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REPORT ON THE WATERS OF QUATSINO SOUND, ALICE ARM, THE EFFECT
OF THE PULP MILL AT PORT ALICE, 1927

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by

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Introduction

The following report is the summary of an investigation of the waters of Alice Arm (South East Arm), Quatsino Sound, conducted at the request of the Fisheries Department and initiated in consequence of certain complaints on account of the alleged harmful effect of the waste from the pulp mill at Port Alice upon the fishing industry of the region in question.

On board the C.G.S. "Malaspina" in charge of Captain Laird, we arrived at North Harbour, Forward Inlet, Quatsino Sound, on the evening of August 16th. Friday, August 17th, was occupied making collections, as described in more detail below; most of the analyses were made at once in order that no changes might take place before the records were obtained; the pulp plant was visited and through the courtesy of the management a complete demonstration and description of the process was given by the chemist in charge. The boat was tied up at the mill-wharf where it remained over night and where a series of water samples were obtained. En route, the fisheries guardian was interviewed and his verbal report on the route, the present and past status of the fish found in Quatsino Sound was received.

Stations Established

Five stations were established: (1) midway between Brockton and Limestone Islands, main channel Quatsino Sound; (2) off Klootchbaleesh River near the mouth of South East Arm; (3) between Mist Rock and Dog Island; (4) North

East of the pass bordered by Long Island, and (5) one boat width ("Malaspina") from the wharf of the Port Alice pulp mill. These stations were located at distances of 15, $7\frac{1}{2}$, $3\frac{1}{2}$, $1\frac{1}{4}$ and 0.01 miles from the pulp mill. The first station was established for purposes of comparison; since it was in the main channel of the sound which has several arms and since it is open to the full effect of the tide its waters may be regarded as characteristic of the area. The other stations, all in South East Arm, should show progressively the effect, if any, of the waste products upon the waters of this region.

Samples

At each of the stations described above, water samples were taken with a closing water bottle at depths of: bottom, 60 feet, 30 feet, 15 feet, 6 feet, 3 feet and at the surface; several additional surface samples were taken at the wharf; altogether, 53 samples were obtained. These were separated into two portions, the first was used for chemical-physical analyses and the second was preserved to be examined microscopically for wood fibre and small plants and animals which serve as fish food (plankton). The samples are numbered 2,679 to 2,702. They were placed in series with samples taken at other parts of the coast of British Columbia. The bottom samples were at depths 360 feet (station 1), 480 feet (station 3), 219 feet (station 4) and 42 feet (station 5). The bottom samples should detect the presence of any solid material heavier than water and the near surface samples contain any readily soluble materials dissolved in the wash water (waste liquor) which floats on the heavier salt water, as well as a large proportion of the waste wood pulp and any living forms constituting the fish food. In addition to the above mentioned samples, ten gallons of surface water were poured through a fine cloth net and thereby

additional samples of the wood fibre, plankton, etc., were obtained at each station.

Analyses

For each sample the following determinations were made: temperature, specific gravity, salinity (chloride per litre), acidity (pH) and oxygen content. Standard methods of analyses were employed in each case; the Mohr method for chloride; the Winkler method for oxygen; the colorometric method for acidity (pH), using the La Motte standards; the temperatures were determined with a Negretti & Zambra reversing deep sea thermometer and the density (specific gravity) with standard hydrometers. These data have been tabulated in the forms attached.

Acidity

It may be noted that the sulphur dioxide used in the sulphite process forms an acid (sulphurous) when dissolved in water and if discharged in the waste liquor in amounts sufficient to be toxic after dilution by sea water, it can be detected. The normal acidity of sea water ranges from 7.8 pH to 8.5 pH. The water of Alice Arm falls well within these limits and even within a few hundred feet of the discharge pipe, although somewhat below the normal for surface water, does not exceed the limits for normal sea water.

Oxygen

Under ordinary conditions, sea water on the continental shelf ranges in oxygen content from 50 per cent saturation at or below 300 feet to near saturation for the upper layers. It is found, however, that in deep undis-

turbed basins the bottom water may be practically devoid of oxygen (e.g. Saanich Inlet). On the other hand an abundance of microscopic plant life at the surface may result in super-saturation with respect to oxygen. It is generally recognized that pollution of natural waters by sewage and industrial wastes results in pronounced lowering of oxygen values. Sulphite in particular, if present in any considerable quantity, unites with oxygen to form sulphate with a corresponding decrease in free oxygen content. The oxygen values of the waters in South East Arm were normal. In no case did the bottom samples fall below 40 per cent saturation and at the station near the mouth (#2) super-saturation was attained at the surface. At the wharf of the pulp mill the water was more than 80 per cent saturated with oxygen. (See table I).

Salinity

In general the salinity of water along shores is an expression of the amount of river water which has become mixed with the sea water. Water of the open sea has a salinity of 18.0 to 19.0, expressed as chloride per liter, while the water in the Strait of Georgia near the mouth of the Fraser River at the surface may have a value of 4.0 or even less. The upper layer of lighter, less saline water is often quite stable. The salinity of the water in Alice Arm should give a measure of the amount of fresh water brought down by streams plus that used as ash water and also indicate the amount of circulation and the discharge to the open sea of this waste-containing water. The analyses (table I) show that the water at the bottom of Alice Arm is practically that of the open sea, 18.1 to 18.9, and is undisturbed, while at the surface the salinity is similar to that in Haro or Rosario Straits and is considerably above that of any part of the Strait of Georgia at the same

period of the year (August); in other words, the salinity is such as would permit the growth of abundant fish food.

Amount of Wood-fibres

The amount of wood fibre suspended in the water was estimated from the samples collected by counting the number of fibres in one cubic centimeter of the specimen. This number was multiplied by 4,450 in order to indicate the number of fibres per gallon of sea water (see table III). In Quatsino Sound at a distance of 15 miles from the mill there are from 9 to 13.5 thousand wood fibres per gallon according to the depth, the fibres being more numerous near the surface. The number gradually increases as the pulp mill is approached until at the wharf there were approximately 30,000 at a depth of 3 feet, 20,000 at depths from 6 to 30 feet and 40,000 at the bottom expressed as numbers of wood fibres per gallon. This number may be compared with the number of fibres in a piece of paper prepared by the same mill, one inch square and $1/25$ inch thick, namely about 360,000. In other words the number of wood fibres in a square inch of paper, $1/25$ inch thick, is the amount contained in 12 gallons of water near the surface at the wharf and is also equal to that contained in 9 gallons at the bottom.

The particles of material known as fibres are extremely small. Those found in paper ranged from 20 to 45 millimetres in length, that is from $1/12$ to $1/5$ inches (ca). The particles found in the sea water as waste are generally smaller; even near the wharf many of the fibres discarded were not more than 1 millimetre ($1/25$ inch) long and the size of particles which remain suspended is progressively smaller the greater the distance from the mill; at 15 miles distance, although there are still about 10,000 fibres per gallon the length

of each does not exceed 0.4 mm. (1/60 inches). These fibres are also more irregular in outline. In addition to the above there are in each sample approximately five times the number of extremely small wood particles, nearly cubical, about 0.025 millimetres (1/1000 inches) in cross section which in wood structures bind the fibres together and are known as medullary ray cells.

Living Forms

The microscopic animals and plants found in sea water not only constitute the primary fish food but also their presence may be taken as an indicator of the suitability of the chemical and physical conditions for organisms in general, including fish. The appended table demonstrates the presence of diatoms (*Chaetoceros*, *Skeletonema*, etc.), Peridinians, Tintinnidae, Copepoda and larvae at all the stations, even at the wharf (with the exception of diatoms at station #4 - 1 1/4 miles from the mill); it may be noted, however, that these reappear at station #5, i.e., at the wharf). These forms are such as may be expected normally in sea water at the season when the samples were taken.

The organisms mentioned above, although present, were not found in the immense quantities which characterize areas where the pilchard are abundant. A similar condition obtained in several other inlets and sounds on the west coast of Vancouver Island at the same time, Esperanza Inlet and Alberni Canal, for instance, while at Nootka and to a less extent at Tofino the plankton was abundant and pilchards were being caught. These fluctuations are still problematic and require further investigation.

Fish in Quatsino Sound

The verbal statement of the fishery guardian given before the captain

of the "Malaspina" and the undersigned may be summarized as follows:

1. That salmon are being caught in Quatsino Sound in South East Arm, as formerly.
2. That the herring were abundant and spawned freely in South East Arm last season; that some dead herring were found on shore but the cause is not definitely known.
3. That there was a pilchard "run" to the head of Alice Arm two years ago but this circumstance has not recurred last year, nor this year to date; also that pilchards may have been present previously but were not recorded.

Discussion

A report on Investigation of Pollution of Streams issued by the Bureau of Prevention of Stream Pollution for the State of New York (1923) shows that the oxygen content of water falls very rapidly when sewage or industrial waste is discharged into a stream, often reaching less than 10 per cent saturation. The water of Quatsino sound is 95 per cent saturated at a distance of 1 1/4 miles from the pulp mill (see table I).

Another report on the Pollution of Streams by Sulphite Pulp Waste, written by E.B. Phelps (Washington 1909), estimates the amount of sulphite waste liquor discharged into the streams of U.S. in 1906 as 3,227 million gallons. It is natural that the question should arise as to the disposal of this great amount of waste and the recovery of the streams which have received such a great load. This report gives the following table:

Materials in Waste Liquor per Ton of Pulp

	<u>Pounds</u>
Wood material	2,000
Calcium sulphate	449
Sulphur dioxide (not included in total below)	18
Sulphur (additional in combination)	196
Total solid matter	<u>2,645</u>

At Port Alice the bark and knots are sent to the burners and the quality of the wood used and the nature of the process are such that the pulp waste is approximately 10 per cent the amount utilized compared with 100 per cent, as for instance, in the Washington report. The "white water" is again used and the sulphur dioxide content of the waste liquor is reduced thereby.

It is evident that improved methods have been advantageous to the pulp industry and have reduced the hazard to the fishery industry.

A Biological Survey of the Upper Mississippi River with Special reference to Pollution, by A.H. Weibe (1928), Bulletin of the Bureau of Fisheries, shows that in little more than 50 miles distance this comparatively small body of water has practically recovered from the waste of the two cities, St. Paul and Minneapolis. The oxygen content is taken as the one of the most significant criteria.

Conclusions

1. That the chemical and physical properties of the water in South East Arm, Quatsino Sound, were well within the limits of sea waters of the continental shelf at the time of this investigation.

2. That organisms such as are characteristic of similar regions were present there. The fluctuation in the quantity and the causes need further

3. The economic varieties of fish have been found in the sound since the pulp mill was established and evidence is wanting to show that the supply has been materially or definitely altered.

4. Further investigation of the effect of wood fibre and of "ligno-sulphonic" acids on fish is desirable, particularly in the case of young fish.