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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: A₁ 55°02'N 14°02'E /the Arkona Sea/, B₁ 55°20'N 15°45'E /the Bornholm Deep/, B₂ 55°13'N 17°02'E /western part of the Słupsk Furrow/, K₄ 55°00'N 18°35'E /NE from Rozewie/, and G₂ 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 hauls 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 ⁰ /oo	S 40 ⁰ /oo
Brackish-water	/Bw/	5	S 20
Fresh-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 next group containing 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 but 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 K₄/ 73 species were found, and in the western part of the Skupsk Furrow - only 62 species. The Bornholm Deep with its 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 diatoms, 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, brackish - 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 concerned 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, especially dropped the number of brackish-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 Aphanizomenon flos-aquae.

In autumn - the strongly prevailing 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-aquae; Bacillariophyceae by the species: Peridinium pellucidum and Ceratium tripos. After them came the group of Chrysophyceae 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, Skeletonema costatum, Chaetoceros holsaticus, Aphanizomenon flos-aquae and Nodularia spumigena.

Near the bottom only scarce 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 A₁, B₁ and B₂ /i.e., in the Arkona Sea, Bornholm Deep and western part of the Slupsk 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 A₁, B₁ and K₄ /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, viz., temperature, salinity and nutrient contents of water.

The western part of the sea showed greater variability of phytoplankton composition, as the salinity groups were concerned - 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

of the Vistula-river mouth. 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 Skeletonema 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 brackish character 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 conditioned 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 its occurrence in the southern Baltic was noted all over the year except for autumn. From time to time some species typical for a particular season 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 temperature in those years /by 1 - 2° higher than average for the southern 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
	<u>Euglenineae</u>				
bw	<i>Euglena viridis</i> Ehrenb.	.	.	+	+
	<u>Dinoflagellatae</u>				
o	<i>Ceratium arcticum</i> Ehrenb. / Cl.	+	.	.	.
m	<i>Ceratium fusus</i> Ehrenb. /	+	+	+	+
o	<i>Ceratium macroceros</i> Schrank	+	.	.	.
m	<i>Ceratium tripos</i> O.F.M. / Nitzsch.	+	+	+	+
m	<i>Dinophysis acuminata</i> Clap. Lachm.	+	+	+	+
o	<i>Dinophysis acuta</i> Ehrenb.	.	.	+	+
m	<i>Dinophysis norvegica</i> Clap. Lachm.	+	+	+	+
m	<i>Dinophysis ovum</i> Schütt.	+	.	+	.
na	<i>Dinophysis ovum</i> v. <i>baltica</i> Pauls.	.	+	.	.
m	<i>Dinophysis rotundata</i> Levand.	.	+	+	.
bw	<i>Gonyaulax triacantha</i> Jürg.	.	.	+	+
bw	<i>Gymnodinium rhomboides</i> Schütt.	.	+	+	.
	<i>Gymnodinium</i> sp.	.	.	+	+
bw	<i>Peridinium breve</i> Pauls.	.	.	+	.
bw	<i>Peridinium catenatum</i> Levand.	+	+	+	+
o	<i>Peridinium depressum</i> Bail.	.	.	+	+
bw	<i>Peridinium divergens</i> Ehrenb.	+	+	+	.
bw	<i>Peridinium finlandicum</i> Pauls.	.	.	+	.
m	<i>Peridinium granii</i> Ostenfeld	+	.	.	+
o	<i>Peridinium ovatum</i> / Pouchet /	.	.	.	+
na	<i>Peridinium pellucidum</i> / Bergh. / Schütt.	+	+	+	+
na	<i>Peridinium stenii</i> Jürg.	+	+	+	+
m	<i>Peridinium triquetra</i> / Stein /	.	.	.	+
	<i>Peridinium</i> sp.	.	+	+	+
	<u>Pyrocystae</u>				
o	<i>Pyrocystis lunula</i> Schütt.	.	.	+	.
	<u>Chrysophyceae</u>				
m	<i>Dinobryon balticum</i> / Schütt. / Lemm	+	+	+	+
	<u>Silicoflagellatae</u>				
m	<i>Ebria tripartita</i> / Schum. / Lemm.	+	+	+	+
	<u>Cyanophyceae</u>				
fw	<i>Anabaena flos-aquae</i> Breb.	+	+	+	+
fw	<i>Anabaena solitaria</i> Kleb.	.	.	.	+
fw	<i>Anabaena spiroides</i> Kleb.	+	+	+	+
bw	<i>Aphanizomenon flos-aquae</i> / L. / Ralfs.	+	+	+	+
fw	<i>Aphanothoece microscopia</i> Nüg.	.	.	+	.
bw	<i>Gleocapsa crepidinum</i> Thuret	.	.	+	.
fw	<i>Gleocapsa limnetica</i> / Lemm. / Holl.	.	+	+	+
fw	<i>Gleocapsa minuta</i> / Nitzsch. / Holl.	.	.	+	.
	<i>Gleocapsa</i> 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 Agardh	+	+	.	.
	Oscillatoria sp.	.	+	+	.
<u>Bacillariophyceae</u>					
bw	Achnanthes taeniata Grun.	+	+	+	+
m	Actinocyclus chrenbergi Ralfs.	+	+	+	+
m	Asterionella bleakeleyi Smith.	.	+	+	+
fw	Asterionella gracillima /Hantz./Heib.	.	.	+	.
	Asterionella sp.	+	.	.	.
m	Chaetoceros affinis Land.	.	+	.	+
o	Chaetoceros borealis Bail.	+	+	+	+
m	Chaetocera 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 lacinosus Schütt.	+	+	+	.
m	Chaetoceros pseudocrinitus Ostf.	.	.	+	+
m	Chaetoceros similis Cl.	.	.	+	+
m	Chaetoceros socialis Lauder	+	+	.	+
bw	Chaetoceros subtilis Cl.	+	+	.	+
bw	Chaetoceros wighamii 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	Lymnophora lyngbyei /Kütz./Grun.	.	+	.	.
bw	Melosira juergensi Ag.	+	.	+	+

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

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