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Changes in qualitative composition of the southern Baltic phytoplankton against the hydrological background for 1971-1974

by

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Introduction

In this contribution the variations occurring in the composition of phytoplankton species were analyzed and compared with the simultaneous changes in hydrological agents such as temperature, salinity and nutrients. The investigations were conducted in the period embracing four years: 1971-1974. The first two years were worked on by Z. Ringer, the last two - by the author of this contribution.

Material and method of investigation

The material derived from some routine stations located in the southern Baltic area: A_1 55°02'N 14°02'E /the Arkona Sea/, B_1 55°20'N 15°45'E /the Bornholm Deep/, B_2 55°13'N 17°02'E /western part of the Słupsk Furrow/, K_4 55°00'N 18°35'E /NE from Rozewie/, and G_2 54°50'N 19°20'E /southern part of the Gdańsk Deep/. Phytoplankton samples were taken every season with a Kopenhagen net, No 25, in vertical halus from the bottom to the sea surface, successively from the water layers: 0-15 m depth, 15-30m, 30-50m, 50-70 m, 70-90 m, 90 m - bottom. The samples were preserved on board the research vessel with 4 % - formaline.

To make the floristic analysis the author took advantage of following papers: Brand-Apstein /1908/; Hustedt /1962/; Lebour /1930/; Pascher /1915/; Wołoszyńska /1928/; Siemińska /1946/; Starmach /1968/.
With respect to, salinity the species were classified according to Z.Ringer /1973/.

Species	/Symbol/	Salinity degree of the environment the species lives in
Oceanic /o/ and maritime /m/		$20^{o}/oo$ S $40^{o}/oo$
Brackish-water	/Bw/	5 S 20
Frsh-water	/Fw/	S 5
Cosmopolite	/C/	indifferent to the salinity degree, thus dwelling, as well in marine as in fresh-water basins

Results of investigation

During the period considered 144 taxonomic units were distinguished: 17 of them were determined only as for genus:

124 as for species;
2 as for subspecies;
1 as for from.

The systematic composition of phytoplankton is given in Table I. There can be seen that the group of Bacillariophyceae decidedly prevailed, since to this belonged as many as 48% of species dwelling in the regions investigated. Chlorophyceae constituted the nest group contatining 19% of species. Further proceeded

Dinoflagellatae with 17% and Cyanophyceae with /14%/, whereas each of the remaining taxonomic groups, i.e. Eugleninae, Chrysophyceae, Silicoflagellatae, and Pyrocystae counted only 1 species. The author would like to emphasize that the number of species in particular groups varied from year to year, showing, however, a trend to increase from 1971 to 1973. This increasing trend was particularly conspicuous in the case of diatoms. After a mass occurrence of diatoms in 1973 the number of species of this group markedly dropped in 1974.

The general number of species varied not only from year to year bu there were also very distinct differences depending upon the sea region. During the whole period of investigation the greatest number of species was noted in the Arkona Sea /92/. In the Gdańsk Deep as many as 90 species were distinguished. In the region NW from Rozewie /at station K_4/ 73 species were found, and in the western part of the Słupsk Furrow - only 62 species. The Bornholm Deep with it's 57 species revealed itself to be the poorest one.

With regard to salinity degree the phytoplankton of the southern Baltic showed a decided prevalence of brackish-water species /41 species/, the next place belonged to marine species /36/. A comparatively great contribution /33/ of fresh-water species to the general number of species also was evident. The remaining groups were represented by considerably lower numbers of species: 12 groups belonged to oceanic species, 5 to cosmopolite ones. Diatoms and Bacillariophyceae constituted the main groups of oceanic and marine species.

The plant group classified as brackish-water species was mainly represented by diatomas, and, in a lesser degree by Chlorophyceae, Cyanophyceae and Bacillariophyceae.

Among the fresh-water species Chlorophyceae and diatoms prevailed.

Particular groups classified with respect to salinity of waters they live in, occurred in amounts varying from region to region. In the Arkona Sea great share of oceanic, marine and brackish-water species was noted. In the remaining Baltic regions the number of these organisms was markedly lower. Fresh-water and cosmopolite species first of all occurred in the Gdańsk Deep and in a lesser degree in the region NE from Rozewie. Quantitative changes in species composition of particular ecologic groups with respect to salinity were observed as depending not only upon the region but also upon the year. The 1971 year was characteristic due to a rather small participation of marine, bracksih - and fresh-water organisms. A rapid increase in number of these species took place in 1972, and in 1973 the peak as their number is concerend was attained. A particularly great number of species in 1973 was found to appear within the oceanic group of organisms. In 1974 the number of species markedly diminished, espesially dropped the number of brachish-water and fresh-water species. Changes in qualitative composition of the southern Baltic phytoplankton became evident in particular years of investigation. Beside the species which occurred only in a concrete vegetation season, as for example Dinobryon balticum or Nodularia spumigena, there were some species which did occur in many a season of the same year, e.g., Aphanizomenon flos-aquae. However, because as a rule, in particular season particular plant species were found to occur, the occurrence of phytoplankton species in the southern Baltic may be considered a seasonal one.

The winter season was characteristic by occurrence of diatoms and Cyanophyceae, the last group also being, dominant in the spring period, but it may be added here that there were not the same species at both the times, and also not the same in different years.
Dinobryon balticum /Chrysophyceae/ should have been considered species typical for spring during all the four years of investigation.
In summer - Cyanophyceae together with a considerable contribution of diatoms decidedly prevailed. During the whole period of observation the summer season revealed itself to be that of maximum development of Aphinizomenon flos-aquae.
In autumn - the strongly prevalling species belonged to diatoms. Coscinodiscus granii was even a species which occurred in this season in each of the years concerned.

Both, qualitative and quantitative composition of phytoplankton visibly differentiated with depth, Most abundant was the phytoplankton within the top water layer /0-15 m depth/. At that depth the following diatoms mainly occurred: Coscinodiscus granii, Chaetoceros borealis, Actinocyclus ehrenbergii, Chaetoceros danicus and Nitzschia holsatica.

Next to them Cyanophyceae should be listed. They were represented by the species: Aphanizomenon flos-aque; Bacillariophyceae by the species: Peridinium pellucidum and Ceratium tripos. After them came the group of Crysophyceae only represented by Dinobryon balticum.
With increasing depth both the number of species and frequency of occurrence visibly diminished. In intermediate water layer /30-59 m/ first of all were noted the species such as:

Chaetoceros borealis, Coscinodiscus granii, Sceletonema costatum Chaetoceros holsaticus, Aphanizomenon flos-aquae and Nodularia spumigena.

Near the bottom only scarse specimens were found to dwell. The species recognized near the bottom were: Chaetoceros borealis and Coscinodiscus granii.

When discussing the phytoplankton of the southern Baltic it also may be mentioned that at stations A_1, B_1 and B_2 /i.e, in the Arkona Sea, Bornholm Deep and western part of the Słupsk Furrow/ the appearance of a pollution indicator, viz., Nitzschia palea was noted in 1972, /Ringer 1973/. Once more this species was noted to be present in 1973 at stations A_1 B_1 und K_4 /NE from Rozewie/. Thus was evident that Nitzschia palea was moving from the West to the East. Since 1974 this species has seemed to disappear from the Baltic waters.

Discussion

The qualitative composition of phytoplankton was analysed from three points of view: regionalization, seasonality of occurrence and salinity degree peculiar to the environment in which particular species live. The investigation results obtained on qualitative composition of phytoplankton in the southern Baltic for 1971-1974 revealed a great variability of the species composition as depending upon hydrologic conditions which also were changing from year to year, wiz., temperature, salinity und nutrient contents of water.
The western part of the sea showed greater variability of phytoplankton composition, as the salinity groups were concerend - in comparison with the remaining Baltic regions which are lying more eastwardly. This variability was caused by an influx of the North Sea waters into the Baltic, that took place in 1972 /and in 1974/, as

with those waters a number of oceanic and typical marine species entered the Baltic area.

The influx of 1972 was extremely strong. Due to it a considerable increase in general number of phytoplankton species was noted, before all in the Arkona Sea and in the Bornholm Deep. In the subsequent year a further increase in number of species was found, though there was no other influx of oceanic waters in the meantime. The only reason for this fact may be that in 1972 not all the species were found in samples perhaps because of small number of their representatives, which further on reproduced themselves and became sufficiently numerous to be detected in samples from 1973.
As early as in 1974 most of the species considered to be indicators of salt water influxes disappeared from the southern Baltic.
Table II illustrates sporadic appearance of oceanic and marine species in this area since 1956 /Ringer 1974/. Certain phytoplankton species after having been brought by influxes became adapted to the Baltic hydrologic conditions. The species such as Dinobryon norvegica and Ceratium tripos which were found during 1969 influx may be counted to such adapted organisms as they have endured in the Baltic up to the present.

Whereas the western part of the sea remained under visible influence of the North Sea, the eastern part of it, especially the Deep of Gdańsk, was exposed to the influence of river discharge. The rivers brought in considerable amounts of nutrients. This fact together with temperatur of surface waters higher than elsewhere in the Baltic were sufficient to bring about an enrichment of this area in multiple fresh-water plankton species most probably due to the vicinity

Table II. The composition of marine and oceanic species scasionally appeared in the South Baltic in the period 1956-1974.

G a t u n k i	l a t a								
	56	59	67	68	70	71	72	73	74
Chaetoceros similis	+							+	+
Chaetoceros atlinaticus		+							
Coscinodiscus jonesianus		+							
Caratium furca		+							
Chaetoceros diadema		+	+	+					
Chaetoceros decipiens		+		+	+		+	+	+
Chaetoceros densus		+				+			
Chaetoceros affinis		+	+	+	+		+		+
Dictyocha fibula					+				
Distephanus speculum					+				
Thalassiosira nana					+				
Ceratium arcticum					+				
Ceratium macroceros					+				
Dinophysis norvegica					+	+	+	+	+
Ceratium fusus					+	+	+	+	+
Lycmophora lyngbyei							+		
Detonula schröderi							+		
Rhizosolenia hebetata							+		+
Asterionella bleakeleyi							+	+	+
Peridinium depressum								+	
Chaetoceros didymus								+	
Coscinodiscus obsurus								+	
Rhizosolenia alata f. gracillima								+	
Thalassiosira decipiens								+	
Pyrocystis lunula								+	
Chaetoceros pseudocrinitus								+	+
Coscinodiscus stellaris								+	+
Ditylium brightwelli								+	+

of the Vistula-river mounth. The highest amounts of nutrients in the Gdańsk Deep were found in 1973 /Andrulewicz, 1974/. In the same year also the highest number of fresh-water species was noted there. The effect of river water inflow exerted on species composition of phytoplankton was visible, though to a lesser degree, also in the area NW from Rozewie /K4/.

The region comparatively least differentiated as regards the species composition of phytoplankton was the Słupsk Furrow. The species which were known from the whole southern Baltic were found to occur in this region. None of plankton groups with respect to salinity was found to prevail markedly, i.e. none of the groups that would characterize either an influx of saline water from the North Sea, or fresh river waters. This fact resulted from the transitive position of the Słupsk Furrow, that stretches between the Bornholm Deep and the Gdańsk Deep.

The observations from 1971 - 1972 showed the phytoplankton of the southern Baltic to undergo incessant changes.
As many as 16 % of all the species determined occurred all - over the investigated area. Thus these species may be considered characteristic for the southern Baltic, at least for the period under consideration. Certain of them frequently occurred in mass, thus they were dominants. From the point of view of salinity these species were marine and brackish-water ones. Here belonged; Dinobryon balticum, Aphanizomen flos-aque, Nodularia spumigena, Actinocyclus ehrenbergii, Coscinodiscus granii and Sceletonema costatum. In the general composition of phytoplankton the brackish-water and marine species decidedly prevailed over others. This

fact should undoubtedly be connected with the brakkish charakter of the Baltic waters.

Qualitative changes of the phytoplankton became also apparent during a single vegetation year due to the event of seasonality. Certain species occurred only in certain seasons as undoubtedly conditionned by their demand for appropriate temperature. Such a species as Dinobryon balticum was only found to occur at the spring time, whereas Nodularia spumigena - only in summer. Aphanizomenon flos-aque /Cyanophyceae/ revealed considerable tolerance against the temperature since it occurrence in the southern Baltic was noted all over the year except for autumn. From time to time some species typical for a particularseason also appeared at another time if only the needed thermic conditions endured. As example may be given Conscinodiscus granii which must be considered typical for the autumn season, nevertheless in the period 1973 - 1974 it was found to be also present in winter because of a relatively higher winter tempeature in those years /by 1 - 2° higher than average for the souther Baltic/. The vertical distribution of phytoplankton species was indirectly depending on temperature and directly on light intensity. In the top water layer /0 - 15 m depth/ where both of those factors showed relatively maximum values the phytoplankton was most abundant as well to the number of species as to the number of cells of each of them.

With increasing depth and decreasing temperature and light intensity the phytoplankton amount notably dropped. At the bottom least amounts of plants were noted.

Table I. Composition of phytoplankton species in the South Baltic in the period 1971 - 1974.

	Species	Year			
		1971	1972	1973	1974
1	2	3	4	5	6
	Euglenineae				
bw	Euglena viridis Ehrenb.	•	•	+	+
	Dinoflagellatae				
o	Ceratium arcticum/Ehrenb./ Cl.	+	•	•	•
m	Ceratium fusus /Ehrenb./	+	+	+	+
o	Ceratium macroceros Schrank	+	•	•	•
m	Ceratium tripos /O.F.M./Nitzsch.	+	+	+	+
m	Dinophysis acuminata Clap.Lachm.	+	+	+	+
o	Dinophysis acuta Ehrenb.	•	•	+	+
m	Dinophysis norvegica Clap.Lachm.	+	+	+	+
m	Dinophysis ovum Schütt.	+	•	+	•
m	Dinophysis ovum v.baltica Pauls.	•	+	•	•
m	Dinophysis rotundata Levand.	•	+	+	•
bw	Gonyaulax triacantha Jörg.	•	•	+	+
bw	Gymnodinium rhomboides Schütt.	•	+	+	•
	Gymnodinium sp.	•	•	+	+
bw	Poridinium breve Pauls.	•	•	+	•
bw	Poridinium catenatum Levand.	+	+	+	+
o	Peridinium depressum Bail.	•	•	+	+
bw	Peridinium divergens Ehrenb.	+	+	+	•
bw	Peridinium finlandicum Pauls.	•	•	+	•
m	Peridinium granii Ostenfeld	+	•	•	+
o	Peridinium ovatum /Pouchet/	•	•	•	+
m	Peridinium pellucidum /Bergh./Schütt	+	+	+	+
m	Peridinium stenii Jörg.	+	+	+	+
m	Peridinium triqueta /Stein/	•	•	•	+
	Peridinium sp.	•	+	+	+
	Pyrocystae				
o	Pyrocystis lunula Schütt.	•	•	+	•
	Chrysophyceae				
m	Dinobryon balticum /Schütt./Lemm	+	+	+	+
	Silicoflagellatae				
m	Ebria tripartita /Schum./Lemm.	+	+	+	+
	Cyanophyceae				
fw	Anabaena flos-aquae Breb.	+	+	+	+
fw	Anabaena solitaria Kleb.	•	•	•	+
fw	Anabaena spiroides Kleb.	+	+	+	+
bw	Aphanizomenon flos-aquae /L./Ralfs.	+	+	+	+
fw	Aphanothece microscopia Näg.	•	•	+	•
bw	Gloeocapsa crepidinum Thuret	•	•	+	•
fw	Gloeocapsa limnetica /Lemm./Woll.	•	+	+	+
fw	Gloeocapsa minuta /Kütz./Woll.	•	•	+	•
	Gloeocapsa sp.				

1	2	3	4	5	6
bw	Lyngbya bipunctata Lemm.	•	•	+	+
c	Lyngbya limnetica Lemm.	•	•	+	+
	Lyngbya sp.	•	•	+	+
bw	Merismopedia glauca /Ehrenb./ nag.	•	•	+	•
bw	Merismopedia punctata Meyen	•	•	+	+
bw	Merismopedia tenuissima Lemm.	+	+	+	•
c	Microcystis aeruginosa Kütz.	+	+	+	+
fw	Microcystis flos-aquae /Wittr./Kirchn.	+	+	•	•
bw	Nodularia spumigena Mert.	+	+	+	+
fw	Oscillatoria tenuis Agerdh	+	+	•	•
	Oscillatoria sp.	•	+	+	•
	Bacillariophyceae				
bw	Achnanthes taeniata Grun.	+	+	+	+
m	Actinocyclus ehrenbergi Ralfs.	+	+	+	+
m	Asterionella bleakeleyi Smith.	•	+	+	+
fw	Asterionella gracillima /Hantz./Heib.	•	•	+	•
	Asterionella sp	+	•	•	•
m	Chaetoceros affinis Land.	•	+	•	+
o	Chaetoceros borealis Bail.	+	+	+	+
m	Chaetecera brevis Schütt.	+	+	+	+
bw	Chaetoceros curvisetus Cl.	•	•	+	•
bw	Chaetoceros danicus Cl.	+	+	•	•
m	Chaetoceros debilis Cl.	+	•	+	+
o	Chaetoceros decipiens Cl.	•	+	+	+
o	Chaetoceros densus Cl.	+	•	•	•
m	Chaetoceros didymus Ehrenb.	•	•	+	•
o	Chaetoceros gracilis Schütt.	+	+	+	+
bw	Chaetoceros holsaticus Schütt.	+	+	+	+
m	chaetoceros laciniosus Schütt.	+	+	+	•
m	Chaetoceros pseudocrinitus Ostf.	•	•	+	+
m	Chaetoceros similis Cl.	•	•	+	+
m	Chaetoceros socialis Lauder	+	+	•	•
bw	Chaetoceros subtilis Cl.	+	+	•	+
bw	Chaetoceros wighami Bright.	+	+	+	+
	Chaetoceros sp.	•	+	•	+
m	Coscinodiscus granii Gouhg.	+	+	+	+
o	Coscinodiscus obscurus Schmidt	•	•	+	+
m	Coscinodiscus stellaris Ropeb.	•	•	+	+
	Coscinodiscus sp.	•	•	+	•
bw	Coscinosira polychorda Gran.	•	+	•	+
fw	Cyclotella comta /Ehrenb./ Kütz.	•	•	•	+
fw	Cyclotella melosiroides /Kirchn./Lemm	•	•	•	+
fw	Cyclotella meneghiniana Kütz.	+	+	+	+
fw	Cyclotella socialis Schütt.	•	•	+	+
fw	Cyclotella stelligera Cl.et Grun.	•	•	+	+
fw	Cymbella prostrata /Berk./ Cl.	•	•	+	•
bw	Diatoma elongatum /Lyngb./Ag.	•	+	•	+
	Diatoma sp.	•	+	•	•
m	Detonula schröderi /P.Bergoni/	•	+	•	•
bw	Diploneis interrupta /Kütz./Cl.	•	+	+	+
fw	Ditylium brightwelli /West/Grun.	•	•	+	+
bw	Epithemia sorex Kütz.	•	•	+	•
fw	Fragilaria crotonensis Kitt.	•	•	+	+
	Fragilaria sp.	•	•	+	•
bw	Cyrosigma acuminatum /Kütz./Rabh.	•	•	+	•
m	Lycmophora lyngbyei /Kütz./Grun.	•	+	•	•
bw	Melosira juergensi Ag.	+	•	+	+

1	2	3	4	5	6
bw	Melosira moniliformis /Müll./Ag.	•	•	+	+
c	Melosira nummuloides /Dillw./Ag.	•	+	+	+
fw	Melosira undulata /Ehrenb./Kütz.	•	•	+	•
c	Navicula placentula /Ehrenb./ Grun.	•	•	+	•
	Navicula sp.	•	+	+	+
bw	Nitzscha closterium /Ehrenb./W.Sm.	•	+	+	+
fw	Nitzschia holsatica Rust.	•	•	+	+
fw	Nitzschia palea /Kütz./W.S.	•	+	+	•
bw	Nitzschia seriata Cl.	•	•	+	•
	Nitzschia sp.	•	•	•	+
o	Rhizosolenia alata f.gracillima Cl.	•	•	+	•
bw	Rhizosolenia fragilissima Berg.	•	+	+	+
m	Rhizosolenia hebetata Berg.	•	+	•	+
m	Rhizosolenia hebetata f.semispina /Rensen/	•	+	•	•
bw	Rhizosolenia setigera Bright.	•	•	+	•
fw	Rhoicosphaenia curvata /Kütz./.Grun.	•	•	+	•
m	Sceletonema costatum /Grev./Cl.	+	+	+	+
bw	Synedra ulna /Nitzsch./Ehrenb.	•	•	+	+
	Syndera sp.	•	•	+	•
m	Thalassionema nitzschioides Grun.	+	•	+	+
bw	Thalassiosira baltica /Grun./Ostf.	+	+	+	+
m	Thalassiosira gravida Cl.	•	+	+	•
m	Thalassiosira decipiens /Grun./Jörg.	•	•	+	•
	Thalassiosira sp.	•	•	+	•
	Chlorophyceae				
fw	Ankistrodesmus convolutus Corda	•	•	+	•
bw	Ankistrodesmus falcatus /Corda/Ralfe	+	+	•	•
bw	Ankistrodesmus falcatus v.mirabile W.u G.S. West	•	+	•	+
fw	Ankistrodesmus nivalis /Chod./Brunn.	+	•	•	•
bw	Dictyosphaerium ehrenbergianum Naeg.	+	+	+	+
bw	Dictyosphaerium pulchellum Wood.	•	•	+	•
	Characium sp.	•	•	+	•
fw	Chlorella vulgaris Beyerink	•	•	+	•
fw	Crucigenia lunaris /Lemm./Wille	•	+	•	•
fw	Crucigenia tetrapedia /Kirchn./	•	+	•	•
	Crucigenia sp.	•	+	•	•
m	Halosphaera viridis Schmitz.	•	+	•	•
fw	Kirchneriella obesa/West./Schm.	•	+	+	+
fw	Oocystis lacustris Chodat.	+	+	•	+
fw	Oocystis solitaria Wittr.	•	+	•	•
bw	Oocystis submarina Lagrh.	•	+	+	+
	Oocystis sp.	•	+	+	•
fw	Pediastrum boryanum /Turp./Ehrenb.	+	+	+	+
fw	Pediastrum duplex Meyen	•	•	+	+
fw	Pediastrum duplex v.genuinum Al.Braun	•	+	•	•
fw	Pediastrum kawaraiskyi Schmidle	•	•	+	+
c	Scenedesmus acuminatus /Lag./Chod.	+	+	•	•
fw	Scenedesmus quadricauda /Trup./Breb.	+	+	+	+
bw	Scenedesmus obliquus /Trup./Ag.	•	+	•	•
m	Trochiscia brachiolata /Möb./Lemm.	+	+	+	+
bw	Trochiscia colvei Lemm.	+	+	+	+
bw	Trochiscia multispiosa /Moeb./Lemm.	•	+	•	+

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