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An Inventory of East Coast Vancouver Island Streams Important to Chum Salmon

F.J. Fraser
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Technical Report Series PAC/T-74-21

Southern Operations Branch
Pacific Region

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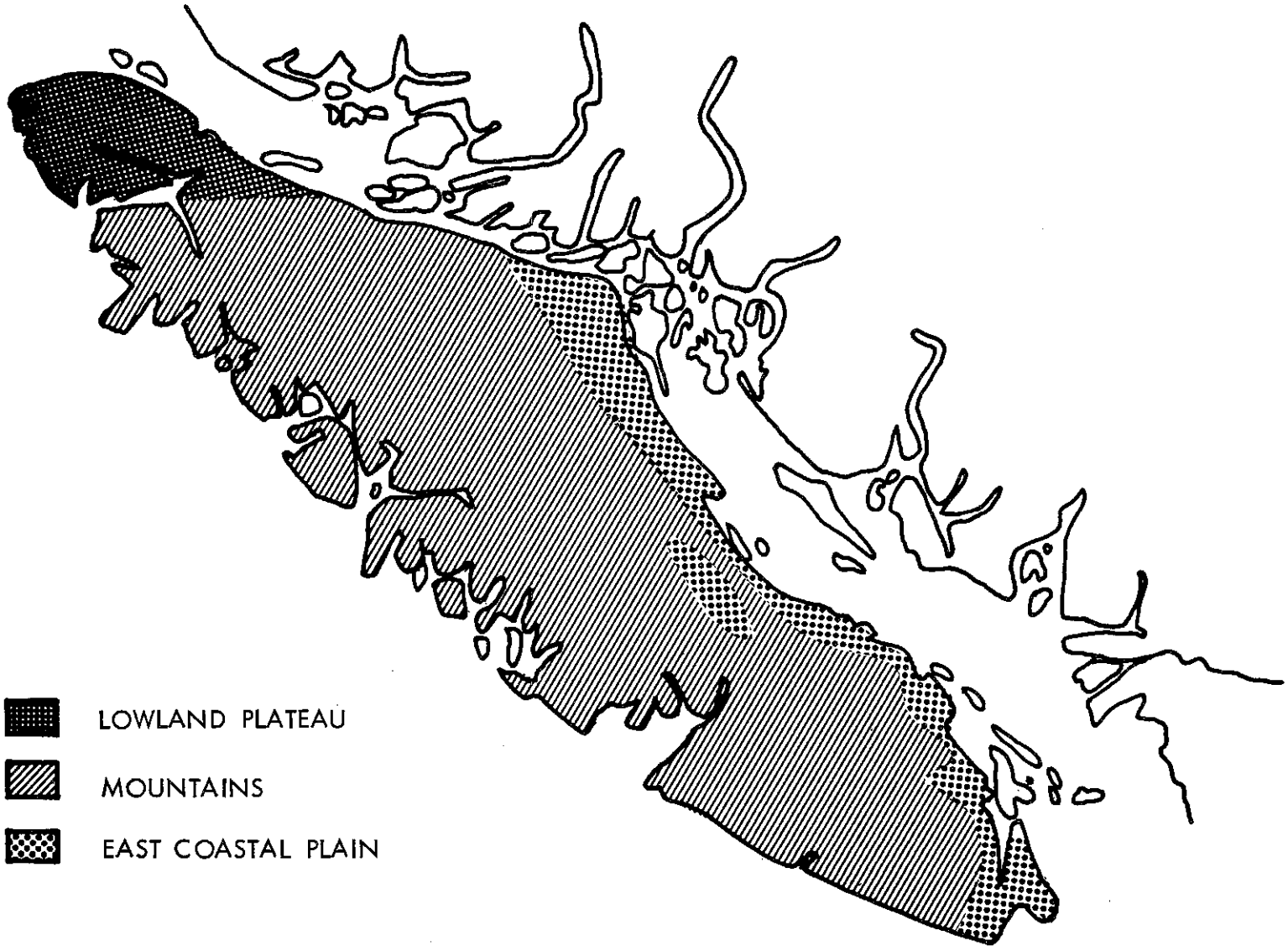

FIGURE 1 PHYSIOGRAPHIC REGIONS OF VANCOUVER ISLAND.

INTRODUCTION

Geography

Vancouver Island, oriented in a northwest-southeast direction off the southern coast of British Columbia, measures approximately 290 miles by 60 miles and is about 13,000 square miles in area (Figure 1). Vancouver Island consists of a series of northwest trending mountains flanked on its eastern shore by a narrow coastal plain and on its western shore by an island studded, deeply fiorded coast.

The east coastal plain represents an emerged portion of the Pacific Coast Downfold, a great trough extending from the Gulf of California to Alaska. The east coastal plain is generally less than 500 feet above sea level and forms a narrow strip from the southeastern tip of the island to the northern end of the Strait of Georgia. In width, it averages eight miles but varies from less than one mile near Chemainus to 13 miles near Campbell River. The east coastal plain, together with the neighbouring Fraser Valley, is one of the few extensive lowland areas in British Columbia. Its mild marine climate and rich soil make the east coastal plain one of the most favourable parts of British Columbia for human habitation (Anon. 1959). Although representing only a small portion of the area of Vancouver Island, the east coastal plain supports over 90 percent of the population.

From Salmon River northward to Nimpkish River, the Vancouver Island mountain ranges extend to the coast. Streams in this area flow between mountains with up to 5,500 foot elevations. At the north end of the island, the mountain ranges end abruptly along an east-west line through the mouth of Quatsino Sound. Streams northwest of Nimpkish River pass through terrain consisting of areas of flatland separated by low rolling ranges of hills whose highest elevation is about 2,500 feet above sea level. Whereas streams in the east coastal plain and upper lowland areas are generally short, small systems, rivers from Salmon River to Nimpkish River are extensive systems with numerous tributaries.

Climate

Generally, Vancouver Island has a mild marine climate. The west coast of the island has a relatively wet climate with a total annual precipitation over 100 inches and the east coast climate is relatively dry with an annual precipitation of 30-70 inches (Anon. 1959). Mean annual rainfall is 68 inches at Port Hardy, 50-60 inches from Alert Bay south to Parksville, and from 30-40 inches from Parksville south to Victoria. About three quarters of the precipitation occurs from October to March. Summers are characterized by low rainfall and clear sunny weather. Most of the streams are characterized by high winter runoff and low summer flows.

Economics and Industrial Activity

Forestry, agriculture, fishing, mining, and tourism are the main economic activities on Vancouver Island with forestry being the most important (Anon. 1959). Logging operations over the past 100 years have removed much of the mature forest from readily accessible areas and second growth stands are now appearing. Logging operations, pulp and paper, hydro-electric development, gravel removal, domestic and industrial water usage, and an expanding population are threatening many of the salmon producing streams on the east coast of Vancouver Island.

Salmon Resource

The east coast Vancouver Island streams support populations of five species of Pacific salmon. The only significant sockeye population *(Oncorhynchus nerka)* spawns in the Nimpkish River system with an average escapement for the last ten years of 77,000. Table I lists the escapements of chinook *(O. tshawytscha)*, coho *(O. kisutch)*, chum *(O. keta)*, and pink *(O. gorbuscha)* salmon to the three different geographical areas of the east coast of Vancouver Island—upper lowland (Upper Vancouver Island), mountainous (Johnstone Strait), and east coastal plain (Mid and Lower Vancouver Island). Approximately 92 percent of chum escapement, and 75 percent of the coho and chinook escapement, return to streams of the east coastal plain. Pinks are present only in streams from Puntledge River northward and 97 percent of escapement is in the Upper Vancouver Island and Johnstone Strait areas. Salmon escapements to the east coast of Vancouver Island have for the last ten years (1964-1973) averaged 371,000 chum, 502,000 even-year pinks, 69,000 odd-year pinks, 137,000 coho, and 23,000 chinook. East coast Vancouver Island chums account for approximately 25 percent of the chum escapement in southern British Columbia, even-year pinks account for 40 percent, odd year pinks about 3 percent, coho about 30 percent, and chinook about 15 percent.

Listed in order of importance in Table II are approximately 30 percent of the total number of salmon bearing streams on the east coast of Vancouver Island. However, these streams contain 90 percent of the total chum, pink, and chinook escapement and 80 percent of the total coho escapement on the east coast of the island.

Stream Inventory Survey

During the summers of 1969 and 1970, chum producing streams of the east coast of Vancouver Island were surveyed by personnel of the Fisheries Service to provide an inventory of potential chum spawning areas as an aid in resource management; in particular, to optimize utilization of available spawning area. The amount of gravel suitable for chum spawning was estimated and observations made on conditions affecting salmon production within the streambed and the watershed. Possible or actual barriers to upstream migration were examined and evaluated, as were any other factors thought to have a bearing on the stream's productivity. While some observations were made concerning other species of salmon, the emphasis was on chum salmon and particularly upon estimating the chum spawning capacity of each stream. Of the 35 streams surveyed, 27 are located in the east coastal plain, 4 in the Johnstone Strait area, and 4 in the upper lowland area.

METHODS

A Toko optical range finder was used to determine stream dimensions at estimated high-water levels (debris line). The length and width of the stream were determined in convenient adjoining subsections and an accompanying photograph taken. From these measurements, the wetted area was calculated. On the four rivers surveyed in 1969 (Little Qualicum, Chemainus, Cowichan, and Koksilah), an estimate of the total spawning area for all species of salmon was made as a percent of the wetted area of each subsection. The percent of this total spawning area within each subsection, which could be utilized by chum salmon, was then estimated. On the rivers surveyed in 1970 (all the remaining), the spawning area suitable for chums was estimated directly as a percent of the wetted area in each subsection. From the estimate of the total chum spawning area, an estimate of the capacity of the stream was made.

Chum capacity of a stream is calculated using the figure of 1.1 square yards of spawning gravel per fish. This figure is based on spawning behaviour studies by Giles (1967) in the artificial spawning channel #1 at the Big Qualicum River Project and has been corroborated by the observations of natural spawning by various Fisheries Service personnel. This figure allows 2.2 square yards per spawning pair (ignoring unequal sex ratios and multiple spawning by males) and would provide optimum use of the available spawning area.

In this survey, it is assumed that no intertidal spawning takes place even though extensive gravel occurs in many streams in the intertidal zone (Appendix 1).

DISCUSSION

From estimates of spawning capacity from the survey and estimated escapement figures, it is possible to consider the present utilization of available spawning area. Chum escapement as a percentage of estimated chum capacity is presented in Table III. The more northerly streams of Vancouver Island show poor utilization by chum salmon. Since 1960, the streams of Upper Vancouver Island and Johnstone Strait areas, particularly the Quatse, Keogh, Cluxewe, Kokish and Tsultan, Adam and Eve, and Salmon Rivers, have utilized less than five percent of the available surveyed spawning area. However, these streams are large producers of pink salmon; and much of the gravel suitable for chums is also suitable for pink salmon.

Neave (1953) states that "in general, pink and chum salmon occupy somewhat different ecological niches. In fact, one or other usually dominates in a given stream or portion of a river system". It appears that, biologically, these streams are more suitable for pink than chum salmon. However, substantial increases in chum populations should still be possible, at least to the levels of the early 1950's. A few streams support large populations of both species, e.g. Nimpkish and Puntledge.

Only two large streams on Vancouver Island approach or exceed the calculated spawning capacity—Big Qualicum and Little Qualicum. Since 1963, the Big Qualicum has been the site of a major enhancement project of the Fisheries Service and includes flow control, spawning channels, and a hatchery. Since 1950, escapements to east coast Vancouver Island streams have averaged only 32 percent (range 12-59%) of calculated chum capacity. Escapements of pinks in Table III include even and odd year races. However, in recent years, only the even year populations have been important in the Tsulquate, Quatse, Keogh, Cluxewe, Kokish, and

Campbell Rivers. Only the Adam and Salmon Rivers have large even and odd-year escapements. If pink and chum escapements are combined, Vancouver Island streams are still only utilized to 58 percent (range 22-83%) of capacity.[1] In addition to the chum capacity of 1,190,400 in Table III a further 458,800 chums could be accommodated in 504,700 square yards of potentially usable spawning area which exists upstream of the present limits of chum migration. The Cowichan and Salmon Rivers contain 73 percent of this potentially usable spawning area. If this additional capacity is included, chum utilization since 1950 is lowered to 19 percent of capacity and chum plus pink utilization is lowered to 42 percent.

Information on spawning times is available in the International North Pacific Fisheries Commission Bulletin #23 and Department of Environment, Fisheries Service, spawning ground and tagging reports. Although there are discrepancies in some of the information, in most cases the information from different sources coincides. Table III shows the times of peak spawning from spawning ground reports and tagging information. Peak spawning for east coast Vancouver Island pinks occurs from mid September to early October with most occurring in late September. Peak spawning for east coast Vancouver Island chums occurs from mid October to mid December with most spawning in late November and early December. Of the larger chum producers (>10,000 spawners), Nanaimo and Chemainus spawn early (late October-early November), Puntledge and Little Qualicum in the middle (late November), and Nimpkish, Big Qualicum and Cowichan spawn late (early December).

One major chum producing stream, the Campbell River, was not surveyed. At the time the survey was to be undertaken, river flow was too high for any visual measurement of spawning area. Later on, time limitations prevented a return to the river. Escapements for the Campbell River are included at the bottom of Table III.

This survey provides much needed information for salmon management and a data base for more extensive stream information from these and other salmon bearing streams. Surveys of these streams during spawning and incubation, are needed to evaluate such questions as spawning distribution, siltation, flow variation, gravel stability, pink and chum cohabitation, or any factor which could impair or reduce a wetted area's adequacy as spawning area.

ACKNOWLEDGEMENTS

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[1]Pink capacity is computed using a figure of 1.0 square yards per spawner.

APPENDIX 1

Intertidal Spawning

The exact extent and efficiency of intertidal spawning has not been determined for the Vancouver Island streams examined. Studies in Alaska, however, have shown that chums will spawn successfully down to the six foot tide level in an area of 12 foot mean high tides (Bailey, 1964). The factors these studies showed to be most important in determining successful intertidal incubation are silting, temperature, and salinity (Helle, 1964; Thorsteinson, 1965). The gradient through the intertidal zone must be sufficient to counteract the silting which occurs at high tides, or there must be sufficient upwelling of groundwater to maintain circulation through the redds. The periodic influx of saltwater over the redds increases the average incubation temperature and significantly increases the rate of development. Dissolved oxygen varies with temperature but levels probably never become critical during the late fall and winter incubation period. Oxygen problems are more likely to be encountered due to lack of circulation through the redds. Intragravel salinity also increases with the oncoming tide. The precise individual effect of these factors or how they interrelate has yet to be determined under controlled condition (Thorsteinson, 1965). The Alaskan field observations show that survival gradually decreases down to zero percent at the six foot tide level (Mattson et al, 1962, 1963, 1964; Bailey, 1964). However, in the upper portions of the intertidal, survival and growth can in some cases be better than that in freshwater (Rockwell, 1956). This is attributed to the moderating effect on temperatures of the saltwater during the extremes of Alaskan winters.

The results of the studies outlined above are useful in predicting the extent and success of intertidal spawning in the rivers under examination. These rivers flow over a coastal plain of varying width before entering the sea. This leads to low gradients through the intertidal with the resultant silt deposition leading to unfavourable spawning and incubation conditions. Any ameliorating effect tidewater might have on the temperature in redds in the intertidal of these streams would not be as significant as that experienced in the more extreme Alaskan climate.

The extensive silting which occurs in the estuaries of the streams examined makes them practically useless as spawning areas with one notable exception. The top 2,500 feet of the Chemainus estuary has a slightly higher gradient and is reported to have upwellings of freshwater through the gravel in some areas (G. Wilson, pers. comm.). These conditions have not been thoroughly examined during spawning and incubation but assuming their existence, this section provides 6,752 square yards of spawning area with a potential capacity of 6,100 chum spawners. These figures are included in the totals for the river. On all other streams, the intertidal spawning capacity was not included but closer examination might reveal groundwater upwelling similar to that reported for the Chemainus (particularly on the Cowichan). The question of intertidal spawning requires further investigation.

TABLE I Salmon Escapements of the East Coast of Vancouver Island (x1000)

Area	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	Mean	
CHUM												
Upper Vancouver Island (Stranby-Hyde Cr.)	13.65	9.43	3.28	1.92	16.00	4.85	4.15	0.53	4.65	2.16	6.06	
Johnstone Strait (Nimpkish-Salmon R.)	16.78	15.80	40.16	17.45	55.83	7.93	19.58	8.25	21.98	26.55	23.03	
Mid Vancouver Island (Amor de Cosmos-Englishman R.)	123.75	40.11	146.53	118.90	337.05	232.60	300.18	165.56	247.05	324.87	203.66	
Lower Vancouver Island (Nanoose-Goldstream R.)	78.30	80.73	220.95	126.45	169.18	142.54	104.19	55.50	226.35	177.86	138.21	
Total	232.48	146.07	410.92	264.72	578.06	387.92	428.10	229.84	500.03	531.44	370.96	
PINK											**Even**	**Odd**
Upper Vancouver Island	134.50	30.06	506.50	7.12	466.00	3.04	458.70	6.25	124.70	17.24	338.08	12.74
Johnstone Strait	111.40	104.30	144.58	7.80	185.00	9.60	129.43	61.54	171.93	71.80	148.47	51.01
Mid Vancouver Island	7.45	8.75	17.65	6.90	14.60	1.27	14.55	2.92	20.63	6.05	14.97	5.18
Total	253.35	143.11	668.73	21.82	665.60	13.91	602.68	70.71	317.26	95.09	501.52	68.93
COHO												
Upper Vancouver Island	27.30	22.75	19.55	9.73	20.33	3.20	24.70	7.50	3.11	7.30	14.55	
Johnstone Strait	26.25	50.50	23.00	8.70	18.90	3.00	40.75	18.53	12.15	17.75	21.95	
Mid Vancouver Island	89.90	60.18	80.55	24.36	38.06	15.58	57.39	59.75	21.48	31.28	47.85	
Lower Vancouver Island	119.03	22.10	47.40	46.73	20.89	40.97	91.57	88.64	15.38	38.65	53.14	
Total	262.48	155.53	170.50	89.52	98.18	62.75	214.41	174.42	52.12	94.98	137.49	
CHINOOK												
Johnstone Strait	9.28	4.60	3.60	2.48	8.28	0.80	6.75	1.58	8.33	11.53	5.72	
Mid Vancouver Island	8.18	11.33	6.93	5.65	5.60	7.90	6.32	9.23	9.36	5.98	7.65	
Lower Vancouver Island	8.63	11.13	16.93	4.95	9.18	9.05	9.24	8.81	10.81	9.69	9.84	
Total	26.09	27.06	27.46	13.08	23.06	17.75	22.31	19.62	28.50	27.20	23.21	
SOCKEYE												
Nimpkish	100.00	30.00	120.00	100.00	35.00	100.00	50.00	75.00	60.00	100.00	77.00	

TABLE II Streams on the East Coast of Vancouver Island supporting major populations of Pinks, Chums, Coho and Chinook.

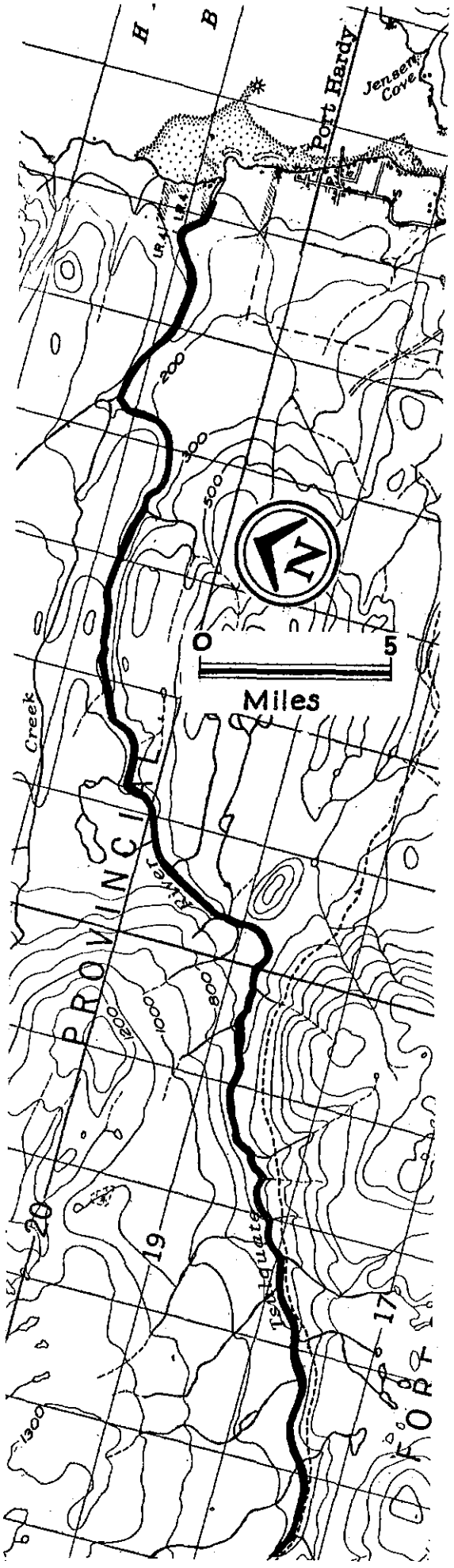
PINK	Mean Escapement 1964-1973	CHUM	Mean Escapement 1964-1973
EVEN YEAR			
Keogh	92,000	Big Qualicum	87,930
Bear	87,000	Cowichan	61,000
Quatse	80,200	Little Qualicum	54,977
Stranby	62,250	Puntledge	33,750
Nahwitti	57,900	Nanaimo	33,250
Cluxewe	33,200	Nimpkish	21,300
Adam	27,700	Chemainus	13,325
Tsulquate	14,600	Tsable	8,360
		Goldstream	7,380
ODD YEAR		Holland	5,585
Adam	36,200	Englishman	5,400
Salmon	10,500		
Keogh	6,100		
Tsitika	3,040		
Tsolum	2,174		
Cluxewe	1,990		
Tsulquate	1,536		

COHO	Mean Escapement 1964-1973	CHINOOK	Mean Escapement 1964-1973
Cowichan	39,900	Cowichan	8,000
Nimpkish	15,000	Campbell	5,200
Oyster	7,850	Nimpkish	4,615
Black	7,786	Nanaimo	1,500
Tsolum	7,030	Big Qualicum	1,101
Koksilah	7,030		
Keogh	4,715		
Salmon	4,450		
Big Qualicum	3,776		
Little Qualicum	3,360		
Quatse	3,040		
Nanaimo	2,925		
French	1,883		
Stranby	1,318		

TABLE III Comparison of chum escapement to the East Coast of Vancouver Island with calculated chum capacity. Pink escapements and time of peak chum and pink spawning are also included.

Stream	Calculated Capacity (in thousands)	ESCAPEMENT IN THOUSANDS 1950-1959	1960-1969	1970-1973	ESCAPEMENT AS % OF CHUM CAPACITY 1950-1959	1960-1969	1970-1973	PEAK SPAWNING Chum	Pink
Upper Vancouver Island									
1. Tsulquate	.2	*1.2 (2.3)	0.6 (3.6)	0.3 (11.7)	600	300	150	L. Oct.	L. Sept.
2. Quatse	49.0	7.8 (25.7)	5.1 (39.8)	1.0 (23.4)	16	10	2	L. Oct.	L. Sept.
3. Keogh	20.4	5.0 (47.8)	2.2 (43.8)	1.0 (46.4)	25	11	5	M. Oct.	L. Sept.
4. Cluxewe	72.8	2.7 (9.1)	0.8 (15.5)	0.2 (10.8)	4	1	0	M. Oct.	M. Sept.
SUB-TOTAL	142.4	16.7 (84.9)	8.7 (102.7)	2.5 (92.3)	12	6	2		
Johnstone Strait									
5. Nimpkish	99.3	58.0 (5.8)	24.3 (5.3)	17.6 (5.0)	58	24	18	E. Dec. (Dec. 8)**	
6. Kokish & Tsultan	20.1	2.0 (2.5)	0.4 (2.3)	0.2 (0.6)	10	2	1	L. Oct.	L. Sept.
7. Adam & Eve	77.1	3.1 (24.1)	1.1 (35.1)	0.8 (40.0)	4	1	1	L. Oct.	E. Sept.
8. Salmon	208.1	5.8 (8.5)	1.5 (12.5)	0.9 (8.4)	3	1	0	M. Nov.	M. Sept.
SUB TOTAL	404.6	68.9 (40.9)	27.3 (55.2)	19.5 (54.0)	17	7	5		
Mid-Vancouver Island									
10. Oyster	10.8	5.3 (39.7)	0.5 (1.7)	0.4 (1.3)	49	5	4	M. Nov.	M. Sept.
11. Tsolum	44.9	0.7 54.0)	1.0 (4.7)	0.2 (5.3)	2	2	0	L. Nov.	E. Oct.
12. Puntledge	55.5	33.0 (22.1)	33.4 (2.9)	40.9 (1.1)	59	60	74	M. Nov. (Nov. 25)	L. Sept.
13. Tsable	9.5	7.9	6.5	6.9	83	69	73	M. Nov. (Nov. 16)	
14. Cowie	0.9	4.2	0.8	0.4	457	87	44	L. Nov.	
15. Wilfred	4.6	1.3	0.9	1.6	28	20	35	L. Nov. (Nov. 21)	
16. Waterloo	1.3	1.6	0.6	0.4	119	45	30	L. Nov.	
17. Rosewall	8.7	3.3	1.8	2.1	38	21	24	L. Nov. (Dec. 1)	
18. Cook	7.7	4.2	1.6	4.5	55	21	59	M. Nov.	
19. McNaughton	3.8	4.8	0.9	2.2	127	24	58	L. Nov. (Dec. 12)	
20. Nile	0.5	0.4	0.2	0.1	81	40	20	L. Nov.	
21. Big Qualicum	75.0	41.0	55.5	120.6	55	74	161	E. Dec. (Dec. 7)	
22. Little Qualicum	72.1	43.0	42.5	66.2	60	59	92	L. Nov. (Nov. 28)	
23. French	0.9	0.8	0.6	1.0	86	65	108	E. Nov.	
24. Englishman	42.5	8.1	3.6	7.4	19	9	18	M. Nov. (Nov. 20)	
SUB-TOTAL	338.2	159.6 (115.8)	150.4 (9.3)	254.9 (7.7)	47	44	75		
Lower Vancouver Island									
25. Nanoose	14.6	2.3	1.0	7.6	16	7	52	E. Nov. (Nov. 6)	
26. Bonell	6.0	7.0	2.2	4.1	117	37	68	M. Nov. (Nov. 8)	
27. Nanaimo	76.6	48.8	20.1	38.4	64	26	50	L. Oct. (Nov. 9)	
28. Bush	4.5	5.4	2.3	4.4	119	51	97	E. Nov. (Oct. 31)	
29. Walker	0.2	1.6	0.3	0.3	737	138	138	L. Nov.	
30. Holland (103rd)	1.8	7.0	4.7	5.9	385	259	325	L. Oct. (Oct. 29)	
31. Stocking Lake	1.3	3.6	1.7	4.2	274	129	320	M. Nov. (Nov. 11)	
32. Chemainus	21.2	37.6	9.2	13.8	177	43	65	L. Oct. (Nov. 4)	
33. Bonsall	0.5	0.8	0.2	0.3	147	37	55	E. Dec.	
34. Cowichan	158.7	64.0	55.5	53.8	40	35	34	E. Dec. (Dec. 18)	
35. Koksilah	13.3	2.5	5.3	3.0	19	40	23	L. Nov.	
36. Goldstream	6.5	13.3	7.0	5.5	205	108	85	M. Nov. (Nov. 22)	
SUB-TOTAL	305.2	193.9	109.5	141.3	64	36	46		
TOTAL	1,190.4	439.1 (241.6)	295.9 (167.2)	418.2 (154.0)	37	25	35		
9. Campbell River		2.4 (2.0)	1.3 (1.3)	3.1 (2.2)				M. Nov.	

*Number preceding brackets is chum escapement, number in brackets is pink escapement.
**Number in brackets from tagging data (A. D. Anderson pers. comm.).



TSULQUATE RIVER 50° 127°NE

LOCATION:
Flows east into Hardy Bay, north of Port Hardy, Rupert District.

CHARACTER:
Flowing from Kains Lake, the Tsulquate River, with several small tributaries, forms a moderate sized drainage system. It has a stable flow and few scouring or silting problems. The upper sections of the river are steep with a boulder bottom. The lower areas are of slight gradient but with little gravel.

OBSTRUCTIONS:
A series of falls 2.5 miles upstream from tide water forms a total barrier to migrating salmon. In 1970, a three foot concrete dam, with associated intakes, was constructed 1.7 miles above the estuary to supply water to the Port Hardy District. A fishway was provided to allow salmon to pass to the 0.7 miles of river above the dam. However, the steep grade and lack of gravel make this section unsuitable for chum spawning.

APPLICATION:
Water supply to Port Hardy District.

GENERAL:
The Tsulquate is noted as mainly a producer of pink salmon with an average even year escapement of 8,400 (1960-1972). Since chums are reluctant to attempt to pass over a barrier to make use of fishway facilities, the survey of July 1970 was from the dam site to the estuary.

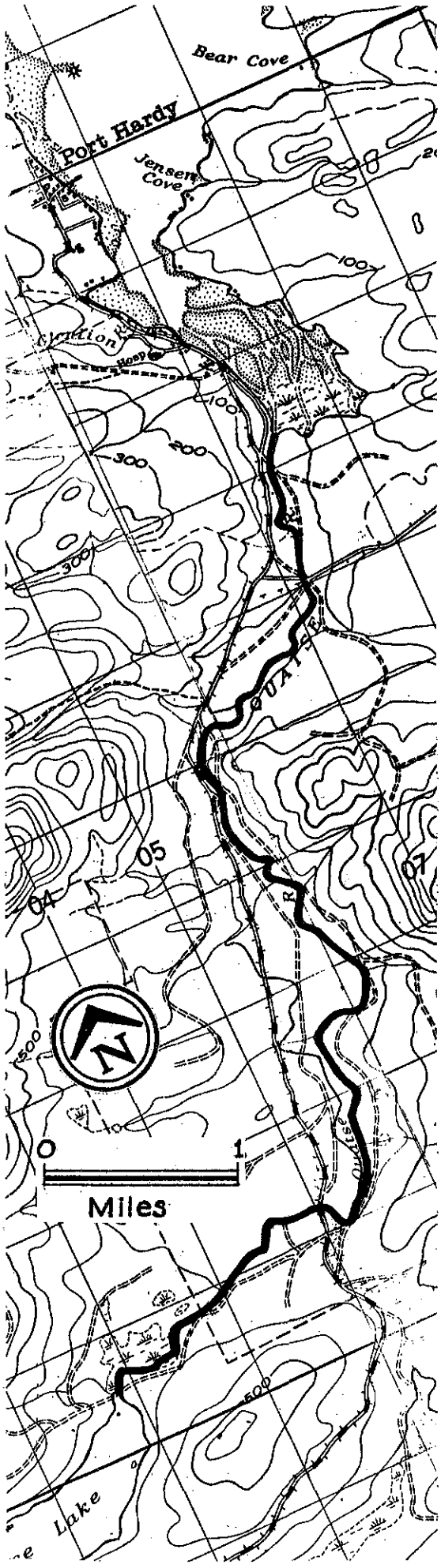
Tsulquate River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2	Spawning as % of Wetted Area
Main River	1,450	16	24,750	162	147	0.7%

Mean Chum Escapements

1950-59	1960-69	1970-73
1,202	585	310

Area above fishway, 1.7 miles from the mouth. No chum spawning area is present above the fishway.



QUATSE RIVER 50° 127°NE

LOCATION:
Flows north into Hardy Bay, south of Port Hardy, Rupert District.

CHARACTER:
Beginning at Quatse Lake, the river is joined by several short tributaries to form this moderate sized drainage system. The upper sections are steep with a boulder bottom while the lower areas are of moderate gradient and contain extensive gravel beds.

OBSTRUCTIONS:
In 1960 a fishway was constructed on falls 6.5 miles upstream from tidewater. In addition, blasting has been carried out on a series of falls between the fishway and the outlet of Quatse Lake. This was done to allow passage of pink and sockeye salmon during periods of low flow. The fishway may be regarded as the upper limit of the chum salmon migration although there have been instances of their passing this point.

APPLICATION:
The proximity of Port Hardy has led to a multiple use of the Quatse River. Logging operations in the upper watershed have resulted in extremely variable flows. Erosion and scouring are a problem but this system is stabilizing as second growth occurs in the logged areas. Gravel removal near the mouth has also been a concern and there are several water licences issued for the river. Chum migration is usually late in the fall tending to reduce chances of meeting inadequate flow conditions. However, reports of low level water conditions on the Quatse River as late as November do exist.

GENERAL:
The area surveyed in July 1970 is the 6.5 mile section between the fishway and estuary. The figures presented here are for the 3 mile section upstream from tidewater. The slight gradient and large amount of gravel make this an important chum spawning section. Pink salmon, which are the most abundant species in this system, have an average even year escapement of 64,900 (1960-1972).

Quatse River—Chum Spawning Area Dimensions

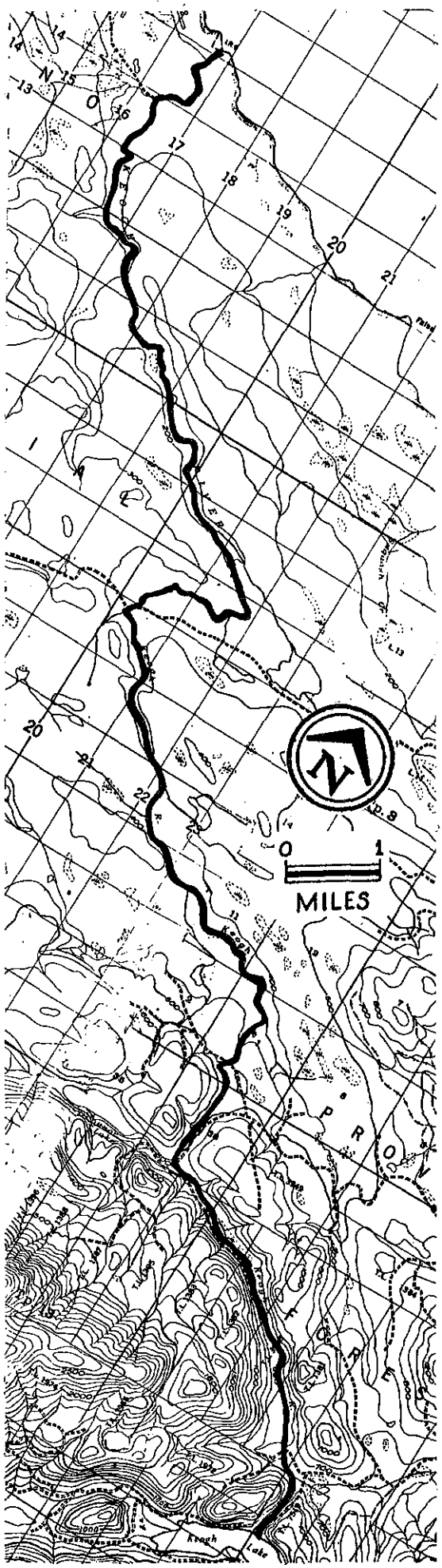
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	5,158	31	163,361	53,928	49,025	33%

A further 1,357 sq. yds. of usable spawning area is present above the three mile section listed above.

Mean Chum Escapements

1950-59	1960-69	1970-73
7,750	5,070	980

Section of river just below the fishway 6.5 miles from the mouth. The steep gradient and lack of gravel make this section unsuitable for chums.



KEOGH RIVER 50° 127°NE

LOCATION:
Flows north into Queen Charlotte Strait, south-east of Beaver Harbour, Rupert District.

CHARACTER:
Beginning at Keogh Lake, the river has a low gradient. Gravel is plentiful in the upper sections. Below this, gravel is sparse until 3.5 miles from the mouth, where there are continuous stretches of gravel suitable for chum spawning.

OBSTRUCTIONS:
No permanent obstructions exist although numerous log jams are present. Beaver dams are a problem in the upper reaches in some years.

APPLICATION:
Logging operations have been carried out in the watershed for many years and have led to highly variable flows. However, silting and erosion are very light.

GENERAL:
The survey of July 1970 began 12.2 miles upstream and continued to the mouth. The figures presented here cover the bottom 3.5 miles where the chum mainly spawn. This river is primarily a pink salmon producer with an average even year escapement of 69,800 (1960-1972).

Keogh River—Chum Spawning Area Dimensions

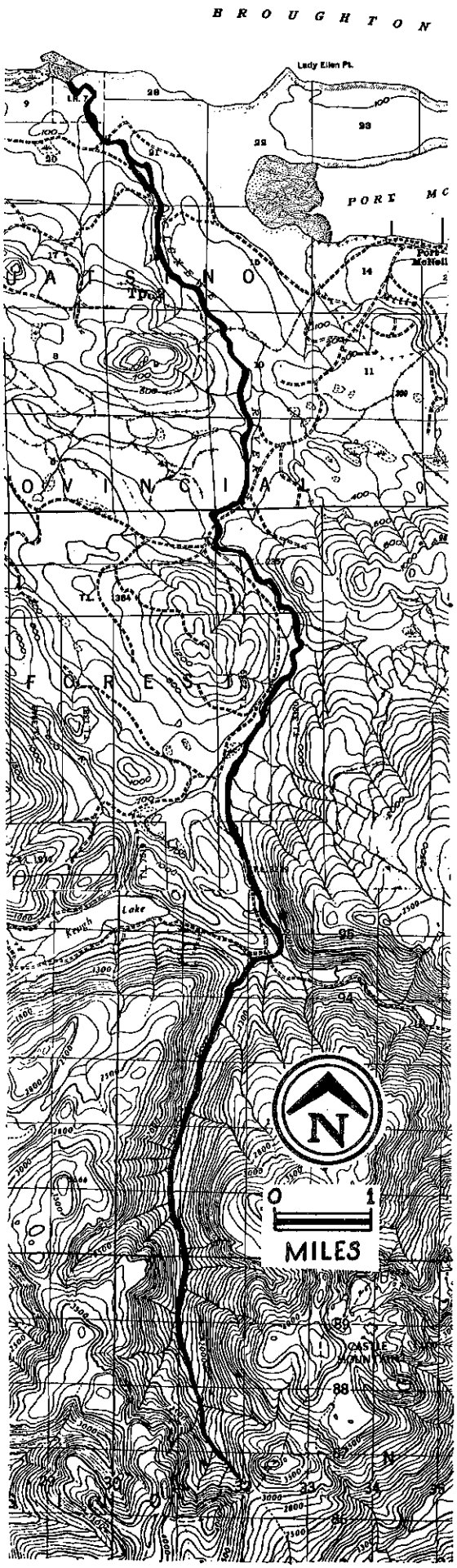
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	5,178	22	109,590	22,393	20,357	20%

A further 58,346 sq. yds. of potentially usable chum spawning area is present above the 3.5 mile section which chums presently utilize.

Mean Chum Escapements

1950-59	1960-69	1970-73
5,000	2,150	980

Section of river 2.5 miles upstream containing fair chum spawning gravel and an excellent gradient.



CLUXEWE RIVER 50° 127°NE

LOCATION:
Flows north-west into Broughton Strait, west of Port McNeil P.O., Rupert District.

CHARACTER:
The river is joined by several short tributaries to form this moderate sized drainage system. The upper sections have boulder bottoms, while the lower sections have extensive good spawning gravel.

OBSTRUCTIONS:
No obstructions exist on the system, but the presence of a large beaver colony is a potential threat in the upper reaches.

APPLICATION:
In the past, heavy logging in the watershed has led to highly unstable flows, with resulting damage through erosion and scouring. However, the stream is stabilizing as second growth occurs in the watershed. Log jams have been a chronic problem on the system, although damage has been averted in most cases through remedial action on the part of the logging companies involved. Other industrial operations involving the stream include gravel removal, occurring about 2 miles from the mouth, and the Island Redi-mix plant which holds a water licence on the stream.

GENERAL:
In total, 14 miles of the stream were surveyed in July 1970 though only the results for the bottom 4 miles (one mile from the highway bridge to tidal waters) are presented here. This is the area that pink and chum salmon utilize. The average even year pink escapement is 26,400 (1960-1972).

Cluxewe River—Chum Spawning Area Dimensions

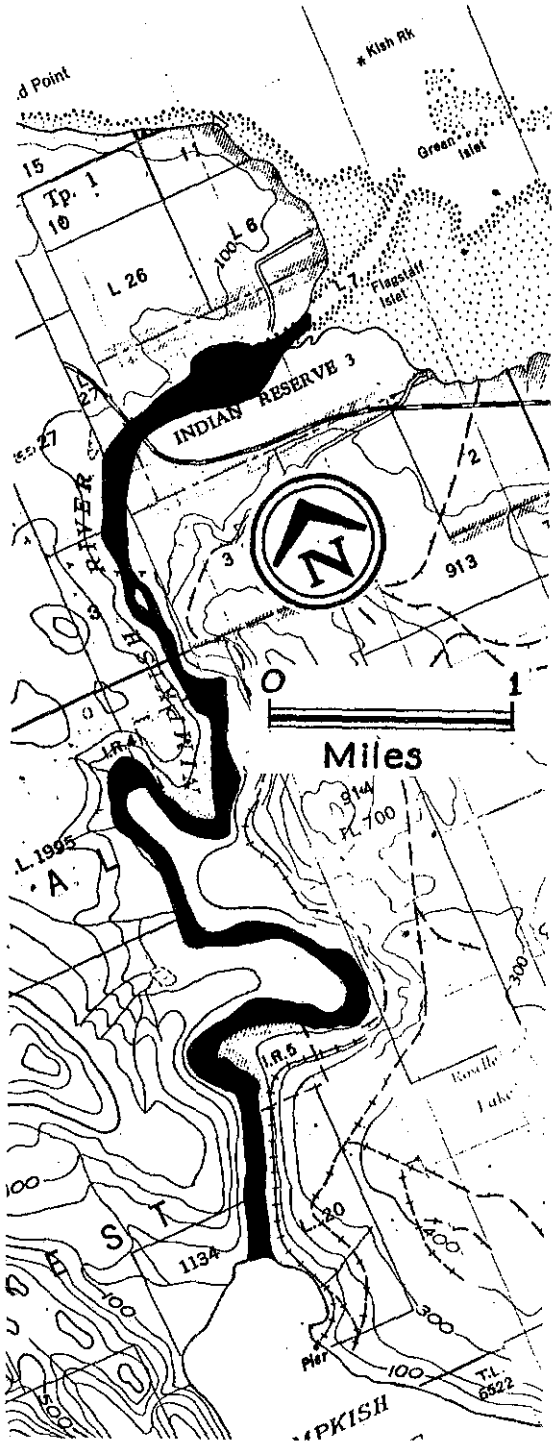
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	5,081	29	194,084	80,116	72,833	41%

A further 37,541 sq. yds. of potentially usable chum spawning area is present above the four mile section which chums presently utilize.

Mean Chum Escapements

1950-59	1960-69	1970-73
2,700	830	230

Extensive gravel 7.3 miles from the mouth. During years of high winter flows, gravel shifting may seriously reduce egg survival.



NIMPKISH RIVER 50° 126°NW

LOCATION:
Flows north-west into Broughton Strait through Nimpkish Lake, Rupert District.

CHARACTER:
Beginning at Vernon Lake, the river is joined by Davie River, draining Schoen and Klaklakama Lakes, and Woss River, draining Woss Lake. The large size of the drainage area (768 sq. miles) has spread logging of the watershed over a long enough period of time to keep flow patterns relatively stable. Discharges from 1927 until the station was discontinued in 1938 are presented below. Nimpkish River, from Nimpkish Lake to Broughton Strait, is a large, deep river with a few fairly large areas of gravel.

Nimpkish River Discharges (cfs)

Year	Maximum	Minimum	Mean
1927	45,000	330	4,800
1928	42,500	480	4,730
1929	16,700	590	3,740
1930	34,800	453	3,800
1931	23,600	535	4,700
1932	29,600	705	4,050
1933	25,900	660	4,800
1934	22,400	615	5,000
1935	44,300	330	5,180
1936	21,700	607	4,470
1937	14,900	729	3,880
1938	27,100	720	5,100
Average	29,042	563	4,521

OBSTRUCTIONS:
A natural rock obstruction situated 20 miles above the head of Nimpkish Lake, Karmutsen Falls, was eliminated by blasting a fishway around it in 1953. This rock fishway now permits salmon to migrate into the Schoen and Klaklakama Lakes system.

APPLICATION:
The watershed has been extensively logged over the past years, with operations progressing from the original valley sites to the present day sites at higher elevations. The hydro-electric potential of the system has been examined and a dam proposed for the Lower Nimpkish 0.5 miles upstream from the sea. The dam would be a 150 foot, rock filled structure with appropriate fish passage facilities. Such a dam would obliterate 80% of the chum spawning in the system. Nimpkish Iron Mines, located 6 miles south-east of Nimpkish Lake, was in operation from 1960—1963. The open pit mining included processing at the site and the remaining pile of waste material situated on the bank poses a possible slide threat. Under certain saturated conditions, this waste pile could sluff into the river.

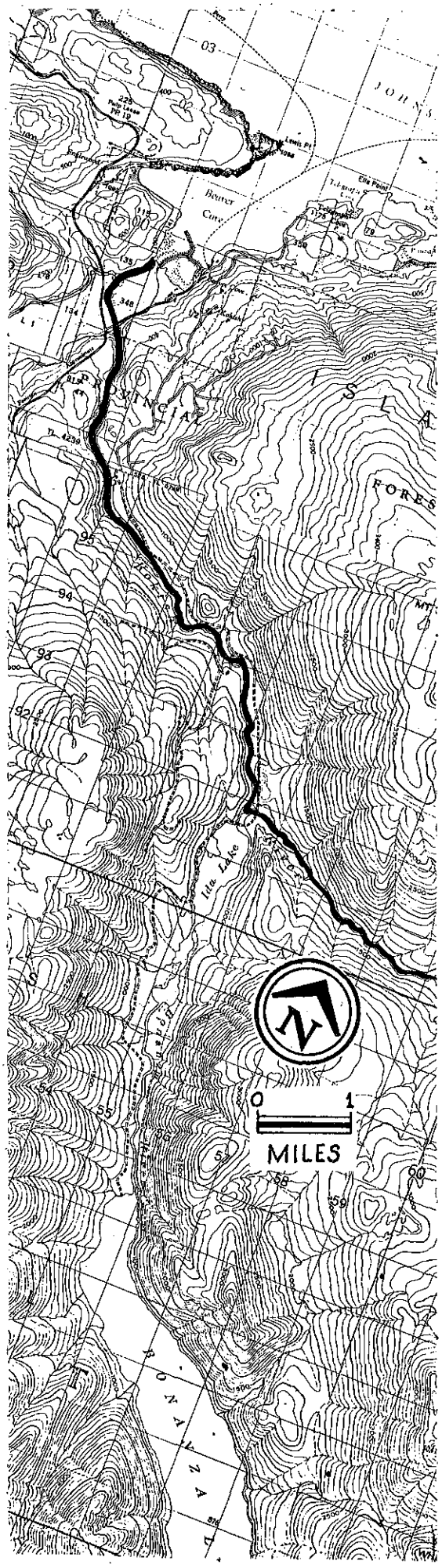
GENERAL:
Of the streams in the southern half of the province, the fishery of Nimpkish stocks is second in value only to that of the Fraser. Spawning occurs throughout the length of the system with the major areas being Woss Lake, which supports the majority of sockeye and springs, and the Nimpkish River (Nimpkish Lake to Broughton Strait), which supports the entire run of chums, some chinooks and the majority of pinks. The figures presented below are from this latter section which was surveyed in July 1970. The average pink escapement for this system is 5,200 (1960-1973).

Nimpkish River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	1,673	127	2,296,417	109,255	99,323	5%

Mean Chum Escapements

1950-59	1960-69	1970-73
58,000	24,250	17,630



KOKISH AND TSULTAN RIVERS 50° 126°NW

LOCATION:
Kokish River flows north into Beaver Cove, south-east of Englewood, Rupert District.

Tsultan River flows north-east into Kokish River, south of Englewood.

CHARACTER:
Kokish River is the result of the Ida Lake, Bonanza River and Lake system, which begins at the 876′ level, draining an area of 104 sq. miles. The best spawning gravel in this system is located in the Tsultan River, from the junction of the Kokish to a point just less than 2 miles upstream. Water discharge records were taken on the Kokish River at a point 1.75 miles downstream from the Bonanza River and 0.5 miles from the mouth of the Kokish.

Kokish River Discharges (cfs)

Year	Maximum	Minimum	Mean
1927	2,630	46	826
1928	10,100	29	665
1929	5,040	7	559
1930	4,450	21	534
1931	5,940	7	356
1932	2,380	110	534
1933	4,010	095	748
1934	5,080	44	616
1935	11,800	16	722
1936	7,200	22	613
1937	2,790	66	573
1938	3,360	13	638
1939	2,280	24	577
1940	3,340	46	742
1941	2,160	10	—
1957	1,400	100	—
1958	1,980	20	—
1959	5,200	50	—
1960	4,200	70	525
1961	6,400	15	595
1962	5,800	45	478
1963	6,800	40	—
1964	6,500	90	691
1965	3,500	24	410
1966	3,800	53	690
1967	2,740	20	—
1968	4,610	50	796
1969	1,840	71	593
1970	2,400	120	548
Average	4,473	46	610

OBSTRUCTIONS:
The Kokish River from Ida Lake to the junction of the Tsultan River has large rocks and boulders. It contains a section of rapids and an impassable rock falls at the top end. A rock falls 5 miles upstream on the Tsultan River marks the end of salmon migration.

GENERAL:
Little or no chum spawn in the upper Kokish River due to the harsh conditions. This system was surveyed in July 1970. The average even year pink escapement is 3,000 (1960-1972).

Kokish and Tsultan Rivers—Chum Spawning Area Dimensions

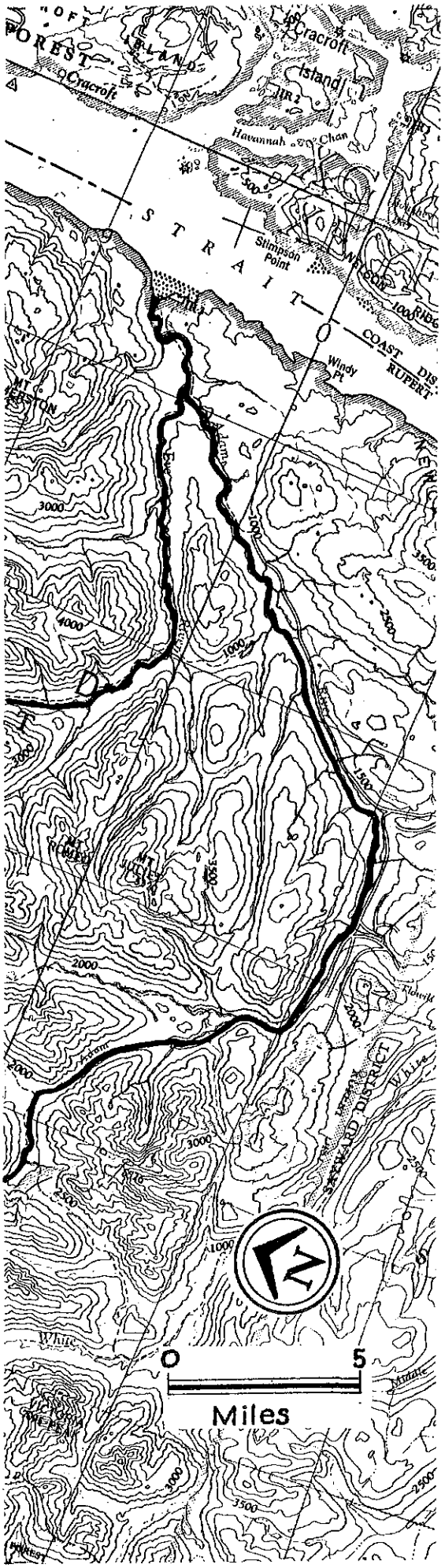
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Tsultan	3,352	46	50,150	16,689	15,171	33%
Kokish*	5,052	21	146,150	2,801	2,546	2%
Kokish**	2,842	34	112,405	2,606	2,369	2%
TOTAL	11,246	21	308,705	22,096	20,086	7%

*from junction up
**from junction down

Mean Chum Escapements

1950-59	1960-69	1970-73
2,025	372	220*

*3 yrs. only



ADAM AND EVE RIVERS 50° 126°SE

LOCATION:
Flows north into Johnstone Strait, south-east of Cracroft Island, Rupert District.

CHARACTER:
A major tributary, the Eve River, enters the Adam River 3 miles from the mouth. The Adam and Eve Rivers have a combined drainage area of 245 sq. miles with the Adam comprising 150 sq. miles of this. The lower Adam from the mouth to the confluence with the Eve River, is of low gradient, 100'-150' wide, containing moderate to good spawning areas. The .25 mile of Adam River from the confluence with the Eve River to the obstruction upstream is 50'-60' wide with a streambed of coarse gravel, boulders and bedrock. The Eve River, above the confluence for a distance of 8-10 miles, has a moderate gradient and good sections of spawning gravel.

OBSTRUCTIONS:
An obstruction, located 3.25 miles from the mouth of the Adam River, prevents access of salmon beyond this point. The river flows through a narrow, steep walled canyon with a water surface drop of 100' in 1200' which includes two nearly vertical falls of 30' in the first 500'.

APPLICATION:
This drainage area has been extensively logged.

GENERAL:
A total of 5 miles were surveyed in July 1970, starting on the Eve River, about one mile above the confluence with the Adam. The lower Adam River has cut a new course through old logging slash. The section is badly jammed but passable to fish. This section, from the confluence to tidal waters, was used for the chum spawning area dimensions. The average odd year pink escapement for these rivers is 51,600 (1961-1973).

Lower Adam and Eve River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd²)	Spawning Area (yd²)	Capacity @ 1.1 yd² per fish	Spawning as % of Wetted Area
Main River	6,600	40	272,333	80,767	73,425	30%
Channels	1,017	18	18,986	4,094	3,722	22%
TOTAL	7,617		291,319	84,861	77,147	29%

Mean Chum Escapements

1950-59	1960-69	1970-73
3,100	1,060*	750**

*8 yrs. only
**1 yr. only

One of three side channels into which Adam River splits 3.9 miles from the mouth. Photo shows passable log jam.

SALMON RIVER 50° 125°SW

LOCATION:
Flows north-east and north-west into Salmon Bay, Johnstone Strait, Sayward District.

CHARACTER:
The elevation of the Salmon River drops sharply from 3,700' to 2,00 ' in its first 5 miles, then gradually over the next 40 miles. Very little scouring or silting takes place in this river. Its main tributaries are the White and Memekay Rivers. These three rivers have a combined drainage area of 467 sq. miles. The White River flows north-east into the Salmon River about 7 miles upstream from the mouth. The streambed is generally made up of coarse gravel which is unsuitable for chum spawning. Coho and chinooks, however, spawn as far as 30 miles upstream. Several times a year mud slides in this area cause very heavy silting. Some scouring takes place.

Water Discharges Recorded Near Sayward (cfs)

Year	Maximum	Minimum	Mean
1957	45,000	410	2,440
1958	25,900	175	2,380
1959	47,500	251	2,660
1960	17,700	201	2,020
1961	57,700	210	3,010
1962	31,000	185	1,860
1963	44,200	275	—
1964	50,800	323	2,970
1965	88,960	156	1,490
1966	28,700	138	2,450
1967	18,600	910	2,440
1968	26,800	249	2,760
1969	16,200	134	2,220
1970	9,000	189	1,390
Average	36,290	272	2,315

OBSTRUCTIONS:
Approximately 20 miles upstream from the mouth, there is a falls created by a log jam of wind falls, debris, and some cut logs; however, access to the river above the jam is not impaired to any great extent, and salvage or removal operations would be detrimental to spawning areas downstream. A log jam, 13 miles upstream, appears passable to migrating salmon but could be a partial block during low water. This jam is almost one mile long.

APPLICATION:
The entire watershed has and will continue to undergo extensive logging operations. Water is diverted from this system to the Campbell River by means of a dam. The water diversion licence, held by B.C. Hydro, provides for a release of 100 cfs between August 20th and November 15th, ensuring adequate levels for migration and spawning, and 83 cfs for the remainder of the year, as measured at the gauging station approximately 2 miles above the confluence with the Memekay River.

GENERAL:
The survey of August 1970 covered the Salmon River from 18 miles upstream to the estuary and the White River for about 2 miles above the confluence. The chum spawning dimensions are based on the 3 mile section, upstream from tidal waters, which the chum utilize. The average pink escapement of the Salmon River is 11,400 (1960-1973).

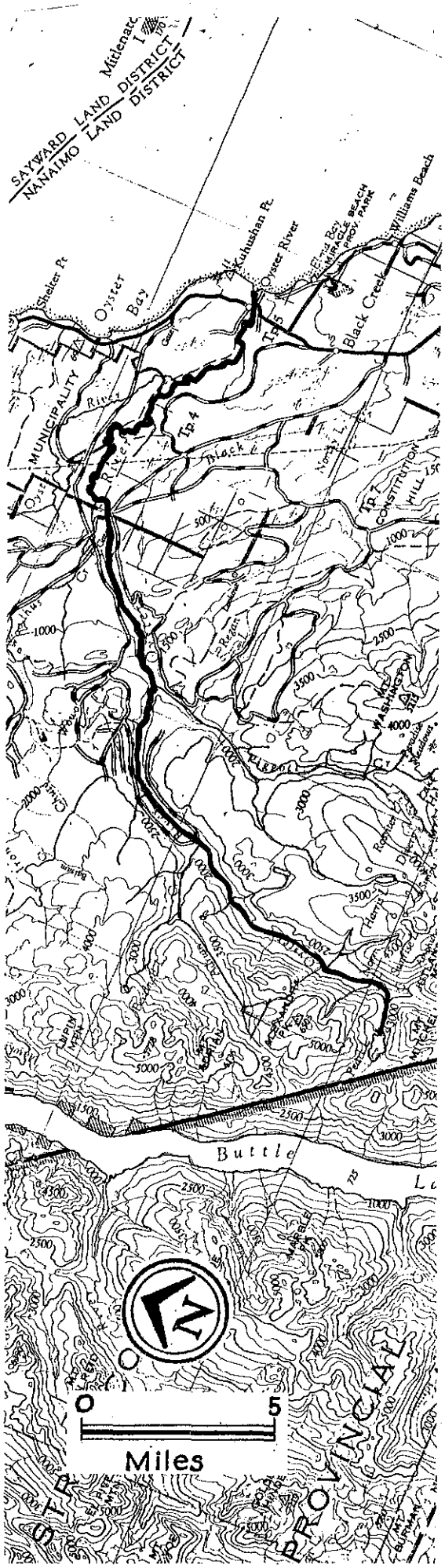
Salmon River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	5,558	87	491,889	228,881	208,074	47%

A further 178,522 sq. yds. of potentially usable chum spawning area is present above the four mile section which chums presently utilize.

Mean Chum Escapements

1950-59	1960-69	1970-73
5,780	1,460	940



OYSTER RIVER 49° 125°NE

LOCATION:
Flows east into Strait of Georgia, south of Kuhushan Point, Comox District.

CHARACTER:
The Oyster River, 18 miles in length, enters the Strait of Georgia 20 miles south of Campbell River. Two main tributaries, the Little Oyster and Woodhus, connect with the mainstream on the northside and are part of the total drainage area of 70 sq. miles. The average discharges in cfs through the years 1914 to 1916 are as follows—maximum 2,076; minimum 256; mean 677. These gauge readings were taken one mile from the mouth.

OBSTRUCTIONS:
There is an impassable falls 13 miles upstream from the mouth on the main Oyster. Leading up to this are sections of boulders and canyons. Beaver dams are a problem in the tributaries.

APPLICATION:
This stream has been very much affected by forest removal. Flash floods have displaced the gravel in large areas and there appears to be little opportunity for replenishment from natural sources.

GENERAL:
This system is used mainly by coho which presently utilize just the Oyster and Little Oyster Rivers for spawning and rearing. A coho fry transplant was initiated in 1968 to Woodhus Creek and an estimated 400-500 adults returned in 1970 but were unable to negotiate the falls. As well as coho, chum find the falls and rapids in Woodhus impassable and consequently spawn mainly in the Oyster River and very lightly in the Little Oyster. Pinks have an average escapement of 1,400 (1960-1973). The stream survey of September 1970 measured an area 3.2 miles from the mouth of the Oyster River downstream. This system is not classed as an important chum salmon producer.

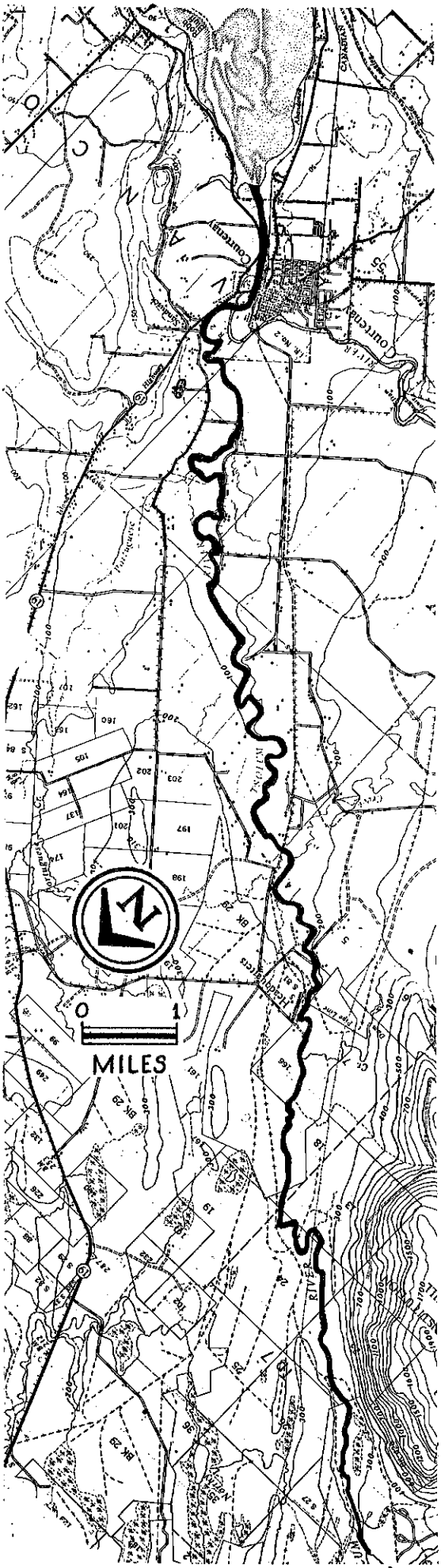
Oyster River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	4,642	43	206,292	11,903	10,821	6%

Mean Chum Escapement

1950-59	1960-69	1970-73
5,300	480	350

Section 0.8 miles from the mouth. Note erosion of clay banks by frequent flash floods.



TSOLUM RIVER 49° 124°NW

LOCATION:
Flows south-east into Courtenay River, in Courtenay, Comox District.

CHARACTER:
This 18 mile long river contains several tributaries including a 25 mile lake (Wolf Lake) which gives it an overall drainage of 98 sq. miles. The section of stream used by chums tend to be very unstable with extensive shifting of gravel. The major gravel deposits (used by pink salmon) are located upstream of 9 miles from the mouth.

Tsolum River Discharges Near Courtenay (cfs)

Year	Maximum	Minimum	Mean
1915	1,850	3.0	424
1916	1,780	2.0	334
1956	3,830	4.0	361
1965	4,240	1.0	218
1966	7,340	13.0	472
1967	8,840	1.2	532
1968	7,260	1.5	545
1969	3,310	124.0	688
1970	3,160	3.9	262
Average	4,623	17.1	426

OBSTRUCTIONS:
A concrete dam and control works were installed at the outlet of Wolf Lake by the Department of Fisheries in 1964 to release up to 25 cfs for six weeks and thus supplement the flow for the 10 miles to the river estuary. Low flows occurring in August and September have been observed to prevent the upstream migration of adult fish resulting in significant mortality in some years. High flows occurring in the late fall and winter months scour the stream.

APPLICATION:
Water diversions for domestic and agricultural purposes complicate the low flow problem. Logging has been carried out in this area for many years. The construction of logging roads throughout the watershed has contributed greatly to the stream's silting problem. The lack of good quality gravel areas in lower reaches was caused by gravel removal from the lowermost 3 miles in 1943 and 1944 for the construction of the Comox Airport. The Tsolum system has been threatened by pollution. Crown Zellerbach, in 1957-58, sprayed deciduous trees in the area threatening the resource and Washington Mountain Copper Mine, in 1965, threatened the Wolf Lake area with mine effluent. The mine was closed down in the spring of 1965. The Fisheries Research Board of Canada commenced a hatchery research program on Wolf (Headquarters) Creek in 1968 to evaluate incubation techniques.

GENERAL:
This stream is mainly a pink salmon producer and chums spawn only in the first 3.8 miles. It was this chum spawning area which was surveyed in September 1970. The average pink escapement from this system is 5,000 (1960-1973).

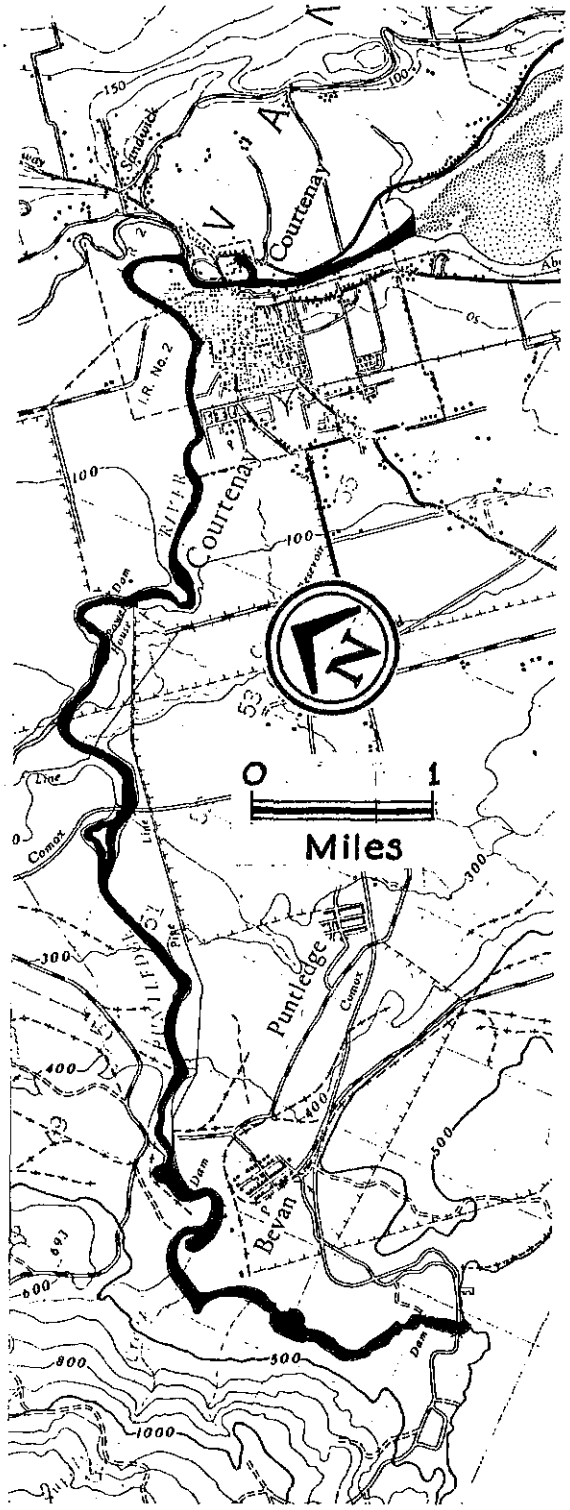
Tsolum River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	3,850	35	131,444	49,378	44,889	38%

Mean Chum Escapement

1950-59	1960-69	1970-73
660*	960**	200***

*9 yrs. only
**8 yrs. only
***1 yr. only



PUNTLEDGE RIVER 49° 124°NW

LOCATION:
Flows north-east into Courtenay River, Comox District.

CHARACTER:
Beginning at Comox Lake, the river, approximately 8-10 miles long, drains a 200 sq. mile area. The Puntledge River system has three tributaries; Brown River, Morrison Creek and Tsolum River, none of which contribute significantly to chum salmon spawning. Chum salmon spawn from the powerhouse to the Tsolum River with the heaviest concentration from Morrison Creek downstream. Early chinook salmon and steelhead use the artificial spawning channel which lies only a few miles from the lake. Downstream from where the Tsolum meets the Puntledge is referred to as the Courtenay River. Light silting and erosion persist in this lower section each year, with little silting occurring throughout. Flow control by power development prevents, to some extent, extreme low water in this river.

Puntlege River Discharges At Courtenay (cfs)

Year	Maximum	Minimum	Mean
1916	4,400	320	1,270
1917	3,360	170	942
1918	3,649	819	1,823
1919	5,950	550	1,930
1920	6,220	355	1,650
1956	8,330	212	1,500
1957	4,580	80	—
1965	2,400	291	948
1966	7,480	315	1,590
1967	8,670	620	1,630
1968	11,100	556	1,810
1969	5,550	579	1,680
1970	1,870	438	1,060
Average	5,658	408	1,486

OBSTRUCTIONS:
A storage dam, a power intake diversion dam, a power house, an artificial spawning channel and two rock falls are located on this river. Both falls (Nils and Stotan) are passable to salmon, but at certain low water conditions, chinook mortalities can be high due to rock injuries incurred while jumping the falls.

APPLICATION:
Power development is the main use of this river. There is also some gravel removal near the mouth.

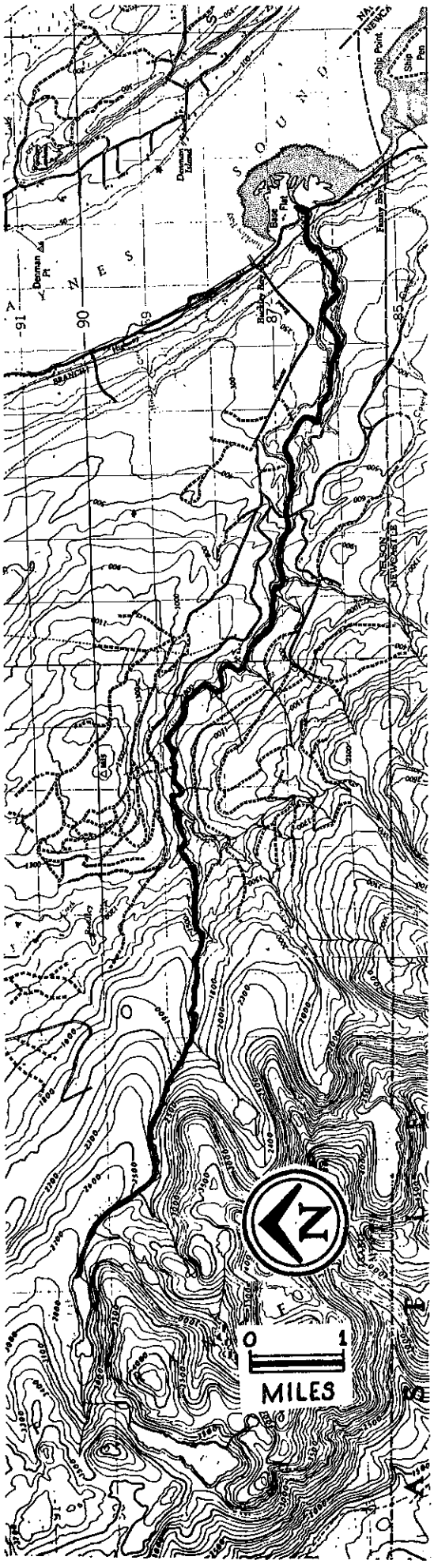
GENERAL:
Between the powerhouse and the diversion dam, the streambed is mainly shale and bedrock, therefore no salmon spawn in this section. Large boulders make up the biggest part of the area below the powerhouse but as the stream progresses, the gravel becomes finer and the most suitable stretch is found below the Condensary Bridge. The stream survey, June 1970, measured the area from the powerhouse to the confluence with the Tsolum River. The Puntledge River has an average escapement of 2,500 pinks (1960-1973).

Puntledge River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	9,117	55	510,977	50,753	46,139	10%
#1 Side Channel	162	11	1,680	238	216	14%
#2 Side Channel	308	15	4,917	1,436	1,306	29%
#3 Side Channel	450	26	11,056	8,669	7,881	78%
TOTAL	10,037	46	528,630	61,096	55,542	12%

Mean Chum Escapements

1950-59	1960-69	1970-73
33,000	33,400	40,875



TSABLE RIVER 49° 124°NW

LOCATION:
Flows east into Baynes Sound, Nelson District.

CHARACTER:
Tsable River drains an area of 42 sq. miles.

Tsable River Discharges Near Fanny Bay (cfs)

Year	Maximum	Minimum	Mean
1961	8,100	9.0	401
1962	2,300	13.0	239
1963	4,150	9.0	326
1964	5,630	10.0	302
1965	3,260	12.0	181
1966	3,120	13.0	334
1967	3,400	5.6	317
1968	8,000	6.4	363
1969	2,350	19.4	322
1970	2,220	7.7	185
Average	4,253	10.5	297

OBSTRUCTIONS:
An impassable 20 foot falls located 3.5 miles upstream is a total block to migrating adult salmon.

APPLICATION:
The headwaters of the Tsable are located in a former coal mining area. Mine effluent has entered the stream at times but appears to be no problem now. Water licences have been issued on the stream.

GENERAL:
Coho prefer to use the entire spawning area, where as the chums use only the lower half. The stream survey of June 1970 covered the section from the falls downstream. Only the first 1.75 miles from the mouth are utilized by chums and only measurements from this section are tabulated.

Tsable River—Chum Spawning Area Dimensions

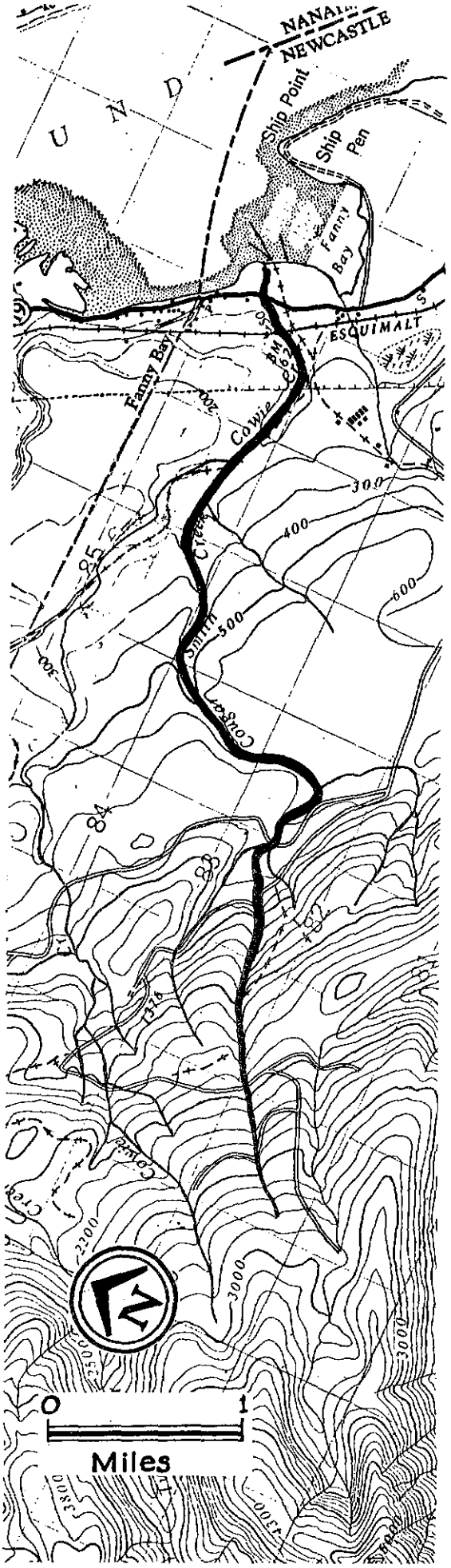
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Stream	3,200	30	97,750	10,408	9,462	11%

A further 21,533 sq. yds. of chum spawning area is present upstream of the area normally utilized by chums.

Mean Chum Escapements

1950-59	1960-69	1970-73
7,870	6,530	6,900

The area 3.7 miles from the mouth. Little or no spawning area is present below here for two miles.



COWIE CREEK 49° 124°NW (Cougar Creek)

LOCATION:
Flows north-east into Fanny Bay, Newcastle District.

CHARACTER:
Cowie Creek is 3 miles long with low gradient. Cougar-Smith, a tributary of Cowie Creek, has a total accessible length of one mile, ending with impassable falls. Cowie and Cougar-Smith Creeks drain an area of 9.2 sq. miles.

OBSTRUCTIONS:
Two falls occur on Cowie Creek. The first, a passable 4 foot drop, is situated below the forks, about one mile above the mouth. The second falls, 3 miles upstream, has a 30 foot drop and is a complete block to migrating adult salmon.

GENERAL:
A large percentage of the area between the two falls is comprised of large boulders and coarse gravel. Coho are thinly distributed in the middle to upper reaches, while chum salmon are located mainly in the bottom section from the highway bridge down. This means that chum stay well below the first falls. The stream survey of July 1970 was carried out only in that portion of the system pertaining to chums.

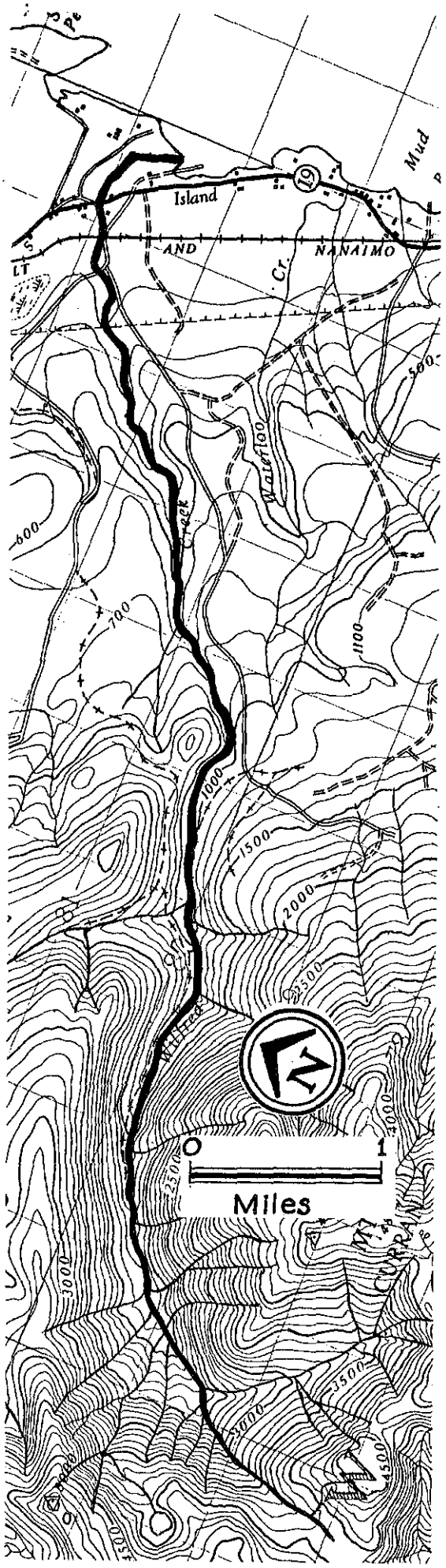
Cowie Creek-Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd²)	Spawning Area (yd²)	Capacity @ 1.1 yd² per fish	Spawning as % of Wetted Area
Main River	522	11	5,992	1,011	919	17%

Mean Chum Escapements

1950-59	1960-69	1970-73
4,150	755	425

Section 0.6 miles from the mouth with boulders, rocks, logs, and relatively little chum spawning area.



WILFRED CREEK 49° 124°SW (Coal Creek)

LOCATION:
Flows north-east and south-east into Baynes Sound, north of Mud Bay, Newcastle District.

CHARACTER:
This 8 mile creek, also known as Coal Creek, originates in the mountains at the 4,500' level and drains an area of 12.8 sq. miles. Below the falls, 75% of the streambed is either boulders or coarse gravel.

OBSTRUCTIONS:
An impassable 20' falls is situated 2.4 miles upstream from the estuary.

APPLICATION:
As a result of extensive logging of the watershed, during the summer the water level can be very low, while there can be extreme flood conditions in the winter. Erosion, silting and scouring appear to be moderate.

GENERAL:
Chum salmon generally spawn in the first 1.5 miles of stream while the coho spawn throughout. This first section was surveyed in July 1970 and the figures, excluding tidal waters, are presented below.

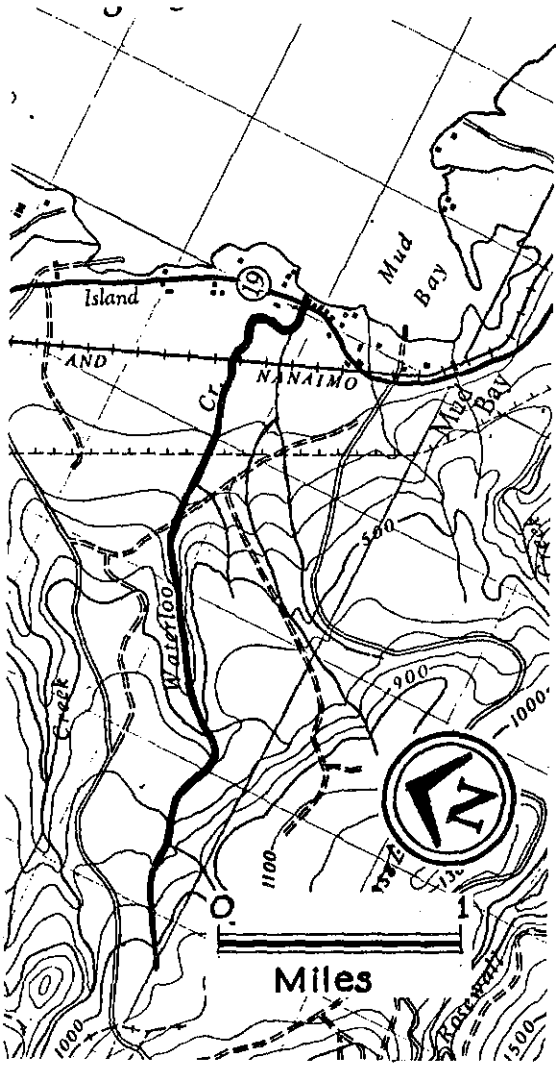
Wilfred Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	179	12	21,672	5,061	4,601	23%

Mean Chum Escapements

1950-59	1960-69	1970-73
1,330	870	1,563

Course change of creek (old course in foreground is 2 feet higher than new course). Old course continues for 800 feet to estuary of five arms which flood at high tide.



WATERLOO CREEK 49° 124°SW

LOCATION:
Flows east into Baynes Sound, north of Mud Bay, Newcastle District.

CHARACTER:
This 2 mile long creek drains an area of 3.2 sq. miles. Seventy-five percent of the streambed is made up of boulders with steep gradient.

APPLICATION:
Logging has resulted in Waterloo nearly drying up in the summer and having a short, severe flood period in mid-December due to its unstable watershed.

GENERAL:
Coho spawn throughout the system while chums utilize the lower 0.5 mile from the railroad bridge to the estuary. This section has a streambed of coarse gravel and was surveyed in July 1970.

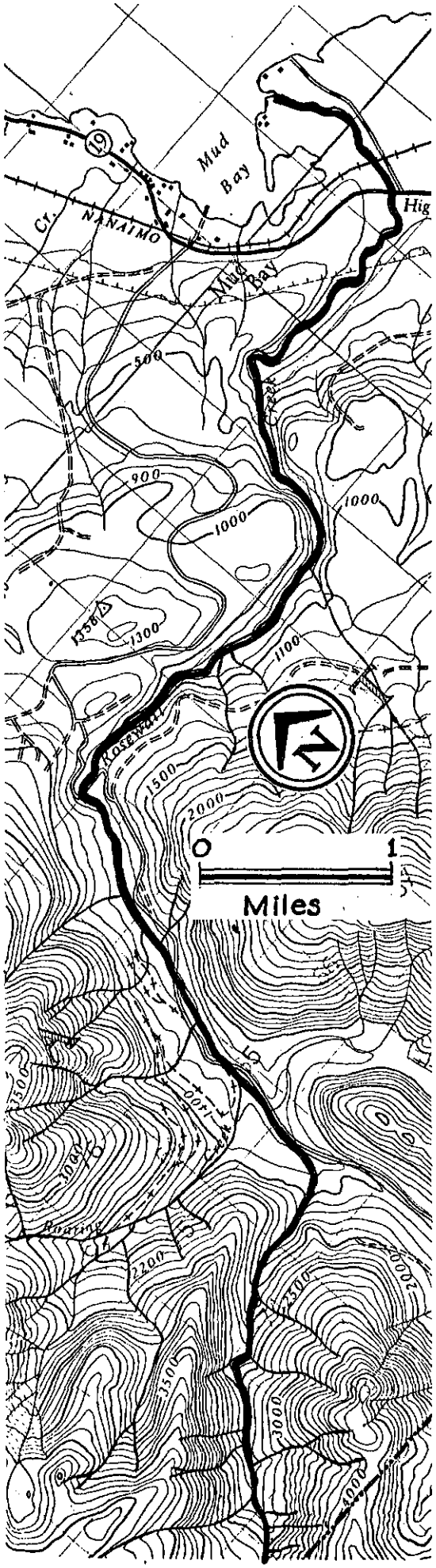
Waterloo Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	622	8	4,650	1,479	1,345	32%

Mean Chum Escapement

1950-59	1960-69	1970-73
1,640	560	410

Section below railway bridge. Area above 0.5 miles from the mouth contains very limited chum gravel.



ROSEWALL CREEK 49° 124° SW

LOCATION:
Flows north-east into Mud Bay, west of Deep Bay, Newcastle District.

CHARACTER:
Rosewall Creek drains a 17.5 sq. mile area. Coarse and fine gravel make up 50% of the streambed although the fine gravel (pea size) is constantly shifting.

Rosewall Creek Discharges At The Mouth(cfs)

Year	Maximum	Minimum	Mean
1968*	2,540	0	—
1969**	745	0	119.0
1970	1,040	0	66.3

*May to December
**April to December

OBSTRUCTIONS:
An impassable falls, with a 70′ drop over a 300′ horizontal distance, is situated 2.4 miles upstream.

APPLICATION:
Logging operations and extensive forest burns have resulted in very rapid run-offs in this stream. These freshets have caused heavy erosion to gravel banks, resulting in gravel build-up over the lower 0.5 mile.

GENERAL:
Coho spawn throughout the stream up to the falls, while chums utilize mainly the lower mile, which commonly dries up completely during droughts. It is this latter section which was surveyed in July 1970.

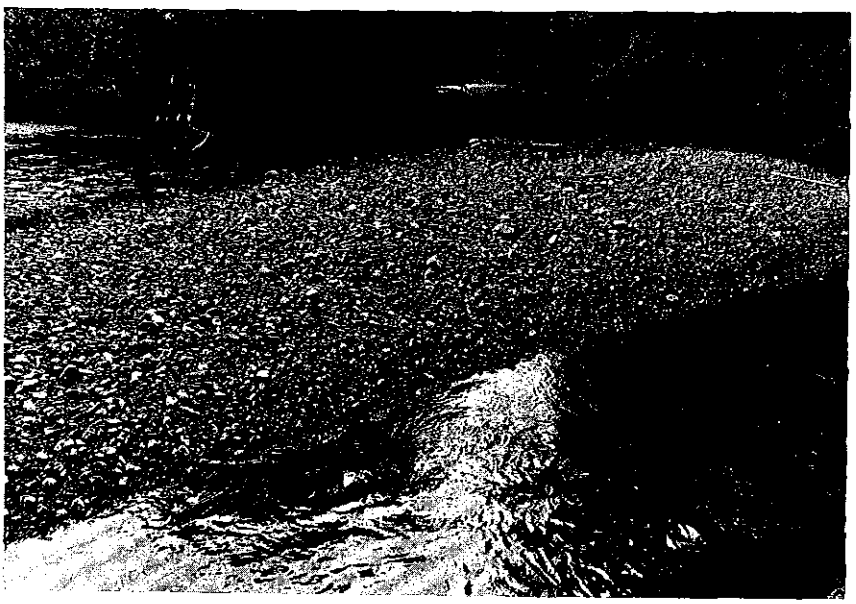
Rosewall Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	1,433	60	28,834	9,542	8,675	33%

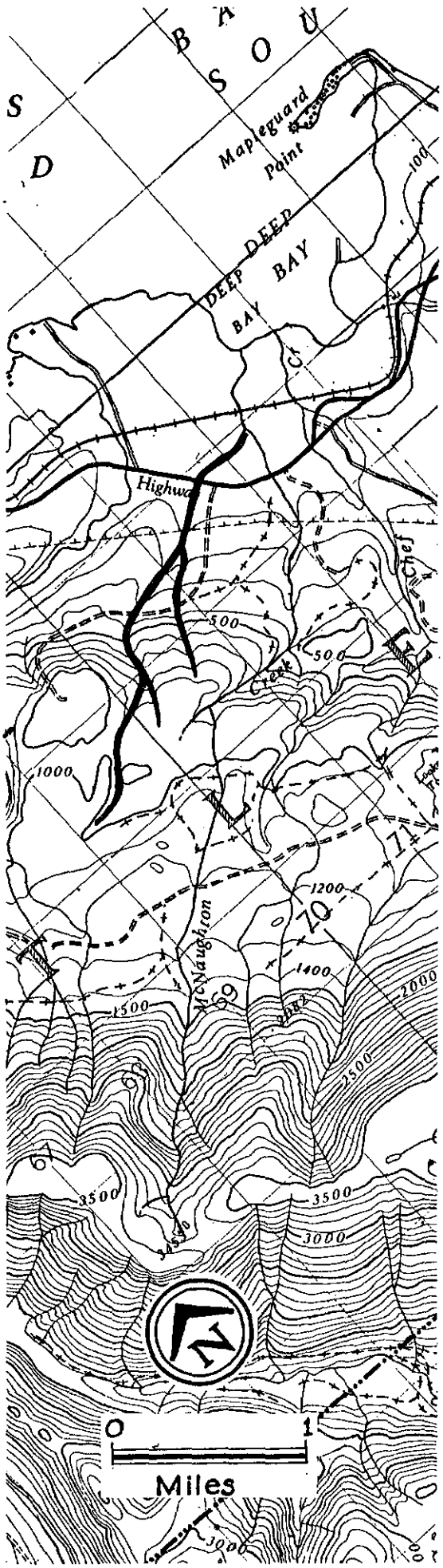
A further 2,851 sq. yds. of chum spawning area is present above the normal chum spawning area.

Mean Chum Escapements

1950-59	1960-69	1970-73
3,300	1,780	2,060



Section 0.6 miles from the mouth (0.1 miles above tidal boundary). This 0.2 mile section above tidal boundary contains excellent spawning area. Above this for 1.2 miles chum spawning area makes up about 17 percent of wetted area.



COOK CREEK 49° 124°SW

LOCATION:
Flows north into Deep Bay, north-west of Bowser, Newcastle District.

CHARACTER:
Cook Creek is a network of small streams originating at the 3,500 foot level near Mount Schofield, some 6 miles from the coast, which join and flow northward into Deep Bay. This system drains a 7.3 sq. mile area. Cook Creek is joined on the north, 700 yards above the estuary, by McNaughton Creek. This is also a chum salmon producing stream and is dealt with separately in this report. Water levels are extremely low in the summer and, like most streams in this area, are at a flood condition by mid-December. Thirty percent of the lower reaches are subject to erosion and scouring.

OBSTRUCTIONS:
A 20 foot vertical falls, located 1.6 miles from the estuary, marks the end of salmon spawning in the creek. Coho will spawn up to this point while chum use only the lower half mile from tidal waters.

APPLICATION:
The watershed had been extensively logged off years ago. Second growth timber is now stabilizing the stream to some extent.

GENERAL:
The survey of June 1970 was from the falls to the estuary.

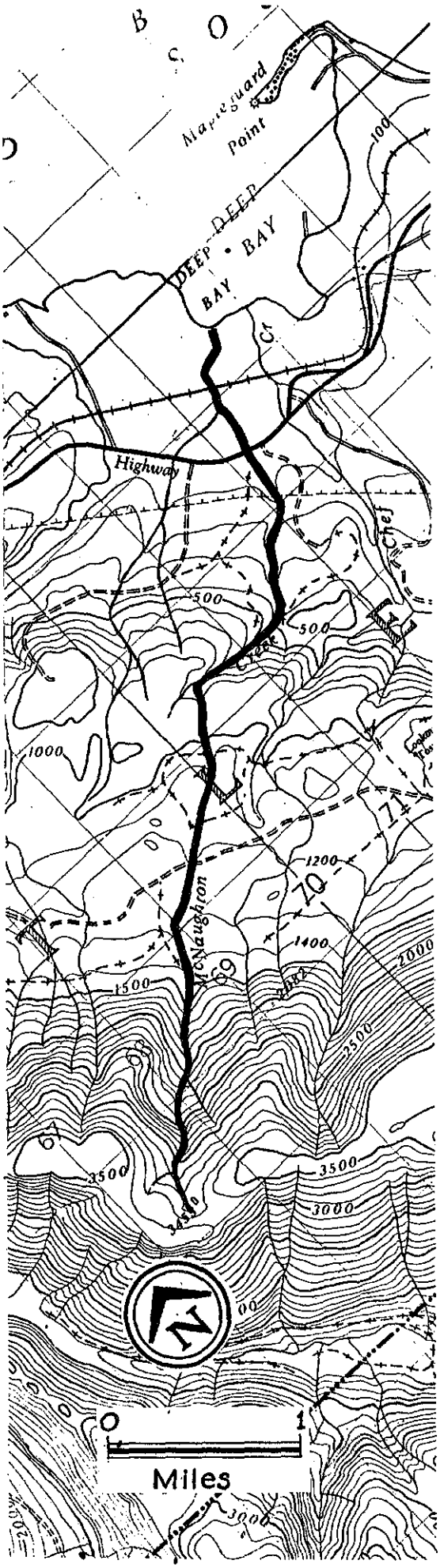
Cook Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	1,655	15	26,095	8,433	7,666	32%

Mean Chum Escapements

1950-59	1960-69	1970-73
4,150	1,630	4,450

Section just below highway bridge 1.8 miles from the mouth. Very little chum spawning area until 1.2 miles from the mouth.



McNAUGHTON CREEK 49° 124°SW

LOCATION:
Flows north-east into Cook Creek, Newcastle District.

CHARACTER:
McNaughton Creek drains a 3.4 sq. mile area over a distance of 5 miles north-east into Cook Creek, which is treated separately in this report. McNaughton Creek originally possessed its own estuary but has since been diverted easterly in Cook Creek.

OBSTRUCTIONS:
A rock falls, 2 miles upstream, marks the end of spawning migration. An extensive beaver dam at the bottom end of the creek has backed water up at least 1,000 feet. There is no immediate plan to remove the dam.

APPLICATION:
Logging has left its mark on this stream especially in the lower sections where new channels have been formed and logging debris left in the streambed. During the winter floods, the water spreads throughout this swamp, while in the summer all but one of the many small channels dry up. There tends to be about 15% erosion and silting with moderate souring in the lower section.

GENERAL:
Coho spawn up to the rock falls, while chum utilize only the bottom 0.5 mile. The stream survey of June 1970 was conducted on this latter section.

McNaughton Creek—Chum Spawning Area Dimensions

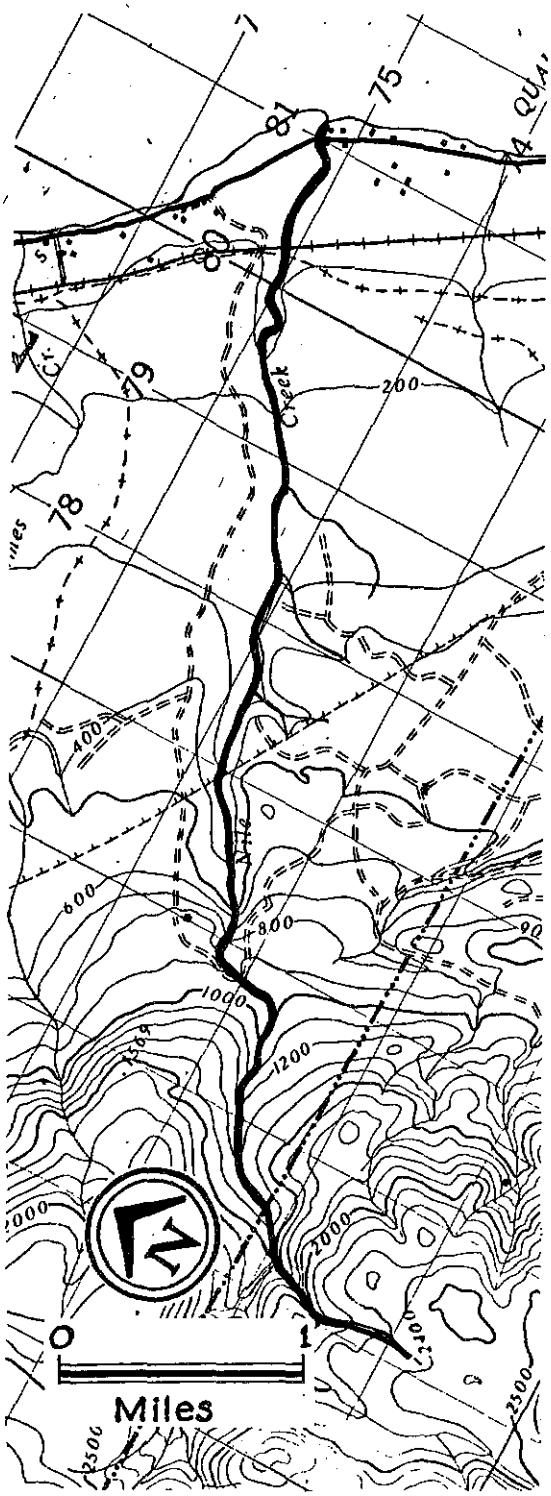
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Channels	242	6	1,528	827	751	54%
Main Creek	535	12	8,080	3,330	3,028	41%
TOTAL	777	9	9,608	4,157	3,779	43%

Mean Chum Escapements

1950-59	1960-69	1970-73
4,830*	860	2,230

*9 yrs. only

Creek just downstream from junction of side channel 0.2 miles from the mouth. Good spawning area is present from old logging road to junction with Cook Creek.



NILE CREEK 49° 124°SW

LOCATION:
Flows north-east into Qualicum Bay, Newcastle District.

CHARACTER:
Nile Creek drains an area of 7 sq. miles. The streambed consists mostly of fine and coarse gravel and frequent pools.

Nile Creek Discharges Recorded Near The Mouth (cfs)

Year	Maximum	Minimum	Mean
1960	409	5.6	28.6
1961	615	2.3	39.0
1962	420	5.0	30.2
1963	659	6.1	41.9
1964	642	5.0	42.2
1965	373	3.9	25.6
1966	543	4.8	43.1
1967	418	5.7	37.5
1968	625	7.2	45.1
1969	238	6.8	34.4
1970	418	6.1	24.6
Average	487	5.3	35.7

OBSTRUCTIONS:
A series of falls 3.3 miles from the mouth are a complete barrier to salmon. Beaver dams are also obstructions on this stream.

APPLICATION:
Water licences have been approved on this creek for domestic water use by the local district.

GENERAL:
Coho appear throughout the entire section of the stream while chums utilize only the lower 0.75 miles. It is this section, from the railroad bridge to the mouth, which was surveyed in September 1970.

Nile Creek—Chum Spawning Area Dimensions

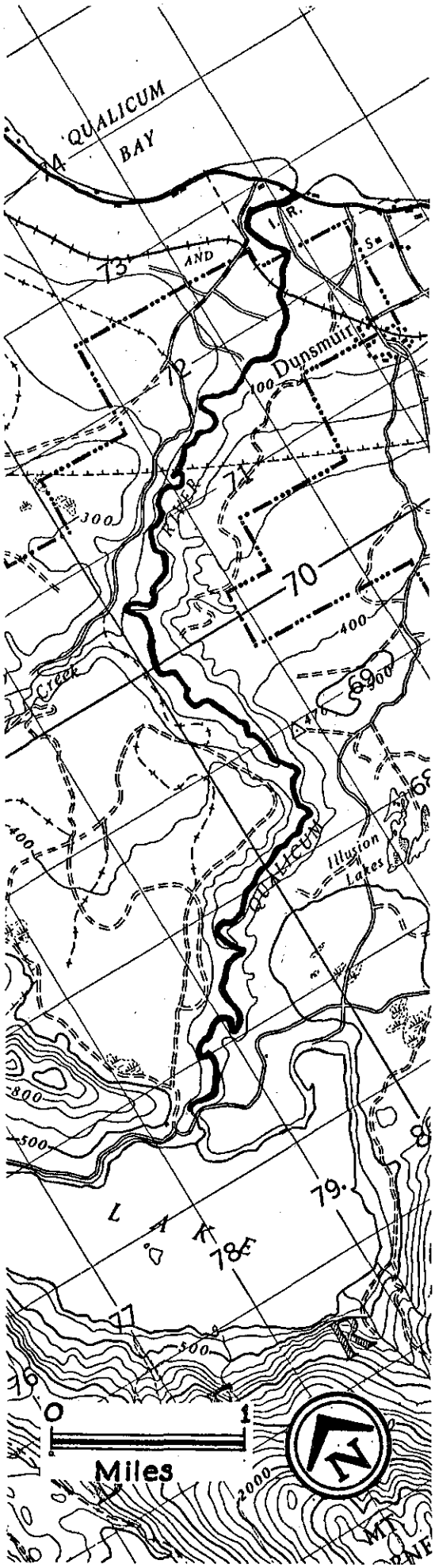
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	1,017	10	10,177	546	496	5%

Mean Chum Escapement

1950-59	1960-69	1970-73
370*	150	135

*9 yrs. only

Beaver dam 0.7 miles from the mouth. Little spawning area is present above this dam.



BIG QUALICIUM RIVER 49° 124°SW

LOCATION:
Flows north-east into Strait of Georgia, south of Qualicum Bay, Newcastle District.

CHARACTER:
Beginning at Horne Lake, the Big Qualicum River flows 7 miles to the sea, draining an area of 58 sq. miles. Hunts Creek is the only significant tributary of the system. In 1963, flow control was implemented.

Big Qualicum River Discharges Near Bowser (cfs)

Year	Maximum	Minimum	Mean
1959	1,200	34.0	370
1960	1,360	25.1	243
1961	3,200	13.7	335
1962	1,260	31.6	210
1963	1,490	24.5	235
1964	1,480	28.6	—
1965	393	61.0	180
1966	735	95.2	262
1967	850	86.0	291
1968	818	72.7	290
1969	842	124.0	279
1970	504	54.0	161
Average	1,178	54.2	260

OBSTRUCTIONS:
An impassable series of four falls, with a drop of 190′, are located 6.5 miles from the mouth, half a mile from Horne Lake.

APPLICATION:
This system's watershed has been extensively logged. In the lower areas, second growth is well established, but in the upper watershed the logging is recent and there is little second growth. Since 1959, the Big Qualicum River has been an important area of Canadian fish cultural activity. The development has included total control of the rivers flow, partial control of its temperature, spawning channel construction, improvement of existing spawning areas, transplant experiments and operation of an experimental hatchery. The basic aim of the Big Qualicum River Development Project is to provide optimum conditions for the migration, spawning, incubation, and rearing of salmon and trout. The hatchery and rearing facility was constructed in 1967 and has operated continuously since then, incubating and rearing chinook and coho salmon.

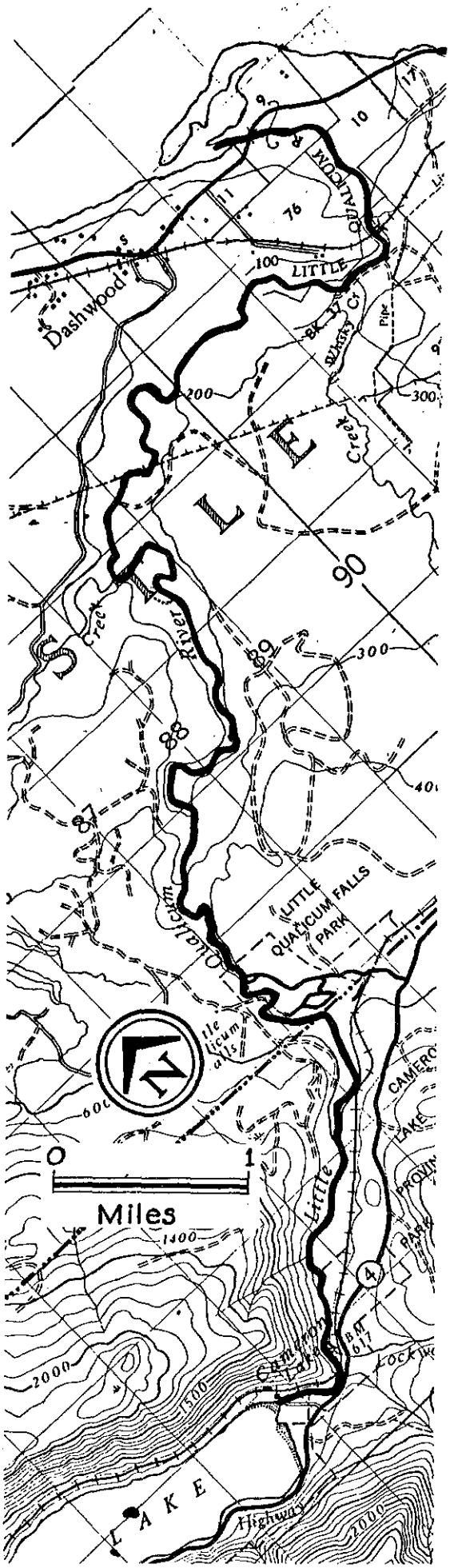
GENERAL:
In conjunction with the flow and temperature control programs, two spawning channels were constructed adjacent to the Big Qualicum River. The first of these was constructed in 1963 and operated as a spawning channel until 1969. Subsequent to that, it has been used as a rearing channel for chum salmon. The second spawning channel was constructed in 1967 and is used exclusively as a spawning channel for chum salmon. This second channel and the river were measured in the survey carried out in September 1970.

Big Qualicum River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River above Hunt's Cr.	6,692	18	119,054	10,925	9,932	9%
Main River below Hunt's Cr.	5,768	20	111,447	52,870	48,064	47%
Spawning Channel	1,133	17		17,000	17,000	
TOTAL				80,795	74,996	

Mean Chum Escapement

1950-59	1960-69	1970-73
41,000	55,520	120,640



LITTLE QUALICUM RIVER 49° 124°SE

LOCATION:
Flows north-east and north-west into Strait of Georgia, west of Qualicum Beach, Newcastle District.

CHARACTER:
Little Qualicum River flows approximately 11 miles from Cameron Lake to the Strait of Georgia. With its two tributaries, Kinkade and Whiskey Creeks, it has a total drainage area of 96 sq. miles.

Little Qualicum River Discharges Near Qualicum Beach (cfs)

Year	Maximum	Minimum	Mean
1961	11,200	136.6	618
1962	4,210	54.0	328
1963	4,700	50.0	457
1964	5,930	63.6	544
1965	2,850	29.0	282
1966	3,500	25.0	468
1967	3,260	42.0	493
1968	5,430	62.0	529
1969	1,630	60.9	424
1970	1,310	32.1	282
Average	4,402	55.5	443

OBSTRUCTIONS:
Little Qualicum Falls, located 9.4 to 8.9 miles from the mouth, form a total barrier to salmon, dropping approximately 200 feet over 0.5 miles.

APPLICATION:
The upper portion of the watershed has undergone moderate logging, while the lower portion flows through second growth.

GENERAL:
This system containe some excellent spawning gravel. The survey, conducted in 1969, began at the 'Glory Hole', about one mile downstream from the falls, and continued 7.9 miles to the mouth. The river was divided into three sections as follows:
(1) the 'Glory Hole' to the power line (7.9 miles to 5.0 miles from the mouth).
(2) the power line to the Island Highway bridge (5.0 miles to 0.9 miles from the mouth).
(3) the estuary.

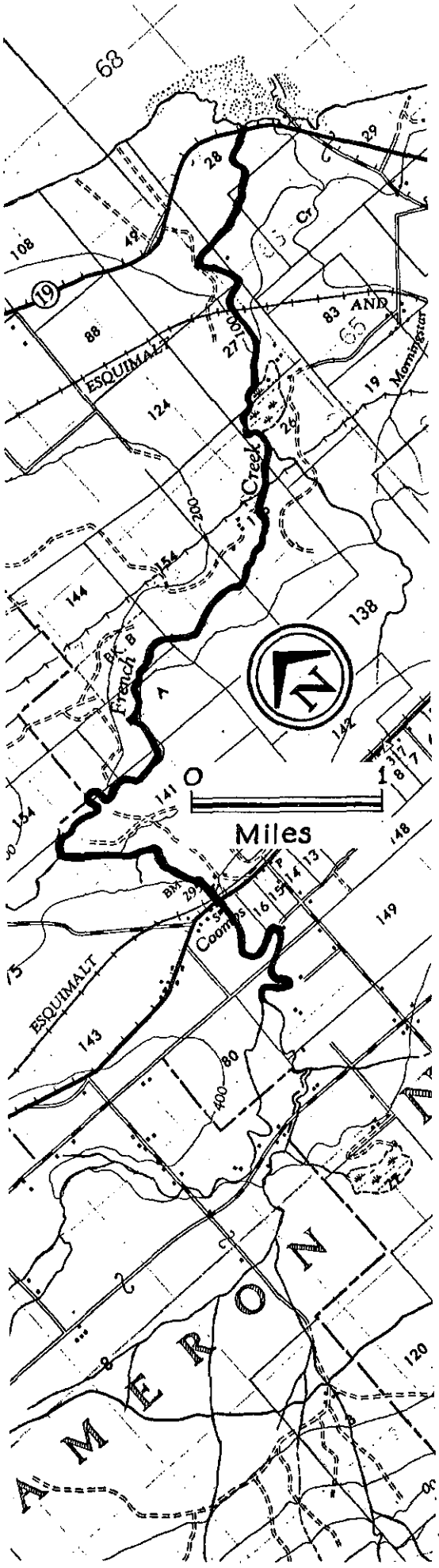
Little Qualicum River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1yd^2 per fish	Spawning as % of Wetted Area
(1) Main River	4,608	26	117,514	35,456	32,233	30%
Channels	1,300	9	11,667	8,250	7,500	71%
(2) Main River	7,292	25	172,913	35,642	32,407	21%
TOTAL	12,367		302,094	79,354	72,140	26%

Mean Chum Escapements

1950-59	1960-69	1970-73
43,000	42,500	66,190

An excellent spawning area 6.2 miles from the mouth.



FRENCH CREEK 49° 124°SE

LOCATION:
Flows north-east into Strait of Georgia, west of Parksville, Nanoose District.

CHARACTER:
French Creek is 9.2 miles long and drains an area of 28 sq. miles.

French Creek Discharges* at Coombs (cfs)

Year	Maximum	Minimum	Mean
1969	182	0	31.3
1970	263	0	12.6

*for the months of April to September

OBSTRUCTIONS:
A partial obstruction, Brooks Falls, located 5.7 miles from the mouth, was eliminated in 1960 by the construction of fishway. There is also an impassable 20 foot falls situated on the west fork approximately 0.25 miles upstream from the confluence with main stream.

APPLICATION:
Several water licences have been issued on this system.

GENERAL:
Coho can be found scattered throughout to the headwaters. Though chums go as far as Brooks Falls, they tend to utilize the lower reaches and it was this section that was surveyed in September 1970.

French Creek—Chum Spawning Area Dimensions

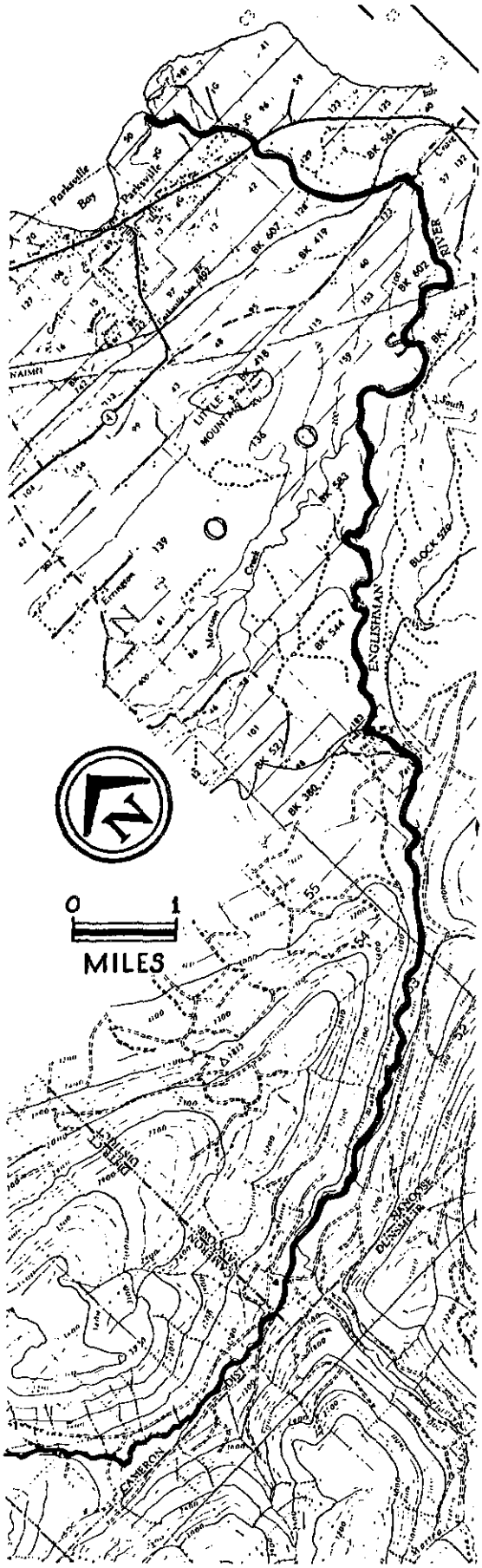
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	1,282	9	11,594	1,023	930	9%

Mean Chum Escapements

1950-59	1960-69	1970-73
808	560*	990

*9 yrs. only

Creek 1.2 miles from the mouth. Chum spawning area is limited here and none is present above this point.



ENGLISHMAN RIVER 49° 124°SE

LOCATION:
Flows north into Strait of Georgia, east of Parksville, Nanoose District.

CHARACTER:
Approximately 20 miles in length, draining a total area of 111 sq. miles, this system, originating at the 5,285 foot level near Mount Moriarty, is joined in the lower section by Morison Creek on the northside, and South Englishman River on the southside. Over 80% of the streambed is made up of boulders or coarse gravel. The table below shows three years of discharges before the station was discontinued in 1917. These records were obtained prior to the logging of the watershed. In 1970, the mean discharge from May to September was 143 cfs, with a miximum of 732 cfs and a minimum of 6 cfs.

Englishman River Discharges near Parksville (cfs)

Year	Maximum	Minimum	Mean
1915	3,020	23	450
1916	3,680	15	481
1917	1,880	15	304

OBSTRUCTIONS:
Ten miles from the mouth, a series of falls, with an overall drop of 100 feet, form a complete block to migrating salmon.

APPLICATION:
The upper reaches of the Englishman watershed have been heavily logged consequently resulting in extreme variations in water levels, especially during the heavy December freshet. At this time erosion, silting and scouring are severe, usually in the middle and lower areas of the river. The section of river below the falls has only large boulders left due to scouring. Water licences have been granted to Parksville and surrounding farms in the area. There has also been some gravel removal near the mouth.

GENERAL:
The average pink escapement for this system is 100 (1960-1972). The survey of June 1970 was conducted from the confluence of the Englishman and South Englishman Rivers to the estuary. The figures presented below are for the 3.9 mile section from tidal waters which chum mainly utilize.

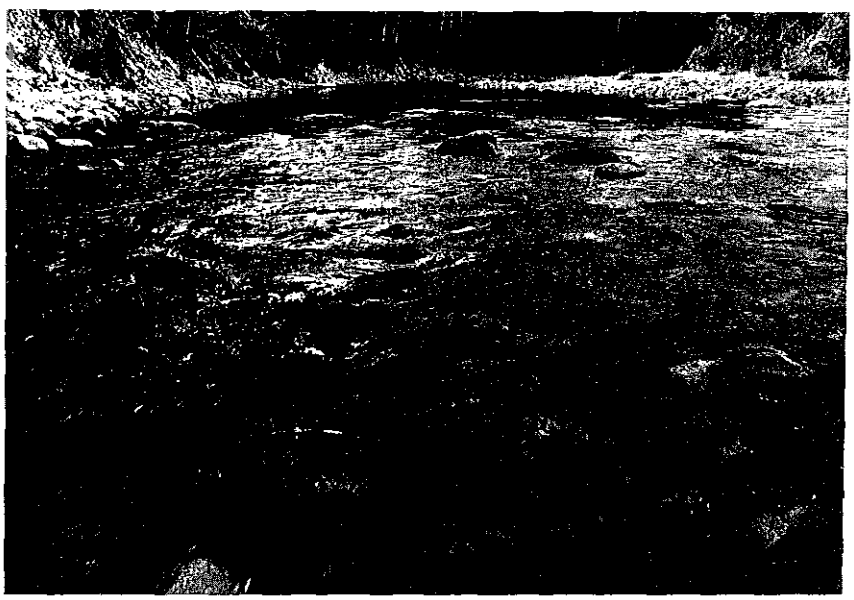
Englishman River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	6,417	31	202,847	46,181	41,983	23%

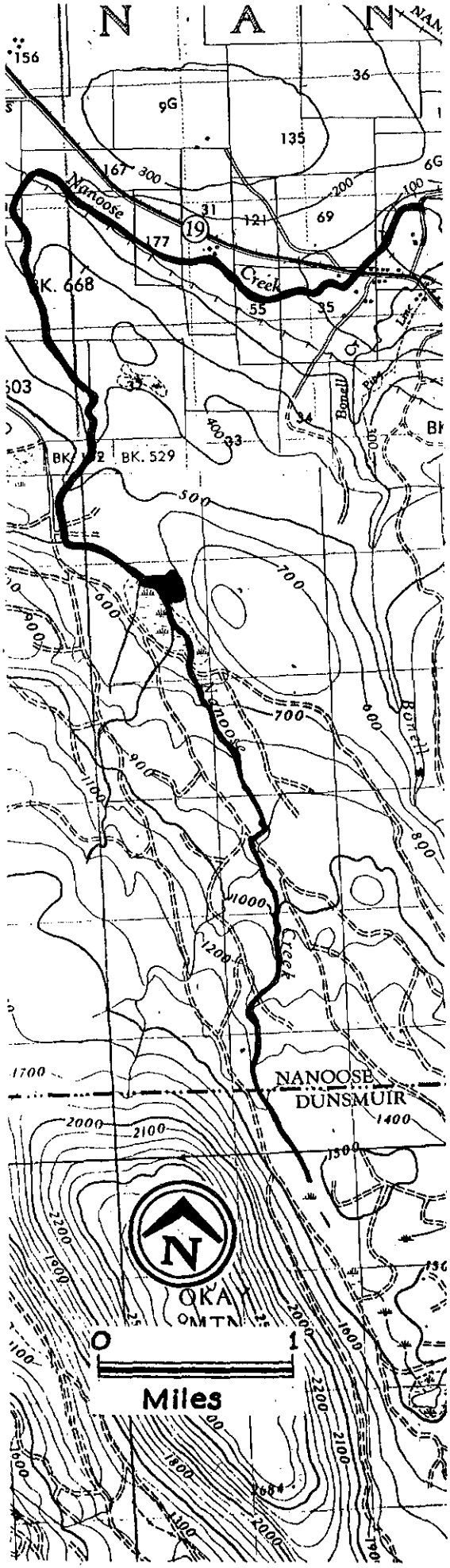
A further 4,887 sq. yds. of potentially usable chum spawning area is present above the 3.6 miles presently utilized.

Mean Chum Escapements

1950-59	1960-69	1970-73
8,080	3,580	7,380



A section of river 9.0 miles from the mouth. Boulders, rocks and fast water make up most of the river from here to 3.7 miles from the mouth.



NANOOSE CREEK 49° 124°SE

LOCATION:
Flows north and east into Nanoose Harbour, Nanoose District.

CHARACTER:
This winding stream meanders in a north-easterly direction into the head of Nanoose Bay just north of Bonell Creek. Well known for its flash floods twenty years ago, Nanoose Creek is now stabilizing with the establishment of second growth timber on the watershed. Discharge records, taken near the mouth, for the months of April to September 1970 are—68.1 maximum, 0.29 minimum, 2.8 mean (cfs).

OBSTRUCTIONS:
A falls, 3 miles from the mouth, is a complete barrier to migrating chums. There are also several small log jams in this lower section of the creek.

GENERAL:
Coho are able to go over the falls at ideal water levels and spawn upstream. This top section is filled with boulders and very coarse gravel unsuitable for chum spawning. The stream survey conducted in June 1970 was carried out from the falls downstream to the mouth.

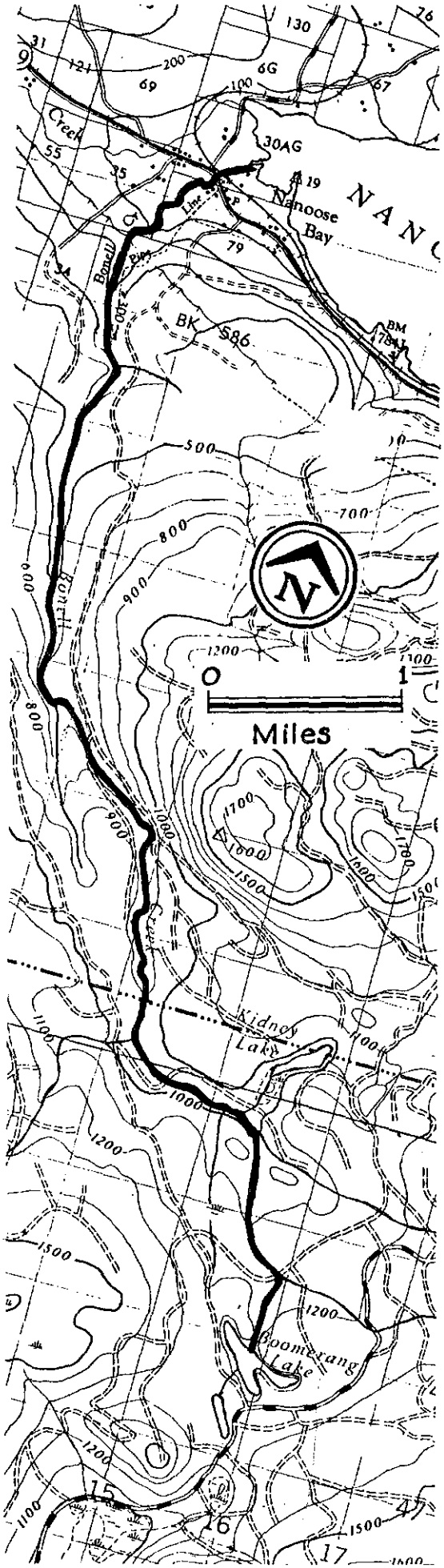
Nanoose Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	4,364	9	39,126	16,017	14,561	41%

Mean Chum Escapements

1950-59	1960-69	1970-73
2,270	1,000	7,550

Section of creek 1.4 miles from the mouth containing good chum spawning gravel.



BONELL CREEK 49° 124°SE

LOCATION:
Flows north-east into head of Nanoose Harbour, Nanoose District.

CHARACTER:
Flowing from a small lake and swamp lands through second growth timber, Bonell Creek has a highly variable flow pattern. The upper section which contains coarse gravel and boulders is unsuitable for spawning. The lower mile is gravel bars. High water flows re-arrange these bars and accumulate gravel at tide water so that minor channel changes take place each year. In dry summers, portions of this system are dry. These factors may contribute to the greater than normal intertidal spawning in this system. Usually chum salmon spawn in the first half mile of the stream while coho utilize up to 2.5 miles.

OBSTRUCTIONS:
A total impasse is formed by an 80' natural water fall 3 miles from tide water.

GENERAL:
Although the survey of June 1970 covered the stream from 2 miles downstream to the mouth, the chum spawning area dimensions are based on the lower half mile, excluding tidal waters. These estimates do not take into account the intertidal spawning of this stream.

Bonell Creek—Chum Spawning Area Dimensions

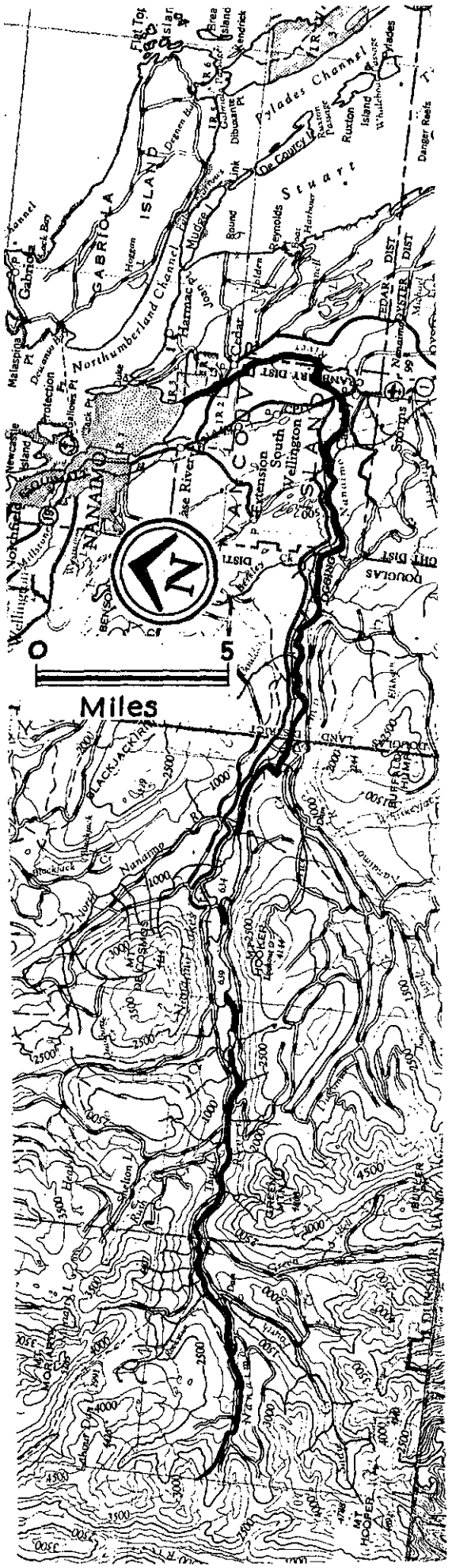
Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	818	13	10,739	6,589	5,990	61%

An additional 3,567 sq. yds. of potentially usable chum spawning area is present above the area now utilized.

Mean Chum Escapement

1950-59	1960-69	1970-73
6,980	2,200	4,050

Log jam 1.7 miles from the mouth. This jam and others on creek appear passable to salmon.



NANAIMO RIVER 49° 123°SW

LOCATION:
Flows east and north into Nanaimo Harbour, Nanaimo District.

CHARACTER:
A series of four small lakes draining eastward mark the beginning of the Nanaimo River which quickly meets the South Nanaimo River and carries on some 16 miles to Nanaimo Harbour. Haslam Creek joins in on the southside of the lower section to make a total drainage area of 249 sq. miles. The top end of the river is made up of rocks and coarse gravel down to Haslam Creek where much better gravel continues to the mouth.

Nanaimo River Discharges (cfs)

Year	Maximum	Minimum	Mean
Near Extension			
1949	8,390	77	1,160
1950	26,000	61	1,600
1951	17,000	29	1,780
1952	10,500	48	1,310
1953	16,400	37	1,370
1954	9,440	160	1,690
1955	16,900	68	1,380
1956	22,000	58	1,500
1957	12,400	55	1,370
1958	10,200	140	1,170
1959	23,800	72	1,490
1960	26,000	80	1,240
1961	54,600	102	1,860
1962	14,900	97	1,110
1963	31,300	112	1,600
1964	27,000	100	1,580
Average	20,427	81	1,451
Near Cassidy			
1965	10,100	120	1,234
1966	15,200	151	1,259
1967	11,200	143	1,511
1968	21,200	151	1,800
1969	7,870	151	1,380
1970	9,240	111	995
Average	12,468	138	1,363

APPLICATION:
The District of Nanaimo has their reservoir dam on the South Nanaimo River. Logging has been carried out throughout most of the watershed. Gravel removal is a problem in the lower section. MacMillan-Bloedel holds a water licence on the river and in addition has storage facilities on Fourth Lake.

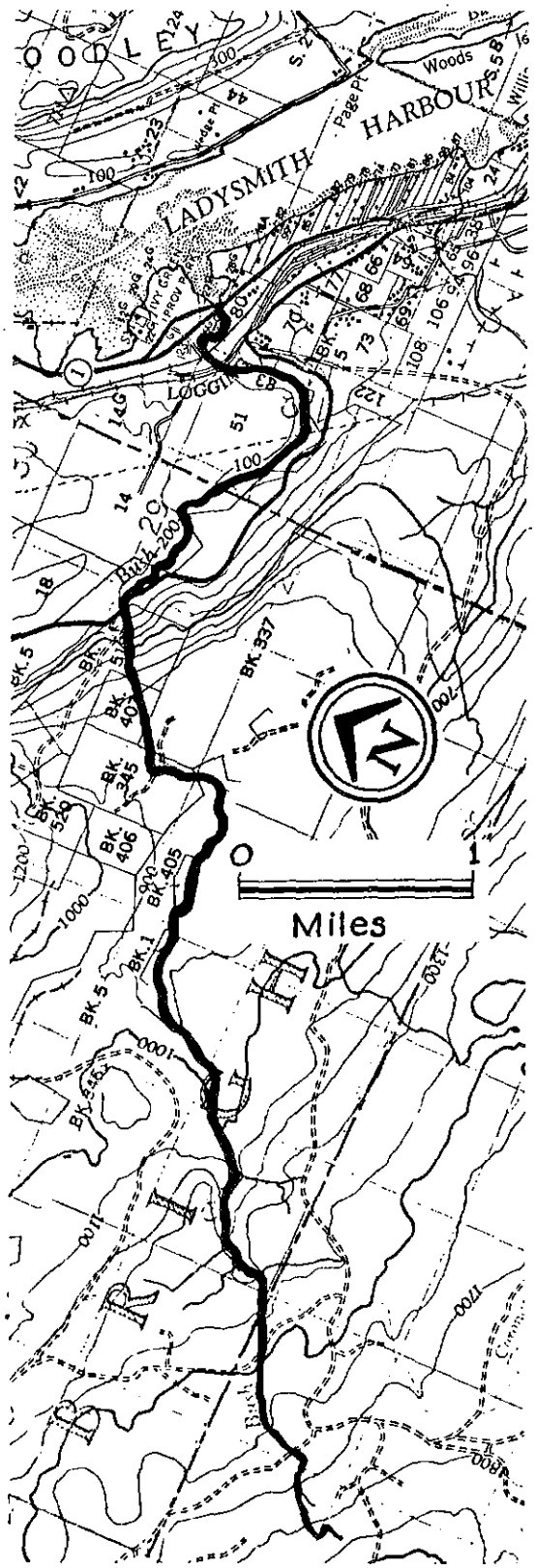
GENERAL:
Chum spawning occurs throughout the lower 8 miles utilizing main river, side channels, Haslam Creek and Polkinghorne Slough. The survey in 1970 measured this area and the breakdown of the individual sections are given below.

Nanaimo River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	5,975	45	271,111	37,249	33,863	14%
Polkinghorne Slough	2,148	18	42,600	25,573	23,248	60%
Side Channels	1,202	17	20,583	11,752	10,684	57%
Haslam Creek	2,467	25	62,939	9,631	8,755	15%
TOTAL	11,792		397,233	84,205	76,550	21%

Mean Chum Escapements

1950-59	1960-69	1970-73
48,750	20,100	38,380



BUSH CREEK 49° 123°SW

LOCATION:
Flows north-east into Ladysmith Harbour, Oyster District.

CHARACTER:
This stream is mostly large rock and pools. Flowing through untouched second growth timber, it has a very constant and stable flow.

OBSTRUCTIONS:
Two miles from tide water, there are impassable rock falls.

GENERAL:
Chum salmon tend to spread out over the entire system below the falls, while coho prefer the upper mile. The measurements given below are from the survey conducted in June 1970 which covered the first 1.5 miles upstream from the mouth.

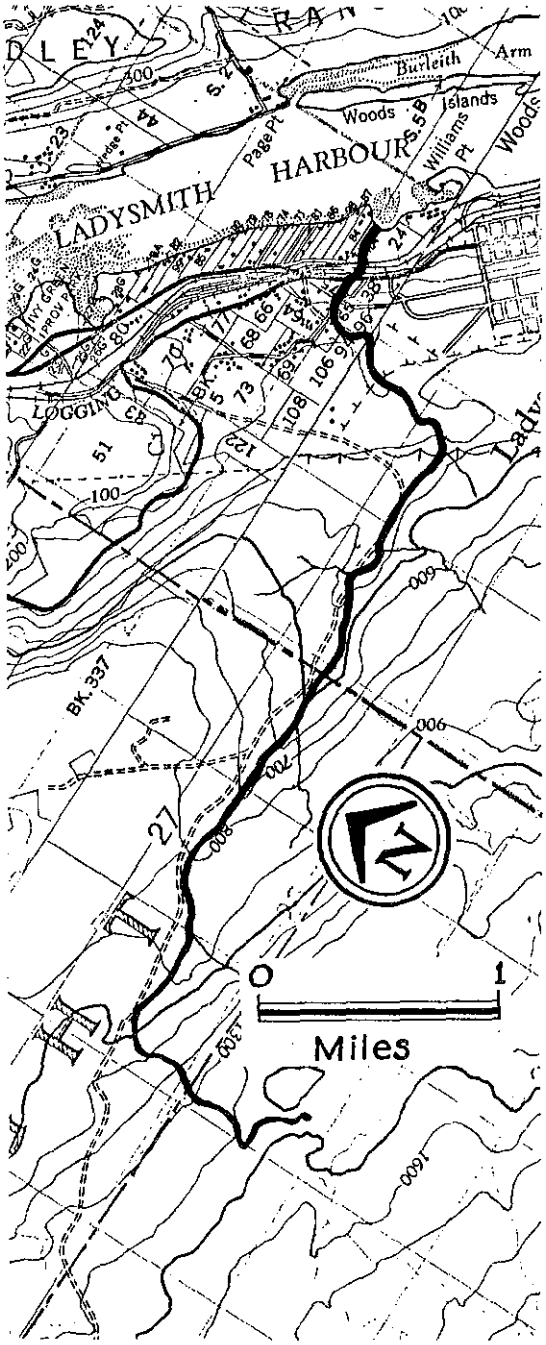
Bush Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	1,988	11	22,014	5,000	4,545	23%

Mean Chum Escapement

1950-59	1960-69	1970-73
5,360	2,270	4,380

Section of excellent chum spawning area 1.0 miles from the mouth.



WALKER CREEK 48° 123°SW

LOCATION:
Flows north and east into Ladysmith Harbour, Oyster District.

CHARACTER:
Walker Creek is a small stream with limited watershed. Debris in the stream helps to conserve the water supply.

OBSTRUCTIONS:
Steep rapids 1.75 miles from the mouth are a total block to migrating salmon. In years of low water, a flat cement apron road culvert, situated 200 feet upstream becomes an obstruction to spawning adults. Also, a highway culvert, 0.75 miles upstream from the mouth, is impassable at low flows. The most suitable spawning grounds are above this culvert.

GENERAL:
During normal flows, coho utilize the first 1.25 miles of the stream and the chum use the first 0.75 miles. The stream survey, completed in September 1970, was on the section that the chums utilize.

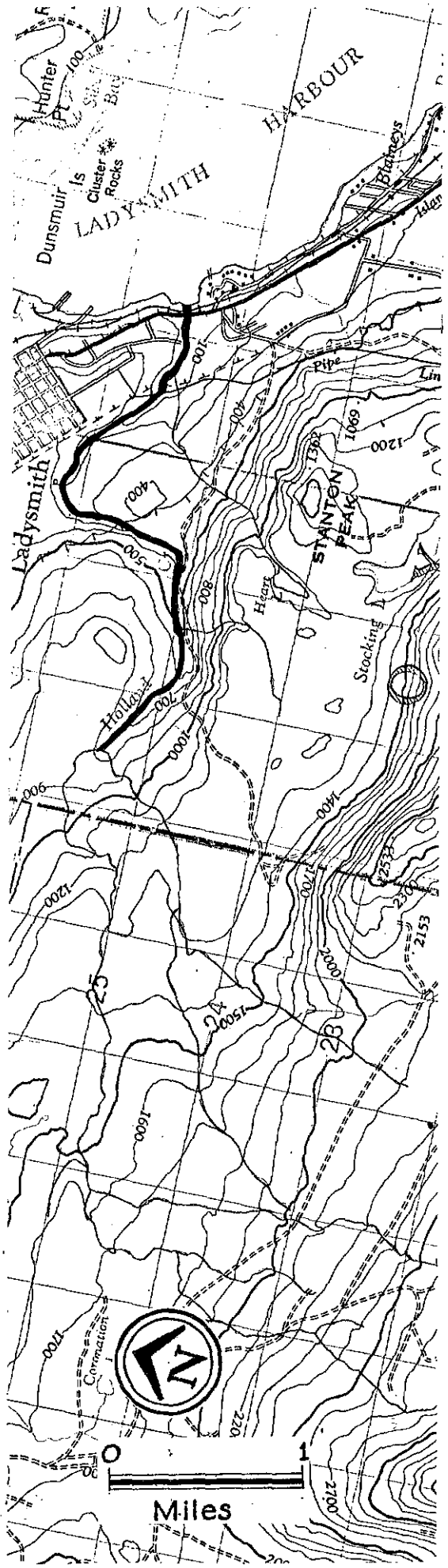
Walker Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	432	4	1,711	239	217	14%

Mean Chum Escapements

1950-59	1960-69	1970-73
1,565	318	270

Chum spawning area 700 feet from the mouth.



HOLLAND CREEK 48° 123°NW

LOCATION:
Flows east into Ladysmith Harbour, south of Ladysmith, Oyster District.

CHARACTER:
The upper portion of this stream is made up of large boulders and very coarse gravel. The lower portions contain coarse gravel.

OBSTRUCTIONS:
A natural falls located 2 miles upstream is impassable to migrating adult salmon.

APPLICATION:
A small dam above the falls supplies water to the town of Ladysmith. Below the dam adequate flows are maintained to support the existing population of chum salmon. There is practically no scouring throughout this system and very little silting.

GENERAL:
Chums utilize all of the spawning area up to the falls. The stream survey measurements were taken in June 1970.

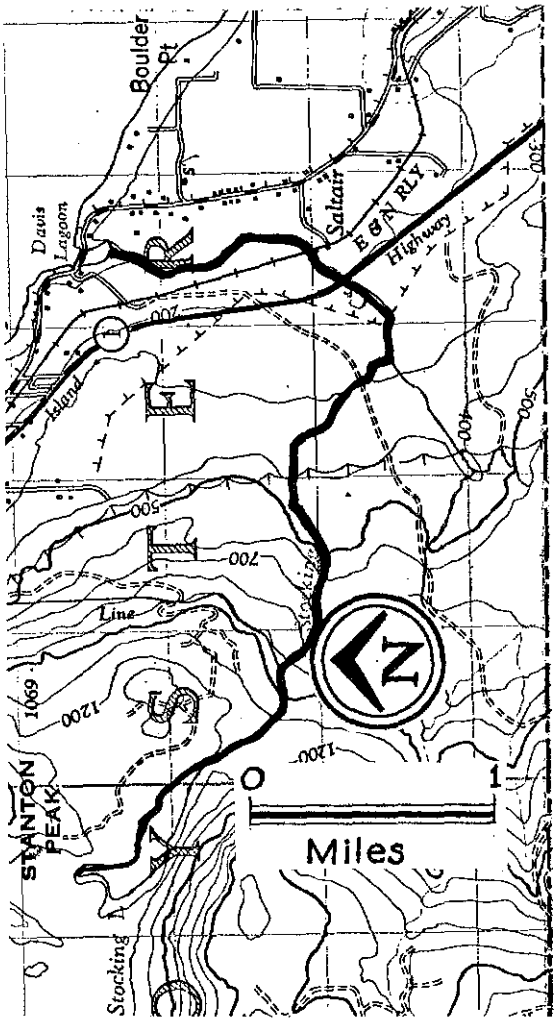
Holland Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	1,110	12	13,386	1,999	1,817	15%

Mean Chum Escapements

1950-59	1960-69	1970-73
6,980	4,650	5,850

Good spawning area 0.2 miles from the mouth of the creek.



STOCKING CREEK 48° 123°SW

LOCATION:
Flows east and north into Davis Lagoon, south-east of Ladysmith, Oyster District.

CHARACTER:
Flowing out of Stocking Lake, this small system supplies water for Ladysmith and Saltair. Little or no flow leaves the lake during a dry season.

OBSTRUCTIONS:
An eight foot falls, situated 0.5 miles upstream, is a complete block to salmon.

APPLICATION:
This system supplies water for Ladysmith and Saltair. Saltair water district's ten inch main pipeline has a four inch valve to provide releases down the creek for migrating adults in the fall.

GENERAL:
Chums spawn below the falls and on down into tidal water. Very good gravel exists in this lower section where scouring and erosion is practically nonexistant. On this limited spawning area, which was surveyed in 1970, overcrowding is a definte problem in years of high adult returns.

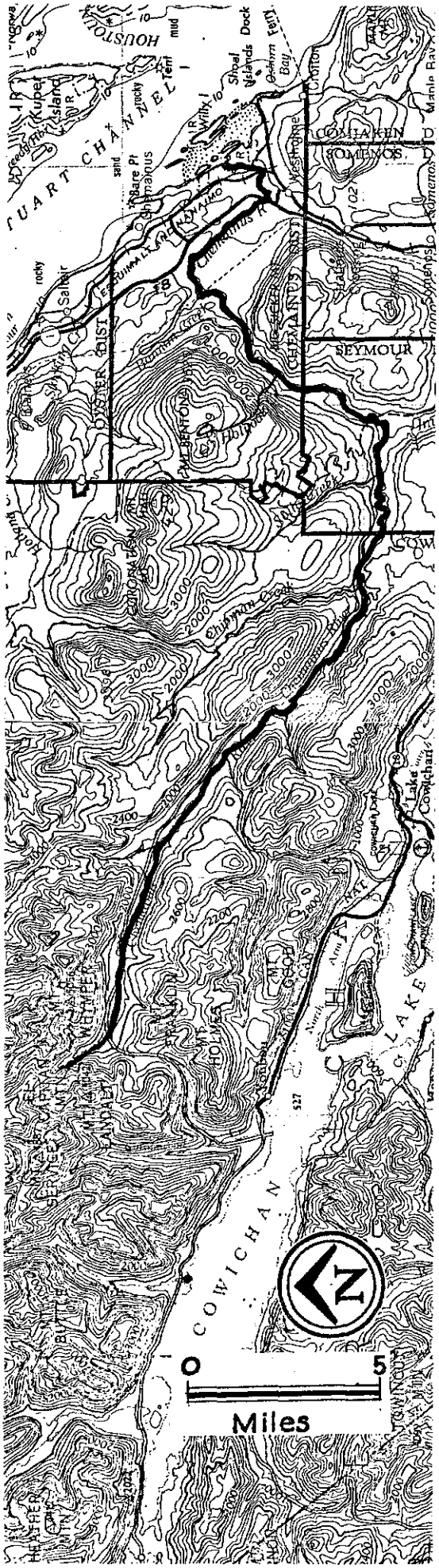
Stocking Lake Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	261	11	2,697	1,445	1,314	54%

Mean Chum Escapements

1950-59	1960-69	1970-73
3,630	1,720	4,180

Impassable 8 foot falls 0.4 miles from the mouth.



CHEMAINUS RIVER 48° 123°NW

LOCATION:
Flows east, south-east and north into Stuart Channel, south of Chemainus, Chemainus District.

CHARACTER:
The Chemainus River flows for 33 miles through a drainage area of 146 sq. miles. The area below Copper Canyon has an average gradient of 5/1000 feet. The area immediately below the canyon has large rocks and scoured gravel. It is subject to high water velocities. Good gravel starts one mile above the Island Highway Bridge and extends to tide water for a distance of about 3 miles. The 2 mile area below the Old Highway Bridge, though intertidal, contains extensive gravel suitable for spawning and offers good rearing areas for the appropriate species.

Chemainus River Discharges Near Westholme (cfs)

Year	Maximum	Minimum	Mean
1955	6,860	8.0	635
1956	11,300	5.5	630
1957	6,320	2.5	573
1958	2,490	8.0	498
1959	5,220	38.0	778
1960	9,100	18.0	602
1961	9,700	7.3	790
1962	6,190	8.0	580
1963	8,560	8.0	755
1964	8,500	12.0	692
1965	6,650	10.0	416
1966	5,590	11.0	739
1967	7,900	8.0	803
1968	16,100	19.8	897
1969	3,680	36.0	595
1970	7,130	4.5	532
Average	7,581	12.8	657

OBSTRUCTIONS:
A significant obstruction exists 7.5 miles upstream in Copper Canyon. The falls and the canyon below them present a total barrier to chum salmon.

APPLICATION:
The upper drainage area has been extensively logged, mostly in the last decade. The whole Chemainus system has extreme fluctuations in temperature and flow due to this watershed logging. The lower river is bordered by farm land and second growth forest. Extensive gravel removal in the lower reaches and extreme flows from the watershed are important factors in the chum salmon decline in this system.

GENERAL:
The measurements for the chum spawning area dimensions are based on the first 4 miles from the mouth (excluding tidal waters) which the chum mainly utilize although the stream survey, done in 1969, covered from the canyon downstream.

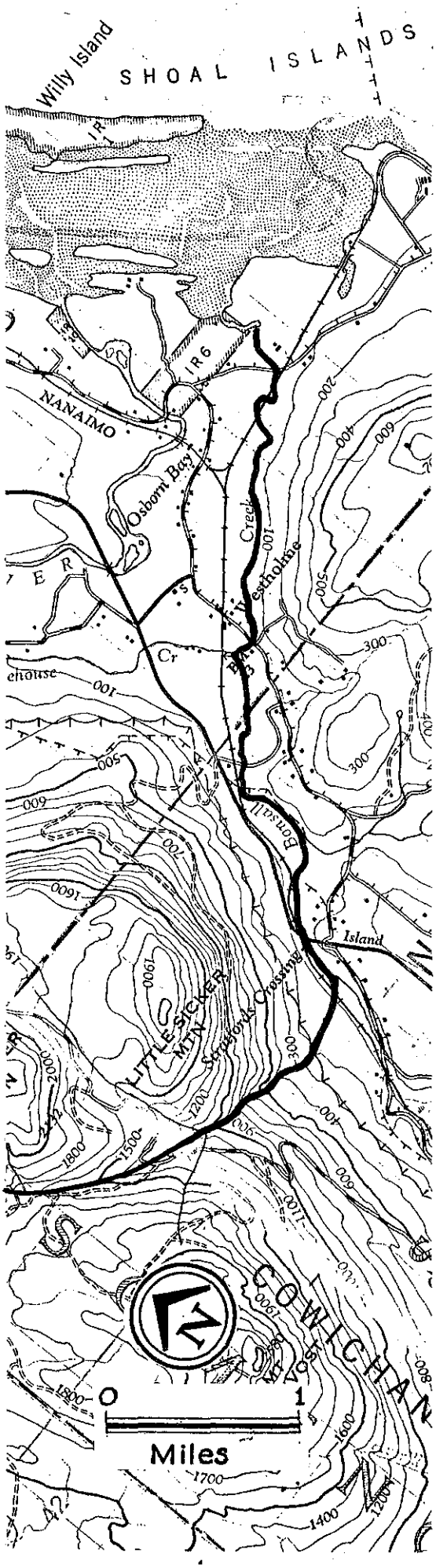
Chemainus River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	4,017	40	163,864	23,316	21,196	14%

An additional 3,420 sq. yds. of potential chum spawning area exists above the area presently utilized.

Mean Chum Escapements

1950-59	1960-69	1970-73
37,600	9,200	13,810



BONSALL CREEK 48° 123°NW

LOCATION:
Flows north-east into Stuart Channel, north-west of Osborn Bay, Chemainus District.

CHARACTER:
This stable creek has very little erosion and no scouring. The streambed in the lower sections is mainly sand, silt and mud with very little gravel.

OBSTRUCTION:
A cement culvert, 5 miles upstream, creates a total block for migrating salmon.

GENERAL:
Coho, which are the dominant species in this stream, use the entire 5 mile section for spawning purposes. The first mile of the stream is utilized by chums. This section was surveyed in September, 1970.

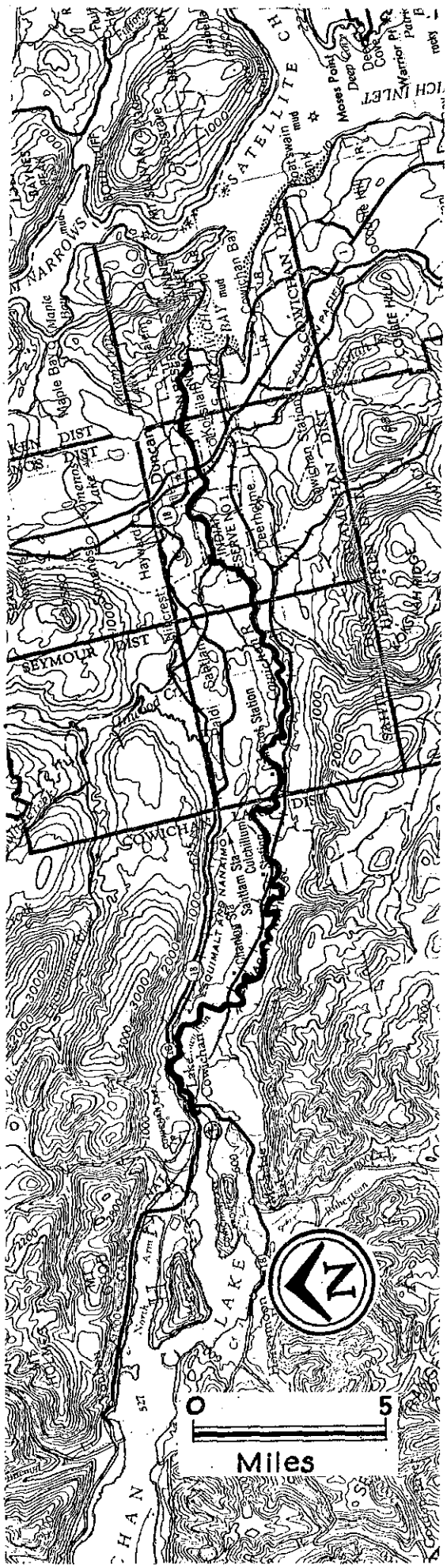
Bonsall Creek—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main Creek	825	8	7,208	599	545	8%

Mean Chum Escapements

1950-59	1960-69	1970-73
780	210	270

Low gradient, pools, sand, silt and some gravel in a section of creek. This is typical of most of creek from highway bridge downstream.



COWICHAN RIVER 48° 123°NW

LOCATION:
Flows east into Cowichan Bay, Cowichan District.

CHARACTER:
The Cowichan River flows approximately 33 miles from Cowichan Lake to the sea, dropping 531 feet with an average gradient of 3/1000 feet. The river itself has few major tributaries with most of the 322 sq. miles of drainage being located around Cowichan Lake. From Cowichan Lake to Skutz Falls is mostly made up of large boulders and holding pools. From Skutz Falls to River Bottom Road is partly made up of canyon with areas of bare rock exposed and contains many pools with large rock bottoms. An estimated 10% of the spawning areas of these sections is suitable for chum spawning. Both these sections contain many rearing areas for appropriate species. From the River Bottom Road, the amount of spawning area suitable for chum increases to tidewater. The estuary supports no spawning but contains many suitable rearing areas for coho, chinook and steelhead.

Cowichan River Discharges Near Duncan (cfs)

Year	Maximum	Minimum	Mean
1960	9,020	155	1,650
1961	19,700	84	2,320
1962	7,480	162	1,447
1963	10,800	200	2,258
1964	4,640	236	—
1965	6,920	145	1,320
1966	9,170	125	1,990
1967	12,800	145	2,190
1968	15,900	180	2,460
1969	5,300	176	1,680
1970	5,420	150	1,300
Average	9,741	160	1,862

OBSTRUCTIONS:
Skutz Falls is the only significant obstruction on the river. It is served by two fishways (high and low level), both constructed in 1956.

APPLICATION:
While the land immediately adjacent to the river is relatively undisturbed, the watershed surrounding the lake contains some of the most complete and extensive logging slashes in the province. This extensive logging affects both discharge and temperature in the river. The river is under partial flow control as a result of a weir structure operated at the outlet of Cowichan Lake by B.C. Forest Products Ltd. Under a 1964 water licence this company stores water in the lake to be released during the months of low flow. The licence provides for a minimum release during the period of control of 250 cfs, with 100 cfs of this being removed just above Duncan and piped to the company's pulp mill at Crofton. The City of Duncan also removes 7 cfs for domestic water supplies. However, due to a miscalculation, the lake will only provide enough storage to maintain approximately 180 cfs during periods of low flow.

Cowichan River Discharges At Lake Cowichan (cfs)

Year	Maximum	Minimum	Mean
1955	7,210	154	1,670
1956	7,520	62	1,810
1957	4,870	200	1,450
1958	6,850	64	1,590
1959	6,690	182	1,700
1960	4,980	183	1,530
1961	11,100	133	1,970
1962	5,680	210	1,340
1963	6,360	208	1,790
1964	7,080	171	1,980
1965	4,130	187	1,190
1966	6,500	180	1,780
1967	10,100	205	1,950
1968	11,500	266	2,110
1969	3,970	259	1,530
1970	3,780	205	1,220
Average	6,770	179	1,663

GENERAL:
This partial flow control is of little value as far as chum salmon are concerned since they enter the system too late in the fall to benefit from the maintenance of flow it provides during drought periods and since it provides no control of high flows. The earlier spawning species and those which rear in the system, however, probably derive great benefit from it. The survey, conducted in 1969, started at this weir structure and continued to the estuary. Most of the chums spawn in the first 5 miles upstream from the mouth and it is this area which is used in the spawning area dimensions table. Some chum do spawn above Skutz Falls to within 5 miles of the lake. There are also some reports of chums entering Lake Cowichan and spawning in

streams flowing into it. If this is true, it must be a rare occurrence. Skutz Falls and the fishways associated with it can probably be regarded as the upstream limit to which chum spawning can be extended. Past experience (e.g., on the Columbia at Bonneville Dam) has shown that chums do not make extensive use of fishways even to reach their former spawning areas.

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	9,675	44	418,958	174,569	158,699	42%

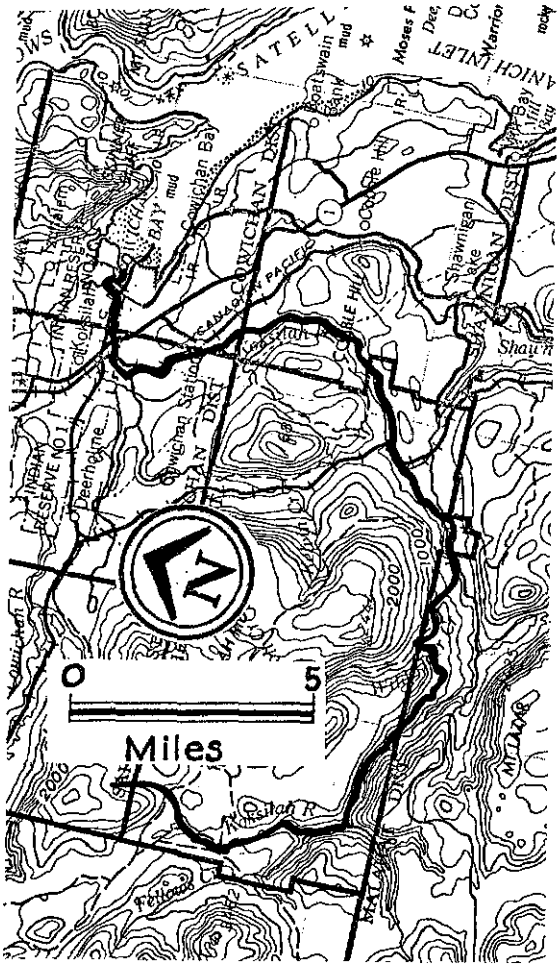
An additional 190,864 sq. yds. of potentially usable chum spawning area exists above the area presently utilized by chums.

Mean Chum Escapements

1950-59	1960-69	1970-73
64,000	55,500	53,750

A flood control program which has been proposed for the Cowichan and Koksilah Rivers adjacent to the City of Duncan, the Cowichan Indian Reserve and the Municipality of North Cowichan, would drastically alter the environment in this portion of the river. Since the Cowichan River only drops approximately 25 feet to low tide in the 5 miles from the Island Highway Bridge to the sea, this portion of the stream experiences much gravel deposition and shifting of channels accompanied by periodic flooding. The proposed changes include dyking and channelling of the rivers from White Bridge on the Cowichan and from the E&W Railway Bridge on the Koksilah downstream to the mouth. This would result in the cutting off of side channels used as spawning areas by chums, destruction of the normal pool-riffle environment, elimination of shaded hiding areas and a general lowering of productivity. The straightening of the channel would result in an increased gradient with increased velocity of flow. This would markedly affect chum spawning behaviour as well as lead to streambed scouring. Temperatures in this system would also rise.

Downstream view of fishway at Skutz Falls.



KOKSILAH RIVER 48° 123°NW

LOCATION:
Flows north-east into Cowichan Bay, Cowichan District.

CHARACTER:
The Koksilah River flows approximately 25 miles through an 86 sq. mile drainage area south of the Cowichan Valley to join the south estuary of the Cowichan River. Due to the low gradient, the lower reaches of the Koksilah experience the same problems of gravel deposition and channel shifting as the lower Cowichan. The nine mile section above the Marble Falls is made up of mostly large rock. Canyon exists for about 2 miles below Marble Falls. Since the bottom is mostly large rock, none of this canyon is suitable for spawning by any species although the pools could be utilized by coho, chinook and steelhead for rearing. The rest of the river has some good spawning areas although the gravel is not a good size, being either too small or too large. The estuary is made up of reaches overhung with brush and would provide excellent rearing.

Koksilah River Discharges At Cowichan Station (cfs)

Year	Maximum	Minimum	Mean
1955	360	17.0	76
1956	952	17.0	153
1957	6,300	17.0	29
1958	265	5.0	35
1959	3,180	9.0	84
1960	5,540	10.2	288
1961	6,700	8.0	425
1962	2,720	9.8	264
1963	4,710	9.4	360
1964	4,740	11.8	432
1965	2,710	10.0	238
1966	4,080	11.4	333
1967	5,220	7.2	435
1968	6,440	14.0	424
1969	3,680	15.0	306
1970	3,540	5.9	268
Average	3,821	11.1	259

OBSTRUCTIONS:
Marble Falls is located approximately 12 miles upstream from the mouth. Several old pieces of cement-work remain from an earlier attempt to make the falls passable but these now have little effect.

APPLICATION:
The watershed has undergone extensive logging at the upper end but the lower portions are relatively undisturbed.

GENERAL:
Much of the spawning area below the canyon is of marginal quality due to the small gravel diameter and the low gradient which leads to extensive silt deposition. The low gradient makes extensive stream improvement unlikely. The most efficient use of this system would probably be through utilization of its rearing potential for coho, chinook and steelhead with transplants from systems in which production exceeds rearing capacity. The Koksilah River survey began at the entrance of Nine Mile Creek approximately 20 miles upstream from salt water. The chum spawning area dimensions are on the first 5.5 mile section from tidal which the chum mainly utilize. The lower reaches of this stream are included in the proposed Cowichan-Koksilah flood control project. The effects of this project are outlined in the section on the Cowichan River.

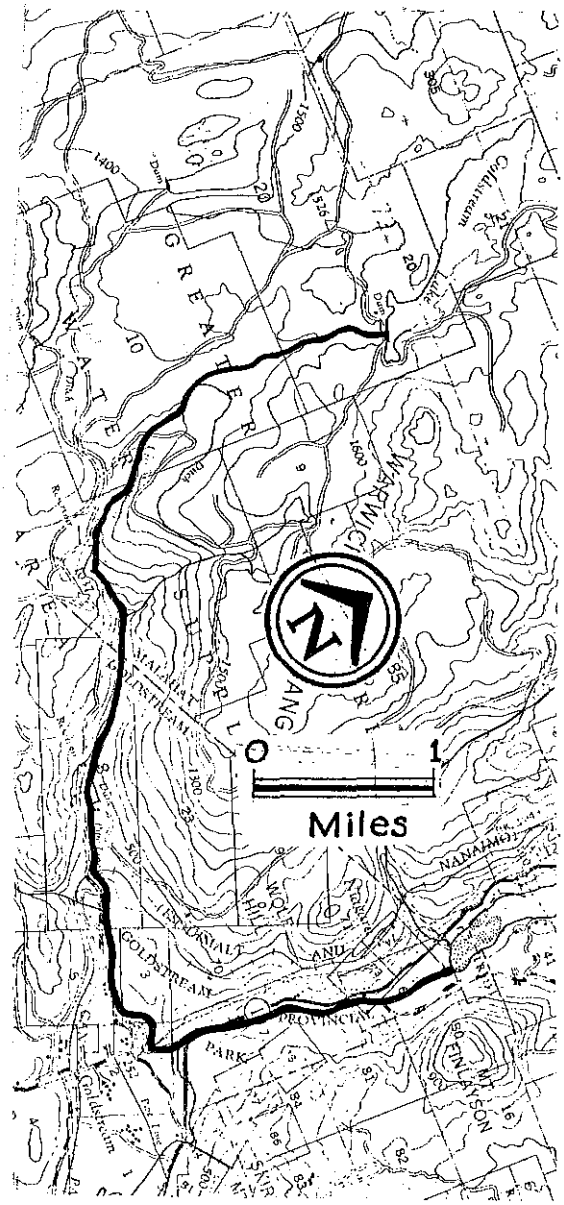
Koksilah River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	8,543	15	136,542	14,626	13,296	11%

A further 1,819 sq. yds. of potentially usable chum spawning area occurs upstream of that which chums presently utilize.

Mean Chum Escapement

1950-59	1960-69	1970-73
2,500	5,250	3,000



GOLDSTREAM RIVER 48° 123°SW

LOCATION:
Flows south-east and north into head of Finlayson Arm, Goldstream District.

CHARACTER:
Draining a system of lakes, this river flows east then north into Finlayson Arm at the end of Saanich Inlet. The lower half mile of the stream is a riffle area having a low gradient with a streambed of suitable spawning gravel. The larger section above this (0.5-1.5 miles upstream) is a more shallow pool and steep riffle area having larger size gravel. The uppermost accessible mile has a relatively steep gradient with large boulders and some bed-rock. There is no evidence of scouring, silting or erosion in this stable system.

OBSTRUCTIONS:
A twenty foot falls completely blocks salmon on their upstream migration 2.5 miles from the mouth.

APPLICATION:
The Goldstream River watershed is one of two supplying water to the Greater Victoria area and therefore, the stream flow is under control. The control has resulted in extreme low levels during the summer and early fall. This situation is a menace to both fry rearing in the river and adults attempting to enter the system.

GENERAL:
Three-quarters of the potential spawning area lies in the lower-most half mile of this stream. Except for the low water levels, this river would be an ideal spawning stream. The stream survey of the accessible section of this river was carried out in June 1970.

Goldstream River—Chum Spawning Area Dimensions

Section	Length (yd)	Width (yd)	Wetted Area (yd^2)	Spawning Area (yd^2)	Capacity @ 1.1 yd^2 per fish	Spawning as % of Wetted Area
Main River	3,747	10	40,459	7,131	6,483	18%

Mean Chum Escapements

1950-59	1960-69	1970-73
13,300	6,980	5,500

Section of river below falls. This 1.2 mile section contains little suitable chum spawning area.

TSULQUATE RIVER

Downstream view from bridge near mouth.

QUATSE RIVER

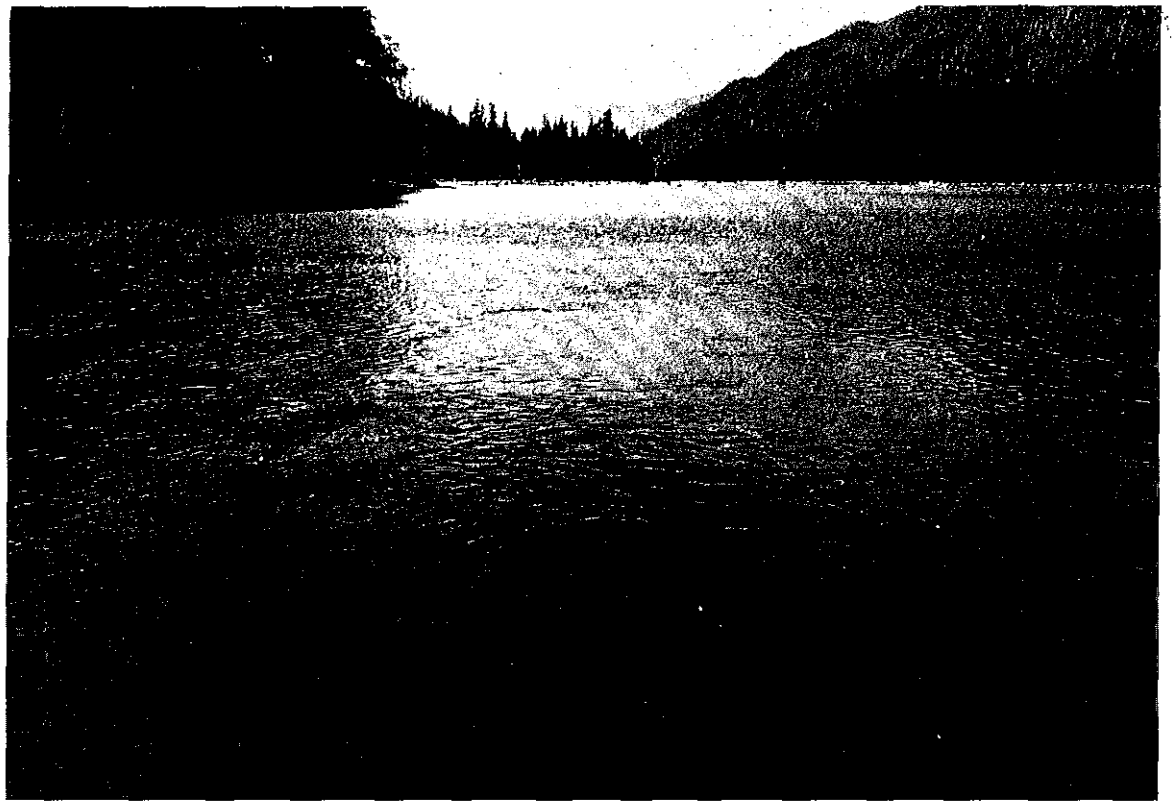
Section of river just below the highway bridge 3.0 miles from the mouth. The relatively slight gradient and large amount of gravel make this an important chum spawning area.

KEOGH RIVER

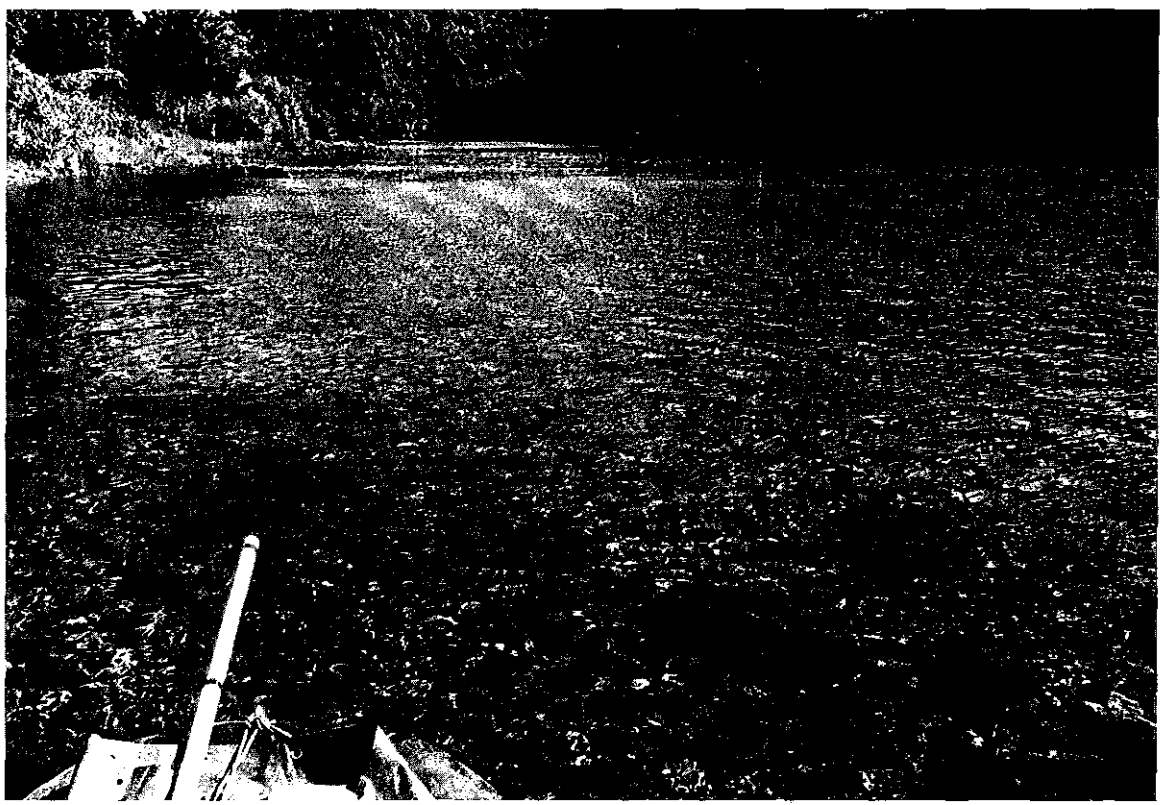
The mouth of the river. This area consists of mud, rocks, and bedrock.

CLUXEWE RIVER

Good spawning area just above the highway bridge 3.0 miles from the mouth.



The bottom end of Nimpkish Lake, 13 miles from the mouth. This marks the upstream limit of chum spawning.



A section just above the tidal influence containing about 10 percent chum spawning gravel.

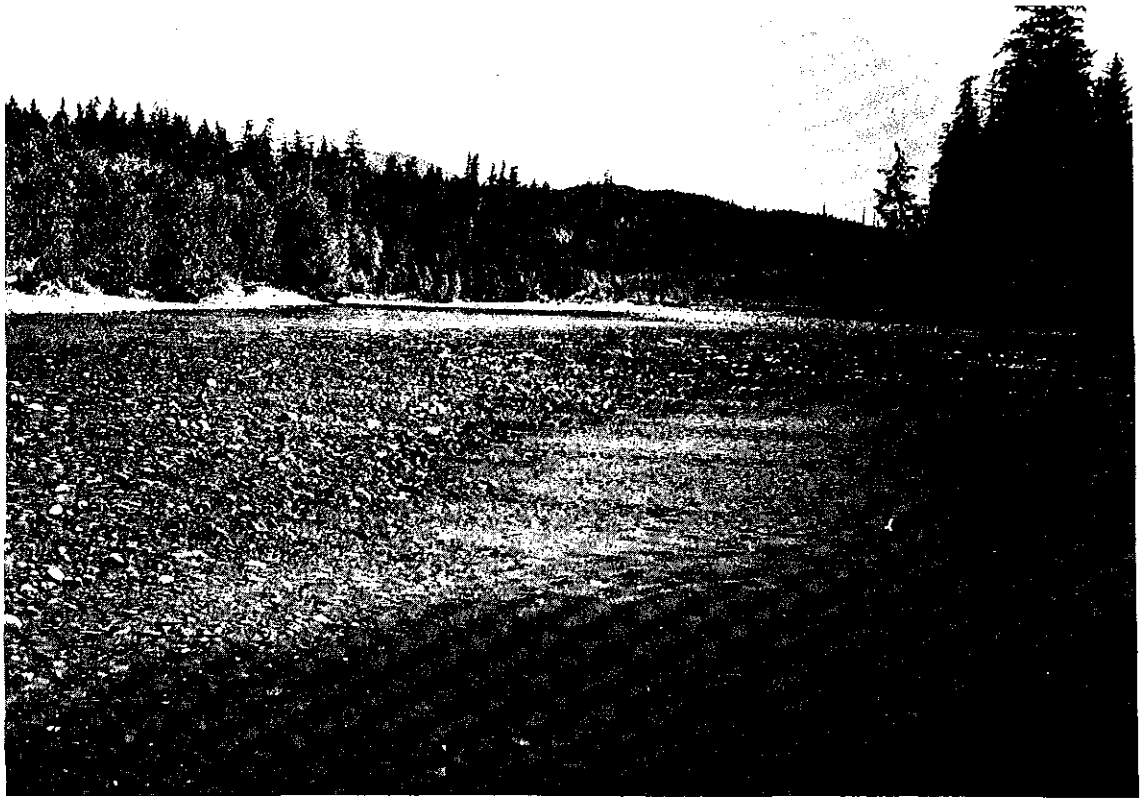
KOKISH RIVER

A side channel of the Kokish 1.6 miles from the mouth. If spawning flows are adequate, this side channel provides excellent chum spawning area.

TSULTAN RIVER

Section of Tsultan 1.9 miles from junction with Kokish with excellent chum spawning area. The Tsultan possesses 75 percent of the chum spawning area in the Kokish-Tsultan system.

ADAM AND EVE RIVERS



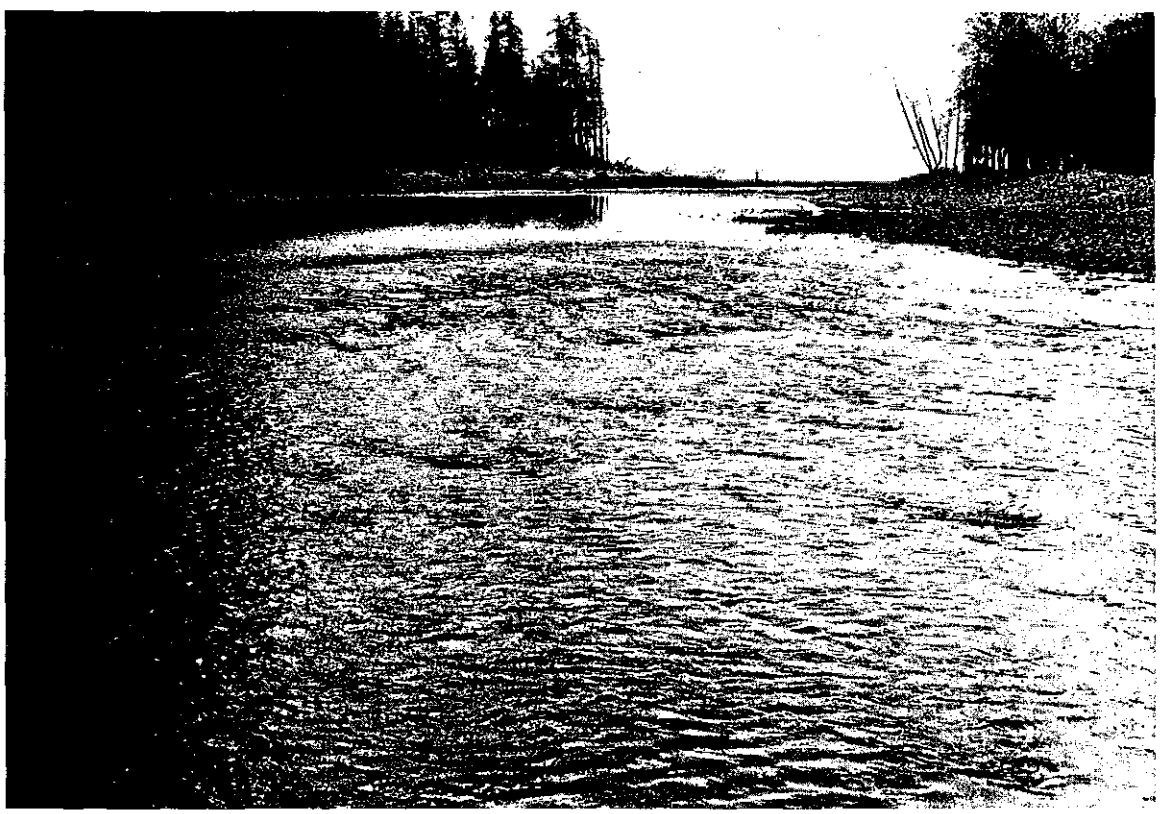
Adam River 4.3 miles from the mouth. A good section of chum spawning extends from just above the confluence with the Eve River for a mile downstream to split of Adam River into three channels.

SALMON RIVER

Excellent spawning area in the Salmon River 3.1 miles from the mouth. A 1,200 foot side channel containing good chum gravel joins with the main river here (top right of photo).

A portion of the mile long log jam 13 miles from the mouth.

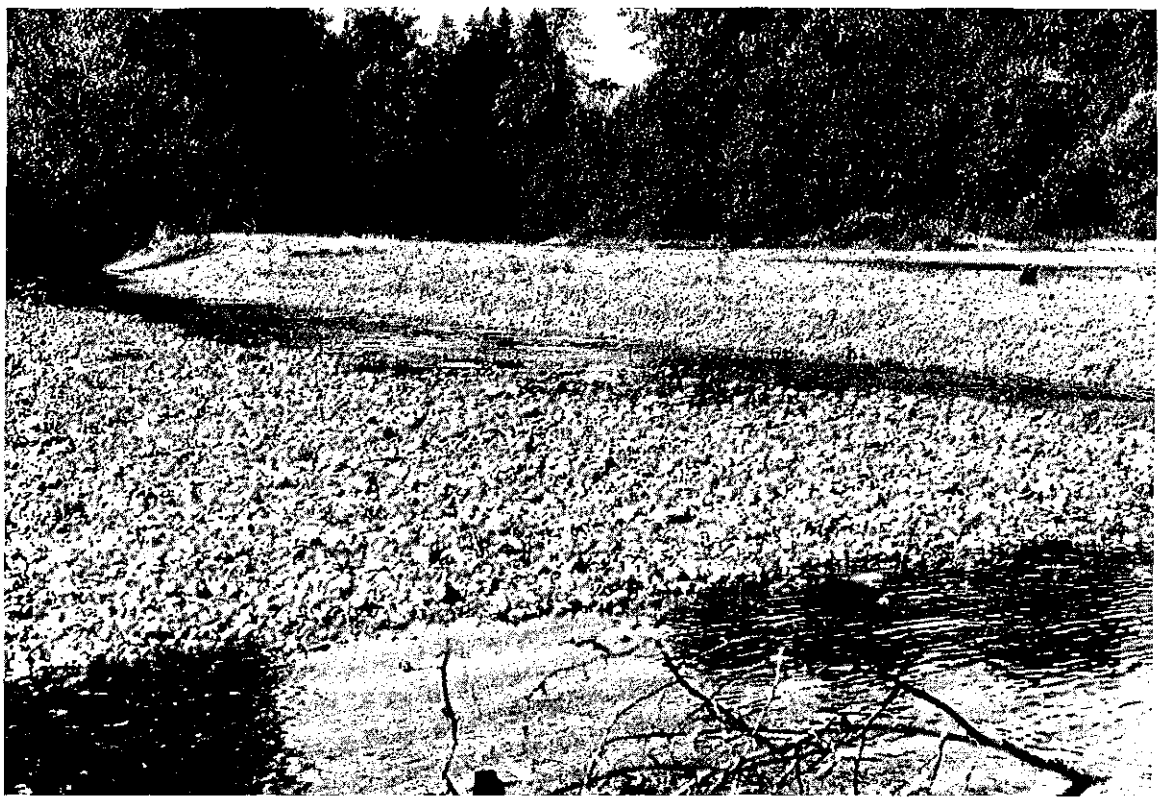
OYSTER RIVER



Mouth of Oyster River and estuary.

TSOLUM RIVER

Bend in river 3.5 miles from the mouth. High flows have eroded banks and deposited large amounts of mud and sand into river.



A good section of chum spawning area 1.3 miles from the mouth.

PUNTLEDGE RIVER

Powerhouse 4.9 miles from the mouth. Flow is approximately 1,000 cfs.

A section of a 1,400 foot side channel below the Condensary bridge. This channel contains excellent chum spawning area.

TSABLE RIVER

A section of river 1.8 miles from the mouth. Most of chum spawning is from here downstream.

COWIE CREEK

A 350 foot tidal section with good chum gravel if any tidal spawning occurs. A 300 foot section above this contains the only good chum spawning area.

WILFRED CREEK

Estuary of new course of creek. An estuary 1,500 feet long provides excellent rearing for fish.

WATERLOO CREEK

Section of good chum spawning area. A section 0.2 miles long above tidal boundary contains the only good chum spawning area.

ROSEWALL CREEK

Tidal section 1,000 feet long containing good chum gravel. Estuary continues another 1,500 feet to mouth.

COOK CREEK

Section of creek 0.8 miles from the mouth. A 0.4 section above tidal area 0.8 miles from the mouth has excellent chum spawning area. At time of survey, creek was dry from above railway bridge 1.5 miles from mouth to junction with McNaughton Creek 0.9 miles from mouth.

McNAUGHTON CREEK

Lateral view of beaver dam which is situated about 100 feet from junction with Cook Creek.

NILE CREEK

Spawning area frequented by chums—a 700 foot section 0.3 miles from the mouth above the tidal influence.

Upstream view of spawning channel adjacent to the river, 1.1 miles from the mouth.

A prime chum spawning area below the B.Q.R. Project counting fence.

LITTLE QUALICUM RIVER

A log jam 6.0 miles from the mouth. Log jam causes river to split into three channels.

FRENCH CREEK

A tidal section of the creek below the highway bridge, 0.4 miles from the mouth.

ENGLISHMAN RIVER

A good chum spawning area 3.2 miles from the mouth.

NANOOSE CREEK

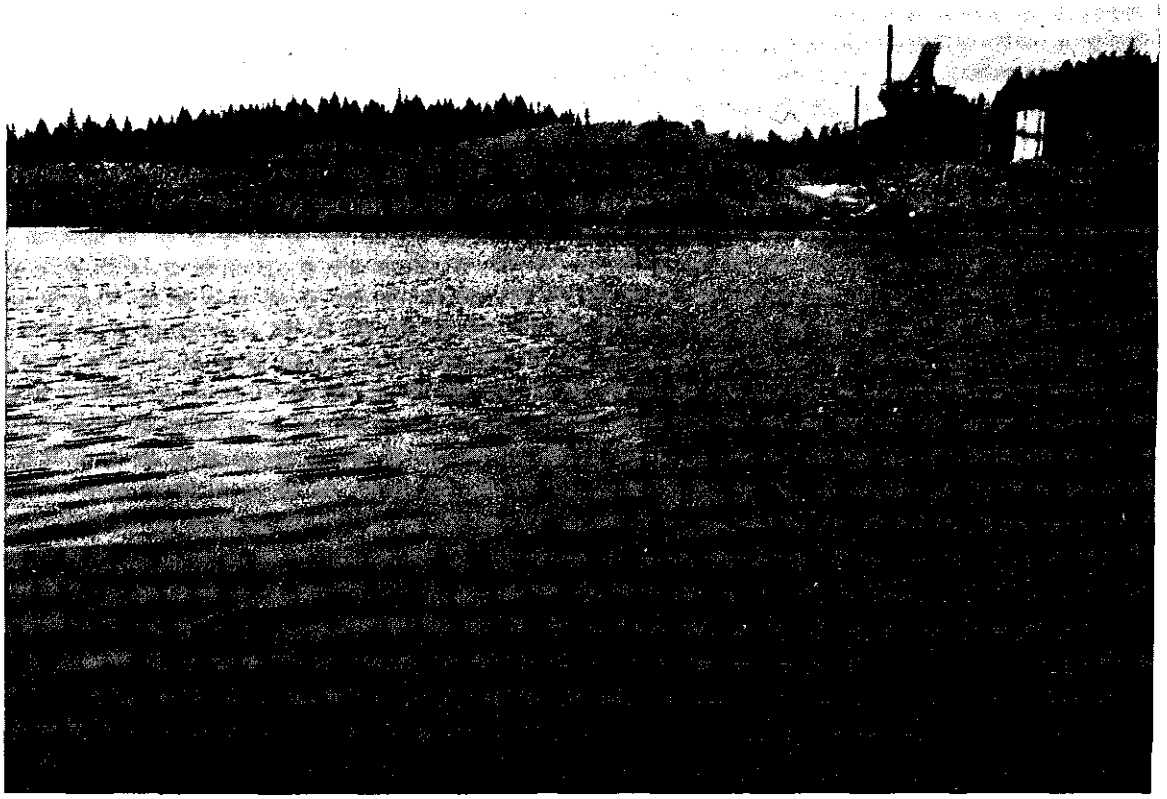
An area of creek 1.1 miles from the mouth. Note pilings and corrugated tin to prevent bank erosion and weir to increase water level.

BONELL CREEK

Section of creek 0.8 miles from the mouth. At the time of the survey (June 19), creek was dry in many places.

NANAIMO RIVER

Excellent chum spawning area in Polkinghorne Slough. This slough produces a major portion of the Nanaimo River chum population.

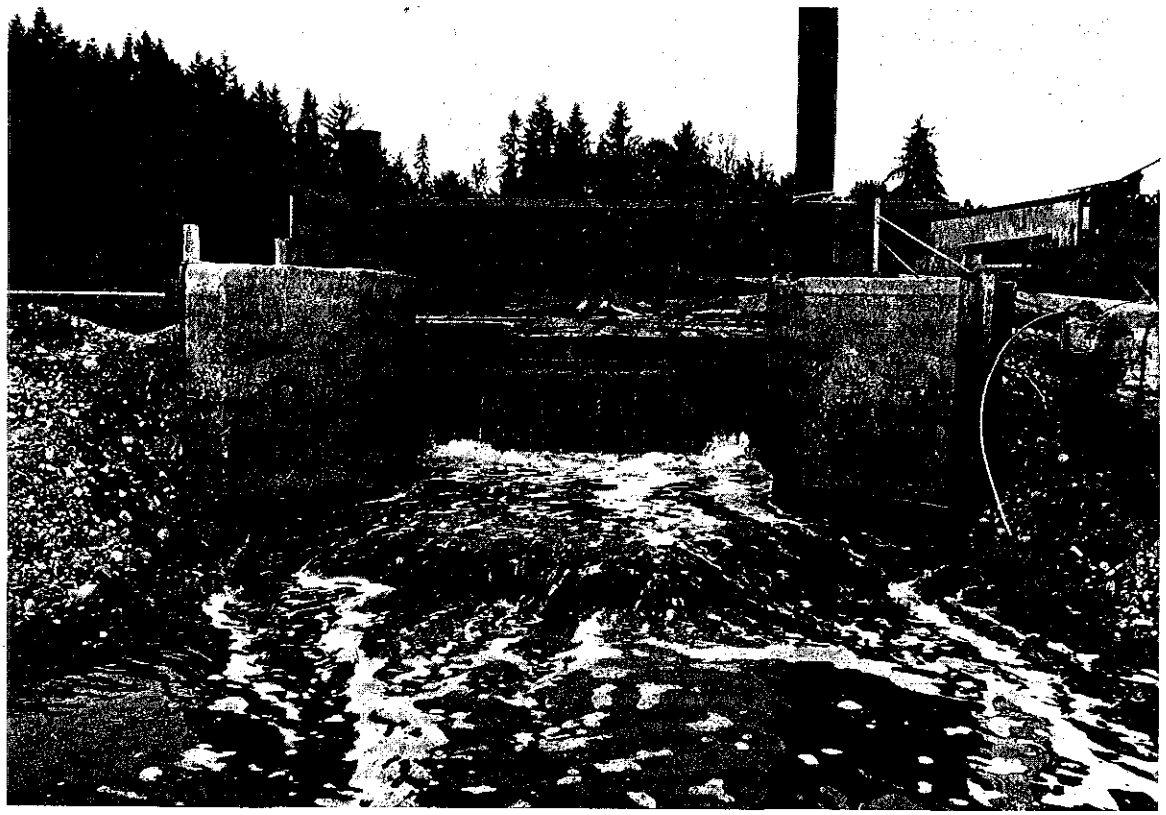


View of LaFarge Cement Co. from across Nanaimo River about one mile from the mouth. LaFarge removes gravel from river for its' operation.

BUSH CREEK

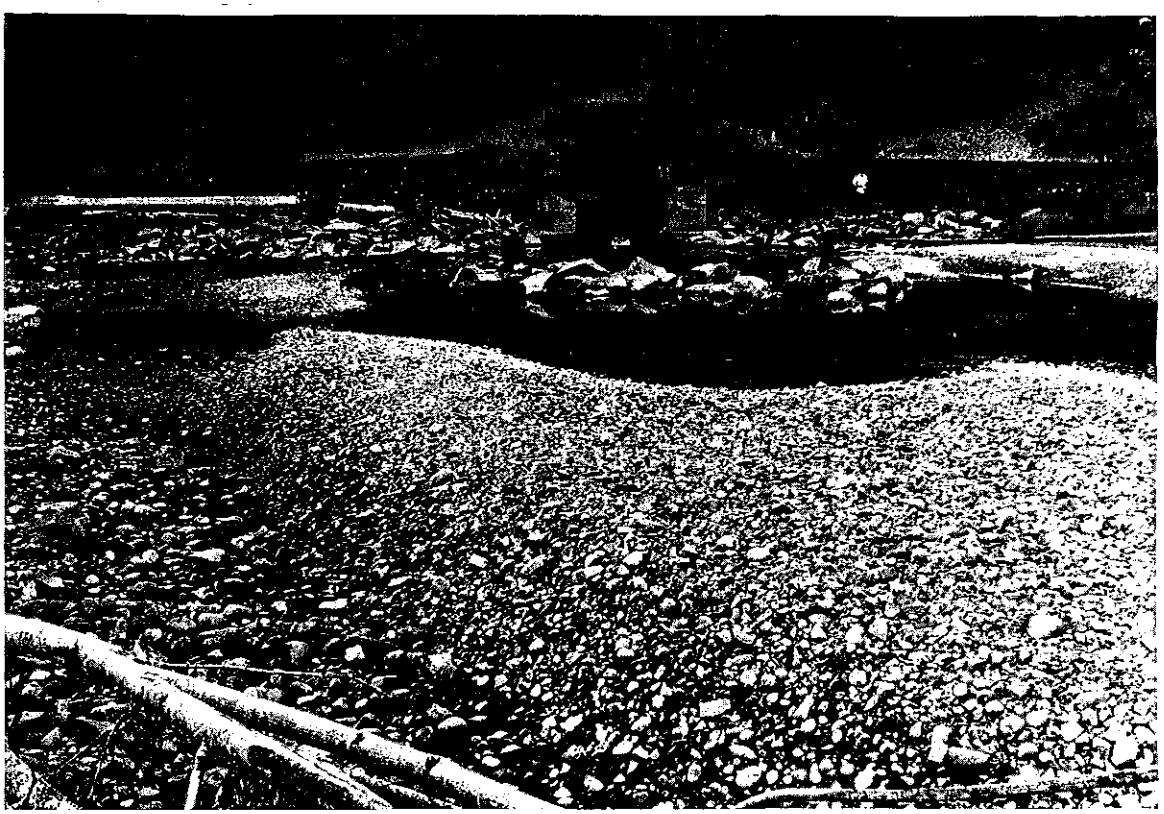
The estuary and mouth of creek.

WALKER CREEK



Weir at mouth of creek for holding water for a booming ground. This may hinder migrating chum.

HOLLAND CREEK



Upstream view of culvert through which creek passes under Island Highway 500 feet from the mouth.

STOCKING CREEK

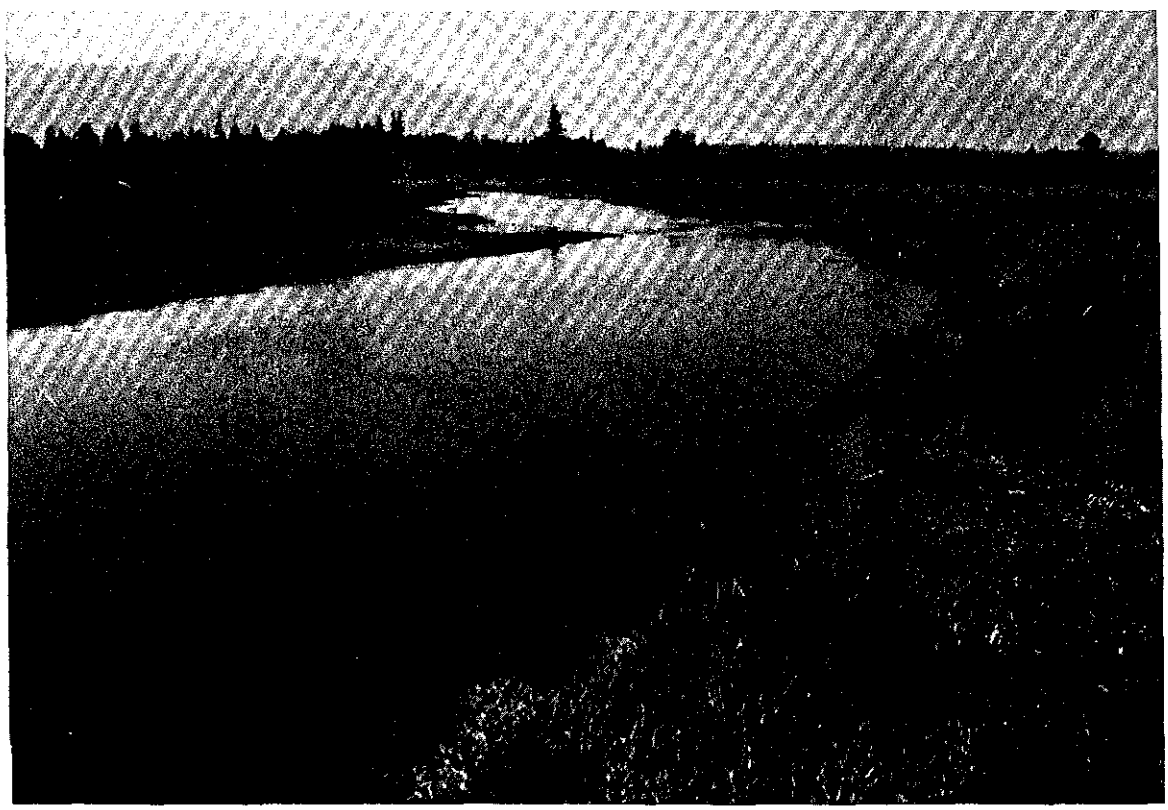
Section of good chum spawning area 300 feet downstream of falls.

CHEMAINUS RIVER

One area of gravel removal on the river. During survey in 1969, gravel removal under permit was noted in three separate locations on the river.

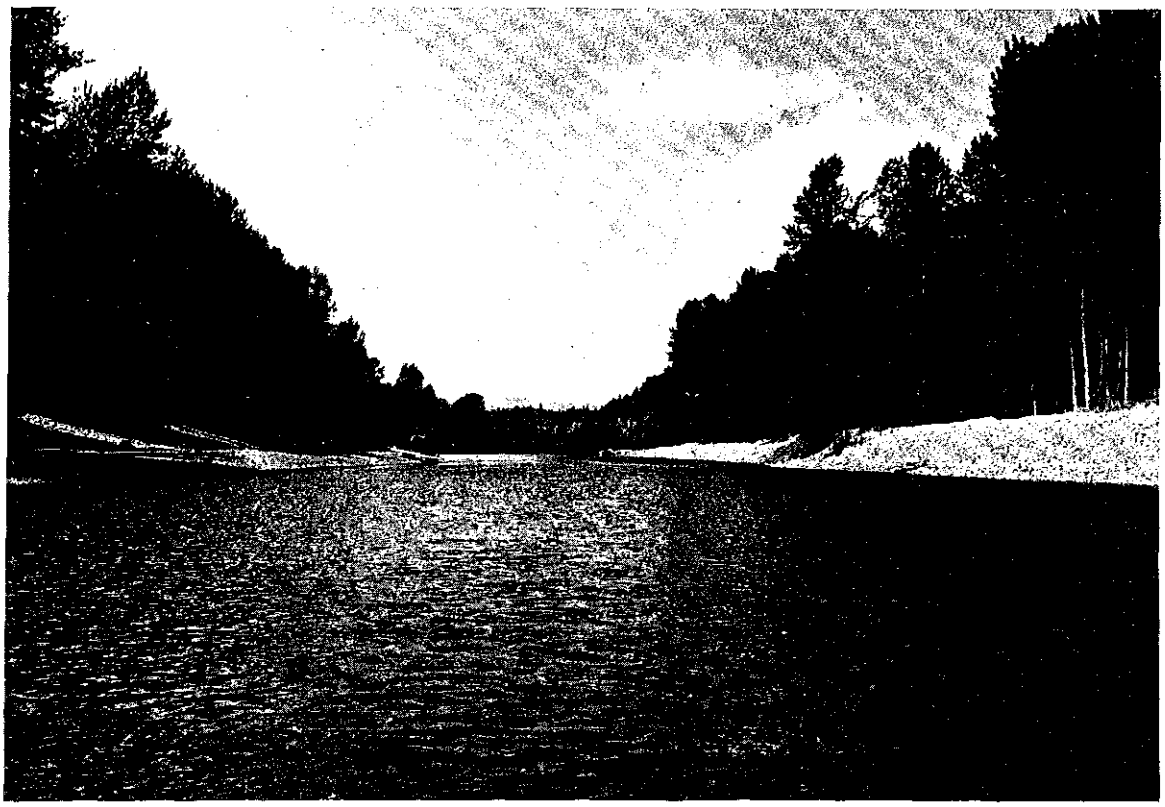
A sample of excellent gravel in intertidal area about 1.0 miles from the mouth.

BONSALL CREEK



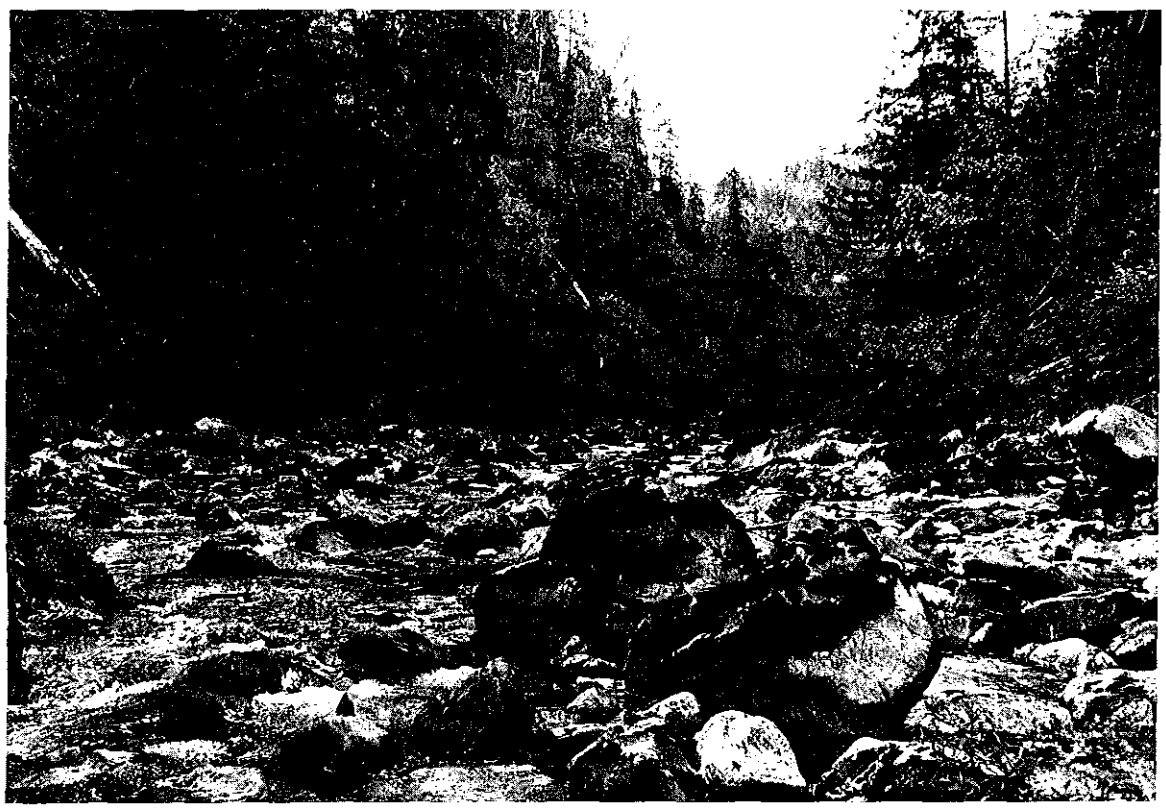
Estuary of creek.

COWICHAN RIVER



Section of river downstream of Island Highway bridge (background of photo) with excellent chum gravel. Note bulldozer and dyking.

KOKSILAH RIVER



Canyon section of river below Marble Falls. Photo is typical of this 2.7 mile section below the falls.

Section of river 0.2 miles below Cowichan Station. Note pools and overhanging brush which provide excellent rearing areas for coho and chinook juveniles.

GOLDSTREAM RIVER

A section of river 0.9 miles from the mouth. A 0.6 mile section from 1.2 miles from the mouth downstream contains excellent chum gravel.