

DESCRIPTIVE LIMNOLOGY OF LAKE 120, A MEROMICTIC LAKE
ON THE PRECAMBRIAN SHIELD IN NORTHWESTERN ONTARIO

by

PAUL CAMPBELL

A thesis
submitted to the Faculty of Graduate Studies
in partial fulfilment of the requirements for the
degree of Master of Science

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RATIONALE

Detailed studies have been carried out on the effects of logging stream watersheds, for example, Likens *et al.* (1970), Bormann *et al.* (1974) or Aubertin and Patric (1974). However, little work of this nature has been directed towards lakes. The Experimental Lakes Area (ELA) in Northwestern Ontario (see Volume 28, No. 2, J. Fish. Res. Bd. Canada) provided an ideal location for such a lake study since excellent field facilities were available in an area which was actively being logged by the Minnesota and Ontario Pulp and Paper Company (MANDO).

Lake 120 (Figure 1) located southeast of Kenora, Ontario, (93°50'W, 49°39'N) was chosen in 1968 for this study for a number of reasons. It was estimated by MANDO that its watershed would be logged in 1970-71 which allowed 2-3 years to describe the lake prior to any disturbance. From a practical point of view, Lake 120 was of the type that would most typically be deemed important economically or aesthetically; that is, the water is relatively clear and of high quality and the lake is of such a depth and morphology that thermal stratification occurs during the summer. Hydrologically, the system appeared to be a relatively simple one. The lake is a headwater lake (see map insert Volume 28, No. 2, J. Fish. Res. Bd. Canada) in an apparently sealed granite basin and the narrow (approximately 20 meters) outflow channel with bedrock sides allowed the measurement of discharge (Figure 2). There is little littoral vegetation in the lake and the soils and terrestrial vegetation are rather uncomplicated.



FIGURE 1. Aerial view of Lake 120. October, 1970.

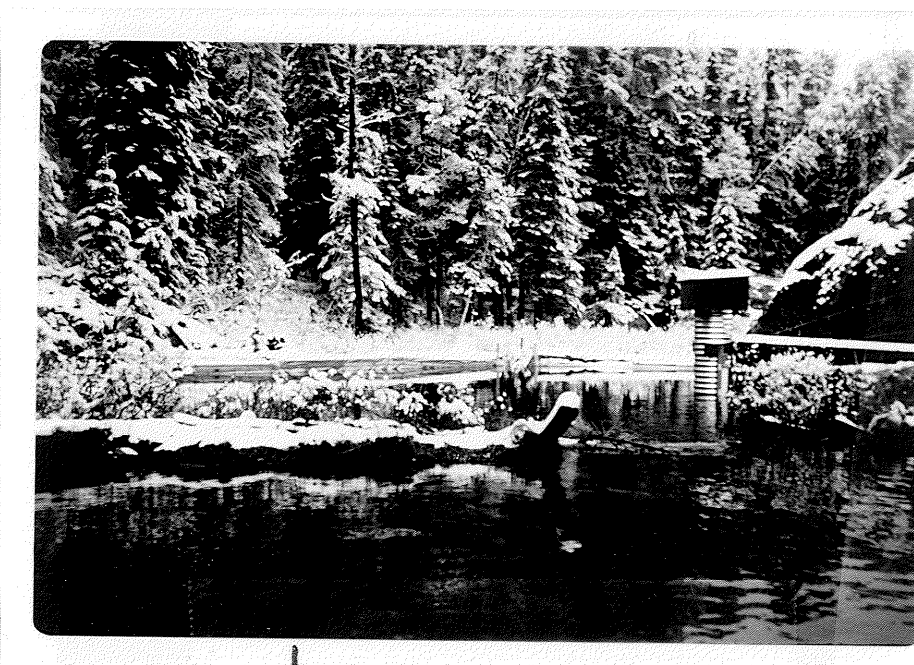


FIGURE 2. Weir and recording well at the outlet of Lake 120. November, 1970. The weir was built at the second of a series of three aged beaver dams. Note first beaver dam in foreground.

This manuscript is a limnological description of the watershed and lake ecosystem before logging.

DESCRIPTION OF THE STUDY AREA

The surface of Lake 120 is approximately 410 meters above sea level. A stream which flows intermittently enters the lake at its south end (Figure 3). The lower half of this stream flows through a black spruce bog with mosses and Labrador tea (*Ledum groenlandicum* Oeder.). Runoff in most other parts of the watershed is direct to the lake, not *via* streamflow. Bottomley (1974) describes in detail runoff processes and mechanisms in ELA. Water leaving the lake through the outflow progresses through a series of small lakes to Dryberry Lake, from Dryberry Lake to Lake of the Woods which drains into the Winnipeg River to Lake Winnipeg. Lake Winnipeg flows to Hudson Bay and the Arctic Ocean *via* the Nelson River (see Figure 1, Brunskill & Schindler 1971).

With exception of the above-mentioned black spruce, the predominant tree species on the rather steep, well-drained slopes of the watershed is jack pine (*Pinus banksiana* Lamb.). Balsam fir (*Abies balsamea* (L.) Mill.) is usually the predominant species in the understory of jack pine or black spruce (*Picea mariana* (Mill.) BSP.). There are two stands of trembling aspen (*Populus tremuloides* Michx.) in the watershed and there are red maples (*Acer rubrum* L.) interspersed among black spruce in and just upslope from the bog. A description of the vegetation in ELA, including a species list of aquatic macrophytes is given by Brunskill and Schindler (1971). There is little littoral vegetation about Lake 120.

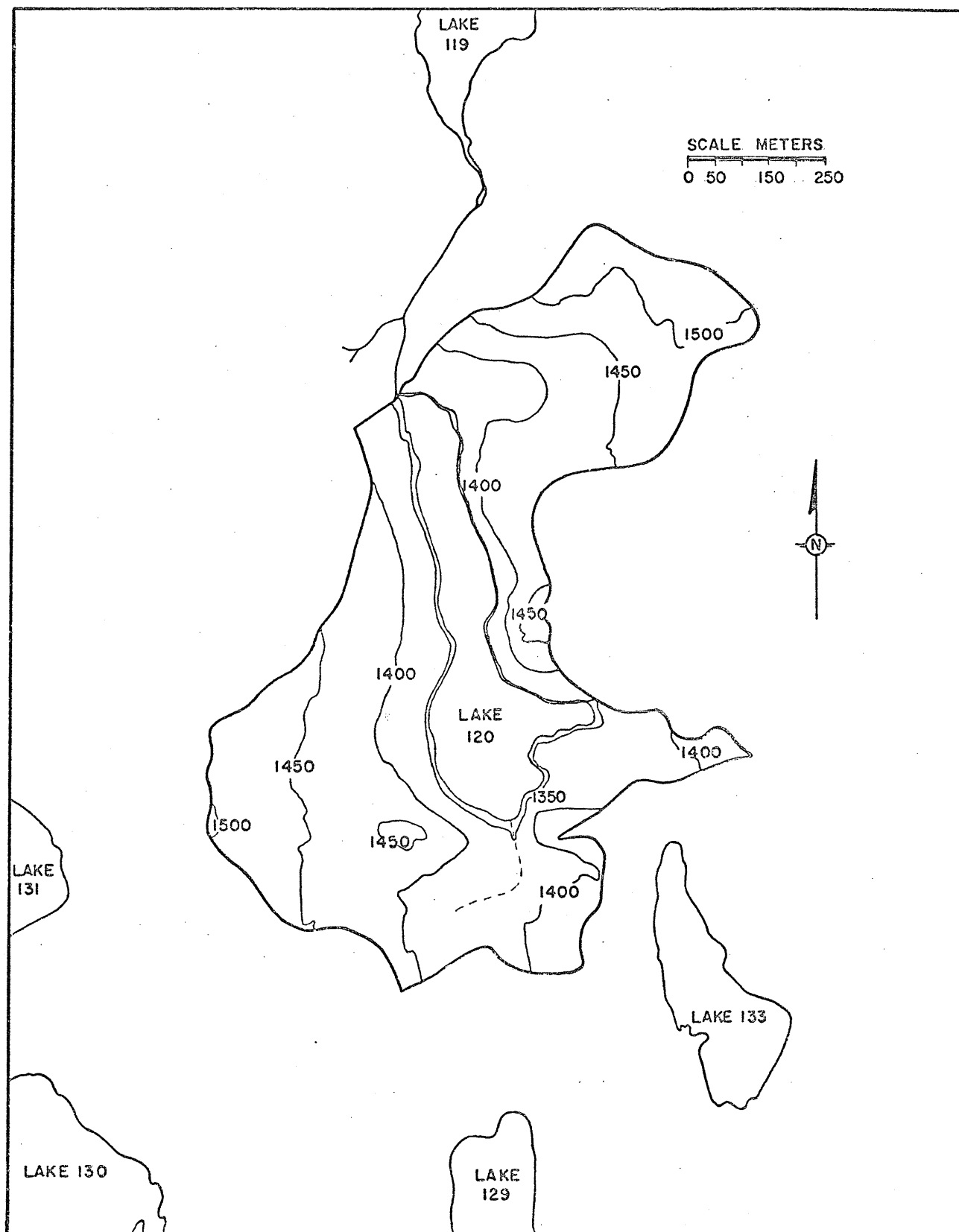


FIGURE 3. Outline and contour map of the Lake 120 watershed. Contour intervals are 50 feet.

Geologically, the drainage basin is as described by Brunskill and Schindler (1971). Detailed discussions of the chemistry and weathering of the granodiorite bedrock and the glacial till in the region are found in Brunskill *et al.*, (1971) and Schindler *et al.*, (1976). An account of the glacial history of the area may also be found in Brunskill and Schindler (1971).

Most of the Lake 120 drainage basin is exposed bedrock covered only with an organic layer. However, in the depression where bog is located, the bedrock is overlain by a sandy till deposit. In the slightly sloping, well drained areas of this depression, soils are typically degraded dystric brunisols (after the The System of Soil Classification For Canada, Canada Department of Agriculture, 1970). The L-H horizon is an organic black mat about 5 cm thick. The leached, grey Ae_j horizon varies from 2-5 cm in thickness. A Bm₁ horizon of about 7 or 8 cm overlies coarse, rusty brown sand (Bm₂ horizon) up to 30-40 cm deep. All sand grains and pebbles comprising the Bm₂ horizon are rounded suggesting that the till overlying the bedrock has been water worked. Towards the center of the depression, the surface levels off and the organic mat thickens to about 10 cm. Drainage is poor here and gleyed dystric brunisols have developed. In the center of the depression, surface deposits are saturated with water and are overlain by peat and moss. There is no profile development and these soils would therefore be classified as regogleysols.

Based on meteorological records from stations in the vicinity of ELA, Brunskill and Schindler (1971) reported annual mean temperatures between 0.5 and 2.2°C. January mean temperatures ranged from -19.4 to

-16.1°C and July mean temperatures from 18.3 to 20°C. Schindler *et al.*, (1976) recorded at the ELA camp site, during the years 1970-73, annual precipitation ranging from 700 mm to 970 mm. Evapotranspiration averaged about 65% of annual precipitation during those four years. Runoff on the Lake 239 watershed was between 220 and 350 mm per year. Maximum runoff occurs during and immediately after ice melt. Lake 120 becomes free of ice between April 15 and May 15. The lake is usually ice-covered by the third week in November.

A brief history of the human population and land use of the area may be found in Brunskill and Schindler (1971).

METHODS

Physical Measurements

Figure 3 is from a portion of a formline map provided by L.A. Smithers, director of the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario. Contours on this map were used to delineate the boundary of the Lake 120 watershed. Drainage area (A_d) was determined by planimetry.

On July 20, 1969, a lake level datum mark was cut into a rock ledge on the east shore (Station 20, Figure 4). The surface of the lake was 0.91 meters below datum. Sonar transects (a Raytheon Model DE 119D 200 kc Fathometer was used) and construction of the bathymetric chart were performed as described by Brunskill and Schindler (1971). Length of shoreline (L), and maximum length and width of the lake were determined by chartometer. A planimeter was used to calculate lake surface area (A_0) and areas at 2 meter contour intervals. Volumes at 2 meter intervals, total lake volume, mean depth (\bar{z}), shore development (D_L) and volume development (D_V) were calculated after Welch (1948).

Between September, 1969 and August, 1972, fifty vertical profiles were taken at the point of maximum depth (see Figure 4, for exact location of the sampling station). In the initial stages of the investigation, samples were also taken approximately half way up the north arm of the lake (depth about 8-9 meters). However, no difference was found between the quality of the water in the north arm and that of the 0 to 9 meters stratum at the south station. So, in November 1969,

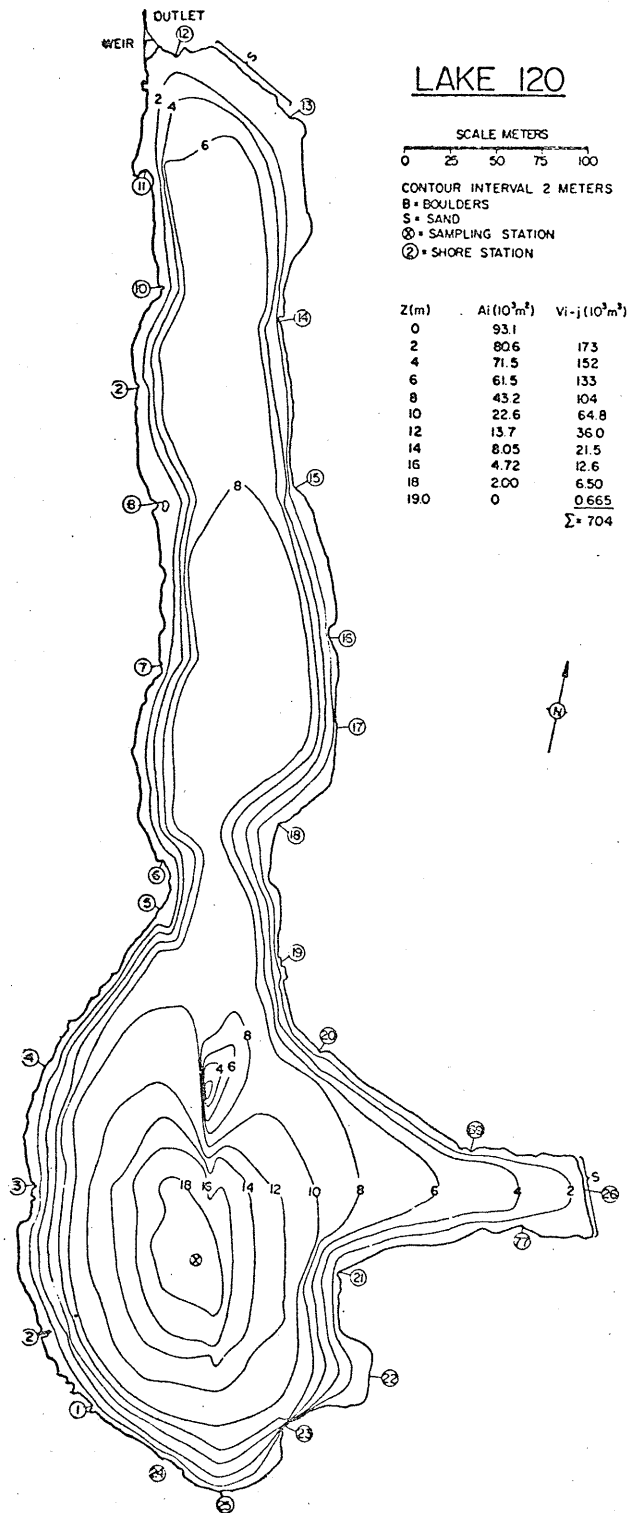


FIGURE 4. Bathymetric chart of Lake 120.

sampling at the north station was discontinued and profiles from the south station taken to be representative of the entire lake. During the open-water season, outflow samples were also collected.

Estimates of light penetration were made in two ways. Routinely, Secchi visibility was measured with a 25 cm diameter Secchi disc. In 1971-72, a Whitney model LMT-8A submersible photometer (cadmium sulphide cell) was also used to measure light transmittance at depth intervals of 1 meter or less. 100% transmittance was taken to be at 0.1 meter. Total solar radiation was recorded by means of an Eppley pyrhelimeter mounted on a tower near the middle of Lake 239. Elaboration on subsurface light measurement including how to calculate photosynthetically useful light reaching a given depth may be found in Vollenweider (1961, 1969) and Schindler (1971). Schindler (1971) also gives an equation probably only applicable to ELA which relates Secchi disc visibility to light transmission. In this study, visual colour of the disc was also recorded at half Secchi depth.

Temperatures were measured *in situ* at 1 meter intervals with either a Yellow Springs model 43 TD tele-thermometer (readable to about 0.2°C) or a Whitney thermistor TC-SA (readable to about 0.02°C). These instruments were calibrated against a U.S. National Bureau of Standards mercury thermometer.

Conductivity was also measured *in situ* at depth intervals of 1 meter or less. A Beckman RB3 Solu Bridge Conductance Meter calibrated against 0.001 and 0.0001 N KCl standard solutions (American Public Health Association, 1965) was used.

Chemical Measurements

Water samples were routinely collected from the lake at a minimum of seven depths, namely 1, 5, 8, 11, 14, 16 and 18 meters. A 3-litre, clear, plexiglass van Dorn sampler was used. From each depth, a 1-litre polyethylene bottle was rinsed and filled for chemical analysis, a 300 ml glass BOD bottle for oxygen measurement and a 150 ml capped bottle for phytoplankton counts. Phytoplankton samples were immediately preserved with Lugol's solution (Kling and Holmgren, 1972).

Dissolved oxygen was determined by the azide modification of the Winkler method (American Public Health Association, 1965) within hours of collection.

At each depth, three samples of suspended particulate material were collected by filtration through pre-ignited (16 hours at 550°C) 4.25 cm diameter Whatman GF/C filters. The Mandel Scientific Company Ltd. claims these glass fiber filters retain particles as small as 1.2 μm . Filters for particulate phosphorus (PP) analysis were stored in screw-cap vials and shipped to the Freshwater Institute (FWI) in Winnipeg for analysis. Phosphorus was extracted from the filter and converted to orthophosphate by heating with dilute HCl (Stainton *et al.*, 1974), and orthophosphate was then determined by the molybdate method of Murphy and Riley (1962). Filters for particulate carbon (PC) and particulate nitrogen (PN) analysis were desiccated in the dark and stored in individual plastic petri dishes. PC and PN were determined simultaneously at the FWI on a modified Carlo Erba Model 1102 Elemental Analyzer (Hauser, 1973 and Stainton *et al.*, 1974). Filters for chlorophyll analysis were frozen

and stored in the dark when it was not possible to analyze the same day as collection. The filters were ground in a 90% acetone medium and the extract fluorescence was measured on a Turner Model III Fluorometer (Strickland and Parsons, 1968). The instrument responds primarily to chlorophyll a. However, equivalent concentrations of phaeopigments elicited a fluorescence of 50% of the chlorophyll a standard. In natural water systems it is unlikely that phaeopigments are absent. As a result, the chlorophyll measurements reported in this study represent unknown proportions of chlorophyll a and phaeopigments, and are probably an overestimation of chlorophyll a.

The filtrate from above was divided into two aliquots. After preservation with 1 ml of 1N HCl, 100 ml was set aside for major cation analysis in Winnipeg. Total dissolved calcium, (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe) and manganese (Mn) were determined using a Perkin Elmer Model 403 atomic absorption spectrophotometer (Stainton *et al.*, 1974).

The remaining filtrate was used for analyses performed in the field laboratory. Dissolved organic carbon (DOC) was measured by gas chromatography (a Fisher Hamilton Model 29 gas partitioner was used) after oxidation to CO₂ (Menzel and Vaccaro, 1964; Stainton, 1973). Nitrate was reduced to nitrite in a cadmium copper reduction column (Wood *et al.*, 1967). The sum of nitrate plus nitrite-nitrogen in the water sample was determined as nitrite either manually or by an automated method using a Technicon Autoanalyzer (Stainton *et al.*, 1974). Phosphate-phosphorus (PO₄-P) was determined by the molybdate method of Murphy and

Riley (1962) either manually or by Technicon Autoanalyzer (Stainton *et al.*, 1974). It should be noted that the method is apparently capable of hydrolyzing labile organic phosphorus compounds, resulting in an overestimate of $\text{PO}_4\text{-P}$ and hence biologically available phosphorus (Stainton *et al.*, 1974). Henceforth, the phosphorus determined by this method will be referred to as soluble reactive phosphorus (SRP). Total dissolved nitrogen (TDN) and dissolved phosphorus (TDP) were determined after ultraviolet photochemical combustion (Armstrong and Tibbitts, 1968). Acidification, addition of H_2O_2 and U.V. photo-oxidation for 4 hours as described by Stainton *et al.* (1974) converted organic phosphorus compounds to phosphate which was determined as outlined above. Similarly, at pH 9 with addition of H_2O_2 and U.V. irradiation for 16 hours, organic nitrogen compounds and ammonia were essentially all decomposed and oxidized to nitrite with a small residual of nitrate which was determined as above (Stainton *et al.*, 1974). However, for some water samples rich in nitrogen and organic carbon, determinations of TDN gave values less than corresponding independent measurements of ammonia-nitrogen ($\text{NH}_3\text{-N}$). It has since been discovered by Stainton (personal communication) that for TDN levels greater than $35 \mu\text{moles litre}^{-1}$ a significant fraction of ammonia usually persisted after photo-oxidation. Since such waters are very high in organic matter it is likely that, during irradiation, oxygen was depleted before all ammonia was converted to nitrite or nitrate. This problem may be overcome by determining $\text{NH}_3\text{-N}$ as well as $\text{NO}_3\text{+NO}_2\text{-N}$. Stainton *et al.* (1976) have also developed a new method for TDN whereby organic nitrogen compounds, nitrate and nitrite are converted

to and measured as ammonia. At any rate, due to the unreliable nature of the method used in this study, TDN concentrations greater than 35 $\mu\text{moles litre}^{-1}$ have not been reported.

Hydrogen ion concentration (pH), specific conductance, $\text{NH}_3\text{-N}$, dissolved inorganic carbon (DIC), methane-carbon ($\text{CH}_4\text{-C}$) and soluble reactive silicon (Si) were determined on unfiltered water in the field laboratory. $\text{NH}_3\text{-N}$ was done by the phenol-hypochlorite method of Solorzano (1969). Both manual and automated adaptations of the method are described by Stainton *et al.* (1974). Measurement of total carbon dioxide concentrations (CO_2 or DIC) was done by helium stripping into a Fisher Hamilton Model 29 gas partitioner (Stainton 1973). Concentrations of H_2CO_3 , $\text{CO}_3^{=}$ and HCO_3^- were calculated from total carbon dioxide measurements, temperature and pH (Garrels and Christ, 1965). Methane was determined by the method of Rudd *et al.* (1974) or Rudd *in* Stainton *et al.* (1976). Methane was stripped from solution with helium into a Pye 104 gas chromatograph equipped with a flame ionization detector and a phenyl isocyanate/Porasil C column. Soluble reactive silicon was determined after the molybdenum blue method of Armstrong and Butler (1962). Both the manual and automated procedures as outlined by Stainton *et al.*, (1974) were used.

A Spectronic 100 spectrophotometer was used for all colorimetric analyses described above which were performed manually. Precisions to be expected when the above methods are used on waters collected in the Experimental Lakes Area are given by Stainton *et al.*, (1974 or 1976).

Hydrology

In order to compute water and elemental budgets, it was necessary to monitor the outflow of the lake. A V-notch weir was constructed and a recording well installed (Figure 2). Water Survey of Canada first obtained a full year's hydrologic data in 1973. Water budgets during the years 1970-72 were computed by extrapolation from the Lake 239 watershed (Schindler *et al.*, 1976).

Sediment Traps

On 8 April, 1970, traps for the collection of sediment (Brunskill, 1969b) falling to the lake bottom were installed at a depth of 17 meters, approximately 25 meters south of the sampling station shown in Figure 4. The traps were removed from the lake on 20 September, 1973. The tubes were kept in the dark and refrigerated at 5°C prior to analysis in Winnipeg.

Water content of the sediment was determined by freeze-drying at about -30°C. Ashed weight of the sediment was measured after ignition at 550°C for 4 hours. Freeze drying was done in a VirTis Mechanically Refrigerated Freeze Mobile Cabinet Model 10-146MR-BA. Procedures were outlined by the supplier's manual. Determinations of chlorophyll, total phosphorus, nitrogen and carbon were performed on the sediment trap samples as described above for suspended sediments. Carbonate (inorganic) carbon ($\text{CO}_3\text{-C}$) was liberated from the sediment into low carbon water as CO_2 (Stainton, 1973). The liberated CO_2 was determined as for DIC described above. Calcium, potassium, iron, manganese, silicon,

aluminum (Al), and titanium (Ti) were determined simultaneously by X-ray fluorescence spectrometry on an A.R.L. multichannel vacuum X-ray quantometer (Wilson *et al.*, 1965). Precisions are reported by Wilson *et al.* (1969).

Phytoplankton and Primary Productivity

Approximately once a month during the open-water seasons of 1971 and 1972, ^{14}C primary productivity experiments were carried out *in situ* at depths of 1, 3, 5, 7, 10 and 13 meters. Procedures in the field were as described by Schindler and Holmgren (1971). Two light bottles and one dark bottle were suspended at each depth, usually between 10:00 and 14:00 hours. Prior to incubation, each 125 ml sample was inoculated with 1 microcurie of ^{14}C (0.05 ml of $2\ \mu\text{C ml}^{-1}$ solution). Uptake of total carbon (particulate plus extracellular products) was determined as described by Schindler *et al.*, (1972). Formulas used in computing incubation production (mg C litre^{-1}) and full-day photosynthesis ($\text{mg C litre}^{-1}\ \text{day}^{-1}$) are given by Schindler *et al.*, (1972) and Schindler and Holmgren (1971), respectively.

Phytoplankton counts were done on 1 to 10 ml of preserved sample (see above for sample collection and preservation) after sedimentation in a settling chamber using the Utermöhl technique described by Margalef in Vollenweider (1969). Identifications and counts were done using a Wild Model mn 40 inverted microscope with phase contrast illumination (Kling and Holmgren, 1972). Taxonomic keys used are listed by Schindler and Holmgren (1971). Live biomass was computed by assuming a density of

1 gram ml⁻¹ and estimating cell volumes from geometric shapes (Findenegg *in* Vollenweider, 1969).

RESULTS

Physical Limnology

The terrestrial drainage area of Lake 120 (Figure 3) and lake surface area were determined to be 60.4 and 9.31 hectares, respectively. Maximum relief in the watershed is approximately 55 meters. Maximum length and width of the lake are 788 and 304 meters, respectively, and length of the shoreline is 2,130 meters. Areas and volumes at 2 meter contour intervals are reported in Figure 4. The maximum depth (Z_m) of Lake 120 was found to be 19.0 meters and mean depth was calculated to be 7.55 meters. Shore development (D_L) = 1.97 was higher than any reported by Brunskill and Schindler (1971) for 14 other ELA lakes. A high D_L as well as a low slope of the hypsographic curve (Figure 5, constructed after Welch, 1948) between 6 and 10 meters are reflections of the two relatively shallow arms which radiate to the north and east from a rather circular, deep basin (Figure 4). About 42% of the lake bottom lies at a depth of between 6 and 10 meters. Volume development (V_L) = 1.19 indicates that, overall, the lake basin walls are concave towards the waters.

Depth distribution of temperature with time is given in Figure 6 and Table 1 of the appendix. Ice melted from the lake during the last week of April or first week of May. Warming of the surface waters took place very quickly with the establishment of a thermocline at about 3 meters depth by the end of May. During the summer, the thermocline rested at 4-5 meters. Temperatures to 24°C were recorded at the surface

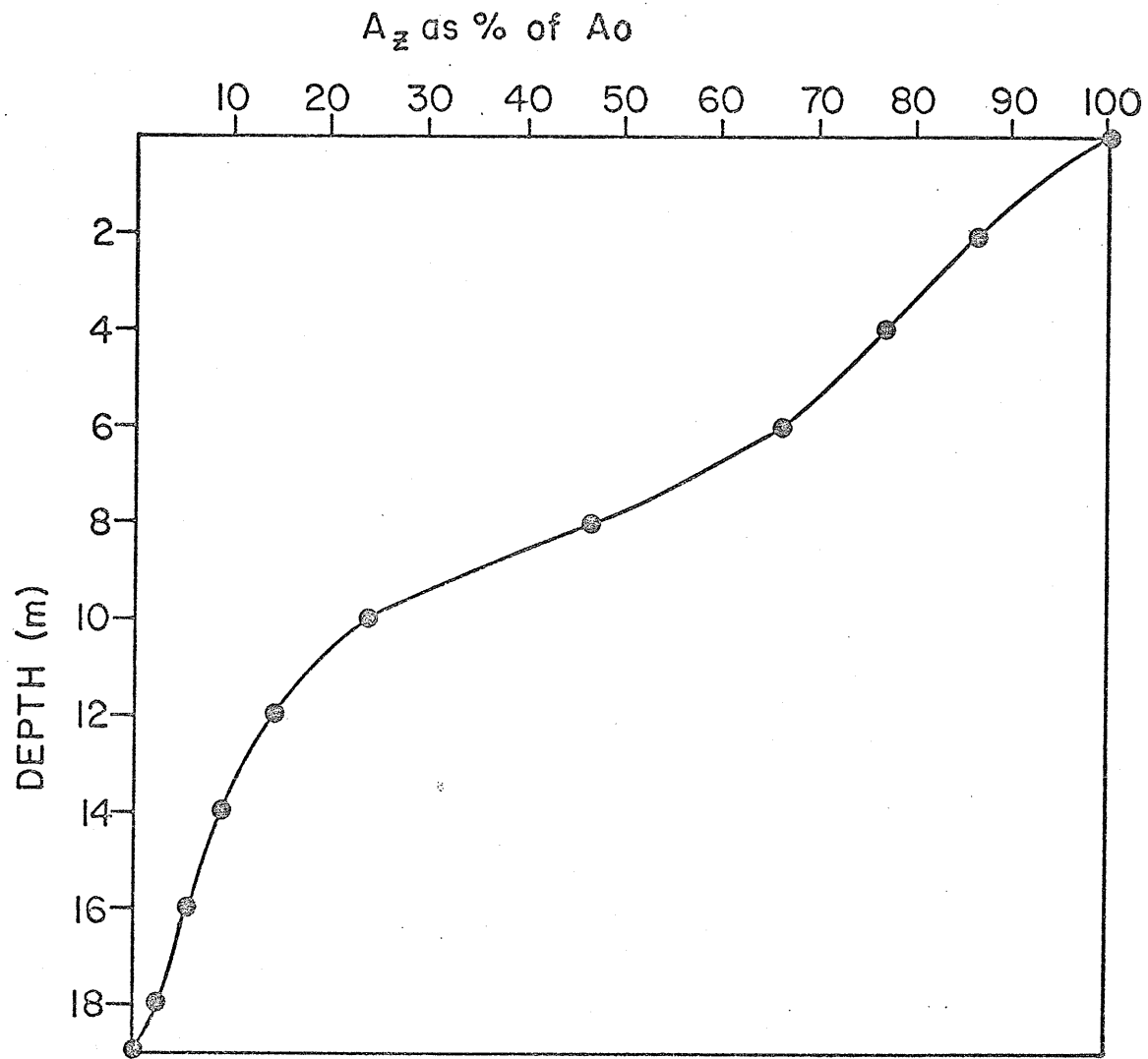


FIGURE 5. Percentage hypsographic curve for Lake 120.

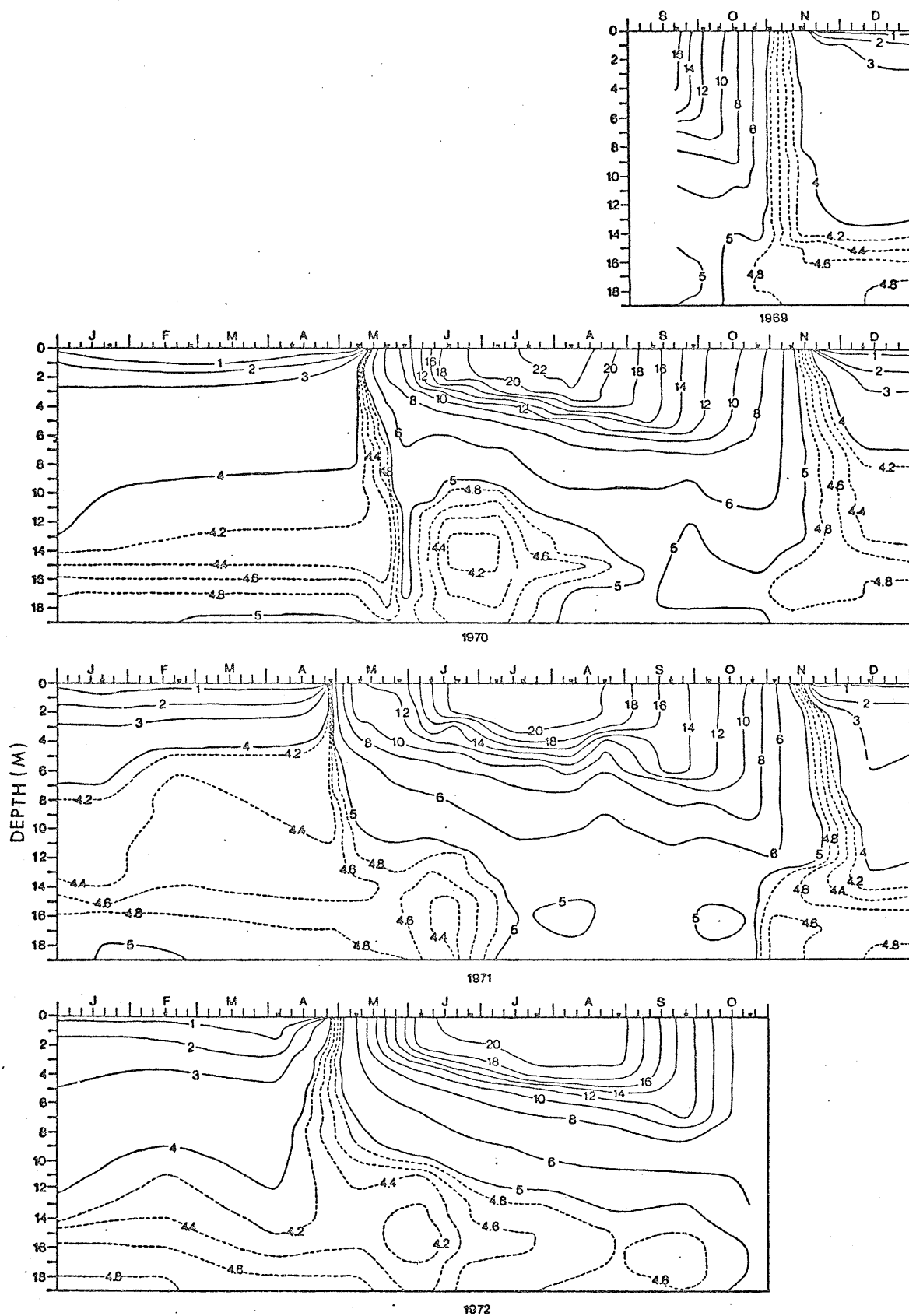


FIGURE 6. Depth-time distribution of temperature for Lake 120, 1969-1972. Isotherms are in degrees centigrade ($^{\circ}\text{C}$).

during July and August. Coincidental with the warming of the upper strata, cooling of the waters at depths greater than 10 meters took place. In this lower stratum, minimum temperatures for the year were recorded during June. A cooling center was observed between 14 and 16 meters. With the onset of autumnal cooling and circulation in September, the thermocline was depressed to 6 or 7 meters. By late October or early November, waters above 14-16 meters had reached homothermy. However, homothermy was never observed from surface to bottom. At all times of the year, a rise in temperature of 0.1 to 0.3°C occurred between 16 meters and the bottom. Ice cover was usually established by mid November.

Summer, winter and total annual heat budgets (H_{bs} , H_{bw} and H_{ba}) were calculated after Hutchinson (1957). The formula

$$H_z = V_z (\theta_z - 4^\circ)$$

was used to calculate at 1 meter depth intervals the heat energy (H_z) required to raise or lower the recorded temperature to 4°C

where V_z = volume of 1 meter thick stratum at depth z
 θ_z = temperature (°C) at depth z .

Since the bottom waters were cooling while overlying waters were gaining heat (see above), separate heat budgets were computed for the 0-14 and 14-19 meter strata. Since water temperatures below 14 meters never

dropped lower than 4°C , for this region only, an annual heat budget was calculated based on the difference between maximum and minimum heat content. Heat budgets for the entire lake (0-19 meters) were also derived. The latent heat of melting of the ice cover was included in winter heat budgets. Maximum ice thickness was usually recorded in February and ranged from 30-42 cm. A summary of the heat budgets for Lake 120 during the years 1969-72 is reported in Table 1. For the 0-14 meter stratum, the average annual heat budget was $12,890 \text{ cal cm}^{-2} \text{ A}_0$. Thirty percent of this budget ($3,930 \text{ cal cm}^{-2} \text{ A}_0$) was attributable to raising the water from the winter minimum to a state of homothermy at temperature of maximum density (4°C). Almost 70% of the H_{bw} ($2,710 \text{ cal cm}^{-2} \text{ A}_0$) was accounted for by the heat energy required to melt the ice cover. Consumption of heat energy was maximal during May and June at a rate of about $115 \text{ cal cm}^{-2} \text{ A}_0 \text{ day}^{-1}$. In terms of total calories consumed (or released), the average annual heat budget for 14-19 meters was extremely small (27.6×10^9 calories) compared to that of 0-14 meters (12.0×10^{12} calories). Figure 7 is a plot against time of the total heat energy (calories) that would be consumed or liberated in achieving a state of homothermy at 4°C . It shows clearly that, during the open-water season, thermal trends in the 14-19 meter stratum are the inverse of those in the 0-14 meter stratum. While the waters from 0-14 meters were warming during June and July, the 14-19 meter stratum reached a state of minimum heat content. Similarly, during the fall when the surface waters were cooling, the waters from 14-19 meters were usually warmer than at any other time of year.

TABLE 1. Heat budgets for Lake 120, 1969-1972. Computations were done after Hutchinson (1957).

YEAR	STRATUM (meters)	SUMMER	WINTER	ANNUAL	
		H_{bs} (calories $\text{cm}^{-2}A_o$)	H_{bw} (calories $\text{cm}^{-2}A_o$)	H_{ba} (calories $\text{cm}^{-2}A_o$)	(calories $\text{cm}^{-2}A_{14}$)
1969	0-19	9586	4295	13881	
	0-14	9551	4300	13851	
	14-19			30.95	357.9
1970	0-19	8915	3294	12209	
	0-14	8897	3304	12201	
	14-19			46.36	536.1
1971	0-19	8566	3520	12086	
	0-14	8538	3534	12072	
	14-19			18.09	209.2
1972	0-19	8866	4586	13452	
	0-14	8846	4591	13437	
	14-19			23.09	267.1

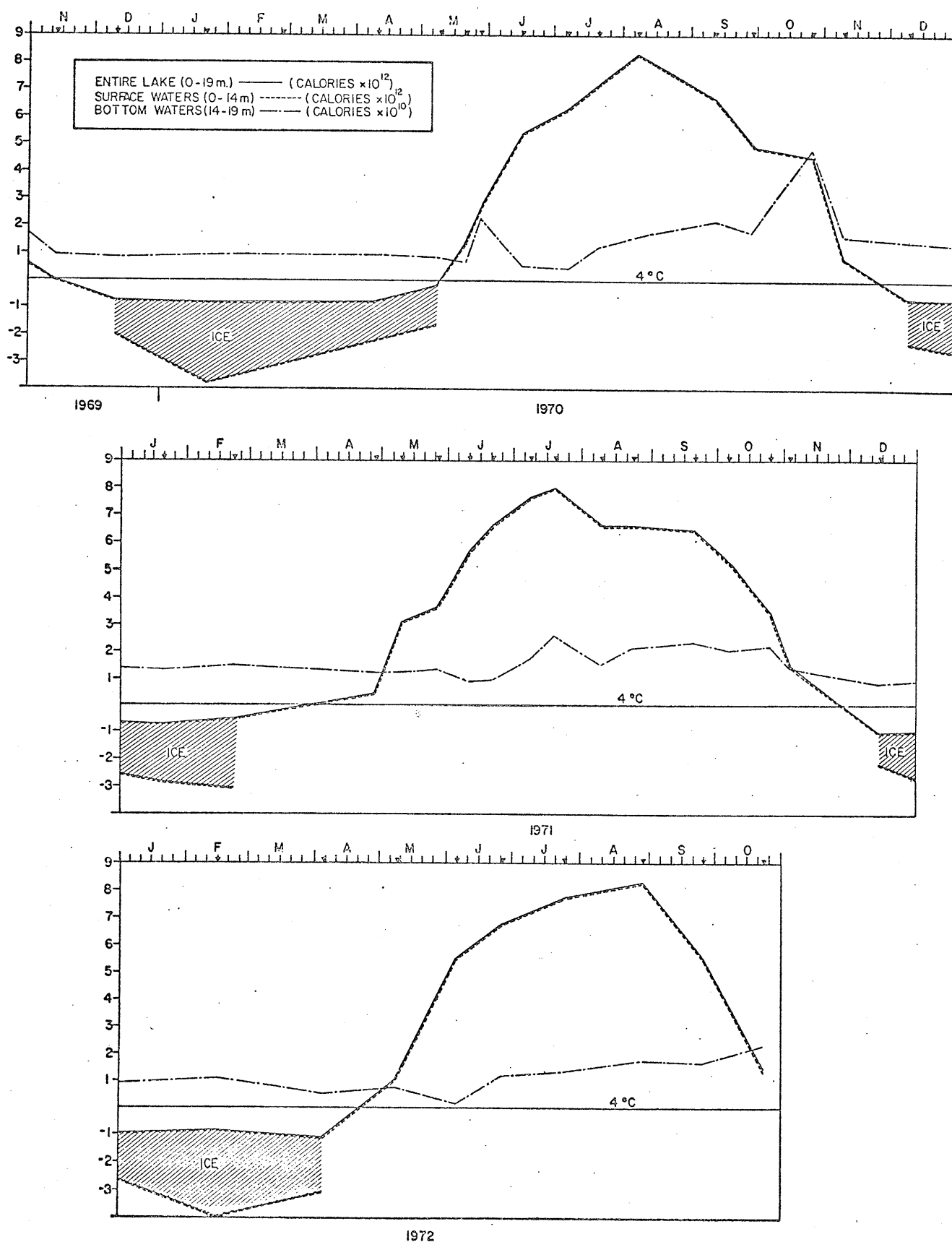


FIGURE 7. Heat budgets for Lake 120, 1969-1972. Total heat energy (calories) that would be consumed or liberated to achieve a state of homothermy at temperature of maximum density (4°C) is plotted against time.

According to Birge (1916),

$$B_z = \frac{V_z \cdot z(\Delta\rho)}{A_o}$$

gives the work performed per $\text{cm}^2 A_o$ in distributing the annual heat income of a layer of water 1 meter thick,

where

V_z = volume of the 1 meter thick stratum

$\Delta\rho$ = the thermal density change corresponding to

minimum heat content and maximum heat content.

No work was calculated for the latent heat of melting of the ice cover. Depth distributions of work accomplished in the 0-14 meter stratum and the 14-19 meter stratum during 1970, 1971 and 1972 are illustrated in Figure 8. It can readily be seen from this figure that about 90% of the work was done in the first 6 meters, that is most of the work was used in depressing the thermocline. The total amount of work (B) performed in distributing the annual heat incomes of the 0-14 meter stratum and the 14-19 meter stratum was derived by summation. These data are presented in Table 2. Work performed in the 0-14 meter stratum ranged from 228-252 $\text{g cm cm}^{-2} A_o \text{ year}^{-1}$, whereas that done in the 14-19 meter stratum was from 0.3 to 1.5 $\text{g cm cm}^{-2} A_o \text{ year}^{-1}$.

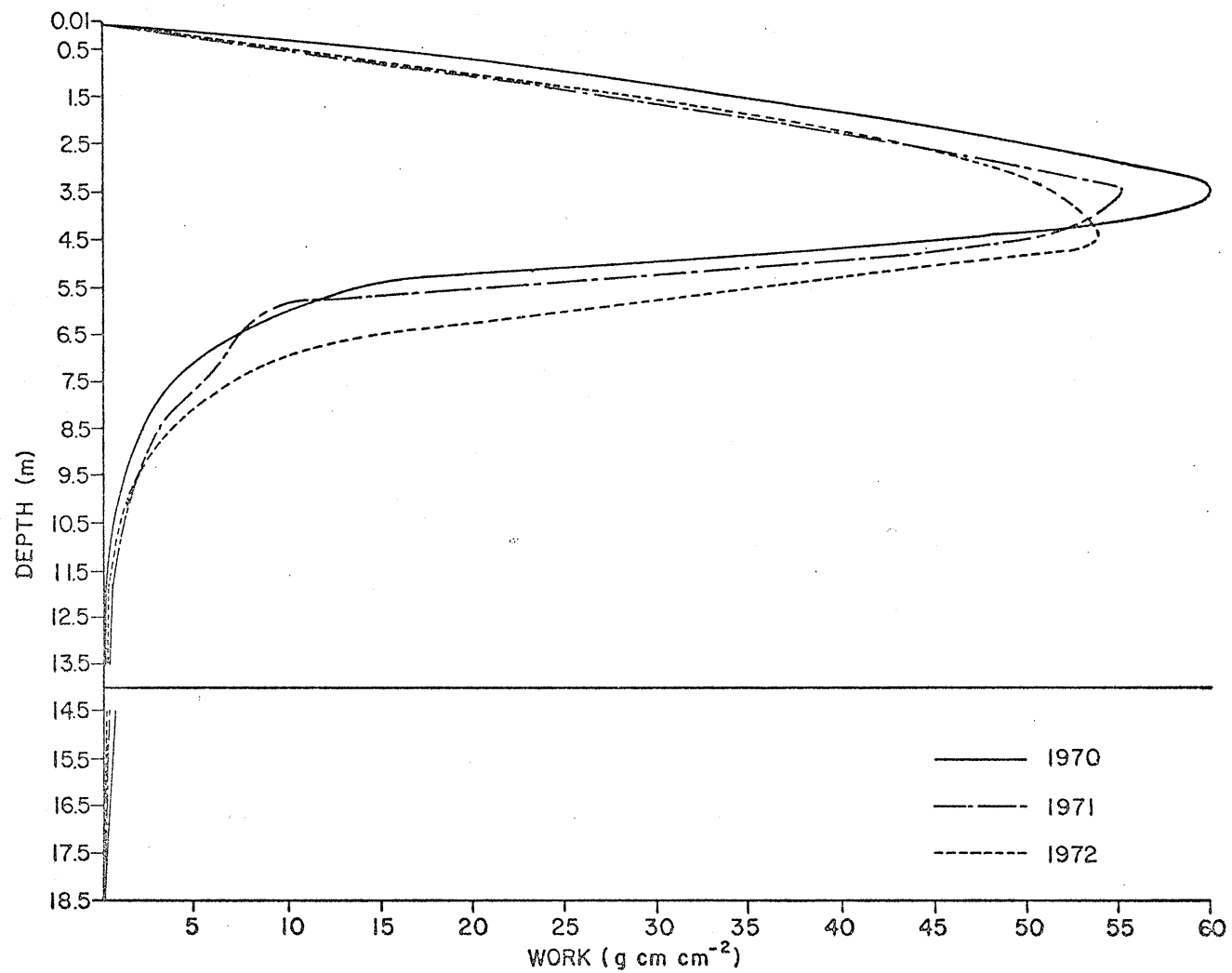


FIGURE 8. Work performed in distributing the annual heat incomes of Lake 120 during the years 1970, 1971 and 1972.

TABLE 2. Work (B) performed in distributing the annual heat incomes of Lake 120 in 1970, 1971 and 1972, and efficiencies (H_{ba^*}/B) of the work. The method used in deriving B was after that of Birge (1916) for computing work of the wind. H_b/B as a measure of efficiency was described by Schindler (1971). Melting of the ice cover is excluded from H_{ba^*} and B.

YEAR	STRATUM (meters)	H_{ba^*} (calories $\text{cm}^{-2}A_o$)	WORK (B) ($\text{g}\cdot\text{cm cm}^{-2}A_o$)	EFFICIENCY (H_{ba^*}/B) (calories per $\text{g}\cdot\text{cm}$)
1970	0-14	9811	232.9	42.1
	14-19	46.36	1.45	32.0
1971	0-14	9363	228.1	41.0
	14-19	18.09	0.384	47.1
1972	0-14	10091	251.7	40.1
	14-19	23.09	0.341	67.7

Hutchinson (1957) concluded that B/H_{bs} is an indicator of the efficiency of wind work in distributing the summer heat income of a lake. Schindler (1971), however, has pointed out that since heat income depends on wind work the ratio H_{bs}/B is a measure of efficiency; the higher the ratio, the greater the efficiency. For Lake 120, H_{ba^*}/B (H_{ba^*} does not include heat used in melting ice cover) is presented in Table 2. For the 0-14 meter stratum, the average H_{ba^*}/B was 41.1 calories per gram cm. The average H_{ba}/B for the 14-19 meter stratum was 50.0 calories per gram cm.

In general, Secchi visibility was relatively constant during spring and summer at depths of 4-5 meters (Table 2, appendix). Also constant was the depth at which light transparency (as measured by photometer) became less than 1% (Table 3, appendix). This depth was usually 8 meters and average vertical extinction coefficients ($\bar{\epsilon}_v^\lambda$) varied little, ranging from 0.59 to 0.72 (Figure 32). Only late in October during the time of maximum circulation was Secchi visibility reduced considerably; for example, 2.6 meters was a minimum on October 23, 1972. On October 23, 1972, maximum $\bar{\epsilon}_v^\lambda$ of 0.92 was also recorded. Colour at half Secchi depth was usually yellow-green during spring and summer but intensified in the late fall to orange or brown.

Chemical Limnology

In situ conductances at depths 0-13 meters were generally less than 50 $\mu\text{mhos cm}^{-1}$ at 25°C (Figure 9, and Table 4 in appendix). However, a marked increase was observed from 14 meters to the bottom. Conductance

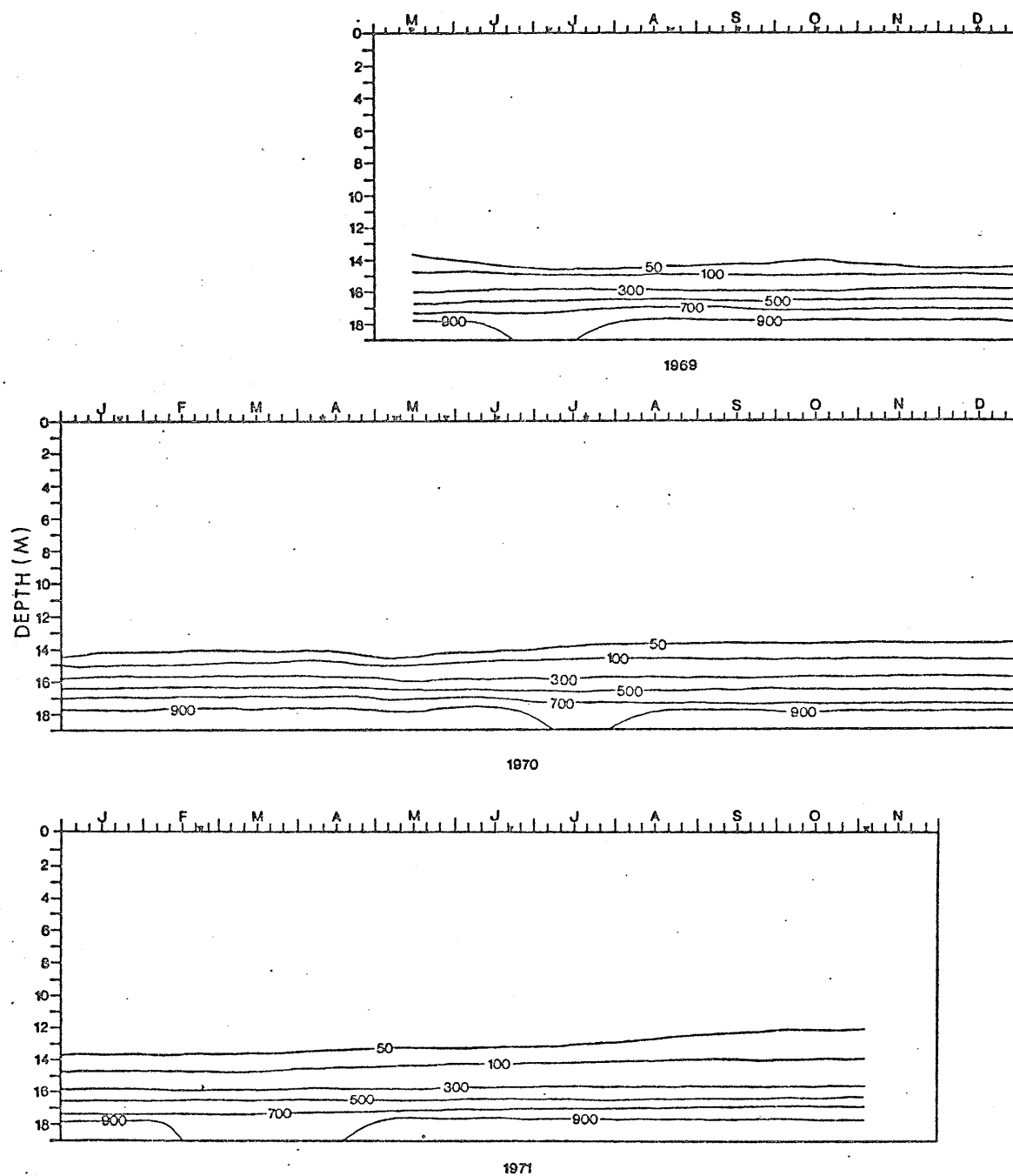


FIGURE 9. Depth-time distribution of conductivity measured *in situ* in Lake 120, 1969-1971. Isoleths are $\mu\text{mho cm}^{-1}$.

of the bottom waters was up to 50 times that of the surface waters. Maximum conductances of $800-1100 \mu\text{mhos cm}^{-1}$ were always recorded between 18 and 19 meters. Little temporal variation in the conductivity gradient was observed.

Hydrogen ion concentration (as pH) ranged from 5.8 to 7.0 (Table 5, appendix). Profiles of pH were found to be dichotomous with minimum pH between 11 and 14 meters depth. For only very brief times, coinciding with spring and fall circulation, pH at depths 0-14 meters was rather uniform but consistently lower than that of the deeper waters. Only in very deep waters (18 meters) could it be said that pH remained constant (6.6-6.7) from season to season (Figure 10).

During the course of this study, dissolved oxygen was never detected below 16 meters (Table 6, appendix). Oxygen occurred at depths as great as 16 meters only during times of vernal and autumnal circulation. Under winter ice and during summer stratification, further depletion of oxygen was observed in the deep waters. Depletion was more severe during the summer than during the winter (Figure 11). By late summer, concentrations were usually less than $1 \text{ mg O}_2 \text{ liter}^{-1}$ below 10 or 11 meters whereas at the end of winter concentrations were lower than 1 mg liter^{-1} at depths greater than about 13 meters. Maximum oxygen concentration was observed during late summer at or just below the thermocline. Maxima during the winter were observed directly below the ice surface.

Depth-time distribution of total dissolved carbon dioxide ($\text{CO}_2 +$

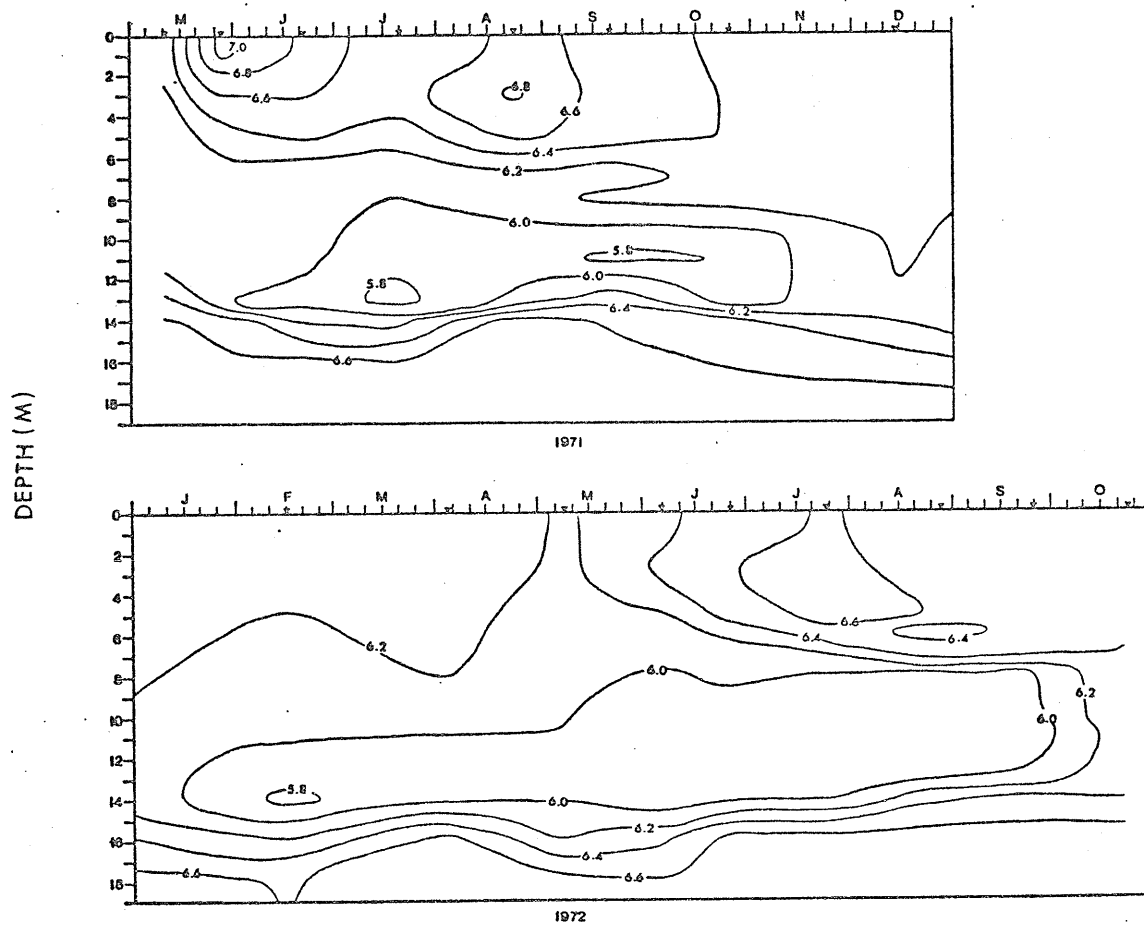


FIGURE 10. Depth-time distribution of $-\log$ hydrogen ion concentration (pH) in Lake 120, 1971-1972. Isopleths are pH units.

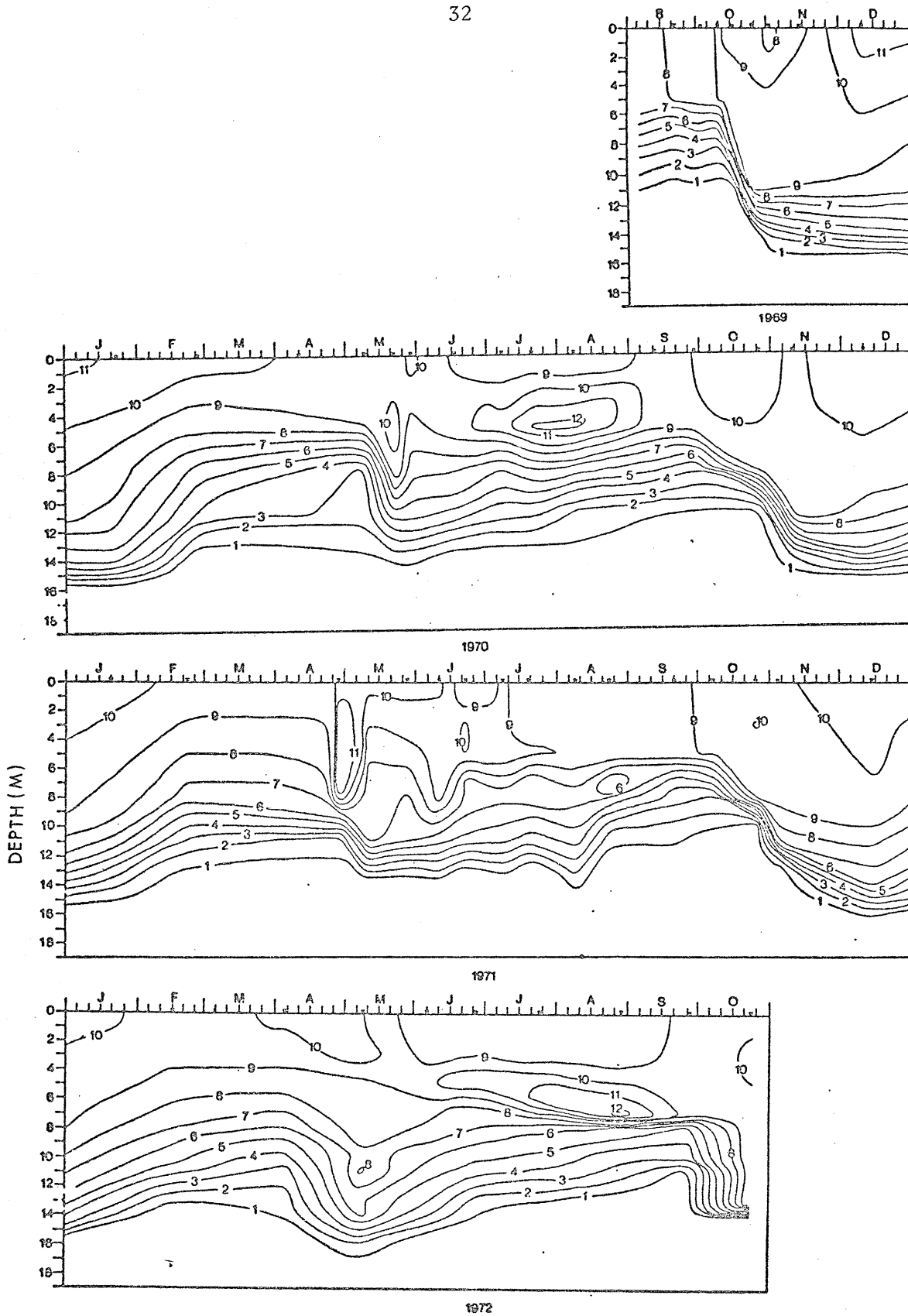


FIGURE 11. Depth-time distribution of dissolved oxygen (O_2) in Lake 120, 1969-1972. Isopleths are $mg\ liter^{-1}$. O_2 was not detectable at the 1-meter depth interval immediately below the 1 $mg\ liter^{-1}$ isopleth.

$\text{H}_2\text{CO}_3 + \text{HCO}_3^- + \text{CO}_3^{=}$) appeared inversely related to trends in dissolved oxygen. The deep anaerobic waters were CO_2 enriched. Up to 12,000 $\mu\text{moles } \Sigma\text{CO}_2 \text{ liter}^{-1}$ were measured at 18 meters, whereas at depths less than 14 meters, ΣCO_2 concentrations greater than 300 $\mu\text{moles liter}^{-1}$ were uncommon (Table 7, appendix). ΣCO_2 concentrations greater than 300 $\mu\text{moles liter}^{-1}$ at depths less than 14 meters (Figure 12) coincided with summer and winter oxygen depletion. Similarly, minimum ΣCO_2 concentrations of less than 100 $\mu\text{moles liter}^{-1}$ were observed in the surface waters during the summer which at least in part coincided with oxygen maxima. Although the deep waters (14-18 meters) were always greatly enriched in ΣCO_2 with respect to the overlying waters, it should be noted that in terms of absolute concentrations a marked decrease was observed in the bottom waters during the winter. In this stratum, ΣCO_2 during February to April was approximately one half that observed during mid and late summer. Concentrations of dissolved methane in the bottom waters equalled those for total carbon dioxide (Table 8, appendix). As with ΣCO_2 , Figure 13 shows that amounts of methane in the bottom waters during winter were also about one half the summer maximum of almost 11,000 $\mu\text{moles liter}^{-1}$. In the aerobic stratum, methane was usually not detectable. A marked concentration gradient was also evident for dissolved organic carbon. DOC from 0-14 meters ranged from about 50 to 500 $\mu\text{moles liter}^{-1}$ but at 18 meters ranged from 2,300 $\mu\text{moles liter}^{-1}$ during late winter to over 9,000 $\mu\text{moles liter}^{-1}$ in mid summer (Figure 14 and Table 9, appendix). It should be noted that, on an average, from 0-14 meters almost 70% of the total dissolved carbon was organic whereas from 14-19 meters less than 30% was organic (Table 3).

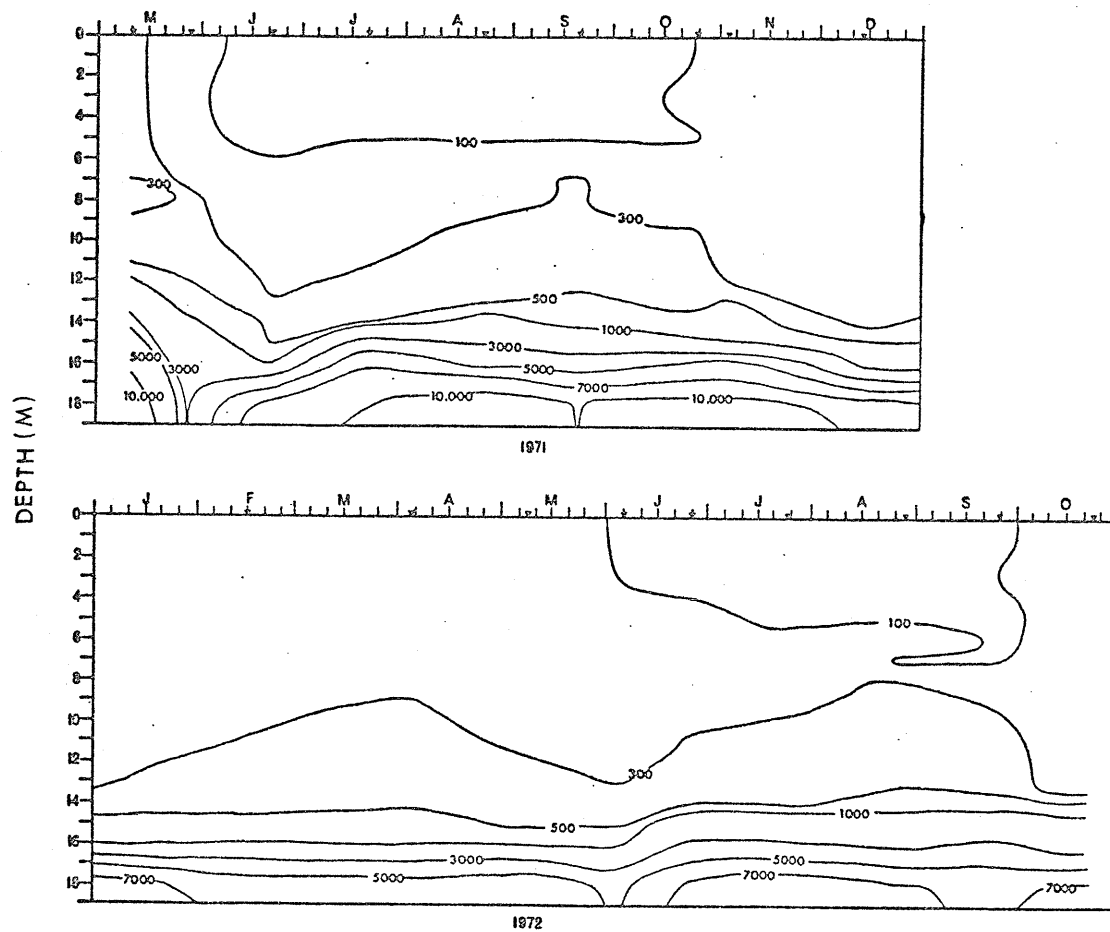


FIGURE 12. Depth-time distribution of total dissolved carbon dioxide (CO₂+H₂CO₃+HCO₃⁻+CO₃⁼) in Lake 120, 1971-1972. Isopleths are μmoles liter⁻¹.

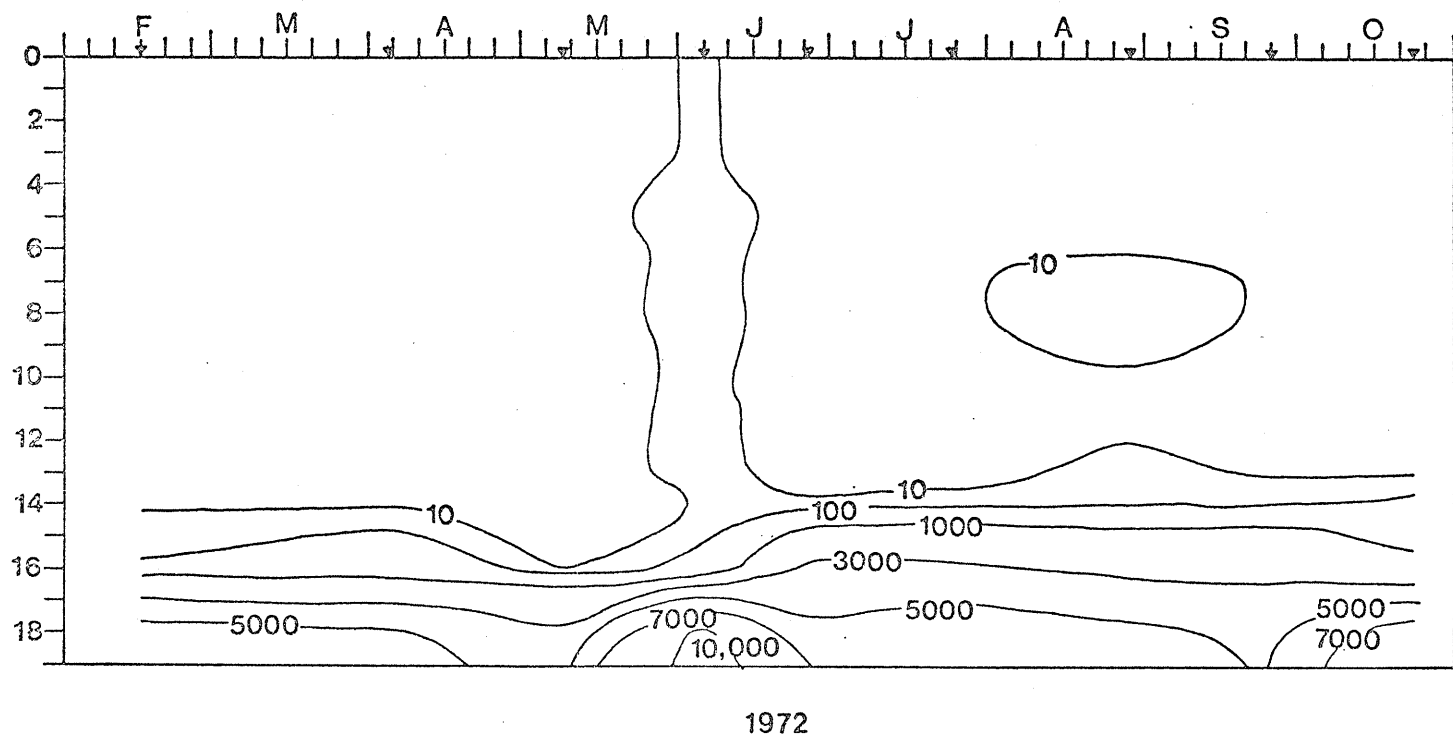


FIGURE 13. Depth-time distribution of dissolved methane (CH₄) in Lake 120 during 1972. Isoleths are $\mu\text{moles liter}^{-1}$.

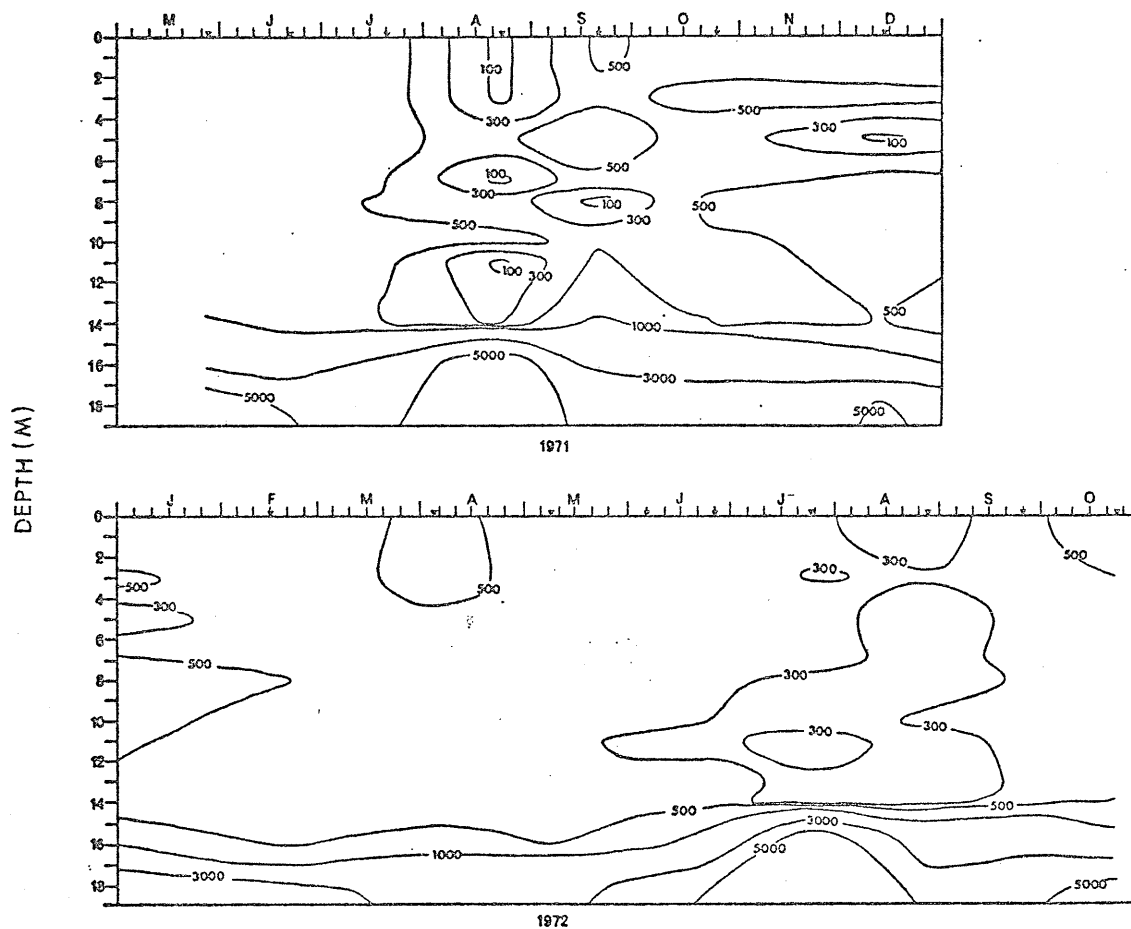


FIGURE 14. Depth-time distribution of dissolved organic carbon (DOC) in Lake 120, 1971-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

TABLE 3. Average concentrations of dissolved inorganic, dissolved organic, and suspended fractions of carbon, nitrogen and phosphorus measured in Lake 120 during 1971 and the percentage contribution of each fraction to the total.

		MEAN CONCENTRATION ($\mu\text{moles liter}^{-1}$)		CONC'N z=14-19 CONC'N z= 0-14	% OF TOTAL	
		z=0-14	z=14-19		z=0-14	z=14-19
C	Dissolved inorganic ($\Sigma\text{CO}_2 + \text{CH}_4$)	235	7353	31	29	69
	Dissolved organic (DOC)	498	2939	6	62	28
	Suspended (PC)	73.6	352	5	9	3
N	Dissolved inorganic ($\text{NH}_3 + \text{NO}_2 + \text{NO}_3$)	3.03	822	271	15	89
	Dissolved organic ($\text{TDN} - [\text{NH}_3 + \text{NO}_2 + \text{NO}_3]$)	12.71	74*	6	61	8
	Suspended (PN)	4.93	26.78	5	24	3
P ^x	Dissolved inorganic (SRP) [†]	0.06	0.33	6	13	15
	Dissolved organic (TDP-SRP)	0.23	0.82	4	48	38
	Suspended (PP)	0.19	1.00	5	40	47

* From determinations carried out in 1974. In 1974 $\text{NH}_3 + \text{NO}_2 + \text{NO}_3$ nitrogen was 91% of TDN.

x Most individual determinations of P were at or below the limits of detection of the methods employed during this study.

† Probably includes some dissolved organic phosphorus (see Methods Section).

From Table 3 it can also be seen that dissolved nitrogen from 0-14 meters was predominantly organic (80%). However, as for dissolved carbon, the trend was reversed from 14-19 meters. The organic fraction in that part of the lake was only about 8% of the total dissolved nitrogen. (Recall that in the methods section it was stated that during this study determinations for TDN $>35 \mu\text{moles liter}^{-1}$ were found to be unreliable for these kinds of samples. As a result, no TDN data will be reported here for the 14-19 meter stratum. More reliable TDN determinations carried out in 1974 were used to compute the dissolved organic fraction cited above where dissolved organic nitrogen = $\text{TDN} - [\text{NH}_3 + \text{NO}_2 + \text{NO}_3\text{-N}]$). A paucity of dissolved inorganic nitrogen was observed in the oxygenated waters (Tables 10 and 11, appendix). $\text{NO}_3 + \text{NO}_2\text{-N}$ concentrations ranged from undetectable (<0.07) to less than $10 \mu\text{moles liter}^{-1}$; $\text{NH}_3\text{-N}$ was usually less than $1 \mu\text{mole liter}^{-1}$. TDN (Table 12, appendix) was usually between 10 and $20 \mu\text{moles liter}^{-1}$. From the depth-time distribution shown in Figure 15 it can be seen that a buildup of $\text{NO}_3 + \text{NO}_2\text{-N}$, centered usually at about 11 meters, occurred twice each year. These buildups concurred with times of maximum oxygen depletion under winter ice and during summer stratification. Levels of $\text{NH}_3\text{-N}$ (in essence, dissolved inorganic nitrogen) in the 14-19 meter stratum were well over $2,000 \mu\text{moles liter}^{-1}$ by late summer (Figure 16). As for dissolved carbon, in these waters concentrations of $\text{NH}_3\text{-N}$ were reduced by at least one half by late winter. $\text{NO}_3 + \text{NO}_2\text{-N}$ reported at depths below 14 meters should probably be looked upon with suspicion since no correction was made during analysis for absorbance due to the natural colour of the water; also, it is possible that during sample collection and preparation exposure to air oxidized a small

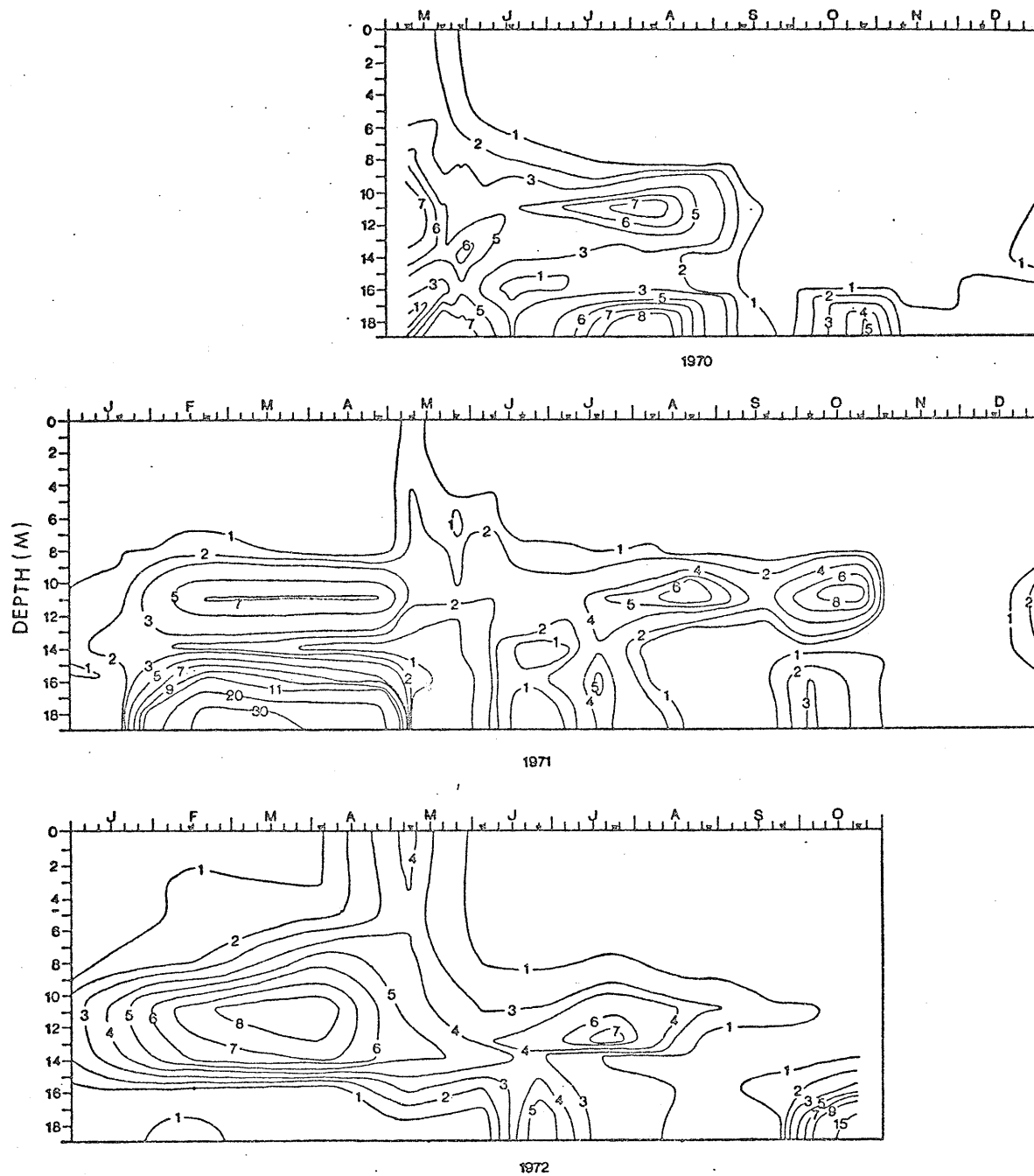


FIGURE 15. Depth-time distribution of nitrate plus nitrite nitrogen ($\text{NO}_3 + \text{NO}_2\text{-N}$) in Lake 120, 1970-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

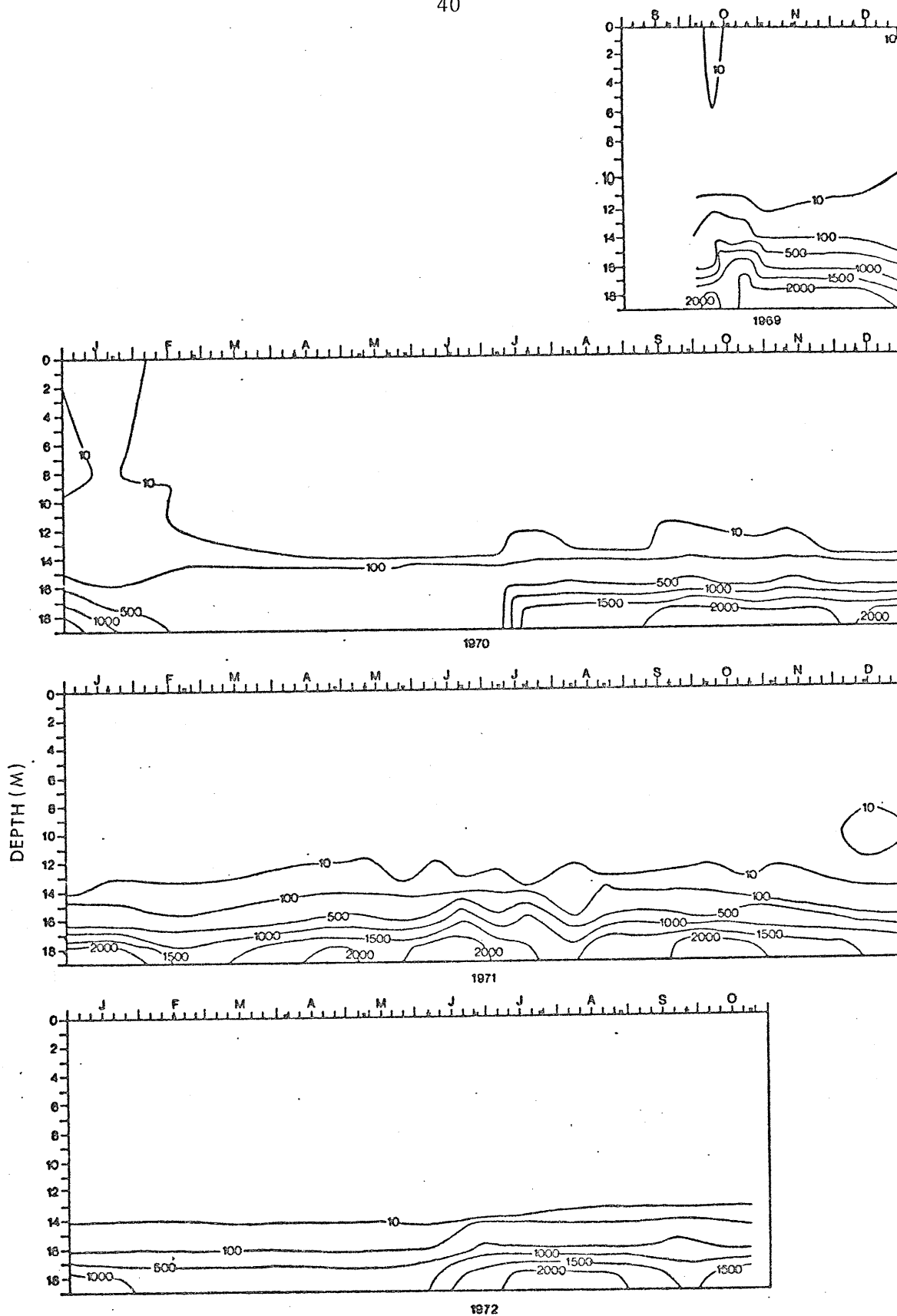


FIGURE 16. Depth-time distribution of ammonia nitrogen ($\text{NH}_3\text{-N}$) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

fraction of the $\text{NH}_3\text{-N}$.

Since SRP determinations (Table 13, appendix) were usually at the limit of detection of the method, and since detection of some organically bound P as well as dissolved inorganic P ($\text{PO}_4\text{-P}$) was likely, the data must be interpreted with caution. At any rate, SRP from 0-14 meters ranged from undetectable (<0.03) to $0.2 \mu\text{moles liter}^{-1}$. In the bottom waters, concentrations increased to maxima of $2.0 \mu\text{moles liter}^{-1}$ during summer but during mid and late winter decreased to about $0.2 \mu\text{moles liter}^{-1}$ (Figure 17). Concentrations of TDP (Table 14, appendix) were also considerably higher in the bottom waters than in the surface waters. Up to $1.0 \mu\text{mole liter}^{-1}$ of TDP was recorded at depths 0-14 meters. Greater than $5 \mu\text{moles liter}^{-1}$ were observed at 18 meters in late summer but during winter concentrations were usually less than $2 \mu\text{moles liter}^{-1}$ (Figure 18). A concentration of TDP greater than $12 \mu\text{moles liter}^{-1}$ was recorded in the surface waters on one occasion (August 7, 1970). It is possible that such high levels recorded on that day resulted from contamination during analysis. Unlike carbon and nitrogen, no marked shift to a predominance of dissolved inorganic P over dissolved organic P was observed in the bottom waters. Dissolved inorganic P in the 0-14 meter stratum was less than 20% TDP; in the 14-19 meter stratum dissolved inorganic P was still less than 30% TDP (Table 3).

Individual determinations of suspended carbon, nitrogen and phosphorus are reported respectively in Tables 15, 16 and 17 of the appendix. Average concentrations of PC, PN and PP in the 0-14 meter stratum during 1971 were 75, 5 and $0.2 \mu\text{moles liter}^{-1}$ respectively.



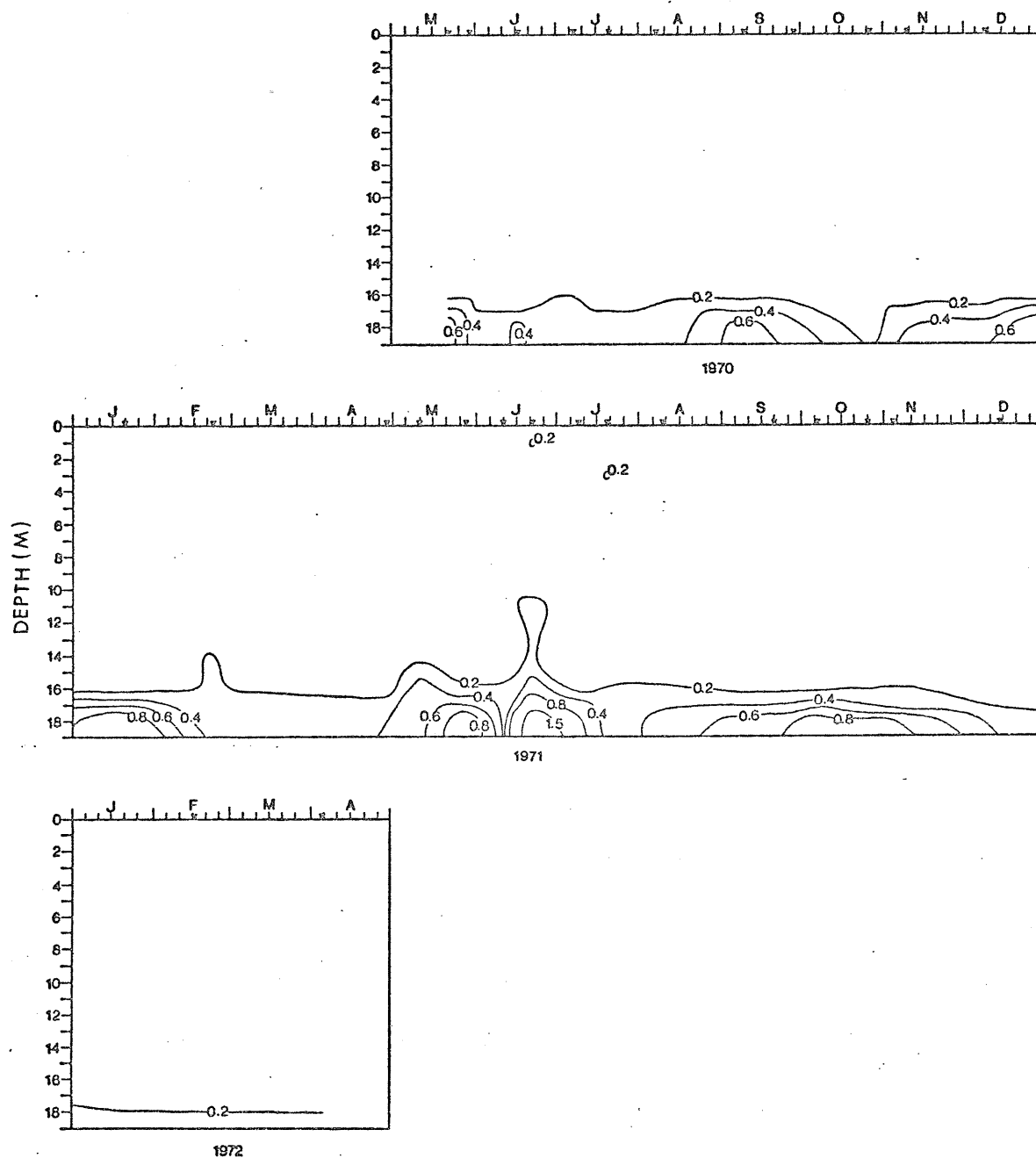


FIGURE 17. Depth-time distribution of soluble reactive phosphorus (SRP) in Lake 120, 1970-1972. SRP is not only a measure of dissolved inorganic phosphorus ($\text{PO}_4\text{-P}$) but also to some extent a measure of organically bound phosphorus in solution. Isopleths are $\mu\text{moles liter}^{-1}$.

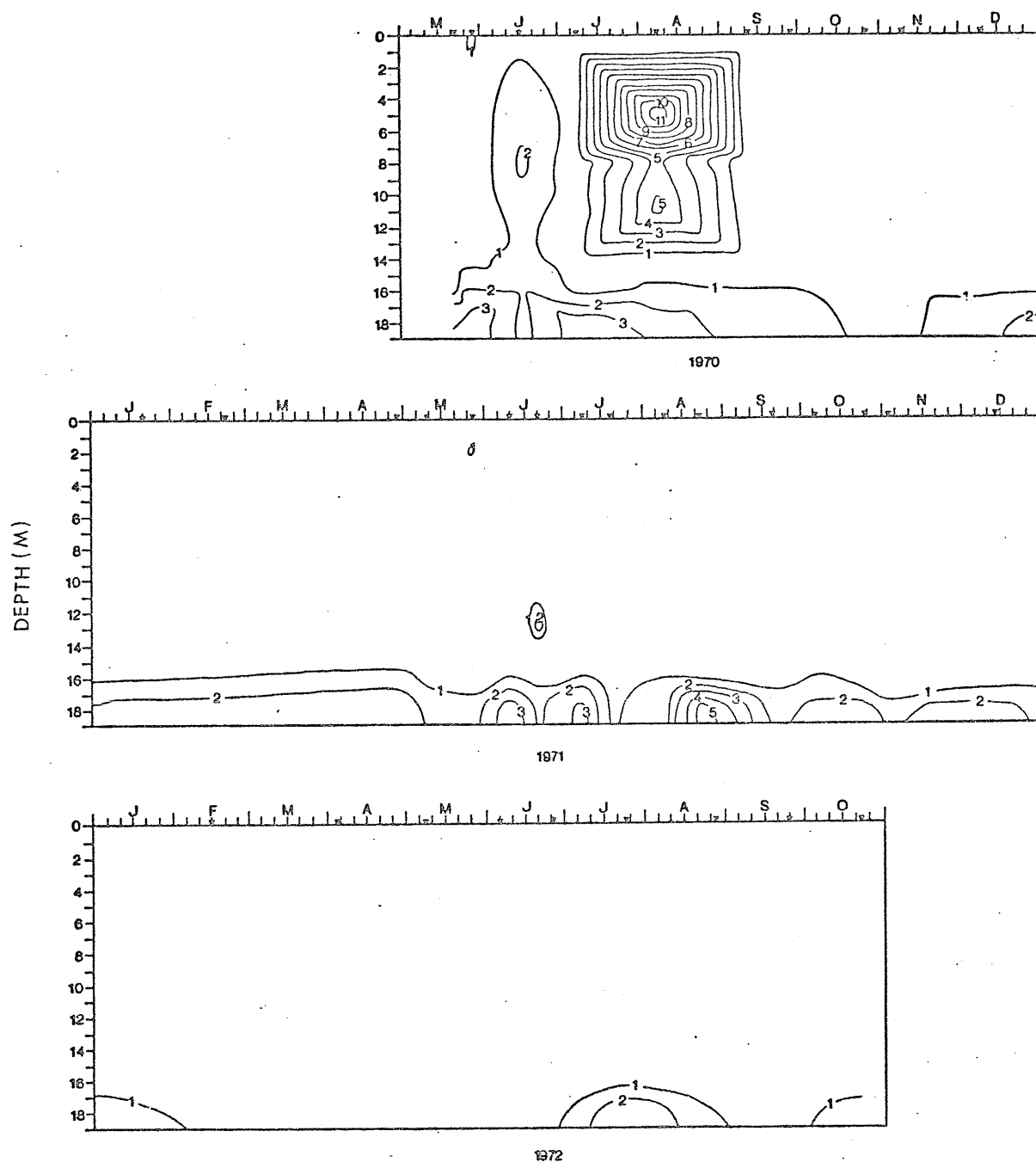


FIGURE 18. Depth-time distribution of total dissolved phosphorus (TDP) in Lake 120, 1970-1972. High levels determined at 5, 8 and 11 meters on August 7, 1970 may have been a result of contamination during analysis. Isopleths are $\mu\text{moles liter}^{-1}$.

Sharp rises in concentration were observed from 14-19 meters. In this stratum, average concentrations of PC, PN and PP were 5 times higher than in overlying waters (Table 3). Depth-time distribution of PC, PN and PP are shown in Figures 19, 20 and 21, respectively. Nutrients in the suspended phase in both the surface and bottom waters were at a minimum during the winter. At 18 meters depth, PC concentrations rose from winter minimums of about $150 \mu\text{moles liter}^{-1}$ to greater than $1,000 \mu\text{moles liter}^{-1}$ during summer. Similarly, concentrations of PN at this depth were observed to increase from less than 20 to greater than $75 \mu\text{moles liter}^{-1}$ and PP increased from less than 1 to greater than $3 \mu\text{moles liter}^{-1}$. During summer stratification, the highest levels of particulate nutrients in the 0-14 meter stratum were recorded at depths corresponding to the lower reaches of the thermocline.

Concentrations of soluble reactive silicon (Si) at depths 0-14 meters ranged from about $40\text{-}70 \mu\text{moles liter}^{-1}$ (Table 18, appendix). Si was depleted to levels less than $50 \mu\text{moles liter}^{-1}$ at depths 0 to about 8 meters during summer stratification. Values less than $50 \mu\text{moles liter}^{-1}$ were also observed under winter ice during January and February of 1971 (Figure 22). Concentrations of Si greater than $400 \mu\text{moles liter}^{-1}$ were observed at 18 meters during the summer. By the end of winter, concentrations in the deep waters had usually halved. Average concentrations of Si observed during 1971 in the 0-14 meter and 14-19 meter strata are reported in Table 4. On an average, levels of Si in the 14-19 meter stratum were four times those of the 0-14 meter stratum.

Average concentrations of dissolved Ca, Mg, Na, K, Fe, and Mn in

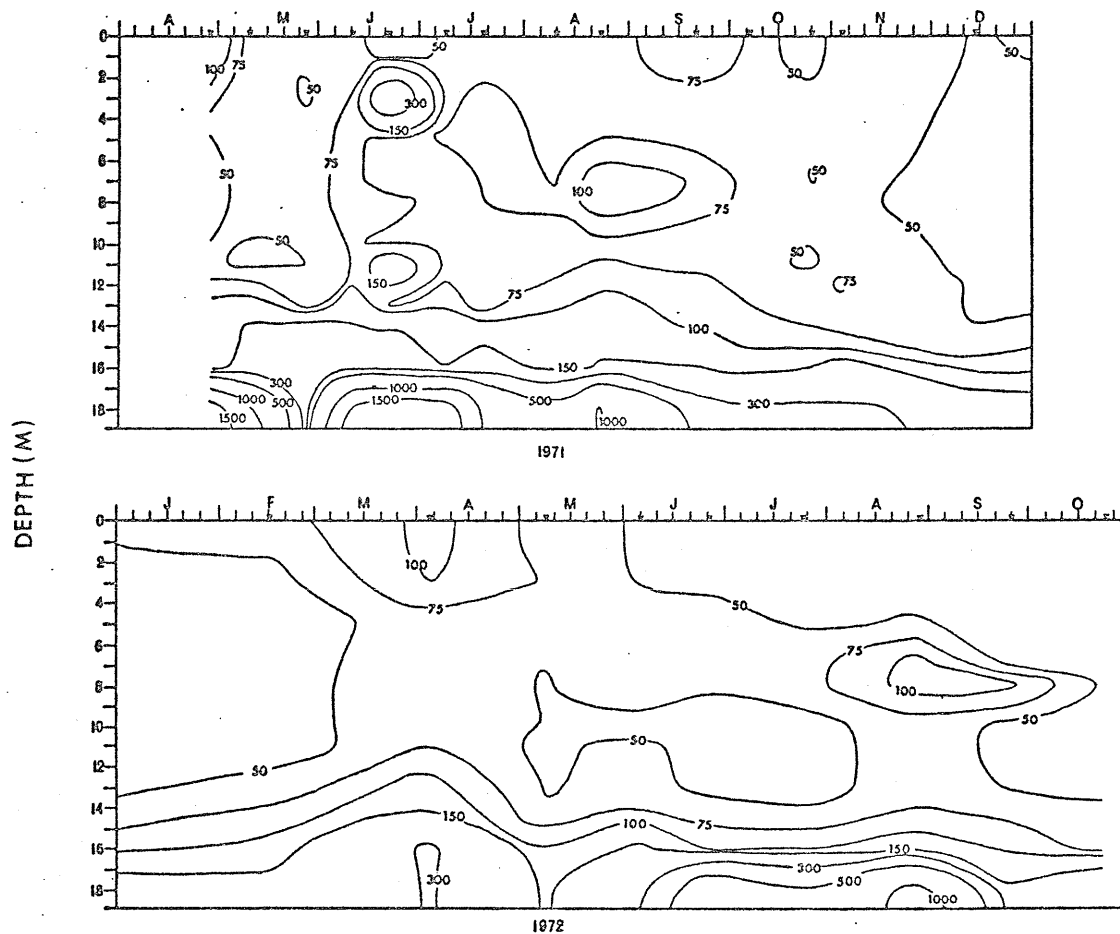


FIGURE 19. Depth-time distribution of suspended particulate carbon (PC) in Lake 120, 1971-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

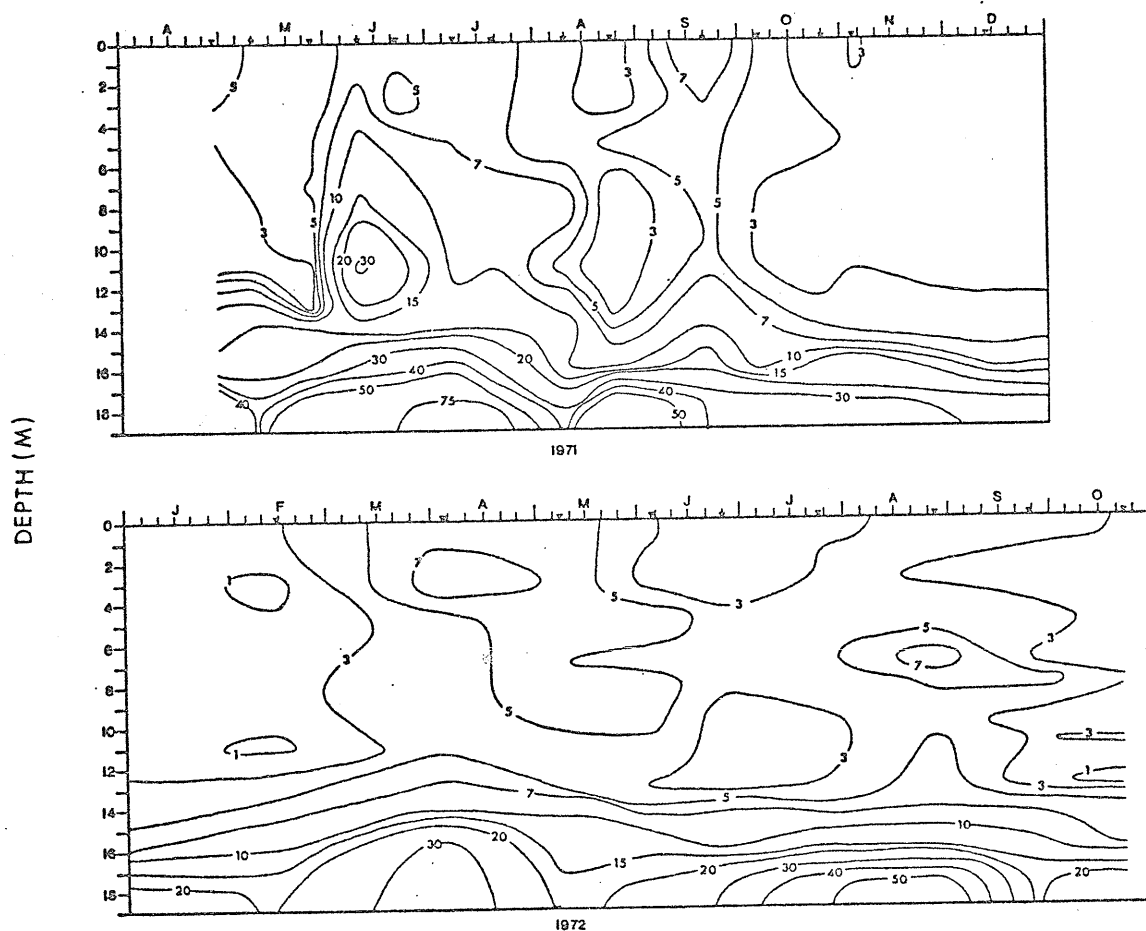


FIGURE 20. Depth-time distribution of suspended particulate nitrogen (PN) in Lake 120, 1971-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

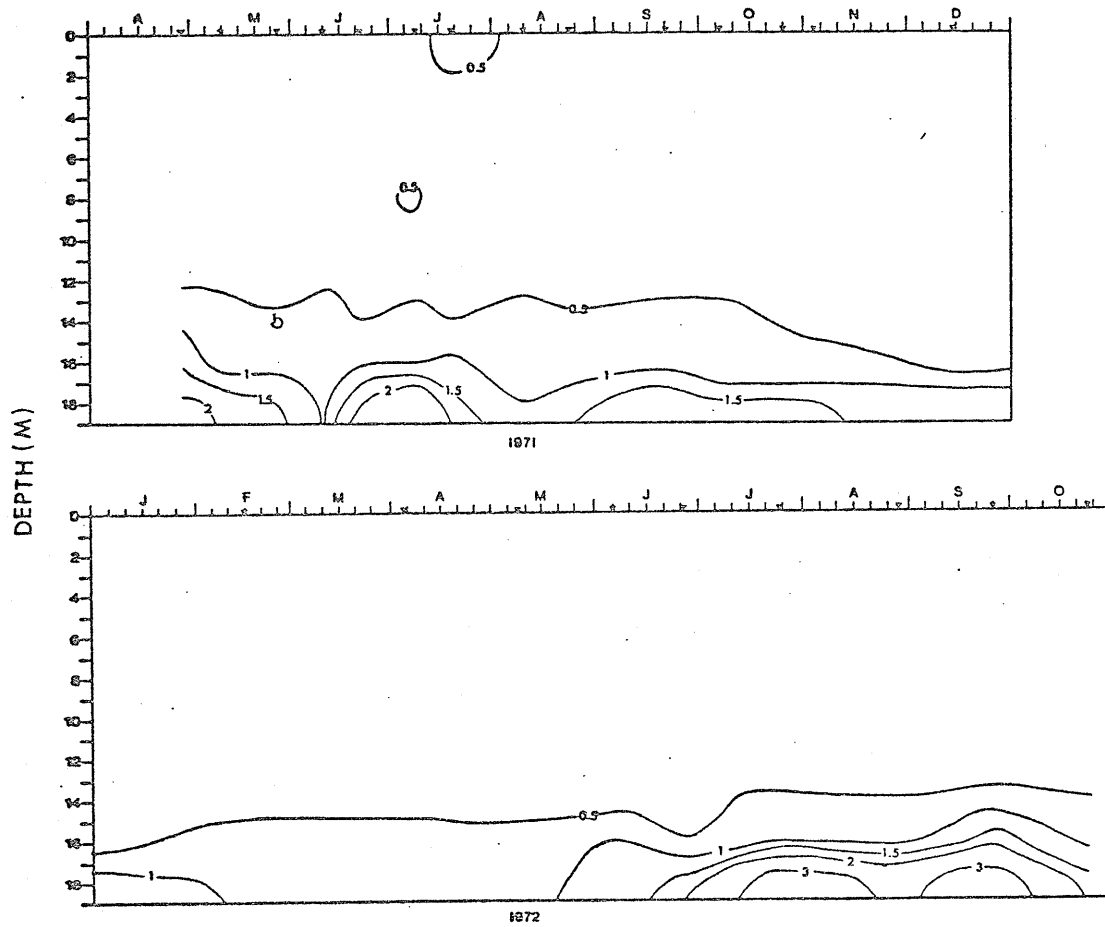


FIGURE 21. Depth-time distribution of suspended particulate phosphorus (PP) in Lake 120, 1971-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

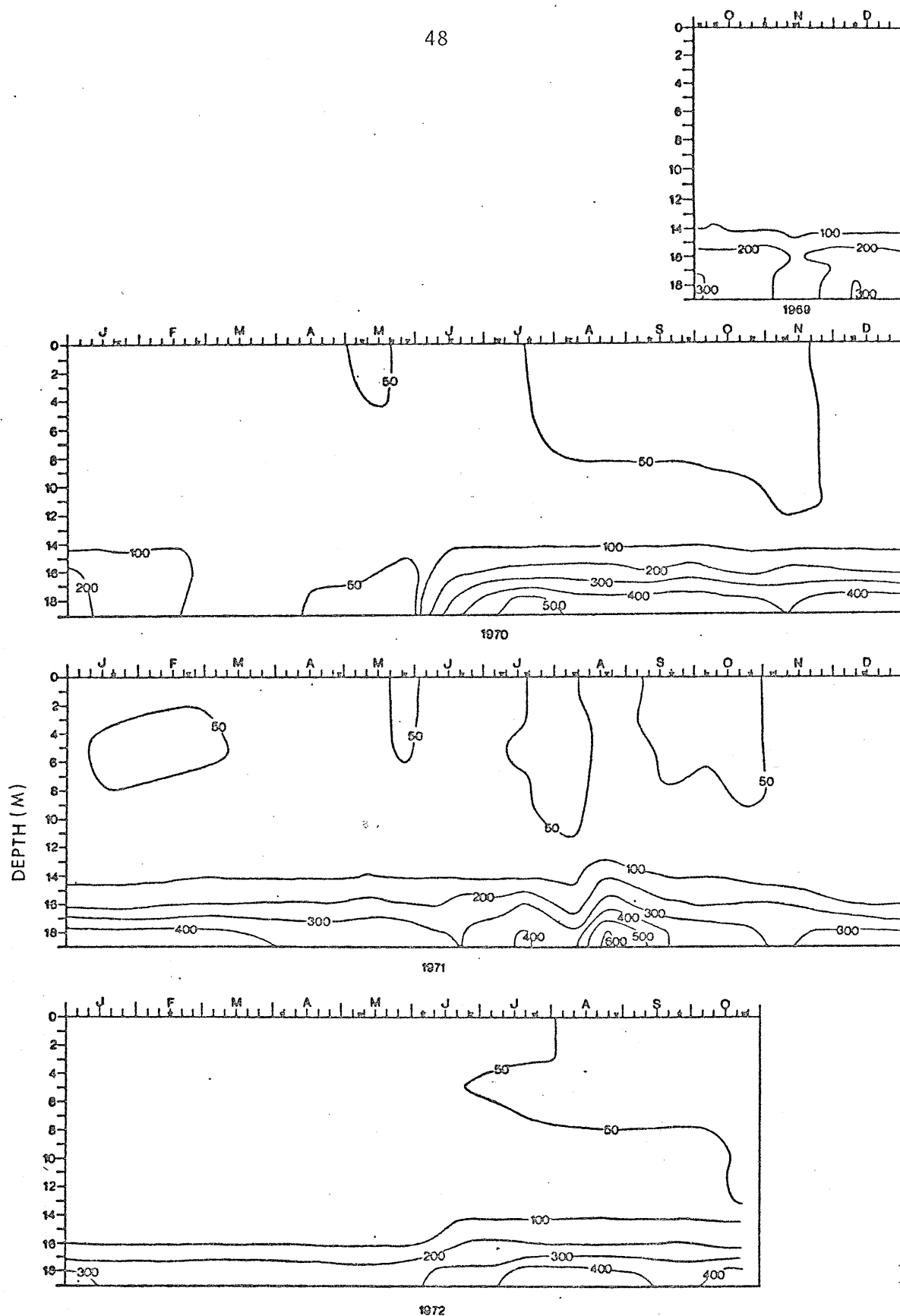


FIGURE 22. Depth-time distribution of soluble reactive silicon (Si) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

TABLE 4. Average concentrations of soluble reactive silicon (Si), dissolved calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe) and manganese (Mn) in Lake 120 during 1971.

	AVERAGE CONCENTRATION ($\mu\text{moles liter}^{-1}$)		CONC'N z = 14-19
	z = 0-14	z = 14-19	CONC'N z = 0-14
Si	56	224	4
Ca	38	330	9
Mg	23	40	2
Na	31	38	1
K	6	19	3
Fe	5	1260	250
Mn	2	48	24

the 0-14 and 14-19 meter strata are also reported in Table 4. For all the above-mentioned cations, enrichment was observed in the 14-19 meter stratum. However, the degree of enrichment varied considerably. The concentration of Fe in the bottom waters was 250 times that of the surface waters whereas that for sodium was only slightly greater than 1 (Table 4). Individual determinations of Ca, Mg, Na, K, Fe, and Mn are reported respectively in Tables 19, 20, 21, 22, 23 and 24 of the appendix. As a rule, concentrations of major cations in the 0-14 meter stratum varied little from season to season (Figures 23, 24, 25, 26, 27 and 28). However, noticeable decreases in Ca, Mg, Na and K levels were observed during January and February of 1971. The relative order of abundance (moles) of these dissolved cations in the surface waters was $\text{Ca} > \text{Na} > \text{Mg} > \text{K} > \text{Fe} > \text{Mn}$. In the 14-19 meter stratum the order was very different where $\text{Fe} > \text{Ca} > \text{Mn} > \text{Mg} > \text{Na} > \text{K}$. In the bottom waters there was a marked seasonal variation in concentration. Without exception, concentrations of the above-mentioned cations were much lower during the winter than during the summer.

Hydrological and Chemical Budgets

Annual water budgets for Lake 120 during 1970, 1971 and 1972 were computed by extrapolation. Precipitation, runoff, and evaporation were measured on the nearby Lake 239 watershed (Schindler *et al.*, 1976). Storage in the lake was assumed to be zero (storage never accounted for more than 4% of the annual input of water to Lake 239). Outflow from the lake was calculated by subtracting lake surface evaporation from the

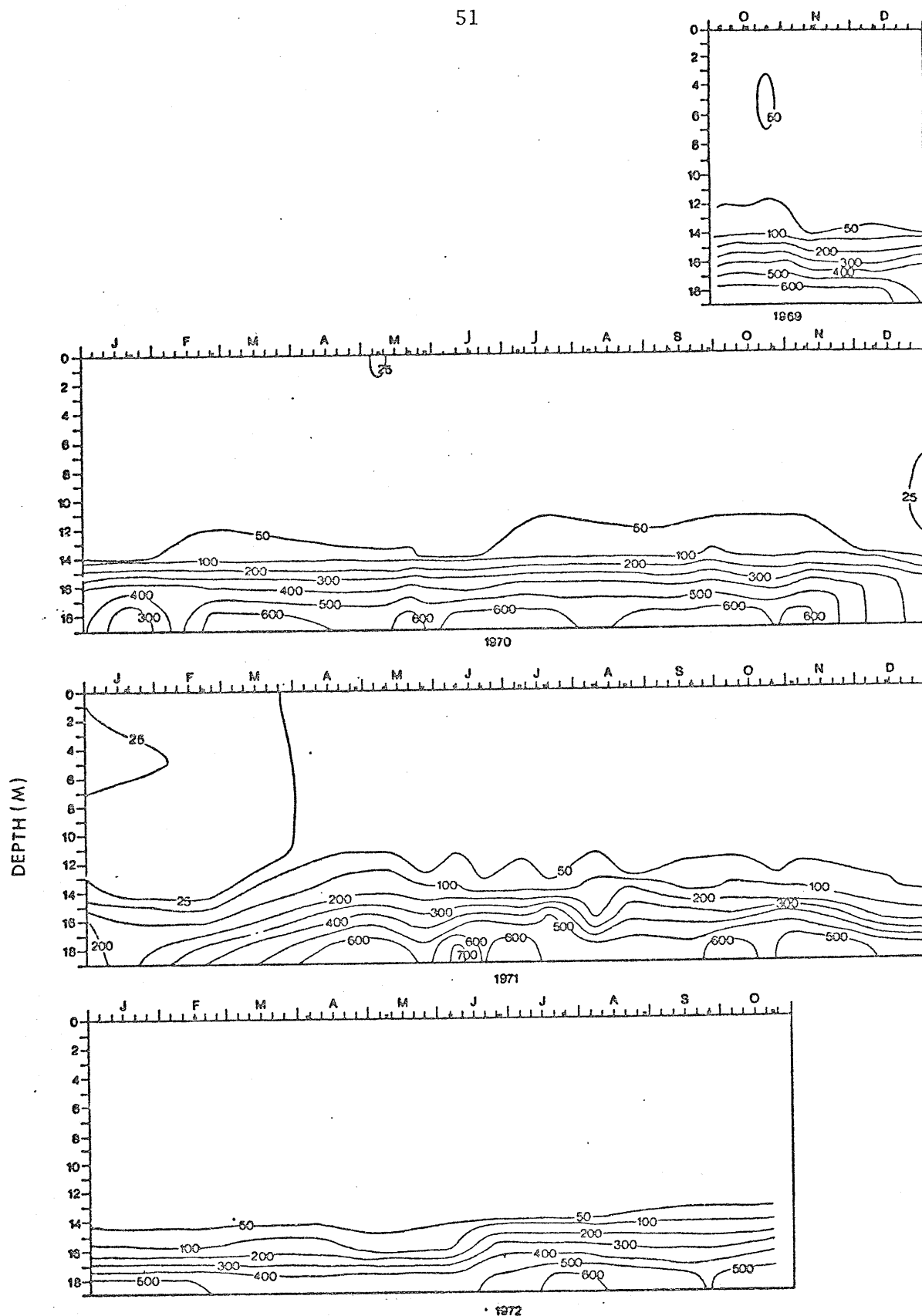


FIGURE 23. Depth-time distribution of dissolved calcium (Ca) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

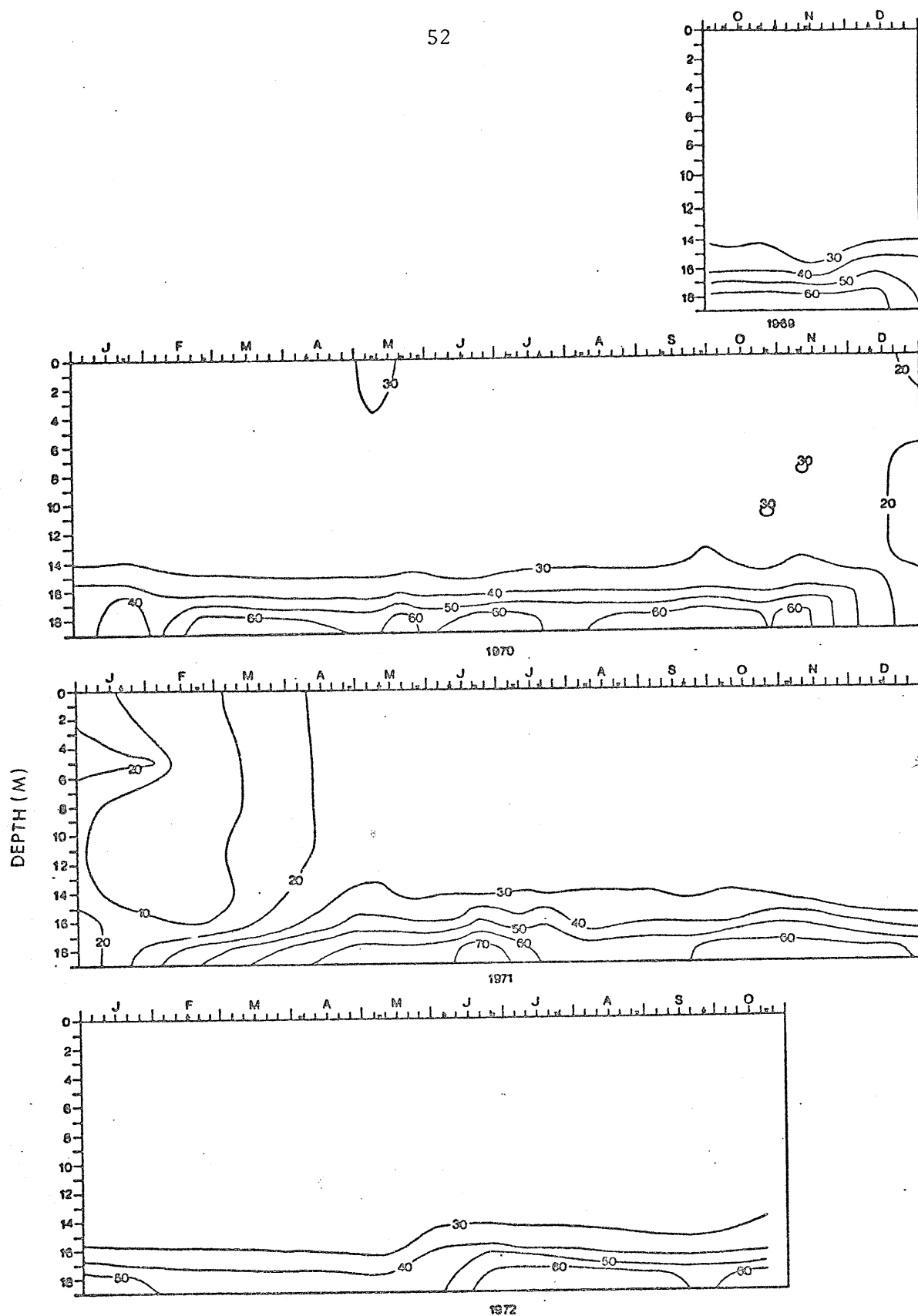


FIGURE 24. Depth-time distribution of dissolved magnesium (Mg) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

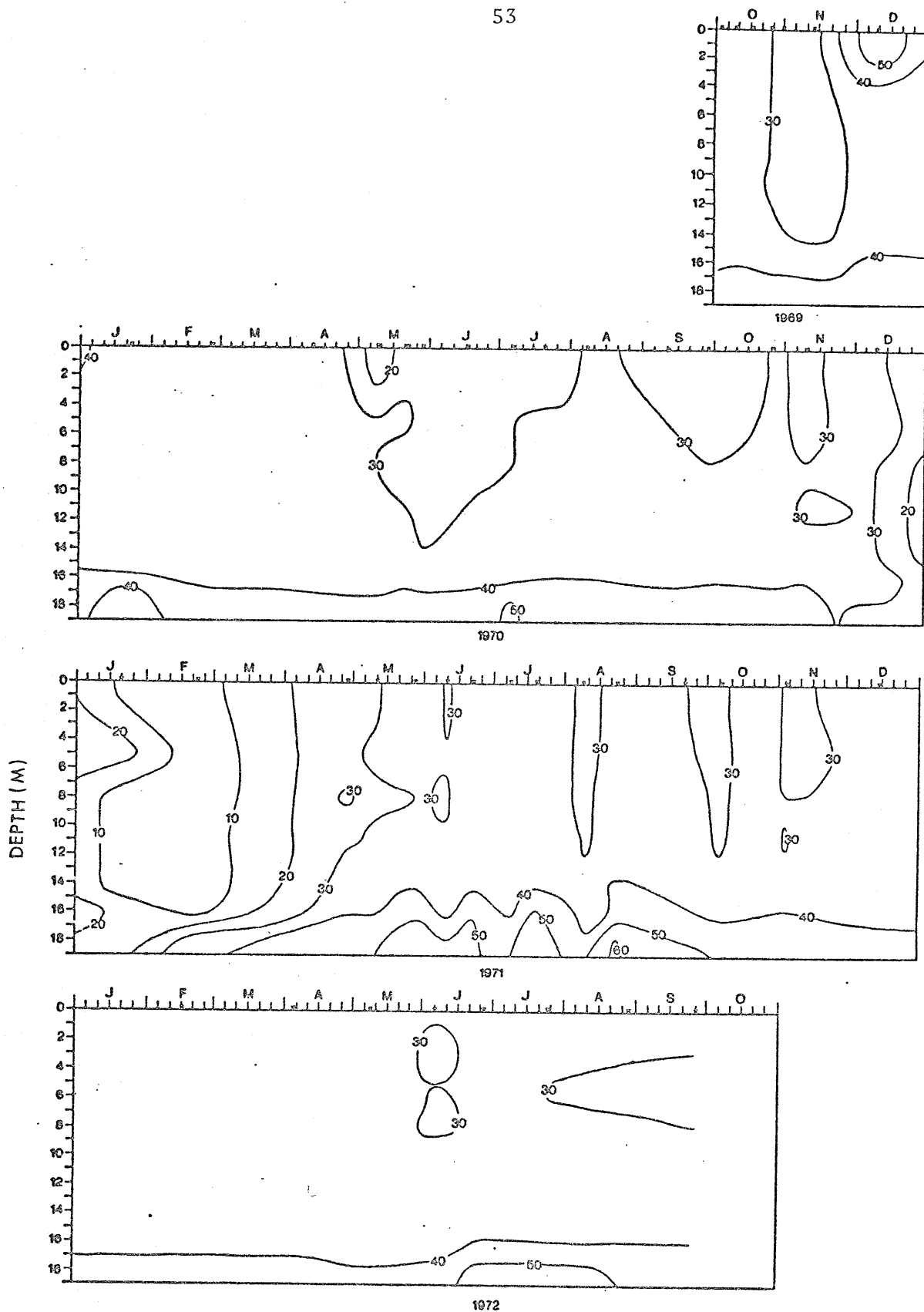


FIGURE 25. Depth-time distribution of dissolved sodium (Na) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

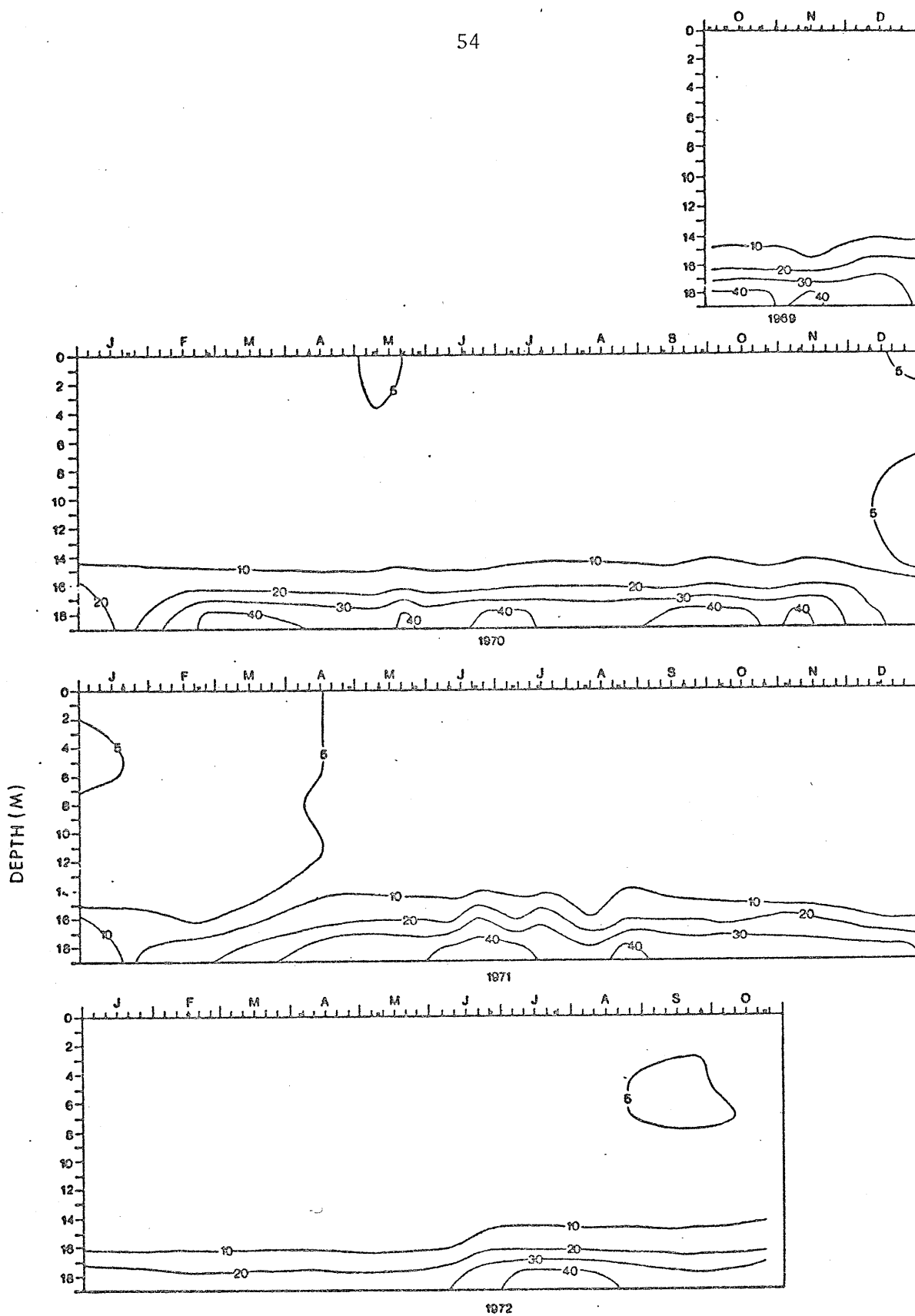


FIGURE 26. Depth-time distribution of dissolved potassium (K) in Lake 120, 1969-1972. Isopleths are $\mu\text{moles liter}^{-1}$.

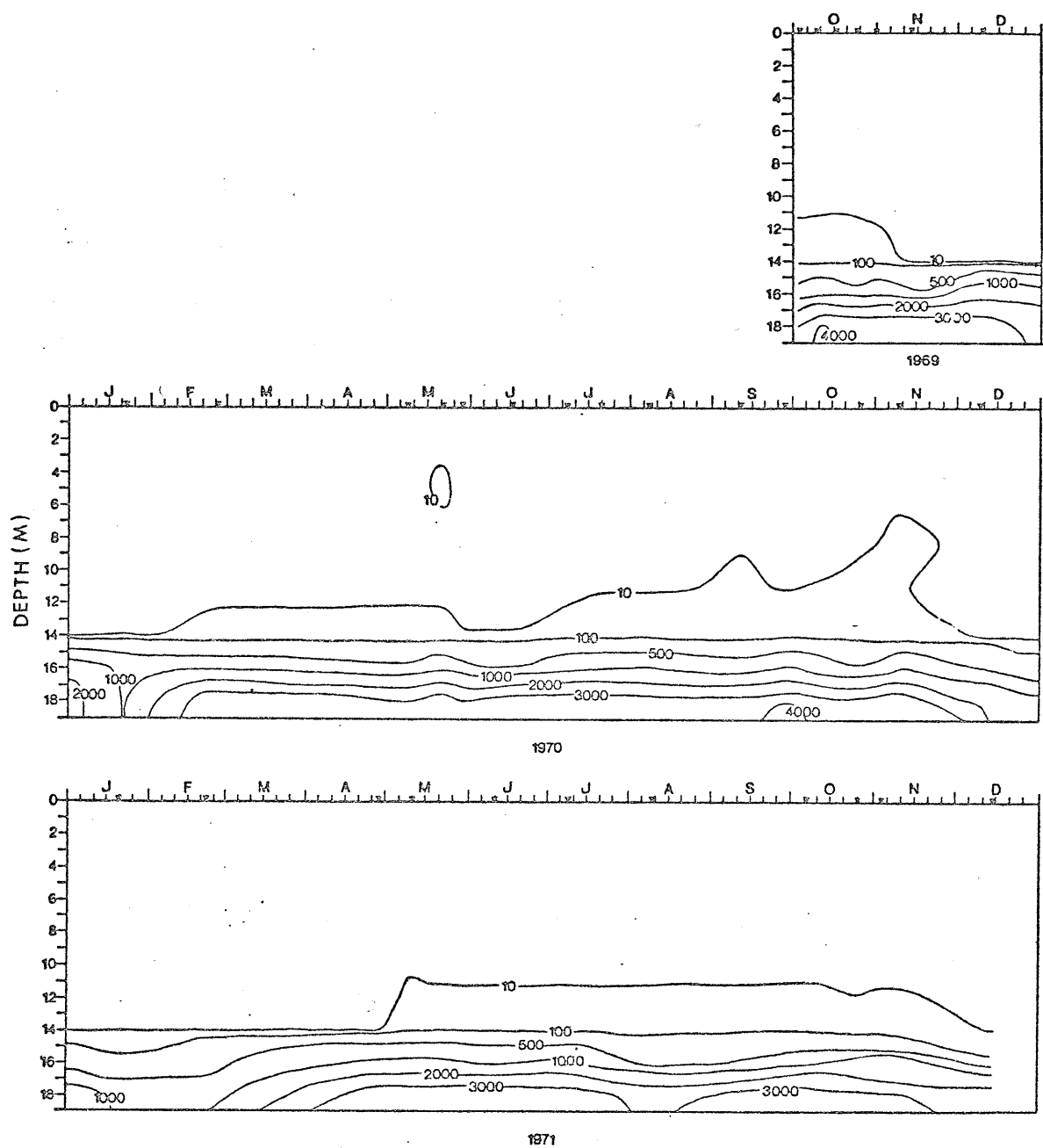


FIGURE 27. Depth-time distribution of dissolved iron (Fe) in Lake 120, 1969-1971. Isopleths are $\mu\text{moles liter}^{-1}$.

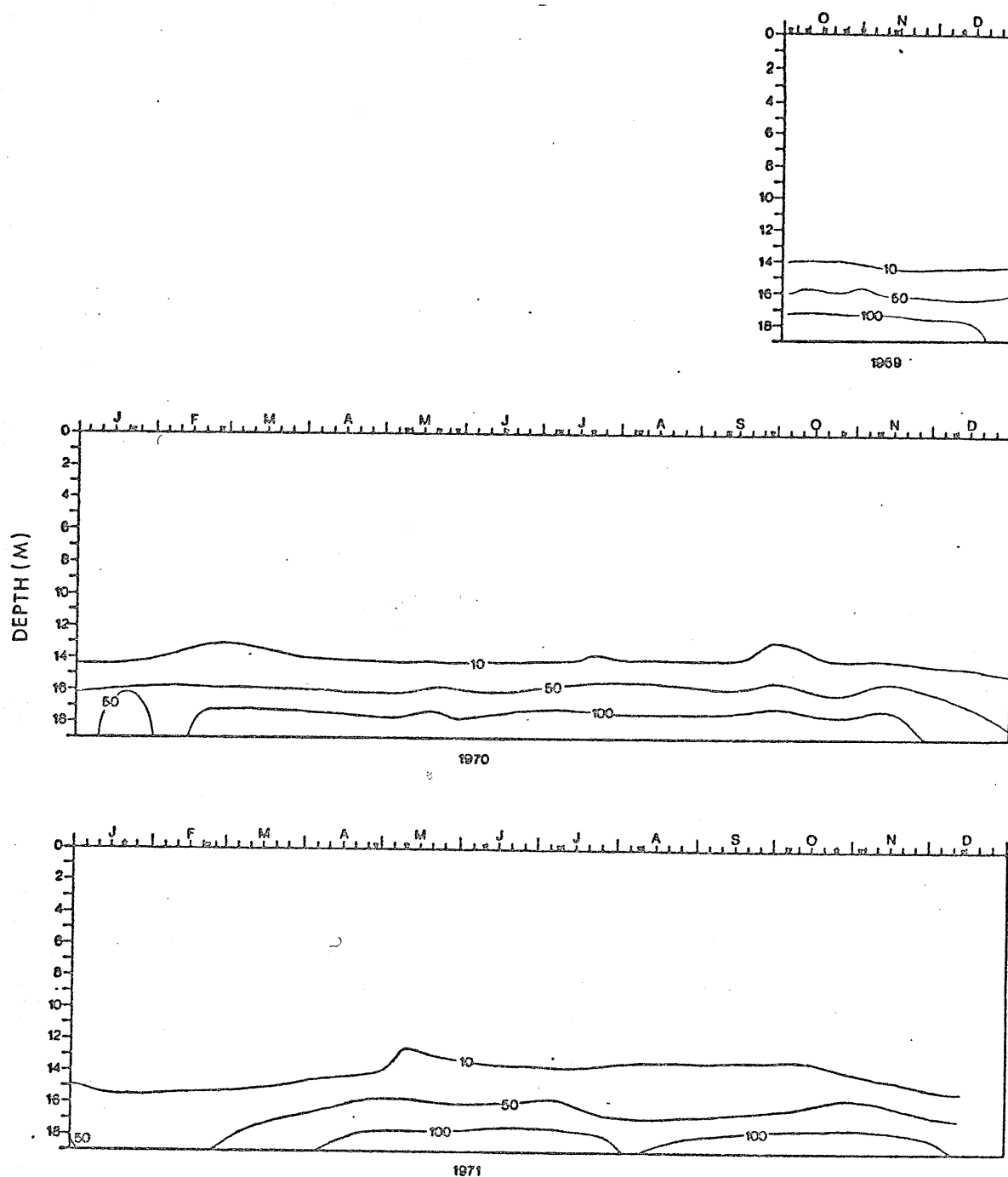


FIGURE 28. Depth-time distribution of dissolved manganese in Lake 120, 1969-1971. Isopleths are $\mu\text{moles liter}^{-1}$.

total input (total input = runoff + precipitation direct to the lake surface). From Table 5 it can be seen that computed outflows (1970-1972) are in reasonable agreement when compared with that measured directly by Water Survey of Canada during 1973. About 70% of the total input of water to the lake was by runoff from the terrestrial watershed. The remaining 30% was by precipitation direct to the lake surface. It is unlikely that in a granite basin such as that of Lake 120 that there exists subsurface inflow from adjacent watersheds. Over 80% of the water that left the lake did so *via* the outlet. Less than 20% of the total water loss was by evaporation. A minimum estimate of water renewal time ($\tau = 3.0$ to 4.8 years) was computed by dividing total annual outflow into lake volume.

Annual chemical budgets were also computed for Lake 120 by extrapolation of data from the Lake 239 watershed (Schindler *et al.*, 1976). Input of an element to Lake 120 *via* precipitation was determined by direct application, on an areal basis, of values for input *via* precipitation to the surface of Lake 239. Input *via* runoff was similarly computed by extrapolation from the Lake 239 Northwest sub-basin which best represented the characteristics of the Lake 120 watershed. Loss of an element in a year from the lake outflow was obtained by multiplying annual outflow (Table 5) by the mean concentration of the element measured in the Lake 120 outflow (annual mean concentrations were derived from the individual determinations reported in the appendix, Tables 7-23 inclusive). Lake "retention" of an element was computed by taking the difference between total input and outflow *via* the outlet.

TABLE 5. Annual water budgets for Lake 120. Precipitation, runoff and evaporation were measured on the Lake 239 watershed (Schindler *et al.*, 1976). Storage in the lake was assumed to be zero. Outflow from the lake *via* the outlet during 1970-72 was calculated by subtracting surface evaporation from total input. Residence time of water in the lake was computed by dividing lake volume by annual flow through the outlet.

		1970		1971		1972		1973		MEAN (1970-72)	
		m ³	m	m ³	m	m ³	m	m ³	m	m ³	m
Precipitation direct to lake surface		89,900	0.967	74,700	0.803	65,200	0.701			76,600	0.824
IN	Runoff	179,300	1.923	196,800	2.116	134,600	1.447			170,200	1.830
	Total	269,200	2.895	271,500	2.919	199,800	2.148			246,800	2.654
Evaporation from lake surface		45,700	0.491	37,900	0.407	52,300	0.562			45,300	0.487
OUT	Outflow through outlet	223,500	2.404	233,600	2.512	147,500	1.586	154,200*		201,500	2.167
	Total	269,200	2.895	271,500	2.919	199,800	2.148			246,800	2.654
Residence time (years)		3.1		3.0		4.8		4.6		3.5	

* Measured directly by Water Survey of Canada

Annual budgets of total (suspended + dissolved) carbon (ΣC), nitrogen (ΣN) and phosphorus (ΣP) and dissolved calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe) and silicon (Si) are reported in Table 6. Usually, over 90% of the total carbon as well as the dissolved Ca, Mg, Na, K, Fe and Si entering the lake were supplied by runoff. In contrast, slightly more than half of total nitrogen and phosphorus was supplied by precipitation direct to the lake surface. "Retention" (input - output) by the lake was 50-60% for total carbon, nitrogen and phosphorus and dissolved silicon (lake "retention", especially of carbon, nitrogen and phosphorus, is elaborated upon in the discussion). The removal of dissolved Ca, Mg, Na, K and Fe *via* the outflow was about equal to their input to the lake *via* precipitation and runoff (also see discussion).

Sedimentation

A comparison of the elemental composition of the sediment collected in sediment traps from 1970-73 with surface (0-20 cm) bottom sediment analyzed by Brunskill *et al.* (1971) is presented in Table 7. It can readily be seen that the elemental compositions were very similar. Approximately 95% of the weight of the fresh unaltered sediment was water. About 50% of the weight of freeze-dried sediment was lost upon ignition which is an estimate of sediment organic matter. Net (over a period of slightly more than 3 years) sedimentation rates (grams meter⁻² year⁻¹) of freeze-dried sediment as well as rates for individual elements (moles meter⁻² year⁻¹) are also presented in Table 7. It was obvious when

TABLE 6. Estimated annual budgets of total (suspended + dissolved) carbon (ΣC), nitrogen (ΣN) and phosphorus (ΣP) and dissolved calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe) and silicon (Si) for Lake 120, 1970, 1971 and 1972.

Element	Year	INPUT TO LAKE (moles x 10 ³)			OUTFLOW VIA OUTLET		COMPUTED RETENTION ((A) - (5))	
		Precip'n ⁽¹⁾	Runoff ⁽³⁾	Total ^(A)	Total ⁽⁵⁾ (moles x 10 ³)	% of Input	Total (moles x 10 ³)	% of Input
ΣC	1971	34.16	387.5	421.7	256.5	61	165.2	39
	1972	20.60	234.1	254.7	82.01	32	172.7	68
	Mean	27.38	310.8	338.2	169.3	50	168.9	50
ΣN	1971	4.86	5.88	10.74	6.38	59	4.36	41
	1972	4.77	3.04	7.81	2.98	38	4.83	62
	Mean	4.82	4.46	9.28	4.68	50	4.60	50
ΣP	1971	0.158	0.140	0.298	0.158	53	0.140	47
	1972	0.073	0.049	0.122	0.047	39	0.075	61
	Mean	0.116	0.095	0.211	0.103	49	0.108	51
Ca	1970	1.21	6.09	7.30	9.77	134	-2.47	-34
	1971	0.768	10.39	11.15	10.58	95	0.57	5
	1972	0.651	4.51	5.16	6.20	120	-1.04	-20
	Mean	0.876	7.00	7.88	8.85	112	-0.97	-12
Mg	1970	0.344	5.34	5.68	5.54	98	0.14	2
	1971	0.387	7.09	7.48	5.79	77	1.69	23
	1972	0.337	3.33	3.67	2.99	81	0.68	19
	Mean	0.356	5.25	5.61	4.77	85	0.84	15
Na	1970	0.847	8.03	8.88	6.66	75	2.22	25
	1971	0.741	10.75	11.49	7.31	64	4.18	36
	1972	0.363	4.48	4.84	4.31	89	0.53	11
	Mean	0.650	7.75	8.40	6.09	73	2.31	27
K	1970	0.383	1.03	1.41	1.40	99	0.01	1
	1971	0.236	1.77	2.01	1.42	71	0.59	29
	1972	0.160	0.787	0.947	0.826	87	0.121	13
	Mean	0.260	1.20	1.46	1.22	84	0.24	16
Fe	1972	-	0.643	0.643	0.590	92	0.053	8
Si	1970	0.062	23.72	23.78	11.53	48	12.25	52
	1971	1.26	34.03	35.29	12.36	35	22.93	65
	1972	0.074	16.71	16.78	7.35	44	9.43	56
	Mean	0.465	24.82	25.29	10.41	41	14.88	59

TABLE 7. Comparison of Lake 120 bottom sediment (from Brunskill *et al.*, 1971) with material collected in sediment traps during 1970-73 and estimates of annual net sedimentation rates in the south basin. All concentrations are per gram of dried sediment. Sedimentation rates are for freeze dried sediment. The sedimentation rate of material collected in the traps and freeze dried was computed to be 13.3 grams per meter² lake surface per year or 91.3 grams per meter² chemocline area per year.

	BOTTOM SEDIMENT (0-20 cm)	SEDIMENT COLLECTED IN TRAPS	SEDIMENTATION RATE PER METER ² PER YEAR	
			Chemocline (A ₁₄)	Surface (A ₀)
Water content (% of fresh unaltered sediment)	94.5	95		
Ashed weight (% of dry weight)	57.9	48.0		
Chlorophyll <u>a</u> plus phaeopigments (µg)	15.6	10.8	986	144
C (mMoles)	16.83	21.04	1920	280
CO ₃ -C (mMoles)	-	0.88	80.3	11.7
N (mMoles)	1.29	1.66	152	22.1
P (mMoles)	0.07	0.07	6.39	0.93
Ca (mMoles)	0.12	0.04	3.65	0.53
Mg (mMoles)	0.07	-	-	-
Na (mMoles)	0.12	-	-	-
K (mMoles)	0.08	0.08	7.30	1.06
Fe (mMoles)	0.51	0.96	87.6	12.8
Mn (mMoles)	0.01	0.03	2.74	0.40
Si (mMoles)	7.47	6.99	638	93.0
Al (mMoles)	1.54	1.58	144	21.0
Ti (mMoles)	0.03	0.02	1.83	0.27

comparing concentrations of suspended C, N and P in the 14-19 meter stratum with concentrations in the 0-14 meter stratum (Table 3) that sediment was, in effect, being concentrated by funneling into the smaller volume of the deep anaerobic waters. As a result, if the amounts of sediment collected in the traps were applied directly to the lake surface area, great overestimates of sedimentation rates would be obtained. If the amount of P collected in the traps was applied directly to A_0 to compute a total annual sedimentation rate of P to the lake bottom this value would be 5.5 times the retention (input-output) computed in Table 6. The assumption was then made that sediment collected in the traps actually estimated the sedimentation rate at depth 14 meters and the lake surface area under which this sediment must have been derived to give a 5.5 times overestimate for P was then computed. The lake surface area so computed was $44,275 \text{ m}^2$ which is reasonably close to the $55,000 \text{ m}^2$ lake surface area of the south basin (if the northern limit of the south basin is taken to be a transect between Shore Stations 6 and 18, Figure 4). So, it seems that essentially all of the autochthonous and allochthonous sediments deposited in the south basin were funneled into the bottom waters and sediments below a depth of 14 meters; sedimentation rates per square meter lake surface area have been computed on that basis. Phosphorus was chosen in computing a lake surface sedimentation correction factor because it was the only element for which budgets were determined in total (suspended plus dissolved) and for which it could positively be

said that no gaseous flux would occur at the surface of the lake (as is not the case for carbon and nitrogen). That is, the agreement between "retention" computed in Table 6 and measured sedimentation should be better for phosphorus than for any of the other elements studied here. The average net annual sedimentation rate of freeze-dried sediment was computed to be $13.3 \text{ grams meter}^2 \text{ A}_0 \text{ year}^{-1}$ or $91.3 \text{ g m}^{-2} \text{ A}_{14} \text{ yr}^{-1}$. The net sedimentation rates of specific elements are given in Table 7.

Phytoplankton and Primary Productivity

Concentrations of chlorophyll ranged from less than 1 to $22 \mu\text{g liter}^{-1}$ (Table 25, appendix). In midwinter, concentrations of chlorophyll in the 0-14 meter stratum were less than $1 \mu\text{g liter}^{-1}$. However, in the 14-19 meter stratum, levels rarely dropped below $3 \mu\text{g liter}^{-1}$. Concentrations of chlorophyll in the bottom waters increased during the summer to $5\text{-}10 \mu\text{g liter}^{-1}$. Higher chlorophyll concentrations (up to $20 \mu\text{g liter}^{-1}$) were usually recorded in the region just below the thermocline in July and August (Figure 29).

Individual determinations of the biomass of live phytoplankton (wet weight) are presented in Table 26 of the appendix. Average biomass of phytoplankton in the 0-14 meter water column on any given sampling date is given in Figure 30 and Table 26 of the appendix. Average phytoplankton biomass was at a minimum (250 mg m^{-3}) in mid winter when depth profile maxima were located between 0 and 3 meters (Figure 31). Chrysophyta* accounted for at least 80% of the total biomass (Figure 30). From 0-11 meters depth *Botryococcus braunii* was the major contributor to algal

* In this study, Chrysophyta includes only the Xanthophyceae and Chrysophyceae. The Diatomeae have been treated separately.

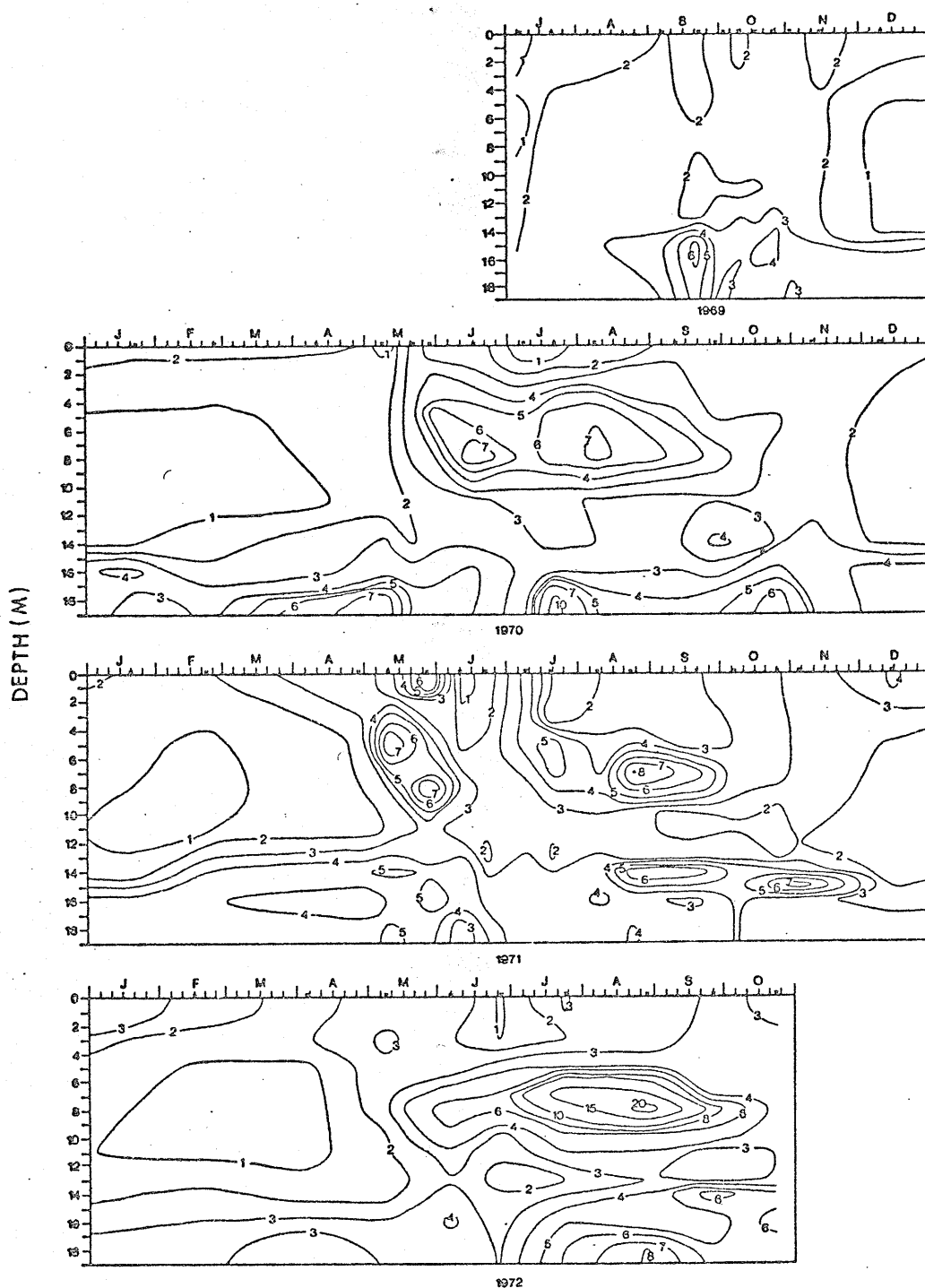


FIGURE 29. Depth-time distribution of chlorophyll *a* plus phaeophytin in Lake 120, 1969-1972. Isopleths are $\mu\text{g liter}^{-1}$.

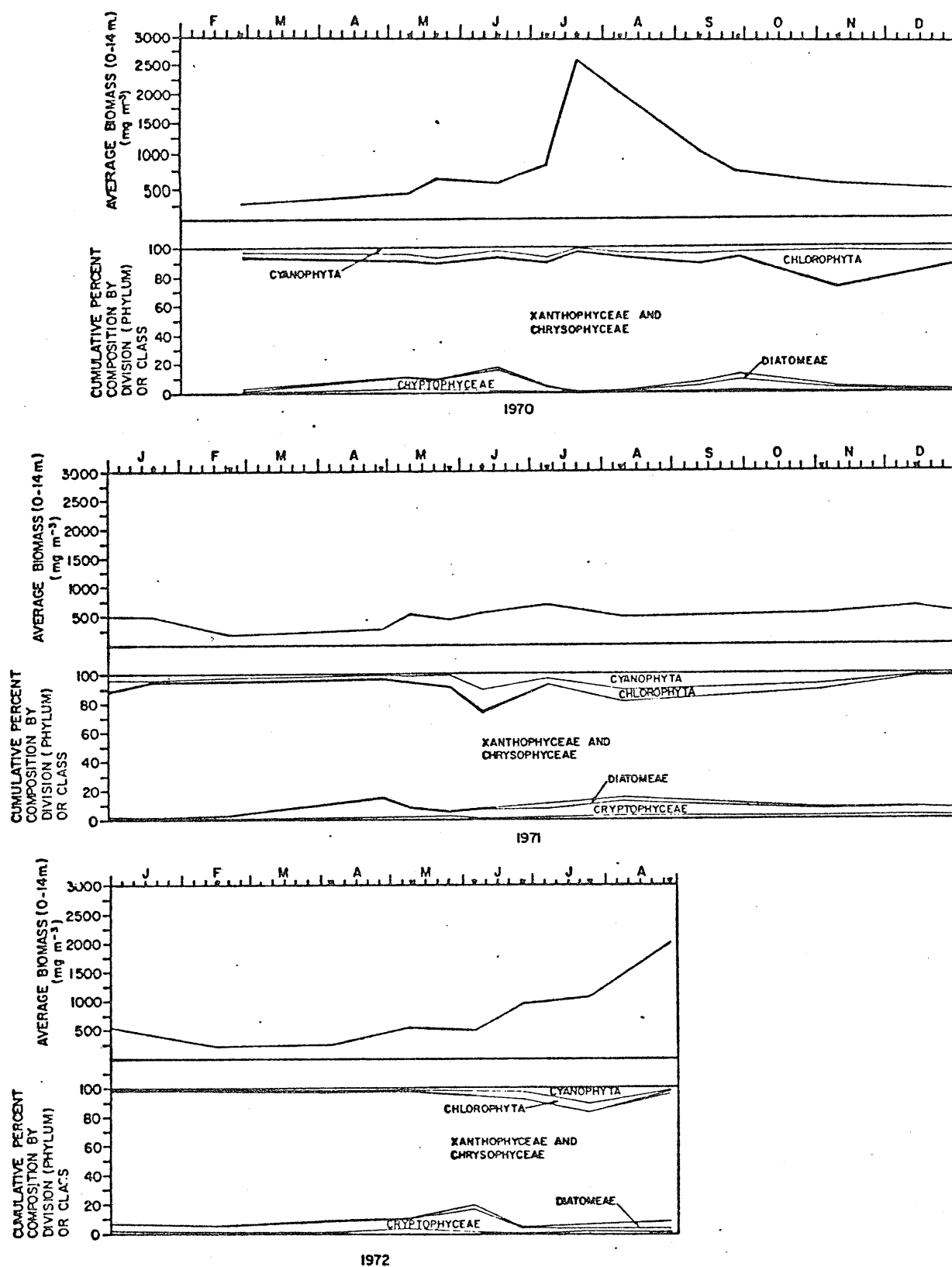


FIGURE 30. Temporal variation of the average biomass (wet weight) and the composition of the phytoplankton in Lake 120, 1970-1972.

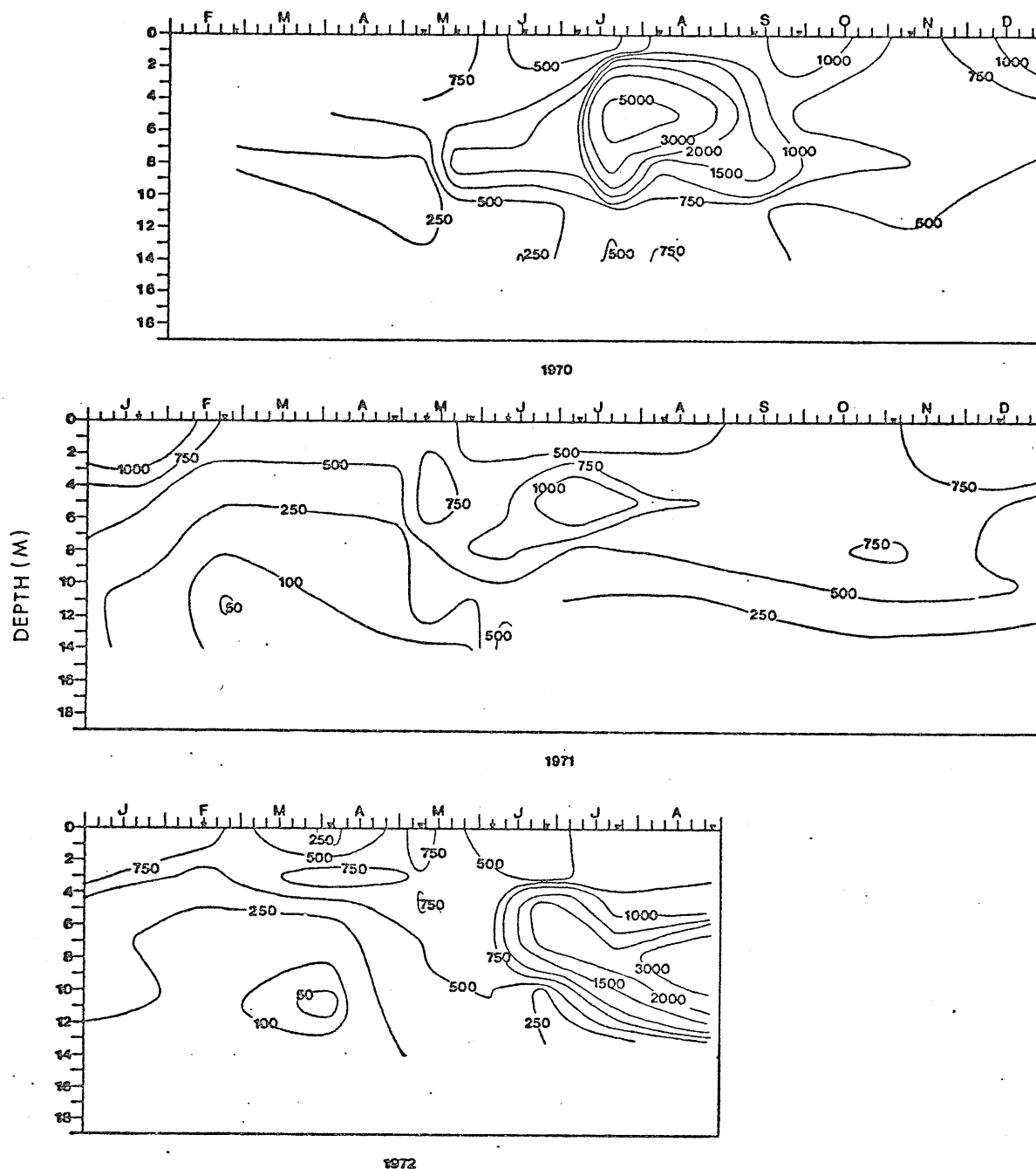


FIGURE 31. Depth-time distribution of live phytoplankton biomass in Lake 120, 1970-1972. Isopleths are mg m^{-3} (wet weight).

biomass. At 14 meters, however, the Chrysophyta were not usually dominant. Rather, small blue-greens or the Cryptophyceae (usually *Cryptomonas playturis* or *Cryptomonas obovata*) were dominant. Immediately after the ice cover melted, average biomass rose to $500-600 \text{ mg m}^{-3}$. During this time a short-lived pulse was observed for the Cryptophyceae; that is there was a rise in the total biomass such that they constituted up to about 15% of the total algal population (Figure 30). However, in terms of the depth profile there was no change from winter in the location of dominant groups. The Cryptophyceae (and usually small blue-greens) accounted for a major portion of the biomass at 14 meters only. At depths above 14 meters *Botryococcus braunii* and, irregularly, *Dinobryon* species were the major fraction. During late May and early June the average biomass remained constant or declined slightly. Similarly, little change was observed in the composition of the population. By mid to late June, however, the standing crop began to increase rapidly, attaining a maximum level of greater than $2,000 \text{ mg m}^{-3}$ in July or August. During this rise in biomass, a small pulse was observed for both the Cyanophyta and Chlorophyta (each of these divisions constituted up to 5% of the total biomass at this time). These pulses were due to the predominance of *Ankistrodesmus* species at a depth of 1 meter and a predominance of small blue-greens at 14 meters. It should be noted, however, that the biomass at these depths remained relatively constant or even decreased (Figure 31). The rapid increase in biomass was attributable to a buildup of standing crop just below the thermocline at depths of 5-8 meters. *Chrysosphaerella* colonies were the main contributors of biomass in this

stratum; secondary contributors were *Botryococcus braunii*, *Dinobryon* species and *Mallomonas* species. It should be noted that during the summer of 1971 the peak biomass attained was just under 700 mg m^{-3} (Figure 31). Unlike the summers of 1970 and 1972, *Chrysosphaerella* species were not abundant. Rather, only *Botryococcus braunii* was predominant in the 5-8 meter stratum. Following peak biomass in July and August, a gradual decline was observed throughout late summer and early fall. The Cyanophyta and Chlorophyta each usually constituted up to 5% of the total biomass during that time of the year and a second weak pulse in the Cryptophyceae was observed in August or September. This second pulse was due to the presence of *Cryptomonas* species at depths of 11-14 meters, although small blue-greens were also present in large numbers. The exceptional pulse in Chlorophyta (about 25% of total biomass) observed only in November of 1970 was the result of a prevalence of *Oocystis* species from 8-14 meters. As a rule, *Botryococcus braunii* was prominent throughout the water column by the time of fall turnover although small blue-greens were sometimes of secondary importance at 14 meters depth. Average biomass by this time had declined to about 500 or 600 mg m^{-3} (Figure 30). Maximum biomass in the water column was centered at 8 meters depth (Figure 31). It was not until after ice cover had been established that maximum biomass relocated immediately below the surface.

Vertical profiles of primary productivity in Lake 120 were always dichotomous (Figure 32a and 32b). Peak autotrophic net uptake of carbon by phytoplankton was usually observed at 1 or 3 meters and at 10 or 13 meters. Maximum productivity occurred during spring ($354 \text{ mg C m}^{-2} \text{ day}^{-1}$ on June 21, 1971 and $240 \text{ mg C m}^{-2} \text{ day}^{-1}$ on June 5, 1972). Minimum

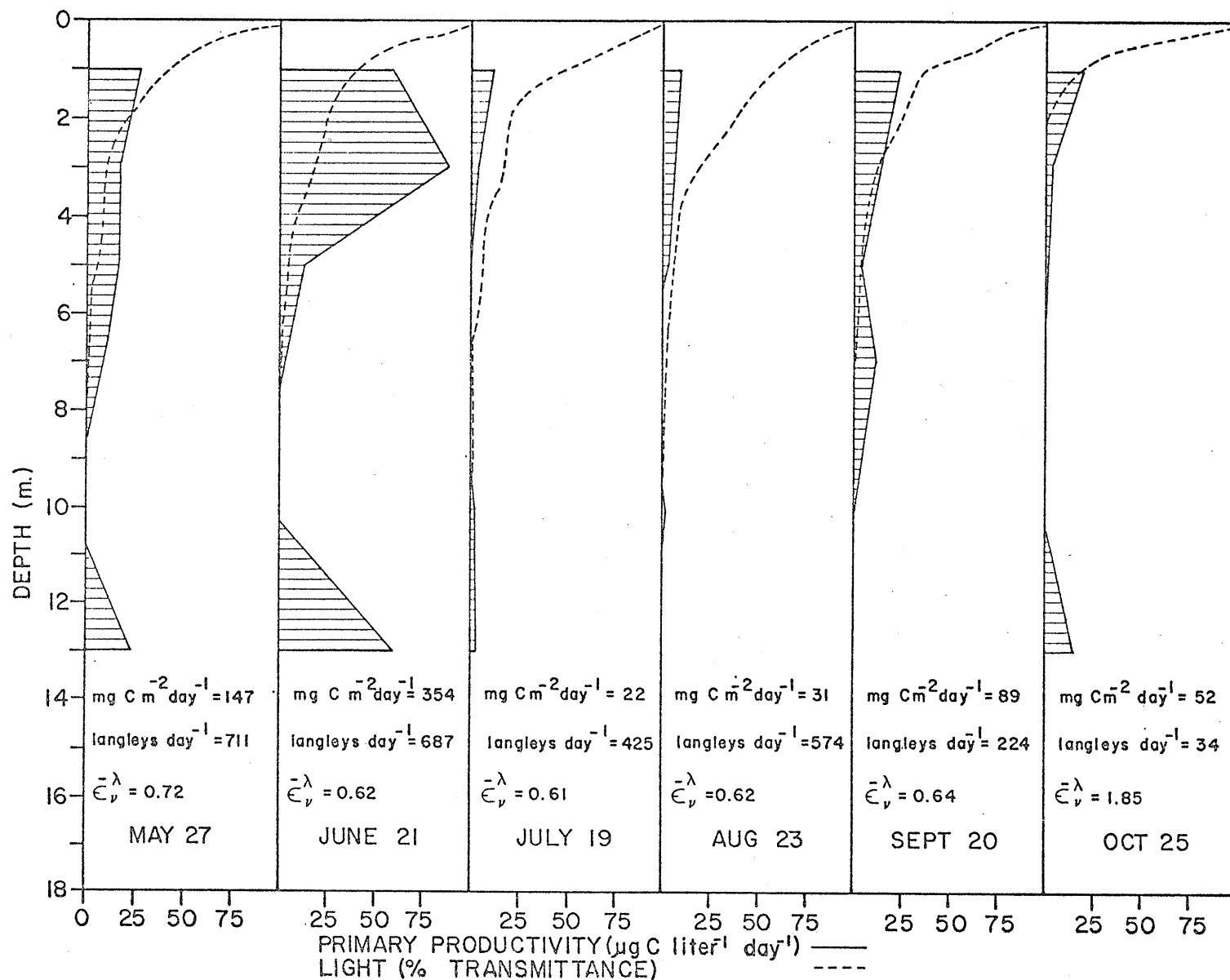


FIGURE 32a. Depth profiles of daily net productivity of phytoplankton and % transmittance of light in Lake 120 during 1971.

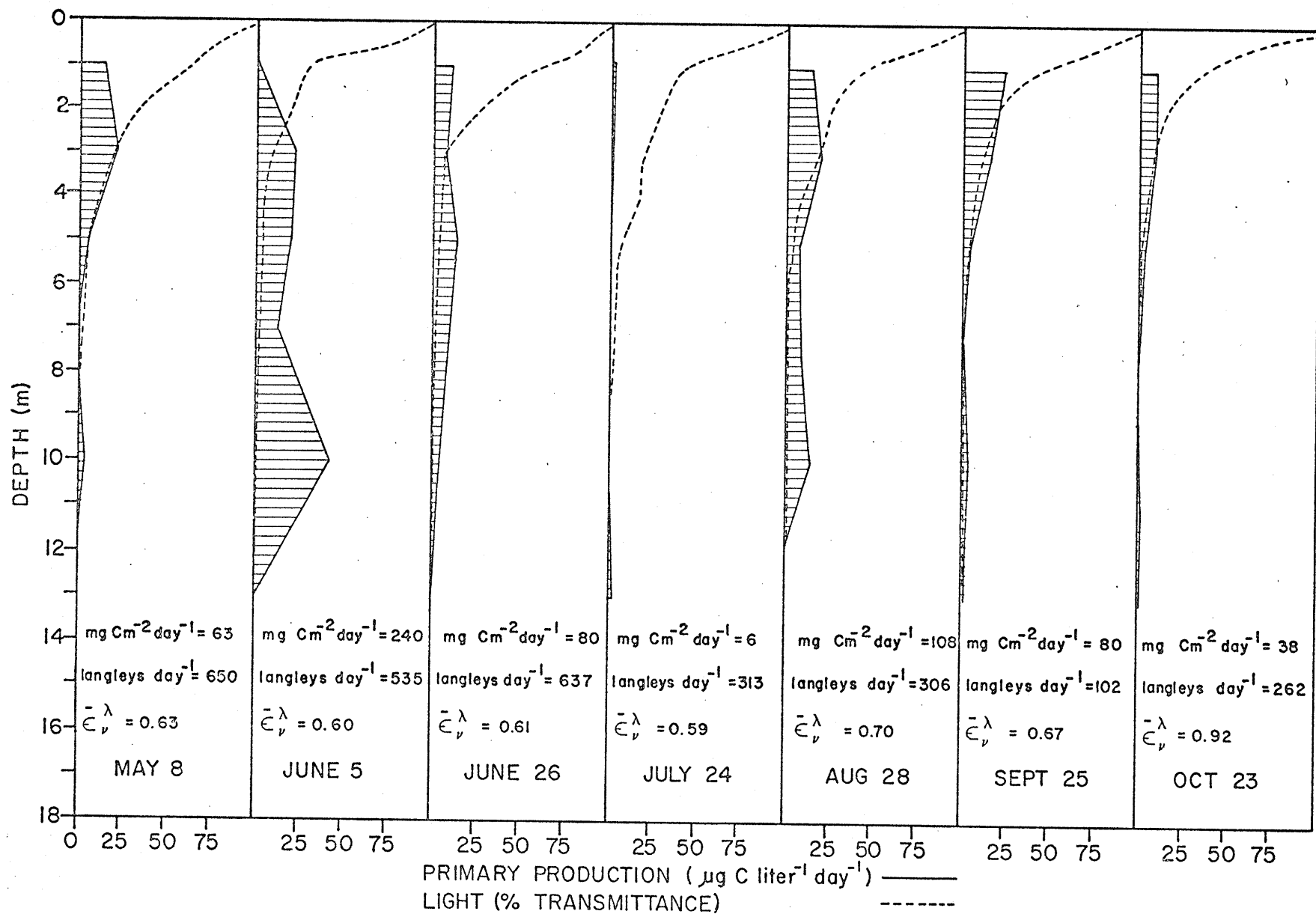


FIGURE 32b. Depth profiles of daily net productivity of phytoplankton and % transmittance of light in Lake 120 during 1972.

productivity occurred during the summer stagnation ($29 \text{ mg C m}^{-2} \text{ day}^{-1}$ on July 19, 1971 and $6 \text{ mg C m}^{-2} \text{ day}^{-1}$ on July 24, 1972). Although no ^{14}C experiments were carried out in winter on Lake 120, Schindler (1972) estimated that in the ELA 16% of annual phytoplankton production occurred during the six months when ice covered the lakes. This estimate was used in computing annual production in Lake 120 to be 25.0 and 18.9 g C m^{-2} in 1971 and 1972, respectively. Milligrams of carbon fixed per meter³ per day at specific depths as well as daily averages for the 1-13 meter water column are reported in Table 27 of the appendix.

DISCUSSION

Lake 120 is meromictic after the definition of Hutchinson (1957). The depth of the chemocline in Lake 120 is variable but on an average rests at 14 meters. The monimolimnion (14-19 meters) constitutes less than 3% of the total lake volume. Lake Valkiajarvi in Finland (Merilainen, 1970) is, especially in terms of morphometry and physical and chemical properties, remarkably similar to Lake 120. Like Lake 120, the monimolimnion of Lake Valkiajarvi constitutes a very small proportion (6.5%) of the total volume. Kjensmo (1967 and 1968) also described "iron meromictic" soft water Lakes Skjennungen, Store Aaklungen and Svinsjoen near Oslo, Norway.

For approximately 150 days of the year, Lake 120 is completely protected from wind by the ice cover. During the open-water season the lake is sheltered from the full force of the winds by the high, steep slopes surrounding it (Figure 3). Further, the morphology and orientation of the basin is such that at lake surface level winds often blow from different directions simultaneously and effectively work against each other. Partial circulation does, however, take place in Lake 120. In spring, solar insolation is high when the ice cover disappears. As a result, within a few days thermal stratification is established and circulation has in the meantime only been accomplished to a depth of about 14 meters. In fall, circulation is of somewhat longer duration and mixing occurs to a depth of 16 meters. Once fall homothermy is established in the mixolimnion, the water temperature is

usually close to 4°C and shortly thereafter the winter ice cover is established which severely reduces further mixing.

The winter heat budget, H_{bw} (Table 1) is considerably lower than those reported by Schindler (1971) for ten other ELA lakes. This may also be a reflection of the protection of the lake surface from wind. Ice accounted for the major portion of winter heat incomes. During most of the winter a good insulative layer of snow covered the ice which was not greatly disturbed by wind. As a result, ice thickness on Lake 120 never exceeded 30-40 cm whereas Schindler (1971) reported maximum ice thickness from 0.5 to 1.0 meters for other ELA lakes. Summer heat budgets, on the other hand, were only lower than those for 2 of the 10 above-mentioned ELA lakes. Lake 120 proved to be more efficient (in terms of Birgean wind work) than all but one other shallow ELA lake in distributing its relatively high summer heat income. A very high H/B for Lake 120 was at first puzzling but was likely due to radiant heating of shallow waters. Vallentyne (in Schindler, 1971) suggested that part of the work attributed to wind in the Birgean calculation may actually be performed by inverse density currents induced by radiative warming of water in contact with the lake bottom in littoral regions. Lake 120 has a larger littoral region ($D_L = 1.97$) in relation to its profundal zone than all of the other ELA lakes ($D_L = 1.04$ to 1.78) considered by Schindler which may account for the more efficient heating observed in Lake 120. Summer heat incomes of Lake 120 were higher than those reported by Kjensmo (1967) for meromictic Lakes Skjennungen and Store Aaklungen and by Merilainen (1970) for Lake Valkaijarvi. Since

$D_L = 2.15$ for Lake Store Aaklungen is higher even than that of Lake 120, it is supposed that smaller heat incomes for these European lakes is a result of their being situated at 10-12° higher latitude and in a maritime climate.

The very small heat budget calculated for the monimolimnion (Table 1) was of no consequence when compared with that of the mixolimnion. However other observations were interesting. Geothermal heating ($38.7 \text{ cal cm}^{-2} \text{ yr}^{-1}$; from Hutchinson, 1957) would account for only 7-18% of the annual heat income of the monimolimnion. It is also unlikely that exothermal heating from microbial degradation of detritus was in any way a major contributor (Hutchinson, 1957). Maximum heat content of the monimolimnion usually occurred in October and was probably attributable to a limited introduction of warmer water from above the chemocline during fall circulation. That the annual heat income of the monimolimnion was usually distributed more efficiently than that of the mixolimnion (Table 2) is difficult to explain.

Summer cooling events such as that observed repeatedly in the monimolimnion of Lake 120 during June have also been reported by Kjensmo (1967) and Merilainen (1970) who attributed such cooling to seepage of groundwater into the monimolimnion. However, neither investigator cited any direct evidence to substantiate such an influx. On July 30, 1973, a depth profile of water age was estimated for Lake 120 based on He^3 , He^4 , and T determinations (Torgersen *et al.* 1974). They found that the monimolimnetic waters, especially at 17 meters, were "years old" in comparison to relatively young water in the mixolimnion. However, it was also discovered that

the water at 15 meters depth was younger than water above and below this depth (sampling depths in the monimolimnion were 14, 15 and 17 meters). Torgersen *et al.* (1974) concluded that 15 meter water was a mixture of old monimolimnetic water and young groundwater, and further suggested that the groundwater flowing in at 15 meters was from local spring runoff, halting once the spring rains and snow were depleted. The cooling phenomenon observed in the monimolimnion of Lake 120 during spring and early summer might then be the result of an injection of snowmelt groundwater.

Analyses of groundwater in the Northwest sub-basin of ELA Lake 239 (Cherry and Schindler, unpublished data) showed that concentrations of Si, Mg, and Na were 2 to 7 times greater than concentrations normally found in the depth interval of 14-16 meters in Lake 120. Groundwater in the Lake 120 basin is probably chemically similar to that of the Northwest sub-basin. Torgersen *et al.* (1974) estimated the water at 15 meters was 95% 2-month old groundwater. If significant influx of groundwater occurs during spring, it might be expected that noticeable increases of these elements would be observed at the depths concerned. From Table 8 it can be seen that at a depth of 16 meters average concentrations of Si, Mg and Na did rise slightly during the time of the monimolimnetic cooling. No such increase was observed at 14 meters. What should be drawn from Table 8, however, is that waters from 14-16 meters were chemically similar to surface runoff in the Northwest sub-basin of Lake 239. At no time did concentrations of these conservative elements from 14-16 meters approach those found in Lake 239 groundwater.

TABLE 8. Average concentrations of dissolved silicon (Si), magnesium (Mg) and sodium (Na) in groundwater and runoff water of the Northwest subbasin of the Lake 239 watershed and concentrations of Si, Mg and Na observed in Lake 120 at 14 and 16 meters immediately prior to and during spring cooling of the monimolimnion. Units of concentration are $\mu\text{moles liter}^{-1}$.

	GROUNDWATER	RUNOFF	MONIMOLIMNION LAKE 120			
	NORTHWEST SUBBASIN	NORTHWEST SUBBASIN	PRE-COOLING, MAY 1-15		COOLING, MAY 15-JULY 15	
			14 meters	16 meters	14 meters	16 meters
Si	388	146	82	125	81	165
Mg	125	28	27	33	27	37
Na	213	49	31	35	33	39

From this line of evidence it does not seem likely that monimolimnetic cooling during June and July was greatly affected by groundwater.

Rather, I suggest that in spring, after peak runoff from snow-melt has passed, a residual mass of cool (about 4°C) melt water remains in the bog at the south end of the lake. If such a residual of cold melt water does exist and is slowly displaced by warmer runoff from spring rains, it could slide down the side of the basin through the warmer and less dense surface waters and finally come to rest at a depth below which the monimolimnetic waters are of greater density. Temperature variation between 14 and 19 meters is never more than a few tenths of a degree (Figure 6). As a result, there is little density difference in the monimolimnion due to temperature. However, from Figure 33 it can be seen that higher concentrations of chemical constituents result in a very sharp increase in density at depths below 14 meters. It is entirely possible then that a "lens" of runoff water at a temperature of about 4°C and chemical composition similar to that of the region of the chemocline would be prevented from descending to depths much greater than 15 meters. From Figure 6 it can be seen that the "center" of cooling in the monimolimnion ranged from 14-16 meters in the years 1970-1972.

In order to estimate the demand by a lake for a particular chemical species, a number of input and output components must be considered. Those considered for the Lake 120 system are illustrated in Figure 34. Input of an element to the water column may be by

- ① precipitation (including dry fallout) direct to the lake surface;

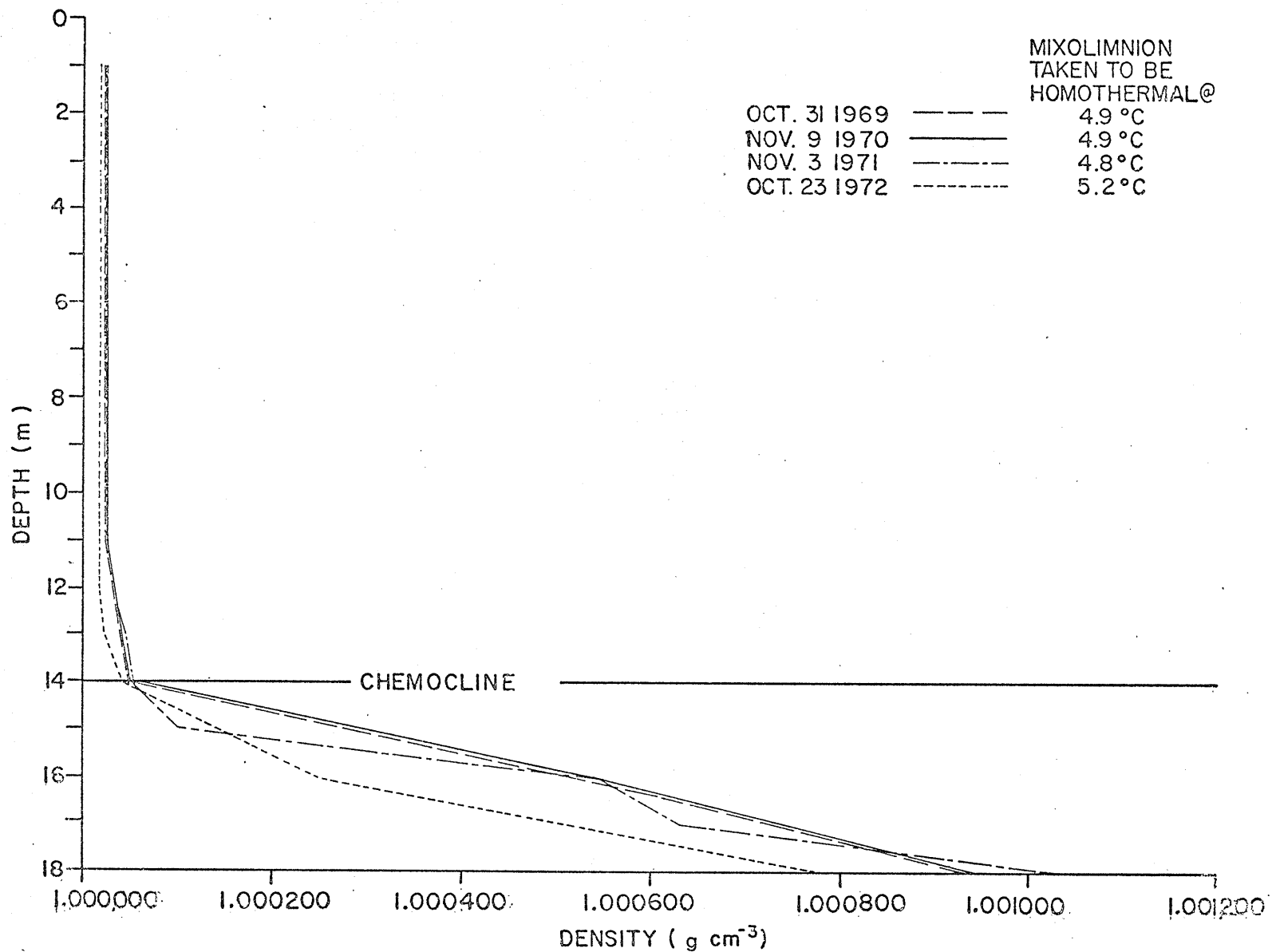


FIGURE 33. Variation of water density with depth in Lake 120 at times during fall circulation when the mixolimnion was homothermal at the temperature of the chemocline.

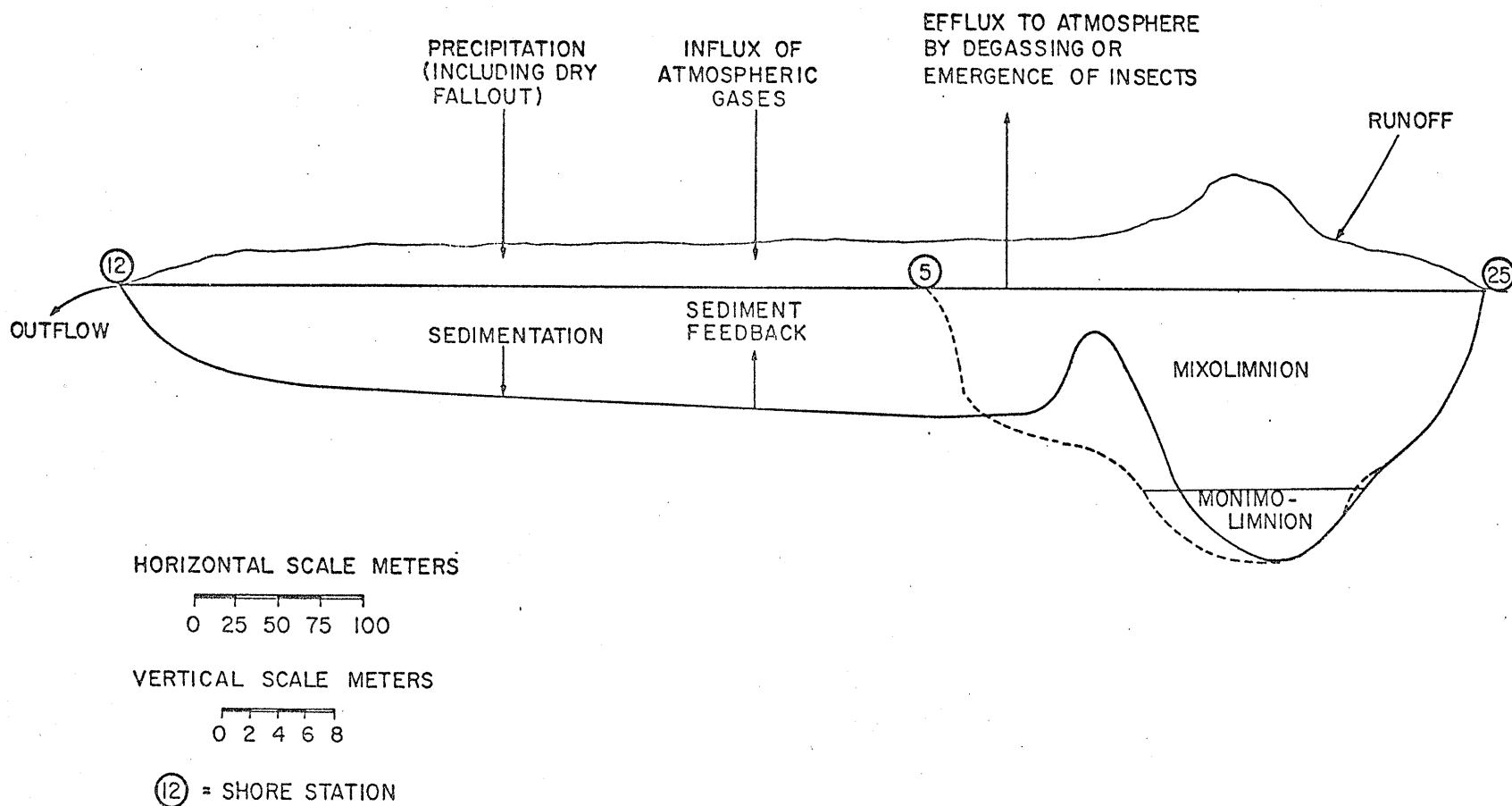


FIGURE 34. Longitudinal sections of Lake 120 and inflow-outflow components considered in the estimation of annual chemical budgets.

- ② invasion of atmospheric gases at the surface;
- ③ runoff from the terrestrial portion of the watershed;
- ④ feedback from the bottom sediments.

Removal of an element from the lake waters may be by

- ⑤ outflow;
- ⑥ sedimentation to the lake bottom;
- ⑦ degassing or emergence of insects into the atmosphere.

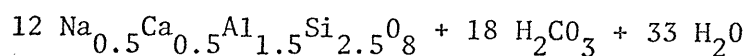
In this study, components ①, ③ and ⑤ were estimated (Table 6). Net sedimentation over a short term (⑥ - ④) was also measured (Table 7). Neither component ② or component ⑦ was measured but their difference can be estimated. That is flux of an element at the lake surface (exclusive of input *via* precipitation and dry fallout). can be had from the following relation:

$$(① + ③) - (⑤ + ⑥ - ④) = (② - ⑦).$$

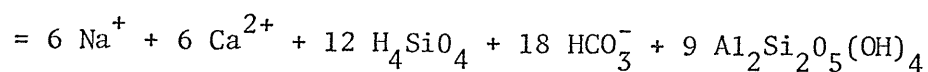
If for a particular element (② - ⑦) is negligible, then computed "retention" (① + ③ - ⑤) presented in Table 6 would theoretically be equal to net sedimentation (⑥ - ④) presented in Table 7.

In this study, cations were determined only in the dissolved phase. Although reasonable assumptions can be made as to the role of particulate matter in some of the components outlined above, interpretation of the cation data presented in Tables 6 and 7 is, nevertheless, restricted. Runoff (as opposed to precipitation direct to the lake surface) accounted for 90-98% of the input of dissolved Ca, Mg, Na and Si to the lake

(Table 6); 82% of the input of K was from runoff. A large contribution of the above-mentioned cations by runoff was not unexpected since they are weathering products of the least stable and major minerals (plagioclase and biotite) in soils and bedrock of ELA. After Stumm and Morgan (1970).

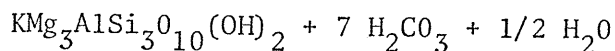


plagioclase (andesine)

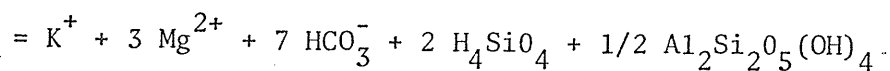


kaolinite

and



biotite



kaolinite.

The above representation of chemical weathering in the ELA is undoubtedly an over simplification of a more complex process (see Brunskill *et al.*, 1971). However, the resulting molar ratios of Si, Ca, Mg and Na to K would be 14, 6, 3, 6:1 which compares well with ratios found in groundwater of the Northwest sub-basin of Lake 239. Ratios of Si, Ca, Mg and Na to K in Northwest sub-basin groundwater are 12.5, 6.1, 4.6, 7.9:1 (Cherry and Schindler, unpublished data). The fact that the proportion of K entering the lake *via* runoff is somewhat smaller than for other

major cations may reflect a potassium uptake by biota of the terrestrial portion of the watershed (Schindler *et al.*, 1976). Such K requirements are apparently a common occurrence in the Canadian Shield. Particulate Si, Ca, Mg, Na and K in runoff has not to date been reported for ELA. However, in proportion to the dissolved phase, particulate input to the lake *via* runoff is likely small. Bormann *et al.*, (1969) found for those elements that 81-98% of their transport in streams in the Hubbard Brook Experimental Forest was in the dissolved phase. On the other hand, they found that 98% of the iron transported was particulate. In the ELA much of the iron in runoff water is likely associated with dissolved, colloidal or particulate humic matter. The relative proportions are at this time unknown.

It is also likely that most of the Ca, Mg, Na, K and perhaps Si in Lake 120 outflow waters is dissolved and that the flux through A_0 (② - ⑦) is negligible. It might be expected that element "retention" computed in Table 6 should agree reasonably well with net annual sedimentation (Table 7). Such a comparison is presented in Table 9. With the exception of Ca and Fe, the agreement between "retention" and sedimentation is satisfactory. Sedimentation of Fe into sediment traps was 24 times the computed retention, and 1.8 times the total input to the lake (Table 9) suggesting that a significant and large fraction of the Fe in inflow waters was not accounted for. Such iron may be sorbed to or may be an integral part of particulate matter entering the lake. It would also seem that a significant (though probably not large) fraction of the calcium in runoff was particulate since net sedimentation was 20

TABLE 9. A comparison of computed annual "retention" (outflow-inflow) and average annual net sedimentation of Ca, Mg, Na, K, Fe and Si in Lake 120. Determinations of cations in outflow and inflow waters were carried out only on filtered samples.

	(moles $\times 10^3$ year ⁻¹)		
	AVERAGE ANNUAL "RETENTION" IN 1971 AND 1972 (FROM TABLE 6)	AVERAGE ANNUAL NET SEDIMENTATION 1970-1973 (FROM TABLE 7)	SEDIMENTATION MINUS RETENTION AS % OF TOTAL * INPUT TO LAKE
Ca	-0.97	0.05	13
Mg	0.84	-	-
Na	2.31	-	-
K	0.24	0.10	-10
Fe	0.05	1.19	177
Si	14.88	8.66	-25

* If outflow of cations from Lake 120 via particulate matter is taken to be insignificant, then the percentage presented here could be construed as a very rough estimate of the magnitude of particulate input compared to dissolved input.

$$\text{i.e. } \frac{\text{particulate input}}{\text{dissolved input}} \times 100$$

times computed "retention" (Table 9). Kjensmo (1967) reported that Ohle (1934) showed that 'coniferous humic matter' adsorbed calcium. Although the particulate input may be small compared to the dissolved fraction, exclusion of the particulate fraction might lead to erroneous conclusions concerning "retention" in the lake. In the case of calcium, computed annual "retention" based only on dissolved input and output would lead to the conclusion that an efflux greater than influx to the sediments was occurring each year since outflow of dissolved Ca *via* the outlet exceeded total inflow. Consideration of the input by particulate matter could possibly result in a completely different interpretation, that is that there is a net sedimentation of Ca each year as shown by the sediment trap data. In investigations of budgets for these elements it would seem necessary to establish their transport *via* particulate matter in order to compute accurate and reliable rates of lake retention.

Essentially all carbon, nitrogen and phosphorus supplied to the ELA watersheds originates from the atmosphere (Schindler *et al.*, 1976). Precipitation is the sole source of phosphorus; bedrock and soils of ELA are poor in phosphate. Input of carbon and nitrogen to terrestrial regions is by both precipitation and atmospheric fixation. Schindler *et al.*, (1976) observed high (greater than 80%) retention of phosphorus and nitrogen entering the terrestrial portion of the Lake 239 watershed *via* precipitation and suggested that forest growth was retaining these elements. Such a dependence of the terrestrial vegetation on P and N is reflected by the fact that less than half of the annual supply of P and N to Lake 120 was by runoff (Table 6) even though the terrestrial drainage is 6.5 times the lake surface

area. About 92% of the carbon entering the lake was, however, supplied by runoff. In the runoff about 43% of the P was particulate, 17% of the N was particulate whereas only 3% of the carbon was particulate. A similar trend was observed in the outflow of Lake 120 which probably indicates the same order of nutrient limitation exists for lake plankton as for terrestrial vegetation. On an average, 59% of the P in outflow waters was particulate, 35% of the N was particulate and 17% of the C was particulate.

The obvious explanation for "retention" by Lake 120 of 50-60% of the input of P, N, C and Si (Table 6) is assimilation of these elements by plankton. Some fraction of the plankton settles to the sediments carrying the assimilated nutrients with it. Especially at times when circulation is restricted (>90% of the year) the surface and therefore the outflow waters would tend to contain less of these elements than inflowing water. At no time is allochthonous particulate matter a significant fraction of the seston in Lake 120. The above statement can be substantiated as follows. If all the particulate C, N or P supplied to the lake in a year by precipitation and runoff remained in suspension, (i.e., if no degradation took place and there was no sedimentation and no removal *via* the outflow), only 1/4 of the average concentration of suspended material found in the mixolimnion would be attained. Of course, considerable amounts of suspended material were flushed out of the lake, did fall to the sediments and did degrade in the water column; so, at any given instant, allochthonous particulate material must be only a very small part of total seston. Since in the P, N and C budgets both

particulate and dissolved phases were measured, it can be determined if computed lake "retention" is equivalent to sedimentation.

A comparison of computed annual "retention" and net sedimentation of ΣC , ΣN and ΣP is presented in Table 10. Without exception, "retention" was greater than net sedimentation. That is, there was an apparent net loss to the atmosphere of these elements or in other words, component (7), loss by degassing or emergence at the lake surface was larger than component (2), fixation of atmospheric gases at the lake surface. In the case of phosphorus, component (2) should be zero. A comparison of pCO_2 in Lake 120 surface waters with atmospheric pCO_2 (Figure 35) suggests that there should be a flux of CO_2 from the lake to the atmosphere. Schindler *et al.*, (1976) suggest that fixation of N by aquatic flora is insignificant in comparison to other sources of N to Lake 239. Annual losses of C, N and P from Lake 120 to the atmosphere (Table 10) were estimated by taking the difference between "retention" and sedimentation, that is $((1) + (3) - (5)) - ((6) - (4))$. According to Table 10, 85% 55% and 19% of the C, N and P "retained" by the lake (Table 6) was lost to the atmosphere. That is actual annual retention (net sedimentation) of C, N and P by the lake was not 50%, 50% and 51% of the input *via* precipitation and runoff but rather was 8%, 22% and 41% respectively. Loss to the atmosphere of C, N and P was 42%, 27% and 10% of the annual input to the lake. Vallentyne (1952) estimated rates of removal of nitrogen and phosphorus from Lake Opinicon, Ontario by emerging zoobenthic insects. He found that $5 \mu\text{moles P m}^{-2} \text{ A}_0 \text{ day}^{-1}$ were removed from the lake by emerging insects. Based on Table 10 and an open-water season of

TABLE 10. Comparison of C, N and P losses from Lake 120 *via* the outflow, sedimentation and the atmosphere. Values given below are averages for the years 1970-72. Total input *via* precipitation and runoff, outflow *via* the outlet and computed retention (total inflow minus outflow) are from Table 6. Net sedimentation is from Table 7.

	RETENTION (TOTAL IN- PUT MINUS OUTFLOW)	NET SEDIMENTATION			LOSS TO THE ATMOSPHERE (RETENTION-SEDIMENTATION)			OUTFLOW VIA OUTLET	
	K moles per year	K moles per year	% of retention	% of total input	K moles per year	% of retention	% of total input	K moles per year	% of total input
ΣC	168.9	26.07	15	8	142.8	85	42	169.3	50
ΣN	4.60	2.06	45	22	2.54	55	27	4.68	50
ΣP	0.108	0.087	81	41	0.021	19	10	0.103	49

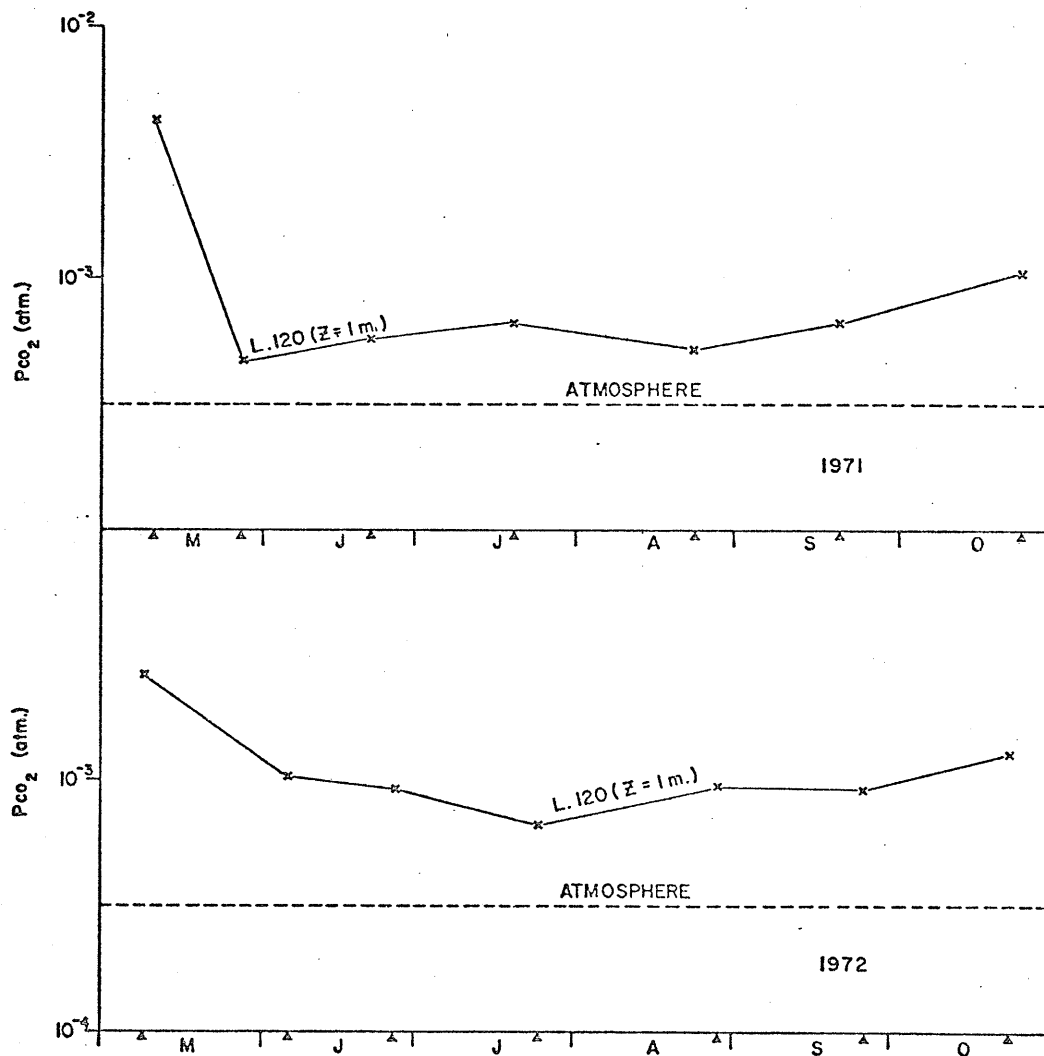


FIGURE 35. Partial pressure of CO₂ at a depth of 1 meter in Lake 120 and partial pressure of CO₂ in the atmosphere during the open water seasons of 1971 and 1972.

200 days, the loss of P from Lake 120 was only $1 \mu\text{mole m}^{-2} A_o \text{ day}^{-1}$.

The net removal of nitrogen to the atmosphere during the open-water season on Lake 120 was determined to be $140 \mu\text{moles m}^{-2} A_o \text{ day}^{-1}$.

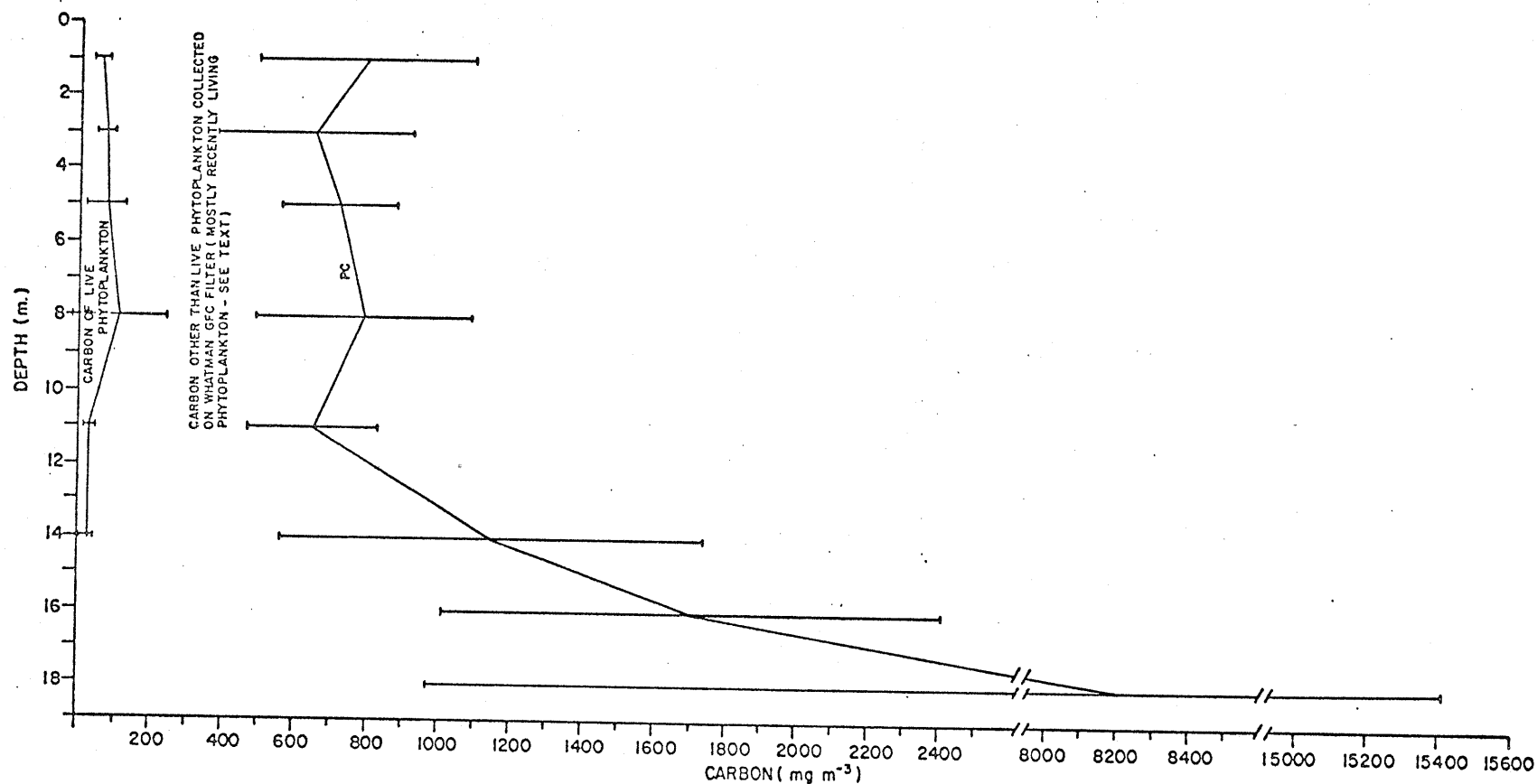
Vallentyne found that the molar ratio of N:P in the invertebrates he investigated was 32:1. Based on this ratio, the N evasion from Lake 120 by insect emergence would be expected to be about $32 \mu\text{moles m}^{-2} A_o \text{ day}^{-1}$ of the open-water season. Slightly more than $100 \mu\text{moles N m}^{-2} \text{ day}^{-1}$ appears to be exiting from the surface of Lake 120 as a result of some other mechanism, possibly denitrification. Andersen (1971) found that up to 54% of annual N inputs to shallow, eutrophic Danish lakes were lost by denitrification. It is possible that this process may account for a considerable portion of the loss of N from Lake 120 to the atmosphere. If carbon is assumed to be 50% of the dry weight of emerging insects (Bierle, 1972), the molar ratio C:P in the insects of Vallentyne would be about 220:1.

Using the same logic as above, about $220 \mu\text{moles of C m}^{-2} A_o \text{ day}^{-1}$ could emerge as insect biomass from Lake 120. However, on an average, $7,700 \mu\text{moles C m}^{-2} A_o$ was lost to the atmosphere each day of the open-water season (Table 10). That loss of gaseous CO_2 to the atmosphere is occurring throughout the open-water season was shown in Figure 35. It is suggested then that the average rate of evasion of CO_2 from the surface of Lake 120 to the atmosphere during this study was about $7,500 \mu\text{moles m}^{-2} A_o \text{ day}^{-1}$.

The concentrations of nutrients and major ions in the mixolimnetic waters of Lake 120 (Tables 3 and 4) are close to the average presented for 40 other ELA lakes and exhibit the same seasonal trends described by Armstrong and Schindler (1971). On the other hand, the concentrations

of Eh sensitive ions in the monimolimnetic waters (Tables 3 and 4) are rather high, with concentrations of dissolved Fe reaching 4.2 mMoles liter⁻¹. Merilainen (1970) reported total iron levels as high as 6.8 mMoles liter⁻¹ but the fraction that was particulate is unknown.

The highest levels of particulate organic material in the mixolimnion were observed during summer (Figures 19 and 20). As a result, supply to and accumulation of particulate organic matter in the monimolimnion was also highest at this time of year. This is reflected by the migration of the depth of oxygen depletion in the bottom waters. Oxygen depletion above the chemocline was more severe during summer stagnation than under winter ice (Figure 11). It was shown above that little particulate organic matter suspended in the water column was allochthonous. If live phytoplankton is assumed to be 10% carbon (Strickland, 1960), the live biomass figures in Table 26 of the appendix can be compared with the suspended carbon measured in the lake (Table 14, appendix). In Figure 36 the average phytoplankton biomass (mg C m⁻³) and total suspended carbon measured during the years 1971 and 1972 are plotted against depth. It can be seen that even in the mixolimnion live phytoplankton are only a small but rather constant fraction (10%) of the total suspended carbon. Round (1965) reported that, on an average, chlorophyll a ranges from 0.2 to 0.6% of the weight of carbon in live freshwater phytoplankton. From the data used to construct Figure 36, it was found that in the years 1971 and 1972, chlorophyll measured in the mixolimnion was about 6.2% of the calculated carbon content of live phytoplankton. Such a high average chlorophyll content of the



AVERAGE MEASURED ON 15 SAMPLING DATES DURING WINTER, SPRING, SUMMER & FALL 1971-72

FIGURE 36. Average concentrations of total suspended particulate carbon (PC) and carbon of live phytoplankton in Lake 120 during 1971 and 1972.

live phytoplankton is unreasonable. It was discovered, however, that chlorophyll taken as a percent of total suspended carbon was, on an average, 0.5. This suggests that most of the particulate carbon fraction not accounted for in the mixolimnion by live phytoplankton was very recently living phytoplankton (containing chlorophyll and chlorophyll degradation products). This accounts for the remarkable similarity between the mixolimnetic portions of the isopleth diagrams of PC and chlorophyll (Figures 19 and 29, respectively) and also live phytoplankton biomass (Figure 31) since live phytoplankton-C from 1-11 meters is a rather constant fraction of the total particulate carbon (Figure 36). During summer stratification, concentrations of PC and chlorophyll at 10-14 meters are much lower than in waters above or below. This may indicate that much of the particulate organic material originating in the epilimnion and thermocline of the mixolimnion is not funneled into the monimolimnion but is decomposed before reaching the chemocline.

In the monimolimnion where temperature remains relatively constant (4-5°C) throughout the year, changes in the rates of formation of anaerobic decomposition products such as NH_3 , CH_4 , CO_2 and H_2S are probably dependent mainly on the rate of supply of particulate matter. That most of the nitrogen and carbon in the monimolimnion is inorganic in contrast to the mixolimnion where it is mainly organic (Table 3) may reflect a more "complete" breakdown of C and N compounds in the monimolimnion to primary mineral components. It should be noted that the fraction of inorganic P in the monimolimnion remains small. This is perhaps an indication of a heavy demand for P by anaerobes. If feed-back from

the monimolimnion to the mixolimnion were insignificant, then a decreased supply of particulate organic matter to the bottom during winter would not result in lower concentrations of NH_3 , CO_2 and CH_4 . However, in winter, levels of these primary decomposition products in the monimolimnion do decrease significantly (Figures 12, 13 and 16). Under winter ice, physical mixing processes are probably minimal, but bubbling (especially of CH_4) and diffusion through the sharp chemical gradient in the monimolimnion and chemocline coupled with bacterial processes at the chemocline effect a transfer from the monimolimnion across the chemocline into the mixolimnion. For example, Rudd (1974) measured oxidation rates of CH_4 to CO_2 in Lake 120. He found that 98% of the bacterial oxidation of methane was occurring in the chemocline. About two-thirds of the methane oxidized was converted to CO_2 . Based on rates reported by Rudd, bacterial oxidation alone could deplete the monimolimnion of CH_4 in about 1 1/2 years. It becomes obvious from this example then how lowering the rate of supply of organic matter to the monimolimnion during the six winter months can result in significant reductions in levels of the primary degradation products CH_4 , CO_2 and NH_3 .

Even for the conservative elements Ca, Mg, Na, K and Si, concentrations in the monimolimnion are probably largely a function of supply of detrital particulate matter. That their enrichment in the monimolimnetic waters is less than for other chemical species can be attributed to lack of demand by the biota of the lake for these elements. However, they are contained in trace amounts in autochthonous particulate matter and in

the case of calcium, for example, may be sorbed to coniferous humic matter (see above). Utilization of Si by phytoplanktonic diatoms and Chrysophyceae depletes dissolved Si in the mixolimnion and is especially obvious during the summer months (Figure 22). Although the input of conservative elements to the monimolimnetic waters and sediments appears to be relatively small compared to carbon or nitrogen, dissolution and degradation of the particulate matter funneled into the monimolimnion must account for the enrichment of these elements. Lerman and Brunskill (1971) found that concentrations of Ca, Mg, Na, K and Si in the interstitial waters of ELA lake sediments were greater than in overlying lake water by as much as a factor of 6, and they estimated that diffusional flux from the sediments could contribute up to 15-30% of the input of these elements to the lake in a year. In the case of the monimolimnetic region of Lake 120, a sharp concentration gradient occurs not just between the interstitial waters and overlying lake water but also through the monimolimnion to the chemocline. The poorly mixed monimolimnetic waters can probably also be thought of as the interstitial water and the mixolimnion as the overlying lake waters of Lerman and Brunskill. In addition to mixing of the upper regions of the monimolimnion with the mixolimnion during spring and fall overturn, conservative elements must be returned to the mixolimnion by diffusional flux at all times of the year. If the rate of supply of the source material is reduced in winter, then the rate of supply of the conservative elements (by dissolution or degradation) to the interstitial and monimolimnetic waters will also be reduced. If the rate of diffusion across the chemocline remains constant

(concentration gradients of these elements change little over time at the chemocline), then it is possible that a net loss of conservative elements from the deep waters of the monimolimnion could result at times when their supply to and production from the sediments is reduced (Figures 22, 23, 24, 25 and 26).

Unlike conservative cations, iron and manganese are chemically responsive to redox potential (Mortimer, 1941). Brunskill *et al.* (1971) reported the Eh of the interstitial waters of Lake 120 to be from -80 to -160 mV. These measurements were not done *in situ* and it is possible, therefore, that the Eh was even lower. Very low Eh in the monimolimnion and the extremely high concentrations of iron and manganese are again basically controlled by supply of organic matter and lack of O_2 supply. The oxidative decomposition of organic matter in the sediments or in the water column results in a production of electrons. Oxidative decomposition does not cease after complete utilization of the available free oxygen and in the monimolimnetic waters of Lake 120 the redox potential becomes very low. The production of "free" electrons allows the solubilization of iron and manganese by reduction. Fe^{3+} is likely reduced to soluble Fe^{2+} in the monimolimnion and Mn^{3+} reduced to soluble Mn^{2+} . Unlike C and N or the conservative ions, mechanisms such as bacterial oxidation or diffusion likely do not transfer Fe and Mn across the chemocline and into the mixolimnion. Inorganic or microbial oxidation at or above the chemocline probably causes the formation of precipitates such as ferric hydroxide. Significant feedback of iron or manganese to the mixolimnion likely occurs only when the upper part of

the monimolimnion is scraped off at times of spring and fall circulation. As long as low monimolimnion redox potential is maintained, most reactive iron or manganese that reaches the chemocline will be solubilized in the monimolimnion by reduction to Fe^{2+} or Mn^{2+} . If, during periods of stagnation, the rate of oxidation of monimolimnetic iron or manganese at the chemocline is rather constant, but the production of electrons (i.e., rate of supply of organic matter) necessary to reduce and re-solubilize the oxidized iron or manganese is lowered, then a lower concentration of dissolved iron and manganese should be expected. In comparison to summer, winter concentrations of iron and manganese were much lower in the monimolimnion of Lake 120 when the supply of organic matter was not so plentiful (Figures 27 and 28).

It would seem that in the 17-18 m deep waters of Lake 120, precipitation of siderite (FeCO_3) or even rhodochrosite (MnCO_3) is possible. Such precipitation then could also be in part responsible for lower CO_2 levels in the monimolimnion during winter. Solubility products for both FeCO_3 and MnCO_3 are about $10^{-10.7}$ moles² liter⁻² (Garrels and Christ, 1965). $[\text{Fe}] [\text{CO}_3]$ at 18 meters has been observed as high as 10^{-8} moles² liter⁻² and $[\text{Mn}] [\text{CO}_3]$ up to 3.4×10^{-10} moles² liter⁻². Further, pCO_2 of 10^{-1} was often observed at 18 meters depth in Lake 120. A stability diagram, Stumm and Morgan (1970, Figure 5-8c, page 186) shows that at such a pCO_2 and $\text{pH} = 6.6-6.8$, siderite is thermodynamically stable. Formation of FeCO_3 or MnCO_3 could explain the CO_3 detected in the sediment collected in the traps set in the monimolimnion of Lake 120 (Table 7). No evidence of siderite in Lake 120 surface bottom sediments was found by X-ray

diffraction analyses, but detection of siderite at < 2% dry weight would not be expected (B. Graham, personal communication). However, in carrying out Rn analyses on samples of Lake 120 bottom waters, oxidation of CH_4 to CO_2 led to spontaneous formation of a green precipitate which removed the Fe^{++} (T. Torgersen, personal communication). X-ray diffraction analyses did suggest the presence of small (approximately 0.2% dry weight) amounts of rhodochrosite in the surface bottom sediments of Lake 120 (B. Graham, personal communication).

During times when concentrations of the predominant ions (Fe , CO_2 , NH_3) are drastically reduced in the monimolimnion, no marked change in conductivity was observed (Figure 9). Why conductivity remained constant from season to season in the deep waters of Lake 120 is not clear.

The dichotomous nature of the pH profiles (Figure 10) may be in part due to the degradation (and therefore net production of CO_2) of sinking plankton in the region between the thermocline and chemocline. It was suggested above that much of the planktonic material originating in the upper reaches of the mixolimnion was degraded before reaching the chemocline. Any excess CO_2 produced by such respiration will, at pH less than 8, be hydrolyzed to H_2CO_3 (Hutchinson, 1957). It is possible, however, that maximum concentrations of hydrogen ion in the region 8-14 meters is also a reflection of a number of possible microbiological oxidations specific to the chemocline. It was shown above that there is a significant rate of oxidation of methane to CO_2 at 14 meters by bacteria. Weakly associated hydrogen ion in the form of H_2SO_4 may be liberated to the mixolimnion by bacterial oxidation of H_2S . From

solubility curves of FeS, Hutchinson (1957, Figure 204, page 761), the concentration of H_2S in the monimolimnion of Lake 120 should never exceed about $3 \mu\text{moles liter}^{-1}$. However, whether or not the oxidation of H_2S to H_2SO_4 is significant, compared with production of CO_2 in reducing the pH at 8-14 meters, would be dependent on the rate of production of H_2S in the monimolimnion and the rate of its oxidation at the chemocline. These rates are unknown but since sulfur is only a minor constituent of plankton (Round, 1965), it is probably reasonable to assume that rates of production of CO_2 and CH_4 by anaerobic decomposition far exceed that for H_2S . Another bacterial process that is evident especially during periods of stagnation is the oxidation of ammonia to nitrite and nitrate. Accumulation of $\text{NO}_3 + \text{NO}_2\text{-N}$ above the chemocline is obvious in Figure 15. The oxidation of H_2S and NH_3 result in the liberation of energy which is utilized in the assimilation of carbon in chemosynthesis (Ruttner, 1963).

Schindler and Holmgren (1971) classified ELA lakes according to primary productivity - depth curves (Type 1, 2 or 3) and phytoplankton standing crop and species composition (Class A, B or C). Kling and Holmgren (1972) gave detailed descriptions of seasonal patterns of biomass and species composition of Class A, B and C lakes with specific examples. In terms of live biomass, Class A lakes were described as having winter minima of approximately 70 mg m^{-3} and summer maxima of around $1,200 \text{ mg m}^{-3}$. Phytoplankton standing crops in Class B lakes ranged from $1,000 \text{ mg m}^{-3}$ in winter to $2,800 \text{ mg m}^{-3}$ in summer. Biomass levels in Lake 120 during winter (200 mg m^{-3}) were nearly as low as

would be expected of a Class A lake. In 2 out of 3 summers, however, maximum levels of 2,000 and 2,600 mg m^{-3} approached those expected of a Class B lake. A maximum biomass of 700 mg m^{-3} recorded in 1971 may be attributable to unusually cool and wet weather throughout most of the summer. In terms of phytoplankton biomass, then, the classification of Lake 120 by the Schindler-Holmgren scheme is not well defined, but it might be called a Class A-B lake or oligotrophic-mesotrophic.

In both Class A and Class B lakes, Chrysophyceae and Xanthophyceae are at all times of the year the major component of algal biomass. Diatoms are never significant in Class B lakes but during the summer may be responsible for 10-20% of the biomass in Class A lakes. At no times do diatoms account for more than 5% of the biomass in Lake 120. During mid-late winter, 30-50% of the biomass in Class A lakes is Cryptophyceae. In Lake 120, the Cryptophyceae never accounted for more than 15% of the standing crop. It would appear that Lake 120, in terms of its phytoplankton composition, fits into the B classification. Schindler and Holmgren (1971) pointed out that a curious feature of Class B lakes is a high biomass of apparently healthy algal cells that lies deeper than the bottom of the euphotic zone. Lake 120 adheres to this criterion of a Class B lake as the maximum standing crop in Lake 120 during summer stratification was usually centered at about 8 meters, the depth at which transmittance of light declines to less than 1%. However, also recall that the usual dominant in the region of maximum biomass was *Chrysosphaerella*. Although *Chrysosphaerella* is found in Class B lakes, at no time of the year is it dominant. Kling and Holmgren (1972)

reported *Chrysosphaerella* species as being dominant only in Class A lakes during the summer. So, in terms of seasonal trends in the composition of the phytoplankton, Lake 120 most closely resembles an ELA Class B lake but is also in some ways characteristic of classification A. The phytoplankton of "iron-meromictic" Lakes Valkiajarvi, Skennungen and Store Aaklungen (Merilainen, 1967 and 1970; Kjensmo, 1967) has not yet been investigated. Meromictic Lake Svinsjoen near Oslo is unlike Lake 120 in that it is moderately eutrophic and the Diatomeae and Chlorophyta are dominants in the spring and summer, respectively (Lande, 1973).

The three above-mentioned types of vertical productivity profiles are illustrated in Schindler (1972). The slightly dichotomous Type 2 profile with the first peak a few meters below the surface and the second peak well below the thermocline most closely resembles the profiles typical of Lake 120 (Figures 32a and 32b). However, Type 2 production curves elsewhere in ELA are characteristic of large ($A_0 > 1000$ ha), clear, but nutrient limited lakes with very deep euphotic zones. Lake 120 is certainly not a large, clear lake (Figure 4). Further, the second (lower) C-14 uptake peak in Lake 120 was at depths well below the point where light transmittance was 1%, that is well out of what is normally considered to be the euphotic zone (Vollenweider, 1969). Even in Type 3 lakes, which are small with comparatively nutrient-rich hypolimnia, the lower production peak is well above the depth at which light transmittance declines to less than 1%. Since photosynthesis occurs regularly at depths to 13 meters (Figures 32a and 32b) at levels well below 1%

light transmittance, the C-14 uptake profile of Lake 120 cannot be characterized as Type 1, 2 or 3. Primary production was studied in Lakes Svinsjoen (Lande, 1973) and Lake Valkiajarvi (Merilainen, 1967 and 1970). In both of these meromictic lakes production profiles were always Type 1, that is a single peak in productivity was observed at a depth of 1/2 - 1 meter. No productivity occurred at depths below the euphotic zone in these lakes.

In the region just above the chemocline (13 meters), productivity peaks in Lake 120 coincided with a dominance of small blue-green algae not usually found elsewhere in the water column. It is possible then that this unique population (unique in comparison to the phytoplankton assemblages in the waters above) is extremely tolerant of very low light levels and takes advantage of the "nutrient-rich" environment just above the chemocline. Such a situation is more or less analogous to the Type 3 profile where the lower production peak is a result of a more favourable hypolimnetic nutrient regime. Type 3 lakes of the ELA exhibit a greater rate of production per unit area than Types 1 or 2. Although Lake 120 differs from Type 3 lakes in that the second production peak is below the depth of 1% light transmittance, it might still be expected that since it does have 2 production maxima that production per unit area would be relatively high compared with other ELA lakes, especially Types 1 or 2. At all times of the year, the estimated photosynthetic productivity of Lake 120 per $\text{m}^2 A_0$ is as low or lower (both on a per volume basis and per $\text{m}^2 A_0$) than for every one of the 16 ELA lakes reported on by Schindler (1972). As a result, the

annual primary productivity is also much lower than for all other ELA lakes studied. Annual phytoplankton production in Lake Valkiajarvi, which closely resembles Lake 120 in almost every respect, was estimated by Merilainen (1970) to be $10-19 \text{ g C m}^{-2} \text{ year}^{-1}$ which is even lower than that of Lake 120. From daily rates reported by Lande (1973) it would appear that annual production is much higher in the moderately eutrophic meromictic Lake Svinsjoen compared to Lake 120.

During the open-water season of 1971, the average time required to replace the algal population was calculated to be 5.6 days. In 1972 (recall that maximum summer biomass in 1972 was 3 times that of 1971) the average turnover time of the phytoplankton standing crop was 11.6 days. Since standing crops in Lake 120 were relatively high, especially in mid summer, and since estimated primary productivity was lower than that of other ELA lakes, the average turnover of the phytoplankton appears to be 25 times longer than reported for other ELA lakes by Schindler and Holmgren (1971). Since in mid summer the depths of minimum productivity (usually 6-8 meters) always coincided with the depths at which the maximum standing crop was lying, turnover times in the region just below the thermocline were up to a month or longer. However, dissolved oxygen was always at a maximum in this stratum (Figure 11). So, although fixation of carbon by these algal cells (predominantly *Chrysosphaerella* and *Botryococcus braunii*) was a very slow process, it would seem that photosynthesis far exceeded respiration. Minimum levels of CO_2 observed in the surface waters during summer (Figure 12) did not coincide with supersaturation of oxygen. Schindler (1972) attributed

most of the loss of CO_2 from surface waters during spring and summer to evasion to the atmosphere, a function of increasing temperature. Such losses were estimated above.

Although replacement of phytoplankton standing crop just below the thermocline was extremely slow, in the depth interval just above the chemocline (predominantly small blue-greens) turnover times as rapid as 0.4 days were observed. Even if the blue-green algae there are very tolerant to low light levels, it is difficult to imagine why turnover of phytoplankton is more rapid than in the euphotic zone above the thermocline (usual turnover time of blue-green algae = 3-4 days, Dr. F.P. Healey, personal communication). Although no conclusive evidence exists, it is possible that in the region of the chemocline much of the photosynthesis was by bacteria. Thompson (1974) was able to culture green photosynthetic sulfur bacteria from water collected at the chemocline in Lake 120. Green photosynthetic bacteria could, then, be largely responsible for the observed primary production at 13 meters. However, no estimation of bacterial numbers was made by Thompson, so it is impossible at this time to determine to what degree turnover time (based on summation of algal and bacterial standing crops) would be altered.

It is worth contemplating why primary production in Lake 120 is lower than other ELA lakes. It was shown above that, after correction for emergence, 41% of the total annual input of P to Lake 120 was retained. If the same correction for emergence is made to the data of Schindler *et al.* (1976), the average annual retention of P by Lake 239 in 1971 and 1972 was 61%. This suggests that more phosphorus was

utilized by the biota of Lake 239 than that of Lake 120. Lower utilization by Lake 120 of a likely limiting nutrient such as P could mean that availability of some other essential element is reduced in comparison to Lake 239. A number of workers have shown iron to be a limiting element. For example, Menzel and Ryther (1961) and Menzel *et al.*, (1963) found under certain conditions that iron was critically limiting to growth of phytoplankton in the Sargasso Sea. Sakamoto (1971) showed that in ELA lakes, Fe was essential to phytoplankton growth and that under certain circumstances could be considered a limiting nutrient. He suggested that in more humic lakes limitation by iron would be more severe since iron bound to humic matter is not readily available to the phytoplankton. More highly coloured water suggests that Lake 120 is probably "more humic" than Lake 239. It is possible that utilizable iron is not so readily available to the phytoplankton of Lake 120. It is also possible that in more humic waters there is less readily utilizable P available due to complexing of phosphorus with the iron bound to humic matter. Explanations of the sort outlined above may account for lower production in Lake 120 than in Lake 239. However, many lakes in the ELA are even "more humic" than Lake 120 and yet primary production is higher than in Lake 120. Why phytoplankton growth in Lake 120 is lower than in other very humic lakes is, at this time, uncertain. If primary production in Lake 120 were greater, it is likely that the increased supply of organic matter would cause an upward migration of the monimolimnion.

The meromictic (chemical) stability of Lake 120 was computed after

Hutchinson (1937) at fall turnover when the mixolimnion was homothermal at the temperature of the chemocline (temperature of homothermy of the mixolimnion varied from 4.8 to 5.2°C). The chemical contribution to the densities previously presented in Figure 33 was obtained by summation of the concentrations of the major dissolved species in the lake. In the years 1969-1972, the densities ranged from 1.00002 gm cm⁻³ in the mixolimnion up to about 1.0009 gm cm⁻³ in the bottom waters of the monimolimnion. That is, in the monimolimnion, the chemical contribution to density was up to about 45 times that in the mixolimnion. Computations of persistency (P') were carried out at 1 meter intervals.

$$P' = A_{c_i} (z_{c_i} - z_{g, \text{mixo}}) (\rho_2 - \rho_1)$$

where z_{c_i} = arbitrary depth of chemocline

A_{c_i} = area of the chemocline at arbitrary depth z_{c_i}

$z_{g, \text{mixo}}$ = depth of the center of gravity of the mixolimnion at depth z_{c_i}

ρ_1 = density of the mixolimnion

ρ_2 = density of the monimolimnion

Plots of P'/A_0 against depth (Figure 37) show that the present chemocline (14 meters) is well below the depth of maximum persistency (7 meters). The magnitude of persistency was much less in the years 1971 and 1972 than 1969 and 1970. This reflects a decreased chemical contribution to density in the monimolimnion in 1971 and 1972 (Figure 33). Lower

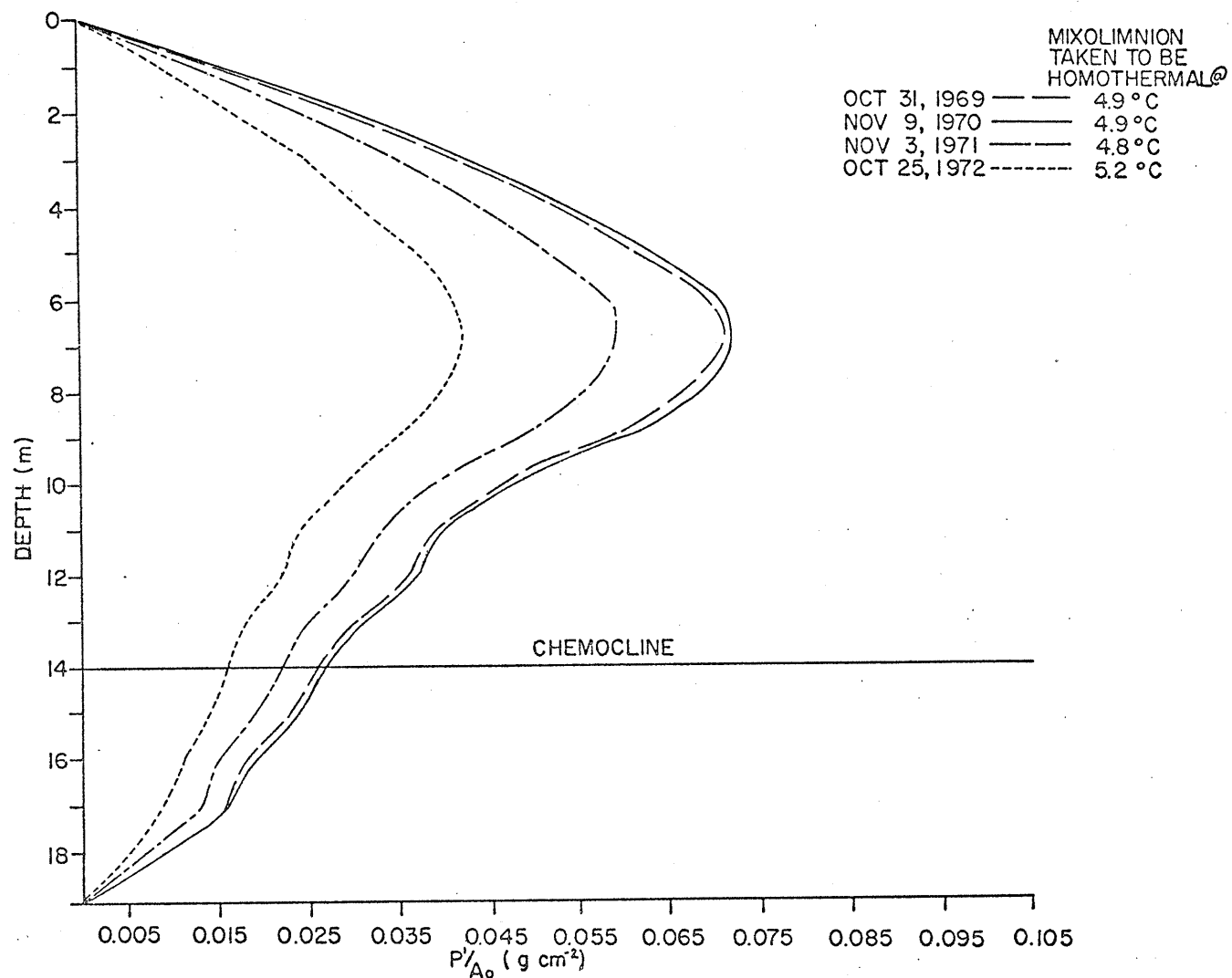


FIGURE 37. Variation of persistency (P') per unit lake surface area with depth. Persistency was computed (after Hutchinson, 1937) during fall turnover when the mixolimnion was homothermal at the temperature of the chemocline.

concentrations of dissolved chemical species in the monimolimnion in the fall of 1971 and 1972 may have been due to a decreased rate of supply of organic matter during the summer, and/or more wind work performed at the surface of the lake resulting in more severe "scraping off" of the top of the monimolimnion and therefore greater dilution. To what degree each of the above was a contributing factor is impossible to ascertain.

Meromictic stabilities (S') computed for Lake 120 ranged from 5.5 to $9.5 \text{ gm cm cm}^{-2}$.

$$S' = (z_c)(V_{\text{moni}}) \left[\frac{(\rho_2 - \rho_1)}{A_o} \right]$$

where z_c = actual depth of chemocline

V_{moni} = volume of monimolimnion

A_o = lake surface area

ρ_1 and ρ_2 = as above.

Walker (1974) pointed out that meromictic (chemical) stability is not necessarily a real reflection of the nonthermal stability of a lake since there are meromictic lakes which are not chemically stratified and have, at times of isothermy, a (chemical) stability ostensibly of zero. Such cases of meromixis reflect a morphometrically and climatically determined factor that presently has no quantitative basis in limnology. Keeping this limitation in mind, it is still probably safe to say that $S' = 5.5-9.5 \text{ gm cm cm}^{-2}$ reflects a rather precarious meromixis in Lake 120; S' of

Lake 120 is extremely low compared with others reported. For example, S' of Fayetteville Green Lake is $1,700 \text{ gm cm cm}^{-2}$ (Brunskill, 1969a); S' for Big Soda Lake is $60,000 \text{ gm cm cm}^{-2}$ (Hutchinson, 1937). Meromictic stabilities of the "iron-meromictic" lakes of Norway and Finland have not been reported.

It was not the purpose of this study nor is it possible here to accurately predict specific events which would occur in Lake 120 as a result of removing the forest from its watershed. However, it seems possible that deforestation could either enhance or destroy the meromixis. If, after removal of the forest, rates of supply of allochthonous organic matter to the lake or rates of supply of elements essential to the growth of the lake biota were to increase, it seems reasonable to assume that the depth of the chemocline would rise and the meromictic stability would increase. On the other hand, it is also possible following deforestation that demand for nutrient elements by pioneer plant species in the terrestrial watershed would exceed that presently exhibited by the forest. As a result, nutrient supply to the lake and, therefore, supply of autochthonous organic matter to the monimolimnion would likely decrease. A reduction in the rate of supply of autochthonous organic matter to the monimolimnion would tend to a reduction in monimolimnetic volume and a decrease in S' . At present, the forest provides the lake surface with a certain degree of wind protection. Deforestation might allow sufficient wind work on the surface of Lake 120 to cause complete autumnal and/or vernal circulation.

SUMMARY

A study was carried out in order to describe Lake 120 prior to the logging of its watershed. Lake 120 was determined to be biogenically meromictic. The monimolimnion was less than 3% of the total lake volume. Concentrations of nutrients and major cations in the monimolimnion appeared to be dependent on the rate at which particulate matter was produced and funneled into that region of the lake. It was shown that particulate organic matter in the mixolimnion is largely live or recently-living phytoplankton. As a result, the supply of biodegradable particulate matter to the monimolimnion is mainly a function of primary production.

Winter, summer and annual heat budgets were estimated. Winter heat budgets were mainly accounted for by the latent heat of melting of the ice cover. That winter heat budgets were lower than for other ELA lakes was attributed to the relatively thin ice cover. Lake 120 is well sheltered (in comparison to most other ELA lakes) and reduced sweeping of the ice by the wind resulted in greater insulation of the lake by snow. Summer heat budgets, on the other hand, were relatively high and Lake 120 was more efficient than most other ELA lakes at distributing its summer heat income. Such efficient heating of the lake was attributed to its large littoral region. The thermal regime of the monimolimnion was found to be out of phase with that of the mixolimnion. While the mixolimnion was gaining heat during the spring, the monimolimnion was at the same time cooling. Loss of heat by the monimolimnion was probably by the introduction of a cold water mass. It is likely that during spring

a "lens" of cool residual melt-water originating in the bog at the south end of the lake, slides down the side of the basin through the warmer waters of the mixolimnion and comes to rest in the region of equivalent density just below the chemocline. Maximum heat content of the monimolimnion usually occurred during fall circulation. This is due to a limited mixing of the upper region of the monimolimnion with warmer mixolimnetic waters.

The chemistry of the mixolimnetic waters of Lake 120 was similar to that of other ELA lakes. The monimolimnetic waters were greatly enriched in degradation products of organic matter such as NH_3 , CH_4 and CO_2 and in the redox sensitive elements Fe and Mn. Concentrations of dissolved iron in the monimolimnion were as high as any previously recorded in natural waters. Carbon and nitrogen in the mixolimnion were largely in organic form whereas in the monimolimnion most of the C and N was inorganic. Phosphorus, on the other hand, was largely organic in both the mixolimnion and monimolimnion. This suggests that much of the P entering the waters of the monimolimnion and the sediments is retained by anaerobic microbes.

By way of estimated annual budgets, it was shown that sedimentation of the dissolved conservative cations was small compared to the annual input to the lake. About 59% of the Si, 41% of the P and 22% of the N entering the lake in a year was retained in the sediments. Although particulate iron was not determined in this study, it was deduced that a large fraction of the annual input of Fe to Lake 120 was particulate and that probably 65% of the total annual input was retained in the sediments. Only 50% of the C,

50% of the N and 51% of the P entering the lake was found to exit *via* the outlet. Ten percent of the annual input of P, 27% of the annual input of N and 42% of the annual input of C was apparently lost to the atmosphere. It was estimated that P exiting at the surface of the lake could be largely accounted for by emerging insects. Most N and C lost to the atmosphere was likely by gaseous evasion. Average rates of evasion of C and N to the atmosphere were estimated to be 7,500 and 100 $\mu\text{moles m}^{-2} \text{A}_0$ per day of the open-water season.

At all times of the year, phytoplankton in Lake 120 were predominantly Chrysophyceae and Xanthophyceae. Biomass ranged from about 200 mg m^{-3} in mid winter to usually greater than 2,000 mg m^{-3} in mid summer. It was impossible, however, to clearly fit Lake 120 into a classification scheme for ELA lakes based on phytoplankton biomass, species composition and productivity depth profiles previously established by Schindler and Holmgren (1971). Based on biomass and seasonal changes in phytoplankton composition, Lake 120 is a Class A-B lake, i.e., oligotrophic - mesotrophic. The usual productivity-depth profile in Lake 120 is not, however, like that for other ELA lakes studied to date. In addition to a productivity peak near the surface, one was usually found in the region just above the chemocline well below the lower limits of what is usually considered to be the euphotic zone. Small blue-green algae were usually dominant in the depth interval of the second productivity peak but were likely not entirely responsible for the production there; green photosynthetic bacteria may also play a major role. Even though productivity profiles for Lake 120 were dichotomous, annual productivity was lower

than for any other ELA lake studied to date. It was hypothesized since Lake 120 is "more humic" than some other ELA lakes that binding to humic matter results in a lower availability to the phytoplankton of utilizable phosphorus and/or iron. Such an explanation may be partly valid. However, it is impossible to explain why productivity is higher in lakes even "more humic" than Lake 120.

The chemocline of Lake 120 was found to be well below the depth of maximum persistency. It is likely that if primary production in Lake 120 were greater, the monimolimnion would be much more extensive than it is at present. Meromictic (chemical) stability was computed to be 5.5 to 9.5 gm cm cm⁻². Such a low stability indicates that the meromixis of Lake 120 is precarious.

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APPENDIX

RAW PHYSICAL, CHEMICAL AND BIOLOGICAL DATA COLLECTED
ON LAKE 120 IN THE YEARS 1968-1972

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TABLE 1. Individual determinations of temperature (°C) in Lake 120, 1968-1972.

DEPTH (m)	DATE						
	12/11/68	22/1/69	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69
0	4.4	0	11.6	17.5	21.6	23.0	21.9
1	4.4	1.3	11.3	17.5	21.7	22.1	21.8
2	4.3	2.3	10.9	17.5	21.7	21.6	21.8
3	4.3	2.8	9.6	16.8	19.4	21.1	21.6
4	4.3	3.0	8.8	16.0	17.1	19.5	21.3
5	4.3	3.1	6.7	12.8	12.9	14.4	16.1
6	4.3		5.9	9.1	9.8	11.0	12.2
7	4.3	3.3	5.5	8.3	8.2	8.4	9.7
8	4.2		5.4	7.7	7.7	7.4	8.4
9	4.2	3.8	5.2	7.3	7.1	6.7	7.5
10	4.1	3.8	4.8	7.0	6.6	5.9	6.9
11	4.2	4.0	4.5	6.6	6.2	5.4	6.3
12	4.1	4.0	4.4	6.2	5.8	4.8	5.9
13	4.1	4.0	4.3	5.7	5.7	4.6	5.8
14	4.1	4.0	4.2	5.6	5.6	4.4	5.7
15	4.7	4.2	4.2	5.4	5.5	4.3	5.6
16	4.6	4.3	4.3	5.2	5.4	4.3	5.5
17	4.6	4.7	4.5	5.2	5.4	4.3	5.4
18	4.6			5.5	5.6	4.4	5.5
19	4.7				5.7	4.5	5.6

TABLE 1 (cont.)

DEPTH (m)	DATE						
	16/9/69	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69
0	18.0	16.7	12.0	10.9	8.3	5.8	5.0
1	18.0	16.3	12.0	10.7	8.3	5.8	4.9
2	17.9	16.2	11.9	10.5	8.3	5.8	4.8
3	17.9	16.1	11.9	10.4	8.3	5.8	4.8
4	17.8	16.0	11.9	10.3	8.3	5.8	4.8
5	17.1	15.8	11.9	10.3	8.3	5.8	4.8
6	12.4	12.9	11.8	10.3	8.3	5.8	4.8
7	9.3	9.8	11.3	10.3	8.3	5.8	4.8
8	8.0	8.3	8.8	9.2	8.3	5.8	4.8
9	7.0	7.3	7.6	7.8	8.3	5.8	4.8
10	6.3	6.3	6.9	6.8	6.6	5.8	4.8
11	5.7	5.9	6.2	6.2	5.8	5.8	4.8
12	5.2	5.4	5.8	5.7	5.3	5.7	4.8
13	4.6	5.2	5.4	5.6	5.1	5.2	4.8
14	4.5	5.1	5.1	5.1	5.0	5.1	4.9
15	4.4	5.0	5.1	5.0	4.9	4.9	4.8
16	4.3	4.9	5.0	5.0	4.8	4.8	4.75
17	4.3	4.8	5.0	5.0	4.8	4.8	4.75
18	4.3	4.9	5.0	5.0	4.8	4.8	4.8
19		5.0	5.0	5.0	4.9	4.9	4.85

TABLE 1 (cont.)

DEPTH (m)	DATE						
	13/11/69	10/12/69	22/1/70	26/2/70	10/4/70	8/5/70	21/5/70
0	3.5	0.5	0.4	0.3	0.5	1.8	8.5
1	3.8	2.6	1.3	0.7	0.8	3.9	8.5
2	3.9	3.0	2.7	2.6	2.3	4.0	8.5
3	3.9	3.1	3.1	3.2	3.2	4.0	6.5
4	4.0	3.2	3.4	3.5	3.5	4.0	5.8
5	4.0	3.2	3.5	3.6	3.7	4.0	5.2
6	4.0	3.4	3.6	3.8	3.9	4.0	5.1
7	4.0	3.5	3.7	3.9	3.9	4.0	4.8
8	4.0	3.5	3.9	3.9	3.9	4.0	4.8
9	4.1	3.6	3.9	4.0	4.0	4.1	4.7
10	4.1	3.7	4.0	4.0	4.1	4.1	4.5
11	4.1	3.7	4.0	4.1	4.1	4.1	4.4
12	4.1	3.8	4.1	4.1	4.1	4.2	4.3
13	4.1	3.9	4.1	4.2	4.2	4.2	4.2
14	4.1	4.1	4.2	4.2	4.2	4.2	4.2
15	4.6	4.3	4.4	4.4	4.4	4.3	4.3
16	4.6	4.7	4.6	4.6	4.6	4.6	4.4
17	4.6	4.75	4.8	4.8	4.8	4.8	4.5
18	4.7	4.8	4.9	4.9	4.9	4.9	4.6
19	4.7	4.8	4.9	5.0		5.0	4.8

TABLE 1 (cont.)

DEPTH (m)	DATE						
	28/5/70	16/6/70	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70
0	10.5	19.4	20.3	22.7	24.1	16.7	13.0
1	10.3	19.9	20.6	21.9	23.2	16.8	12.9
2	9.9	19.3	20.4	21.6	22.5	16.9	12.8
3	8.3	12.9	17.7	19.8	21.8	16.8	12.8
4	7.1	8.9	11.2	12.8	18.0	16.8	12.8
5	6.7	7.1	8.2	9.4	11.0	16.1	12.7
6	6.4	6.0	6.8	7.1	9.0	10.7	11.2
7	5.9	5.3	5.8	6.4	7.5	8.2	8.3
8	5.8	5.2	5.6	6.1	6.8	7.1	7.0
9	5.8	5.0	5.2	5.8	6.4	6.3	6.0
10	5.7	4.8	4.7	5.3	5.8	5.9	5.8
11	5.1	4.6	4.5	5.0	5.2	5.3	5.1
12	5.1	4.3	4.3	4.8	5.0	5.3	5.0
13	5.1	4.2	4.2	4.7	4.9	5.2	4.9
14	5.1	4.2	4.2	4.6	4.9	5.1	4.9
15	5.1	4.2	4.2	4.5	4.5	5.1	4.8
16	5.1	4.3	4.25	4.6	4.8	5.0	4.8
17	5.1	4.4	4.3	4.7	5.0	5.0	4.9
18	4.8	4.5	4.4	4.75	5.0	5.0	5.0
19	4.8	4.6	4.5	4.8	5.0	5.05	5.0

TABLE 1 (cont.)

DEPTH (m)	DATE							
	26/10/70	9/11/70	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71
0	9.9	5.25	1.0	0.3	0.7	4.7	11.9	12.5
1	9.8	5.25	1.7	1.3	1.4	4.7	11.9	11.9
2	9.7	5.25	2.8	2.3	2.6	4.7	11.7	11.3
3	9.6	5.25	3.1	3.1	3.5	4.7	9.4	10.9
4	9.3	5.25	3.3	3.7	3.8	4.7	7.8	10.3
5	9.0	5.25	3.5	3.8	4.2	4.7	5.9	8.1
6	8.9	5.25	3.8	3.9	4.35	4.6+	5.5	6.5
7	8.8	5.25	4.1	4.0	4.5	4.6	5.4	6.0
8	8.6	5.2	4.2	4.2	4.5	4.4	5.3	5.8
9	8.5	5.2	4.2	4.2	4.5	4.3	5.2	5.6
10	8.2	5.2	4.3	4.2	4.55	4.3	5.0	5.4
11	7.2	5.15	4.3	4.3	4.55	4.4	4.9	5.0
12	7.0	5.15	4.35	4.3	4.6	4.4	4.8	4.9
13	6.8	5.15	4.4	4.3	4.6	4.4	4.7	4.8
14	6.5	4.9	4.6	4.4	4.6	4.4	4.5	4.7
15	6.3	4.8	4.7	4.5	4.7	4.6	4.6	4.6
16	6.1	4.7	4.8	4.9	4.8	4.7	4.7	4.6
17	6.05	4.7	4.8	4.9	4.9	4.8	4.7	4.7
18	6.2	4.8	4.9	5.0	4.95	4.8	4.8	4.7
19	6.2	4.9	4.95	5.0	5.0	4.9	4.9	4.8

TABLE 1 (cont.)

DEPTH (m)	DATE						
	10/6/71	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71
0	17.8	21.2	21.5	21.1	21.8	20.0	15.0
1	17.8	21.2	21.0	21.1	21.8	19.7	15.2
2	17.5	20.9	20.6	21.1	22.0	19.7	15.2
3	15.4	14.0	20.2	21.0	19.6	18.6	15.2
4	12.1	13.2	16.4	18.7	17.8	11.7	15.2
5	8.8	9.4	12.1	12.9	14.2	9.5	15.2
6	6.9	8.1	9.1	8.9	10.6	8.2	15.2
7	6.2	6.7	7.5	8.3	8.4	7.0	9.6
8	5.9	6.2	6.9	7.4	7.6	6.3	8.5
9	5.6	5.7	6.5	6.9	6.8	6.0	7.3
10	5.2	5.3	6.0	6.5	6.1	5.7	6.6
11	4.9	5.1	5.6	5.9	5.6	5.5	6.1
12	4.8	4.7	5.3	5.8	5.4	5.5	5.6
13	4.6	4.7	5.1	5.4		5.1	5.5
14	4.5	4.6	4.9	5.4	5.1	5.0	5.1
15	4.4	4.4	4.8	5.3	5.0	5.0	5.1
16	4.4	4.4	4.8	5.0	4.9	5.0	5.2
17	4.4	4.4	4.8	5.1	4.9	5.1	5.2
18	4.5	4.4	4.9	5.2	5.1	5.1	5.2
19	4.5	4.4	5.0	5.2			

TABLE 1 (cont.)

DEPTH (m)	DATE						
	6/10/71	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72
0	12.8	9.6	6.2	0.7	0.7	0.1	6.0
1	12.8	9.4	6.2	1.8	1.7	0.7	5.9
2	12.8	9.2	6.2	2.3	2.2	1.3	5.8
3	12.8	9.1	6.2	2.6	2.7	2.4	5.7
4	12.8	9.1	6.2	2.8	3.1	2.8	5.5
5	12.8	9.1	6.2	2.9	3.3	3.2	5.4
6	12.8	9.1	6.2	3.0	3.5	3.4	5.2
7	11.3	9.1	6.2	3.1	3.7	3.6	5.0
8	8.3	9.1	6.2	3.3	3.9	3.8	4.9
9	7.3	8.8	6.2	3.5	4.0	3.8	4.8
10	6.4	7.0	6.2	3.8	4.1	3.9	4.6
11	5.8	6.3	6.2	3.8	4.2		4.4
12	5.5	5.8	6.0	3.9	4.2	4.0	4.4
13	5.2	5.6	5.0	4.0	4.2		4.3
14	5.1	5.1	4.8	4.1	4.4	4.1	4.3
15	5.0	5.1	4.7	4.4	4.5	4.2	
16	4.9	5.0	4.6	4.7	4.6	4.3	4.4
17	4.9	5.0	4.5	4.7	4.7		4.5
18	5.0	5.1	4.5	4.8	4.8	4.6	4.6
19			4.5	4.8	4.8	4.7	4.7

TABLE 1 (cont.)

DEPTH (m)	DATE					
	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72
0	19.4	21.4	20.6	21.0	12.8	6.0
1	19.4	20.8	20.6	21.0	13.1	6.0
2	19.0	19.7	20.6	20.9	13.1	6.0
3	13.8	17.6	20.6	20.5	13.1	6.0
4	9.2	13.5	19.1	19.2	13.1	6.0
5	7.3	9.1	12.0	15.4	13.1	6.0
6	6.4	7.7	9.3	11.2	13.1	6.0
7	5.9	6.6	7.6	8.9	12.3	6.0
8	5.6	6.2	7.0	7.8	9.0	6.0
9	5.3	5.7	6.3	6.9	7.5	6.0
10	4.9	5.3	5.9	6.3	6.6	6.0
11	4.4	5.1	5.4	5.8	5.9	6.0
12	4.2	4.8	5.0	5.4	5.1	6.0
13	4.2	4.6	4.8	5.1	5.0	6.0
14	4.1	4.6	4.7	4.9	4.9	5.2
15	4.0	4.5	4.6	4.8	4.8	5.1
16	4.0	4.5	4.6	4.8	4.7	5.0
17	4.2	4.6	4.6	4.8	4.7	5.0
18	4.2	4.7	4.7	4.9	4.7	5.0
19	4.3	4.7	4.8	4.9	4.8	5.1

TABLE 2. Secchi disc visibilities (meters) and colours observed at half Secchi depth in Lake 120, 1968-1972.

	12/11/68	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69	16/9/69
SECCHI DEPTH	3.9	5.0	6.2	6.0	6.7	6.3	5.0
SECCHI COLOUR	yellow	brown green		yellow	yellow	yellow brown	
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
SECCHI DEPTH	6.0	6.2	5.2	5.0	4.2	4.2	4.0
SECCHI COLOUR	yellow	turbid	yellow orange	orange turbid	yellow orange	orange turbid	orange turbid
	8/5/70	21/5/70	28/5/70	16/6/70	7/7/70	20/7/70	7/8/70
SECCHI DEPTH	4.0	4.3	4.7	4.3	4.8	5.0	2.5
SECCHI COLOUR	yellow brown	yellow brown	yellow orange	green yellow	yellow turbid	yellow turbid	yellow green
	11/9/70	28/9/70	26/10/70	9/11/70	28/4/71	10/5/71	27/5/71
SECCHI DEPTH	5.2	6.0	3.8	3.8	4.8	4.1	4.3
SECCHI COLOUR	green yellow	green yellow	green yellow	green yellow			

TABLE 2 (cont.)

	10/6/71	21/6/71	8/7/71	9/8/71	23/8/71	20/9/71	25/10/71
SECCHI DEPTH	4.5	4.0	4.6	4.2	4.1	4.2	5.5
SECCHI COLOUR		green yellow	yellow	yellow brown	green	yellow green	brown
	3/11/71	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72
SECCHI DEPTH	4.1	4.2	3.8	5.3	4.2	4.5	4.5
SECCHI COLOUR	yellow brown	yellow green	yellow green	yellow green	green	yellow green	yellow green
	23/10/72						
SECCHI DEPTH	2.6						
SECCHI COLOUR	orange						

TABLE 3. Depth profiles of percentage light transmittance in Lake 120, 1971-1972. 100% transmittance was taken to be at 0.1 meters.

DEPTH (m)	DATE						
	27/5/71	21/6/71	19/7/71	23/8/71	20/9/71	25/10/71	8/5/72
0.1	100	100	100	100	100	100	100
0.25	82	90	90	90	80	78	90
0.5	61	64	78	76	70	48	78
1	44	42	50	58	38	18	64
2	22	25	21	39	25	1.2	34
3	10	18	18	21	12	0.4	20
4	8	9	9	10	7	0.09	12
5	4.7	4.2	5.2	6.1	4.1		5
6	2.1	2.6	2.8	4.0	2.0		3.8
7	0.9	1.2	1.4	2.1	0.9		1.4
8	0.5	0.8	0.74	0.9	0.5		0.75
9	0.25	0.42	0.42	0.5	0.26		0.40
10	0.10	0.2	0.22	0.24	0.14		0.20
11	0.04	0.1	0.14	0.12	0.08		0.09
12	0.007	0.05	0.064	0.058	0.05		
13			0.035	0.030			

TABLE 3 (cont.)

DEPTH (m)	DATE					
	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72
0.1	100	100	100	100	100	100
0.25	84	92	92	88	88	80
0.5	76	84	74	76	76	62
1	30	60	42	45	44	36
2	19	26	30	24	18	14
3	9	6.4	20	18	10.8	8
4	3.8		16	8	6.8	4
5	3.4	3.2	6.8	4.2	3.6	1.6
6	2.6	2.6	3.6	1.2	1.9	0.8
7	1.4	2.0	2.8	0.60	1.0	0.08
8	0.72	1.6	0.75	0.36	0.44	0.058
9	0.4	0.64	0.43	0.12	0.21	
10	0.21	0.38	0.28	0.064	0.12	
11	0.10	0.22	0.16	0.038	0.064	
12	0.055	0.15	0.09	0.026	0.024	
13		0.05	0.05	0.020		
14		0.023				

TABLE 4. In situ conductivities measured in Lake 120, 1969-1971. Units of conductance are $\mu\text{mhos cm}^{-1}$ at 25°C.

DEPTH (m)	DATE						
	22/1/69	22/4/69	15/5/69	6/7/69	22/8/69	16/9/69	16/10/69
1	<40	<40	<40	<40	<40	<40	<40
13			<40		38	<40	<40
13.5					43		
14	<40	<40	63	<40	52	42	50
14.5					125		
15	90	80	110	103	215	100	100
15.5					335		
16	280	190	300	340	520	300	320
16.5					760		
17	800	590	590	650	860	690	660
17.5	800		920		970		
18			980	830	1030	975	960
18.5					1010	1000	1000
19					980	930	975

TABLE 4. (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	10/4/70	8/5/70	28/5/70	16/6/70	20/7/70
1	<40	<40	<40	<40	<40	<40	<40
13			<40				<40
13.5					<40	<40	59
14	<40	38	42	<40	62	63	90
14.5				42	110	126	169
15	130	100	125	94	220	200	250
15.5					340	335	335
16	350	390	380	320	500	470	470
16.5					700	710	625
17	700	710	740	660	850	890	730
17.5				940	970	990	810
18	975	1000	1000	950	1050	1010	830
18.5	978		1030				
19	950	1000			1020	1000	810

TABLE 4.(cont.)

DEPTH (m)	DATE		
	22/2/71	21/6/71	3/11/71
1	<40	<40	<40
11			<40
12			45
13	<40	<40	76
13.5	61		
14	77	77	102
14.5	112		
15	193	157	154
15.5	340		
16	490	360	360
16.5	600		
17	730	662	710
17.5	820		
18	850	1150	1080
18.5	830	1110	
19			1000

TABLE 5. Individual determinations of pH in Lake 120, 1969-1972.

DEPTH (m)	DATE						
	16/9/69	21/5/70	28/5/70	16/6/70	26/10/70	10/5/71	27/5/71
0	6.37						
1	6.46	6.03	5.80	4.63	6.61	6.28	7.05
2							6.76
3							6.59
5	6.30	5.86	5.91	6.17	6.37	6.06	6.29
7	5.87						6.09
8		5.94	5.71	6.03	6.28	6.07	6.05
10	5.71						6.06
11		5.73	5.89		5.70	6.10	6.00
12	5.51						6.02
13							6.54
14		5.81	5.94	4.47	6.17	6.63	6.64
16		6.41	6.48	6.45	6.44	6.66	6.67
18		6.48	6.56	6.63	6.46	6.68	
Outflow					6.48	6.33	

TABLE 5 (cont.)

DEPTH (m)	21/6/71	19/7/71	23/8/71	DATE 20/9/71	25/10/71	14/12/71	15/2/72
1	6.75	6.43	6.66	6.55	6.35	6.27	6.23
2	6.76						
3	6.61	6.51	6.83	6.51	6.39	6.30	6.24
5	6.44	6.30	6.64	6.52	6.39		6.20
7	6.02	6.01	6.12	6.04	6.35	6.28	
8	6.16	6.00	6.08	6.26	6.32		6.10
10	6.06	5.89	5.94	5.89	5.91	6.23	
11	6.04	5.85	5.89	5.76	5.81		6.02
13	5.91	5.74	6.05	6.34	5.90		
14	6.19	6.14	6.67	6.58		6.17	5.76
16	6.65	6.61	6.69	6.65		6.48	6.22
18	6.71	6.64	6.73	6.70		6.68	6.59
Outflow	6.81	6.33	6.85	6.39			

TABLE 5 (cont.)

DEPTH (m)	DATE						
	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72
1	6.37	6.17	6.36	6.52	6.62	6.50	6.43
3	6.40	6.14	6.43	6.59	6.70	6.48	6.46
5	6.27	6.11	6.20	6.48	6.67	6.59	6.51
6					6.55	6.29	
7		6.08	6.07	6.07	6.21	6.58	6.49
8	6.21	6.06	5.98	6.04	6.00	6.00	5.99
10		6.01	5.88	5.92	5.97	5.92	5.95
11	6.00	5.99	5.86	5.90	5.94	5.87	5.90
13		6.00	5.85	5.86	5.94	5.96	6.04
14	5.94	5.99	5.84	5.93	5.95	6.34	6.40
16	6.66	6.18	6.34	6.64	6.67	6.70	6.72
18	6.68	6.66	6.61	6.67	6.70	6.69	6.73
Outflow		6.51	6.32	6.51			6.63

TABLE 5 (cont.)

DEPTH		DATE
(m)	23/10/72	
1	6.39	
3	6.41	
5	6.46	
7	6.39	
8	6.40	
10	6.39	
11	6.31	
13	6.38	
14	6.38	
16	6.70	
18	6.70	

TABLE 6. Individual determinations of dissolved oxygen (O_2) in Lake 120, 1968-1972. Units of concentration are $mg\ liter^{-1}$.

DEPTH (m)	DATE						
	12/11/68	6/7/69	6/9/69	21/9/69	2/10/69	9/10/69	16/10/69
0	9.25						
1	9.25	8.67	7.54	8.22	8.58	9.08	
4		10.00	7.73				
5	9.10			8.10	8.60	9.04	9.02
6		7.83	7.00				
7				4.68			
8					3.83	3.14	8.99
9	9.15		2.97				
10				1.09			
11					0.40	0.26	0.27
12			T ⁺				
13	8.95			UD			
14		UD			UD	UD	UD
15			UD	UD			
16					UD	UD	UD
17	UD*	UD*					
18			UD	UD	UD	UD	UD

+ T = Trace

*UD = Undetectable

TABLE 6 (cont.)

DEPTH (m)	DATE						
	24/10/69	31/10/69	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70
1	8.52	7.76	11.34		10.16	9.74	9.46
5	9.27	9.33	10.14	9.36	8.20	8.96	10.44
8	9.12	9.36	9.64	8.36	5.56	2.80	9.66
11	9.13	9.00	8.68	7.68	3.56	2.40	5.44
14	UD	2.25	4.62	5.36	UD	0.82	1.30
16	UD	UD	UD	UD	UD	UD	UD
18	UD	UD	UD	UD	UD	UD	UD
	28/5/70	16/6/70	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70
1	10.18	8.96	8.52	8.68	8.44	9.26	10.04
5	8.60	9.68	10.56	12.00	12.40	9.40	9.88
8	7.54	7.12	6.06	6.98	6.60	5.28	4.36
11	5.36	4.68	3.44	3.26	1.82	1.14	1.00
14	1.44	0.36	0.26	0.26	0.68	0.20	UD
16	UD	UD	UD	UD	UD	UD	UD
18	UD	UD	UD	UD	UD	UD	UD

+ T = Trace

*UD = Undetectable

TABLE 6 (cont.)

DEPTH (m)	DATE						
	26/10/70	9/11/70	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71
1	10.40	9.80	10.76	10.20	9.68	10.48	10.00
5	10.00	9.68	10.20	9.60	8.04	17.40	8.18
8	9.64	9.80	9.60	9.00	6.56	10.58	7.42
11	1.08	9.68	8.82	6.84	2.80	1.64	7.00
14	UD	2.40	5.64	2.36	UD	UD	UD
16	UD	UD	UD	UD	UD	UD	UD
18	UD	UD	UD	UD	UD	UD	UD

	27/5/71	10/6/71	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71
1	10.10	10.02	8.31	9.16	8.01		8.95
2	9.83						
3	9.60		10.14		8.15		8.85
5	8.51	9.50	10.00	9.84	9.27	8.78	8.90
7	7.49		6.70		6.34		5.17
8	6.95	9.40	6.80	6.40	6.35	6.48	6.11
10	6.79		5.61		4.48		2.44
11	6.16	5.40	4.60	4.20	3.37	4.40	1.40
13	1.70		0.80		0.24		UD
14	0.10	0.38	0.86	UD	UD	1.20	UD
16	UD	UD	UD	UD	UD	UD	UD
18	UD	UD	UD	UD	UD	UD	UD

+ T = Trace

*UD = Undetectable

TABLE 6 (cont.)

DEPTH (m)	DATE						
	20/9/71	6/10/71	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72
1	8.80	9.25	9.81	9.75	10.70	9.57	10.11
3	8.80		10.00		10.17	9.28	9.43
5	8.70	9.20	9.80	9.54	10.14	8.76	8.61
7	4.30		9.51		9.97		
8	3.55	3.10	9.40	9.62		7.20	6.15
10	1.75		0.40		9.00		
11	1.20	0.26	0.45	7.25		4.61	2.58
12				3.14			
13	UD		0.20	UD			
14	UD	UD		UD	5.99	UD	1.13
15				UD			
16	UD	UD		UD	1.10	UD	UD
17				UD			
18	UD	UD		UD	UD	UD	UD
	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72
1	10.00	8.25	8.31	8.31	8.20	9.30	9.94
3	10.55	8.59	8.99	8.39	8.27	9.50	10.13
5	8.77	9.80	10.73	10.99	10.08	9.78	9.98
6				11.46			
7	8.98	8.30	7.21	8.89	12.40	9.72	9.79
8	8.78	7.87	7.05	6.21	5.90	4.70	10.01
10	7.59	6.22	5.22	4.75	3.24	3.33	9.84
11	8.07	5.53	4.50	3.81	2.69	0.50	9.69
13	6.11	4.08	1.73	1.15	0.10	0.19	10.09
14	6.19	3.18	1.01	UD	UD	UD	0.63
16	1.99	UD	UD	UD	UD	UD	UD
18	UD	UD	UD	UD	UD	UD	UD

+ T = Trace

*UD = Undetectable

TABLE 7. Individual determinations of total carbon dioxide ($\text{CO}_2 + \text{H}_2\text{CO}_3 + \text{HCO}_3^- + \text{CO}_3^{=}$) in Lake 120, 1969-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	16/9/69	24/10/69	10/12/69	21/5/70	28/5/70	16/6/70	26/10/70
0	71						
1	66	31	115	172	137	232	116
3	63	46					
5	93	46		268	280	189	100
7	259	43					
8				195	413	254	106
10	377	38					
11				349	317		
12	437						
14		349	257	693	463	2810	483
16	1624	1120	3407	4470	4300	2900	2200
18	5653	8200	5142	17200	15940	14330	2000
Outflow							104

TABLE 7 (cont.)

DEPTH (m)	DATE						
	10/5/71	27/5/71	21/6/71	19/7/71	23/8/71	20/9/71	25/10/71
1	368	118	76	55	61	71	101
2		119					
3		109	72	54	62	86	106
5	389	115	76	97	82	84	99
7		278	122	195	264	312	115
8	257	313	239	205	259	316	114
10		339	228	252	351	349	375
11	415	371	258	287	362	367	384
13		628	304	349	483	545	442
14	1720	1100	420	455	1400	734	
16	8850		561	6800	4470	3750	
18	13750	2910	7680		12320	9925	
Outflow	54		94	54	65	74	147

TABLE 7 (cont.)

DEPTH (m)	3/11/71	14/12/71	15/2/72	DATE 4/5/72	8/5/72	5/6/72	26/6/72
1	124	148	176	190	236	82	90
3		153	170	197	233	95	79
5	132		178	205	238	154	114
7		163			248	192	235
8	141		219	264	263	219	246
10		185			292	247	301
11	194		303	376	260	221	302
12	304						
13	551				365	299	387
14	629	285	415	430	352	315	437
15	1110						
16	6500	826	668	884	592	662	3280
17	7200						
18	12150	8700	5910	5650	6700	4440	7240
Outflow	130				218	112	100

TABLE 7 (cont.)

DEPTH (m)	DATE			
	24/7/72	28/8/72	25/9/72	23/10/72
1	73	86	90	140
3	79	85	99	137
5	87	91	87	133
6	112	160		
7	203	174	96	139
8	273	310	234	139
10	298	347	343	126
11	328	392	391	136
13	446	481	426	143
14	443	625	598	
15				592
16	3290	2750	3440	
17				2400
18	8530	7160	6580	7710
Outflow	128		34	

TABLE 8. Individual determinations of methane (CH_4) in Lake 120, 1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72
1	UD*	2	UD	12	UD	UD	UD
3	UD	UD	UD	12	UD	UD	UD
5	UD	UD	UD	20	1	UD	UD
6						UD	1
7			UD	16	UD	UD	57
8	UD	UD	UD	17	UD	UD	57
10			UD	14	UD	UD	UD
11	UD	UD	UD	15	1	UD	UD
13			UD	16	UD	UD	17
14	UD	UD	UD	11	15	19	104
16	114	264	4	184	3340	3280	2650
18	5970	5210	3410	10800	5460	6480	5560
Outflow				8	1	1	

* UD = Undetectable

TABLE 8 (cont.)

DEPTH (m)	DATE	
	25/9/72	23/10/72
1	UD	1
3	UD	1
4	UD	1
7	UD	1
8	UD	1
10	UD	UD
11	UD	UD
13	9	UD
14	83	143
16	2680	1370
18	4380	8490
Outflow	UD	

TABLE 9. Individual determinations of dissolved organic carbon (DOC) in Lake 120,
1971-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	27/5/71	21/6/71	19/7/71	23/8/71	20/9/71	25/10/71	14/12/71
1	690	614	653	32	529	421	
2	674	594					
3	726	624	635	45	458	555	602
5	746	508	513	478	608	401	58
7	691	552	526	42	471	355	592
8	703	549	487	419	27	585	
10	720	575	526	536	466	473	549
11	734	558	551	55		343	
13	687	709	495	217	699	361	
14	1197	716	505	249		483	501
16	2614	2061	3525	6746	2032	2422	1230
18	7056	4779	4647	6303		3680	5096
Outflow	714	886	625	1345	530	358	

TABLE 9 (cont.)

DEPTH (m)	DATE						
	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72
1	345	563	420	470	346	348	179
3		557	440	463	392	288	324
5		475	387	393	382	436	99
6						339	
7			442	441	353	421	163
8	507		408	357	361	224	221
10			422	447	291	188	334
11		437	437	188	263	394	203
13			402	422	346	256	187
14	399	415	460	391	382	154	236
16	476	563	498	742	1516	7310	1857
18		2363	2258	3450	5282	9232	3742
Outflow			421	393	388	424	306

TABLE 9 (cont.)

DEPTH (m)	DATE	
	25/9/72	10/23/72
1	470	561
3	395	
5	390	431
7	390	433
8	315	367
10	314	326
11	353	401
13	327	440
14	371	513
16	2412	1346
18	4361	5486
Outflow	308	

TABLE 10. Individual determinations of nitrate plus nitrite nitrogen ($\text{NO}_3 + \text{NO}_2\text{-N}$) in Lake 120, 1968-1972. Units of concentration are $\mu\text{moles N liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	6/9/69	16/9/69
0	2.0						
1	1.4	1.6	0.2	0.1	UD*	4.9	0.1
4				0.2	UD	0.1	
5	0.7						0.1
6				0.1	UD	0.3	
9	0.7						
10							1.0
12			4.6				
13	0.6					0.3	
14				1.8	0.6		
15			0.4			UD	
17	6.6		0.9	2.9	6.5		
18						5.9	

* UD = Undetectable

TABLE 10 (cont.)

DEPTH (m)	DATE						
	2/10/69	9/10/69	31/10/69	26/2/70	8/5/70	21/5/70	28/5/70
1	0.1	0.2	0.4	0.7	2.8	1.8	0.9
5	0.1	0.1	0.2	1.2	1.9	2.4	1.3
8	UD	0.1	0.4	4.3	5.6	2.1	2.8
11	0.9	0.4	0.2	9.5	8.6	5.2	3.9
14	0.4	0.3	0.5	1.9	6.6	5.3	6.4
16	0.6	2.2	2.5	1.1	4.0	2.0	4.6
18	2.4	18	14	UD	UD	9.4	7.5
Outflow					1.6		0.6
	16/6/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70	9/12/70
1	UD	UD	0.1	UD	0.2	0.3	0.1
5	UD	UD	UD	UD	UD	0.2	0.1
8	1.9	UD	UD	UD	UD	0.2	UD
11	4.8	8.0	1.6	0.1	0.1	0.2	0.4
14	3.4	2.5	0.9	0.3	0.3	0.1	0.5
16	UD	2.7	0.9	0.6	0.9	0.3	1.3
18	2.9	9.5	1.4	0.7	5.1	1.6	1.4
Outflow	UD	UD	0.6	0.2	0.3	0.4	0.3

* UD = Undetectable

TABLE 10 (cont.)

DEPTH (m)	DATE						
	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71
1	0.6	0.2	0.1	1.5	UD	0.2	0.1
2					UD		
3					UD		0.6
5	UD	0.2	0.1	2.1	1.0	1.1	0.1
7					0.9		0.9
8	0.7	1.5	0.1	2.3	1.9	2.5	1.1
10					1.9		2.6
11	1.7	7.1	7.1	2.3	2.4	2.0	3.0
13					0.2		2.5
14	2.6	1.6	0.4	0.4	0.9	2.1	0.6
16	1.1	12	5.4	1.8	0.1	2.0	1.2
18	1.0	34	24	UD	0.1	2.3	0.1
Outflow			0.1	5.5	0.1	0.8	1.6

TABLE 10 (cont.)

DEPTH (m)	DATE						
	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71	25/10/71
1	0.1	0.2	0.4	0.1	UD	0.1	0.2
3		0.2		0.1	UD		0.1
5	0.1	0.1	0.1	0.1	UD	UD	0.1
7		0.7		0.2	UD		0.2
8	1.1	0.9	1.1	0.1	UD	UD	0.1
10		2.7		6.2	2.7		7.6
11	2.8	4.9	5.9	7.1	3.1	7.9	8.7
13		4.9		0.4	0.1		1.1
14	1.0	3.7	0.3	0.2	0.3	0.5	
16	2.7	5.4	0.5	0.5	0.9	3.1	
18	1.3	4.6	2.4	0.4	0.4	3.2	
Outflow	0.7	1.4	0.5	0.4	0.2	UD	0.1

TABLE 10 (cont.)

DEPTH (m)	DATE						
	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72
1	0.6	0.4	0.8	0.9	4.4	0.1	UD
3		0.4	1.1	0.9	4.1	0.1	0.1
5	0.5	0.4	1.1	1.4	3.8	0.1	0.1
7		0.3			4.1	0.4	0.4
8	0.5		1.9	5.6	4.4	0.8	0.5
10		0.3			4.4	2.5	2.1
11	0.8		7.8	8.9	4.5	2.9	3.0
12	0.5						
13	0.4				5.5	3.8	5.1
14	0.6	0.4	6.1	7.5	5.1	4.9	3.3
15	1.0						
16	0.8	0.6	0.5	0.1	3.2	1.8	4.4
17	0.8						
18	0.9	0.6	1.1	0.5	0.9	0.4	6.0
Outflow	0.9				4.1	0.1	0.3

TABLE 10 (cont.)

DEPTH (m)	DATE			
	24/7/72	28/8/72	25/9/72	23/10/72
1	0.3	0.1	0.1	0.1
3	0.1	0.1	0.1	UD
5	0.2	0.1	0.1	UD
6	0.1			
7	0.2	0.1	0.1	UD
8	1.2	0.1	0.1	UD
10	3.8	1.6	0.6	UD
11	5.5	3.3	1.9	UD
13	7.9	0.2	0.4	UD
14	0.6	0.4	0.6	0.9
16	1.6	0.7	1.4	3.3
18	1.6	0.5	1.0	18
Outflow	0.2	0.1	0.2	

TABLE 11. Individual determinations of ammonia nitrogen ($\text{NH}_3\text{-N}$) in Lake 120, 1969-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	15/5/69	6/7/69	20/7/69	16/9/69	2/10/69	9/10/69	16/10/69
1	0.6	2.3	0.1	0.4	0.1	19	2.9
4		1.4	0.1				
5				0.5	0.4	12	0.1
6		1.2	0.3				
8					0.8	4.9	6.4
10				0.2			
11					1.5	1.1	8.9
12	0.5						
14		143	15		104	255	178
15	200						
16					308	510	1765
17	3570	1520	1455				
18					1870	2120	1675

* UD = Undetectable

TABLE 11 (cont.)

DEPTH (m)	DATE						
	24/10/69	31/10/69	13/11/69	10/12/69	22/1/70	26/2/70	8/5/70
1	0.1	1.3	UD*	4.9	16	1.7	2.8
5	1.9	0.6	1.6	5.1	13	1.3	2.6
8	0.7	0.1	2.3	6.1	11	1.9	0.4
11	1.0	2.6	7.0	9.6	31	0.3	1.8
14	153	19	18	33	39	21	4.6
16	1865	948	806	832	93	270	248
18	2335	2200	2295	2325	670	300	422
Outflow							0.6
	21/5/70	28/5/70	16/6/70	7/7/70	20/7/70	7/8/70	11/9/70
1	UD	0.4	0.2	UD	0.1	0.2	0.5
5	1.1	0.4	0.1	0.4	0.1	0.8	0.1
8	UD	0.4	0.6	0.1	0.4	0.3	0.1
11	UD	UD	1.1	0.1	0.8	0.2	0.4
14	7.8	1.1	2.6	9.2	21	12	11
16	226	334	272	250	442	554	420
18	159	458	426	316	1720	1870	1925
Outflow		0.2	0.4	UD	0.4	0.9	0.6

TABLE 11 (cont.)

DEPTH (m)	DATE						
	28/9/70	26/10/70	9/11/70	9/12/70	20/1/71	22/2/71	28/4/71
1	UD	1.7	0.1	0.5	0.2	1.6	2.4
5	UD	0.4	UD	0.7	0.6	1.0	0.3
8	UD	0.4	0.4	0.4	0.4	0.8	0.1
11	UD	0.8	0.8	0.4	0.6	UD	0.4
14	34	16	22	2.1	14	13	29
16	612	335	592	324	204	124	588
18	2305	2000	2105	1920	2345	1075	2085
Outflow	0.3	1.2	0.1	0.6			UD
	10/5/71	27/5/71	10/6/71	21/6/71	8/7/71	19/7/71	9/8/71
1	0.2	0.5	0.9	0.9	1.3	5.3	0.3
2		0.4					
3		0.1		0.3		2.5	
5	4.1	0.1	1.1	0.4	0.8	0.5	0.1
7		0.1		1.2		0.5	
8	1.5	0.1	0.9	1.5	1.0	0.3	0.1
10		0.1		1.9		1.2	
11	2.0	0.1	1.4	2.6	2.3	5.3	0.4
13		2.9		7.7		3.4	
14	32	20	28	23	17	11	23
16	594	418	628	1400	584	1045	101
18	1930	1860	2285	2300	1820	1550	1070
Outflow	UD	0.4	0.6	1.8	5.5	1.6	1.6

TABLE 11 (cont.)

DEPTH (m)	DATE						
	23/8/71	20/9/71	6/10/71	25/10/71	3/11/71	14/12/71	15/2/72
1	0.5	0.5	0.4	0.5	0.9	1.2	3.9
3	0.4	0.5		0.1		1.4	3.8
5	0.8	0.5	0.1	0.5	0.9	1.2	3.1
7	0.4	0.5		0.5		1.4	
8	0.3	0.1	0.3	0.5	0.9		3.1
10	0.4	0.1		0.7		13	
11	0.1	0.6	0.1	0.4	2.3		1.4
12					3.4		
13	6.9	11		0.5	15		
14	104	32	22		25	7.1	8.4
15					86		
16	522	566	383		846	72	43
17					1020		
18	1980	1960	2380		1800	1390	764
Outflow	5.4	20	UD	0.5	2.1		

TABLE 11 (cont.)

DEPTH (m)	DATE						
	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72
1	2.0	0.5	2.3	1.3	0.6	0.6	1.0
3	2.0	UD	1.0	1.3	0.5	0.4	0.4
5	3.0	UD	2.3	1.1	0.6	0.4	0.4
6					0.5		
7		UD	1.0	1.1	0.6	0.4	0.6
8	1.1	UD	0.4	1.0	0.6	0.9	0.4
10		UD	1.3	1.1	0.6	0.4	0.6
11	4.5	UD	1.0	1.3	1.6	0.5	1.2
13		UD	1.8	2.1	0.9	4.9	2.8
14	3.6	1.2	3.1	8.6	13	17	21
16	55	13	31	526	451	387	588
18	754	677	869	1720	2220	1980	1240
Outflow		0.0	1.4	2.3	1.1	1.9	4.4
23/10/72							
1	0.5						
3	0.4						
5	0.4						
7	0.4						
8	0.1						
10	0.4						
11	0.4						
13	0.5						
14	26						
16	241						
18	1860						

TABLE 12. Individual determinations of total dissolved nitrogen (TDN) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	6/9/69	9/10/69
0	21						
1	14	12	7.8	9.9	6.9	7.5	6.9
4				10	7.8		
5	12					7.5	10
6				8.6	8.0		
8							8.0
9	18						
10						8.6	
11							8.7
12			13				
13	16						
	31/10/69	13/11/69	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70
1	7.6	7.4	11	15	8.3	15	UD*
5	7.2					21	4.9
8	6.9	8.6	10	13	11	20	0.1
11	6.6	8.0	11	14	15	17	0.4
Outflow						19	

* UD = Undetectable

TABLE 12 (cont.)

DEPTH (m)	DATE						
	28/5/70	7/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	UD	3.2	21	18	18	20	27
5	UD	4.2	21	19	17	16	27
8	UD	6.4	21	21	20	15	27
11	UD	12	24	19	18	16	26
Outflow	UD	2.7	71	20	16	19	30
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71
1	14	19		17	17	9.4	21
2						10	
3						11	
5	8.8	19	28	15	18	11	26
7						9.9	
8	8.6	19	29	16	16	9.4	23
10						7.7	
11	10	22	41	19	17	12	24
13						12	
Outflow	7.8			16	14	12	23

TABLE 12 (cont.)

DEPTH (m)	DATE						
	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71
1	13	21	18	17	28	9.1	16
3	12		16		22	7.4	
5	13	19	9.6	17	28	12	13
7	14		13		23	6.6	
8	20	17	13	20	18	9.1	15
10	14		14		21	11	
11	17	20	17	20	23	13	16
13	20		17		51	11	
Outflow	17	11	13	19	33	18	15
	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72
1	13	12	11	16	14	20	13
3	13		11	13	13	17	13
5	13	16	12	14	14	14	12
7	13		12			16	12
8	11	11		14	15	15	12
10	13		17			16	17
11	16	13		15	19	16	15
12		13					
13	14	22				16	16
Outflow	15	14				14	12

TABLE 12 (cont.)

DEPTH (m)	DATE				
	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72
1	15	11	17	17	17
3	12	10	13	13	12
5	14	11	12	13	16
6		10			
7	15	11	12	12	
8	14	11	11	11	16
10	17	14	15	13	16
11	14	13	19	14	15
13	16	17	16	18	13
Outflow	12	12	13	17	

TABLE 13. Individual determinations of soluble reactive phosphorus (SRP) in Lake 120, 1968-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	6/7/69	20/7/69	6/9/69	16/9/69	2/10/69
0	0.1						
1	<0.1	0.3	UD*	0.1	0.5	<0.1	0.1
4			<0.1	<0.1	<0.1		0.1
5	<0.1					<0.1	
6			UD	0.1	1.2		
8							0.1
9	0.1						
10						<0.1	
11							<0.1
13	<0.1				0.6		
14			<0.1	<0.1			<0.1
15					0.2		
16							0.1
17	<0.1		0.1	UD	0.5		
18							0.4

* UD = Undetectable

TABLE 13 (cont.)

DEPTH (m)	DATE						
	31/10/69	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70	17/7/70
1	<0.1	UD	0.3	UD	UD	UD	<0.1
4	<0.1	UD					
5			0.3	UD	UD	UD	UD
8	<0.1	UD	0.2	UD	UD	UD	<0.1
11	<0.1	UD	0.1	UD	UD	UD	UD
14	<0.1	UD	0.1	UD	UD	UD	UD
16	<0.1	UD	0.3	0.1	0.1	UD	0.2
18	0.4	UD	0.5	0.8	0.3	0.4	0.3
Outflow			0.1		UD	UD	UD
	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70	9/12/70
1	0.1	<0.1	UD	0.1	UD	UD	UD
5	<0.1	<0.1	UD	0.1	UD	UD	UD
8	0.1	0.1	<0.1	0.1	UD	UD	UD
11	0.1	<0.1	<0.1	0.1	UD	0.1	UD
14	<0.1	0.1	UD	0.1	UD	UD	UD
16	0.1	0.1	0.1	0.1	<0.1	0.1	<0.1
18	0.3	0.2	0.7	1.9	0.1	0.4	0.5
Outflow	0.1	<0.1	UD	0.1	UD	UD	UD

TABLE 13 (cont.)

DEPTH (m)	DATE						
	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71
1	UD	UD	UD	UD	UD	0.1	0.2
2					UD		
3					UD		0.1
5	UD	<0.1	UD	UD	0.1	0.1	<0.1
7					UD		<0.1
8	UD	<0.1	UD	0.1	<0.1	0.3	<0.1
10					UD		0.1
11	UD	UD	UD	0.1	0.1	0.1	0.3
13					0.1		0.2
14	UD	0.2	UD	0.1	0.1	0.1	0.2
16	0.1	0.2	0.1	0.5	0.2	0.2	0.5
18	1.0	0.2	0.4	0.5	1.0	0.4	2.0
Outflow			UD	0.1	UD	0.1	0.1

TABLE 13 (cont.)

DEPTH (m)	DATE						
	8/7/71	19/7/71	9/8/71	20/9/71	6/10/71	25/10/71	3/11/71
1	UD	<0.1	<0.1	UD	<0.1	UD	<0.1
3		0.2	0.2	0.1		UD	
5	UD	0.1		<0.1	<0.1	UD	<0.1
7		0.1		0.1		<0.1	
8	UD	0.1	<0.1	0.1	0.1	UD	<0.1
10		0.1		<0.1		<0.1	
11	UD	0.1	UD	0.1	<0.1	<0.1	<0.1
12							<0.1
13		0.1		<0.1		UD	<0.1
14	UD	0.1	0.1	<0.1	0.1		0.1
16							0.1
16	0.1	0.2	0.2	0.1	0.1		0.2
17							0.2
18	0.9	0.2	0.5	0.7	0.9		0.8
Outflow	UD	<0.1	0.2	0.2	0.1	<0.1	<0.1

TABLE 13 (cont.)

DEPTH (m)	DATE		
	14/12/71	15/2/72	4/4/72
1	<0.1	<0.1	<0.1
3	0.1	0.1	<0.1
5	<0.1	<0.1	<0.1
7	<0.1		
8		<0.1	<0.1
10	0.1		
11		<0.1	<0.1
14	0.1	0.1	0.1
16	<0.1	0.1	0.1
18	0.3	0.2	0.2

TABLE 14. Individual determinations of total dissolved phosphorus (TDP) in Lake 120,
1970-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	21/5/70	28/5/70	16/6/70	7/7/70	7/8/70	11/9/70	28/9/70
1	0.3	1.0	0.9	0.2	0.4	0.1	0.3
5	0.1	0.1		0.5	12.1	0.1	0.3
8	0.4	0.1	2.2	0.2	4.3	0.2	0.3
11	0.2	0.1	1.6	0.2	5.3	0.3	0.5
14	0.4	0.6	1.3	0.5	0.6	0.5	0.9
16	0.9	2.1	1.9	0.8	1.1	1.0	1.0
18	2.8	3.8	1.7	3.6	2.5	1.4	1.5
Outflow		0.2	UD*	0.1	8.4	0.3	0.2

* UD = Undetectable

TABLE 14 (cont.)

DEPTH (m)	DATE						
	26/10/70	9/11/70	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71
1	0.3	0.3	0.1	0.6	0.3	0.6	0.3
5	0.4	0.3	0.1	0.4	0.2	0.4	0.6
8	0.2	0.2	0.1	0.3	0.3	0.4	0.7
11	0.4	0.3	0.2	0.5	0.4	0.5	0.8
14	0.5	0.8	0.2	0.7	0.9	0.9	0.7
16	0.5	0.6	0.7	0.9		1.3	0.7
18	0.6	0.7	1.8	2.5		2.9	1.6
Outflow	0.2	0.5	0.1			0.3	1.4

TABLE 14 (cont.)

DEPTH (m)	DATE						
	27/5/71	10/6/71	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71
1	0.5	0.2	0.2	0.3	0.2	0.3	0.1
2	1.0						
3	0.5		0.2		0.3		0.1
5	0.9	0.4	0.4	0.3	0.5	≤0.1	0.1
7	0.5		0.2		0.2		UD
8	0.4	0.1	0.2	0.2	0.6	0.1	0.1
10	0.2	0.1	0.3	0.2	0.3		0.1
11	0.4		0.4		0.3	0.1	UD
13	0.5		2.6		0.3		0.4
14	0.4	0.5	0.4	0.6	0.4	0.7	0.3
16	0.5	0.9	0.6	1.0	0.7	0.9	0.4
18	1.4	3.7	1.8	3.3	0.8	1.9	5.4
Outflow	0.1	0.3	0.3	0.3		0.4	UD

TABLE 14 (cont.)

DEPTH (m)	DATE						
	20/9/71	6/10/71	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72
1	0.1	0.3	0.1	0.1	0.1	0.1	0.2
3	0.1		0.2		0.1	0.1	0.4
5	0.1	0.3	0.2	0.1	0.1	0.1	0.1
7	0.1		0.2		0.1		
8	0.2	0.3	0.2	0.1		0.1	0.7
10	0.2		0.2		0.1		
11	0.2	0.4	0.1	0.1		0.1	0.3
12				0.1			
13	0.1		0.2	0.2			
14	0.3	0.7		0.3	0.1	0.2	0.7
15				0.4			
16	0.5	0.9		0.7	0.1	0.2	0.3
17				0.7			
18	1.5	2.3		1.9	2.2	0.5	0.6
Outflow	0.3	0.3	0.2	0.2			

TABLE 14 (cont.)

DEPTH (m)	DATE						
	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72
1	0.2	0.2	0.1	<0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
6				<0.1			
7	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1
10	0.2	0.1	0.1	<0.1	0.1	0.1	0.1
11	0.1	0.1	0.2	<0.1	0.1	0.1	0.1
13	0.2	0.1	0.1	0.1	0.1	0.1	0.1
14	0.2	0.1	0.1	0.1	0.1	0.2	0.2
16	0.2	0.1	0.3	0.3	0.4	0.4	0.4
18	0.6	0.4	0.5	2.9	1.0	0.7	1.3
Outflow	0.1	0.1	0.1	0.1	0.1	0.1	

TABLE 15. Individual determinations of suspended particulate carbon (PC) in Lake 120, 1969-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	6/7/69	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71	8/7/71
1	430	128	62	72	68	37	54
2				48			
3				44		499	
4	475						
5		48	73	66	81	66	77
6	690						
7				62		55	
8		43	57	61	88	88	61
10				52		68	
11		54	45	50	75	239	57
13				53		74	
14	935	134	153	165	152	139	116
16		143	158	163	198	237	149
17	12700						
18		1830	996	211	1600		1790
Outflow		51	58	48	198	1040	

TABLE 15 (cont.)

DEPTH (m)	DATE						
	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71	25/10/71	3/11/71
1	65	68	60	96	71	31	70
3			57	64		63	
5	97	64	76	65	67	53	65
7	76		117	98		49	
8	75	78	117	93	67	60	53
10	49		68	51		51	
11	63	65	77	70	58	46	62
12							81
13	61		110	89		72	67
14	108	110	121	95	83		63
15							93
16	202	114	157	153	115		180
17							168
18	968	596	1020	382	320		347
Outflow	53	729	151	48	60		130

TABLE 15 (cont.)

DEPTH (m)	DATE						
	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72
1	48	58	108	65	47	33	46
3	45	39	101	73	48	39	47
5	41	38	60	57	65	68	43
6							63
7				51	64	66	
8		37	69	48	76	53	66
10	45			49	37	41	
11		33	73	44	54	42	30
13				48	59	43	33
14	49	76	130	52	70	61	52
16	83	110	318	102	162	96	96
18	204	159	309	141	245	688	529
Outflow				47	191	61	33

TABLE 15 (cont.)

DEPTH (m)	DATE		
	28/8/72	25/9/72	23/10/72
1	45	45	45
3	38	45	44
5	52	39	48
7	109	41	41
8	112	103	46
10	61	46	30
11	74	36	47
13	72	47	21
14	74	64	61
16	115	95	67
18	1110	163	236
Outflow	31	54	

TABLE 16. Individual determinations of suspended particulate nitrogen (PN) in Lake 120, 1969-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	22/4/69	6/7/69	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71
1	0.3	3.0	7.6	4.1	4.2	5.6	5.4
2					3.3		
3					3.1		3.7
4		3.2					
5			2.9	5.0	4.7	11	
6		5.6					
7					5.2		
8			2.6	2.9	4.7	16	
10					4.1		
11			2.9	2.4	2.6	32	
13					2.9		
14		17	14	16	15	12	
16			16	16	21	34	
17		50					
18			69	37	70	67	
Outflow			3.6	4.0	5.3	39	

TABLE 16 (cont.)

DEPTH (m)	DATE						
	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71	25/10/71
1	6.4		3.9	1.5	9.9	4.4	1.5
3				1.5	7.1		2.2
5	6.9		2.9	6.1	5.6	3.9	3.9
7		8.8		1.6	6.4		1.4
8	7.9	9.1	9.0	0.9	5.7	2.8	1.4
10		9.7		1.5	5.1		1.2
11	8.3	10	3.7	1.5	6.0	2.8	0.9
13		12		1.9	9.5		3.7
14	15	14	12	4.5	10	7.3	
16	45	31	10	9.9	19	7.7	
18	84	58	30	73	38	40	
Outflow	5.2		38	0.6	4.3	2.6	

TABLE 16 (cont.)

DEPTH (m)	DATE						
	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72
1	3.1	1.8	2.8	6.7	6.4	3.1	1.6
3		2.7	0.4	8.6	6.7	2.1	1.4
5	2.4	1.2	1.4	4.2	6.6	6.6	3.8
7					5.1	3.9	3.0
8	1.9	1.1	2.3	4.8	5.3	5.9	3.6
10		1.6			5.6	5.6	1.7
11	2.6		0.6	4.4	3.7	4.4	2.1
12	4.2						
13	3.6				4.4	2.9	1.7
14	3.9	3.9	6.1	9.1	9.7	4.9	6.4
15	7.5						
16	22	6.0	10	34	11	13	10
17	18						
18	37	24	19	37	17	22	30
Outflow	1.6				6.6	21	3.0

TABLE 16 (cont.)

DEPTH (m)	DATE			
	24/7/72	28/8/72	25/9/72	23/10/72
1	2.9	3.2	3.3	2.9
3	3.2	2.9	2.1	1.7
5	4.0	3.6	3.6	2.4
6	4.7			
7		8.4	2.9	1.6
8	3.9	5.4	5.9	3.3
10		3.9	2.2	1.4
11	2.1	5.4	2.9	3.3
13	3.1	6.1	1.6	0.2
14	5.1	6.4	6.0	5.2
16	13	13	11	6.3
18	48	57	19	24
Outflow	2.4	1.8	2.5	

TABLE 17. Individual determinations of suspended particulate phosphorus (PP) in Lake 120, 1969-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	6/7/69	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71	8/7/71
1	<0.1	0.3	0.2	0.1	0.1	0.1	0.1
2				0.1			
3				0.1		0.1	
4	<0.1						
5		0.2	0.2	0.1	0.1	0.2	0.1
6	<0.1						
7				0.1		0.2	
8		0.2	0.2	0.1	0.2	0.3	0.6
10				0.1		0.3	
11		0.2	0.2	0.1	0.1	0.2	0.1
13				0.2		0.3	
14	<0.1	0.9	0.8	1.0	0.7	0.5	0.8
16		1.4	0.7	0.8	0.8	0.9	1.0
17	<0.3						
18		2.1	1.9	1.5	0.9	2.0	2.7
Outflow		0.2	0.2	0.1		0.9	0.1

TABLE 17 (cont.)

DEPTH (m)	DATE						
	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71	25/10/71	3/11/71
1	0.9	0.2	0.3	0.1	0.4	0.2	0.1
3	<0.1		0.1	<0.1		0.2	
5	<0.1	0.2	0.5	<0.1	0.3	0.2	0.2
7	0.1		0.1	0.1		0.1	
8	<0.1	0.1	0.1	0.1	0.3	0.1	0.1
10	0.1		0.1	0.1		0.2	
11	0.1	0.2	0.1	0.2	0.3	0.2	0.3
13	0.2		0.4	0.5		0.4	0.4
14	0.5	0.7	0.6	0.5	0.6		0.4
15							0.5
16	1.1	0.6	0.6	0.7	0.3		0.9
17							0.9
18	1.6	1.0	1.3	1.9	1.5		1.5
Outflow	<0.1	1.4	0.3	<0.1	0.3	0.3	0.1

TABLE 17 (cont.)

DEPTH (m)	DATE						
	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72
1	0.2	0.1	0.1	0.2	0.2	0.2	0.1
3	0.2	0.1	0.1	0.3	0.1	0.1	0.1
5	0.1	<0.1	0.1	0.2	0.4	0.3	0.1
6							0.2
7	0.2			0.2	0.3	0.2	0.2
8		0.1	<0.1	0.1	0.3	0.2	0.1
10	0.1			0.2	0.3	0.2	0.1
11		0.1	0.1	0.1	0.2	0.2	0.1
13				0.2	0.2	0.3	0.2
14	0.2	0.2	0.2	0.2	0.2	0.4	0.6
16	0.1	0.9	0.9	0.7	1.0	0.5	0.9
18	1.4	0.9	0.7	0.9	1.1	1.6	3.5
Outflow				0.2	0.6	0.1	0.1

TABLE 17 (cont.)

DEPTH (m)	DATE		
	28/8/72	25/9/72	23/10/72
1	0.1	0.3	0.1
3	0.1	0.2	0.2
5	0.2	0.1	0.1
7	0.3	0.1	0.1
8	0.4	0.2	0.1
10	0.2	0.2	0.1
11	0.2	0.2	0.2
13	0.4	0.4	0.1
14	0.5	0.6	0.5
16	0.7	1.7	0.8
18	2.7	3.5	1.6
Outflow	0.1	0.2	

TABLE 18. Individual determinations of soluble reactive silicon (Si) in Lake 120, 1968-1972. Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	6/7/69	20/7/69	6/9/69	16/9/69	2/10/69
0	52						
1	68	4.8	51	62	52	43	58
4			49	63	50		
5	28					45	59
6			52	64	42		
8							62
9	36						
10						52	
11							83
13	39				78		
14			68	117			98
15					127		
16							238
17	520		370	482			
18					415		331

TABLE 18 (cont.)

DEPTH (m)	DATE						
	9/10/69	31/10/69	13/11/69	10/12/69	22/1/70	26/2/70	8/5/70
1	59	71	56	58	60	56	17
5	54	74	58	54	55	57	67
8	64	70	58	55	59	65	74
11	80	67	59	58	64	74	86
14	102	82	58	62	72	86	79
16	230	276	189	254	167	96	60
18	231	237	115	310	152	90	29
Outflow							56
	21/5/70	28/5/70	16/6/70	7/7/70	20/7/70	7/8/70	11/9/70
1	52	59	56	58	49	48	41
5	58	58	57	54	51	38	38
8	58	61	60	52	57	49	48
11	62	68	67	69	70	67	67
14	76	83	83	80	86	81	84
16	41	13	165	222	235	253	207
18	13	UD*	301	475	544	452	447
Outflow		55	53	58	55	48	40

TABLE 18 (cont.)

DEPTH (m)	DATE						
	28/9/70	26/10/70	9/11/70	9/12/70	20/1/71	22/2/71	28/4/71
1	39		46	57	53	52	70
5	40	42	44	56	48	45	64
8	48	41	46	54	50	54	72
11	67	58	44	55	61	66	83
14	88	73	62	66	78	87	87
16	247	164	231	201	144	198	210
18	463	413	375	461	429	425	356
Outflow	42	44	47	70			49
	10/5/71	27/5/71	10/6/71	21/6/71	8/7/71	19/7/71	9/8/71
1	55	47	53	54	52	50	48
2		47					
3		48		53		50	
5	57	47	59	54	51	46	40
7		53		50		50	
8	59	49	59	51	54	51	41
10		53		62		55	
11	59	54	66	63	63	58	47
13		58		69		65	
14	101	86	90	79	85	74	85
16	230	203	190	269	236	308	127
18	372	384	304	294	384	408	315
Outflow	55	49	54	49	54	51	50

TABLE 18 (cont.)

DEPTH (m)	DATE						
	23/8/71	20/9/71	6/10/71	25/10/71	3/11/71	14/12/71	15/2/72
1	64	38	37	45	54	61	57
3	71	27		45		58	54
5	57	47	45	43	54	58	53
7	75	45		45		59	
8	62	54	57	43	53		57
10	73	60		55		59	
11	87	62	60	55	57		66
12					62		
13	102	77		58	77		
14	189	89	96		81	65	85
15					109		
16	352	217	189		214	100	94
17					233		
18	616	393	359		285	321	263
Outflow	66	46	62	49	54		

TABLE 18 (cont.)

DEPTH (m)	DATE						
	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72
1	63	57	58	54	51	47	39
3	58	58	56	54	51	47	39
5	56	60	57	49	42	37	38
7		59	59	58	48	35	39
8	65	59	56	58	55	50	53
10		60	62	64	61	62	62
11	79	61	64	65	66	72	68
13		67	70	75	73	79	77
14	90	67	71	80	80	90	84
16	88	84	95	213	198	194	208
18	268	235	296	320	450	414	360
Outflow		60	46	51	51	51	40

TABLE 18 (cont.)

DEPTH	DATE
(m)	23/10/72
1	47
3	47
5	47
7	47
8	47
10	47
11	47
13	47
14	85
16	163
18	430

TABLE 19. Individual determinations of dissolved calcium (Ca) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69
0	55						
1	21	32	32	38	47	40	42
4				37	46	40	42
5	41						
6				39	42	45	45
9	22						
12			35				
13	24					60	172
14				42	77		
15			191			219	257
17	40		484	499	524		
18						671	653

TABLE 19 (cont.)

DEPTH (m)	DATE						
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
1	42	37	40	42	42	40	45
4	42						
5		40	40	42	57	40	40
7	45						
8		42	45	42	42	42	40
11	47	35	32	32	42	42	42
13	62						
14		75	87	85	90	70	42
15	192						
16		364	421	411	401	429	299
18	559	661	656	661	651	636	636

TABLE 19 (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	26/2/70	18/5/70	21/5/70	28/5/70	16/6/70
1	45	47	42	22	40	40	40
5	41	43	42	42	42	40	45
8	41	42	42	42	40	40	42
11	42	44	45	40	42	40	45
14	52	47	60	52	52	47	47
16	279	452	392	357	399	382	382
18	649	220	631	564	623	571	626
	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	40	37	37	40	40	50	37
5	40	42	37	40	40	42	42
8	42	42	40	45	40	42	42
11	45	45	42	40	35	47	42
14	60	90	75	67	110	70	80
16	421		431	379	416	309	421
18	633	611	584	613	636	591	613
Outflow	37	40	55	50	37	47	40

TABLE 19 (cont.)

DEPTH (m)	DATE						
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71
1	40	15	10	39	38	45	37
2						38	
3						40	
5	37	34	6	38	38	38	40
8	35	11	5	39	38	40	38
10						41	
11	37	4	8	36	38	41	40
13						51	
14	42	9	11	157	155	125	109
16	339	100	71	448	434	344	417
18	359	142	327	694	678	531	734
Outflow	37			37	37	57	38

TABLE 19 (cont.)

DEPTH (m)	DATE						
	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71
1	38	38	44	37	46	35	37
3	38		41		36	36	
5	38	38	44	36	36	35	37
7	40		42		39	38	
8	39	39	44	38	37	39	39
10	39		40		36	38	
11	40	38	46	40	32	33	29
13	43		37		45	67	
14	75	91	73	117	215	69	112
16	491	438	506	189	384	359	326
18	579	690	541	540	554	539	685
Outflow	56	37	53	37	35	47	37

TABLE 19 (cont.)

DEPTH (m)	DATE						
	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72
1	39	39	45	44	44	41	39
3	38		42	43	40	40	40
5	38	39	42	42	40	40	40
7	40		41			40	39
8	41	42		43	40	40	41
10	39		46			40	41
11	34	40		47	37	40	40
12		40					
13	39	79				41	40
14		100	51	32	32	41	43
15		213					
16		487	125	107	153	61	90
17		520					
18		431	537	499	426	461	456
Outflow	76	42				43	44

TABLE 19 (cont.)

DEPTH (m)	DATE			
	26/6/72	24/7/72	25/9/72	23/10/72
1	42	37	39	44
3	39	37	38	40
5	42	38	39	42
7	41	38	40	39
8	41	39	44	40
10	41	39	44	39
11	42	40	39	39
13	42	36	44	44
14	44	50	77	78
16	359	349		364
18	516	626	489	589
Outflow	40	38	45	

TABLE 20. Individual determinations of dissolved magnesium (Mg) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69
1	13	16	24	30	28	24	26
4				27	26	25	26
5	26						
6				25	28	26	27
9	14						
12			27				
13	16					29	46
14				27	31		
15			31			32	33
17	28		52	48	50		
18						70	70

TABLE 20 (cont.)

DEPTH (m)	DATE						
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
1	25	25	24	25	24	24	23
5	25	26	24	25	26	24	23
7	27						
8		29	26	24	24	23	23
10	28						
11		29	26	26	24	23	23
13	29						
14		29	28	28	29	26	23
15	32						
16		36	36	36	35	36	31
18	58	63	65	65	64	63	63

TABLE 20 (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70
1	28	30	24	11	23	23	22
5	27	27	23	24	23	23	23
8	26	28	26	24	23	23	23
11	26	28	25	25	24	24	23
14	27	30	26	26	25	26	25
16	47	42	35	33	36	35	33
18	65	37	65	56	64	57	60
	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	22	22	22	22	23	28	22
5	23	23	23	26	23	24	25
8	23	23	23	27	25	26	30
11	24	24	24	28	26	30	29
14	26	27	26	27	31	27	30
16	36		37	35	37	33	39
18	64	59	59	62	67	59	63
Outflow	22	22	33	27	22	27	24

TABLE 20 (cont.)

DEPTH (m)	DATE						
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71
1	25	10	7	26	26	25	26
2						24	
3						24	
5	24	22	4	26	26	23	26
7						25	
8	23	6	4	26	26	25	26
10						25	
11	24	2	7	25	27	26	26
14	24	6	4	32	31	27	29
16	33	16	8	42	42	39	40
18	34	16	35	63	64	63	69
Outflow	21			26	25	25	26

TABLE 20 (cont.)

DEPTH (m)	DATE						
	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71
1	25	26	25	25	24	23	27
3	25		25		23	24	
5	25	26	25	25	24	23	27
7	24		24		23	26	
8	25	26	25	26	23	25	28
10	25		24		26	25	
11	25	26	26	27	24	25	28
13	26		26		24	27	
14	27	30	28	30	30	27	30
16	51	42	49	31	36	38	37
18	75	66	54	56	57	58	67
Outflow	26	25	26	26	21	25	26

TABLE 20 (cont.)

DEPTH (m)	DATE						
	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72
1	26	23	25	27	27	25	26
3	26		23	26	25	24	26
5	22	23	23	26	24	23	26
7	21		23			23	24
8	21	27		26	25	23	26
10	25		25			23	27
11	26	24		27	25	23	26
12		25					
13	26	27				23	26
14		34	26	28	26	24	26
15		33					
16		49	31	30	28	25	40
17		52					
18		68	61	44	43	41	47
Outflow	22	23				23	26

TABLE 20 (cont.)

DEPTH (m)	DATE			
	26/6/72	24/7/72	25/9/72	23/10/72
1	26	24	23	26
3	26	23	23	25
5	25	23	23	25
6		23		
7	25	24	24	24
8	26	25	25	25
10	26	24	26	24
11	26	24	25	24
13	27	25	26	26
14	27	27	28	30
16	41	37	31	35
18	63	69	57	63
Outflow	25	24	24	

TABLE 21. Individual determinations of dissolved sodium (Na) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69
0	37						
1	11	30	34	33	37	30	31
4				33	37	31	31
5	35						
6				33	37	32	33
9	13						
12			36				
13						35	34
14	15			40	71		
15			36			35	35
17	24		45	65	80		
18						50	50

TABLE 21 (cont.)

DEPTH (m)	DATE						
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
1	30	30	31	31	30	29	29
4	30						
5		30	30	31	30	29	29
7	32						
8		32	32	30	30	29	29
10	33						
11		38	33	34	29	29	29
13	34						
14		35	33	33	33	30	29
15	36						
16		37	38	38	36	36	33
18	45	49	49	49	46	45	46

TABLE 21 (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70
1	59	34	31	13	28	28	28
5	32	31	30	30	31	28	29
8	31	32	30	30	28	29	29
11	31	33	31	30	30	29	30
14	32	33	31	31	31	30	31
16	44	42	36	35	37	36	35
18	46	37	46	43	46	43	46
	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	29	29	30	29	29	30	29
5	30	30	30	30	28	30	29
8	30	30	30	30	30	31	30
11	31	32	30	32	33	33	29
14	33	33	33	31	34	32	32
16	38		40	37	38	37	39
18	50	48	47	47	49	48	48
Outflow	31	29	30	32	28	30	29

TABLE 21 (cont.)

DEPTH (m)	DATE						
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71
1	33	9	6	29	29	37	29
2						36	
3						35	
5	32	25	3	29	31	35	30
7						36	
8	31	5	3	30	29	30	29
10						37	
11	30	1	5	29	31	36	30
13						37	
14	31	5	3	34	33	39	32
16	37	17	7	39	39	47	37
18	28	12	34	47	48	57	50
Outflow	29			29	30	35	28

TABLE 21 (cont.)

DEPTH (m)	DATE						
	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71
1	37	33	37	28	32	30	29
3	36		37		31	31	
5	35	32	36	28	33	31	28
7	38		39		33	33	
8	38	31	33	29	33	32	29
10	35		31		34	34	
11	36	30	41	29	34	34	29
13	36		42		34	34	
14	38	32	38	32	43	34	32
16	47	38	51	33	42	42	37
18	58	48	55	43	60	50	48
Outflow	37	29	35	29	32	32	28

TABLE 21 (cont.)

DEPTH (m)	DATE						
	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72
1	35	29	32	35	35	37	30
3	36		32	33	33	33	29
5	36	28	32	31	32	32	30
7	34		30			35	29
8	34	30		32	32	33	29
10	37		31			33	32
11	37	29		32	34	31	30
12		30					
13	38	32				31	30
14		33	33	34	34	30	31
15		34					
16		41	34	35	35	32	34
17		43					
18		47	47	44	44	41	43
Outflow	33	30				29	29

TABLE 21 (cont.)

DEPTH (m)	DATE		
	26/6/72	24/7/72	25/9/72
1	33	30	31
3	31	30	30
5	33	30	28
6		30	
7	31	31	29
8	31	30	30
10	30	30	31
11	30	31	30
13	31	31	32
14	31	33	31
16	41	40	40
18	53	54	47
Outflow	29	30	29

TABLE 22. Individual determinations of dissolved potassium (K) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69
0	6						
1	2	20	8	6	5	5	5
4				6	5	5	5
5	6						
6				6	5	6	6
9	3						
12			11				
13	3					7	7
14				6	7		
15			14			9	9
17	12		32	36	32		
18						44	44

TABLE 22 (cont.)

DEPTH (m)	DATE						
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
1	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5
7	6						
8		6	6	5	5	5	5
10	6						
11		7	6	6	5	5	5
13	7						
14		7	7	7	7	6	5
15	8						
16		14	15	15	14	15	11
18	33	42	42	42	41	39	40

TABLE 22 (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70
1	7	7	6	3	5	5	5
5	6	6	5	6	5	5	5
8	6	6	6	6	5	5	5
11	6	6	6	6	5	5	6
14	6	7	6	6	6	6	6
16	24	17	15	13	15	14	13
18	39	15	43	34	41	35	39
	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	5	5	5	5	5	7	5
5	6	6	5	7	5	6	6
8	6	6	6	7	6	6	8
11	6	6	6	7	6	7	7
14	7	8	7	6	8	7	8
16	16		18	15	18	13	18
18	42	38	37	40	44	38	41
Outflow	5	5	10	8	5	6	5

TABLE 22 (cont.)

DEPTH (m)	DATE						
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71
1	6	2	1	6	6	6	6
2						6	
3						6	
5	6	5	1	6	6	6	6
7						6	
8	6	2	1	7	7	6	6
11	5	<1	1	6	7	6	6
13						7	
14	6	1	1	9	8	7	7
16	13	8	4	18	19	19	16
18	21	9	13	39	40	36	42
Outflow	6			7	6	6	6

TABLE 22 (cont.)

DEPTH (m)	DATE						
	21/6/71	8/7/71	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71
1	7	8	6	6	6	5	6
3	6		6		6	5	
5	6	8	6	6	6	5	6
7	7		6		7	6	
8	7	7	5	6	6	6	6
10	7		6		6	6	
11	8	5	7	6	6	6	7
13	7		7		7	7	
14	8	7	7	8	10	6	7
16	30	18	28	10	18	18	14
18	45	42	36	30	41	36	40
Outflow	6	6	5	7	6	6	6

TABLE 22 (cont.).

DEPTH (m)	DATE						
	25/10/71	3/11/71	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72
1	7	6	7	6	6	10	6
3	7		6	6	5	8	6
5	7	6	6	6	6	7	6
7	7		6			8	6
8	6	7		6	5	7	6
10	7		7			7	7
11	8	6		6	6	7	6
12		6					
13	9	7				7	6
14		8	7	7	6	6	6
15		9					
16		23	9	8	8	7	8
17		25					
18		37	32	21	22	21	24
Outflow	7	5				6	6

TABLE 22 (cont.)

DEPTH	DATE			
(m)	26/6/72	24/7/72	25/9/72	23/10/72
1	6	6	5	7
3	6	6	5	7
5	6	6	4	10
6		6		
7	6	6	4	6
8	6	6	5	7
10	6	6	5	7
11	6	7	5	7
13	6	7	6	7
14	6	7	6	9
16	16	16	15	15
18	38	44	30	40
Outflow	5	6	5	

TABLE 23. Individual determinations of dissolved iron (Fe) in Lake 120, 1968-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69	16/9/69
0	<1						
1	<1	3	<1	1	UD*	<1	
4			<1	1	UD	<1	
5	1						
6			1	1	<1	<1	
9	<1						
12		7					
13	<1				23	22	
14			13	32			
15		152			172	222	
16							520
17	<1	2490	2240	2220			
18					4180	4120	3490

* UD = Undetectable

TABLE 23 (cont.)

DEPTH (m)	DATE						
	21/9/69	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69
1	UD	1	1	1	3	4	3
5	<1	1	<1	2	4	4	3
7	<1						
8		2	3	2	2	3	3
10	5						
11		6	6	8	3	4	3
13	26						
14		39	48	48	52	29	4
15	148						
16		685	840	825	685	875	565
18	2720	3980	4050	3960	3820	3750	3850

TABLE 23 (cont.)

DEPTH (m)	DATE						
	10/12/69	22/1/70	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70
1	5	3	3	<1	2	2	<1
5	4	3	1	1	15	1	1
8	5	6	1	2	2	3	2
11	12	5	4	6	6	4	4
14	9	5	17	16	16	11	11
16	1590	919	810	610	875	660	550
18	3690	959	3940	3060	3760	3060	3550
	7/7/70	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70
1	<1	1	<1	<1	1	9	4
5	1	4	1	7	<1	4	4
8	1	4	2	8	5	5	16
11	3	5	5	14	8	18	11
14	22	49	37	37	79	47	54
16	970		1080	795	1130	565	1130
18	3780	3410	3350	3600	4090	3390	3780
Outflow		UD	9	13	<1	6	3

TABLE 23 (cont.)

DEPTH (m)	DATE						
	9/12/70	20/1/71	22/2/71	28/4/71	10/5/71	10/6/71	8/7/71
1	2	2	1	3	3	3	3
5	2	2	1	3	3	4	4
8	4	1	1	3	3	3	4
11	3	UD	1	3	11	5	5
14	7	6	5	2	98	65	52
16	565	130	394	1100	1140	959	1080
18	2010	833	633	3570	3570	3780	3580
Outflow	2			5	4	3	2

TABLE 23 (cont.)

DEPTH (m)	DATE						
	9/8/71	6/10/71	25/10/71	3/11/71	14/12/71	24/7/72	23/10/72
1	1	4	3	4	3	1	1
3			3		3	<1	1
5	7	2	3	4	3	1	2
6						1	
7			3		2	2	2
8	3	6	3	10		2	2
10			6		22	1	1
11	5	8	5	7		1	2
12				15			
13			16	45		4	1
14	69	75		63	6	20	51
15				165			
16	285	699		1610	116	753	384
17				1880			
18	2550	3674		3140	2510	3580	1340
Outflow	4	3	3	5		2	

TABLE 24. Individual determinations of dissolved manganese (Mn) in Lake 120, 1969-1972.

Units of concentration are $\mu\text{moles liter}^{-1}$.

DEPTH (m)	DATE						
	15/5/69	6/7/69	20/7/69	22/8/69	6/9/69	16/9/69	21/9/69
1	2	<1	<1	UD*	UD*		<1
4		<1	<1	<1	UD*		
5							<1
6		1	1	1	<1		
7							1
10							3
12	2						
13				7	7		7
14		5	9				
15	27			23	29		23
16						40	
17	91	82	91				
18				131	123	113	100

* UD = Undetectable

TABLE 24 (cont.)

DEPTH (m)	DATE						
	2/10/69	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69	10/12/69
1	<1	<1	<1	1	1	1	1
5	<1	<1	<1	1	1	1	1
8	1	2	1	1	1	1	1
11	3	4	4	1	1	1	1
14	8	10	10	10	5	1	3
16	50	56	54	51	57	40	32
18	128	129	128	127	125	127	109
	22/1/70	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70	7/7/70
1	1	<1	UD*	<1	<1	<1	UD*
5	1	<1	<1	1	<1	<1	<1
8	1	<1	<1	1	1	<1	1
11	1	1	3	1	1	1	2
14	3	14	6	5	4	6	7
16	53	54	47	56	50	46	59
18	33	128	107	125	106	120	126
Outflow							<1

* UD = Undetectable

TABLE 24 (cont.)

DEPTH (m)	DATE						
	20/7/70	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70	9/12/70
1	<1	UD*	UD*	<1	<1	1	<1
5	1	<1	UD*	<1	<1	1	<1
8	1	1	1	1	<1	1	<1
11	1	2	3	5	5	1	<1
14	11	9	8	13	9	9	2
16		62	53	63	41	63	44
18	117	112	119	130	115	123	69
Outflow	<1	1	<1	<1	<1	1	<1
	20/1/71	22/2/71	28/4/71	10/5/71	10/6/71	8/7/71	9/8/71
1	1	1	1	2	1	1	1
5	1	1	1	2	2	2	2
8	1	1	1	1	2	2	2
11	1	1	1	4	2	2	2
14	2	2	8	16	12	11	12
16	13	14	57	57	52	56	22
18	27	40	109	109	118	114	91
Outflow			1	2	2	1	2

TABLE 24 (cont.)

DEPTH (m)	DATE				
	6/10/71	25/10/71	3/11/71	14/12/71	24/7/72
1	2	2	2	2	<1
3		2		2	<1
5	2	2	2	1	<1
6					<1
7		2		1	1
8	3	2	2		1
10		4		2	1
11	4	4	3		1
12			5		
13		6	8		3
14	12		10	3	8
15			20		
16	41		69	15	47
17			91		
18	118		109	95	116
Outflow	2	2	2		<1

TABLE 25. Individual determinations of chlorophyll (chlorophyll a plus phaeophytin) in Lake 120, 1968-1972. Units of concentration are $\mu\text{grams liter}^{-1}$.

DEPTH (m)	DATE						
	12/11/68	22/4/69	6/7/69	20/7/69	6/9/69	21/9/69	2/10/69
0	2.5						
1	2.1	1.9	0.8	1.4	2.0	1.6	2.8
4			1.1	2.0	2.2		
5	2.2					1.6	2.2
6			0.5	2.4	2.7		
7						2.2	
8							2.5
9	2.1						
10						1.8	
11							1.9
13	2.1				2.1	1.9	
14			1.9	2.6			2.7
15					3.7	6.5	
16							3.6
17	2.0		2.1	2.1			
18					3.1	5.6	2.7

TABLE 25 (cont.)

DEPTH (m)	DATE						
	9/10/69	16/10/69	24/10/69	31/10/69	13/11/69	10/12/69	22/1/70
1	1.4	2.4	2.4	2.3	1.7	2.5	2.0
5	2.5	2.4	2.0	2.2	2.1	1.0	0.9
8	5.1	2.8	2.5	2.1	2.2	0.8	0.7
11	1.4	1.8	2.3	2.3	2.0	0.8	0.8
14	3.9	3.2	4.1	2.9	2.1	0.8	0.8
16	3.0	4.6	4.1	3.5	3.9	3.5	4.4
18	3.5	3.8	3.5	2.9	3.4	3.7	2.5
	26/2/70	8/5/70	21/5/70	28/5/70	16/6/70	7/7/70	20/7/70
1	2.0	1.0	3.2	2.9	2.3	0.8	1.0
5	0.8	1.6	3.6	6.4	5.7	5.0	6.4
8	0.5	1.6	3.1	3.8	7.9	5.9	6.1
11	0.6	1.2	2.4	2.6	2.9	3.3	3.3
14	1.6	3.2	2.0	2.7	2.7	2.8	3.3
16	2.2	3.3	3.3	3.4	4.2	2.8	1.9
18	3.6	7.7	4.5	4.6	4.1	2.3	10.9
Outflow		1.4		2.7	3.7	1.4	1.0

TABLE 25 (cont.)

DEPTH (m)	DATE						
	7/8/70	11/9/70	28/9/70	26/10/70	9/11/70	9/12/70	20/1/71
1	1.3	2.9	2.9	2.6	2.8	2.5	1.5
5	6.9	4.1	2.7	3.0	2.7	1.7	1.2
8	7.3	5.8	4.6	2.3	2.7	1.3	1.0
11	2.9	2.6	2.9	2.4	2.6	1.5	0.7
14	3.0	2.7	4.3	2.9	3.5	1.6	1.3
16	2.9	3.0	2.5	4.2	3.3	4.7	4.7
18	4.6	4.0	4.4	6.8	3.8	4.1	4.4
Outflow	6.2	2.7	2.2	3.0	3.0	1.8	
	22/2/71	28/4/71	10/5/71	27/5/71	10/6/71	21/6/71	8/7/71
1	1.6	3.9	2.2	7.2	0.7	1.3	4.5
2				2.6			
3				2.5		1.6	
5	0.8	2.1	8.3	4.8	1.7	2.3	4.5
7				5.4		2.8	
8	0.6	2.0	3.1	8.5	3.8	2.5	2.8
10				4.4		2.1	
11	1.0	1.3	2.2	3.3	2.6	2.2	2.5
13				3.1		1.7	
14	4.0	4.9	5.2	4.9	4.8	2.8	3.4
16	4.1	3.3	4.1	5.3	4.8	3.8	3.1
18	4.0	4.4	5.2	4.5	2.2	4.3	3.5
Outflow		2.5	2.9		1.3	5.2	2.0

TABLE 25 (cont.)

DEPTH (m)	DATE						
	19/7/71	9/8/71	23/8/71	20/9/71	6/10/71	25/10/71	3/11/71
1	2.0	2.0	2.8	2.9	3.7	3.2	2.0
3	0.9		2.3	2.3		3.3	
5	5.7	3.2	3.9	2.1	3.1	3.5	2.7
7	5.2		8.1	6.3		3.6	
8	4.2	4.3	6.9	5.7	3.3	2.9	2.9
10	2.6		2.1	1.8		1.5	
11	2.1	2.3	2.2	1.6	1.7	1.4	2.3
12							2.0
13	1.9		2.5	2.7		1.9	2.5
14	3.0	3.5	6.9	6.6	4.4		3.9
15							7.8
16	3.4	4.2	3.1	2.9	4.2		3.3
18	3.8	3.2	4.0	3.3	4.0		3.5
Outflow	1.5	12.5			3.3		3.4

TABLE 25 (cont.)

DEPTH (m)	DATE						
	14/12/71	15/2/72	4/4/72	8/5/72	5/6/72	26/6/72	24/7/72
1	4.0	2.7	1.5	2.9	2.7	0.9	3
3	2.7	1.4	1.9	3.2	2.1	1.0	2
5	1.9	0.9	0.7	2.8	2.3	3.5	4
6							12
7	1.7			2.8	5.1	6.3	18
8		0.6	0.4	2.7	7.4	6.1	12
10	1.2			1.9	5.3	2.5	5
11		0.6	0.6	1.9	3.6	2.2	4
13				1.5	2.9	1.6	2
14	1.3	2.4	1.6	1.5		2.1	3
16	2.5	3.0	3.3	3.2	4.0	2.5	5
18	3.6	3.4	2.4	3.2	3.8	2.9	6

TABLE 25 (cont.)

DEPTH (m)	DATE		
	28/8/72	25/9/72	23/10/72
1	2	3.3	2.8
3	2	3.9	3.2
5	4	3.5	3.2
7	16	3.6	3.3
8	22	9.0	3.3
10	4	4.5	3.3
11	4	2.6	3.0
13	3	2.5	3.1
14	4	6.5	5.2
16	4	4.3	6.6
18	8	5.1	5.6

TABLE 26. Individual determinations of live phytoplankton biomass and the average daily biomass in the 0-14 meter water column in Lake 120, 1970-1972. Units of concentration are mg fresh weight meter⁻³.

DEPTH	DATE						
(m)	26/2/70	8/5/70	21/5/70	16/6/70	7/7/70	20/7/70	7/8/70
1		971.8	910.0	370.8	348.3	457.5	872.6
5	300.0	693.4	612.5		1330.1	6565.3	6016.6
8	227.5	197.8	1181.5	1111.5	1167.8		1109.7
11	363.5	180.3	312.6	348.2	550.5	560.0	592.1
14		280.4	393.3	238.1	727.5	447.4	805.2
\bar{x}_{0-14}	279.5	423.3	645.5	589.8	828.5	2638.1	2079.7
	11/9/70	28/9/70	9/11/70	20/1/71	22/2/71	28/4/71	10/5/71
1	893.6	1252.4	591.6	1495.9	636.5	613.0	690.0
5	1246.0	654.7	697.1	549.3	265.1	361.4	967.5
8	1973.6	999.8	747.6	344.9	108.3	110.4	459.4
11	532.4	431.7	562.4	183.6	45.1	144.1	390.0
14	537.8		378.7	227.8	59.7		90.2
\bar{x}_{0-14}	1033.8	767.5	580.2	488.7	196.5	276.2	532.1

TABLE 26 (cont.)

DEPTH (m)	DATE						
	27/5/71	10/6/71	8/7/71	9/8/71	3/11/71	14/12/71	15/2/72
0						974.2	
1	419.7	384.8	257.5	413.3	728.7		800.9
3						1012.6	404.2
5	646.7	721.9	1501.5	778.7	596.6	518.5	232.5
7						341.8	
8	770.0	811.1	420.0	528.7	803.4		155.7
10						544.9	
11	225.6	343.1	224.5	186.0			135.0
12					387.1		
14	90.4	678.3			141.9		162.1
\bar{x}_{0-14}	447.7	555.5	695.8	492.5	547.2	670.2	236.1

TABLE 26 (cont.)

DEPTH (m)	DATE					
	4/5/72	8/5/72	5/6/72	26/6/72	24/7/72	28/8/72
1	204.6	838.5	360.6	384.0	700.0	656.5
3	986.6	726.6	591.4	388.5	691.0	737.7
5	281.6	776.5	532.9	2485.9	823.2	867.8
7	138.7	485.5		2294.6		
8		486.7	685.8		2273.7	5080.1
10		463.1	512.3	190.2		
11	21.0					
13					175.3	533.7
14	156.1	272.3	382.8	266.2		
\bar{x}_{0-14}	247.5	516.9	492.3	933.4	1052.0	1996.8

TABLE 27. Individual determinations of primary productivity and average daily productivities in the 1-13 meter water column in Lake 120, 1971-1972. Productivity rates are μ grams C fixed per liter per day.

DEPTH (m)	DATE						
	27/5/71	21/6/71	19/7/71	23/8/71	20/9/71	25/10/71	8/5/72
1	26.9	59.6	12.0	8.9	24.2	20.0	13.5
3	16.2	88.2	8.7	6.0	13.5	3.0	20.2
5	16.0	13.6	0.2	2.8	3.6	1.8	4.9
7	8.8	2.6	0.0	0.0	11.7	0.3	0.0
10	0.0	0.0	2.0	1.5	0.4	0.0	3.0
13	22.6	59.9	2.3	0.0	0.0	14.2	0.0
\bar{x}_{0-13}	12.3	30.0	2.4	2.6	7.4	4.3	5.2
	5/6/72	26/6/72	24/7/72	28/8/72	25/9/72	23/10/72	
1	0.9	9.7	1.3	14.5	23.2	9.3	
3	21.0	6.8	0.3	19.4	16.0	8.1	
5	18.8	12.8	0.1	7.4	4.4	2.6	
7	12.5	10.0	0.0	7.6	0.6	0.7	
10	41.8	3.2	0.3	13.9	4.0	1.6	
13	0.0	0.0	1.9	0.0	1.8	0.5	
\bar{x}_{0-13}	19.8	7.0	0.5	10.7	5.5	3.2	