ENVIRONMENTAL PROTECTION SERVICE
PACIFIC REGION

MARINE ENVIRONMENTAL SURVEILLANCE MONITORING AT B.C. SOUTH COAST PULPMILLS 1981-1982

Regional Program Report: 83-17

by

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Abstract

During 1981 and 1982, the Environmental Protection Service monitored changes in water quality and benthic conditions associated with mill effluents at Crofton, Powell River, Port Alberni, Port Mellon and Woodfibre. Parameters examined included water column temperature, salinity, dissolved oxygen, colour, sediment character and trace metals in sediments. Sediments at Crofton, Powell River, Port Alberni and Port Mellon were also analyzed for total volatile residues. Benthic infauna were surveyed at Port Mellon and Port Alberni.

Surveys at north coastal and interior mills will be reported elsewhere.

Résumé

Au cours de l'année 1981 et 1982, 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 Crofton, Powell River, Port Alberni, Port Mellon et Woodfibre. 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 sediments. On a élalement prélevé des sediments à Crofton, Powell River, Port Alberni et Port Mellon pour en analyser les particules et residus volatils. On a procédé à une étude de la faune benthique à Port Mellon et Port Alberni.

Les enquêtes faites à proximité des usines situées le long du littoral septentrional et à l'intérieur des terres feront l'objet d'un autre rapport.

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SUMMARY

Crofton-Stuart Channel

The November water quality survey results indicate a well mixed water column. Dissolved oxygen levels below 5 mg/l were detected only below 50 meters. Cadmium concentrations were slightly elevated in marine sediments near the outfall. Since redistribution of contaminated sediments by mechanisms such as dredging is unlikely, elevated cadmium is not of major concern.

Powell River-Malaspina Strait

An August survey of water quality in Malaspina Strait showed no apparent impact from sub-surface effluent discharge. High levels of cadmium continue to occur at stations close to the mill and the previous discharge location.

Port Alberni-Alberni Inlet

The most critical aberrant water quality parameter in Alberni Harbour is dissolved oxygen. Low levels (>5 mg/l) were detected at or below 5 metre depths at all stations in the inner harbour while the mill was operating.

Heavy metal contamination, particularly cadmium, is apparent in most of the inner harbour. Zinc concentrations were highly elevated immediately adjacent to the effluent outfall and the assembly dock. It is believed the zinc originates from the discharged sludge spoil from the biological treatment pond. Further study is recommended.

Port Mellon-Thornbrough Channel

The effects of surface effluent discharge do not appear to extend to central Thornbrough Channel as water quality parameters are stable. Further study will determine the impact of sub-tidal discharge of effluent through the newly installed diffuser.

Benthic invertebrate communities were examined at 3 sites. Results will be used for future comparison, primarily alteration of community structure. Trace metal analysis revealed elevated cadmium levels only at the station located nearest the pulpmill.

Woodfibre - Howe Sound

Water quality surveys do not indicate widespread impact from effluent discharge. Trace metal analysis results do not warrant concern at this time. Impacts on the receiving environment appear to be limited in extent, although locally serious, and further benthic community study is recommended.

1. INTRODUCTION

1.1 Study Areas

The Environmental Protection Service annually conducts surveillance and compliance monitoring programs at coastal pulpmills.

In 1981, surveillance monitoring was conducted at the pulpmills located at Crofton, Powell River, Port Alberni, Port Mellon, Woodfibre, (Figure 1) and Porpoise Harbour, B.C. Data from March, 1982 survey at Alberni Inlet are also included as it was considered part of the winter period. Data from Porpoise Harbour will be reported separately.

The purpose of the surveys was to examine and assess enviornmental quality at mills which are proposing or instituting major pollution abatement measures.

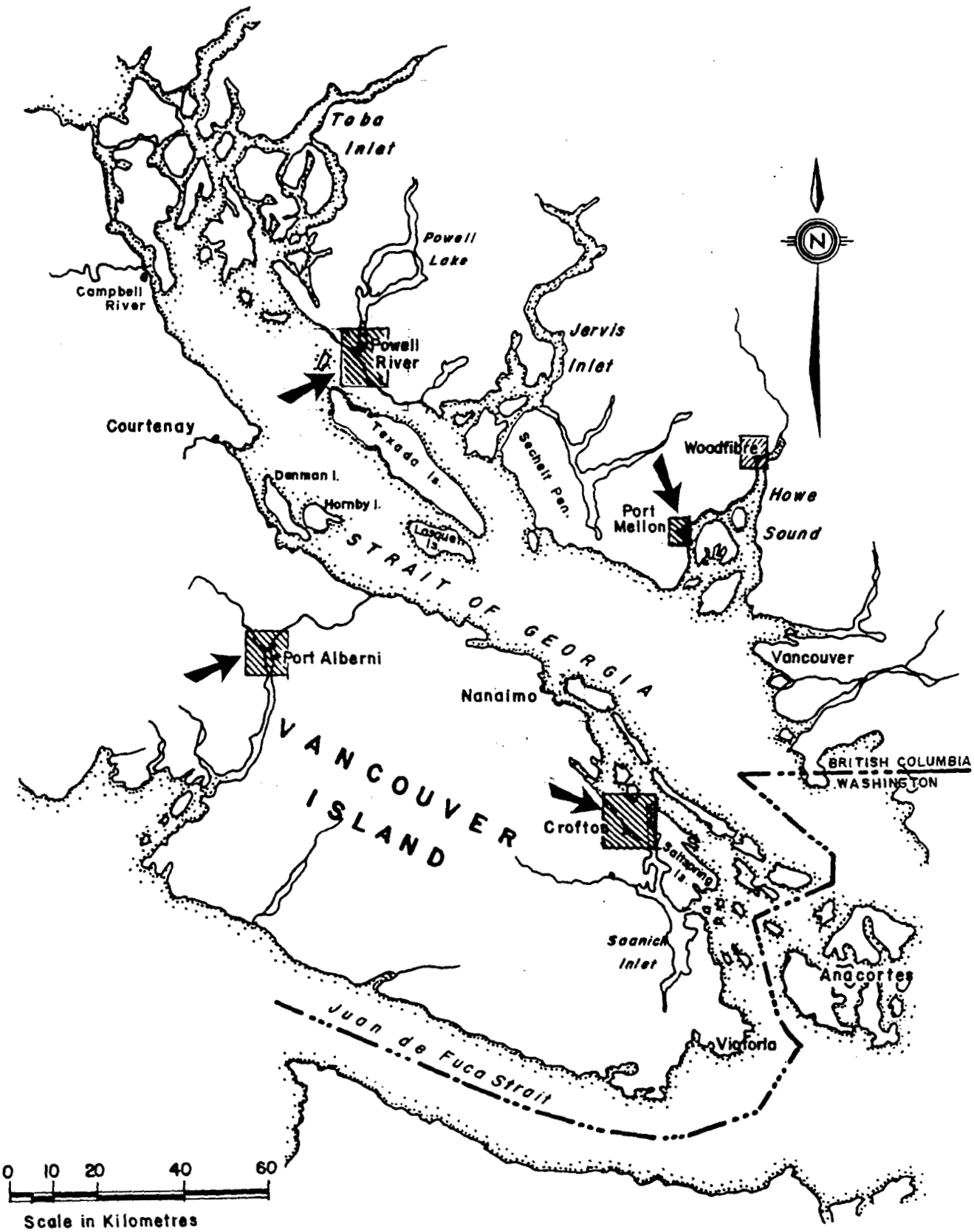

FIGURE 1 LOCATION MAP, 1980

2. METHODS AND MATERIALS

Water quality was surveyed at the four pulp mill sites during 1981-1982. 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 invertebrates were collected at Port Alberni and Port Mellon for population and community structure analysis.

2.1 Hydrographic Sampling. 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.

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^1 = 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 tristimulus method. (DOE Laboratory Manual 1979).

2.2 Benthic Sampling.

2.2.1 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 collected at Port Mellon and Port Alberni. Uniform volumes of sediments were washed and sieved on a 0.5 mm screen with low pressure water, preserved in 10% buffered formalin and stored in isopropyl alcohol prior to identification and counting.

3. CROFTON-STUART CHANNEL

3.1 Perceived Impacts

3.1.1 Receiving Water. Depressed dissolved oxygen levels frequently occur in bands at 25-50 meters depth, due to entrainment of deeper, oxygen-poor waters (Dobrocky Seatech, 1977) or to poor mixing and entrapment of effluent (Sullivan, 1980), or to a combination of both. Dobrocky Seatech (1977) further speculated that lignin stain in the effluent would decrease light transmission and affect primary productivity, thus adding to the oxygen deficit.

3.1.2 Benthic Quality. An extensive fibre bed has developed 1.6 to 3.2 km to the northwest and southeast (Ellis, 1970) which extends approximately 300 metres offshore. This has resulted in reduced benthic communities in the vicinity of the twin diffusers.

3.1.3 Intertidal. The discharge of BKME from the Crofton mill has decimated once productive oyster populations in the area.

Zinc contamination in oyster tissues has been largely eliminated since changes on the bleaching process were instituted, however, the deteriorated oyster conditions still persists.

3.2 Effluent Data

Effluent data for 1981 supplied by the company for suspended solids and BOD_5 are presented below. Toxicity tests (3) were passed 67% of the time at a LC_{50} = 30% (v/v).

	Actual	Permitted
BOD_5	34.7 kg/t (18.9-43.0)	46,600 kg/day
SS	12.6 kg/t (6.3-23.6)	23,800 kg/day

The BOD_5 levels exceed permit requirements on 9 of the 11 sampling periods.

3.3 Results and Discussion

3.3.1 Water Quality. A cursory water survey was conducted in November 1981. Due to time and equipment restraints some rearrangements were made in station locations previously sampled (Figure 2).

Temperature and salinity profiles were uniform with depth (Table 1).

The dissolved oxygen levels recorded at the bottom during this survey are below 5 mg/l, with the exception of Station 8, between Kuper and Saltspring Islands. The absence of a zone of depressed oxygen at mid-depth could be due to natural environmental variation or to lingering effects from one prolonged industry shutdown which ended in late September or to changes in effluent quality (Section 3.2).

3.3.2 Benthic. Trace metal analysis of marine sediments revealed high concentrations of cadmium at the stations immediately adjacent to the outfalls (Stations 1, 2, 3 and 4) and directly north of the outfalls (Station 6)(Figure 2, Table 2, 3, 4.).

It has been speculated that high cadmium levels observed at other BC coastal pulpmills sites were associate with zinc hydrosulphite used in the bleaching process. The levels of zinc recorded during this survey are high enough to suggest this as the source of this cadmium here. Although cadmium is very toxic at low concentrations, its toxicity is a function of the proportion of free cadmium ions which in sea water is very low (Konasewich et al, 1982). The levels present do not indicate environment hazards as long as sediments are not redistributed, by such mechanisms as dredging, which is unlikely.

Further sediment work should be undertaken to determine the actual extent of the contamination in sediments and levels in tissues.

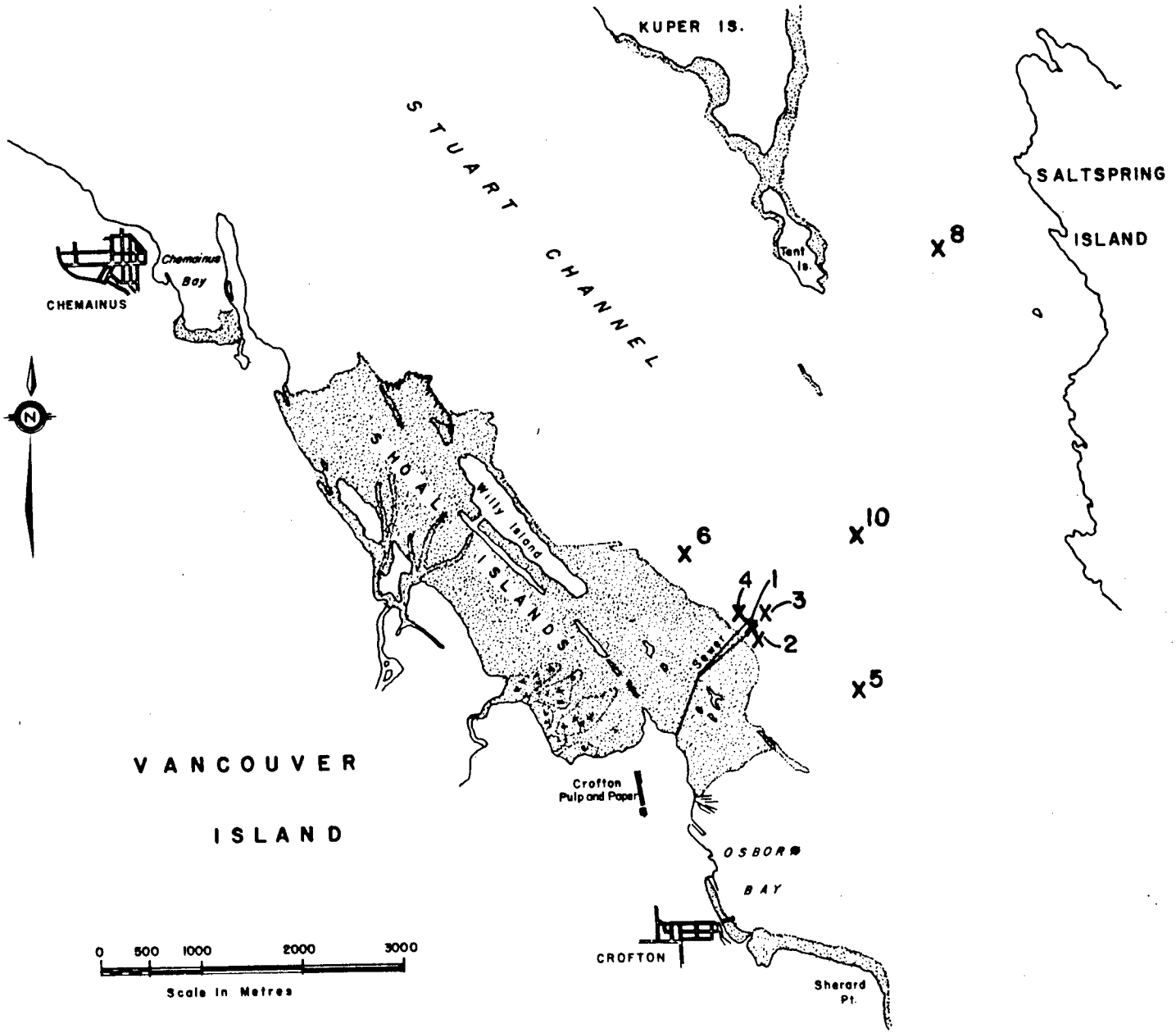

FIGURE 2 WATER QUALITY STATIONS - STUART CHANNEL, 1981

TABLE 1 WATER QUALITY RESULTS - CROFTON, B.C., NOVEMBER 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	11.02	24.98	8.88	96.71
2.0	10.81	28.14	9.19	101.69
5.0	10.73	28.29	7.65	84.58
10.0	10.74	28.79	7.64	84.77
25.0	10.65	29.46	5.58	62.07
65.0	10.66	29.90	3.43	38.27
Station 2				
0.0	11.19	26.78	8.60	95.12
2.0	10.89	27.86	8.73	96.60
5.0	10.82	28.16	8.62	95.42
10.0	10.74	28.85	6.43	71.37
25.0	10.65	23.39	5.93	65.93
55.0	10.59	29.77	4.64	51.65
Station 3				
0.0	10.88	27.92	9.81	108.57
2.0	10.87	27.97	9.82	108.69
5.0	10.86	28.06	8.10	89.69
10.0	10.75	28.73	7.47	82.87
25.0	10.63	29.42	5.06	56.24
50.0	10.55	29.74	5.03	55.93
100.0	10.68	29.98	3.65	40.77
Station 4				
0.0	10.95	26.20	8.17	89.54
2.0	10.86	28.01	8.18	90.54
5.0	10.74	28.22	8.81	97.39
10.0	10.75	28.66	7.36	81.61
25.0	10.66	29.44	5.27	58.62
35.0	10.60	29.64	5.26	58.51

TABLE 1 WATER QUALITY RESULTS - CROFTON, B.C., NOVEMBER 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 5				
0.0	11.58	23.16	9.35	101.90
2.0	10.84	27.90	8.77	96.96
5.0	10.76	28.68	7.97	88.41
10.0	10.75	28.80	7.44	82.58
25.0	10.64	29.45	5.42	60.27
50.0	10.58	29.76	3.04	56.08
117.0	10.68	30.03	3.47	38.77
Station 6				
0.0	10.95	27.96	10.25	113.65
2.0	10.93	28.15	10.14	112.52
5.0	10.92	28.23	9.09	100.90
10.0	10.70	28.66	6.94	76.87
25.0	10.65	29.44	5.15	57.27
50.0	10.60	29.81	4.69	52.23
100.0	10.68	29.97	3.52	39.31
Station 8				
0.0	11.10	24.21	9.64	104.65
2.0	10.89	27.52	8.22	90.75
5.0	10.80	28.72	7.65	84.96
10.0	10.71	28.76	6.88	76.27
25.0	10.40	29.30	6.24	68.94
30.0	10.52	29.43	6.02	66.75
Station 10				
0.0	11.35	25.33	9.97	109.63
2.0	10.76	28.21	8.75	96.76
5.0	10.71	28.63	8.49	94.04
10.0	10.73	28.87	7.39	82.02
25.0	10.64	29.38	5.53	61.46
50.0	10.58	29.74	4.26	47.40
100.0	10.67	29.92	3.79	42.30
165.0	10.65	30.11	3.46	38.65

TABLE 2 TRACE METAL LEVELS IN MARINE SEDIMENTS
GRAB SAMPLES - CROFTON, B.C.
NOVEMBER 1981
(mg/kg)

STATION	Hg	Cd	Pb	Zn	Cu
C-1	L0.125	2.29	9.0	206.0	36.0
C-2	L0.139	2.54	11.9	178.0	49.3
C-3	L0.143	1.41	19.1	154.0	55.2
C-4	0.169	3.46	14.5	192.0	66.7
C-5	0.208	0.71	21.6	133.0	51.5
C-6	0.169	3.4	19.7	278.0	60.5
C-8	0.139	L0.6	11.8	74.2	19.9
C-10	0.171	0.7	19.3	102.0	42.9

TABLE 3 TOTAL VOLATILE RESIDUES AND PARTICLE SIZING
GRAB SAMPLES - CROFTON, B.C.
NOVEMBER 1981
(grams)

STATION	TVR (mg/kg)	SAMPLE WEIGHT	35 MESH (500 um)		60 MESH (250 um)		100 MESH (149 um)		230 MESH (62.5 um)		L230 MESH	
			WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED
C-1	120	53.5	3.8	7.1	14.3	26.7	15.0	28.0	14.7	27.5	5.7	10.7
C-2	150	51.8	0.1	0.2	4.8	9.3	12.8	24.7	22.8	44.0	11.3	21.8
C-3	120	26.5	0.2	0.8	1.3	4.9	1.7	6.4	5.1	19.2	18.2	68.7
C-4	270	18.1	0.1	0.6	0.9	5.0	2.3	12.7	5.6	30.9	9.2	50.8
C-5	120	13.6	0.1	0.7	0.6	4.4	0.7	5.1	3.4	25.0	8.8	64.7
C-6	140	20.4	0.1	0.5	1.1	5.4	2.0	9.8	4.2	20.6	13.0	63.7
C-8	40	15.3	0.1	0.7	0.9	5.9	1.4	9.2	2.9	19.0	10.0	65.4
C-10	40	17.0	0.2	1.2	1.1	6.5	1.4	8.2	3.1	18.2	11.2	65.9

TABLE 4 SEDIMENT CHARACTERIZATION - GRAB SAMPLES
NOVEMBER 1981 - CROFTON, B.C.

STATION	DEPTH	REMARKS
C-1	73 m	Fibre, sandy, strong H_2S odor
C-2	80 m	Fibre, H_2S odor
C-3	95 m	Natural brown sediments, shell fragments, polychaetes tubes
C-4	40 m	Fibre, H_2S odor
C-5	117 m	Brown coloured, natural sediments, fine wood fragments
C-6	98 m	Brown natural sediments, some coarse fibre
C-8	32 m	Brown sediments, shell fragments
C-10	177 m	Natural sediments

4. POWELL RIVER - MALASPINA STRAIT

4.1 Perceived Impacts

4.1.1 Receiving Water. Receiving water quality studies conducted since the diffuser installation indicate no apparent impact on dissolved oxygen from effluent discharge (Sullivan, 1981). Prior to the diffuser, effluent could easily be detected in surface waters by colour intensity (also low salinity and decreased light penetration), and its movement was largely dependent on tidal and prevailing weather conditions (Nelson, 1979).

4.1.2 Benthic. Heavy fibre loading has reduced benthic communities in the area adjacent to the mill. Installation of a clarifier in 1978 reduced the amount of wood waste entering the receiving environment. The build-up of sludge beds generated measurable quantities of hydrogen sulphide gas (Werner and Hyslop, 1968).

Heavy metal contamination of marine sediments has also been reported in the area adjacent to the pulpmill. Recurrent dredging to maintain depth for vessel berthing has sparked concern about disposal methods because of possible re-release to the environment. Biological samples collected in 1978 did not indicate significant accumulation in tissues of mercury or other metals (Nelson, 1979).

In 1979 and 1980, deep benthic studies in Malaspina Strait conducted by EPS and the company were designed to examine the impact of deep water discharge of effluent. Preliminary results were not conclusive and further study of benthic communities and the fate of deepwater diffused effluents is warranted.

4.1.3 Intertidal. The installation of a submerged diffuser system (August, 1980) has alleviated impacts on the intertidal communities. Zinc concentrations were elevated in Pacific oysters, but process changes

instituted by the pulpmill in the early 1970's appear to have reduced zinc concentrations in oyster tissues.

4.2 Effluent Data

Effluent data for 1981 supplied by the company for suspended solids and BOD_5 is presented below. Toxicity tests in January, February and March were passed at an LC_{50} = 56% (v/v).

	Actual	Permitted
BOD_5	19.9 kg/t (16.8-24.5)	44,500 kg/day
SS	18.5 kg/t (12.3-25.5)	30,500 kg/day

Suspended solids levels exceeded provincial permit levels 64% of the occassions measured.

4.3 Results and Discussion

4.3.1 Water Quality. The water quality results (Figure 3, Table 5) indicate a well mixed water column. Surface temperatures (to 10 metres) were recorded in a range from 16.16 to 17.50°C. Salinities from 23.99 to 30.32 o/oo do not show any strong fresh water influence in the vicintiy of the mill.

The dissolved oxygen profiles also reflect the well mixed water column. At 50 and 100 metre depths, D.O. levels were recorded at or above 5.0 mg/l, indicating no apparent impact from sub-surface effluent discharge.

4.3.2 Benthic Quality. Trace metal analysis (Figure 4, Tables 6, 7, & 8) confirmed a previously identified problem of cadmium contamination at several stations close to the mill and the previous discharge location.

Values at stations MS-5, MS-7, MS-9 and MS-11 were 6.07, 7.23, 4.86 and 2.34 mg/kg respectively. Zinc concentrations are correspondingly high at these locations. Cadmium probably originated as a contaminant in zinc hydrosulphite which was formerly used in the bleaching process. If valid, it does not indicate continuing pollution, although it presents problems for dredging and disposal of dredgate. At the stations with elevated metal levels, the sediments were decomposing (primarily wood fibre) as evidenced by the strong H_2S odor present.

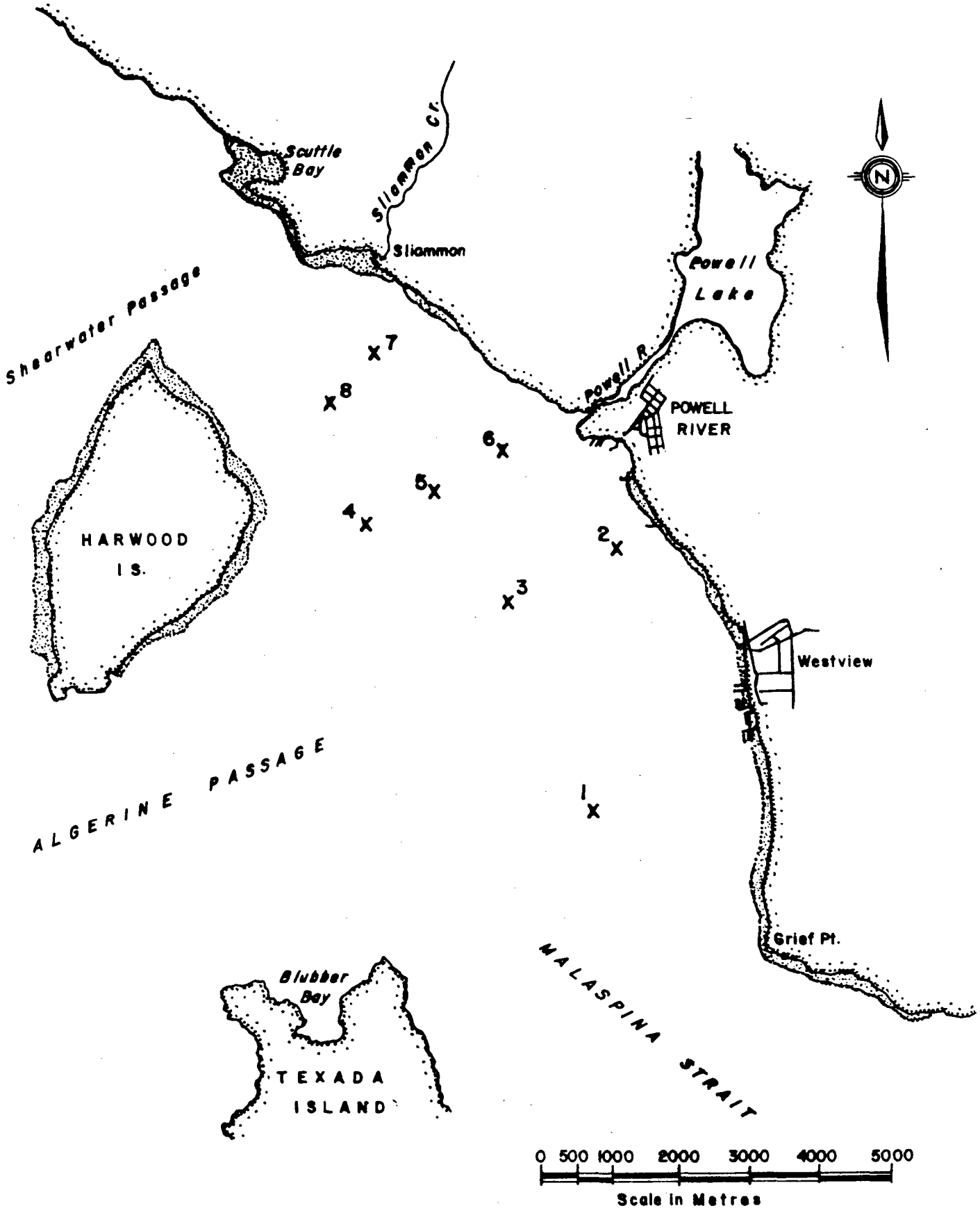

FIGURE 3 WATER QUALITY STATIONS - POWELL RIVER
August, 1981

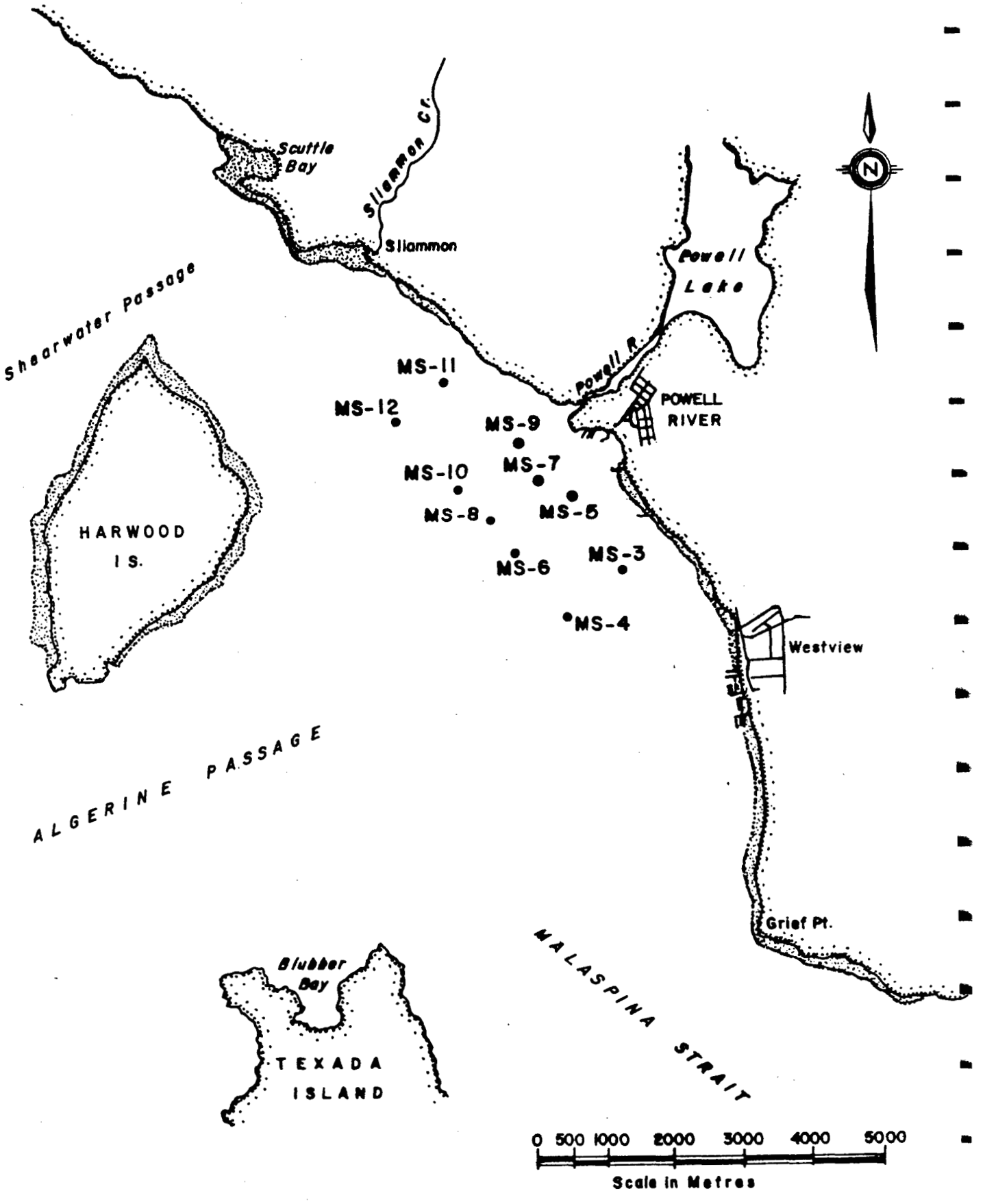

FIGURE 4 BENTHIC GRAB SAMPLES - POWELL RIVER
August, 1981

TABLE 5 WATER QUALITY RESULTS - POWELL RIVER, B.C., AUGUST 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	16.90	26.22	9.90	123.04
2.0	16.72	26.30	10.30	127.63
5.0	16.43	26.68	10.30	127.21
10.0	16.16	26.51	10.20	125.16
25.0	12.39	28.32	8.50	97.53
50.0	9.60	29.47	5.10	55.38
100.0	8.96	30.16	5.20	55.88
Station 2				
0.0	16.91	26.05	10.50	130.38
2.0	16.80	26.07	10.50	130.11
5.0	16.71	26.12	10.50	129.93
10.0	17.02	26.28	10.30	128.38
25.0	12.57	28.36	8.40	96.78
50.0	9.24	29.67	5.00	53.92
Station 3				
0.0	16.98	26.12	9.90	123.15
2.0	16.96	26.14	10.00	124.38
5.0	16.79	26.31	10.30	127.81
10.0	16.76	26.39	10.40	129.04
25.0	13.63	28.07	8.90	104.71
50.0	9.65	29.39	5.40	58.67
100.0	8.96	30.26	5.30	57.00
Station 4				
0.0	16.69	26.55	10.50	130.24
2.0	16.65	26.55	10.50	130.14
5.0	16.59	26.57	10.10	125.03
10.0	16.58	26.57	10.20	126.24
25.0	12.71	28.18	8.80	101.57
50.0	9.95	29.27	5.90	64.50
100.0	9.00	30.19	5.50	59.18

TABLE 5 WATER QUALITY RESULTS - POWELL RIVER, B.C., AUGUST 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 5				
0.0	17.11	23.99	10.60	130.40
2.0	17.03	26.09	10.40	129.47
5.0	16.94	26.23	10.70	133.10
10.0	16.70	26.44	10.70	132.64
25.0	13.08	28.07	8.80	102.32
50.0	9.64	29.42	5.60	60.85
100.0	8.99	30.32	4.90	52.75
Station 6				
0.0	16.91	24.60	10.50	129.17
2.0	17.19	25.99	10.50	131.04
5.0	17.10	26.09	10.50	130.91
10.0	17.09	26.27	10.20	127.30
25.0	11.72	28.60	7.00	79.28
50.0	9.46	29.54	5.40	58.47
Station 7				
0.0	17.18	25.71	10.40	129.55
2.0	17.11	25.69	10.50	130.60
5.0	17.10	25.70	10.40	129.32
10.0	17.11	26.13	10.10	125.97
25.0	11.48	28.65	7.20	81.15
45.0	9.91	29.30	5.80	63.36
Station 8				
0.0	17.50	25.77	10.50	131.65
2.0	17.49	25.80	10.40	130.40
5.0	17.43	25.99	10.30	129.16
10.0	17.30	26.19	10.30	129.01
25.0	11.31	28.76	6.80	76.41
50.0	9.91	29.28	5.70	62.26
100.0	9.01	30.19	5.10	54.88

TABLE 6 TRACE METAL LEVELS IN MARINE SEDIMENTS
GRAB SAMPLES - POWELL RIVER, B.C.
AUGUST 1981
(mg/kg)

STATION	Hg	Cd	Pb	Zn	Cu
MS-3	L0.132	L.661	L6.61	15.9	8.01
MS-4	L0.130	L.658	7.15	36.6	21.4
MS-5	0.241	6.07	27.5	261.0	92.9
MS-6	L0.132	L.669	L6.93	41.9	20.2
MS-7	L0.200	7.23	29.0	292.0	96.8
MS-8	L0.133	L.651	8.69	34.4	28.3
MS-9	L0.192	4.86	23.1	266.0	72.2
MS-10	L0.185	.764	12.6	38.5	19.9
MS-11	0.365	2.34	21.3	173.0	41.9
MS-12	L0.196	L.661	L8.18	40.6	21.8

TABLE 7 TOTAL VOLATILE RESIDUES AND PARTICLE SIZING
GRAB SAMPLES - POWELL RIVER, B.C.
AUGUST 1981

STATION	TVR (mg/kg)	SAMPLE WEIGHT	35 MESH (500 um)		60 MESH (250 um)		100 MESH (149 um)		230 MESH (62.5 um)		L230 MESH	
			WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED
MS-3	48	114.2	20.6	18.0	28.7	25.1	35.0	30.6	22.2	19.4	7.7	6.7
MS-4	80	56.4	1.0	1.8	10.0	17.7	7.7	13.7	22.6	40.1	15.1	26.8
MS-5	506	27.9	13.6	48.7	6.0	21.5	3.3	11.8	1.9	6.8	3.1	11.1
MS-6	112	30.9	1.5	4.9	6.5	21.0	4.8	15.5	11.5	37.2	6.6	21.4
MS-7	550	30.0	3.7	12.3	8.6	28.7	10.2	34.0	0.8	2.7	6.7	22.3
MS-8	88	85.3	12.3	14.4	16.1	18.9	16.6	19.5	27.3	32.0	13.0	15.2
MS-9	485	37.4	7.4	19.8	11.5	30.7	10.7	28.6	3.2	8.6	4.6	12.3
MS-10	245	60.1	12.4	20.6	15.5	25.8	9.4	15.6	16.2	27.0	6.6	11.0
MS-11	282	35.8	1.1	3.1	10.3	28.8	10.0	28.0	13.3	37.2	1.1	3.1
MS-12	138	72.7	12.8	17.6	20.5	28.2	6.4	8.8	18.9	26.0	14.1	19.4

TABLE 8 SEDIMENT CHARACTERIZATION - POWELL RIVER, B.C.
AUGUST 1981

STATION	DEPTH	REMARKS
MS-3	69 m	Fibre, polychaete tubes, no H_2S odor
MS-4	158 m	Natural sediment, brown color
MS-5	69 m	Brown sediment, fibre & wood fragments
MS-6	120 m	Brown sediment, fibre
MS-7	75 m	Brown sediment, fibre & wood fragments H_2S odor
MS-8	117 m	Brown sediment, fibrous
MS-9	67 m	Brown sediment, fibre & wood fragments H_2S odor
MS-10	100 m	Sandy sediment, wood debris
MS-11	40 m	Brown sediment, fibre, H_2S odor
MS-12	96 m	Brown, sandy sediment, some wood debris, no H_2S odor

5. PORT ALBERNI - ALBERNI INLET

5.1 Perceived Impacts

5.1.1 Receiving Water. Alberni Harbour water quality has consistently exhibited a poor and highly variable oxygen regime. Although the dissolved oxygen is influenced by seasonal changes and river flow, the effluent discharge from the pulpmill appears to be the single most important feature in creating this condition. The installation of a biological treatment facility in 1970 to reduce BOD (biological oxygen demand) in the effluent, did little to improve water quality below the halocline. The condition persists to date. Below the halocline depth (which varies between two and five metres depending on river flow and season), D.O. levels are seldom recorded above 5 mg/l. It was suggested by Parker and Sibert (1972) that colour in the effluent blocked photosynthesis below the halocline with a resultant reduction of oxygen in this zone. Colour removal attempts were inconclusive (Sullivan, 1978). In addition, competition between phytoplankton and bacteria has resulted in a nitrate growth limitation and therefore reduced productivity (Parker and Sibert, 1975). It is a complex system of hydrodynamics involving poor primary production, organic waste with high BOD, low oxygen-saturated incoming water and respiration by aquatic organisms, all of which contribute to the depressed oxygen zone.

D.O. above the halocline is strongly influenced by Somass River water. The surface effluent is dispersed and diluted by freshwater inflow, and although effluent BOD does remove oxygen, D.O. levels are usually highly saturated.

5.1.2 Benthic Quality. The benthic environment in the inner harbour clearly shows the impact of heavy industrialization on benthic infaunal communities and sediment quality. High BOD waste in the past has contributed to an anoxic environment and the input of pulpmill effluent

and debris from associated forest products industries perpetuate this problem. The benthic invertebrate populations in the inner harbour are not typical of estuarine systems. EPS records (Sullivan, 1980) show a depauperate community structure at station located inside Polly Point. The feeding habits of juvenile salmonids were observed to be altered by Birtwell and Harbo (1980). A study in progress by the University of Victora centres on the gutless bivalve, Solemya reidi, a species peculiar to pulpmill areas, possibly for food availablity or predator avoidance, but notably areas of extraodinary carbon energy sources (Reid and Bernard, 1980).

5.1.3 Biobasin Dredging Program. The failure of the biological treatment facility to effectively reduce BOD because of solids settling in the biobasin required that the company dredge during December-January of 1980-1981 and 1981-1982. The company conducted an extensive monitoring program at the request of the federal government during the 1981-1982 dredging period. Analysis of the results have been prepared by the company. A survey of benthic and water quality was completed by EPS in March 1982. The results are presented in this report.

5.2 Effluent Data

Effluent data for 1981 supplied by the company for suspended solids and BOD_5 is presented below toxicity tests (8) were passed 87.5% of the time at an LC_{50} = 90% (v/v).

	Actual	Permitted
BOD_5	13.5 kg/t (7.1-24.3)	17.5 kg/ADt
SS	13.3 kg/t (6.6-31.5)	10.0 kg/ADt

Suspended solid greatly increased in Janauary and December due to biobasin dredging operations and in September following start-up after a two month closure due to labour disputes.

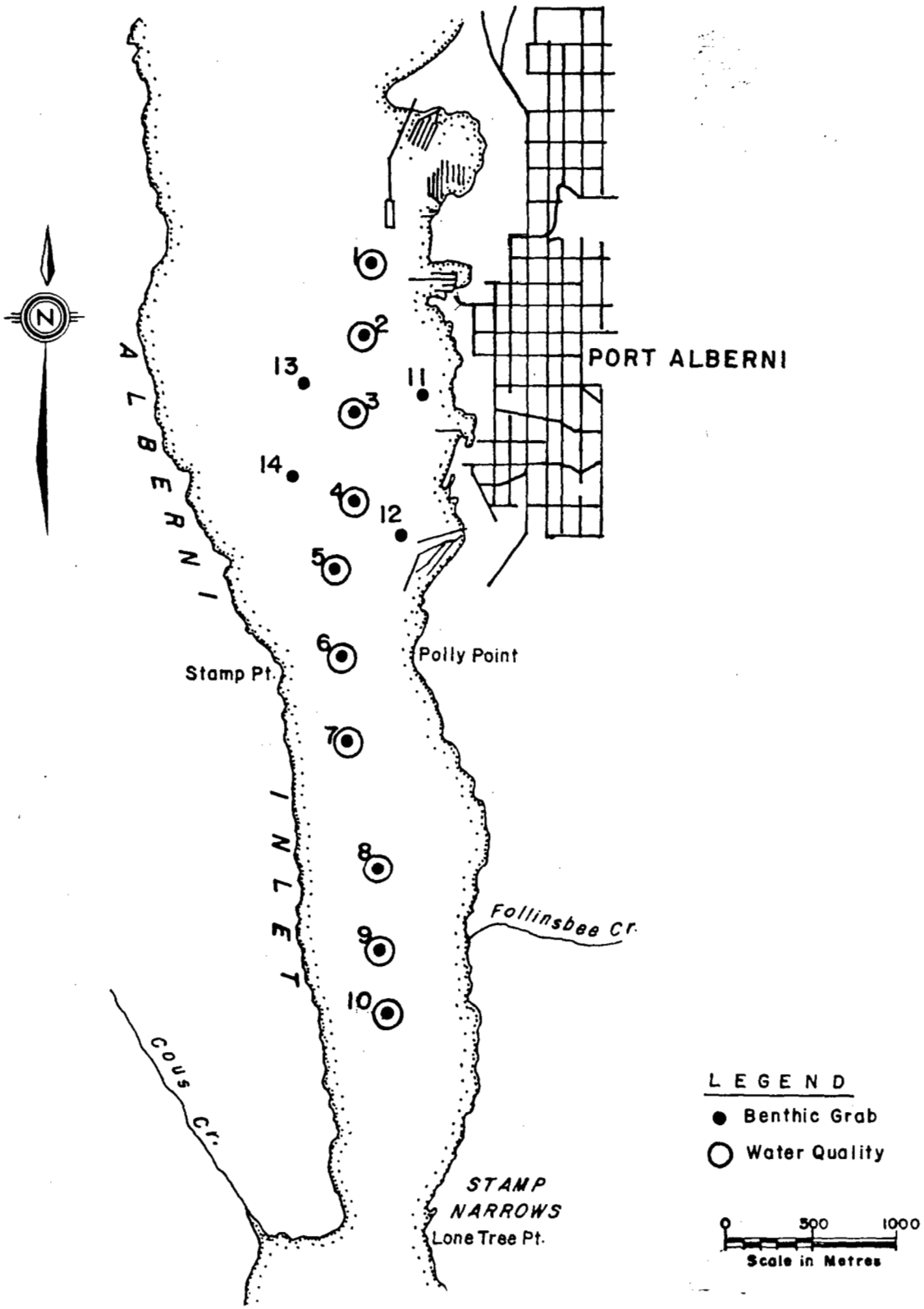

FIGURE 5 WATER QUALITY AND BENTHIC GRAB STATIONS - ALBERNI INLET - 1981

5.3 Results and Discussion

5.3.1 Water Quality. The distinct temperature and salinity stratification often observed in Alberni Harbour was identified at 2-5 metres in June 1981 (Table 9). Salinities were between 1.48 and 10.20 o/oo at the 2 metre depth at all stations, a clear indication of the Somass River. The dissolved oxygen levels at all stations at 5 metres and below were less than 4.35 mg/l. At several stations (Figure 5), samples hear the bottom were below 1 mg/l. This severely limits available living space for fisheries stocks (Birtwell and Harbo, 1980).

July 1981 water quality (Table 10) was similar to that measured in June; however, surface water temperatures are noticeably higher (20°C). D.O. levels are exceedingly poor at and below 5 metres, with the exception of Station 10, approximately 5 km from the outfall.

Following a closure of the mill due to a labour dispute, a survey in September (Table 11) showed low D.O. values were only observed at or below 10 metre sampling depths (Since this was not a regularly scheduled pulpmill monitoring survey not all stations and depths were sampled.) The distinct stratifications of salinity and temperatures are not apparent in September.

The water quality results from 4 March 1982, (Table 12) which followed the biobasin dredging program and the annual clarifier bypass operation show a very stable dissolved oxygen regime, including those depths in and below the halocline. The profiling was repeated on 5 March (Table 13) with similar results. It would appear from these numbers that conditions are periodically environmentally acceptable in Alberni Harbour despite past history. The system is known to fluctuate seasonally, and as a result of waste input, however, water quality results such as this are encouraging.

Colour is well contained above 5 metres (Tables 14, 15 and 16) at all stations. As expected, levels are highest (17 colour units) in the surface waters immediately adjacent to the outfall.

Residue analysis results from March 1982 are presented in Table 17. There is no clear pattern of non-filterable or volatile non-filterable residues in the inner harbour, indeed in several samples non-filterable residues were below detection limits (< 5 mg/l). Levels will vary with river flow rates and seasonal growth of plankton populations.

Dissolved metal results (Table 18) were well below levels that would generate concern.

5.3.2 Benthic Quality

5.3.2.1 Sediment. Trace metal analysis results from June 1981 and March 1982 are comparable (Tables 19 to 23). Two features of the results are worth noting. Elevated cadmium levels occur at most sites in the inner harbour and extend to the dumpsite vicinity. Lowest levels are recorded at stations 1, 2 and 3 in June 1981. Similar results were recorded in March, with low levels at Station 11 (Figure 5) and in the Somass River sediment (Station 17). Cadmium > 2 mg/kg was found at Stations 8 and 10 (near the ocean dumpsite) and Station 16 (Biopond). The higher levels recorded in March 1982 may be an analytical anomaly.

Zinc levels are uniform, with the following exceptions. Somass River sediment, or likely background levels, was recorded at 128 mg/kg. Near the assembly dock, Station 1, zinc concentrations were 479.0 to 522.0 mg/kg, June and March surveys, respectively. Immediately adjacent to the effluent discharge location, 2460 mg/kg were found and in a Biobasin sludge sample, 5060 mg/kg was recorded. Clearly, zinc has been discharged from the biobasin in very high quantities.

The elevated zinc concentrations undoubtly result from past use of zinc hydrosulphite at the pulpmill. The presence of very high zinc levels, similar to those in the biobasin, in a location where zinc was previously much lower suggests appreciable, rapid settling of biobasin

sludge during discharge. The additional load of biobasin wastes in the inner harbour is not a desirable occurrence in view of the severely degraded environment at present.

5.3.2.2 Benthic Invertebrates (Appendix I). The analysis of benthic invertebrates showed little variation from results collected in June 1980 (Sullivan, 1981).

The most dominant taxa were polychaetes, Schistomeringos sp. being most common. (This genus was created in 1974 as a result of splitting Dorvillea into Dorvillea and Schistomeringos.)

A large number of the bivalve, Diplodonta orbellus was recorded, particularily at Station 7.

Numbers of individuals were low and the dominance by polychaetes and virtual exclusion of other taxa point to a poor and depauperate benthic community.

Depths at each station will effect to some degree the community structure. Substrates at most stations are wood fibre or wood debris which will also effect numbers and types of organisms.

TABLE 9 WATER QUALITY RESULTS - PORT ALBERNI, B.C., JUNE 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	14.89	1.73	8.65	88.98
2.0	14.81	1.78	8.40	86.29
5.0	10.79	29.54	2.55	28.47
10.0	10.14	30.33	2.68	29.64
Station 2				
0.0	15.31	1.82	8.20	85.13
2.0	14.70	2.44	7.90	81.27
5.0	10.92	28.04	2.35	26.05
10.0	10.14	30.94	3.08	33.87
Station 3				
0.0	15.19	2.20	8.40	87.17
2.0	14.64	3.10	9.25	95.40
5.0	10.70	28.98	2.58	28.64
10.0	10.18	30.83	2.80	31.10
15.0	10.02	31.25	1.10	12.21
Station 4				
0.0	15.25	1.48	8.60	89.00
2.0	14.70	5.49	7.60	79.56
5.0	10.89	27.75	2.70	29.85
10.0	10.18	30.78	2.70	29.98
15.0	10.04	31.22	0.75	8.32
20.0	9.99	31.47	0.65	7.22
Station 5				
0.0	15.30	2.13	8.10	84.22
2.0	14.39	6.32	7.60	79.42
5.0	10.40	29.68	3.50	38.77
10.0	10.14	30.87	2.80	31.08
15.0	10.02	31.25	0.81	8.99
20.0	9.92	31.54	0.40	4.44

TABLE 9 WATER QUALITY RESULTS - PORT ALBERNI, B.C., JUNE 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 6				
0.0	15.31	2.51	8.40	87.54
2.0	14.50	6.42	7.90	82.80
5.0	10.60	29.98	3.40	37.91
10.0	10.15	30.92	3.85	42.75
15.0	10.08	31.14	3.50	38.86
25.0	9.89	31.67	0.50	5.55
Station 7				
0.0	15.45	2.78	8.15	85.31
2.0	14.39	6.94	7.80	81.81
5.0	10.80	28.62	2.68	29.74
10.0	10.32	30.79	4.35	48.45
15.0	10.09	31.55	3.60	40.09
30.0	9.88	32.14	1.10	12.24
Station 8				
0.0	14.94	5.61	8.25	86.85
2.0	13.97	10.20	7.80	82.65
5.0	10.59	30.42	1.60	17.89
10.0	10.22	31.15	4.00	44.56
20.0	9.97	32.21	1.60	17.85
40.0	9.77	33.53	1.40	15.69
Station 9				
0.0	15.10	5.52	8.45	89.20
2.0	14.84	5.81	8.30	87.30
5.0	11.17	25.38	3.54	38.78
10.0	10.23	31.95	4.96	55.57
20.0	9.99	32.14	2.40	26.77
50.0	9.69	33.29	2.40	26.80
Station 10				
0.0	15.21	6.04	8.30	88.08
2.0	15.03	6.06	8.40	88.82
5.0	11.12	25.58	3.50	38.35
10.0	10.21	31.68	3.75	41.92
25.0	9.92	32.51	0.60	6.70
60.0	9.60	32.73	1.70	18.87

TABLE 10 WATER QUALITY RESULTS - PORT ALBERNI, B.C., JULY 1981

DEPTH (m)	TEMPERATURE (°C)*	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0	23.28	5.24	9.35	115.00
2	19.51	8.57	8.75	102.57
5	10.89	30.40	2.50	28.12
10	10.31	31.30	3.65	40.82
Station 2				
0	22.80	3.62	9.05	109.43
2	20.84	10.86	8.25	100.48
5	11.09	30.04	3.50	39.45
10	10.34	31.33	1.85	20.69
Station 3				
0	23.68	4.15	9.10	112.20
2	21.54	9.84	7.65	93.75
5	11.27	30.48	3.55	40.29
10	10.32	31.33	2.25	25.13
Station 4				
0	24.09	-	8.95	-
2	19.53	10.01	8.65	102.24
5	11.21	30.16	3.80	42.98
10	10.38	31.17	3.0	33.55
18	9.92	31.75	0.90	10.00
Station 5				
0	22.60	7.98	9.2	113.73
2	17.63	17.28	6.6	78.63
5	13.16	25.58	3.8	43.54
10	10.72	30.96	2.4	27.01
20	10.06	31.79	0.5	5.57

TABLE 10 WATER QUALITY RESULTS - PORT ALBERNI, B.C., JULY 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 6				
0	-	7.83	8.5	-
2	22.50	7.81	8.8	108.47
5	12.57	28.94	3.2	37.02
10	10.90	30.81	3.9	44.04
20	10.20	31.46	1.3	14.51
Station 7				
0	22.62	7.21	8.7	107.10
2	22.27	7.97	8.6	105.66
5	11.35	30.28	3.7	42.04
10	10.77	31.06	4.5	50.73
25	9.94	31.81	0.9	10.01
Station 8				
0	-	7.37	8.4	-
2	18.95	17.38	6.6	80.70
5	11.20	30.49	3.8	43.09
10	10.75	31.05	4.30	48.45
25	9.93	31.84	0.60	6.67
50	9.69	32.14	2.05	22.71
Station 9				
0	22.16	9.91	8.95	110.01
2	21.90	10.19	8.80	108.82
5	11.19	30.56	4.50	51.05
10	10.56	31.18	3.50	39.30
25	9.88	31.85	2.00	22.21
50	-	32.16	2.30	-
Station 10				
0	22.37	9.18	8.70	107.86
2	21.48	9.36	8.75	106.86
5	11.17	14.92	7.30	74.88
10	10.56	30.89	4.85	54.35
25	9.89	31.65	1.80	19.97
50	9.62	32.16	2.45	27.11

*Stations 1-4 PLESSEY CTD RESULTS

TABLE 11 WATER QUALITY RESULTS - PORT ALBERNI, B.C., SEPTEMBER 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0	18.21	4.55	7.70	86.30
2	16.35	19.90	7.50	88.54
5	16.20	24.50	7.60	89.97
10	11.33	31.29	3.60	41.14
Station 2				
0	18.26	7.12	7.50	85.13
2	16.14	21.65	7.70	99.55
5	-	25.18	6.30	-
10	-	31.24	2.40	-
Station 3				
0	17.81	11.67	8.00	93.24
2	16.67	20.27	7.50	89.28
5	15.28	24.31	6.70	79.57
10	11.59	31.15	3.60	41.37
Station 4				
0	17.82	13.91	8.30	97.18
2	16.04	21.20	7.30	86.39
5	14.93	24.70	5.90	69.73
10	11.13	32.67	2.20	25.28
Station 5				
0	17.77	9.87	8.00	91.42
2	15.73	22.99	7.10	84.42
5	14.47	25.54	6.20	73.02
10	11.23	31.39	2.30	26.25
Station 6				
0	17.91	10.26	8.00	91.84
2	16.70	22.32	7.10	85.74
5	14.46	26.67	6.40	75.91
10	11.36	31.50	2.00	22.90
25	10.39	31.71	0.80	8.97
Station 10				
0	17.57	11.66	8.30	95.40
2	16.01	22.56	7.50	89.39
5	13.71	27.91	5.70	67.13
10	11.23	31.36	3.50	39.95
25	10.40	31.71	2.00	22.44
50	9.73	32.11	1.20	13.30

TABLE 12 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 4,1982

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	4.43	4.18	0.10*	0.82
1.0	4.98	4.87	11.45	95.34
2.0	6.82	14.18	9.45	87.11
3.0	7.83	26.01	8.05	81.92
4.0	8.13	28.54	7.55	78.70
5.0	8.24	27.89	7.25	75.44
10.0	8.47	28.19	7.05	73.91
Station 2				
0.0	4.58	2.55	12.10	98.41
1.0	4.58	2.98	12.20	99.47
2.0	6.77	14.11	9.05	83.28
3.0	8.03	27.02	7.35	75.68
4.0	8.08	27.76	7.55	78.20
5.0	8.13	28.10	7.40	76.92
10.0	8.46	28.83	6.55	68.96
Station 3				
0.0	4.88	2.61	12.15	99.62
1.0	5.08	3.40	11.95	98.92
2.0	6.00	10.09	10.15	89.45
3.0	7.41	24.66	8.10	80.90
4.0	8.02	27.35	7.40	76.33
5.0	8.12	27.96	7.45	77.34
10.0	8.48	28.86	6.40	67.41
15.0	8.48	29.05	6.75	71.20
Station 4				
0.0	4.88		12.30	
1.0	5.08	2.49	12.15	100.07
2.0	6.59	10.82	9.85	88.48
3.0	7.72	25.90	8.00	81.15
4.0	8.03	27.28	7.75	79.92
5.0	8.03	27.77	8.20	84.83
10.0	8.42	29.03	7.85	82.67
15.0	8.55	28.91	7.10	74.94

TABLE 12 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 4, 1982

(Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 5				
0.0	4.87	2.23	12.15	99.38
1.0	5.17	3.74	11.85	98.52
2.0	6.75	13.20	9.60	87.81
3.0	7.71	23.86	8.10	81.06
4.0	7.91	27.44	7.95	81.84
5.0	8.12	27.77	7.15	74.13
10.0	8.39	28.30	6.20	64.93
15.0	8.55	28.84	6.50	68.58
20.0	8.80	28.83	5.35	56.77
Station 6				
0.0	4.88	2.46	12.02	98.46
1.0	4.97	3.04	12.00	98.86
2.0	6.05	12.12	10.00	89.30
3.0	7.71	25.78	8.30	84.11
4.0	7.92	27.32	8.05	82.82
5.0	8.02	27.79	8.10	83.79
10.0	8.47	28.04	6.65	69.65
15.0	8.40	29.39	7.45	78.60
20.0	8.80	28.84	6.95	73.75
25.0	8.80	29.78	6.25	66.75
Station 7				
0.0	4.88	2.29	12.10	99.03
1.0	5.08	3.11	11.95	98.76
2.0	6.30	11.96	10.20	91.58
3.0	7.71	24.41	8.25	82.86
4.0	7.89	27.48	8.30	85.42
5.0	8.02	27.86	8.10	83.83
10.0	8.31	27.82	7.90	82.32
15.0	8.35	28.63	7.50	78.63
25.0	8.54	28.45	7.10	74.69

TABLE 12 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 4, 1982

(Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 8				
0.0	4.87	1.99	12.60	102.93
1.0		3.03	11.75	
3.0	6.07	25.75	10.45	101.66
3.0	7.71	25.66	8.35	84.54
4.0	7.91	27.27	8.20	84.31
5.0	7.96	28.14	8.30	85.93
10.0	8.13	28.12	7.95	82.64
15.0	8.39	29.74	7.10	75.07
20.0	8.54	28.73	7.05	74.30
50.0	10.26	31.27	2.00	22.32
Station 9				
0.0	4.89	2.05	12.25	100.15
1.0	5.09	3.27	11.60	95.98
2.0	6.64	19.06	9.00	85.11
3.0	7.83	27.32	8.30	85.21
4.0	7.99	27.64	8.00	82.61
5.0	8.08	28.14	8.00	83.08
10.0	8.17	29.11	8.25	86.42
15.0	8.27	28.03	7.70	80.27
20.0	8.52	28.77	7.75	81.67
55.0	10.20	31.15	2.20	24.50
Station 10				
0.0	5.16	19.07	12.25	111.57
1.0	5.07	20.19	11.70	107.07
2.0	6.21	30.59	10.40	104.82
3.0	7.79	27.44	8.35	85.70
4.0	7.89	27.47	8.30	85.42
5.0	8.09	27.87	8.00	82.95
10.0	8.22	28.41	7.80	81.41
15.0	8.27	28.62	7.90	82.67
20.0	8.57	28.90	7.25	76.56
60.0	10.30	31.34	1.45	16.21

*rogue number

TABLE 13 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 5, 1982

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	5.20	3.89	10.85	90.36
1.0	6.48	10.82	10.50	94.05
2.0	6.78	15.90	9.50	88.39
3.0	7.52	17.31	9.25	88.42
4.0	7.92	25.54	7.80	79.32
5.0	7.95	26.53	7.50	76.82
Station 2				
0.0	4.98	2.15	12.85	105.37
1.0	5.66	8.83	11.20	97.11
2.0	6.53	13.28	10.05	91.48
3.0	7.34	20.74	8.50	82.65
4.0	7.85	26.21	7.85	80.04
5.0	7.90	27.44	8.05	82.84
10.0	8.24	28.20	6.85	71.44
Station 3				
0.0	5.03	2.65	12.60	103.74
1.0	5.68	7.68	11.25	96.95
2.0	6.81	14.48	9.90	91.39
3.0	7.49	18.51	9.25	89.01
4.0	7.82	26.24	7.95	81.01
5.0	7.89	27.29	8.30	85.32
10.0	8.19	28.03	7.60	79.07
15.0	8.35	28.46	6.50	68.07
Station 4				
0.0	5.03	3.37	12.05	99.61
1.0	5.50	7.37	11.40	97.60
2.0	6.09	9.33	10.90	95.84
3.0	7.24	21.14	8.50	82.65
4.0	7.85	26.90	8.25	84.51
5.0	7.98	27.60	8.05	83.10
10.0	8.18	28.36	6.70	69.84
15.0	8.31	28.59	7.10	74.36

TABLE 13 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 5, 1982

(Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 5				
0.0	5.23	2.90	12.45	103.18
1.0	5.52	6.11	11.75	99.93
2.0	5.84	9.44	10.80	94.43
3.0	7.71	25.45	7.75	78.36
4.0	7.97	27.06	7.50	77.11
5.0	7.96	27.65	8.00	82.57
10.0	8.29	28.22	6.90	72.05
15.0	8.50	28.59	6.35	66.80
20.0	8.60	28.80	6.50	68.64
Station 6				
0.0	5.23	3.39	12.30	102.23
1.0	5.65	5.55	11.60	98.67
2.0	7.19	12.34	9.05	83.25
3.0	7.79	26.20	8.40	85.51
4.0	7.95	27.53	7.95	81.96
5.0	8.05	27.82	8.05	83.35
10.0	8.33	28.39	6.45	67.49
15.0	8.58	28.66	5.95	62.75
20.0	8.60	28.81	5.95	62.84
25.0	8.70	29.03	6.00	63.61
Station 7				
0.0	5.23	3.55	12.25	101.89
1.0	5.77	4.47	12.90	109.37
2.0	6.17	9.01	10.60	93.20
3.0	7.39	20.01	8.90	86.25
4.0	7.76	26.58	8.45	86.18
5.0	7.91	27.67	8.15	84.02
10.0	8.12	28.34	7.90	82.22
15.0	8.29	28.92	6.85	71.87
20.0	8.19	28.94	5.80	60.71
25.0	8.86	29.20	4.90	52.20

TABLE 13 WATER QUALITY RESULTS - PORT ALBERNI, B.C., MARCH 5, 1982

(Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 8				
0.0	5.25	4.17	11.85	98.97
1.0	5.59	4.60	11.75	99.25
2.0	5.81	8.33	11.10	96.35
3.0	6.18	14.61	9.75	88.67
4.0	6.20	24.66	8.70	84.31
5.0	6.65	26.75	8.65	85.95
10.0	8.05	28.34	7.90	82.09
15.0	8.25	28.63	7.30	76.37
20.0	8.46	28.91	7.00	73.72
50.0	10.24	28.86	2.10	23.05
Station 9				
0.0	5.35	3.30	12.45	103.74
1.0	5.52	4.82	11.95	100.88
2.0	6.41	10.50	10.75	95.95
3.0	7.41	21.47	8.90	87.07
4.0	7.70	26.90	8.70	88.78
5.0	7.81	27.34	8.60	88.26
10.0	8.11	28.33	7.90	82.19
15.0	8.26	28.70	8.05	84.27
20.0	8.72	28.93	7.50	79.49
25.0	10.24	31.50	2.00	22.35
Station 10				
0.0	5.30	3.84	12.00	100.16
1.0	5.64	6.35	11.45	97.81
2.0	6.09	9.61	10.85	95.54
3.0	7.42	21.61	8.50	83.26
4.0	7.78	26.69	8.65	88.32
5.0	7.88	27.53	8.70	89.53
10.0	8.08	28.41	8.25	85.81
15.0	8.25	28.38		
20.0	8.71	28.95	7.50	76.49
60.0	10.24	31.46	2.30	25.69

TABLE 14 COLOUR ANALYSIS - PORT ALBERNI, B.C., JUNE 1981 (colour units)

DEPTH (m)	Station 1	2	3	4	5	6	7	8	9	10
0	12	17	9	8	12	7	9	9	7	4
2	12	11	9	6	6	6	7	5	8	6
5	0	1	0	1	0	0	1	0	2	3
10	0	0	0	0	0	0	0	0	0	0

TABLE 15 COLOUR ANALYSIS - PORT ALBERNI, B.C., JULY 1981 (colour units)

DEPTH (m)	Station 1	2	3	4	5	6	7	8	9	10
0	6	5	1	6	5	4	3	7	6	-
2	4	7	6	7	6	5	7	7	1	4
5	1	0	0	1	4	4	1	0	3	3
10	2	0	0	0	1	1	0	0	1	-

TABLE 16 COLOUR ANALYSIS - PORT ALBERNI, B.C., MARCH 1982 (colour units)

DEPTH (m)	Station 1	2	3	4	5	6	7	8	9	10
0	17	9	11	11	7	10	9	8	8	3
2	8	8	10	8	9	11	6	11	4	5
5	0	0	2	0	1	1	1	0	1	1
10	0	0	1	1	1	0	0	1	1	0

TABLE 17 WATER QUALITY: NON-FILTERABLE RESIDUES AND VOLATILE NON-FILTERABLE RESIDUES - PORT ALBERNI, B.C. MARCH 1982
(mg/l)

STATION		DEPTH (metres) 0	1	2	3	4	5	10	15	20	25	50
1	NFR	17	15	23	23	17	19	10				
	VNFR	L5	14	L5	L5	L5	L5	L5				
2	NFR	10	10	12	L5	L5	6	10				
	VNFR	L5	L5	L5	L5	L5	L5	L5				
3	NFR	7	L5	L5	7	L5	L5	9	L5			
	VNFR	L5	L5	L5	L5	L5	L5	9	L5			
4	NFR	L5	L5	L5	10	11	L5	7	12			
	VNFR	L5	L4	L5	5	L5	L5	7	6			
5	NFR	L5	6	L5	10	11	17	11	35	12		
	VNFR	L5	L5	L5	10	L5	13	L5	L5	L5		
6	NFR	10	7	15	46	29	12	38	L5	9	6	
	VNFR	L5	L5	L5	11	L5	5	11	L5	9	L5	
7	NFR	8	7	14	15	5	23	27	23		23	
	VNFR	8	6	8	11	5	9	10	13		7	
8	NFR	9	8	20	28	19	L5	50	20	27		7
	VNFR	9	8	L5	9	6	L5	18	7	10		6
9	NFR	L5	6	23	21	10	L5	25	28	11		9
	VNFR	L5	L5	5	L5	L5	L5	6	8	10		L5 (55m)
10	NFR	5	11	7	6	10	9	40	13	16		18
	VNFR	L5	L5	L5	L5	5	L5	9	6	5		5 (60m)

TABLE 18 DISSOLVED METALS - PORT ALBERNI, B.C. MARCH 1982
(ug/ml)

STATION	DEPTH	Hg	Cd	Pb	Zn	Cu
1	0 m	L.0002	L.0002	.014	.0167	.0101
	5 m	L.0002	.0004	.004	.0085	.0195
2	0 m	L.0002	.0005	.007	.0124	.0175
	5 m	L.0002	.0004	L.002	.0114	.0038
3	0 m	L.0002	.0005	.018	.0179	.0132
	5 m	L.0002	.0007	L.002	.0143	.0051
4	0 m	L.0002	.0002	.006	.0092	.0105
	5 m	L.0002	.0004	L.002	.0115	.0153
5	0 m	L.0002	L.0002	.005	.0093	.0067
	5 m	L.0002	L.0002	L.002	.0098	.0124
6	0 m	L.0002	L.0002	L.002	.0031	.0022
	5 m	L.0002	.0003	L.002	.0166	.0031
7	0 m	L.0002	L.0002	L.002	.0022	.0053
	5 m	L.0002	.0003	.002	.0095	.0031
8	0 m	L.0002	L.0002	L.002	.0022	.0115
	5 m	L.0002	.0005	L.002	.0095	.0057
9	0 m	L.0002	L.0002	.015	.0098	.0055
	5 m	L.0002	.0003	L.002	.0113	.0035
10	0 m	L.0002	L.0002	L.002	.0019	.0020
	5 m	L.0002	L.0002	.002	.0107	.0078

TABLE 19 TRACE METAL LEVELS IN MARINE SEDIMENTS - GRAB SAMPLES - PORT ALBERNI, B.C., JUNE 1981

(mg/kg dry weight)

STATION	Cd	Pb	Zn	Cu
1	L0.58	20.7	479.0	63.1
2	L0.58	7.93	285.0	59.8
3	L0.58	10.3	155.0	68.9
4	0.805	10.3	219.0	63.8
5	0.640	10.6	212.0	65.5
6	0.929	11.0	217.0	72.3
7	0.782	10.8	182.0	62.8
8	0.871	L6.71	180.0	58.6
9	0.856	12.5	260.0	60.1
10	0.918	16.9	329.0	67.4

TABLE 20 TRACE METAL ANALYSIS IN MARINE SEDIMENTS
GRAB SAMPLES - PORT ALBERNI, B.C.
MARCH 1982
(mg/kg dry weight)

STATION	Hg	Cd	Pb	Zn	Cu
1	0.39	0.8	22.0	522.0	77.1
2	0.32	0.5	16.0	225.0	71.3
3	0.34	0.8	18.0	242.0	75.9
4	0.56	1.2	17.0	253.0	73.3
5	0.50	1.6	20.0	237.0	73.5
6	0.55	1.3	21.0	236.0	75.3
7	0.67	1.7	22.0	241.0	74.3
* 8	0.69	2.2	17.0	230.0	76.5
9	0.60	1.8	17.0	218.0	74.9
10	0.67	2.2	25.0	284.0	80.1
11	0.45	0.7	18.0	252.0	74.0
12	0.49	1.4	17.0	269.0	72.9
13	0.31	1.2	18.0	262.0	75.3
14	0.64	1.6	19.0	328.0	67.8
15	0.35	1.4	28.0	2460.0	82.7
16	0.37	2.1	45.0	5060.0	195.0
17	0.41	0.8	9.0	128.0	48.4

TABLE 21 TOTAL VOLATILE RESIDUES AND PARTICLE SIZING
GRAB SAMPLES - PORT ALBERNI, B.C.
JUNE 1981

STATION	TVR (mg/kg)	SAMPLE WEIGHT	35 MESH (500 um)		60 MESH (250 um)		100 MESH (149 um)		230 MESH (62.5 um)		L230 MESH	
			WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED
1	181	59.5	9.8	16.5	18.1	30.4	11.0	18.5	12.9	21.7	7.7	12.9
2	159	37.5	7.0	18.7	10.4	27.7	8.1	21.6	8.7	23.2	3.3	8.8
3	105	113.4	1.9	1.7	26.5	23.4	23.3	20.5	30.7	27.0	31.0	27.3
4	109	80.9	1.3	1.6	19.2	23.7	9.7	12.0	11.7	14.5	39.0	48.2
5	126	44.1	0.4	0.9	10.2	23.1	5.2	11.8	4.0	9.1	24.3	55.1
6	126	43.1	4.0	9.3	6.1	14.2	3.9	9.0	5.8	13.5	23.3	54.1
7	144	69.1	17.2	24.9	15.1	21.9	8.7	12.6	9.1	113.2	19.0	27.5
8	132	78.7	7.4	9.4	14.9	18.9	9.6	12.2	4.8	6.1	42.0	53.4
9	135	40.8	3.7	9.1	8.0	19.6	6.9	16.9	7.3	17.9	14.9	36.5
10	152	58.6	7.5	12.8	11.6	19.8	7.8	13.3	5.0	8.5	26.7	45.6

TABLE 22 TOTAL VOLATILE RESIDUES AND PARTICLE SIZING
GRAB SAMPLES - PORT ALBERNI, B.C.
MARCH 1982

STATION	TVR (mg/kg)	SAMPLE WEIGHT	35 MESH (500 um)		60 MESH (250 um)		100 MESH (149 um)		230 MESH (62.5 um)		L230 MESH	
			WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED
1	190	66.9	10.0	14.9	15.8	23.6	14.6	21.8	16.9	25.3	9.6	14.3
2	130	83.4	5.9	7.1	23.6	28.3	15.9	19.1	24.4	29.3	13.6	16.3
3	130	64.4	9.6	14.9	12.1	18.8	8.6	13.4	16.7	25.9	17.4	27.0
4	120	66.5	10.0	15.0	10.7	16.1	5.1	7.7	13.3	20.0	27.4	41.2
5	120	61.2	13.2	21.6	9.5	15.5	4.7	7.7	8.7	14.2	25.1	41.0
6	120	60.4	24.3	40.2	13.4	22.2	5.0	8.3	5.8	9.6	11.9	19.7
7	170	62.0	23.3	37.6	12.9	20.8	7.0	11.3	7.5	12.1	11.3	18.2
8	140	39.6	10.0	25.3	8.0	20.2	3.3	8.3	5.2	13.1	13.1	33.1
9	140	71.0	30.8	43.4	11.8	16.6	5.0	7.0	6.5	9.2	16.9	23.8
10	150	49.5	10.5	21.2	7.3	14.7	3.3	6.7	6.8	13.7	21.6	43.6
11	140	49.0	8.4	17.1	12.0	24.5	6.4	13.1	11.3	23.1	10.9	22.2
12	110	72.7	13.4	18.4	12.0	16.5	5.0	6.9	11.8	16.2	30.5	42.0
13	140	60.4	25.5	42.2	7.8	12.9	5.9	9.8	11.0	18.2	10.2	16.9
14	90	70.8	22.2	31.4	16.4	23.2	6.2	8.8	9.4	13.3	16.6	23.4
15	310	24.3	16.1	66.3	3.7	15.2	1.5	6.2	2.0	8.2	1.0	4.1
16	830	13.2	10.9	82.6	1.7	12.9	0.2	1.5	0.3	2.3	0.1	0.8

15 = Outfall, 16 = Biobasin

TABLE 23 SEDIMENT CHARACTERIZATION - PORT ALBERNI, B.C.
MARCH 1982

STATION	DEPTH	REMARKS
1	13 m	Strong H_2S odor, black decomposing fibre, white bacterial growth on surface of decomposing organic matter.
2	14 m	Strong H_2S odor, black decomposing wood fibre, bacterial growth on surface.
3	18 m	H_2S odor, black decomposing wood fibre, fine brown sediment on surface.
4	20 m	Fine, grey sediment, no odor, some wood fragments.
5	20 m	Fine, natural sediment, grey colour, no odor, wood debris.
6	27 m	Coarse sand, thin brown sediment on surface, no odor.
7	36 m	Natural sediment, wood debris.
8	59 m	Natural sediment, brown-green colour, no odor or wood debris.
9	63 m	Fine sediment, slight odor, no fibre or wood debris.
10	68 m	Natural sediment, grey-green colour, no odor or fibre.

Continued...

TABLE 23 SEDIMENT CHARACTERIZATION - PORT ALBERNI, B.C.
MARCH 1982

STATION	DEPTH	REMARKS
11	19 m	Black decomposing sediment, strong H_2S odor, thin layer sediment on surface.
12	28 m	Brown fine sediment (1 cm) over black, soft sediment, no H_2S odor, wood fragments.
13	16 m	Black decomposing sediment, thin brown surface layer, strong H_2S odor.
14	21 m	Grey-brown sediment, small rocks and wood fragments, no H_2S odor.
15		At outfall containment perimeter.
16		Biobasin sludge.
17		Somass River sediment.

6. PORT MELLON - THORNBROUGH CHANNEL

6.1 Perceived Impacts

6.1.1 Receiving Water. Phytoplankton productivity (Stockner, et al, 1975; Stockner and Costella, 1976) at Port Mellon was 90% reduced between sites near the pulpmill and the control site (2 km from the mill). Poor light conditions were shown to be the major cause.

In preference-avoidance experiments, juvenile chinook, coho and chum salmon avoided surface waters near the pulpmill and high colour significantly correlated with these findings (Birtwell and Harbo, 1980).

6.1.2 Benthic. The gasiferous fibre beds adjacent to the outfalls and the debris from log handling and storage have impacted subtidal communities in the vicinity of the mill (McDaniel, 1973).

Observations from the PISCES IV submersible (EPS, 1976) substantiated the findings of Chang and Levings (1976) that substrate type was important in structuring bottom communities. The fine fibrous sediment typical of pulpmill areas is avoided by most marine species tested.

6.1.3 Intertidal. Discharge of lime mud and fibre build-up on the intertidal area has severly depressed intertidal communities southeast of the pulpmill. The disposal of lime mud terminated several years ago but the effects of the smothering still persist (Levings and McDaniel, 1976).

Pedlow (1974) studied the effects of BKME on the growth and physiology of Pacific oysters transplanted to the Port Mellon area. Proximity to the pulpmill correlated with mortality and deteriorated oyster condition within a zone of influence of between 0.5 and 0.8 km south of the mill.

6.2 Effluent Data

Effluent data for 1981 supplied by the company for suspended solids and BOD_5 is presented below. No toxicity data was made available.

	Actual	Permitted
BOD_5	30.7 kg/t (24.5-42.5)	17,400 kg/day
SS	17.9 kg/t (11.4-28.9)	10,150 kg/day

The suspended solids levels exceed federal standards (7.8 kg/ADt) for all months sampled. It has been noted that with level "B" discharge, a fibre bed will undoubtly develop at the end of the diffuser.

6.3 Results and Discussion

6.3.1 Water Quality. The salinity profiles for both June and August, 1981, indicate the influence of freshwater input, with surface salinities from 6.24 to 8.40 o/oo in June and 7.85 to 9.64 o/oo in August (Tables 24 and 25, Figure 6). Standard hydrographic depths were not employed during the June survey. Temperature profiles are typical of B.C. coastal waters for summer surveys, with thermoclines more pronounced in August. Dissolved oxygen profiles were stable to depth at the stations sampled. The impact of the pulpmill discharge has in the past been localized, primarily effecting intertidal and sub-tidal benthic communities (Nelson, 1979), and the June survey confirmed that pattern. The band of highly oxygen saturated water observed at 2 metres in August at several stations is unusual, possibly the result of a phytoplankton bloom.

6.3.2 Benthic Quality.

6.3.2.1 Sediment. Trace metal analysis results are presented in Tables 26, 27 and 28 (Figure 7). Cadmium levels are elevatd: 4.54 mg/kg,

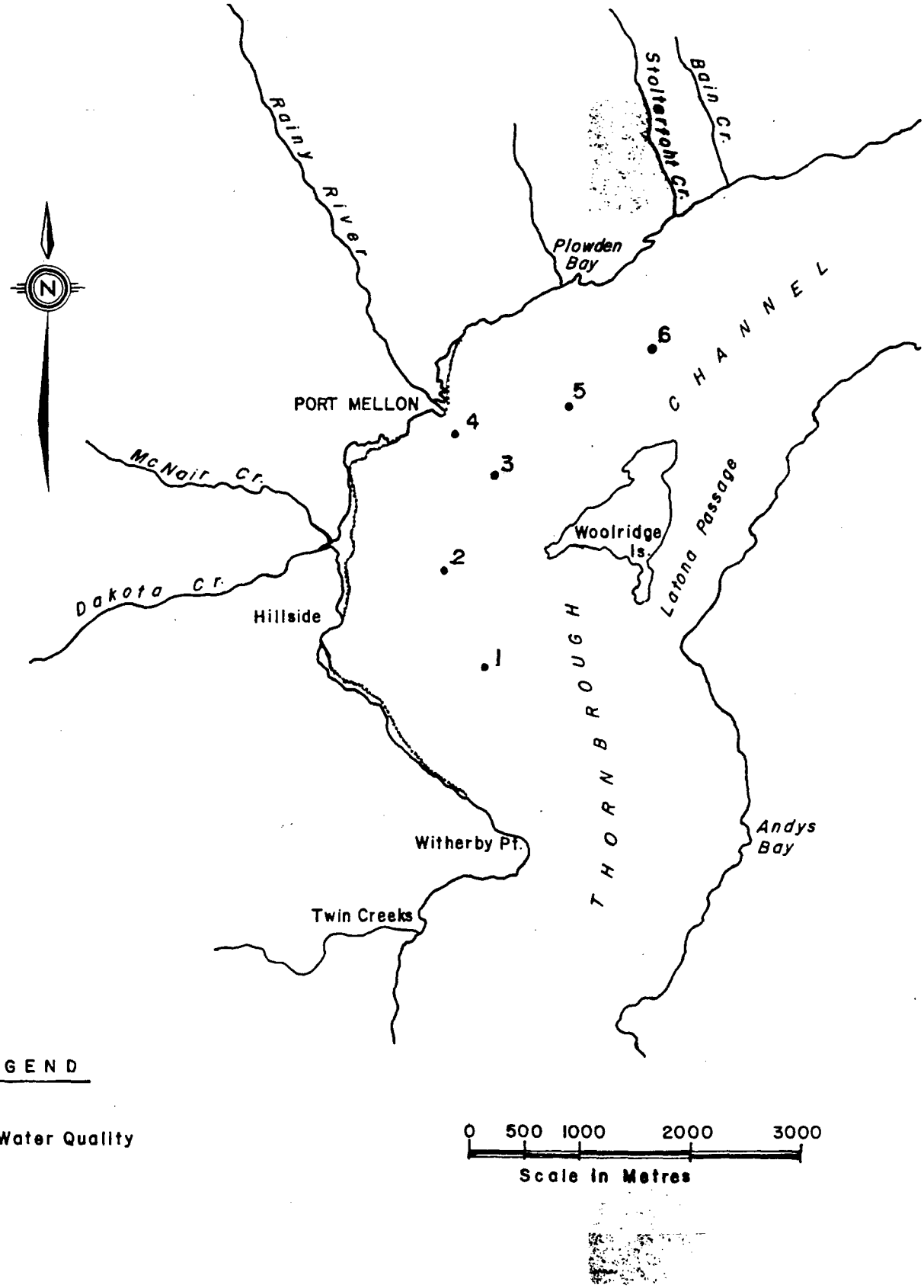

FIGURE 6 WATER QUALITY STATIONS, THORNBROUGH CHANNEL - 1981

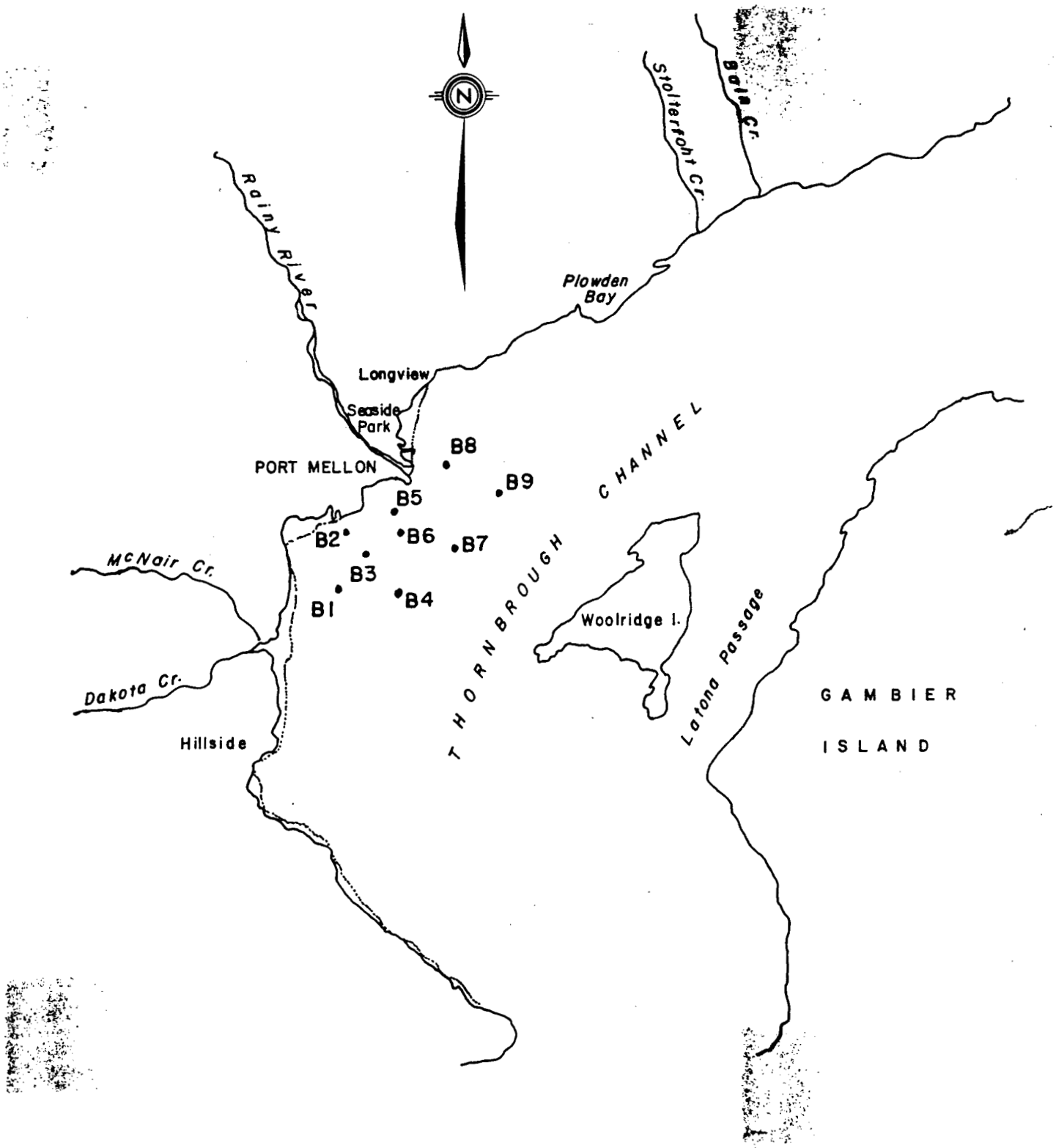

FIGURE 7 BENTHIC GRAB STATIONS - THORNBROUGH CHANNEL - 1981

at Station B2, the site sampled closest to the pulpmill operation. Zinc and copper concentrations were also highest at this location. Sediments at Station B2 contained large amounts of fibre and wood debris and had a strong H_2S odor, indicative of decomposition (Tables 26 and 27). Future benthic surveys will concentrate efforts in sub-tidal areas closer to the mill to document existing benthic quality, as well as periodic examinations of previously sampled locations.

6.3.2.2 Benthic invertebrates. Benthic invertebrates were collected at 3 locations in 1981 (Appendix II). The sediments were composed of sandy brown mud with some wood debris, but an absence of fibre. The communities at all stations were dominated by polychaetes. At Station B5, nearest the pulpmill, Diplodonta orbellus were collected in large numbers.

TABLE 24 WATER QUALITY RESULTS - PORT MELLON, B.C., JUNE 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	14.39	8.40	9.40	99.42
5.0	12.24	21.89	7.90	86.66
10.0	10.22	26.37	7.10	76.62
20.0	8.84	29.12	6.70	71.30
40.0	8.58	29.58	6.30	66.85
100.0	8.80	30.24	5.70	61.06
Station 2				
0.0	13.63	6.24	10.10	103.82
5.0	11.77	21.93	7.70	83.61
10.0	10.11	26.74	7.00	75.53
20.0	8.80	29.21	6.20	65.97
40.0	8.59	29.72	7.20	76.48
100.0	8.81	30.25	5.90	63.22
Station 3				
0.0	14.40	6.73	9.70	101.63
5.0	12.88	17.98	8.20	88.99
10.0	10.12	26.56	6.90	74.38
20.0	8.79	29.19	6.10	64.87
40.0	8.59	29.72	5.60	59.48
100.0	8.81	30.24	5.90	63.23

TABLE 24 WATER QUALITY RESULTS - PORT MELLON, B.C., JUNE 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 4				
0.0	14.66	6.91	10.00	105.46
5.0	12.53	17.64	8.40	90.29
10.0	10.00	26.56	6.90	74.19
20.0	14.16	29.06	5.90	70.65
40.0	8.60	29.70	5.90	62.68
80.0	8.69	30.06	5.70	60.82
Station 5				
0.0	14.92	8.02	9.70	103.51
5.0	12.13	20.25	8.40	90.97
10.0	10.04	26.76	7.00	75.42
20.0	8.83	29.15	6.00	63.86
40.0	8.63	29.70	5.60	59.54
100.0	8.80	30.25	5.60	60.00
Station 6				
0.0	15.11	7.62	9.90	105.80
5.0	12.93	16.64	8.40	90.15
10.0	9.94	26.97	6.80	73.20
20.0	8.89	29.00	6.20	66.01
40.0	8.61	29.74	5.70	60.58
100.0	8.79	30.25	5.90	63.20

TABLE 25 WATER QUALITY RESULTS - PORT MELLON, B.C., AUGUST 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 1				
0.0	19.13	9.64	10.30	120.62
2.0	17.84	22.20	12.80	157.90
5.0	15.23	26.17	10.60	127.33
10.0	12.93	27.32	8.90	102.63
25.0	10.42	28.66	10.10	111.16
50.0	9.05	29.63	5.70	61.17
100.0	9.01	30.44	5.20	56.06
Station 2				
0.0	19.72	8.91	10.10	119.07
2.0	17.63	21.98	12.80	157.05
5.0	14.92	26.04	11.20	133.56
10.0	12.55	27.53	7.70	88.20
25.0	10.41	28.65	5.90	64.92
50.0	9.08	29.60	5.90	63.36
100.0	8.96	30.44	5.10	54.92
Station 3				
0.0	19.48	8.89	9.80	115.02
2.0	17.66	22.51	12.80	157.66
5.0	15.41	25.95	6.20	74.65
10.0	12.55	27.50	8.20	93.90
25.0	10.31	28.72	6.00	65.90
50.0	9.02	29.63	5.50	58.98
100.0	8.97	30.43	4.90	52.77

TABLE 25 WATER QUALITY RESULTS - PORT MELLON, B.C., AUGUST 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station 4				
0.0	19.69	9.25	9.80	115.72
2.0	18.08	22.05	12.80	158.49
5.0	15.74	25.45	11.40	137.74
10.0	12.40	27.59	8.30	94.79
25.0	10.16	28.81	6.40	70.09
50.0	9.04	29.61	5.70	61.14
Station 5				
0.0	19.69	9.58	10.70	126.58
2.0	18.81	13.93	11.50	137.32
5.0	17.35	23.56	12.80	157.77
10.0	12.38	27.66	8.30	94.81
25.0	10.25	28.78	6.30	69.12
50.0	9.06	29.61	5.90	63.33
Station 6				
0.0	19.17	7.85	9.80	113.64
2.0	19.30	10.88	10.80	127.80
5.0	16.91	24.56	11.70	143.90
10.0	13.37	27.10	9.30	108.11
25.0	10.11	28.88	11.70	128.03
50.0	9.10	29.61	5.50	59.09
100.0	8.99	30.41	5.40	58.17

TABLE 26 TRACE METAL LEVELS IN MARINE SEDIMENTS
GRAB SAMPLES - PORT MELLON, B.C.
NOVEMBER 1981
(mg/kg)

STATION	Hg	Cd	Pb	Zn	Cu
B1	0.160	1.41	23.2	89.4	70.8
B2	L0.139	4.54	163.0	297.0	140.0
B3	0.166	1.33	40.5	109.0	87.1
B4	0.260	1.3	35.0	112.0	94.0
B5	0.192	0.7	28.3	85.6	66.0
B6	0.217	1.0	32.8	102.0	89.4
B7	0.166	0.6	26.9	81.1	62.4
B8	L0.144	L0.6	22.4	66.2	49.9
B9	L0.135	L0.6	16.3	59.4	39.5

TABLE 27 TOTAL VOLATILE RESIDUES AND PARTICLE SIZING
GRAB SAMPLES - PORT MELLON, B.C.
NOVEMBER 1981

STATION	TVR (mg/kg)	SAMPLE WEIGHT	35 MESH (500 um)		60 MESH (250 um)		100 MESH (149 um)		230 MESH (62.5 um)		L230 MESH	
			WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED	WEIGHT RETAINED	% RETAINED
B1	190	31.9	3.9	12.2	9.6	30.1	4.8	15.0	7.6	23.8	6.0	18.8
B2	250	33.4	10.6	31.7	7.5	22.5	6.7	20.0	5.2	15.6	3.4	10.2
B3	270	38.9	8.2	21.1	9.5	24.4	5.7	14.7	8.4	21.6	7.1	18.3
B4	220	61.6	3.2	5.0	7.0	11.4	11.1	18.0	20.0	32.5	20.3	33.0
B5	210	78.5	7.5	9.6	27.7	35.3	24.1	30.7	14.1	18.0	5.1	6.5
B6	180	36.3	1.5	4.1	3.1	8.5	3.5	9.6	11.2	30.9	11.6	39.5
B7	180	29.4	0.8	2.7	3.1	10.5	5.0	17.0	8.9	30.3	11.6	39.5
B8	120	40.7	0.2	0.5	2.8	6.9	8.7	21.4	14.0	34.4	15.0	36.9
B9	70	41.0	5.8	14.1	9.9	24.1	10.8	26.3	9.5	23.2	5.0	12.2

TABLE 28 SEDIMENT CHARACTERIZATION - GRAB SAMPLES
PORT MELLON, B.C. - NOVEMBER 1981

STATION	DEPTH	REMARKS
B1	152 m	Black, fibrous mud, wood debris, bark.
B2	26 m	Fibre, wood debris, some H_2S odor.
B3	143 m	Brown, sandy mud, some coarse fibre, shell fragments.
B4	205 m	Fine, brown mud.
B5	92 m	Sandy mud, black wood debris.
B6	153 m	Brown mud, some wood debris, molluscs.
B7	208 m	Brown mud, black wood debris.
B8	164 m	Sandy, brown mud, some wood debris.
B9	223 m	Sandy mud, covered with bark and wood debris.

7. WOODFIBRE - HOWE SOUND

7.1 Perceived Impacts

7.1.1 Receiving Water. The receiving water studies indicate that the environmental impacts from Woodfibre effluent discharges are confined to a relatively localized area adjacent to the mill and extend a short distance south of the mill. Good circulation and flushing in the surface waters due to the Squamish River flow has reduced environmental impacts of the surface effluent discharge (Nelson, 1979).

The strong light attenuating properties of kraft mill effluent were shown to be the major cause of reduced phytoplankton productivity. The impact appeared to be restricted to the immediate area of the pulpmill and the effect on total Howe Sound production was small (Stockner et al, 1975). Under certain conditions, nutrient enrichment from the effluent could enhance productivity if light conditions were suitable (Stockner and Costella, 1976).

Surface dissolved oxygen is strongly influenced by the Squamish River flow. The stratification created during freshet aids in dilution and dispersion of effluent discharged at the surface. The effects of tides, winds and currents also lessen the impact of KME. The deep benthic situation is also complex. Poor flushing and exchange because of restricted subsurface flow over the sill can result in an anoxic environment. Renewal occurs approximately every 3 years (Bell, 1974). Data collected by EPS in August 1981 shows a well mixed oxygen regime to 100 metres. The November 1981 data showed extremely low D.O. levels (< 1.0 mg/l below 100 metres) which is typical of the deep basin waters in Upper Howe Sound.

7.1.2 Benthic. Deep benthic communities have been examined by Levings, et al (1978), Levings and McDaniel (1980) and Levings (1980). Infrequent deep water exchange in upper basin results in a periodic anoxic environment, with devastating effects on marine invertebrates.

Subtidal communities examined by McDaniel (1973) show a reduction in diversity of marine invertebrates near the mill. The author concluded a combination of low salinity, turbidity, silt-loading and fibre deposition were responsible for the poor community structure. In addition, the build-up of a sludge bed can compound a poor dissolved oxygen regime by adding biological oxygen demands.

A Pisces IV dive film recorded in May 1979 by EPS, documents benthic conditions adjacent to the mill.

Benthic chemistry data was collected by EPS in November 1981. The heavy metal results indicate most metal levels do not warrant concern, although there is a slight elevation of cadmium in the immediate vicinity of the mill.

Further information on the receiving environment is available in Hoos and Vold (1974) and the Air and Water Quality Work Group Final Report for the Squamish Estuary Management Plan.

7.1.3 Intertidal. Local impact is severe (Levings and McDaniel, 1976) but restricted to mill vincinity. Toxic components of the effluent are believed responsible for the degradation in the intertidal zone, as well as the physical impact of log booming and log storage.

7.2 Effluent Data

Effluent data for 1981 supplied by the company for suspended solids and BOD_5 is presented below.

	Actual	Permitted
BOD_5	44.1 (30.8-60.9) kg/t	18,270 kg/day
SS	93.3 (23.6-161.1) kg/t	9,560 kg/day

No toxicity tests were conducted.

7.3 Results and Discussion

7.3.1 Water Quality. Water quality results are presented for August and November 1981 (Tables 29 and 30, Figure 8). The salinity profiles indicate the influence of freshwater input (both Mill Creek and the Squamish River) with surface salinities from 2.18-4.10 o/oo in August and from 2.38-12.73 o/oo in November. (The November survey was more extensive than August. See Tables). Temperature profiles are typical of B.C. coastal water, with the thermocline more pronounced later in the season. Dissolved oxygen profiles show stable conditions in the surface waters. At depth, however (greater than 150 meters) dissolved oxygen is very low (less than 1 mg/l). This is typical of deep basins and has been observed previously (Levings, 1980).

7.3.2 Benthic Quality. Trace metal analyses of marine sediment, in November, 1981 (Figure 8) do not show elevated levels of Hg, Cd, Cu, Pb or Zn (Table 31). It is known that fibre and wood debris have accumulated on the bottom and the spread of fibre remains the most pressing environmental concern in the area.

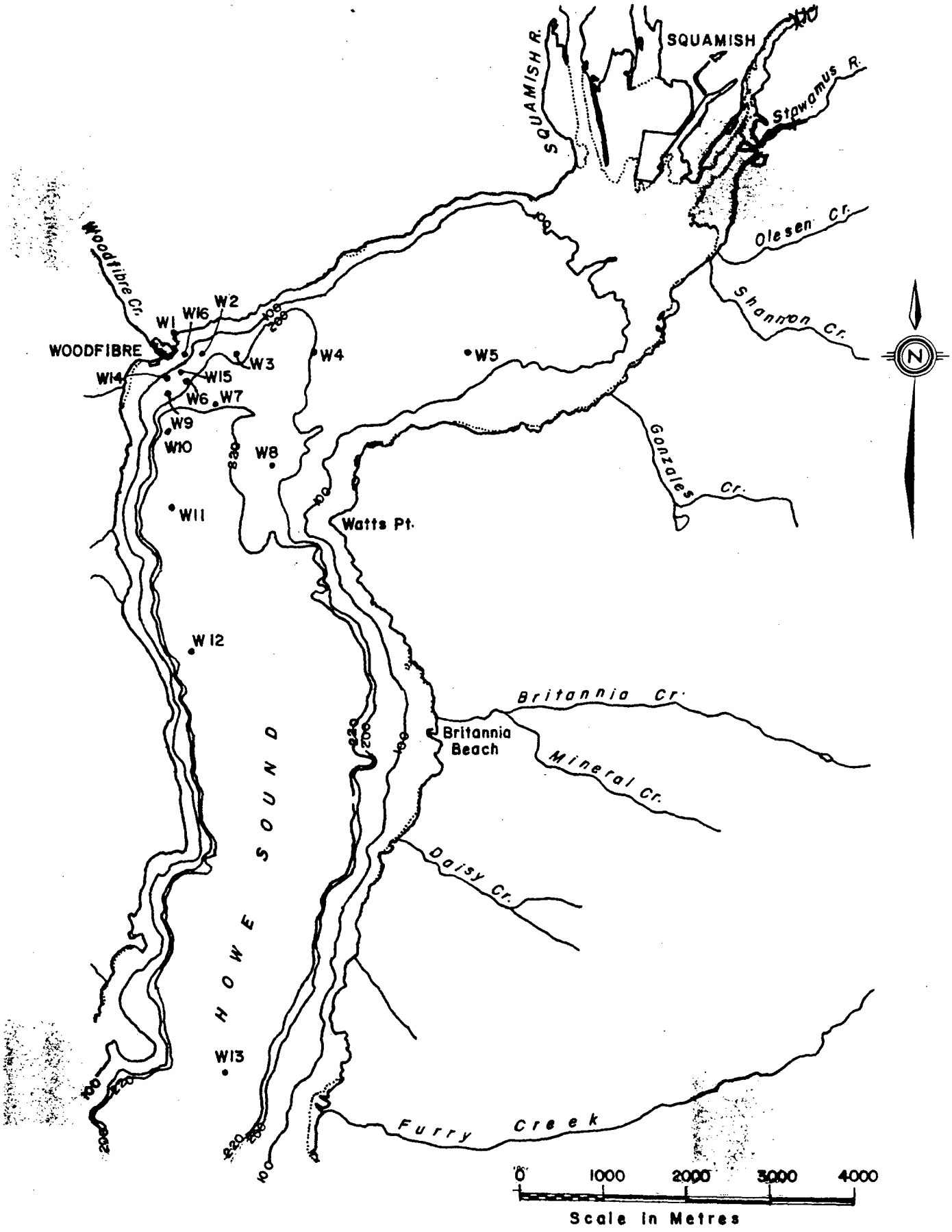

FIGURE 8 WATER QUALITY AND BENTHIC GRAB STATIONS - August and November 1981

TABLE 29 WATER QUALITY RESULTS - WOODFIBRE, B.C., AUGUST 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-1				
0.0	13.43	2.26	10.80	108.07
2.0	13.61	3.26	10.90	110.11
5.0	14.80	23.95	11.80	138.49
10.0	13.16	26.42	9.90	114.06
25.0	9.86	28.45	6.90	74.87
50.0	9.20	29.38	6.90	74.19
Station W-2				
0.0	14.47	2.50	10.40	106.51
2.0	13.98	9.26	11.40	120.16
5.0	14.45	24.71	12.10	141.68
10.0	13.31	26.06	10.20	117.62
25.0	10.21	28.41	6.40	69.97
50.0	9.10	29.57	6.20	66.59
100.0	8.74	30.22	4.30	45.99
Station W-3				
0.0	14.93	2.34	10.80	111.57
2.0	13.30	13.50	11.20	119.34
5.0	15.26	24.10	13.10	155.36
10.0	13.20	26.09	9.90	113.91
25.0	9.91	28.41	6.20	67.33
50.0	9.14	29.53	5.90	63.41
100.0	8.73	30.24	4.00	42.78
Station W-4				
0.0	15.13	4.10	10.90	114.21
2.0	14.23	22.38	12.20	140.08
5.0	16.02	25.17	13.70	166.16
10.0	14.76	28.17	12.80	154.30
25.0	10.54	29.46	7.00	77.67
50.0	9.00	30.30	7.20	77.53
100.0	8.66	-	4.10	-

Continued...

TABLE 29 WATER QUALITY RESULTS - WOODFIBRE, B.C., AUGUST 1981 (Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-5				
0.0	14.33	2.70	11.10	113.48
2.0	13.78	3.13	11.40	115.49
5.0	15.72	18.00	13.00	149.75
10.0	14.09	25.82	12.20	142.80
25.0	10.73	27.86	7.10	78.28
50.0	8.97	29.47	6.40	68.48
100.0	8.56	30.36	3.90	41.58
Station W-6				
0.0	13.84	2.18	10.70	107.95
2.0	13.29	3.69	11.10	111.64
5.0	14.98	24.03	11.80	139.08
10.0	13.15	26.23	10.50	120.80
25.0	10.15	28.45	6.20	67.72
50.0	9.27	29.37	6.20	66.77
100.0	8.82	30.26	4.00	42.88

TABLE 30 WATER QUALITY RESULTS - WOODFIBRE, B.C., NOVEMBER 1981

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-1				
0.0	7.07	8.25	14.25	127.58
2.0	7.07	8.34	13.77	123.34
5.0	10.45	27.62	9.75	106.65
10.0	9.54	28.87	6.43	70.31
25.0	9.54	29.82	5.34	58.04
50.0	9.23	30.20	4.47	48.36
Station W-2				
0.0	7.53	3.07	12.79	112.40
2.0	7.79	5.68	11.37	102.07
5.0	10.50	26.74	7.91	86.11
10.0	10.27	28.53	6.12	67.07
25.0	9.60	29.74	5.37	58.42
50.0	9.40	30.11	5.28	57.32
100.0	9.00	30.45	3.52	37.94
150.0	8.25	30.61	0.82	8.69
190.0	8.15	30.63	0.35	3.70
Station W-3				
0.0	7.80	3.77	13.15	116.80
2.0	8.86	14.42	11.86	115.03
5.0	10.52	26.80	7.42	80.85
10.0	10.26	28.55	6.06	66.41
25.0	9.59	29.79	5.44	59.17
50.0	9.42	30.14	4.88	53.01
100.0	9.01	30.43	3.57	37.84
150.0	8.27	30.59	0.96	10.18
200.0	8.11	30.66	0.31	3.28
Station W-4				
0.0	15.13	4.10	10.90	114.21
2.0	14.23	22.38	12.20	140.08
5.0	16.02	25.17	13.70	166.16
10.0	14.76	28.17	12.80	154.30
25.0	10.54	29.46	7.00	77.67
50.0	9.00	30.30	7.20	77.53
100.0	8.66	-	4.10	-
150.0	8.26	30.60	0.84	8.90
200.0	8.15	30.63	0.38	4.02

Continued...

TABLE 30 WATER QUALITY RESULTS - WOODFIBRE, B.C., NOVEMBER 1981 (Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-6				
0.0	7.93	3.87	13.66	121.77
2.0	7.79	6.77	12.57	113.54
5.0	10.45	26.32	9.16	99.41
10.0	10.18	28.73	6.05	66.26
25.0	9.65	29.75	5.22	56.86
50.0	9.45	30.14	5.01	54.46
100.0	9.03	30.45	3.45	37.22
150.0	8.28	30.59	1.07	11.35
200.0	8.15	30.63	0.30	3.17
Station W-7				
0.0	7.37	2.38	12.33	107.52
2.0	7.53	3.44	13.06	115.02
5.0	8.79	11.55	12.61	119.99
10.0	10.51	26.30	7.80	84.70
25.0	9.65	29.76	4.20	45.75
50.0	9.44	30.11	5.09	53.31
100.0	9.02	30.46	3.55	38.29
150.0	8.28	30.60	1.01	10.72
200.0	8.19	30.63	0.54	5.72
220.0	8.14	30.64	0.35	3.70
Station W-8				
0.0	7.29	6.09	14.19	126.13
2.0	7.34	6.31	14.12	125.82
5.0	10.40	25.39	11.68	125.76
10.0	10.30	28.41	7.70	84.37
25.0	9.69	29.73	6.59	71.44
50.0	9.41	30.09	4.22	45.74
100.0	9.21	30.29	5.25	57.00
150.0	8.25	30.62	0.94	9.97
210.0	8.14	30.66	0.44	4.66
Station W-9				
0.0	7.71	3.78	12.74	112.92
2.0	7.52	5.23	12.40	110.38
5.0	10.50	26.51	10.63	115.54
10.0	10.08	28.92	5.62	61.49
25.0	9.63	29.75	5.14	55.96
50.0	9.44	30.13	4.73	51.40
100.0	9.07	30.44	3.81	41.14
150.0	8.29	30.60	1.18	12.52
170.0	8.19	30.63	0.51	5.40

Continued...

TABLE 30 WATER QUALITY RESULTS - WOODFIBRE, B.C., NOVEMBER 1981 (Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-10				
0.0	7.53	2.42	13.64	119.42
2.0	7.56	3.00	13.82	121.48
5.0	8.76	13.10	10.66	123.92
10.0	10.50	25.81	10.07	108.97
25.0	9.67	5.90	29.69	64.26
50.0	9.40	30.11	5.33	57.86
100.0	9.01	30.45	3.53	38.07
150.0	8.29	30.59	1.35	14.33
200.0	8.17	30.63	0.53	5.61
220.0	8.14	30.64	0.43	4.55
Station W-11				
0.0	8.43	7.62	12.80	117.49
2.0	8.73	10.62	12.76	120.57
5.0	9.14	13.92	12.63	122.92
10.0	10.34	24.91	10.55	113.32
25.0	9.62	29.79	5.72	62.27
50.0	9.38	30.03	5.33	57.80
100.0	9.23	30.45	4.41	47.80
150.0	8.30	30.58	1.14	12.10
200.0	8.17	30.63	0.37	3.92
230.0	8.13	30.64	0.33	3.49
Station W-12				
0.0	9.26	9.10	12.46	118.17
2.0	9.64	17.14	11.71	117.11
5.0	10.07	22.22	11.78	123.34
10.0	10.52	26.38	9.85	107.04
25.0	9.72	29.67	6.03	65.75
50.0	9.43	30.00	5.73	62.20
100.0	9.31	30.47	4.62	50.18
Station W-13				
0.0	8.83	12.73	12.64	121.26
2.0	8.85	12.87	12.49	119.97
5.0	10.16	22.74	11.43	120.32
10.0	10.54	27.19	8.54	93.34
25.0	9.70	29.76	5.89	64.23
50.0	9.51	30.12	5.31	57.80
100.0	9.27	30.51	4.03	43.74
150.0	8.30	30.59	1.60	16.98
200.0	8.14	30.64	0.75	7.93
250.0	8.12	30.65	0.51	5.39
275.0	8.11	30.65	0.41	

Continued...

TABLE 30 WATER QUALITY RESULTS - WOODFIBRE, B.C., NOVEMBER 1981 (Continued)

DEPTH (m)	TEMPERATURE (°C)	SALINITY (°/oo)	DISSOLVED OXYGEN (mg/l)	% SATURATION
Station W-14				
0.0	7.69	4.41	14.09	125.25
2.0	7.75	7.87	13.67	124.16
5.0	10.49	26.43	10.61	115.25
10.0	10.35	28.16	7.46	81.70
25.0	9.65	29.73	4.46	48.57
50.0	9.34	30.15	4.82	52.26
100.0	9.07	30.44	3.97	42.86
130.0	8.45	30.55	1.51	16.08
Station W-15				
0.0	6.84	7.12	14.30	126.45
2.0	7.27	11.55	12.49	114.59
5.0	10.43	27.72	7.50	82.05
10.0	10.13	28.76	6.41	70.12
25.0	9.49	29.84	5.35	58.09
50.0	9.22	30.18	4.69	50.72
110.0	8.84	30.47	3.20	34.37
Station W-16				
0.0	7.14	3.62	13.90	121.37
2.0	10.05	12.31	10.24	119.70
5.0	10.50	26.55	9.32	101.33
10.0	10.33	28.40	6.41	70.28
25.0	9.60	29.78	5.66	61.59
50.0	9.40	30.11	5.21	56.56
75.0	9.16	30.32	4.11	44.44

TABLE 31 TRACE METAL LEVELS IN SEDIMENTS - WOODFIBRE
NOVEMBER, 1981

STATION	Hg	Cd	Cu	Pb	Zn
W-2	> 0.139	>.647	144.0	16.4	101.0
W-3	> 0.130	>.66	80.0	11.1	71.4
W-4	> 0.137	>.636	70.8	10.3	72.9
W-7	> 0.132	>.645	86.9	11.1	76.5
W-8	> 0.132	>.644	76.4	9.26	73.5
W-9	0.591	>.661	125.0	15.3	101.0
W-10	> 0.141	>.65	101.0	14.3	75.5
W-11	> 0.141	>.662	105.0	14.7	93.8
W-12	> 0.143	>.66	88.7	13.4	83.4
W-15	0.264	1.33	106.0	15.1	85.2
W-16	> 0.133	1.02	153.0	16.9	90.3

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APPENDICES

I PORT ALBERNI BENTHIC INVERTEBRATES
MARCH 1982

II PORT MELLON BENTHIC INVERTEBRATES
NOVEMBER 1981

APPENDIX I

PORT ALBERNI BENTHIC INVERTEBRATES
March 1982

		STATION NUMBER													
		1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14
POLYCLADIDA																
	Unid. sp. (damaged)															1
ANNELIDA Polychaeta	Hesperonoe sp.						1									
	Polynoidae sp. (damaged)									2						
	Pleisidice aspera															1
	Phyllodocidae sp. (damaged)				1											
	Gyptis brevipalpa				1											
	Ophiodromus pugettensis		3		4	2							2	1	2	1
	Hesionidae sp. (damaged)						1									
	Sigambra bassi				9	5	3			2	2	1				1
	Nereidae sp. (damaged)							1								
	Nephtys cornuta						3			2	1					
	Glycera capitata						5		10							
	Glyceridae sp. (damaged)							6		2	2					1
	Glycinde armigera					2	1					1				
	Onuphis iridescens									1				1		
	Lumbrinereis sp. (damaged)						6		5							1
	Schistomeringos sp.	3	24	45	39	17	6	9	9	4			3	7	8	4
	Scoloplos acmeceps					1										
	Scoloplos pugettensis						2	2	9							
	Scoloplos sp. (damaged)					2										
	Aricidea lopezi					9	46			4	4	12		5		3

APPENDIX I

PORT ALBERNI BENTHIC INVERTEBRATES
March 1982

		STATION NUMBER													
		1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Aricidea sp. (damaged)					3	11			2	2	14		2		
	Paraonis spinifera										3	4		1		
	Paraonis sp. (damaged)						1			6						
	Prionospio sp. (damaged)						6									
	Spiophanes sp. (damaged)					2										
	Spionidae sp. (damaged)						8		3							
	Cossura longicirrata											1				
	Armandia brevis					1			4							
	Capitella capitata		16	36	71								56		8	
	Heteromastus filiformis											1		1		
	Capitellidae sp. (damaged)						1									
	Praxillela affinis					4	6	11	20					13		
	Asychis disparentata							4								
	Pectinaria californiensis						1	2	1							
	Amage anops						34	47	92					3		11
	Amphicteis scaphobranchiata					4	1	1								
	Ampharetidae sp. (damaged)							128		2	2	1				
MOLLUSCA Gastropoda	Thais sp. (juv.)				3											
Pelecypoda	Solemya sp.				8	4	3	6	40	4	1	2	1	1		3
	Diplodonta orbellus				1	34	106	485	1065	22	17	12		19		34
	Macoma balthica				7	5	6	13	21	2	2			6		3
	Veneridae sp.								4					1		1

APPENDIX I

PORT ALBERNI BENTHIC INVERTEBRATES
March 1982

		STATION NUMBER													
		1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ARTHROPODA Copepoda	Unid. Harpacticoid							4								
Cumacea	Eudorella sp.											1				
	Diastylis sp.						1	8								2
Decapoda	Axiopsis spinulicauda													1		
	Brachyurd sp. (damaged)						1									
ECHINODERMATA																
Ophuiroidea	Unid sp. (damaged)						1									
CHORDATA	Ascidia sp.															4

APPENDIX II PORT MELLON BENTHIC INVERTEBRATES

TAXA	Stations B5	B7	B8
COELENTERATES			
Actinaria sp. (damaged)		4	2
ANNELIDA			
Polychaeta			
Pholoe minuta	1	1	
Etoeone longa	1		
Syllis alternata	3		
Exogone sp. (damaged)			1
Nephtys cornuta	1	1	1
Glycera sp. (juvenile)	1		1
Lumbrinereis sp. (damaged)	2		1
Protodorvillea gracilis	28	8	10
Schistomeringos sp.			1
Aricidea lopezi			1
Aricidea sp. (damaged)	1		
Paraonis gracilis			1
Polydora socialis	12		
Prionospio cirrifera			2
Prionospio steenstrupi	36		12
Prionospio sp. (damaged)	25	4	6
Cossura longicirrata		1	
Capitella capitata	6	1	
Heteromastus sp. (damaged)	11	4	5
Capitellidae sp (damaged)	1		
Praxillela affinis	1	2	
Maldanidae sp. (damaged)		3	1
Owenia fusiformis			2
Polycirrus caliendrum		1	
Oligochaeta			
U.I.D. spec.		21	1
MOLLUSCA			
Pelecypoda			
Solemya sp.			1
Diplodonta orbellus	50		1
Macoma balthica	1		

Continued...

APPENDIX II PORT MELLON BENTHIC INVERTEBRATES

TAXA	Stations B5	B7	B8
ECHIURA			
U.I.D. spec.	1		
ARTHROPODA			
Leptostraca			
Nebalia pugettensis	1		2
Tanaidacea			
Leptochelia savignyi	69		1
Isopoda			
Munidae sp.	1		
Amphipoda			
Paraphoxus sp.	7	14	15
Gammaridea sp. (damaged)		1	
Ostracoda			
U.I.D. sp.	3	1	