ANNAL. BIOL. TIHANY | 41 | 205–216 | HUNGARIA 1974

THE PRIMARY PRODUCTION OF PHYTOPLANKTON IN LAKE BALATON OCTOBER 1972 — MARCH 1973

SÁNDOR HERODEK and GIZELLA TAMÁS

Biological Research Institute of the Hungarian Academy of Sciences, Tihany, Hungary

Received: 15th March, 1974

One of the main limnological characteristics of lakes is the primary production of phytoplankton. Lake Balaton was first studied from this respect by the STEEMANN NIELSEN's (1952) ^{14}C method in May—September 1961 (BÖSZÖRMÉNYI et al., 1962). Since then detailed investigations were started in April 1972. From this time on, the primary production was measured fortnightly at four different depths by the ^{14}C method throughout a whole year. Data of the first half-year were published in a separate paper (HERODEK and TAMÁS, 1973). This paper contains the data of the second half-year, and summarizes the results of the whole year.

Methods

Water was sampled in the pelagial, two kilometres east of Tihany at 25, 100, 200 and 300 cm depths. In aliquot parts of the samples the individuals of the algal species were counted by the Utermöhl's technique. The biomass of the single species was obtained by multiplying these counts by the average volume of individuals.

Of the samples an other aliquot of 100 ml was transferred into pyrex glass flasks, and after adding 20 μCi $Na_2{}^{14}CO_3$ they were lowered to their original places and there exposed for four hours (10^h—14^h). Subsequently, the samples were filtered through membrane filter and the radioactivity of algae was measured by liquid scintillation. Each value was reduced by that of the dark parallel. The total carbonic acid content of the water was determined, and the weight of carbon fixed by the algae calculated. Details of the methods were described earlier (HERODEK and TAMÁS, 1973). The production per unit of surface area was calculated by supposing that the sample at 25 cm represents half a metre thick, and each of the other three samples one metre thick water layers. The daily production was obtained by extrapolating from the four hours of exposal to the period between sunrise and sunset (HÜBEL, 1971).

Results

Water temperature, Secchi transparency, total irradiation, surface and underwater illumination data are presented in *Table I*. Further characteristics of experimental days:

Oct. 12. Sunshine, few clouds. Moderate wind, weak waves.
Oct. 26. Sunshine, thin clouds. Weak wind and moderate waves, then calm.
Nov. 11. Sunshine, thin clouds. Calm.
Nov. 28. On the previous three days strong wind. Sunshine. Moderate wind, moderate waves.
Dec. 21. The day before very strong wind. Sunshine. Moderate wind and moderate waves, then calm. Thin ice lamellae on the water surface. Next day the lake was frozen.
Jan. 17. The lake covered by 25 cm thick ice and 4 cm thick snow.
Jan. 31. The lake covered by 25 cm thick, opaque ice, and 1 cm water on the ice.
Febr. 19. The ice cover disrupted eleven days before. On the two days preceding the experiment a strong wind swept away the remaining ice. Sunshine, moderate wind, moderate waves.
March. 1. Previously very strong storm lasting for four days. Strong sunshine, floating clouds. Strong wind, very strong waves.
March. 15. Raining, later thin, then again thick clouds. Strong wind, very strong waves, then calm, unruffled surface.
March. 29. Thin clouds. Weak wind, moderate waves, then calm.

In the samples collected from the four depths on the 25 days during the whole year altogether 124 algal species, 6 varieties and 1 form were found. Their distribution among the phyla was the following: Cyanophyta 13, Euglenophyta 11, Pyrrophyta 6, Chrysophyta 40, Chlorophyta 61. Between October 1972 and March 1973, 92 species, 4 varieties and 1 form were found in the following distribution: Cyanophyta 10, Euglenophyta 7, Pyrrophyta 2, Crysophyta 45, Chlorophyta 33. For easier survey only those 24 species are listed separately in *Table II*, whose biomass reached the 10 mg · m^{-3} during the year. The biomasses of the other species are summed up for each phylum. Regarding the biomass values of Cyanophyta and the Euglenophyta, they play inferior roles. In October—November, when the biomass of phytoplankton was rather low, with the concentration of 0.2 mg · l^{-1} a Chlorophyta species, *Closterium aciculare* dominated. In this colder half-year among the Pyrrophyta algae *Cryptomonas erosa* attained 0.1 mg · l^{-1} in the ice covered

TABLE I

Environmental factors

Date	12 X.	26 X.	9 XI.	28 XI.
Water temperature °C	12	9	10	5
Global radiation during exposal cal/cm^2*	174	91	110	121
Global radiation in the whole day cal/cm^2*	308	181	177	173
Secchi transparency cm	96	84	106	25
Illumination at the surface Klux	48.3	24.6	24.6	—
Illumination in the different depths in percent of the surface illumination				
25 cm	67.5	73.8	79.6	—
100 cm	30.0	28.3	40.7	—
200 cm	15.0	15.2	22.2	—
300 cm	7.5	7.4	11.1	—
Bottom	6.0	6.5	9.3	—

* Measured by thermopile at the Meteorological Station of Siófok.

water. However, similar to the other half-year, the phytoplankton was generally dominated by diatoms, *Cyclotella bodanica* and *Cyclotella ocellata* representing the largest masses.

The annual curve of the biomass of the total phytoplankton *(Fig. 1)* has two maxima, one in April, and one in June—July, both around 4 mg $\cdot$ l^{-1}. From the end of September the mass rapidly decreased, the lowest value, 0.3 mg $\cdot$ l^{-1} was measured at the end of December. The biomass of the phytoplankton in the ice-covered lake was similar to that of the autumn. After the ice had thawed the mass increased rapidly, but till the end of March it did not attain the level of the previous April. Since the availability for filter feeding animals depends on the size of the algae (GLIWITZ, 1969), the mass of the length groups is given separately in *Fig. 1.* In spite of the big changes in the total biomass, the proportion of these groups remained fairly constant. Algae, shorter than 20 μ amounted about to one fifth of the total biomass. In most parts of the year, algae of 20—30 μ length gave more than the half of the total mass, whose bulk comprised a single species: *Cyclotella bodanica.* The explanation may lie in the larger size of the species, i.e. it cannot be incorporated by the zooplankton. In June, *Surirella robusta* and *Melosira granulata,* in August—September *Ceratium hirundinella,* i.e. algae longer than 30 μ, predominated.

The first data on the annual cycle of planktonic phytomass are known from 1947 (SEBBSTYÉN, 1954; TAMÁS, 1955). By the technique, used at that time, algae shorter than 10 μ could not be detected. Under all circumstances these small algae form but a few per cent of the present plankton. The mass of algae over 10 μ is now eightfold higher than it was 25 years ago. Compared to 1965, the first year, when the phytoplankton was counted by the technique used now (TAMÁS, 1974), the mass increased to its fourfold. For brevity's sake in *Table I* and *Fig. 1* only the averages of the four depths are presented. The mass of the total phytoplankton is not the same in the four depths *(Table III)*, but in the averages of the experimental days there was no difference between the water layers. The average biomass of the samples collected at the 25 investigated days throughout the year were 1.9 mg $\cdot$ l^{-1} at 25 cm, 1 m and 2 m depths, and 1.7 mg $\cdot$ l^{-1} at 3 m *(Fig. 2)*.

21 XII.	28 XII.	17 I.	31 I.	19 II.	1 III.	15 III.	29 III.
1	0	0	0	1	3	5	11
97	92	38	74	155	80	103	166
141	128	53	108	261	137	148	303
35	39	—	—	23	26	62	65
30.5	30.5	13.7	5.7	46.3	40.9	48.3	38.4
64.6	70.0	9.2	42.9	42.5	52.6	69 4	58.4
15.6	13.7	3.3	30.0	5.4	6.3	34.0	16.7
2.1	3.1	1.5	20.7	0.5	0.6	12.5	6.3
0.3	0.8	1.0	12.9	0.0	0.0	3.5	2.1
0.1	0.4	0.8	8.6	0.0	0.0	2.1	1.2

TABLE II

The biomass of the phytoplankton
$10^6 \mu^3/l$

	12 X.	26 X.	9 XI.	28 XI.	21 XII.	28 XII.	17 I.	31 I.	19 II.	1 III.	15 III.	29 III.
Cyanophyta												
Microcystis flos-aquae	1	1	—	1	—	—	—	—	—	—	—	—
Aphanizomenon flos-aquae	5	—	—	—	—	—	—	—	—	—	—	—
Other species	42	50	27	41	6	5	11	6	7	21	23	28
Total	48	51	27	42	6	5	11	6	7	21	23	28
Euglenophyta												
Total	2	1	1	1	—	—	2	2	—	—	—	2
Pyrrophyta												
Cryptomonas erosa	4	1	4	—	6	3	119	106	68	49	57	20
Ceratium hirundinella	33	2	—	—	—	—	—	—	—	—	—	—
Peridinium inconspicuum	—	—	—	—	—	—	—	—	—	—	—	—
Total	37	3	4	—	6	3	119	106	68	49	57	20
Chrysophyta												
Chromulina sp.	3	1	1	—	—	1	1	—	—	—	—	—
Amphora ovalis	2	1	1	27	21	22	—	—	20	42	26	4
Cyclotella bodanica	13	60	126	459	222	136	302	315	310	484	581	802
Cyclotella ocellata	2	7	34	104	71	37	55	61	82	95	136	158
Cyclotella quadriiuncta	5	6	19	1	2	1	1	1	5	—	13	12
Cymatopleura elliptica	13	2	7	148	30	30	—	—	—	56	45	60
Cymatopleura solea	17	—	—	17	21	11	—	—	—	36	16	34
Diploneis elliptica	—	—	—	—	1	—	—	—	—	44	—	—
Melosira granulata	—	—	—	—	—	—	—	—	—	—	—	—
Navicula gracilis	3	—	1	—	1	4	—	—	31	25	—	—
Navicula radiosa	—	—	—	2	1	3	—	—	6	—	—	—
Nitzschia acicularis	1	1	1	2	1	1	4	10	5	8	101	131
Nitzschia amphibia	—	1	1	9	3	2	—	—	9	11	1	6
Nitzschia hungarica	—	—	—	—	7	1	—	—	1	31	2	16
Nitzschia sigmoidea	1	—	1	21	11	21	—	—	11	52	11	90
Surirella robusta	—	—	—	—	—	—	—	—	18	—	—	—
Surirella turgida	—	—	1	—	13	—	—	—	—	—	—	—
Other species	20	20	64	18	25	10	28	48	40	74	61	54
Total	80	99	257	808	430	280	391	435	538	958	993	1367
Chlorophyta												
Closterium aciculare	188	141	144	200	10	3	1	—	3	1	1	—
Oocystis solitaria	9	14	23	12	1	1	7	3	2	—	—	2
Other species	21	33	30	21	12	6	11	16	86	17	17	23
Total	218	188	197	233	23	10	19	19	91	18	18	25
Sum total of all algae	385	342	486	1084	465	298	542	568	704	1046	1091	1442
g/m²	1.3	1.2	1.7	3.8	1.6	1.0	1.9	2.0	2.5	3.7	3.8	5.0

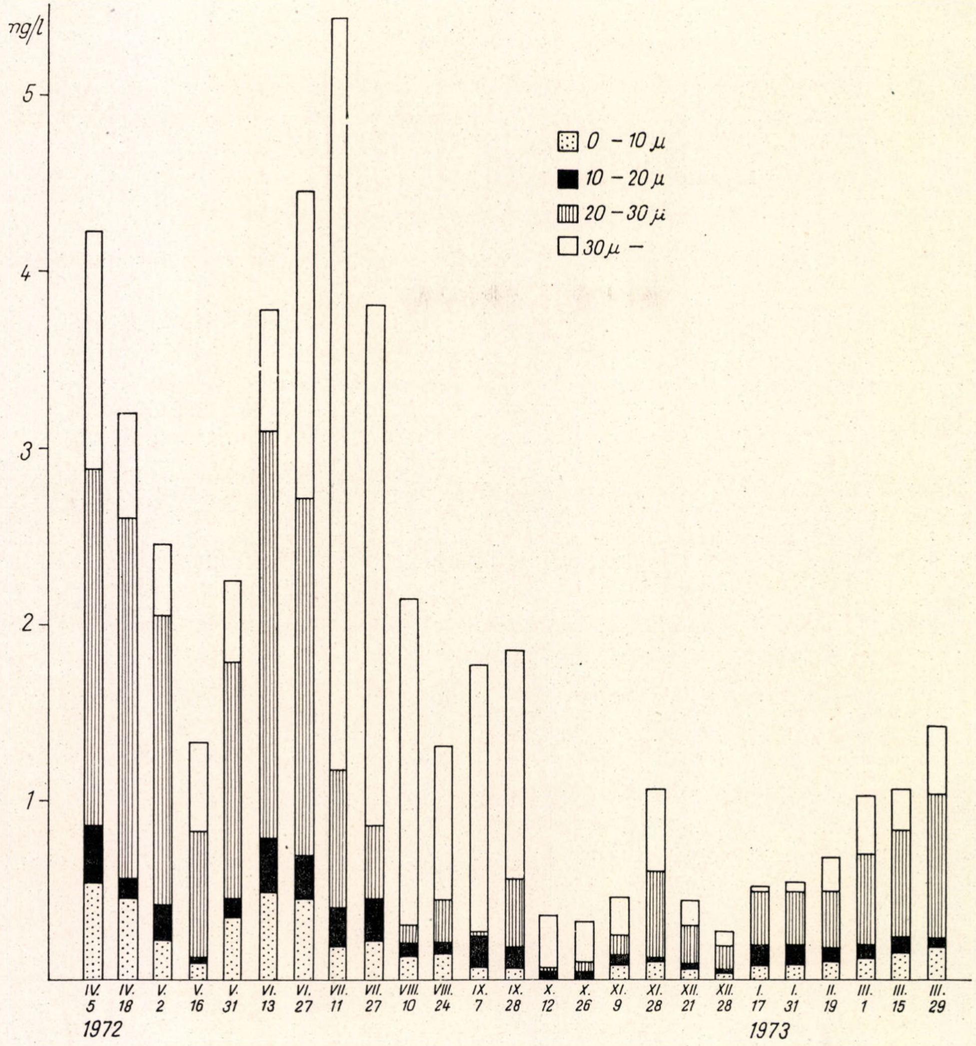

Fig. 1. Annual cycle of the biomass of the total phytoplankton, and that of length groups

The vertical distribution of production proved to be rather variable in this half-year, too *(Table IV).* After long heavy storms (Nov. 28, March 1) and in the poorly illuminated water under the snow-covered ice (Jan. 17) the uppermost while under the snow-free ice by maximal light penetration (Jan. 31) the deepest layer was the most productive. Of the 25 days, investigated during the whole year the maximum was at 25 cm in 5 days, at 1 m in 10 days, at 2 m in 7 days and at 3 m depth in 3 days. The variability of the vertical profile of primary production is a consequence of the rapidly changing transparency of the lake. In this rather turbulent but shallow lake, the transparency is limited by the amount of mud, swirled up from the bottom. While the average biomass of the 25 days investigated during the year was the same at the four depths, the productivity of these layers definitely differed. The

TABLE III

The biomass of the phytoplankton at different depths $10^6\mu^3/100$ ml

Depth, cm	12. X.	26. X.	9. XI.	28. XI.	21. XII.	28. XII.	17. I.	31. I.	19. II.	1. III.	15. III	29. III
25	48	29	36	88	72	40	54	5	94	96	66	170
100	32	30	45	122	51	44	28	43	58	171	125	182
200	47	21	57	121	53	14	73	65	94	119	74	173
300	31	52	49	91	21	25	60	87	45	26	149	63

TABLE IV

The production of the phytoplankton at different depths μg C/100 ml/4 hours

Depth, cm	12. X.	26. X.	9. XI.	28. XI.	21. XII.	28. XII.	17. I.	31. I.	19. II.	1. III.	15. III	29. III
25	0.88	0.70	1.26	4.40	2.60	0.92	1.30	0.07	0.99	2.60	2.12	1.25
100	1.93	1.51	3.16	3.25	7.17	2.24	0.67	2.07	2.35	2.54	4.55	6.63
200	3.02	2.40	4.64	0.50	5.15	2.01	0.30	2.72	0.36	0.39	4.99	3.58
300	2.30	0.76	3.69	0.00	1.18	0.63	0.08	3.13	0.12	0.22	2.45	1.54

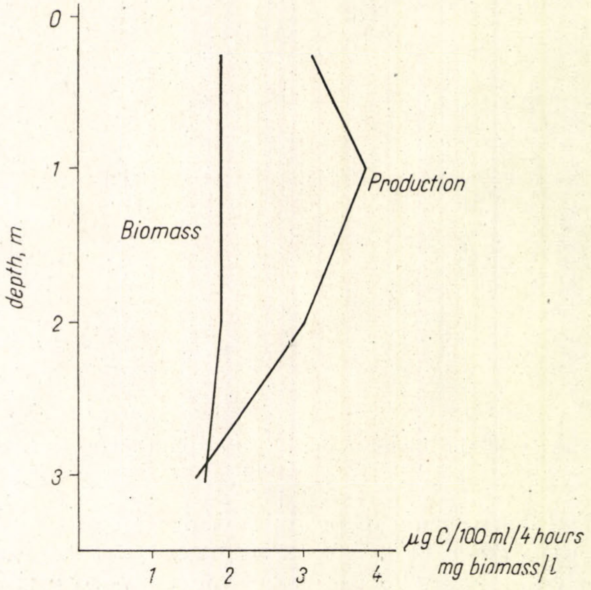

Fig. 2. The annual average of biomass and production at the different depths

average productions, expressed in μg C · 100 ml^{-1} · 4 h^{-1} were 3.1 at 25 cm, where usually photoinhibition was observed, 3.8 at 1 m, where the optimal illumination was the most frequent, 3.0 at 2 m where light insufficiency occurred more frequently, and only 1.6 at 3 m, where in half of the cases very low if any photosynthesis was found *(Fig. 2)*.

In the production per unit surface *(Fig. 3)* the differences were larger in this half-year, than in the previous one. On the 21st of December, 148 mg

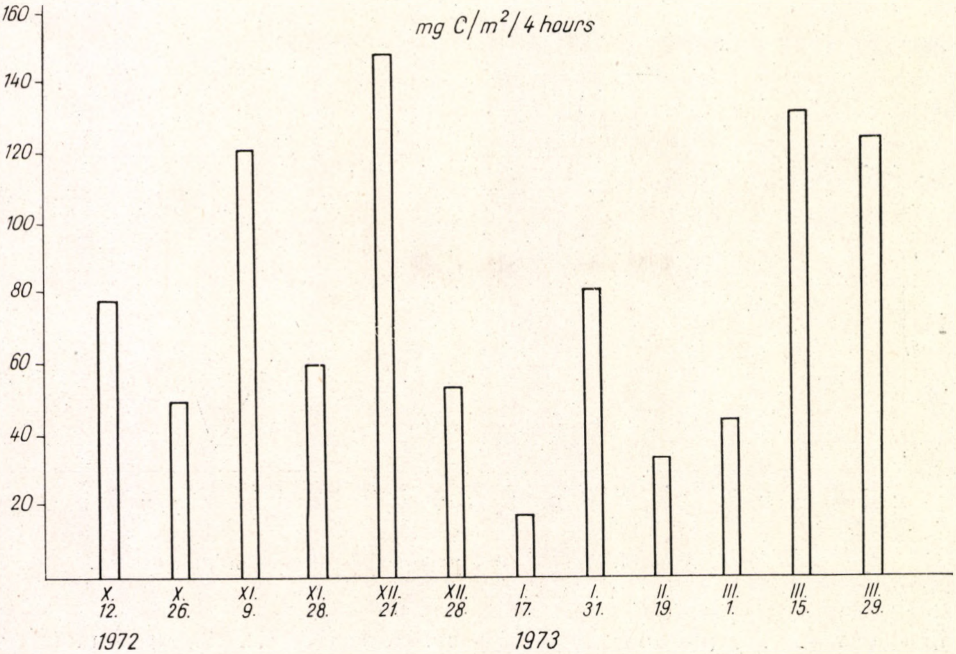

Fig. 3. Primary production of phytoplankton per unit surface

$C \cdot m^{-2} \cdot 4\ h^{-1}$, on the 19th of February only 19 mg $C \cdot m^{-2} \cdot 4\ h^{-1}$ were measured. The lowest production was found under the snow-covered ice on the 17th of January, while on the 31st of January the production under the snow-free ice attained the autumnal level.

The daily productions per unit surface area regarding the whole year are presented in *Fig. 4.* In spring and summer the production was high and fairly equilibrated. Contrary to other lakes, strong spring and summer peaks were not recorded. The maxima and minima in this period reflect rather the actual weather conditions, the turbidity of the water on the investigated days, then changes of longer duration. Thawing of ice is accompanied in other lakes by a rapid increase of primary production. This was not the case in Lake Balaton. The lake got rid of the ice by the middle of February, but the strong increase of production was observed first at the middle of March. By the end of March, the production attained the level of the previous April. The annual cycle of primary production in Lake Balaton is more balanced than in other lakes.

The seasonal changes in the primary production were also smaller than those in the biomass. The maximal intensity of carbon fixation by unit of biomass, 36 mg $C \cdot h^{-1} \cdot g$ fresh weight^{-1} was found at 2 m depth on the 28th of December. In the water layer, where the biggest quantity of carbon was fixed by unit mass of algae, the average fixations in the warmer, and in the colder half-years and in the total year were 6.5, 17.7 and 11.9 mg $C \cdot h^{-1} \cdot g$ fresh weight^{-1}, respectively. The corresponding values regarding the total water column were half as much, 3.4, 9.7 and 6.4 mg $C \cdot h^{-1} \cdot g$ fresh weight^{-1}

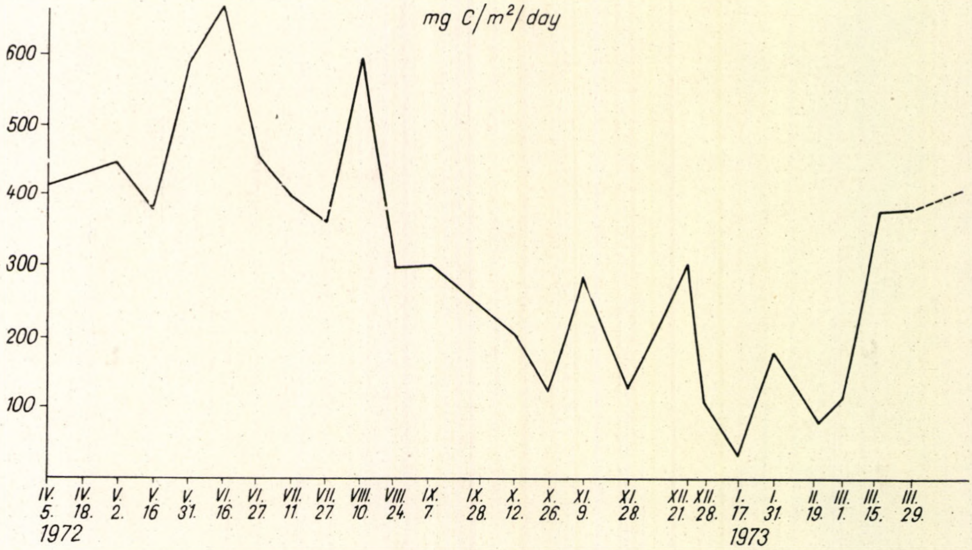

Fig. 4. Annual cycle of the production of phytoplankton

in the two half-years and the total year, respectively. A smaller amount of algae showed a higher specific performance. Assuming that 10 per cent of the total biomass consists of carbon, the time needed by the phytoplankton to fix the amount of carbon corresponding to its own carbon content can be calculated. In Lake Balaton this value ranged between 0.5 and 5 days, its average being 2.5 days in the warm half-year, 1.7 days in the cold half-year and 2.1 days in the total year. In Lake Erken, where the productivity is similar to that of Lake Balaton, this "renewal time" was 3 days (Nauwerck, 1963), while in the much more productive Lake Esrom this value was only 0.1 day (Jónasson and Kristiansen, 1967). Similar short renewal time was found in the hypertrophic part of Lake Balaton in the summer of 1973 (Herodek and Tamás, unpublished data).

Calculated from the area under the curve in *Fig. 1* the total annual production is 114 g C · m^{-2} · $year^{-1}$.

Discussion

According to the annual primary production oligotrophic, mezotrophic, eutrophic and hypertrophic lakes are distinguished by Winberg (1961) oligotrophic, natural eutrophic and polluted eutrophic ones by Rodhe (1969). The 114 g C · m^{-2} annual primary production of phytoplankton of Lake Balaton falls within the range of natural eutrophic lakes *(Fig. 5)*. Due to its shallowness Lake Balaton is not a typical lake, therefore, its primary production corresponding to that of eutrophic lakes does not result in the syndrome characteristic for typical eutrophic lakes. One of the consequences of the shallowness is the frequent swirling up of the mud. This way the organic matter is more rapidly destroyed than would be the case at the bottom of a cold,

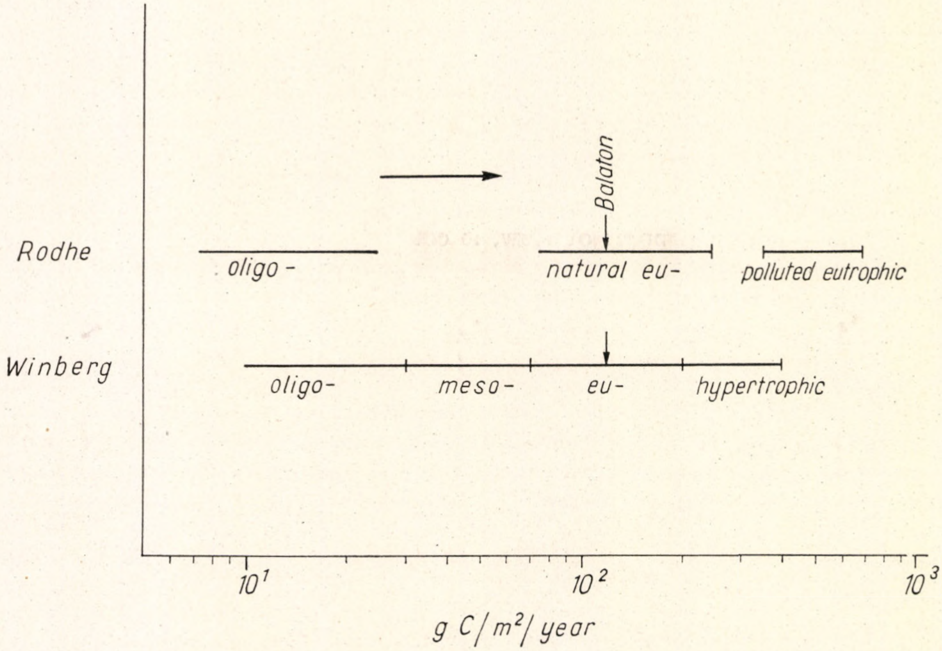

Fig. 5. Position of Lake Balaton on the scale of lakes based on their primary production

anaerobic, stagnant hypolimnion in a typical lake. This explains, why the mud contains only 1.5—1.8 per cent of organic carbon (Ponyi et al., 1972; Frankó and Ponyi 1973) by an eutrophic level of planktonic primary production.

The energetic income of the ecosystem of Lake Balaton consists of the planktonic, benthic and littoral photosynthesis, and the organic matter carried by the inflows. In the ice-free Lake Balaton there is usually no benthic production. On the other hand, when the lake is covered by snow-free ice, the primary production of the benthos is as high as that of the summer phytoplankton. The benthic production is thus of seasonal character, and its yearly total changes from year to year depending on the duration of snow-free ice (Herodek and Oláh, 1973). In average it may amount to about one fifth of that of the phytoplankton. The production of reed grass stands *(Miriophyllo Potametum potametosum perfoliati)* was measured in the two most densely covered parts of the lake, i.e. in the Keszthely Bay in 1969 (Kárpáti and Varga, 1970) and in the Szigliget Bay in 1970 (Kárpáti, 1972). In those areas where the coverage exceeded 1 per cent, the masses of *Potamogeton perfoliatus* were 0.3 and 1.3 kg fresh weight $\cdot$ m^{-2} in the Keszthely Bay and in the Szigliget Bay respectively. In *Potamogeton perfoliatus* the organic matter amounts to 7 per cent of the fresh weight (Kárpáti and Bedő, 1970). Accordingly, the annual production per square metre of the most dense reed grass stands is similar to that of the phytoplankton. The ratio of the reed grass production to the planktonic primary production is therefore similar to the ratio of the area of the dense reed grass spots to the total surface of the lake, i.e. the reed grass production is only a few thousand parts of the phytoplanktonic one. The biomass per square metre is higher in the reed belts, even if it changes according to regions and zones. The dry reed, harvested in the winter amounted to 0.3—0.4 kg $\cdot$ m^{-2} in the *Scirpeto-Phragmitetum phragmitetosum* (Tóth, 1960). Of this amount, however, only a small part reaches open water. The rate of carbon fixation in the diatom mass vegetation on the stony shores of the lake was 2 g C $\cdot$ m^{-2} $\cdot$ h^{-1} (Felföldy, 1958), this being an intensive local production, but insignificant regarding the total metabolism of the lake.

From a practical point of view, it could be of interest to compare the amount of the allochtonous organic matter with that produced in the lake. In summer 1970 the chemical oxygen demands of River Zala and of some springs and sewage water inflows that were chosen as representatives were measured twice for three days. By extrapolating from these representative measurements to all waters entering the lake, their chemical oxygen demand would be 30 metric ton O_2 $\cdot$ day^{-1} (Radics, 1972). This is a first approximation only, and the measurement of chemical oxygen demand is not identical with that of the organic matter, however, it could be useful to compare this value with the amount of O_2 and organic matter produced by the phytoplankton. By extrapolating from the 114 g C $\cdot$ m^{-2} $\cdot$ $year^{-1}$ production to the 600 km^2 surface area of the lake 68 400 metric ton C $\cdot$ $lake^{-1}$ $\cdot$ $year^{-1}$ is obtained, the average daily production being 187 metric ton C $\cdot$ $lake^{-1}$. If $1 \text{ g C} = 10$ kcal and $1 \text{ g } O_2 = 3.51$ kcal, then $187 \text{ metric ton C} = 533 \text{ metric ton } O_2$. The chemical oxygen demand of all inflowing waters is only 5.6 per cent of this value. According to our recent investigations the phytoplankton is eight times more productive in the Keszthely Bay, than at Tihany. The chemical oxygen demand of the inflowing waters is therefore only 4 per cent of the oxygen production of the phytoplankton, and the amount of organic matter revealed in this oxygen demand is only 4 per cent of that produced by the algae. This value, whatever rough estimate it is, speaks for the importance of the removal of inorganic nutrients in addition to that of organic matters from the waters entering the lake.

Summary

The biomass and the primary production of phytoplankton were measured throughout a whole year fortnightly in the pelagial two kilometres east of Tihany at four depths. Data of the first half-year were published earlier. The present paper surrenders data of the second half-year and summarizes the results of the whole year.

Algae were counted by the Utermöhl's microscope, and the biomass of the single species was obtained by multiplying these counts with the average volume of the individuals. The biomass was low during autumn and in the ice-covered lake, and increased rapidly after the ice had thawed. Its average was 2.5 g $\cdot$ m^{-2} in this cold half-year. During the whole year the biomass ranged between 19.5 g $\cdot$ m^{-2} (11th July) and 1.0 g $\cdot$ m^{-2} (28th December) its yearly average being 1.9 g $\cdot$ m^{-3} alike at 25, 100 and 200 cm depths and 1.7 g $\cdot$ m^{-3} at 300 cm depths.

The production of phytoplankton was determined by the ^{14}C technique. The vertical distribution of the production varied much, depending on the

turbidity of the water. The maximum was usually found at 1 m or 2 m depths, but in storms the uppermost layer, during long calms and in the snow-free frozen lake the deepest layer were the most productive.

The production was lower in autumn and winter than in spring and summer, but this difference is smaller than in other lakes, and smaller than the seasonal changes of the biomass.

The annual primary production of phytoplankton was 114 g C · m^{-2}. This production falls within the range of the productivity of natural eutrophic waters, and forms the main source of organic matter in this lake.

Acknowledgement

We thank G. Major for the global radiation data.

REFERENCES

Böszörményi Z., E. Cseh, L. Felföldy, E. Szabó (1962): A Balatonban C^{14}-módszerrel végzett fotoszintézis mérés módszertani kérdéseiről. — *Annal. Biol. Tihany* **29**, 39—63.

Felföldy L. (1958): A contribution to the ecology and biological productivity of the diatom mass-vegetation on the stony shores of Lake Balaton. — *Annal. Biol. Tihany* **25**, 331—342.

Frankó A., J. Ponyi (1973): Seasonal change of the organic carbon content of Lake Balaton during 1972. — *Annal. Biol. Tihany* **40**, 185—189.

Gliwitz Z. M. (1969): The share of algae, bacteria and trypton in the food of the pelagic zooplankton of lakes with various trophic characteristics. — *Bull. Acad. Pol. Sci., Ser. Sci. biol.* **17**, 159—165.

Herodek S., J. Oláh (1973): Primary production in the frozen Lake Balaton. — *Annal. Biol. Tihany* **40**, 197—206.

Herodek S., G. Tamás (1973): The primary production of phytoplankton in Lake Balaton April—September 1972. — *Annal. Biol. Tihany* **40**, 207—218.

Hübel H. (1971): Primärproduktion des Phytoplanktons. ^{14}C- oder Radiokohlenstoffmethode. — *in: Ausgewählte Methoden der Wasseruntersuchung, VEB Gustav Fischer Verlag, Jena.*

Jónasson P. M., J. Kristiansen (1967): Primary and secondary production in Lake Esrom. Growth of *Chironomus anthracinus* in relation to seasonal cycles of phytoplankton and dissolved oxygen. — *Int. Revue ges. Hydrobiol.* **52**, 163—217.

Kárpáti I. (1972): Hínárállományok primér produkciójának kutatása a Szigligeti-öbölben. — *Vízgazdálkodási Kutató Intézet Tájékoztatója* 72—73.

Kárpáti I., Gy. Varga (1970): A Keszthelyi-öböl hínárvegetációja kutatásának eredményei. — *A Keszthelyi Agrártudományi Főiskola Közleményei* **12**, 1—67.

Kárpáti V., I. Bedő (1970): Data to the knowledge of composition of the most frequently occurring reed-grass species in Lake Balaton. — *Annal. Biol. Tihany* **37**, 183—197.

Nauwerck A. (1963): Die Beziehungen zwischen Zooplankton und Phytoplankton im See Erken. — *Symbolae Botanicae Upsaliensis* **17**, 1—163.

Ponyi J., J. Oláh, A. Frankó (1972): Distribution of organic matter and bacteria in the upper layer of bottom deposit in the open water of Lake Balaton. — *Annal. Biol. Tihany* **39**, 141—148.

Radics I. (1972): A Balaton 1970. évi vizsgálatai. — *Vízgazdálkodási Tudományos Kutató Intézet Tájékoztatója* 73—76.

Rodhe W. (1969): Crystallization of eutrophication concepts in Northern Europe. — *in: Eutrophication: causes, consequences, correctives. Proceedings of a Symposium. National Academy of Sciences, Washington D. C.*

Sebestyén O. (1954): Mennyiségi planktontanulmányok a Balatonon. III. Pelagikus Dinoflagellaták biomasszája. (Módszertani tanulmány). — *Annal. Biol. Tihany* **22**, 185—197.

STEEMANN NIELSEN E. (1952): The use of radio-active carbon (C^{14}) for measuring organic production in the sea. — *J. Cons. Int. Explor. Mer* **18**, 117—140.

TAMÁS G. (1955): Mennyiségi planktontanulmányok a Balatonon. VI. A negyvenes évek fitoplanktonjának biomasszája. — *Annal. Biol. Tihany* **23**, 95—109.

TAMÁS G. (1974): The biomass change of phytoplankton in Lake Balaton during the 1960s. — *Annal. Biol. Tihany* **41**, 323—342.

TÓTH L. (1960): Phytozönologische Untersuchungen über die Röhrichte des Balaton-Sees. — *Annal. Biol. Tihany* **27**, 209—242.

WINBERG G. G. (1961): Винберг Г. Г.: Современное состояние и задачи изучения первичной продукции водоемов. Первичная продукция морей и внутренних вод. — *Издательство Министерства Высшего, Среднего Специального и Профессионального Образования БССР Минск.*

A FITOPLANKTON TERMELÉSE A BALATONBAN
1972 OKTÓBER—1973 MÁRCIUS KÖZÖTT

Herodek Sándor és *Tamás Gizella*

Összefoglalás

1972. áprilisa óta Tihany előtt a nyíltvízben kéthetente, négy mélységben mértük egy éven keresztül a fitoplankton tömegét és termelését. Az első félév adatait előző cikkünk ismertette. Ez a dolgozat a hidegvizű félév adatait közli, és összefoglalja az egész évi vizsgálat eredményeit.

Az algákat Utermöhl mikroszkóppal számláltuk, és az egyedszámot az egyedek átlag térfogatával szorozva kaptuk a fajok tömegét. Az átlagos biomassza ebben a félévben 2,5 g/m^2 volt, ősszel és a jég alatt igen alacsony, a jég olvadása után erősen emelkedő irányú. Az egész év folyamán a biomassza 19,5 g/m^2 (júl. 11) és 1,0 g/m^2 (dec. 28) között változott, évi átlaga 25 cm, 1 m és 2 m mélyen egyaránt 1,9 és 3 m mélyen 1,7 g/m^3 volt.

A fitoplankton termelését ^{14}C módszerrel határoztuk meg. A termelés vertikális eloszlása nagyon változatos volt a víz zavarosságától függően. Leggyakrabban 1 vagy 2 méteren volt a maximum, viharos időben azonban a felszínen, hosszú szélcsönd után és hómentes jég alatt a legmélyebb rétegben.

Ősszel és télen a termelés alacsonyabb, mint tavasszal és nyáron, ez a különbség azonban lényegesen kisebb, mint a biomasszánál, és más tavakhoz képest kiegyensúlyozott a termelés évi alakulása. A turnover idő évi átlaga 2,1 nap.

A fitoplankton évi termelése 114 g C/m^2. Ez a mérsékelten eutróf vizek termelési szintjének felel meg, és a Balatonban a szervesanyag fő forrását képezi.