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STUDIES ON THE PLANKTONIC ECOLOGY OF LAKE TANGANYIKA

by

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PREFACE

Because of the infrequency of routine limnological observation on Lake Tanganyika and because much of the information produced by this cooperative research program has not been available before (nor will it be produced again in the foreseeable future), it was believed that as much of the original data as possible should be archived so that it would be available to future investigators or managers of Lake Tanganyika. Further publication in primary journals is planned, but the data will appear in summarized form. Any interpretations or conclusions offered in this report should be considered as preliminary.

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ABSTRACT

Hecky, R. E., E. J. Fee, H. Kling, and J. M. W. Rudd. 1978. Studies on the planktonic ecology of Lake Tanganyika. Can. Fish. Mar. Serv. Tech. Rep.: iv + 51 p.

Two biological surveys were carried out on Lake Tanganyika. The first cruise was at the end of the wet season (April-May) when phytoplankton biomass was low (average chlorophyll of 0.7 $\mu g\ L^{-1}$) and the second was at the end of the dry season (September-October) when biomass was high (average chlorophyll of 1.7 $\mu g\ L^{-1}$). The parameters measured were: temperature profiles, Secchi disk and quantum meter transparencies, chlorophyll, major ions and nutrients, phytoplankton, bacterial and protozoan biomass, primary production, plankton respiration rates, methane concentration profiles and methane oxidation rates.

On the basis of chemistry and chlorophyll concentrations the lake is divisible into three regions: North lake, the region north of the Ubwari peninsula; Central lake, between the Ubwari peninsula and Cape Kibwesa; and South lake, south of Cape Kibwesa. In spite of a sharp decline of Secchi disk visibility between the two cruises there was no increase in the vertical extinction coefficient.

During the first cruise primary production rates were undetectably low and respiration rates high. On the second cruise the production rates were measurable but incapable of offsetting the respiratory requirement of the plankton. It is concluded that primary production in 1975 was insufficient to meet the respiratory demand of the plankton community let alone sustain populations at higher trophic levels. Bacterial heterotrophy may be important in supplying fixed carbon to higher trophic levels. The substrates supporting the bacteria could be H_2S, CH_4, NH_4^+, and organic matter from the perennially anoxic hypolimnion mixed directly into surface waters during the dry season or transported across the seasonal thermocline in the wet season. Seasonal data on protozoan and phytoplankton biomass showed that the former was consistently high, approaching or surpassing the phytoplankton biomass, while the latter was very low at all times with the maximum observed concentration, 1,570 mg m^{-3}, occurring in October. In spite of extremely low biomass, the phytoplankton species composition was similar to eutrophic temperate lakes.

Key words: phytoplankton; heterotrophic organisms; biomass; primary production; respiration; chemosynthesis; limnology; chemistry; fishery resources; trophodynamic cycle.

RESUME

Hecky, R. E., E. J. Fee, H. Kling, and J. M. W. Rudd. 1978. Studies on the planktonic ecology of Lake Tanganyika. Can. Fish. Mar. Serv. Tech. Rep.: iv + 51 p.

Les auteurs ont procédé à deux campagnes biologiques du lac Tanganyika, la première à la saison des pluies (avril-may), alors que la biomass du phytoplancton était faible (0.7 $\mu g\ L^{-1}$ de chlorophylle en moyenne, l'autre à la fin de la saison sèche (septembre-octobre), la biomasse étant à cette période-là élevée (1.7 $\mu g\ L^{-1}$ de chlorophylle en moyenne). Les paramètres suivants ont été mesurés: le profil de la température; la transparence, mesurée par le disque de Secchi et par le compteur des quanta; la teneur en chlorophylle, en principaux ions, et en substances nutritives; la biomasse de phytoplancton, des bactéries et des protozoaires; la production primaire; la respiration chez le plancton; le profil de la concentration du méthane et sa vitesse d'oxydation.

D'après les concentrations de substances chimiques et de chlorophylle, le lac peut se diviser en trois parties: la partie septentrionale, située au nord de la péninsule Ubwari; la partie centrale, entre cette dernière et le cap Kibwesa; et la partie méridionale, au sud de ce dernier. En dépit de la forte diminution de la visibilité du disque de Secchi lors de la seconde expédition, le coefficient d'extinction verticale n'a pas augmenté.

Au cours de la première campagne, la production primaire a été imperceptible et la respiration élevée. Lors de la seconde, la production primaire a pu être measurée, mais elle ne contrebalançait la demande respiratoire du plancton. Il en ressort que, en 1975, la production primaire n'a pas suffi à la demande respiratoire du plancton, chargé à lui seul d'approvisionner les chaînes trophiques supérieures. Les bactéries hétérotrophes doivent être bien représentées pour fournir le carbone lié à ces dernières. Le substrat des bactéries pourrait être H_2S, CH_4, NH_4^+, et les matières organiques de l'hypolimnion anoxique en permanence, mélangées directement aux eaux de surface, à la saison sèche, ou transportées au-delà de la thermocline, à la saison des pluies. D'après les données saisonnières, la biomasse des protozoaires a été constamment élevée, approchant de celle du phytoplancton ou la dépassant, tandis que ce dernier a toujours été peu important, sa concentration maximale ayant été de 1.570 mg m^{-3} en octobre. Malgré sa biomasse extrêmement réduite, les espèces du phytoplancton étaient comparables en nombre à celles des lacs eutrophes des régions tempérées.

Mots-clés: phytoplancton; organismes hétérotrophes; biomasse; production primaire; respiration; chimiosynthèse; limnologie; chimie; ressources halieutiques; cycle trophique.

INTRODUCTION

Lake Tanganyika (Fig. 1) is the second largest mass of fresh water in the world. With a surface area of 32,600 km^2 and a volume of 18,900 km^3 it is truly a great lake. Although its size, hydrography and biology have attracted scientific interest since the lake's discovery in the mid-nineteenth century only recently has its value as a fishery become appreciated. The wise development of this fishery is now an important issue for the four countries surrounding the lake (Burundi, Tanzania, Zaire, and Zambia) and various international assistance organizations (U.N.F.A.O., World Bank, etc.). Reasonably precise estimation of the maximum sustainable fish yield is required so that the proper scale of investment and development effort can be planned.

The first estimate of sustainable yield was made by Kufferath (1952) who estimated the total biomass in the lake from geochemical considerations. He then assumed that ichthyomass was 1% of total biomass and that a fishery could safely harvest 20% of the ichthyomass annually. His minimum estimate in 1952 was a sustainable yield of 10 kg ha^{-1}. In 1956, after further consideration including examination of some echo sounding records from the lake, Capart and Kufferath (1956) increased their estimate of maximum sustainable yield to 35 kg ha^{-1}.

Mechanized purse-seining fisheries have been in operation in Zambia since 1956 and Burundi since 1962. This industrial fishing supplements the traditional dip net fishery and the developing artisanal lift net fishery in these countries. By 1970 annual yields from all fisheries of approximately 80 kg ha^{-1} were being sustained in Burundi and Zambia with some years exceeding 100 kg ha^{-1} (Mann and Ngomirakiza 1973; Coulter 1970). Based on this experience the potential of the whole lake for sustained fish production appeared to be on the order 250,000 metric tons (Department of Fisheries FAO 1973) i.e. an average of 78 kg ha^{-1}.

Recently (1973-1975) more detailed acoustical surveys have suggested an even higher standing crop than previously with estimates as high as 800 kg ha^{-1} (Johannesson 1974) and a mean of 500-600 kg ha^{-1} (D. W. Chapman personal communication). Although uncertainty about the interpretation of the acoustical records must be attached to these estimates, these standing crops and yields are comparable to unfertilized tropical fish ponds and eutrophic tropical lakes (Lowe-McConnell 1967).

Two planktophagous clupeid species, *Stolothrissa tanganicae* (Regan) and *Limnothrissa miodon* (Boulenger), account for 80% by weight of total landings in Lake Tanganyika. The life cycle of *Stolothrissa* is entirely pelagic, but the fry of *Limnothrissa* occupy inshore areas (Coulter 1970). Four predatory species, *Luciolates stappersii*, *Lates microlepis*, *Lates mariae* and *Lates angustifrons*, constitute most of the remaining 20% of the total catch. *L. stappersii* has a completely pelagic life cycle while the younger stages of the other *Lates* spp. occupy the littoral. The adults of all these predators feed on the clupeids.

Because the fishery is dependent on the relatively simple pelagic food web, the productivity of this food web should set limits on the fish production. Some descriptive studies (Coulter 1963, 1969, 1970) have suggested strong correlations between plankton abundance and clupeid abundance. However, previous investigations on the limnology and phytoplankton (Beauchamp 1939; Meel 1954) emphasize that for most of the year phytoplankton (actually net plankton by their methods) are scarce. Beauchamp classified the lake as oligotrophic. Meel concurred that phytoplankton (net plankton) was extremely sparse most of the year, but was hesitant to suggest that the lake was oligotrophic because of the swarms of zooplankton and fish observed at night. The trophic status of the lake and especially the productivity at the primary level has become increasingly enigmatic with higher estimates of fish production. Symoens (1959) observed massive phytoplankton blooms of short duration. His observations were visual and non-quantitative. Conclusions on the plankton production have been precluded by the lack of adequate spatio-temporal quantitative studies on the plankton.

In 1975 a cooperative program of research between the Freshwater Institute (FWI) and the U.N.F.A.O. Fisheries Project at Bujumbura and Kigoma was conducted. Objectives of the FWI research were to make the first quantitative estimate of the annual primary production of Lake Tanganyika, to define for the first time quantitatively the spatio-temporal patterns of primary production and algal biomass in the lake, to estimate the metabolic activity of the plankton, and to assess the possible contribution of bacterial production to total production. The program was aimed at defining the productive base of the pelagic fishery and as such it is naturally complementary to continuing efforts to define the sustainable yield of the fishery.

METHODS

Two complete north-south transects were made in Burundi and Tanzanian waters by Lady Alice II, a 40 ft. vessel operated by the U.N.F.A.O. Fisheries Project at Bujumbura. Cruises were made in April-May 1975 and October-November 1975, the dates being chosen in order to assess plankton biomass and activity at the low and high periods of the algal seasonal cycle (Coulter 1969). In addition to these cruises, phytoplankton populations off Bujumbura and Kigoma were monitored throughout 1975 to establish the complete annual cycle.

The April-May cruise was immediately preceded by a cooperative research cruise on Lady Alice II conducted by chemists from Massachusetts Institute of Technology, Cambridge, U.S.A. (Dr. J. Edmond and Dr. S. Stallard) and geochemists from Scripps Institution of Oceanography, San Diego, U.S.A. (Dr. H. Craig and Dr. R. Weiss). Therefore, detailed information on chemical conditions and mixing processes for the lake will be available in the future. During the second Freshwater Institute cruise in October-November, chemical samples were taken along the entire south-north transect and analyses presented in this report were completed by the Analytical Unit of the Freshwater Institute in Winnipeg.

During the April-May cruise 104 stations were occupied at various locations on the lake while 134 stations were completed on the second cruise (Fig. 1). The parameters examined at these stations are indicated in Tables 1 and 2. On both cruises, stations are highly clumped around five locations: 1) off Bujumbura, 2) off Kigoma, 3) off the Lubugwe River, 4) off Kipili and 5) off Kipanga and Kala. These locations were the sites of detailed studies on spatio-temporal variation in the structure and activity of the plankton community including depth profiles and diurnal sampling. All other stations were made by stopping for sampling only and processing of samples was done under way.

WATER SAMPLING

The bulk of the sampling was done with 2 litre polyvinylchloride Niskin bottles. As indicated in the station lists (Tables 1 and 2), samples from various depths were taken and either analysed separately or combined and subsamples for the various analyses were withdrawn from the pooled sample. Integrated samples were initially taken with a pump (stations I-1 through I-6 in Table 1); but, as the results were not reproducible and the method was inconvenient, we changed to the Niskin bottle. On the second cruise a 4 L integrating sampler similar to that described by Fee(1976) was used but was again abandoned in favor of the Niskin bottle (after station II-33) because of degassing problems that made it impossible to do respiration experiments on these samples. Surface samples for chlorophyll and water chemistry were taken by dipping a 500 mL polyethylene sample bottle while the ship was underway.

CARBON DIOXIDE UPTAKE

Samples were siphoned into ten 60 mL Pyrex dissolved oxygen bottles. An aliquot (1.0 or 1.5 mL) of $NaH^{14}CO_3$ stock solution (activity was 36 $\mu Ci\ mL^{-1}$ on the first cruise and 11 $\mu Ci/mL^{-1}$ on the second cruise) was injected into each bottle using a Cornwall automatic syringe. After thorough shaking to distribute the isotope, two bottles were placed into each chamber of an incubator (Shearer 1976) in which four light levels were maintained. Light levels were normally held at about 340, 110, 33 and 10 micro-Einsteins $m^{-2}\ sec^{-1}$. Two bottles were placed in the dark to measure nonphotosynthetic carbon uptake. The incubator was filled with lake water which was continuously renewed to maintain the incubator at lake temperature. Incubation was normally 8 hours on the first cruise and 4 hours on the second cruise.

Two methods were used to assay radiocarbon uptake at the end of the incubation. On the first cruise acidification and bubbling (Schlinder et al. 1972) was used. On the second cruise the entire contents of each bottle was filtered through 0.45 µm pore size membrane filters which were then dried in a desiccator. Filters were stored with desiccant for a maximum of two months before being fumed over concentrated HCl and being counted. The radioactivity of samples in both cruises was measured with a Picker Liquimat 220 liquid scintillation counter using a dioxane based fluor (Schindler 1966) and corrected for quenching using an automatic external standard channels ratio.

It is necessary to know the concentration of dissolved inorganic carbon (DIC) to calculate absolute rates of carbon dioxide uptake. This was calculated from alkalinity titrations made with 0.1N HCl and pH measurements; the alkalinity was found to be nearly constant in surface waters and the DIC used for all photosynthetic carbon uptake calculations was 6400 µmoles L^{-1}.

Estimates of the daily integral rate of carbon uptake were made with the numerical model of Fee (1973). Briefly, the surface irradiance curve was digitized at 5-min intervals over the day and for each value of surface irradiance the measured light extinction curve was used to calculate the absolute irradiance throughout the water column; the incubator-determined photosynthesis vs. light curves were used to calculate the instantaneous photosynthesic rate for each depth; these simulated *in situ* photosynthesis profiles were then numerically integrated to give instantaneous areal rates. By integrating these data the daily rate was obtained. For reasons explained later, no correction was made for diurnal variation of photosynthesis vs. light curves, and the light response relation was interpolated linearly. Autoradiography of plankton carbon uptake was done with the method of Knoechel and Kalff (1976).

METHANE OXIDATION

Lake water samples were taken in two liter Niskin bottles. Subsamples were collected in three 125 mL ground glass stoppered reagent bottles following methods for dissolved oxygen analysis (Strickland and Parsons 1968) except that in this case, to minimize atmospheric gas exchange, the bottle volume was allowed to overflow at least three times. When only the depth of no detectible oxygen was of interest, not all samples were titrated, and only a visual estimation of the presence of iodine (O_2) was made. The subsamples were assayed as described previously (Rudd et al. 1974; Rudd and Hamilton 1975) for methane oxidation rate, the proportions of methane carbon converted to bacterial cell material and carbon dioxide, and for methane and oxygen concentrations.

In some samples methane oxidation occurred in the presence of a noticeable hydrogen sulphide smell. This was probably a result of contamination of the sample with atmospheric oxygen and not by a proposed anoxic methane oxidation process which has been observed only in association with sulphate reducing bacteria in sediments (Reeburgh 1976; Reeburgh and Heggie 1977; R. S. Hanson pers. comm.). Therefore, methane oxidation rates in all hydrogen sulphide containing samples were assumed to be zero for the purpose of calculation of areal and annual methane oxidation rates. Inclusion of rates measured in the presence of hydrogen sulfide would not significantly increase the rates we report.

CHLOROPHYLL *A*

A measured volume (normally about 350 mL) was passed through a GF/C glass fiber filter which was stored up to 2 months in a darkened desiccator. Analysis was made according to the methods outlined by Stainton et al. (1974) which estimates chlorophyll *a*. Chlorophyll was analysed for each primary

production sample incubated. Also transects of the lake were made on each cruise, sampling surface chlorophyll at 10 km intervals from a station near the southern end of the lake to a station near the northern end. These transects were completed within three days on the first cruise and six days on the second cruise, and therefore yield a nearly contemporaneous overview of chlorophyll distribution over the whole lake.

PLANKTON RESPIRATION

Respiration was measured by determining oxygen consumption rates in 140 or 300 mL oxygen bottles kept in the dark. Two samples were fixed immediately after sampling with alkaline iodide and manganous sulfate. After 24 hr (± 2 hr) another two bottles were fixed. Oxygen concentrations were measured by titration to an electrometric endpoint following the method of Golterman (1969). Precision with this method was ±0.02 ppm.

LIGHT AND TEMPERATURE

Lambda Instruments Co. underwater quantum sensor was used for measuring irradiances in the incubator and light extinction in the lake. A similarly constructed quantum cell for use in air was mounted on top of the mast of the Lady Alice II and was used in combination with a Hewlett Packard strip chart recorder to continuously monitor surface irradiances. A Secchi disc reading was also made at each station. Depth profiles of temperature were made with a standard bathythermograph. Precision was ± 0.1°C.

PLANKTON BIOMASS AND IDENTIFICATION

Samples of lake water were transferred to 125 mL bottles and fixed immediately with acid Lugol's solution. Following analysis they were further preserved in 2% formalin. Comparison of preserved material with live samples indicated that preservation of even sensitive Protozoa was very good. Aliquots were settled in 25 mL settling chambers and counts were made with a Wild M40 inverted microscope. The analysis is basically the Utermohl method as modified by Nauwerck (1963). Bacteria counts were done on formalin only preserved samples using the technique of Daley and Hobbie (1975). Cell volumes were estimated from cell dimensions and geometric shape. Biomass was calculated by multiplying cell counts by the volume of the appropriate species assuming a specific gravity of one. The following keys were used in the algal identifications: Bourrelly (1966, 1968), Desikachary (1959), Evans (1962), Huber-Pestalozzi (1938, 1941, 1942, 1950), Komarek and Ettl (1958), Skuja (1948, 1956, 1964), Uherkovich (1966), and West (1907). Protozoa identifications are based on: Bick (1972), Corliss (1961, 1974), Fauré-Fremiet (1969), Kahl (1930-1935), Kudo (1966) and Noland (1959).

CHEMISTRY

Aliquots of water were placed into color coded liquid scintillation vials (20 mL capacity) already containing preservatives for the specific analyses to be done. The types of vials and their preservatives were: glass with 0.1 mL of saturated $HgCL_2$ for dissolved organic carbon; glass with 0.1 mL of 4N H_2SO_4 for total dissolved nitrogen, total dissolved phosphorus, and total dissolved iron; glass with 0.5 mL of 3N HCl for sodium, potassium, magnesium and calcium; and plastic with no preservative in the vial for silicon, chloride, and sulfate. Water filtered through a Whatman GF/C glass fiber filter was used for samples in the glass vials; unfiltered water was placed in the plastic vial. All analyses were done according to the techniques outlined in Stainton et al. (1974).

RESULTS AND DISCUSSION

TEMPERATURE

Coulter (1969) describes and discusses the seasonal thermal cycle of Lake Tanganyika, and they also describe the consequences of stratification and mixing on the distribution of oxygen and nutrients. Briefly, the lake is meromictic with an anoxic hydrogen sulfide-containing monimolimnion below a depth of 100-200 m (Coulter 1963). A seasonal thermocline occurs from approximately 25 to 75 m depth with annual circulation to the maximum depth of detectible oxygen during the cool, windy season of May to September.

Our temperature profiles along the length of Lake Tanganyika in October are presented in Fig. 2. Interpretations of individual temperature profiles in Lake Tanganyika are complicated by the presence of internal seiches (Coulter 1969). The major and minor modes of these seiches have periods of between 2 and 30 days. Seiches may account for the upward displacement of the thermocline (*sensu* Hutchinson 1957) off Kigoma (Stn. 25, 34, 39) by 28 m in the space of 5 days. However, it would not likely explain the difference in thermal structure between stations 54 and 56. These stations are 29 km apart and were sampled within three hours of each other on the same day. The thermocline off Kibwesa is 28 m lower than near Lubugwe and the maximum temperature gradient is much steeper. Evidence to be presented later indicates that a major water mass boundary persists near Kibwesa. Thermocline depths recorded north of Station 56 (Stn. 1, 6, 8, 25, 34, 39, 54 and 126) are shallower and more variable ($\bar{Z}$ = 40 ± 13 m) while stations off Kibwesa and south (excluding Stn. 59) have deeper and more stable thermoclines ($\bar{Z}$ = 55 ± 7 m). Station 59 off Karema had the warmest water temperature and weakest stratification. This station is affected by the shoaling depth off Karema and the strong winds channeled along the Rukwa rift (Coulter 1969). Its thermal structure is atypical of the southern part of the lake offshore. The difference in the thermal stratification between the north and south end of the lake at the end of October is demonstrated by comparing Stations 73 (Kipanga) and 126 (Bujumbura). The southern mixed layer is much warmer, deeper, and more stable. At the time of our second cruise the southern part of the lake excepting near Karema was well-stratified while in the northern part stratification was just being reestablished after the mixing period.

TRANSPARENCY

Tables 1 and 2 contain the Secchi disk depths for the first and second cruises, respectively.

The decrease of Secchi disk visibility from the first to the second cruises was greatest at Kigoma (6.7 m) and least in the offshore Burundi waters (1.4 m); the mean decrease between paired stations was 3.8 m.

Tables 3 and 4 present the raw data and derived extinction coefficients from the two cruises. In contrast to the Secchi disk values, transparency did not decrease from the first cruise to the second. The conspicuous floating masses of blue-green algae that were frequently observed on the second cruise were effective in decreasing Secchi disk visibility but had little effect on light penetration.

The Secchi disk has previously been the only semi-quantitative estimator of phytoplankton abundance (Coulter 1969). Our results indicate that in Lake Tanganyika it is mostly sensitive to light scattering by floating algae accumulating near the surface. Therefore, although it is useful in determining the times of maximum biomass, it overestimates changes in light transmission and depth of the euphotic zone. Lake Tanganyika is highly transparent at all times with an average depth of the euphotic zone of 30 m. Melack (1976a) found a similar depth for the euphotic zone near Kitaza.

CHLOROPHYLL *A*

At the primary productivity stations, equal amounts of water from several depths (Tables 1 and 2) in the euphotic zone were pooled; and analyses were done on the composite sample. Also, usually at the main stations where diurnal primary productivity experiments were conducted, profiles of chlorophyll concentration at discrete depths were performed. The above chlorophyll analyses were mostly done on the north-to-south leg of each cruise. On the return south-to-north transect of each cruise, surface (0.5 m) chlorophyll samples were taken every hour while underway, allowing estimation of surface chlorophyll concentrations at approximately 10 km intervals along the entire length of the lake. On the second cruise, in areas of dense accumulations of algae at the surface, pooled samples from various depths in the euphotic zone were taken for comparison with the surface sample. On both cruises the south-north transect of surface chlorophyll was completed within 3 days on the first cruise and 6 days on the second to give an overview of chlorophyll distribution in the whole lake. The results for the two cruises are given in Tables 1 and 2.

April-May

On the first cruise, chlorophyll concentrations in Lake Tanganyika were almost always less than 1 mg m^{-3}. The mean chlorophyll concentration for the surface waters of the entire lake based on the south-north transect was 0.5 mg m^{-3} (Table 5) while the mean concentration for the euphotic zone based on profiles and pooled samples was 0.7 mg m^{-3}. Substantially higher values than for the surrounding water mass were observed at stations I-17, I-18, and I-19 off the Malagarasi River, $\bar{X}$ = 0.6 mg m^{-3}, and station I-100 off the Ruzizi River, 2.7 mg m^{-3}.

The transect values of surface chlorophyll indicated three reasonably distinct water masses in the lake, excluding the river-influenced stations. South of Cape Kibwesa (South Lake) the mean chlorophyll was 0.7 mg m^{-3}. This region also had the highest single offshore chlorophyll concentration, 2.6 mg m^{-3}. There was only one station in this region with a value as low as 0.3 mg m^{-3}. Between Cape Kibwesa and the northern tip of the Ubwari Peninsula (Central Lake) chlorophyll concentrations at the surface were uniformly low, 0.3 ± 0.1 mg m^{-3}. North of the Ubwari Peninsula (North Lake) surface chlorophyll concentrations were again higher, 0.7 ± 0.2 mg m^{-3}. Chlorophyll concentrations for the euphotic zone showed the same general pattern (Table 5). The concentrations were usually higher in the depth-integrated samples than in the surface samples, but the discrepancy was not large except in the North Lake where the mean of the depth-integrated samples was twice the mean of the surface values.

October-November

Chlorophyll concentrations in surface waters were substantially higher during the second cruise. The mean was 3.1 mg m^{-3}, an increase of 600%, but the variance and range observed was much greater than in April-May (Table 6). The observed increase in euphotic zone chlorophyll concentrations was much less with a mean of 1.7 mg m^{-3} as compared to 0.7 mg m^{-3} during the first cruise.

The same water masses were distinguishable as during the first cruise when chlorophyll concentrations at the surface were compared. However, in October-November the Central Lake had the highest mean concentration, 5.2 mg m^{-3}, during the transect while the North Lake was lower at 1.6 mg m^{-3} and the South Lake was the lowest at 0.6 mg m^{-3} (Table 6). The euphotic zone concentrations in these regions were not so clearly delimited between the three proposed water masses. This is at least partially due to the time lag between the transect and the occupation of the main stations in the Central Lake. Euphotic zone concentrations on the north-south leg (main stations) ranged from 0.8 to 2.6 mg m^{-3}, with a mean of 1.1 mg m^{-3}. On the south-north leg, depth integrated samples were taken when algal accumulations at the surface were noted. The concentrations in the euphotic zone of the Central Lake during the south-north leg of the second cruise range from 1.2 to 4.5 mg m^{-3}, mean of 2.6 mg m^{-3} (Table 6). Euphotic zone chlorophyll concentrations had increased by a factor of 2.5 within 10 days.

Increases in surface concentrations of chlorophyll in the Central Lake were even more dramatic as the dominant blue-green algae accumulated near the surface. In Table 7, surface samples and depth-integrated samples from the same stations are compared. The highest surface concentrations at stations 103 and 112 were more than double the euphotic zone concentrations. Surface accumulations also explain the high variance of surface chlorophyll concentrations observed in the Central Lake. Although the surface concentrations tend to overestimate euphotic zone chlorophyll concentrations, they are useful in water mass discrimination as the proposed water masses are confirmed by nutrient analyses to be presented later.

DISCUSSION

The first cruise was done in April-May as it was thought that the lake would be at a minimum in algal standing crop after a prolonged period of stratification during the rainy season. Observations on chlorophyll concentrations indicate that this expectation was fulfilled. It was hoped that the first cruise might also coincide with the onset of upwelling in the south. Although surface chlorophyll concentrations in the South Lake were as high as observed anywhere in the lake at that time, algae were not present in the abundance usually attained during the dry season after upwelling begins (Coulter 1970).

The timing of the second cruise was chosen to observe the lake near the period of maximum algal biomass. The cruise appears to have bracketed or overlapped the period of maximum algal biomass in the North and Central Lake. The South Lake had the lowest chlorophyll concentrations observed on the second cruise, but the euphotic zone chlorophyll was still double the value of the first cruise. The period of maximum algal biomass in the South Lake was probably missed by our two surveys, but the general objective of the surveys, to estimate primary productivity during periods of relatively low and high algal standing crops in Lake Tanganyika was realized.

CHEMISTRY

All chemical analyses from the October-November cruise are given in Table 8. Major ion values in Table 12 are in excellent agreement with those reported by Edmond (1975), Kilham and Hecky (1973) and Kufferath (1952)with exception of the sulfate ion. Edmond (personal communication) finds 2.5 mg L^{-1} while Kilham and Hecky report a value of 13.9 mg L^{-1} and Kufferath reports a much lower value of 3 mg L^{-1} . Many of the major ion values reported by Degens et al. (1971) differ substantially from the values reported by the aforementioned investigators and ourselves. In view of the consistency over 25 years among other investigators, some of the results of Degens et al. are probably in error. The high concentrations of ions and the long residence time of water in this immense lake (approximately 1,000 years) make it unlikely that the differences are simply the result of an unusual seasonal variation.

In the section reporting chlorophyll results, three major water masses were tentatively delimited. In Table 9 the mean chemical compositions of these water masses are reported as well as three stations influenced by the Malagarasi plume. The chemical results confirm that these are distinguishable water masses. The North Lake and Central Lake are indistinguishable in their major ion concentrations. However, these two regions are distinct from the South Lake in sulfate and chloride concentrations. A significantly higher sulfate concentration indicates that the south basin of the lake is relatively isolated from the central basin. The chloride concentration is also higher, but the dispersion of our data is too great to reach a conclusion. Craig (1975) observed similar chloride values and found the differences significant.

Among the nutrients summarized in Table 9, total dissolved phosphorus gives the clearest discrimination between water masses while silicon concentrations in the north and south basins are significantly different from those in the central basin. The other nutrient values, DOC and TDN, also show substantial differences, but they have higher variances associated with the mean estimates. However, two parameter plots of these nutrients against chlorophyll usually results in non-overlapping groups which demonstrate the dissimilarities of the water masses (Fig. 3). The greater scatter of the chlorophyll values in the central basin were discussed in the previous section.

PLANKTON BIOMASS

APRIL-MAY

Phytoplankton

The following results are a summary of the data collected in each of 13 major regions of the lake (Figure 4) from the southern end near Zambia to the northern waters of Burundi. The values in Fig. 4 are usually averages of two or more samples from each region (Table 10).

The maximum regional biomass during the April-May cruise was 362 mg m^{-3} near the Malagarasi River. Here the dominant algal groups were Peridineae 36%, Chrysophyceae 32%, and Chlorophyta 15%. There was at this time an individual sample biomass of 884 mg m^{-3} at 3 m in the Malagarasi plume which was 91% Peridineae. The minimum regional biomass of 57 mg m^{-3} was recorded off Kibwesa and was 55% Chlorophyta, 21% Cryptophyceae and 19% Chrysophyceae.

Considering the lake from the south to the north the following algal distribution occurred. During the first survey Kipanga (1, Fig. 4), the southern most area, had an average biomass of 169 mg m^{-3} composed primarily of 37% Cyanophyta, 27% Chlorophyta, and 18% Chrysophyceae. Progressing northward the biomass began to decline. Kipili (2, Fig. 4) had a value of 138 mg m^{-3} composed of 35% Cyanophyta, 25% Chrysophyceae, 16% Chlorophyta, and 15% Diatomeae. Karema (3, Fig. 4) was similar with 131 mg m^{-3}, 40% Cyanophyta, 23% Chrysophyceae, 20% Chlorophyta, but only 4% Diatomeae. Near the Luvubu River and Cape Kibwesa (4 and 5, Fig. 4) the regional biomasses were half the value of Karema, 64 mg m^{-3} and 56 mg m^{-3}, respectively. Both areas had approximately the same proportion of Chlorophyta. The major difference was in the percentage of Peridineae present. The Luvubu River had 14% compared to 3% in the Kibwesa region which is not influenced by a river.

The waters off Lubugwe, Cape Kungwe and Cape Kabogo (6, 7 and 8, Fig. 4) had similar biomasses (79 mg m^{-3}, 81 mg m^{-3} and 83 mg m^{-3}, respectively). Lubugwe and Cape Kabogo were dominated by Chrysophyceae, while the Chlorophyta were of primary importance near Cape Kungwe. The Cyanophyta were of third importance here, but had not been present at all near the Luvubu River or Kibwesa. The three northern areas Kigoma, Rumonge, and Bujumbura (11, 12 and 13, Fig. 4) had biomass values of 119 mg m^{-3}, 115 mg m^{-3} and 100 mg m^{-3}, respectively. Chrysophyceae (46%, 34% and 44%, respectively) were of primary importance in all three regions, with Chlorophyta of secondary importance at Rumonge and Bujumbura and Cyanophyta at Kigoma. Throughout the entire lake the Cryptophyceae were usually of

4th importance ranging from 5% to 21% of the biomass, while the Peridineae with the exception of the Luvubu and Malagarasi Rivers, composed only 2-3%.

During the first survey the dominant cyanophytes were *Anabaena circinalis* (*Anabaena flos-aquae* var. *circinalis* in Symoens 1956) in the south end of the lake and *Chroococcus limneticus* and *C. dispersus* in the north near Kigoma, Rumonge and Bujumbura. The other groups had more or less constant species composition, and varied throughout the lake only in absolute abundance with the exception that *Glenodinium pulvisculus* was dominant in the region of the Malagarasi River while Peridineae in other areas of the lake were mainly a very small *Gymnodinuim varians*.

Three diurnal sampling series (early morning to late evening) were completed for estimation of primary production, chlorophyll and phytoplankton at Kigoma (I-11 to I-16), Lubugwe (I-27 to I-32), and Kipili (I-42 to I-46) (Table 1 and Table 10). Maxima in phytoplankton biomass occurred during the early morning and mid-afternoon. The pattern was consistent for the three stations although the maxima were weakly developed and the daily range was not much greater than that observed for replicate sampling at Rumonge (Table 10).

In some of the regions samples were taken at various distances from shore to monitor the horizontal variation. Kipanga, for example, was sampled at stations 5 km (I-47), 16 km (I-48) and 26 km (I-49) from shore; Bujumbura at the opposite end of the lake was sampled at stations 5.6 km (I-104), 10 km (I-103) and 15 km (I-102) from shore. There was a trend of decreasing biomass from the inshore areas to the open water at Kipanga but not at Bujumbura (Table 10). The biomass decreased from 271 mg m^{-3} to 65 mg m^{-3} at Kipanga but increased to 186 mg m^{-3} from 96 mg m^{-3} at Bujumbura. Kipili had 186 mg m^{-3} at the 10 km offshore station, with a progressive decrease through the north, central and south stations in the archipelago with biomass values as follows: 160 mg m^{-3}, 157 mg m^{-3} and 133 mg m^{-3}, respectively. There was also a difference in composition between the 10 km station, which was dominated by Cyanophyta, to the central and south stations, which were dominated by Chrysophyceae and Diatomeae. At the north station all groups were evenly balanced. Karema was slightly higher at the offshore station than at the 1.6 km station (149 mg m^{-3} compared to 113 mg m^{-3}). The composition of the inshore station was 44% Cyanophyta and 18% Chrysophyceae compared to 35% Cyanophyta and 28% Chrysophyceae at the offshore station. Chlorophyta composed 20% at both stations. As a rule, the percentage of Chrysophyceae was greater in the offshore areas throughout the lake. The same trend appeared to hold true during the October sampling.

Protozoa

During the first survey samples were analysed for protozoa. The highest regional protozoan biomass, 241 mg m^{-3}, was found at Cape Kabogo (9, Fig. 4). Biomasses at the stations north of Cape Kungwe (I-22) and in the Malagarasi River plume (I-18 and I-19) were also high, 120 mg m^{-3} and 180 mg m^{-3}, respectively. Other areas of considerable biomass were the north end of the lake (13, Fig. 4), 210 mg m^{-3}, and Kipili (2, Fig. 4) 144 mg m^{-3}, in the south end of the lake. The lowest biomasses ranged between 60 mg m^{-3} and 90 mg m^{-3}. The dominant genera were *Strombidium, Didinium* and *Coleps*. Individual protozoan volumes ranged from 500 μm^3 to 50,000 μm^3.

In the diurnal samples there was no consistent pattern in Protozoa compared to that of the phytoplankton. In two cases the maximum occurred during the early morning, i.e. Kigoma and Kipili, with a progressive decline towards evening. The Lubugwe station was low in the morning with a progressive increase towards evening. It is quite possible that different water masses were sampled at the same station through the day.

OCTOBER-NOVEMBER

Phytoplankton

During the second survey the regional pattern of maximum and minimum biomass (Fig. 5, Table 11) was reversed from that of the first survey. Kipanga (9, Fig. 5) at this time had an average biomass of approximately 25 mg m^{-3} composed of Chlorophyta 77%, Chrysophyceae 14% and Cryptophyceae 9% (Table 11). There was, in this area, a very high amount of detritus, so high at some stations as to make biomass estimates impossible. Progressing northward to Kipili (8, Fig. 5) the biomass increased to an average of 105 mg m^{-3} with the same components predominating, but declined in the Karema region (7, Fig. 5) to 70 mg m^{-3} with a low near the Luvubu River (II-58) of 54 mg m^{-3}. At the Luvubu station the dominants also changed to Chlorophyta 42%, Chrysophyceae 23% and Diatomeae 22%. In the Kibwesa region the biomass was 81 mg m^{-3} composed of 50% Chlorophyta, 30% Chrysophyceae, 9% Diatomeae and 9% Cryptophyceae (6, Fig. 5). The Lubugwe region (5, Fig. 5) had a biomass of 67 mg m^{-3} with Chlorophyta dominating and approximately equal proportions of the Chrysophyceae, Diatomeae and Cryptophyceae. The Malagarasi River region on October 16, 1975 had a biomass of 105 mg m^{-3} with the predominant algal groups Cyanophyta 53%, Chlorophyta 30% and Diatomeae 10%. The region had had the maximum biomass in April 1975 with Peridineae dominating.

At Kigoma samples were taken from the 8th October to 13th October. The maximum biomass observed on the second survey, 1574 mg m^{-3}, occurred at 14:55 on 10th October during diurnal sampling. The average for the day was 742 mg m^{-3} composed of 80% Cyanophyta, and 15% Chlorophyta. The biomass on the 8th and 9th October was 260 mg m^{-3}, 100 mg m^{-3} on the 12th and 194 mg m^{-3} on the 13th. *Anabaena circinalis* was the most abundant species at all times.

North of Kigoma in the Rumonge region (2, Fig. 5) the average biomass was 110 mg m^{-3} with a change in composition from Chlorophyta-Diatomeae-Cyanophyta to Chlorophyta-Chrysophyceae-Diatomeae between stations II-17 and II-19.

In the north end of the lake the biomass averaged 593 mg m^{-3} at the beginning of the survey on October 4, 6 and 7, dominated by Diatomeae 64%, and Chlorophyta 32% (1A, Fig. 5). At the end of the survey on November 4th and 5th, the average was 607 mg m^{-3}, 54% Chlorophyta, 22% Cyanophyta and 12% Chrysophyceae (1B, Fig. 5).

During the October-November survey four diurnal samplings were performed at Kitaza, Kigoma, Lubugwe, and Kipili. There was no consistent pattern of diurnal variation although the daily range was much greater than that observed in replicate sampling at station II-26. Most of the diurnal variation is probably due to movement of water masses.

In general the ratio of protozoa to phytoplankton was high in the southern areas of the lake during this survey (Fig. 5). At Kipanga the ratio was low only 0.33 but it increased to 0.51 at Kipili and to 2.10 at Lubugwe (9, 8 and 5, Fig. 5). The protozoan biomass in these regions was rather low ranging from 85 mg m^{-3} at the south end to 140 mg m^{-3} off Lubugwe. At the Malagarasi (4, Fig. 5) the ratio of protozoans to phytoplankton had decreased to 0.36. At Kigoma the protozoan biomass was low. The ratio ranged from .04 to .13 during the week of sampling. From Kigoma to Bujumbura the ratio of Protozoa to phytoplankton was between 0.16 and 0.25. On the 6th of October when the survey began the ratio was 0.26 while on November 4-5 it was 0.96. During the diurnal observation off Kitaza on November 4th the Protozoa had a maximum recorded value 1046 mg m^{-3} which was 2.1 times greater than the phytoplankton biomass at the time. The average for the day was 391 mg m^{-3} which was 0.96 of the phytoplankton biomass. The predominant genera were *Stentor, Vorticella, Strombidium.*

Bacteria

Daley and Hobbie (1975) discuss methodological problems of enumerating bacteria and compare their method (which we used) with others. The countability of cells declines with storage time, and our estimates are likely to be low because of this. Bacteria were sampled during the October-November survey but less frequently than phytoplankton; therefore, they are summarized here with regard to the three main water masses described in the chlorophyll section. Results are given in Table 12 and summarized in Table 13. There are significant differences between the water masses in their bacterial concentrations just as there were in chlorophyll and chemical concentrations. The bacterial concentrations appear to have an inverse relationship with chlorophyll. The Central Lake had the most variable and highest chlorophyll concentrations while the South Lake had the lowest (Table 6). Bacterial concentrations are highest and similar in the North and South Lake, while they are significantly lower in the Central Lake.

At II-25 bacterial numbers increased in the depth zone where oxygen disappeared. This depth distribution is probably characteristic of the lake. The methane oxidation rates at II-25 were the lowest observed in the lake so that the increase observed was likely minimal compared to the rest of the lake. The counts on this close interval depth profile indicate considerable structure in the water column near the perennial thermocline. A similar impression was given by the nutrient profiles at station II-125 (Table 8). In contrast a bacterial profile in the euphotic zone at II-123 was more homogeneous, and the average of the profile was within 20% of the bacterial numbers estimated from a continuously integrated sample over the same depths.

JULY SURVEY

A much less extensive plankton survey was made during mid-July by the Kigoma Echo Sounding Group (U.N.F.A.O.) from which some phytoplankton samples were analyzed. Results (Table 14) indicate that the biomass values were much lower than the spring survey: 37 mg m^{-3} at Wampembe, 57 mg m^{-3} at Kibwesa, 69 mg m^{-3} at Kipili and 154 mg m^{-3} at Cape Kungwe. The composition changed from a predominance of Chlorophyta and Cryptophyceae in the three southern areas to Diatomeae at Cape Kungwe. The biomass at Kigoma itself was somewhat lower, only 60 mg m^{-3} composed primarily of Diatomeae, Chrysophyceae, and Chlorophyta. During this period, the north end of the lake at the Bujumbura 14 km station, had a biomass of 200 mg m^{-3}, composed of 37% Diatomeae, 32% Chlorophyta, and 18% Chrysophyceae.

SEASONAL SUCCESSION

Seasonal changes in phytoplankton and protozoan biomass and composition were monitored off Bujumbura and Kigoma stations from February-March 1975 to October-November 1975 (Fig. 6 and 7). Samples off Bujumbura were taken weekly at 5 m intervals to depths of 25-30 m. During the month of February samples were taken to 50 m (thermocline). However, it was found that in general below 20 m the phytoplankton biomass was negligible, and the decrease in transmissometer values in this region found by Coulter (1977) were due to layers of accumulated detritus. The values reported are average values for the euphotic zone. Kigoma sampling occurred at monthly intervals with somewhat more frequent sampling during July and October. The samples were again taken at 5 m intervals to 30 m and integrated. A species list (Table 15) of phytoplankton was compiled, but the protozoa were only taken to genera where possible as the aspect of major interest was the seasonal distribution of biomass in comparison to that of the phytoplankton.

Bujumbura

At the onset of sampling in early February, 1975 the biomass was 160 mg m^{-3} with Chlorophyta, Cyanophyta, and Chrysophyceae the predominant algal groups. The biomass declined into March reaching a minimum of 60 mg m^{-3} and remained less than 100 mg m^{-3} until the beginning of May. The composition throughout this period remained Cyanophyta-Chlorophyta. By May the Cyanophyta had decreased considerably and the order of dominance became Chrysophyceae-Chlorophyta-Cryptophyceae. Throughout the period February-May the major components of each of the predominating groups were: Cyanophyta: *Chroococcus limneticus, Ch. limneticus* v. *dispersus;* Chlorophyta: *Sphaerocystis schroeteri, Gloeocystis* sp., *Coelastrum reticulatum, Lobocystis dichotoma* v. *mucosa,* plus several species of the genera, *Lagerheimia, Monoraphidium,* and *Treubaria*; Chrysophyceae: *Ochromonas* spp., *Chromulina* spp., *Erkenia subaequiciliata, Salpingoeca frequentissima, Bicoeca* spp. and *Monosiga* sp.; and Cryptophyceae: *Rhodomonas minuta* v. *nannoplanktica* and *Katablepharis ovalis.* Throughout June, July and the beginning of August the biomass rose to around 200 mg m^{-3} with Diatomeae dominating, composed of species of the genera *Synedra, Nitzschia,* and occasionally *Cyclotella* and *Rhizosolenia* (see species list, Table 15, for the actual species). There was a

brief period in August when the biomass dropped and the composition changed back to Chlorophyta. With the onset of the rains in early September the biomass increased to 300 mg m^{-3} but crashed a week later to 100 mg m^{-3} although still dominated by Chlorophyta. As the biomass began again to increase the Diatomeae recovered rapidly and reached the maximum recorded value of 930 mg m^{-3}. This population dropped off rapidly, but the biomass increased again to 810 mg m^{-3} as the composition changed to Chlorophyta-Cyanophyta and Chrysophyceae. The Cyanophyte was *Anabaena circinalis* while the major species of the other groups remained much the same as mentioned earlier.

The vertical distribution (Fig. 8) of phytoplankton off Bujumbura varied somewhat throughout the season. From February through to April there was an accumulation of plankton at 5-10 m. Later in the year as the dry season progressed and the winds increased, the phytoplankton appeared more or less homogeneous.

The protozoa biomass varied considerably more than that of the phytoplankton throughout the year (Fig. 9). February through April appeared to be the period of highest biomass. The maximum during this time was around 460 mg m^{-3} (almost three times the phytoplankton value of 160 mg m^{-3}). From April to August the population was generally declining. A minimum of approximately 10 mg m^{-3} in August was reached followed by a gradual increase as the phytoplankton increased with the onset of the rains in September. Throughout the year the population appeared to build up to a peak every three to four weeks and then decline. Approximately at the similar intervals much of the population in the 0-5 m depths appeared to be in cellular division.

The vertical distribution (Fig. 10) of protozoans was similar to that of the phytoplankton. Early in the year there were large accumulations at 5-10 m dropping to 15 m as the season progressed and becoming completely dispersed with the winds later in the dry season.

At the beginning of the year there was a predominance of the genera *Strombidium*, *Haltaria*, *Strobilidium* and cf. *Uronema*. As the Diatomeae became abundant in the plankton the protozoa composition changed to species of the genera *Tintinidium*, *Stentor*, *Strombidium* plus *Haltaria* sp. with the others in smaller abundance. The *Tintinidium* sp. built its lorica completely of diatom frustules.

Kigoma

Sampling of phytoplankton at the Kigoma station (Fig. 7) began in March, a month later than at the Bujumbura station. At this time the average biomass was 60 mg m^{-3} dominated by Cyanophyta, Chlorophyta, and Chrysophyceae species similar to those of the Bujumbura area. The general pattern of succession appeared much the same as that of the Bujumbura area until July although the average biomass remained much lower, less than 100 mg m^{-3} with the Diatomeae never reaching the proportions that they achieved off Bujumbura. The proportion of Chrysophyceae was also higher with a lower proportion of Chlorophyta although the overall composition of species was the same. In September the biomass began to rise, as the components changed to those of the groups Cyanophyta-Chlorophyta. On 11 October the biomass reached a maximum of 730 mg m^{-3}, 83% of which was the cyanophyte *Anabaena circinalis*. Vertical distribution was monitored occasionally but showed no significant variation.

The protozoan biomass (Fig. 9) was low from March to July at which time it rose to 410 mg m^{-3}, approximately eight times the phytoplankton standing crop at the time. This appeared to be the maximum for the year as it dropped back to around 50 mg m^{-3} for the rest of the season. The predominating genera were as at Bujumbura with the addition of *Didinium*, *Vorticella*, and what looked like a *Holophyra*.

Discussion

Compared to lakes in the temperate zone, Lake Tanganyika is an ultroligotrophic lake on the basis of biomass (Vollenweider 1968). Generally in Canada such lakes are found to be dominated by Chrysophytes throughout the entire year (Kling and Holmgren 1973). This Chrysophyceae dominance was however not the case for Lake Tanganyika. On the basis of dominant algal groups Lake Tanganyika is more similar to a eutrophic prairie pot-hole where phytoplankton of the Chlorophyta-Cyanophyta groups dominate (Kling 1975).

Compared to the Great Lakes of Canada (Munawar and Munawar 1975), Lake Tanganyika favorably resembles most closely Lake Superior which is the most oligotrophic having a biomass of generally < 600 mg m^{-3}; but on the basis of composition there is no resemblance as all the Great Lakes contained plankton composed primarily of phytoflagellates of either Chrysophyceae-Cryptophyceae or Cryptophyceae and dinoflagellates, while Lake Tanganyika plankton was primarily composed of coccoid chlorophyta, filamentous cyanophytes and *Nitzchia*-like diatoms. On the basis of biomass at the time of maximum standing crop (2048 mg m^{-2}) Lake Tanganyika compared favorably with Lake Baikal which according to Moskalenko (1972) had an average maximum standing crop of 2790 mg m^{-2} within a 0-25 m layer over the years 1964-68. The phytoplankton of Lake Baikal was composed primarily of diatoms and dinoflagellates compared to diatoms, chlorophytes and cyanophytes at the times of maximum productivity in Lake Tanganyika.

The protozoan population in Lake Tanganyika was extremely important in the total biomass. On the average, the protozoan standing crop was nearly equivalent to and frequently greater than the phytoplankton biomass in this lake. This is very high compared to other lakes, whether tropical or temperate. In samples from the other African Rift lakes the protozoan to phytoplankton ratio was less than .05 while in Canadian Shield, prairie, and Arctic lakes the ratio is approximately 0.10-0.20. The ciliated protozoans of primary importance were of the genera *Strombidium*. These organisms contained symbiotic zoochlorella which may have been responsible for their ability to maintain such large numbers compared to the phytoplankton. Other genera of protozoa found in relatively large numbers were primarily bacteria feeders.

PLANKTON METABOLISM

PRIMARY PRODUCTION

The data from cruises I and II are given in Tables 16 and 17, respectively. On the first cruise the rate of uptake of carbon in the dark equaled or exceeded uptake in the light in 24 out of 38 experiments. Furthermore, in those instances when the dark uptake was lower than the light uptake, the uptake rates in the light usually did not resemble photosynthesis vs. light response curves; that is, the uptake at low irradiances were not consistently lower than the rates at higher irradiances. We initially suspected our methodology, but the acidification and bubbling method gave consistent results in a methods comparison experiment done on the second cruise. In oligotrophic ocean waters the ratio of light fixation to dark fixation often becomes very low as well (Morris et al. 1971). Therefore our observations are perhaps not surprising in view of the low standing crops in April-May. This tendency is probably exacerbated in Lake Tanganyika by dark uptake of CO_2 by bacteria to be discussed later. We interpret these results to mean that phytoplankton photosynthesis was unmeasurably low in most of the lake at the time of the first cruise. Accordingly, no estimates of integral daily production rates have been made for that period. On the second cruise the carbon uptake rates of the dark bottles were lower than the rates in the light bottles, and the photosynthesis vs. light curves were classical rectangular hyperbolae which is characteristic of an active photosynthetic system.

Since the work of Arthur and Rigler (1967) filtration correction curves are often used when radioassay of primary production is done by membrane filtration. Table 18 contains filtration correction curves for a complete set of irradiances at an offshore station at Kigoma on October 13, 1975. At the three highest irradiances there is no consistent decline of activity per mL filtered with increasing volume filtered. Only in the dark is there a marked decline of activity, per mL, with increasing volume filtered and the magnitude of this decline is attributable to a single data point. Because of these data, we have not made any routine correction for filtration.

One of the goals of our research was to determine the feasibility of estimating local algal growth rates from measurements of chlorophyll. Accordingly, the rate of carbon uptake at light saturation per unit of chlorophyll (the assimilation number, A) has been calculated (Table 17). A varied from 1.8 to 20.5 mgC mg^{-1}chl hr^{-1} with a mean value of 5.7 and a coefficient of variation of 70%. Chlorophyll concentration alone cannot be used as an indicator of primary productivity in Lake Tanganyika. Our mean A value is equivalent to 19 mgO_2 mg^{-1}chl hr^{-1} assuming a productivity quotient of 1.2. Ganf (1975) found the mean A value in Lake George (Uganda) to be about 17 mg O_2 mg^{-1}chl hr^{-1} for extensive synoptic surveys while Talling (1965) found a mean A of 25 for a variety of African lakes. Their coefficients of variation were lower than ours, but the lakes they examined were considerably more productive.

We did a few primary production experiments in which changes of oxygen concentration were measured (Table 19). During the first cruise the technique lacked precision and the difference between the bottles in the light and in the dark was not meaningful. These results was analogous with the carbon results from the first cruise, i.e. poor precision and inconsistent light responses. On the second cruise the only oxygen experiment done had good precision, and the light response was acceptable. However, even in this experiment net production (i.e. O_2 production in the light exceeds rate of dark consumption) occurred only at the highest light intensity.

Possible diurnal variation of photosynthesis vs. light curves was another problem that demanded resolution before incubator results from one part of the day could be extrapolated to all parts of the day. Four diurnal experiments were performed during the second cruise and the data given in Table 20. The importance of diurnal variation is best assessed by comparing the estimates of daily integral primary production made by extrapolating each curve over the entire day. Table 20 shows that there is very wide variability attributable to diurnal variation, but no single pattern describes all dates. However, estimates made from samples taken before mid-morning are similar. Samples taken after 9 a.m. show no consistent pattern, giving estimates both higher and lower than the morning samples. Correcting rates for sampled chlorophyll concentration did not reveal any consistant pattern either. For this reason, diurnal variation of photosynthesis vs. light curves could not be modelled as suggested by Fee (1975). Rather daily integral primary production rates were calculated on the basis of the single productivity light response curve available at most stations.

Samples for autoradiographic analysis were taken on October 14, 1975 from a station 6 mi off Kigoma. After injection of ^{14}C, replicate samples were placed in the incubator at 130 μ Einsteins m^{-2} sec^{-1} and in the dark for 1 hr. They were fixed with Lugol's iodine solution and formalin. There was much more detritus than living material in the samples and the only alga present in sufficient abundance to count was *Anabaena circinalis*. Two distinct colonial forms were present: large, tightly packed colonies containing about 700 cells and single strands with 10 to 20 cells. There was no difference in the carbon uptake per cell between these two colony forms. This species had a carbon fixation rate of 0.3 picograms C $cell^{-1}$ hr^{-1}. This rate is comparable to the low rate of growth of a similar *Anabaena* species that occurred in Lac Hertel (a small eutrophic Canadian Lake) just prior to a dramatic decline in the population (Knoechel and Kalff 1975). This rate corresponds to a doubling time of 100 to 140 hr under optimum growth conditions. Dark uptake rates for *Anabaena* were approximately 20% of the light uptake rates. However, a substantial portion of the uptake of $^{14}CO_2$ in the dark was done by organisms not active in the light sample. Most of the detectable dark uptake was associated with filmy detritus and large bacterial cells. These results indicate that $^{14}CO_2$ uptake in the light and in the dark is being mediated by different organisms and the standard dark correction for photosynthetic production estimates may be inappropriate in Lake Tanganyika.

Samples from several depths were taken on 12 October and 4 November to determine the vertical distribution of photosynthetic potential. On both dates the surface sample demonstrated higher carbon uptake rates than the deeper samples. The more extreme case was on 4 November, and on this date

we also had a pooled sample from five depths for comparison. The estimate of daily integral primary production using the single pooled sample was 843 mg C m^{-2} day^{-1} while the estimate with the five discrete samples was 719 mg C m^{-2} day^{-1} - the deviance being 15% of the mean. This error is small compared to the difference that was observed among different samples taken at one place with a single sampling technique at different times of day (diurnal variation discussed above, Table 20). We have therefore accepted our pooled samples as being representative of the average conditions in the water column.

Table 21 gives the estimates of daily integral primary production both for actual surface light conditions as recorded and with cloudless weather. Because of the results of the autoradiographic experiments, integral production is calculated with and without correction for dark uptake. Production rates for actual weather, corrected for dark uptake, varied from 0.1 to 3.1 gC m^{-2} day^{-1}, mean 1.1 gC m^{-2} day^{-1}; potential production under cloudless conditions varied from 0.3 to 3.1 gC m^{-2} day^{-1}, mean 1.42 gC m^{-2} day^{-1}. Without correction for dark uptake, the daily integral production rates nearly double, on the average, for either actual or cloudless weather. The range for actual weather becomes 1.0 to 3.8 gC m^{-2} day^{-1}, mean of 2.3 gC m^{-2} day^{-1} while cloudless rates range from 1.2 gC m^{-2} day^{-1} to 4.0 gC m^{-2} day^{-1} with a mean of 2.6. The elimination of the dark correction also substantially reduces the standard deviation of the mean estimate when expressed as a percentage of the mean from 52% to 30% for cloudless estimates and from 59% to 36% for actual weather estimates. Clearly variance in dark uptake rates is a major source of variance in production estimates if a dark correction is applied. Without dark correction the lake is nearly homogeneous in its daily rates of integral primary productivity with stations in the North and Central Lake having mean estimates of 2.6 gC m^{-2} day^{-1} in cloudless weather while the South Lake is insignificantly lower at 2.5 gC m^{-2} day^{-1}.

RESPIRATION

The respiration rates for the two cruises are given in Tables 1 and 2, respectively. Because different bottle sizes were used on the two cruises, an experiment was done at the start of the second cruise to determine whether bottle size influenced the oxygen depletion rate. Table 22 shows that there is no trend in the respiratory rate with bottle sizes representing a twofold range in surface area to volume ratio, all gave similar rates. This is support of our belief that these results are not artifacts of enclosure. Also our measured rates are similar to the range observed by Melack (1976) 3.8 to 8.7 mgC m^{-3} hr^{-1} near Kitaza in April 1972. Quite contrary to all other parameters, the rate of respiration declined from the first cruise to the second cruise at all stations. The greatest decline was at Cape Kibwesa and the least was at Lubugwe River (5.07 and 0.21 mgC m^{-3} hr^{-1}); the mean decrease between paired stations was 2.18 mgC m^{-3} hr^{-1}.

METHANE OXIDATION

Methane oxidizing activity in lakes with anoxic bottom water has been found to occur during periods of stratification in a narrow zone near the depth of zero oxygen concentration (Rudd and Hamilton 1975, Rudd et al. 1974, 1976, Jannasch 1975). In these lakes the methane oxidizers consumed almost all of the methane as it diffused up to the depth of zero oxygen concentration. Thus methane concentrations in the oxygenated portion of the water column were very low but increased rapidly below the depth of zero oxygen concentrations. A similar situation was expected in Lake Tanganyika even though previous Belgian expeditions had not detected dissolved methane (Dussart, pers. comm.).

During a North to South cruise on the lake, the depth of zero oxygen concentration descended progressively (Table 23). Methane concentrations in the oxygenated layer were very low (< 0.5 µM), but increased rapidly below the depth of zero oxygen concentration (Fig. 11).

Samples for methane oxidizing activity were taken at close depth intervals above and below the depth of zero oxygen concentration. The oxidizers were active only within a narrow zone of approximately 10 m depth at the oxic/anoxic interface (Fig. 12). The thickness of this methane oxidation zone was similar in depth to that given by Jannasch (1975) for Lake Kivu, but was approximately ten times greater than that reported by Rudd and Hamilton (1975) for Lake 227, a small Canadian shield lake. This large difference probably reflects higher rates of vertical diffusion of dissolved substances in the larger lakes.

The highest rates of methane oxidation occurred at both ends of the lake (Fig. 12). Towards the centre of the lake rates were either lower (Lubugwe, II-53) or undetectable (Kigoma, II-25). The reduced rates at the Lubugwe and Kigoma stations may be explained by the breakdown of stratification and mixing of the upper layer of the lake to the depth of zero oxygen which occurs during the dry windy season of May to September (Coulter 1963). At the time of sampling surface waters in these areas were experiencing algal blooms and/or significant increases in algal biomass (see section on chlorophyll results). After each of the mixing periods the depth of zero oxygen concentration would decrease. If this happened quickly enough the zone of methane oxidation would not become well established at the depth of zero oxygen concentration for a period of time. There is some evidence that this was occurring at the Kigoma station on October 9, 1975 when the methane oxidation and oxygen profiles were taken. At that time the oxygen concentration of a 40 m thick layer of water between 75-115 m was uniformly about 0.1 mg L^{-1}. Consequently the depth of zero oxygen concentration would probably have risen quickly from 120 m to about 75 m since respiration rates in this warm (25° C) water are high. Thus during the dry season methane oxidation may be of variable intensity depending on when and where circulation has occurred.

During the rainy season of October to April, the upper portion of the lake is thermally stratified without interruption (Coulter 1963) and the methane oxidizers would become well established at the

depth of zero oxygen concentration. During this time it would be likely that methane oxidizing acitvity would be similar to that which was observed at the Bujumbura, Kipili and Kipanga stations (Fig. 12). The average areal rate for these stations was 5.8 mMoles $CH_4 m^{-2}$ day (Table 23). If this figure is taken as an average daily areal rate for the rainy season, then the total amount of methane oxidized during that period of the year would be 1.24 Moles m^{-2} or 15.0 gC m^{-2}. During the dry season (May-September, when different parts of the lake are intermittently mixed to the depth of zero oxygen concentration, methane oxidizing activity would probably be more closely approximated by all of the profiles shown in Fig. 12. By integrating the oxidation rates within the zone of activities of all the profiles, it is estimated that the average daily rate during the dry season was 3.8 mMoles CH_4 m^{-2} day^{-1} and the total amount of methane oxidized during the dry season would be 0.6 Moles CH_4 m^{-2} or 7.2 gC m^{-2}. A rough estimate of total annual methane oxidation in Lake Tanganyika is 1.84 Moles CH_4 m^{-2} $year^{-1}$ or 22.1 gC m^{-2} $year^{-1}$.

This estimate is remarkably close to the estimated annual rate of methane oxidation for Lake Kivu given by Jannasch (1975). Expressed on an areal basis his annual rate estimate was 2.6 Moles CH_4 m^{-2} $year^{-1}$. In both of these lakes rates of methane oxidation must be controlled by rates of vertical transport of dissolved methane to the depth of zero oxygen concentration. Since oxidation rates were similar in the two lakes even though the methane concentration gradient below the depth of zero oxygen concentration was much steeper in Lake Kivu (Deuser et al. 1973), rates of vertical transport to the depth of zero oxygen concentration must be much slower in Lake Kivu. The slower rates of vertical mixing in Lake Kivu are probably associated with the rapid increase of salt content of Lake Kivu water with depth (Degens et al. 1973) as well as the smaller lake size. The faster diffusion rates in Lake Tanganyika are sufficient to keep methane concentrations in the bottom water relatively low in comparison to Lake Kivu's high (20 mMolar) and evidently increasing concentrations (Deuser et al. 1973). Thus the effects of methane cycling on these two lakes in terms of oxygen consumption, particulate production and carbon recycling are probably quite similar even though the "standing crop" of methane in Lake Tanganyika is much lower.

Since little dissolved methane was found above the depth of zero oxygen concentration in Lake Tanganyika and as no methane oxidizing activity could be found in surface water samples in which the methane concentration had been artificially increased, it is unlikely that methane was bubbling out of the monimolimnion. Therefore diffusion of methane to the depth of zero oxygen concentration was the only means of escape from the anoxic bottom waters. If vertical diffusion of dissolved substances out of the monimolimnion were in equilibrium with input, then the annual rate of methane production in the anoxic bottom waters would equal the annual rate of methane oxidation within the narrow zone of activity at the depth of zero oxygen concentration (i.e. 1.84 Moles CH_4 m^{-2} $year^{-1}$ or 22.1 gC m^{-2} $year^{-1}$).

An average of 74 percent of the methane oxidized at all of the stations was converted to carbon dioxide, with the remainder being incorporated into bacterial cell material. This is a relatively high respiration rate in comparison to methane oxidizers active in a North temperate lake. Rudd and Hamilton (in prep.) found that only 50% of the methane oxidized in Lake 227 was converted to carbon dioxide. Thus the Lake 227 methane oxidizers were twice as effective as the Lake Tanganyika oxidizers in converting methane carbon to cell material. This high rate of respiration seems to be a general characteristic of the entire planktonic microbial community of Lake Tanganyika.

DISCUSSION

The hypothesis upon which this research was undertaken was that fish production in Lake Tanganyika is ultimately dependent upon algal production. General ecological theory suggests that about 1% of net algal production should convert to fish production in a simple food chain where zooplankton are the main fish food. Melack (1976b) has suggested that fish yield in tropical lakes including Tanganyika is a logarithmic function of gross primary productivity. If this were true, primary production estimates would serve as independent estimates of fish production against which estimates of fish production made with echo-sounding equipment (Chapman 1976) could be evaluated. As the precision of these acoustically based methods is still uncertain, an independent estimate would make investment in fisheries development programs less risky. Unfortunately we conclude that the general hypothesis under which the program was initiated is untenable in Lake Tanganyika.

If algal primary production were the only process introducing fixed carbon to the planktonic community, then the net production available for transfer to the consumer trophic levels would be obtained by subtracting planktonic respiration from gross production. The radiocarbon method of estimating primary production is generally thought to measure something between net and gross production as estimated by the oxygen change method (Vollenweider 1969). The productivity quotient, P.Q. (moles of O_2 liberated per mol CO_2 incorporated), of the photosynthetic process varies between 1.0, if hexose is the sole organic carbon product, to ca. 3.3, if fat is the major product. Westlake (1965) suggests that 1.2 is a more reasonable long term average for natural communities.

In Lake Tanganyika oxygen changes resulting from photosynthesis are near the limits of detection for the oxygen method, but on the second trip when productivity was higher it was possible to determine a P.Q. at station II-37 (Table 24). The results of autoradiography at this station indicated that organisms not active in the light (130 μE m^{-2} sec^{-1}) accounted for a proportion of dark uptake of $^{14}CO_2$. If the radiocarbon rates of carbon uptake are corrected for dark uptake the resulting P.Q. values range from 2.3 to 2.7 at the highest light levels down to 1.2 at the lowest level. However, if the dark correction is not made the P.Q. values are between 1.6 and 2.0 at highest light down to 0.75 at the lowest light level. With or without dark correction, the P.Q. value at high light is much higher than expected for healthy, actively growing algal cells.

Station II-37, however, may not be representative of the general situation in Lake Tanganyika. In particular it had the lowest assimilation number, A = 1.8 mgC mg^{-1} chl hr^{-1}, we observed in the

surface waters of the lake. Also the rate of carbon fixation per cell of *Anabaena* was extremely low as indicated by autoradiography. The cells may not have been in good physiological condition and much of the chlorophyll may have been inactive. This would yield a low assimilation number which would in turn be consistent with a high P.Q. Our mean A value for the lake, using dark corrected optimum carbon uptake values, are typical of other A values from African waters based on oxygen production estimates, and this should mean that in general dark corrected rates will yield a close approximation to gross production if a productivity quotient of 1.2 is assumed. The magnitude, behavior and variability of uptake of carbon in the dark confounds a simple interpretation of the data for any single location. At this point it is probably safest to offer estimates of both dark corrected and non-corrected uptake, and base discussion on both.

Other studies comparing the oxygen and radiocarbon methods in natural communities have found P.Q. to be variable and ranging much higher than physiological consideration, i.e. nature of the fixed carbon product, could explain. Explanations usually invoke methological problems such as 1) rapid loss of volatile radiocarbon activity from filters during drying, Wallen and Geen (1968), 2) loss of isotopically labelled fixed carbon because of cell breakage during filtration (Arthur and Rigler 1967), and 3) lack of estimation of labelled dissolved organic carbon excreted during the incubation period (Fogg and Watt 1965).

Correction for the first problem is not in general use, and comparison studies of radiocarbon activity on dried filters and immediate acidification and bubbling of labelled samples done by one of us (R. E. Hecky, unpublished) on Canadian lakes indicates that it certainly is not a ubiquitous problem. The second and third problems are likely to be of varying significance depending on the particular organisms present and the environmental conditions making a general correction factor impossible. Our single filtration correction curve at station II-37 indicated that correction was only significant for the dark treatment. Underestimation of photosynthetic production because of loss of radioisotopically labelled dissolved excreted organic carbon in the filtration method is currently a contentious issue in limnology *vide* Sharpe (1977) and Fogg (1977). One of the most thorough studies yet of the problem concluded that there is not likely to be accumulation of excreted material in nature as it is rapidly incorporated into particulate carbon (Wiebe and Smith 1977). Because of the lack of evidence indicating that the radiocarbon method using short incubations consistently underestimates gross production by a large margin and the agreement we obtained between our assimilation numbers derived from the radiocarbon method and other assimilation numbers from African lakes based on gross oxygen production, we tentatively accept our estimates as a near approximation to gross production.

During April-May 1975 photosynthetic carbon uptake was virtually undetectable while the average rate of respiration (assuming a mixed layer of 30 m depth and excluding results from stations at river mouths) was 3.6 gC m^{-2} day^{-1}. Because transparency did not change between the two surveys, we can estimate a probable primary productivity for the lake if we assume the assimilation number in April-May is the same as in October-November, i.e. 5.7 mgC mg^{-1} chl hr^{-1}. Under these assumptions primary production will be nearly proportional to chlorophyll content. The mean chlorophyll content of the euphotic zone was 0.7 mg m^{-3} in April-May and 1.7 mg m^{-3} in October-November. Therefore the areal rate of photosynthesis in April-May would be 0.9 gC m^{-2} day^{-1} (0.7/1.7 X 2.2 gC m^{-2} day^{-1}) using the October-November rate which was not corrected for dark uptake[1]. This level of production would leave a respiratory deficit of over 2.5 gC m^{-2} day^{-1} in the plankton during the April-May period.

In October-November 1975 the average photosynthetic primary production rate (uncorrected for dark uptake) was 2.2 gC m^{-2} day^{-1}, but the average respiration rate was 2.6 gC m^{-2} day^{-1} for a 30 m mixed layer. If a respiratory quotient of 0.8 rather than 1.0 is applied the respiration rate would be 2.1 and there would still be no significant net synthesis of fixed carbon. Thus, even at the time of maximum primary production, daily integral photosynthetic production is barely adequate to offset the metabolic requirements of the planktonic community. Integral primary production rates using the standard dark correction would result in much larger deficits during both surveys. These results are confirmed by the attempts to measure primary production using the oxygen evolution method. In the single acceptable experiment only at the highest irradiance value in the incubator was a positive net photosynthetic production observed. Even this station, when the whole epilimnetic water column is considered for 24 hours, would suffer a significant oxgyen deficit.

The unexpected conclusion is that *in situ* primary productivity does not supply enough fixed carbon to support even the respiratory requirements of the micro plankton let alone yield net production to the larger crustacean zooplankton and the fish community. This conclusion would not be altered even by extending the October-November productivity rates through the entire year. If this were done and an annual respiration rate computed by averaging the results of the two cruises the respiration deficit would be -0.9 gC m^{-2} day^{-1} (2.2 gC m^{-2} day^{-1} (prod) - 3.1 gC m^{-2} day^{-1} (resp) = -0.9 gC m^{-2} day^{-1}) assuming an R. Q. of 1 or -0.5 gC m^{-2} day^{-1} using an R. Q. of 0.8 for there to be a positive net plankton productivity available for secondary and fish production, another source of fixed carbon must be important in Lake Tanganyika. The present annual fish yield of 80 kg ha^{-1} should require a daily net production of 0.22 gC m^{-2} at a minimum assuming fish yield to be one per cent of net primary production. For this to be attained at observed rates of carbon uptake, respiration would have to be less than half the measured value. It is unlikely that methodological considerations alone explain the observed deficit.

Sources of fixed carbon on a scale adequate to support the observed deficit are few. There are virtually no data on the mass of organic carbon imported to the lake by rivers and atmospheric fallout, but it would be surprising if they were a major contribution to the organic carbon budget of

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[1] Use of primary production estimates not corrected for dark uptake will yield maximum possible estimates for gross production.

the lake. The renewal time of Lake Tanganyika based on its present volume, net evaporation, and outflow at the Lukuga River is on the order of 430 years (Hecky 1978). Most of the rivers entering the lake are cooler than the epilimnion and descend, upon entering, into the hypolimnion (Hutchinson 1957, p. 465) so that their contribution is dispersed over the entire mass of the lake before affecting the epilimnion. In view of the large mass of the lake and the relatively small contribution that imports are thought to make to the internal stores of fixed organic carbon, the large quantities of energy-rich reduced substances such as CH_4, H_2S, NH_4^+, already in the lake are probably the most realistic sources of energy for the pelagic ecosystem.

Bacterial heterotrophic production and chemosynthesis may balance the apparent carbon deficit left by primary production in comparison with community respiration and fish production. With the exception of methane oxidizing bacteria discussed above, we have made no direct measurement of bacterial synthesis. The estimated rates of net bacterial production by methane oxidation amount to less than 10% of primary production under the most realistic set of assumptions and don't significantly effect the carbon deficit.

There are suggested indirect methods in the literature which might be applied with caution to our data on respiration rates and dark CO_2 uptake to suggest some possible rates of heterotrophic bacterial synthesis. Only on the second cruise were bacterial populations directly enumerated so discussion of bacterial production will be limited to the data of the second cruise. All respiration and dark CO_2 uptake measurements were performed on samples from the euphotic zone. These near surface waters are well oxygenated and only heterotrophic bacterial production would be expected. The following formulae are often applied (Sorokin and Kadota 1972) to estimate heterotrophic bacterial synthesis (P):

1) $P = 0.08\ (D)$ mgC m^{-3} d^{-1}

or 2) $P = 16.7\ (A)$ µgC m^{-3} d^{-1}

where D = rate of oxygen consumption attributable to bacteria (mg O_2 m^{-3} d^{-1}) and A = rate of dark uptake of CO_2 (µgC m^{-3} d^{-1}).

To use the above equations corrections should be made for oxygen consumption and dark CO_2 uptake by phytoplankton and protozoa. As we did not physically or biochemically separate these components, specific respiration values from the literature must be applied to biomass estimates (Table 25). The mean plankton respiration for the second cruise is 9.5 mg O_2 m^{-3} hr^{-1} of which 1.1 mg O_2 m^{-3} hr^{-1} is probably attributable to the phytoplankton and protozoa (Table 25). Applying equation 1) above to the remaining 8.4 mg O_2 m^{-3} hr^{-1} yields a daily bacterial synthesis of 16 mgC m^{-3}. For the mean bacterial biomass at that time, 9.5 mgC m^{-3}, a doubling time of 0.6 days is calculated. As the bacterial population estimate is probably low because of loss of countable cells in heavy detritus, the calculated doubling time is probably somewhat low also. In a 30 m mixed layer, heterotrophic bacterial production could be adding about 0.5 gC m^{-2} d^{-1} to the plankton. This is approximately 25% of gross primary production during October-November. During the April-May period, respiration rates were higher, ca. 13.5 mgO_2 m^{-3} hr^{-1} while the biomass of phytoplankton was 50% lower than in October-November. Heterotrophic bacterial synthesis might approach 1.0 gC m^{-2} d^{-1} for a 30 m mixed layer at that time. Heterotrophic bacterial production would not be restricted to the upper mixed layer, but would extend to the oxic-anoxic interface which can be up to 100 m in the northern half of the lake and 200 m in the south.

The other approach to estimating heterotrophic bacterial production suggested by Sorokin and Kadota utilizes data on dark CO_2 uptake. Again the method strictly applies only to bacterial populations, and to use measurements on mixed populations probable dark CO_2 uptake by other plankton components must be considered. If the autoradiographic experiment at station II-37 is taken as representative of dark CO_2 uptake phenomena, then two corrections can be calculated and applied to the mean dark uptake, 3 mgC m^{-3} hr^{-1}, observed during October-November. Firstly, the observed dark uptake of *Anabaena circinalis*, the dominant alga, was 20% of its uptake in the light (130 µE m^{-2} s^{-1}). Therefore the proportion of the total dark uptake attributable to algal uptake can be estimated at 35% with the remaining 65% credited to the bacteria. The second correction is less straight-forward. At station II-37, many of the bacteria taking up CO_2 in the dark were not active in the light. Therefore the daily dark CO_2 uptake rate in the euphotic zone will vary with light intensity. There is no information to allow a realistic modelling of this process, but for the sake of discussion we have arbitrarily reduced the measured dark uptake rate by 50% for the 12 hr of daylight. These two corrections give a mean dark CO_2 uptake rate attributable to bacteria of 35 mgC m^{-3} day^{-1}. Applying equation 2) for heterotrophic metabolism, 585 mgC m^{-3} day^{-1} is estimated which is impossibly high (bacteria divisions would be 60 day^{-1}) and oxygen demand would have to be 50 times the observed.

The high dark CO_2 uptakes are enigmatic. Following Sorokin and Kadota (1972, p. 87) substantial chemosynthetic production could be inferred, but such chemosynthesis should not occur in the well-oxygenated surface layers of Lake Tanganyika. We have no explanation for these high dark CO_2 uptakes, but they are a persistent feature of the plankton ecology of the lake and light-inhibited organisms seem to be involved in the process. Further research is required to understand the potential contribution of this process to the trophic ecology of the lake. Utilizing the oxygen demand method of estimating heterotrophic synthesis, the rates of bacterial synthesis are reasonable for the observed populations. This bacterial synthesis is secondary production, as it requires the presence of complex organic material to sustain it, and therefore it does not help balance the fixed energy deficit in the plankton. However, the calculated integral rates of 0.5-1.0 gC m^{-2} day^{-1} represent a significant source of particulate carbon throughout the year.

Primary production alone cannot support the energetic requirements of the present biological community in Lake Tanganyika. For the lake to be in steady-state in regard to its energy requirements in 1975, organic carbon imports would have to be immense or production during brief upwelling episodes must be tremendous. The second cruise occurred during periods of rapid increase of algal biomass in the northern and central portions of the lake and although production rates were high they were not substantially greater than measured respiration. Whether or not the carbon-deficit persists over longer periods is uncertain, but we know of no reason to

consider 1975 unusual. The lake requires more intensive study on plankton dynamics to understand the basis of its high secondary production and especially the probable role of bacterial heterotrophy.

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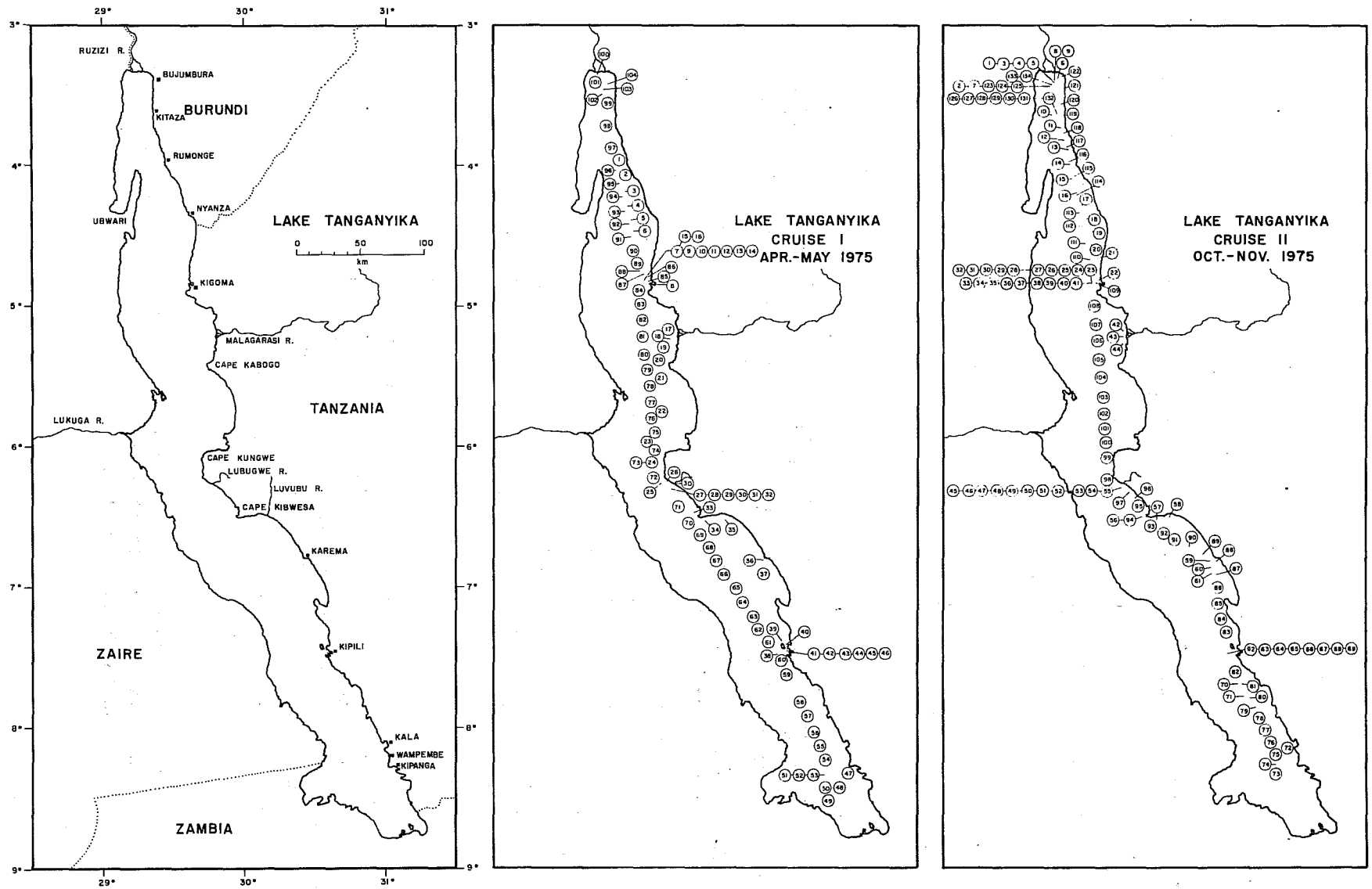

Fig. 1. Station locations on Lake Tanganyika.

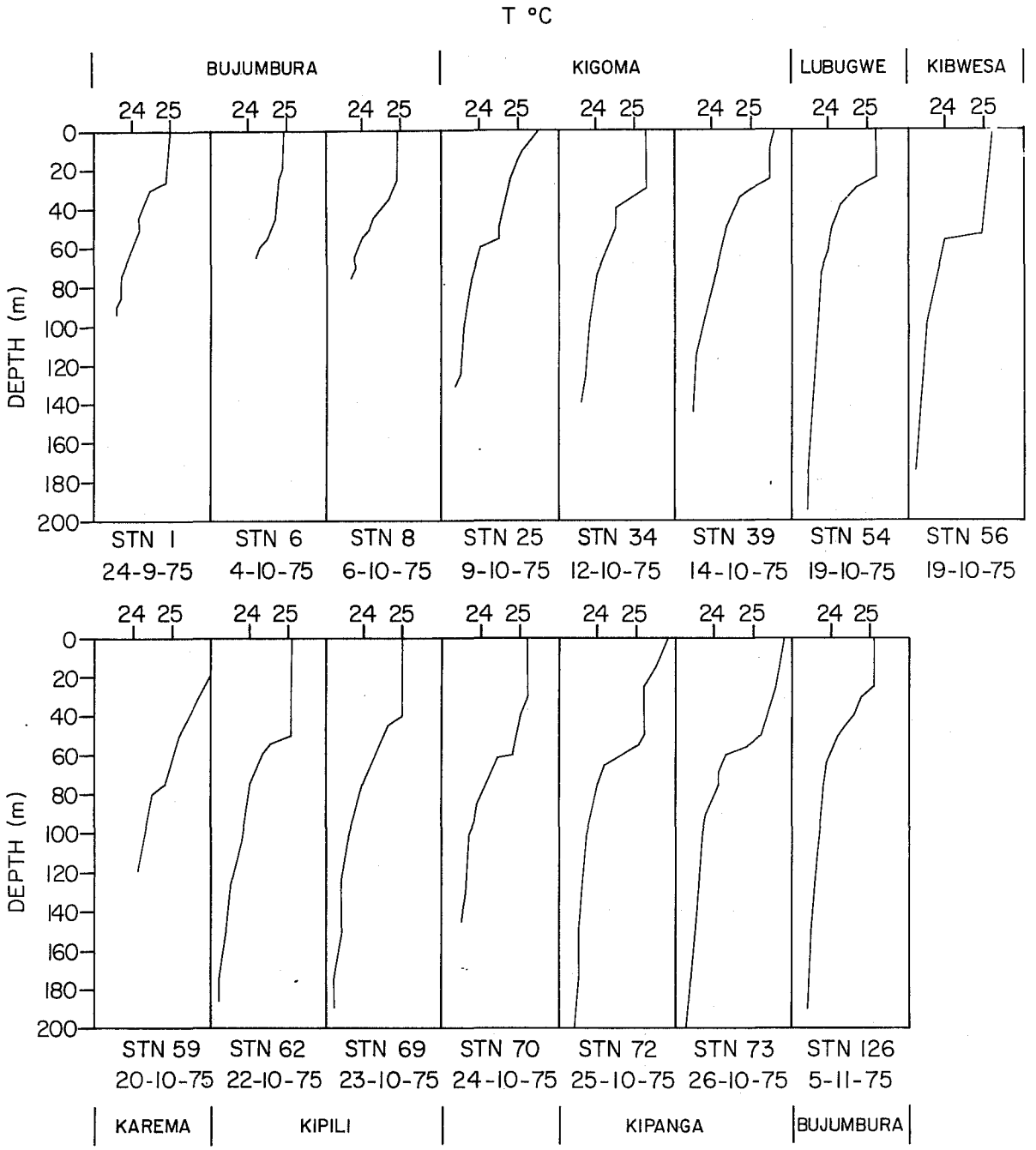

Fig. 2. Temperature profiles by station in Lake Tanganyika in October-November, 1975. Place names refer to nearest port.

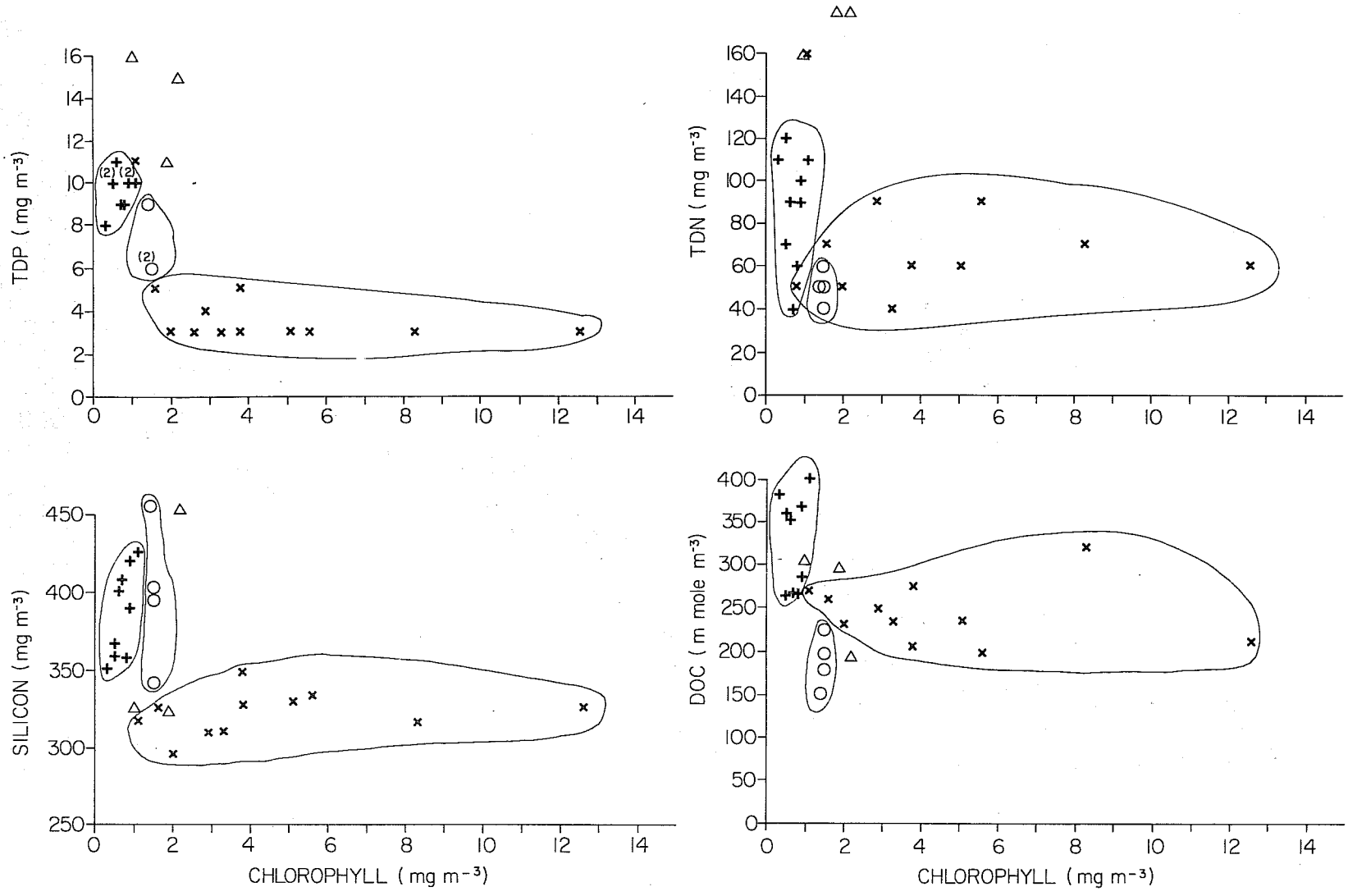

Fig. 3. Total dissolved phosphorus (TDP), totaldissolved nitrogen (TDN), silicon (Si)and dissolved organic carbon (DOC) vs. chlorophyll for stations in lake Tanganyika. (O) represents North Lake station, (X) is Central Lake, (+) is South Lake, and (Δ) is a station near the Malagarisi River.

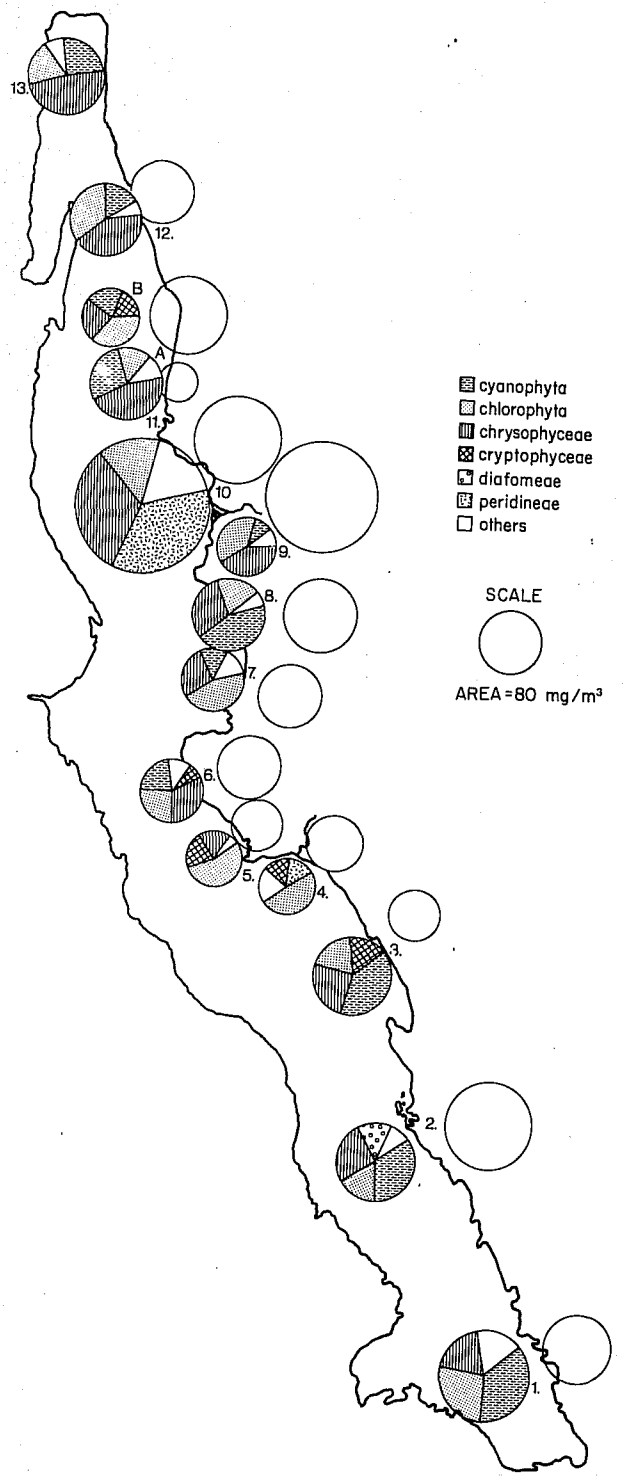

Fig. 4. Algal biomass and composition (pie circles) and protozoan biomass (open circles) for regions of Lake Tanganyika, April-May, 1975. The regions with stations included in the mean (in parentheses) are as follows: 1. Kipanga (47-53), 2. Kipili (38-46), 3. Karema (36-37), 4. Luvubu (35), 5. Kibwesa (33-34), 6. Lubugwe (27-32), 7. Cape Kungwe (23-24), 8. Cape Kungwe North (22), 9. Cape Kabogo (20-21), 10. Malagarasi (17-19), 11a. Kigoma (7), 11b. Kigoma (85-89), 12. Rumonge-Kigoma (2-6) and 13. Bujumbura (101-104).

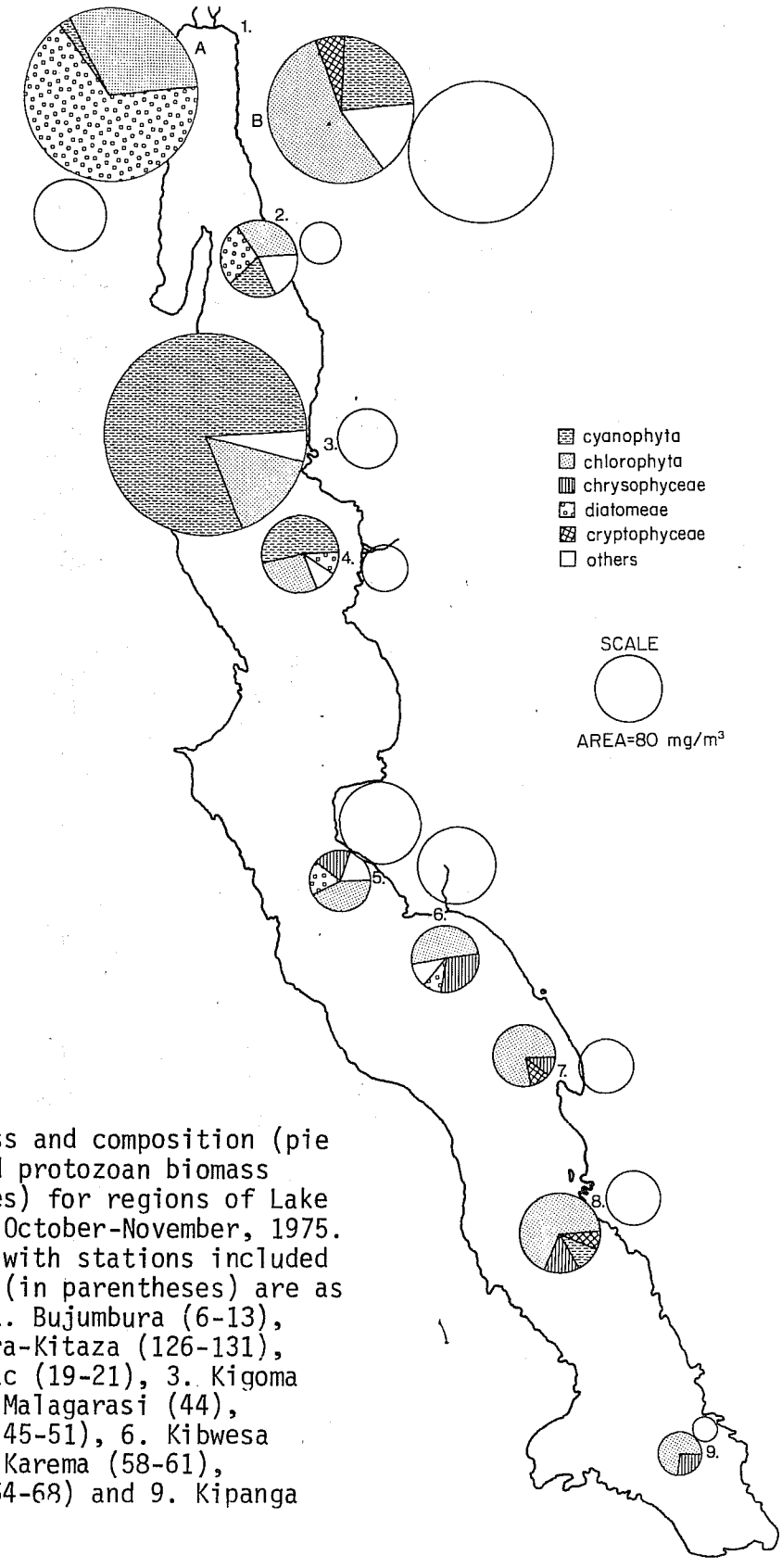

Fig. 5. Algal biomass and composition (pie circles) and protozoan biomass (open circles) for regions of Lake Tanganyika, October-November, 1975. The regions with stations included in the mean (in parentheses) are as follows: 1a. Bujumbura (6-13), 1b. Bujumbura-Kitaza (126-131), 2. Nyanza lac (19-21), 3. Kigoma (29-33), 4. Malagarasi (44), 5. Lubugew (45-51), 6. Kibwesa (56-57), 7. Karema (58-61), 8. Kipili (64-68) and 9. Kipanga (73).

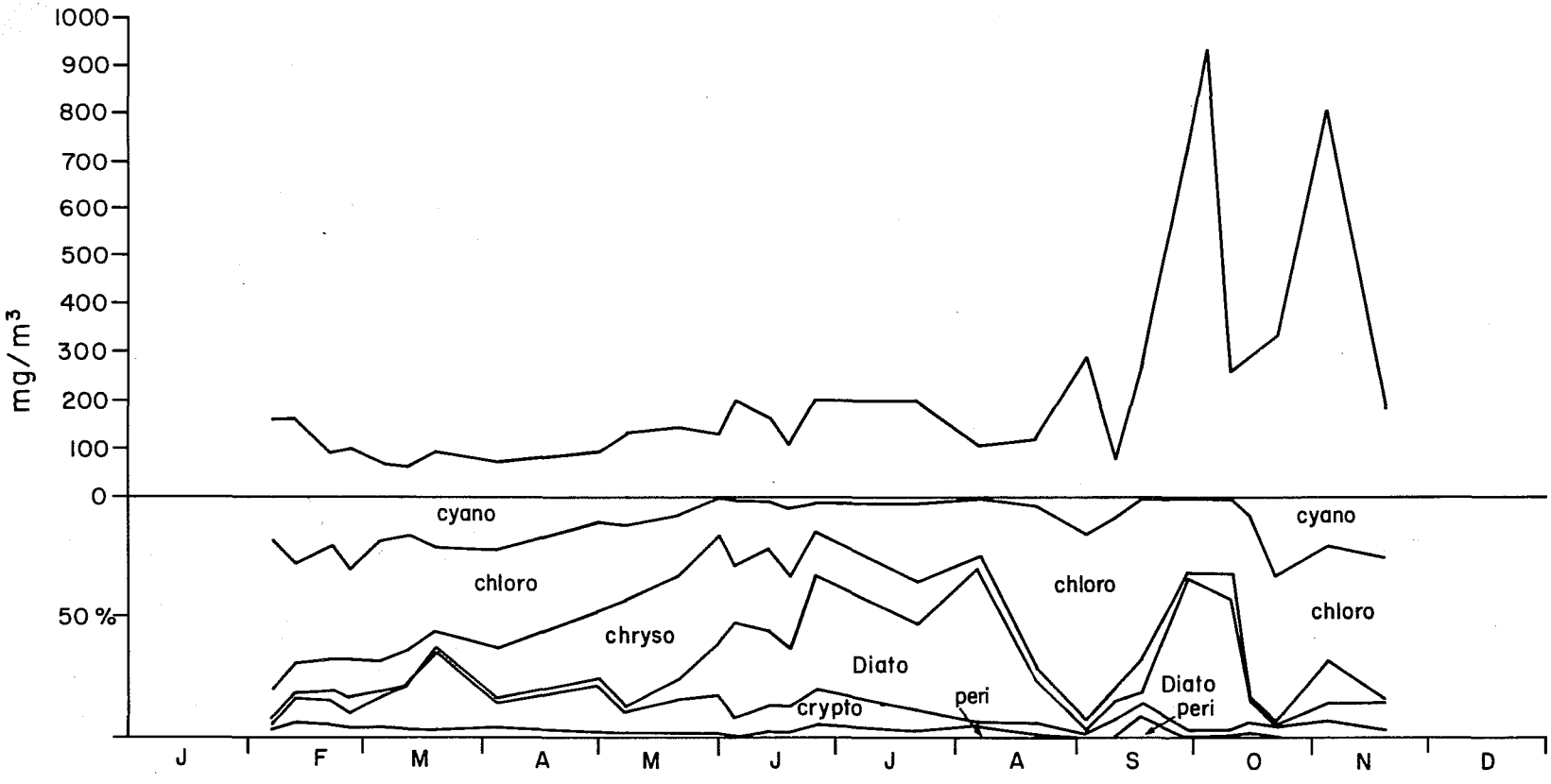

Fig. 6. Seasonal variation in phytoplankton biomass and composition off Bujumbura.

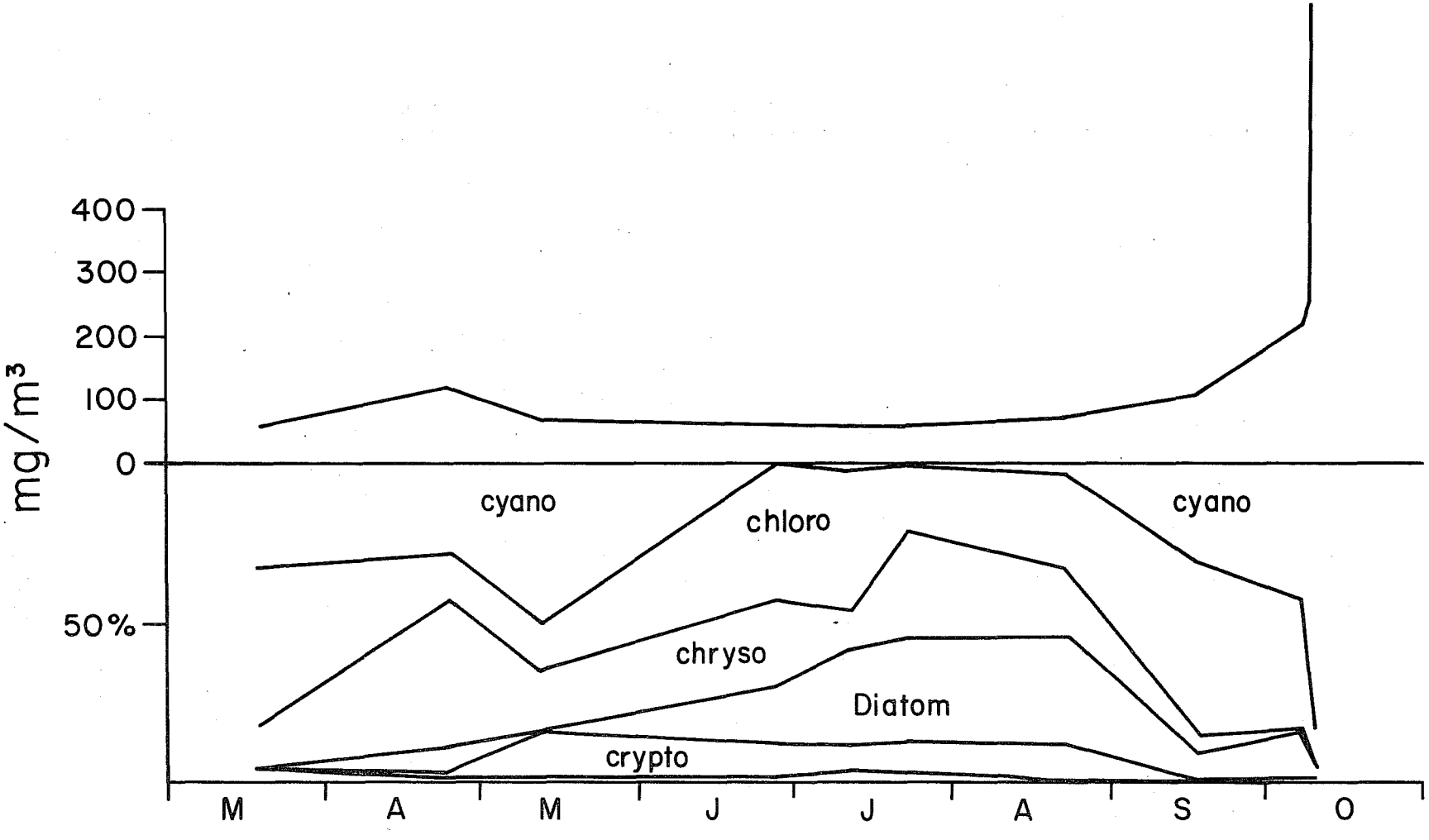

Fig. 7. Seasonal variation in phytoplankton biomass and composition off Kigoma.

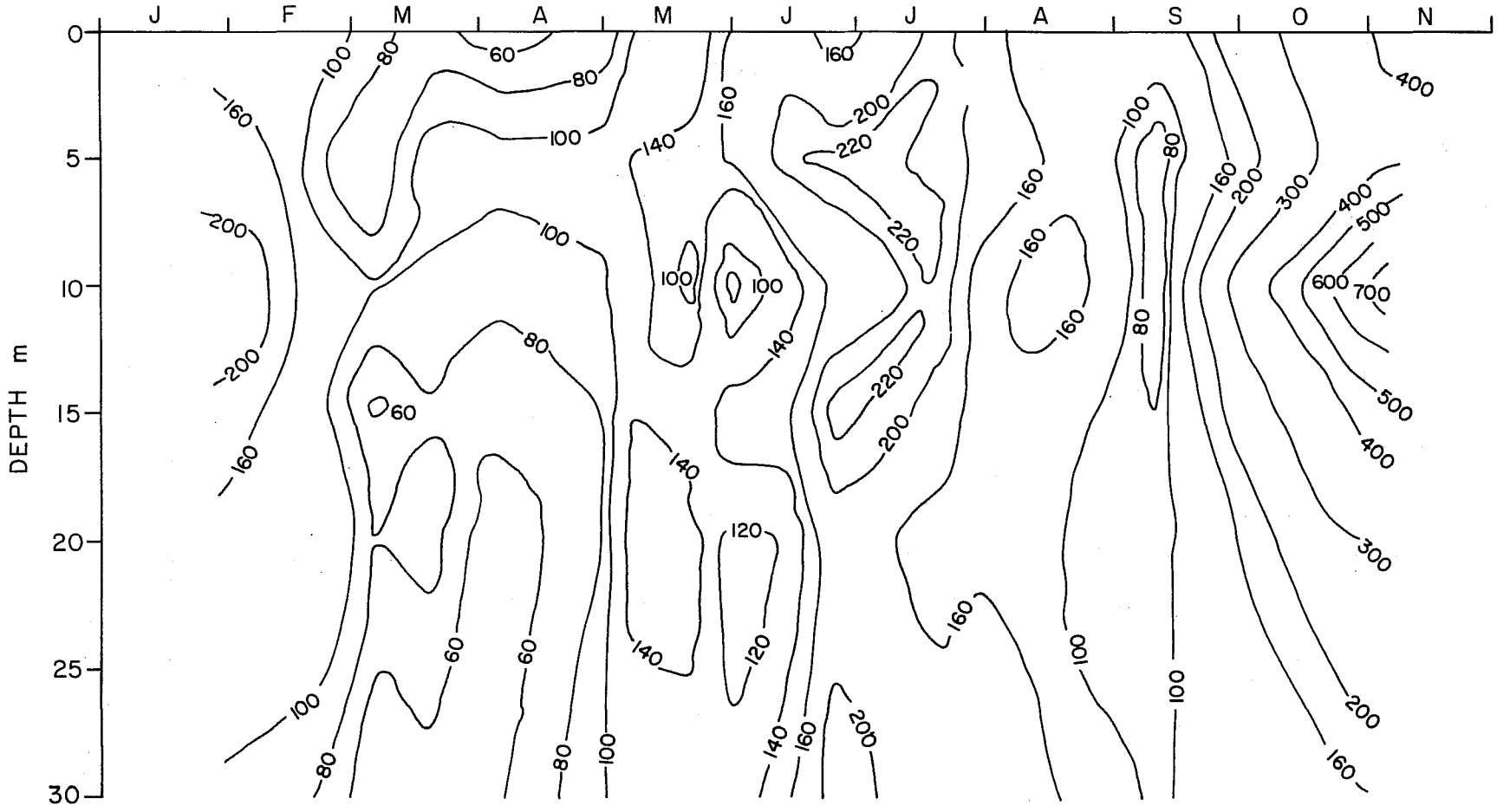

Fig. 8. Depth distribution of algal biomass through the year off Bujumbura. Isopleths contain equivalent concentrations of algae in mg m^{-3}.

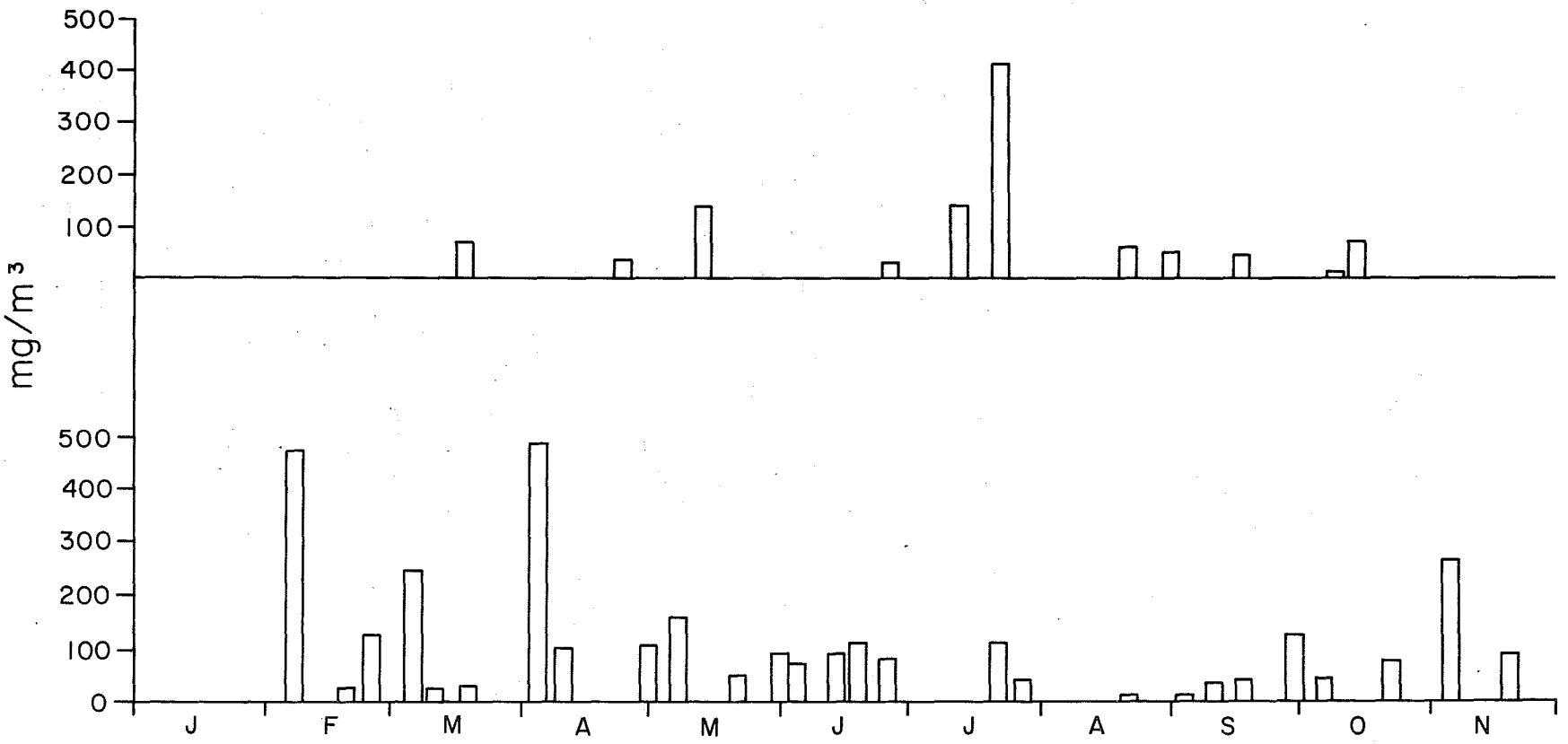

Fig. 9. Seasonal variation in abundance of protozoa. The upper panel is of stations off Kigoma while the lower panel is off Bujumbura.

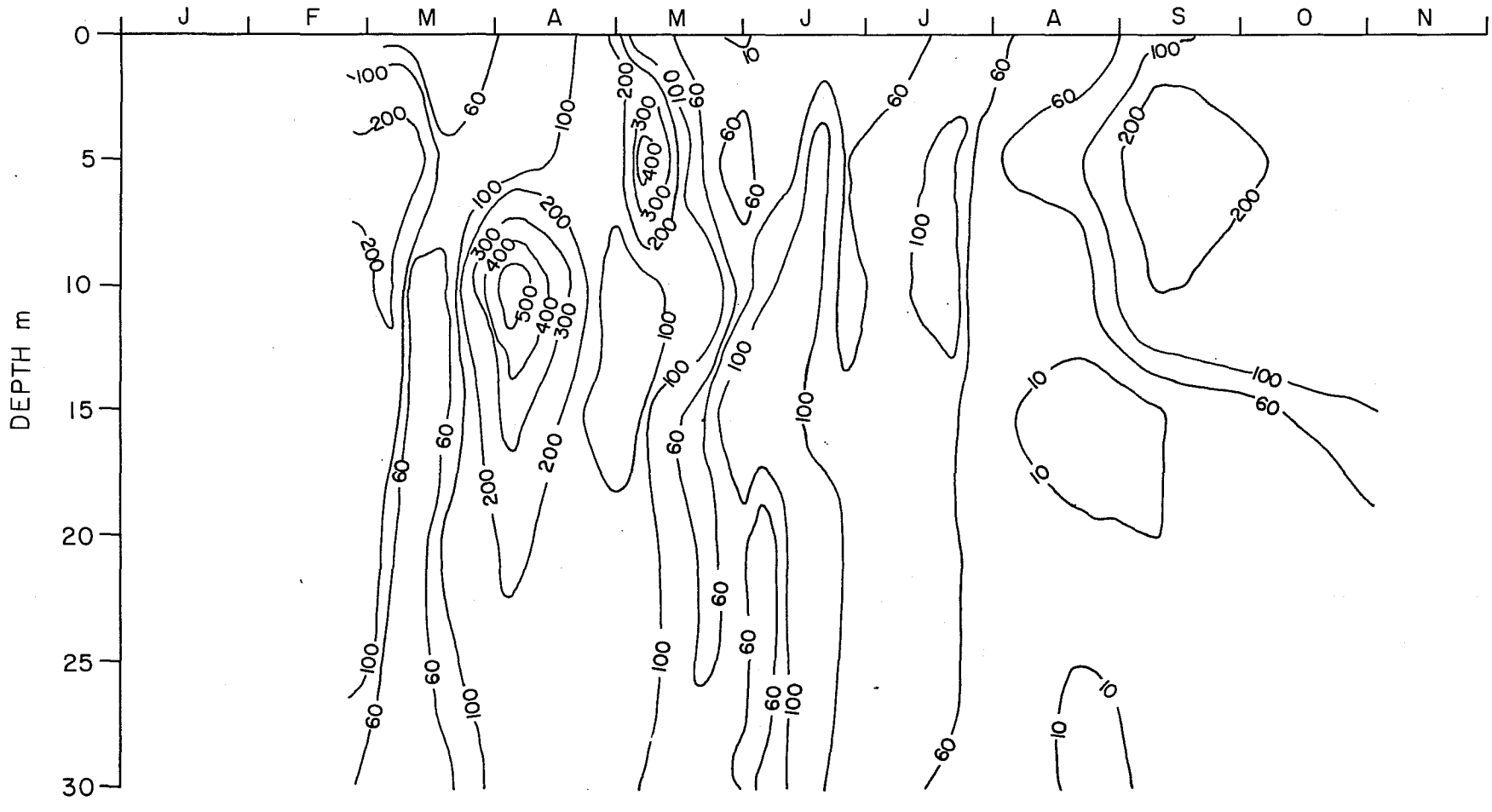

Fig. 10. Depth distribution of protozoa through the year off Bujumbura. Isopleths connect equivalent concentrations in units of mg m^{-3} biomass.

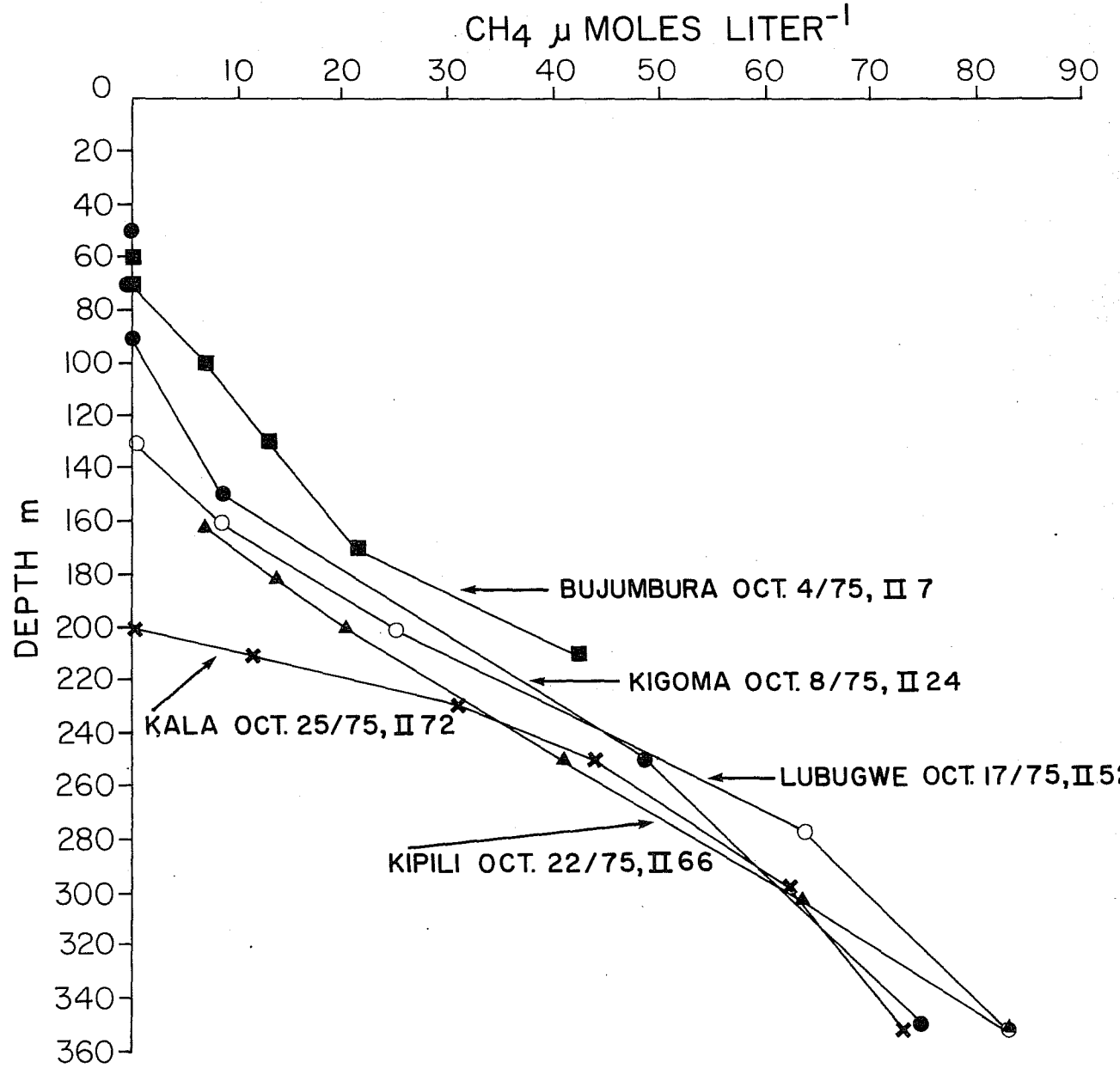

Fig. 11. Depth of zero oxygen concentration (indicated by arrow) and methane concentrations at five sampling stations on Lake Tanganyika.

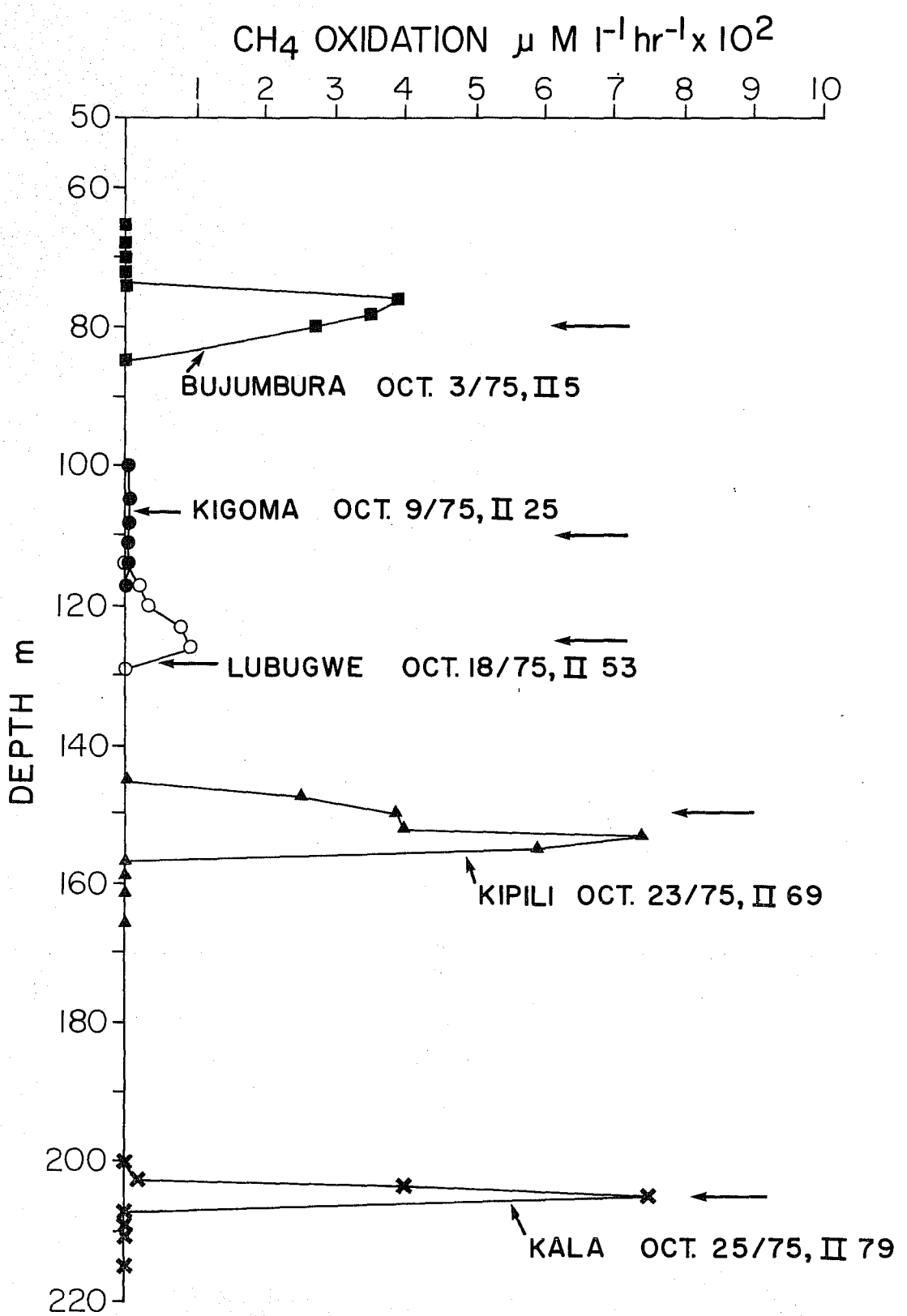

Fig. 12. Profiles of rates of methane oxidation at five sampling stations on Lake Tanganyika. Arrows indicate depth of zero oxygen concentration.

Table 1. Station list for the first Lake Tanganyika cruise. Locations given in Fig. 1. Times for stations I-7 through I-95 are East African Time. All other stations are Central African Time. P means sampled depths were pooled for analysis, a dash between depths indicates that the samples were pumped continuously between the specified depths.

Station	Date	Time	Sampling Depth (m)	Secchi Disk (m)	Extinction Coefficient (ln unit m^{-1})	Chlorophyll (mg m^{-3})	Plankton Biomass	Respiration (mgC m^{-3} hr^{-1})	Primary Production
I-1	22-4-75	1830	0-20			0.4	X	9.36	
I-2		1930	0-20			0.5	X	4.44	
I-3		2030	0-20			0.4	X	3.48	
I-4		2140	0-20			0.7	X	5.72	
I-5		2240	0-20			0.5	X	5.51	
I-6		2320	0-20			0.7	X	1.96	
I-7	24-4-75	1030	5, 10, 15, 20 P		0.17	0.3	X	3.83	X
I-8		1100			0.16				
I-9	25-4-75	1215	5			0.5	X	1.40	X
I-10		1245	15			0.7	X		X
I-11	26-4-75	0810	5		0.17	1.0	X		
I-12		0930	5		0.23	0.5			
I-13		1100	5			0.5			
I-14		1200	0-20			0.7	X		
			0			0.7			
			5			lost			
			10			1.2			
			15			0.8			
			20			1.0			
I-15		1615	5			0.5	X		
I-16		1950	5			0.5	X		
I-17	28-4-75	1217	5, 15 P	12.0	0.26	0.3	X	6.87	X
I-18		1235	3	4.8	0.33	0.7	X	4.50	X
I-19		1400	5, 7.5, 10 P		0.14	0.8	X	4.63	X
I-20		1545	10	17.0	0.17	0.4	X		
I-21		1715	5, 10 P	18.5		0.3	X		
I-22		1915	5, 10 P			0.2	X		
I-23	30-4-75	1015	5, 10, 15, 20 P	16.5		0.3	X	7.06	X
I-24		1115	5, 10, 15, 20 P	17.3	0.13	0.1	X	4.89	X
I-25		1245		18.2					
I-26		1315		19.0					
I-27	1-5-75	0645	5, 10, 15 P			0.2	X	2.66	X
I-28		1050	0	18.5	0.15	1.0			
			5			0.3			
			10			0.5			
			15			0.4			
			20			0.6			
			30			0.7			
			50			0.2			
I-29		1115	5, 10, 15 P			0.3	X		X
I-30		1145	5, 10, 15 P	14.5	0.14	0.4	X		X
I-31		1530	5, 10, 15 P			0.4	X		X
I-32		1900	5, 10, 15 P			0.4	X		
I-33	3-5-75	1110	5, 10, 15 P	14.0				7.88	X
I-34		1210	5, 10, 15 P	14.0				8.13	X
I-35		1330	5, 10, 15 P	12.5	0.15				X
I-36	4-5-75	1030	5, 10, 15 P	15.0	0.17			5.22	X
I-37		1130	5, 10, 15 P	17.5	0.13			5.15	X
I-38	5-5-75	0800	5, 10, 15 P			0.6	X	3.83	X
I-39		0900	5, 10, 15 P	15.0	0.19			5.76	X
I-40		0950	5, 10, 15 P	14.0	0.17			4.23	X
I-41		1020	5, 10, 15 P	15.5	0.16			5.72	X
I-42	6-5-75	0645	5, 10, 15 P			0.5	X	4.57	X
I-43		1100	5, 10, 15 P	13.5	0.15	0.6	X		X
I-44		1200	5	15.5	0.13	0.6			
			25			0.4			
			35			0.8			
			50			0.4			
I-45		1530	5, 10, 15 P						X
I-46		1900	5, 10, 15 P						X
I-47	9-5-75	0830	5, 10, 15 P	12.5	0.21	0.8	X	5.18	X
I-48		0930	5, 10, 15 P	13.7	0.18	0.5	X		X
I-49		1040	5, 10, 15 P	11.5	0.16	0.6	X	5.22	X
I-50		1140	5, 10, 15 P	14.0	0.16	0.7	X	6.85	X
I-51		1250	5, 10, 15 P	13.2	0.16	0.8	X	3.85	X

Table 1. (Continued)

Station	Date	Time	Sampling Depth (m)	Secchi Disk (m)	Extinction Coefficient (ln unit m^{-1})	Chlorophyll (mg m^{-3})	Plankton Biomass	Respiration (mgC m^{-3} hr^{-1})	Primary Production
I-52		1315	0			0.8			
			5			0.7			
			10			0.9			
			15			0.8			
			20			0.7			
			30			0.9			
			40			0.6			
			50			0.5			
I-53		1335	1.0			0.7	X	5.36	X
I-54		1530	0.5			2.6			
I-55		1624	0.5			0.8			
I-56		1720	0.5			0.6			
I-57		1845	0.5			0.4			
I-58		1925	0.5			0.3			
I-59		2130	0.5			0.9			
I-60		2220	0.5			0.6			
I-61		2315	0.5			0.7			
I-62	10-5-75	0020	0.5			0.5			
I-63		0120	0.5			0.5			
I-64		0220	0.5			0.5			
I-65		0325	0.5			0.7			
I-66		0420	0.5			0.6			
I-67		0520	0.5			1.4			
I-68		0630	0.5			0.7			
I-69		0725	0.5			0.4			
I-70		0820	0.5			0.5			
I-71		0920	0.5			0.3			
I-72	11-5-75	0730	0.5			0.4			
I-73		0830	0.5			0.3			
I-74		0930	0.5			0.3			
I-75		1030	0.5			0.2			
I-76		1130	0.5			0.2			
I-77		1230	0.5			0.2			
I-78		1330	0.5			0.2			
I-79		1430	0.5			0.2			
I-80		1530	0.5			0.3			
I-81		1630	0.5			0.2			
I-82		1730	0.5			0.2			
I-83		1830	0.5			0.2			
I-84		1930	0.5			0.8			
I-85	12-5-75	1020	5, 10, 15 P	18.0	0.16	0.4	X	3.67	X
I-86		1100	0.5			0.3			
I-87		1130	5, 10, 15 P	17.0	0.13	0.5	X	3.97	X
I-88		1200	0.5			0.2			
I-89		1245	5, 10, 15 P	18.0	0.13	1.3	X	5.13	X
I-90		1315	0.5			0.2			
I-91		1430	0.5			0.2			
I-92		1515	0.5			0.3			
I-93		1625	0.5			0.2			
I-94		1720	0.5			0.2			
I-95		1820	0.5			0.6			
I-96		1905	0.5			0.5			
I-97		2030	0.5			0.6			
I-98		2120	0.5			0.7			
I-99		2220	0.5			0.9			
I-100	14-5-75	0740	5, 10, 15 P	4.8	0.53	2.7		6.94	X
I-101		0810	5, 10, 15 P	10.0	0.25	1.3	X	3.98	
I-102		0840	5, 10, 15 P	12.5	0.19	1.1	X	3.91	X
I-103		0940	5, 10, 15 P	15.3	0.16	1.3	X	4.66	X
I-104		1030	5, 10, 15 P	14.5	0.17	1.8	X	3.95	X

Table 2. Station list for second Lake Tanganyika cruise. Locations given in Fig. 2. Times for stations I-22 through I-115 are East African Time. All other stations are recorded on Central African Time. P means sampled depths were pooled. N/A means not applicable.

Station	Date	Time	Depth	Secchi Disc (m)	Extinction Coefficient (ln unit m^{-1})	Temp.	O_2	Chlorophyll (mg m^{-3})	Plankton	Respiration (mgC m^{-3} hr^{-1})	Primary Production	Methane Profile	Methane Oxidation	Hydrogen Sulfide	Chemistry
II-1	24-9-75	0900	0-30	14.0		X	X		X		X	X			
II-2	30-9-75	0930	5	10.3			X		X	2.23					
II-3	1-10-75	1000					X								
II-4	2-10-75	0845					X								
II-5	3-10-75	0800					X						X		
II-6	4-10-75	0800	5,10,15,20 P	10.0	0.20	X			X		X				
II-7		1030										X			
II-8	6-10-75	1845				X									
II-9		1900	0.5						X						
II-10		2000	0.5						X						
II-11	7-10-75	1630	0.5						X						
II-12		1730	0.5						X						
II-13		1840	0.5						X						
II-14		1940	0.5						X						
II-15		2040	0.5						X						
II-16		2140	0.5						X						
II-17		2240	0.5						X						
II-18		2340	0.5						X						
II-19	8-10-75	0040	0.5						X						
II-20		0140	0.5						X						
II-21		0240	0.5						X						
II-22		1150	0.5		.15			0.9	X		X				X
II-23		1240	0-25				X	0.8	X		X				X
II-24		1315					X					X			
II-25	9-10-75	1145				X	X						X		
II-26		1305							X						
II-27	10-10-75	0740	0-25	8.0	.20			0.5	X	1.63	X				
II-28		0750	0,5,10,15,20,25 P						X	5.55					
II-29		1000	0-25	9.1	.19			2.1	X		X				
II-30		1220	0-25	9.8	.18			2.0	X		X				
II-31		1455	0-25	9.1	.19			2.6	X		X				
II-32		1725	0-30	11.1	.17			1.0	X		X				
II-33		1855	0-25	13.0				1.1	X		X				
II-34	12-10-75	0830	0	12.5	.15	X		0.7	X		X				
			5					0.7	X		X				
			10					0.7	X		X				
			15					0.9	X		X				
			20					0.7	X		X				
			25					0.8	X		X				
II-35		0845	0,5,10,15,20,25 P							3.36					
II-36	12-10-75	0915											X		
II-37	13-10-75	0830	0,5,10,15,20,25 P	11.2							X				
II-38		1000											X		
II-39	14-10-75	0930		12.0		X							X		
II-40		1100	0,5,10,15,20,26 P								X				
II-41		1115					X								
II-42	16-10-75	0917	0,2.5,5,7.5,10,12.5 P	5.5	.32			2.2	X	4.85	X				X
II-43		1015	0,5,10,15,20,26 P	13.1	.13			1.0	X	3.52	X				X
II-44		1117	0,5,10,15,20,26 P	12.6	.16			1.9	X	5.84	X				X
II-45	17-10-75	0700	0,5,10,15,20,26 P	15.0				0.9	X	2.45	X				X
II-46		0730												X	
II-47		1000	0,5,10,15,20,26 P	14.3				1.1	X		X				
II-48		1300	0,5,10,15,20,26 P	14.0	.14			0.8	X		X				
II-49		1330												X	
II-50		1600	0,5,10,15,20,26 P	14.0				1.0	X		X				
II-51		1900	0,5,10,15,20,26 P	13.6				0.7	X		X				
II-52		1930										X			
II-53	18-10-75	0750					X						X		
II-54	19-10-75	0730				X									
II-55		0740	75						X						
II-56		1035	0,5,10,15,20,26 P	12.2	.16	X		0.9	X	2.99	X				
II-57		1145	0,5,10,15,20,26 P	11.8	.16			0.7	X		X				
II-58		1240	0,5,10,15 P	12.4				0.9	X		X				
II-59	20-10-75	1030	0,5,10,15,20,26 P	14.1	.15	X		1.0	X	2.42					X
II-60		1120	0,5,10,15,20,26 P	11.4	.15				X		X				
II-61		1210	0,5,10,15,20,26 P	12.9				1.2	X		X				X
II-62	22-10-75	0720	0,5,10,15,20,26 P	12.5		X		1.3	X	1.94	X				X
II-63		0820					X							X	
II-64		0955	0,5,10,15,20,26 P					1.7	X		X				
II-65		1300	0,5,10,15,20,26 P	11.7	.17			1.5	X		X				

Table 2. (Continued)

Station	Date	Time	Depth	Secchi Disc (m)	Extinction Coefficient (ln unit m^{-1})	Temp.	O_2	Chlorophyll (mg m^{-3})	Plankton	Respiration (mgC m^{-3} hr^{-1})	Primary Production	Methane Profile	Methane Oxidation	Hydrogen Sulfide	Chemistry
II-66		1345										X			
II-67		1615	0,5,10,15,20,26 P	12.6	.17			1.4	X		X				
II-68		1850	0,5,10,15,20,26 P	11.1				1.2	X		X				
II-69	23-10-75	0820				X							X		
II-70	24-10-75	0830	0,5,10,15,20,26 P	13.7	.17	X		1.4	X		X				X
II-71		1000	0,5,10,15,20,26 P	13.8	.16			1.2	X		X				
II-72	25-10-75	0740				X	X					X	X		
II-73	26-10-75	0700	0,5,10,15,20,26 P	13.8	.18	X		1.1	X	2.72	X				X
II-74		0815	0,5,10,15,20,26 P	12.2	.17			1.2	X	2.20	X				
II-75		0915	0,5,10,15,20,26 P	13.4	.15			0.9	X		X				X
II-76		1030	0.5					0.8							
II-77		1130	0.5					0.7							X
II-78		1230	0.5					0.9							
II-79		1330	0.5												X
II-80		1430	0.5					0.7							
II-81		1530	0.5					0.6							X
II-82		1630	0.5					0.6							
II-83	27-10-75	0920	0.5					0.5							X
II-84		1020	0.5					0.6							
II-85		1120	0.5					0.5							X
II-86		1220	0.5					0.4							
II-87		1320	0.5					0.3							X
II-88		1420	0.5					0.3							
II-89	28-10-75	0705	0.5					0.9							X
II-90		0805	0.5					0.8							
II-91		0905	0.5					0.8							X
II-92		1005	0.5					7.0							
II-93		1105	0.5					3.8							X
II-94		1205	0.5					1.1							
II-95		1305	0.5					5.1							X
II-96		1405	0.5					20.4							
II-97		1505	0.5					12.6							X
II-98	30-10-75	0650	0.5					2.5							
II-99		0750	0.5	15.4				1.1							X
			0,5,10,15,20,26 P					1.2		2.47					
II-100		0910	0.5					2.5							
II-101		1010	0.5	12.9				3.3							X
			0,5,10,15,20,26 P					2.6		2.60					
II-102		1125	0.5					2.7							
II-103		1225	0.5	11.9				8.3							X
			0,5,10,15,20,26 P					4.1		10.61					
II-104		1334	0.5					6.3							
II-105		1444	0.5	16.0				1.3							X
			0,5,10,15,20,26 P					1.6		3.64					
II-106		1600	0.5					5.3							
II-107		1700	0.5					3.8							
II-108		1800	0.5					5.3							
II-109	31-10-75	2320	0.5					2.9							X
			0,5,10,15,20,26 P					4.5		4.94					
II-110	1-11-75	0030	0.5					6.3							
II-111		0130	0.5					5.6							X
II-112		0230	0.5					7.4							
			0,5,10,15,20,26 P					3.0		3.01					
II-113		0338	0.5					2.0							X
II-114		0438	0.5					1.9							
II-115		0538	0.5					1.5							X
			0,5,10,15,20,26 P					1.2		2.94					
II-116		0548	0.5					1.3							
II-117		1648	0.5					1.5							X
II-118		0748	0.5					1.6							
II-119		0848	0.5					1.5							X
II-120		0948	0.5					1.3							
II-121		1048	0.5					1.4							X
II-122		1148	0.5					2.4							

Table 2. (Continued)

Station	Date	Time	Depth	Secchi Disc (m)	Extinction Coefficient (ln unit m^{-1})	Temp.	O_2	Chlorophyll (mg m^{-3})	Plankton	Respiration (mgC m^{-3} hr^{-1})	Primary Production	Methane Profile	Methane Oxidation	Hydrogen Sulfide	Chemistry
II-123	4-11-75	0915	0	12.0				1.9	X		X				
			5					1.8	X		X				
			10					1.6	X		X				
			15					1.8	X		X				
			20					1.7	X		X				
			0-20					2.3	X		X				
II-124		1015	0,5,10,15,20,26 P							3.88					
II-125		1100	70				X		X						X
			76						X						X
			78						X						X
			79						X						X
			83						X						X
			88						X						X
II-126	5-11-75	0615	0,5,10,15,20,26 P	13.2	.24	X		2.2	X	3.57	X				
II-127		0900	0,5,10,15,20,26 P	12.9	.19			1.7	X		X				
II-128		0930	0					1.5							X
			10					1.9							
			20					1.7							
			30					1.6							X
			40					1.7							
			50					1.2							
II-129		1145	0,5,10,15,20,26 P	12.1	.23			2.7	X		X				
II-130		1500	0,5,10,15,20,26 P	9.0				4.5	X		X				
II-131		1750	0,5,10,15,20,26 P					4.7	X		X				

Table 3. Light penetration and calculated extinction coefficients (E) for the first Lake Tanganyika cruise. The units of the entries in the table are μEinsteins m^{-2} sec^{-1}.

		Depth, m															
Station	E	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I-7	.17 m^{-1}	479					140					89					
I-8	.16	457					170					97					
I-11	.17	586					220					102					
I-12	.23	1214					510					260					32
I-17	.26	1107					162					84					
I-18	.33	1036	750	540	380	280	195										
I-19	.14	486					230					120					
I-20	.17	714		400		310		220		155		120					
I-24	.13	1429		850		680		550		430		340					
I-28	.15	1214				600		430		340		270					
I-30	.14	136		78		62		49		39		31					
I-35	.15	1250					520					290					
I-36	.17	1268					440					240					
I-37	.13	1286					630					350					
I-39	.19	750		440		320		220		160		105					
I-40	.17	964		570		430		320		220		165					
I-41	.16	1143			650		440		360		250		188		143		105
I-43	.15	1179			530	450	430	380	320	270	218	192	167	148	131	112	100
I-44	.13	1379			800		630		480		350		292		238		182
I-47	.21	482				185		115		78		63					
I-48	.18	946				390		290		195		155					
I-49	.16	1161				620		430		320		230					
I-50	.16	1429				590		480		370		270					
I-51	.16	1393				650		520		375		270					
I-85	.16	1214								340		260					
I-87	.13	1339				730		580		460		360					
I-89	.13	1607					650					420					
I-100	.53	1393		193	103	76	48	31	22.5	13.5							
I-101	.25	757			300	235	175	140	108	91	72	59					
I-102	.19	750				280	230	200	170	150	120	100					
I-103	.16	1107			530	470	410	350	300	260	225	200					
I-104	.17	1321					500	450	390	330	290	245					

Table 4. Light penetration and calculated extinction coefficients (E) for the second Lake Tanganyika cruise. The units of the entries in the table are μEinsteins m^{-2} sec^{-1}.

		Depth, m															
Station	E	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
II-6	.20	428					110					46					19.5
II-22	.15	1107					325					185					110
II-27	.20	371					95					39					18
II-29	.19	471					120					52					25
II-30	.18	471			180		125		90		63		49		37		28
II-31	.19	271			88		60		42		30		22		16.5		12.5
II-32	.17	171			71		50		35		27		20.5		16		12
II-34	.15	1392					550		450		350						
II-42	.32	561	275		145		76		41		21.8		12		6.7		3.8
II-43	.13	1250	900		600		440		350		300		230		190		160
II-44	.16	1571					600		430		310		235		170		135
II-48	.14	829			330		260		205		168		134		105		88
II-56	.16	329					100		69		55		43		33		26
II-57	.16	314					96		72		55		42		35		25
II-59	.15	126	90	69	57.5	49	42	37	31.9	27.6	24.3	21.2	18.8	17.8	15.1	13.2	11.8
II-60	.15	313	178	150	126	107	91.5	79.2	69.0	60.2	48.8	47.0	41.5	36.9	31.0	27.4	23.8
II-65	.17	368					97		68		53		43		32		25
II-67	.17	464					150	130	108	95	77.5	66.5	58	50	43	38	34.5
II-70	.17	743					245	200	170	147	126	108	93	81	67.9	59.5	53.0
II-71	.16	1250					475	415	350	300	250	230	192	168	148	132	113
II-73	.18	173				55.0	46.5	38.5	33	28.2	23.9	20.3	17.6	15.4	13.2	11.7	10.2
II-74	.17	625					185	149	128	115	94	84.5	73	62	54	46	40
II-75	.15	1007					370	315	255	230	200	177	155	140	123	112	94
II-126	.24	986		175	132	102	80	65	53.5	44.5	37	31	25.7	21	18.2	15.4	11.8
II-127	.19	964				340	270	230	192	159	132	108	91.5	77.5	64.5	55	46
II-129	.23	1793					480		300		185		128		84		60

Table 5. Concentrations of chlorophyll (mg m^{-3}) in the main water masses of Lake Tanganyika based on 0.5 m samples from transect stations (9 May - 12 May) and pooled depth samples from primary production stations during April-May 1975. Mean, standard deviation, range and number of stations for each water mass given.

	Transect stations	Primary production stations
South Lake	0.7 ± 0.5 0.3 to 2.6 n = 18	0.7 ± 0.1 0.5 to 0.8 n = 10
Central Lake[1]	0.3 ± 0.1 0.2 to 0.8 n = 21	0.5 ± 0.3 0.1 to 1.3 n = 21
North Lake[1]	0.7 ± 0.2 0.5 to 0.9 n = 5	1.4 ± 0.3 1.1 to 1.8 n = 4
Whole Lake	0.5 ± 0.4 0.2 to 2.6 n = 44	0.7 ± 0.5 0.1 to 2.7 n = 39

[1] Stations I-17, I-18, and I-100 were excluded from this analysis because they are influenced by nearby large rivers. They are included in the Whole Lake statistics.

Table 6. Mean, standard deviation, and range of concentrations of chlorophyll (mg m^{-3}) in the main water masses of Lake Tanganyika based on surface samples from transect (26 Oct. to 3 Nov.) and pooled depth samples at the primary production stations in each water mass during Oct. - Nov. 1975.

	Transect stations (0.5m)	Depth-integrated stations during transect (0-26m)	Primary production Stations (0-26m)
South Lake	0.6 ± 0.2 0.3 to 0.9 n = 15		1.3 ± 0.2 0.9 to 1.7 n = 12
Central Lake[1]	5.2 ± 4.3 1.1 to 20.4 n = 23	2.6 ± 1.4 1.2 to 4.5 n = 7	1.2 ± 0.6 0.8 to 2.6 n = 18
North Lake	1.6 ± 0.4 1.2 to 2.4 n = 8		2.5 ± 1.3 1.2 to 4.7 n = 9
Whole Lake	3.1 ± 3.7 0.3 to 20.4 n = 46		1.7 ± 1.0 0.5 to 4.5 n = 49

[1] Stations II-42, II-43, and II-44 in the Malagarasi plume are excluded in this summary. They are included in the whole lake statistics.

Table 7. Comparison of chlorophyll concentrations between samples taken at 0.5 m and samples pooled from depths of 0, 5, 10, 15, 20 and 26 m. Concentrations are in mg m^{-3}. Mean and standard deviation of the seven stations given in last line.

Station	0.5 m	0-26 m	Difference
II-99	1.1	1.2	-0.1
II-101	3.3	2.6	0.7
II-103	8.3	4.1	4.2
II-105	1.3	1.6	-0.3
II-109	2.9	4.5	-1.6
II-112	7.4	3.0	4.4
II-115	1.5	1.2	0.3
	3.7 ± 3.0	2.6 ± 1.4	

Table 8. Chemical results for stations sampled in October-November 1975. DOC is dissolved organic carbon, TDN is total dissolved nitrogen, TDP is total dissolved phosphorus and Chl a is chlorophyll a.

Station	Depth m	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	Cl mg/L	SO_4 mg/L	Si mg/L	DOC µmole/L	TDN µg/L	TDP µg/L	Chl a µg/L
II-22	0-25	61.0	31.9	37.4	10.4	28.0	6.1	0.410	229	110	7	0.9
23	0-25	63.0	31.6	40.4	11.6	29.5	6.9	0.350	305	180	7	0.8
42	0-12.5	61.8	32.2	39.6	11.3	27.0	7.1	0.453	194	180	15	2.2
43	0-26	63.1	32.9	39.8	11.4	28.5	7.3	0.326	305	160	16	1.0
44	0-26	61.5	31.9	39.6	11.1	27.5	7.1	0.324	297	180	11	1.9
45	0-26	62.2	31.7	39.3	11.3	27.0	7.3	0.347	363	70	7	0.9
59	0-26	62.8	32.3	39.9	11.5	29.5	4.3	0.386	324	90	8	1.0
61	0-26	62.1	31.7	39.2	11.2	28.5	5.3	0.397	260	90	9	1.2
62	0-26	62.4	31.7	39.4	10.9	27.5	7.1	0.417	261	90	10	1.3
70	0-26	62.1	31.7	39.2	11.3	27.0	7.5	0.404	253	60	10	1.4
73	0-26	63.6	32.0	39.2	11.2	28.0	7.7	0.426	401	110	10	1.1
75	0-26	62.8	32.0	39.7	10.9	26.5	8.1	0.420	285	100	10	0.9
77	0-26	63.1	31.4	38.6	10.7	19.0	7.9	0.408	267	40	9	0.7
79	0.5	62.8	32.3	39.3	11.2	30.5	7.7	0.409	288	60	11	
81	0.5	62.4	32.0	39.6	11.0	27.0	7.7	0.401	352	90	11	0.6
83	0.5	63.6	32.3	38.8	11.0	27.0	7.5	0.367	264	70	10	0.5
85	0.5	62.8	32.6	39.0	10.8	26.5	7.9	0.359	360	120	10	0.5
87	0.5	62.6	32.0	38.7	11.1	26.5	7.3	0.351	382	110	8	0.3
89	0.5	62.4	32.6	39.2	11.2	25.5	7.3	0.390	369	90	10	0.9
91	0.5	62.9	32.9	38.8	11.0	27.0	7.1	0.358	266	60	9	0.8
93	0.5	62.6	32.6	38.9	11.1	25.5	6.7	0.349	277	60	5	3.8
95	0.5	62.9	33.2	39.1	11.3	25.0	6.5	0.330	237	60	3	5.1
97	0.5	62.4	32.6	38.9	11.0	26.0	6.5	0.326	212	60	3	12.6
99	0.5	64.0	32.3	38.5	10.9	26.0	6.5	0.318	271	160	11	1.1
101	0.5	62.0	32.3	38.6	10.9	28.0	6.3	0.311	235	40	3	3.3
103	0.5	63.4	33.5	39.1	11.2	27.5	4.9	0.316	322	70	3	8.3
105	0.5	64.0	33.2	38.8	11.0	28.0	5.9	0.326	261	70	5	1.6
107	0.5	63.2	32.6	38.6	11.0	27.0	6.3	0.328	207	50	3	3.8
109	0.5	63.1	32.9	38.9	11.1	26.5	6.3	0.310	250	90	4	2.9
111	0.5	63.1	32.6	38.3	10.7	26.5	6.5	0.334	200	90	3	5.6
113	0.5	63.7	33.2	38.6	11.0	25.0	6.5	0.296	232	50	3	2.0
115	0.5	61.8	32.9	38.1	10.8	27.0	5.9	0.342	226	50	6	1.5
117	0.5	63.9	33.2	39.1	10.9	26.5	5.9	0.403	180	40	6	1.5
119	0.5	62.8	32.3	38.6	11.0	26.0	6.5	0.395	198	60		1.5
121	0.5	58.3	29.6	36.1	10.2	26.0	6.7	0.456	152	50	9	1.4
125	70m	60.3	32.0	36.7	10.5	28.5	5.1	1.23	191	120	69	
	76m	62.0	32.3	39.0	11.1	28.5	5.5	1.54	163	60	60	
	78m	62.8	31.4	38.4	11.1	29.0	5.5	1.68	205	40	71	
	79m	63.1	31.7	38.4	11.1	29.0	5.3	1.65	153	50	54	
	83m	62.4	32.0	38.0	10.8	30.5	5.3	1.76	292	40	68	
	88m	62.1	31.4	38.7	11.2	29.0	5.1	1.86	260	50	76	
128	0m	62.0	32.9	38.8	10.8	28.0	5.5	0.415	305	50	6	1.5
	30m	62.8	32.9	38.5	11.0	27.5	5.7	0.420	304	60	6	1.6

Table 9. Mean chemical composition of main water masses in Lake Tanganyika in Oct. - Nov. 1975. Na, K, Mg, Ca, Cl, SO_4 and Si are given in mg L^{-1}. TDN, TDP and chlorophyll a are in µg L^{-1}. DOC is in µmoles L^{-1}. The standard deviation of all samples from a water mass is given in parentheses; n is the number of samples from each water mass.

	Na	K	Mg	Ca	Cl	SO_4	Si	DOC	TDN	TDP	Chl
Malagarasi plume (Stn. 42-44, n=3)	62.1 (0.9)	32.3 (0.5)	39.6 (0.1)	11.3 (0.2)	27.7 (0.8)	9.9 (0.1)	0.368 (0.074)	265 (62)	173 (12)	14 (3)	1.7 (0.6)
South Lake (Stn. 73-91, n=10)	62.9 (0.4)	32.2 (0.4)	39.1 (0.4)	11.0 (0.2)	27.2 (1.4)	7.6 (0.3)	0.389 (0.028)	323 (54)	85 (26)	10 (1)	0.7 (0.3)
Central Lake (Stn. 93-113, n=11)	63.1 (0.6)	32.8 (0.4)	38.8 (0.2)	11.0 (0.2)	26.4 (1.1)	6.3 (0.5)	0.322 (0.014)	245[1] (35)	72[1] (33)	4[1] (2)	4.6[1] (3.4)
North Lake (Stn. 115-121, n=4)	61.7 (2.4)	32.0 (1.6)	37.9 (1.3)	10.7 (0.4)	26.4 (0.5)	6.3 (0.4)	0.399 (0.047)	189 (31)	50 (8)	7 (2)	1.5 (0.1)

[1] With station 99 excluded, DOC = 238 ± 26 µmole L^{-1}, TDN = 64 ± 16 µg L^{-1}, TDP = 4 ± 1 µg L^{-1}, Chl = 4.9 ± 3.3 µg L^{-1}.

Table 10. The April-May survey of phytoplankton and protozoan biomass. Station locations are given in Fig. 1 and sampling depths and times in Table 1.

Station Number	Station	Biomass mg m^{-3}		Percent Composition						
		Phyto	Proto	Cyano	Chloro	Eug	Chryso	Dia	Crypt	Peri
I-101	Ruzizi	128.3	139.2	27	29	-	26.5	3	1	2
I-102	Bujumbura	186.7	293.9	15	22	-	60	1	1	1
I-103	Bujumbura	116.9	215.0	12	15	-	65	4	2	2
I-104	Bujumbura	95.6	192.4	47	8	-	27	-	14	5
	Average 101-104	132.0	210.0	25	18.5	-	48	2	4.5	2.5
I-85	Kigoma	70.7	125.4	10	44	-	15	-	29	2
I-87	Kigoma	73.1	95.2	50	15	-	19	-	14	2
I-89	Kigoma	46.2	170.2	2	55	-	34	1	7	2
	Average 85-89	63.0	130.0	21	38	-	23	-	17	2
I-1	Rumonge	118.4	38.1	25	27	-	40	-	6	1
I-1	Rumonge	102.6	41.6	19	30	-	43	-	6	1
I-1	Rumonge	149.8	54.0	13	22	-	56	-	7	1
I-1	Rumonge	112.6	85.5	9	60	-	29	-	5	2
	Average I-1 replicates	120.8	55.0	17	35	-	42	-	5	1
I-2	Rumonge	116.5	98.4	28	42	-	23	-	77	1
I-3	Rumonge	110.7	28.0	16	29	-	32	-	21	2
I-4	Rumonge	120.4	139.3	31	23	-	28	1	14	4
I-5	Rumonge	68.9	41.7	17	54	-	15	-	13	1
I-6	Rumonge	122.5	52.7	16	43	-	28	-	11	2
	Average 2-6	107.8	72.0	21.6	38.2	-	25.2	-	13.2	2
I-11	Kigoma	105.2	155.3	20	32	-	36	-	11	2
I-12	Kigoma	173.7	74.5	28	14	-	54	-	2	2
I-13	Kigoma	72.7	22.3	60	24	-	8	-	8	1
I-15	Kigoma	112.5	25.8	36	33	-	25	-	5	1
I-16	Kigoma	49.4	31.5	9	50	-	37	-	2	1
I-10	Kigoma	91.7	64.4	35	29	-	26	-	6	3
I-7	Kigoma integrated	118.9	30.3	28	15	-	46	9	1	2
	Average	103.4	57.7	31	28	-	33	2	5	2
I-17	Malagarasi	104.3	69.7	25	17	-	47	1	2	7
I-18	Malagarasi	883.7	179.5	1	2	-	3	2	1	91
I-19	Malagarasi	98.5	179.5	-	27	-	45	6	12	11
	Average 17-19	362.2	142.9	9	15	-	32	3	5	36
I-20	C. Kabogo N	47.3	226.4	2	47	-	40	1	9	1
I-21	C. Kabogo S	118.4	255.5	19	28	-	41	-	9	3
	Average 20-21	82.9	241.0	11	38	-	40.5	.5	9	2
I-22	C. Kungwe N	113.9	120.3	43	20	-	30	-	6	2
I-23	C. Kungwe	73.8	59.4	16	54	-	21	1	5	4
I-24	C. Kungwe	87.7	103.1	12	35	-	32	1	13	7
	Average 23-24	80.8	81.3	14	44.5	-	26.5	1	9	5.5
I-27	Lubugwe	97.4	43.0	14	20	-	26	9	9	2
I-29	Lubugwe	66.7	71.7	21	32	-	34	2	8	4
I-31	Lubugwe	96.8	104.4	32	25	-	23	11	8	2
I-32	Lubugwe	56.3	105.0	18	29	-	24	3	22	4
I-30	Lubugwe Bay	87.7	166.9	5	32	-	41	-	18	4
	Average 27-32	79.3	81.0	21	27	-	32	6	12	3

Table 10. (Continued)

Station Number	Station	Biomass (mg m^{-3})		Percent Composition						
		Phyto	Proto	Cyano	Chloro	Eug	Chryso	Dia	Crypt	Peri
I-33	Kibwesa N	52.8	35.5	2	56	-	20	3	17	2
I-34	Kibwesa S	60.1	54.8	-	54	-	18	-	24	4
	Average 33-34	56.5	45.1	1	55	-	19	2	21	3
I-35	Luvubu R.	64.0	59.5	-	48	-	19	1	17	14
I-36	Karema	112.6	56.7	44	20	-	18	-	15.8	2
I-37	Karema	149.0	34.8	35	19	-	28	8	9	1
	Average 35-37	130.8	45.8	40	19.5	-	23	4	12.5	1.5
I-38	Kipili	186.4	126.3	57	22	-	10	3	6	1
I-39	Kipili N	160.1	89.2	27	14	-	32	9	16	1
I-40	Kipili C	156.9	238.4	21	26	-	18	30	4	3
I-41	Kipili S	133.5	165.2	34	6	-	32	17	9	2
I-42	Kipili	153.3	325.2	44	10	-	25	14	5	3
I-43	Kipili	109.6	154.0	49	10	-	17	13	6	4
I-45	Kipili	130.8	2.0	21	15	-	43	19	1	1
I-46	Kipili	76.6	48.1	28	22	-	20	16	12	1
	Average 38-46	138.4	143.5	35	16	-	25	15	7	2
I-47	Kipanga	271.6	117.3	32	14	-	18	27	8	1
I-48	Kipanga	69.6	86.0	16	43	-	21	5	13	1
I-49	Kipanga	65.5	52.7	53	30	-	5	-	12	-
I-50	Kipanga	83.7	42.6	27	24	-	25	-	22	1
I-51	Kipanga	180.3	205.8	42	28	-	14	5	6	6
I-53	Kipanga	203.0	27.2	51	20	1	27	-	1	-
	Average 47-53	168.6	88.6	37	27	-	18	6	10	3

Table 11. The October-November survey of phytonlankton and protozoan biomass. Station locations are given in Fig. 1 and sampling depths and times in Table 2.

Station		Biomass (mg m^{-3})		Percent composition						
		Phyto	Proto	Cyano	Chloro	Eug	Chryso	Dia	Crypt	Peri
II-6	Bujumbura	929.6	41.8	2	19	-	1	78	-	-
II-9	Bujumbura	273.9	35.1	2	47	-	1	48	2	-
II-11	off Magara	631.5	202.9	2	39	-	2	57	-	-
II-13	Rumonge	536.8	106.0	3	24	-	3	68	1	1
	Average	592.0	96.5	2	32	-	2	63	1	
II-15	Rumonge	103.5	14.7	1	87	-	5	6	2	-
II-17	Rumonge	122.6	47.1	8	81	-	8	2	-	-
II-19	Rumonge	124.9	24.0	12	33	-	8	46	-	-
II-21	Rumonge	89.7	20.8	15	54	-	14	11	5	-
	Average 19-21	110.0	27.0	18	34	-	11	28	1	
II-22	Kigoma	294.1	7.6	8	64	-	8	20	1	-
II-23	Kigoma	225.2	12.6	43	40	-	1	15	1	-
	Average 22-23	260.0	10.0	25	52	-	5	17	1	-
II-26	Kigoma	243.0	16.8	52	38	-	2	8	-	-
II-26	Kigoma	247.2	16.8	64	28	-	1	7	-	-
II-26	Kigoma	279.3	8.6	52	38	-	1	9	-	-
II-26	Kigoma	275.0	24.6	57	33	-	1	8	1	-
	Average II-26	261.0	16.7	56	34	-	2	8	-	-
II-29	Kigoma	634.4	32.2	80	15	-	1	3	-	2
II-30	Kigoma	388.0	112.0	77	16	-	0	4	2	1
II-31	Kigoma	1572.6	76.7	94	5	-	-	1	-	-
II-32	Kigoma	709.7	88.5	82	15	-	-	2	-	-
II-33	Kigoma	407.3	40.6	67	25	-	2	3	2	-
	Average 29-33	742.4	70.0	80	15		1	3	1	1
II-34	Kigoma	401.4	11.6	79	18	-	2	1	-	-
II-34	Kigoma	253.6	4.6	59	36	-	2	2	-	-
II-34	Kigoma	111.5	8.6	31	58	-	3	6	2	-
II-34	Kigoma	125.4	95.8	36	59	-	2	3	-	1
II-34	Kigoma	81.1	5.4	14	77	-	4	1	4	-
II-34	Kigoma	130.4	16.3	21	72	-	-	7	-	-
	Average 34 0-25	183.0	23.7	40	53	-	2	3	1	-
II-37	Kigoma	194.2	20.2	32	51	-	8	9	-	-
II-44	Malagarasi	105.1	38.1	53	30	-	1	10	5	0
II-45	Lubugwe	74.2	113.0	2	42	-	17	22	13	4
II-47	Lubugwe	72.9	163.9	4	20	-	22	33	15	6
II-48	Lubugwe	106.3	62.9	6	61	-	2	13	14	1
II-50	Lubugwe	59.2	250.9	-	46	-	28	1	25	-
II-51	Lubugwe	60.6	32.7	1	58	-	5	22	13	1
	Average 45-51	66.7	140.1	2	42	-	18	20	17	3
II-56	Kibwesa	91.0	172.1	5	39	-	40	13	3	-
II-57	Kibwesa	70.6	61.7	-	61	-	20	4	15	-
	Average 56-57	80.8	116.9	3	50	-	30	9	9	-
II-58	Luvubu	54.0	103.8	7	42	-	23	22	5	1
II-59	Karema	65.6	55.2	1	83	-	4	1	11	-
II-60	Karema	76.4	22.2	3	66	-	22	-	8	-
II-61	Karema	68.7	64.6	0	82	-	5	1	11	1
	Average 58-61	70.2	47.3	1	77	-	10	-	10	1

Table 11. (Continued)

Station		Biomass (mg m^{-3})		Percent composition						
		Phyto	Proto	Cyano	Chloro	Eug	Chryso	Dia	Crypt	Peri
II-62	Detritus									
II-64	Kipili	257.5	13.0	-	93	-	3	-	4	-
II-65	Kipili	23.5	43.9	2	89	-	6	1	3	-
II-67	Kipili	52.0	28.6	2	55	-	14	-	26	2
II-68	Kipili	88.7	10.7	27	27	-	38	-	8	-
	Average 64-68	105.4	24.1	8	66	-	15	-	10	-
II-70	Detritus									
II-71		24.2	9.6	-	82	-	-	-	18	-
II-73	Detritus									
II-74		26.9	7.3	-	72	-	28	-	-	-
II-75	Detritus									
	Average 71 & 74									
II-123	Bujumbura	413.8	144.2	25	65	-	7	1	2	-
II-123	Bujumbura	357.5	150.5	44	44	-	11	-	1	-
II-123	Bujumbura	755.7	162.2	40	40	-	8	-	12	-
II-123	Bujumbura	457.3	101.2	16	64	-	1	1	18	-
II-123	Bujumbura	299.9	43.7	7	57	-	9	2	23	1
	Average 123 profile	456.8	120.4	26	54		7	2	11	-
II-123	Bujumbura integ.	807.5	252.4	20	48	-	17	7	7	-
II-126	Kitaza	370.1	52.0	10	68	-	7	9	5	-
II-127	Kitaza	503.0	190.8	16	64	-	10	1	9	-
II-129	Kitaza	378.7	477.1	31	60	-	2	1	5	1
II-130	Kitaza	371.4	1046.2	34	57	-	-	7	2	-
II-131	Kitaza	413.3	189.0	26	47	-	12	-	15	-
	Average 126-131	407.0	391.0	23	59	-	6	4	7	-

- Euglenophyta are not present in significant abundance.

Table 12. Bacterial concentrations in Lake Tanganyika during October-November 1975. Number of replicates counted, if more than one, in parentheses. P means samples from several depths pooled for analysis (see Table 2).

Station	Depth	Bacteria X 10^5 mL^{-1}
12	0.5	9.6
25	60	2.8
	90	2.9
	100	2.2 (2)
	105	6.8 (2)
	109	5.3 (2)
	111	4.2 (2)
	114	1.8 (3)
	117	5.2 (2)
	120	4.6 (2)
	130	1.4 (2)
27	0-25	4.2
40	0-26 P	3.0
42	0-12.5 P	13
43	0-26 P	4.8
44	0-26 P	5.1
45	0-26 P	3.5
56	0-26 P	5.4
59	0-26 P	5.4
60	0-26 P	6.2
61	0-26 P	5.8
62	0-26 P	10
64	0-26 P	5.9
65	0-26 P	6.7
67	0-26 P	6.8
68	0-26 P	7.4
73	0-26 P	9.5
74	0-26 P	7.0
75	0-26 P	8.1
123	0-20	12
	0	7.2
	0.2	12
	5	9.0
	10	8.5
	20	12
126	0-26 P	14
127	0-26 P	3.7
129	0-26 P	10
130	0-26 P	7.8
131	0-26 P	5.1

Table 13. Mean bacterial concentrations for the three water masses in Lake Tanganyika in October-November 1975. The standard deviation, range and number of stations (n) in each water mass are given as well.

	Bacteria cells X 10^5 mL^{-1}
South	7.2 ± 1.5 5.4 to 10 n = 11
Central*	4.1 ± 0.9 3.0 to 5.1 n = 5
North	8.9 ± 3.65 3.7 to 14 n = 7
Whole Lake	7.6 ± 3.0 3.0 to 14 n = 30

* Station II-42 in the Malagarasi plume is excluded. It had 12 X 10^5 bacterial cells mL^{-1}. Also the depth profile from station II-25 is excluded.

Table 14. The July survey of nannoplankton biomass in the central and southern portions of the lake. Stations were near the localities named.

			Biomass mg m^{-3}				Percentage composition			Percentage composition of phytoplankton						
Station	Date	Depth	Total	Phyto	Proto	Zoo	Phyto	Proto	Zoo	Cyano	Chloro	Eug	Chryso	Dia	Crypt	Peri
Kibwesa	26/7/75	0-20m integ.	109.3	56.5	7.2	45.6	52	7	42	5	81	-	6	-	7	-
Kipili	24/7/75	"	178.4	64.0	68.8	45.6	36	39	26	5	51	-	13	-	31	-
Wampembe	25/7/75	"	116.1	37.2	33.3	45.6	32	29	39	-	19	-	33	1	46	1
Cape Kungwe	23/7/75	"	195.0	154.5	40.5	-	79	11	0	-	8	-	5	87	-	-
Kigoma	22/7/75	"	476.4	62.5	413.9	-	13	87	0	-	22	-	33	32	10	3

Table 15. Phytoplankton and protozoan species found in Lake Tanganyika in 1975.

Species List

Cyanophyta

Microcystis aeruginosa Kützing
Microcystis stagnalis var. *pulchra* Lemmermann
Microcystis flos-aquae (Wittr.) Kirchner
Aphanacapsa delicatissima W. et G. S. West
Aphanacapsa elachista var. *conferta* W. et G. S. West
Aphanacapsa elachista W. et G. S. West
Aphanacapsa sp.
Aphanatheca clathrata W. et G. S. West
Aphanatheca clathrata var. *brevis* Bachmann
Aphanatheca clathrata cf. *planctonica* G. M. Smith
Aphanatheca sp.
Diplocystis inerta (Lemm.) Drouet et Daily
Chroococcus limneticus Lemmermann
Chroococcus dispersus (V. Keiss) Lemmermann
Merismopedia punctata Lemmermann
Merismopedia glauca (C.) Nägeli
Anabaena circinalis Rabenhorst
Anabaenopsis tanganyikae (G. S. West) Woloszynska
Oscillatoria limnetica Lemmermann
Oscillatoria tanganyikae G. S. West
Spirulina laxissima G. S. West
Lyngbya limnetica Lemmermann

Euglenophyta

Trachelemonas volvocina Ehrenberg

Chlorophyta

Collodictyon triciliatum Carter
Chlamydomonas sp.
Sphaerocystis schroeteri (Chod.) Lemmermann
Chlorella sp.
Oocystis lacustris Chodat
Oocystis parva West
Chodatella (Lagerheim) *cingula* G. M. Smith
Chodatella (Lagerheim) *subsala* Lemmermann
Chodatella quadriseta Lemmermann
Tetraedron trigonum var. *gracile* (Reinch) Detoni
Treubaria triappendiculata Bernard
Nephrocytium agardhianum Nägeli
Nephrocytium limneticum (G. M. Smith) Skuja
Kirchnerella cf. *obesa* (West) Schmidle
Monoraphidium contortum (Thuret. in Bréb.) Komarkova
Monoraphidium setiforme (Nyg.) Komarkova
Monoraphidium convolutum (Corda) Komarkova
Dictyosphaerium pulchellum Wood
Dictyochlorella globosa Silva
Dictyochlorella reniformis (Korch) Silva
Westella botryoides (West) Wildeman
Lobocystis dichotoma var. *mucosa* Bourrelly
Pediastrum simplex (Meyen F. J. F.) Lemmermann
Coelastrum reticulatum (Sorg.) Lemmermann
Coelastrum microporum Nägeli
Coelastrum cambricum Archer
Crucigenia cf. *irregularis* Wille
Scenedesmus arcuatus var. *platydiscus* Smith
Scenedesmus denticulatus var. *linearis* Hansgirg
Scenedesmus quadricauda (Turpen) Brébisson
Scenedesmus quadricauda var. *maximum* West
Planctonema cf. *lauterborni* Schmidle
Coccomyxa sp.
Stichococcus cf. *minutissima* Skuja
Chlorella sp. from Strombidium
Pachycladon sp.

Chrysophyceae

Chromulina spp.
Mallomonas sp.
Erkenia subaequiciliata Skuja
Ochromonas spp.
Heterochromonas sp.
Chrysostephanosphaera globulifera Scheiffel
Bicoeca conica Lemmermann
Bicoeca planktonica Kisselew
Kephyrion cupuliforme Conrad
Salpingoeca frequentissima (Zach.) Lemmermann
Desmarella moniliformis Kent
Monosiga robusta Stoker
Cercoboda sp.

Diatomeae

cf. *Microsiphona potamos* Weber
Cyclotella meneghiniana Kützing
Cyclotella kützingiana Thwaites
Cyclotella spp.
Stephanodiscus sp.
Synedra acus var. *angustissima* (cf.) Grunow
Synedra cf. *acus* var. *radians* (Kütz.) Hustedt
Synedra beroliensis (cf.) possibly *Nitzschia* sp.
Rhizosolenia eriensis H. L. Smith
Navicula sp.
Nitzschia asterionelliodes (cf.) Müller
Nitzschia nyassensis (cf.) Müller
Nitzschia lacustris (cf.) Hustedt
Nitzschia closterium (cf.) (Ehr.) W. Smith
[1]*Nitzschia* spp.
Surirella linearis W. Smith
Surirella robusta var. *splendida* (Ehr.) v. Heurk
Denticula sp.

Cryptophyceae

Rhodomonas lens Pascher et Ruttner
Rhodomonas minuta var. *nannoplanktica* Skuja
Katablepharis ovalis Skuja
Cryptaulax cf. *conoidea* Skuja
Cryptomonas cf. *erosa* Ehrenberg

Peridineae

Peridinium africanum Lemmermann
Peridinium apiculatum Lemmermann
Gymnodinium mirablis Penard
Gymnodinium profundum Schifler
Gymnodinium varians Maskell
Gymnodinium cf. *albulum* Lindemann
Glenodinium pulvisculus (E.) Stein
Glenodinium quadridens (Stein) Schiller
Glenodinium sp.

Protozoa

Coleps hirtus
Didinium cf. *nasutum*
Mesodinium sp.
Uronema sp. cf.
Cinetochilum sp. cf.
Cyclidium sp. cf.
Vorticella cf. *nebulifera* O. F. Müller var. *similis*
Vorticella sp.
Tokophyra sp.
Acineta sp.
Stentor sp.
Haltaria cf. *grandinella*
Tintinnidium cf. *fluviatile*
Strobilidium sp.
Strombidium cf. *viride*
Strombidium sp.

[1]For absolute specific identifications of the *Nitzschia-Synedra* genera an electron microscope must be used. This is presently being undertaken.

Table 16. The rate of uptake of inorganic carbon as measured in the incubator during the first Lake Tanganyika cruise. "Dark" is the rate in the dark. "P1" through "P4" are the rates at irradiances "I1" through "I4". The units of irradiance are μEinsteins m^{-2} sec^{-1} and carbon uptake rates are in mgC m^{-3} hr^{-1}. Unless otherwise noted the depth of the sample is that given in Table 1.

Station	Dark	I1	P1	I2	P2	I3	P3	I4	P4
I-7	13.70	12.9	18.86	42.0	26.84	131.5	26.44	439.9	24.20
	114.55		50.95		38.68		32.14		37.59
I-9	21.50	19.2	11.73	60.1	12.14	183.7	12.01	571.8	14.24
	24.63		26.58		10.24		10.15		
I-10	12.39		9.26		9.61		9.00		13.00
	8.32		12.49		9.45		10.50		8.77
I-17	1.84	12.7	2.89	38.3	3.26	124.7	3.81	403.6	3.97
	2.15		2.12		2.48		1.40		2.36
I-18	2.53	12.4	2.58	38.8	2.82	122.4	3.41	414.9	2.77
	2.45		2.94		3.79		2.64		
I-19	2.16	13.8	2.46	41.4	2.92	125.8	2.90	392.2	2.48
	3.14		3.19		2.47		2.58		3.19
I-23	5.88	12.7	8.01	41.3	8.21	131.5	5.45	422.9	14.80
	6.49		6.22		9.30		5.83		8.38
I-24	11.21	12.7	7.58	41.3	6.39	131.5	5.92	422.9	5.19
	6.71		7.36		2.28		9.02		11.37
I-27	4.84	11.2	10.51	35.7	7.45	119.0	9.45	419.5	5.50
	8.37		5.52		3.97		4.08		5.50
I-27	2.81	11.2	3.53	35.7	3.50	119.0	4.43	419.5	4.21
	3.41		4.26		3.81		3.76		3.30
I-29	7.58	11.2	3.56	35.7	4.41	119.0	3.57	419.5	4.64
	3.74		3.60		3.59		3.55		3.97
I-30	3.59	11.2	2.93	35.7		119.0	2.72	419.5	3.65
	2.93						3.15		3.86
I-31	6.15	11.2	2.79	35.7	4.42	119.0	3.28	419.5	3.42
	3.00		2.93		2.91		3.35		4.08
I-33	8.94	12.1	8.43	38.6	8.30	123.6	7.93	412.7	8.40
	8.22		7.93		9.74		8.50		7.33
I-34	1.43	12.1	2.12	38.6	2.47	123.6	3.64	412.7	15.31
	2.78		2.22		2.39		3.07		7.32
I-35	2.78	12.1	2.84	38.6	3.65	123.6	5.67	412.7	2.91
	3.19		4.33		4.63		3.84		3.96
I-36	4.43	12.2	4.72	38.3	4.05	127.0	4.94	420.6	4.52
	4.41		4.57		5.22		4.35		5.54
I-37	4.77	12.2	4.21	38.3	5.15	127.0	7.91	420.6	6.51
	4.94		6.19		3.40		4.08		5.54
I-38	6.98	11.1	6.42	36.2	8.40	117.9	6.70	396.7	7.38
	4.55		7.26		8.79		7.72		9.17
I-39	4.99	11.1	5.19	36.2	3.38	117.9	6.43	396.7	4.88
	5.48		5.75		6.38		5.29		5.19
I-40	3.45	11.1	3.43	36.2	3.25	117.9	3.76	396.7	3.72
	4.25		3.74		3.04		3.64		3.79
I-41	2.12	11.1	6.56	36.2	2.48	117.9	2.44	396.7	3.08
	2.71		2.38		2.11		2.39		6.14
I-42	2.50	12.5	3.07	39.6	2.98	125.8	3.32	400.1	4.10
	3.01		2.98		2.70		3.08		3.50
I-43	2.81	12.5	6.52	39.6	7.14	125.8	3.78	400.1	4.98
	4.66		5.26		3.73		3.52		
I-45	2.29	12.5	3.16	39.6	3.51	125.8	2.92	400.1	2.81
	3.56		3.78		3.31		3.23		
I-46	3.43	12.5	3.75	39.6	3.19	125.8	4.36	400.1	3.24
	3.98		3.60		3.54		3.08		3.12
I-47	6.17	11.4	6.32	36.0	7.68	115.6	4.24	387.6	6.99
	5.02		6.02		7.65		8.94		9.28
I-48	9.93	11.4	11.46	36.0	8.71	115.6	7.45	387.6	8.08
	8.89		8.62		11.95		10.29		13.93
I-49	10.32	11.4	6.63	36.0	6.55	115.6	4.74	387.6	4.54
	5.42		5.29		4.92		4.78		4.87
I-50	4.21	11.4	3.72	36.0	3.82	115.6	3.54	387.6	3.88
	2.99		3.32		3.91		3.90		3.99
I-51	2.34	11.4	3.89	36.0	2.49	115.6	3.40	387.6	3.83
	3.33		3.76		3.22		3.44		3.75
I-85	5.41	11.8	7.95	37.6	5.30	117.9	6.20	396.7	6.65
	8.41		7.35		7.28		7.81		7.60
I-87	4.94		5.55		4.59		5.27		5.01
	4.57		5.26		5.81		4.85		7.45
I-89	5.82	11.8	11.85	37.6	10.07	117.9	13.83	396.7	10.77
	7.97		6.35		6.31		8.20		9.55
I-100	9.72	10.7	9.86	33.7	10.06	110.0	10.80	393.3	11.91
	9.75		10.07		10.08		10.24		10.55
I-102	1.63	10.7	1.33	33.7	1.31	110.0	1.66	393.3	1.96
			1.61		1.57		1.92		1.73
I-103		10.7	1.31	33.7	1.43	110.0	1.34	393.3	1.67
	1.23		0.92		1.44		1.94		1.70
I-104	1.75	10.7	1.71	33.7	1.83	110.0	1.86	393.3	2.82
	1.65		1.62		1.47		1.78		1.74

Table 17. The rate of uptake of inorganic carbon as measured in the incubator during the second Lake Tanganyika cruise. "Dark" is the rate in the dark. "P1" through "P4" are rates at irradiances "I1" through "I4". The units of irradiances are μEinsteins m^{-2} sec^{-1} and carbon uptake rates have units of mgC m^{-3} hr^{-1}. Unless otherwise noted depth of sample is that given in Table 2. "A" is the assimilation number, mgC mg^{-1} chl, i.e. productivity at optimum light per unit of chlorophyll.

Station	Depth	Dark	I1	P1	I2	P2	I3	P3	I4	P4	A
II-6		6.75	20.9	9.10	47.1	7.80	119.0	11.60	410.8		2.5
		6.45		9.00		8.40		10.70			
II-22		4.78	12.6	4.74	37.7	5.69	132.4	7.21	458.9	16.20	10.4
		4.26		5.05		5.00		7.63		11.50	
II-23		2.58		4.83		3.34		5.49		6.38	3.2
		5.32		6.41		3.35		5.03		6.67	
II-27		2.86	12.3	8.20	39.8	6.91	147.1	9.70	545.0	12.47	20.5
				9.24		7.49		9.48		13.71	
II-29		5.85	13.3	7.61	42.2	8.04	154.0	15.80	536.7	20.00	5.9
		3.75		7.53		8.79		20.70		14.20	
II-30		2.44	11.6	4.63	39.9	4.56	141.9	7.64	506.7	11.67	4.3
		2.98		3.93		4.19		7.82		11.14	
II-31		2.85	12.8	5.85	42.8	7.79	146.4	12.17	518.9	17.16	5.6
		2.85		2.23		9.54		11.14		17.41	
II-32		4.78	13.0	3.14	42.9	3.44	146.8	5.84	498.9	8.83	4.3
		3.85		2.63		3.52		6.57		8.33	
II-33		3.41		3.93		4.85		6.36		7.82	4.6
		3.65		3.88		5.10		6.53		9.26	
II-34	0.1	1.48	13.3	3.72	44.8	3.70	148.7		535.4	5.06	5.3
		1.17		3.44		3.02					
II-34	5.0	0.84	13.3	1.39	44.8	1.65	148.7	2.40	535.4	2.60	2.3
		0.87		1.33		1.49		2.37		2.39	
II-34	10.0	1.25	13.3	1.61	44.8	1.27	148.7	3.03	535.4	3.23	2.9
		1.24		1.17		1.23		2.50		3.37	
II-34	15.0	1.24	13.3	1.33	44.8	1.61	148.7	2.95	535.4	4.37	2.9
		1.36		1.40		1.71		2.66		3.50	
II-34	20.0	2.78	13.3	5.51	44.8	1.38	148.7	5.66	535.4	4.58	2.9
		6.45		2.05				3.90		3.59	
II-34	26.0	2.01	13.3	1.62	44.8	1.44	148.7	1.80	535.4	2.15	0.4
		1.62		1.45		1.50		1.77		2.06	
II-37	(4 hr)*	1.04	13.6	2.92	37.4	2.05	142.0	3.47	498.3	4.37	1.8
		1.15		2.84		2.39		3.73		4.71	
II-37	(8 hr)*	3.94	13.6	1.22	37.4	2.96	142.0	2.57	498.3	4.40	1.6
		1.59		1.14		1.86		2.56		4.90	
II-42		2.38	15.0	1.56	42.7	3.74	129.6	9.73	406.2	14.62	5.6
		2.20		1.58		4.21		7.96			
II-43		2.11	16.6	2.09	45.3	3.16	128.9	8.57	407.9	3.51	3.3
		2.20		1.92		3.93		6.12		7.35	
II-44		7.03	10.4	5.33	33.0	3.95	114.3	5.43	406.9	7.02	2.6
		2.11		7.09		4.50		5.73		7.01	
II-45		2.30	13.4	2.86	47.9	5.28	160.0	5.66	543.0	9.35	6.1
		2.59		3.17				6.25		6.56	
II-47		3.37		2.98		5.67		8.16		8.69	6.2
		2.99		2.95		4.63		10.90		11.28	
II-48		2.59	11.4	4.32	40.8	7.45	147.0	4.46	506.0	12.84	12.2
		2.86		5.42		10.51		4.68		12.14	
II-50		5.25		3.58		8.52		7.17		13.21	9.3
		4.86		9.01		6.68		7.38		15.43	
II-51		1.56		2.37		2.19		5.35		5.83	6.4
		1.52		2.56		2.28		4.40		6.17	
II-56		1.26	14.3	1.52	49.7	2.86	170.4	10.08	546.7	12.94	18.3
		1.12		1.77		3.75		5.98		22.33	
II-57		1.57	14.3	2.77	49.7	3.86	170.4	4.66	546.7	4.40	3.4
		1.95		2.39		2.26		4.34		3.58	
II-58		1.33	14.3	1.92	49.7	2.76	170.4	5.47	546.7	3.52	5.1
		1.43		1.78		3.32		6.46		6.35	
II-59		1.53	11.3	2.21	39.0	4.65	147.6	4.40	527.8	3.66	2.6
		1.41		6.05		3.53		3.59		3.93	
II-60		1.82	12.2	2.95	43.0	4.53	144.7	5.00	518.8	3.67	--
		1.63		2.37		4.06		3.37		3.93	
II-61		2.02	11.8	2.68	40.7	3.59	144.3	4.03	519.3	5.53	2.8
		1.99		2.44		3.83		5.61		5.23	

* Incubation period in parentheses.

Table 17. (Continued)

Station	Depth	Dark	I1	P1	I2	P2	I3	P3	I4	P4	A
II-62		2.35	12.6	6.26	42.8	6.72	152.6	10.32	527.0	10.16	8.4
		2.38		6.51		5.22		9.31		16.30	
II-64		3.23	11.4	8.88	39.7	10.80	141.7	9.21	521.8	7.66	3.9
		3.07		7.09		8.62		8.03		7.75	
II-65		1.63		2.21		5.03		6.65		5.13	3.5
		1.57		2.01		4.93		7.09		6.12	
II-67		5.80		7.42		7.03		6.11		9.80	2.6
		6.45		8.16						10.35	
II-68		2.67		2.83		7.52		6.11		5.88	5.7
		2.44		3.10		11.31				5.43	
II-70		1.62	14.6	2.67	46.7	6.87	153.0	14.44	519.9	18.52	12.0
		1.64		2.54		4.88		12.32		18.40	
II-71		2.64		9.45		3.35		6.77		6.53	4.1
		2.54		9.59		9.80		8.33		5.96	
II-73		2.56	13.3	4.68	43.1	6.16	145.1	10.05	505.9	14.20	10.8
		2.69		4.93		7.41		10.89		14.82	
II-74		3.03		5.78		4.52		7.41		6.98	2.6
		4.58		3.31		4.07		6.37		5.98	
II-75		3.95		5.42		5.12		10.88		10.62	8.3
		3.62		7.37		4.54		11.66		7.08	
II-123	0.1	5.17		25.00		14.39		9.72		18.70	6.4
		4.86		16.80		17.75		10.19		15.54	
II-123	5.0	4.69		5.13		6.18		9.09		10.92	4.1
		4.74		4.88		6.06		8.41		13.23	
II-123	10.0	4.48		4.63		5.93		10.48		11.97	5.0
		4.44		4.79		6.07		11.03		12.81	
II-123	15.0	4.60		5.28		6.45		8.60		13.86	4.8
		4.15		4.87		6.57		8.67		12.29	
II-123	21.0	4.52		5.77		7.23		10.61		11.97	4.8
		4.43		5.62		6.87		10.11		13.34	
II-123		4.81		6.24		7.59		11.03		15.12	4.2
		4.30		5.93		8.00				13.44	
II-126		7.54	11.4	10.18	40.4	11.76	138.6	11.36	476.7	14.13	3.1
		7.34		10.28		10.08		11.46		14.53	
II-127		3.65		6.36		6.17		14.90		18.91	8.1
		3.71		5.37		5.69		17.71		15.90	
II-130		2.91	11.2	5.64	38.8	6.31	141.9	15.22	533.3	28.16	4.9
		2.98		7.84		7.04		11.96		21.94	
II-131		3.73	12.2	6.49	41.6	6.08	147.7	17.45	499.3	16.79	2.4
		4.38		7.58		5.71		13.39		13.50	

Table 18. Filtration correction curves from station II-37 (10 km off Kigoma on October 13, 1975). The entries in the body of the table are in units of dpm mL^{-1} filtered, corrected for the background counting rate of the counter.

Irradiance	mL filtered						
μEinsteins m^{-2} sec^{-1}	1	2	4	8	16	32	64
Dark	67.1	35.4	23.4	23.2	25.6	24.8	22.3
13.6	37.6	25.7	31.5	26.6	30.9	28.2	28.7
37.4	65.5	49.1	49.8	50.7	51.3	55.9	76.6
142.0	101.7	103.9	108.9	129.0	161.3	104.0	109.4
498.3	90.3	92.3	155.6	156.4	135.2	149.1	80.5

Table 19. Primary production rates as measured by changes of oxygen concentration. The data have been converted to carbon units assuming photosynthetic and respiratory quotients of 1. The incubation time in all experiments was 8 hr.

Irradiance		Production mgC m^{-3} hr^{-1}	
μEinsteins m^{-2} sec^{-1}	mg O_2 L^{-1}	Gross	Net
Station I-42 May 5, 1975 Kipili, Tanz.			
Initials	7.32, 7.32		
Darks	7.12, 7.16		
11.1	6.94, 7.26	- 1.88	-10.31
34.9	7.19, 7.13	0.94	- 7.50
111	7.14, 7.16	0.47	- 7.97
352	7.13, 7.37	5.16	- 3.28
Station I-12 April 26, 1975 Kigoma, Tanz.			
Initials	7.11, 6.99		
Darks	6.85, 7.01		
13	6.95, -	0.94	- 4.69
40	6.94, 7.44	12.19	6.56
125	6.93, 7.01	1.88	- 3.75
400	7.18, 6.98	7.03	1.41
Station II-37 October 13, 1975 Kigoma, Tanz.			
Initials	7.64, 7.69		
Darks	7.50, 7.55		
13.6	7.57, -	2.11	- 4.45
37.4	7.66, 7.64	5.86	- 0.70
142.0	7.61, 7.68	5.63	- 0.94
498.3	7.70, 7.74	9.14	2.58

Table 20. Carbon uptake as a function of time and irradiance. The tabulated rates have units of mgC m^{-3} hr^{-1} and are the averages of replicate experiments. The rates for the lighted parts of the incubator are corrected for dark uptake, which is given in the last column. All times have been converted to Central African Time which is similar to sun time at the longitude of Lake Tanganyika. The column labeled "I" is the estimate of daily integral primary production using the photosynthesis vs. light curve for the entire day and has units of gC m^{-2}. Chlorophyll (Chl) is in mg m^{-3}.

			Light compartment					
		Chl	I	4	3	2	1	D
10 Oct.	St. 27-33							
	0640	0.5	1.9	5.86	4.34	6.73	10.23	2.86
	0900	2.1	2.2	2.77	3.62	13.45	12.30	4.80
	1120	2.0	1.1	1.57	1.67	5.02	8.70	2.71
	1355	2.6	1.8	1.19	5.82	8.81	14.44	2.85
	1625	1.0	0.1	-1.43	-0.84	1.89	4.27	4.32
	1755	1.1	0.7	0.38	1.45	2.92	5.01	3.53
17 Oct.	St. 46-51							
	0600	0.9	1.3	0.57	2.84	3.51	5.51	2.45
	0900	1.1	1.1	-0.22	1.97	6.35	6.81	3.18
	1200	0.8	1.9	2.15	6.26	1.85	9.77	2.73
	1500	1.0	1.2	1.24	2.55	2.22	9.27	5.06
	1800	0.7	0.8	0.93	0.70	3.34	4.46	1.54
22 Oct.	St. 62-68							
	0620	1.3	1.7	4.02	3.61	7.45	10.87	2.37
	0855	1.7	1.8	4.84	6.56	5.47	4.56	3.15
	1200	1.5	0.9	0.51	3.38	5.27	4.03	1.60
	1515	1.4	0.5	1.67	0.91	-0.15	3.95	6.13
	1750	1.2	1.3	0.41	6.86	3.56	3.10	2.56
5 Nov.	St. 126-131							
	0615	2.2	0.8	2.79	3.48	3.97	6.89	7.40
	0900	1.7	1.2	2.19	2.25	12.63	13.73	3.68
	1500	4.5	2.6	3.80	3.73	10.65	22.11	2.95
	1750	4.7	1.8	2.98	1.84	11.37	11.09	4.06

Table 21. Integral daily primary production estimates for Lake Tanganyika. Estimates are given with and without reduction of volumetric rates to account for uptake of $^{14}CO_2$ in the dark.

	Cloudless weather gC m^{-2} day^{-1}		Actual weather gC m^{-2} day^{-1}	
Station	With	Without	With	Without
II-6	0.99	2.94	0.82	2.51
II-22	1.49	3.46	1.03	2.89
II-23	0.44	1.82	0.35	1.55
II-27	2.30	3.31	1.91	2.79
II-29	2.71	4.44	0.22	3.68
II-30	1.48	2.53	1.13	2.05
II-31	2.37	3.41	1.79	2.69
II-32	0.29	1.95	0.11	1.58
II-33	0.87	2.23	0.66	1.86
II-34*	0.38	1.20	0.40	1.17
II-37	0.95	1.37	0.91	1.32
II-42	0.85	1.26	0.70	1.05
II-43	1.30	2.26	1.07	1.90
II-44	0.51	2.46	0.43	2.10
II-46	1.77	2.86	1.27	2.28
II-47	1.77	3.18	1.13	2.44
II-48	2.38	3.61	1.90	3.04
II-50	1.73	4.00	1.20	3.32
II-51	1.10	1.79	0.77	1.42
II-56	2.27	2.76	1.36	1.78
II-57	0.62	1.26	0.48	1.01
II-58	0.89	1.38	0.66	1.08
II-59	1.11	1.75	0.91	1.43
II-60	0.80	1.49	0.57	1.09
II-61	0.82	1.63	0.52	1.13
II-62	2.45	3.41	1.68	2.44
II-64	2.25	3.55	1.82	2.86
II-65	1.32	1.98	0.89	1.42
II-67	0.64	3.29	0.50	2.75
II-68	1.73	2.83	1.26	2.20
II-70	3.10	3.76	3.10	3.76
II-71	1.92	2.90	1.92	2.90
II-73	2.26	3.25	2.14	3.10
II-74	0.62	2.07	0.60	1.99
II-75	1.52	2.91	1.47	2.81
II-123*	0.80	1.80	0.72	1.66
II-123	0.94	1.94	0.84	1.78
II-126	0.83	2.45	0.77	2.29
II-127	1.36	2.17	1.20	1.96
II-130	2.84	3.77	2.60	3.48
II-131	1.92	3.18	1.77	2.97
$\bar{X}$	1.43	2.58	1.11	2.18
s.d.	±0.75	0.86	±0.66	0.78

* Estimates made with samples from discrete depths.

Table 22. The effect of bottle size on oxygen depletion rates. Sample from Station II-2. Initial and final oxygen concentrations in mg L^{-1}, and conversion to carbon assumes R.Q. of 1.

Bottle Size	Initial Oxygen	Final Oxygen	mgC m^{-3} hr^{-1} rate
60 cc	6.80, 6.81	6.63, 6.75	1.80
140 cc	--	6.62, 6.80	1.56
300 cc	6.74, 6.82	6.68, 6.66	1.72
550 cc	6.81, 6.81	6.67, --	2.19

Table 23. Depth of zero oxygen concentration and areal rate of methane oxidation at five sampling stations on Lake Tanganyika during October 1975.

Station Location	Depth of Zero Oxygen	mMoles CH_4 m^{-2} day^{-1}
II-5	80	4.9
II-25	110	0.0
II-55	125	1.5
II-69	150	9.6
II-72	205	3.0

Table 24. Calculation of productivity quotient for station II-37. Incubation for carbon experiment was four hours and for the oxygen experiment it was eight hours. Calculations based on carbon uptake corrected and uncorrected for dark uptake.

	Uncorrected for dark			Corrected for dark		
Light level	mmoles hr^{-1}		P. Q.	mmoles hr^{-1}		P. Q.
μE m^{-2} sec^{-1}	CO_2	O_2	$\Delta O_2/\Delta CO_2$	CO_2	O_2	$\Delta O_2/\Delta CO_2$
Dark	.09					
13	.24	0.18	0.75	.15	0.18	1.20
37	.19	0.49	2.58	.10	0.49	4.90
142	.30	0.48	1.60	.21	0.48	2.29
498	.38	0.77	2.03	.29	0.77	2.66

Table 25. Calculated mean biomass and respiration rates for Lake Tanganyika plankton in October and November. Underlined values are from literature. Bacterial rates derived by difference from total.

Plankton Component	Biomass mg m^{-3} (dry wt.)	Specific Respiration Rate μgO_2 mg^{-1} (d.w.) hr^{-1}	Respiration Rate μgO_2 m^{-3} hr^{-1}
Phytoplankton	34	30	1020
Protozoa	16	75	1200
Bacteria (Vol. = .25)	38	191	7280
Total	88		9500