

Scientific Excellence • Resource Protection & Conservation • Benefits for Canadians
Excellence scientifique • Protection et conservation des ressources • Bénéfices aux Canadiens

A Preliminary Report on the Chinook Productivity Study Conducted on the Cowichan River During 1993

D. A. Nagtegaal, J. R. Candy and B. Riddell

Science Branch
Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, British Columbia
V9R 5K6

1995

**Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2315**



Fisheries
and Oceans

Pêches
et Océans

Canada

Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 901-1425 were issued as Manuscript Reports of the Fisheries Research Board of Canada. Numbers 1426-1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

19/210

Canadian Manuscript Report of
Fisheries and Aquatic Sciences 2315

7 1995

1995

A PRELIMINARY REPORT ON THE CHINOOK PRODUCTIVITY STUDY CONDUCTED
ON THE COWICHAN RIVER DURING 1993

by

D. A. Nagtegaal, J. R. Candy and B. Riddell

Science Branch
Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, British Columbia
V9R 5K6

©Minister of Supply and Services Canada 1995

Cat. No. 97-4/2315E

ISSN 0706-6473

Correct citation for this publication:

Nagtegaal, D. A., J. R. Candy and B. Riddell. 1995. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1993. Can. Manusc. Rep. Fish. Aquat. Sci. 2315: 84 p.

LIST OF TABLES

TABLES	PAGE
1. Daily counts at the enumeration fence site, 1993	21
2. Daily counts by time interval at the enumeration fence site, 1993	23
3. Visual survey data collected for the Cowichan River by Fishery Officers	24
4. Indian food fish catch estimates for the Cowichan River	27
5. Summary of chinook broodstock collected by the Cowichan Hatchery, 1993	28
6. Adult chinook escapement used for hatchery broodstock, Cowichan River	29
7. Summary of chinook broodstock age data, 1993	30
8. Length-frequency of chinook tagged at the enumeration fence, 1993	31
9. Length-frequency of chinook sampled from the Native food fishery, 1993	32
10. Summary of age data collected for chinook sampled during the Native food fishery, 1993	33
11. Length-frequency of chinook sampled on the spawning grounds, 1993	34
12. Summary of chinook age data collected on the spawning grounds, 1993	35
13. Length-frequency of chinook broodstock collected for the Cowichan R. hatchery, 1993	36
14. Water temperature and depth at the enumeration fence site, 1993	37
15. Daily discharge in cu. m/sec for 1993	38
16. Summary of chinook tagged at the enumeration fence, 1993	39
17. Summary of chinook tag and recovery data, 1993	43

LIST OF APPENDICES

APPENDIX	PAGE
1. Chinook hatchery release data, 1980-1993	77
2. Tag code data from chinook sampled on the spawning grounds, 1993	79
3. Tag code data for chinook sampled from the Native food fishery, 1993	84

LIST OF FIGURES

FIGURE	PAGE
1. Cowichan River survey areas	59
2. Map of Indian Food fishery management zones	61
3. Daily fence count	63
4. Fence count compared with swim survey data	65
5. Daily chinook count vs discharge	67
6. Chinook stream life	69
7. Native food fishery catch data, 1971-1993	71
8. Chinook escapement estimates, 1953-1993	73
9. Cowichan hatchery juvenile chinook releases	75

LIST OF TABLES (cont'd)

TABLES	PAGE
18. Chinook carcass capture-recapture summary, 1993	45
19. Chinook carcass capture histories, 1993	46
20. Chinook radio tracking summary, 1993	47
21. Petersen chinook escapement estimates by sex, Cowichan River, 1993	48
22. Recoveries from chinook tagged in successive weeks at the fence, divided according to week of recovery upstream (Schaeffer escapement estimates)	49
23. Jolly-Seber carcass capture-recapture statistics for chinook after pooling	50
24. Incidence of tagged chinook recovered on the spawning grounds, by period, in the Cowichan R., 1993	51
25. Proportion of the tag application sample recovered on the spawning grounds, by period, 1993	52
26. Incidence of tagged chinook recovered on the spawning grounds, by section of river and by period, 1993	53
27. Sex composition of application and recovery samples of tagged chinook, Cowichan R., 1993	54
28. Summary of adult chinook escapement estimates	55
29. Total adult chinook returns to the Cowichan R., 1975-1993	56

ABSTRACT

Nagtegaal, D. A., J. R. Candy and B. Riddell. 1995. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2315: 84 p.

In 1993, the Biological Sciences Branch, Pacific Biological Station, conducted a study of chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. Major components of this ongoing study include: i) enumeration of spawners, ii) estimation of native food fish catch, iii) recording hatchery broodstock removals, iv) biological sampling and coded-wire tag (CWT) data collection. Both live and carcass mark-recapture studies were conducted to augment the fence count. Total return of adult chinook to the Cowichan River was estimated to be 7,312 in 1993. It was estimated that less than half the spawners made it to the traditional spawning grounds above Skutz Falls. This was probably due to unusually low water levels during the fall. The number of natural spawners was estimated to be 5,047. Fishery Officers estimated the adult chinook escapement to be 5,200. In addition, a water management plan is described which was intended to aid upstream movement of chinook.

RÉSUMÉ

Nagtegaal, D. A., J. Candy and B. Riddell. 1995. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2315: 84 p.

La Direction des sciences biologiques de la Station de biologie de Nanaïmo a entrepris en 1993 une étude de la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) de la rivière Cowichan. Les principaux volets de cette étude continue sont: i) le dénombrement des géniteurs, ii) l'estimation des prises de la pêche d'alimentation autochtone, iii) la détermination du nombre de géniteurs prélevés à des fins piscicoles et iv) l'échantillonnage biologique et l'obtention de données de marquage par fils codés. Des études de marquage-recapture, de poissons vivants et de carcasses, ont été effectuées afin de compléter les dénombrements par barrières de comptage. La remontée totale de quinnats adultes dans la rivière Cowichan a été estimée à 7 312 poissons en 1993. On a estimé que moins de la moitié des géniteurs avaient atteint les frayères traditionnelles situées en amont de Skutz Falls; cela s'explique probablement par le faible niveau des eaux à l'automne. Le nombre de géniteurs naturels a été estimé à 5 047 et les agents des pêches ont estimé à 5 200 poissons l'échappée des quinnats adultes. Les auteurs décrivent un plan de gestion qui devrait permettre de favoriser la remontée des quinnats.

INTRODUCTION

Considerable interest has been focused towards the chinook salmon (*Oncorhynchus tshawytscha*) stocks in the southern portion of the Strait of Georgia over the past several years due to the perceived decline in these stocks and their importance to the local fisheries (Farlinger et al. 1990). The Biological Sciences Branch, Pacific Biological Station, initiated a study of chinook productivity to assess rebuilding strategies and to evaluate the effects of harvest management policies for these stocks. In the fall of 1988, a study was implemented on the Cowichan River with additional information collected from the Squamish and Nanaimo River systems. The objectives of this study include: i) quantitatively determining the optimum spawning requirement for chinook salmon in the Cowichan River (this involved investigations of the determinants of juvenile production, interactions between hatchery and wild chinook, and estimation of the spawning escapement and catch attributed to the hatchery and wild components of the total run), and ii) development of guidelines for establishing escapement targets for other B. C. chinook stocks (Nagtegaal et al., 1994).

Hatchery production of chinook on the Cowichan River began in 1980 (Cross et al., 1991). Chinook fry releases have increased from 64,681 in 1980, to 3.4 million in 1993. Marked releases also began in 1980 and in 1993 approximately 7% of the total number of chinook released were coded-wire tagged (Appendix Table 1).

As an adjunct to this study a water management plan, implemented in 1988 (KPA Engineering Ltd. 1991), was maintained on the Cowichan River by the Fisheries Branch. The rationale behind this plan was to increase water flow for a short period (2-5 days) during the early part of the chinook run. This was intended to aid upstream movement of chinook. These fish may otherwise be obstructed in their upstream migration and suffer pre-spawn mortalities due to typically low water levels in the Fall.

The purpose of this report is to present the results of the adult escapement enumeration component of the chinook productivity study conducted on the Cowichan River during the fall of 1993.

METHODS

Components of escapement enumeration include: i) enumeration of chinook salmon at the counting fence; ii) estimation of native food fishery catch; iii) recording of hatchery broodstock

removals; iv) collection of biological data and sampling of coded-wire tag (CWT) recoveries; v) live and carcass mark-recapture studies for both adult and jack chinook, and vi) radio tracking.

A detailed description of the methodology used to collect the above information was presented in Nagtegaal et al. (1994). Some changes were made in 1993 and are described below.

The counting fence was placed in the same location as in previous years (Fig. 1).

FENCE OPERATION:

In 1993, the counting fence was operated from August 22 through to November 22. Due to excellent conditions (low water levels throughout the duration of the project) we were able to monitor virtually the entire chinook run. Counts were recorded by fifteen minute intervals for adult and jack chinook, adult and jack coho, and chum. If identification was in doubt those fish were recorded as unknown. Water depth, temperature, and clarity, and weather conditions were recorded four times per day. On a daily basis the fence was cleaned of leaves and other debris. Records of fish collected at the fence by the hatchery staff were also kept.

SWIM SURVEY:

Traditionally, Fishery Officers have been involved in escapement enumeration, but due to extenuating circumstances they were not involved this year. Five swim surveys were, however, conducted in conjunction with Cowichan Tribes River Management to estimate the spawning population of chinook. The swims were made in the upper section of the river (Birdhouse to Three Firs pool; Fig. 1) on Sept. 23, 30, Oct. 14, 28, and Nov. 4. Each survey was conducted by three experienced swimmers and one person in a canoe who recorded the data. Each swimmer (one in the middle and one on each side of the river) counted the fish seen within their range of visibility. The three swimmers attempted to keep abreast as they approached each pool while the person in the canoe lagged behind within hailing distance. Counts were recorded by pool/riffle and then compiled by river section. When possible the same swim team was used for each survey to maintain consistency in counting procedures.

It was intended that the swim survey estimates remain independent of the fence count. Even though no fence count information was passed on to the swim teams during the season, general trends in escapement numbers were known.

NATIVE FOOD FISHERY:

In 1990, a systematic approach was developed by the Cowichan Tribes to monitor the fishery more closely and to better estimate the native food fish catch (Paige, Unpubl.). This approach involved recording catch and effort by management zone within the native fishing boundaries (Fig.2). A crew of four observers patrolled the fishery on a daily basis and interviewed fishermen for numbers caught by area and total time spent fishing. In this way, weekly estimates of catch per unit effort (CPUE) were obtained. CPUE was adjusted for daily changes in fishing effort and differences in effort among fishing zones. These data were then extrapolated over time and area to estimate total catch by week.

BIOLOGICAL DATA:

Biological data for chinook were collected from four sources: i) hatchery broodstock samples; ii) enumeration fence; iii) mark/recapture (spawning ground); and iv) native food fishery. Hatchery staff collected biological data and recorded the incidence of coded-wire tagged fish from the chinook broodstock. Random samples of chinook from the beginning, middle and end of the run, were trapped at the enumeration fence and sampled for length, sex, scale, and checked for missing adipose fin. The goal was to sample approximately 25% of the chinook run. On the spawning grounds chinook were sampled for length, sex, scale, presence/absence of a fence tag and adipose fin.

A member of the Cowichan Tribes was hired to collect biological data from the native food fishery. The person monitored both the traditional chinook spear fishery as well as the in-river gillnet fishery. Data for length, sex, age and adipose clip were recorded from the catch by management zone on a daily basis. The person interviewed as many fishermen as possible and attempted to sample fish from all management zones. Due to concentrated fishing effort in certain zones and lack of cooperation from some fishermen, not all areas were sampled equally.

MARK-RECAPTURE:

Live mark-recapture involved tagging chinook jacks and adults at the enumeration fence and their subsequent recovery on the spawning grounds. This was intended to provide an independent estimate of escapement to augment the fence count and swim survey estimate. Chinook were individually dipnetted out of the fish trap

at the fence, tagged with a Ketchum¹ aluminum sheep ear tag on the operculum, and immediately released. Fish were placed in a quiet pool just above the trap to allow for recovery. Fish showing signs of physical injury were not tagged. Length, sex, and adipose clip information was recorded for all tagged fish. An opercular punch was used as a secondary tag on some chinook.

A two man crew in an inflatable boat daily surveyed the upper section of the river (Fig. 1) and collected all available chinook carcasses. This section of the river above Skutz Falls represents the area where the majority of chinook spawning typically occurs. A second crew collected carcasses from the middle section of the river (Fig. 1). For each fish collected the location, length, sex, and presence/absence of the adipose fin, spawning condition, and tag number were recorded. A 4.2 m (14 ft) pole with a gaff hook attached to the end was used to recover carcasses. Some carcasses were likely missed if they ended up in pools too deep for retrieval.

A multiple capture-recapture program involved the tagging and subsequent recovery of chinook jack and adult carcasses on the spawning grounds. All chinook carcasses (including those that had previously been tagged at the fence) were individually tagged with a Ketchum aluminum sheep ear tag on the operculum and immediately released. Location of capture and release, length, sex, and adipose clip information was recorded for each carcass recovered. Tag numbers of previously marked carcasses were recorded and the carcass returned to the river in the same site as captured. Two crews were used to survey the upper and middle sections of the river on a daily basis.

Carcasses recovered on the spawning grounds that were originally tagged at the fence were treated the same as untagged carcasses recovered on the spawning grounds. All coded-wire tagged fish recovered on the the spawning grounds were biosampled and the head removed for future processing.

RADIO TRACKING:

Ten chinook were tagged at the fence with a Holohil² radio transmitter, which was inserted through the mouth into the gut of the fish, and a uniquely numbered spaghetti tag mounted posterior to the dorsal fin. Fish were released in a quiet pool just above the trap to allow for recovery. Individual fish could be

¹Ketchum Manufacturing Ltd., Ottawa, Canada.

²Holohil Systems PD-2 transmitters (130-235 Mhz)
3387 Stonecrest Rd., Woodlawn, Ontario, Canada, KOA-3M0

identified by the unique frequency emitted by the radio transmitter. Only fish considered to be in good condition were tagged. Every few days both the upper and middle sections of the river (Fig. 1) were surveyed using a scanning receiver³ mounted on an inflatable boat. When fish were encountered the location and transmitter frequency were recorded. Radio tracking was conducted until it was assumed that all fish had spawned and died.

POPULATION ESTIMATE:

Adult chinook salmon escapement estimates were calculated based on the live mark-recapture data using both simple (Chapman modification) and stratified Petersen formula (Schaefer method; Ricker 1975). Escapement estimates were also generated from the carcass capture-recapture data using both Petersen (Chapman modification) and a modified open population Jolly-Seber model (Sykes and Botsford 1986, Schwartz et al. 1993).

A) Simple Petersen:

1) Estimated total chinook escapement (N_t):

$$N_{(t)total} = N_{(m)males} + N_{(f)females}$$

Where:

$$N = \frac{(M + 1) (C + 1)}{(R + 1)}$$

(calculated separately for both males and females)

2) Estimated 95% confidence limits of N_t :

$$N_t \pm 1.96 \sqrt{V_t}$$

Where:

C = total number of fish recovered

M = total number of fish tagged

R = total number of tagged fish recovered on the spawning grounds

³Advanced Telemetry Systems Model Challenger 4000 scanning receiver (159-162 Mhz) with a 4-element Yagi antenna.

N_t = total escapement estimate

and: V_t = variance of escapement estimate;

$$= \frac{(N^2) (C - R)}{(C + 1) (R + 2)}$$

(calculated separately for both males and females)

B) Stratified Petersen:

1) Estimated total chinook escapement (N_t):

(time of marking was divided into periods designated by i , and time of recovery into periods designated by j , where each period represents one week)

$$\text{Where: } N_t = \sum N_{ij} = \sum \left(R_{ij} \times \frac{M_i}{R_i} \times \frac{C_j}{R_j} \right)$$

in which:

M_i is the number of adults marked in the i th period of marking

C_j is the number of adults examined in the j th period of recovery

R_{ij} is the number of adults marked in the i th period which are recovered in the j th period

R_i is the total recaptures of tagged adults in the i th period

R_j is the total recaptures of tagged adults in the j th period

2) Estimated 95% confidence limits of N_t :

The upper and lower 95% confidence limits for the estimate were obtained using fiducial limits for the Poisson distribution. These were calculated by substituting the observed number of adult recaptures for the unknown term (X) in E. S. Pearson's formula;

$$X + 1.92 \pm 1.96 \sqrt{X + 1.0} ,$$

and then substituting the results into the formula for N_i above (Ricker 1975, Seber 1982).

C) Jolly-Seber:

A comprehensive computer program POPAN-3 (Arnason et. al. 1992) was used to conduct the analysis. The Jolly-Seber model allows estimation of population size at each sampling time as well as survival rates and birth numbers between sampling times. Notation for the model is described below:

1) Statistics:

- m_i = the number of marked fish captured in the i th sample
($i=1, \dots, k$)
- u_i = the number of unmarked fish captured in the i th sample
($i=1, \dots, k$)
- n_i = $m_i + u_i$, the total number of fish captured in the i th sample
($i=1, \dots, k$)
- R_i = the number of n_i that are released after the i th sample
($i=1, \dots, k-1$). $R_i \leq n_i$ because of losses on capture
- r_i = the number of R_i fish released at i that are captured again
($i=1, \dots, k-1$)
- z_i = the number of fish captured before i , not captured at i ,
and captured again later ($i=2, \dots, k-1$)

RESULTS

ENUMERATION FENCE:

Daily counts at the enumeration fence are contained in Table 1, and compared with water depth recorded at the fence (Fig. 3). Total counts recorded during this period were: 5,058 adult chinook; 5,768 jack chinook; 9,502 adult coho; 5,616 jack coho; 154,793 chum and 19 unidentified salmon.

During the season, jack chinook tended to enter the river earlier than adult chinook. Daily counts were summarized by one hour intervals (Table 2) and we note that peak movement of adult chinook occurred between 0900 and 1100 in the morning and jack chinook between 1800 and 2000 in the evening. Approximately 73% of adults and 70% of jacks migrated past the fence during daylight hours.

During several shifts throughout the migration period an independent count was made at the enumeration fence to determine the accuracy of the counting procedure and species identification. On several occasions, fish were visually identified by an observer in the counting tower and then captured in the fish trap and identified by a second observer. Of the 147 fish examined, two fish (1.4%) were incorrectly identified.

SWIM SURVEYS:

A summary of visual surveys conducted by Fisheries Officers from 1981-1993 is presented in Table 3. Total escapement estimates for each year are for adult chinook only. The 1993 escapement of adult chinook was estimated by Cowichan Tribes River Management to be 3500 (Fig. 4). All swim surveys were conducted under good conditions (low water and clear visibility) and no major difficulties were encountered.

At the end of the season, based on the swim survey data and after reviewing the fence count, Fishery Officers adjusted the escapement estimate upward to 5200 (T. Fields, pers. comm.). It was understood that due to low water conditions, substantial numbers of chinook did not spawn in the upper end of the river, and consequently were not observed in the swim surveys.

NATIVE FOOD FISHERY:

Estimates of the native food fish catch of chinook since 1981 are listed in Table 4. This catch estimate was determined by the River Management Unit of the Cowichan Tribes (Wayne Paige, pers. comm.). According to our observer, the adult chinook catch estimate was one of the lowest in recent years even though optimal fishing conditions prevailed (John Charlie, pers. comm.). Based on this native food fish sampling program an estimated 650 adult chinook were taken in the fishery (John Charlie, pers. comm.). It was very difficult to assess the quality of the data collected from either of these sources but it was apparent that some discrepancies continue to exist as in previous years.

HATCHERY COMPONENT:

In 1993, 2200 chinook were removed from the river by the Cowichan River hatchery staff, of which 98% were collected below the enumeration fence (Table 5). This was the largest number taken for broodstock since 1981 (Table 6). Primarily three and four year old chinook were used for broodstock (Table 7).

BIOLOGICAL DATA:

During 1993, 837 adult and 376 jack chinook were sampled at the fence site for adipose marks, approximately 16% of the estimated run. The mark rate for males was 4.7%, for females was 11.7%, and for jacks was 2.2% (Table 8).

An estimated 20% of the native food fish catch was sampled (Table 9). The majority of the chinook taken in the food fishery were three and four year olds (Table 10) with a considerable number of jacks taken as well. This was likely due to the fact that the fishery is most active during the earlier part of the run when relatively more jacks are in the river than adults.

Table 8 lists the size frequency of chinook tagged at the counting fence. Table 11 contains a length-frequency summary of chinook sampled on the spawning grounds. The majority of chinook sampled on the spawning grounds were jacks (Table 12). Considerably more adult females were recovered on the spawning grounds than males.

Length-frequency summaries of chinook broodstock collected and sampled at the hatchery are listed in Table 13. The hatchery staff randomly sampled approximately 25% of all broodstock and then selectively sampled all remaining adipose clipped chinook. The adipose mark rate was 22.0% for males, 16.0% for jack chinook, and 22.7% for females. The mark rate from hatchery samples was considerably higher than from data collected at either the fence or from the spawning grounds.

Coded-wire tag (CWT) recovery information for chinook sampled on the spawning ground is listed in Appendix Table 2 and for the native food fishery in Appendix Table 3. Approximately 46% of the recovered fish were from the late hatchery release group (released as smolts) and 35% from the early release group (released as fry).

WATER RELEASE STUDY:

The release of additional water stored in Lake Cowichan occurred on September 26 at noon. Water temperature and stage were monitored at the counting fence (Table 14) and discharge at the Water Survey Canada recording station at the Island highway in Duncan (Table 15). Note that with the increased flow a corresponding increase in the daily chinook count occurred (Fig. 5). There were no other water releases since there wasn't sufficient storage available (T. Fields, pers. comm.).

RADIO TRACKING:

Eight adult and two jack chinook were tagged and tracked between Sept. 13 and Nov. 19 (Table 20) according to techniques described by Eiler et. al. (1991). We attempted to tag three groups of fish (beginning, middle and end) during the course of the season. Four fish were tagged but never tracked to their final spawning destination and were not recovered in the carcass sampling program, possibly due to predator removal. Whether the transmitters failed or they were removed from the river is unknown.

Of the six chinook that were successfully tracked, five were not impeded by low water conditions, even at Skutz Falls and Marie Canyon. These two sites have been considered as partial barriers to upstream movement during low water conditions. From carcass recovery, however, we noted that an unusually large number of chinook spawned below Skutz Falls this year.

We also examined the relationship between the time chinook were tagged and released at the fence site and the subsequent date of recovery on the spawning ground (Fig. 6). Fish that arrive in August spend more time in the river prior to spawning than those that arrive towards the end of October. Fish that were radio tagged at the fence in the middle of September took approximately one month to travel the 20 Km upstream to the spawning ground. Peak spawning occurred late in October and the majority of spawning activity took place during a two week time span.

MARK-RECAPTURE:

Table 16 summarizes the tagging data for chinook at the fence and Table 17 lists the recovery data for chinook sampled on the spawning grounds. Both tagging (Aug.25-Nov.5) and recovery (Oct.21-Nov.22) were spread over several weeks during peak migration and spawning. In 1993, 768 adult and 361 jack chinook were tagged. Of the 2206 fish sampled on the spawning grounds, 41 tagged males, 78 tagged females, and 22 tagged jack chinook were recovered. Approximately one-quarter (24%) of the adult tagged fish recovered had lost the operculum tag but had an obvious mark on the operculum indicating that a tag had been applied.

Four tagged jack chinook, two females and two males (<1% of total fish tagged) were recovered on the fence that had presumably died from tagging. These fish were found dead on the fence just a few hours after tagging. Initial mortality due to the tagging procedure must have been low otherwise more tagged chinook would have ended up dead on the fence. The only measure of longer term mortality was the number of pre-spawn mortalities recovered on the spawning grounds. Only five tagged female chinook, representing less than 1% of the tagged females examined, were

recovered on the spawning grounds that had died before spawning. Approximately 6% of the untagged female chinook recovered had died before spawning.

Table 18 contains a summary of the carcass capture-recapture data by tagging period. A total of 1161 adult and 1005 jack chinook carcasses were tagged and released. The number of times carcasses were recaptured after initially being tagged and released is listed in Table 19. Approximately 64% of the adult and 77% of jack carcasses were tagged but never recaptured. Smaller and lighter jack chinook carcasses are more readily swept downstream and less likely to be recovered than the heavier adult carcasses. This is generally the case during the fall and a potential source of bias, but due to the very low flow this year, the usual scenario of carcasses being swept downstream was not a significant problem.

Simple Petersen:

The escapement of chinook adults calculated from the live mark-recapture data was 7,627 with lower and upper 95% confidence limits of 5,765 and 9,489. The escapement estimate of female and male chinook was 4,203 and 3,424, respectively (Table 21).

The escapement estimate of adults based on carcass mark-recapture data (Table 21) was 4,601 with lower and upper 95% confidence limits of 3,843 and 5,359, respectively. The estimates for males (1,880) was slightly less than that for females (2,721).

Stratified Petersen:

The total adult escapement estimate using the Schaeffer method was calculated to be 7,749, with lower and upper 95% confidence limits of 3,172 and 21,333 (Table 22). Estimates could not be calculated by sex using this method since too few tagged fish were recovered during each recovery period.

Jolly-Seber:

Using the modified Jolly-Seber approach we generated estimates for adult chinook only. Summary statistics for the analysis are contained in Table 23. The capture-recapture estimate was calculated to be 4,282 adults +/- 457 (2 SD).

Potential biases:

Some of the typical biases associated with mark-recapture experiments (Ricker 1975) are listed below and were examined in some detail for the live mark-recapture data only.

1. Temporal bias:

Temporal bias in the tagging sample was examined by comparing the mark incidence between periods in the recovery sample (Table 24). Mark incidence was significantly higher during the first week ($P < 0.05$; chi-square). For the purpose of comparison the data from the first week of recovery was therefore combined with data from the second week. When mark incidence was compared with the tagging periods pooled in this way, no significant differences between periods was observed ($P > 0.05$).

Recovery bias was examined by stratifying the application sample by period and comparing proportions recovered (Table 25). Since sample sizes were small the first three application periods were combined. No significant differences were observed ($P > 0.05$; chi-square).

2. Location bias:

Spatial bias in the application sample was examined by comparing the mark incidence between the upper and middle river sections in the recovery sample (Table 26). There was no significant difference between the upper and middle sections of the river ($P > 0.05$; chi-square). Recovery bias was not examined since all fish were tagged at the enumeration fence.

3. Fish size:

Size related bias in the application sample was examined by comparing the continuous POH length frequency distributions of marked and unmarked recoveries from the spawning ground (Table 8 and 11). No significant differences were observed in males or females ($P > 0.05$; Kolmogorov-Smirnov two sample test). Size related bias in the recovery sample could not be examined since all fish that were captured at the fence were either taken for broodstock or tagged and released.

4. Fish sex:

Sex related bias in the application sample was examined by comparing the sex ratio of the marked and unmarked spawning ground recoveries (Table 27). Bias in the recovery sample was examined by partitioning the application sample into recovered and non-recovered components and comparing the sex ratios in each. In both cases, no significant differences were found ($P > 0.05$; chi-square).

DISCUSSION

ENUMERATION FENCE:

Enumeration data could only be collected for the time the

fence was in full operation. Although this was the period during which most chinook were presumed to enter the river we have no information regarding the numbers that may have entered before or after the fence operation. Due to virtually ideal conditions in the Fall of 1993, the fence was in operation for what we understood to be essentially the entire run. Even so, the fence count of 5058 adults and 5768 jack chinook should be considered an incomplete count of the total run, but the most accurate one available.

The floating fence design adapted well to the considerable changes in flow that occurred during the fall on the Cowichan River. Although it was intended to be self-cleaning, field staff were required to maintain a regular cleaning schedule during times when leafy debris and heavy rains made it difficult for the fence to remain afloat. Due to the considerable number of deciduous trees along the banks of the river, a combination of wind, rain and leaves are the main causes of fence failure. This remains an ongoing problem that is very difficult to overcome (Cousens et. al., 1982; Johnston et. al., 1986).

SWIM SURVEY DATA:

Among the biases typically associated with swim surveys, the procedure used by Fishery Officers to extrapolate actual swim counts to total estimates warrants some consideration (Burns, unpubl). Assumptions concerning the distribution of chinook in the river at the time of the survey are the basis for expanding these counts to estimate total escapement. In 1991, it became apparent that during high water flow conditions in early fall, expansions based on the swim survey results overestimated total escapement (Nagtegaal et al., 1994). The results of the 1992 swim surveys support the hypothesis that during low water flow conditions in late fall, expansions based on swim survey results underestimate the number of spawners. Low water flow conditions persisted into late fall again this year. Since survey counts and Fishery officer expanded estimates in 1993 were again substantially less than the fence count over the same time period, the swim survey information was assumed to have again underestimated total escapement (Fig. 4).

Low flow conditions lead to underestimation of spawners because the distribution of fish in the river is affected by flow. Generally, in low water years, not as many fish make it to the traditional spawning areas above Skutz Falls. Expansion of swim surveys conducted in the upper area alone tend to underestimate the number of fish. Conversely, during high water years most of the fish make it above Skutz Falls so the expansion factor tends to overestimate the number of fish. It may be helpful to incorporate water flow conditions when expanding swim survey data to estimate escapement.

NATIVE FOOD FISHERY:

Since we did not have the opportunity to directly assess catch estimation procedures developed by the Cowichan Tribes River Management Unit, no comments could be made regarding the methodologies used. The 1993 catch estimate of 295 adult chinook seemed to be low relative to the fence count, the prevailing fishing conditions and based on our observer sampling information. The biological observer sampled 160 adult chinook and 62 jacks and estimated that he had monitored approximately 20% of the total catch (John Charlie, pers. comm.). On this basis, he estimated the total food fish catch to be approximately 650 adults, although he suggested that the 1993 fishing season had been one of the worst in the past 15 years (Fig. 7). At best, these two estimates could be considered to be the upper and lower range of the actual food fish catch.

BIOLOGICAL DATA:

Significant differences were noted in the adipose mark rate between the random broodstock sample recorded by the hatchery staff and the data collected by our field staff. The incidence of adipose clipped fish in the chinook sampled at the counting fence (4.7%-males; 11.7%-females) and on the spawning ground (13.3%-males; 18.8%-females) was significantly less than the hatchery chinook (22.0%-males; 22.7%-females) broodstock sample ($P < 0.05$, chi-square). Cumulative frequency distributions were also compared by sex between hatchery, fence and spawning ground samples for adult chinook. Significant differences were detected for both sexes ($D_{obs} > D_{alpha}$; Kolmogorov-Smirnov) between hatchery and fence samples and between males from the hatchery sample and the spawning ground. No significant differences ($D_{obs} < D_{alpha}$) were found between females from the hatchery sample and the spawning ground. A broader size range for both sexes was sampled at the fence than those fish selected for broodstock by the hatchery. Typically, the hatchery collects broodstock from various locations in the river and randomly samples 25% to 50% of males, females and jacks at the hatchery after the fish are spawned. In addition, all other adipose-clipped fish collected for broodstock are selectively sampled for production assessment purposes. No definite conclusions could be made concerning these discrepancies, however, differences have been noted in previous years as well (Nagtegaal et al., 1994).

WATER RELEASE STUDY:

Weather conditions, water temperature and flow rate all affect the timing of migration of spawning salmon. It appears the water release provided some opportunity for fish (primarily jacks) to move upstream (Fig. 5), but the magnitude, duration, and timing of the water release pulse may not have had as much impact as in previous years. Approximately 5% of the total escapement of adults and 9% of the total jacks passed by the fence during the water release period. The weather had been warm and dry for some time prior to the release. To what extent the weather conditions contributed to the impact of the water release on upstream movement is unknown. The effect on chinook survival of increased water temperatures in the river, due to releasing warmer surface water from the lake, is also unknown.

MARK-RECAPTURE:

Typically, fall rains that occur during peak spawning cause high flows and turbid water. Carcasses are often trapped in deep pools and cannot be seen or easily recovered due to the turbid conditions. However, conditions for carcass recovery were ideal in 1993, with flows less than 750 cfs and good water clarity. We were able to recover and sample approximately 24% of the total chinook escapement. If we assume that the fence count was the preferred estimate of escapement (Table 28), then the stratified Petersen and Jolly-Seber estimates based on carcass mark-recapture compared favourably with the fence count (90% and 85% of the fence count, respectively). However, the estimate based on live mark-recapture was at least 30% greater than the fence count, a reflection of the low tag recovery rate (recovered only 11% of fence tagged adults vs 24% of unmarked adults).

We are still unclear as to the reasons for the low recovery rate of adults tagged at the fence. Although some potential biases in the tag application and recovery of live fish were examined, it was assumed that these would not substantially bias the total escapement estimate. Therefore, it is likely that some unquantified bias must have existed. The carcass mark-recapture information indicated that the carcass removal rate (presumably due to predators) to be greater than 60%. One possibility would be that pre-spawning mortality was greater for tagged fish due to the stress of handling and that these weaker fish were selectively removed by predators. However, we did not observe a higher rate of unspawned tagged female carcasses relative to untagged fish.

Biases that are generally inherent in mark-recapture studies as they apply to chinook enumeration typically tend to

cause overestimation (Tschaplinski and Hyatt 1991; Simpson 1984). Calculations based on live mark-recapture data overestimated escapement by greater than 30% even though our marking and sampling rates were high. Comparison with chinook mark-recapture studies in other river systems (Nelson 1994, Frith and Nelson 1994, Farwell et. al. 1991), indicated that escapement estimates based on tag and recovery rates that were considerably lower than in this study, provided acceptable estimates. It may be prudent to incorporate at least two independent measures of escapement.

SEAL PREDATION:

Although seal predation was not directly assessed in this study, it is worthwhile to examine the impact seals have on chinook in Cowichan Bay. In 1988, the number of seals gradually increased from a low of 30 in April to a peak of about 100 in December. According to Olesiuk et al. (1990) harbour seals consume an estimated 9 tonnes of salmon annually in Cowichan Bay. An estimated 23% (Sept.) to 48% (Nov.) of the harbour seal's diet in Cowichan Bay was comprised of salmon (Bigg et. al. 1990). Based on these data, consumption of chinook salmon could potentially range from 500 to 1000 adults. This data was collected in 1988 when low flows in the Cowichan River persisted until the end of October. Predation likely increases the longer chinook salmon remain in the estuary waiting for high water to move upstream.

ESCAPEMENT ESTIMATE:

Escapement estimates for the Cowichan River were primarily based on the fence data since it was assumed that this was the preferred enumeration technique. Total return of adult chinook to the Cowichan River was determined to be equal to the sum of the fence count, the numbers removed for broodstock below the fence, and the number of fish taken by the native food fishery. On this basis we calculate the total return to the Cowichan River from Aug. 23 - Nov. 22, 1993 to be 7,312 (Table 29). This should be considered a minimum estimate since these numbers are based on the fence count and assume that no chinook were in the river prior to or after the counting fence was in place. If we include our observer estimate for the Native food fish catch and a seal predation estimate of 850, then it is probable that the total return of chinook in 1993 was closer to 8,500 adults. The number of natural spawners was calculated to be 5,047 (Table 29). This was based on the fence count minus the chinook adults removed for broodstock at and above the fence.

Chinook escapements have fluctuated over the past 20 years with a low of 1200 in 1986/87 to a high of 10,000 in 1991 (Fig. 8).

For ten out of the past 16 years escapements have ranged between 5000 and 6000 adults with no increasing or decreasing trend evident. Although chinook production seems to have remained fairly constant, increases are anticipated due to the substantial increases in hatchery releases (Fig. 9)

ACKNOWLEDGEMENTS

We would like to thank , Rob Hanelt, Austin Holman, Julian Sturhahn, Dave Ferguson, Duaine Hardie, John Paige, Chuck Joe, John Charlie, Wayne Paige, Brandon Fox and Dave Burton for their involvement in the construction of the enumeration fence, collection of migration and biological data. We thank Trevor Fields, Bob Tupniak, and Ricardo Carrera, Fishery officers for the Department of Fisheries and Oceans in Duncan, for their helpful assistance, swim survey data, and native food fishery catch estimates. We thank the River Management Unit of the Cowichan Tribes, in particular Wayne Paige, Doug August, and Alec Johnny for their cooperation and assistance in acquiring Native food fishery data and swim survey results. We thank John Charlie for working with the River Management Unit to collect biological and catch data from the Native food fishery. We thank Doug Millerd, manager of the Cowichan hatchery, for providing broodstock capture data. We thank the conscientious sport fishermen who returned the aluminum tags from the chinook they caught in the Cowichan River. We thank the City of Duncan for allowing us to use their access road to the counting fence site and granting us storage space, power and water from their pumphouse facility. We thank Brian Tutty from the Department of Fisheries and Oceans, B. Hollingshead, the Regional Water Manager for British Columbia, and A. Jezierski from Fletcher Challenge Ltd. for coordinating the water release management plan for the Cowichan River.

LITERATURE CITED

- Arnason, A.N., D.W. Miller, and C. Lapkowski. 1992. Installation and user's manual for running POPAN-3 on IBM PC microcomputers under DOS or Windows 3. The Charles Babbage Research Centre. Univ. of. Manitoba.
- Bigg, M.A., G.M. Ellis, P. Cottrell, and L. Milette. 1990. Predation by Harbour seals and Sea lions on adult salmon in Comox Harbour and Cowichan Bay, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1769: 31p.
- Burns, T. An assessment of Chinook salmon enumeration methods in the Cowichan River. Unpublished manuscript.
- Charlie, J. 1993. Biological Observer. 2675 Mission Rd., Duncan, B.C., V9L-3X3. Personal communication.
- Cousens, N.B.F., G.A. Thomas, C.G. Swann, and M.C. Healey. 1982. A review of salmon escapement estimation techniques. Can. Tech. Rpt. Fish. Aquat. Sci: 1108.
- Cross, C.L., L. Lapi, E. A. Perry. 1991. Production of chinook and coho salmon from British Columbia hatcheries, 1971 through 1989. Can. Tech. Rpt. Fish. Aquat. Sci: 1816.
- Eiler, H., B.D. Nelson, R.F. Bradshaw. 1991. Radio tracking chinook salmon (*Oncorhynchus tshawytscha*) in a large turbid river. Pp 202-206 in A. Uchiyama and C.J. Amlaner, Jr. (eds.), Biotelemetry XI, Proceedings of the Eleventh International Symposium on Biotelemetry, Aug. 29-Sept. 4, 1990, Yokohama, Japan. Waseda Univ. Press, Tokyo.
- Farlinger, S., N. Bourne, B. Riddell, D. Chalmers, and A. Tyler (Eds). 1990. Pacific stock assessment review committee (PSARC) annual report for 1989. Can. Manusc. Rep. Fish. Aquat. Sci. 2064: 236p
- Farwell, M.K., N.D. Schubert, and L.W. Kalnin. 1991. Enumeration of the 1990 Harrison River chinook salmon escapement. 1991. Can. Manusc. Rep. Fish. Aquat. Sci. 2111: 26p
- Fields, T. 1993. Fishery officer, Department of Fisheries and Oceans, Box 241, 230 Underwood St., Duncan, B.C., V9L-3X3. Personal communication.
- Frith, H.R., and T.C. Nelson. 1994. Abundance, age, size, and coded wire tag recoveries for chinook salmon escapements of Campbell and Quinsam Rivers, 1993. Can. Manusc. Rep. Fish. Aquat. Sci. 2251: 59p

- Inland Waters Directorate. Historical stream flow summary, British Columbia, 1993. Water Survey of Canada, Ottawa.
- Johnston, N.T., J.R. Irvine, and C.J. Perrin. 1986. A comparative evaluation of fence count, mark-recapture and Bendix sonar estimates of salmon escapements in the Keogh River, a variable-flow coastal B.C. stream. Can. Tech. Rep. Fish. Aquat. Sci. 2111: 44p
- K.P.A. Engineering Ltd. 1991. Cowichan Lake Storage Assessment. Unpublished Report.
- Kuhn, B.R. 1988. The MRP-Reporter program: a data extraction and reporting tool for the mark recovery program database. Can Tech. Rep. Fish. Aquat. Sci. 1625: 145p
- Millerd, D. 1993. Personal communication. Cowichan River Community Economic Development hatchery manager. P.O. Box 880, Duncan, B.C., V9L-3Y2.
- Nagtegaal, D.A., P. J. Starr, and B. Riddell. 1994. A preliminary report on the chinook productivity study conducted on the Cowichan River, 1988 and 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2233: 53p
- Nagtegaal, D.A., J. Candy, and B. Riddell. 1994. A preliminary report on the chinook productivity study conducted on the Cowichan River during 1990 and 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2265: 71p
- Nelson, T.C. 1994. Abundance, age, size, and coded wire tag recoveries for chinook salmon escapements of Kitsumkalem River, 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2249: 47p
- Olesiuk, P.F., M.A. Bigg, G.M. Ellis, S.J. Crockford, and R.J. Wigen. 1990. An assessment of the feeding habits of Harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis. Can. Tech. Rep. Fish. Aquat. Sci. 1730: 135p
- Paige, W. 1992. Cowichan River Management Unit: Salmon Catch Statistical Program for 1991/1992. Cowichan Indian Band. Unpublished manuscript.
- Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382p.
- Schwartz, C.J., R.E. Bailey, J.R. Irvine, and F.C. Dalziel. 1993. Estimating salmon escapement using capture-recapture methods. Can. J. Fish. Aquat. Sci. 50: 1181-1197.

- Shardlow, T., R. Hilborn, and D. Lightly. 1987. Components analysis of instream escapement methods for Pacific salmon (*Oncorhynchus* spp.). Can. J. Fish. Aquat. Sci. 44: 1031-1037
- Simpson, K.S. 1984. The accuracy fo mark-recapture estimates of escapements. p. 209-225 in Symons, P.E.K. and M. Waldichuk (eds.) Proceedings of the Workshop on Stream Indexing for salmon escapement estimation, West Vancouver, B.C. 2-3 February 1984. Can. Tech. Rep. Fish. Aquat. Sci. No. 1236: 258 p.
- Sykes, S.D., and L.W. Botsford. 1986. Chinook salmon (*Oncorhynchus tshawytscha*), spawning escapement based on multiple mark-recapture of carcasses. Fish. Bull. 84(2).
- Tschaplinski, P.J., and K.D. Hyatt. 1991. A comparison of population assessment methods employed to estimate the abundance of sockeye salmon (*Oncorhynchus nerka*) returning to Henderson Lake, Vancouver Island, during 1989. Can. Tech. Rep. Fish. Aquat. Sci. 1798: 101p
- Zar, J. 1984. Biostatistical analysis. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 718p

Table 1. Daily counts at the enumeration fence site, 1993.

Date (ddmm)	Chinook		Coho		Chum	Unknown ¹
	Adult	Jack	Adult	Jack		
23/08	2	0	0	0	0	0
24/08	5	14	0	0	0	1
25/08	6	19	0	0	0	2
26/08	1	1	0	0	0	0
27/08	1	3	0	0	0	0
28/08	2	4	0	0	0	0
29/08	0	15	0	0	0	0
30/08	2	12	0	0	0	2
31/08	1	22	0	0	0	0
01/09	0	17	1	0	0	0
02/09	1	10	0	0	0	0
03/09	1	8	0	0	0	0
04/09	0	10	1	1	0	1
05/09	1	14	1	1	0	0
06/09	6	23	3	0	0	0
07/09	1	45	0	1	0	0
08/09	1	21	3	0	0	0
09/09	3	22	0	4	0	0
10/09	1	5	1	0	0	0
11/09	6	6	0	0	0	0
12/09	4	7	0	1	0	0
13/09	3	13	7	1	0	3
14/09	4	8	3	2	0	0
15/09	15	21	1	5	0	2
16/09	2	4	1	2	0	0
17/09	10	20	1	2	0	0
18/09	6	19	0	2	0	1
19/09	0	2	3	2	0	0
20/09	32	10	1	6	0	0
21/09	31	10	2	5	0	0
22/09	7	2	2	2	0	0
23/09	11	8	0	2	0	0
24/09	10	2	1	1	0	1
25/09	6	7	0	0	0	0
26/09	5	10	2	1	0	1
27/09	105	484	37	24	1	0
28/09	9	9	9	4	0	1
29/09	28	30	8	2	0	0
30/09	35	7	7	4	0	0
01/10	55	3	3	4	0	0
02/10	55	14	8	5	0	0
03/10	13	5	3	1	0	0
04/10	13	1	3	0	0	0
05/10	23	6	9	8	0	1
06/10	377	320	36	58	1	0
07/10	65	28	9	7	0	0
08/10	23	3	1	1	0	0
09/10	14	1	1	0	0	0

Table 1 (cont.)

Date (ddmm)	Chinook		Coho		Chum	Unknown ¹
	Adult	Jack	Adult	Jack		
10/10	28	0	4	3	0	2
11/10	80	23	7	1	0	0
12/10	637	344	37	54	2	0
13/10	354	555	85	82	0	0
14/10	61	38	19	30	1	1
15/10	46	36	17	18	0	0
16/10	23	15	12	6	1	0
17/10	56	82	23	15	0	0
18/10	115	148	23	12	0	0
19/10	86	44	21	11	0	0
20/10	57	64	14	5	1	0
21/10	100	208	16	15	1	0
22/10	501	617	51	79	96	0
23/10	535	789	92	171	89	0
24/10	538	611	523	211	723	0
25/10	25	65	120	151	8	0
26/10	11	39	217	91	19	0
27/10	18	26	56	40	11	0
28/10	11	28	71	69	51	0
29/10	49	41	500	295	32	0
30/10	36	29	319	156	17	0
31/10	18	23	214	88	39	0
01/11	22	28	241	97	28	0
02/11	14	34	621	431	268	0
03/11	18	33	1440	1425	2820	0
04/11	4	3	315	58	380	0
05/11	108	15	168	121	270	0
06/11	5	13	79	53	67	0
07/11	13	7	292	167	327	0
08/11	13	23	328	63	1059	0
09/11	18	13	174	87	695	0
10/11	6	13	86	59	532	0
11/11	11	12	155	49	1222	0
12/11	2	7	244	75	2125	0
13/11	1	12	92	74	2060	0
14/11	392	281	1431	473	9809	0
15/11	28	83	498	193	22298	0
16/11	4	9	176	87	9210	0
17/11	4	12	285	107	19422	0
18/11	2	0	40	34	7734	0
19/11	3	7	33	18	4643	0
20/11	1	11	66	92	20901	0
21/11	0	0	105	87	39471	0
22/11	2	2	24	4	8359	0
TOTAL:	5058	5768	9502	5616	154793	19

¹Unidentified salmon

Table 2. Daily counts by time interval, 1993.

Time	Chinook		Jack	
	Adult No.	%	No.	%
0000-0100	114	2	41	1
0100-0200	91	1	36	1
0200-0300	151	2	85	2
0300-0400	298	4	125	3
0400-0500	300	4	135	3
0500-0600	330	4	114	3
0600-0700	287	4	85	2
0700-0800	305	4	87	2
0800-0900	328	4	128	3
0900-1000	710	9	172	4
1000-1100	764	10	324	9
1100-1200	463	6	184	5
1200-1300	327	4	103	3
1300-1400	298	4	102	3
1400-1500	369	5	179	4
1500-1600	278	3	123	3
1600-1700	354	5	192	5
1700-1800	290	4	168	4
1800-1900	496	6	355	10
1900-2000	455	6	408	11
2000-2100	292	4	252	7
2100-2200	201	2	164	4
2200-2300	121	2	69	2
2300-2400	118	2	63	2

Table 3. Visual survey data collected for the Cowichan river by Fishery Officers.

Chinook								
Method ¹	Date	Count	Jacks		Adults		River Segment ²	
			Count	Estimate	Count	Estimate		
1981	S	Sept. 12	175		208	1000	2-4	
	S	Oct. 2	103		93	1500	2-4	
	S	14	364		1160	4000	2-4	
	H	22			2000		1-7	
	S	23			3200	5000	2-4	
Estimate for Season ³						5500		
1982	S	Sept. 14	199		131	600	2-4	
	S	Oct. 13			153		2-4	
	H	19	saw few fish on spawning grounds					1-13
	F	Nov. 8				4000		
Estimate for Season						4500		
1983	S	Sept. 8	38		61	254	2-6	
	S	15	62		121	504	2-6	
	S	28	190		470	1838	1-2	
	S	Oct. 7	207		425	1804	2-6	
	S	14	802		997	2836	2-7	
	S	25	901		1113	4500	1-6	
Estimate for Season						4500		
1984	S	Aug. 28	80		84	400	2-5	
	S	Sept. 6	25		72		2-5	
	S	13	79		80		3-11	
	S	19	35		71		2-6	
	S	26	291		434		2-6	
	S	Oct. 3	205		283		3-7	
	S		206		282	2200	8-11	
	S	23	525		1300	5000	1-6	
	S	Nov. 1	350		1276		1-6	
Estimate for Season						5000		
1985	S	Sept. 12	39		46	220	2-6	
	S	17	42		10		12-13	
	S	18	210		33		2-6	
	S	27	245		104	456	2-6	
	S	Oct. 3	244		99	360	2-6	
	S	10	285		219		2-6	
	S	16	293		347		2-6	
	S	31	229		934	3500	1-6	
Estimate for Season						3500		

Table 3. (cont.)

Method ¹	Date	Chinook				River Segment ²	
		Count	Jacks Estimate	Adults Count	Adults Estimate		
1986	S	Sept. 9	295		85	300	2-6
	S	18	46		29	300	3-6
	S	24	161		56	350	12-13
	S	Oct. 7	1310		223	1000	2-6
	S	29	613		473	1200	1-6
	S	Nov. 6	1178		491	1200	1-6
	H	8			515		1-13
Estimate for Season						1200	
1987	S	Sept. 9	30	300	10	50	3-8
	S	17	111		16	75	2-6
	S	25	112		16	75	3-6, 11-12
	S	Oct. 6	196	800	115	400	2-6
	S	15	196		96		1-6
	H	16		saw very few spawners			1-13
	S	28	417		468		1-6
	S	Nov. 6	329		649		1-6
Estimate for Season						1200	
1988	S	Aug. 25	100		50		2-6
	S	Sept. 1	271		149	700	2-6
	S	23	1464		271	1000	2-6
	S	Oct. 3	821	1600	1094	3500	2-6
	S	14	2008		2076	4000	1-6
Estimate for Season						5500	
1989	S	Sept. 11	151		58	300	2-6
	S	21	95		39	350	3-6
	S	Oct. 5	95		48	700	2-3
	S	18	719		350	1200	2-6
	S	Nov. 1	1537		2267		2-6
Estimate for Season						5000	
1990	S	Aug. 29	254		54	250	2-6
	S	Sept. 14	385		89	1000	3-6
	S	27	3169		477	2200	2-3
	S	Oct. 19	4297		2382	5000	2-6
Estimate for Season						5300	

Table 3. (cont.)

Method ¹	Date	Chinook				River Segment ²	
		Jacks Count	Jacks Estimate	Adults Count	Adults Estimate		
1991	S	Sept.	19		1882	6000	2-6
	S	Oct.	2		2873	7500	2-6
	S		17		2924	8700	2-6
	S		31		3502 ⁴	9000	2-6
Estimate for Season						10000	
1992	S	Sept.	16	5	8		2-5
	S	Oct.	2	124	46	200	2-6
	S		15	359	291	700	2-6
	S		15	113	162		2-6
	S		27	514	797	2000	1-6
	S		28	591	767		1-6
	S	Nov.	13	506	467		1-6
	S		13	450	640 ⁵		1-6
Estimate for Season						7500	
1993	S	Sept.	23	23	14	47	2-6
	S		30	81	62	210	2-6
	S	Oct.	14	207	199	676	2-6
	S		28	127	327	1111	2-6
	S	Nov.	4	480	987	3355	
Estimate for Season ⁶						5200	

¹S - Swim survey, H - Helicopter survey, F - boat survey

²Refer to Fig. 1

³Total escapement estimate for adult chinook

⁴516 chinook carcasses were counted in this total

⁵28 chinook carcasses were counted in this total

⁶1993 swim surveys conducted by Cowichan Tribes River Management Unit, total escapement determined by Fishery Officers.

Table 4. Native food fish catch estimates for the Cowichan river.¹

Year ²	Adult Chinook	Jack Chinook
1981	1500	1500
1982	1000	1000
1983	250	1000
1984	355	700
1985	1000	1000
1986	800	800
1987	800	800
1988	681	450
1989	1055	250
1990	604	214
1991	270	100
1992	260	12
1993	295	22

¹Includes reported native spear fishery and in-river gillnet fishery catches.

²Since 1988 data were collected by Cowichan Tribes River Management unit. Prior to 1988, data were collected by the local Fishery Officers

Table 5. Broodstock collection¹ for the Cowichan hatchery, 1993

Date	Below fence			Above fence		
	M	J	F	M	J	F
Oct. 6	137	22	178			
7	171	48	202			
12	171	25	208			
13	58	22	65			
14	118	7	120			
15	27	0	27			
18	63	4	58	4	3	7
19	136	54	111			
21	17	2	28			
22	8	8	10			
Nov. 8	14	1	25			
10	1	0	6			
Totals: ²	921	193	1038	4	3	7

¹Based on broodstock collection records in the field.

²Counts compiled at the hatchery differed somewhat from field data; 925 adult males, 228 jacks, and 1047 females.

Table 6. Adult chinook escapement used for hatchery broodstock, Cowichan River¹.

Year	No. of fish collected
1981	282
1982	534
1983	242
1984	278
1985	175
1986	315
1987	582
1988	678
1989	535
1990	327
1991 ²	1755
1992	1850
1993	2200

¹ The Salmon Enhancement Program (B. Cordocedo, pers. comm.) provided numbers on broodstock collection from 1981-1987. The brood stock numbers provided included jacks, but no reliable records were kept. It was estimated that about 10-15 jacks were collected per year, except in the first few years. These estimates were subtracted from the broodstock numbers provided to give an estimate of the number of adult chinook removed from the system.

²In addition, 284 males were removed for broodstock but later returned to the river.

Table 7. Summary of chinook broodstock age data, 1993

Age	Males	Females	Total
2	24	0	24
3	108	162	270
4	44	188	232
5	1	17	18
Total:	177	367	544

Total number of regenerate scales (unaged) read: 169

Table 8. Length-frequency¹ of chinook tagged at the enumeration fence, 1993

Length (cm)	Males	Jacks	Females	Total
30		2		2
31		4		4
32		11		11
33		17		17
34		28		28
35		19		19
36		28		28
37		35		35
38		43		43
39		29		29
40		41		41
41		8		8
42		35		35
43		27		27
44		15	1	16
45		10	0	10
46	1	8	2	11
47	4	5	1	10
48	3	3	1	7
49	3		1	4
50	4		0	4
51	4		0	4
52	3		2	5
53	5		3	8
54	2		1	3
55	4		2	6
56	1		1	2
57	5		2	7
58	2		2	4
59	5		1	6
60	11		15	26
61	15		18	33
62	12		9	21
63	9		25	34
64	12		21	33
65	11		18	29
66	7		8	15
67	14		13	27
68	7		22	29
69	9		15	24
70	21		47	68
71	17		28	45
72	15		21	36
73	15		40	55
74	11		23	34
75	11		20	31
76	6		9	15
77	4		13	17
78	6		15	21
79	2		14	16
80	16		26	42
81	5		8	13
82	1		5	6
83	3		9	12
84	2		0	2
85	1		1	2
86	0		1	1
87	2		3	5
88	1		1	2
89	1		2	3
90	0		1	1
91	1		1	2
92	0		0	0
93	0		0	0
94	2		0	2
Total:	296	368	472	1136
Adipose clips:	14	8	55	77
Mark rate (%):	4.7	2.2	11.7	6.8

¹Hypural length

Table 9. Length-frequency¹ of chinook sampled from the native food fishery on the Cowichan R., 1993.

Length (cm)	Chinook			Total
	Males	Jacks	Females	
23		1		1
24		0		0
25		0		0
26		0		0
27		0		0
28		0		0
29		0		0
30		2		2
31		0		0
32		0		0
33		0		0
34		0		0
35		1		1
36		4		4
37		5		5
38		6		6
39		6		6
40		5		5
41		7		7
42		6		6
43		9		9
44		8		8
45	7			7
46	7			7
47	6			6
48	1			1
49	4			4
50	4			4
51	2			2
52	2		1	3
53	1		1	2
54	2		0	2
55	0		0	0
56	0		0	0
57	6		0	6
58	3		2	5
59	0		1	1
60	4		3	7
61	0		6	6
62	0		2	2
63	2		2	4
64	1		9	10
65	2		4	6
66	0		3	3
67	1		7	8
68	2		2	4
69	1		2	3
70	1		4	5
71	1		1	2
72	2		3	5
73	1		7	8
74	2		5	7
75	3		3	6
76	0		4	4
77	1		3	4
78	0		4	4
79	0		1	1
80	3		1	4
81	0		1	1
82	2		2	4
83	1		0	1
84	1		0	1
85	0		1	1
86			1	1
Total:	75	62	85	222
Adipose clip:	10	8	10	28
Mark rate (%):	13.3	12.9	11.8	12.6

¹Hypural length

Table 10. Summary of native food fishery chinook age data, 1993

Age	Males	Females	Unknown	Total
2	2	2	62	66
3	19	24	7	50
4	14	30	2	46
5	3	7		10
Total:	38	64	75	177

Total number of regenerate scales (unaged) read: 34

Table 11. Length-frequency¹ of chinook sampled on the spawning grounds, 1993

Length (cm)	Males	Jacks	Females	Total
19		1		1
20		0		0
21		1		1
22		4		4
23		6		6
24		2		2
25		2		2
26		1		1
27		2		2
28		4		4
29		10		10
30		19		19
31		29		29
32		64		64
33		64		64
34		88		88
35		93		93
36		79		79
37		89		89
38		76		76
39		68		68
40		73		73
41		52		52
42		56		56
43		38		38
44		27		27
45		21		21
46	1	12	1	14
47	3	15	2	20
48	5	13	0	18
49	3	8	0	11
50	4	2	2	8
51	14	0	5	19
52	4	2	4	10
53	13		5	18
54	16		5	21
55	12		17	29
56	13		13	26
57	17		15	32
58	17		16	33
59	23		27	50
60	28		34	62
61	26		36	62
62	18		23	41
63	26		38	64
64	37		33	70
65	26		41	67
66	25		38	63
67	21		49	70
68	15		36	51
69	11		43	54
70	26		35	61
71	15		28	43
72	14		30	44
73	10		23	33
74	4		12	16
75	2		19	21
76	4		20	24
77	7		12	19
78	3		9	12
79	7		6	13
80	4		10	14
81	1		3	4
82	4		1	5
83	0		4	4
84	0		2	2
85	1			1
86	1			1
Total:	481	1021	697	2199
Adipose clips:	64	61	131	256
Mark rate (%):	13.3	6.0	18.8	11.6

¹Hypural length

Table 12. Summary of chinook age data from spawning ground samples, 1993

Age	Males	Females	Unknown ¹	Total
2	24	14	795	833
3	209	181	27	417
4	125	315	10	450
5	7	39		46
Total:	368	553	833	1754

Total number of regenerate scales read: 348

¹Age 2 unknowns were all jack chinook

Table 13. Length-frequency¹ of chinook broodstock collected by the Cowichan hatchery, 1993

Length (cm)	Males	Jacks	Females	Total
32		1		1
33		1		1
34		1		1
35		4		4
36		0		0
37		1		1
38		0		0
39		3		3
40		2		2
41		2		2
42		0		0
43	1	4		5
44	1	1		2
45	0	0		0
46	0	0		0
47	1	2		3
48	0	0		0
49	1	2		3
50	2	1		3
51	6		1	7
52	1		1	2
53	3		1	4
54	4		1	5
55	2		4	6
56	1		0	1
57	6		3	9
58	10		10	20
59	7		7	14
60	9		13	22
61	14		14	28
62	5		9	14
63	6		17	23
64	4		13	17
65	2		11	13
66	7		19	26
67	3		24	27
68	7		18	25
69	0		26	26
70	5		10	15
71	2		16	18
72	2		24	26
73	2		14	16
74	0		8	8
75	1		12	13
76	1		5	6
77	1		3	4
78	1		2	3
79			3	3
80			2	2
81			2	2
82			1	1
83			0	0
84			0	0
85			0	0
86			0	0
87			1	1
Total:	118	25	295	438
Adipose clips:	26	4	67	97
Mark rate (%):	22.0	16.0	22.7	22.1

¹Hypural length

Table 14. Water temperature and stage height at the enumeration fence, 1993.

Date	Depth (cm)	Temp. (Deg. C)	Date	Depth (cm)	Temp. (Deg. C)
Aug. 23	250	18	Oct. 09	211	13
24	246	17	10	258	11
25	241	17	11	251	12
26	253	18	12	247	14
27	268	18	13	251	14
28	271	18	14	251	14
29	262	18	15	258	14
30	259	17	16	255	13
31	270	17	17	261	13
Sep. 01	264	17	18	255	12
02	253	18	19	255	13
03	260	19	20	257	11
04	263	19	21	247	13
05	260	19	22	263	13
06	259	19	23	291	13
07	266	19	24	350	12
08	265	19	25	333	12
09	259	18	26	330	11
10	258	18	27	322	11
11	260	18	28	341	12
12	260	17	29	406	13
13	260	17	30	406	12
14	263	17	31	398	12
15	260	16	Nov. 01	396	10
16	262	17	02	386	12
17	259	16	03	398	12
18	259	15	04	400	10
19	260	16	05	400	10
20	264	16	06	400	11
21	261	16	07	390	11
22	258	14	08	400	10
23	258	14	09	393	10
24	265	14	10	376	10
25	260	14	11	363	9
26	257	14	12	366	9
27	382	14	13	350	9
28	423	15	14	346	9
29	415	16	15	346	10
30	403	15	16	350	9
Oct. 01	383	15	17	353	9
02	321	15	18	363	9
03	250	14	19	343	9
04	255	15	20	343	9
05	252	15	21	400	13
06	254	15	22	430	7
07	251	14			
08	248	13			

Table 15. Daily discharge¹ in cu.m/sec for 1993.

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	73.6	18.2	10.8	5.4	4.5	10.7	11.5
2	72.6	19.3	10.3	5.1	4.4	4.7	11.7
3	70.4	18.4	9.6	5.1	4.4	4.2	13.2
4	67.6	18.2	8.9	5.2	4.5	4.6	12.9
5	65.2	17.6	8.2	4.8	4.5	4.8	12.5
6	65.3	17.2	7.6	4.9	4.4	4.9	12.1
7	62.8	16.5	7.4	4.8	4.5	4.8	11.9
8	60.4	15.8	7.2	4.8	4.5	4.7	11.6
9	58.5	17.6	6.7	5.1	4.5	4.6	11.3
10	58.1	22.3	6.7	5.3	4.6	5.1	10.9
11	56.5	22.6	6.5	5.0	4.5	4.9	10.5
12	53.6	23.3	6.3	4.9	4.5	4.9	9.5
13	51.3	22.8	6.1	4.9	4.4	4.7	9.4
14	45.9	21.7	6.4	4.7	4.6	4.7	8.9
15	34.4	22.2	6.1	4.8	4.7	4.9	8.7
16	32.6	21.7	6.0	4.9	4.7	4.6	8.7
17	30.1	21.3	6.4	4.9	4.7	4.8	8.9
18	24.3	20.5	6.3	4.7	4.6	5.0	9.4
19	21.3	19.2	5.9	4.5	4.6	5.0	9.5
20	22.1	16.9	5.9	4.5	4.8	5.3	9.6
21	24.0	16.3	5.7	4.5	4.7	4.9	10.1
22	26.1	15.3	5.8	4.5	4.7	5.7	10.2
23	26.7	14.9	6.2	5.1	4.8	7.4	10.4
24	26.1	13.8	5.9	4.9	5.7	9.3	10.4
25	25.3	12.8	5.8	4.8	13.6	8.3	11.0
26	23.5	12.5	5.6	4.6	13.4	8.1	11.1
27	21.0	11.9	5.6	4.7	12.8	7.8	11.5
28	19.5	11.2	5.6	4.6	12.0	9.5	12.2
29	16.7	11.2	5.2	4.4	12.8	12.5	13.5
30	16.2	11.3	5.4	4.4	12.0	12.0	16.3
31	17.2		5.6	4.7		11.5	
Total:	1268.9	527.6	208.7	150.9	173.8	199.4	329.4
Mean:	40.9	17.5	6.7	4.8	5.8	6.4	11.0

¹Water Survey of Canada data recorded at the Island Highway bridge in Duncan.

Table 16. Summary of chinook tagged at the enumeration fence¹, 1993

Date (dd/mm)	Male		Female		Jacks	
	Tagged	Untagged	Tagged	Untagged	Tagged	Untagged
2508	0	0	1	0	0	0
3008	1	0	1	0	8	0
3108	0	0	1	0	15	0
0109	0	0	0	0	14	0
0209	0	0	1	0	7	0
0309	1	0	0	0	10	0
0409	0	0	0	0	4	0
0509	1	0	0	0	6	0
0609	4	0	1	0	27	0
0709	2	0	2	0	39	0
0809	0	0	0	0	25	0
0909	2	0	1	0	23	0
1009	1	0	0	0	4	0
1109	2	0	6	1	6	0
1209	3	0	1	0	6	0
1309	1	0	1	0	13	0
1409	0	0	4	0	7	0
1509	6	0	9	0	15	0
1609	2	0	3	0	7	0
1709	1	0	7	0	15	0
1809	1	0	5	0	18	0
1909	0	0	0	0	2	0
2009	15	0	16	0	10	0
2109	10	0	17	0	10	0
2209	2	0	5	0	2	0
2309	4	0	7	0	1	0
2409	4	0	4	0	2	0
2509	2	0	4	0	6	0
2609	4	0	1	0	10	0
2709	45	0	56	0	8	0
2809	4	0	6	0	0	0
2909	12	0	16	0	0	0
3009	17	0	17	0	1	0
0110	18	0	34	0	0	0
0210	16	0	49	0	10	0
0310	5	0	8	0	5	0
0410	5	0	7	0	1	0
0510	6	0	13	0	2	0
0610	10	0	18	0	0	0
0710	7	0	17	0	2	0
0810	5	0	6	0	0	0
0910	3	0	8	0	1	0
1010	7	0	11	0	0	0
1110	13	0	32	0	0	0
1210	1	0	3	0	0	0
1410	11	0	12	0	0	0
1510	7	0	12	0	2	0
1610	7	0	13	0	1	0
1710	11	0	14	0	3	0
1810	4	0	6	0	0	0
1910	6	0	9	0	0	0
2010	0	0	1	0	0	0

Table 16 (con't)

Date (dd/mm)	Male		Female		Jacks	
	Tagged	Untagged	Tagged	Untagged	Tagged	Untagged
2510	3	0	0	0	3	0
2610	2	0	0	0	3	0
2710	4	0	4	0	6	0
0511	0	0	0	0	1	0
Total:	298	0	470	1	361	0

Table 16 (con't)

Date (dd/mm)	Male		Female		Jacks	
	Clip	Noclip	Clip	Noclip	Clip	Noclip
2508	0	0	0	1	0	0
3008	0	1	0	1	0	8
3108	0	0	0	1	0	15
0109	0	0	0	0	1	13
0209	0	0	0	1	0	7
0309	0	1	0	0	0	10
0409	0	0	0	0	1	3
0509	0	1	0	0	0	6
0609	0	4	0	1	0	27
0709	0	2	0	2	2	37
0809	0	0	0	0	0	25
0909	0	2	0	1	1	22
1009	0	1	0	0	0	4
1109	0	2	3	4	0	6
1209	0	3	0	1	1	5
1309	0	1	0	1	0	13
1409	0	0	1	3	0	7
1509	1	5	2	7	0	15
1609	0	2	0	3	0	7
1709	0	1	0	7	0	15
1809	0	1	0	5	0	18
1909	0	0	0	0	0	2
2009	2	13	2	14	1	9
2109	1	9	0	17	0	10
2209	0	2	0	5	0	2
2309	0	4	2	5	0	1
2409	0	4	0	4	0	2
2509	0	2	0	4	0	6
2609	0	4	0	1	0	10
2709	3	42	14	42	0	8
2809	0	4	1	5	0	0
2909	0	12	4	12	0	0
3009	0	17	1	16	0	1
0110	0	18	2	32	0	0
0210	2	14	5	44	1	9
0310	0	5	1	7	0	5
0410	0	5	1	6	0	1
0510	0	6	2	11	0	2
0610	2	8	1	17	0	0
0710	0	7	4	13	0	2
0810	0	5	0	6	0	0
0910	0	3	0	8	0	1
1010	1	6	0	11	0	0
1110	0	13	3	29	0	0
1210	0	1	1	2	0	0
1410	0	11	1	11	0	0
1510	1	6	1	11	0	2
1610	0	7	1	12	0	1
1710	0	11	0	14	0	3
1810	1	3	0	6	0	0
1910	0	6	2	7	0	0
2010	0	0	0	1	0	0

Table 16 (con't)

Date (dd/mm)	Male		Female		Jacks	
	Clip	Noclip	Clip	Noclip	Clip	Noclip
2510	0	3	0	0	0	3
2610	0	2	0	0	0	3
2710	0	4	0	4	0	6
0511	0	0	0	0	0	1
Total:	14	284	55	416	8	353

¹Tagged refers to chinook tagged at the fence with a Ketchum aluminum sheep ear tag.
Clip refers to chinook with adipose fin clipped.

Table. 17. Recoveries of chinook tagged at the enumeration fence, 1993.

Release data					Recovery data			
Date (ddmm)	Loc ¹	Len ²	Sex ³	Adip ⁴	Tag ⁵	Date (ddmm)	Loc	Days at large
08/09	40	0550	J	P	2226	0311	11	56
11/09	40	0630	F	P	2288	2110	75	40
15/09	40	0730	F	A	2538	0411	40	50
16/09	40	0400	J	P	2573	0511	08	50
17/09	40	0460	F	P	2591	0311	10	47
18/09	40	0760	F	P	3044	0911	09	52
20/09	40	0650	M	P	3024	1511	37	56
21/09	40	0750	F	P	3116	1911	10	59
21/09	40	0730	F	P	3094	0511	27	45
22/09	40	0660	F	P	3120	0311	10	42
22/09	40	0730	F	P	3124	0311	55	42
22/09	40	0690	M	P	3202	0511	08	44
22/09	40	0650	F	P	3119	0911	12	48
23/09	40	0700	F	P	3211	1511	10	53
23/09	40	0440	J	P	3205	0511	34	43
27/09	40	0700	F	A	3129	0811	54	42
27/09	40	0620	F	P	3292	2710	75	30
27/09	40	0510	M	P	3287	0411	85	38
27/09	40	0790	F	P	3196	0911	11	43
27/09	40	0640	F	A	3145	2110	73	24
27/09	40	0740	M	P	3290	0311	62	37
27/09	40	0770	M	P	3133	2110	62	24
27/09	40	0730	F	P	3266	1211	10	46
27/09	40	0760	F	P	3191	0311	54	37
27/09	40	0670	M	P	3177	1011	31	44
27/09	40	0730	F	P	3256	2910	22	32
29/09	40	0720	F	A	2720	0811	57	40
29/09	40	0720	F	P	2731	0511	12	37
30/09	40	0820	M	P	2766	2710	63	27
30/09	40	0690	M	P	2746	1211	16	43
01/10	40	0590	M	P	2798	0811	40	38
01/10	40	0600	F	P	2782	0511	31	35
01/10	40	0700	F	P	2801	1711	56	47
01/10	40	0770	F	P	2784	0911	10	39
01/10	40	0640	F	P	2789	1211	16	42
01/10	40	0530	F	P	2808	1711	53	47
01/10	40	0710	M	P	2775	0511	55	35
01/10	40	0650	F	P	2791	1211	17	42
01/10	40	0700	F	P	2795	2710	55	26
01/10	40	0640	F	P	2789	0911	14	39
01/10	40	0650	F	A	2814	0111	60	31
01/10	40	0640	F	P	2793	2110	56	20
02/10	40	0790	F	A	2855	0911	12	38
02/10	40	0730	F	A	2933	2510	54	23
02/10	40	0730	F	P	2852	2910	12	27
02/10	40	0690	F	P	2868	0511	12	34

Table. 17 (con.'t)

Release data:						Recovery data:		
Date (ddmm)	Loc ¹	Len ²	Sex ³	Adip ⁴	Tag ⁵	Date (ddmm)	Loc	Days at large
02/10	40	0810	F	P	2829	0811	54	37
04/10	40	0740	M	P	3528	2110	61	17
05/10	40	0730	F	P	3544	0811	54	34
06/10	40	0750	F	P	3559	0811	54	33
06/10	40	0730	F	P	3574	0111	51	26
07/10	40	0830	F	P	2611	2910	12	22
07/10	40	0750	F	A	2677	0511	27	29
07/10	40	0800	M	P	2679	1511	10	39
08/10	40	0780	F	P	2693	1211	11	35
09/10	40	0660	M	P	2700	2110	77	12
09/10	40	0870	F	P	2634	0311	67	25
09/10	40	0700	F	P	2633	0511	55	27
10/10	40	0650	F	P	2638	1911	56	40
11/10	40	0720	F	A	2663	0411	52	24
11/10	40	0770	M	P	2919	0511	23	25
11/10	40	0770	M	P	2919	0511	23	25
11/10	40	0770	F	P	2904	0811	56	28
11/10	40	0660	F	A	2670	0411	52	24
11/10	40	0800	F	P	2903	2510	53	14
11/10	40	0650	F	P	2915	0911	08	29
11/10	40	0700	F	P	2901	2910	24	18
11/10	40	0780	F	P	2674	2910	31	18
14/10	40	0700	F	P	2944	2610	76	12
14/10	40	0490	M	P	2947	0511	54	22
14/10	40	0800	F	P	2945	2110	80	7
15/10	40	0790	F	P	2963	0811	80	24
15/10	40	0680	F	P	2966	0411	51	20
15/10	40	0740	F	P	2955	0111	63	17
16/10	40	0660	F	A	2975	0111	73	16
16/10	40	0610	F	P	2997	0311	55	18
16/10	40	0780	F	P	2992	2910	33	13
16/10	40	0750	F	P	2996	1211	10	27
17/10	40	0670	F	P	3615	0511	59	19
17/10	40	0800	M	P	3610	2710	74	10
18/10	40	0630	F	P	3661	0811	60	21
19/10	40	0680	F	A	3670	1511	59	27
19/10	40	0680	F	P	3663	0911	23	21
19/10	40	0770	F	P	3671	1911	10	31
27/10	40	0530	M	P	3633	0411	77	8
05/11	40	0440	J	P	3639	1911	53	14

¹Refer to Fig 1., all fish tagged at the counting fence.

²Length in mm.

³Sex: M - male, F - female, J - jack

⁴Adipose (P) present or (A) absent

⁵Opercular tag number

Table 18. Cowichan River chinook carcass capture-recapture summary, 1993.

Date	Tagged		Recaptures		Recovery Rate	
	Adults	Jacks	Adults	Jacks	Adults	Jacks
Oct. 21	12	3	3	0	25.0%	0.0%
22	2	0	0	0	0.0%	
23	0	1	0	0		0.0%
24	0	1	0	0		0.0%
25	8	3	2	2	25.0%	66.7%
26	45	11	16	1	35.6%	9.1%
27	34	9	9	1	26.5%	11.1%
28	32	23	4	0	12.5%	0.0%
29	35	5	13	1	37.1%	20.0%
30	0	1	0	0		0.0%
31	0	1	0	0		0.0%
Nov. 1	79	39	29	11	36.7%	28.2%
2	33	22	14	3	42.4%	13.6%
3	76	68	41	19	53.9%	27.9%
4	63	33	15	10	23.8%	30.3%
5	164	139	73	45	44.5%	32.4%
6	0	1	0	0		0.0%
7	0	1	0	0		0.0%
8	132	130	38	33	28.8%	25.4%
9	102	76	52	28	51.0%	36.8%
10	67	114	28	28	41.8%	24.6%
11	15	20	2	2	13.3%	10.0%
12	58	43	27	17	46.6%	39.5%
13	0	1	0	0		0.0%
14	0	1	0	0		0.0%
15	58	87	27	16	46.6%	18.4%
16	15	13	1	1	6.7%	7.7%
17	71	99	25	10	35.2%	10.1%
18	0	1	0	0		0.0%
19	49	48	3	0	6.1%	0.0%
20	11	10	0	0	0.0%	0.0%
Nov. 21	0	1	0	0		0.0%
Totals:	1161	1005	422	228	36.3%	22.7%

Table 19. Cowichan River chinook carcass capture histories, 1993

Sex	No. Tagged	Number of times carcass was recaptured					Norecaps ¹
		1	2	3	4	5	
Males	472	106	44	17	4	-	301
Jacks	1009	175	45	10	2	-	777
Females	691	155	73	15	9	1	438

¹ Carcasses that were tagged but never recaptured
(Males - 64%, Jacks - 77%, Females - 64%)

Table 20. Chinook radio tracking summary, 1993

Tag Code	Sex ¹	Tag Date	Recovery history								
238	M	13/09	16/09	28/09	22/10	03/11	10/11				
Recovery location: ²			64	31	4	10	11				
257	J	13/09	16/09	20/09	24/09	22/10	05/11	10/11	17/11		
Recovery location:			76	64	64	24	20	24	24		
178	J	14/09	16/09	20/09	28/09	05/10	15/10	22/10	03/11	10/11	17/11
Recovery location:			75	66	39	25	10	10	9	9	9
221	F	14/09	not recovered								
418	F	22/09	24/09	01/10	05/10	22/10	03/11	10/11	17/11		
Recovery location:			62	45	31	10	10	13	13		
379	F	23/09	24/09	01/10	05/10						
Recovery location:			65	45	39						
319	M	23/09	not recovered								
359	F	14/10	01/11	08/11	19/11						
Recovery location:			54	56	56						
341	F	14/10	not recovered								
277	M	18/10	21/10								
Recovery location:			60								

¹ Sex: M - male, F - female, J - jack² Refer to Fig. 1, all fish tagged at counting fence

Table 21. Petersen chinook escapement estimates by sex, Cowichan River, 1993.

A) Live mark-recapture:

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male ¹	3,424	2,435	4,413
Female	4,203	3,330	5,076
Total	7,627	5,765	9,489

B) Carcass mark-recapture:**MIDDLE RIVER**

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male ¹	1,138	902	1,374
Female	1,881	1,595	2,167
Total	3,019	2,497	3,541

UPPER RIVER

Sex	Escapement estimate	95% Confidence limit	
		Lower	Upper
Male ¹	742	624	860
Female	840	722	958
Total	1,582	1,346	1,818

¹ Adult males only, jacks not included

Table 22. Recoveries from chinook tagged in successive weeks at the fence, divided according to week of recovery upstream, and Schaeffer escapement estimates.

	Week of Tagging (i)											Tagged fish Recovered (R _j)	Total fish Recovered (C _j)	C _j / R _j		
	1	2	3	4	5	6	7	8	9	10	11					
Week of Recovery (j):																
1	-	-	-	-	-	-	-	-	-	-	-	-	14	-		
2	-	-	1	-	-	9	3	6	1	-	-	20	159	7.9		
3	-	-	1	3	5	8	4	8	1	1	1	32	412	12.9		
4	-	-	-	1	1	13	3	4	2	-	-	24(43) ¹	395	16.4(9.2)		
5	-	-	-	-	3	2	1	1	2	-	-	9(20)	206	22.9(10.3)		
6	-	-	-	-	-	-	-	-	-	-	-	(4)	15	(3.7)		
Tagged fish recovered (R _i)	-	-	2	4	9	32	11	19	6	1	1					
Total fish tagged (M _i)	1	5	22	44	90	295	118	129	51	13	-					
M _i / R _i	-	-	11	11	10	9.2	10.7	6.8	8.5	13	-					

Computed estimates² of chinook escapement using Schaeffer's method:

	Week of Tagging (i)									
	1	2	3	4	5	6	7	8	9	10
Week of Recovery (j):										
1	-	-	-	-	-	-	-	-	-	-
2	-	-	87	-	-	660	256	280	68	-
3	-	-	142	425	644	950	552	604	109	167
4	-	-	-	101	92	1101	296	215	156	-
5	-	-	-	-	309	190	110	60	175	-
Estimated escapement per period i		-	229	526	1045	2901	1214	1159	508	167

Total escapement estimate: 7,749
 Upper 95% confidence limit: 21,333
 Lower 95% confidence limit: 3,172

¹total number of tagged chinook recovered (in parenthesis) includes chinook that had lost their tag but possessed a secondary mark.

²calculations are based on total tagged/recovered adult chinook only.

Table 23. Jolly-Seber carcass capture-recapture statistics¹ for chinook after pooling².

Period (i)	n_i	m_i	u_i	R_i	r_i	z_i
1	133	0	133	133	14	0
2	233	10	223	233	40	4
3	76	13	63	76	10	31
4	186	22	164	186	54	19
5	140	8	132	140	12	65
6	138	36	102	138	59	41
7	86	19	67	86	26	81
8	24	9	15	24	2	98
9	111	53	58	111	58	47
10	120	47	73	120	45	58
11	143	72	71	143	44	31
12	135	75	60	135	0	0

¹ Statistics:

- m_i = the number of marked fish captured in the i th sample
($i=1, \dots, k$)
- u_i = the number of unmarked fish captured in the i th sample
($i=1, \dots, k$)
- $n_i = m_i + u_i$, the total number of fish captured in the i th sample
($i=1, \dots, k$)
- R_i = the number of n_i that are released after the i th sample
($i=1, \dots, k-1$). $R_i \leq n_i$ because of losses on capture
- r_i = the number of R_i fish released at i that are captured again
($i=1, \dots, k-1$)
- z_i = the number of fish captured before i , not captured at i ,
and captured again later ($i=2, \dots, k-1$)

² Data collected from Oct. 21 to Nov. 21 (Table 18) was grouped into 12 periods for the purpose of the Jolly-Seber analysis

Table 24. Incidence of tagged adult chinook recovered¹ on the spawning grounds by recovery period, Cowichan R., 1993

Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 17-23	7	5.9	14	0.9	50.0
Oct. 24-30	13	10.9	171	10.6	7.6
Oct. 31-Nov.6	50	42.0	523	32.4	9.6
Nov. 7-13	35	29.4	549	34.1	6.4
Nov. 14-20	14	11.8	342	21.2	4.1
Nov. 21-27	0	0.0	13	0.8	0.0
Total:	119	100.0	1612	100.0	7.4

¹includes fish which had lost the tag but had an obvious notch in the operculum or the secondary opercular punch.

Table 25. Proportion of the tag application sample recovered¹ on the spawning grounds, by period, on the Cowichan R., 1993

Application period	Tags applied	Tags recovered ²	Recoveries (%)
Aug. 22-28	1	-	-
Aug. 29-Sept. 4	5	-	-
Sept. 5-11	22	2	9.0
Sept. 12-18	44	4	9.0
Sept. 19-25	90	9	10.0
Sept. 26-Oct. 2	295	32	10.8
Oct. 3-9	118	11	9.3
Oct. 10-16	129	20	15.5
Oct. 17-23	51	6	11.8
Oct. 24-30	13	1	7.7
Total:	768	85	11.1

¹Tag recovery sampling did not begin until Oct. 21, includes tag recovery for adult chinook only.

²includes only those fish recovered with tag intact

Table 26. Incidence of tagged adult chinook recovered¹ on the spawning grounds, by section of river and by period, in the Cowichan R., 1993

Upper River²					
Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 17-23	0	0.0	2	0.3	0.0
Oct. 24-30	6	9.7	35	4.7	17.1
Oct. 31-Nov.6	23	37.1	166	22.5	13.8
Nov. 7-13	27	43.5	329	44.6	8.2
Nov. 14-20	6	9.7	205	27.8	2.9
Total:	62	100.0	737	100.0	8.4

Middle River³					
Recovery Period	Recovered with tag		Total Recovery		Mark incidence
	No.	%	No.	%	%
Oct. 17-23	7	12.1	12	1.4	58.3
Oct. 24-30	7	12.1	136	15.5	5.1
Oct. 31-Nov.6	28	48.3	357	40.8	7.8
Nov. 7-13	8	13.8	220	25.1	3.6
Nov. 14-20	8	13.8	137	15.6	5.8
Nov. 21-27	0	0.0	13	1.5	0.0
Total:	58	100.0	875	100.0	6.6

¹includes fish which had lost the tag but had an obvious notch in the operculum or a secondary opercular mark.

²Refers to the part of river between Birdhouse and Three Firs Pool (sections 1 to 6, Fig.1)

³Refers to the part of the river just below Marie Canyon to the enumeration fence (sections 8 to 12, Fig. 1)

Table 27. Sex composition of application and recovery samples of Cowichan River chinook, 1993

Sex		Application sample			Recovery sample		
		Recovered	Not Recovered	Total	Marked	Unmarked	Total
Male	Percent	29	25	26	29	21	22
	No.	41	255	296	41	439	480
Jacks	Percent	16	35	32	16	48	46
	No.	22	346	368	22	1000	1022
Female	Percent	55	40	42	55	30	32
	No.	78	394	472	78	626	704
Total:	No.	141	995	1136	141	2065	2206

Table 28. Summary of adult chinook escapement estimates for the Cowichan R., 1993.

Method	Estimate	95% Confidence Limits	
		Lower	Upper
Simple Petersen (live M/R)	6,627	5,765	9,489
Stratified Petersen (carcass M/R)	4,601	3,843	5,359
Stratified Petersen (live M/R)	7,749	3,172	21,333
Jolly-Seber (carcass M/R)	4,281	3,824	4,738
Fence Count ¹	5,047		

¹ Number of adults recorded at the fence minus the adults removed for broodstock above the fence.

Table 29. Total adult chinook returns to the Cowichan R., 1975-1993.

Year	Natural spawner	Brood stock	Native catch	Total return
1975	6500		900	7400
1976	3460		1000	4460
1977	4150		1000	5150
1978	4370		500	4870
1979	8750	195	500	9445
1980	5950	337	1500	7787
1981	6050	282	1500	7832
1982	5450	534	450	6434
1983	4550	242	250	5642
1984	5050	278	355	5683
1985	3550	175	468	4193
1986	1250	315	481	2046
1987	1200	582	455	2237
1988	4712	678	681	6071
1989	996 ¹	535 ²	1055	2586
1990	4164	326	604	5094
1991	4086 ³	1755	270	5065
1992	6676	1850	260	8678
1993	5047	1970	295	7312

¹Numbers of adults recorded at the fence (5058) minus the adults removed for broodstock above the fence (11).

²Total broodstock removed.

³Includes 2000 adult chinook estimated to have passed by the fence during the period of high water

FIGURES

Fig. 1 Cowichan River Survey Areas:**Swim survey locations were:**

- 1 - Bird House pool
- 2 - Road pool
- 3 - Train trestle (mile 70.2)
- 4 - Old pick-up site
- 5 - Maple tree
- 6 - Three Firs pool
- 7 - Skutz Falls
- 8 - Marie Canyon
- 9 - Bible Camp
- 10 - Cowichan side channel
- 11 - Sandy pool
- 12 - Sewer
- 13 - JC pool

Carcass recovery survey areas:

Bird House (1) to Three Firs pool (6) represents the Upper survey section.

Marie Canyon (8) to enumeration fence (A) represents the Middle survey section.

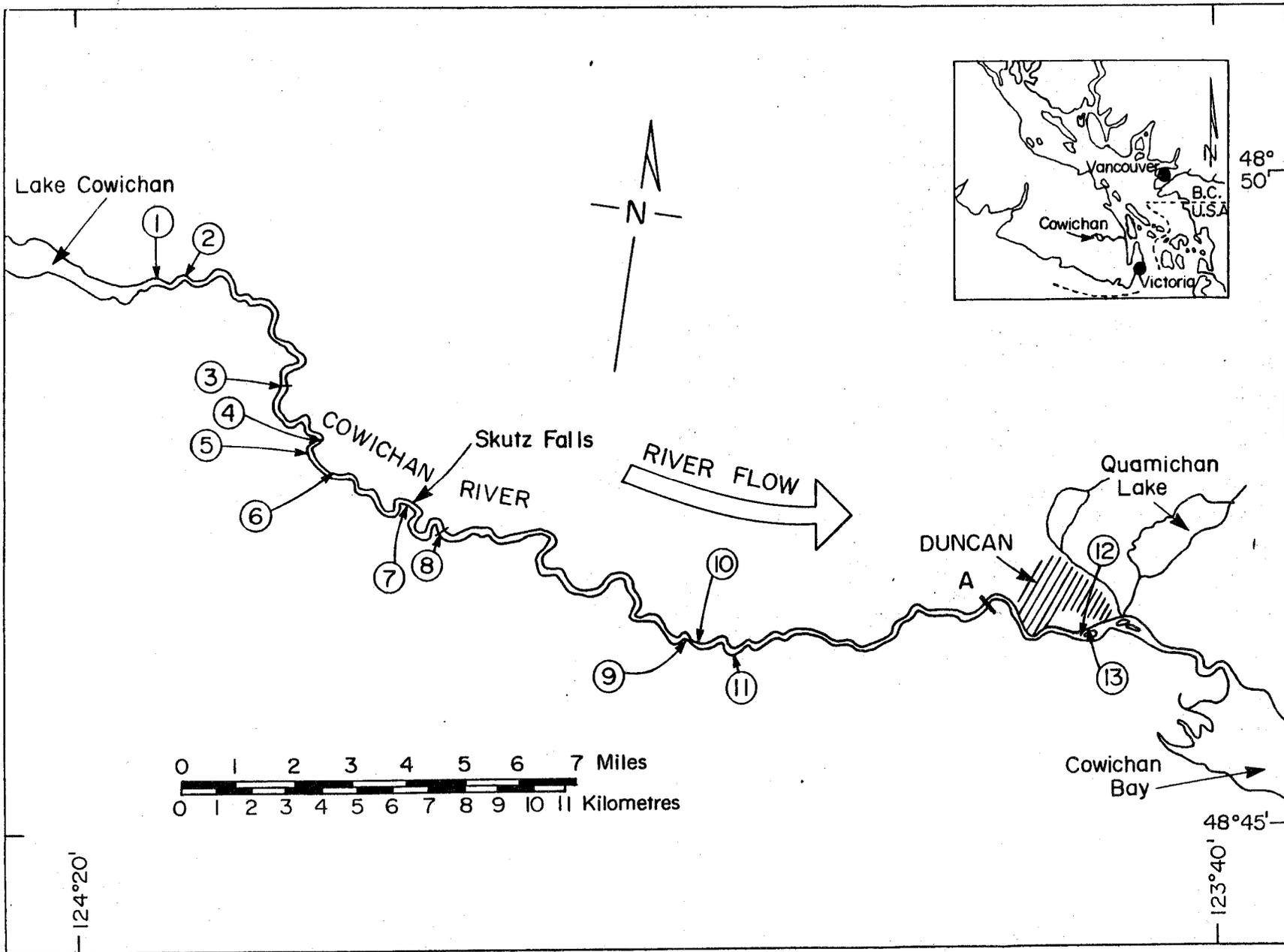
A - refers to the adult enumeration fence

Tag recovery and radio tracking locations:

Locations numbered 1 to 45 are in the upper river section, those numbered 46 to 83 are in the middle river section.

Carcass and tag recovery areas do not correspond to each other.

Note: The section of river that changed course in 1991 was between the Train Trestle (3) and the Old pickup site (4).



**Fig. 2 River Management Zones for
Native Food Fishery**

A-Cliffs to Silver bridge

B-Silver bridge to JC's place

C-Quamichan to Black creek

D-Powerline to Elliot's barn

E-Elliot's barn to Brian's pool

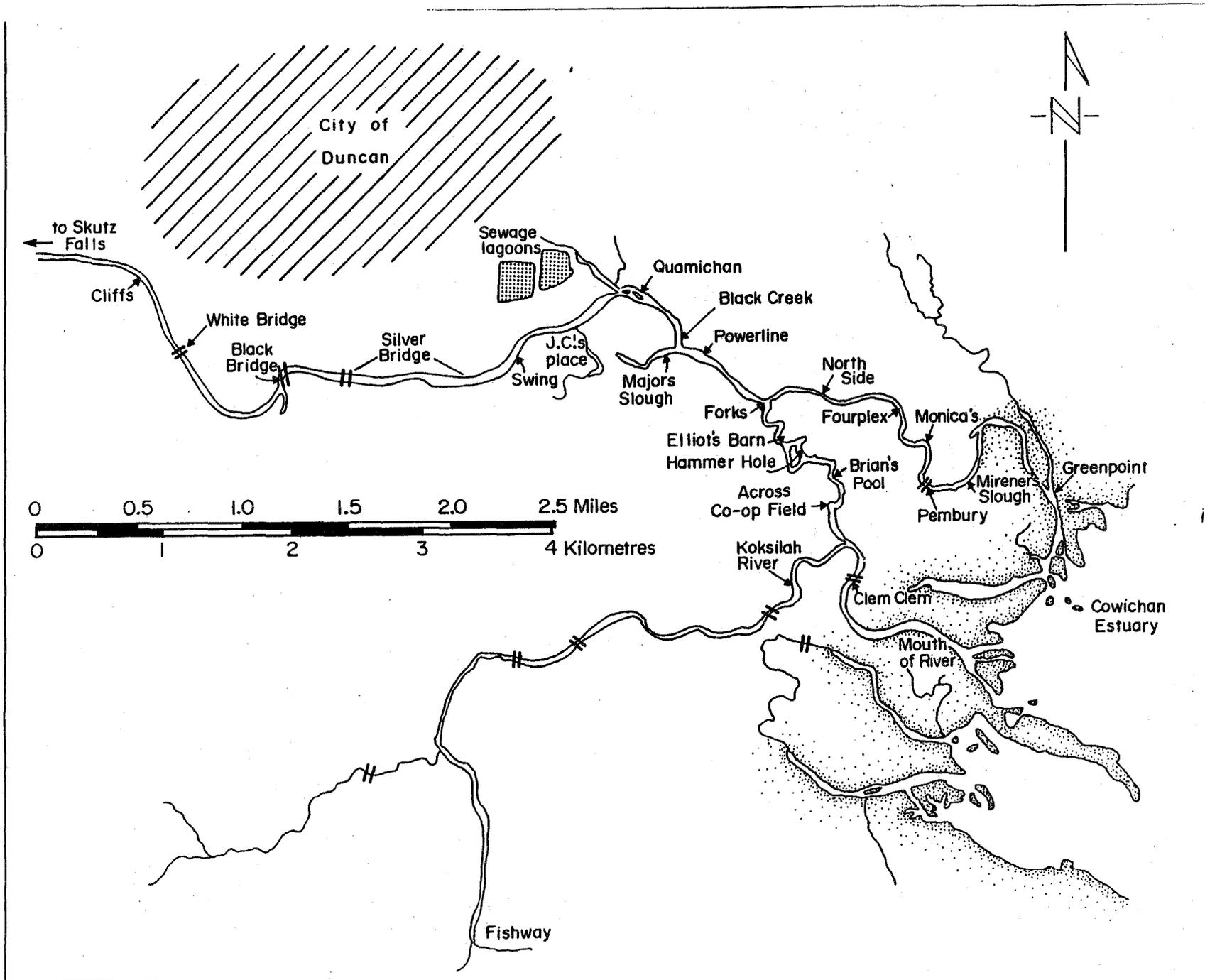
F-Brian's pool to Clem Clem and
part of Koksilah

G-Clem Clem to mouth

H-North side to Four plex

I-Four plex to Meriner's
slough

J-Meriner's slough to mouth



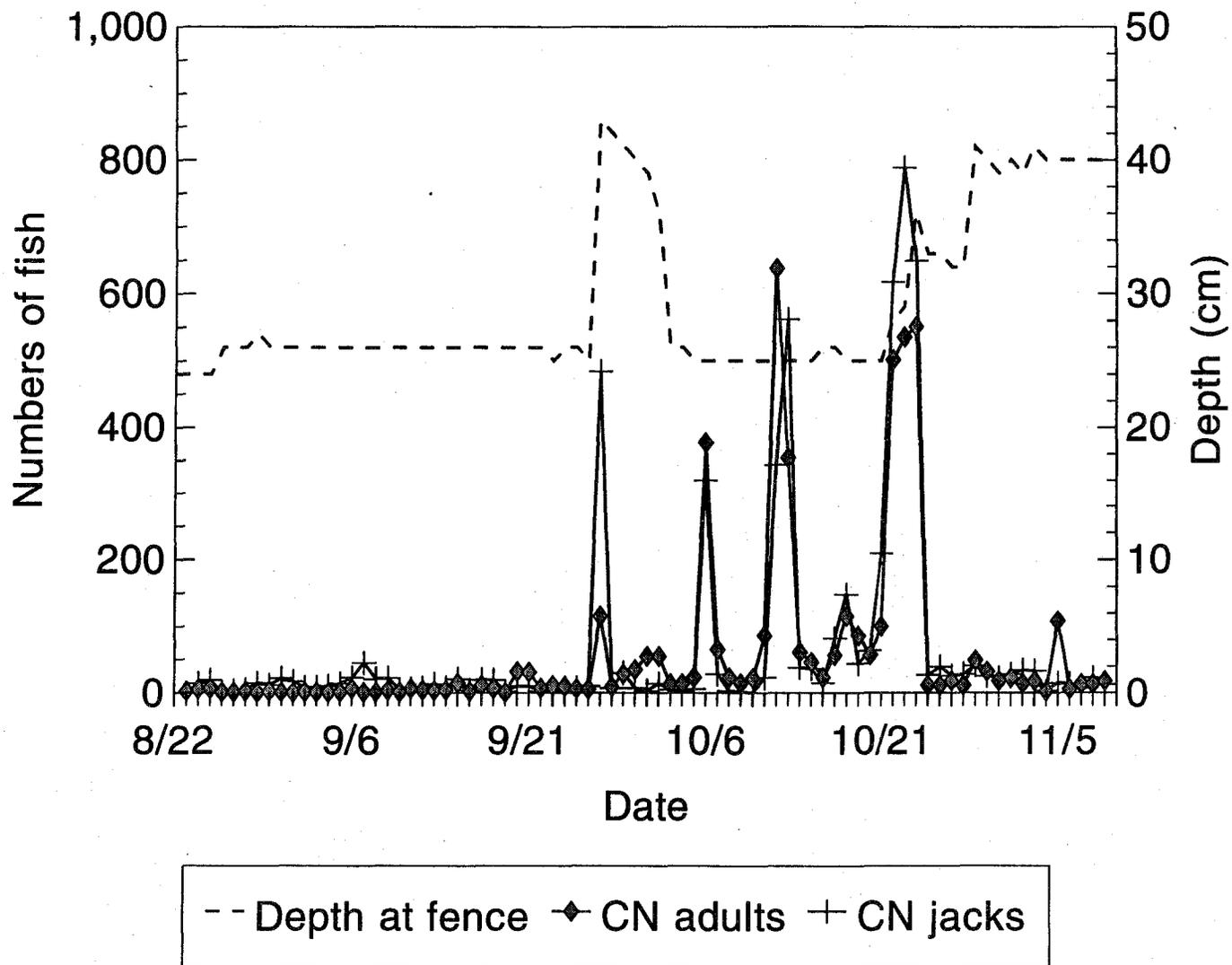
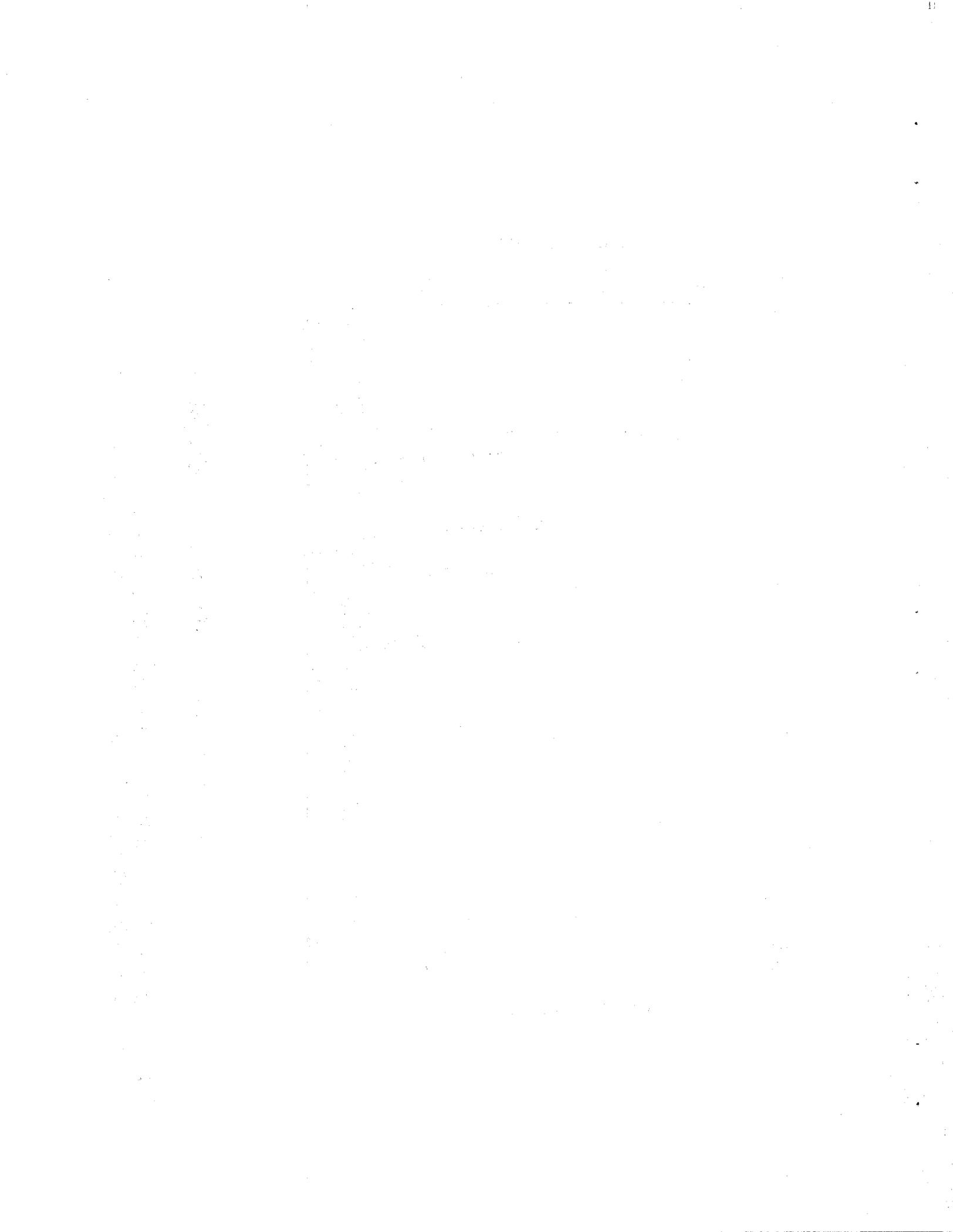


Fig. 3. Daily chinook fence count and water depth.

(Note: additional water released Sept. 26 at 1200 Hr., weir completely opened on Oct. 28.)



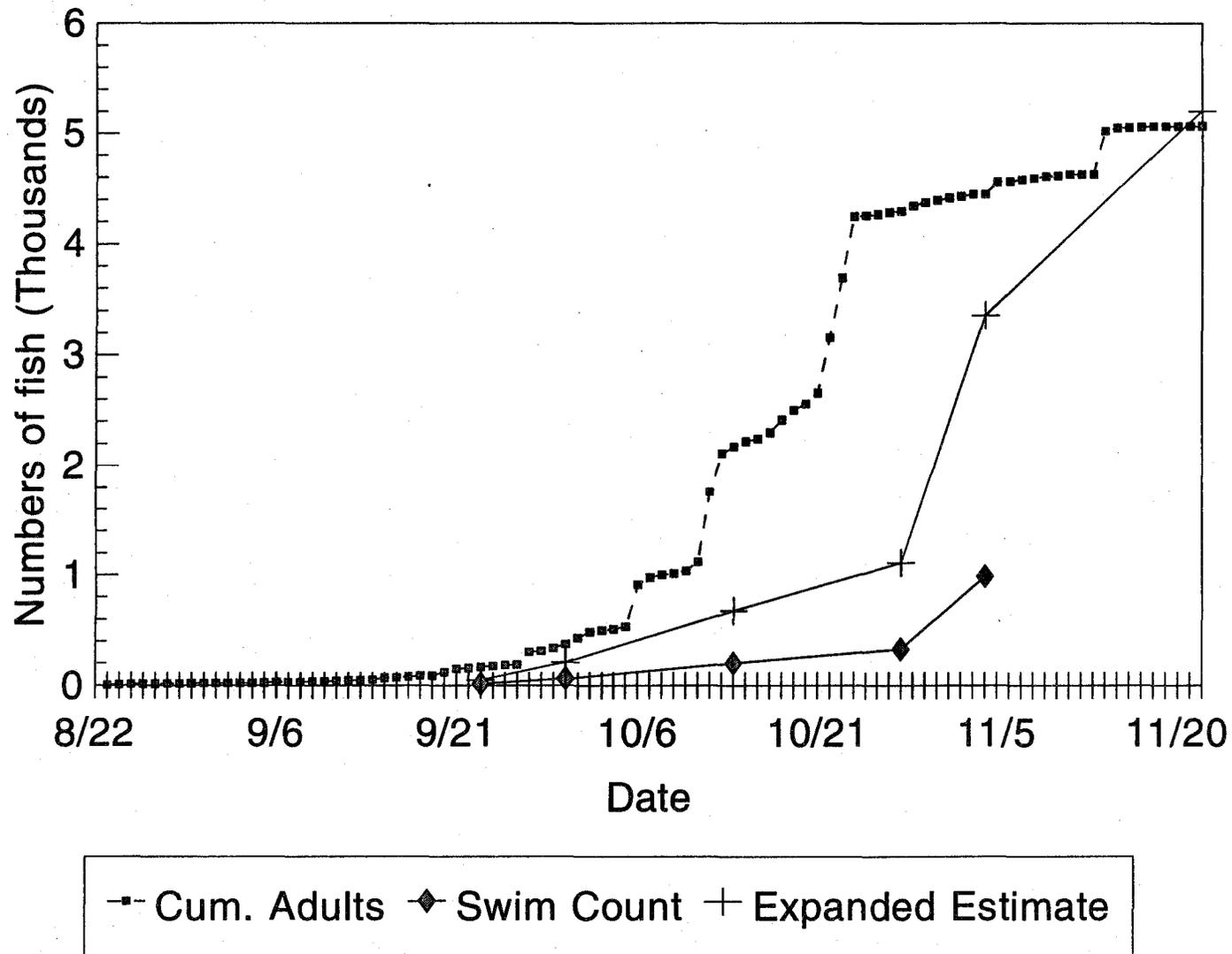
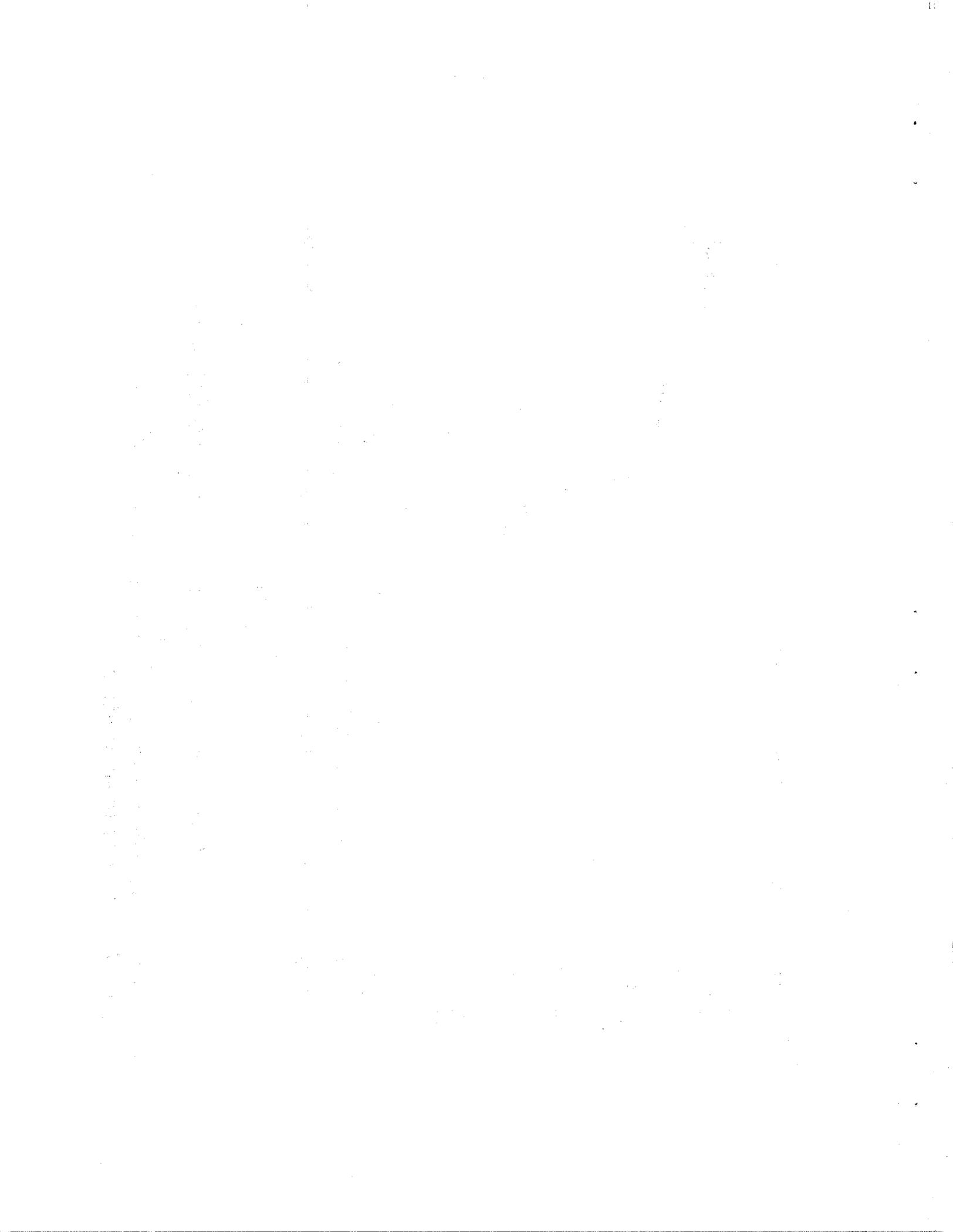


Fig. 4. Cumulative number of adult chinook past the fence compared to swim counts and expanded escapement estimates.



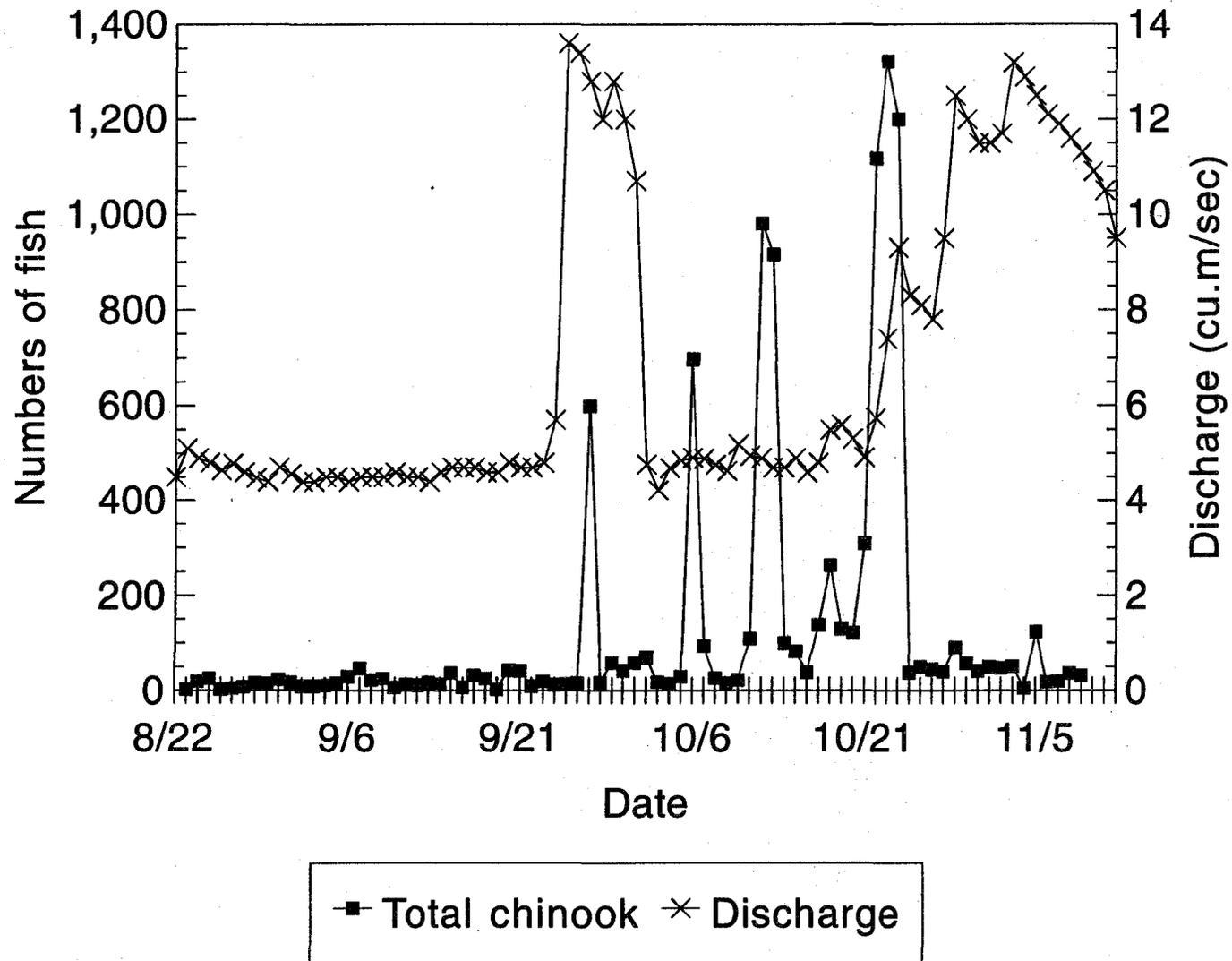


Fig. 5. Daily chinook fence count and river discharge.

(Note: additional water released Sept. 26 at 1200 Hr., weir completely opened on Oct. 28.)

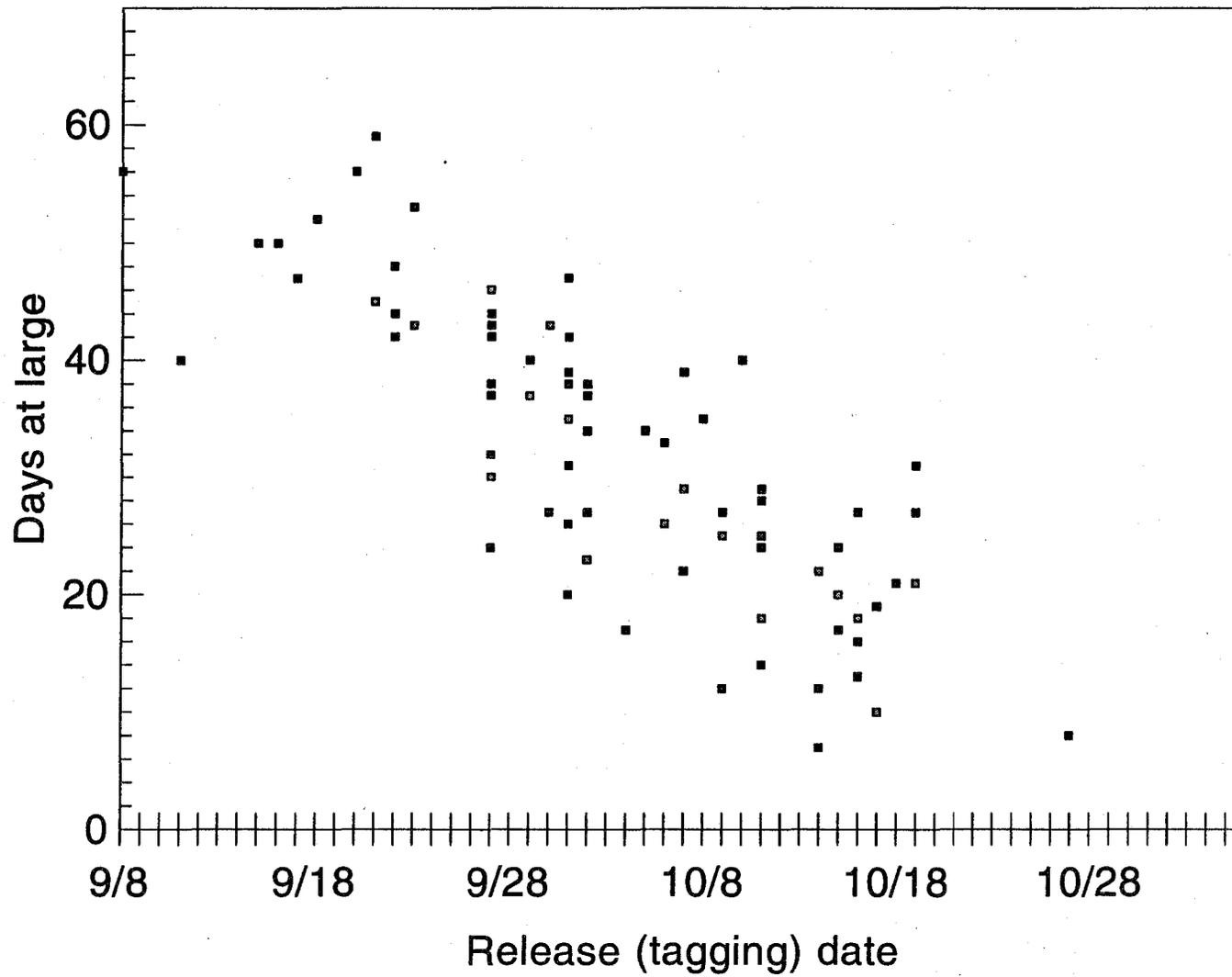
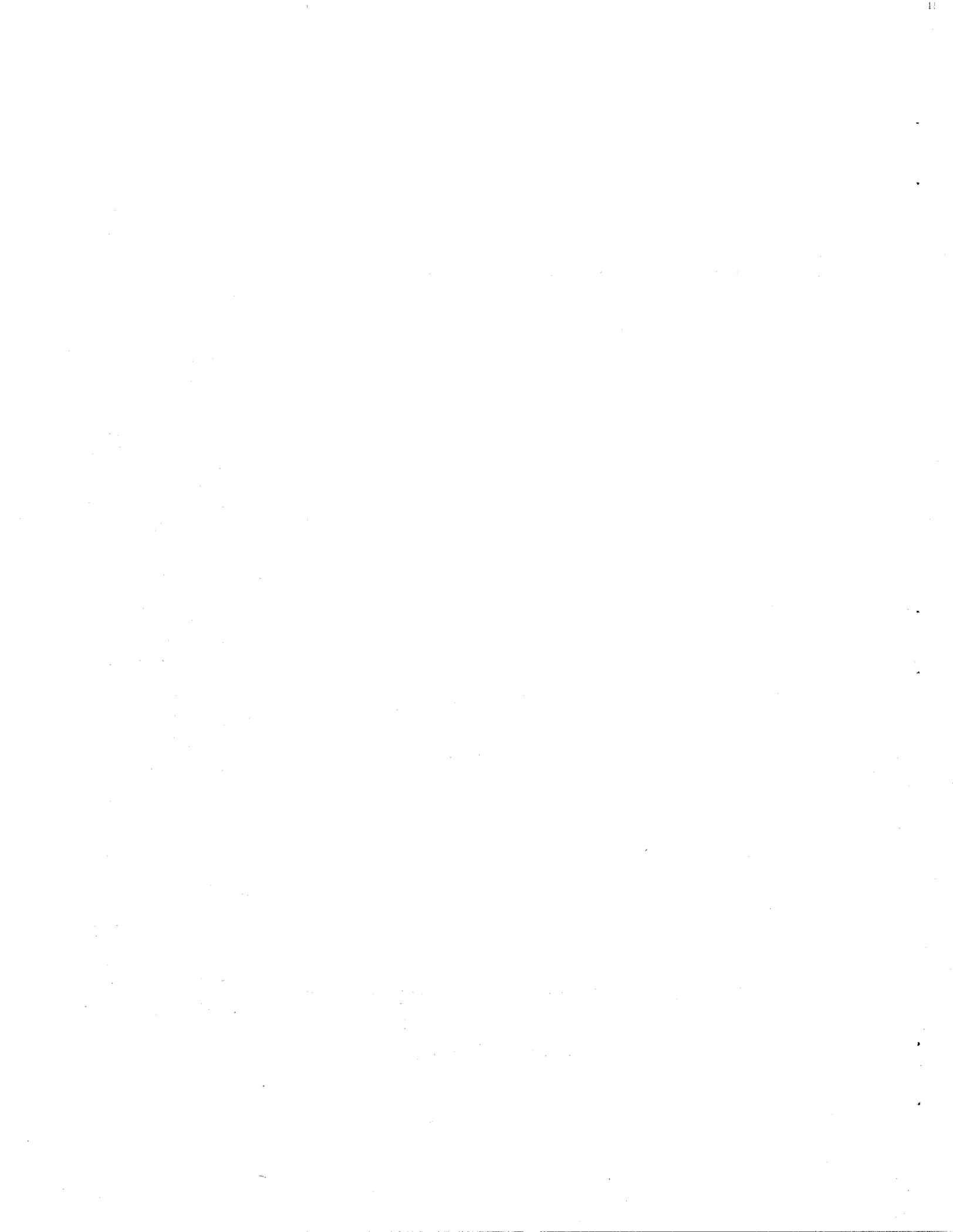


Fig. 6. The number of days chinook were at large in relation to the date of tagging at the fence.



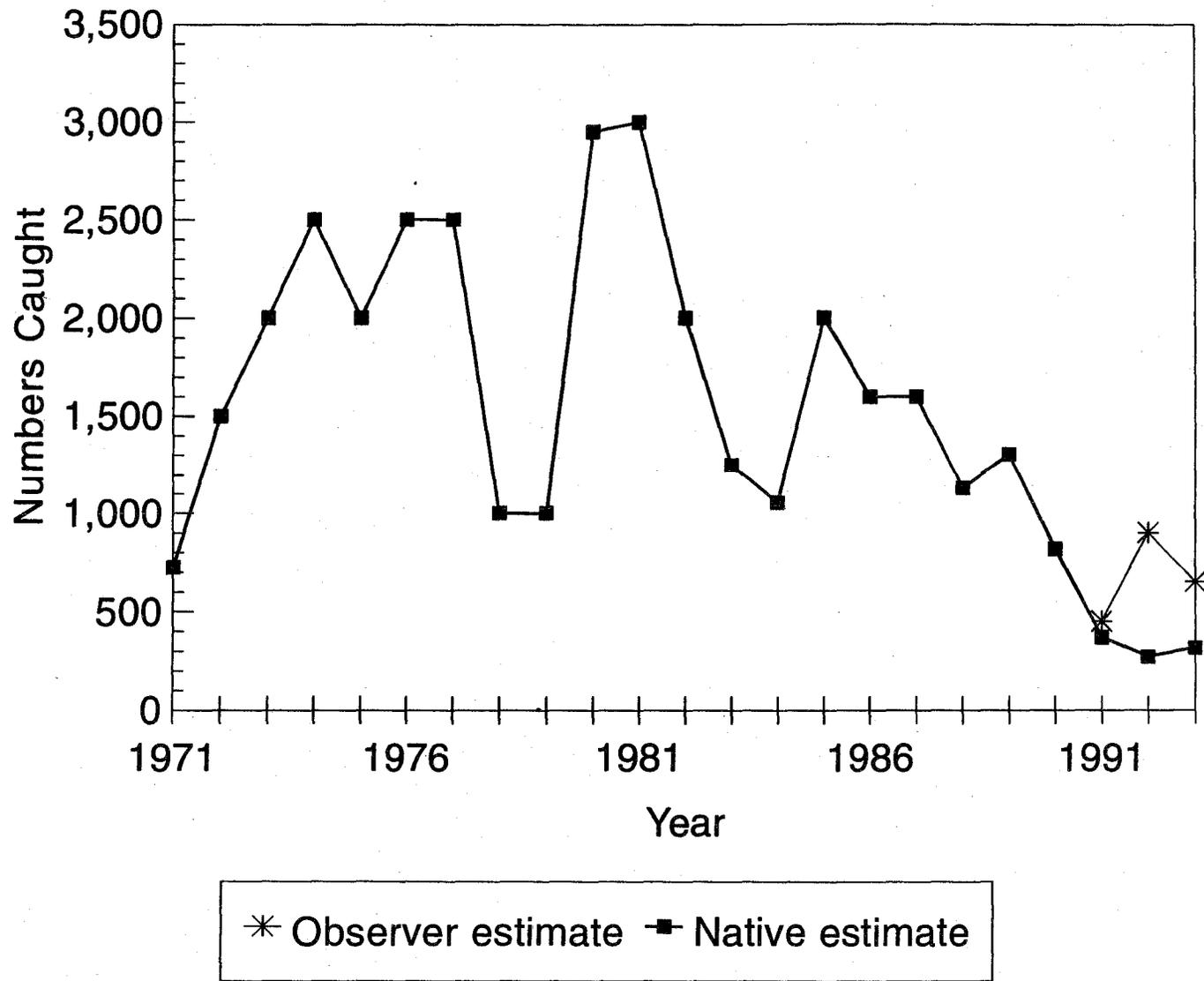


Fig. 7. Native food fishery chinook catch data, Cowichan river, 1971-1993.

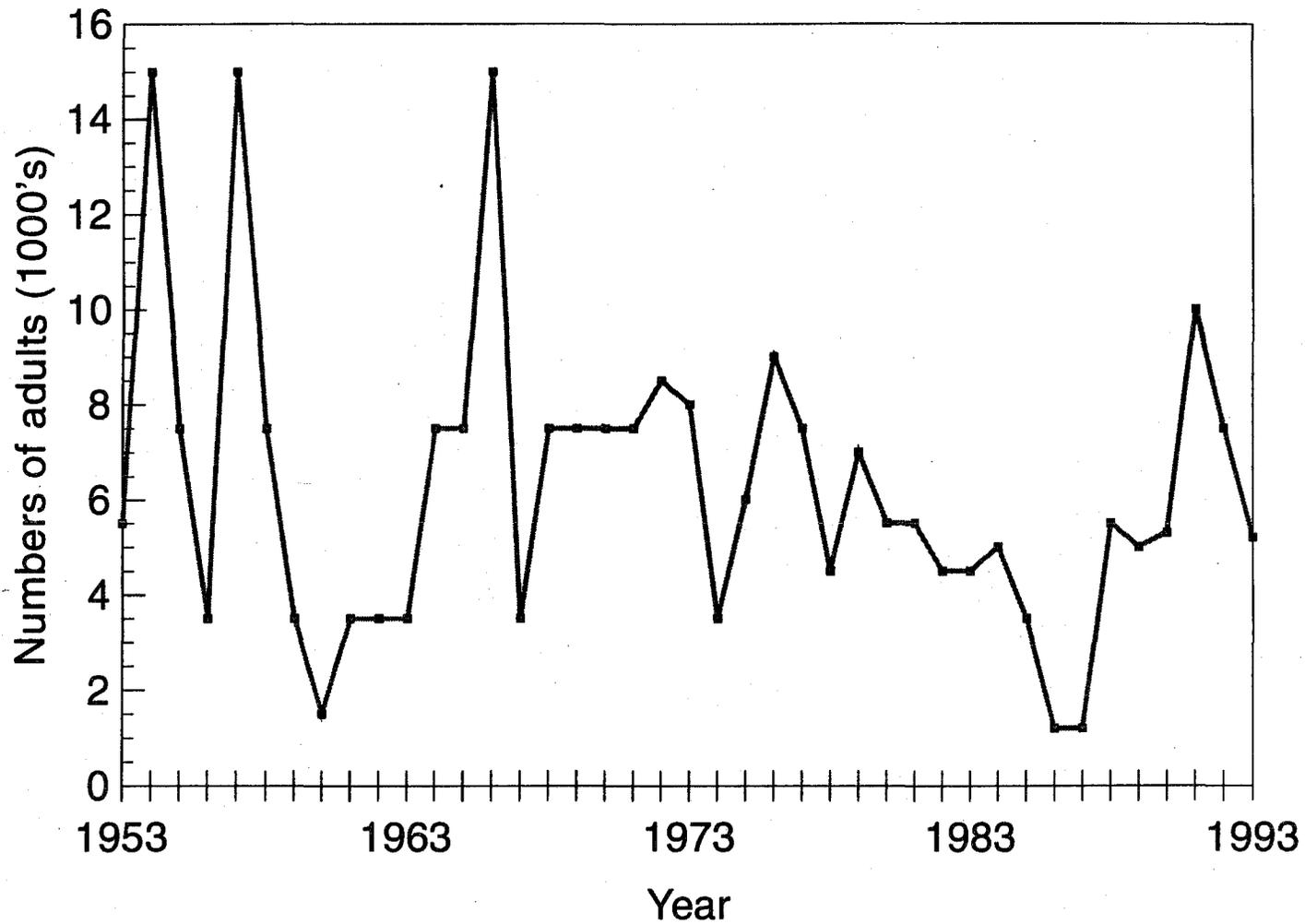
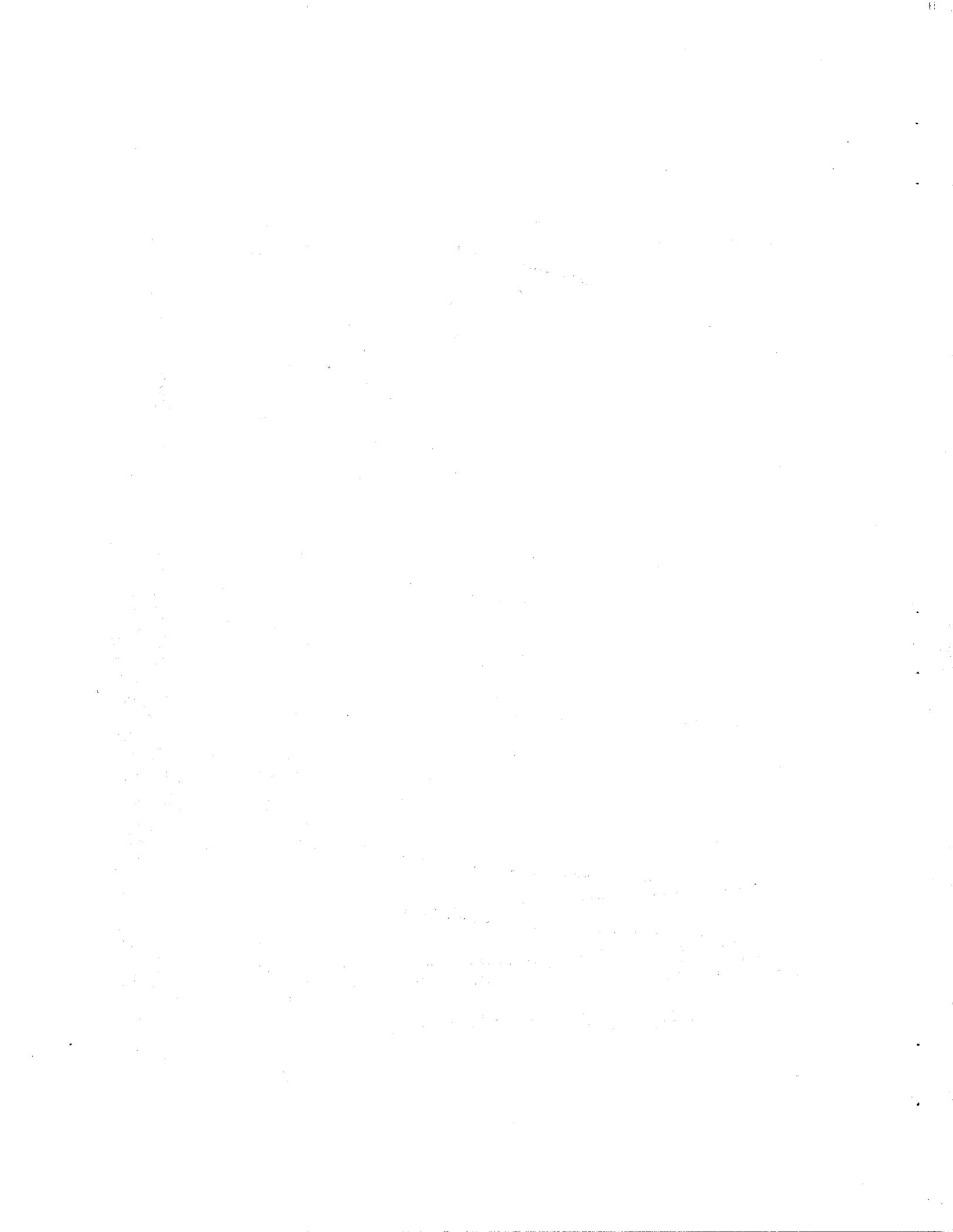


Fig. 8 Adult chinook escapement estimates for the Cowichan River, 1953-1993.

(estimates up to 1988 were based on swim surveys, stream walks, and helicopter flights)

(estimates from 1988 to present were based on fence count and mark-recapture data)



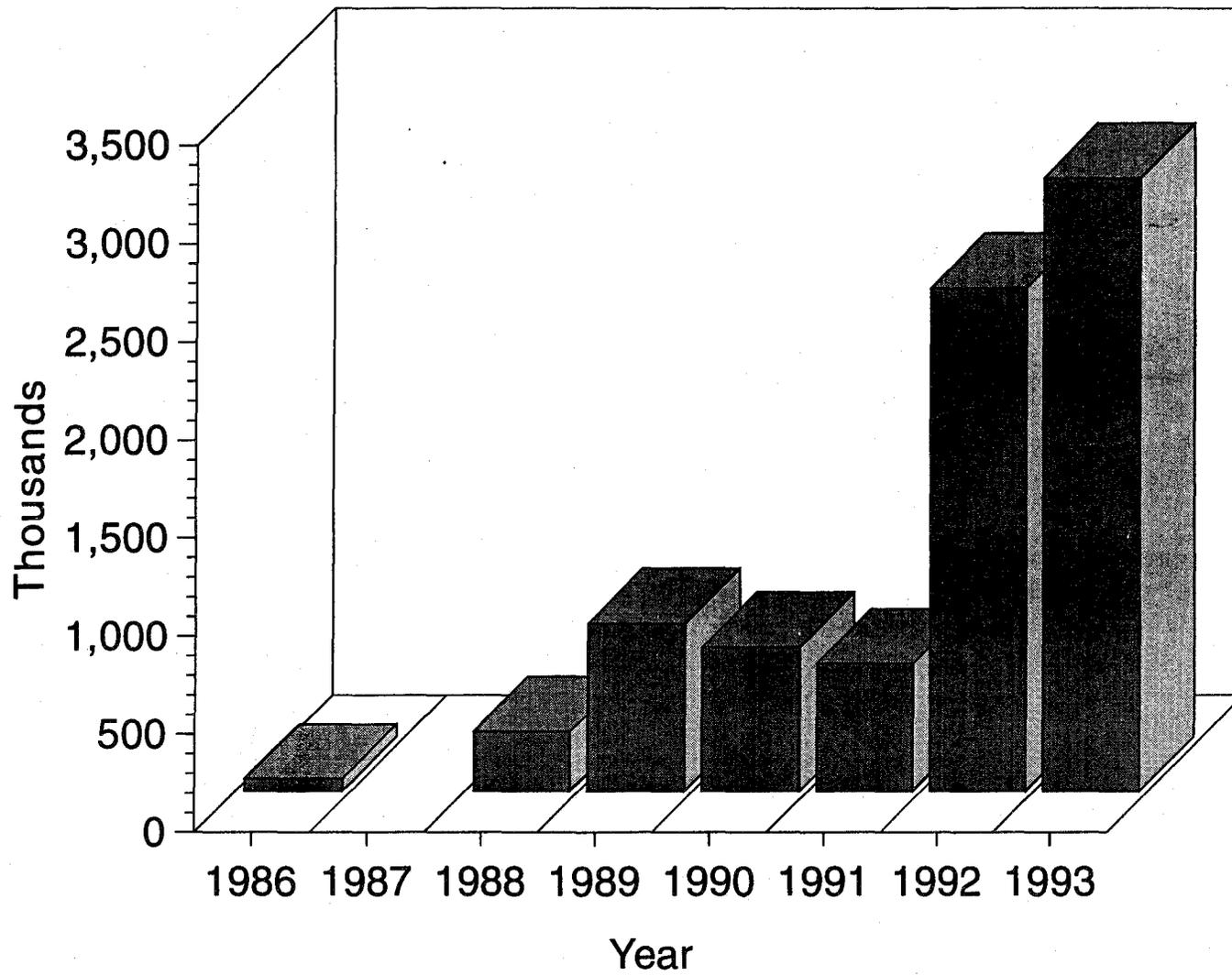
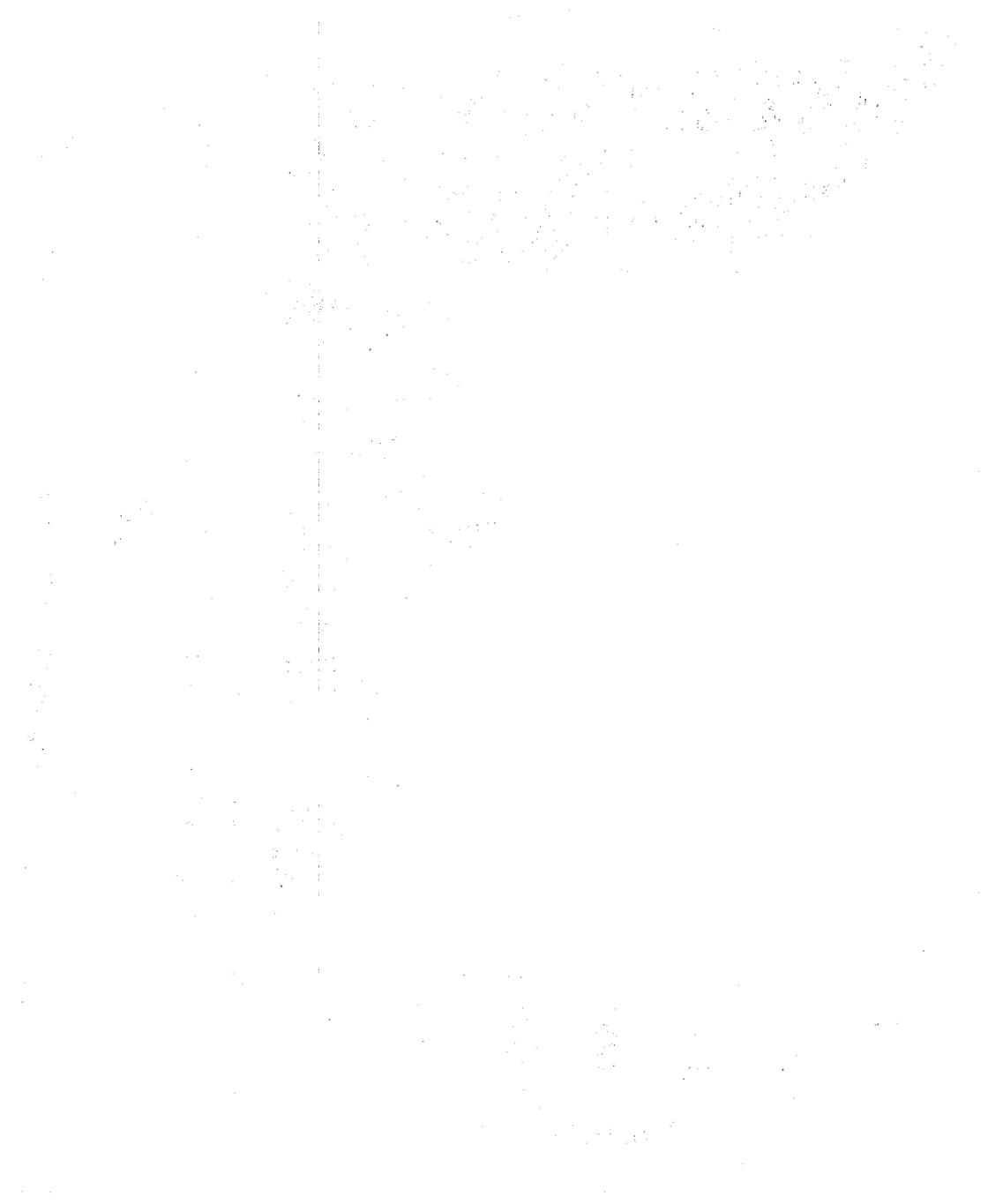


Fig. 9. Hatchery chinook released into the Cowichan system as fry (3 gm) and as pre-smolts (6 gm).



Appendix Table 1. Cowichan hatchery chinook releases¹, 1980-1993.

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weight (gm)	Release Date	Release site
						ddmmmyy:ddmmmyy	
021846	79	31628	32134	98.4	2.8	:07May80	0118-COWICHAN RIVER
022060	79	32034	32547	98.4	2.8	:07May80	0399-SKUTZ FALLS
022158	80	52519	65000	80.8	2.3	:09Jun81	0118-COWICHAN RIVER
022307	81	30179	30373	99.4	3.1	:12May82	0118-COWICHAN RIVER
022339	82	49135	224944	21.8	2.9	:14May83	0399-SKUTZ FALLS
022831	83	50613	101000	50.1	4.3	:25May84	0355-KOKSILAH RIVER
NOCN8311	83	0	200000	0.0	4.3	:31May84	0118-COWICHAN RIVER
NOCN8411	84	0	187823	0.0	4.8	13May85:14May85	0118-COWICHAN RIVER
023803	85	25365	25804	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
023804	85	25455	25895	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
023911	85	11980	12187	98.3	4.3	23May86:24May86	0118-COWICHAN RIVER
NOCN8619	86	0	321172	0.0	4.0	13May87:22May87	0118-COWICHAN RIVER
NOCN8620	86	0	54608	0.0	3.5	:21May87	0355-KOKSILAH RIVER
024334	87	14298	14334	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024729	87	25360	25424	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024730	87	25869	25934	99.7	3.4	:18Apr88	0118-COWICHAN RIVER
024731	87	27428	27497	99.7	7.1	18Apr88:18May88	0185-COWICHAN LAKE
024732	87	27271	27339	99.8	7.1	:18May88	0185-COWICHAN LAKE
024733	87	26911	26978	99.8	7.1	:18May88	0185-COWICHAN LAKE
024734	87	23521	23580	99.7	7.1	:18May88	0185-COWICHAN LAKE
024735	87	26719	26786	99.7	3.4	18Apr88:18May88	0118-COWICHAN RIVER
024945	87	26461	26594	99.5	4.9	:25May88	0324-COWICHAN R UPP
024946	87	26658	26792	99.5	4.9	:25May88	0324-COWICHAN R UPP
024947	87	26761	26895	99.5	4.9	:25May88	0324-COWICHAN R UPP
025008	87	26817	26952	99.5	4.9	:25May88	0324-COWICHAN R UPP
NOCN8731	87	0	387071	0.0	8.2	:26May88	0324-COWICHAN R UPP
024860	88	25117	25243	99.5	3.7	:28Apr89	0118-COWICHAN RIVER
025012	88	26595	54768	48.6	6.5	:21May89	0118-COWICHAN RIVER
025013	88	25982	54154	48.0	6.5	:21May89	0118-COWICHAN RIVER
025015	88	23058	24894	92.6	3.7	:28Apr89	0118-COWICHAN RIVER
025016	88	26821	26821	100.0	3.7	:28Apr89	0118-COWICHAN RIVER
025017	88	27611	28175	98.0	3.7	:28Apr89	0118-COWICHAN RIVER
025523	88	27531	56123	49.1	6.5	:21May89	0118-COWICHAN RIVER
025524	88	27205	55378	49.1	6.5	:21May89	0118-COWICHAN RIVER
025749	88	26922	133331	20.2	6.1	:15May89	0185-COWICHAN LAKE
025750	88	27036	133446	20.3	6.1	:15May89	0185-COWICHAN LAKE
025751	88	23106	130107	17.8	6.1	:15May89	0185-COWICHAN LAKE
025752	88	26169	132842	19.7	6.1	:15May89	0185-COWICHAN LAKE
020352	89	28287	28573	99.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
020522	89	27072	36800	73.6	6.5	22May90:23May90	0118-COWICHAN RIVER
020622	89	27787	37242	74.6	6.5	22May90:23May90	0118-COWICHAN RIVER
020623	89	28164	37619	74.9	6.5	22May90:23May90	0118-COWICHAN RIVER
020624	89	28331	37786	75.0	6.5	22May90:23May90	0118-COWICHAN RIVER
020938	89	28312	28312	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
020939	89	26218	26218	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
026103	89	27145	27145	100.0	3.4	12Apr90:12Apr90	0118-COWICHAN RIVER
026255	89	26400	119674	22.1	7.2	:14May90	0185-COWICHAN LAKE
026256	89	25693	119497	21.5	7.2	:14May90	0185-COWICHAN LAKE
026257	89	25790	119325	21.6	7.2	:14May90	0185-COWICHAN LAKE
026258	89	25219	118748	21.2	7.2	:14May90	0185-COWICHAN LAKE
020333	90	25687	94172	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
020334	90	25898	94384	27.4	8.4	15May91:15May91	0185-COWICHAN LAKE
020335	90	25739	94224	27.3	8.4	15May91:15May91	0185-COWICHAN LAKE
020336	90	27135	27135	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020337	90	26631	26631	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020338	90	27046	27046	100.0	3.3	17Apr91:17Apr91	0118-COWICHAN RIVER
020339	90	26721	34318	77.9	6.4	21May91:22May91	0118-COWICHAN RIVER
020340	90	26993	34592	78.0	6.4	21May91:22May91	0118-COWICHAN RIVER
020341	90	26533	33995	78.0	6.4	21May91:22May91	0118-COWICHAN RIVER
020342	90	25437	92182	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
020343	90	25391	92136	27.6	4.8	17Jun91:18Jun91	0118-COWICHAN RIVER
NOCN9044	90	0	5086	0.0	5.4	26Jun91:26Jun91	0367-COWICHAN ESTUA

Appendix Table 1 (cont.)

Tag Code	BY	Number Tagged	Number Released	CWT % Mark	Weight (gm)	Release Date	Release site
						ddmmyy:ddmmyy	
180513	91	26972	336330	8.0	5.0	17May92:17May92	0185-COWICHAN LAKE
180514	91	25964	335584	7.7	5.0	17May92:17May92	0185-COWICHAN LAKE
180515	91	27694	175107	15.8	4.0	21Apr92:22Apr92	0335-COWICHAN R LOW
180516	91	27148	174834	15.5	4.0	21Apr92:22Apr92	0335-COWICHAN R LOW
180517	91	27471	248584	11.1	5.3	20May92:21May92	0324-COWICHAN R UPP
180518	91	27277	248389	11.0	5.3	20May92:21May92	0324-COWICHAN R UPP
180519	91	27432	160695	17.1	3.8	21Apr92:22Apr92	0335-COWICHAN R LOW
180520	91	27001	160262	16.8	3.8	21Apr92:22Apr92	0335-COWICHAN R LOW
180521	91	26871	27444	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUA
180522	91	26852	27424	97.9	6.3	29May92:29May92	0367-COWICHAN ESTUA
NOCN9127	91	0	158361	0.0	2.4	25Mar92:25Mar92	0118-COWICHAN RIVER
NOCN9145	91	0	513053	0.0	5.7	19May92:20May92	0324-COWICHAN R UPP
180209	92	24770	98974	25.0	6.3	25May93:25May93	0367-COWICHAN ESTUA
180210	92	26383	327416	8.1	5.9	17May93:19May93	0324-COWICHAN R UPP
180550	92	25311	326344	7.8	5.9	17May93:19May93	0324-COWICHAN R UPP
181042	92	53620	412953	13.0	6.5	25May93:25May93	0118-COWICHAN RIVER
181043	92	54235	901937	6.0	5.6	10May93:10May93	0185-COWICHAN LAKE
181044	92	55027	907719	6.1	3.6	07Apr93:07Apr93	0324-COWICHAN R UPP
NOCN9231	92	0	437840	0.0	3.7	11May93:11May93	0324-COWICHAN R UPP

Note:

Tag code: refers to Coded Wire tag code (NOCN refers to releases unassociated with a given tag code)

BY: refers to brood year

¹Data compiled from the Mark Recovery Program (MRP) database (Kuhn 1988).

Appendix Table 2. Tag code data from chinook sampled on the spawning grounds, 1993.

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
291093	0700	1	90	02-03-40	LR	31
291093	0666	1	90	02-03-40	LR	41
021193	0595	2	90	02-03-40	LR	88
221193	0590	2	90	02-03-40	LR	53
191193	0542	2	90	02-03-40	LR	16
091193	0592	2	90	02-03-40	LR	22
271093	0690	1	90	02-03-40	LR	54
051193	0550	1	90	02-03-40	LR	18
171193	0590	2	90	02-03-40	LR	60
101193	0614	1	90	02-03-40	LR	57
051193	0568	2	90	02-03-40	LR	31
041193	0658	1	90	02-03-40	LR	52
151193	0575	2	90	02-03-40	LR	53
091193	0595	1	90	02-03-40	LR	27
051193	0535	1	90	02-03-40	LR	60
041193	0641	2	90	02-03-40	LR	52
101193	0600	2	90	02-03-40	LR	62
081193	0555	2	90	02-03-40	LR	54
031193	0592	2	90	02-03-40	LR	54
081193	0640	1	90	02-03-40	LR	54
121193	0555	1	90	02-03-40	LR	16
081193	0525	1	90	02-03-29	CHE	54
051193	0615	2	90	02-03-33	LP	12
191193	0621	2	90	02-03-33	LP	10
121193	0582	1	90	02-03-33	LP	10
051193	0595	1	90	02-03-33	LP	18
221193	0594	2	90	02-03-34	LP	53
031193	0650	2	90	02-03-35	LP	60
011193	0480	1	90	02-03-35	LP	51
031193	0645	2	90	02-03-36	ER	64
271093	0560	2	90	02-03-36	ER	74
011193	0642	2	90	02-03-36	ER	73
271093	0720	1	90	02-03-36	ER	64
081193	0589	2	90	02-03-36	ER	43
041193	0660	2	90	02-03-36	ER	87
281093	0630	2	90	02-03-36	ER	88
031193	0715	1	90	02-03-36	ER	60
151193	0576	1	90	02-03-37	ER	53
271093	0590	1	90	02-03-37	ER	64
051193	0600	1	90	02-03-37	ER	65
031193	0637	1	90	02-03-37	ER	10
261093	0610	2	90	02-03-37	ER	84
081193	0550	2	90	02-03-37	ER	54
051193	0644	1	90	02-03-37	ER	60
031193	0565	2	90	02-03-37	ER	73
031193	0565	2	90	02-03-37	ER	73
041193	0650	2	90	02-03-37	ER	85

Appendix Table 2 (cont.)

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
011193	0592	1	90	02-03-37	ER	51
051193	0650	1	90	02-03-37	ER	25
191193	0643	2	90	02-03-37	ER	53
101193	0557	2	90	02-03-38	ER	60
161193	0625	2	90	02-03-38	ER	50
171193	0574	2	90	02-03-38	ER	72
171193	0623	2	90	02-03-38	ER	13
081193	0635	2	90	02-03-38	ER	54
031193	0630	2	90	02-03-38	ER	74
151193	0620	2	90	02-03-38	ER	54
021193	0640	1	90	02-03-38	ER	79
081193	0635	2	90	02-03-38	ER	58
011193	0395	0	90	02-03-38	ER	73
081193	0575	2	90	02-03-38	ER	60
021193	0610	2	90	02-03-38	ER	85
051193	0600	2	90	02-03-38	ER	54
011193	0605	2	90	02-03-38	ER	60
051193	0564	2	90	02-03-39	LR	34
151193	0655	2	90	02-03-39	LR	59
121193	0590	2	90	02-03-39	LR	19
171193	0631	2	90	02-03-39	LR	63
011193	0646	2	90	02-03-39	LR	54
031193	0630	1	90	02-03-39	LR	60
151193	0540	2	90	02-03-39	LR	56
051193	0584	2	90	02-03-39	LR	59
281093	0630	1	90	02-03-39	LR	85
101193	0546	2	90	02-03-39	LR	58
051193	0600	2	90	02-03-39	LR	55
031193	0655	1	90	02-03-39	LR	54
101193	0605	2	90	02-03-39	LR	31
081193	0695	1	90	02-03-39	LR	39
051193	0625	2	90	02-03-39	LR	12
171193	0550	2	90	02-03-39	LR	56
171193	0645	2	90	02-03-41	LR	53
041193	0604	2	90	02-03-41	LR	39
081193	0550	2	90	02-03-41	LR	56
171193	0568	2	90	02-03-41	LR	57
121193	0672	2	90	02-03-41	LR	10
051193	0630	1	90	02-03-41	LR	11
121193	0580	1	90	02-03-41	LR	13
121193	0613	2	90	02-03-41	LR	10
161193	0600	1	90	02-03-41	LR	40
081193	0572	2	90	02-03-41	LR	54
101193	0535	1	90	02-03-41	LR	32
021193	0650	1	90	02-03-41	LR	84
051193	0601	2	90	02-03-41	LR	12
021193	0650	1	90	02-03-41	LR	84
051193	0601	2	90	02-03-41	LR	12

Appendix Table 2 (cont.)

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
121193	0601	2	90	02-03-41	LR	34
041193	0621	2	90	02-03-41	LR	41
031193	0650	2	90	02-03-41	LR	59
191193	0510	2	90	02-03-41	LR	57
021193	0640	2	90	02-03-41	LR	75
171193	0613	1	90	02-03-41	LR	56
051193	0554	2	90	02-03-42	LR	59
011193	0575	1	90	02-03-42	LR	55
081193	0590	1	90	02-03-42	LR	55
031193	0612	1	90	02-03-43	LR	10
021193	0555	2	90	02-03-43	LR	80
021193	0595	1	90	02-03-43	LR	85
051193	0555	1	90	02-03-43	LR	54
261093	0590	1	90	02-03-43	LR	85
101193	0670	2	90	02-03-43	LR	30
051193	0670	1	89	02-03-52	ER	60
281093	0750	2	89	02-03-52	ER	87
041193	0696	2	89	02-03-52	ER	40
021193	0700	2	89	02-04-29	CHE	76
091193	0700	1	89	02-05-22	LP	85
051193	0635	2	89	02-05-22	LP	73
081193	0650	2	89	02-05-22	LP	54
081193	0710	2	89	02-05-22	LP	56
051193	0745	2	89	02-05-22	LP	63
091193	0610	2	89	02-05-22	LP	17
081193	0782	2	89	02-05-22	LP	44
041193	0664	2	89	02-05-22	LP	40
051193	0710	2	89	02-05-22	LP	73
261093	0800	1	89	02-06-22	LR	79
091193	0650	2	89	02-06-22	LR	83
281093	0680	2	89	02-06-22	LR	79
021193	0810	1	89	02-06-22	LR	75
051193	0800	2	89	02-06-22	LR	54
121193	0650	2	89	02-06-22	LR	13
081193	0610	1	89	02-06-22	LR	54
051193	0705	1	89	02-06-22	LR	54
081193	0597	2	89	02-06-22	LR	53
171193	0665	2	89	02-06-23	LR	56
091193	0742	2	89	02-06-23	LR	12
291093	0670	1	89	02-06-23	LR	12
011193	0635	2	89	02-06-23	LR	56
041193	0690	2	89	02-06-24	LR	77
011193	0760	2	89	02-06-24	LR	60
021193	0770	2	89	02-06-24	LR	83
091193	0649	2	89	02-06-24	LR	14
081193	0745	2	89	02-06-24	LR	53
041193	0760	2	89	02-06-24	LR	84
091193	0711	2	89	02-06-24	LR	14

Appendix Table 2 (cont.)

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
041193	0605	2	89	02-06-24	LR	76
011193	0765	2	89	02-09-38	ER	65
081193	0585	1	89	02-09-38	ER	54
091193	0797	2	89	02-09-38	ER	82
271093	0780	2	89	02-09-38	ER	64
151193	0707	2	89	02-09-38	ER	53
091193	0692	2	89	02-09-39	ER	65
041193	0750	1	89	02-09-39	ER	80
011193	0625	2	90	02-14-53	CHE	53
011193	0595	2	90	02-14-53	CHE	63
281093	0545	2	90	02-14-54	CHE	82
271093	0650	1	90	02-53-11	MIL	69
041193	0520	1	90	02-53-11	MIL	86
081193	0700	1	88	02-57-50	LP	54
101193	0665	2	89	02-61-03	ER	58
031193	0605	2	89	02-61-03	ER	62
051193	0680	2	89	02-61-03	ER	55
191193	0682	2	89	02-61-03	ER	62
091193	0652	2	89	02-62-55	LP	11
151193	0665	1	89	02-62-55	LP	53
051193	0673	2	89	02-62-55	LP	16
121193	0638	2	89	02-62-56	LP	34
091193	0654	2	89	02-62-56	LP	08
081193	0692	2	89	02-62-56	LP	54
091193	0615	2	89	02-62-56	LP	27
121193	0730	2	89	02-62-57	LP	13
081193	0670	2	89	02-62-57	LP	57
171193	0620	2	89	02-62-57	LP	07
091193	0670	2	89	02-62-58	LP	09
121193	0730	2	89	02-62-58	LP	10
281093	0700	1	89	02-62-61	SAN	84
101193	0192	0	92	18-02-10	LR	57
021193	0330	0	91	18-05-20	ER	81
191193	0380	0	91	18-05-20	ER	53
041193	0368	0	91	18-05-20	ER	52
221193	0352	0	91	18-05-20	ER	53
171193	0387	0	91	18-05-15	ER	56
151193	0392	0	91	18-05-15	ER	53
091193	0440	0	91	18-05-15	ER	73
171193	0426	0	91	18-05-15	ER	59
081193	0648	1	91	18-05-15	ER	54
171193	0340	0	91	18-05-15	ER	54
191193	0335	0	91	18-05-15	ER	56
171193	0339	0	91	18-05-15	ER	63
151193	0355	0	91	18-05-15	ER	73
191193	0408	0	91	18-05-15	ER	20
151193	0370	0	91	18-05-16	ER	59
151193	0350	0	91	18-05-16	ER	59

Appendix Table 2 (cont.)

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
081193	0445	0	91	18-05-16	ER	60
101193	0370	0	91	18-05-16	ER	58
031193	0365	0	91	18-05-16	ER	54
051193	0430	0	91	18-05-16	ER	54
041193	0420	0	91	18-05-16	ER	86
081193	0420	0	91	18-05-16	ER	56
081193	0445	0	91	18-05-16	ER	53
171193	0380	0	91	18-05-16	ER	54
051193	0330	0	91	18-05-16	ER	54
051193	0427	0	91	18-05-17	LR	59
191193	0340	0	91	18-05-17	LR	59
031193	0480	0	91	18-05-17	LR	59
021193	0347	0	91	18-05-17	LR	75
101193	0300	0	91	18-05-17	LR	57
031193	0450	0	91	18-05-17	LR	54
151193	0520	0	91	18-05-17	LR	53
081193	0400	0	91	18-05-17	LR	56
191193	0475	0	91	18-05-17	LR	69
041193	0380	0	91	18-05-17	LR	80
151193	0370	0	91	18-05-18	LR	54
101193	0380	0	91	18-05-18	LR	56
191193	0480	0	91	18-05-18	LR	59
151193	0377	0	91	18-05-18	LR	63
171193	0380	0	91	18-05-18	LR	56
191193	0414	0	91	18-05-19	ER	56
031193	0414	0	91	18-05-19	ER	10
091193	0474	0	91	18-05-19	ER	73
101193	0340	0	91	18-05-21	SEA	53
151193	0400	0	91	18-05-21	SEA	59
081193	0380	0	91	18-05-21	SEA	53
101193	0392	0	91	18-05-21	SEA	57
081193	0390	0	91	18-05-22	SEA	56
101193	0301	0	91	18-05-22	SEA	57
151193	0370	0	91	18-05-22	SEA	54

¹ Sex; 1 - male, 2 - female, 0 - jacks

²Release locations:

ER; early hatchery release (during April)

LR; late hatchery release (during May)

LP; hatchery fish released from pens in Lake Cowichan (during May)

SEA; hatchery fish released from pens in Cowichan estuary (during June)

MIL; hatchery fish released at Millstream Cr.

CHE; hatchery fish released in Chemainus R.

SAN; Cowichan R. hatchery stock transferred to seapen site in Saanich Inlet.

³Recovery locations (refer to Fig. 1):

Appendix Table 3. Tag code data from chinook sampled in the native food fishery, 1993.

Recovery Date	Length (mm)	Sex ¹	BY	Tagcode	Release location ²	Recovery location ³
190993	0220	0	92	18-10-42	LR	B
210993	0590	2	90	02-03-38	ER	H
260993	0620	2	91	18-05-18	LR	H
260993	0400	0	91	18-05-20	ER	H
260993	0430	0	91	18-05-15	ER	H

¹ Sex; 1 - male, 2 - female, 0 - jacks

²Release locations:

ER; early hatchery release (during April)

LR; late hatchery release (during May)

LP; hatchery fish released from pens in Lake Cowichan (during May)

SEA; hatchery fish released from pens in Cowichan estuary (during June)

MIL; hatchery fish released at Millstream Cr.

CHE; hatchery fish released in Chemainus R.

SAN; Cowichan R. hatchery stock transferred to seapen site in Saanich Inlet.

³Recovery locations (refer to Fig. 2)