# A Preliminary Report on Juvenile Chinook Production in the Cowichan River, 1999

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## ABSTRACT

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In 1991, Fisheries and Oceans Canada (DFO), Pacific Biological Station began a study of juvenile chinook salmon (*Oncorhynchus tshawytscha*) productivity in the Cowichan River. The 1999 study is concerned primarily with the enumeration and out-migration timing of naturally-reared chinook juveniles. The estimated production of naturally-reared chinook juveniles from the 1998 brood year was 173,225 (95% CL: 85,159 – 193,718. The release of juvenile chinook from the Cowichan River hatchery totaled 2,543,109. Of these, 2,142,563 hatchery-reared chinook were released above the trapping site. Egg to fry survival for naturally-reared chinook was estimated to be 2.2% (95% CL: 1.08% - 2.47%). Trapping results maintain that most hatchery-reared chinook migrate to the Cowichan estuary within one week of release. Interaction between naturally-reared and hatchery-reared chinook juveniles is therefore believed to be limited.

## RESUME

Nagtegaal, D. A. and E. W. Carter. 2000. A preliminary report on juvenile chinook production in the Cowichan River, 1999. Can Manuscr. Rep. Fish. Aquat. Sci. 2504: 38 p.

En 1991, la Station de biologie du Pacifique de Pêches et Océans Canada a entrepris une étude de la productivité des quinnats juvéniles (*Oncorhynchus tshawystcha*) dans la rivière Cowichan. L'étude de 1999 porte principalement sur le dénombrement et le moment de la dévalaison des quinnats juvéniles sauvages. On a estimé à 173 225 (niveau de confiance à 95 % : 85 159-193 718) la production de quinnats juvéniles de l'année d'éclosion 1998. L'écloserie de la Cowichan a libéré un total de 2 543 109 quinnats juvéniles, dont 2 142 563 en amont de la trappe. Dans le cas des quinnats d'écloserie, on a estimé que la survie de l'œuf jusqu'à l'état d'alevin était de 2,2 % (niveau de confiance à 95 % : 1,08 % à 2,47 %). D'après les résultats obtenus au niveau de la trappe, presque tous les quinnats d'écloserie sont descendus vers l'estuaire de la Cowichan dans la semaine qui a suivi leur libération. Il y aurait donc peu d'interaction entre les quinnats juvéniles sauvages et les quinnats d'écloserie.

## INTRODUCTION

Situated in southeastern Vancouver Island, the Cowichan watershed is one of the most important salmonid producing systems draining into the Strait of Georgia (Candy et al. 1995). Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), chum (*O. keta*), steelhead (*O. mykiss*), cutthroat (*O. clarki*), as well as brown trout (*Salmo trutta*) and dolly varden (*Salmo malma*) spend periods of their life cycle or reside in this system. Historically, the chinook in this system have played an important role in the recreational, aboriginal, and commercial fisheries (Neave 1949). Since 1958 the discharge of the Cowichan River has been controlled by a weir located at the outlet of Lake Cowichan, approximately 50 km upstream from the mouth of Cowichan River (Burns et al. 1988). There have been periods of perceived salmonid population decline that have led to numerous studies (Lister et al. 1971; Candy et al. 1995; Nagtegaal et al. 1994-98).

Recent years have shown a dramatic decrease in the abundance of chinook throughout BC waters. The late 1970's were characterized by peak harvest rates of approximately 750,000 pieces. In the 1980's these rates dropped to numbers less than 25% of their former abundance (Argue et al. 1983).

For this reason, many stock rebuilding initiatives were implemented. In 1979, the Cowichan River Hatchery initiated a chinook enhancement program. Production began with a modest output of less than 70,000 chinook fry and grew to peak production of 3,000,000 smolts (Candy et al. 1996). The hatchery's 1998 brood stock collection was relatively successful. The hatchery managed to produce approximately 2,543,109 chinook smolts (D. Millerd, Cowichan River community economic development hatchery manager, P.O. Box 880, Duncan, B.C.,pers. comm.).

As in previous years, a portion of these hatchery produced chinook were coded-wire tagged. Fisheries managers rely heavily on the information provided by the tagged salmonids to evaluate the strategies for each hatchery program. The data from tag recoveries also provide key information regarding stock migration, harvest rates, and a measure of enhanced contribution to the stock (Nagtegaal et al. 1998). The portion of hatchery produced chinook which were coded-wire tagged (CWT) was 726,063. However, 50,364 smolts in the Early release, 49,743 in the Late release, and 49,685 in the Hatchery release were tagged but not adipose clipped. This was done at the request of the Stock Assessment Division and the Selective Mark Fishery Committee in response to the U.S. mass marking of chinook and the proposed mark only fishery in Puget Sound/Juan de Fuca. Cowichan River chinook were chosen as one of 3 stocks (including Chilliwack and Lower Shushwap) likely to be caught in the proposed fishery and will be considered to be indicators of the impact on other Canadian stocks. Double Index tagging (DIT) will maintain DFO's ability to assess Canadian stocks, by way of pairing a group of CWT tagged chinook with adipose fins clipped (AdCWT) with a chinook group that was only CWT tagged. The ideal selective fishery would be one where there was a significant difference in exploitation rate between the AdCWT group and the CWT group, with only a small difference in survival rate.

In 1985, a chinook rebuilding strategy in conjunction with the Pacific Salmon Treaty, led to the Cowichan's inclusion into a naturally spawning chinook study. Along with the Nanaimo and Squamish River stocks, the Cowichan River was chosen as an escapement indicator to monitor the status of Lower Strait of Georgia chinook stocks and the rebuilding of escapement into these systems (Nagtegaal et al. 1998). The accurate enumeration of chinook migrants is also an important resource management tool. For this reason the results of this ongoing study can be used to assess enhancement strategies and harvest management practices, as well as investigate possible interactions between hatchery-chinook and naturally-reared chinook.

For the purposes of this study, we refer to hatchery fish as those that were spawned and reared in the hatchery environment regardless of parental origin, and naturally-reared fish as those that spawned and reared in the river environment. The naturally-reared juvenile chinook of Cowichan River are considered to be the "ocean-type". This means that they usually migrate to sea within three months of emergence (Healey 1991). Lister et al. (1971) subdivided the Cowichan chinook migrants into two distinct groups. The 'early group' comprises the majority of the migrants and consists mainly of newly emerged fry with an average length of approximately 42 mm. The 'early group' migrates to the estuary in March and April. The 'late group' as described by Lister are larger with lengths averaging over 55 mm. This group may rear in the river system for up to 90 days before migrating to the estuary in May and June. This 'late group' may account for approximately 15% of the total juvenile chinook population.

## METHODS

### STUDY SITE DESCRIPTION

The Cowichan River begins at the Lake Cowichan weir and drains the mountainous slopes of the Vancouver Island range with a watershed area of 840 $km^2$ (Candy et al. 1995). Approximately 40 km north of Victoria, the Cowichan River flows eastward through the City of Duncan, and carries a mean annual discharge of 55 $m^3/s$. Skutz Falls, located 18 km downstream of Lake Cowichan, is a partial obstruction to the upstream migration of chinook spawners (Fig. 1). In 1956 a fishway was built to help alleviate this problem (Lister et al. 1971). The Cowichan chinook spawn primarily in the mainstem, above Skutz Falls.

The rotary trap was placed at the City of Duncan old pumphouse site (Fig. 1). It was assumed that virtually all chinook spawning occurred above this point. Most of the time the trap was located at Site 7B although both sites 7A and 7B were used for this study. This area is a wider section of Cowichan River with canyon walls on one side. Between February 26 and March 17, the rotary trap was moved slightly upstream (7A) and nearer to the shore, therefore decreasing the revolutions per minute (RPM) of the trap in order to reduce damage done to trap construction as a result of high trap RPM.

## FISH CAPTURE

An auger or rotary screw trap, 2.4 m in diameter was used to trap juveniles migrating downstream to the Cowichan Estuary. Fish passing through the cone were collected in a live box. In operation from February 15 to May 27, the trap was held in place by a galvanized steel cable which secured the trap at site 7B (the lower pumphouse site). The trap was set for fishing and then sampled on alternating days. The trap was set at approximately 1900 h and fished continuously until 0700 h the following morning at which time the trapped fish were removed and sampled. The trap was then set again on the following evening after sampling had occurred. During efficiency tests, trapping occurred continuously over 24 hour periods. On efficiency test days the trap was checked at both 0700 and 1900 h to monitor the day and night movement.

All fish captured were enumerated by species and recorded by time period and capture date. Chinook migrants were identified as hatchery or naturally-reared, based on identifiable physical characteristics (size, absence or presence of an adipose fin). Coho were recorded as either fry, one or two year old smolts. Biophysical conditions (water temperature, flow rates, clarity, and weather conditions) were also recorded.

## ABUNDANCE ESTIMATES

Trap efficiency information, using the mark - recapture of Bismarck Brown stained juvenile fish (Ward and Verhoeven 1963), was used to expand the trap catch to estimate total numbers migrating past the trap site. Juvenile chinook and chum were stained, and then released approximately 500 m upstream from the trap site. The number of stained fish recaptured from continuous trapping over the next three to four days was recorded.

The proportion of marked fish recaptured was used to expand the unmarked fish catch and estimate the total number of fish. Mark - recapture estimates were conducted on a biweekly basis.

Trap efficiency was estimated using:

$$Eij = Rij \big/ Mij$$

where:

E is the estimated trap efficiency at site i and sampling week j
R is the number of marked fish recaptured.
M is the number of marked fish released.

Inherent in these efficiency tests were the following assumptions:

*i.* marking of the fish does not affect short term survival of these fish,
*ii.* all marked fish released above the trap site migrate downstream past the trap,

*iii*. marked fish behave the same as unmarked fish, and
*iv*. all recaptured fish were counted.

The total number of fish was estimated by:

$$N_i = U_{ij} \Big/ E_{ij}$$

where:

N is the estimated number of marked fish.
U is the catch of unmarked fish in the trap.

Estimates of daily fish migration were obtained by taking the mean of the days when the trap was in operation to fill in the non-fishing days. For example, when the trap was fishing on Monday and Wednesday, but not on Tuesday the mean catch for the fishing days was inserted for the non-fishing days. Twenty-four hour estimates were extrapolated for the parts of the day when the trap was not in operation. The total abundance estimate was taken from the sum of the daily catch estimates for the duration of the study (Nagtegaal et al. 1997).

The adjusted Petersen estimate (Ricker 1975) was used to obtain confidence limits of trap efficiency. Since there is added uncertainty from using biweekly trap efficiencies, interpolation of unsampled days, and extrapolation for unsampled parts of the day, the confidence limits were considered to be minimum (Nagtegaal et al. 1995; Candy et al. 1996).

## GROWTH

Observations on growth for naturally-reared chinook were obtained by collecting samples from each catch of the rotary trap. Thirty chinook migrants were measured to the nearest mm fork length, and weight was recorded to the nearest one hundredth of a gram.

At the Cowichan River hatchery between 30 to 50 chinook were sampled for each rearing strategy prior to release. Sample data were available for all five hatchery releases.

# RESULTS

## BIOPHYSICAL CONDITIONS

During the study period the discharge of the Cowichan River decreased steadily from 105 $m^3/s$ on February 15 (with a February mean discharge of 118 $m^3/s$) to 75.4 $m^3/s$ on May 27. The mean discharge for March was 91.7 $m^3/s$; for April 54.1 $m^3/s$; and for May 50.9 $m^3/s$ (Inland

Waters Directorate, unpubl.). Flow rates decreased from a high of 2.23 m/s to a low of 0.54 m/s. Water temperatures increased from 6°C to 12°C (Fig. 2).

On a regular basis, there was a build up of small organic debris in the trap. However, when this occurred there was no noticeable difference in the fishing efficiency of the rotary trap.

Water clarity at the trapping site was recorded as clear or cloudy. For the first month and a half of the study it was recorded as cloudy. From April 5 until the end of the study the water was consistently clear with five exceptions (one at the beginning of April, two near the end of April, and two near the end of May). During the time of the study there were only three days where rain was recorded (Table 1).

## MIGRATION TIMING

At the pumphouse 1358 naturally-reared and 15,096 hatchery chinook juveniles were caught in the auger trap (Table 1). Downstream movement of naturally-reared chinook was observed from February 16 (6) to May 27 (5). The downstream movement of hatchery chinook was observed from March 31 (3962) to May 26 (141). It was understood that the hatchery fish released in the upper river would have reached the trapping site within approximately one week of their release date (Nagtegaal et al. 1998). Naturally-reared chinook migration peaked in the beginning of April (Fig. 3) and this was typical migration timing for the Cowichan River.

## HATCHERY RELEASES

Cowichan River Hatchery had three releases 30 km above the trapping site during the study. There was no overlap in the size range between the hatchery fish and the naturally-reared fish during the first release.

Prior to the second hatchery release, the sampled size of naturally-reared fish was still less than the hatchery fish. However, with the migration of the '90-day' chinook smolts (Lister et al. 1971) there may have been some overlap in size making it difficult to distinguish larger naturally-reared fish from smaller hatchery-reared chinook, especially in the absence of adipose clips.

A total of approximately 2,142,563 hatchery-reared chinook were released above the trapping site (Table 2). Of these fish 250,447 received coded-wire tags (CWT). The early release group (approximately 899,742 fish) was released in the upper Cowichan River on March 31 at the Road pool site. The late release (529,686) occurred on May 10, at the Lake Cowichan Weir site. The lakepen release (713,135) occurred on May 5 at the Lake Cowichan Lakepen site. A hatchery release (300,618) and seapen release (99,928) occurred on May 10 and May 17, respectively. In total the rotary trap caught 87 adipose-clipped hatchery-reared fish.

## TRAP EFFICIENCIES AND ABUNDANCE

At the lower pumphouse site (7B), the mean trap efficiency (Table 4) for naturally-reared chinook was calculated to be 0.23% (Fig. 4). The mean efficiency for all tests was determined to be 3.41%. At the upper pumphouse site efficiency tests were not conducted.

We estimated the total number of naturally-reared chinook migrants in Cowichan River to be 173,225 (95% CL: 85,159–193,718 ) and the number of hatchery-reared chinook to be 1,225,949 (95% CL: 971,172–1,589,046 ). Reports from the Cowichan River Hatchery indicated that a total of 2,142,563 were released above the trapping site.

## DIEL MIGRATION

This year's study did not include a continuous 24-hour trapping component to determine diel migration. For this reason all assumptions of diel movement were obtained from previous studies. The only daytime trapping occurred in conjunction with the trap efficiency tests. These scanty results indicated that the majority of chinook migrants were caught in the over-night sampling, rather than the day-time hours. Additional 24-hour trapping sessions must be completed in order to obtain a more confident estimation of diel migration patterns.

## GROWTH

During the study period, growth rates (mean length and weight) of naturally-reared chinook juveniles changed little until the end of April (Appendix 1). Mean length was consistently recorded at approximately 40 mm and mean weight at .45 - .55 gm. The early release hatchery fish were much larger, with a mean length of 66 mm and weight of 3.07 gm (Appendix 2). This size difference should have made them easily distinguishable from the naturally-reared chinook.

Toward the end of the study, the size of naturally-reared fish showed a length and weight increase, however, subsample sizes were much smaller than in previous sampling (N= 1 to 15). The late hatchery release fish had a mean length of 83 mm and a weight of 6.56 gm (Fig. 5). The lack of an experienced crew may have led to some chinook juveniles being incorrectly identified as hatchery or naturally-reared.

## CODED-WIRE TAG RECOVERIES

During the study, 87 hatchery chinook juveniles out of the total hatchery capture (15,183) were identified as being adipose-clipped (coded-wire tagged). This number represents 0.57% of the total number of hatchery chinook caught in the trap, or .01% of the total number of coded-wire tagged hatchery releases.

# DISCUSSION

## ABUNDANCE ESTIMATES

Approximately 173,225 naturally-reared chinook migrated from Cowichan River in 1999 (95% CL: 85,159-193,718). This estimate did not take into consideration the migration of chinook prior to the installation of the rotary trap or after the study ended. It has been reported (Lister et al. 1971) that there is a later migration of juveniles that peaks in June.

This late migration of chinook has been observed in the Cowichan Lake coho study conducted on the Cowichan River during years prior, however, this study was not carried out in 1999. In past years, the study was conducted using a modified fyke net approximately two kilometers downstream from the Road pool in order to catch smolts.

In his report on the Cowichan River, Neave (1949) discusses a spring run of chinook that spawned primarily around the Cowichan Lake tributaries. He postulated that these spring run fish were near extinct in his time. Whether these populations of chinook are remnants of a spring run or directly related to the lake pen release strategy is unknown.

Chinook abundance estimates using the Bismarck Brown stain to calculate trap efficiency may be biased low. The assumption that stained fish have the same capture rate as unmarked migrant chinook may be untrue. The stained fish have endured more handling and stress associated with the marking process. Therefore, swimming ability and behavior of these fish may be affected and translate into lower recapture rates (Nagtegaal et al. 1997). According to Frith et al. (1995), not all released marked fish are available for recapture. Some fish are lost to predation, disease or residualization.

Water turbidity or clarity would likely affect trap avoidance by migrating chinook. Increased turbidity may decrease the ability of the migrants to avoid capture. Clarity combined with lower flow rates may have the opposite effect, increasing the ability of migrants to avoid capture. During the first month and a half of the study, the water was cloudy, this may have increased capture rates of migrating chinook. Water temperatures rose from 6°C to 12°C during the course of the study.

Flow rates during recapture periods ranged from a high of 2.23 m/s on February 22 to a low of 0.54 m/s on March 12. Flow rates remained relatively low throughout the duration of the study (between 0.50 m/s – 1.50 m/s). Low flow rates and other discharge dynamics, in combination with the cone rotation, may affect the efficiency of the trap (Frith et al. 1995).

For this study it was assumed that trap efficiencies for naturally-reared and hatchery-reared chinook were different. The efficiency information for naturally-reared chinook was obtained through Bismarck Brown efficiency tests conducted through the course of the study. For hatchery-reared chinook, data from the 1995 study were used.

Efficiency tests from other studies (Thedinga et al. 1994, Roper and Scarnecchia 1996) indicate that there are considerable differences in trap efficiencies between species, flow rates and fish size. Biophysical factors such as low flow and clarity along with the use of trap efficiencies for hatchery chinook from previous years may partially account for the low bias in this year's estimate. Wetherall (1970) submitted that higher survival rates of migrants were observed with larger fish and high flows (discharges), while fingerling in stream discharges less than 20 $m^3/s$ had lower survival rates.

Trap efficiencies may be affected by the stream characteristics in which the trap is placed. Site 7B is located in a riffle or run section of the pumphouse site, while site 7E is located in an upstream pool. Roper and Scarnecchi (1996) stated that hatchery-reared fish were often able to avoid a trap in a low velocity riffle area, however, when the trap was positioned at the head of a pool they were often caught. Since sites 7A and 7B were used for this study, the difference in trap avoidance from a low velocity riffle area and the head of a pool was not applicable to this study.

Although considerable research has focussed on understanding the physiological and genetic aspects of chinook emigration, much less information exists on the factors affecting the timing of these migrations. According to Seelbach (1985) and Roper and Scarnecchi (1996), key factors that affect hatchery fish migration timing are size and time of outplanting and water velocities. Roper and Scarnecchi (1998) compared magnitude and emigration timing of chinook juveniles in the South Umpqua River with adult escapemjent and four environmental factors. They determined that the magnitude of adult escapement was closely related to the magnitude of juvenile production and that lunar cycle, photoperiod and stream temperature were key factors affecting the timing of emigration.

A possible reason for the low bias is the misidentification of hatchery fish as naturally-reared fish. An inexperienced crew may account for this. It is interesting to note that on the last day of trapping (May 26), 141 hatchery-reared chinook smolts were captured, indicating that the migration of the late hatchery release (May 10) was not over.

## EGG TO FRY SURVIVAL

To estimate the egg to fry survival rate, an accurate assessment of adult spawners, the percentage of females in the escapement, the average fecundity, and juvenile outmigration are needed. In 1998, the number of chinook natural spawners was estimated to be 4,371. The proportion of females was determined to be 47%, or 2,054. The average fecundity from broodstock biosample data was determined to be 3,826. With this information, the total egg production was estimated to be 7,858,604 (Fig. 6).

The estimated abundance of naturally-reared chinook fry was extrapolated to be 173,225. The egg to fry survival was therefore estimated to be 2.02% (95% CL: 1.08% - 2.47%). This estimate is comparable to survival rates from previous surveys in 1992 - 1994 (Nagtegaal et al.

1997), but is much lower than either the rates experienced in 1995-97 or the estimates of Healey (1991) who reported chinook egg to fry survivals ranging from 8% to 16%.

The differences in survival rates among years may be attributed to many factors ranging from biophysical conditions, chum escapements and spawner distribution (Nagtegaal et al. 1997). Spawner distribution in 1998 was consistent with 1994 and 1995 (most chinook spawning occurred in the middle section of the river) and low chum escapements in recent years seem to have enhanced the egg to fry survival rate (Nagtegaal et al. 1998). However, the low egg to fry survival rate in 1999 (Fig. 7), could be attributed to above average flow in both November and December of 1998. These high flows result in scouring of spawning beds and therefore loss of developing chinook fry. Montgomery et al. (1995) determined that the depth of stream bed scouring due to discharge levels was directly related to egg survival.

## JUVENILE CHINOOK GROWTH

The length - weight sampling during the study showed little increase in average size of naturally-reared chinook until after April 27. Growth information obtained from April 23 to the end of the study is questionable due to smaller subsample sizes. It is unlikely that subsample sizes ranging from 1 to 15 provided accurate population representations.

According to one participant at the trapping site, the identification of naturally-reared versus hatchery chinook became more difficult after the late hatchery release since the length of naturally-reared fish had increased. It is likely that there was an overlap in fish sizes and the incorrect identification of hatchery fish as naturally-reared chinook may have occurred as a result.

## JUVENILE CHINOOK INTERACTION

Some level of interaction between the early naturally-reared chinook (Lister et al. 1971) and hatchery-reared chinook in Cowichan River seems likely. Approximately 85% of the naturally-reared chinook head to the estuary upon emergence and the peak migration of these chinook occurred in early April, approximately the same time as the first hatchery release on March 31. Figure 3 shows that the first hatchery release occurred in the middle of the peak migration of naturally-reared chinook. Thus some interaction between hatchery and naturally-reared chinook migrants was highly possible.

The late hatchery release occurred on May 10. By this time the majority of 'early' chinook migrants had already passed the trapping site, and capture rates of these naturally-reared chinook had decreased substantially. Possible interactions between hatchery released chinook and the 'late' larger migrants could occur even if the hatchery fish move quickly to the estuary upon release, as Candy et al. (1996) indicated. The small numbers of hatchery fish released and the assumed small population of 'late' migrants would suggest a very limited amount of interaction.

## ACKNOWLEDGEMENTS

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Table 1. Rotary screw trap catch data at the pumphouse location, Cowichan River, 1999.

| Set date (DDMM) | Site | W | Temp | Clarity | Sampling Date | Start Time | CNW | CNH | CNC | CM | COF | CO1 | CO2 | BB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15-02 | 7B | 2 | 6C | 2 | 16-02 | 7:30 | 6 | | | 1 | | 2 | | |
| 19-02 | 7B | 2 | 6C | 2 | 20-02 | 8:30 | 16 | | | | 1 | 1 | | |
| 26-02 | 7B | 2 | 5C | 2 | 27-02 | 7:40 | 19 | | | 8 | | 2 | | |
| 01-03 | 7B | 2 | 6C | 2 | 02-03 | 7:25 | 8 | | | 4 | | | | |
| 03-03 | 7B | 2 | 7C | 2 | 04-03 | 7:20 | 7 | | | 9 | | 1 | | |
| 05-03 | 7B | 1 | 6C | 2 | 06-03 | 7:30 | 13 | | | 10 | | 1 | | |
| 08-03 | 7B | 1 | 6C | 2 | 09-03 | 7:20 | 28 | | | 11 | | 2 | | |
| 10-03 | 7B | 2 | 7C | 2 | 11-03 | 7:00 | 32 | | | 16 | | 5 | | |
| 12-03 | 7B | 3 | 5C | 2 | 13-03 | 7:15 | 45 | | | 23 | | 1 | | |
| 15-03 | 7B | 1 | 4C | 2 | 16-03 | 7:15 | 26 | | | 33 | 1 | 1 | | |
| 17-03 | 7B | 1 | 5C | 2 | 18-03 | 7:15 | 115 | | | 222 | 20 | 25 | | |
| 19-03 | 7B | 1 | 6C | 2 | 20-03 | 7:15 | 78 | | | 525 | 33 | 28 | | |
| 22-03 | 7B | 2 | 6C | 2 | 23-03 | 8:00 | 67 | | | 1230 | 2 | 14 | | |
| 24-03 | 7B | 1 | 6C | 2 | 25-03 | 7:15 | 45 | | | 1048 | 13 | 24 | 3 | |
| 26-03 | 7B | 1 | 7C | 2 | 27-03 | 7:15 | 45 | | | 1095 | 2 | 13 | 1 | |
| 29-03 | 7B | 1 | 7C | 2 | 30-03 | 7:15 | 59 | | | 1352 | 16 | 6 | 2 | 6 CM |
| 29-03 | 7B | 2 | 7C | 2 | 30-03 | 19:15 | 32 | | | 261 | 2 | 2 | | |
| 30-03 | 7B | 2 | 7C | 2 | 31-03 | 7:15 | 75 | | | 2086 | 14 | 4 | 1 | |
| 31-03 | 7B | 1 | 8C | 2 | 31-03 | 19:15 | 10 | 3962 | | 310 | 1 | | | |
| 02-04 | 7B | 1 | 8C | 2 | 03-04 | 7:15 | 70 | 600 | 12 | 3094 | 48 | 17 | | |
| 05-04 | 7B | 1 | 9C | 1 | 06-04 | 7:30 | 127 | 99 | | 5481 | 86 | 14 | | |
| 07-04 | 7B | 2 | 8C | 2 | 08-04 | 7:15 | 63 | 19 | | 8817 | 43 | 12 | | |
| 12-04 | 7B | 1 | 9C | 1 | 13-04 | 7:15 | 87 | 28 | | 16538 | 224 | 34 | | |
| 14-04 | 7B | 1 | 10C | 1 | 15-04 | 19:15 | 30 | 13 | | 12260 | 122 | 21 | | 2 CNW; 9 CM |
| 15-04 | 7B | 1 | 10C | 1 | 15-04 | 7:15 | | 1 | | 347 | 6 | 5 | | |
| 16-04 | 7B | 1 | 10C | 1 | 16-04 | 19:15 | 2 | | | 429 | | | | |
| 19-04 | 7B | 1 | 10C | 1 | 17-04 | 19:15 | 25 | 5 | | 9285 | 79 | 21 | | |
| 21-04 | 7B | 3 | 9C | 1 | 20-04 | 19:15 | 45 | 18 | | 4929 | 356 | 51 | | |
| 23-04 | 7B | 1 | 9C | 2 | 22-04 | 7:15 | 42 | 19 | | 5597 | 359 | 63 | | |
| 26-04 | 7B | 1 | 11C | 1 | 24-04 | 19:10 | 12 | 10 | | 3156 | 86 | 38 | | |
| 28-04 | 7B | 1 | 10C | 1 | 27-04 | 19:15 | 9 | 7 | | 1790 | 89 | 70 | | |
| 29-04 | 7B | 1 | 10C | 2 | 29-04 | 19:30 | 3 | 6 | | 1040 | 38 | 71 | | |
| 29-04 | 7B | 1 | 11C | 1 | 29-04 | 7:15 | | | | 53 | 1 | 2 | | |
| 30-04 | 7B | 1 | 11C | 1 | 30-04 | 7:15 | 3 | 8 | | 955 | 24 | | | 13 CM |
| 30-04 | 7B | 1 | 11C | 1 | 01-05 | 7:15 | 5 | 2 | | 1063 | 31 | 25 | | |
| 03-05 | 7B | 1 | 11C | 1 | 04-05 | 7:15 | 16 | 6 | 1 | 2154 | 356 | 94 | | |
| 05-05 | 7B | 2 | 11C | 1 | 06-05 | 7:15 | 4 | 5 | | 750 | 238 | 76 | | |
| 07-05 | 7B | 2 | 10C | 1 | 08-05 | 7:00 | 4 | 3061 | 30 | 943 | 334 | 56 | | |
| 10-05 | 7B | 1 | 11C | 1 | 11-05 | 7:15 | 9 | 2350 | | 351 | 107 | 3 | | |
| 12-05 | 7B | 1 | 11C | 1 | 13-05 | 7:15 | 17 | 1901 | | 388 | 222 | 9 | | |
| 14-05 | 7B | 1 | 11C | 1 | 15-05 | 7:15 | 12 | 288 | | 360 | 227 | 1 | | |
| 17-05 | 7B | 3 | 11C | 1 | 18-05 | 7:15 | 26 | 956 | 3 | 994 | 361 | 5 | | |

Table 1 (cont'd)

| Set date (DDMM) | Site | W | Temp | Clarity | Sampling Date | Start Time | CNW | CNH | CNC | CM | COF | CO1 | CO2 | BB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19-05 | 7B | 2 | 11C | 1 | 20-05 | 7:00 | 5 | 868 | 22 | 287 | 179 | 16 | | |
| 21-05 | 7B | 1 | 11C | 2 | 22-05 | 7:00 | 11 | 723 | 19 | 137 | 143 | 15 | | |
| 26-05 | 7B | 1 | 12C | 2 | 27-05 | 7:00 | 5 | 141 | | 83 | 147 | 11 | | |
| TOTAL: | | | | | | | 1358 | 15096 | 87 | 89525 | 4011 | 862 | 7 | |

**Legend:**

CC - sculpin
CM - chum
CNC - chinook adipose clip
CNH - chinook hatchery
CNW - chinook, wild
CO1 - coho smolt
CO2 - coho 2yr old
COF - coho fry
CT - cutthroat
LL - lamprey
P - perch
RB - rainbow trout
SB - stickleback
SK - sockeye
ST - steelhead
STH - steelhead, hatchery
STW - steelhead, wild

Clarity - 1 Clear
2 Cloudy

Weather - 1 Clear
2 Cloudy
3 Raining

Temp - Water temperature

Table 2. Cowichan hatchery chinook release data, 1999.

| Release Code | Total Released | Tag Code | CWT Tagged | % Tagged | Release Date | Length (mm) | | | Weight (gm) | | | Condition Coefficient |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Mean | Min | Max | Mean | Min | Max | |
| **EARLY** | **899742** | | **100658** | **11%** | | | | | | | | |
| | | 18-37-28 | 25147 | | 31-Mar-99 | 66.66 | 56 | 77 | 3.07 | 1.40 | 5.02 | 1.04 |
| | | 18-37-29 | 25147 | | | | | | | | | |
| | | 18-31-07 | 25182 | | | | | | | | | |
| | | 18-31-08 | 25182 | | | | | | | | | |
| **Lakepen** | **713135** | | **50271** | **7%** | | | | | | | | |
| | | 18-37-26 | 25136 | | 5-May-99 | 80.76 | 65 | 91 | 5.93 | 2.92 | 8.66 | 1.11 |
| | | 18-37-27 | 25135 | | | | | | | | | |
| **Late** | **529686** | | **99518** | **19%** | | | | | | | | |
| | | 18-37-30 | 24888 | | 10-May-99 | 83.88 | 69 | 108 | 6.56 | 2.84 | 14.26 | 1.11 |
| | | 18-37-31 | 24887 | | | | | | | | | |
| | | 18-31-09 | 24872 | | | | | | | | | |
| | | 18-31-10 | 24871 | | | | | | | | | |
| **Hatchery** | **300618** | | **100021** | **33%** | | | | | | | | |
| | | 18-37-32 | 25168 | | 10-May-99 | 83.82 | 71 | 98 | 6.31 | 3.19 | 9.90 | 1.07 |
| | | 18-37-33 | 25168 | | | | | | | | | |
| | | 18-31-11 | 24843 | | | | | | | | | |
| | | 18-31-12 | 24842 | | | | | | | | | |
| **Seapen** | **99928** | | **25127** | **25%** | | | | | | | | |
| | | 18-37-34 | 25127 | | 17-May-99 | 77.24 | 67 | 93 | 5.10 | 2.73 | 9.24 | 1.11 |
| **Total** | **2543109** | | **726063** | **29%** | | | | | | | | |

**Total Released above Trap Site:** **2142563**

**Release Sites:**

Early- upper Cowichan R. (Road Pool)*
Lakepen- Lake Cowichan above the weir (Lakepen site)*
Late- upper Cowichan R. (below weir)*
Hatchery- released directly from Hatchery
Seapen- released from seapens in Cowichan Bay

* indicates that these fish are released above trapping site

Table 3. Expanded daily trap catch estimates at the Cowichan River pumphouse site, 1999.

| Naturally reared | | | | | |
|---|---|---|---|---|---|
| Date | Observed | Missing cells Interpolated | 24-hour Estimates | Extrapolated Estimates | Cumulative Total |
| 16-Feb | 6 | | 7 | 242 | 242 |
| 17-Feb | | 11 | 12 | 443 | 685 |
| 18-Feb | | 11 | 12 | 443 | 1128 |
| 19-Feb | | 11 | 12 | 443 | 1571 |
| 20-Feb | 16 | | 18 | 644 | 2215 |
| 21-Feb | | 17 | 19 | 685 | 2900 |
| 22-Feb | | 17 | 19 | 685 | 3584 |
| 23-Feb | | 17 | 19 | 685 | 4269 |
| 24-Feb | | 17 | 19 | 685 | 4954 |
| 25-Feb | | 17 | 19 | 685 | 5639 |
| 26-Feb | | 17 | 19 | 685 | 6323 |
| 27-Feb | 19 | | 21 | 765 | 7088 |
| 28-Feb | | 13 | 15 | 524 | 7612 |
| 01-Mar | | 13 | 15 | 524 | 8136 |
| 02-Mar | 8 | | 9 | 322 | 8458 |
| 03-Mar | | 7 | 8 | 282 | 8740 |
| 04-Mar | 7 | | 8 | 282 | 9022 |
| 05-Mar | | 10 | 11 | 403 | 9424 |
| 06-Mar | 13 | | 15 | 524 | 9948 |
| 07-Mar | | 20 | 22 | 806 | 10753 |
| 08-Mar | | 20 | 22 | 806 | 11559 |
| 09-Mar | 28 | | 31 | 1128 | 12687 |
| 10-Mar | | 30 | 34 | 1208 | 13895 |
| 11-Mar | 32 | | 36 | 1289 | 15184 |
| 12-Mar | | 38 | 43 | 1530 | 16714 |
| 13-Mar | 45 | | 50 | 1812 | 18527 |
| 14-Mar | | 35 | 39 | 1410 | 19936 |
| 15-Mar | | 35 | 39 | 1410 | 21346 |
| 16-Mar | 26 | | 29 | 1047 | 22393 |
| 17-Mar | | 70 | 78 | 2819 | 25212 |
| 18-Mar | 115 | | 129 | 4632 | 29844 |
| 19-Mar | | 96 | 108 | 3866 | 33710 |
| 20-Mar | 78 | | 87 | 3141 | 36852 |
| 21-Mar | | 72 | 81 | 2900 | 39752 |
| 22-Mar | | 72 | 81 | 2900 | 42651 |
| 23-Mar | 67 | | 75 | 2698 | 45350 |
| 24-Mar | | 56 | 63 | 2255 | 47605 |
| 25-Mar | 45 | | 50 | 1812 | 49418 |
| 26-Mar | | 45 | 50 | 1812 | 51230 |
| 27-Mar | 45 | | 50 | 1812 | 53042 |
| 28-Mar | | 68 | 76 | 2739 | 55781 |
| 29-Mar | | 68 | 76 | 2739 | 58520 |
| 30-Mar | 91 | | 102 | 3665 | 62185 |
| 31-Mar | 85 | | 95 | 3423 | 65608 |
| 01-Apr | | 77 | 86 | 3101 | 68709 |
| 02-Apr | | 77 | 86 | 3101 | 71811 |
| 03-Apr | 70 | | 78 | 2819 | 74630 |
| 04-Apr | | 98 | 110 | 3947 | 78577 |

Table 3 (cont'd)

| Date | Observed | Missing cells Interpolated | 24-hour Estimates | Extrapolated Estimates | Cumulative Total |
|---|---|---|---|---|---|
| 05-Apr | | 98 | 110 | 3947 | 82524 |
| 06-Apr | 127 | | 142 | 5115 | 87639 |
| 07-Apr | | 95 | 106 | 3826 | 91465 |
| 08-Apr | 63 | | 71 | 2537 | 94002 |
| 09-Apr | | 75 | 84 | 3021 | 97023 |
| 10-Apr | | 75 | 84 | 3021 | 100044 |
| 11-Apr | | 75 | 84 | 4200 | 104244 |
| 12-Apr | | 75 | 84 | 4200 | 108444 |
| 13-Apr | 87 | | 97 | 4872 | 113316 |
| 14-Apr | | 59 | 66 | 3304 | 116620 |
| 15-Apr | 32 | | 36 | 1792 | 118412 |
| 16-Apr | | 28 | 31 | 1568 | 119980 |
| 17-Apr | 25 | | 28 | 1400 | 121380 |
| 18-Apr | | 35 | 39 | 1960 | 123340 |
| 19-Apr | | 35 | 39 | 1960 | 125300 |
| 20-Apr | 45 | | 50 | 2520 | 127820 |
| 21-Apr | | 43 | 48 | 2408 | 130228 |
| 22-Apr | 42 | | 47 | 2352 | 132580 |
| 23-Apr | | 27 | 30 | 1512 | 134092 |
| 24-Apr | 12 | | 13 | 672 | 134764 |
| 25-Apr | | 10 | 11 | 560 | 135324 |
| 26-Apr | | 10 | 11 | 560 | 135884 |
| 27-Apr | 9 | | 10 | 504 | 136388 |
| 28-Apr | | 5 | 6 | 280 | 136668 |
| 29-Apr | 3 | | 3 | 168 | 136836 |
| 30-Apr | 3 | | 3 | 168 | 137004 |
| 01-May | 5 | | 6 | 280 | 137284 |
| 02-May | | 10 | 11 | 560 | 137844 |
| 03-May | | 10 | 11 | 560 | 138404 |
| 04-May | 16 | | 18 | 896 | 139300 |
| 05-May | | 10 | 11 | 560 | 139860 |
| 06-May | 4 | | 4 | 224 | 140084 |
| 07-May | | 4 | 4 | 224 | 140308 |
| 08-May | 4 | | 4 | 224 | 140532 |
| 09-May | | 6 | 7 | 336 | 140868 |
| 10-May | | 6 | 7 | 336 | 141204 |
| 11-May | 9 | | 10 | 504 | 141708 |
| 12-May | | 13 | 15 | 431 | 142138 |
| 13-May | 17 | | 19 | 563 | 142701 |
| 14-May | | 15 | 17 | 497 | 143198 |
| 15-May | 12 | | 13 | 398 | 143596 |
| 16-May | | 19 | 21 | 629 | 144225 |
| 17-May | | 19 | 21 | 629 | 144855 |
| 18-May | 26 | | 29 | 861 | 145716 |
| 19-May | | 15 | 17 | 497 | 146213 |
| 20-May | 5 | | 6 | 166 | 146379 |
| 21-May | | 8 | 9 | 265 | 146644 |
| 22-May | 11 | | 12 | 364 | 147008 |
| 23-May | | 8 | 9 | 265 | 147273 |

Table 3 (cont'd)

| Date | Observed | Missing cells Interpolated | 24-hour Estimates | Extrapolated Estimates | Cumulative Total |
|---|---|---|---|---|---|
| 24-May | | 8 | 9 | 265 | 147538 |
| 25-May | | 8 | 9 | 265 | 147803 |
| 26-May | | 8 | 9 | 265 | 148068 |
| Total: | 1317 | | | 148234 | |

Table 3 (cont'd)

Hatchery-reared:

| Date | Observed | Missing cells Interpolated | 24-hour Estimates | Extrapolated Estimates | Cumulative Total |
|---|---|---|---|---|---|
| 30-Mar | | | 0 | 0 | 0 |
| 31-Mar | 3962 | | 4199 | 194405 | 0 |
| 01-Apr | | 2281 | 2417 | 111923 | 0 |
| 02-Apr | | 2281 | 2417 | 111923 | 0 |
| 03-Apr | 600 | | 636 | 29440 | 29440 |
| 04-Apr | | 349 | 369 | 17125 | 46565 |
| 05-Apr | | 349 | 369 | 17125 | 63689 |
| 06-Apr | 99 | | 104 | 4858 | 68547 |
| 07-Apr | | 59 | 62 | 2895 | 71442 |
| 08-Apr | 19 | | 20 | 932 | 72374 |
| 09-Apr | | 23 | 24 | 1129 | 73503 |
| 10-Apr | | 23 | 24 | 1129 | 74631 |
| 11-Apr | | 23 | 24 | 1129 | 75760 |
| 12-Apr | | 23 | 24 | 1129 | 76888 |
| 13-Apr | 28 | | 29 | 1374 | 78262 |
| 14-Apr | | 21 | 22 | 1030 | 79292 |
| 15-Apr | 14 | | 14 | 687 | 79979 |
| 16-Apr | | 9 | 9 | 442 | 80421 |
| 17-Apr | 5 | | 5 | 245 | 80666 |
| 18-Apr | | 12 | 12 | 589 | 81255 |
| 19-Apr | | 12 | 12 | 589 | 81844 |
| 20-Apr | 18 | | 19 | 883 | 82727 |
| 21-Apr | | 18 | 19 | 883 | 83610 |
| 22-Apr | 19 | | 20 | 932 | 84543 |
| 23-Apr | | 14 | 14 | 687 | 85230 |
| 24-Apr | 10 | | 10 | 491 | 85720 |
| 25-Apr | | 8 | 8 | 393 | 86113 |
| 26-Apr | | 8 | 8 | 393 | 86505 |
| 27-Apr | 7 | | 7 | 343 | 86849 |
| 28-Apr | | 6 | 6 | 294 | 87143 |
| 29-Apr | 6 | | 6 | 294 | 87438 |
| 30-Apr | 8 | | 8 | 393 | 87830 |
| 01-May | 2 | | 2 | 98 | 87928 |
| 02-May | | 4 | 4 | 196 | 88125 |
| 03-May | | 4 | 4 | 196 | 88321 |
| 04-May | 6 | | 6 | 294 | 88615 |
| 05-May | | 5 | 5 | 245 | 88861 |
| 06-May | 5 | | 5 | 245 | 89106 |
| 07-May | | 5 | 5 | 245 | 89351 |
| 08-May | 3061 | | 3244 | 150195 | 239547 |
| 09-May | | 2705 | 2867 | 132727 | 372274 |
| 10-May | | 2705 | 2867 | 132727 | 505001 |
| 11-May | 2350 | | 2491 | 115308 | 620310 |
| 12-May | | 2125 | 2252 | 104268 | 724578 |
| 13-May | 1901 | | 2015 | 93277 | 817855 |
| 14-May | | 1094 | 1159 | 53680 | 871535 |
| 15-May | 288 | | 305 | 14131 | 885666 |
| 16-May | | 622 | 659 | 30520 | 916186 |

Table 3 (cont'd)

| Date | Observed | Missing cells Interpolated | 24-hour Estimates | Extrapolated Estimates | Cumulative Total |
|---|---|---|---|---|---|
| 17-May | | 622 | 659 | 30520 | 946706 |
| 18-May | 956 | | 1013 | 46908 | 993614 |
| 19-May | | 912 | 966 | 44749 | 1038364 |
| 20-May | 868 | | 920 | 42591 | 1080954 |
| 21-May | | 795 | 842 | 39009 | 1119963 |
| 22-May | 723 | | 766 | 35476 | 1155439 |
| 23-May | | 432 | 457 | 21197 | 1176636 |
| 24-May | | 432 | 457 | 21197 | 1197833 |
| 25-May | | 432 | 457 | 21197 | 1219030 |
| 26-May | 141 | | 149 | 6919 | 1225949 |
| Total: | 11134 | | 26484 | 1225949 | |

Table 4. Trap efficiency data, pumphouse site, Cowichan River, 1999.

**Pumphouse Site:**

| Date | Flow | Released | | | Recovered | | | % Recovered | |
|---|---|---|---|---|---|---|---|---|---|
| | | Chinook | Chum | Coho | Chinook | Chum | Coho | Chin/Chum | Expansion factor |
| 29-Mar | 10428 | 41 | 261 | 1 | | 6 | | 1.98% | 50.50 |
| 14-Apr | 11295 | 81 | 206 | | 2 | 9 | | 3.83% | 26.09 |
| 29-Apr | 18999 | | 284 | 5 | | 13 | | 4.50% | 22.23 |
| Total: | | 122 | 751 | 6 | 2 | 28 | | 3.41% | 29.30 |
| | | | | | Chinook only: | | | 0.23% | 61.00 |

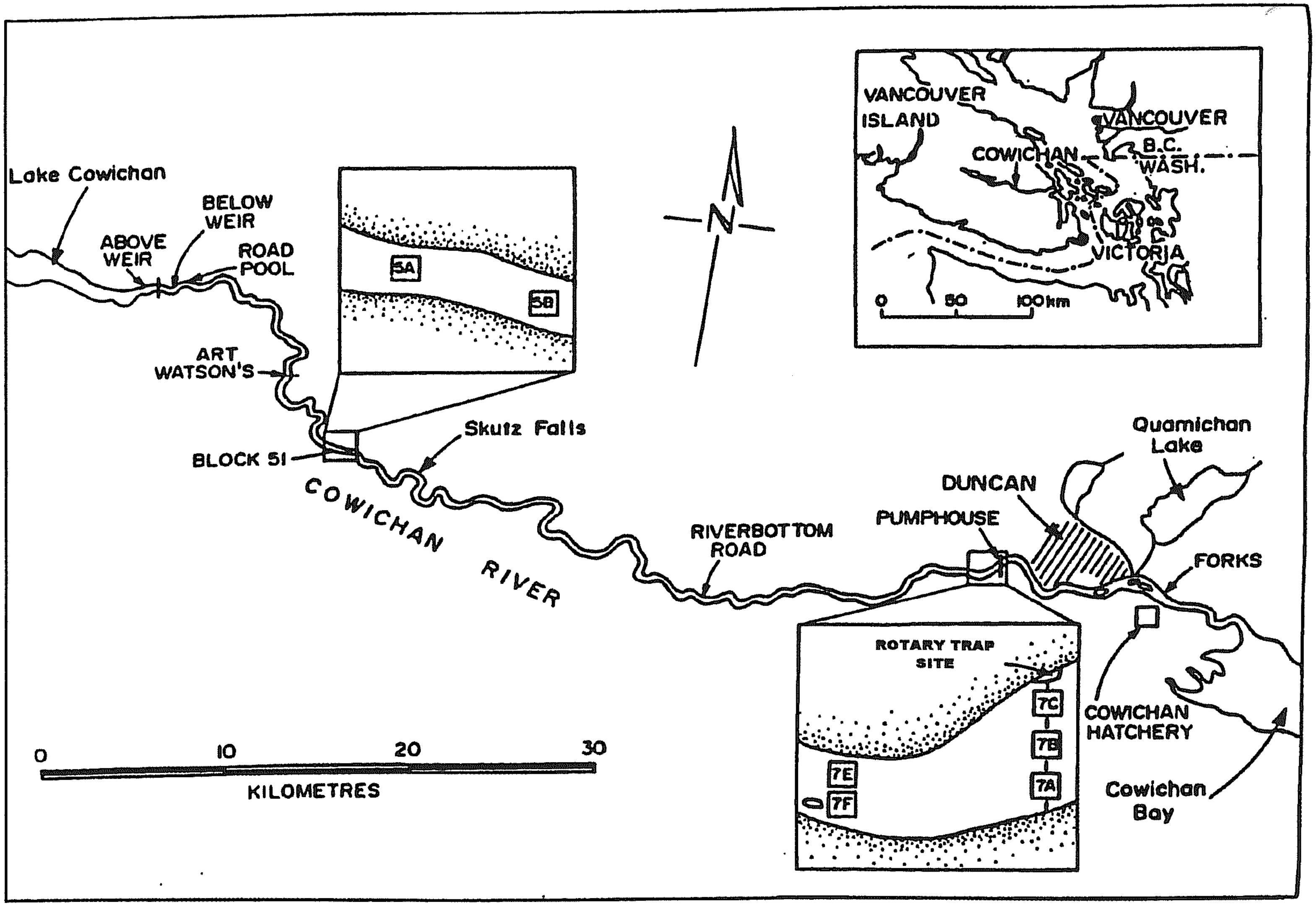



Fig 1. Cowichan River downstream fry trap locations.

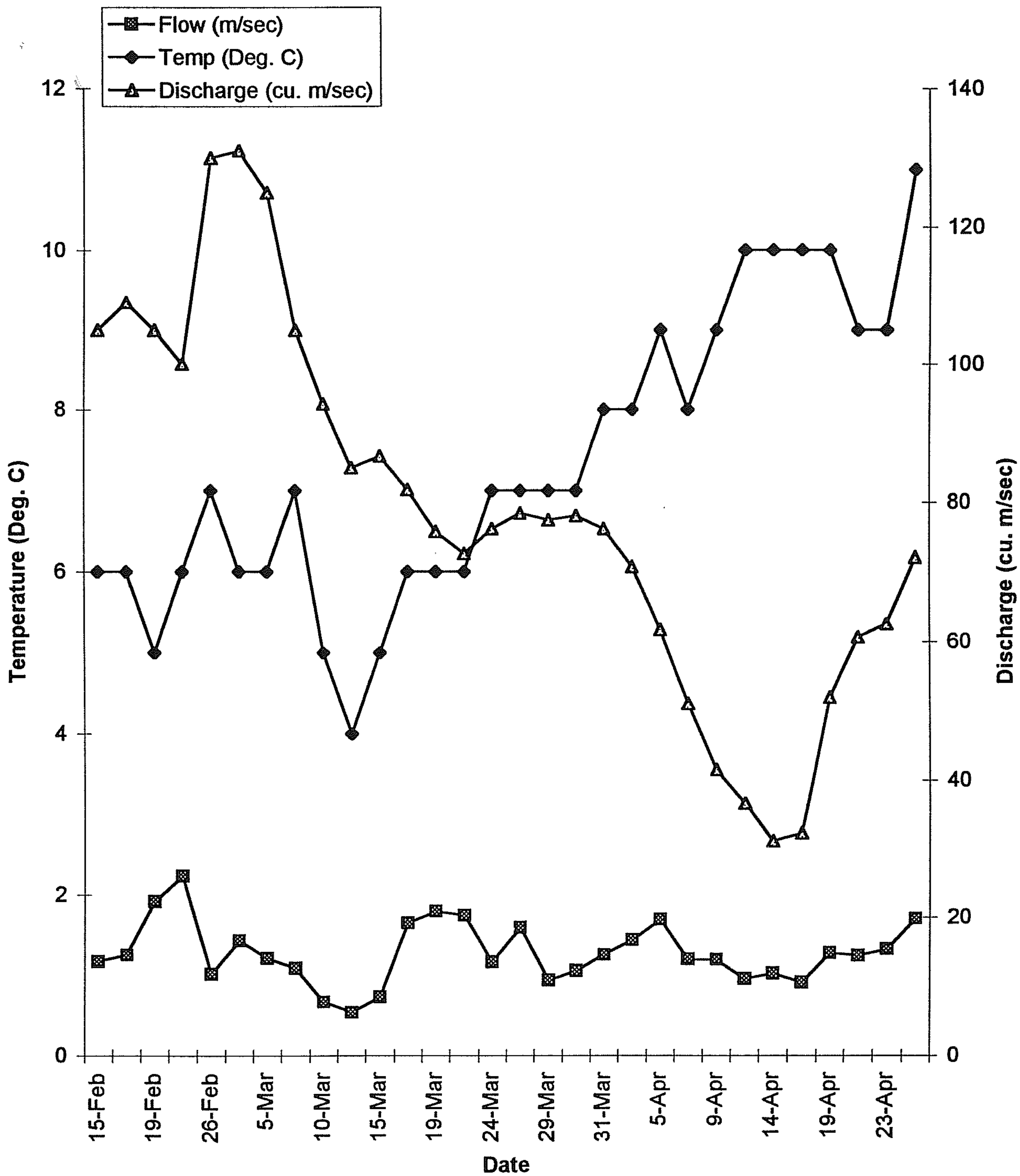
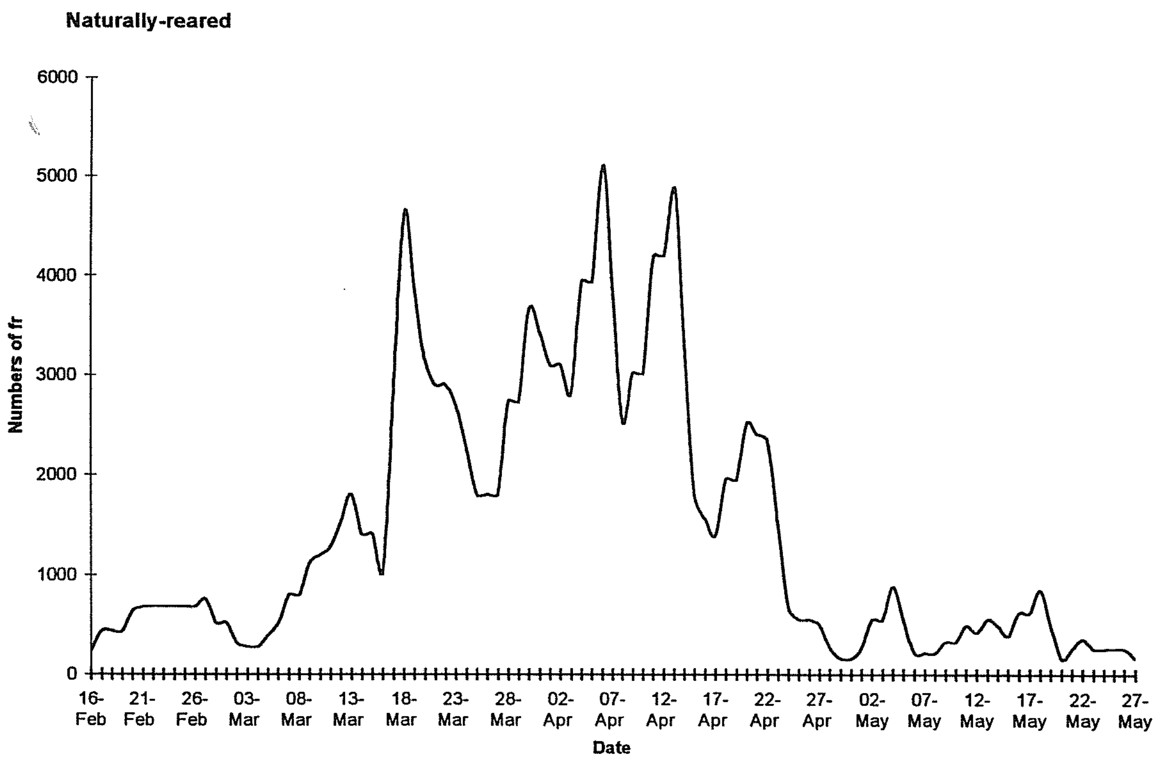



Fig. 2. Biophysical conditions recorded at the pumphouse site, Cowichan River, 1999.



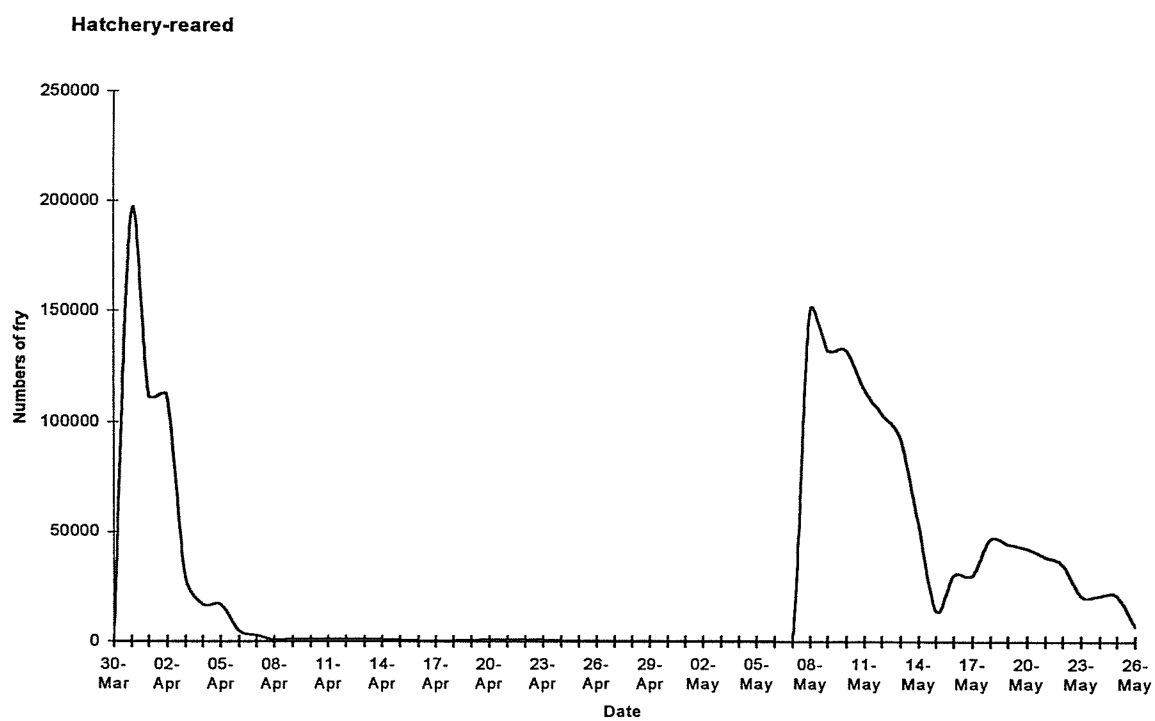
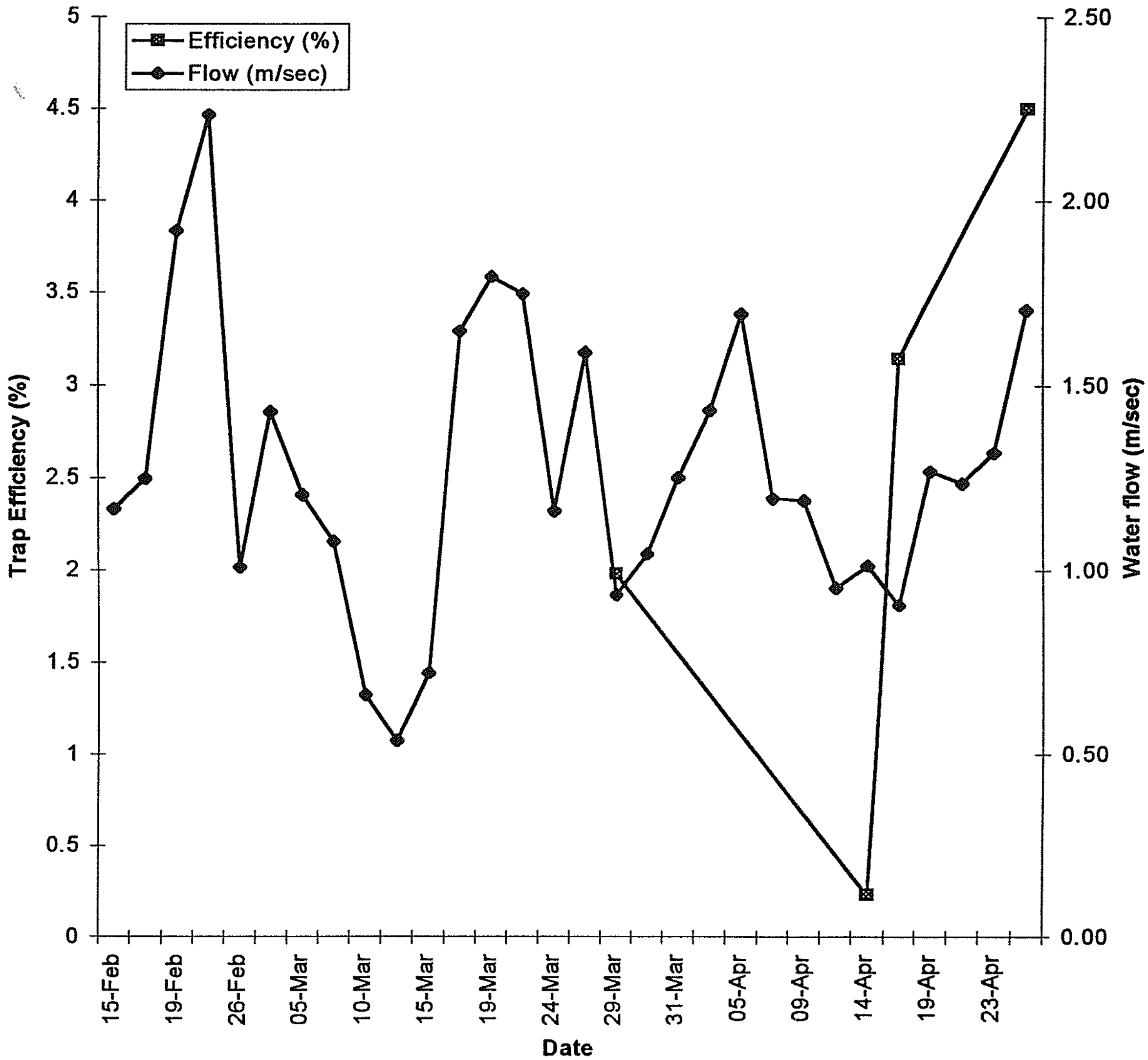
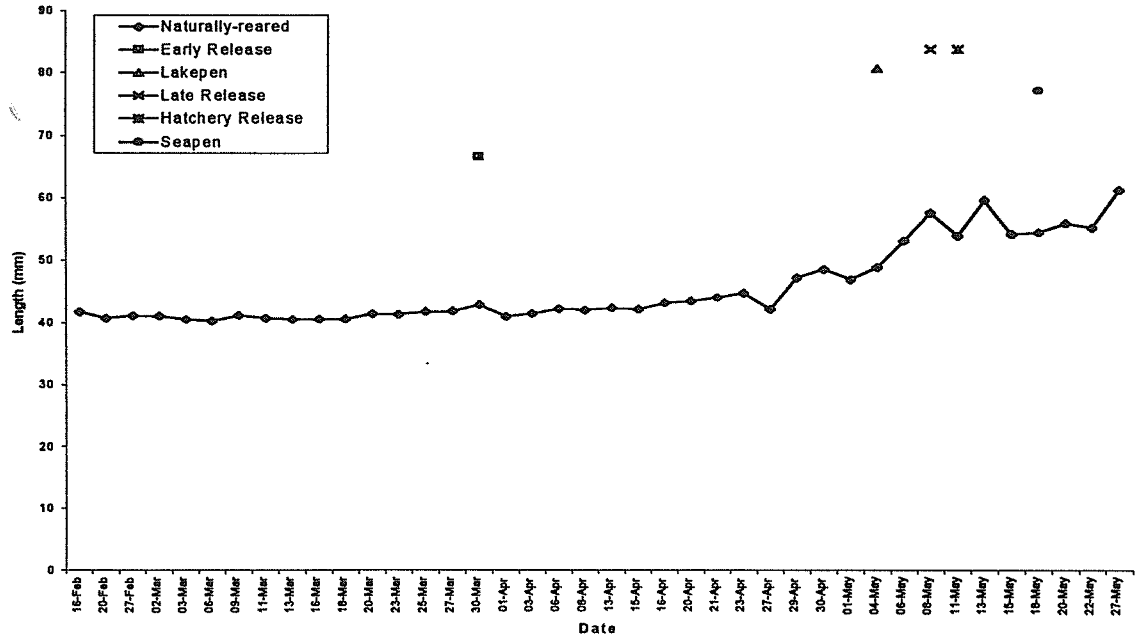




Fig. 3. Daily abundance estiamtes of natural and hatchery chinook fry downstream migration, pumphouse site, 1999.




* Data points 1 (29-Mar), 3 (16-Apr), 4 (26-Apr) on the Efficiency (%) series, are chum efficiencies, and point 2 (14-Apr) is the chinook efficiency.

Fig. 4. Rotary trap efficiency compared with water flow at the pumphouse site, Cowichan River, 1999.



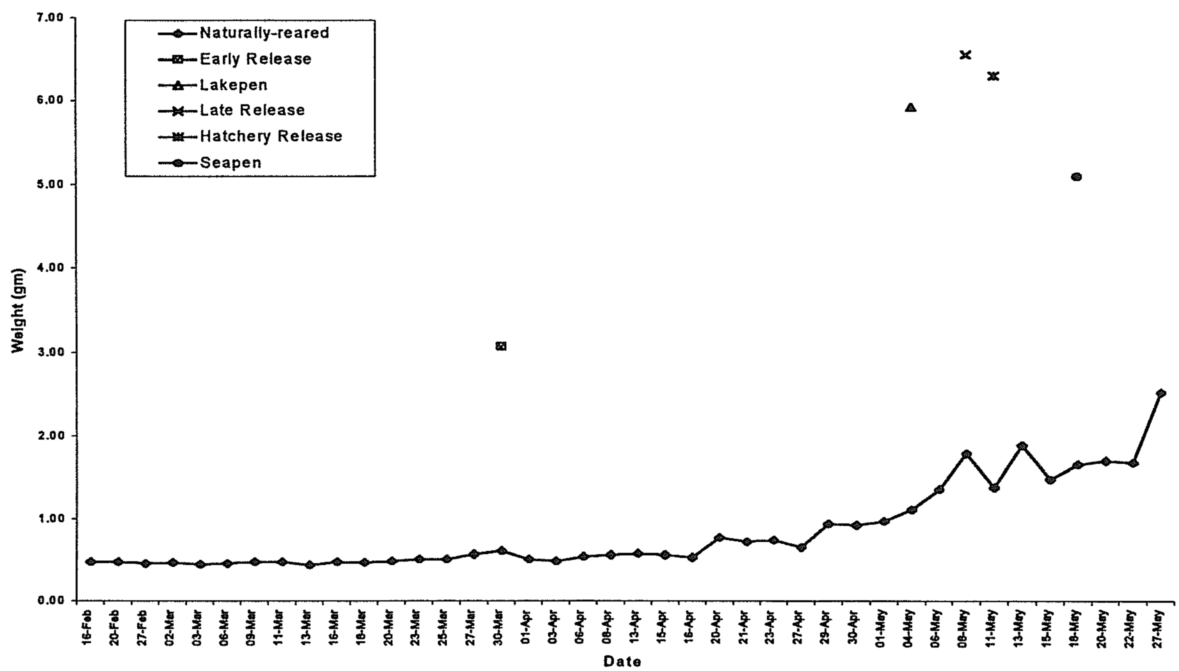




Fig. 5. Length and weight of chinook fry sampled by datae at the pumphouse site, Cowichan River, 1999.

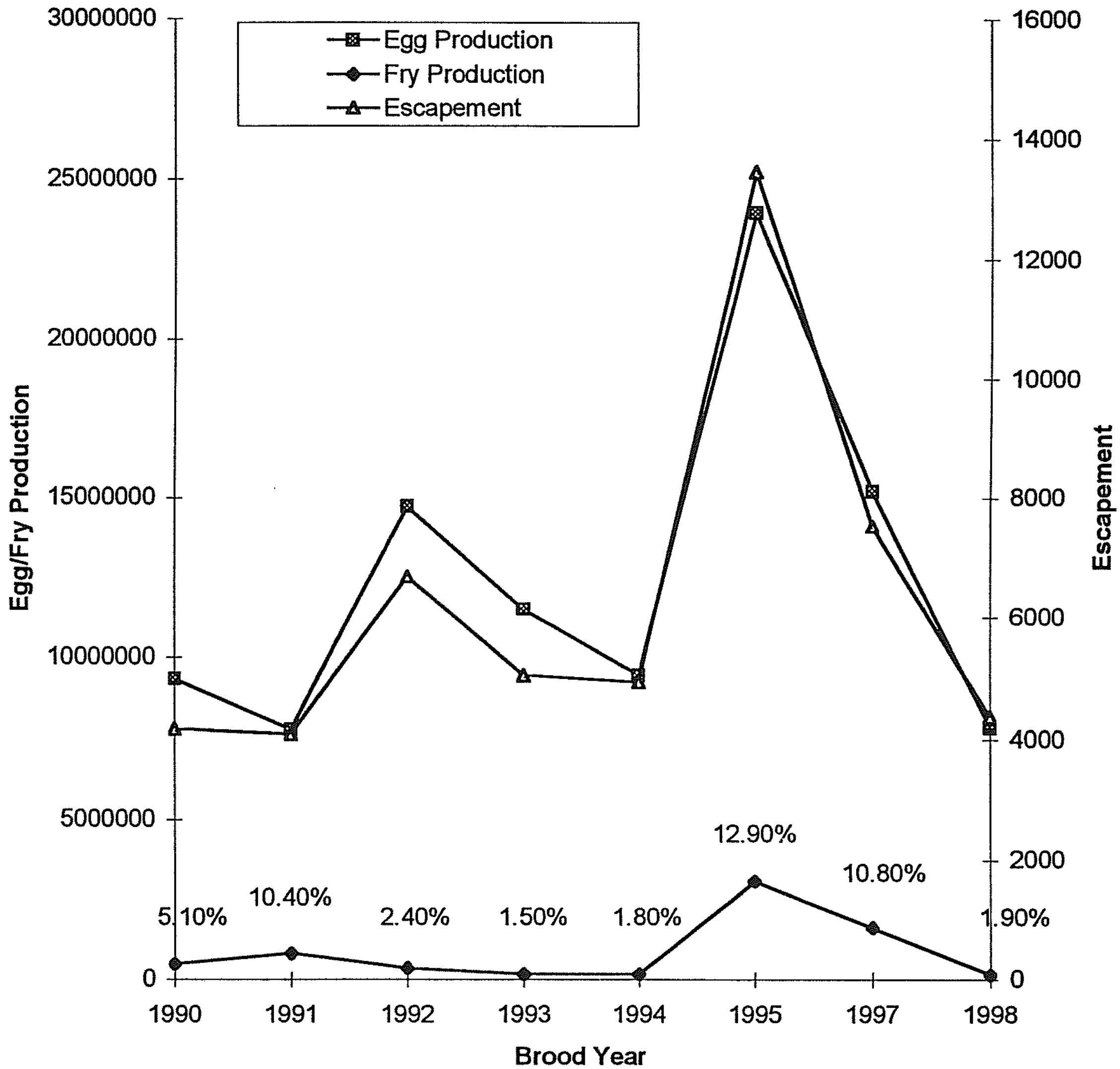



Fig. 6. Egg to fry survival estimates (in brackets) compared to adult escapement and fry production, Cowichan River.

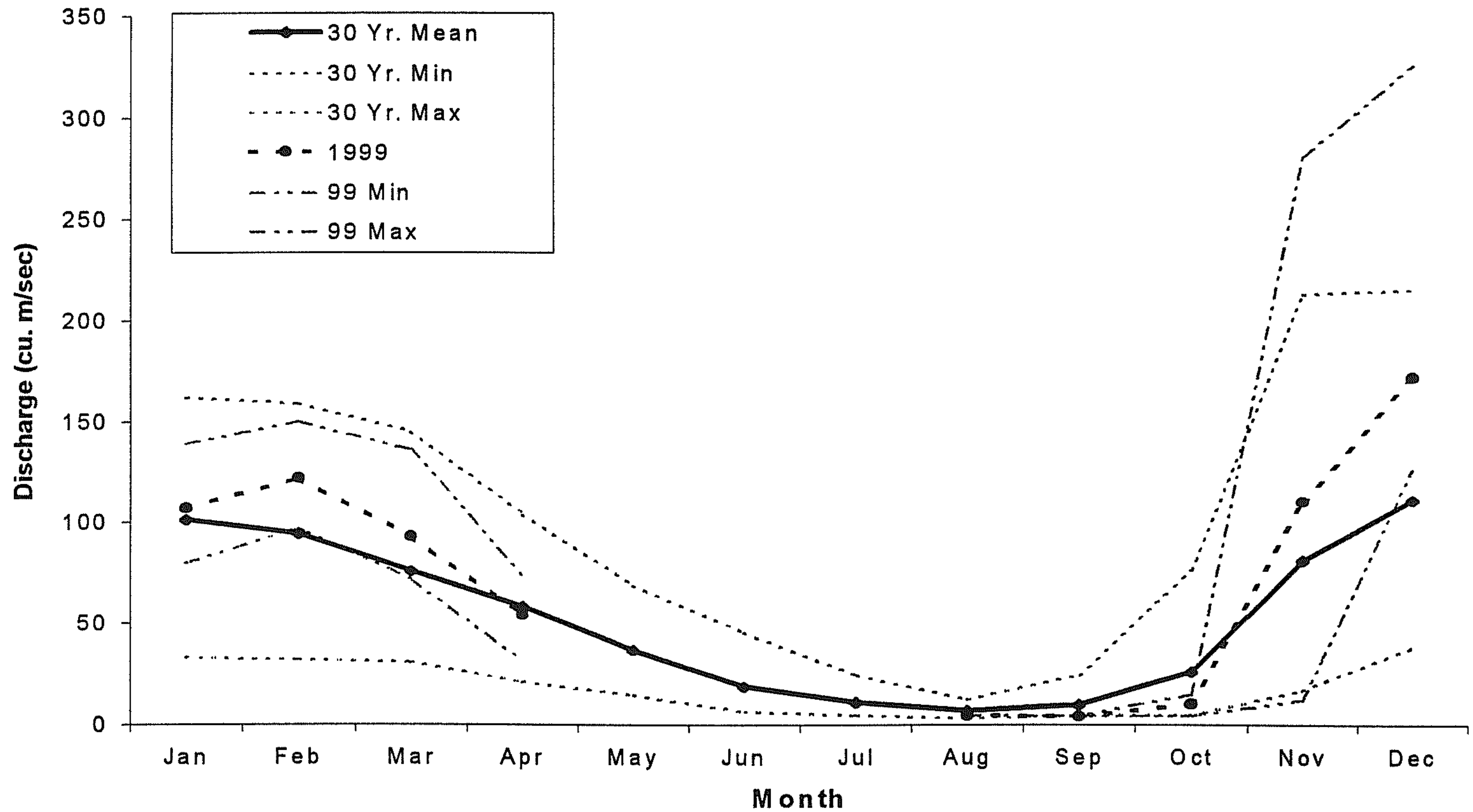



Fig. 7. 1999 Cowichan River discharge (cu. m/sec) compared with 30 year mean.

Appendix Table 1. Biosampling data from naturally-reared chinook fry from the pumphouse site, 1999.

| Date | 16-Feb | | 20-Feb | | 27-Feb | | 02-Mar | | 03-Mar | | 06-Mar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 43 | 55 | 39 | 38 | 42 | 48 | 42 | 52 | 40 | 38 | 42 | 56 |
| | 43 | 49 | 43 | 54 | 40 | 39 | 42 | 46 | 42 | 53 | 41 | 48 |
| | 39 | 37 | 43 | 59 | 42 | 46 | 39 | 48 | 41 | 48 | 42 | 50 |
| | 43 | 52 | 42 | 53 | 38 | 44 | 38 | 37 | 39 | 41 | 40 | 45 |
| | 41 | 44 | 41 | 49 | 40 | 44 | 42 | 50 | 39 | 34 | 38 | 37 |
| | 42 | 50 | 42 | 50 | 40 | 44 | 43 | 53 | 41 | 51 | 38 | 39 |
| | | | 42 | 55 | 42 | 39 | 42 | 41 | 42 | 53 | 39 | 44 |
| | | | 41 | 53 | 42 | 48 | 41 | 48 | | | 41 | 51 |
| | | | 41 | 51 | 43 | 56 | | | | | 39 | 43 |
| | | | 42 | 54 | 40 | 51 | | | | | 39 | 43 |
| | | | 38 | 41 | 40 | 43 | | | | | 41 | 45 |
| | | | 40 | 50 | 42 | 50 | | | | | 42 | 47 |
| | | | 39 | 41 | 44 | 52 | | | | | 42 | 48 |
| | | | 40 | 44 | 42 | 52 | | | | | | |
| | | | 41 | 44 | 42 | 50 | | | | | | |
| | | | 42 | 50 | 44 | 59 | | | | | | |
| | | | 40 | 38 | 41 | 39 | | | | | | |
| | | | 39 | 44 | 41 | 44 | | | | | | |
| | | | 39 | 48 | 38 | 35 | | | | | | |
| Mean length: | 41.83 | | 40.74 | | 41.21 | | 41.13 | | 40.57 | | 40.31 | |
| Mean weight: | | 47.83 | | 48.21 | | 46.47 | | 46.88 | | 45.43 | | 45.85 |

Appendix 1 (cont'd)

| Date | 09-Mar | | 11-Mar | | 13-Mar | | 16-Mar | | 18-Mar | | 20-Mar | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 40 | 46 | 40 | 42 | 40 | 46 | 41 | 47 | 40 | 45 | 43 | 59 |
| | 43 | 53 | 39 | 35 | 42 | 47 | 42 | 50 | 42 | 48 | 42 | 48 |
| | 43 | 56 | 42 | 50 | 40 | 38 | 38 | 37 | 40 | 43 | 42 | 53 |
| | 42 | 43 | 42 | 46 | 38 | 37 | 41 | 47 | 39 | 39 | 40 | 49 |
| | 42 | 52 | 38 | 34 | 41 | 50 | 39 | 41 | 37 | 35 | 40 | 46 |
| | 41 | 46 | 39 | 43 | 42 | 48 | 39 | 48 | 40 | 44 | 44 | 60 |
| | 40 | 50 | 40 | 40 | 38 | 41 | 40 | 47 | 37 | 35 | 42 | 45 |
| | 44 | 54 | 40 | 44 | 41 | 40 | 39 | 34 | 42 | 55 | 45 | 63 |
| | 41 | 44 | 42 | 48 | 39 | 44 | 41 | 51 | 43 | 49 | 44 | 51 |
| | 43 | 47 | 40 | 42 | 42 | 47 | 45 | 62 | 44 | 53 | 40 | 46 |
| | 43 | 51 | 42 | 55 | 40 | 46 | 42 | 50 | 42 | 48 | 44 | 59 |
| | 42 | 51 | 42 | 57 | 41 | 46 | 43 | 65 | 38 | 46 | 40 | 50 |
| | 43 | 55 | 40 | 41 | 37 | 29 | 45 | 63 | 40 | 44 | 38 | 33 |
| | 43 | 54 | 39 | 41 | 44 | 56 | 37 | 34 | 43 | 58 | 40 | 48 |
| | 41 | 50 | 42 | 58 | 42 | 51 | 43 | 53 | 39 | 44 | 39 | 38 |
| | 42 | 50 | 41 | 49 | 39 | 36 | 41 | 47 | 43 | 59 | 40 | 46 |
| | 39 | 38 | 44 | 71 | 39 | 35 | 39 | 44 | 41 | 45 | 41 | 46 |
| | 44 | 63 | 42 | 60 | 44 | 55 | 41 | 49 | 40 | 49 | 43 | 55 |
| | 41 | 48 | 45 | 76 | 40 | 50 | 44 | 60 | 44 | 57 | 40 | 43 |
| | 37 | 35 | 41 | 56 | 38 | 34 | 43 | 61 | 39 | 34 | 39 | 44 |
| | 41 | 45 | 37 | 28 | 40 | 41 | 40 | 47 | 42 | 54 | 40 | 37 |
| | 40 | 41 | 42 | 47 | 42 | 54 | 36 | 28 | 40 | 46 | 45 | 60 |
| | 42 | 53 | 43 | 56 | 40 | 37 | 41 | 51 | 39 | 38 | 40 | 43 |
| | 40 | 45 | 38 | 40 | 43 | 54 | 37 | 31 | 42 | 55 | 41 | 44 |
| | 41 | 54 | 38 | 34 | 40 | 36 | 39 | 44 | 38 | 41 | 41 | 46 |
| | 39 | 45 | 43 | 57 | 38 | 30 | 41 | 49 | 36 | 42 | 42 | 55 |
| | 37 | 30 | 40 | 45 | 44 | 58 | | | 44 | 57 | 43 | 51 |
| | 41 | 49 | 39 | 43 | 44 | 57 | | | 43 | 57 | 41 | 44 |
| | | | 41 | 48 | 39 | 37 | | | 43 | 59 | 41 | 49 |
| | | | 42 | 49 | 41 | 44 | | | 40 | 42 | 44 | 60 |
| Mean length: | 41.25 | | 40.77 | | 40.60 | | 40.65 | | 40.67 | | 41.47 | |
| Mean weight: | | 48.14 | | 47.83 | | 44.13 | | 47.69 | | 47.37 | | 49.03 |

Appendix 1 (cont'd)

| Date | 23-Mar | | 25-Mar | | 27-Mar | | 30-Mar | | 01-Apr | | 03-Apr | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 39 | 46 | 42 | 52 | 42 | 51 | 42 | 61 | 42 | 54 | 41 | 49 |
| | 41 | 49 | 40 | 43 | 38 | 43 | 42 | 69 | 42 | 57 | 40 | 45 |
| | 39 | 40 | 43 | 55 | 43 | 62 | 46 | 90 | 42 | 50 | 42 | 47 |
| | 40 | 50 | 43 | 52 | 40 | 52 | 40 | 46 | 43 | 57 | 44 | 51 |
| | 41 | 50 | 44 | 60 | 43 | 64 | 41 | 46 | 41 | 55 | 43 | 55 |
| | 42 | 53 | 41 | 53 | 42 | 49 | 46 | 67 | 40 | 52 | 44 | 60 |
| | 41 | 50 | 43 | 57 | 41 | 51 | 41 | 58 | 41 | 47 | 39 | 44 |
| | 40 | 43 | 39 | 43 | 42 | 58 | 43 | 71 | 41 | 47 | 43 | 54 |
| | 44 | 61 | 43 | 53 | 42 | 54 | 45 | 66 | 39 | 40 | 40 | 40 |
| | 41 | 50 | 45 | 60 | 42 | 56 | 41 | 52 | 40 | 43 | 41 | 44 |
| | 41 | 52 | 40 | 45 | 39 | 46 | 46 | 71 | 39 | 38 | 42 | 54 |
| | 41 | 49 | 42 | 48 | 45 | 71 | 44 | 54 | 39 | 37 | 40 | 47 |
| | 41 | 50 | 43 | 58 | 49 | 103 | 45 | 64 | 41 | 48 | 42 | 54 |
| | 42 | 53 | 43 | 57 | 44 | 65 | 43 | 59 | 40 | 51 | 41 | 44 |
| | 39 | 37 | 40 | 43 | 39 | 58 | 42 | 64 | 41 | 57 | 42 | 50 |
| | 40 | 52 | 40 | 43 | 42 | 68 | 43 | 62 | 42 | 50 | 41 | 49 |
| | 41 | 52 | 40 | 45 | 39 | 44 | 40 | 42 | 42 | 53 | 41 | 45 |
| | 39 | 38 | 40 | 46 | 43 | 64 | 44 | 65 | 38 | 34 | 40 | 43 |
| | 42 | 52 | 41 | 49 | 41 | 56 | 45 | 64 | 41 | 46 | 42 | 50 |
| | 41 | 46 | 40 | 43 | 44 | 63 | 42 | 50 | 44 | 60 | 40 | 45 |
| | 44 | 59 | 44 | 59 | 42 | 57 | 42 | 65 | 41 | 41 | 42 | 51 |
| | 41 | 45 | 42 | 49 | 42 | 58 | 42 | 53 | 42 | 49 | 43 | 56 |
| | 42 | 52 | 42 | 57 | 41 | 49 | 43 | 66 | 41 | 54 | 42 | 52 |
| | 42 | 46 | 41 | 45 | 43 | 60 | 45 | 62 | 41 | 48 | 42 | 50 |
| | 40 | 45 | 44 | 61 | 44 | 57 | 43 | 64 | 40 | 51 | 40 | 37 |
| | 43 | 57 | 41 | 45 | 40 | 48 | 43 | 53 | 43 | 62 | 42 | 53 |
| | 40 | 48 | 46 | 72 | 43 | 48 | 43 | 64 | 39 | 36 | 40 | 45 |
| | 41 | 50 | 40 | 44 | 41 | 51 | 43 | 64 | 43 | 60 | 42 | 49 |
| | 44 | 68 | 40 | 38 | 43 | 63 | 41 | 58 | 40 | 44 | 42 | 56 |
| | 49 | 100 | 44 | 58 | 40 | 49 | 44 | 56 | 45 | 103 | 43 | 52 |
| Mean length: | 41.37 | | 41.87 | | 41.97 | | 43.00 | | 41.10 | | 41.53 | |
| Mean weight: | | 51.43 | | 51.10 | | 57.27 | | 60.87 | | 50.80 | | 49.03 |

Appendix 1 (cont'd)

| Date | 06-Apr | | 08-Apr | | 13-Apr | | 15-Apr | | 16-Apr | | 20-Apr | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 42 | 53 | 41 | 48 | 40 | 46 | 43 | 69 | 43 | 57 | 44 | 70 |
| | 43 | 62 | 41 | 49 | 42 | 57 | 46 | 72 | 37 | 39 | 47 | 91 |
| | 43 | 59 | 43 | 53 | 42 | 55 | 43 | 51 | 44 | 53 | 43 | 74 |
| | 43 | 52 | 41 | 48 | 45 | 70 | 43 | 67 | 42 | 54 | 43 | 86 |
| | 41 | 50 | 43 | 53 | 42 | 55 | 41 | 55 | 40 | 48 | 47 | 97 |
| | 42 | 56 | 43 | 62 | 38 | 49 | 41 | 54 | 42 | 53 | 50 | 132 |
| | 40 | 45 | 45 | 73 | 40 | 50 | 47 | 85 | 41 | 49 | 43 | 71 |
| | 42 | 55 | 42 | 52 | 42 | 57 | 42 | 52 | 43 | 44 | 44 | 81 |
| | 43 | 62 | 40 | 48 | 42 | 51 | 42 | 51 | 43 | 57 | 39 | 56 |
| | 42 | 50 | 43 | 59 | 44 | 58 | 41 | 58 | 42 | 56 | 42 | 69 |
| | 44 | 59 | 44 | 65 | 41 | 48 | 40 | 52 | 45 | 68 | 47 | 80 |
| | 43 | 58 | 43 | 64 | 41 | 47 | 40 | 51 | 42 | 63 | 41 | 58 |
| | 43 | 56 | 41 | 53 | 44 | 69 | 42 | 49 | 45 | 68 | 41 | 54 |
| | 41 | 52 | 41 | 52 | 42 | 56 | 45 | 68 | 37 | 26 | 42 | 78 |
| | 48 | 82 | 41 | 46 | 42 | 49 | 43 | 68 | 41 | 46 | 48 | 104 |
| | 43 | 63 | 44 | 59 | 43 | 64 | 38 | 26 | 40 | 48 | 43 | 65 |
| | 44 | 57 | 40 | 46 | 43 | 52 | 41 | 54 | 58 | 43 | 42 | 67 |
| | 43 | 58 | 39 | 47 | 43 | 54 | 41 | 52 | 53 | 47 | 41 | 74 |
| | 42 | 49 | 42 | 52 | 43 | 60 | 47 | 51 | 47 | 77 | 39 | 59 |
| | 41 | 47 | 42 | 57 | 43 | 62 | 40 | 50 | 42 | 56 | 43 | 80 |
| | 44 | 51 | 43 | 66 | 44 | 63 | 44 | 52 | 44 | 58 | 43 | 69 |
| | 38 | 40 | 43 | 56 | 46 | 77 | 40 | 50 | 45 | 61 | 40 | 53 |
| | 43 | 50 | 42 | 60 | 45 | 68 | 44 | 65 | 42 | 52 | 46 | 87 |
| | 43 | 54 | 42 | 62 | 42 | 55 | 44 | 58 | 45 | 60 | 48 | 89 |
| | 43 | 55 | 43 | 59 | 43 | 68 | 42 | 44 | 40 | 42 | 44 | 70 |
| | 40 | 43 | 42 | 66 | 39 | 41 | 39 | 53 | | | | |
| | 43 | 67 | 44 | 63 | 43 | 67 | 40 | 58 | | | | |
| | 40 | 47 | 44 | 57 | 43 | 67 | 42 | 53 | | | | |
| | 40 | 42 | 38 | 43 | 43 | 53 | 45 | 63 | | | | |
| | 43 | 54 | 43 | 55 | 44 | 69 | 42 | 52 | | | | |
| Mean length: | 42.33 | | 42.10 | | 42.47 | | 42.27 | | 43.32 | | 43.60 | |
| Mean weight: | | 54.27 | | 55.77 | | 57.90 | | 56.10 | | 53.00 | | 76.56 |

Appendix 1 (cont'd)

| Date | 21-Apr | | 23-Apr | | 27-Apr | | 29-Apr | | 30-Apr | | 01-May | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 43 | 56 | 41 | 49 | 48 | 99 | 51 | 119 | 56 | 126 | 47 | 85 |
| | 52 | 143 | 45 | 89 | 43 | 60 | 47 | 87 | 46 | 81 | 50 | 111 |
| | 45 | 78 | 47 | 97 | 46 | 70 | 44 | 76 | 44 | 69 | 52 | 132 |
| | 43 | 64 | 48 | 107 | 38 | 45 | | | | | 42 | 70 |
| | 42 | 59 | 44 | 61 | 41 | 74 | | | | | 44 | 86 |
| | 43 | 56 | 44 | 71 | 40 | 52 | | | | | | |
| | 43 | 68 | 46 | 75 | 42 | 64 | | | | | | |
| | 52 | 139 | 43 | 62 | 42 | 59 | | | | | | |
| | 44 | 59 | 44 | 59 | 41 | 61 | | | | | | |
| | 52 | 130 | 43 | 62 | | | | | | | | |
| | 42 | 54 | 45 | 67 | | | | | | | | |
| | 44 | 69 | 46 | 82 | | | | | | | | |
| | 42 | 64 | 47 | 81 | | | | | | | | |
| | 45 | 81 | | | | | | | | | | |
| | 49 | 108 | | | | | | | | | | |
| | 45 | 70 | | | | | | | | | | |
| | 44 | 63 | | | | | | | | | | |
| | 40 | 55 | | | | | | | | | | |
| | 40 | 49 | | | | | | | | | | |
| | 45 | 67 | | | | | | | | | | |
| | 40 | 54 | | | | | | | | | | |
| | 48 | 99 | | | | | | | | | | |
| | 40 | 46 | | | | | | | | | | |
| | 44 | 62 | | | | | | | | | | |
| | 39 | 44 | | | | | | | | | | |
| | 43 | 58 | | | | | | | | | | |
| | 44 | 68 | | | | | | | | | | |
| | 44 | 62 | | | | | | | | | | |
| Mean length: | 44.18 | | 44.85 | | 42.33 | | 47.33 | | 48.67 | | 47.00 | |
| Mean weight: | | 72.32 | | 74.00 | | 64.89 | | 94.00 | | 92.00 | | 96.80 |

Appendix 1 (cont'd)

| Date | 04-May | | 06-May | | 08-May | | 11-May | | 13-May | | 15-May | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 46 | 87 | 63 | 202 | 52 | 151 | 41 | 50 | 67 | 272 | 69 | 306 |
| | 57 | 162 | 53 | 143 | 55 | 143 | 48 | 87 | 58 | 180 | 67 | 249 |
| | 59 | 216 | 54 | 129 | 64 | 229 | 47 | 89 | 65 | 214 | 47 | 102 |
| | 65 | 240 | 43 | 68 | 60 | 193 | 56 | 149 | 67 | 219 | 66 | 216 |
| | 57 | 174 | | | | | 58 | 158 | 63 | 187 | 56 | 167 |
| | 46 | 79 | | | | | 58 | 156 | 67 | 231 | 49 | 101 |
| | 46 | 89 | | | | | 56 | 151 | 56 | 163 | 52 | 115 |
| | 46 | 82 | | | | | 60 | 197 | 52 | 123 | 45 | 78 |
| | 40 | 58 | | | | | 62 | 201 | 66 | 259 | 50 | 120 |
| | 54 | 143 | | | | | | | 61 | 184 | 44 | 65 |
| | 49 | 108 | | | | | | | 70 | 260 | 52 | 118 |
| | 45 | 85 | | | | | | | 41 | 66 | | |
| | 43 | 66 | | | | | | | 54 | 170 | | |
| | 45 | 70 | | | | | | | 62 | 220 | | |
| | 43 | 59 | | | | | | | 56 | 167 | | |
| | 42 | 52 | | | | | | | 51 | 115 | | |
| | | | | | | | | | 45 | 85 | | |
| Mean length: | 48.94 | | 53.25 | | 57.75 | | 54.00 | | 59.75 | | 54.27 | |
| Mean weight: | | 110.63 | | 135.50 | | 179.00 | | 137.56 | | 189.38 | | 148.82 |

Appendix 1 (cont'd)

| Date | 18-May | | 20-May | | 22-May | | 27-May | |
|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) | Lgth(mm) | Wt(gm) |
| | 54 | 161 | 55 | 163 | 56 | 180 | 60 | 232 |
| | 60 | 223 | 53 | 137 | 59 | 208 | 61 | 237 |
| | 53 | 198 | 61 | 221 | 58 | 200 | 64 | 271 |
| | 59 | 192 | 52 | 134 | 53 | 133 | 62 | 261 |
| | 47 | 106 | 59 | 194 | 60 | 214 | 60 | 263 |
| | 56 | 189 | | | 57 | 184 | | |
| | 56 | 159 | | | 52 | 129 | | |
| | 52 | 126 | | | 50 | 112 | | |
| | 53 | 123 | | | 52 | 131 | | |
| | 52 | 129 | | | 60 | 216 | | |
| | 57 | 208 | | | 52 | 141 | | |
| | 57 | 174 | | | | | | |
| | 48 | 117 | | | | | | |
| | 60 | 211 | | | | | | |
| | 48 | 118 | | | | | | |
| | 59 | 255 | | | | | | |
| | 60 | 211 | | | | | | |
| | 57 | 191 | | | | | | |
| | 56 | 165 | | | | | | |
| | 59 | 186 | | | | | | |
| | 57 | 175 | | | | | | |
| | 61 | 218 | | | | | | |
| | 58 | 198 | | | | | | |
| | 52 | 126 | | | | | | |
| | 46 | 95 | | | | | | |
| | 41 | 62 | | | | | | |
| Mean length: | 54.54 | | 56.00 | | 55.36 | | 61.40 | |
| Mean weight: | | 166.00 | | 169.80 | | 168.00 | | 252.80 |

Appendix Table 2. Biosampling data of hatchery-reared chinook, 1999.

| Date | 31-Mar-99 | | | | 5-May-99 | | | |
|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Lgth(mm) | Wt(g) | Wt(g) | Lgth(mm) | Lgth(mm) | Wt(g) | Wt(g) |
| | 76 | 64 | 4.86 | 2.53 | 90 | 91 | 8.36 | 8.47 |
| | 72 | 60 | 3.82 | 1.89 | 90 | 72 | 8.66 | 3.64 |
| | 66 | 67 | 2.96 | 3.19 | 78 | 73 | 5.20 | 3.82 |
| | 66 | 69 | 2.91 | 3.01 | 85 | 85 | 6.59 | 6.42 |
| | 69 | 65 | 3.35 | 2.79 | 86 | 83 | 6.94 | 6.02 |
| | 68 | 67 | 3.07 | 3.31 | 65 | 84 | 2.92 | 7.02 |
| | 62 | 63 | 2.28 | 2.45 | 82 | 86 | 5.86 | 7.9 |
| | 68 | 64 | 3.14 | 2.76 | 73 | 88 | 3.70 | 7.05 |
| | 68 | 60 | 3.16 | 2.23 | 74 | 77 | 4.10 | 5.88 |
| | 64 | 56 | 2.63 | 1.79 | 75 | 80 | 4.75 | 5.38 |
| | 76 | 65 | 4.89 | 2.67 | 81 | 78 | 5.82 | 5.38 |
| | 69 | 68 | 3.53 | 3.55 | 72 | 72 | 3.76 | 4.01 |
| | 63 | 70 | 2.50 | 3.67 | 78 | 82 | 5.24 | 6.39 |
| | 63 | 64 | 2.56 | 2.57 | 79 | 80 | 5.02 | 5.29 |
| | 70 | 69 | 3.50 | 3.28 | 76 | 79 | 4.85 | 4.96 |
| | 55 | 69 | 1.40 | 3.49 | 77 | 80 | 5.77 | 5.64 |
| | 61 | 72 | 2.05 | 4.14 | 85 | 80 | 6.22 | 5.46 |
| | 62 | 77 | 2.36 | 5.02 | 82 | 89 | 6.03 | 7.52 |
| | 68 | 73 | 3.17 | 4.17 | 85 | 85 | 7.44 | 6.55 |
| | 69 | 60 | 3.54 | 1.95 | 86 | 83 | 7.33 | 6.43 |
| | 65 | 70 | 2.86 | 3.41 | 88 | 82 | 7.78 | 6.41 |
| | 65 | 71 | 2.94 | 3.72 | 78 | 84 | 5.21 | 6.35 |
| | 73 | 70 | 3.75 | 3.86 | 83 | 80 | 6.22 | 5.47 |
| | 68 | 68 | 2.91 | 3.2 | 89 | 80 | 7.77 | 5.14 |
| | 63 | 63 | 2.14 | 2.62 | 82 | 82 | 5.70 | 6.79 |
| Mean length | 66.66 | | | | 80.76 | | | |
| min | 56 | | | | 65 | | | |
| max | 77 | | | | 91 | | | |
| Mean weight | | | 3.07 | | | | 5.93 | |
| min | | | 1.40 | | | | 2.92 | |
| max | | | 5.02 | | | | 8.66 | |

Appendix Table 2 (cont'd)

| Date | 10-May-99 | | | | 10-May-99 | | | |
|---|---|---|---|---|---|---|---|---|
| | Lgth(mm) | Lgth(mm) | Wt(g) | Wt(g) | Lgth(mm) | Lgth(mm) | Wt(g) | Wt(g) |
| | 95 | 88 | 9.01 | 6.89 | 87 | 85 | 7.53 | 6.80 |
| | 88 | 69 | 7.51 | 3.58 | 88 | 87 | 7.11 | 7.82 |
| | 88 | 73 | 7.45 | 3.95 | 92 | 82 | 9.25 | 6.36 |
| | 78 | 73 | 5.18 | 3.84 | 80 | 84 | 5.84 | 5.60 |
| | 81 | 95 | 5.58 | 10.10 | 82 | 79 | 5.16 | 5.09 |
| | 88 | 90 | 6.98 | 7.74 | 78 | 82 | 4.67 | 5.55 |
| | 83 | 84 | 5.92 | 6.17 | 90 | 73 | 7.77 | 4.06 |
| | 94 | 93 | 8.90 | 8.53 | 77 | 75 | 4.70 | 8.24 |
| | 80 | 96 | 5.40 | 9.53 | 97 | 71 | 9.90 | 3.19 |
| | 85 | 69 | 6.94 | 2.84 | 89 | 90 | 8.23 | 8.23 |
| | 73 | 87 | 4.03 | 6.78 | 78 | 93 | 5.01 | 8.68 |
| | 81 | 88 | 5.52 | 7.19 | 88 | 90 | 7.31 | 7.38 |
| | 85 | 100 | 6.43 | 11.18 | 98 | 93 | 9.51 | 8.54 |
| | 71 | 108 | 3.31 | 14.26 | 79 | 93 | 4.81 | 7.87 |
| | 91 | 89 | 7.72 | 7.65 | 75 | 84 | 4.59 | 5.98 |
| | 81 | 85 | 5.69 | 6.22 | 75 | 84 | 4.14 | 6.44 |
| | 71 | 75 | 3.65 | 4.69 | 91 | 85 | 8.45 | 6.25 |
| | 81 | 92 | 5.34 | 8.66 | 83 | 77 | 6.59 | 4.74 |
| | 76 | 76 | 4.06 | 4.90 | 80 | 81 | 5.24 | 5.26 |
| | 81 | 90 | 5.64 | 7.77 | 89 | 83 | 7.88 | 6.04 |
| | 78 | 100 | 5.12 | 11.12 | 95 | 84 | 9.00 | 6.48 |
| | 91 | 74 | 7.90 | 4.02 | 83 | 85 | 6.03 | 6.60 |
| | 83 | 77 | 6.09 | 6.80 | 78 | 77 | 4.77 | 4.00 |
| | 92 | 76 | 8.60 | 6.93 | 83 | 76 | 6.12 | 3.85 |
| | 70 | 82 | 3.09 | 5.83 | 88 | 75 | 6.99 | 3.69 |
| Mean length | 83.88 | | | | 83.82 | | | |
| min | 69 | | | | 71 | | | |
| max | 108 | | | | 98 | | | |
| Mean weight | | | 6.56 | | | | 6.31 | |
| min | | | 2.84 | | | | 3.19 | |
| max | | | 14.26 | | | | 9.90 | |

Appendix Table 2 (cont'd)

| Date | 17-May-99 | |
|---|---|---|
| | Lgth(mm) | Wt(g) |
| | 78 | 5.18 |
| | 88 | 8.17 |
| | 76 | 4.32 |
| | 93 | 8.79 |
| | 96 | 7.31 |
| | 92 | 9.24 |
| | 85 | 7.76 |
| | 74 | 4.88 |
| | 77 | 4.43 |
| | 73 | 3.94 |
| | 73 | 3.99 |
| | 72 | 3.59 |
| | 70 | 3.43 |
| | 73 | 3.64 |
| | 91 | 8.19 |
| | 69 | 3.21 |
| | 71 | 3.95 |
| | 85 | 7.53 |
| | 76 | 4.23 |
| | 73 | 4.22 |
| | 70 | 2.87 |
| | 67 | 2.73 |
| | 74 | 3.91 |
| | 78 | 4.98 |
| | 67 | 2.94 |
| Mean length | 77.24 | |
| min | 67 | |
| max | 93 | |
| Mean weight | | 5.10 |
| min | | 2.73 |
| max | | 9.24 |