Calcareous Nannoplankton Thanatocoenoses in Surface Sediments from Seas Around Japan

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Yuichiro Tanaka*

ABSTRACT

Calcareous nannoplankton thanatocoenoses have been investigated in 437 surface sediments collected from seas around the Japanese Islands and 34 species are identified. The geographical distributions of coccolith species are delineated separately from coastal (*Gephyrocapsa oceanica*, *Helicosphaera carteri* s.l. and *Braarudosphaera bigelowii*) to oceanic water forms (*Florisphaera profunda*, *Calcidiscus leptoporus*, and *Rhabdosphaera clavigera*) and from cold (*Coccolithus pelagicus*) to warm water forms (*F. profunda*, *R. clavigera*, *Umbilicosphaera sibogae* and *Calciosolenia* spp.), as determined by oceanic conditions.

The Q-mode cluster analysis of the coccolith floras yields ten biotopes based on the distribution pattern of characteristic species. These biotopes can be explained by the combination of salinity and temperature. Transfer functions formulated through multiple regression analysis relating the assemblages to such parameters as mean annual surface temperatures and salinities also give accurate estimates for water temperature and salinity, with standard errors of 1.30°C and 0.14‰, respectively. Temperature and salinity, therefore, are important parameters in controlling the distribution of coccolith floras in this area.

Transfer functions have been applied to coccolith floras, which have existed for the last 22,000 years and preserved in sediments penetrated by three piston cores in the present-day domain of the Kuroshio Current and of the Kuroshio front. The warm and cool events contemporary to the well known series of episodes in the Atlantic Ocean, and the phase called the Yayoi regression at about 2,000 years B.P. are recognized.

Kew words: Calcareous nannoplankton thanatocoenoses, Seas around Japanese Islands, Transfer function

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INTRODUCTION

Coccolithophorids are generally restricted in the photic zone and most

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abundant in the uppermost 50 m of water masses (Honjo and Okada, 1974) in the world oceans except the Arctic and Antarctic Oceans. The distributions of calcareous nannoplankton biocoenoses and thanatocoenoses have been studied in various marine environments. Okada and Honjo (1973) investigated horizontal and vertical distributions of living coccolithophorids in the North and Central Pacific. The biocoenoses indicate well-defined floral assemblages closely related with water masses (McIntyre and Bé, 1967 ; Honjo and Okada, 1974).

The distribution of calcareous nannoplankton thanatocoenoses in surface sediments was studied by McIntyre and Bé (1967) and McIntyre and McIntyre (1971) in the Atlantic Ocean, and by Geitzenauer *et al.* (1976), McIntyre *et al.* (1970), Roth and Berger (1975), and Roth and Coulbourn (1982) in the Pacific Ocean. There is a good correspondence between the nannoplankton assemblages in surface sediments and those in the water column due to the rapid transfer of coccoliths to the seafloor in fecal pellets (Roth *et al.*, 1975 ; Honjo, 1976).

In the last decade, a number of publications have appeared, which dealt with coccolith assemblages in neritic and marginal seas.

In the western Pacific Ocean, these studies have been carried out in the following areas : the Okinawa Trough (Chen, 1979), the South China Sea (Chen and Shieh, 1982 ; Vorol, 1985), Sendai Bay in Japan (Takayama, 1972), the western Pacific Ocean (Okada, 1982), the East China Sea (Wang and Samtleben, 1983 ; Zhang and Siesser, 1986), and the western Tasman Sea (Burn, 1975). Most of them are mainly concerned with the distribution of thanatocoenoses, but have not described in detail critical factors controlling their distribution.

Loubere (1982) indicated that microfossil species distributions represent the integration of many factors controlling biological production in the oceans. That is, the relative abundance of species in sediments does not always reflect such a unique paleoceanographic variable as temperature.

Seas around Japan are especially interesting in this respect because of their particular geographical, hydrological and biological features. The hydrographic regime in the study area is dominated by the warm Kuroshio, cold Oyashio Currents and coastal water systems on the Pacific side, and the Tsushima Warm Current and nearly homogeneous deep water, called the Proper Water (Moriyasu, 1972) on the Sea of Japan side. These water systems are characterized by distinct attributes of salinity, temperature and nutrients.

The purpose of this study is : (1) to determine the distribution of calcareous nannoplankton thanatocoenoses in surface sediments from seas around Japan, (2) to establish a quantitative relationship between coccolith assemblages and oceanographic conditions of the Kuroshio, Oyashio and coastal water regions, and (3) to interpret changes in oceanographic patterns during the last 22,000 years by using the transfer functions formulated on the basis of coccolith assemblages in surface sediments.

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TOPOGRAPHY AND OCEANOGRAPHY

The topography on the Pacific side of the study area is roughly divided into four general topographies by features of the Island Arcs and oceanic trench systems (Sugimura and Uyeda, 1973) (Fig. 1). The Japan Trench runs parallel to the Northeast Honshu Arc and curves toward the Izu-Ogasawara Trench along the Izu-Ogasawara Arc. In the north, it meets the southern end of the Kurile Trench. The Nankai Trench lies at depths between 3,000 m and more than 4,500 m along the Southwest Honshu Arc. The Shikoku Basin, consisting of a broad and flat abyssal plain, extends to the south of the Nankai Trough. This basin lies at an average depth of 4,000 m and is bordered by the Izu-Ogasawara Island Arc on the east and by the Kyushu-Palau Ridge on the west. To the south of Kyushu, the Ryukyu Trench runs along the Ryukyu Arc. There is the Okinawa Trough from 1,000 m to 2,700 m deep, which lies behind the Ryukyu Arc.

Continentward of the island arcs are marginal seas, such as the Sea of Japan and the East China Sea. The northern half of the Sea of Japan is occupied by a flat and deep abyssal plain, called the Japan Basin (3,000 m depth); in the southern half, there developed are the Yamato Basin, Tsushima Basin, and Korea Plateau.

Surface waters off the Japanese Islands have geographically been subdivided into three regions: the subtropical, subarctic, and neritic. Each region is summarized below (Figs. 2 and 3).

The subtropical region in the study area extends from about 22°N to 37°N in latitude. The surface temperature and salinity annually range from 19° to 27°C and 34.4 to 34.9‰, respectively.

The subarctic region is located between 37°N and 42°N latitude in the study area. The surface temperature and salinity annually range from 11° to 18°C and 33.4 to 34.2‰, respectively.

The neritic region lies on the continental shelves around the Japanese Islands and the East China Sea. The surface waters are characterized by their low salinity (33.0–34.2‰) because of freshwater inflow from the mainlands.

The boundary between the subtropical

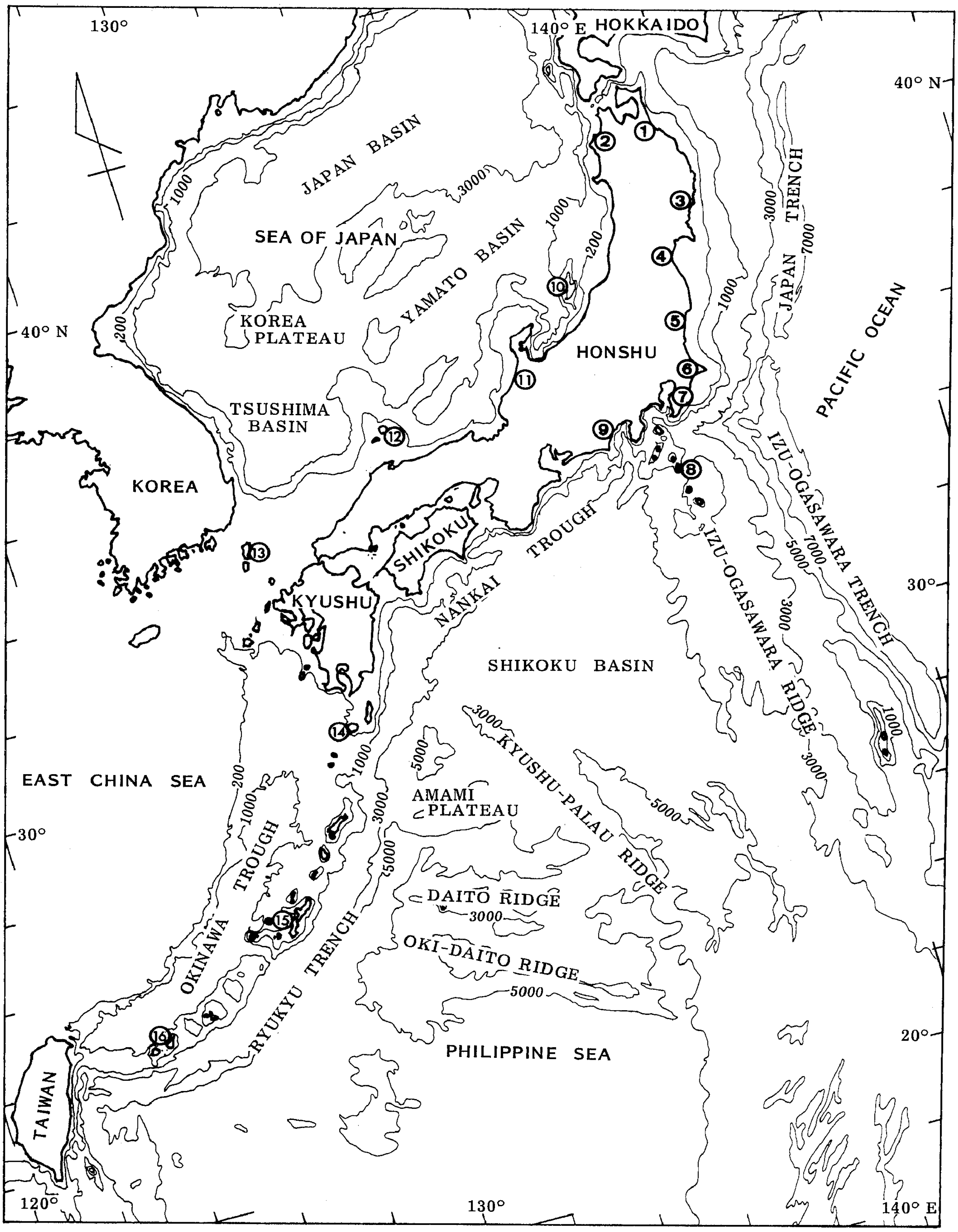

Fig. 1. Seas around Japan in the study area. 1 : Hachinohe, 2 : Nishitsugaru, 3 : Kamaishi, 4 : Sendai, 5 : Joban, 6 : Choshi, 7 : Boso Peninsula, 8 : Mikura-jima Island, 9 : Shizuoka, 10 : Sado Island, 11 : Kanazawa, 12 : Oki Island, 13 : Tsushima Island, 14 : Yakushima Island, 15 : Okinawa Island, 16 : Ishigaki Island.

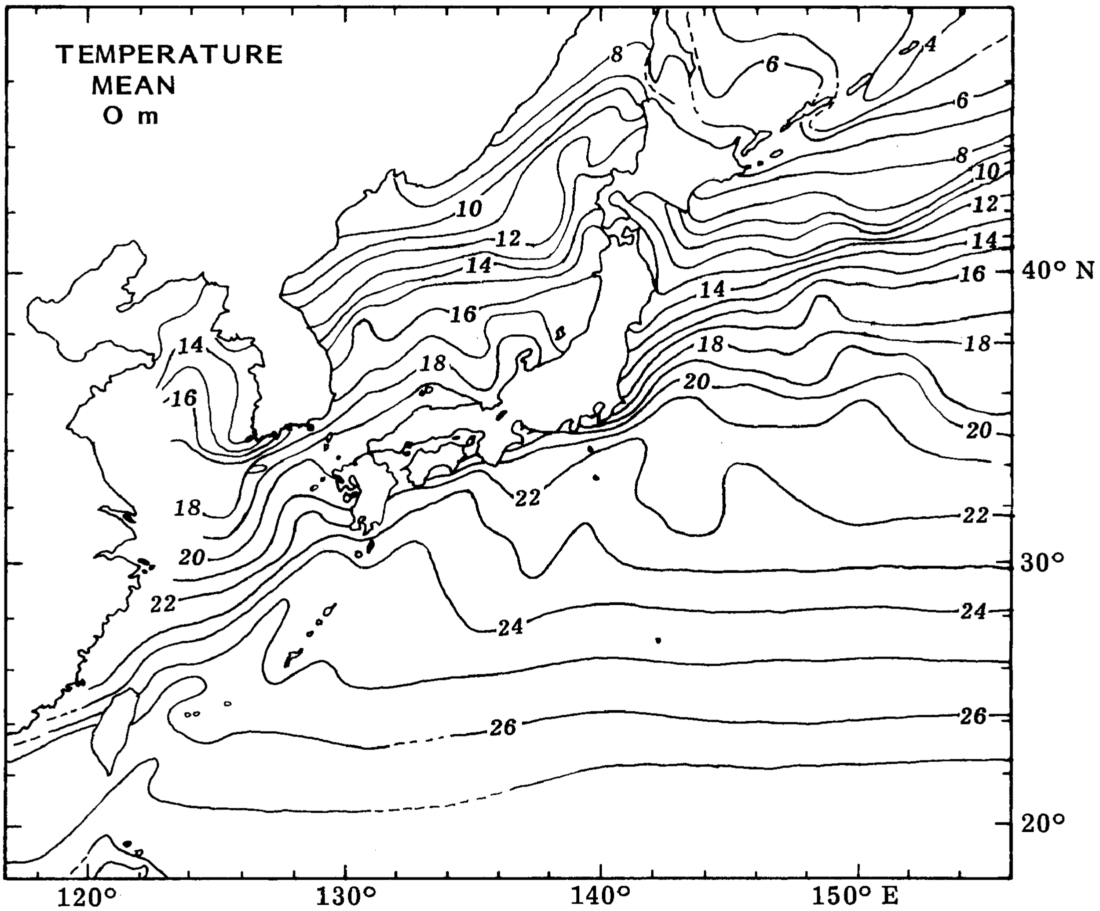

Fig. 2. Annual mean surface water temperature (after J.O.D.C., 1975).

and subarctic regions demarcates the extension of the Kuroshio Current and the Oyashio Current. The Kuroshio is a dominant, warm surface current in the western Pacific. Having been derived from the Pacific North Equatorial Current, this current is formed near the Philippines. Then it turns northward, and flows northeastward along the eastern margin of Kyushu. A branch of the Kuroshio Current runs westward near Yakushima Island and flows northward to the west of Kyushu. The mixed water mass formed by this branching current and coastal waters of the East China Sea — the Tsushima Warm Current — flows into the Sea of Japan. The Tsushima Warm Current flows into the Pacific Ocean through a strait between Honshu and Hokkaido (Moriyasu, 1972). The Oyashio Current is a cold, low-salinity water mass and is formed along the east coast of Kamchatka and flows southward along the Pacific coast of northeast Honshu.

COCCOLITH THANATOCOENOSES IN SURFACE SEDIMENTS

a. MATERIAL AND METHODS

The surface sediment material treated in this study consists of 407 samples collected by grab samplers, 15 core top sediments, and 15 dredgings collected by the Geological Survey of Japan, Ocean Research Institute of the University of Tokyo, Department of Marine Science of

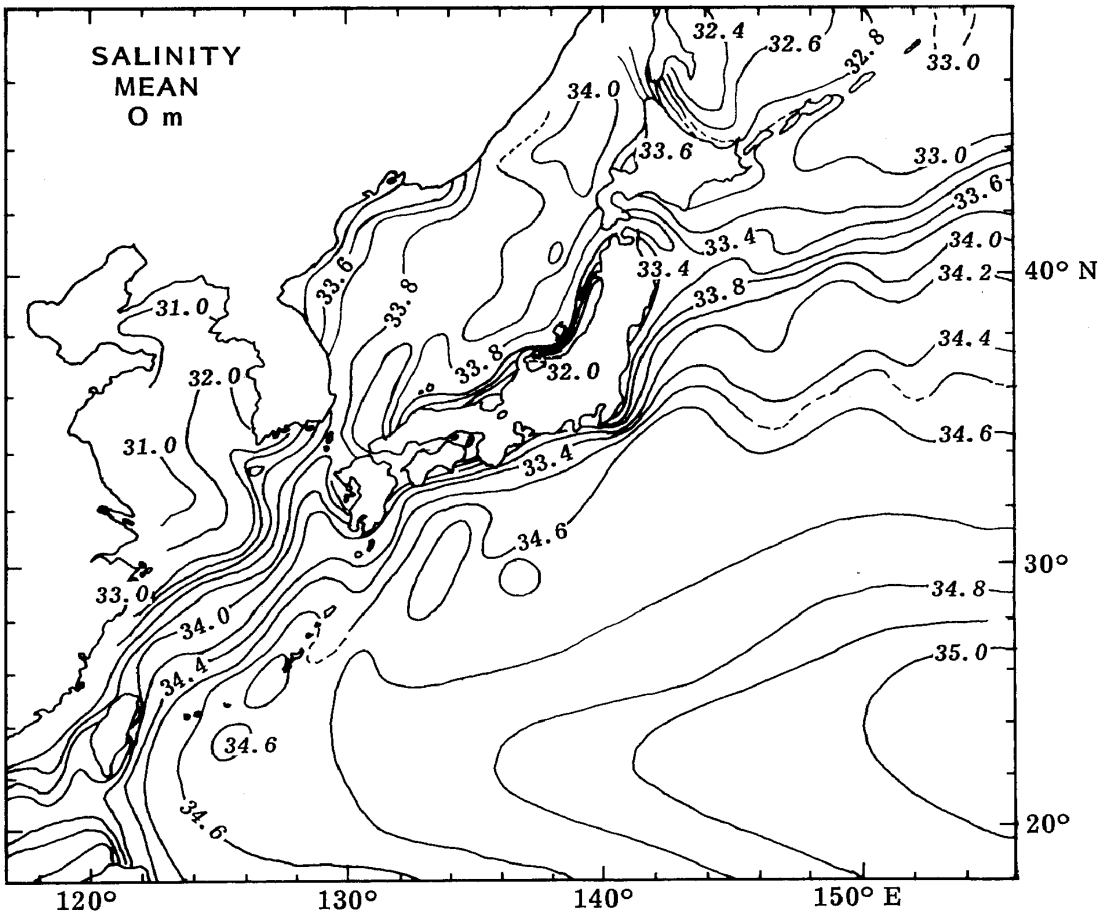

Fig. 3. Mean annual surface water salinity (after J.O.D.C., 1975)

the University of the Ryukyus, and the Faculty of Fisheries of Kagoshima University. These samples range from 22°N to 42°N in latitude and from 41 m to 4,075 m in water depth. Of the total of 437 samples, 40 are devoid of coccoliths due to dissolution. The sample locations are shown in Fig. 4 and Appendix 1.

The samples vary in lithology from silty clay in a deeper part to sand in a shallower part of the sea. Descriptions of sedimentary characters of most of the samples have already been given in reports by Arita and Kinoshita (1977, 1983), Inouchi (1978), Nohara *et al.* (1980), Nakamura *et al.* (1984), Ikehara and Kawahata (1985, 1986), Fujioka *et al.* (1987), Katayama and Ikehara (1988), and Ikehara (1988).

Smear slides were examined to check nannofossils under a light microscope at a magnification of ×1,500. Five hundred specimens were identified and counted on each slide at random. Some samples were also studied with a scanning electron microscope (SEM) to identify and study detailed morphologies of coccoliths. The overall preservation of the samples examined is good to moderate.

Species compositions are shown in Appendix 2.

b. RESULTS

b-1. Frequency distribution along transects

Thirty-four species coming under 23 genera were recognized in a total of 397 surface sediment samples. Species di-

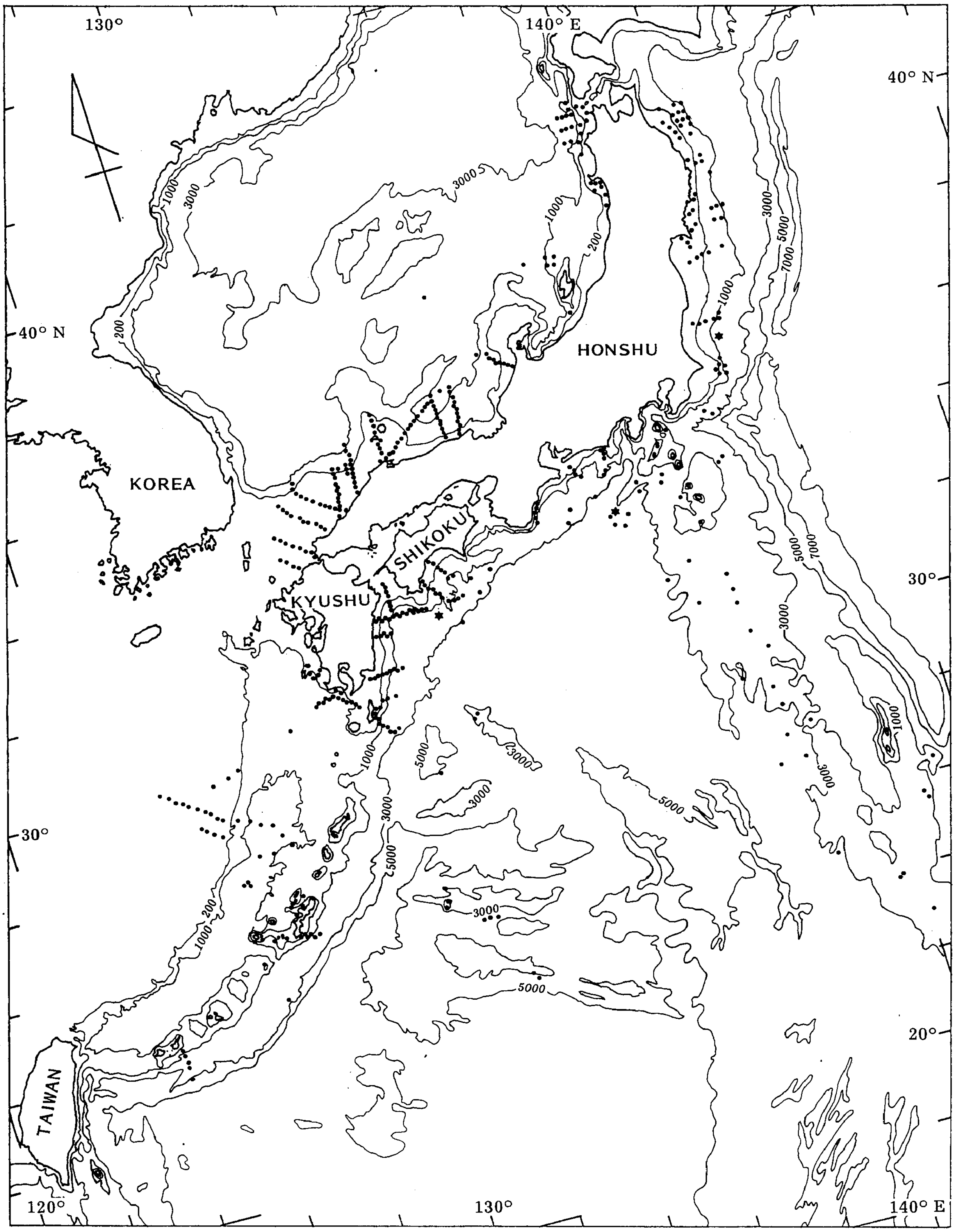

Fig. 4. Map showing the location of surface sediment samples and three piston cores. Closed circle symbol : surface sediment ; star symbol : piston core.

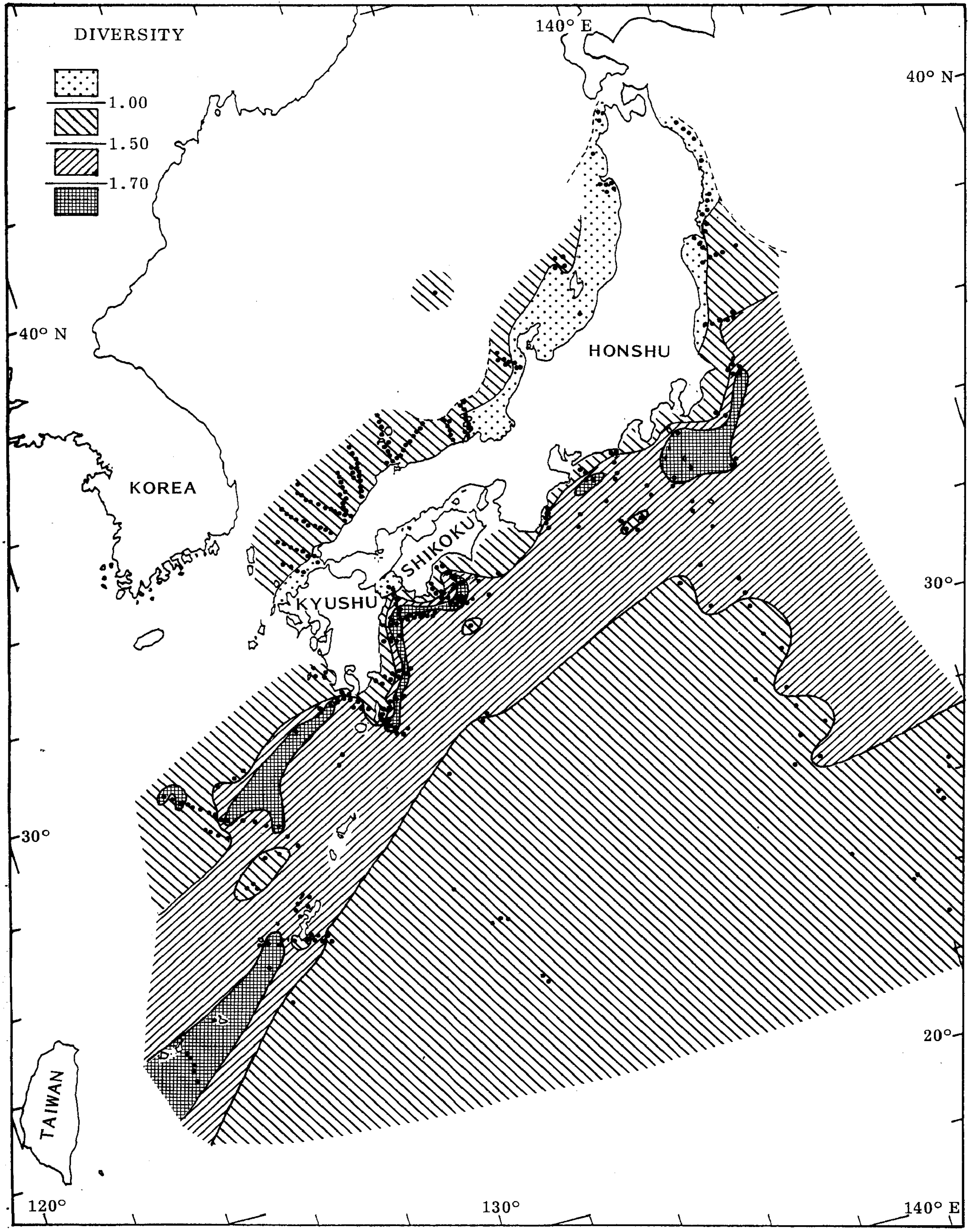

Fig. 5. Map showing the geographic distribution of Shannon-Wiener's species diversity in the study area.

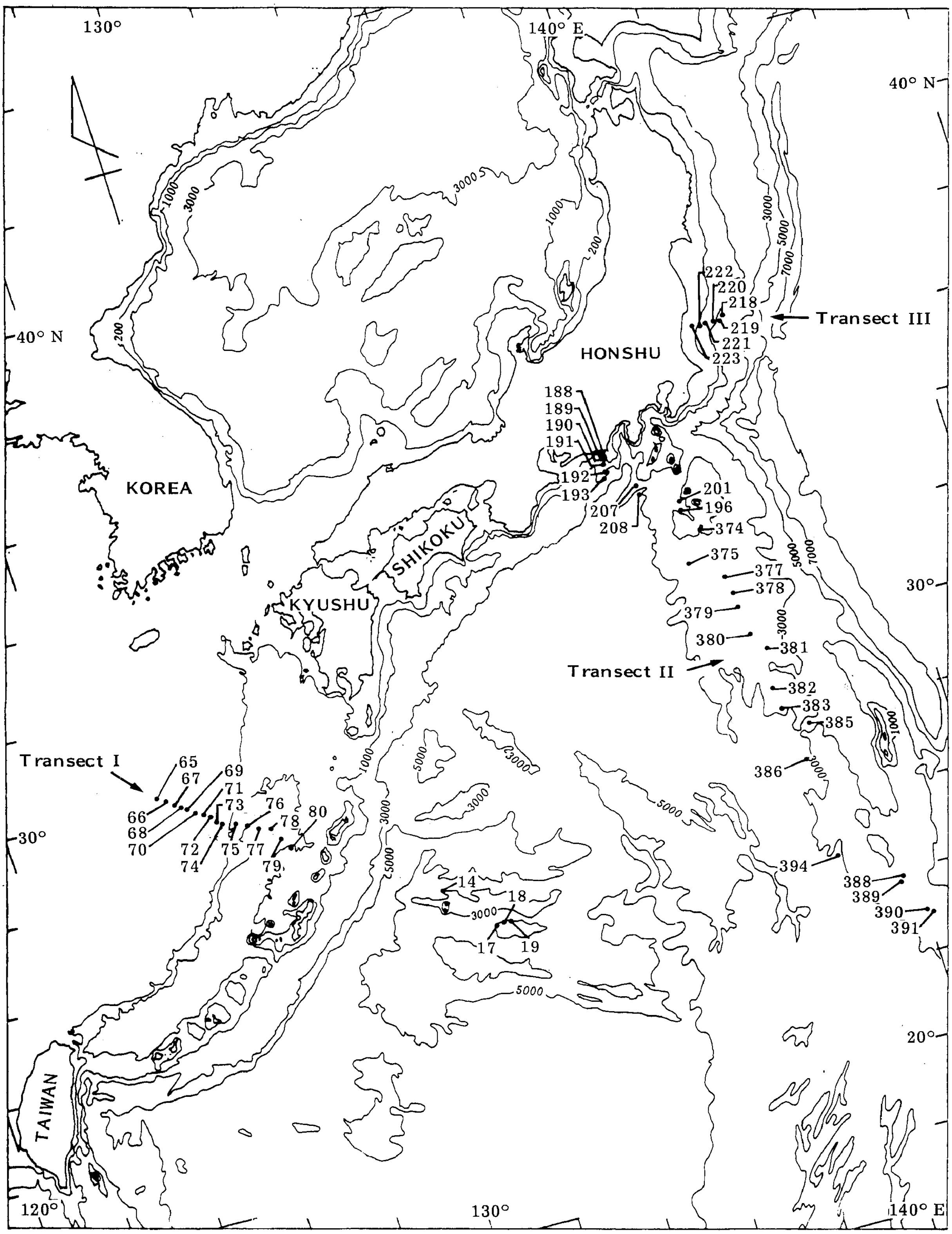

Fig. 6. Location map of three main transects, across which geographical distribution of characteristic coccolith species are shown in Figs. 7–9.

versity in each sample is shown in Fig. 5. The diversity is expressed by the Shannon-Wiener information function. The values of diversity vary from lower than 1.00 to 1.70 bit. On the Pacific side, these values are lowest along the coast of Joban to Hachinohe, and higher on slopes and basins along the course of the main Kuroshio Current. It is highest on the slope at latitudes lower than 36°N, excluding those of the Izu-Ogasawara Ridge and along the Ryukyu Trench. In the Sea of Japan, the values are lower than 1.00 bit along the coast of central and north Honshu.

Figures 7–9 show the relative abundances of selected taxa in thanatocoenoses along three main sections located in Fig. 6.

b-1-1. Transect I

Transect I is situated along a line from

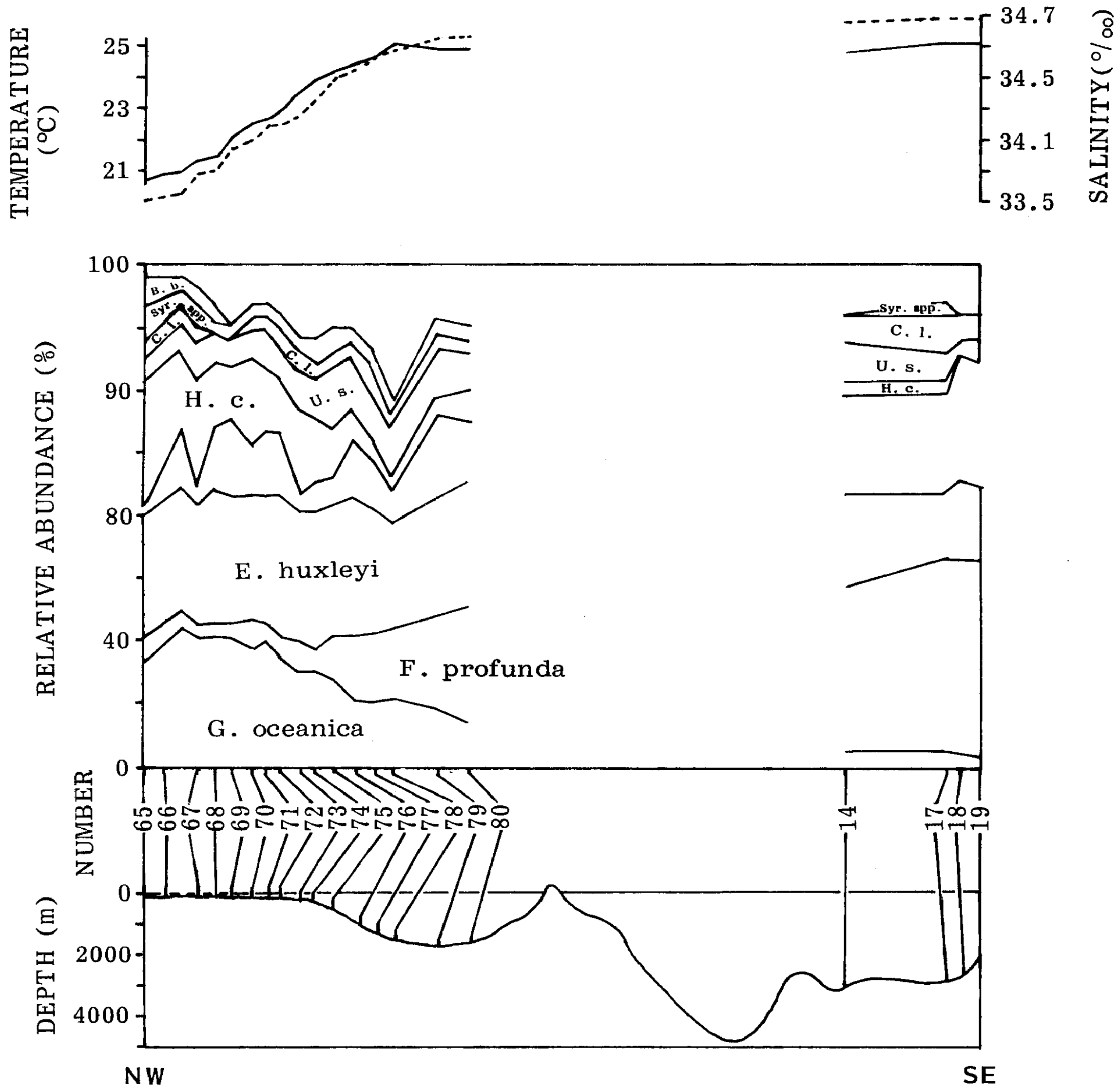

Fig. 7. Relative species abundances along Transect I. B.b. : *Braarudosphaera bigelowii*, C.l. : *Calcidiscus leptoporus*, H.c. : *Helicosphaera carteri* s.l., R.c. : *Rhabdosphaera clavigera*, Syr. spp. : *Syracosphaera* spp., U.s. : *Umbilicosphaera sibogae*, Sal. : salinity, Temp. : temperature.

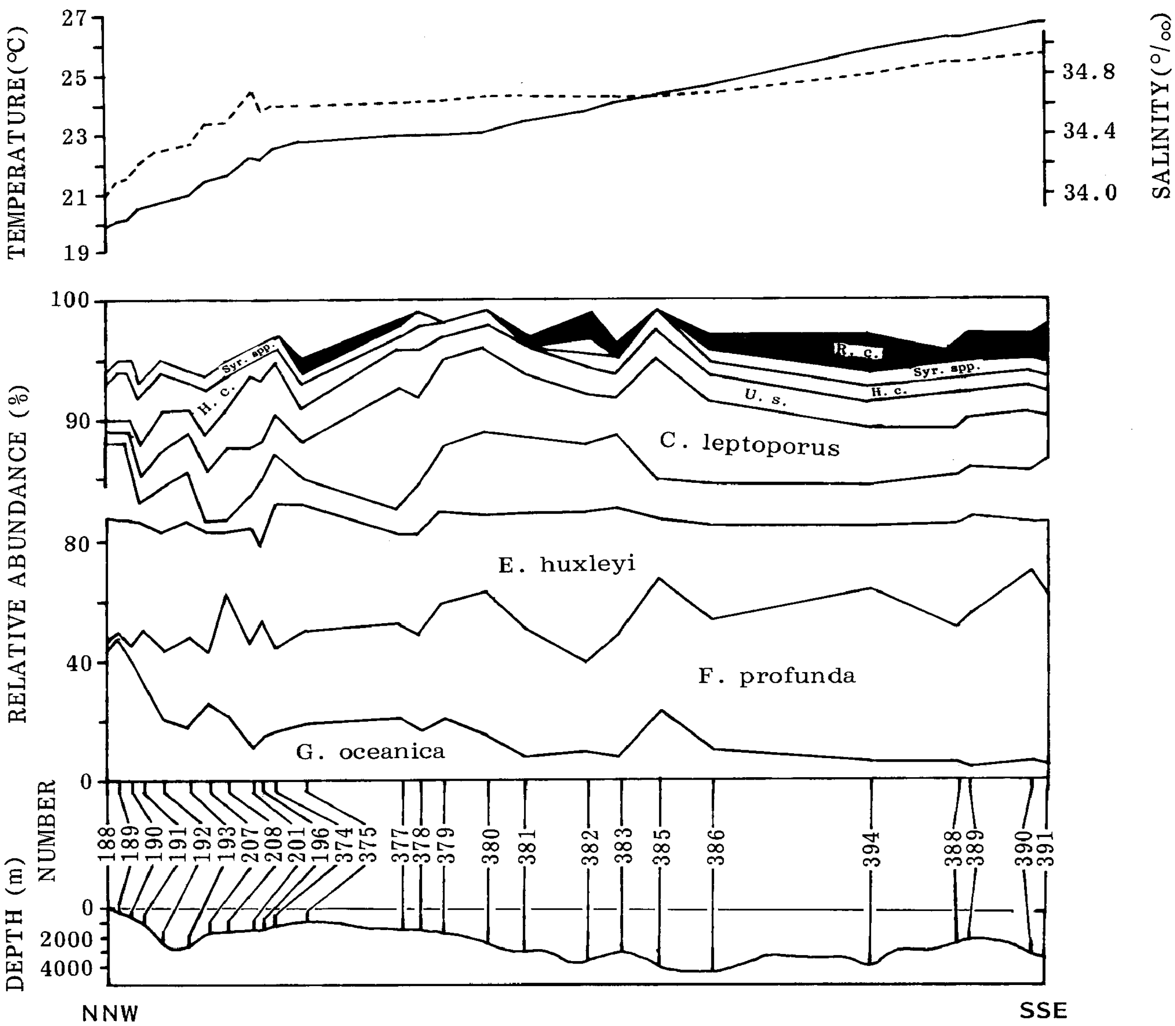

Fig. 8. Relative species abundances along Transect II. See Fig. 7 for abbreviations.

the shelf of the western East China Sea to the Oki-Daito Ridge (Fig. 6). All assemblages are dominated by *Gephyrocapsa oceanica*, *Emiliania huxleyi*, and *Florisphaera profunda*. These three species account for 80% or more of the total flora (Fig. 7). *G. oceanica* and *E. huxleyi* each take up 40% of the assemblage and *F. profunda* is subordinate, with 10% on the shelf of the East China Sea. This pattern is reversed: *F. profunda* increases to more than 60% in sediments along the Okinawa Trough and on the Oki-Daito Ridge. Among the minor species *Braarudosphaera bigelowii* is only found on the shelf of the East China Sea, and *Helicosphaera carteri* s.l. decreases southeastward.

b-1-2. Transect II

Transect II is located along a line running from off Shizuoka to the Izu-Ogasawara Ridge (Fig. 6). Dominant species are also *F. profunda*, *E. huxleyi* and *G. oceanica* (Fig. 8). At sites 188 to 201, distinctly observed there is a negative correlation between *F. profunda* and *G. oceanica*. *F. profunda* is higher than 40% to the south of site 379 and often exceeds 60%. Among the minor species, *Calcidiscus leptoporus* is relatively abundant, reaching 4 to 8%. Other species

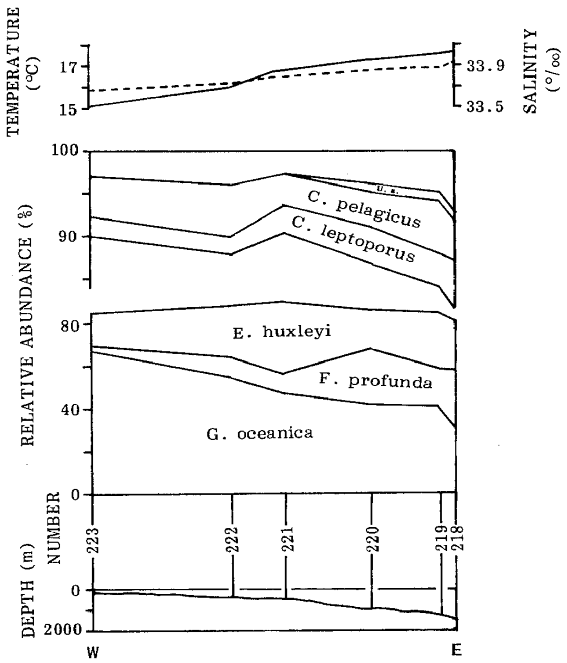

Fig. 9. Relative species abundances along Transect III. See Fig. 7 for abbreviations.

are less abundant throughout this transect.

b-1-3. Transect III

Transect III is situated off Joban (Fig. 6). The flora is dominated by *G. oceanica* which comprises approximately 70% of the coccoliths. *F. profunda* never exceeds 15% of the flora (Fig. 9). Among the minor species, two noticeable taxa are *Coccolithus pelagicus* and *C. leptoporus*. *C. pelagicus* occupies 3 to 5% in abundance.

b-2. Geographical distribution of selected coccoliths

Figures 10 to 20 present the distribution pattern of 11 relatively abundant coccolith species from seas around Japan.

1) *Gephyrocapsa oceanica* (Fig. 10)

Pacific : This species is most abundant in coastal areas, particularly off the Choshi-Hachinohe area and along the east coast of Kyushu (more than 60%). The species has a tendency to decrease with increasing distance from the coast.

Sea of Japan : This species is found throughout the west coastal zone of Honshu, with the highest abundance on the shelves.

2) *Florisphaera profunda* (Fig. 11)

Pacific : This species is distributed from shelf to basin in the Pacific Ocean. It occurs with percentages less than about 10% in shelf sediments, but increases gradually offshore, and becomes very abundant at latitudes lower than 29°N (more than 50%).

Sea of Japan: This species occurs throughout the shelf and slope sediments.

3) *Emiliania huxleyi* (Fig. 12)

Pacific : This species has a wide distributional range throughout the study area. Higher abundances are found in the shelf edge to slope area from the East China Sea to off the Boso Peninsula and on the eastern central Izu-Ogasawara Ridge.

Sea of Japan: This species occurs throughout the shelf and slope. High values are found off eastern Tsushima Island and from off northern Sado Island to off Nishitsugaru.

4) *Umbilicosphaera sibogae* (Fig. 13)

Pacific: This species is distributed throughout the Pacific Ocean except off Kamaishi and northward. Its peak abundances occur in such regions as the Okinawa Trough to eastern Nankai Trough, and the Central Shikoku Basin to off Mikura-jima Island.

Sea of Japan : This species is found off north Sado Island and southward, with peak abundances on the shelf and slope from off Oki Island to off east Tsushima Island.

5) *Syracosphaera* spp. (Fig. 14)

Pacific : This species complex is found between 20°N and 36°N latitude in the study area and off Kamaishi. Its peak abundances occur on the slope from off Ishigaki Island to off southern Kyushu, the East China Sea and off southeast

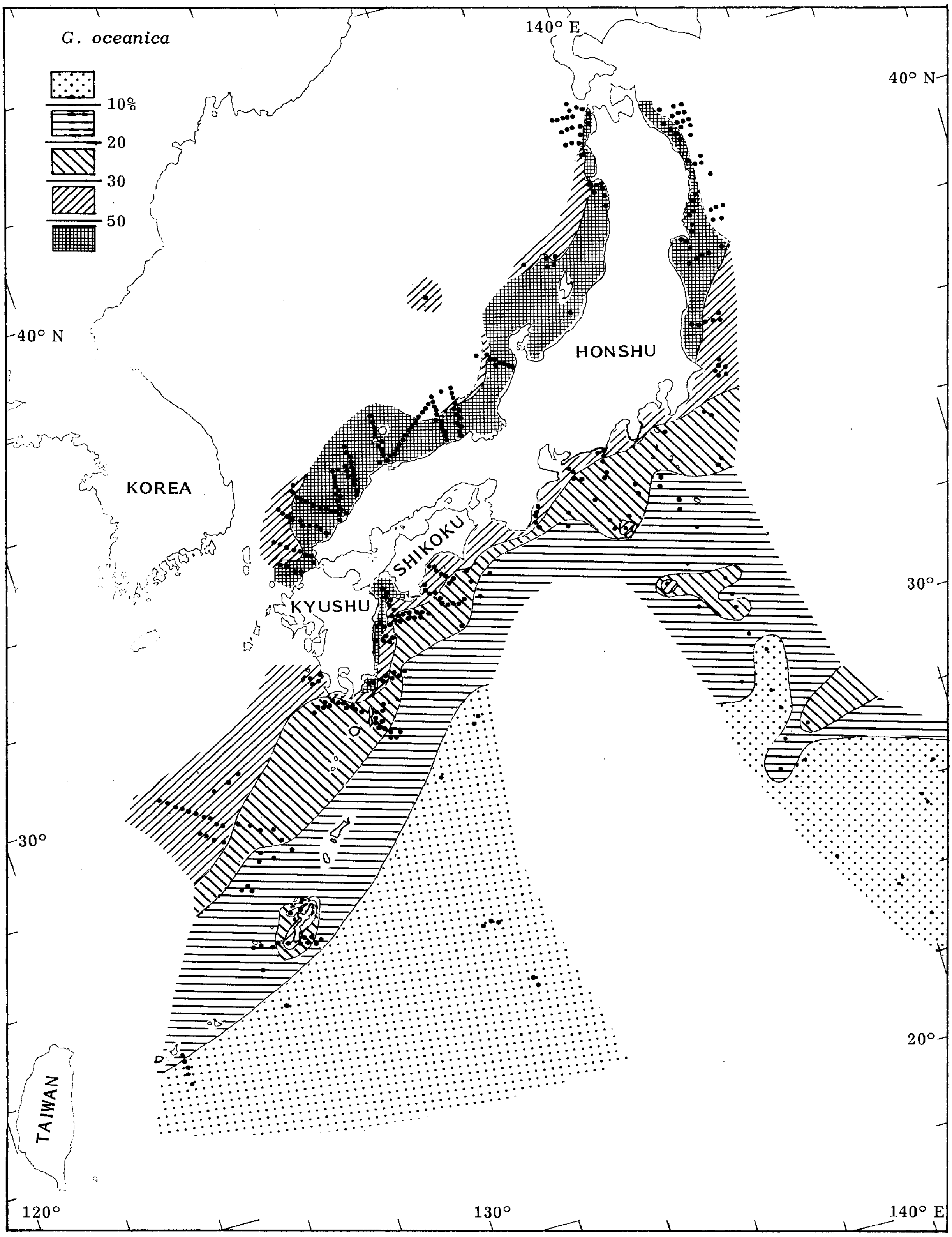

Fig. 10. Distribution of *Gephyrocapsa oceanica* in surface sediments of the study area

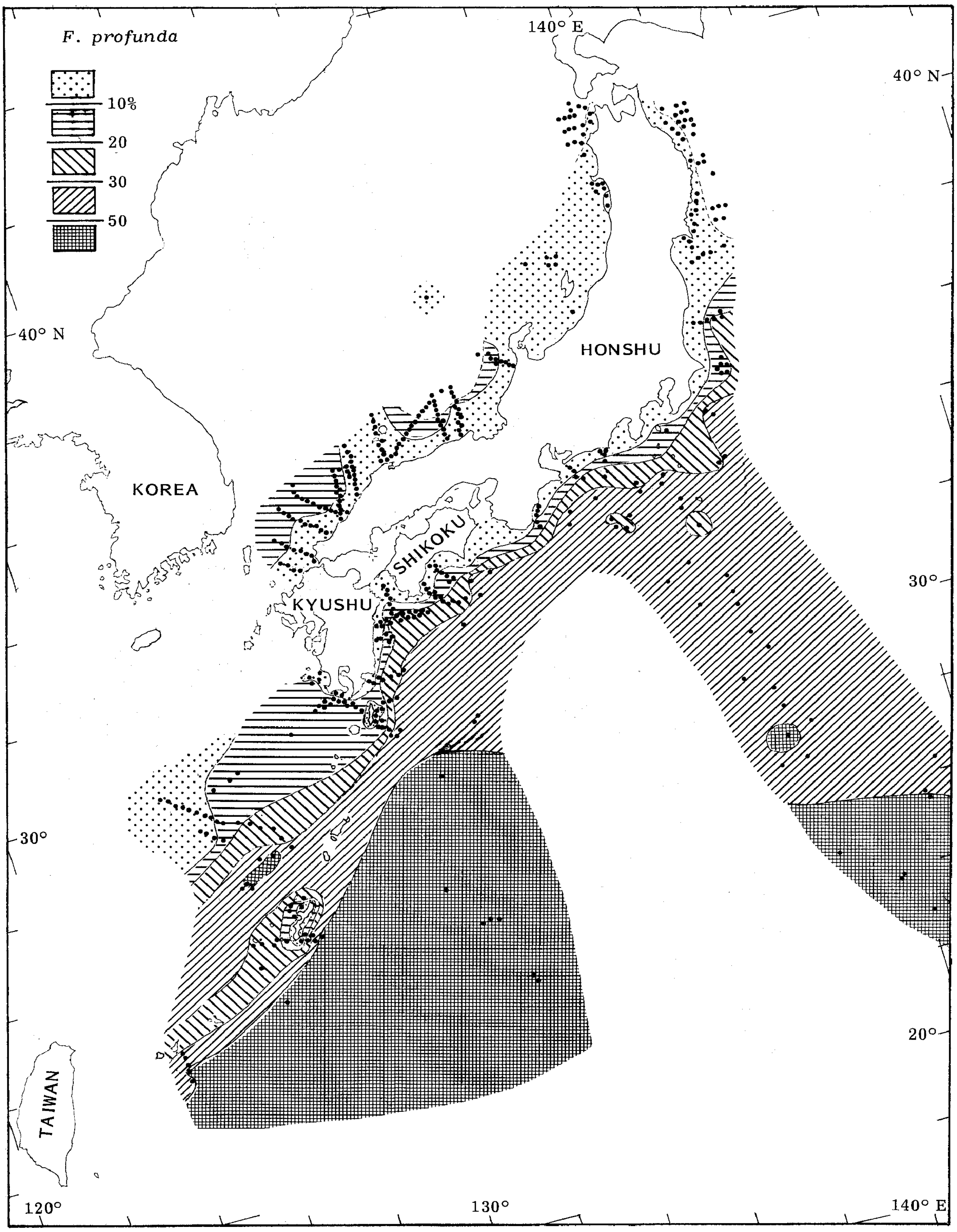

Fig. 11. Distribution of *Florisphaera profunda* in surface sediments of the study area.

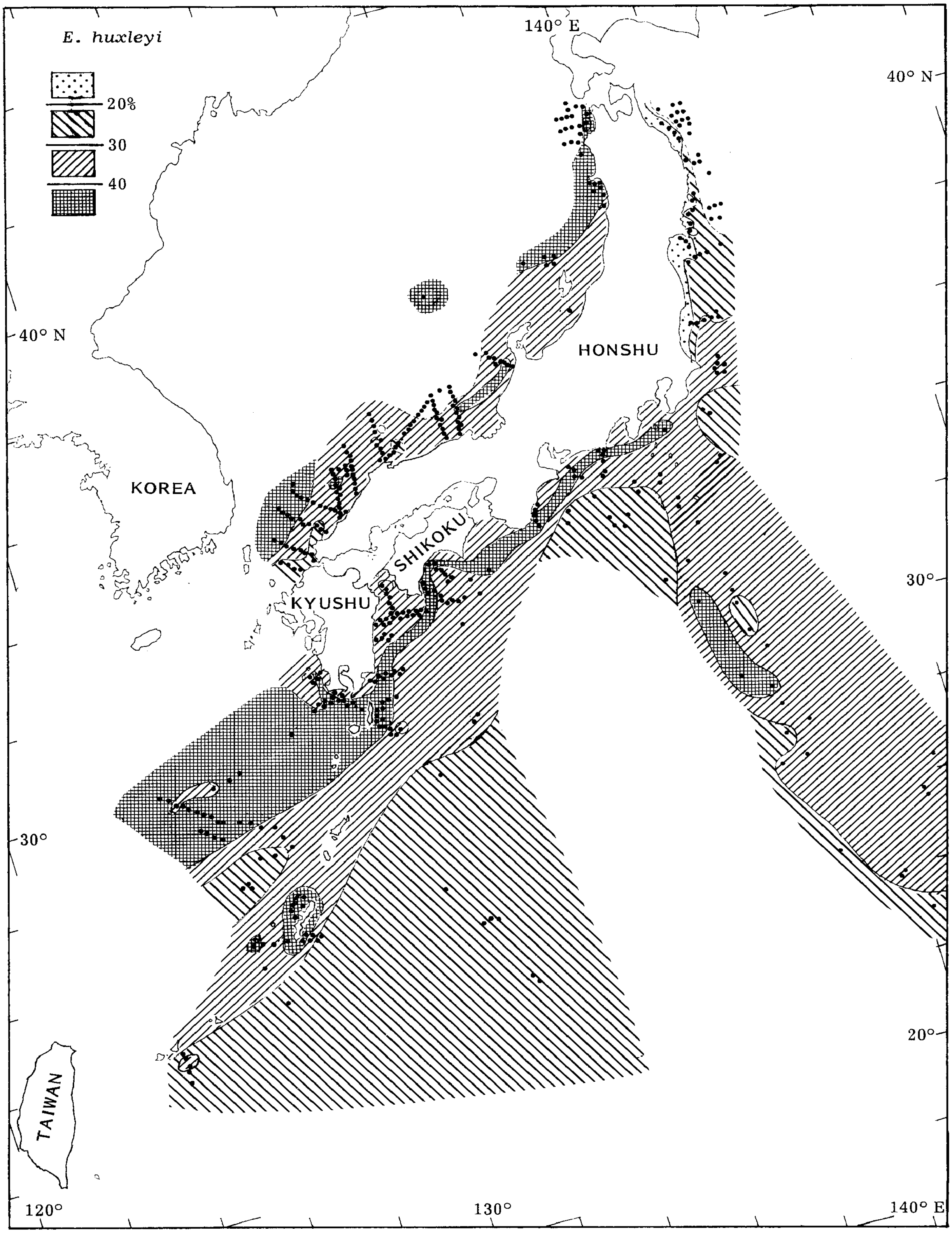

Fig. 12. Distribution of *Emiliania huxleyi* in surface sediments of the study area.

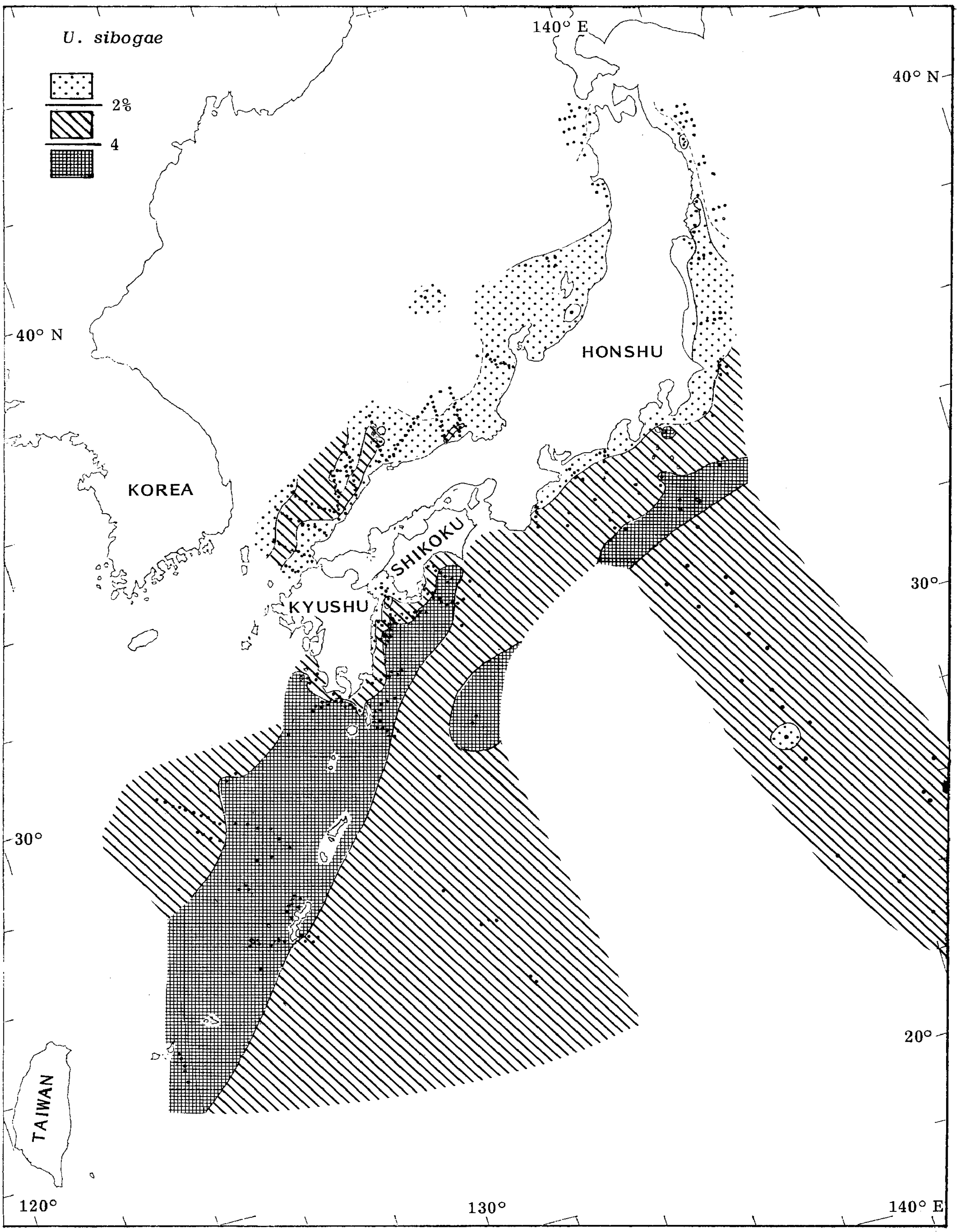

Fig. 13. Distribution of *Umbilicosphaera sibogae* in surface sediments of the study area.

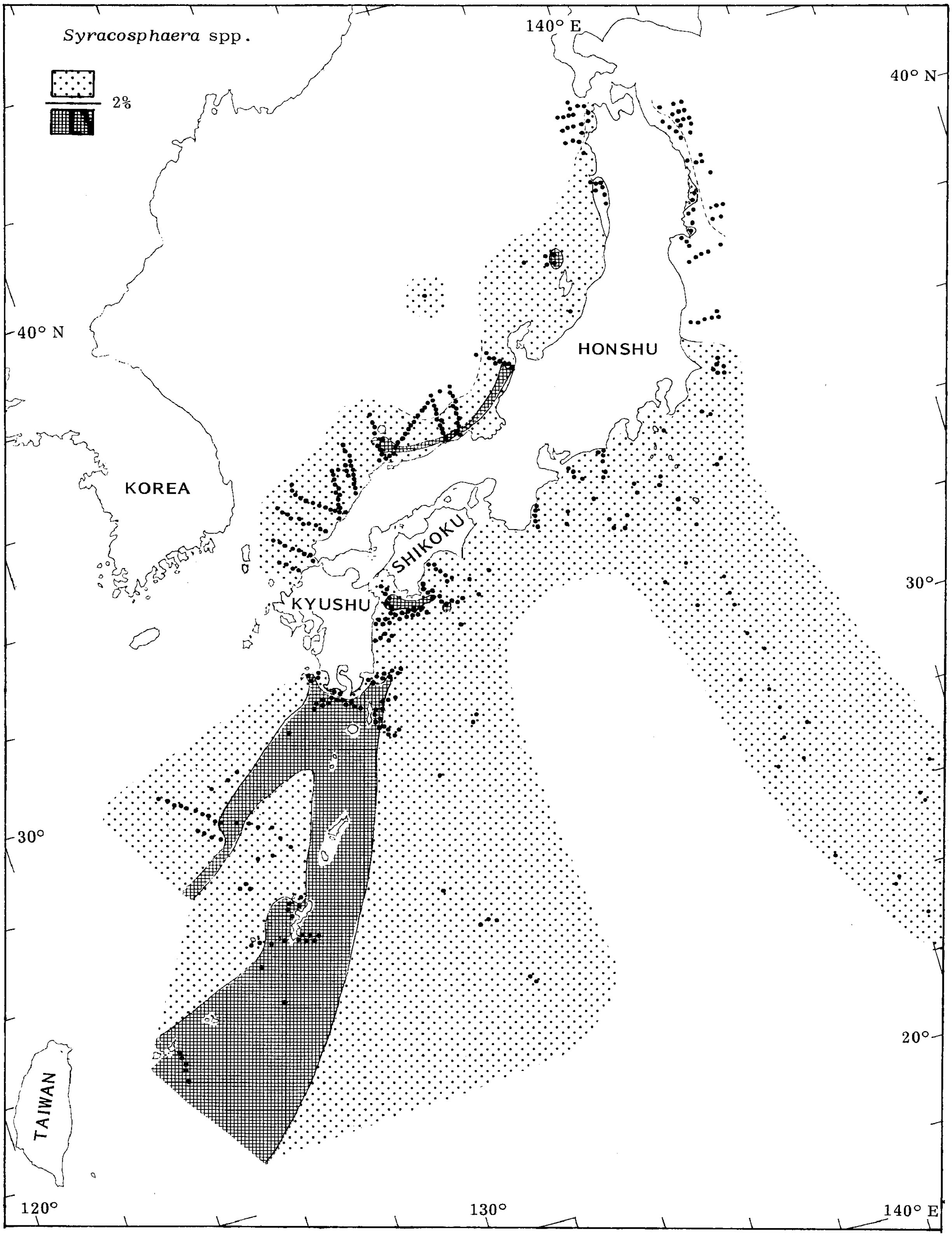

Fig. 14. Distribution of *Syracosphaera* spp. in surface sediments of the study area.

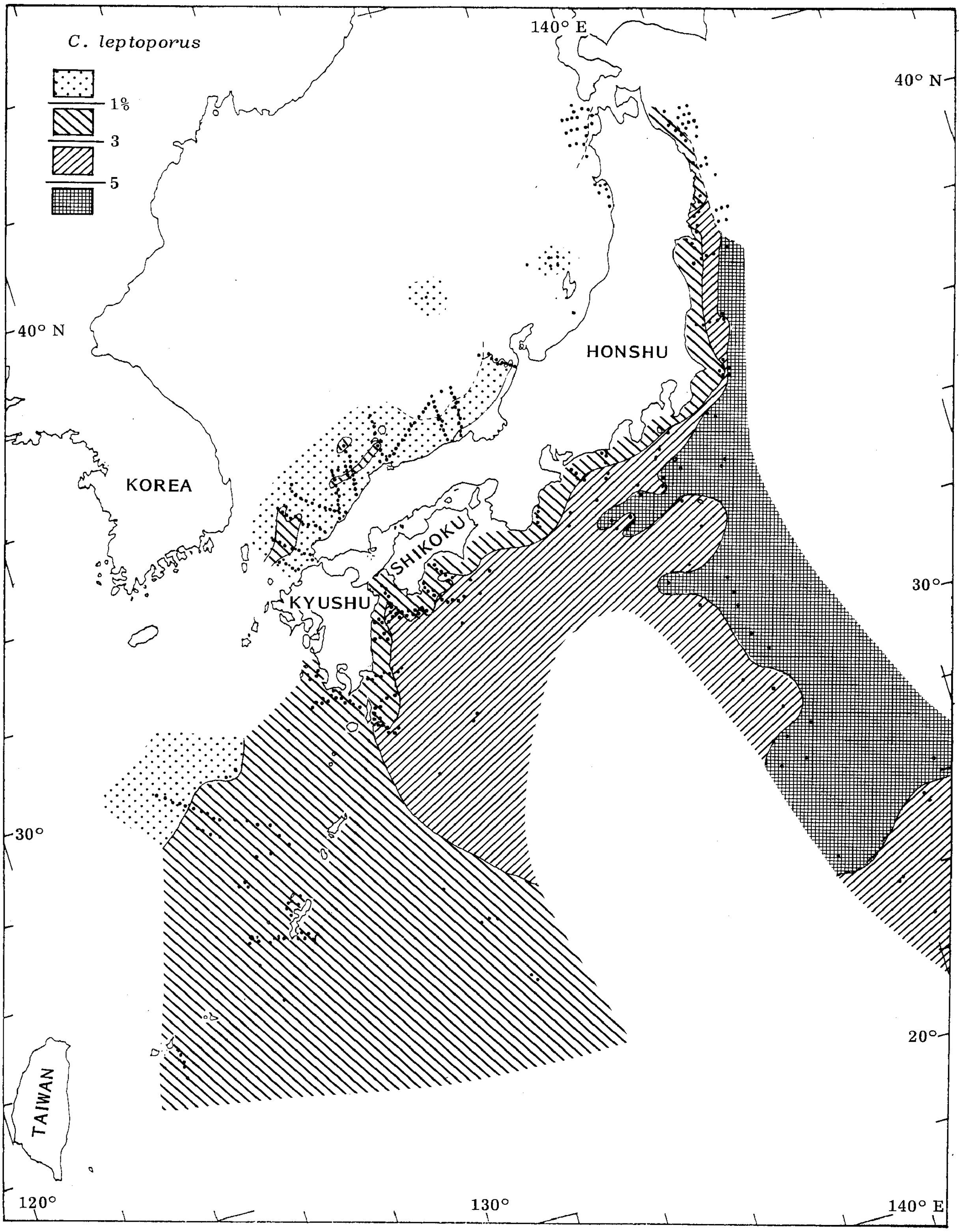

Fig. 15. Distribution of *Calcidiscus leptoporus* in surface sediments of the study area.

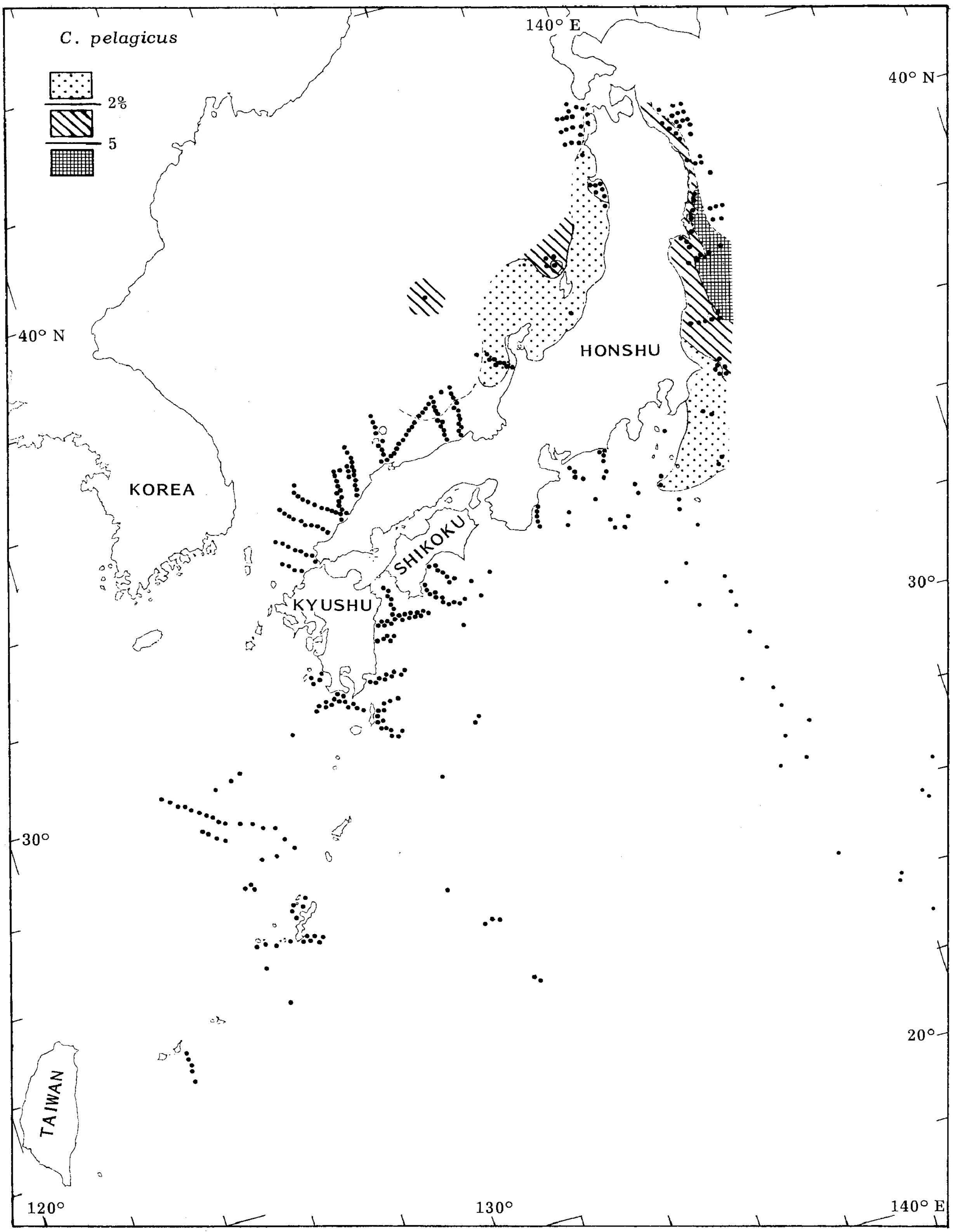

Fig. 16. Distribution of *Coccolithus pelagicus* in surface sediments of the study area.

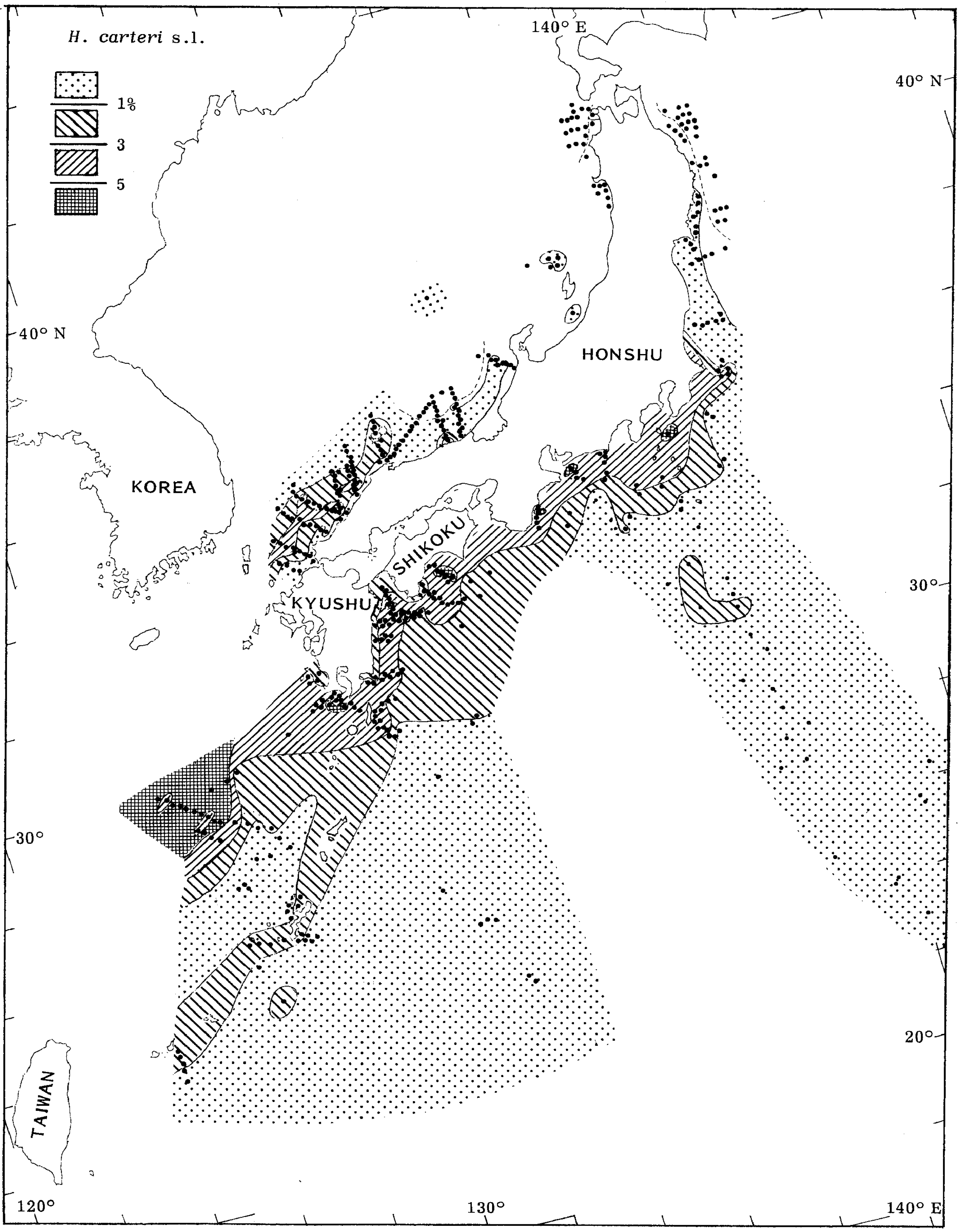

Fig. 17. Distribution of *Helicosphaera carteri* s.l. in surface sediments of the study area.

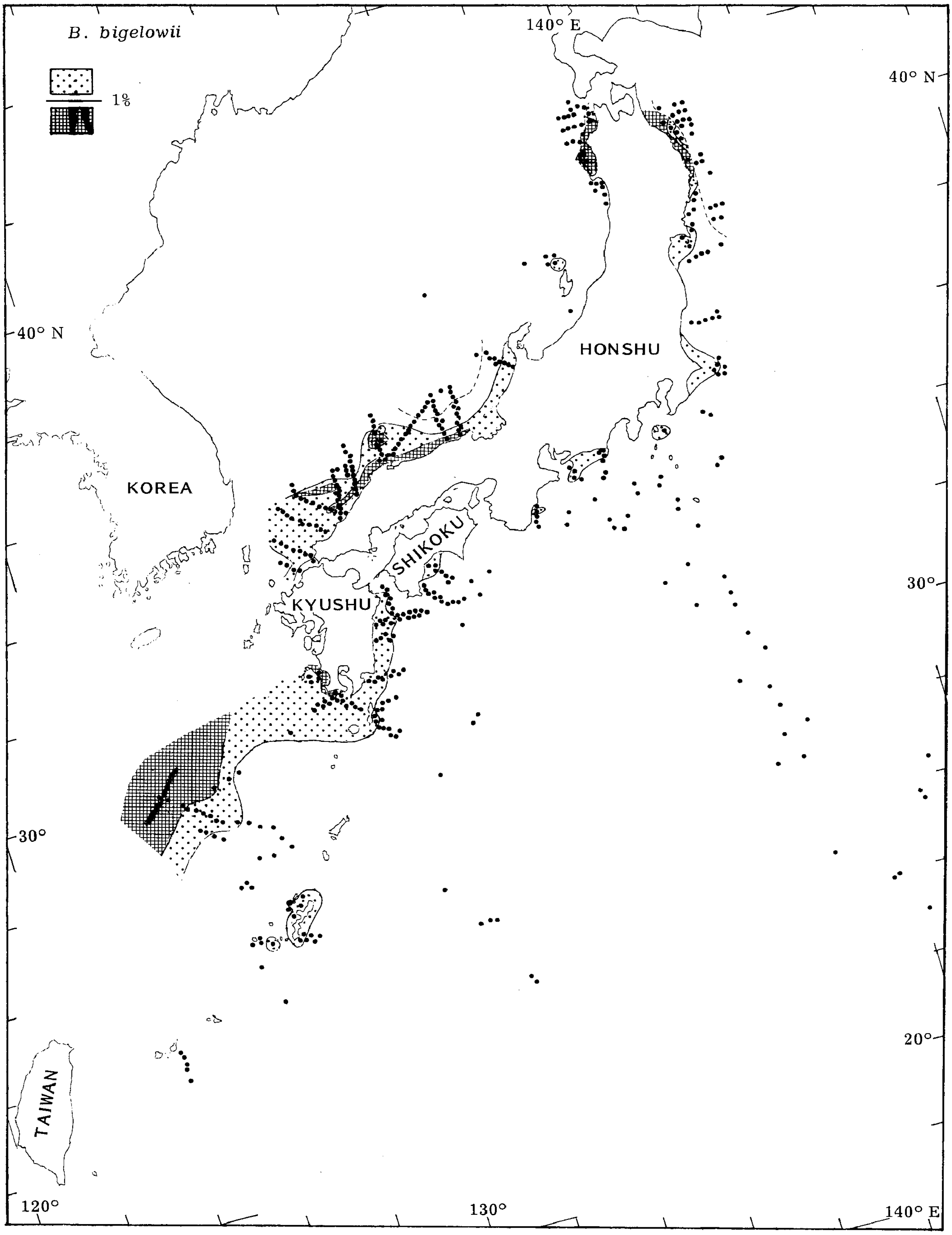

Fig. 18. Distribution of *Braarudosphaera bigelowii* in surface sediments of the study area.

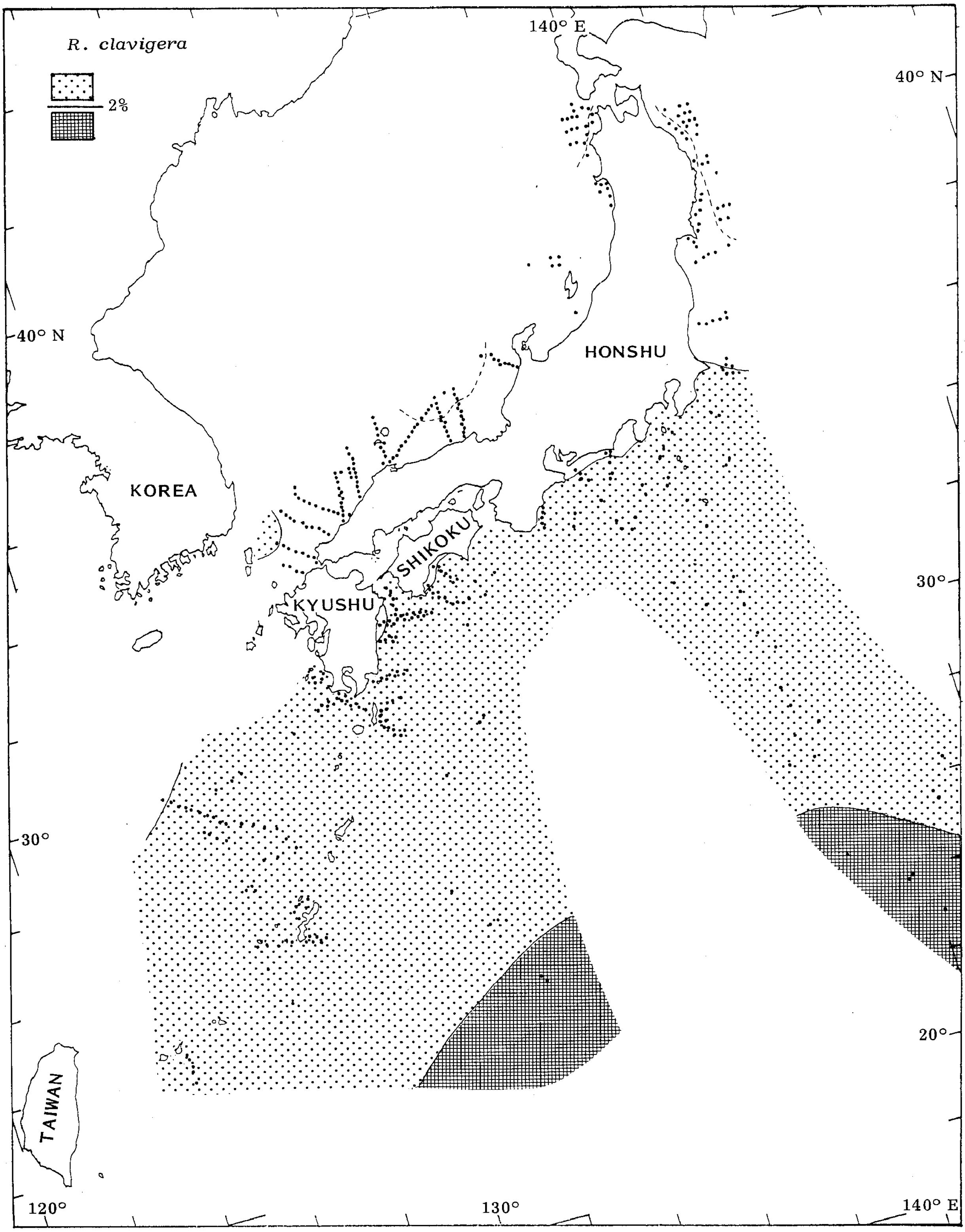

Fig. 19. Distribution of *Rhabdosphaera clavigera* in surface sediments of the study area.

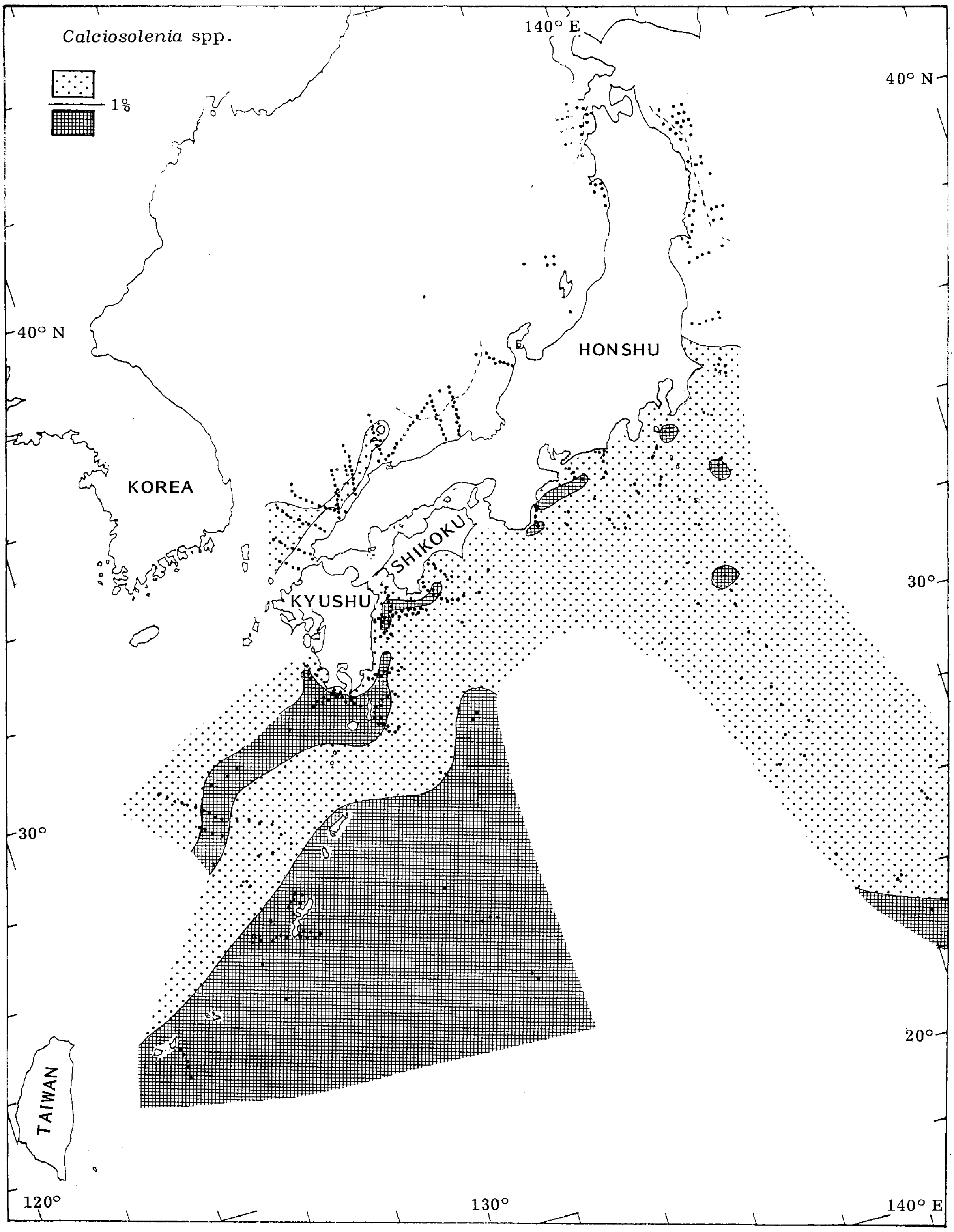

Fig. 20. Distribution of *Calciosolenia* spp. in surface sediments of the study area.

Shikoku.

Sea of Japan : This complex is found throughout shelf and slope sediments, with its peak abundance from off Oki Island to off the west coast of Kanazawa.

6) *Calcidiscus leptoporus* (Fig. 15)

Pacific : This species is widely distributed in the Pacific and East China Sea. Peak abundances occur from the Izu-Ogasawara Ridge to off Sendai. The species has a tendency to increase offshore.

Sea of Japan : This species is found in shelf and slope sediments from off east Tsushima Island to off east Kanazawa.

7) *Coccolithus pelagicus* (Fig. 16)

Pacific : This species has a restricted range from off Mikura-jima Island to off Hachinohe. High abundances of this species occur from off the Joban to Kamaishi area.

Sea of Japan : This species is distributed from off the Kanazawa to Nishitsugaru area, with its peak abundances located to the northwest of Sado Island.

8) *Helicosphaera carteri* s.l. (Fig. 17)

Pacific : This taxon is distributed along the shelves of Kamaishi to Sendai and at latitudes lower than 36°N (Fig. 17). This taxon shows an increasing tendency in abundance shoreward.

Sea of Japan : This taxon occurs from areas east of Tsushima Island to off Kanazawa, and in the sea adjacent to Sado Island.

9) *Braarudosphaera bigelowii* (Fig. 18)

Pacific : This species is found only in shelf and shelf edge regions, with peak abundances on the shelf of the East China Sea and off Hachinohe.

Sea of Japan : This species occurs in shelf sediments from off east Tsushima Island to off Kanazawa, and off Nishitsugaru.

10) *Rhabdosphaera clavigera* (Fig. 19)

Pacific : This species is distributed in latitudes lower than 36°N, with peak abundances on the eastern Oki-Daito Ridge and the south Izu-Ogasawara Ridge.

Sea of Japan : This species is only distributed off Tsushima Island.

11) *Calciosolenia* spp. (Fig. 20)

Pacific : This complex is found in latitudes lower than 36°N as is the case of *R. clavigera*. Peak abundances occur on the slope of the Pacific side and in the Philippine Sea.

Sea of Japan : This complex is distributed at a depth of 100 m from off east Tsushima to off the Oki Islands.

The distributions of the above-mentioned species are delineated separately (Figs. 10–20) from coastal to oceanic water forms and from cold to warm water forms, as determined by oceanic conditions, such as the mean annual salinities and temperatures (Figs. 2 and 3). *G. oceanica*, *H. carteri* s.l. and *B. bigelowii* dominate assemblages of coastal water. In contrast, *F. profunda*, *C. leptoporus* and *R. clavigera* dominate assemblages from oceanic water. *C. pelagicus* dominates assemblages from cold surface water, whereas *F. profunda*, *R. clavigera*, *U. sibogae* and *Calciosolenia* spp. dominate assemblages from warm surface water.

c. FLORAL ANALYSIS

c-1. Cluster analysis

In order to determine sample groups based on the relative abundance of coccolith species in each sample, a technique of cluster analysis (Kaesler, 1966 ; Mello and Buzas, 1968) was applied. The Q-mode cluster analysis was conducted by using a NEAC-ACOS model 1000 computer in the Tohoku University Computer Center. The program used is written by Dr. Shiro Hasegawa. Clustering was carried out upon the matrix using the weighted pair group method with simple arithmetic average. The distance among samples was represented by Horn's measurement of overlap (Horn, 1966). Fifteen species (Table 1), with abundances greater than 2% in any

Table 1. List of coccolith taxa used for cluster and regression analyses.

Braarudosphaera bigelowii (Gran and Braarud) Deflandre
Calcidiscus leptoporus (Murray and Blackman) Loeblich and Tappan
Calciosolenia spp.
Coccolithus pelagicus (Wallich) Schiller
Crenalithus spp.
Emiliania huxleyi (Lohmann) Hay and Mohler
Florisphaera profuda Okada and Honjo
Gephyrocapsa ericsonii McIntyre and Bé
Gephyrocapsa oceanica Kamptner
Gephyrocapsa oceanica var. A
Helicosphaera carteri s.l.
Rhabdosphaera clavigera Murray and Blackman
Syracosphaera spp.
Umbellosphaera tenuis (Kamptner) Paasche
Umbilicosphaera sibogae (Weber-van Bosse) Gaarder

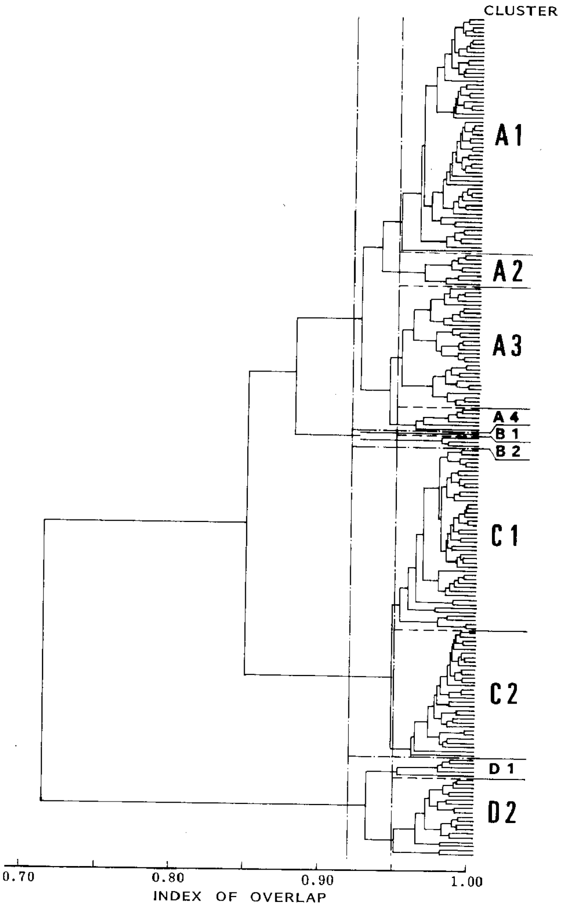

Fig. 21. Dendrogram showing the result of Q-mode cluster analysis of coccolith thanatocoenoses in seas on the Pacific side of Japan. See Appendix 3 for composition of sample groups.

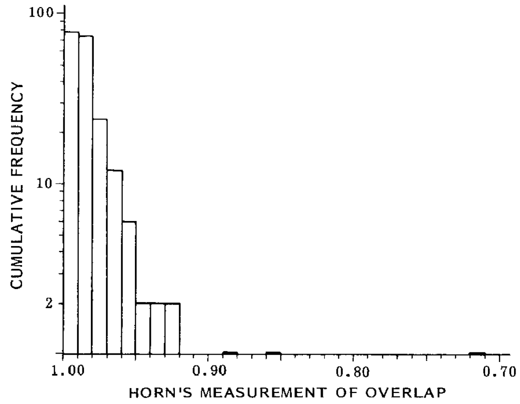

Fig. 22. Frequency distribution of fusing in the dendrogram shown in Fig. 21.

given sample, and 204 samples selected by taking into account intervals between samples were used in this calculation. The result of the Q-mode cluster analysis is shown in Fig. 21. The samples were classified into four groups at a level of 0.92 similarity in the dendrogram, then divided into ten subgroups at a level of 0.95 similarity. These levels were chosen on the basis of a break in the frequency distribution of fusing (Ujiié and Kusukawa, 1969 ; Ujiié, 1973) as indicated in Fig. 22. The areal distribution and characteristic species of these sample groups (biotopes) are shown in Fig. 23 and Table 2.

1) Cluster A1 is characterized by the

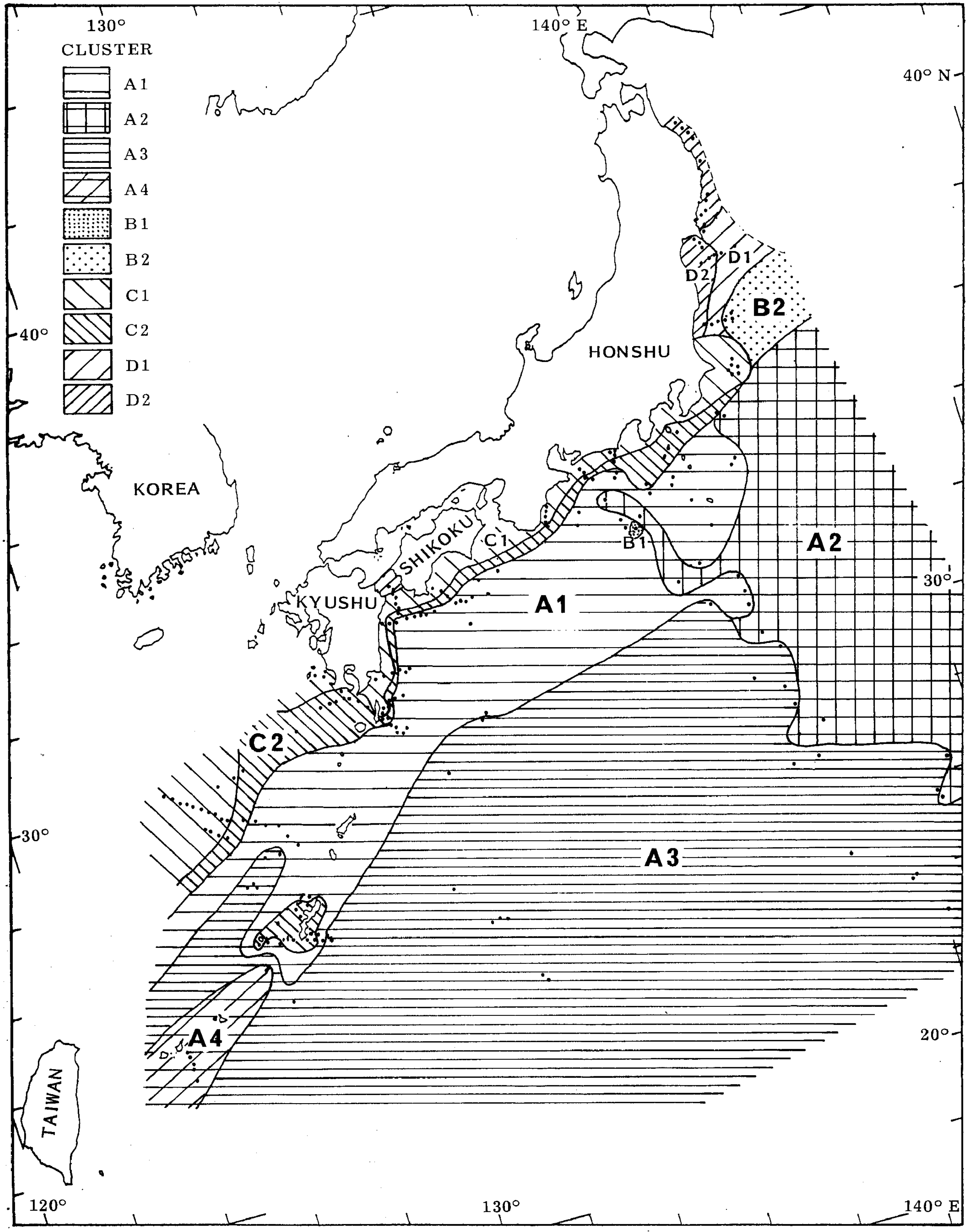

Fig. 23. Areal distribution of biotopes of coccolith thanatocoenoses in seas on the Pacific side of Japan.

Table 2. Characteristic species of biotopes in seas on the Pacific side of Japan determined by cluster analysis.

Cluster	Dominant species	Accompanied species
A1	*Umbilicosphaera sibogae*	*Emiliania huxleyi* *Helicosphaera carteri* s.l.
A2	*Calcidiscus leptoporus*	*Florisphaera profunda*
A3	*Florisphaera profunda*	*Rhabdosphaera clavigera* *Umbellosphaera tenuis*
A4	*Syracosphaera* spp. *Umbilicosphaera sibogae* *Florisphaera profunda* *Calciosolenia* spp.	
B1	*Calcidiscus leptoporus* *Umbilicosphaera sibogae*	
B2	*Calcidiscus leptoporus* *Coccolithus pelagicus*	
C1	*Helicosphaera carteri* s.l.	*Braarudosphaera bigelowii* *Emiliania huxleyi*
C2	*Emiliania huxleyi*	*Helicosphaera carteri* s.l. *Calciosolenia* spp.
D1	*Coccolithus pelagicus*	*Gephyrocapsa oceanica*
D2	*Gephyrocapsa oceanica*	*Coccolithus pelagicus*

peak abundance of *Umbilicosphaera sibogae* and subordinate occurrences of *Emiliania huxleyi* and *Helicosphaera carteri* s.l. This cluster is located in the main course of the Kuroshio Current, and extends its distribution to an area off south Boso. Species diversity is comparatively high, ranging from 1.5 to 1.7.

2) Cluster A2 comprises peak abundances of *Calcidiscus leptoporus* and a subordinate occurrence of *Florisphaera profunda* in areas east of the Izu-Ogasawara Ridge. Species diversity is as high as that of cluster A1.

3) Cluster A3 is dominated by *F. profunda* and subordinate occurrences of *Rhabdosphaera clavigera* and *Umbellosphaera tenuis*. This cluster occupies mostly south of the main flow of the Kuroshio Current. Species diversity is lower as compared with those of clusters A1 and A2.

4) Cluster A4 is characterized by the occurrences of *F. profunda*, *U. sibogae*, *Syracosphaera* spp., and *Calciosolenia* spp. This cluster is confined to an area which is subjected to the relatively strong influence of the Kuroshio Current. This cluster seems to be closely related to both clusters A1 and A3, but is higher in species diversity than these two clusters.

5) Cluster B1 is characterized by the occurrence of *C. leptoporus* and *U. sibogae*. This cluster, consisting of a unique sample, is located at a site in the eastern Nankai Trough which is as deep as 4,065 m. As compared with the adjacent region, the diversity of this cluster is particularly low (Fig. 5). Consequently, the biotope of this region seems to have been formed as a result of differential dissolution of species.

6) Cluster B2 is characterized by the predominance of *C. leptoporus* with associated occurrence of *Coccolithus pelagicus*. This cluster is geographically situated off Choshi, which lies in the mixing zone of the cold Oyashio and warm Kuroshio Currents.

7) Cluster C1 is characterized by the dominant occurrence of *H. carteri* s.l., and by common abundances of. *Braarudosphaera bigelowii* and *E. huxleyi*. This cluster occupies shallow water re-

gions of the East China Sea to off Choshi. Species diversity is low (in general, 1.0 to 1.5). This cluster appears to be related to the fresh water inflow from the mainlands.

8) Cluster C2 is dominated by *E. huxleyi*, with common occurrences of *H. carteri* s.l. and *Calciosolenia* spp. This cluster represents the front region formed between cluster C1 and clusters A1 and A2. Therefore, the diversity exceeds 1.7 in most of the area.

9) Cluster D1 is characterized by *C. pelagicus* in association with *Gephyrocapsa oceanica*. This cluster is found in an area off Joban to Kamaishi. Diversity is lower than 1.5. This region is under the influence of the cold Oyashio Current.

10) Cluster D2 is dominated by *G. oceanica* and is characterized by *C. pelagicus*. This cluster is located along the coast of from Joban to Hachinohe. Species diversity is lowest throughout this region (1.0<).

Each group involves a distinct floral characteristic, since all the clusters are distinguished on the basis of similarity of abundances of species contained in each sample.

Figure 24 shows the relationships between the mean and standard deviation of salinity and of temperature for each cluster. Figures 23 and 24 show that there are two kinds of clusters: one is composed of stations in regions under the surface waters of the Kuroshio Current, and coastal regions adjacent to the Kuroshio Current (clusters A1, A2, A3, A4, B2, C1, and C2); the other comprises stations in the subarctic Pacific under the Oyashio Current and adjacent coastal regions (clusters D1 and D2). The surface water of the former is characterized by high temperatures and high salinities as compared with those of the latter. Clusters A1+A2 and A3+A4, subdivisions of cluster A separated at a level of 0.93 similarity in Fig. 21, are defined by higher surface mean annual

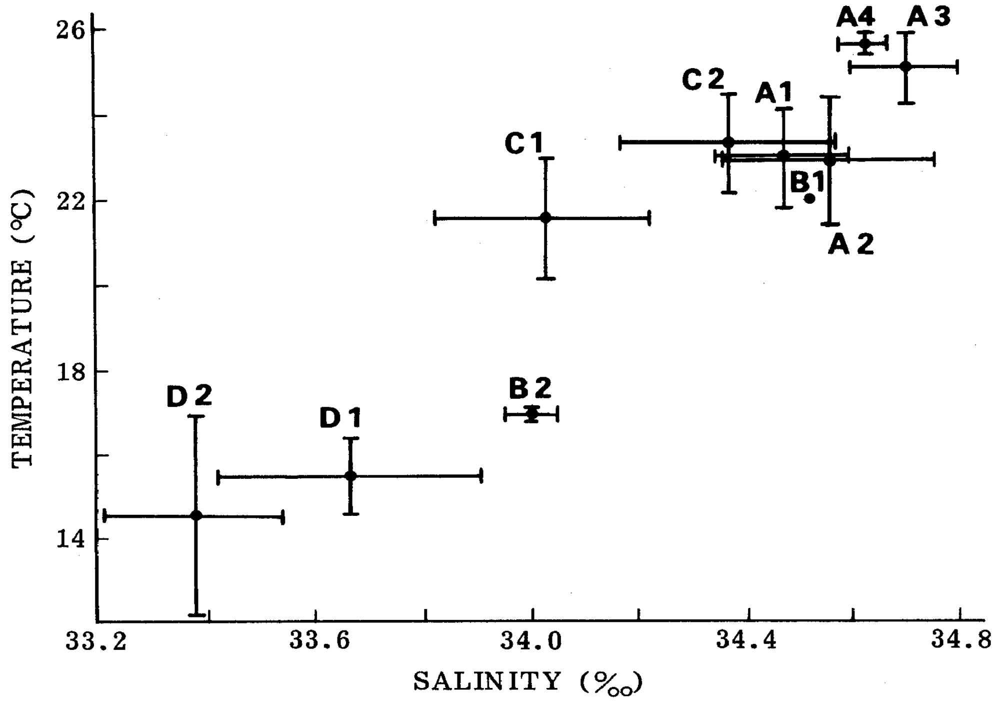

Fig. 24. Relationships between the mean and standard deviation of salinity and of temperature for each biotope determined by the Q-mode cluster analysis on the Pacific side of Japan.

salinities and temperatures of the latter. Clusters A3 and A4 are distinguished by a slight difference in salinity values. Clusters D1 and D2 are recognized by higher surface mean annual salinities of the former, although the surface mean annual temperatures are comparable. Clusters D1 and B2 are reasoned by the differences between low salinities and temperatures of the Oyashio Current and high salinities and temperatures of the Kuroshio front. Clusters C1 and C2 may be ascribed to the differences in surface mean annual temperatures and salinities. Clusters C2, A1 and A2 can be defined by a slight difference of surface mean annual salinities.

These facts support the idea that each region divided by the cluster analysis can be explained by means of water conditions, such as salinity and temperature. That is, the biotopes in seas around Japan are defined largely by the combination of salinity and temperature.

c-2. Regression analysis

As mentioned above, important floral changes in seas on the Pacific side are associated with changes of salinity and temperature. The procedure of multiple regression analysis (a standard stepwise procedure) was used to verify the relationship between coccolith floras and such environmental parameters as temperature and salinity, and to formulate multiple regression equations.

The samples and species used in this analysis are the same as those for cluster analysis.

The estimated mean annual surface water salinities (Sa) are given by:

$Sa = -0.2910$ (% *B. bigelowii*) $+ 0.0280$ (% *C. leptoporus*) $- 0.0523$ (% *C. pelagicus*) $- 0.0157$ (% *G. oceanica*) $- 0.0306$ (% *H. carteri* s.l.) $+ 0.0596$ (% *Syracosphaera* spp.) $+ 34.75$, and temperatures (Ta) by:

$Ta = -0.1610$ (% *C. leptoporus*) $- 0.7178$ (% *C. pelagicus*) $- 0.0940$ (% *G. oceanica*) $+ 0.7033$ (% *R. clavigera*) $+ 0.2877$ (% *U. sibogae*) $+ 24.6$

The accuracy of these equations can be judged from their amount of contribution and the standard errors of estimates (Table 3). The contribution values are 0.89 and 0.85 for mean annual surface salinity and temperature equations, respectively. The standard error of estimates is 0.14‰ (approximately 8.1% of the range (33.2–34.93‰)) for annual mean surface salinity and 1.30°C (approximately 9.4% of the range (12.8–26.7°C) for mean annual surface temperature. Hence, these equations explain nearly 90% of the original measurements.

Figure 25 plots the observed versus estimated values. It is evident that there are differences larger than the standard error in particular portions. Geographic examination shows that large residuals for salinities are confined to the coastal areas (Fig. 26a). Large residuals for temperatures are distributed in coastal areas and on the Izu-Ogasawara Ridge (Fig. 26b): underestimates are mainly on the southwest and overestimates on the northeast of off Shikoku which represents a demarcating region of temperatures above and below 22.0°C. Such distributions of residuals

Table 3. Summary of statistics concerned with mean annual surface water salinity and temperature transfer functions.

	Mean annual salinity	Mean annual temperature
Multiple correlation coefficient	0.95	0.92
Contribution ratio	0.89	0.85
Standard error of estimate	0.14 ‰	1.30 °C

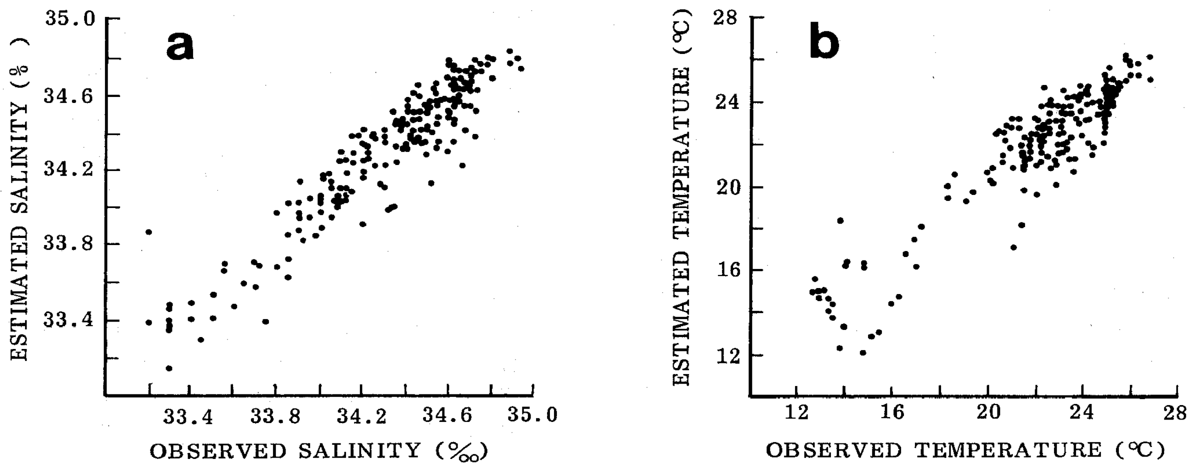

Fig. 25. Scatter diagrams of observed values versus transfer function estimates in seas on the Pacific side of Japan. (a) represents mean annual surface water salinity; (b) represents mean annual surface water temperature.

are apparently related to a considerable degree to geographic peculiarities due to unpredictable water conditions around islands on the shelf and upper slope. In addition, it is suspected that the temperature equation subserves its constant use because consistent deflection is found between overestimates on the northeast and underestimates on the southwest of off Shikoku.

d. DISCUSSION

Cluster and regression analyses demonstrate that temperatures and salinities are the two most critical factors controlling the distribution of coccolith floras in this area. It is noteworthy that four major water masses in the seas on the Pacific side of Japan are represented by characteristic coccolith floras.

Oda *et al.* (1983) investigated planktonic foraminifer assemblages in surface sediments from seas off northeast Honshu by means of Q-mode principal components factor analysis. As a result, they recognized four varimax assemblages which represent the Tsugaru Warm Current, Oyashio, Kuroshio, and coastal waters. These assemblages correspond in their geographic distribution to some of the clusters determined in this study: cluster D1 to the Oyashio assemblage, cluster C2 to the Kuroshio assemblage, and cluster D2 to the coastal water assemblage. This result proves that the assemblages of calcareous nannoplankton thanatocoenoses were largely under the control of water masses.

Studies on coccolith distributions in surface sediments from various shallow water areas of the western Pacific Ocean such as western Tasman Sea (Burns, 1975) and the East China Sea (Wang and Samtleben, 1983; Zang and Siesser, 1986) revealed a prominent tendency for *Gephyrocapsa oceanica* to decrease and *Emiliania huxleyi* to increase from the coast to oceans. Similar trends were also recognized in the seas on the Pacific side (Figs. 7, 8 and 9). This tendency seems to be associated with changing salinity. For example, distinctions among clusters C1, C2 and A1 and between clusters D1 and D2 are clearly made with regard to salinity values (Fig. 24).

The peak abundance of *E. huxleyi*, a characteristic species of cluster C2, can be attributed to strategic sample sites situated closely to the oceanic front. Similar results were obtained in an upwelling area of the Benguela Current off

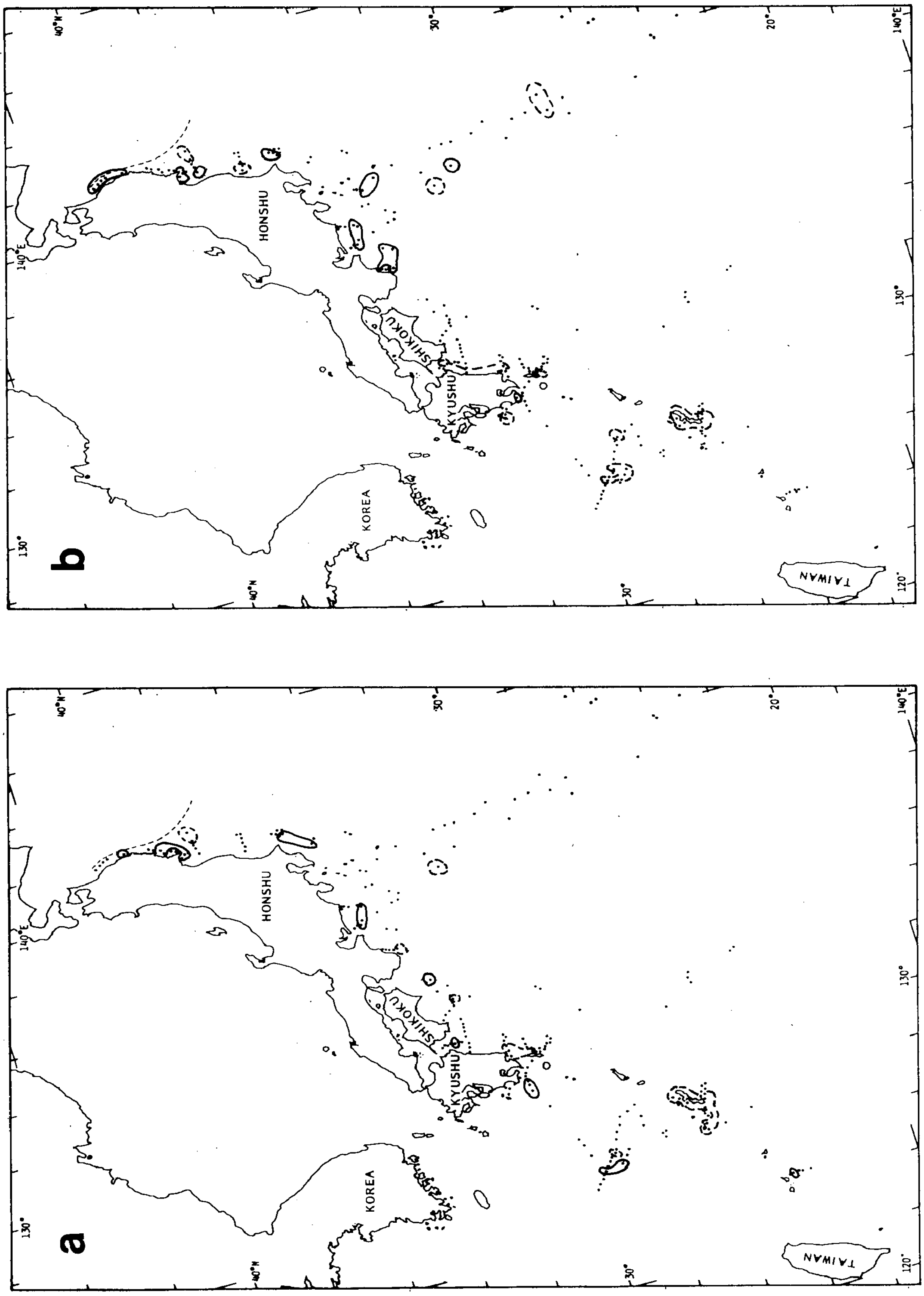

Fig. 26. Geographic distribution of residuals of mean annual surface water salinity (a) and temperature (b) estimates calculated by transfer function. Solid lines enclose overestimates greater than one standard error. Dashed lines enclose underestimates greater than one standard error.

Cape Town (Winter, 1984).

McIntyre and Bé (1967) noticed that *Umbilicosphaera sibogae* occurred in great abundances in temperate to subtropical regions in the Atlantic Ocean. In the present study area, the main flow of the Kuroshio Current along the western margin of the western North Pacific is marked particularly by cluster A1 which is characterized by the peak abundance of *U. sibogae.* Hence, the peak abundance of *U. sibogae* may signify water masses of moderate temperature and salinity.

On the other hand, the frequency peaks of *F. profunda*, *Calcidiscus leptoporus* and *Coccolithus pelagicus* are recognized in clusters A3, A2 and D1, respectively, possibly due to the effect of water temperatures (Figs. 2 and 23). McIntyre and Bé (1967) indicated that an increase of relative frequencies of *C. leptoporus* marked a transition from warm to colder floras. On the other hand, the trend of those changing species abundances with changing temperatures is not recognized in coastal regions, *e.g.* from off Boso to Joban because of the less saline water.

Although water depth *per se* is not a significant controlling factor, it is a ready term referring to general oceanic features. From this point of view, Okada's (1983) divisions are advocated: shelf, slope, and basin, or marginal seas. The relative frequency of *F. profunda* is, however, poorly related with depth below about 500 m (Okada, 1983; Fig. 27 in this study). In addition to this tendency, the relative abundance of *F. profunda* tends to increase offshore or southward (Fig. 11) with increasing temperature. Hence, the above-described features suggest that the interpretation of oceanic conditions using coccolith floras must be made on the basis of two or more factors. Loubere (1982) reported in his study of the planktonic foraminifer *Globigerinoides ruber* the operation of two oceanographic parameters (temperature and salinity) to control its distribution. This study verified that the distribution of coccolith assemblages in seas adjacent to the Japanese Islands can be explained by either temperature or salinity, or a combination of both.

In summary, cluster analysis based on the relative frequency of coccolith species in each sample leads to recognition of ten sample groups. The distribution of these sample groups can be equated with the effect of mean annual surface temperature and/or salinity. Although seas around Japan in the study area are under extremely complicated oceanic conditions, the information obtained suggests that coccolith floras mirror oceanographic environments.

Problems met in this study include: 1) the transfer function introduces considerable errors in the estimate of environmental parameters for coastal regions, and 2) two such factors as temperature and salinity alone may not fully explain the distinction among clusters C2, A1 and A2; further work is needed to deduce a third oceanic factor that controls non-uniform distributions of coccolith floras.

DOWN-CORE ANALYSIS

a. GENERAL OUTLINE

In the Northwest Pacific, Moore *et al.* (1980) indicated an increased winter cooling and equatorward shift of the frontal zone between the Subarctic and Transition Zones at 18,000 years B.P. Thompson (1981) concluded that the largest climate change had occurred in the temperate (Transitional) region between 30°N and 40°N latitude along the Pacific coast of Japan, enabling the southward penetration of the Oyashio

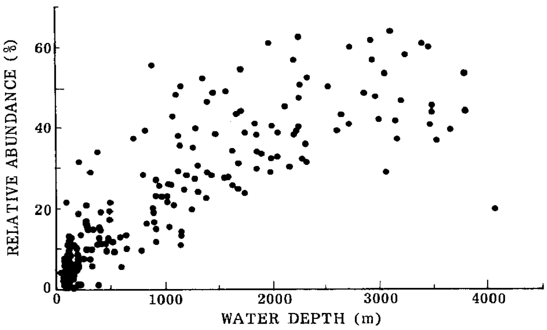

Fig. 27. Relations between the relative abundance of *Florisphaera profunda* and water depth in the sea on the Pacific side of Japan.

Current. Chinzei *et al.* (1987) illustrated the history of warming processes, the northward shift of the Kuroshio front, during the last 20,000 years. They analyzed it using the combination of warm and cold water species of all the major microfossil groups (planktonic and benthic foraminifera, coccoliths, diatoms and radioralians) and oxygen isotopic composition. This analysis based on the distribution patterns of species in modern oceanic water regions, however, has inherent limits in the geographic applicability because geographic distributions of species are clearly linked to the extent of individual water masses with their characteristic attributes.

CLIMAP Project Members (1976) have established a standard method of paleoceanographic reconstructions. The technique of Imbrie and Kipp (1971), used in the CLIMAP Project Members (1976), has successfully been adopted and applied to the Atlantic coccolith assemblages by Roche *et al.* (1975).

Here the writer attempts to demonstrate the significance of coccolith paleotemperature and paleosalinity estimates using the transfer functions formulated in the preceding section for the last 22,000 years.

b. MATERIALS

Three piston cores (KH83-2-13, KH79-3-4, and KT81-19-1) were selected, by reason of a well-preserved state of microfossils contained in them, from the core collection of the Ocean Research Institute of the University of Tokyo for a detailed biostratigraphic study of coccolith floras and application of the transfer functions. The cores selected are from geographic areas currently under the influence of the Kuroshio Current. Their locations are shown in Fig. 4 and Appendix 1. Complete descriptions of two cores (KH79-3-4, and KT81-19-1) have already been given by Chinzei *et al.* (1987). Brief descriptions of these three cores run as follows:

KH83-2-13

This core was taken off Shikoku at a depth of 1,600 m. The 349 cm-long core is composed of a dark greenish gray, silty clay, and contains ash layers at 93-94 cm and 340-343 cm depths.

KH79-3-4

This core was taken off Shizuoka at a depth of 3,343 m. This core is 563 cm in total length and the upper 173 cm, which was estimated to be younger than 2,200 years B.P., was analyzed here. The core consists of a dark greenish gray, weakly bioturbated silty clay, containing ash layers at 47 cm and 170-174 cm depths.

KH81-19-1

The core, 243 cm long, comes from off Joban in water 1,545 m deep, being located north of the Kuroshio front. This core consists of a homogeneous, calcareous, or diatomaceous silty clay, which contains several ash layers.

In order to deduce the paleoceanography in the Kuroshio Current area, a time framework was constructed for these cores by referring to radiocarbon dates and ages established for some particular ash layers as shown in Table 4. Oxygen isotope analyses of planktonic and benthic foraminifera, ^{14}C dating and ages of ash layers have previously been published for cores KH79-3-4 and KT81-19-1 (Chinzei *et al.*, 1987).

Sample spacing down core is about 10 cm, which is approximately equivalent to 640 years for KH83-2-13 ; 1,200 years for KH79-3-4 ; and 530 years for KT81-19-1.

c. BIOSTRATIGRAPHY

c-1. **KH83-2-13** (Fig. 28)

Throughout the whole sequence, *Florisphaera profunda*, *Gephyrocapsa oceanica* and *Emiliania huxleyli* are abundant. They are also dominant in surface sediments of the seas around Japan. *F. profunda*, which dominates surface sediment assemblages in a warm, high salinity region is common below 165 cm core depth, and is abundant above. *G. oceanica* is highest in abundance at 265 cm horizon, and gradually decreases upward in the core, and increases again in the interval from 60 cm to 0 cm. *E. huxleyi*, which has a peak abundance in the boundary region between coastal and oceanic waters, is dominant throughout the core.

Among the minor species, *Calcidiscus leptoporus* occurs in relatively large numbers at a horizon ranging from 165 cm to 285 cm in the core. *Helicosphaera carteri* s.l., which occurs in surface sediments of a warm, lower salinity region, gradually decreases upward in the core. *G. oceanica* var. A, which inhabits the cold water region (Chin and Okada, 1985), occurs only below 205 cm core depth.

c-2. **KH79-3-4** (Fig. 29)

F. profunda, *G. oceanica* and *E. huxleyi* also dominate the entire core. The vertical frequency distributions of *F. profunda* and *G. oceanica* in this core are similar to those in core KH83-2-13. *F. profunda* is more abundant above 74 cm core depth. *G. oceanica* reaches a peak abundance at 34 cm horizon, and gradually decreases upward to 34 cm horizon, but again increases toward the top of the core.

Among the minor species, *H. carteri* s.l. is found in low abundances, in part, above 100 cm horizon. *Coccolithus pelagicus*, which inhabits cold water, occurs only at horizons below 84 cm core depth. *Rhabdosphaera clavigera*, occurring in abundance in surface sediments of a warm, high salinity region, does not occur within the interval between 34 and 0 cm.

Peak abundances of *C. pelagicus*, *C. leptoporus* and *F. profunda* are successively recognized in surface sediments from north to south. A similar succession is also observed in the interval from

Table 4. Radiocarbon dates and marker tephras of cores KH83-2-13, KH79-3-4 and KT81-19-1.

Core	Radiocarbon datings		Marker volcanic ashes		
	Depth from the top (cm)	Age	Depth from the top (cm)	Volcanic ash	Age
KH83-2-13			93-94	Akahoya Ash	6,300 B.P.
			340-343	Aira-Tanzawa Ash	22,000 B.P.
KH79-3-4	66-74	9,520±185	47	Akahoya Ash	6,300 B.P.
	90-100	13,400±200	170-174	Aira-Tanzawa Ash	22,000 B.P.
	116-124	16,000±610			
KT81-19-1	200-210	10,100±480	20	Asama B	1,100 A.D.
	227-243	12,100±300	126-130	Akahoya Ash	6,300 B.P.

100 cm to 65 cm horizons.

c-3. KT81-19-1 (Fig. 30)

The base of this core is assumed to be 12,100 years old, being younger than that of cores KH83-2-13 and KH79-3-4. Abundant species are *G. oceanica*, *E. huxleyi* and *F. profunda*. *G. oceanica* is low in abundance at 170 cm horizon, and tends to increase to a maximum of 60% of the total flora in an interval between 170 cm and 30 cm. The relative abundance of *E. huxleyi* is lowest at 30 cm horizon, and tends to be in direct opposition to that of *G. oceanica*. *F. profunda* is common throughout the core.

Among the minor species, *C. pelagicus* occurs more abundantly at an interval between 200 cm and 230 cm depths. *C. leptoporus* is rather abundant at horizons above 200 cm, and its abundance tends to be opposite to that of *C. pelagicus*.

In these three cores, there recognized is a positive correlation between the relative abundances of *C. leptoporus* and *H. carteri* s.l., and particularly, the diametrical frequencies of these species at 110 cm horizon in core KH79-3-4 and at 200 cm horizon in core KT81-19-1. These features suggest that open-sea water strongly affected above these levels because the occurrence of *C. leptoporus* increases offshore and that of *H. carteri* s.l. increases shoreward in surface sediments.

d. ANALYSIS AND DISCUSSION

Transfer functions of temperature and salinity were applied to down-core samples of these three cores. Estimates of mean annual surface temperature (*Ta*) and salinity (*Sa*) for the past 22,000 years are shown in Fig. 31.

Estimates for core KH83-2-13 show a *Ta* range of 2.5°C ranging from 21.9°C to 24.4°C. *Sa* estimates show a 0.39‰ variation from 34.23‰ to 34.62‰.

Core KH79-3-4 has a total *Ta* range of 4.1°C from 20.5°C to 24.6°C. The *Sa* range is 0.67‰ from 33.89‰ to 34.56‰.

Estimates for core KT81-19-1, which represents only the last 12,000 years, show a *Ta* range of 8.3°C from 12.9°C to 21.2°C. *Sa* estimates range from 33.56 ‰ to 34.41‰, with a 0.85‰ variation.

The ranges of temperature and salinity increase northeastward. This may be interpreted as a reflection of the relative positions of these cores: the most northeasterly core site of the three would be subject to stronger influences of south- and northward shifts of the front and steeper gradients of temperature and salinity between the Kuroshio and Oyashio Currents.

At 19,000 years B.P. temperatures were the lowest, which are probably typical of the last glacial conditions. The lowest salinity may have also been caused by the inflow of coastal water associated with the lowering sea level at that time. Between 15,000 and 11,000 years B.P., two cores, KH83-2-13 and KH79-3-4, exhibit a temperature increase. This warm event corresponds to the Termination $\mathrm{I_A}$ reported by Duplessy *et al.* (1981) in the Atlantic Ocean.

Warm stable oceanic conditions continued between 10,000 and 6,000 years B.P. in the southwest sea area off Shizuoka, whereas off Joban the cool event occurred between 11,000 and 10,000 years B.P. Chinzei *et al.* (1987) also recognized this event. At 8,000 years B.P., the warmest temperature, which would correspond to the end of Termination $\mathrm{I_B}$ (Duplessy *et al.*, 1981), is found to have occurred in all three cores. Salinity was highest at the site of core KT81-19-1, being as high as 34.45‰, and also two other core sites were comparatively high at that time. These facts are explained by the northward advance of the Kuroshio Current.

From 5,000 years B.P. to the present, three cores exhibit a temperature decrease. Particularly, at 2,000 years B.P. a cold period which corresponds to the phase called the Yayoi regression is

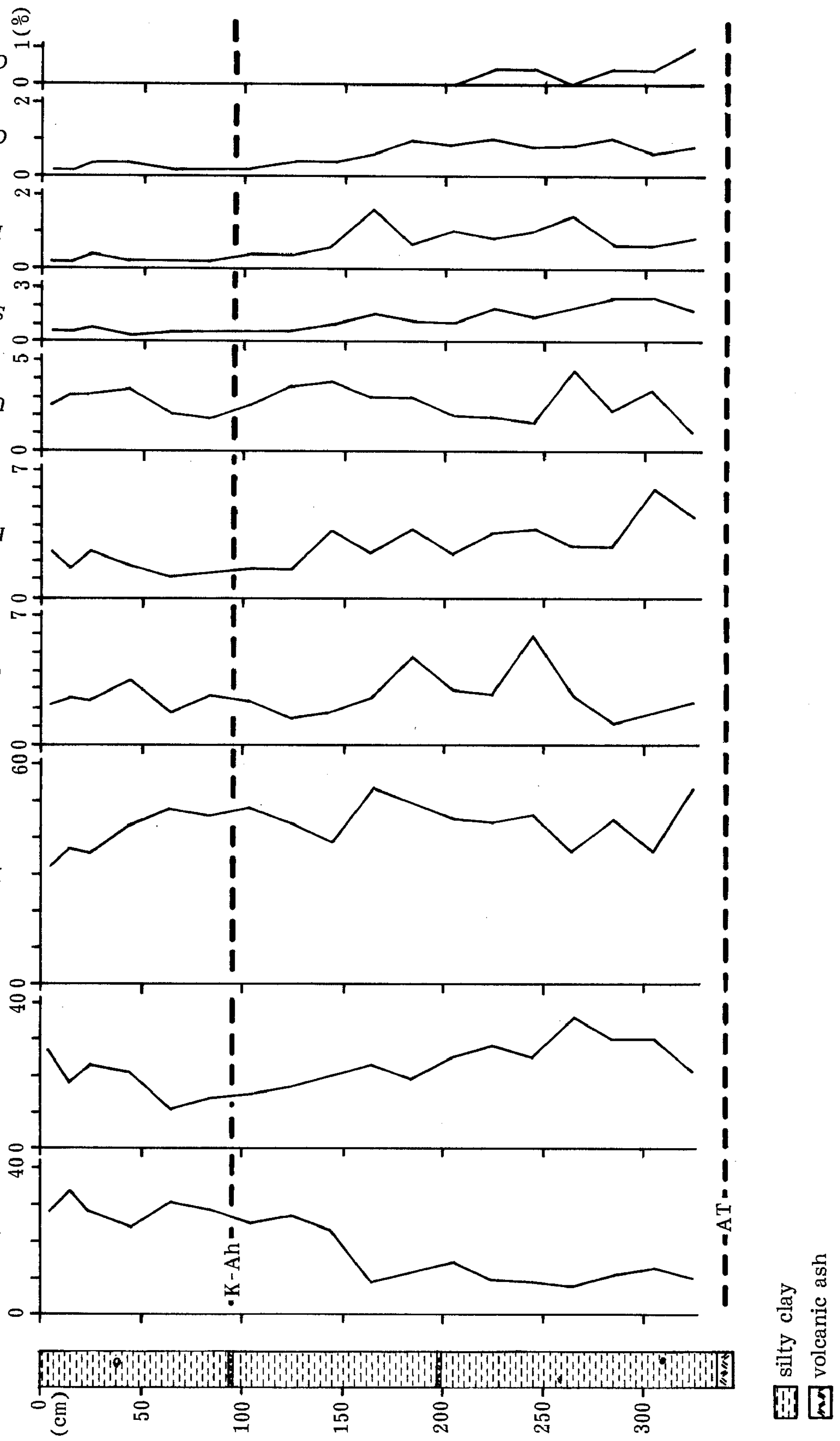

Fig. 28. Vertical distribution of selected coccolith species in core KH83-2-13.

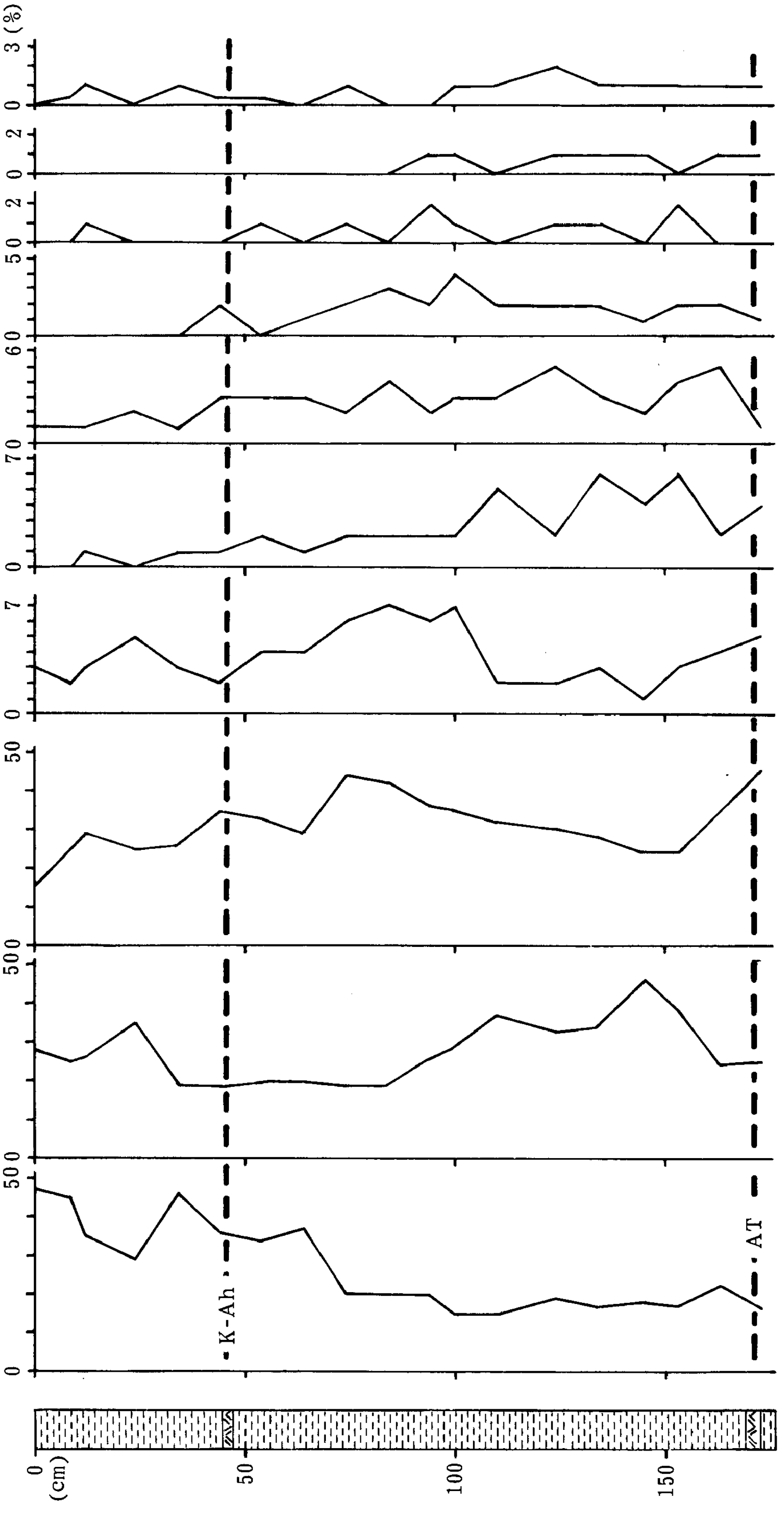

Fig. 29. Vertical distribution of selected coccolith species in core KH79-3-4.

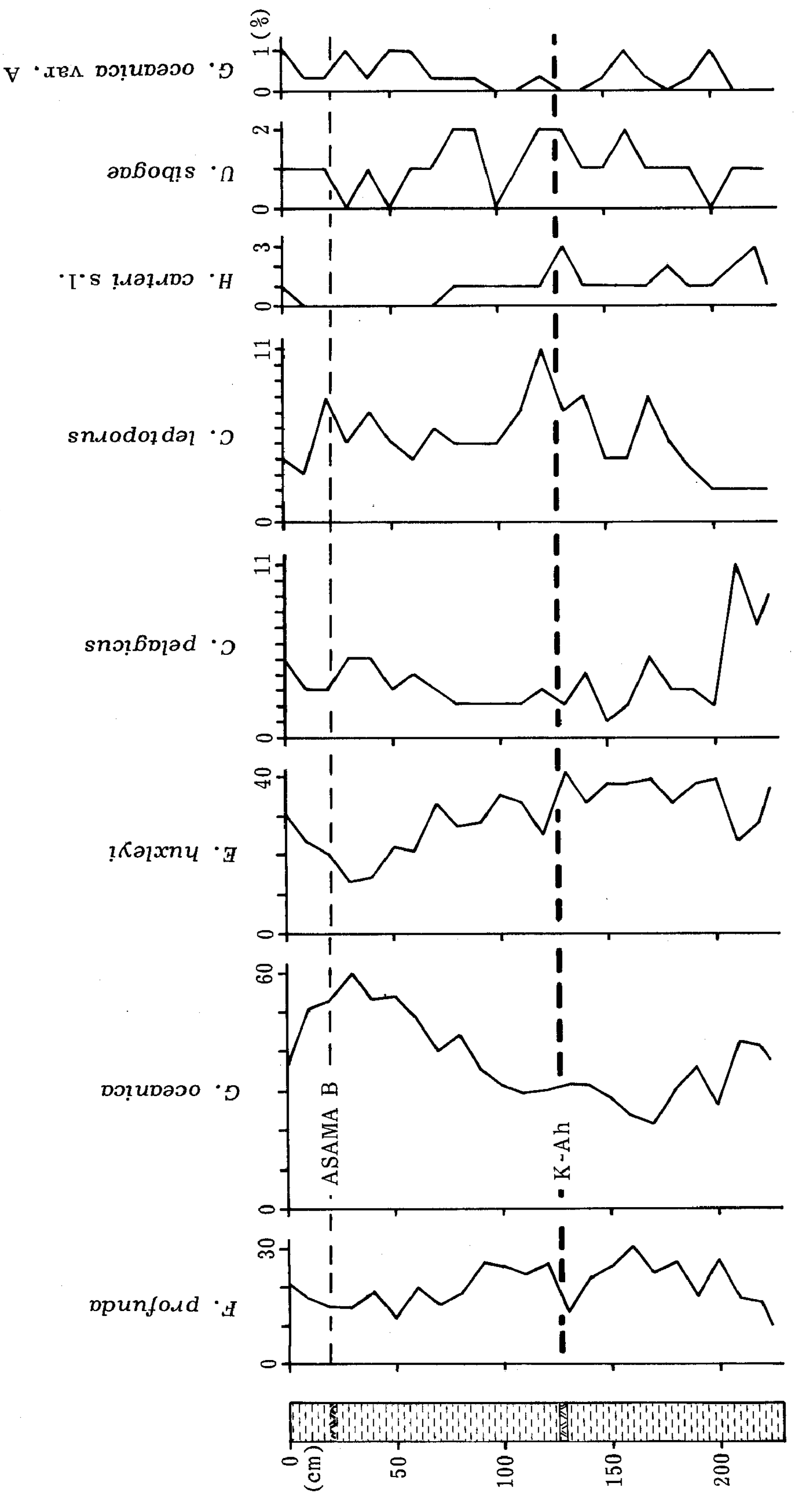

Fig. 30. Vertical distribution of selected coccolith species in core KT81-19-1.

recognized in only core KT81-19-1.

As mentioned above, temporal fluctuations of oceanographic parameters along the Pacific coast of Japan are similar to those climatic patterns which have been demonstrated in the Atlantic Ocean (Duplessy *et al.*, 1981 ; Ruddiman and McIntyre, 1981 ; Balsam, 1981) and in the North Pacific Ocean (Sancetta, 1979).

Although remarkable fluctuations of

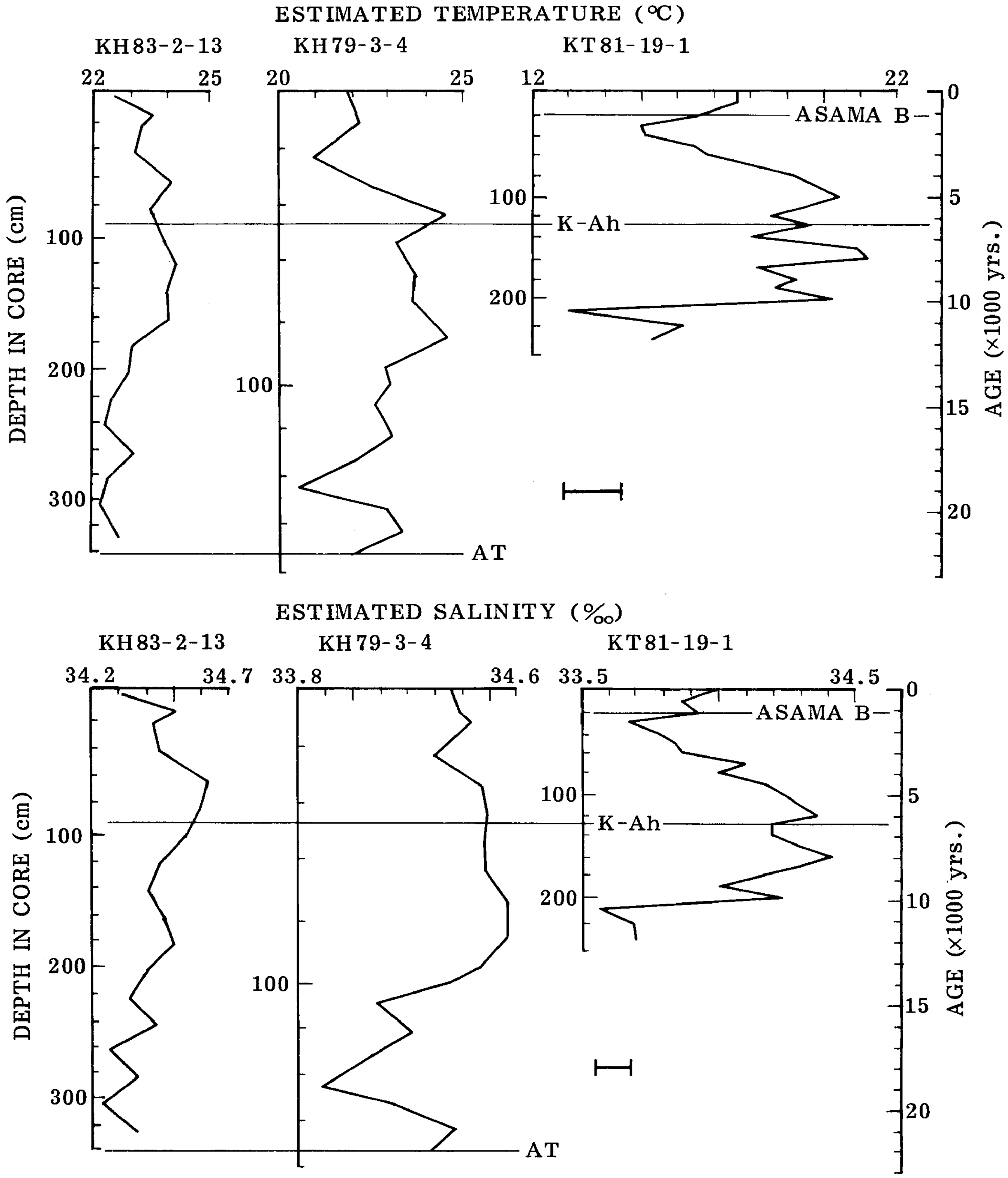

Fig. 31. *Ta* and *Sa* estimates versus depth in cores KH83-2-13, KH79-3-4 and KT81-19-1. Horizontal bar shows the range of standard error.

the relative frequency of *E. huxleyi* are not recognized in core KH83-2-13, which is located in the highest temperature region among these three cores, temperature changes in other cores after 19,000 years B.P. result from its fluctuations. *E. huxleyi* dominates surface sediment assemblages in an upwelling area, that is, a peak abundance of this species is recognized in the front between coastal and oceanic waters. An increase in relative frequencies of *E. huxleyi* from 19,000 to 10,000 years B.P., therefore, represents a strong development of the Kuroshio Current in waters off the Shizuoka to Joban region.

In cores KH83-2-13 and KH79-3-4, the relative abundance of *E. huxleyi* decreases, whereas *F. profunda* increases in abundance at the horizon assignable to about 10,000 years B.P. After 10,000 years B.P., the abundance of *F. profunda* suggests that these core sites in the main Kuroshio Current were under relatively warm, stable oceanic conditions because this species dominates warm offshore areas. In core KT81-19-1, *C. pelagicus*, which decreased in abundance from about 10,000 to 4,000 years B.P., again became increased after 4,000 years B.P. This result suggests that the Oyashio Current, once receded in response to the advance of the Kuroshio front, came to penetrate southward.

CONCLUSIONS

(1) The distribution of coccoliths is delineated separately for coastal and oceanic water forms and for cold and warm water forms, as determined by oceanic conditions.

(2) Q-mode cluster analysis of 15 coccolith species in 204 surface sediment samples from seas on the Pacific side distinguishes 10 biotopes that have close relationships with surface water masses characterized largely by the combination of salinity and temperature.

(3) Transfer functions derived from multiple regression analysis of coccolith assemblages against mean annual surface water temperatures and salinities demonstrate that coccolith floras are closely related to such oceanographic parameters.

(4) Estimates of mean annual surface water temperatures through transfer functions, disclose cold stages at 19,000 years B.P. and 2,000 years B.P., and warm stages at 15,000 to 11,000 years B. P. and 8,000 years B.P. along the Pacific coast of Japan for the last 22,000 years, all are in approximate correspondence to those observations made in the North Atlantic Ocean.

FLORAL REFERENCE LIST

Genera and species are listed in alphabetical order. The original references are given for each of the species. Additional references are selected from descriptions and illustrations that are helpful for understanding the taxonomic status of respective forms.

Braarudosphaera bigelowii (Gran and Braarud) Deflandre
  Pontosphaera bigelowi Gran and Braarud, 1935, p. 388, text-fig. 3.
  Braarudosphaera bigelowi (Gran and Braarud) Deflandre, 1947, p. 439, text-figs. 1-5.

Calcidiscus leptoporus (Murray and Blackman) Loeblich and Tappan
  Coccosphaera leptopora Murray and Blackman, 1898, p. 430, 439, pl. 15, figs. 1-7.
  Cyclococcolithus leptoporus (Murray and Blackman) Kamptner, 1954,

p. 23–24, text-fig. 20 : McIntyre and Bé, 1967, p. 569, pl. 7, figs. a-c.

Calcidiscus leptoporus (Murray and Blackman) Loeblich and Tappan, 1978, p. 1390–1392.

Ceratolithus cristatus Kamptner

Ceratolithus cristatus Kamptner, 1950, p. 154 : Norris, 1965, p. 19–21, pl. 11, figs. 1–4 ; pl. 12, figs. 1–4.

Coccolithus pelagicus (Wallich) Schiller

Coccosphaera pelagica Wallich, 1877, p. 348, pl. 11, figs. 1–2, 5, 8–11D.

Coccolithophora pelagica (Wallich) Lohmann, 1902, p. 138–139, pl. 5, figs. 58a, c.

Coccolithus pelagicus (Wallich) Schiller, 1930, p. 246–247, text-figs. 123, 124a, c : McIntyre and Bé, 1967, p. 570, pl. 8, figs. a-c.

Cricosphaera quadrilaminata Okada and McIntyre

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Discolithina japonica Takayama

Discolithina japonica Takayama, 1967, p. 189–190, pl. 9 ; pl. 10, figs. 1, 2a-d : Bartolini, 1970, p. 148, pl. 3, figs. 1–3.

Discosphaera tubifera (Murray and Blackman) Ostenfeld

Rhabdosphaera tubifer Murray and Blackman, 1898, p. 438–439, pl. 15, figs. 8–10.

Discosphaera tubifer (Murray and Blackman) Ostenfeld, 1900, p. 200 : Lohmann, 1902, p. 141–142, pl. 5, figs. 47–48, 48a, 50.

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Emiliania huxleyi (Lohmann) Hay and Mohler

Pontosphaera huxleyi Lohmann, 1902, p. 130, pl. 4, figs. 1–9 ; pl. 6, fig. 69.

Emiliania huxleyi (Lohmann) Hay and Mohler in Hay *et al*., 1967, p. 447, pl 10, figs. 1–2 ; pl. 11, figs. 1–2.

Florisphaera profunda Okada and Honjo

Coccolithophorid sp. 1. Throndsen, 1972, p. 58, text-figs. 29–32.

Florisphaera profunda Okada and Honjo, 1973, p. 373–374, pl. 2, figs. 4–5 : Okada and McIntyre, 1977, p. 36.

Florisphaera profunda var. *elongata* Okada and McIntyre

Florisphaera profunda var. B. Okada and Honjo, 1973, p. 374, pl. 1, fig. 6 ; pl. 2, fig. 6.

Florisphaera profunda Okada and McIntyre var. *elongata* Okada and McIntyre, 1977, p. 36, 38.

Gephyrocapsa caribbeanica Boudreaux and Hay

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Gephyrocapsa ericsonii McIntyre and Bé

Gephyrocapsa ericsonii McIntyre and Bé, 1967, p. 571, pl. 10 ; pl. 12, fig. b.

Gephyrocapsa oceanica Kamptner

Pontosphaera huxleyi Lohmann, 1902 (part), p. 130, pl. 4, fig. 1.

Gephyrocapsa oceanica Kamptner, 1943, p. 45 (not figured) : Okada, 1970, pl. 1, fig. 4 : Gaarder and Hasle, 1971, p. 533, fig. 6d-f : Okada and McIntyre, 1977, p. 10–11, pl. 3, figs. 3–9.

Hayaster perplexus (Bramlette and Riedel) Bukry

Discoaster perplexus Bramlette and Riedel, 1954, p. 400, pl. 36, fig. 9 : Black and Barnes, 1961, p. 141, pl. 24, fig. 1.

Hayaster perplexus (Bramlette and Riedel) Bukry, 1973, p. 308.

Helicosphaera carteri (Wallich) Kamptner

"Coccosphaera" carterii Wallich,

1877, p. 347-348, pl. 17, figs. 3-4, 6, 7, 7a, 12S, 17.

Helicosphaera carteri (Wallich) Kamptner, 1954, p. 21-23, text-figs. 17-19 : Black and Barnes, 1961, p. 139-140, pls. 22-23 : Gaarder, 1970, fig. 2e-f : Jafar and Martini, 1975, p. 381-390, pl. 1, figs. 4-5.

Helicosphaera hyalina Gaarder

Helicosphaera hyalina Gaarder, 1970, p. 113-119, text-figs. 1a-g, 2a-d, 3a.

Helicosphaera pavimentum Okada and McIntyre

Helicosphaera pavimentum Okada and McIntyre, 1977, p. 14, pl. 4, figs. 6-7.

Helicosphaera wallichii (Lohmann) Okada and McIntyre

Coccolithophora wallichi Lohmann, 1902 (part), p. 138, pl. 5, figs. 58, 58b.

Helicosphaera wallichii (Lohmann) Okada and McIntyre, 1977, p. 14-15, pl. 4, fig. 8.

Neosphaera coccolithomorpha Lecal-Schlauder

Neosphaera coccolithomorpha Lecal-Schlauder, 1950, p. 163-167, text-figs. 4-6 ; pl. 6, fig. 4.

Oolithotus fragilis (Lohmann) Okada and McIntyre

Coccolithophora fragilis Lohmann, 1912, p. 49, 54, text-fig. 11.

Cyclococcolithina fragilis (Lohmann) Wilcoxon, 1970, p. 82.

Oolithotus fragilis (Lohmann) Okada and McIntyre, 1977, p. 11, pl. 4, fig. 3.

Pontosphaera discopora Schiller

Pontosphaera discopora Schiller, 1925, p. 11, pl. 1, fig. 4 : Gaarder and Hasle, 1971, p. 536, text-fig. 10a-d : Boudreaux and Hay, 1969, p. 271, pl. 6, figs. 1-7.

Pontosphaera multipora (Kamptner) Roth

Discolithus multiporus Kamptner, 1948, p. 5, fig. 9, pl. 1.

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Pontosphaera syracusana Lohmann

Pontosphaera syracusana Lohmann, 1902, p. 130-131, pl. 4, fig. 10 : Gaarder and Hasle, 1971, p. 536, figs. 10e-f.

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Rhabdosphaera clavigera Murray and Blackman. Gaarder and Hasle, 1971, p. 536, text-fig. 11.

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Rhabdosphaera longistylis Schiller

Rhabdosphaera longistylis Schiller, 1925, p. 40, pl. 4, fig. 40.

Syracosphaera halldalii Gaarder and Hasle

Syracosphaera halldalii Gaarder and Hasle, 1971, p. 536.

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Syracosphaera histrica Kamptner, 1941, p. 84, 104, pl. 6, figs. 65-68 : Boudreaux and Hay, 1969, p. 279, pl. 8, figs. 10-19.

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Syracosphaera lamina Lecal-Schlauder, 1951, p. 286-287, text-fig. 23 ; Okada and McIntyre, 1977, p. 22-23, pl. 7, figs. 7-8.

Syracosphaera mediterranea Lohmann

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Syracosphaera molischi Schiller, 1925, p. 21, text-figs. Ka-b.

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APPENDIX 1

Sources of surface sediment samples and cores KH83-2-13, KH79-3-4 and KT81-19-1

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
1	GDP-8	st.3	33°28.8'N	136°51.5'E	1992
2		st.21	33°22.0'N	136°50.8'E	2250
3		st.15	33°56.8'N	136°15.8'E	100
4		st.17	33°55.5'N	136°17.6'E	200
5		st.18	33°54.7'N	136°18.5'E	280
6		st.19	33°54.3'N	136°19.2'E	360
7		st.20	33°54.2'N	136°20.2'E	490
8		st.13	32°41.7'N	134°16.0'E	1750
9		st.14	32°44.6'N	134°37.0'E	2046
10		st.9	29°49.5'N	133°18.0'E	1133
11		st.10	29°51.6'N	133°18.0'E	1460
12	GDP-21	st.1-A	28°46.5'N	132°07.9'E	3460
13		st.1-B	28°46.5'N	132°07.9'E	3460
14		st.2	26°17.9'N	131°30.0'E	3050
15		st.5	23°45.0'N	133°02.3'E	2730
16		st.6	23°45.8'N	133°02.0'E	1970
17		st.14	25°24.5'N	132°18.0'E	3390
18		st.15	25°27.0'N	132°19.2'E	2918
19		st.16	25°29.9'N	132°18.9'E	2250
20	Dive	291	27°14.0'N	127°04.0'E	1400
21	RN-8	P-1	24°12.7'N	124°23.7'E	1077
22		P-3	24°07.5'N	124°24.1'E	1674
23		P-2	23°59.9'N	124°23.5'E	2198
24		P-4	23°07.5'N	124°24.1'E	2527
25		P-5	23°36.6'N	124°22.2'E	3147
26		P-6	25°37.4'N	126°55.9'E	964
27	RN-84	SM-4	26°06.7'N	127°12.6'E	108
28		SM-5	26°05.9'N	127°13.2'E	198
29		SM-6	26°05.2'N	127°13.5'E	320
30		D-3	26°03.3'N	127°14.2'E	731
31		D-4	26°02.5'N	127°14.2'E	831
32		D-5	26°02.1'N	127°15.0'E	1109
33		D-6	26°01.6'N	127°15.9'E	1366
34	KT84-14	P-1	24°45.5'N	127°01.5'E	2200
35	DELP'84	D-1	28°03.7'N	127°40.5'E	890
36		D-2	28°04.3'N	127°40.2'E	1160
37		D-3	27°30.9'N	127°09.1'E	1578
38		D-6	27°30.3'N	126°51.6'E	1405
39		D-7	27°35.0'N	127°09.3'E	1720
40	OK79	OK-41	26°10.1'N	128°01.9'E	575
41		OK-57	26°11.9'N	128°02.1'E	300
42		OK-60	26°19.1'N	128°04.0'E	315
43		OK-68	26°54.1'N	128°00.8'E	205
44		OK-74	26°51.7'N	127°58.0'E	247
45		OK-76	26°52.0'N	127°49.7'E	275
46		OK-84	26°48.1'N	128°05.8'E	92
47		OK-89	26°46.2'N	127°46.2'E	385

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
48	OK79	OK-94	26°45.6'N	127°47.9'E	375
49		OK-112	26°38.0'N	127°44.0'E	280
50		OK-155	26°16.3'N	126°47.9'E	88
51		OK-178	26°16.0'N	127°07.9'E	310
52		OK-180	26°16.0'N	127°00.2'E	379
53		OK-182	26°16.1'N	126°51.8'E	165
54		OK-186	26°02.2'N	127°12.0'E	125
55		OK-203	26°06.0'N	127°18.0'E	80
56	NAGO-80	st.26	26°33.8'N	127°52.5'E	245
57		st.62	26°34.1'N	127°55.6'E	92
58		st.67	26°34.2'N	127°53.7'E	194
59	NAKAG.-83	st.16	26°13.5'N	127°58.8'E	100
60		st.24	26°12.8'N	127°56.0'E	54
61		st.57	26°14.6'N	127°51.8'E	27
62	KIN-83	K59	26°25.1'N	128°00.4'E	71
63		K38	26°21.7'N	128°01.1'E	103
64		K37	26°21.6'N	128°00.2'E	35
65		st.31	29°54.6'N	125°38.3'E	75
66		st.30	29°48.7'N	125°48.2'E	85
67		st.29	29°42.7'N	125°57.2'E	88
68		st.28	29°37.1'N	126°07.1'E	104
69		st.27	29°30.9'N	126°16.1'E	114
70		st.36	29°26.0'N	126°25.0'E	116
71		st.37	29°18.7'N	126°35.5'E	106
72		st.38	29°14.0'N	126°44.0'E	114
73		st.39	29°08.0'N	126°53.0'E	124
74		st.40	29°03.0'N	127°02.0'E	186
75		st.41	28°57.1'N	127°10.9'E	480
76		st.42	28°52.1'N	127°20.0'E	1025
77		st.43	28°47.2'N	127°29.7'E	1060
78		st.45	28°35.1'N	127°47.0'E	1190
79		st.46	28°23.0'N	128°05.0'E	1136
80		st.47	28°11.1'N	128°11.1'E	1260
81		st.25	29°46.2'N	126°59.0'E	113
82		st.24	29°53.9'N	127°19.1'E	130
83		st.23	30°09.2'N	128°01.4'E	415
84		st.19	30°31.2'N	129°04.0'E	845
85		G-24	28°54.0'N	126°14.0'E	140
86		G-25	28°50.0'N	126°22.0'E	140
87		G-26	28°43.0'N	126°33.0'E	140
88		G-27	28°39.0'N	126°42.0'E	159
89	GH84-3	st.206	31°13.6'N	130°24.6'E	74
90		st.207	31°09.1'N	130°23.0'E	268
91		st.191	31°06.9'N	130°32.4'E	230
92		st.200	31°05.6'N	130°26.8'E	282
93		st.208	31°04.6'N	130°21.4'E	316
94		st.216	31°03.5'N	130°16.3'E	342

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
95	GH84-3	st. 234	31°01.2'N	130°05.6'E	376
96		st. 248	31°00.0'N	130°00.1'E	404
97		st. 262	30°58.8'N	129°54.6'E	447
98		st. 279	31°57.6'N	129°49.2'E	518
99		st. 201	31°01.1'N	130°25.2'E	316
100		st. 193	30°57.7'N	130°29.2'E	276
101		st. 182	30°54.1'N	130°32.9'E	248
102		st. 169	30°50.7'N	130°36.9'E	223
103		st. 160	30°47.3'N	130°41.0'E	200
104		st. 149	30°43.8'N	130°44.6'E	187
105		st. 151	30°34.6'N	130°41.6'E	164
106		st. 89	30°26.5'N	131°03.8'E	154
107		st. 90	30°21.8'N	131°02.4'E	146
108		st. 75	30°18.7'N	131°06.0'E	652
109		st. 60	30°14.7'N	131°10.0'E	1390
110		st. 46	30°11.2'N	131°13.9'E	1750
111		st. 32	30°08.0'N	131°17.9'E	1984
112		st. 19	30°04.0'N	131°21.5'E	1897
113		st. 10	30°01.5'N	131°21.5'E	2309
114		st. 3	30°02.4'N	131°31.0'E	2710
115		st. 253	31°40.4'N	130°08.5'E	75
116		st. 270	31°39.2'N	130°03.1'E	105
117		st. 285	31°38.1'N	129°57.8'E	218
118		st. 295	31°41.6'N	129°53.9'E	239
119		st. 304	31°35.7'N	129°46.9'E	493
120		st. 11	30°41.3'N	131°33.9'E	1694
121		st. 25	30°40.1'N	131°28.6'E	1315
122		st. 40	30°39.1'N	131°23.1'E	924
123		st. 88	30°31.0'N	131°05.3'E	125
124		st. 72	30°32.4'N	131°10.8'E	214
125	GH83-2	st. 373	31°14.5'N	131°10.0'E	100
126		st. 369	31°14.6'N	131°14.5'E	115
127		st. 366	31°14.5'N	131°19.2'E	128
128		st. 359	31°14.1'N	131°27.3'E	179
129		st. 353	31°14.6'N	131°32.4'E	310
130		st. 340	31°14.6'N	131°36.8'E	662
131		st. 324	31°14.5'N	131°41.6'E	924
132		st. 307	31°14.6'N	131°45.7'E	1004
133		st. 288	31°14.4'N	131°50.5'E	1094
134		st. 268	31°14.6'N	131°54.9'E	1315
135		st. 258	31°59.4'N	131°55.2'E	847
136		st. 278	31°59.3'N	131°50.5'E	709
137		st. 297	31°58.9'N	131°46.0'E	560
138		st. 314	31°59.6'N	131°41.7'E	323
139		st. 330	31°59.5'N	131°37.1'E	51
140		st. 152	32°22.1'N	132°49.1'E	900
141		st. 158	32°21.9'N	132°44.6'E	1252

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
142	GH83-2	st.165	32°22.0'N	132°39.8'E	1435
143		st.173	32°22.6'N	132°35.7'E	1568
144		st.181	32°22.1'N	132°31.0'E	1638
145		st.190	32°22.1'N	132°26.2'E	1643
146		st.200	32°22.0'N	132°21.8'E	1641
147		st.210	32°22.0'N	132°17.6'E	1589
148		st.220	32°22.0'N	132°13.2'E	1484
149		st.230	32°21.9'N	132°08.7'E	1257
150		st.239	32°22.0'N	132°04.0'E	1022
151		st.247	32°22.0'N	131°59.6'E	767
152		st.253	32°21.8'N	131°55.2'E	468
153		st.273	32°22.1'N	131°50.5'E	189
154		st.292	32°22.0'N	131°46.1'E	102
155		st.309	32°22.1'N	131°41.5'E	41
156		st.229	32°26.5'N	132°08.5'E	908
157		st.228	32°31.0'N	132°08.5'E	787
158		st.227	32°35.3'N	132°08.4'E	650
159		st.226	32°39.9'N	132°08.5'E	386
160		st.224	32°48.9'N	132°08.5'E	103
161		st.223	32°53.4'N	132°08.4'E	91
162		st.221	33°02.5'N	132°08.5'E	86
163		st.130	32°53.5'N	133°02.5'E	60
164		st.123	32°49.0'N	133°07.0'E	117
165		st.115	32°44.5'N	133°11.5'E	278
166		st.106	32°40.0'N	133°16.0'E	667
167		st.96	32°35.3'N	133°20.6'E	922
168		st.85	32°31.0'N	133°25.4'E	1009
169		st.72	32°31.2'N	133°29.4'E	996
170		st.59	32°26.7'N	133°34.2'E	981
171		st.30	32°26.5'N	133°43.1'E	1047
172		st.15	32°26.9'N	133°49.2'E	1215
173		st.87	33°16.0'N	133°20.5'E	72
174		st.76	33°11.5'N	133°25.1'E	115
175		st.64	32°07.2'N	133°30.0'E	262
176		st.51	33°02.4'N	133°34.0'E	598
177		st.38	32°57.9'N	133°38.4'E	930
178		st.24	32°53.5'N	133°43.0'E	1037
179		st.9	32°53.5'N	133°47.4'E	1046
180	KH83-2	P-3	32°23.8'N	133°15.6'E	1600
181		st.4-1	32°25.9'N	133°17.3'E	2250
182		st.4-2	32°25.5'N	134°17.1'E	2110
183	KT87-10	P-5	31°51.5'N	133°34.2'E	3200
184	KT85-6	G-10	34°23.0'N	137°10.2'E	100
185		G-9	34°19.3'N	137°13.1'E	196
186		G-8	34°15.6'N	137°16.5'E	587
187		G-7	34°10.0'N	137°21.1'E	1249
188		G-6	34°37.3'N	138°00.0'E	44

Site No.	Cruise	Station	Latitude	Longitude	Depth(m)
189	KT85-6	G-5	34°35.7'N	138°00.1'E	94
190		G-4	34°34.2'N	138°00.0'E	187
191		G-3	34°10.6'N	138°00.1'E	495
192		G-2	34°10.6'N	138°00.0'E	938
193		G-1	34°01.8'N	137°58.1'E	1406
194		D-1	32°59.6'N	137°44.7'E	3656
195		D-2	33°39.1'N	137°30.9'E	3534
196	KT86-10	G-1	33°08.1'N	139°24.3'E	1294
197		G-2	33°37.2'N	139°08.6'E	1860
198		G-3	33°40.3'N	140°30.0'E	1693
199		P-3	33°48.0'N	140°38.3'E	1867
200		P-4	33°38.4'N	139°10.6'E	1862
201		D-1	33°07.8'N	139°30.4'E	1144
202	KT86-11	P-5	32°50.6'N	137°53.2'E	4065
203		P-6	33°05.9'N	137°43.0'E	3059
204		P-3	33°18.6'N	138°09.8'E	4047
205	GH80-3	D439	34°45.7'N	140°35.3'E	1850
206		D437	34°34.6'N	139°30.4'E	387
207		D433	33°45.3'N	138°28.2'E	900
208		D432	33°33.8'N	138°28.2'E	2600
209		P184	35°30.1'N	141°19.7'E	1150
210		P185	35°35.2'N	141°19.8'E	1160
211		RC-80	35°35.8'N	141°10.2'E	135
212		D417	35°36.4'N	141°13.4'E	275
213		D418	35°42.3'N	141°16.7'E	538
214	GH81-2,-3	st.266	36°42.0'N	141°54.8'E	94
215		st.267	36°42.2'N	141°04.6'E	135
216		st.268	36°42.0'N	141°15.3'E	341
217		st.269	36°42.2'N	141°25.9'E	626
218		st.270	36°42.2'N	141°35.8'E	1048
219		st.271	36°40.0'N	141°39.6'E	1557
220		st.272	36°40.2'N	141°30.6'E	810
221		st.273	36°40.1'N	141°20.0'E	463
222		st.274	36°40.0'N	141°10.2'E	256
223		st.275	36°40.1'N	141°59.9'E	125
224		st.260	36°44.0'N	141°39.1'E	1118
225		st.261	37°44.1'N	141°30.6'E	702
226		st.262	36°43.9'N	141°19.7'E	405
227		st.263	36°44.0'N	141°10.0'E	175
228		st.256	36°46.2'N	141°05.5'E	137
229		st.129	37°48.0'N	141°39.9'E	211
230		st.131	37°48.0'N	141°19.9'E	82
231		st.100	37°57.7'N	142°05.3'E	598
232		st.103	37°56.0'N	141°50.0'E	322
233		st.110	37°53.9'N	141°34.0'E	140
234		st.104	37°56.0'N	141°39.2'E	143
235		st.66	38°06.1'N	141°25.0'E	93

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
236	GH81-2, -3	st. 51	38°09.9'N	141°25.1'E	74
237		st. 16	38°24.0'N	141°39.9'E	136
238		st. 17	38°21.9'N	141°35.9'E	105
239		st. 25	38°20.0'N	141°20.0'E	26
240		st. 135	37°46.1'N	141°35.1'E	140
241	GH81-1	st. 64	38°58.0'N	141°46.9'E	98
242		st. 56	38°59.0'N	141°50.0'E	119
243		st. 93	38°44.0'N	141°40.2'E	128
244		st. 92	38°46.1'N	141°44.9'E	147
245	GH76	st. 145	40°34.4'N	141°45.6'E	84
246		st. 134	40°29.5'N	141°47.9'E	82
247		st. 131	40°26.6'N	141°56.2'E	106
248		st. 85	39°45.2'N	142°02.1'E	94
249		st. 120	40°18.2'N	142°00.5'E	108
250	GH85-2	st. 57	31°51.1'N	130°20.9'E	49
251		st. 36	33°55.3'N	130°14.0'E	66
252		st. 20	33°59.7'N	130°07.1'E	69
253		st. 4	34°04.3'N	130°00.4'E	91
254		st. 151	34°02.4'N	130°50.4'E	33
255		st. 129	34°07.1'N	130°43.9'E	65
256		st. 107	34°11.5'N	130°36.9'E	90
257		st. 85	34°16.0'N	130°30.1'E	99
258		st. 64	34°20.4'N	130°23.5'E	112
259		st. 43	34°24.7'N	130°16.6'E	112
260		st. 27	34°29.2'N	130°09.8'E	115
261		st. 11	34°33.5'N	130°03.0'E	114
262		st. 231	34°31.0'N	131°21.7'E	66
263		st. 214	34°35.5'N	131°15.0'E	85
264		st. 196	34°40.0'N	131°08.3'E	93
265		st. 178	34°44.4'N	131°01.5'E	115
266		st. 161	34°48.9'N	130°54.8'E	130
267		st. 140	34°53.3'N	130°28.0'E	124
268		st. 118	34°57.7'N	130°41.1'E	127
269		st. 96	35°02.1'N	130°34.4'E	136
270		st. 75	35°07.2'N	130°27.7'E	128
271		st. 54	35°11.0'N	130°20.8'E	135
272		st. 296	35°09.3'N	131°40.3'E	135
273		st. 269	34°55.6'N	131°37.8'E	120
274		st. 255	35°00.0'N	131°31.1'E	126
275		st. 239	35°04.4'N	131°24.4'E	124
276		st. 222	35°08.9'N	131°17.6'E	120
277		st. 204	35°13.3'N	131°10.8'E	127
278		st. 186	35°17.8'N	131°04.1'E	141
279		st. 169	35°22.3'N	130°57.4'E	148
280		st. 148	35°26.8'N	130°50.7'E	155
281		st. 281	34°42.4'N	131°43.2'E	50
282		st. 282	34°46.7'N	131°43.7'E	82

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
283	GH85-2	st.283	34°51.1'N	131°44.6'E	104
284		st.284	34°55.9'N	131°46.2'E	127
285		st.285	35°00.2'N	131°46.6'E	133
286		st.286	35°04.5'N	131°47.0'E	136
287		st.287	35°08.7'N	131°47.5'E	137
288		st.288	35°12.9'N	131°48.0'E	140
289		st.289	35°18.2'N	131°48.4'E	145
290		st.290	35°21.4'N	131°48.8'E	149
291		st.291	35°25.6'N	131°49.3'E	153
292		st.293	35°34.1'N	131°50.1'E	173
293		st.294	35°38.4'N	131°50.5'E	200
294		st.295	35°42.6'N	131°51.0'E	227
295		st.309	35°42.3'N	131°58.4'E	235
296		st.330	35°33.5'N	132°11.7'E	181
297		st.331	35°37.7'N	132°12.1'E	202
298		st.332	35°42.3'N	132°05.2'E	242
299		st.280	35°42.7'N	131°47.9'E	223
300	GH86-2	st.23	35°06.0'N	132°17.9'E	67
301		st.24	35°12.0'N	132°18.0'E	124
302		st.25	35°18.0'N	132°18.0'E	142
303		st26	35°24.0'N	132°18.1'E	152
304		st.27	35°30.0'N	132°18.0'E	170
305		st.28	35°36.0'N	132°18.0'E	185
306		st.29	35°42.1'N	132°18.0'E	225
307		st.30	35°48.0'N	132°18.0'E	295
308		st.31	35°53.9'N	132°18.1'E	482
309		st.32	35°59.9'N	132°18.0'E	873
310		st.33	35°05.9'N	132°18.0'E	1150
311		st.97	35°34.1'N	132°60.0'E	68
312		st.108	35°44.0'N	133°06.1'E	74
313		st.109	35°50.0'N	133°06.1'E	85
314		st.110	35°55.9'N	133°06.6'E	76
315		st.111	36°01.5'N	133°06.0'E	59
316		st.112	36°13.9'N	133°06.0'E	96
317		st.113	36°20.1'N	133°05.9'E	166
318		st.114	36°26.1'N	133°06.1'E	178
319		st.115	36°32.0'N	133°06.0'E	194
320		st.116	35°35.9'N	133°12.0'E	58
321		st.124	35°40.0'N	133°18.0'E	58
322		st.135	35°44.0'N	133°24.0'E	70
323		st.146	35°48.0'N	133°30.0'E	98
324		st.157	35°52.0'N	133°36.0'E	185
325		st.169	36°55.6'N	133°42.0'E	185
326		st.180	35°60.0'N	133°47.9'E	200
327		st.191	36°03.9'N	133°54.0'E	231
328		st.203	35°07.9'N	134°00.2'E	355
329		st.214	36°12.0'N	134°06.1'E	857

Site No.	Cruise	Station	Latitude	Longitude	Depth (m)
330	GH86-2	st. 258	35°44.0'N	134°36.0'E	135
331		st. 259	35°50.1'N	134°35.9'E	230
332		st. 260	35°56.0'N	134°36.0'E	269
333		st. 261	36°01.9'N	134°36.1'E	318
334		st. 262	36°08.0'N	134°36.1'E	877
335		st. 263	36°13.9'N	134°36.0'E	1115
336	GH87-2	st. 40	35°42.4'N	134°57.5'E	65
337		st. 41	35°46.9'N	134°58.1'E	135
338		st. 42	35°51.3'N	134°58.9'E	221
339		st. 43	35°55.6'N	134°59.5'E	251
340		st. 44	36°00.2'N	134°59.9'E	270
341		st. 45	36°04.4'N	135°00.5'E	282
342		st. 46	36°08.8'N	135°01.1'E	309
343		st. 47	36°13.2'N	135°01.7'E	338
344		st. 48	36°17.5'N	135°02.3'E	385
345		st. 49	36°21.8'N	135°02.9'E	477
346		st. 50	36°26.4'N	135°03.4'E	545
347		st. 225	36°44.9'N	136°35.9'E	45
348		st. 226	36°48.1'N	136°31.9'E	72
349		st. 227	36°51.0'N	136°28.0'E	112
350		st. 228	36°54.0'N	136°24.0'E	216
351		st. 229	36°57.0'N	136°20.0'E	283
352		st. 230	37°00.0'N	136°16.0'E	341
353		st. 231	37°02.9'N	136°11.9'E	432
354		st. 232	37°00.1'N	136°08.0'E	595
355	KT85-15	G-1	39°03.1'N	134°20.7'E	336
356		G-3	37°31.5'N	138°22.3'E	207
357		G-6	38°39.0'N	137°41.8'E	168
358		G-7	38°34.2'N	138°23.0'E	202
359		G-10	38°32.4'N	138°18.0'E	122
360		G-11	38°31.6'N	138°15.1'E	507
361		G-12	38°30.7'N	138°11.8'E	846
362		D-2	38°35.8'N	135°10.0'E	1542
363		P-2	38°37.0'N	135°09.5'E	1059
364	AKITAOKI	st. 55	39°47.0'N	139°58.0'E	30
365		st. 63	39°31.0'N	139°58.0'E	53
366		st. 80	39°41.0'N	139°56.0'E	55
367		st. 108	39°19.0'N	139°54.0'E	61
368		st. 127	39°47.0'N	139°50.0'E	68
369		st. 156	39°49.0'N	139°44.0'E	100
370		st. 161	39°39.0'N	139°44.0'E	162
371	GH77-3	st. 154	40°24.0'N	139°40.1'E	112
372		st. 222	41°03.9'N	140°10.2'E	109
373		st. 231	41°07.8'N	140°09.6'E	98
374	GH84-2	RC299	32°30.1'N	139°39.5'E	1290
375		RC307	31°48.1'N	139°07.2'E	2154
376		RC308	31°30.0'N	138°32.0'E	3464

Site No.	Cruise	Station	Latitude	Longitude	Depth(m)
377	GH84-2	RC319	31°19.1'N	139°50.2'E	2052
378		RC334	30°57.9'N	139°53.1'E	2279
379		RC344	30°42.3'N	139°50.0'E	2220
380	GH84-4	RC350	30°04.0'N	139°57.7'E	2960
381		RC361	29°33.1'N	140°12.8'E	2649
382		RC368	28°39.1'N	140°03.4'E	2320
383		RC372	28°14.9'N	140°06.1'E	2998
384		RC375	29°00.0'N	139°25.2'E	3175
385		RC378	27°45.0'N	140°36.2'E	3490
386	GH85-1	RC382	27°00.0'N	140°17.1'E	3488
387		RC391	26°59.9'N	139°43.8'E	3802
388	GH85-3	RC400	23°55.8'N	141°38.1'E	2256
389		RC401	23°55.5'N	141°36.0'E	2255
390		RC403	22°56.1'N	142°08.0'E	3103
391		RC404	22°49.6'N	142°34.7'E	2928
392	GH84-4	P441	30°52.1'N	139°03.9'E	1987
393	GH85-1	P464	27°33.2'N	139°59.9'E	3795
394	GH86-1	P491	24°43.5'N	140°23.4'E	3241
395	KT86-9	st. 8	26°13.9'N	143°12.6'E	2853
396		st. 9	25°31.2'N	142°43.2'E	1717
397		st. 10	25°30.6'N	142°47.8'E	2334
core	KH83-2-13		32°23.8'N	133°15.6'E	1600
	KH79-3-4		33°09.0'N	137°41.9'E	3343
	KT81-19-1		36°15.9'N	141°31.8'E	1545

APPENDIX 2

Species composition of calcareous nannoplankton thanatocoenoses in 397 samples collected from seas around Japan

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
SAMPLE	GDP-8											GDP-21								
NUMBER	3	21	15	17	18	19	20	13	14	9	10	1-A	1-B	2	5	6	14	15	16	
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	M	G
Acanthoica spp.																				
Braarudosphaera bigelowii																				
Calcidiscus leptoporus	17	14	4	6	6	6	5	14	13	17	13	15	13	11	9	10	13	9	9	10
Calciosolenia spp.	+	1	3	1	1	2	3	1	1	2	5	1	1	4	6	3	1	1	2	1
Ceratolithus cristatus	1		+							1										
Coccolithus pelagicus						+		1												
Crenalithus spp.	2	3	1	10	4	2	3	1	4	2	4	2	6	1	4	7	6	7	6	2
Cricosphaera quadrilaminata																				
Discolithina japonica					+					1										1
Discosphaera tubifera				2	1		+			2									1	
Emiliania huxleyi	146	136	177	194	199	209	211	145	200	170	164	202	117	145	106	105	111	125	120	88
Florisphaera profunda	205	201	40	36	39	55	86	193	194	191	245	191	298	266	300	305	304	308	312	325
F. profunda var. elongata	6	16	2	1	1	4	4	9	7	8	6	6	7	6	6	6	6	7	2	11
Gephyrocapsa caribbeanica																				
G. oceanica	97	91	238	182	203	163	134	106	48	67	30	47	38	30	28	24	31	23	20	34
G. oceanica var. A									1			6		1				4	2	
G. ericsonii	1	1	1	3			1		1	1	1	5		1	1		1	1	1	
Hayaster perpolexus																				
Helicosphaera carteri	8	7	16	24	19	20	13	6	7	6	4	6	2	2	4	2	3	2	2	2
H. hyalina		1				1	1	+	+	1	1	+	+	1		+		+	+	+
H. pavimentum	3	3	4	9	5	10	6		1											
H. wallichii	+	1	1	1	1	2	1	1	1	3	+	+	+						+	+
Neosphaera coccolithomorpha							+			+		1	+	1		+		+		2
Oolithotus fragilis	1	1	+	1	+	2	4	3	1	1	2	+	1	2	1	1	+	1	1	2
Pontosphaera discopora					+					+										
P. multipora																				
P. syracusana	+					+														
P. spp.																				
Rhabdosphaera clavigera	1	2	1	3	1	1	+		1	3	2	6	2	6	8	11	5	4	6	2
R. longistylis																				1
Syrocosphaera histrica							+				1			+		+		+		
S. lamina		1		1			+	+						+						
S. pulchra	2	2	2	5	4	3	3	1	3	3	4	1	2	2	4	4	3	1	2	3
S. spp.	1	1	2	2	1	2	3	1	+	1	1	+	+	+	1	1	3	+	+	1
Thoracosphaera spp.			1	+	+			+										+		+
Umbellosphaea irregularis			1		1		1			1	1	1		1		2	1	+	+	1
U. tenuis	3	1		1	2	1	3	1	1	4	2	+		1	8	5	2	1	3	4
Umbilicosphaera hulburtiana	2	1	1	2	3	2	2	1	1				+	2	1	1				1
U. sibogae	13	16	5	15	9	15	16	16	15	18	17	9	11	17	13	13	10	6	11	10
Total	509	500	500	499	500	500	500	500	500	503	503	499	498	500	500	500	500	500	500	501

	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
SAMPLE	RN87	P-					RN84							KT84-14	DELP'84					OK-79						
NUMBER	1	3	2	4	5	6	SM4	SM5	SM6	D-3	D-4	D-5	D-6	P-1	D-1	D-2	D-3	D-6	D-7	41	57	60	68	74	76	84
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.																										
Braarudosphaera bigelowii							2	1	1											1	+	1	+	+	+	
Calcidiscus leptoporus	7	5	11	8	12	7	6	4	4	6	7	5	6	10	4	5	4	7	8	4	12	1	5	6	6	5
Calciosolenia spp.	8	5	8	6	1	4	4	5	5	8	8	7	8	7	3	3	1	1		5	8	5	6	6	7	12
Ceratolithus cristatus		1	1	1	1	1			+	+				1	1	1								+		
Coccolithus pelagicus																										
Crenalithus spp.	10	6	6	8	3	7	7		2	7	3	4	2	4	5	4	6	5	1	3	10	9	9	5	5	7
Cricosphaera quadrilaminata													1													
Discolithina japonica			+	1	+			+	2		1	1	1		1						1				1	
Discosphaera tubifera	+	2	+	+		1	2	1	1	1	1	1	+			+				1	1		1	1	1	1
Emiliania huxleyi	144	152	161	117	140	194	265	204	191	162	163	144	124	113	136	129	138	128	99	238	239	202	217	183	226	243
Florisphaera profunda	215	218	191	251	208	128	45	94	108	187	196	241	262	284	296	252	246	232	270	84	98	98	158	136	82	36
F. profunda var. elongata	3	8	8	9	6	6	4	2	3	10	6	10	5	2	7	13	9	4	10	2	5	3	3	4		2
Gephyrocapsa caribbeanica																										
G. oceanica	47	32	41	38	47	63	129	151	145	79	75	55	51	34	46	57	71	86	77	110	76	150	60	103	129	149
G. oceanica var. A	3	5	3	1	13	5																				
G. ericsonii	10	5	4	5	3	8	3	1			1									5	1		1	1		
Hayaster perpolexus																							1			
Helicosphaera carteri	8	5	7	3	4	3	4	7	5	4	3	3	3	8	4	3	2	4	3	4	4	5	5	6	5	7
H. hyalina	1		1	+	+	2	1		1	+	1	1	+		+	+	+	+	+	1	1	1		1	+	
H. pavimentum										+	+	+	+												+	
H. wallichii			+			1	1	1	1		+	+	1	+	+	1	+	1	1	1	1		1	1	1	1
Neosphaera coccolithomorpha	3	2	1	1	1	1	1	1	1	+	+	+	1	1	+	1	+	+	+	+	1	1	1	2		
Oolithotus fragilis	1	2	4	3	1	2	1	1	+	1	2	1	2	2	1	1	1	2		2	1	1	1	1	3	1
Pontosphaera discopora			+				+		1		+			+							1		1		1	
P. multipora			1																							
P. syracusana			+				+				1			+									+	+		
P. spp.																										
Rhabdosphaera clavigera	6	6	8	5	4	7	1	3	3	2	4	3	3	4	1	1	1	1	1	3	4	1	1	4	2	1
R. longistylis				+		1													+		+					
Syrocosphaera histrica	1	2	6	2			1	1	1	1	1	1	1	1		1	+	+	+	1	1	1	2	1	+	1
S. lamina		1	+	1	+	1	1		1	1	+	1	1	1				+		1	1			1	+	1
S. pulchra	6	6	8	7	7	11	4	7	8	4	4	4	4	6	2	3	2	3	2	3	5	4	3	5	5	3
S. spp.	2	1	2	1	1	1	3	2	3	2	2	2	3	3	2	1	+	1	1	4	5	2	2	4	4	4
Thoracosphaera spp.	1	1	1	1					+	1													+	+		1
Umbellosphaea irregularis	2	2	1	4	1	3	1	1	2	1	1	1	2	2	1	1	1	1	1	1	2		+	1	1	
U. tenuis	5	3	7	7	2	8	1			1	1	1	3	2	4	1	+	2	5	4	1	1	1	1	1	
Umbilicosphaera hulburtiana		1	1	2	2	2	1	+	+	1	1	1					+	+	+	1	1		+	1	1	1
U. sibogae	16	29	18	19	42	31	12	13	11	21	17	13	16	15	20	22	18	22	18	21	20	14	21	26	19	24
Total	499	500	500	501	499	498	500	500	500	500	499	500	500	500	534	500	500	500	497	500	500	500	500	500	500	500

	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73
SAMPLE										NAGO'80			NAKAG.'83			KIN'83			K.M.'80								
NUMBER	89	94	112	155	178	180	182	186	203	26	62	67	16	24	57	K59	K38	K37	31	30	29	28	27	36	37	38	39
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.											1		1						2		1	+	+	+		1	+
Braarudosphaera bigelowii		+	+				+				+	1	3	6	6	1	1	2	8	4	6	3	1	2	1	1	1
Calcidiscus leptoporus	3	2	5	5	7	7	6	3	5	6	4	6	6	6	9	4	5	10	3	2	4	2	2	4	3	3	7
Calciosolenia spp.	13	8	7	5	6	8	9	4	6	6	4	6	2	3	2	3	4	5	2	1	2	1	1	1	1	3	2
Ceratolithus cristatus					+	1	2		+								1									+	1
Coccolithus pelagicus																											
Crenalithus spp.	5	4	1	5	4	7	9	7	1	10	7	2	10	7	3	7	8	5	2	3	1	6	7	4	6	7	8
Cricosphaera quadrilaminata																											
Discolithina japonica						1			+				1		1		1			1		+	+				1
Discosphaera tubifera	+	+	1		2	3	1	1	+	2	1	1	1	2		1	2	4	1	+	+	+	+		+	+	+
Emiliania huxleyi	204	221	260	240	181	149	211	183	226	176	208	242	203	232	139	203	213	222	208	198	196	210	212	194	207	224	209
Florisphaera profunda	55	183	80	107	143	170	116	211	59	59	47	21	23	26	17	14	29	20	41	30	18	20	26	45	30	36	51
F. profunda var. elongata	2	1	4	5	7	8	5	6	1	3	2	2	2	1			2		4	6	3	3	4	3	3	4	4
Gephyrocapsa caribbeanica																					1				5		
G. oceanica	182	52	99	94	96	86	96	61	158	188	205	166	208	170	292	230	184	179	171	232	207	212	209	192	204	177	155
G. oceanica var. A																											
G. ericsonii	2		1	1							1	2	1	1	3	1	1	1		1					1	1	4
Hayaster perpolexus																											
Helicosphaera carteri	4	3	5	9	7	6	6	3	9	4	4	5	6	16	13	4	5	5	37	17	34	20	18	28	22	17	27
H. hyalina	+	+	1	1	+		+		1	1	+	1	+	1					3	1	3	2	1	2	1	1	1
H. pavimentum	+									+				1					1	1		1	1	1	+	1	1
H. wallichii	1		+		1	2	+	1	1	+	1	2	1		1		1	1	10	2	3	3	2	5	1	1	4
Neosphaera coccolithomorpha		+	+	+	+	1	2	1			+	1	2	1		1	2	1	1			+	+			1	+
Oolithotus fragilis	2	1	2		1	2	1	2		1	1	1				1	1	1		+	1		+		+	1	2
Pontosphaera discopora		+				1		1					1	2	1		1				+		+				+
P. multipora							1																				
P. syracusana						+	+			+			1	1											+		
P. spp.																											
Rhabdosphaera clavigera	1	2	2	4	7	5	3	2	2	5	1	1	2	2			4	3		+	1		+	+	+	1	
R. longistylis																			+	+	1	+	+	+	+	1	
Syrocosphaera histrica	+	1	1	1	2	2	2	1	2	2	1	+	2	1	1	1	2	2	1	+	1	+	1	+	1	1	1
S. lamina	1	1				1	1	1	1			1	+				1			+	+	+	+	1	1	1	1
S. pulchra	2	2	4		3	8	8	5	4	3	4	5	6	8	4	5	5	7	5	1	3	1	2	1	1	1	1
S. spp.	2	2	4	1	3	3	2	2	6	6	3	8	4	4	2	4	6	5	8	4	7	3	2	4	2	3	2
Thoracosphaera spp.	+					1		+			2		1		1				1	+	1	1	+	+	2	1	1
Umbellosphaea irregularis		+	1		2	3	+	1	+	1	2	1	2	1					1	+	+	1	1	+	+		+
U. tenuis	1	1	1		1	3	1	+		3		1	1			1	1	1	1	+	1		+	1	+		1
Umbilicosphaera hulburtiana	+	2	1	1	2	1	+	1		1	1	2			1		2	1	1	2	1	1	2	1	+	+	1
U. sibogae	20	14	25	18	19	21	21	18	20	22	10	22	10	8	4	19	18	25	12	8	15	10	8	12	9	11	14
Total	500	500	505	497	494	500	503	515	502	499	510	500	500	500	500	500	500	500	524	514	511	500	500	501	501	499	500

	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101
SAMPLE																GH84-3												
NUMBER	40	41	42	43	45	46	47	25	24	23	19	G24	G25	G26	G27	206	207	191	200	208	216	234	248	262	279	201	193	182
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.	1			+			+									1												
Braarudosphaera bigelowii	1	1						3	2		+		2			5	+	1	1	2		2	1	+	2	1	+	1
Calcidiscus leptoporus	4	6	4	5	6	5	7	4	3	2	8	4	5	9	5	5	5	7	6	9	6	8	7	10	7	8	6	6
Calciosolenia spp.	6	3	2	2	1	+	1	2	1	3	3			1	.4	1	4	1	+	5	3	2	6	6	3	4	5	4
Ceratolithus cristatus	+	+	+		+		+						1					1	1	+	+						1	
Coccolithus pelagicus																												
Crenalithus spp.	10	7	6	6	7	9	5	5	6	10	4	1	6	5	6	11	8	2	2	1	3	4	1	5	8	4	6	3
Cricosphaera quadrilaminata																												
Discolithina japonica	1	+		1			1	+	+	+	+							+	1	+		1			1	1		1
Discosphaera tubifera	1	+	+	1		+					1						+	1	+			1	1	1			2	1
Emiliania huxleyi	220	212	219	194	173	196	197	190	201	215	208	227	218	205	211	204	135	201	206	223	205	194	197	196	233	214	224	255
Florisphaera profunda	37	64	109	128	124	143	178	67	58	74	82	55	31	39	75	21	104	77	77	71	74	42	95	85	59	72	84	58
F. profunda var. elongata	2	8	4	16	13	3	9	5	9	3	14	2	5	1	2	1	7	7	7	5	5	1	15	14	4	9	5	5
Gephyrocapsa caribbeanica			1					1	1													1						
G. oceanica	155	142	110	104	109	98	71	173	168	167	121	180	188	197	162	203	190	154	145	132	146	174	119	109	122	127	118	113
G. oceanica var. A					6		1				2								2									
G. ericsonii	1	1	1		22		1	1	1	1				1					1			1	1	1				1
Hayaster perpolexus																												
Helicosphaera carteri	17	10	6	4	5	3	4	21	19	7	10	12	21	19	13	15	15	11	15	13	14	21	13	16	17	14	17	13
H. hyalina	2	2	2	1	1	1	1	2	2	1	1	2			1		2	1	1	1	1	1		1	1	1		
H. pavimentum	1	+	2					1	+	+	+	1	2			2	2						1			1	1	+
H. wallichii	4	2	2	2	2	1	1	2	2	1	3	1		1	3	2	1	4	2	2	2	5	1	1	4	2	1	2
Neosphaera coccolithomorpha	1	1	1		1	1	+			+	1					+	+	1	+	1	1	1	1	2	+		3	1
Oolithotus fragilis	1	1	+	1	2	+	1		1	1	1			2		2	2										2	2
Pontosphaera discopora		+	+						+		1									+	1	+				+	1	+
P. multipora																												
P. syracusana																1						1	1					
P. spp.																												
Rhabdosphaera clavigera	1	1	1	1	1	2	2	1	+	1	3					+	1	1	1	2	3	2	1	2	2	2	1	2
R. longistylis																												
Syrocosphaera histrica	2	1	1	1		1	1	1	1	+	1	1					1	2	2	1	2	1	1	4	2	1	+	2
S. lamina	1	1	1					+		+	1						+	1					1			1	1	1
S. pulchra	4	3	1	1	2	2	2	2	1	1	3	3	2	1	1	2	2	3	3	3	3	4	3	6	3	4	3	5
S. spp.	4	6	2	3	1	1	2	3	5	2	4	1			1	2	3	4	2	5	5	5	3	2	4	3	+	3
Thoracosphaera spp.	3	+			1	1		+	1	1	1		2	2		1	+	1	2	2	3	2	1	+	1	1	1	2
Umbellosphaea irregularis	1	2	5	2	2	2	1		+		4						+			2	+		1	2	1	1	+	1
U. tenuis	3	1	2	1	1	1	2	1		1	1	1	2				1	+	1			+	1	1		1	2	
Umbilicosphaera hulburtiana	2	1	2	1	1	+	1	2	2	1	1		2				1	1	1	1	1	2	1	2	1		1	
U. sibogae	16	24	18	19	22	20	18	14	18	8	20	9	16	16	15	11	16	17	21	19	23	24	27	34	25	28	15	20
Total	502	500	502	494	503	490	507	501	502	500	499	500	503	499	499	490	500	499	500	500	501	500	500	500	500	500	500	502

	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124
SAMPLE NUMBER	169	160	149	151	89	90	75	60	46	32	19	10	3	253	270	285	295	304	11	25	40	88	72
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	M	M	G	G	G	G	G	G	G	G	G
Acanthoica spp.														1	+				1		+		
Braarudosphaera bigelowii	2	+	2	1			1							3	1	2	1	1					
Calcidiscus leptoporus	5	4	5	6	4	13	7	15	17	12	13	13	17	5	2	3	5	6	7	9	8	6	11
Calciosolenia spp.	3	6	5	4	1	4	4	4	1	1	1	1	+	2	2	4	3	4	2	3	7	1	3
Ceratolithus cristatus	1	+				1		1					1							1			1
Coccolithus pelagicus																							
Crenalithus spp.	11	9	6	6	11	3	4	2	2	1	2		2	4	7	6	6	7	7	9	8	5	7
Cricosphaera quadrilaminata				2	3																1		
Discolithina japonica		+	1		2	1	+	+	1	+							+				1		+
Discosphaera tubifera		+		1	+	+		1								1	1	+	+	+	1	1	1
Emiliania huxleyi	217	244	270	257	139	205	208	205	191	207	184	175	140	183	211	180	172	193	181	197	232	199	236
Florisphaera profunda	68	55	52	48	19	54	68	111	120	144	167	179	205	29	33	36	39	63	155	121	58	16	7
F. profunda var. elongata	3	5	1	1	1	1	3	7	13	6	19	6	14	2	4	2		3	3	4	2		1
Gephyrocapsa caribbeanica								1															
G. oceanica	132	132	117	119	269	143	135	83	101	80	71	90	93	233	218	214	232	151	104	100	113	224	173
G. oceanica var. A						5	4	4															
G. ericsonii	2				1	1		2						2	1	1	2	7	1			2	1
Hayaster perpolexus																							
Helicosphaera carteri	23	11	13	10	6	15	20	11	12	9	5	7	4	9	8	19	13	15	6	9	10	16	19
H. hyalina	1	1	1	1	+	1	1	1	1	1	1	1			+	1	1	1	1	+	1	3	+
H. pavimentum	1			1	+										1		+	+		1			
H. wallichii	1	+	1	2	1	4	4	3	1	3	2	2	1	1		1	1	2	1	+	2	2	+
Neosphaera coccolithomorpha	+	+	1	+	+	1	1	1	1	1	+	1	1	1	+		+	+	1	1	2	+	1
Oolithotus fragilis	1	2		2	2		1							1	+	1	+	2	1	6	3	1	
Pontosphaera discopora						1	1	+		+		+											+
P. multipora																							
P. syracusana								1	1								+			1	1		1
P. spp.																2							
Rhabdosphaera clavigera	1	1	1	1	1	1	2	3	2	3	1	1	1		+	+	1	2	2	2	2	+	1
R. longistylis																							
Syrocosphaera histrica	+	1	1	2	1	2	2	1	1	1	1	1	1	+	+	+	+	2	1	1	1	+	
S. lamina			+	1	1										+	3	+	1		+	2		+
S. pulchra	4	4	3	3	3	4	3	2	2	3	3	2	2	1	1	4	2	4	3	3	4	2	4
S. spp.	2	1	2	3	3	3	5	7	3	2	3	1	1	4	2	2	1	5	1	3	4	3	4
Thoracosphaera spp.	1	+	+	1	1	1	2	+	1		1	1	1	1	+	1	2	1	1	1	+		1
Umbellosphaea irregularis			1	1	1	1	1	1	2	1	1	1	1					+	1	2	1	+	1
U. tenuis	1	1	1	1	2	1	1	1			1		1		+			3	1	1	1		3
Umbilicosphaera hulburtiana	1	2	1	2	3	1		2	1		1	1	1	3			2	4		1	4	1	1
U. sibogae	20	21	15	23	24	30	21	21	26	24	23	17	14	15	9	16	15	23	19	25	31	18	23
Total	501	500	500	499	499	497	499	491	500	499	500	500	501	500	500	499	499	500	500	501	500	500	500

	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145
SAMPLE	GH83-2																				
NUMBER	373	369	366	359	353	340	324	307	288	268	258	278	297	314	330	152	158	165	173	181	190
ABUNDANCE	C	C	A	A	A	A	A	A	A	A	A	A	A	A	C	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.						1			1							1	1				
Braarudosphaera bigelowii	1	1	1	+	+	+						+	1	2							
Calcidiscus leptoporus	5	7	6	5	7	9	10	18	17	11	13	12	6	7	4	12	18	10	12	12	13
Calciosolenia spp.	1	1	2	1	2	4	.3	1	1	1	+	1	2	2	1	1	1	+	1	1	
Ceratolithus cristatus						+		1	+							1	2				+
Coccolithus pelagicus																					
Crenalithus spp.	10	8	10	2	3	4	4	1	3	6	2	3	3	5	5	2	1	3	2	3	
Cricosphaera quadrilaminata																					
Discolithina japonica	+	+										+			+		+				
Discosphaera tubifera		+		+	+	+						+				+	+				
Emiliania huxleyi	174	189	232	250	199	216	202	170	184	190	175	188	167	197	195	197	174	173	177	160	170
Florisphaera profunda	11	26	22	30	50	100	135	110	103	153	81	90	73	32	6	101	93	141	137	171	151
F. profunda var. elongata		1	1	3	1	5	5	14	12	14	16	13	6	1	6	13	5	12	12	8	11
Gephyrocapsa caribbeanica											2	2				1					
G. oceanica	260	221	195	182	198	111	93	106	122	76	159	149	182	207	267	129	159	121	120	114	131
G. oceanica var. A											2		3	5		1		1		2	
G. ericsonii	2								1	1	1	1		1		1		1	1	1	1
Hayaster perpolexus																					
Helicosphaera carteri	14	16	13	11	16	14	13	19	15	9	15	14	14	12	9	14	16	9	7	7	8
H. hyalina	1	1	1	1	+	1	2	2	1	1	+	1	1	1		1	1	1	+	1	+
H. pavimentum		+	+					1			+				1						
H. wallichii	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	2	1	1	1	1
Neosphaera coccolithomorpha	+		+	1	1	1	+	1	3		1	1	1	1		+	1	1	2	+	+
Oolithotus fragilis	+	1	+			3	2	3	1	1	1				+						
Pontosphaera discopora					+						+			+							
P. multipora																					
P. syracusana									+		1		2	1		+	+			+	+
P. spp.						+	+														+
Rhabdosphaera clavigera	+			1	1	2	2	1	1	1	2	1	1	1		1	1	1	1	1	+
R. longistylis										+											
Syrocosphaera histrica	+	1	+	+	+	1		+		1	1	1		+		1	1	1	1	+	+
S. lamina		2	+		1	1	+	2		+											
S. pulchra	2	1	1	+	1	2	2	2	1	3	2	2	2	3	3	2	2	2	2	1	2
S. spp.	3	4	4	2	1	4	3	2	1	2	1	2	1	4	2	1	+	1		1	1
Thoracosphaera spp.	1	+	1	1	1	1	+	1		+	1	+	1	2	1						+
Umbellosphaea irregularis	1	3			2	1	1	1	1	1		1	1	1		1		1	1	1	
U. tenuis				1	1	1	1	6	2	5	1	2	4	1		+	+	2	1	2	
Umbilicosphaera hulburtiana	1	1			1	1		2	1	1	1	2	1	2	1		3	1		1	1
U. sibogae	12	15	10	8	13	16	21	35	28	23	20	22	25	11	4	18	20	17	23	12	10
Total	500	500	500	500	500	500	500	500	500	501	500	510	499	500	506	501	501	500	501	500	500

SAMPLE	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174
NUMBER	200	210	220	230	239	247	253	273	292	309	229	228	227	226	224	223	221	130	123	115	106	96	85	72	59	30	15	87	76
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	C	C	C	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.									1	5			1	2	1	1	2											+	
Braarudosphaera bigelowii					1				1	1					1						+							1	+
Calcidiscus leptoporus	19	14	16	14	20	8	13	5	8	1	10	13	23	10	6	3	3	3	5	7	8	14	15	17	12	21	13	5	5
Calciosolenia spp.	1	1	+	1	3	1	3	+	1	1	1	3	2	3	1		2	2	1	1	3	3	1	1	1			2	2
Ceratolithus cristatus	+		+			+			1			1	+								+		+		+	+	1		
Coccolithus pelagicus																													
Crenalithus spp.	5	2	1	1	1	3	2	3	5	8	2	6	5	19	7	1	2	3	3			3	1	1		6	8	6	6
Cricosphaera quadrilaminata																													
Discolithina japonica		+	+			+	1	+	+			1			+	+	1				+	1	+		+				
Discosphaera tubifera	+																								+				
Emiliania huxleyi	165	152	130	179	147	195	168	174	149	168	194	194	169	176	192	133	76	220	223	241	215	205	165	189	204	160	155	212	215
Florisphaera profunda	129	154	191	133	116	111	57	18	12	4	96	49	52	7	14	16	8	24	30	46	80	74	156	116	125	131	141	12	27
F. profunda var. elongata	15	29	16	2	11	7	10	1	1	1	6	2	3	1				1	2	3	2	2	29	8	8	12	14		1
Gephyrocapsa caribbeanica	1												7									1							
G. oceanica	127	127	119	117	138	137	182	270	273	290	150	176	158	216	256	335	391	230	200	161	154	137	92	120	99	109	123	234	207
G. oceanica var. A	3		2				4			5		1																	
G. ericsonii	2	1					1				2	1	2	5				1	1	2	1				1	3	2		
Hayaster perpolexus																													
Helicosphaera carteri	10	4	8	12	21	13	19	17	20	11	11	16	23	21	10	5	8	7	13	14	13	19	17	18	14	16	16	11	14
H. hyalina	+	+	1	1	1	2		+	1	+		1	1	1	2	+	+		1	+	1	+		1	2	1	3	+	+
H. pavimentum								+				+	1			1	+		1							1		+	1
H. wallichii	2	1	1	1	2	2	2	+	1		2	1	2	+	2	1	2	1	1	1	1	2	1	1	2	+	+	2	1
Neosphaera coccolithomorpha	1	1	+	1	1	+	+		+	1	1		1		+				+		+	1				1			+
Oolithotus fragilis								+		1			2													2	1		1
Pontosphaera discopora																+				1									
P. multipora																						+							
P. syracusana	1				1		1	+				1		2								+	+		+				
P. spp.	1			1	1				+				+	1						1						+		1	
Rhabdosphaera clavigera	+	1		1	2	1	1		2		1	1	3	2		+	+			+	+	1	1		1	1			+
R. longistylis									+																				
Syrocosphaera histrica	1	+	+	1	1	1	1			1	+		+					1	+	1	1	1	+	1	1			+	1
S. lamina													+																
S. pulchra	1	1	1	2	3	2	2	1	3	+	2	4	4	3	1	1	1	1	2	1	2	3	4	3	5	4	2	1	1
S. spp.	2		1	2	1	2	6	1	2	1	2	5	2	7	1	1	+	2	1	1	1	4	1	1	2	2	2	3	3
Thoracosphaera spp.		1		1	1		1	2	3		1	2	2	1	1	1	1	1	2	1	1		1	1	2		1	1	+
Umbellosphaea irregularis	1	1	1		1		1		1				1	2								1		1	1	1			+
U. tenuis	1	1				1	1				1	1	1	1						1	1	1		1	1		1		+
Umbilicosphaera hulburtiana	1	1	+	1	1	1	1	1	1	1	1	3	3	2	1	+	1		1	1	1	1			1	1	1	1	1
U. sibogae	12	9	10	15	27	13	23	5	10	5	17	18	30	19	4	1	2	6	13	16	16	26	17	20	18	28	16	8	14
Total	501	501	498	486	501	500	500	498	496	505	500	500	498	501	500	500	500	503	500	500	501	500	501	500	500	500	500	500	500

	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
SAMPLE						KH83-2			KT87-10	KT85-6												KT86-10				
NUMBER	64	51	38	24	9	P-3	4-1	4-2	P-5	G10	G9	G8	G7	G6	G5	G4	G3	G2	G1	D1	D2	G-1	G-2	G-3	P-3	P-4
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.												3	1		1	1	1	1								
Braarudosphaera bigelowii	1										1	1		1		2										
Calcidiscus leptoporus	9	13	17	12	15	11	10	16	26	8	7	11	19	6	5	6	8	14	13	17	16	17	16	23	28	25
Calciosolenia spp.	1	1	1	1	1	1	1	1			1	2.	3		+	2	1	1	1	1	+	1		6	+	1
Ceratolithus cristatus	+												1				+	+			1			1		
Coccolithus pelagicus												1		1									1	2	1	+
Crenalithus spp.	9	18	10	7	7	7	5	3	1	21	1	8	2	10	13	4	4	7	2	5	8	4	5	2	2	5
Cricosphaera quadrilaminata																										
Discolithina japonica											+	1	+	+		+		+					+		+	
Discosphaera tubifera																										
Emiliania huxleyi	185	155	193	190	138	169	146	150	113	164	202	211	187	206	181	212	181	196	196	142	116	162	152	174	152	152
Florisphaera profunda	33	63	62	99	94	139	215	227	234	29	41	65	99	21	17	25	97	115	144	197	184	199	192	125	149	169
F. profunda var. elongata	1	8	6	5	12	6		6	5	3	1	15	10	9	1	3	13	8	18	9	11	4	10	7	4	9
Gephyrocapsa caribbeanica										1	3					2									3	
G. oceanica	210	178	159	132	173	135	84	59	103	230	207	137	129	215	238	208	154	113	95	111	145	73	94	111	133	90
G. oceanica var. A	1	3					1	2					1	2	2										3	
G. ericsonii											1	2	2	1	1	2								2		1
Hayaster perpolexus																										
Helicosphaera carteri	22	23	14	12	18	10	9	9	4	16	15	14	11	12	14	17	14	14	7	6	4	8	6	9	5	12
H. hyalina	1		1	2	2	1	1	+	1	5	2	2	1	+	2		2	1	+			+	+	+		1
H. pavimentum	1	2	1		1	1										4	+	+	+	+	+			+	+	1
H. wallichii	2	3	4	3	5	1	+	2		5	2	5	3	2	2	1	3	2	2	+	+	2	2	2	1	2
Neosphaera coccolithomorpha		1			1		+					+	1	+	+	+	+	+	1	+	1	1	1	+		1
Oolithotus fragilis	1	1	1	2	1	1	1	3	+		+				+	+		1		1				1	1	1
Pontosphaera discopora															+		+	+						+		
P. multipora																										
P. syracusana		+			1	+											+			+						
P. spp.																				+						
Rhabdosphaera clavigera	1	+	+	1	1	1	1	1	+		1	1	+			+	+	1	1		1	+		1	1	1
R. longistylis																										
Syrocosphaera histrica		2	1		1					+	1	1	1	1	1		1	1	1			1		1		
S. lamina	+	1		1												+							1	+		2
S. pulchra	2	2	2	2	1	2	2	1	1	1	3	1	3	2	2	2	2	2	2	1	1	1	1	3	1	2
S. spp.	2	2	3	2	2	1	1	1		2	1	1	1	1	2	1	1	3	2	1	1	2	1	2	+	3
Thoracosphaera spp.		1	1	1	+			+	+	2	1	1		+	1	1	1		+			1	1	1	+	
Umbellosphaea irregularis	2	1	1	1	3					1	+	1	2		1		+		1	+		1	1	1	1	1
U. tenuis	1	+		1	1						+	1		1		1		2	1	+	2	1	1	3	+	1
Umbilicosphaera hulburtiana	1	1	1	1			1	2	+	4	2	2	5	3	3	1	2	2	1	+		1	1	2	1	1
U. sibogae	14	21	22	23	21	13	16	17	12	7	7	13	18	6	7	7	15	15	12	9	10	21	17	21	14	18
Total	500	500	500	498	499	499	494	500	500	499	500	500	500	500	494	502	500	499	500	500	501	500	503	500	500	499

	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225
SAMPLE		KT86-11			GH80-3									GH81-2, -3											
NUMBER	D-1	P-5	P-6	P-3	D439	D437	D433	D432	P184	P185	RC80	D417	D418	266	267	268	269	270	271	272	273	274	275	260	261
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	C	C	C	A	A	A	A	A	A	A	C	A
PRESERVATION	G	M	G	M	G	G	G	G	G	G	G	G	G	M	M	G	G	G	G	G	G	G	G	M	G
Acanthoica spp.																									
Braarudosphaera bigelowii						+	1				1	2													
Calcidiscus leptoporus	20	45	32	14	27	15	18	28	26	26	7	9	12	10	12	12	36	19	28	21	14	11	9	26	34
Calciosolenia spp.	1		1			8	1	1	1	1	1	2	1												
Ceratolithus cristatus		+	1		+	1	1	+	+			+					1	1							
Coccolithus pelagicus			1		2				12	11	1	3	4	5	27	24	31	28	22	19	22	28	22	37	33
Crenalithus spp.	2	9	7	7	3	3	10	7	14	5	8	13	5	5	6	4	11	16	17	8	13	8	3	5	2
Cricosphaera quadrilaminata																									
Discolithina japonica						+				+	+		+												
Discosphaera tubifera						2																			
Emiliania huxleyi	189	113	140	111	103	204	193	107	182	150	153	197	181	92	93	97	140	131	119	88	162	122	75	131	111
Florisphaera profunda	178	98	144	190	205	64	84	196	55	72	64	50	46	6	34	22	71	78	138	142	48	46	10	91	78
F. profunda var. elongata	10	8	13	16	12	6	9	10	2	8	6	2	2	2	2	7	17	19	17	8	1	5	3	6	3
Gephyrocapsa caribbeanica		2	2	2					1	4		1	3		4	7	8					1	6		
G. oceanica	49	170	135	144	138	131	132	115	170	196	244	191	228	309	316	304	161	202	153	204	232	273	369	203	236
G. oceanica var. A		12														1			2				2		
G. ericsonii		6									2	2	1			1	7								
Hayaster perpolexus																									
Helicosphaera carteri	5	9	5	1	3	22	14	7	10	12	5	8	4				1	1	2	2	2	3			1
H. hyalina			+		+	+	1	1	2		+	1	+				1	1							
H. pavimentum						3	1	1	3	1	1	2	1				1								
H. wallichii	2	2	1		+	1	3	3	1		+	+	+						+	1					
Neosphaera coccolithomorpha	1		+			2					1														
Oolithotus fragilis		1				2	4	3	1	1	+	1	+				1								
Pontosphaera discopora		1				+	+			+	+	+	1												
P. multipora																									
P. syracusana						+	1				+														
P. spp.																									
Rhabdosphaera clavigera	2		+		+	2	2		1		+	1													
R. longistylis									2		1		+												
Syrocosphaera histrica	2					+	+																		
S. lamina						1	1		+		+		+												
S. pulchra	2	3	1		2	5	3	2	2	1	1	2	1			1	3							1	
S. spp.	2	+	1		+	3	3	1	2	1	+	2	1					+	+						
Thoracosphaera spp.	2					+	+		+				+										1		
Umbellosphaea irregularis	1		1				+				+	+	+			2									
U. tenuis	2	1	1		1	2	1	1		1	+	1	1	2		6	2	1	1						
Umbilicosphaera hulburtiana	1	1	1		+	1	1	1	1			1	+				2								
U. sibogae	29	19	13	6	4	23	16	16	12	10	4	9	6			2	6	3	3	6	1	2			2
Total	500	500	500	491	500	501	500	500	500	500	500	500	498	431	494	490	500	500	502	499	495	499	500	500	500

	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249
SAMPLE																GH81-1				GH76-4				
NUMBER	262	263	256	129	131	100	103	110	104	66	51	16	17	25	135	64	56	93	92	145	134	131	85	120
ABUNDANCE	A	A	A	A	A	C	C	A	A	A	A	A	A	C	C	C	C	C	C	C	C	C	C	C
PRESERVATION	G	G	G	G	G	M	M	G	M	G	G	G	G	M	M	M	M	M	M	M	M	M	M	M
Acanthoica spp.		1				2																		
Braarudosphaera bigelowii		1	+							2			1		1									
Calcidiscus leptoporus	14	15	3	16	10	32	6	7	19	6	2	17	9	11	3	15	5	7	13	7		2	5	
Calciosolenia spp.																						3		7
Ceratolithus cristatus																								
Coccolithus pelagicus	14	30		78	40	38	45	17	14	6	6	23	4	31	7	23	24	25	20	15	8	17	18	18
Crenalithus spp.	9	15	3	20	13	4	9	8	7	6	6	17	15		5	3		3		4		6	5	8
Cricosphaera quadrilaminata																								
Discolithina japonica																								
Discosphaera tubifera																								
Emiliania huxleyi	143	112	57	63	82	124	115	127	139	85	72	52	177	37	177	84	125	107	66	71	82	78	118	78
Florisphaera profunda	71	38	7	7	8	29	30	18	8	5	4	4	14	6	11	7	4	3	2	5	3	3	5	10
F. profunda var. elongata		1			1	8	3													2				
Gephyrocapsa caribbeanica		4					5	2	7	2	2							7	5		3	5	2	3
G. oceanica	248	251	423	313	330	261	285	322	300	395	416	347	274	411	292	362	337	346	390	401	405	348	347	372
G. oceanica var. A				1																				
G. ericsonii																								
Hayaster perpolexus																								
Helicosphaera carteri		16	2		1				5			2	2	3	2	1	2							
H. hyalina		1	1																					
H. pavimentum		1																						
H. wallichii		+														1								
Neosphaera coccolithomorpha																								
Oolithotus fragilis																								
Pontosphaera discopora																								
P. multipora																								
P. syracusana																								
P. spp.																								
Rhabdosphaera clavigera		1														1						2		
R. longistylis																								
Syrocosphaera histrica																								
S. lamina																								
S. pulchra		2	1		1								2		1	2	1							
S. spp.		+	1										1			1	1							
Thoracosphaera spp.		+															1							
Umbellosphaea irregularis																								
U. tenuis																								
Umbilicosphaera hulburtiana																								
U. sibogae	1	2	2				3	1	1				1		1	3		2						4
Total	500	491	500	498	486	498	501	502	500	507	508	462	500	499	500	503	500	500	496	505	501	464	500	500

	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270
SAMPLE	GH-85-2																				
NUMBER	57	36	20	4	151	129	107	85	64	43	27	11	231	214	196	178	161	140	118	96	75
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.										+		+									
Braarudosphaera bigelowii		1				1	1	2	1	1	1	2		1	2		1		1	1	1
Calcidiscus leptoporus	1	2	1	1	1	1	1	1	3	4	3	2	+	+	2	+	1	5	3	1	3
Calciosolenia spp.				1		+	1	+	1	1	1	1		1	2		+				
Ceratolithus cristatus																					
Coccolithus pelagicus	2																				
Crenalithus spp.	3	2	2	1	6	7	6	6	10	4	11		2		3	1	3				
Cricosphaera quadrilaminata																					
Discolithina japonica										+											
Discosphaera tubifera												+					+				
Emiliania huxleyi	130	100	134	144	123	145	151	181	200	190	198	215	183	127	134	182	160	188	179	220	212
Florisphaera profunda	16	19	44	29	25	10	22	83	44	66	92	76	28	30	42	44	40	43	54	64	76
F. profunda var. elongata	1		3	4	3		2	9	4	7	9	8	3	3	4	5	5	5	6	6	7
Gephyrocapsa caribbeanica																					
G. oceanica	337	364	302	298	328	326	301	193	208	194	159	176	276	320	287	247	273	234	243	180	186
G. oceanica var. A																					
G. ericsonii																					
Hayaster perpolexus																					
Helicosphaera carteri	2	5	5	6	3	8	6	14	13	16	15	10	3	3	5	7	2	11	7	9	9
H. hyalina								1	1	+	+	+		1	1	1	1	1		2	1
H. pavimentum				1			+	+	1	1	+	1		2		1					
H. wallichii	1	2	2	4		+	+	1	1	1	+	+	1	2	4	3	3	4	5	3	2
Neosphaera coccolithomorpha																					
Oolithotus fragilis						+	+			+	+	+									
Pontosphaera discopora																					
P. multipora																					
P. syracusana																					
P. spp.																					
Rhabdosphaera clavigera												+					+				1
R. longistylis																					
Syrocosphaera histrica												+									
S. lamina							+				+	+									
S. pulchra	2	1	1	1	4	1	2	1	2	2	2	3	1	1	3	2	2	1		1	2
S. spp.	1	1	1	1	1	+	1	1	1	1	1	1	1	3	2	1	1	3	1	1	2
Thoracosphaera spp.						+	+			+		+		+	1	1	1				
Umbellosphaea irregularis																					
U. tenuis																	+				
Umbilicosphaera hulburtiana						+	+	+	1	1	1			+							
U. sibogae	4	5	5	9	6	1	6	10	10	12	11	5	2	7	8	5	7	11	8	12	13
Total	500	502	500	500	500	500	500	503	501	501	504	500	500	501	500	500	500	506	507	500	515

	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299
SAMPLE NUMBER	54	296	269	255	239	222	204	186	169	148	281	282	286	284	285	286	287	288	289	290	291	293	284	295	309	330	331	332	280
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.	3		1				+	3				+	1		2		1						1						
Braarudosphaera bigelowii	4			2	5	1	1	2	3			1	1	4	.1	1	1	+	+			+			1				
Calcidiscus leptoporus	1	1	1	2	1	2	1	3	3		1	1	1	2	1	3	4	2	2	2	3	3	2	3	1	1	2	3	2
Calciosolenia spp.			1			1	+	+			1	1	1	1	+	1	1		1		+								
Ceratolithus cristatus																													
Coccolithus pelagicus																					1	2	2	5	1	1	1	3	
Crenalithus spp.	2	6	3					1	1	2	9		1	1		1	1		2	1	2	3	3	6	2	3	3	1	3
Cricosphaera quadrilaminata																													
Discolithina japonica																													
Discosphaera tubifera																+													
Emiliania huxleyi	201	209	173	163	199	185	201	204	222	209	158	138	101	126	142	153	139	184	190	199	171	188	170	192	191	140	147	174	153
Florisphaera profunda	90	11	73	50	1	66	46	75	63	71	30	40	41	30	63	53	45	69	53	74	67	63	80	59	80	77	83	92	45
F. profunda var. elongata	5		7	6		7	5	8	6	8		3		3	7	6	4	7	6	8	7	7	8	7	4	7	8	7	2
Gephyrocapsa caribbeanica								1																1					
G. oceanica	177	265	217	249	265	213	227	176	176	184	284	295	323	304	264	250	278	220	219	199	226	216	215	210	214	265	250	211	287
G. oceanica var. A																													
G. ericsonii					1																								
Hayaster perpolexus																													
Helicosphaera carteri	3	1	7	10	12	6	7	7	9	3	5	7	6	8	7	7	8	7	10	5	7	6	8	5	2	3	2	2	4
H. hyalina	1					2	+			2		+	1	1		1	1	1							+	+			
H. pavimentum			1	+	1	+	+	1	1				1	2	1	1	1	1	2		1		+		+				
H. wallichii	2	1	2	2	1	2	1	1	4	5	2	1	4	2	1	1	2	1	1	1	+	4	1	1	1	+		1	1
Neosphaera coccolithomorpha																													
Oolithotus fragilis																													
Pontosphaera discopora																													
P. multipora																													
P. syracusana																													
P. spp.																													
Rhabdosphaera clavigera								1									+	+										1	
R. longistylis																													
Syrocosphaera histrica																													
S. lamina																													
S. pulchra	2	1	3	2	1	2	2	3	3	1	2	1	5	2	2	3	2	2	2	2	1		1	1			+	1	1
S. spp.	2		1	2	2	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1		1	1	
Thoracosphaera spp.	+		+										+				+	+											
Umbellosphaea irregularis																													
U. tenuis	+			1												2			+	2	1								
Umbilicosphaera hulburtiana	+	1	1			1		1		1	1	4	1		1	1	+		1		1	1	1	1					
U. sibogae	7	3	9	11	11	10	8	12	7	9	7	8	11	12	7	12	11	5	12	6	10	7	6	8	2	3	3	3	7
Total	500	499	500	500	500	500	500	500	499	496	501	501	500	499	500	498	500	500	502	500	499	501	499	500	500	500	500	500	505

	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327
SAMPLE	GH86-2																											
NUMBER	23	24	25	26	27	28	29	30	31	32	33	97	108	109	110	111	112	113	114	115	116	124	135	146	157	169	180	191
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Acanthoica spp.																												
Braarudosphaera bigelowii	1	3	1	1								3	1	1	5	5	3				13	1	2	2	2		1	1
Calcidiscus leptoporus		1	2	2	3	2	3	4	2	1			1	1	5	2	2	2		2	1					1		4
Calciosolenia spp.		2	2												2	3	2											
Ceratolithus cristatus																												
Coccolithus pelagicus																			1	1					2	2	2	1
Crenalithus spp.	9	3					1	3		5	1	8	4	12	7	9	3	9	5	7	5	9	1	4				3
Cricosphaera quadrilaminata																												
Discolithus japonica																												
Discosphaera tubifera																												
Emiliania huxleyi	155	161	165	169	149	172	178	151	153	151	191	159	165	169	149	153	135	163	168	150	195	140	97	73	154	148	179	148
Florisphaera profunda	15	21	41	24	26	35	40	44	32	45	45	13	20	32	22	16	24	32	53	38	26	36	72	10	37	46	51	49
F. profunda var. elongata			1			1	2	2	1	1		1		4		1	2	1	3	2		1	3		2	2	6	6
Gephyrocapsa caribbeanica																												
G. oceanica	304	285	255	275	296	273	267	281	299	293	255	301	281	254	281	270	295	262	250	289	240	301	316	389	288	290	253	278
G. oceanica var. A																												
G. ericsonii	1												1															
Hayaster perpolexus																												
Helicosphaera carteri	4	7	12	9	11	6	3	6	6		4	2	8	3	10	6	18	12	9	2	4	3	+	1	4	5	3	1
H. hyalina		1	5				1							2	1	1	1											
H. pavimentum																												
H. wallichii	1	2	2	2								2		3	1		1				1	1						
Neosphaera coccolithomorpha																												
Oolithus flagilis																												
Pontosphaera discopora																												
P. multipora																												
P. syracusana																												
P. spp.																												
Rhabdosphaera clavigera			1												1													
R. longistylis																												
Syrocosphaera histrica			2															1										
S. lamina																												
S. pulchra	2		2									3	7	4	5	4	3	6	3	1	6	1	5	19	3	2	3	4
S. spp.	2	5	2	3	1			1	3	1	2	3	3	1	3	3	4	1	1	3	3	3	1	4	1			3
Thoracosphaera spp.	1	1							1	1			1	1	1	3	1		1		1						1	
Umbellosphaea irregularis																												
U. tenuis																												
Umbilicosphaera hulburtiana																												
U. sibogae	5	8	10	14	10	6	4	7		2	2	4	8	13	7	24	7	11	6	5	5	4	3	1	6	4	1	1
Total	500	500	503	499	496	495	499	499	497	500	500	499	500	500	500	500	501	500	500	500	500	500	500	503	499	500	500	499

SAMPLE	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355
									GH87-2																			GH85
NUMBER	203	214	258	259	260	261	262	263	40	41	42	43	44	45	46	47	48	49	50	225	226	227	228	229	230	231	232	G1
ABUNDANCE	A	C	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	C
PRESERVATION	G	M	M	G	G	G	G	G	G	G	G	G	G	G	G	G	M	M	M	G	G	G	G	G	M	M	M	M
Acanthoica spp.			1																		2		5	2				
Braarudosphaera bigelowii			8	1					3	1	1									1	2	5						
Calcidiscus leptoporus	2		1	2	1	1				2	2	1		4	2	3	1	1	3		1		1				1	
Calciosolenia spp.			1	+							1																	
Ceratolithus cristatus																												
Coccolithus pelagicus	1	3	1	2	1	2					1		1	1	3	2	1	2	6			1	1			3	1	68
Crenalithus spp.	7	3	10		1		8	5	4	13	3	1	5	3	3				4	2	1	9	3		5	3		28
Cricosphaera quadrilaminata																												
Discolithina japonica																												
Discosphaera tubifera																												
Emiliania huxleyi	150	159	167	169	152	144	162	149	189	205	197	161	138	88	126	218	145	164	172	122	269	223	175	180	135	190	181	151
Florisphaera profunda	73	105	20	24	38	61	88	63	2	23	22	29	39	50	59	38	81	93	66		7	16	18	64	85	69	77	24
F. profunda var. elongata	2	3	1	2	3			1		1	1	1	1	1		1	3		1				1			1		2
Gephyrocapsa caribbeanica																												
G. oceanica	260	224	259	280	296	281	240	281	297	233	253	301	310	349	303	232	268	239	239	364	210	231	287	253	268	228	238	225
G. oceanica var. A																												
G. ericsonii				1					1																			
Hayaster perpolexus																												
Helicosphaera carteri	1	1	11	8		4				3	5		1	3	1							1	1			1		1
H. hyalina			1	+					1	1									1									
H. pavimentum			1																									
H. wallichii			1	1	1														1									
Neosphaera coccolithomorpha																												
Oolithotus fragilis																												
Pontosphaera discopora																												
P. multipora																												
P. syracusana																												
P. spp.																												
Rhabdosphaera clavigera			+	1																								
R. longistylis																												
Syrocosphaera histrica																												
S. lamina			+								1																	
S. pulchra			7	4		2		1	3	6	3	2	1		1	2			5	10	5	10	2	1		2		
S. spp.			1	2	3	2				2												1						
Thoracosphaera spp.	1		1	+							2										1							
Umbellosphaea irregularis																												
U. tenuis																												
Umbilicosphaera hulburtiana										4											1	1		1	1		1	
U. sibogae	3	1	8	3	4	2	2		1	6	8	4	4	1	2	3	1	1	2	1	1	3	7		5	3	1	
Total	500	499	500	500	500	499	500	500	501	500	500	500	500	500	500	499	500	500	500	500	500	501	501	501	499	500	500	499

	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382
SAMPLE									AKITA							GH77-3			GH84-2 RC-						GH84-4 RC-		
NUMBER	G3	G6	G7	G10	G11	G12	D2	P2	55	63	80	108	127	156	161	154	222	231	299	307	308	319	334	344	350	361	368
ABUNDANCE	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	A	A	A	A	A	A	A	A	A
PRESERVATION	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	G	G	M	M	G	M	G	G	G
Acanthoica spp.		1	1	2										1													
Braarudosphaera bigelowii		1		4			4									8	3	2									
Calcidiscus leptoporus				1	7	2	1	1			2			1					14	17	23	45	38	32	36	27	18
Calciosolenia spp.			1																2	1		4			1	1	1
Ceratolithus cristatus																				1				1			
Coccolithus pelagicus	4	4	17	24		15	1	14		4						4	2	5									
Crenalithus spp.	5	12	7	9	5	13	14			3	3					2		4	7	7	3		5	1	7	7	5
Cricosphaera quadrilaminata																											
Discolithina japonica																											
Discosphaera tubifera																											
Emiliania huxleyi	180	206	211	155	152	155	245	68	80	281	328	191	215	316	225	231	193	312	212	191	83	151	170	147	123	187	242
Florisphaera profunda	21	18	19	15	24	7	12	21			3		3	3	3	5	5	5	134	149	203	161	158	192	234	216	155
F. profunda var. elongata	3	2	2	2		2		2																			
Gephyrocapsa caribbeanica	2	7	3							1																	
G. oceanica	284	239	223	268	309	300	198	393	417	207	164	309	282	174	272	243	306	165	81	94	174	103	83	102	72	38	43
G. oceanica var. A																											1
G. ericsonii																										1	1
Hayaster perpolexus																											
Helicosphaera carteri			1	1		1	1											1	6	9	2	5	10	3	3	1	5
H. hyalina																			+	+					+		
H. pavimentum																			1					+			
H. wallichii																				1		1		+		1	
Neosphaera coccolithomorpha																			2	+							+
Oolithotus fragilis																			3	1		1	1		+	1	1
Pontosphaera discopora																											1
P. multipora																											
P. syracusana																											
P. spp.																											
Rhabdosphaera clavigera				1			2									1			1	3	1	1	2	1	2	4	7
R. longistylis																											
Syrocosphaera histrica																			+							+	+
S. lamina																											
S. pulchra		5	9	11		2	8		3	4				2		4	2	5	4	3	1	3	2	2	2	1	3
S. spp.	1	2	2	2			7												1	1			2				1
Thoracosphaera spp.				1	1														1			+					
Umbellosphaea irregularis																			1						1	1	1
U. tenuis																			1	1			1	1	1	1	
Umbilicosphaera hulburtiana		1				1													2						+		1
U. sibogae		2	4	3		2	7												17	14	9	16	21	11	9	11	9
Total	500	500	500	499	498	500	500	499	500	500	500	500	500	497	500	498	511	499	490	493	499	491	493	493	491	498	495

	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397
SAMPLE				GH85-1	RC-	GH85-3	RC-			GH84-4	GH85-1	GH86-1	KT86-9		
NUMBER	372	375	378	382	391	400	401	403	404	441	464	491	8	9	10
ABUNDANCE	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PRESERVATION	G	G	M	G	G	G	G	G	G	M	A	G	G	G	G
Acanthoica spp.															
Braarudosphaera bigelowii															
Calcidiscus leptoporus	13	18	45	35	31	18	21	24	11	19	40	24	25	15	19
Calciosolenia spp.	1		1	1	1	2	1	1	3		1	1	1	1	1
Ceratolithus cristatus			1	1	1		1	3	2						
Coccolithus pelagicus															
Crenalithus spp.	16	3	3	5	10	5	9	12	7	8	6	12	8	11	8
Cricosphaera quadrilaminata															
Discolithina japonica															
Discosphaera tubifera															
Emiliania huxleyi	195	211	91	160	157	163	164	78	131	212	85	102	174	175	157
Florisphaera profunda	207	183	224	217	218	251	230	307	281	160	264	285	239	218	263
F. profunda var. elongata															
Gephyrocapsa caribbeanica															
G. oceanica	39	53	112	45	55	21	27	30	23	62	85	28	29	51	22
G. oceanica var. A				1											
G. ericsonii					3					1		1			
Hayaster perpolexus															
Helicosphaera carteri	3	4	3	4	3	2	5	3	3	7	2	6	1	4	5
H. hyalina		+						1	2					1	
H. pavimentum											+				
H. wallichii	+					+		1		1		1			
Neosphaera coccolithomorpha			+	1	+				1			1		+	
Oolithotus fragilis	2	1	1	1	+	3	2	2	2	1	1	1	1	2	3
Pontosphaera discopora													+	+	
P. multipora													+		
P. syracusana	+	+			+										
P. spp.															
Rhabdosphaera clavigera	4	7	2	7	7	9	8	8	13	5	2	14	3	3	6
R. longistylis															
Syrocosphaera histrica									+						
S. lamina														+	
S. pulchra	1	2	+	3		4	6	3	3	1	1	5	2	2	4
S. spp.	1			1		1		+	+				+	1	+
Thoracosphaera spp.															
Umbellosphaea irregularis	1					1	1		1					+	
U. tenuis	1	1	1	1		3	1	1	5	1	1	1	1	1	2
Umbilicosphaera hulburtiana															
U. sibogae	10	12	8	12	8	13	9	8	8	18	6	10	8	8	10
Total	494	495	492	495	494	496	485	482	496	496	494	492	492	493	500

APPENDIX 3

Cluster sample groups

Sample numbers being given with reference to Figure 21 from top to bottom within each cluster

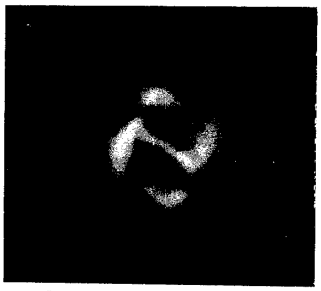
Cluster A1	1, 114, 8, 148, 183, 2, 197, 196, 200, 208, 144, 194, 203, 379, 377, 199, 9, 80, 112, 201, 111, 113, 193, 10, 182, 76, 77, 79, 120, 131, 121, 374, 375, 140, 192, 142, 172, 146, 171, 134, 133, 110, 169, 187, 180, 191, 156, 150, 109, 198, 378, 30, 31, 51, 52, 43, 78.
Cluster A2	195, 204, 376, 205, 385, 380, 393, 396.
Cluster A3	11, 32, 33, 34, 14, 35, 36, 38, 37, 39, 13, 18, 19, 15, 16, 391, 17, 390, 394, 381, 395, 386, 387, 388, 389, 397, 382, 383, 384, 392.
Cluster A4	21, 23, 22, 24, 25, 26.
Cluster B1	202.
Cluster B2	218, 219, 220.
Cluster C1	3, 185, 6, 85, 165, 4, 73, 70, 81, 82, 72, 74, 157, 5, 71, 190, 164, 86, 87, 127, 188, 129, 212, 115, 118, 66, 68, 69, 116, 106, 125, 189, 154, 123, 160, 184, 65, 67, 124, 159, 209, 210, 211, 213.
Cluster C2	7, 100, 84, 94, 45, 75, 98, 102, 122, 92, 186, 167, 206, 207, 107, 108, 152, 83, 88, 27, 104, 46, 47, 55, 28, 29, 49, 96, 50, 158, 90.
Cluster D1	221, 222, 231, 232, 238.
Cluster D2	223, 249, 241, 230, 237, 233, 234, 242, 243, 235, 247, 236, 246, 245, 248, 239, 244, 161, 162.

Plates 1–7

Plate 1

Scale bar $= 5\ \mu m$

Fig. 1. *Gephyrocapsa oceanica* Kamptner
Cross-polarized light. Sample 130.
Fig. 2. *Gephyrocapsa oceanica* var. A
Cross-polarized light. Sample 128.
Fig. 3. *Gephyrocapsa* spp. (small size)
Cross-polarized light. Sample 108.
Fig. 4. *Emiliania huxleyi* (Lohmann) Hay and Mohler
Cross-polarized light. Sample 127.
Fig. 5. *Florisphaera profunda* Okada and Honjo
Cross-polarized light. Sample 19.
Fig. 6. *Florisphaera profunda elongata* Okada and McIntyre
Cross-polarized light. Sample 24.
Fig. 7. *Calcidiscus leptoporus* (Murray and Blackman) Loeblich and Tappan
Cross-polarized light. Sample 377.
Fig. 8. *Umbellosphaera irregularis* Paasche
Cross-polarized light. Sample 22.
Figs. 9, 10. *Pontosphaera discopora* Schiller
9, cross-polarized light; 10, phase contrast. Sample 80.
Fig. 11. *Syracosphaera lamina* Lecal-Schlauder
Cross-polarized light. Sample 57.
Fig. 12. *Umbellosphaera tenuis* (Kamptner) Paasche
Cross-polarized light. Sample 96.
Figs. 13, 16. *Pontosphaera multipora* (Kamptner) Roth
13, cross-polarized light; 16, phase contrast. Sample 106.
Figs. 14, 17. *Discolithina japonica* Takayama
14, cross-polarized light; 17, phase contrast. Sample 79.
Figs. 15, 18. *Ceratolithus cristatus* Kamptner
15, cross-polarized light; 18, phase contrast. Sample 72.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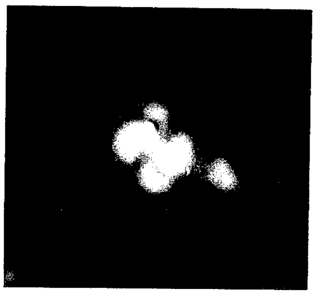
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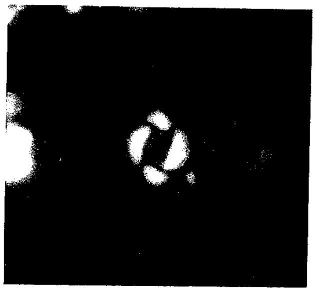
3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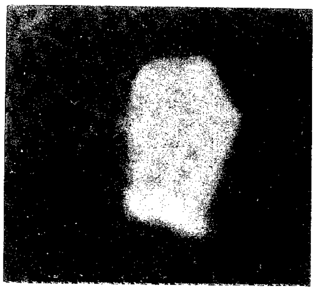
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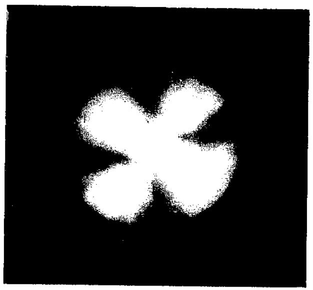
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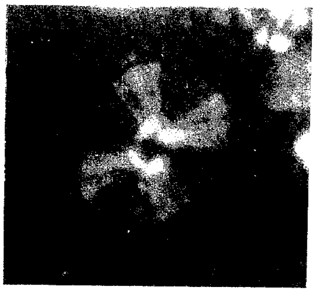
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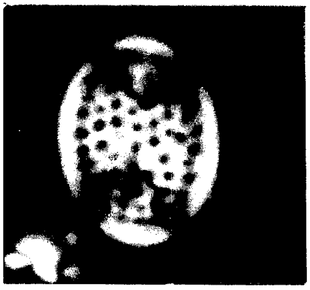
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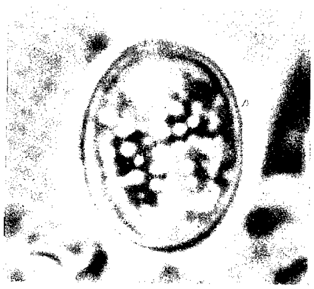
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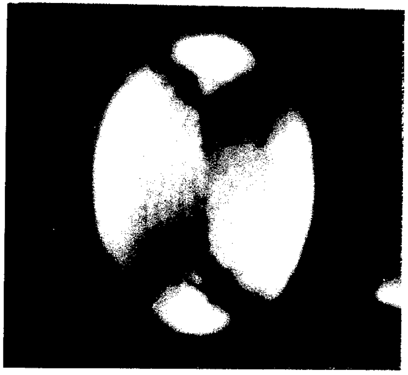
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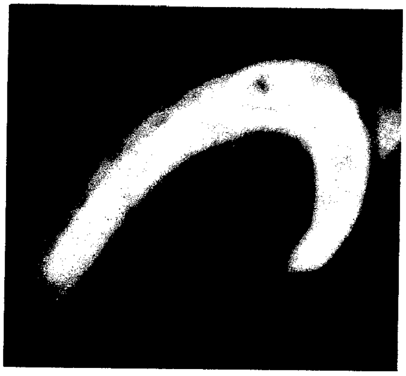
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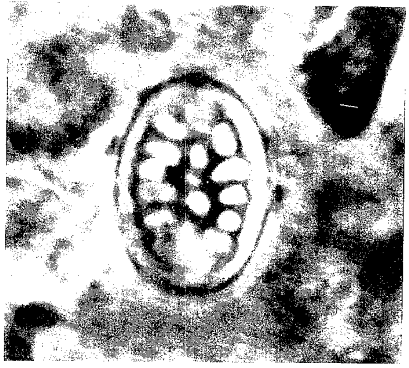
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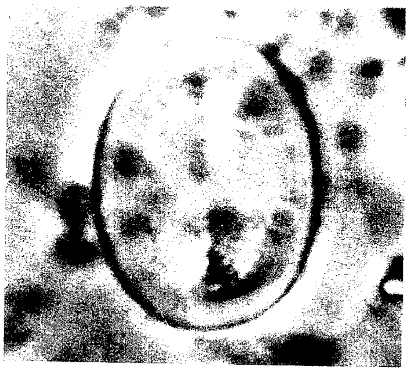
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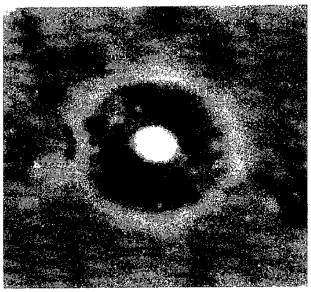
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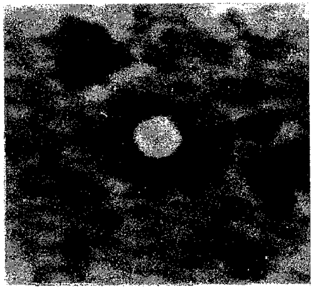
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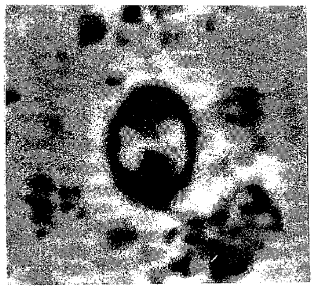
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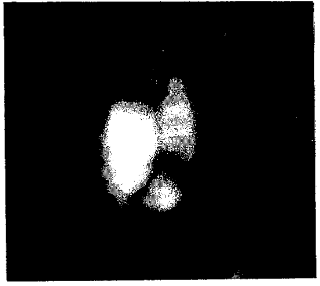
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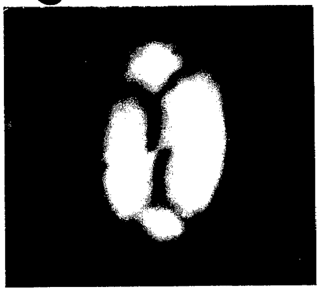
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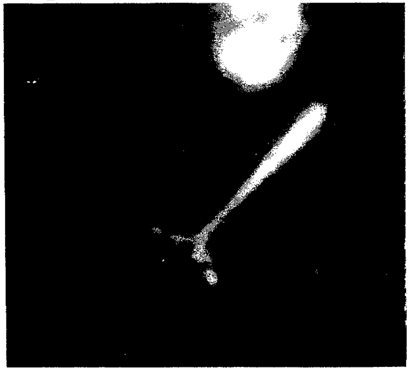
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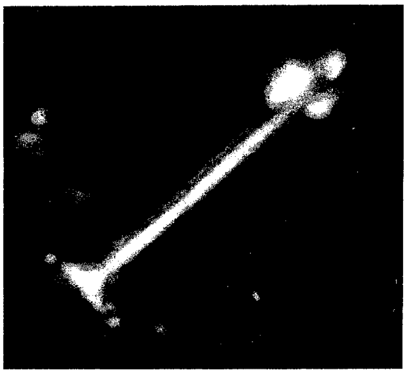
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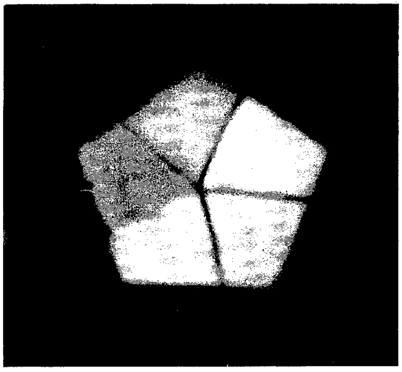
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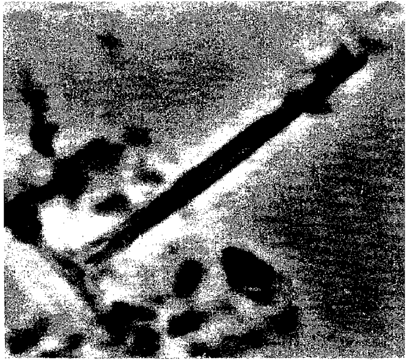
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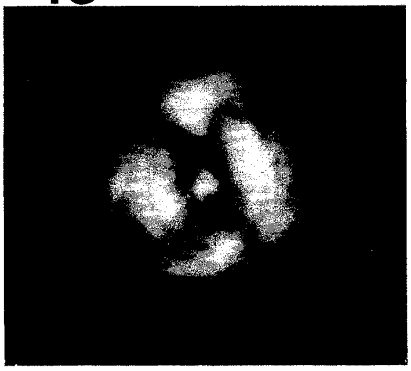
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Plate 2

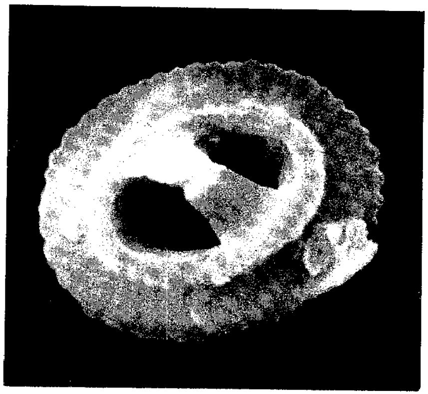
Scale bar=5 μm

Figs. 1-2, 5-6. *Umbilicosphaera sibogae* (Weber-van Bosse)
1, 5, cross-polarized light; 2, 6, phase contrast. 1-2, sample 106. 5-6, sample 94.
Figs. 3-4. *Calciosolenia* sp.
3, cross-polarized light; 4, phase contrast. Sample 56.
Figs. 7-8. *Cricosphaera quadrilaminata* Okada and McIntyre
7, cross-polarized light; 8, phase contrast. Sample 31.
Figs. 9, 10. *Helicosphaera carteri* (Wallich) Kamptner
9, 10, cross-polarized light. 9, sample 106. 10, sample 66.
Fig. 11. *Helicosphaera pavimentum* Okada and McIntyre
Cross-polarized light. Sample 6.
Figs. 12, 15. *Braarudosphaera bigelowii* (Gran and Braarud) Deflandre
Cross-polarized light. 12, sample 47. 15, sample 49.
Figs. 13, 16. *Rhabdosphaera clavigera* Murray and Blackman
13, cross-polarized light; 16, phase contrast. Sample 15.
Figs. 14, 17. *Rhabdosphaera longistylis* Schiller
14, cross-polarized light; 17, phase contrast. Sample 54.
Fig. 18. *Coccolithus pelagicus* (Wallich) Schiller
Cross-polarized light. Sample 137.

Plate 3

Scale bar = 1 μm

Figs. 1-3, 6. *Gephyrocapsa oceanica* Kamptner
Distal view. 1, sample 25. 2, sample 6. 3, sample 68. 6, sample 140.
Fig. 4. *Gephyrocapsa oceanica* var. A
Distal view. Sample 176.
Fig. 5. *Gephyrocapsa ericsonii* McIntyre and Bé
Distal view. Sample 21.
Fig. 7. *Florisphaera profunda elongata* Okada and McIntyre
Individual plate. Sample 390.
Fig. 8. *Florisphaera profunda* Okada and Honjo
Individual plate. Sample 390.
Fig. 9. *Emiliania huxleyi* (Lohmann) Hay and Mohler
Distal view. Sample 126.
Fig. 10. *Umbilicosphaera sibogae* (Weber-van Bosse) Gaarder
Distal view. Sample 16.
Fig. 11. *Umbilicosphaera sibogae foliosa* (Kamptner) Okada and McIntyre
Distal view. Sample 16.
Fig. 12. *Umbilicosphaera hulburtiana* Gaarder
Distal view. Sample 14.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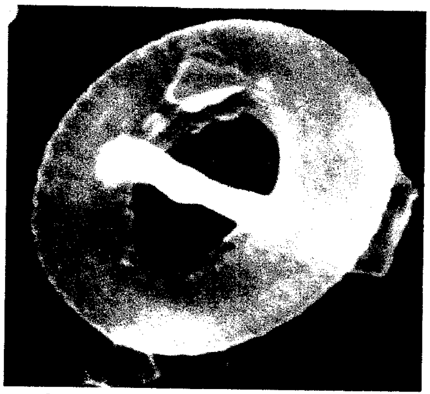
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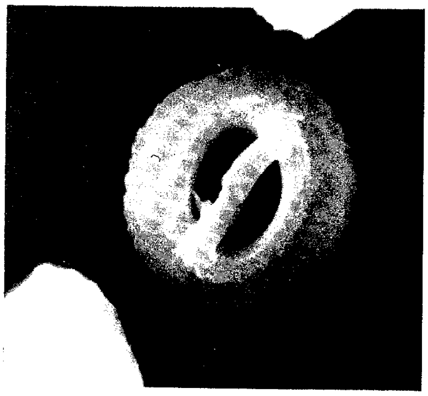
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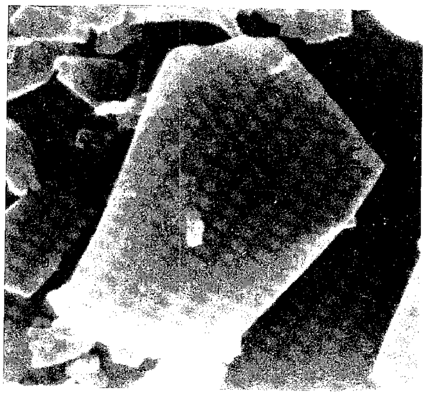
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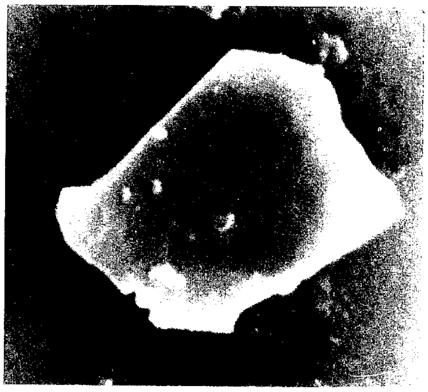
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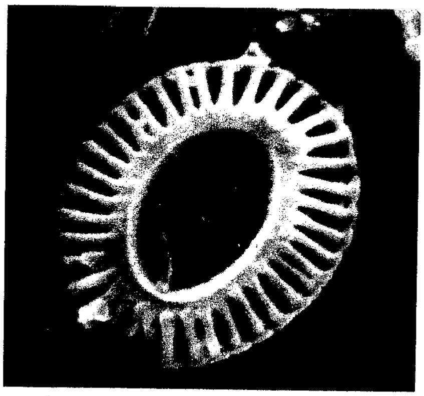
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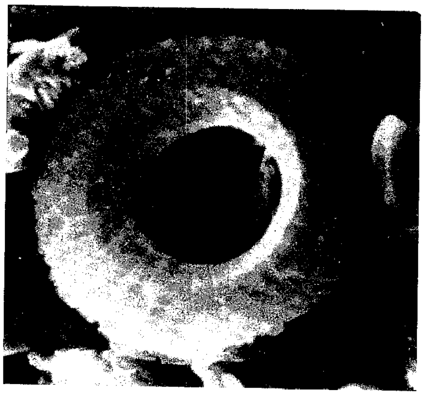
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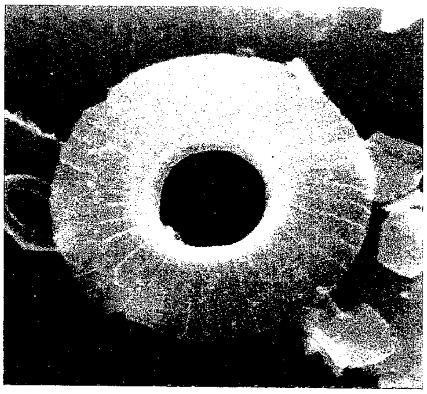
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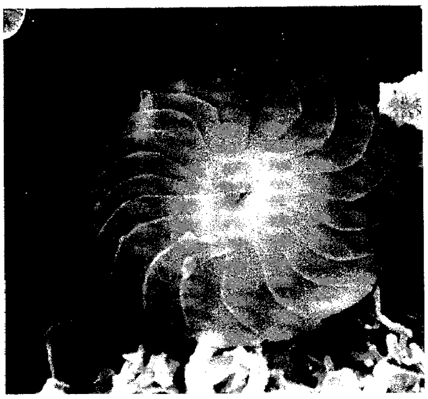
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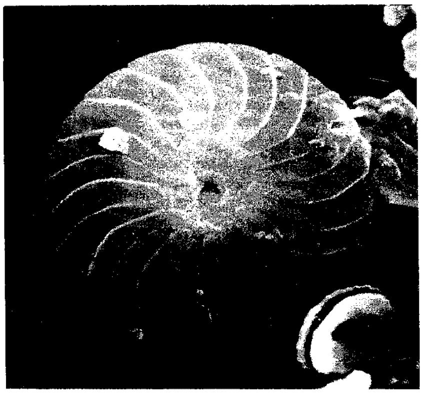
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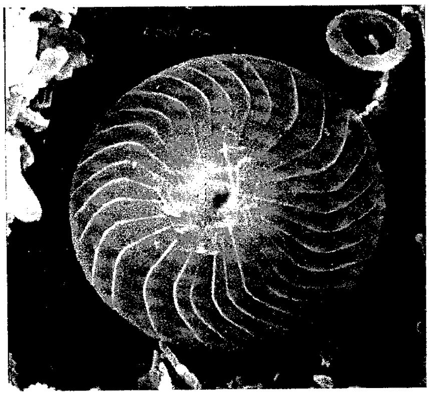
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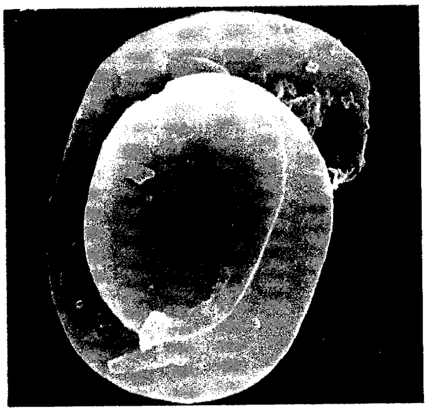
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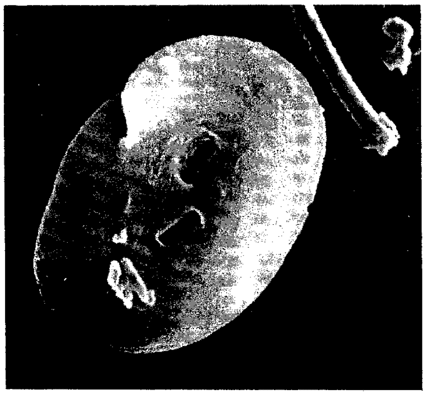
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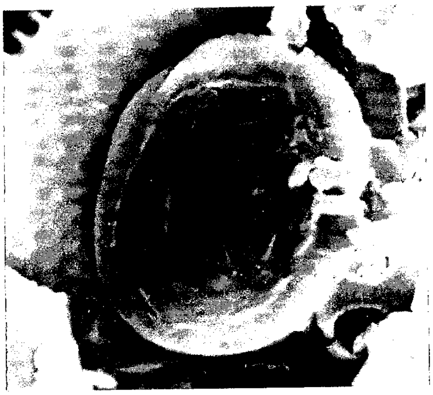
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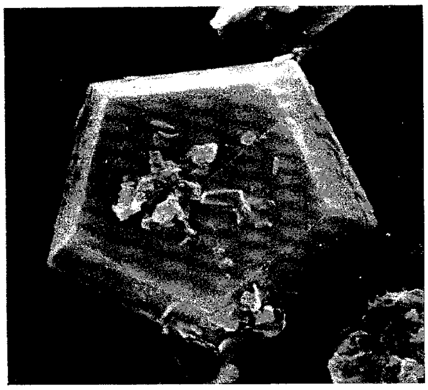
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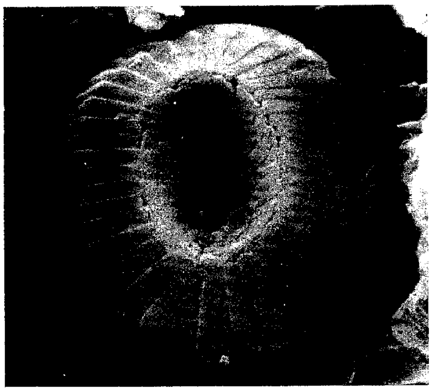
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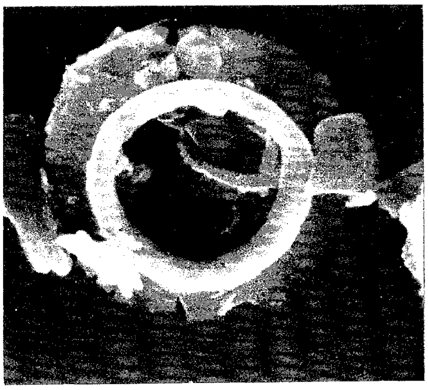
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Plate 4

Scale bar $= 1\ \mu$m

Figs. 1–3. *Calcidiscus leptoporus* (Murray and Blackman) Loeblich and Tappan
Distal view. 1, sample 377. 2, sample 378. 3, sample 16.
Figs. 4, 5. *Helicosphaera carteri* (Wallich) Kamptner
4, proximal view, sample 68 ; 5, distal view, sample 6.
Fig. 6. *Helicosphaera wallichii* (Lohmann) Okada and McIntyre
Distal view. Sample 19.
Figs. 7, 8. *Helicosphaera pavimentum* Okada and McIntyre
Distal view. Sample 6.
Fig. 9. *Braarudosphaera bigelowii* (Gran and Braarud) Deflandre
Sample 47.
Figs. 10, 11. *Coccolithus pelagicus* (Wallich) Schiller
Distal view. 10, sample 144. 11, sample 138.
Fig. 12. *Neosphaera coccolithomorpha* Lecal-Schlauder
Distal view. Sample 76.

Plate 5

Scale bar = 1 μm

Figs. 1, 4. *Umbellosphaera irregularis* Paasche
1, distal view, sample 16 ; 4, proximal view, sample 19.
Figs. 2, 5. *Oolithotus fragilis* (Lohmann) Okada and McIntyre
2, distal view, sample 14 ; 5, proximal view, sample 69.
Figs. 3, 6. *Hayaster perplexus* (Bramlette and Riedel) Bukry
3, distal view, sample 19 ; 6, proximal view, sample 20.
Fig. 7. *Umbellosphaera tenuis* (Kamptner) Paasche
Distal view. Sample 23.
Fig. 8. *Rhabdosphaera clavigera* Murray and Blackman
Rhabdolith. Sample 23.
Fig. 9. *Pontosphaera multipora* (Kamptner) Roth
Sample 19.
Fig. 10. *Discosphaera tubifera* (Murray and Blackman) Ostenfeld
Sample 19.
Fig. 11. *Acanthoica* sp. ?
Sample 47.
Fig. 12. *Discolithina japonica* Takayama
Proximal view. Sample 142.


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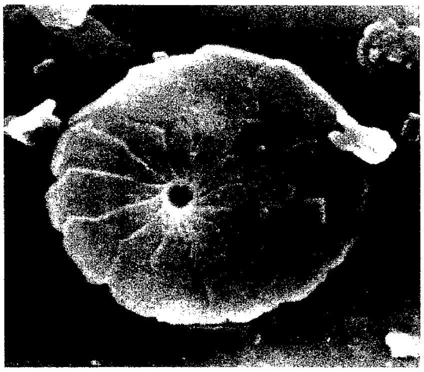
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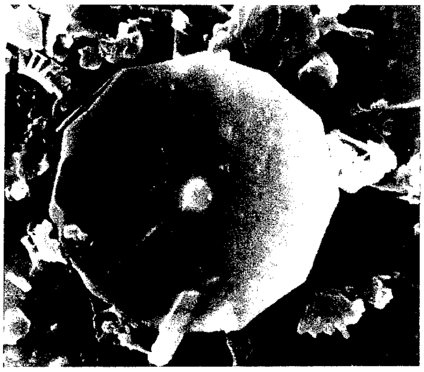
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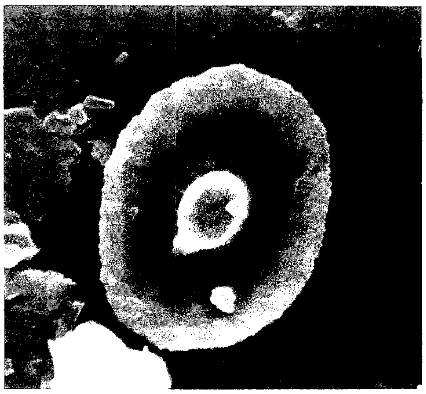
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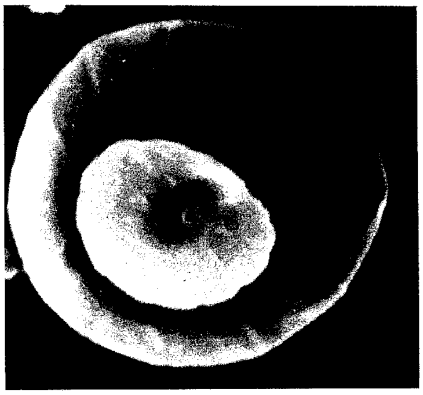
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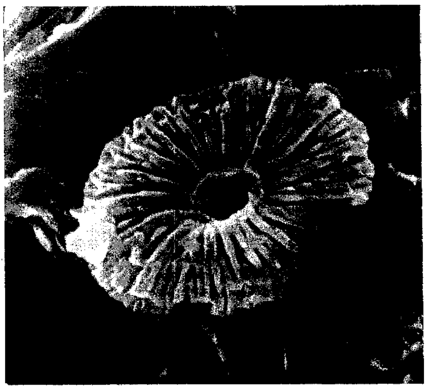
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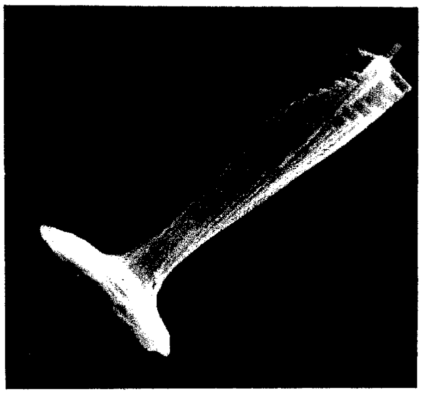
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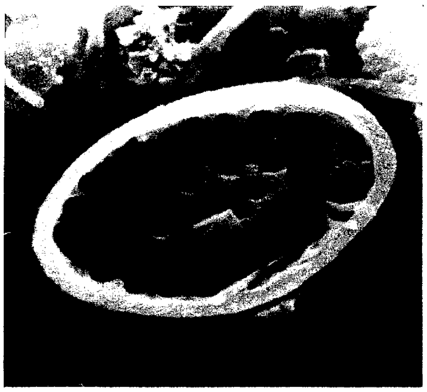
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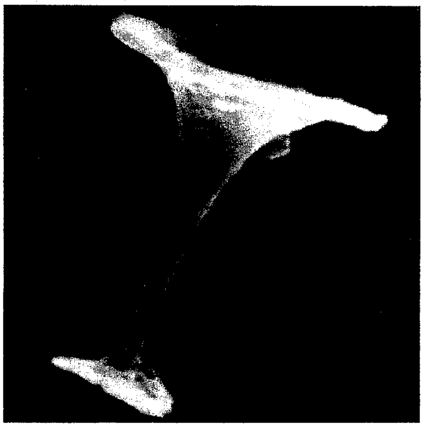
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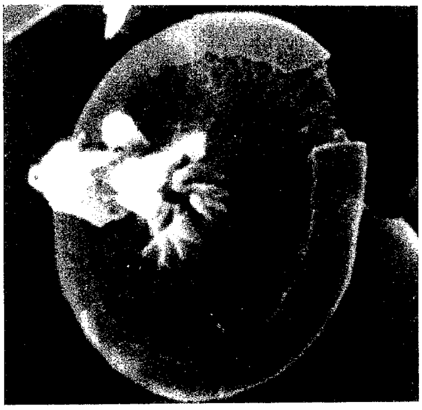
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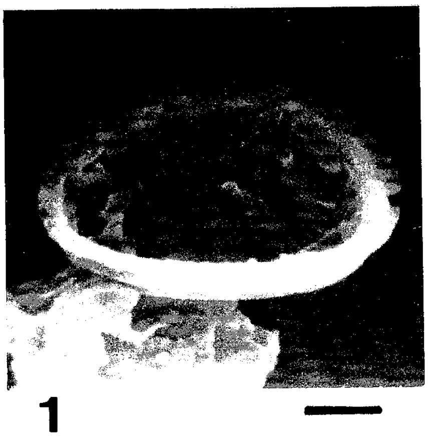
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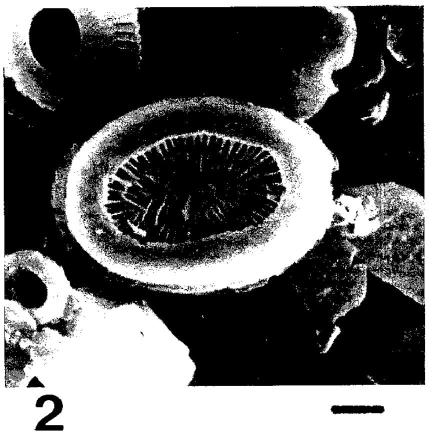
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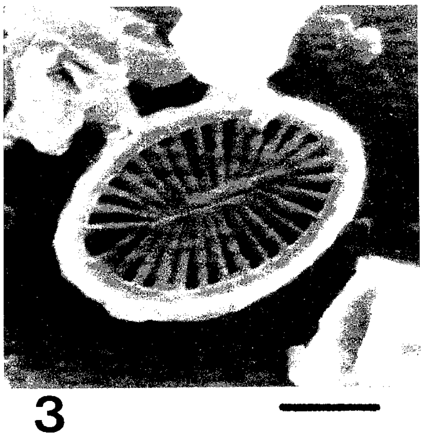
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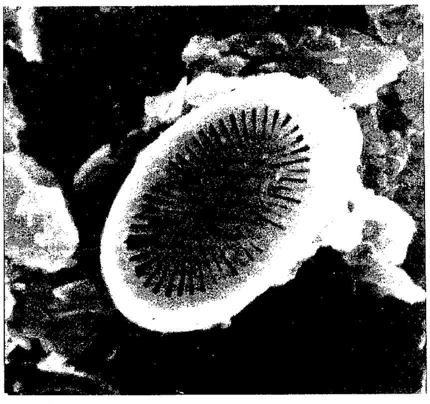
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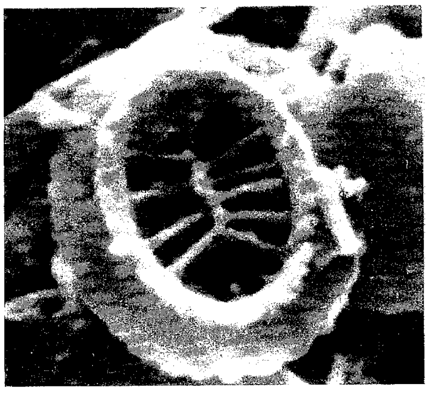
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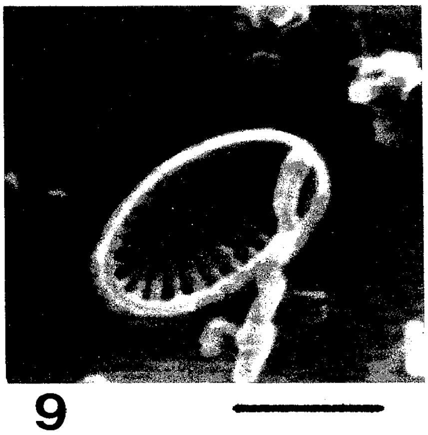
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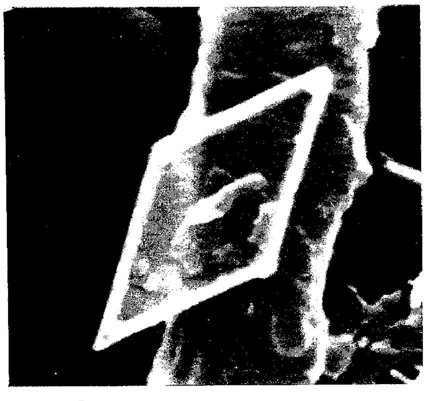
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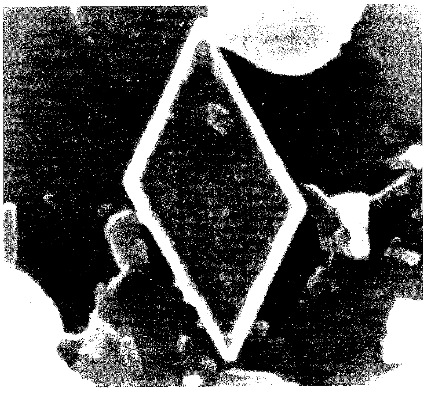
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12

Plate 6

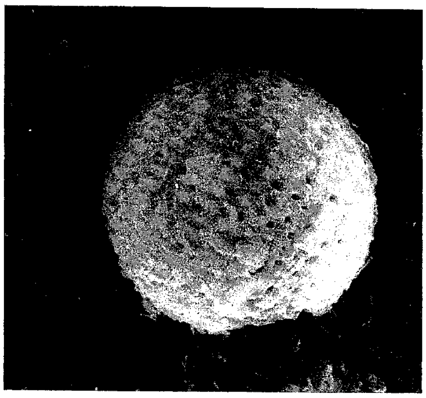
Scale bar = 1 μm

Figs. 1, 2. *Syracosphaera pulchra* Lohmann
1, distal view, sample 19 ; 2, proximal view, sample 23.
Fig. 3. *Syracosphaera lamina* Lecal-Schlauder
Proximal view. Sample 19.
Fig. 4. *Syracosphaera mediterranea* Lohmann
Distal view. Sample 19.
Fig. 5. *Syracosphaera* sp.
Proximal view. Sample 65.
Fig. 6. *Syracosphaera* sp.
Proximal view. Sample 4.
Fig. 7. *Syracosphaera halldalii* Gaarder and Hasle
Distal view. Sample 69.
Fig. 8. *Syracosphaera molischii* Schiller
Distal view. Sample 69.
Fig. 9. *Syracosphaera* sp.
Proximal view. Sample 24.
Fig. 10. *Calciosolenia* sp.
Proximal view. Sample 19.
Fig. 11. *Calciosolenia* sp.
Distal view. Sample 14.
Fig. 12. *Calciosolenia* sp.
Distal view. Sample 30.

Plate 7

Scale bar = 1 μm

Figs. 1–2. *Thoracosphaera heimii* (Lohmann) Kamptner
1, sample 56. 2, sample 56.
Fig. 3. *Thoracosphaera tuberosa* Kamptner
Sample 60.
Fig. 4. *Scyposphaera* ? sp.
Sample 19.
Fig. 5. *Anthosphaera* sp.
Sample 5.
Fig. 6. *Crenalithus* sp.
Distal view. Sample 19.
Fig. 7. *Gephyrocapsa oceanica* Kamptner
Coccosphere. Sample 70.
Fig. 8. *Emiliania huxleyi* (Lohmann) Hay and Mohler
Coccosphere. Sample 68.
Fig. 9. *Crenalithus* sp.
Coccosphere. Sample 19.
Fig. 10. "Fecal pellet" made of coccospheres (*Florisphaera profunda*). Sample 68.
Fig. 11. *Ceratolithus cristatus* Kamptner
Sample 127.



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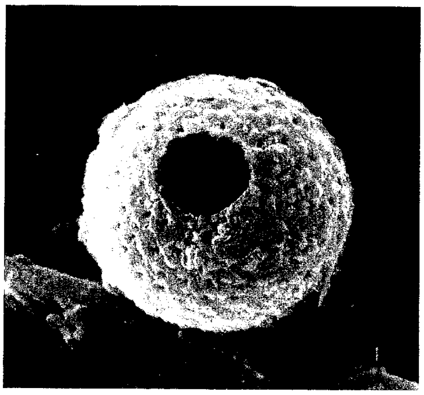

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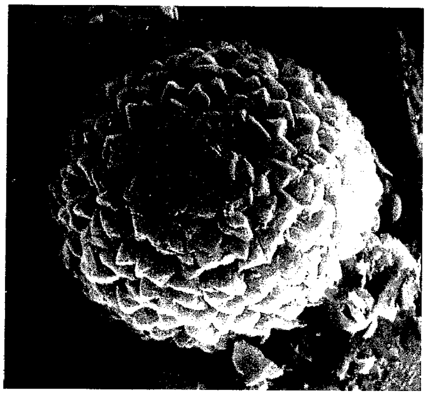

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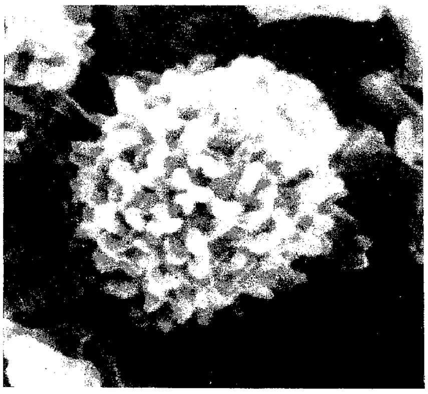

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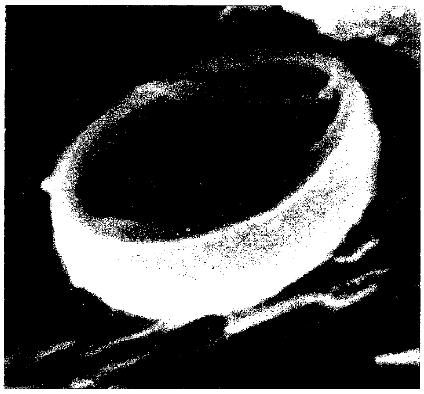

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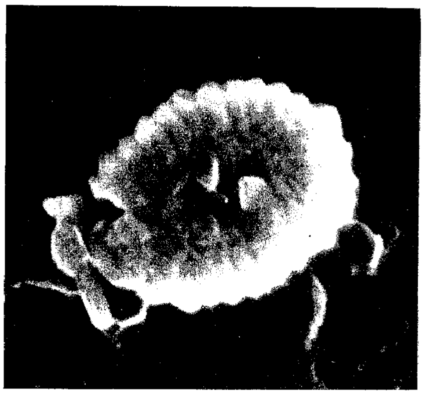

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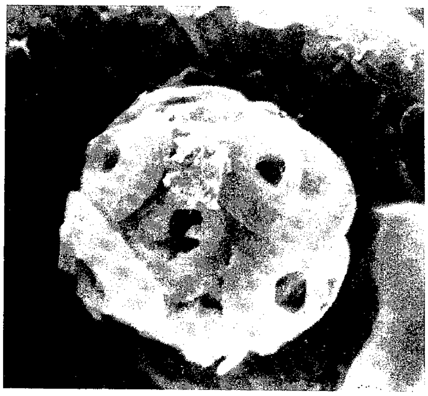

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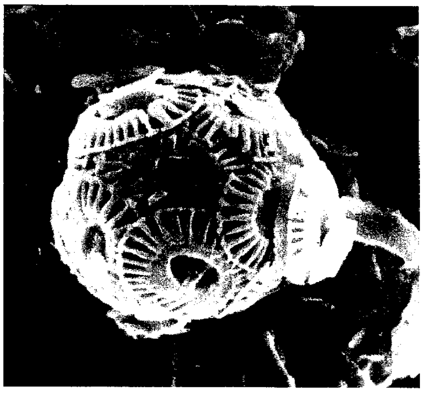

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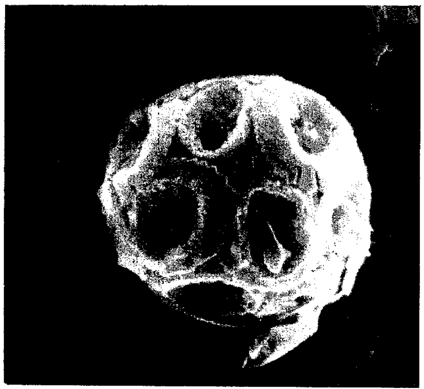

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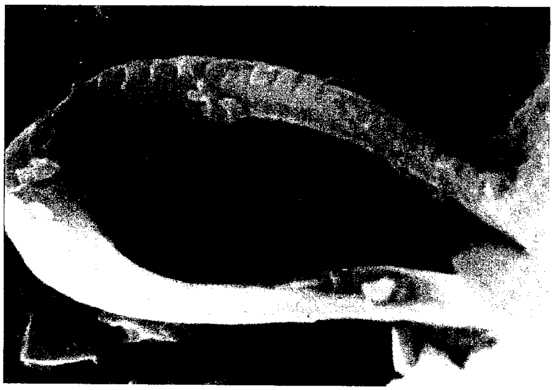

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