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DIATOMS OF LAKE DEPOSITS FROM THE POLISH BALTIC COAST
III. LAKE SARBSKO

Okrzemki w dennych osadach zbiorników wodnych polskiego pobrzeża Bałtyku
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ABSTRACT. This paper presents the results of a study on diatoms in the profile of deposits of Lake Sarbsko (northern Poland). A total of 302 taxa have been determined in 26 samples. The results obtained make it possible to distinguish three stages of development of the diatomaceous flora. Meso- and euhalobous and halophilous diatoms, characteristic of the Littorina period, prevailed at the first stage. The composition of diatoms in that part of deposits indicates that at the time of their sedimentation Lake Sarbsko was a shallow bay of the Baltic Sea. The most numerous forms of the second stage were oligohalobous-indifferent diatoms. The change in the composition of diatoms was due to the isolation of Lake Sarbsko from the sea and, in consequence, the considerable desalting of its water. In the third stage the oligohalobous indifferent diatoms were still predominant, but their proportion fluctuated owing to marked periodical inflows of sea-water into the lake. The top portion of the profile contained nearly exclusively indifferent diatoms, typical of shallow lakes.

INTRODUCTION

The present paper is a continuation of the studies on deposits in the bodies of water of the Polish Baltic Coast. The previous papers give the results of studies on the diatom flora of the Vistula Lagoon. Lake Druzno and Lake Jamno (Przybyłowska-Lange 1974, 1976, 1979).

There are only few publications concerning Lake Sarbsko. Szopowski (1962), Rosa (1963), Mielczarski (1964) and Wypych (1973) deal with the topography, the geological structure of this body of water and its surroundings and the old forms of its shore, while Sander (1953) and Guttowa (1956) discuss its present-day bottom fauna.

The palynological studies carried out by Tobolski (1967) on the material from a profile taken in the central part of the lake show that it includes deposits from the Older Atlantic onwards.

The history of the development of Lake Sarbsko is closely connected with changes occurring in the Baltic itself and the formation of the barrier-beach, now separating the lake from the sea.

Study area

In the past Lake Sarbsko was part of Lake Łebsko and both these bodies of water are relicts of a sea-bay separated from the sea by a barrier-beach. Lake Sarbsko is 800 m away from the sea-shore and its altitude is 0·5 m a.s.l. (Mielczarski 1964). Its southern shore is flat, woodless and wet in part, whereas the northern one is 22 m a.s.l. high (dunes overgrown with woods). The River Chełst flows through Lake Sarbsko and the River Łeba and a canal connect it to Lake Łebsko (Fig. 1).

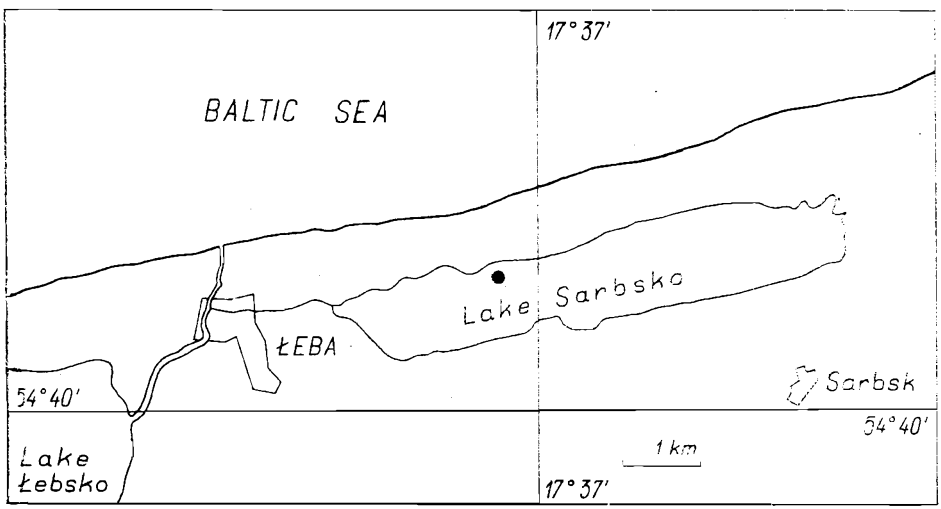

Fig. 1. Lake Sarbsko. ● — location of profile

Now it is a shallow lake, the mean depth being 1·7 m and the maximum depth 2·6 m. It is 6·5 km long and 1·2 km wide and its poorly developed shore-line is 15 km long. It is being intensely grown over nowadays and, at a result, its surface is getting smaller and smaller.

Lake Sarbsko is nearly quite desalted: in 1953 the average concentration of chlorine ranged from 0·02 to 0·1‰ (Guttowa 1956). Nowadays a small amount of sea-water flows in through Lake Łebsko, especially in stormy weather.

MATERIAL AND METHODS

The core for study was taken by means of an Instorf drill from the ice by the Department of Marine Geomorphology and Geology of the Institute of Meteorology and Water Management at Gdynia. It was taken in the northern part of the lake, not far from the barrier-beach where the depth of water is up to 2 m. The length of the profile is 3·90 m.

The lithological description of the profile (Table 1) was prepared by J. Zachowicz according to the Troels-Smith system (1955).

Samples for diatom analysis were taken at intervals of 5–20 cm, according to lithological changes in the deposits. A total of 26 samples were examined. There were no diatom frustules at all in the bottom portion of the sand layer (3·90–3·60 m). The samples of this part were very carefully examined by both the decantation and the flotation method.

Table 1

Depth in m	Description of profile
0.00-0.25	silt with calcareous gyttja and fine detritus
0.25-0.30	fine sand with some silt
0.30-0.35	sandy silt
0.35-0.55	silt with fine sand and detritus
0.55-0.65	silt with fine detritus
0.65-0.95	fine sand with detritus
0.95-1.00	silt with detritus and Mollusca shells
1.00-1.40	calcareous gyttja with silt and fine detritus
1.40-1.55	calcareous gyttja with silt, small sand content
1.55-1.95	silty calcareous gyttja with some sand, and many Mollusca shells
1.95-2.05	fine sand with silt and numerous Mollusca shells
2.05-2.15	silt with calcareous gyttja and numerous Mollusca shells
2.15-2.25	silt with detritus and some sand
2.25-2.52	fine sand with silt and detritus, and Mollusca shells (Cardium edule)
2.52-2.70	silt with calcareous gyttja and some sand
2.70-3.00	silt with sand
3.00-3.05	silt with detritus
3.05-3.26	sandy silt and numerous Mollusca shells (Cardium edule)
3.26-3.30	sandy silt
3.30-3.57	sandy silt and many Mollusca shells
3.57-3.60	sandy silt with detritus
3.60-3.90	fine sand

In the remaining samples the diatoms were separated from the deposit by the decantation method after its calcium carbonate had been resolved (10% HCl) and the organic remnants removed (20% H_2O_2). The diatom frustules were enclosed in pleurax (1·9 refractive index).

Five hundred diatoms were counted in each sample. The proportion of particular taxa is given in percentages. The diatoms were grouped in respect to their halinity requirements according to Kolbe's (1927) halobion system modified by Hustedt (1953): euhalobous (E), mesohalobous (M) and oligohalobous species, these last being divided into halophilous (H) and indifferent (I) as well as halophobous ones (Hb) (Fig. 2).

According to the pH requirements, the taxa are classified in accordance with Hustedt's (1937–1939) system as alkalibiontic (Alb), alkaliphilous (Alf), indifferent (Ind), acidophilous (Acf) and acidobiontic (Acb) ones. Most of the meso- and euhalobous diatoms have not been classified in respect of their

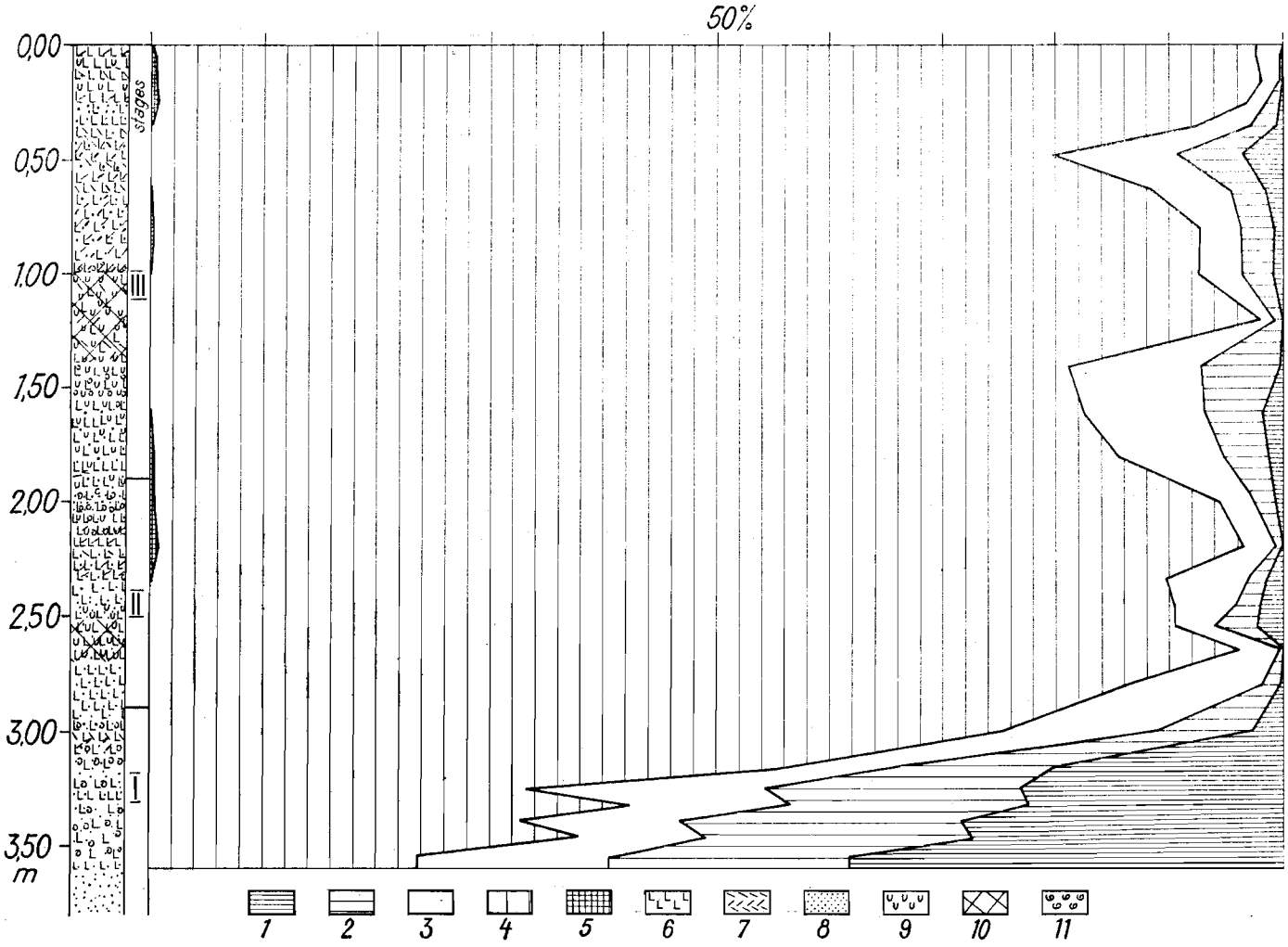

Fig. 2. Lake Sarbsko. Percentage value of diatom halobion groups. 1 — euhalobous, 2 — mesohalobous, 3 — halophilous 4 — indifferent, 5 — halophobous, 6 — Argilla granosa, 7 — Detritus herbosus, 8 — Grana arenosa, 9 — Limus calcareus, 10 — Limus detrituosus, 11 — Acervus test. (moll.)

Table 2

Lake Sarbsko. Percent proportion of diatoms according to pH requirements

Sample No	Depth in m	Stages	Alkaliphilous	Alkalibiontic	Indifferent	Acidophilous	Unclassifed
1	0.00 - 0.10		86.0	6.5	6.5	0.4	0.6
2	0.10 - 0.20		88.0	6.2	5.2	0.4	0.4
3	0.20 - 0.30		88.3	3.8	6.2	0.6	0.8
4	0.30 - 0.40		84.3	6.2	8.4	-	1.4
5	0.40 - 0.55		75.6	15.2	0.4	-	9.0
6	0.55 - 0.70	III	85.0	10.6	0.8	0.4	3.4
7	0.70 - 0.90		84.6	9.8	3.2	0.2	2.0
8	0.90 - 1.10		82.4	12.4	1.9	-	3.2
9	1.10 - 1.30		81.1	10.9	7.5	-	0.4
10	1.30 - 1.50		72.5	20.4	6.0	0.4	0.8
11	1.50 - 1.70		77.2	14.2	3.8	-	5.0
12	1.70 - 1.90		80.0	15.5	2.4	-	2.0
13	1.90 - 2.10		72.6	19.8	4.6	0.4	2.6
14	2.10 - 2.27		68.2	28.6	2.4	0.4	0.6
15	2.27 - 2.40		79.3	13.3	15.2	-	2.2
16	2.40 - 2.50	II	80.3	13.9	2.0	-	3.9
17	2.50 - 2.58		76.6	16.6	2.6	-	4.2
18	2.58 - 2.70		70.4	24.0	4.8	-	0.6
19	2.70 - 2.90		76.3	21.0	1.0	-	1.2
20	2.90 - 3.10		78.1	12.2	2.0	-	7.8
21	3.10 - 3.20		70.4	5.4	4.2	-	20.1
22	3.20 - 3.30		45.8	14.0	4.9	-	35.2
23	3.30 - 3.35	I	58.8	7.6	5.0	-	28.6
24	3.35 - 3.44		56.6	4.0	5.0	-	34.8
25	3.44 - 3.50		60.8	5.2	5.9	-	28.0
26	3.50 - 3.60		47.8	5.8	5.8	-	40.8

relation to the pH of water for lack of information about their present-day requirements (Table 2).

As regards habitats, the taxa have been divided into planktonic (Pl), benthonic (Be), epiphytic (Ep) and epiphytic-planktonic (Ep-Pl) groups (Table 3). The inclusion of diatoms in particular ecological groups is based mostly on the characteristics given in the following papers and monographs: Hustedt (1930–1966), Cleve-Euler (1951–1955), Foged (1954, 1964, 1968, 1969, 1970, 1972, 1976), Fjerdingstad (1954), Brockmann (1954), Miller (1964), Siemińska (1964), Simonsen (1962) and Florin (1977).

QUALITATIVE AND QUANTITATIVE COMPOSITION OF DIATOM FLORA

All through the profile the diatom flora was very rich in respect to both quality and quantity; 302 taxa have been determined, 270 of them belonging to the order *Pennales* and 32 to the *Centrales* (Table 3*).

The number of taxa in particular samples ranged from 49 (1·20 m) to 96 (1·80 m). The diatom flora was less diversified as regards taxa in the upper part of the profile and more diversified in the lower. The most diversified composition of taxa throughout the profile characterized the oligohalobous-indifferent diatoms.

The oligohalobous-indifferent diatoms formed 23·6 (at the bottom of the profile) to 98·4% (0·15 m) of all the specimens. The proportion of the oligohalobous-halophilous diatoms ranged between 1·0 (1·20 m) and 20·6% (3·25 m) and that of meso- and euhalobous species was the greatest in the lower portion of the profile (3·60–3·10 m), where the mesohalobous taxa formed 8·4–25·0% and the euhalobous ones 2·6–38·2% of the total number of specimens. In the upper part of the profile their proportion decreased rapidly and at the very top of it the mesohalobous diatoms occurred only as single specimens, whereas the euhalobous species were missing at all. Halophobous diatoms were encountered only in few samples and then only in very small numbers (Fig. 2).

The frequency of diatoms of particular halobion groups in various parts of the profile permits the distinction of three main stages in the development of the diatom flora of Lake Sarbsko.

SUCCESSION OF DIATOM FLORA

Stage one

This stage includes the deposits of the profile segment between 3·60 and 2·90 m. The frequent lithological changes indicate the unsettled conditions at the time when this layer was being deposited (Table 1).

The composition of its diatom flora was diversified and included 68 to 92 taxa of great frequency. It was a characteristic composition, in which the meso-, euhalobous and halophilous species predominated, while the oligo-

Table 3 is under the cover.

halobous-indifferent ones occurred in the smallest numbers observed throughout the profile (23·6–75·2%). The most numerously represented species of indifferent diatoms were *Fragilaria pinnata*, *F. construens* var. *venter*, *F. brevistriata*, *Opephora martyi*, *Cocconeis thumensis*, *C. diminuta*, *Amphora ovalis* var. *pediculus* and var. *libyca*.

The proportion of oligohalobous-halophilous species in this layer was the highest compared with the remaining parts of the profile and ranged from 11·1 to 20·6% of the specimens. *Epithemia turgida* with var. *westermanni*, *E. sorex* and *Amphora staurophora* played the most important part here and *Rhicosphenia curvata*, *Cocconeis pediculus*, *Diploneis smithii* var. *pumila*, *Fragilaria construens* var. *subsalina* and *Cyclotella meneghiniana* were less numerous.

The percentage of euhalobous diatoms was the highest at the bottom of the profile, where it reached its maximum value of 38·2%. In the upper part of the deposits referred to the first stage their number decreased gradually and in the top sample of this layer it was as small as 2·6%. The proportion of mesohalobous diatoms changed in a similar way (8·4–25·0% of the total of specimens).

The composition of the meso- and euhalobous diatoms was characteristic exclusively of this portion of deposits. It included *Chaethoceros* sp. div., *Cocconeis acutellum* with var. *parva*, *Actinocyclus ehrenbergii* with var. *crassa*, *Grammatophora oceanica*, *Synedra tabulata* with var. *fasciculata*, *S. pulchella*, *Diploneis didyma*, *D. interrupta*, *D. smithii* with var. *rhombica*, *Opephora marina*, *O. schulzi*, *Rhopalodia musculus*, *Achnanthes delicatula*, *A. hauckiana*, *Campylodiscus clypeus* with var. *bicostata*, *C. echeneis*, *Hyalodiscus scoticus*, *Navicula humerosa*, *Rhabdonema arcuatum*, *Rhizosolenia alata*, *Nitzschia sigma* and *Terpsinoë americana*. The remaining species were encountered as single specimens.

The above-mentioned meso- and euhalobous species occurred in the largest numbers in the deposits of the first stage, while in the higher part of the profile they decreased considerably in number and the ranges of some of them were restricted to the bottom layer only.

The epiphytic diatoms dominated in the first stage. The planktonic species played a maior part only at the bottom of the profile (33·6%), their number in all the higher layers being small, from 6·2 to 17·0% of the total number of specimens (Table 3).

The alkaliphilous diatoms were marked by the greatest diversity and abundance (45·8–78·1%). The percentage occurrence of the alkalibiontic species ranged between 1·0 and 14·0% and that of the indifferent species between 2·0 and 5·9%. A large number of diatoms, mainly meso- and euhalobous ones, have not been classified according to the pH of water (Table 2).

Stage two

This stage includes the layer at a depth from 2·90 to 1·90 m. The composition of diatoms differs considerably from that at the preceding stage (Table 1).

It shows a rapid fall in the occurrence of euhalobous (0–2·2%), mesohalobous (0·4–3·8%) and halophilous diatoms (2·2–12·2%). The somewhat more numerous occurrence of their specimens was observed only in the middle part of the layer of this stage. The oligohalobous-indifferent species prevailed decidedly, their percentage being 86·2–96·4% (Fig. 2).

The increase in the number of specimens of the planktonic species, which at a depth of 2·27 m reach the maximum (42·6%) for the whole profile, is in addition to the fall in the proportion of the meso- and euhalobous diatoms, a characteristic change in the composition of the diatoms in the second stage. The occurrence of the planktonic species was not constant, though. Their number fluctuated within fairly wide limits of 5·8–42·6%. They were most numerous in the upper and lower parts of the deposits of the second stage. In the middle part, where a small increase in the numbers of the meso- and euhalobous diatoms (up to 3·8 and 2·2%, respectively) was observed, the planktonic diatoms occurred in smaller numbers (5·8–7·6%). The most important planktonic oligohalobous-indifferent diatoms were *Stephanodiscus astraea*, *Melosira granulata*, *M. italica* and *Cyclotella comta*. In the deposits of the first stage these planktonic diatoms were few in number or quite missing.

The species of *Fragilaria* were still the most numerous of the epiphytic diatoms, here however their percentages exceeded those in the first stage. The most numerous species were *F. pinnata* with var. *lancettula*, *F. brevistriata*, *F. construens* with var. *binodis* and *F. inflata* (this last being sporadic in the previous stage). *Amphora ovalis* var. *pediculus*, var. *libyca*, *Synedra amphicephala*, *Cocconeis thumensis*, *Achnanthes clevei*, *Epithemia zebra*, *Navicula tuscula* with var. *minor*, *N. pseudotuscula* and *N. scutelloides* were also observed. The species of the genus *Cymbella* were more frequent, too. The number of specimens of *Opephora martyi* decreased in comparison with the previous stage and so did the percentage frequency of halophilous diatoms of the species *Epithemia sorex*, *E. turgida*, *Amphora staurophora* and *Cocconeis pediculus*.

The alkaliphilous diatoms were still the most numerous (68·2–80·3% of the total number of specimens). The percentage of alkalibiontic species increased (13·3–28·6%) compared with the previous stage and the indifferent diatoms occurred in small numbers (1·0–4·8%). Single specimens of the acidophilous species were observed in the upper part of the layer representing this stage (Table 2).

Stage three

The last developmental stage of the diatom flora of the profile covers the deposits of its remaining part (0–1·90 m) (Table 1). The most characteristic change in the composition of the diatom flora of the third stage was a rapid fall in the number of planktonic diatoms. At a depth of 0·15 m the number of their specimens formed scarcely 2·4%, being the minimum value in the whole profile. The epiphytic fresh-water diatoms predominated decidedly in the third stage. The *Fragilaria* species still played the most important role,

being more numerous than they were in the preceding stage (45·0–75·2%). At a depth of 1·20 m, where they reached the highest value, *Fragilaria inflata* with var. *istvanffyi* occurred in great quantities (60·3% of the total number of specimens). The increase in percentage of *Epithemia intermedia*, *E. zebra*, *Navicula scutelloides*, *N. hungarica* and, out of the halophilous species, *Epithemia turgida* and *E. sorex* also *Amphora ovalis* var. *libyca* and var. *pediculus*, *Cocconeis diminuta*, *Navicula tuscula* with var. *minor* and *Achnanthes clevei* were important elements of this flora in the deposits of the third stage. The species *Opephora martyi*, playing a marked role in the two previous stages, in the third stage occurred in a considerably smaller proportion.

The values of diatoms of particular halobous groups also underwent rather great fluctuations, reflecting the changing ecological conditions in this water body. In the lower portion of the layer (1·90–1·30 m) there was an increase in the percentage of mesohalobous (to 7·2%) and euhalobous (to 1·8%) diatoms as compared with their occurrence in the lower layers. *Campylodiscus clypeus*, *Mastogloia elliptica*, *Anomoeoneis costata* and *Achnanthes hauckiana* were the most numerous.

The percentage frequency of halophilous diatoms increased likewise (9·5–11·2%) and *Epithemia turgida*, *E. sorex* and *Cyclotella meneghiniana* were the most abundant of them (Table 3).

In the overlying portion of the deposits of the third stage (1·30–1·10 m) the change in the composition of the diatom flora was strongly marked by the almost complete disappearance of meso- and euhalobous diatoms and a great decrease in the halophilous ones. The oligohalobous-indifferent diatoms reached 98·0% of the total of specimens, *Fragilaria inflata* (20·0%) and var. *istvanffyi* (40·0%) being the most characteristic species of this portion of deposits. In the zone from 1·10 to 0·40 m the composition of diatoms changed. The frequency of meso- and euhalobous and halophilous diatoms increased again (2·8–6·0, 0·6–3·4 and 3·6–10·9%, respectively). They are represented by the same species that occurred in the underlying portion corresponding to this stage. The oligohalobous-indifferent diatoms formed 79·4–92·7% in this layer.

Fragilaria brevistriata, *F. construens* var. *venter* and *F. pinnata* were the most important taxa here. *Fragilaria inflata* and var. *istvanffyi*, abundant in the lower portion of the deposits of this stage, decreased in number.

A successive change in the composition of diatoms was observed from a depth of 0·40 m upwards. It consisted in an increase in the percentage frequency of oligohalobous-indifferent diatoms (92·4–98·4%), which here reached the maximum value in the whole profile (98·4%). The species of *Fragilaria* were still the most abundant. In the top portion of the profile the number of specimens of *Fragilaria construens* and var. *binodis* increased and so did again that of *F. inflata*. *Amphora ovalis* var. *pediculus*, *Opephora martyi*, *Achnanthes clevei*, *A. exigua*, *Epithemia zebra* and *Navicula schoenfeldii* were less numerous.

There were only low percentages of meso- and euhalobous diatoms in this

part of deposits. The euhalobous species formed 0–0·4%, the mesohalobous species 0·2–2·4% and the halophilous ones 1·6–4·7% (Table 3).

The alkaliphilous diatoms still occurred in the largest numbers in the layer included in this stage. The alkalibiontic species formed 9·8–27·2% in the lower portion of the deposits of this stage (up to a depth of 0·40 m) and above this level their percentage fell to 3·8%, the lowest value in the whole profile. Acidophilous diatoms appeared in the top part of the profile (Table 2).

CHANGES IN THE ECOLOGICAL CONDITIONS OF LAKE SARBSKO

No palynological study has been carried out for this profile, which makes it difficult to determine the age of changes observed in the composition of the diatom flora. A pollen analysis made by Tobolski (1967) on the material taken at a certain distance from the profile under study makes it possible to give only the approximate time of the changes.

In the bottom part of the profile examined by Tobolski there was a 16 cm layer of fen-peat, the age of which he referred to the Older Atlantic (VI acc. to Firbas), whereas the present profile begins with a 30 cm layer of sand (3·90–3·60 m), in which no diatoms were observed. The lack of peat may have been connected here with the Littorina transgression, which is the more probable since the profile examined for diatoms was situated in the northern part of the lake and then nearest the sea.

This supposition has been confirmed by the results obtained by Wypych (1973), who, on the basis of several borings made in the deposits of Lake Sarbsko, found the existence of a discontinuous layer of peat, which passed into varigrained sand with gravel. A considerable quantity of plant detritus occurring in this layer was regarded by him as the product of destruction of the upper portion of peat caused by the Littorina transgression.

As has already been mentioned, diatoms were absent in the bottom part of the profile. Neither did Tobolski observe any plant pollen in the sand layer overlying the peat directly. It may be supposed that their absence was caused by their having been washed out owing to the progress of transgression.

The meso-, euhalobous and halophilous species were dominant in the deposits of the first developmental stage of the diatom flora, while the oligohalobous-indifferent species were here less numerous than in the whole remaining part of the profile. Nearly all meso- and euhalobous diatoms found in this portion of deposits were admittedly characteristic of the Littorina Sea. The species *Terpsinoë americana*, the very indicator species of that period, was observed continuously throughout the layer corresponding to the first stage except two bottom samples only, whereas both in the Vistula lagoon and in Lake Druzno and Lake Jamno this species was encountered quite sporadically.

The maximum percentage frequency of meso- and euhalobous diatoms and the simultaneous fall in the value of the oligohalobous-indifferent ones

indicate that the water salinity of Lake Sarbsko was then the greatest in the whole history of its development. The results of studies on the diatoms of this lake suggest that it was embraced by the transgression of the Littorina Sea, which is also clearly reflected by the lithological change of deposits described by Wypych (1973). This certainly took place during the last and greatest Littorina transgression on the boundary between the Atlantic and Sub-boreal (Sauramo 1958).

Thus the sedimentation of the first-stage material should be referred to the Younger Atlantic and the beginning of the Sub-boreal. At that time the area of the present Lake Sarbsko was probably a rather shallow sea bay as evidenced by the low percentage of planktonic species and the domination of littoral diatoms. The very bottom portion of the profile with its greater proportion of planktonic species (33·6% of the total of specimens) was an exception. The quantity of these species decreased above and in the last sample they formed hardly 6·2%. It should be accepted that the water level of this water body came down gradually and at the time of the sedimentation of the upper portion of the first-stage deposits, which already showed a distinct freshening of water, it had been considerably lowered. In the composition of the diatom flora it was expressed by a decreased frequency of planktonic species.

On the basis of the old shore forms surrounding the areas of the lakes Łebsko and Sarbsko on the southern side, Rosa (1963) states that after the period of the maximum Littorina transgression the water level in this area lowered by about 1·5–2·0 m, as indicated, among other things, by the cliff and abrasive cut out in the bar on the Lake Sarbsko side.

The composition of the diatom flora of the first stage in Lake Sarbsko was as a rule similar to that observed in the lakes Jamno and Druzno and in the Vistula Lagoon in the Younger Atlantic (Przybyłowska-Lange 1974, 1976, 1979). The differences were reduced to various quantitative relations. In Lake Sarbsko the meso- and euhalobous diatoms occurred in larger numbers and their values were fairly even with the exception of the top portion of the deposits of this stage. In the Vistula Lagoon and Lake Druzno three levels with the greater frequency of these diatoms were distinctly marked and separated from each other by intervals representing periods of the desalination of these water bodies.

In the second stage of sedimentation the composition of diatoms clearly indicates the marked desalination of water. In the lower part of this layer (2·64 m) there were nearly exclusively oligohalobous diatoms. Such a manifest freshening of Lake Sarbsko, expressed by a rapid change in the composition of the diatom flora, suggests that it was caused by the Łebsko barrier-beach, well developed at that time and separating Lake Sarbsko from the sea. In the middle part of the layer of this stage (2·58–2·27 m) an increase in the frequency of meso- and euhalobous diatoms indicates the temporary inflow of sea-water into the lake. In the higher portion of the deposits of this stage the water was

freshened again, which was indicated by the complete disappearance of meso- and euhalobous species from the diatom flora.

Special attention should be given to the occurrence of planktonic diatoms in the deposits of the second stage. A marked increase in their frequency was observed in the period of the desalination of this water body. In the upper part of this layer (2·27 m) they reached the maximum value for the whole profile (42·6% of the total of specimens). In its middle part, which showed the influence of the inflow of sea-water, the frequency of planktonic diatoms was noticeably decreased.

The remarkable predomination of alkaliphilous diatoms and the increased value of the alkalibiontic as compared with their state in the previous stage prove an increase in the alkalinity of water at the time of formation of the second-stage deposits.

These deposits seem to have been formed in the Sub-boreal, when the regression of the Littorina Sea occurred in the Baltic area. There were essential differences in the composition of the diatom flora of that period between Lake Sarbsko and Lake Jamno (Przybyłowska-Lange 1979). If there were large numbers of meso- and euhalobous diatoms in Lake Jamno at that time, in Lake Sarbsko these diatoms were almost completely lacking. A similar situation was observed in the Vistula Lagoon and Lake Druzno, where in the Sub-boreal period the meso- and euhalobous diatoms were also encountered in only small numbers (Przybyłowska-Lange 1974, 1976).

In the third stage of development of Lake Sarbsko the oligohalobous-indifferent diatoms, represented chiefly by epiphytic species, were still predominant, while the planktonic species already played a minor role.

The fluctuations in the frequencies of various halobion groups of diatoms in the deposits of this stage indicate changeable ecological conditions in the lake. The cause of these changes was, above all, the periodical inflow of sea-water into it. Greater inflows were marked twice in the deposits of the third stage by more abundant occurrence of meso-, euhalobous and halophilous species. They were separated from each other by deposits formed in the period when the water body underwent desalination.

The first distinct increase in the salinity of water, expressed by the higher percentages of eu- and mesohalobous and halophilous diatoms (to 1·8, 7·2 and 11·2% of the total of specimens, respectively), occurred in the profile at a depth of 1·90–1·30 m. The small rise in the frequency of planktonic diatoms in this layer seems to indicate that the inflow of sea-water into the lake was accompanied by only a slight rise of the water level.

A change in the composition of diatoms was observed at a depth of 1·30–1·10 m. The percentage frequency of meso-, euhalobous and halophilous diatoms decreased noticeably in favour of oligohalobous-indifferent species (rise to 98·0%). This change was connected with a more marked freshening of the water. There was also a decrease in the planktonic diatoms.

A successive rise in the salinity of water occurred at a depth of 1·10–0·40 m.

The frequency of eu- and mesohalobous and halophilous diatoms increased again (to 3·4, 6·0 and 10·9%, respectively). Also this change in the ecological conditions, caused by an increased inflow of sea-water, was accompanied by only a small rise in the water level, as indicated by the slight increase in the frequency of planktonic diatoms.

The composition of diatoms at the top of the profile (from 0·40 m upwards) clearly indicates that the lake had undergone a marked desalination. There were nearly exclusively oligohalobous-indifferent diatoms here and they reached the maximum values of frequency for the whole profile examined (98·4% of the total number of specimens).

At that time Lake Sarbsko grew also shallower, which in the composition of diatoms was reflected by a fall in the frequency of planktonic diatoms; at a depth of 0·15 m their number was the lowest observed in the whole profile (2·4%). The composition of the diatom flora of the top part of the profile is characteristic of shallow water bodies.

The pH of water in the lake also changed in the period of formation of this portion of deposits. The alkaliphilous diatoms were still the most numerous, the frequency of alkalibiontic decreased and that of indifferent diatoms increased, which indicates the less alkaline pH of water compared with that in the lower portion of deposits.

The deposits of the third stage were formed in the Sub-atlantic. Lake Jamno (Przybyłowska-Lange 1974) had also two horizons with increased frequencies of mesohalobous and halophilous diatoms referred to that period and giving evidence of intensified inflows of sea-water. The differences concern only quantitative relations. In Lake Jamno, situated west of Lake Sarbsko, these inflows were marked by a far greater increase in the frequency of mesohalobous and halophilous diatoms.

It may therefore be supposed that the process of isolation of Lake Sarbsko from Lake Łebsko had already been completed before the end of the third stage, since the composition of its diatoms suggests the complete desalination of water, which in turn, indicates the lack of direct communications with the sea.

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STRESZCZENIE

OKRZEMKI W DENNYCH OSADACH ZBIORNIKÓW WODNYCH POLSKIEGO POBRZEŻA BAŁTYKU. III. JEZIORO SARBSKO

Praca zawiera wyniki badań okrzemek w profilu osadów dennych jeziora Sarbsko. W 26 badanych próbach oznaczono 302 taksony. W spągowej części warstwy piaszczystej (3,90–3,60 m) nie obserwowano zupełnie skorupek okrzemek.

Uzyskane wyniki badań pozwoliły na wydzielenie trzech etapów rozwoju flory okrzemek jeziora Sarbsko. W osadzie pierwszego etapu (3,60–2,90 m) dominowały okrzemki mezo-, euhalobowe i halofilne, podczas gdy słodkowodne (oligohalobowe obojętne) występowały najmniej licznie w porównaniu z całą resztą profilu. Wszystkie niemal okrzemki mezo-, jak i euhalobowe obserwowane w tej części osadu uważane są powszechnie za charakterystyczne dla morza litorynowego. Rezultaty badań nad okrzemkami jeziora Sarbsko skłaniają do przypuszczenia, że było ono objęte transgresją litorynową, co znalazło również wyraźne odbicie w zmianach litologicznych osadu podanych przez Wypycha (1973).

Okres sedymentacji pierwszego etapu należy odnieść do młodszego okresu atlantyckiego i początku subborealnego. W tym czasie obszar jeziora Sarbsko był dość płytką zatoką morską, o czym świadczy niewielki udział gatunków planktonowych i panowanie okrzemek litoralnych. Wyjątek stanowi sama tylko spągowa część badanego osadu (3,60–3,50 m), gdzie obserwowano większy udział gatunków planktonowych (33,6%). Powyżej ilość ich malała i w ostatniej próbie pierwszego etapu (3,10–2,90 m) stanowiły 6,2%.

W okresie sedymentacji drugiego etapu (2,90–1,90 m) skład okrzemek różnił się znacznie od występującego w etapie poprzednim. Obserwowano raptowny spadek okrzemek euhalobowych, mezohalobowych i halofilnych. Nieco większy udział ich okazów zaznaczył się jedynie w środkowej części etapu (2,58–2,27 m), co wskazuje na okresowy tylko większy dopływ wód morskich do jeziora. W okresie sedymentacji osadu drugiego etapu zdecydowanie dominowały oligohaloby obojętne. Charakterystyczną zmianą w składzie okrzemek drugiego etapu był — obok spadku udziału okrzemek o charakterze słonolubnym — wzrost ilości gatunków planktonowych, osiągających na głębokości osadu 2,27 m wartość maksymalną dla całego profilu (42,6%).

W trzecim etapie obejmującym osad całej reszty profilu to jest 1,90 m, panowały nadal okrzemki oligohalobowe obojętne, ale ich udział wahał się. Powodem tych zmian było okresowe większe napływanie wód morskich, za-

znaczone w osadzie trzeciego etapu dwukrotnie (1,90–1,30 m i 1,10–0,40 m) przez liczniejsze wystąpienie okrzemek o charakterze słonolubnym.

W okresie sedymentacji stropowej części profilu (od 0,40 m) skład okrzemek wskazuje wyraźnie, że jezioro Sarbsko uległo znacznemu wysłodzeniu i wypłyceniu. Występowały tu niemal wyłącznie okrzemki oligohalobowe obojętne, litoralne. Skład okrzemek tej części osadu skłania do przypuszczenia, że proces izolacji jeziora Sarbsko od jeziora Łabsko był już w tym czasie zakończony.

Lake Sarbsko. Percent proportion of diatom taxa

Abbreviations: E - euhalobous, H - halophilous, Hb - halophobous, I - indifferent, M - mesohalobous, Be - benthonic, Ep - epiphitic, Pl - plankton, Alf - acidophilous, Alb - alkalibiontic, Alk - alkaliphilous, Ind - indifferent (circumneutral)

Depth in m				0,10	0,20	0,30	0,40	0,55	0,70	0,90	1,10	1,30	1,50	1,70	1,90	2,10	2,27	2,40	2,50	2,58	2,70	2,90	3,10	3,20	3,30	3,35	3,44	3,50	3,60
No. of sample				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Achnanthes affinis Grun.	I	Ep	Alf			0,6																							
bottnica Cl.		Ep						+					+																
breviceps Ag.	M	Ep	Alf					0,2											0,2						0,2	0,2			0,2
clevei Grun.	I	Ep(Be)	Alf	1,0	0,6	1,6	1,4	0,6	0,2	1,2	1,8	0,6	1,8	0,4	1,0	4,8	4,2	0,2	0,4	2,0	0,6	1,2	0,2		0,2	+	0,2	0,8	
var. rostrata Hust.	I	Ep(Be)	Alf		0,2	+	1,4			0,4	0,2	+	0,8	0,4		2,0	1,2			0,2	0,2							0,2	
conspicua A.Mayer	I	Ep	Alf	1,0	0,2	0,2	0,2					0,4																	
var. brevistriata Hust.	I	Ep	Alf									0,4																	0,2
delicatula (Kütz.) Grun.	M	Ep																					0,6	1,0	1,8	0,4	0,8	1,0	0,6
exigua Grun.	I	Ep	Alf	0,6	1,4	1,8						0,2								0,2	0,2								
var. heterovalvata Krasske	I	Ep	Alf			0,2										0,6				0,2									
hauckiana Grun.	M	Ep	Alf				0,2	0,6	0,6	0,6	0,2	0,2	0,2	1,2	0,6	0,6		0,6	0,2	1,8	0,2	0,2	0,6	0,4	0,4	0,8	2,4	2,0	0,4
var. rostrata Schulz	M	Ep	Alf								0,2									0,2				0,2		0,2	0,6		
lanceolata (Bréb.) Grun.	I	Ep	Alf	0,2	0,4	0,2	0,2	0,2		0,2	0,6	0,4	0,2			0,2	0,2							0,2				0,2	
var. capitata O. Müll.	I	Ep	Alf			0,4			+	+																			
var. elliptica Cl.	I	Ep	Alf	+	0,2	0,2	0,2			0,2	0,8	0,6	0,6	0,4	0,2	0,4	0,8	0,2		0,4	0,6							0,4	
var. rostrata (Østr.) Hust.	I	Ep	Alf		0,2						0,2					0,2													
lemmermannii Hust.	I	Ep																	0,2	0,2			0,8	0,2			0,2		
linearis (W.Sm.) Grun.	I	Ep	Ind	0,6		1,2																					0,4		
minutissima Kütz.	I	Ep	Ind										+														+		
sp.																							0,8						
Actinocyclus ehrenbergi Ralfs	E	Pl							0,2	0,2				+	0,2					0,2	+		0,4	1,0	2,1	1,3	1,0	1,2	5,6
var. crassa (W.Sm.) Hust.	E	Pl						0,2			0,2	+		0,4				0,4						1,0	0,4	1,9	2,2	3,1	0,6
var. ralfsii (W.Sm.) Hust.	E	Pl																								0,2			
Amphora coffeaeformis Ag.	M	Be	Alf					0,2	0,2																0,2				
commutata Grun.	M	Be					0,2	0,4	0,2	0,2	0,2		0,2	0,2	+				0,2		0,2		0,2		0,4	0,2	+		0,2
macilenta Greg.	M	Be													+									0,2		0,8	0,2		
ovalis Kütz.	I	Be	Alf	0,4			0,2		0,4	0,2	0,6	0,2		0,4	0,2	0,4	0,4	0,2	0,6	0,4		0,2			0,2	0,4			0,2
var. libyca (Ehr.) Cl.	I	Be	Alf	0,2	0,6	0,6	2,2	0,8	2,6	1,4	1,4	0,2	2,0	1,2	1,8	0,4	2,0	1,8	0,8	1,2	1,4	5,2	1,4	0,6	1,0	0,2	0,8	0,4	0,4
var. pediculus Kütz.	I	Be-Ep	Alf	5,4	3,2	2,8	1,2	1,2	1,0	2,1	1,8	4,1	3,2	9,0	4,0	7,2	6,6	7,9	9,7	9,9	6,2	6,8	7,5	1,8	5,6	1,9	2,0	1,7	0,6
staurophora J. Dannfelt	H	Be												1,0				0,6	0,6	0,8			1,6	3,6	1,7	1,7	2,8	3,5	1,4
Anomoeoeneis costata (Kütz.) Hust.	M	Be	Alb		0,2	0,2	0,4	0,4	0,6	0,6	0,4		1,2		0,2		0,2						0,2		0,2				
exilis (Kütz.) Cl.	Ind	Be	Alb	0,2									0,2																
sphaerophora (Kütz.) Pfitz.	H	Be	Alb						0,2	0,2			0,2																
Baccilaria paradoxa Gmelin	M	Pl	Ind										0,2	0,2												0,2			0,4
Biddulphia levis Ehr.	M	Be	Alf																						0,8				
polymorpha (Grun.) Wolle	M	Be																							0,4				
Caloneis amphisbaena (Bory) Cl.	H	Be	Alf		0,2				0,2							0,2		0,2				+		0,2					
var. subsalina (Dork.) Cl.	M	Be	Alf					0,2																		+	0,2		
bacillum (Grun.) Mer.	I	Be	Alf	+				0,2	0,2		+			0,2		+				0,2			0,2						
brevis (Greg.) Cl.	E	Be																	+							0,2			
permagna (Bail.) Cl.	M	Be																									0,2	0,6	
schumanniana (Grun.) Cl.	I	Be	Alf															0,2											
silicula (Ehr.) Cl.	I	Be	Alf		+															+		0,2							
var. peisonis Hust.	I	Be	Alf																							+			
Campylodiscus clypeus Ehr.	M	Be	Alf		+		0,4	0,4	0,8	0,4	0,6	0,2	3,4	0,2	0,6	0,2	0,2	0,2	0,2	+		0,4	0,4	0,2	0,6	0,2	0,2	0,2	0,2	
var. bicostata (W.Sm.) Hust.	M	Be	Alf																			+		0,2	0,2		0,2	0,2	
echeneis Ehr.	M	Be	Alf						+												+			0,4	0,8	0,4			
noricus Ehr.	I	Be	Alf								+																		
var. hibernica (Ehr.) Grun.	I	Be	Alf	0,2																									
Chaetoceros holsaticus Schütt.	E	Pl						1,0	0,6		+			0,6	0,4	0,2		0,6	1,1	0,8			1,0	4,9	1,9	1,5	2,2	7,3	12,4
sp. div.	E(M)	Pl					0,4	1,8	0,4	0,4	0,4		0,2	0,6	0,4	0,4		0,2	0,6	1,0		0,2	0,4	3,7	0,6	3,1	5,8	2,4	12,4
Cocconeis diminuta Pant.	I	Ep	Alf	0,4	0,4	1,6	0,8	+	1,2	0,4	0,4	+	1,2	5,2	0,8	1,6	0,4	2,0	2,2	2,2	0,8		3,0	5,3	3,9	1,9	2,4	0,4	0,8
diculus (Schum.) Cl.	I	Ep	Alf	0,4		0,4		0,2	0,6	0,6	0,2	1,2	0,2	0,6	0,2	2,6	0,2		0,2	1,4	1,2		0,6						0,4
pediculus Ehr.	H	Ep	Alf	0,2	0,2			2,9	0,2		+		0,4	0,6	0,2	0,2		+					0,6		1,0	0,8	0,4	+	1,8
placentula Ehr.	I	Ep	Alf	0,2	0,8	0,2	0,4	1,2	0,2	0,2	0,2		0,4	0,2	0,6			0,4	0,6	0,6	0,2	0,8	0,6	0,2	0,4	0,2	0,4	0,4	
var. euglypta (Ehr.) Cl.	I	Ep	Alf																0,2				0,2	1,4					1,0
var. libeata (Ehr.) Cl.	I	Ep	Alf										+			0,2								0,6		0,2		0,4	0,2
quarnerensis Grun.	E	Ep	Alf																								+		+
scutellum Ehr.	E	Ep	Alf			0,2		0,2							+	0,2			0,2	+				5,4	5,2	6,7	10,0	11,8	5,2
var. parva Grun.	E	Ep																						2,4	7,8	3,4	4,4	3,7	2,6
thumensis A.Mayer	I	Ep	Alb							1,0	1,8	0,4	2,2	0,6	1,0	1,6	1,8	2,0	4,8	7,2	0,4						0,2	0,2	
Coscinodiscus astreomhalus Ehr.	E	Pl																						0,2	0,2			0,4	
kutzingii A.Schmidt	M	Pl																	0,2	0,2									
oculus-iridis Ehr.	E	Pl																						+		0,2	+		
sp. div.	M-E	Pl														+										0,4	0,2	0,2	
Cyclotella comta (Ehr.) Kütz.	I	Pl	Ind	1,6	0,8	3,6	3,2	0,2	3,6	2,0	1,6	0,2	1,4	0,8	0,6	1,4	0,8	4,0	1,0	0,8	1,8	0,8	1,0					0,2	
var. paucipunctata Grun.	I	Pl	Ind			0,4															0,2		0,2						
var. spectabilis Cl.	I	Pl	Ind													0,6													
kützingiana Thw.	I	Pl	Ind	0,2		0,6					0,2																		0,6
meneghiniana Kütz.	H	Pl(Lit)	Alf		0,2	+	1,2	2,6	2,8	0,8	1,4	0,2	0,6	4,0	0,4	0,4	0,8	5,0	1,7	1,2	0,2	2,3	2,8	0,6	0,4	0,6	+		1,4
Cymatopleura elliptica (Bréb.) W.Sm.	I	Be	Alf		0,2							0,2	0,4	0,2		0,4	0,2			0,2		0,2							
solea (Bréb.) W.Sm.	I	Be	Alf	+	+		0,2	+	+	0,2	0,2					0,2	0,4				0,8						0,2		
Cymbella affinis Kütz.	I	Ep	Alf	0,2	0,2		0,2			0,2			+									0,4	0,2						
amphicephala Näg.	I	Ep	Ind										+		0,4														
aspera (Ehr.) Cl.	I	Ep	Alf	0,2	+										0,2		0,4												
cistula (Hemp.) Grun.	I	Ep	Alf					+	0,2	+			0,2					+				0,2							
cuspidata Kütz.	I	Ep	Ind							0,2			0,2		+	+		0,2			0,2	+							
cymbiformis (Ag.?Kütz.) V.H.	I	Ep	Alf				+			0,2	0,2		+																
ehrenbergii Kütz.	I	Ep	Alb					0,2	0,4	0,2	+			0,2	0,2		0,2			0,2									
helvetica Kütz.	I	Ep	Alf												0,2							0,2							
hustedtii Krasske	I	Ep	Alf																			+	0,2						
hybrida Grun.	I	Ep	Alf													0,2													
lanceolata (Ehr.) V.H.	I	Ep	Alf	+												0,2			0,2										
leptoceros (Ehr.) Grun.	I	Ep	Alb																				0,2						
microcephala Grun.	I	Ep	Alf		0,2										0,2			+											
parva (W.Sm.) Cl.	I	Ep	Alf	0,2																									
prostrata (Berkeley) Cl.	I	Ep	Alf														0,2												
pusilla Grun.	M	Ep	Ind								0,2				0,2														
reinhardtii Grun.	I	Ep	Ind						+						+														
sinuata Greg.	I	Ep	Ind		0,2								+			0,2					+								
turgida (Greg.) Cl.	I	Ep	Alf	0,2	0,2			0,2					0,2	0,4	0,6	0,2		0,2					0,2	0,2					
ventricosa Kütz.	I	Ep	Ind										0,4	+	0,2	+	0,2	0,2	0,2		0,2	+							
Diatoma elongatum (Lyngb.) Ag.	H	Pl	Ind	0,2	0,4	0,4													0,2										
Diploneis didyma (Ehr.) Cl.	M	Be	Alf	0,2			0,2	0,4	0,2	0,2				0,8		0,2	0,2		0,2	0,2			0,2	1,2	2,7	2,9	3,0	2,2	1,4
domblittensis (Grun.) Cl.	I	Be	Alf		0,2	+	0,2		+	0,4	0,4		0,2	+	0,2			0,2	+	0,8	1,4	0,6							
elliptica (Kütz.) Cl.	I	Be	Alf																	0,2									
interrupta (Kütz.) Cl.	M	Be															0,2		0,2	+			0,2	0,4	1,0	0,8	1,4	2,9	0,4
ovalis (Hilse) Cl.	H	Be	Alf		0,2																		0,2						
pseudoovalis Hust.	H	Be	Alf								+				0,2													0,6	
smithii (Bréb.) Cl.	M	Ep				+					0,2		+	0,2	0,2				0,2	0,2			0,2	0,6	1,0	0,6	0,8	1,0	0,4
var. pumila (Grun.) Hust.	H	Ep												+									0,2	0,6	1,0	0,6	0,8	1,0	0,4
var. rhombica Mer.	M	Ep						0,2	0,2	0,4	0,4		0,2	0,4	0,2			0,2	0,2		0,2		0,4	0,4	1,4	0,8	0,4	0,4	1,4
Epithemia argus Kütz.	I	Ep	Alb				0,2		0,2					0,2	+	0,2		0,4	0,4	+		0,2							0,2
var. alpestris Grun.	I	Ep	Alb			0,2																		0,2					
hyndemannii W.Sm.	I	Ep	Alf	0,2				+	0,2	0,2	0,2		0,6	0,2	0,8		0,2	0,2				0,4		0,2	0,2	0,4			
intermedia Fricke	I	Ep	Alf		+	0,2	2,0	1,0	2,6	2,2	2,0	0,2	2,0	3,8	2,6	1,2	0,2	0,8	1,2	0,6	1,0	3,7	1,0	0,2		0,2	0,2		+
sorex Kütz.	H	Ep	Alb	0,2	0,2	0,2	1,0	1,4	1,6	0,8	1,0	+	3,2	3,4	0,8	0,2	0,2		0,8	0,6	0,4	2,3	3,8	1,6	1,7	0,8	0,4	0,4	6,4
var. gracilis Hust.	H	Ep	Alb							0,2													0,2						
turgida (Ehr.) Kütz.	H	Ep	Alb	0,2		0,2	0,6	2,6	1,2	0,6	0,2		6,6	1,4	5,7	0,8	0,4	1,8	1,0	1,4	1,6	5,8	2,0	2,8	3,1	4,2	3,0	2,2	1,8
var. granulata (Ehr.) Grun.	H	Ep	Alb												0,4		0,2								0,2				
var. westermannii (Kütz.) Grun.	H	Ep						0,2					+	0,4	0,2		0,2		0,2		0,8			1,0	9,9	4,3	5,0	1,4	1,4
zebra (Ehr.) Kütz.	I	Ep	Alb	1,5	2,2	0,4	0,8	2,0	0,6	0,4	1,0	0,2	3,6	1,4	2,6	1,4	1,4	2,0	2,7	1,2	0,6	0,2	1,4	0,2	0,6	0,2		0,2	0,2
var. porcellus (Kütz.) Grun.	I	Ep	Alb	0,6				0,2	0,2				0,6						0,2				0,8			0,2			
var. saxonica (Kütz.) Grun.	I	Ep	Alb						0,4	0,6			1,0							0,4		0,2	0,2						
Eunotia lunaris (Ehr.) Grun.	I	Be-Ep	Ind			+																							
pectinalis (Kütz.) Rabh.	Hb	Be-Ep	Acf							0,2																			
Fragilaria bicapitata Mayer	I	Ep-Pl	Ind										0,6																
brevistriata Grun.	I	Ep-Pl	Alf	3,6	0,6	8,5	12,3	11,3	24,7	33,8	22,9	1,2	18,7	18,0	27,0	10,6	3,4	10,3	12,4	6,0	4,0	11,6	14,7	4,3	1,0	1,7	1,4	2,1	1,2
var. subcapitata Grun.	I	Ep-Pl	Alf						2,4	2,5	2,8		3,4	1,2	4,0				1,2	0,8	1,8	8,3	2,0						
capucina Desm.	I	Ep-Pl	Alf													0,8													
construens (Ehr.) Grun.	I	Ep-Pl	Alf	6,4	3,4	5,8	3,2	0,8	1,0	2,3	2,6	1,0			0,4	1,6	2,2	0,6	1,0	0,8	0,2	0,8	+	0,2	0,2	0,8	0,2	1,4	0,4
var. binodis (Ehr.) Grun.	I	Ep-Pl	Alf	11,6	19,0	6,7	0,4	0,9			0,2	1,6	2,0	0,2	0,2	1,6	1,6		0,2	0,2									
var. exigua (W.Sm.) Schulz	I	Ep-Pl	Alf				0,4	4,9	1,0									0,4											
var. subsalina Hust.	H	Ep-Pl	Alf				0,8	0,4		0,8	0,2	0,6	0,2		0,6	0,4									0,4	0,4	1,0	0,8	0,6
var. triundulata Reich.	I	Ep-Pl	Alf					2,6	0,6		0,2		1,2						0,2		0,4								
var. venter (Ehr.) Grun.	I	Ep-Pl	Alf	15,2	16,0	23,1	23,9	15,6	9,4	21,2	15,6	1,6	8,0	7,0	10,9	1,2	2,2	13,9	5,7	4,0	1,4	5,0	7,5	8,3	2,1	9,6	4,8	3,9	1,8
inflata (Heid.) Hust.	I	Ep-Pl	Alf	13,2	13,6	7,7	0,6			1,2	2,2	20,3	1,8	0,4	0,8	12,8	8,6			1,6	17,0				0,4			0,2	
var. istvanffyi (Pant.) Hust.	I	Ep-Pl	Alf	1,2	1,6	3,6	0,4			2,3	8,2	40,0	+		0,6	0,8	0,2				0,2					+			
intermedia Grun.	I	Ep-Pl	Alf									1,0	0,2																
lapponica Grun.	I	Ep-Pl	Alf	3,2	7,6	+						0,2			0,4	0,2		0,2			0,2	0,4		+		0,4	+		
pinnata Ehr.	I	Ep-Pl	Alf	11,8	4,4	3,8	20,2	16,8	19,5	6,4	10,1	0,4	11,2	16,0	11,5	2,0	1,8	9,9	18,1	23,2	2,8	15,1	18,2	11,8	6,0	11,6	7,8	7,5	6,0
var. lancettula (Schum.) Hust.	I	Ep-Pl	Alf	0,6	1,2	1,8	9,7	10,9	8,0				0,6		1,4	0,8	0,4	11,7	16,2	4,0	0,4	4,6	1,4	1,8					
virescens Ralfs	I	Ep-Pl	Ind	1,2	1,6	1,2	1,4	0,2	0,4											0,8									
var. capitata Østr.	I	Ep-Pl	Ind		0,6																								
var. elliptica Hust.	I	Ep-Pl	Ind																					0,4					
var. mesolepta v. Schonf.	I	Ep-Pl	Ind	0,4	0,4	1,6				1,0	1,2	7,3	0,4		0,2					0,2	1,0								
var. oblongella Grun.	I	Ep-Pl	Ind						0,2	0,2	0,2							0,4			0,2			0,8		0,6	0,2	0,2	
Gomphonema acuminatum Ehr.	I	Ep	Alf												0,2													0,2	
var. brebissonii (Kütz.) Cl.	I	Ep	Alf	0,2																									
angustatum (Kütz.) Rabh.	I	Ep	Alf							+																			
var. productum Grun.	I	Ep	Alf		0,2																								
intricatum Kütz.	I	Ep	Alf							+			+																
var. dichotomum (Kütz.) Grun.	I	Ep	Alf					+					+									0,2							
longiceps Ehr.	I	Ep	Alf									+																	
var. subclavatum Grun.	I	Ep	Alf										+																
olivaceum (Lyngb.) Kütz.	I	Ep	Alb							0,2			+											0,2	0,4	0,2	0,2		
parvulum var. subellipticum Cl.	I	Ep	Ind	0,2																									
Grammatophora hamulifera Kütz.	E(M)	Ep									0,2		+	0,2									0,4						
marina (Lyngb.) Kütz.	E	Ep																								0,6	0,8		
oceanica (Ehr.) Grun.	E	Ep													0,2				0,2	+			0,4	3,5	4,0	3,8	3,6	1,0	1,8
var. macilenta W.Sm.	E	Ep																0,2						0,4	0,9	0,4	1,2	0,2	

Depth in m				0,10	0,20	0,30	0,40	0,55	0,70	0,90	1,10	1,30	1,50	1,70	1,90	2,10	2,27	2,40	2,50	2,58	2,70	2,90	3,10	3,20	3,30	3,35	3,44	3,50	3,60
No. of sample				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Gyrosigma acuminatum (Kütz.) Rabh.	I	Be	Alb						0,2							0,2													
attenuatum (Kütz.) Rabh.	I	Be	Alb	1,2	1,6	+		0,2				0,2	0,4		0,2	+	0,2				0,2						+	0,2	
Hantzschia virgata (Roper) Grun.	M	Be																								+	0,2		
Hyalodiscus scoticus (Kütz.) Grun.	M	Pl(Ep)	Alf																				0,2	0,2	0,2	0,4	0,6	0,8	0,2
Licmophora paradoxa (Lyngb.) Ag.	E(M)																			0,2									
Mastogloia braunii Grun.	M	Ep	Alf				+	0,2	0,2					0,2	0,4	0,4		0,2	+	0,2		0,2	0,8	0,2	0,6				0,2
elliptica (Ag.) Cl.	M	Ep	Alf					0,2		0,4			1,2		0,4	0,2			0,2	0,2			0,2						
var. dansei (Thw.) Cl.	M	Ep	Alf					0,2		+				0,2	1,0			0,2		0,2		0,4	0,4						
exigua Lewis	M	Ep						0,2																					
pumila (Grun.) Cl.	M	Ep	Alf				0,2						0,2																
smithii Thw.	H	Ep	Alf					0,2	0,2		0,2		+									0,4							
var. amphicephala Grun.	H	Ep(Be)	Alf	0,2	0,2		+								0,2						0,2								
var. lacustris Grun.	H	Ep	Alf																				0,2		0,2				
Melosira arenaria Moore	I	Be-Pl	Alf																			+		+		0,2		+	
distans (Ehr.) Kütz.	Hb	Be-Pl	Acf	0,2																									
granulata (Ehr.) Ralfs	I	Pl	Alf		0,2		+			0,2	0,2	0,2	0,2			5,0	8,0	0,6	0,2	0,4	2,4	1,7					+		
var. angustissima (O.Müll.) Hust.	I	Pl	Alf																		0,2								
var. muzzanensis (Meist.) Hust.	I	Pl	Alf															0,2											
islandica subsp. helvetica O. Müll.	I	Pl	Alf									+	0,2						+										
italica (Ehr.) Kütz.	I	Pl	Ind	0,4	0,4	0,6				0,2	0,4	0,2	0,8		0,2	3,8	12,0	1,0		0,6	2,6	4,1							
jüergensii Ag.	M	Pl	Alf																							+			
nummuloides (Dillw.) Ag.	M	Pl	Alf																					0,2			+		
sulcata (Ehr.) Kütz.	F	Pl	Alf																							0,4	0,2	0,2	
varians Ag.	H	Pl	Alf					+																					
Meridion circulare Ag.	I	Be	Alf		0,2																								
Navicula anglica Ralfs	I	Be	Alf		+										0,2	0,6					0,4		0,2			0,4	0,4		
var. subsalsa Grun.	H	Be	Ind													0,4											0,4		
bacillum Ehr.	I	Be	Ind	0,2	+	+				0,2						0,2	0,2		0,2	+	+				0,2				
cari Ehr.	I	Be	Alf											+															
cincta (Ehr.) Kütz.	H	Be	Alf		+	+	0,7	0,2		+	0,4	0,2	0,4	0,2	0,2	0,2		+			0,2	+		0,6	0,4		0,2		
var. heufleri Grun.	H	Be	Alf	0,2											+														
clementis Grun.	H	Be	Alf										+											0,2					
var. acuta A.Cl.	H	Be																							0,2				
crucicula (W.Sm.) Donk.	M	Be	Ind																								0,2		
var. obtusa Grun.	M	Be	Ind																						+				
cryptocephala Kütz.	I	Be	Alf	0,2	0,4										0,2							0,2	0,2						
cuspidata Kütz.	I	Be	Alf		+			0,4	0,2						0,4			+											
dicephala (Ehr.) W.Sm.	I	Be	Alf	0,2												+													
digitoradiata (Greg.) A. Schmidt	M	Be	Alf																			0,2					0,2		
forcipata Grev	M	Be	Alf																	0,2		+	0,2			0,2			
gastrum Ehr.	I	Be	Ind					+	+				+	0,4		0,2	+				0,2	+							
gracilis Ehr.	I	Be	Alf					0,2			0,2												0,2			0,2	0,2		
humerosa Bréb.	M	Be						0,2							+					0,2				0,2	0,4	0,2	0,2	+	0,4
hungarica Grun.	I	Be	Alf	0,2	0,2	0,2	2,3	2,7	1,6	1,2	1,0	0,2	0,2	1,2	1,4	0,2		0,6	0,2			0,2	0,6		0,2	0,2		0,2	0,2
var. capitata (Ehr.) Cl.	I	Be	Alf											0,2	0,4														
var. linearis Østr.	H	Be					0,2	0,2	0,4	0,4					0,2				0,2				0,2						
lacustris Greg.	I	Be	Ind												0,2					+									
lanceolata (Ag.) Kütz.	I	Be	Alf										0,2					0,2											
laterostrata Hust.	I	Be	Alf	+																+									
latissima Greg.	M(E)	Be																										0,2	
marina Ralfs	E	Be																								0,2			
menisculus Schum.	I	Be	Alf	0,2							0,2												0,2						
oblonga Kütz.	I	Be	Alf			0,4		+	0,6		+		0,4	0,4	0,4	0,2		0,4						0,4				+	
palpebralis Bréb.	E(M)	Be											+								0,2				0,2				
peregrina (Ehr.) Kütz.	M	Be	Alf					+					0,4												0,2				
placentula (Ehr.) Grun.	I	Be	Alf																		+	0,2							
f. rostrata Mayer	I	Be	Alf				0,2		+	+																			
platystoma Ehr.	I	Be																			+	0,2							
var. pantocsekii Wisł. et Kolbe	I	Be													0,2														
protracta Grun.	M	Be	Ind			0,6	0,2																						
f. elliptica Gallik	M	Be	Ind																						+			+	
pseudotuscula Hust.	I	Be	Alb	0,2		+		0,2	0,2	1,0	0,2		0,4	0,2	0,4	0,4	0,4	1,4	0,2	0,2	+	+	0,2						
pupula Kütz.	I	Be	Ind	0,2		0,2											+												
pygmea Kütz.	M	Be	Alb																					0,2		0,2			
radiosa Kütz.	I	Be	Ind	0,2	0,6	0,8	0,2			+						0,2	0,2				0,4	0,6							
var. tenella (Bréb.) Grun.	I	Be																		0,2									
reinhardtii Grun.	I	Be	Alb			0,2											0,2				0,2								
rhynchocephala Kütz.	I(H)	Be	Alf	0,2	0,6	0,4	0,4	0,2	0,2					0,6		0,2			0,4	0,2	0,2	+	0,8	1,8	0,2	0,8	0,8		0,8
salinarum Grun.	M	Be	Alb																							+			
f. capitata Schultz	M	Be													0,2														
schoenfeldii Hust.	I	Be	Alf	0,4	0,6	2,5					0,2	0,2	0,2				0,4									0,2		0,2	
scutelloides W.Sm.	I	Be	Alb	0,2	0,6	0,4	+	0,8	0,2	1,0	3,4	2,3	0,6		0,4	1,4		0,2	0,2	1,8	1,4					0,2			
seminulum Grun.	I	Be	Alb																							0,8			
tuscula (Ehr.) Grun.	I	Be	Alb		+	0,2	0,8	0,2	0,4	0,2	0,6		0,2	0,2	0,2	1,0	0,8	0,4	0,4	0,2	0,6	0,1	1,0						
f. minor Hust.	I	Be	Alb		0,2	0,4	0,6	0,2	0,2	0,6	0,6	+	0,2	2,0	0,8	0,2	1,2	1,2	0,8	0,4	0,4	0,8	1,0					0,2		
f. rostrata Hust.	I	Be	Alb							0,2							0,2												
viridula Kütz.	I(H)	Be	Alf	0,8		0,6					0,2					0,2	0,2				0,2						0,2			
Neidium dubium (Ehr.) Cl.	I	Be	Ind		0,2											0,2	0,2				+								
iridis (Ehr.) Cl.	I	Be	Ind		0,2										+						+								
opulentum Hust.	I	Be				0,2																							
Nitzschia acuta Hantzsch	I	Be	Alf			+																							
amphibia Grun.	I	Be	Alf	0,4						0,2				0,4									0,2					0,2	
angularis W.Sm.	I	Be																									0,2		
angustata (W.Sm.) Grun.	I	Be	Alf		0,2							0,2				0,2	0,8		0,2	0,2	0,6								
var. acuta Grun.	I	Be	Alf			0,2											0,2				0,2								
dissipata (Kütz.) Grun.	I	Be	Alf																							0,2			
frustulum (Kütz.) Grun.	H	Be	Alf								0,2										+		0,2			0,2	0,2		
hungarica Grun.	M	Be	Alf																					0,2					
kützinhiana Hilse	I	Be	Alf		0,2			0,2																					
microcephala Grun.	I	Be	Alf												0,2								0,2	0,2		0,2			
pervula Levis	H	Be	Alf												0,2														
punctata (W.Sm.) Grun.	E	Be												0,2												0,2	0,2	0,2	
var. coarctata Grun.	E	Be																									+		
recta Hantzsch	I	Be	Alf	0,4		0,2								0,2		0,4	0,2			0,2	0,4	0,2							
scalaris (Ehr.) W.Sm.	M	Be	Ind			0,2		0,2						0,2		+										0,2		0,2	
sigma (Kütz.) W.Sm.	M	Be	Alf																				0,2	0,2	0,4	0,2	0,2	0,2	
sigmoidea (Ehr.) W.Sm.	I	Be	Alf															0,2			0,2	0,2		0,2			0,2	0,2	
tryblionella Hantzsch	M	Be	Alf																						+			0,2	
var. levidensis (W.Sm.) Grun.	H	Be	Alf	0,2																						*		+	
Opephora martyi Héribaud	I	Ep	Alf	3,4	3,4	1,2	0,6	1,2	1,0	1,4	2,4	2,8	2,0	3,0	1,0	3,4	7,6	1,8	2,0	3,1	2,4	1,0	3,3	13,0	7,2	2,7	5,4	9,0	6,9
marina (Greg.) Petit	E	Ep												0,8										0,4	2,3	0,3	2,0	2,9	1,4
schulzi (Brock.) R. Simonsen	M	Ep								0,2			0,2	0,4	0,2					0,2			0,4	0,4	2,0	1,9	0,6	0,6	0,8
Ostrupia zachariasii (Reich.) Hust.	I	Be	Ind													+	+			0,2									
Pinnularia cardinalis (Ehr.) W.Sm.	I	Be	Alf						0,2		+		0,2																
maior (Kütz.) Cl.	I	Be	Ind	0,4																									
microstauron (Ehr.) Cl.	I	Be	Ind										0,2		0,2	0,2				0,2	0,2								
var. brebissonii (Kütz.) Hust.	I	Be	Ind												0,2														
viridis (Nitzsch) Ehr.	I	Be	Ind	1,4	1,2	+	0,2	0,2	0,2	0,2	0,2	0,2	0,4		+	0,2	0,2	0,2		0,2	0,2	+							
var. leptogongyla (Ehr.?Grun.) Cl.	I	Be	Ind														+												
Pleurosigma elongatum W.Sm.	M	Be																					0,2					0,4	
Rhaphoneis amphiceros Ehr.	M	Ep(Be)																								0,2		0,2	
Rhabdonema arcuatum (Ag.) Kütz.	E	Ep																							0,2	0,4	0,8		
minutum Kütz.	E	Ep																							0,2		0,8	0,2	
Rhizosolenia alata Brightw.	E	Pl																								0,4	0,2	0,8	
Rhoicosphenia curvata (Kütz.) Grun.	E	Ep	Alf		0,2	0,2	0,2	0,2		0,4	0,2	+	0,6	0,8	0,2	0,2	0,2	0,4	0,8	0,2	0,2	0,6	1,6	0,2	0,6	0,4	0,4	0,4	1,6
Rhopalodia gibba (Ehr.) O. Müll.	I	Ep	Alb	0,6	0,2		0,4	0,2	0,6	0,2	0,2		0,2	0,2	0,4		+	0,4		+	0,4	0,2	0,2	0,2	0,2	0,4			0,4
var. ventricosa (Ehr.) Grun.	I	Ep	Alb																0,2					0,2					
gibberula (Ehr.) O. Müll.	M	Ep	Alb																								+	+	
var. heurckii O. Müll.	M	Ep	Alb													+													
musculus (Kütz.) O. Müll.	M	Ep	Ind																					0,2	1,4	0,4	0,6	0,2	0,8
Stauroneis phoenicenteron Ehr.	I	Be	Ind															0,4											
Stephanodiscus astraea (Ehr.) Grun.	I	Pl	Alb	0,2		0,4	0,2	0,2		0,4	0,2	2,4	0,8	0,2	0,4	9,8	17,6	2,7	1,0	2,4	15,0	5,6				+		0,4	
var. minutulus (Kütz.) Grun.	I	Pl	Alb	0,6	0,6											0,4	3,4				1,8	0,8					0,2		
Surirella biseriata Bréb.	I	Be	Ind	+																	0,2								
var. bifrons (Ehr.) Hust.	I	Be	Alf		0,2																								
f. punctata Meist.	I	Be														+													
linearis var. helvetica (Brun) Meist.	I	Be	Ind		0,2											+	0,2												
ovata Kütz.	I	Be	Alf	0,2	+			0,2								0,2			0,2		0,2	0,4		0,2		0,4			
var. crumena (Bréb.) V.H.	H	Be	Alf						0,2																			0,2	
var. pinnata (W.Sm.) Hust.	I	Be	Alf										+		0,2	0,2					+								
striatula Turp.	M	Be						0,2	0,2						0,2					0,2				+	0,2	0,2	0,2	0,2	
Synedra acus Kütz.	I	Pl	Alf			0,4			0,2												0,2								
var. angustissima Grun.	I	Pl	Alf																		1,2								
amphicephala Kütz.	I	Ep	Alf	0,8	0,6	0,6							0,2	1,4		0,6	0,6	6,9	3,2	0,8	10,6	0,8	1,6						
berolinensis Lemm.	I	Pl	Ind								0,4	+	1,2	1,0															
capitata Ehr.	I	Ep	Alf					0,2																		0,2			
crystalina (Ag.) Kütz.	M	Ep	Alf																						0,2	0,2	0,2	0,4	
gaillonii (Bory) Mür.	M	Ep																						0,2		0,2			
parasitica (W.Sm.) Hust.	I	Ep	Alf	0,2	0,4					0,2					+	0,2													
var. subconstricta Grun.	I	Ep	Alf										0,2																
pulchella (Ralfs) Kütz.	M	Ep						0,8					+	0,4	0,4			0,2					1,2	1,6	0,2	0,2	0,2	0,2	2,8
tabulata (Ag.) Kütz.	M	Ep	Ind					1,0		0,2		0,2	0,2	0,4	0,2	0,2			0,2				0,6	2,6	2,9	3,5	3,8	4,5	5,0
var. fasciculata (Kütz.) Grun.	M	Ep					0,6	0,2	0,2		0,6		+	0,4					0,2				1,0	0,5	1,4	0,8	0,5	0,6	1,2
tenera W. Sm.	I	Ep	Ind	0,2	+				+																				
ulna (Nitzsch) Ehr.	I	Ep	Alf												0,2					0,2	0,2			0,2		0,8	0,2		0,4
var. biceps (Kütz.) Schoenf.	I	Ep	Alf													0,6										0,2	0,2	0,2	
vaucheriae Kütz.	I	Ep	Alf		0,2				0,2		0,2		+		0,2			0,2	0,2			0,2							
Tabellaria fenestrata (Lyngb.) Kütz.	Hb	Ep-Pl	Acf	0,2	0,4	0,6										0,2	0,4										+		
flocculosa (Roth) Kütz.	Hb	Ep-Pl	Acf			+															+								
Terpsinoë americana (Bail.) Ralfs	M	Be																					0,2	+	0,8	0,2	0,6		
Thalassiosira baltica (Grun.) Ostf.	M	Pl																								0,4	0,2		
decipiens (Grun.) Jorg.	M	Pl				0,2																							