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

MARINE MONITORING NEAR THE GOLD RIVER PULPMILL ON MUCHALAT INLET, B.C. 1986, 1988, 1989

EP REGIONAL DATA REPORT: 91-08

By

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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. Gold River has been part of an annual routine marine monitoring programme which includes all coastal mills. Water quality records focus on temperature, salinity, dissolved oxygen and colour relative to water depth. Sediment grabs were collected for trace metal, volatile residue and particle size analysis. Biota for trace metal analyses were collected and included intertidal algae and subtidal trawls of fish and crustaceans.

Data reports summarize the methods used for collection and analysis. Results are presented in tabular or graphical form without analysis or interpretation. The sole intention of these reports is to provide historical data.

RESUME

La Protection de l'Environnement a échantillonné les eaux marines réceptrices aux environs des usines de pâte côtières depuis 1976. Gold River a fait partie d'un programme d'échantillonnage marin de routine annuel incluant toutes les usines côtières. 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, et de grosseur de particules. Du matériel biologique fut recueilli pour des analyses de métal à l'état de trace et inclue des algues intertidales ainsi que des poissons et crustacés attrapés au chalut.

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.

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1.0 INTRODUCTION

Canadian Pacific Forest Products Limited has operated a kraft mill at Gold River, B.C. since 1967 (Figure 1). Untreated effluent is discharged into Muchalat Inlet, on Vancouver Island, via a diffuser located at 20 m depth. In 1989, the mill expanded production by installing a Chemical Thermal Mechanical Pulp (CTMP) newsprint mill with peroxide bleaching. CTMP effluent receives secondary treatment in an aerated lagoon. Production was to be almost 700 ADTD (air dried tonnes per day) with a 71.5% increase in total suspended solids (TSS), 24% increase in five-day biochemical oxygen demand (BOD5), and a 13% increase in flow (based on 1986-1987 mill production data). Appendix I provides an effluent summary for 1987.

Gold River kraft mill currently produces 710 tonnes of bleached kraft pulp per day (Beak Associates, 1991). Since 1980 the mill has been able to meet the B.C. Ministry of Environment Protection 96h LC50 objective of 34%. A variety of monitoring is done annually by industry and government to ensure compliance with existing water quality guidelines.

Environmental Protection Service (EP) has been responsible for conducting surveillance and compliance monitoring programs at coastal pulpmills since 1976. This report continues a series of data reports of marine environmental surveillance by Environment Protection of Muchalat Inlet near the discharge of the Canadian Pacific Forest Products Limited, Gold River, pulpmill. Water, sediment and biota quality records from 1986, 1988 and 1989 are presented.

1.1 Oceanography

Baseline oceanographic data was collected prior to the operation of the mill by Tully (1936), Pickard (1963), T.W. Beak Consultants Ltd. (1967) and Walidichuk *et al.* (1968). Deep water oxygen depressions are a natural feature of Muchalat Inlet as a result of restricted deep water flushing due to shallow depths and channel restrictions around Gore Island. The main flow into the inlet is via Williamson Passage over the 120 m sill (Tully, 1936).

More recently, the quality of the receiving environment in the vicinity of the mill has been described in Environment Canada reports (Sullivan and Nelson, 1979; Sullivan, 1979; Petrie and Holman, 1983; Sullivan, 1987). The mill has also conducted various water quality and intertidal studies in the vicinity of the mill between 1966-1986 (Griffiths, 1984). In general, the mill appears to have little impact on the surface water quality, phytoplankton productivity levels or the intertidal macrofaunal community (Sullivan, 1979).

Seaconsult (1991) has reviewed the historical trends in water quality in Muchalat Inlet over the past 24 years. An attempt was made to explain the post-mill lowering of dissolved oxygen in intermediate and lower water layers. The data on interannual variability of Gold River discharge could not be correlated with this observation. Water quality was also studied during major periods of mill shutdown in 1990. An initial assessment based on very limited data indicated an average 1.5 mg/L rise in dissolved oxygen during mill shutdown. Wide variation was observed in the water quality data.

1.2 Fisheries

Fisheries resource information of Muchalat Inlet has been reviewed by Knapp and Cairns (1978) and more recently by Fisheries and Oceans Canada (DFO) personnel, J. Morrison (pers. comm., 1989) and W. Knapp (pers. comm., 1990).

Gold River supports runs of all five salmon species as well as steelhead and cutthroat trout. The sockeye and chinook runs in the Gold River are one of two major sockeye and chinook runs in the Nootka Sound system. The coho run is the most significant out of the 36 streams found in Nootka Sound. The ten-year average (1975-1984) returns for salmon species are listed below:

Sockeye	Coho	Pink	Chum	Chinook
3182	1033	417	2495	1204

No commercial salmon fishery occurs in this area and only a minor sport fishery for chinook and coho salmon year-round. There is some native salmon food fishery.

Rockcod and lingcod are present along the shorelines of Muchalat Inlet and a minor fishery exists for these groundfish. Large numbers of anchovies are present throughout the inlet. Adult herring are occasionally present throughout Muchalat Inlet in the winter months. There is no commercial herring fishery in the area.

Prawns are harvested near the mill, at the mouth of the Gold River, by two commercial boats. There is a minor prawn fishery all along the shoreline of Muchalat Inlet. Crabs are also recreationally fished in the area.

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. Gold River was on this list and closures resulted for crab and prawn fisheries (Figure 2). In 1991, Beak Associates Consulting Ltd. carried out a comprehensive organochlorine monitoring program for Muchalat Inlet in the vicinity of the Gold River mill. Results of this study found elevated levels of AOX, dioxins and furans, and various chlorinated organic compounds in mill effluent. Dioxin and furans were found in all biota samples taken from Muchalat Inlet with the highest concentrations in crab hepatopancreas and rockfish liver. Further sampling resulted in the extension of the crab fishery closure area and a continuation of the prawn fishery closure.

1.3 <u>Bioassay Data</u>

Table 1 lists bioassay data from Gold River for the period 1980-1986 (from Kay, 1986). The mill has been able to meet the British Columbia Ministry of Environment (BCMOE) objective of 96h LC50 of 34%. With the installation of secondary treatment, mill effluent will be non-toxic by 1992.

TABLE 1: BIOASSAY DATA FROM GOLD RIVER MILL, (modified from Kay, 1986)

YEAR	96h LC50 (% vol. effluent)	PASS/FAIL
1975	30	2P/1F
1976	65	5F
1977	65	6F
1978	ND	ND
1979	30	ND
1980	30	2P/4F
1981	30	1P/1F
1982	30	4P
1983	30	4P
1984	30	3P
1985	34	2P
1986	34	2P

2.0 MATERIALS AND METHODS

Sampling in Muchalat Inlet was done from the C.S.S. *Vector* on August 29, 1986, July 30 and 31, 1988 and September 12 and 13, 1989 at stations shown in Figure 3. Stations were located using ship's LORAN-C and radar. Station positions are described in Appendix II. Table 2 summarizes 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

Water samples were collected at discrete depths with polypropylene N.I.O. water bottles using standard oceanographic techniques at stations depicted in Figure 3. Conductivity, temperature and depth (CTD) profiles were taken using a Plessy Instruments Model 9400 CTD sensor as described by Goyette and MacLeod (1984) in 1986 and a Guildline 8770 CTD/DO sensor in subsequent years.

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

Sediment grabs were taken at the stations depicted in Figure 3 using a stainless steel 0.1 m^2 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 freeze-dried and passed through a 100-mesh (0.177 mm) nylon sieve then digested in a 4:1 nitric-hydrochloric acid solution, and analyzed using a Perkin-Elmer Inductively Coupled Argon Plasma (ICAP) Optical Emission Spectrophotometer. Low-level cadmium was analyzed using a Jarrel Ash 850 Atomic Absorbtion Spectrophotometer (AAS) with an FLA 100 graphite tube furnace.

2.3 Biota Samples

In August 1986, spatially composited samples of *Fucus* sp. were collected. Several fronds of *Fucus* sp. were collected by hand from a few locations in the upper intertidal zone of each station, placed in plastic bags and frozen prior to analysis.

Dungeness crab, prawn and shrimp tissues were collected from a trawl at Station GRT-4 during the same 1986 sampling trip. In July 1988, ratfish (*Hydrolagus colliei*), sidestripe shrimp (*Pandalopsis dispar*), Dungeness crab (*Cancer magister*), pink shrimp (*Pandalus borealis*) and prawn (*Pandalus platyceros*) tissues were collected for trace metal analysis. As with the algae, samples were placed in plastic bags and frozen prior to analysis.

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 2: WATER, SEDIMENT AND BIOTA SAMPLING STATIONS, WATER QUALITY SAMPLES

WATER QUALITY STATIONS				
DATE	**STATION**	**CTD**	**DO**	**COLOUR**
Aug. 29, 1986	GR-0	X	X	X
	GR-1	X	X	X
	GR-3	X	X	X
	GR-5	X	X	X
	GR-7	X	X	X
	GR-9	X	X	X
	I-1			X
	I-2			X
	I-3			X
	I-4			X
	I-4.5			X
	I-5			X
	I-7			X
July 30, 1988	GR-0	X	X	X
	GR-1	X		X
	GR-3	X		X
	GR-5	X		X
	GR-7	X		X
	GR-9	X		X
	GRT-4	X		X
Sept. 12, 1989	GR-0	X		X
	GR-1	X		X
	GR-3	X		
	GR-5	X		
	GR-7	X		X
	GR-9	X		X
	GRT-4	X		

CTD Conductivity, Temperature, Depth
DO Dissolved Oxygen

TABLE 2 (CONT.): WATER, SEDIMENT AND BIOTA SAMPLING STATIONS

SEDIMENT SAMPLES

DATE	STATION	DEPTH (m)	PS/TM	H_2S	SVR
Aug. 29, 1986	I-1	0	X		X
	I-2	0	X		X
	GR-4	265	X		X
	GR-5	377	X		X
July 31, 1988	GRT-1	156	X		X
	GR-1	165	X		X
	GR-3	303	X	X	X
	GR-4	371	X	X	X
	GR-5	382	X	X	X

PS Particle Size
SVR Sediment Volatile Residue
TM Trace Metals (via ICAP & Hg - 1988)
H_2S Reducing Odour Present/Absent, Colour Noted
SVR Sediment Volatile Residue

BIOTA SAMPLES

DATE	STATION	BIOTA SAMPLED	TRACE METAL
Aug. 29, 1986	I-1,2,3,4,5,7	Intertidal algae (*Fucus* sp.)	X
	I-4.5		
Aug. 12, 1986	GRT-4	Dungeness crab	X
		Prawn	X
		Shrimp	X
July 30, 1988	GRT-4	Ratfish	X
		Dungeness crab	X
		Sidestripe shrimp	X
		Prawn	X

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

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

3.0 RESULTS

3.1 Water Quality

Salinity, temperature, dissolved oxygen (DO), % oxygen saturation and colour data from Muchalat Inlet are listed in Tables 4 to 16. There was a subsurface colour maximum at 10 m at all stations (except reference site GR-9) which was coincident with the dissolved oxygen minimum of the upper 20 m. Similar correlations between high colour (effluent presence) and low DO (influence of effluent BOD) have been noted at other mills discharging to fjords with estuarine circulation (Colodey, 1987).

TABLE 4: WATER QUALITY DATA - MUCHALAT INLET, AUGUST 1986

STATION	DEPTH (m)	SALINITY (ppt)	TEMP (°C)	DO (mg/L)	DO SAT. (%)	COLOUR (ADMI)
GR-0	0	27.2	18.5	7.8	110.7	14
	2	27.6	18.3	7.5	96.7	14
	4	30.1	15.3	7.5	92.6	14
	10	31.8	11.6	5.3	61.2	31
	20	32.2	11.2	6.3	72.3	8
	50	33.0	8.4	2.0	21.6	6
	190	33.3	7.9	1.7	18.2	6
GR-1	0	26.0	20.1	8.1	106.9	13
	2	27.3	19.1	7.8	101.9	13
	4	28.2	17.7	7.2	92.1	15
	10	32.0	11.2	3.1	35.5	21
	20	32.0	10.5	3.2	36.1	16
	50	32.9	8.5	1.2	13.0	5
	150	33.3	7.9	2.2	23.5	6
GR-3	0	27.5	18.5	7.9	102.2	13
	2	27.4	18.4	7.6	98.0	14
	4	29.1	16.4	6.4	80.3	14
	10	31.5	11.8	3.2	37.0	22
	20	32.2	10.4	2.6	29.3	18
	50	32.9	8.5	2.2	23.8	6
	190	33.4	7.8	1.7	18.2	5
GR-5	0	28.4	17.7	7.6	97.3	15
	2	28.5	17.5	7.4	94.5	13
	4	28.9	17.1	7.6	96.5	12
	10	31.7	11.8	3.0	34.8	23
	20	32.3	11.6	6.8	78.8	8
	50	33.0	8.4	2.3	24.9	6
	150	33.4	7.8	1.7	18.2	7
GR-7	0	29.8	16.5	7.8	98.5	12
	2	30.0	16.3	7.6	95.7	12
	4	30.1	16.3	7.7	97.0	12
	10	31.8	12.9	4.2	49.9	17
	20	32.3	11.5	6.4	74.0	7
	50	33.1	8.3	2.0	21.6	6
	150	33.4	7.8	1.5	16.0	6
GR-9	0	31.1	17.4	10.8	140.0	10
	2	31.4	16.4	10.7	136.3	11
	4	31.4	16.3	10.8	137.3	9
	10	32.0	14.2	9.4	114.9	8
	20	32.2	11.9	7.5	87.4	7
	50	32.8	8.8	3.0	32.7	6
	200	33.4	7.8	2.8	29.9	6

TABLE 5: WATER QUALITY, MUCHALAT INLET, JULY 30, 1988, TEMPERATURE (°C)

DEPTH (m)	STATION						
	GR-0	GR-1	GR-3	GR-5	GR-7	GR9	GRT-4
0	18.2	19.4	18.9	17.1	ND	15.1	15.1
2	17.4	16.2	16.6	16.5	ND	14.9	14.0
5	12.6	13.3	12.5	10.3	ND	11.6	11.6
10	9.2	9.3	9.1	9.1	8.9	9.6	9.9
15	8.9	9.07	8.9	8.9	8.8	8.7	9.3
20	8.8	8.99	8.8	8.8	8.8	8.7	8.8
50	8.6	8.70	ND	8.6	8.6	8.3	8.4

ND No Data

TABLE 6: WATER QUALITY, MUCHALAT INLET, JULY 30, 1988, SALINITY (ppt)

DEPTH (m)	STATION						
	GR-0	GR-1	GR-3	GR-5	GR-7	GR-9	GRT-4
0	9.0	9.4	8.5	19.6	ND	26.1	25.3
2	19.2	20.5	20.4	20.7	ND	26.4	25.9
5	27.7	27.3	29.2	28.6	ND	31.1	29.4
10	32.1	32.3	32.3	32.2	32.4	32.3	31.9
15	32.4	32.5	32.5	32.5	32.5	32.5	32.2
20	32.5	32.6	32.5	32.6	32.5	32.5	32.4
50	32.7	32.7	ND	32.7	32.7	32.7	32.7

ND No Data

TABLE 7: WATER QUALITY, MUCHALAT INLET, JULY 30, 1988, DISSOLVED OXYGEN (mg/L) AND % OXYGEN SATURATION

DEPTH (m)	GOLD RIVER STATION													
	GR-0		GR-1		GR-3		GR-5		GR-7		GR-9		GRT-4	
	DO	%SAT	DO	%SAT	DO	%SAT	DO	%SAT	DO	%SAT	DO	%SAT	DO	%SAT
0	7.0	79.7	7.1	83.4	7.0	81.0	6.4	76.6	ND	ND	6.7	80.3	5.8	69.1
2	6.0	72.0	5.3	62.7	6.0	71.4	5.4	64.3	ND	ND	6.2	74.2	5.6	65.4
5	3.4	39.0	3.3	38.4	3.0	34.7	2.9	31.8	ND	ND	5.7	65.5	3.7	42.1
10	2.5	26.8	2.0	22.0	2.5	27.4	2.0	21.9	2.6	28.3	4.7	52.1	4.9	54.4
15	2.8	30.5	1.9	20.9	2.6	28.4	2.6	28.4	2.5	27.2	3.1	33.7	4.2	46.2
20	2.6	28.3	1.7	18.7	2.5	27.2	2.3	25.0	2.5	27.2	3.1	33.7	3.2	34.8
50	2.4	26.0	1.9	20.7	ND	ND	2.4	26.0	2.3	25.0	4.1	44.2	3.5	37.8

ND No Data

TABLE 8: WATER QUALITY, MUCHALAT INLET, TEMPERATURE (°C), JULY 31, 1988

DEPTH (m)	STATION GR-0	GR-1	GR-7	GRT-4
0	18.4	18.0	18.3	16.6
2	15.4	17.0	18.2	16.3
5	9.3	10.3	10.1	10.8
10	9.2	9.3	9.2	9.6
15	8.9	9.1	8.9	9.3
20	8.8	9.0	8.8	8.9
50	8.6	8.7	8.6	8.4

TABLE 9: WATER QUALITY, MUCHALAT INLET, SALINITY (ppt), JULY 31, 1988

DEPTH (m)	STATION GR-0	GR-1	GR-7	GRT-4
0	16.4	7.0	15.9	23.1
2	22.7	19.8	17.4	23.7
5	32.1	31.1	31.3	31.4
10	32.1	32.1	32.1	32.2
15	32.5	32.4	32.4	32.2
20	32.6	32.5	32.5	32.4
50	32.7	32.7	32.7	32.7

TABLE 10: WATER QUALITY, MUCHALAT INLET, DISSOLVED OXYGEN (mg/L) AND % OXYGEN SATURATION, JULY 31, 1988

DEPTH	GR-0		GR-1		GR-7		GRT-4	
(m)	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT
0	6.6	79.4	6.7	75.6	6.7	80.1	6.9	83.5
2	5.0	59.0	5.4	64.5	6.5	78.3	6.9	83.3
5	1.9	20.9	1.5	16.7	2.3	25.6	5.1	57.7
10	2.0	21.9	2.4	26.3	2.5	27.4	5.1	56.4
15	2.4	26.2	2.1	23.0	3.0	32.7	4.1	45.1
20	2.7	29.4	2.0	21.9	2.8	30.5	3.6	39.2
50	2.4	26.0	2.2	23.9	2.4	26.0	3.6	38.8

TABLE 11: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 12, 1989, TEMPERATURE (°C)

DEPTH (m)	STATION						
	GR-O	GR-1	GR-3	GR-5	GR-7	GR-9	GRT-4
0	19.2	20.6	16.4	17.3	13.4	14.4	13.0
2	12.1	13.6	13.6	11.6	14.0	13.9	12.8
4	10.8	10.4	10.9	10.1	10.7	13.5	12.7
6	10.1	10.3	10.5	10.5	10.7	12.2	12.0
10	9.5	9.8	9.7	10.0	10.7	11.1	10.9
20	9.1	9.2	9.1	9.8	10.0	10.1	10.4
50	8.4	8.6	8.4	8.4	8.4	8.6	8.5
150	8.2	8.2	8.3	8.2	8.3	8.4	8.4

TABLE 12: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 12, 1989, SALINITY (ppt)

DEPTH (m)	STATION						
	GR-O	GR-1	GR-3	GR-5	GR-7	GR-9	GRT-4
0	26.8	25.0	28.0	27.0	30.2	20.7	31.0
2	31.1	30.4	30.4	31.5	29.9	30.9	31.1
4	31.8	31.8	31.8	32.1	31.9	31.2	31.5
6	32.0	31.9	31.9	32.1	32.0	32.3	32.0
10	32.0	32.2	32.1	32.2	32.3	32.6	32.6
20	32.5	32.5	32.5	32.6	32.6	32.8	32.7
50	33.1	33.2	33.1	33.1	33.1	33.1	33.1
150	33.5	33.6	33.5	33.5	33.4	33.5	33.3

TABLE 13: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 12, 1989, COLOUR

DEPTH (m)	STATION		
	GR-O	GR-1	GR-7
0	10	13	13
2	14	18	7
4	13	18	8
6	17	13/9	9/11
10	<5	6	<5
20	<5	<5	<5
50	<5	<5	<5
150	<5	<5	<5

TABLE 14: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 12, 1989, DISSOLVED OXYGEN (mg/L) AND % OXYGEN SATURATION

DEPTH (m)	GOLD RIVER STATION													
	GR-O		GR-1		GR-3		GR-5		GR-7		GR-9		GRT-4	
	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT
0	5.0	65.19	5.2	68.78	4.6	57.29	6.0	75.57	4.3	51.07	6.4	72.98	5.4	63.91
2	2.6	30.20	2.6	31.06	3.0	35.84	2.0	23.04	4.7	56.42	5.9	71.17	5.1	60.14
4	1.7	19.27	1.1	12.36	1.4	15.91	2.5	27.96	2.1	23.78	5.3	63.47	5.0	59.03
6	2.7	30.17	1.1	12.35	1.8	20.29	2.5	28.22	1.9	21.52	6.2	72.77	4.7	54.78
10	2.9	31.97	1.9	21.11	2.4	26.58	2.9	32.37	2.8	31.78	5.3	60.85	4.8	54.86
20	2.6	28.48	2.6	28.54	2.6	28.48	2.7	30.10	3.0	33.59	3.7	41.57	3.6	40.68
50	2.2	23.81	1.7	18.50	1.8	19.48	2.2	23.81	2.2	23.81	2.6	28.26	2.6	28.20
150	0.8	8.64	0.6	6.48	0.8	8.66	0.9	9.72	1.5	16.22	2.4	26.03	2.4	26.00

TABLE 15: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 13, 1989, TEMPERATURE (^oC)

DEPTH (m)	STATION				
	GR-O	GR-1	GR-3	GR-9	TL-1
0	15.9	16.1	15.7	15.2	17.2
2	13.1	12.8	13.2	14.1	17.0
4	10.8	10.6	10.6	14.0	16.2
6	10.3	9.9	10.3	ND	14.6
10	9.6	9.6	9.8	ND	ND
20	9.2	9.0	9.1	ND	ND
50	8.4	8.5	8.4	ND	ND
150	8.2	8.3	8.2	ND	ND

ND No Data

TABLE 16: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 13, 1989, SALINITY (ppt)

DEPTH (m)	STATION				
	GR-O	GR-1	GR-3	GR-9	TL-1
0	28.3	27.8	28.4	30.9	30.8
2	30.1	30.7	30.5	31.3	31.1
4	31.8	31.8	31.9	31.7	31.5
6	31.9	32.1	32.0	ND	32.2
10	32.1	32.4	32.1	ND	ND
20	32.5	32.5	32.5	ND	ND
50	33.1	33.1	33.1	ND	ND
150	33.5	33.4	33.5	ND	ND

ND No Data

TABLE 17: WATER QUALITY, MUCHALAT INLET, SEPTEMBER 13, 1989, DISSOLVED OXYGEN (mg/L) AND % OXYGEN SATURATION

DEPTH (m)	GOLD RIVER STATION									
	GR-0		GR-1		GR-3		GR-9		TL-1	
	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT	DO	% SAT
0	5.1	62.98	3.6	44.49	4.7	57.85	6.7	83.00	6.4	82.48
2	3.4	40.09	2.4	28.23	2.8	33.17	5.3	64.35	6.4	82.33
4	1.7	19.27	1.1	12.42	2.0	22.59	5.9	71.68	7.0	88.86
6	2.2	24.68	2.1	23.37	2.4	26.94	7.2	88.88	ND	ND
10	3.1	34.26	2.9	32.12	2.5	27.76	ND	ND	ND	ND
20	2.9	31.84	2.2	24.04	2.9	31.77	ND	ND	ND	ND
50	2.1	22.72	1.7	18.44	2.0	21.64	ND	ND	ND	ND
150	0.9	9.72	1.0	10.82	0.8	8.64	ND	ND	ND	ND

ND No Data

3.2 Sediment Quality

Deep water sediment sampling via grab was difficult due to the depth of Muchalat Inlet (>300 m). Sediment was collected from two deep water sites and two intertidal areas adjacent to the mill (Figure 2). One deep water site (GR-4) served as a reference location because it is about 20 km seaward of the mill, near Gore Island. One intertidal site (I-2) was located on the east bank of the Gold River and served as a reference for mill intertidal site I-1. Particle size, sediment volatile residue (SVR) and trace metal results are reported in Tables 18 and 19.

The median particle size of the intertidal sediments was finer than the deep water areas, where medium sand was collected. Maximum levels of iron (5.79%), chromium (104 μg/g), copper (143 μg/g), nickel (39 μg/g), lead (52 μg/g) and zinc (132 μg/g) were all found at the intertidal mill site (I-1) on the mill foreshore area. Concentrations of iron, chromium and copper in this area (I-1), were above levels known to cause damage to benthic invertebrate populations (Tetra Tech, 1986). Sediment volatile residue levels were also higher in the intertidal areas adjacent to the mill (18-20%). The lowest sediment volatile residue value was from the reference site (GR-4: <10%).

It is not known why levels of mercury, copper, lead and zinc were relatively higher at station GR-4 compared to GR-5, but natural sources are suspected. Sullivan (1987) reported similar values for mercury, cadmium, lead and zinc from a reference site (#10) in nearby Eliza Passage:

	Hg	Cd	Pb	Zn
GR-4	0.212	0.81	20	116
Eliza Passage	0.218	0.82	16	106

In summary, the most degraded sediments sampled (in terms of appearance, metal and volatile residue contamination) were from the mill foreshore station I-1. Sediment from station GR-5 had a reducing surface layer with wood fibres, and a relatively high SVR (13.2%) which may indicate the deposition of the mill effluent suspended solids load at this site.

TABLE 18: SEDIMENT VOLATILE RESIDUE, PARTICLE SIZE AND TRACE METALS, MUCHALAT INLET, AUGUST 1986

STN	DEPTH (m)	MEDIAN PART. SIZE	SILT +CLAY (%)	SVR (%)	Al (%)	As (µg/g)	Fe (%)	Hg (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
I-1	0	fine sand	20.5	20.4	1.97	<8	5.79	0.124	0.23	104	143	39	52	132
I-2	0	fine sand	24.1	17.9	2.85	<8	3.26	0.051	0.14	40.7	56.2	23	3	59.9
GR-5	377	med. sand	24.1	13.2	3.05	<8	3.94	0.122	ND	47.2	49.2	28	9	89.9
GR-4	265	med. sand	10.6	<10	3.51	<8	3.51	0.212	0.81	51.4	102	32	20	116

TABLE 19: SEDIMENT VOLATILE RESIDUE, PARTICLE SIZE AND TRACE METALS, MUCHALAT INLET, JULY 1988

STN	DEPTH (m)	MEDIAN PART. SIZE	SILT +CLAY (%)	SVR (%)	Al (%)	As (µg/g)	Fe (%)	Hg (µg/g)	Cd (µg/g)	Cr (µg/g)	Cu (µg/g)	Ni (µg/g)	Pb (µg/g)	Zn (µg/g)
GRT-1	156	med. sand	23.4	12.1	2.6	<8	2.9	0.19	ND	41.4	44.4	27	10	115
GR-1	165	med. sand	21.8	13.5	2.7	<8	3.1	0.16	<8	42.6	80.5	25	<8	97.6
GR-3	303	v.fine sand	45.2	16.4	3.1	<8	3.7	0.08	<8	41.4	111	25	<8	45.5
GR-4	371	v.fine sand	43.4	20.9	2.8	<8	3.5	0.10	<8	39.6	102	27	<8	53.3
GR-5	382	v.fine sand	55.8	11.8	3.1	<8	3.8	0.10	<8	44.8	107	30	<8	70.2

3.3 Biota Quality

Samples of *Fucus* sp. were collected in 1986 and analyzed for metals (Table 20). In addition, trawls were conducted in the same year and biota collected (Dungeness crab, prawn and shrimp) were analyzed for metals (Table 21). Trawls were repeated at the same location in 1988. The metals analysis for these biota (ratfish, Dungeness crab, sidestripe shrimp and prawn) are presented in Table 22.

TABLE 20: *Fucus* sp. Analysis, Muchalat Inlet, 1986

CONC (μg/g)	STATION							
	I-3	I-3	I-4	I-4	I-4.5	I-5	I-5	I-7
Hg	0.12	0.09	0.12	0.12	0.07	<.03	<.03	0.03
Al	17	21	17	20	19	15	10	21
As	28	28	41	39	31	30	30	25
Cd	1.2	1.0	1.5	2.7	1.2	1.3	1.0	1.0
Cr	0.5	0.5	0.5	0.4	<0.4	0.5	1.5	0.5
Cu	2.1	2.3	3.2	2.8	2.1	1.5	1.6	2.8
Fe	52.5	47.3	50.5	47.4	41.6	37.2	26.9	54.0
Mg	9400	9240	9390	8640	9040	9060	9030	8270
Mn	72.5	60.1	82.1	88.3	65.6	65.1	56.5	65.5
Ni	4	5	6	10	5	5	4	4
Pb	<2	<2	<2	<2	<2	<2	<2	<2
Sb	<4	<4	<4	<4	<4	<4	<4	<4
Sr	565	615	630	563	555	479	434	640
Ti	1.1	0.9	0.7	1.0	1.0	0.8	0.8	1.3
Zn	68.2	64.0	87.1	90.0	58.2	49.2	49.0	51.2
% mois.	65.3	64.0	71.0	62.6	55.1	69.5	74.4	63.1

TABLE 21: GOLD RIVER BIOTA, STATION GRT-4 (TRAWL), AUGUST 1986

CONC. (μg/g)	DUNGENESS CRAB				PRAWN						PINK SHRIMP	
	CLAW[1]	CLAW[2]	HEPATO[1]	HEPATO[2]	33mm	46mm	43mm	38mm	22mm	POOLED HEPATO	TAIL	TAIL
Cd	0.10	0.29	ND	ND	ND	0.17	0.11	0.11	0.26	0.10	0.12	0.51
Pb	0.37	0.16	<0.04	0.15	0.24	0.27	0.08	0.27	0.33	0.20	0.19	0.23
Hg	0.34	0.28	0.98	0.48	0.36	0.94	0.32	0.27	0.13	0.18	0.13	0.19
Al	15	34	17	29	13	16	6	13	41	14	64	37
As	109	86	802	72	226	226	370	129	81	243	71	72
Ba	3.42	1.01	0.65	1.08	0.12	<0.09	<0.08	<0.08	0.10	<0.08	0.26	0.30
Be	<0.08	<0.08	<0.08	<0.08	<0.08	<0.09	<0.08	<0.08	<0.08	<0.08	<0.09	<0.08
Cd	<0.2	<0.2	7.4	58.8	0.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.3
Co	<0.4	<0.4	4.2	5.2	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cr	1.1	2.1	6.9	3.0	1.1	0.7	0.5	0.6	0.5	1.2	3.8	1.8
Cu	20.5	24.5	459	249	53.6	41.8	48.8	37.0	34.5	34.6	29.1	38.9
Fe	51.3	77.1	681	259	99.9	30.8	24.9	24.9	63.5	32.5	120	72.1
Mg	3810	2510	3480	4090	1750	1810	1600	1710	1780	1660	1860	1820
Mn	38.4	7.4	20.3	17.9	3.6	2.5	1.8	4.4	7.9	3.4	11.8	6.8
Ni	4	<2	21	74	<2	<2	<2	<2	<2	<2	<2	<2
Sb	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Sn	<0.8	<0.8	<0.8	<0.8	<0.8	<0.9	<0.8	<0.8	<0.8	<0.8	<0.9	<0.8
Sr	869	248	43.5	59.9	14.2	16.9	14.5	14.8	15.0	13.8	21.7	15.2
Ti	<0.2	1.4	2.6	3.0	0.6	0.8	<0.2	0.7	2.1	0.6	3.3	2.0
V	<0.4	<0.4	5.4	5.8	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Zn	276	245	139	173	73.1	67.9	65.8	62.3	62.5	64.1	59.2	55.9
% mois.	74.1	77.2	80.0	77.8	76.2	76.5	76.8	76.5	77.4	76.0	75.9	75.5

[1] Dungeness crab, male, 170mm, 703g
[2] Dungeness crab, female, 150mm, 413g

TABLE 22: GOLD RIVER BIOTA, STATION GRT-4 (TRAWL), JULY 1988

CONC. (μg/g)	RATFISH[1]	DUNGENESS CRAB[2]	SIDESTRIPE SHRIMP[3]	SIDESTRIPE SHRIMP	SIDESTRIPE SHRIMP	PRAWN[4]
Hg	0.19	0.48	0.09	0.16	0.11	0.32
Al	4	40	112	19	35	8
As	53	343	50	73	66	242
Cd	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cr	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Cu	6.2	90.2	28.6	27.6	32.7	43.1
Fe	354	539	122	23.0	37.9	16.4
Mg	80	1270	3020	3120	3160	3200
Mn	0.93	14.9	5.5	6.4	6.0	10.1
Ni	<2	8	<2	<2	<2	<2
Pb	<4	<4	<4	<4	<4	<4
Sb	<4	<4	<4	<4	<4	<4
Sr	0.3	20.1	435	435	455	469
Ti	1.6	3.8	8.4	2.6	3.0	2.0
Zn	7.8	101	47.7	46.5	47.0	52.3
% mois.	67.5	66.0	77.8	76.8	76.5	74.8

1 Ratfish (liver) 58cm 1055g
2 Dungeness crab 150cm 465g (female, hepato)
3 Sidestripe shrimp (tail)
4 Prawn (tail)

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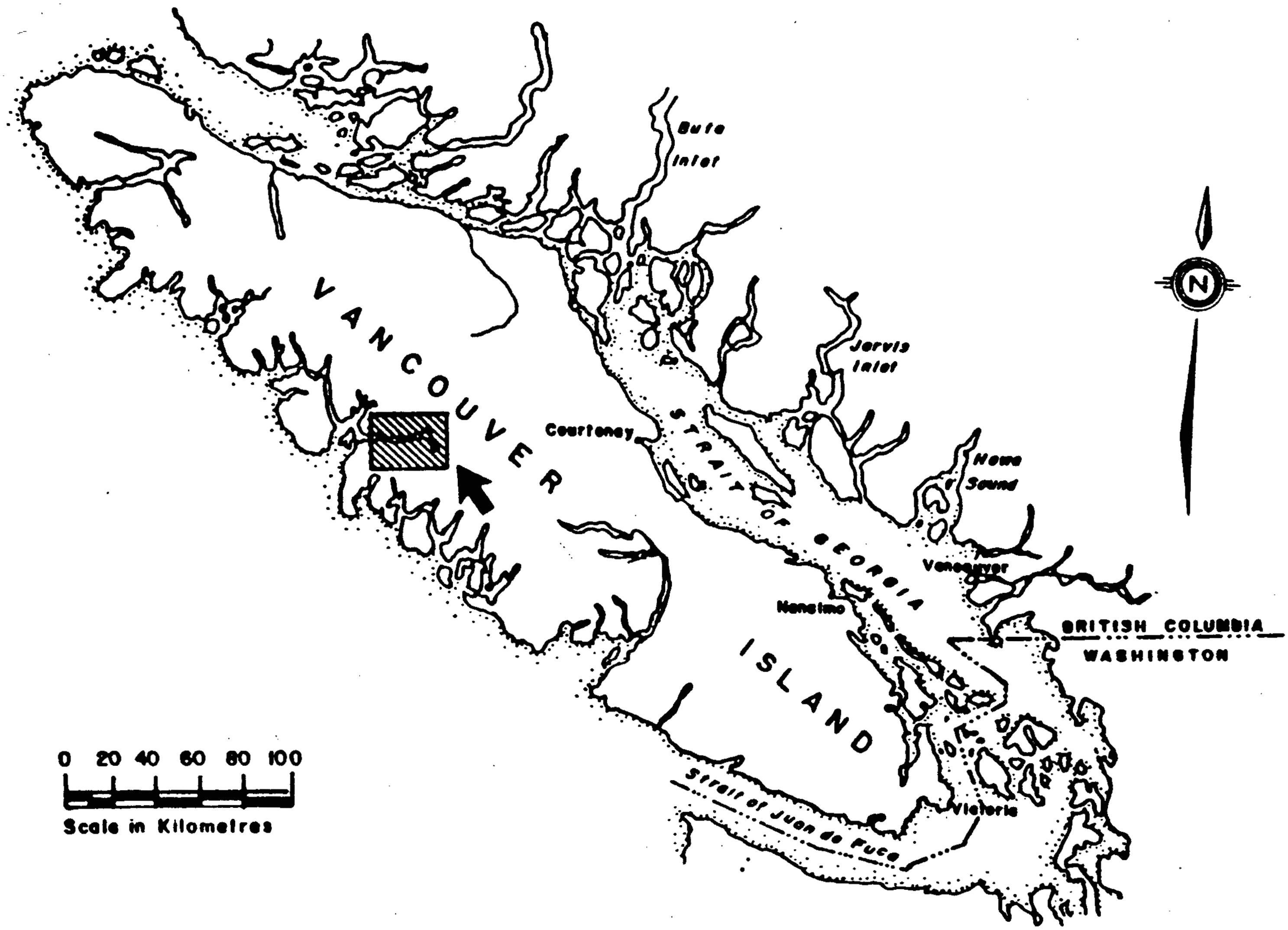

FIGURE 1: LOCATION MAP - MUCHALAT INLET

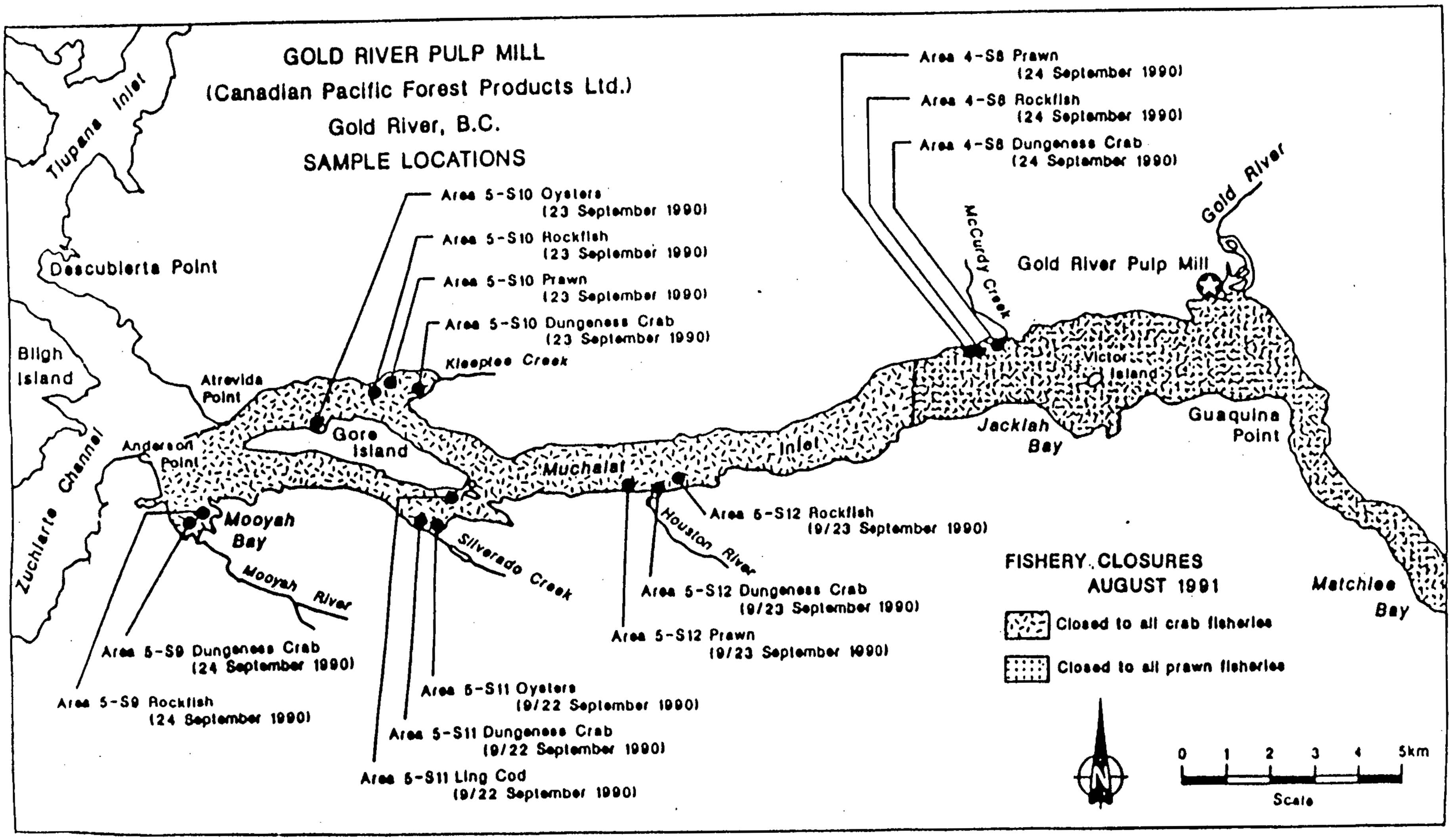

FIGURE 2: GOLD RIVER FISHERIES CLOSURES, 1991

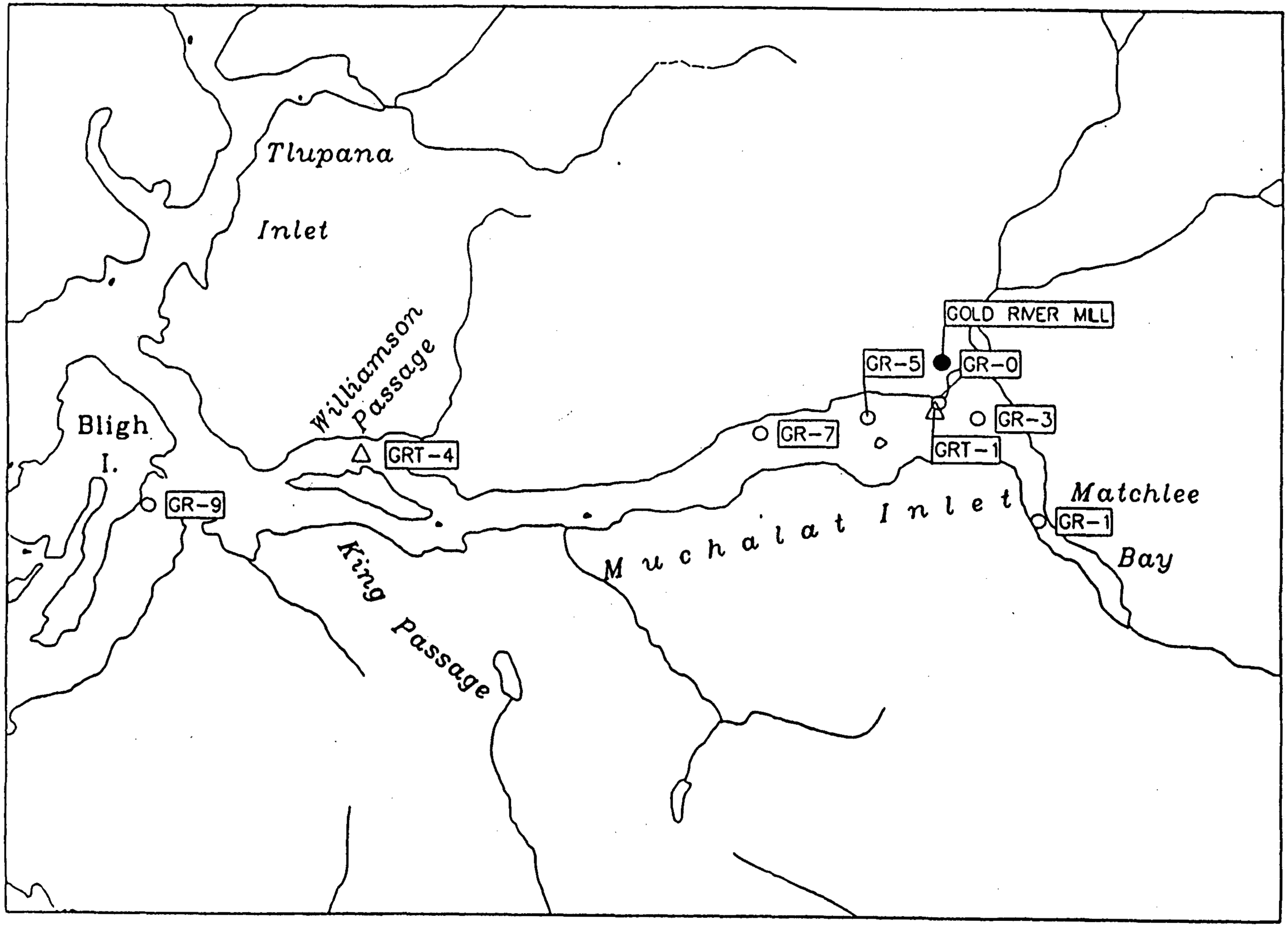

FIGURE 3: GOLD RIVER SAMPLE SITES

APPENDICES

APPENDIX I: PACIFIC REGION PULP AND PAPER INDUSTRY EFFLUENT SUMMARY

Company: Canadian Pacific Forest Products Ltd.
Mill: Gold River
Location: Gold River

Year: 1987

	===FLOW===	=PRODUCTION=		===TSS (FED)===			==TSS (PROV)==	===BOD5 (FED)===			==BOD5 (PROV)==	==TOXICITY (PROV)==		
	Aver. (m3/d)	Av. (ADt/d)	# of days	Av. (kg/ADt)	# of Tests	% Comp.	Av. (tonne/d)	Av. (kg/ADt)	# of Tests	% Comp.	Av. (tonne/d)	# of Tests	% Comp.	Av. 96LC50 (%v/v)
Yearly Values	136,583	703	343	16.17	145	37%	9.27	30.32	45	91%	19.63	6	67%	52

EFFLUENT QUALITY REQUIREMENTS

	FLOW (m3/d)	TSS	BOD5	TOXICITY (%v/v)
Federal (kg/ADt)	---	10.30	47.90	96LC20 = 65
Provincial (tonne/d)	147,000	13.30	25.30	96LC50 = 30

APPENDIX II: GOLD RIVER SAMPLING STATION LOCATIONS

DATE	STATION	DEPTH (m)	LATITUDE	LONGITUDE
29 Aug/86	GR-1	350	49°40.38 N	126° 8.05'W
	GR-0	205/183	49°40.48'N	126° 7.82'W
	GR-1	158	49°38.30'N	126° 5.10'W
	GR-2	ND	49°39.85'N	126° 6.01'W
	GR-3	312/403	49°40.00'N	126° 6.95'W
	GR-4	ND	49°40.19'N	126° 8.30'W
	GR-5	377	49°40.23'N	126° 9.47'W
	GR-6	ND	49°39.89'N	126°11.21'W
	GR-7	363	49°39.60'N	126°12.90'W
	GR-8	ND	49°38.88'N	126°15.71'W
	GR-9	245	49°39.24'N	126°28.41'W
	GRT-1 (Trawl)	368 Start Finish	49°40.30'N 49°40.15'N	126° 7.70'W 126° 7.05'W
	GRT-4 (Trawl)	265 Start Finish	49°39.47'N 49°39.47'N	126°23.52'W 126°24.50'W
30 July/88 31 July/88	GR-0	371	49°40.48'N	126° 7.82'W
	GR-1	165/170	49°38.30'N	126° 5.10'W
	GR-3	303	49°40.00'N	126° 6.55'W
	GR-5	382	49°49.23'N	126° 9.47'W
	GR-7	363	49°39.60'N	126°12.90'W
	GR-9	245	49°39.24'N	126°28.41'W
	GRT-1 (Trawl)	158 Start Finish	49°40.16'N 49°40.30'N	126° 7.30'W 126° 7.95'W
	GRT-4 (Trawl) (Grab)	147 Start 154 Finish 156	49°39.60'N 49°39.47'N 49°39.45'N	126°25.10'W 126°24.17'W 126°24.05'W
12 Sept/89 13 Sept/89	GR-0	349	49°40.45'N	126° 8.00'W
	GR-1	156	49°38.30'N	126° 5.10'W
	GR-3	ND	49°40.00'N	126° 7.00'W
	GR-5	363	49°40.40'N	126° 9.40'W
	GR-7	355	49°39.60'N	126°12.65'W
	GR-9	248	49°39.25'N	126°28.40'W
	GRT-4	152	49°39.47'N	126°24.15'W
	TP-1	260	49°45.30'N	126°26.66'W

APPENDIX III: RESULTS FOR GOLD RIVER PULP MILL EFFLUENT MONITORING, 1990

PARAMETER	SEPT 24, 1990	OCT 16, 1990
CHLOROANISOLE/2,3,4,5-TETRA	<0.005	<0.005
/2346+56-TETRA	<0.005	<0.005
/PENTA	<0.002	<0.002
CHLOROPHENOL/2,3,4,5-TETRA	<0.005	<0.005
/2,3,4-TRI	<0.01	<0.01
/2,3,5-TRI	<0.01	<0.01
/2,3,6-TRI	<0.01	<0.01
/2,4,5-TRI	<0.01	<0.01
/2,4,6-TRI	1.41	3.48
/2346+2356-TETRA	<0.005	<0.005
/PENTA	0.317	0.396
RESIN ACID/12-CHLORO-DHA	<0.01	0.03
/14-CHLORO-DHA	<0.01	0.02
/8(14)ABIETENIC	<0.01	<0.01
/ABIETIC	<0.01	0.44
/DEHYDROABIETIC	<0.01	0.99
/DICHLORO-DHA	<0.01	<0.01
/DIHYROISOPIMARIC	<0.01	<0.01
/ISOPIMARIC	<0.01	0.32
/NEOABIETIC	<0.01	<0.01
/PALUSTRIC	<0.01	0.28
/PIMARIC	<0.01	<0.01
/SANDARACOPIMARIC	<0.01	0.27