ENVIRONMENTAL PROTECTION BRANCH
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PULP MILL ENVIRONMENTAL ASSESSMENT
MacMILLAN BLOEDEL CO. LTD.
HARMAC PULP DIVISION

Regional Program Report: 79-8

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 co-operation of various other government agencies and the 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 Co. Ltd., Harmac Pulp Division mill near Nanaimo, B.C.

RÉSUMÉ

Au mois d'octobre 1976, le Service de la Protection de l'environnement a entrepris d'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 qualite environnementale de chacune des régions et déterminé quelles seraient les études supplèmentaires 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 MacMillan Bloedel Co. Ltd., Harmac Pulp Division.

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SUMMARY AND CONCLUSIONS

1. The installation of in-plant effluent controls has reduced the levels of biological oxygen demand (BOD_5) and suspended solids (SS) thereby lessening the effluent's impact on the aquatic receiving environment. The impact of the effluent has been further reduced by the installation of a deep-water effluent diffuser in Northumberland Channel.

2. The water circulation in Northumberland Channel is good, allowing for rapid dilution of the effluent to the point where no significant water quality problems have been identified or would be anticipated.

3. Due to the density stratification of Northumberland Channel the discharged effluent is trapped at depth before it reaches the surface waters.

4. Since the installation of the submarine diffuser, the diversity of the intertidal biotic communities has increased, approaching more natural levels.

5. Observations carried out during Pisces IV submersible dives in April, 1978 noted an accumulation of fibre beginning to occur on the bottom in the vicinity of the diffuser end. The Environmental Protection Service feels that this should be monitored closely such that corrective measures may be taken before a significant fibre bed develops.

6. Log storage on the Nanaimo River estuary is a problem which needs to be resolved in light of the total watershed enhancement plans for salmonids which are planned for the Nanaimo River system.

1 INTRODUCTION

1.1 Location

MacMillan Bloedel's Harmac pulp mill is located approximately 5.5 km southeast of Nanaimo on the eastern shore of Vancouver Island and the western side of Northumberland Channel (49°08.3'N; 123°51.5'N) (Figure 1). Northumberland Channel is a tidal passage, trending approximately northwest-southeast between Gabriola and Vancouver Islands on the western side of the Strait of Georgia. The channel is approximately 3.5 nautical miles (6.5 km) long by an average of 0.8 n mi (1.5 km) wide with a mean low tide depth of 60 meters (Waldichuk, 1965; Landucci, 1974).

1.2 Climate

The climate of the area is characterized by long, cool generally dry summers and short, mild, wet winters (Bell and Kallman, 1976). The average annual rainfall of the Nanaimo region is 1011 mm. The mean daily temperature ranges from 2.6°C in January to 17.8°C in July. Winds are generally modifications of the overall wind systems in the Strait of Georgia. The prevailing wind direction is east to southeast during autumn and winter months, with westerly and northwesterly winds predominating in the summer months (Bell and Kallman, 1976).

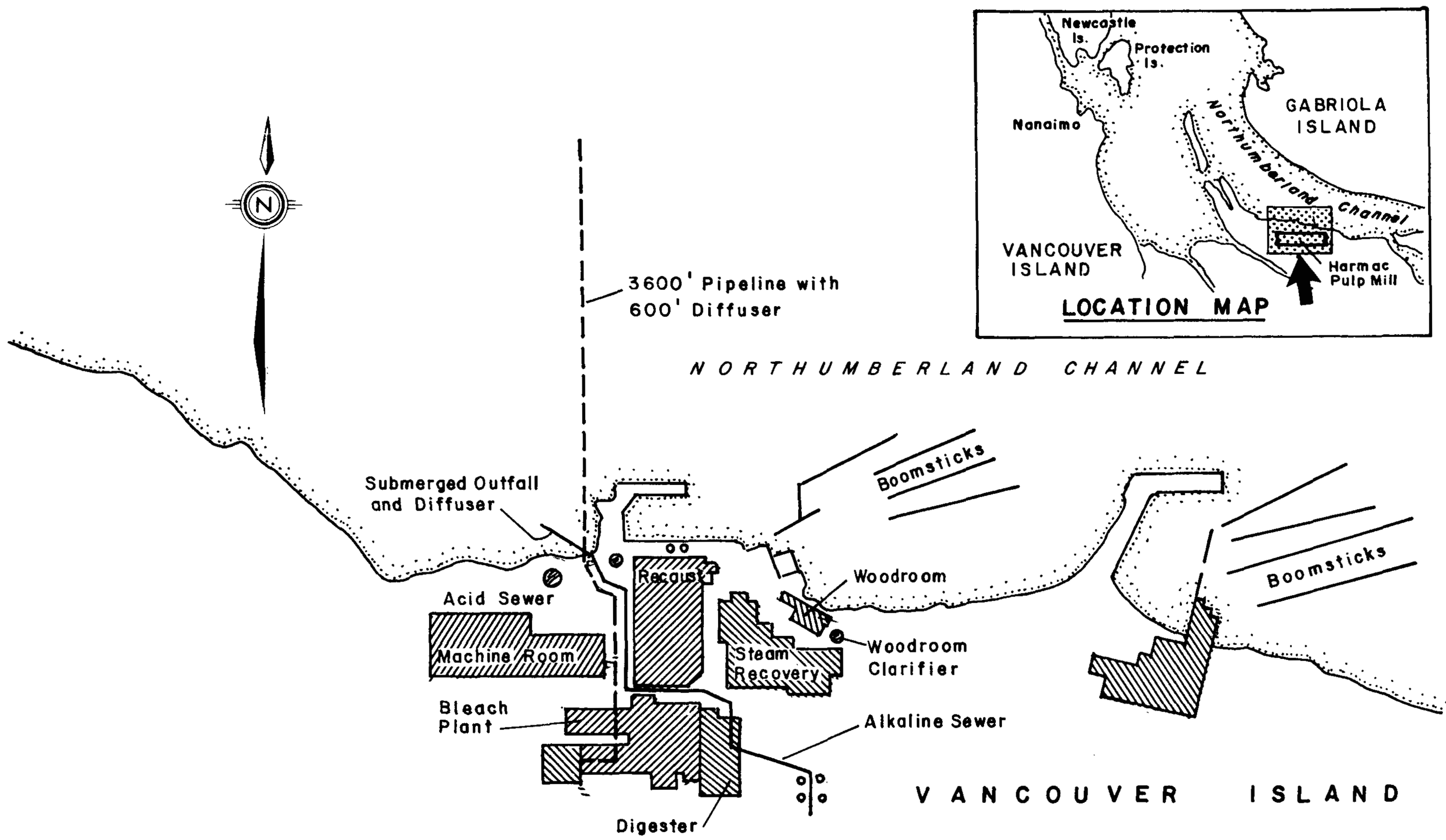

FIGURE I MacMILLAN BLOEDEL LTD., HARMAC DIVISION

2 MILL OPERATIONS

2.1 Mill History

The Harmac pulp mill began operations in 1950 with an original production capacity of 350 TPD (McLean and Tanner, 1974). An expansion in 1954 increased production to 750 TPD while further expansion in 1963 increased the productive capacity to the present 1300 TPD. Production in 1977 averaged 935 TPD. The mill is presently reputed to be the largest producer of full bleached kraft pulp in British Columbia.

2.2 Mill Processes

Harmac at the present time has two Wood Mills. No. 1 Wood Mill contains one 60 inch (152 cm) Hansel hydraulic barker (McLean and Tanner, 1974) which had an average 1973 production of 292 BDT/D. The effluent from this process is treated by three Tyrock bark dewatering screens and one effluent clarifier 100 ft (30.5 m) in diameter. No. 3 Wood Mill contains one 30 inch Nicholson Mechanical Barker and one 54 inch (137 cm) Nicholson Mechanical Barker. In 1973 the average hogfuel production was 368 ODT/D. The mill utilized an average of 717 ODT/D, with the difference being purchased.

Wood chips required for pulping are produced at the mill (27%) with the remainder being purchased from outside sources. The pulping process consists of 12 batch digesters and one Kamyr digester (McLean and Tanner, 1974). Details on the remainder of the processes are contained in McLean and Tanner (1974).

2.3 Effluent Treatment

An elaborate recycling system for process water is employed at Harmac. This has been outlined in McLean and Tanner (1974) and is presented below.

(a) Evaporator condensate (1150 gpm) is reused on Brown Stock Washers and to a limited extent in the Recausticizing department. Mainly fresh water is used for dregs and mud washing in the recaust area.

(b) Evaporator foul condensate is sewered.

(c) Evaporator surface condenser clean water (5000 gpm) is used for stock consistency control on brown and bleach screens.

(d) Kamyr and Batch Digester condensate is passed through a turpentine recovery system and then sewered.

(e) G-2 turbogenerator condenser and steam plant reclaim water (2700 gpm) is reused for stock dilution in bleach screening.

(f) Bleach screen room white water (9000 gpm) is reused for bleach plant stock dilution.

(g) Machine wire pit white water (10 300 gpm) is reused for stock dilution in the bleached stock screening process.

All mill effluent, including sewage is mixed prior to discharge (McLean and Tanner, 1974) and discharged through a diffuser 1140 m offshore from the mill at a depth of 105 m (Bell and Kallman, 1976). Discharge through this diffuser began in January 1976.

Harmac also has an elaborate spill detection system consisting of 26 conductivity probes placed at strategic locations (McLean and Tanner, 1974). Detail of the exact locations of the conductivity probes is contained in this report.

2.4 Solid Waste Disposal

Approximately 230 m^3/day of solid waste is trucked to a site near the mill (McLean and Tanner, 1974). The wastes disposed of in this manner include such general mill wastes as green dregs, waste lime mud, hog wastes, slaker grits, etc. The material is composed of approximately 42% combustible and 58% inert material. The dump site drains north into a small creek which according to the local Fishery Officer is devoid of life.

There is an incidental leachate from the chip storage pile for the mill which is ditched to a log pond (McLean and Tanner, 1974).

3 EFFLUENT QUALITY

3.1 Federal and Provincial Effluent Quality Requirements

The Provincial Pollution Control Branch Permit for Harmac was amended on October 21, 1977, in order to upgrade the mill's pollution control measures. The effluent objectives outlined in this amended permit are presented in Table 1.

Improvements and spill control measures were also authorized in the amended permit, with the works to be installed and operating on or before December 31, 1978. The works authorized included two clarifiers; a continuous digester process draining system; brown stock, bleach and machine area fibre spill reclaim system; a green liquor dregs filter; an emergency lime mud storage basin; a proposed recovery-recaust area chemical spill collection system; a central alarm and monitoring system; a sanitary effluent treatment plant and a submerged diffuser outfall. The submerged diffuser outfall was installed and operating on January 1, 1976.

When the Federal Government Pulp and Paper Effluent Regulations (Environment Canada, 1971) are applied to Harmac the company will be required to comply with effluent standards of biological oxygen demand (BOD_5), suspended solids (SS), and toxicity as shown in Table 2. The Federal requirement for SS is expressed as a given number of pounds per air dry ton (lb/ADT) of product. As such the amount of material permitted to be deposited can change from day to day depending on the production rate of the mill. The terms of the amended PCB permit, however, stipulate a maximum amount of material which may be deposited in a given day regardless of the production rate of the mill. As such, it is difficult to compare the two requirements in terms of compliance. Tables 3, 4 and 5 present the results of the routine monitoring carried out by Harmac and the Environmental Protection Service.

3.2 Accidental Spills

Examination of the Environmental Protection Service files on Harmac reveals a continued history of spill problems mainly with regard

TABLE 1 PROVINCIAL OBJECTIVES

Characteristic	Value
Discharge Volume	48 000 000 gpd
pH Range	6.5 - 8.5
Temperature Maximum	35°C
Floatable Solid	Negligible
Total Suspended Solids	26 400 lbs/day (20 lb/ADT)
BOD	59 400 lbs/day (45 lb/ADT)
Toxicity (TLm_{96})	30%
Mercaptans	< 2.0 mg/l
Sulphides	< 1.0 mg/l
Residual Chlorine	< 0.1 mg/l
Toxicity (TLm_{96})	50% survival at 30% effluent concentration over 96 hour exposure time

TABLE 2 FEDERAL REQUIREMENTS

Process	Allowable Discharge	
	SS	BOD_5
Hydraulic Debarking	5 lb/ODT of wood	
Kraft Pulping	7 lb/ADT	64 lb/ADT
Kraft Bleaching	6 lb/ADT	27 lb/ADT
Kraft Sheet Formation	2 lb/ADT	
Toxicity	80% survival at 65% V/V concentration over 96 hours	

TABLE 3 1976 EFFLUENT QUALITY RESULTS

Month	Flow x 10^6 IG/D	BOD_5 LB/ADT	BOD_5 Tons	Suspended Solids LB/ADT	Suspended Solids Tons
January	45.0	58.8	30.34	24.5	12.68
February	47.9	52.1	28.03	18.3	9.85
March	49.9	51.1	29.84	21.3	12.44
1st Quarter	47.6	54.0	29.40	21.4	11.66
April	49.6	43.8	23.32	21.9	11.66
May	53.4	38.0	19.10	25.3	12.71
June	52.6	49.0	26.23	26.8	14.35
2nd Quarter	51.9	43.6	22.88	24.7	12.91
July	53.5	56.6	31.41	22.1	12.26
August	55.4	36.2	21.41	24.3	14.37
September	52.1	40.3	21.52	29.7	15.86
3rd Quarter	53.7	44.4	24.78	25.4	14.16
October	50.2	45.7	23.79	18.3	9.53
November	53.8	39.6	23.34	23.3	13.74
December	50.0	40.2	20.34	39.2	19.84
4th Quarter	51.3	41.8	22.49	26.9	14.37
Yearly Average	51.1	46.0	24.89	24.6	13.28

TABLE 4 1977 EFFLUENT QUALITY RESULTS

Month	Flow $\times 10^6$ IG/D	BOD_5 LB/ADT	BOD_5 Tons	Suspended Solids LB/ADT	Suspended Solids Tons
January	44.8	55.4	20.25	28.8	10.53
February	47.7	37.0	19.89	21.0	11.29
March	51.3	-	-	22.5	12.52
1st Quarter	47.9	46.2	20.07	24.1	11.45
April	49.7	39.2	19.79	26.0	13.13
May	54.2	43.2	23.93	21.4	11.86
June	53.9	41.3	23.56	22.1	12.61
2nd Quarter	52.6	41.2	22.43	23.2	12.53
July	54.7	45.2	27.32	22.3	13.48
August	53.5	64.5	32.67	28.1	14.23
September	49.4	48.0	20.78	25.9	11.21
3rd Quarter	52.5	52.6	26.92	25.4	12.97
October	52.6	41.1	22.46	22.6	12.35
November	38.6	53.8	14.01	52.7	13.73
December	44.5	47.3	22.30	22.8	12.16
4th Quarter	45.2	47.4	19.59	33.7	12.75
Yearly Average	49.6	46.85	22.25	26.6	12.43

TABLE 5 RESULTS OBTAINED IN E.P.S BIOASSAY PROGRAM

Sample Date	% Mortality Over 96 hours, Static Testing Concentration (% V/V) Effluent (neutralized)						Sample pH
	100	87	65	42	30		
December 12, 1977	100	100	100	0	0		6.7
November 22, 1977	0	0	0	0	0		6.6
June 6, 1977	100	70	70	0	0		6.7
April 27, 1977	0	0	0	0	0		7.3
February 9, 1977	100	100	20	0	0		6.9
	100	65	45	32	12.5	5.6	
December 2, 1976	100	100	100	75	0	0	6.0
October 27, 1976	100	60	0	0	0	0	6.7
July 13, 1976	100	100	100	0	0	0	6.8
March 23, 1976	100	100	100	100	100	50	3.3
March 23, 1976	100	100	20	0	0	0	6.9
March 17, 1976	100	0	0	0	0	0	6.8
March 17, 1976	-	-	-	-	100	0	3.7
March 15, 1976	100	100	100	100	40	0	4.7
March 15, 1976	100	0	0	0	0	0	6.5
March 8, 1976	100	0	0	0	0	-	6.7
March 8, 1976	60	0	0	0	0	0	6.8
March 2, 1976	100	100	30	0	0	0	6.7
March 2, 1976	100	100	100	100	0	0	4.2
February 16, 1976	100	100	100	12.5	0	0	7.1
January 21, 1976	100	100	100	100	100	0	3.8

to green liquor spills resulting in the loss of saltcake (Na_2SO_4). Black liquor spills have also occurred. These spills have always been small such that no fish kills have occurred and no charges have been laid. It is anticipated that spills will no longer be a problem when the spill control technology is installed and operating by the end of 1978.

4 RECEIVING ENVIRONMENT

4.1 Oceanography

Northumberland Channel was described by Waldichuk (1965) as "a partially mixed tidal system having relatively rapid replacement of its waters". Physical and chemical oceanographic data were collected by Waldichuk in September 1975; July 1957; May 1961; July 1962; July 1963; May 1965 and June 1965 (Waldichuk, Meikle and Markert, 1968); by H.A. Simons (International) Ltd. (1973); by Packman in 1975 (Packman, 1977); by Ketcham in 1976 (Ketcham, 1977) and by Dobrocky Seatech Ltd. (1977). All of these studies indicated that Northumberland Channel is vertically stratified and exhibits those characteristics normally associated with a well flushed system.

The physical and chemical oceanography of the system can be described as follows:

1. Most of the water entering Northumberland Channel is of Strait of Georgia origin. A major portion of the surface water funnels out through Dodd Narrows and False Narrows while the deep water exchanges with the Strait of Georgia via Fairway Channel (Waldichuk, 1965). The fact that most of the surface water exits through Dodd and False narrows is due to the flood tidal wave, which advances up the Strait of Georgia faster than it does up Stuart Channel. Therefore, water originating in the Strait of Georgia enters Northumberland Channel before the tidal wave has advanced up Stuart Channel and through Dodd Narrows.
2. The surface flood tide currents are characterized by a strong northwesterly flow emanating from Dodd Narrows. These currents then cross over to and follow the south side of Gabriola Island until deflected westward by the advancing tidal wave from the Strait of Georgia. The ebb tide currents are characterized by a strong easterly flow on the south side and east end of the channel, accompanied by a strong northwesterly flow on the north side at the northwest end. These two opposite flowing currents produce an anti-clockwise gyre in the vicinity of the Harmac effluent diffuser (Waldichuk, 1965).

3. Northumberland Channel is highly stratified with respect to physical and chemical oceanographic parameters (Figures 2 and 3).
4. According to Waldichuk (1965) surface water passing either from Northumberland Channel to Stuart Channel or vice versa becomes thoroughly mixed with deeper water when passing through Dodd Narrows. This forms a homogenous water mass which, being denser than the surface layer in the receiving water body, tends to slide underneath it (Figure 4).
5. Although the water movements in Northumberland Channel are predominantly tidal, there exists a three layer system of net currents. This system has been described by Waldichuk (1965) and Dobrocky Seatech et al (1977). The system consists of a surface current with a net southeasterly flow, a current at a depth of 6 meters with a net northwesterly flow and current in the denser bottom water which has a net southeasterly flow. A diagrammatic view of this system is presented in Figure 5.

In 1973, H.A. Simons (International) Ltd. conducted a study directed toward the design of an effluent diffuser for Harmac and the prediction of effluent trapping depths using that diffuser. The outcome of that study was a diffuser designed to the specifications mentioned previously, and with predicted effluent trapping depths of 40 meters to 70 meters during the period June to October, and above 30 meters from November through May. The "measured trapping level" was defined in this report to be the lower limit of effluent once the plume has reached an equilibrium height. Calculations of the trapping level were conducted utilizing a computer model of the density stratification of Northumberland Channel with the input of effluent density characteristics. The model was assumed to be a no-current situation which would represent the worst case.

In 1977, a study was conducted by Dobrocky Seatech Ltd. to assess the actual performance of the diffuser with respect to effluent dispersion under operating conditions. In this study current and water column characteristics measurements were made. The effluent plume was

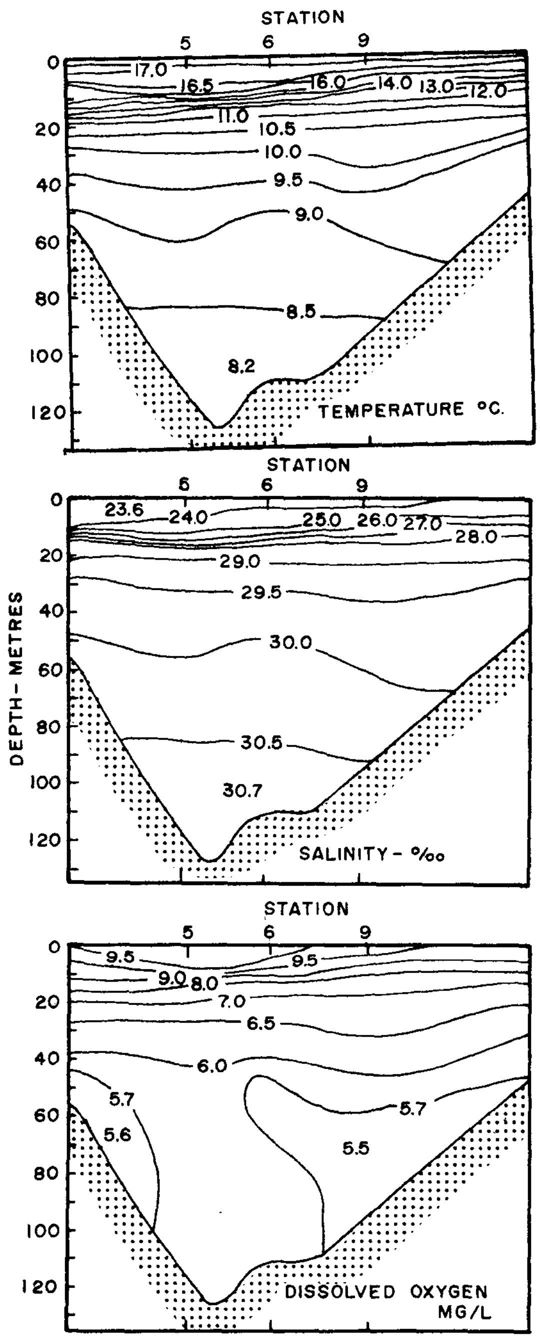

FIG. 2 DISTRIBUTION OF PROPERTIES IN A VERTICAL SECTION THROUGH NORTHUMBERLAND CHANNEL DURING THE SURVEY OF JULY 17, 1962. WALDICHUCK, 1965.

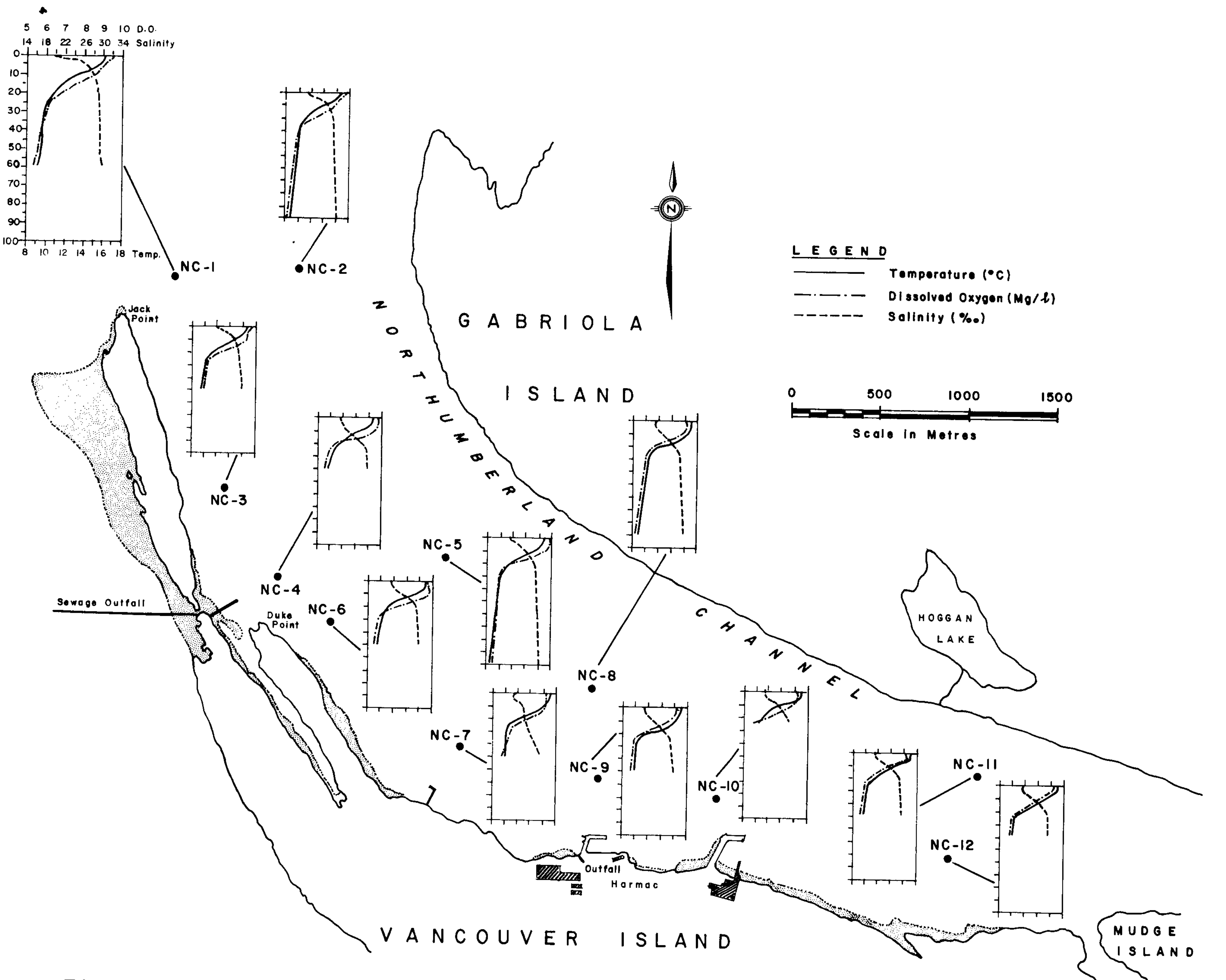

FIGURE 3 OCEANOGRAPHIC DATA (NORTHUMBERLAND CHANNEL (Packman 1977)

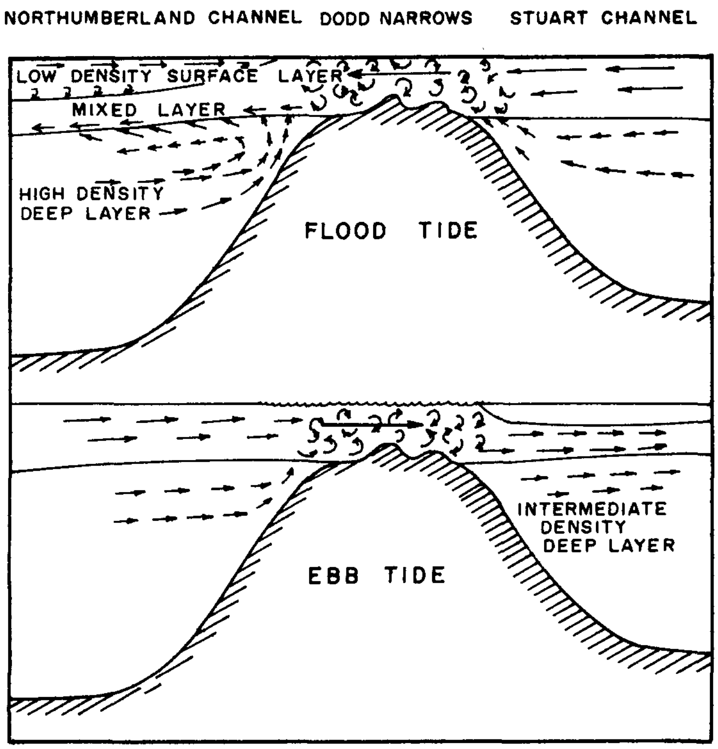

FIG 4 SCHEMATIC DIAGRAM SHOWING HYPOTHETICAL MODEL OF WATER MOVEMENT THROUGH NORTHUMBERLAND CHANNEL, DODD NARROWS, AND STUART CHANNEL, ON FLOOD AND EBB. WALDICHUCK (1965)

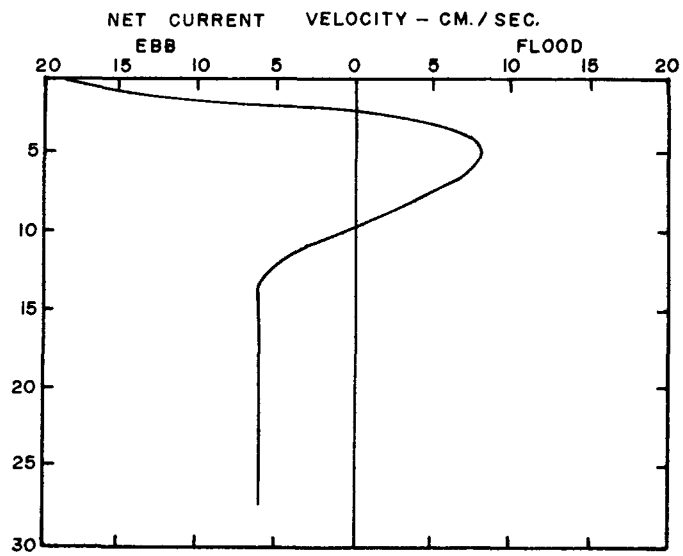

FIG 5 NET CURRENTS AT STATION N-5 FOR A 25 HOUR PERIOD JULY 8-9 1957 WALDICHUCK (1965)

also tracked using Rhodamine B dye injected into the effluent line on shore with concentrations of the dye in Northumberland Channel being measured using a fluorometer. Predictions made by H.A. Simons that between November and May the effluent would be trapped between a depth of 29 and 23 meters were determined to be reasonably accurate. Dobrocky Seatech et al (1977) found that the trapping depth was actually between 20 meters and 40 meters below the surface at the time of their sampling in January, 1977.

The measured dilutions at the top of the plume were found to be generally between 100:1 and 200:1 which was greater than the predicted dilution of 77:1, although there was one occasion when a dilution of only 40:1 was measured (Dobrocky Seatech et al, 1977). It was also emphasized in this report that the computer predictions were based only on a stagnant vertical density gradient and that with the currents which are always present in Northumberland Channel, the trapping level should be expected to be deeper with a greater degree of effluent dilution.

The effluent plume was reported to lie between the 60 and 80 metre depths in August 1976, based on personal observations in August 1976, from the Pisces IV submersible in Packman (1977).

The data of Packman (1977) and Ketcham (1977) provide useful informaton respecting the expected decrease in dissolved oxygen concentrations in the water column of Northumberland Channel resulting from the discharge of Kraft mill effluent. The data of Packman (1977) were collected in August 1975, when the mill was not operating and no effluent was being discharged. The data of Ketcham (1977) were collected in the summer of 1976, when the mill was in full operation. Comparison of the two data sets does not indicate a significant reduction in dissolved oxygen occurring as a result of the effluent discharge. This appears to confirm that good flushing is available for the effluent. The situation should continue to be monitored in the future however.

4.2 Biological Effects

4.2.1 Intertidal Effects. The effects of the discharge of effluent from Harmac have been monitored by MacMillan Bloedel since 1970 as part of the conditions of their Pollution Control Board permit. Reports resulting from these studies have been released on an almost annual basis. These reports which include Beak (1970), Melville (1973), Melville (1974), Ketcham (1975), Ketcham (1977) and Ketcham (1978), document the effects of the effluent both before and after the installation of the submarine diffuser in January 1976. All of the intertidal studies conducted by the mill utilized some form of artificial substrate in the form of fibre glass plates, bricks and roughened plexiglass plates.

The studies of Beak (1970), Melville (1973) and Melville (1974) all indicated a significant detrimental effect attributable to the effluent, ranging from Duke Point to Joan Point, mainly on the mill side of Northumberland Channel. It was noted that the effects of the effluent extended a greater distance in a southeasterly direction away from the mill in accordance with the established pattern of flow in the surface waters of Northumberland Channel, which have a net flow southeast through Dodd Narrows.

Melville (1973) noted that the effluent appeared to have its greatest effects on larval and juvenile life stages of fauna which settled in the intertidal zone during the period April-October. Beak (1970) reported periods of heavy barnacle die off in the vicinity of the mill, and noted that periphyton growth was generally poor in the zone of influence.

Post diffuser studies were reported in Ketcham (1977 and 1978). In Ketcham (1977) a definite increase in speciation and numbers of animals was noted in the intertidal zone within the previous zone of influence. This improvement was attributed to the absence of effluent in the surface waters. The dominant faunal forms noted during 1976 included barnacles (Balanus sp.), copepods, nematodes, amphipods, insect larvae, mussels (Mytilus sp.) and periwinkles (Littorina sp.). Enteromorpha intestinalis was well established on the artificial substrates at all stations.

Ketcham (1978) reported that although the diversity indices in the vicinity of the mill were depressed in 1976 and 1977, abundance and speciation were discernably higher throughout the study area. This was again attributed to the absence of effluent in the surface waters. In the 1976 sampling year barnacle settlement was very successful and overshadowed other growth, resulting in low diversity indices. In 1977, however, the speciation was better balanced, resulting in higher diversity indices. It was hypothesized by Ketcham (1978) that, "interspecific competition for space during 1976 was upset by the disappearance of effluents from surface waters and that the adjustment to a more diverse community structure was nearing completion in 1977". It was suggested that intertidal monitoring could be discontinued at least for 1978, as the effluent appeared to be having little effect in that zone.

4.2.2 Benthic Effects. The only significant benthic biological sampling program conducted in Northumberland Channel was carried out by the Environmental Protection Service in 1976 (Packman, 1977). In this program, 12 stations were sampled in Northumberland Channel. The results indicated a build-up of bark and woodchips in the vicinity of Harmac with a concurrent shift in community structure from an infaunal community to an epifaunal community. The diversity indices remained relatively unchanged, however.

In April 1978, two dives were conducted in Northumberland Channel by the Environmental Protection Service, using the Pisces IV submersible. On these dives it was noted that the effluent rose vertically from the diffuser. Pelagic and benthic epifaunal animals in the vicinity of the outfall appeared to stay away from the direct effluent stream. The bottom at the end of the diffuser was swept clean by currents set up by the effluent stream and the beginnings of fibre deposition were observed to extend out approximately 40 meters from the diffuser end. The infaunal community appeared to be blanketed but some epifaunal forms such as crabs, shrimp and some fish were noted on top of the fibre.

4.2.3 Toxicity. In 1977, E.V.S. Consultants under contract to MacMillan Bloedel, Harmac Division conducted laboratory studies of the toxicity of Harmac bleached Kraft mill effluent to eggs, larval and juvenile herring, extrapolating their findings to measured in situ conditions. One aim of the study was to evaluate the suitability of herring early life stages as bioassay organisms for the assessment of the effects of pulp mill effluent. It was felt that these organisms would be highly sensitive and being planktonic would give an indication of the effects of the BKME on the local plankton community. Herring were also used because they have historically been abundant in Northumberland Channel (Bell and Kallman, 1976).

The conclusions from the work with larval herring were that:

1. "Using 96-hour LC-50's as a criterion of acute toxicity, both yolk-sac and older herring larvae are about two to three times as sensitive to bleached kraft mill effluent as sticklebacks and underyearling rainbow trout."
2. No effects were observed with herring larvae at concentrations exceeding the maximum in situ concentration of Harmac BKME.
3. Recent herring egg hatch was increased 9-60% by BKME at 0.002 to 0.1 of the 96 hour LC-50 concentrations. At 0.5 and 1.0 of 96 hour LC-50 concentrations hatch was reduced by 52-60%.
4. Sublethal development studies revealed that BKME concentrations up to 0.05 of the 96 hour LC-50 value of BKME for rainbow trout had no effect on the growth or survival rates of larval herring up to six weeks age. These results suggest that in situ concentrations of Harmac BKME have a minimal impact on the development of herring larvae.
5. It may be assumed that herring larvae are representative of the sensitive life forms comprising the marine zooplankton and are appropriate for use in sublethal growth and development bioassays.
6. The limit of response in the sublethal studies combined with the fact that the effluent is predominantly non-toxic and the dilutions achieved by the diffuser suggests that the present operation of Harmac effluent discharge is not having any appreciable adverse effect on the zooplankton of Northumberland Channel (Dobrocky Seatech et al, 1977).

The conclusions from the work with juvenile herring were that:

1. No significant effects on growth, appetite or conversion efficiency were observed in juvenile herring exposed for 36 days to Harmac BKME at in situ concentrations. These results were consistent with published data for salmonids.
2. Chronic exposure to 0.001 to 0.005 of Harmac BKME would not provide a stress which would exclude herring from Northumberland Channel nor would it have a direct effect on growth, feeding or food conversion efficiency. Similarly, slugs of Harmac BKME at 2% concentration would also not appear to have any appreciable adverse effect on the growth of juvenile herring (Dobrocky Seatech et al, 1977).

4.2.4 Fibre Deposition. No significant deposition of fibre stemming from the Harmac discharge has been reported in the past. Packman (1975) reported on the analysis of 12 grab samples in Northumberland Channel which contained no fibre stemming from the pulping process. This may have been due to the fact that the discharge had historically been into the surface waters which have good dispersion qualities. In April 1978, Pisces submersible dives were conducted to inspect the Harmac effluent diffuser (Packman, 1978). At that time an accumulation of what appeared to be fibre was apparent adjacent to the end of the diffuser and extending up to 40 m out from the end. This accumulation had occurred since the diffuser installation in 1976, and was probably due to the reduced circulation in the bottom water in Northumberland Channel. The accumulation should be closely monitored such that if a fibre bed begins to develop, corrective measures may be taken.

An accumulation of wood and bark debris was noted mainly southeast of the mill both in grab samples and by SCUBA diving (Packman, 1977). This material had originated from log booming and chip transport activities.

4.2.5 Estuarine Log Storage. Harmac utilizes portions of the Nanaimo River estuarine mud flats for the storage of log booms. This kind of activity has known detrimental effects on the productivity of the flats including:

1. The deposition of bark and wood debris which blankets the benthos.
2. The prevention of light penetration to the bottom due to log booms, thereby affecting the growth of eelgrass and other plant life.
3. Channeling resulting from the wash of tug boats taking log booms back and forth across the delta.

As a result of these and other effects log booming has been shown to reduce salmon fry production. The whole question of log booming is presently being examined in light of proposed developments at Duke Point which may further increase log storage demands.

5 NATURAL RESOURCES

5.1 Fisheries Resource

An assessment of the fisheries resource in the waters surrounding Harmac is contained in an internal report compiled by the Fisheries and Marine Service (Knapp and Futer, 1978). This report is contained in Appendix I and discusses the resource and the impact of the pulp mill on the resource.

5.2 Migratory Bird Resource

The major portion of the migratory bird habitat located near Harmac is the Nanaimo River estuary. Bell and Kallman (1976) state that this estuary is the largest on Vancouver Island and is an extremely important waterbird over-wintering and staging area. Diving ducks utilize the seaward portion of the estuary. This utilization is however dependent upon the state of the tide and boating and booming activities. The birds are readily displaced to other parts of the estuary and into Northumberland and Stuart channels.

Opposite the pulp mill on cliffs of Gabriola Island is a large nesting colony comprised of 350-400 pairs of pelagic cormorants. Also nesting on these cliffs are glaucous-winged gulls and pigeon guillemots (Bell and Kallman, 1976; Trethewey, 1977).

As yet the pulp mill does not appear to have had a significant impact on the migratory bird utilization of the area. The main impact appears to have been the alienation of portions of the Nanaimo River estuary through log-booming activities.

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APPENDIX I

MACMILLAN BLOEDEL PULPMILL, HARMAC, B.C.
B.C. FOREST PRODUCTS PULPMILL, CROFTON, B.C.
FISHERIES RESOURCES OF FISHERIES AND
MARINE SERVICE STATISTICAL AREAS 17 AND 18

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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DEPARTMENT OF FISHERIES AND THE ENVIRONMENT
FISHERIES AND MARINE SERVICE

MacMillan Bloedel Harmac Pulp Mill and B.C. Forest Products Crofton Pulp Mill

Fisheries Resources of Fisheries and Marine Service Statistical Areas 17 and 18

by
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Water Quality Division
Habitat Protection Unit
Resource Services Branch

1978

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MACMILLAN BLOEDEL HARMAC PULP MILL AND B.C. FOREST PRODUCTS CROFTON PULP MILL FISHERIES RESOURCES OF FISHERIES AND MARINE SERVICE STATISTICAL AREAS 17 AND 18

I INTRODUCTION

There are two pulp mills located on the southeastern coast of Vancouver Island. They are MacMillan Bloedel's Harmac pulp mill and B.C. Forest Product's Crofton pulp mill (Figure 1). The former is situated on the west shore of Northumberland Channel south of Nanaimo, within Fisheries Statistical Area 17. The latter is located on the west side of Stuart Channel at Osborn Bay north of Duncan, in Statistical Area 18. Together, Areas 17 and 18 encompass the southwestern half of the Strait of Georgia and extend some 70 miles along the coast. Within them, the major population centers are Nanaimo, Ladysmith and Duncan.[1,2]

In delineating the zone of influence of the Harmac and Crofton mills on local fisheries resources, it is assumed that the severity of the effect varies approximately inversely with distance from the pulp mill effluent discharge. Oceanographic considerations affecting effluent dispersion must, of course, be taken into consideration, since eddy currents and other factors that concentrate effluent could alter the extent of pollution effects.

In Northumberland Channel, the net movement of water is to the southeast and almost all of the Harmac mill effluent is directed through Dodd Narrows (Figure 2). Biological surveys have indicated that a measurable detrimental effect on intertidal life has occurred between Duke Point 2 km northwest of the mill to Joan Point 2.7 km southeast of the mill and also at Mudge and Gabriola Islands bordering on False Narrows.(3) These observations would seem to indicate that the salmon of the Nanaimo and Holden Rivers are most likely affected by mill effluent (Figure 2).

In the vicinity of the Crofton mill, oceanographic features cause mill effluent to be dispersed in a south-southwesterly direction towards Sansum Narrows (between Saltspring Island and Maple Bay on Vancouver Island), with lesser amounts being directed northwest into the Shoal Island (Figure 2). Apparently, effluent tends to concentrate in Booth Bay on Saltspring Island (across Stuart Channel from the effluent diffusers). A theoretical calculation of toxic units in the receiving water based upon bioassay data and estimated dilution factors have indicated that sufficient toxicity is

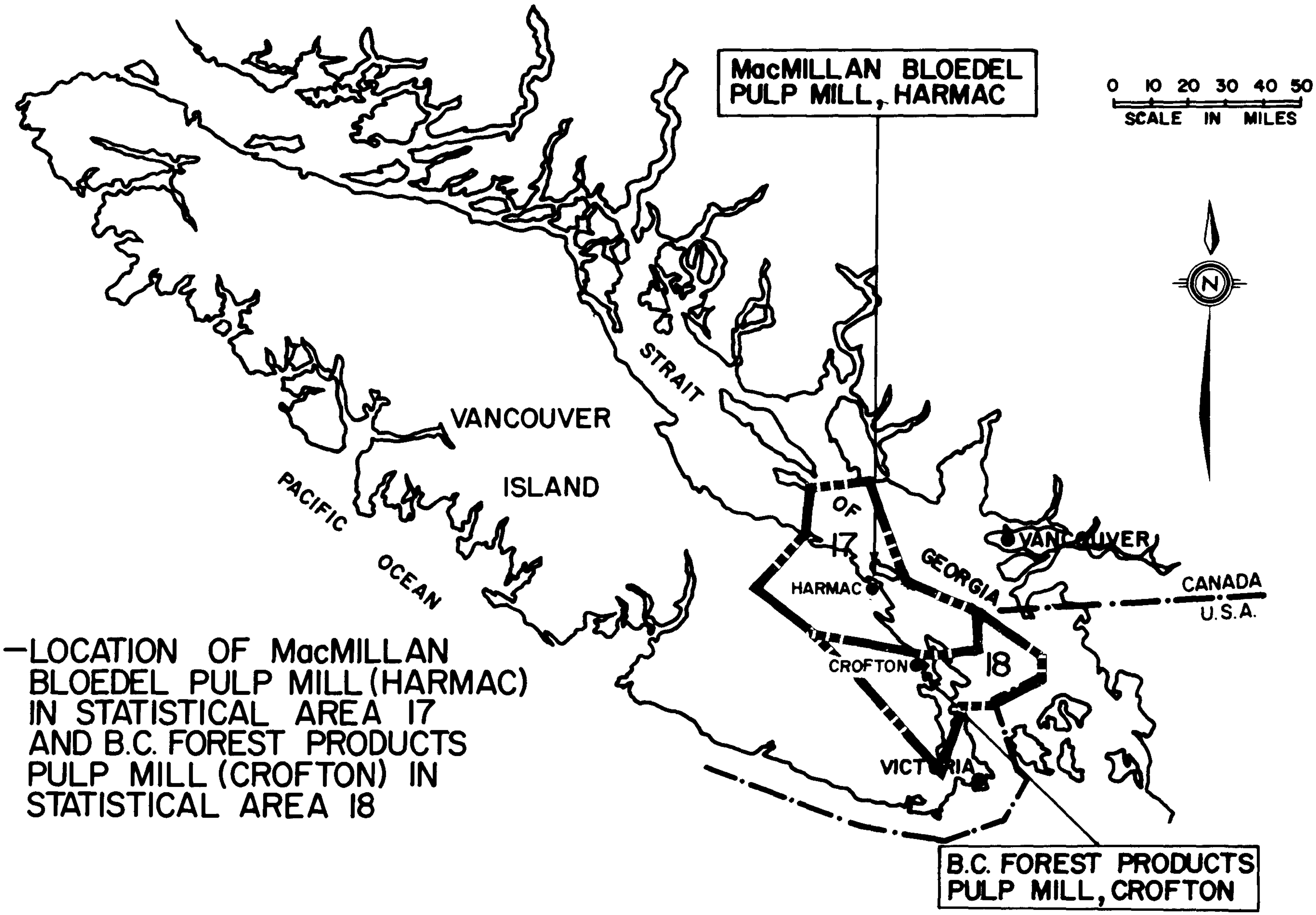

FIGURE 1—LOCATION OF MacMILLAN BLOEDEL PULP MILL (HARMAC) IN STATISTICAL AREA 17 AND B.C. FOREST PRODUCTS PULP MILL (CROFTON) IN STATISTICAL AREA 18

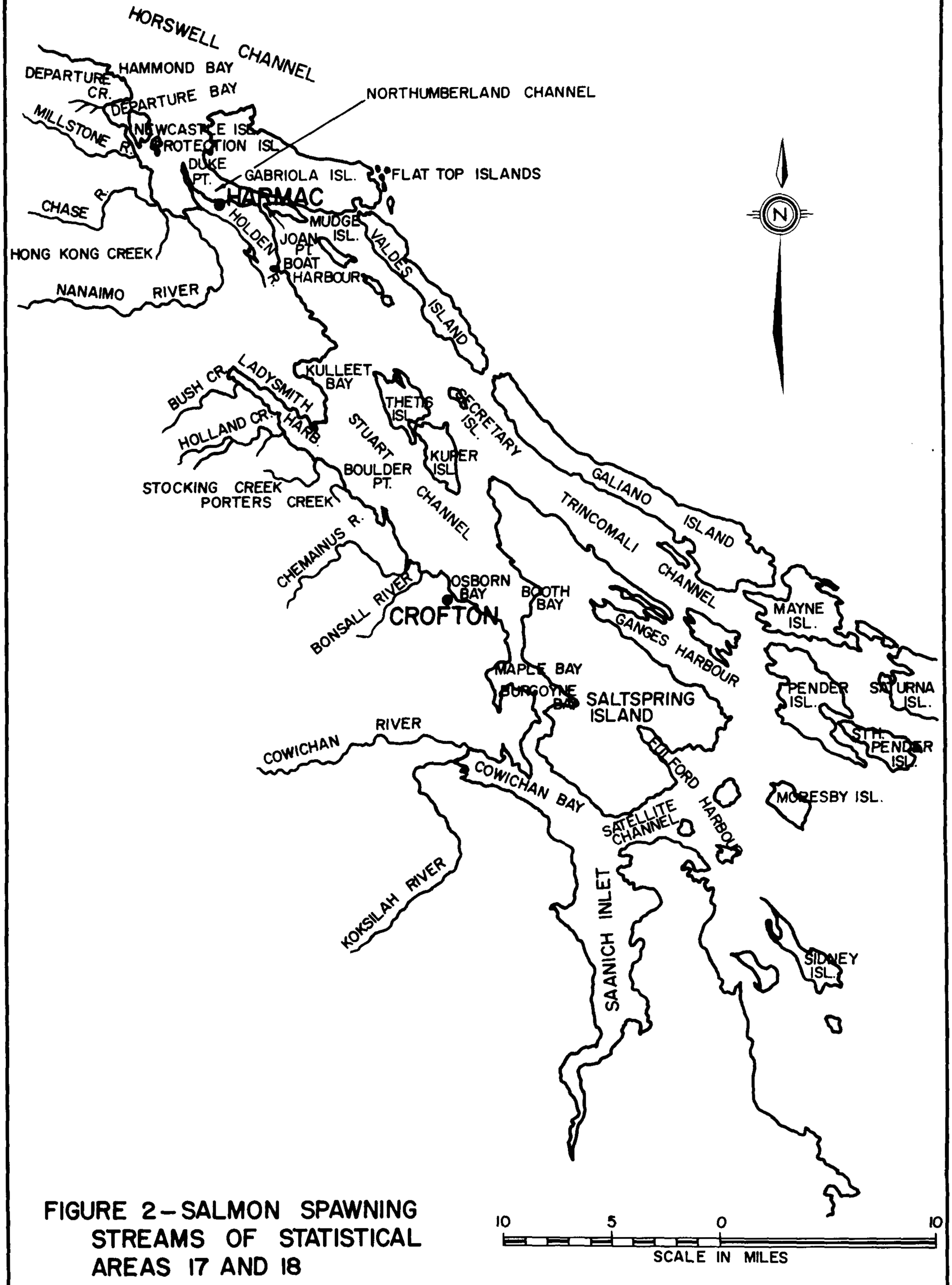

FIGURE 2 – SALMON SPAWNING STREAMS OF STATISTICAL AREAS 17 AND 18

present in the vicinity of the outfall to produce sublethal effects in salmonids.(4) These findings suggest that the productivity of the Chemainus and Bonsall rivers (Figure 2) could be threatened by the operation of the mill. The Cowichan and Koksilah rivers are further away from the effluent source and thus would be under less influence from the effluent. However, a portion of the Koksilah River stocks are reported to migrate through Johnstone Strait and down the coast to the river mouth. This could conceivably bring them through Stuart Channel and Sansum Narrows where they would be exposed to effluent-containing waters.

Both the Harmac and Crofton mills utilize water from nearby freshwater sources on a regular basis. This is another factor to be considered in an evaluation of the effect of these two pulp mills on salmon productivity. Harmac obtains water directly from the Nanaimo River (2) while Crofton draws its requirements from the lower Cowichan River.(1) Water flow recordings are continually taken to aid in regulating river flow. However, the danger of critical low river discharge periods always exists. At these times the rivers could have insufficient flows for fall spawning migration. In addition, it has been shown that low summer flows and elevated water temperatures can lead to increased competition between juvenile salmonids for food and rearing space, as well as increased predation by other species.

II SALMON

A. Commercial Fishery

All five species of Pacific salmon are taken commercially within the boundaries of statistical Areas 17 and 18. Ten year averages (1966-1975) indicate that chinook salmon make up the bulk (34.1%) of the commercial salmon catch (in pieces) while sockeye, chum, pink and coho salmon represent 28.8%, 15.4%, 12.1% and 9.6% of the catch within these areas respectively.

Salmonids originating in Areas 17 and 18 also form a portion of the catch from other parts of the Strait of Georgia and its approaches, the Strait of Juan de Fuca, and the west coast of Vancouver Island. Specifically, Nanaimo River chinook and coho contribute to the west coast of Vancouver Island and Strait of Georgia troll fisheries as well as the commercial net fisheries in Johnstone Strait, the Strait of Georgia and Juan de Fuca Strait. Nanaimo River chum are taken in the Straits of Georgia and Juan de Fuca by the gill-net and purse seine fisheries. Chemainus River stocks contribute

TABLE I

Commercial Salmon Catch (5)

AREA 17

YEAR	CHINOOK	JACKS	SOCKEYE	COHO	PINK	CHUM	STEELHEAD
1975	43,683	490	19,511	13,246	18,663	8,764	4
1974	54,470	314	123,329	12,403	729	17,508	5
1973	57,335	357	18,997	5,103	22,615	23,068	2
1972	96,850	42	9,323	13,431	4,587	91,005	26
1971	121,877	427	90,914	32,166	53,801	816	8
1970	33,133	203	3,073	13,312	216	19,717	2
1969	30,643	41	4,219	5,380	8,002	9,064	4
1968	27,631	1	118	12,735	143	27	8
1967	37,044	6	1,830	11,394	1,192	7	1
1966	27,726	134	616	17,846	107	413	16
1966-75 (mean)	53,039	201	27,193	13,702	11,005	17,039	7

AREA 18

YEAR	CHINOOK	JACKS	SOCKEYE	COHO	PINK	CHUM	STEELHEAD
1975	3,512	561	11,840	4,884	45,103	464	9
1974	7,762	334	118,141	2,579	670	44	3
1973	5,442	367	7,686	4,900	12,458	33,451	11
1972	4,923	149	3,558	2,921	5	38,267	15
1971	5,852	352	41,106	6,042	24,555	140	21
1970	3,994	22	1,884	1,365	195	5,967	1
1969	6,932	329	25,700	1,225	1,121	4,475	5
1968	5,478	22	2,378	1,579	5	11,882	35
1967	3,947	57	9,324	1,536	14,408	1	11
1966	4,387	24	3,026	1,628	25	152	8
1966-75 (mean)	5,218	222	22,464	2,866	9,854	9,484	12

to the Strait of Georgia and Johnstone Strait net Fisheries. Fish from Stuart Channel streams form the bulk of the spring and early summer coho catch for the eastern Strait of Georgia. Cowichan chinook and coho are taken in troll fisheries off the west coast of Vancouver Island and net fisheries in Juan de Fuca Strait and Satellite Channel. The main Canadian net fisheries exploiting Cowichan-Koksilah chum are also located in the latter two areas. (1,2)

Table I shows catch statistics for Areas 17 and 18 between 1966 and 1975. Table X presents landed values for Area 17 salmon catches for 1967-1975.

B. Escapements

Historically, Areas 17 and 18 have contributed substantially to the total B.C. salmon catch. In terms of productivity, the Cowichan River is viewed as one of the most important systems on Vancouver Island and certainly the most significant within Areas 17 and 18. Of the remaining large systems, the Nanaimo River ranks next in importance while the Koksilah and Chemainus Rivers support sizeable but smaller salmon runs. Numerous other creeks also contribute to the total productivity (Figure 2).

All five Pacific salmon species have historically been recorded in the four major river systems mentioned above. However, sockeye and more recently pink are only very rarely seen. Table II gives escapement figures for Areas 17/18.

Fish migrating to the Nanaimo, Chemainus, Cowichan and Koksilah River systems contribute to different fishing stocks as a result of their varying migratory routes. Tagging studies have shown that Chemainus River fish migrate through Johnstone Strait. The majority of those destined for the Cowichan and Koksilah pass through the Strait of Juan de Fuca, while a small portion of Koksilah River stocks return via Johnstone Strait.

Coho

The Cowichan River supports the largest coho run on Vancouver Island (10 year average 1966-1975: 34, 100 spawners). Sizeable populations are also found in the Koksilah, Nanaimo, Bonsall and Chemainus systems, with 10 year average escapements (1966-1975) of 5,200, 3,000, 1,400, and 600 fish respectively. Less significant runs exist in numerous smaller creeks including Bush, Chase, Departure, Holden, Holland, Hong Kong, Porters, Rocky Bay, and Stocking (Table II). Of these, Chase Creek has the largest coho run with an average of 425 spawners in 1974-1975.

TABLE II

AVERAGE (1966-1975) SALMON ESCAPEMENT TO AREAS 17 AND 18 (6)

SYSTEM	SOCKEYE	CHINOOK	COHO	CHUM	PINK	STEELHEAD
NANAIMO	few	1,400	3,000	35,500	450 (1951-60)	2,400 (1955-62)
CHEMAINUS	-	50	600	14,700	-	250 (1951-70)
DEPARTURE	-	-	25 (1964-73)	-	-	-
ROCKY BAY	-	-	15	25	-	-
BONSALL	-	-	1,400	300	-	-
BUSH	-	-	150	3,100	-	-
HOLLAND	-	-	75	4,800	-	few
PORTERS	-	-	25	10	-	-
STOCKING	-	-	25	3,000	-	-
CHASE	-	-	425 (1974-75)	100 (1974-75)	-	-
HOLDEN LAKE	-	-	75 (1938)	25 (1938)	-	-
COWICHAN R.	-	6,500	34,100	56,500	-	2,800 (1960-69)
KOKSILAH	-	350	5,200	4,000	-	150 (1959-68)
TOTALS (Approx.)	few	8,300	45,115	122,174	450	5,600

\- None Observed

Upstream coho migration takes place in the late summer and early fall. Spawning occurs from late August/early September to January, with slight variations in timing occurring from one river system to the next. Timing for the four major rivers are shown below.

PERIOD OF SPAWNING(1,2)

(Peak spawning periods are underlined)

Nanaimo	Aug. - Oct. - Dec.
Chemainus	Oct. - Nov./Dec. - Jan.
Cowichan	Sept. - Oct./Nov. - Dec
Koksilah	Sept. - Oct./Nov. - Dec.

Juvenile coho emerge in the spring and, typically, remain in freshwater for up to a year before migrating to the sea. In their second spring they move downstream as smolts to the estuarine environment where they feed and continue their development.

Chum

The Cowichan and Nanaimo Rivers support sizeable runs of chum (56,500 and 35,500 spawners respectively) as do, to a slightly lesser extent, the Chemainus, Holland, Koksilah, Bush, Stocking and Bonsall systems. Average escapements (1966-1975) for the latter six systems are 14,700, 4,800 4,000, 3,000, 3,000 and 300 fish respectively. Smaller runs also occur in numerous other creeks as noted in Table II.

Tagging studies have indicated that the majority of the Cowichan/Koksilah chum return to their natural streams via Juan de Fuca Strait with a small component passing through Johnstone Strait.

Upstream chum migration takes place during the late summer and early fall. Spawning begins soon after arrival in the streams and generally ends in December or January. Peak periods vary according to the stream as shown below.

PERIOD OF SPAWNING(1,2)

(Peak spawning periods are underlined)

Nanaimo	Sept. - Oct. - Dec.
Chemainus	Sept. - Oct. - Dec.
Cowichan	Oct. - Nov./Dec. - Jan.
Koksilah	Oct. - Nov./Dec. - Jan.

Chum fry emerge in the Spring after which the majority of the fry migrate directly downstream to an estuarine environment. Studies in the Nanaimo River Estuary indicated that juveniles spent up to 15 days in the estuary flats and a further 24-28 days in other nearshore environment.(2)

Chinook

Two runs of chinook salmon are recorded for the Nanaimo and Cowichan/Koksilah rivers. A spring run typically enters the streams from early April to late June and a fall run enters in the late summer or early fall. In the Cowichan, the smaller-sized, early run fish mature in the deep pools in the upper river and Cowichan Lake before spawning in the fall. Peak spawning times vary slightly from one river to the next as noted below.

PERIOD OF SPAWNING(1,2)

(Peak spawning periods are underlined)

Nanaimo	May - Sept. - Nov.
Chemainus	Sept. - Oct.
Cowichan	June - Sept./Oct. - Nov
Koksilah	June - Sept./Oct. - Nov.

Chinooks returning to the Cowichan and Koksilah Rivers gather in Cowichan Bay before beginning their upstream migration. The Cowichan run is by far the larger of these two, with a 10-year (1966-1975) average of 6,500 spawners as compared with only 325 in the Koksilah. The Chamainus run is very small averaging only 60 fish over the past 10 years (1966-1975), while the Nanaimo run is intermediate in size between the Cowichan and Koksilah with an average of 1,370 fish.(1,2)

After emergence, juvenile chinook display two periods of seaward migration. The majority migrate seaward some 3 months after emergence, and a smaller number migrate after a year of freshwater rearing.

Pink

Areas 17 and 18 currently support virtually no pink salmon stocks. No pinks have been reported in the Nanaimo River since 1960 although previous to that small numbers (an average of 450 spawners, 1951-1960) were recorded. Reports of pinks in the Cowichan and Chemainus do occur but most infrequently. The Koksilah supports no pink stock at all.

Sockeye

A situation similar to that described for pink salmon exists with sockeye stocks in Areas 17 and 18. Reports of sockeye have not been made for the Chemainus or Koksilah rivers and sockeye have only rarely been seen in the Cowichan River. A few (25 or less) are occasionally seen in the Nanaimo River. These are thought to be strays, descendents of introduced fish, or kokanee undertaking a seaward migration.

Anadromous Trout

Steelhead spawn in the Nanaimo River and its tributaries as well as the Cowichan, Koksilah and Chemainus Rivers. Small numbers are also found in local creeks including Chase and Millstone. Spawning generally takes place twice annually, one run in the spring and another in the winter. Although escapement figures are not available for all years in any of the major streams, average escapements for those years available are 2,800 for the Cowichan (1960-1969); 2,400 for the Nanaimo (1955-1962); 250 for the Chemainus (1961-1970); and 150 for the Koksilah (1959-1968).

Steelhead emergence is thought to begin in May and peak in June/mid-July. Up until spring of their third year, when smolt transformation occurs, juveniles reside in their natal streams migrating between the colder headwaters in the summer and warmer, lower reaches in the winter. As smolts, they migrate seaward in April/May, whereupon some remain in the estuarine environment for a time and some proceed directly into the sea.

Migratory cutthroat occur in the Nanaimo and its tributaries, the Cowichan, Chemainus and Koksilah Rivers and the Chase, Hong Kong and Holden Lake Creeks.

C. Sport Fishery

i) Tidal

Sport fishing in the coastal waters of Areas 17 and 18 is extremely popular. Apparently, over 30% of Duncan, Gulf Islands and Ladysmith residents own boats, and over 65% of their use is for fishing purposes. Similarly, almost 30% of Nanaimo and Gabriola Island residents own boats - and 85% of boat use is for fishing.(1,2) Figure 3 shows popular sport salmon fishing regions in Areas 17 and 18.

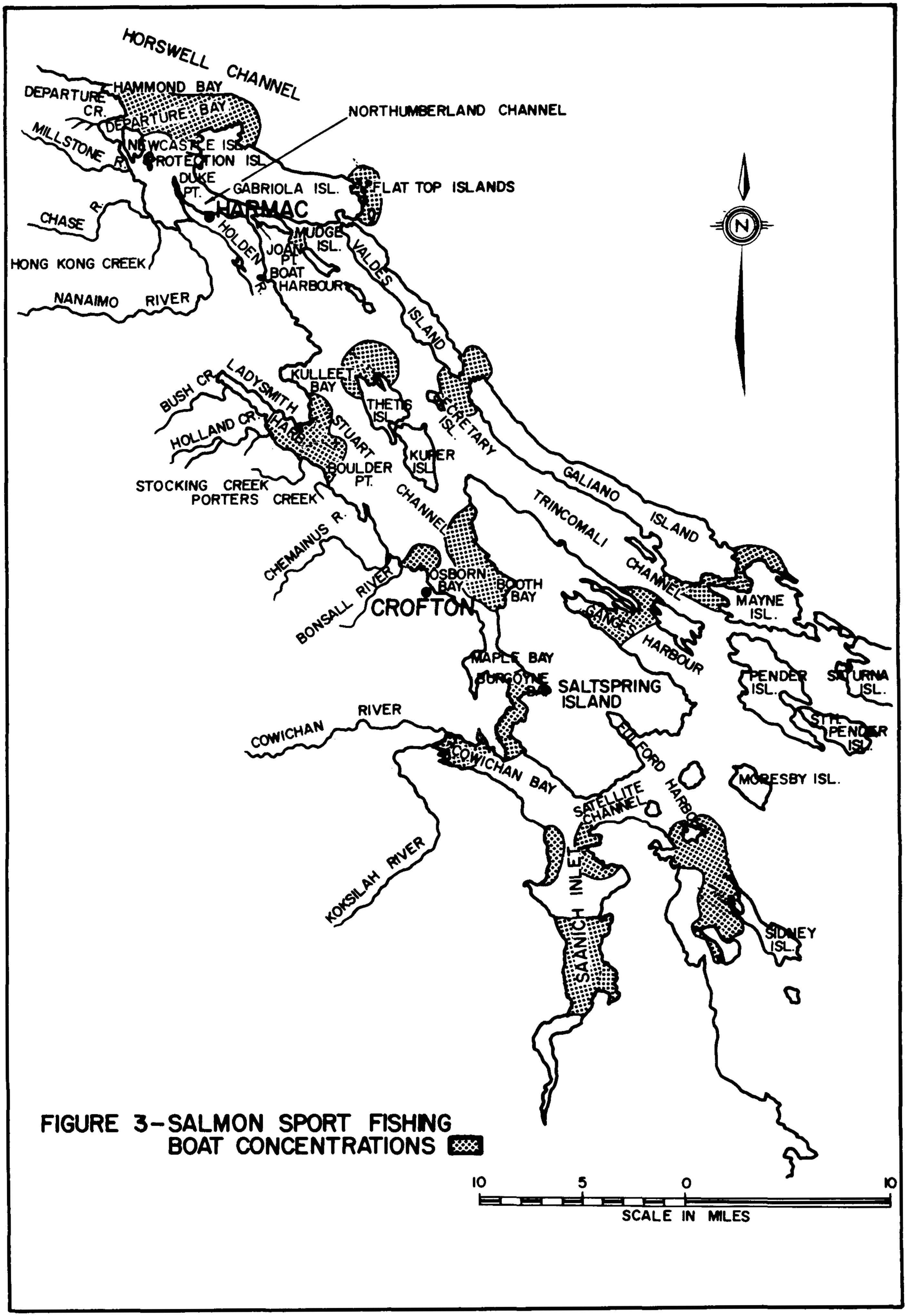

FIGURE 3-SALMON SPORT FISHING BOAT CONCENTRATIONS

In the Nanaimo area some 90% of the tidal sport fishing occurs within the boundaries of the Nanaimo Harbour where fish of mixed origin are taken. In late July - early August, chinook fishery exists at the north end of Northumberland Channel and takes predominately, fish bound for the Nanaimo River. The Georgia Strait sport fishery also takes coho and chinook originating from streams draining into Nanaimo Harbour.(2) As shown in Figure 3, sport fishing is not undertaken on a regular basis in the vicinity of the Harmac mill.

Within Area 18, one of the areas in B.C. most extensively fished by sportsmen, Cowichan-Koksilah and Chemainus fish contribute substantially to the catch. Though fishing effort is spread over a considerable area, Cowichan Bay in particular is noted for its late summer and fall chinook and coho fishery.(1) It should be noted that the area within the zone of influence of the Crofton mill is a popular sport fishing area (Figure 3). However, the effect of mill effluent in fishing success has not been extensively studied.

Over the past 10 years (1966-1975) in Areas 17 and 18, coho (excluding grilse) have constituted 36.3% of the sport catch, chinook and coho grilse 33.5%, chinook (including jacks) 28.3% and pink, sockeye and chum salmon 1.9% (Table III).

ii) Non-Tidal

Being close to several large population centers, Area 17 and 18 rivers are subject to heavy sport fishing pressure.

In Area 17 the Nanaimo lakes watershed is a popular fishing area. Rainbow and cutthroat trout are taken in First, Second and Fourth Nanaimo lakes and Panther, and Echo lakes introduced rainbows are also taken in Heart and Williams lakes. Chinook and coho salmon and steelhead trout are taken in the first 16 km of the Nanaimo River. The South Nanaimo River is officially closed to fishing as it is the Nanaimo City water source.(2)

The Chase and Holland Rivers also contribute to the steelhead catch, though to a less extent than previously mentioned systems.

In Area 18 the Cowichan Valley has been recognized historically as a prime sport fishing area. It, together with the Koksilah and Chemainus rivers, are heavily utilized particularly for steelhead and cutthroat which dominate the sport catch.

Table IV shows steelhead sport catch figures for 1974-1976.

TABLE III

Tidal Salmon Sport Fishery(8)

AREA 17

YEAR	CHINOOK*	COHO	SPRING GRILSE	COHO GRILSE	PINKS & OTHERS**	TOTAL	EFFORT BOAT DAYS	AVG. CATCH BOAT DAYS
1975	14,960	18,035	8,480	7,555	290	49,320	39,927	1.2
1974	6,045	27,425	4,170	13,875	435	51,950	33,149	1.6
1973	5,120	7,420	5,680	12,065	345	30,630	22,225	1.4
1972	9,855	5,105	6,730	5,415	320	27,425	23,763	1.2
1971	5,620	29,853	2,590	14,550	103	52,716	28,373	1.9
1970	3,725	10,600	3,425	13,900	-	31,650	25,275	1.2
1969	8,050	10,950	2,850	6,625	100	28,575	26,325	1.1
1968	6,890	8,480	15,070		160	30,600	20,050	1.5
1967	6,150	5,700	10,450		150	22,450	19,950	1.1
1966	6,250	8,075	17,050		-	31,375		
1966-75 mean	7,266	13,164	13,748		190	35,669		
AREA 18								
1975	12,618	5,531	1,759	1,479	488	21,875	-	-
1974	7,830	6,260	990	2,042	1,402	18,524	28,392	0.7
1973	11,530	4,084	2,558	1,820	1,920	21,912	24,617	0.9
1972	7,189	4,185	1,655	3,965	820	17,814	21,337	0.8
1971	11,977	11,775	2,865	1,415	485	28,517	26,464	1.1
1970	10,000	9,775	4,950	2,150	150	27,025	29,050	0.9
1969	6,025	4,550	2,200	1,825	1,200	15,800	24,950	0.6
1968	7,410	10,490	3,830		1,490	23,220	27,580	0.8
1967	6,625	8,950	2,850		1,200	19,625	21,850	0.9
1966	8,100	10,075	2,450		100	20,725		
1966-75 mean	8,930	7,567	4,080		925	21,504		

Includes Jacks

* Others includes Sockeye & Chum

TABLE IV

Non-Tidal Sport Catch - Steelhead* (9)

AREAS 17/18

STREAM	DAYS FISHED		NO. ANGLERS		KEPT		RELEASED		KEPT/DAY	CATCH/DAY
	Reported	Estimated	Reported	Estimated	Reported	Estimated	Reported	Estimated		
Chase										
1975/76	1	5	1	5	0	0	0	0	0	0
1974/75	-	-	-	-	-	-	-	-	-	-
Chemainus										
1975/76	202	1012	42	203	31	154	20	101	0.153	0.252
1974/75	137	466	27	92	17	57	17	57	0.124	0.248
Cowichan										
1975/76	1822	9048	277	1347	343	1707	196	980	0.188	0.296
1974/75	2383	8120	364	1203	271	924	199	680	0.114	0.197
Holland										
1975/76	6	30	1	5	1	5	0	0	0.167	0.167
1974/75	-	-	-	-	-	-	-	-	-	-
Koksilah										
1975/76	253	1271	37	180	42	210	19	95	0.166	0.241
1974/75	296	1009	57	194	43	146	33	112	0.145	0.257
Nanaimo										
1975/76	1757	8431	202	954	259	1227	144	714	0.147	0.229
1974/75	1258	4304	187	640	205	698	107	363	0.163	0.248

* Steelhead statistics are obtained by a postcard survey system and estimates are made from reported figures.

\- No record

D. Indian Food Fishery

Approximately 500 Indians live on reserves in the Nanaimo area. A sizeable food fishery is undertaken close to the mouth of the Nanaimo River. The catch, which consists of both salmon (chum, coho and chinook) and steelhead trout, is taken mainly with gill-nets although a few fish are occasionally speared. Chum make up the bulk of the Area 17 catch with an 8-year annual average (1968-1975) of 2,039 fish. Yearly coho and chinook catches average (1968-1975) 251 and 108 fish respectively (Table V).(2)

The Cowichan Valley has one of the largest Indian communities on Vancouver Island. Their food fishery is conducted largely on the lower Cowichan River using spears, gaffs, and, to a limited extent, gill-nets. Chum make up the bulk of the catch (an average of 3,100 pieces from 1966-1975) although coho and chinook are also taken in sizeable quantities (an average of 1,900 and 1,050 pieces respectively from 1966-1975). Steelhead are taken in smaller numbers (Table V).(1)

III HERRING

Areas 17 and 18 encompass extensive herring spawning grounds. Since 1971, Saltspring, Prevost, Saturna, Thetis, Gabriola, Newcastle and Protection islands have all been utilized for spawning. On Vancouver Island, spawning sites are located intermittently along the coast from Ladysmith Harbour, north to Nanoose Bay (Figure 4). Although Nanaimo Harbour and the immediate area along the delta front was at one time utilized, no spawn has been observed there in the past 15 years. Records show that the annual spawn for Areas 17 and 18 combined, over the past three years (1972-1976) has averaged approximately 35.8 statute miles. This represents an average of 11.3% of the total B.C. spawn for this time period. Estimates of numbers of spawners and amount of spawn deposited for Areas 17 and 18 is presented in Table VI.

Spawn is deposited in the late winter on kelp, eelgrass, rockweed, rocks, pilings and even trash between high tide to a depth of about 11 m. Juveniles hatch approximately 2 weeks after egg deposition and rear in estuarine or nearshore waters. During this time they form an important link in salmon-supporting food chains.(2)

Biological surveys have indicated measurable pulp mill effects on intertidal organisms in the area between Mudge and Gabriola Islands. This area is extensively utilized by spawning herring stocks.(3) However, information is not available regarding the effects of the effluent on the mature herring or the development of juveniles. The False Narrows Area, northeast of Mudge Island, has been the most important spawning site for herring in the past 6 years (1971-1976).

TABLE V

Indian Food Fishery(10)

AREA 17

YEAR	CHINOOK	COHO	CHUM	STEELHEAD
1975	60	50	1,750	-
1974	75	95	2,750	-
1973	90	145	3,150	-
1972	50	60	2,975	-
1971	175	545	1,800	-
1970	150	750	2,450	-
1969	10	65	760	-
1968	255	300	680	-
1967	-	-	-	30
1966	-	-	-	-
1968-75	100	250	2,000	-

AREA 18

1975	1,500	4,000	2,000	
1974	2,500	2,500	5,000	
1973	2,000	1,500	2,200	
1972	1,500	1,500	3,000	
1971	725	2,450	1,375	25
1970*	910	3,280	2,204	30
1969**	250	770	3,400	20
1968	525	1,065	5,395	75
1967	280	510	4,008	150
1966	380	1,025	2,772	200
1966-75	1,000	1,900	3,100	

* 10 sockeye salmon

** 5 pink salmon

TABLE VI

Herring Catch, Spawners, Amount of Spawn (5,11,12,13,14)

AREA 17

YEAR	CATCH 000's Lb.	CATCH MILLIONS FISH	SPAWNERS* MILLIONS FISH	CATCH & SPAWNERS MILLIONS FISH	SPAWN STATUTE MILES	
					1976	44.4
1975	10,805	-	-	-		34.1
1974	4,897	-	-	-		56.6
1973	7,288	26.4	231.2	257.6		23.3
1972	6,226	22.9	53.0	75.9		10.6
1971	1,063	4.6	305.9	309.5		23.2
1970	271	4.5	243.4	247.9		16.3
1969	740	2.8	9.9	12.8		
1968	461	9.9	155.7	165.5	25 yr. avg.	
1967	762	314.6	13.0	327.6	1940-64	22.5
1966	4,271	196.8	3.6	200.4		
1956-65	53,538	254.3	130.2	384.5		

AREA 18

YEAR	CATCH 000's Lb.	CATCH MILLIONS FISH	SPAWNERS* MILLIONS FISH	CATCH & SPAWNERS MILLIONS FISH	SPAWN STATUTE MILES	
					1976	2.6
1975	6,517	-	-	-		19.7
1974	1,744	-	-	-		10.6
1973	1,807	5.7	50.6	56.3		19.8
1972	3,631	17.4	55.8	73.2		12.2
1971	2,165	7.6	75.5	83.1		18.6
1970	1,488	1.9	105.3	107.2		18.0
1969	736	4.1	60.2	64.3		
1968	92	13.1	71.4	84.5	25 yr. avg.	
1967	1,994	55.2	12.3	67.4	1940-64	3.0
1966	9,220	31.4	16.2	47.6		
1956-65	25,610	153.1	25.0	178.1		

* Calculated from square yards of spawn and fecundity.

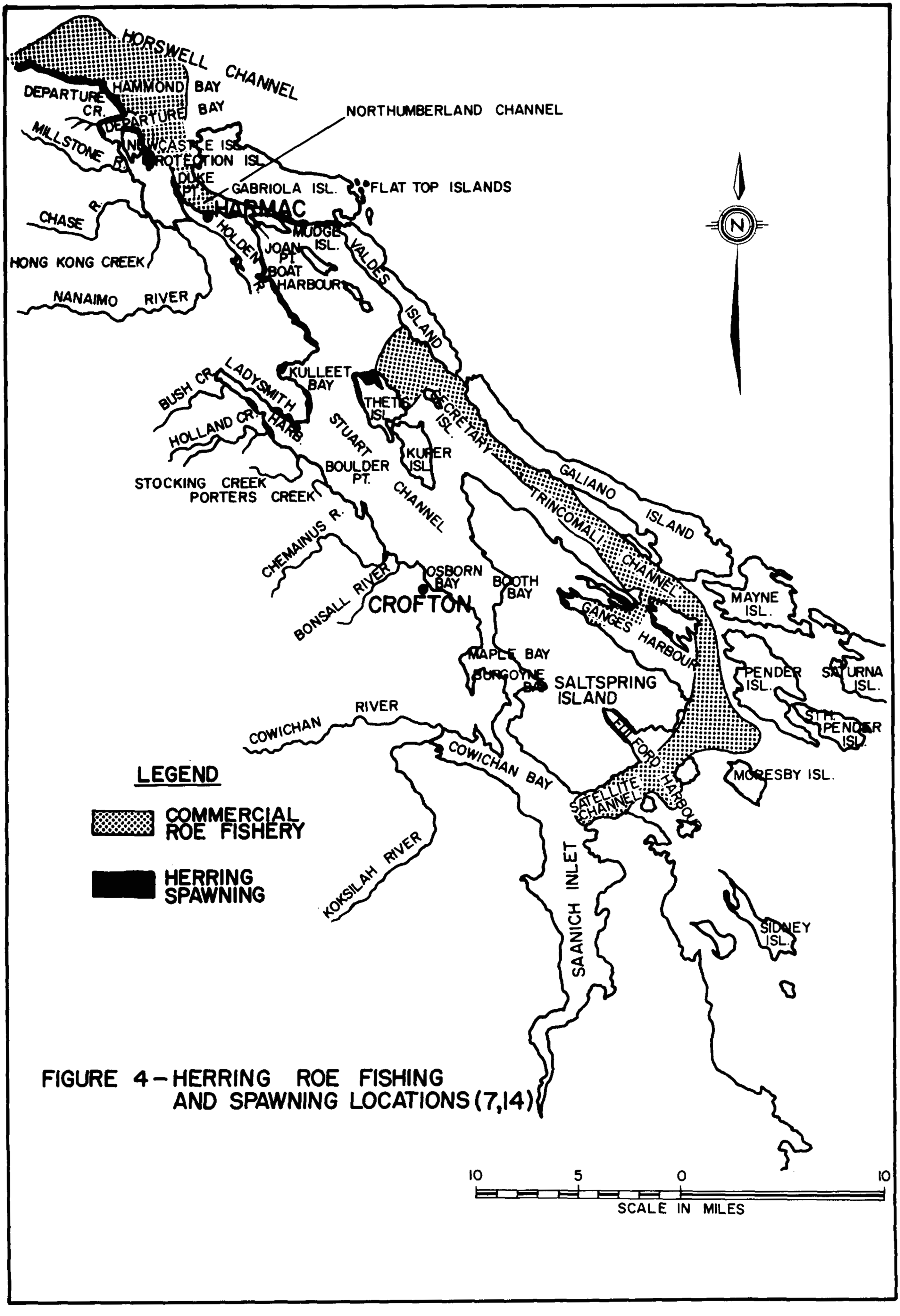

FIGURE 4 - HERRING ROE FISHING AND SPAWNING LOCATIONS (7,14)

Herring in Areas 17 and 18 support a sizeable roe fishery contributing approximately 11.7% towards the total B.C. catch. Gill-nets and seines are used to take adult fish just prior to the spawning period in the spring (February - April). The roe fishery has replaced the herring reduction fishery that existed in B.C. up until 1971. Herring catch statistics for 1956-1975, both by weight and number of fish is presented in Table VI. Estimates of herring stocks (catch + spawners) are also presented. Table X shows landed values of the herring catch in Area 17 for 1967-1975.

Most of Area 17 and 18's herring catch (72% from 1966-1975) is taken in Area 17 (Table VI). In this region, the Horsewell Bluff - Nanoose Bay area is particularly noted for its returns. As shown in Figure 4, this herring fishing area lies within the zone of influence of the Harmac mill. Trincomali Channel also contributes to the roe herring catch (Figure 4). Ladysmith Harbour, the Chamainus River estuary - Osborn Bay area, and Cowichan Bay (Cowichan/Koksilah River estuary) are closed to net fishing and do not contribute to the roe fishery. However, both the Cowichan and Chemainus estuary areas undoubtedly contribute to herring production by providing rearing areas.

IV CRUSTACEANS

Crabs, shrimp, and prawns are taken commercially in Areas 17 and 18. Table VII presents crustacean catch statistics for this area. It is generally felt that these statistics under-estimate the resource, as significant amounts are sold to the public directly from the boats. As they are reported, however, mixed shrimp taken in Areas 17 and 18 represent 17.7% of the B.C. catch by weight, prawns represent 3.3% and crabs 1.3%

Commercial shrimp trawling and prawn trapping is carried out north of Newcastle Island in the Five Finger Island and Hudson Rocks area in the northern part of Northumberland Channel, and near the Flat Top islands (Figure 5). Dungeness crab (Cancer magister) are fished extensively in the Nanaimo estuary area, particularly southwest of Jack Point at low tide in late spring and early summer. The crabs in the Nanaimo estuary account for almost the entire Area 17 crab catch as presented in Table VII. (1.3% of average 1966-1975 B.C. catch).

In Area 18, prawn trapping is carried out on a small scale by salmon fishermen in the off-season. More important is the Stuart Channel, particularly Sansum Narrows, shrimp trawling

TABLE VII

Commercial Crustacean/Mollusc Catch(5)

(000's Lb.)

AREA 17

YEAR	PRAWNS	MIXED SHRIMP/ PRAWNS	CRABS IN SHELL	ABALONE	BUTTER CLAMS	LITTLENECK JAPANESE	LITTLENECK NATIVE	MIXED CLAMS	OYSTERS (SHUCKED) U.S. GAL.
1975	6	64	58	-	102	62	68	3	12,089
1974	13	111	47	-	175	42	72	-	16,576
1973	6	86	8	-	206	89	129	-	24,164
1972	45	103	2.9	7.3	83	54	120	-	19,622
1971	3.3	53	12.8	-	194	144	289	11	15,515
1970	8.0	49	18.2	-	271	134	103	32	10,619
1969	.8	193	15.3	-	173	32	109	9	16,447
1968	.3	529	13.6	-	251	78	44	32	18,558
1967	.8	520	20.2	-	464	31	61	-	21,973
1966	4.6	352	17.5	-	446	7	25	-	25,976
1956-65	1.8	271	9.1	-	222	46	12	18	33,979
1966-75	4.7	206	21.4	.1	237	67	102	9	18,154

AREA 18

YEAR	PRAWNS	MIXED SHRIMP/ PRAWNS	CRABS IN SHELL	ABALONE	BUTTER CLAMS	LITTLENECK JAPANESE	LITTLENECK NATIVE	MIXED CLAMS	OYSTERS (SHUCKED) U.S. GAL.
1975	-	48	72	-	43	20	25	-	-
1974	1	3	10	-	29	11	21	-	-
1973	1	171	13	-	47	19	47	-	-
1972	0.8	185	14.7	7.0	300	411	300	.6	-
1971	0.5	69	16.2	-	134	101	175	10.3	-
1970	0.2	3	15.1	3.5	121	11	36	.4	-
1969	-	-	16.7	-	29	36	21	6.7	-
1968	-	4	12.2	-	55	41	51	.7	-
1967	-	30	11.6	-	10	59	9	-	-
1966	0.2	27	8.6	-	63	22	7	-	-
1965-66	-	5	7.1	-	80	28	18	5.0	67
1966-75	0.4	54	18.9	1.1	83	73	67	1.9	-

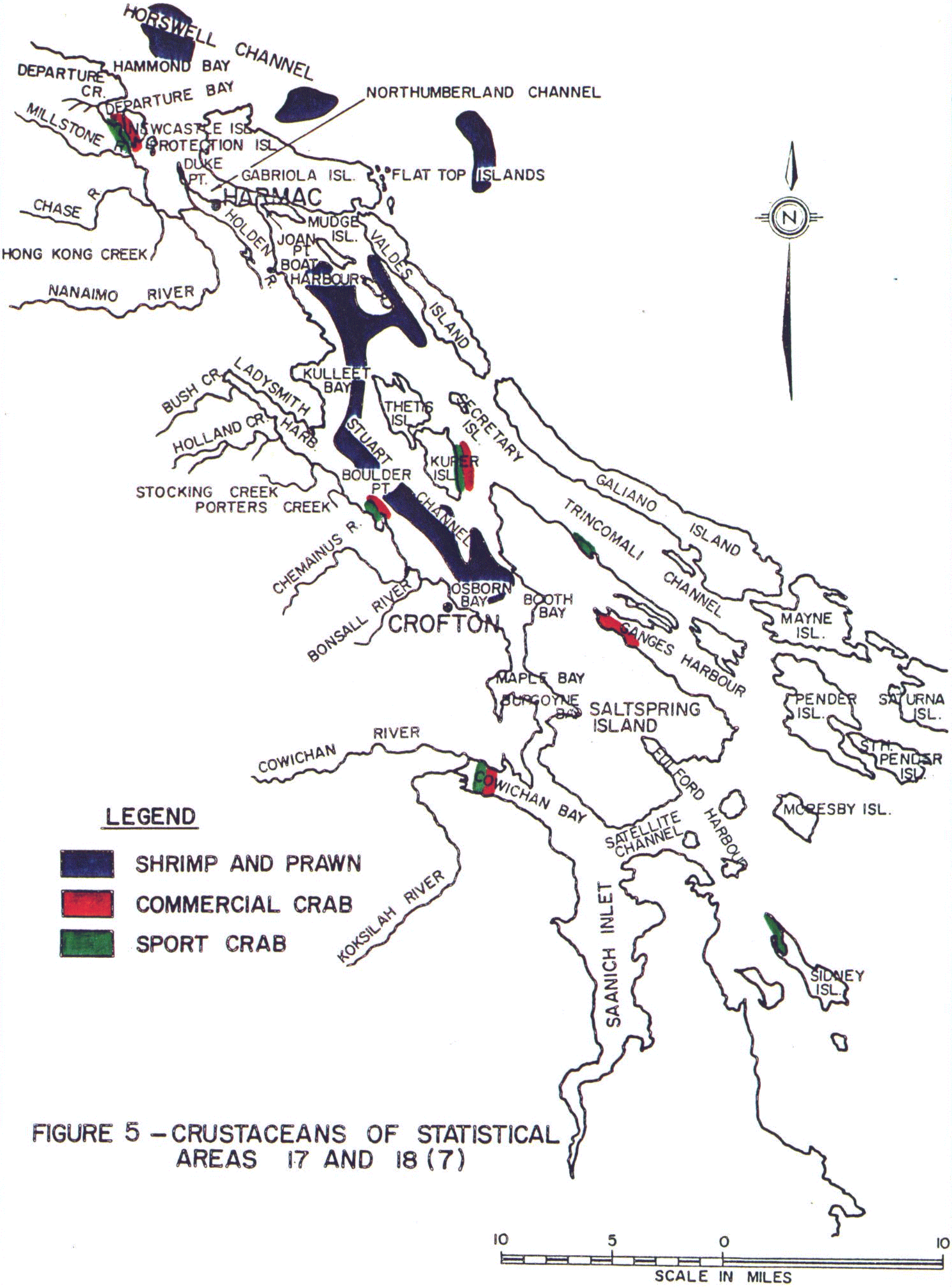

FIGURE 5 – CRUSTACEANS OF STATISTICAL AREAS 17 AND 18 (7)

grounds which contributes a significant proportion of the B.C. catch. This fishery is undertaken within the zone of influence of the Crofton Mill (Figure 5). Crab trapping is done on a small scale off Shoal, Kuper, Saltspring and Sidney Islands and in Cowichan Bay (Figure 5).

Table VIII presents landed values of Area 17 and 18 invertebrate fisheries.

V MOLLUSCS

Areas 17 and 18 are productive shellfish regions both in terms of a commercial and recreational resource. Unfortunately, many of the most suitable growing areas are presently closed to the taking of shellfish owing to bacterial or viral contamination (Figure 6). A close check is kept on contamination levels in shellfish-growing areas and closures are instituted where deemed necessary.

Suitable shellfish growing areas in the Nanaimo region, particularly the lower portion of the Nanaimo estuary, are populated by species of bivalves, including butter clams (Saxidomus giganteus), Japanese littleneck clams (Venerupis japonica), and native littleneck clams (Protothaca staminea) as well as Pacific oysters (Crassostrea gigas). Other edible but less popular resident species include horse clams (Tresus capax and T. nuttallii) soft-shelled clams (Mya arenaria) and cockles (Clinocardium nuttallii). Outside the estuary, oysters are found in abundance along the northwest shore of Newcastle and Protection Islands and Duke Point lagoon on the west side of Northumberland Channel, north of Harmac. Other oyster beds are shown in Figure 7. (2)

Butter clams, Japanese littleneck and native littleneck clams are also found in the Cowichan-Chemainus estuary area. In addition, Ladysmith Harbour, the Crofton-Chemainus area and Thetis Island are some of the most important oyster-producing areas of B.C. These and other shellfish growing areas of significance are shown in Figure 7. Virtually all oyster culture has historically been done on leased portions of the intertidal zone, often under estuarine conditions. Unfortunately, as mentioned previously, shellfish restrictions prohibit the taking of bivalves in many of the aforementioned areas (Figure 6) unless decontamination procedures are undertaken. That is, the harvesting of oysters from contaminated areas is permitted only if oysters are relaid on a registered commercial oyster lease in a non-contaminated area for a minimum of two weeks, or if they are purified using ultraviolet treated seawater at the Ladysmith depuration plant.

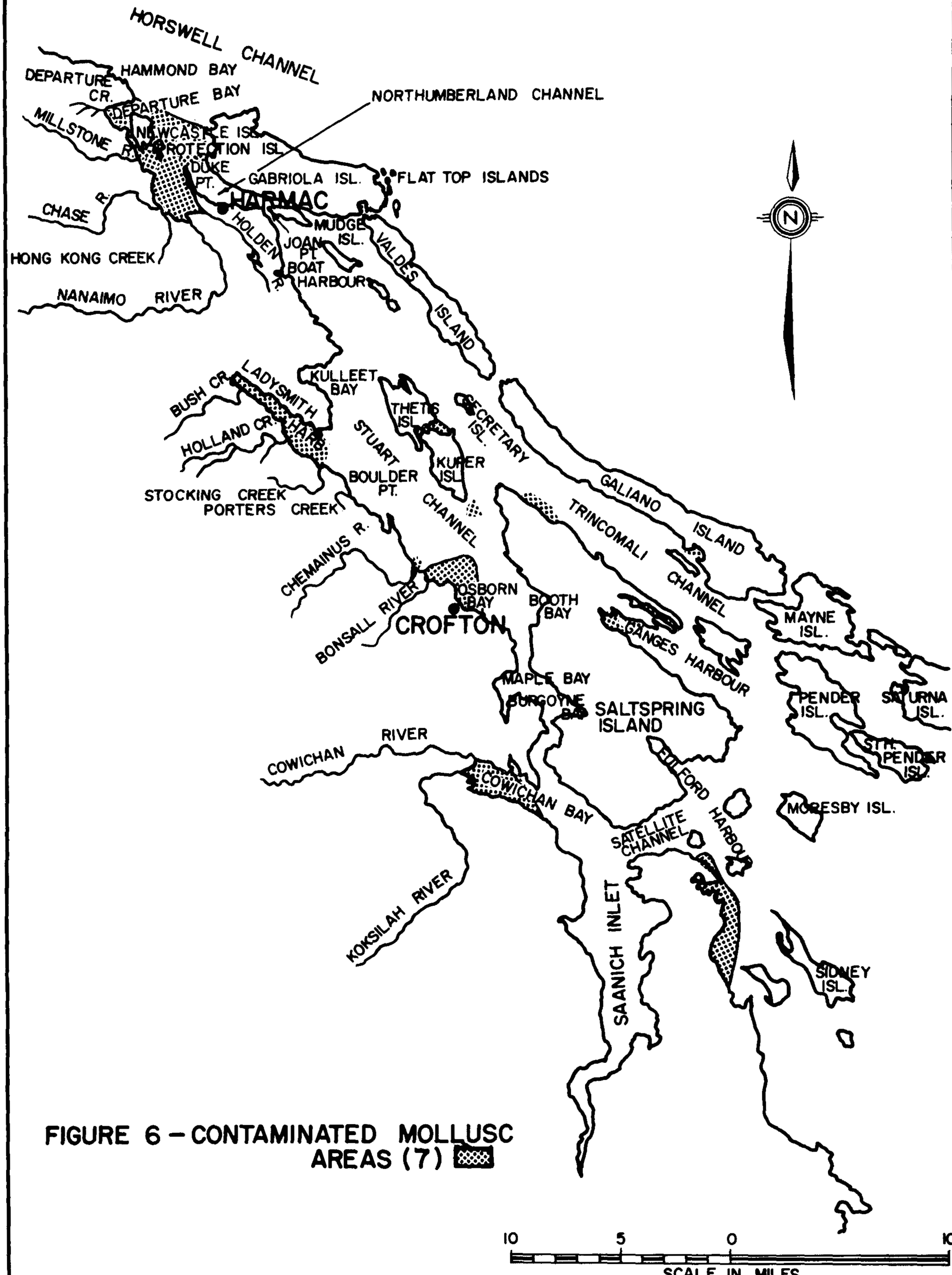

FIGURE 6 – CONTAMINATED MOLLUSC AREAS (7)

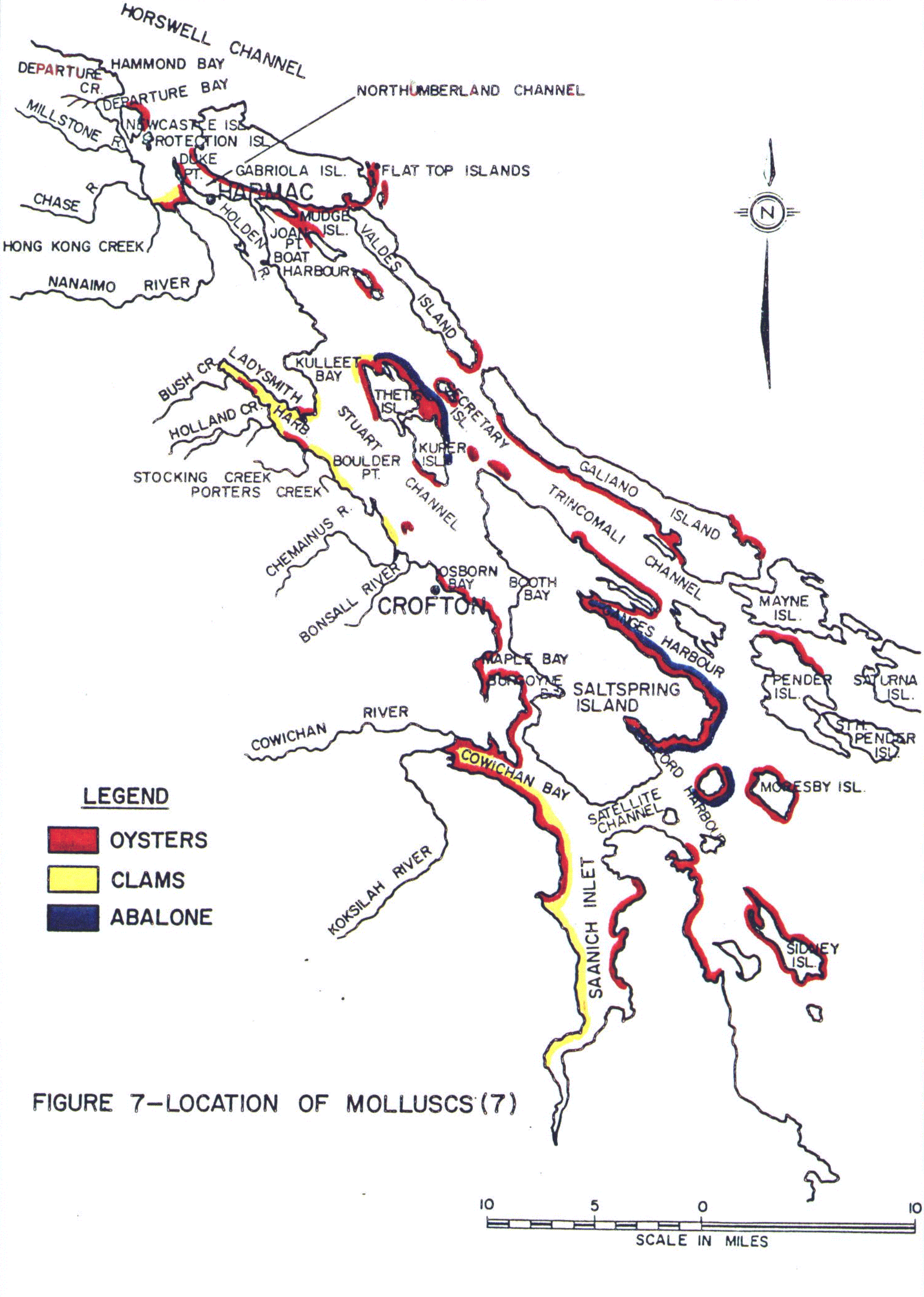

FIGURE 7–LOCATION OF MOLLUSCS (7)

TABLE VIII

Annual Reported Landed Values of Invertebrate Fisheries[1,2]
($000's)

AREA 17

YEAR	PRAWNS	SHRIMP	CLAMS	CRAB	ABALONE	OYSTERS
1975	5.7	29	33	40	-	-
1974	9	41	36	28	-	-
1973	6	34	47	5	3	157
1972	3	38	33	1	-	117
1971	2	18	65	4	-	91
1970	4	12	96	3	-	71
1969	-	44	26	3		97
1968	-	96	26	2		115
1967	-	91	32	3		126

AREA 18

YEAR	PRAWNS	SHRIMP	CLAMS	CRAB	ABALONE	OYSTERS
1975	-					
1974						
1973	1	62	113	6	2	
1972	1	61	121	5	3	
1971	-	19	43	5	-	
1970	-	10	14	3	1	
1969	-	-	7	3		
1968	-	1	10	2		
1967	-	5	6	2		

As oysters are an important recreational resource, a provincial oyster reserve has been established at Boulder Point on the south shore of the entrance to Ladysmith Harbour. Here oysters are laid exclusively for recreational harvesting.

Ladysmith Harbour is also an important area for oyster seed collection in B.C. Here, spatfall occurs with predictable frequency and at considerable densities. This is in contrast to the typical situation in B.C. oyster-growing areas where spatfall is erratic and the timing variable. Because of over-crowding, considerable amounts of seed are transferred from floats in Ladysmith Harbour to growing areas along the coast where development to maturity occurs.(1)

The species of commercially important molluscs in Areas 17 and 18 listed in order of decreasing significance to the provincial catch are: Japanese littleneck (43.7% by weight of B.C. catch, 1966-1975 average), native littleneck (32.7%), butter clams (23.5%), oysters (16.7%), abalone (2.2%), and razor clams (0.3%) (Table VII).

The effect of pulp mill effluent on oysters may be evidenced in several ways, namely; mortality, reduced growth rate, reduced condition factor (fatness), and effect on breedings.(16) An investigation into the effect of Harmac kraft mill effluent on local oysters has been made. Oysters experimentally planted into the area exposed to mill effluent were found to undergo a reduction in condition factor (fatness) and growth rate. Oysters resident in the zone of mill influence, particularly Dodd Narrows, were found to be slower growing and less well-nourished than controls.(2)

The Crofton mill is located in the immediate vicinity of extensive oyster-growing grounds (Figure 6.). A survey of condition factors in Pacific oysters in the vicinity of the mill outfall showed conditions to be best at a station most distant from the outfall (3 km) and lowest adjacent to it.(4) Commercial production in the Crofton area was terminated in 1964-1965 due to deleterious effects of the pulp mill.(16)

Molluscan filter feeders, have the ability to accumulate potentially toxic heavy metals to levels greatly in excess of those occurring in their environment.(16) Until recently, zinc hydrosulphite was used as a brightening agent in newsprint manufacture. The zinc which this process produced as a byproduct was released to surrounding water where it was accumulated by local shellfish. In the vicinity of the Crofton mill, oysters were effected by zinc contamination from between Chemainus Bay and Shoal islands on the northwest, to beyond

Burgoyne Bay to the southeast. To the north, elevated zinc concentrations in oysters were detected as far as Secretary Islands in Trincomali Channel (off the eastern shore of Kuper Island).(17) Mussels and clams examined did not show significant zinc contamination.(17)

Molluscs within Areas 17 and 18 are the resources which probably suffer most as a result of the presence of the pulp mill effluent. Harvests, particularly in Area 18, have been reduced dramatically due to restrictions necessitated by various pollution sources.

VI HALIBUT AND GROUNDFISH

Halibut taken from Areas 17 and 18 represent a very small part (1966-1975 average 0.005%) of the total B.C. catch. Similarly, cod, flounder, sole, and ocean perch have constituted an average of only 4.9%, 3.6% 1.6% and 0.25% respectively of the total B.C. catch (1966-1975). Skate is the only groundfish in Areas 17 and 18 which provides more than 10% of the provincial catch (10.3%) (Table IX). Figure 8 shows areas where lingcod are taken both commercially and by sport fishermen. Table X shows landed values for some Area 17 groundfish for 1967-1975.

Groundfish stocks including lemon soles, which spawn to the north of the Crofton mill in the Gulf Islands(Pylades Channel and west of the DeCourcy group of Islands), and grey cod which follow the herring through satellite and Trincomali Channels, are valuable fish which may be affected by pulp mill effluent.(18)

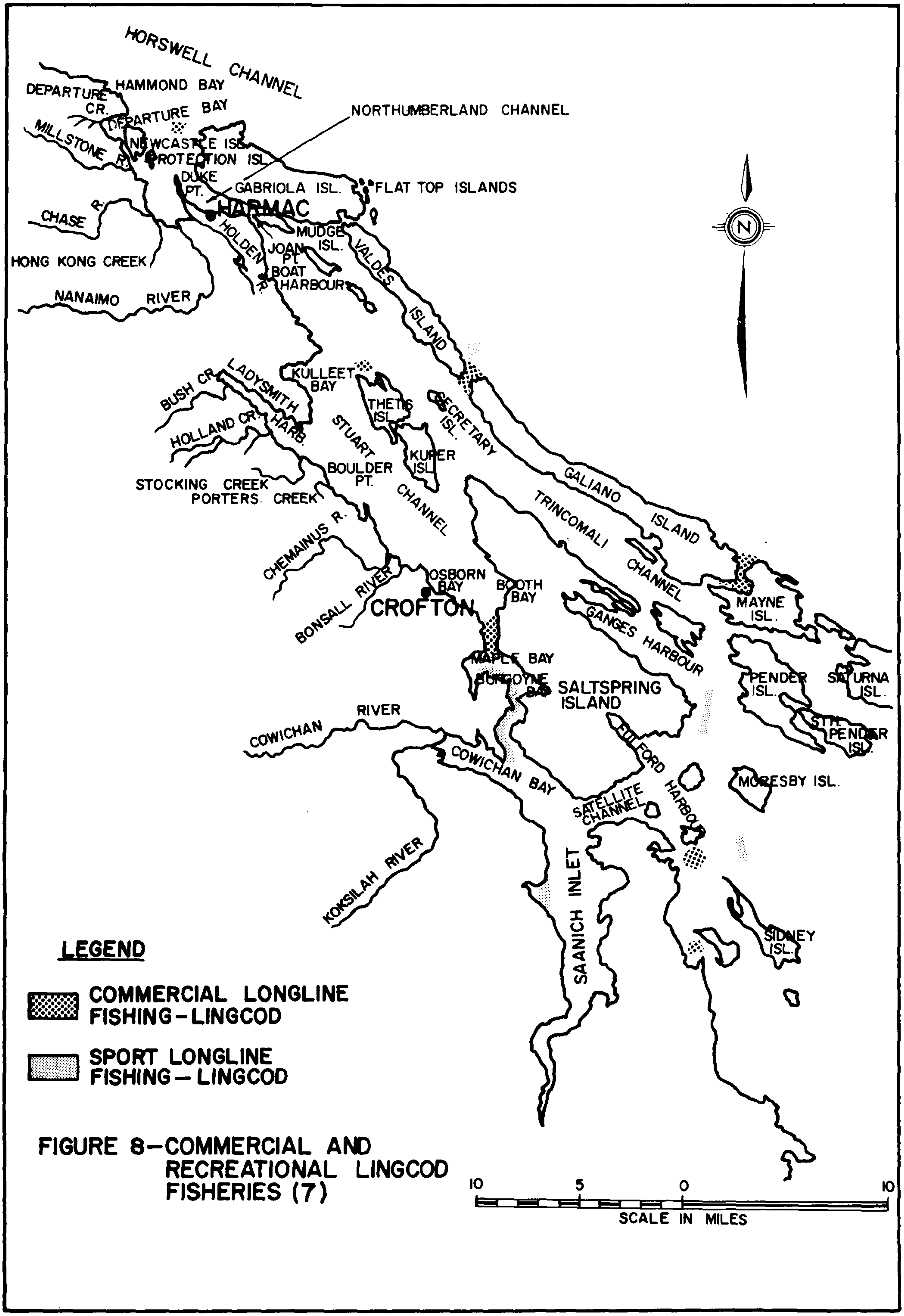

FIGURE 8—COMMERCIAL AND RECREATIONAL LINGCOD FISHERIES (7)

TABLE IX

Commercial Catch - Groundfish(5)

(000's Lb.)

AREA 17

YEAR	HALIBUT	SOLE	COD*	FLOUNDER	SKATE	OCEAN PERCH
1975	-	66	416	3	4	13
1974	-	46	494	2	3	5
1973	1	48	510	1	1	8
1972	0.2	35	783	1.3	2.6	14.6
1971	1.9	34	976	1.8	4.8	24.7
1970	8.4	49	684	3.2	6.1	0.1
1969	-	72	385	10.3	12.4	12.0
1968	0.1	52	546	3.9	8.5	1.8
1967	-	69	449	4.8	7.7	0.4
1966	-	79	282	3.5	2.4	3.3
1956-65	0.1	84	773	4.9	8.8	10.5
1966-75	1.2	55	552	3.5	5.2	8.3

AREA 18

YEAR	HALIBUT	SOLE	COD*	FLOUNDER	SKATE	OCEAN PERCH
1975	-	118	613	6.0	9	-
1974	-	109	524	4.0	9	1
1973	-	134	469	8	6	-
1972	-	87	349	2.1	4.5	-
1971	-	89	480	3.6	10.3	0.5
1970	-	111	464	1.0	14.6	1.6
1969	0.1	87	328	3.8	15.3	0.4
1968	0.1	96	308	12.1	18.9	0.2
1967	-	59	394	4.8	12.8	0.2
1966	-	76	312	1.7	18.5	-
1956-65	0.6	102	533	4.5	16.7	2.2
1966-75	-	97	424	4.7	11.9	0.8

* Cod = red, rock, ling, grey, black

TABLE X

Annual Reported Landed Values in $000's for Area 17 (2)

YEAR	SALMON	HERRING	HALIBUT	SOLE	RED AND ROCK COD	LING COD	GREY COD	BLACK COD	DOGFISH	AREA TOTAL **
1975	401	1,129	1	12	5	64	26	*	18	1,766
1974	901	784	*	7	6	80	35	1	67	2,003
1973	529	614	1	6	5	51	27	2	178	1,663
1972	483	187	*	3	5	44	47	3	3	973
1971	598	41	1	3	4	58	56	2	2	949
1970	228	10	3	3	4	59	14	1	*	949
1969	154	37	*	5	2	28	6	*	*	405
1968	108	26	*	4	3	28	14	*	11	433
1967	126	13	*	5	1	17	17	*	10	442

* Nil

** All Species Including Shellfish

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