ENVIRONMENTAL PROTECTION BRANCH
ENVIRONMENT PROTECTION SERVICE
PACIFIC REGION

PULP MILL ENVIRONMENTAL IMPACT ASSESSMENT
OCEAN FALLS CORPORATION,
OCEAN FALLS, B.C.

Regional Program Report: 79-6

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 contains a brief description of the location, history, processes and environmental impact of the Ocean Falls Corporation mill at Ocean Falls, B.C. The major impact is a significant accumulation of fibre on the bottom of the inlet adjacent to the mill and extending approximately 1.75 nautical miles (3.15 km) down inlet. The fibre deposit has a high oxygen demand which contributes to depressed dissolved oxygen levels in the bottom waters at the inlet's head.

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 qualité environnementale de chacune des régions et déterminé quelles études supplémentaires seraient utiles.

Ce rapport fournit des renseignements sure l'historique et l'emplacement de l'Ocean Falls Corporation, entreprise industrielle située à Ocean Falls, en Colombie-Britannique. Il traite également des méthodes d'exploitation et des répercussions mésologiques de celles-ci. L'incidence la plus sérieuse consiste en une importante accumulation de fibres sur le fond de l'inlet, adjacent à l'établissement.

Ce dépòt, que s'étend sur une distance de 1,75 milles marins (3,15 kilometres), consomme une grande quantité de'oxygène dissous, de sorte qu'il n'en reste qu'une très faible concentration au fond de l'eau, à la tête de l'inlet.

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SUMMARY AND CONCLUSIONS

The Ocean Falls Corporation pulp mill has reduced its pollution load considerably since the discontinuation of chemical pulping in 1967. The termination of hydraulic debarking in 1977 further reduced the organic loading imposed upon the waters at the head of Cousins Inlet. The most serious impact of the mill at present is its continued fibre deposition. The fibre bed has been observed to extend 1.75 n mi. (3.25 km) down inlet from the mill (Packman et al, 1975; and Packman, 1976). During a Pisces IV submersible dive in 1976 (Packman, 1976) recolonization of the surface of the fibre bed was apparent at its furthest extremity.

The toxicity of the effluent is due mainly to zinc which is used as a bleaching agent to brighten the pulp. However the zinc concentrations in the receiving environment are not acutely toxic and there is not a serious problem of zinc accumulation in the local fauna.

Damage to the intertidal or shallow subtidal communities in the inlet appears negligible. As well, the salmon runs in the Martin River are not being significantly impacted by the mill effluent.

Significant reductions in total suspended solids and BOD_5 are required to further reduce the impact of the mill upon the receiving environment of Cousins Inlet. Negotiations are presently underway with the Ocean Falls Corporation to determine how this may be accomplished.

1 INTRODUCTION

The Ocean Falls Corporation paper mill is located at the head of Cousins Inlet approximately 325 miles north of Vancouver (Figure 1). Cousins Inlet heads due north from the junction of Fisher and Dean channels, between Bella Bella and Bella Coola. Three rivers, the Martin, Link and Ikt, flow into Cousins Inlet, as well as numerous small runoff streams. The Link River, dammed to form Link Lake reservoir, provides a continuous flow of 1×10^6 imp gal/day (3.8×10^6 litres/day) into the head of Cousins Inlet. This flow is constant year-round but may be decreased in the case of an extremely dry summer.

The climate of Ocean Falls is extremely wet, having an average of 221 days per year with measurable precipitation and a mean annual precipitation of 172.82 inches. Due to its modified maritime climate, air temperatures at Ocean Falls fluctuate very little throughout the year. A complete summary of precipitation and temperature data collected by the Atmospheric Environment Service is contained in Table 1.

Cousins Inlet is surrounded by rugged mountainous terrain with a forest cover representative of the coastal Western Hemlock - Western Red Cedar Zone (Krajina, 1965). Hunting and fishing are the major recreational attributes of this area for the local residents. In the past, both shores of Cousins Inlet were utilized extensively for log-booming, an activity which extended well beyond Coolidge Point. However, at present, due to decreased production and the import of semi-bleached kraft pulp, booming activities have greatly decreased, such that booms are only located in that part of the inlet adjacent to the pulp mill. The inlet is also used for marine and floatplane transportation. Government and private wharves and two marinas are located directly adjacent to the town for use by fishing vessels, coastal freighters, barges and craft belonging to the local populace (Packman et al, 1975). A berth for the British Columbia Ferries Corporation's "Queen of Prince Rupert" is presently being constructed.

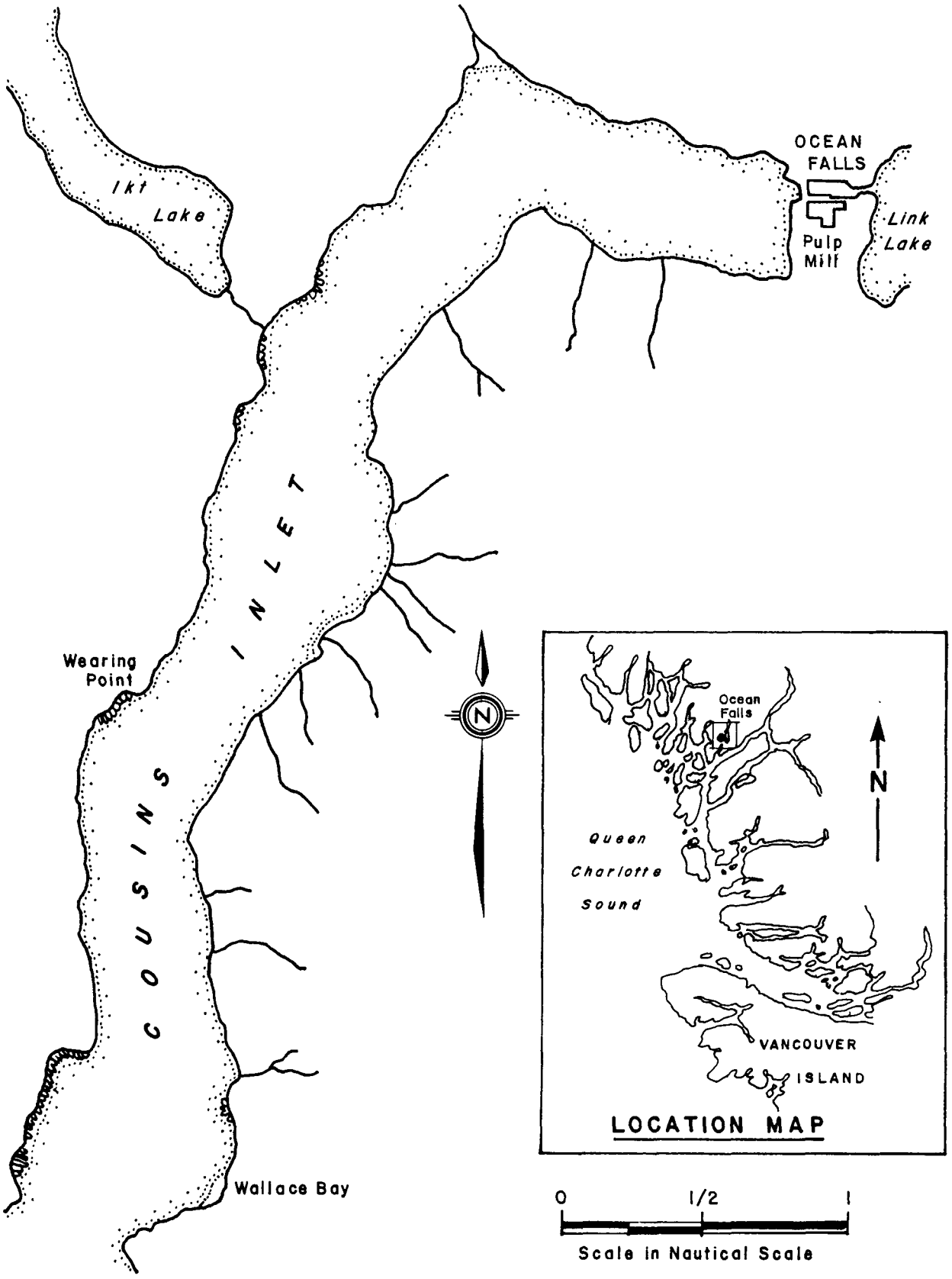

FIGURE I COUSINS INLET

TABLE 1 CLIMATOLOGICAL DATA FOR OCEAN FALLS
(From AES Temperature and Precipitation 1941-1970, British Columbia)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean Daily Temp. °F	32.9	36.7	39.0	44.2	51.5	57.1	60.8	61.5	57.6	48.8	40.8	36.0	47.2
Mean Rainfall (inches)	16.43	13.73	12.94	12.52	7.96	6.97	6.39	9.25	14.84	25.46	20.48	19.56	166.54
Mean Snowfall (inches)	20.3	13.9	6.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	5.6	15.6	62.7
Mean Total Precip.	18.46	15.12	13.60	12.59	7.97	6.97	6.39	9.25	14.84	25.47	21.04	21.13	172.82
No. Days w Mean Precip.	21	18	19	19	16	15	14	14	17	23	23	22	221

2 MILL OPERATIONS (after Bergman, 1973)

The first industry at Ocean Falls was a sawmill established in 1908. A dam was constructed in 1910 to form Link Lake and provide water power. The sawmill was later replaced by a pulp and paper mill operation beginning in 1912 with a 150 ton per day groundwood pulp mill. In 1917 a sulphite and a sulphate kraft pulp mill and four paper machines were added. Two addtional paper machines were installed in the twenties and the dam was raised. The layout of the mill is detailed in Figure 2.

In 1965, the groundwood mill was modernized and No. 6 paper machine was shut down. In 1966 No. 3 paper machine was shut down. In 1967 the Kraft pulp mill, the bleach plant, the sulphite pulp mill, lime plant, and kraft recovery boilers were shut down as they were obsolete and no longer economic units. In July 1971, No.1 paper machine was shut down.

In May 1972, Crown Zellerbach announced that the balance of the mill (numbers 2, 4, and 5 paper machines, woodmill, and groundwood mill) would be closed down by the end of March 1973, as the operation was no longer economic. The operation was phased out as planned by Crown Zellerbach, but prior to the shutdown the mill was purchased by the Provincial Government and is currently being operated as Crown Corporation.

The mill is presently producing about 280 tons of newsprint per day, with the groundwood mill supplying groundwood pulp, and semi-bleached kraft pulp imported from outside sources. For more information on the history of the mill and the Ocean Falls area in general, the reader is referred to Ramsey (1971), (Packman et al, 1975).

The situation at Ocean Falls has not changed significantly from that reported in Packman et al, (1975). The one process change which has occurred, however, is the change over from a hydraulic debarker to a mechanical debarker in February 1977. This totally eliminated one source of effluent from the mill complex.

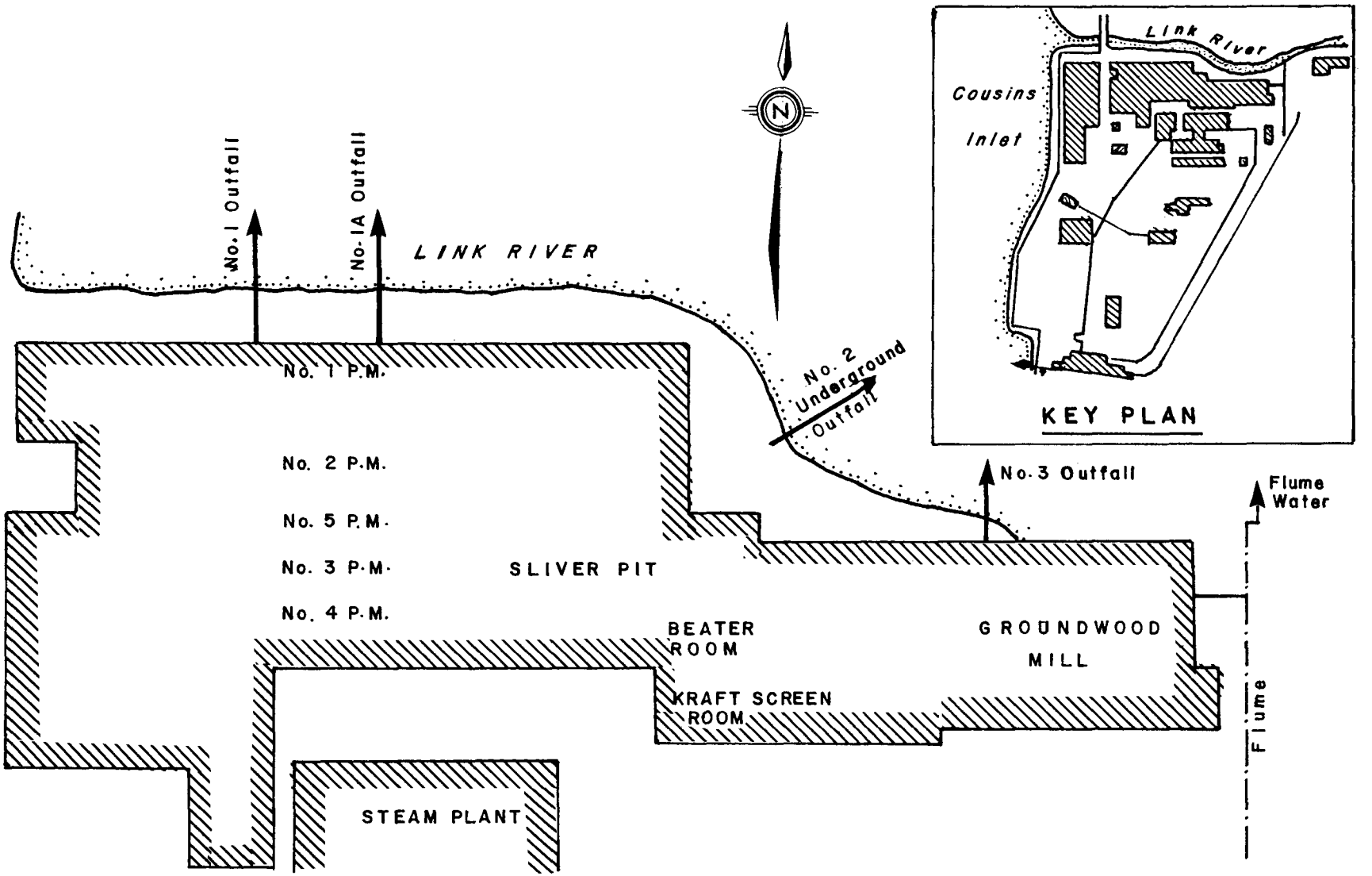

FIGURE 2 OCEAN FALLS CORPORATION

3 EFFLUENT QUALITY

3.1 Discharge Sources

The effluent from the Ocean Falls mill is discharged at a combined rate of approximately 15 000 000 Imperial gallons/day (57 x 10^6 litres/day) through five outfalls into the head of Cousins Inlet (Figure 2). A brief description of each sewer follows (after Bergman, 1973).

Flume Water. The blocks from the woodmill are conveyed to the groundwood mill by means of a block flume. Water for the flume is supplied from Link Lake to the woodmill end of the flume and discharged at the groundwood mill end of the flume into Cousins Inlet. The flume water is not recirculated, but makes a single pass through the flume. No treatment is applied to this discharge and it is not considered as an effluent source for regulation purposes.

No. 1 Sewer. This sewer services the Steam Plant and is basically clean water. It is also the main sewer handling domestic effluent. No treatment is applied to this discharge.

No. 3 Sewer. This sewer services the groundwood mill and contains coarse screen rejects, secondary cowan screen rejects, and white water overflow. It also receives some domestic wastes. The treatment for this discharge includes a "saveall" for groundwood and paper machine white water and a shredder and refiner for groundwood coarse and fine screen rejects.

Nos. 1A and 2 Sewers. These two sewers service the newsprint machines. No. 2 sewer contains primarily white water overflow from the paper machine broughton boxes while No. 1A sewer contains the tertiary centricleaner rejects. Losses from the paper machine Jonson screens are negligible due to the large size of the holes in the screen plate. No treatment is applied to this discharge.

All mill wastes are discharged into the large flow of well aerated water from the tailrace of the hydro-electric plant.

In addition to the discharge of fibre and associated BOD_5, the Ocean Falls Corporation is the only mill on the west coast still utilizing zinc hyrosulphite for groundwood bleaching. The remainder have

switched to sodium hydrosulphite bleaching using the Boral process. The company maintains that their operation could not produce a marketable product without zinc bleaching.

3.2 Federal and Provincial Requirements

The effluent standards for the various discharges of the Ocean Falls Corporation mill are set out in the Provincial Government Pollution Control Branch Permit No. PE-3832 which was issued on August 22, 1975, and amended on December 5, 1975. These are set out in Table 2. The relative requirements of the Provincial and Federal governments with regard to the total mill discharge are outlined in Table 3. The results of the effluent quality monitoring program carried out by the mill for the Provincial and Federal governments are presented in Tables 4 and 5. A bioassay program was conducted by the Environmental Protection Service, the results of which are presented in Table 6.

In-plant control measures to reduce SS and BOD_5 are planned as outlined below (Adams, 1978).

1. Reject Refiner Installation

   A 1000 HP reject refiner will be installed in the fall of 1978 to recover all groundwood Cowan screen rejects presently entering #3 sewer. They anticipate reducing the average suspended solids from 14.6 ADTPD to 7.9 ADTPD.

2. Reclaiming Paper Machine White Water Fines

   Since the installation of the drum Saveall in January, 1976, to recover fines from all excess Paper Machine white water, it has not been able to handle the entire volume of white water. Plans to correct this are as follows:

   a) Instrument changes have been made to give the Groundwood Mill priority for Paper Machine white water prior to the Saveall. This along with upcoming reductions in freshwater usage on the Paper Machines, should result in the total recovery of suspended solids from excess Paper Machine white water.

TABLE 2 POLLUTION CONTROL BRANCH PERMIT REQUIREMENTS

	Two Newsprint Paper Machines and Groundwood Mill	Steam Plant	Groundwood Mill Block Flume
Effluent Vol. Weekly Avg. (IGPD)	4 861 440	515 500	8 712 000
Daily Max. (IGPD)	6 196 800		9 600 000
Total Suspended Solids (lbs/day)	9 450		
Settleable Solids (ml/l)	2.5		
BOD_5 (lbs/day)	12 600		
Zinc (lbs/day)	1 260		
pH Range (within 15' of outfall)	6.1 - 8.5	6.1 - 8.5	6.1 - 8.5
Temperatue Maximum (°C)	35	35	35
Toxicity (TLm 96)	50% Survival in 12.5 % effluent	50% Survival in 12.5% eff.	50% Survival in 12.5% effluent
Floatable Solids	Negligible	Negligible	Negligible
Treatment	In-plant fibre recovery facilities, out-plant treatment as required, submerged outfalls. To be operational by 31/12/78	In-plant suspended solids recovery facilities, submerged outfall.	Discharge to head of tailrace.

TABLE 3 FEDERAL EFFLUENT QUALITY REQUIREMENTS

	BOD_5	Suspended Solids	Toxicity
Federal	30 lb/ADT*	Mechanical Pulping..13 lb/ADT	80% survival in 65% (V/V).
		Bleaching.....2 lb/ADT	Effluent over 96 hours.
		Single Product - Groundwood.....5 lb/ADT	
		Paper Making - Kraft.....3 lb/ADT	

* Proposed Guideline.

TABLE 4 OCEAN FALLS COPORATION - 1976 EFFLUENT QUALITY RESULTS

Month	Flow $x10^6$ IG/D	BOD_5 LB/ADT	BOD_5 Tons	Suspended Solids LB/ADT	Suspended Solids Tons
January	15.5	38.1	5.18	147.5	20.07
February	15.3	40.3	5.81	133.7	19.26
March	15.2	33.9	4.86	124.8	17.91
1st Quarter	15.3	37.4	5.28	135.3	19.08
April	15.0	33.6	4.82	114.5	16.43
May	14.5	37.4	5.41	112.1	16.21
June	15.0	35.2	5.00	103.3	14.67
2nd Quarter	14.8	35.4	5.08	110.0	15.77
July	15.3	45.3	6.19	136.2	18.59
August	15.4	30.6	4.35	125.2	17.84
September	15.6	36.3	4.79	159.1	21.01
3rd Quarter	15.4	37.4	5.11	140.2	19.15
October	16.2	40.0	5.78	142.8	20.63
November	15.9	29.4	4.12	131.5	18.42
December	16.2	32.9	4.66	155.1	21.94
4th Quarter	16.1	34.1	4.85	143.1	20.33
Yearly Average	15.4	36.1	5.08	132.2	18.58

TABLE 5 OCEAN FALLS COPORATION - 1977 EFFLUENT QUALITY RESULTS

Month	Flow $x10^6$ IG/D	BOD_5 LB/ADT	BOD_5 Tons	Suspended Solids LB/ADT	Suspended Solids Tons
January	15.6	24.4	3.53	119.3	17.24
February	15.2	29.8	4.23	108.5	15.41
March	14.7	40.2	5.33	84.8	11.23
1st Quarter	15.2	31.5	4.36	104.2	14.63
April	14.2	22.6	2.74	74.7	9.04
May	15.2	39.9	5.78	85.8	12.44
June	15.2	24.0	4.58	87.4	11.76
2nd Quarter	14.9	32.2	4.37	82.6	11.08
July	15.5	46.9	6.10	112.5	14.62
August	15.6	65.5	9.10	135.5	18.84
September	15.4	50.0	7.17	113.3	16.25
3rd Quarter	15.5	54.1	7.46	120.4	16.57
October	15.2	33.7	4.68	96.7	13.44
November	15.1	37.8	5.19	70.6	9.67
December	14.1	43.0	5.53	112.8	14.49
4th Quarter	14.8	38.2	5.13	93.4	12.53
Yearly Average	15.1	39.0	53.3	100.2	13.70

TABLE 6 RESULTS OF E.P.S. BIOASSAY PROGRAM

Sample Date	% Mortality Over 96 Hours (Static Test) Concentration (% V/V) Effluent								Sample pH
	65	49	30	18	10	5.6	3.2	1.8	
Dec. 13, 1977	100		100	100	100	60	40	0	5.3
Nov. 10, 1977	100	100	100	100	100	70	50	10	5.1
Aug. 27, 1977	100	100	100	80	60	20	0		5.1
July 12, 1977	100	100	100	100	100	100	100	100	4.6
May 3, 1977	100	100	100	100	100	100	100	90	5.7
March 8, 1977	100	100	100	100	20	20	0	0	6.1
Jan. 3, 1977	100	100	70	30	0	0	0	0	5.8

	Concentration (% V/V) Effluent								
	100	65	45	32	12.5	5.6	3.2	1.0	
Nov. 2, 1976	100	60	40	0	15	0			6.0
Sept. 1, 1976		100	100	100	100	20			5.8
July 5, 1976	100	100	100	100	100	80	80	0	4.8
April 29, 1976	100	100	100	100	100	100			5.1
March 3, 1976	70	70	30	0	0	0			5.7

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

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

b) In the past, reuse of Paper Machine white water fines has resulted in a decrease in newsprint brightness. The mill is presently attempting to raise the brightness of the unbleached pulp by culling out low quality wood in the woodmill.

3. Reuse of Saveall Effluent

The Saveall effluent is being investigated as a possible replacement for fresh water which is presently being used on both paper machines and Saveall showers. A completion date for this project is unavailable at this time due to the extensive piping which is required. This project is expected to reduce fibre loss by 1 ADTPD.

4. Reclaiming Tertiary Centricleaner Reject

This project involves the routing of tertiary centri-cleaner rejects to a clarifier and then back to the refiner. This is projected to reduce suspended solids losses by 2.4 ADTPD, however, the project will only be implemented if the previously outlined projects do not bring the suspended solids losses to within the Provincial Level "B" Objectives of 4.7 ADTPD.

4 RECEIVING ENVIRONMENT

4.1 Oceanography

Oceanographic data dealing with Cousins Inlet has been reported on five occasions by Federal agencies (Waldichuk, 1962, Waldichuk et al, 1968; Bishop et al, 1970; Packman et al, 1975; Packman, 1976). All of these reports have agreed on the fact that Cousins Inlet is highly stratified with respect to temperature, salinity and dissolved oxygen, typical of a deep marine fjord with a substantial input of well aerated fresh water at its head (Figures 3 and 4).

The circulation that exists in a situation such as prevails in Cousins Inlet may be described as follows:

1) Well aerated fresh water flows in at the head of the inlet from the Link River.
2) This water spreads out over the surface of the inlet in the form of a low salinity layer.
3) A halocline is thereby established which along with the thermocline creates a two-layer system which for the most part prevents the vertical exchange of water.
4) The surface layer is continually propelled seaward by the fresh water input at the inlet's head.
5) Bottom water is entrained up to the surface at the head of the inlet by the continual seaward movement of the low salinity surface layer.
6) This entrainment of bottom water results in a net up inlet flow of oceanic bottom water as no sill exists at the inlet mouth to inhibit such a flow.
7) Replenishment of bottom water with oceanic bottom water is generally a slow process often resulting in a stagnation of the bottom water at the inlet head. This phenomenon may produce depressed dissolved oxygen concentrations, a condition compounded by the fact that oceanic bottom water is often in itself low in dissolved oxygen.

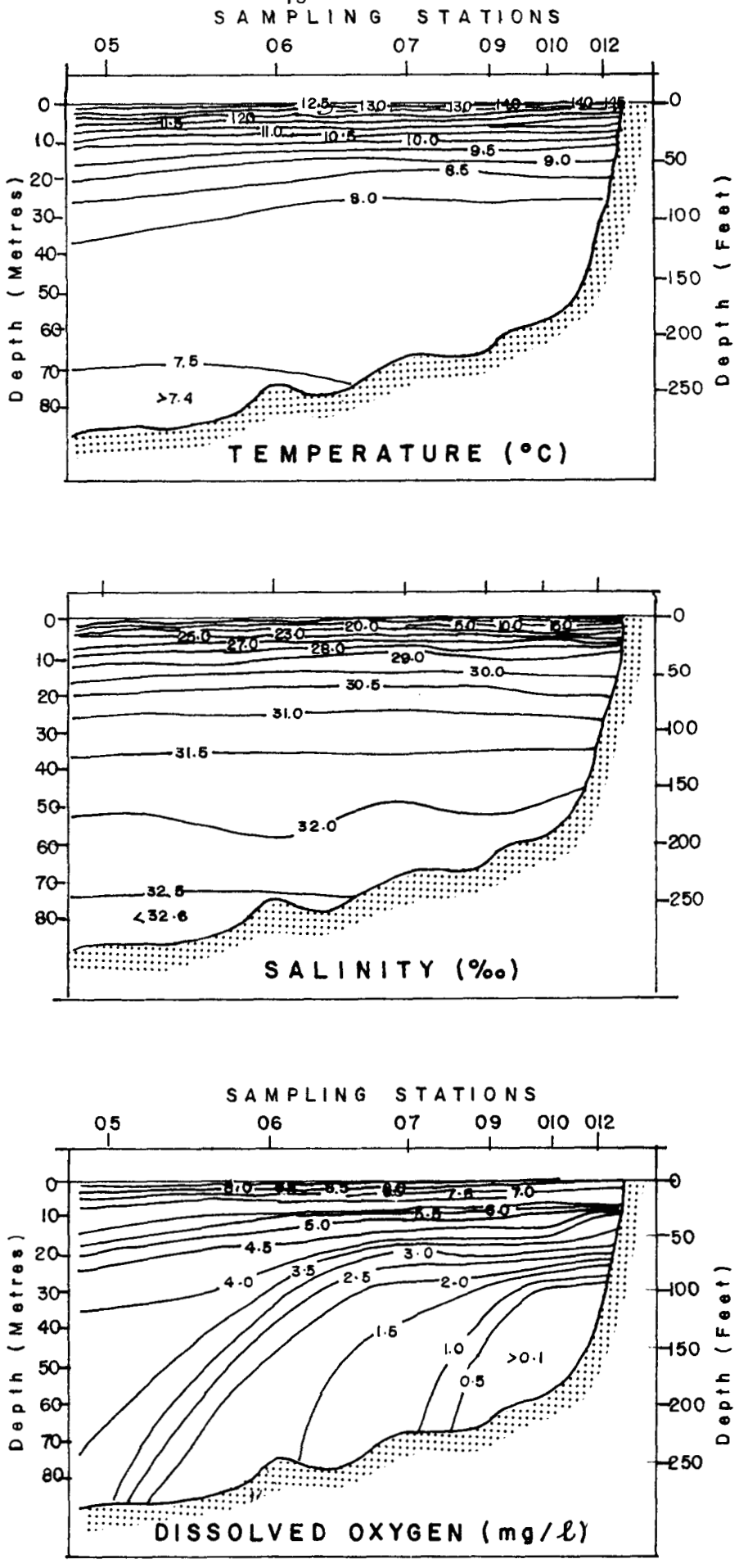

FIGURE 3 WATER COLUMN PROFILES - COUSINS INLET (Waldichuk, 1962)

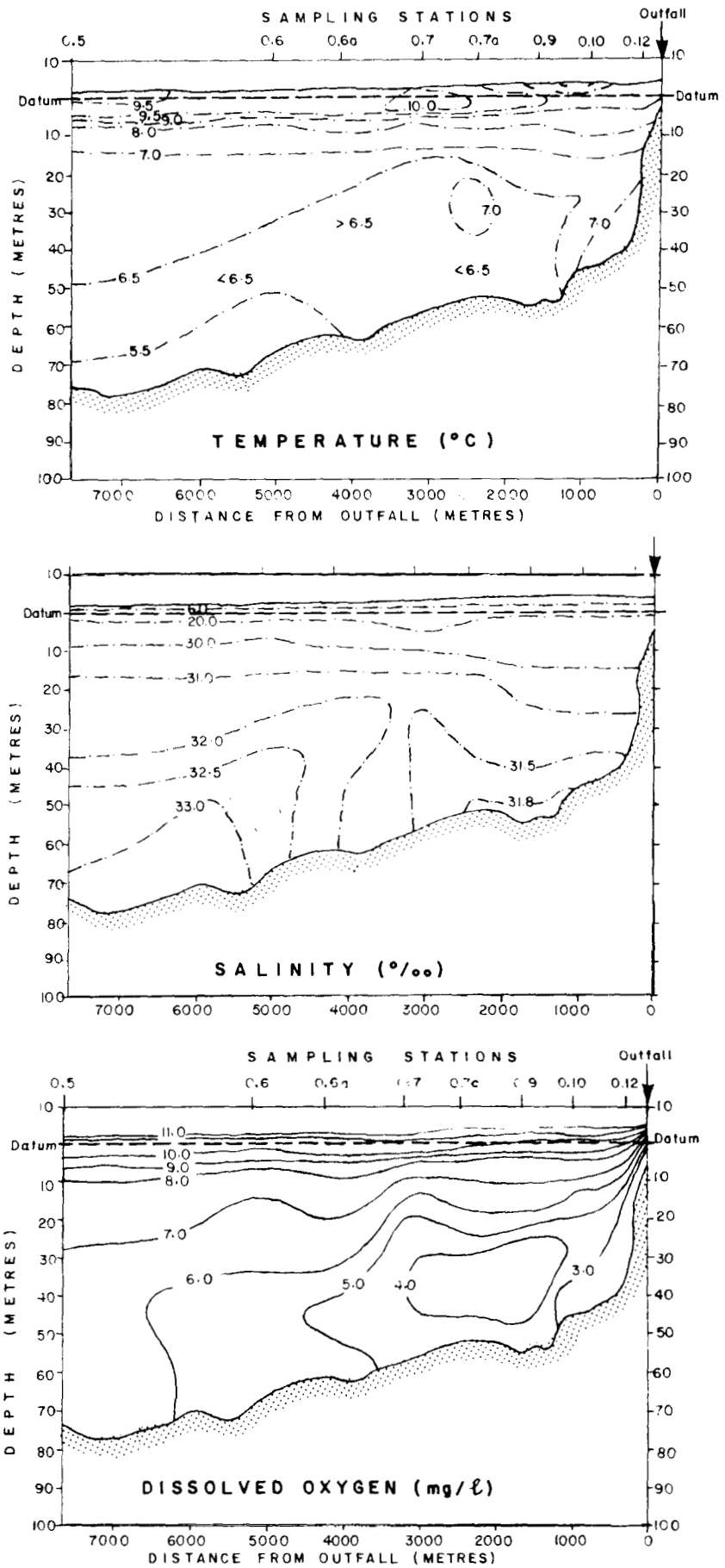

FIGURE 4 WATER COLUMN PROFILES - June 11, 1974
(Packman et al, 1975)

At Ocean Falls the good surface dispersion of mill effluent is enhanced by initial discharge into the well aerated tailrace of the hydroelectric dam on the Link River. However suspended solids, generally in the form of cellulose fibre contained in the discharges, tend to flocculate out of the water column when they come in contact with salt water. This has over time resulted in a signficant accumulation of fibre in the form of a fibre bed, on the bottom of Cousins Inlet, extending up to 1.75 n.mi. (3.25 km) down the inlet from the mill site (Packman et al, 1975). This accumulation of fibre on the bottom has resulted in a high oxygen demand on the adjacent water mass, which has contributed to very low dissolved oxygen values in the bottom water at the inlet head (Figures 3, 4 and 5). This situation was much worse before the cessation of chemical pulping in 1967 as is evident in the data of Waldichuk (1962) presented in Figure 3. Work presented by Packman (1976) indicated that dissolved oxygen values in the bottom water at the head of the inlet were still as low as 1.46 mg/l in October of that year.

Beak Consultants Ltd. (1976, 1977) conducted water quality sampling in the upper reaches of Cousins Inlet - April 1976, September 1976, May 1977 and October 1977. The parameters examined included temperature, salinity, dissolved oxygen, transparency (Secchi disc), true colour, pH, non-filterable residue and suspended fibre concentration. Beak also found Cousins Inlet to be a two layered system, however, their dissolved oxygen values were significantly higher than those presented by Packman et al (1975) and Packman (1976). This was attributed to a general improvement in water quality conditions at the inlet head. Whether or not these values are comparable to those of the Environmental Protection Service is, however, questionable as the state of the tide was not included in the Beak reports. The work reported in the two papers by Packman was conducted on a rising tide which would represent a worst case situation. Also the methodology in the two series of reports differ (Beak used a YSI D.O. meter while E.P.S. used the azide modification of the Winkler method) which might account for differences in the data.

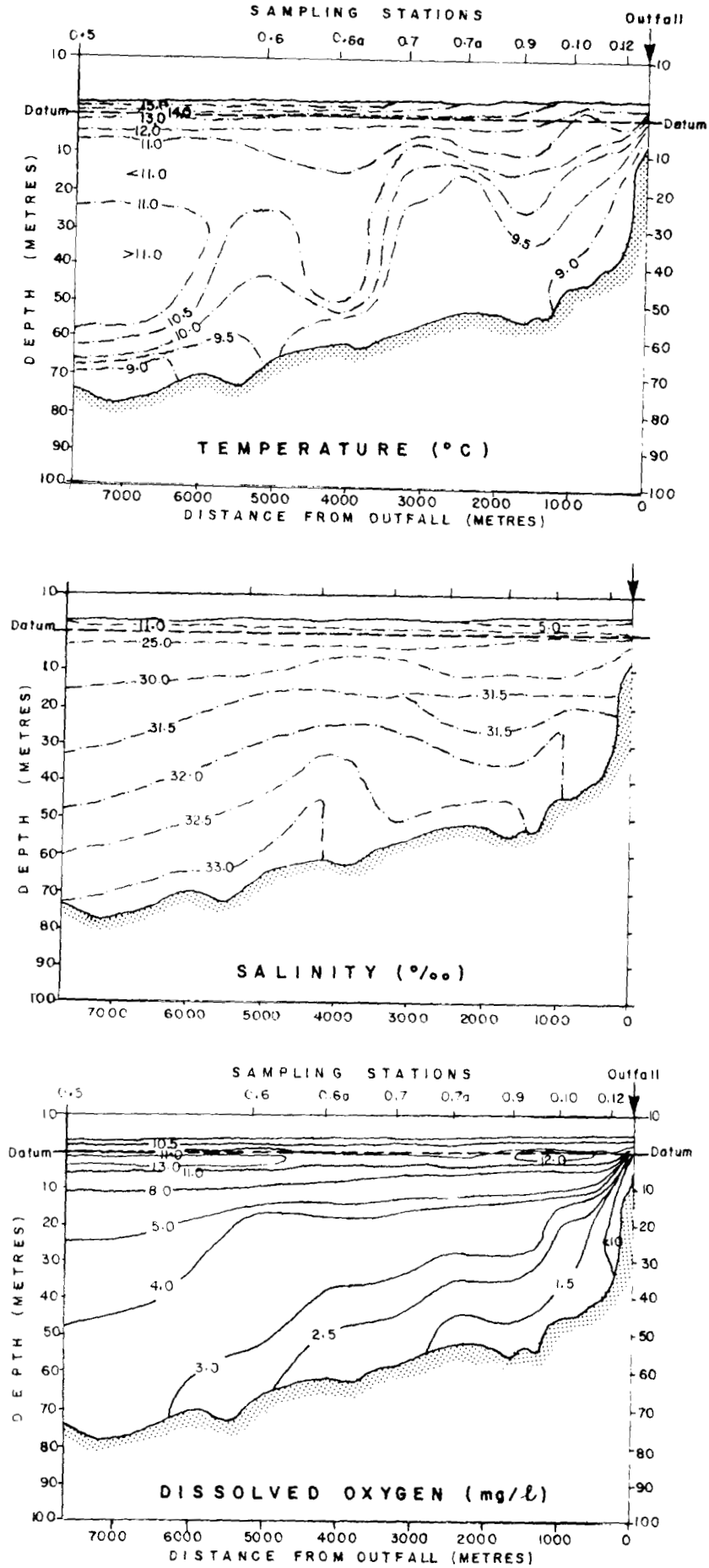

FIGURE 5 WATER COLUMN PROFILES - September 4, 1974
(Packman et al, 1975)

4.2 Benthic Sediments

The sediments of Cousins Inlet have been reported as having an overlying fibre mat extending approximately 1.75 nautical miles (3.25 km) down the inlet from the mill site (Levings, 1973 and Packman et al, 1975). At the upper end of the inlet close to the mill the fibre is highly reduced, having a high hydrogen sulphide concentration. The thick layer of black reduced fibre is overlain with a layer of fresh undecomposed white fibre to a depth of 1.5 cm. Further down the inlet at approximatley 1.75 n.mi. (3.25 km) a transition zone between fibre and natural sediment is apparent. High concentrations of fecal pellets are present in this area. Levings (1973) has hypothesized that these pellets may have originated with zooplankton and had not broken down due to the lack of dissolved oxygen in water, which would have inhibited biological activity.

In 1976, direct observations of the fibre bed were made from the Pisces IV submersible. A description of the fibre bed at the head of the inlet is contained in a report on the work (Packman, 1976).

"The fibre bed was initially white and had the appearance of a field of snow, undulating, with an occasional log projecting. It was apparent that the mat was not greatly compacted, as shock waves would ripple through it if disturbed. As the dive progressed, grey and black patches became apparent on the surface of the fibre bed where the underlying anaerobic decomposition had for some reason been exposed." This may have been due to the activities of Capitellid polychaetes concentrated in these patches.

Photographs of the fibre bed are also presented in that report. A description of the bottom in the estimated "transition zone" is also presented. At that point the bottom was described as having a brown detrital layer overlying the black hydrogen sulphide ooze of the fibre bed. Patches of black ooze covered in part by a white bacterial slime, were reported protruding through the detrital layer. Extensive patches of small wood chips and many logs were also reported.

It is necessary for the mill to dredge sediment and fibre from in front of their deep-sea dock every two years. Dredging was carried out in 1975 and a further 40 000 yards^3 were removed in early 1978.

Dredging in an area with anoxic sediments can cause fish-kills by stirring up oxygen deficient water which sometimes contains toxic hydrogen sulphide into the surface waters frequented by fish (Waldichuk, 1962). In 1975, the dumping of this material was reported to have taken place in mid-channel off Wearing Point in Cousins Inlet (Hoos pers com). This situation was reviewed, in 1978, and as a result a more suitable dumping location was selected in mid-channel between the mill and Coolidge Point. In this manner benthic smothering was limited to an already degraded area over the existing fibre bed.

4.3 Biology

Since 1967, there has been no discharge of kraft or sulphite mill effluent into Cousins Inlet, therefore, those sources of toxic discharges are no longer a problem. Chinook salmon and rainbow trout were reared in floating pens and fed an artificial diet in an aquaculture experiment conducted from October 1971 to May 1972 at a site just west of the Martin River, in Cousins Inlet. Results from this study indicated that the salmon grew at a normal rate, apparently uninhibited by their proximity to the pulp and paper mill. This would tend to indicate that the runs of salmon utilizing Cousins Inlet and the Martin River should not be adversely affected by the mill discharge (Waldichuk, 1962).

Potential problems associated with the zinc concentrations in the effluent were identified by unpublished work carried out by the Environmental Protection Service in 1973. This work revealed that, "*Mytilus edulis*, the only intertidal bivalve found in Cousins Inlet at that time, contained approximately twice the concentration of zinc found in *M. edulis* collected from a control station established in Elcho Harbor some 25 miles from Ocean Falls (Env. Can., unpub., 1974). Although the actual concentrations found were relatively low this condition should still be considered a cause for concern.

The use and subsequent discharge of zinc was also reflected in toxic responses exhibited by fingerling coho salmon exposed to the various mill effluents. Grab samples were collected in October 1973 by Environment Canada, transported to Vancouver and tested under static

conditions for 96 hours using freshwater as the diluent. Sewer 3 was found to be the most toxic with an LC_{50} of 3.2%, followed by sewers 1A, the woodmill, and 2, with LC_{50}'s of 15.5%, 18% and 42%, respectively, and the remainder which were not acutely toxic. These results corresponded directly with zinc concentrations of the effluents as analyzed by the B.C. Research Council during a 5-day period in early October of the same year (Bergman, 1973).

Results of the this survey ranged from an average of 35 ppm of zinc in effluent from Sewer 3, to 7-10 ppm from Sewers 1A and 2 and none in the remainder. The high toxicity of the woodmill effluent could not be attributed to zinc as none was present, but was probably due to resin acids or other organic derivatives associated with the effluent from this operation.

The most serious effect of the historical and present discharges of the mill complex on the biological communities of Cousins Inlet has been the fibre bed deposition with its high oxygen demand and its unsuitability as a substrate. Levings (1973) and Packman et al, (1975) have reported little or no biological epifauna or infauna in the head of Cousins Inlet, as deduced from grab sampling programs. This information was determined to be partially erroneous as a result of the Pisces IV submersible dives reported by Packman (1976). The biological observations in the vicinity of Coolidge Point (Track No. 1, Figure 6) were described as follows:

> "No life was initially apparent on the fibre bed itself, however, sea anemones (Metridium senile) and ascidians (Ascidia peritropa) were present on logs projecting from the bed. In the area where grey and black patches were observed, tube dwelling polychaetes (Capitella sp.) were observed, extending above the surface of the fibre, in the black patches. A few poachers (Agonidae) and a tomcod (Microgadus proximus) were also observed (Packman, 1976)."

A dive conducted in the transition zone (Track No. 2, Figure 6) was described as follows:

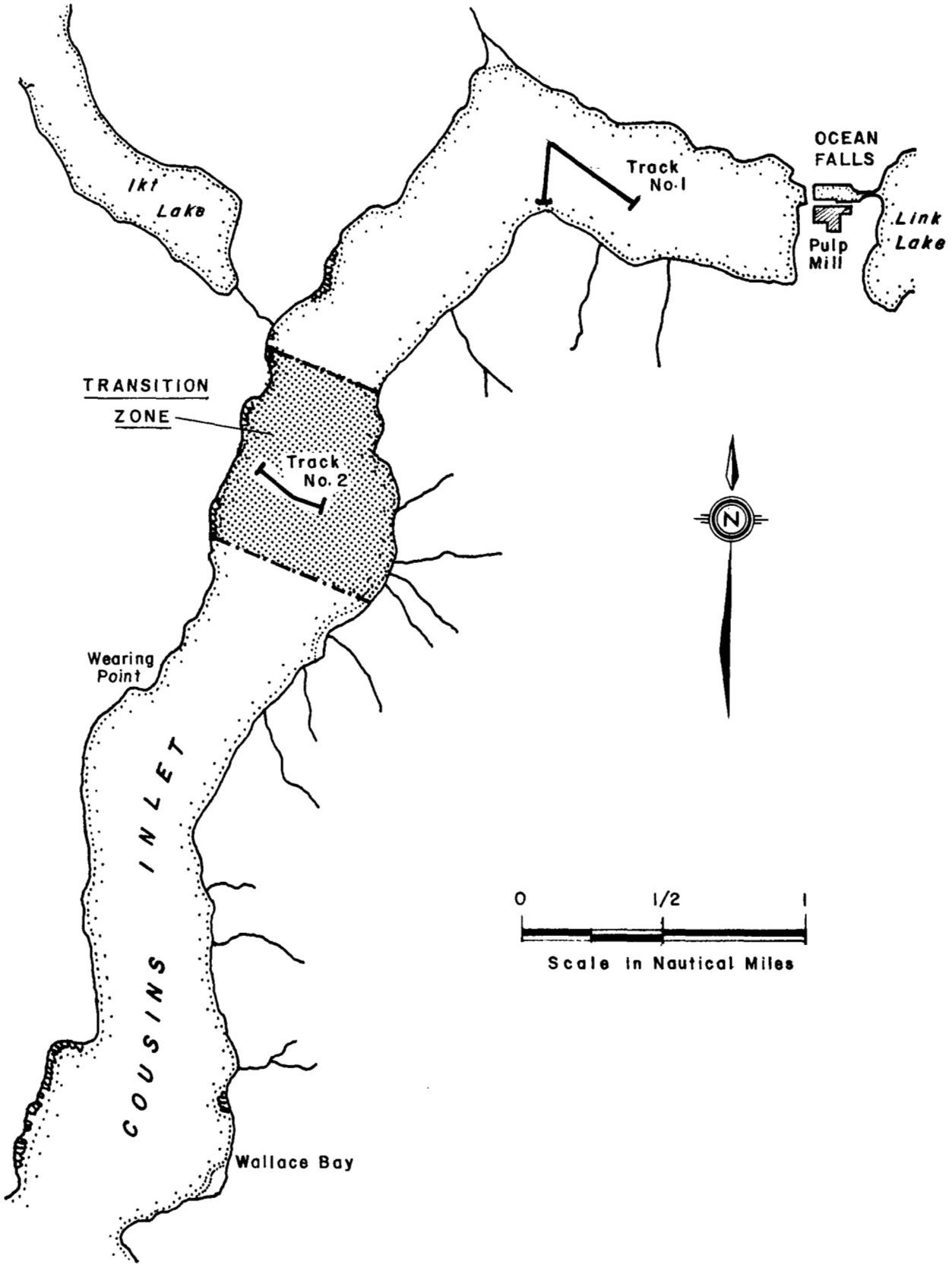

FIGURE 6 PISCES IV DIVE TRACKS AND APPROXIMATE AREA OF RECOLONIZATION

"Benthic fauna was abundant throughout the dive. The most abundant form throughout the first portion was a small, thin white sea pen which reached concentrations of up to 50/metres^2. This lifeform was observed on all bottom types except the rocky terrain. Other major lifeforms observed on the "recolonized fibre bed" were poachers (Agonidae), ronquils (Bathymasteridae), pricklebacks (Stichaeidae), pink shrimp (Pandalus borealis), burrowing anemones (Pachycerianthus sp.), and sedentary polychaetes such as Cirratula sp. (Packman, 1976)."

It was hypothesized in the report of Packman (1976) that the fibre bed in the "transition zone" was undergoing recolonization as a result of the cessation of chemical pulping in 1967.

Intertidal and shallow subtidal observations in Cousins Inlet conducted by Levings (1972), Packman et al (1975), Beak (1976) and Beak (1977) indicated that no serious damages had been incurred in these zones except in the immediate vicinity of the mill. Levings (1972) reported a "thick growth of filamentous algae" along the south shore of Ocean Falls Harbour but that the algae had not inhibited the establishment of a "normal" community. Packman et al (1975), stated that the conditions in the intertidal and shallow subtidal zones had improved markedly since the shutdown of the chemical pulping processes in 1967 and that there were no readily observable deleterious effects stemming from the present discharges of the mill at that time.

Beak (1976, 1977) indentified two areas where damage to the intertidal zone had occurred, but not necessarily as a result of mill effluent. The two areas indicated were in the foreshore on both the north and south side of the mill. The intertidal zone on the south side had been damaged by the presence of a landfill site directly adjacent to the foreshore while the north side had been degraded by oil originating in a marina associated with shipping activities.

Environmental monitoring work conducted by Beak Consultants Ltd. during 1976 and 1977 also included zooplankton studies (Beak

Consultants Ltd, 1976; Beak Consultants Ltd., 1977). The zooplankton samples were reported to contain large numbers of polychaete and bivalve larvae. The consultants concluded that these data were an indication of recovery of the benthic communities at the inlet head. However, the larval stages of these groups were not specifically identified as being animals inhabiting soft muddy bottoms as opposed to the rocky sides of the inlet which have been relatively unaffected by the mill. The consultants have also not established that the larval forms actually originated with the community at the head of Cousins Inlet as opposed to being carried there from other areas by water circulation.

5 NATURAL RESOURCES

5.1 Fisheries

Cousins Inlet supports small but viable runs of coho, pink and chum salmon which have been noted as having spawned in the Martin River since spawning records of that system were begun in 1920 (Packman et al, 1975). The escapement data for the the Martin River from 1951 to 1975 are presented in Table 7.

TABLE 7 SALMON ESCAPEMENT FOR MARTIN RIVER

Year	Coho	Chum	Pink
1975	750	1500	75
1974	2000	10000-12000	500
1973	1000	3500	400
1972	2500	1500	750
1971	3500	7500	3500
1961-70	765	1063	345
1951-60	1615	165	175

It was stated in the Fisheries and Marine Service Submission (1977) to the Pulpmill Review (Appendix I) that "Comparison of these figures with escapements from Area 8 as a whole indicates that the Martin River accounted for an average of 0.4% of the total pink escapement, 4% of the chum escapement and 5% of the coho escapement from 1971 to 1975." Therefore, it may be seen that the Martin River does have a significant input into the salmonid production of Area 8 as a whole even though it does not support a fishery of its own.

The F.M.S. Submission (1978) also states that:

The period of upstream salmon migration to the Martin River extends from mid-August to the end of the summer, with the peak being in September to October. The pink salmon arrive in the river first and the coho last. It is thought that the fish destined for the Martin River travel via Dean Channel along the north side of King Island and up Cousins Inlet.

Juvenile stocks of pink and chum appear to move out of the Martin River/Cousins Inlet area in their first season after emergence, while immature coho can be seen in the inlet for the entire summer period.

Apparently, upstream migrating adult salmon and downstream migrating juveniles do not show any signs of behavioural abnormalities which might be attributable to the presence of mill effluent in Cousins Inlet. Adult migrants congregate at the head of the Martin River prior to heading upstream to spawn and do not demonstrate avoidance reactions towards effluent-containing waters.

Cousins Inlet appears to be an important area for rearing of juvenile salmonids originating in the Martin River. Packman et al, (1975) and Nelson (1974) reported large numbers of salmon juveniles, in the shallow intertidal areas of the inlet and around the docks, respectively. "Although this would suggest a minimal influence of existing effluent on stocks, no studies on sub-lethal effects have been undertaken in the area" (FMS, 1977).

Although there is no commercial fishery in Cousins Inlet there is a significant sports fishery for salmon, crabs, shrimp and prawns. Herring are abundant in the inlet but stocks are not of sufficient size to be commercially important.

Groundfish were reported in the bottom of Cousins Inlet in the Pisces IV dive observations reported in Packman (1976), however, the up-inlet extent of groundfish is limited by low dissolved oxygen concentrations and the presence of the fibre bed.

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APPENDIX I

OCEAN FALLS PULP MILL, OCEAN FALLS, B.C.
FISHERIES RESOURCES OF FISHERIES AND MARINE SERVICE
STATISTICAL AREA 8

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

Ocean Falls Pulp Mill
Fisheries Resource of Fisheries and Marine Service Statistical Area 8

by
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Water Quality Division
Habitat Protection Unit
Resource Services Branch
1978

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OCEAN FALLS PULP MILL
FISHERIES RESOURCES OF
FISHERIES AND MARINE SERVICE STATISTICAL AREA 8

I INTRODUCTION

The Ocean Falls pulp mill is located at the head of Cousins Inlet in the Bella Coola Subdistrict, Fisheries Statistical Area 8 (Figure 1). Area 8, situated in the center of the coastal mountain range, is one of the largest statistical areas on the coast, encompassing approximately 11,000 square miles including about 488 miles of coastline. Its major centers of population are in the Bella Coola Valley and at Ocean Falls.(1)

II SALMON

A. Commercial Fishery

Historically, the waters of Area 8 have supported one of the largest Pacific coast salmon fisheries. Annual catch statistics show that over the past five years an average of 12.8% of the salmon catch for the northern coast (north of Cape Caution) has been taken in this area. The catch, including sockeye, coho, pink, chum, and chinook salmon is taken by seine and gill-net in nearshore waters. Trolling has never been a large operation in this area. Commercial fishing occurs mainly in Fisher-Fitzhugh Sound, North Bentinck Arm and the Dean, Kimsquit and Bella Coola Rivers (Figure 2). Table I shows the commercial catch statistics for Area 8 between 1956 and 1975.(2)

A commercial salmon fishery does not exist in Cousins Inlet where the Ocean Falls pulp mill is located (3) although commercial boats operate in Fisher Channel to the entrance of the inlet.(4)

B. Escapement

Within the Bella Coola Subdistrict, 29 salmon spawning streams are listed. These streams contain approximately 87 lineal miles of spawning grounds (1) some of which are sizeable river systems with additional spawning tributaries and lakes. Major spawning streams include the Bella Coola-Atnarko, Dean, Kimsquit, Koeye and Kwatna rivers (Figure 2). Escapement figures for these streams are given in Table II. Table III gives escapements for the whole of Area 8.

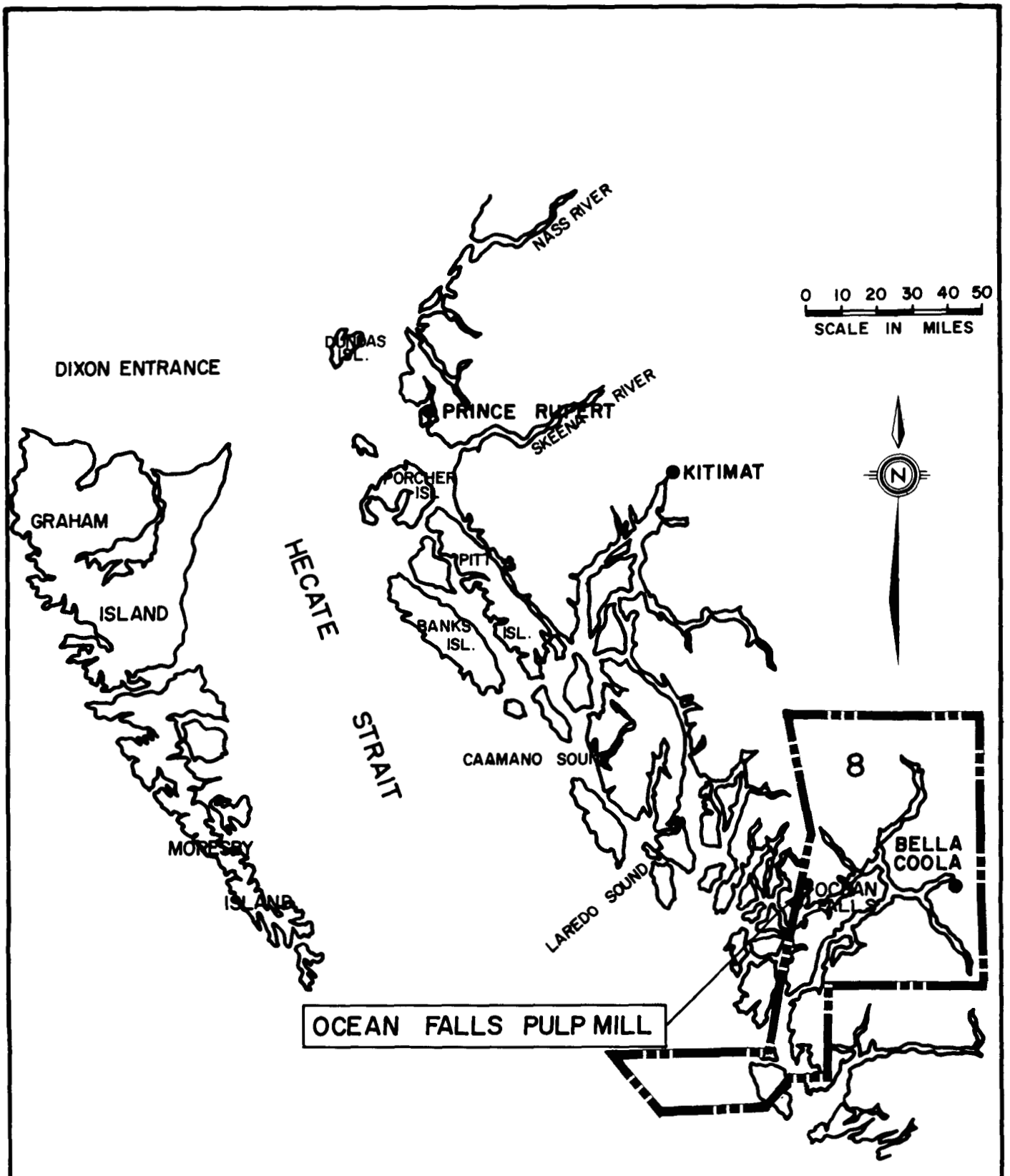

FIGURE I–LOCATION OF OCEAN FALLS PULP MILL IN STATISTICAL AREA 8

TABLE I

Commercial Salmon and Steelhead Catch(2)

(Pieces 1963-75, CWT 1956-62)

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK	(JACK)	STEELHEAD
1975	226050	57586	95783	134748	28309	(12172)	1831
1974	129967	126083	2874495	198966	31041	(13728)	1191
1973	223571	104805	64467	251573	16961	(21956)	1687
1972	85948	134595	1104756	233774	23837	(7977)	1169
1971	167920	114018	41220	60822	13069	(4815)	2297
1970	101317	121261	2052282	356960	16097	(15541)	1235
1969	43818	38194	18869	98006	12607	(3316)	794
1968	199754	216389	5435438	281936	22456	(4636)	1573
1967	234861	38810	43612	90187	21462	(4790)	2719
1966	82136	164452	2123244	199779	17318	(3889)	2583
1965	77890	80940	587907	49028	20376	(5274)	2215
1964	306644	167130	2852077	347861	25449	(4844)	2892
1963	151844	114496	2025211	318953	12486	(3824)	2572
1962	7434	12462	465272	45624	2950	(168)	368
1961	5729	11799	104750	23309	1785	(187)	273
1960	3465	7314	60689	18028	2295	(230)	288
1959	3439	8104	21989	9877	3703	(198)	244
1958	11553	13092	36411	41724	3828	(214)	484
1957	2394	10722	17334	31840	1881	(61)	336
1956	5279	15881	40366	31832	1896	(106)	368
10 yr. avg 1966-75	149633	111619	1385416	190675	29597 (includes jacks)		1707

TABLE II

Mean Escapements of Major Spawning Streams of Area 8 (6)

SPECIES	BELLA COOLA/ATNARKO			CASCADE			DEAN		
	1947-55	1956-65	1966-75	1947-55	1956-65	1966-75	1947-55	1956-65	1966-75
SOCKEYE	64,000	5,900	42,000	-	-	few	500	few	500
CHINOOK	13,000	2,100	2,000	-	-	-	1,700	few	2,900
COHO	23,000	5,500	2,100	800	1,000	300	4,400	4,800	4,400
CHUM	53,800	4,200	43,800	10,000	13,100	9,300	11,800	7,100	3,900
PINK	87,200	930,000	540,000	4,100	2,000	2,100	6,300	3,500	3,800
STEELHEAD	4,800	3,000	light	-	-	-	3,000	few	19,000

SPECIES	KOEYE			KIMSQUIT			KWATNA		
	1947-55	1956-65	1966-75	1947-55	1956-65	1966-75	1947-55	1956-65	1966-75
SOCKEYE	2,000	1,900	2,100	6,700	3,300	26,500	-	few	few
CHINOOK	-	-	-	1,500	800	40	-	few	700
COHO	7,000	4,500	4,700	6,200	2,100	1,000	4,600	8,700	9,100
CHUM	7,500	2,800	3,500	25,000	29,600	51,000	16,800	7,500	15,500
PINK	84,200	44,700	60,200	7,000	3,300	15,000	39,100	42,700	64,000
STEELHEAD *	-	few	few	1,400	few	-	-	-	-

*Steelhead are only noted incidental to salmon escapements. Figures are therefore not reliable.

TABLE III

Escapement for Area 8 (6)

YEAR	COHO	CHUM	PINK	SOCKEYE	CHINOOK
1975	46,000	95,000	148,000	99,000	8,000
1974	50,000	145,000	1,400,000	60,000	21,000
1973	69,000	284,000	165,000	94,000	26,000
1972	35,000	224,000	1,355,000	45,000	21,000
1971	38,000	80,000	250,000	155,000	33,400

TABLE IV

Escapement for Martin River(6)

YEAR	COHO	CHUM	PINK
1975	700	1,500	100
1974	2,000	10-12,000	500
1973	1,000	3,500	400
1972	2,500	1,500	750
1971	3,500	7,500	3,500
Avg. 1961-70	800	1,000	300
Avg. 1951-60	1,600	200	200

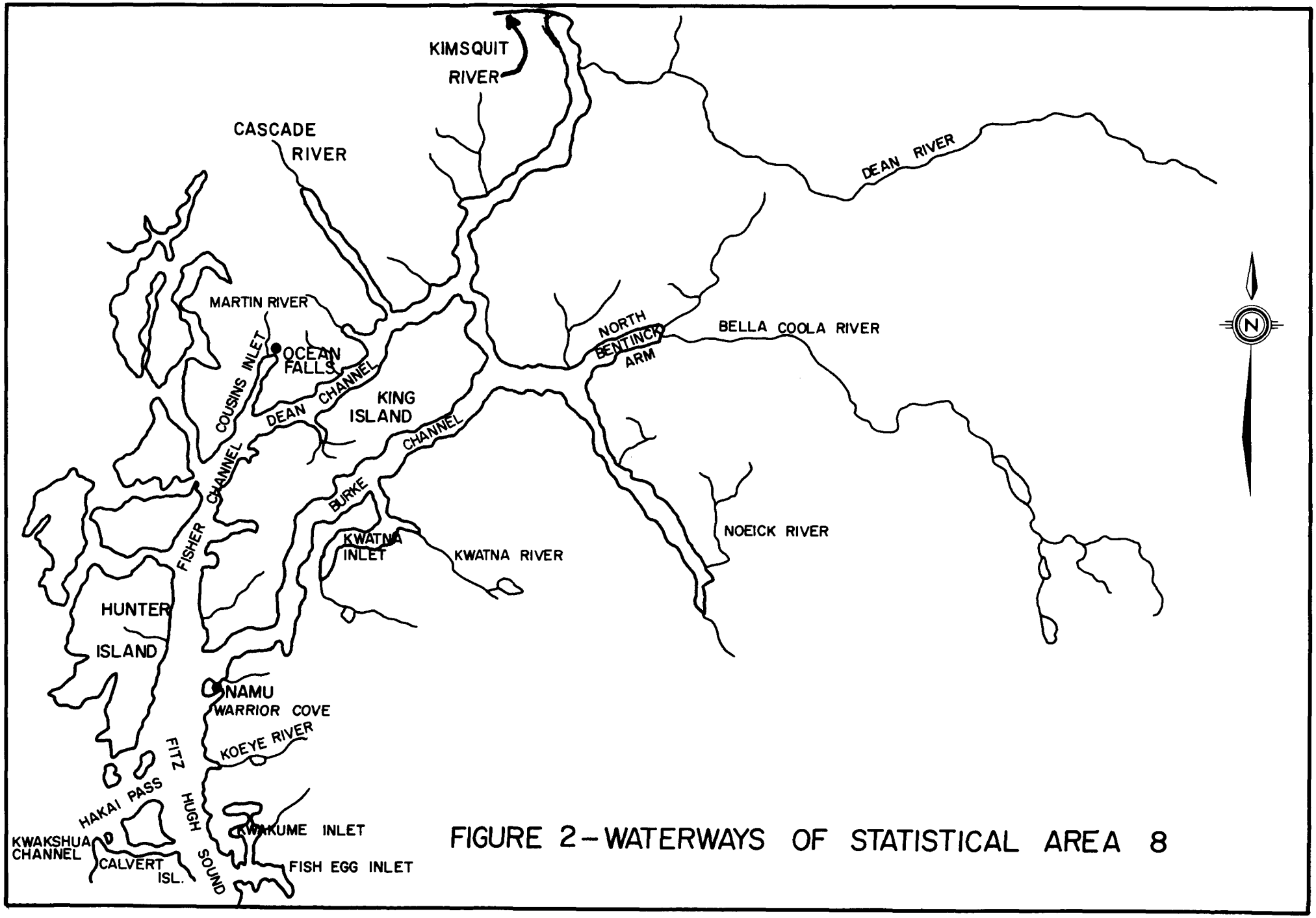

FIGURE 2 – WATERWAYS OF STATISTICAL AREA 8

Salmon, on their spawning migration, do not pass the Ocean Falls pulp mill. However, since 1920 there have been small but viable runs of coho, pink, and chum salmon to the Martin River; about two miles west of the mill.(5)

The Martin River is the only spawning stream draining into Cousins Inlet and thus would be the focus of interest in any evaluation of the effects of the Ocean Falls mill on local salmon productivity.

Table IV presents escapement figures for the Martin River. Comparison of these figures with escapements for Area 8 as a whole indicates that the Martin River accounts for an average of approximately 0.4% of the total pink escapement, 4% of the chum escapement, and 5% of the coho escapement from 1971 to 1975. Sockeye and chinook salmon are not present in this system. Unfortunately, records of escapement to the Martin River for the period prior to the establishment of the Ocean Falls mill in 1912, are not available.

The period of upstream salmon migration to the Martin River extends from mid-August to the end of the summer, with peak spawning occurring September to October. Pink salmon arrive in the river first and coho last.(4) It is thought that the fish destined for the Martin River travel via Fisher Channel along the north side of King Island and up Cousins Inlet.(4)

Juvenile stocks of pink and chum appear to move out of the Martin River/Cousins Inlet area in their first season after emergence, while immature coho can be seen in the inlet for the entire summer period.(4)

Water quality studies have indicated that effluent dispersion in Cousins Inlet is relatively good. Dissolved oxygen levels in surface waters (in which migrating juvenile salmon from the Martin River would probably frequent) are adequate and not likely to cause fish mortalities.(7)

A rearing study involving chinook salmon and rainbow trout was conducted in Cousins Inlet by the University of Washington and Crown Zellerbach in 1971/1972.(8) The study site was located about 2 miles from the mill on the west shore of the Martin River outlet. The results of the study showed that Chinook salmon and rainbow trout growth rates, under the prevailing conditions in Cousins Inlet, were comparable to chinook and rainbow in Puget Sound, Washington. There were neither abnormal mortalities nor impairment of appearance or flavour.(8) These findings would indicate that at least the surface water quality of Cousins Inlet is adequate for the rearing of Martin River salmonids.

Adult migrants congregate at the head of the Martin River prior to heading upstream to spawn and do not demonstrate avoidance reactions towards effluent-containing waters. Apparently, upstream migrating adult salmon and downstream migrating juveniles do not show any signs of behavioural abnormalities which might be attributable to the presence of mill effluent in Cousins Inlet.(9)

Large numbers of coho fingerlings (perhaps originating from the Martin River system) have been seen in inshore Cousins Inlet waters (5) and around the docks in front of the pulp mill.(7) Although this would suggest that waters around the mill are not acutely toxic no studies on sublethal effects have been undertaken in the area.

Fish kills have never been reported in Cousins Inlet.(4)

C. Salmon Sports Fishery

i) Tidal

The tidal sports fishery in Area 8 has been increasing in importance over the past few years. In addition to local residents of Ocean Falls, Bella Coola, Namu, and the several logging camps in the area, an increasing number of tourists are frequenting the area. The Koeye River and Hakai Pass are favourite spots, the latter particularly for summer catches of chinook and coho salmon. Kwatna Inlet and Namu Harbour also contribute to the chinook salmon sport catch during the mid-summer months. Some trolling for winter chinook is successfully undertaken in North Bentinck Arm. It is significant that the bulk of the coho caught in the area are taken by Ocean Falls residents fishing in Cousins Inlet during the fall when the fish are schooling at the mouth of the Martin River.(1) Although no spawning is doucmented for the Martin River a few chinook are also reportedly taken in Cousins Inlet.(9) Table V presents sport fishery catches for Area 8 for 1965 to 1975.(10)

ii) Non-Tidal

Non-tidal sport fishing in Area 8 occurs mainly on the Bella Coola-Atnarko and Dean river systems. Smaller fisheries exist on the Kwatna and Koeye and occasionally the Noeick and Kimsquit rivers. In the Bella Coola-Atnarko system steelhead and chinook are taken in the spring and summer while coho are caught in the fall. The Dean River is best known for its steelhead, chinook, and to a smaller extent, coho catches. The Kwatna and Koeye rivers are noted for their coho.(1)

TABLE V

Tidal Salmon Sport Fishery Catch (Pieces)(10)

Area 8

YEAR	CHINOOK	JACKS	COHO	PINKS & OTHERS *
1975	2440	387	670	30
1974	768	180	695	20
1973	277	106	330	-
1972	918	174	475	330
1971	no report	no report	no report	no report
1970	375	100	225	-
1969	350	100	125	-
1968	120	130	260	-
1967	325	150	550	50
1966	100	25	475	-
1965	400	200	475	75
10 yr. avg. (1965-75 excluding 1971)	607	155	428	50

* Others include chum and sockeye.

\- None taken

In the future, the non-tidal sport fishery in Area 8 will likely increase in importance as it is within vacation range of large population centers. Guide camps and lodges presently exist which cater to non-resident fishermen, many of them American. Tweedsmuir Park has recently been established on the Atnarko in anticipation of a large influx of tourists.

Table VI presents steelhead sport catch statistics for 1974-1976.(11)

E. Indian Food Fishery

There is not a sizeable Indian population in the Ocean Falls area and accordingly there is only a small Indian food fishery in Cousins Inlet.(4)

Salmon and steelhead native fisheries exist in the Bella Coola-Atnarko, Namu Harbour, Fisher-Fitzhugh Channel, and North Bentinck Arm areas. The bulk of the catch is made with short gill-nets in the lower 4 miles of the Bella Coola River. However, set nets are used for steelhead, chinook, and sockeye in some areas. Small seines and commercial gill-nets are occasionally used in Fitzhugh Sound.(1)

Eulachon are taken by seine and trap in the spring (mid-April to May) in the Bella Coola River and in the Kimsquit and South Bentinck Arm areas.

Table VII gives catch statistics for Indian Food Fishery for 1965 to 1975, from Area 8.

III HERRING

Herring were originally fished predominantly for reduction to fertilizer and meal, but are presently utilized strictly as a food and roe resource. The size of herring stocks are carefully monitored by the Fisheries and Marine Service. From 1969 to 1971 inclusive, the herring fishery in Area 8 was closed to allow replenishment of depleted stocks.(1)

Comparison of the central coast subdistrict herring catch statistics with those for Area 8 (13) indicate that the latter accounted for 14%, 36% and 6% of the total (Areas 7-10) roe herring fishery catch in 1974, 1975 and 1976 respectively. The Area 8 catch represents a 3-year average of 2.6% of the

TABLE VI

Non-Tidal Sport Catch - Steelhead (11)

Area 8

STREAM	DAYS FISHED		NUMBER OF ANGLERS		RETAINED/DAY	CATCH/DAY
	Reported	Estimated	Reported	Estimated		
Atnarko						
1975-76	254	753	77	248	0.307	0.409
1974-75	323	1009	83	251	0.282	0.520
Bella Coola						
1975-76	1517	4838	268	853	0.358	0.627
1974-75	1264	3998	195	599	0.313	0.545
Dean						
1975-76	1453	3479	322	793	0.292	1.372
1974-75	1533	3453	322	712	0.315	1.183
Koeye						
1975-76	-	-	-	-	-	-
1974-75	1	1	1	1	0	1
Noeick						
1975-76	20	67	1	3	0	0.100
1974-75	3	9	2	6	0	0

- No Records

* Steelhead reported figures are obtained from postcard surveys. Estimates are compiled from these results.

TABLE VII

Indian Food Fishery Catch (Pieces)[1,12]

Area 8

YEAR	SOCKEYE	COHO	PINK	CHUM	CHINOOK	STEELHEAD	EULACHON (CWT)
1975	5500	1000	100	1000	250	350	240
1974	3940	850	4700	1430	220	350	190
1973	4000*	1500	90	275	200	750	220
1972	1600	3000	1700	2300	425	150	120
1971	3958	1647	80	643	691	244	300
1970	1480	2350	3200	1375	570	190	165
1969	3170	302	170	152	763	287	140
1968	1220	2130	2750	1245	965	275	190
1967	2650	425	750	110	907	347	207
1966	2090	1680	1110	350	675	430	165
1965	2323	1272	800	70	844	347	210
10 yr. avg. 1966-75	2995	1488	1465	908	566	337	193

* 360 jacks

total west coast catch. Area 8 catches are taken with seines and gill-nets from late March to early June, largely in Burke and Kwakshua Channels and also at Kwatna Rocks.(1)(Figure 3)

Schools of herring are frequently observed in the vicinity of the pulp mill docks in Cousins Inlet.(7) However, there have not been any recent assessments of the size of the herring stocks.

There is no herring fishery presently in Cousins Inlet. Prior to 1967, a "reduction fishery" existed but it was discontinued when herring ceased to be taken for reduction purposes in B.C. Cousins Inlet herring are considered too small to be taken for food purposes and their roe is insufficient in quantity to support a viable roe fishery.(9)

Herring spawning locations in Area 8, as shown in Figure 3, include the Burke Channel, Kwakshua Channel, North and South Bentinck Arms, Kimsquit Bay, Warrior Cove, Illahie Inlet, and Kwakume Inlet.(13) A 25 year average (1940-1964) of 5.7 statute miles of herring spawn has been recorded for Area 8, although over the past 5 years (1970-1976) a significantly higher (45.1 statute miles) amount has been documented.(13)

Until approximately 5 years ago a very small amount of herring spawn was deposited in Cousins Inlet. However, it was not of sufficient quantity to be included in the Area 8 statistics.(9)

Table VIII gives herring catch statistics, spawning stock estimates, and total stock estimates for Area 8.(13, 14, 15, 16)

IV HALIBUT AND GROUNDFISH

Commercial halibut fishing in Area 8 is light, representing only about 1.4% of the north coastal catch.(2) A large part of the catch is made by trollers although there is a small longline fishery in Kwakshua Channels and Burke Narrows.(1) Table IX shows the catch statistics for this species.

Aside from halibut, the commercial groundfish catches consist predominantly of ocean perch, which are usually landed off the west coast of Calvert Island.

Groundfish are not taken commercially in Cousins Inlet (4) although the occasional rock cod is reportedly taken by sports fishermen.(9)

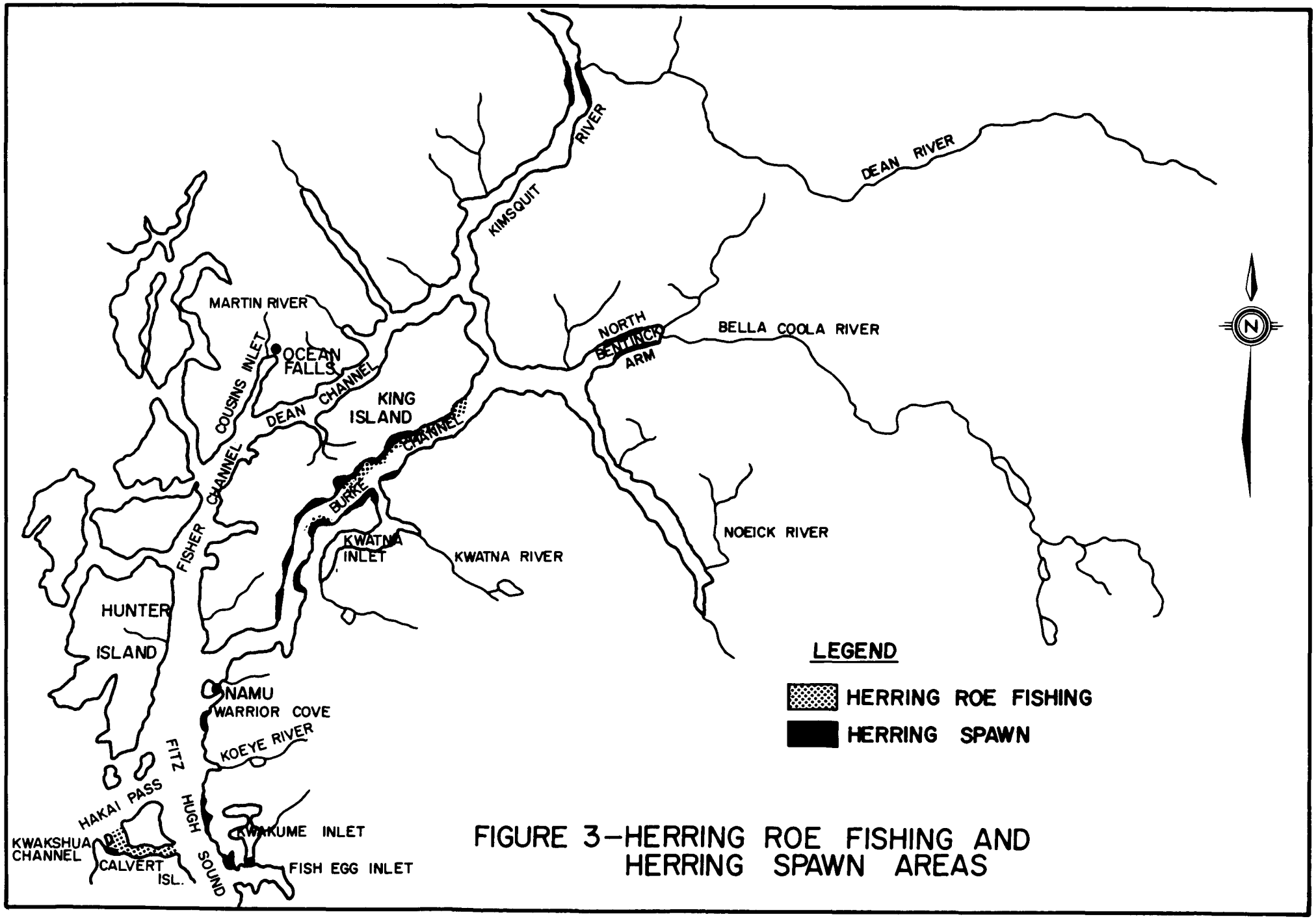

FIGURE 3–HERRING ROE FISHING AND HERRING SPAWN AREAS

TABLE VIII

Commercial Herring Catch and Estimates of Total Herring Stock in Area 8 (13,14,15,16)

YEAR	COMMERCIAL CATCH (000's lb.)	COMMERCIAL CATCH (millions of fish)	SPAWNERS* (millions of fish)	TOTAL**
1975	6433	information	not	available
1974	2167	information	not	available
1973	4116	12.8	93.1	105.9
1972	7024	29.7	48.2	77.9
1971	0	0	63.1	63.1
1970	0	0	106.9	106.9
1969	0	0	2.7	2.7
1968	1753	24.8	6.8	31.6
1967	2489	66.7	34.6	101.3
1966	21746	229.0	3.6	232.6
1965	19763	29.6	15.4	45.0
1964	38270	161.0	1.0	162.0
1963	38152	92.6	11.0	103.6
1962	17376	166.6	45.7	212.3
1961	20890	31.6	12.6	44.2
1960	1007	12.3	29.0	41.3
1959	7845	60.0	5.5	65.5
1958	9893	68.7	13.4	82.1
1957	14660	81.8	2.5	84.3
1956	1057	7.9	3.3	11.2
10 yr. avg. (most recent years)	4572.8	55.4	37.5	92.9

* Spawner data from square yards of spawn and fecundity

** Total = Catch (millions of fish) + Spawners (millions of fish)

- Nil

TABLE IX

Commercial Catch for Groundfish (2)

(000's lb.)

YEAR	HALIBUT	SOLE	COD*	FLOUNDER	SKATE	OCEAN PERCH
1975	234	790	2088	-	29	-
1974	140	381	866	-	6	3685
1973	256	249	959	-	17	2634
1972	345	609	2347	-	18	3308
1971	84	583	713	0.1	2.8	1872
1970	319	388	414	0.1	17	1695
1969	107	605	445	0.1	4.5	1995
1968	67	424	609	-	6.4	1607
1967	54	493	480	-	1.9	500
1966	367	830	819	0.7	0.8	3505
1965	85	671	1038	-	3	1981
1964	54	603	715	0.7	2.3	700
1963	127	1027	686	0.6	3	948
1962	117	1018	1095	-	10.5	1162
1961	84	686	529	-	2	194
1960	146	1119	781	-	5.4	625
1959	193	739	1267	-	8.7	196
1958	90	805	969	-	3.3	-
1957	487	430	513	-	6.1	20
1956	200	541	517	-	1.9	259
10 yr. av. 1966-75	197.3	535.2	974	0.1	10.3	2080.1

* Includes: red, black, rock, ling cod.

V CRUSTACEANS AND MOLLUSCS

Both crustacean and mollusc fisheries in Area 8 are of modest size.(Table X) Butter clams are periodically taken although recently smaller quantities have been recorded than in 1959 and 1960.(2) Crabs are infrequently taken commercially. The Area 8 shrimp and prawn catch is historically sporadic and of small proportions. In 1974, a government sponsored experimental project subsidized the processing of the catch of a few shrimping vessels operating off the west coast of Calvert Island. The following year there was an increased interest in commercial shrimp and prawn fishing and Area 8 catches were recorded as good. The fishing was undertaken in Kwatna Inlet, Fishegg Inlet and Kwakshua Channel.(1)

Commercial crustacean and mollusc fisheries do not exist in Cousins Inlet.(3)

In the immediate vicinity of the pulp mill (up to about 2 miles from the head of the inlet) fibre deposits have covered the substrate resulting in the depletion of macrobenthos.(17) Beyond the immediate vicinity of the mill faunal surveys indicate conditions are currently unaffected by pulp mill activities. However, uniform growth of juvenile mussels and barnacles indicate possible recolonization of previously destroyed populations. (5)

TABLE X

Commercial Crustacean/Mollusc Catch (2)

(000's lb.)

YEAR	SHRIMP/PRAWNS	CRABS (IN SHELL)	BUTTER CLAMS
1975	40	-	-
1974	405	-	-
1973	111	-	7
1972	-	-	46.2
1971	-	-	130.5
1970	-	-	-
1969	-	-	-
1968	1.8	-	-
1967	-	-	-
1966	-	-	-
1965	-	-	-
1964	5.6	0.3	-
1963	-	0.3	1.8
1962	-	-	16.4
1961	-	-	34.5
1960	-	-	296
1959	-	-	211.2
1958	-	-	83
1957	-	-	16.3
1956	-	-	-
10 yr. av. 1966-75	55.78	-	18.37

- No catch

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