

VI. QUATERNARY CALCAREOUS NANNOPLANKTON IN DEEP SEA PISTON CORES OFF KII PENINSULA

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Introduction

Calcareous nannoplankton biostratigraphy has greatly contributed to the understanding of correlation of deep sea sediment cores and paleo-environment changes over the last decade. In the areas around the Japanese Islands, no information is available regarding the detailed vertical distribution of nannoplankton in sediment cores, except for the Lamont Core V21-98 (TAKAYAMA, 1970: 1973) and DSDP cores (ELLIS, 1975). This article presents the preliminary results of a study of Quaternary nannoplankton flora of two deep sea piston cores, P49 and P58, which were obtained during the GH75-3 and -4 cruises from the Muroto Trough and from the southern foot of the Koshu Seamount, northern Shikoku Basin, both to the south of Kii Peninsula (Fig. VI-1).

Location and related data of the piston cores studied are shown in Table VI-1.

Core P49 is from the flat bottom in the southern part of the Muroto Trough, about 40 km in a southwest direction from Shionomisaki. The precise location in relation to bathymetry is shown in the sedimentological map of INOUCHI and KINOSHITA (1977), which indicates the location is in an area of clayey silt. According to OKUDA (1977), the

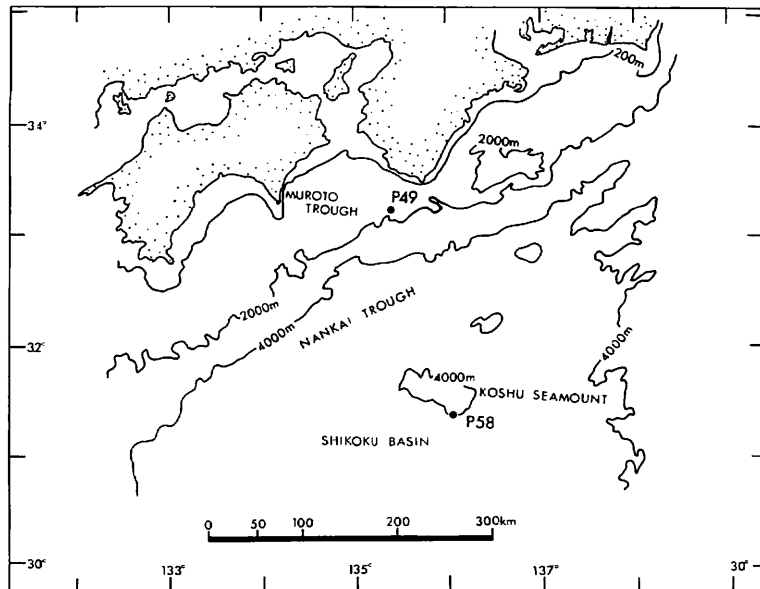


Fig. VI-1 Location map of piston cores.

Table VI-1 Location and related data of the piston cores.

Sta. no.	Core no.	Latitude	Longitude	Depth	Core length
GH75-3-327	P49	33°14.0'N	135°25.2'E	1,566 m	345 cm
GH75-4-366	P58	31°19.0'N	136°05.4'E	4,000 m	484 cm

location of the core is near the boundary of the distribution areas of their P (Middle Pleistocene-Recent) and K3 (Early-Middle Pleistocene) formations.

Core P49, measuring 345 cm in total length, consists largely of muddy sediment interbedded with ca. 30 cm thick layer of volcanic ash at a depth of 55–85 cm and some thin layers of the same material at around 230 cm depth. Also, several thin layers of fine sand are interbedded at around the 300 cm depth.

Core P58 is from the southern foot of the Kosu Seamount in the northern Shikoku Basin, about 240 km from Shionomisaki to the south. It also consists largely of muddy sediment. Of a total core length of 484 cm, the upper 0–246 cm is characterized by silt interbedded with a volcanic ash layer at a depth of 31–45 cm and becoming tuffaceous in places. The lower 246–484 cm is nearly exclusively composed of clay.

The core were sampled at 10-cm intervals. Observations (by C. TOKOYODA) was made with a JEOL JSM-U3 scanning electron microscope at a magnification of 3000–5000X. Counts were made of 250 random specimens in each sample.

Nannoplankton Assemblage

Results of observations are summarized in Figs. 2 and 3.

In Core P49 thirteen species were determined, including one undetermined species of *Thoracosphaera*. Of these, *Gephyrocapsa oceanica* is the most dominant. The species ranges between 60–80% of the species present over a 0–160 cm interval and tends to decrease to the minimum of 13% of all species with the interval from 160 cm to 260 cm. In the lower part of the core the percentage of *Gephyrocapsa oceanica* increases to around 50%.

Emiliana huxleyi is not present in the lower part, and only appears in the 0–240 cm part of the core with an abundance of 10–20% except at the lowest interval of its occurrence. The abundance of *E. huxleyi* tends to be the reverse of that of *G. oceanica*.

Cyclcoccolithus leptoporus and *Helicopontosphaera kamptneri* are rather abundant. They range from several percent to around 20%. *C. leptoporus* is rather abundant in the middle to upper parts and decreases in the lower part of the core, while *H. kamptneri* is not abundant in the middle-upper interval and markedly increases toward the bottom of the core where it occupies about 40% of the whole nannoplankton population.

Umbilicosphaera mirabilis is present throughout nearly all the core with an abundance of less than 5%, and it tends to decrease in the lower part similar to *C. leptoporus*.

The other identified species are of minor or insignificant abundance throughout the core. Of these, *Rhabdosphaera clavigera* is relatively abundant in the middle part, where it attains more than 5%.

Coccolithus pelagicus occurs below 220 cm, and is particularly abundant at the 260 cm level. It is also found in the uppermost interval of the core.

Helicopontosphaera wallichii occurs in the middle-upper part, but again in minor

abundance. A few percent of *H. sellii*, *Discolithina japonica*, *Discoaster brouweri rutellus*, and *Ceratolithus cristatus* occur over a very limited interval of the core.

In core P58 twelve species were identified. The uppermost 35 cm part of the core is barren of nannoplankton remains. All other than *Ceratolithus rugosus* are conspecific to those identified in Core P49. *Coccolithus pelagicus* and *Discoaster brouweri rutellus* are not present.

Gephyrocapsa oceanica represents the most dominant species throughout the core as well as in Core P49. It typically ranges from 40 to 60%, but has a large fluctuation from about 30 to a maximum at 65%.

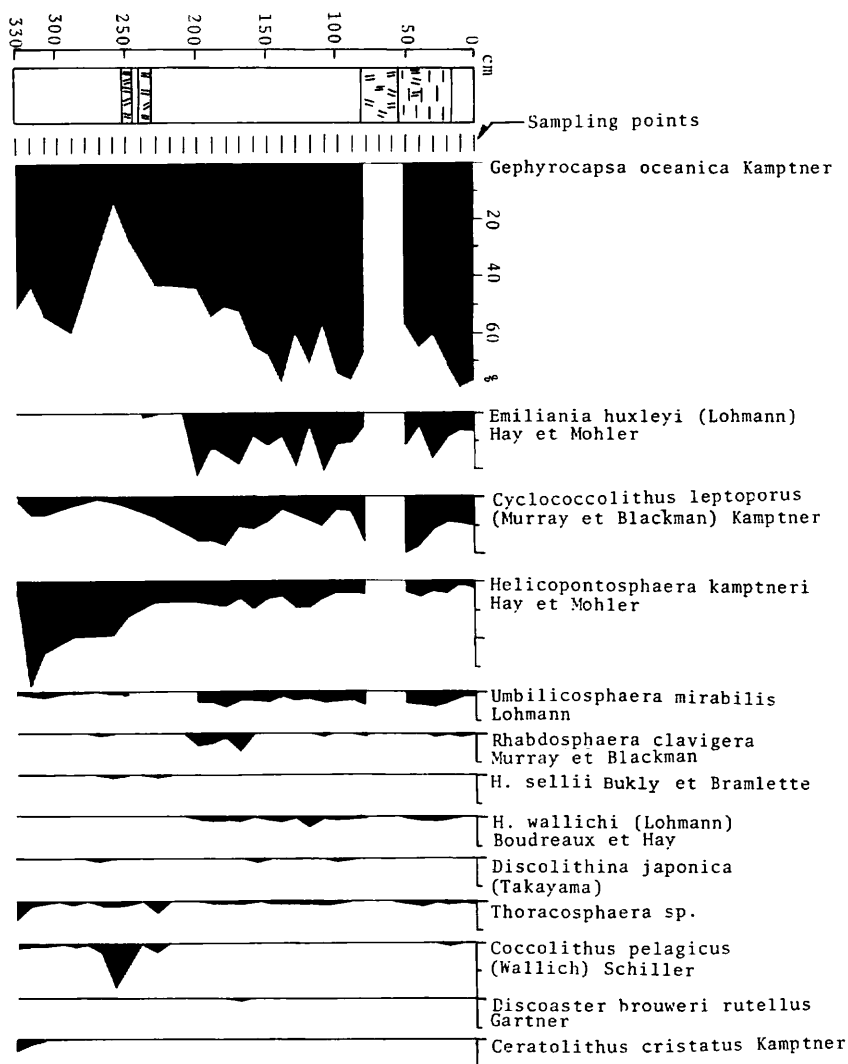


Fig. VI-2 Relative frequency of the calcareous nannoplankton in Core P49.

Emiliania huxleyi occurs throughout the core with abundance from around 20% to more than 50%, in contrast to Core P49. A reverse pattern of distribution with *G. oceanica* is apparent.

Cyclococcolithus leptopolus, *Helicopontosphaera kamptneri*, and *Umbilicosphaera mirabilis* occur as less abundant but rather common forms throughout the core. Other species are found at limited intervals as in Core P49.

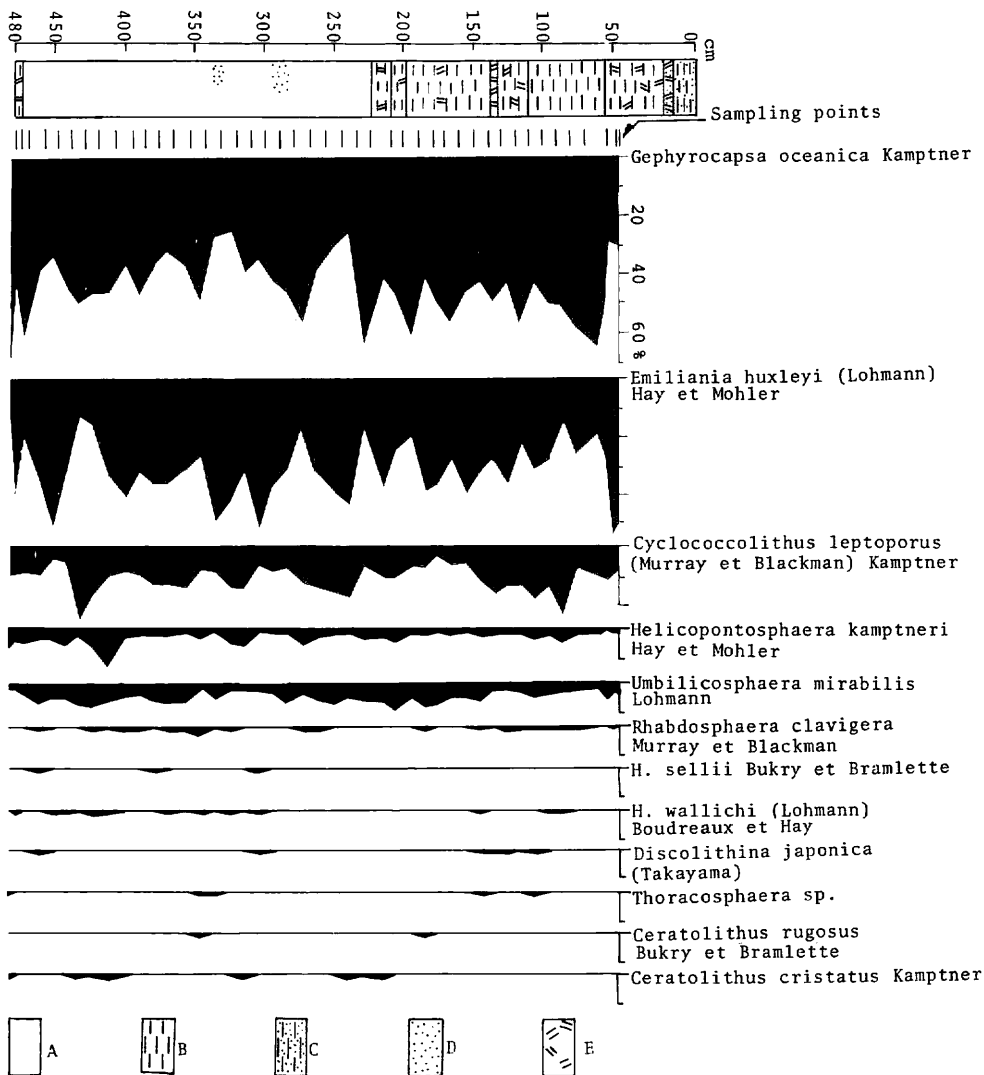


Fig. VI-3 Relative frequency of the calcareous nannoplankton in Core P58.
Legend A: clay B: silt C: silty sand D: sand E: volcanic ash

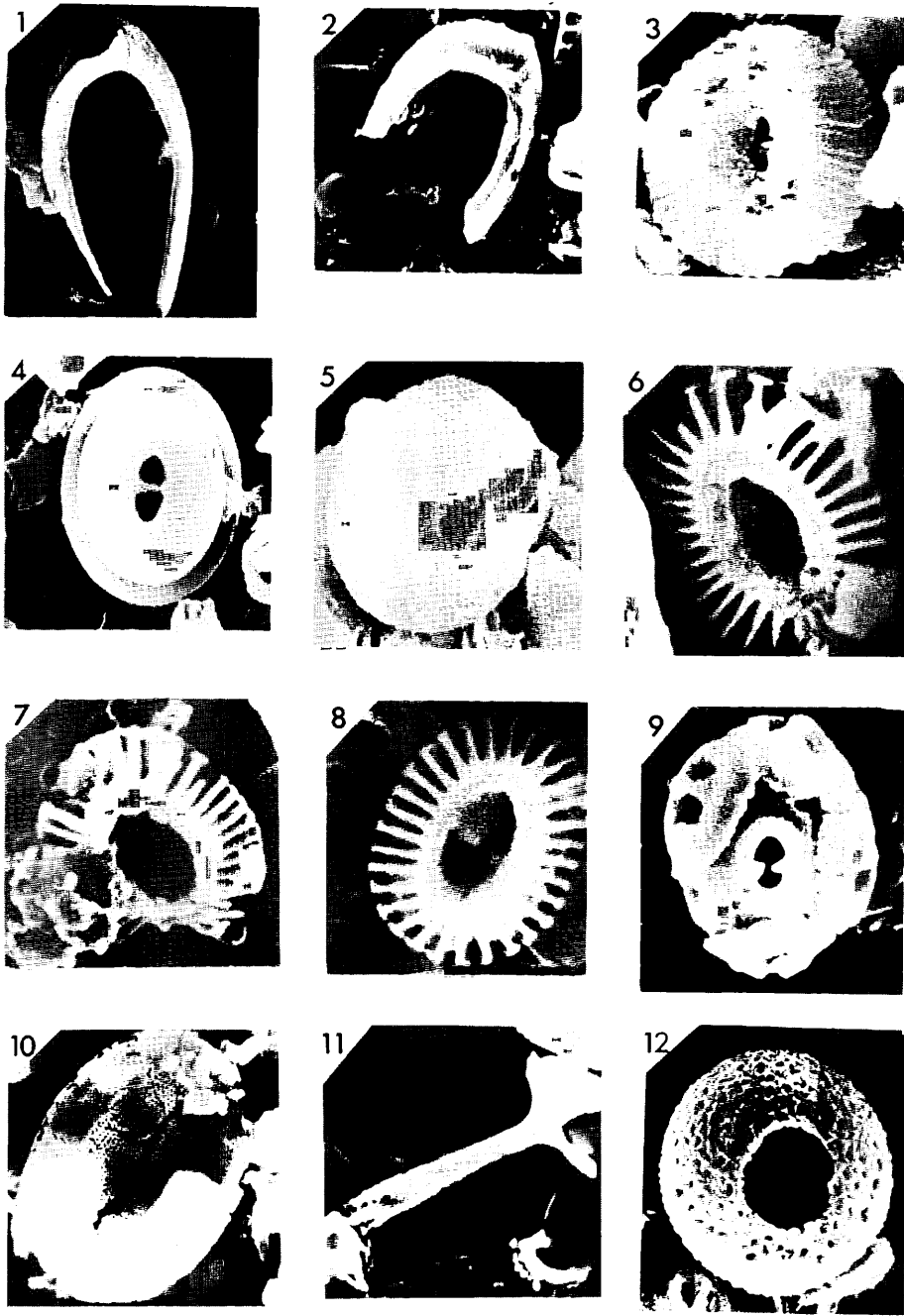


Fig. VI-4 Representative forms of calcareous nannoplankton from Core P49 and P58.

1. *Ceratolithus cristatus* KAMPTNER P58 250 cm × 2500, 2. *C. cfr. cristatus* KAMPTNER P58 230 cm × 2500, 3. *Coccolithus pelagicus* (WALLICH) SCHILLER P49 230 cm × 3000, 4. *Coccolithus pelagicus* (WALLICH) SCHILLER P58 240 cm × 2500, 5. *Cyclococcolithus leptoporus* (MURRAY et BLACKMAN) KAMPTNER P49 200cm × 3500, 6. *Emiliana huxleyi* (LOHMANN) HAY et MOHLER P49 200cm × 9000, 7. *Emiliana huxleyi* (LOHMANN) HAY et MOHLER P49 00 cm × 8500, 8. *Emiliana huxleyi* (LOHMANN) HAY et MOHLER P58 420cm × 10000, 9. *Gephyrocapsa oceanica* KAMPTNER P58 240cm × 4000, 10. *Discolithina japonica* (TAKAYAMA) P58 340 cm × 4000, 11. *Rhabdosphaera clavigera* MURRAY et BLACKMAN P58 160cm × 4500, 12. *Thoracosphaera* sp. P49 40cm × 2500.

Discussion

Of the species determined three species, *Emiliana huxleyi*, *Gephyrocapsa oceanica*, and *Umbellosphaera mirabilis* are considered to have a temperature-dependent structural variation (MCINTYRE, 1967; GARTNER, 1972; GEITZENAUER, 1972). Although this study is a preliminary one without the examination of the structural variation of the species, some aspects of the biostratigraphy of the cores and paleo-climate changes can be discussed to some extent.

Middle to Upper Quaternary biostratigraphic zonation of nannoplankton has been discussed by several authors, with respect to areas around the Japanese Islands. The zonation by MARTINI (1971) and GARTNER (1969), with the *Emiliana huxleyi*, *Gephyrocapsa oceanica*- (*Gephyrocapsa*-), and *Pseudoemiliana lacunosa* Zones in descending order, has been modified by TAKAYAMA (1973), who established an *Umbellosphaera irregularis* Zone between the *E. huxleyi*- and *G. oceanica* Zones, on the basis of a study of the Lamont Core V21-98 from the Oki-Daito Ridge.

ELLIS (1975) followed BUKRY's (1973a, b) zonation system in his study on DSDP cores from the Philippine Sea and the Sea of Japan, in which the different divisions were used for *G. oceanica*- and *P. lacunosa* Zones of MARTINI (1971). ELLIS discriminated *G. oceanica* Zone and underlying *G. caribbeanica* Zone as of nearly equivalent to MARTINI's *G. oceanica* Zone plus *P. lacunosa* Zone; while ELLIS designated his *G. oceanica* Zone as including MARTINI's *G. oceanica* Zone and the upper part of *P. lacunosa* Zone.

NISHIDA (1977) recognized the three zones established by MARTINI (1971) and applied them for the columns on and around the Japanese Islands.

On the other hand, GARTNER (1977) revised the previous zonation of the Pleistocene sequence for tropical and temperate regions. He newly separated *E. huxleyi* Acme Zone from the previous *E. huxleyi* Zone in its upper part by the dominance of the species, and proposed a new zonation system for the zones below *P. lacunosa* Zone. According to him, *E. huxleyi* Zone redefined ranges from the first appearance of the species at 0.27 m. y. B. P. to 0.07 m. y. B. P., and *E. huxleyi* Acme Zone ranges from the beginning of *E. huxleyi* dominance (0.07 m. y. B. P.) to the present.

With respect to Core P49, *E. huxleyi* is restricted in the middle-upper interval so that the interval may be correlated with the *E. huxleyi* Zone (s. l.)* or the *E. huxleyi* Acme Zone.

When we assume the interval to represent the *E. huxleyi* Acme Zone, the lack of the species in the interval below 240 cm may be interpreted to have resulted from the relatively poor flourishing during the time before the Acme Zone. If it is true, the rate of sedimentation would be calculated as large as ca. 3 cm/1000 y. for the time of the Acme Zone. This value seems to be somewhat large, considering from the geological situation of Core P49 near the southern periphery of the Muroto Trough, where the boundary of the distribution areas of the Middle Pleistocene-Recent formation and the Early-Middle Pleistocene formation are found, according to OKUDA (1977).

* *E. huxleyi* Zone hitherto used by many authors is here called *E. huxleyi* Zone (s. l.) in order to distinguish from the redefined zone by GARTNER (1977).

On the other hand, if the interval of *E. huxleyi* is correlated with *E. huxleyi* Zone (s. l.), the *E. huxleyi* Acme Zone cannot be discriminated in the core. This may have resulted from that the zone is originally missing because of non-deposition of sediment or that the species was not prevail during the time of deposition in the area of P49, although no conclusions can be made about this problem at present.

At any rate, our data can give no definite conclusion as for the biostratigraphic situation of the interval of *E. huxleyi* in Core P49, although its identification to the *E. huxleyi* Acme Zone might be less possible from a geological consideration.

If the correlation of the interval with the whole *E. huxleyi* Zone (s. l.) would be tentatively accepted, the lower interval which lacks *E. huxleyi* in Core P49 can be correlated with the *G. oceanica* Zone as *P. lacunosa* is not present. *Umbellosphaera irregularis*, cool or cold species according to GARTNER (1972), is absent so that the *U. irregularis* Zone of TAKAYAMA (1973) cannot be recognized in Core P49. However, the stenothermal cold water type *Coccolithus pelagicus* appears in abundance over an interval of several tens-of-centimeters just below the lower boundary of the *E. huxleyi* Zone (s. l.). This suggests that this interval represents a cold climate deposition zone immediately before 0.27 m.y. and hence it might be correlated with the paleotemperature Stage 10 (EMILIANI, 1958) (Mindel Glacial or Kansan Glacial), if GARTNER and EMILIANI (1976)'s view on the correlation of calcareous nannoplankton zones and paleotemperature stages is accepted.

Below the abundant interval of *C. pelagicus*, there is an increase in the abundance of *Helicopontosphaera kamptneri* and *Ceratolithus cristatus*. Both are considered to be indicators of warm climate (WISE, 1973; GARTNER, 1972). This suggests that this interval represents a warm climate just before the cold climate interval represented by *C. pelagicus*, and therefore it might be correlated with the paleotemperature Stage 11 within Mindel/Günz Interglacial.

The above consideration indicates that the sporadical occurrences of *Helicopontosphaera sellii*, *Discolithina japonica*, and *Discoaster brouweri rutellus* have been resulted from the secondary deposition, because they are the Pliocene-Early Pleistocene and Pliocene forms.

There is no doubt that Core P58 is within the *E. huxleyi* Zone (s. l.) from the abundance of this species throughout the core. However, here also the discrimination of *E. huxleyi* Acme Zone is not possible, and any estimation of core chronology is very difficult. The whole interval might be correlated with the *E. huxleyi* Acme Zone. In any event, it is notable that *Ceratolithus cristatus* appears at some intervals in the lower-middle part of the core, accompanied by relatively abundant amounts of *Helicopontosphaera kamptneri*. This suggests repeated warm climate intervals at the deposition of the *E. huxleyi* Zone (s. l.) or *E. huxleyi* Acme Zone, although their ages are uncertain at the present time and there is no indication of a cold climate interval between them from the data.

Throughout both the cores, the distribution of *Coccolithus pelagicus* is somewhat interesting. It is certainly recognizable in the *G. oceanica* Zone tentatively correlated in P49, while it is absent (P58) or very rare (P49) in the *E. huxleyi* Zone (s. l.). *C. pelagicus* was considered to have become extinct during the Pliocene in the Oki-Daito Ridge core which is a long way to the south of the present area (TAKAYAMA, 1973). According to

NISHIDA (1973), *C. pelagicus* is rare in the bottom materials of the area about 100 km from Hachijo Island to the northeast, but it is considerably abundant in the area of the Takuyo Seamount, although their biostratigraphic situation is not definite. Also, the DSDP cores in the northern Philippine Sea (Sites 296, 297, and 298) comprise the species of the *E. huxleyi* Zone, though poorly (ELLIS, 1975). From the above discussion, it is probable that *C. pelagicus* disappeared during Pliocene in the southern sea, but the species survived rather abundantly till the time of the *G. oceanica* Zone and less abundantly during that of the *E. huxleyi* Zone (s. l.) in the northern rim of the Philippine Sea.

Another interesting fact is the inverse correlation of the abundance of *G. oceanica* and *E. huxleyi* in the *E. huxleyi* Zone (s. l.) of both cores. The significance of this is not clear, because the occurrences are not correlated with climate indicators discussed above and ecological types of both the species have not been analyzed yet.

Summary

Cores P49 and P58 yielded 12 to 13 calcareous nannoplankton species which are dominated by *G. oceanica* and *E. huxleyi*. Although any definite conclusion cannot be given as for a biostratigraphic situation, Core P49 might extend from a part of the *G. oceanica* Zone to the *E. huxleyi* Zone (s. l.). Its base possibly represents the warm climate Stage 11 under the assumption that the interval of *E. huxleyi* can be correlated with the *E. huxleyi* Zone (s. l.), but the age of the top is uncertain, because of the problem whether the *E. huxleyi* Acme Zone is applicable to the core or not. Core P58 is considered to be within the *E. huxleyi* Zone (s. l.) or alternatively might represent the *E. huxleyi* Acme Zone. Analytical results of both the cores suggest that the stenothermal cold water type *C. pelagicus* survived rather abundantly till the time of the *G. oceanica* Zone and less abundantly during the time of *E. huxleyi* Zone (s. l.). The final conclusion concerning biostratigraphy and paleo-environmental changes still remains to be given by a further study including analyses of the temperature-dependent morphotypes of the eurythermal species, *G. oceanica*, *E. huxleyi*, and *U. mirabilis*.

Acknowledgments

We are grateful to Dr. S. NISHIDA of Nara University of Education and Dr. T. TAKAYAMA of Kanazawa University for their helpful instructions, encouragements, and critical readings of the manuscript. Special thanks are due to Dr. Y. ENDO of the Geological Survey of Japan, whose instruction and suggestion regarding SEM observations of C. TOKOYODA made this study successful.

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