Biological Reconnaissance of Mathers and Pallant Creeks, Queen Charlotte Islands, December 1977 to December 1978

B. G. Shepherd

Salmonid Enhancement Program
Department of Fisheries and Oceans
Vancouver, British Columbia V6E 2P1

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Errata for Shepherd, B.G. 1982. Biological reconnaissance of Mathers and Pallant Creeks, Queen Charlotte Islands, December 1977 to December 1978. Can. MS Rep. Fish Aquat. Sci. No. 1648: vi + 121 p.

ERRATA

Pg #	Subject Heading	Current Statement	Corrected Statement
ii	Correct citation for this publication	Aquat. Sci. ____:	Aquat. Sci. No. 1648
18	Mathers Well Water	Mathers ground water was notable	Mathers ground water was notably
28	Suspended Solids	... levels rose to 12 mg/l	... levels rose to 121 mg/l
65	Species Distributions	... were observed spawing	... were observed spawning
73	Chadsey Creek	This suggests that Carmichael	This suggests that Chadsey
75	Discussion	... the incubation period_	... the incubation period)

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BIOLOGICAL RECONNAISSANCE OF MATHERS AND PALLANT CREEKS, QUEEN CHARLOTTE ISLANDS, DECEMBER 1977 TO DECEMBER 1978

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B.G. Shepherd

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Department of Fisheries and Oceans

Vancouver, B.C. V6E 2P1

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ABSTRACT

The results of Salmonid Enhancement Program studies of the water quality and juvenile salmonid populations of Pallant and Mathers Creeks for the calendar year 1978 are presented. Data include weather records, water quality, incubation, fry migration, predator/competitor, and habitat studies, primarily for chum and coho salmon. Probable water quality problems (dealing specifically with suspended solids loadings in surface waters, ammonia levels in well water, and possibly zinc levels in all sources) were identified. Analyses of stream algal populations indicated a potential for fouling of incubating eggs. Monitoring of water temperatures at both creeks, Mosquito Lake, and Cumshewa Inlet pointed up potential problems for rearing fish at Mathers Creek and in the outlet area of Mosquito Lake. Hydraulic sampling and monitoring of fry migrations aided in further defining spawning distributions, and suggested a significant underestimate of the abundance of spawners at Pallant in 1977. Freshwater and estuarine rearing of chum fry was found to be minimal for both stocks. Chum and coho fry growth parameters and rates were found to be similar to those found for other British Columbia stocks. Evaluation of physical habitat and the potential competitors and predators of chum and coho fry in the Pallant system indicated that chum fry should be reared in seapens near the Pallant estuary, and coho fry should be released into Pallant Creek above the lake.

KEY WORDS: Queen Charlotte Islands, chum, coho, *Oncorhynchus keta*, *Oncorhynchus kisutch*, water quality, juveniles, migration, freshwater rearing, estuarine rearing.

RÉSUMÉ

Ce rapport présente les résultats des études, faites en 1978 dans le cadre du Programme de mise en valeur des salmonidés, sur la qualité l'eau et les populations de saumons juvéniles des ruisseaux Pallant et Mathers. Des données sont fournies sur la température, la qualité de l'eau, l'incubation, la migration des alevins, les prédateurs et compétiteurs, et concernant des études de l'habitat, surtout des saumons kétas et cohos. On a identifié les problèmes probables de qualité de l'eau découlant en particular des charges de solides en suspension dans les eaux de surface, les niveaux d'ammoniaque dans l'eau de puits et les niveaux possibles de zinc dans toutes les sources). Les analyses des populations algales des ruisseaux ont démontré un potentiel de pollution des oeufs en incubation. L'observation suivie des températures de l'eau des deux ruisseaux, du lac Mosquito et de l'inlet Cumshewa a fait ressortir les problèmes potentiels d'élevage de poissons au ruisseau Mathers et à la sortie du lac Mosquito. L'échantillonnage hydraulique et l'observation suivie des migrations d'alevins ont permis une meilleure délimitation des répartitions de fraie et font entrevoir une sous-évaluation sensible de l'abondance des géniteurs au ruisseau Pallant en 1977. L'élevage en eau douce et en eau saumâtre des alevins de saumon kéta a été minime pour les deux stocks. Les paramètres et les taux de croissance des alevins de saumons kéta et coho sont semblables à ceux des autres stocks de la Colombie-Britannique. L'evaluation de l'habitat physique et des compétiteurs et prédateurs potentiels des alevins de saumons kéta et coho dans le réseau fluvial Pallant a démontré que les alevins de saumon coho devraient être élevés dans des parcs en filet pres de l'estuaire du ruisseau Pallant et que les alevins de saumon kéta devraient être relâchés dans le ruisseau Pallant en amont du lac.

Mots-clés: île Reine-Charlotte, saumon kéta, saumon coho, Oncorhynchus keta, Oncorhynchus kisutch, qualité de l'eau, juvéniles, migration, élevage en eau douce, élevage en eau saumatre.

INTRODUCTION

In 1976, the North Coast Geographic Working Group of the Salmonid Enhancement Program selected Pallant and Mathers Creeks (Figs. 1 - 3) as chum salmon streams with high potential for enhancement. The Salmonid Enhancement Program began investigation of these two creeks in August, 1977. A previous report (Shepherd, 1978) presented the data available up to December, 1977, pertaining to the water quality and chum salmon spawning populations of Pallant and Mathers Creeks. The present report provides analyses of the 1978 juvenile data collected by the Salmonid Enhancement Program from these two creeks. Program activities in 1978 included weather records, water quality, incubation, fry migration, predator/competitor, and habitat studies. Coho were examined concurrently with the chum populations, as minor enhancement of the coho stocks is also planned for both sites. In addition, data from 1977 on the algal populations of both creeks are presented in this report.

P. McCart Biological Consultants were retained to carry out the 1978 adult bio-reconnaissance studies at Mathers Creek, and a report has been completed (Glova *et al.*, MS 1979). All adult work at Pallant Creek will be included in a forthcoming, separate report on the 1978 pilot hatchery operation.

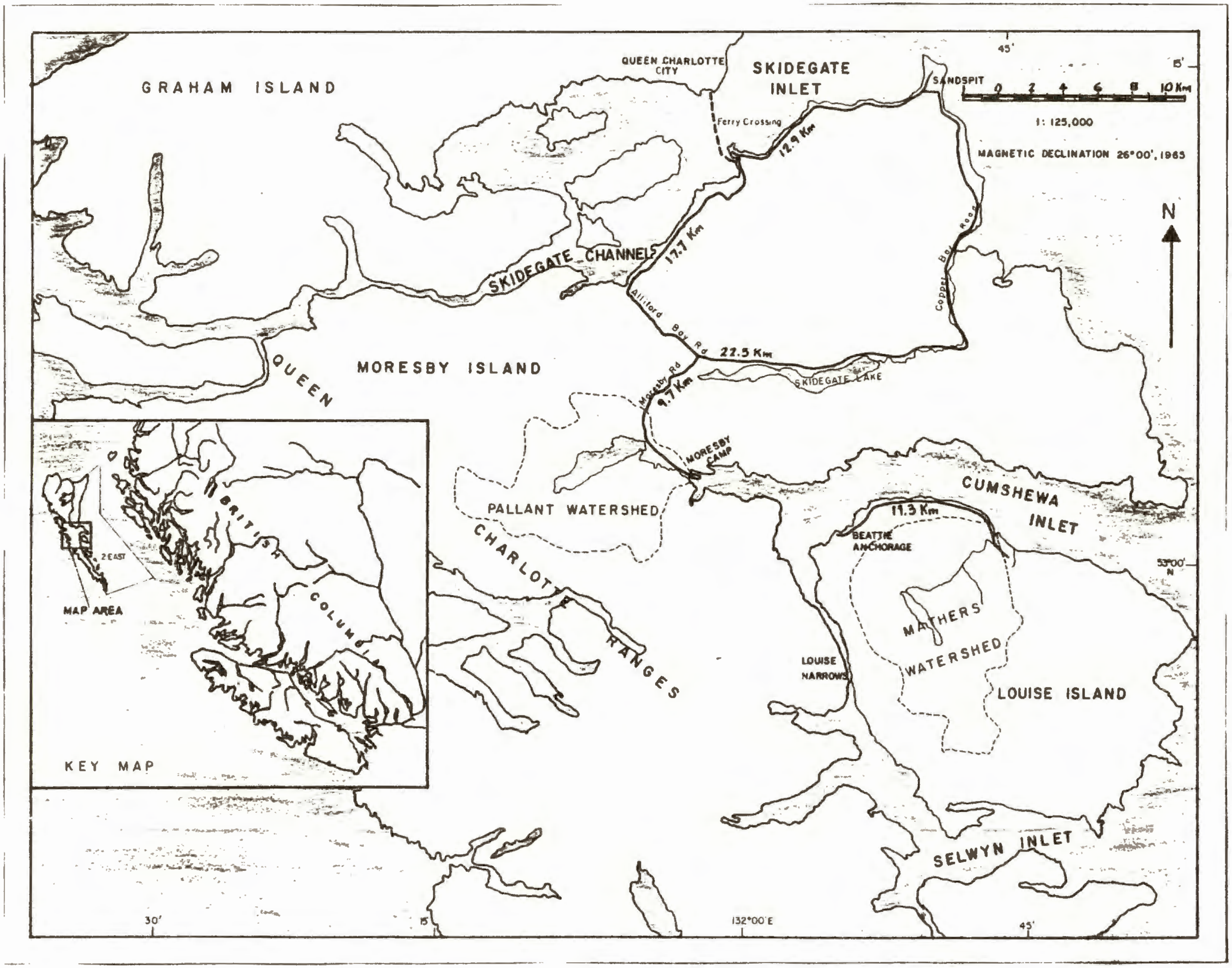

Figure 1: Geographic location of Pallant and Mathers Creeks.

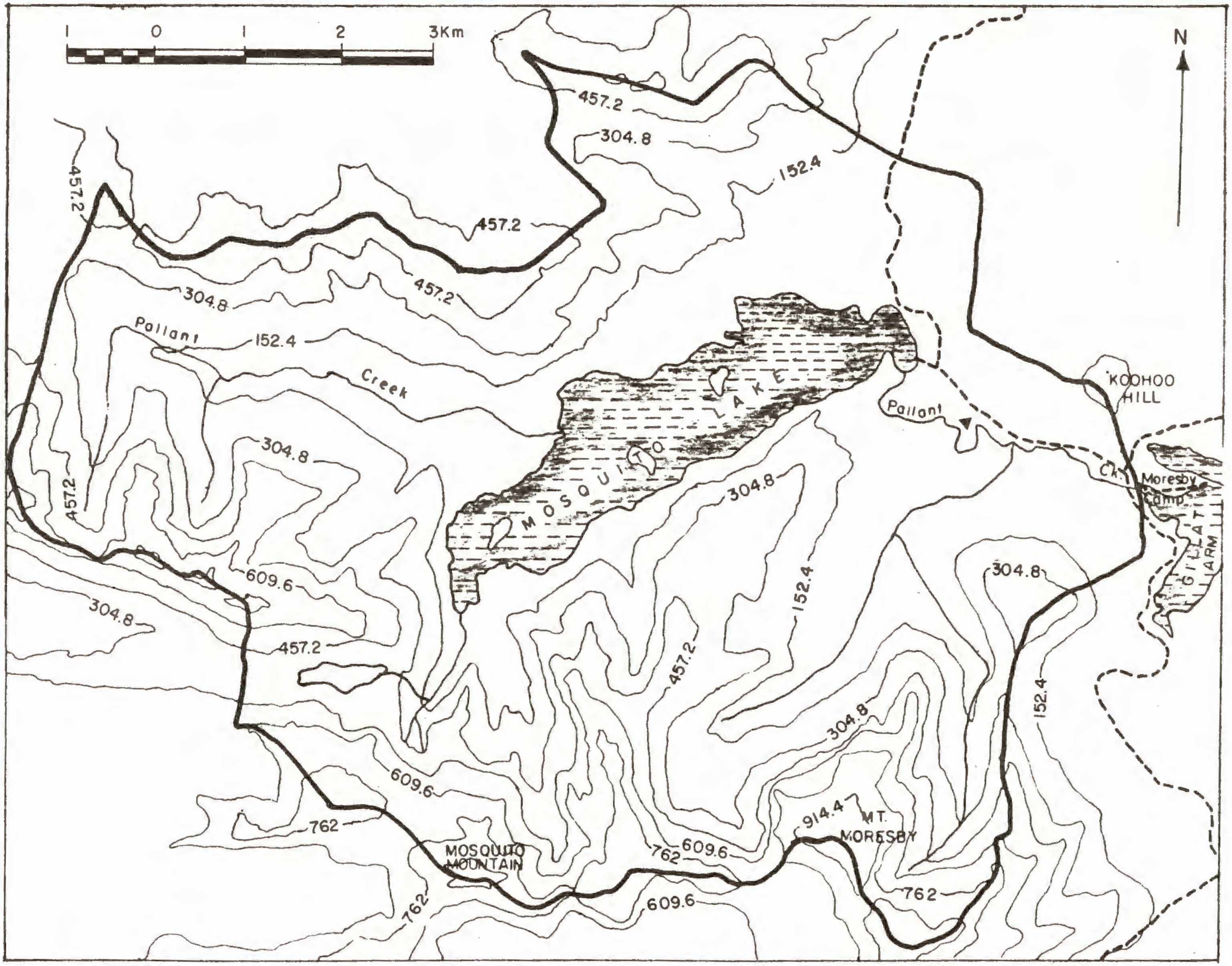

Figure 2: Topographical map of Pallant watershed.

▼ (Project site)

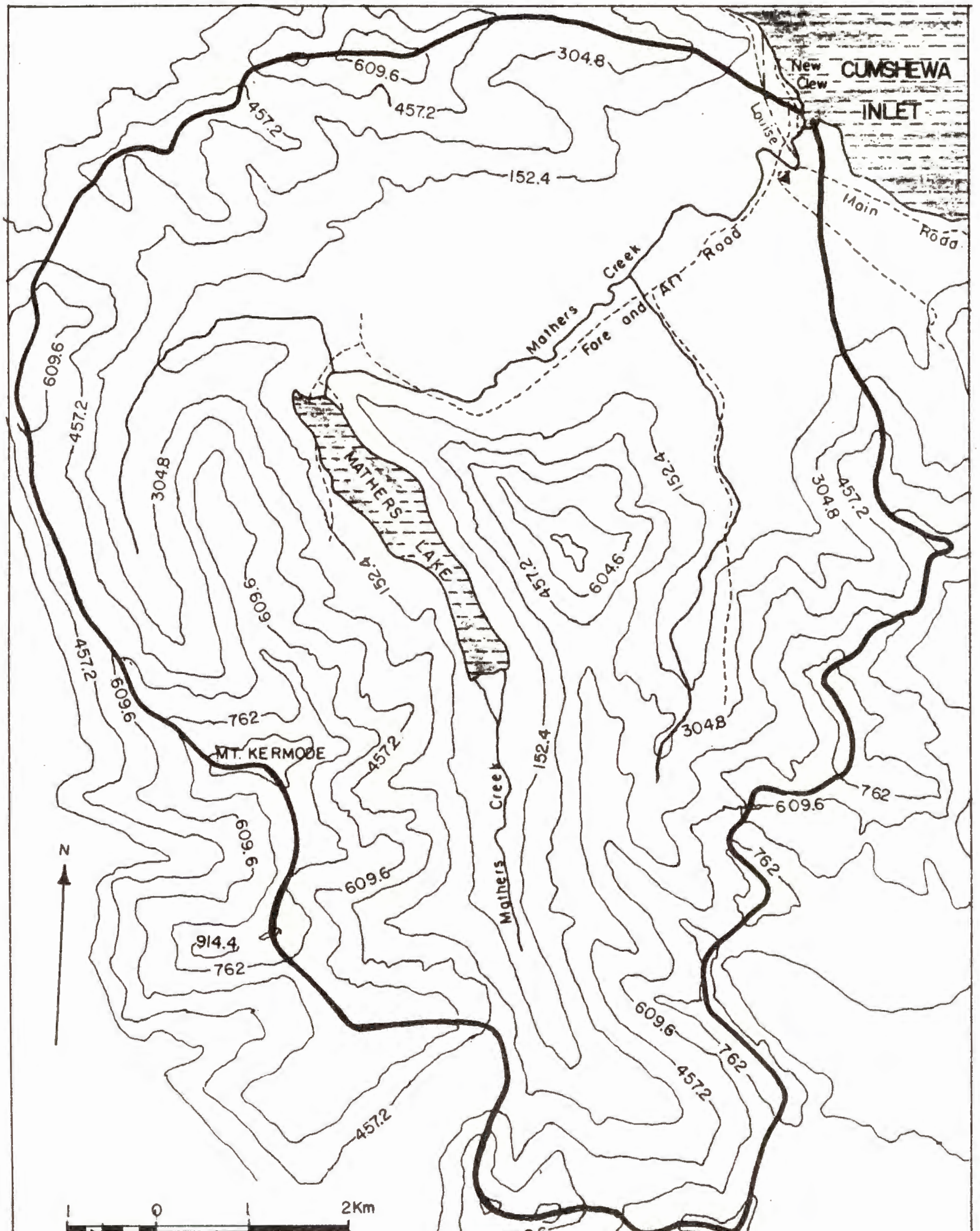

Figure 3: Topographical map of Mathers watershed.

▼ (Project site)

METHODS

WEATHER RECORDS

It was noted during the 1977 fall program that rainfall at the Sandspit airport appeared to vary considerably from that experienced at Mathers and Pallant Creeks. An AES standard thermometer shelter was erected at the Pallant hatchery site, and a Taylor 2701 rain gauge and 545-C maximum-minimum thermometer were installed. Beginning April 14, 1978, daily readings were taken at 0730 - 0800 h.

WATER QUALITY SAMPLING

A full sampling series was done routinely each month at Pallant Creek (poor weather often restricted access to Mathers Creek). Each series consisted of the following:

Sample Size	Analyses Requested	Preservation and Storage	Analytical Group
2.0 ℓ	NO_3, NO_2, TPO_4, SiO_2, SO_4, FR/NFR	refrigerated	EPS/FMS lab.
0.2 ℓ	Extractable Metals (see Table 3 for listing)	1 ml conc. HNO added; refrigerated	"
1.0 ℓ	Particle Size	refrigerate or freeze	CanTest
1.0 ℓ	Algal Species-Size, Composition and Abundance	sample added to 25 ml Lugol's sol'n; kept dark (additional Lugol added as required to maintain amber colour).	UBC (to Apr 78) Beak (to Mar 79)

Particle size samples also were taken whenever the creek water was high or turbid. Sampling and analysis methods except for algal samples, were given in

Shepherd (1978). The analysis methods for the algal samples are given in Appendix 1. In addition to sampling the creek water for algae, a test stack of nine Heath trays was installed at Pallant on January 27, 1976, utilizing a gravity-fed water line from the hatchery intake area. This water line suffered a broken connection at some time previous to April 12, 1977. The second and eighth trays (from the top) were scrubbed clean on April 25 and the flow restored. A one-liter sample of the wash water from each tray was taken after allowing the larger fines to settle, and was examined for algae.

Two groundwater test wells were drilled near the outlet of Mathers Creek during September, 1978. The second well drilled was the first pumped, and was sampled 7 - 10.5 h after pumping commenced on October 8, 1978. On-site testing included use of a Weiss saturometer to determine total dissolved gas pressures, Winkler oxygen determinations, use of a Hach DR-EL kit to determine the presence of any gross pollutants and measurements of water temperature by pocket thermometer. The other well was sampled on October 13, 2 - 4.5 h after pumping commenced. On-site testing was done using the Hach DR-EL kit, a Hach large-sample oxygen kit and a pocket thermometer. Samples for nutrients, extractable metals, and particle size were taken at the end of the sampling period on both days and shipped by air to the EPS-FMS Vancouver laboratory for analysis.

Water temperatures were monitored using 31-day Wexler recording thermographs, located upstream of the intake at the Pallant hatchery site, and upstream of the fry trapping site at Mathers Creek. The Mathers Creek records are incomplete, as a falling tree damaged the thermograph; spot temperatures were taken with a pocket thermometer, and an instream Taylor maximum-minimum thermometer and a Ryan 30-day thermograph were also used. Weekly surface temperatures were taken with a pocket thermometer at various points throughout Cumshewa Inlet during spring. Three vertical temperature stations were established in Mosquito Lake (Fig. 8) and were sampled at least monthly (see Habitat Survey Methods section for further details).

For water levels, staff gauges were installed on both creeks near the fry trapping sites, and were read daily.

INCUBATION STUDY

To evaluate the progress of development and the survival of Pallant chum eggs/alevins, a sampling program was carried out January 10 - 12, 1978, using a standard "Alaskan" backpack hydraulic sampler (Fig. 4), and a circular metal-frame net enclosing 1.0 sq. ft. (.093 sq. m), similar to the design described by McNeil (1964). Eight sampling areas were selected on the basis of adult spawning in 1977 (Fig. 5). In each of these areas, the best substrate available near either bank and at the centre of the stream was sampled. Usually, three of these cross-sections (top, middle, and bottom) were sampled, but fewer were done in areas 5, 7 and 8, because of limited availability of suitable gravel. For each site, the numbers and stage of development of live and dead eggs and alevins were recorded.

FRY MIGRATION STUDIES

On both creeks, two inclined plane traps (0.6 x 0.9 m mouth) suspended from a cable (Fig. 6) were used to monitor the freshwater phase of migration. One trap was fished continuously at the same location (Fig. 7) during the periods April 6 - June 15 at Pallant Creek, and April 6 - May 22 at Mathers Creek. The second incline plane was set for 24 h on various dates throughout the migration period and at various points in the cross-section, to determine the lateral variation in fry passage and thus estimate the total fry run. In the shallower areas where the inclined plane traps were unable to fish properly, fyke nets (#281 marquisette mesh; mouth opening 0.6 x 0.9 m at Pallant, 0.3 x 0.6 m at Mathers) with attached live boxes (similar to Craddock, 1961; see also Fig. 6) were used. A fyke net (0.6 x 0.9 m mouth) with a detachable cod end was also used at Pallant to periodically check fry migration prior to installation of the inclined plane traps, and afterwards at various locations upstream in both systems to check fry distributions. The routine fry trapping sites were located just above tidal influence on both streams, and in both instances were just upstream of the adult counting fence sites used in 1977. Besides using cross-sectional variations in catches to determine the total fry run,

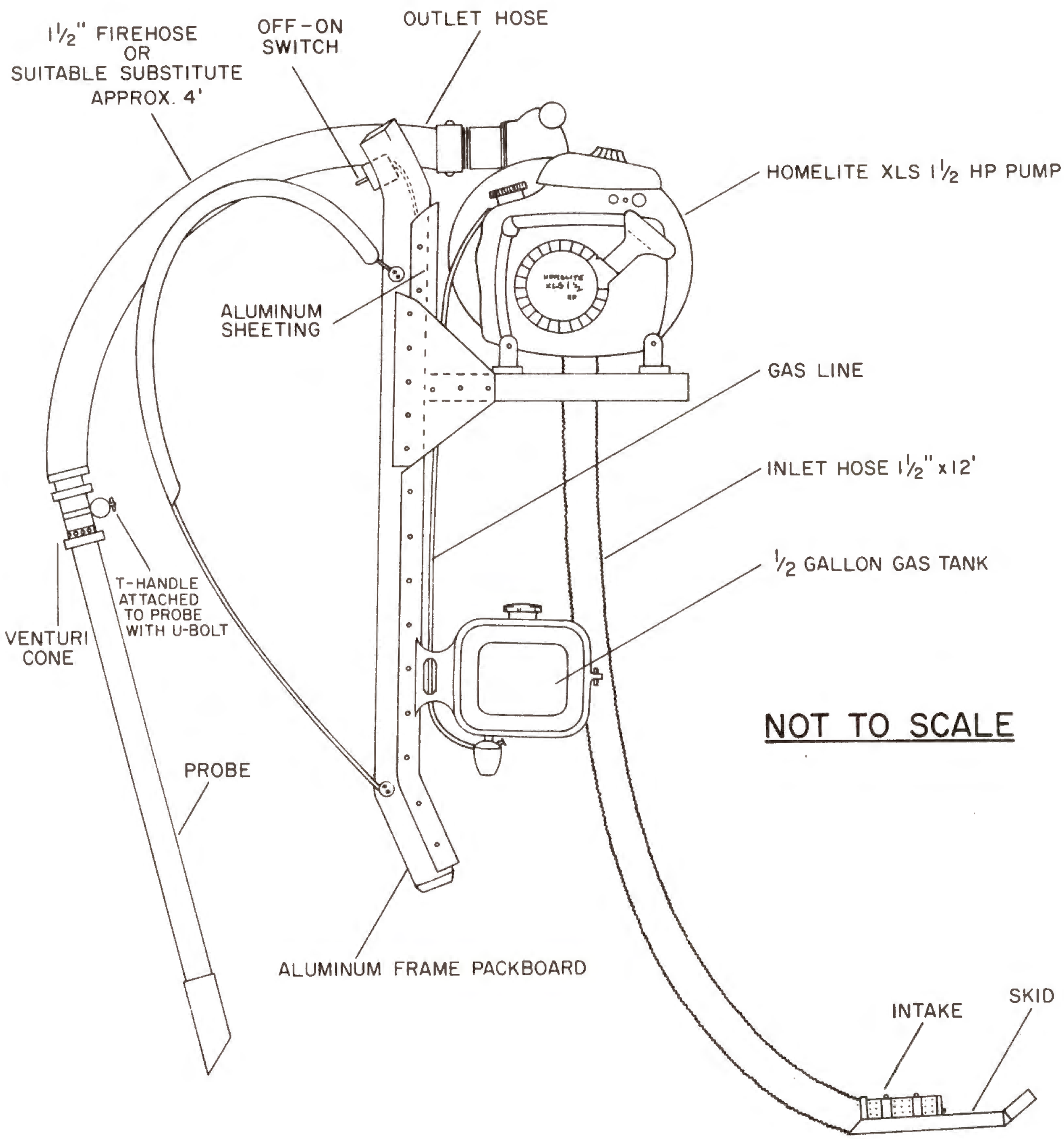

Figure 4: Sketch of "Alaskan" backpack hydraulic sampler used in Pallant Creek incubation study, 1978.

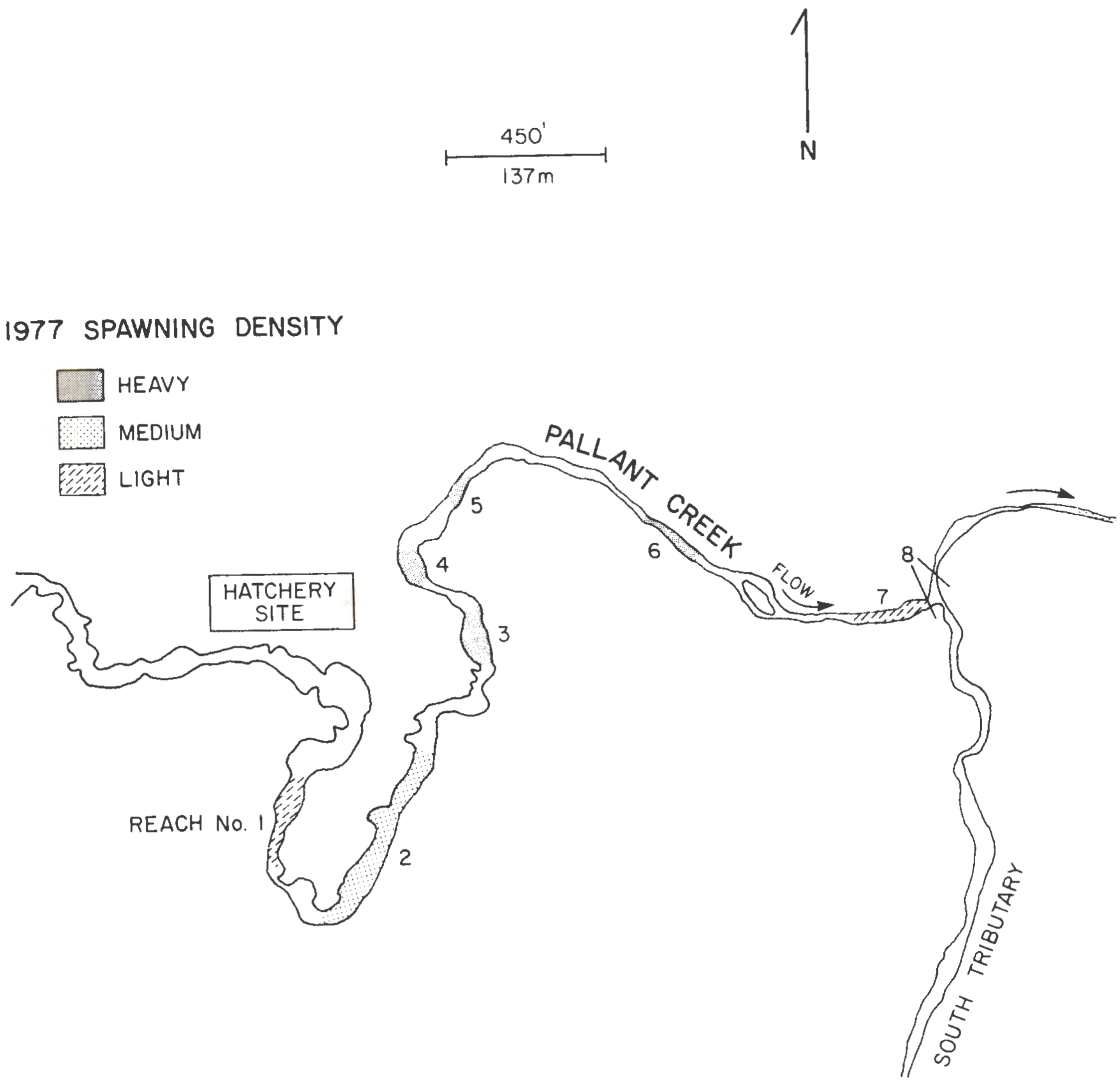

Figure 5: Distribution of adult chum spawners in Pallant Creek for 1977, and areas numbered where hydraulic sampling was done in February, 1978.

Figure 6: Equipment used to trap migrant chum fry at Pallant Creek in 1978. Fyke net with trailing live box at bottom of photo; incline plane in fishing position at centre of photo; beached incline plane (rear to camera) at top of photo.

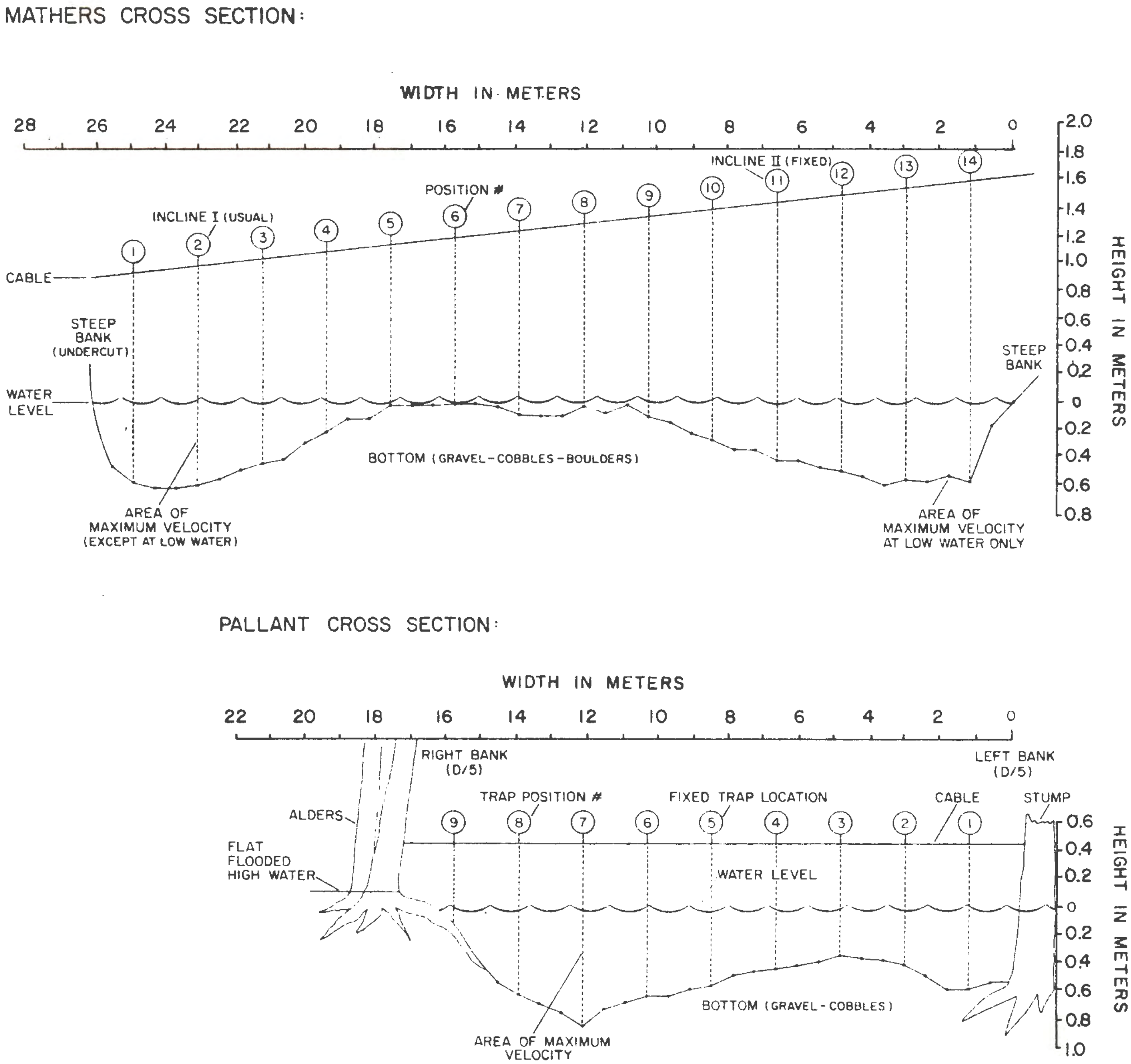

Figure 7: Cross sections of Mathers and Pallant Creeks at the downstream fry trapping locations used in 1978.

mark-recapture estimates were made using dyed fish during the latter portion of the migration period. Each time, approximately 1 000 fish were immersed for 3 h (starting 1800 h PDST) in an aerated solution of Bismark Brown 'Y' (field measurement 3/8 teaspoon per 5 gal water, or approximately 0.08 g/ ℓ); the fish then were held until dark in a bucket with screened ports that was set in the stream, and were released at 2300 h PDST, approximately 0.4 km upstream of the traps. All fish trapped overnight were individually sorted and counted using small dipnets; suspected predators of fry that were caught in the traps were killed, and their gut contents examined and related to length. Any fry found in the guts were added to the total count. Traps were routinely inspected and cleaned morning and evening, and water levels were read at 0800 h from a staff gauge near the cable crossing. All fry captured at 0800 h were held in screened buckets until late dusk (2230 h) and released downstream of the traps. Samples of chum and coho fry were preserved weekly (bi-weekly during peak migration) in 10 percent formalin, held for a least 6 weeks, and then individually measured for length and weight after being blotted dry.

Distribution and behavior of chum fry in the estuaries of both creeks and in Cumshewa Inlet were also monitored. Visual sightings of chum fry were made during weekly foot or boat shoreline surveys on calm, bright mornings from early April to the end of June. Aspects of behavior noted included: school size, direction of movement, fry depth in relation to the bottom, and substrate types. Visual sightings were verified when possible using a dipnet (0.5 x 0.5 m). Fry were also captured by beach seining (mesh size 1 cm stretch in wings and 3 mm in centre) near the end of the period. Some of the fry captured were preserved in 10 percent formalin and processed similarly to those fry sampled from the creeks.

PREDATOR/COMPETITOR SURVEYS

Besides examining the gut contents of predators that were caught in the fry traps, other methods were used to roughly estimate the extent of actual and potential predation and competition that exists in the systems. Gillnets (38 mm mesh) and minnow traps baited with borax-preserved salmon roe were set for 24 h throughout the Pallant system, angling was attempted at various points in both systems, and other relevant observations were noted.

HABITAT SURVEYS

The major tributaries to Mosquito Lake were walked for much of their lengths on several occasions to estimate their potential for natural rearing of hatchery-produced coho fry.

A cursory examination of the limnology of Mosquito Lake was undertaken to provide general data useful in evaluating potential water quality problems during lake turnover, and in choosing rearing and release sites for hatchery-produced chum and coho fry. The lake's bathymetry was determined in February, 1978, using a Raytheon Model DE-719 echosounder. This machine did not produce a satisfactory trace of the bottom beyond 45 m (150 ft.); therefore, spot checks of basin depths were also determined with a weighted handline. Vertical temperature series were taken at each of three stations (Fig. 8), using a YSI Model 43 telethermometer. Temperatures were measured at 1 m intervals in the region of a thermocline, and at 5 m intervals elsewhere. Sampling was routinely carried out monthly from January - November, 1978, but was increased in frequency as the isothermal state was approached in November. From June - October, 1978, monthly plankton samples were collected at five locations on Mosquito Lake (Fig. 8) using a Wisconsin plankton net (113 µ mesh, 22 cm mouth opening). Three of the plankton samples were 2 min horizontal tows at constant speed, beside the boat and with the net breaking the surface of the water; the other two samples were vertical hauls, one from the bottom (7 m) at the lake outlet, and the other from mid-water (18 m) at the deepest established temperature station. Samples were preserved immediately in approximately 100 cc of 3 percent buffered formalin and were analyzed at a later date. Analysis consisted of a general scan of each sample using a Bausch and Lomb dissecting microscope at 15 - 60X, tentative identification of the different organisms noted during the scan, and counting of the species present in a 5 ml subsample.

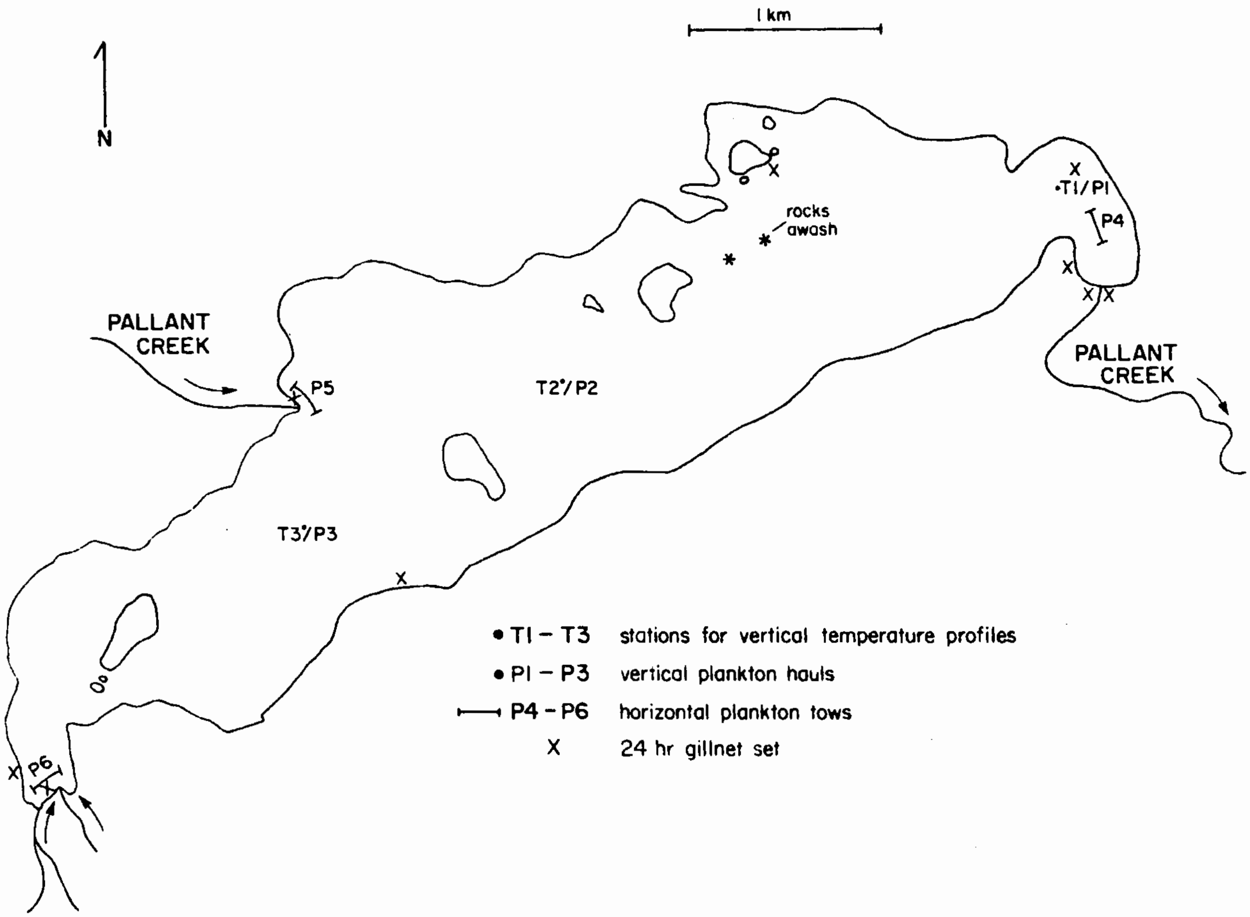

Figure 8: Locations of temperature, plankton, and fish sampling stations in Mosquito Lake, 1978.

The three other major salmon streams (Braverman, Chadsey, and Carmichael) in Cumshewa Inlet were examined briefly as to their potentials for chum salmon relative to Pallant and Mathers Creeks. In each case, the lower 1 km of each creek was walked, and notes made of substrates, flows, temperatures, fish presence/absence, and other relevant observations.

RESULTS

WEATHER

Daily weather records from the Pallant hatchery site have been compiled for the period April 14 - December 31, 1978, in Appendix 2. Comparison of weekly averages of the daily readings from the Pallant hatchery site and Sandspit airport (Table 1) confirmed that considerable climatic variations occur between these two sites. For the period April 14 - June 30, 1978, Pallant Creek averaged twice the precipitation, 1°C lower minimum and 2°C higher maximum daily temperatures than experienced at Sandspit. Higher precipitation had been expected (Shepherd, 1978), as the Pallant watershed is more closely associated with the Queen Charlotte Mountain Range. The larger variation in daily temperatures at Pallant also is not surprising, as the hatchery site is about 5 km inland, while Sandspit airport is virtually surrounded (and thus moderated) by the sea. It was also confirmed that daily precipitation patterns are very different for the two stations (Fig. 9). Of particular note was the October 30 - November 1 storm event. Approximately 46 cm of rain, coupled with high winds, was recorded at the Pallant Creek hatchery site over 55 h; this may be compared to the value of 25 cm in the same period that was experienced at Terrace and Prince Rupert and which resulted in considerable flood damage.

WATER QUALITY

Nutrients

Pallant and Mathers Creek Water. As in previous samplings, no nutrient parameter value from either creek exceeded recommended limits for fish culture

TABLE 1: Comparison of 1978 weekly average weather records from the Pallant Creek hatchery site (P) with those from Sandspit airport (S).

DATES	DAILY TEMPERATURES (°C)				DAILY PRECIPITATION (mm)		
	MINIMUM		MAXIMUM		to 1000	to 0800	P as
	S	P	S	P	S	P	% of S
Apr 14-21 Avg.	4	2	10	13	1.2	0.5	42
(Range)	(0-7)	(-2-6)	(9-11)	(11-14)	(0.0-5.6)	(0.0-3.8)	
22-30	5	5	11	13	3.6	3.8	106
	(3-8)	(2-8)	(9-13)	(12-15)	(0.0-14.3)	(0.0-17.3)	
May 01-08	5	5	11	13	3.6	8.0	222
	(1-6)	(1-7)	(9-14)	(9-15)	(0.0-12.4)	(TR-22.6)	
09-16	6	5	12	13	0.8	2.9	363
	(5-8)	(1-8)	(10-14)	(10-18)	(0.0-2.0)	(0.0-13.7)	
17-23	7	5	12	14	0.7	1.2	171
	(5-10)	(2-7)	(11-13)	(10-16)	(0.0-2.0)	(0.0-7.9)	
24-31	7	6	13	13	1.9	6.1	321
	(5-9)	(4-10)	(11-16)	(11-18)	(0.0-6.0)	(0.0-30.5)	
Jun 01-08	10	7	16	23	0.1	0.3	300
	(9-11)	(6-9)	(16-17)	(17-27)	(0.0-0.4)	(0.0-2.0)	
09-16	11	9	16	17	1.4	2.8	200
	(9-12)	(6-11)	(13-18)	(14-22)	(0.0-5.3)	(0.0-15.0)	
17-23	11	9	18	19	0.3	0.2	67
	(9-12)	(6-12)	(16-20)	(15-27)	(0.0-2.4)	(0.0-1.3)	
24-30	10	10	16	19	0.1	TR	-
	(6-13)	(6-13)	(14-17)	(15-25)	(0.0-0.6)	(0.0- TR)	
Jul 01-08	12	10	17	19	1.2	0.7	58
	(9-14)	(5-13)	(13-19)	(16-21)	(0.0-6.2)	(0.0-5.8))	
09-16	12	11	17	17	2.0	1.8	90
	(10-13)	(8-13)	(15-19)	(13-23)	(0.0-14.4)	(0.0-12.7)	

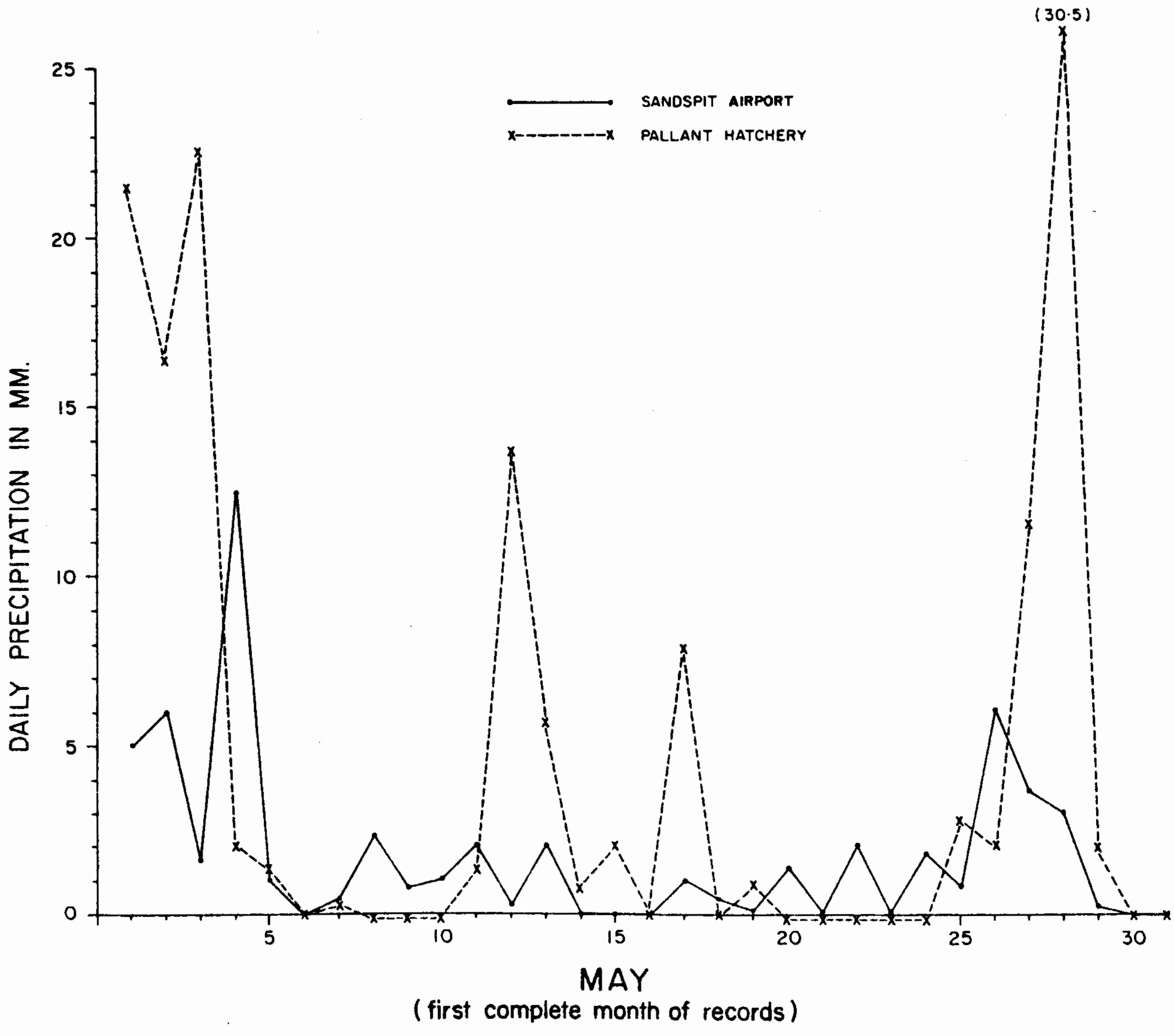

Figure 9: Comparison of daily precipitation at the Pallant Hatchery site and Sandspit Airport for May, 1978.

(Sigma, MS 1979), although Pallant pH slightly exceeded the optimum for incubation of fish eggs (Tables 2A, B).

Mathers Well Water. Total phosphate values were found to be at levels in excess of recommended (Shepherd, MS 1978), but would be of concern only from the standpoint of possible algal blooms. Of much greater concern was the finding of 0.36 mg/ ℓ ammonia (determined for well #1 sample only). At the pH (8.1) and temperature (7.5°C) recorded, this results in 7 ppb NH_3, which exceeds the recommended maximum of 2 ppb NH_3 (Sigma, MS 1979). In view of this finding, further pump-testing of the wells was scheduled for April of 1979.

Extractable Metals

Pallant and Mathers Creek Water. Most determinations fell within recommended limits (Sigma, MS 1979), except for copper, iron, and zinc levels at both creeks (Tables 3A, B). Barium also demonstrated an order of magnitude increase over previous normals[1] in one sample. Further sampling indicated that the copper and barium high readings were not significant. Although iron levels have been high, analyses have been for total iron, while recommended limits apply to ferrous iron only (Sigma, MS 1979). At the pH levels found, the iron levels found in the creeks' surface waters would be largely in the ferric form. Zinc levels at both creeks rose and stayed disturbingly high through the latter part of 1978; however, this was probably a result of sample bottle or reagent contamination.

Mathers Well Water. Mathers ground water was notable higher in Ca, Mg, Mn, Na, and Sr Levels, but all parameters remained within acceptable limits, except Zn. In view of the elevation in zinc levels experienced in the surface waters of both creeks (see preceeding section), this result is suspect.

[1]No information known to author as to fish tolerance of barium.

TABLE 2A: Suspended solids, nutrients, and miscellaneous water quality parameters for Mathers Creek, as determined by EPS/FMS Laboratory (values boxed exceed recommended limits--see Shepherd, 1978).

SAMPLE DATE (NO. OF SAMPLES)		SUSPENDED SOLIDS				NUTRIENTS					MISCELLANEOUS				
		FR	NFR	TURB	COND	NO_2	NO_3	TPO_4	SiO_2	SO_4	Cl_2	Si	pH	ALK	HARD
I. SUMMARY OF SAMPLING UP TO DECEMBER, 1977:															
Oct 76–Nov 77	$\bar{X}$	38	10	0.8	44	N/D	.079	.011	2.1	3.0	4.2	–	7.0	17.4	–
(n=10, less in	max	47	85	2.0	50	.006	.120	.042	4.8	3.6	4.7	–	7.1	36.0	–
some cases)	min	28	N/D	N/D	39	N/D	.047	N/D	1.4	2.0	3.8	–	6.9	10.0	–
II. 1978 SAMPLING:															
Jan 12		40	N/D	–	–	N/D	.095	N/D	2.0	3.0	–	1.89	–	–	–
Feb 8		32	7	–	–	"	.104	"	N/D	2.5	–	–	–	–	–
Apr 13		37	N/D	–	–	"	.076	"	1.7	2.7	–	1.03	–	–	16.3
May 10		35	"	–	–	"	.062	"	1.8	2.5	–	1.66	–	–	18.4
Jun 8		41	"	–	–	"	.043	"	2.0	1.6	–	1.46	–	–	–
Jul 5		50	"	–	–	"	.056	"	2.3	2.5	–	–	–	–	20.3
Aug 2		54	"	–	–	"	.076	.005	2.6	3.0	–	–	–	–	32.2
Sep 12		40	"	–	–	"	.110	.007	1.8	3.0	–	–	–	–	21.3
Oct 8 (stream)		–	–	–	–	"	.062	.016	2.1	4.0	–	–	–	–	23.6
Oct 8 (well #2)		–	–	–	–	"	N/D	.145	5.6	1.1	–	–	–	–	82.9
Oct 13 (well #1)		183	N/D	N/D	287	"	"	.073	5.8	1.3	12.5	5.30	8.1	127.0	66.0
Dec 7 (stream)		40	5	1.7	42	"	.070	.008	0.5	2.9	4.3	1.35	7.0	11.3	14.4

(N/D = Not Detectable)

TABLE 2B: Suspended, solids, nutrients, and miscellaneous water quality parameters for Pallant Creek, as determined by EPS/FMS Laboratory (values boxed exceed recommended limits--see Shepherd, 1978).

SAMPLE DATE (NO. OF SAMPLES)		SUSPENDED SOLIDS				NUTRIENTS					MISCELLANEOUS				
		FR	NFR	TURB	COND	NO_2	NO_3	TPO_4	SiO_2	SO_4	Cl_2	Si	pH	ALK	HARD
I. SUMMARY OF SAMPLING UP TO DECEMBER, 1977:															
Oct 76–Dec 77	$\bar{X}$	38	N/D	0.5	50	N/D	.048	N/D	1.5	3.2	3.9	–	7.4	15.9	–
(n = 9, less in	max	42	N/D	1.3	51	N/D	.013	N/D	3.4	4.4	4.1	–	7.5	17.0	–
some cases)	min	35	N/D	N/D	48	N/D	.068	N/D	0.5	2.5	3.7	–	7.2	15.0	–
II. 1978 SAMPLING:															
Jan 12		40	N/D	–	–	N/D	.073	N/D	1.7	4.1	–	1.53	–	–	–
Feb 8		31	"	–	–	"	.075	"	0.6	3.6	–	–	–	–	19.0
Apr 10 (Flood)		42	"	–	–	"	.067	"	1.6	2.9	–	0.96	–	–	15.0
Apr 13		46	"	–	–	"	.070	"	1.6	2.8	–	0.95	–	–	14.7
May 11		41	"	–	–	"	.059	"	1.5	3.1	–	1.40	–	–	18.8
May 27 (Flood)		39	"	–	–	"	.044	"	1.2	3.0	–	1.39	–	–	21.9
Jun 9		41	"	–	–	"	.039	"	1.5	1.7	–	1.03	–	–	–
Jul 6		43	"	–	–	"	.036	"	1.4	2.9	–	–	–	–	19.6
Aug 3		43	"	–	–	"	.030	.005	1.3	2.4	–	–	–	–	35.8
Sep 13		41	"	–	–	"	.046	N/D	1.4	3.3	–	–	–	–	44.6
Nov 1 (Severe Flood)		25	121	–	–	"	–	–	–	–	–	–	–	–	–
Dec 7		42	20	6.7	50	N/D	.061	.031	0.9	2.7	4.5	1.54	7.4	14.9	19.1

(N/D = Not Detectable)

TABLE 3A: Extractable metals in Mathers Creek water, as determined by EPS/FMS Laboratory (values boxed exceed recommended limits--see Shepherd, 1978).

SAMPLE DATE (NO. OF SAMPLES)		Cu	Fe	Pb	Zn	Ca	Mg	Na	K	Cd	Ni	Mn	Al	Ba	Co	Cr	Mo	Sb	Sn	Sr	Ti	V	As	Hg	Se
		METAL mg/l																							
I. SUMMARY OF SAMPLING TO DECEMBER, 1977:																									
Oct 76–Nov 77	$\bar{X}$	N/D	.35	N/D	.02	4.3	.76	2.7	.22	–	–	.05	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
(n=8 max, less	max	N/D	.50	N/D	.05	5.7	.90	3.0	.38	–	–	.05	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
for some metals)	min	N/D	.19	N/D	N/D	3.3	.57	2.4	.10	–	–	.05	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
II. 1978 SAMPLING:																									
Jan 12		N/D	.24	N/D	N/D	5.1	.80	3.2	.23	N/D	N/D	.01	N/D	.010	N/D	N/D	N/D	N/D	N/D	.019	N/D	N/D	N/D	N/D	N/D
Feb 8		"	.26	"	.03	3.0	.55	2.2	–	"	"	.02	"	.008	"	"	"	"	"	.014	"	"	"	"	"
Apr 13		"	N/D	"	.12	5.6	.59	2.2	–	"	"	.01	"	.007	"	"	"	"	"	.013	"	"	"	"	"
May 10		"	.16	"	.07	6.1	.74	3.6	–	"	"	.01	"	.008	"	"	"	"	"	.018	"	"	"	"	"
Jun 8		"	.23	"	.83	10.1	.72	3.7	–	"	"	.02	"	.082	"	"	"	"	"	.021	"	"	"	"	"
Jul 5		"	.27	"	N/D	6.4	1.04	3.9	–	"	"	.02	"	.007	"	"	"	"	"	.026	"	"	"	"	"
Aug 2		"	.42	"	.27	11.0	1.15	5.0	–	"	"	.03	"	.037	"	"	"	"	"	–	"	"	"	"	"
Sep 12		"	.22	"	.35	7.1	.85	3.4	–	"	"	.01	"	.041	"	"	"	"	"	.018	"	"	"	"	"
Oct 8 (Stream)		"	.45	"	.34	8.0	.87	4.0	–	"	"	.02	"	.051	"	"	"	"	"	.019	"	"	"	"	"
" (Well #2)		"	.04	"	.37	17.8	9.33	34.5	–	"	"	.16	N/D	.053	"	"	"	"	"	.116	"	"	"	"	"
Oct 13 (Well #1)		"	.08	"	.42	15.7	6.50	33.5	–	"	"	.17	N/D	.095	"	"	"	"	"	.123	"	"	"	"	"
Dec 7 (Stream)		.01	.24	"	.13	4.7	0.67	1.8	.20	"	"	.01	.15	.006	"	"	"	"	"	.016	"	"	"	"	"

(N/D = Not Detectable)

TABLE 3B: Extractable metals in Pallant Creek water, as determined by EPS/FMS Laboratory (values boxed exceed recommended limits--see Shepherd, 1978).

SAMPLE DATE (NO. OF SAMPLES)		Cu	Fe	Pb	Zn	Ca	Mg	Na	K	Cd	Ni	Mn	Al	Ba	Co	Cr	Mo	Sb	Sn	Sr	Ti	V	As	Hg	Se
		METAL mg/l																							
I. SUMMARY OF SAMPLING UP TO DECEMBER, 1977:																									
Oct 76–Dec 77	$\bar{X}$	N/D	.09	N/D	N/D	5.6	.90	2.4	.16	–	–	.006	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
(n=9 max, less	max	N/D	.11	N/D	.02	6.5	1.00	2.6	.21	–	–	.012	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
for some metals)	min	N/D	.08	N/D	N/D	3.8	.72	2.0	.11	–	–	N/D	–	–	–	N/D	–	–	–	–	–	–	–	N/D	–
II. 1978 SAMPLING:																									
Jan 12		N/D	.08	N/D	N/D	6.5	.99	2.6	.02	N/D	N/D	.013	N/D	.003	N/D	N/D	N/D	N/D	N/D	.015	N/D	N/D	N/D	N/D	N/D
Feb 8		"	.20	"	.04	5.9	1.03	2.3	–	"	"	.021	"	.005	"	"	"	"	"	.017	"	"	"	"	"
Apr 10 (Flood)		"	N/D	"	N/D	4.8	.75	2.0	–	"	"	.011	"	N/D	"	"	"	"	"	.012	"	"	"	"	"
Apr 13		"	"	"	"	4.7	.74	1.9	–	"	"	.007	"	"	"	"	"	"	"	.009	"	"	"	"	"
May 11		"	.03	"	.02	6.1	.87	2.9	–	"	"	.009	"	"	"	"	"	"	"	.015	"	"	"	"	"
May 27 (Flood)		"	.05	"	.04	7.4	.82	2.6	–	"	"	.012	"	"	"	"	"	"	"	.016	"	"	"	"	"
Jun 9		"	.05	"	N/D	5.5	.83	2.7	–	"	"	.008	"	"	"	"	"	"	"	.015	"	"	"	"	"
Jul 6		"	.04	"	"	6.2	1.04	2.7	–	"	"	.009	"	"	"	"	"	"	"	.018	"	"	"	"	"
Aug 3		"	.08	"	**.60**	12.6	1.05	3.3	–	"	"	.016	"	.065	"	"	"	"	"	–	"	"	"	"	"
Sep 14		"	.04	"	**.60**	12.7	3.12	1.8	–	"	"	.004	"	N/D	"	"	"	"	"	.020	"	"	"	"	"
Dec 7		**.02**	**.83**	"	**.17**	5.8	1.14	1.8	.17	"	"	.046	.45	.005	"	"	"	"	"	.016	"	"	"	"	"

(N/D = Not Detectable)

Suspended Solids

Non-filterable residues (NFR) as determined by the FMS laboratory were at undetectable levels in all Pallant Creek samples up to November 1, 1978 (Table 2B). The severe storm experienced on that date produced NFR values up to 121 mg/ ℓ , and NFR was still elevated (20 mg/ ℓ) into December. NFR at Mathers Creek, however, has been as high as 85 mg/ ℓ in samples taken during much less severe freshets (Table 2A). Unfortunately, no samples were taken at Mathers during the November storm. A more detailed analysis of NFR was undertaken by CanTest Ltd., and the following observations have been drawn from the data (Table 4A, B):

a) Use of just those samples from the probable incubation period (October - April, 1976 - 1978) did not markedly change the results, until the samples taken during the severe flooding in the fall of 1977 were added (Table 5). With the flood samples added, average NFR was increased approximately 50 percent.

b) Pallant Creek, on average, carries one-quarter (by weight) of the suspended solids that either Mathers Creek or Atnarko River does, and one-half of that found in Kitimat well water (Table 6).

c) No marked variations in particle size distributions (by weight or number) were found when comparable samples for the four systems were examined, except that Atnarko demonstrated nearly double the percentage of 14 - 20 μ particles and up to half the 80^{+} μ particles found elsewhere.

d) Filtration to the 14 μ level would remove 70 percent (by weight) of the suspended solids in Mathers Creek water, but only 50 percent at Pallant. Filtration to the 10 μ level would not help removal of total suspended solids at Mathers, but would increase removal at Pallant to 75 percent. Filtration to the 5 μ level would remove 85 percent of the total suspended solids at Mathers, and 80 percent at Pallant.

TABLE 4A: Composition of Mathers Creek suspended solids, as determined by CanTest Ltd., Vancouver.

SAMPLE DATE (NO. OF SAMPLES)		mg/l S.S.[a]	mg/l AS % OF TOTAL mg/l: 0.45µ	5µ	14/10µ[c]	VOLATILES AS % OF mg/l RETAINED ON EACH FILTER: 0.45µ	5µ	14/10µ[c]	TOTAL NO. PARTICLES ON 14/10µ[b] FILTER	SIZE DISTRIBUTION AS % OF TOTAL NO.: 14-20/10-20µ[b]	20-40µ	40-60µ	60-80µ	80µ+
I. SUMMARY OF SAMPLING UP TO DECEMBER, 1977:														
Apr - Nov (n=9)	$\bar{x}$	10.7	19	18	63	17	34	33	17,400	34	20	19	15	12
	max	54.2	57	43	98	63	67	52	25,000	60	40	29	37	18
	min	1.4	1	1	29	0	0	0	8,000	10	5	10	5	5
II. 1978 SAMPLING:														
Jan 12		3.0	27	33	40	38	40	16	9,000	22	33	11	11	22
Feb 8		6.2	3	23	74	50	43	87	19,000	32	16	32	10	10(14µ)
Apr 13[b]		4.6	35	9	56	38	50	15	60,000	75	10	7	5	3(10µ)
May 10		5.8	14	7	79	38	50	4	70,000	58	20	10	6	6
May 28 (Flood)		4.8	4	4	92	50	50	18	60,000	80	12	3	3	2
Jun 8		2.4	8	8	84	50	50	30	55,100	91	5	2	1	1
Jul 15[c]		2.1	10	43	47	0	11	20	3,100	68	8	13	6	5
Aug 2		4.6	4	26	70	0	33	94	8,000	60	24	11	3	2
Sep 12		1.8	12	44	44	50	50	25	9,650	63	22	8	3	4
Oct 8 (Stream)		10.4	4	8	88	75	50	65	9,300	54	18	8	12	8
Oct 8 (Well #2)		2.5	16	32	52	75	50	38	1,250	24	56	8	8	4
Oct 13 (Well #1)		3.5	23	34	43	50	67	20	1,500	59	20	7	7	7
Nov 10 (2 samples)		25.2	1	2	97	25	25	61	14,800	24	27	27	14	8
Nov 10		20.4	6	10	84	17	25	53	7,600	29	29	20	11	11
Dec 7		6.8	12	12	76	88	50	62	8,400	36	27	20	10	7

[a] per 250 ml sample.

[b] 10µ membrane used for analysis of larger particles from Apr 13 on.

[c] 10µ membrane used in place of 14µ for all phases of analyses from Jul 5 on.

TABLE 4B: Composition of Pallant Creek suspended solids, as determined by CanTest Ltd., Vancouver.

SAMPLE DATE (NO. OF SAMPLES)		TOTAL SIZE DISTRIBUTION mg/l AS % OF TOTAL mg/l: S.S.[a]	0.45μ	5μ	14/10μ[c]	VOLATILES AS % OF mg/l RETAINED ON EACH FILTER: 0.45μ	5μ	14/10μ[c]	TOTAL NO. PARTICLES ON 14/10μ[b] FILTER	SIZE DISTRIBUTION AS % OF TOTAL NO.: 14-20/10-20μ[b]	20-40μ	40-60μ	60-80μ	80μ+
I. SUMMARY OF SAMPLING UP TO DECEMBER, 1977:														
Apr – Dec	$\bar{X}$	3.3	33	29	38	19	19	31	12,300	33	15	21	16	15
(n=6)	max	8.0	66	40	68	62	50	52	23,000	66	17	33	32	29
	min	0.6	3	17	17	0	0	0	6,000	14	4	11	4	4
II. 1978 SAMPLING:														
Jan 12		1.4	14	43	43	50	50	33	8,000	25	13	25	25	12
Feb 8		2.0	10	10	80	50	50	25	11,000	27	27	18	9	18 (14μ)
Apr 10[b]		2.6	15	15	70	50	25	11	20,800	72	14	10	2	2 (10μ)
Apr 16 (Flood)		1.6	37	13	50	50	50	38	6,100	82	10	3	3	2
May 11		1.4	29	14	57	50	50	38	12,300	81	8	4	3	4
May 27		1.9	5	11	84	-	50	13	12,200	82	5	3	5	5
Jun 9		1.0	40	20	40	50	50	50	4,500	74	11	4	2	9
Jul 6[c]		2.0	10	40	50	50	50	20	19,500	56	21	15	5	3
Aug 3		3.3	18	9	73	0	33	92	5,450	75	18	3	3	1
Sep 13		0.8	25	25	50	50	50	25	4,200	73	19	6	1	1
Sep 30 (Flood)		3.2	13	25	62	75	50	20	3,300	30	21	12	15	21
Oct 2 (Flood)		7.6	5	11	84	75	50	56	4,300	21	16	19	21	23
Oct 10		4.8	8	25	67	50	33	38	3,500	17	11	14	23	35
Oct 31 (Severe)		14.8	3	5	92	50	25	50	9,000	29	20	17	11	23
Nov 1 (Flood)		93.2	1	3	96	25	14	30	(too dense to count)					
Nov 23		23.6	5	9	86	33	20	22	14,600	28	36	17	9	10
Dec 7		18.8	2	24	74	25	18	43	12,800	26	31	23	11	9

*
[a] per 250 ml sample.
[b] 10μ membrane used for size distribution analysis from Apr 10 on.
[c] 10μ membrane used in place of 14μ for all phases of analyses from Jul 5 on.

TABLE 5: Mean values for compositions of suspended solids, all samples versus samples taken during the potential incubation period (October – April, 1976 to 1978).

SAMPLES DATE(S) (NO. OF SAMPLES)		TOTAL mg/l S.S	SIZE DISTRIBUTION AS % OF TOTAL mg/l			VOLATILES AS % OF mg/l RETAINED ON EACH FILTER		
			0.45 μ	5 μ	10/14 μ	0.45 μ	5 μ	10/14 μ
A. **MATHERS**:								
Overall	$\bar{X}$	8.7	14	18	68	30	38	25
(n = 22)	max	54.2	57	44	98	88	67	94
	min	1.4	1	1	29	0	0	0
Oct – Apr	$\bar{X}$	12.5	15	18	68	32	38	49
(n = 11)	max	54.2	35	43	98	88	67	65
	min	1.4	1	1	40	0	0	15
B. **PALLANT**:								
Overall	$\bar{X}$	8.2	19	21	60	32	34	34
(n = 23)	max	93.2	66	43	96	75	50	92
	min	0.6	1	3	17	0	0	0
Oct – Apr	$\bar{X}$	12.9	14	20	66	33	30	36
(n = 14)	max	93.2	40	43	96	75	50	56
	min	0.6	1	3	20	0	0	0

TABLE 6: Compositions of suspended solids at Mathers and Pallant Creeks, as compared to the compositions found at the Atnarko and Kitimat facilities (data courtesy of R. Hilland and M. Farwell). Samples using 14μ filter only.

SAMPLE LOCATION (NO. OF SAMPLES)	TOTAL SIZE DISTRIBUTION mg/l	mg/l AS % OF TOTAL		mg/l	VOLATILES AS % OF mg/l RETAINED ON EACH FILTER			TOTAL NO. PARTICLES ON 14μ FILTER	SIZE DISTRIBUTION AS % OF TOTAL NO.				
	S.S.[a]	0.45μ	5μ	14μ	0.45μ	5μ	14μ		14–20μ	20–40μ	40–60μ	60–80μ	80μ+
MATHERS (n = 16)	8.2	18	16	66	28	40	32	16,800	33	21	19	14	13
PALLANT (n = 13)	2.6	27	23	50	32	34	30	12,400	32	16	21	16	15
ATNARKO (n = 13)	8.9	14	20	66	NO ANALYSIS			108,000	54	17	10	9	10
KITIMAT (n = 3)	4.6	19	18	64	36	41	59	9,000	37	18	12	11	22

*

[a] per 250 ml sample.

It was noted that the test stack of Heath trays contained considerable sediment when inspected in April, 1977 (Fig. 10). It is recognized that the period of operation (late January - mid-April) did not closely correspond to the anticipated period of incubation (late September - February), and that flows were interrupted during the latter portion of the period. Nevertheless, the amount of sediment noted in the trays indicated a greater problem that would be expected from the creek water sampling alone. This concern was exemplified by the severe storm of October 30 - November 1, 1978. Suspended solids levels rose to 12 mg/ ℓ at peak storm flows and remained at 20 - 25 mg/ ℓ or greater up to the end of December (by weight, the majority of the suspended particles were 10 μ or larger). Sedimentation within the Heath trays was prolonged and heavy.

Algae

A total of 45 and 50 genera were identified from Mathers and Pallant Creek samples, respectively (Table 7). Although the number of genera per class were similar for both creeks, the dominant genera often differed between the creeks (Table 8). The algal populations in the test stack of Heath trays at Pallant Creek also differed from the populations found in the Creek water. One genera, Chlamydomonas, is considered basically a still-water organism, and its abundance is likely a result of the flow to the trays being interrupted. In the creek water, highest diversities were recorded in late October, but highest total algal cell numbers were found from late May through September (Table 8). All of the algal genera associated with incubation problems at Atnarko (Shepherd, 1978) were found at Mathers Creek, and all but one at Pallant Creek. Furthermore, Ulothrix and Navicula were found in high numbers in the Heath trays. Examination of cell sizes by genera indicated that, while filtration would be increasingly effective down to 5 μ , only slight improvements could be expected between 50 and 15 μ (Fig. 11).

A heavy mat of filamentous algae developed in the area of the hatchery intake in early June, 1978. However, it is unlikely that similar growth would occur during the probable incubation period (mid-October - May); water

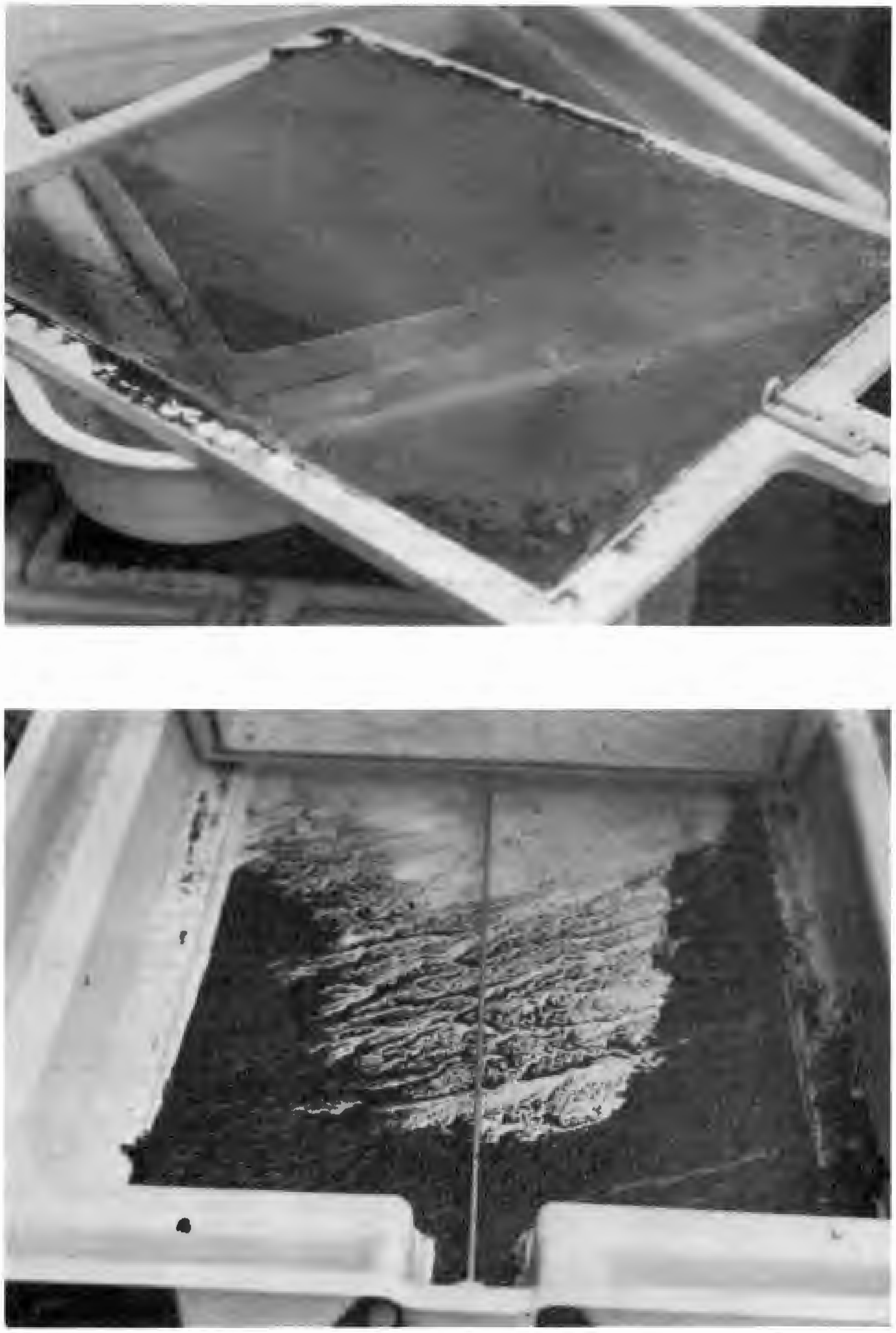

Figure 10: Representative sediment accumulations found in test stack of Heath trays run at Pallant Creek, late January to mid-April, 1978.

TABLE 7: Algal type, presence, cell size, and abundance for Mathers (M) and Pallant (P) Creeks from 1977-78 samples.

CLASS Genera	L in um	W in um	Location M	Location P	Comments
BACCILARIOPHYCEAE (DIATOMS)			(22)	(22)	
Acnanthes	12 (8-16)	6	X	X	dominant/abundant, except in Jan.
Amphora	30	10		X	rare in Oct only.
Amphipleura	84	11		X	common Jul, Aug (P).
Anomeoneis	25	6		X	common Jul, abundant Aug (P).
Asterionella	120	6		X	common in Oct only.
Caloneis	27	-	X		Apr only.
Cocconeis*	18-23	9-10	X	X	common Nov-Jan, Apr.
Coscinodiscus	7	-	X		Apr only.
Cyclotella	-	7-40 dia (most 13)	X	X	dominant/abundant throughout.
Cymbella	13-150 (most 30)	6-60 (most 6)	X	X	usually common; abundant in Jun.
Diatoma	13-34	-	X	X	Apr only (M); May only (P).
Diploneis	17-25	12		X	common Oct, Apr.
Denticula	19	6	X		common Jul (M).
Epithemia	47	-	X		May only.
Eunotia	30-150	9-15	X	X	present periodically.
Fragilria	35-60 (filament)	5-30 (most 10)	X	X	common Oct-Jan (P); rare (M).
Frustulia*	44	-	X		May only.
Gomphonema	20-90 (most 30)	6-20 (most 6)	X	X	common Oct-Nov, Feb-Jun.
Hannaea	50-180 (most 100)	3-15 (most 7)	X	X	rare Oct-Jun (M,P); common May (M).
Melosira	12 (10-15)	7-9	X	X	common/abundant (P); rare (M) Oct-Jun.
Meridion	30	9	X	X	rare and occasional.
Navicula*	10-150 (most 20-30)	6-40 (most 6-9)	X	X	common/abundant throughout.
Neidium	38	17	X	X	common Jul (M); abundant Jul-Aug (P)
Nitzschia	20-150 (most <50)	3-15 (most <10)	X	X	rare-common Oct-Jun.
Pinnularia	110-360	20-45	X	X	rare and occasional.
Pleurosigma	120-150	20		X	rare Oct-Nov only.
Rhizolenia	7	-		X	Apr only.
Rhoicosphenia	18	-	X		May only.
Rhopalodia	175-225	18-30	X	X	rare and occasional.
Stephanadiscus	21	-	X	X	abundant Sep (P).
Surirella	40-110 (most 100)	20-40 (most 30)	X	X	rare Oct-Apr only.
Synedra	20-300 (most 20-30)	3-20 (most 7-15)	X	X	common throughout.
Tabellaria	35	5	X	X	common Sep-Mar.
CHLOROPHYCEAE (GREENS)			(7)	(9)	
Ankistrodesmus	30-75 (most 45)	2-3	X	X	dominant Oct-Feb (M); present Jan-Feb.
Chlamydomonas	13	-	X		abundant Jul (M).
Chlorasaccus	18	-		X	common Sep (P).
Closterium	35-225 (most 200)	2-35 (most <4)	X	X	rare-common Jan-Feb (M,P); Jun (M).
coccoid	(in gelatinous colonies 20-75)			X	dominant Nov only.
Cosmarium	-	20 dia		X	rare Oct only.
Elakatothrix	15	3	X	X	abundant Oct-Nov only.
Gloeocystis	40 (colony)	-	X		rare and occasional to Feb.
Micrasterias	-	150-185 dia		X	rare Oct-Nov only.
Mougeotia	150-400 (filament)	7-15 (filament)	X	X	common Oct only.
Staurastrum	60-90	60		X	rare and occasional to Feb.
Stigeoclonium	400-1000	15-200	X		rare and occasional fragments to Feb.
Ulothrix*	100-1000 (filament)	15	X	X	abundant Oct-Nov only.
CHRYSOPHYCEAE (GOLDS)			(2)	(3)	
Chrysococcus	7-18 (most 8)	-		X	Apr-Jun only.
Dinobryon	150	75		X	common Oct only.
Batrachospermum	50-300 (fragment)	50-200 (fragment)	X		common/abundant Oct-Nov only.
Kephyrion	5-7 (most 5)	-	X	X	rare (M); abundant Apr-Jun (P).
Mallomanas	25	9	X	X	abundant Sep (M,P).
CRYPTOPHYCEAE			(2)	(2)	
Chroomanas	11	6	X	X	abundant Jul/Sep (M); common Jul (P).
Cryptomonas	15-45 (most 20)	9-20 (most 9)	X	X	common/abundant throughout.
Rhondomonas	5-15 (most 10)	6-9 (most 6)	X	X	abundant/dominant throughout.
CYANOPHYCEAE (BLUE-GREENS)			(4)	(3)	
Anabaena	-	3-7 dia	X	X	common Oct (M); abundant Jan-Feb (M,P).
Coelosphaerium	(colony dia 3)			X	rare Oct only.
Kirchneriella	7	-	X		May only.
Merismopaedia	12	12	X		abundant Oct only.
Oscillatoria*	-	3-6 dia	X	X	abundant (M); rare (P); Oct-Nov, Feb.
DINOPHYCEAE (DINOFLAGELLATES)			(2)	(2)	
Glenodinium	20-26	-	X	X	Apr-May.
Gymnodinium	50	28		X	common Aug (P).
Peridinium	-	15-30 (most 20)	X	X	common Oct only.
		TOTAL NO. OF GENERA	(45)	(50)	

*Genera found to cause problems at Atnarko.

TABLE 8: Total numbers of algal cells, dominant genera, and total number of genera found at Mathers and Pallant Creeks in 1977-78.

Date	No. at Mathers	Dominant Genera	Total No. of Genera	No. at Pallant	Dominant Genera	Total No. of Genera
5 Oct 1977	52,990	Ankistrodesmus Acnanthes	31	85,810	Cyclotella(1°) Rhodomonas(2°)	37
20 Oct 1977	54,664	Ankistrodesmus Acnanthes	37	38,412	Rhodomonas Acnanthes	37
9 Nov 1977	(too silty to count)		-	19,662	Acnanthes Cyclotella	31
28 Dec 1977	(weather prevented collection)		- -	11,963	Acnanthes Navicula	25
12 Jan 1978	14,008	Acnanthes Cyclotella	22	37,046	Rhodomonas Anabaena	25
8 Feb 1978	15,930	Acnanthes Rhodomonas	27	30,413	Rhodomonas Cyclotella	-
10 Apr 1978	-	-	-	88,214	Cyclotella Acnanthes	33
13 Apr 1978	23,981	Acnanthes Cyclotella	36	-	-	-
16 Apr 1978	-	-	-	67,130	Cyclotella Acnanthes	25
10 May 1978	46,183	Acnanthes Cyclotella	28	-	-	-
11 May 1978	-	-	-	165,241	Kephyrion Cyclotella	20
27 May 1978	-	-	-	374,768	Kephyrion	23
8 Jun 1978	144,765	Acnanthes Gomphonema	20	-	-	-
9 Jun 1978	-	-	-	159,930	Cyclotella Kephyrion	28
6 Jul 1978	-	-	-	89,727	Cyclotella Acnanthes	21
15 Jul 1978	118,616	Acnanthes Fragilaria	24	-	-	-
2 Aug 1978	155,989	Acnanthes Synedra	17	-	-	-
3 Aug 1978	-	-	-	83,583	Cyclotella Acnanthes	20
31 Aug 1978	-	-	-	459,680	Cyclotella Acnanthes	23 Heath #7
				519,350	Cyclotella Acnanthes	27 Heath #2
12 Sep 1978	245,300	Cyclotella Merismopedia	9	-	-	-
13 Sep 1978	-	-		144,992	Cyclotella Chroomonas	21

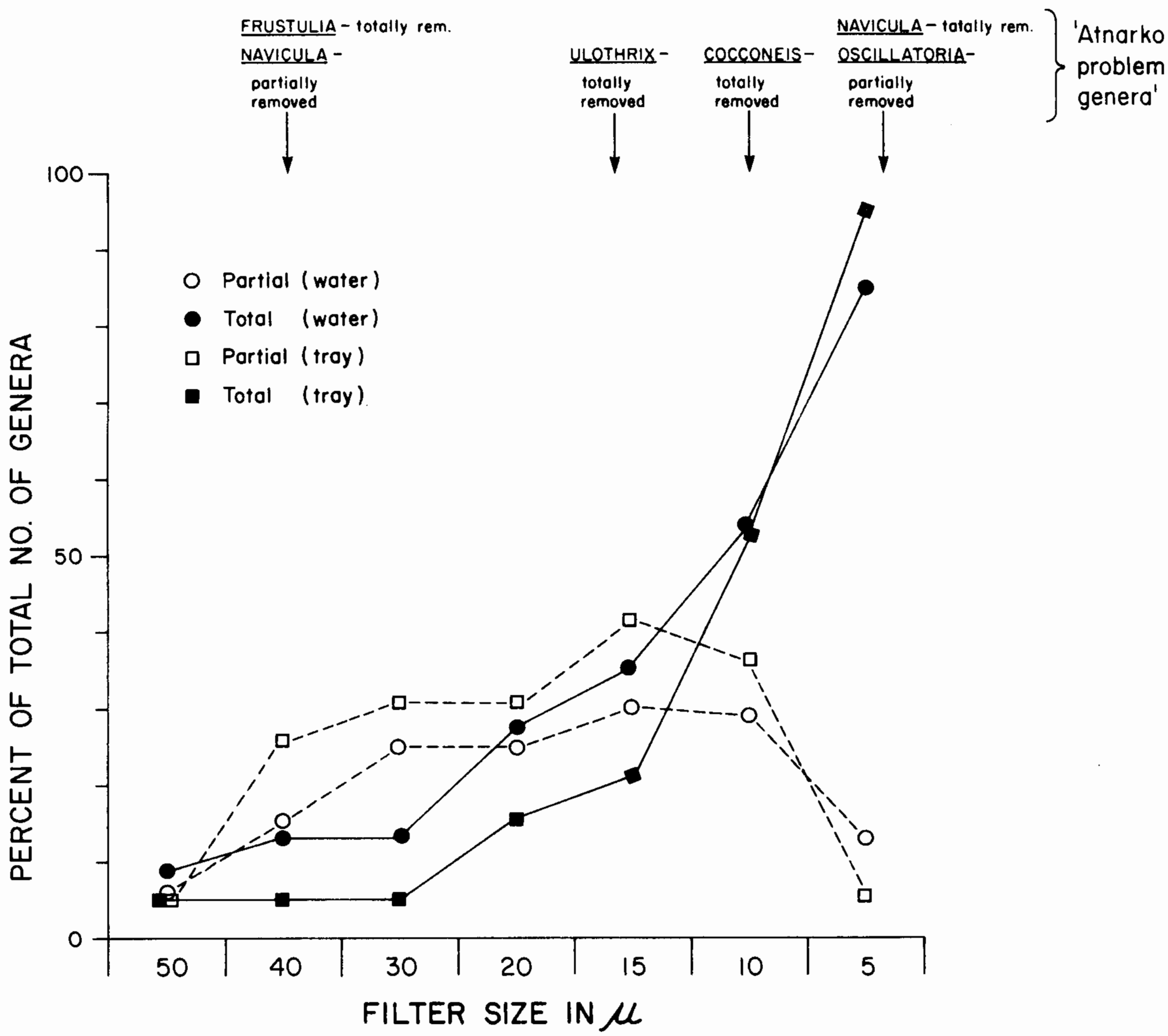

Figure 11: Theoretical filtration efficiencies for Pallant Creek algae, with removal of "Atnarko problem species" noted specifically.

temperatures are considerably lower during this period, and incubation would be broken into two separate phases--eggs will be incubated up to hatch stage in Heath trays, then will be transferred to gravel incubators.

Temperatures

Pallant and Mathers Creeks. Daily temperature fluctuations at Pallant Creek increased up to 4.5°C in early June, and the maximum temperature recorded was 22°C (Fig. 12A). Temperature regimes were similar at Mathers Creek during the period of thermograph operation (Fig. 12B). The two readings available from a maximum-minimum thermometer that had been set instream on May 28 showed maximums of 23°C when read on July 5, and 21°C on July 30. These maxima are higher than recorded in 1977, and are quite close to the upper lethal temperature limit of 24°C established for salmon by Brett (1952). If these values are normal, high summer water temperatures at Mathers Creek may cause problems in the year-round rearing of coho. Mid-winter temperatures were found to be 0.5 - 3°C lower at Mathers than at Pallant, and fell as low as 0.5°C at Mathers in February. These lower temperatures may be partially accounted for by the greater length of creek (8 vs 2 km) between the lake and the thermograph location at Mathers. If subgravel winter temperatures are similarly lower, incubation times will be longer for Mathers salmon stocks.

Cumshewa Inlet. The available surface water temperatures from various points throughout Cumshewa Inlet (Fig. 13) since late April, 1977 have been compiled in Fig. 14. In general, mid-inlet temperatures remained below 10°C until the third week of May, then rose to a maximum of 14°C up to mid-July. Temperatures adjacent to the Pallant estuary (including the bay north of the causeway) varied 1 - 2°C above and below mid-inlet temperatures. These variations were not consistent, and probably were the result of complex interactions between freshwater outflows, stage of tide, weather, and time of day. Near-shore temperatures farther east (farthest point Kingui Island) along Cumshewa Inlet similarly varied 1 - 2°C from off-shore, but usually the near-shore temperatures were higher than off-shore. Two temperatures taken

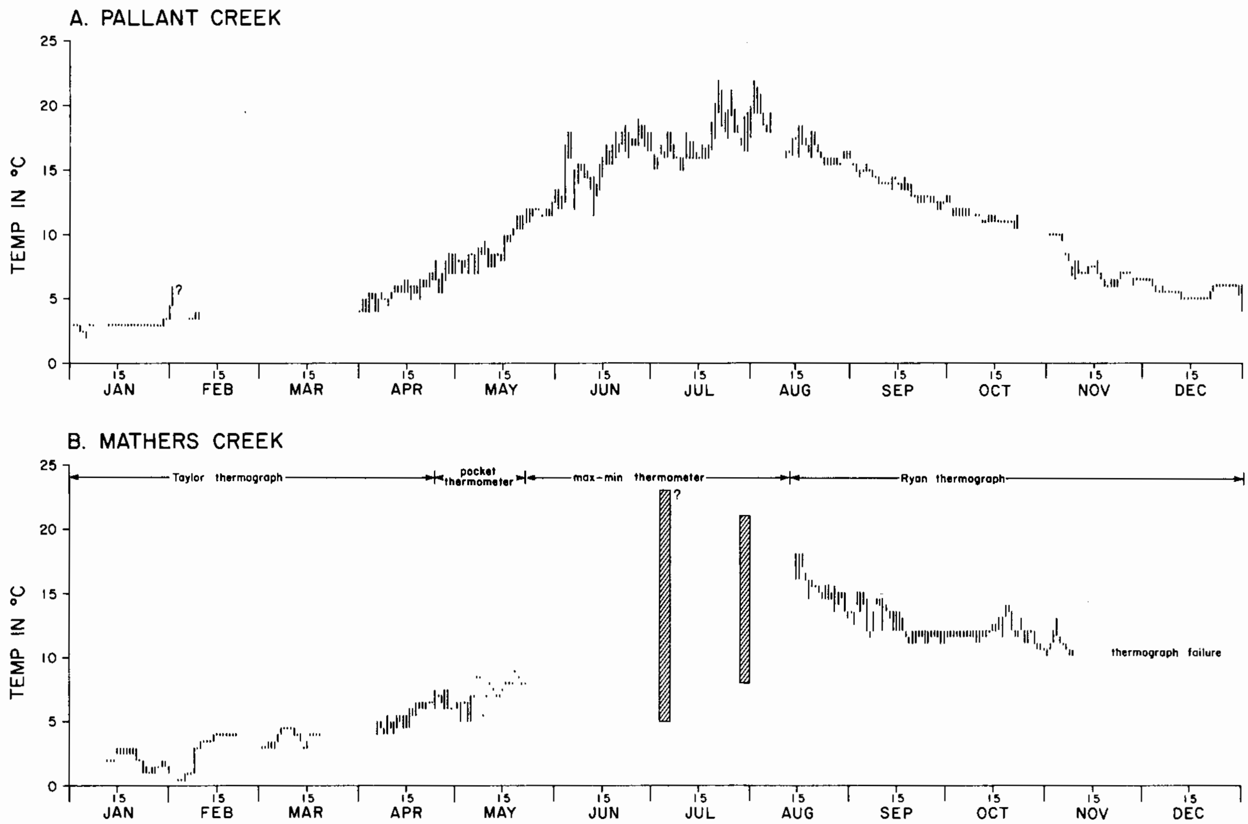

Figure 12: Daily water temperature ranges for Pallant and Mathers Creeks, January to December, 1978.

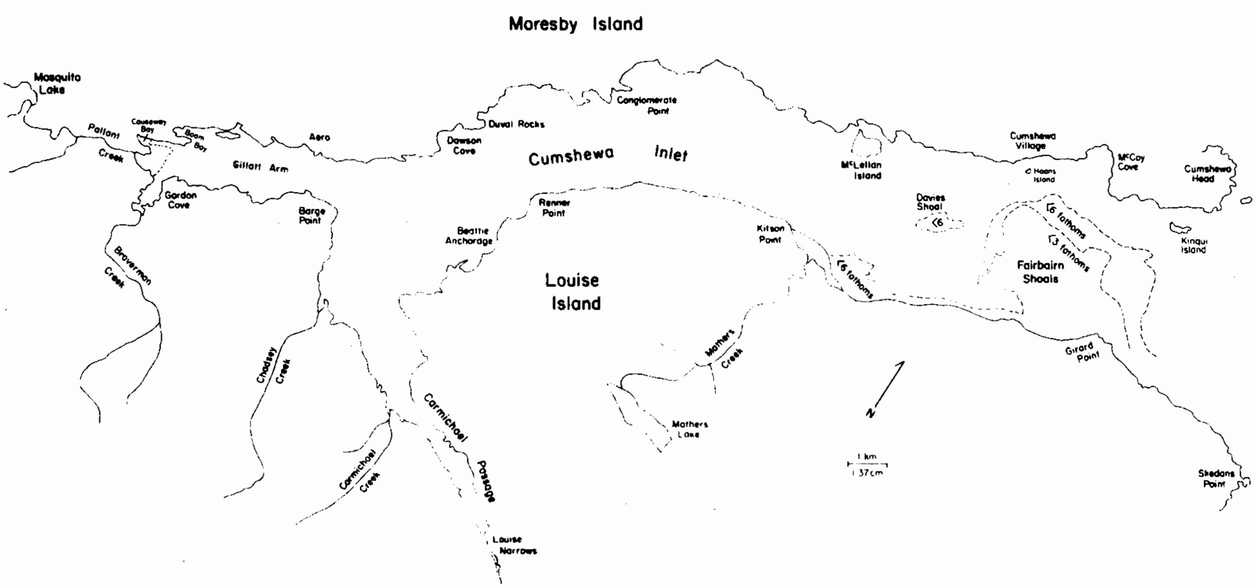

Figure 13: Location names used in Cumshewa Inlet chum fry survey, 1978.

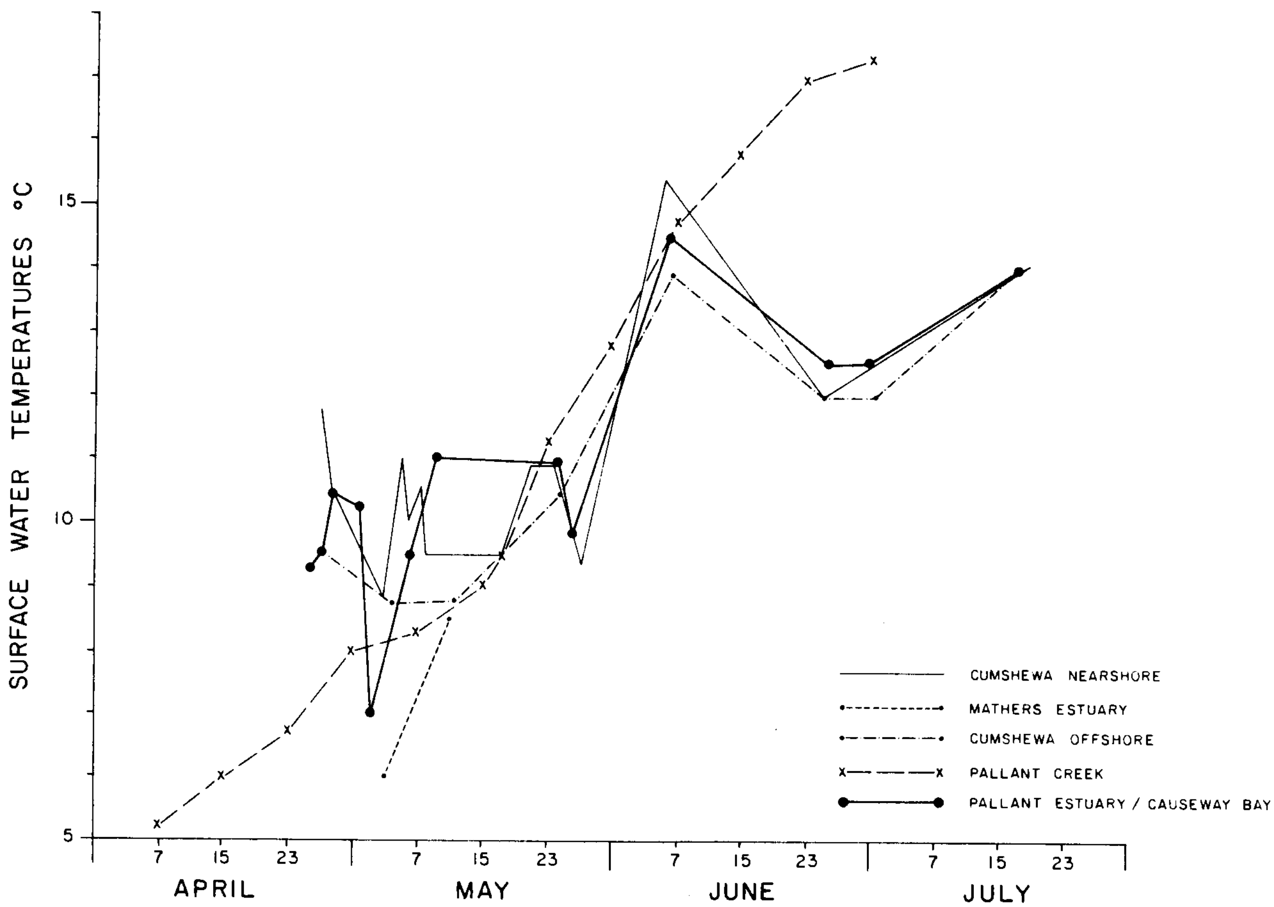

Figure 14: Comparative water temperatures for Cumshewa Inlet, Pallant and Mathers estuaries, and Pallant Creek, from April to July, 1978.

adjacent to the Mathers estuary were, much lower (down to 6°C) than elsewhere; also, the temperature of a spring on an inter-tidal flat to the west of Aero was surprisingly higher (15°C in late April) than elsewhere.

Mosquito Lake. Vertical temperature profiles at the three stations (Fig. 8) are summarized in Fig. 15. The lake remained isothermal January through April. Thereafter, a thermocline began to develop; by August, the epilimnion was 8 m thick and 18.5°C at the surface, and the hypolimnion temperature had increased to 7°C, indicating active mixing. Several mid-water temperature reversals, noted at all three stations, also indicated considerable mixing action. After August, the epilimnion cooled while increasing in depth to 15 m, probably as the result of continued wind-mediated mixing. The lake turned over in mid-November, at a temperature of 9°C. The water temperatures in the outlet bay were often dissimilar to those of the other two stations, and apparently could change rapidly on a daily basis (see June 3 and 7 profiles in Fig. 15). There is no good explanation as to the formation of the apparent reverse thermocline noted on November 16, 1978.

In general, this lake would be classified as a second-class dimictic lake that is heavily influenced by oceanic climate (Hutchinson, 1957). Characteristics of this classification are that the lake seldom freezes; there is prolonged mixing during the winter period; spring heating begins early, but progresses slowly; and that the stability of the epilimnion is low.

Streamflows

Staff gauge readings, which were taken in conjunction with the spring 1978 fry trapping programs, are presented elsewhere in this report (Figs. 18, 19). Additional data, available through the courtesy of two other groups, are presented here:

Mathers Creek. Engineering staff of the Salmonid Enhancement Program installed a Stevens Type F continuous (30-day) recorder in Mathers Creek

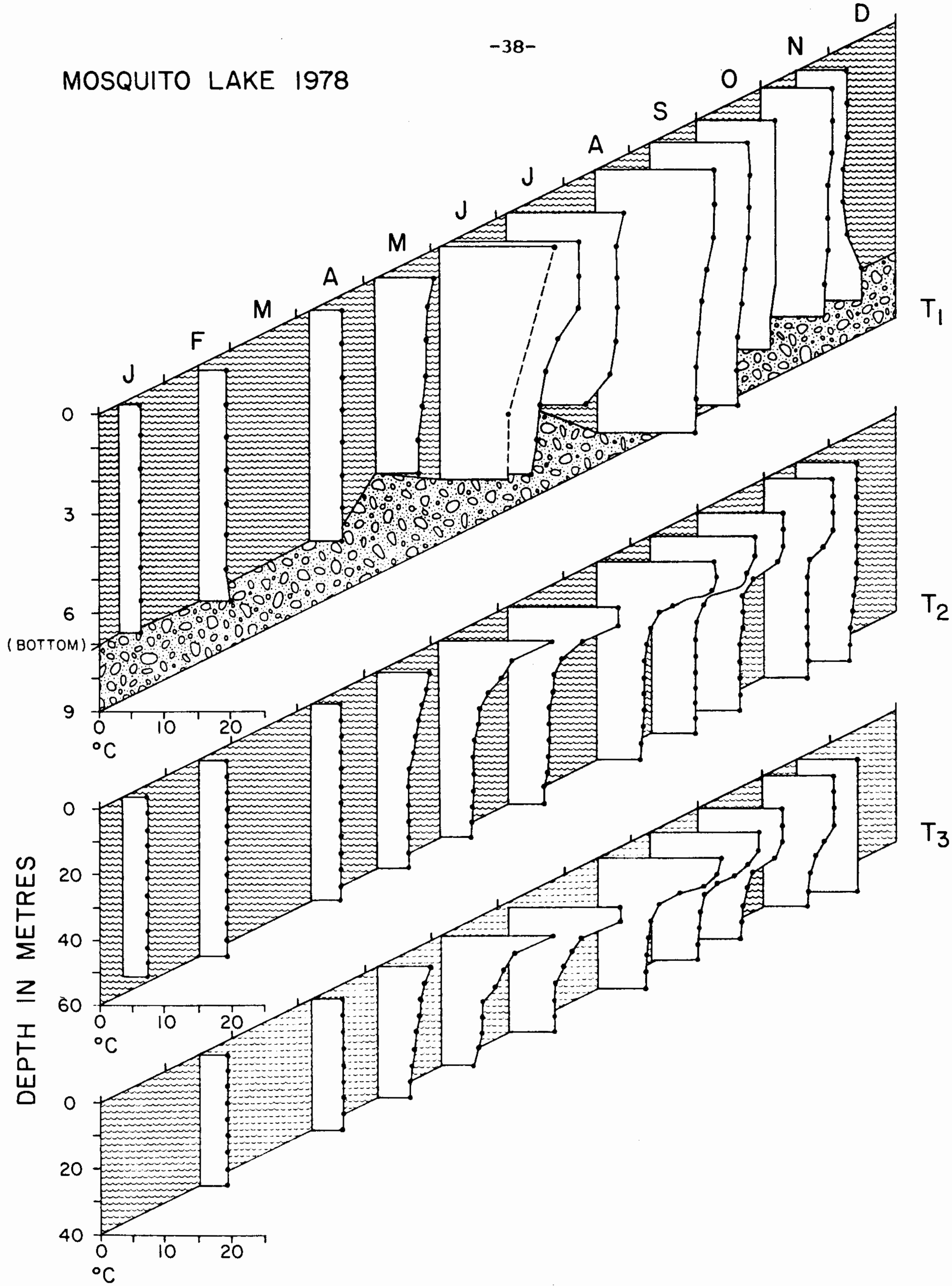

Figure 15: Monthly vertical temperature profiles for the three regular sampling stations (see Fig. 8) in Mosquito Lake, 1978.

beginning in November, 1977. Records available to late May, 1978, have been summarized in Fig. 16A; several equipment malfunctions rendered the June to September charts unreadable, and a severe flood on November 1 destroyed the station. Creek levels rather than actual discharges have been presented, as only one discharge determination (2,930 ℓ /sec at 0.24 m on March 2, 1978) was done. However, stage-discharge data for Mathers Creek during 1962 - 1964 are available from the Water Survey of Canada (Fig. 16A), and fitting of the 1977 - 1978 data to their rating curve allowed gross approximation of discharges. During the period of operation of the WSC manual gauge, discharges ranged from 625 to 26,500 ℓ /sec. However, the readings were both diurnally and seasonally incomplete, and a wider actual range is likely. The maximum discharge to date from the continuous water level recorder has been estimated to be in the vicinity of 36,000 ℓ /sec (but the station was destroyed by the severe flood of November 1, 1978). Daily variations of up to 21,000 ℓ /sec have been noted in both sets of data. Although it might be concluded that fluctuations in Mathers flows are not quite as extreme as at Pallant, the data are seasonally incomplete, and staff-gauge readings taken by the biological field crew in the fall of 1977 would in fact indicate the opposite conclusion (Shepherd, 1978). Further work will be necessary to clarify this matter.

Pallant Creek. Preliminary flow data for the period October 1977 to October 1978, were obtained from the Water Survey of Canada (Fig. 16B). Recorded flows reached a maximum of 44,000 ℓ /sec in late October 1977, and a minimum of 1,400 ℓ /sec in early January, 1978. Other than the first major fall freshet occurring slightly later than usual (Shepherd, 1978) the hydrograph is normal for the period. Only minor freshets were experienced during the fry migration study. An extremely severe flood on November 1, 1978, rendered the WSC gauge inoperable; the replacement of this station is planned for the spring of 1979.

INCUBATION

Sampling results have been summarized in Table 9. Comparison of the egg distribution with the estimated spawner distribution (Fig. 5) did not show a

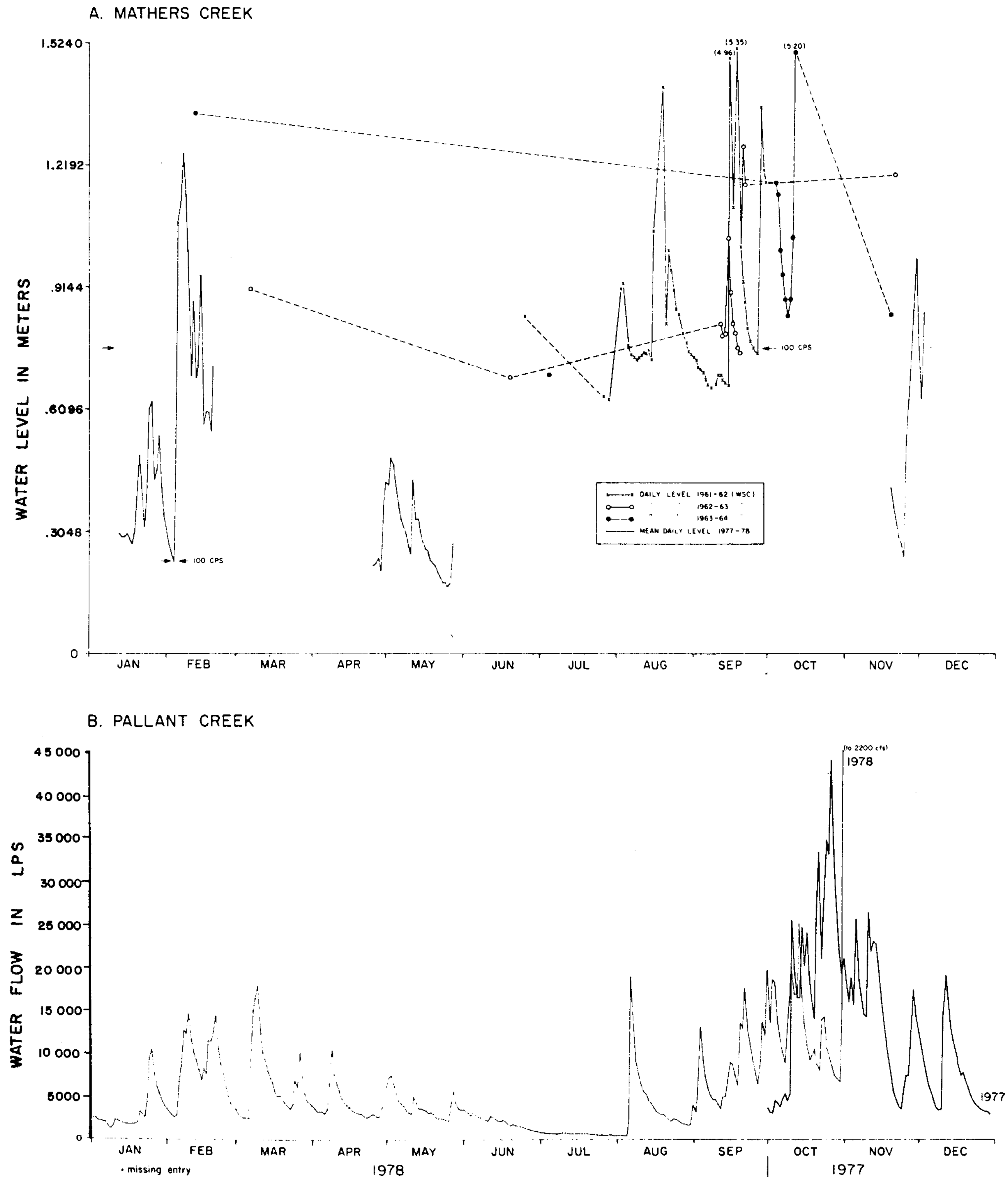

Figure 16: Daily streamflow data for Mathers and Pallant Creeks, 1977-1978 (plus previous data for Mathers Creek. All Pallant and pre-1977 Mathers data courtesy of Water Survey of Canada (unpublished preliminary data).

TABLE 9: Summary of hydraulic sampling undertaken at Pallant Creek in January, 1978.

Spawning Area #	Loc'n in Area	Location in Cross-Section (looking downstream)								
		Right Bank			Center			Left Bank		
		# Live	# Dead	% Dead	# Live	# Dead	% Dead	# Live	# Dead	% Dead
1(L)*	Top	6	0	0	–	–	–	0	10	100
	Middle	2	0	0	–	–	–	6	1	14
	Bottom	17	65	79	0	9	100	0	3	100
2 (M)	Top	406	24	6	307	2	1	33	0	0
	Middle	0	1	100	187	5	3	211	9	14
	Bottom	2	1	33	37	2	15	0	2	100
3 (H)	Top	1	5	83	207	18	8	23	4	15
	Middle	3	0	0	41	11	21	165	16	9
	Bottom	84	3	3	32	2	6	0	2	100
4 (H)	Top	85	1	1	5	10	67	13	0	0
	Middle	3	2	40	16	30	65	–	–	–
	Bottom	11	2	15	3	1	25	–	–	–
5 (H)	Top	0	4	100	0	1	100	0	10	100
6 (H)	Top	0	1	100	271	20	7	–	–	–
	Middle	–	–	–	8	48	86	0	2	100
	Bottom	0	1	100	–	–	–	–	–	–
7 (L)	Middle	4	4	50	N/D	N/D	N/D	–	–	–
8 (S)	Above Trib	N/D	N/D	N/D	308	8	3	N/D	N/D	N/D
	Below Trib	N/D	N/D	N/D	–	–	–	N/D	N/D	N/D

* Classification according to spawning observations:

L = Light H = Heavy
M = Medium S = Scattered

good relationship. Although the results are variable[1], it appears that the highest numbers of eggs were found in the upper spawning areas and the highest apparent mortality occurred in the lower areas (Fig. 17A). Similarly, highest numbers of eggs were found at the tops of each area, and apparent mortality was slightly higher at the bottoms of each area (Fig. 17B). Egg numbers were highest in the centres of each area and apparent mortality was higher near the left bank than at the centre or right bank (Fig. 17C). Most of the variations noted could be explained on the basis of downstream siltation from the active cutting at the lower end of the oxbow (on the left bank), and perhaps added to locally by upstream redd construction. Overall, the number of eggs/m^2 were greater than double the number predicted from spawning data (Table 10). These data, together with the 1978 fry migration data (see following section) suggest that the number of spawners were considerably underestimated in 1977. Therefore, the McNeil (1964) method of calculation of overall survival--which should be lower than the apparent survival, as it accounts for eggs that have disappeared through predation, decay, scouring, etc.--is not meaningful, as it requires accurate estimation of egg deposition. Hence, the overall apparent survival (live/live + dead) of 88 percent is retained as a maximum estimate of survival up to the end of January. Apparent survival compared closely with the egg-to-fry survival calculated from fry trapping at the Big Qualicum chum spawning channel (memo from J.R. Paine to H.S. Genoe, on March 16, 1973); however, their hydraulic sampling was done after hatching, and controlled flows eliminated scouring as a mortality factor. In uncontrolled streams, egg-to-fry survival is usually less than 10 percent (Bakkala, 1970). In the absence of a permanent adult fence to allow accurate adult enumeration, the hydraulic sampling program for Pallant Creek will have to be continued into March to better gauge survivals.

During the hydraulic sampling at Pallant in January, 1978, the stage of development of recovered embryos decreased upstream. Mainly alevins were found at the lower end (near the hatchery site). Weights and diameters or lengths of

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[1] Spawning areas 5, 7, and 8 are to be discounted because of their small sample sizes.

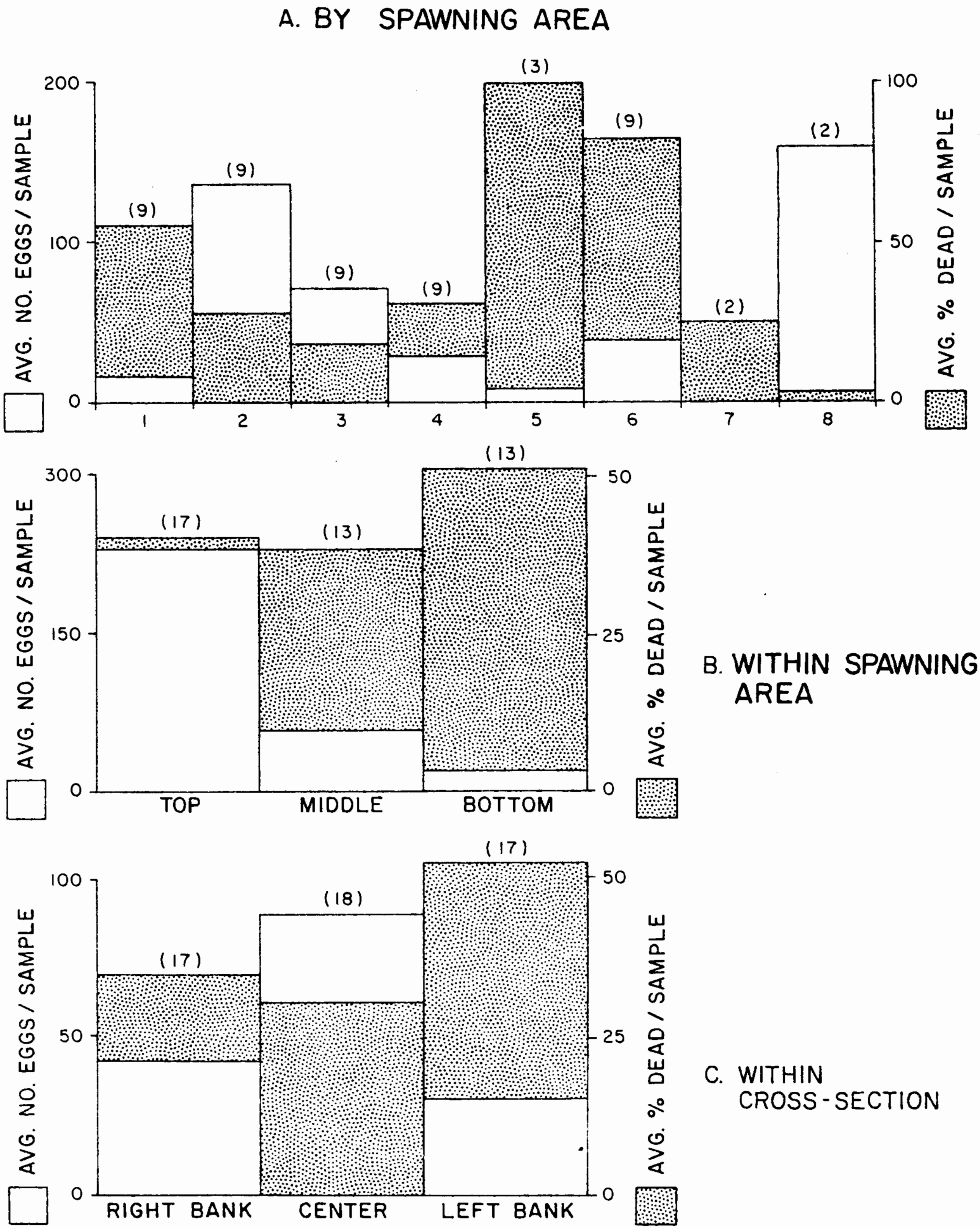

Figure 17: Abundance and mortality of incubating chum eggs in Pallant Creek, January 1978. Refer to Fig. 5 for locations of reaches.

TABLE 10: Actual eggs/m^2 from 1978 Pallant Creek hydraulic sampling, in comparison with estimate made from 1977 adult observations.

Estimated No. of Spawners:	3,000
Sex Ratio (Females as%):	51.4%
Females in Population:	1,542
Mean POH* length of Females:	561 mm
POH-Fecundity Relationship:	F = 10.97 POH - 3422
Mean Fecundity:	2,732
Total Eggs:	4,212,744
Egg Retention as %:	2.2%
No. Eggs Retained:	92,680
Net No. Eggs Available:	4,120,064
Area of Documented Spawning:	14,750 m^2
Eggs/sq m:	279
Actual Eggs/sq m:	602

*POH = Postorbital-hypural length

embryos (Table 11), together with the shape and relative size of the yolk sac, indicate that the embryos had accumulated 350 - 450 T.U. (°C) according to Bakkala's (1970) review. The available temperature data from 1977 and 1978 therefore suggest that the majority of the eggs were deposited in the last two weeks of October, 1977.

FRY MIGRATION

Timing of Migration

Graphs depicting the daily variation in catches of abundant fish species in the continuously-fishing traps at Mathers and Pallant Creeks are shown in Fig. 18; daily water levels and temperatures are also given. The starting, peak, and ending dates for each species are summarized in Table 12. Differences in timing between the Pallant and Mathers chum stocks were slight; in both creeks, chum migration increased sharply when water temperatures reached 6°C, and migration peaks were associated with freshets. Coho fry and smolt migrations in both creeks also were similar, except that peak migrations occurred during the first freshet at or above 7°C (approximately 1 - 2 weeks after the peaks in chum fry migration).

Diurnal variation in fry movement was examined on two separate occasions at each creek (Fig. 19). As Hunter (1959) and others have found, the majority of fry migration occurred during darkness. Peak migration occurred between 2200 and 2300 h PST at Pallant, and 0100 - 0200 h at Mathers. Peak periods were also associated with the peak water level in each night; this is considered to account for the difference between the April 29 - 30 series and the May 2 - 3 series at Mathers Creek. On April 29 - 30, a freshet (12 cm rise) occurred early in the evening, and the migration was correspondingly early (2130 - 2230 h). On May 2 - 3, water levels fluctuated less than 2 cm overnight, and the migration peak was 2 - 3 h later than on April 29 - 30. Therefore, the May 2 - 3 variation is considered to be the standard in the

TABLE 11: Sizes (ranges in parentheses) of preserved chum embryos taken during hydraulic sampling at Pallant Creek in 1978, and preserved for at least 6 weeks.

Sample Site	Embryo Type	n	Average Length(mm)	Average Weight(mg)
#2(near hatchery)	Eyed Eggs	30	7.7(dia.) (-)	245 (240-270)
" "	Embryos Blown From Eggs	9	20.2 (18-22)	215 (190-230)
#3(down-stream)	Alevins	7	28.1 (28-29)	207 (200-220)
#4(down-stream)	Alevins (smaller yolk sac)	8	29.6 (27-34)	234 (170-350)
#8(near S. tributary)	Buttoned fry	2	31 (-)	200 (-)

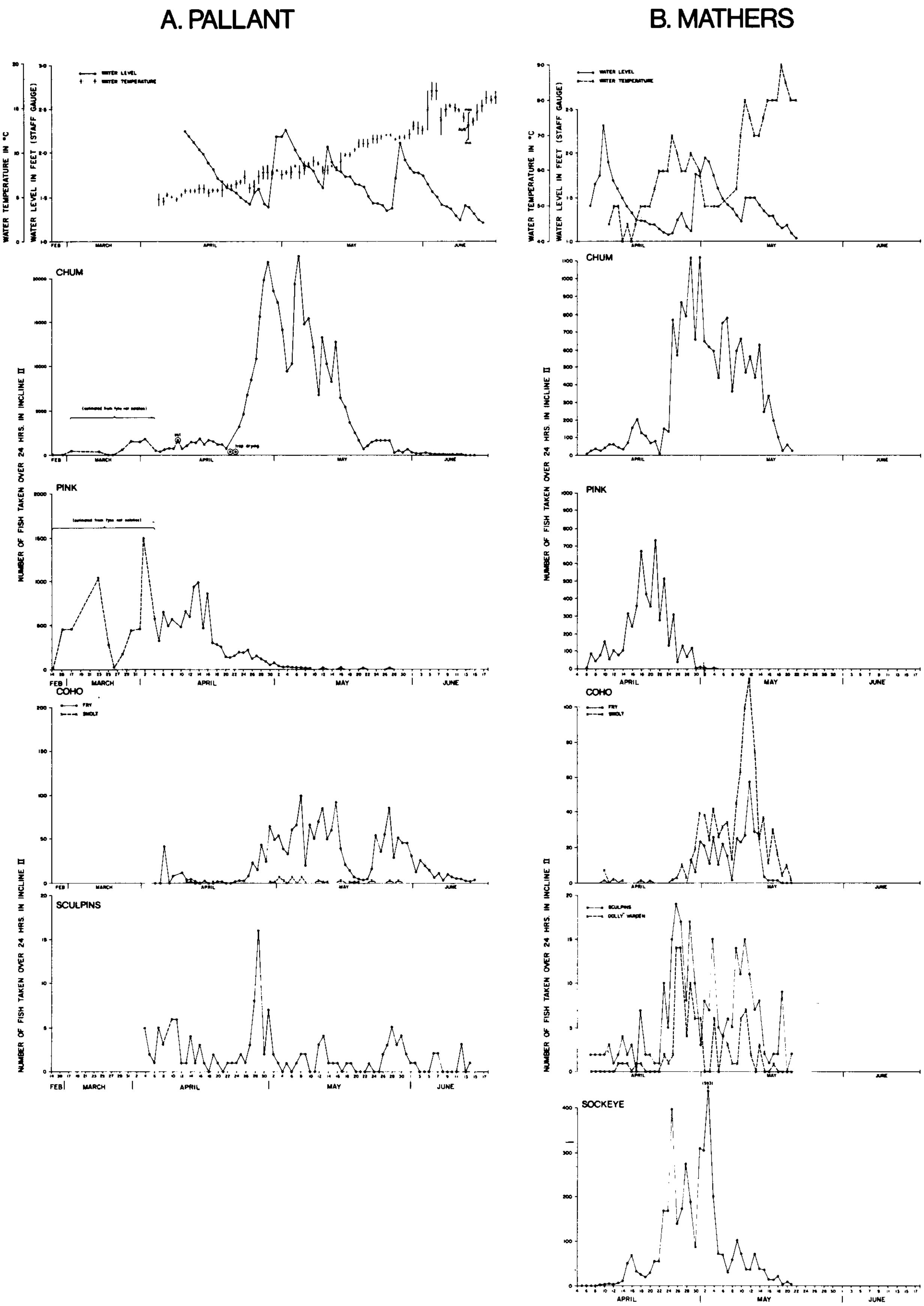

Figure 18: Daily water temperatures, water levels, and juvenile migrations during the monitor periods at Pallant and Mathers Creeks, in 1978.

TABLE 12: Summary of seasonal timing of 1977 downstream migrations.

	Pallant	Mathers
CHUM		
Start	after Feb 28, before Mar 17	before Apr 6
Primary Peak	May 7	Apr 29
Secondary Peak	Apr 30	May 1
End	Jun 15	very low May 21 (pulled)
PINK		
Start	Feb 14 or earlier	before Apr 6
Primary Peak	Apr 14 Apr 2	Apr 21
Secondary Peak	Apr 16 (incline only) Mar 23 (Fyke est.)	Apr 19
End	May 27	May 11
COHO FRY		
Start	Feb 28 or earlier	Apr 10
Primary Peak	May 7	May 12
Secondary Peak	May 15	May 13
End	after Jun 15	May 19
COHO SMOLTS		
Start	Apr 11	Apr 10
Primary Peak	May 2/5/7	May 12
Secondary Peak	May 2/5/7	May 11
End	May 29	after May 22
SOCKEYE SMOLTS		
Start		Apr 9
Primary Peak		May 3
Secondary Peak	only a few fry noted	Apr 25
End		after Apr 21
SCULPINS		
Start	before Apr 4	before Apr 6
Primary Peak	Apr 29	Apr 26
Secondary Peak	Apr 28	Apr 27/29
End	after Jun 14	after May 21
DOLLY VARDEN JUVENILES		
Start	–	Apr 12
Primary Peak	–	Apr 26/27
Secondary Peak	–	29
End	–	May 18

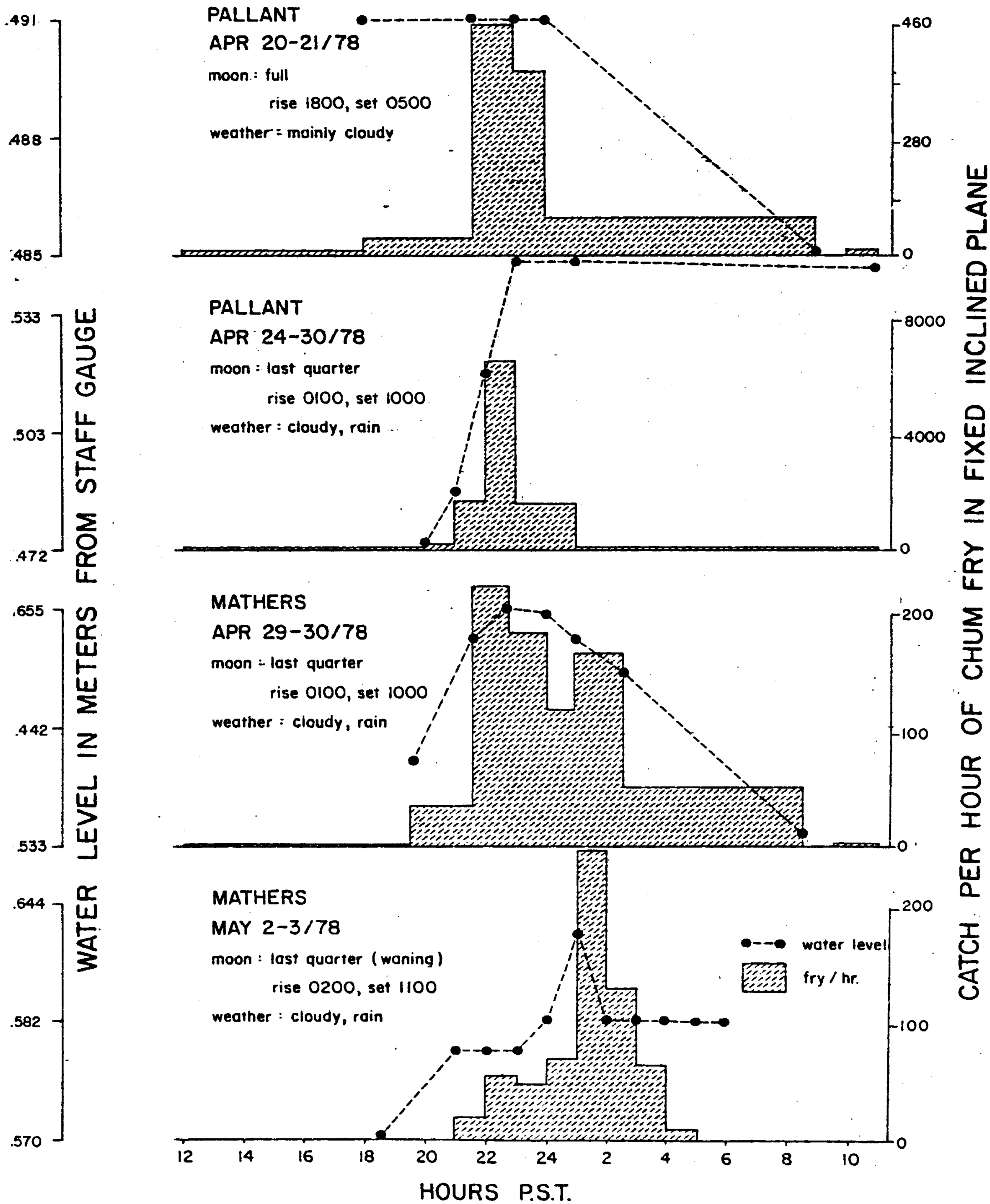

Figure 19: Daily variation in chum fry migration at Pallant and Mathers Creeks, 1978, compared to water levels, phase of moon, and weather.

absence of freshets. Assuming that both stocks of fry emerge at the same light level, the 2 - 3 h difference between the creeks' peak nightly migration suggest that Mathers fry are emerging from farther upstream than at Pallant. From the published fry migration rates reviewed by Bakkala (1970), it is calculated that fry at Mathers Creek emerge 3 - 5 km farther upstream than at Pallant (i.e., 5 - 6 km upstream of the Mathers fry traps). This would cover Mathers Creek from the beginning of the braided area upstream to Mathers lake, or the section of the southern tributary from 2.0 - 3.5 km upstream.

Instream Distribution of Fry

Various locations (Table 13) upstream of the regular trapping sites were sampled to confirm chum spawning distributions within the system. These fyke net sets indicated that:

(1) The southern tributary to the Pallant mainstem was not successfully used by chum spawners in 1977.

(2) The southern tributary to the Mathers mainstem was used (to a lesser degree than the mainstem) by chum spawners in 1977.

(3) Chum spawning in the Mathers mainstem occurred up to Mathers Lake.

Chum fry distributions within the cross-sections were also examined at the regular trapping sites. As may have been expected from the data of McDonald (1960), the lateral distribution of fry at Pallant Creek was almost the mirror image of the bottom contour and probable velocity pattern (Figs. 7B, 20A), except that fry numbers tended to be heavier than expected towards the left bank (looking downstream). This skew in the fry distribution is likely the result of fry being carried to the outside of a large right hand curve upstream of the trap site. Some temporal variation in fry distribution also was noted on the right bank side (worst range 75 - 275 percent at position 6), probably in connection with changes in flows. However, the relative velocity pattern at Pallant remained constant throughout the study. This is in contrast to Mathers,

TABLE 13: Miscellaneous fyke net sets at Mathers and Pallant in 1978 (not on regular fry trapping cross-sections).

DATE / TIME SET	P/U	LOCATION	CATCH	COMMENTS
Mathers Creek:				
May 1 – 1400	May 2 1400	S. tributary 50 m u/s of Mathers Creek	14 chum fry	–
May 6 – 1400	May 7 1600	S. tributary 150 m u/s of Mathers Creek	180 chum fry 3 coho fry 1 coho smolt 1 sculpin	–
May 7 – 1600	May 8 1400	S. tributary, 150 m u/s from Mathers Creek	40 chum fry 5 coho fry	8.5°C @ p/u
May 8 – 1400	May 9 1030	Mathers Creek, 150 m u/s from S. tributary	58 chum fry 3 coho fry	6.5°C @ p/u
May 13 – 1600	May 14 1400	Mathers Creek, 0.5 km from Mathers Lake	443 chum fry 241 coho fry 24 coho smolts	
Pallant Creek:				
Apr 29 – 1400	Apr 30 1400	S. tributary to Pallant Creek, 100 m u/s from confluence	1 non-salmonid fry (1 cm long)	

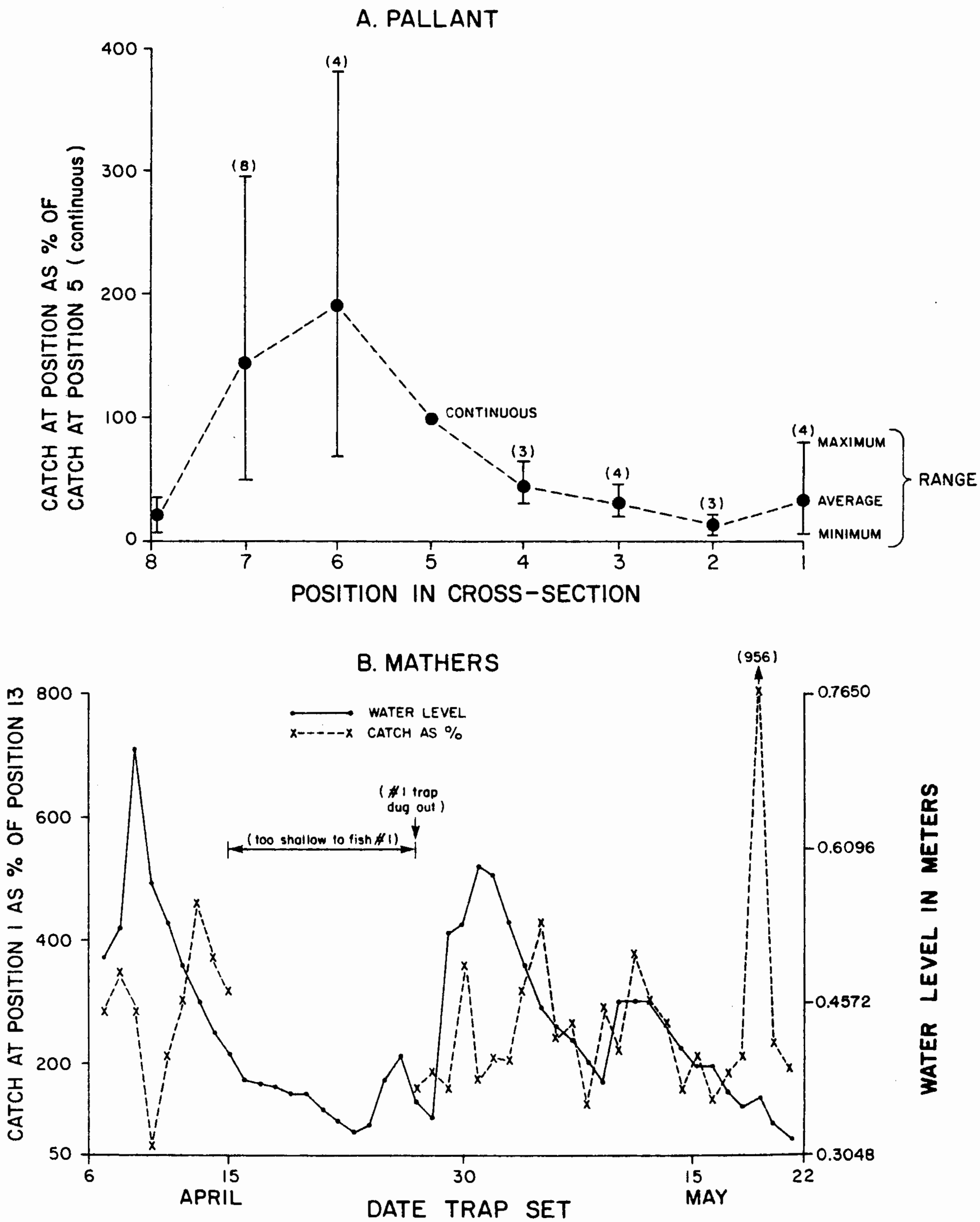

Figure 20: Variations in trap catches of chum fry, 1978. A. Variation in catches within cross section at Pallant Creek. B. Variation in catches with water level at Mathers Creek.

where the velocity pattern changed drastically with flow--the point of maximum velocity switched from the right channel at high-to-moderate flows, to the left channel at low flows (Fig. 7A). This may account for the large temporal variations noted in relative catches between the two regular traps (range 50 - 800 percent; Fig. 21B).

Only two regular trapping sites were used at Mathers, due to the restricted size and depth of the channels throughout most of the migration period. The smaller fyke net/live box combination used at Mathers captured very few fry, while the larger fyke net at Pallant was quite effective in trapping fish. Therefore, for the above reasons, a lateral fry distribution curve could not be developed for Mathers Creek.

Instream Behavior of Fry

On April 4 - 5, pink and chum fry that had been trapped at Pallant during the night and sorted and counted the following morning, were observed upon their release at approximately 1200 h PST the same day. Chum fry held briefly in the quiet backwater where they had been released, then individually moved slowly downstream and away from the shore, until they came to fast water (30 - 60 cm/sec). At that point, the fry immediately oriented upstream as if attempting to hold position, but were transported downstream by the current. Pink fry held in the backwater in schools, or individually swam downstream and outwards into fast water. At no time did the pink fry attempt to hold against the current, but instead actively swam downstream. Even when frightened, neither species demonstrated any cover-seeking behavior. This probably is a result of the fry having had schooling experience (Hoar, 1976) during trapping and processing. In any event, the daytime behavior noted was considered to be detrimental to fry survival, so fry were thereafter held in large buckets and released at late dusk (2200 - 2300 h PST).

The stomachs of the larger chum fry taken in the latter stages of migration were checked to see if freshwater feeding had commenced. Four of the six fish examined had organic particles of extraneous origin in their guts, indicating that feeding had begun.

Magnitude of Runs

The procedure used to estimate the total number of chum fry at each creek is outlined in Table 14. Both mark-recapture and cross-sectional methods produced similar estimates of the size of the fry population at Pallant (best estimates of 5.7 and 4.0 million fry, respectively). The Mathers population was calculated to be less than a million fry, using the mark-recapture method only (for reasons discussed in previous section). The Mathers population may have been slightly underestimated for the following reasons:

(1) Unlike Pallant, the Mathers trap also captured large numbers of coho smolts during the dye tests. Only a few of these smolts were sacrificed to check for consumption of dyed fry, so post-trapping predation of dyed fry may be higher than shown.

(2) While all of the Pallant recaptures were made overnight, dyed fry at Mathers were recaptured over two days (despite releases being a similar distance upstream in both cases). This slower out-migration may have resulted in higher pre-trapping predation of dyed fry, particularly in view of the observed changes in daytime behavior of previously-trapped fry that were discussed earlier in this report.

The sizes of the spawning runs at Pallant and Mathers that would be required to produce such fry runs have been calculated in Table 15. At Mathers, the spawning estimate made in 1977 could have produced the number of fry observed, but the best estimate would be 2 - 3 x higher, or 6,000 spawners. At Pallant, it appears that the spawning run was underestimated by an order of magnitude, unless egg-to-fry survivals were unusually high; the maximum estimate of egg-to-fry survival at Pallant (Table 16) of 48 percent could absorb most of the difference. Underestimation of the spawning run could have occurred either by rapid turnover of spawning waves, or by additional spawning after termination of observations at the end of November. Examination of the fry migration timing curve for Pallant (Fig. 20) indicated that the bulk of the fry migration occurred within a four-week period. Moreover, the developmental stages of the

TABLE 14: Methods of estimation of magnitudes of chum fry runs at Mathers and Pallant Creeks, 1978.

		MATHERS	PALLANT
A. MARK-RECAPTURE METHOD:			
(1) Dye Tests (Recap/marked)	#1	.024 on May 10	.057 on May 8
(Recap/marked)	#2	.026 on May 13	.073 on May 10
(Recap/marked)	#3	.029 on May 14	.054 on May 11
(Recap/marked) $\bar{x}$ (95% C.I.)		.026(.020–.030)	.061(.036–.087)
(2) Total No. Fry Trapped		15,884 to May 18	348,948 to Jun 11
(3) Total Estimated Run[1]	$\bar{x}$	631,083	5,720,459
	max	820,409	9,693,000
	min	497,217	4,010,897
B. CROSS-SECTION METHOD:		N/A	
(1) Proportion of Run Caught in Continuous Trap $\bar{x}$ (range)		–	.175(.088–.357)
(2) Proportions Halved to Adjust for Entire Stream Width (1 m sampled/2 m river)		–	.088(.044–.179)
(3) Total No. Fry Trapped		–	348,948 to Jun 11
(4) Total Estimated Run	$\bar{x}$	–	3,965,318
	max	–	7,930,636
	min	–	1,949,430

[1]Estimated from Pallant data that 3.3% of the run would have passed at Mathers after trapping was stopped; total for Mathers was adjusted accordingly.

embryos collected during hydraulic sampling indicated that the majority of the eggs were deposited in late October. Therefore, late spawning is discounted as a major error factor. The possible problem of rapid turnover of spawning waves may be resolved with an intensive adult tagging program but a better solution to the overall problem would be the construction of a permanent adult counting fence.

Estuarine Distribution and Behavior of Fry

The following summary was made of the observations contained in Appendix 3. At Pallant Creek, most of the chum fry migrated directly to sea, but some were noted holding and schooling with other chum or coho fry along the stream margins in June. However, by June 25, chum fry were no longer observed in the creek. After leaving Pallant Creek, few fry remained in the estuary proper; the few that did were in the upper areas, and appeared to have been stranded during falling tides in pools that had no outflow. There was a definite northward movement of fry once in saltwater. Heavy fry concentrations were found in the bay to the north of the Moresby Camp causeway, from mid-April on (Fig. 13); substantially fewer fry were observed in Gordon Cove (to the south of the estuary). Fry were common all along the northern shoreline of Cumshewa Inlet up to McCoy Cove, from early May on. The southern shoreline of Cumshewa Inlet, which is mainly rock cliffs, remained relatively barren of chum fry except for small schools along the other margins of Gordon Cove, and also a large accumulation at Barge Point (the latter may have been fry from Chadsey and Carmichael Creeks). Fry remained in good numbers in Causeway Bay at least until the end of June; thereafter, the fry appeared to move offshore. Although surface rises remained common over deeper areas of the bay into mid-July, the fish sounded upon the approach of a boat, and species identification was not possible. A similar offshore movement of chum fry began in early June and was complete by mid-July along the northern shoreline of Cumshewa Inlet.

The majority of Pallant Creek fry appeared to follow the main stream channel through the estuary, which exits to the north over deep water at the end

TABLE 15: Comparison of the calculated numbers of adults required to produce the fry runs at Mathers and Pallant in 1978, versus the visual estimates of spawners made in 1977 (Shepherd, 1978).

	MATHERS	PALLANT	
(1) Best Estimate of No. of Fry	1×10^6		5×10^6
(2) Egg-to-Fry Survival:	.10*	.10*	.48**
(3) No. of Eggs Deposited:	1×10^7	5×10^7	1×10^7
(4) No. of Eggs/Female:	2,919	2,732	2,732
(5) No. of Female Spawners:	3,426	18,301	3,660
(6) Sex Ratio (% Females)	.51	.51	.51
(7) Total No. of Spawners	6,718	35,884	7,177
Visual Estimate of Spawners:	2000-3000	3,000	

* Bakkala, 1970
**see Table 16

TABLE 16: Estimation of egg-to-fry survival from hydraulic sampling data collected at Pallant in 1978.

(1) Estimate of total egg deposition from Jan. hydraulic sampling ($14{,}750\ m^2 \times 602\ egg/m^2$)	=	9×10^6
(2) Best estimate of no. of fry	=	5×10^6
(3) Percent survival, eyed egg to fry (5×10^6)/(9×10^6)	=	55%
(4) Percent survival to eyed egg (No. dead eggs/no. dead + live eggs)	$\leq$	88%
(5) Percent survival, egg to fry (.88 x .55)	$\leq$	48%

of the causeway. At low tides, it seemed that the fry moved along with the outflow current across the bay, over this deep water. Upon gaining the northern shoreline, the fry then followed the shoreline into Causeway Bay. On high tides, it appeared that fry followed the shoreline around the causeway and into the bay. It is possible that construction of this causeway may have resulted in additional predation of fry, by prematurely forcing the fry out over deep water and into the reach of large aquatic predators on low tides. Although inquiries as to the date of construction of the causeway have been made, this information remains lacking, and thus cannot be compared to the pattern of stock decline.

Upon entering saltwater, the fry stayed close to shore, usually in water depths of less than 1 m, and over a variety of substrates. The fry generally moved with the current (eastward during rising tides, westward during falling), and were often seen actively surface feeding. Most schools were found in protected bays, although some schools were noted along exposed stretches as well. Pink and chum fry were found to be schooling together at times. Once the fry reached approximately 5 cm in length, they shifted to a mid-water position over deeper intertidal areas (up to 5 m), and showed greater attraction to cover such as kelp beds or the observer's boat. Also, fright behavior changed: small fry moved shorewards or parallel to the shore if disturbed (and in fact could not be forced into deep water), while larger fry sounded away from shore.

The observations made at Pallant are similar to those made by other researchers (Bakkala, 1970; Allen, pers. comm.). At Mathers, however, fry could not be found in the estuary or nearby coastal shallows. It may be that, due to the highly exposed nature of the shoreline in this area, the chum fry rapidly move offshore, perhaps into the large kelp beds on the Fairbairn Shoals.

It was also noted that heavy plankton blooms occurred down to 15 m throughout Cumshewa Inlet in late April through early May, which was during the time of peak migration of chum fry.

Growth of Fry

Lengths, weights, condition, and developmental indices for chum and coho fry taken during 1978 are summarized in Fig. 21. Overall length, weight, development, and condition values (Table 17) were similar to those found by other researchers (Bakkala, 1970; Bams, 1970). Trends in development during the fry migration period are as follows:

Length. Although confidence intervals overlapped in most cases, the mean size of Pallant chum fry tended to decline during the period of heavy migration, then increased in size near the end of migration. The latter increase in length is probably the result of delayed migration and freshwater feeding. The decrease in size during the earlier portion of the run can not be explained, although it appears to be real; Bams (1970) noted a similar pattern in his study. Lengths of Mathers chum fry were similar to those of Pallant fry. Growth rates[1] were calculated to be up to 1.04 percent of initial migrant length per day; this is comparable to the rates found for other B.C. chum stocks, which averaged 1.07 percent (range 0.77 - 1.60%) per day (Fedorenko *et al.*, 1979). Average lengths of coho fry remained relatively constant throughout the sampling period at Pallant. Mathers coho were similar in size to those at Pallant.

Weight. Confidence intervals again overlapped for most samples. Average weights of Pallant chum fry were variable but, overall, remained relatively constant for the sample period. Mathers chum fry were similar in weight to those at Pallant. Chum fry from Cumshewa Inlet showed gains in weight much earlier than increases in length, and growth rates were calculated to be up to 3.58 percent per day; this, again, is comparable to other B.C. chum stocks, which averaged 3.93 percent (range 2.99 - 6.20 percent) per day (Fedorenko *et al.*, 1979). Average weights of coho fry at Pallant varied, but remained within the range of confidence intervals. Mathers coho fry appeared to be lighter than Pallant fry.

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[1]Growth rate = $(\ln_b - \ln_a)/(t_b - t_a) \times 100$; where 'a' is initial, 'b' is final, and 't' is in days.

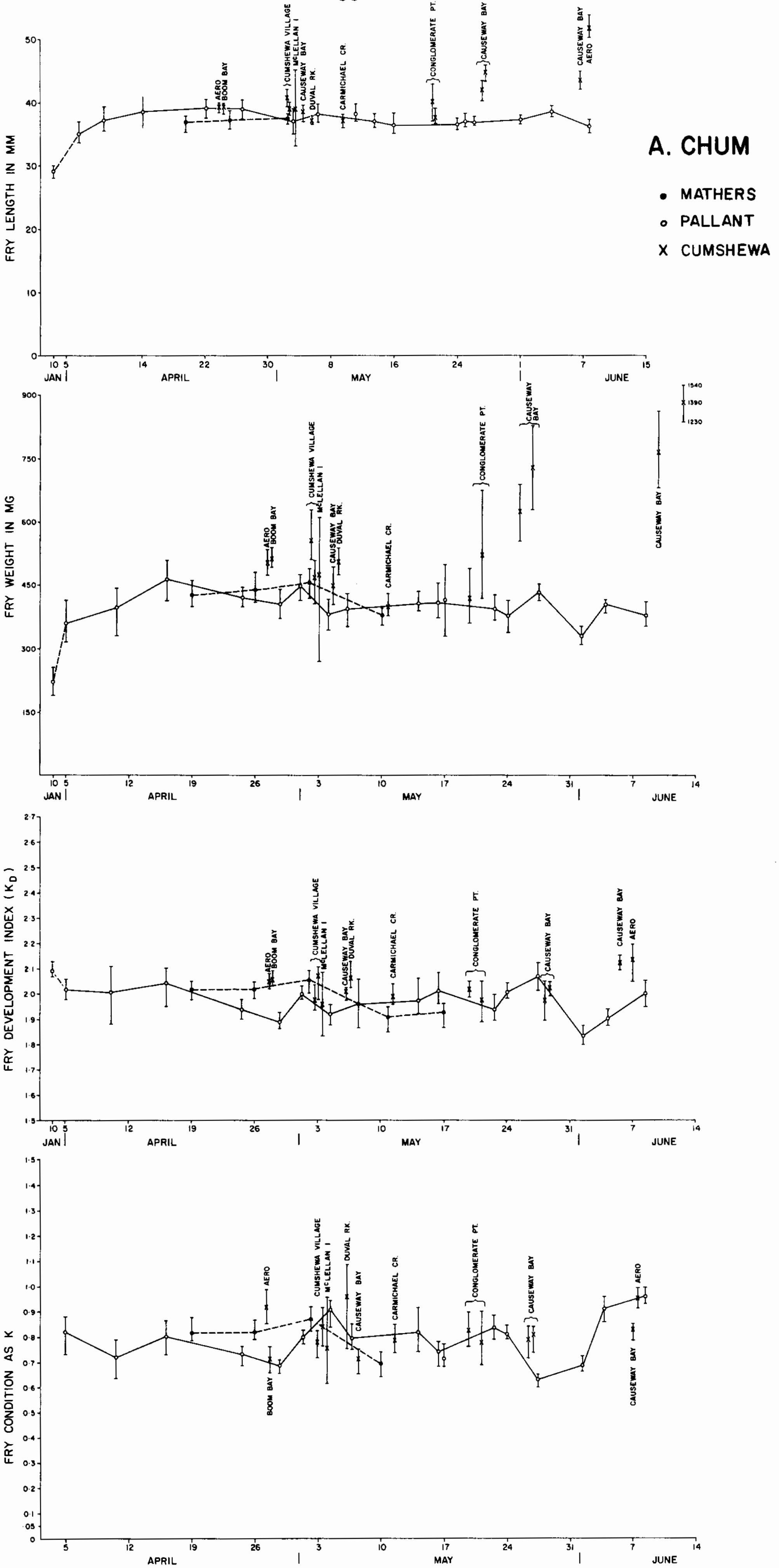

Figure 21A: Length, weight, and condition factor variations with time and location for Pallant Creek, Mathers Creek, and Cumshewa Inlet chum fry stocks, 1978.

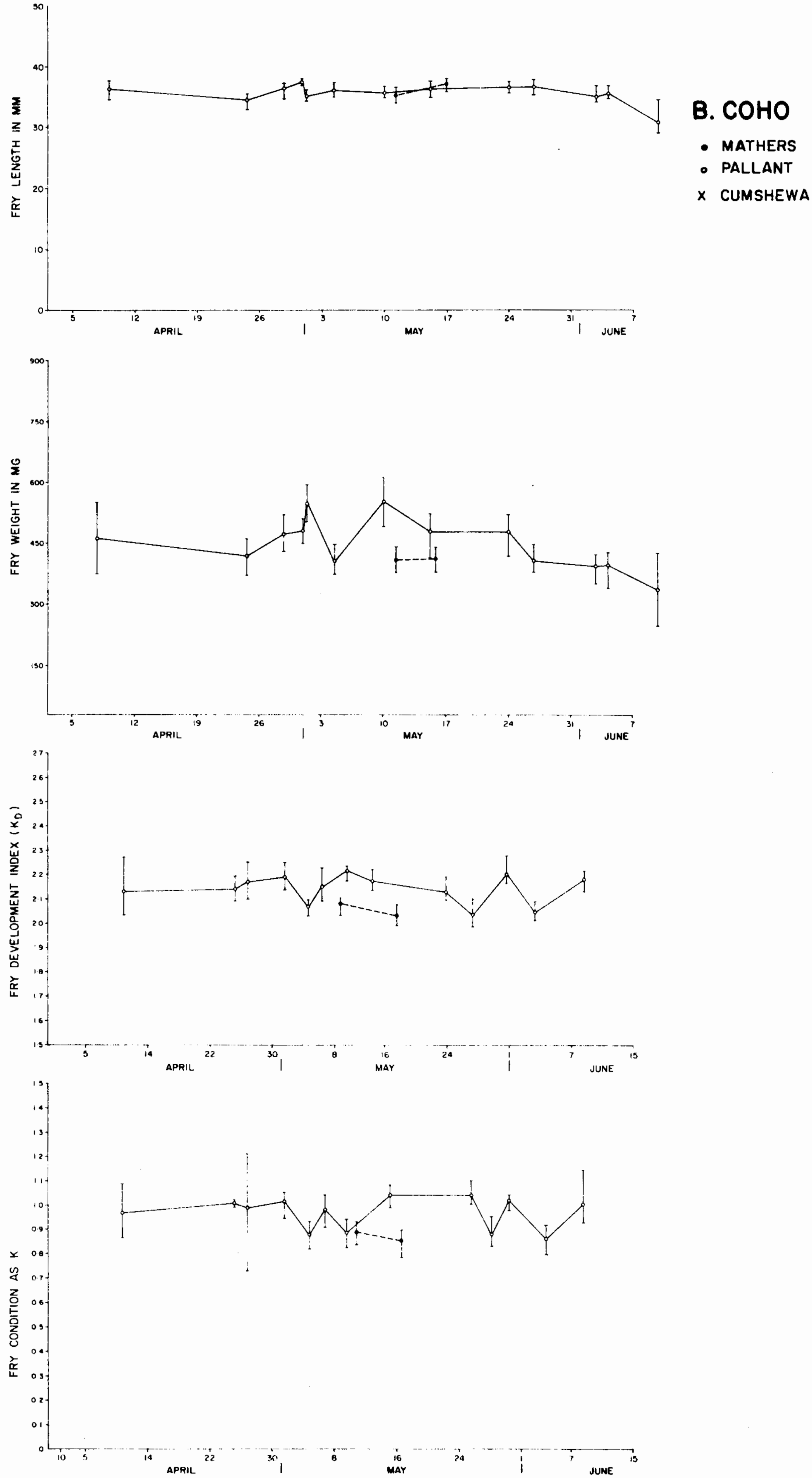

Figure 21B: Length, weight, and condition factor variations with time and location for Pallant Creek, and Mathers Creek coho fry.

TABLE 17: Summary of mean fry size parameters

Species	Creek	n	L[1] (mm)	W[1] (mg)	K_D[2]	K[3]
CHUM	Pallant	200	37.7	404	1.96	0.776
	Mathers	50	37.9	423	1.97	0.775
COHO	Pallant	126	35.4	420	2.14	0.960
	Mathers	26	36.1	411	2.05	0.876

[1] L and W are from preserved specimens; add 5% to L and subtract 10% from W to approximate live values (Parker, 1963).

[2] $K_D = \frac{10 \sqrt[3]{W \text{ in g}}}{L \text{ in mm}}$; see Bams (1970).

[3] $K = \frac{10^5 \times W \text{ in g}}{L \text{ in mm}}$; Fulton's K, per Ricker (1975); alevins excluded.

Development Index. For Pallant chum fry, confidence intervals largely overlapped during the sample period. A decline in the index was expected, and seemed to have occurred over the period, but was masked by variability. Mathers chum fry samples exhibited similar trends to Pallant. Values of the development index at Pallant and Mathers Creeks during the peak migration period corresponded well to those found by Bams (1970).

The development index for coho fry at Pallant Creek, although variable, showed no drop over the sampling period. Mathers fry had significantly lower index values than Pallant fry in the same period; it is uncertain whether this is due to a difference in developmental stages, or to population differences in length and weight at a given developmental stage.

Condition. Condition of Pallant chum fry was variable, but appeared to be increasing at the end of the sampling period. Mathers chum fry were similar in condition to those of Pallant. Condition of fry in Cumshewa Inlet was not markedly different from creek fry.

Condition of Pallant coho fry was variable, and may have been a result of flow fluctuations (higher flows flushing out weaker fry). Mathers coho fry had similar or lower condition values to Pallant fry.

PREDATION AND COMPETITION

Species Distributions

The presence of predators or competitors of chum and coho fry throughout the Pallant system was checked using gill nets, minnow traps, seine nets, and visual observations (Appendix 4). A list of the species captured and their gross distributions are provided in Table 18. In several species, distributions changed markedly during the study period. Adult steelhead moved into the system to spawn from December - May, peaking in February. Mature cutthroat were caught near the mouths of the lake tributary and outlet streams in early April, and most fish caught in early June were spawned out. At least two age classes of

TABLE 18: Presence and general distributions of potential and actual chum predator/competitor species in the Pallant system, 1978.

		Portion of Pallant System														
Common Name	Predator (P) or Competitor (C)	S. trib. at lakehead	N. trib. at lakehead	Pallant Cr. (lake trib.)	Upper Mosquito Lake	Middle Mosquito Lake	Lower Mosquito Lake	Pallant Cr. lake to 3rd falls	Pallant Cr. 3rd falls to 2nd falls	Pallant Cr. 2nd falls to 1st falls	Pallant Cr. 1st falls to S. trib.	S. trib. to Pallant Cr.	Pallant Cr. S. trib to gorge	Pallant Cr. gorge to tidal	Estuary and Causeway Bay	Species
Rainbow/steelhead	P								X	0	X	X	X	X		Salmo gairdneri
Cutthroat	P		X	X	X	X	0	X			X		X			Salmo clarki clarki
Dolly Varden	P		X	X	X	X	X				X	0	X	X	X	Salvelinus malma
Kokanee	C				X	0	X									Oncorhynchus nerka
3-Spine stickleback	C				X	X	X	?		X					X	Gasterosteus aculeatus
Tomcod	?														X	Microgadus proximus
Pacific cod	P														X	Gadus macrocephalus
Shiner perch	C/P?														X	Cymatogaster aggregata
Copper rockfish	P?														X	Sebastes caurinus
Sculpins	P	X	X	0	?	?	?	X	X	X	X			0	X	Cottus aleuticus
Coho (smolts)	P									X	X	0	X	X	X	Oncorhynchus kisutch
Herring (juv.)	C														X	Clupea harengus pallasi
No. of Species	TOT	1	3	3	5	5	5	3	2	4	5	3	4	4	9	
	P	1	3	3	3	3	3	2	2	3	5	3	4	4	6	
	C				2	2	2	1		1					3	

X Present
0 Heavy
? Assumed to be present

juvenile cutthroat also were common downstream of Mosquito Lake in early April; this is in contrast to the lack of cutthroat noted here by a Fish and Wildlife Branch inventory crew in late May (Caw, MS 1978). It may be that juvenile cutthroat migrate into Mosquito Lake at this time, but it is considered more likely that differing capture methods are responsible. Sea-run Dolly Varden were observed spawing in the lower portion of the Pallant system from late June to early July. Juvenile kokanee were observed surface-feeding in schools throughout Mosquito Lake; larger kokanee have been caught only by deep-water trolling. Shiner perch became very abundant in the intertidal zone in early June. Sculpins appeared to peak in their downstream movements along with the peak chum fry migration, but were common throughout the system except in the southern tributary to the mainstem. In the marine environments herring juveniles may compete with chum fry, but appeared to utilize deeper waters than the chum.

Gut Contents

The stomach contents from most of the actual/potential predator species, listed above, are detailed in Appendix 5. It should be noted that the stomach contents of predators taken from the incline plane traps are more indicative of maximum satiation levels than of natural predation rates (Moyle, 1977). Sculpin maximum predation of fry varied exponentially with the size of sculpin (Fig. 22). Mathers Creek supported a run of larger sculpins than did Pallant (maximum total lengths of 195 mm and 150 mm, respectively). Up to 61 fry were counted in the gut of a 175 mm sculpin from Mathers; the predicted maximums at Pallant ranged from 33 fry for the largest sculpin (150 mm) to 6 fry for the average sculpin (80 mm). Actual predation in the traps was often much less; 75 - 90 mm sculpins averaged 3 fry per stomach. As was reported by Hunter (1959), sculpins less than 50 mm in total length did not consume fry.

Other predator species caught in the fry traps were: (1) coho smolts, 17 of which averaged 108 mm in fork length and had consumed an average of 3 fry; (2) rainbow juveniles, 2 of which averaged 110 mm and consumed an average of 8 fry; and (3) Dolly Varden, 12 of which averaged 157 mm and had consumed an average of 6 fry. The maximum stomach capacities of these species appear to be

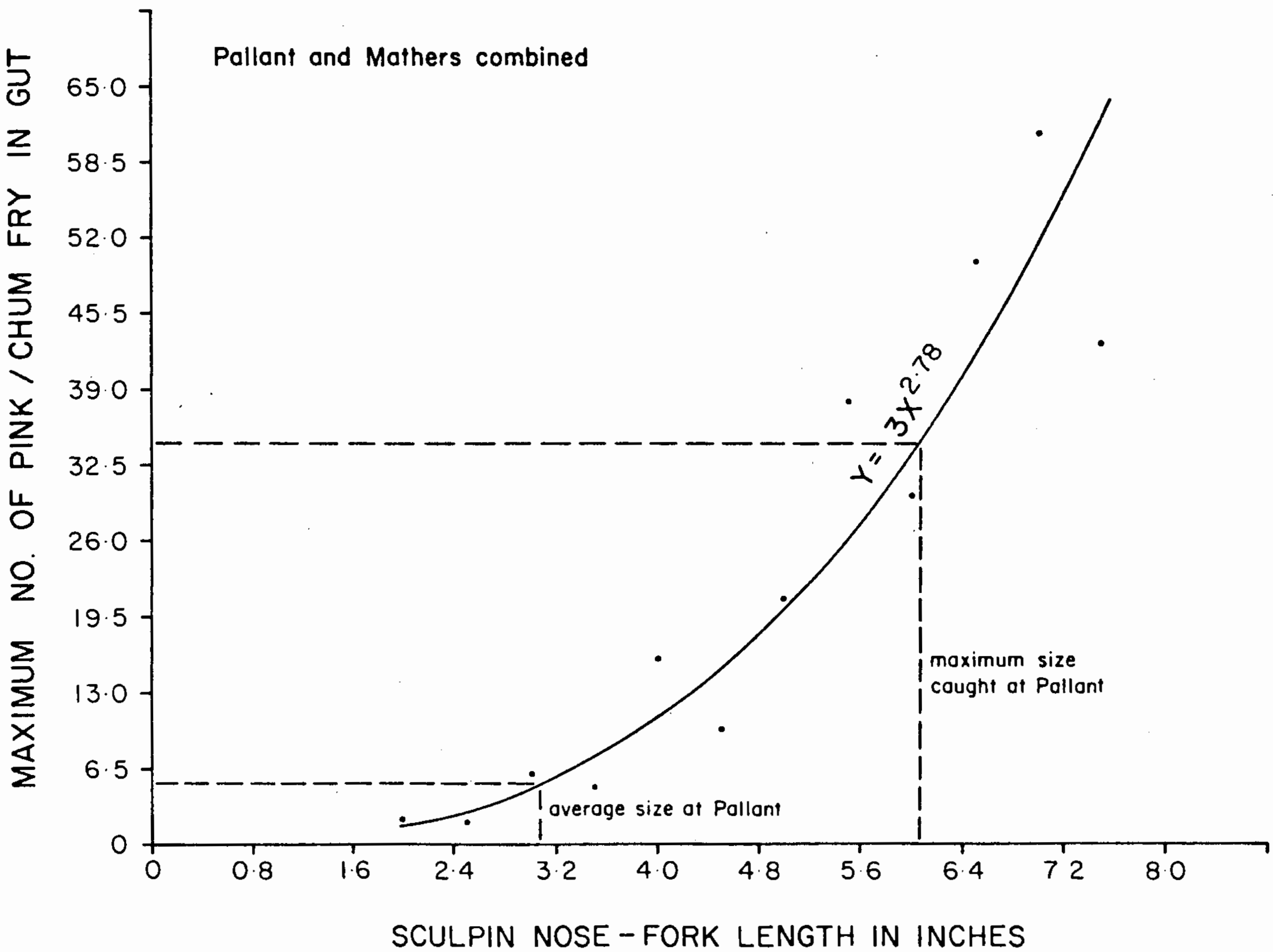

Figure 22: Sculpin satiation curve developed during Pallant and Mathers fry migration studies, 1978.

smaller than for sculpins of equivalent size, particularly in the case of larger individuals. Under natural conditions, however, sculpin and salmonid feeding behaviors are diferent (Moyle, 1977), and might alter the relative predation rates.

The most common species captured in Mosquito Lake that could be considered potential predators of fry were cutthroat trout and Dolly Varden. The gut contents from Mosquito Lake specimens of these two species suggested interactive segregation similar to that found by Andrusak and Northcote (1971). Cutthroat had fed mainly on prey items commonly found in the water column and on the water surface. Of 75 stomachs sampled, almost 50 percent had fish remains in them (39 percent sticklebacks, 7 percent sculpins, 4 percent unidentified). Other prey items were terrestrial insects (31 percent of stomachs), aquatic insects (7 percent), and molluscs (4 percent); 23 percent of the stomachs had debris, 7 percent had unidentifiable remains, and 19 percent were empty. The smallest cutthroat caught that had consumed fish, had a post-orbital hypural length of 148 mm (range of sizes of cutthroat caught in the gill nets was 96 - 400 mm). Dolly Varden (post-orbital lengths of 111 - 225 mm) were exclusively bottom feeders in Mosquito Lake, and appeared to individually specialize on certain items, such as molluscs. However, Dolly Varden captured in the estuary area did consume chum fry; one specimen 260 mm in length contained 48 chum fry.

HABITAT

1. Mosquito Lake Tributaries

These tributaries were evaluated largely as to their physical potential to support coho populations.

a) North Tributary of Head of Lake. The lower kilometer of this tributary was walked on April 6. In the lower 0.5 km, the creek's main channel has considerable gravel suitable for spawning, as well as adequate coho/trout rearing areas. However, the lower 0.5 km also had many high-water side channels, suggesting that this stream can be 'flashy'. Water temperatures were low (4 - 5°C), and the productivity appeared to be low (only a few fish seen, few prey items and no periphyton slime on/under rocks). Above the lower 0.5 km, at a sharp bend under a rock bluff, the gradient and substrate size increased markedly, and had become a continuous riffle through large boulders within the next 0.5 km. It had been expected that, because this tributary was lake-headed, the fluctuation in flows would be damped somewhat. Nevertheless, a spot check of the stream in late June showed the creek to be dry in its lower sections, save for isolated pools (B. Eccles, pers. comm.).

b) South Tributary of Head of Lake. The lower kilometer of this creek also was walked on April 6, and was found to be mainly dry at this time. The creek appeared to be extremely flashy, having no well-defined stream bed, except for a short section just above Mosquito Lake. Small sculpins and sticklebacks were seen in isolated pools (5.5°C) just above the lake only. Subsequent visits showed this tributary to be a high-water runoff channel only.

c) Pallant Creek Tributary. On April 6, the water temperature was 5.5°C in Pallant Creek. Although the lower 200 m was heavily silted, rearing and spawning habitat above this section appeared to be excellent. Productivity appeared to be low (few aquatic insects or fish seen) at this time. Inspections of the stretches 0.4 - 1.4 km and 1.7 - 2.7 km upstream of the lake in late May (water temperatures 9 - 11.5°C) showed moderate utilization by fish, and confirmed 1977 aerial observations of a significant amount of suitable spawning gravel throughout, except in a heavily braided section approximately 2 km above the lake. Rearing habitat was very limited (straight gravel channel, with bedrock outcrops, little cover) above 2.5 km. The creek was visited again in early July, and was found to have very low flows (30 ℓ /sec maxminum) with salmonid fry common in pools.

d) Minor Tributaries. Minor tributaries on the northern shore at the eastern end of Mosquito Lake were casually examined in early April, and were considered to have only very minor spawning and rearing potentials (flows were inadequate in all cases).

2. Mosquito Lake

The bathymetry of Mosquito Lake was compiled from echo-soundings and hand-line soundings (Fig. 23). The shoreline gradient is for the most part very steep, which was somewhat of a surprise considering the number of islands that are present. Most of the littoral shallows that do exist are concentrated on the northern side of the lake, and are most extensive between the Pallant Creek tributary and the lake outlet.

Temperature data from the three established lake stations were presented in the Water Quality results section. From the point of view of fish habitat, the rapid temperature variations (presumably from wind-generated seiche action) experienced in the outlet bay may be detrimental to rearing salmon fry.

Plankton analyses (Table 19, Fig. 24) indicated the following: (1) Total plankter numbers increased over July to September and then leveled off in October. (2) Numbers per liter - as calculated from vertical hauls only - reached a maximum of 40/ ℓ , which can be considered moderately productive (T. Cleugh, pers. comm.). (3) Littoral plankter abundances increased towards the head of the lake in the surface tows. (4) Average levels of abundance were higher (21/ ℓ vs 3/ ℓ) and contained more cladocerans in the 7 m vertical haul at the outlet, than in the 18 m haul at midbasin; this indicated a restriction of productivity with depth.

3. Pallant Estuary

A substrate map is provided (Fig. 25).

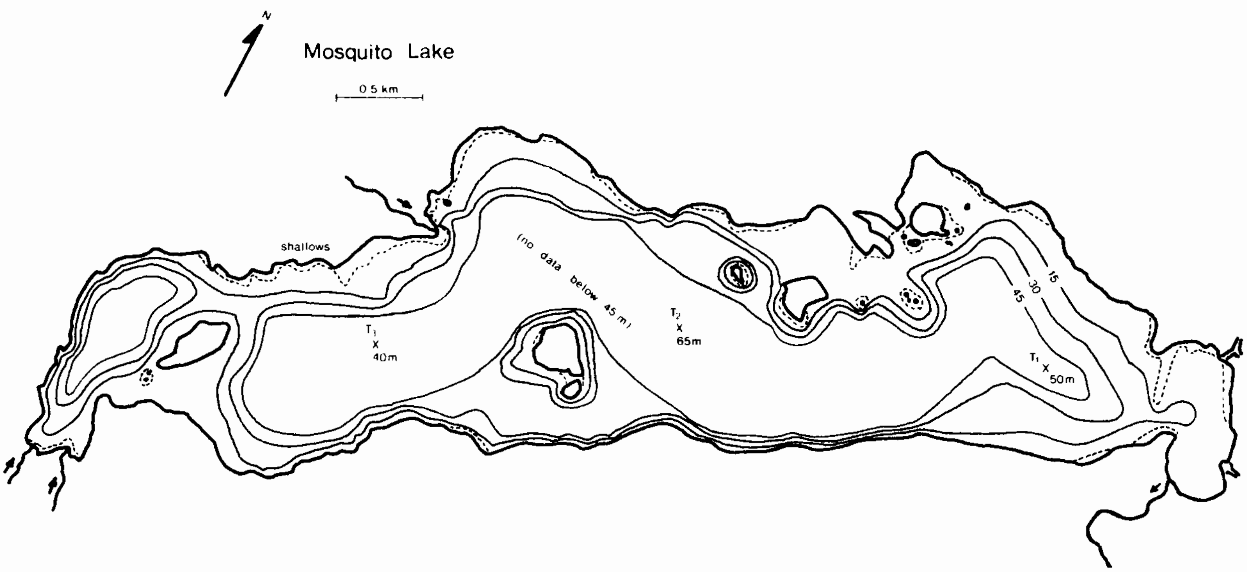

Figure 23: **Bathymetry of Mosquito Lake (no data below 45m, except for handline determinations at temperature stations).**

TABLE 19: Mosquito Lake plankton listing

ARACHNIDA	–	Aracina (water mites)
CLADOCERA	–	Bosminidae
	–	Dalphnia pulex
	–	Holopedium gibberum
COPEPODA	–	Espischura nevadensis (nauplii)
DIPTERA	–	Chironomidae (larvae and terrestrial adults)
	–	Ephemeroptera (larvae)
	–	Hymenoptera (terrestrial adults)
OSTRACODA		
ROTIFERA	–	Kellicottia sp
	–	Polyarthra sp
	–	Conochilus

Also, algae colonies of Ceratium, Botryococcus, and Volvox spp. abundant at times.

N.B. Cyclops sp. found by Stockner and Shortreed (pers. comm.) September 1977, not found in present study.

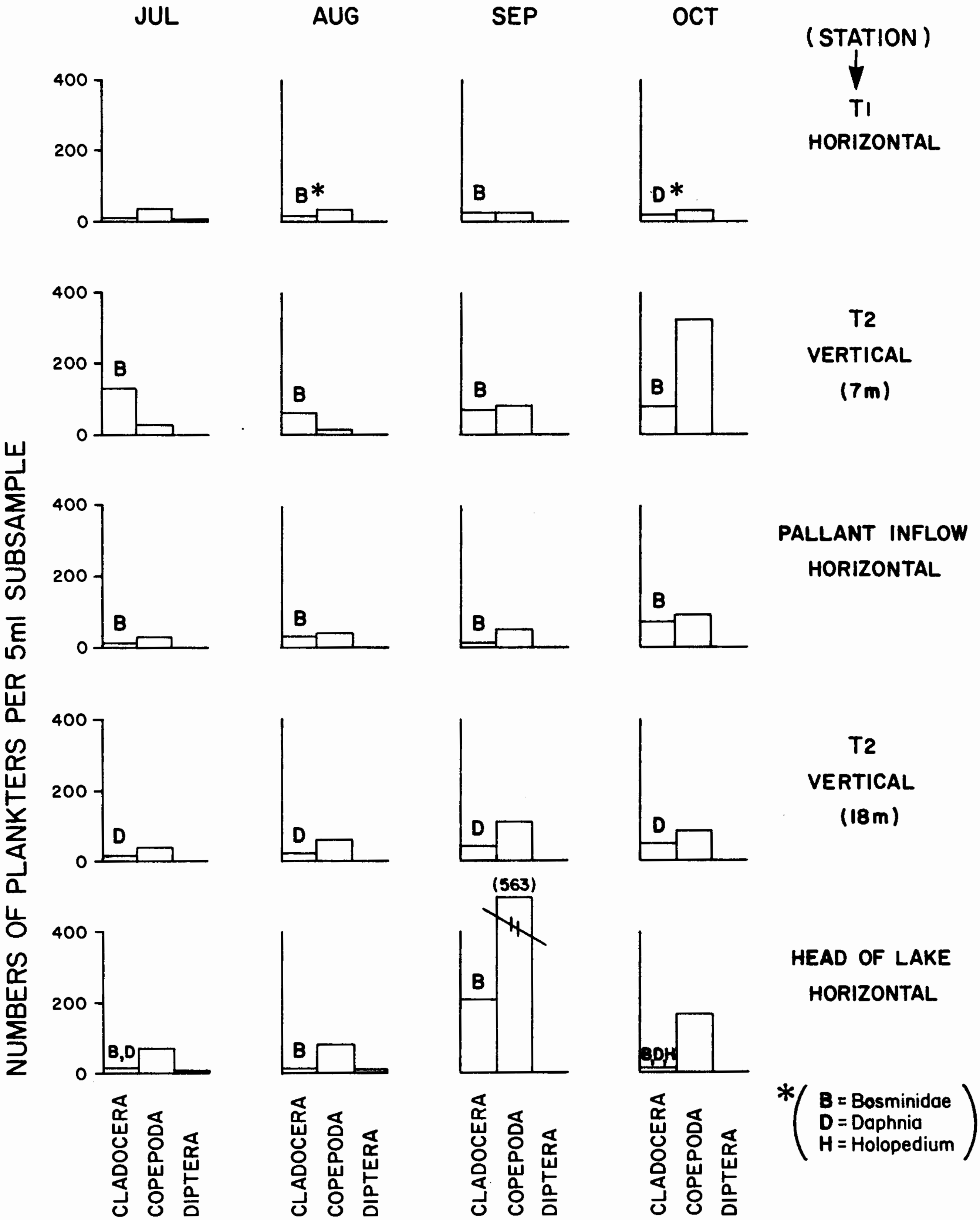

Figure 24: Temporal and spatial changes in abundance of the major plankter groups in Mosquito Lake, 1978.

4. Other Cumshewa Inlet Creeks

The lower sections of these creeks were walked during April and early May to gain a better appreciation of their potential for chum salmon enhancement, relative to Pallant and Mathers Creek.

a) Braverman Creek. Although chum salmon never have been reported to spawn in Braverman Creek, its accessibility and proximity to Pallant Creek suggested evaluation. There was a set of falls at the mouth of this creek that probably restricts upstream movement of fish during low tides. The lower 0.5 km consisted mainly of bedrock jumps and deep pools suitable for holding. Between 0.5 and 0.8 km upstream, there were short stretches of gravel suitable for spawning, interspersed with cobbles and boulders. Beyond 0.8 km, the amount of boulder increased rapidly, and bedrock outcrops were frequent. The stream gradient rapidly increased, and a set of impassable falls (15 + m high) were observed within 1.5 km of the mouth. In general, salmon spawning and rearing capability for this stream was considered to be very limited, although it may have some potential for trout. Small numbers of adult pink, chum, and coho were observed in this creek in the fall of 1978 by P. Slobodzian.

b) Carmichael Creek. Within 0.5 km of its mouth, there was a drop 3 - 4 m high into a plunge pool; coho may be able to pass this obstruction, but it would be impassable to chum salmon. The majority of the non-tidal section below this falls was bouldery, with patches of gravel suitable for spawning. Flow at time of inspection (May 10) was approximately 15 cfs; water temperature was 6°C. Spawning, holding, and rearing habitats for salmon were considered limited.

c) Chadsey Creek. The lower 1.5 km (limit of walk) of this creek had considerable clean gravel, but it was poorly sorted, largely angular in shape, and piled in dunes. This suggests that Carmichael Creek may have flashy flows and an unstable stream bed. Water temperature at

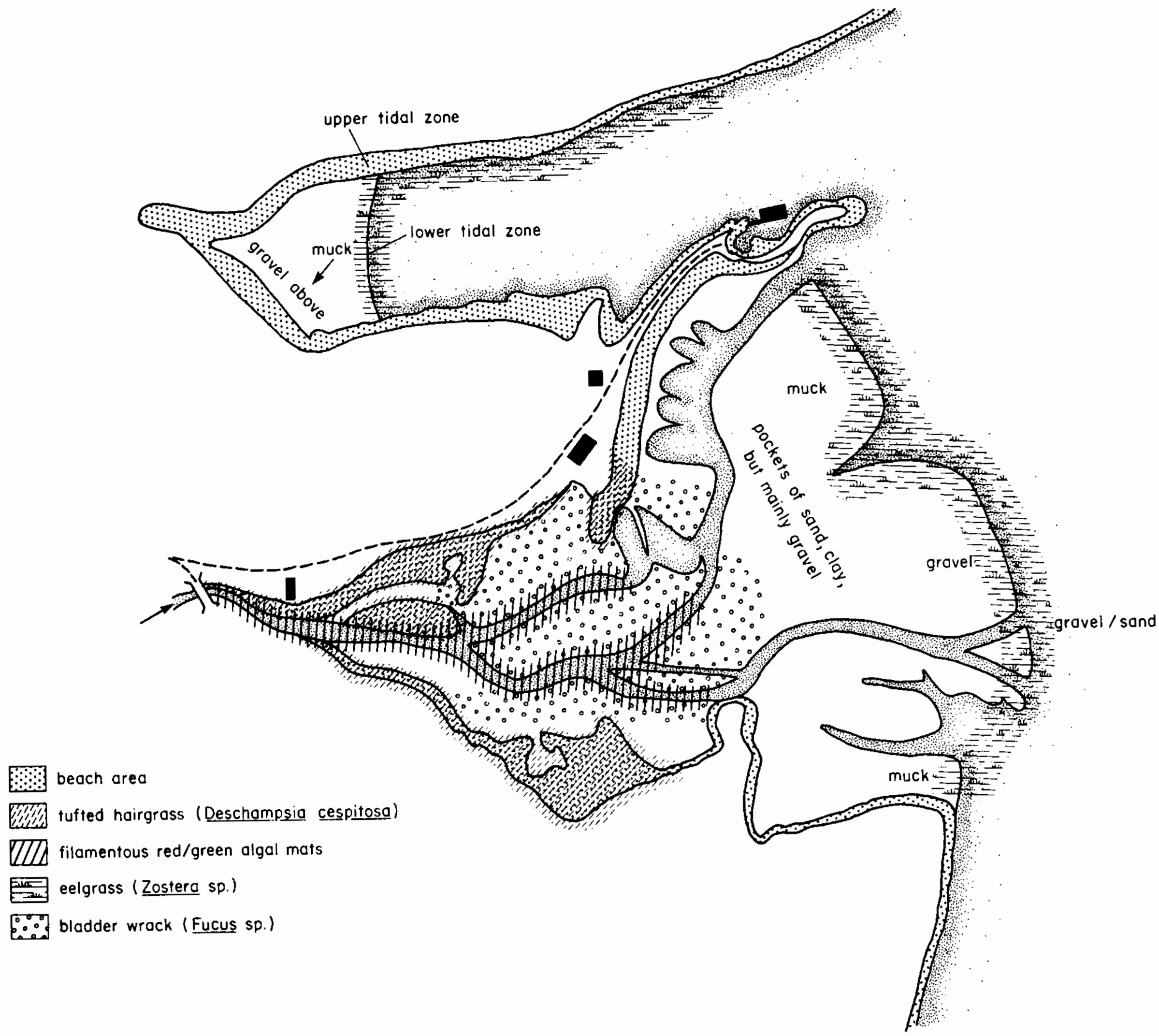

Figure 25: Distribution of major subtrate and vegetation types found in the vicinity of the Pallant estuary, 1978.

time of inspection was 6.5°C. No fish were seen in the stream, but 60 chum salmon skeletons were observed along the stream banks from tidal influence upstream approximately 1.0 km to a large log jam. This creek presently would appear to have moderate potential for chum salmon spawning and rearing.

DISCUSSION

Several questions regarding enhancement methods for the Cumshewa Inlet facilities have been raised, and at least partial answers can be given them with the aid of the present bio-reconnaissance data:

Can the Mathers and Pallant Facilities Use Unfiltered Water?

The answer for Mathers Creek is a definite no, with regard to incubation facilities. Suspended solids loadings were unacceptably high, all algal species found to cause problems at Atnarko were present, and there may be high zinc levels. Filtration to the 10 μ level would be the minimum required for incubation; 5 μ would be preferred.

A qualified yes to unfiltered water might be given in the case of Pallant Creek. Under normal circumstances, suspended solids loadings were very low, to the point of being comparable with the Kitimat well water that has been used for the successful incubation of chinook eggs. At Pallant, however, the suspended solids will be partly composed of algae, and all of the Atnarko problem species were found to be present. In addition, the accumulation of silt in the test stack of Heath trays, and the existence of filamentous algae mats in the intake area of the creek, indicated that there may be problems; normally these should be minimal, due to loading of the eggs later in the year (when water temperatures are lower, and because of the transfer of eyed eggs from Heath trays to gravel incubators midway through the incubation period. The severe flooding experienced in late 1978 produced unacceptably high suspended solids loadings; however, the recurrence interval for such a storm is unknown at present. Ideally, this facility should possess the capability to intermittently filter intake water to the 10 μ level.

<u>What would be the Best Rearing and Release Sites for Chum and Coho Fry?</u>

It will be necessary to feed fry of both species up to 1 g, to minimize predation and increase adult returns over the natural situation. The following rearing strategies appear to be best:

1) Coho should be reared to at least 1 g body size at the hatchery site, or in pens in the outlet bay of Mosquito Lake. On-site rearing would be preferable, if space is available. Once fed up to size, the fry should be released into the upper reaches of Pallant Creek (above Mosquito Lake). The pilot release should be monitored as to growth and movement downstream of the fry. Such a release should maximize the amount and diversity of potential rearing habitat for the coho, and hopefully would minimize chum-coho interaction.

2) There are two alternatives as to chum fry rearing sites. The first would be rearing in pens in the outlet bay of Mosquito Lake, and the second would be rearing in pens in Causeway Bay. Of the two (barring disease problems), saltwater rearing appears to have the most promise; water temperatures may be higher initially and less variable than in Mosquito lake, freshwater predation would be eliminated, and the fry may gain experience with the actual food items that they would consume on release. If the fry were reared in Mosquito lake and released near the outlet, they would be forced to migrate over three falls and past an additional block of potential predators that occur above the falls (and predation may worsen when coho are released to rear in the upper Pallant system). Release of fry into Causeway Bay is therefore recommended. Test-rearing groups of fry in each location appears to be warranted, particularly if adult returns can be monitored.

When should the Chum Fry be Released?

The majority of rearing and release information comes from Japanese hatcheries. Data obtained by Moberly and Lium (1977) and R. Ginetz (pers. comm.) indicate that the Japanese approach is to short-term rear the fry to the largest possible size before migration, but that the feeding program takes second place to timing the release, so as to place the fry in the marine environment at a optimum time for feeding and growth. For the Japanese, this optimum is indicated by offshore surface temperatures of 10°C. It is recognized that the Japanese oceanographic situation is quite different from ours. The more productive Japanese hatcheries are under the immediate influence of the cold Oyashio current, which flows south and mixes in a variable fashion with the warm Kuroshio current off northern Honshu. This area is considered to be part of the Western Subarctic Domain (Dodimead et al., 1962), which is characterized by three cyclonic gyres and high salinity.

In contrast, the Central Subarctic Domain has only the Alaskan gyre, which is considered a warm, low-salinity current. Cool, high-salinity water occurs only as a result of upwelling from wind stress 80 - 300 km offshore (Pickard, 1966). Both domains are modified considerably and in a complex manner as they approach the coast, which further clouds the matter. However, in the absence of information specific to the B.C. situation, the Japanese results are assumed to have relevance. As can be seen from Fig. 26, information on surface water temperatures for the Cumshewa Inlet area is very sparse. Analysis of the data provided by Hollister and Sandnes (1972), Freeland (pers. comm.), and Giovando (pers. comm.) indicated that the Cape St. James long-term values would be closest to, although lower than, those of Cumshewa Inlet. In 1978, Cumshewa Inlet temperatures reached 10°C, approximately three weeks after both the peak chum fry migration date and the first obvious plankton bloom (i.e., at the end of May).

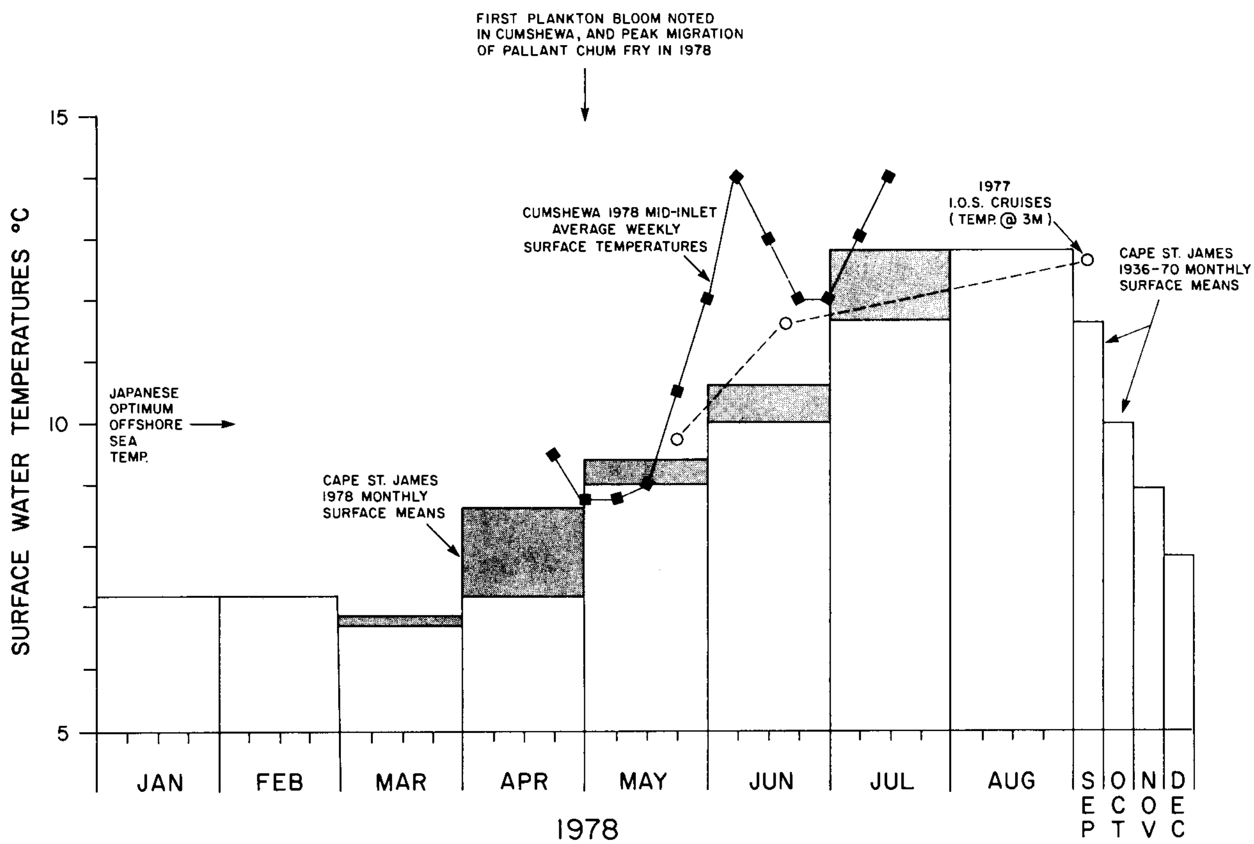

Figure 26: Summary of available water temperature data nearest to Cumshewa Inlet (see text for data source references).

SUMMARY

1. This report summarizes the juvenile bio-reconnaissance data for Mathers and Pallant Creeks, as collected by Salmonid Enhancement Program personnel during the calendar year 1978. These data include weather records, water quality, incubation, fry migration, predator/competitor and habitat studies (primarily on chum and coho). This report also summarizes the analyses of algal samples taken in 1977 and 1978. For 1978, adult studies are covered in two separate reports.

2. Considerable climatic variation exists between the Pallant Creek hatchery site and the Sandspit Airport weather station. Pallant Creek averaged twice the precipitation and experienced a 3°C wider range in daily temperature fluctuations than at Sandspit Airport. The inland location of the Pallant hatchery site, and its closer association with the Queen Charlotte Mountain Range are suggested to be responsible. Precipitation patterns also were found to be very different for the two stations.

3. Most nutrient and extractable metal levels fell within the recommended limits for hatchery operation. However, single determinations of copper at both creeks did exceed limits, and barium showed unusual fluctuation. Further sampling indicated that these determinations were not significant. In addition, zinc levels rose dramatically at both creeks in the latter half of the year, but these values are viewed with suspicion. Sampling of wells at Mathers Creek showed detrimental levels of ammonia.

4. Total suspended solids loadings at Pallant Creek had been less than 4 mg/ ℓ , until a severe storm at the end of October; thereafter, loadings ranged from 121 to 20 mg/ ℓ , which are considered detrimental to the hatchery operation. Mathers Creek has routinely produced up to 85 mg/ ℓ , unacceptably high for a hatchery facility. Filtration efficiencies were predicted to be as follows:

Filtration Level(μ)	% (by wt) of Particles Removed	
	Pallant	Mathers
14	50	70
10	65	70
5	80	85

5. The algal communities of both creeks were diverse (45 genera at Mathers, 50 at Pallant) and contained the nuisance genera found at Atnarko. Diversities were greatest in October, although total abundances were highest between May and September. Filtration efficiencies are predicted to be increasingly effective down to 5 μ , but only slight improvements would occur between 50 and 15 μ .

6. Water temperatures at Pallant Creek (4.5°C maximum daily range, 22°C overall maximum) were within the zone of thermal tolerance for chum and fingerlings. Water temperatures at Mathers, although showing a similar maximum daily range to that at Pallant, closely approach coho thermal tolerance during summer. Minimum winter temperatures at Mathers also were more extreme (0.5 - 3°C lower) than at Pallant.

7. Cumshewa Inlet water temperatures remained below 10°C until the third week of May, then rose to a maximum of 14°C by mid-July. Nearshore temperatures varied ±1 - 2°C from those offshore. The coldest temperatures (6°C) were recorded in the vicinity of the Mathers estuary; the warmest temperature reading (15°C) came from an intertidal spring near Aero.

8. Mosquito Lake temperature profiles showed an isothermal condition from January - April. By August, an 8 m-thick epilimnion showing some temperature reversals had developed, and hypolimnion temperature was 7°C, indicating considerable mixing action. The outlet bay also appeared to be subject to wind-generated seiches. The lake turned over in mid-November at 9°C. Mosquito Lake was classified as a second-class dimictic lake, heavily influenced by oceanic climate.

9. Streamflows at Mathers Creek have varied from 600 to 36,000 ℓ /sec, with daily variations of up to 21,000 ℓ /sec; however, these data are seasonally incomplete, and maximum flows are probably well in excess of the recorded maximum. The available data from Pallant Creek for the period October, 1977 - October, 1978 indicated a fairly average flow pattern for this period.

10. Hydraulic sampling of Pallant chum eggs in February, 1978 did not show a good relationship with the estimated spawner distribution and density. It appeared that the highest numbers of eggs were deposited in the upper spawning areas, that the highest mortality occurred in the lower reaches and that overall the number of eggs/m^2 were at least twice that expected from the estimated number of spawners. Uncertainty as to the accuracy of the adult count forced rejection of the McNeil method of calculation of survival rate. An overall apparent survival rate (live/live + dead) of 88 percent therefore was retained as a maximum estimate of egg survival to the end of January. The stage of development of the recovered eggs increased downstream, but the majority of eggs were calculated to have been deposited in the last two weeks of October, 1977.

11. Fry migration timings were similar in both creeks. Species summaries are as follows:

Species	Start	Peak	End
Chum	before 2nd wk Mar	1st wk May	3rd wk Jun
Pink	before 2nd wk Feb	2nd wk Apr	4th wk May
Coho	3rd wk Feb	2nd wk May	after 2nd wk June
Sockeye	2nd wk Apr	2nd wk May	after 3rd wk April
Sculpin	1st wk Apr	4th wk Apr	after 2nd wk June
Dolly Varden	2nd wk Apr	4th wk Apr	3rd wk May

12. Chum fry migrated downstream during darkness. Peak migration (in the absence of freshets) occurred at 2200 - 2300 h PST at Pallant, and at 0100 - 0200 h PST at Mathers. The difference in the timing of peak migrations was hypothesized to result from the Mathers spawning area being

further upstream than at Pallant. It was calculated that Mathers fry originated from the braided section below Mathers Lake and/or from the southern tributary some 2.0 - 3.5 km above its confluence with Mathers Creek.

13. Fyke net sets in both systems were used to confirm chum spawning distribution. Fry captures indicated that: the southern tributary to the Pallant mainstem was not utilized; the southern tributary to the Mathers mainstem was utilized, but to a lesser degree than the mainstem; the Mathers mainstem was utilized up to Mathers Lake.

14. The lateral distribution of chum fry at Pallant essentially mirrored the bottom contour and velocity pattern, allowing for the outward thrust of an upstream corner. Relative flow patterns across the cross-section at Pallant remained fairly constant during the trapping period; this was in contrast to Mathers, where the main flow switched channels, depending on discharge.

15. The magnitude of the chum fry run was estimated by two methods at Pallant Creek. The first method, which used the lateral distribution of fry, led to an estimate of 9 percent of the fry being caught in the incline plane that was continuously fished, or a total estimated run of 4.0×10^6 fry. The second method, which used a dye-recapture technique, led to an estimated 6 percent of fry trapped, or a total run of 5.7×10^6 fry. Mathers estimates were from dye-recapture only, and were 3 percent of fry trapped and a total run of 0.6×10^6 fry.

16. Assuming normal egg-to-fry survival rates, the numbers of spawners required to produce the above numbers of fry were calculated to be 7,000 at Mathers (2 - 3 x higher than estimated in 1977), and 30,000 at Pallant (10 x higher than estimated). It appeared that a rapid turnover of spawners on the Pallant grounds, rather than a late spawning run, was the source of the error at Pallant Creek. The construction of a permanent fence would be most helpful in determining the spawning run accurately.

17. Freshwater and estuarine rearing of chum fry was minimal at both creeks. Once in Cumshewa Inlet, Pallant fry moved rapidly to the east along the northern shoreline, but greatest fry numbers were found in the first bay north of the creek mouth. Initially, fry were within 1 m water depth of the shoreline; however, as the fry grew, they began to shift to deeper water. This offshore movement began in early June and was complete by mid-July. Behavioral observations were very similar to those made on other stocks. Mathers fry could not be located once they had migrated downstream. It was further noted that fry migration peaks occurred at the same time as the development of plankton blooms in Cumshewa Inlet. Migrating fry at Pallant Creek seemed to be prematurely forced into deep water on low tides, because of a causeway constructed just to the north of the main channel.

18. Size parameters of emergent fry were similar at both creeks, and agreed with those found for other chum stocks:

Species	n	Length (mm)	Weight (mg)	K_D	K
Chum	250	38	415	1.97	0.776
Coho	152	36	415	2.10	0.918

There were no statistically significant trends in any of the parameters over the migration period. However, fry captured along Cumshewa Inlet were rapidly growing (up to 1.04%/day in length and 3.58%/day in weight in the first month of sea life), at rates comparable to other B.C. stocks.

19. Actual and potential competitors and predators of chum and coho fry caught in the Pallant system included:

Species	Type of Interaction	Location(s) Present
Rainbow/Steelhead	Predator	Lower Pallant Cr. (below 3rd falls)
Cutthroat	"	Upper Pallant Cr. (above 3rd falls)
Dolly Varden	"	Throughout, except for 1st to 3rd falls
Kokanee	Competitor	Mosquito lake
Stickleback	"	Mosquito Lake, Pallant estuary
Tomcod	Predator (?)	Estuary
Pacific cod	Predator	"
Shiner perch	Mainly Comp.	"
Copper Rockfish	Predator (?)	"
Sculpins	Both	Throughout, except for S. tributary
Coho smolts	Predator	Lower Pallant Cr. (below 2nd falls)
Herring	Competitor	Estuary

A satiation curve was developed for sculpins preying on salmon fry. Relative stomach capacities for coho smolts, Dolly Varden, and juvenile rainbow appeared to be lower than for similar-sized sculpins. The diet of Mosquito Lake cutthroat trout included a high (50% by presence) piscine component. The diet of Dolly Varden in Mosquito Lake suggested that interactive segregation with the cutthroat was operating; Dolly Varden were virtually exclusively benthic feeders. However, Dolly Varden captured in the Pallant estuary did feed on chum fry.

20. Mosquito Lake tributaries were evaluated as to their physical ability to support coho fry. The two tributaries at the head of Mosquito Lake were found to be limited in rearing habitat, and subject to drying. The one other major tributary, Pallant Creek, contained considerable rearing habitat, but was subject to quite low summer flows. All minor tributaries were considered to have very low rearing potentials.

21. Mosquito Lake bathymetry investigations revealed steeply-sloping shoreline gradients, particularly on the southern side of the lake. Littoral

shallows were limited and were most extensive between the Pallant Creek inlet and outlet mouths.

22. Three other Cumshewa Inlet creeks were inspected, and only Chadsey Creek offered any potential for chum salmon.

23. From the bio-reconnaissance data to present, it is concluded that: unfiltered water from Mathers Creek would be unsuitable for an incubation facility; that unfiltered water from Pallant Creek should present minor incubation problems only; that coho fry should be reared at the Pallant hatchery site or in pens at Mosquito Lake, then test-released into the upper reaches of Pallant Creek (above the lake); that chum should be test-reared in pens, in Causeway Bay, marked so as to be able to evaluate adult returns, and released in Causeway Bay when water temperatures reach 10°C, or when wild chum fry move offshore.

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APPENDIX 1: ALGAL ANALYSIS METHODS

A. UNIVERSITY OF BRITISH COLUMBIA (K. Munro, pers. comm.):

One or two 50 ml subsamples were removed and settled for at least 24 h in Zeiss settling chambers. A Zeiss inverted microscope was used to identify and count algae. For each sample, a complete survey of the chamber bottom was made at 125X to count large cells, colonies, filaments and fragments; and two transects were made at 312X to count smaller cells. If algae were not abundant, a second sample was settled and counted. Algal numbers in the 50 ml samples were converted to numbers per liter. Cell size and colony or filament size was measured on each alga.

Conversion Factors (multiplied by cells/sample to obtain cells/ ℓ .)

125X -	one sample C.F. =	20
	two samples	10
312X -	one sample (two transects)	364
	two samples (four transects)	182

B. BEAK CONSULTANTS LTD. (A. Gavin, pers. comm.):

The procedure of preparing a membrane filter began by determining, by trial examination of a few prepared filters from randomly selected sample bottles, a suitable volume to filter and, if necessary, dilution or concentration. Samples collected from the same location of the same date usually were batch-processed.

The volume of the sample was first determined by pouring it into a litre-graduated cylinder. This information was recorded on the phytoplankton analysis data form. Other information for the data form was obtained from the sample transmittal form and from knowledge of volume of preservative used. Information pertaining to the treatment of the subsample for filtering was entered in appropriate sections of the form.

The volume to be filtered was pipetted into the previously prepared filter holder. If staining (e.g., Lugol's) was to be done, a small amount (<0.2 ml) of stain was placed on a wet filter prior to delivery by pipette. This precedure was followed when the subsample had been concentrated or was an aliquot of the original subsample. The stain (0.3 ml/100 ml) was added in the process of diluting samples when dilution was necessary. After pipetting directly into the centre of the filter holder, the vacuum pump was switched on, and filtering (0.45 pm MF-Millipore filter) proceeded at a gentle vacuum of 100 mm Hg.

When filtering was complete, the damp filter was removed with tweezers, and excess filter was trimmed away (unless 24 mm diameter filters were used), so the remainder fit completely under a cover slip. The filter was then placed on three or four drops of immersion oil on a previously labelled microslide. The slide was placed on a hotplate regulated at a temperature of 70 - 80°C with a surface thermometer. Once the filter became transparent (10 - 15 min), through the evaporation of the water and the wicking-up of immersion oil by the filter, the slide was removed from the hotplate. A drop of immersion oil was placed at the side of the filter near the label, and the cover slip was gently lowered onto the surface of the filter from the drop to the outer edge. The filter was then ready for examination. Filter slides were protected until analysis in flat, labelled cardboard microslide trays.

The filter funnel, pipette and graduated cylinder were rinsed thoroughly with distilled or tap water to remove adhering algae prior to next filtration.

Identification of planktonic algae to species was done prior to counting, using an inverted Wild microscope. The identification procedure was assisted by examining diatom frustule slides and wet mounts of subsample material, trial preparation filters, and the acual counting filter at 1000X (oil immersion) immediately following counting.

Diatom frustule slides were prepared by pipetting a small amount of sediment from a sample bottle (after suitable filter slides have been prepared) onto a cover slip placed on a warm hotplate (70°C). When desired, a wetting agent such a Kodak Photo-Flo 200 solution was first applied to the cover slip to aid in distributing sediment over the slip surface. Once the material dried, and a sufficiently dense coating (like a dusty surface) was visible on the slip, the hotplate was turned to high. The slip was left at a high temperature for 15 - 29 min to char and shrink protoplasm, thus increasing visible details of frustules. The frustule-covered surface of the cover slip was then placed on a labelled microslide that had two drops of a resin-mounting media (Cargille Carmount - 165) on it. The slide was placed on a warm hotplate (c. 100°C) for 15 - 20 min to allow the toluene solvent of the resin to evaporate. When bubbling ceased, the slide was removed to a cool surface, and the cover slip was gently depressed with a small, blunt instrument (as resin hardens quickly) to permit viewing with oil-immersion lens.

"Units" counted refered to cells of diatoms, other chryophytes and to colonies of blue-green or green algae. "Average longest dimension" was determined for the most abundant taxa by averaging the actually measured, longest dimensions of at least 10 individuals. Since most of the taxa encountered were represented by only a very few individuals, averages were made from 1 - 10 individuals per taxon. A maximum of 200 units were identified and counted from each sample.

APPENDIX 2. Daily weather records, by month, for the Pallant Creek hatchery site.

APRIL

Day	Time	Temperature °C Maximum	Temperature °C Minimum	In. of Rain	% Cloud Cover
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13	STATION INSTALLED @ 1000 HRS.				
14	0800	13	0	–	0
15	0800	12	–1	–	0
16	0800	14	–2	–	0
17	0800	13	4	–	75
18	0800	11	3	–	75
19	0800	11	2	–	100
20	0730	14	4	–	100
21	0700	14	6	0.15	100
22	0730	11	4	TR	100
23	0730	12	6	TR	100
24	0700	13	5	TR	75
25	0800	15	8	0.21	100
26	0730	14	7	0.02	100
27	0730	13	2	0.39	0
28	0730	13	2	–	75
29	0730	13	3	0.05	100
30	0730	13	6	0.68	75
	(n)	($\bar{x}$)	(x)	(Σ)	($\bar{x}$)
	17	12.9	3.5	1.50	69

APPENDIX 2 (Cont'd)

MAY

Day	Time	Temperature °C Maximum	Minimum	In. of Rain	% Cloud Cover
1	0730	18	7	0.85	100
2	0730	12.5	5	0.64	100
3	0800	9	6	0.89	100
4	0730	10	1	0.08	25
5	0730	15	1	0.05	80
6	0730	14	3	TR	90
7	0730	14	7	0.01	50
8	0730	14	6	TR	75
9	0730	15	1	–	75
10	0730	15	2	–	100
11	0730	11	8	0.05	75
12	0700	13	6	0.54	80
13	0715	10	5	0.23	100
14	0715	11	8	0.03	90
15	0730	14	5	0.08	25
16	0730	18	7	TR	100
17	0700	10	5	0.31	25
18	0730	14	5	TR	75
19	0730	16	6	0.03	100
20	0730	14	7	TR	25
21	0730	15	2	–	10
22	0730	15	4	–	75
23	0600	16	4	–	0
24	0730	17.5	4	–	50
25	0730	14	8	0.11	100
26	0730	14	6	0.08	90
27	0600	12	10	0.45	100
28	0730	11	6	1.20	100
29	0700	12	5	0.08	75
30	0730	18	4	–	25
31	0730	12	6	–	0
	(n) 31	($\bar{X}$) 13.4	($\bar{x}$) 5.2	(Σ) 5.71	($\bar{x}$) 68

APPENDIX 2 (Cont'd).

JUNE

Day	Time	Temperature °C Maximum	Temperature °C Minimum	In. of Rain	% Cloud Cover
1	0730	22	8	–	5
2	0730	23	19	–	0
3	0730	25	9	–	0
4	0730	27	7	–	0
5	0730	23	8	–	0
6	0730	21	6	–	0
7	0730	23	7	–	50
8	0730	17	10	0.08	100
9	0730	16	10	TR	75
10	0730	17	10	0.02	80
11	0730	15	10	0.59	100
12	0730	14	10	0.20	100
13	0730	19	11	0.06	100
14	0730	16	6	0.02	0
15	0630	18	7	–	0
16	0730	22	7	–	25
17	0730	22.5	10	0.05	75
18	0730	15	7	–	10
19	0730	16	11	–	0
20	0730	21	10	–	25
21	0700	17	12	–	25
22	0700	17	6	–	0
23	0730	26.5	8	–	75
24	0800	25	10	TR	100
25	0800	16	10	–	100
26	0730	15	13	TR	75
27	0715	20	12	–	50
28	0730	18	11	–	50
29	0730	20	6	–	75
30	0730	20	6	–	75
	(n)	($\bar{x}$)	($\bar{X}$)	(Σ)	($\bar{x}$)
	30	18.9	9.2	1.02	44

APPENDIX 2 (Cont'd).

JULY

Day	Time	Temperature °C Maximum	Temperature °C Minimum	In. of Rain	% Cloud Cover
1	0730	19	5	–	75
2	0730	17	7	–	75
3	0800	18	7	–	75
4	0800	20	13	–	75
5	0800	20	12	–	75
6	0730	21	13	TR	75
7	0730	21	12	–	100
8	0800	16	10	0.23	100
9	0730	13	10	0.50	100
10	0800	17	8	–	0
11	0730	23	12	0.06	50
12	0730	20	13	TR	50
13	0730	19.5	12	–	100
14	0730	16	9	TR	100
15	0630	17	12	TR	100
16	0800	16	13	0.02	100
17	0730	18	12	0.02	100
18	0730	15	13	0.08	100
19	0700	19	12	0.02	25
20	0600	27	12	–	0
21	0730	28	14	–	0
22	0800	29	10	–	0
23	0800	26	13	–	25
24	0800	18	10	–	40
25	0800	28	10	–	50
26	0800	21	12	–	40
27	0730	21	12	–	100
28	0630	16	12	0.04	100
29	0730	19	10	–	100
30	0800	20	10	–	0
31	0800	27	10	–	0
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	31	20.2	10.6	0.97	62

APPENDIX 2 (Cont'd)

AUGUST

Day	Time	Temperature °C Maximum	Minimum	In. of Rain	% Cloud Cover
1	0700	26	10	–	0
2	0700	28	9	–	10
3	0700	23	8	–	0
4	0745	23	10	–	–
5	0800	17	11	0.40	–
6	0800	17	13	2.76	–
7	0800	18	14	1.41	–
8	0800	22	11	TR	–
9	0800	23	12	0.02	–
10	0800	17	13	–	–
11	0830	19	12	0.14	–
12	0730	16	12	0.08	60
13	0730	20	12	0.01	100
14	0730	17	13	0.17	100
15	0730	20	13	TR	100
16	0730	19	10	0.02	0
17	0730	24	11	–	100
18	0730	20	14	0.08	100
19	0730	20	13	0.22	25
20	0830	19	8	0.57	50
21	0730	27	10	–	60
22	0630	18	11	–	100
23	0730	15	10	0.37	100
24	0730	16	12	0.08	75
25	0730	19	12	TR	100
26	0730	13	20	0.06	90
27	0800	18	13	0.09	90
28	0730	18	14	0.07	100
29	0700	17	12	0.10	75
30	0730	21	13	TR	100
31	0730	15	13	0.84	100
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	31*	19.5	11.9	7.52	71

(* 23 for cloud cover)

APPRNDIX 2 (Cont'd).

SEPTEMBER

Day	Time	Temperature °C Maximum	Temperature °C Minimum	In. of Rain	% Cloud Cover
1	0800	16	9	0.37	75
2	0900	16	11	0.60	100
3	0800	16	10	1.46	100
4	0730	15	11	0.53	100
5	0830	20	6	–	0
6	0800	22	7	–	10
7	0800	23	6	–	10
8	0800	17	9	–	100
9	0800	13	11	–	100
10	0930	15	10	0.42	50
11	0800	17	11	TR	100
12	0730	17	13	TR	100
13	0730	15	7	0.91	50
14	0730	19	11	0.41	75
15	0730	15	11	0.92	100
16	0730	15	9	0.63	90
17	0830	14	5	0.16	20
18	0730	18	4	–	20
19	0830	16	9	0.82	100
20	0730	16	8	0.88	100
21	0800	11	8	1.41	100
22	0730	14	7	0.17	100
23	0730	15	5	0.09	100
24	0830	14	5	0.07	40
25	0830	15	5	–	40
26	0930	17	5	–	40
27	0800	17	13	0.51	100
28	0800	15	13	1.26	100
29	0730	15	10	0.43	100
30	0730	13	11	1.85	100
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	30	16.0	8.7	13.94	74

APPENDIX 2 (Cont'd).

OCTOBER

Day	Time	Temperature °C Maximum	Minimum	In. of Rain	% Cloud Cover
1	0800	17	10	.06	100
2	0800	13	10	.34	100
3	0900	15	10	1.47	50
4	0730	15	8	TR	90
5	0800	13	8	0.09	100
6	0800	15	11	0.02	100
7	0800	15	10	0.08	30
8	0930	14	10	1.05	100
9	0800	13	6	0.07	40
10	0800	13	8	2.11	30
11	0800	13	8	0.64	50
12	0800	12	5	0.11	100
13	0800	14	6	1.47	100
14	0800	14	10	.33	100
15	0800	17	7	–	10
16	0600	14	8	TR	40
17	0800	15	10	–	100
18	0800	16	9	0.09	100
19	0800	17	7	.53	0
20	0800	12	5	.14	50
21	0800	12	5	.15	100
22	0900	12	6	1.09	100
23	0800	14	8	.86	100
24	0800	10	6	.14	20
25	0800	12	6	.04	100
26	0900	10	3	0.21	20
27	0800	10	3	–	50
28	0800	10	5	.46	100
29	0800	7	2	.25	0
30	0800	10	3	.34	100
31	0800	14	11	6.35	100
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	31	13.1	7.2	18.49	70

APPENDIX 2 (Cont'd).

NOVEMBER

Day	Time	Temperature °C Maximum	Minimum	In. of Rain	% Cloud Cover
1	0800	16	10	7.19	100
2	0800	14	7	5.29	100
3	0800	15	5	0.58	100
4	0930	13	2	0.65	100
5	0930	10	4	2.20	100
6	0800	12	10	3.77	100
7	0800	10	5	.30	80
8	0830	7	1	0.38	0
9	0800	9	3	0.03	80
10	0800	6	-2	-	95
11	0800	7	1	1.15	100
12	0800	7	3	.28	60
13	0800	9	-1	-	95
14	0800	6	-1	0.08	100
15	0800	10	5	1.90	100
16	0900	9	-1	0.11	40
17	0900	9	0	0.19	100
18	0800	3	-2	-	2
19	0830	4	-3	-	0
20	0800	6	-4	-	0
21	0800	5	-4	-	90
22	0800	7	-2	.04	100
23	0800	9	2	.25	80
24	0800	8	4	.25	100
25	0800	10	1	.12	80
26	0800	10	5	.05	100
27	0800	14	7	1.23	100
28	0800	10	4	0.16	100
29	0830	8	3	0.17	100
30	0830	9	4	0.82	50
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	30	9.1	2.2	27.19	78

APPENDIX 2 (Cont'd).

DECEMBER

Day	Time	Temperature °C Maximum	Minimum	In. of Rain	% Cloud Cover
1	0800	8	-2	–	60
2	0800	10	1	.56	95
3	0800	11	4	1.26	80
4	0800	7	2	.21	100
5	0800	8	0	.07	80
6	0800	9	1	–	20
7	0800	4	1	.05	100
8	0800	8	3	.38	100
9	0800	10	4	.70	90
10	0800	5	3	.33	100
11	0900	5	1	.30	40
12	0830	9	8	.94	100
13	0800	10	10	4.52	100
14	0800	10	4	1.82	100
15	0900	5	2	.50	100
16	0800	5	0	.47	100
17	0800	3	-3	0	0
18	0800	0	-4	0	0
19	0830	4.5	4.5	1.13	100
20	0800	7	0	1.34	100
21	0900	7	6	1.68	100
22	0900	6	4	.57	80
23	0900	6	3	.84	90
24	0900	9	3	.40	90
25	0900	5	-1	.08	80
26	0900	13	0	.43	95
27	0830	3	-4	–	10
28	0830	2	-4	–	100
29	0830	2	-2	–	90
30	0830	0	-2	–	100
31	0900	0	-1	–	100
	(n)	($\bar{x}$)	($\bar{x}$)	(Σ)	($\bar{x}$)
	31	6.2	1.3	18.58	81%

APPENDIX 3: SUMMARY OF OBSERVATIONS OF CHUM FRY IN CUMSHEWA INLET, 1978 (see Fig. 13 for locations).

Date, Stage of Tide, Weather and Water Conditions	Locations(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
Apr 3 - Low (4.8 ft) - overcast, drizzle	Pallant Estuary (Foot)	- only juvenile sculpins observed. - estuary habitat mapped (Fig. 25)
Apr 7 - rising from low (2.0) - overcast, rain	Pallant Estuary (Foot)	- no fry observed. - Causeway Bay habitat mapped (Fig. 25).
Apr 9 - rising from low (2.6) sunny periods	Mathers Estuary (Foot)	- no fry observed; many seagulls present.
Apr 11 - low (4.1) sunny	Mathers Estuary (Skindive)	- only sculpins seen.
Apr 12 - low (5.1) - overcast	Pallant Estuary, Causeway Bay (Foot)	- no fry on estuary proper; a few surface-feeding fry (sp?) seen at head of Causeway Bay, near small stream, over eelgrass and mud.
Apr 23 - rising to high (21.1) - mainly sunny	E of Mathers (Scuba)	- heavy plankton bloom noted 0-45 ft. (FPC Arrow Post noted plankton blooms on echosounder a few days earlier).
Apr 24 - high (21.0) - sunny periods	Mathers Estuary (Foot)	- only a few fry seen.
Apr 25 - rising from low (2.1) - overcast, showers	Pallant Estuary (Foot)	- no fry seen
Apr 26 - low (1.7) - overcast, showers - water T 9-9.5 ^{o}C	Pallant Estuary (Boat)	- one school of $<$ 100 chum fry at southern side of estuary, over eelgrass edging on river outwash channels 3-4 ft deep.

APPENDIX 3: (Cont'd).

Date, Stage of Tide, Weather and Water Conditions		Location(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
Apr 27 (a.m.)	- low (2.6) - mainly sunny - water T 8.5-10°C	Pallant Estuary, Causeway Bay (Boat)	- many schools of 100's-1000's of chum fry across from main stream to head of Causeway Bay, over eel-grass and sunken logs, bordering on rubble. Fry were surface feeding while swimming with current (into bay) over water depths mainly 1-3 ft, rarely to 10 ft. - no fry found in estuary proper or along S shore of Causeway Bay, except for a few fry stranded in seepage area normally flooded at high tide on the S side of Causeway Bay.
		Mathers Estuary (Foot)	- no fry seen.
Apr 27 (p.m.)	- rising to high (19.0) - mainly sunny, windy - water T 12°C (15°C springs @ Aero)	Cumshewa Inlet, N shore to Aero (Boat)	- schools of <1000 chum fry common to Aero; mainly in protected bays but undisturbed. Schools were noted actively moving to E along exposed shoreline. Fish were actively surface-feeding near shore (1-3ft).
Apr 28	- over low (3.8) and rising to high (18.1) - mainly sunny - water T 9.5-10.5°C	Cumshewa Inlet, N and S shores, Moresby to Aero (Boat)	- schools of <1000 chum fry common from Causeway Bay (most abundant) to Aero on the N shore; only one school of <50 salmon fry (sp?) on S side just W of Barge Point, over large boulders and 10ft depth. No fry from there W until Gordon Cove. Schools of <1000 chum fry common there in small bays seaward of the obvious freshwater influence of Braverman Creek.
Apr 30	- N/A - sunny	Mathers Estuary (Foot)	- small fry school seen below bridge, appeared to be larger than those captured in trap.
May 1	- falling to low (5.7) - overcast, rain	Mathers Estuary (Foot)	- no fry observed.

APPENDIX 3: (cont'd.)

Date, Stage of Tide, Weather and Water Conditions	Location(s) Inspected (Methods)	Fry, Location, Behavior, Habitat, and Miscellaneous Observations
May 2 - low (5.6) - cloudy, rain, wind - water T 10 - 10.5°C	Causeway Bay (Foot)	- chum fry present, but poor visi- precluded estimate of relative abundance. FPC *Arrow Post* crew noted chum fry around Moresby dock during high tide, and echo-sounding taken down Cumshewa on their way in earlier in the day showed plankton bloom to 4 fm, particularly in Gillatt Arm.
May 3 - rising to high (19.0) - showers and sunny periods - water T 7°C	Pallant Estuary, Causeway Bay (Foot, Boat)	- most fry seen on S shore of Causeway Bay, over 4-5 ft deep water and near the bottom, also at dock. - no fry seen on N shore of estuary at Causeway.
May 3 - low (5.4) (p.m.) - showers, sunny	Pallant Estuary Causeway Bay (Foot, Boat)	- good numbers of chum on S side of Causeway Bay, including schools of <100 at dock; surface-feeding over 2-3 ft depth, but moving deeper when disturbed. Fry near dock held general position in large circular movements of school.
May 4 - rising to high (19.5) - sunny	Cumshewa, Aero to Duval Rk. (Boat)	- chum fry common in sheltered bays; generally found over 1-3 ft of water, cobble substrate.
May 5 - rising to high (19.9) - sunny - water T 11°C (in McCoy Cove	Cumshewa, Cumshewa Village to McCoy Cove (Boat)	- school of approx. 500 chum fry in McCoy Cove; did not appear markedly larger than creek migrants.
May 6 - rising from low (2.7) - mainly sunny - water T 9.5°C	Pallant Estuary (Boat)	- some dimpling along front of estuary; no fry seen until S of the estuary proper. Undisturbed school of approx. 50 fry seen in 1-3 ft of water over logs and open. School generally moved with current but swam in circles along path. When alarmed, fry swam with the current or moved into deeper water.
	Causeway Bay (Boat)	- fry in Casueway Bay were most abundant on the N shore just across from the dock, but were heavy on S side as well. Schools moved with the current when alarmed and might have been

APPENDIX 3: (cont'd.)

Date, Stage of Tide, Weather and Water Conditions	Location(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
May 6 – cont'd.	Causeway Bay (Boat)	orienting with the drifting boat; when the boat was held stationary, no fry movement with the current was noted.
	Mathers Estuary (Boat)	– no fry observed on estuary and beaches on either side of Mathers Creek.
	Cumshewa Village (Boat)	– school seen in small bay just west of village site, over a relatively open rock-sand area.
May 7 – rising from low (2.4) – sunny	Pallant Estuary (Foot)	– total of <1000 chum fry found in dewatered pools on N side of estuary from the bridge to just below the first main fork (no fry were found in pools with well-defined flows out of them).
	Gordon Cove (Foot)	– all small bays were fry found previously were dewatered; no fry observed.
– water T 10.5°C	Cumshewa, McLellan I. (Boat)	– mixed school of pink and chum fry of varying size found in a protected bay. School was in the shallows, over cobble-boulder bottom with some seaweed cover. A visible plankton bloom was also present.
May 8 – rising from low (2.5) – sunny periods – Tater T 9.5°C	Cumshewa Conglomerate Pt. (Boat)	– school found in a protected bay, in shallows over a gravel-sand bottom with light *Fucus* sp. cover. There was a visible plankton bloom.
May 9 – low (2.5) – sunny – water T 11°C (Causeway Bay)	Cumshewa, both sides from Moresby to Aero (Boat)	– crew of FPC *Arrow Post* found schools of salmon fry to be common on the N shore, and only one small school of larger salmon (coho?) were found on the S shore, to the E of the mouth of Gordon Cove. – echosoundings made by FPC *Arrow Post* in Cumshewa in a.m. showed no obvious plankton blooms.
May 3-10 – N/A (May 10 water T 9.0°C offshore in Cumshewa Inlet)	Pallant Estuary, Creek proper (Foot)	– chum fry noted to be common in schools <100 throughout creek from tidal influence to hatchery site during previous week.

APPENDIX 3: (cont'd.)

Date, Stage of Tide Weather and Water Conditions	Location(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
May 10 - rising to high (18.6) - overcast, wind	Carmichael Passage, near Chadsey Cr. (Boat)	- school of approx. 200 chum fry seen just to S of Chadsey Cr, in shallows over open gravel bottom (stream delta).
May 17 - high (16.4) - sunny periods - water T 9.5°C	Cumshewa, McCoy Cove (Boat)	- schools of mainly pink fry found on E side, over cobble-gravel bottom with light Fucus sp. cover.
May 19 - rising to high (18.2)	Cumshewa, both sides Moresby to Aero (Boat)	- schools of <100 chum fry still common on N shore (most abundant in Causeway Bay). One large school of approx. 3-5000 fry found on S shore just W of Barge Pt; small schools of chum found on S shore in small bays. Gordon Cove too rough to observe.
May 21 - rising from low (1.7) - mainly sunny - water T 10-12°C	Cumshewa, Conglomerate Pt area (Boat)	- several chum schools seen, mainly over open, rocky, protected sections.
May 23 - rising from low (0.0) - sunny	Cumshewa, McCoy Cove to McLellan I. (Boat, Skindive)	- chum fry schools abundant. Schools often seen 4 ft deep in kelp beds over 20 ft bottom; schools also in shallows still.
May 24 - rising from low (0.0) - cloudy - water T 10.5 - 11°C	Cumshewa, Kingui I to McCoy Cove (Boat)	- only two schools of <50 chum fry seen at 4 ft and deeper in kelp beds.
	Causeway Bay (Boat)	- fry still abundant, now noticeably larger than those caught in the downstream traps. Heavy surface-feeding on S shore in seepage area.
	Cumshewa, Moresby to Beatty Anch.	- Echosoundings from FPC Arrow Post showed no plankton blooms.
May 25 - near low (0.6) - sunny periods - water T 9 - 10°C	Causeway Bay (Boat)	- fry abundant near surface at 3-5 ft in depth; coho smolt seen with fry in mouth.

APPENDIX 3: (cont'd.)

Date, Stage of Tide, Weather and Water Conditions	Location(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
May 25 – cont'd. – water T 10°C	Pallant Estuary (Foot)	– a few chums at S edge of estuary and a few in dewatered pools upstream of first main fork. Also approx. 50 coho fry in mouth of small stream on S side of the estuary near the first fork.
May 26 – falling to low (1.5) – cloudy – water T 9 – 9.5°C	Gordon Cove (Boat)	– a very few fry present (4 schools of < 50 seen; some of the fry very small.
May 31 – near high (17.1) – sunny, hot	Cumshewa McCoy Cove area (Boat)	– several schools of 20-50 large chum and pink fry along the beaches.
	Cumshewa Davey I (Boat)	– schools of surface-feeding fish approx. 3 in long (sp?) over deep water.
Jun 5 – N/A – sunny, hot – stream T 16°C	Pallant Creek above tidal infl. (Foot)	– a few chum fry mixed with coho fry of similar size along creek margins.
Jun 6 – rising from low (2.4) – sunny, calm – water T 14 – 15°C	Causeway Bay (Boat)	– abundance of fry down slightly. Most fry 3-5 cm long, near surface over 5-15 ft depths (some small fish still near shore). Water was clear throughout.
	Pallant Estuary (Boat)	– a few small schools of large fry surface-feeding along edge of drop-off in front of estuary. – deeper waters along drop-off were murky, suggesting a plankton bloom.
– water T 15.5°C (Aero shore)	Cumshewa, both sides near Aero (Boat)	– Large, loose schools of chum fry 4-5 mml just W of Aero; found mid-water to surface over 5-20 ft depths. Fry were actively feeding near the surface and would orient to the cover of the boat. – a few small schools of small chum were seen just W of Barge Pt on the S shore of Cumshewa, over depths of 7-10 ft.

APPENDIX 3: (cont'd.)

Date, Stage of Tide, Weather and Water Conditions	Location(s) Inspected (Methods)	Fry Location, Behavior, Habitat, and Miscellaneous Observations
Jun 6 - cont'd.	Cumshewa, near Moresby (Boat)	- only a few chum were found in the first bay E of Causeway Bay.
Jun 13 - falling to low (6.6) - sunny	Cumshewa, Causeway Bay to Aero (Boat)	- chum fry in schools of 5-10 up to 50 common from Causeway Bay (most abundant) to Aero. Fish, large, found from 1-6 ft (mostly 5-6 ft) in rocky areas, and sounded into deeper water when disturbed.
Jun 25 - around low (2.2) - cloudy, windy - water T: 12°C - Aero, Inlet 12.5°C - Causeway	Cumshewa, Causeway Bay and Area (Boat)	- chum fry abundant at head of Causeway Bay; fry were surface-feeding over 6-8 ft deep, open bottom. Fry sounded when approached in boat. Also schools of approx. 200 sticklebacks, 8 mm long, present. - chum fry present at Aero, but wind made estimate of relative abundance impossible.
	Pallant Creek (Foot)	- chum fry no longer along margins.
Jul 1 - rising to 16.8 - poor visibility - water T: 12.5°C - Causeway 12°C - Inlet	Cumshewa, Causeway Bay (Boat)	- fry still present in bay. Surface rises over 2 m depths common. - plankton bloom noted in bay.
Jul 10 - falling to 4.3 - poor visibility	Cumshewa, Causeway Bay (Walk)	- surface rises in bay still common (sp. unknown).
Jul 17 - rising to high (17.7) - overcast, calm - water T 14°C throughout	Cumshewa, Causeway Bay to McLellan I (Boat)	- very few rises in Causeway Bay; fry sound long before boat approaches. No fry noted along shoreline.

APPENDIX 4: SUMMARIES OF OBSERVATIONS OF PREDATORS AND COMPETITORS IN THE PALLANT SYSTEM AND CUMSHEWA INLET, 1978.

DATE/Time SET - P/U	LOCATION(S)	SPECIES	COMMENTS
A. GILLNET CATCHES:			(N.B.- PoH = postorbital-hypural; FL = nose-fork)
Apr 6- Apr 8 1200 0900	rock bluff at head of Mosquito Lk	2 cutthroat (CT)	- 266-362 mm PoH (CT). - too rough to p/u on Apr 7.
Apr 6-Apr 7 1400 1400	at outlet of Mosquito Lk	6 cutthroat	- 162-267 mm (CT), 221 (DV), 126 (K). - mature female.
May 6-May 7 1600 1400	SW corner of outlet bay in Mosquito Lk	10 cutthroat 1 Dolly Varden (DV) 1 kokanee (K)	- 150-258 mm (CT), 221 (DV), 126 (K). - some CT females mature.
May 6-May 7 1630 1430	center of outlet bay (from deadheads), in Mosquito Lk	6 cutthroat 1 Dolley Varden 1 kokanee	- 134-245 mm (CT), 214 (DV), 128 (K).
May 9-May 10 1800 0900	under logging bridge over Pallant Cr	nil	- from high slack (19.3) over 6.9 low, 20.4 high falling to low (3.4).
May 13-May 14 1400 0900	near outlet of Mosquito Lk	5 cutthroat	- 146-276 mm PoH.
May 13-May 14 1430 1000	S shore of Mosquito Lk, across from Pallant Pallant Cr lake tributary	11 cutthroat	- 148-296 mm PoH.
June 4-Jun 5 1500 1500	among deadheads on NW side of Causeway Bay, Cumshewa Inlet	3 Dolly Varden 1 tomcod 1 Pacific cod 6 shiner perch 3 copper rockfish 7 sculpins	 - Microgadus proximus 260 mm. - Gadus macrocephalus 250 mm. - Cymatogaster aggregata 100-127 mm. - Sebastes caurinus 145-170 mm. - sp. unknown; 170-200 mm.

APPENDIX 4: (cont'd.)

DATE/TIME SET - P/U	LOCATION(S)	SPECIES	COMMENTS
Jun 7-Jun 8 1400 1130	in bay to E of Pallant Cr lake tributary	13 cutthroat 1 Dolly Varden	- net badly tangled. - 125-400 mm (CT), 163 (DV). - many CT spawned out.
Jun 7-Jun 8 1430 1145	off creek delta at head of lake	17 cutthroat 1 Dolly Varden 2 kokanee	- 96-267 mm (CT), 111 (DV), 144-150 (K). - many CT spawned.
B. SEINE CATCHES:			
May 26 1100	S shore of Causeway Bay Bay at boat launch Cumshewa Inlet	500 (approx.) chum fry ? Dolly Varden ? coho smolts ? sculpins	- near low (1.5 ft)
Jun 7 1000	beach to W of Aero, Cumshewa Inlet	? chum, pink fry ? shrimp ? coho smolts ? rockfish	- rising from low (2.6 ft).
Jun 7 1100	S shore of Causeway Bay at boat launch, Cumshewa Inlet	as per May 26 set, plus ? shiner perch	
C. MINNOW TRAP AVERAGE CATCHES:			
Jan 11-Jan 12 1100 1430	Pallant Cr in oxbow log jam (no traps = n = 3)	3.7 coho 1.7 rainbow 0.7 sculpin	- 4^{o}C.
Feb 13-Feb 14 1300 1300	mouth of N tributary at head of Mosquito Lk. (n = 1)	2 Dolly Varden 3 scuplin	- 60-80 mm FL(DV). - 4^{o}C.

APPENDIX 4: (cont'd.)

DATE/TIME SET - PU	LOCATION(S)	SPECIES	COMMENTS
Feb 13 - Feb 14 1300 1300 (cont'd.)	mouth of S tributary at head of Mosquito Lk (n = 1)	nil	- 4°C.
	mouth of Pallant Cr tributary to lake (n = 1)	1 sculpin	- 5°C.
Apr 7 - Apr 8 1315 1330	Pallant Cr, between lake and 3rd falls (n = 5)	3.6 sculpins (SC) 1.8 cutthroat	- 100-150 mm FL(SC). - 50-125 mm FL(CT). - 6°C
1415 1430	Pallant Cr, between 3rd and 2nd falls (n = 4)	1.0 sculpin 0.3 steelhead smolt (SH)	- 50-75 mm FL(SC). - 100 mm FL(SH). - 6°C
1515 1530	Pallant Cr, just d/s of 2nd falls (n = 3)	0.7 sculpin 1.3 rainbow (RB) 0.3 steelhead smolt 1.7 coho smolts (CO)	- 125 mm FL(SC). - 75-150 mm FL(RB). - 125 mm FL(SH). - 100-125 mm FL(CO). - 6°C
Apr 26 - Apr 27 1245 1300	Pallant Cr @ hatchery intake (u/s 1st falls) (n = 1)	7 rainbow	- 75-125 mm FL. - 6°C
	Pallant Cr, from 1st falls d/s to S tributary (n = 4)	1.5 sculpins 1.8 rainbow 0.8 coho juvenile	- 50-150 mm FL(SC). - 50-100 mm FL(RB). - 1 CO smolt, 2 fry. - 6°C
1600 1530	S tributary of Pallant Cr (n = 5)	4.6 rainbow 8.2 Dolly Varden 6.7 coho smolts	- 50-125 mm FL(RB). - 75-150 mm FL(DV).

APPENDIX 4: (cont'd.)

DATE/TIME SET - P/U	LOCATION(S)		SPECIES	COMMENTS
Jun 3-Jun 4 0900 0900	N tributary at head of Mosquito Lk (n = 6)	1.5 0.7 0.3	sculpins cutthroat Dolly Varden	- 50-100 mm FL(SC). - 75-125 mm FL(CT). - 14°C
1030 1000	S tributary at head of Mosquito Lk (n = 6)	1.7	sculpins	- 50-100 mm FL(SC). - 15°C
Jun 26-Jun 27	Pallant Cr, 1st falls d/s to gorge (n = 6)	6.8 0.2 0.3 2.7	rainbow cutthroat Dolly Varden coho fry	- 75-150 mm FL(RB). - 125 mm FL(CT). - 100-150 mm FL(DV). - 50- 65 mm FL(CO).
	Pallant Cr, gorge pool d/s to bridge (n = 6)	5.8 1.0	sculpins coho fry	- 50-125 mm FL(SC). - 50 mm FL(CO). - 16°C

D. MISCELLANEOUS OBSERVATIONS:

Mar 20	Pallant Cr, below hatchery	2	steelhead	- angled by caretaker.
Apr 3	Pallant Cr, estuary	many	sculpins	- most 50 mm FL or less. - visual at low tide.
Apr 12	Mathers estuary	3	steelhead	- observed holding in pool at low tide.
Apr 25	Pallant Cr, u/s fry traps	1	steelhead	- fresh sea-run; angled.
Apr 26	Mathers estuary	1	seal	- observed at mouth.
May 6	Pallant Cr, between 1st and 2nd falls	1	steelhead	- visual by caretaker.

APPENDIX 4: (cont'd.)

DATE/TIME SET - P/U	LOCATION(S)		SPECIES	COMMENTS
Apr 28 - Apr 29 1300 1345	Pallant Cr, S tributary d/s to gorge (n = 6)	0.5	cutthroat	- 50 - 75 mm FL(CT).
		1.8	rainbow	- 75 - 125 mm FL(RB).
		2.0	Dolly Varden	- 75 - 175 mm FF(DV).
				- 7°C.
1630 1630	Pallant Cr, gorge pool d/s to bridge (n = 5)	5.2	sculpins	- 50 - 125 mm FL(SC).
		0.2	rainbow	- 100 mm FL(RB).
		2.4	coho smolts	
May 6 - May 7 1330 1330	Pallant Cr, 2nd falls d/s to 1st falls (n = 11)	0.1	stickleback (SB)	- 50 - mm FL(SB).
		0.3	rainbow	- 100 - mm FL(RB).
		0.4	coho fry/smolts	- 50 - 150 mm FL(CO).
		0.4	sculpins	- 150 mm FL(SC).
				- 7°C.
May 23 - May 24 1600 1515	Pallant Cr, lake tributary, from old bridge 0.5 km u/s (n = 6)	6.7	sculpins	- 75 - 125 mm FL(SC).
		2.0	cutthroat	- 75 - 175 mm FL(CT).
		0.3	Dolly Varden	- 100 mm FL(DV).
				- 11.0°C.
1645 1600	from old bridge 0.5 km d/s (n = 6)	3.8	sculpins	- 75 - 100 mm FL(SC).
		0.7	cutthroat	- 100 - mm FL(CT).
		0.8	Dolly Varden	- 75 - 150 mm FL(DV).
				- 11.5°C.
May 27 - May 28 1315 0830	Pallant Cr, lake tributary, from washed-out crossing 0.5 km u/s (n = 6)	0.5	sculpins	- 100 - 125 mm FL(SC).
		3.0	cutthroat	- 75 - 175 mm FL(CT).
		0.3	Dolly Varden	- 100 - mm (DV).
				- 9.0 - 9.5°C.
	from washed-out crossing 0.5 km d/s (n = 5)	0.6	sculpins	- 75 - 125 mm FL(SC).
		2.4	cutthroat	- 75 - 125 mm FL(CT).
				- 9.5 - 10°C.

APPENDIX 4: (cont'd.)

DATE/TIME SET - P/U	LOCATION(S)	SPECIES	COMMENTS
May 6 (cont'd.)	Mosquito Lk, outlet bay	cutthroat ?	- 16 all <17 cm angled by caretaker. - schools of fry approx. 5cm seen near outlet.
	Mosquito Lk, near temp Stn. #2	kokanee	- large kokanee caught by trolling at 30 m (native pers. comm. with caretaker).
May 9	Cumshewa Inlet	herring (juv)	- schools in deeper water. - visual by FPC Arrow Post.
May 19	Cumshewa Inlet, both sides Moresby to Aero	shiner perch, cod	- schools common along steep rock faces (visual from boat by technician).
May 25	Cumshewa Inlet, Causeway Bay	coho (juv)	- seen with chum fry in mouth.
Jun 3	Mosquito Lake	kokanee (juv)	- many small schools observed surface-feeding.
Jun 4	Mosquito Lake	12 cutthroat	- angled (with fly) by caretaker.
Jun 6	Cumshewa Inlet, Causeway Bay	shiner perch, juvenile salmonids	- high numbers seen in area; larger perch appeared to stalk chum fry.
	Cumshewa Inlet, W of Barge Pt	shiner perch (juv)	- high numbers present along beach, together with a few small schools of chum fry.
	Cumshewa Inlet, offshore in W end	?	- many schools of smolt-sized fish surface-feeding.
Jun 7, 8	Mosquito Lake	kokanee (juv)	- observed surface-feeding in small schools in calm areas of lake.

APPENDIX 4: (cont'd.)

DATE/TIME SET - PU	LOCATION(S)	SPECIES	COMMENTS
Jun 17	Mosquito Lake	cutthroat	- fishing derby held on lake
Jun 19	S tributary of Pallant Creek	coho (fry)	- walked in previous week; noted 1000's of coho fry in tributary, with most above fork.
	Pallant Cr, below 1st falls	rainbow; coho	- 6-8 rainbow 35 cm in length, and several coho smolts caught by anglers in previous week.
Jun 26,27	Pallant Cr, hatchery to bridge	900 Dolly Varden; coho fry	- 7 kg (approx) sea-run fish in 3 schools of 300 seen by caretaker from S tributary downstream; also large numbers of coho fry present from hatchery to bridge.
	Cumshewa Inlet, Causeway Bay	sticklebacks	- large schools observed along shore of bay.
Jul 1	Pallant Cr, estuary	21 seals	- hauled out on flats.

APPENDIX 5: STOMACH CONTENTS DATA FROM PREDATOR/COMPETITOR SPECIES AT PALLANT AND MATHERS CREEKS, 1978.

A. GILLNET DATA:

[a](CT = cutthroat, DV = Dolly Varden, k = kokanee, SB = stickleback, SC = sculpin)

[b](dig. = digested, terrest = terrestrial)

Date	Location	Catch Method	Species[a]	POH in mm	Sex	Stomach Contents[b]
Apr 7	Mosquito Lk, near outlet	gillnet	CT	259	F	sticks, SB.
			"	267	F	2 SB. worm, beetle (terrest).
			"	234	F	SB, insects (terrest).
			"	176	?	unidentifiable (dig).
			"	175	?	caddis fly (adult).
			"	162	?	egg mass (SC?).
Apr 8	Mosquito Lk, near head	gillnet	CT	362	F mature	empty.
			"	266	M	3 SB (approx 7 cm).
May 6	Mosquito Lk, near outlet	angled	CT	165	M	mud, insects (terrest).
			"	165	M	sticks, beetles (terrest).
			"	138	F	sticks, larvae, beetles (terrest).
			"	125	?	seeds, beetles (terrest).
			"	147	F	seeds, caddis larva, beetles (terrest).
May 7	Mosquito Lk, near outlet	gillnet	CT	258	F sp out	empty.
			"	234	F sp out	SB, *Pisidium*.
			"	244	F sp out	2 SB, mud.
			"	216	M	SB, caddis larva.
			"	208	M mature	SB, insects (terrest).
			"	189	M	SC eggs.
			"	187	F	4 SB, mayfly (adult).
			"	150	F	SC (approx 7 cm), SB.
			"	150	F	wood chips
			"	156	F	fish (dig).
			DV	221	F	100's of snails (*Lymnaea*).
			K	126	F	mud.

APPENDIX 5: (cont'd.)

Date	Location	Catch Method	Species[a]	POH in mm	Sex	Stomach Contents[b]
May 7 (cont'd)	Mosquito Lk, middle of outlet bay	gillnet	CT	240	M	SB, insects (terrest).
			"	245	M	several SB (dig).
			"	243	F	SB.
			"	187	F	SB.
			"	165	F	mud.
			"	134	M	empty.
			DV	214	F	mud/sticks (packed).
			K	128	M	plankton.
May 14	Mosquito Lk, near outlet	gillnet	CT	254	M	empty.
			"	244	F	empty.
			"	276	M	SB.
			"	260	M	3 ST approx 3 cm.
			"	146	?	terrest (ant cases).
	Mosquito Lk, S shore across from Pallant Cr inlet	gillnet	CT	161	F	SB's (1-4 cm + dig).
			"	184	M	3 SB.
			"	148	?	SB (dig), hemlock needles.
			"	204	F	3 SB.
			"	246	F	roundworm (parasite).
			"	269	M	SC eggs, rocks, beetle.
			"	250	F	SB.
			"	296	F	empty.
			"	251	M	4 SB.
			"	267	F	2 SB.
			"	247	F	1 lamprey larva (7 cm).
Jun 5	Cumshewa Inlet, Causeway Bay	gillnet	DV	260	-	48 chum fry.
			"	295	-	3 herring (13 cm).
			"	290	-	1 herring, 1 tapeworm.
			tomcod	260	-	herring (vertebrae).
			cod	250	-	2 herring, 1 chum fry.
			rockfish(3)	145-170	-	all empty.
			sculpins(7)	170-200	-	all empty.

APPENDIX 5: (cont'd.)

Date	Location	Catch Method	Species[a]	POH in mm	Sex	Stomach Contents[b]
Jun 8	Mosquito Lk, near Pallant Cr inlet	gillnet	CT	400	F	1 juv salmonid.
			"	325	M sp out	unidentifiable (dig).
			"	258	F sp out	empty.
			"	250	F	empty.
			"	204	M	SB.
			"	200	M	SB.
			"	203	F	bark, beetle (terrest).
			"	186	M	SC, sand.
			"	185	F	snails, dig remains.
			"	181	M	*Pisidium*, terrest.
			"	176	M	SB.
			"	176	F	unidentifiable (dig).
			"	125	M	empty.
			DV	163	F	sticks.
	Mosquito Lk, off delta at head	gillnet	CT	267	F sp out	SB, 10 cm SC.
			"	249	F	unidentifiable (dig).
			"	228	M	empty.
			"	245	F	debris, tapeworm.
			"	266	M	SB, insects (terrest).
			"	204	M	insects (terrest).
			"	189	F	insects (terrest), caddis larva.
			"	168	F	SB, sticks, insects (terrest).
			"	179	M	insects (terrest).
			"	149	F	insects (terrest).
			"	142	F	sticks, aquatic insects.
			"	153	M	empty.
			"	132	F	empty.
			"	137	F	empty.
			"	137	F	insects (terrest), sticks.
			"	146	?	empty.
			"	96	?	insects (terrest).
			K	144	M	plankton.
			"	150	F	plankton.
			DV	111	?	empty.

APPENDIX 5: (cont'd.)

B. INCLINED PLANE DATA: ([a]SX = sockeye, CO = coho, Sm = smolt)
([b]fry too digested to determine species)

i) Mathers Rainbow Trout (RB) and Dolly Varden (DV)

Length (Nose-Fork) cm		No. of Fry Pink	Dig.[b]	Chum	Other Species[a]	Fry Total
11.5	RB	10		-	-	10
10.5	RB	5		-	-	5
13.0	DV	7		3	-	10
10.5	DV	5		-	-	5
26.0	DV	1		-	-	1
32.0	DV		3		-	3
13.2	DV	8		-	-	8
11.6	DV		8		-	8
12.9	DV	-		5	-	5
12.3	DV	-		7	-	7
15.1	DV	-		8	-	8
15.2	DV	-		6	-	6
14.2	DV	-		7	-	7
12.1	DV	-		5	-	5

ii) Mathers Coho Smolts

Length (Nose-Fork) cm	Pink	Dig.[b]	Chum	Other Species[a]	Fry Total
8.9	-		3	-	3
12.1	-		4	-	4
11.5	-		4	-	4
11.0	-		3	-	3
11.7	-		2	-	2
8.0	-		-	-	0
10.6	-		3	-	3
10.7	-		2	-	2
11.4	-		3	-	3
11.4	-		4	-	4
11.0	-		3	-	3
11.2	-		3	-	3
11.7	-		2	-	2
11.6	-		2	-	2
11.3	-		2	-	2
10.0	-		2	-	2
8.8	-		1	-	1

iii) Mathers Sculpins

Length (Nose-Fork) cm	Pink	Dig.[b]	Chum	Other Species[a]	Fry Total
19.5		42		-	42
13.0		20		-	20

APPENDIX 5: (cont'd.)

Length (Nose-Fork) cm	Pink	No. Fry Dig.[b]	Chum	Other Species[a]	Fry Total
14.0	16		2	-	18
9.9	3		1	-	4
19.0	37		5	1 sculpin	43+
10.0	34		-	2 sculpins	361
8.5	2		-	-	2
15.0	8		7	1	16+
9.5	5		-	-	5
5.5	-		-	-	0
10.5	4		-	-	4
10.0		1	-	-	1
10.0	-		7	-	7
13.8	4		-	1 SX sm	5+
16.7	3		9	1 sculpin, 1 SX	14+
16.2	18		32	-	50
17.5	-		60	1 CO	61+
17.5		8	6	1 SX sm	15+
16.0	-		8	2 SX sm, 1 lamprey larva	11+
15.5	-		16	-	16
11.0	-		6	-	6
18.5	1		21	2 SX sm, 1 CO sm	25+
11.5	-		10	-	10
13.5	-		12	-	12
15.8	-		30	-	30
15.9	-		37	-	37
13.6	-		14	-	14
13.7	-		17	-	17
17.1	-		17	1 CO, 1 sculpin	19+
12.4	-		17	-	17
9.2	-		3	-	3
14.4	-		3	2 SX sm	5+
16.4	-		31	2 CO	33+
14.5	-		37	1 CO	38+
16.5	-		10	-	10
8.7	-		4	1 SX	5+
13.1	-		17	1 CO	18+
7.4	-		1	-	1
8.0	-		-	-	0
16.8	-		29	1 sculpin	30+
16.9	-		16	2 SX, 1 CO	19+
15.4	-		16	1 CO	17+
12.7	-		18	-	18
9.3	-		3	-	3
18.3	-		6	1 SX	7+
15.6	-		18	1 SX	19+
14.6	-		17	-	17
12.4	-		14	-	14
12.6	-		11	-	11

APPENDIX 5: (cont'd.)

Length (Nose-Fork) cm	No. Fry Pink	No. Fry Dig.[b]	No. Fry Chum	Other Species[a]	Fry Total
14.3	-		3	1 SX	4+
8.7	-		2	-	2
15.0	-		24	-	24
9.4	-		2	-	2
14.5	-		10	-	10
9.0	-		3	-	3
15.0	-		17	1 CO	18+
15.2	-		13	1 CO	14+
16.0	-		-	-	0
16.5	-		22	1 SX, 1 sculpin	24+
12.5	-		12	-	12
11.0	-		4	-	4
10.0	-		3	-	3
11.5	-		5	-	5
9.0	-		1	-	1
15.0	-		23	-	23
16.5	-		32	1 SX	33+
16.0	-		32	-	32
12.0	-		10	-	10
11.5	-		6	-	6
16.5	-		14	1 SX	15+
13.5	-		16	-	16
13.0	-		20	1 SX	21+
17.0	-		17	1 SX	18+
13.0	-		18	-	18
14.0	-		6	-	6
13.5	-		3	1 SX	4+
14.5	-		1	1 SX	2+
12.0	-		6	-	6
15.5	-		12	-	12

iv) Pallant Sculpins

Length (Nose-Fork) cm	No. Fry Pink	No. Fry Dig.[b]	No. Fry Chum	Other Species[a]	Fry Total
7.6	3		-	-	3
6.4	1		-	-	1
5.0	2		-	-	2
6.4	2		-	-	2
7.6	1		-	-	1
8.9	-		3	-	3
10.2	-		16	-	16
10.2	3		-	-	3
7.6	2		-	-	2
6.4	1		-	-	1
5.0	-		2	-	2
5.0	-		2	-	2
5.0	-		2	-	2
14.0	-		22	-	22+

APPENDIX 5: (cont'd.)

Length (Nose-Fork) cm	No. Fry Pink	Dig.[b] Chum	Other Species[a]	Fry Total
15.2	-	19	1 sculpin	20
10.2	-	16	-	16
6.4	-	1	-	1
5.0	-	1	-	1
5.0	-	2	-	2
7.6	-	6	-	6
7.6	3	1	-	4
15.2	-	19	-	19
6.4	-	1	-	1
7.6	3	-	-	3
7.6	4	-	-	4