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BIOTIC STRUCTURE AND PROCESSES IN THE LAKE SYSTEM OF R. JORKA WATERSHED (MASURIAN LAKELAND, POLAND)
X. BIOMASS AND DISTRIBUTION OF SUBMERGED MACROPHYTES*

ABSTRACT: For five lakes of the system of the r. Jorka watershed determined were: the range of distribution, biomass and floristic composition of submerged macrophytes. The characteristics of vegetation in Lake Majcz Wielki confirmed its mesotrophic character, whereas in remaining lakes it indicated an advanced eutrophy.

KEY WORDS: Lakes, submerged macrophytes, lake littoral.

Contents

1. INTRODUCTION

Submerged macrophytes are an important link in the functioning of lake ecosystems; they are significant for the formation of

* Praca wykonana w ramach problemu międzyresortowego MR II/15 (grupa tematyczna „Ekologiczne podstawy jakości i czystości wód powierzchniowych").

environment and from the biocoenotic point of view (P i e c z y ń-s k a and O z i m e k 1976). The species composition, range of distribution and biomass allow to conclude about the trophic character of the lake.

The aim here has been a characteristic of submerged macrophytes in five lakes of the r. Jorka watershed on the basis of broad analysis of these lakes. It included the surface covered by submerged vegetation, its range, floristic composition and maximal biomass of aboveground and underground parts.

2. AREA AND METHODS

The studies were conducted in the years 1978 and 1980, in five lakes of the r. Jorka watershed (Majcz Wielki, Inulec, Głębokie, Zełwążek and Jorzec). Characteristics of lakes examined are given in Table I.

Table I. Characteristics of five lakes of the r. Jorka watershed according to data of Inland Fisheries Institute (1958)

Lake	Trophic state	Depth (m)		Surface area of lake (ha)	Surface area of the littoral		Surface area overgrown by submerged macrophytes (ha)
		max.	mean		ha	per cent of lake surface area	
Majcz Wielki	mesotrophic	16.4	6.0	161.5	69.5	42.4	49.5
Inulec	eutrophic	10.1	4.6	178.3	56.1	31.3	29.0
Głębokie	eutrophic	34.3	11.8	47.3	10.9	22.9	7.7
Zełwążek	eutrophic	7.4	3.7	11.5	6.7	58.2	4.1
Jorzec	eutrophic	11.6	5.5	41.9	9.4	22.2	3.3

The surface area covered by submerged macrophytes, the range, floristic composition and biomass at the height of the vegetation season (August) were analysed. In profiles, every 0.5 m of depth (from the shore to the farthest end of macrophyte range), macrophytes were collected by the Bernatowicz type sampler (of a surface area 0.16 m^2). The plants were washed to remove periphyton, segregated into species. Fresh and dry weight were determined separately for underground and aboveground parts.

3. RESULTS

The distribution of submerged macrophytes in five lakes of the r. Jorka watershed is shown in Figures 1-5.

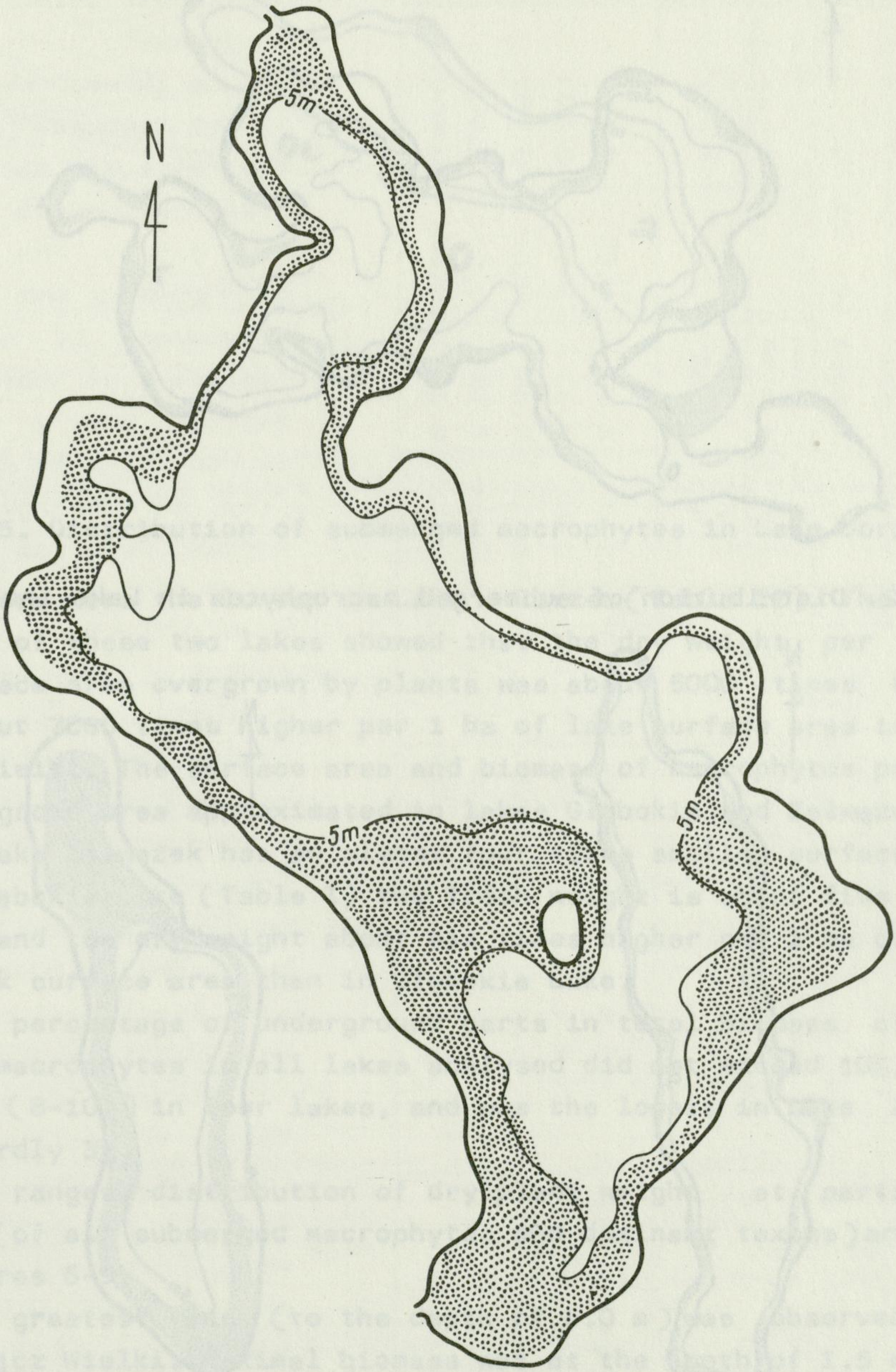

Fig. 1. Distribution of submerged macrophytes in Lake Majcz Wielki

The submerged plants covered the greatest surface area, had the highest biomass per 1 ha of surface area overgrown by plants and per 1 ha of lake surface area in Lake Majcz Wielki; the same

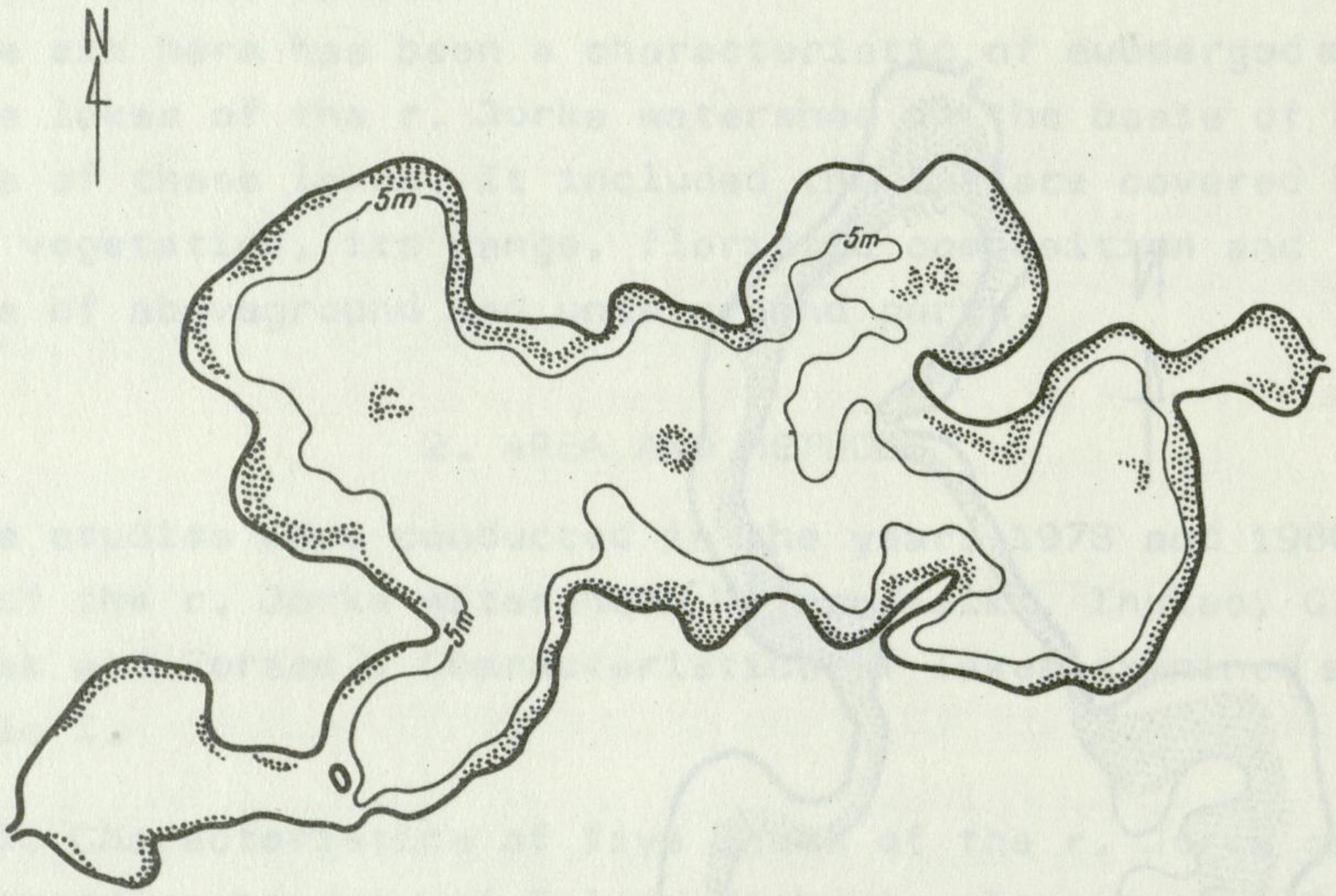

Fig. 2. Distribution of submerged macrophytes in Lake Inulec

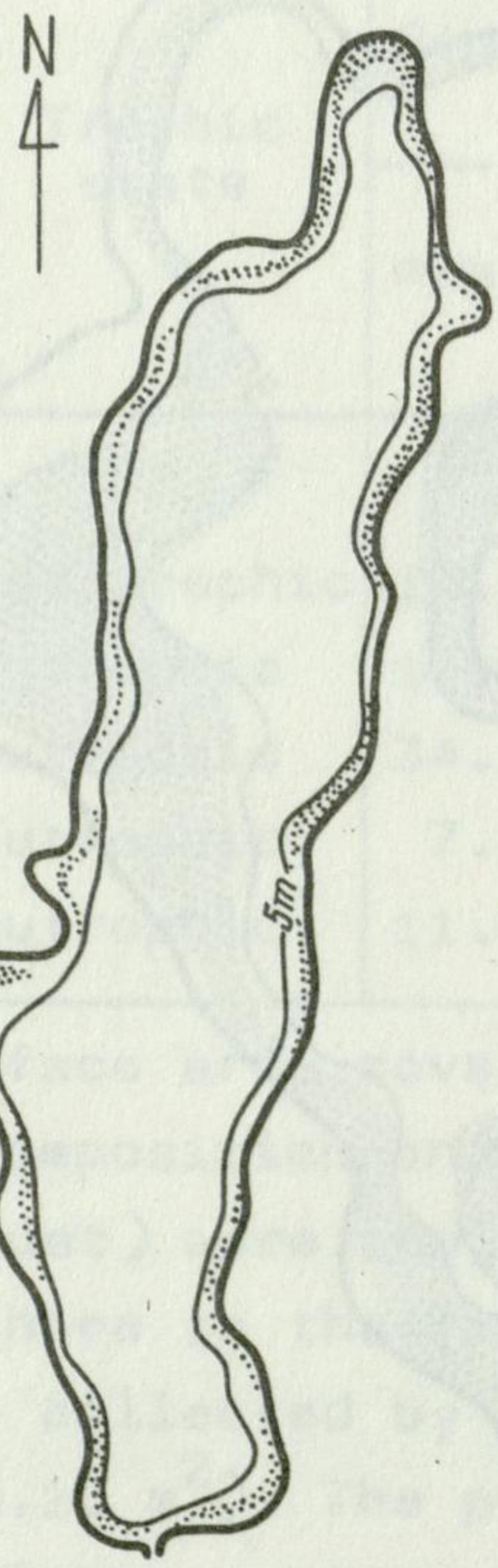

Fig. 3. Distribution of submerged macrophytes in Głębokie Lake

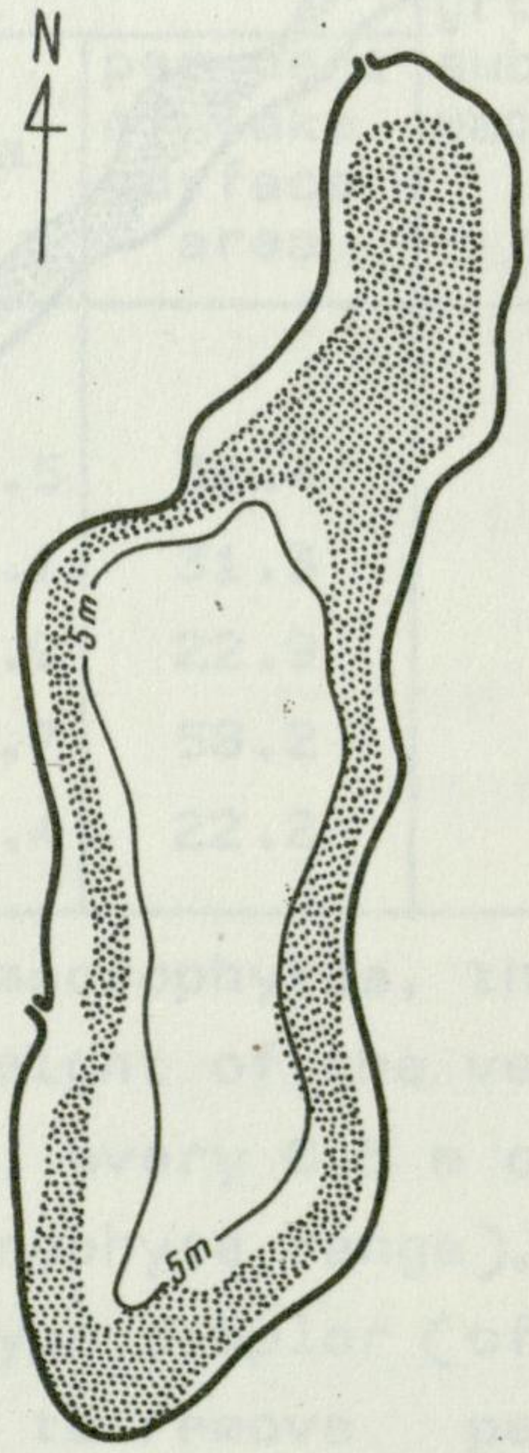

Fig. 4. Distribution of submerged macrophytes in Lake Zełwążek

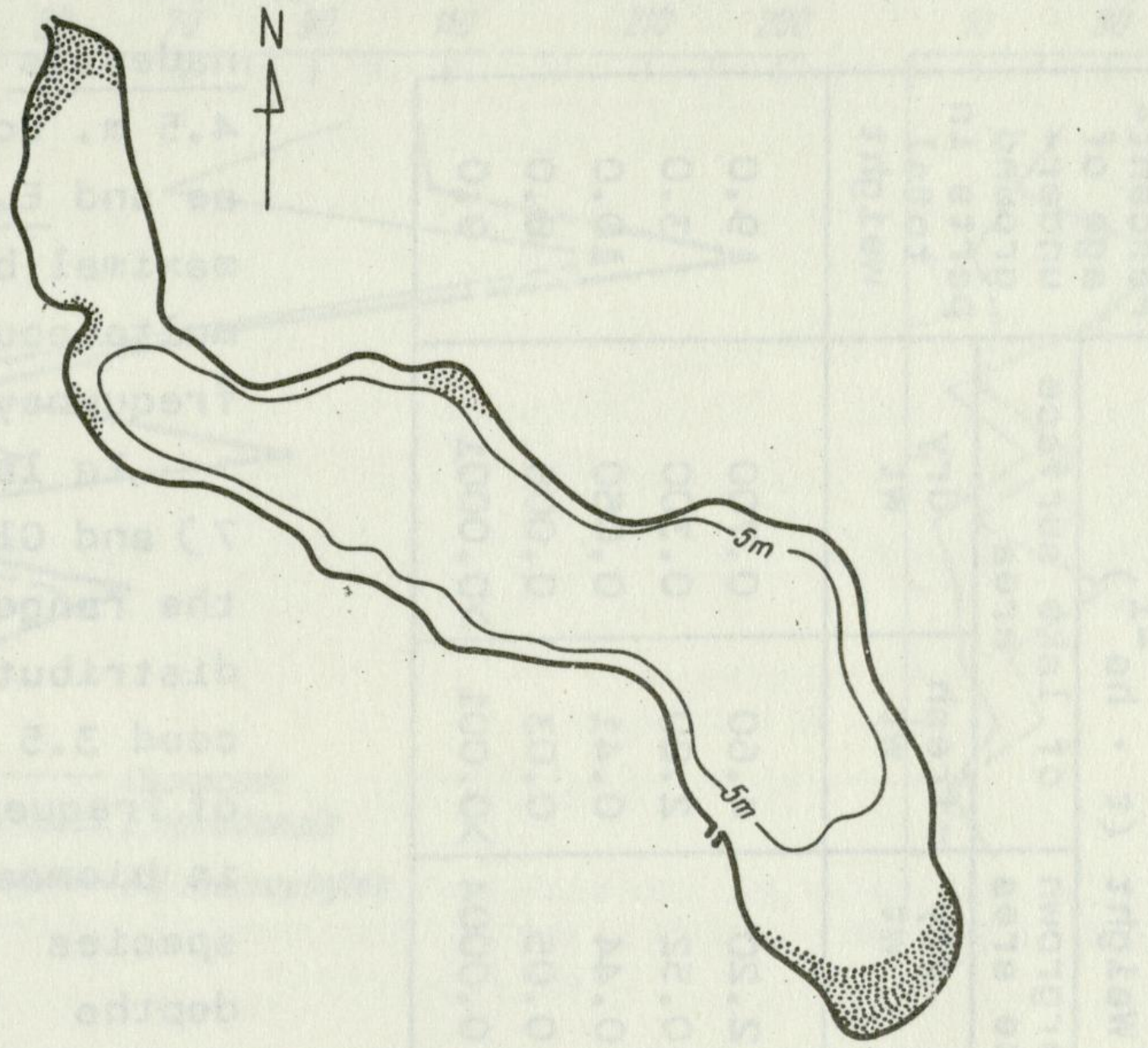

Fig. 5. Distribution of submerged macrophytes in Lake Jorzec

parameters were the lowest in Lake Jorzec (Table II). The comparison of these two lakes showed that the dry weight per 1 ha of surface area overgrown by plants was about 5000 times higher and about 7000 times higher per 1 ha of lake surface area in Lake Majcz Wielki. The surface area and biomass of macrophytes per 1 ha of overgrown area approximated in lakes Głębokie and Zełwążek. Because Lake Zełwążek has an almost four times smaller surface area than Głębokie Lake (Table I) the fresh weight is about five times higher and the dry weight about six times higher per 1 ha of Lake Zełwążek surface area than in Głębokie Lake.

The percentage of underground parts in total biomass of submerged macrophytes in all lakes analysed did not exceed 10%, was similar (8-10%) in four lakes, and was the lowest in Lake Zełwążek, hardly 3%.

The ranges, distribution of dry plant weight at particular depths (of all submerged macrophytes and dominant taxons) are given in Figures 6-9.

The greatest range (to the depth of 6.0 m) was observed in Lake Majcz Wielki. Maximal biomass was at the depth of 1.5 m; main contribution of Characeae to the depth of 3.5 m, and of Elodea ca-

Table II. Biomass of aboveground and underground parts of submerged macrophytes in five lakes of the r. Jorka watershed; August 1978*, 1979** and 1980***

Lake	Surface area occupied by macrophytes (ha)	Total weight (t)		Weight ($t \cdot ha^{-1}$)				Percentage of underground parts in total weight
		fresh wt	dry wt	of overgrown surface area		of lake surface area		
				fresh wt	dry wt	fresh wt	dry wt	
Majcz Wielki*	49.5	742.50	108.90	15.00	2.20	4.60	0.700	9.0
Żełwążek**	6.5	25.40	3.40	3.90	0.52	2.20	0.300	3.0
Głębokie***	6.0	19.20	2.60	3.20	0.44	0.41	0.050	10.0
Inulec**	22.0	5.70	1.10	0.260	0.05	0.03	0.006	8.0
Jorzec**	2.5	0.009	0.001	0.0035	0.0004	>0.001	>0.0001	9.0

nadensis between 3.5 and 4.5 m. Both for Characeae and E. canadensis the maximal biomass was simultaneous with maximal frequency.

In lakes Inulec (Fig. 7) and Głębokie (Fig. 8) the range of macrophyte distribution did not exceed 3.5 m. The curves of frequency and changes in biomass of dominant species at particular depths had a similar course. In Lake Żełwążek (Fig. 9) submerged macrophytes occurred to the depth of 5 m, not very abundantly from the depth of 3.5 m, as indicated by their biomass and frequency. It should be pointed out that higher frequency is not always accompanied by an increase in plant biomass. In Lake Jorzec the macrophytes were scarce and occurred only to the depth of 1.5 m.

The most abundant floristic composition was observed in Lake Majcz Wielki - 11 species of vascular plants and Characeae, among which P e r e y r a - R a m o s (1981) identified 7 species (Chara rudis A. Braun, Ch.

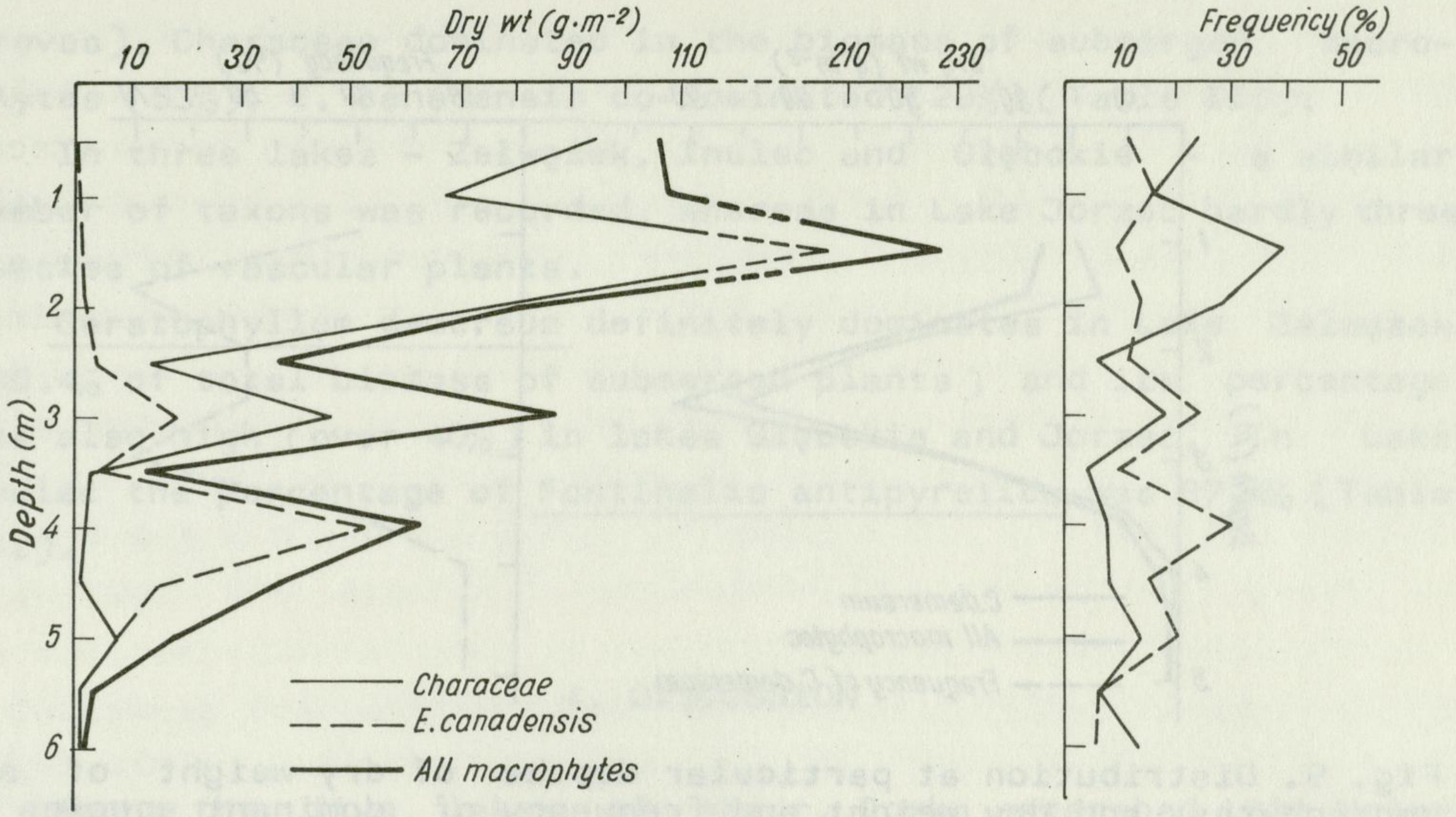

Fig. 6. Distribution at particular depths of dry weight of all macrophytes, and dry weight and frequency of dominant taxons in Lake Majcz Wielki

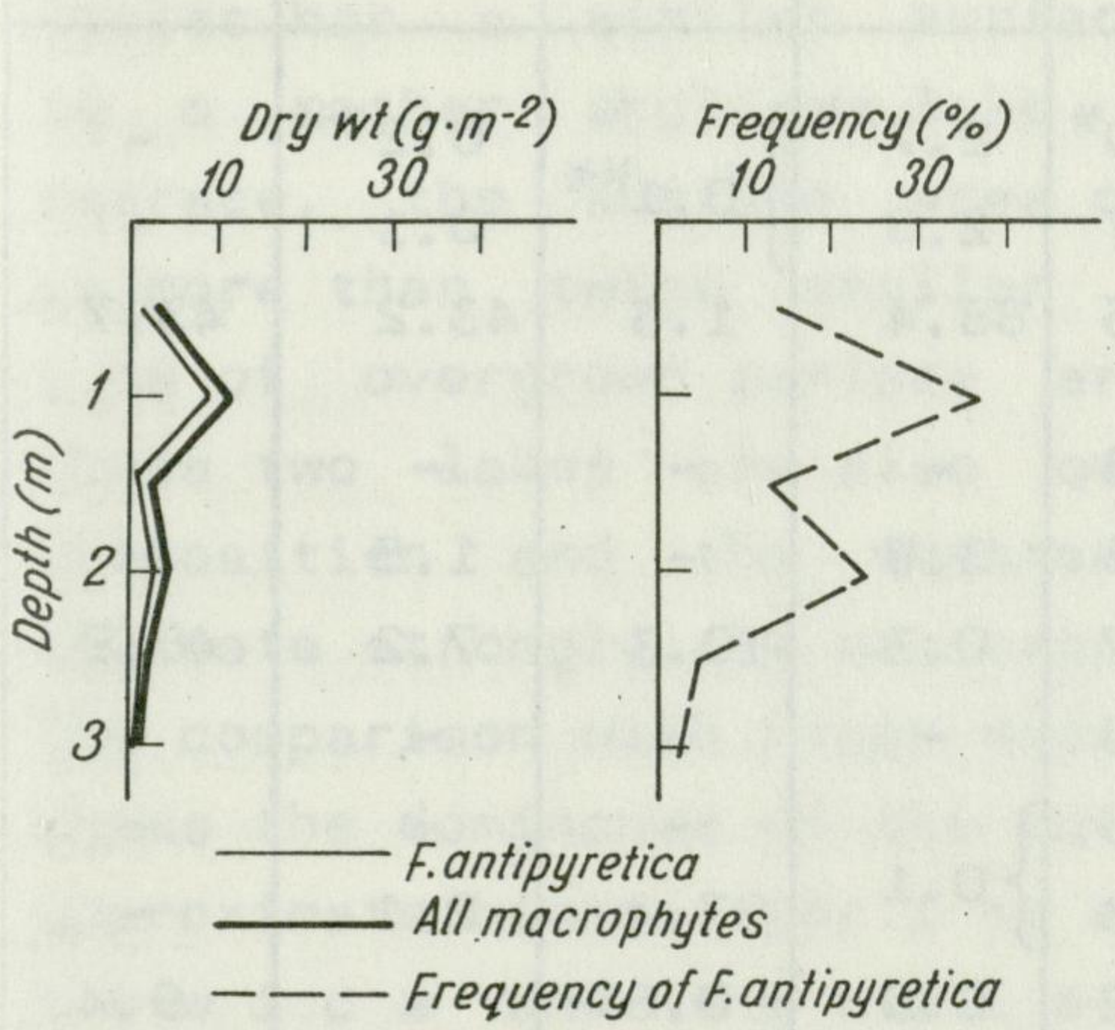

Fig. 7. Distribution at particular depths of dry weight of all macrophytes, and dry weight and frequency of dominant species in Lake Inulec

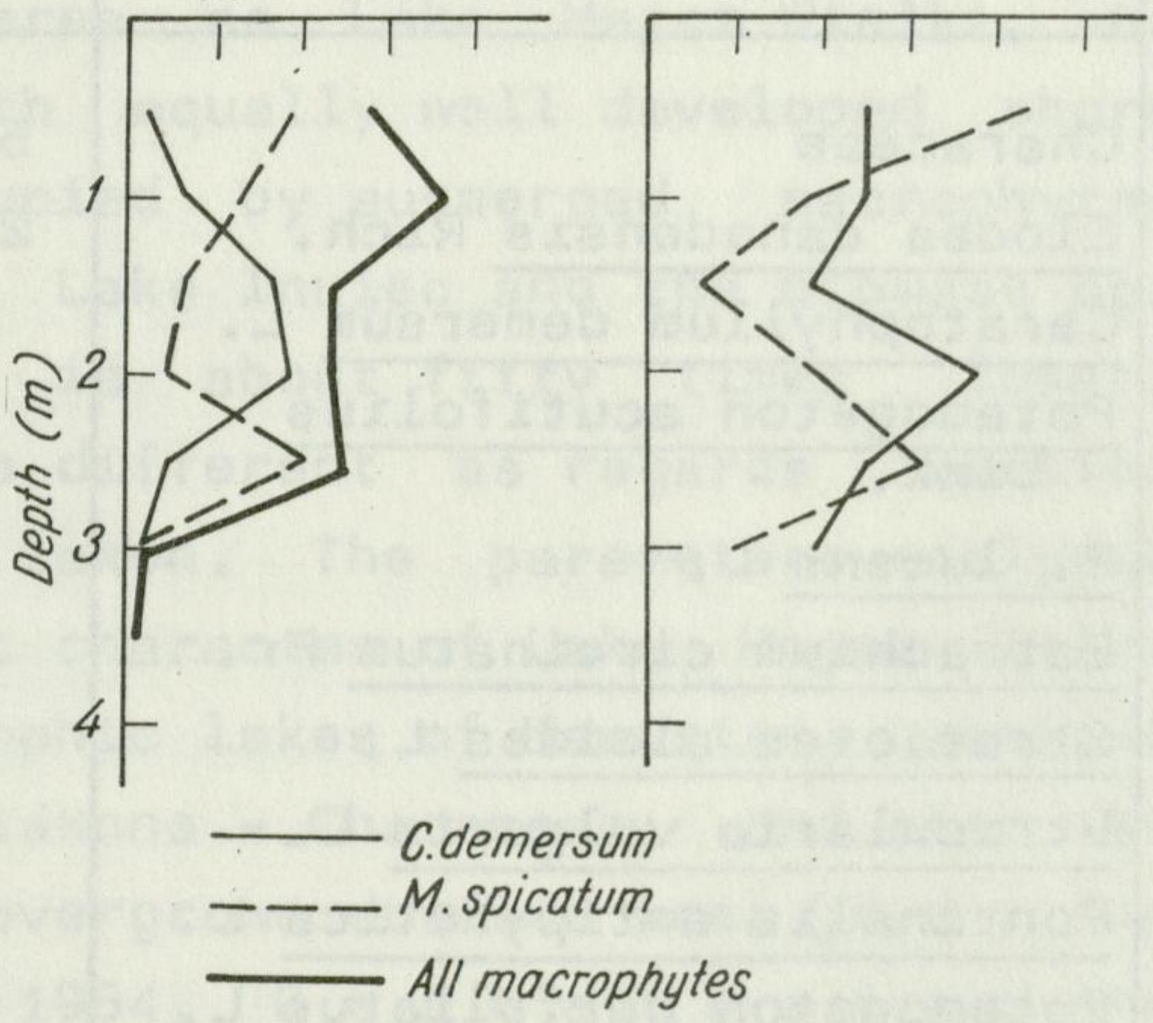

Fig. 8. Distribution at particular depths of dry weight of all macrophytes, and dry weight and frequency of dominant species in Głębokie Lake

contraria Kutz, Ch. jubata A. Braun, Ch. tomentosa L., Ch. fragilis Desvaux, Ch. vulgaris L. and Nitellopsis obtusa (Desvaux) J.

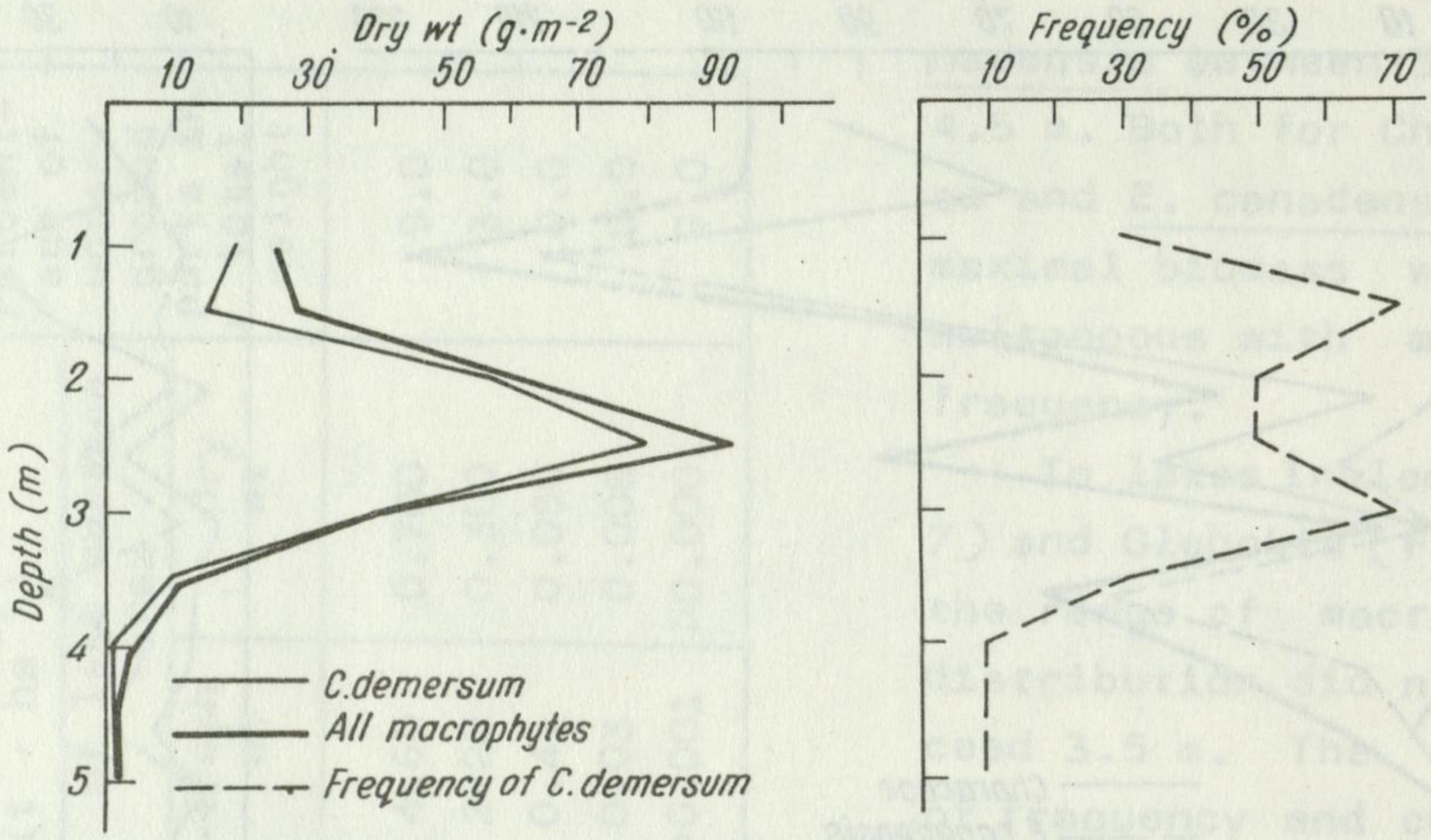

Fig. 9. Distribution at particular depths of dry weight of all macrophytes, and dry weight and frequency of dominant species in Lake Żełwążek

Table III. Percentage of particular taxons in total biomass of submerged macrophytes in five lakes of Masurian Lakeland

Taxons	Majcz Wielki	Żełwążek	Inulec	Głębokie	Jorzec
Characeae	53.0*	2.7**	0.1**	0.2**	-
Elodea canadensis Rich.	28.7	2.0		0.1	-
Ceratophyllum demersum L.	7.5	88.4	1.3	43.2	43.7
Potamogeton acutifolius Link.	3.8	-	-	-	-
P. lucens L.	2.6	3.8	-	1.5	-
Batrachium circinatum Fr.	1.7	0.3	10.3	7.2	46.9
Stratiotes aloides L.	1.5	-	-	-	-
Utricularia vulgaris L.	0.5	0.1	-	-	-
Fontinalis antipyretica L.	0.3		87.4	2.1	-
Potamogeton perfoliatus L.	0.2	0.9	0.6	-	9.4
P. obtusifolius Mert. et Koch.	0.1	0.9	-	-	-
Myriophyllum spicatum L.	0.1	0.9	0.1	44.9	-
Sagittaria sagittifolia L.			-	-	-
Potamogeton pectinatus L.	-		0.2	-	-
Heleocharis acicularis R. et Sch.	-			0.8	-

*7 species. **Nitellopsis obtusa.

Groves). Characeae dominated in the biomass of submerged macrophytes (53%), E. canadensis co-dominated (28%)(Table III).

In three lakes - Zełwążek, Inulec and Głębokie - a similar number of taxons was recorded, whereas in Lake Jorzec hardly three species of vascular plants.

Ceratophyllum demersum definitely dominates in Lake Zełwążek (88.4% of total biomass of submerged plants) and its percentage was also high (over 40%) in lakes Głębokie and Jorzec. In Lake Inulec the percentage of Fontinalis antipyretica was 87.4% (Table III).

4. DISCUSSION

Among the five lakes of the r. Jorka watershed Lake Majcz Wielki is outstanding as regards the parameters analysed. The surface area covered by submerged macrophytes is the greatest there as well as the range of distribution, biomass and species composition of macrophytes (18 species). The comparison of two lakes morphometrically similar shows that although Lake Inulec has a similar surface area as Lake Majcz Wielki, and is a rather shallow lake with equally well developed shore terrace, the surface area occupied by submerged macrophytes is more than twice smaller in Lake Inulec and the biomass per 1 ha of overgrown surface area is about fifty times lower. These two lakes are also quite different as regards species composition and the dominant taxon. The parameters analysed indicate strongly the mesotrophic character of Lake Majcz Wielki. The comparison with other mesotrophic lakes of Masurian Lakeland shows the dominance of the same taxons - Characeae, and also an approximate biomass per 1 ha of overgrown surface area (B e r n a t o w i c z and R a d z i e j 1964, B e r n a t o w i c z and P i e c z y ń s k a 1965, B e r n a t o w i c z, P i e c z y ń s k a and R a d z i e j 1968). According to the floristic typology of Polish lakes made by B e r n a t o w i c z (1960) Lake Majcz Wielki can be distinctly classified as Chara type. Lakes Głębokie, Zełwążek and Jorzec can be considered as belonging to Myriophyllum type, for which, according to B e r n a t o w i c z (1960), the indicatory plants are Myriophyllum and Ceratophyllum. Lake Inulec cannot be classified according to B e r n a t o-

wicz's (1960) classification. In the first three lakes dominate species preferring eutrophic water (Podbielkowski and Tomaszewicz 1979), even not much sensitive to pollution (Eloranta 1970, Ozimek 1978). Their dominance indicates the advanced trophic state of lakes discussed. In case of lakes Inulec and Jorzec, this is also confirmed by low plant biomass per 1 ha of overgrown surface area and the 24% smaller surface area covered by submerged macrophytes (comparison with data of the Inland Fisheries Institute 1958). As it has been observed by Ozimek and Kowalczewski (in press) (on the basis of comparison of biomass and surface area occupied by submerged macrophytes in the Mikołajskie Lake during 17 years) strong eutrophication is accompanied by a decrease in biomass of submerged plants and the surface area they occupy.

The contribution of underground parts to total plant biomass in all lakes analysed is low, because the plants which mainly dominate rarely take root (Ceratophyllum demersum, Batrachium circinatum) or have poorly developed underground parts in the form of rhizoides (Fontinalis antipyretica, Characeae). Thus they are of no greater significance neither in the biomass nor in the cumulation of elements. Because the dominant plants maintain aboveground shoots all the year round, they are of great significance in stopping the nutrients.

5. SUMMARY

In the years 1978-1980, the surface area, range of distribution, biomass and floristic composition of five lakes of the r. Jorka watershed (Majcz Wielki, Inulec, Głębokie, Zełwążek and Jorzec) were determined.

The highest biomass - 2.2 tons of dry weight per 1 ha of overgrown surface area - was found in Lake Majcz Wielki, and the lowest one - only 0.0004 $t \cdot ha^{-1}$ - in Lake Jorzec. The percentage of underground parts in total plant biomass was low and did not exceed 10% (Table II).

The range of plant distribution in lakes examined was much differentiated: from 6.0 m in Lake Majcz Wielki (Fig. 6), 5.0 m in Lake Zełwążek (Fig. 9), 3.5 m in lakes Inulec and Głębokie (Figs. 7, 8), to hardly 1.5 m in Lake Jorzec.

The most abundant floristic composition was observed in Lake Majcz Wielki - 11 species of vascular plants and 7 species of Characeae, whereas the least abundant one was in Lake Jorzec - only 3 species of vascular plants (Table III).

The biomass, range of distribution, species composition of plants confirm the mesotrophic character of Lake Majcz Wielki; in the case of remaining lakes they indicate the less or more advanced eutrophy.

6. POLISH SUMMARY

W latach 1978-1980 określono powierzchnię, zasięg występowania, biomasę i skład florystyczny 5 jezior dorzecza rzeki Jorki (Majcz Wielki, Inulec, Głębokie, Zełwążek i Jorzec).

Najwyższą biomasę - 2,2 t. s.m. na 1 ha powierzchni porośniętej - stwierdzono w jeziorze Majcz Wielki, najniższą - tylko 0,0004 $t \cdot ha^{-1}$ w jeziorze Jorzec. Udział części podziemnych w całkowitej biomasie roślin jest niski i nie przekracza 10% (tab. II).

Zasięg roślin w badanych jeziorach jest bardzo zróżnicowany: od 6,0 m w jeziorze Majcz Wielki (rys. 6), 5,0 m w jeziorze Zełwążek (rys. 9), 3,5 m w jeziorach Inulec i Głębokie (rys. 7, 8) do zaledwie 1,5 m w jeziorze Jorzec.

Najbogatszy skład florystyczny stwierdzono w jeziorze Majcz Wielki - 11 gatunków roślin naczyniowych i 7 gatunków Characeae, najuboższy w jeziorze Jorzec - tylko 3 gatunki roślin naczyniowych (tab. III).

Biomasa, zasięg, skład gatunkowy roślin potwierdzają mezotroficzny charakter jeziora Majcz Wielki; w przypadku pozostałych jezior wskazują na mniej lub bardziej zaawansowaną eutrofię.

7. REFERENCES

1. B e r n a t o w i c z S. 1960 - Charakterystyka jezior na podstawie roślin naczyniowych [Characteristics of lakes on the basis of vascular plants] - Roczn. Nauk roln. 77-B-1: 79-103.
2. B e r n a t o w i c z S., P i e c z y ń s k a E. 1965 - Organic matter production of macrophytes in Lake Tałtowisko - Ekol. pol. A, 13: 113-124.
3. B e r n a t o w i c z S., P i e c z y ń s k a E., R a-

d z i e j J. 1968 - Biomass of macrophytes in Lake Śniardwy - Bull. Acad. pol. Sci. Cl. II. Sér. Sci. biol. 16: 625-629.

4. B e r n a t o w i c z S., R a d z i e j J. 1964 - Produkcja roczna makrofitów w kompleksie jeziora Mamry [Annual production of the macrophytes in the complex of Lake Mamry] - Pol. Arch. Hydrobiol. 12: 307-348.
5. E l o r a n t a P. 1970 - Pollution and aquatic flora of waters by sulphite cellulose factory at Mäntta, Finnish Lake District - Ann. Bot. Fenn. 7: 63-141.
6. O z i m e k T. 1978 - Effect of municipal sewage on the submerged macrophytes of a lake littoral - Ekol. pol. 26: 3-39.
7. O z i m e k T., K o w a l c z e w s k i A. (in press) - Long term changes of submerged macrophytes in eutrophic Mikołajskie Lake - Aquat. Bot.
8. Pereyra-Ramos E. 1981 - The ecological role of Characeae in the lake littoral - Ekol. pol. 29: 167-209.
9. P i e c z y ń s k a E., O z i m e k T. 1976 - Ecological significance of lake macrophytes - Int. J. Ecol. Environ. Sci. 2: 115-128.
10. P o d b i e l k o w s k i Z., T o m a s z e w i c z H. 1979 - Zarys hydrobotaniki [General hydrobotany] - Państwowe Wydawnictwo Naukowe, Warszawa, 531 pp.