

A Preliminary Report on the Adult Chinook Salmon Escapement Study Conducted on the Nanaimo River During 1996

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A PRELIMINARY REPORT ON THE ADULT CHINOOK SALMON ESCAPEMENT STUDY
CONDUCTED ON THE NANAIMO RIVER DURING 1996

by

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ABSTRACT

Carter, E.W., and D.A. Nagtegaal. 1998. A preliminary report on the adult chinook salmon escapement study conducted on the Nanaimo River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2450: 29 p.

In 1996, 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; 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 1247 in 1996. After removal of broodstock by the hatchery, the number of natural spawners was estimated at 990 for fall chinook. Based on swim survey information in the upper Nanaimo River, 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. 1998. A preliminary report on the adult chinook salmon escapement study conducted on the Nanaimo River during 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2450: 29 p.

En 1996, 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 1 247 la remonte totale de quinnats d'automne adultes dans la Nanaimo en 1996. Après prélèvement de géniteurs pour l'écloserie, le nombre total de géniteurs naturels a été estimé à 990 pour la remonte d'automne. D'après des observations des poissons en remonte dans le cours supérieur de la Nanaimo, 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.

INTRODUCTION

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 (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 1996, 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 to 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 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 1996 there were about 475,000 fall run and 171,000 spring run chinook fry released. Coded-wire tagging of chinook began in 1979 and by 1996, approximately 16% of fall chinook fry and 24% of spring 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 (*Salmo clarki clarki*), and Dolly Varden (*Salvelinus malma*).

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 1996 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 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 including improvements that were made to the project in 1996 are explained below.

ENUMERATION FENCE

Observations at the fence (Fig. 1) began on 14 August 1996. 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.

Modifications to the fence in 1996 included the installation of an additional 20 resistance board panels. This limited the use of the higher maintenance cedar/vexar panels to less than 25% of the total fence compared to about 50% in 1995.

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 accurate, the mark-recapture data enabled us to estimate the sex composition of the population.

The carcass recovery operation involved a two-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.

Less frequent excursions were made to a two to three km section of river below First Lake to locate spring run chinook stock carcasses in an attempt to estimate the escapement of this population since our fence operation was not in place when this stock entered the system. Population estimates for the spring stock were primarily based on swim surveys in the vicinity of First Lake. Although greater effort was expended surveying the area below First Lake looking for spring stock carcasses in 1996, there was difficulty locating and recovering enough adult chinook carcasses to estimate the population.

Biological data were collected primarily from spawned out chinook carcasses collected 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 forwarded to the Head Recovery Program (J.O. Thomas....). In addition, 100 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 pre-defined localities in the river (Fig. 2).

Swim surveys in the vicinity of First Lake were conducted on 12 and 24 September to estimate the number of spring run chinook. A single swim survey in the lower river between the Island highway bridge and the Forks was conducted on 30 September to estimate the number and observe the spawning distribution of fall run chinook. Additional surveys were conducted downstream of the fence on 04 September, 16 September, 24 September, and 09 October to estimate the number of fall run chinook holding below the fence.

¹ Ketchum Manufacturing Ltd., Ottawa, Canada

WATER MANAGEMENT PLAN

Three man-made reservoirs in the Nanaimo River system have been utilized 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 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 $\sim 10 \text{ m}^3/\text{sec}$ was conducted in 1989. A release flow target of 4 days at $11.3 \text{ m}^3/\text{sec}$ 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 continuous operation from 14 August until 14 October 1996 when it was evident that virtually all chinook were in the system. The fence count was considered to be the most accurate estimate of escapement since it was a direct count of fall run chinook moving into the system. The fence was situated close to the river mouth so there was very little possibility of chinook spawning downstream of the fence. In addition, chinook selected for broodstock by the hatchery were removed upstream of the fence so these would also have been accounted for at the fence. Based on counts at the enumeration fence, we estimated the total return of fall run adult chinook to be 1247 and jack chinook to be 960. The number of natural spawners for the fall run was estimated to be 990, which was the fence count minus the broodstock removal upstream.

Continuous problems with fish movement through the trap occurred in 1995. Major modifications were made to the area above and below the fence in 1996. First, prior to fence installation, a fan-shaped trough narrowing toward the trap box from the downstream side of the fence was excavated. We hoped that this holding area would allow the fish to see a passage upstream through the trap box. Fence staff regularly reported seeing fish holding in this pool.

The second modification was the building of a large berm about 1 m high and 50 m long extending on a $\sim 45^\circ$ angle upstream from the trap box. The intention was to divert more flow through the trap box and encourage the fish to pass through. Although water flow seemed to

increase, we did not conduct any flow meter tests to measure this. In spite of both of these modifications, we still experienced problems with the fish refusing to pass through the trap box.

Due to this problem, we decided it was again necessary to herd fish upstream with a seine net from a number of pools downstream of the fence where they had been holding. This was conducted on 17 September between 1200 h and 1600 h.

Since the largest pulse of fish movement was related to human intervention, it was difficult to determine a particular time interval when a larger proportion of chinook naturally moved passed the counting fence. With this in mind, the period between 1700 h and 1800 h showed the highest percentage of movement with 18% of adults and 22% of jacks (Table 2). Other peaks occurred between 0700 h to 0800 h (17% adults, 8% jacks) and 1600 h to 1700 h (13% adults, 16% jacks).

Comparisons of fish movement to water depth and temperature (Table 3) indicated no obvious trends although on a rising tide staff observed more fish holding below the fence.

The floating fence design worked well provided that debris was removed regularly. Although surface debris could be easily removed from the resistance-board fence panels, the low flow in the river again allowed large amounts of algae to build up beneath the fence and was difficult to remove. The fewer cedar/vexar panels used this year were placed on the shallower side of the river and though more difficult to maintain, did not present as large a problem as in 1995.

MARK-RECAPTURE AND BIOLOGICAL DATA COLLECTION

The carcass mark-recapture program began on 24 October and was discontinued on 21 November 1996. 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 the conditions in 1996, about 13% of the chinook that passed the counting fence were sampled.

The escapement estimate of adults based on carcass mark-recapture data was 981 with lower and upper 95% confidence limits of 821 and 1,142, respectively (Table 4). Based on the mark-recapture data, the simple Petersen model estimate compared very favourably, underestimating the fence data by only 1%. Chinook escapements have fluctuated over the last 20 years from a low of 210 (1981) to a high of 3000 (1984; Table 9). The adult return in 1996 represents the second highest in ten years.

During the sampling period 160 adult fall run chinook carcasses were examined and 30 of these were recaptured (Table 5). There were considerably more females than males recovered (69%, 31%). Adult chinook were comprised of 3, 4, and 5-year olds with the majority being 3-year olds (Table 6).

Length-frequency data from carcass recovery show a larger mean length for females compared to males and jacks (63.4 cm, 60.3 cm, 43.0 cm, respectively; Table 7).

From the mark-recapture data we determined an adipose-clip mark rate of 15.7% of the total run. The mark rate for males was 17.4%, females 13.5%, and jacks 23.8% (Table 7). CWT recovery data showed that all chinook were Nanaimo River releases and the majority (67%) were 1993 brood year (Appendix Table 1).

SWIM SURVEYS

Because the counting fence was put into place on 14 August, the intention was to enumerate the fall run chinook. Swim surveys conducted in the vicinity of First Lake on 12 September and 24 September were used to estimate the spring run chinook. According to these surveys, the escapement estimate for the total return of the spring run chinook in 1996 was 600 adults and 100 jacks (Table 8).

The swim survey estimate on 30 September, for chinook holding between the Island Highway bridge and the fence, was considerably lower than the numbers of fish recorded passed the fence up to that date. One explanation for this could be that the majority of these fish had moved upstream of the traditional spawning areas for fall run chinook. Alternatively, fish holding in large, deep pools with poor visibility within the traditional spawning areas may have been undetected by swimmers.

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, Lands and Parks (BCMOELP) in June 1989. A team comprised of members from the BCMOELP, Greater Nanaimo Water District, MacMillan Bloedel Limited, Nanaimo First Nation, and 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 pulpmill 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).

Water releases in 1996 occurred on 26 September and on 11 October (Inland Waters Directorate, 1996; Fig. 3). Although we did not observe an increase in the number of fish passing through the trap during the first release, the water release resulted in an increase of fish moving up

to the fence. The combined conditions of a larger water release and some rain, the second release was a success and increased upstream movement for chinook, coho, and chum.

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Table 1. Daily counts at the Nanaimo River enumeration fence, 1996.

Month	Day	No. Chinook Adults	No. Chinook Jacks	No. Coho Adults	No. Coho Jacks	No. Chum
August	14	4	0	0	0	0
	15	2	84	0	0	0
	16	0	1	0	0	0
	17	0	0	0	0	0
	18	0	0	0	0	0
	19	0	1	0	0	0
	20	0	0	0	0	0
	21	0	0	0	0	0
	22	0	0	0	0	0
	23	0	0	0	0	0
	24	0	2	0	0	0
	25	0	4	0	0	0
	26	0	1	0	1	0
	27	0	0	0	0	0
	28	0	0	0	0	0
	29	0	1	0	0	1
	30	0	2	0	0	0
	31	0	2	0	0	0
September	1	0	0	0	0	0
	2	0	0	1	0	2
	3	1	0	0	0	0
	4	0	3	0	0	0
	5	1	2	0	0	0
	6	0	1	0	0	0
	7	215	62	0	0	0
	8	22	3	1	1	2
	9	6	7	0	0	0
	10	1	1	0	0	0
	11	15	9	0	0	0
	12	179	130	0	0	0
	13	5	0	0	0	0
	14	21	19	0	0	0
	15	1	0	0	0	0
	16	7	8	0	0	0
	17	498	489	0	0	0
	18	26	5	0	0	0
	19	13	27	0	0	0
	20	1	1	0	0	0
	21	0	0	0	0	0

Table 1. (cont'd)

Month	Day	Chinook Adults	Chinook Jacks	Coho Adults	Coho Jacks	Chum
September	22	0	1	0	0	0
	23	9	14	1	0	0
	24	9	8	2	0	5
	25	28	7	3	0	1
	26	8	9	4	3	26
	27	1	4	0	0	12
	28	0	2	0	2	22
	29	0	0	1	3	9
	30	0	1	3	3	8
October	1	0	0	0	2	6
	2	2	0	1	4	6
	3	2	2	0	1	2
	4	0	0	0	0	197
	5	2	1	0	0	365
	6	0	0	0	0	0
	7	1	4	2	0	9
	8	4	2	0	0	7
	9	6	3	3	6	41
	10	19	8	24	19	294
	11	42	9	77	28	591
	12	0	0	1	2	197
	13	94	20	47	103	2167
	14	2	0	0	21	1371
Total		1247	960	170	198	5338

Table 2. Daily counts of fall run chinook by time interval at the Nanaimo River enumeration fence, 1996.

Time Period	No. Chinook Adults	Percent	No. Chinook Jacks	Percent
0000 - 0100	5	0.4	32	3.3
0100 - 0200	5	0.4	22	2.3
0200 - 0300	6	0.5	18	1.9
0300 - 0400	7	0.6	10	1
0400 - 0500	8	0.6	12	1.3
0500 - 0600	11	0.9	10	1
0600 - 0700	18	1.4	16	1.7
0700 - 0800	210	16.8	80	8.3
0800 - 0900	44	3.5	16	1.7
0900 - 1000	14	1.1	12	1.3
1000 - 1100	7	0.6	3	0.3
1100 - 1200	23	1.8	4	0.4
1200 - 1300	100	8.1	88	9.2
1300 - 1400	108	8.7	42	4.4
1400 - 1500	23	1.8	19	2
1500 - 1600	38	3	23	2.4
1600 - 1700	165	13.2	156	16.3
1700 - 1800	220	17.6	208	21.5
1800 - 1900	52	4.2	36	3.8
1900 - 2000	65	5.4	35	3.6
2000 - 2100	91	7.3	82	8.5
2100 - 2200	11	0.9	10	1
2200 - 2300	8	0.6	12	1.3
2300 - 2400	8	0.6	14	1.5
Total	1247	100.0	960	100.0

Table 3. Average depth and water temperature recorded at the Nanaimo River enumeration fence, 1996.

Month	Day	Depth (cm.)	Temp. (°C)	Month	Day	Depth (cm.)	Temp. (°C)
Aug.	14	0	0	Sept.	26	80	12
	15	59	21		27	84	13
	16	63	20		28	62	12
	17	66	20		29	63	14
	18	61	19		30	67	13
	19	61	18	Oct.	1	65	12
	20	61	18		2	66	12
	21	62	18		3	60	12
	22	72	17		4	65	12
	23	61	19		5	78	12
	24	82	19		6	74	13
	25	76	20		7	76	13
	26	66	20		8	73	14
	27	60	20		9	72	14
	28	58	20		10	71	14
	29	59	20		11	87	13
	30	72	20		12	82	12
	31	61	20		13	85	11
Sept.	1	61	19		14	105	11
	2	62	17				
	3	61	18				
	4	60	17				
	5	66	17				
	6	64	16				
	7	67	38				
	8	64	17				
	9	63	17				
	10	60	17				
	11	67	17				
	12	67	17				
	13	81	17				
	14	63	18				
	15	66	16				
	16	64	16				
	17	61	16				
	18	72	15				
	19	69	15				
	20	62	15				
	21	62	14				
	22	66	14				
	23	58	12				
	24	59	13				
	25	64	12				

Table 4. Petersen chinook escapement estimates, by sex, for fall run chinook based on carcass mark-recapture, Nanaimo River, 1996.

Sex	Escapement Estimate	95% Confidence Limit	
		Lower	Upper
Male ¹	295	210	380
Female	666	536	796
Total	981	821	1,142

¹ Adult males only, jacks not included.

Table 5. Summary of fall run chinook sampled during the carcass mark-recapture program on the Nanaimo River, 1996.

Date	No. Examined		No. Tagged ¹		No. Recaptured	
	Males	Females	Males	Females	Males	Females
2410	8	6	8	6	0	0
0111	5	18	5	18	2	0
0411	6	21	6	21	0	8
0511	8	8	8	8	0	0
0611	6	12	6	12	0	0
0711	0	3	0	2	0	4
0811	4	3	4	3	4	0
1211	6	16	6	16	1	1
1311	0	0	0	0	0	1
1511	1	1	1	1	1	0
1811	5	16	5	16	1	0
2011	0	7	0	7	0	6
2111	0	0	0	0	0	1
Total	49	111	49	110	9	21

¹Ketchum operculum tag

Table 6. Age composition, by sex, for fall run chinook sampled during the carcass mark-recapture program on the Nanaimo River, 1996.

Age	No. of Males	No. of Females	Total	Proportion
2	10		10	0.13
3	16	34	50	0.68
4	1	12	13	0.18
5	0	1	1	0.01
Total	27	47	74	1.00

Table 7. Length-frequency of fall run chinook sampled during the carcass mark-recapture program on the Nanaimo River, 1996.

Length (cm)	Males	Jacks	Females
31	0	1	0
32	0	0	0
33	0	0	0
34	0	0	0
35	1	0	0
36	0	1	0
37	0	0	0
38	0	1	0
39	0	2	0
40	0	0	0
41	0	0	0
42	0	3	0
43	1	2	0
44	0	1	0
45	0	3	0
46	0	1	0
47	0	4	0
48	0	2	0
49	0	0	0
50	2	0	0
51	1	0	0
52	1	0	1
53	0	0	2
54	0	0	0
55	1	0	0
56	3	0	6
57	2	0	3
58	1	0	10
59	4	0	6
60	6	0	7
61	2	0	6
62	6	0	13
63	1	0	10
64	2	0	10
65	3	0	4

Table 7 (cont.)

Length (cm)	Males	Jacks	Females
66	1	0	4
67	1	0	5
68	3	0	4
69	1	0	3
70	1	0	1
71	1	0	2
72	0	0	6
73	0	0	1
74	0	0	4
75	0	0	1
76	1	0	1
77	0	0	0
78	0	0	1
Total	46	21	111
Mean Length	60.3	43.0	63.4
Adipose-clipped	8	5	15
Mark Rate	17.4	23.8	13.5

Table 8. Swim surveys conducted on the Nanaimo River, 1996.

Survey Type	Date	Area	No. Chinook Adults	No. Chinook Jacks
Swim	Sept. 4	Below fence	300	100
Swim	Sept. 16	Below fence	370	220
Swim	Sept. 24	Below fence	450	65
Swim	Oct. 9	Below fence	250	55
Swim	Sept. 12	Green Cr. to Bore Hole	175	100
Swim	Sept. 24	First Lake	15	25
Swim	Sept. 30	Below Hwy Bridge	407	286

Table 9. Total adult chinook returns to the Nanaimo River, 1975-1996.

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	1692 ¹	311 ²	0	2003 ³
1996	1431 ¹	416 ²	0	1847 ³

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

² Combined broodstock removal for spring and fall stock.

³ Count at enumeration fence plus estimate of spring run.

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FIGURES

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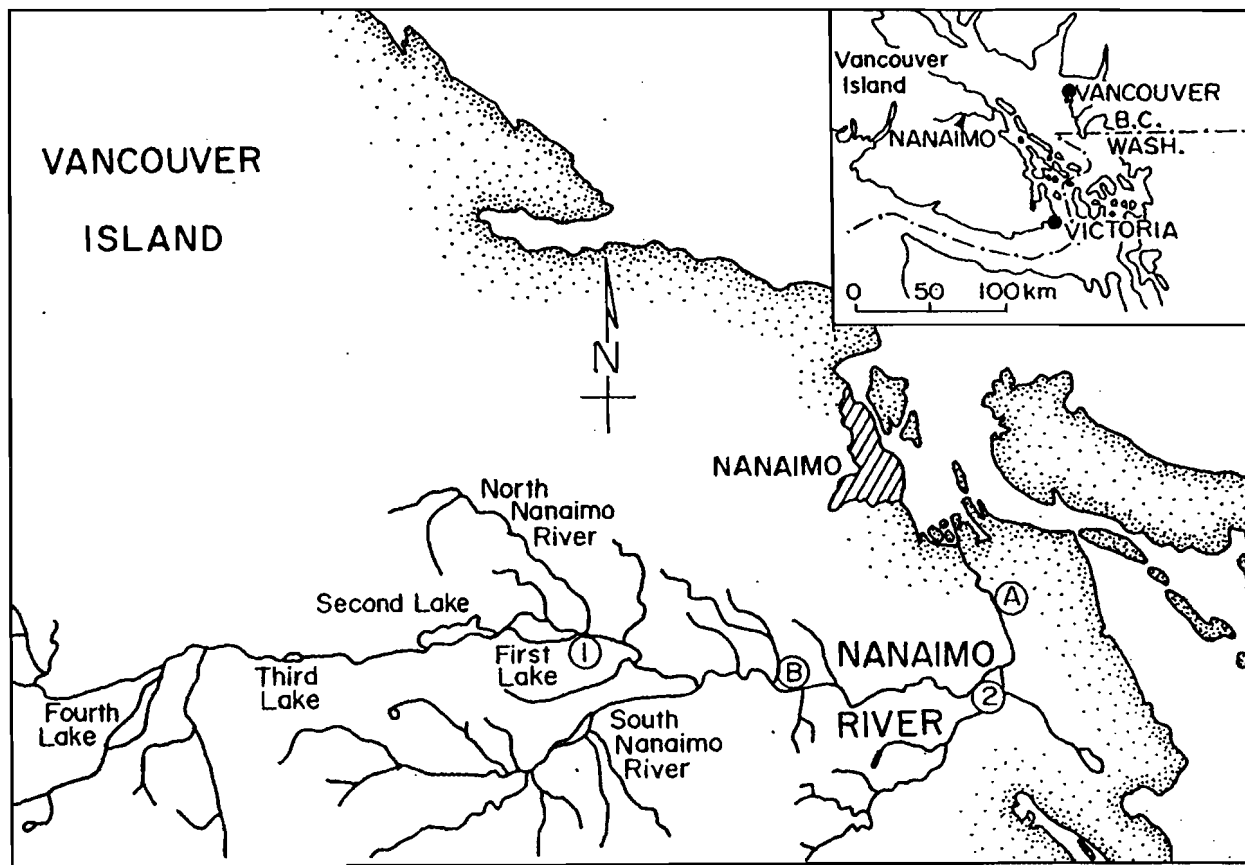


Figure 1. Nanaimo River study area.

LEGEND:

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

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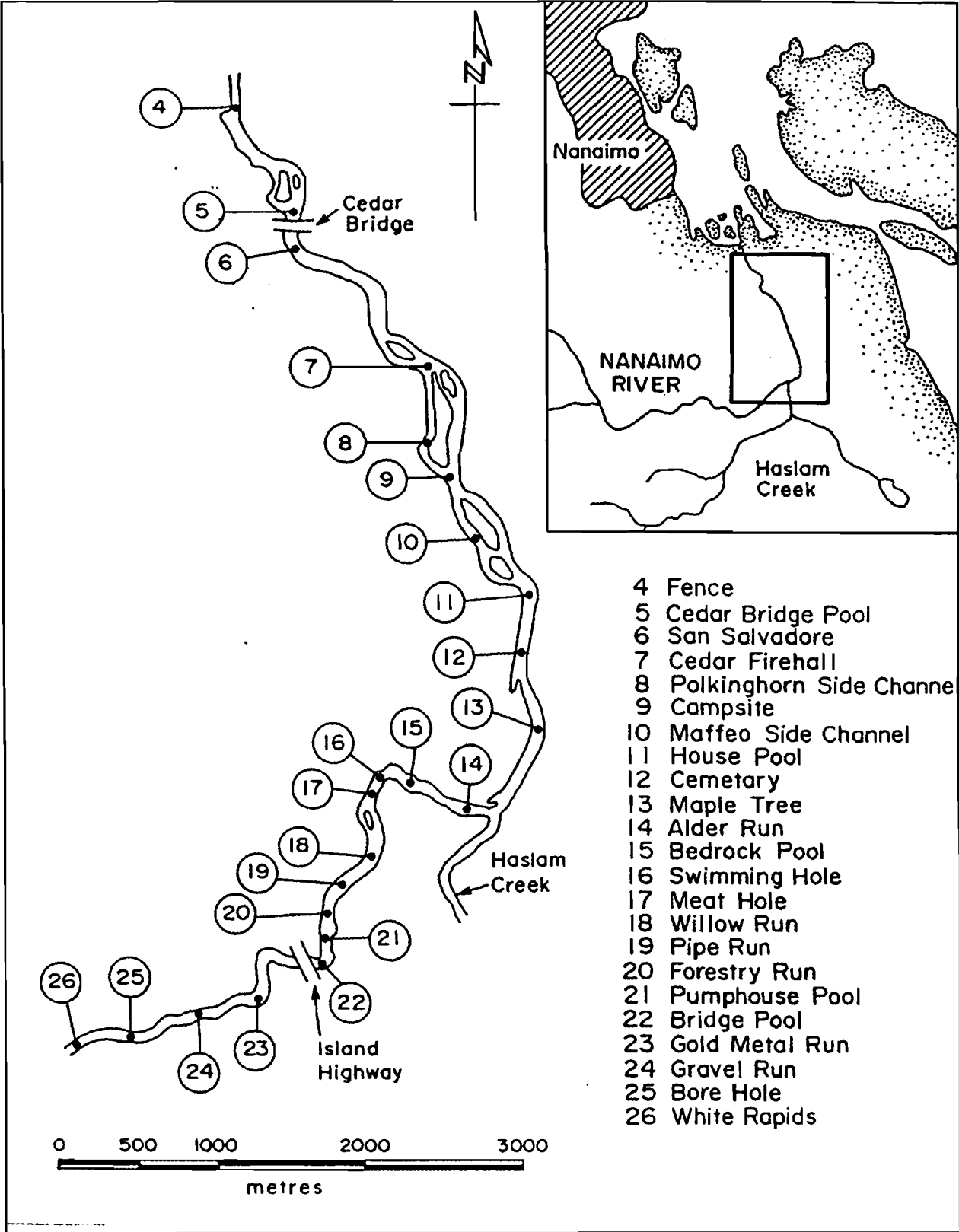
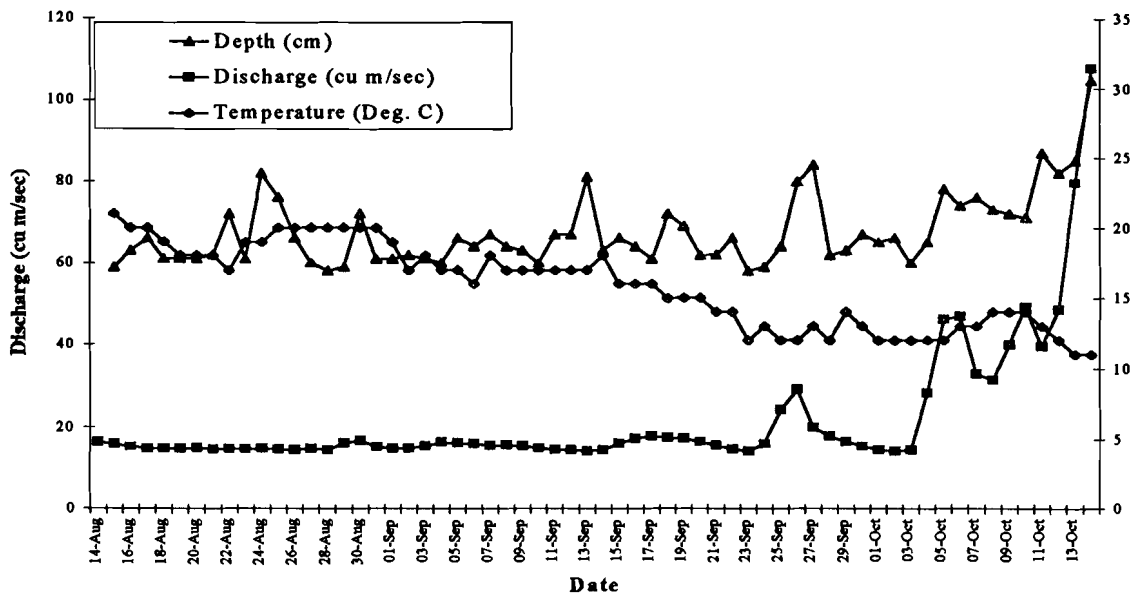


Figure 2. Swim and mark-recapture sites on the Nanaimo River.

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Daily discharge for the Nanaimo River



Mean monthly discharge for the Nanaimo River

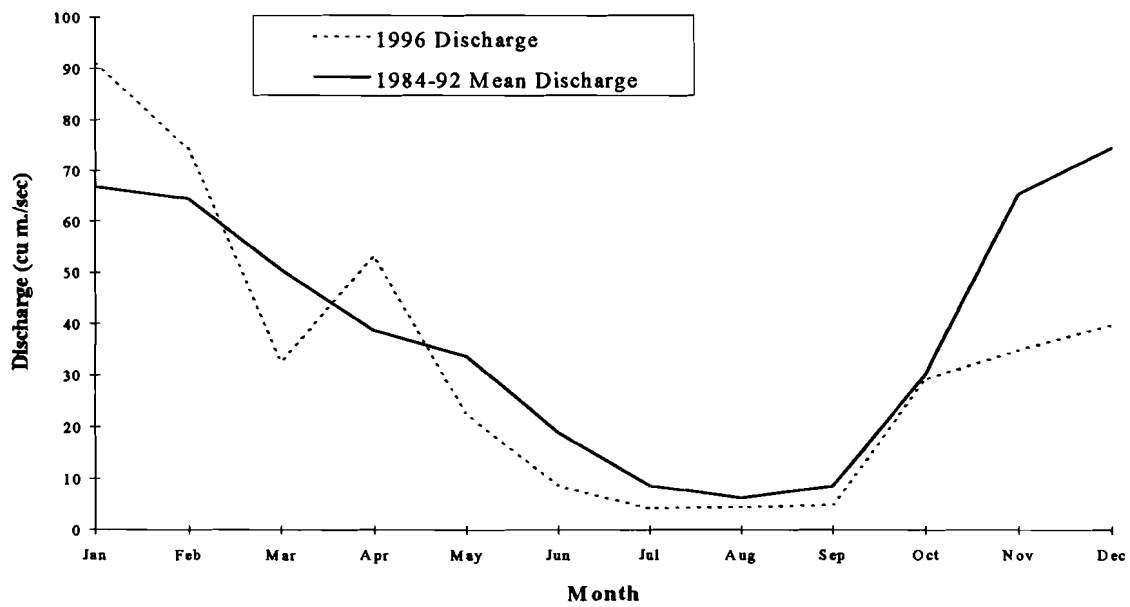


Fig. 3. Discharge data for the Nanaimo River.

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Appendix Table 1. Tag code data from chinook sampled during the carcass recovery program on the Nanaimo River, 1996.

Recovery Date	Release Location	Recovery Location¹	Length	Sex	Brood Year	E-Label No.
961024	Nanaimo River	20	615	M	93	340634E
961024	Nanaimo River	19	504	M	94	340636E
961024	Nanaimo River	19	572	M	93	340637E
961024	Nanaimo River	19	640	F	93	340638E
961101	Nanaimo River	18	664	F	93	340639E
961101	Nanaimo River	18	620	F	93	340640E
961101	Nanaimo River	18	622	M	93	340641E
961104	Nanaimo River	21	640	F	93	340643E
961104	Nanaimo River	20	585	F	93	340642E
961104	Nanaimo River	16	455	M	94	340644E
961104	Nanaimo River	16	627	F	93	340645E
961104	Nanaimo River	14	640	F	93	340646E
961104	Nanaimo River	13	415	M	94	340647E
961106	Nanaimo River	18	668	M	93	340949E
961106	Nanaimo River	18	605	F	93	340650E
961108	Nanaimo River	18	560	M	93	340653E
961112	Nanaimo River	19	619	M	92	340655E
961112	Nanaimo River	18	609	F	93	340656E
961112	Nanaimo River	15	704	M	93	340657E
961112	Nanaimo River	15	580	F	93	340658E
961115	Nanaimo River	14	622	M	94	340648E
961118	Nanaimo River	11	470	M	94	340659E
961118	Nanaimo River	11	700	F	92	340660E
961118	Nanaimo River	07	393	M	94	340661E

¹ See Fig. 2 for recovery locations