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SEASONAL VARIATION OF PHYTOPLANKTON POPULATIONS AND PRIMARY PRODUCTION IN THE SLUICE DOCK AT OSTEND (BELGIUM)

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ABSTRACT

The Sluice Dock at Ostend has been investigated for phytoplankton populations and primary production for the years 1971 and 1972. Nannoplankton is demonstrated to take the prominent part in pelagic primary production . The seasonal cycle shows a short spring outburst of Eutreptiella marina followed by a depressed production period (May). The summer is the most productive period . Several nannoplanktonic populations appear successively in this period. The depression of May is discussed in relation with zooplankton activity .

INTRODUCTION

The Sluice Dock (Bassin de Chasse) at Ostend is a shallow lagoon connected by sluices to the harbour of Ostend and is principally devoted to oyster-farming. The average depth is about 1,5 m and the area about 86 ha. As a rule the basin is kept full from March to September.

The phytoplankton of the Sluice Dock is not well known although the biotope has been studied since 1938. VAN MEEL (1965) has studied the netplankton of the basin and has estimated the total phytoplankton biomass from chlorophyll determinations. He has emphasized the relative importance of what he called ultraplankton but considered this ultraplankton was mostly bacteria.

In a previous paper (MOMMAERTS, 1971), the ultraplankton was demonstrated to be actually nannoplankton : at least 37 species of algae belonging to the classes Cryptophyceae, Haptophyceae, Prasinophyceae, Dinophyceae and Euglenophyceae were recorded. The Bacillariophyceae were principally represented by a nannoplanktonic species : *Thalassiosira pseudonana* HASLE & HEIMDAL (= *Cyclotella nana* HUSTEDT). Netplankton ~~never~~ seldom seemed to play an important role in primary production in the Sluice Dock. In the benthos however, SOMERS (1972) emphasized the presence of many Bacillariophyceae.

Our purpose is to complete these observations and to discuss their relationship to potential primary production.

MATERIAL AND METHODS

The nannoplanktonic populations of the Sluice Dock at Ostend were investigated from March to September for the years 1971 and 1972. The samples were taken, at the beginning of the afternoon, usually once a week in the centre of the lagoon. A 150 ml bottle was filled with surface water and immediately fixed with acetic lugol. Another bottle of one litre was filled in the same way but not fixed and brought back in a portable refrigerator to the laboratory for immediate observation, picking out and culturing of the living organisms. Another sample was collected for measuring primary production with the 14-C method.

Counting

In the laboratory, one or more subsamples varying from 1 to 20 ml (according to the presumed density of the phytoplankton), were allowed to settle in a counting cell and examined with the inverted microscope (UTERMOHL, 1936). Counts were generally made along one diameter of the counting cell, sometimes along 2 or 3 if the organisms were sparsely distributed. In some cases of high density, only a few quadrats chosen at random were counted. The numerations generally include 100 to 150 (sometimes 300) individuals of the dominant population. According to LUND _et al_ (1958) this is more than enough to reach a highly significant level.

Successive numerations made on the same sample have shown that

1) equivalent subsamples give results distributed according to the Poisson law;
2) a small subsample (2 ml) gives significantly higher results than a subsample of a larger volume (10 ml).

JACQUES (1968) observed the same phenomenon and attributed the lower yield of big subsamples to the abundance of detritic material which partly hides the smaller organisms. However, we preferred to use the results given by the 10 ml subsamples because smaller volumes often contained less species.

Primary production

The potential primary production was measured by incubating samples for 3 to 4 hours in a water-bath at 15 $\pm$ 1°C and illuminated by Philips 33 fluorescent tubes. The light intensity (about 10,000 lux) is considered to be enough to keep most of species in the light-saturated state of photosynthesis. All the manipulations were made as in MOMMAERTS, 1973.

RESULTS

Biomass of phytoplankton

In order to estimate the standing crop and as cell numbers are not directly related to actual biomasses, we have calculated the cell volumes. Indeed, algal sizes vary considerably from the one species to the other.

Table I gives the calculated volumes of the different phytoplanktonic species. It then appears that the small peak in cell numbers in the springtime (fig. 1 and 2) corresponds to an algal volume (hence a biomass) of the same order of magnitude as in the early summer.

Seasonal evolution of the phytoplankton

1. General evolution

   Figures 1 and 2 show the total number of phytoplankton cells (stippled line) and total algal volume (solid line) for the periods March-August 1971 and 1972. The curves show one or two peaks during the spring. The maximum development of the nannoplankton occured from the beginning of June till the end of August. During 1971 the two peaks of 10th June and 1st July reached respectively 37,000 and 38,500 cells/ml (1.7 and 1.1 10^6 μm^3/ml). The peak of 19th July 1972 reached the remarkable number of 179,000 cells/ml (5.4 10^6 μm^3/ml).

2. Succession of nannoplanktonic populations and potential production in a central sampling station.

   Fig. 3 and 4 show the total algal volume of the different nannoplanktonic populations in 1971 and 1972, together with the potential production curve. The relationship between the potential production figures and the phytoplanktonic volumes is apparent : a maximum of primary production generally corresponds to the maximum development of one or more phytoplanktonic populations.

The first peak observed in the year was due to the growth of an Euglenophyceae : Eutreptiella marina DA CUNHA (1,970 cells/ml = 4.8 10^6 μm^3/ml on May 6th 1971; and 321 cells/ml = 7.8 10^5 μm^3 on April 18th 1972). The latter figure gave a poor indication of the real abundance of Eutreptiella in the Sluice Dock, due to an unusually strong inhomogeneity in phytoplankton distribution. Indeed numbers up to 3,850 cells/ml (9.4 10^6 μm^3/ml) were recorded in other places of the lagoon the same day.

An earlier peak of Skeletonema costatum CLEVE (3,600 cells/ml = 4.6 10^5 μm^3/ml) was observed on March 21th 1972. Its occurrence is discussed later.

Phytoplanktonic biomass remained high on and after the beginning of June.

In June 1971, a first peak appeared on June 10th and was mainly due to very small Bacillariophyceae and Cryptophyceae : Thalassiosira pseudonana (22,500 cells/ml = 6.8 10^5 μm^3/ml), and Plagioselmis punctata BUTCHER (12,400 cells/ml = 3.7. 10^5 μm^3/ml).

Together with Pyramimonas grossii PARKE (Prasinophyceae), Apedinella spinifera THRONDSEN (Chrysophyceae), various Dinophyceae (mainly Katodinium rotundatum (LOHM.) FOTT and Gymnodinium cf. pygmaeum LEBOUR) and some Chlorophyceae (mainly Chlamydomonas sp), these two populations provided most of the phytoplanktonic production until the end of June 1971.

On June 17th, many cells of an undetermined species of Chrysochromulina (Haptophyceae) were recorded, together with many cysts of Chrysophyceae, most probably belonging to the genus Chrysococcus. On the same day, the observation of living material showed clearly the presence of many species which were not normally present in the Sluice Dock. This event coincided with the unexpected partial opening of the sluices connecting the lagoon to the Ostend harbour on 17th June. On June 24th 1971 a new population of very small cells (3-4 μm) appeared. These were easily mistaken for Thalassiosira pseudonana once fixed and probably belonged to the genus Nephroselmis (Prasinophyceae). During the following months, the nannoplankton was principally composed of Plagioselmis punctata, Thalassiosira pseudonana and this Nephroselmis. At the end of July, Pyramimonas grossii and Apedinella spinifera reappeared.

In June 1972 increasing numbers of Pyramimonas grossii and Plagioselmis punctata were recorded during the first fortnight. Later on populations of Thalassiosira pseudonana and Chrysochromulina sp. appeared and became progressively dominant (July 12th 1972). Nephroselmis (?) was abundant with these two species and an enormous density was reached during the second half of July (179,000 cells/ml = 5.4 10^6 μm^3/ml on July 19th 1972). In August, Pyramimonas grossii, Plagioselmis punctata and Thalassiosira pseudonana were dominant and their abundance did not diminish until September 1972.

DISCUSSION

An inventory of the phytoplanktonic species that actually take a prominent part in pelagic primary production has been attempted in too few ecosystems. As in most known instances, the smallest forms (nannoplankton) were dominant in the Sluice Dock at Ostend.

The succession of several populations has been demonstrated. A definite parallelism in the evolution of phytoplanktonic populations was observed for the two years. Chronology : a peak of *Skeletonema costatum* was observed first (March 1972). Then, an early spring bloom of *Eutreptiella marina* (April-May) followed. The isolated occurrence of an *Eutreptiella* bloom draws attention to the autecology of this species. This might be connected to the fact that the bloom coïncided with the exhaustion of organic matters in the Sluice Dock (PODAMO, 1972). The semi-heterotrophic characteristics known for most Euglenophyceae probably apply to *Eutreptiella*. This peak was followed by a period of about one month without any important production (this aspect is discussed further below). Then (from June to August) primary production became important until the sluices were opened again.

Among the different species, it is necessary to distinguish between indigenous and imported populations. It is known that the sluices were opened once in 1971 and several times in 1972 for partial replenishment.

Skeletonema costatum seems to be one of the imported species. Indeed it usually developed in the Sluice Dock about a week after the sluices had been opened and persisted then for about a fortnight. In the same way some marine neritic diatoms observed by SOMERS in 1972 and many flagellates (especially Apedinella spinifera, Pyramimonas grossii and Katodinium rotundatum) can also be listed as imported species. Amongst the dominant species, Eutreptiella marina, Cryptophyceae (especially Plagioselmis punctata), Thalassiosira pseudonana and small Prasinophyceae (one of them probably belonging to the genus Nephroselmis) are probably indigenous. We know however that at least Eutreptiella marina and Thalassiosira pseudonana can also be abundant in Ostend harbour.

The production / standing crop ratio (i.e. productivity; here potential production / algal volume) ~~was~~ is usually very revealing, as related to the specific composition as well as to the physiological state of the phytoplankton. We think however that in the Sluice Dock productivity is indicative of environmental characteristics rather than an indicator of the specific composition of the phytoplankton. One can see e.g. (1972) that the productivity diminishes all the time when Eutreptiella marina is the only species present. This can be related to the simultaneous nitrate-and probably other nutrients - decrease (fig. 5). In May the productivity increased quickly. This might be linked to several possible stimulations : quick temperature increase at the beginning of May (from 10 to 15°C in a few days), or excretions by the zooplankton (e.g. ammonium). So far, the diminution of productivity in June cannot be explained.

The low production period in May deserves special attention. Indeed, phytoplankton should be blooming at this time of the year (cf. other marine ecosystems). The high productivity demonstrated at this time of the year supports this impression. The zooplankton (mostly copepods) curve shows a tremendous peak at this time of the year (fig. 6) and may be zooplankton prevents all phytoplankton increase by grazing most of the produced stock. This particular behaviour of the Sluice Dock ecosystem is possible because the zooplankton is not sufficiently limited by predators. The grazing effect in the Sluice Dock at Ostend will be discussed in a future paper.

ACKNOWLEDGEMENTS

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LEGEND OF FIGURES

Fig. 1 : Total number of cells / ml and total algal volume of the nannoplankton in the Sluice Dock at Ostend (Belgium) in 1971.

Fig. 2 : Total number of cells / ml and total algal volume of the nannoplankton in the Sluice Dock at Ostend (Belgium) in 1972.

Fig. 3 : Succession of species, algal volume / ml and potential production of the nannoplankton in the Sluice Dock at Ostend (Belgium) in 1971.
A : *Skeletonema costatum*, B : *Eutreptiella marina*, C : *Plagioselmis punctata*, D : *Pyramimonas grossii*, E : *Apedinella spinifera*, F : Dinophyceae, G : *Cryptomonas* div. sp., H : *Thalassiosira pseudonana* + *Nephroselmis* (?) + *Chrysochromulina* sp., J : Chlorophyceae.

Fig. 4 : Succession of species, packed cell volume / ml and potential production of the nannoplankton in the Sluice Dock at Ostend (Belgium) in 1972.
Same letters as in fig. 3.

Fig. 5 : Phytoplanktonic productivity (potential production / algal volume) in the Sluice Dock at Ostend (Belgium) in 1972 (black circles ~~dashed line~~). The evolution of nitrate concentration (open circles ~~thin solid line~~) is given at the same time.

Fig. 6 : Phytoplanktonic potential production (thick line) and of zooplankton biomass (thin line) in the Sluice Dock at Ostend (Belgium) in 1972.

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Species	Volume in μm^3
Eutreptiella marina	2.440
Cryptomonas div. sp.	546
Dinophyceae	400
Platymonas tetrathele	340
Apedinella spinifera	200
Pyramimonas grossii	150
Skeletonema costatum	126
Chrysochromulina sp.	113
Nephroselmis (?)	33
Plagioselmis punctata	30
Thalassiosira pseudonana	30

Table I. : Mean cell volumes of the most important nanno-plankton species in the Sluice Dock at Ostend (Belgium), calculated with the microscope..

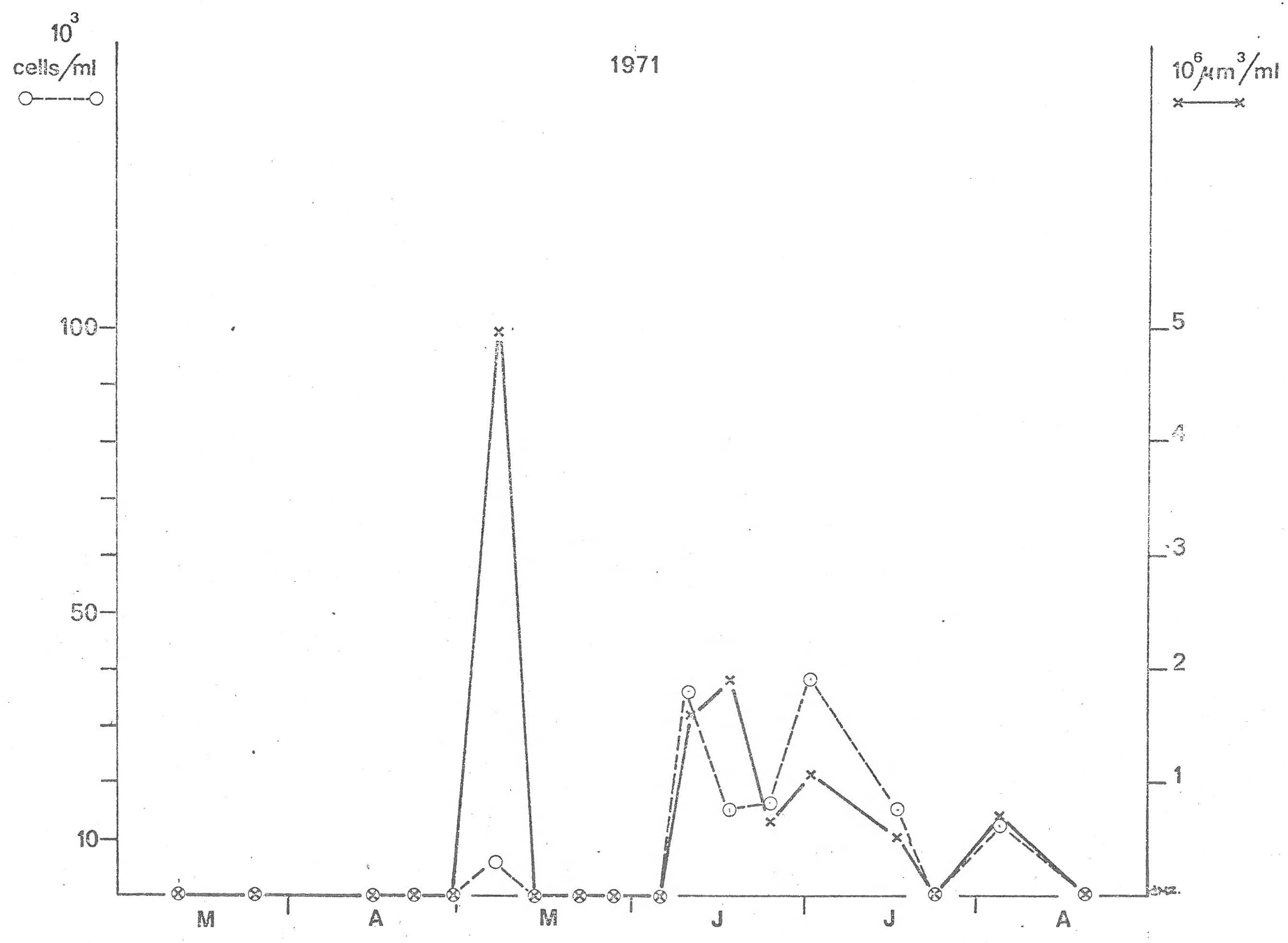


FIG 1

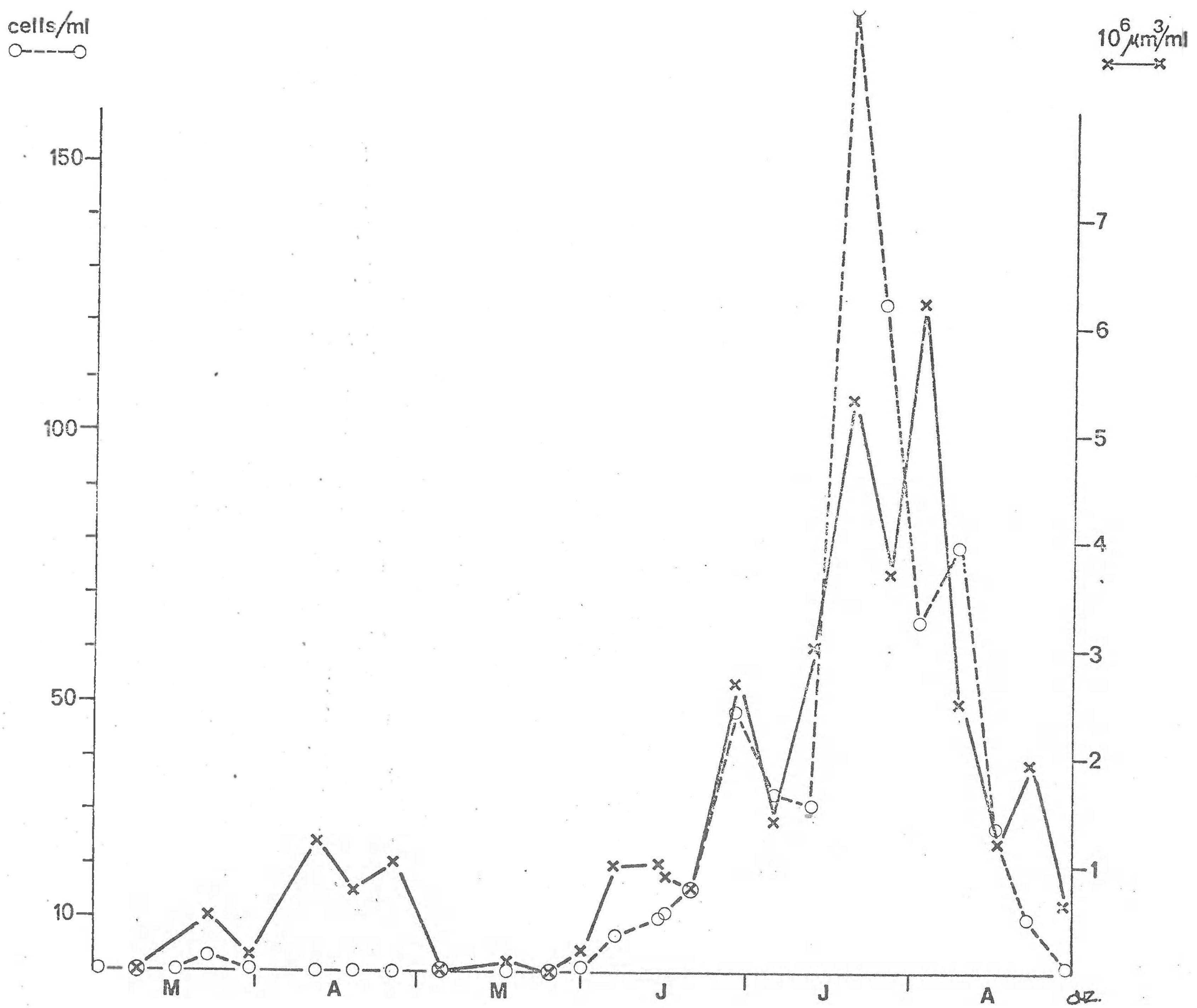
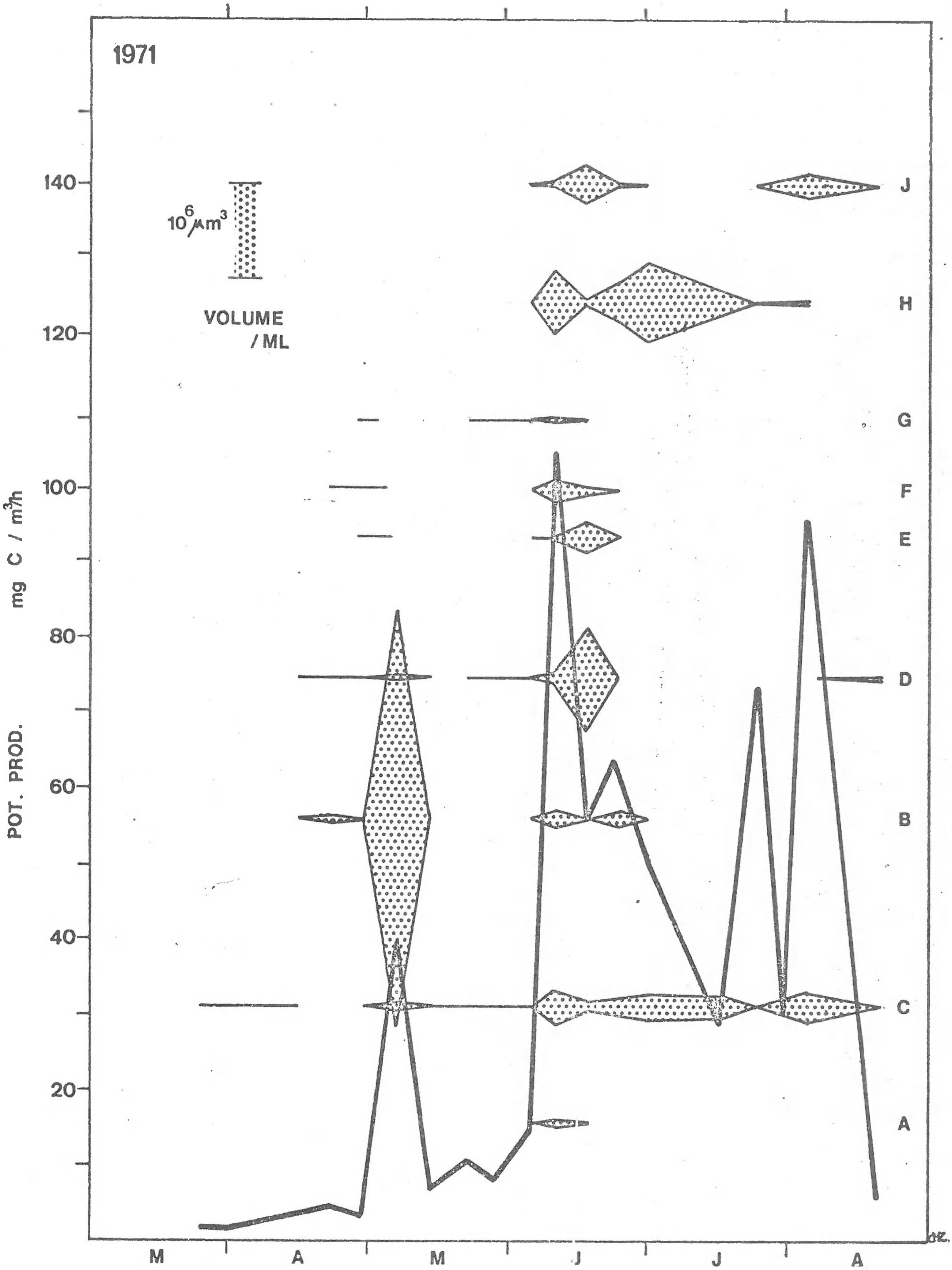


Fig 2



1971
10⁶ µm³
VOLUME / ML
POT. PROD. mg C / m³/h
140
120
100
80
60
40
20
J
H
G
F
E
D
B
C
A
M
A
M
J
J
A

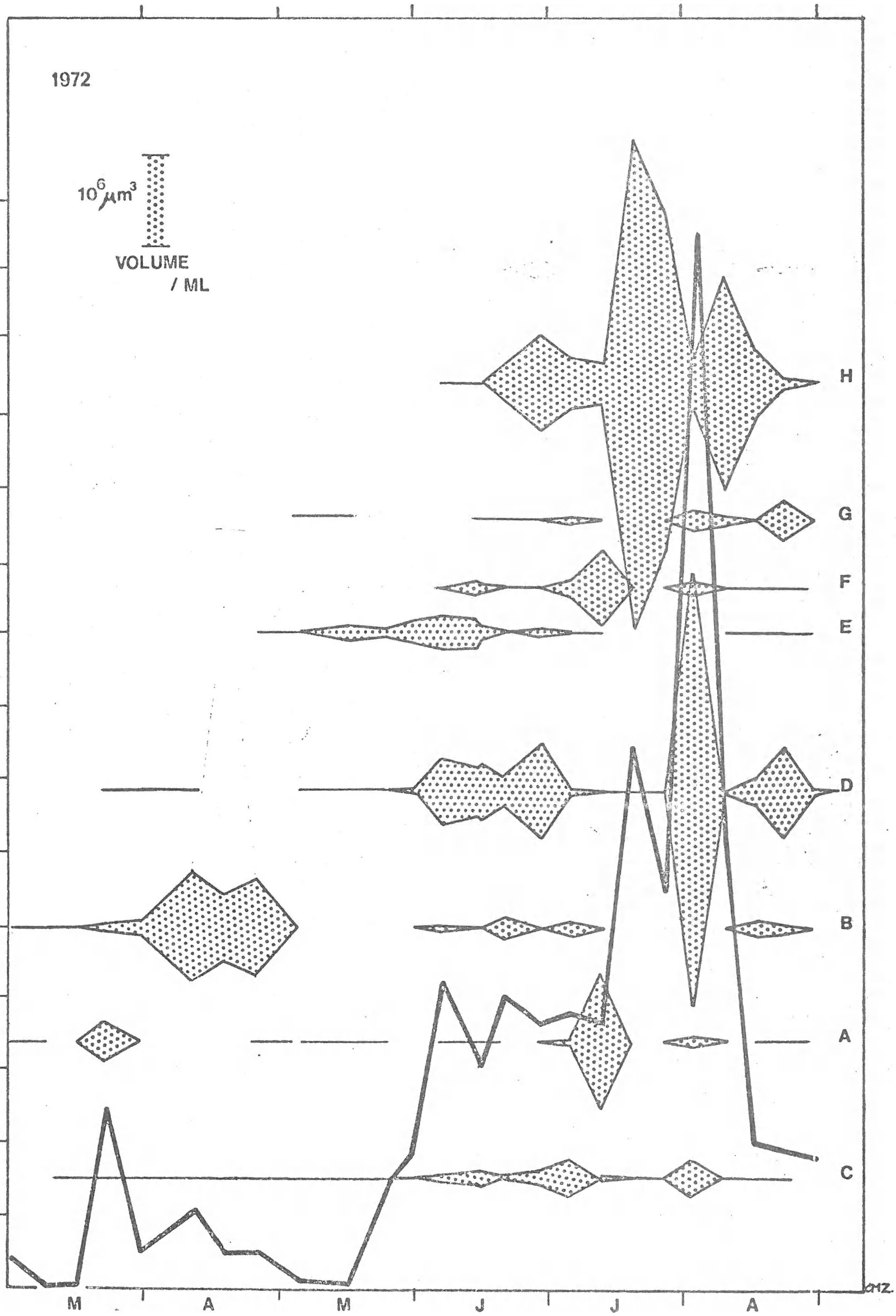
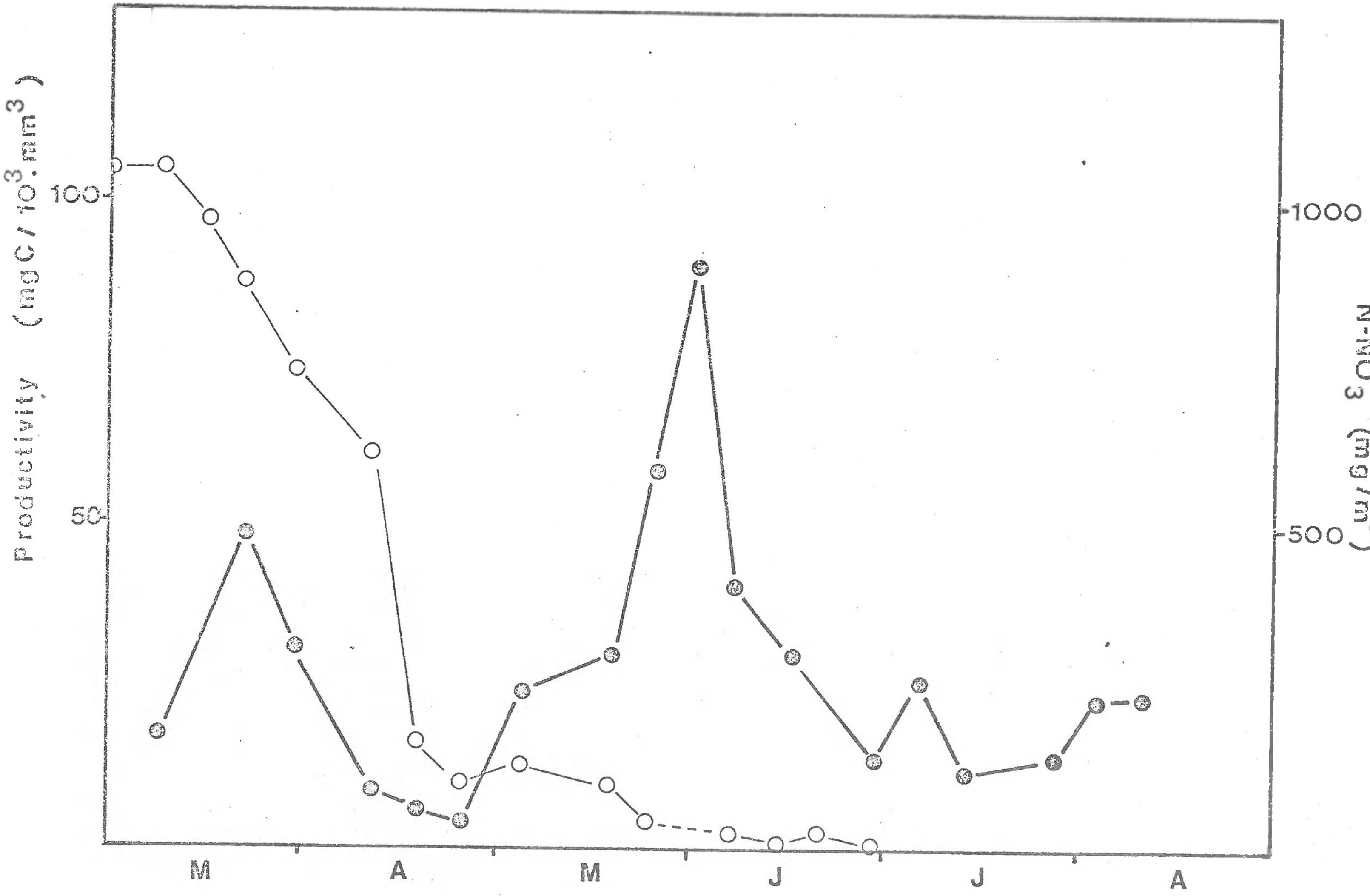
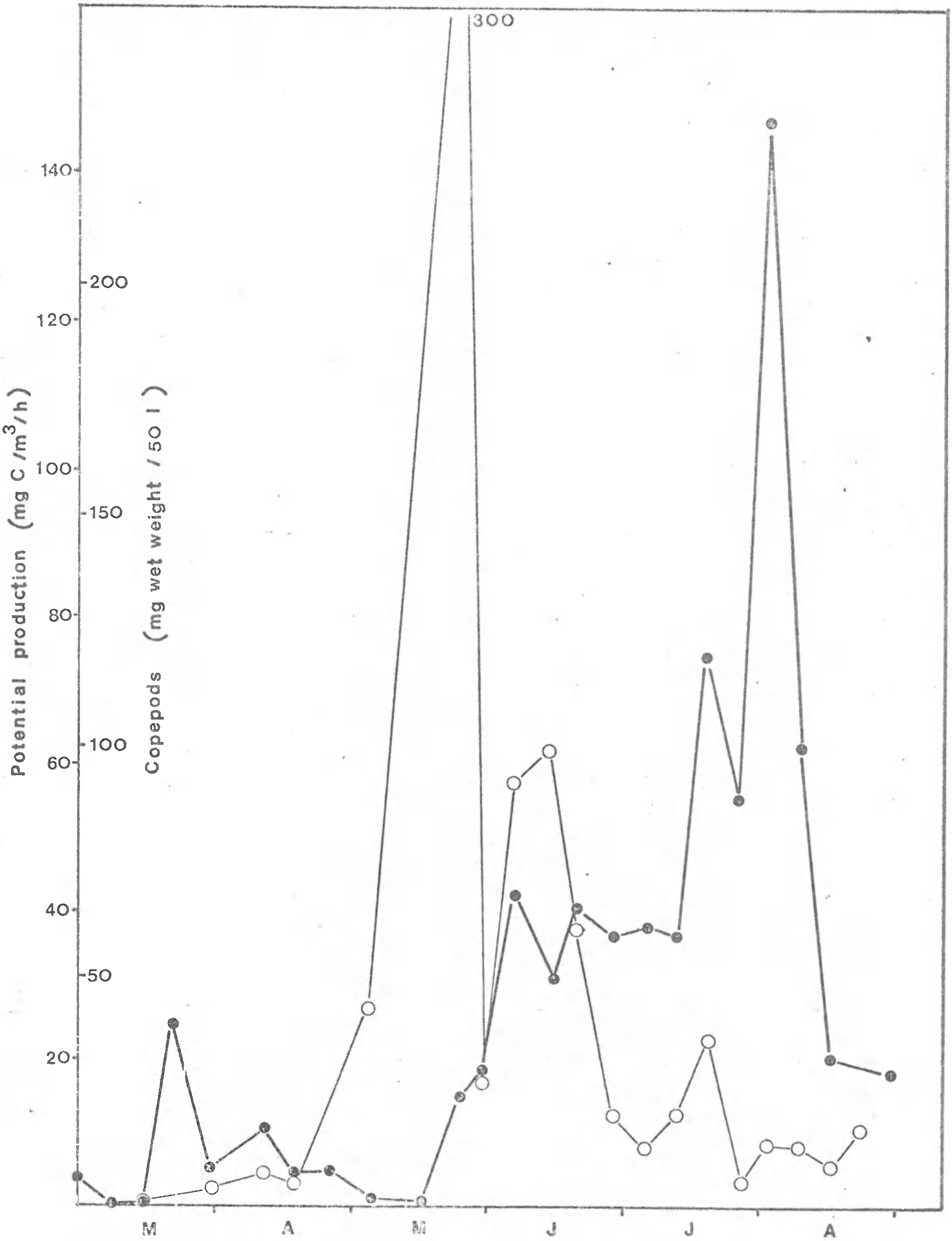

1972
$10^6 \mu m^3$
VOLUME / ML
POT. PROD. mg C / m³/h
140
120
100
80
60
40
20
H
G
F
E
D
B
A
C
M
A
M
J
J
A
CHZ.

FIG 4



Productivity (mg C / 10^3.mm^3)
100
50
N-NO$_3^-$ (mg/m^3)
1000
500
M
A
M
J
J
A


300
140
200
120
Potential production (mg C/m3/h)
Copepods (mg wet weight / 50 l)
100
150
80
60
100
40
50
20
M
A
M
J
J
A

6