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# COMP OSIT IONAND SE ASONALCHANGES OF NANOFLAGELLATES IN THE GDAŃSK BASIN (SOUTHERN BALTIC)

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Composition and seasonal changes of nanoflagellates (2–20 μm body size) were investigated from January 1987 until January 1988 at three stations in the Gdańsk Basin. Nine groups of flagellates were distinguished: the *Cryptophyceae, Dinophyceae, Chrysophyceae, Prymnesiophyceae, Prasinophyceae, Chlorophyceae, Euglenophyceae,Choanoflagellida,* and the group of other heterotrophic nanoflagellates. Total abundance of nanoflagellates at the inshore station ranged from 0.2 to $6.1 \cdot 10^3$ ind./ml (mean of $2.1 \cdot 10^3$ ind./ml), while the biomass varied from 10 to 604 μg/dm$^3$ (mean of 149 μg/dm$^3$). The values were lower in offshore waters. The *Dinophyceae,* constituting – on the average – 30% of the total biomass, *Prymnesiophyceae* (32% of the total abundance) and *Cryptophyceae* were dominants at all the stations. The *Choanoflagellida* as well as the other heterotrophic nanoflagellates contributed significantly to the abundance (11 and 18%, respectively). A succession of the dominant taxa is discussed.

## INTRODUCTION

The interest in small marine flagellates (2–20 μm body size) has increased in recent years, exceptional algal blooms caused by those organisms being one of the reasons. In May 1988, the flagellate *Chrysochromulina polylepis* (about 10 μm in size) caused an unusual bloom associated with mass mortality of fish and bottom fauna in the North Sea (Dahl et al. 1989). On the other hand, heterotrophic nanoflagellates form a very important link in pelagic food webs by virtue of transferring energy between bacteria and larger suspension feeders, mainly ciliates (Fenchel 1982a, 1982b).

Studies on nanoflagellates in the Baltic Sea are scarce and rather limited in scope. Papers written by Andrushaitis and Boikova (1985), Boikova (1984), and Senichkina (1985) give information on vertical and horizontal distribution of these organisms in the Baltic. Other papers (Edler et al. 1984; Huttunen and Kuparinen 1986; Niemi 1975) include some information on qualitative composition. The aim of the present study was to identify the major groups of autotrophic and heterotrophic nanoflagellates and to describe seasonal changes of the dominant taxa.

## MATERIALS AND METHODS

Samples were collected from January 1987 until January 1988, usually twice a month, at three stations (92A, G2, R6) in the Gdańsk Basin (Fig. 1). During that period, water surface temperature ranged within −0.3 to 16.5°C, the mean salinity being of about 7.5‰ (range: 6.9–8.1‰). Samples were taken with a 9 $dm^3$ van Dorn water sampler from the depths of 0, 5, 10, and 15 m, a 50-ml subsample being taken for

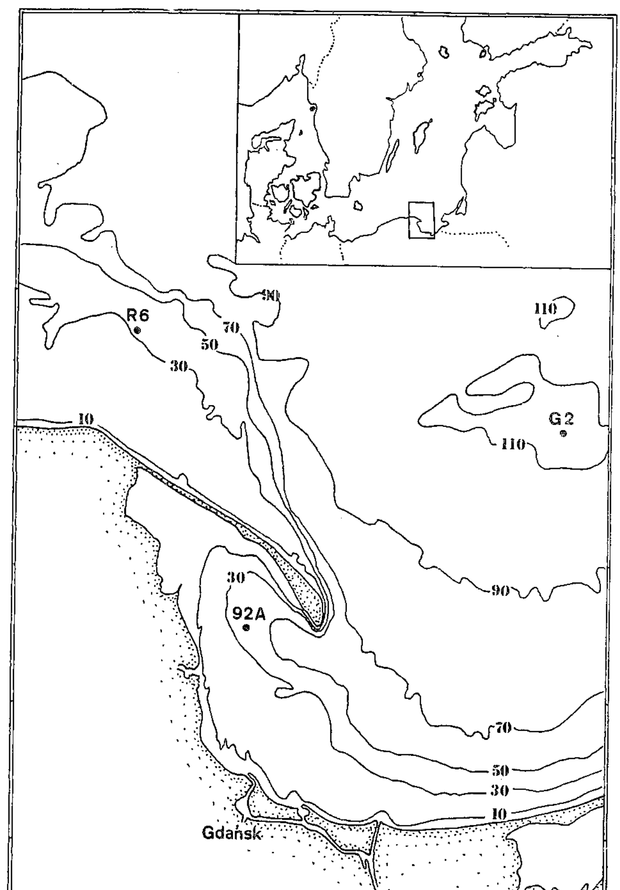


Fig. 1. Location of sampling stations in the Gdańsk Basin. Depths are given in metres

analysis from each depth level; integrated 200-ml samples were prepared and fixed with glutardialdehyde solution (0.25% final concentration).

Organisms were identified and enumerated using an inverted light microscope (the Utermohl technique); 10-ml subsamples were allowed to settle for 24 h prior to inspection. The organisms were counted using a 40X objective (total magnification of 900X). Nanoflagellate volumes were estimated from stereometric formulae by assuming a simple geometric shape for each organism. Nanoflagellates measuring from 4 to 1000 $\mu m^3$ were counted. Generally, they included forms measuring from 2 to 15 μm, and rarely 20 μm, in length. However, elongated dinoflagellates were 25 μm long, some euglenoids reaching even 40 μm (but not exceeding 1000 μm).

Identification of the organisms to the major taxa only was possible. Throndsen (1980) provides advice on how to optimize light microscopy application to naked flagellates.

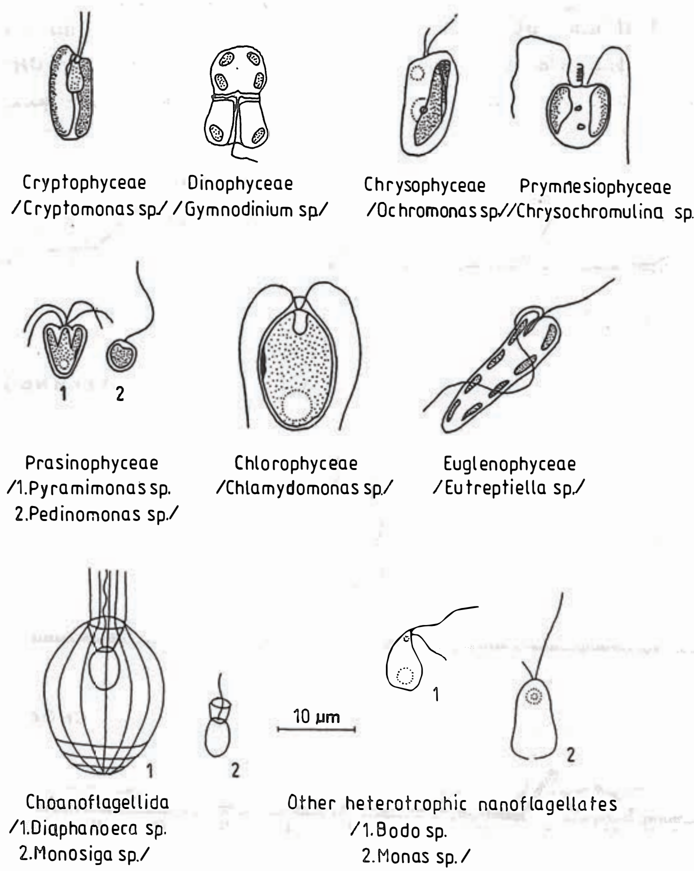


Fig. 2. Groups of nanoflagellates and some genera recorded in the Gdańsk Basin in 1987

## RESULTS AND DISCUSSION

During the study, the following taxa of nanoflagellates were distinguished (Fig. 2):

*Cryptophyceae*. Specimens of this algal class can be distinguished under a light microscope by their shape and two subequal flagella. Chloroplasts are green, brownish or reddish. Cell size ranged within 3–20 μm. At 92A, the group showed a peak biomass of 92 μg/dm$^3$ occurring in the second half of August. At two other stations, G2 and R6, peaks were observed in September (Fig. 3). The group constituted the major component of nanoflagellates in autumn and winter. The dominant genus was *Cryptomonas*; however, systematics of the class is unclear and in need of revision (Thomsen 1987; Throndsen 1983).

*Dinophyceae*. Although these flagellates are often larger than other nanoplanktonic organisms, a significant portion of dinoflagellates includes forms measuring 7–15 μm. Many of them are heterotrophic. The *Dinophyceae* were found to totally dominate the nanoflagellate biomass, particularly at 92A where the maximum biomass

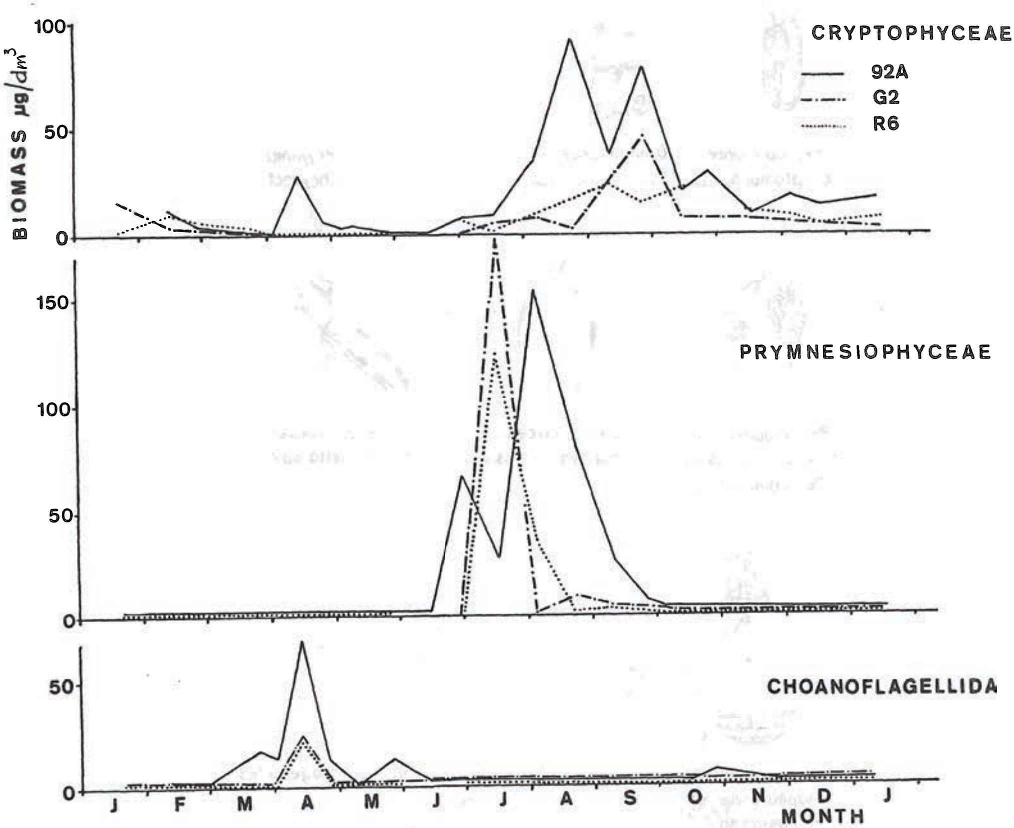


Fig. 3. Changes in biomass of *Cryptophyceae, Prymnesiophyceae,* and *Choanoflagellida* at stations 92A, G2, and R6 (0–15 m layer) during 1987

of 419 μg/dm$^3$ was observed in July (Fig. 4). The peak was caused by one species, *Prorocentrum balticum.* An earlier peak was observed in May and was caused by *Gymnodinium* and *Gyrodinium* – like cells, probably mainly heterotrophic, and by *Katodinium rotundatum*. The maximum biomasses were much lower in the off shore than in inshore waters (G2: 64 μg/dm$^3$ and R6: 47 μg/dm$^3$), the peaks being higher in May than in July.

*Chrysophyceae.* The cells have one flagellum or two unequal flagella each. Chloroplasts are yellowish, yellowish-green or brown. The group was of some importance at the inshore station 92A where the peak biomass of 132 μg/dm$^3$ was recorded in June. Unfortunately, no samples could be taken in mid-June at G2 and R6. The dominant species were members of the family Pedinellaceae (*Apedinella spinifera, Pseudopodinella* sp., *Pedinella tricostata*). *Chromulina* and *Ochromonas* were the less abundant genera.

*Prymnesiophyceae.* Each cell carries two equal flagella and another thread-like organelle, the haptonema. Chloroplasts are yellow or yellowish-green. This algal class played the most important role in summer, particularly in July and in the first half of August, during which period prymnesiomonads were the most abundant component of the entire nanoplankton. At G2, the peak density of 6.8·10$^3$ ind./ml (biomas of 178

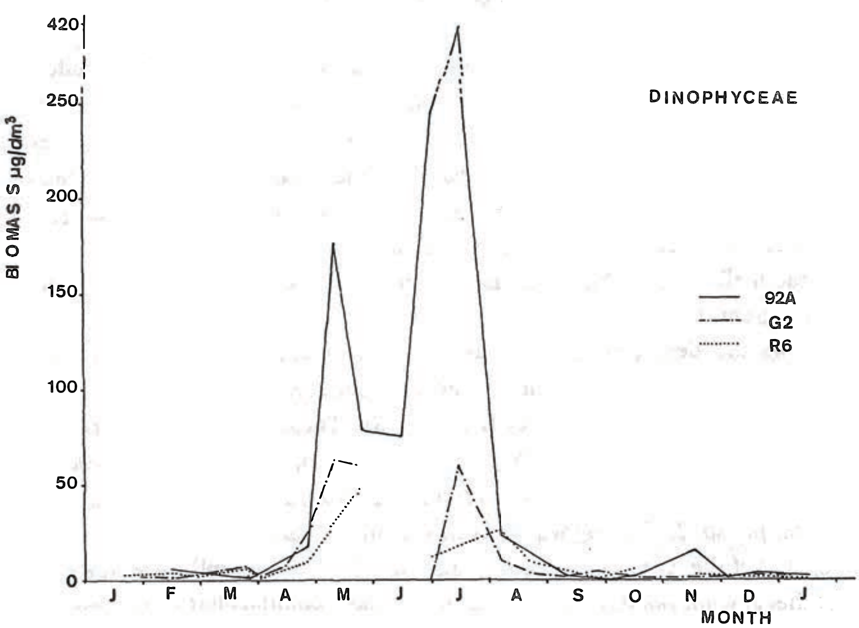


Fig. 4. Changes in biomass of *Dinophyceae* at stations 92A, G2, and R6 (0–15 m layer) during 1987

μg/dm$^3$) was recorded in July (Fig. 3). The cells observed were usually smaller than 10 μm. The most important genera were *Chrysochromulina* (in summer)and *Prymnesium* (more abundant in spring).

***Prasinophyceae.*** Often very small (2–8 μm) flagellates which have one, two or four flagella. Chloroplasts are olive green. Members of the class may on occasion contribute significantly to the abundance and biomass. The genera *Pyramimonas* and *Pedinomonas* were absolutely predominating. Other genera recorded were *Micromonas* and *Nephroselmis.*

***Chlorophyceae.*** Members of the group have two equal flagella; chloroplasts are green or pale green. *Chlamydomonas* and *Dunaliella* were the major genera. Cell size ranged within 7–20 μm. The group was of a minor importance at all the stations.

***Euglenophyceae.*** The cells are seldom smaller than 20 μm, but are very elongated, their volumes being rather low. *Eutreptiella* was the dominant genus. Small (20–40 μm) *Euglena* and *Eutreptia* forms were also recorded. The class was of no great importance.

***Choanoflagellida.*** These colourless flagellates may have lorica; each has a single flagellum. Cells missing the lorica and collar are sometimes not longer than 2 μm. However, most cells ranged within 2–7 μm of length. The group dominated at the three stations in early spring, especially in mid-April. The maximum biomass of 68 μg/dm$^3$ abundance: 2.2·10$^3$ ind./ml) was observed at 92A (Fig. 3) and was caused by the genus *Diaphanoeca.* Other common genera included *Monosiga, Calliacantha,* and *Pleurosiga.*

**Other heterotrophic nanoflagellates.** This artificial group contained the following types of nanoflagellates: kinetoplastids (e.g. *Bodo* spp.), protomonadids (e.g. *Monas* spp.), heterotrophic chrysomonads (*Parachrysomonas* sp., *Calycomonas* sp.), heterotrophic cryptomonads (e.g. *Leucocryptos marina*), and colourless chloromonad-like cells. The group was composed mainly of flagellates masuring 2–6 μm and being, most probably, mostly kinetoplastids and protomonadids. Identification of the smallest cells was practically impossible. The maximum densities were about 10$^3$ ind./ml (biomass: 24 μg/dm$^3$).

Fig. 5. shows the densities and biomass of nanoflagellates at the three stations during the period of study. The maximum densities occured at all the stations in July. The peak at 92A was followed by peaks at G2 and R6. These three peaks were caused mainly by the very small (3–5 μm) *Chrysochromulina* sp. 1. In the first week of August at 92A, the high density of 5·10$^3$ ind./ml was caused by the larger (6–10 μm) *Chrysochromulina* sp. 2. The highest densities of the *Choanoflagellida* in spring (2.2·10$^3$/ml) and of the *Cryptophyceae* in autumn (2.1·10$^3$ ind./ml) were lower than densities of the *Prymnesiophyceae* in summer. The nanoflagellate biomass peaks were also recorded in July. Dinoflagellates (smaller than 20 μm) dominated at 92A, whereas prymnesiomonads were dominating in offshore waters at that time. The total

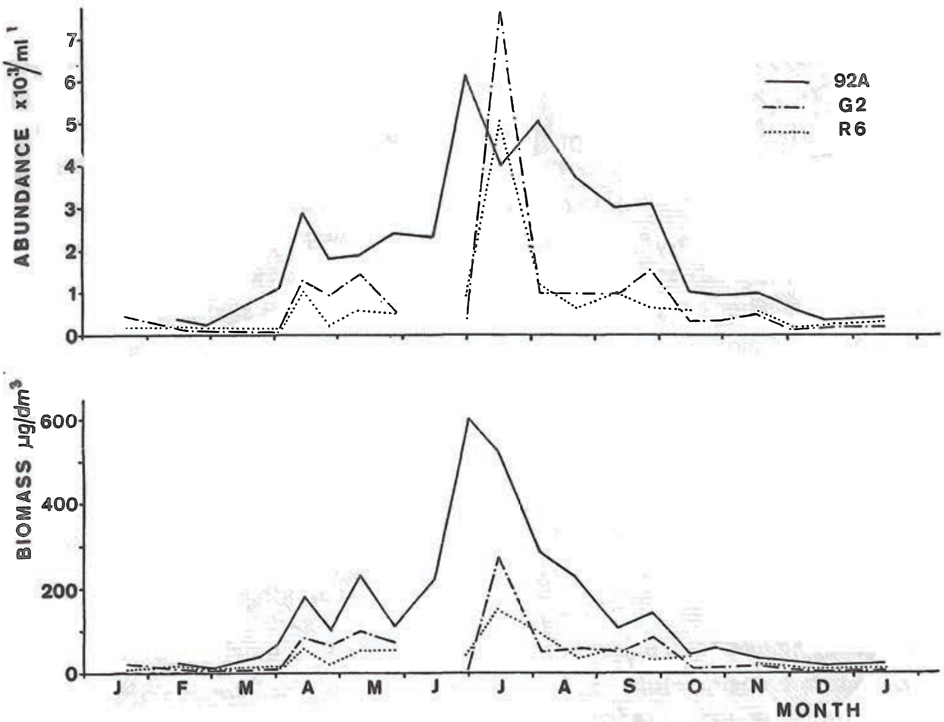


Fig. 5. Changes in total abundance and biomass of nanoflagellates at stations 92A, G2, and R6 (0–15 m layer) during 1987

nanoflagellate abundance at the inshore station 92A ranged within $0.2–6.1 \cdot 10^3$ cells/ml (mean of $2.1 \cdot 10^3$ cells/ml) during the year. Mean densities of nanoflagellates at the offshore stations G2 and R6 were lower (1.0 and $0.7 \cdot 10^3$ /ml, respectively). The total biomass of these organisms at 92A ranged within 10–604 µg/dm$^3$ (mean of 149 µg/dm$^3$), while mean values in offshore waters were much lower: 51 µg/dm$^3$ and 41 µg/dm$^3$ at G2 and R6, respectively.

Fig. 6 shows the mean annual pert cent composition of nanoflagellate abundance and biomass at the three stations. The *Prymnesiophyceae* were most important in terms of abundance and contributed, on the average, 32% of the total density. The *Dinophyceae* turned out to dominate the biomass as they made up 30% of the total mean value. The *Cryptophyceae* were the third most important group, contributing 15% to the abundance and 16% to the biomass. These three algal classes were the dominants. The *Choanoflagellida* and the group of other heterotrophic nanoflagellates contributed a significant percentage to the total abundance (11 and 18%, respectively).

In June and July 1978, Senichkina (1985) studied nanoflagellates in the Southern Baltic and estimated their densities and biomass in the Gdańsk Basin. She counted live

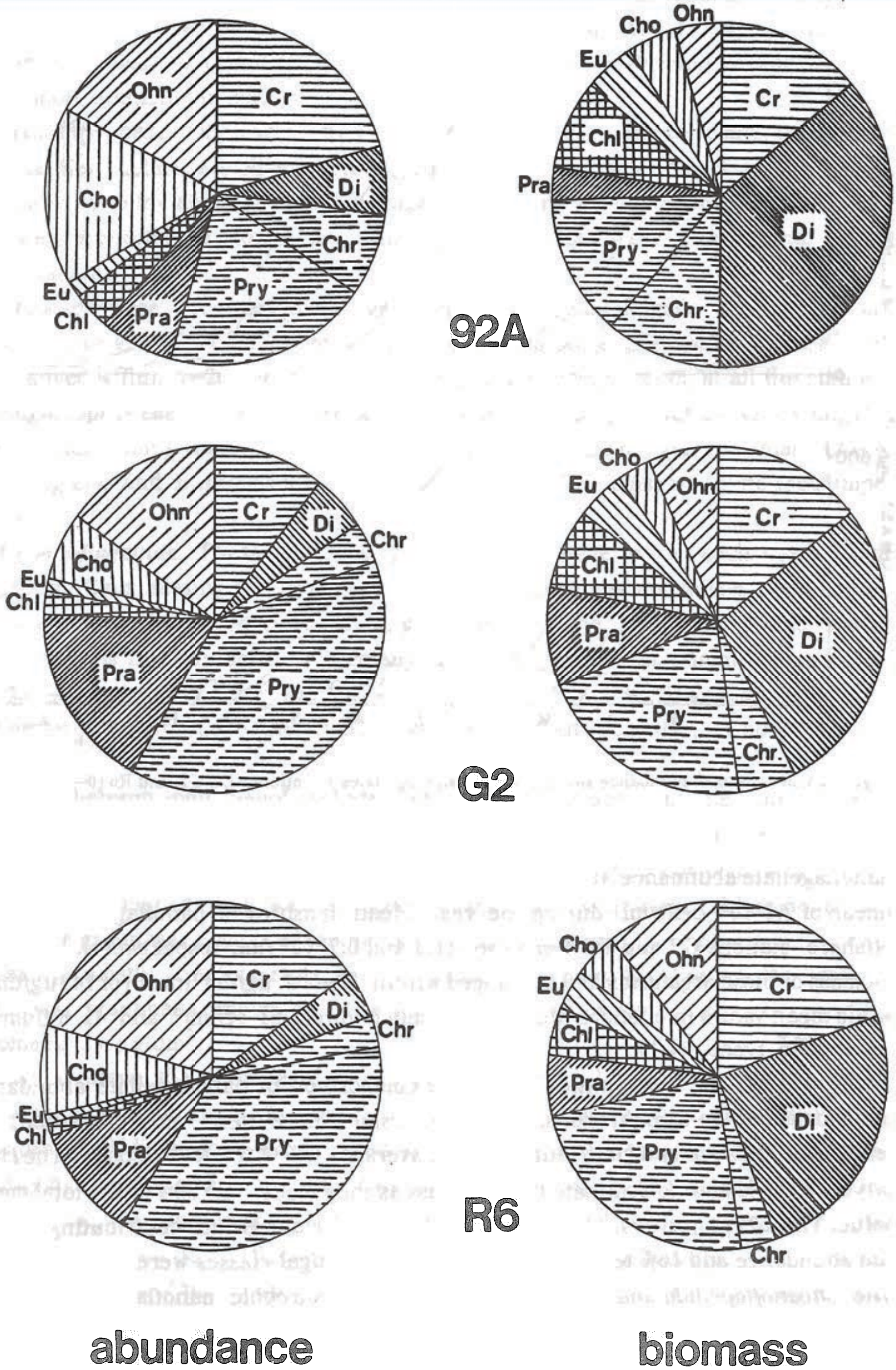


Fig. 6. Per cent composition of annual mean nanoflagellate abundance and biomass at stations 92A, G2, and R6 (0–15 m layer) in 1987. Cr = *Cryptophyceae*; Pry = *Prymnesiophyceae*; Pra = *Prasinophyceae*; Chl = *Chlorophyceae*; Eu = Euglenophyceae; Cho = *Choanoflagellida*; Ohn = other heterotrophic nanoflagellates

cells and reported densities (within the 0–10 m layer) varying from 0.2 to $1.6 \cdot 10^3$ ind./ml (mean of $0.8 \cdot 10^3$ ind./ml), while her biomass values ranged between 30 and 154 µg/dm$^3$ (mean of 102 µg/dm$^3$). Senichkina's results are considerably lower than those presented in this paper and obtained during the same seasons. In this study, the mean abundance of $3.8 \cdot 10^3$ ind./ml was found and the mean biomass was 262 µg/dm$^3$. The differences may have resulted from a different methodology or from changes in the area of study that might have taken place.

Andersen and Sørensen (1986) studied the population dynamics and trophic coupling in pelagic microorganisms in eutrophic coastal waters (Limfjorden, Denmark). They found the populations examined (pelagic bacteria, heterotrophic and autotrophic nanoflagellates) to show strong, successive fluctuations in size from May and throughout the summer. A total of 8 peaks in nanoplankton densities were observed and connected with a tight coupling between nanoplankton and ciliates. In the Gdańsk Basin, a single major peak of nanoplankton was recorded in summer, but sampling intensity was lower than that in Anderson and Sørensen (1986).

## CONCLUSIONS

Considerable differences in the abundance and biomass of nanoflagellates were observed at three stations in the Gdańsk Basin. The values obtained at the inshore station 92A were much higher than those at the offshore stations G2 and R6. However, the succession pattern of dominant taxa was similar. Early spring domination of the *Choanoflagellida,* growth of the *Dinophyceae* in May and July, summer development of the *Prymnesiophyceae,* and domination of the *Cryptophyceae* in autumn and winter are the main features of the succession.

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