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CONSERVATION AND PROTECTION  
ENVIRONMENTAL PROTECTION SERVICE  
PACIFIC AND YUKON REGION  
NORTH VANCOUVER, B.C.

MARINE MONITORING  
IN HOWE SOUND  
NEAR THE PORT MELLON PULPMILL  
HOWE SOUND, B.C.  
1983, 1986

EP REGIONAL DATA REPORT: DR 92-05

By

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MARCH 1992

**REVIEW NOTICE**

Data reports are prepared to make preliminary data available without full analysis or interpretation. This report has been reviewed by the Environmental Effects Branch, Environmental Protection and approved for limited distribution. For further information, please contact:

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**ABSTRACT**

Environmental Protection has monitored marine waters around coastal pulpmills since 1976. Howe Sound has been part of this annual routine marine monitoring programme. Water quality records were kept of temperature, salinity, dissolved oxygen and colour relative to water depth. Marine sediment was collected for trace metals, volatile residue, particle size and chlorophenol analysis. Trawls of fish and crustaceans were collected, identified and analyzed for trace metals.

This data report summarizes the sampling done in Howe Sound by Environmental Protection in November 1983 and April 1986 around Port Mellon, B.C. Methods used for collection and analysis are described and results are presented without analysis or interpretation. The sole intent of this report is to provide historical data from Howe Sound.

### RESUME

La Protection de l'Environnement a échantillonné les eaux marines réceptrices aux environs des usines de pâte côtières depuis 1976. Howe Sound a fait partie d'un programme d'échantillonnage marin de routine annuel. Les données de qualité de l'eau sont concentrées sur la température, salinité, oxygène dissous, et couleur en relation à la profondeur d'eau. Des échantillons instantanés de sédiment furent recueillis pour des analyses de métal à l'état de trace, de résidu volatil, grosseur de particules, et des analyses de chlorophenols. Des poissons et crustacés attrapés au chalut furent recueillis, identifiés et analysés pour métaux à l'état de trace.

Ce rapport de donnée résume l'échantillonnage fait dans le Howe Sound par la Protection de l'Environnement en Novembre 1983 et Avril 1986. Les rapports de données résument les méthodes utilisées pour l'échantillonnage et l'analyse. Les résultats sont présentés en tables ou graphiques sans analyse ni interprétation. La seule intention de ces rapports est de fournir des données historiques de Howe Sound.

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## 1.0 INTRODUCTION

Port Mellon, B.C. has been the site of a kraft pulpmill since 1908. The mill is presently under the joint ownership of Canfor Corporation and Oji Paper Company Ltd. and is known as Howe Sound Pulp and Paper Ltd. Through continued expansion and modernization, production has reached 1,000 tonnes per day of bleached kraft pulp and 585 tonnes of newsprint (Cirrus, 1990). The facility also produces thermomechanical pulp (TMP).

The mill is located on the Rainy River on the west side of Thornbrough Channel which separates Gambier Island from the mainland (Figure 1). Historically, pulpmill effluent was discharged into the surface waters of Howe Sound near the mouth of the Rainy River. In 1982 a submarine diffuser system was installed which carried effluent to a depth of approximately 115 metres below the surface (Cross, 1989). Effluent discharge volumes for 1987 are summarized in Appendix I and results for effluent monitoring on November 7, 1990 are found in Appendix II. In 1991, total suspended solids (TSS) averaged 10,140 kg/day and biochemical oxygen demand (BOD) averaged 2,000 kg/day. Seaconsult studied effluent dispersion of the Port Mellon outfall and identified layers of effluent trapping through dye tracing in 1990 (Hodgins and Knoll, 1990).

With its proximity to Vancouver, B.C., the Howe Sound watershed is an important recreational, industrial, and residential area. Two major pulpmills, forestry, mining, shipping, and recreational use have all had an impact on the aquatic environment of Howe Sound. Consequently, there has been extensive multidisciplinary study of the area. Most recently this information has been summarized by the Howe Sound Environmental Science Workshop (1991).

In November 1989, a national dioxin study by Environment Canada and Fisheries and Oceans Canada demonstrated the presence of dioxins and furans in harvested fish and shellfish in the vicinity of several pulpmills. Port Mellon was on this list and closures resulted for prawn and crab fisheries (Figure 2). Extensive closures for shellfish harvesting in Howe Sound have created considerable public concern. Annual monitoring is carried out so



that trends in dioxin levels can be detected. Recreational and native harvesting of crab and oysters remained open with some consumption guidelines.

## 2.0 MATERIALS AND METHODS

Sampling at Port Mellon was done from the C.S.S. Vector on November 16, 1983 and on April 7, 1986 at stations shown in Figure 3. Stations were located using ship's LORAN-C and radar. Station positions are described in Appendix II. Tables 1 and 2 summarize water quality, sediment and tissue parameters sampled, and techniques are summarized in Table 3. Lab analyses were done at the EP/DFO West Vancouver laboratory.

### 2.1 Water Samples

In 1983 water samples off Port Mellon were collected from six stations in Thornbrough Channel as shown in Figure 3. Samples were collected at discrete depths with polypropylene N.I.O. (National Institute of Oceanography) water bottles using standard oceanographic techniques. Conductivity, temperature and depth (CTD) profiles were taken using a Guildline 8770 CTD/DO sensor. Water samples were not collected in 1986 due to equipment problems and time constraints.

**2.1.1 Analytical Procedures - Water.** Oxygen concentrations were determined in the ship's lab using the azide modification of the Winkler method. The equations of Gameson and Robertson (1955) were used in the calculation of percent dissolved oxygen saturation:

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

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

where: C = saturation of oxygen in the sample water

S = salinity of the sample water

T = corrected temperature of the sample water

A = observed dissolved oxygen concentration in the sample

Nutrient samples were immediately frozen after collection (Strickland and Parsons, 1971), then analyzed using an automated

colourimeter (Technicon Auto-analyzer II). Tri-stimulus colour values of previously frozen samples were determined spectrophotometrically in the lab.

## **2.2 Sediment Samples**

Benthic samples were collected from six stations on November 16, 1983 and 14 stations on April 7, 1986. They were analyzed for particle size, sediment volatile residue, trace metals, PCB and resin acids. In 1986, mercury analysis was also done.

Sediment grabs were taken at the stations depicted in Figure 3 using a stainless steel 0.1 m<sup>2</sup> Smith-MacIntyre grab. The surficial (2 cm) sediment layer was collected using a plastic scoop, avoiding the sediment near the sides of the grab. Samples for trace metal, volatile residue and particle size analysis were placed in paper sediment bags inside plastic bags and immediately frozen. Sediments collected for PCB and resin acid analysis were collected using a heat-treated metal spoon and stored frozen in heat-treated glass jars.

**2.2.1 Analytical Procedures - Sediment.** Sediment samples were analyzed by the EP/DFO West Vancouver Laboratory for trace metals, volatile residue and particle size according to the procedures described by Swingle and Davidson (1979) with some modification by the lab (Millward and Kluckner, 1989). Trace metal samples were dried at 60°C and passed through a nylon sieve (0.15 mm mesh) then digested in a 4:1 nitric:hydrochloric acid solution diluted slightly with 1 ml of distilled water. Samples were digested in a microwave oven for 15 minutes at 720 joules/sec (watts). Trace metals were determined using a Perkin-Elmer Inductively Coupled Argon Plasma (ICAP) Optical Emission Spectrophotometer. A Jarrel Ash 850 Atomic Absorption Spectrophotometer (AAS) with an FLA 100 graphite tube furnace was used to detect low-level cadmium. Electron capture gas liquid chromatography was used for PCB and resin acid determination.

### 2.3 Biota Samples

Two trawl sites were sampled on April 7, 1986 to compare tissue metal levels in prawns and sole to previous years and spatially within 1986. Fish and invertebrate tissue were collected for trace metal analysis from trawls taken at Port Mellon Stations 3 and 9. Samples were placed in plastic bags and frozen prior to analysis. The following species were used for analysis:

English sole	<i>Parophrys vetulus</i>
Pacific Hake	<i>Merluccius productus</i>
Arrowtooth Flounder	<i>Atheresthes stomias</i>
Prawn	<i>Pandalus platyceros</i>
Dover sole	<i>Microstomus pacificus</i>
Shrimp	<i>Spirontocaris</i> sp.

**2.3.1 Analytical Procedures - Biota.** At the EP/DFO West Vancouver Lab, samples were thawed, blended, freeze-dried and oxidized in a low temperature asher. The ash (metallic salts) was dissolved in warm concentrated nitric acid, then analyzed on the ICAP Spectrophotometer. Low-level cadmium was analyzed using a Jarrel Ash 850 Atomic Absorption Spectrophotometer (AAS) with an FLA 100 graphite tube furnace.

**TABLE 1: PORT MELLON SAMPLING SUMMARY, NOVEMBER 16, 1983**

STATION	WATER			SEDIMENT		
	CTD	DO	COLOUR	PS	SVR	TM
PM-1	X	X	X	X	X	X
PM-2	X	X	X	X	X	X
PM-3	X	X	X	X	X	X
PM-4	X	X	X	X	X	X
PM-5	X	X	X	X	X	X
PM-6	X	X		X	X	X

**TABLE 2: PORT MELLON SAMPLING SUMMARY, APRIL 7, 1986**

STATION	SEDIMENT				BIOTA
	PS	SVR	TM	PCB & RA	ICAP & Hg
PM-1	X	X	X	X	
PM-2	X	X	X	X	
PM-3	X	X	X	X	
PM-4	X	X	X	X	
PM-5	X	X	X	X	
PM-6	X	X	X	X	
PM-7	X	X	X	X	
PM-8	X	X	X	X	
PM-9	X	X	X	X	
PM-10	X	X	X	X	
PM-11	X	X	X	X	
PM-12	X	X	X	X	
PM-13	X	X	X	X	
PM-1 TRAWL					X
PM-2 TRAWL					X

CTD      Conductivity, Temperature, Depth  
 DO       Dissolved Oxygen  
 PS       Particle Size  
 TM       Trace Metal  
 SVR      Sediment Volatile Residue  
 RA       Resin Acids  
 PCB      Polychlorinated Biphenyls

**TABLE 3: SUMMARY OF ENVIRONMENTAL PROTECTION METHODS FOR WATER, SEDIMENT AND TISSUE ANALYSES**

<b>SAMPLE TYPE</b>	<b>METHODS</b>	<b>REFERENCE</b>
<b>WATER</b>		
Salinity, temperature, depth	CTD	Goyette & MacLeod, 1984
Dissolved Oxygen	Azide Modification of Winkler	Swingle & Davidson, 1979 Gameson & Robertson, 1955
Colour	Spectrophotometer	Swingle & Davidson, 1979
<b>SEDIMENT</b>		
Particle Size	Freeze drying, Screening	Swingle & Davidson, 1979 Griffiths, 1967
Trace Metals	ICAP Optical Emmission Spectrophotometer	Swingle & Davidson, 1979 Millward & Kluckner, 1989
Volatile Residue	Wt. loss on ignition 550°C for 1 hr.	Swingle & Davidson, 1979
<b>TISSUE</b>		
Trace Metals	ICAP Optical Emission Spectrophotometer	Swingle & Davidson, 1979

### 3.0 RESULTS

#### 3.1 Water Quality

Salinity, temperature, dissolved oxygen (DO), % oxygen saturation and colour data from Port Mellon water quality stations PM 1-6 are listed in Tables 4 to 7. Results of effluent monitoring for the Port Mellon mill on November 7, 1989 for chloroanisoles, chlorophenols and resin acids are found in Appendix II.

#### 3.2 Sediment Quality

Results of sediment sampling in Howe Sound are summarized in Tables 8 and 9. Resin acids and PCBs were not detected in sediments in 1983 or 1986.

#### 3.3 Biota Quality

Table 10 lists the results of trace metal analyses on several different species of marine fish and invertebrates collected in Howe Sound trawls at Port Mellon Trawl Stations 1 and 2.

**TABLE 4: WATER QUALITY, PORT MELLON, NOVEMBER 16, 1983  
TEMPERATURE (°C)**

DEPTH (m)	PORT MELLON STATION NUMBER					
	PM-1	PM-2	PM-3	PM-4	PM-5	PM-6
0	8.18	8.13	7.80	7.84	8.18	8.18
5	9.11	8.90	9.02	8.72	8.99	8.41
10	9.34	9.29	9.31	9.36	9.42	9.36
20	10.06	10.02	10.17	10.13	10.15	10.08
50	9.97	10.04	10.04	10.02	9.97	9.93
100	9.79	10.02	10.10	10.06	10.10	9.95
BOTTOM <sup>1</sup>	9.42	9.61	9.43	ND	9.54	9.68
<sup>1</sup> DEPTH(m)	200	210	185	105	215	225

**TABLE 5: WATER QUALITY, PORT MELLON, NOVEMBER 16, 1983  
SALINITY (ppt)**

<b>DEPTH</b> <b>(m)</b>	<b>PORT MELLON STATION NUMBER</b>					
	<b>PM-1</b>	<b>PM-2</b>	<b>PM-3</b>	<b>PM-4</b>	<b>PM-5</b>	<b>PM-6</b>
<b>0</b>	10.62	10.66	9.24	10.53	12.38	11.26
<b>5</b>	21.73	19.77	21.03	19.26	20.57	15.74
<b>10</b>	23.78	23.61	23.71	24.06	24.41	24.10
<b>20</b>	28.83	28.37	28.87	28.90	29.26	28.86
<b>50</b>	30.24	30.20	30.22	30.25	30.26	30.25
<b>100</b>	30.47	30.52	30.53	30.56	30.53	30.52
<b>BOTTOM</b>	30.67	30.83	30.61	ND	30.83	30.89



**TABLE 6: WATER QUALITY, PORT MELLON, NOVEMBER 16, 1983  
DISSOLVED OXYGEN (ppm) and % OXYGEN SATURATION**

DEPTH (m)	PORT MELLON STATION NUMBER											
	PM-1			PM-2			PM-3			PM-4		
	DO (mg/L)	%OXY. SAT.		DO (mg/L)	%OXY. SAT.		DO (mg/L)	%OXY. SAT.		DO (mg/L)	%OXY. SAT.	
0	10.2	99.3		10.2	95.1		10.3	94.4		10.3	95.2	
5	9.0	110.3		9.0	90.3		8.8	89.2		8.9	88.6	
10	8.3	105.6		8.3	86.1		7.8	81.0		8.5	88.6	
20	5.5	76.5		5.0	54.4		4.8	52.6		4.3	47.1	
50	4.5	63.9		4.4	48.5		4.5	49.6		4.4	48.5	
100	4.4	62.7		4.7	51.9		4.7	52.0		4.6	50.9	
BOTTOM	2.8	39.9		2.5	27.4		3.5	38.2		ND	ND	
										2.7	29.0	
										4.5	49.6	
										4.4	48.4	
										4.5	49.2	
										4.6	50.5	
										4.6	50.7	
										4.5	49.6	
										2.3	25.3	

**TABLE 7: WATER QUALITY, PORT MELLON, NOVEMBER 16, 1983  
COLOUR (ADMI)**

DEPTH (m)	PORT MELLON STATION NUMBER				
	PM-1	PM-2	PM-3	PM-4	PM-5
0	12	<5	5	9	7
5	<5	<5	5	<5	<5
10	<5	<5	<5	<5	<5
20	<5	<5	<5	<5	<5
50	14	<5	<5	<5	<5
100	<5	<5	<5	<5	<5

**TABLE 8: SEDIMENT VOLATILE RESIDUE, PARTICLE SIZE AND TRACE METALS,  
PORT MELLON, HOWE SOUND, NOVEMBER 16, 1983**

STN	DEPTH (m)	MEDIAN PARTICLE SIZE	SILT +CLAY (%)	SVR (%)	Al (%)	As (µg/g)	Fe (%)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
1	221	granules	6.3	12.5	3.18	9.5	3.45	0.5	38.4	136	25	40	189
2	228	v.coarse sand	7.9	12.2	2.94	<8	3.14	0.6	34.8	107	20	33	154
3	223	fine sand	15.8	12.4	2.43	<8	2.56	0.8	29.9	70	11	32	109
4	142	medium sand	4.8	18.3	2.14	<8	2.83	0.8	32.1	94	9	26	102
5	233	medium sand	20.3	9.8	2.86	8	2.96	0.4	28.0	71	13	26	111
6	238	granules	10.3	10.2	3.14	<8	3.38	0.5	34.7	103	20	33	156

TABLE 9: SEDIMENT VOLATILE RESIDUE, PARTICLE SIZE AND TRACE METALS (dry wt.), PORT MELLON, APRIL 7, 1986

STN	DEPTH (m)	MEDIAN PARTICLE SIZE	SILT +CLAY (%)	SVR (%)	Al (%)	As (µg/g)	Fe (%)	Hg (µg/g)	Cd (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
0	164	medium sand	26.0	13.7	2.74	<8	3.48	0.52	0.5	106.4	27	42	121
1	160	v.fine sand	26.0	14.8	2.04	<8	2.34	0.18	1.5	76.7	17	21	96.1
2	77	v.fine sand	24.3	23.8	1.99	<8	2.27	0.22	3.7	106	21	56	151
3	140	fine sand	16.1	17.2	1.96	<8	2.32	0.33	1.6	95.9	20	53	111
4	200	v.fine sand	24.8	16.2	2.05	<8	2.27	0.18	1.4	66.3	18	27	96.2
5	109	fine sand	10.2	23.7	1.79	<8	2.43	0.11	3.0	71.8	25	34	92.0
6	143	medium sand	8.9	12.2	2.06	<8	2.68	0.21	1.5	101	23	59	114
7	196	fine sand	10.4	10.6	1.79	<8	2.19	0.26	1.1	64.6	14	31	79.7
8	142	fine sand	8.4	7.8	1.52	<8	2.21	0.08	0.9	41.8	11	11	56.2
9	210	fine sand	10.4	12.6	1.70	<8	2.41	0.11	1.2	53.4	13	16	70.2
10	100	v.fine sand	18.9	9.1	1.43	<8	1.82	0.09	0.7	34.0	8	14	48.6
11	211	v.fine sand	34.8	16.4	2.46	<8	3.16	0.40	0.8	79.3	19	40	104
12	214	fine sand	28.3	11.1	2.49	12	3.33	0.36	0.8	82.7	23	36	115
13	217	fine sand	23.9	11.6	2.29	<8	2.87	0.34	0.5	76.3	20	32	103

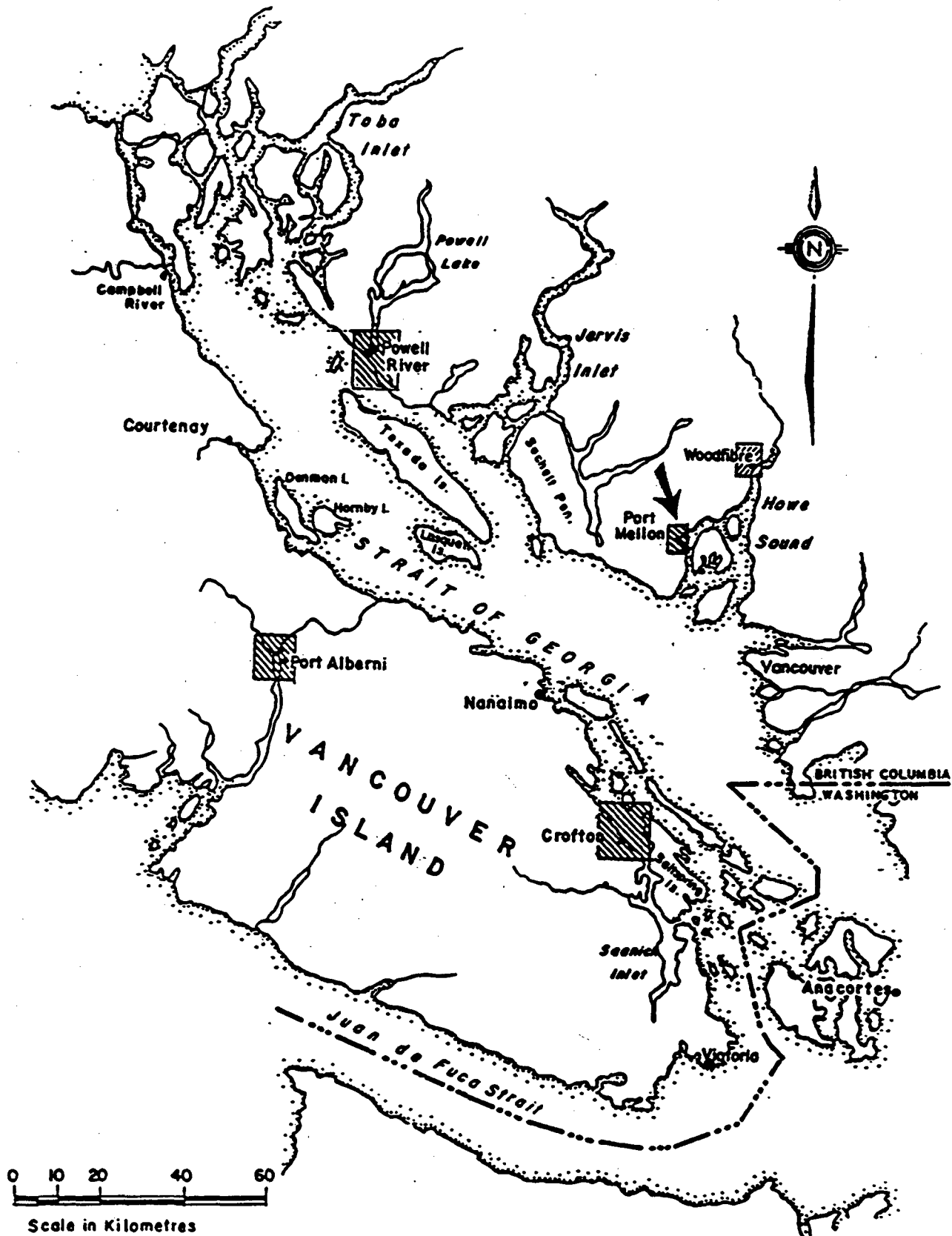
**TABLE 10: PORT MELLON, TRACE METALS IN BIOTA (dry weight),  
APRIL 7, 1986 (SHRIMP DATA NOVEMBER 16, 1983)**

$\mu\text{g/g}$	ENGLISH SOLE	DOVER SOLE	DOVER SOLE	DOVER SOLE	PACIFIC HAKE	FLOUNDER	SHRIMP	
							MEAN <sup>1</sup>	SD
Cd	0.075	0.040	0.042	0.040	0.047	0.046	0.260	0.
Pb	0.27	0.24	0.41	0.11	0.29	0.21	0.09	0.
Hg	0.20	0.23	0.14	0.61	0.18	2.09	0.27	0.
Al	19	12	6	9	9	23	42	30
As	101	31	35	71	54	9	48	45.
Ba	0.12	<0.10	0.20	<0.08	0.14	0.18	ND	ND
Be	<0.08	<0.10	<0.08	<0.08	<0.08	<0.08	ND	ND
Co	<0.4	<0.5	<0.4	<0.4	<0.4	<0.4	ND	ND
Cr	0.4	<0.5	0.5	<0.4	<0.4	1.8	0.7	0.
Cu	1.3	1.1	1.2	0.8	0.5	0.6	25.3	9.
Fe	55.4	40.7	20.6	21.1	20.9	59.8	71.3	56.
Mg	1110	1190	1130	1240	1440	1310	ND	ND
Mn	9.57	5.40	6.22	1.87	1.91	3.11	ND	ND
Ni	10	3	2	<2	<2	3	<2	
Sb	<4	<5	<4	<4	<4	<4	ND	ND
Sn	<0.8	<1	<0.8	<0.8	<0.8	<0.8	ND	ND
Sr	8.40	1.50	5.72	1.90	9.75	7.38	ND	ND
Ti	0.9	0.2	<0.2	0.3	0.3	1.4	ND	ND
V	<0.4	<0.5	<0.4	<0.4	<0.4	<0.4	ND	ND
Zn	16.8	20.9	19.7	15.9	17.9	19.0	53.0	5.
% moisture	81.0	81.4	81.1	84.2	79.3	86.0	ND	ND

<sup>1</sup> n = 21

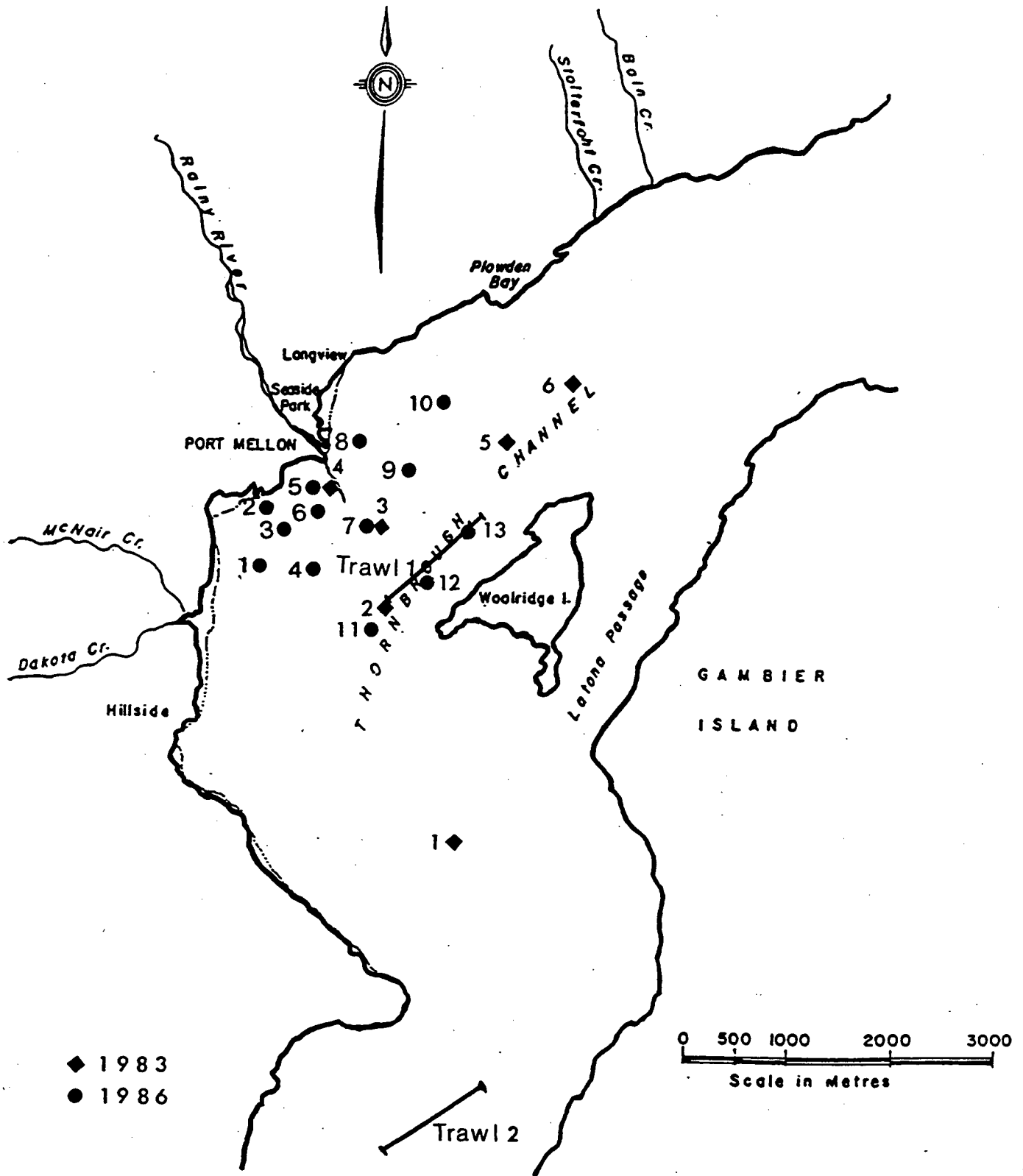
## REFERENCES

- Cirrus Consultants. 1990. Environmental Impact Statement. Summary Expansion and Modernization. Prepared for Howe Sound Pulp and Paper Limited Port Mellon, British Columbia.
- Cross, S.F. 1989. 1988 Environmental Monitoring of Effects Related to Surface Kraft Pulpmill Effluent Discharge at Port Mellon, B.C. Prepared by AQUAMETRIX Research Ltd. for Howe Sound Pulp and Paper Limited, Port Mellon, British Columbia.
- Dwernychuk, L.W. 1989. Bottom Sediments and Biological Tissues: A Baseline Organochlorine Contamination Survey in Howe Sound January/February 1989. Prepared for Howe Sound Pulp and Paper Limited, Port Mellon British Columbia and Western Pulp Limited Partnership, Squamish Operations, Squamish, B.C.
- Gameson, A.L.H., and K.J. Robertson. 1955. The Solubility of Oxygen in Pure Water and Seawater. J. Appl. Chem. 5:502.
- Goyette, D., and L. MacLeod. 1984. A Computer-Controlled Water Column Profiling System. EPS Regional Program Report 84-09.
- Griffiths, J.C. 1967. Scientific Methods in Analysis of Sediments. McGraw Hill, New York. 41 pp.
- Hodgins, D.O., and M. Knoll. 1990. Effluent Dispersion Study for the Port Mellon Outfall in Howe Sound, British Columbia. Prepared for Howe Sound Pulp and Paper Limited, Port Mellon, British Columbia Seaconsult Marine Research Ltd.
- Howe Sound Environmental Science Workshop. 1991. Workshop Program Outline Abstracts, Field Guidebook to Lower Howe Sound Watershed, September 30-October 3, 1991, Bowen Island, B.C. Geological Survey of Canada.
- Millward, C.G., and P.D. Kluckner. 1989. Microwave Digestion Technique for the Extraction of minerals from Environmental Marine Sediments for Analysis by Inductively Coupled Plasma Atomic Emission-Spectrometry and Atomic Absorption Spectrometry. Journal of Analytical Atomic Spectrometry. Vol. 4.
- Strickland, J.D.H., and T. Parsons. 1971. A Practical Handbook of Seawater Analysis. Bull. Fish. Res. Board Can. 167. 311 pp.
- Swingle, J.D.H., and J.W. Davidson. 1979. Environmental Laboratory Manual Environmental Protection Service. West Vancouver, B.C.

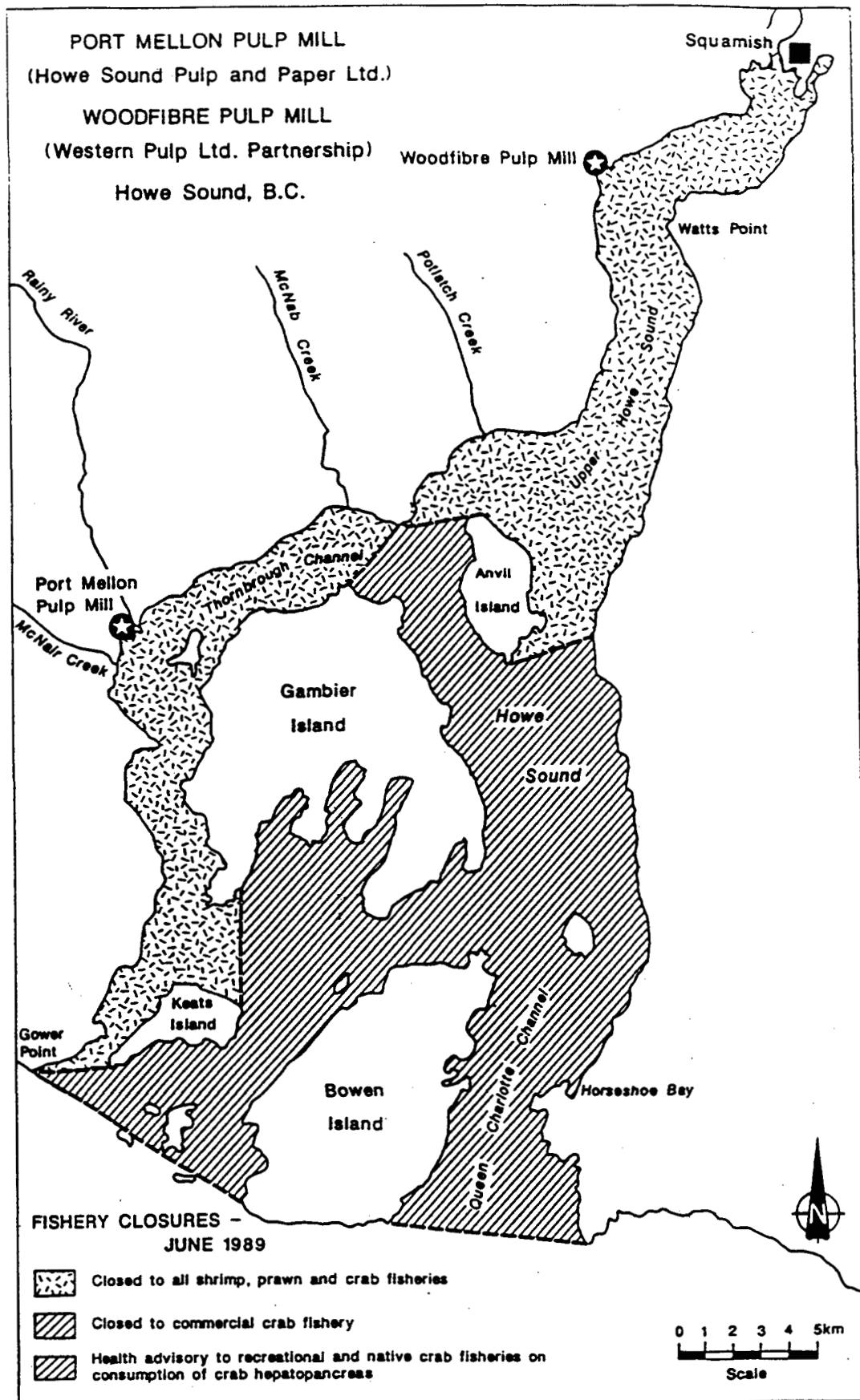


**FIGURE 1: LOCATION MAP - HOWE SOUND**

Can you put in a dot  
for Nanaimo, Anacortes,  
and (maybe) Victoria?



**FIGURE 3:** PORT MELLON SAMPLE SITES



**FIGURE 2:** HOWE SOUND FISHERIES CLOSURES, 1989



## **APPENDICES**

# **APPENDIX I: PACIFIC REGION PULP AND PAPER INDUSTRY EFFLUENT SUMMARY**

Company: Canadian Forest Products Limited  
 Mill: Howe Sound Pulp  
 Location: Port Mellon  
 Year: 1987

Yearly Values	==FLO==		-PRODUCTION=		==TSS (FED)==		==TSS (PROV)==		===BOD5 (FED)===		==BOD5 (PROV)==		==TOXICITY (PROV)==	
	Aver. # of (m3/d)	days	Aver. # of (ADT/d)	days	Aver. # of (kg/ADT)	Tests Comp.	Aver. # of (kg/ADT)	Tests Comp.	Aver. # of (kg/ADT)	Tests Comp.	Aver. # of (tonne/d)	Tests Comp.	Aver. # of Tests	% Comp.
	61,473	352	647	348	10.09	147 30%	6.52	147	26.46	44 91%	15.74	44	1	0%

## **EFFLUENT QUALITY REQUIREMENTS**

	FLOW		TSS		BOD5		TOXICITY	
	(m3/d)						(%v/v)	
Federal (kg/ADT)	---		7.80		47.90		96LC20 = 65	
Provincial (tonne/d)	117,000		10.15		17.40		96LC50 = 30	

**APPENDIX II:****RESULTS FOR PORT MELLON PULP MILL EFFLUENT MONITORING,  
NOVEMBER 7, 1990**

PARAMETER	UNITS	
CHLOROANISOLE/2,3,4,5-TETRA	µg/L	<0.005
/2346+56-TETRA	µg/L	<0.005
/PENTA	µg/L	<0.002
CHLOROPHENOL/2,3,4,5-TETRA	µg/L	<0.005
/2,3,4-TRI	µg/L	<0.01
/2,3,5-TRI	µg/L	<0.01
/2,3,6-TRI	µg/L	<0.01
/2,4,5-TRI	µg/L	<0.01
/2,4,6-TRI	µg/L	<0.01
/2346+2356-TETRA	µg/L	<0.005
/PENTA	µg/L	0.279
RESIN ACID/12-CHLORO-DHA	mg/L	<0.01
/14-CHLORO-DHA	mg/L	<0.01
/8(14)ABIETENIC	mg/L	<0.01
/ABIETIC	mg/L	0.29
/DEHYDROABIETIC	mg/L	0.19
/DICHLORO-DHA	mg/L	<0.01
/DIHYROISOPIMARIC	mg/L	<0.01
/ISOPIMARIC	mg/L	0.37
/NEOABIETIC	mg/L	<0.01
/PALUSTRIC	mg/L	<0.01
/PIMARIC	mg/L	<0.01
/SANDARACOPIMARIC	mg/L	<0.01

**APPENDIX III:**

**PORT MELLON SAMPLING STATION LOCATIONS, HOWE SOUND,  
NOVEMBER 16, 1983**

	HYDROCASTS & CTD	
STATION	LATITUDE	LONGITUDE
1	49°29.88'N	123°27.99'W
2	49°30.57'N	123°28.56'W
3	49°31.05'N	123°28.43'W
4	49°31.20'N	123°28.70'W
5	49°31.55'N	123°27.69'W
6	49°31.55'N	123°27.24'W
	TRAWL STATIONS	
STATION	LATITUDE	LONGITUDE
TRAWL-1 (START)	49°30.75'N	123°28.30'W
(FINISH)	49°30.22'N	123°28.50'W

**APPENDIX III (cont.):**

**PORT MELLON SAMPLING STATION LOCATIONS, HOWE SOUND,  
APRIL 7, 1986**

STATION	DEPTH (m)	HYDROCASTS & CTD	
		LATITUDE	LONGITUDE
0	164	49°28.71'N	123°27.52'W
1	160	49°30.84'N	123°29.20'W
2	77	49°31.10'N	123°29.12'W
3	140	49°31.00'N	123°29.05'W
4	200	49°30.85'N	123°28.87'W
5	109	49°31.15'N	123°28.78'W
6	143	49°31.08'N	123°28.82'W
7	196	49°31.00'N	123°28.50'W
8	142	49°31.35'N	123°28.45'W
9	201	49°31.20'N	123°28.20'W
10	100	49°31.57'N	123°28.10'W
11	211	49°30.60'N	123°28.70'W
12	214	49°30.75'N	123°28.20'W
13	217	49°31.05'N	123°27.85'W
STATION		TRAWL STATIONS	
		LATITUDE	LONGITUDE
TRAWL-1 (START)	110	48°54.05'N	123°38.28'W
(FINISH)		48°53.61'N	123°37.86'W
TRAWL-2 (START)	95	48°56.62'N	123°41.52'W
(FINISH)		48°56.28'N	123°41.00'W

**APPENDIX III (cont.):****PORT MELLON SAMPLING STATION LOCATIONS, HOWE SOUND,  
APRIL 7, 1986**

STATION	DEPTH (m)	SEDIMENT GRABS	
		LATITUDE	LONGITUDE
1	60	48°53.54'N	123°38.04'W
2	64	48°53.45'N	123°37.88'W
3	110	48°53.61'N	123°37.85'W
4	80	48°53.63'N	123°38.12'W
5	126	48°53.18'N	123°37.19'W
6	110	48°53.98'N	123°38.59'W
7	206	48°52.39'N	123°35.71'W
8	38	48°55.52'N	123°36.42'W
9	104	48°56.46'N	123°41.25'W
10	170	48°54.00'N	123°37.22'W
11	75	48°54.30'N	123°39.10'W
12	102	48°53.78'N	123°38.30'W
13	67	48°53.30'N	123°37.52'W
CORE C-1	60	48°53.54'N	123°38.04'W

**APPENDIX IV:****NUTRIENT LEVELS IN WATER, PORT MELLON, NOVEMBER 16, 1983**

STATION	DEPTH (m)	T-PO <sub>4</sub> (mg/L)	NO <sub>2</sub> (mg/L)	NO <sub>3</sub> (mg/L)	NH <sub>3</sub> (mg/L)
1	0	0.046	<0.005	0.15	0.013
	5	0.070	0.006	0.27	0.019
	10	0.073	0.006	0.29	0.019
	20	0.081	<0.005	0.35	0.010
	50	0.085	<0.005	0.36	0.008
	100	0.082	<0.005	0.35	0.010
	200	0.106	<0.005	0.36	0.010
2	0	0.062	<0.005	0.18	0.012
	5	0.070	0.006	0.28	0.018
	10	0.053	0.005	0.25	0.016
	20	0.081	<0.005	0.37	0.009
	50	0.092	<0.005	0.39	0.008
	100	0.083	<0.005	0.36	0.010
	210	0.119	<0.005	0.40	0.009
3	0	0.042	<0.005	0.16	0.014
	5	0.059	0.007	0.25	0.021
	10	0.056	0.006	0.23	0.019
	20	0.081	<0.005	0.33	0.008
	50	0.085	<0.005	0.38	0.009
	100	0.089	<0.005	0.38	0.008
	185	0.097	<0.005	0.37	0.011
4	0	0.073	<0.005	0.21	0.011
	5	0.064	0.006	0.27	0.019
	10	0.065	0.007	0.28	0.019
	20	0.079	<0.005	0.28	0.009
	50	0.080	<0.005	0.33	0.011
	105	0.077	<0.005	0.35	0.010
5	0	0.050	<0.005	0.20	0.011
	5	0.067	0.006	0.24	0.025
	10	0.067	0.006	0.28	0.025
	20	0.088	0.005	0.37	0.025
	50	0.084	<0.005	0.36	0.010
	100	0.083	<0.005	0.36	0.010
	215	0.116	0.005	0.38	0.012