ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

MARINE ENVIRONMENTAL SURVEILLANCE MONITORING AT B.C. SOUTH COAST PULPMILLS 1980

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by

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ABSTRACT

During 1980, the Environmental Protection Service monitored changes in water quality and benthic conditions associated with pulp mill effluents at Powell River, Crofton, Harmac, Port Alberni, and Port Mellon. Parameters examined included water column temperature, salinity, dissolved oxygen, colour, sediment character and trace metals in sediments. Sediments at Powell River and Port Mellon were also analysed for total volatile residues. Epibenthic fauna were trawled at Crofton and benthic infauna were surveyed at Port Alberni and Port Mellon.

RÉSUMÉ

Au cours de l'année 1980, le Service de la protection de l'environnement a relevé les changements survenus dans la qualité de l'eau et analysé les dépôts benthiques ayant subi l'effet des effluents des usines de pâte à papier de Powell River, Crofton, Harmac, Port Alberni et Port Mellon. Parmi les paramètres étudiés, on trouve la température de la colonne d'eau, la salinité, la quantité d'oxygène dissous, le couleur, le type de sédimentation et la présence de métaux à l'état de traces dans les sédiments. On a également prélevé des sédiments à Powell River et Port Mellon pour en analyser les particules et résidus volatils. On a pêché au chalut, à Crofton, des spécimens de la faune épibenthique et on a procédé à une étude de la faune benthique à Port Alberni et à Port Mellon.

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SUMMARY

Crofton - Stuart Channel

In November 1980 oxygen was depressed at depths between 25-50 metres at all Stuart Channel stations. Apparently the oxygen is being depleted by pulpmill effluent which is restricted to these depths by poor mixing. Benthic communities were similar to those sampled in 1979 and no heavy metal contamination was apparent.

Harmac - Northumberland Channel

In November effluent was being well dispersed in Northumberland Channel. Analysis of sediments indicated mercury levels were not elevated. There was no apparent trend of heavy metal contamination in relation to the diffuser. Surveys to examine fibre deposition and its effects on the benthic environment have been initiated and will be presented under separate cover.

Powell River - Malaspina Strait

During two 1980 surveys, there was no obvious impact from effluent on dissolved oxygen in Malaspina Strait. During November, D.O. levels below 50 metres were consistently below 5.0 mg/l. Although this appears to be a natural, seasonal phenomenon, discharge of effluent through the newly installed diffuser may be a contributing factor.

Benthic samples near the mill, collected during both surveys, did not indicate elevated levels of mercury, zinc, copper or lead. Cadmium levels were exceptionally high at all stations, as in 1979.

Port Alberni - Alberni Inlet

The water column in the inner harbour was highly stratified in June 1980. Dissolved oxygen below the halocline was strongly depressed for a considerable distance from the outfall.

Benthic communities were simple and depauperate, consisting mainly of polychaete worms in the harbour. The low oxygen environment and substrate of wood waste are dominant factors effecting the benthic community. Trace metal analysis at selected sites did not reveal levels to warrant immediate concern.

Port Mellon - Thornbrough Channel

Water column profiles at Port Mellon were typical of winter conditions in coastal waters. Dissolved oxygen was low at 200 metres, typical of deep basin water. Colour values were high in surface waters.

The benthic community composition was poor possibly because of the wood debris and fibre substrate. Heavy metals in sediments were not seriously elevated.

1. INTRODUCTION

1.1 Study Areas. The Environmental Protection Service annually monitors coastal pulp mills to document changes in water quality and sediments associated with pulp mill effluents. Compliance with the Pulp and Paper Liquid Effluent Regulations is monitored by auditing company reports pursuant to provincial permit conditions, by conducting periodic bioassays of liquid effluent and by site inspections as necessary. Compliance surveillance is reported elsewhere. Changes in the receiving environment, the subject of this report, are monitored by on-site surveys of water quality, benthic conditions and heavy metal analysis. Results of environmental monitoring and information on compliance at each mill are used to assess effectiveness of permit conditions in protecting main resources.

In 1980, conditions in the receiving environment were monitored at the pulpmills located at Crofton, Harmac, Powell River, Port Alberni, and Port Mellon. (Figure 1)

2. METHODS AND MATERIALS

Water quality was surveyed at the five pulp mill sites during June and November, 1980. At each station, water was sampled for dissolved oxygen, temperature, salinity and colour analysis.

Benthic evaluation included marine sediment sampling for trace metals, total volatile residues and particle size. Benthic fauna collected with an otter trawl were analyzed for trace metal content.

2.1 Hydrographic Sampling. At each station samples were collected for temperature, dissolved oxygen, salinity and colour. All samples were collectd with NIO (National Institute of Oceanography) bottles equipped with paired, protected, reversing thermometers.

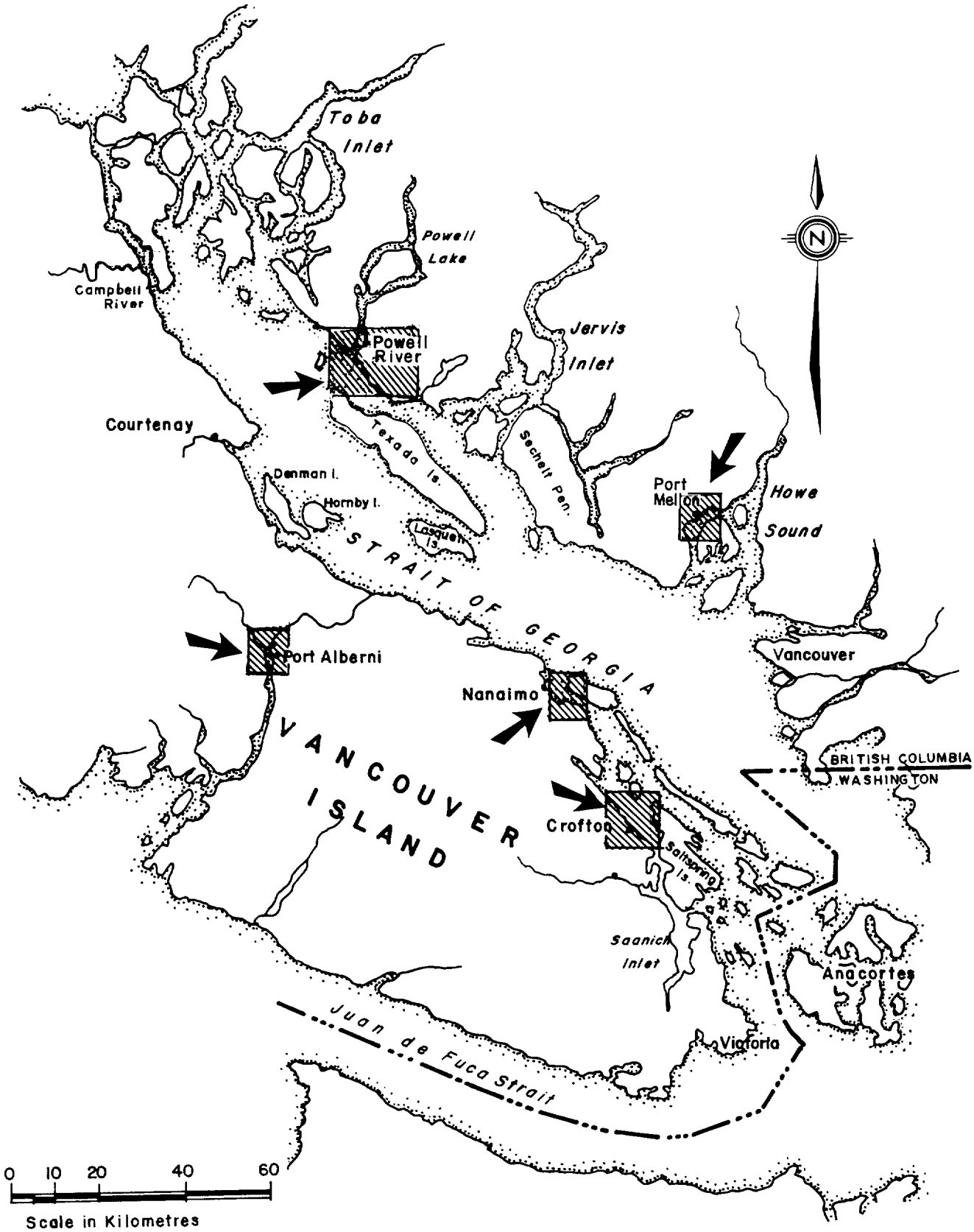

FIGURE 1 LOCATION MAP, 1980

Temperature values recorded were recalculated to temperature at depth using the equations:

$$T = T' + \Delta T$$

$$\Delta T = \left[\frac{(T' - t)(T' + Vo)}{K}\right]\left[1+\frac{(T' - t)(T' + Vo)}{K}\right] + I$$

where: T = corrected temperature

T' = observed temperature in the main thermometer

t = observed temperature in the auxiliary thermometer

Vo = inner space of main thermometer up to 0°C.

K = apparent coefficient of expansion of Hg.

I = thermometer calibration coefficient (Sverdrup et al, 1946)

Dissolved oxygen was measured using the azide modification of the Winkler method (DOE Laboratory Manual 1979).

Salinity was calculated from conductivity values measured on a Guildline Autosal (Model 8400).

Percent saturation of dissolved oxygen was calculated using the equation of Gameson and Robertson (1955):

$$C = \frac{475 - (2.65 \times S)}{33.5 + T}$$

$$\% \text{ Saturation} = \frac{A}{C} \times 100$$

where: C = saturation of oxygen in the sample water

S = salinity of the sample water

T = corrected temperture of the sample water

A = observed dissolved oxygen concentration in the sample

Colour values were determined by the platinum-colbalt tissue comparison method during the June survey. In November the more refined tristimulus method was employed. (DOE Laboratory Manual 1979).

2.2 Benthic Sampling.

2.2.1 Benthic Trawls. Benthic trawls were conducted at selected locations near Crofton. The trawling gear consisted of an otter trawl with 3.8 cm mesh body, 1.27 cm mesh cod end liner and 5.8 metre throat. The trawl was lowered to the bottom with a 3 to 1 scope (three times the amount of hydrographic wire as the depth at the trawl location) and towed on the bottom for an estimated 0.8 kilometer. After each tow, the contents of the trawl were washed, sorted, identified, counted, weighed and photographed.

2.2.2 Sediment Samples. A 0.1 m^2 Smith McIntyre Grab Sampler was used to collect bottom sediment at each grab station. Samples were removed and frozen in plastic bags prior to analysis for trace metals, total volatile residue and particle size. Benthic infauna were noted.

Bottom cores were obtained with a BENTHOS gravity corer. Intact cores were extruded and measured. Samples were removed from selected depths to plastic bags and frozen prior to analysis.

3. Crofton - Stuart Channel

3.1 Survey Rationale. Surveys were conducted in Stuart Channel to collect baseline information on the area prior to the possible expansion of the pulpmill and extension of the diffuser. Water quality has been periodically depressed especially in the vicinity of the diffuser

(Sullivan, 1981). Fibre deposition in the area of the diffuser has also been a concern. Stuart Channel supports a viable commercial shrimp and groundfish fishery (Knapp and Futer, 1978). The effect of existing effluent handling and the need for further environmental controls was investigated by examining the benthic communities in the area.

3.1.1 Effluent Data. Effluent data for 1980 supplied by the company for suspended solids and BOD_5 are presented below. Toxicity tests were conducted in April, October, November and December and passed at LC_{50} = 30% (v/v).

	Actual	Permitted
BOD_5	35.4 kg/ADT (31.9-38.1)	30.0 kg/ADT
SS	15.0 kg/ADT (8.6-23.8)	17.5 kg/ADT

3.2 Results and Discussion

3.2.1 Water Quality. In June, high surface (above 25 metres) temperatures from 10.0-13.34°C (Table 1) were recorded at all stations (Figure 2). Below 25 metres, temperatures were from 8.58-10.0°C. Salinity was uniform with depth at all stations, with slightly lower surface values.

High dissolved oxygen levels (8.8-13.3 mg/l) were recorded above 10 metres and there was no apparent depression of dissolved oxygen below this depth or near the diffuser.

In November, the temperature and salinity profiles were uniform with depth (Table 2). The dissolved oxygen condition was considerably different from the summer sampling period with all values in the surface layers lower. There appeared to be a band of low (2.6-4.6 mg/l) dissolved oxygen between 25-50 metres at all stations in Stuart Channel. Station 8, between Kuper and Saltspring Islands, does not show this decrease. It is therefore possible, because of poor mixing at this time of year, that

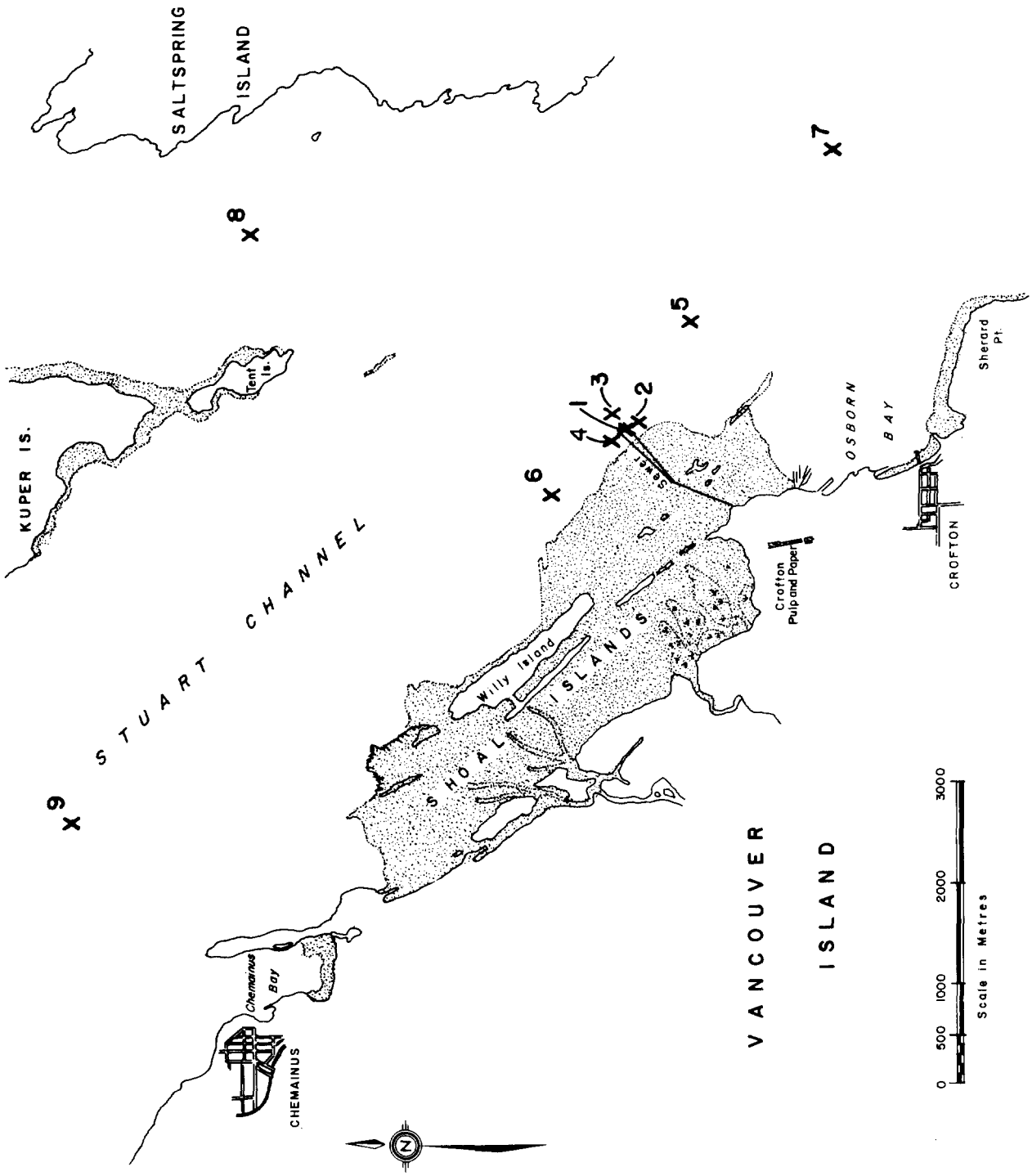

FIGURE 2 WATER QUALITY STATIONS - CROFTON, June and November, 1980

TABLE 1: WATER QUALITY RESULTS - STUART CHANNEL, JUNE 1980

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	13.08	26.44	11.30	129.99
	2.0	13.13	26.38	11.50	132.38
	5.0	12.27	26.61	12.30	139.18
	10.0	11.95	26.85	11.40	128.29
	25.0	10.34	28.77	8.40	92.35
	50.0	9.11	29.15	7.00	74.98
	90.0	8.59	29.32	6.10	64.63
2	0.0	13.03	26.44	12.20	140.19
	2.0	12.97	26.46	12.40	142.33
	5.0	12.67	26.38	12.50	142.48
	10.0	12.25	26.79	11.70	132.50
	25.0	11.97	28.85	8.20	93.55
	50.0	9.52	29.17	7.00	75.71
	90.0	8.92	29.30	6.10	65.12
3	0.0	12.78	26.44	13.00	148.57
	2.0	12.88	26.32	12.80	146.50
	5.0	12.37	26.38	12.50	141.53
	10.0	11.64	27.22	10.80	121.02
	25.0	10.36	28.66	8.50	93.42
	50.0	9.31	29.21	7.30	78.59
	100.0	8.60	29.87	5.90	62.74
	115.0	8.63	29.77	6.10	64.88
4	0.0	12.70	26.40	11.80	134.60
	2.0	12.73	26.49	11.60	132.47
	5.0	12.47	26.55	12.70	144.28
	10.0	11.44	27.45	9.80	109.48
	25.0	10.39	28.62	8.50	93.47
	50.0	9.21	29.15	6.90	74.09
	80.0	8.63	29.28	6.30	66.78

TABLE 1: WATER QUALITY RESULTS - STUART CHANNEL, JUNE 1980
(Continued)

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
5	0.0	13.07	26.44	13.10	150.66
	2.0	13.06	26.40	13.00	149.44
	5.0	12.75	26.42	12.40	141.61
	10.0	11.72	27.11	10.80	121.14
	25.0	10.00	28.86	8.10	88.41
	50.0	9.09	29.22	6.90	73.92
	100.0	8.58	29.34	6.00	63.56
	125.0	9.01	29.49	6.20	66.42
6	0.0	12.99	26.38	12.70	145.75
	2.0	13.09	26.40	12.60	144.94
	5.0	12.48	26.55	12.60	143.17
	10.0	10.73	28.24	8.80	97.27
	25.0	9.83	29.09	8.00	87.11
	50.0	9.00	29.15	6.90	73.73
	95.0	8.60	29.36	6.00	63.59
7	0.0	13.37	26.47	12.40	143.55
	2.0	13.31	26.38	12.60	145.60
	5.0	12.85	26.53	13.00	148.89
	10.0	12.02	26.87	12.10	136.41
	25.0	10.46	28.64	8.70	95.82
	50.0	9.39	29.39	7.50	81.00
	100.0	8.58	29.34	5.80	61.44
	190.0	9.32	29.70	6.60	71.31
8	0.0	13.29	26.36	12.50	144.36
	2.0	13.18	26.53	12.60	145.35
	5.0	12.57	26.72	12.60	145.35
	10.0	11.44	27.21	10.40	116.00
	25.0	10.24	28.62	8.40	92.05
	30.0	9.97	28.86	7.90	86.18

TABLE 1: WATER QUALITY RESULTS - STUART CHANNEL, JUNE 1980
(Continued)

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
9	0.0	13.24	26.29	13.30	153.35
	2.0	12.97	26.31	13.00	149.06
	5.0	12.48	26.68	12.80	145.57
	10.0	11.27	27.62	10.10	112.53
	25.0	10.26	28.77	8.60	94.38
	50.0	8.99	29.09	6.90	73.69
	90.0	8.60	29.34	5.80	61.46

TABLE 2: WATER QUALITY RESULTS - STUART CHANNEL, NOVEMBER 1980

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	10.05	28.00	7.10	77.15
	2.0	10.58	29.00	5.70	63.10
	5.0	10.49	30.00	5.90	65.62
	10.0	10.51	30.00	5.50	61.20
	25.0	10.67	30.00	3.80	42.44
	50.0	10.37	31.00	4.60	51.37
2	0.0	10.97	30.00	4.80	53.97
	2.0	10.68	30.00	5.30	59.21
	5.0	10.80	31.00	5.20	58.63
	10.0	10.47	31.00	5.70	63.79
	25.0	10.79	29.00	3.30	36.71
	50.0	10.38	31.00	4.40	49.14
3	0.0	10.17	28.00	7.40	80.62
	2.0	10.40	28.00	6.60	72.79
	5.0	10.47	29.00	6.10	67.37
	10.0	10.47	29.00	5.60	61.84
	25.0	10.58	30.00	4.20	46.81
	50.0	10.48	30.00	4.60	51.15
	90.0	10.15	30.00	5.10	56.28
4	0.0	10.00	27.00	7.40	79.80
	2.0	10.36	28.00	5.70	62.37
	5.0	10.58	28.00	6.30	69.28
	10.0	10.54	30.00	5.60	62.36
	25.0	10.64	29.00	3.90	43.24
	50.0	10.39	30.00	4.30	47.72
	75.0	10.21	30.00	5.00	55.26

TABLE 2: WATER QUALITY RESULTS - STUART CHANNEL, NOVEMBER 1980
(Continued)

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
5	0.0	10.26	28.00	7.80	85.17
	2.0	10.26	28.00	6.50	70.96
	5.0	10.42	29.00	6.90	76.12
	10.0	10.55	29.00	5.50	60.85
	25.0	10.63	29.00	3.90	43.23
	50.0	10.38	30.00	4.70	52.14
	100.0	10.15	30.00	5.10	56.28
6	0.0	10.06	28.00	7.00	76.08
	2.0	10.37	28.00	6.80	74.43
	5.0	10.59	28.00	5.80	63.80
	10.0	10.67	30.00	4.80	53.60
	25.0	10.68	30.00	3.40	37.98
	50.0	10.33	30.00	4.40	48.76
	80.0	10.15	30.00	5.00	55.18
7	0.0	9.97	28.00	7.00	75.92
	2.0	10.08	27.00	6.90	74.54
	5.0	10.41	28.00	6.20	67.92
	10.0	10.79	28.00	4.60	50.83
	25.0	10.80	29.00	3.20	35.60
	50.0	10.34	29.00	4.70	51.75
	100.0	10.16	29.00	5.10	55.92
8	0.0	10.33	27.00	7.00	76.04
	2.0	10.59	28.00	5.20	57.20
	5.0	10.60	29.00	5.00	55.38
	10.0	10.26	29.00	5.70	62.65
	25.0	10.32	30.00	5.30	58.73
	35.0	10.23	28.00	5.20	56.73

TABLE 2: WATER QUALITY RESULTS - STUART CHANNEL, NOVEMBER 1980
(Continued)

STATION (Crofton)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
9	0.0	10.33	26.00	4.10	44.25
	2.0	10.18	27.00	4.10	44.39
	5.0	10.30	28.00	4.10	44.81
	10.0	10.40	28.00	6.40	70.10
	25.0	10.75	30.00	2.60	29.09
	50.0	10.39	30.00	4.30	47.72
	85.0	10.19	30.00	3.20	35.35

the effluent is being held to these depths and its biochemical oxygen demand (BOD) is reducing dissolved oxygen. The same phenomenon was recorded at Crofton during November 1979 (Sullivan, 1981), but not at several other pulp mill sites.

3.2.2 Benthic. Trawls were conducted at 3 stations in Stuart Channel (Figure 3) in June (Appendix I). The trawl catches were similar to those in 1979. Since no heavy metal contamination was apparent in 1979 in species sampled, additional samples were not analysed in 1980.

Pandalopsis dispar (side stripe shrimp) and Brisaster sp. were common at Station CR-1 in both trawls.

Brisaster sp. dominated the trawl catch at Station CR-2. This was also apparent in 1979. Although the trawl catch in Osborn Bay, Station CR-3, was small it contained several fish species and few shrimp.

4. Harmac - Northumberland Channel

4.1 Survey Rationale. Water quality parameters were measured in Northumberland Channel to evaluate the effect of the diffuser system installed in 1976. Sediment chemistry samples were collected to determine the extent, if any, of fibre build-up near the diffuser and the degree of trace metal contamination. Because high mercury levels were detected in Northumberland Channel in 1979, further sampling was undertaken in 1980. (Sullivan, 1981)

4.1.1 Effluent Data. Effluent data for 1980 supplied by the company for suspended solids and BOD_5 are presented below. Toxicity tested in April, October, November and December passed at an LC_{50} =30%(^{v}/v).

	Actual	Permitted
BOD_5	22.4 kg/ADT (18.1-25.2)	27,000 kg/day
SS	14.1 kg/ADT (10.0-18.2)	12,000 kg/day

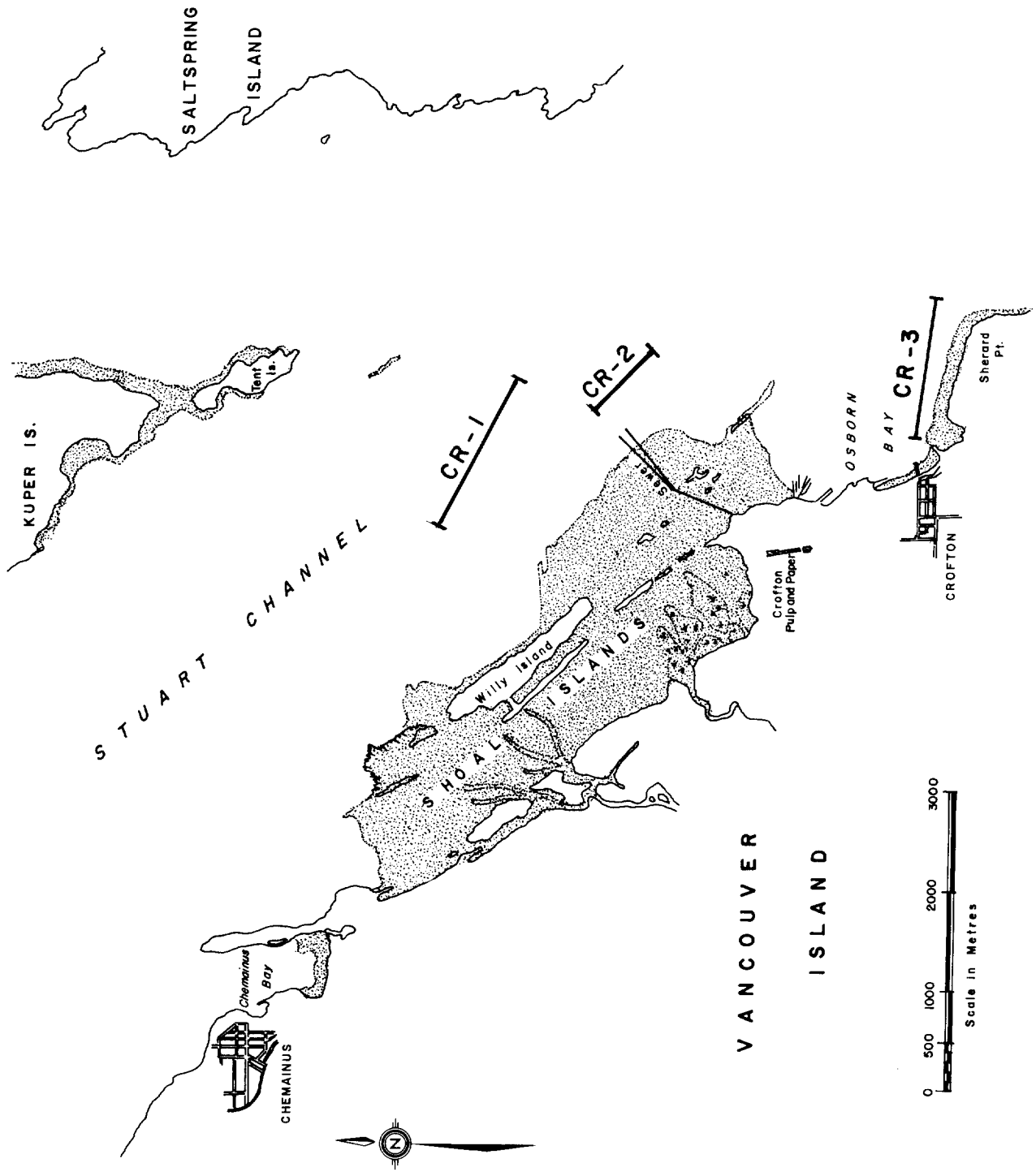

FIGURE 3 TRAWL LOCATIONS - CROFTON - June 1980

4.2 Results and Discussion

4.2.1 Water Quality. Water quality data were not collected during June 1980. In November, temperature and salinity profiles were very uniform with depth (0-100 metres: 9.08 to 9.89°C and 26.0 to 29.0 °/oo respectively) (Figure 4, Table 3). There was no appreciable depression in the dissolved oxygen profiles, even near the diffuser, with values of 4.70 to 8.60 mg/l from 0-100 metres. According to Waldichuk (1965), Northumberland Channel is a well flushed system. The results of the water quality survey suggest the effluent as being effectively dispersed and diluted.

4.2.2 Benthic. Because during July 1979 unexpected, elevated mercury levels were recorded in Northumberland Channel, stations were resampled in 1980 (Figure 4). Mercury levels in 1980 were low at all stations (Table 4) suggesting that the July 1979 data were erroneous. Zinc, copper and lead concentrations were not considered to be unnaturally high at any station locations; however, cadmium concentrations were considered to be elevated over background levels. There did not appear to be any trend of higher trace metal concentrations in relation to the diffuser.

5. Powell River - Malaspina Strait

5.1 Survey Rationale. Surveys were conducted in Malaspina Strait to monitor the effects of the diffuser installed in 1980 on the receiving environment. Preliminary studies in 1979 were designed to collect baseline information on benthic community structure (Young, 1979), trace metal contamination in sediments and tissue, fibre accumulation and water quality (EPS, 1981). Water quality measurements were recorded with particular attention to dissolved oxygen and colour. Since trace metal contamination was previously recorded in marine sediments,

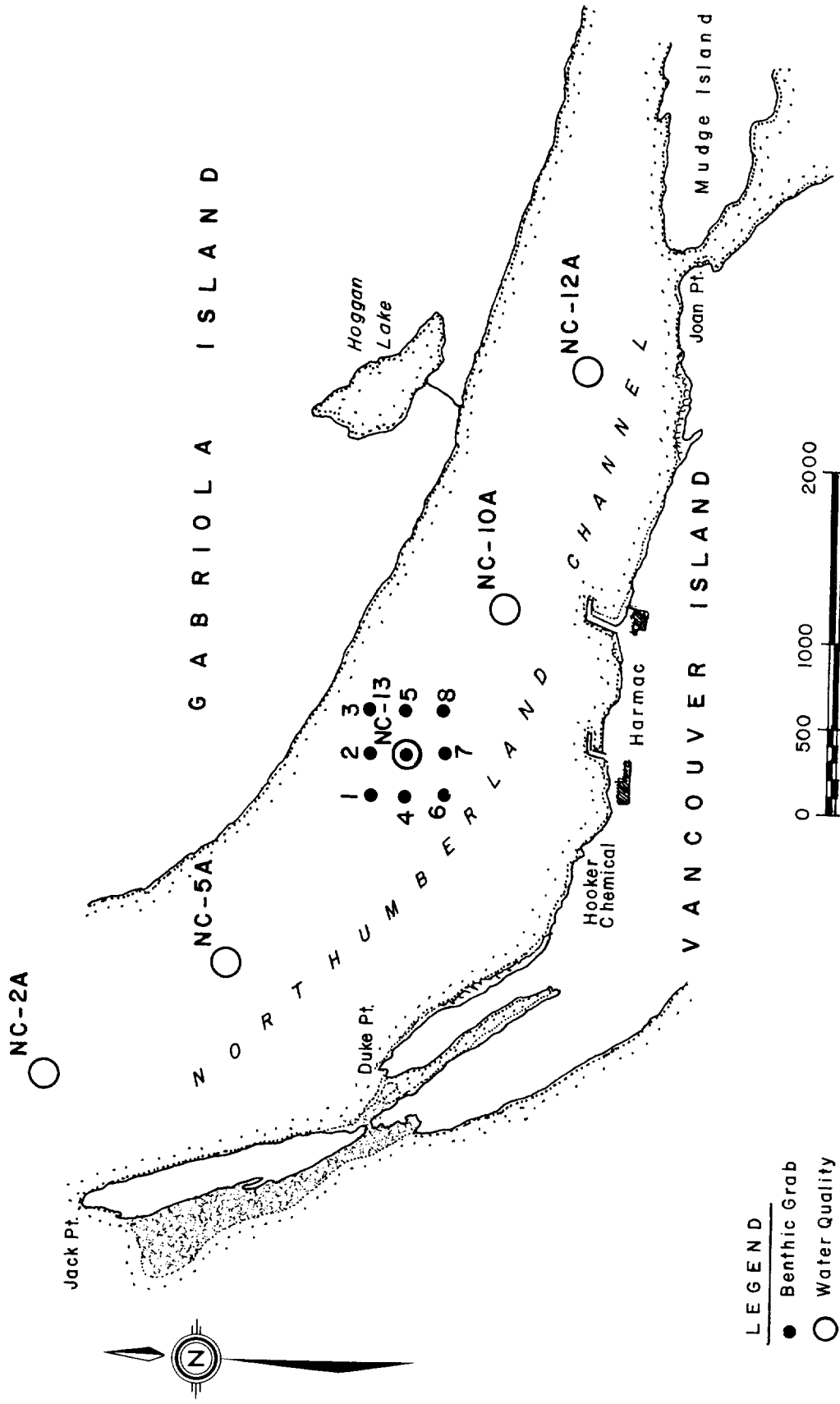

FIGURE 4 WATER QUALITY AND BENTHIC GRAB STATIONS - NORTHUMBERLAND CHANNEL - November, 1980

TABLE 3: WATER QUALITY RESULTS - NORTHUMBERLAND CHANNEL, NOVEMBER 1980

STATION (NC)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
2A	0.0	9.68	26.00	8.20	87.18
	2.0	9.89	27.00	7.50	80.66
	5.0	9.80	27.00	6.90	74.05
	10.0	9.77	28.00	6.30	68.02
	25.0	9.78	28.00	6.20	66.95
	50.0	9.49	29.00	5.40	58.30
	100.0	9.47	29.00	5.90	63.67
5A	0.0	9.56	26.00	7.50	79.53
	2.0	9.87	26.00	8.60	91.85
	5.0	9.83	27.00	6.80	73.03
	10.0	9.85	28.00	6.10	65.98
	25.0	9.88	26.00	6.30	67.29
	50.0	9.60	27.00	5.60	59.82
	100.0	9.47	29.00	4.70	50.73
13	0.0	9.80	26.00	7.50	79.96
	2.0	9.81	27.00	7.30	78.36
	5.0	9.80	27.00	7.00	75.13
	10.0	9.88	28.00	6.20	67.10
	25.0	9.80	27.00	5.70	61.17
	50.0	9.63	29.00	5.20	56.33
10A	0.0	9.72	26.00	8.10	86.21
	2.0	9.83	26.00	7.80	83.23
	5.0	9.81	29.00	7.20	78.31
	10.0	9.84	29.00	6.60	71.84
	25.0	9.80	28.00	5.80	62.67

TABLE 3: WATER QUALITY RESULTS - NORTHUMBERLAND CHANNEL, NOVEMBER 1980 (Continued)

STATION (NC)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
12A	0.0	9.08	26.00	8.60	90.17
	2.0	9.50	26.00	8.00	84.71
	5.0	9.82	28.00	7.30	78.90
	10.0	9.79	28.00	6.50	70.20
	25.0	9.80	27.00	5.70	61.17
	50.0	9.59	27.00	5.00	53.41

TABLE 4: TRACE METAL ANALYSIS IN SEDIMENTS
NORTHUMBERLAND CHANNEL, 1980
GRAB AND CORE SAMPLES (mg/kg)

STATION	Hg	Cd	Zn	Cu	Pb
June 1980					
C - 1	> 0.135	0.88	96.5	74.0	69.0
C - 2	> 0.133	1.15	95.5	62.0	64.0
C - 3	> 0.124	1.20	95.5	64.5	65.0
C - 4	> 0.133	0.83	93.0	62.0	68.5
NC-13	> 0.116	0.95	103.0	66.5	70.5
C - 5	> 0.125	1.27	108.0	67.0	71.5
C - 6	> 0.125	0.89	102.0	74.0	75.5
C - 7	> 0.133	0.67	98.0	70.5	69.0
C - 8	> 0.130	1.34	106.0	68.5	69.5
November 1980					
C - 1 (0 -10)	0.178	0.73	99.0	67.5	75.0
(10-20)	0.155	0.67	92.0	59.0	70.5
C - 2 (0 -10)	> 0.132	> 0.56	82.5	53.0	69.0
(10-20)	> 0.095	> 0.56	56.0	35.4	53.0
C - 3 (0 -10)	> 0.127	0.58	76.0	53.5	63.0
(10-20)	> 0.100	0.62	54.0	34.2	54.5
C - 4 (0 -10)	0.126	0.83	78.0	61.5	72.5
(10-20)	> 0.097	0.98	56.5	41.2	63.0
NC-13 (0 -10)	0.151	0.84	81.0	64.0	77.5
(10-20)	> 0.096	0.76	49.7	27.2	46.0
C - 5 (0 -10)	> 0.096	> 0.56	64.5	38.9	55.0
(10-20)	> 0.096	> 0.55	55.5	38.0	52.5
C - 6 (0 -10)	0.157	0.79	81.0	55.5	64.5
(10-20)	> 0.097	0.60	62.0	39.3	57.5
C - 7 (0 -10)	0.164	0.87	79.0	51.5	63.0
(10-20)	> 0.099	1.00	58.5	32.0	49.7
C - 8 (0 -10)	> 0.099	0.73	75.5	43.6	57.0
(10-20)	> 0.089	0.59	52.0	27.6	48.7

particularily adjacent to the booming ground, these locations were resampled in 1980 to monitor the spread, if any, of trace metals.

5.1.1 Effluent Data. Effluent data for 1980 supplied by the company for suspended solids and BOD_5 is presented below. Toxicity tests were conducted in December only and passed at an LC_{50} = 30% (v/v).

	Actual	Permitted
BOD_5	20.2 kg/ADT (15.5-27.4)	44,690 kg/day
SS	19.0 kg/ADT (10.6-27.3)	30,340 kg/day

Suspended solids levels in 1980 were relatively high by federal standards (13.9 kg/ADT). The concern of wider fibre deposition in Malaspina Strait because of the action of the diffuser could be lessened if the suspened solids were reduced in the effluent.

5.2 Results and Discussion

5.2.1 Water Quality. In June 1980, the thermocline was recorded between 10-25 metres (Figure 5, Table 5). Average temperatures above 10 metres were 12°C and below were between 8-9°C. Surface salinities, above 10 metres, were measured from 20-25 °/oo and below this depth were more stable, being from 29-30 °/oo. The dissolved oxygen profiles indicate no apparent impact from effluent discharge. D.O. values were recorded in a range from 9.6 to 11.0 mg/l above 10 metres and below this depth were always above 5.0 mg/l.

The November 1980 profiles were typical of winter water quality (Table 6). A slight negative temperature gradient was evident at the surface (above 10 metres) and the water column became progressively more saline with depth. Dissolved oxygen values above 50 metres were from 7.7 to 9.2 mg/l; however, below this depth D.O. levels at all stations were below 5 mg/l.

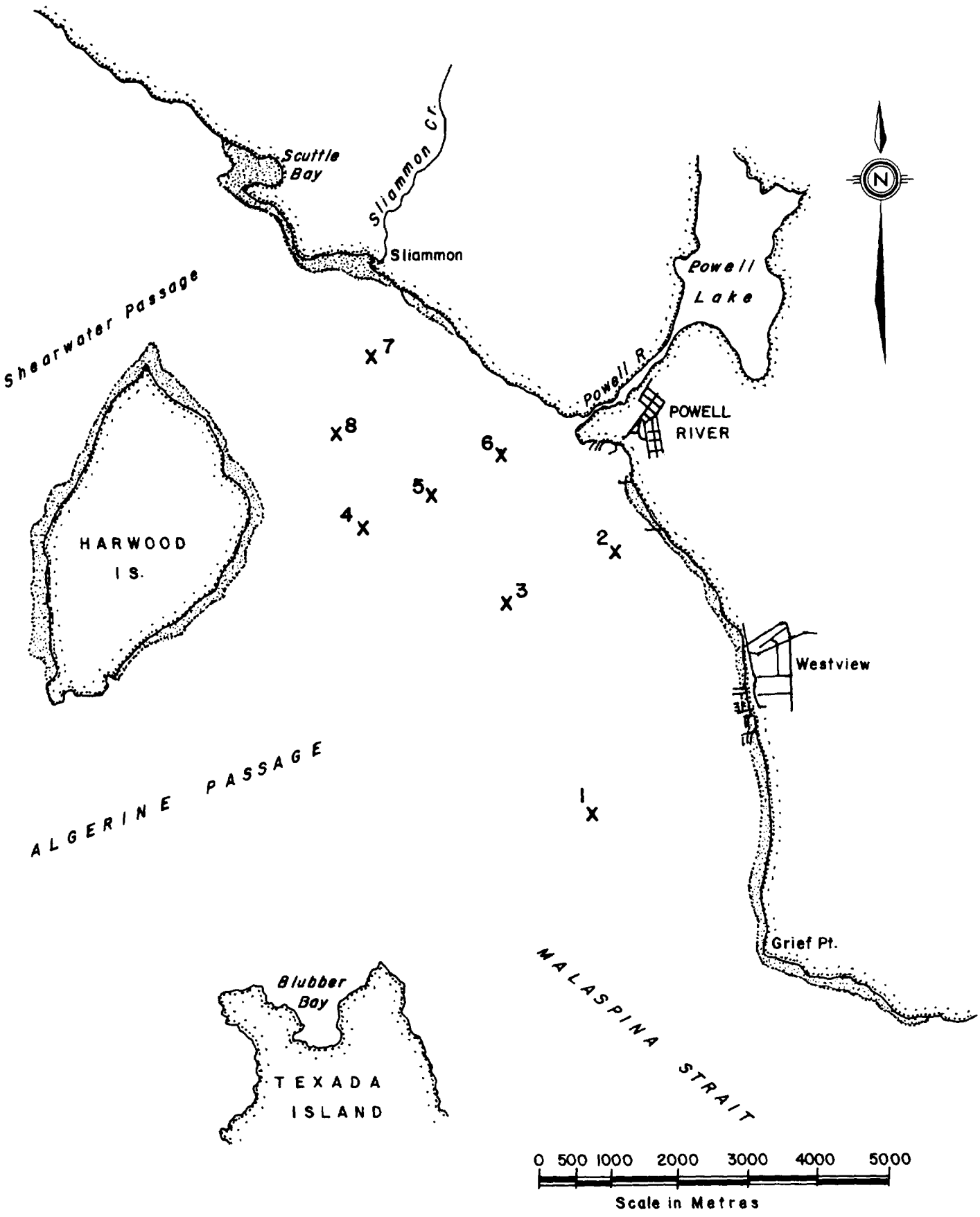

FIGURE 5 WATER QUALITY STATIONS - POWELL RIVER
June and November, 1980

TABLE 5: WATER QUALITY RESULTS - POWELL RIVER, B.C., JUNE 1980

STATION (PR)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	12.62	23.83	10.70	119.83
	2.0	12.56	23.85	10.90	121.92
	5.0	12.56	23.96	10.60	118.65
	10.0	12.13	25.91	9.60	107.82
	25.0	10.31	28.47	7.90	86.63
	50.0	8.38	29.53	6.20	65.45
	100.0	8.08	29.93	6.20	65.15
2	0.0	12.52	22.29	10.80	119.49
	2.0	12.56	23.30	10.40	115.91
	5.0	12.55	23.63	10.30	115.03
	10.0	12.54	24.13	10.20	114.24
	25.0	9.24	29.19	6.80	73.09
	50.0	9.05	29.72	6.30	67.64
3	0.0	12.61	---	10.70	---
	2.0	12.55	23.93	10.60	118.60
	5.0	12.55	24.13	10.30	115.40
	10.0	12.24	25.84	9.60	108.00
	25.0	9.15	29.09	6.70	71.82
	50.0	8.28	29.62	6.20	65.33
	100.0	8.18	29.97	6.40	67.42
	160.0	8.52	30.23	5.40	57.46
4	0.0	12.63	23.48	10.50	117.34
	2.0	12.62	23.61	10.40	116.30
	5.0	12.52	24.48	10.50	117.82
	10.0	12.41	25.29	10.20	114.77
	25.0	9.27	25.24	6.90	72.31
	50.0	8.36	29.64	6.20	65.47
	100.0	8.17	29.98	6.20	65.31
	155.0	8.51	30.21	5.40	57.44

TABLE 5: WATER QUALITY RESULTS - POWELL RIVER, B.C., JUNE 1980
(Continued)

STATION (PR)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
5	0.0	12.73	20.70	11.00	121.04
	2.0	12.62	23.58	10.70	119.62
	5.0	12.63	23.95	10.60	118.81
	10.0	12.36	25.41	9.80	110.25
	25.0	8.82	29.30	6.20	66.03
	50.0	8.26	29.68	6.20	65.33
	100.0	8.05	29.78	6.30	66.09
	115.0	8.09	29.98	6.20	65.19
6	0.0	12.55	22.00	10.60	117.13
	2.0	12.53	23.32	10.70	119.21
	5.0	12.54	24.19	10.40	116.52
	10.0	12.26	25.84	9.90	111.44
	25.0	8.81	29.45	6.50	69.29
	50.0	8.26	29.83	6.10	64.34
	65.0	8.05	29.87	6.30	66.13
7	0.0	12.65	22.11	10.50	116.37
	2.0	12.53	23.54	10.40	116.03
	5.0	12.53	24.11	10.00	111.98
	10.0	12.42	25.04	10.00	112.37
	25.0	8.97	29.43	6.60	70.61
	50.0	8.37	29.87	6.10	64.53
8	0.0	12.22	21.19	10.70	116.81
	2.0	12.51	24.37	10.30	115.47
	5.0	12.51	24.52	10.30	115.58
	10.0	12.40	24.93	9.80	109.99
	25.0	9.16	29.00	6.80	72.87
	50.0	8.26	29.76	6.30	66.42
	100.0	8.06	29.98	6.30	66.20
	130.0	8.31	30.12	5.70	60.30

TABLE 6: WATER QUALITY RESULTS - POWELL RIVER, B.C., NOVEMBER 1980

STATION (PR)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	9.76	28.00	9.20	99.29
	2.0	9.39	24.00	9.20	95.92
	5.0	9.57	26.00	8.80	93.33
	10.0	9.91	27.00	8.50	91.46
	25.0	10.15	28.00	8.10	88.21
	50.0	9.14	30.00	4.60	49.60
	100.0	9.05	30.00	4.40	47.32
	180.0	8.85	28.00	4.10	43.32
2	0.0	9.31	24.00	8.90	92.61
	2.0	9.57	24.00	8.70	91.09
	5.0	10.00	26.00	8.80	94.25
	10.0	9.56	28.00	8.70	93.47
	25.0	10.08	28.00	8.00	86.98
	50.0	9.26	30.00	4.50	48.65
	68.0	9.25	---	4.50	---
3	0.0	9.30	28.00	8.80	93.97
	2.0	9.58	26.00	9.10	96.55
	5.0	9.90	26.00	9.00	96.19
	10.0	9.97	26.00	8.80	94.20
	25.0	10.07	28.00	7.70	83.71
	50.0	9.25	30.00	4.60	49.72
	100.0	8.95	30.00	4.70	50.45
	160.0	8.79	30.00	4.20	44.90
4	0.0	9.63	24.00	9.20	96.45
	2.0	9.76	24.00	8.90	93.58
	5.0	9.88	26.00	8.70	92.93
	10.0	9.95	26.00	8.60	92.02
	25.0	10.14	26.00	8.20	88.11
	50.0	9.12	30.00	4.80	51.72
	100.0	9.01	30.00	4.50	48.37
	160.0	8.83	28.00	4.10	43.38

TABLE 6: WATER QUALITY RESULTS - POWELL RIVER, B.C., NOVEMBER 1980
(Continued)

STATION (PR)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
5	0.0	9.74	24.00	9.10	95.65
	2.0	9.68	24.00	9.10	95.50
	5.0	9.99	26.00	8.60	92.11
	10.0	10.01	26.00	8.60	92.15
	25.0	10.08	28.00	8.20	89.15
	50.0	9.12	30.00	4.60	49.57
	100.0	8.91	30.00	4.40	47.18
	130.0	8.82	30.00	4.20	44.95
6	0.0	9.94	24.00	9.00	95.04
	2.0	9.87	24.00	8.90	93.83
	5.0	9.98	24.00	8.80	93.01
	10.0	10.06	26.00	8.30	89.03
	25.0	10.08	26.00	8.20	87.99
	60.0	9.26	30.00	4.40	47.57
7	0.0	9.66	20.00	9.10	93.08
	2.0	9.77	24.00	9.10	95.72
	5.0	9.89	26.00	8.80	94.02
	10.0	9.77	26.00	8.60	91.62
	25.0	10.08	27.00	7.70	83.17
	40.0	10.28	30.00	4.70	52.03
8	0.0	9.52	24.00	9.20	96.21
	2.0	9.54	24.00	9.10	95.21
	5.0	9.89	24.00	8.70	91.75
	10.0	9.78	26.00	8.60	91.65
	25.0	10.23	26.00	8.30	89.37
	50.0	9.11	28.00	4.80	51.03
	100.0	9.00	30.00	4.30	46.20
	120.0	8.78	30.00	4.30	45.97

Colour analysis results from both June and November surveys are presented in Table 7. Overall, colour values are low. A reduction in colour is noted from June to November surveys, particlarly at 0 and 2 metres. This may be a function of the diffuser installation, a seasonal variation or a combination of both.

5.2.2 Benthic

5.2.2.1 Trace Metal Analysis

Sediment stations sampled in June 1980 are shown in Figure 6 and those of November 1980 in Figure 7.

Mercury levels were not considered to be elevated at stations sampled in June and November (Table 8). Previous testing (1979) had shown some areas adjacent to the pulpmill and the floating breakwater to contain levels well above the limits permitted for ocean disposal under the Ocean Dumping Control Act. Values in 1980 were recorded from >0.182. to 0.999 mg/kg.

The ODCA specifies 0.6 mg/kg cadmium as an upper limit for allowing ocean disposal. Values recorded during both 1980 surveys were exceptionally high, from 2.92 to 10.5 mg/kg. The results of the 1979 survey also showed consistently high cadmium levels at most of the stations sampled.

In June, levels of zinc, copper and lead at the stations sampled were not elevated. In November, however, at stations H, I and K, zinc levels were recorded at 467.0, 630.0 and 720.0 mg/kg respectively. Copper was measured at 1460.0 mg/kg at Station I. Reasons for the disparity are not evident.

Tests for polychlorinated biphenyls (PCB) at Stations H, I, J, K, L and N in November were negative (>0.005 ug/g). Analysis of total volatile residue showed sediments to be uniformly high in organic matter, consistent with field observations of black, sulfurous smelling sediments characteristic of reducing conditions (Table 9).

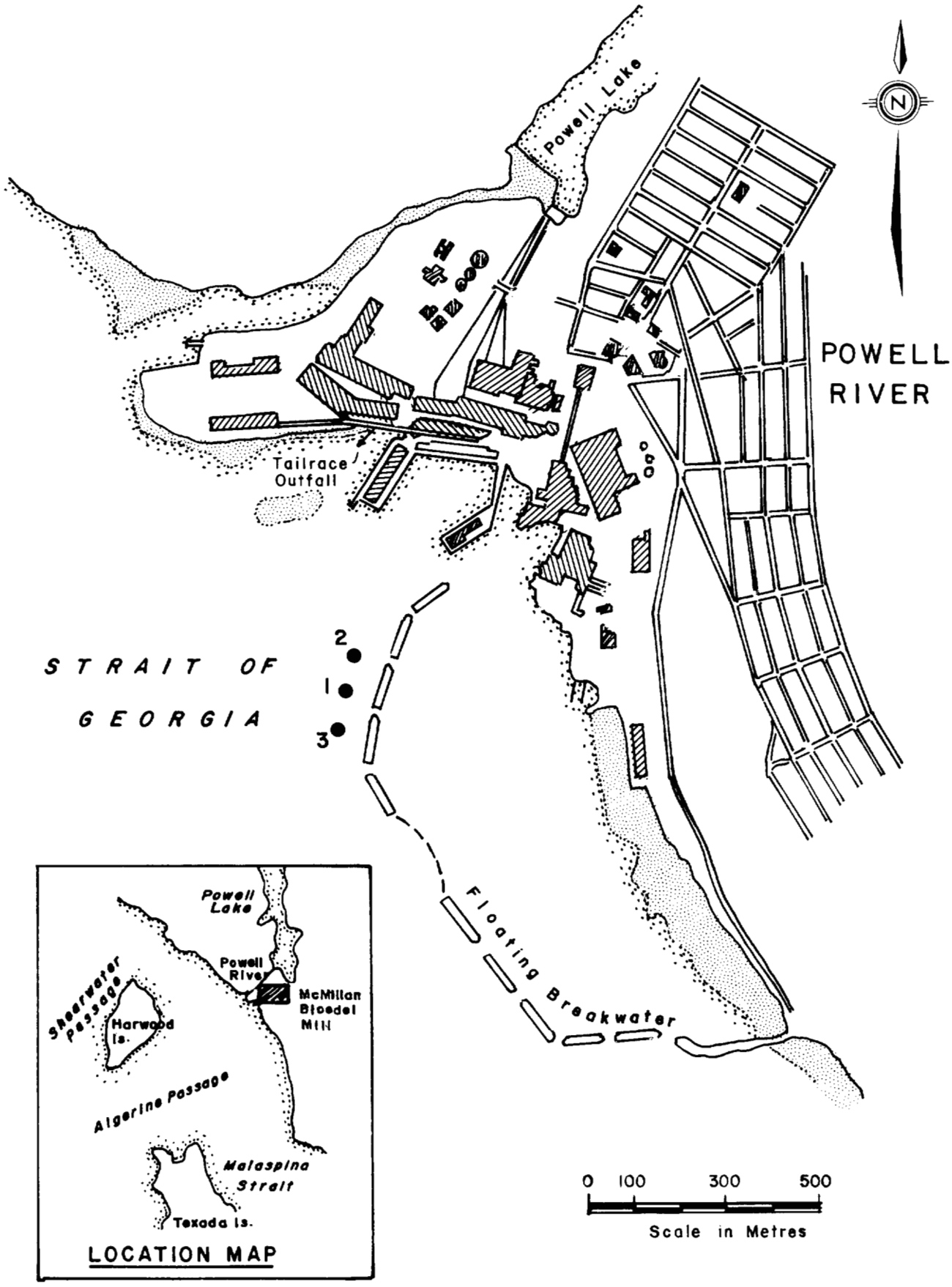

FIGURE 6 BENTHIC CORE AND/OR GRAB STATIONS - POWELL RIVER - June, 1980

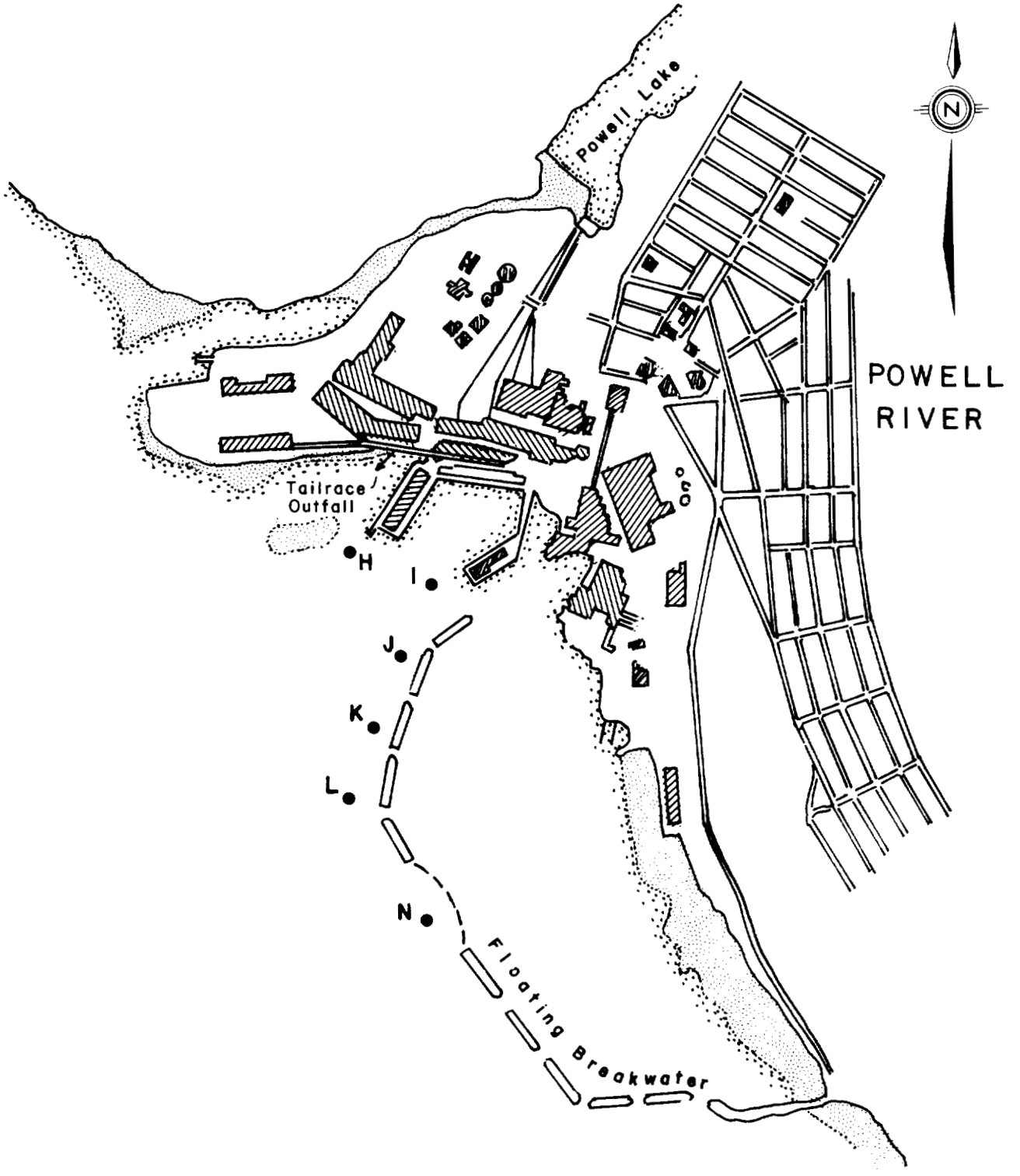

FIGURE 7 NEARSHORE BENTHIC GRAB STATIONS - POWELL RIVER - November 1980

TABLE 7: COLOUR ANALYSIS, POWELL RIVER, B.C., 1980
(Colour units)

DEPTH (m)	0	2	5	10
STATION				
June 1980				
PR-1	6	6	0	3
PR-2	7	5	5	4
PR-3	0	4	5	4
PR-4	4	4	0	7
PR-5	7	5	0	6
PR-6	5	6	4	4
PR-7	12	0	5	6
PR-8	6	3	0	4
November 1980				
PR-1	3	2	1	2
PR-2	2	3	2	2
PR-3	3	2	2	1
PR-4	3	2	1	1
PR-5	4	2	2	2
PR-6	5	4	1	0
PR-7	0	0	1	1
PR-8	2	2	1	26*

*rogue number

TABLE 8: TRACE METAL ANALYSIS IN SEDIMENTS
POWELL RIVER, 1980
(mg/kg)

STATION	Hg	Cd	Zn	Cu	Pb
June 1980					
PR-1 (0 - 8 cm)	0.702	4.36	383.0	87.5	60.5
PR-1 (25-22 cm)	0.277	2.92	285.0	105.0	51.0
PR-2 (grab)	> 0.196	7.46	356.0	134.0	55.0
PR-3 (0 - 8 cm)	> 0.182	5.77	386.0	92.0	63.5
PR-3 (40-45 cm)	> 0.196	6.87	306.0	109.0	71.0
November 1980					
STN. H	0.999	10.5	467.0	154.0	131.0
STN. I	0.457	7.4	630.0	1460.0	131.0
STN. J	0.598	5.4	312.0	158.0	71.0
STN. K	0.223	8.6	720.0	191.0	74.9
STN. L	0.248	6.1	391.0	260.0	70.0
STN. N	0.262	5.8	344.0	83.5	48.9

TABLE 9: TOTAL VOLATILE RESIDUES AND PARTICLE SIZE OF SEDIMENTS, PORT RIVER, B. C., NOVEMBER, 1980

STATION	TVR (mg/g)	35 MESH		60 MESH		230 MESH		> 230 MESH	
		weight retained	percent retained	weight retained	percent retained	weight retained	percent retained	weight retained	percent retained
STN. H	620	0.3	6.5	0.9	19.6	2.2	47.8	1.2	26.1
STN. I	600	1.0	23.8	1.6	38.1	1.4	33.3	0.2	4.8
STN. J	650	0.2	9.5	0.7	33.3	1.1	52.4	0.1	4.8
STN. K	690	0.7	18.9	1.5	40.5	1.3	35.1	0.2	5.4
STN. L	690	1.0	31.2	1.1	34.4	1.0	31.3	0.1	3.1
STN. N	610	1.3	50.0	0.7	26.9	0.4	15.4	0.2	7.7

6. Port Alberni - Alberni Inlet

6.1 Survey Rationale. The first of a series of surveys was conducted in Alberni Inlet in June 1980 to examine the benthic and water quality condition in the inner harbour. The most prominent environmental concern has been the poor dissolved oxygen condition in the harbour, particularily below the halocline. A contributing factor to low D.O. below the halocline is the high BOD created by the build-up of wood debris, fibre and wood chips on the benthic environment. A second important feature is the high colour in the effluent. The light necessary for photosynthesis below the halocline is blocked by colour in the surface layers and oxygen generation is therefore low (Parker and Sibert, 1972).

6.1.1 Effluent Data. Effluent data for 1980 supplied by the company for suspended solids and BOD_5 is presented below. Toxicity tests (8) were passed 63% of the time at an LC_{50} = 90% ($^v/v$)

	Actual	Permitted
BOD_5	9.3 kg/ADt (6.3-14.8 kg/ADT)	17.5 kg/ADT
SS	15.9 kg/ADt (9.0-53.2 kg/ADT)	10.0 kg/ADT (yearly average)

The biological treatment facility was scheduled for maintenance dredging to improve its efficiency and allow reduction of BOD_5 before discharge. The level of suspended solid greatly increased in December 1980 (53.2 kg/ADT). Further studies will evaluate the effectiveness of this measure.

6.2 Results and Discussion

6.2.1 Water Quality (Tables 10 & 11). Both temperature and salinity profiles show a strong stratification between 2 and 5 metres.

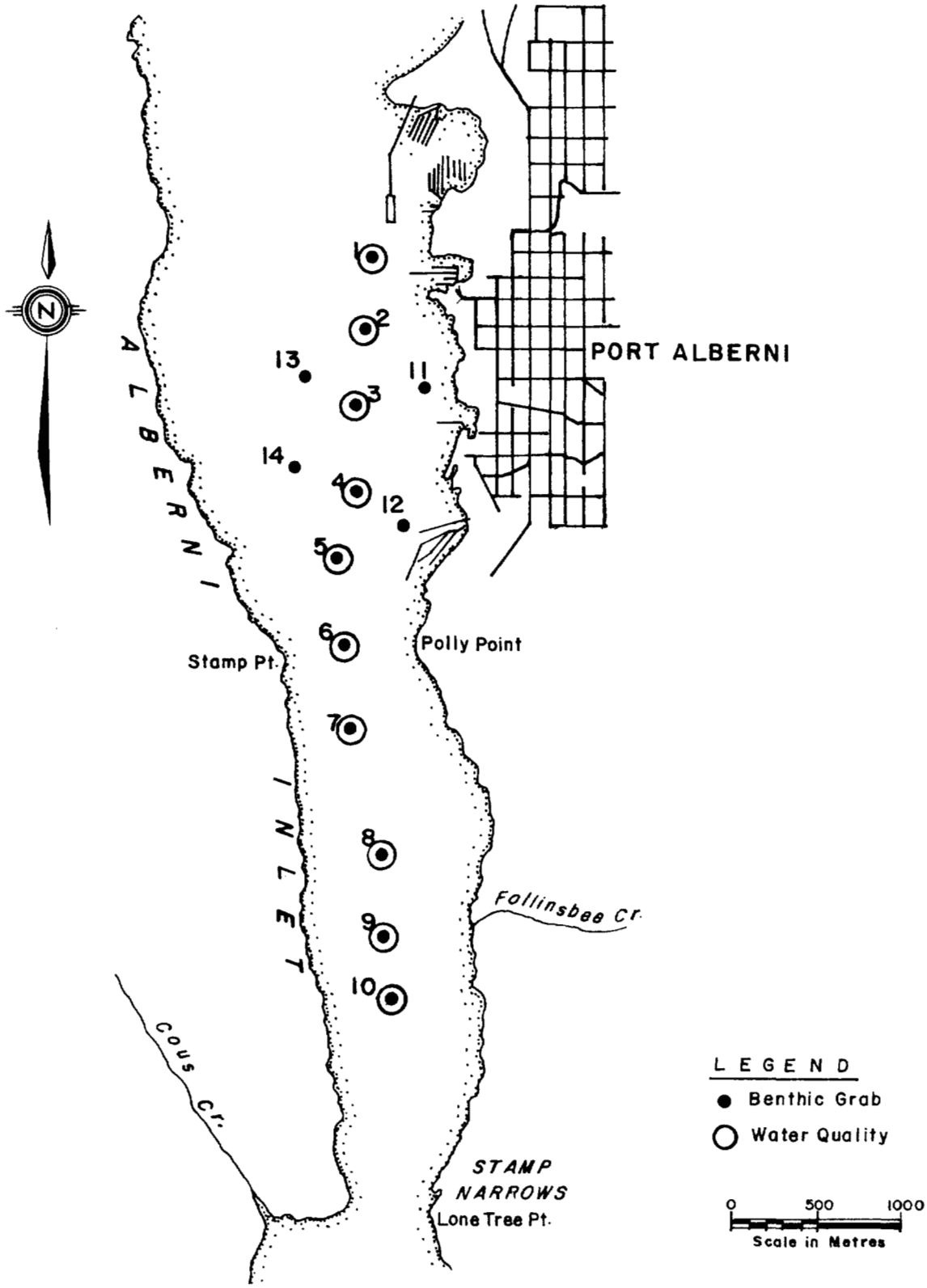

FIGURE 8 WATER QUALITY AND BENTHIC GRAB STATIONS - ALBERNI INLET - June, 1980

TABLE 10: WATER QUALITY RESULTS - ALBERNI INLET, JUNE 1980

STATION	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	13.52	1.20	9.20	91.68
	2.0	13.61	1.36	8.00	79.96
	5.0	11.57	20.07	3.50	37.39
	10.0	9.82	30.30	1.30	14.32
2	0.0	13.96	2.64	8.50	86.19
	2.0	14.64	7.05	7.30	77.01
	5.0	10.24	28.62	2.20	24.11
	10.0	9.73	31.00	0.70	7.70
3	0.0	14.56	3.99	7.60	78.65
	2.0	14.40	4.18	7.60	78.46
	5.0	10.45	24.17	3.00	32.89
	10.0	9.73	31.15	0.80	8.81
	15.0	9.75	31.00	0.60	6.60
4	0.0	14.54	3.97	7.80	80.67
	2.0	14.91	8.90	7.30	78.29
	5.0	10.21	29.19	2.70	29.68
	10.0	9.73	31.28	0.50	5.51
	18.0	9.62	31.63	2.00	22.84
5	0.0	14.49	3.76	8.10	83.59
	2.0	14.72	5.94	7.60	79.79
	5.0	10.96	27.06	2.20	24.25
	10.0	9.73	31.19	0.40	4.41
	20.0	9.54	31.65	2.50	27.51

TABLE 10: WATER QUALITY RESULTS - ALBERNI INLET, JUNE 1980
(Continued)

STATION	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
6	0.0	14.43	3.71	8.60	88.62
	2.0	14.60	6.79	7.50	78.94
	5.0	14.28	19.04	1.60	18.01
	10.0	9.75	31.21	1.50	16.54
	25.0	9.49	31.72	2.60	28.59
7	0.0	15.00	6.60	7.60	80.57
	2.0	14.58	8.24	7.20	76.39
	5.0	9.93	30.37	2.00	22.02
	10.0	9.73	31.36	1.50	16.54
	25.0	9.46	31.70	3.60	39.56
8	0.0	15.00	6.34	8.00	84.68
	2.0	14.94	7.15	7.60	80.72
	5.0	10.34	28.15	2.90	31.75
	10.0	9.72	31.05	2.90	31.92
	25.0	9.46	31.92	4.10	45.11
	40.0	9.45	31.84	4.60	50.57
9	0.0	14.66	9.44	7.20	77.05
	2.0	13.98	11.31	6.70	71.49
	5.0	10.43	28.60	3.10	34.12
	10.0	9.72	31.19	2.90	31.94
	25.0	9.45	31.72	4.20	46.15
	50.0	9.65	31.84	4.90	54.13
10	0.0	14.97	7.99	7.60	81.17
	2.0	14.28	10.87	7.10	76.84
	5.0	10.23	29.76	2.80	30.19
	10.0	9.74	31.22	2.70	29.76
	25.0	9.47	31.55	3.60	39.52
	50.0	9.41	31.74	5.10	55.99

Surface temperatures were between 13.52° and 15.00°C and salinities were between 1.20 and 11.31 °/oo. The salinity range in the surface waters clearly indicates fresh water from the Somass River. Below the halocline, oceanic water with salinities from 24.17 to 31.00 °/oo was evident.

Dissolved oxygen levels below the halocline were noticeably depressed for a considerable distance from the outfall. Values as low as 0.50 mg/l were recorded at 10 metres at Station 4. Company results from 12 June 1980, also show low D.O. at 3 and 9 metres at the Hohm Island Station. (EPS files)

At Stations 8, 9 and 10, D.O. below 25 metres was improved; however, a layer of poor oxygen levels was observed from 5-10 metres at these stations. This layer of poor, dissolved oxygen possibly originates from entrainment of low dissolved oxygen water from the inner harbour. The presence of effluent in the surface waters, and mixing in the upper zone at these stations has undoubtly reduced the amount of dissolved oxygen brought into the system from the Somass River. (Sullivan, 1978).

According to Birtwell (1980), the depauperate oxygen conditon below the halocline could severely restrict the habitat available to fish. The lack of oxygen generation by phytoplankton below the halocline exacerbates the poor dissolved oxygen caused by a high biochemical oxygen demand in this zone.

6.2.2 Benthic. Trace metal analysis of sediments from benthic stations 1, 2, 9 and 10 (Figure 8) are presented in Table 11. The levels do not warrant concern.

Benthic community composition is presented in Appendix I. Dominant taxa were polychaetes, Dorvillea pseudorubrovitata being the most numerous species, with small numbers of bivalves and amphipods also present. Numbers of individuals were low and the virtual absence of taxa other than polychaetes demonstrate a poor community structure.

At most stations, the substrate is largely wood chips or wood fibre, which originate from log handling and storage and pulpmill effluent, and undoubtly effect the number and types of organisms. The depths

TABLE 11: TRACE METAL ANALYSIS IN SEDIMENTS
ALBERNI INLET JUNE, 1980
(mg/kg)

STATION	Hg	Cd	Zn	Cu	Pb
1	0.441	> 0.55	270.0	65.5	67.5
2	0.363	> 0.56	246.0	72.5	65.5
9	0.535	1.22	323.0	66.0	64.0
10	0.637	0.90	515.0	52.0	59.5

at which the samples were collected varied between stations (13-58 metres) and may also be a factor in types of organisms collected.

7. Port Mellon - Thornbrough Channel

7.1 Survey Rationale. The first of a series of surveys to collect baseline information prior to the installation of a diffuser scheduled for 1982 was conducted in November 1980. Previous studies in the area have shown that major impacts from the pulpmill include severely deteriorated intertidal communities from past discharge of lime mud, build-up of a fibre bed adjacent to the outfalls and to a somewhat lesser extent, a decrease in phytoplankton productivity near the mill due to the strong light attenuating properties of KME (Nelson, 1979).

The company plans to install a submarine diffuser at a depth of 100 metres near the mouth of the Rainy River, and has announced a major mill expansion and modernization program.

7.1.1 Effluent Data. Effluent quality data for 1980 for BOD_5 and suspended solids are presented below. No toxicity testing data was available. The 1980 averages are:

	Actual	Permitted
BOD_5	27.9 kg/ADT (18.6-38.1)	30.0 kg/ADT
SS	21.3 kg/ADT (12.0-37.0)	17.5 kg/ADT

(CFP, Howe Sound Pulp Division)

Based on effluent data supplied by the company, suspended solids levels (monthly averages) are over the permitted level more than 50% of the time.

The operating permit for the pulpmill was amended in February, 1981. Effluent quality to Level 'B', including toxicity, must be met by 31 March, 1982.

7.2 Results and Discussion

7.2.1 Water Quality. Water quality results from the November survey (Figure 9) are typical of winter profiles (Table 12). Surface temperatures were slightly lower, with maximum temperatures, 9.83-10.19°C from 5-10 metres. Below this depth, values were uniform to 200 metres (8.99 to 9.42°C). Surface salinities above 10 metres were from 14 to 26°/oo ppt. Below this depth, values were more uniform, from 28-30°/oo.

The dissolved oxygen levels at all stations above 25 metres were recorded in a range from 6.6 to 9.3 mg/l. At or below 25 metres, values were generally below 5 mg/l. The low values, 3.4 to 3.8 mg/l, at 200 metres are typical of deep basin water where exchange rates are slow.

Colour analysis showed high colour values at the surface, particularly at Station 4 (Table 13). Colour was not carried to the 10 metre depth where values of 0 or 1 were recorded. The installation of a deep diffuser will allow for dilution and dispersion of colour, at depth, and hopefully remove the impact from the productive surface zone.

7.2.2 Benthic. Trace metal analysis of sediments from Thornbrough Channel (Figure 9) did not indicate any serious elevation in the metals measured (Table 14). Analyses of sediments for polychlorinated biphenyls were all below the detection limit of 0.005 ug/g.

Benthic community composition is presented in Appendix I. Total numbers and diversity of organisms was low at all stations. The absence of large tube dwelling polychaetes and a low number of bivalves was noted. At most of the sites, wood chips and debris were a portion of the substrate, which possibly accounts for the species composition.

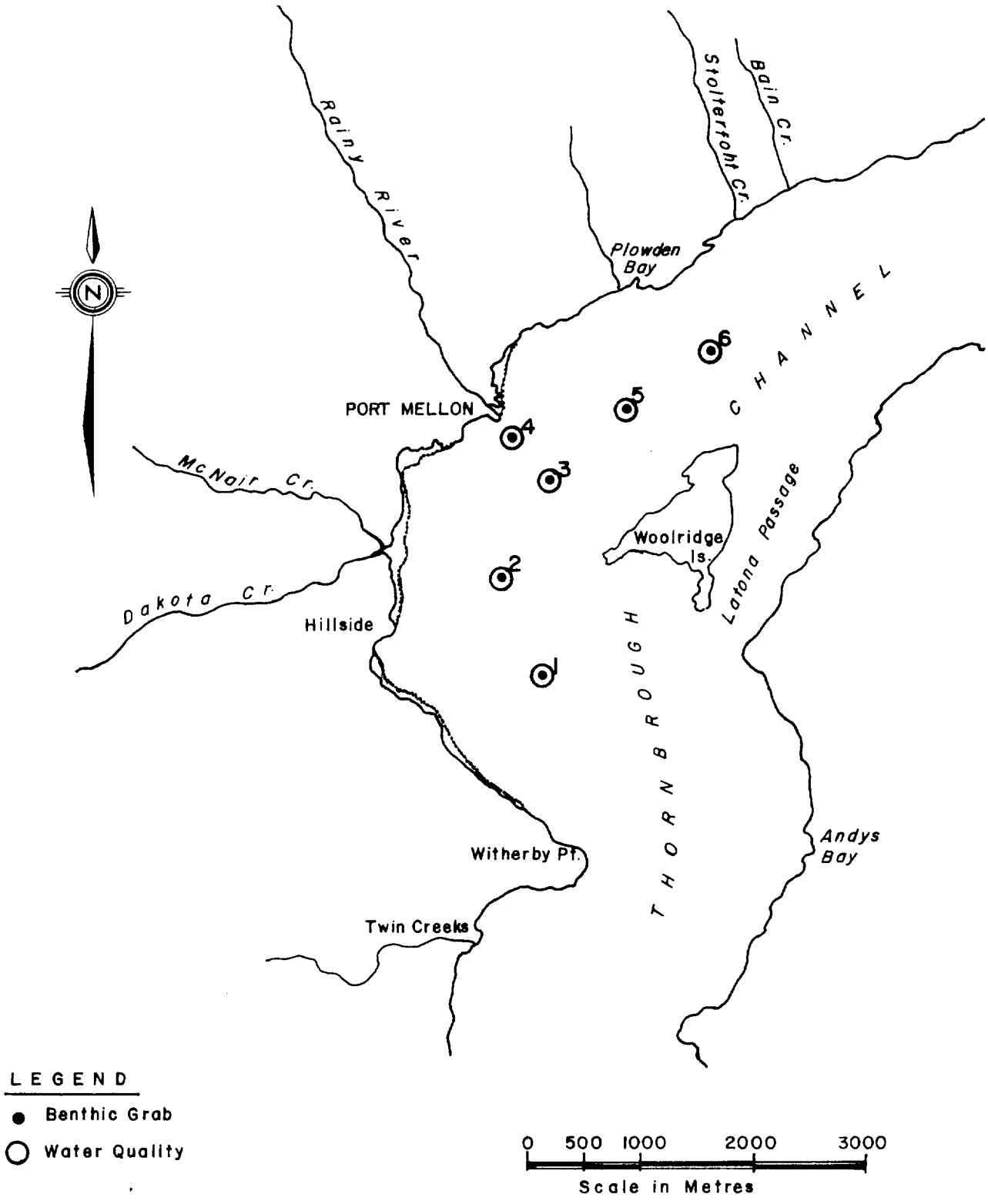

FIGURE 9 WATER QUALITY AND BENTHIC GRAB STATIONS - THORNBROUGH CHANNEL, 1980

TABLE 12: WATER QUALITY RESULTS - THORNBROUGH CHANNEL, NOVEMBER 1980

STATION (PM)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
1	0.0	7.97	18.00	9.00	87.34
	2.0	8.91	22.00	8.70	88.55
	5.0	10.15	26.00	6.60	70.94
	10.0	9.91	28.00	5.30	57.40
	25.0	9.42	29.00	4.90	52.82
	50.0	9.30	30.00	4.90	53.03
	100.0	8.99	30.00	4.70	50.50
	200.0	9.21	30.00	3.40	36.72
2	0.0	8.12	28.00	9.00	93.45
	2.0	9.08	26.00	8.60	90.16
	5.0	9.87	30.00	7.80	85.53
	10.0	10.04	28.00	5.40	58.66
	25.0	9.29	29.00	4.80	51.58
	50.0	9.36	28.00	4.70	50.26
	100.0	9.09	30.00	5.00	53.84
	200.0	9.22	30.00	3.60	38.89
3	0.0	8.76	20.00	8.70	87.12
	2.0	9.03	20.00	8.50	85.66
	5.0	10.03	25.00	7.20	76.68
	10.0	10.05	27.00	5.20	56.13
	25.0	9.32	29.00	4.90	52.70
	50.0	9.30	28.00	4.80	51.26
	100.0	9.12	30.00	4.80	51.72
	175.0	9.03	28.00	4.00	42.45

TABLE 12: WATER QUALITY RESULTS - THORNBROUGH CHANNEL, NOVEMBER 1980 (Continued)

STATION (PM)	DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
4	0.0	7.83	14.00	9.30	87.77
	2.0	9.02	20.00	8.60	86.65
	5.0	10.19	24.00	7.10	75.40
	10.0	10.00	29.00	5.20	56.81
	25.0	9.26	29.00	5.00	53.70
	50.0	9.33	30.00	4.80	51.99
	100.0	9.12	30.00	4.90	52.80
	135.0	9.02	29.00	4.60	49.13
5	0.0	8.20	17.00	8.90	86.31
	2.0	8.76	20.00	8.60	86.11
	5.0	9.96	22.00	7.80	81.35
	10.0	10.16	30.00	5.70	62.93
	25.0	9.37	30.00	4.90	53.11
	50.0	9.27	29.00	4.80	51.57
	100.0	9.31	30.00	4.80	51.96
	200.0	9.20	29.00	3.80	40.75
6	0.0	8.65	18.00	8.80	86.80
	2.0	9.15	15.00	8.50	83.30
	5.0	9.83	26.00	7.50	80.03
	10.0	10.15	28.00	5.50	59.89
	25.0	9.30	28.00	4.90	52.32
	50.0	9.35	30.00	4.90	53.09
	100.0	9.34	28.00	4.90	52.37
	225.0	9.40	30.00	3.40	36.88

TABLE 13: COLOUR ANALYSIS, PORT MELLON, 1980
(Colour units)

DEPTH (m)	0	2	5	10
STATION				
November 1980				
PM-1	17	8	1	0
PM-2	15	7	5	0
PM-3	9	7	4	1
PM-4	23	8	3	0
PM-5	12	11	5	1
PM-6	14	10	4	1

TABLE 14: TRACE METAL ANALYSIS IN SEDIMENTS
PORT MELLON, B.C., 1980
(mg/kg)

STATION	Hg	Cd	Zn	Cu	Pb
PM-1	0.999	0.67	190.0	137.0	103.0
PM-2	1.09	0.97	173.0	129.0	106.0
PM-3	> 0.200	0.56	67.0	45.3	61.0
PM-4	0.687	> 0.56	56.0	36.8	45.8
PM-5	0.770	0.67	168.0	121.0	106.0
PM-6	0.788	> 0.56	187.0	135.0	110.0

TABLE 15: TOTAL VOLATILE RESIDUES AND PARTICLE SIZE OF SEDIMENTS, PORT MELLON, B. C., 1980

STATION	TVR (mg/g)	35 MESH		60 MESH		230 MESH		> 230 MESH	
		weight retained	percent retained	weight retained	percent retained	weight retained	percent retained	weight retained	percent retained
PM-1	110	0.2	1.3	5.0	31.4	6.5	40.9	4.2	26.4
PM-2	130	0.1	1.8	1.3	23.2	2.1	37.5	2.1	37.5
PM-3	260	5.1	30.0	3.7	21.8	7.2	42.4	1.0	5.9
PM-4	16	4.3	25.7	7.6	45.5	4.3	25.7	0.5	3.0
PM-5	96	0.1	1.1	1.3	14.9	4.9	56.3	2.4	27.6
PM-6	91	0.1	1.0	1.8	18.2	4.8	48.5	3.2	32.2

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APPENDICES

APPENDIX I TRAWL DATA

CROFTON

Station C-1, Tow 1

80-06-05

	TIME (PDT)	DEPTH (m)
Begin Fishing	0815	173
Stop Fishing	0825	146

SPECIES		COUNT
ANTHOZOA		noted
ARTHROPODA		
Crustacea	Pandalus playtceros	3
	P. borealis	5
	P. jordani	38
	Pandalopsis dispar	34
	Spirontocaris spp.	20
	Crangonidae	20
	Pasiphaea pacifica	noted
ECHINODERMATA		
Echinoidea	Brisaster sp.	300
Holothuroidea	Unid. holothurians	33
	Chiridota sp.	noted
CHORDATA		
Pisces	Lyopsetta exilis (juvenile)	1

APPENDIX I TRAWL DATA

CROFTON

Station C-1, Tow II

80-06-05

	TIME (PDT)	DEPTH (m)
Begin Fishing	0903	121
Stop Fishing	0917	119

SPECIES		COUNT
MOLLUSCA		
Cephalopoda	Rossia sp.	1
ARTHROPODA		
Crustacea	Rocinela sp.	1
	Pandalus platyceros	1
	P. borealis	6
	P. jordani	96
	Pandalopsis dispar	200
	Spirontocaris spp.	noted
	Crangonidae	25
	Pasiphaea pacifica	noted
ECHINODERMATA		
Ophiuroidea	Unid. ophiuroidea	noted
Echinoidea	Brisaster sp.	400
Holothuroidea	Chiridota sp.	noted
CHORDATA		
Pisces	Merluccius productus	1

APPENDIX I TRAWL DATA

CROFTON

Station C-2

80-06-05

	TIME (PDT)	DEPTH (m)
Begin Fishing	0955	131
Stop Fishing	1005	144

SPECIES		COUNT
ARTHROPODA		
Crustacea		
	Pandalus platyceros	4
	P. borealis	7
	P. jordani	1
	Pandalopsis dispar	1
	Spirontocaris spp.	10
	Crangonidae	8
	Chionoecetes sp. (juv)	1
ECHINODERMATA		
Echinoidea	Brisaster sp.	3000
Holothuroidea	Chiridota sp.	noted
	Unid holothurians	10
CHORDATA		
Pisces	Bathyagonus nigripinnis	

N.B. clean trawl

APPENDIX I TRAWL DATA

CROFTON

Station C-3

80-06-05

	TIME (PDT)	DEPTH (m)
Begin Fishing	1047	63
Stop Fishing	1059	30

SPECIES		COUNT
CNIDARIA	Unid. actinarians	noted
MOLLUSCA		
Cephalopoda	Rossia sp.	1
ARTHROPODA		
Crustacea	Pandalus playceros	1
	P. jordani	43
	Spirontocaris sp.	1
	Crangonidae	noted
	Eualus sp.	1
	Pagarus sp.	1
ECHINODERMATA		
Asteroidea	Henricia sp.	5
CHORDATA		
Pisces	Parophyrs vetulus	8
	Lepidopsetta bilineata	7
	Hippoglossoides elassodon	1
	Sebastes elongatus	7

APPENDIX II

PORT ALBERNI BENTHIC INVERTEBRATES
June 1980

		STATION NUMBER													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
ANNELIDA Polychaeta	Harmothoe imbricata					1		1							
	Gyptis brevipalpa	1	2										1		
	Sigambra tentaculata														2
	Cheiloneris cyclurus				2										
	Nereis sp. (no prob.)				1				1						
	Glyceridae (mangled)								1						
	Glycera capitata				2		3	4				1			1
	Glycera robusta														2
	Glycera tesselata														2
	Onuphis iridescens								1						
	Lumbrineris sp. (no post.)					1	2	2	5		1				
	Lumbrineris luti					1									
	Dorvillea pseudorubrovittata	10	19	12	1		1	1					62	169	5
	Scoloplos sp.								1						
	Leitoscoloplos pugettensis									1					
	Cirrophorus branchiatus				1										
	Aricidea lopezi				1	3				2		2			
	Aricidea neosuecica									1					
	Paraonella platybranchia								1	1					
	Spionidae (mangled)										2				
	Laonice cirrata						2								
	Polydora sp.							1							
	Prionospio steenstrupi								1						
	Polydora hamata							2		2					
	Myriochele oculata							1							

APPENDIX II

PORT ALBERNI BENTHIC INVERTEBRATES (Continued)
June 1980

		STATION NUMBER													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Cirratulidae (no post.)								1						
	Tharyx sp.									1					
	Branchiomaldane vincenti				2										
	Maldanidae (no post.)				6										
	Maldane glebifex				1	2									
	Praxillella affinis affinis					4	1								3
	Praxillella affinis pacifica											6			
	Capitella capitata		7	9							1		13		
	Heteromastus filobranchus				2										
	Mediomastus sp.							2							
	Disoma sp.					2		1				1			
	Ampharetidae (mangled)							1							1
	Amage anops				1	1		2							6
	Amphicteis scaphobranchiata						2					1			
	Neoamphitrite robusta					1									
ARTHROPODA	Amphipoda (mangled)					1	2	1	1		1				
MOLLUSCA Bivalvia	Bivalvia (no shells)				10	17		45		6	3	6			
	Bivalvia (mangled)														6
	Axiinopsida sp.						23		12	5					
	Macoma sp.						1								
	Solemya sp.						1	7		1	2				
	Thyasira sp.					9	1								
ECHINODERMATA	Ophiuroidea (arm only)							1							

APPENDIX II: DESCRIPTION OF PORT ALBERNI BENTHIC SAMPLES

STATION	VOLUME	REMARKS
PA- 1	large	organic detritus, some wood fibre & wood chips
PA- 2	medium	largely mud & polychaete tubes, little organic debris
PA- 3	small	organic detritus
PA- 4	medium	largely wood chips, some sand
PA- 5	medium	polychaete tubes and mud
PA- 6	small	organic detritus
PA- 7	very large	gravel, wood chips
PA- 8	very large	wood chips & gravel
PA- 9	very large	wood fibre & chips, little gravel
PA-10	very large	organic detritus, wood chips, little fibre
PA-11	medium	mud-black ooze, polychaete tubes
PA-12	small	fine silt, some wood fibre
PA-13	small	wood fibre, little sand
PA-14	medium	wood chips, rocks, gravel

APPENDIX III

PORT MELLON BENTHIC INVERTEBRATES
November 1980

PHYLUM CLASS	SPECIES	NO. OF INVERTEBRATES/STATION					
		1	2	3	4	5	6
ANNELIDA Polychaeta	Polychaeta (unid.)		1	2			1
	Polynoida (unid.)			3			
	Harmothoe imbricata			4	3		
	Phyllodocidae (unid.)			1			
	Syllis sp.			1		1	
	Nephtys sp.	4		1		3	
	Nephtys californiensis						3
	Glycera capitata		1	1		1	1
	Glycera tesselata		1				
	Onuphis iridescens	2	1				
	Dorvillea annulata			4			
	Aricidea neosuecica	1				1	
	Aricidea quadrilobata	3					
	Spionidae (unid.)			1			
	Polydora sp.				1		
	Prionospio sp.	2		1	83		
	Prionospio steenstrupi				1		
	Spiophanes berkeleyorum	1					
	Cossura sp.	1				1	
	Flabelligera affinis	1					
	Barrentolla americana	2					
	Capitella capitata				1		
	Maldane glebifex		1			1	1
	Myriochele oculata					1	
	Amage anops	1				1	
	Melinna cristata		1				

APPENDIX III

PORT MELLON BENTHIC INVERTEBRATES

November 1980

PHYLUM / CLASS	SPECIES	NO. OF INVERTEBRATES/STATION					
		1	2	3	4	5	6
MOLLUSCA Amphineura	*Chaetoderma sp.*					1	
Bivalvia	*Solemya sp.*			1			
ARTHROPODA Crustacea	*Nebalia pugettensis*				4		
	Amphipoda (unid.)			11	3		
SIPUNCULA	unid.		1				1
ECHIURA	unid.	1					
ECHINODERMATA							
Holothuroidea	unid.				2		
	Molpadia sp.	1		2		2	1

PORT MELLON BENTHIC SAMPLES

	DESCRIPTION OF SAMPLES
STATION	SUBSTRATE TYPE
Sta. 1	small wood chips, few empty polychaete tubes
Sta. 2	large & small wood chips, no stones, polychaete tubes or shell frags.
Sta. 3	little mud, small & large wood chips, no polychaete tubes or bivalve shell fragments
Sta. 4	90% sand, 10% wood chips
Sta. 5	wood chips, shell fragments
Sta. 6	some shell fragments, 80% small wood chips