ENVIRONMENTAL PROTECTION BRANCH
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PACIFIC REGION

PULP MILL ENVIRONMENTAL IMPACT ASSESSMENT
CANADIAN FOREST PRODUCTS LTD.
HOWE SOUND PULP DIVISION

Regional Program Report: 79-2

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 Canadian Forest Products pulp mill at Port Mellon, Howe Sound, B.C.

RÉSUMÉ

Au mois d'octobre 1976, le Service de la protection de l'environnement a entrepris de'évaluer les répercussions mésologiques des fabriques de pâtes et papiers de la Colombie-Britannique. Aidé de l'industrie et de divers autres organismes gouvernementaux, il a réuni une documentation concernant les ressources ainsi que certains résultats de contrôles portant sur l'environnement affecté. Après avoir étudié ces données, le Service a évalué la qualité environnementale de chacune des régions et déterminé quelles seraient les études supplémentaires qui resteraient a réaliser. Ce rapport fait connaître les résultats ayant trait à l'évaluation des contrecoups imputables à la fabrique de pâte de la Canadian Forest Products de Port Mellon, sur l'environnement du détroit de Howe.

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CONCLUSIONS

The environmental impacts of discharges from the Canadian Forest Products mill at Port Mellon have been well documented and the zone of influence reasonably well defined by receiving environment studies. The impacts appear to be largely related to the discharge of lime mud and wood fibres and to a lesser extent the light attenuating properties of bleached kraft mill effluent. The effluent control program currently underway at the mill concentrates on these problems by proposing the installation of in-plant facilities to reduce the loss of suspended solids and toxic substances to the receiving waters. The effectiveness of these pollution abatement measures will be assessed by Fisheries and Environment Canada in 1979.

The installation of a diffuser outfall system for combined effluents will improve the present effluent dispersion problems associated with near-shore, surface discharge. Studies have shown that optimal dispersion would be achieved by discharging as far into Thornbrough Channel as possible and by avoiding the poorly flushed bay to the south of the mill. To ensure maximum disposal on a year-round basis the seasonal variations in temperature and salinity stratification should be taken into account. Although not presently available, data on sub-surface current movements in the area would be useful in determining diffuser placement.

Future receiving environment studies on the rehabilitative capacity of the Port Mellon area following improvements to effluent quality would be valuable in assessing the effectiveness of pollution abatement measures. Particular improvement should be noted in the shoreline communities south of the mill and in phytoplankton productivity adjacent to the mill. A determination of benthic communities should be made in the area chosen for the diffuser system to enable assessment of alterations to bottom life resulting from the new disposal system.

1 INTRODUCTION

The Canadian Forest Products Ltd. (Canfor), Howe Sound Division pulp mill is located at Port Mellon, British Columbia, at the mouth of the Rainy River (Figure 1). The mill is situated on the west shore of Howe Sound in the tide-swept Thornbrough Channel.

Built in 1908 by the B.C. Wood Pulp and Paper Co. under Captain H.J. Mellon the mill is the second oldest in B.C. and was designed to produce 20 tons per day of paper made from "soda" pulp. Until 1951, when acquired by its present owners, the mill had changed hands 11 times. In 1951 as a Canadian Forest Products mill the average daily production was 120 tons per day of unbleached Kraft pulp. At present the mill production averages about 540 air dried tons (ADT) per day of Kraft pulp.

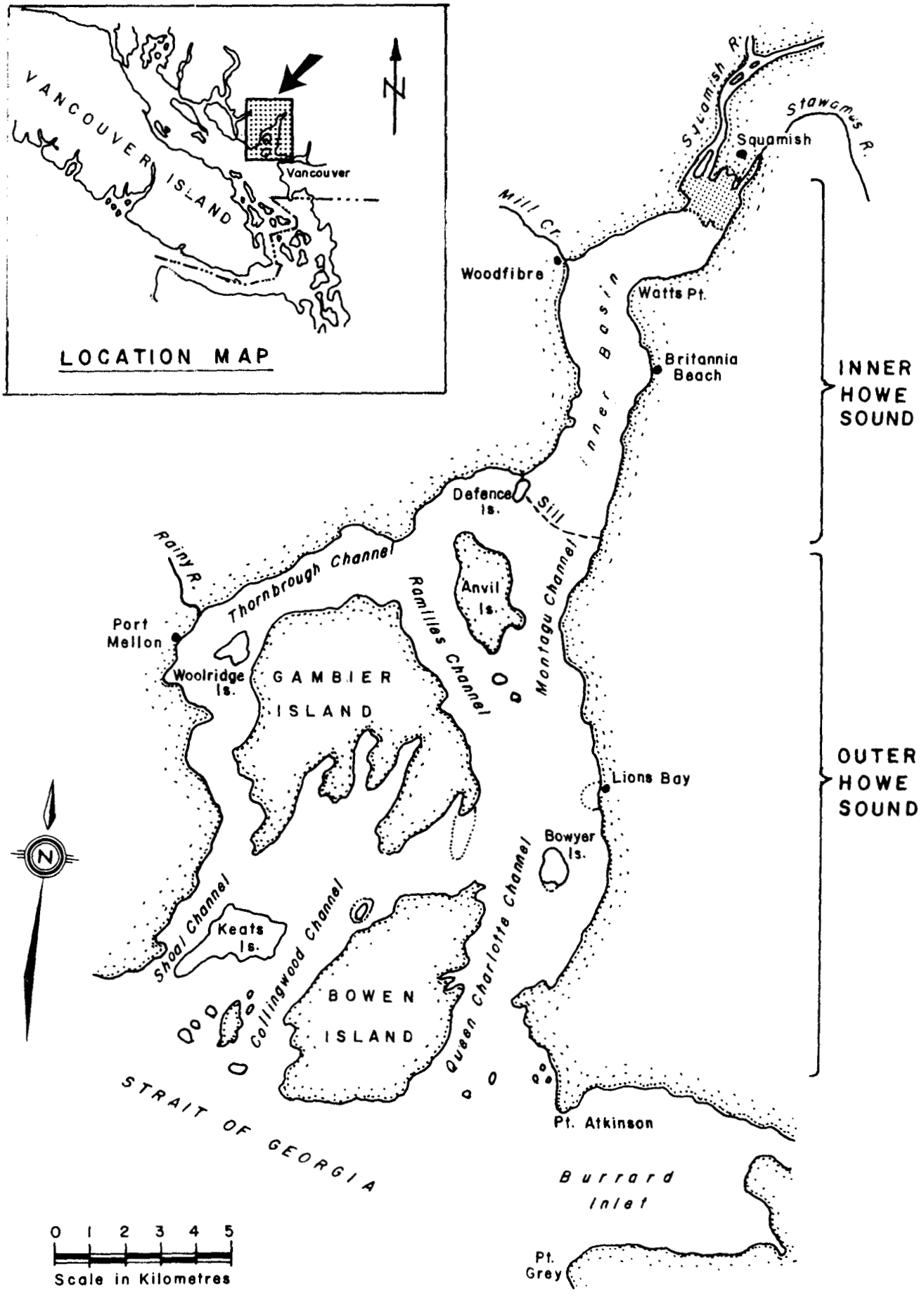

FIGURE 1 HOWE SOUND

2 MILL OPERATIONS

The Kraft pulp produced at Port Mellon is primarily full-bleached with semi-bleached, and unbleached grades secondary. The mill utilizes wood by-products in the form of chips and sawdust purchased on the open market or supplied by company sawmills. Process water is drawn from the Rainy River at a rate of approximately 87 million litres per day. The effluent is discharged into Thornbrough Channel by means of two outfalls (Figure 2).

The alkaline effluent pipe, exposed at low tide, carries waste from the pulping and chemical recovery processes, and from the caustic extraction portion of the bleach plant operation. The flow rate for this effluent stream is approximately 68 million litres per day. The acidic bleach plant effluent pipe, which discharges just below tide level, drains the chlorination and chlorine dioxide treatment stages of the bleaching process at a flow rate of approximately 19 million litres per day. The Canadian Forest Products pollution abatement program includes a provision for the installation of a submerged diffuser outfall system to carry combined acid, alkaline, and sanitary effluents from the mill and townsite. For a more detailed discussion of mill operations including the sewer system, effluent characteristics, and pollution abatement facilities refer to Tanner (1975).

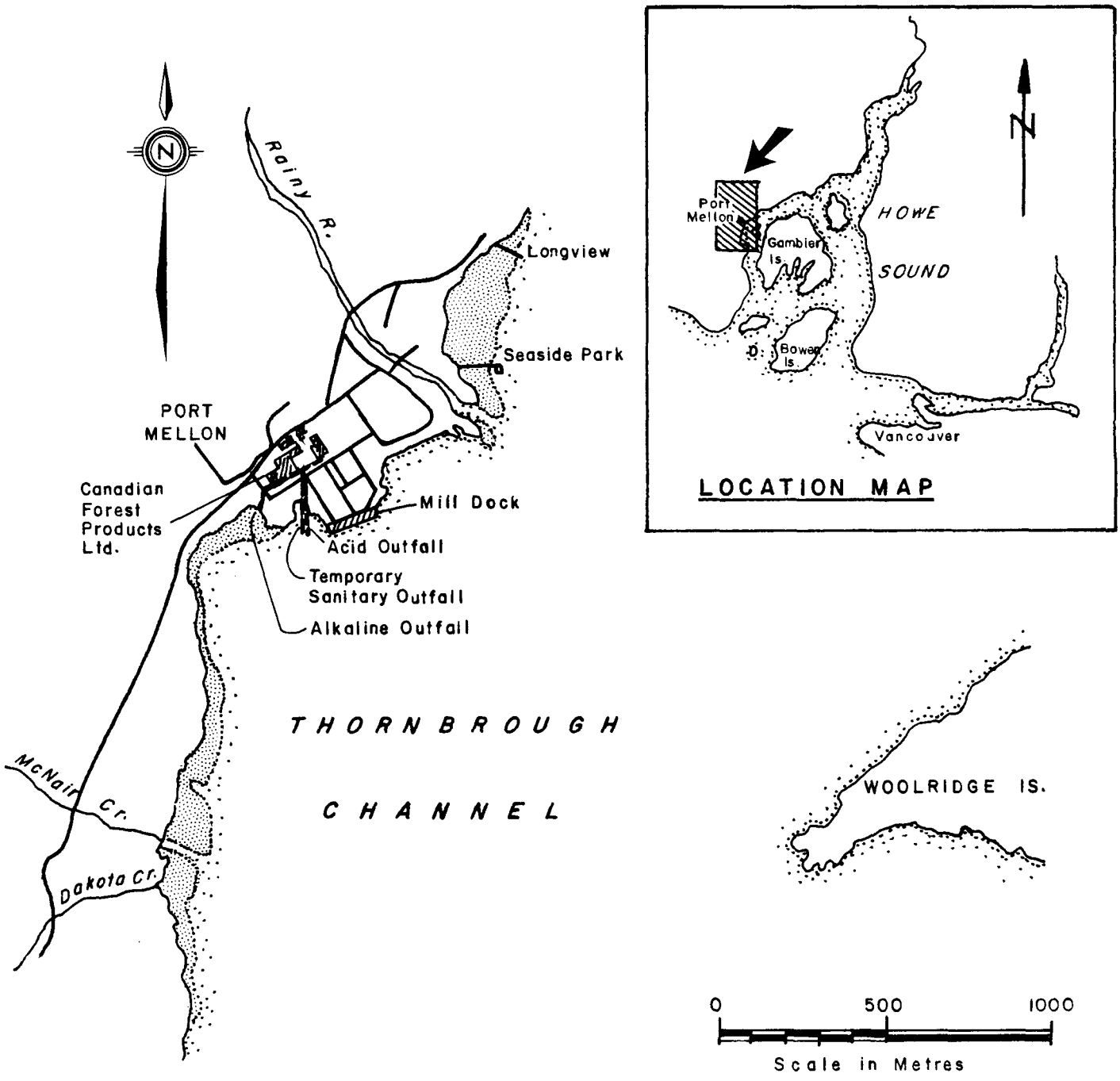

FIGURE 2 CANADIAN FOREST PRODUCTS LTD., PORT MELLON, B. C.

3 EFFLUENT QUALITY

3.1 Government Regulations

Canfor currently discharges bleached kraft mill effluent (BKME) under a permit issued by the Pollution Control Board (PCB) of the British Columbia Provincial Government. The permit, PE-1149 was issued on November 25, 1976 and amended May 3, 1977. Effluent characteristics stipulated in the permit are shown in Table 1 and outlined in a report on Pollution Control Objectives for the Forest Products Industry of British Columbia (1974). As an existing mill Howe Sound Division will be required by Federal Government Pulp and Paper Effluent Regulations (Environment Canada 1971) to meet certain standards of biological oxygen demand (BOD_5), suspended solids (SS), and toxicity (Table 2).

In addition to their effluent permit Canfor possess a pulpmill refuse permit, PR-4679 obtained from the PCB in April, 1977. Under this permit the company is authorized to disposed of up to 46 cubic metres per day of industrial solid wastes on the foreshore east of the Rainy River mouth. These wastes consist mainly of grits from the slaking-causticizing operation, ashes from the power boilers, off quality chips and hog fuel, clinkers from the lime kiln and some of the lime mud (spent calcium carbonate) which becomes excess to the process due to upsets.

3.2 Effluent Characteristics

3.2.1 BOD and SS. Tables 3 and 4 show levels of BOD and SS based on full-bleached effluent from the Canfor mill for 1976 and 1977 respectively. These measurements are taken routinely by mill personnel and the results sent to the Federal and Provincial regulatory agencies.

3.2.2 Toxicity. In December, 1975 an effluent monitoring program was initiated by Environment Canada to determine the range of toxicity associated with mill effluent. The company participated in the program by

TABLE 1 P.C.B. PERMIT REQUIREMENTS FOR INDUSTRIAL EFFLUENT FROM CANADIAN FOREST PRODUCTS LTD., HOWE SOUND PULP DIVISION

Effluent Characteristics	Value
pH Range	6.5 - 8.5
Temperature	95°F
Floatable Solids	negligible
Total Suspended Solids	19 000 lb/day
$B.O.D._5$	38 000 lb/day
Toxicity (LC_{50})	12.5%
Mercaptans	< 2.0 mg/l
Sulphides	< 1.0 mg/l
Residual Chlorine	< 0.1 mg/l

TABLE 2 FEDERAL EFFLUENT REGULATIONS FOR CANADIAN FOREST PRODUCTS LTD., HOWE SOUND PULP DIVISION

Pulp Division	S.S.	$B.O.D._5$
Kraft Pulping	7 lb/ADT	64 lb/ADT
Kraft Bleaching	6 lb/ADT	27 lb/ADT
Pulp Sheet Formation	2 lb/ADT	

Toxicity - 80% survival at 65% effluent concentration (v/v) over 96 hour continous flow testing.

TABLE 3 1976 EFFLUENT QUALITY RESULTS FOR CANADIAN FOREST PRODUCTS LTD., HOWE SOUND PULP DIVISION

Month	Flow x10 IG/D	BOD_5 LB/ADT	BOD_5 Tons/Day	Suspended Solids LB/ADT	Suspended Solids Tons/Day
January	24.2	39.4	10.07	91.4	23.35
February	22.9	35.5	9.25	78.1	20.35
March	23.1	40.0	11.20	91.1	25.50
1st Quarter	23.4	38.3	10.17	86.9	23.07
April	21.7	44.2	8.79	101.4	20.18
May	22.4	37.1	9.97	105.6	28.36
June	24.2	43.2	11.53	75.1	20.01
2nd Quarter	22.8	41.5	10.10	94.0	22.85
July	23.4	27.5	7.72	118.4	33.26
August	23.4	63.5	16.85	106.5	28.28
September	23.0	64.5	16.79	117.0	30.48
3rd Quarter	23.3	51.8	13.79	114.0	30.67
October	23.9	78.8	17.53	114.4	25.45
November	21.2	53.7	13.96	74.6	19.40
December	20.7	42.7	11.39	70.0	18.66
4th Quarter	21.9	58.4	14.29	86.3	21.17
Yearly Average	22.9	47.5	12.09	95.3	24.44

TABLE 4 1977 EFFLUENT QUALITY RESULTS FOR CANADIAN FOREST PRODUCTS LTD., HOWE SOUND PULP DIVISION

Month	Flow x10 IG/D	BOD_5 LB/ADT	BOD_5 Tons/Day	Suspended Solids LB/ADT	Suspended Solids Tons/Day
January	19.7	56.5	14.45	72.5	18.52
February	20.8	57.2	15.18	77.5	20.57
March	20.2	61.8	16.83	75.1	20.48
1st Quarter	20.2	58.5	15.49	75.0	19.86
April	20.6	65.6	17.12	141.8	37.00
May	18.7	51.7	14.42	98.4	27.45
June	18.9	56.6	15.91	115.3	32.41
2nd Quarter	19.4	58.0	15.82	118.5	32.29
July	-	-	-	-	-
August	18.7	51.6	11.87	119.4	27.47
September	17.4	41.0	11.05	93.6	25.23
3rd Quarter	18.1	46.3	11.46	106.5	26.35
October	16.6	52.5	15.39	50.6	14.82
November	17.2	53.3	15.80	118.2	35.07
December	17.2	66.5	17.52	85.9	22.64
4th Quarter	17.0	57.4	16.24	84.9	24.18
Yearly Average	18.7	55.1	14.75	96.2	25.67

DEPARTMENT OF FISHERIES AND THE ENVIRONMENT
FISHERIES AND MARINE SERVICE

Canadian Forest Products, Port Mellon Pulp Mill
Rayonier, Woodfibre Pulp Mill
Fisheries Resources of Fisheries and Marine Service Statistical Area 28

by
W. Knapp
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Water Quality Division
Habitat Protection Unit
Resource Services Branch
1978

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CANADIAN FOREST PRODUCTS, PORT MELLON PULP MILL
RAYONIER,WOODFIBRE PULP MILL
FISHERY RESOURCES OF
FISHERIES AND MARINE SERVICE STATISTICAL AREA 28

I INTRODUCTION

Howe Sound,a part of Statistical Area 28 (Figure 1), is enclosed by 75 miles of coastline and its 17 salmon spawning streams contain 46 linear miles of spawning grounds, 85% of which are found in the Squamish-Stawamus River systems at the head of the Sound. Two pulp mills are located on the western side of Howe Sound, Rayonier's Woodfibre mill near the head of the Sound, and Canadian Forest Products, Port Mellon mill opposite Gambier Island (Figure 2).(1)

II SALMONIDS

A. Stocks

Howe Sound river systems harbour steelhead and Dolly Varden (char) as well as four species of Pacific salmon *(Onchorynchus* sp*)*: coho, chum, pink, and chinook. Stocks mainly originate from the Squamish-Stawamus River systems at the head of Howe Sound. Chum and odd-year pink stocks provide the major harvest to the commercial fishery outside the Sound.(2) Coho and chinook provide a good sport fishery, particularly since 1969 when Howe Sound was closed to commercial fishing. Chinook stocks appear to have been decreasing since 1970 (Table I) while other salmon stocks have fluctuated widely from year to year. Stocks (Table I) were calculated from salmon escapement data because of inadequate commercial and sport fishing harvest data specific to Howe Sound. Proposed enhancement facilities for this area includes construction of a hatchery on the Cheakamus River capable of producing 45,000 chinook and 50,000 coho salmon, and 1,000 steelhead trout. In addition it would include a spawning channel for pink and chum salmon.(6)

B. Commercial Fisheries

Stocks of Howe Sound pink and chum salmon are largely harvested by net fisheries in the Strait of Georgia, Johnstone Strait, and Juan de Fuca Strait. Stocks of chinook

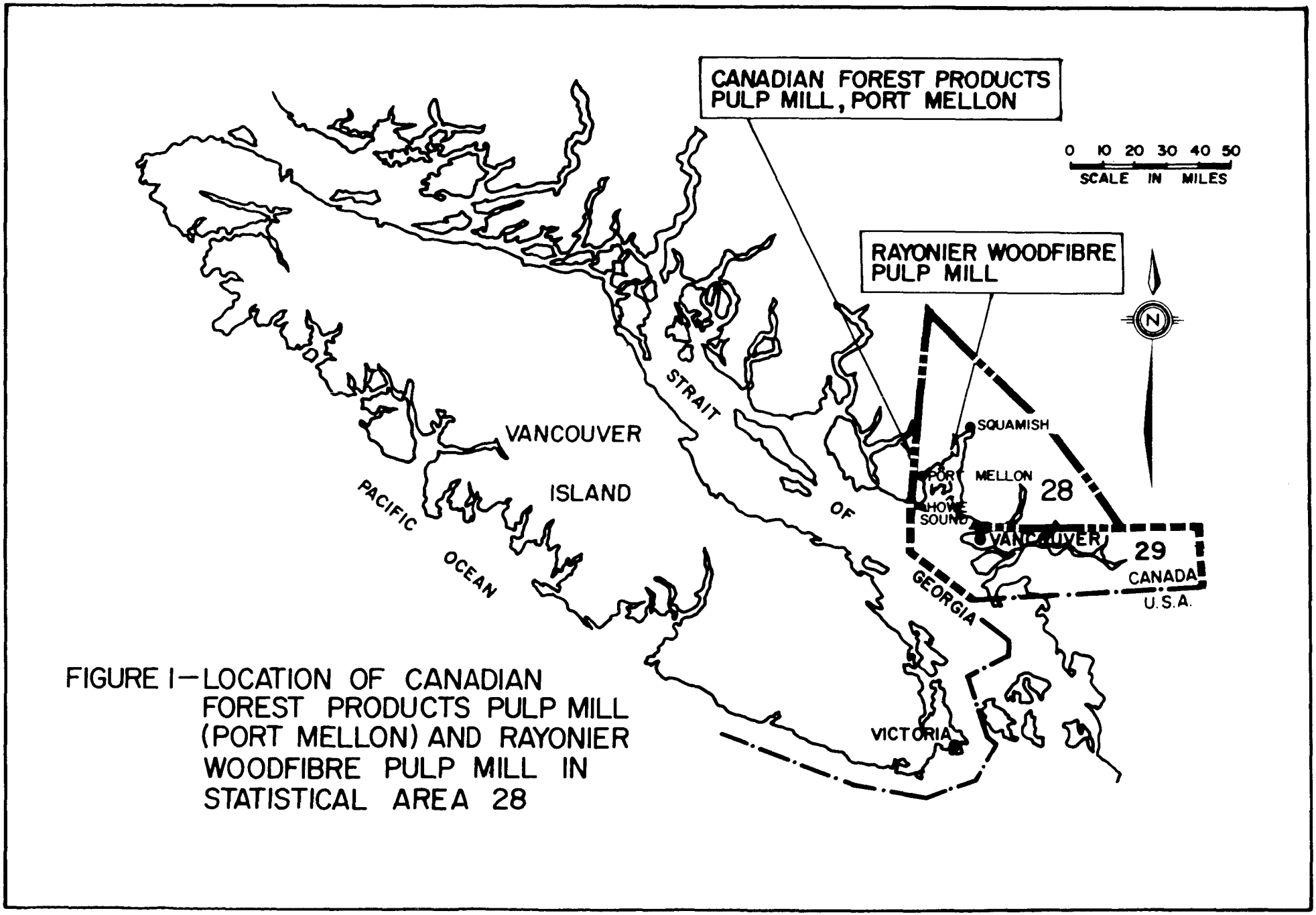

FIGURE 1—LOCATION OF CANADIAN FOREST PRODUCTS PULP MILL (PORT MELLON) AND RAYONIER WOODFIBRE PULP MILL IN STATISTICAL AREA 28

TABLE I

Estimates* of Mean Annual Total Stock** of Howe Sound Salmon(3,4,5,6)

YEAR	CHINOOK	COHO	CHUM	PINK Even/Odd
1956-59	92,500	71,500	161,000	0/673,000
1960-64	71,000	104,000	70,500	0/673,000
1965-69	102,000	56,000	94,500	0/240,000
1970	155,000	128,000	224,000	0
1971	56,000	120,000	66,500	120,500
1972	47,000	34,000	640,000	4,000
1973	69,000	110,000	471,000	690,000
1974	47,000	534,500	285,000	0
1975	12,000	225,500	68,500	125,000
1966-75	69,000	136,000	221,000	750/418,000

* Calculated from catch: escapement ratios. Chinook 5:1; Coho 4:1; Chum 2:1; Pink 5:1 (6)

** Stock = Escapement + Catch

and coho salmon are subjected to commercial and sport fisheries in tidal waters outside Howe Sound as well as sport fisheries within the Sound.(7)

The Available sport catch statistics include Area 29 (lower Fraser River and Gulf of Georgia, Figure 1) landings and are not specifically related to Howe Sound stocks. The combined sport-commercial harvest (Table II) was estimated using Howe Sound escapements (Table III) and accepted catch to escapement ratios. Based on coastwide information, these ratios are given as 5:1 for chinook, 4:1 for coho, 2:1 for chum, 5:1 for pink.(6)

C. Sport Fishery

i) Tidal

Tidal sport fishing in Howe Sound is concentrated in the early months of the year near Horseshoe Bay, the lower eastern portion of the Sound, Thornborough Channel and Halkett Bay (Gambier Island). In August, large chinook are caught off Britannia Beach. Catches of large chinook have also been reported off Woodfibre and Port Mellon mills.(7) Winter sport fishing for chinook salmon occurs at the head of Howe Sound.(1)

ii) Non-Tidal

A large non-tidal sport fishery occurs on the streams of the Squamish system. As an example, sport catch of 300 chinook, and 600 coho were recorded in 1972, a particularly poor year.(1) Sport steelhead yields for Squamish River streams, including the Stawamus, Squamish, Mamquam, and Cheakamus Rivers and Ashlu Creek are shown below:

ESTIMATES* OF SQUAMISH RIVER (AND TRIBUTARIES) STEELHEAD HARVESTS(9)

Years	Days Fished	No. Anglers	Catch	Catch/day
1975-76	8,098	2,115	1,907	0.235
1974-75	9,594	1,987	1,695	0.176
1973-74	10,703	2,279	1,349	0.126
1972-73	10,703	2,508	1,553	0.145

* Steelhead figures are obtained by a postcard system and estimates made form reported figures.

TABLE II

Estimated Mean Annual Sport and Commercial Harvest of Salmon(4,8)

YEAR	CHINOOK	COHO	CHUM	PINK Even/Odd
1956-59	74,000	53,000	79,500	0/538,000
1960-64	57,000	76,000	32,000	0/2,240,000
1965-69	81,500	39,000	45,000	0/191,000
1970	124,000	94,000	107,500	0
1971	45,000	87,500	29,000	95,500
1972	37,000	24,000	318,000	3,000
1973	55,000	80,000	235,000	551,500
1974	37,000	398,000	140,500	0
1975	9,000	166,000	32,500	99,000
1966-75	55,000	99,500	107,925	600/199,700

* Equals estimated stock (Table I) less total escapement (Table III) and Indian Food Fish Harvest (Table VIII).

TABLE III

Mean Annual Escapement to Howe Sound Streams(4,5)

YEAR	CHINOOK	COHO	CHUM	PINK Even/Odd	STEELHEAD
1956-59	18,500	17,905	80,500	0/134,603	12,305
1960-64	14,200	25,900	35,800	0/560,705	13,400
1965-69	20,400	13,900	47,305	0/48,000	12,400
1970	31,000	32,000	112,200	0	8,200
1971	11,200	30,000	33,200	24,100	4,500
1972	9,500	8,500	320,100	750	22,600
1973	13,800	27,400	235,600	138,005	19,300
1974	9,300	133,600	142,600	0	26,300
1975	2,300	56,400	34,300	25,000	16,500

C. Escapement

In order to better relate the salmon spawning areas to the possible effects of the Port Mellon and Woodfibre pulp mills, Howe Sound salmon spawning streams were divided into four arbitrary areas (Figure 2); the Squamish-Stawamus system (Table IV), a mid-mill system, (McNab Creek, Table V), Port Mellon systems (Rainy River, McNair/Dakota Creek, Table VI), and Outer Howe Sound systems (Twin, Oulette, Mannion, Langdale, Williamson, West Bay and Long Bay Creeks, Table VII).

Howe Sound streams contain 46.5 linear miles of spawning grounds, 85% of which are found in the Squamish-Stawamus systems at the head of the Sound.(1,4) McNab Creek has 1.5 miles, the Port Mellon area streams have 1.5 miles and the outer Howe Sound streams have 4 linear miles of spawning grounds.

Timing of adult migrations to Howe Sound water systems depends upon the particular fish species, as shown in the following table and Figure 3 (Timing of Cheakamus River runs).

TIMING OF HOWE SOUND SALMON MIGRATIONS(4,5)

Species	Arrival In Streams	SPAWNING Begin	Peak	End
Chinook	mid-late June	mid-July	late Aug.	mid-Sept. - late Oct.
Coho	early Sept. - late Oct.	early Oct. - early Nov.	mid Oct. - late Nov.	early-mid Jan.
Pink	early Aug.	early Aug.	late Sept.	early-mid Oct.
Chum	early Nov.	mid-late Nov.	late Nov.	early Jan.

Seaward migrating juvenile salmon arrive in the estuaries in early spring depending upon environmental conditions (i.e. early freshet) and their residence time there varies according to the species.(10) Juvenile pink salmon leave the freshwater systems immediately after emergence in early spring and are out of the estuary by mid-April. Juvenile coho and chinook salmon spend up to one year in freshwater before migrating downstream to the marine environment. They are in the estuary from early April until mid-August, although chinook are at peak abundance in late June, and coho in late May and again in July. Chum salmon juveniles are present in the estuary from early April until July.(10)

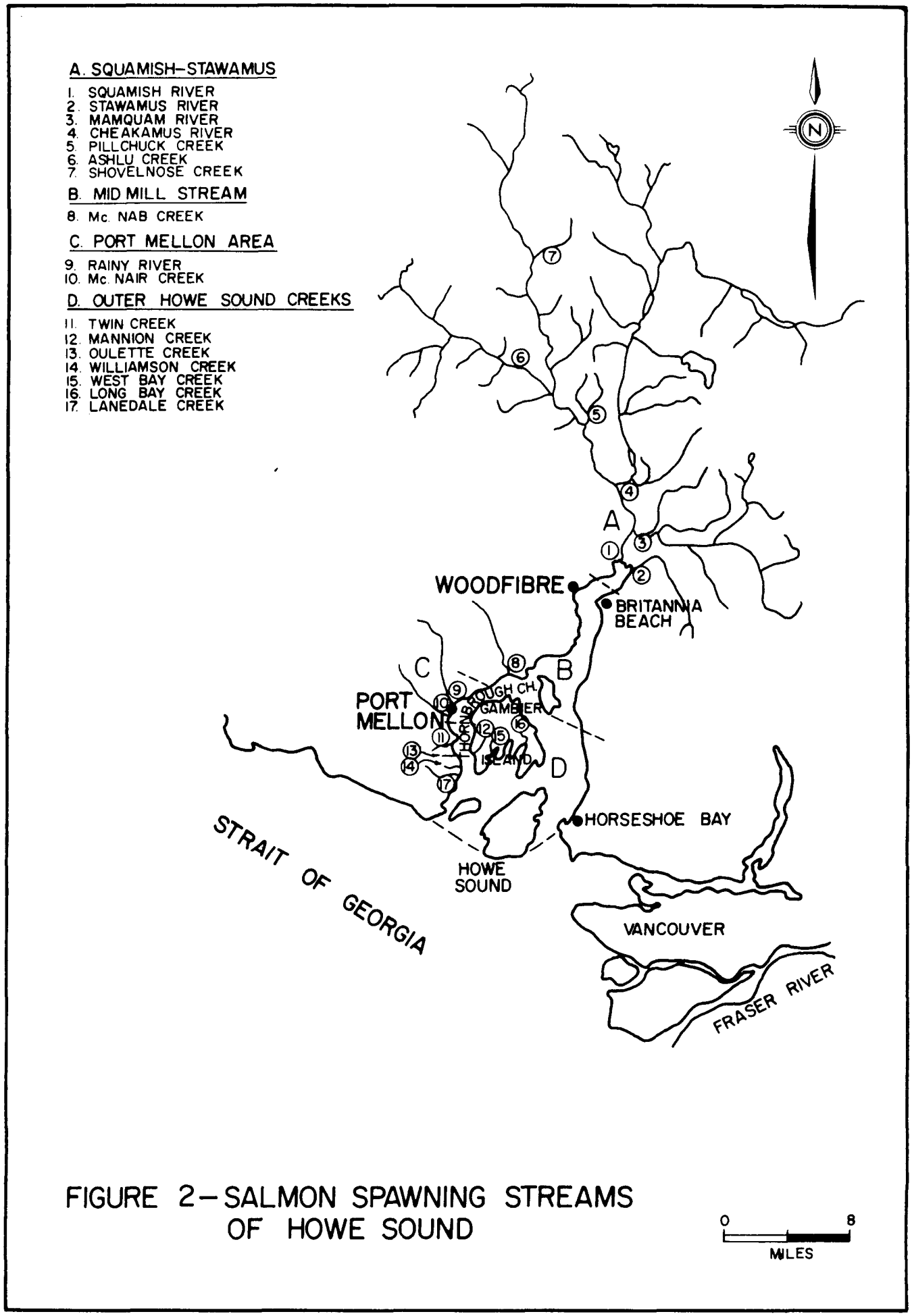

FIGURE 2–SALMON SPAWNING STREAMS OF HOWE SOUND

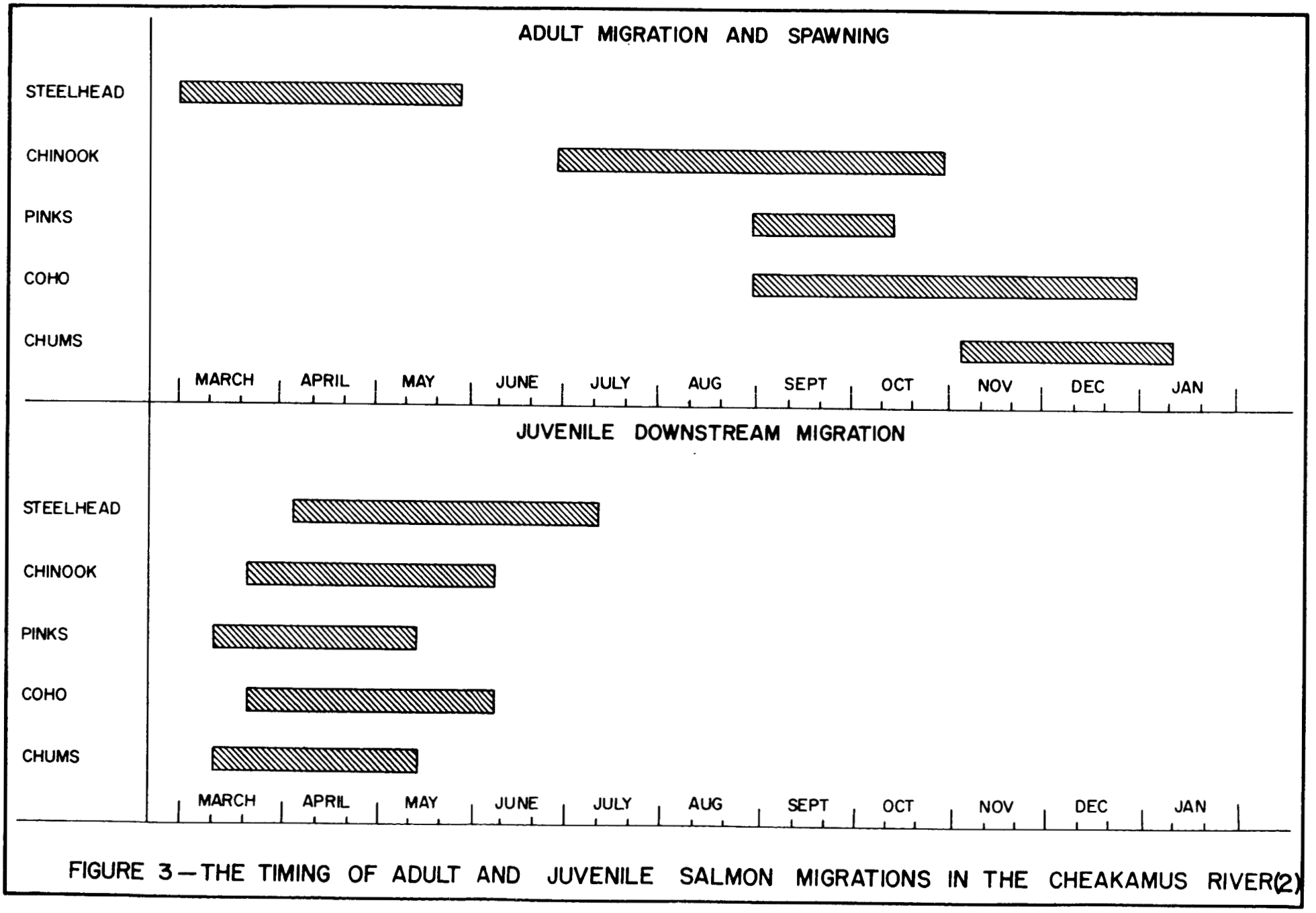

FIGURE 3—THE TIMING OF ADULT AND JUVENILE SALMON MIGRATIONS IN THE CHEAKAMUS RIVER(2)

TABLE IV

Mean Annual Escapements to the Squamish-Stawamus River Systems(4,5)

YEAR	CHINOOK	COHO	CHUM	PINK Even/Odd	STEELHEAD
1956-59	18,500	18,900	80,409	0/134,300	12,300
1960-64	14,200	26,000	34,600	0/560,600	13,400
1965-69	20,400	14,000	44,000	0/48,000	12,400
1970	31,000	31,800	100,700	0	8,200
1971	11,200	29,800	23,200	24,100	4,500
1972	9,500	8,400	308,000	700	22,500
1973	14,000	27,000	225,400	138,000	19,300
1974	9,500	133,500	139,700	0	26,300
1975	2,500	56,300	31,500	25,000	16,500

TABLE V

Mean Annual Escapements to McNab Creek(4,5)

1956-59	0	200	0/250
1960-64	0	125	0/25
1965-69	0	200	0/25
1970	200	600	0
1971	150	150	0
1972	UNK	UNK	0
1973	350	350	0
1974	75	400	0
1975	25	50	0

TABLE VI

Mean Annual Escapements to the Port Mellon Area(4,5)

Rainy River

YEARS	CHUM	COHO	PINK	STEELHEAD
NO RECORDS PRIOR TO 1971				
1971	25	25	N/O	N/O
1972	25	25	N/O	25
1973	25	25	25	25
1974	25	75	N/O	25
1975	25	75	N/O	25
1976	N/O	N/O	N/O	N/O

McNair/Dakota Creeks

NO RECORDS PRIOR TO 1971				
1971	N/O	N/O	N/O	N/O
1972	10	N/O	N/O	N/O
1973	10	N/O	N/O	N/O
1974	35	25	N/O	N/O
1975	UNK	UNK	N/O	N/O
1976	N/O	N/O	N/O	N/O

TABLE VII

Mean Annual Chum Escapements to Outer Howe Sound Streams(4,5)

YEARS	TWIN	OULETTE	MANNION	LANGDALE	WILLIAMSON	WEST BAY	LONG BAY
1965-69		850			N/O	350	1,000
1967-76	*	1,500	*	*	1,400	1,200	1,500
1970	N/O	4,000	200	200	1,500	1,500	3,000
1971	N/O	3,000	100	50	3,400	2,200	1,100
1972	200	3,000	250	150	4,000	2,400	2,200
1973	150	1,500	750	75	2,200	1,800	3,000
1974	25	25	25	25	75	1,500	200
1975	N/O	200	400	25	25	1,600	200
1976	N/O	N/O	125	N/O	100	300	1,500

N/O = None Observed

* = No records Prior to 1970

Squamish-Stawamus Systems

The Squamish-Stawamus River systems produce 100% of the chinook, 99.8% of the coho, 95.8% of the chum, and almost 100% of the pink escapements to Howe Sound (Tables III, IV). If necessary, adults coming to this area could bypass the highest concentrations of effluent from the two mills by migrating along the eastern edge of the sound or by moving in the deeper waters beneath the effluent. The largest impact on the salmon stocks in this area is probably related to developments on the estuary itself (i.e. landfilling, dredging, dumping of industrial and municipal effluents, and storing log booms.)(10,11)

Primary production in marshlands and intertidal areas is very important to salmonid juveniles; benthic algae and sedges (grass-like plants) provide food (detritus or algae) for amphipods and other benthic invertebrates which are then preyed upon by fish. Of the 1,200 acres of the delta of the Squamish River, nearly 100 acres have been lost due to land filling and dyke construction.(10) Storing logs in Mamquam Channel has led to the accumulation of wood/debris causing physical "smothering" of benthic organisms and reductions in species diversity.(10)

Logging of the upper watersheds of the Squamish River system has resulted in flooding and the subsequent destruction of redds. This probably had an adverse influence on salmonid production in recent years. In 1973, floods destroyed 30 to 50% of coho and chum salmon spawn and up to 25% of pink and chinook salmon spawn.(7) In 1975, immense damage to pink and chinook spawning grounds resulted in losses of 80% of the salmon eggs.(7)

Systems between Port Mellon and Woodfibre

McNab Creek, located between the Woodfibre and Port Mellon pulp mills, has produced up to 600 chum (1970) and 350 coho (1973) (Table V). This creek has had diminishing stocks of pink salmon with none being recorded since 1969.(4,5) Adult salmon returning to this stream could, if necessary, avoid the worst concentrations of pulp mill effluent by migrating up the east side of Howe Sound and then through Ramillies Channel. There is, however, no evidence to suggest that the migrating salmon need to avoid the effluent. The mouth of McNab Creek is used for log storage. Such activity could have an adverse effect on salmon rearing.

Systems in the Port Mellon Area

Streams in the vicinity of Port Mellon produce only minor numbers of fish: 75 coho, 25 chum, 25 pink and 25 steelhead in 1974. These originate mainly from the Rainy River. (4,5) Adult and juvenile salmon may pass through high concentrations of effluent when arriving at or leaving waters adjacent to the Port Mellon pulp mill. The area around the mouths of Rainy River and McNair/Dakota Creek are used for log booming, which may have an effect on the rearing juvenile salmonids.

Historically the Rainy River was the most productive river in the Port Mellon Area. Records for 1924 to 1946, indicate that 7,000 chum and an equal number of odd-year pink salmon as well as 200 steelhead trout were common escapement to that stream.(4) In 1946 runs began falling off, presumably because houses for Port Mellon employees were being built on the banks of the river.(4) In 1954 the mill constructed a diversion dam and fishway, 3/4 of a mile upstream of the mouth. The Rainy River was not listed as a salmon spawning stream from 1947 to 1970. However, recent records (1971-1975) show some low returns of fish: 25-75 coho, 25 chum, 25 steelhead and a few odd-year pink salmon to the river. Only coho and steelhead have been reported above the dam where good spawning gravels are located. Below the dam where chum and pink salmon spawn poor spawning gravels are reported.(4) Recent observations have indicated that with adequate fish passage facilities fish stocks could be improved.(4)

Outer Howe Sound systems

Outer Howe Sound streams only produce chum salmon. The average annual total escapement to these streams has been 5,600 fish from 1967 to 1976. The mouths of all streams in the area are used as log booming or storage grounds which may have some adverse effect on juvenile salmon.(11)

D. Indian Food Fishery

Approximately 20 Indian families participate in the Howe Sound Indian food fishery. Fish are usually harvested using set nets in the Squamish River.(1) The harvest consists mainly of coho, chum and odd-year pink salmon with coho and chum being of greatest importance (Table VIII). Chinook harvests are low, although they have increased over the years. Harvests of other species such as steelhead and Dolly Varden char have fluctuated.(1)

III HERRING

Herring spawning takes place in Howe Sound (Figure 4)

TABLE VIII

Mean Annual Salmon Harvest by the Howe Sound Indian Food Fishery[7]

YEAR	DOLLY VARDEN	CHINOOK	COHO	CHUM	PINK Even/Odd	STEELHEAD
1956-59	UNK	27	513	1,163	0/400	18
1960-64	UNK	170	2,100	2,860	0/3,000	28
1965-69	50	99	2,620	2,160	0/933	12
1970	UNK	125	2,200	4,800	0	0
1971	UNK	250	2,500	4,500	1,100	0
1972	UNK	547	1,379	2,112	0	3
1973	UNK	500	2,100	900	700	200
1974	UNK	360	2,870	2,250	0	25
1975	UNK	500	3,050	2,000	1,300	0
1966-75		258	2,360	2,606	0/880	28

UNK = Unknown

TABLE IX

Howe Sound Herring Catch, Spawners, Stock and Statute Miles of Spawn[12,13,14]

YEAR	CATCH	SPAWNERS	TOTAL STOCK	MILES OF SPAWN
	(Millions of Pieces)			
1956-59	<0.001	0.70	0.70	0.58
1960-64	0.20	27.7	27.90	2.61
1965-69	0.15	1.60	1.75	.56
1970	0.03	0.72	0.75	0
1971	0	UNK	UNK	.81
1972	0	0	0	0
1973	0	0	0	0
1974	0	UNK	UNK	.45
1975	0	0	0	0

* Catch calculated from commercial statistics (3) assuming 3,480 fish/ton.(14)

UNK = Unknown

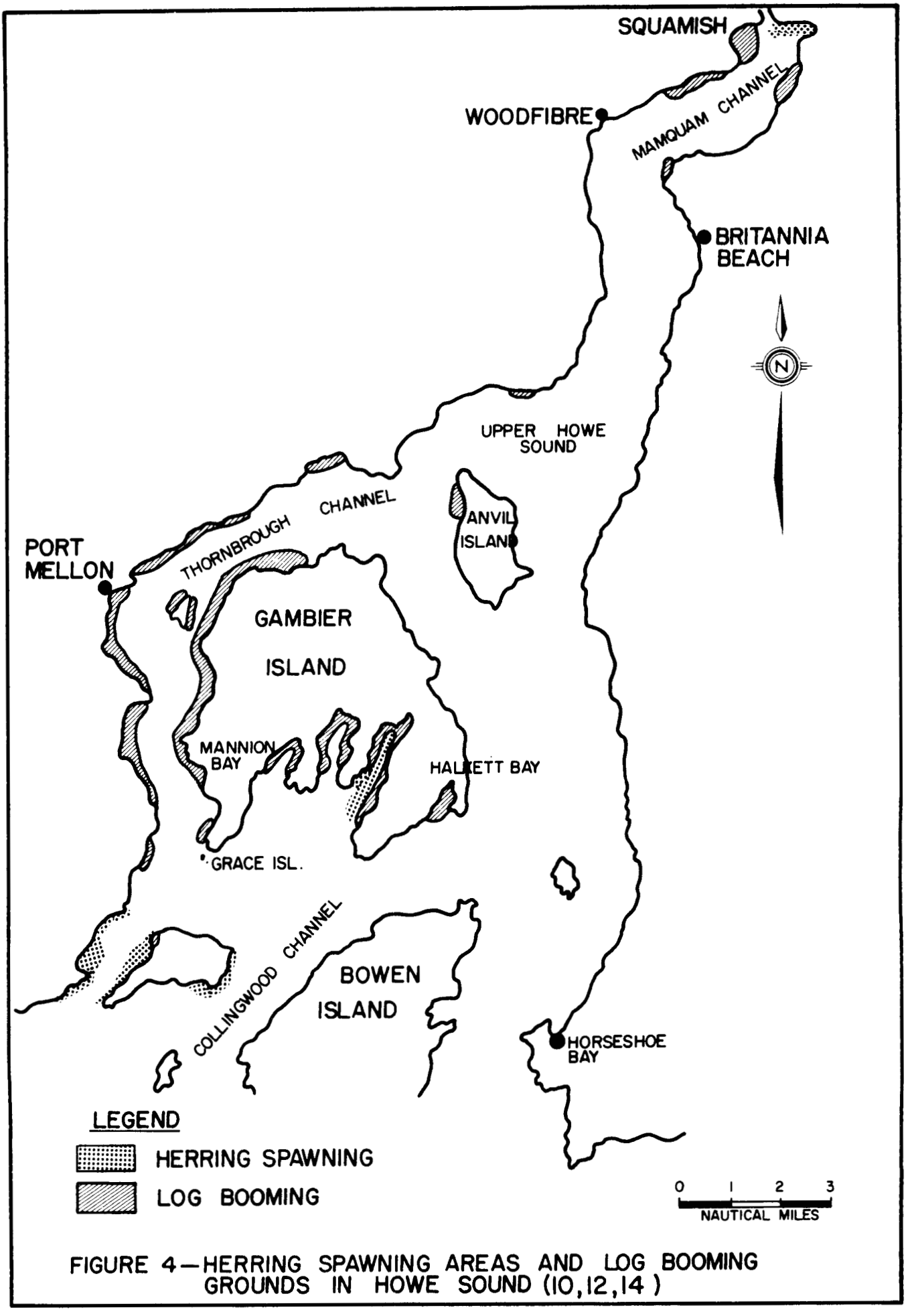

FIGURE 4—HERRING SPAWNING AREAS AND LOG BOOMING GROUNDS IN HOWE SOUND (10,12,14)

in mid-March. Egg deposition normally occurs within the shallow intertidal area where the eggs adhere to kelp, rockweed, eelgrass, rocks and other stable substrate. However, spawning has also been noted (to 1962) not only in eelgrass near Mamquam channel but also on creosoted dock pilings where vegetation was scarce (high mortality of eggs occurred on the creosoted pilings).(2) Historical herring spawning areas in Mamquam channel have been lost due to landfilling and log storage which resulted in displacement of spawning substrate.(2) Despite catches of all age groups and observations of large juvenile stocks in the Mamquam Channel area in 1969 no spawning occurred at this location.(2,10)

A commercial gillnet, herring fishery was conducted at the head of Howe Sound during the 1960's(1). Since a ban on harvesting herring for reduction purposes was in effect in the late 1960's and early 1970's, catch statistics for this period, reflects the bait, food, and roe fishery.(2) A small sport fishery is also conducted by jigging at the head of Howe Sound.(1)

Howe Sound herring stocks have been adversely affected by industrial development. Such development will eventually render the area unfit as a herring spawning area.(1) Herring kills have been observed on occassions when large numbers of herring are at the head of Howe Sound.(15) These mortalities may be due to low dissolved oxygen levels or by hydrogen sulphide evolving from wood debris on the bottom of Mamquam Channel.(10) Other herring kills were reported in 1968 and 1969 in the vicinity of Britannia Beach, but the cause was not discovered(1).

IV GROUNDFISH

Since 1970, upper Howe Sound (Figure 2) has been closed to commercial groundfish fisheries due to mercury contamination from the FMC chlor-alkali plant.(1) Most groundfish are now taken outside Howe Sound, although the occasional dragger works in the lower Sound.(16) The mean annual commercial catch is indicated in Table X.

V CRUSTACEANS

Since 1970, upper Howe Sound has also been closed to commercial shellfish harvesting due to mercury contamination.(1) Large populations of shrimp were reportedly fished in upper Howe Sound prior to the 1970 closure (Table XI).(10) Populations of shrimp are known off Grace and Gambier Islands, although they are not exploited.(10) Most shrimp fishing now occurs outside the Sound.(16)

TABLE X

Mean Annual Commercial Harvest of Groundfish and Other Non-Salmon Species (CWT) in Area 28, Including Howe Sound(3)

YEAR	FLOUNDER & SOLE	COD	SMELT	DOGFISH	NON-FOOD & OTHER FISH
1956-59	9.5	28.5	3.0	0	8.1
1960-64	.4	61.4	19.0	0	30.2
1965-69	14.6	14.0	40.6	38.2	4.0
1970	0	0	63	<.5	2
1971	0	2	0	0	2
1972	0	0	0	0	15
1973	0	10	0	1,740	<5
1974	0	0	0	170	10
1975	0	0	0	0	<5

TABLE XI

Mean Annual Commercial Harvest of Crustaceans, Shellfish and Molluscs (CWT) in Area 28, Including Howe Sound(3)

YEAR	SHRIMP & PRAWN	CRABS	C L A M S NATIVE LITTLENECK	BUTTER
1956-59	3,809	1,092	72.8	22.0
1960-64	2,356	1.092	2.6	.4
1965-69	2,136	738	0	0
1970	1,420	278	0	0
1971	1,109	273	0	0
1972	1,471	157	0	0
1973	1,450	330	0	0
1974	1,070	570	0	0
1975	1,090	1,670	0	0

Populations of crabs are relatively large, but not sufficient to support a commercial fishery (10,16). Commercial crab harvesting occurs outside Howe Sound and recreational prawn and crab fishing occurs near the entrance to the Sound.(10)

VI MOLLUSCS

There have not been any mollusc fisheries in Howe Sound since 1960. The harvest statistics (Table XI) are mainly for areas outside Howe Sound.(1) Oysters on Gambier Island have high levels of zinc and copper which are thought to have originated from Britannia mine.(10) The area of the mainland northwest of Gambier Island is an important oyster zone, while to the south of this is an area with commercially harvestable clams.(10)

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sending composite effluent samples on a regular basis to the E.P.S. bioassay laboratory in Vancouver for toxicity testing. The results of these tests appear in Table 5. Federal and Provincial toxicity requirements are given in the table for reference. The program of toxicity testing was terminated by E.P.S. in December, 1977.

3.2.3 Pollution Abatement Program. Canfor is currently engaged in an effluent control program based on requirements of their PCB effluent discharge permit and taking into account the Federal Governments concern with Kraft mill effluent. The program, largely involving the installation of in-plant pollution abatement facilities, is outlined by Oei and Wasik (1976). The main objectives of the program are to significantly reduce the loss of suspended solids to 21 lb/ADT by 1980 and to reduce the release of sulphides, mercaptans, and other toxic components of KME by controlling black liquor spills. In-plant works authorized in the PCB permit are to be completed and in operation by January, 1979 at which time Canfor expects to meet the PCB permit requirements in all effluent characteristics.

The company's effluent control program also proposes the installation of a submerged outfall diffuser system to carry combined acid, alkaline, and sanitary effluents. As stipulated in their discharge permit this system is to be completed and in operation by January, 1980. The company intends to delay installation of the diffuser outfall until completion of the in-plant facilities to ensure a reduction in suspended solids before the diffuser goes on the line to avoid plugging or burial of the diffuser pipe. The delayed installation would also allow the company to consider new effluent characteristics in the diffuser design.

TABLE 5 BIOASSAY RESULTS, CANADIAN FOREST PRODUCTS LTD., HOWE SOUND PULP DIVISION

Sample Date	% Survival Over 96 Hours, Static Testing Concentration (% V/V) Effluent						Sample pH
	100	65	45	32	12.5	5.6	
December 10, 1975	0	0	0	0	100	100	10.7
February 11, 1976	87	100	100	100	100	100	9.3
March 31, 1976	0	0	0	40	100	100	10.4
June 10, 1976	0	0	0	0	100	100	7.8
December 9, 1976	0	0	0	100	100	100	7.8
	100	65	42	30	24	18	
February 2, 1977	0	0	0	60	100	100	7.4
March 30, 1977	0	0	20	80	100	80	10.0
June 8, 1977	0	0	0	0	50	70	7.3
August 3, 1977	100	100	100	100	100	100	7.3
October 12, 1977	0	0	0	0	40	100	7.6
December 7, 1977	0	0	60	100	100	100	7.5

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

PCB Bioassay Requirement -50% survival in 12.5% (V/V) effluent concentration over 96 hours, static testing.

4 RECEIVING ENVIRONMENT

4.1 Oceanography

Oceanographic investigations in Howe Sound have extended over many years. In the late 1950's and the 1960's the area was monitored almost on an annual basis (Waldichuk, et al, 1968) in view of the heavy industrialization in the Sound. More recently, current measurements and other oceanographic observations have been reported by Bell (1973, 1974) and currents in surface waters of upper Howe Sound by Pond (1973) and in the Port Mellon area by Landry (1976). A detailed review of oceanographic data for Howe Sound is presented in Environment Canada's Special Estuary Series (Hoos and Vold, 1975).

Howe Sound essentially contains two aquatic systems as a result of the relatively shallow threshold sill (61 metres) near the northeast end of Anvil Island (Figure 1). The area behind the sill, known as the upper basin or upper Howe Sound, is a true fjord reaching a maximum depth of about 290 metres and forms an estuarine system due to the influence of the Squamish River. The sill inhibits the regular flushing of the deep waters in the upper basin. The lower basin (south of the sill) more closely represents a true Sound, being characterized by a broad body of water with scattered islands. The lower basin has a maximum depth of approximately 250 metres and empties directly into the Strait of Georgia. Howe Sound has a net seaward flow of low salinity surface water and a net inland flow of sub-surface oceanic water.

Oceanographic data collected in Port Mellon area by the Pacific Environment Institute, Vancouver, B.C., between 1971 and 1976 is summarized in Pedlow (1974). Seasonal variations in the degree of temperature and salinity stratification were noted in the area. During spring and summer months stratification can be quite pronounced due to freshwater run-off entering the system, however, in late fall and winter

stratification becomes less evident. Near the pulp mill outfalls at Port Mellon surface salinity can be low and effluent concentrations high in the upper 0.5 to 1.0 metres of water, particularly during freshet and quiescent wind conditions. The high effluent concentrations are sometimes associated with altered pH, elevated temperature and high fibre content in surface waters adjacent to the outfall. Discolored water has been noted 0.5 to 1.5 km to the south of the pulp mill and mixed deeper (2-3 metres) in the water column.

As a result of Canfors proposal to install a diffuser outfall system a co-operative water movement study was conducted in the Port Mellon area by the Ocean and Aquatic Sciences Group, Patricia Bay, B.C. and the Pacific Environment Institute. Water movements were studied utilizing drift drogues tracked by radar over a 72 hour period in September, 1974. Results of this study as reported by Landry (1976) indicated a complex system in the upper 1 metre of water off the mill with water movement being influenced by wind, tide, and other factors as yet undescribed. Surface water movement off the mill dock was generally more rapid than in the small bay to the south of the mill into which flows the alkaline mill effluent. There was a net transport of effluent out of the mill area with the slowest dispersion in the less-well flushed bay to the south.

Based on the drogue study Davis (1975) suggests discharging mill effluent as far as possible out into Thornbrough Channel to optimize dispersion. Two possible diffuser locations were offered for consideration; a) extending from the mill dock in an easterly direction or b) due east of the small groin on the south shore of the Rainy River mouth. Canfor is presently investigating the engineering aspects of diffuser placement.

4.2 Impact Studies

4.2.1 Canadian Forest Products Ltd. Monitoring Program. As stipulated in their Provincial effluent discharge permit Canfor is required to carry out a receiving water monitoring program to determine the effects of its effluent discharges on the receiving environment. The program authorized by PCB was to be similar to the monitoring outline prepared by Beak Consultants Ltd. (Beak, 1975) for the company and included qualitative intertidal studies, periphyton and zooplankton determinations, fish bioassays and sediment analyses. The results of the program, which started in 1977, are to be summarized and submitted to the PCB annually.

4.2.2 Shoreline Studies. Studies by Hardon (1970) and Nassichuk (1972) revealed severely depressed intertidal communities in the vicinity of the pulp mill and an absence of life in the small bay to the south of the mill. The natural substrate south of the mill is covered by fibre and lime mud which was historically discharged through the alkaline sewer. Werner and Hyslop (1968) described an oval bed of gasiferous (H_2S) sediment extending southeast of the alkaline outfall. In contrast, the area north of the pulp mill, which is shielded from the influence of effluent by the freshwater inflow from the Rainy River, showed normal populations.

Although marine disposal of lime mud was terminated several years ago the effects of smothering and burial persist as reported by Levings and McDaniel (1976). After reviewing data from several field studies these authors concluded that the zone of influence of the pulp mill, as documented by degraded shoreline biota, extends 1 to 2 km south of the mill outfalls.

4.2.3 Benthic Studies. Chang and Levings (1976) studied the effects of ocean dumping on benthic invertebrates by subjecting several invertebrate species common to Howe Sound to a variety of substrate types. One

of the substrates tested was sediment composed of fine fibrous material with strong H_2S odor collected near an effluent outfall at Port Mellon. This sediment was avoided by most individuals of all species tested even though its physical characteristics allowed burrowing by these species. The Port Mellon sample was typical of many pulp mill sediments with high organic matter content (wood fibres) which produce H_2S gas and deplete oxygen as a result of bacterial decomposition. Some substrate types tended to attract certain animals, for instance mobile epifauna were attracted to hard surfaces such as rocks and large wood debris.

These findings were substantiated by observations made in Thornbrough Channel from the Pisces IV Submersible. The submersible studies were conducted by EPS, Pacific Region, in August, 1976. Three transects, (464, 465, and 466) run off McNab Creek, Dakota Creek and Woolridge Island respectively (station locations shown on Figure 3) indicated the importance of substrate type in structuring bottom communities. Mobile invertebrates such as shrimp, prawns, and squat lobsters, commonly observed in areas characterized by logs, bark, and rocks, were noticeably scarce in areas with a soft, muddy substrate (see Appendix I for submersible observations).

The impact of Canfor pulp mill effluent on deep benthic organisms appears to be largely confined to the gasiferous beds of fibrous material adjacent to the outfalls. Although the effects of log handling and storage activities may not be as obvious the impact can be substantial in terms of the amount of wood debris and the extensive area affected (McDaniel, 1973).

4.2.4 Effluent Toxicity and Sublethal Effects. Pedlow (1974) studied the effects of BKME on the growth and physiology of Pacific oysters transplanted to the Port Mellon area. Oysters placed in a cage 200 metres from the alkaline outfall all died within a year and were heavily fouled with fibre and lime mud. These oysters showed little or

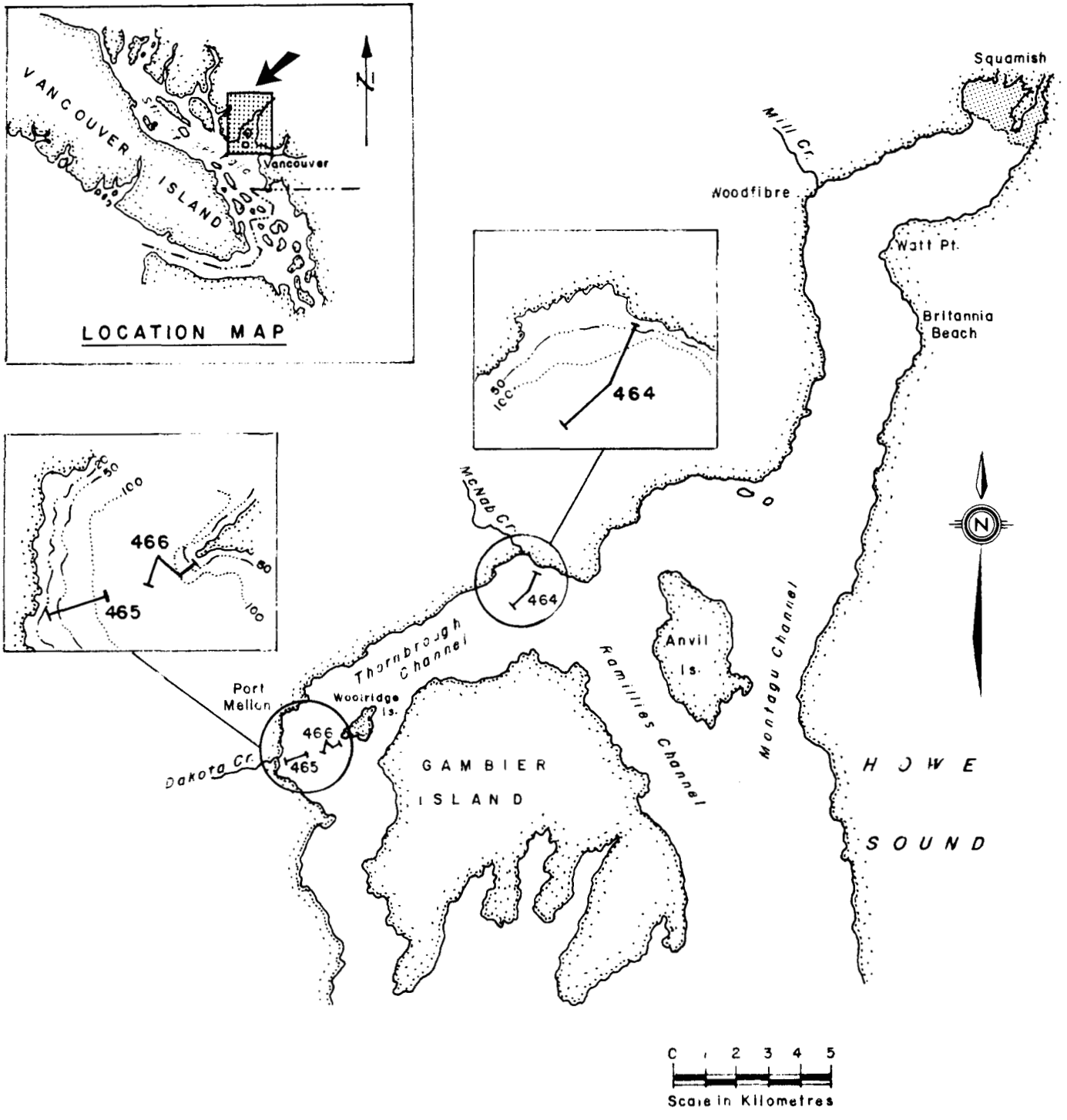

FIGURE 3 SUBMERSIBLE DIVE LOCATIONS (AUGUST 1976)

no growth, thin and brittle shells, poor condition factor (plumpness), discoloured watery meat and weak adductor muscles compared to apparently healthy oysters placed about 1.6 km south of the outfall. Along the series of cage positions oyster condition deteriorated and mortality increased as the mill was approached. Results of this study suggest a zone of influence extending to a point between 0.5 and 0.8 km south of the mill.

Acute toxicity testing and sublethal effects studies with salmon have been carried out using effluent from the Port Mellon mill since 1971 (Davis, 1973 , Davis and Mason, 1973). These studies have generally shown the effluent to be toxic (96 hour LC_{50}) to fish at a concentration of 50-60% full strength of neutralized, aerated full-bleached effluent. The toxicity measurements varied between a 96 hour LC_{50} of 20% full strength to non-toxic. Davis (1976) summarized the data of various workers on the incipient sublethal response threshold concentrations for salmonids to three types of kraft mill effluent. He suggests that for neutralized whole bleached effluent a number of sub-lethal effects will be present at a discharge dilution of 0.1 of the LC_{50}, a few at 0.05 LC_{50}, and only rarely at 0.02 LC_{50}. Based on current knowledge, Davis recommended that the Port Mellon diffuser design achieve a dilution equivalent to at least 0.05 LC_{50} and that a 50 to 1 dilution would minimize most known sublethal effects on salmon.

Studies by Greer (1976) and Birtwell (1976) demonstrated an avoidance reaction by juvenile chinook and chum salmon to surface waters (1.5 m) in the vicinity of the Port Mellon mill. Juvenile salmon typically school upon entering estuaries and show a preference for near-surface and near-shore zones. Therefore, any factors disrupting this behaviour may be detrimental to the normal functions of the salmon. However, in the case of Port Mellon where effluent outfalls are located at, or just below tide level, the avoidance reaction may favour the survival of the salmon by enabling them to detect and avoid contaminated

waters. The survival value of the avoidance reaction will be dependent on the suitability of the alternative habitat utilized by the displaced fish. The authors point out limitations in interpretation due to the possible complex interaction between KME and other water quality variables in determining fish behaviour.

4.2.5 Phytoplankton Productivity. Stockner et al (1975) examined the relationship between BKME and phytoplankton production in waters adjacent to Woodfibre and the Port Mellon pulp mills in Howe Sound. Primary production near the Port Mellon Mill was about 90% lower than at the control site located 2 km from the mill. However, the effect of Woodfibre and Port Mellon discharges on the total Howe Sound production was calculated to be only 2 to 4%. The strong light attenuating properties of KME, as opposed to toxic substances in the effluent, were shown to be the major cause of reduced primary production. Stockner's data showed a similarity in density and species composition of phytoplankton populations between pulp mill and control stations. On this basis the author postulated that as the phytoplankton encounter effluent and reduced light conditions, they become metabolically inactive and remain quiescent until light conditions improve.

This concept was substantiated by a later study (Stockner and Costella, 1976) which suggested that growth inhibition (toxicity) by substances in the effluent only occurred at effluent concentrations greater than 20% and that nutrients in the effluent could in fact result in growth enhancement in regions of low effluent concentrations and good light conditions. The study also demonstrated that good water circulation and well flushed conditions are the most important physical factors reducing the impact of KME on coastal waters. The production near the Woodfibre mill which is located in a more actively flushed area under direct influence of the Squamish River was only 22% less than the corresponding control site.

5 NATURAL RESOURCES

5.1 Fisheries Resource

A detailed discussion of fishery resources in Fisheries and Marine Service (F.M.S.) Statistical Area 28 (encompassing Howe Sound) has been prepared by F.M.S. (Knapp and Cairns 1978, F.M.S. Internal Report) and is presented in Appendix III. The following will be a brief summary of this information.

Howe Sound river systems contain steelhead trout, dolly vardon, char and four species of Pacific Salmon, i.e., pink, chum, coho and chinook. The salmon originate mainly from the Squamish-Stawamus river system at the head of the Sound. Stocks of Howe Sound pink and chum salmon are harvested by net fisheries in the Strait of Georgia, Johnstone Strait, and Juan de Fuca Strait. Coho and chinook are caught commercially and by sport fishermen in the tidal waters outside Howe Sound and also provide a good sport fishery within the Sound. In 1969 Howe Sound was closed to commercial fishing to preserve stocks.

A few coho, chum, pink salmon and a few steelhead trout are found in the vicinity of Port Mellon. These are mainly from the Rainy River with a limited number from McNair and Dakota creeks. Prior to 1946, several thousand chum and pink salmon reportedly utilized the Rainy River. To provide process water to the pulp mill a diversion dam and fishway was constructed on the Rainy River in 1954. Large stockpiles of gravel are reported above the dam, while below the dam, where the chum and pink spawn, there are poor spawning grounds. Recent records for the Rainy River (1971-1975) show low returns of salmonids; 25-75 coho, 25 chum, a few odd-year pink and 25 steelhead. Adult and juvenile salmon may pass through high concentrations of effluent when arriving at or leaving waters adjacent to the pulp mill and rearing juvenile salmonids may be influenced by log handling activities near the mouths of spawning streams.

5.2 Migratory Bird Resource

Howe Sound is generally recognized as a valuable habitat for migratory waterbirds throughout the year. The Squamish estuary is located between two important waterfowl areas, the Fraser delta and the Pemberton valley, and as such is a stop over for birds migrating between these areas. In addition to wintering and migratory habitat, Howe Sound sustains several breeding bird colonies. During most of the wintering and migration period, waterbirds can be found scattered along the shoreline with the largest concentration, numbering several thousand individuals of over 60 species, being found on the Squamish estuary. Smaller estuaries at the mouths of most creeks entering the Sound provide valuable habitat for dabbling ducks and other water-related birds. Thornbrough Channel into which Canfor discharges its effluent is known to support large numbers of wintering diving ducks. For additional information on migratory bird resources provided by the Canadian Wildlife Service (Trethewey, 1977, pers. com.) refer to Appendix II.

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APPENDIX I

SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV

a) Howe Sound - August 26, 1976 (Dive 464)
b) Howe Sound - August 26, 1976 (Dive 465)
c) Howe Sound - August 27, 1976 (Dive 466)

APPENDIX I (a) SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV
Howe Sound - August 26, 1976

DIVE : 464
LOCATION : Thornbrough Channel, off McNab Creek
OBSERVER : H. Nelson
PILOT : F. Chambers

POSITION :	Submerge	Surface
	49°32.88 N	49°33.55 N
	123°23.28 W	123°22.52 W
Turn :	49°33.12 N	
	123°22.80 W	

DURATION : 3.2 hours
TIME : 0915 hours
70 mm Series : 259-323
16 mm Rolls : #22, 23, and 24 (focus at 6', 2 light sources)
DEPTH : 230 m

OBSERVATIONS :
Good surface visibility. On descent, large inert particles with a few plankters.
100 m - the number of large particles decreased, number of zooplankters increased. Visibility good.
200 m - many pelagic amphipods, several Ctenophores and a few fish approx. 2" long. Visibility decreasing.
230 m - on the bottom visibility 12'. Substrate a skiff of brown sediment over fine grey sediment.
Moving over the mud, bottom, animals observed were: several shrimp (Spirontocaris sp. and sidestripes, Pandolopsis dispar.)

- a few large anemones (football) and metridium sp.
- several eel pouts.
- large Gastropods.
- a few orange starfish (Pseudarcaster sp.).
- many large sidestripes and squat lobsters (Munida sp.)

- single spider crab, single Cancer magister
- single rock fish (red snapper), single skate
- few sculpins, pelagic shrimp
- few brittle stars
- At 1030 hours the bottom life had not changed appreciably. No flounders or sole have been observed.
- at 1035 hours more wood, bark, and leaves cover the bottom.
- the number of Munida sp. increase proportionately to amount of wood debris on botton.
- END 16 mm roll 22.
- BEGIN 16 mm roll 23 - 1050 hours.
- at frame 520 focus changed to 4' continue to end of roll 23.
- a few flounder and sole have been seen.
- Chiridota laevis
- large brittle stars
- single octopus, single Squalus sp., single hake

190 m - another substrate change to sand, boulders, and leaves
- several prawns
- at frame 645 of roll 23 (16mm) 2 extra light source were put on.
- very abundant Munida sp.
- END 16 mm roll 23 - 1140 hours

100 m - BEGIN 16 mm roll 24 (back to 6' focus)
- ling cod, C. magister
- passed over a ridge of fine sediment, presumably originating from McNab Creek

700 m - begin moving up cliff face, visibility good, approx. 30'
- many sponge; C. magister, anemones, tube worms, clam shells, starfish in clear sphere (identification unknown).
- END 16 mm roll 24.

SUMMARY

Three substrate types encountered, each with a corresponding change in benthic communities, both qualitative, and quantitative as noted. Habitat very important in structuring bottom communities.

APPENDIX I (b) SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV
Howe Sound - August 26, 1976

DIVE : 465
LOCATION : Thornbrough Channel off Hillside Gravel Plant
OBSERVER : H. Nelson
PILOT : F. Chambers

POSITION :	Submerge	Surface
	49°30.35 N	49°30.21 N
	123°28.82 W	123°29.47 W

DURATION : 2.7 hours
TIME : 1525 hours
70 mm Series : 323-377
16 mm Rolls : #25, 26, 27, 28 (focus 6')
DEPTH : 220 m

OBSERVATIONS :
Surface visibility fair.
Descending, large inert particles (white) in suspension
100 m - siphonophores, amphipods, ctenophores, cumaceans, megalops
150 m - inert particles smaller, pelagic shrimp, large lobed ctenophores, small fish
220 m - Botton - soft substrate, mud. Visibility 12'
- many zooplankters, mainly copepods.
- several sea pens (sea whip), eel pouts, burrowing anemones.
- Spirontocaris sp., Munida sp., several prawns, large gastropods (Neptunia sp.) on logs
- single red snapper, single Tanner crab
- END 16 mm roll 25
- BEGIN 16 mm roll 26

145 m - moving towards Hillside Gravel Plant
- encountering wood debris, logs and bark
- increasing numbers of prawns, Metridium sp., Munida sp. (very abundant and large), snails

- single red snapper
- END 16 mm roll 26

50 m - BEGIN 16 mm roll 27 - logs and Metridium sp.
- BEGIN 16 mm roll 28 - moving out from under log booms and heading south off bottom

125 m - back on bottom, usual benthos, single octopus, few Ctenodiscus sp.
- begin ascent
- END 16 mm roll 28

SUMMARY

Benthic communities in this area were quite similar to those encountered off McNab Creek (dive #464). However, no flounder or sole were seen and prawns were present in greater numbers. The Munida sp. off Hillside, present in large numbers around the wood debris, seemed to be larger. Very large Metridium sp. on the logs.

APPENDIX I (c) SUBMERSIBLE DIVING OBSERVATIONS - PISCES IV
Howe Sound - August 27, 1976

DIVE : 466
LOCATION : Thornbrough Channel, Centre Channel east to Woolridge Island
OBSERVER : D. Goyette
PILOT : F. Chambers

POSITION :	Submerge	Surface
	49°30.40 N	
	123°28.45 W	
Turn :	49°30.60 N	
	123°28.36 W	
Turn :	49°30.58 N	49°30.55 N
	123°28.10 W	123°27.95 W

DURATION : 3.0 hours
TIME : 0920 hours
70 mm Series : 378-455 (Roll #2)
16 mm Rolls : #29 - 32
DEPTH : 225 m

OBSERVATIONS :
Surface layer of freshwater to 10 m.
Visibility - clear
Few amphipods appearing to 50 m.
Larval fish at 75 m.
Few ctenophores, zooplankton not very abundant, some detritus.
Increasing numbers of zooplankton below 75 m - largely amphipods, siphonophores, and occasional ctenophores, no euphausids.
Large ctenophores (Bolinopsis sp.) appearing at 100 m. These normally seen at this depth.
125 m - increasing number of various jellyfish, no euphausids observed (similar to previous dives)
210 m - lantern fish common
- larger concentration of copepods

225 m - on the bottom, visibility approximately 12 feet
- sediment - light brown on the surface
- light grey colour in disturbed areas

Munida very abundant, Mediaster sp., shrimp (pandalid), Colus sp. - common.

Few sidestripe, burrowing anemones - abundant, occasional sea whip.

Colus sp. very abundant along logs.

Bottom - relatively free of wood debris, only occasional log and cedar bark.

Munida sp. very abundant around wood debris.

A number of red snappers was observed by pilot.

Few eelpouts.

Roll 29 changed at 225 m.

Slope increasing at 225 m - base of cliff - numbers of burrowing anemones increased, increase in bark and wood deposits, large amount of sponge debris at base of cliff.

First 80 feet of roll 30 taken at the base of cliff.

Munida sp. anemones very numerous.

Large white anemones concentrated along logs (filmed).

200 m - light film of sediment over rocks, considerably less than Howe Sound area
- large numbers of "horn" sponges growing on rock face, cloud sponge also present.

185 m - continued along cliff
- "horn" sponge very abundant, many Munida sp. inside and around clusters of sponges.

16 mm footage of small starfish taken at 50 m.

Occasionally Munida sp. seen swimming away from rock face.

Cliff face also covered with numerous brachiopods and a small white, either solitary coral or anemone.

Ascended to 130 m and again ran parallel to cliff. Roll 31 - largely filmed at a depth of 130 m.

Roll 32 taken at 125 m - heading south along rock face
- Munida sp. and sponges - still very numerous
- footage of small rockfish taken at 110 m

60 m - numerous sponges, occasional glass sponge (tubular)
- occasional - yellow banded rockfish, few prawns (not as numerous as dive 465), cloud sponge - abundant
- latter portion of roll 32 taken at 10 m - using extra lites

Roll 33 - taken between 5 and 10 m

SUMMARY

Bottom conditions were basically similar to dive 465 with the exception of less wood debris inshore. Fewer fish were observed than in upper Howe Sound dives. Shrimp were not as abundant as observed in upper Howe Sound. Most abundant animals in deeper areas were Colus sp., Munida sp., and burrowing anemones. "Horn" sponge and Munida sp. were most abundant forms along the rock cliff off Woolridge Island. Fewer prawns were observed than opposite shore (dive 465). Very little sediment deposition was observed along shoreline and the rock cliff was heavily encrusted with sponges.

APPENDIX II

MIGRATORY BIRD RESOURCES IN HOWE SOUND

(Canadian Wildlife Service, Trethewey, 1977, personal communication)

APPENDIX II MIGRATORY BIRD RESOURCES IN HOWE SOUND (Canadian Wildlife Service, Trethewey, 1977, personal communication)

Large flocks of several hundred western grebes are often seen in the deeper-water areas of the Sound, particularly in the Queen Charlotte Channel, Lions Bay to Britannia Beach and Britannia Beach to Squamish areas. Thornbrough Channel, into which the Canadian Forest Products, Port Mellon mill discharges its effluent, is known to support large numbers of wintering diving ducks. Thousands of diving ducks and other diving birds also winter among the islands of the southern part of the Sound, with those areas most favoured being: the eastern mainland shore from Point Atkinson to White Cliff Point; the eastern shoreline of Bowen Island in the vicicity of Deep Bay; the southern shore of Gambier Island; and perhaps most important, the fairly large area centering on the general area of the Pasley-Popham Island group and Barfleur Channel bounded on the west by Gower Point and Shoal Channel, on the north by the south shore of Keats Island, on the south by the open Strait of Georgia and on the east by the south-western shoreline of Bowen Island fronting Collingwood Channel.

Breeding bird colonies are located at:

1. Christie Islet, off the southern tip of Anvil Island
   --glaucous-winged gull, pelagic cormorant, double-crested cormorant and pigeon guillemot.
2. Pam Rock, off the southern tip of Anvil Island
   --glaucous-winged gull.
3. Whyte Islets, in Queen Charlotte Channel
   --glaucous-winged gull.
4. Passage Island, in Queen Charlotte Channel
   --glaucous-winged gull and pigeon guillemot.
5. Grace Islands, off the southwest tip of Gambier Island
   --plunge divers, probably glaucous-winged gulls.

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APPENDIX III

CANADIAN FOREST PRODUCTS PULP MILL, PORT MELLON, B.C.
RAYONIER PULP MILL, WOODFIBRE, B.C.
FISHERIES RESOURCES OF FISHERIES AND MARINE SERVICE
STATISTICAL AREA 28 (Knapp and Cairns 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 designed 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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