Adult Chinook Escapement Assessment Conducted on the Nanaimo River During 1998

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ABSTRACT

Carter, E.W. and D.A. Nagtegaal. 2000. Adult chinook escapement assessment conducted on the Nanaimo River during 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2527: 29 p.

In 1998, Fisheries and Oceans Canada in co-operation with Nanaimo First Nation continued a productivity study of chinook salmon (*Oncorhynchus tshawytscha*) in the Nanaimo River. Areas of concentration for this study included: i) enumeration of returning chinook; ii) collection of biological and coded-wire tag (CWT) data; and iii) estimation of returning chinook using a carcass mark-recapture project as a comparison. Based on the enumeration fence count, we estimated the total return of adult fall chinook to the Nanaimo River to be 1054 in 1998. After removal of broodstock by the hatchery, the number of natural spawners was estimated at 808 for fall chinook. We used observations at First Lake and information compiled during broodstock collection to estimate the total return of the spring chinook stock to be 150-200 adult chinook. We also examined the effects of a water management plan implemented in 1989 to aid the upstream movement of fall chinook.

RÉSUMÉ

Carter, E.W. and D.A. Nagtegaal. 2000. Adult chinook escapement assessment conducted on the Nanaimo River during 1998. Can. Manuscr. Rep. Fish. Aquat. Sci. 2527: 29 p.

En 1998, Pêches et Océans Canada, en collaboration avec la Première nation Nanaimo, a poursuivi une étude de productivité des saumons quinnats (*Oncorhynchus tshawytscha*) de la rivière Nanaimo. Cette étude s'est concentrée sur les objectifs suivants : i) décompte des saumons quinnats effectuant la remonte; ii) collecte de données biologiques et des micromarques magnétisées codées; iii) estimation de l'effectif de la remonte des saumons quinnats en comparant les résultats à un projet basé sur la collecte des micromarques sur la carcasse des poissons. En se basant sur le décompte effectué à la barrière de recensement, nous avons estimé que l'effectif total de remonte des saumons quinnats adultes d'automne dans la rivière Nanaimo s'élevait à 1 054 en 1998. Le nombre de géniteurs naturels a été estimé à 808 pour le saumon quinnat d'automne après prélèvement de géniteurs pour l'écloserie. Nous avons utilisé les données recueillies au lac First et les renseignements compilés pendant la collecte des géniteurs pour estimer l'effectif total de la remonte des saumons quinnats de printemps à 150-200 spécimens adultes. Nous avons également examiné les retombées d'un plan de gestion de l'eau qui fut mise en œuvre en 1989 pour aider la remonte des saumons quinnats d'automne.

INTRODUCTION

Since 1988, considerable interest has been focused on the status of chinook salmon (*Oncorhynchus tshawytscha*) stocks in the lower Strait of Georgia. Commencing in 1988, Fisheries and Oceans Canada (DFO) implemented a chinook productivity study in this region. Along with the Cowichan and Squamish Rivers, the Nanaimo River is one of the lower Strait of Georgia indicator rivers where chinook spawning escapement information is intensively collected. Escapement information is used to evaluate rebuilding strategies and harvest management policies for lower Strait of Georgia chinook (Farlinger et al. 1990). In 1998, DFO, Science Branch, Pacific Biological Station, in conjunction with the Nanaimo First Nation continued to operate a counting fence and collect information on chinook escapements in the Nanaimo River.

There are three separate chinook stocks within the Nanaimo River (Healey and Jordan 1982). This stock separation is based on life history type, run timing, and spawning location. Fall run chinook enter the system in August and hold until they spawn in the lower river, usually downstream of the Nanaimo River Fish hatchery. Fry from this stock migrate to sea immediately after emergence from the gravel. The two upper river spring run chinook stocks enter the system between December and February, migrate during spring runoff, and hold in lakes or deep river pools until spawning in October. One stock spawns within a one km section downstream of First Lake. Fry from this stock rear for approximately 90 days (ocean type) before migrating to sea. The second spring run chinook stock spawns upstream of Second Lake and the fry rear for up to one year (stream type) before migrating to sea.

Hatchery production of chinook on the Nanaimo River began in 1979 (Cross et al. 1991). In that first year, eggs were incubated at the Pacific Biological Station and later released into the river. The first year of production at the hatchery facility was 1980 (1979 brood) when 100,000 chinook fry were released. Over the years fry production has increased, however, it decreased in 1998 when about 84,300 fall run and 169,100 spring run chinook fry were released. Coded-wire tagging (CWT) of chinook began in 1979 and by 1998, 75% of fall run chinook fry and 30% of spring run chinook fry were coded-wire tagged (P. Preston, Nanaimo River Salmonid Enhancement Project Manager, Community Futures Development Corporation of Central Island, 271 Pine Street, Nanaimo, B.C., V9R 2B7. pers. comm.).

In addition to chinook, the Nanaimo River also supports stocks of coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), steelhead trout (*O. mykiss*), cutthroat trout (*O. clarki*), and Dolly Varden (*Salvelinus malma*).

In consultation with various user groups, the B.C. Ministry of Environment, Lands and Parks (BCMELP) initiated a Nanaimo River Water Management Plan in June 1989. The primary goal of the plan was to improve salmon escapement by increasing flows during typically low water levels in the fall while at the same time maintaining adequate flows to satisfy industrial and domestic water use (BCMELP 1993).

In this report we describe the methodology used to estimate chinook escapements to the Nanaimo River and present the results of the adult enumeration study. Spawning distribution and biological survey data collected during the fall of 1998 are also presented.

METHODS

Three methods were employed to estimate chinook spawning escapement in the Nanaimo River. These included fence counts, carcass mark-recapture techniques, and swim surveys. Both fence counts and mark-recapture methods were used to estimate escapement of fall run chinook. Spring run chinook enter the river prior to fence installation, therefore estimates of escapement for this stock were dependent on swims and visual observations at known holding locations and from broodstock capture data at First Lake. Swim surveys were conducted to observe and record spawning distribution of the fall run chinook stock that was enumerated through the fence. Biological data including length, sex, scales and presence/absence of an adipose fin were collected from carcasses during the mark-recapture program.

Fence construction and data collection methods have previously been described in detail by Carter and Nagtegaal (1997). A brief description along with modifications made to the project in 1998 are explained below.

FENCE OPERATION

Observations at the fence (Fig. 1) began on 04 September 1998. Fish counts were recorded by 15-minute intervals for adult and jack chinook, adult and jack coho and chum. When identification was in doubt, fish were recorded in the unknown category. Other information including water depth, water temperature, water clarity, and weather were recorded three times daily. Fence staff were responsible for keeping the fence clear of leaves and other debris to ensure optimal operating capability.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

In addition to the fence counts, adult chinook escapement estimates for the fall stock were also generated from the carcass mark-recapture data using a simple Petersen model (Chapman modification; Ricker 1975). Although the fence counts were considered the most accurate, the mark-recapture data enabled us to estimate the sex composition and enhanced (hatchery) contribution in the population.

The carcass recovery operation involved a two or three-person crew in an inflatable boat searching the river daily for spawned out chinook carcasses. Recovery effort was concentrated on the fall run chinook stock in the area of highest spawning activity between the Island Highway bridge and Nanaimo River Campground. Each carcass was tagged with a numbered Ketchum[1] aluminum sheep ear tag on the left operculum and released into the river. For all recaptures, the tag number and location were recorded. Once recaptured, the carcass was cut up and removed from the river to avoid multiple recaptures.

In previous years, excursions were made to a two to three km section of river below First Lake to locate spring run chinook carcasses in an attempt to estimate the escapement of this population (Carter and Nagtegaal 1997; 1998; 1999). Due to an inability to recover sufficient numbers of carcasses, this was discontinued in 1998. Population estimates for the spring stock were based on visual observations in the vicinity of First Lake.

Biological data were collected primarily from spawned out chinook carcasses recovered and marked during a carcass mark-recapture program on the spawning grounds. Additional biological data were collected from carcasses which washed up onto the fence. Staff at the Nanaimo River Hatchery collected and contributed biological data from the spring run chinook broodstock. Unless otherwise indicated, data summaries presented in this report are from fall run chinook carcasses only. Information and biological samples taken for each fall chinook carcass included capture location, post orbital-hypural length, sex, scale sample, and presence or absence of adipose fin. If the adipose fin was absent, indicating a coded-wire tagged (cwt) fish, the head was removed and placed in a bag with a numbered label. Heads were later catalogued and cwt's were decoded. In addition, otoliths were collected from seven carcasses at the fence to assist in age verification.

SWIM SURVEYS

Swim surveys were conducted by Nanaimo River hatchery staff to estimate number of spawning chinook. To reduce bias, surveys were carried out independently and without knowledge of counts from previous surveys. Swim surveys were normally carried out using three to five swimmers. Swimmers attempted to stay abreast of each other while moving downstream and counts were made independently. Swimmers combined their counts which were recorded by pre-defined localities in the river (Fig. 2).

Visual surveys in the vicinity of First Lake were conducted during broodstock collection and were used to estimate the number of spring run chinook. Swim surveys in the lower river between the Island highway bridge and the Forks were conducted on 10, 17, and 28 September to estimate the number of fall chinook. A single swim below the fence on 2 October along with spot checks from the road were conducted to estimate the number of chinook holding below the fence.

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[1] Ketchum Manufacturing Ltd., Ottawa, Canada

WATER MANAGEMENT PLAN

Three man-made reservoirs in the Nanaimo River system have been utilised to increase flows during periods of low flow between late summer and early fall. Prior to 1989, water releases were conducted based on an informal arrangement between local Fisheries Officers and Harmac Pacific. Fisheries Officers would request a water release when, in their opinion, fish holding in the lower river became threatened due to low water. These requests would be granted by Harmac dependent upon the availability of water in reserve.

A test water release of ~10 m^3/sec was conducted in 1989. A release flow target of four days at 11.3 m^3/sec was established by DFO in consultation with Nanaimo River hatchery staff. Increases in the fall water releases from the reservoirs since 1989 have encouraged spawning migration. These releases have taken place during late September or early October depending on the volume of stored water available. As a result of this information, a water management plan was drafted and approved by the City of Nanaimo, the Greater Nanaimo Water District and Harmac Pacific in 1993.

RESULTS AND DISCUSSION

ENUMERATION FENCE

The counting fence was in operation from 05 September until 19 October 1998. In previous years we attempted to improve the fishway by creating holding pools or diverting water to increase flow and encourage fish movement through the trap box, with little success (Carter and Nagtegaal 1998). In 1998, we decided to move the fence upstream about three km to a site known as San Salvadore at the Nanaimo River campground. This was a narrower section of river (~60 m) than previously used with a more constant flow and which was less susceptible to tidal influence (Fig. 2).

Conditions in 1998 were favourable and allowed us to observe the entire fall chinook run. The run peaked on 27 September when 420 adults and 96 jacks passed the fence (Table 1). This peak is about two weeks later than that observed in 1997 (Carter and Nagtegaal 1999). We estimated a total return of 1054 adult chinook in 1998. The number of natural spawners for the fall run was estimated to be 808, which was the fence count minus the broodstock removed above the fence.

Considering that fish were not herded past the fence again this year, we were able to observe preferred times of natural movement. The period between 1200 h and 1400 h showed the highest percentage of movement of adult chinook with 33.8%. The movement of jacks was distributed throughout the day with no clear preferred time period (Table 2).

Water depth and temperature (Table 3, Figure 3) along with discharge (Figure 4 - bottom) had an influence on fish movement (Figure 4 - Top). This is particularly evident during the period between 24-28 Sept. 98 during a scheduled water release when chinook migration peaked. A second increase in the migration between 11-15 Oct. 98 was not influenced by the natural increase in discharge and depth on 9 Oct. 98.

The relocation of the fence may have inhibited the upstream movement of chum above the fence. Staff indicated that while chinook and coho made every effort to pass through the fence and continue their migration, there were many chum observed spawning below the counting fence. Chum passing through the fence still greatly outnumbered all other species, however.

The floating fence design worked well provided that debris was removed regularly. Water levels were lower than in the previous year but steady enough that fish moved through the trap box with little hesitation. Typically, fish hold beneath the fence as they search for a path through. Along with relocating the fence upstream, we also eliminated the higher maintenance cedar/vexar panels which were extremely difficult to keep clean, particularly in higher flows.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

The carcass recovery program began on 19 October and was discontinued on 12 November 1998. Heavier rain typically associated with the fall, and resulting increase in water flows and suspended debris, create problems when attempting to recapture carcasses in the river. Commonly, carcasses are swept off the spawning grounds and into deep pools or back eddies where recovery can be quite difficult. Given these conditions, we were able to sample an estimated 19% of the chinook that were enumerated at the counting fence.

The escapement of adult chinook based on the Petersen estimate of carcass mark-recapture data was 784 with lower and upper 95% confidence limits of 679 and 889, respectively (Table 9). We consider this to be a low estimate since some chinook may have passed prior to installation or after removal of the fence. Based on the mark-recapture data, the simple Petersen model underestimated the fence data by 26%.

Chinook escapements have fluctuated over the last 20 years from a low of 210 (1981) to a high of 3000 (1984; Table 10). This year's estimate of 1054 is an encouraging improvement over the low return of 690 in 1997.

During the sampling period 318 carcasses were examined and 162 of these were recaptured (Table 5). There were considerably more adult males than females recovered (65%, 35%). Adult chinook were comprised of 3, 4, and 5-year olds with the majority (51%) being 3-year olds (Table 6).

Length-frequency data from carcass recoveries show a larger mean length for females compared to males and jacks (64.3 cm, 56.9 cm, 40.7 cm, respectively; Table 7). Mean length for all three categories in the spring chinook stock were slightly larger (67.9, 57.2, 44.1; Table 8).

From the mark-recapture data we determined an average adipose-clip mark rate of 12.57% of the total run. The mark rate for males was 7.6%, females 8.7%, and jacks 20.4% (Table 7). Coded-wire tag recovery data showed that all but two chinook were Nanaimo River releases and the 1994 and 1995 brood years predominated (Appendix Table 1).

SWIM SURVEYS

Since the counting fence was put into place on 08 September, the intention was to enumerate the fall run chinook. Visual surveys conducted in the vicinity of First Lake were used to estimate the spring run chinook (Table 4). According to these observations, the escapement estimate for the total return of the spring run chinook in 1998 was 150-200 adults (P. Preston, Nanaimo River Salmonid Enhancement Project Manager, Community Futures Development Corporation of Central Island, 271 Pine Street, Nanaimo, B.C., V9R 2B7. pers. comm.).

WATER MANAGEMENT PLAN

With the increase in population in the Nanaimo area and in an effort to satisfy domestic, industrial, agricultural, fishery, wildlife, and recreational needs, a Nanaimo River Water Management Plan was initiated by the B.C. Ministry of Environment (BCMOE) in June 1989. A team comprised of members from the BCMOE, Greater Nanaimo Water District, MacMillan Bloedel Limited, Nanaimo First Nation, and Fisheries and Oceans Canada (DFO) negotiated a water flow management plan. The primary water management issue has been to enhance flows to meet fisheries requirements while maintaining flows to satisfy industrial and municipal needs. This is particularly important during periods of lowest flow (September and October) and in the 10 km section of river below the MacMillan Bloedel Harmac pulp mill water intakes.

The low flow and water levels likely result in delayed fish movement and higher water temperatures which may potentially increase levels of disease and parasites. This is particularly true for the parasite Ich (*ichthyophthirius*) which matures more rapidly with higher temperature (Ministry of Environment, Lands and Parks 1993).

A single water release occurred between 24 and 28 September (Inland Waters Directorate 1998; Fig. 4) and was important in encouraging about 600 fish to pass through the fence during this time. This proved to be the peak movement of the fall chinook migration in 1998.

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Table 1. Daily counts at the Nanaimo River enumeration fence, 1998.

Date (dd-mm)	Depth (cm.)	Temp. (°C)	Chinook Adult	Chinook Jack	Coho Adult	Coho Jack	Chum	Unk
04-Sep	17	21	1	3	0	0	0	0
05-Sep	21	18	2	6	0	4	4	1
06-Sep	15	21	0	1	0	0	0	0
07-Sep	23	20	0	0	0	0	0	0
08-Sep	21	24	0	0	0	0	0	0
09-Sep	17	17	0	0	0	0	0	0
10-Sep	20	18	0	0	0	0	0	0
11-Sep	22	19	0	0	0	0	0	0
12-Sep	20	18	0	1	0	5	0	0
13-Sep	25	19	0	0	0	1	0	0
14-Sep	23	19	3	8	0	0	0	0
15-Sep	25	18	4	7	0	0	0	0
16-Sep	31	18	1	0	0	0	0	0
17-Sep	22	17	0	2	0	3	0	0
18-Sep	24	18	0	3	0	0	0	0
19-Sep	23	17	5	19	0	0	0	0
20-Sep	23	18	1	4	0	0	0	0
21-Sep	35	17	10	1	0	0	0	0
22-Sep	27	16	0	0	0	0	0	0
23-Sep	27	17	3	9	0	0	0	0
24-Sep	24	16	0	6	0	0	0	0
25-Sep	28	17	0	0	0	0	0	0
26-Sep	36	18	36	27	0	0	0	0
27-Sep	41	16	420	96	4	8	13	0
28-Sep	47	18	26	26	5	10	15	1
29-Sep	46	17	27	3	0	5	5	0
30-Sep	38	17	5	7	0	3	0	0
01-Oct	37	16	2	11	0	0	0	0
02-Oct	36	30	38	32	0	1	0	0
03-Oct	27	27	5	19	0	0	0	0
04-Oct	32	14	9	27	0	5	1	1
05-Oct	30	15	1	0	0	0	4	0
06-Oct	29	16	7	5	0	0	8	1
07-Oct	36	16	7	8	0	1	38	0
08-Oct	37	16	7	12	0	0	8	1
09-Oct	27	15	152	92	24	4	284	0
10-Oct	20	15	32	7	4	5	60	0
11-Oct	25	14	43	15	3	1	87	4
12-Oct	30	14	50	24	1	7	1058	0
13-Oct	78	14	69	56	0	300	3649	0
14-Oct	84	11	13	18	0	50	658	0
15-Oct	76	12	50	9	1	1	133	0

Table 1 (cont'd)

Date (dd-mm)	Depth (cm.)	Temp. (°C)	Chinook		Coho		Chum	Unk
			Adult	Jack	Adult	Jack		
16-Oct	55	21	1	2	0	1	864	0
17-Oct	43	12	14	19	2	13	3035	0
18-Oct	53	25	10	15	8	8	1676	0
19-Oct	56	10	0	9	0	0	1825	0
Total			1054	609	52	436	13425	9

Table 2. Total counts by time interval at the Nanaimo River enumeration fence, 1998.

	Chinook			
Time Period	Adult	Percent	Jack	Percent
0000 - 0100	42	4.0	14	7.1
0100 - 0200	53	5.0	8	4.1
0200 - 0300	42	4.0	4	2.0
0300 - 0400	33	3.1	11	5.6
0400 - 0500	24	2.3	4	2.0
0500 - 0600	11	1.0	4	2.0
0600 - 0700	19	1.8	3	1.5
0700 - 0800	80	7.6	1	0.5
0800 - 0900	23	2.2	2	1.0
0900 - 1000	20	1.9	0	0
1000 - 1100	33	3.1	14	7.1
1100 - 1200	58	5.5	8	4.1
1200 - 1300	175	16.6	4	2.0
1300 - 1400	137	13.0	8	4.1
1400 - 1500	14	1.3	20	10.2
1500 - 1600	11	1.0	28	14.2
1600 - 1700	15	1.4	22	11.2
1700 - 1800	22	2.1	1	0.5
1800 - 1900	24	2.3	5	2.5
1900 - 2000	59	5.6	2	1.0
2000 - 2100	44	4.2	10	5.1
2100 - 2200	31	2.9	23	11.7
2200 - 2300	45	4.3	0	0
2300 - 2400	39	3.7	1	0.5
Total	1054	99.9	609	99.9

Table 3. Average depth and water temperature at the Nanaimo River enumeration fence, 1998.

Date (dd -mm)	Depth (cm.)	Temp. (°C)	Date (dd-mm)	Depth (cm.)	Temp. (°C)
04-Sep	21	17	01-Oct	37	16
05-Sep	21	18	02-Oct	36	15
06-Sep	20	18	03-Oct	27	15
07-Sep	23	20	04-Oct	32	14
08-Sep	28	18	05-Oct	30	15
09-Sep	26	17	06-Oct	29	16
10-Sep	20	18	07-Oct	36	16
11-Sep	22	19	08-Oct	37	16
12-Sep	20	18	09-Oct	27	15
13-Sep	25	19	10-Oct	20	15
14-Sep	23	19	11-Oct	25	14
15-Sep	25	18	12-Oct	30	14
16-Sep	31	18	13-Oct	78	14
17-Sep	22	17	14-Oct	84	11
18-Sep	24	18	15-Oct	76	12
19-Sep	23	17	16-Oct	55	12
20-Sep	23	18	17-Oct	43	12
21-Sep	35	17	18-Oct	53	12
22-Sep	27	16	19-Oct	56	10
23-Sep	27	17			
24-Sep	24	16			
25-Sep	28	17			
26-Sep	36	18			
27-Sep	41	16			
28-Sep	47	18			
29-Sep	46	17			
30-Sep	38	17			

Table 4. Swim surveys conducted on the Nanaimo River, 1998.

Date	Area	Chinook Adults
10-Sept	Below Highway Bridge	603
17-Sept	Below Highway Bridge	11
28-Sept	Below Highway Bridge	600

Table 5. Summary of chinook sampled during the carcass mark-recapture program on the Nanaimo River, 1998.

Date	No. Examined			No. Tagged			No. Recaptured		
dd-mm	Males	Females	Jacks	Males	Females	Jacks	Males	Females	Jacks
19-Oct	3	6	2	3	6	2	1	5	0
22-Oct	6	4	0	6	4	0	5	3	0
23-Oct	9	6	0	9	6	0	5	3	0
26-Oct	6	4	2	6	4	2	5	3	1
28-Oct	19	9	3	19	9	3	16	7	3
29-Oct	28	4	10	28	4	10	22	4	7
30-Oct	19	10	5	19	10	5	1	0	0
03-Nov	27	20	14	27	20	14	20	11	6
04-Nov	7	3	2	7	3	2	2	1	1
05-Nov	18	9	2	18	9	2	9	4	2
10-Nov	25	6	3	25	6	3	6	3	2
11-Nov	6	5	6	6	5	6	0	3	1
12-Nov	3	5	1	3	5	1	0	0	0
19-Nov	0	1	0	0	1	0	0	0	0
Total	176	92	50	176	92	50	92	47	23

Table 6. Summary of age data for chinook sampled during the carcass mark-recovery program on the Nanaimo River, 1998.

European Age[1]	Brood Year	Males	Females	Total	Proportion
0.1	1996	90	0	90	0.36
0.2	1995	86	42	128	0.51
0.3	1994	7	25	32	0.13
Total		183	67	250	1

[1] First number indicates the number of annuli formed in freshwater, second number indicates the number of annuli formed in the ocean (Koo 1962).

Total number of regenerate scales read: 51

Table 7. Length-frequency of chinook sampled during the carcass mark-recovery program on the Nanaimo River, 1998.

Length (cm)	Males	Females	Jacks
33	0	0	1
34	0	0	0
35	0	0	1
36	0	0	2
37	0	0	3
38	0	0	4
39	0	0	4
40	0	1	6
41	0	1	9
42	0	0	8
43	1	0	8
44	0	0	8
45	10	0	0
46	10	1	0
47	8	0	0
48	12	0	0
49	5	0	0
50	4	0	0
51	2	2	0
52	6	0	0
53	9	1	0
54	5	0	0
55	3	3	0
56	12	4	0
57	4	3	0
58	11	4	0
59	4	2	0
60	9	7	0
61	4	5	0
62	5	1	0
63	9	9	0
64	8	8	0
65	4	5	0
66	5	5	0
67	3	3	0
68	5	3	0
69	2	3	0
70	0	1	0
71	3	0	0
72	3	5	0
73	3	1	0
74	0	1	0

Table 7 (cont'd)

Length (cm)	Males	Females	Jacks
75	0	7	0
76	0	0	0
77	0	0	0
78	2	1	0
79	0	1	0
80	0	0	0
81	0	0	0
82	0	1	0
83	1	1	0
84	0	1	0
85	0	0	0
86	0	1	0
Total	172	92	54
Mean length	56.9	64.3	40.7
Std. Deviation	8.4	8.4	2.6
Adipose clips	13	8	11
Mark rate	7.6	8.7	20.4

Table 8. Length-frequency of spring run chinook sampled during broodstock collection on the Nanaimo River, 1998.

Length (cm)	Males	Females	Jacks
44			1
45			
46			
47	1		
48	1		
49			
50			
51	1		
52	2		
53			
54	1		
55	1		
56	1	1	
57		2	
58		2	
59			
60		1	
61		2	
62	1	2	
63			
64	3	1	
65			
66		1	
67		2	
68		4	
69		3	
70		1	
71		3	
72		2	
73			
74		1	
75	1	4	
76		1	
77		1	
78			
79		2	
Total	13	36	1
Mean Length	57.2	68.0	44.1
Std. Deviation	8.04	6.61	

Table 9. Petersen chinook escapement estimates by sex, Nanaimo River, 1998.

Sex	Escapement Estimate	95% Confidence Limit	
		Lower	Upper
Male[1]	512	429	595
Female	271	209	333
Total	784	679	889

[1] Adult males only, jacks not included

Table 10. Total adult chinook returns to the Nanaimo River, 1975-1998.

Year	Natural Spawners	Hatchery Broodstock	Indian Food Fish Catch	Total Returns
1975	475		15	490
1976	880		50	930
1977	2380		60	2420
1978	2125		40	2165
1979	2700	41	23	2764
1980	2900	82	200	3182
1981	210	15	100	325
1982	1090	62	21	1173
1983	1600	240	30	1870
1984	3000	178	50	3228
1985	650	264	185	1099
1986	700	258	190	1148
1987	400	357	50	807
1988	650	429	0	1079
1989	1150	402	0	1552
1990	1275	122	0	1397
1991	800	135	0	935
1992	800	377	0	1177
1993	850	528	0	1378
1994	400	280	0	742
1995	1592[1]	311	0	2003[2]
1996	990[1]	257	0	1847[2]
1997	638[1]	52	0	1290[2]
1998	808[1]	246	0	1254[2]

[1] Count at enumeration fence minus broodstock removal above the fence.
[2] Count at enumeration fence plus estimate of spring run

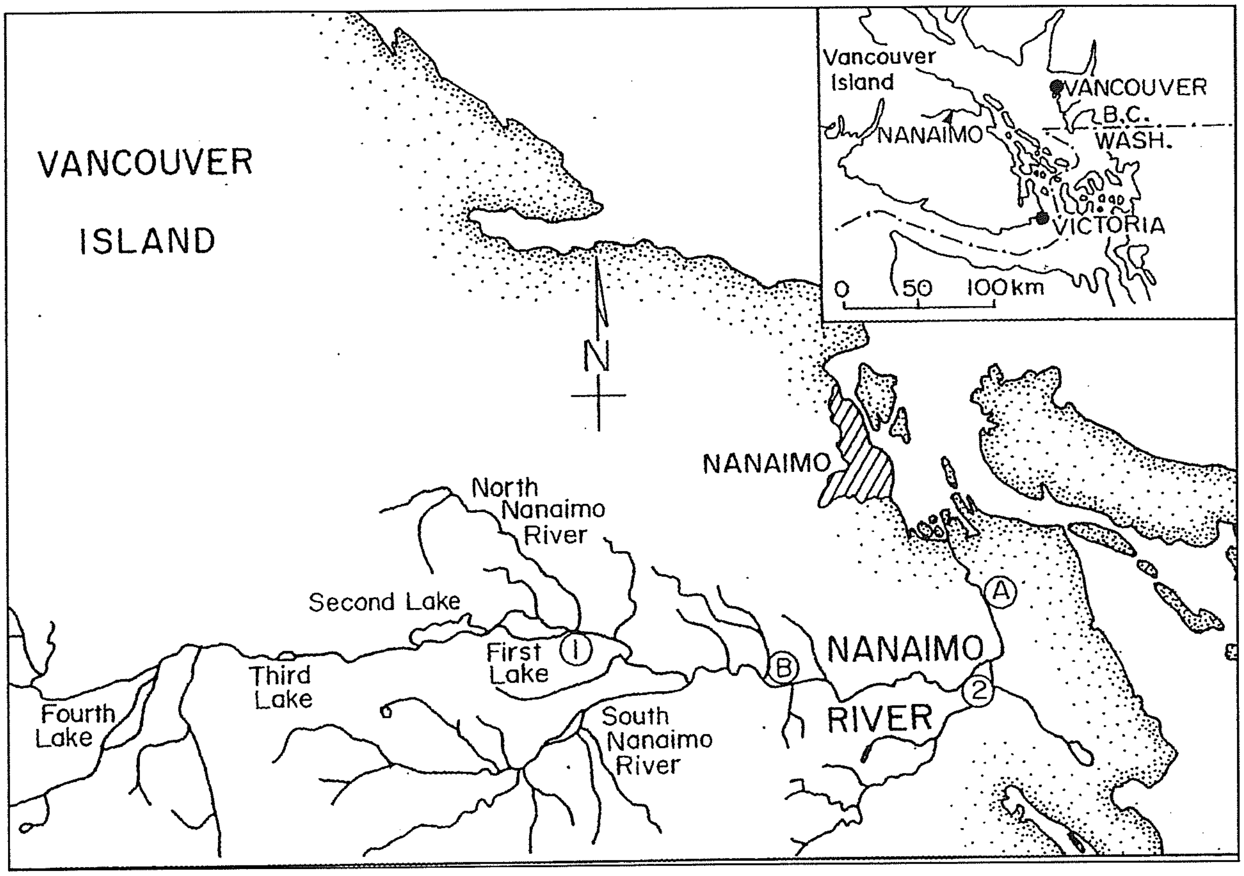


Fig. 1. Nanaimo River study area.

LEGEND:

1	Hatchery Release Site
2	Hatchery Release Site
A	Enumeration Fence Site
A	Downstream Fry Trapping Site

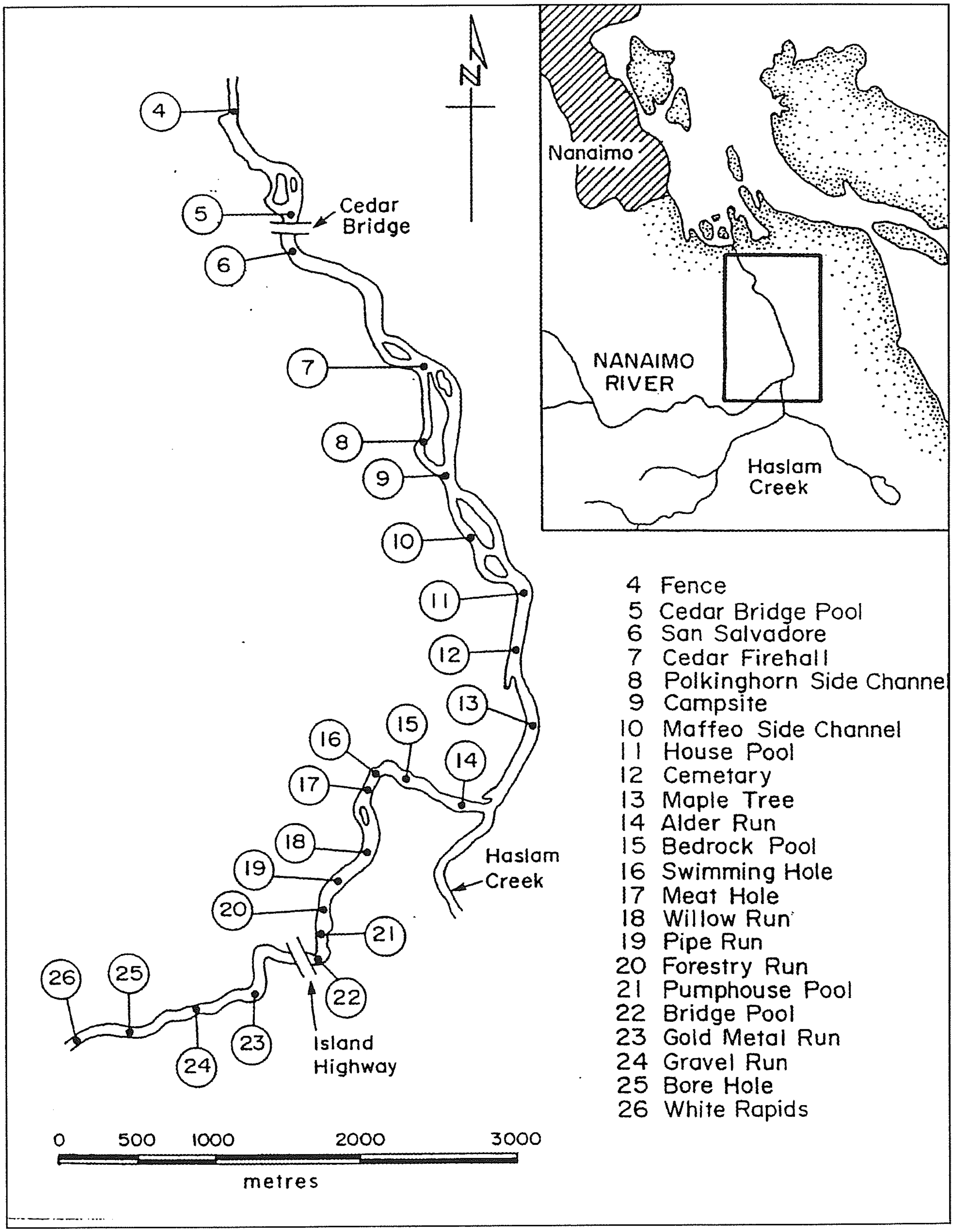


Fig. 2. Swim survey and mark-recapture sites on the Nanaimo River.

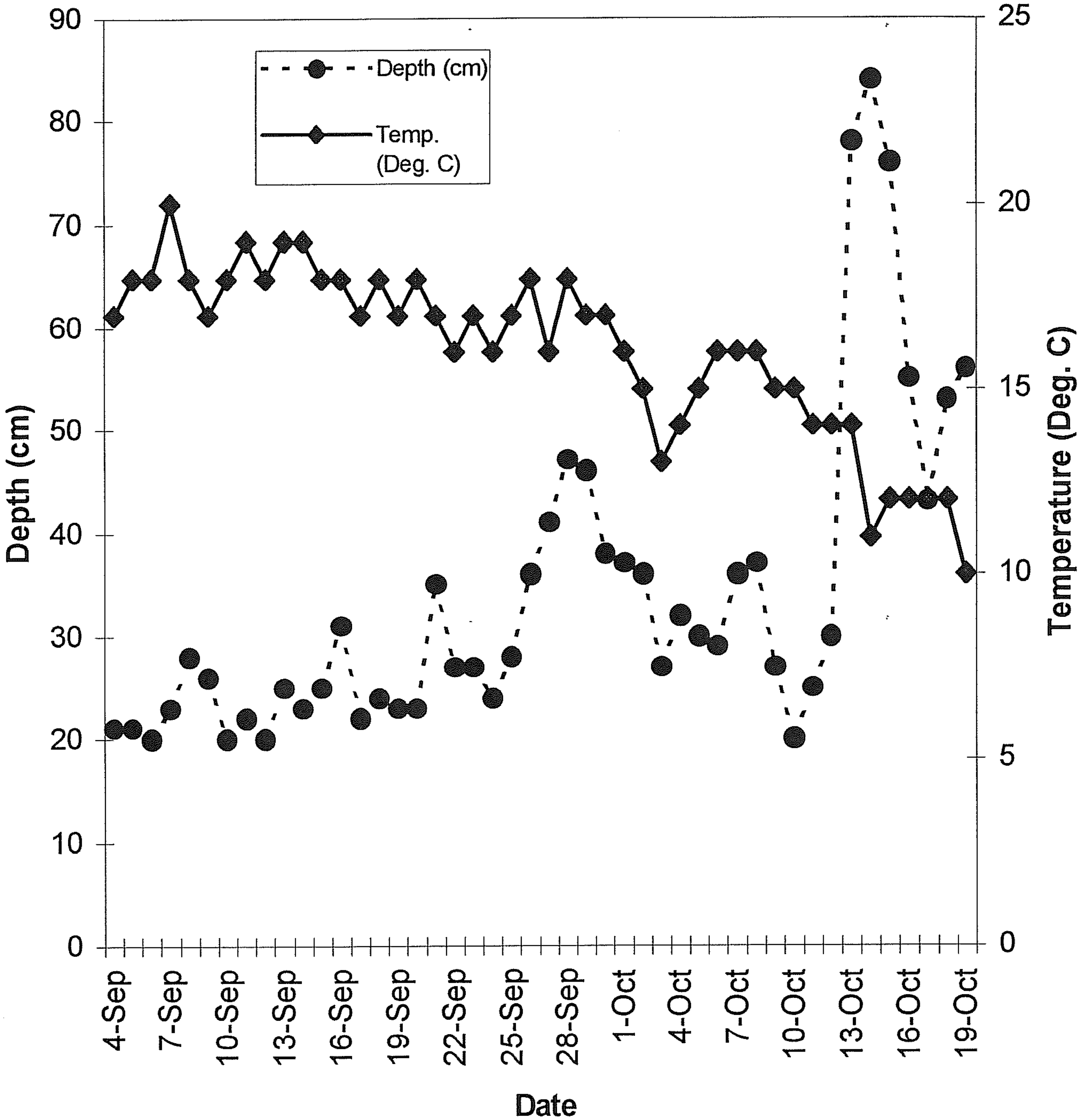
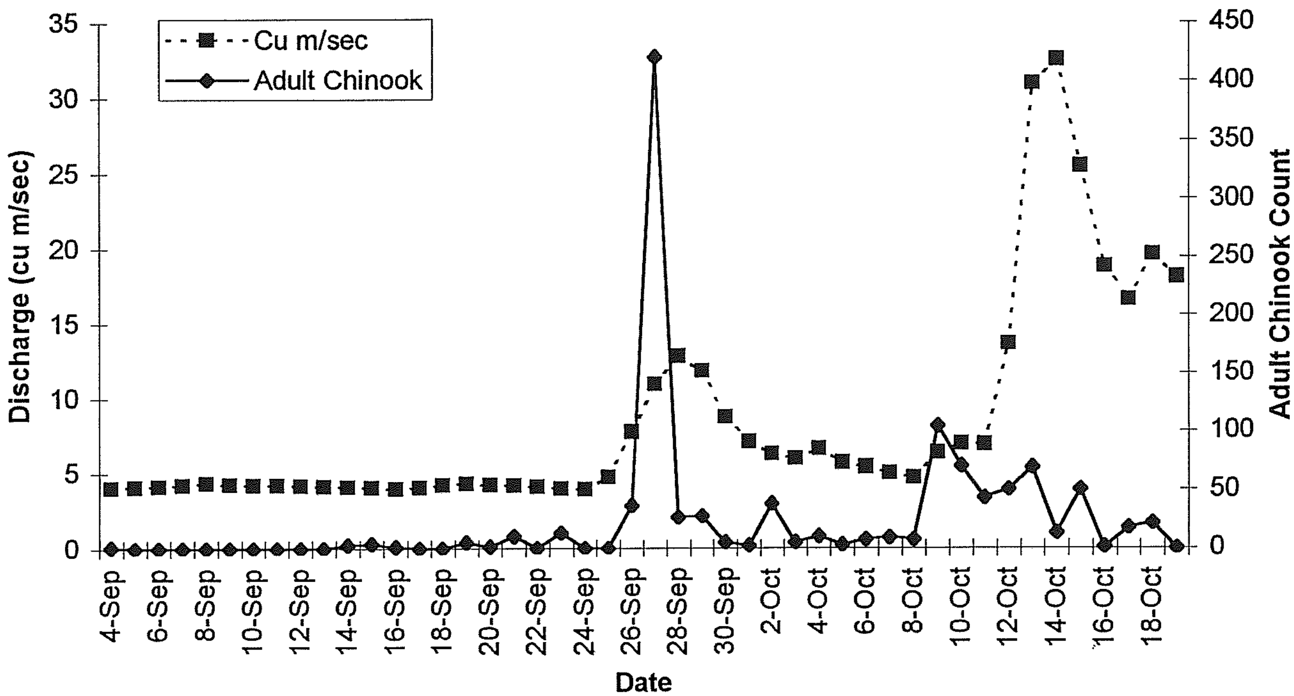


Fig. 3. Average depth and water temperature at the Nanaimo River enumeration fence, 1998.



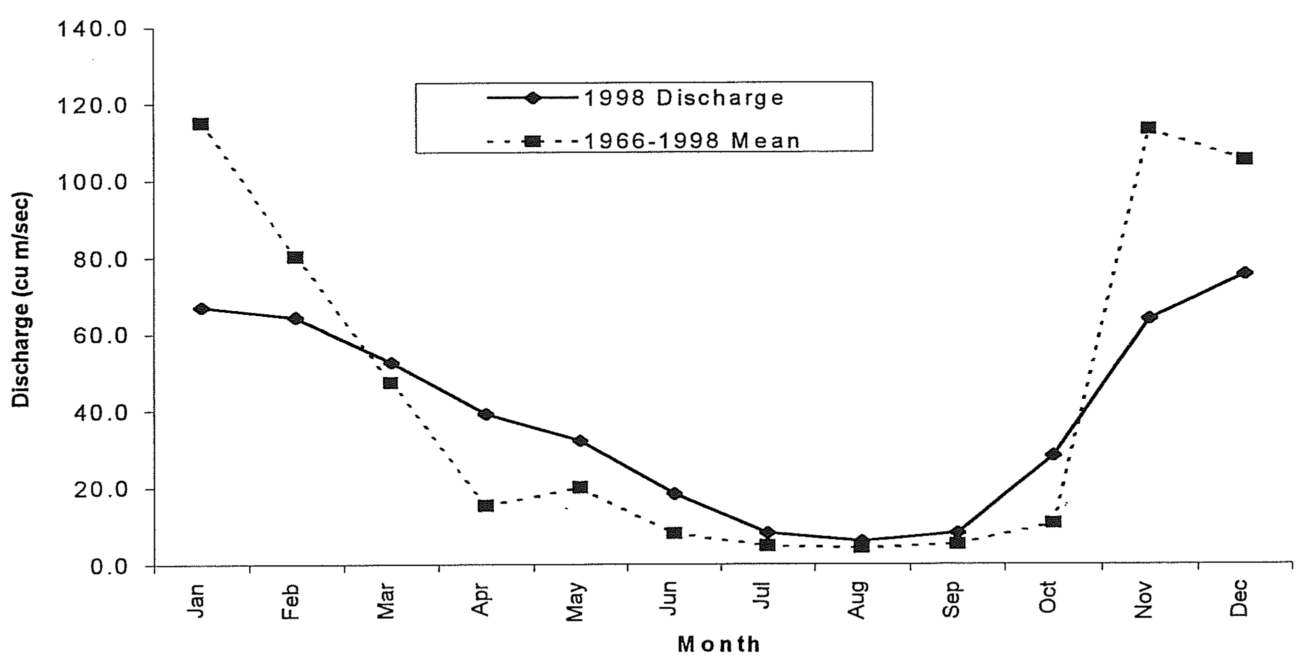


Fig. 4. Discharge and adult chinook count (Top) and mean monthly discharge (Bottom) for the Nanaimo River, 1998.

Appendix Table 1. Coded-wire tag code data from chinook sampled on the spawning grounds, Nanaimo River, 1998.

Recovery Data				Release Data		
Date (ddmmyy)	Location[1]	Length (POH)	Sex[2]	Tag Code	Brood Year	Location
221098	20	623	2	180358	95	Lower Nanaimo
261098	18	687	2	No Pin		
261098	18	566	1	180358	95	Lower Nanaimo
261098	14	579	1	180358	95	Lower Nanaimo
281098	20	380	3	183455	96	Lower Nanaimo
281098	20	455	1	182746	96	Lower Nanaimo
281098	20	480	1	181716	96	Lower Nanaimo
281098	20	327	3	No Pin		
281098	19	630	2	182746	96	Lower Nanaimo
281098	19	665	2	180358	95	Lower Nanaimo
281098	19	720	2	181323	94	Lower Nanaimo
291098	18	440	3	182746	96	Lower Nanaimo
291098	18	430	3	182747	96	Lower Nanaimo
291098	18	430	3	182746	96	Lower Nanaimo
301098	18	650	2	180357	95	Lower Nanaimo
031198	20	550	1	182349	96	Big Qualicum
031198	20	417	3	No Pin		
031198	18	450	1	182746	96	Lower Nanaimo
031198	16	447	3	182840	97	Puntledge
041198	14	495	1	182747	96	Lower Nanaimo
041198	13	460	1	182747	96	Lower Nanaimo
041198	13	428	3	182306	96	Lower Nanaimo
051198	20	363	3	No Pin		
051198	20	414	3	No Pin		
051198	19	655	2	180358	95	Lower Nanaimo
051198	18	715	1	180358	95	Lower Nanaimo
051198	18	440	3	182747	96	Lower Nanaimo
101198	16	486	1	182746	96	Lower Nanaimo
111198	12	466	1	182746	96	Lower Nanaimo
121198	18	435	3	182747	96	Lower Nanaimo

[1] Refer to Fig. 1.
[2] Sex: 1-Male, 2-Female, 3-Jack