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Vancouver Island.

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Introduction

The problem of blue-green algae in Quamichan Lake was brought to the attention of the Pacific Biological Station by Mr. Webster of H. A. Simons, Ltd., consulting Engineers, in a long distance phone call to Dr. J. P. Tully and Mr. M. Waldichuk from Vancouver, January 10, 1955. Mr. Webster pointed out that in their plans for the proposed pulp mill at Crofton, B.C., they were planning to take water from the Cowichan River and divert it into Quamichan Lake which was to act as a type of storage and settling basin. After the particulate material in the Cowichan River water has settled out in the lake, the water would be piped to the millsite at Crofton.

The chief problem appears to be that profuse growths of blue-green algae would interfere with the water quality and probably clog the lines. The question was raised whether the lake would be cleared of the algae by a turnover of the water as proposed in the storage plan or whether other measures would be necessary to eradicate this nuisance. It was pointed out that the use of large quantities of chemicals to such an end would render the water unfit for the pulp mill operation. Large filtering installations were to be avoided also as they run into capital expenditures and maintenance problems.

The present report is based on some studies which were made on the Cowichan River drainage basin from this station during the 1930's and again on Quamichan Lake about 1945. In addition, information is drawn from available literature sources.

Physiographical Description of Quamichan Lake.

Quamichan Lake is a shallow (20 to 25 feet in maximum depth) low-lying valley lake at about 100 feet above sea level. With its northeastern end about 2 miles from Maple Bay it is a typical coastal lake about 2/3 of a mile wide and 2 miles long (Figure 1). It appears to be rapidly filling in from the deposition of the heavy silt load brought down regularly by scouring tributary streams during freshets in the rainy season. Extensive logging in the area seems to have accelerated this trend. With nearby Somenos Lake, only a few feet above sea level, Quamichan Lake apparently forms the remains of a shallow, broad marine embayment. Marshland extending to the north of Somenos Lake suggests a fairly recent reclamation from water-covered territory. During heavy runoff, Quamichan Lake receives water from the MacIntyre, Elkington and two other unnamed creeks at its northeast end. Additionally, it receives drainage from the rich farmlands surrounding the lake. This source probably provides the rich nutrient water which seems to be typical of the lake. During the summer, influent water dwindles to a mere trickle or completely vanishes in dry years. The outflow from the lake leaves by way of Quamichan Creek into the Cowichan River. A dam on the Quamichan

River reduces the discharge so that during the summer there is very little outflow.

Water Characteristics.

Because of its relatively stagnant condition in summer, Quamichan Lake becomes quite warm particularly at the surface (up to 80°F). This condition of warm temperature and bright sunshine encourages the growth of one-celled organisms which generally come under the classification of blue-green algae. Water at the surface becomes supersaturated with dissolved oxygen released from the photosynthesis of the algae. Deep water, which is beyond the penetration of sunlight owing to the dense cover of algae, is in the zone of decomposition where dead vegetation settles and decays under the action of bacteria. Consequently, deep water is usually completely lacking in dissolved oxygen during the late summer. The advent of this condition might be prevented by wind during some years. These biological processes are also reflected in the hydrogen-ion concentration of the water. The surface water may be at a pH as high as 9.88 whereas the deep water may have a pH as low as 7.0 (Neave, 1945).

Biological Observations.

Quamichan Lake is ringed by a thick belt of reeds, mostly <u>Scirpus robustus</u>. Water lilies, <u>Nuphar polysepala</u>, and the water weed, <u>Potamogeton pusillus</u>, are found in restricted areas (Mottley and Carl, 1935).

Observations on the plankton (drifting plant and animal life) in Quamichan Lake were reported by Mottley and Carl (1935) and are quoted in part:

"At the time of the investigation a 'water bloom' was present on Lake Quamichan. In the morning before the breeze disturbed the water the bloom appeared as a slimy yellow-green scum floating on the surface of the lake. Later in the day the organisms making up the bloom became distributed in the upper two-meter layer of water giving it a very turbid appearance. Examination of plankton samples showed that the dominant forms were two species of the blue-green alga, Microcystis."

Also listed in the report were two species of rotifers, one species each of cladocera, copepoda, and insecta of the zooplankton.

When observations were made again on August 20, 1945, the water was brown in colour from the bloom of plankton. The principal organisms in the dense populations were the dinoflagellate, Ceratium (a microscopic plant) and the rotifer, Keratella (a microscopic animal) (Neave, 1945).

Fish fauna in Quamichan Lake consist mainly of the indigenous species, stickleback (Gasterosteus aculeatus), cut-throat trout (Salmo clarkii) and sculpin (Cottus asper). But some land-locked sockeye salmon or kokanee (Oncorhynchus nerka kennerlyi) lake trout (Salvelinus fontinalis), and Dolly Varden char (Salvelinus malma) have also been taken. Kamloops trout

(*Salmo gairdneri* Kamloops), brown trout (*Salmo trutta*), and Atlantic salmon (*Salmo salar*) have been introduced but few have been known to survive.

The Biotic Environment.

The physical and chemical conditions combined with the acute biological changes render the lake unsuitable at times for fish fauna. Indigenous populations of stickleback, cutthroat trout, and sculpins have suffered on occasion and numerous dead fish have been found washed up on the shores (Neave, 1945). Even some dead aquatic mammals and birds, such as muskrats, grebes, and ducks were found along the shore during the fish kill of 1945. Of the several causes for fish kills, the physical and chemical conditions in the lake during that time, August 15 to 20, were chosen as the most likely by Dr. Neave. The fish had to choose between a temperature of 79.5°F, pH of 9.88 and oxygen saturation of 123% at the surface and conditions of approximately 70°F, pH of 7.0 and 0% oxygen near the bottom. Moreover, the presence of dense masses of the plankton can be detrimental in itself to fish.

Probably for these reasons mainly the artificial propagation of game fishes in the lake has not been too successful. Local anglers fishing in Quamichan Lake claimed, during the period of investigation in 1933, that they were not getting adequate returns from the plantings (Mottley, 1933).

Conditions Supporting Algal Development.

Algal growths have been shown to be influenced by many factors such as pH, turbidity (Taft, 1949), sunlight (Strausbough, 1928), temperature, rate of flow of water, and the concentrations in the water of mineral nutrients, including silicates, phosphates, nitrates, carbonates and manganese (Rosenberg, 1939). Decomposition of organic matter and drainage from rich farm lands stimulate algal blooms.

Lund (1954) observed that the richness of algae in a reservoir or lake can be generally related to the surface geology of the catchment area and the land utilization therein. He showed no certain cause for the growth but indicated a relation between the phosphorus, nitrogen and other nutrient elements in the water to growth of algae.

No data are available on the nutrient concentrations in Quamichan Lake, but from the large amount of aquatic vegetation it is judged that phosphates and nitrates are probably present in abundance. Runoff into Quamichan Lake would be anticipated to carry considerable nutrients because of the rich farm lands which it drains. Decaying vegetation in the water liberates additional nutrients. Having very little turnover because of the small volume of affluent water, the lake would tend to concentrate nutrients. It is anticipated that flushing of the lake with Cowichan River water would reduce its nutrient content. Most permanent coastal streams such as the Somass and Fraser Rivers have been shown to possess very little phosphate in their waters and undoubtedly Cowichan River water is similar.

Algae Control.

Alteration of Environmental Conditions.

It can be predicted that at least two changes will occur in Quamichan Lake from its proposed use for a storage basin that will render it less suitable for algal development.

(1) Movement of water in itself will reduce the algae population.

(2) Flushing of the lake by Cowichan River water which is probably poorer in nutrients should reduce the nutrient concentration available for algae.

A rough calculation on the volume of the lake and the water requirements of the pulp mill will furnish some estimate on the frequency of turnover. Taking the lake as approximately rectangular with dimensions of 1.7 statute miles long by 0.7 miles wide and on an average 15 feet deep, the volume is 4.97×10^8 cu. ft. The requirement of the Kraft pulp mill at a production of 400 tons per day with 64,000 U.S. gallons of effluent per ton will be

$$\frac{400 \text{ gal/day} \times 64000 \text{ gal/ton} \times 0.134 \text{ ft}^3\text{/gal}}{24 \times 3600 \text{ sec/day}} =$$

39.6 c.f.s. (cu.ft.per sec.)

Hence turnover will be at the rate of once in

$$\frac{4.97 \times 10^8 \text{ ft}^3}{3.96 \text{ ft}^3\text{/sec} \times 24 \times 3600 \text{ sec/day}} = 146 \text{ days or about}$$

2.5 times per year. The algae should experience a noticeable reduction within the first year.

Chemical Control.

Chemical agents such as copper sulphate, or chlorine compounds, particularly chloramine, have been used at various times to control algae in ponds, lakes and reservoirs (Nason, 1938). This technique has certain disadvantages in that secondary results may be quite as unpleasant as the primary trouble it cured. Chemicals may prove harmful to the fish fauna and/or they may add an undesirable characteristic in the water for pulp mill use. In some cases the dead algae settle suddenly and result in putrid conditions at the bottom of the lake. Recent research (Fitzgerald and Skoog, 1954) however, has shown that an organic compound, 2, 3-dicholoro-naphthoquinone in concentrations as low as 30 to 55 ppb. clumped and effectively killed heavy growths of blue-green algae. These concentrations of the substance were found to be harmless to higher aquatic plants as well as fish. How it would affect the water conditions for pulp mill use is unknown, but such small concentrations can be hardly conceived to be harmful.

It is recommended that a qualified algalogist make a study of the problem following the changes from the present conditions through at least a year of the lake's use as a storage basin.

Summary

The use of Quamichan Lake as a storage basin should be accompanied by a noticeable reduction of blue-green algae therein. This would result primarily from a more rapid turnover of the water and a reduction of nutrients in the lake by replace-

ment with lower nutrient water from Cowichan River. The conditions for fish fauna should be improved with the increased turnover of water.

A more rapid eradication of the blue-green algae could be achieved by concentrations of 30 to 55 ppb (parts per billion) of 2, 3-dichloronaphthoquinone. This is harmless to higher plants and fish fauna but its effect on the water quality for the paper mill is unknown.

The problem should be subject to a detailed study by an algalogist.

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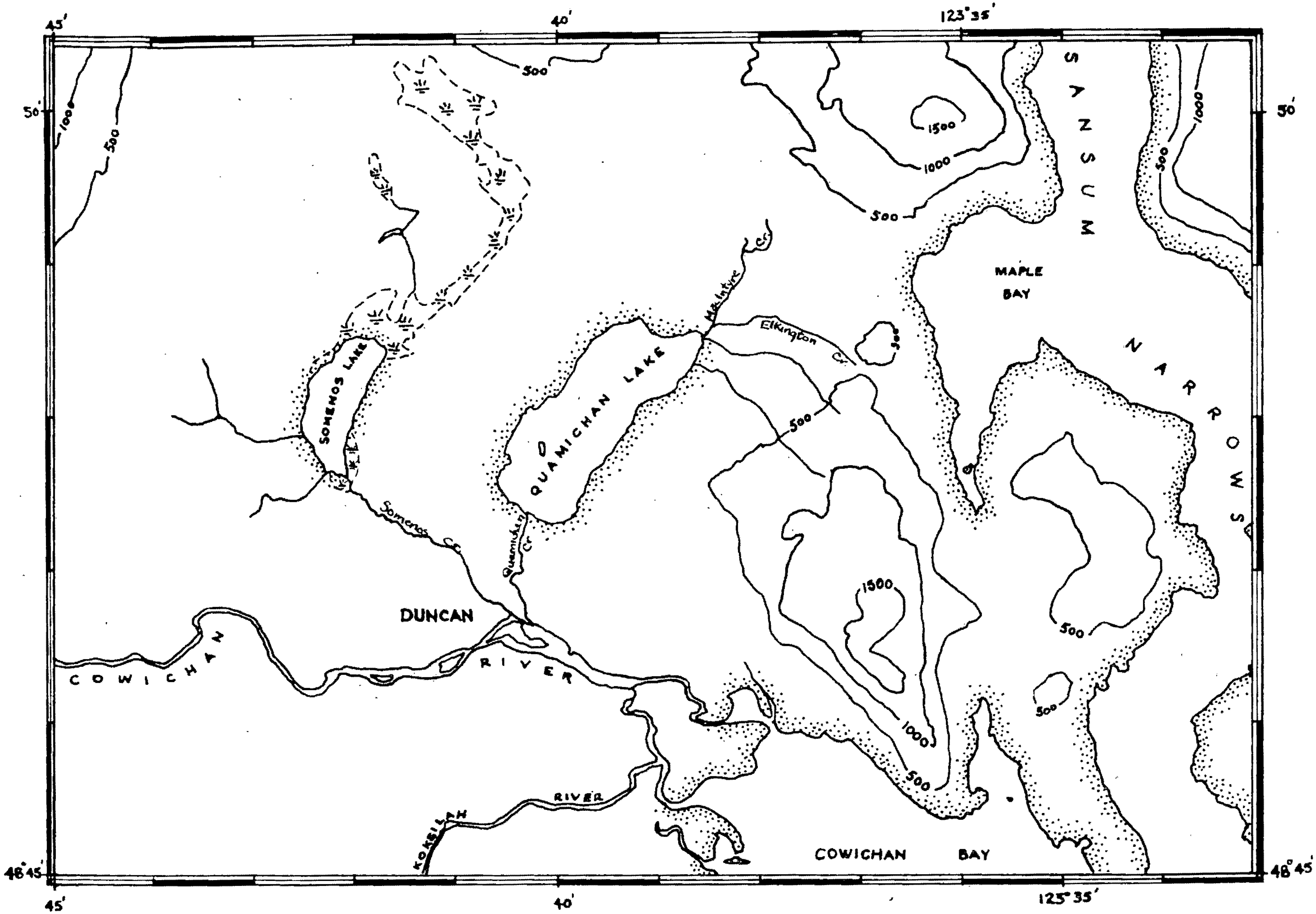

Figure 1. - Map of Quamichan Lake and environs.