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A Preliminary Report on the Chinook Productivity Study Conducted on the Cowichan River, 1988 and 1989

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A PRELIMINARY REPORT ON THE CHINOOK PRODUCTIVITY STUDY CONDUCTED ON THE COWICHAN RIVER, 1988 AND 1989

by

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ABSTRACT

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: 53 p.

In 1988, the Biological Sciences Branch, Pacific Biological Station, initiated a study of chinook productivity in the Cowichan River. Major components of this study include: i) enumeration of spawners; ii) estimation of Native food fish catch; iii) hatchery broodstock collection; iv) biological sampling and coded-wire tag (CWT) data. Total returns of adult chinook to the Cowichan River were estimated to be approximately 6,071 in 1988 and 5,000 in 1989. These were considered to be minimum estimates since in both 1988 and 1989 the enumeration fence was washed out due to high water levels prior to the end of the run. Low water flow conditions in the Fall of 1989 added to the uncertainty of this estimate. Fishery Officers estimated adult chinook returns in 1988 to be 5,500 and in 1989 to be 5,000. In addition, a water management plan was initiated by the Department of Fisheries and Oceans, Fisheries Branch, in conjunction with the B.C. Ministry of Environment and Parks and the B.C. Forest Products Ltd., Pulp and Paper Division in Crofton.

RÉSUMÉ

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: 53 p.

En 1988, la direction des Sciences biologiques, Station de biologie du Pacifique, a lancé une étude sur la productivité des quinnats dans la Cowichan. L'étude comportait les volets suivants : i) dénombrement des géniteurs; ii) estimation des prises de la pêche de subsistance autochtone; iii) prélèvement de géniteurs pour la pisciculture; iv) échantillonnage biologique et données fournies par les micromarques. On a estimé la remonte totale des quinnats adultes dans la Cowichan à 6 071 spécimens en 1988 et 5 000 en 1989. On considère qu'il s'agit là d'un minimum étant donné que, en 1988 et 1989, la barrière de démonbrement a été emportée par les hautes eaux avant la fin de la remonte. Le faible débit observé à l'automne 1989 a ajouté à l'incertitude de cette estimation. Les agents des pêches estiment la remonte de quinnats adultes à 5 500 en 1988 et à 5 000 en 1989. Un plan de gestion des eaux a en outre été mis en place par le ministère des Pêches et des Océans, direction des Pêches, de concert avec le ministère de l'Environnement et des Parcs de Colombie-Britannique et la division des pâtes et papiers de la B.C. Forest Products Ltd., à Crofton.

INTRODUCTION

Considerable interest has been focused towards the chinook 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. The Biological Sciences Branch, Pacific Biological Station, has 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. Previous studies were conducted on the Cowichan River during the 1960's and 1970's (Lister et al, 1971; Argue et al, 1979; Lister et al, 1981).

Hatchery production of chinook on the Cowichan River began in 1980 (Cross et. al.,1991). Total chinook fry releases have increased from 64,681 in 1980 to 855,282 in 1989 (Millerd, pers comm). Marked releases began in 1980, and in 1989 approximately 36% of the total number of chinook released were coded-wire tagged.

As an adjunct to this study a special water management plan on the Cowichan River was implemented in 1988 and 1989. The Department of Fisheries and Oceans (DFO), B.C. Ministry of Environment and Parks, and the B.C. Forest Products Ltd., Pulp and Paper Division in Crofton had been negotiating a water flow management plan as part of a Cowichan watershed salmon production plan (K.P.A. Engineering Ltd.,1991). The rationale behind the water plan was to improve chinook escapement by increasing water flow for a short period (5-10 days) at the appropriate time in an attempt to encourage chinook to migrate upstream. These fish may otherwise be obstructed in their upstream migration, due to typically low water levels in the Fall, and suffer pre-spawn mortalities. The construction of an enumeration fence offered a unique opportunity to assess the success of this type of water release strategy.

Chinook salmon (Oncorhynchus tshawytscha) in the lower portion of the Strait of Georgia (excluding the Fraser River) utilized 17 rivers proceeding south from Toba Inlet on the mainland side of Georgia Strait and from the Big Qualicum River south on the Vancouver Island side of Georgia Strait (Farlinger et. al.,1990). The majority of the production from this stock comes from three rivers managed for naturally spawning chinook

(Squamish, Cowichan, and Nanaimo) and from three rivers dominated by hatchery production (Big Qualicum, Little Qualicum, and Capilano). All of the first three rivers managed for natural stocks also have smaller scale hatchery production. Chinook are not native to the Capilano River and have been transplanted from the Big Qualicum River.

Of the three large inlets (Howe Sound, Jervis Inlet and Toba Inlet) on the mainland side of Georgia Strait, only one (Howe Sound: Squamish River and its tributaries) has associated distributional catch information and a relatively complete time series of recorded escapement data. Information pertaining to the chinook populations in the other mainland inlet rivers is very limited but they are assumed to be similar to the Squamish chinook population in terms of their ocean distribution, run timing, and life history strategy. Escapement information from these rivers (six in statistical areas 15 and 16) is highly variable and very few spawners have recently been recorded for these inlet stocks.

The major spawning stocks on Vancouver Island are fall chinook which return to the spawning grounds from mid-August through October. Entry into freshwater is frequently delayed by low water due to summer droughts in this area. Fortunately, the chinook rivers on Vancouver Island are mostly medium-sized rivers that are lake fed and have partial flow control. Spawning normally occurs from late October to mid-November. Squamish chinook have an earlier return timing and are referred to as late-summer migrants, returning from July to September. There are also smaller spring run chinook stocks (entry into fresh water in May to July) in the Nanaimo and the Cowichan Rivers.

The purpose of this report is to present the results and outline the methodology of the productivity study conducted in the Cowichan River during the fall of 1988 and 1989. More detailed analyses will be presented in a subsequent report.

METHODS

Components of the Cowichan River study, conducted in 1988 and 1989, include: i) enumeration of upstream migrant chinook; ii) estimation of Native food fishery catch; iii) recording hatchery broodstock removals; and iv) collection of biological samples and coded-wire tag (CWT) data from the spawning escapement and broodstock.

In previous years, fishery officers estimated total escapement in the Cowichan River on the basis of swim surveys, observation of spawning grounds, and aerial counts (helicopter) of spawners during peak spawning periods. Attempts were made to

keep the timing of these counts comparable from year to year. In 1988 and 1989 we attempted to compare these procedures with our weir counts.

a) Study area

The Cowichan River flows into Cowichan Bay on the east coast of Vancouver Island, British Columbia, approximately 40 km north of Victoria (Fig. 1). The river flows from Cowichan Lake eastward for 50 km into Cowichan Bay. Skutz Falls, 18 km downstream from Cowichan Lake, presented a partial obstruction to salmon migration which was alleviated by fishways constructed in 1956. The Cowichan drainage area is 840 km^2 and carries a mean annual discharge of 55 m^3/sec (Inland Waters Directorate, 1977). Mean monthly discharges range from 117 m^3/sec in December to 8.3 m^3/sec in August. A low-level flow control dam at the outlet of Cowichan Lake, built in 1957, provides a minimum river discharge of 7 m^3/sec. A fishway in the dam permits fish passage to Cowichan Lake. The Cowichan River system supports chinook, coho and chum salmon populations (Neave 1949). Chinook salmon spawn in the main Cowichan River, principally upstream of Skutz Falls.

A community economic development program hatchery (CEDP) is situated alongside the Cowichan River approximately 3 km upstream from Cowichan estuary. The hatchery is managed by the Salmon Enhancement Program, of DFO. The facility began chinook production with the 1979 brood year.

The Cowichan Indian Band, comprised of approximately 600 family units, resides on reserve land that encompasses much of the area surrounding the lower reaches of the Cowichan River. The Indian food fishery for chinook takes place in the form of a spear fishery during the months of June-October.

b) Enumeration of spawning chinook

i) Construction of counting fence:

The enumeration fence was located approximately 3 km. upstream of the estuary (Fig.1) and well below the traditional chinook spawning grounds. In 1988 the fence was made in three main sections. The largest section consisted of modified seine net (76 mm mesh, 46 m long) suspended diagonally across the middle portion of the river from 8 mm galvanized cable. The cable was supported on one end by a 4.9 m steel tower structure that was secured on the river bed and on the other end was fastened to a large tree with a pulley and winch system. The pulley and winch system was used to raise and lower the net when needed. The tower consisted of a 3.6 m steel pole welded to a 6 mm thick steel plate bolted to a 1.2 m upright section of galvanized steel culvert (1.2 m dia). The pole was also secured

to the steel plate by means of three 6 mm guide wires. Two sections of steel angle were welded at the base of the steel culvert to provide additional stability. When the tower was placed in the river, half the culvert was buried in the river bed and the culvert itself was filled with gravel. To provide additional support 8 mm wire cable was fastened from the tower to three trees, one upstream, one downstream and one directly in line with the cable that the net was fastened to. The net was suspended from the cable between the tower and to a point very near the edge of the river upstream of the tower. The net was secured to the river bed by means of sand bags and a lead line attached to the footrope. Between the tower and the river's edge, a 1.8 m high aluminum picket fence was placed along the river bed. This fence was constructed of 13 mm x 13 mm lengths of aluminum conduit spaced 38 mm apart. The fence was made in 2.4 m sections and supported a 45° angle downstream by tripod aluminum braces. The base of the fence was secured with sand bags to provide additional support. Between river bank and the end of the seine net upstream of the tower a second aluminum pick fence structure was placed. The end of the net was fastened to a short section of picket fence also supported at a 45° angle downstream by tripod aluminum braces. The remaining part of the fence was placed upright and a removable 0.9 m wide aluminum gate was built into this section. This structure was also secured by aluminum braces and sand bags. The gate could be opened by sliding it up or down along u-shaped aluminum angle.

To facilitate the counting procedure flashboards were placed on the upstream side of the gate and were secured to the river bed with sand bags. The flashboards were 1.2 m x 2.4 m sheets of 19 mm plywood painted with a high gloss white marine enamel. A wooden 3.6 m high counting tower was built on the river bank adjacent to the gate section. From this vantage point a person had a clear view downstream as well as upstream of the fence. To enhance counting at night, two 500 watt halogen floodlights were placed on top of the counting tower. With the narrow gate opening it was hoped that few fish would go through at a given time to increase accuracy of counts and identification.

In 1989, the only major change to the fence structure was the addition of a fish trap that was intended to be used for capturing broodstock for the hatchery. This fish trap was constructed of pressure treated wood and placed just ahead of the gate so that all fish migrating upstream had to go through the trap. A set of removable panels were used to either trap fish for broodstock or allow fish to freely pass through the trap.

ii) Counting procedures:

In 1988, the main sections of the counting fence were in place by September 9, but the last part, including the gate, was installed September 13. On September 9 observations were made

while working and from September 10 onwards a regular counting schedule was implemented. Initially four 4-hr shifts were scheduled during the daylight hours: dawn-09:30, 09:30-13:30, 13:30-17:30, 17:30-dusk. On the night of September 14 a trial 24 hour watch was tested. From September 20 through to the end of the survey a 24 hour watch was set up. This was accomplished by scheduling six 4-hour shifts. Counts were recorded in fifteen minute intervals for adult and jack chinook, adult and jack coho and chum. If identification was in doubt those fish were recorded in the unknown category. In addition, water depth and temperature data were recorded at the beginning of each shift from September 16 to the end of the survey. A metre stick and thermometer were fastened to the gate section of the counting fence. On a daily basis the net was lowered and leaves and other debris were removed. On a regular basis (every 2 hours) the observer would walk along the net and aluminum fence to check for holes or fish caught in the webbing. Since the net was made with 3" webbing, small jacks sometimes got caught in the net and would have to be released.

In 1989, the fence was installed from Sept. 8-12 and was in place by Sept. 13. From Sept. 17 through till the end of the project (Oct. 22) a 24 hr. watch was in effect. Recording of data was the same as in 1988 except that records of fish collected by the hatchery staff for broodstock were also kept.

iii) Swim surveys:

Since 1980 swim surveys have been conducted by Fishery Officers to estimate the spawning population of chinook in the Cowichan River. Generally, only the top end of the river (Lake Cowichan to an area referred to as "Three Firs" which is approximately 4 miles upstream from Skutz Falls) was surveyed since few fish have been observed below this area (Fig.1). Counts were usually made by 2-3 swimmers equipped with snorkelling gear accompanied by another person in a canoe or boat. The upper stretch of the river was split up into segments (usually associated with pools) and counts were recorded by segment. Total numbers of adult and jack chinook and coho were discussed by the swimmers at the end of each of these segments before the final tally was recorded by the boat man. The total count from the swim survey was then extrapolated for the whole river on the basis of past observations, discussions with Cowichan Indian Band members and "gut feeling" (T. Fields, Fishery Officer, Duncan, pers. comm.). Early in the season (July-Sept) swim counts were multiplied by a factor of 4.8 to get an estimate of the number of fish in the entire river. This was based on a ratio of the length of river observed to the total length of the river and the assumption that at this time of the season fish were spread out evenly throughout the river. Towards the end of the season actual counts were adjusted to total estimates using a factor less than 4.8 assuming that by this time

most of the fish had moved into the upper section of the river. The quality of the data collected was variable and dependent to a great extent on water conditions (depth and clarity). When the opportunity arose and water conditions were good a helicopter flight was used to count chinook on the spawning grounds during peak periods and this count was used to augment the swim survey data.

c) Native food fishery

Prior to 1983 the Indian food fishery was monitored by DFO, and fishery officers would estimate total catch on the basis of their observations and discussions with local Natives. Since then the Cowichan Indian Band established the Cowichan River Management Unit (CRMU) to enforce conservation by-laws on the reserve. The amount of time and resources spent on monitoring the Indian food fish catch varies from year to year and consequently so does the quality of information collected. The River management team regularly patrols the food fishery and collects data to estimate total food fish catch, however their first priority is enforcement. Routine patrols for these activities do not always coincide with the activities of the spear fishermen, who account for virtually all the chinook Indian food catch.

In addition to the River Management unit's observations, a field technician was hired in 1988 by this program, to closely monitor the traditional spear fishery. The technician's responsibilities included the collection of catch and effort data and biological data (length, sex, scale, CWT tag) on the catch. Since this technician was not a member of the Cowichan Indian Band, it was neccesary for him to work in close conjunction with the River Management team and therefore often went along with them on their routine patrols. Because the River Management team worked short shifts and changed work schedules daily it was impossible for the technician to monitor all the days that the spear fishery was open. The intent was to monitor as many of the peak periods of spear fishing as possible whether that occurred during the day or night. No field technician was hired during the 1989 survey.

The River Management unit in conjunction with DFO implemented a net closure for chinook in the river from July to December and reduced the spear fishery from 5 days per week to 3 days from July to September, 1988. This closure was again in effect in 1989.

d) Hatchery component

Information concerning broodstock collection was to be recorded by the Cowichan (CEDP) hatchery staff. Data included the numbers of fish taken for broodstock by sex and location, and the numbers of fish caught but released during broodstock sampling trips.

e) Biological data

Biological data for chinook were to be collected from four sources: i) hatchery broodstock samples; ii) enumeration fence; iii) carcass weir; and iv) Indian food fishery. It was intended that hatchery staff would collect biological data and record the incidence of CWT tagged chinook from broodstock collections. Secondly, those fish that were caught in the net (counting fence) and did not survive, as well as fish that floated downstream into the net were sampled for length, sex, scale, dorsal and pectoral fin, body depth and checked for missing adipose fin by the field crew that manned the enumeration fence. Thirdly, a special carcass weir was constructed in 1988 to collect spawned chinook for CWT sampling purposes. Field crew were scheduled to collect and sample carcasses from the carcass weir on a daily basis. Additional sampling was to be done at main access points along the river where concentrations of spawners were presumed to exist. Due to poor results in 1988 no weir was put in place during the 1989 study. As indicated earlier, a technician was hired in 1988 to collect biological data from the Native food fishery. In addition, this project funded the application of 200,000 coded-wire tags to juvenile chinook at the Cowichan hatchery.

i) Construction of carcass weir:

In 1988 a fence was constructed 8 km below the head of the river to collect spawned chinook carcasses for biological and CWT sampling purposes. A modified seine net was suspended from 8 mm galvanized cable in the same way as the counting fence. The cable was fastened to a sturdy tree on either side of the river with a pulley and winch system on the one side to allow for the net to be lowered when needed. The net was strung across the river at an angle and a 6 m section of the river left open on the upstream side to allow spawning salmon and the occasional canoeist to get by. The net was secured to the river bed by means of sand bags and a lead line on the footrope.

The net was strategically placed just downstream of the section of river where it was believed that the majority of chinook spawned (T. Fields, pers. comm.). Lister (1971) estimated that, based on a helicopter survey in 1964, 80% of all chinook spawned above the falls. Based on carcass recovery data,

Lister (1981) estimated that approximately 76% of the adult chinook and 82% of the jacks spawned above Skutz falls.

f) Water management plan

The basic concept of the Cowichan River water management plan was the reduction of outflow from Cowichan Lake in June and storage of excess water for release in September to aid chinook migration. The goal to increase chinook escapement was to be accomplished by attracting significant numbers of chinook into the river with the sudden increase in water flow, thereby aiding their migration to the spawning grounds. A weir at the head of the Cowichan River that is managed by the B.C. Forest Products Ltd. in conjunction with the B.C. Water Manager, Ministry of Environment, is used to control the water flow in the river so that a constant adequate water supply is available for the B.C. Forest Products Ltd.'s mill in Crofton. The weir can control water flow only up to a certain height, above which water flows freely over the weir gates. In past years, the water flow was managed to a provisional rule curve to maintain a constant water supply to the mill (Fig.2). The possibility existed to make some adjustments to this provisional rule curve for the Cowichan Lake control which would benefit the fisheries resource. It was suggested that a pulse flow of approx. 500-700 CFS be released at the appropriate time. DFO staff in the Duncan sub-district were to be responsible for determining the time of the water release. Criteria used to determine timing included observations regarding the amount of chinook in Cowichan Bay and in the Cowichan estuary, and appropriate tide schedules relative to peak chinook migration times.

RESULTS

a) Escapement estimates

i) Enumeration fence:

Daily counts at the enumeration fence are contained in Table 1 (1988) and Table 2 (1989). In 1988, daily counts were taken from Sept. 10 to Nov. 2 when part of the counting fence was washed away due to high water. Total counts recorded during this period were: 5164 adult chinook; 4244 jack chinook; 9713 adult coho; 1741 jack coho; 2212 chum; and 50 unknown salmon. Peak migration period for both jack and adult chinook occurred between Sept. 26 - Oct. 4 although jacks tended to enter the river a bit earlier. Daily counts were summarized by one hour intervals (Table 3), most chinook passed the fence between 1800 hrs and 0600 hrs the following day.

On Sept. 28 and 29 an independant count was made by a DFO technician at the enumeration fence to determine the accuracy of the counting procedure and species identification. Although only 85 adults and 52 jacks were observed during this period no discrepancies were recorded.

Daily counts for 1989 were taken from Sept. 13 to Oct. 22 when a section of the fence was again washed away due to high water. Total counts recorded during this period were: 1324 adult chinook; 1022 jack chinook; 567 adult coho; 302 jack coho; 60 chum; and 48 unknown salmon. Peak migration occurred between Oct. 1 and Oct. 13. Daily counts were summarized by one-hour intervals (Table 4) and the majority of fish again moved upstream during the same time interval as in 1988.

ii) Swim surveys:

A summary of swim surveys from 1981-1989 is contained in Table 5. Total escapement estimates for each year are for adult chinook only. The 1988 escapement of adult chinook was estimated by Fishery Officers to be 5500. The count for jack chinook on October 3 was considered to be low because of increased emphasis on counting adults. The count of adult chinook during the October 14 swim survey may have been a bit low since some difficulties were experienced in identifying numbers of adults in certain deep pools. No estimate for these deep pools was accounted for in the survey count but it was felt that a lot of these fish were coho (T. Fields, pers. comm.).

The 1989 escapement of adult chinook was estimated by Fishery Officers to be 5000. Five swim surveys were done between Sept. 11 and Nov. 1. During the swim on Nov 1 it was recorded that many fish were missed in the deeper pools because it was too dark to see, and that a number of fish were also missed in the middle of the river. It was also assumed that considerable numbers of chinook moved into the river when the flow rate increased during the week of Oct 20 after a long period of low flows. Based on these observations the swim count was expanded to a total estimate of 5000 chinook.

b) Native food fishery

Estimates of the Native food fish catch of chinook for 1988 and 1989 are listed in Table 6. It should be noted that these are admittedly poor estimates due to insufficient time and effort spent collecting the data (T. Fields, pers. comm.). In 1988 only 11 adult chinook were observed by the DFO technician hired to monitor the Indian food fishery between September 30 and October 21 (Table 7). As indicated earlier, since the technician had to be accompanied by the Cowichan River Management unit (CRMU) while on reserve and since the CRMU's priority was enforcement, close observation of the food fishery was difficult

to accomplish. In addition, the peak period for the chinook spear fishery had passed by the time the technician was hired to monitor the fishery (D. Lowen, pers. comm.).

During both years there were some difficulties experienced in acquiring accurate catch estimates. It was felt, however, that the methodology used to determine total catch was improving and that the 1989 estimate was more accurate that the value for 1988 (W. Paige, CRMU, pers. comm.).

c) Hatchery component

Broodstock collections were made by the Cowichan hatchery staff above and below the enumeration fence (Tables 8 and 9). In 1988 a total of 90 adult males, 42 jacks and 136 female chinook were collected below the counting fence and 202 adults, 28 jacks and 250 females were collected above the fence. A total of 290 adult chinook and 14 jacks were collected in the fish trap at the counting fence in 1989 while 245 adults and 80 jacks were collected elsewhere in the river. A summary of broodstock collection for 1981-1989 is contained in Table 10. Broodstock biosample data are listed in Table 14 (1988) and Table 15 (1989). Predominantly 2 and 3 year old males and 3 and 4 year old females were used for broodstock (Table 22).

d) Biological data

During 1988, 339 chinook were sampled at the enumeration fence site (Table 11). Approximately 88% of these fish were jack chinook. Only one fin-clipped male was recorded. A total of 132 were sampled at the counting fence during 1989 (Table 12), of which only 14 (jacks) were fin-clipped. Very few fish were sampled from the Indian food fishery (Table 13). One fin-clipped male chinook was recorded in this sample.

Length frequencies for carcass recoveries in 1988 are contained in Table 16. Very few fish were collected and the carcass recovery weir did not work as anticipated. Although the weir was strategically placed downstream of the spawning grounds and was in place when presumably the majority of the chinook should have spawned, only a handful of fish were recovered. Part of the problem may have been due to the nature of the river (T. Fields, pers. comm.). The upper portion of the river has many riffles and deep pools and it may be the case that most carcasses are lost in the deep pools and are not swept very far downstream. However, the sampling crew did not find many carcasses at the various access points along the river above and below the carcass weir either. Access points from Lake Cowichan to areas below Skutz falls were monitored. After the middle of November the carcass weir had to be removed due to high water.

e) Water release study

During the spring months outflow from Cowichan Lake was reduced and additional water stored for a timed release in the fall to aid chinook migration. Fig. 2 shows the water level recorded at the weir in Lake Cowichan during 1988 as compared to 1987. In 1988, release of additional water storage occurred on September 24 and increased water flow and height was monitored at the counting fence (Table 17) and at the Water Survey Canada recording station at the Island highway in Duncan (Table 19). Water depth at the counting fence increased by approximately 50% and the flow increased from 5.4 m^3/sec to 11.0 m^3/sec. Counts of chinook migrating upstream significantly increased when the additional water was released in the Cowichan River (Figs. 3 and 4). Coincidentally it rained during the time that the additional water was released. It is unknown whether the rainfall had any significant effect on the upstream movement of chinook.

Due to some difficulties in negotiating the holdback of water in the spring of 1989, there was less water than anticipated for release in the fall. Release of additional water storage occurred on October 1 and increased water flow and height was monitored at the counting fence (Table 18) and at the Water Survey Canada recording station (Table 20). Water depth at the counting fence increased by almost 10 cm. and the flow increased from 5.4 m^3/sec to 8.3 m^3/sec. Counts of chinook migrating upstream increased when the additional pulse of water was released (Figs. 5 and 6). Since there was no rain during this period the additional water released only increased the water depth at the fence for three days, at which time it returned to its previous level and subsequently dropped lower as the dry weather continued.

DISCUSSION

General

The fence was in operation during the time when most chinook were presumed to have entered the river. We have limited data on the numbers that may have entered after or before the fence was in operation. For example, in 1988 only the data from two swim surveys were available to estimate the numbers that were in the river prior to Sept. 10, and no information to determine how many fish may have entered the river after the fence was washed out on Nov 2. Our data suggests that the run was not over when the fence was washed out since considerable numbers of chinook were still passing by the counting tower during the last days of operation. Lister (1971) observed

migration of chinook in 1965 until Oct. 29 and until Nov.7 in 1966. In 1976 (Lister 1981) observations were made until Nov. 24 and in 1977 to Oct. 29. Based on the 1976 survey estimates approximately 18% of the total run of adult chinook and 11% of the jacks were encountered after Nov.2. During both of these previous studies, water flow rates were similar to the flow rates experienced in 1988 and 1989. It should be noted that the location of the counting tower was at Skutz Falls prior to 1977 and at our present site in 1977. In 1989, it was assumed that the fence was again washed out before the run was over and only one swim survey was done prior to the installation of the fence. It is probable that the total number of spawners in 1988 and 1989 was higher than the fence count.

To more accurately estimate total escapement a fence structure will be required that can better adapt to changes in flow rates. With the present setup it was only possible to maintain the fence in relatively low flow conditions. When water flow rates increased combined with an increase in the debris in the river it was impossible to keep the fence clean. When these conditions persisted the fence could not withstand the increased water pressure. It may also be desirable to install the counting fence at an earlier date.

Traditionally, escapement estimates have been the responsibility of the local Fishery Officers. The quality, reliability, and usefulness of the estimates vary greatly. The methodology used to generate these estimates has, in some instances, been inconsistent and the degree to which the estimate has been based on quantitative data varies from year to year (Anon 1986). Others (Shardlow,1987; Cousens et al.,1982) have attempted to review the accuracy of some of these visual counting techniques and noted that most have not been quantitatively validated. The local Officers in Duncan incorporated several factors into the escapement estimate, such as flow rates, migration timing and fish distribution, but did so primarily in a qualitative manner. Although this approach may not provide us with an absolute estimate it may be sufficient to detect trends in escapement.

The error associated with swim counts (problems caused by water clarity, duplicate counting, missed fish, species identification errors) and extrapolation procedures were difficult to estimate. Among the biases typically associated with swim surveys, the procedure used by the Fishery officers to extrapolate swim counts to total estimates warrants some consideration. Selected areas of the Cowichan river were observed during the surveys and then actual counts extrapolated to estimate the total number of chinook in the river. Assumptions concerning the distribution of chinook in the river at the time of the survey have a significant effect on the extrapolation procedure.

Additional time and effort will be required to collect better native food fish catch data. The CRMU has been reviewing the methodology used to estimate native catch but it may take some time before a proper quantitative method will be implemented. It will be advisable to hire a local native to independently collect catch and biological data possibly eliminating the difficulties encountered this year with the neccesity to work during the same hours as the CRMU.

Unfortunately the carcass weir did not recover as many spawned chinook as hoped. High water conditions persisted during November making it very difficult to recover carcasses. Since the river is made of a series of riffles and pools it may be desirable to employ divers to collect carcasses from the deeper pools. It is imperative that a greater proportion of the total run be sampled for the incidence of coded-wire tagged fish in order to properly assess i) hatchery vs wild chinook production, and ii) to determine spawner returns by brood year.

Escapement estimate:

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 amount of fish taken by the Indian food fishery. On this basis we calculate the total return of adult chinook to the Cowichan River from Sept. 10 - Nov. 2, 1988 to be 6071 (Table 21). This is a minimum estimate since these numbers are based on the enumeration fence count and assumes that no chinook were in the river prior to or after the counting fence was in place. According to the swim survey estimates there may have been up to 700 adults in the river prior to the construction of the counting fence. The Fishery officer's estimate for adult chinook based on swim surveys (5500) was slightly less than the fence estimate. We attempted to keep the Fishery officer's escapement estimate independant of the fence count by not passing on any information to them during the course of the season. Even though they did not recieve any data, they did get some general information concerning the run size through casual conversation. To what extent this information effected their escapement estimate is unknown. The number of natural spawners for 1988 was calculated to be 4712 (Table 21). This was based on the fence count minus the chinook adults removed for broodstock above the fence.

In 1989, we calculated the total return of adult chinook to the Cowichan River from Sept. 13 - Oct. 24 to be 2586 based on the available data (Table 21). Estimates from the swim survey on Sept. 11 indicate that there may have been up to 300 adult chinook in the river prior to the installation of the fence. Since the fence washed out early we can assume that the count at the fence did not encompass the entire chinook run.

We note that the escapement estimate based on the fence count for 1989 was considerably less than for 1988 and also less than the 1989 swim survey estimate. Although the fence in 1989 was functional for a shorter time period than in 1988, if we compare the numbers for the same time period (Sept. 13 - Oct. 24) between years we note that in 1989 70% fewer adults and 72% fewer jack chinook were recorded. This may have in part been due to the lower flow rate recorded during Sept./Oct. in 1989 than in 1988. The timing of chinook that enter the Cowichan river may directly be effected by the flow rate. Chinook may remain in the lower river until the water flow increases above a certain threshold before moving to the spawning grounds in the upper section of the river. If this is the case, then an incomplete fence count during low flow conditions, such as in 1989, may seriously underestimate total escapement.

Based on the swim survey data, approximately 2000 adults entered the river after the fence was washed out. We suggest that the total return of adult chinook to the river in 1989 was likely greater than 2586 and probably closer to the swim survey estimate of 5000. The number of natural spawners was calculated to be 996. These should again be considered as minimum estimates. Low water flow conditions followed by a sudden increase in flows add to the uncertainty of these estimates.

Water release study:

No conclusions could be drawn on the effect of the water release strategy on chinook migration. It is unknown what effect the rainfall in 1988 had on the upstream movement of chinook, and the counts in 1989 are too small to be conclusive. Further years of data are needed to adequately assess this strategy.

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Table 1. Daily counts taken at the enumeration fence site, 1988

Date	Chinook		Coho			
	Adult	Jack	Adult	Jack	Chum	Unknown[1]
Sept. 09	0	3	0	0	0	0
10	0	26	0	13	0	0
11	4	27	0	0	0	0
12	0	18	0	0	0	0
13	0	17	0	0	0	0
14	2	31	0	0	0	0
15	5	32	0	0	0	0
16	1	5	0	0	0	0
17	1	7	0	0	0	0
18	3	29	0	0	0	0
19	8	102	0	0	0	0
20	15	58	0	0	0	0
21	44	68	0	0	0	0
22	26	67	0	0	0	0
23	17	66	0	0	0	0
24	9	43	0	0	0	0
25	60	271	0	0	0	0
26	592	676	0	0	0	0
27	264	327	1	2	0	0
28	118	126	1	2	0	0
29	396	186	16	2	1	0
30	516	261	18	1	1	0
Oct. 01	319	244	39	8	0	0
02	180	143	18	14	1	0
03	214	225	14	7	0	0
04	112	70	87	2	0	0
05	98	66	54	14	0	0
06	27	9	31	9	0	0
07	30	29	64	42	1	0
08	79	23	90	45	0	0
09	46	22	40	54	1	0
10	26	14	46	16	0	0
11	52	13	74	19	0	0
12	31	13	52	10	0	0
13	96	14	181	32	1	0
14	64	33	163	71	4	0
15	106	43	136	101	7	0
16	98	43	185	53	16	0
17	62	31	143	48	35	0
18	52	18	177	17	11	0
19	25	16	54	16	3	0
20	269	59	104	54	54	0
21	72	17	64	20	24	0
22	170	92	161	101	14	0
23	46	18	96	42	14	0
24	21	17	119	29	28	0
25	99	71	564	75	40	0
26	63	47	306	108	61	0
27	37	24	78	44	40	0
28	36	20	70	22	80	0
29	31	58	86	86	79	0
30	106	109	438	222	131	0
31	128	39	1631	164	549	0
Nov. 01	257	143	3519	174	848	50
02	31	15	793	15	168	0
Total:	5164	4244	9713	1741	2212	50

[1]Unidentified salmon

Table 2. Daily counts taken at the enumeration fence site, 1989

DATE		CHINOOK ADULT	CHINOOK JACK	COHO ADULT	COHO JACK	CHUM	UNKNOWN[1]
Sept.	13	0	8	0	0	0	1
	14	1	23	0	0	0	0
	15	0	10	0	0	0	0
	16	0	9	0	0	0	0
	17	3	27	0	0	0	0
	18	21	61	55	10	0	0
	19	21	29	27	16	0	10
	20	10	18	2	3	0	0
	21	16	21	13	2	0	0
	22	8	7	7	9	0	0
	23	6	21	5	3	0	6
	24	4	3	8	9	0	5
	25	11	16	15	11	0	6
	26	44	18	6	9	0	6
	27	50	32	10	23	0	0
	28	24	15	9	12	0	4
	29	29	34	2	10	0	0
	30	15	15	3	8	0	4
Oct.	01	28	58	6	0	0	0
	02	104	87	24	16	4	0
	03	26	18	6	6	0	0
	04	20	8	12	1	1	0
	05	12	9	5	3	0	0
	06	28	13	5	3	0	0
	07	8	12	1	10	0	0
	08	27	16	4	4	0	0
	09	42	24	16	19	0	0
	10	40	26	8	5	0	6
	11	145	78	29	30	0	0
	12	86	69	55	3	1	0
	13	34	26	13	9	0	0
	14	6	6	5	7	0	0
	15	16	11	10	4	0	0
	16	27	3	14	3	1	0
	17	60	19	25	15	5	0
	18	68	52	28	11	1	0
	19	70	45	26	8	3	0
	20	75	27	10	2	1	0
	21	61	21	43	5	24	0
	22	78	27	60	13	19	0
	23	0	0	0	0	0	0
	24 NOT OBS.	0	0	0	0	0	0
TOTAL:		1324	1022	567	302	60	48

[1]Unidentified salmon

Table 3. Daily counts by time interval, 1988

Time	Chinook Adult No.	%	Jack No.	%
0000-0100	338	6	270	6
0100-0200	328	6	282	6
0200-0300	419	8	477	11
0300-0400	315	6	276	6
0400-0500	293	6	277	6
0500-0600	437	8	504	12
0600-0700	199	4	214	5
0700-0800	120	2	112	3
0800-0900	118	2	55	1
0900-1000	156	3	70	2
1000-1100	142	3	61	1
1100-1200	95	2	30	1
1200-1300	9	-	13	-
1300-1400	151	3	44	1
1400-1500	81	2	33	1
1500-1600	101	2	72	2
1600-1700	107	2	58	1
1700-1800	173	3	73	2
1800-1900	260	5	72	2
1900-2000	385	7	265	6
2000-2100	262	5	324	7
2100-2200	196	4	217	5
2200-2300	226	4	227	5
2300-2400	253	5	218	5

Table 4. Daily counts by time interval, 1989

Time	Chinook Adult No.	%	Jack No.	%
0000-0100	113	9	128	12
0100-0200	40	3	39	4
0200-0300	93	7	70	7
0300-0400	77	6	70	7
0400-0500	105	8	81	8
0500-0600	82	6	94	9
0600-0700	70	5	53	5
0700-0800	46	3	20	2
0800-0900	12	1	6	1
0900-1000	9	1	6	1
1000-1100	6	-	0	-
1100-1200	6	-	0	-
1200-1300	1	-	0	-
1300-1400	8	1	7	1
1400-1500	9	1	5	-
1500-1600	22	2	14	1
1600-1700	58	4	6	1
1700-1800	28	2	2	-
1800-1900	28	2	12	1
1900-2000	109	8	69	7
2000-2100	121	9	114	11
2100-2200	100	8	66	7
2200-2300	95	7	92	9
2300-2400	86	6	68	7

Table 5. Swim survey data collected for the Cowichan river by fishery officers stationed in the Duncan subdistrict.

			Chinook				
			Jacks		Adults		
	Method[1]	Date	Count	Estimate	Count	Estimate	River Segment[2]
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
Total 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	
Total 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
Total for Season						4500	
1984	S	Aug. 28	80		84	400	2-5
	S	Sept. 6	25		72		
	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
Total 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
Total for Season						3500	
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	
	H	8			515		1-13
Total for Season						1200	

Table 5 (cont'd)

	Method[1]	Date		Chinook Jacks Count	Chinook Jacks Estimate	Chinook Adults Count	Chinook Adults Estimate	River Segment[2]
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
Total 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
Total 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
Total for Season							5000	

[1]S - Swim survey, H - Helicopter survey, F - boat survey
[2]Refer to Fig. 1
[3]Total escapement estimate for adult chinook

Table 6. Indian food fish catch estimates[1] for the Cowichan river.

Year	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

[1]Catch estimates from 1981-82 based on Fishery Officer's observations. Catch from 1983 to present is based on a combination of Fishery Officer observations and Cowichan River Management Unit estimates.

Table 7. Cowichan river Indian food fishery observations, 1988.

Date	Observation[1] Period	No. of Spear Fishermen	No. of Rods	No. of Chinook Observed	Comments
Sept. 30	N	9	0	3	
Oct. 1	N	11	0	1	
4	N	14	0	1	reports of 15 chinook/spear ten days earlier
6	N	13	0	1	
8	N	8	0	-	
12	N	10	0	-	
15	D	25	8	2	fishermen looking for coho, avoiding chinook
19	D	14	4	1	
20	D	3	0	2	
21	D	24	4	-	

[1]D-day N-night

Table 8. Brood stock collection - Cowichan river - 1988[1].

	Below counting fence[2]			Above counting fence			Mortalities[3]	
	M	J	F	M	J	F	M	F
Sept. 26	21	39	4					
27	2		1					
29	14		38					7
30	11		17				1	
Oct. 1	10		22					
2	7	3	11					6
3	3		5					
4	3		8					
5			4					
6	4		10					
7	2		1					
11	2		1	8		24	5	1
12				12		18	3	6
13				8		19		
14				12		18		
15				2		14		
16	5		11					
17	5		1					
19	1		2	3		2	13	9
20				5		20	4	3
24				1		1	9	3
27				14		13	12	11
29				3		3	19	5
Nov. 1				33		11	15	9
2				33		13	2	4
3				7	11	15	10	7
4				23	7	26		
5				32	2	27		
6				1	6	7		
7				2		14	8	12
8				3	2	5	1	2
14							21	5
17							10	
Total:	90	42	136	202	28	250	133	90

[1]Information provided by D. Millerd, Cowichan R. hatchery manager

[2]Broodstock collection for adult males (M), jacks (J) and females (F) above and below enumeration fence

[3]Combined Jacks & Males - mortalities in holding pens. Not necessarily from fish captured that day

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Table 9. Brood stock collection - Cowichan river - 1989[1].

	Below counting fence[2]			At counting fence			Above counting fence			Mortalities[3]	
	M	J	F	M	J	F	M	J	F	M	F
Sept. 28				5	2	3					
29				4	7	Ø					
30				4	Ø	3					
Oct. 1				16	1	9					
2				51	2	42					
3				19	1	13					
4				7	Ø	11					
5	37	7	21	5	Ø	3					
6	16	5	16	3	1	8					
7	7	6	4	1		Ø					
8	1	6	1	4		3					
9	6	4	2	1		4					
10	3	37	33	2		2					
11	3		48			20					
12	Ø	Ø	Ø			30					
13	Ø	Ø	Ø			17				4	
17											5
19											9
24	5	2	4							2	2
25							6		3		
26							5	1	7	1	8
27							Ø	Ø	1		14
31							2	2	1	5	
Nov. 1											12
6											11
8							7	10	1	5	
9							4		1	8	
Total:	78	67	129	122	14	168	24	13	14	25	61

[1]Information provided by D. Millerd, Cowichan R. hatchery manager

[2]Broodstock collection for adult males (M), jacks (J) and females (F) above, at and below enumeration fence

[3]Mortalities in holding pens, not necessarily from fish captured that day. (jacks and adult males combined)

Table 10. Adult chinook escapement used for hatchery broodstock, Cowichan river[1].

Year	No. of fish collected
1981	282
1982	534
1983	242
1984	278
1985	175
1986	315
1987	582
1988	678
1989	535

[1]Barry Cordocedo (SEP, 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 in the Cowichan River.

Table 11. Length-frequency of chinook samples collected at the counting fence site, 1988

Length[2] (cm)	M	F	Length (cm)	M	F
35	1		63	1	
36	0		64	0	1
37	1		65	0	0
38	0		66	0	0
39	0		67	0	0
40	0		67	2	0
41	1		69	1	0
42	1		70	0	0
43	2		71	0	1
44	4		72	1	0
45	7		73	0	0
46	29		74	2	0
47	32		78	0	1
48	30		79	1	0
49	46		81	0	2
50	39		82	1	0
51	39		83	0	1
52	28		84	1	1
53	13		85	0	1
54	10		86	5	2
55	7		87	0	2
56	3		88	1	2
57	2		89	0	2
58	2		90	2	1
60	1		92	0	1
			93	0	2
			95	1	1
			98		1
Total				317	22

[1]One male fin-clipped fish recorded
[2]Hypural length

Table 12. Length-frequency of chinook samples collected at the counting fence site, 1989[1]

Length[2] (cm)	M	F
43	1	
44	3	
45	4	
46	7	
47	12(2)	
48	14	
49	16(2)	
50	25(3)	
51	15(1)	
52	11(2)	
53	13(1)	
54	2(2)	
55	4(1)	
56	2	
57	1	
66	1	
97	1	
Total	132(14)	

[1]Fin-clipped fish are recorded in parenthesis
[2]Hypural length

Table 13. Length frenquency of chinook sampled from the Indian food fishery, 1988

Length[2] (cm)	M	F
55	1	
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		
67		
68		
69		1
70		
71	1	
72		3
73		
74		1
75		1
76		
77		
78		
79		
80		
81	1	1
82		
83		1
84		
85		
Total	3	8

[1]One male fin-clipped fish recorded
[2]Hypural length

Table 14. Length-frequency of 1988 chinook broodstock collected for the Cowichan River hatchery[1].

Length[2] (cm)	M	F	Length (cm)	M	F
30	1		61	5	3
1	3		2	8	4
2	2		3	3	1
3	8		4	8	8
4	10		5	4	15
5	11		6	8	14
6	12		7	7	17
7	20		8	8	29
8	15		9	7	21
9	13		70	5	37
40	8		1	8	30
1	6		2	6	36
2	10		3	7	27
3	6		4	8	30
4	5		5	7	32
5	3		6	5	28
6	7		7	3	11
7	7		8	3	4
8	8		9	6	7
9	5		80	4	5
50	5		1	2	5
1	1		2	3	4
2	8	1	3	0	2
3	6	0	4	1	2
4	2	0	5		1
5	6	1	6		0
6	6	0	7		0
7	11	0	8		0
8	8	2	9		1
9	4	1	90		
60	11	2			
		Totals:		354	381

[1]8 Male fin-clipped fish and 1 female fin-clipped fish recorded in sample

[2]Hypural length

Table 15. Length-frequency of 1989 chinook broodstock collected for the Cowichan River hatchery[1].

Length[2] (cm)	M	J	F	Length (cm)	M	J	F
30		1		61	9		23
1		5		2	10		12
2		4		3	4		22
3		6		4	5		15
4		8		5	4		22
5		6		6	3		19
6	1	13		7	4		15
7	1	6		8	2		18
8	0	9		9	2		6
9	0	9		70	4		16
40	0	11		1	3		16
1	1	6		2	0		14
2	0	5		3	1		12
3	2	4		4	0		15
4	0	3		5	4		8
5	1	1		6	1		11
6	0	2		7	0		7
7	5	0		8	0		4
8	3	0		9	0		5
9	10	1		80	0		1
50	9	0		1	0		1
1	8	0		2	1		1
2	8	1		3			1
3	12		2	4			0
4	12		1	5			2
5	17		3	6			0
6	9		7	7			1
7	16		5	8			1
8	18		10	9			2
9	10		9	90			
60	13		16				
		Totals:			213	101	322

[1]One male, 5 female and 77 jack chinook were fin-clipped
[2]Hypural length

Table 16. Length frequency of chinook carcass recoveries, 1988

Length[1] (cm)	M	F
34	1	
5	1	
6	1	
7		
8		
9		
40		
1		
2		
3	1	
68		1
9		
70		
1		
2		
3		
4		
5	1	
6		
7		
8		
9		
80	1	
Total	6	1

[1]Hypural length

Table 17. Water temperature and depth at the enumeration fence site, 1988[1]

Date (DDMM)		Depth (CM.)	Temp. (DEG.C)
Sept.	15	-	-
	16	54	16
	17	51	14
	18	49	14
	19	50	14
	20	49	14
	21	48	14
	22	49	14
	23	54	14
	24	53	14
	25	65	14
	26	79	14
	27	77	14
	28	75	15
	29	74	14
	30	72	16
Oct.	1	71	15
	2	72	15
	3	71	15
	4	71	16
	5	70	15
	6	68	15
	7	69	16
	8	66	14
	9	67	14
	10	66	14
	11	66	14
	12	60	15
	13	60	15
	14	62	14
	15	60	14
	16	69	14
	17	67	14
	18	67	12
	19	71	13
	20	83	13
	21	82	13
	22	81	13
	23	81	13
	24	76	13
	25	71	12
	26	70	13
	27	69	12
	28	70	10
	29	68	10
	30	71	11
	31	71	12
Nov.	1	75	12
	2	85	12

[1]Water temperature and depth recorded four times daily, mean value listed in table

Table 18. Water temperature and depth at the enumeration fence site, 1989[1]

Date (DDMM)	Depth (CM.)	Temp. (DEG.C)
Sept. 17	42	-
18	42	15
19	42	15
20	42	15
21	42	16
22	42	16
23	41	15
24	41	17
25	41	16
26	43	16
27	42	15
28	42	15
29	42	16
30	42	15
Oct. 1	48	15
2	50	14
3	52	14
4	35	13
5	39	14
6	38	14
7	39	15
8	39	15
9	39	14
10	39	15
11	39	15
12	40	14
13	41	14
14	41	13
15	41	12
16	43	11
17	42	12
18	42	12
19	42	13
20	42	13
21	45	12
22	52	12
23	61	12
24	79	12

[1]Water temperature and depth recorded four times daily, mean value listed in table

Table 19. Daily discharge in cubic metres per second for 1988[1].

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	41.5	64	52.8	72.4	43.7	38.4	5.67	5.57	4.59	14.1	14.3	105
2	38.9	61.0	51.5	77.5	43.8	40.9	6.04	5.76	5.21	13.5	19.6	104
3	36.2	58.7	50.8	106	43.7	49.1	6.19	5.34	4.82	13.1	45.2	101
4	34.4	55.7	51.2	103	42.2	51.8	5.88	4.73	5.90	12.3	55.7	96.7
5	32.9	53.4	54.3	116	41.0	50.9	5.98	4.61	5.87	12.2	106	94.8
6	31.1	51.3	63.9	136	39.3	47.6	5.99	4.49	6.56	11.5	125	97.2
7	30.0	51.2	62.0	125	38.7	46.7	5.99	4.35	5.89	11.1	110	96.8
8	29.4	49.8	64.1	116	37.0	44.5	5.71	4.43	5.31	10.7	107	93.4
9	30.7	52.4	67.4	109	36.3	41.4	5.80	4.61	5.11	10.3	102	88.6
10	33.6	54.2	64.2	103	35.7	39.0	5.76	4.50	4.91	9.74	102	85.7
11	32.6	58.3	61.5	98.2	35.0	36.3	5.73	4.72	4.32	7.48	105	83.8
12	30.8	69.3	58.6	95.6	35.0	32.7	5.75	4.69	4.77	7.63	120	88.2
13	36.0	79.9	55.5	93.0	36.4	29.6	5.87	4.53	5.50	8.27	113	114
14	123	84.4	54.0	90.6	37.7	26.3	5.88	4.53	6.89	8.48	106	104
15	127	99.0	51.4	87.0	37.4	24.5	5.70	4.57	5.08	9.29	100	100
16	109	93.8	49.5	85.0	38.4	24.1	5.65	5.11	5.00	10.5	95.5	94.0
17	99.9	94.7	48.1	82.6	41.7	23.0	5.55	5.15	4.90	8.49	89.1	90
18	92.5	92.5	46.1	79.3	43.7	22.1	5.45	5.04	4.98	8.86	83.9	86.0
19	85.6	87.7	44.2	75.1	44.3	21.0	5.25	4.89	5.39	10.4	86.0	81.0
20	85.7	83.0	47.5	72.3	42.9	19.5	5.25	4.93	5.09	13.2	97.2	77.0
21	82.7	78.9	51.7	68.9	40.7	19.0	5.59	4.73	4.87	13.3	104	74.0
22	81.5	74.5	57.1	63.1	40.9	14.7	5.17	4.83	5.11	13.3	122	71.0
23	79.4	70.5	83.1	59.8	40.6	14.2	5.11	4.72	5.67	13.1	139	69.0
24	75.7	67.6	85.4	55.6	38.7	12.8	5.09	4.74	5.39	13.0	131	66.0
25	71.8	64.2	91.6	51.1	37.6	11.2	4.96	5.34	11.0	12.4	125	63.0
26	68.1	61.4	105	46.9	35.8	9.79	5.13	5.14	16.7	12.6	117	60.0
27	64.8	57.5	96.0	42.7	35.9	7.45	4.97	4.97	17.5	12.0	117	57.0
28	65.8	55.0	89.5	42.2	40.4	6.30	5.21	5.20	16.2	11.6	119	53.0
29	70.3	53.9	85.4	45.3	42.8	5.88	5.69	4.95	15.6	10.9	115	55.0
30	69.7		80.8	45.3	42.7	5.66	5.75	4.52	15.0	11.1	110	61.0
31	67.1		77.1		41.2		5.59	4.14		12.3		68.0
Total	1957.7	1977.8	2001.3	2443.5	1231.2	816.38	173.35	149.83	219.13	346.74	2981.5	2578.2
Mean	63.2	68.2	64.6	81.5	39.7	27.2	5.59	4.83	7.30	11.2	99.4	83.2
Max	127	99.0	105	136	44.3	51.8	6.19	5.76	17.5	14.1	139	114
Min	29.4	49.8	44.2	42.2	35.0	5.66	4.96	4.14	4.32	7.48	14.3	53.0

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

Table 20. Daily discharge in cubic metres per second for 1989[1].

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	69.0	90.0	49.7	65.3	50.8	6.69	7.29	5.99	5.74	6.40	29.5	56.4
2	70.0	84.0	48.2	77.1	48.6	6.73	6.28	5.52	6.10	5.27	28.3	60.2
3	73.0	75.2	45.5	77.6	47.0	6.68	6.55	5.43	7.89	7.78	28.2	90.4
4	85.0	73.4	43.5	80.7	44.4	6.40	6.43	5.51	7.13	5.04	30.8	176.
5	100.	70.5	48.4	98.7	41.8	6.22	6.31	5.41	7.00	4.71	30.2	144.
6	90.0	68.9	58.5	102	41.3	6.26	6.22	5.29	6.78	4.19	30.9	134.
7	82.0	65.7	57.6	106	40.9	6.31	5.99	5.17	6.29	4.08	32.2	130.
8	76.0	62.5	56.2	99.6	40.3	6.40	6.05	5.43	5.85	4.09	35.2	140.
9	72.0	59.3	61.4	94.8	39.1	6.35	5.81	5.54	5.62	4.27	49.7	131.
10	67.0	56.1	77.3	90.6	37.6	6.20	5.87	5.26	5.44	4.48	90.0	121.
11	65.5	53.9	80.7	87.0	36.6	6.35	5.93	5.25	5.30	4.76	90.6	113.
12	65.0	50.6	87.1	83.4	34.2	6.20	6.16	5.17	5.25	5.10	88.3	106.
13	68.0	47.3	84.6	81.0	32.3	6.19	6.09	5.05	5.19	5.37	84.9	100.
14	69.2	43.4	79.3	80.0	32.1	6.15	5.61	5.66	5.14	5.80	81.7	93.9
15	70.4	41.8	74.2	79.6	20.6	6.19	5.59	5.52	4.97	5.91	78.0	86.7
16	81.0	41.1	73.9	76.3	27.6	6.00	5.92	5.58	5.37	5.95	75.2	79.1
17	118.	40.0	70.0	73.0	25.4	6.50	5.85	5.46	5.85	5.84	71.6	73.9
18	131.	38.8	69.2	69.3	23.8	6.43	5.89	5.54	5.40	6.13	67.7	68.9
19	115.	37.5	66.9	66.8	21.5	6.46	5.64	5.52	5.35	6.29	65.9	65.0
20	106.	36.2	63.8	66.9	18.6	6.50	5.54	5.37	5.45	6.17	67.4	61.5
21	102.	35.5	63.7	67.1	16.6	6.40	5.79	5.86	5.37	7.10	68.4	58.4
22	96.7	48.1	63.4	64.6	15.0	6.22	5.56	5.92	5.30	10.2	65.8	54.9
23	91.1	68.2	61.4	63.2	13.7	6.19	5.63	5.67	5.22	15.7	66.8	52.7
24	86.7	64.7	59.8	58.9	11.0	6.23	5.94	5.60	5.26	22.4	69.2	51.6
25	82.0	58.8	58.2	53.0	10.0	6.50	5.76	5.46	5.42	24.2	68.3	49.4
26	77.0	55.0	57.2	52.4	8.46	6.40	5.65	5.61	6.02	29.1	66.4	47.2
27	74.1	52.7	63.1	52.0	7.44	6.18	5.95	5.77	5.71	32.9	64.4	45.0
28	70.6	51.8	66.9	51.0	7.25	6.20	5.93	5.55	5.53	32.5	62.8	42.4
29	67.4		66.2	51.3	6.99	6.22	5.93	5.32	5.49	32.0	61.5	40.4
30	80.0		64.6	51.6	7.05	6.51	5.85	5.42	5.42	31.6	59.2	38.5
31	96.3		66.3		7.14		5.97	5.30		30.6		38.4
Total	2597.0	1574.0	1986.2	2224.8	825.07	190.46	185.02	170.15	171.85	379.13	1809.1	2549.9
Mean	83.8	56.2	64.1	74.2	26.6	6.35	5.97	5.49	5.73	12.2	60.3	82.3
Max	131	90.0	87.1	106	50.8	6.89	7.29	5.99	7.89	32.9	90.6	176
Min	65.0	35.5	43.5	51.0	6.99	6.00	5.54	5.05	4.97	4.08	28.2	38.4

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

Table 21. Total adult chinook returns[1] to the Cowichan R., 1975-1989.

Year	Natural spawner[2]	Brood stock[3]	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	535	1055	2586

[1]Considered to be minimum estimates based on available data. Data for 1975 to 1987 are based on Fishery Officer records, DFO Duncan Sub-District. Data for 1988 to present are based on enumeration fence counts.

[2]Numbers of adults recorded at the enumeration fence minus the adults removed for broodstock above the fence

[3]Total broodstock removed from the river above and below the enumeration fence

Table 22. Age composition of chinook broodstock collected by Cowichan hatchery.

1988

Age	M[1]	F	Percent by age
2	108	-	22%
3	65	9	15%
4	60	238	61%
5	3	3	1%
UNK_2	249		
Total	735		

1989

Age	M[1]	F	Percent by age
2	79	-	16%
3	148	143	59%
4	22	88	22%
5	3	12	3%
UNK_2	144		
Total	639		

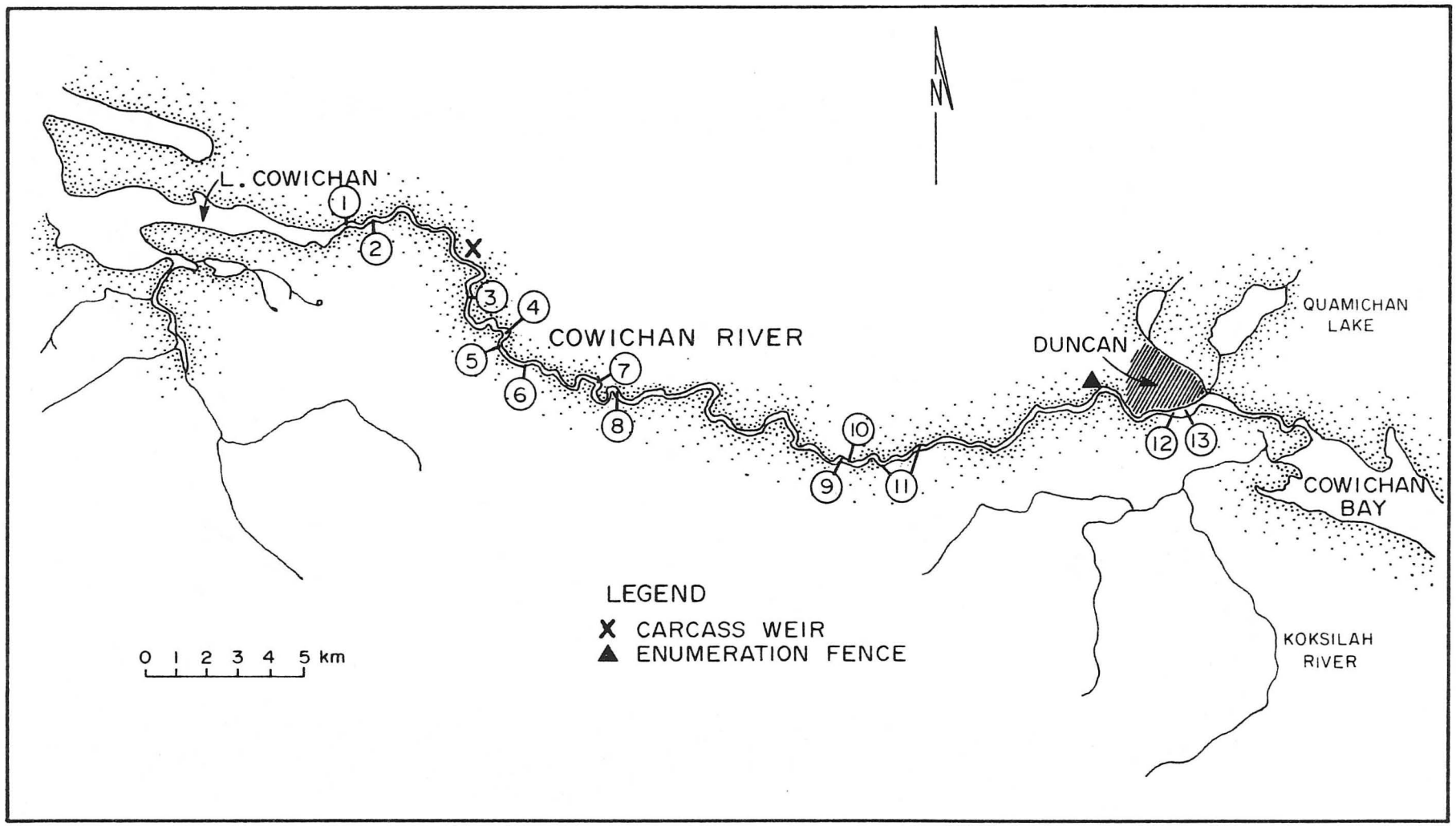
[1]Includes jack chinook
[2]Unreadable scale (due to resorption, regeneration, etc.)

FIGURES

Fig. 1 Map of the Cowichan River.

Legend:

1 - Bird House
2 - Road Pool
3 - 70.2 Block
4 - Old Pickup Site
5 - Maple Tree
6 - Three Firs
7 - Skutz Falls
8 - Marie Canyon
9 - Bible Camp Side Channel
10 - Cowichan Side Channel
11 - Sandy Pool
12 - Sewer Outfall
13 - JC Pool


L. COWICHAN
COWICHAN RIVER
DUNCAN
QUAMICHAN LAKE
COWICHAN BAY
KOKSILAH RIVER
1
2
3
4
5
6
7
8
9
10
11
12
13
N
LEGEND
CARCASS WEIR
ENUMERATION FENCE
0 1 2 3 4 5 km

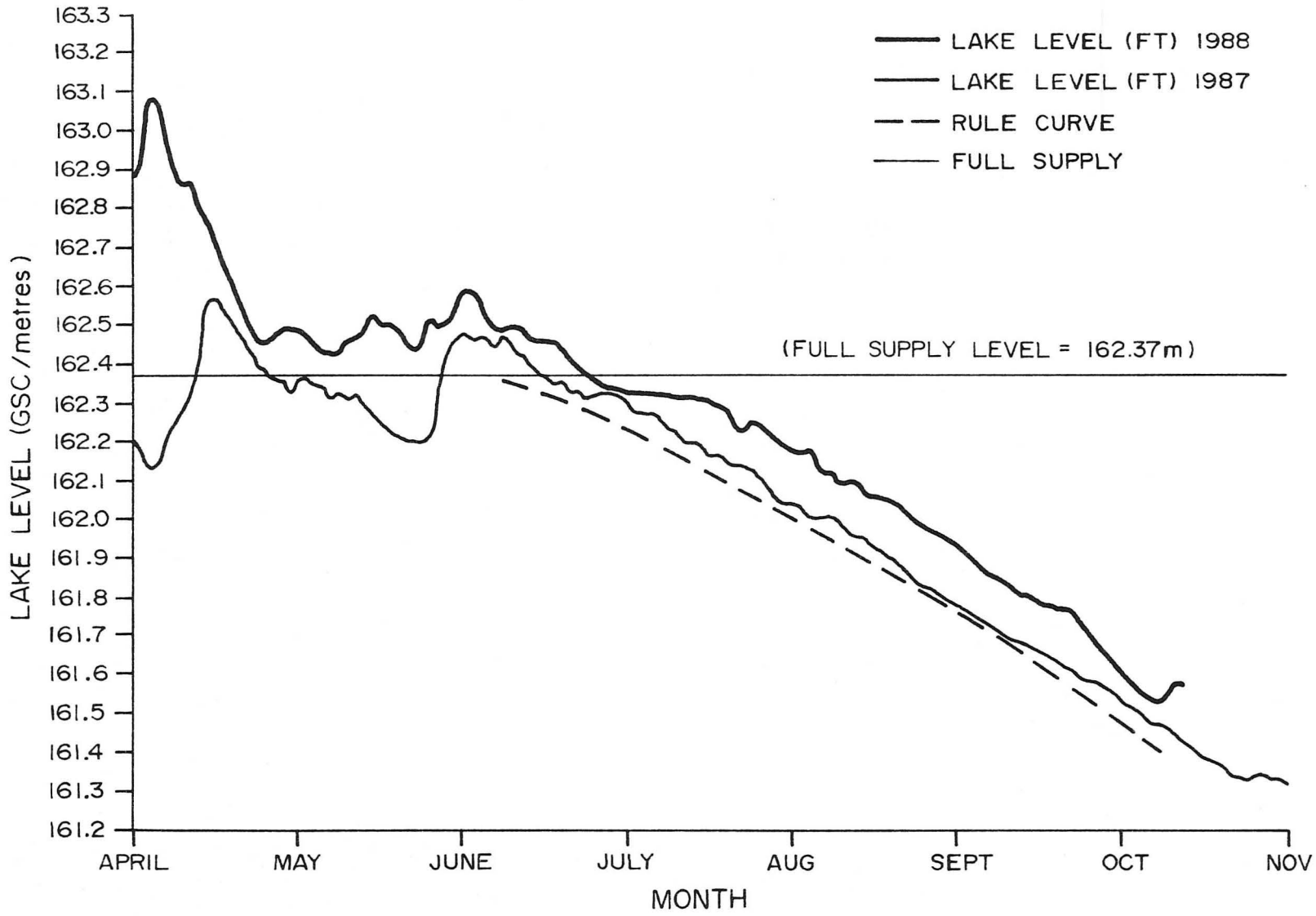


Fig. 2 Water levels recorded at the Cowichan Lake weir for 1988 and 1989.
The Provincial rule curve shows the minimum acceptable water level.

1988 Cowichan River Daily Chinook Counts
Compared with
Daily Flows at the Cowichan Lake Weir

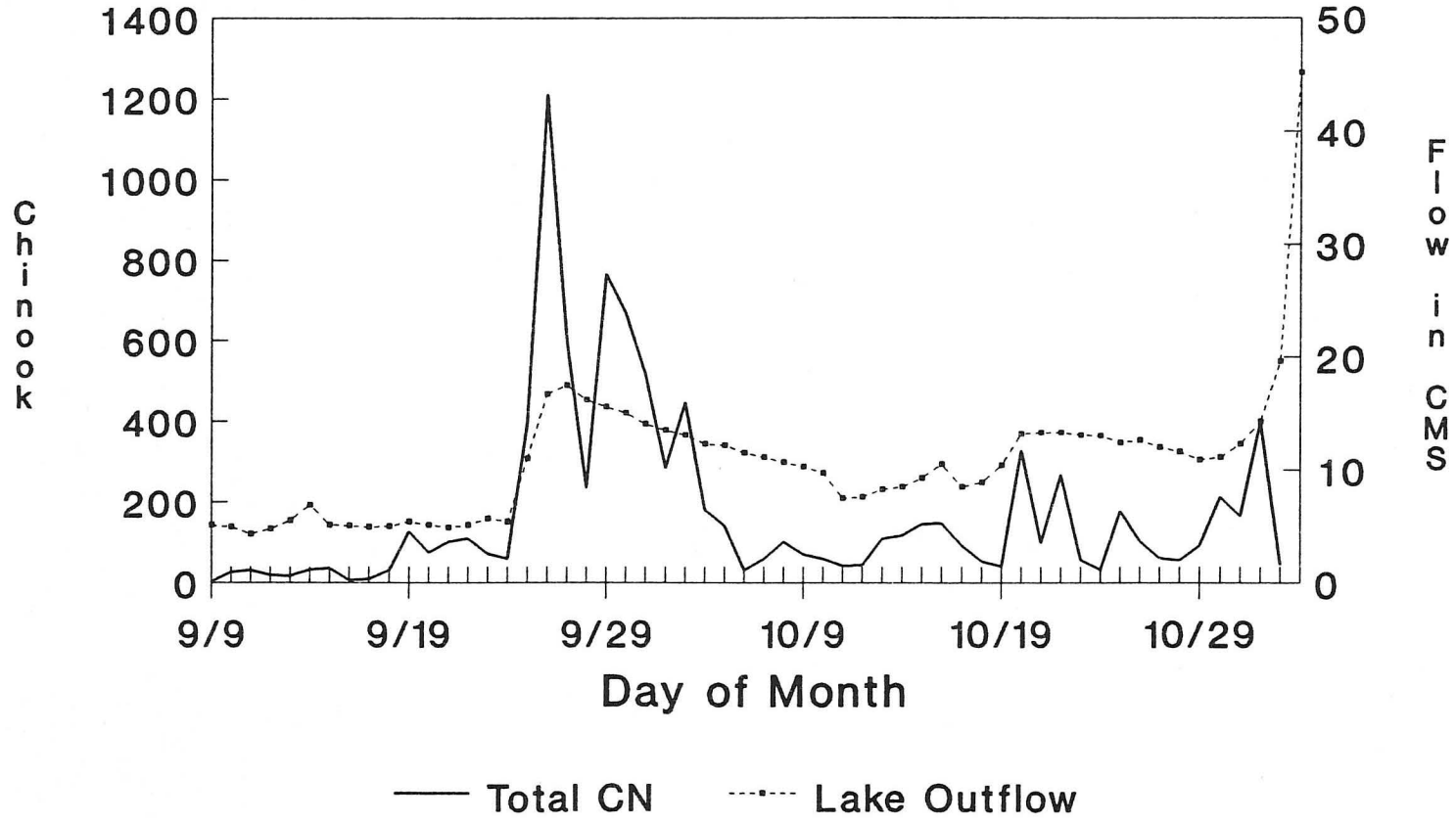


Fig. 3

1988 Cowichan River Daily Chinook Counts
Compared with
Gauge Height at Counting Weir

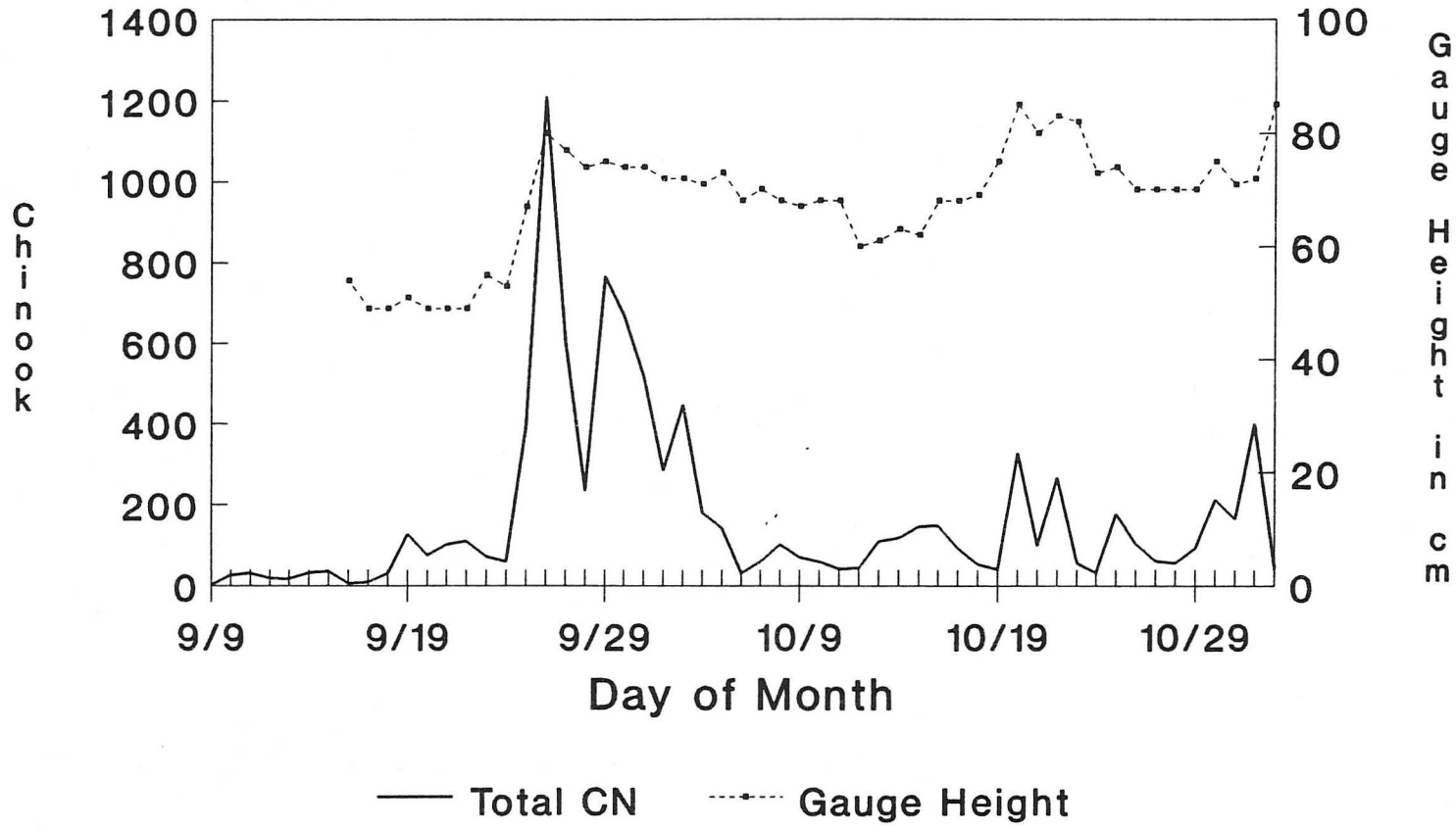


Fig. 4

1989 Cowichan River Daily Chinook Counts
Compared with
Daily Flows at the Cowichan Lake Weir

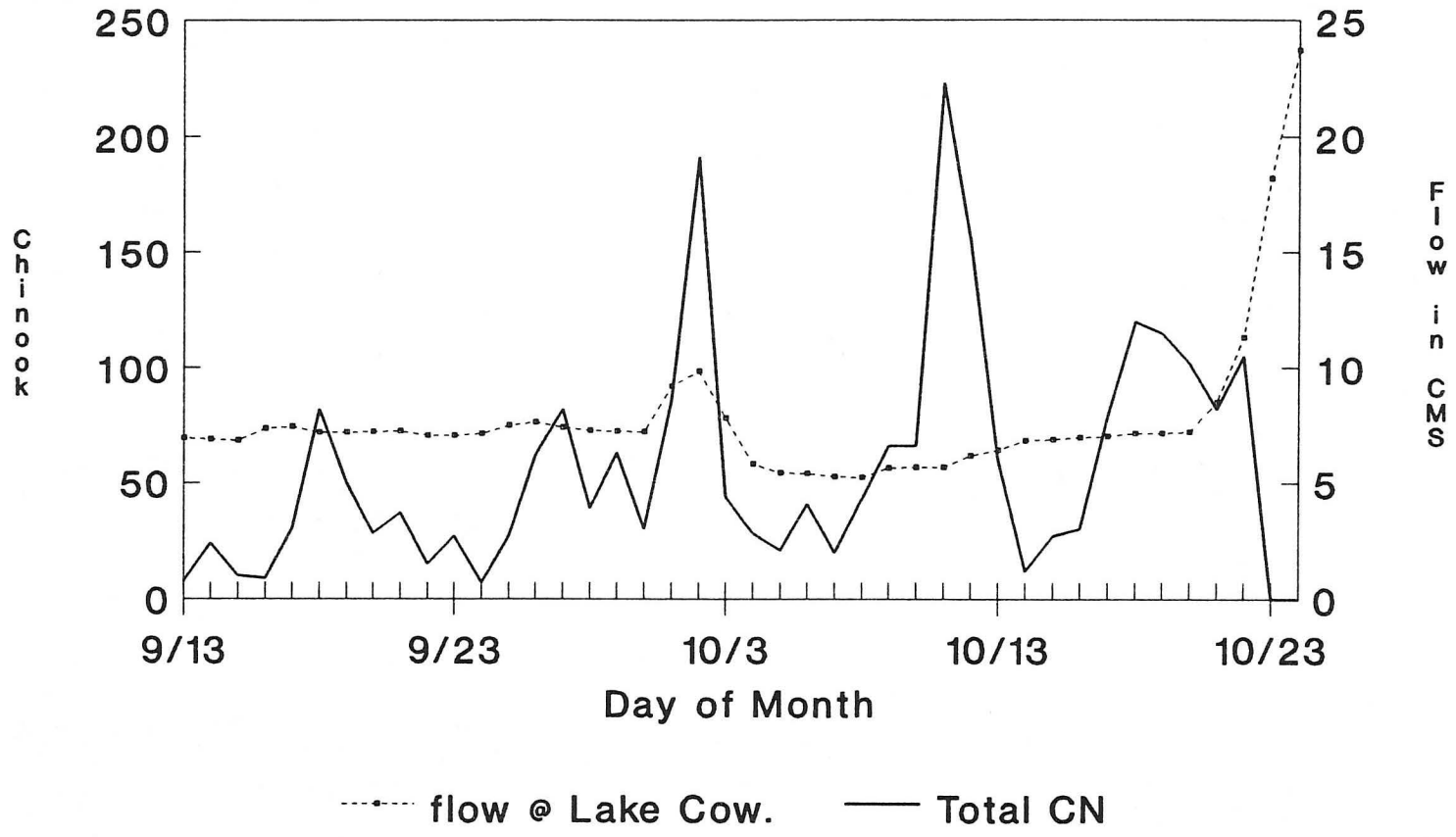


Fig. 5

1989 Cowichan River Daily Chinook Counts
Compared with
Guage Height at Counting Weir

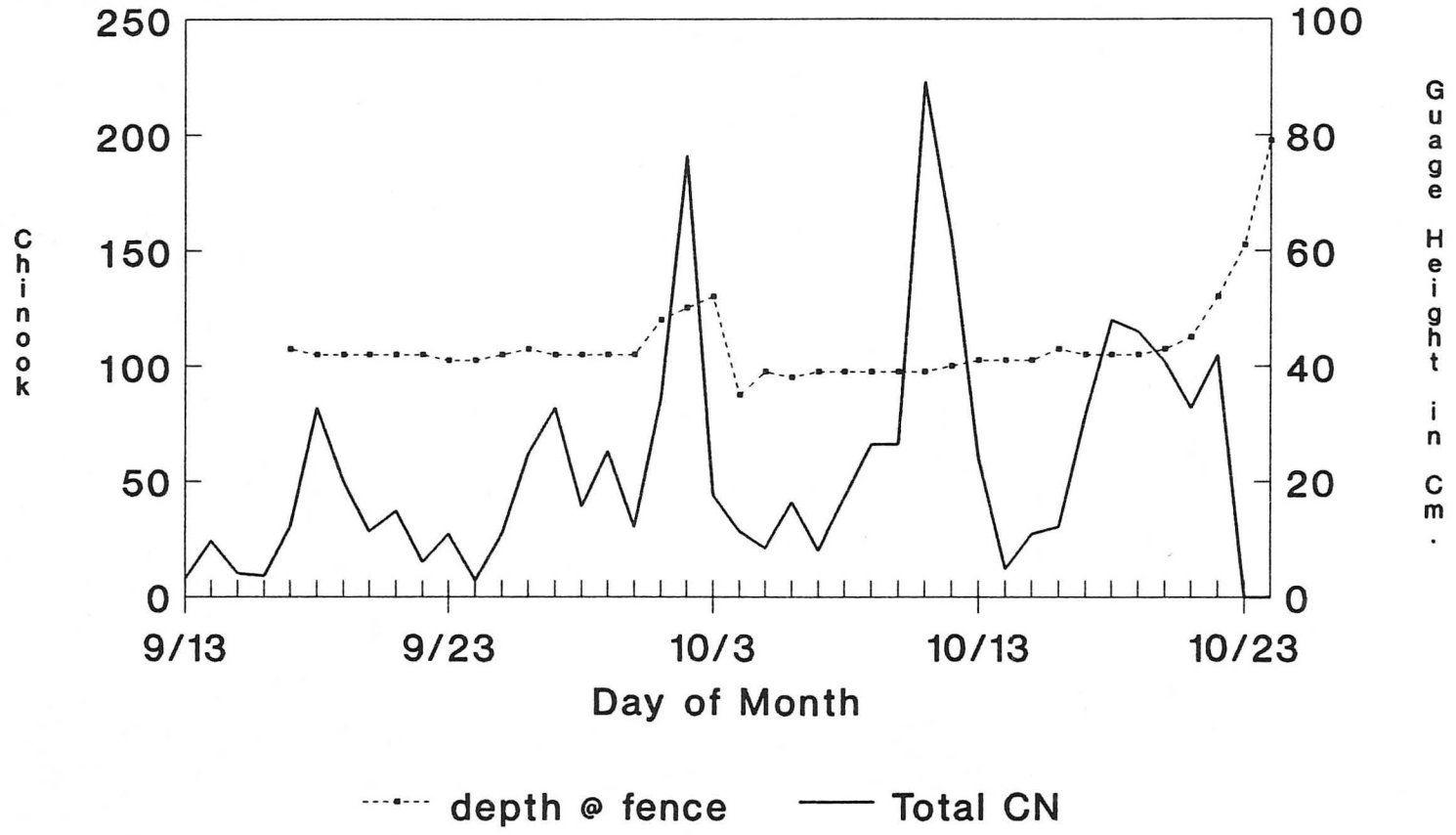


Fig. 6