Department of Environment
Environmental Protection Service
Pacific Region

PULP MILL ENVIRONMENTAL IMPACT ASSESSMENT
MACMILLAN BLOEDEL LTD.,
POWELL RIVER DIVISION

Regional Program Report: 79-14

by

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ABSTRACT

In October 1976, the Environmental Protection Service initiated a program to assess the environmental impact of pulp and paper mills in British Columbia. With the cooperation of various other government agencies and the pulp and paper industry, EPS compiled relevant resource data and receiving environment monitoring information. After reviewing and evaluating the existing information, the environmental quality of each area was assessed and the need for additional monitoring studies determined. This report represents the environmental impact assessment for the MacMillan Bloedel pulp and paper mill complex at Powell River, British Columbia.

RESUME

Au mois d'Octobre 1976, le Service de la protection de l'environnement a entrepris de'evaluer les repercussions mesologiques des fabriques de pates et papeirs de la Colombie-Britannique. Aide de l'industrie et de divers autres organismes gouvernementaux, il a reuni une documentation concernant les ressources ainsi que certains resultats de controles portant sur l'environnement affecte. Apres avoir etudie ces donnees, le Service a evalue la qualite environnemetale de chacune des regions et determine quelles seraient les etudes supplementaires qui resteraient a realiser. Ce rapport fait connaitre les resultats ayant trait a l'evaluation des contrecoups imputables a la fabrique de pate de la MacMillan Bloedel de Powell River, Colombie-Britannique.

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SUMMARY AND CONCLUSIONS

The practice of discharging un-clarified mill effluent into the tailrace at Powell River has resulted in certain environmental impacts along the shoreline northwest of the mill, the southeast shore of Harwood Island, and in the subtidal benthic zone in the immediate vicinity of the mill. The impacts identified have been elevated zinc concentration in oysters, and reduced intertidal communities in areas exposed to mill effluent which is transported in surface waters northwestward and westward after discharge. Heavy fibre loading has reduced benthic communities in the area adjacent to the mill.

Asthetically displeasing brown coloration and foam in surface waters frequently result from the tailrace discharge. High mercury concentrations in bottom sediments close to the mill do not appear to have contaminated the marine biota of the area however dredging operations should be closely monitored for potential releases of mercury to the watercolumn.

The pollution abatement program underway at Powell River should alleviate many of the impacts currently identified in the receiving environment. The discharge of effluent from the kraft mill through a submerged diffuser system should greatly increase the dilution of toxic wastes and prevent their movement into surface waters and subsequently onto intertidal communities. Recently installed fibre removal facilities to treat woodmill and paper machine effluent streams will significantly reduce suspended solids loss and fibre input to the mill area.

A comprehensive environmental monitoring program is to be carried out in conjunction with the submerged diffuser system and the modified tailrace discharge to assess the expected benefits of these measures upon the receiving environment. In addition to the continuation of intertidal, benthic and water quality studies a dye tracer or equivalent study should be carried out following diffuser start-up to determine actual diffusion and dispersion characteristics of the new system.

1 INTRODUCTION

The MacMillan Bloedel pulp mill at Powell River is located on the mainland shore of Malaspina Strait approximately 100 km northwest of Vancouver, British Columbia (Figure 1). The pulp mill was built in 1912 on relatively exposed shoreline just south of the mouth of the Powell River. Water from the river was diverted through the mill area forming a tailrace into which mill effluent is discharged and carried to the surface waters of Malaspina Strait (Figure 2).

The coastline in this portion of the Strait undergoes considerable tidal flushing which aids in the rapid dispersion of mill discharges. The area is susceptible to relatively strong winds which blow predominantly from the southeast in winter and the northeast in summer and result in good mixing and transport of surface waters. Ten floating hulks have been anchored around the mills' log handling and storage area to serve as a floating breakwater adjacent to the mill.

The Powell River area and the Westview township, a few kilometers south of the mill are well known for recreational scuba diving and sport fishing. MacMillan Bloedel is currently planning a major expansion at the Powell River operation which would result in a significant increase in the production of newsprint and provide approximately 100 new jobs in the area.

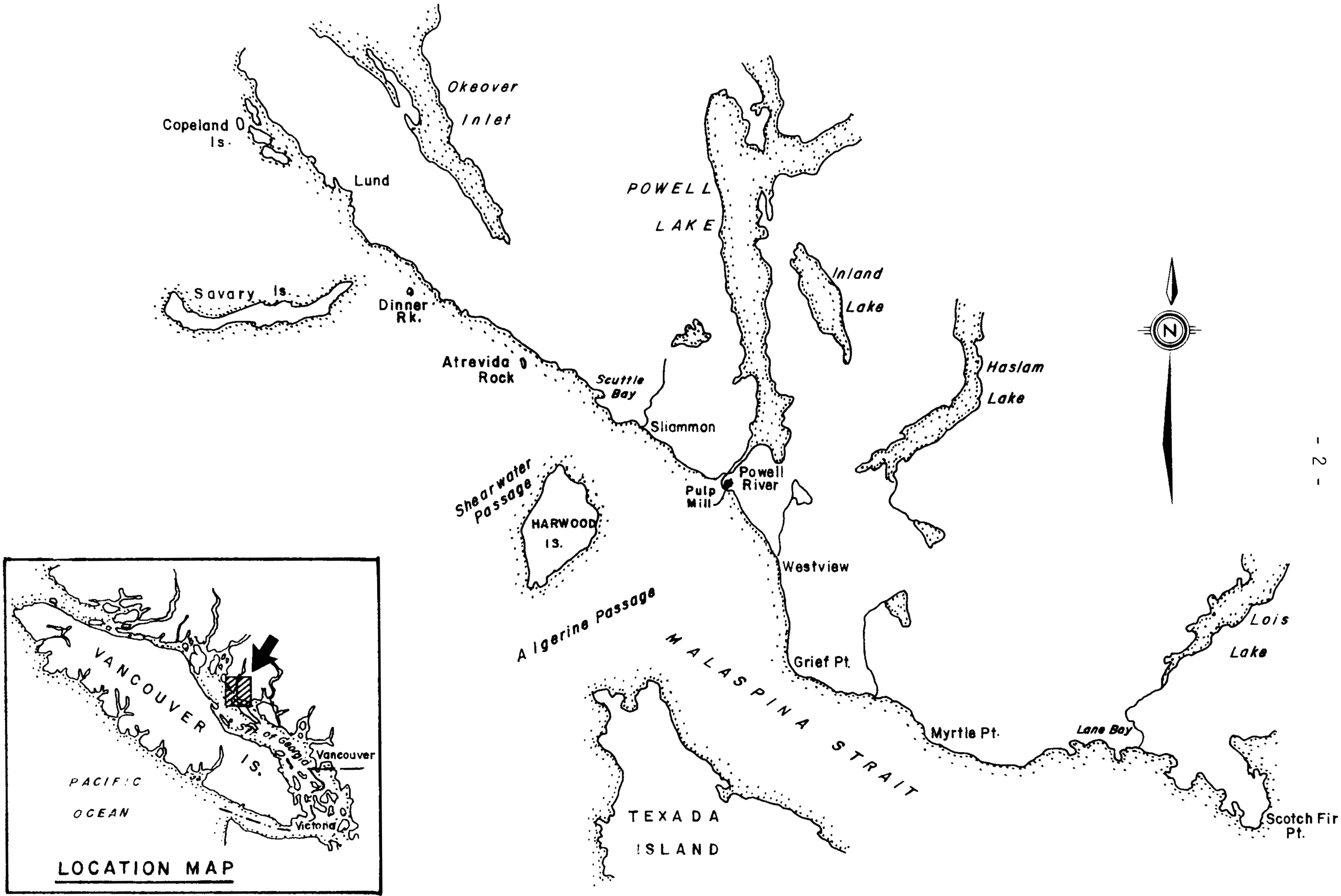

FIGURE I POWELL RIVER

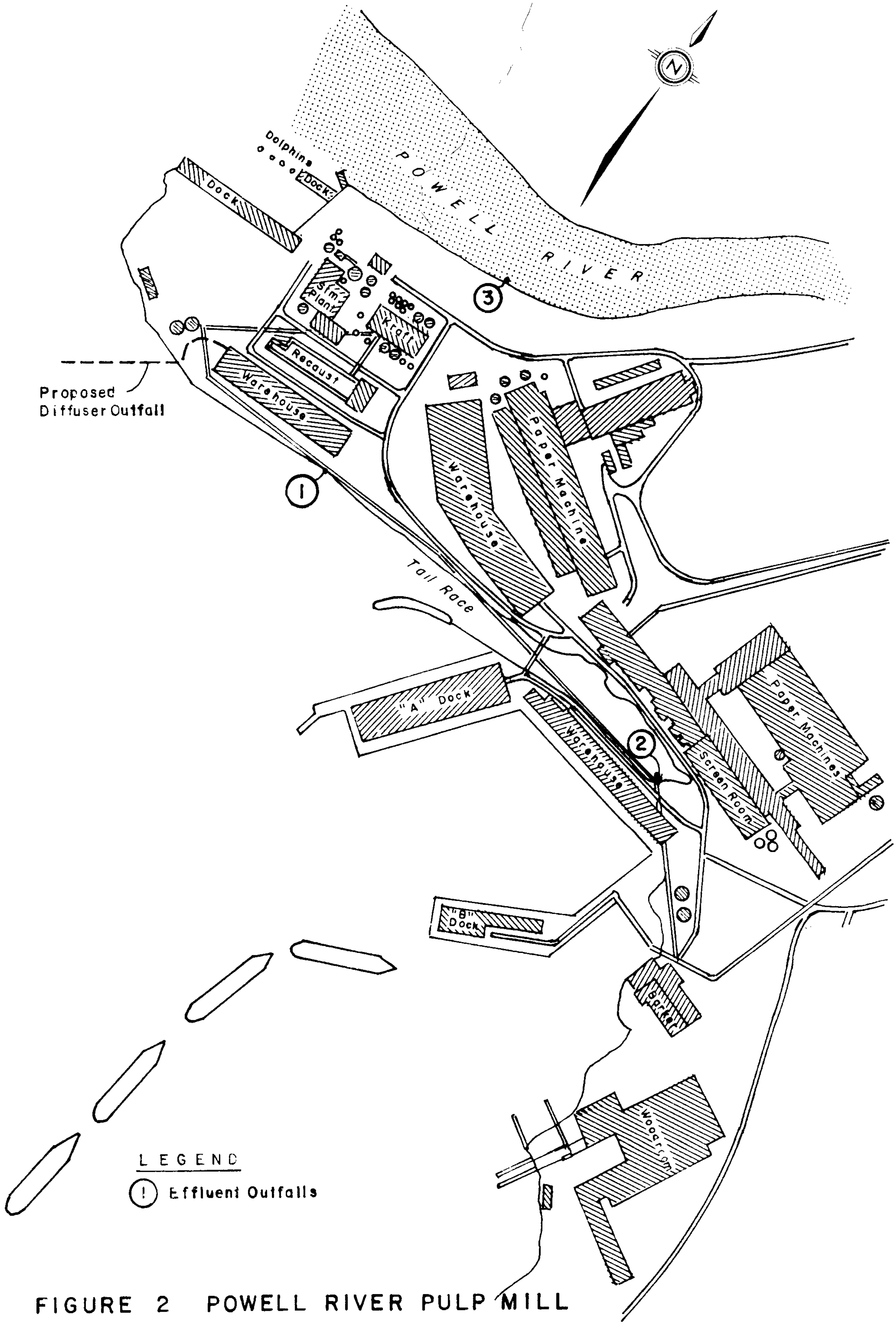

FIGURE 2 POWELL RIVER PULP MILL

2 MILL OPERATIONS

The Powell River Division of MacMillan Bloedel Limited is an integrated producer of forest products. The combined operation presently includes a kraft semi-bleach pulp mill, two stone groundwood mills, one sawdust refiner groundwood mill, one thermo-mechanical pulp mill (TMP), six paper machines numbered from 5 to 10, and a sawmill. The paper machines produce approximately 1650 air dried tons (ADT) of newsprint per day for an average annual production in the order of 570 000 tonnes. The kraft mill produces approximately 600 tons of semi bleached kraft per day. Of this production 400 to 500 tons is added to the groundwood pulp as chemical pulp furnish to make newsprint and the remainder sold as "market pulp".

The planned expansion of newsprint facilities at Powell River will cost an estimated 160 million dollars and will increase the annual newsprint production by 190 000 tonnes or about 33 percent. The additional newsprint will be made in a new twin wire paper machine (designated #11) to be installed as part of the expansion. The pulp needed to furnish the new paper machine will be largely produced by two new lines of the thermo-mechanical pulping process. The new facilities are expected to be in operation by July 1, 1981.

The mechanically ground pulp used in the production of newsprint undergoes a brightening process which formally employed zinc hydrosulphite as a bleaching agent. In 1971, a study contracted by another forest products industry operating on the B.C. coast revealed that zinc entering the receiving environment in mill effluent had resulted in a significant accumulation of this metal in the tissue of oysters and in waters of the area. Subsequent to these findings four groundwood pulp mills on the B.C. coast, including MacMillan Bloedel's Powel River Division, converted to a new bleaching compound and discontinued the use of zinc hydrosulphite.

The wood used in the production of pulp is in the form of lower grade logs supplied locally and wood shipped in from other areas of the Province. The mill is currently shipping in a considerable amount of wood chips annually and will require additional supplies when the expansion is complete. The company is hopeful that they will soon be able to resume logging in an area of Vancouver Island, northwest of Campbell River, which has been under a logging moratorium for three years.

Effluent from the pulp mill is presently discharged through three outfalls designated 1, 2, and 3 as shown on Figure 2. Outfall #1 discharges toxic effluent from the kraft mill into the mouth of the tailrace. Outfall #2 previously discharged fibre bearing effluent from wood mill hydraulic debarkers, mechanical (groundwood) pulp mills, paper machines, and the steam plant. These effluent streams now pass through a new clarifier for fibre removal before discharge. Outfall #2 discharges near the head end of the tailrace. Outfall #3 discharges relatively uncontaminated effluent from the block flume at a point near the mouth of the Powell River.

3 EFFLUENT QUALITY

3.1 Government Regulations

MacMillan Bloedel's Powell River pulp mill currently discharges mill effluent under a permit issued by the Pollution Control Branch (PCB) of the British Columbia Provincial Government. The permit, PE-153, was issued on April 6, 1966, and has been amended several times. The amended permit stipulates minimum effluent standards for the combined effluent streams from outfalls 1 and 2 and for the block flume outfall, number 3, as shown in Table 1. Effluent standards set by the PCB are outlined in a report on Pollution Control Objectives for the Forest Products Industry in British Columbia (1977).

The quantity of effluent discharged from outfalls 1 and 2 is not to exceed 67 500 000 imperial gallons per day (IGPD) or 305 000 cubic metres per day on a weekly average and for the block flume outfall is not to exceed 11 500 000 IGPD (52 000 m^3/day) on a weekly average.

On March 16, 1979, MacMillan Bloedel submitted a new application to the PCB to further amend permit PE-153 such that effluent characteristics would be specific to three separate outfalls, thereby replacing the combined requirements for outfalls 1 and 2. The designation of 3 outfalls in the permit would be compatible with MacMillan Bloedel's recently completed and proposed changes to their effluent treatment system. These changes involve the installation of major external pollution abatement facilities including a clarifier (on-line in October 1978) and submerged outfall and diffuser system. These will be discussed in Section 3.2.3.

As an expanded mill Powell River Division would be expected to comply to Federal Government Pulp and Paper Effluent Regulations (Environment Canada, 1971). The regulations for existing mills impose certain effluent standards for biological oxygen demand (BOD_5), suspended solids (SS), and toxicity as shown in Table 2.

3.2 Effluent Characteristics

3.2.1 BOD and SS. Tables 3 and 4 show levels of BOD and SS in Powell River mill effluent for 1977 and 1978 respectively. These measurements

TABLE 1 PCB PERMIT REQUIREMENTS FOR MACMILLAN BLOEDEL LTD., POWELL RIVER DIVISION

	Effluent Characteristic		Value
Outfalls 1 and 2	Temperature	<	35°C
	Total Suspended Solids	<	66 880 lbs/day (30 500 kg/day)
	BOD_5	<	98 530 lbs/day (44 500 kg/day)
	Toxicity (96 hour LC_{50})	>	30% neutralized effluent concentration
Outfall 3	pH Range		6.5 - 8.5 (within 5 metres)
	Temperature	<	35°C
	Floatable Solids		negligible
	Toxicity (96 hour LC_{50})	>	12.5% effluent concentration

TABLE 2 FEDERAL EFFLUENT REGULATIONS FOR MACMILLAN BLOEDEL LTD., POWELL RIVER DIVISION

Process		Allowable Discharge	
		SS	BOD_5
Hydraulic Debarking		5 lb/ODT (oven dried tons of wood)	
Kraft Pulping		7 lb/ADT	64 lb/ADT
Kraft Bleaching		6 lb/ADT	27 lb/ADT
Mechanical Pulping		13 lb/ADT	
Mechanical Pulp Bleaching		2 lb/ADT	
Pulp Sheet Formation		2 lb/ADT	
Integrated Single Product	- Kraft	3	
	- Groundwood	5	
Specialty Multi-product	- Kraft	25	
	- Groundwood	25	

Toxicity - Installation of submerged effluent diffuser system for the Kraft mill effluent by December 1980. The diffuser to achieve an effluent concentration no greater than 0.05 toxic units. (Discussed in Section 3.2.3).

TABLE 3 1977 FEDERAL EFFLUENT QUALITY RESULTS FOR MACMILLAN BLOEDEL LTD., POWELL RIVER DIVISION

Month	Flow x 10^6 IGPD	BOD_5 LB/ADT	BOD_5 Tons/Day	Suspended Solids LB/ADT	Suspended Solids Tons/Day
January	59.7	52.4	41.61	75.1	59.63
February	59.5	48.2	39.58	69.3	56.93
March	63.4	48.5	39.40	85.1	69.22
1st Quarter	60.9	49.7	40.20	76.5	61.93
April	65.1	45.7	35.56	83.5	64.93
May	56.3	33.1	25.15	87.2	66.25
June	60.8	50.7	39.90	93.6	73.63
2nd Quarter	60.7	43.2	33.54	88.1	68.27
July	62.5	45.3	36.65	79.3	64.15
August	62.8	39.8	31.78	89.3	71.32
September	61.6	41.4	31.74	78.2	59.97
3rd Quarter	62.3	42.2	33.39	82.3	65.15
October	61.9	39.9	33.96	71.7	61.07
November	62.3	45.2	38.06	80.4	67.68
December	64.5	43.9	34.83	75.7	60.08
4th Quarter	62.9	43.0	35.62	75.9	62.94
Yearly Average	61.7	44.5	35.69	80.7	64.57

TABLE 4 1978 FEDERAL EFFLUENT QUALITY RESULTS FOR MACMILLAN BLOEDEL LTD., POWELL RIVER DIVISION

		BOD_5		Suspended Solids	
Month	Flow x 10^6 IGPD	LB/ADT	Tons/Day	LB/ADT	Tons/Day
January	62.4	47.9	37.87	83.3	65.81
February	63.7	43.9	36.71	81.4	68.01
March	62.9	41.4	33.01	74.6	59.41
1st Quarter	63.0	44.4	35.86	79.8	64.41
April	63.4	36.7	29.72	78.1	63.27
May	57.1	41.0	33.52	76.1	62.17
June	58.7	42.1	34.82	73.8	61.07
2nd Quarter	59.7	39.9	32.69	76.0	62.17
July	60.9	35.8	29.87	82.9	70.00
August	60.6	36.5	30.64	82.7	69.44
September	60.6	34.4	27.45	89.2	71.10
3rd Quarter	60.7	35.6	29.32	85.3	70.18
October	55.8	34.3	27.34	70.8	56.44
November	57.9	36.6	28.11	69.6	53.46
December	54.0	33.6	23.86	65.2	46.30
4th Quarter	55.9	34.8	26.44	68.5	52.07
Yearly Average	59.8	38.7	31.08	77.4	62.21

are taken routinely by MacMillan Bloedel personnel and the results forwarded to the Federal and Provincial regulatory agencies. The new clarifier which came on line in October 1978, is expected to approach 85 percent removal efficiency for suspended solids.

3.2.2 Toxicity. In December 1975, an effluent monitoring program was initiated by Environment Canada to determine the toxicity of the Powell River mill effluent to salmonids. MacMillan Bloedel participated in the program by sending composite effluent samples on a regular basis to the Environmental Protection Service (EPS) bioassay laboratory in Vancouver for toxicity testing. Results of these tests are shown in Table 5 along with the Federal and Provincial toxicity requirements. The program of toxicity testing was terminated by EPS in December 1977. MacMillan Bloedel has been relieved of the necessity to comply to the Federal toxicity requirement until such time as the proposed submerged outfall diffuser system is installed and its effects on the receiving environment assessed.

3.2.3 Pollution Abatement Program. MacMillan Bloedel has recently installed a fibre recovery facility which will significantly reduce the amount of suspended solids (by approximately 85%) released to the receiving enviroment. A 91 metre diameter clarifier has been installed to treat effluent from the woodmill hydraulic barker, groundwood (mechanical) pulping, paper machines and the steam plant. The effluent is discharged at outfall #2 after clarification and is expected to contain less suspended solids than the level "B" requirement in the PCB permit, i.e., 32 200 kg per day.

A submerged outfall diffuser system proposed for the Powell River operation will carry the more toxic effluents from the bleached kraft mill (presently discharging at the outfall #1) and discharge through a diffuser pipe into Malaspina Strait southwest of the mill. The approximate location of the proposed diffuser system is shown in Figure 7 in Section 4.2. The diffuser and pipe will extend approximately 800 metres from shore with the diffuser section comprising about 330 metres

TABLE 5 1976-1977 BIOASSAY RESULTS FOR MACMILLAN BLOEDEL LTD., POWELL RIVER DIVISION

Sample Date	% Survival Over 96 Hours, Static Testing Concentration (% v/v) of neutralized effluent							Sample pH
	100	65	45	32	12.5	5.6		
December 8, 1975	0	60	100	100	100	100		6.3
February 23, 1976	0	0	0	20	100	100		6.7
April 26, 1976	0	0	0	0	0	100		3.3
June 11, 1976	0	0	0	14	100	100		4.4
August 13, 1976	0	0	0	0	0	100		3.3
October 8, 1976	0	0	0	0	100	100		3.8
December 22, 1976	0	0	0	100	100	100		6.3
	100	75	65	42	30	24	18	
February 15, 1977	-	60	100	100	100	100	100	6.3
April 18, 1977	0	0	0	60	60	100	100	6.3
June 24, 1977	-	0	0	100	100	100	100	6.6
August 15, 1977	-	0	0	100	100	100	-	6.6
October 14, 1977	-	0	0	50	100	100	100	-

Federal Bioassay Requirement - 80% survival in 65% (v/v) effluent concentration over 96 hours, continuous flow testing.

P.C.B. Bioassay Requirement - 50% survival in 12.5% (v/v) effluent concentration (amended December 1978 to 30% v/v for outfalls 1 and 2) over 96 hours, static testing.

at the end. The downstream end of the diffuser will be approximately 72 metres deep with the upstream end located in about 55 metres.

Design and placement proposals for the diffuser system were made after consultants, retained by MacMillan Bloedel, carried out the following studies:

(i) oceanographic studies to determine tidal and non-tidal current characteristics, mass water movements and disperison rates (Dobrocky Seatech, 1977a);

(ii) lethal and sublethal toxicity testing on juvenile herring with Powell River mill effluent (E.V.S. Consultants, 1977);

(iii) interpretation of oceanogrpahic data and preliminary engineering calculations (Simons, 1977).

The following conclusions based on the consultant's reports were outlined in "Study of Alternatives to Comply with Effluent Permit P.E. 153 (Amended December 15, 1976)" a submission by MacMillan Bloedel to PCB dated July 1, 1977 (on file EPS);

a) An average dilution of 110:1 would be required to obtain an effluent concentration equivalent to not greater than 0.05 toxic units, i.e., to reduce toxicity below the sublethal concentration.
b) The main stream of predominant currents occurs about 2000 ft southwest of the present mill effluent discharge point.
c) The directions of the predominant currents parallel the shore line.
d) A diffuser discharging from a point beginning 2000 ft southwest of the mill would trap effluent between 77 and 176 ft below the surface. This would be well below the zone of photosynthetic activity.
e) Recommended diffuser length is 1150 ft to achieve the desired dilution of 110:1.

The existing effluent discharge permit requires that the submerged outfall and diffuser system be completed and in operation by December 1980. MacMillan Bloedel's application for a permit amendment proposes December 1981 as the completion date. The Federal government has relieved MacMillan Bloedel from meeting the Federal toxicity requirement for at least 7 years. During this period the diffuser system will be installed followed by approximately five years of environmental monitoring to assess the effects of the diffused effluent on the receiving environment.

4 RECEIVING ENVIRONMENT

4.1 Oceanography

The prevailing surface currents in Malaspina Strait flow northward in a counter-clockwise direction with some westward movement through Algerine and Shearwater passages, north and south of Harwood Island (Tully and Dodimead, 1956; Waldichuk and Tabata, 1955). In September 1976, data on currents in the Powell River area were collected by Dobrocky Seatech (1977a) and interpreted by Simons Consulting engineers (Simons, 1977) in conjuction with a proposed submarine outfall system. The predominant currents in the area occurred approximately 600 metres southeast of the pulp mill and moved in a northwest, southeast direction. During the study the net current flow in the harbour was northwest with a net velocity of 0.52 metres/second at 10.5 metres depth and 0.018 metres/second at 37.5 metres. Relatively stronger currents were produced by the tailrace discharge. These flowed predominantly west to southwest with velocities from 0.25 FPS to 1.4 FPS in the top metre of the water column. The semi-diurnal tides in the Strait of Georgia range in vertical height between high and low tides from a maximum of about 5 metres in June and December to a minimum of approximately 4 metres in March and September.

The waters of the Strait of Georgia are typically highly stratified with respect to temperature and salinity particularly during periods of high freshwater runoff or freshet, i.e., spring and summer months. In late fall and winter stratification becomes less evident. Due to strong winds and good tidal flushing the surface waters in the Powell River area are generally well mixed. Waldichuk et al (1968) took water quality measurements in the area in 1960, and concluded that the rapid flushing would effectively prevent serious accumulation of mill wastes except in localized areas close to the mill. Despite the good flushing, various environmental effects attributed to mill effluent have been reported up to several kilometers northwest of the mill. The northward movement of effluent has been confirmed by physical, chemical and biological studies to be discussed in Section 4.2.

4.2 Impact Studies

4.2.1 MacMillan Bloedel Studies. MacMillan Bloedel have conducted various water quality, intertidal and benthic studies in the vicinity of the pulp mill since 1970 (MacMillan Bloedel Studies 1970-1978). The study area extends from Grief Point south of the mill to Lund northwards, and includes stations located on Harwood and Texada islands west of the mill. The measurement of physical and chemical water quality parameters began in 1970 and was supplemented with intertidal biological studies in 1971. The monitoring program was revised slightly in 1976 to conform to requirements contained in the company's PCB effluent discharge permit. In 1977 and 1978 a study of marine sediments and associated benthic fauna near the mill were added to the program. Water quality data were not collected by the company in 1978. However, EPS conducted an equivalent survey in November 1978 while occupying the MacMillan Bloedel water stations.

4.2.1.1 Water quality. Water quality parameters measured by MacMillan Bloedel over the years have included color intensity, salinity, turbidity (secchi disc), temperature, dissolved oxygen (DO), pH, and chlorophyll 'a' content. The presence of effluent in waters of Malaspina Strait was generally indicated by the first three parameters mentioned above while the remaining factors remained relatively constant or fluctuated seasonally. The presence of effluent was indicated by increased color and a decrease in both salinity and light penetration compared to unaffected surrounding waters. The effluent usually remained in the surface layers of the water column with its movement being largely dependent on prevailing weather and tidal conditions.

The movement of mill effluent over a tidal cycle is roughly depicted in Figure 3 extracted from Young, 1977 (as modified from Constantino, 1973). During a flooding tide the effluent tends to move northward along the shore, becoming concentrated just north of the mill and occassionally reaching as far north as Atrevida Reef about 6.5 km from the mill. During an ebb tide the surface effluent cloud generally receeds from its northern borders and becomes most concentrated off the Sliammon indian reserve.

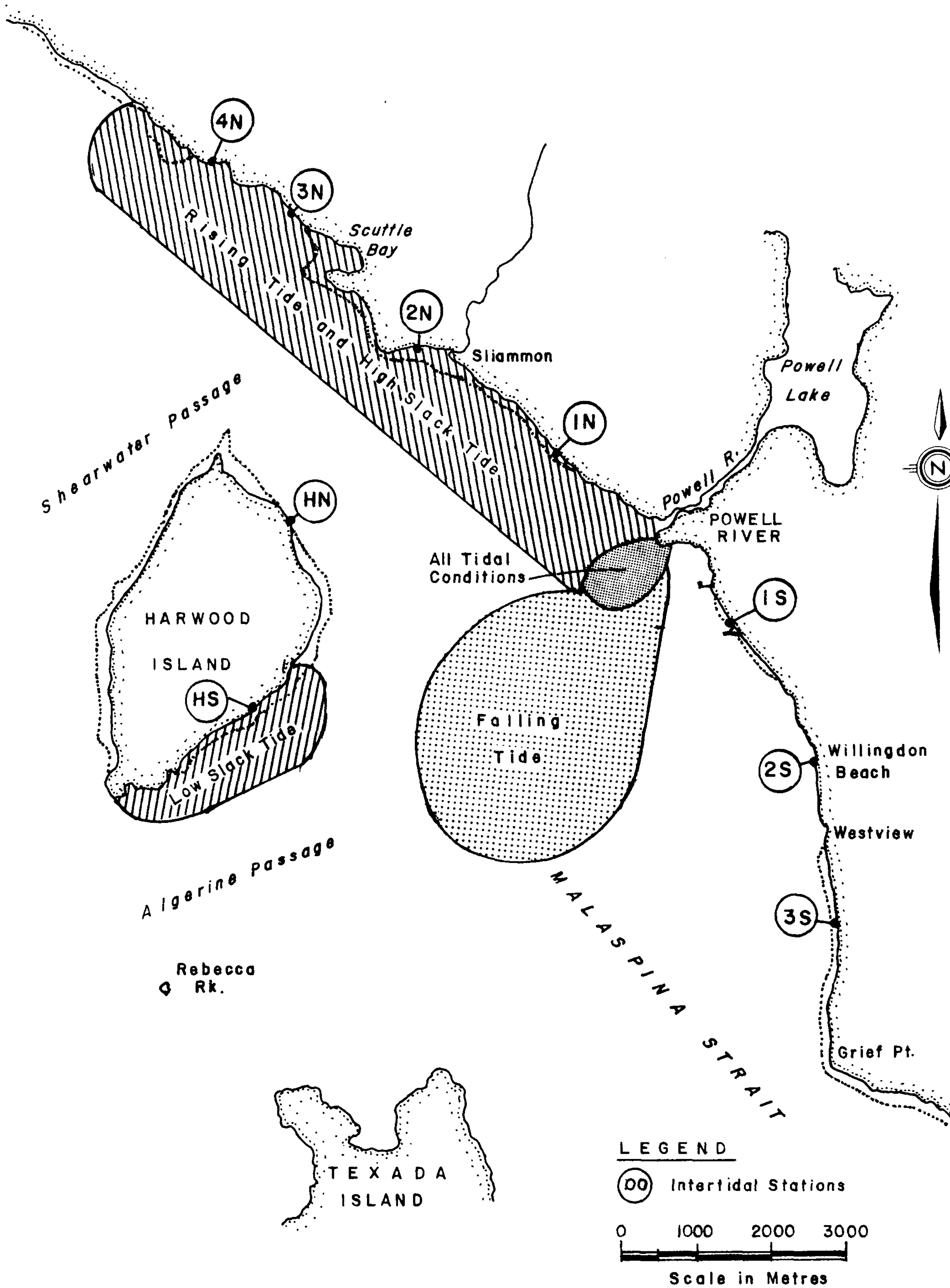

FIGURE 3 EFFLUENT DISPERSAL PATTERNS
(From Young 1977 as modified from Constantino 1973)

Following the 1978 survey water stations 1, 4, 7, and 8 were relocated nearer the pulp mill. The new station locations are shown on Figure 4. At times during a low tide the effluent is detectable to about 6.5 km southeast of the mill and along the southern shore of Harwood Island. When a falling tide is coincident with northeasterly winds, the effluent tends to "hold" near the southern end of Harwood Island.

4.2.1.2 Intertidal biology. MacMillan Bloedel's intertidal monitoring program involved the placement of artificial substrates including bricks and various arrangements of plexiglass plates at 12 shoreline stations. The station locations are shown on Figure 3 with the exception of the two northern stations which are located at Dinner Rock (5N) and Lund (6N). The substrates were left for approximately two month intervals in the spring and summer and then retrieved for the identification and enumeration of attached biota.

The intertidal program showed that mill effluent in the surface waters had a discernable effect on intertidal communities north of the mill. Young (1977) reported that algal growth appeared inhibited at station 1N to 4N inclusive north of the mill and also at station HS on southern Harwood Island. The mean lower low tidal zone at these stations generally appeared bare in comparison to stations south of the mill. Dominant fauna during the spring retrieval included barnacles, insect larvae, copepods, ostracods and nematodes. In the summer, ostracods and copepods were the most prolific invertebrates with nematodes and insect larvae being present in reduced numbers. Enteromorpha sp. and juvenile phaeophytes were the most common algae observed during both periods.

The influence of mill effluent on intertidal communities north of the mill has been demonstrated by other workers in the area. Stevenson et al (1971) found reduced invertebrate and algal populations north of the mill and transplanted mussels suffered higher mortalities north of the mill than at stations south of the mill. Nassichuk (1972) reported that Fucus sp. fronds were brittle in texture, and withered in appearance, at a station near the mouth of the Powell River, whereas

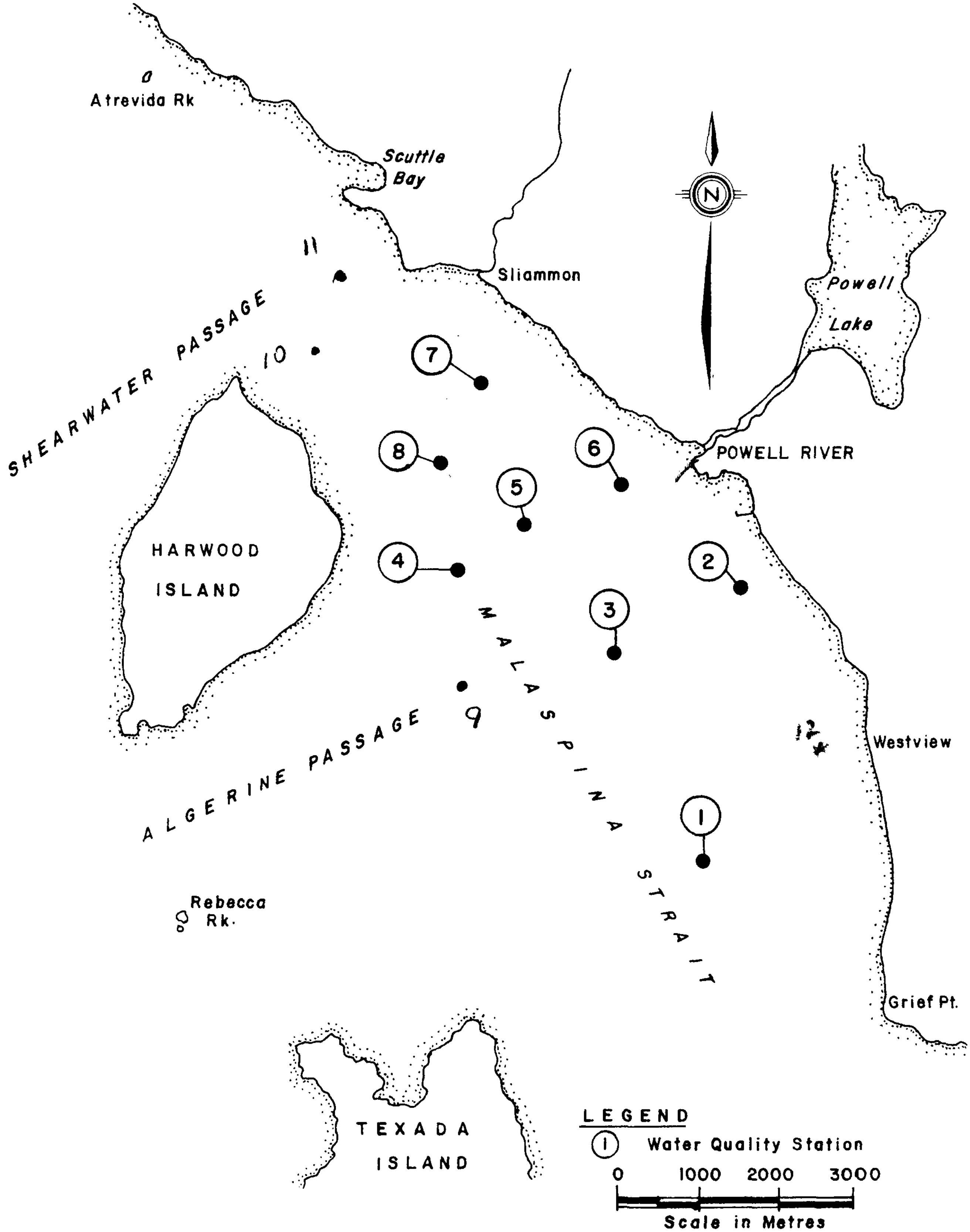

FIGURE 4 WATER QUALITY STATIONS (1979)

specimens of this species a few miles further north appeared structurally normal. Nelson and Goyette (1976) found that the degree of zinc contamination in oysters, which originated from the discharge of a zinc containing bleaching agent previously employed at the mill, was more pronounced north of the mill.

Intertidal studies undertaken by MacMillan Bloedel in 1978 generally showed the trends identified in previous surveys, although colonization appeared to be abnormally low and settlement and distribution patterns were highly variable. This was attributed to fluctuations in natural environmental conditions, and also to limiting factors inherent in the artificial substrates used. The 1979 study will incorporate what is believed to be a more "natural" artificial substate, i.e., an asbestos - concrete aggregate fibre board.

4.2.1.3 Benthic ecology. In 1977, MacMillan Bloedel established benthic sampling stations (Figure 5) to obtain baseline data on substrate characteristics and related benthos prior to the installation of fibre removal facilities and an effluent diffuser system. Results showed that benthic invertebrate communities were related to the degree of organic loading and substrate type. Stations A, B, D, and E were in an area of high fibre deposition and supported more ogranisms of fewer species than did stations more distant from the mill. This relationship of species diversity to abundance is indicative of polluted marine sediments. The dominant organisms inhabiting the high fibre zone were nematodes and polychaetes such as *Capitella capitata*, *Dorvillea* sp. and *Prionospio cirrifera*. Stations C and F represented zones of less degradation due to fibre input and were inhabited by a greater number of species of polychaetes and molluscs. Crabs and brittle stars were also found at these stations although numbers were limited. A considerable reduction in the amount of wood wastes entering the receiving environment will result from the new clarifier which began operation in the fall of 1978.

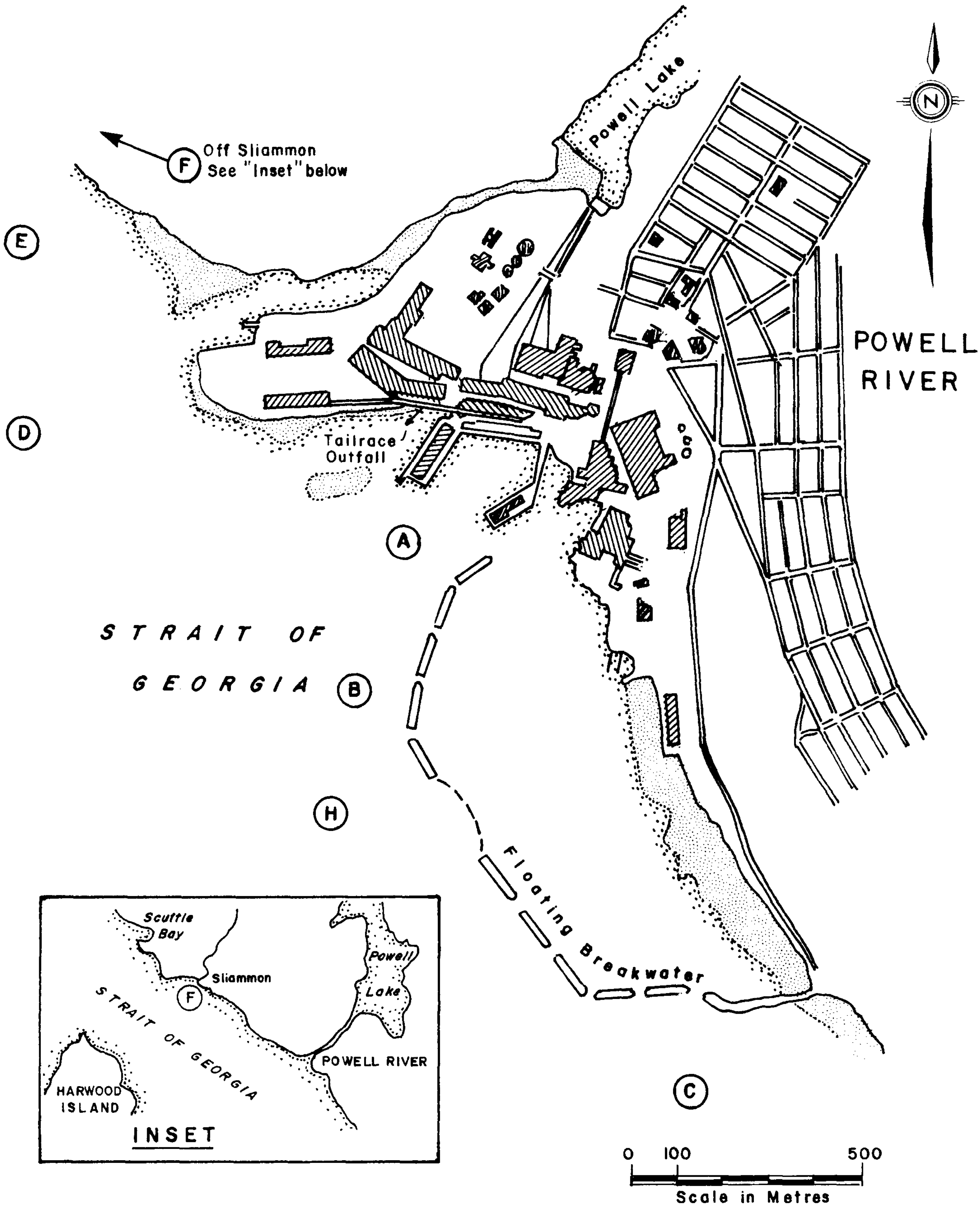

FIGURE 5 MacMILLAN BLOEDEL BENTHIC STATIONS

4.2.2 Federal Government Studies

4.2.2.1 Shellfish contamination. In 1973, the Federal Department of Fisheries and Environment initiated an extensive program to determine the zinc levels in shellfish in the vicinity of groundwood pulp mills on the B.C. coast. Concern was raised when zinc originating from a bleaching agent used in the brightening process for groundwood pulp was found to bioaccumulate in the tissue of oysters inhabiting the mill areas.

The pattern of zinc concentrations in the Pacific oyster, *Crassostrea gigas*, collected in the Powell River area suggested that the net flow of pulp mill effluent was in a northwesterly direction (Environment Canada, 1973; Nelson and Goyette, 1976). An average zinc concentration of 4200 mg/kg (dry weight) found in oysters from Okeover Inlet, well removed from pulp mill influence was chosen as representative of the natural background level for the geographical area. Elevated levels of zinc were found beyond Myrtle Point, 13 km south of the mill and Lund, about 16 km north of the mill. Levels of zinc were notiecably higher in oysters north of the mill than to the south, with the highest average concentration of over 17 000 mg/kg (dry weight) being found in oysters collected just north of the mouth of the Powell River. Zinc contamination in oysters extended westward to Harwood Island where they had an average concentration of 10 600 mg/kg (dry weight) as compared to 5600 mg/kg (dry weight) in oysters obtained from the western tip of Texada Island. By September 1974, four coastal groundwood mills, including Powell River Division, had completed conversions to a new bleaching agent thereby largely eliminating zinc from their effluent discharges. A recent study (Dobrocky Seatech, 1977b) in the vicinity of the groundwood pulp mill at Crofton, B.C. showed that oysters in the area had eliminated zinc from their tissues at approximately 1 g/kg/year following the conversion. Despite the decrease in accumulated zinc the oysters in the Crofton area remain in a deteriorated physical condition.

4.2.2.2 Benthic sediment characteristics. A sediment sampling survey was conducted in conjunction with the shellfish monitoring program in 1973 to determine the extent of fibre deposits off the mill (Sullivan and

DeMill, 1973). The 25 stations occupied indicated that wood wastes including fibre, wood slivers, and bark fragments extended up to 4.5 km north of the mill, over 1.5 km to the south, and 1.5 km offshore. Hydrogen sulfide gas was frequently noted in samples from the area of heavy deposits near the mill. Werner and Hyslop (1968) had previously reported measurable quantities of hydrogen sulfide gas in sludge beds off the Powell River mill during a comprehensive survey of gaseous sediments in polluted areas along the B.C. coast.

During a dredging operation in 1978, dredgeate samples from a site at the north end of the log storage area were analyzed for heavy metal content. Certain of the samples were found to contain mercury (Hg) in excess of 4.0 mg/kg dry weight, which is considerably greater than would be expected since the natural background level for the Strait of Georgia and Howe Sound is approximately 0.1 mg/kg (MacDonald and Wong, 1977). Although the origin of the mercury in the sediments was not ascertained, the company had previously used mercurial slimicides in the log storage area and currently uses caustic soda, containing small amounts of mercury, in mill processes. As a result of these findings the Marine Programs Group of EPS collected additional benthic sediments and biological tissue samples at Powell River in November 1978.

Bottom sediment samples were obtained by coring and crab sampling at the stations shown on Figure 6 and subsequently analyzed for mercury content. The results appear in Table 6. Mercury concentrations ranged from 0.1 mg/kg to 21.0 mg/kg dry weight with the highest levels found in samples from core stations 2 and 3. The highest mercury concentration previously reported in B.C. sediments was 20.0 mg/kg found in sediments close to the F.M.C. mercury-cell chlor-alkali plant in Howe Sound (Thompson and McComass, 1973). These samples were collected after biota in the vicinity of the plant were found to be contaminated by mercury with levels up to 13.0 mg/kg in dungeness crabs. Following controls imposed on the plant to reduce the discharge of mercury, the levels in sediments and biota have decreased. In 1977, sediments containing 7.0 mg/kg were collected near the F.M.C. dock and this was considered a contamination "hot spot" (MacDonald and Wong, 1977).

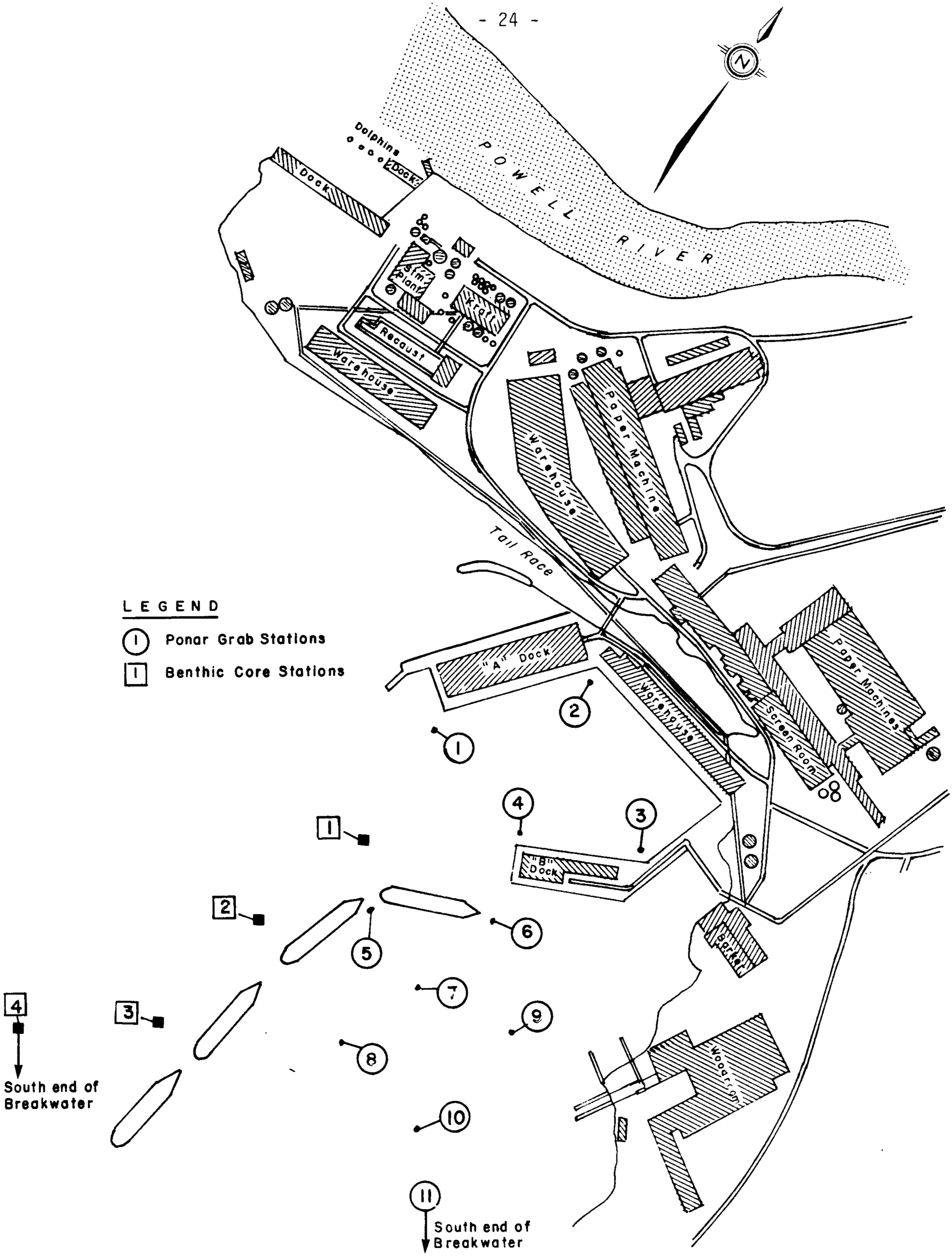

FIGURE 6 E.P.S. SEDIMENT SAMPLING STATIONS

TABLE 6 MERCURY IN SEDIMENT SAMPLES (mg/kg dry weight)

Sampling Method	Station	Depth (m)	Core Fraction (cm)	Description	Hg (mg/kg)
Benthic Core	1	11	0-5	fibre	0.10
			50-55	fibre	1.24
			75-80	sand	4.32
	2	14	0-5	fibre	15.90
			50-55	sand-rock	19.60
	3	19	0-5	fibre	21.00
			25-30	clay	16.80
			50-55	clay	0.38
	4	-	0-5	gravel	0.82
Ponar Grab	1	13		fibre	0.366
				fibre	0.576
	2	11		fibre	0.663
				fibre	0.521
	3	10		fibre	0.811
				fibre	2.01
	4	11		fibre	2.37
				fibre	3.01
	5	16		black fibre	0.738
				black fibre	0.781
	6	16		black fibre	0.717
				black fibre	0.754
	7	15		fibre and	0.581
				grey sediment	0.364
	8	20		fibre	0.316
				fibre	0.598
	9	7		bark chips	2.43
				and fibre	3.07
					3.06
	10	7		fibre	2.75
				fibre	2.86
	11	9		bark chips	2.03
				and fibre	3.81

The data presented in Table 6 suggests that sediments in the vicinity of the Powell River pulp mill are contaminated with mercury. Mercury mobilization studies (Wong et al, 1977) have shown that particulate mercury does not interact with sea water and remains bound to the sediment. However, dredging or dredge spoil disposal of mercury contaminated sediments can result in a "short lived maximum release" of mercury which could be available for pick-up by the biota. This type of activity is periodically required near Piers A and B at the Powell River mill to enable the movement of deep-sea shipping. The analysis of biological samples for mercury content will be discussed in the following section.

4.2.2.3 Biological sampling. The Marine Programs Group obtained biological samples by long-lining, crab trapping and beach seining, and by sampling a portion of a commercial catch belonging to a local long-line fisherman. The stations occupied are shown in Figure 7. Several species of marine organisms were collected and analyzed for mercury content to determine if high mercury levels found in marine sediments were being transmitted to biota in the area. The species collected included *Hydrolagus colliei* (ratfish), *Squalus acanthias* (dogfish), *Sebastes elongatus* (green-stripe rockfish), *Ophiodon elongatus* (lingcod), *Gadus macrocephalus* (graycod), *Ammodytes hexapterus* (sand lance), *Citharichthys* sp. (sand dab), *Platichthys stellatus* (starry flounder), and *Cancer magister* (dungeness crab). The results of these appear in Table 7.

The Canadian Food and Drug regulations impose restraints on aquatic food products with mercury levels in excess of 0.5 mg/kg on wet weight basis. As indicated in Table 7 only two samples exceeded this value. The two species involved have been collected elsewhere in the province, and contained relatively higher levels of mercury than other species samples (Harbo and Birtwell, 1978), and have also exceeded the 0.5 mg/kg level. From the biological data alone the contamination of biota by mercury would not appear to warrant concern at this time.

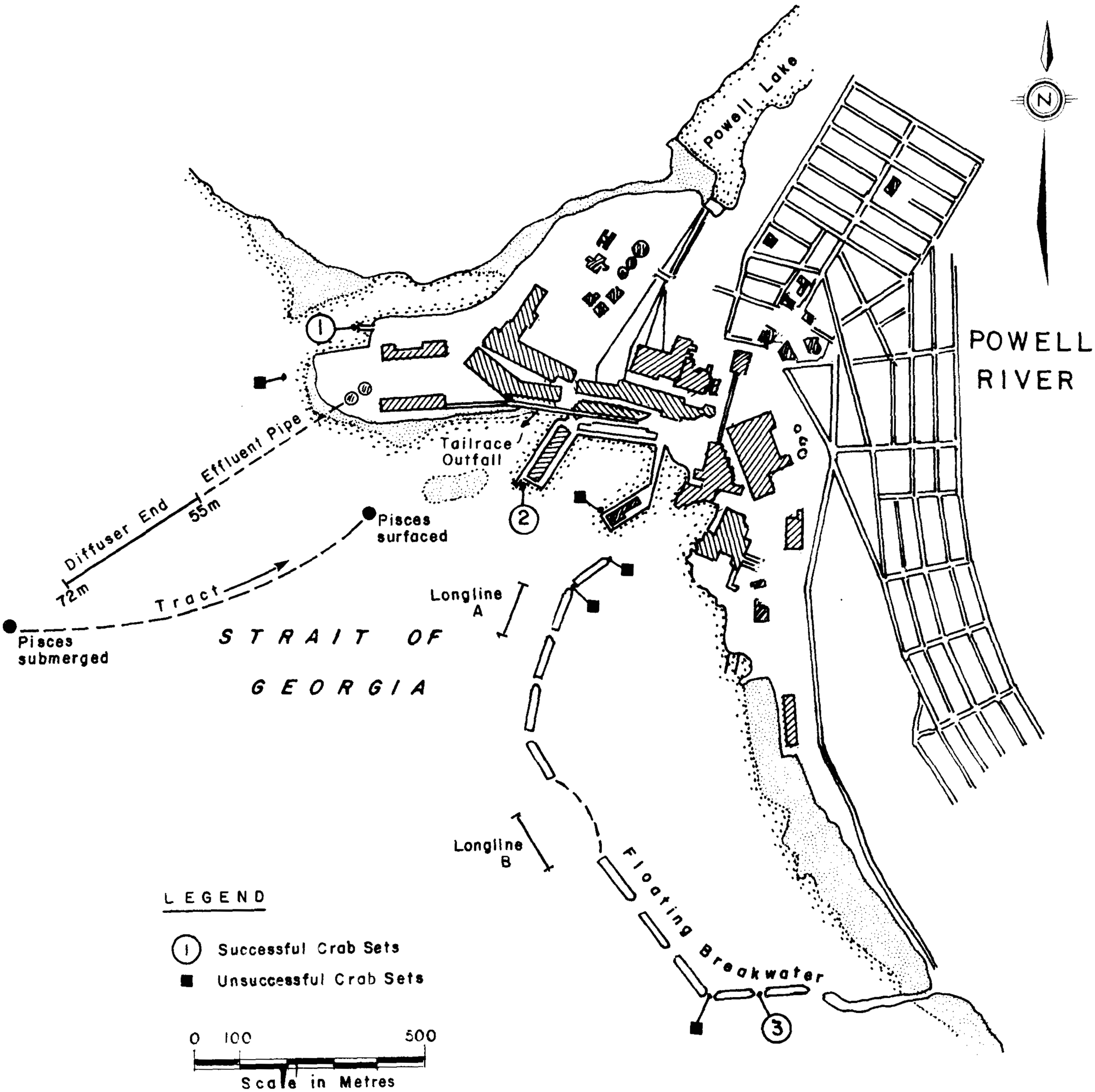

FIGURE 7 E.P.S. BIOLOGICAL SAMPLING STATIONS (1978)

TABLE 7 MERCURY IN TISSUE SAMPLES (mg/kg)

Sampling Method	Station	Species	Hg (mg/kg) Dry Wt.	Hg (mg/kg) Wet Wt.
EPS Long Line	A	ratfish (liver)	-	0.025
		ratfish (liver)	-	0.020
		ratfish (liver)	-	0.020
	B	ratfish (liver)	-	0.034
		ratfish (liver)	-	0.019
Commercial Long Line	off breakwater	dogfish (liver)	-	0.019
		dogfish (liver)	-	0.019
		dogfish (flesh)	2.50	0.574
		rockfish (liver)	1.88	0.869
		rockfish (flesh)	2.13	0.466
		lingcod (flesh)	0.475	0.087
		greycod (flesh)	2.190	0.392
Beach Seine	South of breakwater	sandlance & sculpin (whole)	0.125	0.027
		starry flounders & sand dabs (whole)	0.096	0.021
Crab Trap	1	dungeness crab ( )	2.04	0.329
		dungeness crab ( )	0.389	0.067
	2	ratfish (liver)	-	0.019
		dungeness crab ( )	0.205	0.048
		dungeness crab ( )	1.350	0.228
	3	dungeness crab ( )	1.88	0.324

4.2.2.4 Submersible diving observations. In 1978, EPS utilized the Pisces IV submersible and its mother ship, Pandora II to carry out a benthic study in conjunction with the proposed installation of a submerged outfall and diffuser system at the Powell River pulp mill. Particulars of the dive and complete diving observations are presented in Appendix I.

The submersible dive commenced in 100 metres of water approximately 200 metres seaward of the estimated termination point for the proposed diffuser as shown in Figure 7. The diffuser and pipe are to extend approximately 800 metres from shore with the diffuser portion constituting about 330 metres at the end. The downstream end of the diffuser will be at about 72 m depth and the upstream end at about 55 m depth. Upon reaching the bottom, the Pisces proceeded on a course intended to cover the area into which the diffuser would discharge. As shown in the Figure the course varied slightly from the intended tract, however, bottom characteristics should not be significantly different.

At the beginning of the dive the bottom substrate was characterized by soft sediment (mud) underlying a thin layer of wood particles. It did not appear to be a reducing sediment. As the Pisces moved shoreward the natural substrate appeared to become gravelly (65 m) however it was covered by a progressively thicker layer of fine fibrous wood debris. As the shallower depths were approached (35 m) the wood debris became coarser in nature and seemed to be more recently deposited. The only steep incline was encountered at 30 m and appeared to composed of fibrous wood debris. The incline continued to a depth of 10 m when the bottom levelled off. Benthos encountered during the dive were predominantly small shrimp, and demersal and pelagic fish. Above a depth of 50 m no shrimp were observed and the dominant fish were flounders or sole.

5 NATURAL RESOURCES

5.1 Fisheries Resource

A detailed discussion of the fishery resource in Malaspina Strait and surrounding waters, i.e., Fisheries and Marine Service (FMS) Statistical Areas 15 and 16, is presented in Appendix II (Knapp and Lashmar, 1978, FMS Internal Report). The following will be a brief summary of this information as related to the Powell River area.

Powell River is located on the border of Statistical Areas 15 and 16, which together form the Pender Harbour Subdistrict extending approximately 120 km from Sechelt in the south to Toba Inlet in the north. The Pender Harbour Subdistrict is frequented by all five species of Pacific salmon with chum salmon being present in the highest numbers, followed by coho, chinook, pink and sockeye. Although commercial fishing is permitted throughout the Subdistrict, the total catch is relatively small when compared to other areas. In Area 15, north of Powell River, chinook and coho salmon accounted for 90% of the catch between 1966 and 1975 while chum salmon constituted the major species caught (32.5%) in Area 16 during the same period, followed by sockeye (20%), chinook (17%), coho (17%), and pink (14%).

The Pender Harbour Subdistrict contains approximately 35 spawning streams most of which are located north of Powell River. Streams flowing into Toba Inlet appear to provide the most significant runs while the seven streams in the area of potential pulp mill influence, between Scotch Fir Point and the Copeland islands, are not large producers. Adult and juvenile salmon migrating to and from spawning grounds respectively could pass through mill effluent in the Powell River areas, however, good tidal flushing in Malaspina Strait affords rapid dilution and dispersion of mill discharges. Migrations occur on either side of Texada Island and an extensive fishery in Sabine Channel, southeast of the Island, suggests that this may be the preferred route.

The herring fishery on the eastern shores of the Strait of Georgia is of minor importance compared to the east and west coasts of

Vancouver Island due to smaller resident stocks. Herring spawn in intertidal areas extending from the Copeland Islands to Scoth Fir Point approximately 20 km either side of Powell River. The absence of spawn in a stretch of shoreline about 10 km around the Powell River mill has been attributed to lack of suitable intertidal areas for spawning rather than to mill derived influences.

Commercial oyster fisheries take place in Okeover Inlet and Pendrell Sound, two areas within the Subdistrict but well removed from pulp mill influence. As mentioned previously, Okeover Inlet was used as a control site for the collection of oysters during a government study to delimit the extent of zinc contamination from the pulp mill. This inlet also supplies most of the clams in the Powell River area. Other clam beds, on Savory and Harwood islands, are utilized commercially by the Sliammon Indian band, who primarily harvest the littleneck clam, *Protothaca staminea*. Clam and oyster beds immediately north and south of Powell River have been closed due to contamination by domestic sewage. No commercially exploitable concentrations of shrimp or prawns are known to exist in the Pender Harbur Subdistrict.

5.2 Migratory Bird Resource

Information on the migratory bird resource in the Powell River area is limited. The data presented here were summarized by D. Trethewey (1977, personal communication) of the Canadian Wildlife Service from available information.

It is generally known that the near shore shoal areas of the coast from Scoth Fir Point at the entrance to Jervis Inlet north to the northern tip of Malaspina Peninsula provide thousands of gulls and diving birds with wintering and migratory habitat. Concentrations of birds up to several thousands have occurred in places such as Scuttle Bay during the herring spawning season. Although count data are not available, other spawning areas such as indicated on FMS Figure 3 (page 16 of Appendix II) could be potentially important areas for gulls and diving birds. Gulls and certain diving birds are known to nest on Vivian Island about 10 km west of Powell River in Shearwater Passage.

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APPENDICES

APPENDIX I

SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV
(Environmental Protection Service, 1978)

APPENDIX I SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV
MALASPINA STRAIT - November 30, 1978

DIVE	:	Pisces Dive #719, EPS Tract I (Figure 1)	
LOCATION	:	Off MacMillan Bloedel Pulp Mill at Powell River (proposed diffuser location)	
OBSERVERS	:	R. Hoos and H. Nelson	
PILOT	:	F. Chambers	
POSITION	:	Submerge	Surface
		49° 52.05 N	49° 52.20 N
		124° 34.60 W	124° 33.80 W
DURATION	:	1 hour, 45 minutes	
TIME	:	Start - 1055 hours, Finish - 1240 hours	

TIDES	:	At Campbell River -	Time	Height (metres)
			0515	4.2
			1045	3.2
			1545	4.3

FILM EXPOSED : 16 mm - reels 12, 13, 14
70 mm - frames 33 to 57

The dive commenced in 100 metres of water approximately 200 metres seaward of the estimated termination point for a diffuser proposed for the Powell River pulp mill. The diffuser and pipe are to extend approximately 800 metres from shore with the diffuser portion constituting about 330 metres at the end. The downstream end of the diffuser will be at about 72 m depth and the upstream end at about 55 m depth. Upon reaching the bottom the Pisces proceeded on a closure intended to cover the area into which the diffuser would discharge (see Figure 7 Section 4.2.2). As shown on the Figure the course varied slightly from the intended tract, however, bottom characteristics should not be significantly different.

OBSERVATIONS:

Surface - water clear, few plankton observed.

Descending

20 m - visibility good, surface light, one pelagic polychaete observed, very little suspended material.

30 m - surface light was still evident.

40 m - loss of surface light.

45 m - many pelagic amphipods (white coloration) observed from this depth to the bottom.

75 m - school of herring, 5-10 centimetres in lenght observed.

Surface - at 100 metres

- bottom substrate a fine grey-brown sediment underlying a thin layer of wood particles i.e., not a reducing substrate. Small craters about 5 cms in diameter and larger depressions about 30 cms in diameter.
- bottom visibility 5 to 7 metres and no noticeable current was present.
- benthos consisted of small shrimp with white legs (approximately 2 or 3 per square metre), eel-pouts (Lycodes sp.), flat fish, pelagic polychaetes and amphipods, and dungeness crabs (Cancer magister).
- moved towards shore at a bearing of approximately 060° magnetic up a slight incline. More wood debris encountered, a few large boulders (50 to 100 cms in diameter), a few large pieces of wood debris and logs. Several green striped rockfish (Sebastes elongatus) and orange anemones (Metridium senile) associated with boulders and large wood debris.

87 m - at 1130 hours film reel 12 (short from first touching bottom to a depth of 85 metres) completed and replaced by reel 13. Course change to 040° magnetic. Continued toward shore up a slight incline, substrate became more fibrous in nature and patches of white bacterial slime began to appear. Water became murky briefly. Benthos remained unchanged with the addition of

squat lobsters (Munida quadraspina) and a few prawns (Pandalus platyceros). The numbers of small shrimp increased to 10 to 15 per square metre. Another school of small herring containing several hundred individuals was observed.

84 m - encountered several pieces of large wood debris and a few boulders. Benthos associated with this area included organisms mentioned previously and also rat fish (Hydrolagus colliei), lingcod (Ophiodon elongatus), quillback rockfish (Sebastes maliger) and Neptunea sp. Another school of herring was observed (or possibly the same school reported earlier). Pieces of rusted pipe and stainless steel wire were observed.

75 m - patches of white bacterial slime were more prevalent.

- substrate more fibrous in nature with very fine fibres loosely compacted. Less shrimp observed than previously.

72 m - observed a large skate (Raja sp.).

70 m - at 1200 hours completed 16 mm reel 13 and replaced with reel 14. At this point 17 frames on the 70 mm camera had been exposed, i.e., frame indicator reed 51. The surface tender boat estimated our position to be approximately 3/4 of the way along the intended tract and approximately 500 metres from shore.

65 m - natural substrate in this area appeared to be gravel which had been covered by a fine fibre mat 10 to 30 cms in thickness; wherever a boulder or log had been deposited the fine fibre was displaced beneath the object thereby exposing the gravelly substrate. Many small lingcod (1 to 2 kg) were noted in the area.

58 m - one sea cucumber (Parastichopus sp.)

- more rusted pipe and wire observed

51 m - water became murky again. The small shrimp, present since the beginning of the dive, have disappeared. CTD Probe recordings:

DO 5.7 mg/l

Temp. 9.2°C

- few small squid observed and several flatfish
- patches of white stringy material (bacterial growth?)

43 m - (1230 hours); patches of bacterial slime increased.

36 m - visibility improved, wood debris becoming coarser and appears to be of more recent origin. 70 mm frames 53 and 54 show the coarse nature of the wood debris.

30 m - began moving up steep incline, fibre became progressively more coarse. Visibility increased to 10 to 15 metres with surface light. Many small pieces of white paper were lying on the fibre mat, presumably from the newsprint operation.

10 m - bottom levelled off and Pisces began ascent.

Surfaced - 1240 hours, tender boat estimated the Pisces surfaced approximately 100 metres from boom sticks at the mouth of the tailrace.

APPENDIX II

MacMILLAN BLOEDEL, PULP AND PAPER MILL,
POWELL RIVER, B.C., FISHERIES RESOURCES OF FISHERIES
AND MARINE SERVICE STATISTICAL AREAS 15 AND 16
(Knapp and Lashmar 1978, F.M.S. Internal Report)

The information presented in this document was collated solely for use within the Pacific Region (DFE) "Pulp Mill Review Process": a process designated to determine effluent characteristics, degree of treatment, and effects upon the receiving environment. This task was carried out to identify current and potential conflicts between aquatic resources and effluent disposal in order to priorize pollution abatement efforts.

Opinions expressed in the text reflect the judgement of the authors and contributing personnel.

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DEPARTMENT OF FISHERIES AND THE ENVIRONMENT
FISHERIES SERVICE

MacMillan Bloedel Pulp and Paper Mill (Powell River) Fisheries Resources of Fisheries and Marine Service Statistical Areas 15 and 16

by
W. Knapp
M. Lashmar

Water Quality Division
Habitat Protection Unit
Resource Services Branch

1978

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MACMILLAN-BLOEDEL PULP AND PAPER MILL - POWELL RIVER, B.C.
FISHERIES RESOURCES OF
FISHERIES AND MARINE SERVICE STATISTICAL AREAS 15 AND 16

I INTRODUCTION

The MacMillan-Bloedel pulp and paper mill lies at the mouth of the Powell River, facing Malaspina Strait. It is located on the border of Statistical Areas 15 and 16 which together form the Pender Harbour Subdistrict (Figure 1). The latter stretches from Sechelt in the south to Toba Inlet in the north, a distance of approximately 75 miles. (1)

Effluent discharged onto exposed coastline may be potentially less damaging than that in enclosed locations due to dilution and dispersal by tides, winds, currents and freshwater input. Unfortunately, in some instances, the latter factors may also cause toxic substances to be spread over a wider area, increasing rather than decreasing the area of influence. A report(2) indicated that the mill influence may stretch beyond Myrtle Point in the south and Lund in the north (Figure 2).

Studies have indicated that the net effluent flow is in a northwesterly direction from the mill.(2) It is believed that the effluent moves out from the tailrace and swings west and then north toward Harwood Island.(3) These observations are in agreement with current movement studies carried out by pulp mill personnel. Studies documented some deleterious effects on intertidal flora and fauna, particularly north of the mill.(4,5) These included disparities between diversity indices for organisms and a noticeable reduction in plant abundance.

II SALMON

A. Stocks

Accurate estimates of stocks within the Subdistrict are difficult to obtain because a large proportion of the salmon originating in the area are captured in the Johnstone Strait fishery.(6)

The Pender Harbour Subdistrict contains all five species of Pacific salmon. Total stocks (based on catch plus escapement figures) appear to be higher in Area 16 than in area 15, Powell River. On a species basis, only chinook and coho salmon are higher in the Powell River Area (Table I). Coho show the least variation with average stocks of 39,000 and 31,400 for Areas 15 and 16 respectively. Combined

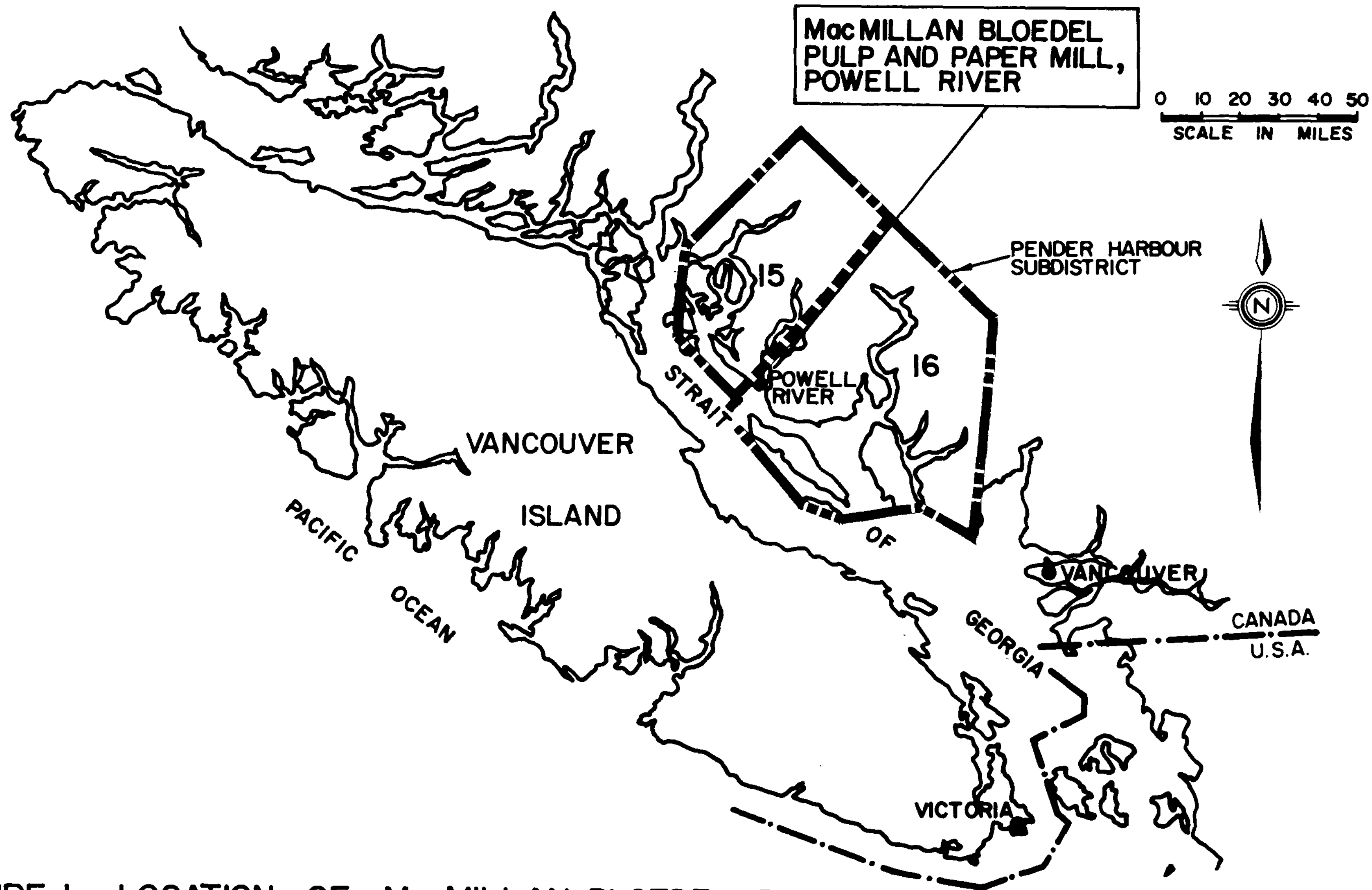

FIGURE 1 — LOCATION OF MacMILLAN BLOEDEL PULP AND PAPER MILL (POWELL RIVER) IN PENDER HARBOUR SUBDISTRICT

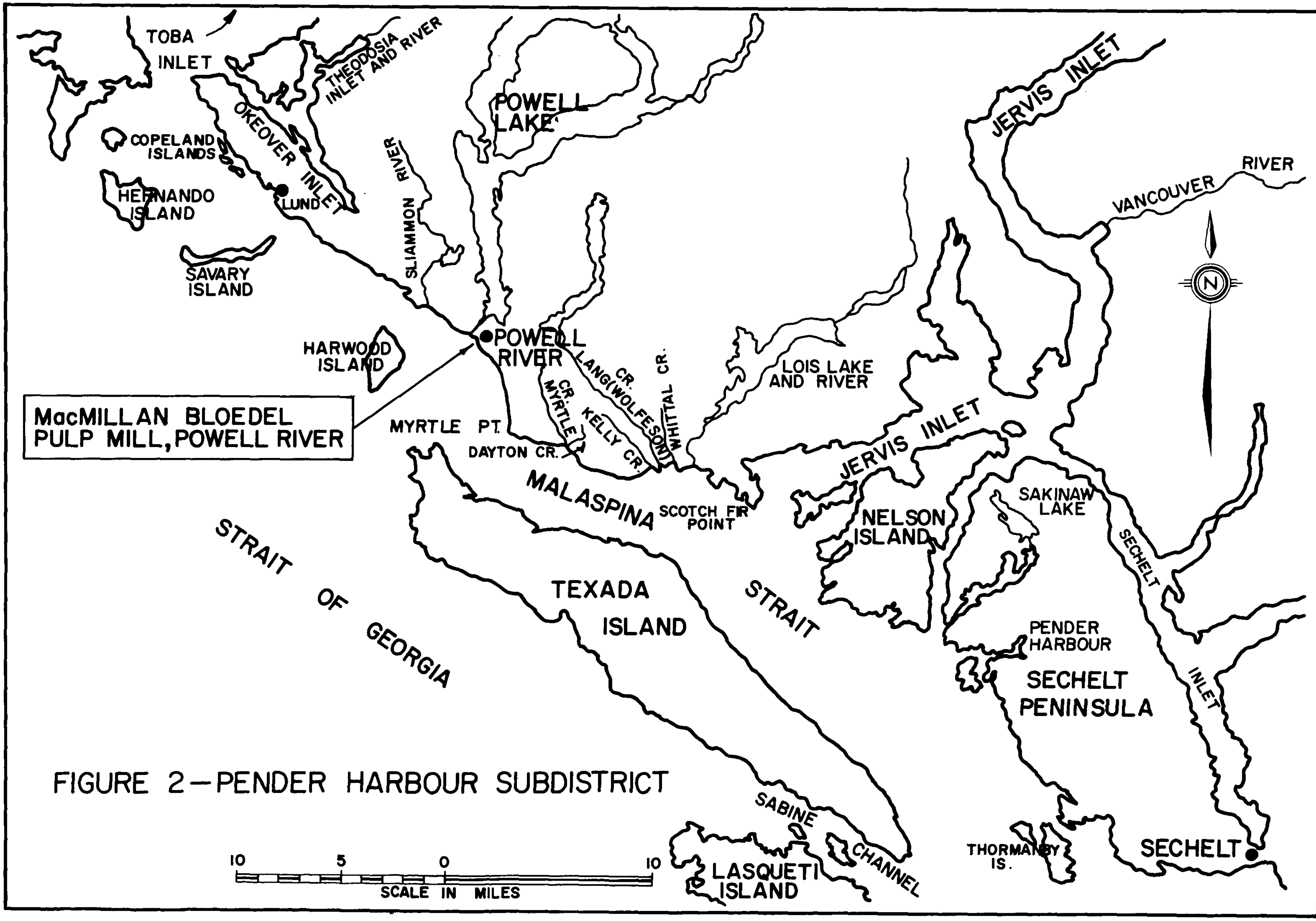

FIGURE 2—PENDER HARBOUR SUBDISTRICT

stocks show chum salmon to be present in the highest numbers, followed by coho, chinook, pink and sockeye salmon. Sockeye stocks have only one major escapement area - the Sakinaw Lake system. The remainder of the stocks are native to other areas.

There are no major enhancement facilities planned for the Subdistrict. Stream clearing was undertaken in 1976 and will continue in 1977. Upwelling boxes are being considered for the Sliammon River in the future. The Sliammon Indian Band has also expressed interest in participating in enhancement activities.(7)

B. Commercial Fishery

Commercial fishing is permitted throughout the Subdistrict. There are no regular gear or species closures, though periodically some mainland inlets (such as Toba or Jervis) may be closed in the fall to protect spawning runs of chum salmon. Closures have occasionally been instituted to protect pink stocks. Trolling which is carried out in most waters is the favoured catch method. However, it is less frequently used in the inlets due to the recreational fishery and the lower catch successes there. Comparatively, little seining or gill netting is done.(6) In recent years, the only significant net fishery (in Area 15) has been for chinook in the early spring.(10) The Area 15 fishery tends to rely primarily on stocks passing through Johnstone Strait to the north, whereas catches in Area 16 depend on stocks originating from both the north and south.

Fisheries and Marine Service records show significant catches of sockeye in Sabine Channel (between Texada and Lasquiti Islands), a small proportion of which are probably headed for the Sakinaw Lake system.(10) Chum have also been taken in Sabine Channel, primarily with gill-nets and secondarily with trolling gear. The Toba River has been considered the most productive area for coho and consequently Toba Inlet, into which it drains, supports a large proportion of the coho gill-net fishery.

As shown in Table II the total catch within the Subdistrict (Area 15 and 16) is relatively small when compared to other areas. The total average catch for all species, 1966-1975, was 126,877 salmon compared to a total of 2,128,345 from Area 6 and 1,866,942 from Area 8.(11) Area 15 average total catch for 1966-1975 was 37,105 pieces. Of this chinook and coho accounted for 90% of these fish. Area 16 had a total average catch for all species for the same period (1966-1975) of 89,682 pieces. Chums constituted 32.5% of the area 16 catch while sockeye, chinook, coho and pink salmon comprised

TABLE I

SALMON STOCK ESTIMATES (COMMERCIAL CATCH PLUS ESCAPEMENT) (8,9)

a) Area 15 - Powell River

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK
1975	10	16193	21736	16627	19426
1974	205	9909	165	28706	22214
1973	75	30995	26085	14965	31262
1972	865	41994	72	75884	35622
1971	580	63947	37735	26157	63579
1970	99	71584	129	18168	45994
1969	92	27976	13775	26470	21759
1968	51	38106	163	84052	22118
1967	8	29681	25305	19106	24480
1966	38	61105	112	44378	27578
AVERAGE	200	39000	125000	35450	31400

b) Area 16 - Pender Harbour

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK
1975	20765	33590	75536	47403	19110
1974	60331	36708	1033	87216	9688
1973	17427	22094	12062	260751	8621
1972	34937	13731	136	120561	25398
1971	38263	46913	93250	37684	30780
1970	10313	35310	670	121875	17318
1969	31810	29075	35191	119185	11309
1968	26344	28087	3919	88900	9921
1967	16591	18604	41396	16218	13134
1966	10970	45648	397	25043	12264
AVERAGE	25775	30976	26359	92483	15754

TABLE II

COMMERCIAL SALMON CATCHES (IN PIECES)[8]

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK
a) Area 15 - Powell River					
1975	10	15468	436	2	19426
1974	205	8859	165	6	22214
1973	75	11395	585	165	21762
1972	865	8974	32	26134	23922
1971	580	32187	585	7	44579
1970	99	30544	79	5468	20994
1969	92	5076	675	Nil	13659
1968	51	7896	151	2	9118
1967	8	11406	1265	6	10880
1966	38	25605	112	3	13578
AVERAGE	202	15741	410	829	20013
b) Area 16 - Pender Harbour					
1975	4765	20480	51156	762	19110
1974	54331	14263	1033	178	9688
1973	15927	11644	1232	169031	8621
1972	30437	6241	136	27951	25398
1971	29763	33228	45625	329	30780
1970	5313	24330	520	58725	17268
1969	18110	8275	2591	34635	11209
1968	6344	6457	3719	50	9821
1967	6591	8134	16686	118	13034
1966	3970	16173	372	18	12264
AVERAGE	17555	14922	12307	29179	15719

20%, 17%, 17% and 14% of the catalogue respectively. Since the main Gulf of Georgia fishery has shifted to Johnstone Strait, there has been a noticeable reduction in catch for the area.(6)

C. Escapement

The Pender Harbour Subdistrict contains approximately 81 miles of spawning ground distributed over 35 streams, 21 in Area 15 and the remainder in Area 16. Table III gives escapements for area 15 and 16 by year and species for 1966 to 1975. Escapements of sockeye to Area 15 are non-existent as this species do not inhabit any of the lake-fed streams in the area. The Sakinaw lakes system is now the only system in area 16 that supports sockeye. Sockeye runs in the Tzoonie River have not been observed since 1969. The chinook run in Area 16 is almost negligible, with an average run of 35 per year. Even-year pinks in the Subdistrict have recently declined to zero. Gross fluctuations in escapements are generally attributable to variability in spawning cycles, changing environmental conditions such as ice scouring and flooding, and commercial fishing pressures.

The following table ranks the most important spawning streams according to species. Ranking is based on the average escapements from 1966 to 1975.

	SOCKEYE	CHINOOK	COHO	CHUM	PINK
1.	Sakinaw Lakes	Toba	Toba	Deserted	Skwawka
2.	Tzoonie River*	Little Toba	Little Toba	Tzoonie	Deserted
3.		Klite	Skwawka	Saltery Bay	Toba
4.		Brem	Tzoonie	Toba	Little Toba

*Last escapement recorded was in 1969.

The failure of a stream to appear under a particular species heading does not necessarily mean that spawning of that species does not occur; rather it indicates that escapements are not as significant when compared to other streams in the area. The Toba thus seems to be the most important river, providing significant runs of chinook, coho, chum and pink salmon, followed by the Little Toba, with comparatively large runs of chinook, coho and pink salmon. None of the seven streams in the area of potential influence (between Scotch Fir Point and the Copeland Islands) appear to be large producers. Table IV shows their escapements for the years 1966 to 1975.

Salmon may be under the influence of the pulp mill effluent during both their adult and juvenile migrations to and from the spawning grounds respectively. Since the effluent tends to flow to the northwest of Powell River, any

TABLE III

SALMON ESCAPEMENTS(12,13)

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK
a) Area 15 - Powell River					
1975		725	21300	16625	Nil
1974		1050	Nil	28700	Nil
1973		19600	25500	14800	9500
1972		33000	50	49750	11700
1971		31760	37150	26150	19000
1970		41000	50	12700	25000
1969		22900	13100	26475	8100
1968		30200	25	84050	13000
1967		18275	24040	19100	13600
1966		15500		44375	14000
AVERAGE	Nil	23400	12100	32300	11400
b) Area 16 - Pender Harbour					
1975	16000	13100	24400	46650	Nil
1974	6000	22450	Nil	87000	Nil
1973	1500	10450	10850	91725	Nil
1972	4500	7490	Nil	92600	Nil
1971	8500	13700	47625	37350	Nil
1970	5000	11000	150	63150	50
1969	3700	20800	32600	84550	100
1968	20000	21600	200	88850	100
1967	10000	10475	24700	16100	100
1966	7000	29475	25	25025	
AVERAGE	8200	16050	14050	63300	50

TABLE IV

SALMON ESCAPEMENTS OF STREAMS BETWEEN SCOTCH FIR POINT AND THE COPELAND ISLANDS(9)

CREEK	1975	1974	1973	1972	1971	AVERAGE	AVERAGE (1966-70)
				a) COHO			
DAYTON	20	20	N.O.	N.O.	N.O.	10	Nil
KELLY	25	25	25	N.O.	120	50	Nil
LANG (WOLFESON)	200	300	200	1000	1000	550	500
LOIS (EAGLE)							
MYRTLE (FROCK)	50	50	25	25	25	25	10
WHITTAL (SIMPKINS)	150	250	50	140	100	138	75
SLIAMMON	100	100	100	600	1000	380	800
				b) CHUM			
DAYTON	200	525	100	2000	600	700	575
KELLY	700	200	300	3000	400	925	325
LANG (WOLFESON)	5000	1800	1000	3000	1200	2240	2620
LOIS (EAGLE)	75	150	150	100	75	100	325
MYRTLE (FROCK)	425	300	200	300	75	250	450
WHITTAL (SIMPKINS)	1500	1450	25	1200	300	900	650
SLIAMMON	4500	5000	7000	3500	3000	4600	5000

N.B. From 1966-1975, Lang Creek recorded a single escapement of 50 pinks in 1971.

N.O. None Observed

fish populations within this area could possibly be affected. Unfortunately, there is insufficient information available to accurately determine the extent to which these waters are used by migrating salmon.(14) Several general observations, however, may prove helpful.

During migration, salmon tend to remain on the side of Georgia Strait from which they originated, moving through Johnstone Strait to the north and Juan de Fuca Strait to the south. While there is considerable variation from year to year, the majority seem to utilize the southern route. On the northern seaward migration, Discovery Passage is probably preferred by the more mature fish, with rearing juveniles staying east of Quadra Island where less turbulent waters permit higher accumulations of food. There does not appear to be any tendency for salmon to use the same route for both spawning migrations of adults and seaward migrations of juveniles.(14)

Migrations past Powell River occur on either side of Texada Island; the proportion of fish utilizing either side is not known. The extensive fishery in Sabine Channel suggests that this may be the preferred route. In 1973, Sabine Channel was the source of most of the sockeye, coho and chum catches for Area 16.(10) Pink salmon also used Sabine Channel, with local populations migrating via Malaspina Strait to the spawning streams. Only small numbers of chum use Juan de Fuca Strait, most preferring Johnstone Strait at the north end of Vancouver Island. Local populations of chum move via Malaspina Strait to the spawning grounds. The majority of chinook in the Pender Harbour Subdistrict spawn in Toba Inlet streams. They tend to be a very mobile species, particularly in the nearshore areas. Occasionally, chinook form rearing concentrations within the Strait of Georgia or in the mouths of inlets. One such concentration has been reported at the southern end of Texada Island. Coho are also quite mobile, but range mainly in offshore waters.(15)

Timing of salmon migrations and spawning for the Subdistrict is tabulated below.

SPECIES	UPSTREAM MIGRATION	SPAWNING
SOCKEYE	July to September	November - December; peak: mid-November.
CHUM	late Octber to mid-November	late October to late November; peak: late October; in some creeks, there may be an early December run.
COHO	late October to mid-December	late November - December, may extend to January; peak: late November

SPECIES	UPSTREAM MIGRATION	SPAWNING
PINK	late September to late October	late September to late October; peak: late Oct.
CHINOOK (Toba Inlet Streams)	April to August	April to end of Oct.; peak: variable.

D. Sport Fishery

i) Tidal

The tidal sport fishery for the Pender Harbour Subdistrict occurs from Lund, south through Malaspina Channel to Scotch Fir Point. Most of the sport fishing is done from small boats, however, about 5% is done from shore. Apart from the Toba Inlet channel fishery and the mouth of Jervis Inlet (coho and chinook fishery), there are no areas of particular importance for any one species. (6)

Table V gives the salmon sport catch and effort for Statistical Areas 15 and 16. Five year averages from 1966 to 1970 and 1971 to 1975 show increases in the numbers of fish taken: (from 13,480 to 29,357, in Area 15, and from 17,312 to 25,145 pieces in Area 16.) The increases in fishing effort in boat days: (from 11,103 to 19,723 in Area 15, and from 12,906 to 24,140 in Area 16 are also given). Tagging programs have shown that the Qualicum and Capilano hatchery facilities have had a significant beneficial effect on the sport fishery. (10)

ii) Non-Tidal

The non-tidal sport fishery is relatively minor in size, with the emphasis on lake rather than stream fishing. The major species caught are steelhead and coastal cutthroat trout. The main sport fishing streams are Lang (Wolfeson) Creek and the Theodosia and Brem rivers. However, extensive utilization of the latter two is limited by accessibility. Of the streams between Copeland Island and Scotch Fir Point, only Lang Creek shows returns for steelhead. They are given in the following table.

Lang Creek Steelhead Sport Catch, Effort And Number of Anglers(16)

YEAR	EFFORT (DAYS FISHED)	NUMBER OF ANGLERS	CATCH (PIECES)
1975-76	500	58	111
1974-75	500	59	92
1973-74	281	45	67
1972-73	697	105	179
1966-67	433	138	214

TABLE V

SALMON SPORT CATCH AND EFFORT[17]

YEAR	CHINOOK	COHO	PINKS & OTHERS	TOTAL	EFFORT (BOAT DAYS)
a) Area 15 - Powell River					
1975	10180	20675	475	31330	20575
1974	11230	27100	455	38785	22958
1973	8539	5899	35	14473	16605
1972	10502	10148	14	20664	18031
1971	6386	35082	67	41535	20448
5 YEAR AVERAGE	9367	19781	209	29357	19723
1970	4775	21425	-	26200	17450
1969	4200	9025	-	13225	14950
1968	3400	9500	-	12900	10280
1967	2600	2075	50	6325	5525
1966	1725	5957	-	8750	7310
5 YEAR AVERAGE	3340	9600	10	13480	11103
b) Area 16 - Pender Harbour					
1975	7095	18500	280	25875	24780
1974	4245	25265	-	29510	23370
1973	5980	8815	67	14862	24070
1972	6870	10028	6	16904	21879
1971	6563	31853	160	38576	26600
5 YEAR AVERAGE	6157	18892	103	25145	24140
1970	3725	7900	-	11625	17175
1969	3100	9750	75	12925	12875
1968	3320	23390	-	26710	12620
1967	2775	9000	200	13775	11700
1966	2075	17350	-	21525	10160
5 YEAR AVERAGE	2999	13478	55	17312	12906

For 1966-67, Coho and Chinook Grilse were included in "combined Grilse", with values of 1050 and 1600 pieces for Area 15 and 2100 and 1800 for Area 16.

E. Indian Food Fishery

Two local Indian bands, the Sliammons from north of Powell River and the Sechelts from the Pender harbour area fish Areas 15 and 16. A small group also fish out of Squirrel Cove on the east side of Cortes Island. The Indians of Areas 15 and 16 probably rely less on the food fishery than more isolated bands since a large number are employed in the pulp mill and other local industries.

The Sliammons do most of their fishing near the Sliammon River, either near the mouth, or in the river itself.(8) Some fishing is also done in the Okeover Arm - Theodosia Inlet area. Set nets and gaffs are the predominant gear types, the latter in streams where set nets are not practical.

Table VI itemizes the native catches for the area from 1966 to 1975. Chum are caught most frequently followed by coho and chinook. It is not known whether herring spawn is utilized by the Sliammons. In the shellfish harvest, littleneck clams are taken off Savary and Harwood Islands and from the top of Okeover Inlet.

III HERRING

Figure 3 gives the Area 15 and 16 herring spawn locations from 1970 to 1975. These show that virtually the whole length of coastline from the Copeland or "Ragged" Islands to Scotch Fir Point is used for spawning. The areas of concentration are Scuttle Bay and the Copeland Islands. The only unused spawning area is a strip of coastline approximately 6 miles long surrounding Powell River where the absence of spawn is apparently due to the lack of suitable intertidal areas rather than the proximity of the mill or townsite. Following hatching of eggs virtually any area along the coast may be utilized for rearing of juvenile herring.(18)

The herring fishery on the eastern shores of the Strait of Georgia is of minor importance compared to the east and west coasts of Vancouver Island because of the smaller resident stocks. The last roe herring fishery occurred in 1973 near Grief Point. At present, the only herring harvest is for bait off the north end of Texada Island.(19) Table VII gives the annual herring catch and statute miles of herring spawn for areas 15 and 16.

TABLE VI

TOTAL INDIAN FOOD FISHERY(10)

YEAR	COHO	CHINOOKS	CHUM	PINKS	SOCKEYE
a) Area 15 - Powell River					
1975	200	300	3000		
1974	100	150	2000		
1973	50	100	1400		
1972	132	184	1320	5	
1971	113	75	1952		
1970	113	105	1625		
1969	96	36	2162		
1968	112	23	2356		
1967	10		200		
1966	450		950		
AVERAGE	137	97	1696	0.5	
b) Area 16 - Pender Harbour					
1975	N O	F O O D	F I S H E R Y		
1974	N O	F O O D	F I S H E R Y		
1973	637				
1972	1	4	228		
1971	93	2	1197		8
1970			200		
1969	50	5	300	10	11
1968	34	11	349		4
1967	200	10	600	100	10
1966	200	25	400		
AVERAGE	122	28	327	11	3

TABLE VII

COMMERCIAL HERRING CATCH AND MILES OF SPAWN(18,20,21,22)

YEAR	CATCH (IN CWT)	STATUTE MILES OF SPAWN
a) Area 15 - Powell River		
1975	980	9.0
1974	20	4.5
1973	20	6.9
1972	3737	6.2
1971	Nil	11.2
1970	1603	9.0
1969	Nil	6.9
1968	Nil	1.1
1967	2770	0.3
1966	520	-
AVERAGE	965	
b) Area 16 - Pender Harbour		
1975	10470	2.9
1974	3920	0.7
1973	9810	3.7
1972	40598	6.9
1971	3782	5.1
1970	4322	14.9
1969	5626	8.1
1968	2532	3.8
1967	3111	7.1
1966	12911	5.9
AVERAGE	9708	

CWT = 100 lb.

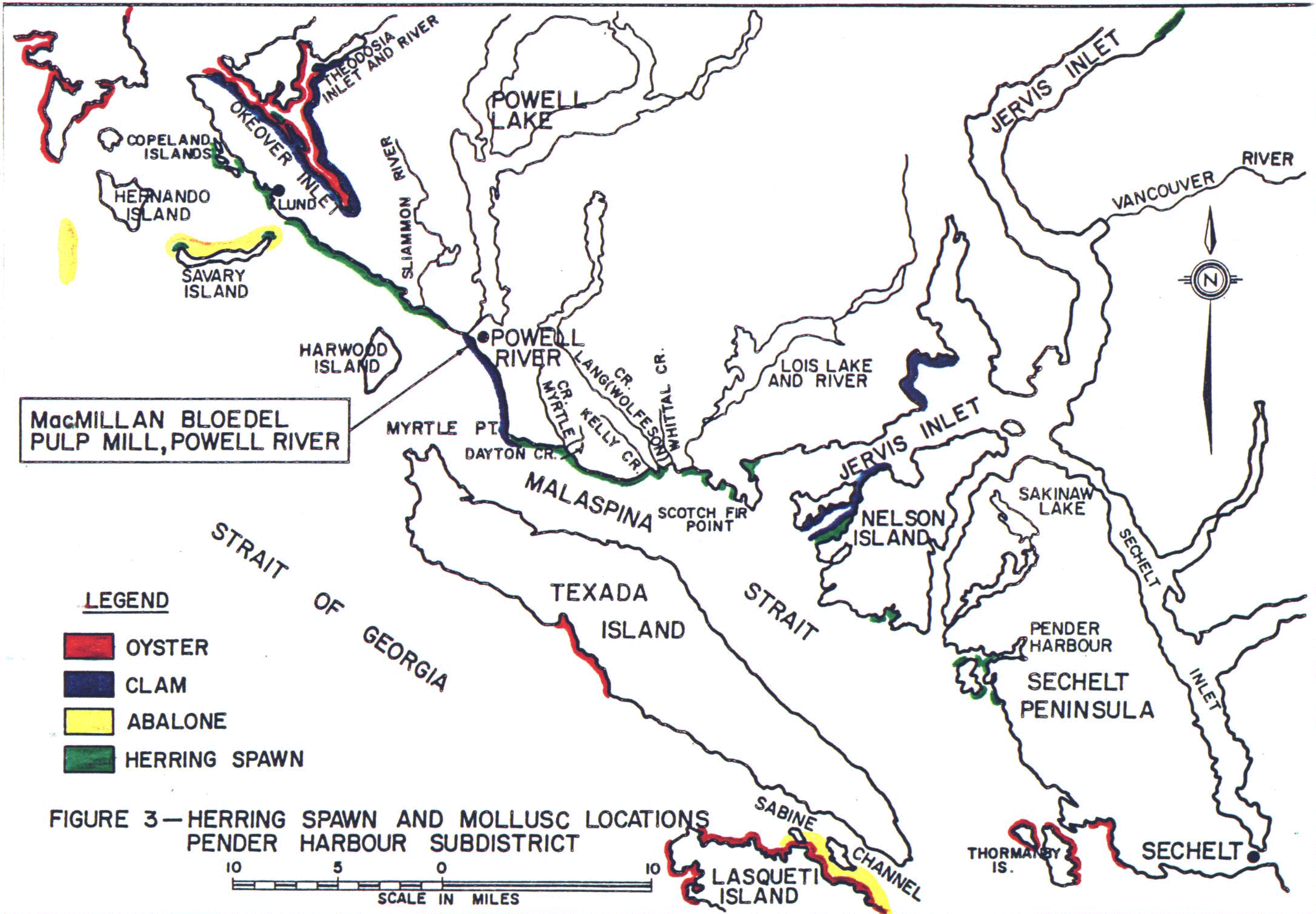

FIGURE 3—HERRING SPAWN AND MOLLUSC LOCATIONS PENDER HARBOUR SUBDISTRICT

IV HALIBUT AND GROUNDFISH

Halibut and groundfish are of minimal importance in the Pender Harbour Subdistrict as a whole and the Powell River vicinity in particular.(23) Halibut are usually taken commercially during the hook and long-line cod fishery while grayfish, some non-food fish and perch are taken incidentally in the dragger fishery. Several hundredweight of red and rock cod are also taken.

Table VIII gives the annual halibut and groundfish commercial catches in hundredweight.

V MOLLUSCS

The most important areas of commercial oyster harvest, Okeover Inlet and Pendrell Sound are remote from the Powell River pulp mill. Small numbers of oysters are also taken by the sport fishery in these areas. Okeover Inlet was used as a control site for a study of zinc contamination of shellfish by pulp mill effluent. Considerably lower levels were found in this area compared to the coastline adjacent to Powell River.(2)

Okeover Inlet is the source of most of the clams in the Powell River area. Clams are available along the shoreline immediately north and south of Powell River, however the area has been closed in recent years due to sewage contamination. The same areas also provide most of the sport catch. The Sliammon Indians carry on a commercial harvest, primarily for littleneck clams around Savary and Harwood Islands and at the top end of Okeover Inlet. Table VIII gives commercial catches for shellfish. Figure 3 shows the location of clam, oyster and abalone beaches.(6,23,24) The map gives only rough indications of stock locations and may be incomplete in many respects.

VI CRUSTACEANS

While minor prawn fishing activities have taken place occasionally in the waters surrounding Texada Island(8) no major concentrations are known to exist.(1) Table VIII gives the available catch figures.

TABLE VIII

COMMERCIAL CATCH STATISTICS, OTHER SPECIES (8)

YEAR	STEELHEAD Pieces	HALIBUT CWT	GROUNDFISH CWT	SHRIMP CWT	CLAMS CWT	OYSTERS (U.S. Gal.)	CRABS CWT
a) Area 15 - Powell River							
1975	5	< 500	1480		270	5738	
1974	32	Nil	580		1230	3692	
1973	2	Nil	1140		1830	1227	
1972	3	Nil	799	2	2504	549	
1971	8	Nil	1262	7	53	890	
1970	6	Nil	1458	6	12	5208	
1969	Nil	Nil	1155	5	Nil	15071	
1968	Nil	Nil	441	Nil	173	3478	
1967	1	Nil	392	Nil	Nil	15114	
1966	6	Nil	386	NO RECORD			
AVERAGE	6		916		606	5096	
b) Area 16 - Pender Harbour							
1975	17	Nil	640	50	270	1055	500
1974	6	Nil	460	10	620	891	
1973	9	Nil	1090	10	290	896	
1972	18	Nil	2052	34	437	907	2
1971	23	Nil	186	17	530	832	
1970	18	Nil	1583	9	760	1834	
1969	9	Nil	2822	9	2	2525	
1968	19	2	2104	25	14	2136	
1967	13	1	2511	32	234	1559	
1966	16	Nil	2354	34	338	2033	
AVERAGE	14		1580	23	351	1466	

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