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Seasonal Phytoplankton Assemblages in Northeastern Coastal Waters of the United States

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ABSTRACT

The composition, concentration, and distribution of phytoplankton is discussed for the northeastern coastal waters. Areas of highest cell numbers included near shore waters adjacent to major estuary systems, Georges Bank, locations in the Gulf of Maine, and scattered sites along the shelf break. Areas of lowest cell concentrations were found at mid-shelf, within the Gulf of Maine, and in the more seaward stations. Seasonal patterns of succession occurred, with areas of high cell concentrations dominated by small-sized diatoms (e.g. *Skeletonema costatum, Leptocylindrus danicus, Asterionella glacialis*) and several ultraplankton components. The seasonal presence of 678 phytoplankton is noted.

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INTRODUCTION

In two earlier articles by Marshall and Cohn (1981a, b), studies in the northeastern coastal waters were discussed, with a presentation of phytoplankton concentrations and community structure given for two fall months. In this paper, features of the annual phytoplankton distribution in northeastern coastal waters of the United States are described in relation to seasonal assemblages and dominant species throughout the year. Emphasis has been placed on the actual phytoplankton composition because of the relationships these populations have in sustaining fishery resources, and to characterize those species that are seasonally present within this trophic system. This type of information would not be available when more indirect methods of assessing phytoplankton abundance are used (e.g., chlorophyll "a" measurements). The information obtained in this study will provide a broad reference source of seasonal species composition and concentrations over the northeastern shelf region. To this data base will be added ongoing monitoring information on phytoplankton for future analysis and application to regional fishery concerns.

METHODS

Water samples were obtained from eight Ocean Pulse/MARMAP cruises over portions of the United States northeastern continental shelf between October 1978 and February 1980. Station coordinates and cruise tracks are given in the National Marine Fisheries Service (NMFS) cruise reports (BELOGORSK 78-03, 78-04, 79-01; DELAWARE 79-03, 79-05, 79-11; ALBATROSS 79-06, 80-02). During each cruise, NMFS personnel collected the samples and provided support data. Collection and analysis protocol has been previously described (Marshall and Cohn, 1981a). It includes taking 500 ml water samples which are subsequently examined with an inverted microscope using a modified Utermohl technique. In this report, the results are based on surface samples preserved with buffered formalin solution.

Duplicate samples were also taken during each cruise and examined by both investigators to assure quality control for species identification. The classification used here generally follows the format given by Hendey (1974), Parke and Dixon (1976), and Van Landingham (1976-1979). All data were transferred to the computer files at the NMFS, Sandy Hook Laboratory.

RESULTS

A total of 678 phytoplankters were identified in this study and are listed in Table 1. The species were divided among the Bacillariophyceae (274), Dinophyceae (Pyrrhophyceae)(332), Haptophyceae (Prymnesiophyceae) (19), Euglenophyceae (8), Cyanophyceae (12), Chlorophyceae (13), Xanthophyceae (2), Chrysophyceae (6), Cryptophyceae (7), and Prasinophyceae (5). An additional category composed of unspeciated ultraplankton was also recognized. Several apparently different species were included in this group. They all had cells which were round to ovoid in shape, and less than 10 microns in size (most less than 3 microns). The majority of these species appear to be members of either the Cyanophyce or Chlorophyce.

Continual seasonal coverage of the phytoplankton growth patterns was not possible with only eight cruises (one to five weeks duration) over a 17 month period. Thus, although restricted to the time periods imposed by the eight cruises, growth patterns were identified with characteristic assemblages, were divided into the following monthly categories: October-November, December-March, May, and June-August. This grouping does not infer a strict temporal adherence of these populations to these months, but rather an association of certain phytoplankton to different periods of development within the system, that took place during this series of collections. The occurrence and dominance of the various phytoplankters during these periods are given in Table 1.

SPECIES COMPOSITION

Assemblages in October-November (cruises BELOGORSK 78-03, 78-04)

The phytoplankton during this period were dominated by large concentrations of small-sized diatoms with an assortment of other diatoms, phytoflagellates, and chlorophyceans predominating. At the near shore stations the abundant forms included the diatoms *Asterionella glacialis, Corethron criophilum, Leptocylindrus danicus, Nitzschia pungens, Rhizosolenia delicatula, Skeletonema costatum,* and *Thalassionema nitzschioides*. Other common species included *Nannochloris atomus, Ceratium lineatum, Dinophysis fortii, Gymnodinium* spp.*, Heterocapsa triquetra, Prorocentrum micans, Emiliania huxleyi, Pyramimonas grossi, Dictyocha fibula,* and *Distephanus speculum*. Forms more abundant at the off shore stations were *Guinarida flaccida, Leptocylindrus danicus, Nitzschia pungens, Rhizosolenia imbricata, Skeletonema costatum, Thalassionema nitzschoides, Ceratium* spp.*, Prorocentrum aporum, P. compressum, P. micans, Cyclococcolithus leptoporus, Emiliania huxleyi, Dictyocha fibula, Distephanus speculum,* and *Nannochloris atomus*. In addition to the above, large concentrations of unspeciated ultraplankters were often found at stations throughout the shelf, but in greatest numbers near shore and less frequently along the shelf break.

In total, 427 species were identified during this period, of which 208 were diatoms, 107 pyrrhophyceans, and the remaining 49 species representing eight other phylogenetic classes. Average counts indicated highest cell concentrations were found at near shore stations (78,761 cells/l) compared to the off shore stations (31,212 cells/l) (see Table 2). This collection may be reflective of a species transition from the more typical species of warmer stable waters to those of the cooler, fall turnover period. In general, diatoms were more abundant near shore, averaging 63,900 cells/l compared to 26,800 cells/l for the off shore stations, with a greater number of species found at the near shore stations than at the off shore stations. Other diatoms that did not reach large concentrations, but were common over the shelf at this time included *Actinoptychus senarius, Cerataulina pelagica, Chaetoceros* spp., *Coscinodiscus* spp., *Cylindrotheca closterium, Ditylum brightwellii, Nitzschia seriata, Paralia sulcata, Rhizosolenia* spp., and *Thalassiosira* spp.

The dinophyceans had a larger number of species, but were in lower concentrations near shore, as were the euglenophyceae and prasinophyceae. *Amphidium* spp., *Ceratium* spp., *Dinophysis* spp., *Gonyaulax* spp., *Gymnodinium* spp., *Gyrodinium* spp., *Oxytoxum* spp., *Prorocentrum* spp., and *Protoperidinium* spp. represented the majority of dinoflagellates in this category with *Prorocentrum micans* a characteristic form over the shelf. Although not noted in large concentrations, the coccolithophores were common throughout the area, but more abundant off shore. In contrast, the chlorophyceans, represented mainly by *Nannochloris atomus*, were concentrated at the near shore stations. The silicoflagellates, *Dictyocha fibula* and *Distephanus speculum*, consistently were found throughout the shelf area but were more numerous at mid- and far-shelf stations. The major cyanophyceans were *Oscillatoria erythraea* and *Nostoc commune*. The unspeciated ultraplankton component had the largest concentration of cells at the near shore stations. These cells appeared similar to several coccoid-shaped chlorophycean and cyanophycean species.

The species composition at adjacent stations were usually similar, but often with different species or combinations of species being dominant. Species dominance changed from October to November with *Skeletonuma costatum* being the dominant in October, and *Nannochloris atomus* in November. The fall outburst was associated with *Skeletonema costatum* development, decreased in November. The areas of highest cell concentrations were off Narragansett Bay, lower New York Bay, in portions of the Gulf of Maine, and over Georges Bank (Figures 1 and 2). Lowest levels were found in the Gulf of Maine and at locations along the shelf break. Not included in these cruises were collections in the most southern and northern extremes of the shelf, with the BELOGORSK 78-04 cruise limited to a north central area.

Assemblages of December, February, and March (cruises DELAWARE 79-03, 79-11; ALBATROSS 80-02)

The winter-spring outburst for the northeastern shelf waters is normally associated with this period. The onset of this vernal growth period may begin as early as the November-December period, reaching its climax by late March or early April (Fish, 1925; Gran and Braarud, 1935; Lillick, 1937; Sears, 1941; Riley, 1952; Pratt, 1959). Even with a broad range of times given for the start and duration of the "spring" growth period in this region, the pattern of growth is basically the same. Small-sized diatoms dominate the period, characterized by high concentrations of cells that generally persist through late winter and early spring. The concentrations then decline rapidly, with the dominants replaced by other species in lower concentrations.

The average counts for the near shore stations were 207,468 cells/l, and 153,541 cells/l at the far shore stations. These were the highest combined concentrations for the study. A total of 326 species was noted for this period, consisting of Bacillariophyceae (168), Dinophyceae (113), Haptophyceae (15), Euglenophyceae (2), Cynaophyceae (6), Chlorophyceae (4), Chrysophyceae (8), Cryptophyceae (7), and Prasinophyceae (3). The diatoms and the unspeciated ultraplankton component represented the two most abundant groups with the highest concentrations of cells at the near shore stations. A patchy distribution of stations with low, moderate, and high cell concentrations occurred during cruises in December and February 1979 (Figures 3 and 4). Over this time period, areas of highest cell count were located at coastal stations south of lower New York Bay, Delaware Bay, Chesapeake Bay, and scattered in central shelf areas. During the ALBATROSS 80-02 cruise between 27 February and 5 April 1982, there was a pattern of high levels of cell concentrations over the entire shelf (Figure 5). These numbers (10^5-10^6 cells/l) came mainly from the ultraplankton and represented an extensive development over the entire cruise track. Not included in these collections were samples from the northern shelf and a large part of the Gulf of Maine.

The dominant species during this period included the diatoms: *Leptocylindrus danicus, Skeletonema costatum, Thalassiosira nordenskioldii, Thalassiosira rotula, T. aestivalis, Chaetoceros* spp., *Rhizosolenia* spp., *Asterionella glacialis, Thalassionema nitzschioides,* and *Nitzschia pungens*. In addition there were species that were widely distributed and usually present, but not in high concentrations. These included: *Paralia sulcata, Corethron criophilum, Thalassiosira gravida, Coscinodiscus nitidus, Cerataulina pelagica, Chaetoceros decipiens, Rhizosolenia alata, R. delicatula, R. imbricata, Guinardia flaccida, Ditylum brightwellii, Cylindrotheca closterium,* and *Nitzschia seriata*.

The dinophyceans were common, but not in very high concentrations. Most characteristic of the samples were *Prorocentrum micans, P. minimum, P. balticum, Gymnodinium* sp., *Ceratium lineatum, C. fusus,* and *C. tripos*. Other common forms included the silicoflagellates *Dictyocha fibula* and *Distephanus speculum*, and the coccolithophore *Emiliania huxleyi*. Higher average concentrations of coccolithophores were at the off shore stations, where *Emiliania huxleyi* was most abundant. The unspeciated ultraplankton component consisted of a mixed assemblage containing flagellate and non-flagellated types. Many appeared to be cryptophyceans and chlorophyceans. These were most abundant near shore and downstream from the major estuarine systems. At the off shore stations, they were widely scattered with high numbers at sites near the shelf break.

Assemblages in May (cruise DELAWARE 79-05)

Samples were taken in late spring following the vernal outburst; average cell concentrations were low. The dominant species included a large representation of *Chaetoceros* spp. and an assortment of small-sized diatoms. The dominant species were *Chaetoceros sociale* and *Leptocylindrus danicus* with an unspeciated ultraplankton component abundant. The collections in May were geographically extensive and covered all portions of the shelf between Cape Hatteras and the northern Gulf of Maine (Figure 6).

A total of 230 species was noted with the majority composed of diatoms (104), dinophyceans (91), haptophyceae (13), and the remaining (22) divided among the other groups. The average concentrations per station were 44,730 cells/l for the near shore stations and 34,923 cells/l for the off shore stations. There were only slight differences in average concentrations of diatoms over the shelf. However, values for dinophyceans, haptophyceans, euglenophyceans, and cryptophyceans were significantly higher at off shore stations. The unspeciated ultraplankton component and the cyanophyceans were concentrated near shore. The ultraplankton consisted of several species, round to ovoid in shape and less than 10 microns in size, others of which were flagellated. Xanthophyceans were not noted in these collections. Prasinophyceae were found only at near shore stations and represented by several *Pyramimonas* spp. in low numbers. The most abundant forms at the near shore stations were the diatoms *Chaetoceros sociale* and *Leptocylindrus danicus*, the cyanophycean *Nostoc commune*, and a mixed, unspeciated ultraplankton group.

The compositions of phytoplankton at off shore stations differed from those near the coast in having lower diversity and higher equitability. The prominent diatoms consisted of a few small-sized forms (e.g. *Cylindrotheca closterium*, *Leptocylindrus danicus*) and a variety of chain-forming species including *Cerataulina pelagica, Chaetoceros* sp., *C. compressum, C. curvisetum, Nitzschia pungens,* and *Thalassiosira gravida.* Of the coccolithophores, *Emiliania huxleyi* was common in all the collections, but in higher concentrations over the mid- and outer-shelf. Two other abundant forms over the shelf were *Eutreptia viridis* (euglenophycean) and *Cryptomonas* sp. Representative cryptomonads were widely distributed over the shelf. Other phytoflagellates that were common in the shelf collections included *Prorocentrum minimum, P. balticum, Dinophycis fortii, Ceratium fusus, C. lineatum,* and *C. tripos.*

Throughout the spring collection there was a distinct difference in the concentrations of cells and dominant species. Patchiness was common, with highest cell concentrations found at sites in the Gulf of Maine, Georges Bank, off Rhode Island, outside New York Bay and Delaware Bay, and in portions of the shelf area off North Carolina. High cell numbers were observed in the northern sector extending in a crescent shaped pattern from the northeastern coast of Maine to Georges Bank and Nantucket Shoals. Low concentrations were found at both near and off shore locations scattered over the shelf. The near shore species composition was mainly a mixture of small-sized cells (diatoms and other ultraplankton) with chaetoceran and other chain-forming diatoms common. The numbers of phytoflagellates and larger cell types over the mid- and far-shelf were significantly greater than what was found at the near shore stations.

Assemblages in June, July, and August (cruise ALBATROSS 79-06; BELOGORSK 79-01)

This period contrasted with May, showed an increase in the concentration of phytoplankton over the shelf, with average counts of 75,942 and 65,337 cells/l noted for the near and off shore stations. A total of 316 species was identified during this period with the diatoms (153) and dinophyceans (126) having the greatest representation and the remaining 37 species divided among the other groups. The dominant species at the near shore stations were the diatoms *Skeletonema costatum*, *Leptocylindrus danicus*, *Thalassiosira rotula*, *Asterionella glacialis*, *Cylindrotheca closterium*, and *Hemiaulus sinensis*. At the far stations dominant forms were *Chaetoceros atlanticum*, *Rhizosolenia* spp., *Asterionella glacialis*, and *Thalassiosira rotula*. There were 16 species of *Rhizosolenia* common in the samples, which were widely distributed over the shelf. *Rhizosolenia alata*, *R. alata gracillima*, and *R. imbricata* were most numerous.

With the exceptions of several scattered stations where small-sized diatoms were abundant, none of the other groups were found in high concentrations. The cyanophyceans, dinophyceans, and haptophyceans were well represented in the majority of samples, but were not found in high concentrations. In general, the average concentrations for the diatoms, cyanophyceans, chrysophyceans, and the ultraplankton component had higher values near shore, whereas the haptophyceans and cryptophyceans had greater concentrations at the off shore stations. The values for the dinophyceae, euglenophyceae, chlorophyceae, and prasinophyceae were fairly similar across the shelf, with the xanthophyceans noted only near shore. Other species common over a broad range of shelf stations but not in large concentrations were the cyanophyceans *Nostoc commune* and *Oscillatoria erythraea* and the coccolithophore *Emiliania huxleyi*. Common diatoms included *Coscinodiscus nitidus*, *Eucampia zoodiacus*, *Cerataulina pelagica*, *Chaetoceros decipiens*, *Rhizosolenia* spp., *Guinardia flaccida*, *Thalassionema nitzschioides*, *Nitzschia pungens*, and *Crucigenia fenestrata*. Among the dinophyceans, the most representative species were *Prorocentrum micans*, *P. minimum*, *P. apora*, *P. balticum*, *Dinophysis fortii*, *Amphidinium acutum*, *Ceratium fusus*, *C. lineatum*, *C. tripos*, and *Cryptomonas* sp.

There was again a patchy pattern with high and low cell concentrations over the shelf (Figures 7 and 8). The stations where cell concentrations were greatest included several near shore stations from Maine to North Carolina, those at scattered shelf locations, and Georges Bank.

SUMMARY

Different concentrations of cells occurred throughout each "season", with many similar species common throughout the annual cycle. High cell concentrations were associated with Georges Bank, over and southwest of Nantucket Shoals, various near shore stations in the Gulf of Maine, off Lower New York Bay, southeast and south of Delaware Bay, south of the Chesapeake Bay entrance, at scattered sites over the mid-shelf, and along the length of

the shelf break. High cell concentrations were most consistently found at the near shore stations, with wide ranges of abundance noted over the shelf. Small-sized diatoms (e.g., *Skeletonema costatum, Leptocylindrus danicus, Asterionella glacialis*) were the major components of the spring outburst, the increased growth associated with the summer-early fall periods, and those sites designed as high cell density areas. Later stages of growth followed the classical pattern, dominated by *Chaetoceros* spp. and *Rhizosolenia* spp. and the coccolithophore *Emiliania huxleyi*. However, in contract to the regional succession pattern, the shelf appears to be composed of separate areas of dynamic growth and productive lethargy, that were often out of phase with each other. The phytoplankton of the shelf had not totally moved on cue, but rather were in various stages of the growth and succession process. The areas with greatest potential for growth were generally associated with regions of nutrient enrichment and/or upwelling. Overshadowing these phytoplankton dynamics are the broad, seasonal influences that will affect the initiation and continuance of the major growth patterns observed.

Because the system is not specifically stereotyped in relation to specific times when production peaks will occur over the shelf, certain seasonal periods and sites are consistently more productive than others. Response times for the various growth patterns observed are short, so that phytoplankton composition may serve as an index to productivity quality and food source potential of a particular water mass, which may be easily monitored through both direct sampling and airborne sensory procedures. Due to the fluorescent properties to be defined (Johnson and Harris, 1980) and associated with phytoplankton asemblages derived from analysis of sea truth collections (Jarrett et al., 1981; Farmer, 1981). The use of phytoplankton to monitor the Chesapeake Bay plume over the continental shelf was reported by Marshall (1981). For three different seasons, the waters from the Chesapeake Bay were distinguished from adjacent shelf waters on the basis of the different seasonal assemblages that were present. Areas of most intense mixing, and the apparent remnants of past flow pulses from the Bay could also be identified. The present study and previous work in this area support the feasibility of utilizing phytoplankton assemblages to characterize different water masses over the shelf, that may differ in water quality and productive potential. Since the shelf is so extensive and subject to a vast array of variables that influence phytoplankton growth over short periods of time, a combination of sea surface collections to define the in situ phytoplankton assemblages and remotely sensed information to define the distribution and movement of the various water masses is needed to interpret the relationships of phytoplankton to essential food chains of economically significant fauna. We intend to blend remote sensing information with our present data on phytoplankton assemblage distribution in order to better define the distribution and abundance of phytoplankton over the continental shelf from Cape Hatteras to Nova Scotia in relationship to seasonal and temporal distribution and abundance of living marine resources.

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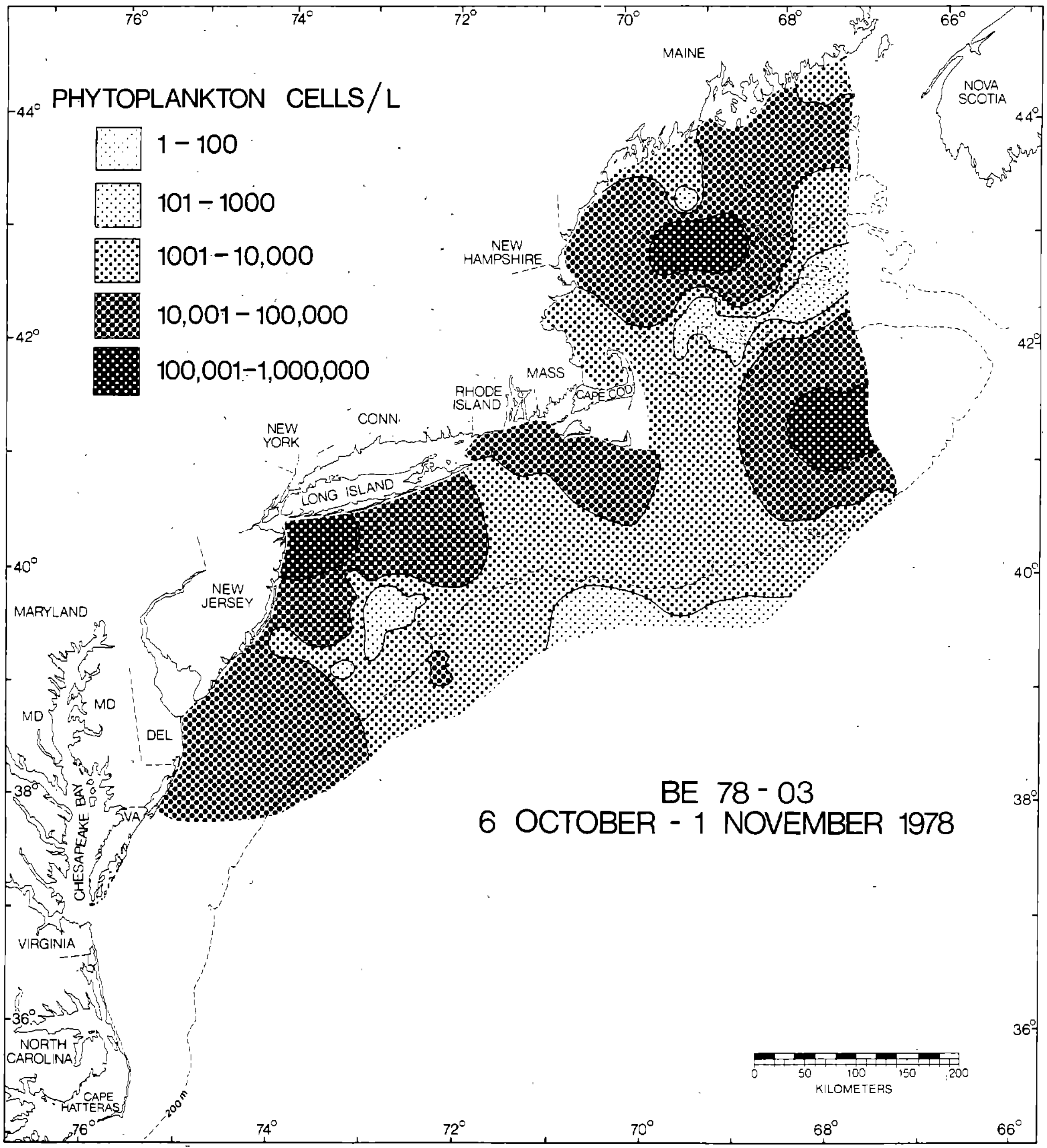

Figure 1. Concentrations of cells per liter during cruise BEL 78-03, 6 October-1 November 1978.

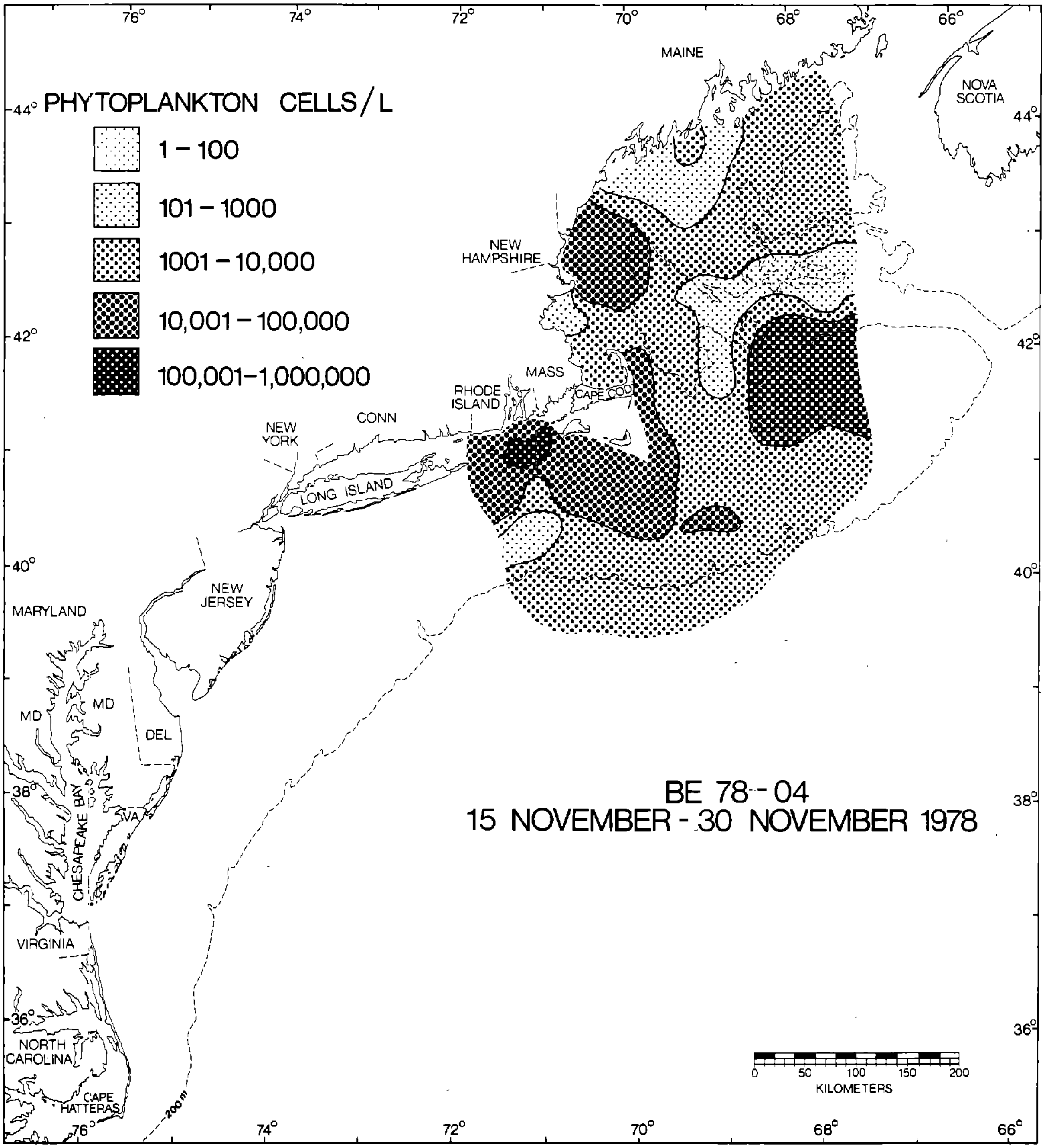

Figure 2. Concentrations of cells per liter during cruise BEL 78-04, 15-30 November, 1978.

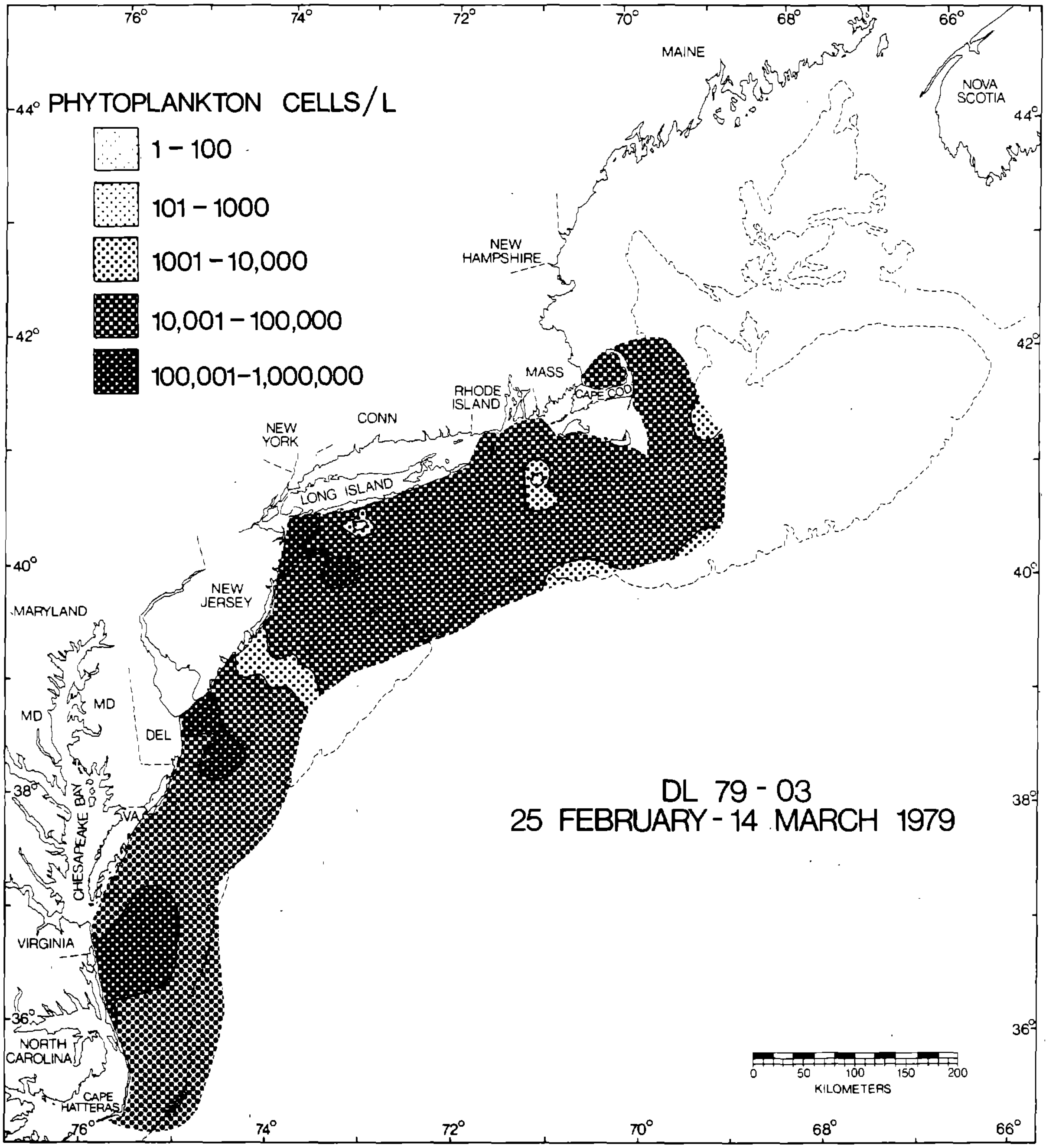

Figure 3. Concentrations of cells per liter during cruise DEL 79-03, 25 February-14 March 1979.

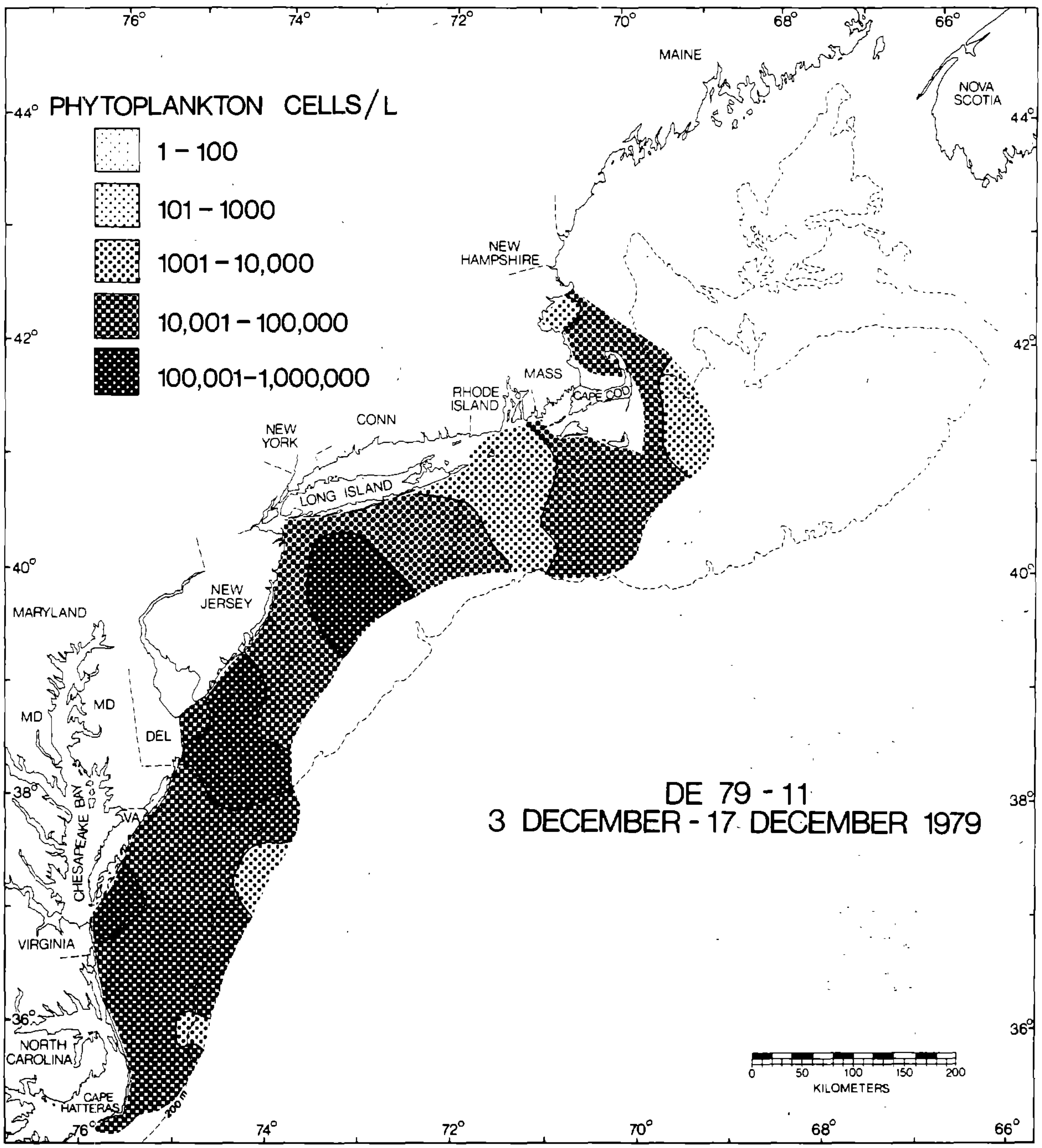

Figure 4. Concentrations of cells per liter during cruise DEL 79-11, 3-17 December 1979.

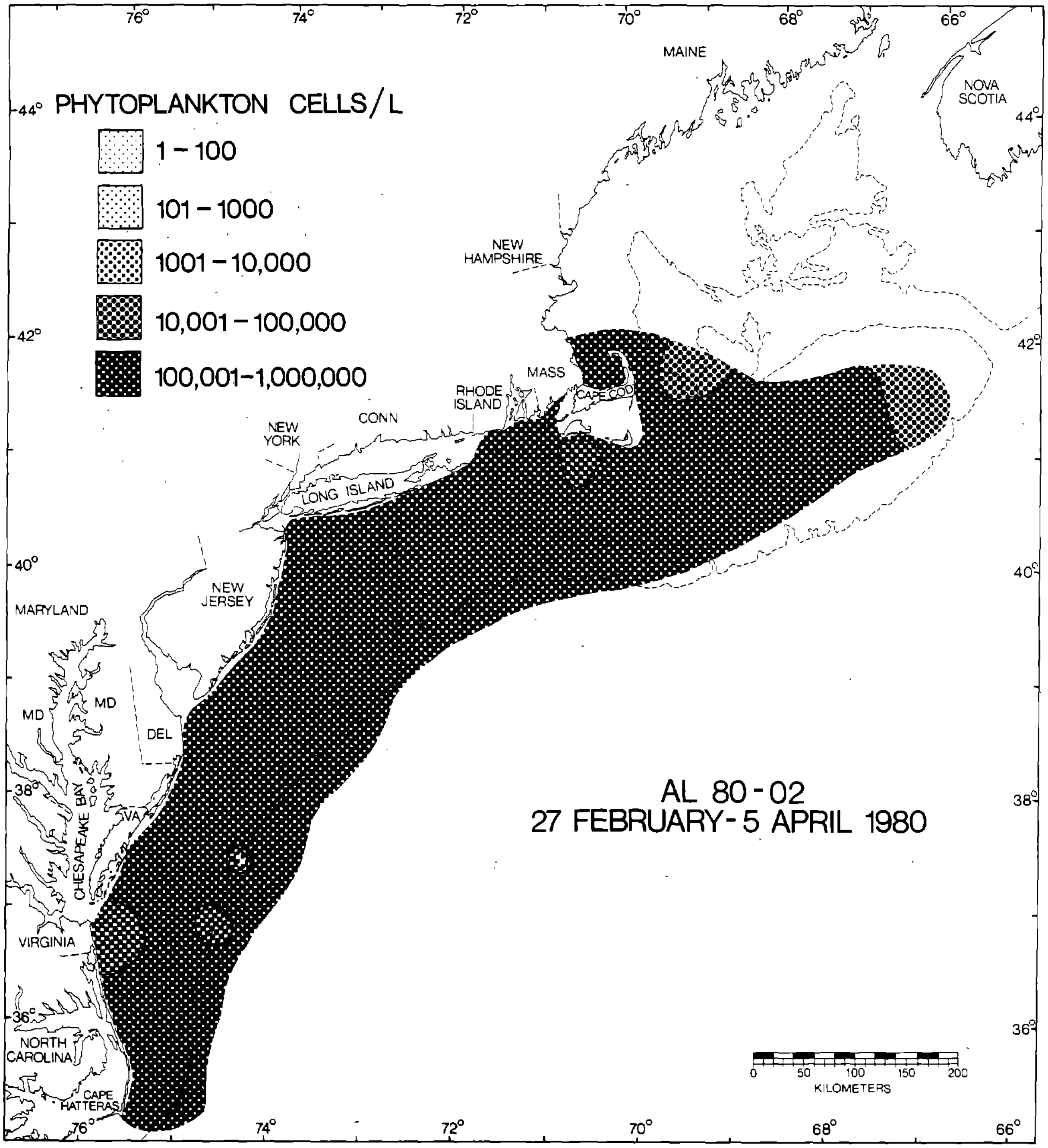

Figure 5. Concentrations of cells per liter during cruise ALB 80-02, 27 February-5 April 1980.

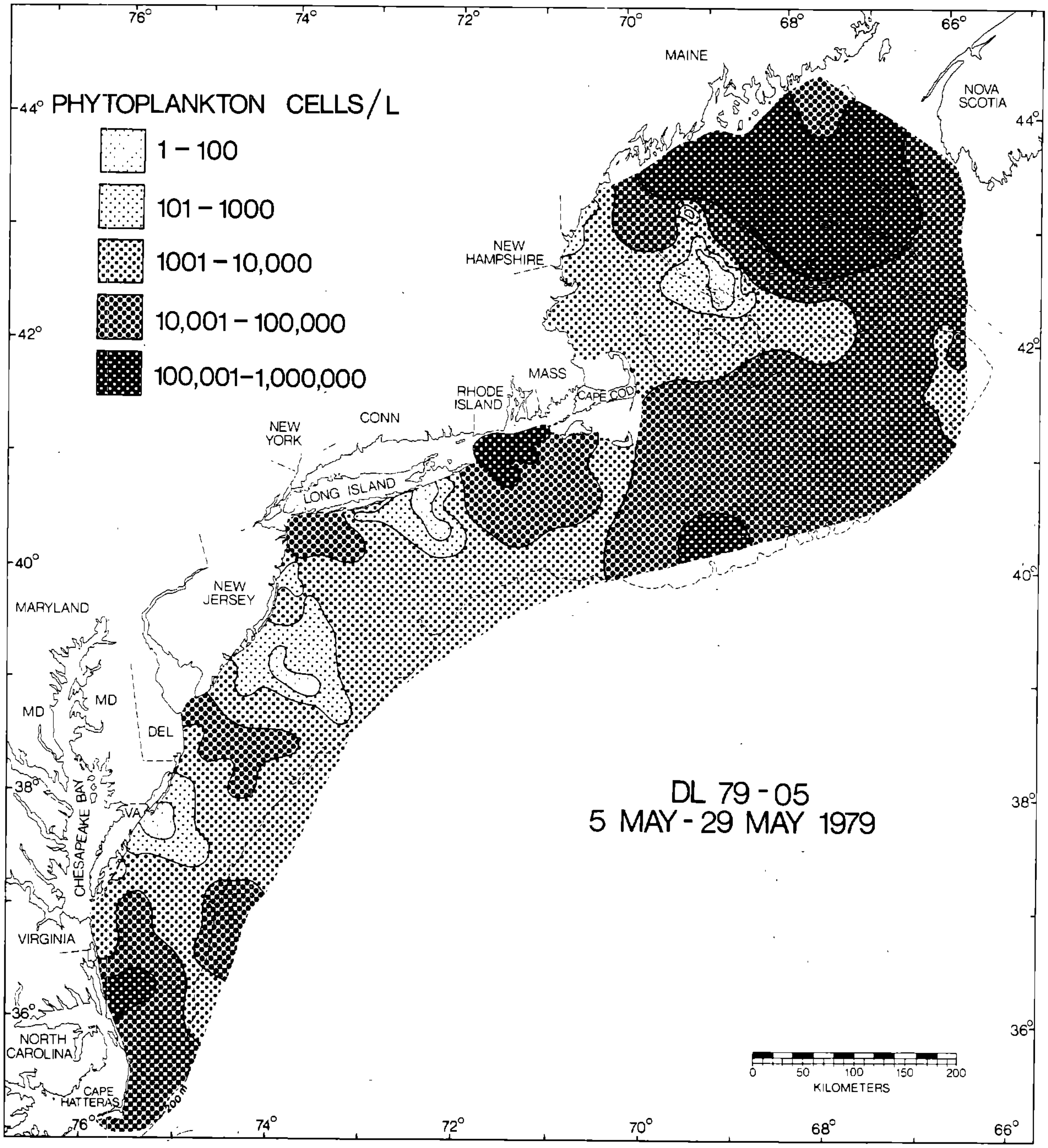

Figure 6. Concentrations of cells per liter during cruise DEL 79-05, 5-29 May 1979.

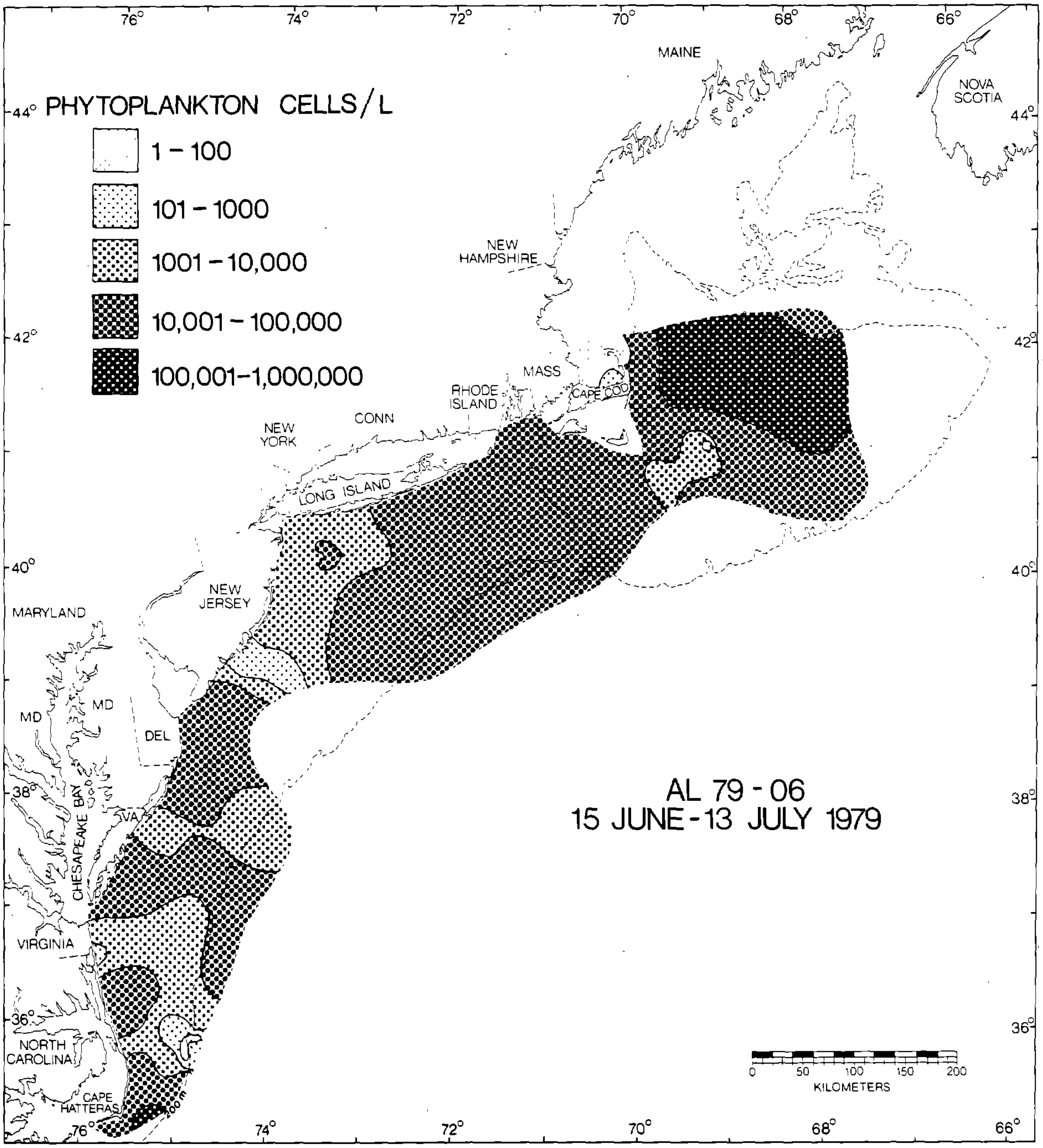

Figure 7. Concentrations of cells per liter during cruise ALB 79-06, 15 June-13 July 1979.

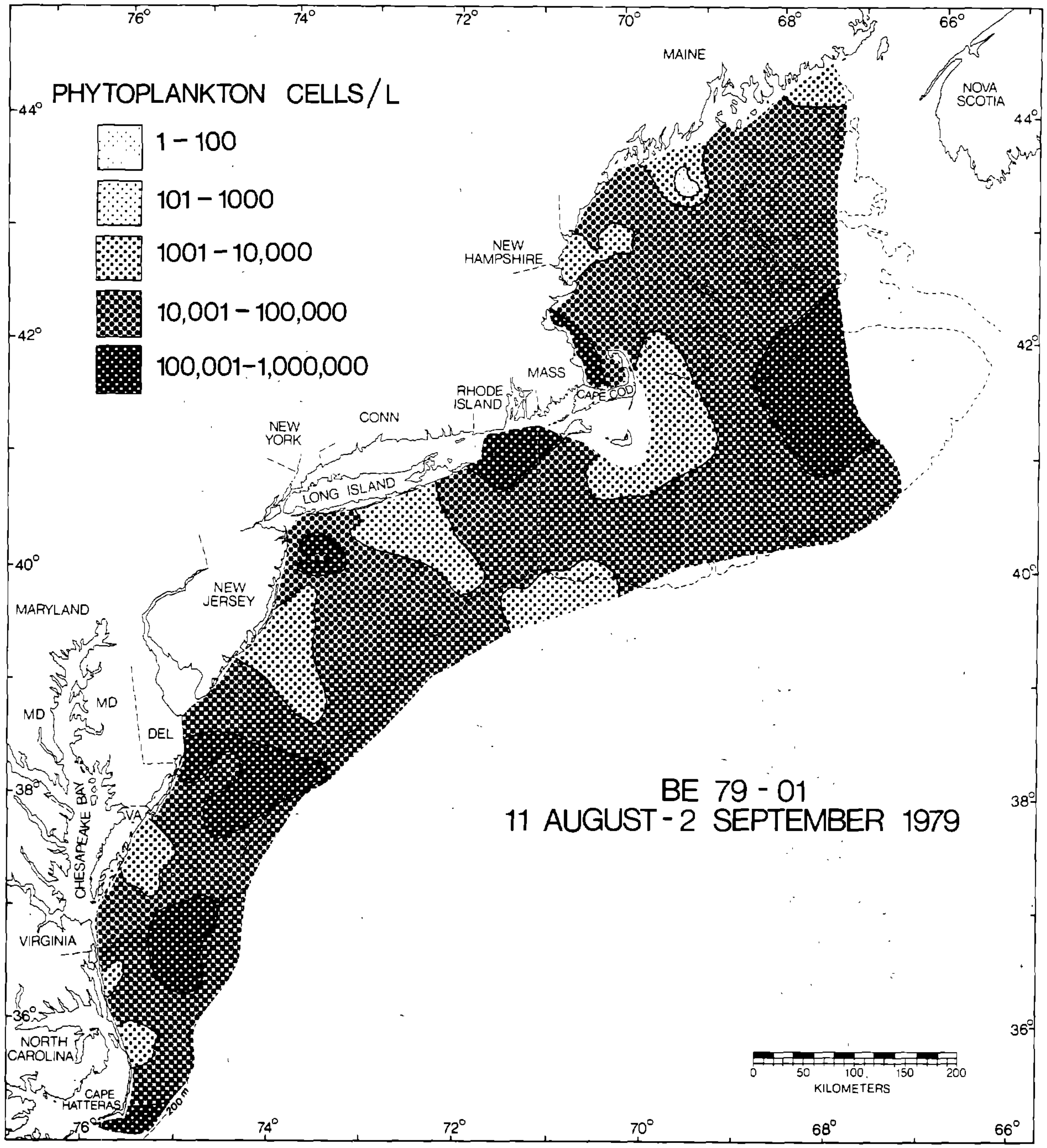

Figure 8. Concentrations of cells per liter during cruise BEL 79-01, 11 August-2 September 1979.

Table 1. Phytoplankton species identified during this study, with their presence noted during four time periods: I (December-March), II (May), III (June-August), and IV (October-November). The degree of dominance is indicated by A, B, or C (A greatest), with x representing presence.

BACILLARIOPHYCEAE	I	II	III	IV
Achnanthes sp.	-	-	-	x
Achnanthes longipes Agardh	x	x	x	x
Actinoptychus sp.	-	-	-	x
Actinoptychus senarius Ehrenberg	C	-	x	x
Amphiprora sp.	-	-	x	x
Amphiprora gigantea var. *decussata* Grunow	-	-	x	-
Amphora sp.	x	x	x	x
Amphora arenaria Donkin	-	-	x	x
Amphora costata W. Smith	x	-	x	x
Amphora crassa Gregory	-	-	-	x
Amphora cuneata Cleve	x	-	x	-
Amphora laevis Gregory	x	-	-	-
Amphora ostrearia Brebisson	-	-	-	x
Amphora ovalis Kutzing	-	-	-	x
Amphora proteoides Hustedt	-	-	x	-
Amphora proteus Gregory	x	-	-	-
Anaulus mediterraneus var. *intermedia* Grunow	-	-	-	x
Asterionella bleakeleyi W. Smith	-	x	-	-
Asterionella formosa Hassale	x	-	x	-
Asterionella glacialis Castracane	A	C	B	B
Asterolampra marylandica Ehrenberg	-	-	-	x
Asteromphalus flabellatus (Brebisson) Greville	-	-	-	x
Asteromphalus heptactis (Brebisson) Ralfs	x	x	-	-
Bacillaria paxillifer (Muller) Hendey	x	-	-	x
Bacteriastrum sp.	-	-	-	x
Bacteriastrum comosum Pavillard	-	-	x	-
Bacteriastrum delicatulum Cleve	C	-	x	-
Bacteriastrum hyalinum Lauder	x	x	x	x
Bacteriastrum varians Lauder	-	-	-	x
Bellerochea malleus (Brightwell) VanHeurck	-	-	-	x
Biddulphia sp.	x	-	x	x
Biddulphia alternans (Bailey) VanHeurck	-	x	x	x
Biddulphia aurita (Lyngbye) Brebisson	x	x	B	x
Biddulphia mobiliensis (Bailey) Grunow	-	x	x	x
Biddulphia regia (Schultz) Ostenfeld	x	-	x	x
Biddulphia sinensis Greville	-	-	-	x
Campylodiscus limbatus Brebisson	-	-	-	x
Campylosira cymbelliformis (Schmidt) Grunow	x	-	x	-
Cerataulina pelagica (Cleve) Hendey	C	B	x	x
Chaetoceros sp.	x	x	x	x
Chaetoceros affine Lauder	x	x	x	x
Chaetoceros atlanticum Cleve	B	x	C	x
Chaetoceros atlanticus var. *neapolitana* (Schroder) Hustedt	-	-	x	-
Chaetoceros breve Schutt	x	-	C	x
Chaetoceros coarctatum Lauder	x	x	x	x

Table 1 (conti.)

	I	II	III	IV
Chaetoceros compressum Lauder	B	C	C	x
Chaetoceros concavicorne Mangin	-	-	-	x
Chaetoceros constrictum Gran	C	-	-	x
Chaetoceros convolutum Castracane	x	-	-	-
Chaetoceros costatum Pavillard	C	x	x	x
Chaetoceros crinitus Schutt	-	-	-	-
Chaetoceros curvisetum Cleve	C	C	x	x
Chaetoceros danicum Cleve	C	x	x	x
Chaetoceros debile Cleve	-	-	-	x
Chaetoceros decipiens Cleve	C	C	C	x
Chaetoceros densum Cleve	-	-	x	x
Chaetoceros didymum Ehrenberg	x	x	x	x
Chaetoceros diversum Cleve	-	-	x	x
Chaetoceros externum Gran	-	-	-	x
Chaetoceros gracile Schutt	C	x	x	x
Chaetoceros laciniosum Schutt	x	-	-	-
Chaetoceros lorensianum Grunow	x	-	-	-
Chaetoceros pelagicum Cleve	-	-	x	x
Chaetoceros pendulum Karsten	x	-	x	x
Chaetoceros peruvianum Brightwell	-	x	x	x
Chaetoceros pseudocurvisetum Mangin	-	-	x	-
Chaetoceros simplex Ostenfeld	-	-	-	x
Chaetoceros sociale Lauder	C	A	x	x
Chaetoceros teres Cleve	C	-	x	-
Chaetoceros tortissimum Gran	x	-	-	x
Climacodium biconcavum Cleve	-	x	-	x
Climacodium frauenfeldianum Grunow	-	-	C	x
Climacosphenia moniligera Ehrenberg	-	-	-	x
Cocconeis sp. #1	x	x	x	-
Cocconeis sp. #2	x	-	-	-
Cocconeis distans Gregory	x	-	x	-
Cocconeis pinnata Gregory	x	x	-	-
Cocconeis scutellum Ehrenberg	C	x	x	x
Cocconeis scutellum var. *ornata* Grunow	x	x	-	-
Corethron criophilum Castracane	B	-	C	B
Coscinodiscus sp.	x	x	x	x
Coscinodiscus apiculiferus Rattray	x	-	-	-
Coscinodiscus asteromphalus Ehrenberg	x	x	-	x
Coscinodiscus centralis Ehrenberg	x	x	-	x
Coscinodiscus cinctus Kutzing	-	-	-	-
Coscinodiscus concinnus W. Smith	-	-	-	x
Coscinodiscus gigas var. *praetexta* (Janasch) Hustedt	x	x	-	-
Coscinodiscus gigas Ehrenberg	x	x	x	x
Coscinodiscus grani Gough	-	x	-	x
Coscinodiscus granulosus Grunow	x	x	x	x
Coscinodiscus kuetzingii Schmidt	-	-	-	x
Coscinodiscus lineatus Ehrenberg	x	-	x	x
Coscinodiscus marginatus Ehrenberg	C	x	x	x
Coscinodiscus nitidus Gregory	B	x	x	x
Coscinodiscus obscurus Schmidt	x	-	x	-
Coscinodiscus oculus iridis Ehrenberg	x	-	-	x

Table 1 (conti.)

	I	II	III	IV
Coscinodiscus perforatus Ehrenberg	-	-	-	x
Coscinodiscus radiatus Ehrenberg	x	-	x	x
Coscinodiscus stellaris Roper	-	-	-	x
Coscinodiscus stellaris var. *symbolophora* (Grunow) Jorgenson	-	-	-	x
Coscinodiscus subbulliens Jorgensen	-	-	-	x
Coscinodiscus tabularis Grunow	-	-	x	-
Coscinodiscus wailesii Gran and Angst	x	x	x	x
Coscinosira sp.	x	x	-	x
Coscinosira polychorda (Gran) Gran	B	-	-	-
Cyclotella sp.	x	x	x	x
Cyclotella caspia Grunow	x	-	-	x
Cyclotella meneghiniana Kutzing	-	-	x	x
Cylindrotheca closterium (Ehrenberg) Reimann and Lewin	C	C	B	x
Cymatosira belgica Grunow	C	x	x	x
Dactyliosolen antarcticus Castracane	-	-	x	x
Dactyliosolen mediterraneus Peragallo	-	-	x	-
Dimerogramma sp.	x	x	-	x
Dimerogramma minor (Gregory) Ralfs	-	-	-	-
Diploneis crabro Ehrenberg	x	-	x	x
Diploneis lineata (Donkin) Cleve	-	-	-	x
Diploneis smithii (Brebisson) Cleve	x	-	-	x
Ditylum brightwellii (West) Grunow	B	x	x	x
Eucampia cornuta (Cleve) Grunow	-	-	-	x
Eucampia zoodiacus Ehrenberg	C	x	C	x
Eunotogramma sp.	-	-	-	x
Fragilaria sp.	x	-	x	x
Fragilaria crotonensis Kitton	-	-	x	x
Fragilaria pinnata Ehrenberg	-	-	-	x
Fragilaria striatula Lyngbye	x	-	x	-
Grammatophora sp.	x	x	x	x
Grammatophora marina (Lyngbye) Kutzing	-	x	x	x
Guinardia flaccida (Castracane) Peragallo	A	B	x	x
Gyrosigma sp.	x	x	x	x
Gryosigma balticum var. *similis* (Grunow) Cleve	x	-	x	x
Gyrosigma fasciola (Ehrenberg) Cleve	-	-	-	x
Gyrosigma hippocampus (Ehrenberg) Hassall	x	x	-	x
Hemiaulus hauckii Grunow	x	x	C	x
Hemiaulus membranaceus Cleve	-	-	x	x
Hemiaulus sinensis Greville	x	-	B	C
Hemidiscus cuneiformis Wallich	-	-	-	x
Isthmia nervosa Kutzing	-	-	-	x
Lauderia borealis Gran	x	-	x	x
Leptocylindrus danicus Cleve	A	A	B	A
Leptocylindrus minimus Gran	x	x	C	x

Table 1 (conti.)

	I	II	III	IV
Licmophora sp.	x	x	x	x
Licmophora abbreviata Agardh	x	-	x	-
Licmophora flabellata (Carmichael) Agardh	x	-	-	x
Licmophora gracilis (Ehrenberg) Grunow	-	-	x	-
Licmophora paradoxa var. *tincta* (Agardh) Hustedt	x	-	x	x
Lithodesmium undulatum Ehrenberg	x	x	x	x
Mastogloia sp.	x	-	-	x
Mastogloia braunii Grunow	-	-	-	x
Mastogloia smithii Thwaites	-	-	x	-
Melosira sp.	-	-	-	x
Melosira granulata (Ehrenberg) Ralfs	x	-	-	x
Melosira hummii Hustedt	x	x	-	x
Melosira moniliformis (Muller) Agardh	x	-	-	x
Melosira nummuloides (Dillwyn) Agardh	x	-	x	x
Navicula sp. #1	x	-	-	x
Navicula sp. #2	x	-	-	-
Navicula sp. #3	-	x	x	-
Navicula abrupta (Gregory) Cleve	-	-	x	x
Navicula arenaria Donkin	-	-	-	x
Navicula cancellata Donkin	x	x	x	-
Navicula clavata Gregory	-	-	x	-
Navicula cuspidata var. *ambigua* (Ehrenberg) Cleve	x	-	-	x
Navicula directa (W. Smith) Cleve	-	-	-	x
Navicula distans (W. Smith) Cleve	x	-	x	-
Navicula forcipata Greville	-	-	x	x
Navicula hennedyii W. Smith	-	-	-	x
Navicula lyra Ehrenberg	x	x	x	x
Navicula palperbralis Brebisson	x	-	x	x
Navicula pavillardi Hustedt	-	-	-	x
Navicula pelagica Cleve	-	-	-	x
Navicula salinarum Grunow	-	-	-	x
Navicula transitans var. *asymmetrica* (Cleve) Cleve	-	-	x	-
Navicula transitans (Cleve) Cleve	x	-	-	-
Nitzschia sp.	x	x	x	x
Nitzschia acuminata (W. Smith) Grunow	x	-	-	-
Nitzschia amphibia Grunow	-	-	x	-
Nitzschia angularis var. *affinis* (Grunow) Grunow	-	-	-	x
Nitzschia bilobata W. Smith	x	-	x	x
Nitzschia clausii Hantzsch	x	-	-	-
Nitzschia delicatissima Cleve	B	x	C	C
Nitzschia forcipata Greville	-	x	-	-
Nitzschia insignis Gregory	x	-	-	-
Nitzschia longissima (Brebisson) Ralfs	C	-	x	-
Nitzschia lorenziana var. *incerta* Grunow	-	-	-	x
Nitzschia lorenziana Grunow	x	x	-	x
Nitzschia lorenziana var. *incurva* Grunow	-	-	-	x
Nitzschia microcephala Grunow	-	-	-	x
Nitzschia obtusa var. *scalpelliformis* Grunow	-	-	-	x

Table 1 (conti.)

	I	II	III	IV
Nitzschia pacifica Cupp	-	-	x	-
Nitzschia proxima Hustedt	x	-	x	x
Nitzschia pungens Grunow	A	B	B	C
Nitzschia recta Grunow	C	-	-	x
Nitzschia seriata Cleve	x	x	C	C
Nitzschia sigma var. *rigida* Grunow	-	-	x	x
Nitzschia spathulata Brebisson	x	-	x	x
Paralia sulcata (Ehrenberg) Cleve	C	C	x	x
Phaeodactylum tricornutum Bohlin	-	-	-	x
Pinnularia cruciformis (Donkin) Cleve	-	-	-	x
Pinnularia gracillma Gregory	-	-	x	-
Pinnularia trevelyana (Donkin) Cleve	-	-	x	-
Plagiogramma staurophorum (Gregory) Heilberg	C	x	C	x
Plagiogramma vanheurckii Grunow	x	-	-	x
Planktoniella sol (Wallich) Schutt	x	-	-	-
Pleurosigma sp.	x	x	x	x
Pleurosigma angulatum (Quekett) W. Smith	x	x	x	x
Pleurosigma delicatulum W. Smith	-	-	x	-
Pleurosigma elongatum W. Smith	x	-	-	x
Pleurosigma hamuliferum Brun	C	-	x	x
Pleurosigma naviculaceum Brebbisson	-	-	x	-
Pleurosigma nicobaricum (Grunow) Grunow	C	-	x	x
Pleurosigma normanii Ralfs	C	x	-	x
Pleurosigma rigidum W. Smith	x	x	-	x
Podosira sp.	x	-	-	x
Rhabdonema arcuatum (Lyngbye) Kutzing	-	-	x	x
Rhabdonema minutum Kutzing	x	-	-	-
Rhaphoneis amphiceros Ehrenberg	x	-	x	x
Rhaphoneis surirella (Ehrenberg) Grunow	C	-	-	x
Rhizosolenia sp.	x	-	-	x
Rhizosolenia alata Brightwell	B	C	B	x
Rhizosolenia alata f. *curvirostris* Gran	x	-	-	-
Rhizosolenia alata f. *gracillima* (Cleve) Grunow	x	x	B	x
Rhizosolenia alata f. *indica* (Peragallo) Gran	-	x	x	x
Rhizosolenia bergonii Peragallo	-	-	-	x
Rhizosolenia calcar-avis Schultze	x	x	x	x
Rhizosolenia castracanei Peragallo	-	x	-	-
Rhizosolenia cylindrus Cleve	-	-	-	x
Rhizosolenia delicatula Cleve	A	B	B	C
Rhizosolenia fragilissima Bergon	C	C	B	x
Rhizosolenia hebetata f. *hiemalis* Gran	x	-	x	x
Rhizosolenia hebetata f. *semispina* (Hensen) Gran	x	x	x	x
Rhizosolenia imbricata Brightwell	B	x	x	C
Rhizosolenia imbricata var. *shrubsolei* (Cleve) VanHeurck	x	-	x	x
Rhizosolenia robusta Norman	-	-	x	-
Rhizosolenia setigera Brightwell	B	x	B	x
Rhizosolenia stolterfothii Peragallo	B	x	x	C
Rhizosolenia styliformis Brightwell	C	C	C	x

Table 1 (conti.)

	I	II	III	IV
Schroederella delicatula (Peragallo) Pavillard	C	-	x	C
Scoliopleura sp.	-	-	-	x
Skeletonema costatum (Greville) Cleve	A	x	A	A
Stauroneis amphioxys Gregory	-	-	-	x
Stephanopyxis palmeriana (Greville) Grunow	x	-	x	x
Stephanopyxis turris (Greville) Ralfs	x	-	x	x
Streptotheca thamesis Shrubsole	-	x	-	x
Striatella unipunctata (Lyngbye) Agardh	x	x	x	x
Surirella sp.	-	x	-	-
Surirella gemma (Ehrenberg) Kutzing	-	x	-	-
Surirella robusta Ehrenberg	x	-	-	x
Synedra sp.	x	-	x	x
Synedra provincialis Grunow	-	-	x	-
Synedra tabulata var. *fasciculata* (Lyngbye) Hustedt	x	-	-	x
Synedra undulata Bailey	x	-	-	x
Tabellaria fenestrata var. *asterionelloides* Grunow	x	C	x	x
Tabellaria fenestrata (Lyngbye) Kutzing	C	-	x	x
Thalassionema nitzschioides Hustedt	A	x	x	C
Thalassiosira sp.	C	-	x	-
Thalassiosira aestivalis Gran and Angst	B	x	x	x
Thalassiosira baltica (Grunow) Ostenfeld	-	-	-	x
Thalassiosira decipiens (Grunow) Jorgensen	x	x	C	x
Thalassiosira delicatula Ostenfeld	-	-	-	x
Thalassiosira eccentrica (Ehrenberg) Cleve	x	x	x	x
Thalassiosira gravida Cleve	C	x	C	x
Thalassiosira nordenskioeldii Cleve	A	x	x	C
Thalassiosira pseudonana (Hustedt) Hasle and Heimdal	x	-	-	-
Thalassiosira rotula Meunier	B	C	B	x
Thalassiosira subtilis (Ostenfeld) Gran	x	-	-	-
Thalassiothrix frauenfeldii Grunow	B	C	x	C
Thalassiothrix longissima Cleve and Grunow	-	-	x	x
Triceratium favus Ehrenberg	x	x	-	x
Tropidoneis antarctica (Grunow) Cleve	-	x	-	x

<u>DINOPHYCEAE</u> (Pyrrhophyceae)

	I	II	III	IV
Amphidinium sp.	x	x	x	x
Amphidinium acutissimum Schiller	C	x	x	x
Amphidinium acutum Lahmann	C	x	x	x
Amphidinium carterae Hulburt	x	-	-	x
Amphidinium crassum Lohmann	-	x	-	x
Amphidinium glaucum Conrad	x	-	-	x
Amphidinium globosum Schroder	-	-	x	-
Amphidinium klebsii Kofoid and Swezy	-	-	-	x
Amphidinium lacustre Stein	-	-	x	-
Amphidinium lanceolatum Schroder	-	-	-	-
Amphidinium latum Lebour	x	-	x	-
Amphidinium operculatum Claparede and Lachmann	-	-	x	x
Amphidinium schroederi Schiller	x	x	x	x
Amphidinium sphenoides Wulff	x	x	x	x

Table 1 (conti.)

	I	II	III	IV
Amphidinium steinii (Lemmermann) Kofoid and Swezy	-	-	x	-
Amphidoma sp.	-	-	x	x
Amphidoma steinii Schiller	-	-	-	x
Amphisolenia bifurcata Murray and Whitting	x	-	-	-
Amphisolenia globifera Stein	-	-	-	x
Ceratium arcticum (Ehrenberg) Cleve	x	-	-	-
Ceratium belone Cleve	-	x	-	x
Ceratium bucephalum (Cleve) Cleve	-	x	-	x
Ceratium candelabrum (Ehrenberg) Stein	-	-	-	x
Ceratium contortum (Gourret) Cleve	-	x	x	x
Ceratium contortum karsteni (Pavillard) Sournia	x	-	-	-
Ceratium contrarium (Gourret) Pavillard	-	-	-	x
Ceratium extensum (Gourret) Cleve	x	x	x	x
Ceratium falcatiforme Jorgensen	-	-	-	x
Ceratium furca (Ehrenberg) Claparede and Lachmann	x	x	x	x
Ceratium fusus (Ehrenberg) Dujardin	C	C	x	x
Ceratium geniculatum (Lemmermann) Cleve	-	-	-	x
Ceratium horridum (Cleve) Gran	x	x	-	x
Ceratium kofoidi Jorgensen	-	-	x	-
Ceratium lineatum (Ehrenberg) Cleve	C	C	x	x
Ceratium longipes (Bailey) Gran	x	x	x	x
Ceratium macroceros (Ehrenberg) VanHoffen	C	x	x	x
Ceratium massiliense (Gourret) Jorgensen	x	x	x	x
Ceratium minutum Jorgensen	x	x	x	x
Ceratium pavillardii Jorgensen	-	-	-	x
Ceratium pentagonum Gourret	x	-	x	x
Ceratium ranipes Cleve	x	-	-	x
Ceratium teres Kofoid	x	-	x	x
Ceratium trichoceros (Ehrenberg) Kofoid	x	x	x	x
Ceratium tripos (Muller) Nitzsch	C	C	x	x
Ceratium tripos var. *atlanticum* (Ostenfeld) Paulsen	C	x	x	x
Cochodinium sp.	-	-	-	x
Cochlodinium constrictum (Schutt) Lemmermann	-	-	x	-
Cochlodinium helicoides Lebour	-	-	-	x
Cochlodinium kofoidii Kofoid	x	x	x	x
Cochlodinium pellucidum Lohmann	-	-	-	x
Dinophysis sp.	x	x	x	x
Dinophysis acuminata Claparede and Lachmann	x	x	x	x
Dinophysis acuta Ehrenberg	x	x	x	x
Dinophysis arctica Mereschkowsky	-	-	x	-
Dinophysis caudata Kent	x	-	x	x
Dinophysis exigua Kofoid and Skogsberg	-	-	-	x
Dinophysis fortii Pavillard	x	x	x	x
Dinophysis hastata Stein	x	-	x	-
Dinophysis lachmanni Paulsen	-	-	-	x
Dinophysis micropterygia Dang	-	-	-	x
Dinophysis norvegica Claparede and Lachmann	x	x	x	x
Dinophysis ovum Schutt	x	x	x	x
Dinophysis parvula (Schutt) Balech	-	-	x	-
Dinophysis punctata Jorgensen	x	x	x	-
Dinophysis rotundata Claparede and Lachmann	x	x	x	-
Dinophysis schuettii Murray and Whitting	-	-	-	x

Table 1 (conti.)

	I	II	III	IV
Dinophysis sphaerica Stein	x	-	x	x
Dinophysis tripos Gourret	x	x	-	x
Diplosalis sp.	-	-	-	x
Diplosalis lenticula Bergh	-	x	-	x
Dissodium asymmetricum (Mangin) Loeblich III	x	-	x	x
Glenodinium sp.	-	-	x	x
Glenodinium danicum Paulsen	x	-	-	x
Glenodinium foliaceum Stein	-	-	-	x
Gonyaulax sp.	x	-	x	x
Gonyaulax birostris Stein	-	-	x	x
Gonyaulax catenata (Lev) Kofoid	-	-	-	x
Gonyaulax conjuncta Wood	-	-	-	x
Gonyaulax diacantha (Meunier) Schiller	x	x	x	x
Gonyaulax diegensis Kofoid	-	-	x	x
Gonyaulax digitalis (Pouchet) Kofoid	B	-	x	x
Gonyaulax excavata (Braarud) Balech	-	x	x	x
Gonyaulax kofoidi Pavillard	x	-	-	-
Gonyaulax milneri (Murray and Whitting) Kofoid	x	-	-	-
Gonyaulax minima Matzenauer	-	-	-	x
Gonyaulax minuta Kofoid and Michener	-	-	-	x
Gonyaulax orientalis Linderman	-	-	x	-
Gonyaulax polyedra Stein	x	-	x	x
Gonyaulax polygramma Stein	-	-	-	x
Gonyaulax scrippsae Kofoid	-	-	x	x
Gonyaulax spinifera (Claparede and Lachmann) Diesing	-	x	-	x
Gonyaulax tricantha Jorgensen	x	x	x	-
Gonyaulax unicornis Lebour	x	x	-	x
Goniodoma sp.	-	-	-	x
Gymnodinium sp. #1	x	-	-	x
Gymnodinium sp. #2	x	x	-	-
Gymnodinium sp. #3	-	x	x	-
Gymnodinium arcticum Wulff	x	x	x	x
Gymnodinium boguensis Campbell	x	-	-	-
Gymnodinium breve Davis	x	-	-	-
Gymnodinium dissimile Kofoid and Swezy	x	-	x	x
Gymnodinium grammaticum (Pouchet) Kofoid and Swezy	x	-	-	x
Gymnodinium minutum Hulburt	-	-	x	x
Gymnodinium nelsoni Martin	x	x	x	x
Gymnodinium punctatum Pouchet	-	-	x	x
Gymnodinium simplex (Lohmann) Kofoid and Swezy	x	x	x	x
Gymnodinium splendens Lebour	x	-	x	x
Gymnodinium stellatum Hulburt	x	x	-	x
Gymnodinium variable Herdman	x	-	x	x
Gyrodinium sp.	x	C	x	x
Gyrodinium aureum (Conrad) Schiller	x	x	-	x
Gyrodinium dominans Hulburt	-	x	-	x
Gyrodinium estuariale Hulburt	x	x	x	x
Gyrodinium fusiforme Kofoid and Swezy	-	-	x	x
Gyrodinium glaebum Hulburt	-	-	-	x
Gyrodinium glaucum Lebour	-	x	-	x
Gyrodinium metum Hulburt	-	-	x	x

Table 1 (conti.)

	I	II	III	IV
Gyrodinium pellucidum (Wulff) Martin	x	-	x	x
Gyrodinium pinque (Schutt) Kofoid and Swezy	-	-	-	x
Gyrodinium resplendens Hulburt	x	-	x	-
Gyrodinium spirale (Berghman) Kofoid and Swezy	x	x	-	x
Gyrodinium uncatenum Hulburt	x	x	x	x
Gyrodinium undulans Hulburt	-	-	-	x
Heterocapsa triquetra (Ehrenberg) Stein	x	x	x	x
Katodinium asymmetricum (Massart) Fott	-	-	-	x
Katodinium rotundatum (Lohmann) Loeblich	-	x	x	x
Noctiluca miliaris Suriray	-	-	-	x
Ornithocercus sp.	-	x	-	-
Ornithocercus thurni (Schmidt) Kofoid and Skogsberg	-	-	-	x
Oxyrrhis marina Dujardin	-	-	-	x
Oxytoxum sp.	x	-	x	x
Oxytoxum constrictum (Stein) Butschli	-	-	-	x
Oxytoxum gladiolus Stein	-	-	x	x
Oxytoxum graate Stein	-	-	-	x
Oxytoxum longiceps Schiller	-	-	x	-
Oxytoxum milneri Murray and Whitting	-	-	x	x
Oxytoxum mitra (Stein) Schiller	-	-	-	x
Oxytoxum parvum Schiller	-	-	x	x
Oxytoxum reticulatum (Stein) Butschli	x	x	x	x
Oxytoxum sceptrum (Stein) Schroder	-	-	-	x
Oxytoxum scolopax Stein	x	x	x	x
Oxytoxum sphaeroideum Stein	-	-	-	x
Oxytoxum tesselatum (Stein) Schutt	-	-	x	-
Oxytoxum turbo Kofoid	-	-	x	x
Phalacroma sp.	x	-	x	-
Podolampas sp.	x	x	-	x
Podolampas elegans Schutt	-	-	x	-
Podolampas palmipes Stein	-	-	-	x
Polykrikos kofoidii Chatton	-	-	-	x
Prorocentrum sp.	x	-	x	x
Prorocentrum aporum (Schiller) Dodge	C	x	x	x
Prorocentrum balticum (Lohmann) Loeblich III	C	C	x	x
Prorocentrum compressum (Bailey) Abe	x	x	x	x
Prorocentrum cordatum (Ostenfeld) Dodge	-	x	-	-
Prorocentrum dentatum Stein	x	x	x	x
Prorocentrum gracile Schutt	-	-	x	x
Prorocentrum lima (Ehrenberg) Dodge	-	-	x	x
Prorocentrum maximum (Gourret) Schiller	-	-	x	x
Prorocentrum micans Ehrenberg	A	C	x	C
Prorocentrum minimum (Pavillard) Schiller	C	A	C	x
Prorocentrum nanum Schiller	-	C	-	-
Prorocentrum obtusum (Karsten) Parke and Dodge	-	-	x	-

Table 1 (conti.)

	I	II	III	IV
Prorocentrum ovum (Schiller) Dodge	-	x	x	-
Prorocentrum rostratum Stein	-	x	x	x
Prorocentrum rotundatum Schiller	-	x	x	-
Prorocentrum scutellum Schroder	x	x	x	-
Prorocentrum triestinum Schiller	C	x	C	-
Prorocentrum vaginulum (Stein) Dodge	x	-	x	-
Protoperidinium sp. #1	x	-	-	x
Protoperidinium sp. #2	x	-	-	-
Protoperidinium sp. #3	-	x	x	-
Protoperidinium abei (Paulsen) Balech	x	-	-	x
Protoperidinium achromaticum (Levander) Balech	x	-	x	-
Protoperidinium bipes (Paulsen) Balech	C	x	x	-
Protoperidinium breve (Paulsen) Balech	x	x	-	x
Protoperidinium brevipes (Paulsen) Balech	x	-	x	x
Protoperidinium cerasus (Paulsen) Balech	C	x	x	x
Protoperidinium claudicans (Paulsen) Balech	x	x	-	x
Protoperidinium conicoides (Paulsen) Balech	x	-	x	x
Protoperidinium conicum (Gran) Balech	-	-	x	x
Protoperidinium curvipes Ostenfeld	-	x	-	-
Protoperidinium depressum (Bailey) Balech	C	x	x	x
Protoperidinium diabolum (Cleve) Balech	x	-	x	-
Protoperidinium divergens (Ehrenberg) Balech	x	-	x	-
Protoperidinium globulum (Stein) Balech	x	x	x	x
Protoperidinium granii (Ostenfeld) Balech	x	x	x	x
Protoperidinium hirobis Abe	x	x	x	-
Protoperidinium leonis (Pavillard) Balech	x	-	-	x
Protoperidinium minutum (Kofoid) Loeblich III	x	-	-	-
Protoperidinium nipponicum (Abe) Balech	x	-	x	x
Protoperidinium oceanicum (VanHoffen) Balech	-	-	x	x
Protoperidinium ovatum Pouchet	x	-	x	x
Protoperidinium pallidum (Ostenfeld) Balech	-	x	x	x
Protoperidinium pellucidum Bergh	x	x	-	x
Protoperidinium penduncu1atum (Schutt) Balech	-	-	x	-
Protoperidinium pentagonum (Gran) Balech	-	-	x	x
Protoperidinium quadridens (Stein) Balech	x	-	-	-
Protoperidinium roseum (Paulsen) Balech	x	x	x	-
Protoperidinium sphaericum (Okamura) Balech	-	-	x	-
Protoperidinium steinii (Jorgensen) Balech	x	C	x	x
Protoperidinium sub-curvipes (Lebour) Balech	-	x	-	-
Protoperidinium subinerme (Paulsen) Balech	-	-	x	x
Pyrocystis fusiformis f. *biconica* Kofoid	-	-	-	x
Pyrocystis lunula Schutt	-	x	-	x
Pyrophacus sp.	-	x	-	x
Pyrophacus horologicum Stein	x	-	x	x
Scrippsiella trochoidea (Stein) Loeblich III	x	x	x	x
<u>HAPTOPHYCEAE (Prymnesiophyceae)</u>				
Acanthoica aculeata Kamptner	-	x	-	-
Calciosolenia murrayi Gran	x	-	-	x
Chrysochromulina minor Parke and Manton	-	-	x	-

Table 1 (conti.)

	I	II	III	IV
Coccolithus sp.	x	-	-	-
Coccolithus pelagicus (Wallich) Schiller	x	x	-	x
Cyclococcolithus leptoporus (Murray and Blackman) Kamptner	x	x	x	x
Discosphaera tubifer (Murray and Blackman) Ostenfeld	-	-	-	x
Emiliania huxleyi (Lohmann) Hay and Mohler	C	A	C	C
Gephyrocapsa oceanica Kamptner	-	x	-	x
Heliocosphaera carteri (Wallich) Kamptner	-	-	-	x
Hymenomonas carterae (Braarud and Fagerland) Braarud	x	x	x	x
Hymenomonas roseola Stein	x	x	-	x
Michaelsaria elegans Gran	x	-	-	-
Ophiaster hydroideus (Lohmann) Lohmann	x	-	-	-
Pontosphaera syracusana Lohmann	x	-	x	x
Rhabdosphaera claviger Murray and Blackman	x	x	x	x
Rhabdosphaera hispida Lohmann	x	-	x	-
Rhabdosphaera stylifera Lohmann	x	x	x	-
Syracosphaera sp.	-	-	-	x
Syracosphaera apsteinii Lohmann	x	x	-	x
Syracosphaera pulchra Lohmann	x	x	x	x
CHRYSOPHYCEAE				
Calycomonas ovalis Wulff	x	x	x	x
Calycomonas wulffii Conrad and Kufferath	x	x	x	x
Dictyocha fibula Ehrenberg	C	x	x	x
Distephanus speculum (Ehrenberg) Haekel	C	C	x	x
Ebria tripartita (Schumann) Lemmermann	x	x	x	x
Mallomonas sp.	-	x	-	x
Ochromonas sp.	-	-	-	x
Olisthodiscus luteus Carter	x	-	x	x
CYANOPHYCEAE				
Agmenellum quadruplicatum (Meneghini) Brebisson	-	-	x	-
Agmenellum thermale (Kutzing) Drouet and Daily	-	-	x	-
Anacystis sp.	B	x	x	x
Anacystis marina (Hansg) Drouet and Daily	C	-	-	x
Gomphosphaeria aponina Kutzing	-	x	x	x
Johannesbaptistia pellucida (Dickie) Taylor and Drouet	-	-	C	x
Nostoc commune Vaucher	x	A	C	x
Oscillatoria sp.	x	-	x	-
Oscillatoria erythraea (Ehrenberg) Kutzing	x	x	x	x
Oscillatoria submembranacea Ardissone and Strafforello	x	x	-	x
Richelia intracellularis Schmidt	-	-	x	x

Table 1 (conti.)

	I	II	III	IV
EUGLENOPHYCEAE				
Euglena sp.	x	x	x	x
Euglena acus Ehrenberg	-	-	-	x
Euglena proxima Dangeard	-	-	x	x
Eutreptia lanowii Steuer	x	x	-	-
Eutreptia marina Cunha	-	-	x	x
Eutreptia viridis Perty	-	x	x	x
Phacus sp.	-	-	x	-
CHLOROPHYCEAE				
Arthrodesmus sp.	-	-	x	x
Arthrodesmus subulatus Kutzing	-	-	x	-
Chlorella sp.	-	-	x	x
Crucigenia crucifera (Wolle) Collins	-	-	x	-
Crucigenia fenestrata Schmidle	x	x	x	-
Crucigenia irregularis Wille	C	-	-	-
Crucigenia tetrapedia (Kirchner) West and West	-	x	x	-
Nannochloris atomus Butcher	-	x	x	A
Pediastrum sp.	-	-	x	-
Pseudotetraedron neglectum Pascher	-	-	x	-
Scenedesmus sp.	x	x	-	-
Scenedesmus quadricauda (Turpin) Brebisson	-	-	x	-
Staurastrum leptocladum var. *insidne* West and West	-	-	-	x
CRYPTOPHYCEAE				
Chroomonas sp.	C	C	C	x
Chroomonas salina (Wislouch) Butcher	x	-	-	x
Chroomonas vectensis Carter	x	x	x	x
Cryptomonas sp.	x	C	C	-
Cryptomonas pseudobaltica Butcher	x	-	x	x
Cryptomonas salina (Wislouch) Butcher	x	x	-	x
Cryptomonas stigmatica Wislouch	x	x	-	x
XANTHOPHYCEAE				
Monodus sp.	-	-	x	-
Monodus guttula Pascher	-	-	-	x
PRASINOPHYCEAE				
Bipedinomonas pyriformis Carter	x	-	-	x
Pyramimonas amylifer Conrad	-	x	-	x
Pyramimonas grossii Parke	x	x	x	x
Pyramimonas obovata Carter	C	x	-	x
Pyramimonas torta Conrad and Kufferath	-	-	x	-

Table 2. Average concentrations of cells per liter of near and far shore stations for the northeastern continental shelf.

	October-November				December-February-March			
	Near shore	No. sp.	Far shore	No. sp.	Near shore	No. sp.	Far shore	No. sp.
Diatoms	63,905	173	26,809	141	51,512	153	46,168	148
Dino	807	136	1,584	103	4,270	98	3,179	89
Hapt	142	14	405	12	583	14	1,376	12
Eugl	21	5	38	1	37	2	200	2
Cyan	24	4	238	4	7,590	7	5	2
Chloro	8,350	3	893	3	5,096	4	2,136	3
Xanth	-	-	213	1	-	-	-	-
Chrys	78	7	273	7	251	8	422	8
Crypto	50	8	13	6	105	7	280	6
Pras	285	4	555	2	89	3	210	3
Unk	5,009	-	191	-	137,939	-	99,565	-
TOTAL	78,671		31,212		207,468		153,541	

	May				June-July-August			
	Near shore	No. sp.	Far shore	No. sp.	Near shore	No. sp.	Far shore	No. sp.
Diatoms	18,884	80	21,492	69	60,281	129	51,503	114
Dino	814	67	3,329	59	3,390	101	3,305	89
Hapt	520	11	6,013	4	116	9	718	6
Eugl	248	3	1,770	2	21	2	28	1
Cyan	1,258	2	13	1	1,362	4	455	6
Chloro	300	2	93	3	613	3	519	5
Xanth	-	-	-	-	2	1	-	-
Chrys	19	7	35	2	51	7	28	5
Crypto	42	5	1,085	2	1,453	3	1,808	2
Pras	4	4	-	-	3	2	1	1
Unk	22,638	-	1,090	-	8,650	-	7,012	-
TOTAL	44,730		34,923		275,942		65,377	

Key:
- Dino - Dinophyceans
- Hapt - Haptophyceans
- Eugl - Euglenophyceans
- Cyan - Cyanophyceans
- Chloro - Chlorophyceans
- Xanth - Xanthophyceans
- Chrys - Chrysophyceans
- Crypto - Cryptophyceans
- Pras - Prasinophyceans