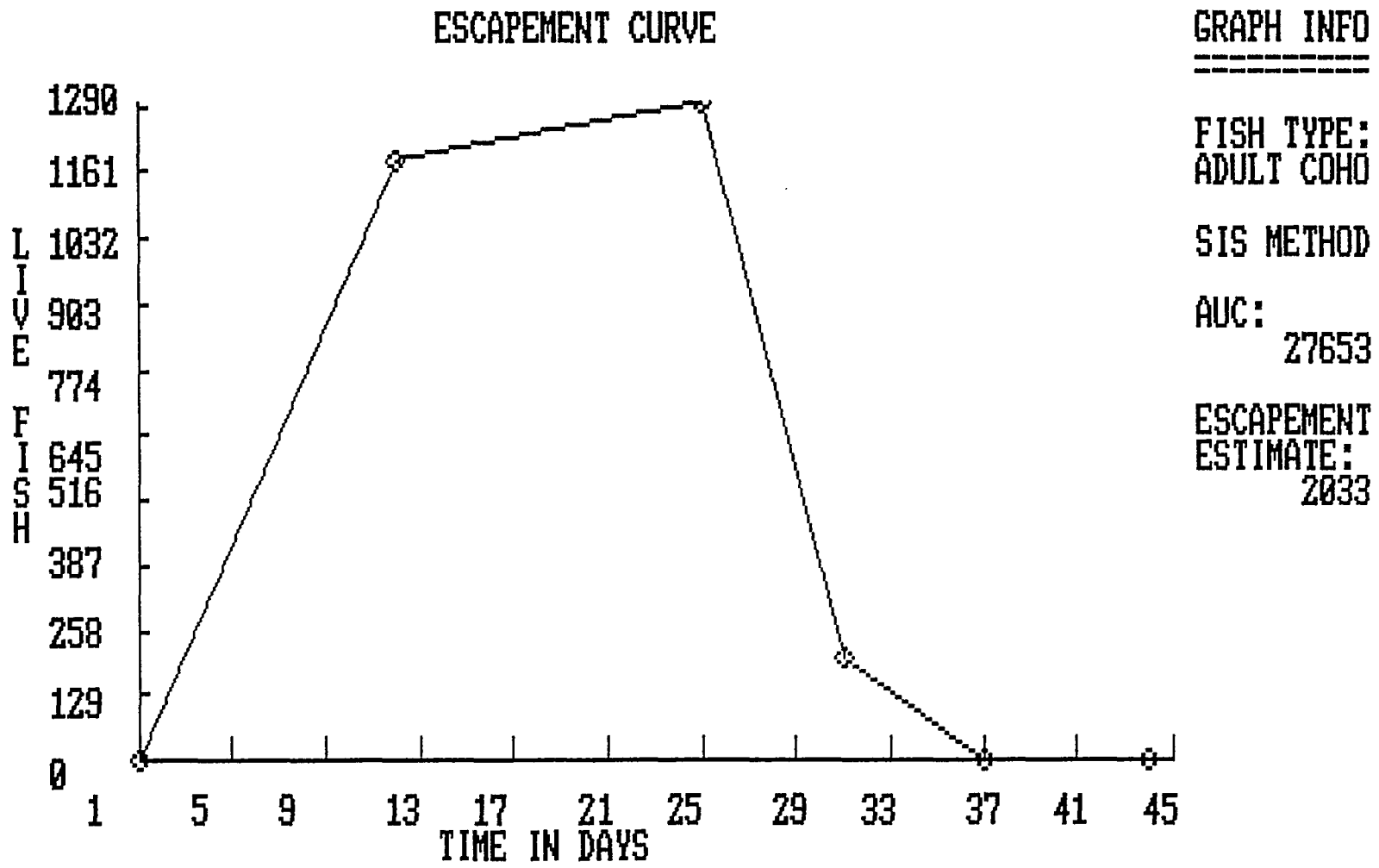


Figure 7. Escapement curve determined from AUC surveys of live coho salmon at Black Creek, 1991 (numbers of live adult coho versus time). Day 1 is November 4, 1991.

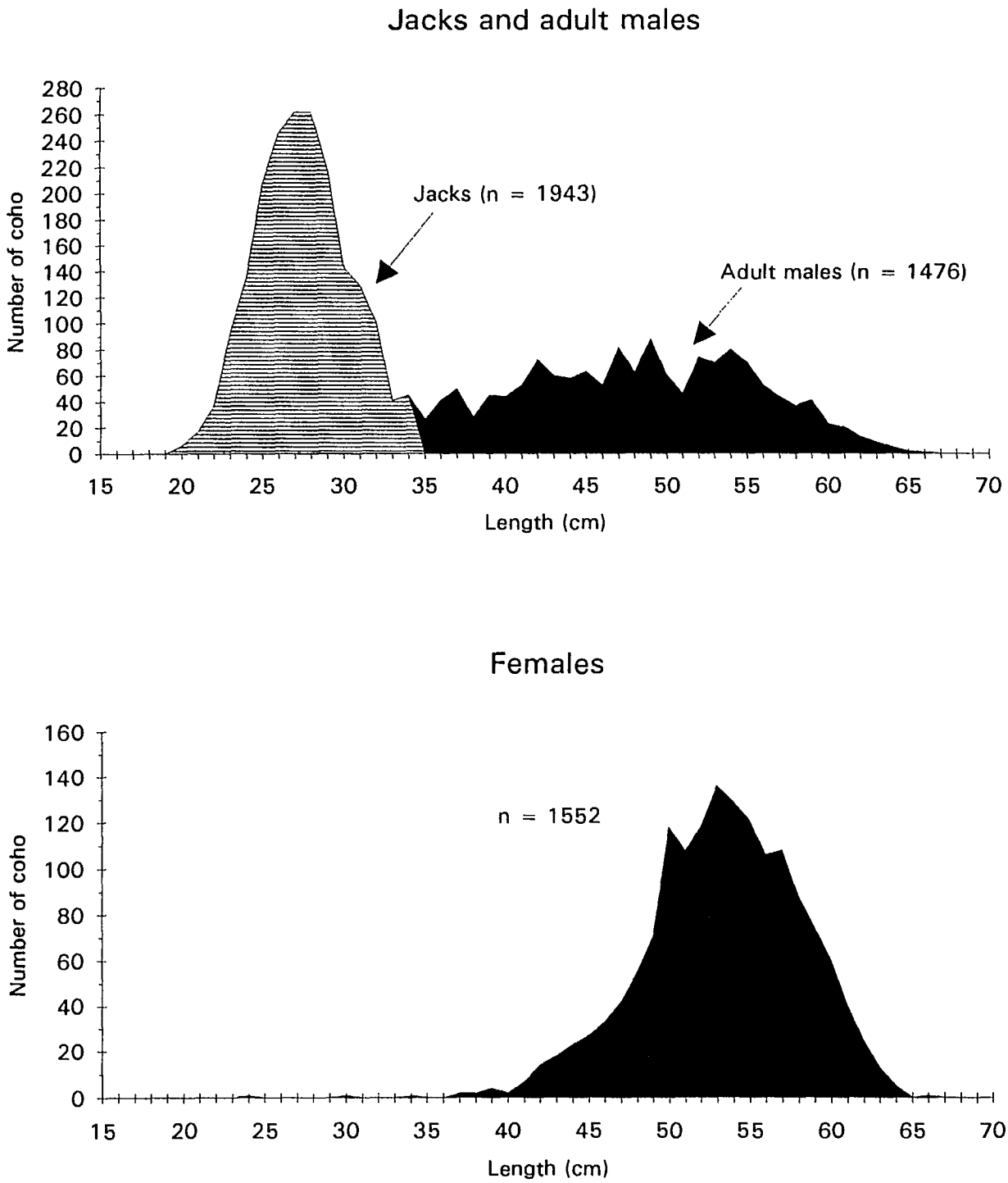


Figure 8. Length-frequency historgams for returning coho salmon at Black Creek, 1991, from all live recovery data.

Appendix A. Biophysical data for Black Creek, April 20 - June 24, 1991.

Appendix A. Biophysical data for Black Creek, April 20 - June 24, 1991.

Date	Time (24 hr)	Maximum water temp. (°C)	Minimum water temp. (°C)	Present water temp. (°C)	Water level Gauge 1 (cm)	Water level Gauge 2 (cm)	Rain 0-5	Wind direction	Wind speed km/hr	Cloud cover (%)
04/20/91	800				68.0		0		0	0
04/21/91	800	15.0	9.0	9.0	67.0		0		0	0
04/22/91	800	13.0	9.0	9.0	67.0		1	NW	10	100
04/23/91	800	13.0	9.5	10.0	66.0	36.0	1	SE	10	95
04/24/91	800	12.0	8.0	8.0	72.5	37.5	0	SW	5	75
04/25/91	800	12.0	8.0	8.0	75.0	37.5	0	NW	5	60
04/26/91	800	12.0	8.0	8.0	74.0	37.5	0		0	95
04/27/91	800	12.0	8.0	8.0	74.0	37.5	0	SE	10	10
04/28/91	800	12.0	8.0	8.0	75.0	36.0	1		0	100
04/29/91	800	10.0	7.0	7.0	75.0	35.0	0	NW	5	10
04/30/91	800	11.0	8.0	8.0	74.0	35.0	0		0	10
05/01/91	800	12.0	9.0	9.0	73.0	33.0	0	NW	10	10
05/02/91	800	11.0	10.0	10.0	72.0	32.5	0		0	10
05/03/91	800	15.0	10.0	10.0	71.0	32.5	0		0	5
05/04/91	800	15.0	10.0	11.0	67.5	30.0	0		0	60
05/05/91	800	14.0	10.0	10.0	67.5	30.0	1		0	100
05/06/91	800	12.0	10.0	10.0	66.0	29.0	0	SW	5	90
05/07/91	800	12.0	10.0	10.0	77.5	42.5	2	SE	10	100
05/08/91	800	10.0	8.0	8.0	83.0	45.0	0		0	75
05/09/91	800	11.0	9.0	9.0	80.0	43.0	0	SE	10	50
05/10/91	800	9.0	9.0	9.0	78.0	40.0	0	NW	5	10
Mean		12.2	8.9	9.0	72.5	36.1				
Max					83.0	45.0				
Min					66.0	29.0				
05/11/91	800	12.0	10.0	10.0	77.5	38.0	0		0	5
05/12/91	800	15.0	12.0	12.0	72.5	37.5	0		0	90
05/13/91	800	13.5	11.0	11.0	72.0	37.0	0	NW	5	50
05/14/91	800	15.0	10.0	10.5	68.0	35.0	0		0	0
05/15/91	800	15.0	12.0	12.0	67.5	34.0	2		0	100
05/16/91	800	12.0	11.0	11.0	66.0	33.0	0		0	85
05/17/91	800	14.0	11.0	11.0	65.0	32.5	0	NW	10	50
05/18/91	800	14.5	10.5	11.0	67.0	31.5	0	NW	5	20
05/19/91	800	15.0	11.0	12.0	65.0	30.5	0		0	15
05/20/91	800	16.0	12.0	13.0	67.5	30.0	0		0	10
05/21/91	800	16.0	12.0	12.0	67.5	29.0	0	NW	15	5
05/22/91	800	15.0	10.0	10.0	64.5	27.5	0	NW	10	10
05/23/91	800	14.5	10.5	11.0	62.0	26.5	0	NW	10	95
05/24/91	800	14.0	11.0	11.0	60.0	26.5	0		0	97

Appendix A. Biophysical data for Black Creek, April 20 - June 24, 1991. (cont.)

Date	Time (24 hr)	Maximum water temp. (°C)	Minimum water temp. (°C)	Present water temp. (°C)	Water level Gauge 1 (cm)	Water level Gauge 2 (cm)	Rain 0-5	Wind direction	Wind speed km/hr	Cloud cover (%)
05/25/91	800	13.0	11.0	11.0	59.0	26.0	0	NW	5	75
05/26/91	800	14.0	11.0	11.0	57.5	25.0	0		0	70
05/27/91	800	15.0	10.5	10.5	55.0	24.0	0	NW	5	80
05/28/91	800	14.0	9.5	10.0	55.0	23.5	0		0	10
05/29/91	800	16.0	10.0	11.5	53.0	23.0	1	SE	5	100
05/30/91	800	14.0	11.0	11.0	52.0	22.5	0	SE	5	82
05/31/91	800	13.0	11.0	11.0	42.0	22.5	0		0	93
06/01/91	800	16.0	11.0	11.0	51.0	22.0	0	NW	10	75
06/02/91	800	16.0	10.5	11.0	51.0	21.0	0	NW	5	20
Mean		14.8	10.8	11.1	56.9	24.9				
Max					67.5	30.0				
Min					42.0	21.0				
06/03/91	800	14.0	9.0	9.0	50.0	21.0	0	NW	5	20
06/04/91	800	12.0	8.0	8.0	50.0	21.0	0		0	25
06/05/91	800	16.0	10.0	10.5	49.0	21.0	0	NW	10	20
06/06/91	800	18.0	10.0	12.0	49.0	21.0	0	NW	5	20
06/07/91	800	18.0	12.0	12.0	52.5	24.5	1	SW	5	98
06/08/91	800	14.0	12.0	12.0	52.5	24.5	0		0	50
06/09/91	800	15.0	13.0	13.0	52.5	23.5	0		0	75
06/10/91	800	15.5	12.5	12.5	52.5	23.5	1		0	100
06/11/91	800	17.5	12.0	12.0	52.0	23.0	0		0	75
06/12/91	800	14.0	12.0	12.0	52.0	23.0	0		0	85
06/13/91	800	14.0	11.5	11.5	54.0	24.5	0		0	100
06/14/91	800	14.0	12.0	12.0	54.0	24.0	0		0	96
06/15/91	800	15.0	11.0	12.0	54.0	24.5	0		0	90
06/16/91	800	14.0	11.5	11.5	58.0	27.5	1		0	100
06/17/91	800	13.0	11.0	12.0	72.0	36.5	0	NW	5	52
06/18/91	800	15.0	12.0	12.0	76.5	37.0	0	NW	10	12
06/19/91	800	16.0	12.5	13.0	73.0	37.5	0		0	10
06/20/91	800	18.0	13.0	14.0	68.0	33.0	0		0	75
06/21/91	800	17.0	15.0	15.0	61.0	30.0	1	SE	5	100
06/22/91	800	16.0	12.0	12.0	60.0	30.0	1	SE	5	100
06/23/91	800	18.0	14.0	14.0	68.5	34.0	0		0	100
06/24/91	800	16.0	14.0	14.0	64.0	30.0	0		0	90
Mean		15.5	11.8	12.1	58.0	27.0				
Max					76.5	37.5				
Min					49.0	21.0				

Appendix B. Catches of juvenile coho at the Black Creek counting fence, by date and sampling period, 1991.

Appendix B. Catches of juvenile coho at the Black Creek counting fence, by date and sampling period, 1991.

Capture date	Operation hours	Total smolt	Total fry	Trap morts	Hold morts	Pred morts	Total pre-tag morts	Tag morts
04/21/91	24	8	0	0	0	0	0	0
04/22/91	24	18	0	0	0	0	0	1
04/23/91	24	10	0	0	0	0	0	0
04/24/91	24	0	0	0	0	0	0	0
04/25/91	24	92	0	0	0	0	0	0
04/26/91	24	6	0	0	0	0	0	0
04/27/91	24	59	0	0	0	0	0	0
04/28/91	24	62	0	0	0	0	0	2
04/29/91	24	38	1	0	0	0	0	0
04/30/91	24	174	0	0	0	0	0	0
05/01/91	24	896	0	0	0	0	0	7
05/02/91	24	691	0	1	0	0	1	3
05/03/91	24	500	0	0	0	0	0	0
05/04/91	24	1442	0	0	0	0	0	0
05/05/91	24	1467	0	0	0	0	0	8
05/06/91	24	1547	0	0	0	0	0	0
05/07/91	24	1026	0	0	1	0	1	0
05/08/91	24	328	3	1	0	0	1	2
05/09/91	24	1876	0	10	0	0	10	12
05/10/91	24	920	0	2	0	0	2	0
	Subtotal	11160	4	14	1	0	15	35
05/11/91	24	1898	0	0	1	0	1	8
05/12/91	24	2452	0	3	0	0	3	0
05/13/91	24	3648	0	0	0	0	0	0
05/14/91	24	4344	0	0	0	0	0	0
05/15/91	24	1395	0	0	0	0	0	0
05/16/91	24	4748	0	0	0	0	0	0
05/17/91	24	1535	0	0	0	0	0	0
05/18/91	24	5435	1	1	0	0	1	0
05/19/91	24	2075	0	25	0	0	25	1
05/20/91	24	2352	0	0	0	0	0	0
05/21/91	24	1674	0	0	0	0	0	0
05/22/91	24	2951	0	7	0	0	7	0
05/23/91	24	2266	0	0	0	0	0	0
05/24/91	24	608	0	1	0	0	1	0
05/25/91	24	221	0	0	0	0	0	0
05/26/91	24	0	0	0	0	0	0	0
05/27/91	24	306	0	0	0	0	0	0
05/28/91	24	1227	0	0	0	0	0	0
05/29/91	24	1069	0	3	0	0	3	0
05/30/91	24	389	1	0	0	0	0	1

Appendix B. (cont.) Catches of juvenile coho at the Black Creek counting fence, by date and sampling period, 1991.

Capture date	Operation hours	Total smolt	Total fry	Trap morts	Hold morts	Pred morts	Total pre-tag morts	Tag morts
05/31/91	24	108	2	1	0	0	1	0
06/01/91	24	183	3	2	0	0	2	0
06/02/91	24	320	3	7	0	0	7	0
	Subtotal	41204	10	50	1	0	51	10
06/03/91	24	87	0	0	0	0	0	0
06/04/91	24	46	0	0	0	0	0	0
06/05/91	24	30	4	0	0	0	0	0
06/06/91	24	51	0	0	0	0	0	0
06/07/91	24	2	0	0	0	0	0	0
06/08/91	24	555	6	224	0	0	224	0
06/09/91	24	198	8	0	0	0	0	0
06/10/91	24	9	0	0	0	0	0	0
06/11/91	24	3	0	0	0	0	0	0
06/12/91	24	2	1	0	0	0	0	0
06/13/91	24	13	1	0	0	0	0	0
06/14/91	24	1	3	0	0	0	0	0
06/15/91	24	6	2	0	0	0	0	0
06/16/91	24	31	0	0	0	0	0	0
06/17/91	24	88	10	1	2	0	3	0
06/18/91	24	165	7	0	2	0	2	0
06/19/91	24	42	0	0	0	0	0	0
06/20/91	24	24	10	0	0	0	0	0
06/21/91	24	47	5	0	0	0	0	0
06/22/91	24	15	10	0	0	0	0	0
06/23/91	24	32	0	0	0	0	0	0
06/24/91	24	65	8	0	0	0	0	0
	Subtotal	1512	75	225	4	0	229	0
	Grand total	53876	89	289	6	0	295	45

Appendix C. Catches of non-coho fish at the Black Creek counting fence, by date, 1991.

Appendix C. Catches of non-coho fish at the Black Creek counting fence, by date, 1991.

Date	Steel-head fry	Steel-head parr	Steel-head smolt no addipose	Steel-head smolt no clip	Steel-head adult no addipose	Steel-head adult no clip	Steel-head kelt no addipose	Steel-head kelt no clip	Cut-throat fry	Cut-throat parr	Cut-throat smolt no addipose	Cut-throat smolt no clip	Cut-throat adult no addipose	Cut-throat adult no clip	Cut-throat kelt no addipose	Cut-throat kelt no clip	Cot-tids	Lam-prey	Stickle-back
04/21/91	0	0	0	1	0	0	0	1	0	0	0	0	0	0	5	6	13	0	1
04/22/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	3	0	1
04/23/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	2	1	1
04/24/91	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	1	0
04/25/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	11	0	0
04/26/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	3	0
04/27/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0
04/28/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
04/29/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	1
04/30/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	1
05/01/91	0	0	0	17	0	0	0	0	0	0	0	2	0	0	10	8	12	0	1
05/02/91	0	0	0	18	0	0	0	0	0	1	0	2	0	0	3	3	8	0	0
05/03/91	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	9	1	1
05/04/91	0	0	0	19	0	0	0	0	0	1	0	5	0	0	10	7	7	0	2
05/05/91	0	0	0	14	0	0	0	0	0	0	1	2	0	0	3	0	5	4	3
05/06/91	0	0	0	3	0	0	0	0	0	1	0	3	0	0	0	4	21	9	3
05/07/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	56	1
05/08/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18	38	5
05/09/91	0	0	0	15	0	0	0	0	0	0	0	11	0	0	8	6	11	4	0
05/10/91	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	12	3	2
05/11/91	0	0	0	9	0	0	0	0	0	0	0	0	0	0	1	10	15	3	1
05/12/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	11	1	2
05/13/91	0	0	0	13	0	0	0	0	0	0	0	2	3	7	0	0	4	1	0
05/14/91	0	0	0	4	0	0	0	0	0	0	0	2	0	0	0	0	2	0	1
05/15/91	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	3	6	1	0
05/16/91	0	0	0	7	0	0	0	0	0	0	0	1	0	0	1	2	10	4	2
05/17/91	0	0	0	4	0	0	0	0	0	1	0	1	0	0	0	0	3	1	0
05/18/91	0	0	0	2	0	0	0	1	0	0	0	4	0	0	0	1	12	0	1
05/19/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	5	1
05/20/91	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	1	12	1	0
05/21/91	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	1	9	0	1
05/22/91	0	0	0	5	0	0	0	0	0	0	0	6	0	0	0	0	3	0	1
05/23/91	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	6	1	0
05/24/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0

Appendix C. Catches of non-coho fish at the Black Creek counting fence, by date, 1991. (cont.)

Date	Steel-head fry	Steel-head parr	Steel-head smolt no addipose	Steel-head smolt no clip	Steel-head adult no addipose	Steel-head adult no clip	Steel-head kelt no addipose	Steel-head kelt no clip	Cut-throat fry	Cut-throat parr	Cut-throat smolt no addipose	Cut-throat smolt no clip	Cut-throat adult no addipose	Cut-throat adult no clip	Cut-throat kelt no addipose	Cut-throat kelt no clip	Cot-tids	Lam-prey	Stickle-back
05/25/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0
05/26/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
05/27/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	1
05/28/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0
05/29/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	1
05/30/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
05/31/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0
06/01/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	1	0
06/02/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	3
06/03/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1	0
06/04/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0
06/05/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	1	0
06/06/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	3	0
06/07/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
06/08/91	0	0	0	7	0	0	0	0	0	0	0	2	0	0	1	0	4	1	1
06/09/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1
06/10/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
06/11/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1
06/12/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
06/13/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0
06/14/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1
06/15/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1
06/16/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
06/17/91	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0
06/18/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	1
06/19/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	3	0
06/20/91	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0
06/21/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	1	1
06/22/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	1	2
06/23/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0
06/24/91	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	1	0
Total	0	0	0	158	0	0	0	3	0	7	1	51	3	7	50	65	575	155	48

Appendix D. Biophysical data for Black Creek, September 22 - December 04, 1991

Appendix D. Biophysical data for Black Creek, September 22 - December 4, 1991.

Date	Time (24 hr)	Maximum water temp. (°C)	Minimum water temp. (°C)	Present water temp. (°C)	Water level Gauge 1 (cm)	Water level Gauge 2 (cm)	Rain 0-5	Wind direction	Wind speed km/hr	Cloud cover (%)
09/22/91	1000	15.0	12.0	12.0	60		0		0	20
09/25/91	1000	16.0	11.0	11.0	58		0	SW	5	10
09/29/91	1000	17.0	1.0	12.0	55		0		0	15
10/15/91	800	12.0	7.0	8.0	50	17	0		0	5
10/16/91	1000	1.0	5.0	7.0	50	17	0	NW	10	30
10/21/91	1200	12.0	6.0	8.0	54	21	0	NW	5	30
10/22/91	800				54	21	0	NW	10	10
10/23/91	900				53	21	0		0	40
10/24/91	1000				54	21	1		0	100
10/25/91	1100			7.0	55	23	1	NW	5	100
10/26/91	1000			5.0	55	24	0	NW	10	15
10/27/91	1100			7.0	55	24	0	NW	5	5
10/28/91	1000			6.0	55	24	0		0	100
10/29/91	1000			5.0	58	27	0		0	10
10/30/91	1000	5.0	3.0	3.0	59	29	0		0	100
10/31/91	800	6.0	4.0	4.0	60	31	2		0	100
11/01/91	800	6.0	3.0	4.0	60	32	0		0	100
11/02/91	800	5.0	3.0	4.0	60	32	0		0	90
11/03/91	800	5.0	3.0	4.0	60	32	2		0	100
11/04/91	730	5.0	4.0	5.0	60	34	1		0	100
11/05/91	800	6.0	4.0	6.0	62	37	2		0	100
11/06/91	800	6.0	5.0	5.0	65	37	0		0	100
11/07/91	700	7.0	5.0	6.0	61	38	3	SE	10	100
11/08/91	700	7.0	5.0	7.0	70	43	1	SE	10	90
11/09/91	700	7.0	7.0	7.0	70	43	0		0	100
11/10/91	700	8.0	6.0	7.0	70	43	0		0	100
11/11/91	700	8.0	7.0	8.0	70	45	3	SE	15	100
11/12/91	730	8.5	7.0	7.0	71	54	0		0	100
11/13/91	730	7.0	6.5	6.5	80	63	1		0	50
11/14/91	730	7.0	5.0	5.0	78	61	0		0	10
11/15/91	800	6.0	5.0	6.0	75	58	1	SE	20	100
11/16/91	700	6.0	6.0	6.0	97	82	4	SE	50	100
11/17/91	1000				141	124	1	SW	10	100
11/18/91	1000				135	120	0		0	60
11/19/91	1000				175	157	5	SE	30	100
11/20/91	1000				170	152	0		0	70
11/21/91	1100				145	128	0		0	80
11/22/91	1100	7.0	5.0	6.0		105	0		0	90

Appendix D. Biophysical data for Black Creek, September 22 - December 4, 1991. (cont.)

Date	Time (24 hr)	Maximum water temp. (°C)	Minimum water temp. (°C)	Present water temp. (°C)	Water level Gauge 1 (cm)	Water level Gauge 2 (cm)	Rain 0-5	Wind direction	Wind speed km/hr	Cloud cover (%)
11/23/91	1100	6.0	5.0	6.0		69	0		0	90
11/24/91	1100	6.0	5.0	6.0		65	3	SE	15	100
11/25/91	1100	6.0	6.0	6.0		64	0	NW	5	95
11/26/91	830	6.0	6.0	6.0		59	2		0	100
11/27/91	830			4.0		55	0	NW	5	5
11/28/91	830	4.0	4.0	4.0		49	1	NW	20	100
11/29/91	830	4.0	4.0	4.0		45	0		0	20
11/30/91	1000	4.0	4.0	4.0		43	0		0	70
12/01/91	1100	5.0	4.0	4.0		39	0	NW	5	60
12/02/91	915	5.0	5.0	5.0		35	0		0	90
12/03/91	900	4.0	4.0	4.0		33	1		0	100
12/04/91	800	4.0	4.0	4.0		34	0	SW	5	70
Mean		6.9	5.2	6.0	74.6	51.3				
Max					175.0	157.0				
Min					50.0	17.0				

Appendix E. Black Creek fence enumerations and upstream recoveries of live adult and jack coho used in mark-recapture estimates, 1991

Appendix E. Black Creek fence enumerations and upstream recoveries of live adult and jack coho used in mark-recapture estimates, 1991. Primary tags were applied at the counting fence and secondary tags were applied upstream. Numbers of primary and secondary tags at large are calculated as the number of fish tagged less the number of fish removed for sampling or as carcasses.

Survey date	Number examined at fence	Number released at fence	Number examined upstream	Number released upstream	Total number examined	Number primary recaps	Number secondary recaps	Total number recaps	Primary tags applied	Secondary tags applied	Total tags applied	Primary tags at large	Secondary tags at large	Total tags at large
Adults														
11/01/04	54	54			54			0	53		53	0	0	0
11/01/05	24	24			24			0	24		24	53	0	53
11/01/06	5	5			5			0	5		5	76	0	76
11/01/07	106	105			106			0	106		106	81	0	81
11/01/08	259	259			259			0	259		259	187	0	187
11/01/09	65	65			65			0	65		65	446	0	446
11/01/10	22	22			22			0	22		22	511	0	511
11/01/11	1116	1116			1116			0	1112		1112	533	0	533
11/01/12	915	915			915			0	914		914	1645	0	1645
11/01/13	481	481			481			0	481		481	2559	0	2559
11/01/14	10	10	15	15	25	15	0	15	10	0	10	3038	0	3038
11/01/15	1	1	40	40	41	38	0	38	1	2	3	3046	0	3046
11/01/16	66	61	1	0	67	1	0	1	61	0	61	3046	2	3048
11/01/17	0	0			0			0	0		0	3099	2	3101
11/01/18	0	0			0			0	0		0	3099	2	3101
11/01/19	0	0			0			0	0		0	3099	2	3101
11/01/20	0	0			0			0	0		0	3099	2	3101
11/01/21	0	0			0			0	0		0	3099	2	3101
11/01/22	0	0			0			0	0		0	3099	2	3101
11/01/23	0	0			0			0	0		0	3099	2	3101
11/01/24	0	0			0			0	0		0	3099	2	3101
11/01/25	0	0			0			0	0		0	3099	2	3101
11/01/26	0	0	74	73	74	63	0	63	0	11	11	3097	2	3099
11/01/27	0	0	6	2	6	6	0	6	0	0	0	3080	13	3093
11/01/28	0	0			0			0	0		0	3058	13	3071
11/01/29	0	0			0			0	0		0	3054	13	3067
11/01/30	0	0			0			0	0		0	3054	13	3067
12/01/01	0	0			0			0	0		0	3054	13	3067
12/01/02	0	0			0			0	0		0	3054	13	3067
12/01/03	0	0	1	0	1	1	0	1	0	0	0	3054	13	3067
12/01/04	0	0	6	3	6	5	0	5	0	0	0	3024	8	3032
12/01/05	0	0			0			0	0		0	2999	8	3007
12/01/06	0	0			0			0	0		0	2999	8	3007
12/01/07	0	0			0			0	0		0	2999	8	3007
12/01/08	0	0			0			0	0		0	2999	8	3007
12/01/09	0	0	3	3	3	1	0	1	0	2	2	2999	8	3007
Totals	3124	3118	146	136	3270	130	0	130	3113	15	3128	2993	8	3001

Appendix E. (cont.) Black Creek fence enumerations and upstream recoveries of live adult and jack coho used in mark-recapture estimates, 1991. Primary tags were applied at the counting fence and secondary tags were applied upstream. Numbers of primary and secondary tags at large are calculated as the number of fish tagged less the number of fish removed for sampling or as carcasses.

Survey date	Number examined at fence	Number released at fence	Number examined upstream	Number released upstream	Total number examined	Number primary recaps	Number secondary recaps	Total number recaps	Primary tags applied	Secondary tags applied	Total tags applied	Primary tags at large	Secondary tags at large	Total tags at large
Jacks														
11/01/04	175	165			175			0	165		165	0	0	0
11/01/05	142	98			142			0	98		98	165	0	165
11/01/06	26	17			26			0	17		17	261	0	261
11/01/07	147	138			147			0	138		138	278	0	278
11/01/08	410	394			410			0	394		394	416	0	416
11/01/09	68	65			68			0	64		64	809	0	809
11/01/10	32	32			32			0	32		32	873	0	873
11/01/11	652	634			652			0	629		629	905	0	905
11/01/12	285	285			285			0	283		283	1534	0	1534
11/01/13	47	47			47			0	47		47	1817	0	1817
11/01/14	3	3	5	5	8	5	0	5	3	0	3	1863	0	1863
11/01/15	1	1	21	21	22	16	0	16	1	0	1	1866	0	1866
11/01/16	3	2			3			0	2		2	1867	0	1867
11/01/17	0	0			0			0	0		0	1869	0	1869
11/01/18	0	0			0			0	0		0	1869	0	1869
11/01/19	0	0			0			0	0		0	1869	0	1869
11/01/20	0	0			0			0	0		0	1869	0	1869
11/01/21	0	0			0			0	0		0	1869	0	1869
11/01/22	0	0			0			0	0		0	1869	0	1869
11/01/23	0	0			0			0	0		0	1869	0	1869
11/01/24	0	0			0			0	0		0	1869	0	1869
11/01/25	0	0			0			0	0		0	1869	0	1869
11/01/26	0	0	22	22	22	19	0	19	0	3	3	1869	0	1869
11/01/27	0	0	5	3	5	5	0	5	0	0	0	1869	3	1872
11/01/28	0	0	1	0	1	1	0	1	0	0	0	1868	3	1871
11/01/29	0	0			0			0	0		0	1867	3	1870
11/01/30	0	0			0			0	0		0	1866	3	1869
12/01/01	0	0			0			0	0		0	1866	3	1869
12/01/02	0	0			0			0	0		0	1866	3	1869
12/01/03	0	0			0			0	0		0	1866	3	1869
12/01/04	0	0	7	4	7	6	0	6	0	0	0	1863	3	1866
12/01/05	0	0			0			0	0		0	1859	3	1862
12/01/06	0	0			0			0	0		0	1859	3	1862
12/01/07	0	0			0			0	0		0	1859	3	1862
12/01/08	0	0			0			0	0		0	1859	3	1862
12/01/09	0	0	3	3	3	1	0	1	0	2	2	1859	3	1862
Totals	1991	1881	64	58	2055	53	0	53	1873	5	1878	1858	3	1861

Appendix F. Stream life values for individual coho salmon recovered as carcasses in Black Creek, 1991

Appendix F. Stream life values for individual coho salmon recovered as carcasses in Black Creek, 1991.

Sex	Date tagged	Date recovered	Days dead	Stream life (days)
M	11/05/91	12/03/91	3	25
M	11/07/91	12/03/91	4	22
M	11/08/91	11/16/91	2	6
M	11/09/91	12/03/91	4	20
M	11/10/91	11/13/91	0	3
M	11/11/91	11/14/91	1	2
M	11/11/91	11/16/91	0	5
M	11/11/91	11/26/91	1	14
M	11/11/91	11/27/91	2	14
M	11/11/91	12/03/91	2	20
M	11/11/91	12/03/91	2	20
M	11/11/91	12/04/91	3	20
M	11/11/91	12/04/91	2	21
M	11/11/91	12/04/91	2	21
M	11/12/91	11/14/91	0	2
M	11/12/91	11/26/91	2	12
M	11/12/91	11/26/91	1	13
M	11/12/91	11/27/91	1	16
M	11/12/91	12/03/91	2	19
M	11/12/91	12/03/91	2	19
M	11/12/91	12/04/91	3	19
M	11/13/91	11/26/91	1	12
M	11/13/91	12/03/91	3	17
F	11/08/91	11/13/91	0	5
F	11/08/91	11/16/91	0	8
F	11/08/91	11/27/91	2	17
F	11/08/91	12/04/91	5	21
F	11/08/91	12/04/91	>5	21
F	11/09/91	11/27/91	2	16
F	11/09/91	12/03/91	4	20
F	11/10/91	11/26/91	1	15
F	11/10/91	11/27/91	2	15
F	11/11/91	11/27/91	1	15
F	11/11/91	11/27/91	2	14
F	11/11/91	11/27/91	2	14
F	11/11/91	11/27/91	2	14
F	11/11/91	11/27/91	1	15
F	11/11/91	11/27/91	3	13
F	11/11/91	12/03/91	3	19
F	11/11/91	12/03/91	3	19
F	11/11/91	12/03/91	2	20
F	11/11/91	12/03/91	2	20
F	11/11/91	12/03/91	3	19
F	11/11/91	12/03/91	3	19
F	11/11/91	12/03/91	3	19
F	11/11/91	12/04/91	2	21
F	11/12/91	11/25/91	0	13
F	11/12/91	11/26/91	1	13
F	11/12/91	11/26/91	1	13
F	11/12/91	11/26/91	1	13
F	11/12/91	11/26/91	2	12
F	11/12/91	11/26/91	0	14
F	11/12/91	11/27/91	2	13
F	11/12/91	11/27/91	2	13
F	11/12/91	11/27/91	2	13

Appendix F. Stream life values for individual coho salmon recovered as carcasses in Black Creek, 1991. (cont.)

Sex	Date tagged	Date recovered	Days dead	Stream life (days)
F	11/12/91	11/27/91	1	14
F	11/12/91	11/27/91	4	11
F	11/12/91	12/03/91	3	18
F	11/12/91	12/03/91	2	19
F	11/12/91	12/03/91	3	18
F	11/12/91	12/03/91	2	19
F	11/12/91	12/04/91	2	20
F	11/12/91	12/04/91	2	20
F	11/12/91	12/04/91	2	20
F	11/12/91	12/09/91	4	23
F	11/12/91	12/09/91	>7	20
F	11/13/91	11/16/91	1	2
F	11/13/91	12/03/91	3	17
F	11/13/91	12/03/91	3	17
F	11/13/91	12/03/91	3	17
F	11/13/91	12/04/91	2	19
F	11/13/91	12/04/91	3	18
F	11/14/91	12/04/91	1	19
F	11/16/91	12/03/91	2	15
J	11/07/91	12/03/91	3	13
J	11/07/91	12/04/91	>5	22
J	11/11/91	11/27/91	4	12
J	11/11/91	12/03/91	3	19
J	11/12/91	11/13/91	1	0
J	11/12/91	12/09/91	4	23
J	11/13/91	12/03/91	2	18

Abbreviations are: M = male; F = female; J = jack