Adult Chinook Escapement Estimate Conducted on the Nanaimo River During 1997

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1999

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2482



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Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2482

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by

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Cat. No. Fs 97-4/2482E

ISSN 0706-6473

Correct citation for this publication:

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Carter, E.W. and D.A. Nagtegaal. 1999. A preliminary report on the adult chinook productivity study conducted on the Nanaimo River during 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2482: 27 p.

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ABSTRACT

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In 1997, 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 1290 in 1997. After removal of broodstock by the hatchery, the number of natural spawners was estimated at 1118 for fall chinook. Based on swim survey and overflight information, the total return of the spring chinook stock was estimated to be 600 adult chinook. We also looked at 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. 1999. A preliminary report on the adult chinook productivity study conducted on the Nanaimo River during 1997. Can. Manuscr. Rep. Fish. Aquat. Sci. 2482: 27 p.

En 1997, le ministère des Pêches et des Océans, en collaboration avec la Première Nation Nanaimo, a poursuivi une étude sur la productivité du saumon quinnat (*Oncorhynchus tshawytscha*) dans la Nanaimo. Les principaux volets de cette étude étaient : i) le dénombrement des quinnats en remonte; ii) la collecte de données biologiques et de l'information fournie par les micromarques codées; iii) l'estimation de la remonte de quinnats en parallèle avec un projet de marquage-récupération des carcasses. À partir du dénombrement fait à la barrière, nous avons estimé à 1 290 la remonte totale de quinnats d'automne adultes dans la Nanaimo en 1997. Après prélèvement de géniteurs pour l'écloserie, le nombre total de géniteurs naturels a été estimé à 1 118 pour la remonte d'automne. D'après des observations sur place et aériennes, nous avons estimé à 600 quinnats adultes la remonte totale de printemps. Nous examinons aussi les effets d'un plan de gestion des eaux mis en oeuvre en 1989 pour faciliter la montaison des quinnats d'automne.

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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 1997, 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 this number has increased and in 1997 there were about 465,000 fall run and 171,000 spring run chinook fry released. Coded-wire tagging (CWT) of chinook began in 1979 and by 1997, 16% of fall run chinook fry and 23% 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 clarki*), and Dolly Varden (Salvelinus malma).

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In consultation with various user groups, the B.C. Ministry of Environment, Lands and Parks (BCMOELP) 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. The purpose of this report is to 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 1997 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 swim survey methodology was used to estimate escapement for this stock. Swim surveys were also conducted to locate 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 1997 are explained below.

FENCE OPERATION

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Observations at the fence (Fig. 1) began on 08 September 1997. 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. For safety reasons, cleaning was only done during daylight hours and when two or more people were at the fence site.

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 of 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 Ketchum¹ 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.

Less frequent 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. Population estimates for the spring stock were based on swim surveys 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. Unless indicated, data summaries presented in this report are from fall run chinook carcasses only. Information and biological samples taken for each 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, 74 otoliths were collected to assist in age verification.

SWIM SURVEYS

As in previous years, swim surveys were jointly conducted by Nanaimo River hatchery staff, Nanaimo First Nation members and DFO employees to estimate numbers 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 predefined localities in the river (Fig. 2).

Swim surveys in the vicinity of First Lake were conducted on 18 July, 12 and 26 September 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 12 and 26 September and 14 October to estimate the number of fall chinook. A single swim below the fence along with spot checks from the road were conducted to estimate the number of chinook holding below the fence.

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 depending on the number of fish

¹ Ketchum Manufacturing Ltd., Ottawa, Canada

holding in the lower end of the river and the request would be granted once Harmac had determined whether there was sufficient water in reserve to release.

A test water release of $\sim 10 \text{ m}^3$ /sec was conducted in 1989. A release flow target of four days at 11.3 m³/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 08 September until 06 October 1997 when high water and debris forced us to discontinue the project. In previous years, attempts to improve the fishway by creating holding pools or diverting water to increase flow and encourage fish movement through the trap box had negligible results (Carter and Nagtegaal, 1998). In 1997, the continuous higher flows kept fish moving through the trap box. This was the first year in three years of operation that we were not forced to herd fish upstream and through the fence.

Since the fence was removed before the end of the chinook run, we were unable to determine an absolute total escapement. However, these counts were used to estimate a total return of 690 adult chinook (Table 1). The number of natural spawners for the fall run was estimated to be 648, which was the fence count minus the broodstock removal above the fence.

Considering that fish were not herded past the fence this year, we were able to observe preferred times of natural movement. The period between 1400 h and 1700 h showed the highest percentage of movement with 38.5% of adults and 35.6% of jacks (Table 2).

Water depth and temperature (Table 3, Figure 3) along with discharge (Figure 4 - bottom) did not appear to have any obvious influence on fish movement (Figure 4 - Top).

The floating fence design worked well provided that debris was removed regularly. Higher water throughout the sampling period disturbed more debris and made fence cleaning a continuous job. The higher maintenance cedar/vexar panels were virtually impossible to keep clean and eventually were forced under water due to high debris load. The steady, high flow also damaged some of the resistance-board fence panels causing them to loosen and come apart and ultimately we were compelled to discontinue the project since fish were able to swim through openings in these panels.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

The carcass recovery program began on 24 October and was discontinued on 21 November 1997. 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. The high water that impacted the effectiveness of the fence in 1997 also made carcass recovery difficult. Given these conditions, we were able to sample an estimated 11% of the chinook that were enumerated at the counting fence.

The escapement estimate of adult chinook based on carcass mark-recapture data was 507 with lower and upper 95% confidence limits of 484 and 530, respectively (Table 8). We consider this to be a low estimate since we had to remove the fence prior to the end of the chinook run. Based on the mark-recapture data, the simple Petersen model underestimated the fence data by 22%.

Chinook escapements have fluctuated over the last 20 years from a low of 210 (1981) to a high of 3000 (1984; Table 9). This year's estimate of 1118 is the lowest of the three years we have been monitoring the adult migration.

During the sampling period 96 carcasses were examined and 17 of these were recaptured (Table 5). There were considerably more females than males recovered (67%, 33%). Adult chinook were comprised of 3, 4, and 5-year olds with the majority (56%) being 3-year olds (Table 6).

Length-frequency data from carcass recovery show a larger mean length for females compared to males and jacks (65 cm, 61.9 cm, 40.9 cm, respectively; Table 7).

From the mark-recapture data we determined an adipose-clip mark rate of 12.57% of the total run. The mark rate for males was 7.7%, females 9.4%, and jacks 29.4% (Table 7). Codedwire tag recovery data showed that all but one chinook were Nanaimo River releases and the 1994 and 1995 brood years predominated (Appendix Table 1).

SWIM SURVEYS

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Because the counting fence was put into place on 08 September, the intention was to enumerate the fall run chinook. Swim surveys conducted in the vicinity of First Lake on 18 July and 12 September were used to estimate the spring run chinook (Table 4). According to these surveys, the escapement estimate for the total return of the spring run chinook in 1997 was 600 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 on 11 September (Inland Waters Directorate, 1997; Fig. 4) but was followed by a steady increase in rainfall so the affect of the water release on fish movement was difficult to detect.

ACKNOWLEDGEMENTS

We would like to thank Dave Key, Chris Good, Tina Wesley, Darrin Manson, Dallas Wyse, Richard Seward, Garnet White, Les Thomas, Tony White, Paul White, Dwayne Manson, and Glen Seward for their assistance in the construction, installation, and monitoring of the enumeration fence as well as the collection of biological data. We gratefully acknowledge the Nanaimo First Nation for providing funding for labour throughout the project, and particularly the involvement of Jason Wyse and John White. We thank Paul Preston and the staff of the Nanaimo River Fish Hatchery for their support, guidance and assistance throughout the project. We also thank Randy Brahniuk, Gordon Curry, and local Fisheries Officers of Fisheries and Oceans Canada for their continued support in the project.

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Date	Depth	Temp.	Chir	nook	Co	ho	Chum	Unk
<u>(dd-mm)</u>	<u>(cm.)</u>	_(°C)	Adult	Jack	Adult	Jack		
· _ /		. ,						_
08 Sep	55	17	25	0	0	0	0	0
00-Sep	68	17	25	0	0	2	0	0
10 Sep	61	17	8	5	12	2	2	2
10-Sep	01 00	17	2	2	12	2	2	2
11-Sep	00 Q/	17	5	2	2	5	0	5
12-Sep	04 50	17	21	10	1	o o	0	0
13-Sep	54	10	31 10	52	14	0	0	0
14-Sep	34 72	17	10	55	5	0	0	0
13-Sep	13	1/	59	2	3	2 11	0	1
10-Sep	/3	15	5	4	9	11	0	1
17-Sep	103	15	405	49	15	4	0	0
18-Sep	127	15	13	4	1	l	0	0
19-Sep	112	15	15	/	0	0	0	0
20-Sep	104	15	8	11	0	0	0	0
21-Sep	95	15	0	l	0	0	0	0
22-Sep	87	16	I	I	10	2	0	0
23-Sep	82	16	11	15	1	0	0	1
24-Sep	88	17	16	13	5	3	0	0
25-Sep	92	16	26	8	1	0	0	0
26-Sep	72	17	8	1	1	4	0	0
27-Sep	123	17	3	4	2	0	12	2
28-Sep	142	17	1	2	0	1	5	0
29-Sep	149	14	1	0	0	0	0	0
30-Sep	134	15	1	0	0	0	1	0
01-Oct	144	14	0	0	0	0	0	0
			<u> </u>	197	79	47	20	<u> </u>

 Table 1. Daily counts at the Nanaimo River enumeration fence, 1997.

		Chi	nook	
Time Period	Adult	Percent	Jack	Percent
0000 - 0100	18	2.6	14	7.1
0100 - 0200	2	0.3	8	4.1
0200 - 0300	17	2.5	4	2.0
0300 - 0400	27	3.9	11	5.6
0400 - 0500	9	1.3	4	2.0
0500 - 0600	10	1.4	4	2.0
0600 - 0700	8	1.2	3	1.5
0700 - 0800	8	1.2	1	0.5
0800 - 0900	2	0.3	2	1.0
0900 - 1000	12	1.7	0	0
1000 - 1100	54	7.8	14	7.1
1100 - 1200	63	9.1	8	4.1
1200 - 1300	6	0.9	4	2.0
1300 - 1400	14	2.0	8	4.1
1400 - 1500	70	10.1	20	10.2
1500 - 1600	70	10.1	28	14.2
1600 - 1700	126	18.3	22	11.2
1700 - 1800	52	7.5	1	0.5
1800 - 1900	24	3.5	5	2.5
1900 - 2000	4	0.6	2	1.0
2000 - 2100	55	8.0	10	5.1
2100 - 2200	15	2.2	23	11.7
2200 - 2300	0	0	0	0
2300 - 2400	24	3.5	1	0.5
Total	690	100	197	100

Table 2. Total counts by time interval at the Nanaimo River enumerationfence, 1997.

Date (dd-mm)	Depth (cm.)	Temp. (°C)
08-Sep	55	17
09-Sep	68	17
10-Sep	61	17
11-Sep	80	19
12-Sep	84	17
13-Sep	52	18
14-Sep	54	17
15-Sep	73	17
16-Sep	73	15
17-Sep	103	15
18-Sep	127	15
19-Sep	112	15
20-Sep	104	15
21-Sep	95	15
22-Sep	87	16
23-Sep	82	16
24-Sep	88	17
25-Sep	92	16
26-Sep	72	17
27-Sep	123	17
28-Sep	142	17
29-Sep	149	14
30-Sep	134	15
01-Oct	144	14

Table 3. Average depth and water temperature at the Nanaimo River enumeration fence,1997.

Date	Area	Chinook Adults	Chinook Jacks
19 Jul	Above/Below First Lake	107	53
12-Sept	Above/Below First Lake	49	33
12-Sept	Below Highway Bridge	75	140
26-Sept	Below Highway Bridge	53	35
14-Oct	Below Highway Bridge	5	2

 Table 4. Swim surveys conducted on the Nanaimo River, 1997.

Date	N	. Examin	. Examined		No. Tagged		No	. Recaptu	red
<u>dd-mm</u>	Males	Females	<u>Jacks</u>	<u>Males</u>	Females	<u>Jacks</u>	Males	Females	Jacks
24-Oct	10	10	2	10	10	2	5	4	1
27-Oct	7	17	7	7	17	7	0	3	0
29-Oct	2	0	3	2	0	3	0	0	0
03-Nov	2	4	2	2	4	2	1	1	0
04-Nov	0	1	0	0	1	0	0	0	0
05-Nov	0	3	1	0	3	1	0	0	0
06-Nov	0	8	1	0	8	1	0	1	0
10-Nov	2	5	0	2	5	0	0	1	0
12-Nov	0	1	1	0	1	1	0	0	0
13-Nov	1	2	0	1	2	0	0	0	0
14-Nov	2	2	0	2	2	0	0	0	0
Total	26	53	17	26	53	17	6	10	1

Table 5. Summary of chinook sampled during the carcass mark-recovery program on the Nanaimo River, 1997.

European Age ¹	Brood Year	Males	Females	Total	Proportion
			_		
0.1	1995	15	2	17	0.23
0.2	1994	19	23	42	0.56
0.3	1993	2	13	15	0.20
0.4	1992	0	1	1	0.01
Total		36	39	75	1

Table 6. Summary of age data for chinook sampled during the carcass mark-recoveryprogram on the Nanaimo River, 1997.

¹First 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: 20

Length (cm)	Males	Females	Jacks
33	0	0	1
34	0	0	0
35	0	0	1
36	0	0	1
37	0	0	2
38	0	0	0
39	0	0	0
40	0	0	4
41	0	0	0
42	0	0	1
43	0	0	0
44	1	0	4
45	0	0	0
46	0	0	2
47	0	0	0
48	0	0	1
49	0	0	0
50	1	0	0
51	1	0	0
52	0	0	0
53	2	0	0
54	2	1	0
55	0	2	0
56	0	4	0
57	2	3	0
58	0	2	0
59	1	3	0
60	1	1	0
61	Ô	1	0
62	Õ	3	0
63	2	1	Õ
64	$\frac{1}{3}$	1	Õ
65	1	2	Õ
66	1	9	Õ
67	2	Ó	õ
68	1	0 7	õ
69	n N	1	õ
70	0 0	1	Õ
70 71	1	1 0	0
71	1	。 っ	Õ
72	1	2 1	0
75 71	1		0

Table 7. Length-frequency of chinook sampled during the carcass mark-recovery program on the Nanaimo River, 1997.

Table 7. (Con	۱ť	'd)
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Length	Males	Females	Jacks
(cm)			
75	0	1	0
76	0	1	0
77	1	1	0
78	0	0	0
79	0	0	0
80	0	0	0
81	0	0	0
82	0	1	0
Total	26	53	17
Mean length	61.9	65.0	40.9
Std. Deviation	8.3	6.7	4.3
Adipose clips	2	5	5
Mark rate	7.7	9.4	29.4

Sex	Escapement	95% Confidence Limit		
		Lower	Upper	
Male ¹	193	173	213	
Female	314	291	337	
 Total	507	484	530	

 Table 8. Petersen chinook escapement estimates by sex, Nanaimo River, 1997.

¹ Adult males only, jacks not included

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Year	Natural	Hatchery	Indian Food	Total	
	Spawners	Broodstock	Fish Catch	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	80 7	
1988	650	429	0	1079	
1989	1150	402	0	1552	
1990	1275	122	0	1397	
1991	800	135	0	935	
1992	800	377	0	11 7 7	
1993	850	528	0	1378	
1994	400	280	0	742	
1995	1692 ¹	311	0	2003 ²	
1996	1431^{1}	416	0	1847 ²	
1997	1118 ¹	172	0	1290^{2}	

 Table 9. Total adult chinook returns to the Nanaimo River, 1975-1997.

¹Count at enumeration fence minus broodstock removal above the fence plus estimate of summer run.

²Count at enumeration fence plus estimate of summer run

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Figure 1. Nanaimo River study area.

LEGEND:

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



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



Figure 3. Average depth and water temperature at the Nanaimo River enumeration fence, 1997.



Figure 4. Discharge and adult chinook count (Top) and mean monthly discharge (Bottom) for the Nanaimo River, 1997.

Recovery Data				Release Data		
Date	Location ¹	Length	Sex	Tag	Brood	Location
(ddmmyy)		(POH)		Code	Year	_
271097	19	730	1	lost-pin	_	
271097	17	770	2	181008	92	Bulkley R.
271097	17	627	1	182159	94	Lower Nanaimo
271097	17	640	2	181323	94	Lower Nanaimo
271097	14	417	3	180358	95	Lower Nanaimo
271097	14	630	2	181324	94	Lower Nanaimo
271097	14	660	2	181324	94	Lower Nanaimo
101197	16	555	2	181323	94	Lower Nanaimo
271097	12	440	3	180358	95	Lower Nanaimo
271097	12	440	3	180356	95	Lake Pen
291097	10	404	3	180356	95	Lake Pen
061197	28	365	3	180355	95	Lake Pen

Appendix Table 1. Coded-wire tag code data from chinook sampled on the spawning grounds, Nanaimo River, 1997.

¹ Refer to Fig. 1.

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