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VARIATION IN SPACE AND TIME OF DIFFERENT PHYTOPLANKTON SPECIES DURING SKAGEX I

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During SKAGEX I surveys were carried out from the northern Kattegat to the border between the Skagerrak and the North Sea in May-June 1990. This paper presents data of some important phytoplankton species with focus on abundance and distribution in the area. The SKAGEX phytoplankton database and its software (OSTROWSKI 1999) was used. The species were from the dinoflagellate genera *Dinophysis* and *Ceratium*; *D. acuminata*, *D. acuta*, *D. norvegica*, *C. furca*, *C. fusus*, *C. lineatum*, *C. longipes* and *C. tripos*, and two diatoms, *Proboscia alata* and *Skeletonema costatum*. During the expedition eight sections including 6-12 stations were sampled, according to an agreed procedure, every third day from 24 May until 20 June. Some of the dinoflagellate species and the diatoms were rather common often occurring in the whole area. There was a difference between species as to their peak times. Maximum cell concentrations were often found around 20 m depth (near the halocline). All species had a pronounced spatial and time variation (patchiness). A closer analysis of the relation between distribution and abundance of the species and the influence of other factors is necessary for a better understanding of the wide variations of the Skagerrak and northern Kattegat phytoplankton.

Emneord - norsk:
1. Skagerrak/Kattegat
2. SKAGEX I
3. Alger

Emneord - engelsk:
1. Skagerrak/Kattegat
2. SKAGEX I
3. Algae

Prosjektleder

Seksjonsleder

VARIATION IN SPACE AND TIME OF DIFFERENT PHYTOPLANKTON SPECIES DURING SKAGEX I

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SUMMARY

During SKAGEX I surveys were carried out from the northern Kattegat to the border between the Skagerrak and the North Sea in May-June 1990. This paper presents data of some important phytoplankton species with focus on abundance and distribution in the area. The SKAGEX phytoplankton database and its software (OSTROWSKI 1999) was used. The species were from the dinoflagellate genera *Dinophysis* and *Ceratium*; *D. acuminata*, *D. acuta*, *D. norvegica*, *C. furca*, *C. fusus*, *C. lineatum*, *C. longipes* and *C. tripos*, and two diatoms, *Proboscia alata* and *Skeletonema costatum*. During the expedition eight sections including 6-12 stations were sampled, according to an agreed procedure, every third day from 24 May until 20 June. Some of the dinoflagellate species and the diatoms were rather common often occurring in the whole area. There was a difference between species as to their peak times. Maximum cell concentrations were often found around 20 m depth (near the halocline). All species had a pronounced spatial and time variation (patchiness). A closer analysis of the relation between distribution and abundance of the species and the influence of other factors is necessary for a better understanding of the wide variations of the Skagerrak and Northern Kattegat phytoplankton.

SAMMENDRAG

Under SKAGEX I ble det i mai-juni 1990 foretatt algeundersøkelser fra det nordlige Kattegat til grensen mellom Skagerrak og Nordsjøen. Denne rapporten presenterer, ved hjelp av SKAGEX phytoplankton database og software (OSTROWSKI 1999), data over noen viktige phytoplanktonarter med fokus på tallrikhet og utbredelse i området. Artene bestod av dinoflagellatene *Dinophysis* og *Ceratium*; *D. acuminata*, *D. acuta*, *D. norvegica*, *C. furca*, *C. fusus*, *C. lineatum*, *C. longipes* og *C. tripos*, og diatomeene *Proboscia alata* og *Skeletonema costatum*. I løpet av perioden ble det tatt prøver fra åtte lokaliteter med 6-12 stasjoner hver tredje dag fra 24. mai til 20. juni i følge standard prosedyre. Noen av dinoflagellatartene og diatomeene var ganske vanlige og forekom ofte i hele området. Det var forskjell mellom artenes kulmineringstidspunkt. Maksimum cellekonsentrasjoner ble ofte funnet i ca 20 m dyp (nær haloklinen). Alle arter hadde en utpreget flekkvis utbredelse i tid og rom. En nærmere analyse av forholdet mellom artenes utbredelse og mengde og innflytelse av andre faktorer er nødvendig for å få en bedre forståelse av de store variasjonene av phytoplankton i Skagerrak og nordlige Kattegat.

INTRODUCTION

The Skagerrak belongs to the transition area between the North Sea and the Baltic Sea. Both seas heavily influence it. The hydrographical conditions in the Skagerrak are complicated and the biological production exceeds that of the adjacent sea areas. Research has been carried out in the area for more than one hundred years, but still there is a lack of knowledge on specific features such as the transport mechanisms and the reasons for the high production in the area. The Danish-Norwegian-Swedish Committee on the Fisheries and Environment in the Skagerrak-Kattegat area therefore suggested additional research, and The Skagerrak Experiment (SKAGEX) was one of two projects initiated. SKAGEX turned out to be a very large international marine research project.

The main aim of SKAGEX was to identify and quantify the different water masses entering and leaving the Skagerrak area and variation over time. It also aimed at investigating the mechanisms that drive the circulation and to study their effects on the biological processes. SKAGEX was divided into four periods (I-IV); in May-June and September 1990, and in January and May 1991. Data on physical, chemical and biological parameters were obtained from stations along eight sections in the Skagerrak-Kattegat area (Fig. 1). DANIELSSEN *et al.* (1997) described oceanographic variability in the Skagerrak and northern Kattegat based on the data from SKAGEX I. This paper includes results obtained during SKAGEX I on abundance, distribution and variation in time and space of some chosen phytoplankton species in the Skagerrak-Kattegat area. The underlying data are stored in a SKAGEX phytoplankton database, developed by M. OSTROWSKI (1999).

MATERIALS AND METHODS

Fig. 1 shows the investigation area during SKAGEX I in which exercise 17 ships took part during different periods. Surveys from the northern Kattegat to the border between the Skagerrak and the North Sea were carried out along eight sections (A-H) every third day from 24 May until 20 June 1990. Stations along the sections were sampled according to an agreed procedure and data on physical, chemical and biological parameters were sampled. The stations are numbered and the lowest numbers are near the coast of Norway and Sweden, with increasing numbers toward the coast of Denmark. The species for which data are presented are members of the genus *Ceratium* Schrank, one of the most common dinoflagellate groups in marine environment: *C. furca*, *C. fusus*, *C. lineatum*, *C. longipes* and *C. tripos*. In addition some of the most common species of the genus *Dinophysis* Ehrenberg in Scandinavian coastal waters, *D. acuminata*, *D. acuta*, *D. norvegica* and *D. rotundata* were presented. The latter species may cause diarrhetic shellfish poisoning (DPS) in man through occurrence in edible mussels. *D. acuminata*, *D. acuta* and *D. norvegica* have been monitored in the Skagerrak since 1984 (DAHL 1989). Two diatoms, *Proboscia alata* and *Skeletonema costatum* have also been dealt with. *S. costatum* is a cosmopolitan (HASLE & SYVERTSEN 1996) and one of the most common phytoplankton species.

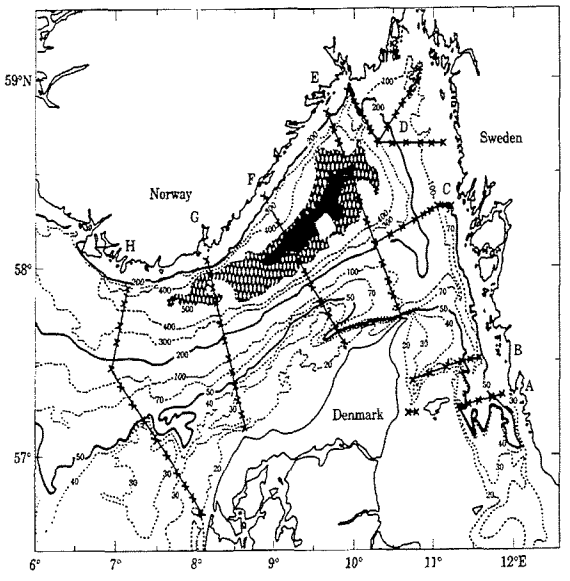

Fig. 1. Map showing the different sections B, C, D, E, F, G and H with the positions of the stations (from DANIELSSEN *et al.* 1997).

In situ fluorescence was measured with a fluorometer from 0 to at least 30 m depth. Phytoplankton samples were collected at all stations at 0, 5 and 10 m depths, at the fluorescence peak and the first standard depth (20 or 30 m) below the peak. Before counting equal amounts of water from 1, 5 and 10 m were mixed and preserved with acidified Lugol's solution, in a concentration of 2 ml/100 ml sample. Plankton samples were counted using the Utermöhl method, and volumes of 10 or 20 ml were sedimented. Larger species were counted in the whole bottom area of the sedimentation chambers, using a magnification of 40-100 times, whereas smaller and more abundant species were counted in smaller sections of the bottom area in magnifications of 100-400 times. The area counted depended on the abundance of the actual species. At least 50 cells of the most abundant species were counted which gives a theoretical error up to 28 % higher for the less abundant species. Detection limit was about 50-100 cells litre^{-1}. Phytoplankton samples were not counted from all of the sections and

stations at every sampling date. The selected stations and days are shown in Table 1. The species selected for this paper are rather large and easy to identify. All samples were counted at a Plankton Sorting Centre at the Sea Fisheries Institute in Gdynia, Poland. The results of phytoplankton counting have then been introduced into the SKAGEX phytoplankton database (OSTROWSKI 1999) used for this paper. The samples from 0-10 m were mainly used during data evaluation because they were regularly taken.

Table 1. Sampling dates and stations included in this study for 0-10 m depth.

Date	Sections							Tot. number of stations
	B	C	D	E	F	G	H	
24.05.90		1, 3, 5, 9			1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12	8, 10, 12		18
27.05.90		1, 3, 5, 7, 9		9, 10, 11, 12	1, 2, 5, 8, 10, 11, 12	1, 2, 4, 5, 6, 10, 11	1, 2, 4, 5, 7, 9, 10, 11, 13, 15	33
30.05.90	1, 3, 5, 6	1, 2, 3, 5, 7, 8, 9		12	1, 2, 5, 8, 10, 11, 12	1, 3, 4, 5, 8, 9, 10, 11	1, 2, 4, 6, 9, 10, 13, 14	35
02.06.90	1, 3, 5, 6	1, 3, 6, 8		10, 11, 12	1, 2, 5, 8, 10, 11, 12	1, 2, 3, 4, 5, 8, 9, 12	1, 2, 4, 6, 8, 10, 12, 14	34
05.06.90	1, 3, 5, 6	4, 6, 8	3, 5, 7, 9	9, 10, 11, 12	1, 2, 5, 8, 10, 11, 12	1, 3, 4, 5, 7, 08, 11	2, 4, 6, 8, 10, 12, 14	36
08.06.90	1, 2, 4, 6	4, 5, 7, 8, 10	3, 5, 7, 9	2, 4, 6, 8, 9, 11, 12	2, 3, 4, 6, 8	1, 2, 3, 4, 5, 7, 9, 10, 11, 12	6, 8, 10, 12, 14, 15	41
11.06.90	1, 2, 4, 6	3, 5, 6, 8, 10	2, 5, 6, 7, 10	1, 2, 4, 6, 8, 9, 11	1, 3, 5, 7, 8, 9, 10, 12	1, 2, 4, 5, 7, 9, 10, 11, 12	6, 8, 10, 12, 14, 15	44
14.06.90	1, 3, 5, 6	3, 4, 6, 8, 10	3, 4, 6, 8, 10	2, 5, 6, 7, 8, 9, 11, 12	1, 3, 4, 5, 6, 7, 8, 9, 11	2, 3, 4, 5, 7, 9, 11, 12	6, 8, 10, 12, 14, 15	45
17.06.90	1, 2, 3, 4, 5, 6	3, 5, 8	1, 3, 5, 6, 9, 10	2, 5, 7, 8, 9, 11, 12	2, 3, 4, 5, 8, 9, 11, 12	2, 4, 5, 6, 7, 09, 11, 12	6, 8, 10, 12, 13, 14, 15	45
20.06.90	1, 2, 4, 6	3, 5, 8		8, 9, 11, 12	1, 2, 3, 4, 5, 6, 8, 9, 11, 12	1, 2, 3, 4, 5, 6, 7, 8, 10, 11	6, 8, 10, 13, 14, 15	37

Maps (Figs 2-14) are illustrating the distribution and the variation in time and space of the species. In addition some Figures and Tables were made during data evaluation. Average cell numbers of the different sections B, E, F, G and H at all sampling dates are illustrated in Fig. 15, and the local distribution of some *Ceratium* and *Dinophysis* species in Flødevigen Bay is shown in Fig. 16 and 17. Figs 18-20 showing the occurrence along sections F and G (cf Fig. 1). Fig. 21 shows the occurrence of some species along section B. Tables 2-5 show the species distribution in section B, F and G where a grouping of different cell numbers of the species is done. Sections F, G and H are in the Skagerrak while section B is in the northern Kattegat (Fig. 1). Detailed numbers from the countings can be found in Appendix 1a-k.

The data presentation of each species includes a description of their abundance, after STEIDINGER & TANGEN (1996) and HASLE & SYVERTSEN (1996) for dinoflagellates and diatoms respectively.

RESULTS

Below are some results regarding the investigated species as deducted from the distribution maps in Figs 2-14.

Ceratium furca (Ehrenberg) Claparède & Lachmann
Distribution: Principally coastal, but found in estuarine and oceanic environments; cosmopolitan in cold temperate to tropical waters.
C. furca was sporadically present through May and June at 0-10 m, and occurred in the Skagerrak with highest cell numbers in the beginning of the period (Fig. 2). The species was only present at 20 m on 8 June. *C. furca* showed a rather patchy distribution in the area. This is also demonstrated for sections F and G in Fig. 18.

C. fusus (Ehrenberg) Dujardin
Distribution: Oceanic to estuarine; principally coastal. Cosmopolitan in cold temperate to tropical waters.
The occurrence of *C. fusus* at 0-10 m increased from the end of May to the beginning of June in both the Skagerrak and northern Kattegat, and it was rather homogeneously distributed in more or less the whole area throughout the investigation period (Fig. 3). The species was not present along the F section at 24 May (Fig. 18C), but in the rest of May it occurred in its southern part. On 2 June it was present along the whole section F with the highest cell numbers (500-5000 cells litre^{-1}) near the Danish coast (station F12). Later in June the species showed a patchy and varying, but wide, distribution in the Skagerrak. The distribution was more or less similar at section G (Fig. 18C and D). *C. fusus* was also common in the northern Kattegat, and rather numerous in section B especially from 8 June (Fig. 18B). On 14 June the concentrations at 20 m depth were higher than in 0-10 m at a number of stations (Fig. 13A).

***C. lineatum* (Ehrenberg) Cleve**
Distribution: Neritic, oceanic; cold temperate to tropical waters. There may be distinct warm water forms.
C. lineatum was present at 0-10 m all sampling dates, but generally occurred at less stations than *C. fusus* and *C. tripos* (Fig. 4). The species was also present at 20 m throughout the period. Maximum cell concentrations of the species, both at 0-10 m ($1{,}6 \cdot 10^4$ cells litre^{-1}) and 20 m ($2{,}3 \cdot 10^4$ cells litre^{-1}) were rather high (sf. also Appendix 1c). At 0-10 m maximum occurred on 27 May at the F section, and at 20 m it was observed on 14 June at section C (Fig. 7B). The species varied at section F and showed a more patchy occurrence from 24 May to 8 June than later (Fig. 18E). At section G the species was most common from 27 May to 8 June (Fig. 18F). Generally it was less common at the northern coast of Denmark, both at section F and G. At section B *C. lineatum* showed a rather patchy distribution but was present on every sampling date from 30 May (Fig. 18C).

***C. longipes* (Bailey) Gran**
Distribution: Coastal. Arctic to cold temperate waters
C. longipes, as *C. lineatum*, was present at fewer stations than *C. fusus* and *C. tripos* but was found in more or less all parts of Skagerrak at 0-10 m (Fig. 5). The occurrence was patchy and sometimes rather scarce at section F (Fig. 18G). At 5 June the species was only observed near the coast of Denmark, but in the rest of the period it was most common at the Norwegian side of Skagerrak. *C. longipes* was most abundant from 27 May until 5 June at section G (Fig. 18H). At section B the species showed a patchy distribution, and was present throughout the

whole period from 30 May (Fig. 18D). Considerably higher concentrations were found at 20 m depth than at 0-10 m depth on 11 June (Fig. 13C).

***C. tripos* (O.F. Müller) Nitzsch**
Distribution: Coastal and oceanic. Cosmopolitan in cold temperate to tropical waters; world-wide distribution.
The occurrence of *C. tripos* increased from late May into June in the Skagerrak-Kattegat area, and the species was common in all parts of the area at 0-10 m (Fig. 6). Average cell numbers per section on each sampling date showed generally increasing occurrence in section E-H (Fig. 15A). In the F section the species showed this increasing tendency toward the middle and end of June with cell numbers between 50-500 cells l^{-1} (Fig. 18I). It was not present at 24 May. At section G *C. tripos* was more or less common throughout the whole period, and occurred mostly with cell numbers between 50-500 cells l^{-1} (Fig. 18J). In section B the species was fairly uniformly distributed throughout the whole period (Fig. 18E). It occurred with 500-5000 cells l^{-1} at station B1 near the Swedish coast in May and June. The abundance was however somewhat varying at station B6 close to the Danish coast.

***Dinophysis acuminata* Claparède & Lachmann**
Distribution: Neritic; typically cold and warm temperate waters.
D. acuminata was especially numerous at 0-10 m along the F section from the Norwegian coast and out into the Skagerrak on 24 and 27 May (Fig. 7, Fig. 19A). The species was present in all Skagerrak in the whole period. It was also present at 20 m. It was observed at section F on the coast of Norway from 24 May (50-500 cells l^{-1}) to 2 June (500-5000 cells l^{-1}) see Fig. 19A. From 8 June the abundance was low and patchy along the section. The species was also most common at section G in the beginning of the period (27 May-8 June) and it generally occurred with highest abundance at and off the Norwegian coast (Fig. 19B). From 2 June to 14 June it was not observed near the Danish coast, and the occurrence was scarce in all Skagerrak from 11 to 20 June. At section B the species was most common at station B12 compared with B1 where it was only present on 30 May and 8 June (Fig. 21F).

***D. acuta* Ehrenberg**
Distribution: Oceanic and neritic; cold temperate, world-wide.
D. acuta was present only at relatively few stations at each sampling date, except for the G section (Fig. 8, Fig. 19D). The species was also observed at 20 m. Along section F it showed a rather scarce and patchy occurrence at 0-10 m (Fig.19C), and at section B it was only observed on station B4 at 17 and 20 June (Fig. 21G).

D. norvegica Claparède & Lachmann
Distribution: Neritic; cold-water species.
D. norvegica was present in quite high concentrations at 0-10 m in the whole area throughout the investigation period (Fig. 9, Fig. 19E). It was also common at 20 m. A close-up of the situation however shows temporal variations, at most sections. As to sections F and G the species was common, but generally showing a small decrease from mostly 500-5000 cells l^{-1} to 50-500 cells l^{-1} toward the end of June, especially along section G. In section B it was common with concentrations between 500-5000 cells l^{-1} all through the period 24 May-20 June (Fig. 21H).

***D. rotundata* Claparède & Lachmann**
Distribution (as *Phalacroma rotundatum*): cold and warm waters; cosmopolitan

D. rotundata was only observed at a few stations throughout the period (Fig. 10). The maximum concentration found at 0-10 m was surprisingly high, $3{,}4 \cdot 10^5$ cells litre^{-1} (Appendix 1i), and also at 20 m rather high cell numbers were observed. Both maxima occurred on 8 June at station C4, and both before and after this date the species showed low or no presence in the same area. Along the F and G sections the species only showed up now and then at 0-10 m. In section B *D. rotundata* was only recorded on 20 June (Figs. 10, and 21).

***Proboscia alata* (Brightwell) Sundström**

Distribution: It is a widespread species, but according to SUNDSTRÖM (1986) its biogeographical limits cannot be determined without further research.

The diatom *Proboscia alata* was very common and numerous at 0-10 m in the whole area during the investigation period (Fig. 11). It was also found commonly at 20 m. On 20 June the maximum occurrence at 0-10 m was at the Norwegian coast, $1{,}9 \cdot 10^5$ cells l^{-1} at station F2 (Appendix 1j), and maximum at 20 m was also high. *P. alata* showed a more or less constant concentration over time except in section B (Fig. 15C) where the values increased strongly 8-17 June. The species was abundant in the whole period at section F, but toward the end of June (17 and 20) it was mainly present on the Norwegian side. The species was also numerous at section G.

***Skeletonema costatum* (Greville) Cleve**

Distribution: Cosmopolitan (absent from the high Arctic and Antarctic).

Skeletonema costatum showed a patchy distribution throughout Skagerrak with greater concentrations in the outer and central Skagerrak on 27 May to 5 June (Fig. 12). It also occurred at 20 m depth with the highest concentrations in outer Skagerrak on 2 June (Fig. 14E). During the peak period the number of cells was much higher along section G than section F (Fig. 20). The highest concentrations at section B were at the end of the investigation period (Fig. 12).

DISCUSSION

For this description of their variability the phytoplankton species dealt with were chosen because they are known to be fairly abundant in the Skagerrak and adjacent areas. Already at the field investigations during SKAGEX I in May-June 1990 the patchy distribution of the species was registered as well as occasional higher concentrations at ca. 20 m depth than at the surface layers. Analyses of data collected in the SKAGEX phytoplankton database have confirmed earlier observations and given further details.

Three species, *Ceratium furca*, *Dinophysis acuta* and *D. rotundata* were present but proportionately scarce throughout the end of May and in June. *C. furca* is common in autumn (DAHL & JOHANNESEEN 1998) while *D. acuta* has its main season in late summer and autumn (DAHL 1989). *D. rotundata* was absent for several days but had a sudden bloom near the Swedish coast on 8 June (Fig. 10).

C. lineatum, *C. longipes*, *C. tripos*, *D. norvegica* and *Proboscia alata* were common and showed the same main pattern over the whole area during the entire period although with variations. Most *Ceratium* species appear in spring and then increase during summer reaching peaks in August-September (DAHL & JOHANNESEN 1998). A few species showed a clearly increasing cell concentration over the area from late May into June, e.g., *C. fusus*, *C. tripos* and *P. alata* while *D. acuminata* and *Skeletonema costatum* showed a decrease, probably demonstrating their character as spring species.

Species along the Norwegian Skagerrak coast belonging to the genus *Dinophysis* are usually found in low concentrations with blooms seldom exceeding $1 \cdot 10^4$cells l^{-1} (DAHL & JOHANNESEN, op.cit.). The high cell concentrations of *D. acuminata* and *D. norvegica* met during SKAGEX I must be considered as very high (Fig. 19).

C. fusus, *C. lineatum*, *C. longipes*, *C. tripos* and *S. costatum* had at times higher cell numbers at 20 m depth than in the surface layer (0-10 m). Maximum chlorophyll-a concentrations during SKAGEX I were generally found at about 20 m, but could sometimes be near the 10 m or the 30 m depth. The surface layer in the Skagerrak formed during the investigation an upper layer, approximately 20 m deep (salinity 20-30 psu) which was separated from the deeper water (salinity 33-35 psu) by a halocline (DANIELSSEN *et. al* 1997) and the importance of this difference for the vertical distribution of the species has to be investigated further.

All investigated species showed a typical patchiness both geographically and during time (Figs 2-14). Figs 18-21 also show pronounced changes of concentrations of cells in space and time. Figs 16 and 17 show the time variation of the *Ceratium* and *Dinophysis* species in the Flødevigen Bay (inner Norwegian coast section F). Although generally demonstrating the same general trend prevailing for the whole region this local area also showed local deviations. The development of *Ceratium lineatum* was, e.g., very weak until the middle of June while at large the species was well represented over the area from the end of May. A similar development occurred for *C. tripos*. The occurrence of *Dinophysis acuminata* died out quicker in the Flødevigen Bay than at several other localities.

On the whole the variations in space and time of the investigated species both in the Skagerrak and the Northern Kattegat were very pronounced. Changes of distribution and cell concentrations generally occurred rapidly and the total number of cells could vary profoundly

from one sampling date to the other (every third day). The various sections were investigated simultaneously, which further underlines the changeability of the phytoplankton system. The reasons are to be sought in the great variability of hydrographic factors which influence the distribution and quantities of different phytoplankton species and which are described by DANIELSSEN *et al.* 1997, based on the SKAGEX results, and others. A closer examination on the relation between the phytoplankton distribution and the influence of physical, chemical and other factors will bring us to a better understanding of the complexity of the Skagerrak-Kattegat area.

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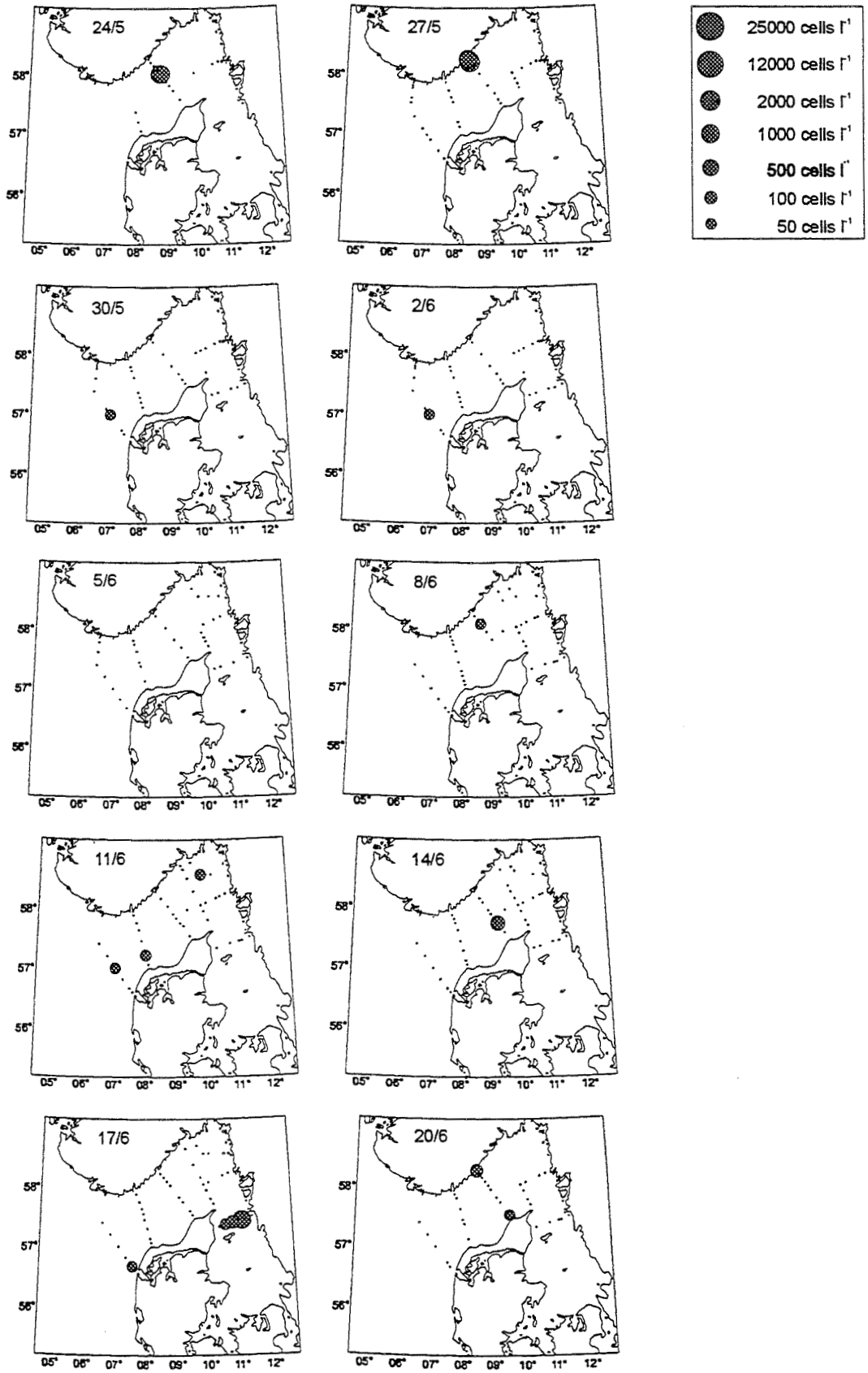


Fig. 2. Occurrence of *C. furca* at 0-10 m from 24 May to 20 June, log scale.

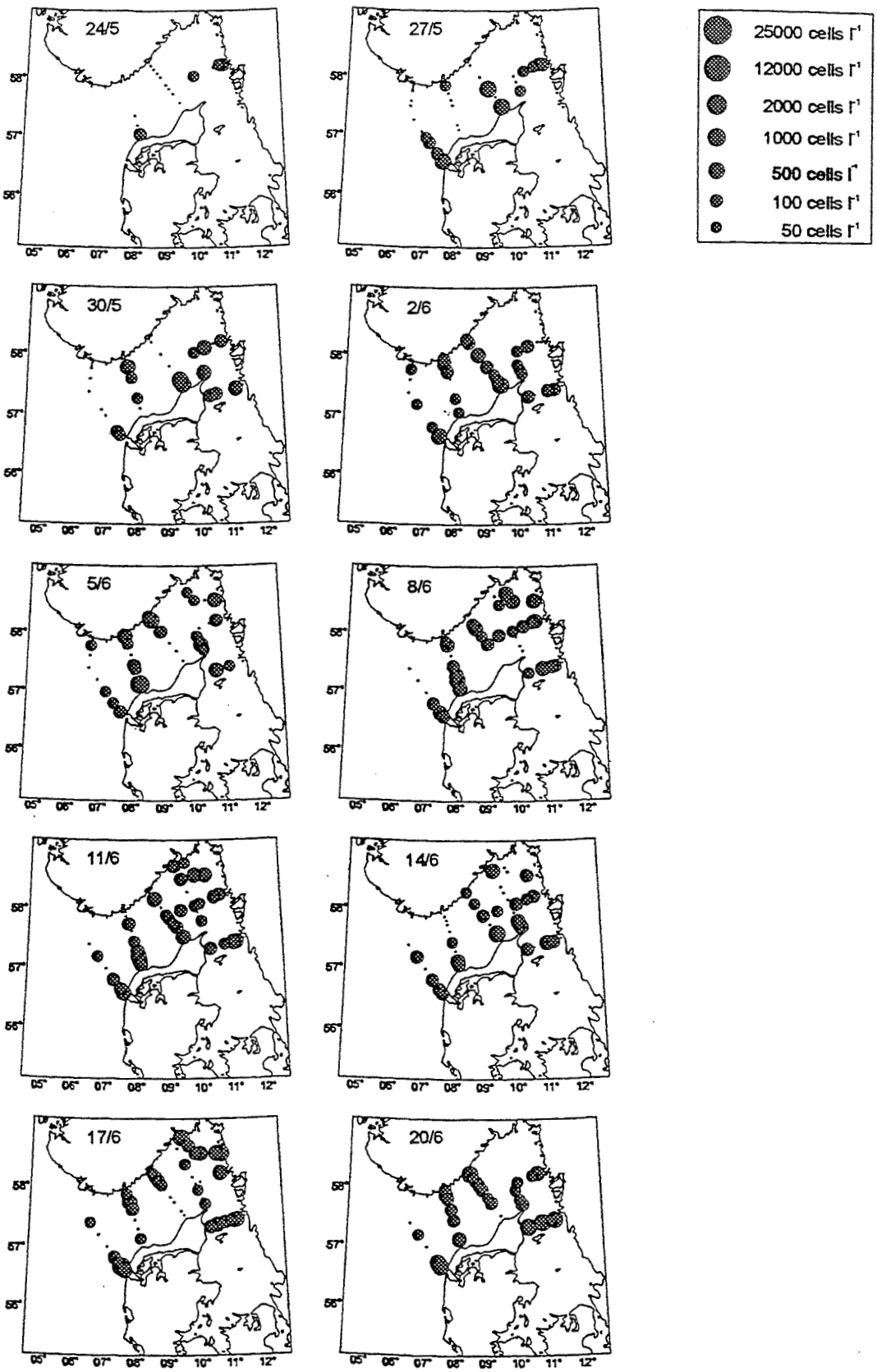


Fig. 3. Occurrence of *C. fusus* at 0-10 m from 24 May to 20 June, log scale.

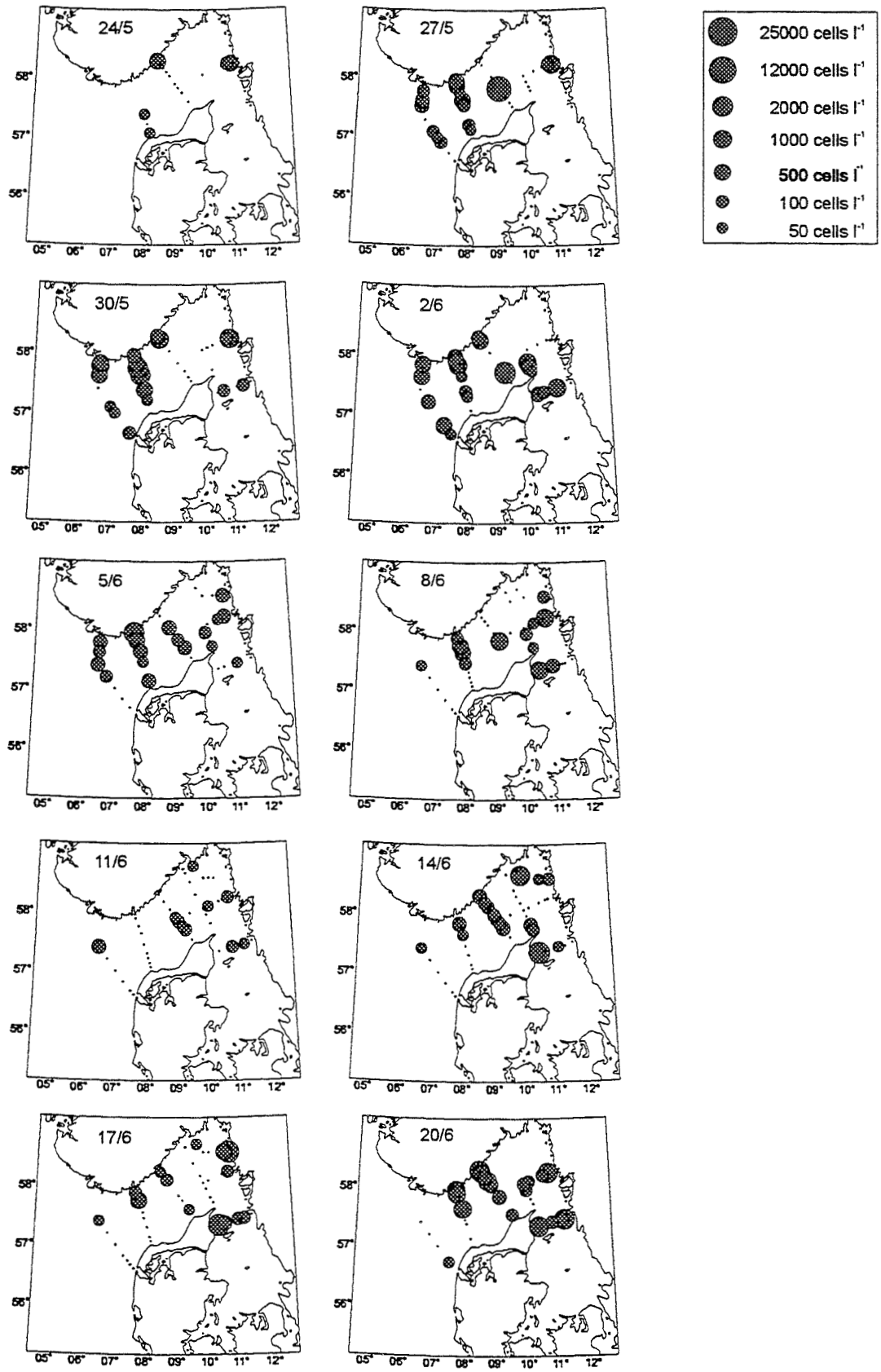


Fig. 4. Occurrence of *C. lineatum* at 0-10 m from 24 May to 20 June, log scale.

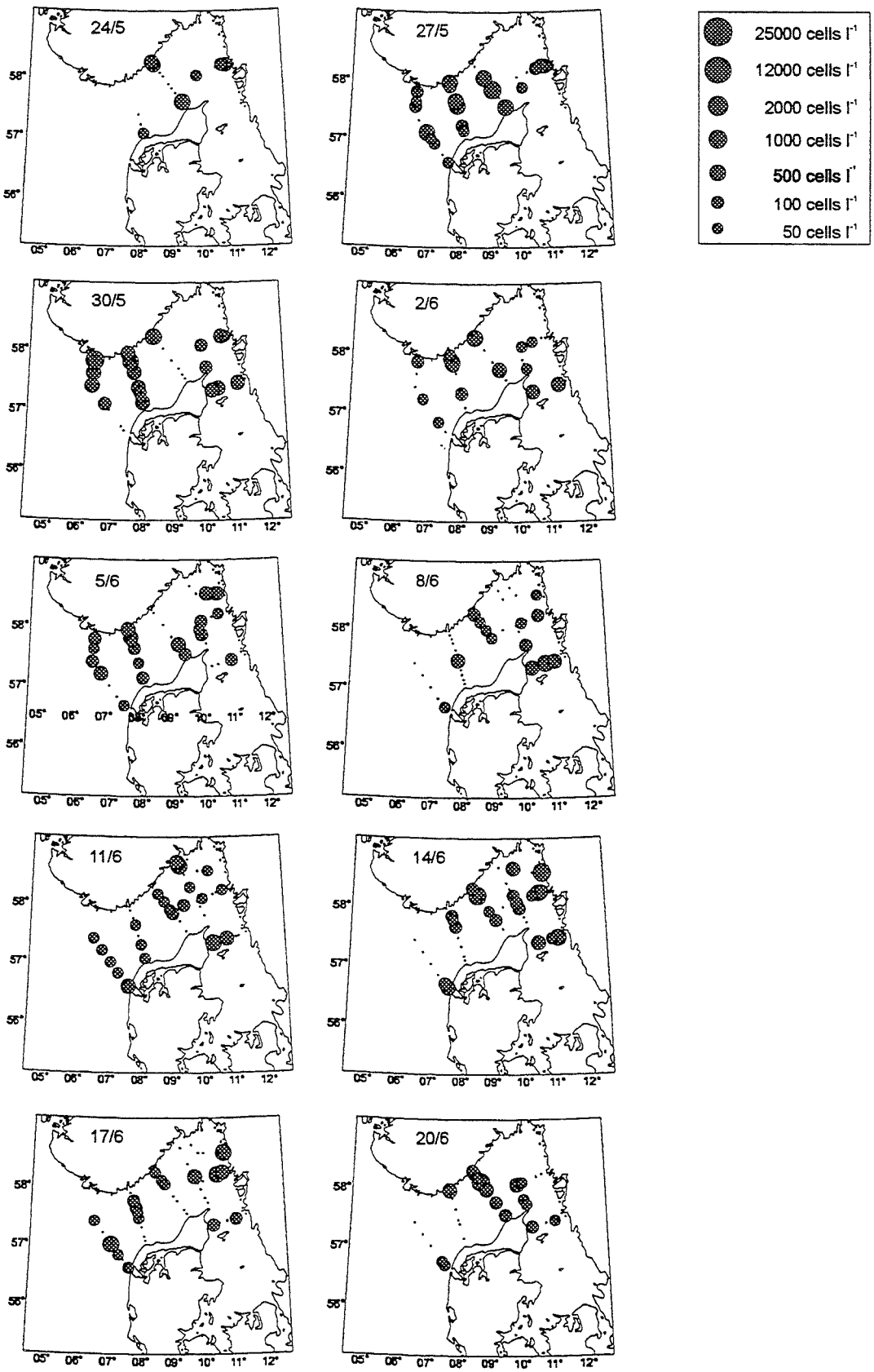


Fig. 5. Occurrence of *C. longipes* at 0-10 m from 24 May to 20 June, log scale.

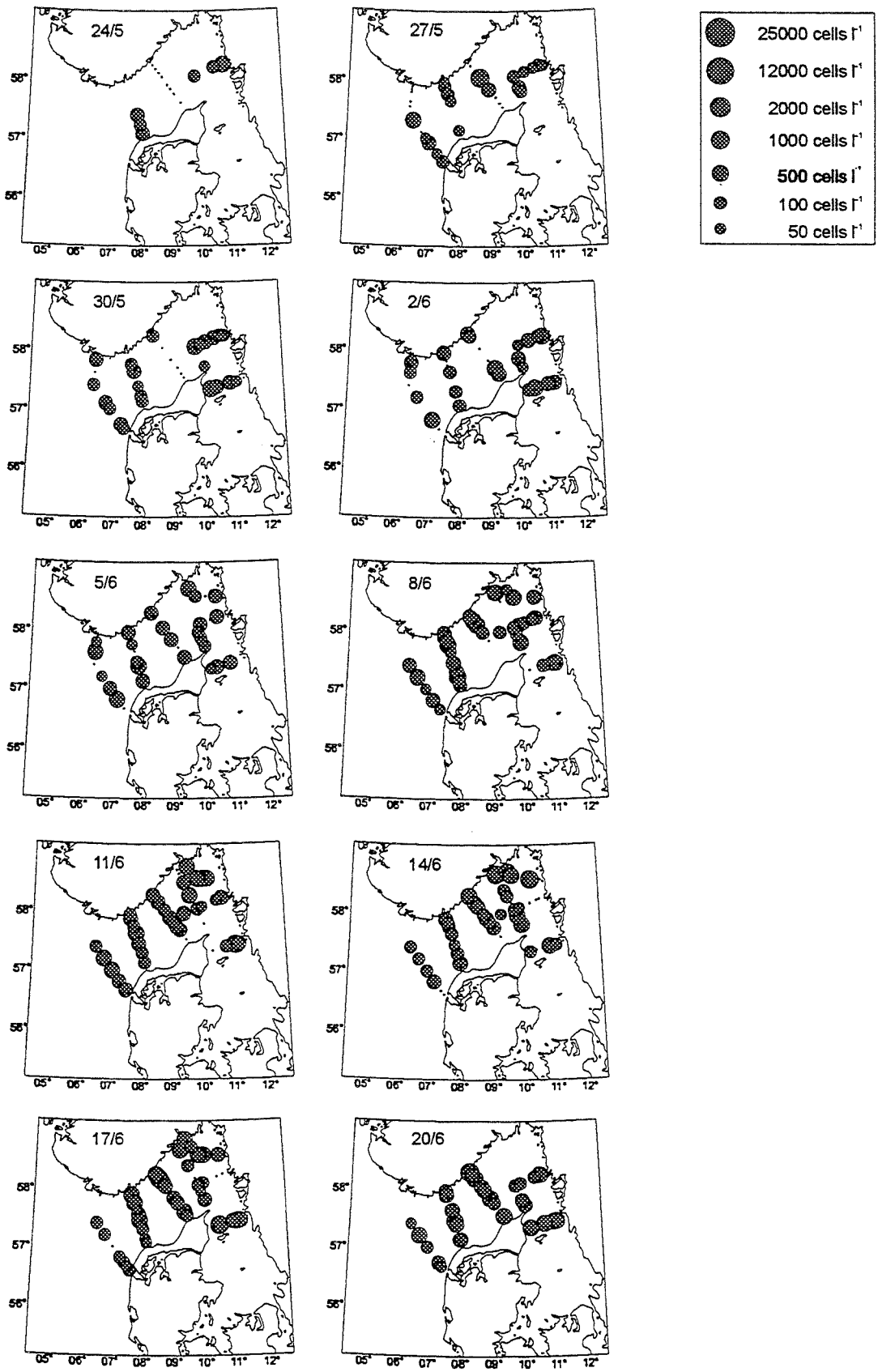


Fig. 6. Occurrence of *C. tripos* at 0-10 m from 24 May to 20 June, log scale.

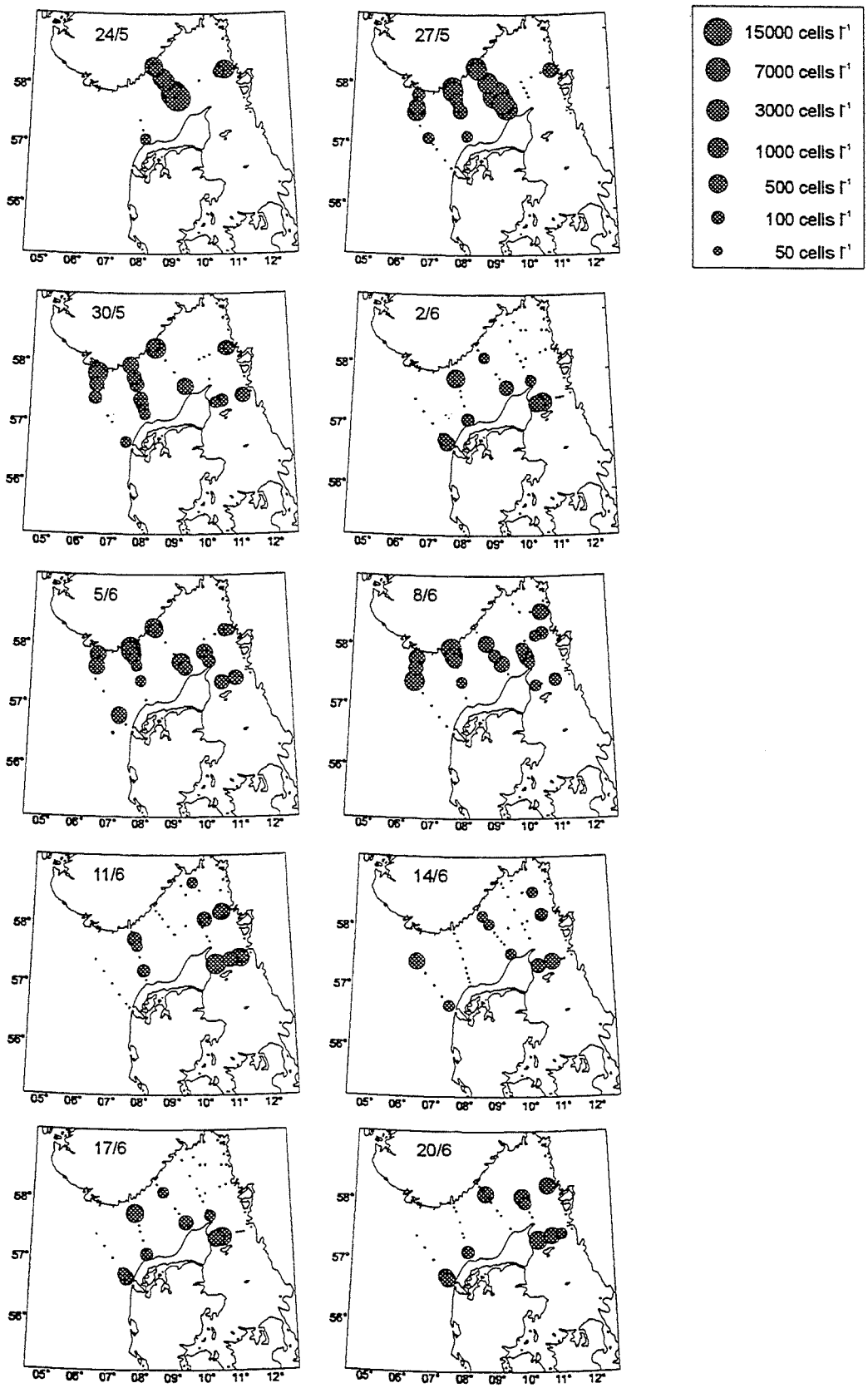


Fig. 7. Occurrence of *D. acuminata* at 0-10 m from 24 May to 20 June, log scale.

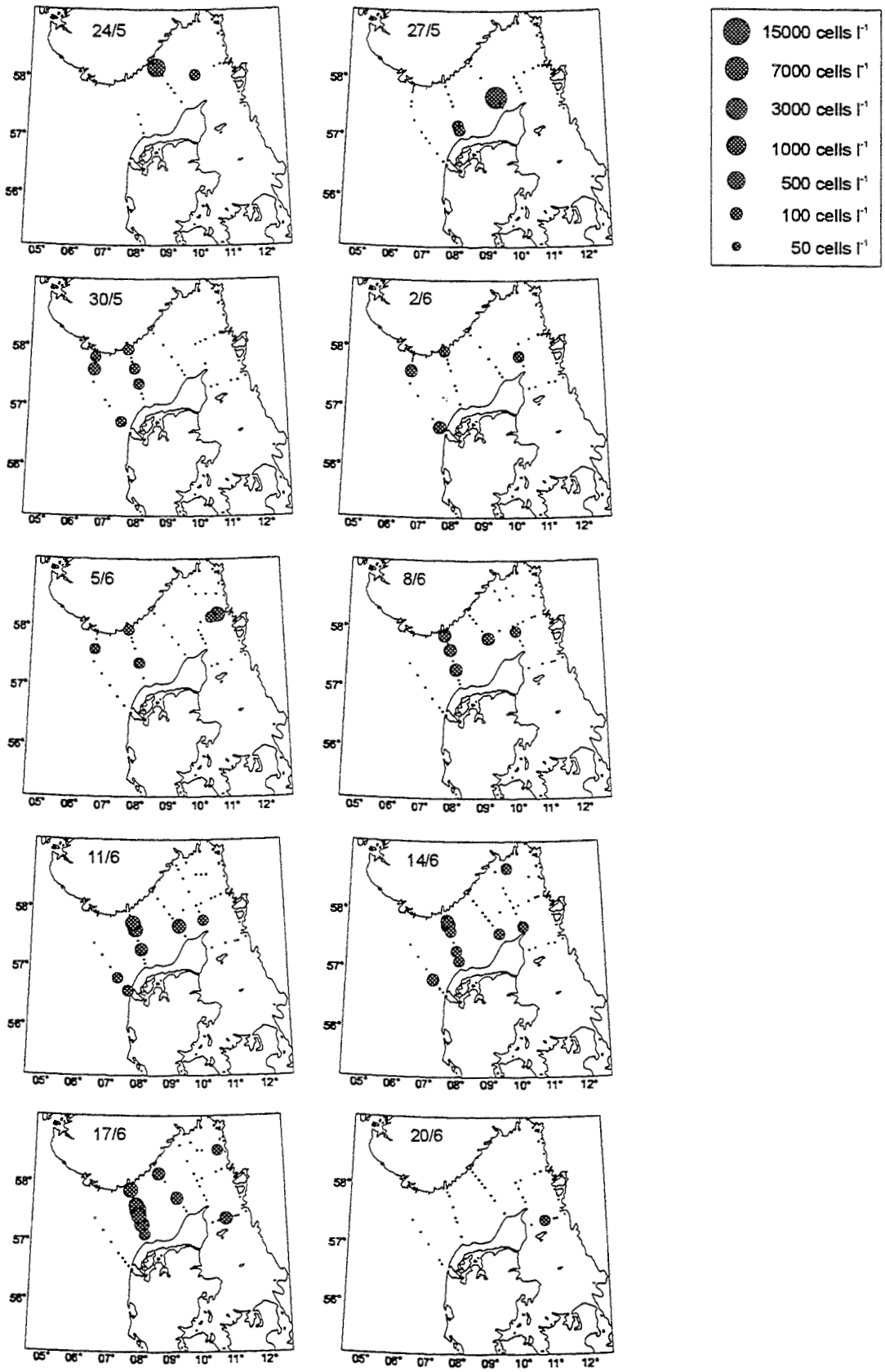


Fig. 8. Occurrence of *D. acuta* at 0-10 m from 24 May to 20 June, log scale.

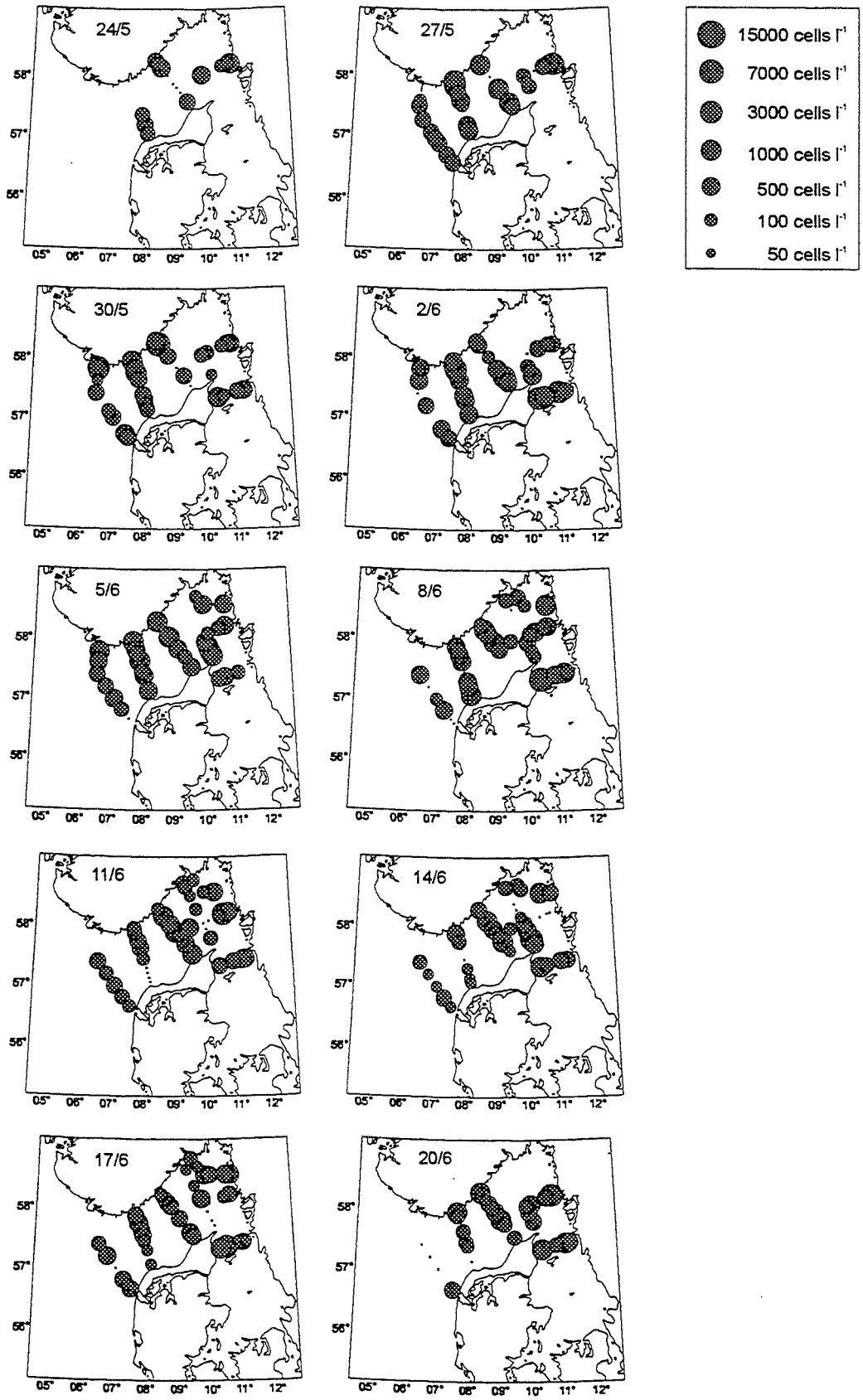


Fig. 9. Occurrence of *D. norvegica* at 0-10 m from 24 May to 20 June, log scale.

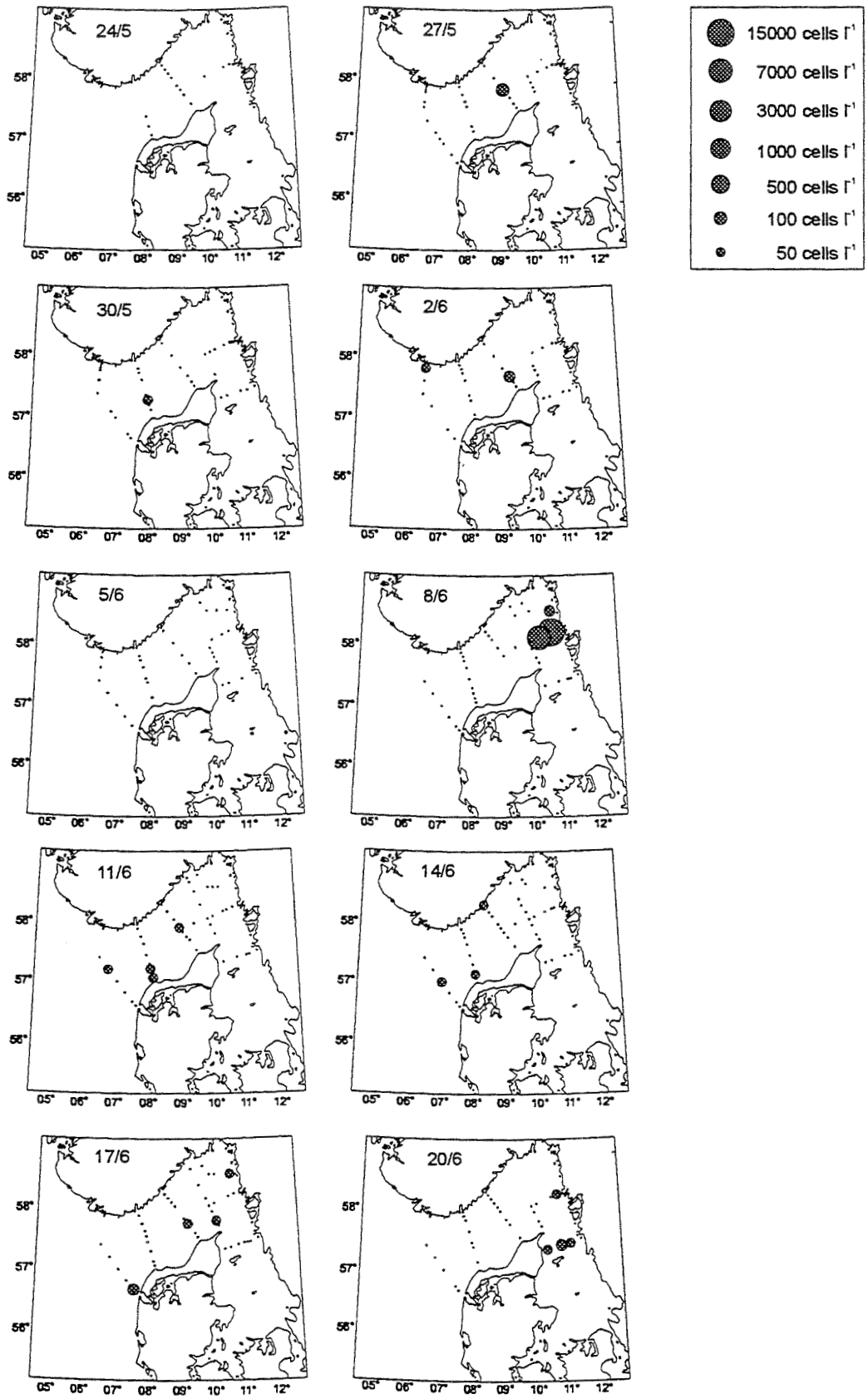


Fig. 10. Occurrence of *D. rotundata* at 0-10 m from 24 May to 20 June, log-scale.

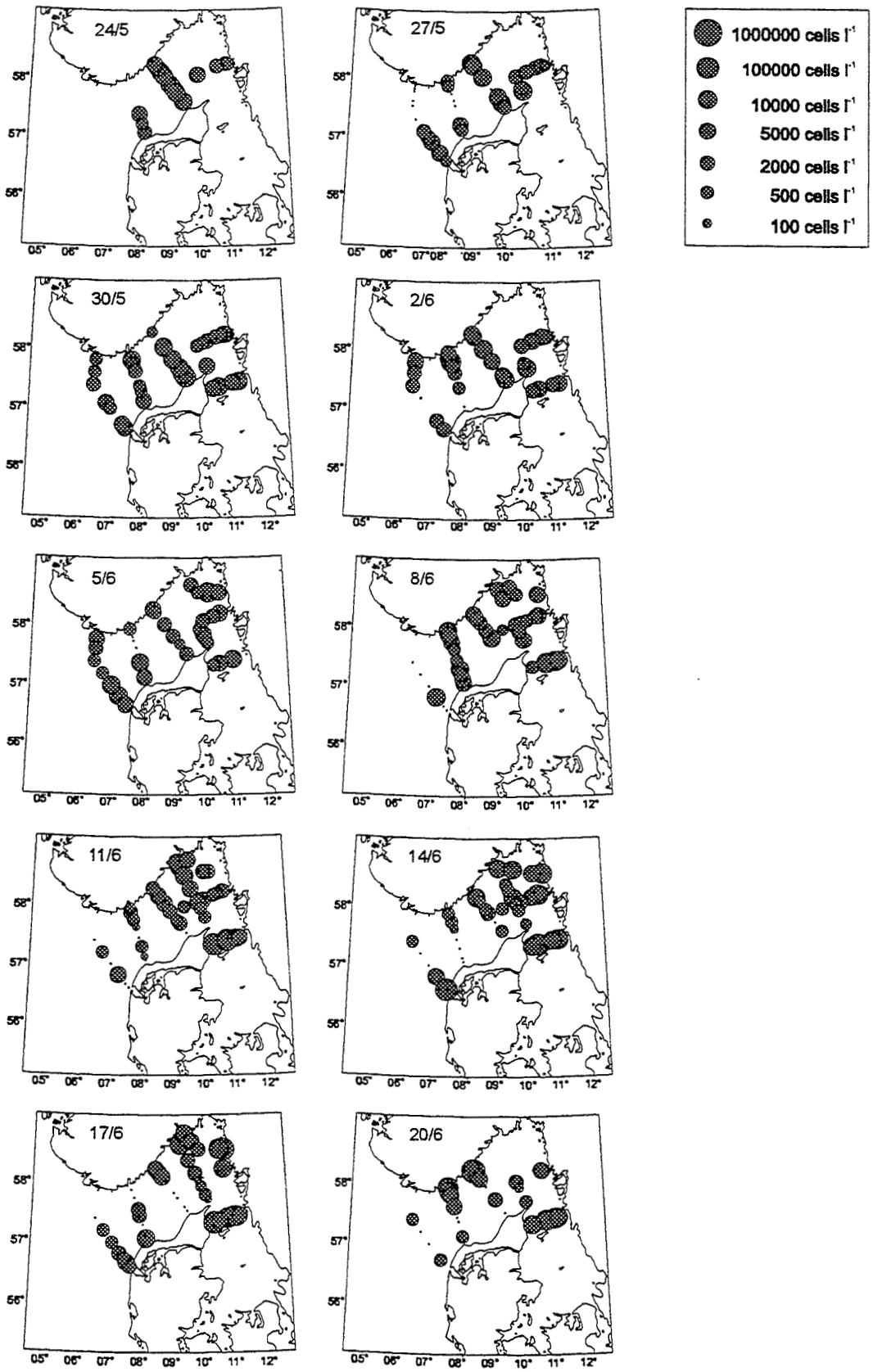


Fig. 11. Occurrence of *P. alata* at 0-10 m from 24 May to 20 June, log scale.

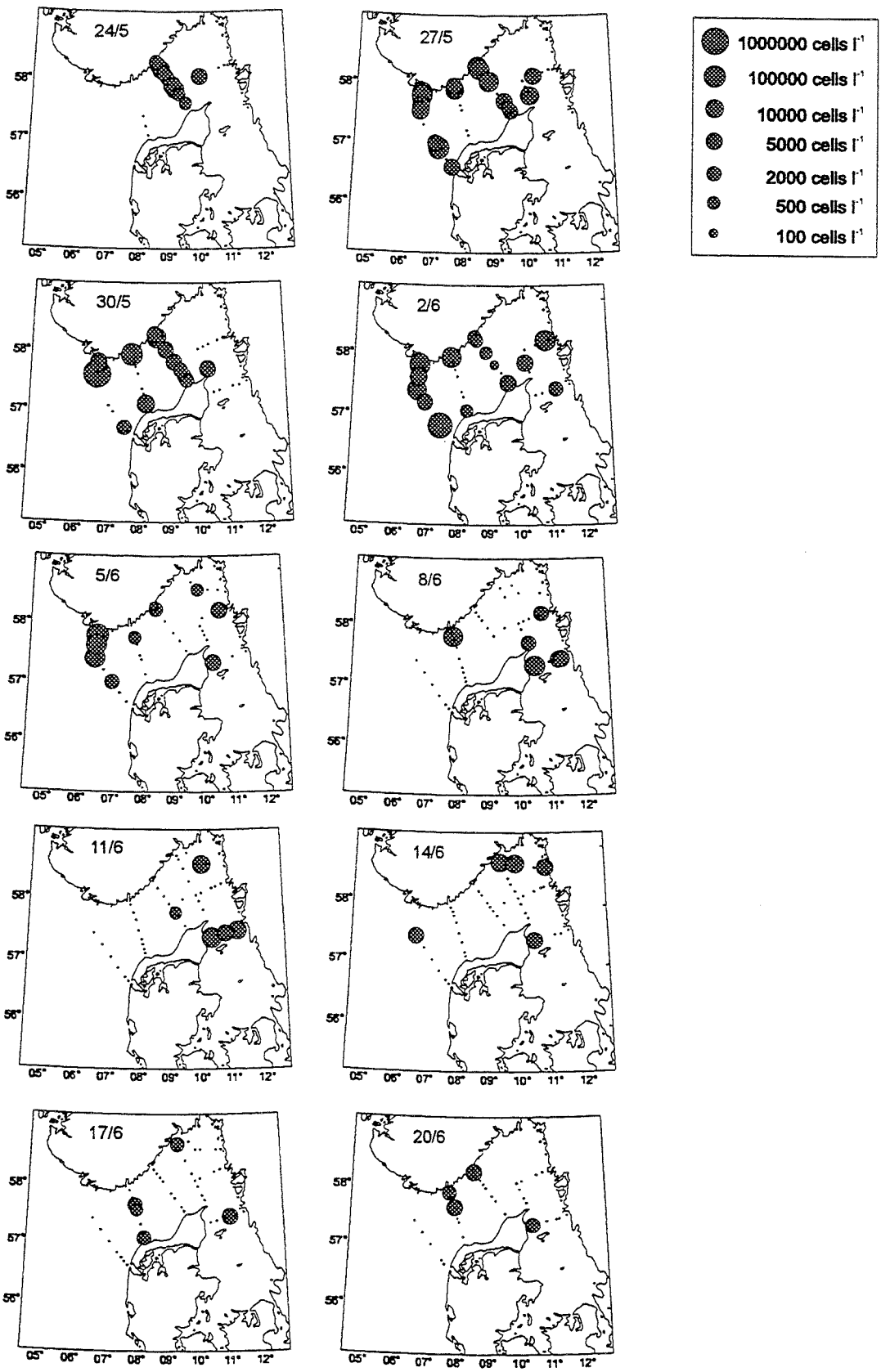


Fig. 12. Occurrence of *S. costatum* at 0-10 m from 24 May to 20 June, log scale.

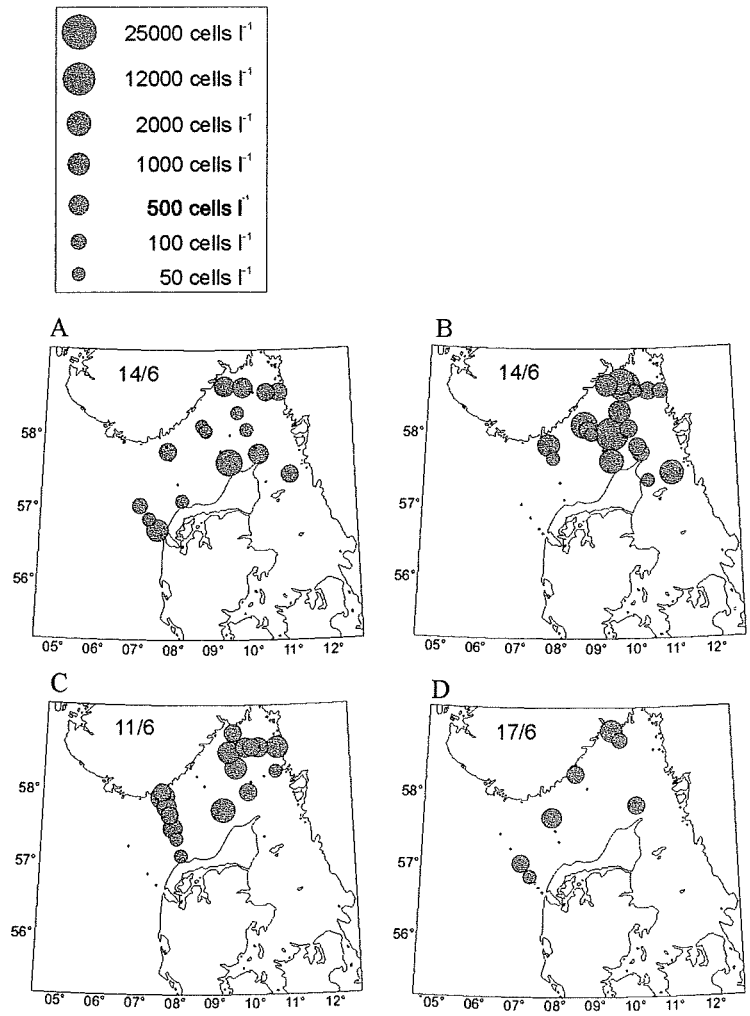


Fig. 13. Occurrence of A) *C. fusus*, B) *C. lineatum*, C) *C. Longipes* and D) *C. tripos* at 20 m on selected dates.

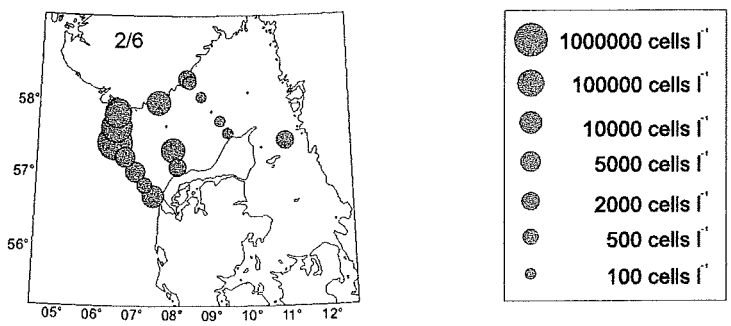
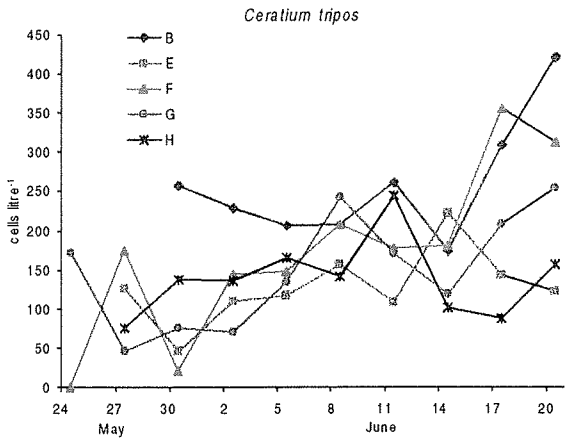
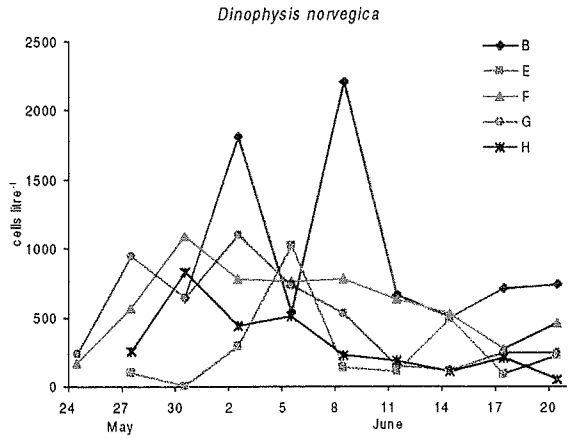


Fig. 14. Occurrence of *Skeletonema costatum* at 20 m on selected dates.

A



B



C

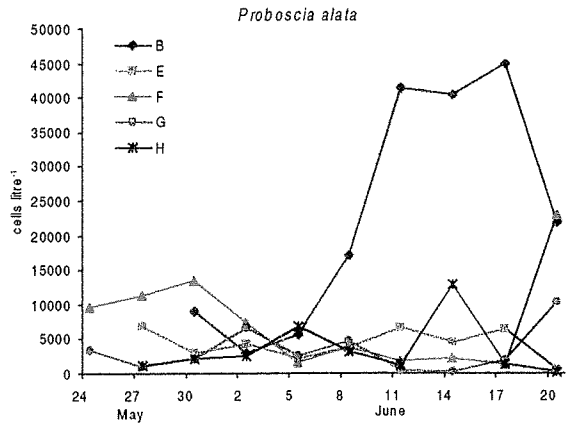


Fig. 15. Occurrence of A) *Ceratium tripos*, B) *Dinophysis norvegica* and C) *Proboscia alata* at sections B, E, F, G and H. Cell numbers are the mean value of the values along each section.

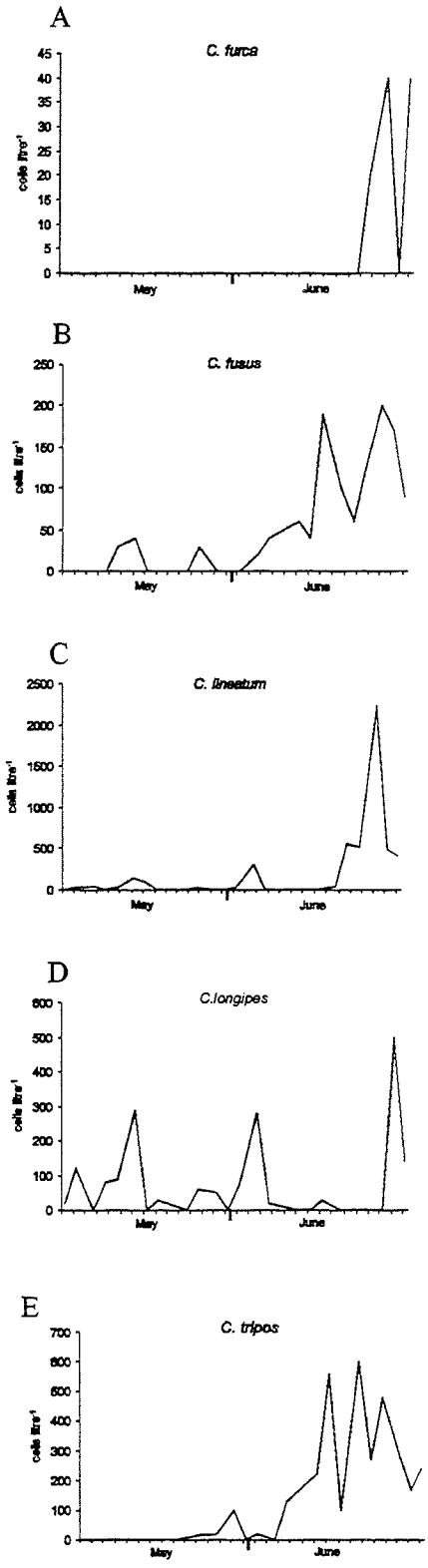


Fig. 16. Distribution of A) *C. furca*, B) *C. fusus*, C) *C. lineatum*, D) *C. longipes* and E) *C. tripos* in Flødevigen Bay in May and June 1990. Data is based on water samples taken every second day in Flødevigen Bay.

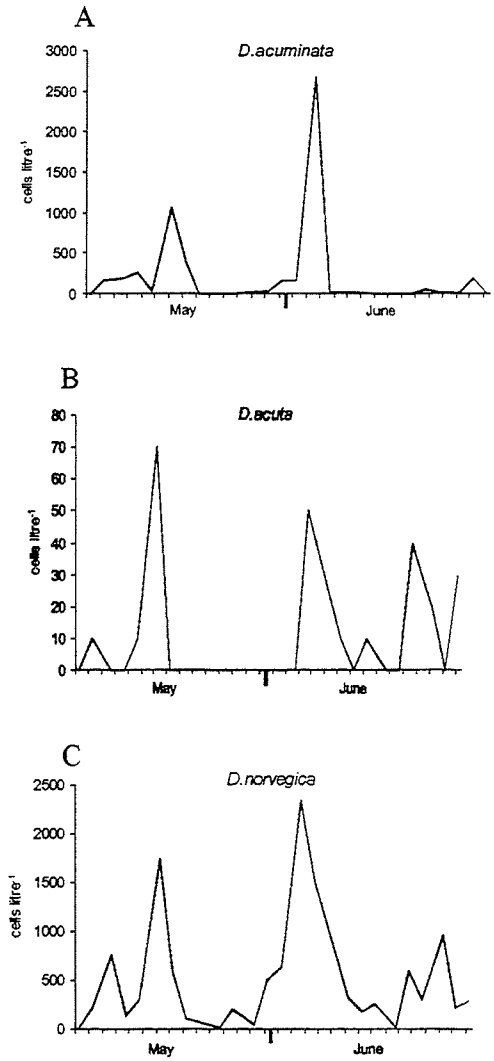


Fig. 17. Distribution of A) *D. acuminata*, B) *D. Acuta* and C) *D. Norvegica* in Flødevigen Bay in May and June 1990. Data is based on water samples taken every second day in Flødevigen Bay.

Fig. 18. Distribution at section F and G of A), B) *Ceratium furca* , C), D) *C. fusus* , E), F) *C. lineatum* , G), H) *C. longipes* and I), J) *C. tripos* .

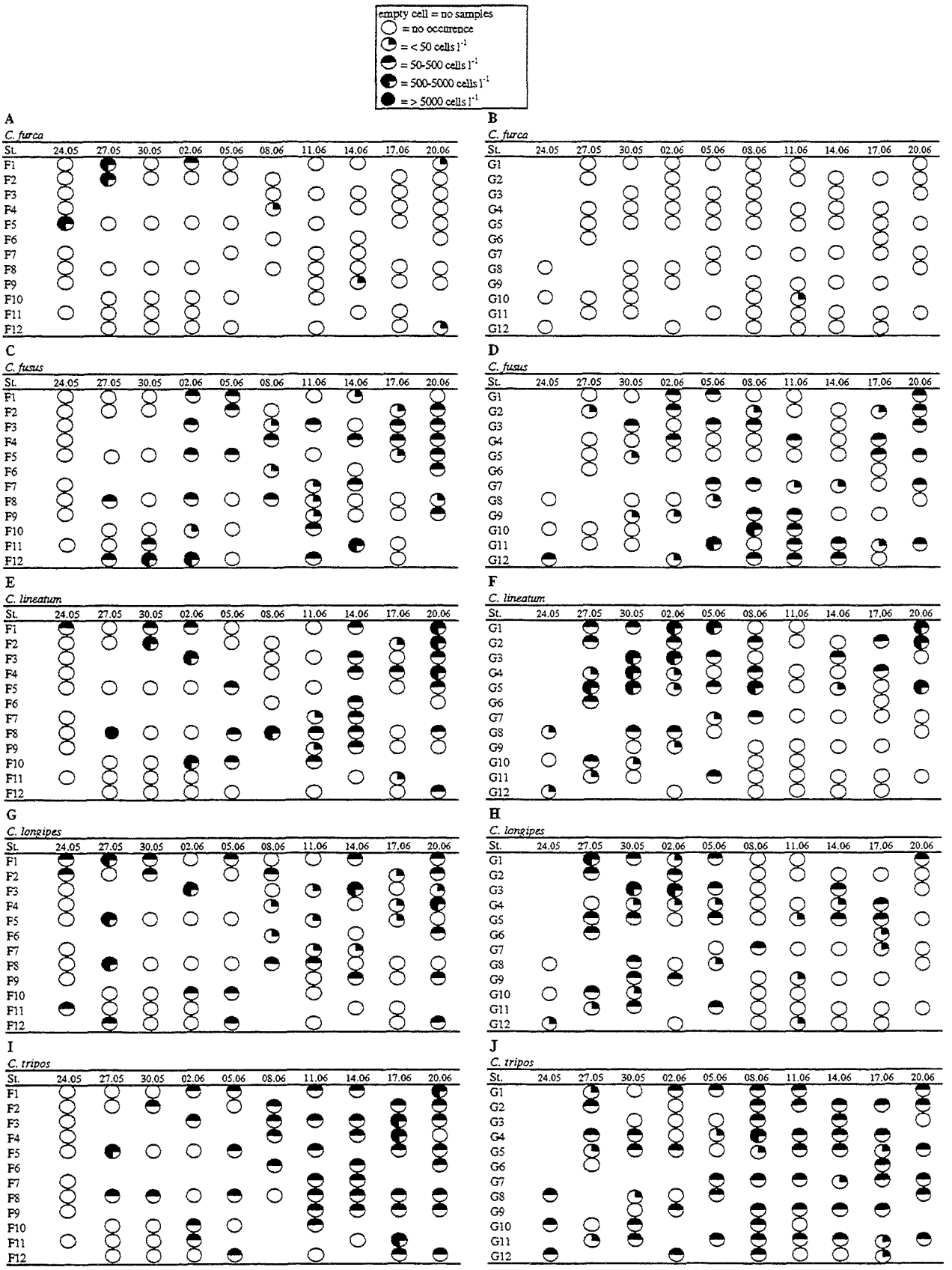


Fig. 19. Distribution at section F and G of A), B) *Dinophysis acuminata*, C), D) *D. acuta*, E), F) *D. norvegica* and G), H) *D. rotundata*.

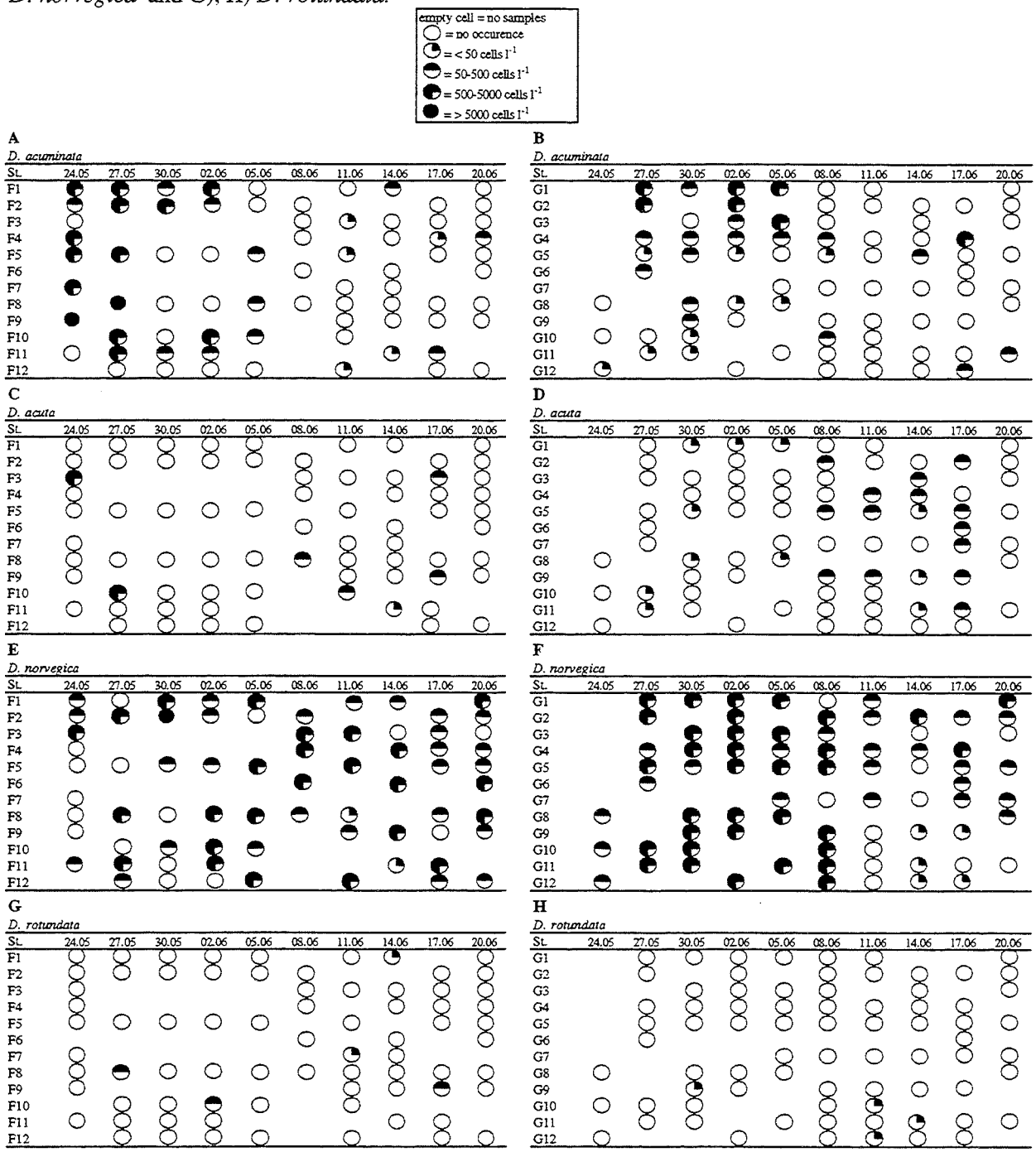


Fig. 20. Distribution at section F and G of A), B) *Skeletonema costatum* and C), D) *Proboscia alata.* The distribution in section B is shown, E) *S. costatum* and F) *P. alata.*

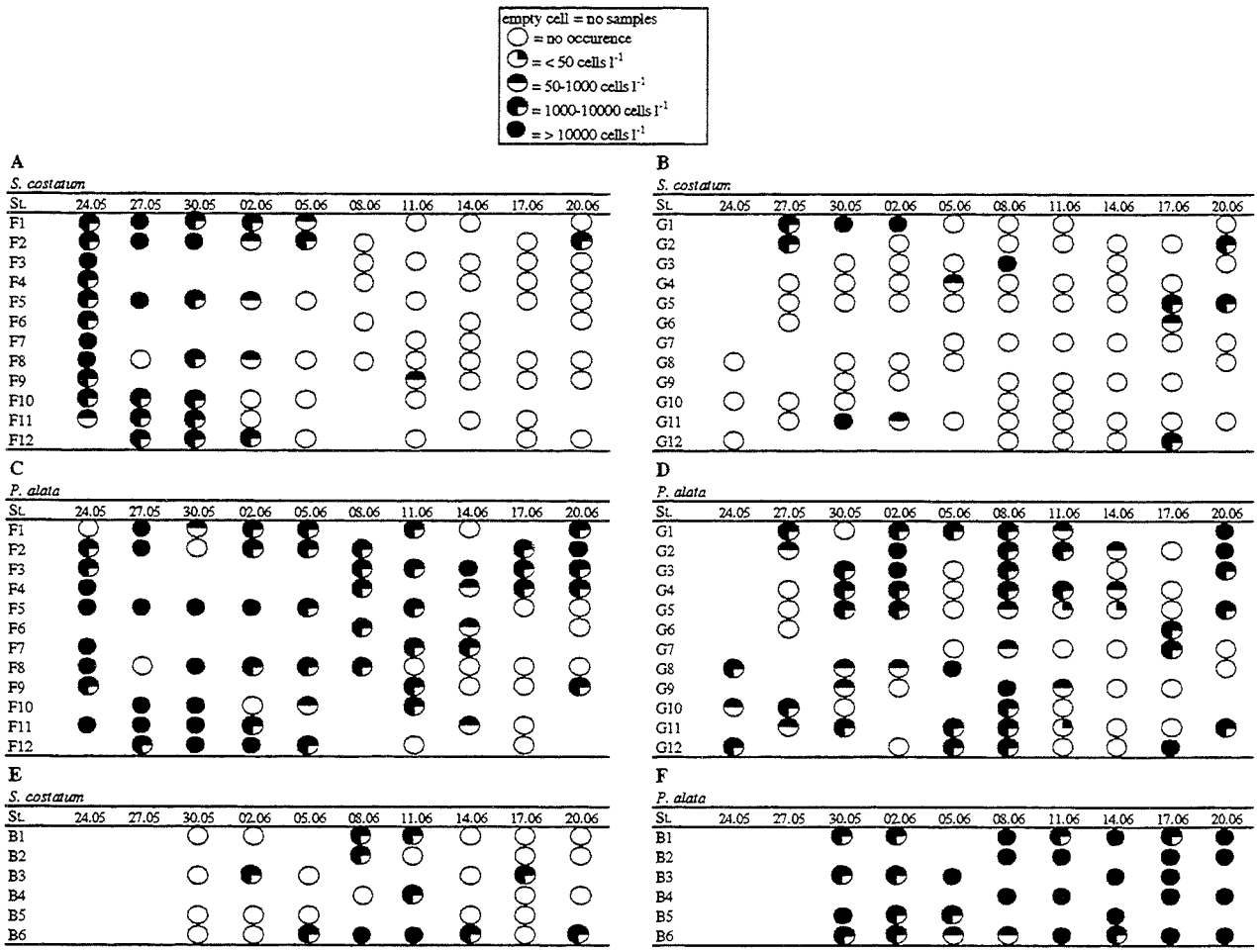
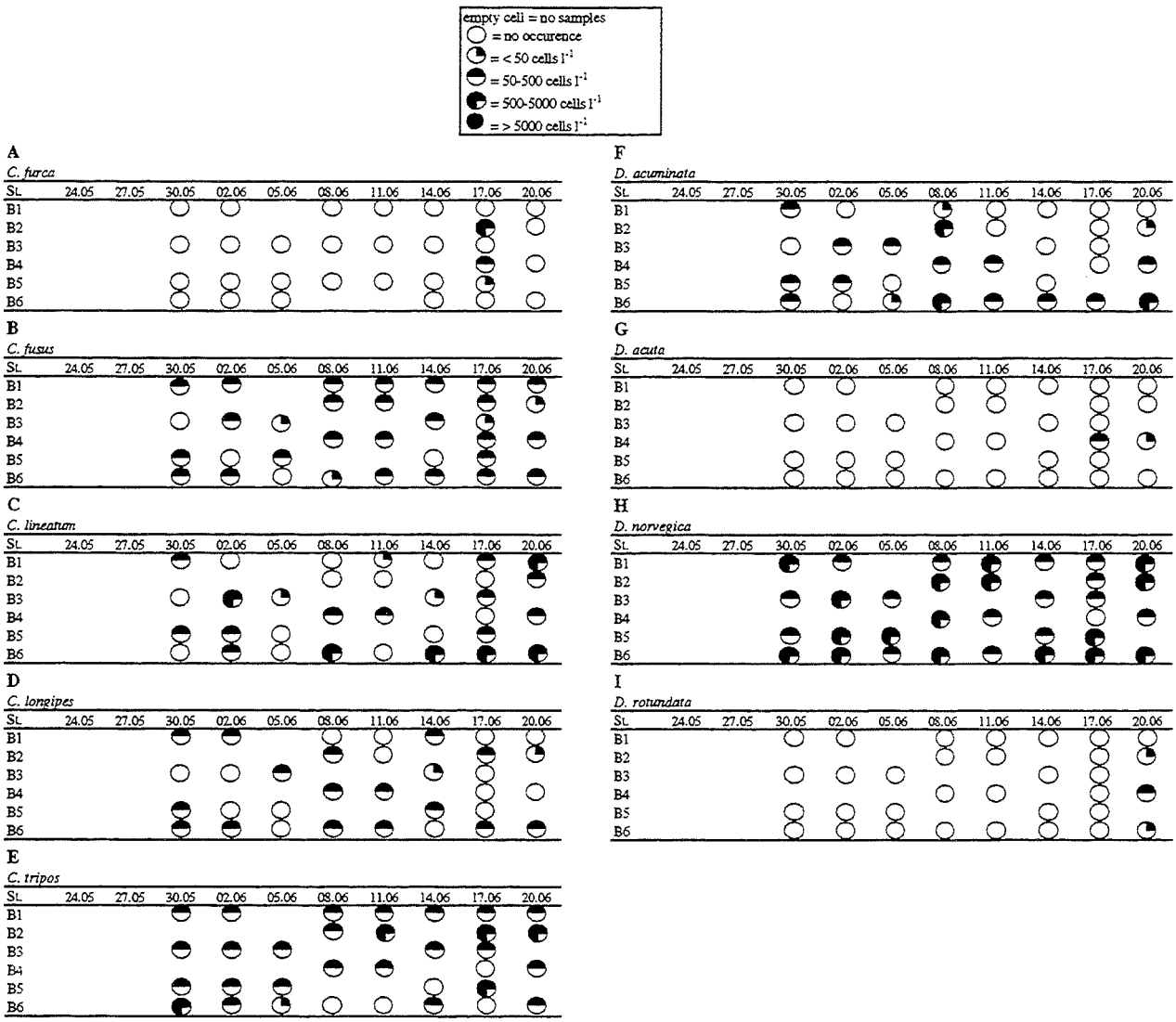


Fig. 21. Distribution at section B of A)-E) *Ceratium* and F)-I) *Dinophysis*.



APPENDIX (1a – k)

Appendix 1a. Cell numbers (cells litre^{-1}) of *C. furca* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			0	0		0	0	0	0	0
B 02						0	0		747	0
B 03			0	0	0			0	0	
B 04						0	0		93	0
B 05			0	0	0			0	48	
B 06			0	0	0	0	0	0	0	0
C 01	0	0	0	0						
C 02			0							0
C 03	0	0	0	0			0	0	0	
C 04					0	0		0		
C 05	0	0	0			0	0		0	0
C 06				0	0		0	0		
C 07		0	0			0				
C 08			0	0	0	0	0	0	0	0
C 09	0	0	0							
C 10						0	0	0		
D 01									0	
D 02							0			
D 03					0	0		0	0	
D 04								0		
D 05					0	0	47		0	
D 06							0		0	
D 07					0		0			
D 08								0		
D 09					0				0	
D 10						0		0	0	
E 01							0			
E 02						0	0	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	0
E 09		0			0	0	0	0	0	0
E 10		0			0					
E 11		0		0	0	0	0	0	0	0
E 12		0	0	0	0	0		0	0	0
F 01	0	700	0	400	0		0	0		100
F 02	0	2000	0		0	0			0	0
F 03	0			0		0	0	0	0	0
F 04	0					48		0	0	0
F 05	1300	0	0	0	0		0		0	0
F 06						0		0		0
F 07	0				0		0	0		
F 08	0	0	0	0		0	0	0	0	0
F 09	0						0	200	0	0
F 10		0	0	0	0		0			
F 11	0	0	0	0				0	0	
F 12		0	0	0	0		0		0	48
G 01		0	0	0	0	0	0			0
G 02		0		0		0	0	0	0	0
G 03			0	0	0	0		0		0
G 04		0	0	0	0	0	0	0	0	
G 05		0	0	0	0	0	0	0	0	0
G 06		0							0	
G 07					0	0	0	0	0	0
G 08	0		0	0	0					0
G 09			0	0		0	0	0	0	
G 10	0	0	0			0	48			
G 11		0	0		0	0	0	0	0	0
G 12	0			0		0	0	0	0	
H 01		0	0	0						
H 02		0	0	0	0					
H 03										
H 04		0	0	0	0					
H 05		0								
H 06			0	0	0	0	0	0	0	0
H 07		0								
H 08				0	0	0	0	0	0	0
H 09		0	0							
H 10		0	48		0	0	48	0	0	0
H 11		0								
H 12				0	0	0	0	0	0	
H 13		0	0						0	0
H 14			0	0	0	0	0	0	48	0
H 15		0				0	0	0	0	0

Appendix 1b. Cell numbers (cells litre^{-1}) of *C. fusus* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			294	143		141	239	100	176	419
B 02						100	235		280	47
B 03			0	96	48			227	45	
B 04						270	50		93	326
B 05			95	0	190			0	191	
B 06			118	143	0	48	100	136	150	326
C 01	141	142	0	0						
C 02			93							
C 03	47	143	0	0			136	0	250	227
C 04					141	188		100		
C 05	0	48	0			93	136		0	46
C 06				94	0		0	50		
C 07		47	261			91				
C 08			0	47	0	0	47	94	0	47
C 09	47	0	47							
C 10						95	139	46		
D 01									324	
D 02							46			
D 03					47	176		0	94	
D 04								0		
D 05					47	188	188		95	
D 06							0		232	
D 07					0		190			
D 08								94		
D 09					238	190			186	
D 10								0	400	
E 01							108			
E 02						0	0	186	0	
E 03										
E 04						46	143			
E 05								0	49	
E 06							0	0		
E 07								0	0	
E 08						48	48	0	0	0
E 09		0			47	0	0	0	50	50
E 10		0			46					
E 11		50		47	235	0	46	190	0	47
E 12		186	0	46	46	0		250	50	141
F 01	0	0	0	100	100		0	48		0
F 02	0	0	0		400	0			45	324
F 03	0			100		93	238	0	139	48
F 04	0					190		59	95	108
F 05	0	0	0	300	100		0		46	143
F 06						48		0		87
F 07	0						47	139		
F 08	0	455	0	100	0	150	48	0	0	47
F 09	0						47	0	0	93
F 10		0	0	46	0		93			
F 11	0	0	400	100				500	0	
F 12		400	500	500	0		238		0	0
G 01		0	0	94	188	0	0			100
G 02		47		200		48	0	0	48	174
G 03			200	0	50	200		0		100
G 04		0	0	94	0	0	95	0	286	
G 05		0	47	0	0	0	0	0	95	87
G 06		0							0	
G 07					94	100	48	48	0	95
G 08	0		0	0	47					0
G 09			46	47		200	95	0	0	
G 10	0	0	0			500	238			
G 11		0	0		762	0	286	238	48	190
G 12	94			46		300	143	143	0	
H 01		0	0	0						
H 02		0	0	47	48					
H 03										
H 04		0	0	0	0					
H 05		0								
H 06			0	0	0	0	0	0	47	0
H 07		0								
H 08				48	0	0	48	95	0	46
H 09		0	0							
H 10		47	0		48	0	0	0	0	0
H 11		95								
H 12				48	48	93	139	93	140	
H 13		94	98						46	523
H 14			48	571	100	186	139	95	714	419
H 15		333				95	188	150	233	0

Appendix 1c. Cell numbers (cells litre^{-1}) of *C lineatum* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			118	0		0	47	0	118	1860
B 02						0	0		0	235
B 03			0	905	48			45	136	
B 04						270	100		0	140
B 05			95	87	0			0	286	
B 06			0	190	0	1148	0	2954	3100	1674
C 01	517	904	752	0						
C 02			651							
C 03	94	143	141	0			136	0	100	1636
C 04					282	795		0		
C 05	0	0	0			0	0		0	91
C 06				0	47		0	0		
C 07		0	0			46				
C 08			0	0	0	0	47	0	0	141
C 09	0	0	0							
C 10						0	0	0		
D 01									0	
D 02							46			
D 03					0	0		0	47	
D 04								2372		
D 05					0	0	0		0	
D 06							0		0	
D 07					0		0			
D 08								47		
D 09					286	95			465	
D 10								150	3800	
E 01							0			
E 02						0	0	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	95
E 09		0			141	95	0	0	0	150
E 10		0			0					
E 11		0		329	0	0	0	286	0	0
E 12		0	0	46	46	47		100	0	0
F 01	424	0	200	200	0		0	190		1500
F 02	0	0	658		0	0			45	1081
F 03	0			500		0	0	108	0	190
F 04	0					0		118	95	757
F 05	0	0	0	0	300		0		0	238
F 06						0		91		0
F 07	0						47	139		
F 08	0	16364	0	0	137	850	95	95	0	190
F 09	0						47	200	0	0
F 10		0	0	4909	200		93			
F 11	0	0	0	0				0	47	
F 12		0	0	0	0		0		0	95
G 01		329	185	564	2021	0	0			1200
G 02		329		400		143	0	0	95	783
G 03			600	800	350	0		190		0
G 04		46	1389	47	0	400	0	0	429	
G 05		564	1598	47	200	619	0	48	0	696
G 06		95							0	
G 07					47	100	0	0	0	0
G 08	47		470	94	0					0
G 09			0	47		0	0	0	0	
G 10	0	143	48			0	0			
G 11		47	0		190	0	0	0	0	0
G 12	47			0		0	0	0	0	
H 01		0	333	329						
H 02		93	706	0	238					
H 03										
H 04		190	524	524	143					
H 05		273								
H 06			0	0	195	48	190	47	47	0
H 07		0								
H 08				286	118	0	0	0	0	0
H 09		95	48							
H 10		47	48		0	0	0	0	0	0
H 11		95								
H 12				333	0	0	0	0	0	
H 13		0	0						0	47
H 14			95	48	0	0	0	0	0	0
H 15		0				0	0	0	0	0

Appendix 1d. Cell numbers (cells litre^{-1}) of *C. longipes* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			176	190		0	0	400	0	0
B 02						300	0		93	47
B 03			0	0	96			45	0	
B 04						432	200		0	0
B 05			190	0	0			200	0	
B 06			176	190	0	286	400	0	150	140
C 01	235	238	47	0						
C 02			0							
C 03	141	238	188	0			46	250	200	0
C 04					47	94		350		
C 05	0	143	0			0	0		350	0
C 06				47	0		0	50		
C 07		0	0			0				
C 08			94	47	94	46	47	0	0	47
C 09	47	0	0							
C 10						0	93	0		
D 01									0	
D 02							0			
D 03					0	0		0	0	
D 04								233		
D 05					0	0	0		0	
D 06							0		0	
D 07					200		48			
D 08								0		
D 09					238	48			0	
D 10								700	600	
E 01							216			
E 02						0	378	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							48	0		
E 07								150	200	
E 08						0	0	94	0	190
E 09		0			47	0	0	140	0	0
E 10		46			93					
E 11		0		0	0	0	0	0	0	47
E 12		93	0	46	0	94		0	0	47
F 01	188	0	0	0	0		0	95		100
F 02	200	0	329		0	95			45	108
F 03	0			500		0	48	865	0	48
F 04	0					48		0	48	649
F 05	0	500	0	0	0		47		46	0
F 06						48		0		174
F 07	0						47	46		
F 08	0	1318	0	0	0	50	95	0	0	0
F 09	0						0	100	0	140
F 10		0	0	182	200		0			
F 11	400	0	0	0				0	0	
F 12		400	0	0	100		0		0	143
G 01		517	231	47	188	0	0			200
G 02		141		300		0	0	0	0	0
G 03			500	500	250	0		143		0
G 04		0	46	47	46	0	0	48	95	
G 05		376	235	0	100	0	48	95	143	0
G 06		381							48	
G 07					0	200	0	0	48	0
G 08	0		235	0	47					0
G 09			139	94		0	48	0	0	
G 10	0	95	48			0	0			
G 11		47	235		95	0	0	0	0	0
G 12	47			0		0	48	0	0	
H 01		0	667	141						
H 02		93	176	0	95					
H 03										
H 04		48	190	0	48					
H 05		136								
H 06			190	0	95	0	48	0	47	0
H 07		0								
H 08				48	176	0	48	0	0	0
H 09		381	95							
H 10		47	0		0	0	48	0	600	0
H 11		48								
H 12				48	0	0	46	0	47	
H 13		0	0						0	47
H 14			0	0	50	47	0	95	0	47
H 15		48				0	188	250	47	47

Appendix 1e. Cell numbers (cells litre^{-1}) of *C. tripos* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			59	190		423	285	100	353	465
B 02						300	658		560	564
B 03			190	190	286			455	272	
B 04						108	100		0	326
B 05			190	435	286			0	667	
B 06			590	96	48	0	0	136	0	326
C 01	329	47	94	423						
C 02			47							
C 03	0	143	141	87			272	0	0	318
C 04					282	282		0		
C 05	94	48	231			93	46		0	91
C 06				235	0		0	0		
C 07		47	174			136				
C 08			141	47	188	185	47	47	141	94
C 09	141	96	419							
C 10						143	278	46		
D 01									370	
D 02							324			
D 03					376	59		517	94	
D 04								326		
D 05					142	376	329		333	
D 06							463		370	
D 07					0		333			
D 08								658		
D 09					286	286			233	
D 10								0	0	
E 01							0			
E 02						324	0	651	476	
E 03										
E 04						0	238			
E 05								140	146	
E 06							381	91		
E 07								0	0	
E 08						143	143	94	95	143
E 09		0			141	143	0	372	50	0
E 10		231			139					
E 11		100		47	47	324	0	429	235	188
E 12		47	46	46	139	0		0	0	282
F 01	0	0	0	300	300		238	428		1000
F 02	0	0	141		0	190			364	216
F 03	0			100		326	238	216	694	333
F 04	0					429		177	571	0
F 05	0	1000	0	0	200		94		227	190
F 06						95		91		174
F 07	0						233	185		
F 08	0	227	0	0	182	0	95	142	190	333
F 09	0						233	200	185	140
F 10		0	0	409	0		278			
F 11	0	0	0	200				0	523	
F 12		0	0	0	200		0		93	429
G 01		47	0	235	188	300	143			300
G 02		94		0		286	286	190	476	261
G 03			0	0	0	200		143		0
G 04		93	139	0	46	500	143	143	333	
G 05		47	188	94	0	48	476	95	48	174
G 06		0							238	
G 07					141	200	190	48	333	476
G 08	188		47	0	376					286
G 09			0	94		300	143	143	143	
G 10	139	0	143			400	0			
G 11		47	94		190	95	143	190	48	286
G 12	188			139		100	0	0	48	
H 01		0	238	47						
H 02		0	0	233	48					
H 03										
H 04		0	0	95	333					
H 05		0								
H 06			143	0	0	190	143	94	94	47
H 07		333								
H 08				95	59	324	381	143	143	556
H 09		0	190							
H 10		47	143		286	48	476	141	0	94
H 11		238								
H 12				476	429	231	278	231	93	
H 13		47	244						139	190
H 14				0	0	47	185	0	48	47
H 15		95				0	0	0	94	0

Appendix 1f. Cell numbers (cells litre^{-1}) of *D. acuminata* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			235	0		47	0	0	0	0
B 02						700	0		0	47
B 03			0	190	96			0	0	
B 04						216	250		0	279
B 05			95	174	0			0	524	
B 06			59	0	48	1810	200	91	250	605
C 01	0	238	47	47						
C 02			140							
C 03	517	0	94	87			0	0	0	364
C 04					94	376		0		
C 05	47	0	0			93	91		0	0
C 06				0	47		0	0		
C 07		0	0			0				
C 08			0	0	0	139	0	0	0	0
C 09	0	0	0							
C 10						0	0	0		
D 01									0	
D 02							0			
D 03					0	59		47	0	
D 04								1070		
D 05					0	0	0		0	
D 06							0		0	
D 07					0		48			
D 08								47		
D 09					286	0			0	
D 10								0	0	
E 01							0			
E 02						0	0	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	381
E 09		0			94	0	0	0	0	100
E 10		0			185					
E 11		0		94	188	0	0	333	0	0
E 12		0	46	93	46	0		50	50	0
F 01	872	1300	100	500	0		0	95		0
F 02	200	800	1504	200	0	0			0	0
F 03	0					0	48	0	0	0
F 04	500					0		0	48	324
F 05	700	1000	0	0	300		47		0	0
F 06						0		0		0
F 07	800						0	0		
F 08	9000	15273	0	0	91	0	0	0	0	0
F 09	9000						0	0	0	0
F 10		2000	0	500	300		0			
F 11	0	3000	400	200				50	142	
F 12		0	0	0	0		47		0	0
G 01		1316	278	1128	1363	0	0			0
G 02		1034		1000		0	0	0	0	0
G 03			0	300	500	0		0		0
G 04		93	185	94	231	200	0	0	571	
G 05		47	235	47	0	48	0	95	0	0
G 06		190							0	
G 07					0	0	0	0	0	0
G 08	0		235	47	47					0
G 09			93	0		0	0	0	0	
G 10	0	0	48			100	0			
G 11		47	47		0	0	0	0	0	95
G 12	47			0		0	0	0	95	
H 01		91	1000	376						
H 02		0	823	0	333					
H 03										
H 04		476	238	333	143					
H 05		636								
H 06			95	0	1191	0	429	47	0	0
H 07		0								
H 08				0	0	0	0	0	0	0
H 09		48	0							
H 10		0	0		0	0	0	0	0	0
H 11		0								
H 12				333	0	0	0	185	0	
H 13		0	0						93	142
H 14			48	0	0	0	46	0	143	140
H 15		0				0	0	50	0	141

Appendix 1g. Cell numbers (cells litre^{-1}) of *D. acuta* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			0	0		0	0	0	0	0
B 02						0	0		0	0
B 03			0	0	0			0	0	
B 04						0	0		93	47
B 05			0	0	0			0	0	
B 06			0	0	0	0	0	0	0	0
C 01	0	0	0	0						
C 02			0							
C 03	0	0	0	0			0	0	0	0
C 04					235	0		0		
C 05	0	0	0			0	0		0	0
C 06				0	47		0	0		
C 07		0	0			0				
C 08			0	0	0	0	0	0	0	0
C 09	47	0	0							
C 10						0	0	0		
D 01									0	
D 02							0			
D 03					0	0		47	0	
D 04								0		
D 05					0	0	0		0	
D 06							0		0	
D 07					0		0			
D 08								0		
D 09					0	0			47	
D 10								0	0	
E 01							0			
E 02						0	0	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	0
E 09		0			0	48	0	0	0	0
E 10		0			0					
E 11		0		0	0	0	46	0	0	0
E 12		0	0	0	0	0		50	0	0
F 01	0	0	0	0	0		0	0		0
F 02	0	0	0	0	0	0			0	0
F 03	500					0	0	0	93	0
F 04	0					0		0	0	0
F 05	0	0	0	0	0		0		0	0
F 06						0		0		0
F 07	0						0	0		
F 08	0	0	0	0	0	100	0	0	0	0
F 09	0						0	0	93	0
F 10		2000	0	0	0		186			
F 11	0	0	0	0				50	0	
F 12		0	0	0	0		0		0	0
G 01		0	46	47	47	0	0			0
G 02		0		0		95	0	0	143	0
G 03			0	0	0	0		95		0
G 04		0	0	0	0	0	143	238	0	
G 05		0	47	0	0	95	238	48	238	0
G 06		0							476	
G 07					0	0	0	0	190	0
G 08	0		47	0	47					0
G 09			0	0		100	95	48	238	
G 10	0	48	0			0	0			
G 11		47	0		0	0	0	48	48	0
G 12	0			0		0	0	0	0	
H 01		0	48	0						
H 02		0	0	0	0					
H 03										
H 04		0	95	95	48					
H 05		0								
H 06			0	0	0	0	0	0	0	0
H 07		0								
H 08				0	0	0	0	0	0	0
H 09		0	0							
H 10		0	0		0	0	0	0	0	0
H 11		0								
H 12				0	0	0	46	93	0	
H 13		0	49						0	0
H 14			0	95	0	0	0	0	0	0
H 15		0				0	47	0	0	0

Appenix 1h. Cell numbers (cells litre^{-1}) of *D. norvegica* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			708	333		188	952	450	59	670
B 02						1200	846		374	1081
B 03			286	3238	190			272	136	
B 04						540	450		0	140
B 05			95	1478	952			200	2381	
B 06			1470	2190	476	6905	400	1045	1300	1070
C 01	1081	2809	893	282						
C 02			140							
C 03	235	762	423	174			546	0	300	2182
C 04					611	705		0		
C 05	94	429	93			231	3182		100	455
C 06				329	188		91	0		
C 07		0	0			546				
C 08			235	0	94	185	0	0	0	564
C 09	752	143	186							
C 10						238	556	91		
D 01									185	
D 02							93			
D 03					94	471		188	47	
D 04								140		
D 05					571	94	94		523	
D 06							0		463	
D 07					0		952			
D 08								1410		
D 09					952	1810			837	
D 10								450	900	
E 01							216			
E 02						139	162	140	48	
E 03										
E 04						0	48			
E 05								0	49	
E 06							95	0		
E 07								50	500	
E 08						0	0	470	0	238
E 09		47			658	476	0	651	0	350
E 10		185			1296					
E 11		0		94	1128	93	232	2000	0	376
E 12		47	0	648	1019	94		550	0	0
F 01	377	0	800	300	1100		95	428		1000
F 02	200	1200	6138	300	0	190			91	432
F 03	500					1628	1238	0	139	48
F 04	0					714		1706	381	324
F 05	0	0	400	100	1600		893		273	238
F 06						1000		682		609
F 07	0						1023	231		
F 08	0	1364	0	500	864	350	48	95	285	1047
F 09	0						93	1000	0	140
F 10		0	300	3318	200		648			
F 11	400	1000	0	900				50	666	
F 12		400	0	0	800		1047		370	238
G 01		2068	1528	846	1222	0	143			1000
G 02		2209		1100		952	238	619	333	216
G 03			800	3300	650	300		0		0
G 04		324	1389	893	463	600	429	143	714	
G 05		611	376	893	1150	714	429	0	429	174
G 06		95							286	
G 07					470	0	95	0	95	190
G 08	141		282	564	611					95
G 09			324	611		500	0	48	48	
G 10	324	810	238			500	0			
G 11		517	188		571	667	0	48	0	0
G 12	235			602		1000	0	48	48	
H 01		0	3381	893						
H 02		0	1235	47	1190					
H 03										
H 04		95	48	857	762					
H 05		364								
H 06			476	0	429	571	333	141	141	0
H 07		286								
H 08				333	294	0	143	48	571	0
H 09		381	143							
H 10		326	286		667	95	286	47	0	0
H 11		381								
H 12				619	190	694	231	370	372	
H 13		423	586						93	0
H 14			428	286	0	0	93	47	286	279
H 15		286				0	0	0	0	0

Appendix 1i. Cell numbers (cells litre^{-1}) of *D. rotundata* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			0	0		0	0	0	0	0
B 02						0	0		0	47
B 03			0	0	0			0	0	
B 04						0	0		0	140
B 05			0	0	0			0	0	
B 06			0	0	0	0	0	0	0	47
C 01	0	0	0	0						
C 02			0							
C 03	0	0	0	0			0	0	0	46
C 04					0	341707		0		
C 05	0	0	0			0	0		0	0
C 06				0	0		0	0		
C 07		0	0			64327				
C 08			0	0	0	0	0	0	0	0
C 09	0	0	0							
C 10						0	0	0		
D 01									0	
D 02							0			
D 03					0	0		0	0	
D 04								0		
D 05					0	0	0		0	
D 06							0		0	
D 07					0		0			
D 08								0		
D 09					0	95			47	
D 10								0	0	
E 01							0			
E 02						0	0	0	0	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	0
E 09		0			0	0	0	0	0	0
E 10		0			0					
E 11		0		0	0	0	0	0	47	0
E 12		0	0	0	0	0		0	0	0
F 01	0	0	0	0	0		0	48		0
F 02	0	0	0	0	0	0			0	0
F 03	0					0	0	0	0	0
F 04	0					0		0	0	0
F 05	0	0	0	0	0		0		0	0
F 06						0		0		0
F 07	0						47	0		
F 08	0	364	0	0	0	0	0	0	0	0
F 09	0						0	0	93	0
F 10		0	0	136	0		0			
F 11	0	0	0	0				0	0	
F 12		0	0	0	0		0		0	0
G 01		0	0	0	0	0	0			0
G 02		0		0		0	0	0	0	0
G 03			0	0	0	0		0		0
G 04		0	0	0	0	0	0	0	0	
G 05		0	0	0	0	0	0	0	0	0
G 06		0							0	
G 07					0	0	0	0	0	0
G 08	0		0	0	0					0
G 09			46	0		0	0	0	0	
G 10	0	0	0			0	48			
G 11		0	0		0	0	0	48	0	0
G 12	0			0		0	48	0	0	
H 01		0	0	47						
H 02		0	0	0	0					
H 03										
H 04		0	0	0	0					
H 05		0								
H 06			0	0	0	0	0	0	0	0
H 07		0								
H 08				0	0	0	48	0	0	0
H 09		0	0							
H 10		0	0		0	0	0	47	0	0
H 11		0								
H 12				0	0	0	0	0	0	
H 13		0	0						0	0
H 14			0	0	0	0	0	0	95	0
H 15		0				0	0	0	0	47

Appendix 1j. Cell numbers (cells litre^{-1}) of *P. alata* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			8972	4769		11975	7021	57439	5554	20988
B 02						31910	12933		41154	28915
B 03			7248	1665	13032			15264	23457	
B 04						24150	64885		41154	22752
B 05			12248	3863	3062			81051	7494	
B 06			7802	1736	652	908	81026	8056	151044	14694
C 01	1916	319	6685	1916						
C 02			3259							
C 03	0	1303	958	7878			1272	2000	9573	3392
C 04					5269	7664		24996		
C 05	1916	2607	2482			1986	848		0	0
C 06				3353	1916		424	3840		
C 07		1276	2612			424				
C 08			958	1437	1437	2482	5748	2395	0	0
C 09	5748	1629	466							
C 10						319	993	913		
D 01									13961	
D 02							5907			
D 03					2395	2058		0	5269	
D 04								8905		
D 05					638	958	0		2234	
D 06							2685		0	
D 07					36292		2804			
D 08								3820		
D 09					4205	4568			23253	
D 10								44675	63821	
E 01							12650			
E 02						6872	14950	20988	40615	
E 03										
E 04						4296	8568			
E 05								954	1366	
E 06							3255	848		
E 07								10636	2127	
E 08						6552	4770	958	48	2664
E 09		0			1916	1762	659	760	250	100
E 10		1986			3971					
E 11		15423		958	1916	3222	1074	0	479	0
E 12		3323	2978	11912	993	0		150	50	479
F 01	0	18700	300	5600	3800		2103	0		4105
F 02	4400	18000	0	6900	900	3364			3816	193200
F 03	5500					1397	3258	13800	3969	4236
F 04	11500					2281		780	3569	3450
F 05	11300	11000	12800	10300	1300		3832		0	0
F 06						2803		892		0
F 07	18400						1863	1986		
F 08	15000	0	14800	3700	1696	8509	0	0	0	0
F 09	8000						955	0	0	2021
F 10		15000	16900	0	300		2148			
F 11	12200	15500	24000	3400				450	0	
F 12		1100	25000	21500	1900		0		0	
G 01		1273	0	3819	958	9700	374			49450
G 02		958		13827		3364	1869	701	0	12236
G 03			8509	29782	0	5700		0		6450
G 04		0	2482	2395	0	5375	701	935	0	
G 05		0	1909	2874	0	935	48	95	0	3220
G 06		0							1402	
G 07					0	860	0	0	1868	0
G 08	7664		479	958	10538					0
G 09			496	0		12100	935	0	0	
G 10	993	3738	0			1700	0			
G 11		479	3353		6124	3271	48	0	0	1021
G 12	1437			0		3600	0	0	12800	
H 01		0	935	3819						
H 02		0	0	5005	7494					
H 03										
H 04		0	467	2804	1869					
H 05		0								
H 06			2340	2127	477	0	0	958	0	479
H 07		0								
H 08				0	705	0	477	0	477	0
H 09		1333	3744							
H 10		2008	619		11144	0	0	0	1063	0
H 11		3276								
H 12				2340	19258	18863	6453	3475	1397	
H 13		3832	4392						993	957
H 14			4996	1869	7551	0	0	319	3541	0
H 15		381				0	0	72300	1437	0

Appendix 1k. Cell numbers (cells litre^{-1}) of *S. costatum* from 24 May until 20 June (0-10 m) at all sections. Blanks means no samples taken.

Station	24.05.90	27.05.90	30.05.90	02.06.90	05.06.90	08.06.90	11.06.90	14.06.90	17.06.90	20.06.90
B 01			0	0		6102	9574	0	0	0
B 02						7446	0		0	0
B 03			0	2080	0			0	6706	
B 04						0	7551		0	0
B 05			0	0	0			0	0	
B 06			0	0	5213	54501	32974	3026	0	2844
C 01	0	0	0	0						
C 02			0							0
C 03	0	0	0	33664			0	0	0	
C 04					3051	1916		0		
C 05	0	0	0			0	0		0	0
C 06				0	0		0	0		
C 07		7021	0			0				
C 08			0	0	0	0	0	0	0	0
C 09	5269	0	0							
C 10						0	0	0		
D 01									0	
D 02							0			
D 03					0	0		0	0	
D 04								10885		
D 05					638	0	0		0	
D 06							17720		0	
D 07					0		0			
D 08								0		
D 09					0	0			0	
D 10								6382	0	
E 01							0			
E 02						0	0	12402	1218	
E 03										
E 04						0	0			
E 05								0	0	
E 06							0	0		
E 07								0	0	
E 08						0	0	0	0	0
E 09		0			0	0	0	0	0	0
E 10		0			0					
E 11		13827		0	0	0	0	0	0	0
E 12		5697	0	0	0	1916		0	0	0
F 01	2545	58000	4600	2800	100		0	0		0
F 02	5600	52000	30552	500	1300	0			0	3450
F 03	12500					0	0	0	0	0
F 04	2000					0		0	0	0
F 05	2700	30000	4000	400	0		0		0	0
F 06						0		0		0
F 07	12800						0	0		
F 08	17000	0	5300	100	0	0	0	0	0	0
F 09	1000						477	0	0	0
F 10		5500	1400	0	0		0			
F 11	800	500	2800	0				0	0	
F 12		2500	1500	6500	0		0		0	0
G 01		6102	61552	33561	0	0	0			0
G 02		9153		0		0	0	0	0	1932
G 03			0	0	0	58050		0		0
G 04		0	0	0	993	0	0	0	0	
G 05		0	0	0	0	0	0	0	1402	5179
G 06		0							935	
G 07					0	0	0	0	0	0
G 08	0		0	0	0					0
G 09			0	0		0	0	0	0	
G 10	0	0	0			0	0			
G 11		0	12204	993	0	0	0	0	0	0
G 12	0					0	0	0	1869	
H 01	140828	7009	114570							
H 02	108388	3880	0	89927						
H 03										
H 04	21027	1173734	12616	24765						
H 05	8055									
H 06		0	56375	58675	0	0	3832	0	0	
H 07	0									
H 08			3738	0	0	0	0	0	0	
H 09	0	0								
H 10	4016	0		2026	0	0	0	0	0	
H 11	75844									
H 12			1009457	0	0	0	0	0		
H 13	0	2395						0	0	
H 14		0	0	0	0	0	0	0	0	
H 15	4572				0	0	0	0		