Geological Survey of Japan Cruise Report No. 24, p. 191-198, 1999

XV. PRELIMINARY REPORT ON THE DISTRIBUTION OF PLANKTIC FORAMINIFERA IN SURFACE SEDIMENTS FROM THE SEAS OFF TOKAI, JAPAN

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Abstract

The relative abundance and distribution patterns of planktic foraminifera in surface sediments from the seas off Tokai have been determined from 19 surface sediment samples. Twenty planktic foraminifera species were distinguished, of which five are described as predominant. They are *Globigerina bulloides, Globorotalia inflata, Neogloboquadrina dutertrei, Neogloboquadrina incompta,* and *Pulleniatina obliquiloculata.* The distributions of these five species are closely related to the flowing pattern of the Kuroshio, as well as general hydrographic conditions of the study area. *G. bulloides* is rich in the coastal and a cold water mass areas where food supply is sufficient to form an eutrophic condition, whereas *G. inflata* is rich in the offshore area. *N. dutertrei* and *P. obliquiloculata* abundantly occur in the current axis area of the Kuroshio which flows parallel to central Honshu. *N. incompta* shows high abundance in the cold water mass area which appears when the Kuroshio meanders southward within a large region off central Honshu.

Introduction

The planktic foraminiferal assemblages accumulated in surface sediments reflect specific oceanographic conditions of overlying seas. The distribution of planktic foraminifera seems to be related to the changes of paths of the Kuroshio which flows parallel to or flows east off south of central Honshu.

In this preliminary report, we attempted to find the relative frequency (%) distributions of planktic foraminifera in the surface sediments taken from seas off Tokai and to discuss the relationship between the planktic foraminferal abundance and the oceanographic conditions of overlying seas.

We acknowledge the officers and crew of the R/V Hakurei-maru, Geological Survey of Japan, and the R/V Ajia-maru for their support during our shipboard work.

Hydrographic conditions of the seas off Tokai

The Kuroshio which is one of the most mighty flows in the world runs northeast

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Keywords: planktic foraminifera, surface sediments, seas off Tokai

along the coast of southwest Japan.

Two stable flow patterns have been known for the Kuroshio (Taft, 1972; Nitani, 1975). One runs parallel to Japanese Islands along the upper portion of the continental slope. The other, the meander, leaves the continental slope, and flows off Enshu-nada. Surrounded by the meander, a cold water mass characterized by upwelling and overflow occurs (Nan'niti, 1958, 1960). As a result, the SST there is 4 to 5°C lower than mean values (Fujimori, 1964).

Material and methods

We examined 19 surface sediment samples for relative frequency (%) distributions of planktic foraminifera in the seas off Tokai. Surface sediment samples were selected along the three transects off Izu, off Omaezaki, and off Hamamatsu, respectively. The sampling sites are shown in Table XV-1 and Fig. XV-1.

The samples were washed and sieved through 63 μ m sieve. Sediments coarser than 63 μ m were split with a microsplitter until the amount was reduced to obtain enough but least numbers of foraminiferal specimens. The planktic foraminifera counting were made on splits of more than 100 specimens which are larger than 180 μ m. All specimens were picked, mounted on assemblage-slides and identified.

Table XV-1 Locations and water depths of surface sediment samples used in this study.

Station No.	Latitude N	Longitude E	Water Depth (m)
55	34° 32.84'	138° 49.90'	146
57	34° 26.60'	138° 55.67'	860
60	34° 17.15'	139° 04.33'	530
61	34° 14.15'	139° 07.62'	70
101	34° 41.72'	138° 16.77'	37
102	34° 38.47'	138° 19.89'	252
103	34° 35.36'	138° 22.87'	368
104	34° 32.20'	138° 25.82'	970
105	34° 29.22'	138° 28.73'	2035
116	34° 23.45'	138° 28.22'	2431
117	34° 20.40'	138° 31.42'	2770
118	34° 17.20'	138° 34.76'	1537
120	34° 10.00'	138° 41.08'	2100
171	34° 36.51'	137° 38.65'	77
184	34° 30.82'	137° 37.97'	291
196	34° 25.21'	137° 37.08'	685
208	34° 19.75'	137° 36.13'	1065
219	34° 13.75'	137° 35.60'	1589
229	34° 11.31'	137° 31.91'	1321

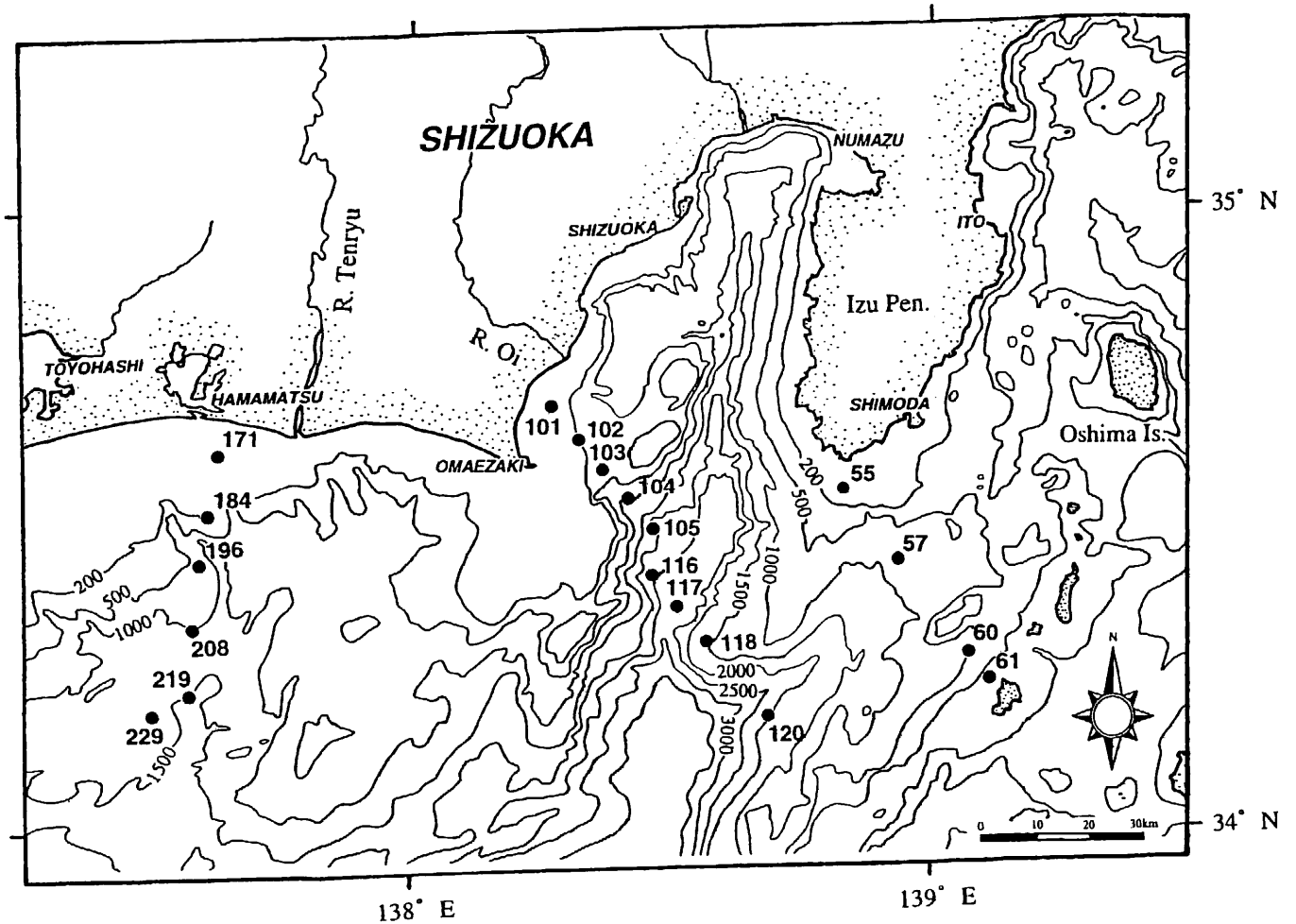

Fig. XV-1 Map showing the localities of surface sediment samples off Tokai, Japan

Table XV-2 Percent frequency distribution of planktic foraminifera in surface sediments off Hamamatsu section.

Sample (GH97-GA97) No.	171	184	196	208	229	219
depth	77m	291m	685m	1065m	1321m	1589m
Globigerina bulloides	12.1	20.2	12.8	18.1	26.1	16.2
Globigerina falconensis	0	7.7	2.6	3.6	2.6	1.5
Globigerina quinqueloba	0	0	0	0	0	0
Globigerinita glutinata	3	0	0	9.6	9.2	10.3
Globigerinella aequilateralis	3	2.9	0	0	0.7	1.5
Globigerinella calida	0	0	0	0	0	0
Globigerinoides conglobatus	3	0	2.6	0	0	1.5
Globigerinoides ruber	3	10.6	7.7	7.2	6.5	10.3
Globigerinoides sacculifer	3	4.8	0	0	1.3	1.5
Globigerinoides tenellus	0	0	0	1.2	0	0
Globorotalia hirsuta	0	1	0	0	0	0
Globorotalia inflata	3	8.7	12.8	15.7	7.8	20.6
Globorotalia menardii	0	1.9	0	1.2	0	1.5
Globorotalia scitula	0	0	0	0	0.7	1.5
Globorotalia truncatulinoides	0	0	0	0	0	0
Neogloboquadrina dutertrei	36.4	24	35.9	16.9	19	11.8
Neogloboquadrina incompta	12.1	7.7	17.9	19.3	13.1	10.3
Orbulina universa	0	1	0	0	0	0
Pulleniatina obliquiloculata	21.2	9.6	7.7	7.2	12.4	11.8
Tenuitella iota	0	0	0	0	0.7	0

Planktic foraminiferal records in surface sediments

Preservation of planktic foraminiferal specimens in 19 sediment samples are generally good except 2 samples (Nos. 118 and 120) off Omaezaki section. However, ill-preserved specimens are brown or green and are probably reworked ones. Those are frequently recognized in almost all samples. Tables XV-2-4 show the relative frequency (%) distributions of planktic foraminifera except for ill-preserved specimens. Among these 19 samples, a total of 20 species belonging to 9 genera were recognized. Predominant species with maximum relative frequencies greater than 10 % in at least two samples of each transect section are: *Globigerina bulloides, Globorotalia inflata*, *Neogloboquadrina dutertrei, Neogloboquadrina incompta*, and *Pulleniatina obliquiloculata*. These five species constitute more than 80% of the planktic foraminiferal assemblage in every one of the surface samples. Besides these species, *Globigerinita glutinata, Globigerinoides ruber* and *Globigerinoides sacculifer* are also commonly found. The occurrences of the rest are sporadic and rare in surface sediments, and the percent frequency does not exceed 5% in any of the examined samples.

Five representative species which show higher percent frequency distribution patterns in surface sediments of the seas off Tokai are discussed below.

Globigerina bulloides (d'Orbigny)

The percent frequencies of this species range from 5.5% to 51.0%. Higher frequencies of 30-51% are shown in the coastal water area off Omaezaki section. This

Table XV-3 Percent frequency distribution of planktic foraminifera in surface sediments off Omaezaki section.

Sample (GH97-GA97) No.	101	102	103	104	105	116	117	118	120
Globigerina bulloides	14.3	26.1	51	39.8	11.1	19.5	8.2	15	8.2
Globigerina falconensis	0	2.2	1	0	0	3.3	0	2.8	0
Globigerina quinqueloba	0	0	0	1.1	0	0	0	0.9	0
Globigerinita glutinata	4.1	3.3	2.1	2.3	0	3.3	3.3	5.6	7.4
Globigerinella aequilateralis	0	2.2	0	1.1	2.8	0	0	0	2.5
Globigerinella calida	0	2.2	0	0	0	0	0	0	0
Globigerinoides conglobatus	2	1.1	1	0	0	0.8	0	0	0
Globigerinoides ruber	14.3	5.4	9.4	1.1	8.3	6.5	1.6	3.3	3.3
Globigerinoides sacculifer	2	2.2	4.2	1.1	5.6	1.6	3.3	0.9	0
Globigerinoides tenellus	2	1.1	1	0	0	0	0	0	0
Globorotalia inflata	12.2	7.6	4.2	9.1	16.7	7.3	24.6	15	20.5
Globorotalia menardii	0	0	0	1.1	0	0.8	0	1.4	3.3
Globorotalia truncatulinoides	0	0	0	0	0	1.6	0	0.5	0.8
Neogloboquadrina dutertrei	32.7	26.1	11.5	31.8	30.6	30.1	26.2	16	31.1
Neogloboquadrina incompta	0	12	7.3	3.4	13.9	16.3	19.7	31	12.3
Orbulina universa	0	0	0	0	0	0	0	0.5	0
Pulleniatina obliquiloculata	16.3	8.7	7.3	8	11.1	8.9	13.1	7	10.7

Table XV-4 Percent frequency distribution of planktic foraminifera in surface sediments off Izu section.

Sample (GH97-GA97) No.	55	57	60	61
Globigerina bulloides	24.4	35.1	7.3	5.5
Globigerina falconensis	1.5	4.5	0	0
Globigerina quinqueloba	0	0	0	0
Globigerinita glutinata	3.5	2.3	1.2	0
Globigerinella aequilateralis	1.5	1.8	0	0
Globigerinella calida	0	0.9	0	0
Globigerinoides conglobatus	0.5	0.5	2.4	9.1
Globigerinoides ruber	14.9	7.2	7.3	5.5
Globigerinoides sacculifer	4.5	3.2	4.9	14.5
Globigerinoides tenellus	1	0.5	0	0
Globorotalia hirsuta	0	0.5	0	0
Globorotalia inflata	15.4	1.8	14.6	20
Globorotalia menardii	3	1.4	0	1.8
Globorotalia scitula	0	0.9	0	0
Globorotalia truncatulinoides	2.5	0.5	6.1	0
Neogloboquadrina dutertrei	12.9	12.2	30.5	18.2
Neogloboquadrina incompta	8	18.9	1.2	3.6
Orbulina universa	0.5	0	0	0
Pulleniatina obliquiloculata	6	8.1	24.4	21.8

species is commonly found in surface sediments of the three sections. However, lower frequencies less than 10% extend to offshore area off both Omaezaki and Izu sections.

Globorotalia inflata (d'Orbigny)

This species shows the percent frequencies ranging from 3.0% to 24.6%. Higher frequency exceeding 15% extends to offshore area.

Neogloboquadrina dutertrei (d'Orbigny)

This species shows percent frequencies higher than 10.0% in all samples with the maximum at 36.4% at the coastal area off Hamamatsu section.

Neogloboquadrina incompta (Cifelli)

This species shows the percent frequencies ranging from 0.0% to 31.0%. Higher frequencies of more than 15.0% are recognized in continental slope area off both Hamamatsu and Omaezaki sections. Lower frequencies of less than 5.0% are shown in all samples off Izu section and coastal area off Omaezaki section. Higher frequencies exceeding 15% extend to offshore area off Hamamatsu and Omaezaki sections where it seems to be optimal for the flourishment of this species.

Pulleniatina obliquiloculata (Parker and Jones)

This species shows the percent frequencies ranging from 6.0% to 25.0%. Higher frequencies more than 20% are mainly recognized in offshore area of Izu section.

Discussion

As mentioned above, two stable branches have been known for the Kuroshio in the study area. One branch runs parallel to Japanese Islands along the upper portion of the continental slope. Two species *N. dutertrei* and *P. obliquiloculata,* defined as gyre margin species by Takemoto and Oda (1997), are the representative species in active current system (Bé, 1977). The consistent abundance of both species in the seas off Tokai can be regarded as an indicator of the axis of the Kuroshio current. The difference in relative frequencies between *N. dutertrei* and *P. obliquiloculata* in surface sediments may be due to a different range of temperature tolerance of the two species. According to Bé, (1977), *N. dutertrei* is a tropical-subtropical species and abundantly occurs in water with temperatures between 10°C to 30°C. On the other hand, *P. obliquiloculata* is a tropical species and abundantly occurs in water with temperatures between 18°C and 30°C. Thus, the temperature tolerance of *N. dutertrei* is wider than that of *P. obliquiloculata,* and the water temperature in the seas off Tokai may be relatively low for *P. obliquiloculata.*

The distribution of planktic foraminifera is related to the change of paths of the Kuroshio which flows east south of central Honshu. When the Kuroshio meanders within a large region south of central Honshu, a cold water mass characterized by upwelling and overflow occurs. According to Sautter and Thunell (1989), who give *Neogloboquadrina incompta* as *N. pachyderma* (d), *N. incompta* prefers cool, eutrophic water where the primary production is high. As *N. incompta* is a transitional water species, and especially a cold water mass species in the domain of the Kuroshio region (Oda and Takemoto, 1992; Takemoto and Oda, 1997), its enrichment in the offshore area off both Hamamatsu and Omaezaki sections is due to the influence of the a cold water mass. *G. bulloides* is a well-known subpolar and upwelling representative species (Bé, 1977). Takemoto and Oda (1997) suggested that this species can tolerate wide ranges of sea surface temperatures and its abundance depends largely on food supply. A consistent and abundant occurrence of *G. bulloides* in seas off Tokai except the offshore area off Izu section may be also due to the influence of upwelling of cold water.

Conclusions

Twenty species belonging to nine genera are recognized in 19 surface sediment samples from the seas off Tokai. The distributional pattern exhibited by the planktic foraminiferal fauna is closely related to the hydrographic conditions. The distribution of five predominant species, *Globigerina bulloides, Globorotalia inflata, Neogloboquadrina dutertrei, Neogloboquadrina incompta* and *Pulleniatina obliquiloculata* can be interpreted as follows:

1. The coastal water area is characterized by *G. bulloides* and the offshore area by *G. inflata.*

2. The axis of the Kuroshio current is dominated by *N. dutertrei* and *P.*

obliquiloculata, whereas the cold water mass area related to the meander of the Kuroshio is dominated by higher frequencies of *N. incompta* associated with *G. bulloides*.

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