

1. PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN—BIOSTRATIGRAPHIC AND CHRONOSTRATIGRAPHIC ANALYSES¹

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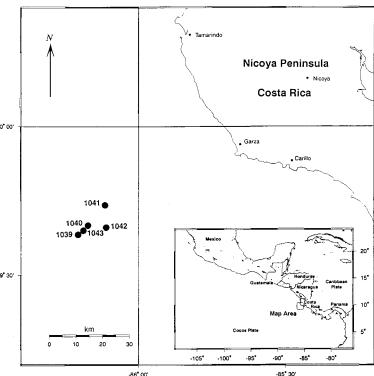
ABSTRACT

From October to December in 1996, Sites 1039 through 1043 were drilled on the lower continental slope and the bottom of the Middle American Trench. Planktonic foraminifers were obtained from 377 samples of the total 487 examined. The Pliocene- to Pleistocene-age sediments of Sites 1039 and 1043 are continuous from Zones N19 through N23. At Sites 1039 and 1040, middle Miocene sediments are also continuous, encompassing Zones N8 through N12. The sequences of the upper part of Sites 1040, 1041, 1042, and 1043 are décollements, tentatively assignable to Zone N19 for Sites 1040, 1041, and 1042 and to Zone N22 for Site 1043. The oldest sediments of these sites are assigned to Zone N7 (latest early Miocene), ~17 Ma in age.

INTRODUCTION

In 1996, Sites 1039 through 1043 were drilled on the lower continental slope and the bottom of the Middle American Trench off the Nicoya Peninsula, Costa Rica, in the East Pacific Ocean (Fig. F1). Planktonic foraminifers were obtained from 377 samples of the total 487 examined. In this article, biostratigraphic and chronostratigraphic analyses of these planktonic foraminifers are presented.

F1. Location of Leg 170 drill sites, p. 7.



¹Ibaraki, M., 2000. Planktonic foraminifers off Costa Rica in the East Pacific Ocean—biostratigraphic and chronostratigraphic analyses. In Silver, E.A., Kimura, G., and Shipley, T.H. (Eds.), *Proc. ODP, Sci. Results*, 170, 1–58 [Online]. Available from World Wide Web: <http://www-odp.tamu.edu/publications/170_SR/VOLUME/CHAPTERS/SR170_01.PDF>. [Cited YYYY-MM-DD]

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METHODS

Biostratigraphic and chronostratigraphic analyses of planktonic foraminifers presented here have been made by the author's shipboard examinations of all core-catcher samples and subsequent onshore examinations of additional samples.

A sample of 10 cm³ (except core-catcher samples) was washed through a 250-mesh screen (0.062 mm) and dried in an oven. Planktonic foraminifers greater than 0.125 mm were selected from the washed residue, and the frequency of occurrence of each species was calculated. Quantitative analyses of species abundances are shown in Tables T1, T2, T3, T4, and T5.

The biostratigraphic zonation of planktonic foraminifers is that of Blow (1969), and chronologic calibrations of Blow's zones are based on those given by Berggren et al. (1995).

Planktonic Foraminiferal Biostratigraphies of Sites 1039 through 1043

As a result of biostratigraphic analyses on sequences of all the sites, the following planktonic foraminiferal zones can be recognized. The lowest part of the Hole 1039C is included in Zone N7 of the latest early Miocene. This is the oldest horizon examined in this time. At Sites 1039 and 1040, middle Miocene assemblages are dominant, and biostratigraphic Zones N8 through N12 are successively established. No late Miocene index species of planktonic foraminifers were recovered. Zones N18 through N23 of the Pliocene–Pleistocene are recognized in the lower part of Hole 1043A, and the Miocene/Pliocene and Pliocene/Pleistocene boundaries were recovered. The sequences of the upper parts of the Sites 1040, 1041, 1042, and 1043 are considered to be décollements (Kimura, Silver, Blum, et al., 1997). Décollements of Sites 1040, 1041, and 1042 are probably assigned to Zone N19 of the Pliocene, and those of Site 1043 are assignable to Zone N22 of the Pleistocene. In the sequences of décollements, no planktonic foraminiferal zonal markers were observed, and reworked species of older ages were frequently found. The lowest sample of Site 1041 is assignable to Zone N10, and that of Site 1042 to Zone N12, which is younger than overlying sequences.

Site 1039

Site 1039 is located immediately seaward of the Middle American Trench, at a water depth of 4351.7 m (Kimura, Silver, Blum, et al., 1997). Planktonic foraminifers are present in all three holes drilled at the site (Holes 1039A, 1039B, and 1039C). Planktonic foraminifers in samples of Site 1039 range from the latest early Miocene to the Pleistocene in age. However, no late Miocene index species were obtained. Hole 1039A, drilled to 28.42 mbsf and composed of three cores, contains only Holocene planktonic foraminifers. Another two holes—Holes 1039B and 1039C, which penetrated to 384.3 and 448.7 mbsf, respectively—contain planktonic foraminifers in most core-catcher samples except Cores 170–1039B-20X and 41X (Table T1).

Hole 1039A and Samples 170–1039B-1H-CC through 18X-CC correspond to Zones N19 to N23 of the Pliocene to Pleistocene (Fig. F2). For Hole 1039B, 148 samples have been examined. The last occurrence (LO)

T1. Distribution of planktonic foraminifers, Site 1039, p. 10.

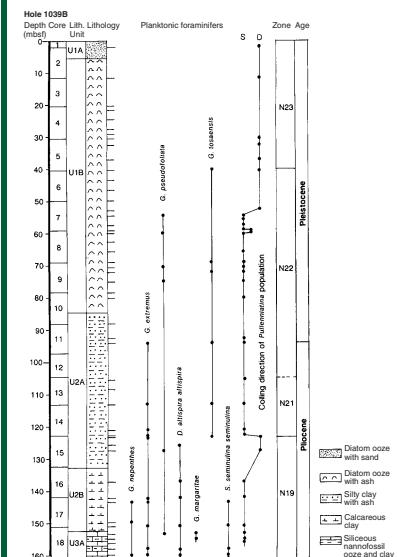
T2. Distribution of planktonic foraminifers, Site 1040, p. 30.

T3. Distribution of planktonic foraminifers, Site 1041, p. 36.

T4. Distribution of planktonic foraminifers, Site 1042, p. 48.

T5. Distribution of planktonic foraminifers, Site 1043, p. 50.

F2. Selected planktonic foraminiferal ranges for Cores 170–1039B-1H through 18X, p. 8.



of *Globorotalia tosaensis* is recognized in Sample 170-1039B-5H-7, 45–47 cm, which indicates an age of 0.65 Ma, assignable to the base of Zone N23. The LO of *Globigerinoides extremus* is recognized in Sample 170-1039B-11H-5, 46–49 cm, indicating a level approximately correlative with the Pliocene/Pleistocene boundary (1.77 Ma). The first appearance of *G. tosaensis* is recognized in Sample 170-1039B-15X-1, 46–48 cm, which indicates an age of 3.35 Ma, assignable to the base of Zone N21. Zones N14 to N18 of the middle Miocene to the early Pliocene can not be established. Zone N13 to N8 of the middle Miocene, corresponding to the lower part of Hole 1039B and the upper part of Hole 1039C, are defined by index species, respectively. The lowest sequence of Site 1039 is assigned to Zone N7 based on the occurrence of *Catapsydrax stainforthi* in Sample 170-1039C-6R-CC.

Site 1040

Site 1040 is located on the area 1.6 km upslope from the toe of the slope off the Nicoya Peninsula, Costa Rica, at a water depth of 4177.0 m (Kimura, Silver, Blum, et al., 1997). Planktonic foraminifers were obtained from all three holes at the site (Holes 1040A, 1040B, and 1040C). Some zonal marker species in these sequences were examined (Table T2).

Planktonic foraminifers in samples from Holes 1040A, 1040B, and the upper part of Hole 1040C are rare or absent, and poorly preserved, and some age marker species of the Miocene to Pleistocene are mixed in the sequences. This interval corresponds to a décollement. Holes 1040A and 1040B and the upper part of Hole 1040C are assigned to Zone N19 of the Pliocene because of the presence of *Dentoglobigerina altispira altispira* and *Sphaeroidinella dehiscens*. The oldest sample of Hole 1040B ranges from 5.32 to 3.95 Ma in the Pliocene, based on the occurrence of sinistrally coiled *Pulleniatina primalis* and *S. dehiscens*. Samples from Cores 170-1040C-1R through 24R are assignable to Zone N19.

Below the décollement, Zones N21, N22, and N23 of the late Pliocene to the Pleistocene are recognized in the interval of Samples 170-1040C-23R-1, 46–48 cm, through 31R-3, 46–48 cm. The base of Zone N23 is recognized at Sample 170-1040C-26R-6, 27–29 cm, based on the LO of *G. tosaensis*. The base of Zone N22 is recognized at Sample 170-1040C-29R-2, 45–47 cm, based on the first appearance of *Globorotalia truncatulinoides*. The base of Zone N21 could not be defined. No late Miocene planktonic foraminifer index species were recovered. Sample 170-1040C-36R-CC is assignable to Zones N13–14 of the middle Miocene. Zones N12, N10, N9, and N8 of the lower middle Miocene are recognized in the interval of Core 170-1040C-36R-CC through the basal core, based on zonal marker species.

At both Sites 1039 and 1040, no upper Miocene sequence was recovered.

Site 1041

The Site 1041 is located on the midslope of the Costa Rica margin, 12 km up from the toe of the slope off the Nicoya Peninsula at a water depth of 3306.0 m (Kimura, Silver, Blum, et al., 1997). For Hole 1041A, 93 samples have been studied. Planktonic foraminifers are rare in samples from this hole (Table T3); however, some age marker species are found. Samples 170-1041A-3X-CC and 17X-CC contain Miocene and Pliocene assemblages. *G. tosaensis* is present in samples from 170-

1041A-5X-CC through 14X-CC. This species ranges from Zone N21 to N22, (Pliocene to Pleistocene; 3.35 to 0.65 Ma). In Sample 170-1041A-5X-CC, the LO of *G. extremus* is recognized, indicating an age of 1.77 Ma. The basal section from Hole 1041A, Sample 170-1041A-18X-CC, contains dextrally coiled *P. primalis*, by which the sample is assignable to the Pliocene (3.95–3.65 Ma). Sample 170-1041B-1R-CC contains *Globorotalia margaritae*, indicating Zone N19 of the Pliocene, and the basal sample from the core, 170-1041B-25R-CC, contains *Globorotalia crassaformis*, ranging from Zone N19 of the Pliocene to the Holocene. All sequences of Hole 1041B are assigned tentatively to Zone N19 of the Pliocene, although some cores include late Miocene planktonic foraminifers. The basal core of Hole 1041C contains *Globorotalia peripheroronta*, which disappears within Zone N10. The basal sequences are, therefore, assignable to Zone N10 or older (middle Miocene).

Site 1042

Site 1042 is located in the seaward edge of the high-amplitude, top-of-prism reflection and 8 km southwest of Site 1041 (Kimura, Silver, Blum, et al., 1997). Planktonic foraminifers are rare to barren in examined samples from Holes 1042A and 1042B (Table T4). Some zonal intervals are identified on the basis of a few diagnostic species.

In Hole 1042A, spot core samples are obtained every 50 m. Planktonic foraminifers were obtained from 10 samples among the 19 examined. Cores 170-1042A-1R through 3R include age-marker species. The sediments of Samples 170-1042A-1R-CC through 3R-CC contain sinistrally coiled *P. primalis*, which ranges in age from 3.95 to 3.65 Ma, and *Sphaeroidinellopsis* spp. Sediments from Sample 170-1042A-2R-CC include *Globorotalia tumida* and *G. margaritae*, indicating Zone N19. The sequences are, therefore, probably assigned to Zone N19 (Pliocene). In Samples 170-1042A-5R-CC and 7R-CC, planktonic foraminifers of the Pleistocene, early middle Miocene, and Eocene are found mixed.

Samples 170-1042B-3R-CC, and 4R-1, 72–77 cm, marker species of Zones N8 and N10 (middle Miocene), are present. The basal core of Site 1042 is assigned to Zone N12 of the middle Miocene, based on the occurrence of *Globorotalia foehsi robusta*, *Globorotalia mayeri*, and *Globorotalia praemenardii*. Thus, the basal sequences of Hole 1042B are younger than the overlying sequences.

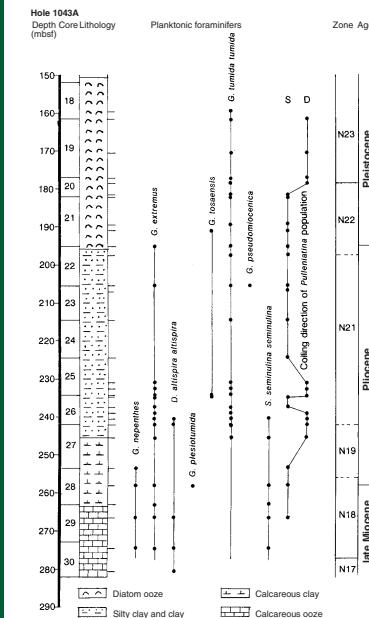
Site 1043

Site 1043 is located on the lowest continental slope of the Middle American Trench off the Nicoya Peninsula (Kimura, Silver, Blum, et al., 1997). Planktonic foraminifers in samples at the site range from the late Miocene to the Pleistocene in age, and zonations are established for Cores 170-1043A-18X through 30X.

Planktonic foraminifers were obtained for 92 of the 108 samples examined (Table T5). Sequences of Cores 170-1043A-18X through 30X are assignable to Zones N17 through N23 (late Miocene to Pleistocene) (Fig. F3).

The upper part of Hole 1043A, Cores 170-1043A-1H through 17X, correspond to the décollement assigned to the Pleistocene. Samples 170-1043A-20X-2, 45–47 cm, through 22X-2, 45–47 cm, are assignable to Zone N22; sequences above Sample 170-1043A-20X-2, 45–47 cm, are assigned to Zone N23. The LO of *G. extremus* is recognized in Sample

F3. Selected planktonic foraminiferal ranges for Cores 170-1043A-18X through 30X, p. 9.



170-1043A-21X-CC, indicating an age of 1.77 Ma, probably assignable to the Pliocene/Pleistocene boundary.

Cores 170-1043A-22X through 26X are assigned to the lower part of Zone N21, based on the presence of *G. tosaensis*, *Sphaeroidinellopsis seminulina*, and dextrally coiling *Pulleniatina*. Core 170-1043A-27X includes Zone N19 of the Pliocene. The Miocene/Pliocene boundary is examined in Sample 170-1043A-28X-4, 45–47 cm, based on the occurrence of abruptly increased Miocene planktonic foraminifers. The base of Zone N18 is recognized in Sample 170-1043A-30X-3, 45–47 cm, in which the first appearance of *G. tumida* is examined. The basal core of Hole 1043A is assigned to Zone N17 of the late Miocene.

Changes of the coiling direction of *Pulleniatina* are useful markers of datum planes. In this core, five horizons of coiling changes are recognized. Of these, a coiling change from sinistral to dextral between Sample 170-1043A-27X-2, 44–46 cm, and 27X-CC, is estimated at 3.95 Ma and correlates to the Pliocene (Berggren et al., 1995). In this core, sinistral horizons of Core 170-1043A-26X are estimated at ~3.1 Ma, based on the presence of *Globorotalia multicamerata* in Sample 170-1043A-25X-5, 46–48 cm.

ACKNOWLEDGMENTS

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Figure F1. Location of Leg 170 drill sites off the Nicoya Peninsula on the Pacific coast of Costa Rica.

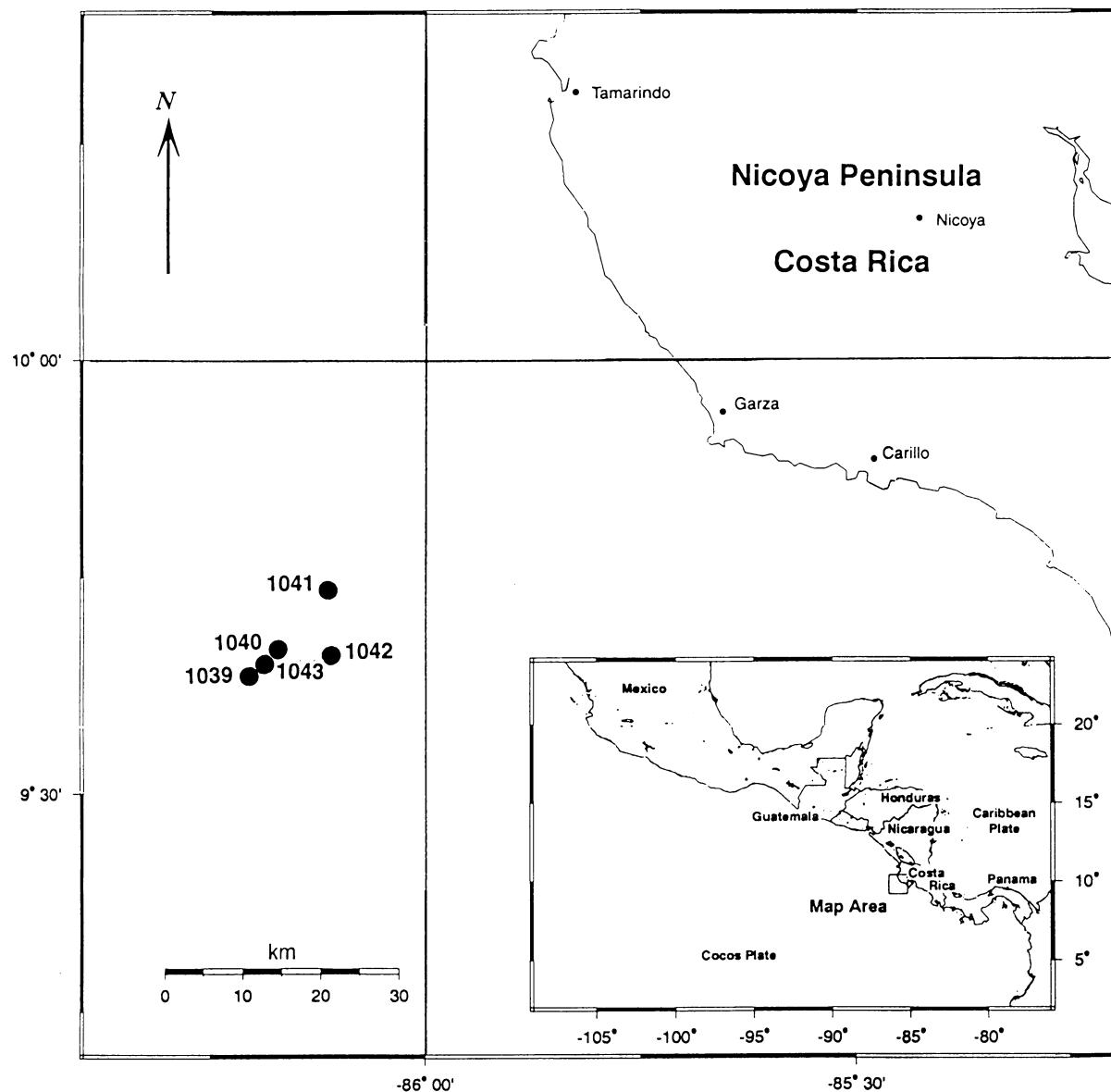


Figure F2. Selected planktonic foraminiferal ranges for Cores 170-1039B-1H through 18X. Ranges are indicated with reference to depth and core number.

Hole 1039B

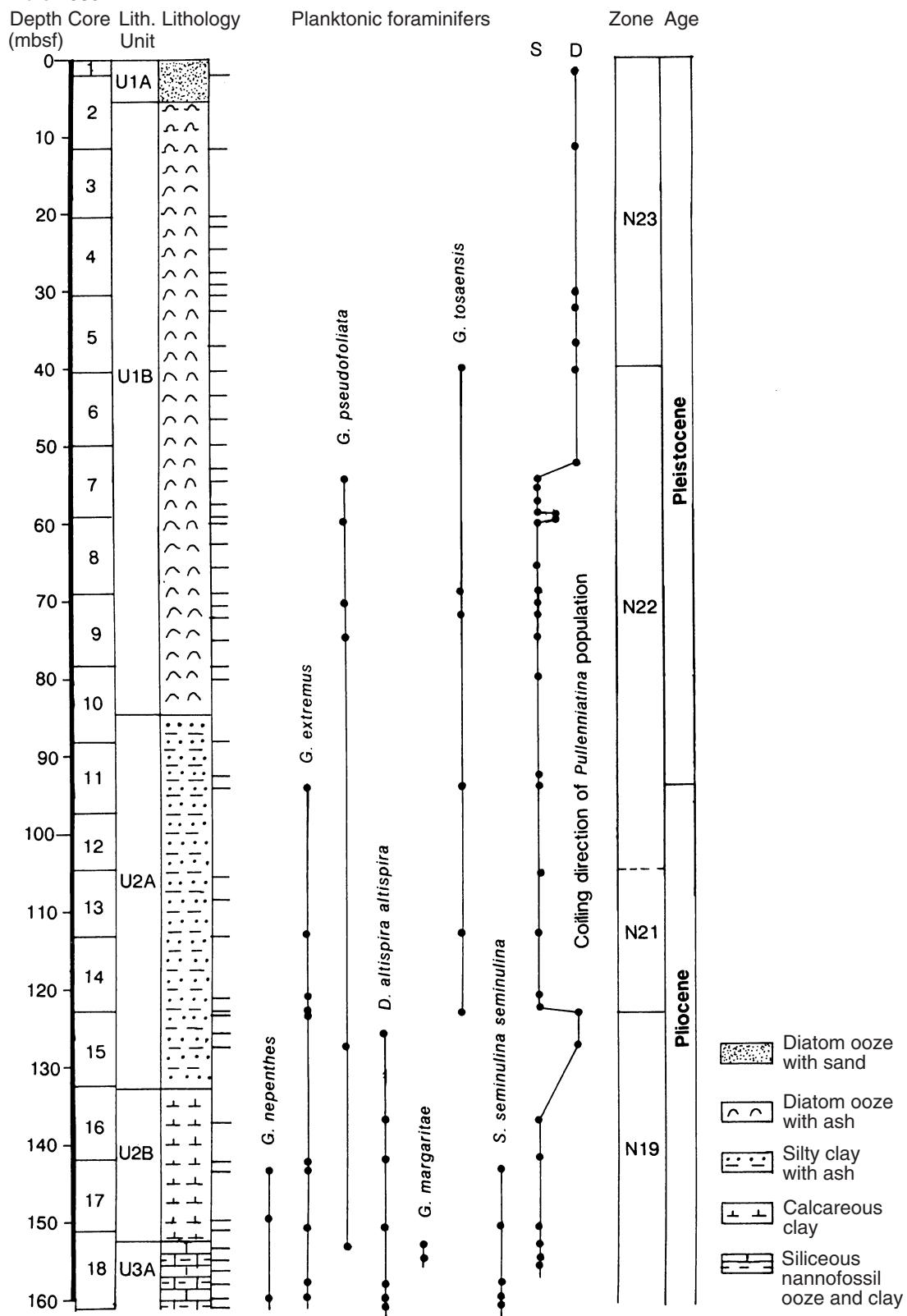


Figure F3. Selected planktonic foraminiferal ranges for Cores 170-1043A-18X through 30X. Ranges are indicated with reference to depth and core number.

Hole 1043A

Depth Core Lithology
(mbsf)

Planktonic foraminifers

Zone Age

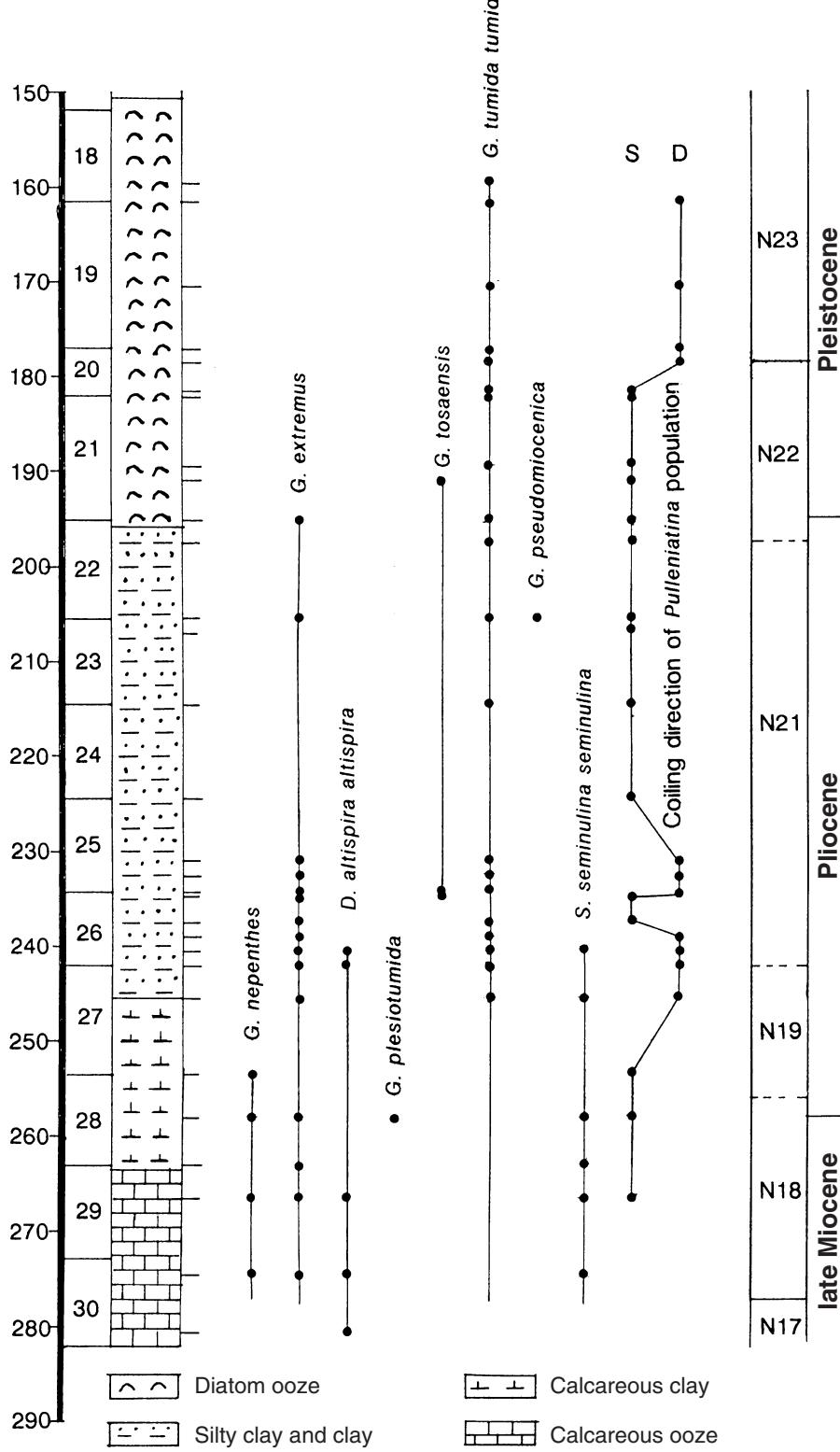


Table T1. Distribution of planktonic foraminifers in Holes 1039A, 1039B, and 1039C. (See table note. Continued on next 19 pages.)

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T1 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T1 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

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PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T1 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN
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Table T1 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

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PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T1 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T1 (continued).

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerina angustumiliata</i>	<i>Globigerina apertura</i>	<i>Globigerina bulloides</i>	<i>Globigerina ciperoensis</i>	<i>Globigerina decoraperta</i>	<i>Globigeina duryi</i>	<i>Globigerina eamesi</i>	<i>Globigerina falconensis</i>	<i>Globigerina foliata</i>	<i>Globigerina nepenthoides</i>	<i>Globigerina praebullroides</i>	<i>Globigerina quinqueloba</i>	<i>Globigerina rubescens</i>	<i>Globigerina sellii</i>	<i>Globigerina woodi</i>	<i>Globigerinoides bolivi</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides cyclostomus</i>	<i>Globigerinoides diminutus</i>	<i>Globigerinoides elongatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerinoides immaturus</i>	<i>Globigerinoides mitra</i>	<i>Globigerinoides obliquus</i>	<i>Globigerinoides parawoodi</i>	<i>Globigerinoides pyramidalis</i>	<i>Globigerinoides quadribulatum</i>	<i>Globigerinoides saccifer</i>
2R-1, 65-100	375.85																											6.5	
3R-CC	386.69																											9.8	
4R-CC	393.60																											10.3	
5R-CC	403.06																											2.8	
6R-CC	417.28																											3.9	
7R-CC	425.50																											*	

Note: * = trace (counts <50 specimens in sample).

Table T1 (continued).

Table T1 (continued).

Table T1 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerinella praesiphonifera</i> <i>Bella digitata</i> <i>Pulleniatina obliquiloculata</i> <i>Pulleniatina primalis</i> <i>Neogloboquadrina acostaensis</i> <i>Neogloboquadrina asanoi</i> <i>Neogloboquadrina blowi</i> <i>Neogloboquadrina continua</i> <i>Neogloboquadrina dutertrei</i> <i>Neogloboquadrina eggeri</i> <i>Neogloboquadrina humerosa</i> <i>Neogloboquadrina incompta</i> <i>Neogloboquadrina pachyderma</i> <i>Sphaeroidinella dehisicens</i> <i>Sphaeroidinellopsis seminulum</i> <i>Sphaeroidinellopsis subdehisicens</i> <i>Globigerinatell insuetia</i> <i>Globorotaloides hexagona</i> <i>Globorotaloides suteri</i> <i>Clavatorella bermudezi</i> <i>Candidina nitida</i> <i>Cratospyrax stainforthi</i> <i>Cratospyrax parvula</i>				
2R-1, 65-100 3R-CC 4R-CC 5R-CC 6R-CC 7R-CC	375.85 386.69 393.60 403.06 417.28 425.50	0.8	2.0	1.4 0.3 0.5	1.4 3.5 2.5 1.0	3.9

Table T2. Distribution of planktonic foraminifers in Holes 1040A and 1040B. (See table note. Continued on next five pages.)

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T2 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T2 (continued).

Table T2 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerina angustumbilicata</i>	<i>Globigerina apertura</i>	<i>Globigerina bulloides</i>	<i>Globigerina duryi</i>	<i>Globigerina falconensis</i>	<i>Globigerina nepenthes</i>	<i>Globigerina nepenthoides</i>	<i>Globigerina praebulloides</i>	<i>Globigerina pseudoceroensis</i>	<i>Globigerina quinqueloba</i>	<i>Globigerina tuberculata</i>	<i>Globigerina selli</i>	<i>Globigerina woodi</i>	<i>Globigerinoides bolivi</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides cyclostomus</i>	<i>Globigerinoides diminutus</i>	<i>Globigerinoides elongatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerinoides immaturus</i>	<i>Globigerinoides mitra</i>	<i>Globigerinoides obliquus</i>	<i>Globigerinoides parawoodi</i>	<i>Globigerinoides quadrilobatus</i>	<i>Globigerinoides ruber</i>	<i>Globigerinoides sacculifer</i>	<i>Globigerinoides sicarus</i>	<i>Globigerinoides subquadratus</i>	<i>Globigerinoides tenellus</i>	<i>Globigerinoides trilobus</i>	<i>Globiquadrina barremoensis</i>	<i>Globiquadrina conglomera</i>	<i>Globiquadrina dehiscens advena</i>	<i>Globiquadrina dehiscens dehiscens</i>
18R-CC	327.11																																		
19R-CC	338.33	*	*																																
20R-CC	350.78		*																																
22R-CC	371.21			3.3	1.9																														
23R-CC	376.20					1.9																													
24R-CC	385.60						5.7																												
25R-CC	397.88																																		
26R-CC	405.74																																		
27R-CC	417.37																																		
28R-CC	425.30																																		
29R-3,	432.57																																		
30R-CC	446.73																																		
31R-CC	454.17																																		
34R-CC	483.46																																		
35R-CC	491.79																																		
36R-CC	502.33																																		
37R-CC	511.76																																		
38R-6	523.13																																		
39R-CC	531.31																																		
40R-CC	544.31																																		
41R-CC	553.94	2.5																																	
42R-CC	563.46																																		
43R-CC	568.57	2.7																																	
44R-CC	579.31	6.7																																	
45R-CC	590.02	0.2																																	
46R-CC	598.86	1.9																																	
47R-CC	611.78	0.8																																	
48R-CC	624.45	2.3																																	
49R-CC	629.99	2.7																																	
50R-CC	638.28	4.1																																	
51R-CC	646.55																																		
52R-2,125-130	650.92																																		

Note: * = trace (counts <50 specimens in sample).

Table T2 (continued).

Table T2 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T3. Distribution of planktonic foraminifers in Holes 1041A, 1041B, and 1041C. (Continued on next 11 pages.)

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T3 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T3 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T3 (continued).

Table T3 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerinella obesa</i>	<i>Globigerinella praesiphonifera</i>	<i>Globigerinella pseudobesa</i>	<i>Pulleniatina obliquiloculata</i>	<i>Pulleniatina praecursor</i>	<i>Pulleniatina primalis</i>	<i>Neogloboquadrina acostaensis</i>	<i>Neogloboquadrina blowi</i>	<i>Neogloboquadrina continuosa</i>	<i>Neogloboquadrina dutertrei</i>	<i>Neogloboquadrina egeri</i>	<i>Neogloboquadrina humerosa</i>	<i>Neogloboquadrina incompta</i>	<i>Neogloboquadrina pachyderma</i>	<i>Neogloboquadrina pseudopima</i>	<i>Sphaeroidinella dehiscens</i>	<i>Sphaeroidinellopsis seminudina</i>	<i>Sphaeroidinellopsis subdehiscens</i>	<i>Globorotaloides hexagona</i>	<i>Turborotalita humilis</i>	<i>Clavatorella nicobarensis</i>	Total specimens
8X-CC	60.46	5	5					2	59	16	1	12	120							26		495	
9X-1, 44-46	60.04																					2	
9X-2, 46-48	61.56																					0	
9X-3, 45-47	63.05																					1	
9X-4, 45-47	64.55																					0	
9X-5, 40-42	66.00																					0	
9X-6, 46-48	67.56																					9	
9X-CC	69.22	5	1					3	15	10			3	2		1				2	7	161	
10X-1, 46-48	69.06		6				2					2		1						2	2	30	
10X-2, 46-48	70.56																					6	
10X-3, 46-48	72.06	1					3		1			4	2	2						9		81	
10X-4, 46-48	73.56											14		3								25	
10X-5, 47-49	75.07																				3	38	
10X-CC	76.23		2				2	56	79	16		53							83			550	
11X-1, 42-44	78.62																					0	
11X-2, 46-48	80.16																					0	
11X-3, 43-46	81.10																					0	
11X-4, 46-48	82.63	3	2				2	2				9	1		1				8			67	
11X-5, 46-48	84.13		5					21				48	3						14			309	
11X-CC	84.99	2						5				17	1						3			72	
12X-1, 40-42	88.30		5									6		2					4			49	
12X-2, 32-34	89.72																					0	
12X-3, 51-53	91.41																					0	
12X-4, 49-51	92.89																					0	
12X-5, 13-15	94.03		1									4		4					8			36	
12X-6, 29-31	95.69																					0	
12X-CC	96.19						1															1	
13X-1, 10-12	97.60			5				9				18		6	2			24			200		
13X-2, 24-26	99.06																					0	
13X-CC	100.78	11	1	10	5	20						14	2					23			164		
14X-1, 119-121	108.29				3	2												1			15		
14X-CC	112.18			7	15	22												20			139		
15X-1, 46-48	117.16																					0	
15X-2, 61-63	118.20																					0	
15X-3, 46-48	119.55																					0	
15X-5, 46-48	121.48																		1			1	
15X-6, 40-42	122.92																					0	
15X-7, 42-44	123.72																					0	
15X-CC	125.09	3		2	8	27	5	21				17	2		2			17	4			417	

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T3 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN
M. IBAKARI

Table T3 (continued).

Table T3 (continued).

Table T3 (continued).

Table T3 (continued).

Core, section, interval (cm)	Depth (mbsf)														
23R-CC	370.49				<i>Globigerinita glutinata</i>										
24R-CC	381.32				<i>Globigerinita uvula</i>										
25R-CC	388.22	16			<i>Orbulina suturalis</i>										
170-1041C-					<i>Orbulina universa</i>										
1R-CC	397.61				<i>Globorotalia anfracta</i>										
2R-CC	407.51				<i>Globorotalia bimarginata</i>										
3R-CC	415.54	20			<i>Globorotalia bermudezi</i>										
					<i>Globorotalia challengerii</i>										
					<i>Globorotalia clementiae</i>										
					<i>Globorotalia crassiformis</i>										
					<i>Globorotalia inflata</i>										
					<i>Globorotalia margaritae</i>										
					<i>Globorotalia mayeri</i>										
					<i>Globorotalia menardii</i>										
					<i>Globorotalia panda</i>										
					<i>Globorotalia peripheronanda</i>										
					<i>Globorotalia plesiotumida</i>										
					<i>Globorotalia praepumilio</i>										
					<i>Globorotalia puncticulata</i>										
					<i>Globorotalia scitula</i>										
					<i>Globorotalia sickensis</i>										
					<i>Globorotalia sphericomiozea</i>										
					<i>Globorotalia thayeri</i>										
					<i>Globorotalia tosaensis</i>										
					<i>Globorotalia tumida</i>										
					<i>Globorotalia ungulata</i>										
					<i>Globorotalia wilesi</i>										
					<i>Globigerinella aequilateralis</i>										
					<i>Globigerinella calida</i>										

Table T3 (continued).

Table T4. Distribution of planktonic foraminifers in Holes 1042A and 1042B. (Continued on next page.)

Table T4 (continued).

Table T5. Distribution of planktonic foraminifers in Holes 1043A. (See table note. Continued on next eight pages.)

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerina angustumiliicata</i>	<i>Globigerina apertura</i>	<i>Globigerina bulloides</i>	<i>Globigerina decoraperta</i>	<i>Globigerina falconensis</i>	<i>Globigerina nepenthes</i>	<i>Globigerina quinqueloba</i>	<i>Globigerina rubescens</i>	<i>Globigerina woodi</i>	<i>Globigerinoides bolivi</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides cyclostomus</i>	<i>Globigerinoides elongatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerinoides immaturus</i>	<i>Globigerinoides obliquus</i>	<i>Globigerinoides quadrilobatus</i>	<i>Globigerinoides ruber</i>	<i>Globigerinoides saccularis</i>	<i>Globigerinoides tenellus</i>	<i>Globigerinoides trilobus</i>	<i>Globoquadrina barroenensis</i>	<i>Globoquadrina conglobata</i>	<i>Globoquadrina dehiscens</i>	<i>Globoquadrina venezuelana</i>	<i>Dentoglobigerina altispira altispira</i>	<i>Dentoglobigerina altispira globosa</i>	<i>Globigerinita glutinata</i>	<i>Globigerinita uvula</i>	<i>Orbulina bilobata</i>			
170-1043A-																																		
1H-CC	7.99	2.8	10.3	2.5				0.3										1.3	2.5															
2H-CC	16.89	*																*																
3X-CC	21.50	4.4	8.8	4.4				5.5	2.2									2.2																
4X-CC	29.76		6.1	2.0					1.0									0.3	0.3	3.7														
5X-CC	38.93	6.4	0.3	0.3				0.8										0.3		1.1														
6X-CC	48.63	*																*																
7X-CC	59.68		3.1	5.9					1.4									0.7																
8X-CC	69.48	*	*	*					*																									
9X-CC	80.69	1.9	3.5	2.5	0.6	0.3	2.2	2.9										2.2	1.6	2.9	1.0	11.7	1.6	0.6	1.6					1.3	18.7			
10X-CC	86.18	3.4	7.4	4.4	2.5			1.5										0.5	1.0	2.5		20.2	4.4	1.0							18.2			
11X-CC	94.82		4.0	1.9														0.9		2.6	1.4	0.7	20.6	4.4	0.7	1.2					2.3	10.0		
12X-CC	109.71		10.1	7.5	1.3			9.4	6.9									1.3	0.6			1.9		22.6	1.9						21.4			
13X-CC	117.14	2.4	1.2	1.8				1.2												1.8	1.8		5.9	37.3		2.0					31.1			
14X-CC	126.35		5.9	5.9				2.0																							27.5			
15X-CC	130.31																			*	*										*			
16X-CC	144.52		9.2	3.9	1.3			0.7	4.6											2.0	3.9	1.3	19.6	2.6		2.6	0.7			26.1				
17X-CC	151.81																				2.1			2.1							14.6			
18X-2, 46-48	159.46		2.7						1.2									1.2				0.9		6.6	1.8	0.9						10.4		
18X-3, 42-44	160.92	*																																
18X-CC	161.52		4.9	1.3														0.5				2.9	0.3	13.5	3.6						0.8		4.9	
19H-1, 46-48	167.56																		3.8															
19H-2, 50-52	169.10																						9.4	3.8							15.1			
19H-3, 46-48	170.56		6.0	1.5				1.1	0.4									0.4	0.2	5.3		11.7	7.9		0.2					9.9				
19H-4, 46-48	171.76		7.4	0.3															1.8	0.6			2.8								5.2			
19H-5, 46-48	173.26	*	*	*				*									*														*			
19H-6, 46-48	174.76	*																			*										*			
19H-CC	176.90	1.1	6.8	2.1															1.5	2.1		6.0	4.7	0.4	1.1	0.6				7.0				
20X-2, 48-50	178.58		10.3	1.7				1.7										1.7		8.6		22.4	6.9	6.9						15.5				
20X-3, 46-48	180.06																																	
20X-4, 46-48	181.56		3.1	0.5				1.4											1.2	3.1	1.4	0.2	9.2	6.8						9.2				
20X-CC	181.89		3.0					3.9	0.2									0.2	2.7	0.9	0.9	14.8	5.7		0.7					7.5				
21X-1, 45-48	186.45																		0.4	0.8	2.9		0.8	4.2							4.6			
21X-2, 46-48	187.96	*																					*								*			
21X-3, 46-48	189.46		4.4	2.9				1.5	0.7									1.5		0.7		15.4								17.6				
21X-4, 45-47	190.95	0.3						13.0	3.0									0.3	0.3	1.0		5.7	1.0							17.3				
21X-5, 46-48	192.46																			*											*			
21X-6, 46-48	193.96	*	*	*	*			*	*											*			*	*							*			
21X-CC	195.13		1.8	0.9	0.7			2.2												0.4	1.1		6.0	5.1	1.3					17.3				

Table T5 (continued).

Table T5 (continued).

PLANKTONIC FORAMINIFERS OFF COSTA RICA IN THE EAST PACIFIC OCEAN

Table T5 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerina angustumiliata</i>	<i>Globigerina apertura</i>	<i>Globigerina bulloides</i>	<i>Globigerina decoraperta</i>	<i>Globigerina falconensis</i>	<i>Globigerina nepenthes</i>	<i>Globigerina quinqueloba</i>	<i>Globigerina rubescens</i>	<i>Globigerina woodi</i>	<i>Globigerinoides bolivi</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides cyclostomus</i>	<i>Globigerinoides elongatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerinoides immaturus</i>	<i>Globigerinoides obliquus</i>	<i>Globigerinoides quadrilobatus</i>	<i>Globigerinoides ruber</i>	<i>Globigerinoides saccularis</i>	<i>Globigerinoides tenellus</i>	<i>Globigerinoides trilobus</i>	<i>Globoquadrina barroenensis</i>	<i>Globoquadrina conglobata</i>	<i>Globoquadrina dehiscens</i>	<i>Globoquadrina venezuelana</i>	<i>Dentoglobigerina altispira altispira</i>	<i>Dentoglobigerina altispira globosa</i>	<i>Globigerinita glutinata</i>	<i>Globigerinita uvula</i>	<i>Orbulina bilobata</i>	
22X-1, 45-47	196.05			1.6	1.6													11.3	4.8										19.4			
22X-2, 45-47	197.55			1.0	0.2		1.4	1.4									0.2	11.0	1.4										28.8			
22X-3, 45-47	199.05			3.6	1.8												0.6	2.4	3.0										29.5			
22X-4, 45-47	200.55			9.1	6.2		1.1										2.2	3.4	1.7	13.1	2.9							21.7				
22X-5, 45-47	202.05			8.6	1.4			0.3									0.7	0.3	0.3	1.4	2.4							43.8	0.3			
22X-6, 45-47	203.55			3.4													1.0	1.4	1.0	3.4	4.8	5.3	2.9						5.8			
22X-7, 42-44	205.03			8.9				1.0										2.6	0.5	18.3	0.5								6.8			
22X-CC	205.45		4.0	0.4	1.1		1.8	0.9									0.6	3.1	3.6	25.1	4.3	0.4	0.9	0.5						13.4		
23X-1, 46-48	205.66		1.8	2.6														1.2	2.4	0.6	11.8	3.6							24.9			
23X-2, 46-48	207.16		4.4		2.0		1.6	2.8									3.2	3.6		17.9	4.4							26.2				
23X-3, 46-48	208.66																*															
23X-CC	214.47			2.6														1.3	2.6	39.0			3.9						9.1			
24X-6, 46-48	222.76	*				*												*		*										*		
24X-CC	224.53	*				*												*	*	*										*		
25X-2, 46-48	226.46	5.3	4.8	3.5													1.4	0.9	0.9	2.6	1.6	9.6	4.4	2.2					31.6			
25X-3, 46-48	227.96	*	*	*													*	*	*		*	*	*						*			
25X-4, 46-48	229.46																*												*			
25X-5, 46-48	230.96	2.3	0.9	0.5				3.7									1.4	1.4	2.8	5.1	0.5	21.7	8.8	3.2	0.5				11.5			
25X-6, 46-48	232.46	3.2	1.3					1.0										2.5	1.0	5.1	1.0	22.5	2.9	1.9	0.3				7.9			
25X-7, 41-48	233.91			3.4														1.7	1.7	6.9		10.3	13.8	5.2					19.0			
25X-CC	234.33		2.8	0.5			0.5												0.5	8.2	3.3	12.5	8.7	3.3	2.0				2.8			
26X-1, 45-47	234.55	7.4						6.2										1.2	6.2	2.5		14.8		3.7	1.2				13.6			
26X-2, 45-47	236.05			6.5				4.3										2.2	2.2	6.5	19.4	5.4	5.4					17.2				
26X-3, 44-46	237.54			*														*	*	*		*	*						*			
26X-4, 46-48	239.06																															
26X-5, 45-47	240.55		1.6					4.8										3.2	3.2	2.4	13.7	8.9	16.1	0.8				0.8	13.7			
26X-CC	241.91	1.0	0.6	1.8	0.4		0.8	1.8										1.0		2.6	6.0	9.7	8.1	1.0	0.2				0.8	4.4		
27X-1, 42-45	244.12																	*		*												
27X-2, 44-46	245.64																		*												*	
27X-5, 46-48	250.16	*																	*													
27X-6, 43-45	251.63																		*													
27X-CC	253.55	20.3	1.7			1.7	0.8	5.9											3.4		3.4	4.2							18.6			
28X-2, 45-47	255.25	*																	*													
28X-3, 45-47	256.75			2.8		1.9		1.9											5.6	1.9	7.5	0.9	2.8	1.9				15.0				
28X-4, 45-47	258.25																		1.7	1.7	10.3		6.9	5.2	1.7					8.6		
28X-5, 45-47	259.75	3.4		*	*	*													*	*	*		*							*		
28X-6, 45-47	261.25																															
28X-7, 36-38	262.66	0.3	0.7	2.4		0.3	0.7	0.5									1.0		2.1	0.3	21.8	2.1	3.5	4.8	2.4	5.2				3.9		
28X-CC	263.13			2.4			0.7	0.5										1.2	2.9	3.4	16.3	0.2	0.5	2.2	3.9	3.9				3.9		

Table T5 (continued).

Table T5 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerinella obesa</i>	<i>Pulleniatina obliquiloculata</i>	<i>Pulleniatina praecursor</i>	<i>Pulleniatina primalis</i>	<i>Neogloboquadrina acostaensis</i>	<i>Neogloboquadrina asanoi</i>	<i>Neogloboquadrina blowi</i>	<i>Neogloboquadrina dutertrei</i>	<i>Neogloboquadrina eggeri</i>	<i>Neogloboquadrina humerosa</i>	<i>Neogloboquadrina incompta</i>	<i>Neogloboquadrina pachyderma</i>	<i>Neogloboquadrina pseudopina</i>	<i>Sphaeroidinella dehiszens</i>	<i>Sphaeroidinellopsis seminulum</i>	<i>Sphaeroidinellopsis subdehiszens</i>	<i>Globorotaloides hexagona</i>	<i>Turborotalita humilis</i>	<i>Candeina nitida</i>	
22X-1, 45-47	196.05	1.6									3.2		0.5	6.5							
22X-2, 45-47	197.55	0.5 3.8						1.9 12.2					3.6	0.6			6.2				
22X-3, 45-47	199.05	3.0 6.0						3.0 0.6	4.2								1.2				
22X-4, 45-47	200.55	0.6 5.1						1.1 1.1	1.7	4.0							5.1				
22X-5, 45-47	202.05	6.2						5.5 8.9		1.7							5.5				
22X-6, 45-47	203.55	11.1						3.4 2.9	3.9		1.4	0.5					1.9				
22X-7, 42-44	205.03	11.5						1.0 0.5	1.0	5.2							2.1				
22X-CC	205.45	5.4									3.6			0.9				2.5			
23X-1, 46-48	205.66	1.8					1.8	4.1 2.3	1.8			1.8					3.0				
23X-2, 46-48	207.16	3.2						1.6 5.2			0.8						4.0				
23X-3, 46-48	208.66																				
23X-CC	214.47	1.3							15.6								3.9				
24X-6, 46-48	222.76								*		*		*				*				
24X-CC	224.53	*						*	*								*				
25X-2, 46-48	226.46	4.4						1.3 2.2	3.5			3.5					11.8	*			
25X-3, 46-48	227.96																				
25X-4, 46-48	229.46	*										*									
25X-5, 46-48	230.96	2.3 1.4						3.7	5.5			0.9					6.9				
25X-6, 46-48	232.46		12.7					2.5 12.0	2.2			0.3					2.9				
25X-7, 41-48	233.91			1.7					3.4		3.4						5.2				
25X-CC	234.33	3.1 7.7							10.2	2.8	3.1	0.3					14.0				
26X-1, 45-47	234.55			7.4 1.2					7.4		3.7						12.3				
26X-2, 45-47	236.05																				
26X-3, 44-46	237.54			6.5 4.3				3.2									8.6				
26X-4, 46-48	239.06			*	*												*				
26X-5, 45-47	240.55				8.1								4.0				4.8				
26X-CC	241.91	5.8		13.5 5.8				0.4		1.2	4.0						0.4 4.2				
27X-1, 42-45	244.12	*																			
27X-2, 44-46	245.64		*	*													*				
27X-5, 46-48	250.16											*									
27X-6, 43-45	251.63																				
27X-CC	253.55	5.9		5.9				1.7			5.1						3.4				
28X-2, 45-47	255.25																*				
28X-3, 45-47	256.75																				
28X-4, 45-47	258.25				0.9						15.9						2.8 3.7				
28X-5, 45-47	259.75		5.2														6.9 3.4				
28X-6, 45-47	261.25			*													*	*			
28X-7, 36-38	262.66	2.1															5.2 1.0 5.2				
28X-CC	263.13	4.4										1.7					1.9 2.7 6.6				

Table T5 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerina angustumiliata</i>	<i>Globigerina apertura</i>	<i>Globigerina bulloides</i>	<i>Globigerina decoraperta</i>	<i>Globigerina falconensis</i>	<i>Globigerina nepenthes</i>	<i>Globigerina quinqueloba</i>	<i>Globigerina rubescens</i>	<i>Globigerina woodi</i>	<i>Globigerinoides bollii</i>	<i>Globigerinoides conglobatus</i>	<i>Globigerinoides cyclostomus</i>	<i>Globigerinoides elongatus</i>	<i>Globigerinoides extremus</i>	<i>Globigerinoides immaturus</i>	<i>Globigerinoides obliquus</i>	<i>Globigerinoides quadrilobatus</i>	<i>Globigerinoides ruber</i>	<i>Globigerinoides saccifer</i>	<i>Globigerinoides tenellus</i>	<i>Globigerinoides trilobus</i>	<i>Globoquadrina baroemoenensis</i>	<i>Globoquadrina conglomerata</i>	<i>Globoquadrina dehiscens</i>	<i>Globoquadrina venezuelana</i>	<i>Dentoglobigerina altispira altispira</i>	<i>Dentoglobigerina altispira globosa</i>	<i>Globigerinita glutinata</i>	<i>Globigerinita uvula</i>	<i>Orbulina bilobata</i>
29X-1, 46-48	263.45																														
29X-2, 46-48	264.96	0.8	5.6	1.3	1.3	0.6					0.6																				
29X-3, 46-48	266.46			2.4	7.1																										
29X-4, 46-48	267.96																														
29X-5, 46-48	269.46		*				*	*																							
29X-6, 46-48	270.96			8.7	5.8			1.0				1.9																			
29X-7, 45-46	272.45								9.4																						
30X-1, 46-48	273.06			3.6	11.5	0.6	1.8																								
30X-2, 46-48	274.56			5.0	1.8		2.4		1.2																						
30X-3, 45-47	276.05	1.9	0.8	6.5	8.0	1.9				1.5		0.4																			
30X-4, 46-48	277.56			1.0	11.5	1.6				8.9																					
30X-6, 46-48	280.56					1.0																									

Note: * = trace (counts <50 specimens in sample).

Table T5 (continued).

Table T5 (continued).

Core, section, interval (cm)	Depth (mbsf)	<i>Globigerinella obesa</i>	<i>Pulleniatina obliquiloculata</i>	<i>Pulleniatina praecursor</i>	<i>Pulleniatina primalis</i>	<i>Neogloboquadrina acostaensis</i>	<i>Neogloboquadrina asanoi</i>	<i>Neogloboquadrina blowi</i>	<i>Neogloboquadrina dutertrei</i>	<i>Neogloboquadrina eggeri</i>	<i>Neogloboquadrina humerosa</i>	<i>Neogloboquadrina incompta</i>	<i>Neogloboquadrina pachyderma</i>	<i>Neogloboquadrina pseudopina</i>	<i>Sphaeroidinella dehiszens</i>	<i>Sphaeroidinellopsis seminulum</i>	<i>Sphaeroidinellopsis subdehiszens</i>	<i>Globorotaloides hexagona</i>	<i>Turborotalita humilis</i>	<i>Candeina nitida</i>
29X-1, 46-48	263.45	11.1			1.9												3.7			
29X-2, 46-48	264.96	4.2			0.8	21.2											2.5			
29X-3, 46-48	266.46																2.4			
29X-4, 46-48	267.96																*			
29X-5, 46-48	269.46																*			
29X-6, 46-48	270.96	17.3						3.8									*			
29X-7, 45-48	272.45							0.9									*			
30X-1, 46-48	273.06	1.8																		
30X-2, 46-48	274.56																			
30X-3, 45-47	276.05	6.1					6.9													
30X-4, 46-48	277.56	6.3					4.2													
30X-6, 46-48	280.56	1.0																		