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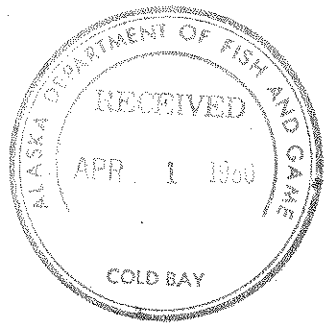
BIOLOGICAL, PHYSICAL, AND CHEMICAL DATA TAKEN AT RUSSELL CREEK, ALASKA PENINSULA, 1978



By

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ABSTRACT

Information related to the topics of enhancing salmon fry survival, developing standards to evaluate hatchery fry quality, and developing data to monitor the pre- and post-period of hatchery influence on the natural system was sought at Russell Creek in 1978. Predation on salmon fry was estimated to be substantial at a mean of 2.2, range 0 to 37, fry per Dolly Varden stomach inspected. Optimum feeding conditions for released hatchery fry into Cold Bay would be expected to occur from mid-July to mid-August with zooplankton densities greater than 11,000 organisms per cubic meter. Over the total outmigration of wild chum salmon fry developmental indices (K_D) averaged 1.96 for fry taken in the main branch of Russell Creek. Age composition of the chum salmon stocks spawning in 1978 was indicated to be 27 percent age 0.2, 69 percent age 0.3, and 3 percent age 0.4. Fecundity of chum salmon averaged 2976 (S.D. = 370).

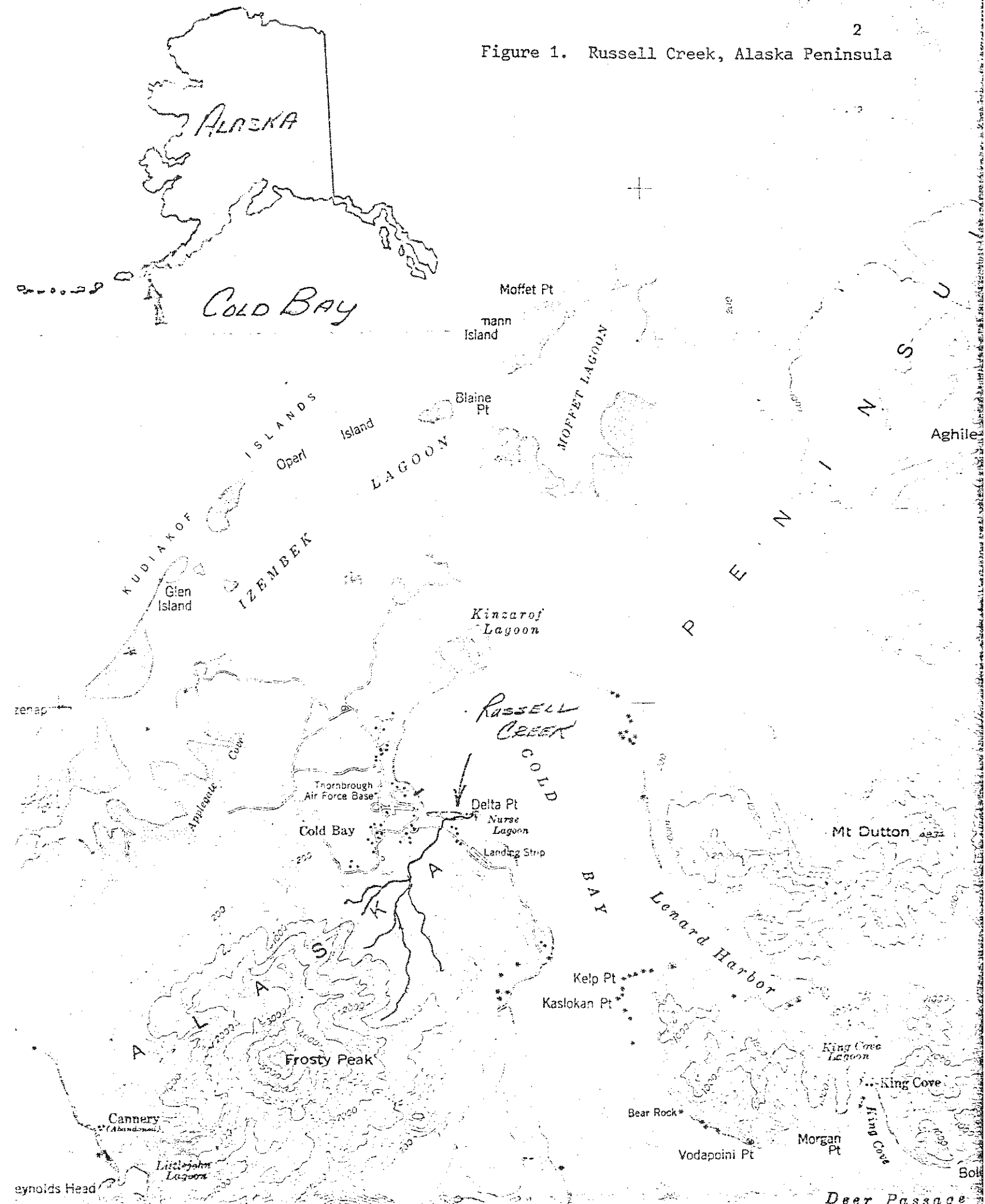
INTRODUCTION

This report is the second in a series of annual reports designed to document biological, physical and chemical data taken at Russell Creek. Russell Creek is located on the west side of Cold Bay on the Alaska Peninsula and is the site of a major ADFG hatchery facility (Figure 1). The information is to assist in developing biological criteria for furthering the goals of the hatchery. Specific areas of interest deal with enhancing the survival of released fry and monitoring certain biological aspects of the chum and pink salmon stocks for comparison and evaluation.

Enhancement of Fry Survival

Predator Investigation. Dolly Varden (Salvelinus malma) predation on chum salmon fry has been widely substantiated, with mortality estimates ranging from 20 to 85 percent (Hunter, 1959; Semko, 1954). Of the major sources of fry mortality in freshwater, Bakkala (1970) cites predation as the most important. Neave (1953) indicated that predation of salmon fry involved relatively fixed numbers from year to year, and was independent of fry quantity. Several characteristics of the char population in Russell Creek have been documented from past biological survey (Bricker, 1978). These characteristics include the following. One, the char prey upon salmon fry. Two, the char outmigrate from the stream in mid-May to early June, coinciding with the ourmigration of chum and pink salmon fry. The larger char preceed the smaller fish in migrating out of the stream. Three, the population of char was estimated at over 20,000 in 1977.

Figure 1. Russell Creek, Alaska Peninsula



Marine Zooplankton Investigation. As salmon fry outmigrate from natal streams they are found in coastal areas until the end of July to mid-August (Sano, 1966). As the fry move into the marine environment from freshwater they feed on zooplankton in contrast to the bottom organisms taken in freshwater (Neave, 1966). The predominance of any one food organism taken appears to be related to availability rather than preference (Bakkala, 1970). Copepods, amphipods, cladocerans, barnacle nauplii, euphausiids, and pteropods have been avocated as the most important organisms in the diet of juvenile chum salmon in inshore waters (Allen and Aron, 1958; Ito, 1964; Le Brasseur, 1966; Birman, 1960; and Commercial Fisheries Review, 1966). Kron and Yuen (1976) suggested that pink salmon fry show a higher preference for harpactecoid copepods, but calanoid copepods were of greater importance as food items due to availability. There is evidence, at least in adult life stages, that chum salmon are less selective in their feeding habits than pink and sockeye salmon (Allen and Aron, 1958; Andrievskaya, 1966). Parker (1962) estimated chum salmon survival to be in the range of 5.4 percent for the coastal juvenile stage, 56,6 percent for the pelagic stage, and 93.0 percent for the coastal adult stage. Evidence suggests high mortalities in the early marine life history is related to nursery area conditions (Taylor, 1976). With proper investigation and planning one aspect of these conditions, food availability, may be optimized in favor of released hatchery fry.

Monitoring chum salmon stocks

Baseline Data Investigation. In the 1970's the State of Alaska initiated a major hatchery program. The Russell Creek Hatchery was part of that program. From both the scientific and political fields opposition was

generated as to the impact of hatchery produced stocks on the natural systems. To scientifically support the concept that under proper management hatcheries do not effect the quality of native stocks propogated, certain biological parameters will be measured on Russell Creek salmon stocks, e.g. age, weight, length and fecundity. This will involve establishing baseline data documenting the significant variation, if any, in the stocks as artifically propagated fish are built-up in the system. The hypothesis to be tested: Is the hatchery's influence of significant impact on the biological parameters, quality, of the existing stocks.

Wild Salmon Fry Study. Young chum salmon emerge from the gravel areas in March, April and May (Neave, 1966). Water temperature is considered the principle factor in determining emergent timing. The fry spend from a few days to several weeks in a stream before moving to sea in April and May (Sano, 1966). Fry migrate downstream almost entirely during darkness (Neave, 1955). The height of the activity occurs within 2 to 3 hours after sunset (Saito, 1950). The downstream migration is thought to be a result of both drifting because of diminished visual orientation and active swimming (Bakkala, 1970).

Bams (1970) indicated greater than 70 percent of the hatchery produced chum salmon fry in his study had similar developmental indices (K_D's) as wild fry at the time of outmigration. The balance of the hatchery fry were considered immature. The information gained from the wild salmon fry study, outmigration timing and developmental indices, will be used in the inseason evaluation of hatchery fry. This evaluation addresses a

specific goal of producing quality fry. The information will be developed into a data base to monitor trends and make forecasts of future natural returns. The forcasts will be important in planning brood stock allocations.

Salmon Escapement Study. The objective of this study is to annually determine the total number, timing and distribution of the salmon escapement into Russell Creek. To manage the Russell Creek salmon stocks inseason counts of salmon entering the stream are required. With the future Russell Creek Hatchery project in operation, consideration will also be necessary for meeting hatchery brood stock requirements.

Several chemical and physical characteristics of Russell Creek were measured to describe and monitor the environment the wild stocks experienced and the future hatchery stocks would encounter.

METHODS

Biological Data

Biological information taken at Russell Creek in 1978 included data on the following topics: salmon fry consumption by Dolly Varden; quantity indices and species composition of the zooplankton population in Cold Bay; age, weight and length statistics for adult chum salmon; fecundity, egg diameter and weight statistics for chum and pink salmon; timing of chum salmon fry outmigration; developmental indices of chum salmon fry; and timing, species composition and distribution of spawning salmon in Russell Creek (Appendix, Figures 2 - 7).

Predator Investigation. Dolly Varden char were sampled in Russell Creek to determine the number of salmon fry per stomach analyzed. Sport fishing gear was used to capture the fish. The date of capture, fork length, color phase, stream location, sex, number of fry per stomach, and presence of insects in the stomach were recorded for each Dolly Varden taken. The stomach analysis consisted of killing the fish, dissecting the stomach and enumerating the number of fry.

Marine Zooplankton Investigation. Zooplankton (pelagic) abundance was sampled at three locations in Cold Bay. The three stations cover a relatively wide area (4 km) near the mouth of Russell Creek where salmon fry would be expected to range in their early marine life history. The first station is approximately 100 meters north of the end of the Cold Bay dock. The second station is approximately 400 to 500 meters north of the mouth of Russell Creek. The third station is approximately 400 to 500 meters north of the Coast Guard navigational aid at Delta Point (Figure 8).

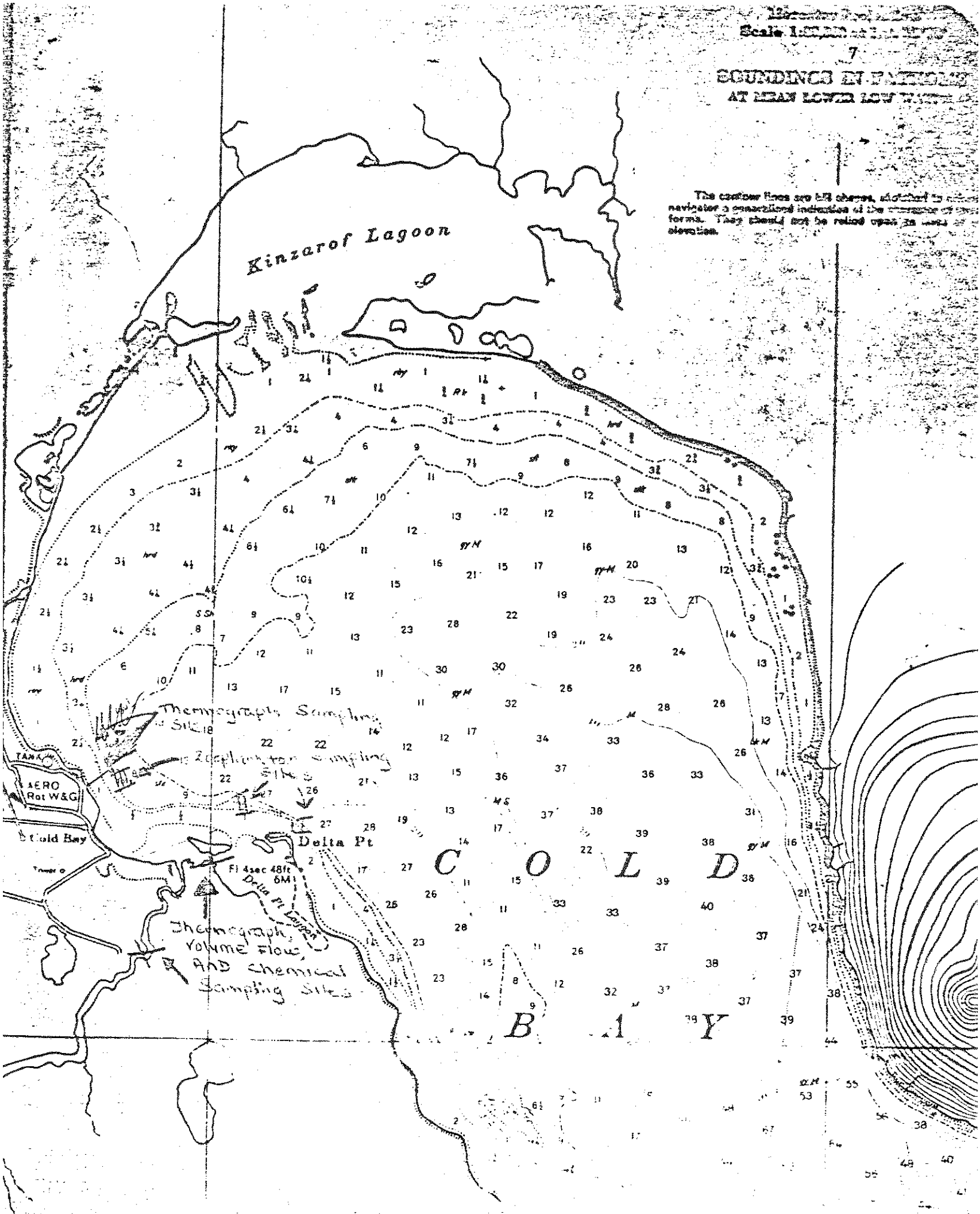


Figure 8. Sampling sites at Russell Creek, Nurse Lagoon, and Cold Bay, 1978.

A Wildco conical style plankton net with straining bucket was used in taking the samples. The diameter of the net is 50 centimeters and it is 150 centimeters long. The mesh size is 243 micron. Fifty-foot deep (15.25 meter) vertical tows were made at the three stations. Weather, surface water temperature and salinity taken with a model 10419 AO refractometer were recorded to describe the conditions for each sample. The samples were processed as follows. First, each sample is diluted to 125 milliliters in a 10 percent formaldehyde solution. One milliliter of the thoroughly mixed sample is taken with a Hensen-Stempel pipet and placed in a Sedgewick-Rafter counting cell. A binocular microscope is used to count the zooplankton per test cell, a .05 milliliter subsample. The summation of five test cells for each 125 milliliter sample is multiplied by 166.9 to gain the number of organisms per cubic meter of water. Major categories of zooplankton (copepods, cladocerans, and rotifers) are identified as per a key by Davis (1955). Samples were normally processed within one or two days.

Baseline Data Investigation. In 1978 chum salmon carcasses found along the stream were sampled to obtain age, length and weight data. Otoliths were taken to age the salmon. A binocular microscope was used to determine annulii on the water immersed otoliths (Kim and Roberson, 1968). Length measurements taken on the carcasses were from the middle of the eye to the posterior end of the hypural plate. Weights were taken with a hand-held Chatillon Model 30 tension scale. The number of eggs remaining in the spawned-out carcasses of female salmon were counted.

Fecundity samples from near ripe fish were taken on both chum and pink salmon. Fork length and weight were recorded for each female. Samples were processed as follows. First, the total number of eggs were weighed and then individually counted. From five samples of 50 eggs, placed in troughs and measured, egg diameter was determined. Individual egg weight was calculated from weighing five samples of 250 eggs each and then determining the mean.

Statistically the data will be handled by analysis of variance using a randomized block design (Steel and Torrie, 1960). Blocks will be the year the data is taken and treatments will be the various parameters measured. Comparison will be made between pre- and post-hatchery influence years. Fry lengths and weights gained in the wild salmon fry study will also be entered in the analysis.

Wild Salmon Fry Study. Standard Wildco drift nets connected to individual live boxes were used in capturing the fry. The nets are one meter long and the mouth of the net is 30.5 x 45.7 centimeters. The netting is number 54 mesh nylon insuring the fry were not gilled. Three traps were placed below the "whirlpool," approximately 1.9 kilometers upstream from the mouth of Russell Creek. The three traps were placed so the stream was divided in roughly 4 equal sections. Sampling started the first of April, the traps were checked once a day and pulled the end of May or first of June. Daily catches were recorded to indicate relative abundance of outmigrants. A sample of fry were taken from each of 6 periods over the two months of sampling. The sampled fry were preserved in five percent formalin for six weeks prior to measuring weight in milligrams with a Mettler P163

electronic balance and fork length in millimeters. Developmental indices are calculated from the following formula: $K_D = (10 \times \text{weight}^{1/3}) \div \text{length}$ as per Bams (1970).

A fourth net was placed in a small tributary to Russell Creek approximately 0.6 kilometers upstream from the mouth of Russell Creek. At this location the complete stream is screened off and all outmigrants were caught.

In conjunction with the fry sampling, continuous water temperatures were taken with Ryan thermographs at Russell Creek, Nurse Lagoon and Cold Bay (Figure 8). The recorders were calibrated with a standard hand thermometer. In all cases the thermographs were positioned at the bottom of the water column at the locations sampled.

To monitor the development of sac-fry while still in the gravel, test digs were made in the small tributary mentioned above. A standard Wildco drift net was stationed downstream of the sample area to catch sac-fry as they were dislodged from the gravel. The sample plots were roughly 30 centimeters square and 10 centimeters deep. The sac-fry sampled were processed as mentioned previously.

Outmigrating fry were also sampled at Nurse Lagoon near the mouth of Russell Creek. This was to record the growth of those fry rearing in the lagoon. A small dip net was used to capture the fish along the shoreline. Lengths and weights were measured.

Salmon Escapement Study. Annual chum and pink salmon escapement data is obtained from the Division of Commercial Fisheries (ADFG) aerial survey records. The aerial surveys are done with a Piper Supercub flying at a

height of approximately 61 to 91.5 meters. The surveys start in mid-July and are concluded in late August or early September. Six to twelve surveys are made annually. Timing of run development, numbers of spawners by species, and distribution are documented.

Physical and Chemical Data

Minimum stream flow measurements and water chemistry determinations were monitored at Russell Creek in 1978. Volume flow measurements were taken at the hatchery site. A velocity rod was used. Model AL36B and N1-8 Hach Chemical Test Kits were used in the stream chemistry analysis.

RESULTS

Biological Data

Predator Investigation. From April 14 to May 31 a total of 95 Dolly Varden char were sampled to analyze stomach contents. The average number of salmon fry found per Dolly Varden was 1.0, 4.5 and 1.2 for the periods April 14 to 27, May 1 to 15 and May 17 to 31 respectively (Table 1). Overall mean number of fry per stomach was 2.2 (S.D.=5.7). Average lengths of the char were 35.8, 34.3 and 28.8 centimeters for the same respective periods.

At the time of sampling 29 percent of the Dolly Varden had salmon fry in their stomachs. Numbers of fry ranged from one to 37 (Appendix, Table 2). Twenty-four percent of the stomachs inspected contained insects. Of the 95 char sampled 72 percent were females. The samples were taken from the lower 2.0 kilometers of Russell Creek (Appendix, Figure 9).

Marine Zooplankton Investigation. From the three sampling stations in Cold Bay a total of 40 zooplankton samples were taken from April 28 to August 22 (Figure 8). Zooplankton densities generally increased through May and June and peaked in mid-July with counts greater than 11,000 zooplankton per cubic meter (Figure 10). With few exceptions the samples were 100 percent calanoid copepods in composition. Surface water temperatures measured at a depth of one meter averaged 9.1 degrees centigrade during July. Salinity sampled at a depth of two meters ranged near 30‰ throughout the sampling period (Appendix, Table 3).

Table 1. Summary of Dolly Varden stomach analysis, Russell Creek, 1978.

Period	$\bar{x}$ number of salmon fry per stomach	S.D.	$\bar{x}$ fish length in cm	S.D.	Number of fish sampled
4/14-4/27	1.0	2.9	35.8	8.1	46
5/1-5/15	4.5	9.0	34.3	7.2	32
5/17-5/31	1.2	2.9	28.8	6.9	17
Overall Summary	2.2	5.7	34.1	7.9	95

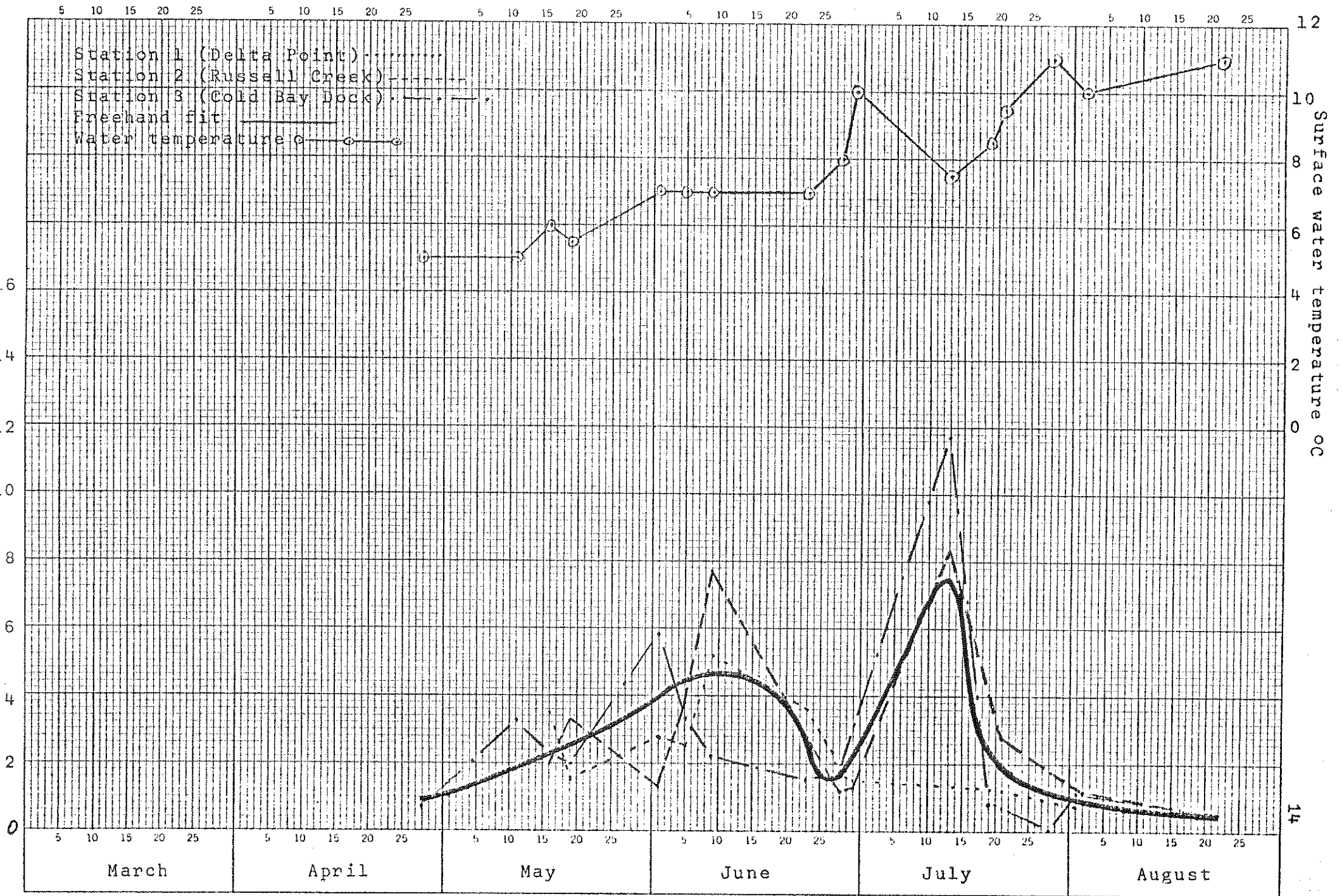


Figure 10. Zooplankton density and associated surface water temperatures, Cold Bay, 1978

Weather conditions at the time of sampling, and wind direction and velocity the day prior to the sample being taken, were recorded. Completely overcast skies with winds from either the SE or NW at 15 miles per hour were typical weather conditions (Appendix, Table 3).

Baseline Data Investigation. A total of 1251 otoliths were sampled from August 18 to October 6. For the 86 percent readable otoliths from this sample, males and females combined, the break-down in age-class structure was I's = 1 percent, II's = 27 percent, III's = 69 percent and IV's = 3 percent (Table 4). Of the total number of readable otoliths 23 percent were considered questionable as to age determination. Males made up 53 percent of the sample.

A total of 72 chum salmon carcasses were measured for hypural length. For a sample taken August 18 to 22 (N=53), males and females combined, the average length for age-classes II, III and IV was 55.7, 56.0 and 57.5 centimeters respectively (Table 5).

A total of 66 chum salmon carcasses were weighed to determine average weight. Males averaged 3.4 kilograms and females averaged 2.8 kilograms. Average weight for males and females combined for age-classes II, III, and IV was 3.1, 3.2 and 3.3 respectively. This was for a sample (N=47) taken August 18 to 22 (Table 6).

Forty-nine female chum salmon carcasses were sampled to determine the number of eggs remaining in the body cavity after spawning. The overall average was 567 eggs (S.D. 962). Egg retention decreased as the

Table 4. Chum salmon age-class structure, Russell Creek, 1978...in percent.

Dates Sampled	Males					Females					Combined			
	Age-classes				Number	Age-classes				Number	Age-classes			
	I	II	III	IV	Sampled	I	II	III	IV	Sampled	I	II	III	IV
8-18 to 8-22	0	19	74	7	59	0	35	63	2	49	0	26	69	5
9-5 to 9-15	0	21	79	0	105	0	16	83	1	109	0	18	81	1
9-27 to 9-29	0	23	73	4	201	0	14	81	5	118	0	20	76	4
10-2 to 10-6	2	31	65	2	199	1	41	52	6	234	1	37	58	4
Totals	1	25	71	3	564	0	29	66	5	510	1	27	69	3

Table 5. Chum salmon average lengths (spawned-out carcasses), Russell Creek, 1978
...hypural length in centimeters.

Dates Sampled	Male average lengths Age-classes					Female average lengths Age-classes					Combined average lengths Age-classes				
	II	III	IV	NR	Total	II	III	IV	NR	Total	II	III	IV	NR	Tota
8-18 to 8-22	55.9	56.5	58.5	54.9	56.3	55.5	55.1	57.0	55.6	55.4	55.7	56.0	57.5	55.3	55.
9-5	-	54.0	-	51.5	53.2	56.1	56.0	-	53.8	55.7	56.1	55.4	-	52.6	55.

NR = Fish whose age was not able to be determined.

Table 6. Chum salmon average weights (spawned-out carcasses), Russell Creek, 1978...in kilograms.

Dates Sampled	Male average weights Age-classes					Female average weights Age-classes					Combined average weights Age-classes				
	II	III	IV	NR	Total	II	III	IV	NR	Total	II	III	IV	NR	Total
8-18 to 8-22	3.4	3.4	4.0	3.3	3.4	2.8	2.8	2.9	3.0	2.8	3.1	3.2	3.3	3.3	3.2
9-5	-	2.9	-	2.9	2.9	2.7	2.8	-	2.3	2.7	2.7	2.8	-	2.6	2.8

NR = Fish whose age was not able to be determined.

age of the fish increased (Table 7). Nine out of the sample of 49, 18 percent, had 2,000 or more eggs remaining in the body cavity.

A total of 19 chum salmon were sampled from August 8 to September 9 for fecundity (Appendix, Table 8). The total number of eggs per fish ranged from 2333 to 3683 and averaged 2967 (S.D. 370). The fork length, snout to fork in tail, of the sample of fish averaged 67.1 centimeters and their average weight was 3.4 kilograms. The weight of the ovaries, egg diameter, and egg weight averaged 609.4 grams, 6.4 millimeters and 199 milligrams, respectively.

A total of 32 pink salmon were sampled August 1 to 16 for fecundity (Appendix, Table 9). Fecundity averaged 1502 (S.D. = 245) and ranged from 990 to 1716. Fish length averaged 50.0 centimeters and fish weight averaged 1.3 kilograms. Ovary weight averaged 229.3 grams, egg diameter 5.8 millimeters and egg weight 151 milligrams.

Wild Salmon Fry Study. From April 4 to June 9 a total of 1311 chum salmon fry were captured at the sampling station in the main branch of Russell Creek. During this same period 7600 chum salmon fry were taken at a small tributary to Nurse Lagoon. The majority of the fry were counted and released. By mid-May approximately 77 percent of the catch at the main branch and 63 percent of the catch at the tributary had occurred (Figures 11 and 12). Approximately 50 percent of the catch at both stations occurred in the period May 1 to 15 (Table 10).

Table 7. Mean number of eggs remaining in spawned-out chum salmon carcasses, Russell Creek, 1978.

Date Sampled	Age-classes				
	II	III	IV	NR	Total
8-18 to 8-22	634	347	-	754	505
9-5	867	676	-	0	665
Overall average	734	480	-	565	567

NR = Fish whose age was not able to be determined.

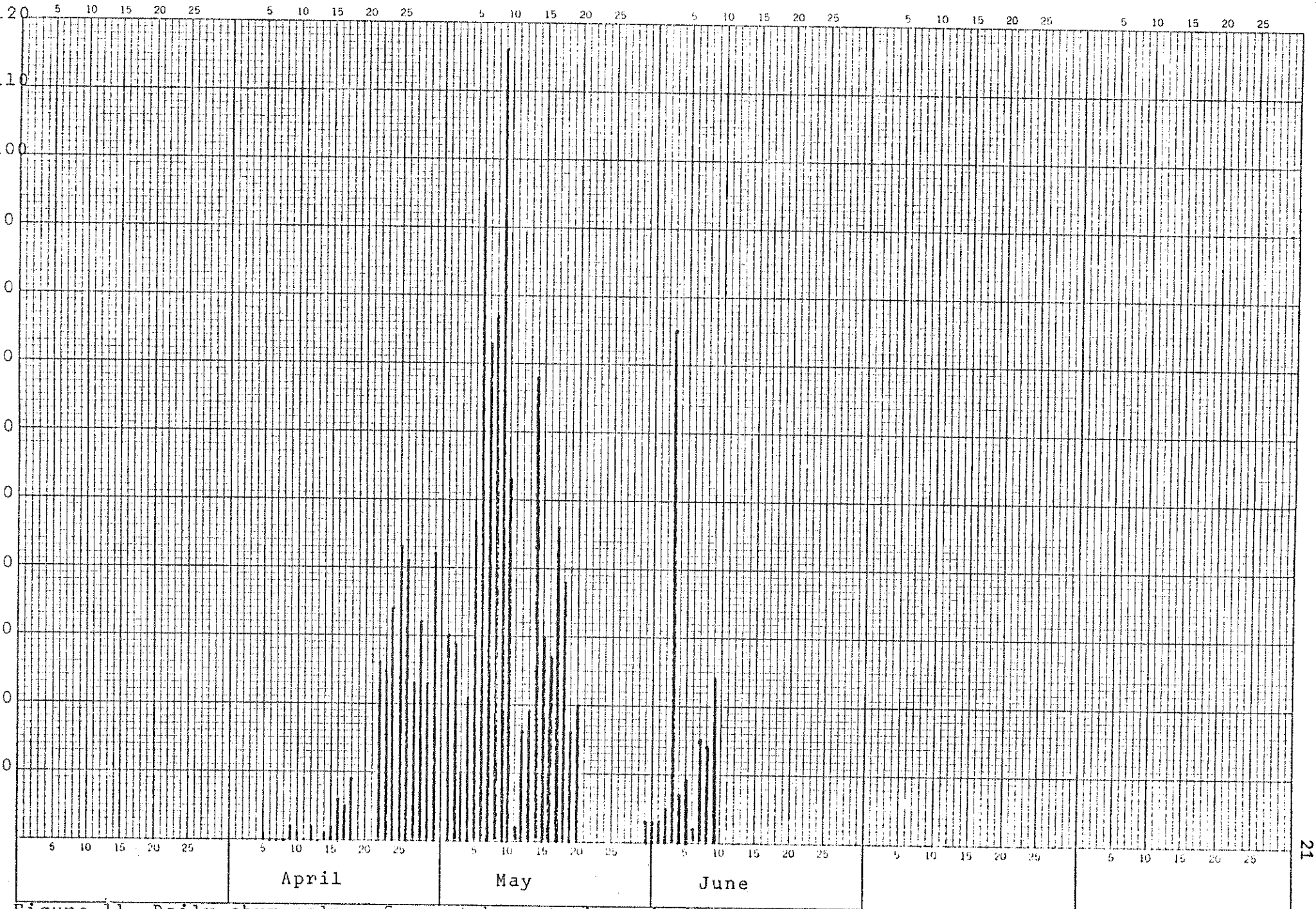


Figure 11. Daily chum salmon fry catches at the main branch of Russell Creek, 1978.

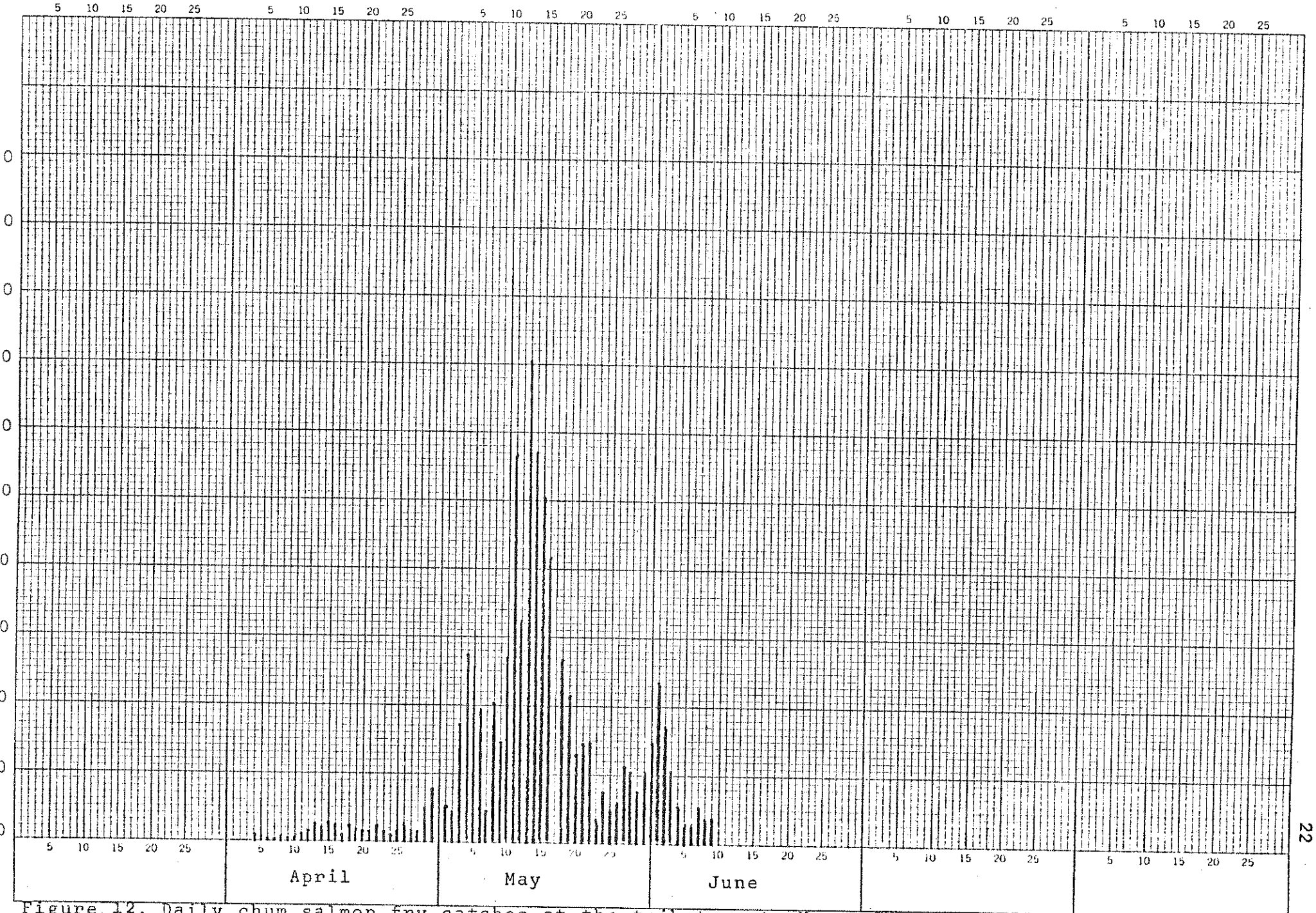


Figure 12. Daily chum salmon fry catches at the tributary to Nurse Lagoon, 1978.

Table 10. Relative magnitude of wild chum salmon fry outmigration from Russell Creek as indicated at two sampling stations.

Period	Cumulative catch			
	Main branch of Russell Creek		Tributary to Horse Lagoon	
	Number	Percent	Number	Percent
April 1-15	9	0.6	136	1.8
April 16-30	318	24.2	482	6.3
May 1-15	1004	76.6	4738	63.1
May 16-31	1157	88.3	6889	90.4
June 1-9	1311	100.0	7600	100.0

Daily stream temperature taken at the time the fry traps were checked averaged 0.1 degrees centigrade warmer in the main branch of Russell Creek as compared to the tributary to Nurse Lagoon ($\bar{x}$ = 4.6, S.D. = 1.7 and $\bar{x}$ = 4.5, S.D. = 1.1 respectively). This was over the period April 13 to June 8.

A total of 279 chum salmon fry were weighed and measured to calculate developmental indices (K_D) from the sample taken at the main branch of Russell Creek (Appendix, Table 11). Weekly average K_D ranged from 1.92, April 17 to 23, to 2.00, May 1 to 7 and 8 to 14, and averaged overall 1.96 (S.D. = 0.05) (Table 12). Overall mean weight was 386 milligrams (S.D. = 48). Overall mean length was 37 millimeters (S.D. = 1.7).

Five hundred and fourteen chum salmon fry from the sampling at the tributary to Nurse Lagoon (Russell Creek) were used to calculate developmental indices over the period April 3 to June 9 (Appendix, Table 13). The mean K_D value was 1.97 (S.D. = 0.06). The weekly average K_D ranged from 1.92, April 17 to 23 and 24 to 30, to 2.02, June 6 to 9 (Table 12). Mean weight and length was 366 milligrams (S.D. = 53) and 36 millimeters (S.D. = 1.6), respectively.

Prior to the fry outmigration sampling a total of 117 chum salmon sac-fry (alevins) were taken at the tributary to Russell Creek (Appendix, Table 14). From the sample (N = 62) taken March 21 and 22 alevin weight averaged 271 milligrams (S.D. = 46). The sample of sac-fry taken April 3 had a mean weight of 340 milligrams (S.D. = 41). Average alevin length during this same interval increased from 32 to 35 millimeters (Table 15).

Table 12. Mean weights, lengths and developmental indices at time of outmigration for Russell Creek wild chum salmon fry at two sampling locations, 1978.

Date	$\bar{x}$ weight in mg	S.D.	$\bar{x}$ length in mm	S.D.	$\bar{x}$ K_D	S.D.	Sample size
			Main branch of Russell Creek				
4/3-4/9	409	39	37	0.6	1.99	0.09	3
4/10-4/16	396	38	38	2.3	1.93	0.08	12
4/17-4/23	373	43	37	1.7	1.92	0.05	62
4/24-4/30	385	45	37	1.6	1.95	0.05	63
5/1-5/7	390	53	37	1.9	1.96	0.05	57
5/8-5/14	387	69	36	2.3	2.00	0.06	27
6/5-6/11	392	45	37	1.3	2.00	0.05	55
Overall Summary	386	48	37	1.7	1.96	0.05	279
			Tributary to Nurse Lagoon				
4/3-4/9	355	32	36	1.5	1.97	0.08	34
4/10-4/16	367	38	36	1.3	1.97	0.06	133
4/17-4/23	370	49	37	1.9	1.92	0.06	55
4/24-4/30	347	55	37	2.1	1.92	0.07	130
5/7-5/10	354	83	36	1.7	2.01	0.05	29
6/6-6/9	388	66	36	1.3	2.02	0.04	133
Overall Summary	366	53	36	1.6	1.97	0.06	514

Table 15. Mean weights and lengths of wild chum salmon sac-fry sampled from gravel beds in a tributary to Russell Creek, 1978.

Date	$\bar{x}$ weight in mg	S.D.	$\bar{x}$ length in mm	S.D.	Number sampled
3/21 & 22	271	46	32	1.6	62
4/3	340	41	35	2.0	55

Table 17. Mean weights and lengths of wild chum salmon fry taken at Nurse Lagoon (estuary at mouth of Russell Creek), 1978.

Date	$\bar{x}$ weight in mg	S.D.	$\bar{x}$ length in mm	S.D.	Number sampled
4/17	412	48	38	1.6	26
4/25	348	53	37	1.5	24
5/2	360	37	36	1.3	27
5/10	367	50	36	1.8	28
5/30	422	54	37	1.4	25
6/1	429	64	37	1.5	27
6/29	729	194	42	3.5	25
Overall summary	436	70	37.5	1.8	182

During and following the fry outmigration from Russell Creek a total of 182 fry were sampled at Nurse Lagoon (Appendix, Table 16). Mean fry weight ranged from 348 milligrams (S.D. = 53), April 25, to 729 milligrams (S.D. = 194), June 29 (Table 17). Average length was 37.5 millimeters (S.D. = 1.8).

Salmon Escapement Study. Approximately 50 thousand chum salmon and 50 thousand pink salmon spawned in Russell Creek in 1978 (Table 18). An aerial survey on July 19 by the Commercial Fisheries Division indicated a total of 5000 chum salmon and 12,000 pink salmon were in the stream (ADFG, 1978). Peak counts were made on August 14 and 30. Fish were concentrated in the main branch of Russell Creek as per a survey on August 14 (Figure 13).

Physical and Chemical Data

Stream temperatures recorded near the hatchery site on Russell Creek for the periods sampled in 1978 ranged from lows of near zero degrees centigrade in January and February to a high of 13.5 degrees on July 28 (Figure 14). A variation of 9.5 degrees, 4.0 to 13.5 degrees, was also recorded on July 28. The warmest monthly average for the days sampled was recorded in August, 11.0 degrees (S.D. = 1.61). The coldest monthly average was in February, 0.6 degrees (Table 19).

Thermograph readings were taken at Nurse Lagoon for the period April to June (Figure 15). A maximum recording of 13.0 degrees was indicated on May 8. High mean temperatures during April and May were 7.8 and 8.7 degrees

Table 18. Russell Creek Chum and Pink Salmon Escapement, 1962-1978

Year	Chum Salmon	Pink Salmon
1962	25,000	50,000
1963	25,000	2,000
1964	50,000	20,000
1965	3,000	2,500
1966	6,000	9,000
1967	3,100	150
1968	18,000	65,000
1969	15,000	1,000
1970	20,000	29,000
1971	18,000	0 seen
1972	10,340	500
1973	8,000	100
1974	12,790	7,800
1975	2,860	350
1976	10,600	35,150
1977	52,000	2,000
1978	50,000	50,000
Even year $\bar{x}$	22,530	29,600
Range	6,000-50,000	500-65,000
Odd year $\bar{x}$	15,870	1,010
Range	3,000-52,000	0-2,500

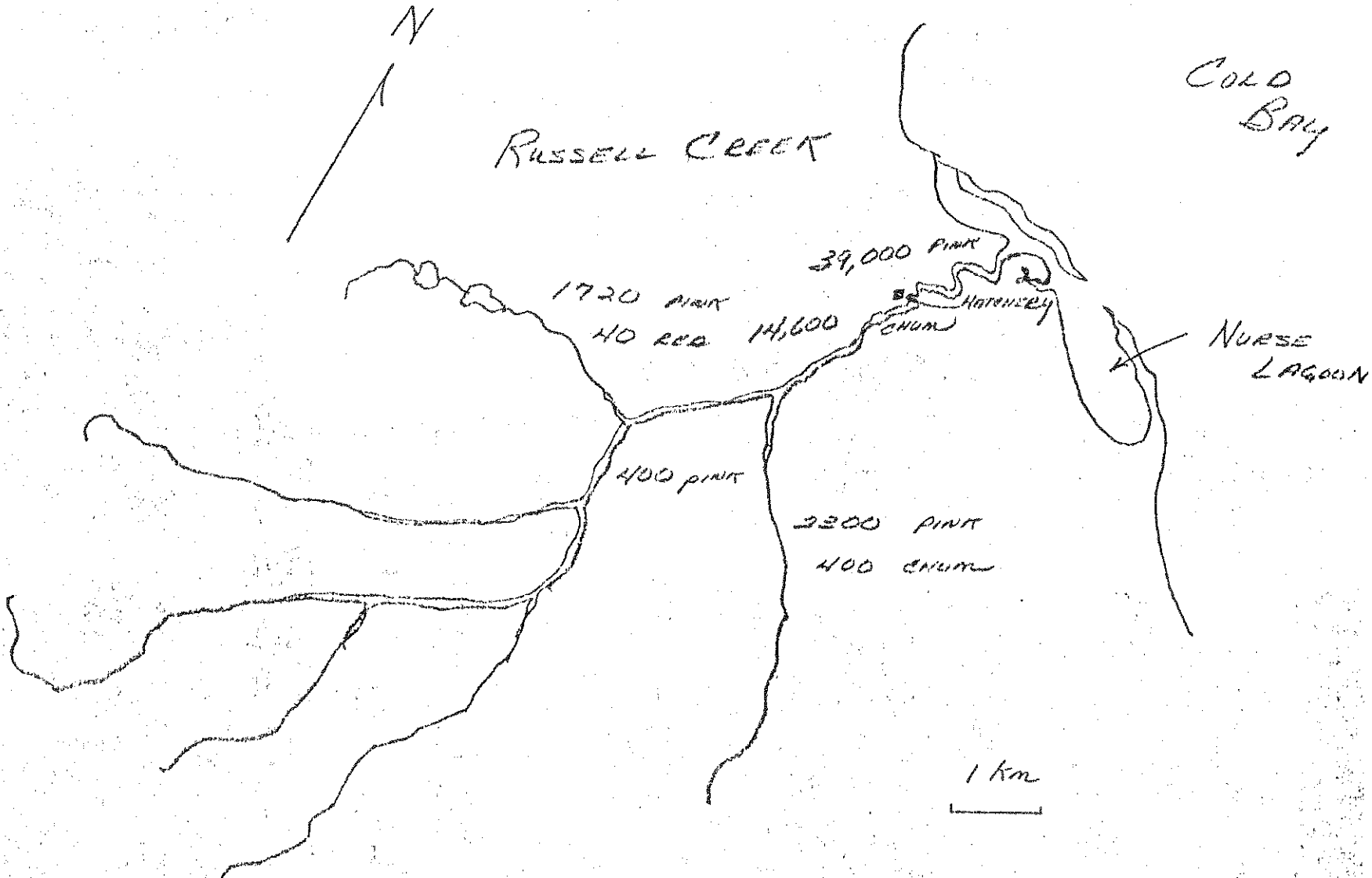


Figure 13. Approximate distribution of chum, pink and red salmon in Russell Creek, August 14, 1978.

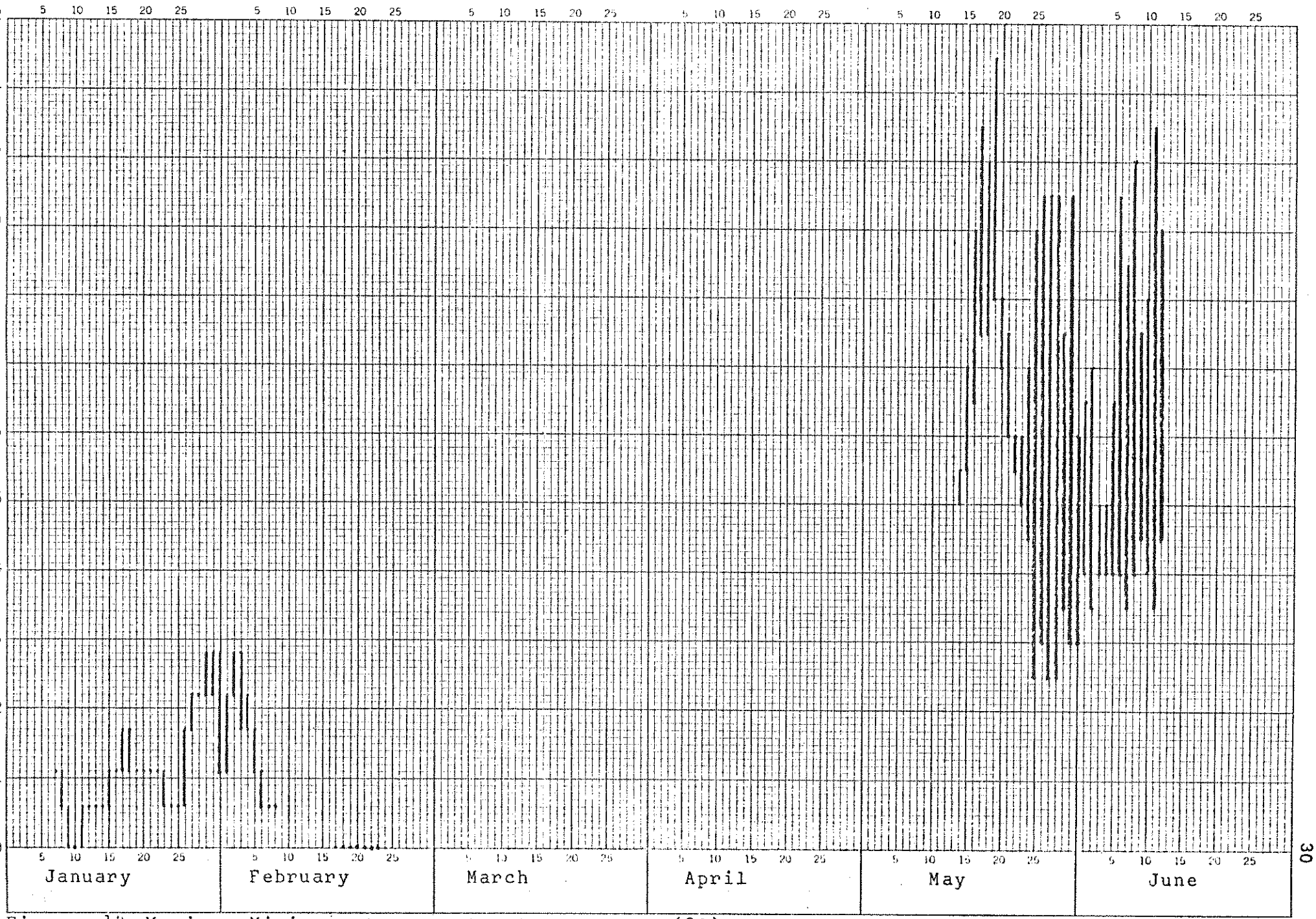


Figure 14. Maximum-Minimum stream water temperature (°C) at Russell Creek, January to June, 1978.

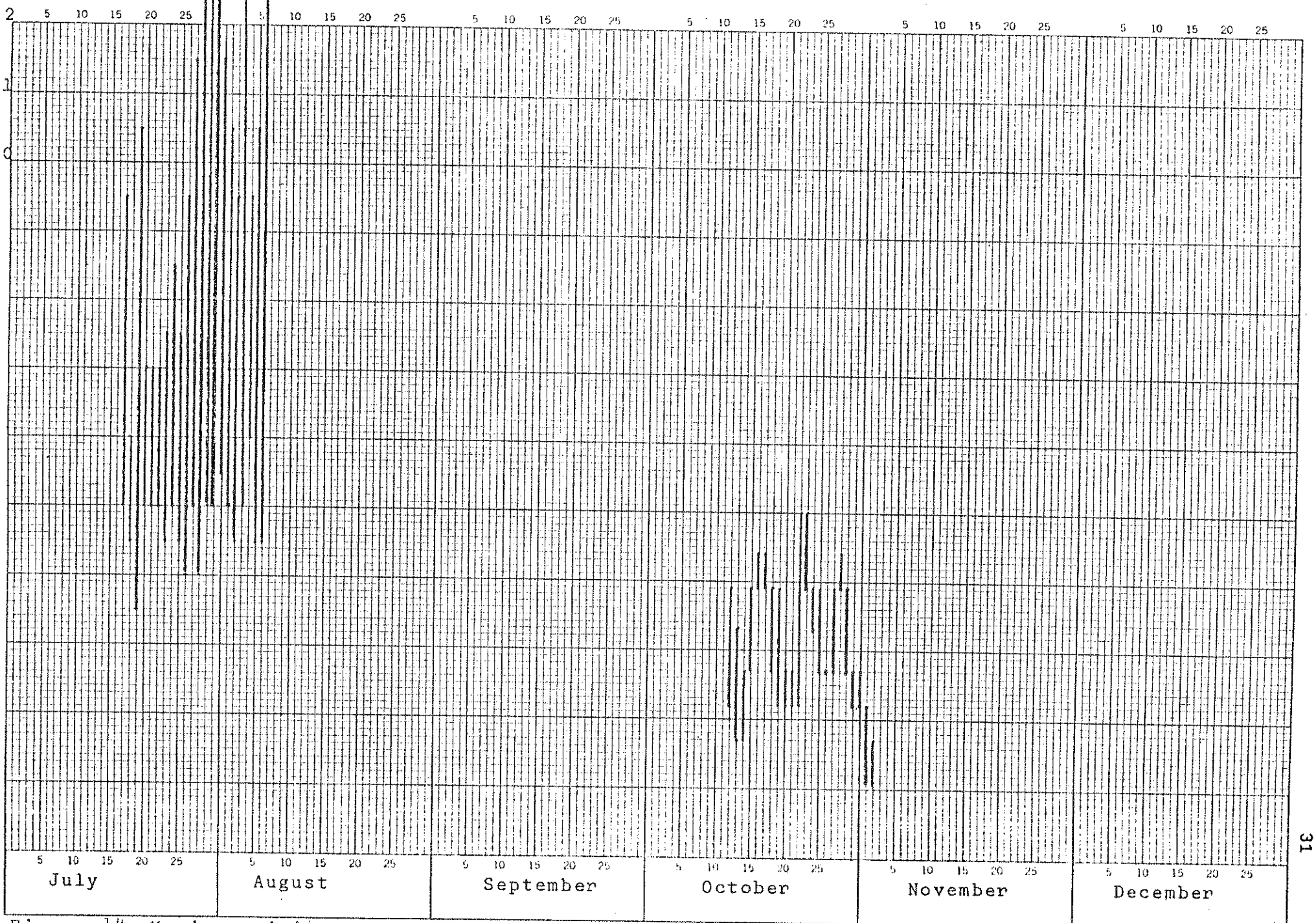


Figure 14. Maximum-minimum stream water temperature (°C) at Russell Creek, July to December, 1978.

Table 19. Mean monthly maximum and minimum stream temperature (°C), Russell Creek, 1978.

Month	Maximum temperature			Minimum temperature		
	Mean	S.D.	Days Sampled	Mean	S.D.	Days Sampled
January	1.3	0.78	24	1.0	0.63	24
February	0.9	1.11	15	0.6	0.75	15
March	-	-	-	-	-	-
April	-	-	-	-	-	-
May	8.3	1.77	18	4.9	1.91	18
June	7.6	1.72	12	4.0	0.33	12
July	9.4	2.43	15	4.7	0.53	15
August	11.0	1.61	6	4.9	0.58	6
September	-	-	-	-	-	-
October	3.7	0.78	20	2.7	0.74	20
November	2.0	0.35	2	1.1	0.0	2
December	-	-	-	-	-	-

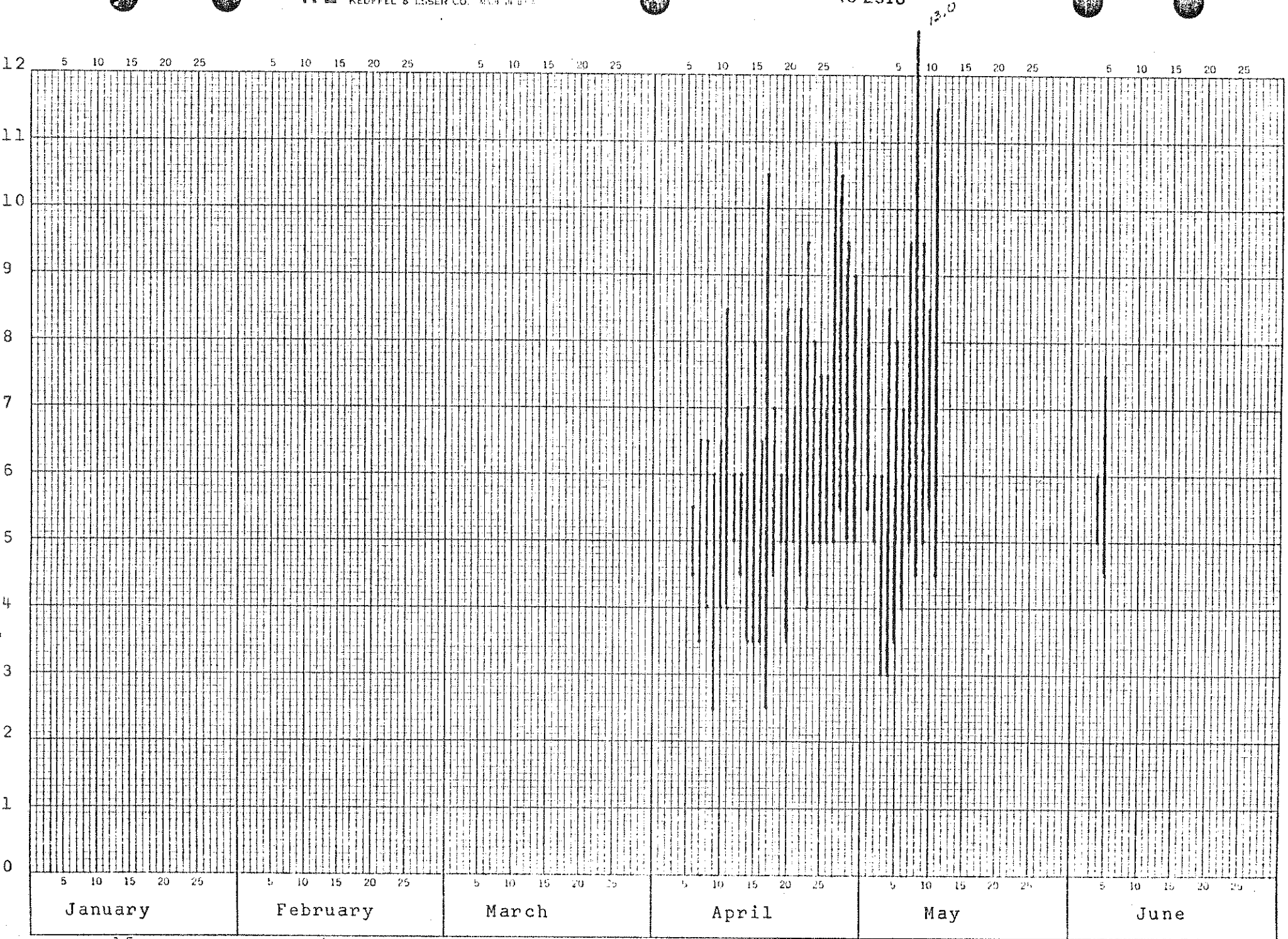


Figure 15. Maximum-minimum water temperature (°C) Nurse Lagoon, April to June, 1978.

respectively (Table 20). Minimum temperatures ranged between 4 to 5 degrees, with May averaging 4.1 (S.D. = 0.92).

Water temperature in Cold Bay near the State dock ranged between 1.5 and 5.5 degrees centigrade, April till the first of June (Figure 16). Maximum mean water temperatures were 2.5 (S.D. = 0.75) for April and 4.3 (S.D. = 0.73) for May. Minimum mean temperatures ranged between 2 to 4 degrees for April and May (Table 20).

Recordings were also taken at a small unnamed lake near Russell Creek. The lake is approximately 800 square meters in surface area and 1 to 2 meters deep. It is located 1.2 kilometers north of the hatchery along the road system and has potential as a possible rearing pond for young coho salmon. A high temperature of 15.0 degrees centigrade was recorded on July 23 (Figure 17). Maximum mean temperatures for June, July, September and October were 10.1, 11.1, 8.2 and 4.5 respectively (Table 20).

A total of 18 volume flow measurements were taken at Russell Creek near the hatchery site from March 21 to November 17. The flow values (minimum) ranged from 3.77 to 15.13 cubic meters per second and averaged 7.42 (S.D. = 3.20) (Figure 18).

Eighteen readings of water chemistry at the same location and period as the above indicated dissolved oxygen ranged from 10 to 15 ppm, dissolved carbon dioxide ranged from less than 5 to 15 ppm, ph ranged from 7.5 to 8.5, ammonium nitrogen ranged from 0 to 0.4 ppm, and total hardness as calcium carbonate ranged from less than 1 to 3 grains per gallon (Table 21).

Table 20. Mean monthly maximum and minimum water temperatures (°C) at Nurse Lagoon, Cold Bay, and an unnamed lake near Russell Creek, 1978.

Month	Maximum temperature			Minimum temperature		
	Mean	S.D.	Days Sampled	Mean	S.D.	Days Sampled
			Nurse Lagoon			
April	7.8	1.57	25	4.3	0.82	25
May	8.7	2.14	11	4.1	0.92	11
June	6.8	1.06	2	4.8	0.35	2
			Cold Bay			
April	2.5	0.75	25	2.2	0.55	25
May	4.3	0.73	31	3.9	0.61	31
June	5.5	0.0	2	4.5	0.0	2
			Unnamed lake			
June	10.1	0.99	24	9.0	0.68	24
July	11.1	1.65	25	9.8	1.05	25
August	-	-	-	-	-	-
September	8.2	0.83	17	7.4	0.90	17
October	4.5	1.81	31	3.1	3.29	31

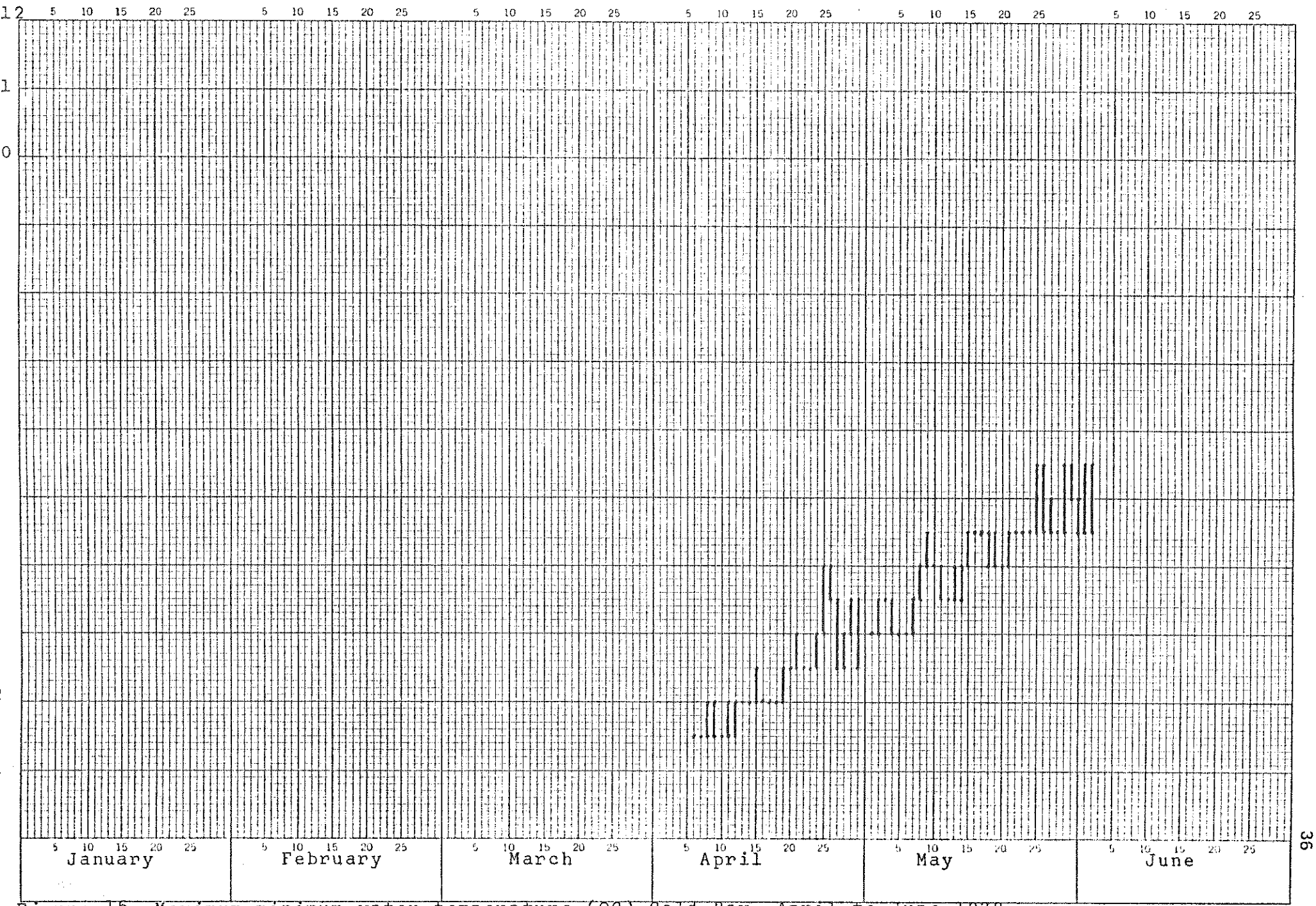


Figure 16. Maximum-minimum water temperature (°C) Cold Bay, April to June 1978.

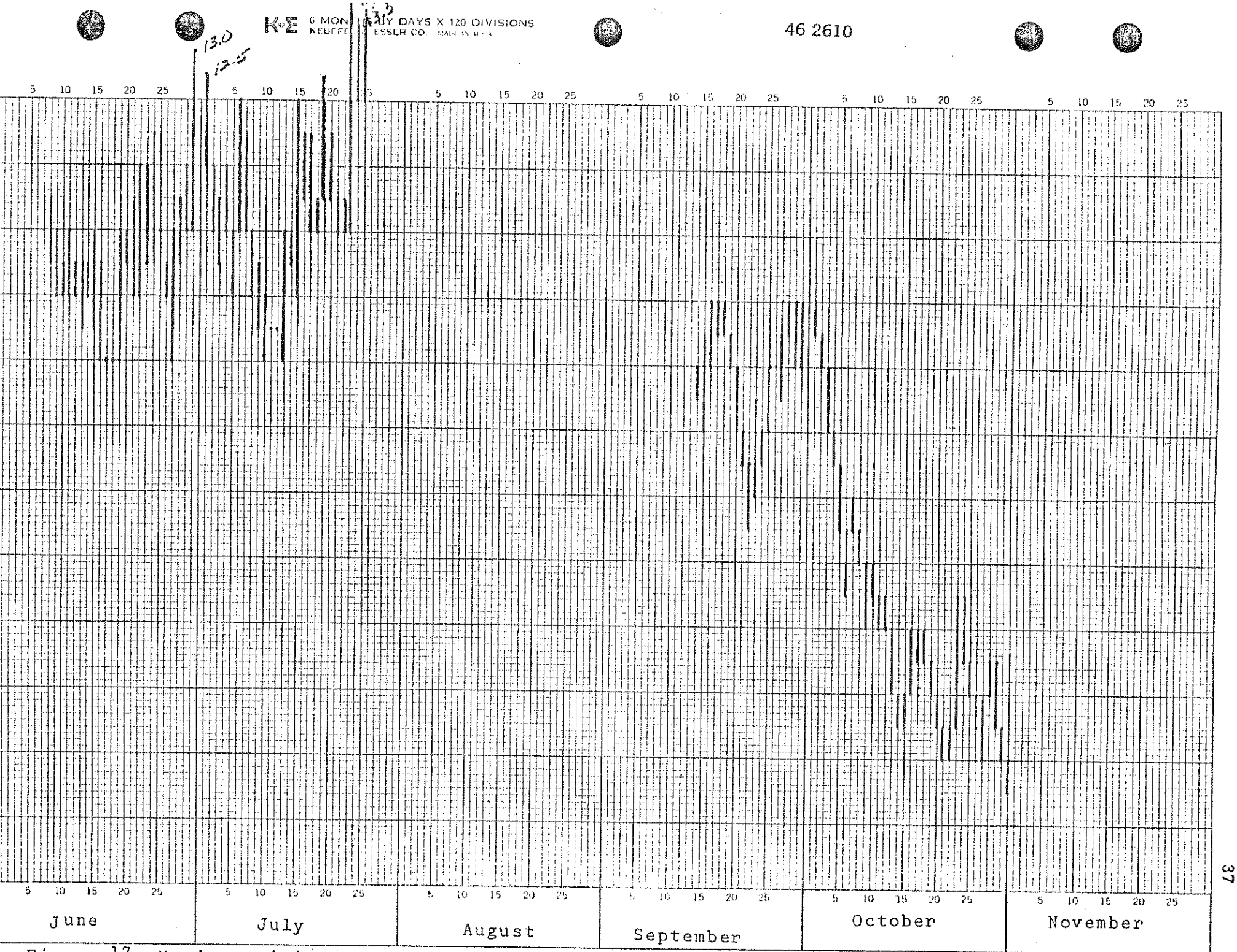


Figure 17. Maximum-minimum water temperature at a small unnamed lake near Russell Creek, June to November, 1978.

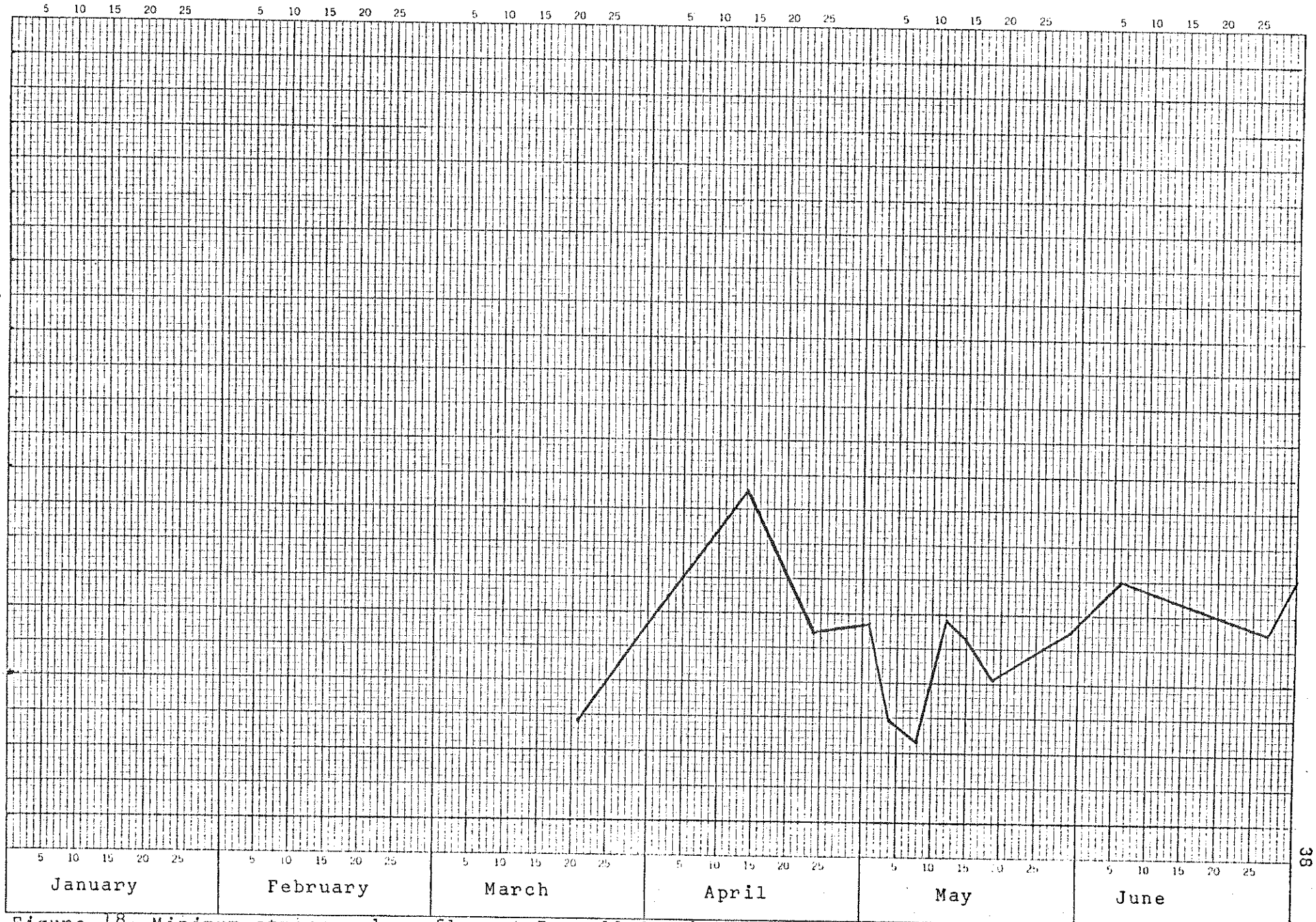


Figure 18. Minimum stream volume flow at Russell Creek, January to June, 1978.

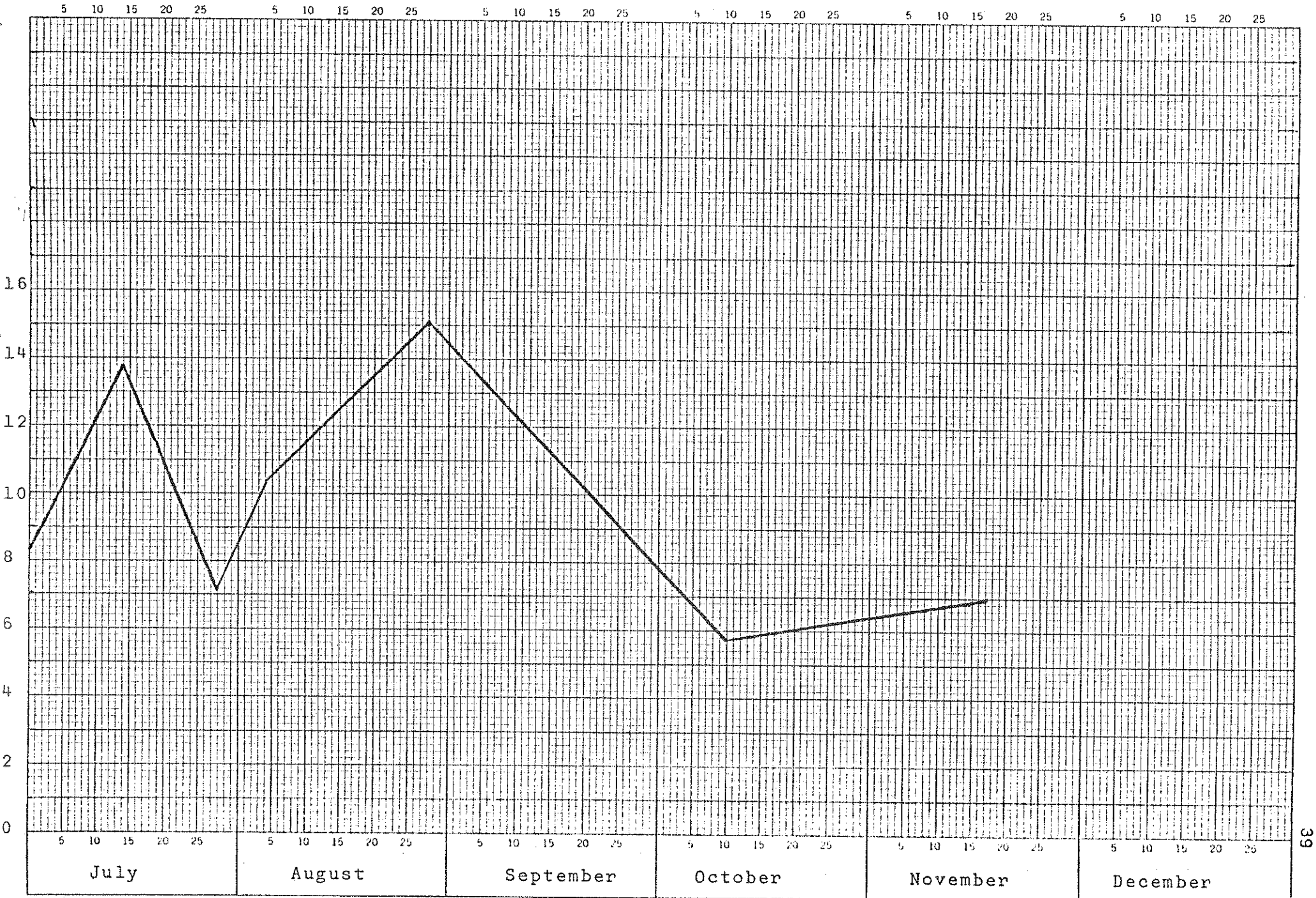


Figure 18. Minimum stream volume flow at Russell Creek, July to December, 1978.

Table 21. Water chemistry of Russell Creek, 1978.

Date	Water Temperature °C	DO_2 ppm	DCO_2 ppm	pH	Ammonium Nitrogen ppm	Hardness grains/gal. $CaCO_3$
3-8	0.0	14	≤ 5	7.5	-	3
4-14	5.0	12	≤ 5	7.5	0-0.2	1
4-24	6.0	12	≤ 5	7.5	0-0.1	1
5-4	6.0	15	≤ 5	7.5	-	1
5-8	10.0	11	≤ 5	7.5	0-0.2	1
5-12	5.5	15	≤ 5	7.5	-	1
5-15	7.0	13	≤ 5	7.5	0-0.2	1
5-24	6.5	13	≤ 5	7.5	0-0.2	1
5-30	9.0	12	≤ 5	7.5	0-0.2	1
6-6	6.0	13	≤ 5	7.5	0-0.2	1
6-19	-	11	≤ 5	7.5	0-0.2	1
6-27	8.0	13	≤ 5	7.5	0-0.2	≤ 1
7-14	-	-	-	7.5	0-0.2	-
7-28	7.0	12	15	7.5	0.2-0.4	1
8-4	8.0	11	15	7.5	0-0.2	1
8-28	7.5	10	10	7.5	0-0.2	1
10-10	6.0	12	10	8.5	0.2-0.4	2
11-17	2.0	14	10	7.5	0-0.2	2

DISCUSSION

Biological Data

The information taken in 1978 will serve as baseline data for the development and evaluation of the Russell Creek incubation facility. Basic parameters on the salmon stocks and ecological conditions effecting them were surveyed. Areas of particular interest involved information related to the topics of enhancing salmon fry survival, developing standards to evaluate hatchery fry quality, and developing data to monitor the pre- and post-effects of the hatchery propogated stocks on the natural system. The philosophy of our biological sampling has been to lay a sound foundation related to general biological concepts. Our prespective is the hatchery is an extremely long term project, and in time will allow many indepth investigations.

Predator Investigation. An average of 2.2 (S.D. = 5.7) fry per Dolly Varden was found in the stomach analysis survey. Feeding and digestive rates are unknown, but using the lower range figure of 20 percent for predation related mortality (Hunter, 1959), the following estimate of numbers of fry lost is derived. Other information entering the calculations include: average chum salmon escapement and estimated fry to adult marine survival, one percent. The estimate equals 500,000 fry taken by Dolly Varden. This is equivalent to 5,000 returning adults. Given the existing Dolly Varden population estimate (20,000-Bricker, 1978) and a period of roughly 50 days the salmon fry would be preyed upon in Russell Creek, yields a conservative estimate of feeding rate per fish of 2.2 fry taken

DISCUSSION

Biological Data

Predator Investigation. An average of 2.2 (S.D. = 5.7) fry per Dolly Varden was found in the stomach analysis survey. Feeding and digestive rates are unknown, but using the lower range figure of 20 percent total predation related mortality from the literature (Hunter, 1959), the following estimate of numbers of fry lost is derived. The estimate, strictly a hypothetical figure, is calculated as follows. Average annual escapement is 19,393 chum salmon. This figure divided by 1 percent marine survival gives average number of fry leaving the system: 1,939,000. This figure in turn divided by 80 percent survival, yields an estimated total number of fry prior to the effects of predation: 2,424,000 fry. Subtracting the 1.9 million fry from the 2.4 million fry equals approximately 500,000 fry lost attributed to char predation. This is equivalent to 5,000 returning adults. Given the existing Dolly Varden population estimate (20,000 - Bricker, 1978) and a period of roughly 50 days the salmon fry would be preyed upon in Russell Creek, yields a conservative estimate of feeding rate per fish of 2.2 fry taken every 4.4 days or .5 fry per day per fish. These preliminary figures are calculated as follows. The 500,000 total fry mortality figure is divided by 50 days to determine average number of fry taken per day by 20,000 char: 10,000 fry. This figure is then divided by 20,000 char to gain 0.5 fry per day per char. Assuming 20 percent total predation and an estimated additional contribution of 5000 fish to the commercial fishery, the potential benefits of decreasing or eliminating Dolly Varden predation would be beneficial.

Marine Zooplankton Investigation. Zooplankton samples taken at Cold Bay in 1978 yielded information on the quantitative and qualitative aspects of

every 4.4 days or .5 fry per day per fish. Even in considering the lower limit figure of an estimated additional contribution of 5000 fish to the commercial fishery, the potential benefits of decreasing or eliminating Dolly Varden predation would be beneficial.

Marine Zooplankton Investigation. Zooplankton samples taken at Cold Bay in 1978 yielded information on the quantitative and qualitative aspects of zooplankton populations present. The development and analysis of this data was aimed at planning future releases of fry from the Russell Creek Hatchery. Preliminary analysis indicate peak number of zooplankton, greater than 11,000 per m^3 occur from mid-July to mid-August. Comparing the data taken at Cold Bay, though for different years, to other studies in Alaska indicate similar ranges of productivity.

AREA	YEAR	PERIOD	MESH SIZE	PREDOMINANT SPECIES	ZOOPLANKTON PER m^3	SOURCE
Cold Bay	1977	April-May	243	calanoid copepod	1500-3000	Bricker, 1978
Cold Bay	1978	April-May	243	calanoid copepod	700-3500	Table 3.
Tutka Bay	1975	April-May	233	calanoid copepod	500-4000	Kron and Yuen, 1975
Port San Juan	1976	April-May	216	cyclopoid & calanoid copepod	30-600	Cooney, et. al. 1978

With few exceptions the zooplankton samples taken at Cold Bay were 100 percent calanoid copepods in composition. Kron and Yuen (1976) found the pink salmon outmigration in Tutka Bay was closely timed with the calanoid copepod bloom in the estuary. They indicated calanoid density was significantly

correlated with time and surface water temperature, $P<.01$ in both cases. Cooney, et. al. (1978) in his investigation at Port San Juan, stated calanoid copepods were consistantly preferred by pink salmon fry in contrast to harpacticoid copepods. For a total of 40 fry sampled calanoids averaged 61 and harpacticoids 7 organisms per fish.

From the sampling in Cold Bay it did not appear that any particular wind direction gave higher counts at any specific station (Table 3). Neither did it appear that predominant winds on the days prior to the sampling influenced density.

Baseline Data Investigation. In 1978 approximately 2.5 percent of the chum salmon run was sampled to establish age composition. The age-class structure of the chum salmon spawning in Russell Creek in 1978 is very similar to 1977 (Bricker, 1978). In both years age 0.3 (III) were dominant at 69 to 76 percent. Age 0.2 (II) fish in both years were second in importance at 22 to 27 percent. Bakkala (1970) indicated that age 0.3 chum salmon are the dominant age-class throughout the world. Sampling 10,300 chum salmon from 1948 to 1958 in the Alaska Peninsula, Prince William Sound and Kodiak areas Thorsteinson's (1963) data indicated an age composition of 9 percent age 0.2, 73 percent age 0.3 and 17 percent age 0.4. Regnart (1967) from a sample of 1266 chum salmon taken in Kotzebue Sound from 1962 to 1965 presented an age-class structure averaging 25 percent age 0.2, 61 percent age 0.3 and 13 percent age 0.4. Considerable year-to-year variation in age composition is common for populations of chum salmon. Also age composition changes as the spawning season progresses. Generally older fish appear in the earlier parts of the run (Mattson, et. al., 1964).

Males made up 53 percent of the sample in 1978 and 58 percent in 1977. Sano (1966) indicated male chum salmon outnumber females at age 0.2, are equal at age 0.3, and females are more abundant at ages 0.4 and 0.5.

In comparing average lengths the 1978 Russell Creek stocks ranged from 1 to 2 centimeters shorter than the 1977 spawners.

On an average the 1978 data indicated 567 eggs were retained by post-spawned chum salmon. Even in considering the large run in 1978, near 100,000 spawners to include pink salmon, the average egg retention appears to be exceptionally high. There is data to support the notion that egg retention increases with increased spawning density (Semko, 1954; Lister and Walker, 1966). In 1977 egg retention averaged 124 for Russell Creek chum salmon, the total chum and pink salmon escapement was 54,000 fish (Table 18). If a density related mechanism is at work, its effects could conceivably have greater impact on the chum salmon. The chum salmon's entry into Russell Creek and peak spawning occur one to several weeks later than that of the pink salmon.

Average fecundity of chum salmon spawning in Russell Creek in 1978 was estimated to be near 2976 eggs (S.D. = 370). Generally, chum salmon fecundities range between 2,000 and 3,000 (Bakkala, 1970). Mattson, Rowland, Hobart (1964) could not demonstrate a significant difference in fecundity of age 0.2, 0.3 and 0.4 chum salmon. Watanabe (1955) found fecundity and egg size increases with length. The apparent inconsistancy of these two statements may emphasize the large overlap in lengths of various age fish. Eastwood (1977) found no significant relationship between length and fecundity of pink salmon at Port San Juan.

The average weight of the female chum salmon gonad in relation to the average body weight of the fish was 17.9 percent. In some streams of the Kamchatka Peninsula the average was 14.3 percent (Semko, 1954). Egg diameter for Russell Creek chum salmon averaged 6.4 millimeters (S.D. = 0.5). Mean egg size was reported at 5.9 millimeters for age 0.2, 6.5 millimeters for age 0.3, and 6.5 millimeters for age 0.4, Alaska Peninsula chum salmon for years 1958 and 1959 (Bureau of Commercial Fisheries).

Wild Salmon Fry Study. Outmigration of chum salmon fry from Russell Creek probably starts in mid-March, peaks in the first two weeks of May, and runs through mid-June. With further investigation it should be possible to document the significance of overwinter stream temperature on the development and timing of outmigration of the wild fry. At this point normal variation in stream temperature (mild versus severe winters) does not appear to effect timing to any noticable degree.

The estimates of developmental indices, 1.96 and 1.97, would indicate the Russell Creek chum salmon fry over the total out-run were at an appropriate stage of development. Although at both sampling stations samples taken at the end of the peak emergence and towards the end of the outmigration may be considered marginally immature (Table 12). Bams (1970) described the growth of chum and pink salmon fry immediately prior and following emergence as: initially a weight increase with increased length; weight leveling-off with increased length; and weight decrease and no increase in length. With the calculated developmental indices (K_D) for the various stages Bams (1970) represents the following summary.

K_D	Description of Fry
2.06	Ventral slit pronounced
2.02	Ventral slit almost closed
1.98	Ventral slit fully closed
1.94	Yolk absorption complete
1.92	Resorption of body tissue

The outmigration of the hatchery and stream fry in his study took place at approximately K_D values of 1.99 to 1.93.

Average alevin weight on March 21 and 22 was estimated at 271 milligrams (S.D. = 46) (Table 15). In the period June 6 to 9 at the tributary to Nurse Lagoon mean fry weight was estimated at 388 milligrams (S.D. = 66) (Table 12). The increase in weight, at this life stage over the 2.5 month period March to June, is in the magnitude of 17 percent of body weight per month. Growth is relatively slow during the period of outmigration as reported in a study in one Hokkaido stream (Kobayashi and Ishikawa, 1964). Levanidov and Levanidova (1957) reported ranges of weight gain for chum salmon fry at time of outmigration, 0.27 to 0.35 grams, in tributaries of the Amur River, U.S.S.R., comparable to the rates at Russell Creek.

Mean lengths of chum salmon fry in Nurse Lagoon from April 17 to June 1 ranged from 36 to 38 millimeters (Table 17). These are the same as mean lengths of outmigrating fry in the stream for the comparable period (Table 12). This evidence along with the casual observation of low numbers of fry in Nurse Lagoon, supports the notion the estuary is only lightly used as a nursery area. The explanation is speculated to be that at low tide the lagoon typically goes dry, with the currents of the main channel moving out into Cold Bay.

Salmon Escapement Study. The chum salmon escapement into Russell Creek in 1978 was 222 percent of the average even-year escapement, 22,500 fish. Pink salmon returned at 169 percent of the average even-year escapement, 29,600 fish (Table 18). Strong escapements have been credited to the elimination of the high seas gillnet fishery, ideal environmental conditions, and stream optimum escapement goals being met.

Wide fluctuations of spawners returning to Russell Creek in the past have been attributed to gravel bed scouring during critical incubation periods. As high as 50 to 90 percent of the eggs and larvae have been reported as destroyed in southeastern Alaska streams as a result of erosion and shifting gravel (McNeil, 1966).

Physical and Chemical Data

Problems were experienced with the operation of the new model "J" Peabody Ryan thermographs, as evident in the gaps in water temperature data (Figures 14 - 17).

The minimum mean stream flow of Russell Creek was estimated at 7.42 cubic meters per second (262 cfs, S.D. = 113). Observed maximum stream flows over the past 6 years may be in the magnitude of 3 to 5 times the minimum flow value.

The water chemistry analysis revealed increases of dissolved carbon dioxide from July through November, 10 to 15 ppm (Table 21). Free carbon dioxide in spawning gravel of some southeastern Alaska streams was 2 to 24 ppm (McNeil, 1962). In laboratory experiments oxygen uptake by salmon eggs was not effected by carbon dioxide levels below 125 ppm (Alderdice and

Wickett, 1958). Apparent increases of ammonia (ammonium nitrogen) in July and October and pH in October may reflect the presence of deteriorating salmon carcasses in the stream. Ammonia as a metabolite of eggs may be deleterious in natural systems under certain conditions (McNeil, 1966).

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NOTE TO THE READER - All citations indicated as "not seen", with one exception, were taken from Bakkala (1970).

APPENDIX

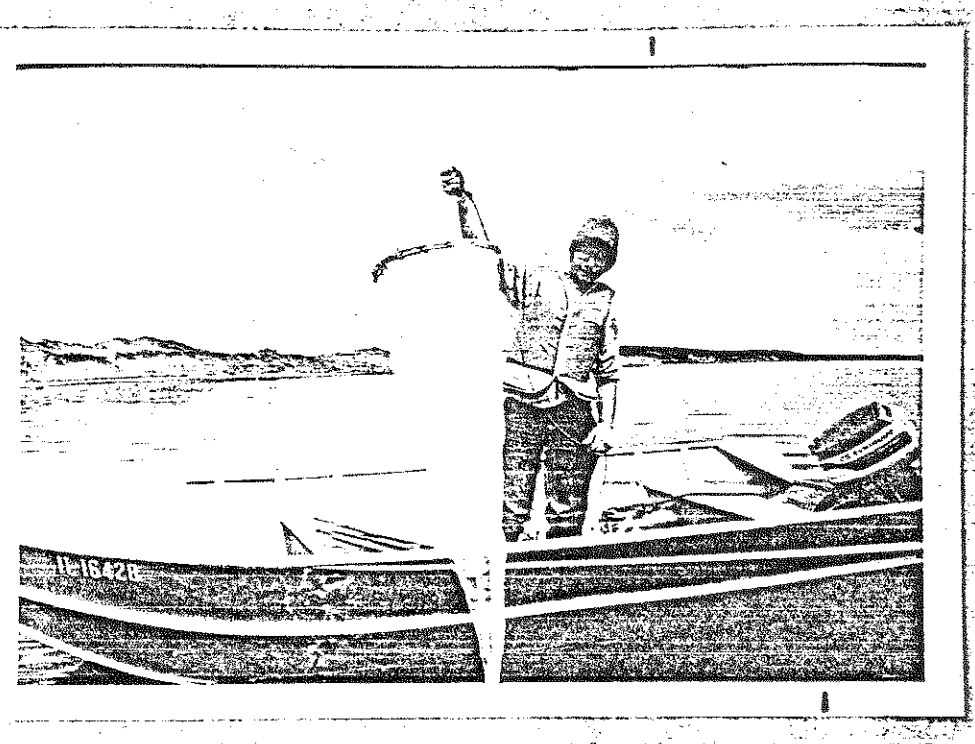

Figure 2. Zooplankton sampling, Cold Bay, 1978.

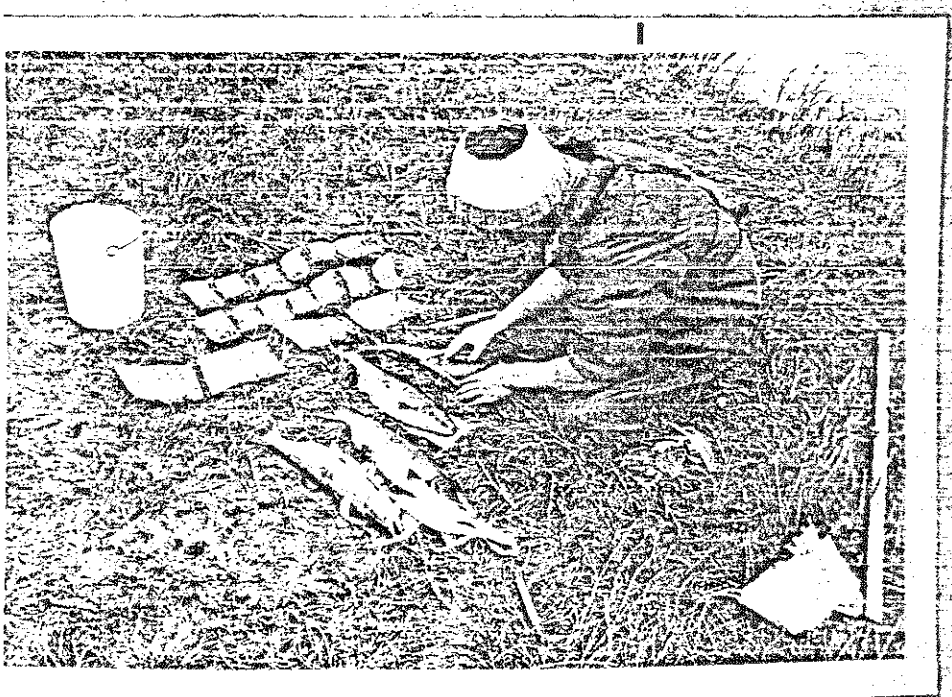

Figure 3. Fecundity sampling, Russell Creek, 1978.

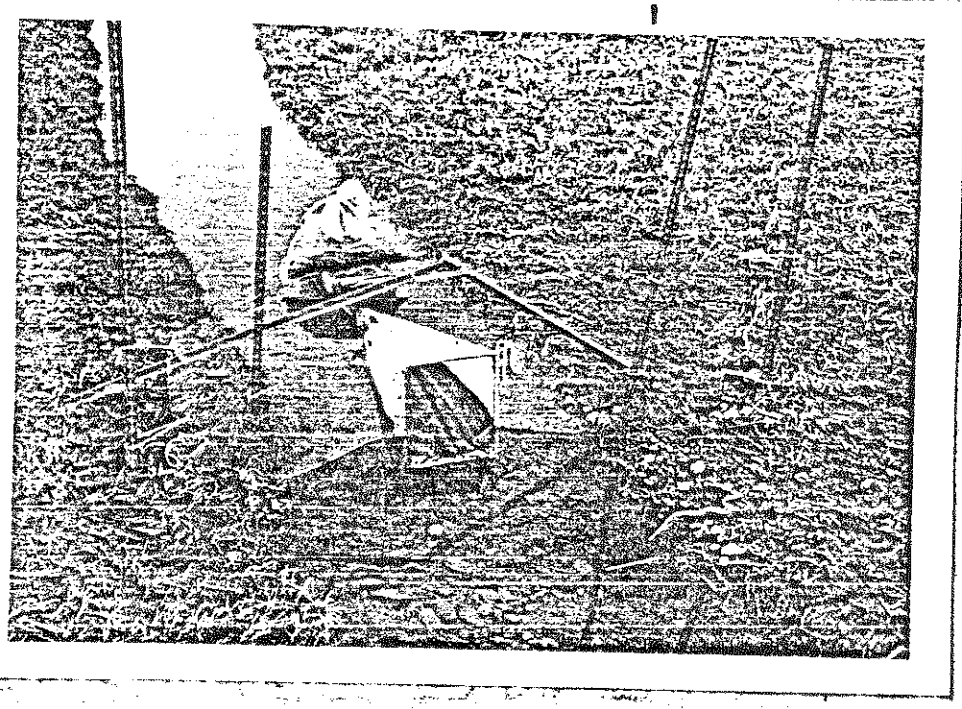

Figure 4. Fry outmigration sampling, tributary to Nurse Lagoon, Russell Creek, 1978.

Figure 5. Checking stream temperature recording thermometer, Nurse Lagoon, 1978.

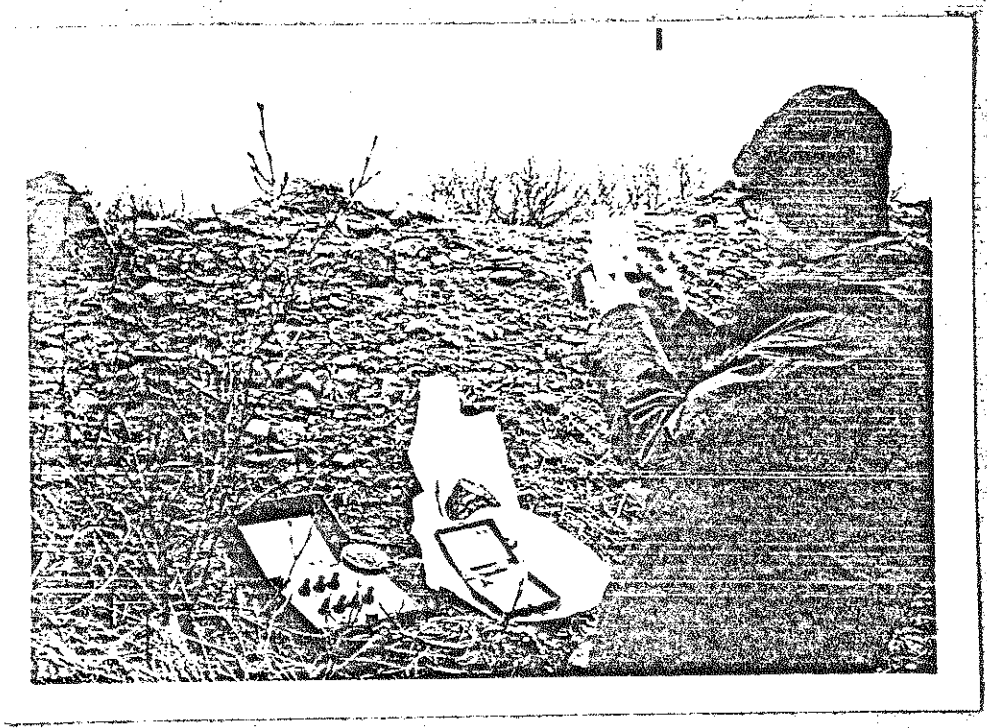

Figure 6. Water chemistry analysis, Russell Creek, 1978.

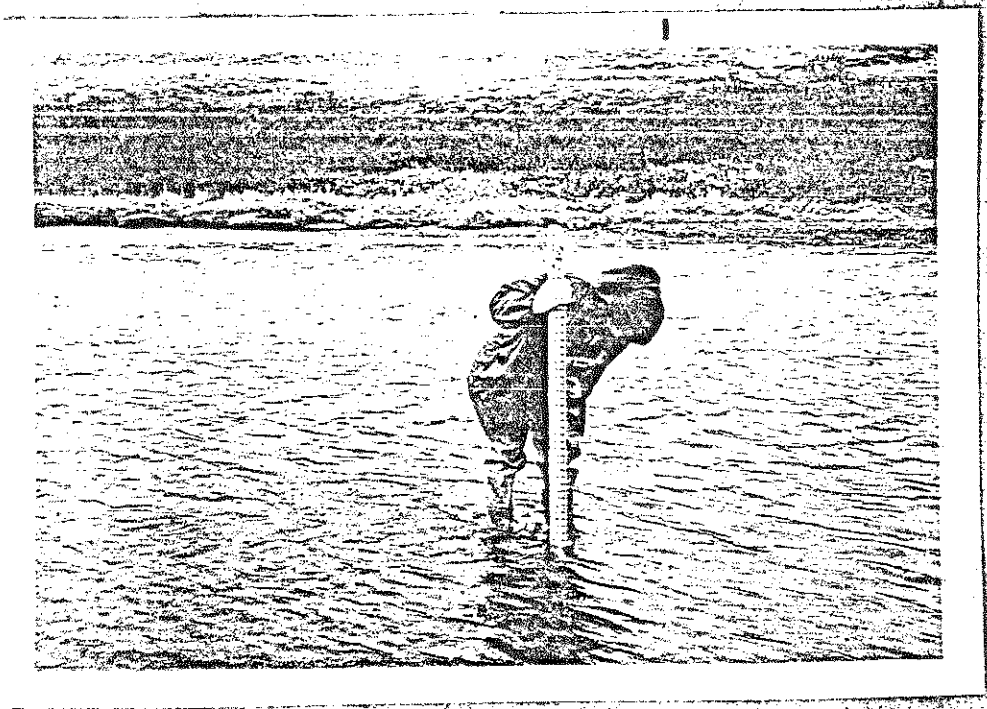

Figure 7. Stream flow guaging, Russell Creek, 1978.

Table 2. Dolly Varden stomach analysis data, Russell Creek, 1978.

Date	Number of fry in stomach	Insects present in stomach(1)	Fish length in cm	Location of capture (2)	Sex	Color phase(3)
4/14	0	-	36.0	1	F	-
4/14	0	-	27.5	1	F	-
4/14	0	-	35.5	1	F	-
4/14	2	-	31.5	1	F	-
4/24	9	-	33.0	3	F	-
4/24	0	-	46.5	3	M	-
4/25	0	-	27.1	1	F	1
4/25	2	-	30.0	3	F	3
4/25	0	-	40.0	2	F	1
4/25	1	-	32.5	2	F	1
4/25	0	-	49.5	2	F	2
4/25	0	-	49.5	2	F	2
4/26	1	-	44.5	2	M	1
4/26	0	-	37.5	2	F	1
4/26	0	+	41.5	2	F	1
4/26	0	+	38.0	2	F	1
4/25	0	-	38.0	2	F	1
4/26	0	-	35.5	2	F	3
4/26	0	-	39.5	1	F	1
4/26	0	-	42.5	1	F	1
4/26	0	-	46.5	1	F	1
4/26	0	-	42.5	1	F	1
4/26	0	-	40.5	1	F	1
4/26	0	-	38.0	1	F	1
4/26	0	-	39.0	1	F	1
4/26	0	-	37.0	1	F	1
4/26	0	-	41.5	1	F	1
4/26	0	-	42.0	1	M	1
4/26	0	-	39.0	1	M	1
4/26	0	-	30.0	1	M	1
4/26	0	-	30.5	1	M	1
4/26	0	-	29.0	1	F	1
4/26	0	-	27.0	1	M	1
4/26	0	+	22.5	1	M	1
4/26	0	+	19.5	1	F	1
4/26	0	+	18.0	1	F	1
4/27	16	-	42.0	3	F	1
4/27	4	+	29.0	3	F	1
4/27	6	-	26.0	3	F	1

Continued...

Table 2. Continued.

Date	Number of fry in stomach	Insects present in stomach(1)	Fish length in cm	Location of capture(2)	Sex	Color phase(3)
4/27	0	-	45.5	1	M	1
4/27	1	-	41.5	1	F	1
4/27	0	-	40.5	1	F	1
4/27	3	+	16.5	1	F	1
4/27	0	-	27.5	1	F	1
4/27	0	-	36.0	1	M	1
4/27	0	-	43.0	3	F	1
Mean	0.98		35.8			
S.D.	2.85		8.1			
5/1	0	-	34.0	1	-	1
5/1	0	-	38.5	1	-	1
5/1	0	-	38.0	1	-	1
5/1	0	-	30.5	1	-	1
5/8	0	+	40.5	2	M	1
5/9	9	-	16.0	1	M	1
5/9	3	-	42.0	3	F	1
5/9	11	-	44.0	3	F	1
5/9	1	+	44.0	3	M	1
5/9	2	+	26.0	3	M	2
5/9	0	-	36.5	3	F	1
5/9	0	-	38.0	3	F	1
5/9	0	-	29.5	3	M	1
5/9	0	-	32.0	3	F	1
5/9	5	+	31.5	3	M	1
5/9	0	-	34.5	3	F	1
5/9	32	-	26.0	3	M	3
5/9	37	-	46.5	3	F	1
5/9	0	-	35.5	3	F	2
5/9	0	+	38.5	3	F	2
5/9	0	-	39.5	3	F	2
5/9	0	-	32.0	3	F	2
5/9	0	+	30.0	3	F	2
5/9	2	+	30.0	3	F	2
5/9	3	+	35.0	3	F	2
5/9	0	-	31.0	3	M	2
5/9	14	+	21.0	3	M	2

Continued...

Table 2. Continued.

Date	Number of fry in stomach	Insects present in stomach(1)	Fish length in cm	Location of capture(2)	Sex	Color phase(3)
5/15	0	-	35.5	2	F	1
5/15	16	-	45.0	3	F	1
5/15	2	-	42.0	3	F	1
5/15	0	+	30.5	3	M	1
5/15	6	+	22.5	3	M	4
Mean	4.5		34.3			
S.D.	9.0		7.2			
5/17	0	-	40.0	1	F	1
5/17	0	+	41.0	1	F	1
5/17	0	-	32.5	1	M	1
5/17	0	-	32.5	1	F	1
5/17	0	-	37.0	1	F	1
5/17	0	-	32.0	1	F	1
5/17	0	-	29.0	1	F	1
5/17	0	+	31.5	1	F	1
5/17	0	-	28.5	1	F	1
5/17	0	-	27.0	1	-	1
5/17	0	-	29.0	1	-	1
5/31	0	+	20.0	3	M	1
5/31	2	+	18.5	3	F	1
5/31	0	+	18.5	3	M	1
5/31	4	-	21.0	3	M	1
5/31	4	-	26.0	3	M	1
5/31	11	-	25.0	3	M	4
Mean	1.2		28.8			
S.D.	2.9		6.9			
Overall Summary						
Mean	2.2		34.1			
S.D.	5.7		7.9			

(1) No insects present = -, insects present = +.
(2) See Figure 3.
(3) Color phase code
1 - Silver below lateral line, dorsal area light blue-green.
2 - Silver below lateral line, dorsal area dark blue-green.
3 - Yellowish below lateral line, dark dorsal area, spots prominant.
4 - Yellowish below lateral line, dark dorsal area, spots prominant, deep orange and white periphery on fins.
Note: Phases 1 and 2 are non-spawning colors and phases 3 and 4 are spawning colors.

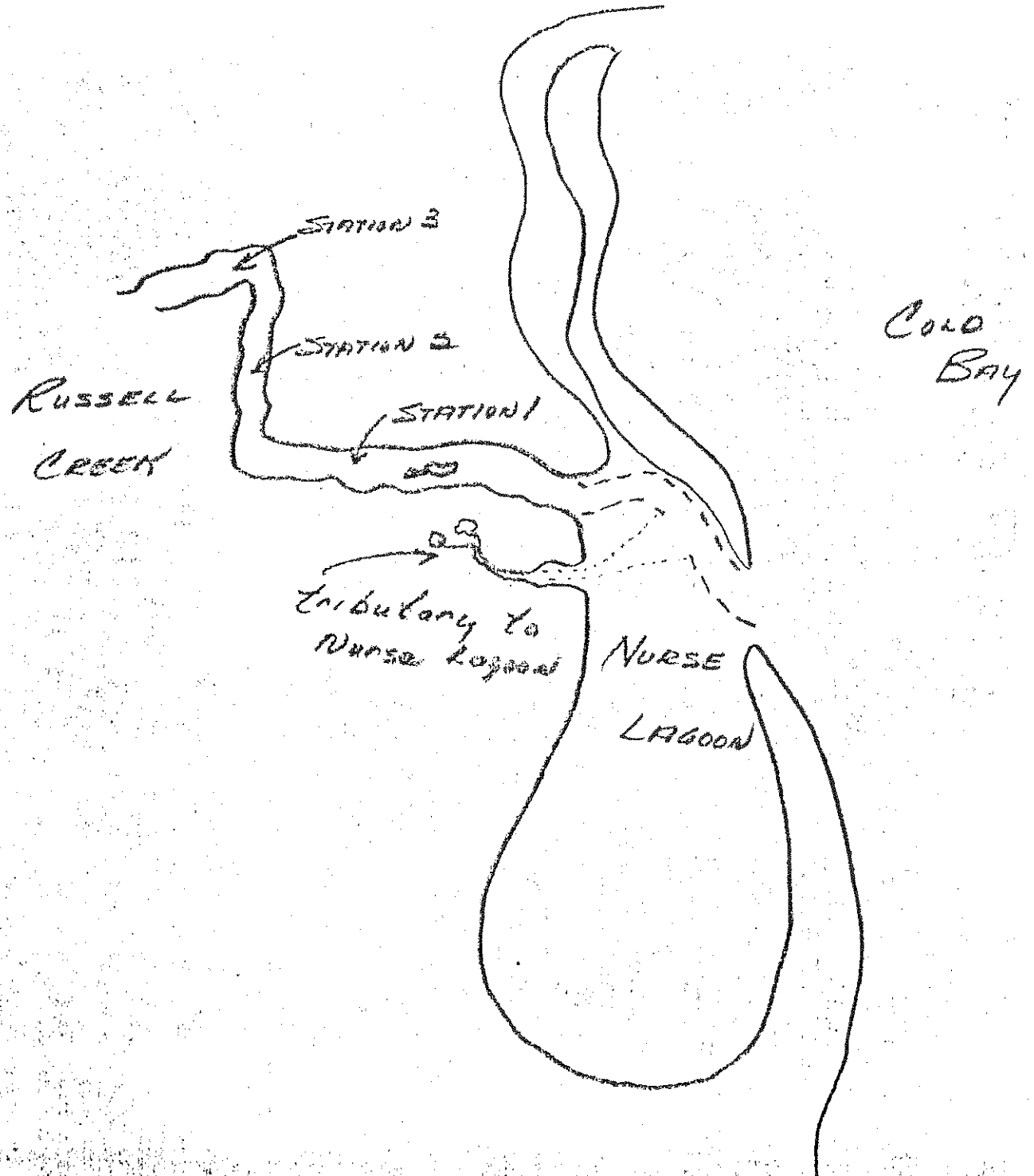

Figure 9. Sampling stations for capturing Dolly Varden, 1978.

Table 3. Zooplankton density at three stations in Cold Bay, 1978...copepods per cubic meter of water.

Date	Sampling Station: Delta Point	Sampling Station: Russell Creek	Sampling Station: Cold Bay Dock	Surface Water Temperature °C	Salinity in ppt	Height & type of cloud cover x 100 feet*	Wind direction & speed...mph: Day of sample	Wind direction & speed...mph: Day prior to sample
4/28	-	-	670	5.0	-	35 ⊕	-	W10
5/11	-	-	3340	5.0	-	50 ◐	SE15	NW24
5/16	3500	2000	2340	6.0	30	20 ⊕	NW15	N16
5/19	1500	3340	2000	5.5	-	20 ⊕	calm	W14
6/1	2670	1340	5840	7.0	-	15 ⊕	NW15-25	NW9
6/5	2500	3840	3340	7.0	18	1 ⊕	-	SE27
6/9	5170	7680	2270	7.0	30	2 ⊕	S5	S16
6/23	3840	2840	1500	7.0	29	15 ⊕	NW<5	S20
6/27	2340	-	-	-	-	25 ⊕	NW20	W16
6/28	1670	1170	1670	8.0	30	3 ⊕	calm	W13
6/30	1500	1340	-	10.0	30	30 ⊕	calm	SE12
7/13	-	8350	11,680	7.5	44(?)	10 ⊕	W15	W20
7/19	-	670	830	8.5	30	50 ◐ 10 ◐	SE15	SE13
7/21	1170	2840	670	9.5	30	30 ◐	SE15	SE20
7/28	-	-	0	11.0	-	clear	SE15-20	N8
8/2	670	1170	1170	10.0	29	2 ⊕ fog	NW5-10	SE28
8/22	0	500	500	11.0	30	50 ⊕	W5	SE14

* ⊕ Solid overcast
◐ Breaks in overcast
◔ Scattered clouds

Table 8. Fecundity, ovary weight, mean egg diameter (N=5x50), and mean egg weight (N=5x250) of a sample (N=19) of Russell Creek chum salmon, 1978.

Date	Fish length in cm	Fish weight in kg	Number of eggs	Weight of ovaries in grams	$\bar{x}$ egg diameter in mm	$\bar{x}$ egg weight in mg
8/7	63.5	2.5	2486	398.1	5.8	157
8/8	62.5	2.6	2932	393.6	5.6	132
8/8	57.7	2.0	2737	342.4	5.6	123
8/14	64.6	3.0	2333	547.1	6.8	231
8/14	70.7	4.0	3062	683.3	6.5	191
8/14	66.7	3.2	2964	561.7	6.0	182
8/14	70.9	4.6	3679	826.9	6.8	221
8/15	69.5	4.2	3093	768.2	6.8	240
8/15	69.6	3.75	3196	569.3	6.3	197
8/16	68.0	3.5	2506	681.2	7.2	280
8/16	68.5	3.1	2768	569.4	6.0	210
9/3	69.7	3.6	3683	806.8	6.5	220
9/3	68.2	3.7	2987	705.4	7.0	236
9/3	63.8	2.75	2623	532.8	6.7	197
9/3	69.4	3.75	3234	755.9	5.9	208
9/5	68.0	3.75	3427	643.5	6.2	185
9/5	68.0	3.6	3059	595.1	6.3	191
9/5	70.5	3.5	2910	619.3	6.1	195
9/9	65.5	2.8	2869	578.5	6.6	194
Mean	67.1	3.4	2976	609.4	6.4	199
S.D.	3.4	0.6	370	136	0.5	37

Table 9. Fecundity, ovary weight, mean egg diameter (N=5x50), and mean egg weight (N=5x250) of a sample (N=32) of Russell Creek pink salmon, 1978.

Date	Fish length in cm	Fish weight in kg	Number of eggs	Weight of ovaries in grams	$\bar{x}$ egg diameter in mm	$\bar{x}$ egg weight in mg
8/1	48.5	1.25	1536	-	5.5	118
8/3	49.0	1.25	1194	184.6	5.6	115
8/8	49.5	1.3	1347	190.0	5.9	140
8/8	52.5	1.5	1554	230.5	5.8	146
8/9	51.4	-	1605	279.6	5.9	175
8/9	49.9	-	1602	241.8	5.7	149
8/9	48.8	-	1170	193.7	5.8	162
8/9	48.2	-	1326	185.0	5.6	139
8/9	52.5	-	1258	205.1	6.5	188
8/14	49.2	1.3	1666	231.4	6.3	152
8/14	47.5	1.2	1562	240.8	5.8	151
8/14	51.1	1.5	1917	316.0	5.6	157
8/14	48.5	1.3	1723	237.3	5.5	137
8/14	47.8	1.2	1420	225.9	6.0	156
8/14	53.5	1.6	1960	301.1	5.8	151
8/14	49.5	1.25	1295	220.9	6.3	169
8/14	47.9	1.2	990	159.6	5.7	150
8/14	50.1	1.3	1806	285.4	6.1	156
8/14	47.4	1.1	1750	251.3	5.4	140
8/14	49.2	1.1	1951	233.6	5.3	108
8/14	54.5	1.75	1547	229.0	5.4	144
8/14	49.0	1.25	1616	242.3	5.8	154
8/14	50.5	1.3	1411	230.4	5.8	163
8/14	51.4	1.5	1586	254.4	5.8	155
8/14	49.5	1.25	1082	140.9	5.1	125
8/14	49.5	1.4	1412	228.0	6.1	176
8/14	50.0	1.3	1442	225.4	5.9	150
8/14	49.4	1.2	1408	189.4	5.9	133
8/16	49.9	1.2	1176	227.1	6.6	185
8/16	50.9	1.5	1716	262.7	6.1	150
8/16	48.6	1.2	1538	223.5	6.1	136
8/16	50.7	1.6	1509	241.7	6.3	217
Mean	50.0	1.3	1502	229.3	5.8	151
S.D.	1.7	.16	245	37.9	.3	22

Table 11. Individual weight, length and developmental index of chum salmon fry sampled at Russell Creek, 1978...mean values follow each week.

Date caught	Date measured	Weight in mg	Length in mm	K_D
4/5	5/17	371	38	1.89
9	22	409	37	2.01
9	22	448	37	2.07
N = 3		409	37	1.99
4/10	5/22	407	39	1.90
12	23	423	40	1.88
12	23	386	37	1.97
14	23	324	33	2.08
14	23	342	36	1.94
15	23	395	36	2.04
15	23	457	40	1.93
16	23	356	39	1.82
16	23	420	40	1.87
16	23	417	40	1.87
16	23	417	40	1.87
16	23	408	38	1.95
N = 12		396	38	1.93
4/17	6/1	424	39	1.93
17	1	396	39	1.88
17	1	460	40	1.93
17	1	377	38	1.90
17	1	406	39	1.90
18	1	430	38	1.97
18	1	396	37	1.98
18	1	344	36	1.95
18	1	370	38	1.89
18	1	444	39	1.96
18	1	403	38	1.94
18	1	422	39	1.92
18	1	396	38	1.93
18	1	381	38	1.91
22	6	352	35	2.02
22	6	321	35	1.96
22	6	358	37	1.92
22	6	309	36	1.88
22	6	332	35	1.98
22	6	304	35	1.92
22	6	280	35	1.87
22	6	282	35	1.87
4/22	6/6	339	37	1.88
22	6	384	36	2.02
22	6	329	35	1.97
22	6	297	35	1.91
22	6	346	35	2.01
22	6	348	35	2.01
22	6	355	36	1.97
22	6	367	37	1.94
22	6	369	37	1.94
22	6	394	39	1.88
22	6	325	36	1.91
22	6	309	34	1.99
22	6	353	37	1.91
22	6	345	36	1.95
22	6	353	36	1.96
23	6	326	37	1.86
23	6	410	40	1.86
23	6	390	38	1.92
23	6	437	41	1.85
23	6	399	39	1.89
23	6	409	39	1.90
23	6	400	39	1.89
23	6	423	40	1.88
23	6	400	36	2.05
23	6	408	39	1.90
23	6	417	39	1.92
23	6	411	40	1.86
23	6	445	40	1.91
23	6	353	38	1.86
23	6	388	37	1.97
23	6	365	37	1.93
23	6	380	38	1.90
23	6	419	38	1.97
23	6	378	37	1.95
23	6	349	37	1.90
23	6	383	39	1.86
23	6	363	38	1.88
23	6	424	39	1.93
23	6	364	37	1.93
23	6	299	36	1.86
N = 62		373	37	1.92

Continued...

Table 11. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D
4/27	6/8	386	37	1.97
27	8	384	37	1.96
27	8	416	38	1.96
27	8	404	39	1.90
27	8	450	39	1.96
27	8	396	39	1.88
27	8	381	37	1.96
27	8	434	38	1.99
27	8	414	38	1.96
27	8	388	37	1.97
27	8	364	38	1.88
27	8	409	39	1.90
27	8	368	38	1.89
27	8	397	38	1.93
27	8	408	39	1.90
27	8	408	37	2.00
27	8	435	39	1.94
27	8	435	39	1.94
27	8	397	39	1.88
27	8	374	38	1.90
27	8	394	37	1.98
27	8	379	37	1.96
27	8	432	40	1.89
30	14	465	39	1.99
30	14	438	39	1.95
30	14	521	41	1.96
30	14	365	35	2.04
30	14	403	38	1.94
30	14	461	39	1.98
30	14	397	37	1.99
30	14	361	36	1.98
30	14	396	39	1.88
30	14	366	36	1.99
30	14	302	35	1.92
30	14	475	38	2.05
30	14	401	36	2.05
30	14	352	36	1.96
30	14	310	35	1.93
30	14	397	37	1.99
4/30	6/14	353	37	1.91
30	14	383	38	1.91
30	14	404	38	1.95
30	14	311	34	1.99
30	14	391	37	1.98
30	14	341	36	1.94
30	14	265	32	2.01
30	14	350	36	1.96
30	14	367	37	1.94
30	14	352	36	1.96
30	14	355	36	1.97
30	14	380	37	1.96
30	14	409	39	1.90
30	14	398	40	1.84
30	14	355	35	2.02
30	14	361	36	1.98
30	14	384	37	1.96
30	14	352	36	1.96
30	14	366	38	1.88
30	14	369	36	1.99
30	14	378	37	1.95
30	14	350	38	1.85
30	14	358	39	1.82
30	14	250	34	1.85
N = 63		385	37	1.95
5/3	6/15	407	37	2.00
3	15	339	37	1.88
3	15	458	39	1.98
3	15	414	38	1.96
3	15	439	38	2.00
3	15	406	36	2.06
3	15	354	36	1.97
3	15	387	39	1.87
3	15	368	37	1.94
3	15	370	36	1.99
4	15	181	29	1.95
5	16	373	36	2.00

Continued...

Table 11. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
5/5	6/16	371	37	1.94	5/5	6/16	387	37	1.97
5	16	379	36	2.01	5	16	335	35	1.98
5	16	380	35	2.07	5	16	286	34	1.94
5	16	502	40	1.99	5	16	377	38	1.90
5	16	414	38	1.96	5	16	406	38	1.95
5	16	398	38	1.94					
5	16	379	36	2.01		N = 57	390	37	1.96
5	16	315	35	1.94					
5	16	386	40	1.82	5/8	6/20	461	38	2.03
5	16	405	40	1.85	8	20	407	36	2.06
5	16	343	34	2.06	8	20	357	34	2.09
5	16	424	36	2.09	8	20	473	39	2.00
5	16	363	37	1.93	8	20	408	37	2.00
5	16	398	36	2.04	8	20	430	38	1.99
5	16	412	39	1.91	8	20	362	36	1.98
5	16	463	40	1.93	8	20	422	37	2.08
5	16	367	37	1.94	8	20	356	36	1.97
5	16	517	40	2.01	8	20	394	37	1.98
5	16	400	38	1.94	8	20	456	38	2.03
5	16	427	37	2.04	8	20	354	37	1.91
5	16	451	39	1.97	8	20	441	38	2.00
5	16	384	36	2.02	8	20	353	35	2.02
5	16	402	38	1.94	8	20	327	34	2.03
5	16	374	37	1.95	8	20	450	38	2.02
5	16	432	39	1.94	8	20	447	39	1.96
5	16	385	37	1.97	8	20	403	36	2.05
5	16	391	38	1.92	8	20	357	36	1.97
5	16	417	39	1.92	8	20	407	37	2.00
5	16	387	38	1.92	8	20	370	36	1.99
5	16	405	39	1.90	8	20	451	39	1.97
5	16	271	34	1.90	8	20	408	37	2.00
5	16	439	39	1.95	8	20	423	39	1.92
5	16	401	38	1.94	8	20	334	32	2.17
5	16	301	35	1.91	8	20	196	31	1.87
5	16	358	37	1.92	8	20	193	31	1.86
5	16	417	38	1.97					
5	16	429	38	1.98		N = 27	387	36	2.00
5	16	447	38	2.01					
5	16	388	38	1.92	6/6	7/19	364	35	2.04
5	16	430	38	1.99	6	19	386	37	1.97

Continued...

Table 11. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
6/7	7/21	456	37	2.08	6/9	8/1	401	35	2.11
7	21	364	36	1.98	9	1	381	37	1.96
7	21	395	37	1.98	9	1	347	36	1.95
7	21	384	36	2.02	9	1	384	37	1.96
7	21	372	37	1.94	9	1	403	36	2.05
7	21	446	37	2.06	9	1	482	39	2.01
7	21	410	38	1.95	9	1	426	37	2.03
7	21	362	36	1.98	9	1	266	34	1.89
7	21	455	38	2.02	9	1	393	36	2.03
7	21	375	36	2.00	9	1	368	35	2.05
7	21	439	38	2.00	9	1	336	35	1.99
7	21	412	36	2.07	9	1	404	36	2.05
7	21	384	36	2.02	9	1	306	33	2.04
7	21	365	36	1.99	9	1	363	36	1.98
7	21	312	34	1.99					
8	20	394	39	1.88		N = 55	392	37	2.00
8	20	389	36	2.03					
8	20	337	35	1.99					
8	20	301	35	1.91					
8	20	397	38	1.93					
8	20	411	38	1.96					
8	20	389	36	2.03					
8	20	410	38	1.95					
8	20	343	35	2.00					
8	20	310	35	1.93					
8	20	408	37	2.00					
8	20	430	37	2.04					
8	20	388	36	2.03					
8	20	422	38	1.97					
9	8/1	430	37	2.04					
9	1	466	39	1.99					
9	1	395	36	2.04					
9	1	396	36	2.04					
9	1	447	37	2.07					
9	1	406	38	1.95					
9	1	423	38	1.98					
9	1	390	35	2.09					
9	1	460	38	2.03					
9	1	449	38	2.02					

Table 13. Individual weight, length and developmental index of chum salmon fry sampled at the tributary to Nurse Lagoon, 1978...mean values follow each week.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
4/4	5/17	398	38	1.94	4/11	5/23	446	37	2.06
4	17	357	36	1.97	11	23	352	35	2.02
4	17	400	37	1.99	11	23	375	37	1.95
4	17	417	38	1.97	11	23	395	38	1.93
4	17	402	37	1.99	11	23	353	35	2.02
4	17	345	36	1.95	11	23	427	36	2.09
4	17	286	36	1.83	11	23	354	36	1.97
4	17	349	37	1.90	11	23	373	37	1.95
4	17	372	38	1.89	11	23	369	35	2.05
4	17	347	35	2.01	11	23	356	37	1.92
4	17	360	34	2.09	11	23	290	33	2.01
5	17	362	35	2.04	11	23	346	35	2.01
5	17	345	34	2.06	11	23	375	37	1.95
5	17	341	32	2.18	12	23	379	37	1.96
5	17	385	35	2.08	12	23	430	38	1.99
6	18	356	37	1.92	12	23	359	36	1.97
6	18	381	36	2.01	12	23	361	36	1.98
7	19	395	38	1.93	12	23	365	35	2.04
7	19	359	35	2.03	12	23	310	35	1.93
7	19	290	37	1.79	12	23	416	36	2.07
8	22	330	36	1.92	12	23	430	39	1.94
8	22	328	34	2.03	12	23	388	37	1.97
8	22	313	34	2.00	12	23	456	39	1.97
8	22	341	36	1.94	12	23	342	35	2.00
8	22	413	38	1.96	12	23	349	36	1.96
8	22	384	38	1.91	12	23	345	35	2.00
8	22	355	36	1.97	12	23	317	32	2.13
8	22	345	35	2.00	12	23	357	36	1.97
8	22	322	37	1.85	12	23	355	35	2.02
8	22	306	36	1.87	13	23	454	38	2.02
9	22	336	33	2.11	13	23	359	34	2.09
9	22	344	35	2.00	13	23	425	37	2.03
9	22	347	37	1.90	13	23	362	36	1.98
9	22	363	35	2.04	13	23	370	36	1.99
					13	23	364	37	1.93
	N = 34	355	36	1.97	13	23	444	38	2.01
					13	23	345	35	2.00
4/10	5/22	431	37	2.04	13	23	406	36	2.06
10	22	437	39	1.95	13	23	362	37	1.93
10	22	442	39	1.95	13	23	374	37	1.95
10	22	344	37	1.89	13	23	361	36	1.98
10	22	362	36	1.98	13	23	400	38	1.94

Continued....

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
4/13	5/23	290	36	1.84	4/15	5/23	351	37	1.91
13	23	366	35	2.04	15	23	382	37	1.96
13	23	377	37	1.95	15	23	338	37	1.88
13	23	330	34	2.03	15	23	384	38	1.91
13	23	273	35	1.85	15	23	355	35	2.02
13	23	382	37	1.96	15	23	337	36	1.93
13	23	358	40	1.78	15	23	359	37	1.92
13	23	359	35	2.03	15	23	342	37	1.89
13	23	376	36	2.00	15	23	362	37	1.93
13	23	356	36	1.97	15	23	326	35	1.97
13	23	342	35	2.00	15	23	349	37	1.90
13	23	370	36	1.99	15	23	370	37	1.94
13	23	428	38	1.98	15	23	345	36	1.95
13	23	328	34	2.03	15	23	443	39	1.95
14	23	445	39	1.96	15	23	390	37	1.97
14	23	404	37	2.00	15	23	367	37	1.94
14	23	345	36	1.95	15	23	351	36	1.96
14	23	397	37	1.99	15	23	311	36	1.88
14	23	338	34	2.05	15	23	390	37	1.97
14	23	432	37	2.04	15	23	435	38	1.99
14	23	355	36	1.97	15	23	405	37	2.00
14	23	381	38	1.91	15	23	374	37	1.95
14	23	358	35	2.03	15	23	290	36	1.84
14	23	444	38	2.01	16	23	303	36	1.87
14	23	340	35	1.99	16	23	286	35	1.88
14	23	369	36	1.99	16	23	286	37	1.78
14	23	393	36	2.03	16	23	345	36	1.95
14	23	355	35	2.02	16	23	353	35	2.02
14	23	369	36	1.99	16	23	342	34	2.06
14	23	320	35	1.95	16	23	374	38	1.90
14	23	290	37	1.79	16	23	347	36	1.95
14	23	357	36	1.97	16	23	343	36	1.94
14	23	376	37	1.95	16	23	355	38	1.86
14	23	385	37	1.97	16	23	337	36	1.93
14	23	370	36	1.99	16	23	355	37	1.91
15	23	379	37	1.96	16	23	438	38	2.00
15	23	357	35	2.02	16	23	342	37	1.89
15	23	375	38	1.90	16	23	357	37	1.92
15	23	404	38	1.95	16	23	331	36	1.92
15	23	365	37	1.93	16	23	355	36	1.97

Continued...

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D
4/16	5/23	319	36	1.90
16	23	369	36	1.99
16	23	345	35	2.00
16	23	370	36	1.99
16	23	347	35	2.01
16	23	341	36	1.94
N = 133		367	36	1.97
4/17	6/1	358	35	2.03
17	1	354	37	1.91
17	1	369	38	1.89
17	1	364	37	1.93
17	1	347	35	2.01
17	1	355	37	1.91
17	1	426	38	1.98
17	1	359	37	1.92
17	1	315	35	1.94
13	1	372	37	1.94
18	1	341	36	1.94
18	1	341	35	2.00
18	1	361	36	1.98
18	1	361	37	1.92
18	1	411	38	1.96
18	1	355	36	1.97
18	1	340	36	1.94
18	1	351	38	1.86
18	1	336	35	1.99
18	1	348	35	2.01
18	1	376	37	1.95
18	1	266	35	1.84
18	1	242	34	1.83
18	1	337	37	1.88
18	1	460	40	1.93
18	1	325	35	1.96
18	1	315	36	1.89
18	1	288	35	1.89
18	1	414	38	1.96
18	1	332	35	1.98
4/22	6/6	398	37	1.99
22	6	406	40	1.85
22	6	378	37	1.95
22	6	441	40	1.90
22	6	520	43	1.87
22	6	348	36	1.95
22	6	353	40	1.77
22	6	379	39	1.86
22	6	418	40	1.87
22	6	416	40	1.87
22	6	365	37	1.93
22	6	371	38	1.89
22	6	426	38	1.98
22	6	447	40	1.91
22	6	359	37	1.92
22	6	371	38	1.89
22	6	322	38	1.80
22	6	435	37	2.05
22	6	389	39	1.87
22	6	427	39	1.93
22	6	354	35	2.02
22	6	416	40	1.87
22	6	296	36	1.85
22	6	421	39	1.92
22	6	379	38	1.90
N = 55		370	37	1.92
4/24	6/6	425	40	1.88
24	6	393	38	1.93
24	6	422	41	1.83
24	6	437	40	1.90
24	6	376	40	1.80
24	6	436	40	1.90
24	6	374	37	1.95
24	6	372	38	1.89
24	6	348	36	1.95
24	6	401	39	1.89
24	6	375	37	1.95

Continued...

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
4/24	6/6	404	40	1.85	4/30	6/13	391	36	2.03
24	6	374	37	1.95	30	13	425	40	1.88
24	6	440	40	1.90	30	13	368	37	1.94
24	6	361	37	1.92	30	13	369	38	1.89
24	6	407	38	1.95	30	13	308	34	1.99
24	6	339	39	1.79	30	13	318	34	2.01
24	6	409	38	1.95	30	13	339	36	1.94
24	6	411	39	1.91	30	13	292	32	2.07
24	6	459	40	1.93	30	13	406	40	1.85
24	6	405	40	1.85	30	13	361	36	1.98
24	6	323	38	1.81	30	13	378	36	2.01
24	6	488	41	1.92	30	13	302	35	1.92
24	6	416	38	1.96	30	13	304	36	1.87
24	6	373	37	1.95	30	13	348	37	1.90
24	6	392	38	1.93	30	13	354	36	1.97
24	6	416	39	1.91	30	13	336	36	1.93
24	6	403	39	1.89	30	13	329	35	1.97
24	6	417	39	1.92	30	13	347	37	1.90
24	6	365	38	1.88	30	13	341	39	1.84
24	6	401	39	1.89	30	13	293	35	1.90
24	6	375	40	1.80	30	13	406	38	1.95
24	6	288	33	2.00	30	13	362	37	1.93
24	6	354	37	1.91	30	13	338	36	1.93
27	8	410	39	1.90	30	13	341	36	1.94
27	8	269	35	1.84	30	13	335	36	1.93
27	8	320	35	1.95	30	13	335	36	1.93
27	8	346	36	1.95	30	13	318	34	2.01
27	8	382	37	1.96	30	13	324	35	1.96
27	8	323	36	1.91	30	13	325	34	2.02
27	8	364	38	1.88	30	13	312	35	1.94
27	8	324	35	1.96	30	13	339	35	1.99
27	8	416	39	1.91	30	13	310	34	1.99
27	8	326	35	1.97	30	13	361	36	1.98
27	8	272	33	1.96	30	13	297	34	1.96
27	8	320	37	1.85	30	13	278	34	1.92
27	8	308	34	1.98	30	13	319	34	2.01
27	8	347	36	1.95	30	13	324	35	1.96
27	8	288	36	1.83	30	13	330	36	1.92
27	8	404	38	1.95	30	13	300	35	1.91
27	8	348	37	1.90	30	13	412	37	2.01

Continued...

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D
4/30	6/13	358	38	1.87
30	13	329	46	1.50
30	13	357	38	1.87
30	13	296	36	1.85
30	13	350	37	1.90
30	13	252	34	1.86
30	13	332	36	1.92
30	13	302	34	1.97
30	13	370	37	1.94
30	13	391	36	2.03
30	13	347	38	1.85
30	13	314	35	1.94
30	13	312	35	1.94
30	13	427	39	1.93
30	13	343	35	2.00
30	13	283	34	1.93
30	13	388	36	2.03
30	13	295	34	1.96
30	13	347	37	1.90
30	13	304	35	1.92
30	13	341	37	1.89
30	13	289	36	1.84
30	13	329	36	1.86
30	13	298	34	1.96
30	13	341	37	1.89
30	13	293	33	2.01
30	13	305	36	1.87
30	13	290	33	2.01
30	13	352	35	2.02
30	13	327	37	1.86
30	13	329	35	1.97
30	13	315	36	1.89
30	13	334	36	1.93
30	13	317	36	1.89
30	13	296	36	1.85
30	13	334	36	1.93
30	13	312	34	1.99
30	13	286	34	1.94
30	13	329	35	1.97
N = 130		347	37	1.92
5/7	6/20	444	37	2.06
7	20	478	39	2.00
7	20	360	36	1.98
7	20	373	39	1.85
7	20	404	37	2.00
7	20	405	36	2.06
7	20	414	38	1.96
7	20	404	36	2.05
7	20	380	37	1.96
7	20	404	37	2.00
7	20	362	35	2.04
7	20	297	34	1.96
7	20	347	36	1.95
7	20	346	36	1.95
7	20	322	36	1.90
7	20	468	38	2.04
7	20	308	33	2.05
7	20	392	35	2.09
7	20	323	34	2.02
7	20	359	36	1.97
7	20	336	34	2.04
7	20	315	33	2.06
7	20	304	34	1.98
7	20	330	34	2.03
7	20	346	35	2.01
10	23	405	37	2.00
10	23	322	33	2.08
10	23	330	34	2.03
10	23	345	34	2.06
N = 29		354	36	2.01
6/6	7/19	464	38	2.04
6	19	363	35	2.04
6	19	401	36	2.05
6	19	466	38	2.04
6	19	389	37	2.97
6	19	492	38	3.08
6	19	384	35	2.08
6	19	364	35	2.04
6	19	409	35	2.06

Continued...

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
6/6	7/19	344	34	2.06	6/7	7/24	334	35	1.98
6	19	394	37	1.98	7	24	452	38	2.02
6	19	341	34	2.06	7	24	408	35	2.12
6	19	475	38	2.05	7	24	389	37	1.97
6	19	343	35	2.00	7	24	351	34	2.07
6	19	369	35	2.05	7	24	403	38	1.94
6	19	518	38	2.11	7	24	407	36	2.06
6	19	371	37	1.94	7	24	364	37	1.93
6	19	369	36	1.99	7	24	359	35	2.03
6	19	402	37	1.99	7	24	397	36	2.04
6	19	397	36	2.04	7	24	405	37	2.00
6	19	338	35	1.99	7	24	371	35	2.05
6	19	306	33	2.04	7	24	362	35	2.04
7	24	405	36	2.06	7	24	383	35	2.07
7	24	358	35	2.03	7	24	354	35	2.02
7	24	386	36	2.02	7	24	398	37	1.99
7	24	397	36	2.04	7	24	387	36	2.01
7	24	467	38	2.04	7	24	406	37	2.00
7	24	501	38	2.09	7	24	419	36	2.08
7	24	407	37	2.00	7	24	347	35	2.01
7	24	373	35	2.06	7	24	353	35	2.02
7	24	397	36	2.04	7	24	327	35	1.97
7	24	388	36	2.03	7	24	287	33	2.00
7	24	366	37	1.93	8	20	374	36	2.00
7	24	392	37	1.98	8	20	394	36	2.04
7	24	415	36	2.07	8	20	412	37	2.01
7	24	421	37	2.03	8	20	386	36	2.02
7	24	404	36	2.05	8	20	294	34	1.96
7	24	367	37	1.94	8	20	433	38	1.99
7	24	430	37	2.04	8	20	430	36	2.10
7	24	386	36	2.02	8	20	417	37	2.02
7	24	396	36	2.04	8	20	407	36	2.06
7	24	294	33	2.01	8	20	406	36	2.06
7	24	271	33	1.96	8	20	397	35	2.10
7	24	319	34	2.01	8	20	378	36	2.01
7	24	398	36	2.04	8	20	377	36	2.01
7	24	414	37	2.01	8	20	319	35	1.95
7	24	420	36	2.08	8	20	407	37	2.00
7	24	397	36	2.04	8	20	410	37	2.01

Continued...

Table 13. Continued.

Date caught	Date measured	Weight in mg	Length in mm	K_D	Date caught	Date measured	Weight in mg	Length in mm	K_D
6/8	7/20	380	35	2.07		N = 133	388	36	2.02
8	20	349	35	2.01					
8	20	373	36	2.00					
8	20	355	34	2.02					
8	20	358	35	2.03					
8	20	426	38	1.98					
8	20	393	37	1.98					
8	20	404	37	2.00					
8	20	393	36	2.03					
8	20	426	38	1.98					
8	20	321	34	2.01					
8	20	416	37	2.02					
9	31	395	36	2.04					
9	31	457	38	2.03					
9	31	359	36	1.97					
9	31	293	33	2.01					
9	31	424	36	2.09					
9	31	545	38	2.15					
9	31	496	38	2.08					
9	31	313	34	2.00					
9	31	379	36	2.01					
9	31	396	37	1.98					
9	31	329	35	1.97					
9	31	390	36	2.03					
9	31	371	35	2.05					
9	31	330	35	1.97					
9	31	408	37	2.00					
9	31	318	35	1.95					
9	31	325	35	1.96					
9	31	393	37	1.98					
9	31	310	35	1.93					
9	31	330	34	2.03					
9	31	339	35	1.99					
9	31	349	36	1.96					
9	31	385	35	2.08					
9	31	410	37	2.01					
9	31	450	37	2.07					
9	31	388	35	2.08					
9	31	317	34	2.01					
9	31	319	34	2.01					

Table 14. Individual weight and length of chum salmon sec-fry sampled at the tributary to Russell Creek, 1978...mean values in summary.

Date taken	Date measured	Weight in mg	Length in mm	Date taken	Date measured	Weight in mg	Length in mm
3/21	5/17	339	34	3/22	5/16	311	31
21	17	335	35	22	16	206	33
21	17	317	32	22	16	247	31
21	17	296	31	22	16	297	32
21	17	286	31	22	16	301	31
21	17	240	34	22	16	202	32
21	17	210	32	22	16	321	33
21	17	316	34	22	16	215	34
21	17	306	34	22	16	298	31
22	16	236	32	22	16	265	32
22	16	318	31	22	16	307	33
22	16	306	34	22	16	304	32
22	16	237	30	22	16	218	33
22	16	307	31	22	16	179	28
22	16	312	31	22	16	150	26
22	16	223	33	22	16	210	32
22	16	318	33	22	16	283	32
22	16	243	33	22	16	244	30
22	16	203	32	22	16	232	32
22	16	238	33	22	16	289	28
22	16	288	29	22	16	320	32
22	16	304	31	22	16	312	33
22	16	315	32	22	16	159	30
22	16	300	31				
22	16	316	32		N = 62	271	32
22	16	320	31				
22	16	231	31	4/3	5/17	338	34
22	16	236	31	3	17	337	36
22	16	235	33	3	17	333	33
22	16	276	31	3	17	357	36
22	16	229	33	3	17	382	35
22	16	269	31	3	17	335	35
22	16	300	32	3	17	377	37
22	16	244	32	3	17	295	33
22	16	250	33	3	17	312	33
22	16	301	31	3	17	301	36
22	16	309	32	3	17	364	37
22	16	296	30	3	17	358	36
22	16	299	33	3	17	392	37

Continued...

Table 14. Continued.

Date taken	Date measured	Weight in mg	Length in mm	Date taken	Date measured	Weight in mg	Length in mm
4/3	5/17	313	35	4/3	5/17	331	36
3	17	386	37	3	17	336	36
3	17	374	38	3	17	378	37
3	17	278	32				
3	17	269	33		N = 55	340	35
3	17	338	35				
3	17	375	36				
3	17	398	37				
3	17	396	37				
3	17	299	38				
3	17	250	35				
3	17	286	35				
3	17	415	38				
3	17	355	36				
3	17	318	35				
3	17	298	31				
3	17	310	34				
3	17	313	32				
3	17	372	39				
3	17	365	36				
3	17	405	38				
3	17	397	38				
3	17	272	35				
3	17	361	37				
3	17	277	33				
3	17	342	34				
3	17	374	39				
3	17	362	37				
3	17	321	33				
3	17	324	35				
3	17	342	36				
3	17	362	37				
3	17	321	33				
3	17	310	34				
3	17	295	33				
3	17	407	38				
3	17	376	38				
3	17	276	31				
3	17	345	37				

Table 16. Individual weight and length of wild chum salmon fry taken at Nurse Lagoon, 1978...mean values in summary.

Date caught	Date measured	Weight in mg	Length in mm
4/17	6/1	426	39
17	1	341	37
17	1	390	36
17	1	416	37
17	1	516	41
17	1	449	39
17	1	386	37
17	1	402	38
17	1	401	39
17	1	387	39
17	1	441	38
17	1	357	38
17	1	376	37
17	1	426	39
17	1	455	39
17	1	432	38
17	1	397	38
17	1	505	42
17	1	385	37
17	1	486	40
17	1	308	34
17	1	388	38
17	1	374	38
17	1	444	39
17	1	431	38
17	1	379	37
	N = 26	412	38
4/25	6/6	364	39
25	6	425	38
25	6	346	37
25	6	358	37
25	6	226	35
25	6	288	36
25	6	338	37
25	6	389	39
25	6	299	36
25	6	410	38
4/25	6/6	347	38
25	6	341	37
25	6	419	40
25	6	396	39
25	6	414	39
25	6	320	36
25	6	280	35
25	6	399	38
25	6	327	35
25	6	297	37
25	6	349	37
25	6	319	37
25	6	416	40
25	6	293	36
	N = 24	348	37
5/2	6/14	384	36
2	14	328	35
2	14	409	38
2	14	402	37
2	14	348	36
2	14	347	37
2	14	390	38
2	14	304	36
2	14	301	36
2	14	393	36
2	14	324	35
2	14	388	38
2	14	351	36
2	14	363	36
2	14	392	37
2	14	306	34
2	14	389	38
2	14	332	34
2	14	341	36
2	14	326	35
2	14	428	36
2	14	331	36

Continued...

Table 16. Continued.

Date caught	Date measured	Weight in mg	Length in mm
5/2	6/14	375	38
2	14	393	37
2	14	310	34
2	14	401	38
2	14	373	37
	N = 27	360	36
5/10	6/23	406	38
10	23	393	36
10	23	332	34
10	23	326	35
10	23	324	34
10	23	520	40
10	23	398	37
10	23	416	36
10	23	398	37
10	23	333	37
10	23	391	38
10	23	371	37
10	23	335	35
10	23	359	36
10	23	292	31
10	23	392	37
10	23	363	36
10	23	404	36
10	23	315	34
10	23	426	37
10	23	382	36
10	23	283	34
10	23	376	36
10	23	323	35
10	23	365	36
10	23	384	36
10	23	289	33
10	23	373	35
	N = 28	367	36
5/30	7/11	443	38
30	11	460	38
30	11	393	36
5/30	7/11	397	37
30	11	329	36
30	11	403	36
30	11	464	38
30	11	520	40
30	11	398	37
30	11	366	35
30	11	469	39
30	11	541	39
30	11	439	37
30	11	412	36
30	11	373	36
30	11	472	36
30	11	429	38
30	11	447	37
30	11	405	35
30	11	470	36
30	11	451	38
30	11	421	37
30	11	328	35
30	11	372	36
30	11	347	35
	N = 25	422	37
6/1	7/14	522	38
1	14	586	38
1	14	505	38
1	14	454	37
1	14	504	38
1	14	415	37
1	14	463	38
1	14	430	38
1	14	398	37
1	14	439	38
1	14	420	36
1	14	519	40
1	14	401	37
1	14	390	35
1	14	394	38
1	14	401	37
1	14	427	39

Continued...

Table 16. Continued.

Date caught	Date measured	Weight in mg	Length in mm
6/1	7/14	494	38
1	14	420	37
1	14	462	39
1	14	314	35
1	14	386	36
1	14	415	36
1	14	332	34
1	14	373	36
1	14	325	34
1	14	390	37
	N = 27	429	37
6/29	8/11	1114	48
29	11	969	46
29	11	770	43
29	11	495	39
29	11	806	46
29	11	919	46
29	11	959	46
29	11	872	45
29	11	525	39
29	11	393	35
29	11	965	46
29	11	759	43
29	11	890	45
29	11	703	42
29	11	893	45
29	11	629	41
29	11	707	42
29	11	820	44
29	11	813	43
29	11	596	40
29	11	593	39
29	11	490	38
29	11	458	36
29	11	597	39
29	11	496	39
	N = 25	729	42