BIOLOGICAL SURVEY
OF
RILEY LAKE

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Ministry
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by

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INTRODUCTION

Early in October, 1968, representatives of the Department of Municipal Affairs and Michael Hough Associates Limited, Landscape Architects and Site Planners, requested that a biological survey be conducted on Riley Lake in connection with a shoreline capability study. The purpose of the survey was: (1) to determine the existing physical and chemical conditions, nutrient levels and corresponding standing crops of algae in Riley Lake; (2) to provide a basis for considering the relationships between water quality and the recognized uses of this lake.

GENERAL DESCRIPTION OF THE STUDY AREA

Riley Lake is located in the Township of Ryde, District of Muskoka, approximately 12 miles southeast of Gravenhurst (Fig.1). It is a "stellate-shaped" lake and appears to be spring-fed, although some drainage enters the lake from a swampy area to the northwest. The lake has an estimated surface area of 350 acres, a maximum depth of 45 feet and a mean depth of 19.5 feet. A minimal low flow from the lake is made more sporadic owing to the activity of beavers which have constructed a dam over the southern arm.

An estimated 140 cottages surround Riley Lake. A survey based on results from 38% of the cottage owners on the lake revealed that 40% of the cottagers use pit privies to dispose of human wastes.

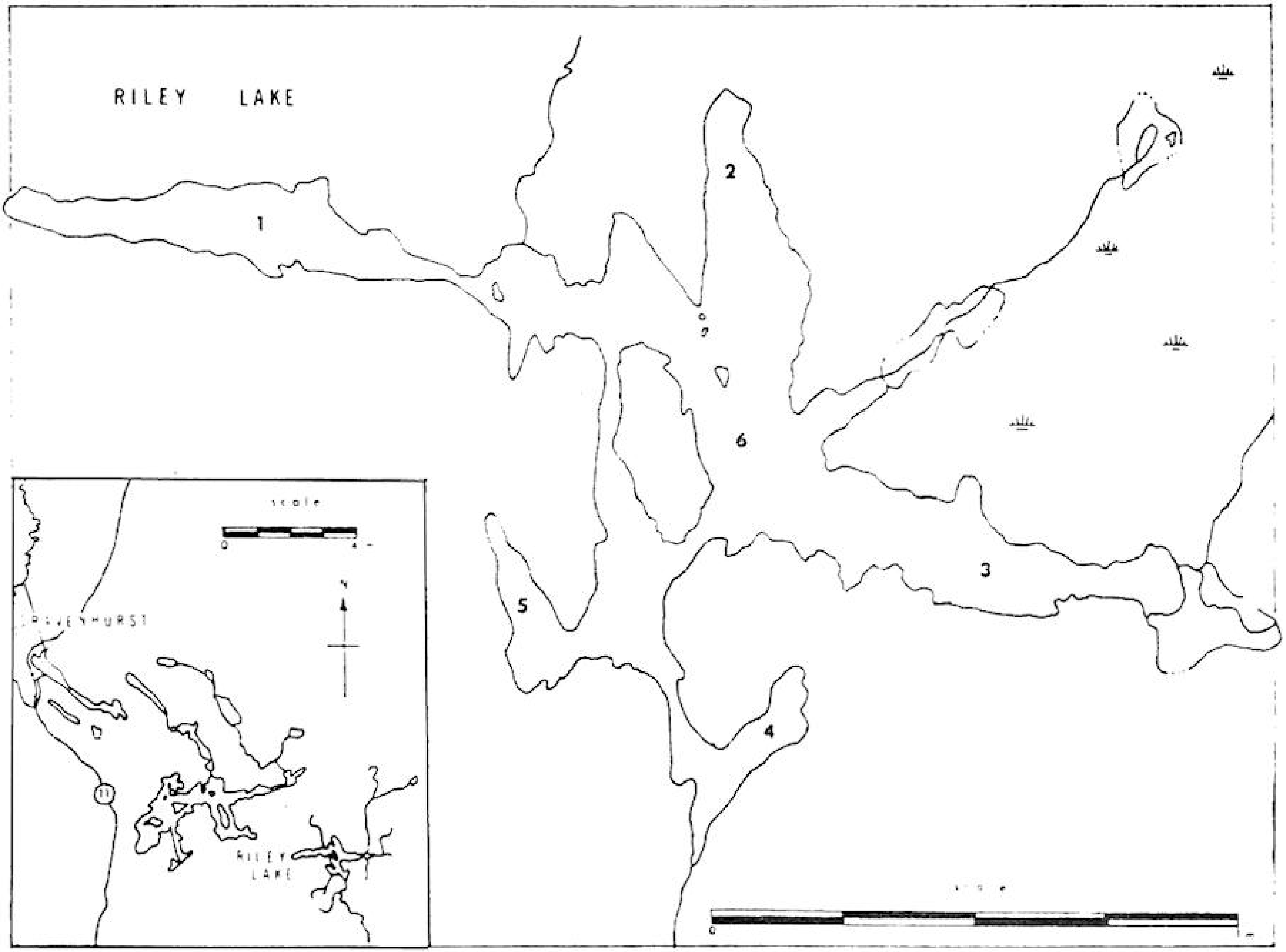

Fig. 1. Location of six sampling sites, Riley Lake, October 15, 1968.

Septic tanks serve the remaining cottages. In a few instances both disposal units are used. Kitchen-sink wastes in the majority of homes enter dry wells or septic tank systems. In a few cases, leeching pits and tile lines are used. Although a septic tank waste disposal service is available, only one-third of the cottages are accessible by road.

METHODS

Field methods

Physical measurements and sample collections were completed on October 16, 1968. Forty-ounce water samples were collected for biological and chemical analyses by means of a Kemmerer sampler. Collections were made at six stations in the lake (Fig. 1). The approximate location and depths of the sampling sites are as follows:

Station 1 -	West arm of lake - 10 feet
Station 2 -	North arm of lake - 10 feet
Station 3 -	East arm of lake - 5 feet
Station 3 -	East arm of lake - 35 feet
Station 4 -	Southeast arm of lake - 5 feet
Station 5 -	Southwest arm of lake - 5 feet
Station 6 -	Centre of lake - 5 feet
Station 6 -	Centre of lake - 35 feet

Samples obtained for algae identification and enumeration were preserved with Lugol's iodine at the time of sampling. All samples were returned to the OWRC laboratory in Toronto for analysis.

Temperature readings were made using a telethermometer. A Secchi disc was used to determine an index of light penetration and pH readings were completed employing a IL Portomatic pH meter. Dissolved oxygen concentrations were established by means of a Hach field kit.

Laboratory methods

Nutrient analyses were performed on each water sample for nitrogen (nitrate nitrogen and ammonia nitrogen), total and soluble phosphorus and silica. Also, determinations for iron were completed. All analyses were conducted following standard procedures (A.P.H.A. *et al.* 1965).

The samples collected for algal analyses were concentrated employing a sedimentation technique modified from Lund (1951).Using the Sedgwick-Rafter counting cell and a magnification of 200X, all algal forms were identified to genus or, where possible, to species. Numerical results were recorded in areal standard units (a.s.u.) per millilitre. One areal standard unit is equal to an area subtended by 400 square microns (Whipple, 1914). An areal value was employed because it is a reliable measurement of the standing crop of phytoplankton (Paasche, 1960) and is a useful means of relating algal levels to problems associated with water quality. Depending on the density of the concentrate. strips or fields were counted. To render results statistically accurate, between 125 and 150 organisms per count were identified and measured.

RESULTS

Physical aspects

On October 15, a definite thermocline was not observed (Fig. 2). However, thermal stratification had occurred earlier in the year as a wide temperature range existed between the surface and bottom (i.e. surface temperature was 16°C; bottom temperature was 9°C). Additionally, a biological survey conducted on July 6, 1959 by the Department of Lands and Forests reported a well-established thermocline (Fig. 2).

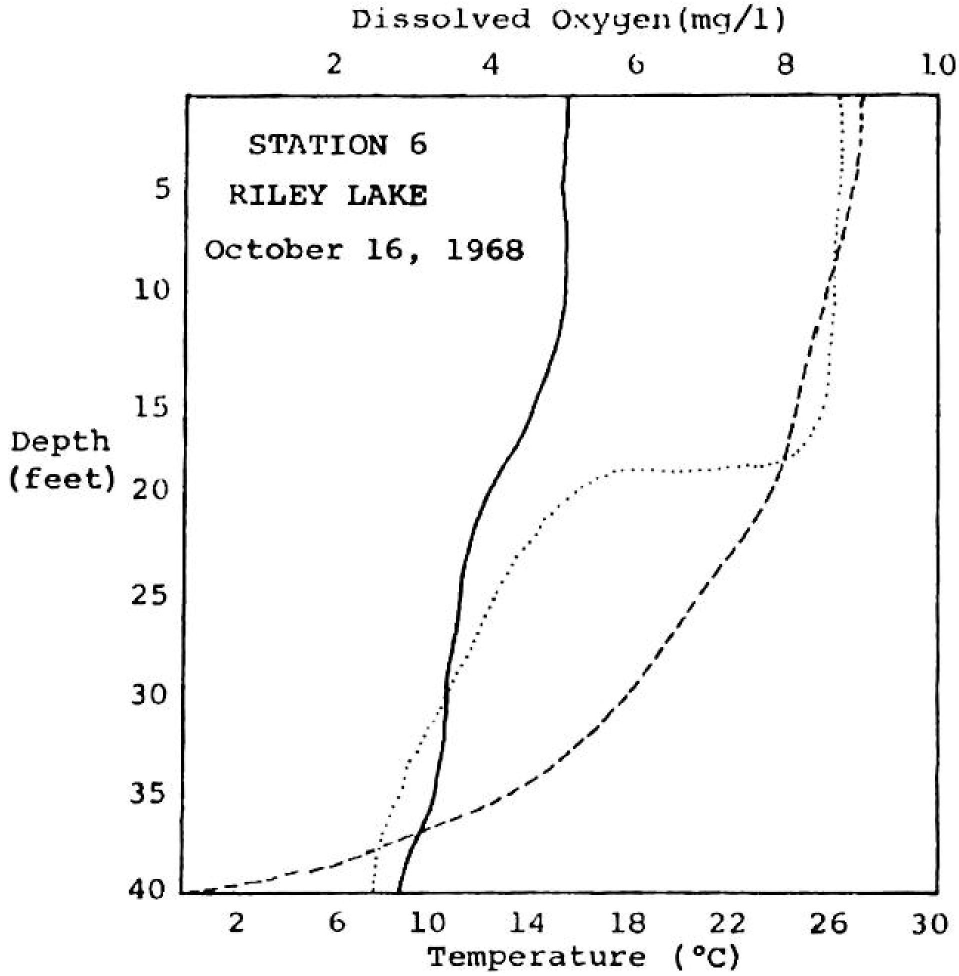

Fig. 2. Temperature (solid line) and dissolved oxygen (broken line) profiles at Station 6. Riley Lake. October 16, 1968. Dotted line is the temperature profile on July 6, 1959.

A Secchi disc reading of 5 feet was obtained at each of the six stations.

<u>Water chemistry</u>

As only minor variations were observed in water chemistry at the six stations, results cited in this report are those recorded at Station 6 in the centre of the lake.

A clinograde oxygen distribution involving oxygen depletion in the deeper strata was observed (Fig. 2). Septic conditions were detected at 40 feet.

The pH was slightly higher at the surface than near the bottom (Fig. 3).

Total phosphorus measured as PO_4 at 5 feet was 0.06 mg/L, while at 35 feet it was 0.15 mg/L. Corresponding values for the soluble fraction were 0.02 and 0.10 mg/L, respectively. At this point, it is significant to note the increases in iron in the lower strata (Fig. 3).

Nitrate values were constant with depth, ranging between 0.00 and 3.01 mg/L as Nitrogen. Free ammonia and silica levels were higher in the deeper waters than in the euphotic zone (Fig. 4).

<u>Algal populations</u>

On October 16, standing crops of algae in epilimnetic waters were extremely high, varying between 790 a.s.u. per ml at 5 feet at Station 4 and 6,898 a.s.u. per ml at 10 feet at Station 1. Relatively low numbers of algae were recorded from 35 feet at Stations 3 and 6 (i.e. 352 and 442 a.s.u. per ml, respectively).

All samples were dominated by the blue-green alga *Aphanizomenon flos-aquae*. Additionally, most samples contained relatively high levels of the blue-green form *Anabaena spiroides*.

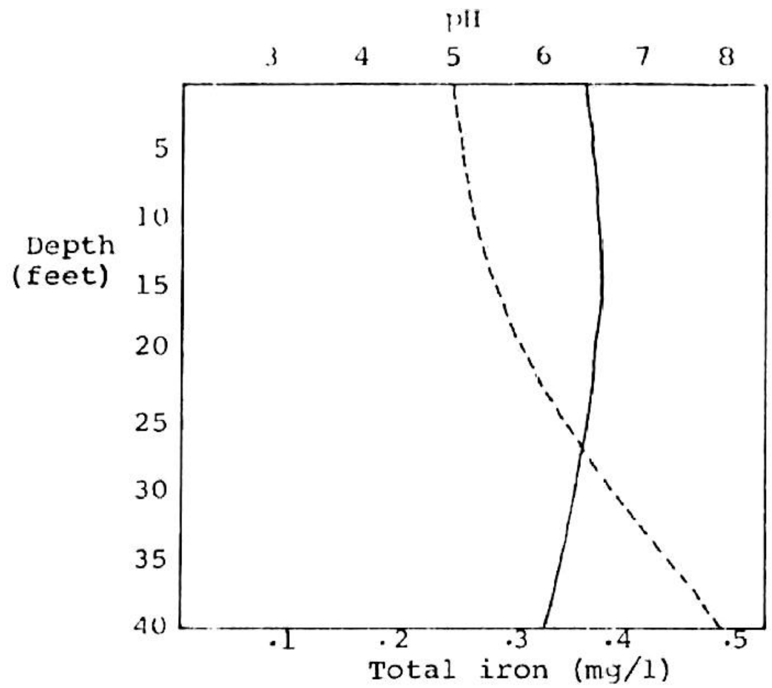

Fig.3. pH (solid line) and total iron profiles at Station 6, Riley Lake. October 16, 1968.

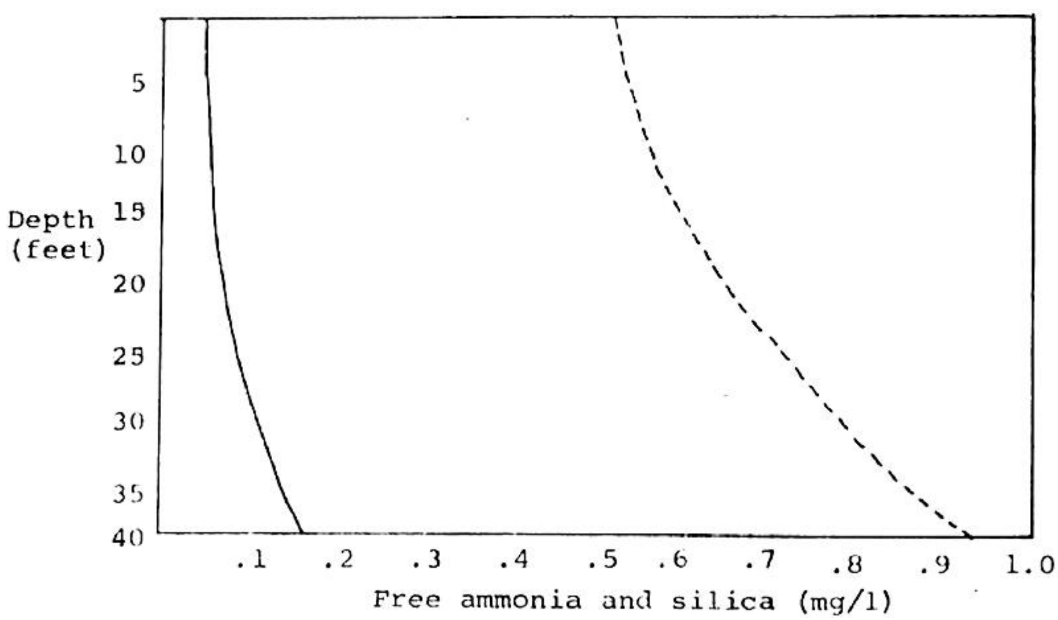

Fig. 4. Free ammonia as Nitrogen (solid line) and silica as SiO_2 (broken line) at Station 6, Riley Lake, October 16. 1968.

Table 1. Summary of phytoplankton data at six locations in Riley Lake, October 16, 1968. All results are recorded in areal standard units per millilitre.

	Sta. 1 10 feet	Sta. 2 10 feet	Sta. 3 5 feet	Sta. 3 35 feet	Sta. 4 5 feet	Sta. 5 5 feet	Sta. 3 5 feet	Sta. 6 35 feet
Blue greens								
Aphanizomenon flos-aquae	2580	1571	639	330	748	1133	1566	391
Anabaena spiroides	560	342			12	219	64	
Gomphosphaeria						180		
Flagellates								
Peridinium	80	34	11	6	5	18		
Cryptomonas	313	38	103	9	4	34	46	9
Trachelomonas		12			21		17	18
Chlamydomonas		18					4	
Greens								
Arthrodesmus	1971							
Crucigenia		20	7					
Dictyosphaerium			19					
Diatoms								
Tabellaria	554			17				22
Melosira	840		192					
Asterionella					32			
Total a.s.u./ml	6898	2035	971	362	790	1616	1697	442

Evidence of a "water-bloom" condition was observed at Station 1 in the western arm of the lake where *Aphanizomenon flos-aquae* attained a level of 2,580 a.s.u. per ml. Also, at Station 1 exceptionally high numbers of the desmid Arthrodesmus (1,071 a.s.u. per ml) and the diatoms *Melosira* and *Tabellaria* (840 and 554 a.s.u. per ml, respectively) were found. Low numbers of flagellated algae including *Peridinium, Cryptomonas, Chlamydomonas* and *Trachelomonas* were observed at most sampling locations. A summary of the data on phytoplankton is provided in Table 1.

DISCUSSION

<u>Principles of eutrophication</u>

Accelerated eutrophication, or the aging of lakes, streams and reservoirs before their time has emerged as one of the major problems confronting water resources management. The amount of biological life which can be supported by oligotrophic or nutrient-poor lakes is limited. These lakes are generally deep, cold and contain relatively clear water. As aging of oligotrophic lakes progresses naturally, the sediments and dissolved minerals associated with land runoff are retained so that the nutrient potential of the water is gradually increased. (A nutrient may be defined as anything that is necessary for the stimulation of growth, reproduction or repair of tissue in an organism.)

The impact of sedimentation and gradual increases in levels of soluble nitrate, phosphate, calcium, silica, manganese and other mineral salts on phytoplankton production or primary productivity in a lake varies with climatic conditions, the shape and *size* of the lake basin, thermal conditions in the lake and turbidity and colour (which affects light penetration and hence the depth of the euphotic zone). As the lakes become shallower and warmer and levels of plant nutrients increase, they support increased phytoplankton populations, and attached forms of algae and vascular aquatic vegetation may develop. The lake is then in an eutrophic or enriched state.

With time, decomposition products from the biota (living matter) and accumulations from inflowing tributaries fill the lake basin so that the lakes take on the physical and biological characteristics of a swamp or marshland. Generally, eutrophication is a slow process measured in geological time, However, it can be dramatically accelerated by artificial inputs from domestic and industrial wastes and agricultural runoff. These natural and induced changes are indicated in Fig. 5.

The following briefly describes how quantitative and qualitative parameters were employed in evaluating conditions of eutrophy in Riley Lake.

The low Secchi disc readings of five feet can be related to the high standing crops of algae in the euphotic zone. For comparative purposes, a Secchi disc reading of 17 feet was observed on October 17, 1968 in Bala Bay of Muskoka Lake, representing an oligotrophic condition.

The lack of oxygen and septic conditions noted in the lower water strata at Station 6 are symptomatic of eutrophic conditions. The hypolimnetic oxygen deficit is related to decomposition of the current year's production of organic matter produced in the euphotic zone following settling to the lake bottom, and to oxidation of previous years' suspended and/or sedimented particulate matter (Gardener and Lee, in press; Zobell, 1940). It is likely that both processes contributed to deoxygenation in the deep waters of Riley Lake.

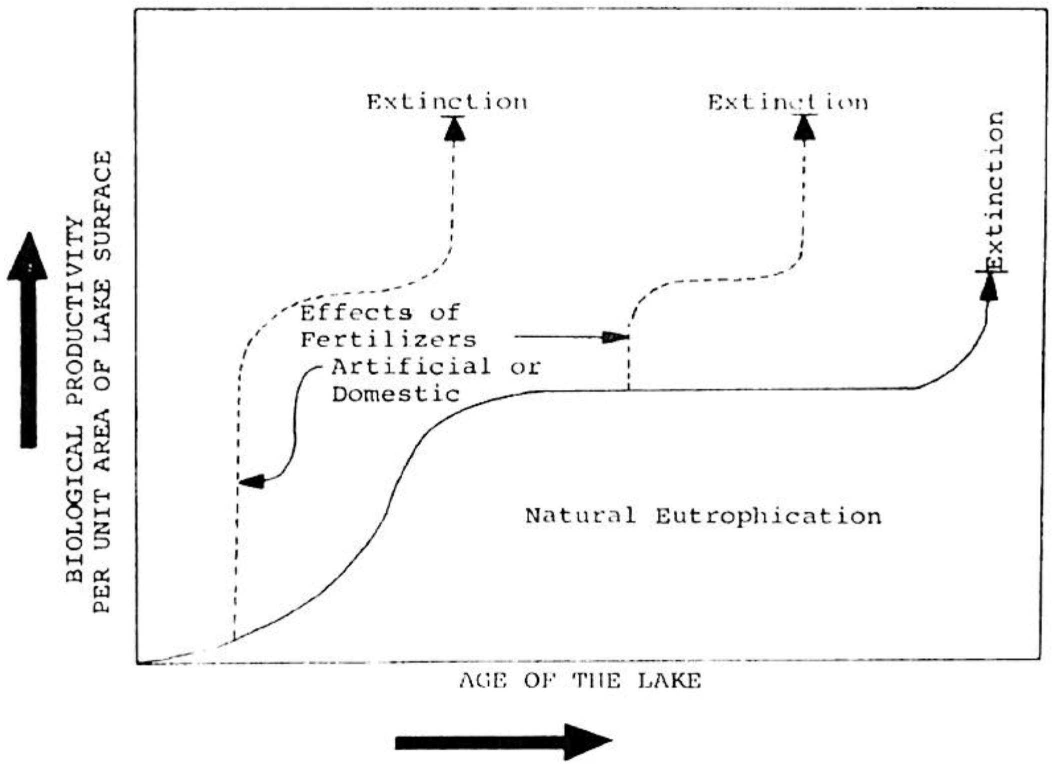

Fig. 5. Natural and induced eutrophication (from Hasler, 1947).

The higher pH values in the euphotic zone of the lake resulted from the reduction of free CO_2 and calcium bicarbonate during photosynthesis. The decrease in pH near the bottom was due to conditions of decomposition and respiration with corresponding CO_2 and bicarbonate increases.

The vertical distribution of nitrogen (nitrate and free ammonia nitrogen), phosphorus (total and soluble fractions), iron and silica are quite different in oligotrophic and eutrophic lakes. In the former type of lake, only minor variations in concentrations of these substances occur with depth. In productive lakes with clinograde oxygen curves, increases of these materials can be found in the deeper waters owing to the reduction conditions present. As described previously, higher values of these nutrients characterized the hypolimnetic waters of Riley Lake.

Natural sources of plant (algal) nutrients to lakes remote from human influence are the atmosphere, precipitation, ground water, runoff from the surrounding drainage area and natural exchange from lake sediments. Each of these sources contributes carbon, nitrogen and phosphorus which are essential nutrients for algal growth. Although micro-nutrients or trace elements such as iron, cobalt, nickel and molybdenum, organic materials and vitamins are required for growth (Menzel and Ryther, 1961; Goldman, 1960; Goldman, 1964; Goldman and Carter, 1965), there is usually no deficiency of these in the aquatic environment.

With the development of cottages around Riley Lake, artificial inputs of carbon, nitrogen and phosphorus from kitchen and laundry wastes and seepage from septic tank systems have contributed to the buildup of nutrients in the lake. Undoubtedly, one of the major nutrient sources is household detergents since these products contain approximately 50% by weight of phosphorus. Phosphorus originating from detergents gains access to the lake following dish-washing and laundering activities. Also, fixation of atmospheric nitrogen by the blue-green algae *Aphanizomenon* sp.(Sawyer, 1961) and *Anabaena* spp. (Hutchinson, 1957) is probably an important source of nitrogen to the lake. It should be emphasized that once nutrients enter Riley Lake, loss of these substances through inflow-outflow exchange or evaporation is virtually negligible. The nutrients are continually re-cycled so that they become available each year in proportionately higher concentrations for plant and algal growth. It may be concluded therefore, that algal populations will undoubtedly increase in future years in Riley Lake.

<u>Significance of eutrophication in Riley Lake</u>

Considering water uses, the effects of eutrophication are undesirable in Riley Lake. Excessive production of blue-green algae impairs the recreational and aesthetic qualities of the lake by decreasing water clarity and through the build-up of accumulations along the shoreline which decompose to create objectionable odours. Additionally, the water of Riley Lake will become increasingly unsuitable as a domestic source of supply for cottagers, and more expensive treatment facilities involving constant maintenance will be required.

Further, the loss of oxygen from the deeper, colder waters of the lake reduces the suitable area for game fish and creates a further limitation on fish production through elimination of desirable fish-food organisms. A Department of Lands and Forests report pre-pared in 1959 indicated that an obvious decline in bass fishing had occurred between 1949 and 1959. Local residents report that sports fishing in the lake is now extremely poor.

<u>Control of nuisance algal growths</u>

The only established method of control involves the use of an algicide such as copper sulphate. This chemical can be applied only under the authority of a permit issued by the OWRC and large-scale applications must be closely supervised. It should be emphasized that chemical control measures provide only temporary relief, and two or more treatments might be required each year. It is likely that most cottagers on the lake will consider this solution as economically impractical. At the present time, there is no easy solution to the enrichment problem; however, considerable study by OWRC personnel as well as scientists throughout the world is now being devoted to ways and means of limiting nutrient inputs to surface waters.

CONCLUSIONS

Although a minimum sampling effort was possible, eutrophication of Riley Lake was evinced by oxygen depletion and higher ammonia, silica, iron and total and soluble phosphorus concentrations in the lower waters; a slight depression of pH in the deeper strata; high standing crops of phytoplankton throughout the lake; and evidence of a "water-bloom" of the blue-green alga *Aphanizomenon flos-aquae*.

This survey does not provide a definite indication of the underlying causes of the present degree of enrichment in Riley Lake. A careful appraisal of the existing waste treatment facilities would more accurately determine the relationship between cottage development and water quality. However, it is certain that the existing cottages and permanent homes are contributing factors in the enrichment of Riley Lake.

If future shoreline development is to occur, facilities for elimination of all domestic wastes and artificial nutrient seepage to the waters of Riley Lake must be effected. Additionally, immediate consideration should be given to eliminating the access of nutrients to the lake by total retention of all cottage wastes for ultimate disposal in a manner which will not affect Riley Lake cr any other valuable aquatic resource. Such a programme would perforce involve an educational programme to ensure that cottagers on Riley Lake would understand the need for and benefits to be derived from action of this type.

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GLOSSARY OF TERMS

EUPHOTIC- The lighted region that extends vertically from the water surface to the Level at which photosynthesis fails to occur because of ineffective light penetration.

KEMMERER WATER SAMPLER - An instrument designed to collect a known volume of water from a pre-determined depth. The sampler construction essentially consists of a brass cylinder with closable rubber stoppers on each end. It is suspended in the water with a rope.

MICRON - A unit of measurement equal to 0.001 millimetres.

SECCHI DISC - A circular metal plate, 20 centimetres in diameter, the upper surface of which is divided into four equal quadrants and so painted that two quadrants directly opposite each other are black and the intervening ones white.

SEDWICK-RAFTER COUNTING CELL - A plankton-counting cell consisting of a brass or glass receptacle 50 by 20 by 1 millimetre sealed to a 1 by 3 inch glass microscope slide. A rectangular cover glass large enough to cover the whole cell is required. The cell has a capacity of exactly1 millilitre.

STANDING CROP - The biota present in an environment at a selected point in time.

STRATIFICATION - In the spring, vertical water temperatures in a lake or reservoir are homogeneous from top to bottom. As summer advances, the surface waters become warmer and lighter than the underlying colder, denser waters. A thermal gradient or stratification is established in which three water layers can be defined. The upper layer or epilimnion represents a warm region of approximately uniform temperature and may vary from a thickness of ten feet or less in shallow lakes to 40 feet or more in deep lakes. The middle layer, or thermocline is a relatively thin region of rapid temperature change. It is usually defined by a change in temperature of 1°C. for each metre of water depth. The lower layer or hypolimnion is the region which extends from the thermocline to the lake bottom, of near-uniform temperature and is generally removed from surface influence (i.e. does not receive oxygen from the atmosphere).